THE D. H. HILL LIBRARY

NORTH CAROLINA STATE COLLEGE
OF AGRICULTURE AND ENGINEERING

SPECIAL COLLECTIONS

S643
R79

THE L. C. GLENN
GEOLOGICAL
COLLECTION

DONATED BY
W. W. AND L. C. GLENN
AS A
MEMORIAL
TO THEIR BROTHER
J. HOWARD GLENN
CLASS OF 1903

**THIS BOOK MUST NOT BE TAKEN
FROM THE LIBRARY BUILDING.**

Digitized by the Internet Archive
in 2010 with funding from
NCSU Libraries

To Professor L. Gilkey
with the respects of the Author.

AN
ESSAY

15-5-8

ON

CALCAREOUS MANURES.

Letting the world know
the value of the manure
the author has written
this book.
THIRD EDITION.

BY EDMUND RUFFIN.

PETERSBURG:

PRINTED FOR THE AUTHOR.

1842.

Entered according to act of Congress, by Edmond Ruffin, in the Clerk's Office of the District Court
of the Eastern District of Virginia.

PREFACE TO THE FIRST EDITION.

THE object of this essay is to investigate the peculiar features and qualities of the soils of our tide-water district, to show the causes of their general unproductiveness, and to point out means, as yet but little used, for their effectual and profitable improvement. My observations are particularly addressed to the cultivators of that part of Virginia which lies between the sea coast and the falls of the rivers, and are generally intended to be applied only within those limits. By thus confining the application of the opinions which will be maintained, it is not intended to deny the propriety of their being further extended. On the contrary, I do not doubt that they may correctly apply to all similar soils, under similar circumstances; for the operations of Nature are directed by uniform laws, and like causes must every where produce like effects. But as I shall rely for proofs on such facts as are either sufficiently well known already, or may easily be tested by any inquirer, I do not choose to extend my ground so far as to be opposed by the assertion of other facts, the truth of which can neither be established nor overthrown by any available or sufficient testimony.

The peculiar qualities of our soils have been little noticed, and the causes of those peculiarities have never been sought; and though new and valuable truths may await the first explorers of this opening for agricultural research, yet they can scarcely avoid mistakes sufficiently numerous to moderate the triumph of success. I am not blind to the difficulties of the investigation, nor to my own unfitness to overcome them; nor should I have hazarded the attempt, but for the belief that such an investigation is all-important for the improvement of our soil and agriculture, and that it was in vain to hope that it would be undertaken by those who were better qualified to do justice to the subject. I ask a deliberate hearing, and a strict scrutiny of my opinions, from those most interested in their truth. If a change, in most of our lands, from hopeless sterility to a high state of productiveness, is a vain fancy, it will be easy to discover and expose the fallacy of my views; but if these views are well founded, none deserve better the attention of farmers, and nothing can more seriously affect the future agricultural prosperity of our country. No where ought such improvements to be more highly valued, or more eagerly sought, than among us, where so many causes have concurred to reduce our products, and the prices of our lands, to the lowest state, and are yearly extending want, and its consequence, ignorance, among the cultivators and proprietors.

In pursuing this inquiry, it will be necessary to show the truth of various facts and opinions which as yet are unsupported by authority, and most of which have scarcely been noticed by agricultural writers, unless to be denied. The number of proofs that will be required, and the discursive course through which they must be reached, may probably render more obscure the reasoning of an unpractised writer. Treatises on agriculture ought to be so written as to be clearly understood, though it should be at the expense of some other requisites of good writing; and, in this respect, I shall be satisfied if I succeed in making my opinions intelligible to every reader, though many might well dispense with such particular explanations. Agricultural works are seldom considered as requiring very close attention; and therefore, to be made useful, they should be put in a shape suited to cursory and irregular reading. A truth may be clearly established—but if its important consequences cannot be regularly deduced for many pages afterwards, the premises will then probably have been forgotten, so that a very particular reference to them may be required. These considerations must serve as my apology for some repetitions—and for minute explanations and details, which some readers may deem unnecessary.

The theoretical opinions supported in this essay, together with my earliest experiments with calcareous manures, were published in the 'American Farmer,' (vol. iii., page 313,) in 1821. No reason has since induced me to retract any of the important positions then assumed. But the many imperfections in that publication, which grew out of my want of experience, made it my duty, at some

future time, to correct its errors, and supply the deficiencies of proof, from the fruits of subsequent practice and observation. With these views, this essay was commenced and finished in 1826. But the work had so grown on my hands, that instead of being of a size suitable for insertion in an agricultural journal, it would have filled a volume. The unwillingness to assume so conspicuous a position as the publication in that form would have required, and the fear that my work would be more likely to meet with neglect or censure than applause, induced me to lay it aside, and to give up all intention of publication. Since that time, the use of fossil shells as manure has greatly increased, in my own neighborhood and elsewhere, and has been attended generally with all the improvement and profit that was expected. But from paying no regard to the theory of the operation of this manure, and from not taking warning from the known errors and losses of myself as well as others, most persons have used it injudiciously, and have damaged more or less of their lands. So many disasters of this kind seemed likely to restrain the use of this valuable manure, and even to destroy its reputation, just as it was beginning rapidly to extend. This additional consideration has at last induced me to risk the publication of this essay. The experience of five more years, since it was written, has not contradicted any of the opinions then advanced—and no change has been made in the work, except in form, and by continuing the reports of experiments to the present time.

It should be remembered that my attempt to convey instruction is confined to a single means of improving our lands, and increasing our profits; and though many other operations are, from necessity, incidentally noticed, my opinions or practices on such objects are not referred to as furnishing rules for good husbandry. In using calcareous manure for the improvement of poor soils, my labors have been highly successful; but that success is not necessarily accompanied by general good management and economy. To those who know me intimately, it would be unnecessary to confess the small pretensions that I have to the character of a good farmer; but to others it may be required, for the purpose of explaining why other improvements and practices of good husbandry have not more aided, and kept pace with, the effects of my use of calcareous manures.

E. R.

Prince George county, Virginia, January 20th, 1832.

PREFACE TO SECOND EDITION.

When the first edition of this essay was published, it met with a reception far more favorable, and a demand from purchasers much greater, than the author's anticipations had reached; and it is merely in accordance with the concurrent testimony of the many agriculturists who have since expressed and published opinions on the subject, to say that the publication has already had great and valuable effects in directing attention, and inducing successful efforts, to the improvement of land by calcareous manures. Experimental knowledge on this head has probably been more than doubled within the last two years; and the narrow limits of the region within which marling had previously been confined, have been enlarged to perhaps ten-fold their former extent. Still, the circumstances now existing, however changed for the better, present a mere beginning of the immense and valuable improvements of soil, and increase of profits, that must hereafter grow out of the use of calcareous manures, *if their operation is properly understood by those who apply them.* But if used without that knowledge, their great value will certainly not be found; and indeed, they will often cause more loss than profit. It is therefore not so important to the farmers of our country at large to be convinced of the general and great value of calcareous manures—and to those in the great Atlantic tide-water region to know the newly established truth, that their beds of fossil shells furnish the best and cheapest of manures—as it is, that all should know in what manner, and by what general laws, these manures operate—how they produce benefit, and when they may be

either worthless or injurious. And this more important end, the author regrets to believe has as yet scarcely been even partially attained, by the dissemination and proper understanding of correct views of the subject. Of course it is not to be supposed that this essay has been read (if even heard of) by one in ten of the many who have been prompted by verbal information to attempt the practice it recommends; and of those who have read, and who have even expressed warm approbation of the work, it has seldom been found that their praise was discriminating, or founded upon a thorough examination of its reasoning and theoretical views, on which principally rests whatever value it may possess. For all persons who are so easily convinced, it may truly be said, that the volume embraced nothing more, and was worth no more, than would be stated in these few words—"the application of calcareous manures will be found highly improving and profitable." It is not therefore at all strange, that the attentive reading of a volume to obtain this truth, was generally deemed unnecessary.

Though the first edition of this work has been nearly exhausted, the circulation has as yet been almost confined to that small portion of the state of Virginia alone in which the mode of improvement recommended had previously been successfully commenced, or had at least attracted much attention. But this district is not better fitted to be thus improved than the remainder of the great tide-water region stretching from Long Island to Mobile—and to a great part of which calcareous manures may be cheaply applied. It is only in parts of Maryland and Virginia that many extensive and highly profitable applications of fossil shells, or marl, have been yet made. In North Carolina the value of the manure has been but lately tried; in South Carolina and Georgia, no notice of it has yet been taken, or at least has not been made known; and in Florida and Alabama, (parts of which are peculiarly suited to receive these benefits,) it is most erroneously thought that such improvements are only profitable for long settled and impoverished countries. The farmers of Pennsylvania have gone far ahead of those of Virginia in manuring with lime—and it is believed (but upon no certain testimony) that in New Jersey, use has been made of the calcareous manure which in Virginia is called marl, as well as of the *green sand*, which they even, still more erroneously call by the same name. But whatever may have been the extent of their use of calcareous manures of every kind, and however great their success, it is believed that our northern brethren have been as little directed by correct views of the operation of these manures, as those of the south, who have neglected them entirely.

But though the circulation of this work will be most useful through the great tide-water region, which is so generally supplied with underlying beds of fossil shells, and so much of the soil of which especially needs such manure, still the assertion may be ventured that there is no part of the country where the views presented, *if true*, are not important to be known; and, if known, would not be highly useful to aid the improvement of soils. It is to the general theory of the constitution of fertile and barren soils, that the attention and severe scrutiny of both scientific and practical agriculturists are invited; and to the several minor points there presented, which are either altogether new, or not established by authority—such as the doctrine of acidity in soils—of the incapacity of poor and acid soils to be enriched—and of the entire absence of carbonate of lime in most of the soils of this country.

The circumstances stated above, have induced the publication of a second edition as a supplement to the 'Farmers' Register,' (and suited to be bound with either volume of that work,) which, in that form, may have the facility of distribution through the mail—and which may be offered at so low a price as to reach, as nearly as possible, that general circulation which is its author's main object.

April, 1835.

PREFACE TO THE THIRD EDITION.

The rapid progress of improvement made by the use of calcareous manures, as well as the many misdirected and less effective attempts to obtain such results, together with the acquisition of much recent and extended information on the subject, all concur in requiring the new and enlarged edition of the Essay on Calcareous Manures, which the author now offers to the agricultural public.

In the few years which have passed since the issue of the preceding edition, it is believed that the use of marl and lime, in lower Virginia, has been extended over thrice as much land as had been previously thus improved; and the previous clear income of the farmers thus fertilizing their lands has probably been already thereby increased in amount by several hundreds of thousands of dollars, and the intrinsic value of the lands raised by as many millions. These great augmentations of annual profits and of the true value of landed capital, from this single source, if they could be accurately estimated, would be seen to have produced an important item of additional revenue to the treasury of the commonwealth. And these additions of wealth to individuals and to the state, would be obvious as well as real, but for the existence of other circumstances which have operated to counteract or to disguise the proper results. The most important of such influences will be merely referred to here in the cursory manner only that the occasion permits.

In the first place—besides the deservedly very low appreciation of all lands in Virginia, founded on the smallness of their products, the market prices were formerly still more reduced by the almost universal urgent desire of proprietors to sell, that they might be enabled then to emigrate to the new and rich lands of the west. The impossibility of selling, even at the lowest valuation price, was the only thing which prevented the actual flood of emigration being so much more swelled as to leave half our lands unoccupied and waste. If purchasers had but presented themselves, fully half the farms in Prince George county (and it is presumed of many other counties) might have been bought up at a considerable deduction from the lowest estimated value; and all the sellers would have removed, with all their capital, to the western wilderness. To the then actual and regular flow of emigration from the now marling district, an effectual barrier has been opposed by the introduction of that mode of improvement. All emigration has ceased wherever by trial of this means the cultivators of the land found their labors to be richly repaid. Thus, in estimating the gains of individuals and of the state, on this score, the comparison should be made, not with the value of property and population which remained twenty years ago, but with what would have remained now, if the then existing inducements to emigration had continued to go on and to increase, as they would have done, with time.

Next—the actual increase of intrinsic value of marled lands is far from being even yet fully appreciated, because of the generally prevailing and very erroneous mode of estimating the values of the increase of permanent net income from land, (as will be made manifest in a part of this essay—) and but few even of those persons who have obtained such values by marling their lands, would estimate them at one-fourth of their true amount. The source of any *permanent net increase* of only \$6 of annual income from land, adds \$100 to the intrinsic value of the land. And this proposition is not the less true, and to the full extent asserted, even though the estimate of private purchasers and sellers, and of public assessors of lands, may all count for the market price but a small proportion of the increased real value.

Next—even whatever of new appreciation the foregoing influences might have permitted to be exhibited in the increased market price of lands, and still more their new real value, have been disguised, or altogether concealed, by the great and frequent fluctuations of all market prices of property, and by the general misdirections of capital and industry, all caused by the universal individual and national gambling (whether voluntary or compulsory,) at the maddening and ruinous

game of paper-money banking—to which system of delusion and fraud this otherwise most blessed country and fortunate people are indebted for so much of disaster, loss, and, still worse, of wide-spread corruption of habits and morals. The enormous apparent and illusory profits promised by this system, and by the stock-jobbers who alone have fattened upon the facilities it offered for fraud and plunder, served powerfully to depress the market price of lands and to discourage agricultural investments and pursuits. For, whatever actual profits the improvement and cultivation of the soil might offer to reward the care and labor of the proprietor, the stocks of various corporations, falsely appreciated by means of a bloated paper currency and by the arts of stockjobbers, *promised* much higher profits, without requiring either care, labor or risk. Thus, the higher that fictitious dividends of profits or the false values of stocks rose, and the stronger became the inducements to make stock investments, the more the prices of lands sunk (comparatively) below their true value, because of the general disposition to convert landed capital to stock capital. But the real and solid increase of income and of wealth to individuals and to the commonwealth, caused by the permanent improvement of the soil, is not the less certain, or the less profitable, because fictitious appreciations of values, caused by the fraudulent banking system, and the consequent speculations and madness of its votaries and victims, have been both so much higher and lower, at different times, as to make the amount of actual improved values appear small in comparison, even if they were not thereby entirely concealed. But these delusive and ruinous causes of fluctuating prices and values are now fast showing their emptiness, and vanishing from view; and whenever the fraudulent paper system shall be completely exposed and entirely exploded, then both lands and paper money system will be estimated at their true value. May the consummation be speedy, complete, and final!

But even though, if properly and accurately estimated, the true value of the lands already marled and limed in Virginia has been increased to the amount of some millions of dollars, the gain is very small compared to that which yet remains ready to be obtained. Marling has not yet been extended over the hundredth part of the surface to which it may be profitably applied—and liming not to the ten-thousandth part of the lands of the state to which lime may be brought. And elsewhere, with the exception of a small part of Maryland, the beginnings of marling only have as yet been made. Nevertheless, these beginnings are the widely scattered seeds which will spring up and spread, and hereafter yield abundant harvests. In South Carolina, more especially, the use of marl has been at last commenced and is now regularly prosecuted under auspices which offer assurance that the rich resources of that state, in calcareous deposits, will not much longer be permitted to lie as dead capital, of which the value was not appreciated or known, and the existence scarcely suspected by the proprietors.

In preparing this new edition, the author has endeavored to avail himself of all recent lights, and to present a full and clear view of the general subject, as well as of all essential details. The general theoretical opinions, as presented in the earlier editions, remain unaltered, and of course the facts of former practice; but in regard to both, while preserving the same substance, the treatment has been enlarged, or the views and statements extended for better illustration and greater clearness. Whatever of other parts of the last edition could be well spared, has been omitted; and much of other additional and new matter introduced. It has been the object of the author to render the work a full and sufficient guide for the conduct of novices in marling and liming, and he trusts that he has not fallen very far short of attaining that object.

December, 1842.

AN
ESSAY
ON
CALCAREOUS MANURES.

PART FIRST—THEORY.

CHAPTER I.

GENERAL DESCRIPTION OF EARTHS AND SOILS.

It is very necessary that we should correctly distinguish *earths* and *soils* and their many varieties; yet these terms are continually misapplied—and, even among authors of high authority, no two agree in their definitions, or modes of classification. Where such differences exist, and no one known method is so free from material imperfections as to be referred to as a common standard, it becomes necessary for every one who treats of soils to define for himself—though perhaps he is thereby adding to the general mass of confusion already existing. This necessity must be my apology for whatever is new or unauthorized in the following definitions.

The *earths* important to agriculture, and which form nearly the whole of the known globe, are only three—*silicious*, *aluminous* and *calcareous*.

Silicious earth, in its state of absolute purity, forms rock crystal. The whitest and purest sand may be considered as silicious earth in agriculture, though none is presented by nature entirely free from other ingredients. It is composed of very hard particles, not soluble in any common acid, and which cannot be made coherent by mixing with water. Any degree of coherence, or any shade of color that sand may exhibit, is owing to the presence of other substances. The solidity of the particles of sand renders them impenetrable to water, which passes between them as through a sieve. The hardness of its particles, and their loose arrangement, make sand incapable of absorbing moisture from the atmosphere, or of retaining any valuable vapor or fluid, with which it may have been in any manner supplied. Silicious earth is also quickly heated by the sun, which adds to the rapidity with which it loses moisture.

Aluminous or *argillaceous earth*, when dry, adheres to the tongue, absorbs water rapidly and abundantly, and when wet forms a tough paste, smooth and soapy to the touch. By burning, it becomes as hard as stone. Clays derive their adhesiveness from their proportion of aluminous earth. This also is white when pure, but is generally colored deeply and variously—red, yellow, or blue—by metallic substances. When drying, aluminous earth shrinks greatly, and becomes a mass of very hard lumps, of various sizes, separated by cracks and fissures, which become so many little reservoirs of standing water when filled by rains, and remain so, until the

lumps, by slowly imbibing the water, are distended enough to fill the space occupied before.

Calcareous earth, or *carbonate of lime*,* is *lime* combined with *carbonic acid*, and may be converted into pure or quick-lime by heat; and quick-lime, by exposure to the air, soon returns to its former state of calcareous earth. It forms marble, limestone, chalk, and shells, with very small admixtures of other substances. Thus the term *calcareous earth* will not be used here to include either *lime* in its pure state, or any of the numerous combinations which lime forms with the various acids, except that one combination (carbonate of lime) which is beyond comparison the most abundant throughout the world, and most important as an ingredient of soils. Pure lime attracts all acids so powerfully, that it is never presented by nature except in combination with some one of them, and generally with the carbonic acid. When this compound is thrown into any stronger acid, as the muriatic, nitric, or even common vinegar, the lime, being more powerfully attracted, unites with and is dissolved by the stronger acid, and lets go the carbonic, which escapes with effervescence in the form of air. In this manner, the carbonate of lime, or calcareous earth, may not only be easily distinguished from silicious and aluminous earth, but also from all other combinations of lime.

The foregoing definition of calcareous earth, which confines that term to the *carbonate* of lime, is certainly liable to objections, but less so than any other designation. It may at first seem absurd to consider as one of the three principal earths which compose soils, *one* only of the many combinations of lime, rather than either *pure lime* alone, or lime in *all* its combinations. One or the other of these significations is adopted by the highest authorities, when the calcareous ingredients of soils are described; and in either sense, the use of this term is more conformable with scientific arrangement, than mine. Yet much inconvenience is caused by thus applying the term calcareous earth. If applied to *lime*, it is to a substance which is never found existing naturally, and which will always be considered by most persons as the artificial product of the process of calcination, and as having no more part in the composition of natural soils, than the manures obtained from oil-cake, or pounded bones. It is equally improper to include under the same general term all the combinations of lime with the fifty or sixty various acids. Two of these compounds, the sulphate and the phosphate of lime, are known as valuable manures; but they exist naturally in soils in such minute quantities, as not to deserve to be considered as important ingredients. A subsequent part of this essay will show why the oxalate of lime is also supposed to be highly valuable as a manure, and far more abundant. Many other salts of lime are known to chemists; and their several qualities, as affecting soils, are entirely unknown—and their

* *Carbonate of lime* is the chemical name for the substance formed by the combination of *carbonic acid* with *lime*. The names of all the thousands of different substances (*neutral salts*) which are formed by the combination of each of the many acids with each of the various earths, alkalies, and metals, are formed by one uniform rule, which is as simple, and easy to be understood and remembered, as it is useful. To avoid repeated explanations in the course of this essay, the rule will now be stated by which these compounds are named. The termination of the name of the acid is changed to the syllable *ate*, and then prefixed to the particular earth, alkali, or metal with which the acid is united. With this explanation, any reader can at once understand what is meant by each of some thousands of terms, none of which might have been heard of before, and which (without this manner of being named) would be too numerous to be fixed in the most retentive memory. Thus, it will be readily understood that the *carbonate of magnesia* is a compound of the carbonic acid and magnesia—the *sulphate of lime*, a compound of sulphuric acid and lime—the *sulphate of iron*, a compound of sulphuric acid and iron—and in like manner for all other terms so formed.

quantities are too small, and their presence too rare, to require consideration. If all the numerous different combinations of lime, having perhaps as many various and unknown properties, had not been excluded by my definition of calcareous earth, continual exceptions would have been necessary, to avoid stating what was not meant. The *carbonate of lime*, to which I have confined that term, though only one of many existing combinations, yet in quantity and in importance, as an ingredient of soils, as well as a part of the known portion of the globe, very far surpasses all the others.

But even if calcareous earth, as defined and limited, is admitted to be the substance which it is proper to consider as one of the three important earths of agriculture, still there are objections to its name, which I would gladly avoid. However strictly defined, many readers will attach to terms such meanings as they had previously understood: and the word *calcareous* has been so loosely and so differently applied in common language, and in agriculture, that much confusion may attend its use. Anything "partaking of the nature of lime" is "calcareous," according to Walker's Dictionary; Lord Kames limits the term to *pure lime*;* Davy† and Sinclair‡ include under it pure lime and all its combinations; and Kirwan,|| Rozier,¶ and Young,§ whose example I have followed, confine the name calcareous earth to the carbonate of lime. Nor can any other term be substituted without producing other difficulties. *Carbonate of lime* would be precise, and it means exactly the same chemical substance; but there are insuperable objections to the frequent use of chemical names in a work addressed to ordinary readers. Chalk, or shells, or mild lime, (or what had been quick-lime, but which, from exposure to the air, had again become carbonated,) all these are the same chemical substance; but none of these names would serve, because each would be supposed to refer to such certain form or appearance of calcareous earth, as they usually express. If I could hope to revive an obsolete term, and with some modification establish its use for this purpose, I would call this earth *calx*—and from it derive *calxing*, to signify the application of calcareous earth, in any form, as manure. A general and definite term for this operation is much wanting. Liming, marling, applying drawn ashes, or the rubbish of old buildings, chalk, or limestone gravel, all these operations are in part, and some of them entirely, that manuring that I would thus call *calxing*. But because their names are different, so are their effects generally considered—not only in those respects where differences really exist, but in those where they are precisely alike.

Calcareous earth in its different forms has been supposed to compose as much as one eighth part of the crust of the globe.** Very extensive plains in France and England are of chalk, pure enough to be nearly barren, and to prove that pure calcareous earth would be entirely so. No chalk is to be found in our country—and it is only from European authors that we can know any thing of its agricultural characters, when nearly pure, or when forming a very large proportion of the surface of the land. The whiteness of chalk repels the rays of the sun, while its loose particles permit water to pass through, as easily as sand;†† and thus calcareous earth is remarkable for possessing some of the worst qualities of both the other

* Gentleman Farmer, page 261, (2d Edin. ed.)

† Agr. Chem. page 223, (Phil. ed. of 1821.)

‡ Code of Agriculture, page 134, (Hartford ed. 1818.)

|| Kirwan on Manures, chap. 1.

¶ "Terres"—Cours Complet d'Agriculture Pratique.

§ Young's Essay on Manures, chap. 3.

** Cleaveland's Mineralogy—On carbonate of lime.

†† Cours Complet d'Agriculture, etc. par l'Abbé Rozier—Art. "Terres."

earths, and which it serves to cure in them (as will hereafter be shown) when used as a manure.

Most of those who have applied chemistry to agriculture consider *magnesia* as one of the important earths.* *Magnesia*, like lime, is never found pure, but always combined with some acid, and its most general form is the carbonate of *magnesia*. But even in this, its usual and natural state, it exists in such very small quantities in soils, and is found so rarely, that its name seems a useless addition to the lists of the earths of agriculture. For all practical purposes, gypsum (though only another combination of lime,) would more properly be arranged as a distinct earth, or element of soils, as it is found in far greater abundance and purity, and certainly affects some soils and plants in a far more important manner than has yet been attributed to *magnesia* in its natural form.

Magnesia (or, more properly speaking, the carbonate of *magnesia*) is here treated as comparatively *unimportant* as an *agricultural earth*, because of its being rarely found, and in but inconsiderable quantities in natural soils, and being unattainable as a manure. It was not thereby intended to be asserted that *magnesia* would not be important as an ingredient of soil and as a manure, if it were abundant as the one, or at command for the other. From the great similarity in chemical properties of *magnesia* to lime, it is most probable that their action in soils is also similar. The alluvial soil of the Red-river bottom, in Arkansas, which is of the highest grade of fertility, I have found by analysis to contain between one and two per cent. of carbonate of *magnesia*, and two to three per cent. of carbonate of lime. The mud deposited by the floods of the Nile, and which forms the celebrated rich soil of Egypt, also contains carbonate of *magnesia*. (*Lyell*, p. 223, vol. i.) Yet most writers have deemed *magnesia* in soils a cause of sterility.

All the earths, when as pure as they are ever furnished by nature, are entirely barren, as might be inferred from the description of their qualities; nor would any addition of putrescent manures† enable either of the earths to support healthy vegetable life.

The mixture of the three important earths in due proportions will correct the defects of all; and with a sufficiency of putrescent animal or vegetable matter, soluble in water, a *soil* is formed, in which plants can extend their roots freely, yet be firmly supported, and derive all their needful supplies of air, water and warmth, without being oppressed by too much of either. Such is the natural surface of almost all the habitable world; and though the qualities and values of soils are as various as the proportions of their ingredients are innumerable, yet they are mostly so constituted that no one earthy ingredient is so abundant but that the texture‡ of the soil is mechanically suited to some one valuable crop; as some plants require a degree of closeness, and others of openness in the soil, which would cause other plants to decline or perish.

Soil seldom extends more than a few inches below the surface, as on the surface only are received those natural supplies of vegetable and animal matters, which are necessary to constitute soil. Valleys subject to inundation have soils brought from higher lands, and deposited by the water,

* *Davy's Agricultural Chemistry*, p. 110. Phila. ed. 1821.

† *Putrescent or enriching manures*, are those formed of vegetable and animal matters, capable of putrefying, and thereby furnishing soluble food to plants. Farm yard and stable manure, and the weeds and other growth of the fields left to die and rot on them, are almost the only enriching manures that have been used as yet in this country.

‡ The *texture* of a soil means the disposition of its parts, which produces such sensible qualities as being close, adhesive, open, friable, &c.

and therefore are of much greater depth. Below the soil is the *sub-soil*, which is also a mixture of two or more earths, but usually is almost as barren as each of the unmixed or pure earths, because it contains very little putrescent matter, the only food for plants.

The qualities and value of soils depend on the proportions of their ingredients. We can easily comprehend in what manner silicious and aluminous earths, by their mixture, serve to cure the defects of each other; the open, loose, thirsty, and hot nature of sand being corrected by, and correcting in turn, the close, adhesive, and water-holding qualities of aluminous earth. This curative operation is merely mechanical; and in that manner it seems likely that calcareous earth, when in large proportions, also acts, and aids the corrective powers of both the other earths. This, however, is only supposition, as I have met with scarcely any such natural soil.

But besides the mechanical effects of calcareous earth, (which perhaps are weaker than those of the other two,) that earth has chemical powers far more effectual in altering the texture of soils, and for which a comparatively small quantity is amply sufficient. The chemical action of calcareous earth, as an ingredient of soils, will be fully treated of hereafter; it is only mentioned in this place to avoid the apparent contradiction which might be inferred, if, in a general description of calcareous earth, I had omitted all allusion to qualities that will afterwards be brought forward as all-important.

Nothing is more wanting in the science of agriculture, than a correct nomenclature of soils, by which the characters might be learned from the names; and nothing has hitherto seemed less attainable. The modes of classing and naming soils, used by scientific authors, are not only different, and opposed to each other, but each one of them is quite unfit to serve the purpose intended. As to the crowd of inferior writers, it is enough to say that their terms are not fixed by any rule, convey no precise meaning, and are worth not much more than those in common use among ourselves, and other practical cultivators, which often vary in their meaning within forty miles of distance. To enable us to judge of the fitness of the names given to soils by others, let us examine those applied by ourselves. We generally describe soils by making a mental comparison with those we are most accustomed to; and though such a description is understood well enough through a particular district, it may have quite a different meaning elsewhere. What are called *clay* or *stiff* soils, in Sussex and Southampton, would be considered *sandy* or *light* soils in Goochland—merely because almost every acre of land in the former counties is sandy, and in the latter, clays are nearly as abundant.

The conflict of definitions, and consequent confusion of terms, cannot be more plainly set forth, than by quoting from some of the highest authorities, the various and contradictory explanations of a term, *loam*, which is so common that it is used by every one who writes or speaks of soils—and which, in some one or other sense, each writer probably considered as forming a very large, if not the greatest proportion of the cultivated soils of his country, and of the world.

“*Loam* denotes any soil moderately cohesive, and more so than loose chalk. By the author of the Body of Agriculture, it is said to be a *clay mixed with sand*.” [Kirwan on Manures—chap. 1.]

“*Loam*, or that species of *artificial soil* into which the others are generally brought by the course of long cultivation.”—“Where a soil is moderately cohesive, less tenacious than clay, and more so than sand, it is known by the name of loam. From its frequency, there is reason to suppose that in some cases it might be called an “*original soil*.” [Sinclair's Code of Agriculture—chap. 1.]

"The word loam should be limited to soils containing at least one third of impalpable earthy matter, *copiously effervescing with acids.*" [Davy's *Agricultural Chemistry—Lecture 4.*] According to this definition by the most scientific writer and highest authority in chemical agriculture, if we except the small portion of shelly land, there is certainly not an acre of *natural loam* between the sea-coast of Virginia and the Blue Ridge mountains—and very few, if any, even in the limestone region.

"By loam is meant *any of the earths combined with decayed animal or vegetable matter.*" [Appendix to *Agr. Chem.* by George Sinclair.]

"Loam—*fat unctuous earth—marl.*" [Johnson's *Dictionary*, Sec. ed., and also Walker's.]

"Loam may be considered a clay of loose or friable consistency, mixed with mica or isinglass, and iron ochre." [Editor of *American Farmer*, vol. iii., page 320.]

It seems most proper to class and name soils according to their *predominant* earthy ingredients, by which term, I mean those ingredients which exert the greatest power, and most strongly mark the character of the soil. The predominant ingredient (in this sense,) is not always the most abundant, and frequently is the least. If the most abundant were considered the predominant ingredient, and gave its name to the soil,* then almost every one should be called silicious, as that earth is seldom equalled in quantity by all the others united. If the earthy parts of a soil were two thirds silicious, and one third of aluminous earth, the peculiar qualities of the smaller ingredient would predominate over the opposing qualities of the sand, and the mixture would be a tenacious clay. If the same soil had contained only one twentieth part of calcareous earth, that ingredient would have had more marked effects on the soil, than could have been produced by either doubling, or diminishing to half their quantity, the silicious and aluminous earths, which formed the great bulk of the soil. If soils were named according to certain proportions of their ingredients, (as proposed by Davy,†) a correct, though limited analysis of a soil would be required, before its name or character could be given; and even then the name and character would often disagree. But every farmer can know what are the most marked good or bad qualities of his soils, as shown under tillage, and those qualities can be easily traced to their predominant ingredients. By compounding a few terms, various shades of difference may be designated with sufficient precision. A few examples will be sufficient to show how all may be applied:—

A *silicious* or *sandy soil* has such a proportion of silicious earth as to show more of its peculiar properties than those of any other ingredient. It would be more or less objectionable for its looseness, heat, and want of power to retain either moisture or putrescent manure;—and not in the least for toughness, liability to become hard after wet ploughing, or any other quality of aluminous earth.

In like manner, an *aluminous* or *clayey soil* would show most strongly the faults of aluminous earth, though much more than half its bulk might be of silicious earth.

The term *loam* is not essential to this plan, but it is convenient, as it will prevent the necessity of frequent compounds of other terms. It will be used for all soils formed with such proportions of sand and aluminous earth, as not to be light enough to be called sandy, nor stiff enough for clay soil. *Sandy loam* and *clayey loam* would express its two extremes—and *loamy*

* Which is the plan of the nomenclature of soils proposed by Rozier. See article "Terres," Cours Complet d'Agriculture, etc.

† Agr. Chem. p. 139.

sand would be still lighter than the former, and *loamy clay* stiffer than the latter.

In all compound names of soils, the last term should be considered as expressing the predominant earthy ingredient. Thus, a *sandy loamy calcareous soil* would be nearer to loam than sand, and more marked by its calcareous ingredient than either. Other ingredients of soils, besides the earths, or any accidental or rare quality affecting their character considerably, may be described with sufficient accuracy by such additional terms as these—a *ferruginous gravelly silicious loam*—or a *vegetable calcareous clay*.

CHAPTER II.

ON THE SOILS, AND STATE OF AGRICULTURE OF THE TIDE-WATER DISTRICT OF VIRGINIA.

—“During several days of our journey, no spot was seen that was not covered with a luxuriant growth of large and beautiful forest trees, except where they had been destroyed by the natives for the purpose of cultivation. The least fertile of their pasture lands, without seeding, are soon covered with grass several feet in height; and unless prevented by cultivation, a second growth of trees rapidly springs up, which, without care or attention, attain their giant size in half the time that would be expected on the best lands in England.”

If the foregoing description was met with in a ‘Journey through Cabul,’ or some equally unknown region, no European reader would doubt but such lands were fertile in the highest degree—and many even of ourselves would receive the same impression. Yet it is no exaggerated account of the poorest natural soils in our own poor country, which are as remarkable for their producing luxuriant growths of pines, and broom grass, as for their unproductiveness in every cultivated or valuable crop. We are so accustomed to these facts, that we scarcely think of their singularity; nor of the impropriety of calling any land barren, which will produce a rapid or heavy growth of any one plant. Indeed, by the rapidity of that growth, (or the fitness of the soil for its production,) we have in some measure formed a standard of the poverty of the soil.

With some exceptions to every general character, the tide-water district of Virginia may be described as generally level, sandy, poor, and free from any fixed rock, or any other than stones rounded apparently by the attrition of water. On much the greater part of the lands, no stone of any kind is to be found of larger size than gravel. Pines of different kinds form the greater part of a heavy cover to the silicious soils in their virgin state, and mix considerably with oaks and other growth of clay land. Both these kinds of soil, after being exhausted of their little fertility by cultivation, and “turned out” to recruit, are soon covered by young pines which grow with vigor and luxuriance. This general description applies more particularly to the *ridges* which separate the *slopes* on different streams. The ridge lands are always level, and very poor—sometimes clayey, more generally sandy, but stiffer than would be inferred from the proportion of silicious earth they contain, which is caused by the fineness of its particles. Whortleberry bushes, as well as pines, are abundant on ridge lands—and numerous shallow basins are found, which are ponds of rain water in winter, but dry in summer. None of this large proportion of our lands has paid the expense of clearing and cultivation, and much the greater part still re-

mains under its native growth. Enough, however, has been cleared and cultivated in every neighborhood to prove its utter worthlessness under common management. The soils of ridge lands vary between sandy loam and clayey loam. It is difficult to estimate their general product under cultivation; but judging from my own experience of such soils, the product may be from five bushels of corn, or as much of wheat, to the acre on the most clayey soils, to twelve bushels of corn, and less than three of wheat, on the most sandy—if wheat were there attempted to be made.

The *slopes* extend from the ridges to the streams, or to the alluvial bottoms, and include the whole interval between neighboring branches of the same stream. This class of soils forms another great body of lands, of a higher grade of fertility, though still far from valuable. It is generally more sandy than the poorer ridge land, and when long cultivated is more or less deprived of its soil, by the washing of rains, on every slight declivity.

The washing away of three or four inches in depth exposes a sterile subsoil, (or forms a "gall,") which continues thenceforth bare of all vegetation. A greater declivity of the surface serves to form gullies several feet in depth, the earth carried from which, covers and injures the adjacent lower land. Most of this kind of land has been cleared and greatly exhausted. Its virgin growth is often more of oak, hickory, and dogwood, than pine; but when turned out of cultivation, an unmixed growth of pine follows. Land of this kind in general has very little durability. Its best usual product of corn may be, for a few crops, eighteen or twenty bushels—and even as much as twenty-five bushels, from the highest grade. Wheat is seldom a productive or profitable crop on the slopes, the soil being generally too sandy. When such soils as these are called rich or valuable (as most persons would describe them,) those terms must be considered as only comparative; and such an application of them proves that truly fertile and valuable soils are very scarce in lower Virginia.

The only very rich and durable soils below the falls of our rivers are narrow strips of high-land along their banks, and the low-lands formed by the alluvion of the numerous smaller streams which water our country. These alluvial bottoms, though highly productive, are lessened in value by being generally too sandy, and by the damage they suffer from being often inundated by floods of rain. The best high-land soils seldom extend more than half a mile from the river's edge—sometimes not fifty yards. These irregular margins are composed of loams of various qualities, but all highly valuable; and the best soils are scarcely to be surpassed in their original fertility, and durability under severe tillage. Their nature and peculiarities will be again adverted to, and more fully described hereafter.

The simple statement of the general course of tillage to which this part of the country has been subjected is sufficient to prove that great impoverishment of the soil has been the inevitable consequence. The small portion of rich river margins, was soon all cleared, and was tilled without cessation for many years. The clearing of the slopes was next commenced, and is not yet entirely completed. On these soils, the succession of crops was less rapid, or, from necessity, tillage was sooner suspended. If not rich enough for tobacco when first cleared, (or as soon as it ceased to be so,) land of this kind was planted in corn two or three years in succession, and afterwards every second year. The intermediate year between the crops of corn, the field was "rested" under a crop of wheat, if it would produce four or five bushels to the acre. If the sandiness, or exhausted condition of the soil, denied even this small product of wheat, that crop was probably not attempted; and, instead of it, the field was exposed to close grazing, from the time of gathering one crop of corn, to that of preparing

to plant another. No manure was applied, except on the tobacco lots; and this succession of a grain crop every year, and afterwards every second year, was kept up as long as the field would produce five bushels of corn to the acre. When reduced below that product, and to still more below the necessary expense of cultivation, the land was turned out to recover under a new growth of pines. After twenty or thirty years, according to the convenience of the owner, the same land would be again cleared, and put under similar scourging tillage, which, however, would then much sooner end, as before, in exhaustion. Such a general system is not yet every where abandoned; and many years have not passed, since such was the usual course on almost every farm.

How much our country has been impoverished during the last fifty years, cannot be determined by any satisfactory testimony. But, however we may differ on this head, there are but few who will not concur in the opinion, that [up to 1831] our system of cultivation has been every year lessening the productive power of our lands in general—and that no one county, no neighborhood, and but few particular farms, have been at all enriched, since their first settlement and cultivation. Yet many of our farming operations have been much improved and made more productive. Driven by necessity, proprietors direct more personal attention to their farms—better implements of husbandry are used—every process is more perfectly performed—and, whether well or ill directed, a spirit of inquiry and enterprise has been awakened, which before had no existence.

Throughout the country below the falls of the river, and perhaps thirty miles above, if the best land be excluded, say one tenth, the remaining nine tenths will not yield an average product of ten bushels of corn to the acre; though that grain is best suited to our soils in general, and far exceeds in quantity all other kinds raised. Of course, the product of a large proportion of the land would fall below this average. Such crops, in very many cases, cannot remunerate the cultivator. If our remaining wood-land could be at once brought into cultivation, the *gross* product of the country would be greatly increased, but the *net* product very probably diminished; as the general poverty of these lands would cause more expense than profit to accompany their cultivation under the usual system. Yet every year we are using all our exertions to clear wood-land, and in fact seldom increase either net or gross products—because nearly as much old exhausted land is turned out of cultivation as is substituted by the newly cleared. Sound calculations of profit and loss, would induce us even greatly to reduce the extent of our present cultivation, in lower Virginia, by turning out and leaving waste, (if not to be improved,) every acre that yields less than the total cost of its tillage.*

No political truth is better established than that the population of every country will increase, or diminish, according to its regular supply of food. We know from the census of 1830, compared with those of 1820 and 1810, that our population is nearly stationary, and in some counties is actually lessening; and therefore it is certain that [to 1830] our agriculture is not increasing the amount of food, or the means of purchasing food—with all the assistance of the new land annually brought under culture. In these cir-

* The foregoing description was written in 1826, and first published in 1831, and particular exceptions to the general correctness of the application had been even then recently exhibited; and, with the passage of every year since, these exceptions have been becoming more numerous and more important, and in a rapidly increasing ratio. These recent facts of improved lands and increased production, as well as their peculiar causes, will be treated of subsequently. The observations and deductions presented in the remainder of this chapter were also of the same date as the foregoing statements, on which they are founded

cumstances, a surplus population, with all its deplorable consequences, is only prevented by the great current of emigration which is continually flowing westward. No matter who emigrates, or with what motive—the enterprising or wealthy citizen who leaves us to seek richer lands and greater profits, and the slave sold and carried away on account of his owner's poverty—all concur in producing the same result, though with very different degrees of benefit to those who remain. If this great and continued drain from our population was stopped, and our agriculture was not improved, want and misery would work to produce the same results. Births would diminish, and deaths would increase: and hunger and disease, operating here as in other countries, would keep down population to that number that the average products of our agricultural and other productive labor could feed, and supply with the other necessary means for living.

A stranger to our situation and habits might well oppose to my statements the very reasonable objection, that no man would, or could, long pursue a system of cultivation of which the returns fell short of his expenses, including rent of land, hire of labor, interest on the necessary capital, &c. Very true; if he had to pay those expenses out of his profits, he would soon be driven from his farm to a jail. But we own our land, our laborers, and stock; and though the calculation of net profit, or of loss, is precisely the same, yet we are not ruined by making only two per cent. on our capital, provided we can manage to live on that income. If we live on still less, we are actually growing richer, (by laying up a part of our two per cent.,) notwithstanding the most clearly proved regular loss on our farming.

Our condition has been so gradually growing worse, that we are either not aware of the extent of the evil, or are in a great measure reconciled by custom to profitless labor. No hope for a better state of things can be entertained, until we shake off this apathy—this excess of contentment, which makes no effort to avoid existing evils. I have endeavored to expose what is worst in our situation as farmers; if it should have the effect of arousing any of my countrymen to a sense of the absolute necessity of some improvement, to avoid ultimate ruin, I hope also to point out to some of their number, if not to all, that the means for certain and highly profitable improvements are completely within their reach.

The cultivators of eastern Virginia derive a portion of their income from a source quite distinct from their tillage—and which, though it often forces them to persist in their profitless farming, yet also, in some measure, conceals, and is generally supposed to compensate for its losses. This source of income is, the breeding and selling of slaves; of which, (though the discussion of this point will not be undertaken here,) I cannot concur in the general opinion that it is also a source of profit.

It is not meant to convey the idea that any person undertakes as a regular business the breeding of slaves with a view to their sale; but whether it is so intended or not, all of us, without exception, are acting some part in aid of a general system, which taken altogether is precisely what I have named. No man is so inhuman as to breed and raise slaves, to sell off a certain proportion regularly, as a western drover does with his herds of cattle. But sooner or later the general result is the same. Sales may be made voluntarily, or by the sheriff—they may be met by the first owner, or delayed until the succession of his heirs—or the misfortune of being sold may fall on one parcel of slaves, instead of another; but all these, are but different ways of arriving at the same general and inevitable result. With plenty of wholesome though coarse food, and under such mild treatment as our slaves usually experience, they have every inducement and facility to increase their numbers with all possible rapidity, without any opposing

check, either prudential, moral, or physical. These several checks to the increase of population operate more or less on all free persons, whether rich or poor; and slaves, situated as ours are, perhaps are placed in the only possible circumstances in which no restraint whatever obstructs the propagation and increase of the race. From the general existence of this state of circumstances, the particular effects may be naturally deduced; and facts completely accord with what these circumstances promise. A gang of slaves on a farm will often increase to four times their original number, in thirty or forty years. If a farmer is only able to feed and maintain his slaves, their increase in value may double the whole of his capital originally vested in farming, before he closes the term of an ordinary life. But few farms are able to support this increasing expense, and also furnish the necessary supplies to the family of the owner; whence very many owners of large estates, in lands and negroes, are throughout their lives too poor to enjoy the comforts of wealth, or to encounter the expenses necessary to improve their unprofitable farming. A man so situated, may be said to be a slave to his own slaves. If the owner is industrious and frugal, he may be able to support the increasing number of his slaves, and to bequeath them undiminished to his children. But the income of few persons increases as fast as their slaves; and if not, the consequence must be, that some of them will be sold, that the others may be supported; and the sale of more is perhaps afterwards compelled, to pay debts incurred in striving to put off that dreaded alternative. The slave first almost starves his master, and at last is eaten by him—at least he is exchanged for his value in food. The sale of slaves is always a severe trial to their owner. Obstacles are opposed to it, not only by sentiments of humanity and of regard for those who have passed their lives in his service—but every feeling he has of false shame comes to aid; and such sales are generally postponed until compelled by creditors, and are carried into effect by the sheriff, or by the administrator of the debtor. But when the sale finally takes place, its magnitude makes up for all previous delays. Do what we will, the surplus slaves *must* be sent out of a country which is not able to feed them; and these causes continue to supply the immense numbers that are annually sold and carried away from lower Virginia, without even producing the political benefit of lessening the actual number remaining. Nothing can check this forced emigration of blacks, and the voluntary emigration of whites, except increased production of food, obtained by enriching our lands, and the consequent increase of farming profits. No effect will more certainly follow its cause than this—that whenever our land is so improved as to produce double its present supply of food, it will also have, and will retain, double its present amount of population. The improving farmer who adds one hundred bushels of corn to the previous product of his country, also effectually adds, and permanently, to its population, as many persons as his increase of product will feed and support.

CHAPTER III.

THE DIFFERENT CAPACITIES OF SOILS FOR RECEIVING IMPROVEMENT.

As far as the nature of the subjects permitted, the foregoing chapters have been merely explanatory and descriptive. The same subjects will be resumed and more fully treated in the course of the following general argument, the premises of which are the facts and circumstances that have been

detailed. The object of this essay will now be entered upon; and what is desired to be proved will be stated in a series of propositions, which will now be presented at one view, and afterwards separately discussed in their proper order.

Proposition 1. Soils naturally poor, and rich soils reduced to poverty by cultivation, are essentially different in their powers of retaining putrescent (or alimentary) manures: and, under like circumstances, the fitness of any soil to be enriched by these manures is in proportion to the degree of its natural fertility.

2d. The natural sterility of the soils of lower Virginia is caused by such soils being destitute of calcareous earth, and their being injured by the presence and effects of vegetable acid.

3d. The fertilizing effects of calcareous earth are chiefly produced by its power of neutralizing acids, and of combining putrescent manures with soils, between which there would otherwise be but little if any chemical attraction.*

4th. Poor and acid soils cannot be improved durably, or profitably, by putrescent manures, without previously making such soils calcareous, and thereby correcting the natural defect in their constitution.

5th. Calcareous manures will give to our worst soils a power of retaining putrescent manures, equal to that of the best—and will cause more productiveness, and yield more profit, than any other improvement practicable in lower Virginia.

Dismissing from consideration, for the present, all the others, I shall proceed to maintain the

FIRST PROPOSITION.—*Soils naturally poor, and rich soils reduced to poverty by cultivation, are essentially different in their powers of retaining putrescent (or alimentary) manures; and, under like circumstances, the fitness of any soil to be enriched by these manures is in proportion to the degree of its natural fertility.*

The *natural fertility* of a soil is not intended to be estimated by the amount of its earliest product, when first brought under cultivation, because several temporary causes then operate either to keep down or to augment the product. If land be cultivated immediately after the trees are cut down, the crop is greatly lessened by the numerous living roots, and consequent bad tillage—by the excess of unrotted vegetable matter—and the coldness of the soil, from which the rays of the sun had been so long excluded. On the other hand, if cultivation is delayed one or two years, the leaves and other vegetable matters are rotted, and in the best state to supply food to plants, and are so abundant, that a far, better crop will be raised than could have been obtained before, or perhaps can be again, without manure. For these reasons, the degree of natural fertility of any soil should

* When any substance is mentioned as *combining* with one or more other substances, as different manures with each other, or with soil, I mean that a union is formed by chemical attraction, and not by simple mixture. *Mixtures* are made by mechanical means, and may be separated in like manner: but *combinations* are chemical, and require some stronger chemical attraction, to take away either of the bodies so united.

When two substances combine, they both lose their previous peculiar qualities, or *neutralize* them for each other, and form a third substance different from both. Thus, if certain known proportions of *muratic acid* and pure or caustic *soda* be brought together, their strong attraction will cause them to combine, immediately. The strong corrosive acid quality of the one, and the equally peculiar alkaline taste and powers of the other, will *neutralize* or entirely destroy each other—and the compound formed is common table salt, the qualities of which are as strongly marked, but totally different from those of either of its constituent parts

be measured by its products after these temporary causes have ceased to act, which will generally take place before the third or fourth crop is obtained. According, then, to this definition, a certain degree of *permanency* in its early productiveness is necessary to entitle a soil to be termed *naturally fertile*. It is in this sense that I deny to any poor lands, except such as were naturally fertile, the capacity of being made rich by putrescent manures only.

The foregoing proposition would by many persons be so readily admitted as true, that attempting to prove it would be deemed entirely superfluous. But many others will as strongly deny its truth, and can support their opposition by high agricultural authorities.

General readers, who may have no connexion with farming, must have gathered from the incidental notices in various literary and descriptive works, that some countries or districts that were noted for their uncommon fertility or barrenness, as far back as any accounts of them have been recorded, still retain the same general character, through every change of culture, government, and even of races of inhabitants. They know that, for some centuries at least, there has been no change in the strong contrast between the barrenness of Norway, Brandenburg, and the Highlands of Scotland, and the fertility of Flanders, Lombardy and Valencia. Sicily, notwithstanding its government is calculated to discourage industry, and production of every profitable kind, still exhibits that fertility for which it was celebrated two thousand years ago. It seems a necessary inference from the many statements of which these are examples, that the labors of man have been but of little avail in altering, generally or permanently, or in any marked degree, the characters and qualities given to soils by nature.

Most of our experienced practical cultivators, through a different course, have arrived at the same conclusion. Their practice has taught them the truth of this proposition; and the opinions thus formed have profitably directed their most important operations. They are accustomed to estimate the worth of land by its natural degree of fertility; and by the same rule they are directed on what soils to bestow their scanty stock of manure, and where to expect exhausted fields to recover by rest, and their own unassisted powers. But, content with knowing the fact, this useful class of farmers have never inquired for its cause; and even their opinions on this subject, as on most others, have not been communicated so as to benefit others.

But if all literary men, who are not farmers, and all practical cultivators, who seldom read, admitted the truth of my proposition, it would avail but little for improving our agricultural operations; and the only prospect of its being usefully disseminated is through that class of farmers who have received their first opinions of improving soils from books, and whose subsequent plans and practices have grown out of those opinions. If poor natural soils cannot be durably or profitably improved by putrescent manures, this truth should not only be known, but be kept constantly in view, by every farmer who can hope to improve with success. Yet it is a remarkable fact, that the difference in the capacities of soils for receiving improvement has not attracted the attention of scientific farmers; and the doctrine has no direct and positive support from the author of any treatise on agriculture, European or American, that I have been able to consult. On the contrary, it seems to be considered by all of them, that to collect and apply as much vegetable and animal manure as possible, is sufficient to ensure profit to every farmer, and fertility to every soil. They do not tell us that numerous exceptions to that rule will be found, and that many soils of apparently good texture, if not incapable of being enriched from the barnyard, would at least cause more loss than clear profit, by being improved from that source.

When it is assumed that the silence of every distinguished author as to certain soils being incapable of being profitably enriched, amounts to ignorance of the fact, or a tacit denial of its truth—it may be objected that the exception was not omitted from either of these causes, but because it was established and undoubted. This is barely possible; but even if such were the case, their silence has had all the ill consequences that could have grown out of a positive denial of any exceptions to the propriety of manuring poor soils. Every zealous young farmer, who draws most of his knowledge and opinions from books, adopts precisely the same idea of their directions—and if he owns barren soils he probably throws away his labor and manure for their improvement, for years, before experience compels him to abandon his hopes, and acknowledge that his guides have led him only to failure and loss. Such farmers as I allude to, by their enthusiasm and spirit of enterprise, are capable of rendering the most important benefits to agriculture. Whatever may be their impelling motives, the public derives nearly all the benefit of their successful plans; and their far more numerous misdirected labors, and consequent disappointments, are productive of national, still more than individual loss. The occurrence of only a few such mistakes, made by reading farmers, will serve to acquit me of combating a shadow—and there are few of us who cannot recollect some such examples.

But if the foregoing objection has any weight in justifying European authors in not naming this exception, it can have none for those of our own country. If it is admitted that soils naturally poor are incapable of being enriched with profit, that admission must cover three fourths of all the high-land in the tide-water district. Surely no one will contend that so sweeping an exception was silently understood by the author of '*Arator*,' as qualifying his exhortations to improve our lands: and if no such exception were intended to be made, then will his directions for enriching soils and his promises of reward be found equally fallacious, for the greater portion of the country for the benefit of which his work was especially intended. The omission of any such exception, by the writers of the United States, is the more remarkable, as the land has been so recently brought under cultivation, that the original degree of fertility of almost every farm may be known to its owner, and compared with the after progress of exhaustion or improvement.

Many authorities might be adduced to prove that I have correctly stated what is the fair and only inference to be drawn from agricultural books, respecting the capacity of poor soils to receive improvement. But a few of the most strongly marked passages in '*Arator*' will be fully sufficient for this purpose. The venerated author of that work was too well acquainted with the writings of European agriculturists, to have mistaken their doctrines in this important particular. A large portion of his useful life was devoted to the successful improvement of exhausted, but originally fertile lands. His instructions for producing similar improvements are expressly addressed to the cultivators of the eastern parts of Virginia and North Carolina, and are given as applicable to all our soils, without exception. Considering all these circumstances, the conclusions which are evidently and unavoidably deduced from his work, may be fairly considered, not only as supported by his own experience, but as concurring with the general doctrine of improving poor soils, maintained by previous writers.

At page 54, third edition of '*Arator*,' "*inclosing*" (i. e. leaving fields to receive their own vegetable cover, for their improvement, during the years of rest) is said to be "the most powerful means of fertilizing the earth"—and the process is declared to be rapid, the returns near, and the gain great.

Page 61. "If these few means of fertilizing the country [corn-stalks, straw, and animal dung,] were skillfully used, they would of themselves suffice to change its state from sterility to fruitfulness."—"By the litter of Indian corn, and of small grain, and of penning cattle, managed with only an inferior degree of skill, in union with inclosing, I will venture to affirm that a farm may in ten years be made to double its produce, and in twenty to quadruple it."

No opinions could be more strongly or unconditionally expressed than these. No reservation or exception is made. I may safely appeal to each of the many hundreds who have attempted to obey these instructions, to declare whether any one considered his own naturally poor soils excluded from the benefit of these promises—or whether a tithe of the promised benefit was realized on any farm composed generally of such soils.

In a field of mine that has been secured from grazing since 1814, and cultivated on the mild four-shift rotation, the produce of a marked spot has been measured every fourth year (when in corn) since 1820. The difference of product has been such as the differences of season might have caused—and the last crop (in 1828) was worse than those of either of the two preceding rotations. There is no reason to believe that even the smallest increase of productive power had taken place in all the preceding fourteen years. Nor has there been, since 1828, in the apparent products of this ground, any manifestation that there has been any more of subsequent than of previous improvement, from the vegetable manurings furnished by its growth.

A still more striking proof, because of the much larger scale, as well as long continuance of the experiment, has been very recently, (in 1842,) as well as in former times, mentioned to me, as confirmation of my views in this respect. Col. George Blow, of Sussex, a highly respectable gentleman, and intelligent and observant farmer, has adhered for nearly 30 years to Taylor's "inclosing system," and with a very mild rotation, on a farm of 600 arable acres, of sandy soil, and originally poor; and has taken but one crop (corn) in every three years. A few spots only of better quality, (the sites of old buildings, &c.,) were put in wheat or oats after the corn; the great body of the land having had regularly two years in three to rest, and to manure itself by its volunteer growth of weeds and grass. Very little grazing, and that but rarely, has been permitted. There could have been no material mistake as to the general products and results; and the proprietor is confident that the land has not improved in production in all this long time. Yet, on soil differently constituted, Col. Blow has improved and increased the products, rapidly and profitably. These two facts, though observed more particularly and for longer time than any others known, agree with, and are but confirmatory of others presented to some extent on almost every farm in the tide-water region of Virginia.

It is far from my intention, by these remarks, and statements of facts, to deny the propriety, or to question the highly beneficial results, of applying the system of improvement recommended by 'Arator,' to soils originally fertile. On the contrary, it is as much my object to maintain the facility of restoring to worn lands their natural degree of fertility, by vegetable applications, as it is to deny the power of exceeding that degree, however low it may have been.

One more quotation will be offered, because its recent date and the source whence it is derived furnish the best proof that it is still the received opinion, among agricultural writers, that all soils may be profitably improved by putrescent manures. An article in the '*American Farmer*,' of October 14th, 1831, on "manuring large farms," by the editor, (G. B.

Smith,) contains the following expressions. "By proper exertions, every farm in the United States can be manured with less expense than the surplus profits arising from the manure would come to. This we sincerely believe, and we have arrived at this conclusion from long and attentive observation. We never yet saw a farm that we could not point to means of manuring, and bring into a state of high and profitable cultivation at an expense altogether inconsiderable when contrasted with the advantages to be derived from it." The remainder of the article shows that putrescent manures are principally relied on to produce these effects; marsh and swamp mud are the only kinds referred to that are not entirely putrescent in their action, and mud certainly cannot be used to manure every farm. Mr. Smith having been long the conductor of a valuable agricultural journal, as a matter of course, is extensively acquainted with the works and opinions of the best writers on agriculture; and therefore, his advancing the foregoing opinions, as certain and undoubted, is as much a proof of the general concurrence therein of preceding writers, as if the same had been given as a digest of their precepts.

Some persons will readily admit the great difference in the capacities of soils for improvement, but consider a deficiency of clay only to cause the want of power to retain manures. The general excess of sand in our poor lands might warrant this belief in a superficial and limited observer. But though clay soils are more rarely met with, they present, in proportion to their extent, full as much poor land. The most barren and worthless soils in the county of Prince George are also the stiffest. A poor clay soil will retain manure longer than a poor sandy soil—but it will not the less certainly lose its acquired fertility at a somewhat later period. When it is considered that a much greater quantity of manure is required by clay soils, it may well be doubted whether the temporary improvement of the sandy soils would not be attended with more profit—or, more properly speaking, with less actual loss.

It is true that the capacity of a soil for improvement is greatly affected by its texture, shape of the surface, and its supply of moisture. Dry, level, or clay soils, will retain manure longer than the sandy, hilly, or wet. But however important these circumstances may be, neither the presence or absence of any of them can cause the essential differences of capacity for improvement. There are some rich and valuable soils with either one or more of all these faults—and there are other soils the least capable of receiving improvement, free from objections as to their texture, degree of moisture, or inclination of their surface. Indeed the great body of our poor ridge lands are more free from faults of this kind, than soils of far greater productiveness usually are. Unless then some other and far more powerful obstacle to improvement exists, why should not all our wood-land be highly enriched, by the hundreds, or thousands, of crops of leaves which have successively fallen and rotted there! Notwithstanding this vegetable manuring, which infinitely exceeds all that the industry and patience of man can possibly equal, most of our wood-land remains poor; and this one fact (which at least is indisputable) ought to satisfy all of the impossibility of enriching such soils by putrescent manures only. Some few acres may be highly improved, by receiving all the manure derived from the offal of the whole farm—and entire farms, in the neighborhood of towns, may be kept rich by continually applying large quantities of purchased manures. But no where can a farm be found, which has been improved beyond its original fertility, by means of the vegetable resources of its own arable fields. If this opinion is erroneous, nothing is easier than to prove my mistake, by adducing undoubted examples of such improvements having been made.

But a few remarks will suffice on the capacity for improvement of worn

lands, which were originally fertile. With regard to these soils, I have only to concur in the received opinion of their fitness for durable and profitable improvement by putrescent manures. After being exhausted by cultivation, they will recover their productive power, by merely being left to rest for a sufficient time, and receiving the manure made by nature, of the weeds and other plants that grow and die upon the land. Even if robbed of the greater part of that supply, by the grazing of animals, a still longer time will serve to obtain the same result. The better a soil was at first, the sooner it will recover by these means, or by artificial manuring. On soils of this kind, the labors of the improving farmer meet with certain success and full reward; and whenever we hear of remarkable improvements of poor lands by putrescent manures, further inquiry will show us that these poor lands had once been rich.

The continued fertility of certain countries, for hundreds or even thousands of years, does not prove that the land could not be, or had not been, exhausted by cultivation; but only that it was slow to exhaust and rapid in recovering; so that whatever repeated changes may have occurred in each particular tract, the whole country taken together always retained a high degree of productiveness. Still the same rule will apply to the richest and the poorest soils—to wit, that each exerts strongly a force to retain as much fertility as nature gave to it—and that when worn and reduced, each kind may easily be restored to its original state, but cannot be raised higher, with either durability or profit, by putrescent manures, whether applied by the bounty of nature, or the industry of man.

CHAPTER IV.

EFFECTS OF THE PRESENCE OF CALCAREOUS EARTH IN SOILS.

PROPOSITION 2.—*The natural sterility of the soils of lower Virginia is caused by such soils being destitute of calcareous earth, and their being injured by the presence and effects of vegetable acid.*

The means which would appear the most likely to lead to the causes of the different capacities of soils for improvement is to inquire whether any known ingredient or quality is always to be found belonging to improvable soils, and never to the unimprovable—or which always accompanies the latter, and never the former kind. If either of these results can be obtained, we will have good ground for supposing that we have discovered the general cause of fertility, in the one case, or of barrenness, in the other; and it will follow that, if we can supply to barren soils the deficient beneficial ingredient—or can destroy that which is injurious to them—their incapacity for receiving improvement will be removed. All the common ingredients of soils, as sand, clay, or gravel—and such qualities as moisture or dryness—a level, or a hilly surface—however they may affect the value of soils, are each sometimes found exhibited, in a remarkable degree, in both the fertile and the sterile. The abundance of putrescent vegetable matter might well be considered the cause of fertility, by one who judged only from lands long under cultivation. But though vegetable matter in sufficient quantity is essential to the existence of fertility, yet will this substance also be found inadequate for the cause. Vegetable matter abounds in all rich land, it is admitted; but it has also been furnished by nature, in quantities exceeding all computation, to the most barren soils known.

But there is one ingredient of which not the smallest proportion can be found in any of our poor soils, and which, wherever found, indicates a soil remarkable for natural and durable fertility. This is *calcareous earth*, or carbonate of lime. These facts alone, if sustained, will go far to prove that this earth is the cause of fertility, and the cure for barrenness.

On some part of most farms touching tide-water, either muscle or oyster shells are found mixed with the soil. Oyster shells are confined to the lands on salt water, where they are very abundant, and sometimes extend through large fields. Higher up the rivers, muscle shells only are to be seen thus deposited by nature, or by the aboriginal inhabitants, and they decrease as we approach the falls of the rivers. The proportion of shelly land in the counties highest on tide-water is very small; but the small extent of these spots does not prevent, but rather aids, the exhibition of the peculiar qualities of such soils. Spots of shelly land, not exceeding a few acres in extent, could not well have been cultivated differently from the balance of the fields of which they formed parts—and therefore they can be better compared with the worse soils under like treatment. Every acre of shelly land is, or has been, remarkable for its richness, and still more for its durability. There are few farmers among us who have not heard described tracts of shelly soil on Nansemond and York rivers, which are celebrated for their long resistance of the most exhausting course of tillage, and which still remain fertile, notwithstanding all the injury which they must have sustained from their severe treatment. We are told that on some of these lands, corn has been raised every successive year, without any help from manure, for a longer time than the owners could remember, or could be informed of correctly. But without relying on any such remarkable cases, there can be no doubt that every acre of our shelly land has been at least as much tilled, and as little manured, as any in the country; and that it is still the richest and most valuable of all our old cleared lands.

The fertile but narrow strips, along the banks of our rivers, (which form the small portion of our high-land of first-rate quality,) seldom extend far without exhibiting spots in which shells are visible, so that the eye alone is sufficient to prove the soil of such places to be calcareous. The similarity of natural growth, and of all other marks of character, are such, that the observer might very naturally infer that the former presence of shells had given the same valuable qualities to all these soils—but that they had so generally rotted, and been incorporated with the other earths, that they remained visible only in a few places, where they had been most abundant. The accuracy of this inference will hereafter be examined.

The natural growth of the shelly soils (and of those adjacent of similar value) is entirely different from that of the great body of our lands. Whatever tree thrives well on the one, is seldom found on the other class of soils— or, if found, it shows plainly, by its imperfect and stunted condition, on how unfriendly a soil it is placed. To the rich river margins are almost entirely confined the black or wild locust, hackberry or sugar-nut tree, and papaw. The locust is with great difficulty eradicated, or the newer growth of it kept under on cultivated lands; and from the remarkable rapidity with which it springs up and increases in size, it forms a serious obstacle to the cultivation of land on the river banks. Yet on the wood-land only a mile or two from the river, not a locust is to be seen. On shelly soils, pines and broom grass [*Andropogon scoparius?*] cannot thrive, and are rarely able to maintain even the most sickly growth.

Some may say that these striking differences of growth do not so much show a difference in the constitution of the soils, as in their state of fertility; or that one class of the plants above named delights in rich, and the other

in poor land. No plant prefers poor to rich soil—or can thrive better on a scarcity of food, than with an abundant supply. Pine, broom-grass, and sheep-sorrel, delight in a class of soils that are generally unproductive—but not on account of their poverty; for all these plants show, by the greater or less vigor of their growth, the abundance or scarcity of vegetable matter in the soil. But on this class of soils, no quantity of vegetable manure could make locusts flourish, though they will grow rapidly on a calcareous hill-side, from which all the soil capable of supporting other ordinary plants has been washed away.

In thus describing and distinguishing soils by their growth, let me not be understood as extending these rules to other soils and climates than our own. It is well established that changes of kind in successive growths of timber have occurred in other places, without any known cause; and a difference of climate will elsewhere produce effects, which here would indicate a change of soil.

Some rare exceptions to the general fertility of shelly lands are found where the proportion of calcareous earth is in great excess. Too much of this ingredient causes even a greater degree of sterility than its total absence. This cause of barrenness is very common in France and England, (on chalk soils,) and very extensive tracts are not worth the expense of cultivation, or improvement. The few small spots that are rendered barren here are seldom (if ever) so affected by the excess of oyster or muscle shells in the soil. These effects generally are caused by beds of fossil sea-shells, which in some places reach the surface, and are thus exposed to the plough. These spots are not often more than thirty feet across, and their nature is generally evident to the eye; and if not, is so easily determined by chemical tests, as to leave no reason for confounding the injurious and beneficial effects of calcareous earth. This exception to the general fertilizing effect of this ingredient of our soils would scarcely require naming, but to mark what might be deemed an apparent contradiction. But this exception, and its cause, must be kept in mind, and considered as always understood and admitted throughout all my remarks, and which therefore it is not necessary to name specially, when the general qualities of calcareous earth are spoken of.

In the beginning of this chapter, I advanced the important fact that none of our poor soils contain naturally the least particle of calcareous earth. So far, this is supported merely by my assertion—and all those who have studied agriculture in books will require strong proof before they can give credit to the existence of a fact, which is either unsupported, or indirectly denied, by all written authority. Others, who have not attended to such descriptions of soils in general, may be too ready to admit the truth of my assertion—because, not knowing the opinions on this subject heretofore received and undoubted, they would not be aware of the importance of their admission.

It is true that no author has said expressly that every soil contains calcareous earth. Neither perhaps has any one stated that every soil contains some silicious or aluminous earth. But the manner in which each one has treated of soils and their constituent parts, would cause their readers to infer that neither of these three earths is ever entirely wanting—or at least that the entire absence of the calcareous is as rare as the absence of silicious or aluminous earth. Nor are we left to gather this opinion solely from indirect testimony, as the following examples, from the highest authorities, will prove. Davy says, “four earths generally abound in soils, the aluminous, the silicious, the calcareous, and the magnesian”*; and the soils

* Davy's Agr. Chem., Lecture 1

of which he states the constituent parts, obtained by chemical analysis, as well as those reported by Kirwan, and by Young, all contain some proportion (and generally a large proportion) of calcareous earth.* Kirwan states the component parts of a soil which contained thirty-one per cent. of calcareous earth, and he supposes that proportion neither too little nor too much.† Young mentions soils of extraordinary fertility containing seventeen and twenty per cent., besides others with smaller proportions of calcareous earth—and says that Bergman found thirty per cent. in the best soil he examined.‡ Rozier speaks still more strongly for the general diffusion, and large proportions of this ingredient of soils. In his general description of earths and soils, he gives examples of the supposed composition of the three grades of soils which he designates by the terms *rich*, *good*, and *middling soils*; to the first class he assigns a proportion of one tenth, to the second, one fourth, and to the last, one half of its amount, of calcareous earth. The fair interpretation of the passage is that the author considered these large proportions as general, in France—and he gives no intimation of any soil entirely without calcareous earth.§

The position assumed above, of the general or universal concurrence of former European authors in the supposed general presence of calcareous earth in soils, could be placed beyond dispute by extracts from their publications. But this would require many and long extracts, too bulky to include here, and which cannot be fairly abridged, or exhibited by a few examples. No author says directly, indeed, that calcareous earth is present in all soils; but its being always named as one of the ingredients of soils in general, and no cases of its absolute deficiency in tilled lands being directly stated, amount to the declaration that calcareous earth is very rarely, if ever, entirely wanting in any soil. We may find enough directions to apply calcareous manures to soils that are deficient in that ingredient; but that deficiency seems to be not spoken of as *absolute*, but *relative* to other soils more abundantly supplied. In the same manner, writers on agriculture direct clay, or sand, to be used as manure for soils very deficient in one or the other of those earths; but without meaning that any soil under cultivation can be found entirely destitute of sand or of clay. My proofs from general treatises would therefore be generally indirect; and the quotations necessary to exhibit them would show what had *not* been said, rather than what *had*—and that they did *not* assert the absence of calcareous earth, instead of directly asserting its universal presence. Extracts for this purpose, however satisfactory, would necessarily be too voluminous, and it is well that they can be dispensed with. Better proof, because it is direct, and more concise, will be furnished by quoting the opinions of a few agriculturists of our own country, who were extensively acquainted with European authors, and have evidently drawn their opinions from those sources. These quotations will not only show conclusively that their authors consider the received European doctrine to be that all soils are more or less calcareous—but also, that they apply the same general cha-

* Agr. Chem., Lect. 4—Kirwan on Manures—and Young's Prize Essay on Manures.

† Kirwan on Manures, article "Clayey Loam."

‡ Young's Essay on Manures.

§ "Composition of soils. Examples of the various composition of soils: *Rich soil*; silicious earth, 2 parts; aluminous, 6; calcareous, 1; vegetable earth, [*humus*] 1; in all, 10 parts. *Good soil*—silicious, 3 parts; aluminous 4; calcareous 2½; vegetable earth, ½ of 1 part; in all, 10 parts. *Middling soil* [*sol mediocre*]; silicious, 1 part; aluminous, 1; calcareous, 5 parts, less by some atoms of vegetable earth; in all, 10 parts. We see that it is the largest proportion of aluminous earth that constitutes the greatest excellence of soils; and we know that independently of their harmony of composition, they require a sufficiency of depth."—Translated from the article "*Terres*," in the "Cours Complet d'Agriculture Pratique, etc par l'Abbe Rozier, 1815"

acter to the soils of the United States, without expressing a doubt or naming an exception. These writers, as all who have heretofore written of soils in this country, have uttered but the echoes of preceding English general descriptions of soils. They seem not to have suspected that any very important difference existed in this respect between the soils of England and of this country, and certainly not one had made the slightest investigation by any attempt at chemical analysis, to sustain the false character thus given to our soils.

1. From a "Treatise on Agriculture," (ascribed to General Armstrong,) published in the American Farmer. [*Vol. i. page 153.*]

"Of six or eight substances, which chemists have denominated earths, four are *widely and abundantly diffused*, and form the crust of our globe. These are silica, alumina, lime, and magnesia."—"In a pure or isolated state, these earths are wholly unproductive; but when decomposed and mixed, and to this mixture is added the residuum of dead animal or vegetable matter, they become fertile, and take the general name of soils, and are again denominated after the earth that most abounds in their composition respectively."

2. Address of R. H. Rose to the Agricultural Society of Susquehanna. [*Am. Far. Vol. ii. p. 101.*]

"Geologists suppose our earth to have been masses of rock of various kinds, but principally silicious, aluminous, calcareous, and magnesian—from the gradual attrition, decay, and *mixture* of which, together with an addition of vegetable and animal matter, is formed the soil; and this is called sandy, clayey, calcareous, or magnesian, according as the particular primitive material preponderates in its formation."

3. Address of Robert Smith to the Maryland Agricultural Society. [*Am. Far. Vol. iii. p. 228.*]

"—The soils of *our country* are in general clay, sand, gravel, clayey loam, sandy loam, and gravelly loam. Clay, sand, and gravel, need no description, &c."—"Clayey loam is a compound soil, consisting of clay and sand or gravel, with a mixture of *calcareous matter*, and in which clay is predominant. Sandy or gravelly loam is a compound soil, consisting of sand or gravel and clay with a mixture of *calcareous matter*, and in which sand or gravel is predominant."

The first two extracts merely state the geological theory of the formation of soils, which is received as correct by the most eminent agriculturists of Europe. How far it may be supported or opposed by the actual constitution and number of ingredients of European soils, is not for me to decide, nor is the consideration necessary to my subject. But the adoption of this general theory by American writers, without excepting American soils, is an indirect, but complete application to them of the same character and composition. The writer last quoted states positively, that the various loams (which comprise at least nineteen twentieths of *our* soils, and I presume also of the soils of Maryland,) contain calcareous matter. The expression of this opinion by Mr. Smith is sufficient to prove that such was the fair and plain deduction from his general reasoning on agriculture, from which source only could his opinions have been derived. If the soils of Maryland are not very unlike those of Virginia, I will venture to assert, that not one in a thousand of all the clayey, sandy, and gravelly loams, contains the smallest proportion of *carbonate of lime*—and that not a single specimen of calcareous soil can be found, between the falls of the rivers and the most eastern body of limestone.

But though the direct testimony of European authors, as cited in a foregoing page, concurs with the indirect proofs referred to since to induce the belief that soils are very rarely destitute of calcareous earth, yet state-

ments may be found of some particular soils being considered of that character. These statements, even if presented by the authors of general treatises, would only seem to present exceptions to their general rule of the almost universal diffusion of calcareous earth in soils. But, so far as I know, no such exceptions are named in the descriptions of soils in any general treatise, and therefore have not the slightest influence in contradicting or modifying their testimony on this subject. It is in the description of soils of particular farms, or districts, that some such statements are made; and even if no such examples had been mentioned, they would not have been needed to prove the existence, in Europe, of some soils, like most of ours, destitute of calcareous earth. These facts do not oppose my argument. I have not asserted, (nor believed, since I have endeavored to investigate this subject,) that there were not soils in Europe, and perhaps many extensive districts, containing no calcareous earth. My argument merely maintains, that these facts would not be inferred, but the contrary, by any general and cursory reader of the agricultural treatises of Europe with which we are best acquainted. It has not been my purpose to inquire as to the existence, or extent, of soils of this kind in Europe. But judging from the indirect testimony furnished by accounts of the mineral and vegetable productions, in general descriptions of different countries, I would infer that soils having no calcareous earth were often found in Scotland and the northern part of Germany, and that they were comparatively rare in England and France.

With my early impressions of the nature and composition of soils, derived in like manner from the general descriptions given in books, it was with surprise, and some distrust, that, when first attempting to analyze soils, in 1817, I found most of the specimens entirely destitute of calcareous earth. The trials were repeated with care and accuracy, on soils from various places, until I felt authorized to assert, without fear of contradiction, that no naturally poor soil, below the falls of the rivers, contains the smallest proportion of calcareous earth. Nor do I believe that any exception to this peculiarity of constitution can be found in any poor soil above the falls; but though these soils are far more extensive and important in other respects, they are beyond the district within the limits of which I propose to confine my investigation.

These results are highly important, whether considered merely as serving to establish my proposition, or as showing a radical difference between most of our soils, and those of the best cultivated parts of Europe. Putting aside my argument to establish a particular theory of improvement, the ascertained fact of the universal absence of calcareous earth in our poor soils leads to this conclusion, that profitable as calcareous manures have been found to be in countries where the soils are generally calcareous in some degree, they must be far more so on our soils that are quite destitute of that necessary earth.

CHAPTER V.

RESULTS OF THE CHEMICAL EXAMINATIONS OF VARIOUS SOILS.

Proposition 2.—continued.

The certainty of any results of chemical analysis would be doubted by most persons who have paid no attention to the means employed for such operations; and their incredulity will be the more excusable, when such

results are reported by one knowing very little of the science of chemistry, and whose limited knowledge was gained without aid or instruction, and was sought solely with the view of pursuing this investigation. Appearing under such disadvantages, it is therefore the more incumbent on me to show my claim to accuracy, or to so explain my method as to enable others to detect its errors, if any exist. To analyze a specimen of soil completely requires an amount of scientific acquirement and practical skill to which I make no pretension. But merely to ascertain the absence of calcareous earth, (or carbonate of lime,) or, if present, to find its quantity, requires but little skill, and less science.

The methods recommended by different agricultural chemists for ascertaining the proportion of calcareous earth in soils agree in all material points. Their process will be described, and made as plain as possible. A specimen of soil of convenient size is dried, pounded, and weighed, and then thrown into muriatic acid diluted with three or four times its quantity of water. The acid combines with, and dissolves the *lime* of the calcareous earth, and its other ingredient, the *carbonic acid*, being disengaged, rises through the liquid in the form of *gas*, or air, and escapes with effervescence. After the mixture has been well stirred, and has stood until all effervescence is over, (the fluid still being somewhat acid to the taste, to prove that enough acid had been used, by some excess being left,) the whole is poured into a piece of blotting paper, folded so as to fit within a glass funnel. The fluid containing the dissolved lime passes through the paper, leaving behind the clay and silicious sand, and any other solid matter; over which, pure water is poured and passed off several times, so as to wash off all remains of the dissolved lime. These filtered washings are added to the solution, to all of which is then poured a solution of *carbonate of potash*. The two dissolved salts thus thrown together, (*muriate of lime* composed of muriatic acid and lime, and *carbonate of potash*, composed of carbonic acid and potash,) immediately decompose each other, and form two new combinations. The muriatic acid leaves the lime, and combines with the potash, for which it has a stronger attraction—and the muriate of potash thus formed, being a soluble salt, remains dissolved and invisible in the water. The lime and carbonic acid being in contact, when let loose by their former partners, instantly unite, and form *carbonate of lime*, or calcareous earth, which being insoluble, falls to the bottom. This precipitate is then separated by filtering paper, is washed, dried and weighed, and thus shows the proportion of carbonate of lime contained in the soil.*

In this process, the carbonic acid which first composed part of the calcareous earth, escapes into the air, and another supply is afterwards furnished from the decomposition of the carbonate of potash. But this change of one of its ingredients does not alter the quantity of the calcareous earth, which is always composed of certain invariable proportions of its two component parts; and when all the lime has been precipitated as above directed, it will necessarily be combined with precisely its first quantity of carbonic acid.

This operation is so simple, and the means for conducting it so easy to obtain, that it will generally be the most convenient mode for finding the proportion of calcareous earth in those manures that are known to contain it abundantly, and where an error of a few grains cannot be very material. But if a very accurate result is necessary, this method will not serve, on account of several causes of error which always occur. Should no calcareous

* More full directions for the analysis of soils may be found in Kirwan's *Essay on Manures*, Rozier's *Cours Complet*, &c., and Davy's *Agricultural Chemistry*.

earth be present in a soil thus analyzed, the muriatic acid will take up a small quantity of aluminous earth, which will be precipitated by the carbonate of potash, and without further investigation, would be considered as so much calcareous earth. And if any compounds of lime and vegetable acids are present, (which for reasons hereafter to be stated, I believe to be not uncommon in soils,) some portion of them may be dissolved, and appear in the result as *carbonate* of lime, though not an atom of that substance was in the soil. Thus, every soil examined by this method of solution and precipitation will yield some small result of what would appear as carbonate of lime, though actually destitute of such an ingredient. The inaccuracies of this method were no doubt known (though passed over without notice) by Davy, and other men of science who have recommended its use; but as they considered calcareous earth merely as one of the earthy ingredients of soil, operating mechanically, (as do sand and clay,) on the texture of the soil, they would scarcely suppose that a difference of a grain or two could materially affect the practical value of an analysis, or the character of the soil under examination.*

The pneumatic apparatus proposed by Davy, as another means for showing the proportion of calcareous earth in soils, is liable to none of these objections; and when some other causes of error peculiar to this method, are known and guarded against, its accuracy is almost perfect, in ascertaining the quantity of calcareous earth—to which substance alone its use is limited. The following representation and description will make the operation quite clear.

"A, B, C, D, represent the different parts of this apparatus. A represents the bottle for receiving the soil. B the bottle containing the acid, furnished with a stop-cock. C the tube connected with a flaccid bladder. D the graduated measure. E the bottle for containing the bladder. When this instrument is used, a given quantity of soil is introduced into A. B is filled with muriatic acid diluted with an equal quantity of water; and the stop-cock being closed, is connected with the upper orifice of A, which is

* "Chalks, calcareous marls, or powdered limestone, act merely by forming a useful earthy ingredient in the soil, and their efficacy is proportioned to the deficiency of calcareous matter, which in larger or smaller quantities seems to be an essential ingredient of all fertile soils; necessary perhaps to their proper texture, and as an ingredient in the organs of plants." [Davy's Agr. Chem. page 21—and further on he says] "Chalk and marl or carbonate of lime only improve the texture of a soil, or its relation to absorption; it acts merely as one of its earthy ingredients."

ground to receive it. The tube C is introduced into the lower orifice of A, and the bladder connected with it placed in its flaccid state into E, which is filled with water. The graduated measure is placed under the tube of E. When the stop-cock of B is turned, the acid flows into A, and acts upon the soil; the elastic fluid generated passes through C into the bladder, and displaces a quantity of water in E equal to it in bulk, and this water flows through the tube into the graduated measure; and gives by its volume the indication of the proportion of carbonic acid disengaged from the soil; for every ounce measure of which two grains of carbonate of lime may be estimated."—*Davy's Agr. Chem.*

The correctness of this mode of analysis depends on two well-established facts in chemistry: 1st, That the component parts of calcareous earth always bear the same proportion to each other, and these proportions are as forty-four parts (by weight) of carbonic acid, to fifty-six of lime. 2d, That the carbonic acid gas which two grains of calcareous earth will yield is equal in bulk to one ounce of fresh water. The process, with the aid of this apparatus, disengages, confines, and measures the gas evolved; and for every measure equal to the bulk of an ounce of water, the operator has but to allow two grains of calcareous earth in the soil acted on. It is evident that the result can indicate the presence of lime in no other combination except that which forms calcareous earth; nor of any other earth, except carbonate of magnesia, which, if present, might be mistaken for calcareous earth, but which is too rare, and occurs in proportions too small, to cause any material error in ordinary cases, and in soils of this region.

But if it be only desired to know whether calcareous earth is entirely wanting in any soil—or to test the truth of my assertion that so great a proportion of our soils are destitute of that earth—it may be done with far more ease than by either of the foregoing methods, and without apparatus of any kind. Let a handful of the soil (without drying or weighing) be thrown into a large drinking glass, containing enough of pure water to cover the soil about two inches. Stir it until all the lumps have disappeared, and the water has certainly taken the place of all the atmospheric air which the soil had enclosed. Remove any vegetable fibres, or froth, from the surface of the liquid, so as to have it clear. Then pour in gently about a table spoonful of undiluted muriatic acid, which by its greater weight will sink, and penetrate the soil, without any agitation being necessary for that purpose. If any calcareous earth is present it will quickly begin to combine with the acid, throwing off its carbonic acid in gas, which cannot fail to be observed as it escapes, as the gas that eight grains only of calcareous earth would throw out, would be equal in bulk to a gill measure. Indeed, the product of only a single grain of calcareous earth, would be abundantly plain to the eye of the careful operator, though it might be the whole amount of gas from two thousand grains of soil. If no effervescence is seen even after adding more acid and gently stirring the mixture, then it is absolutely certain that the soil contained not the smallest portion of carbonate of lime; nor of carbonate of magnesia, the only other substance which could possibly be mistaken for it.

The examinations of all the soils that will be here mentioned were made in this pneumatic apparatus, except some of those which evidently evolved no gas, and when no other result was required. As calcareous earth is plainly visible to the eye in all shelly soils, they only need examination to ascertain its proportion. A few examples will show what proportions we may find, and how greatly they vary, even in soils apparently of equal value.

1. Soil, a black clayey loam, from the top of the high knoll at the end of Coggins Point, on James-river, containing fragments of muscle shells throughout. Never manured and supposed to have been under scouring cultivation and close grazing from the first settlement of the country; then

(1818) capable of producing twenty-five or thirty bushels of corn—and the soil well suited to wheat. One thousand grains, cleared by a fine sieve of all coarse shelly matter, (as none can act on the soil until minutely divided,) yielded sixteen ounce measures of carbonic acid gas, which showed the finely divided calcareous earth to be thirty-two grains.

2. One thousand grains of similar soil from another part of the same field, treated in the same manner, gave twenty-four grains of finely divided calcareous earth.

3. From the east end of a small island, at the end of Coggins Point, surrounded by the river and tide marsh. Soil, dark brown loam, much lighter than the preceding specimens, though not sandy—under like exhausting cultivation—then capable of bringing thirty to thirty-five bushels of corn—not a good wheat soil, ten or twelve bushels being probably a full crop. One thousand grains yielded eight grains of coarse shelly matter, and eighty-two of finely divided calcareous earth.

4. From a small spot of sandy soil, almost bare of vegetation, and incapable of producing any grain, though in the midst of very rich land, and cleared but a few years. Some small fragments of fossil sea-shells being visible, proved this barren spot to be calcareous, which induced its examination. Four hundred grains yielded eighty-seven of calcareous earth—nearly twenty-two per cent. This soil was afterwards dug and carried out as manure.

5. Black friable loam, from Indian Fields, on York-river. The soil was a specimen of a field of considerable extent, mixed throughout with oyster shells. Though light and mellow, the soil did not appear to be sandy. Rich, durable, and long under exhausting cultivation.

1260 grains of soil yielded

168 — of coarse shelly matter, separated mechanically,

8 — finely divided calcareous earth.

The remaining solid matter, carefully separated, (by agitation and settling in water,) consisted of

130 grains of fine clay, black with putrescent matter, and which lost more than one-fourth of its weight by being exposed to a red heat,

875 — white sand, moderately fine,

20 — very fine sand,

36 — lost in the process.

1061

6. Oyster shell soil of the best quality, from the farm of Wills Cowper, Esq., on Nansemond river—never manured, and supposed to have been cultivated in corn as often as three years in four, since the first settlement of the country—now yields (by actual measurement) thirty bushels of corn to the acre—but is very unproductive in wheat. A specimen taken from the surface, to the depth of six inches, weighed altogether

242 dwt., which consisted of

126 — of shells and their fragments, separated by the sieve,

116 — remaining finely divided soil.

Of the finely divided part, 500 grains consisted of

18 grains of carbonate of lime,

330 — silicious sand—none very coarse,

94 — impalpable aluminous and silicious earth,

35 — putrescent vegetable matter—none coarse or unrotted,

23 — loss,

500

It is unnecessary to cite any particular trials of our poor soils, as it has been stated, in the preceding chapter, that all are entirely destitute of calcareous earth—excluding the rare, but well marked exceptions of its great excess, of which an example has been given in the soil marked 4, in the foregoing examinations.

Unless then I am mistaken in supposing that these facts are universally true, the certain results of chemical analysis, as well as more extended general observation, completely establish these general rules—viz. :

1st. *That all calcareous soils are naturally fertile and durable in a very high degree—and,*

2d. *That all soils naturally poor are entirely destitute of calcareous earth.*

It then can scarcely be denied that calcareous earth must be the cause of the fertility of the one class of soils, and that the want of it produces the poverty of the other. Qualities that always thus accompany each other cannot be otherwise than *cause* and *effect*. If further proof is wanting, it can be safely promised to be furnished when the practical application of calcareous manures to poor soils will be treated of, and the effects stated.

These deductions are then established as to all calcareous soils, and all poor soils—which two classes comprise nine-tenths of all. This alone would open a wide field for the practical exercise of the truths we have reached. But still there remain strong objections and stubborn facts opposed to the complete proof and universal application of the proposition now under consideration, and consequently to the theory which that proposition is intended to support. The whole difficulty will be apparent at once when I now proceed to state that nearly all of our best soils, such as are very little if at all inferior in value to the small portion of shelly lands, *are as destitute of calcareous earth (carbonate of lime) as the poorest*. So far as I have examined, this deficiency is no less general in the richest alluvial lands of the upper country—and, what will be deemed by some as incredible, by far the greater part of the rich limestone soils between the Blue Ridge and Alleghany mountains are equally destitute of calcareous earth. These facts were not named before, to avoid embarrassing the discussion of other points—nor can they now be explained, and reconciled with my proposition, except through a circuitous and apparently digressive course of reasoning. They have not been kept out of view, nor slurred over, to weaken their force, and are now presented in all their strength. These difficulties will be considered, and removed, in the following chapters.

CHAPTER VI.

CHEMICAL EXAMINATION OF RICH SOILS CONTAINING NO CALCAREOUS EARTH.

Proposition 2—continued.

Under common circumstances, when any disputant admits facts that seem to contradict his own reasoning, such admission is deemed abundant evidence of their existence. But though now placed exactly in this situation, the facts admitted by me are so opposed to all that scientific agriculturists have taught us to expect, that it is necessary for me to show the grounds on which my admission rests. Few would have believed in the absence of calcareous earth in all our poor soils, forming as they do the

much larger part of all this region—and far more strange is it that the same deficiency should extend to such rich soils as some that will be here cited.

The following specimens, taken from well known and very fertile soils, were found to contain no calcareous earth. Many trials of other rich soils have yielded like results—and, indeed, I have never found calcareous earth in any soil below the falls of the rivers, in which, or near which, some particles of shells were not visible.

1. Soil from Eppes' Island, which lies in James-river, near City Point: light and friable (but not silicious) brown loam, rich and durable. The surface is not many feet above the highest tides, and, like most of the best river lands, this tract seems to have been formed by alluvion many ages ago, but which may be termed recent, when compared to the general formation of the tide-water district.

2. Black silicious loam from the celebrated lands on Back-river, near Hampton.

3. Soil from rich land on Pocason-river, York county.

4. Black clay vegetable soil, from a fresh-water tide marsh on James-river—formed by recent alluvion.

5. Alluvial soil of first-rate fertility above the falls of James-river—dark brown clay loam, from the valuable and extensive body of bottom land belonging to General J. H. Cocke, of Fluvanna.

The most remarkable facts of the absence of calcareous earth are to be found in the lime-stone soils, between the Blue Ridge and Alleghany mountains. Of these, I will report all that I have examined; and none contained any calcareous earth, unless when the contrary will be stated.

Before the first of these trials was made, I supposed (as probably most other persons do) that *lime-stone soil* was necessarily *calcareous*, and in a high degree. It is difficult to get rid of this impression entirely—and it may seem a contradiction in terms to say that a *lime-stone soil* is not calcareous. This I cannot avoid. I must take the term *lime-stone soil* as custom has already fixed it. But it should not be extended to any soils except those which are so near to lime-stone rock, as in some measure to be thereby affected in their qualities and value.

I to 6. Lime-stone soils selected in the neighborhood of Lexington, Virginia, by Professor Graham, with the view of enabling me to investigate this subject. All the specimens were from first-rate soils, except one, which was from land of inferior value. One of the specimens, Mr. Graham's description stated to be "taken from a piece of land so rocky [with lime-stone] as to be unfit for cultivation, at least with the plough. I could scarcely select a specimen which I would expect to be more strongly impregnated with calcareous earth." This specimen, by two separate trials, yielded only one grain of calcareous earth, from one thousand of soil. The other five soils contained none. The same result was obtained from

7. A specimen of alluvial land on North-river, near Lexington.

8. Brown loam from the Sweet Spring valley, remarkable for its extraordinary productiveness and durability. It is of alluvial formation, and before it was drained, must have been often covered and saturated by the Sweet Spring and other mineral waters, which hold lime in solution. The surrounding high land is of lime-stone soil. Of this specimen, taken from about two hundred yards below the Sweet Spring, from land long cultivated every year, three hundred and sixty grains yielded not a particle of calcareous earth. It contained an unusually large proportion of *oxide of iron*, though my imperfect means enabled me to separate and collect only eight grains, the process evidently wasting several more.

About a mile lower down, drains were then making (in 1826) to reclaim

more of this rich valley from the overflowing waters. Another specimen was taken from the bottom of a ditch just opened, eighteen inches below the surface. It was a black loam, and exhibited to the eye some very diminutive fresh-water shells, (perriwinkles, about one tenth of an inch in length,) and many of their broken fragments. This gave, from two hundred grains, seventy-four of calcareous earth. But this cannot fairly be placed on the same footing with the other soils, as it had obviously been once the bottom of a stream, or lake, and the collection and deposit of so large and unusual a proportion of calcareous matter seemed to be of animal formation. Both these specimens were selected at my request by one of our best farmers, and who also furnished a written description of the soils, and their situation.

9. Wood-land, west of Union, Monroe county. Soil, a black clay loam, lying on, but not intermixed at the surface with lime-stone rock. Sub-soil, yellowish clay. The rock at this place, a foot below the surface. Principal growth, sugar maple, white walnut, and oak. This and the next specimen are from one of the richest tracts of high land that I have seen.

10. Soil similar to the last and about two hundred yards distant. Here the lime-stone showed above the surface, and the specimen was taken from between two large masses of fixed rock, and about a foot distant from each.

11. Black rich soil, from wood-land between the Hot and Warm Springs, in Bath county. The specimen was part of what was in contact with a mass of lime-stone.

12. Soil from the western foot of the Warm Spring mountain, on a gentle slope between the court-house and the road, and about one hundred and fifty yards from the Warm Bath. Rich brown loam, containing many small pieces of lime-stone, but no finely divided calcareous earth.

13. A specimen taken two or three hundred yards from the last, and also at the foot of the mountain. Soil, a rich black loam, full of small fragments of lime-stone of different sizes, between that of a nutmeg and small shot. The land had never been broken up for cultivation. One thousand grains contained two hundred and forty grains of small stone or gravel, mostly lime-stone, separated mechanically, and sixty-nine grains of finely divided calcareous earth.

14. Black loamy clay, from the excellent wheat soil adjoining the town of Bedford, in Pennsylvania: the specimen taken from beneath and in contact with lime-stone. One thousand grains yielded less than one grain of calcareous earth.

15. A specimen from within a few yards of the last, but not in contact with lime-stone, contained no calcareous earth; neither did the red clay sub-soil, six inches below the surface.

16. Very similar soil, but much deeper, adjoining the principal street of Bedford—the specimen taken from eighteen inches below the surface, and adjoining a mass of lime-stone. A very small disengagement of gas indicated the presence of calcareous earth—but certainly less than one grain in one thousand, and perhaps not half that quantity.

17. Alluvial soil on the Juniata, adjoining Bedford.

18. Alluvial vegetable soil near the stream flowing from all the Saratoga Mineral Springs, and necessarily often covered and soaked by those waters, and

19. Soil taken from the bed of the same stream—neither contained any portion of carbonate of lime.

Thus it appears that of these nineteen specimens of soils, only four contained calcareous earth, and three of these four in exceedingly small pro-

portions. It should be remarked that all these were selected from situations which, from their proximity to calcareous rock, or exposure to calcareous waters, were supposed most likely to present highly calcareous soils. If five hundred specimens had been taken, without choice, even from what are commonly called lime-stone soils, (merely because they are not very distant from lime-stone rock, or springs of lime-stone water,) the analysis of that whole number would be less likely to show calcareous earth, than the foregoing short list. I therefore feel justified, from my own few examinations, and unsupported by any other authority, to pronounce that calcareous earth will very rarely be found in any soils between the falls of our rivers and the navigable western waters. In a few specimens of some of the best soils from the borders of the Mississippi and its tributary rivers, I have since found calcareous earth present in all—but in very small proportions, and in no case exceeding two per cent.

When the total deficiency of carbonate of lime, in nearly all the soils of Virginia, was first asserted, as above, in the earliest publication of this essay, (1821, in *American Farmer*, vol. iii.,) the proposition was so entirely new, and so opposed to all inferences from authority then existing, that it was indispensably necessary to adduce my facts, as is done above, to sustain the otherwise unsustained doctrine. And such support, for the same reason, continued to be wanting through the two next editions. Now (in 1842) the case is altogether different. The fact of the absence of carbonate of lime, as generally as I had assumed, through the eastern or seaward slope of the United States, and especially in New England, has been confirmed by all the analyses of soils which have been since made by Professor Hitchcock and other accurate scientific investigators; and the proposition, however untenable or incredible it might have been deemed before, is now universally admitted, and indeed is placed beyond question or doubt, as an important feature in the chemical constitution of soils.

The only soils of considerable extent of surface which, from the specimens that I have examined, appear to be highly calcareous, and to agree in that respect with many European soils, are from the *prairies*, those lands of the south-west which, whether rich or poor, are remarkable for being destitute of trees, and covered with grass, so as to form natural meadows. The examinations were made but recently, (in 1834,) and are reported because presenting striking exceptions to the general constitution of soils in this country.

20. *Prairie soil of the most productive kind in Alabama*; a black clay, with very little sand, yet so far from being stiff, that it becomes too light by cultivation. This kind of land is stated by the friend to whom I am indebted for the specimens, to "produce corn and oats most luxuriantly—and also cotton for two or three years; but after that time cotton is subject to the rust, probably from the then open state of the soil, which by cultivation has by that time become as light and as soft as a bank of ashes." One hundred grains of the specimen contained eight of carbonate of lime. All this prairie land in Alabama lies on a substratum of what is there called "rotten lime-stone," (specimens of which contained seventy-two to eighty-two per cent. of lime,) and which rises to the surface sometimes, forming the "bald prairies," a sample of the soil of which (21) contained fifty-nine per cent. of carbonate of lime. This was described as "comparatively poor—neither trees nor bushes grow there, and only grass and weeds before cultivation—corn does not grow well—small grain better—and cotton soon becomes subject to the rust." The excessive proportion of calcareous earth is evidently the cause of its barrenness.

The substratum called lime-stone is soft enough to be cut easily and

smoothly with a knife, and some of it is in appearance and texture more like the chalk of Europe, than any other earth that I have seen in this country.

22. A specimen of the very rich "cane brake" lands in Marengo county, Alabama, contained sixteen per cent. of carbonate of lime. This is a kind of prairie, of a wetter nature, from the winter rains not being able to run off from the level surface, nor to sink through the tenacious clay soil, and the solid stratum of lime-stone below.

23. A specimen from the very extensive "Choctaw Prairie" in Mississippi, of celebrated fertility, yielded thirteen per cent. of carbonate of lime.

Several other specimens of different, but all of very fertile soils from southern Alabama, and all lying over the substratum of soft lime-stone, were found to be *neutral*, containing not a particle of lime in the form of *carbonate*. These specimens were as follows—

24. One from the valley cane land—"very wet through the winter, but always dry in summer—and after being ditched is dry enough to be cultivated in cotton, which will grow from eight to twelve feet high."

25. Another from what is called the best "post-oak land," on which trees of that kind grow to the size of from two to four feet in diameter—having but little underwood, and no cane growth—"thought to be nearly as rich as the best cane land, and will produce 1500 lbs., or more, of seed cotton, or fifty bushels of corn to the acre."

26. Another from what is termed "palmetto land, having on it that plant as well as a heavy cover of large trees growing luxuriantly. It is a cold and wet soil before being brought into good tilth; but afterwards is soft and easy to till, and produces corn and cotton finely. The cane on it is generally small: the soil from four to ten feet deep."*

One more prairie soil only will be adduced, from many analyses which have furnished general results like the foregoing, (20 to 26); and this one is given because it serves as a fair specimen of a very large class of the prairie lands. It was selected by Dr. R. W. Withers, in 1835, and described by him as follows: (*Farmers' Register*, vol. iii., p. 498.)

Soil of Greene county, Alabama, "from our open or *bald* prairie, [*i. e.*, totally without trees,] which has been cultivated for seven or eight years—produces corn very well—nearly fifty bushels to the acre are now standing on the ground; but cotton does not produce so well on it as on poor sandy soil. I feel very confident that this specimen is highly calcareous, as there are many fragments of shells mixed with the soil, and the rock is not two feet from the surface. Of all the specimens hitherto sent, this is the one which will give the nearest approach to the general character of our open prairie land in this part of the country."—This specimen was found to contain 33 per cent. of carbonate of lime.

The foregoing details, respecting lime-stone lands, may perhaps be considered an unnecessary digression, in a treatise on the soils of the tide-water district. But the analysis of lime-stone soils furnishes the strongest evi-

* It is proper to mention a circumstance which may have had some effect in removing the carbonate of lime from these Alabama soils, besides the more general causes which will be traced in the next chapter. With these specimens of soil was sent a collection of the small stones and gravel which were stated to be found generally through these soils, and particularly in the clay sub-soil beneath. Among these there were several fragments of *sulphuret of iron*. This mineral, when decomposing in the earth in contact with carbonate of lime, also decomposes the latter substance, and forms sulphate of lime, (gypsum,) instead. It is well worth inquiry whether sulphuret of iron is generally found in these soils. It may be known by its great weight, and metallic lustre when broken, (which has caused it often to be mistaken for silver ore,) and by giving out fumes of burning sulphur when subjected to strong heat under a blow pipe.

dence of the remarkable and novel fact of the general absence of calcareous earth—and the information thence derived will be used to sustain the following steps of my argument.

All the examinations of soils in this chapter concur in opposing the general application of the proposition that the deficiency of calcareous earth is the cause of the sterility of our soils. And having stated the objection in all its force, I shall now proceed to inquire into its causes, and endeavor to dispel its apparent opposition to my doctrine.

CHAPTER VII.

PROOFS OF THE EXISTENCE OF ACID AND NEUTRAL SOILS.

Proposition 2—continued.

Sufficient evidence has been adduced to prove that many of our most fertile and valuable soils are destitute of calcareous earth. But it does not necessarily follow that such has always been their composition; or that they may not now contain lime combined with some other acid than the carbonic. That this is really the case, I shall now offer proofs to establish; and not only maintain this position with regard to those valuable soils, but shall contend that *lime, in some proportion, combined with vegetable acid, is present in every soil capable of supporting vegetation.*

But while I shall endeavor to maintain these positions, without asking or even admitting any exception, let me not be understood as asserting that the original ingredient of calcareous earth was always the sole cause of the fertility of any particular soil, or that a knowledge of the proportion contained, would serve to measure the capacity of the soil for improvement. Calcareous soils, not differing materially in qualities or value, often exhibit a remarkable difference in their respective proportions of calcareous earth; so that it would seem that a small quantity, aided by some other unknown agent, or perhaps by time, may give as much capacity for improvement, and ultimately produce as much fertility, as ten times that proportion, under other circumstances.

In all naturally poor soils, producing freely pine and whortleberry in their virgin state, and sheep sorrel after cultivation, I suppose to have been formed some *vegetable acid*, which, after taking up whatever small quantity of lime might have been present, still remains in excess in the soil, and nourishes in the highest degree the plants named above, but is a poison to all useful crops; and effectually prevents such soils becoming rich, by either natural or artificial applications of putrescent manures.

In a *neutral soil*, I suppose calcareous earth to have been sufficiently abundant at some former time to produce a high degree of fertility—but that it has been decomposed, and the lime taken up, by the gradual formation of vegetable acid, until the lime and the acid neutralize and balance each other, leaving no considerable excess of either; and that such are all our fertile soils which are not now calcareous.

These suppositions remain to be proved, in all their parts.

No opinion has been yet advanced that is less supported by good authority, or to which more general opposition may be expected, than that which supposes the existence of acid soils. The term *sour soil* is frequently used by farmers, but in so loose a manner as to deserve no consideration. It has been thus applied to any cold and ungrateful land, without intending

that the term should be literally understood, and perhaps without attaching to its use any precise meaning whatever. Dundonald only, of all those who have applied chemistry to agriculture, has asserted the existence of vegetable acid in soils:* but he has offered no analysis of soils in proof, nor any other evidence to establish the fact; and his opinion has received no confirmation, nor even the slightest notice, from later and more able investigators of the chemical characters of soils. Kirwan and Davy profess to enumerate all the common ingredients of soils; and it is not intimated by either that vegetable acid is one of them. Even this tacit denial by Davy more strongly opposes the existence of vegetable acid, than it is supported by the opinion of Dundonald, or any of those writers on agriculture who have admitted its existence. For it cannot be supposed that so able and profound an investigator would have omitted all reference to an ingredient of soils so general, and therefore so important, as is here asserted, even if its presence had been ever suspected by him, much less known. Grisenthwaite, a late writer on agricultural chemistry, and who has the advantage of knowing the discoveries, and comparing the opinions, of all his predecessors, expressly denies the possibility of any acid existing in soils. His *New 'Theory of Agriculture'* contains the following passage: "Chalk has been recommended as a substance calculated to correct the sourness of land. It would surely have been a wise practice to have previously ascertained this existence of acid, and to have determined its nature, in order that it might be effectually removed. The fact really is, that no soil was ever yet found to contain any notable quantity of acid. The acetic and the carbonic are the only two that are likely to be generated by any spontaneous decomposition of animal or vegetable bodies, and neither of them have any fixity when exposed to the air." Thus, then, my doctrine is deprived of even the feeble support it might have had from Dundonald's mere opinion, if that opinion had not been contradicted by later and better authority; and the only support that I can look for, will be in the facts and arguments that I shall be able to adduce.

I am not prepared to question what Grisenthwaite states as a chemical fact, "that no soil was ever yet found to contain any notable quantity of acid." No soil examined by me for this purpose gave any evidence of the presence of uncombined acid. Still, however, the term acid may be applied with propriety to soils in which growing vegetables continually receive acid from the decomposition of others, (for which no "fixity" is requisite,) or in which acid is present, not free, but combined with some base, by which it is readily yielded to promote, or retard, the growth of plants in contact with it. It will be sufficient for my purpose to show that certain soils contain some substance, or possess some quality, which promotes almost exclusively the growth of acid plants—that this power is strengthened by adding known vegetable acids to the soil—and is totally removed by the application of calcareous manures, which would necessarily destroy any acid, if it were present. Leaving it to chemists to determine the nature and properties of this substance, I merely contend for its existence and effects; and the cause of these effects, whatever it may be, for the want of a better name, I shall call *acidity*.

The proofs now to be offered in support of the existence of acid and neutral soils, however weak each may be when considered alone, yet, when taken in connexion, will together form a body of evidence not easily to be resisted.

First proof.—Pine and common sorrel have leaves well known to be acid

* Dundonald's *Connexion of Chemistry and Agriculture*.

to the taste; and their growth is favored by the soils which I suppose to be acid, to an extent which would be thought remarkable in other plants on the richest soils. Except wild locust on the best river land, no growth can compare in rapidity with pines on soils naturally poor, and even greatly reduced by long cultivation. Pines usually stand so thick, on old exhausted fields, that the increase of size in each plant is greatly retarded; but if the whole growth of an acre were estimated, it would probably exceed in quantity the different growth of the richest soils, of the same age and on an equal space. Every cultivator of corn on poor light soil knows how rapidly sorrel* will cover his otherwise naked field, unless kept in check by continual tillage—and that to root it out, so as to prevent the like future labor, cannot be effected by any mode of cultivation whatever. This weed too is considered far more hurtful to growing crops, than any other of equal size. Yet neither of these acid plants can thrive on the best lands. Sorrel cannot even live on a calcareous soil; and if a pine is sometimes found there, it has nothing of its usual elegant form, but seems as stunted and ill-shaped as if it had always suffered for want of nourishment. Innumerable facts, of which these are examples, prove that these acid plants must derive from their favorite soil some kind of food peculiarly suited to their growth, and quite useless, if not hurtful, to cultivated crops.

2nd. Dead acid plants are the most effectual in promoting the growth of living ones. When pine leaves are applied to a soil, whatever acid they contain is of course given to that soil, for such time as circumstances permit it to retain its form, or peculiar properties. Such an application is often made on a large scale, by cutting down the second growth of pines, on land once under tillage, and suffering them to lie a year before cleaning and cultivating the land. The invariable consequence of this course is a growth of sorrel, for one or two years, so abundant and so injurious to the crops, as to more than balance any benefit derived by the soil from the vegetable matter having been allowed to rot. From the general experience of this effect, most persons put pine land under tillage as soon as cut down, after carefully burning (to destroy) the whole of the heavy cover of leaves, both green and dry. Until within a few years, it was generally supposed that the leaves of pine were worthless, if not hurtful, in all applications to cultivated land—which opinion doubtless was founded on such facts as have been just stated. But if they are used as litter for cattle, and heaped to ferment, the injurious quality of pine leaves is destroyed, and they become a valuable manure. This practice is but of recent origin—but is highly approved, and rapidly extending. Still later it has been found that when these leaves are applied unrotted, as raked up in wood-land, to calcareous land, they produce only and always beneficial results; and that this is the best as well as cheapest mode of their application.

On one of the washed and barren declivities (or *galle*) which are so numerous on all our farms, I had the small gullies packed full of green pine bushes, and then covered with the earth drawn from the equally barren intervening ridges, so as nearly to smooth the whole surface. The whole piece had borne nothing previously except a few scattered tufts of poverty grass, and dwarfish sorrel, all of which did not prevent the spot seeming quite bare at mid-summer, if viewed at the distance of one hundred yards. This operation was performed in February or March. The land was not

* Sheep sorrel, or *Rumex acetosa*. The wood sorrel (*Oxalis acetosella*) is of a very different character. The latter prefers rich and even calcareous soils, and I have seen it growing well on places calcareous to excess. It would seem, therefore, that wood sorrel forms its acid from the atmosphere, and does not draw it from the soil, as I suppose to be the case with common sorrel.

cultivated, nor again observed, until the second summer afterwards. At that time, the piece remained as bare as formerly, except along the filled gullies, which, throughout the whole of their crooked courses, were covered by a thick and uncommonly tall growth of sorrel, remarkably luxuriant for any situation, and which, being bounded exactly by the width of the narrow gullies, had the appearance of some vegetable sown thickly in drills, and kept clean by tillage. So great an effect of this kind has not been produced within my knowledge—though facts of like nature, and leading to the same conclusion, are of frequent occurrence. If small pines standing thinly over a broom-grass old-field are cut down and left to lie, under every top will be found a patch of sorrel, before the leaves have all rotted.

3rd. The growth of sorrel is not only peculiarly favored by the application of vegetables containing acids already formed, but also by such matters as will form acid in the course of their decomposition. Farm-yard manure, and all other putrescent animal and vegetable substances, form *acetic acid* as their decomposition proceeds.* If heaps of rotting manure are left without being spread, in a field but very slightly subject to produce sorrel, a few weeks of growing weather will bring out that plant close around every heap; and for some time the sorrel will continue to show more benefit from that rank manuring than any other grass. For several years my winter-made manure was spread and ploughed in on land not cultivated until the next autumn, or the spring after. This practice was founded on the mistaken opinion, that it would prevent much of the usual exposure to evaporation and waste of the manure. One of the reasons which alone would have compelled me to abandon this absurd practice was, that a crop of sorrel always followed, (even on good soils that before barely permitted a scanty growth of it to live,) which so injured the next grain crop as greatly to lessen the benefit from the manure. Sorrel unnaturally produced by such applications does not infest the land longer than until we may suppose the acid to have been removed by cultivation and other causes.

It may be objected, that even if fully admitted, my authorities prove only the formation of a single vegetable acid in soil, the acetic—that my facts show only the production of a single acid plant, sorrel—and that the acid which sorrel contains is not the acetic, but the oxalic.† In reply to such objections, it may be said, that from the application of acids to recently ploughed land, no acid plant except sorrel is made to grow, because that one only can spring up speedily enough to arrest the fleeting nutriment. Poverty grass (*Aristida gracilis* or *A. dichotoma*) grows only on the same kinds of soil, and generally covers them after they have been a year free from a crop, but does not show sooner; and pines require two years before their seeds will produce plants. But when pines begin to spread over the land, they soon put an end to the growth of all other plants, and are abundantly supplied with their acid food, from the dropping of their own leaves. Thus they may be first supplied with the vegetable acid ready formed in the leaves, and afterwards with the acetic acid formed by their subsequent slow decomposition. It does not weaken my argument that the product of a plant is a vegetable acid different from the one supposed to have nourished its growth. All vegetable acids (except the prussic) however different in their properties, are composed of the same three elementary bodies, differing only in their proportions‡—and consequently are all convertible into each other. A little more, or a little less of one or the other of these

* Agr. Chem. p. 187. (Phil. ed.)

† Agr. Chem. Lecture 3.

‡ Carbon, oxygen, and hydrogen. Agr. Chem. Lecture 3, p. 78.

ingredients, may change the acetic to the oxalic acid, and that to any other. We cannot doubt but that such simple changes may be produced by the chemical powers of vegetation, when others are effected far more difficult for us to comprehend. The most tender and feeble organs, and the mildest juices, aided by the power of animal or vegetable life, are able to produce decompositions and combinations which the chemist cannot explain, and which he would in vain attempt to imitate.

4th. This ingredient of soils, which nourishes acid plants, also poisons cultivated crops. Plants have not the power of rejecting noxious fluids, but take up by their roots every thing presented in a soluble form.* Thus the acid also enters the sap-vessels of cultivated plants, stints their growth, and makes it impossible for them to attain that size and perfection which their proper food would ensure, if it were presented to them without its poisonous accompaniment. When the poorest virgin wood-land is cut down, it is covered and filled to excess with leaves and other rotted and rotting vegetable matters. Can a heavier vegetable manuring be desired? And as this completely rots during cultivation, must it not offer to the growing plants as abundant a supply of food as they can require? Yet the best product obtained may be from ten to fifteen bushels of corn, or five or six of wheat, soon to come down to half those quantities. If the noxious quality which causes such injury is an acid, it is as certain as any chemical truth whatever, that it will be neutralized, and its powers destroyed, by applying enough of calcareous earth to the soil; and precisely such effects are found whenever that remedy is tried. On land thus relieved of this unceasing annoyance, the young plants of corn no longer appear of a pale and sickly green, approaching to yellow, but take immediately a deep healthy color, by which it may readily be distinguished from any on soil left in its former state, before there is any perceptible difference in the size of the plants. The crop will produce fifty to one hundred per cent. more, the first year, before its supply of food can possibly have been increased; and the soil is soon found not only cleared of sorrel, but absolutely incapable of producing it. I have anticipated these effects of calcareous manures, before furnishing the evidence; but they will hereafter be established by facts beyond contradiction.

The truth of the existence of either acid or neutral soils depends on the existence of the other; and to prove either, will necessarily establish both. If acid exists in soils, then whenever it meets with calcareous earth, the two substances must combine with and neutralize each other, so far as their proportions are properly adjusted. On the other hand, if I can show that compounds of lime and vegetable acid are present in most soils, it follows inevitably that nature has provided means by which soils can generally obtain this acid; and if the amount formed can balance the lime, the operation of the same causes can exceed that quantity, and leave an excess of free acid. From these premises will be deduced the following proofs.

5th. It has been stated (page 36) that the process recommended by chemists for finding the calcareous earth in soils was unfit for that purpose, because *some precipitate* was always obtained, even when no calcareous earth or carbonate of lime was present. Frequent trials have shown me that this precipitate is considerably more abundant from good soils than bad. The substance thus obtained from rich soils by solution and precipitation, in every case that I have tried, contains some carbonate of lime, although the soil from which it was derived had none. The alkaline liquor from which the precipitate has been separated, we are told by Davy, will, after

* Agr. Chem. Lecture 6, page 186.

boiling, let fall the carbonate of magnesia, if any had been in the soil; but when any notable deposit is thus obtained, it will often be found to consist more of carbonate of lime, than of magnesia. The following are examples of such products:

One thousand grains of tide-marsh soil, (page 40, No. 4,) acted on by muriatic acid in the pneumatic apparatus, gave out no carbonic acid gas, and therefore could have contained no carbonate of lime. The precipitate obtained from the same weighed sixteen grains; which being again acted on by sulphuric acid, evolved as much gas as showed that three grains had become carbonate of lime, in the previous part of the process.

Two hundred grains of alluvial soil from Saratoga Springs (page 41 No. 18,) containing no carbonate of lime, yielded a precipitate of twelve grains, of which three was carbonate of lime—and a deposit from the alkaline solution weighing six grains, four of which was carbonate of lime.

Seven hundred grains of limestone soil from Bedford, Pennsylvania, (part of the specimen marked 14, page 41,) contained about two-thirds of a grain of carbonate of lime—and its precipitate of twenty-eight grains, only yielded two grains: but the alkaline solution deposited eleven grains of the carbonates of lime and magnesia, of which at least five was of the former, as there remained seven and a half of solid matter, after the action of sulphuric acid.*

From this process, there can be no doubt but that the soil contained a proportion of some *salt of lime*, (or lime combined with some kind of acid,) which being decomposed by and combined with the muriatic acid, was then precipitated, not in its first form, but in that of carbonate of lime—it being supplied with carbonic acid from the carbonate of potash used to produce the precipitation. The proportions obtained in these cases were small; but it does not follow that the whole quantity of lime contained in the soil was found. However, to the extent of this small proportion of lime, is proved clearly the presence of enough of some acid (and that not the carbonic) to combine with it. Neither could it have been the sulphuric, or the phosphoric acid; for though both the sulphate and phosphate of lime are in some soils, yet neither of these salts can be decomposed by muriatic acid.

6th. The strongest objection to the doctrine of neutral soils is, that, if true, the salt formed by the combination of the lime and acid must often be present in such large proportions, that it is scarcely credible that its presence and nature should not have been discovered by any of the able chemists who have analyzed soils. This difficulty I cannot remove, but it may be met (or neutralized, to borrow a figure from my subject,) by showing that an equal difficulty awaits those who may support the other side of the argument.

The theory of geologists of the formation of soils, from the decomposi-

* The measurement of the carbonic acid gas evolved was relied on to show the whole amount of carbonates present—and sulphuric acid was used to distinguish between lime and magnesia, in the deposit from the alkaline solution. If any alumina or magnesia had made part of the solid matter exposed to diluted sulphuric acid, the combinations formed would have been soluble salts, which would of course have remained dissolved and invisible in the fluid. Lime only, of the four earths, forms with sulphuric acid a substance but slightly soluble, and which therefore can be mostly separated in a solid form. The whole of this substance (sulphate of lime) cannot be obtained in this manner, as a part is always dissolved; but whatever is obtained, proves that at least two-thirds of that quantity of carbonate of lime had been present; as that quantity of lime which will combine with enough carbonic acid to make 100 parts (by weight) of carbonate of lime, will combine with so much more of sulphuric acid, as to form about 150 parts of the sulphate of lime, or gypsum.

tion or disintegration of rocks, is received as true by scientific agriculturists. The soils thus supposed to be formed, receive admixtures from each other, by means of different operations of nature, and after being more or less enriched by the decay of their own vegetable products, make the endless variety of existing soils.* But where a soil, lying on and thus supposed to have been formed from any particular kind of rock, is so situated that it could not have been moved, or received considerable accessions from torrents or other agents, then, according to this theory, the rock and the soil should be composed of the same materials; and such soils as the specimens, marked 11 and 16, (page 41,) would be, like the rock they touched, nearly pure calcareous earth, instead of being (as they were in truth) destitute, or nearly so, of that ingredient. Such are the doctrines received and taught by Davy, or the unavoidable deductions from them. But, without contending for the full extent of this theory of the formation of soils, (because I consider it almost entirely false,) every one must admit that soils thus situated must have received, in the lapse of ages, some accessions to their bulk, from the effects of frost, rain, sun, and air, on the lime-stone in contact with them. All lime-stone soils, properly so called, exhibit certain marked and peculiar characters of color, texture, and products, which can only be derived from receiving into their composition more or less of the rock which lies beneath, or rises above their surface. This mixture will not be denied by any one who has observed lime-stone soils, and reasons fairly, whether his investigation begins with the causes, or their effects. If then all this accession of calcareous earth remains in the soil, why is it that none, or almost none, is discovered by accurate chemical analysis? Or, if it be supposed not present, nor yet changed in its chemical character, in what possible manner could a ponderous and insoluble earth have made its escape from the soil? To remove this obstacle, without admitting the operation of acid in making such soils neutral, will be attended with at least as much difficulty, as any arising from that admission being made.

7th. But we are not left entirely to conjecture that soils were once more calcareous than they now are, if chemical tests can be relied on to furnish proof. Acid soils that have received large quantities of calcareous earth as manure, after some time, will yield very little when analyzed. To a soil of this kind, full of vegetable matter, I applied, in 1818 and 1821, fossil shells at such a known and heavy rate as would have given to the soil (by calculation) at least three per cent. of calcareous earth, for the depth of five inches. Only a small portion of the shelly matter was very finely divided when applied. Since the application of the greater part of this dressing, (only one-fourth having been laid on in 1818,) no more than six years had passed before the following examinations were made (at end of 1826); and the cultivation of five crops in that time, three of which were horse-hoed, must have well mixed the calcareous earth with the soil. Three careful examinations gave the following results:

No. 1.—1000 grains yielded $7\frac{1}{2}$ of coarse calcareous earth, (fragments of shells,)

And less than $\frac{1}{2}$ of finely divided.

8

* Agr. Chem. p. 131. Also Treatise on Agriculture, (by General Armstrong,) quoted in a preceding page (33) of this essay.

No. 2.—1000 grains yielded 5 of coarse,
2 finely divided.

7

No. 3.—1500 grains yielded 15 of coarse,
2½ finely divided.

17½

The specimens, No. 1 and No. 2, were obtained by taking handfuls of soil from several places, (four in one case, and twelve in the other,) mixing them well together, and then taking the samples for trial from the two parcels. On such land, when not recently ploughed, there will always be an over proportion of the pieces of shells on the surface, as the rains have settled the fine soil, and left exposed the coarser matters. On this account, in making these two selections, the upper half-inch was first thrown aside, and the handful dug from below. No. 3 was taken from a spot showing a full average thickness of shells, and included the surface. I considered the three trials made as fairly as possible, to give a general average. Small as is the proportion of finely divided calcareous earth exhibited, it must have been increased by rubbing some particles from the coarser fragments, in the operation of separating them by a fine sieve. Indeed it may be doubted whether any proportion remained very finely divided—or in other words, whether it had not been combined with acid, as fast as it was so reduced. But without the benefit of this supposition, the finely divided calcareous earth in the three specimens averaged only one and one-fourth grains to the thousand, which is one twenty-fourth of the quantity laid on; and the total quantity obtained, of coarse and fine, is eight grains in one thousand, or about one-fourth of the original proportion. All the balance had changed its form, or otherwise disappeared, in the few years that had passed since the application.

Another similar trial of this soil from the same ground was repeated in July, 1842, which showed that the finely divided *carbonate* of lime, then remaining, was in quantity so small as to be barely perceptible and appreciable. The land had then remained undisturbed by tillage for nine months; and some scattered fragments of shells were exposed to view on the surface generally. For the obvious reasons stated in the preceding paragraph, there will always appear an over-proportion of such fragments, upon the surface of land not recently ploughed; for this reason, as on two of the three former trials, the upper half-inch of surface soil was thrown aside, and the sample for examination taken immediately below. Of this, 2400 grains yielded two grains only of small fragments of shells, and less than one grain of finely divided carbonate of lime; whereas seventy-two grains had been the original quantity furnished to the soil. This result, with those of the earlier trials, agree precisely with what would be expected from the action of acid in soil, and cannot be satisfactorily explained by any other doctrine.*

* Even of this very small amount of fragments of shells found, (2 grains,) more than half was of the very hard gray shells (oyster and scallop,) which seem almost indestructible in soil. They must contain some chemical ingredient which enables them to withstand the acid or other corroding action of soil, to which all the white fossil shells, whether hard or soft, so readily yield in the course of time. I recently observed a most striking proof of this well known general fact of the long durability of these gray shells, and consequently their comparative worthlessness as a manure. On like soil to the subject of the above trials, and near the same spot, I recently (1842) found a small

The very small proportions of finely divided calcareous earth compared to the coarse, in some shelly soils, furnish still stronger evidence of this kind. Of the York river soil, (described page 38 No. 5.)

1260 grains, yielded of coarse calcareous parts,	-	-	-	168 grains.
And of finely divided,	-	-	-	8
				<hr/>
1044 of the rich Nansemond soil, (No. 6.)	-	-	-	544 coarse.
				18 fine.

As many of the shells and their fragments in these soils are in a mouldering state, it is incredible that the whole quantity of finely divided particles derived from them should have amounted to no more than these small proportions. Independent of the action of natural causes, the plough alone, in a few years, must have pulverized at least as much of the shells as was found.

8. In other cases, where the operations of nature have been applying calcareous earth for ages, none now remains in the soil; and the proof thence derived is more striking than any obtained from artificial applications of only a few years' standing. Valleys, subject to be frequently flooded and saturated by the water of lime-stone streams, must necessarily retain a new supply of calcareous earth from every such soaking and drying. Lime-stone water contains the *super-carbonate of lime*, which is soluble; but this loses its excess of carbonic acid when left dry by evaporation, and becomes the carbonate of lime, which not being soluble, is in no danger of being removed by subsequent floods. Thus, accessions are slowly but continually made, through many centuries. Yet such soils are found containing no calcareous earth—of which a remarkable example is presented in the soil of the cultivated part of the Sweet Spring Valley, (No. 8, page 40.)

The excess of carbonic acid, which unites with lime and renders the compound soluble in water, is lost by exposure of the calcareous water to the air, as well as by evaporation to dryness. [*Accum's Chemistry—Lime.*] The masses of soft calcareous rock which are deposited in the rapids of lime-stone streams are examples of the loss of carbonic acid from exposure to the air; and the stalactites in caves, the deposit of the slow-dropping water holding in solution the super-carbonate of lime, are examples of the same effect produced by evaporation. A similar deposit of insoluble carbonate of lime, from both these causes, is necessarily made on all land subject to be flooded by lime-stone waters.

9. All *wood ashes* contain salts of lime, (and most kinds in large proportions,) which could have been derived from no other source than the soils on which the trees grew. The lime thus obtained is principally combined with carbonic acid, and partly with the phosphoric, forming phosphate of lime. The table of Saussure's numerous analyses of the ashes of numerous plants,* is sufficient to show that these products are general, if not universal. The following examples of some of my own few examinations prove that ashes yield calcareous earth in proportions suitable to their kind, although the wood grew on soils destitute of that ingredient—as was ascertained with regard to each of these soils.

and thin but well-marked oyster-shell, (*Ostrea Virginiana*,) apparently as perfect and as well preserved as when it was dug up, and which was a good characteristic specimen of the kind, and as such, has been placed in my cabinet. This shell was part of the dressing spread upon the field for the crop of 1821, and has been since exposed to all the vicissitudes of tillage and of weather for nearly twenty-two years.

* Quoted in Agr. Chem. Lecture 3.

100 GRAINS OF ASHES FROM	WHAT SOIL TAKEN FROM.	CARBONATE OF LIME.	PHOSPHATE OF LIME.
Whortleberry bushes, the entire plants, except the leaves,	Acid silicious loam,	4 grains.	4 grains.
Equal parts of the bark, heart, and sap-wood of an old locust,	The same.	51 "	18 "
Young locust bushes entire	Rich neutral clay loam,	40 "	30 "
Young pine bushes,	Acid silicious loam,	9 "	6 "
Body of a young pine tree,	Acid clay soil,	14 "	18 "

The potash was first carefully taken out of all these samples. The remaining solid matter was silicious sand and charcoal; the proportion of the latter varying according to the degree of heat used in burning the wood, which was not permitted to be very strong, for fear of converting the calcareous earth into quick-lime.

It must be evident and unquestionable that all the carbonate of lime yielded by the ashes had been necessarily furnished in some form by the soil on which the plants grew; and when the soil itself contained no carbonate, as in all these cases, some other compound of lime must have been present, to enable us to account for these certain and invariable results. The presence of a combination of lime with some *vegetable* acid, and none other, would serve to produce such effects. According to established chemical laws, if any such combination had been taken up into the sap-vessels of the tree, it would be decomposed by the heat necessary to convert the wood to ashes; the acid would be reduced to its elementary principles, and the lime would immediately unite with the carbonic acid, (which is produced abundantly by the process of combustion,) and thus present a product of *carbonate of lime* newly formed from the materials of the other substances decomposed.*

On the foregoing facts and deductions, I am content to rest the truth of the existence of acid and neutral soils.

I have chosen to leave all the preceding part of this chapter (with the exception of a few merely verbal corrections and alterations) precisely as it appeared in the first edition of this essay, (January 1832.)† But since that time I have first heard of a discovery, and of consequent investigations by men of science, which seem to furnish direct proof of what I have been contending for, viz.: *the existence of a vegetable acid substance in soils and manures, generally diffused, and often in large proportions, and yet which had not been known or suspected by chemists previously.* The first intimation of this discovery which reached me was in the '*Alphabet of Scientific Gardening*,' by Professor Rennie, published in London in 1833, from which the part relative to this subject will be quoted below. Since, I have seen the French version of the late work of Berzelius, in which his views of humic acid (or, as he names it, the geic acid,) are given more at

* The reasoning on the presence of the carbonate of lime found in ashes, from acid soils, does not apply to the phosphate of lime which is also always present. The latter salt is not decomposed by any known degree of heat, [Art. *Chemistry*, in *Edin. Ency.*] and therefore might possibly have remained unchanged, in passing from the soil to the tree, and thence to the ashes.

† The general position and views taken as to acid and neutral soils are also, in substance and purport, just as they appeared in my first publication on this subject in 1821

length, and from which an extract will be translated and given in the appendix. The facts respecting humic acid, as concisely stated in the following quotation from Professor Rennie, furnish strong confirmation of some of the opinions which I have endeavored to maintain. It will however be left, without farther comment, for the reader to observe the accordance, and to make the application.

"*Humic acid and humin.*—In most chemical books the terms *ulmic acid* and *ulmin* are used, from *ulmus*, elm; but, as its substance occurs in most, if not all plants, the name is bad. I prefer Sprengel's terms, from *humus*, soil.

"This important substance was first discovered by Klaproth, in a sort of gum from an elm; but it has since been found by Berzelius in all barks; by M. Braconnot in saw-dust, starch, and sugar; and, what is still more interesting for our present purpose, it has been found by Sprengel and M. Polydore Boullay to constitute a leading principle in soils and manures. *Humin* appears to be formed of carbon and hydrogen, and the *humic acid* of humin and oxygen. Pure humin is of a deep blackish brown, without taste or smell, and water dissolves it with great difficulty and in small quantities; consequently it cannot, when pure, be available as food for plants.

"Humic acid however, which, I may remark, *is not sour to the taste*, readily combines with many of the substances found in soils and manures, and not only renders them, but itself also, easy to be dissolved in water, which in their separate state could not take place. In this way *humic acid will combine with lime, potass, and ammonia, in the form of humates, and the smallest portion of these will render it soluble in water and fit to be taken up by the spongelets of the root fibres.*

"It appears to have been from ignorance of the important action of the humic acid in thus helping to dissolve earthy matters, that the older writers were so puzzled to discover how lime and potass got into plants; and it seems also to be this, chiefly, which is so vaguely treated of in the older books, under the names of *extractive*, *vegetable extract*, *mucilginous matter*, and the like. Saussure, for instance, filled a vessel with turf, and moistened it thoroughly with pure water, when by putting ten thousand parts of it by weight under a heavy press, and filtering and evaporating the fluid, he obtained twenty-six parts of what he termed *extract*; from ten thousand parts of well dunged and rich kitchen garden mould, he obtained ten parts of *extract*; and from ten thousand parts of good corn field mould, he obtained four parts of *extract*.

"M. Polydore Boullay found that the liquid manure, drained from dung-hills, contains a large proportion of humic acid, which accounts for its fertilizing properties so well known in China and on the continent; and he found it also in peat earth, and in varying proportions in all sorts of turf. It appears probable, from Gay-Lussac having found a similar acid, (technically *azumic acid*.) on decomposing the prussic acid, (technically *hydrocyanic acid*.) that the humic acid may be found in animal blood, and if so, it will account for its utility as a manure for vines, &c. Dobereiner found the gallic acid convertible into the humic."

When the last edition of this essay was published, (in 1835.) the above annunciation had but just before been made, showing that there was indeed high scientific authority for the very general existence of a vegetable acid in soils. And since that time, the fact has been admitted by almost all scientific writers, and has been treated of at length in sundry chemical works and reports of geological surveys in this country. The doctrine of the existence of an acid of soil, of vegetable origin, which before had scarcely any other authority for its support than mine, humble and obscure as that was,

is now of universal acceptance. Still, notwithstanding all that has been written on the subject, very little light has been thrown on it by the chemists who have treated of it. Being myself too little informed to be able to properly digest these different speculations and to balance authorities, and to separate the true and valuable from the erroneous or worthless of what has been lately published, I deem it best still to rely on my own previously published views and proofs only, as presented in the foregoing pages. Therefore, leaving it to chemists to settle their present differences of opinion in regard to the qualities, and even identity, as well as name of the acid of soil, and to clear away the existing confusion and obscurity of their views, I will, for the present, adopt nothing on their authority in this respect. Still, I earnestly hope that their subsequent investigations may be successful in eliciting and determining what is true of this acid—and also in applying the truths ascertained to advance the knowledge of the composition and improvement of soils. For the same reason, I shall also decline adopting any of the various terms which have been successively applied by different, and even the same chemists, to designate the *acid of soil*; as *humic, geic, crenic and apocrenic acid*, &c.

But without the aid of this recent discovery of the humic or geic acid, if the foregoing examinations of soils, and the arguments which follow, remain unquestioned, these two remarkable and important facts may be considered as thereby established beyond dispute or doubt:

1st, 'That calcareous earth, or carbonate of lime, is in general as entirely deficient in the soils of Virginia, as that ingredient had heretofore been supposed, by agricultural writers, to be common in all soils; and,

2d, That, notwithstanding this total absence of the carbonate of lime, that lime in some other form of combination, and in greater or less quantity, is an ingredient of every soil capable of producing vegetation.

Nor do these facts come in conflict with each other; nor either of them with the position which has been contended for, that calcareous matter in proper proportions is necessary to cause fertility in soils. Should some other person, who may be aided by sufficient scientific light, undertake the investigation, he may supply all that is wanting for the direct proof of this theory of the cause of fertility, and perhaps show that the value of a soil (under equal circumstances) is in proportion to the quantity of the *vegetable salt of lime* present in the soil. The direct and positive proof of this doctrine, I confidently anticipate will hereafter be obtained from more full examinations of the humic acid, and its compounds in various soils, and from correct and minute reports of the quantities and kinds of those ingredients, in connexion with the degree of the natural fertility of each soil. As yet, however interesting the recent discovery of humic acid may be to chemists, it does not seem that they have suspected it to have anything like the important bearing on the fertilization of soil which I had attributed to the supposed acid principle or ingredient of soils. Berzelius seems scarcely to have bestowed a thought on this most important application of his investigation of the properties of *geine* and *geic acid*.

Supposing the doctrine to be sufficiently established by my own proofs offered above, it may be useful to trace the formation and increase of acidity in different soils, according to the views which have been presented, and to display the promise which that quality holds out for improving those soils which it has heretofore rendered barren and worthless.

Every neutral soil at some former time must have contained calcareous earth in sufficient quantity to produce the uniform effect of that ingredient of storing up and fixing fertility. The decomposition of the successive growths of plants, left to rot on the rich soil, continually formed vegetable acid, which,

as fast as formed, united with the lime in the soil. At last these two principles balanced each other, and the soil was no longer calcareous, but neutral. Instead of its former ingredient, *carbonate of lime*, it was now supplied with a *vegetable salt of lime*. This change of soil does not affect the natural growth, which remains the same, and thrives as well as when the soil was calcareous; and when brought into cultivation, the soil is equally productive under all crops suited to calcareous soils. If the supplies of vegetable matter continue, the soil may even become acid in some measure, as may be evidenced by the growth of sorrel—but without losing any of its fertility before acquired. The degree of acidity in any one soil frequently varies; it is increased by the growth of such plants as delight to feed on it, and by the decomposition of all vegetable matters. Hence the longer a poor field remains at rest, and not grazed, the more acid it becomes; and this evil keeping pace with the benefits derived, is the cause why so little improvement, or increased product, is obtained from putting acid soils under that mild treatment. Cultivation not only prevents new supplies, but also diminishes the acidity already present in excess, by exposing it to the atmosphere; and therefore the more a soil is exhausted, the more will its acidity be lessened.

We have seen from the proof furnished by the analysis of wood ashes, that even poor acid soils contain a little salt of lime, and therefore must have been slightly calcareous at some former time. But such small proportions of calcareous earth were soon equalled, and then exceeded, by the formation of vegetable acid, before much productiveness was caused. The soil being thus changed, the plants suitable to calcareous soils died off, and gave place to others which produce, as well as feed and thrive on, acidity. Still, however, even these plants furnish abundant supplies of vegetable matter, sufficient to enrich the land in the highest degree; but the antiseptic power of the acid prevents the leaves from rotting for years, and even then the soil has no power to profit by their products. Though continually wasted, the vegetable matter is continually again forming, and always present in abundance; but must remain almost useless to the soil, until the accompanying acidity shall be destroyed.

It may well be doubted whether any soil destitute of lime in every form would not necessarily be a perfect barren, incapable of producing a spire of grass. No soil thus destitute is known, as the plants of all soils show in their ashes the presence of some lime. But it is probable that our sub-soils, which, when left naked by the washing away of the soil, are so generally and totally barren, are made so by their being entirely destitute of lime in any form. There is a natural process regularly and at all times working to deprive the sub-soil of all lime, unless the soil is abundantly supplied. What constitutes soil, and makes the strong and plain mark of separation and distinction between the more or less fertile soil and the absolutely sterile sub-soil beneath? The most obvious cause for this difference which might be stated, is the dropping of the dead vegetable matter on the surface; but this is not sufficient alone to produce the effects, though it may be so when aided by another cause of more power. When the most barren surface earth was formed or deposited by any of the natural agents to which such effects are attributed by geologists, it seems reasonable to suppose that the surface was no richer than any lower part of the whole upper stratum so deposited. If, then, a very minute proportion of lime had been equally distributed through the body of poor earth to any depth that the roots of trees could penetrate, it would follow that the roots would, in the course of time, take up all the lime, as all of it would be wanting for the support of the trees; and their death and decay would afterwards leave

all this former ingredient of the soil in general, on the surface. This process must have the effect, in the course of time, of fixing on and near the surface the whole of a scanty supply of lime, and of leaving the sub-soil without any. But if there is within the reach of the roots more lime than any one crop or growth of plants needs, then the superfluous lime will be permitted to remain in the sub-soil, which sub-soil will then be improvable by vegetable substances, and readily convertible to productive soil. The manner in which lime thus operates will be explained in the next chapter.

Nearly all the wood-land now remaining in lower Virginia, and also much of the land which has long been arable, is rendered unproductive by acidity, and successive generations have toiled on such land, almost without remuneration, and without suspecting that their worst virgin land was then richer than their manured lots appear to be. The cultivator of such soil, who knows not its peculiar disease, has no other prospect than a gradual decrease of his always scanty crops. But if the evil is once understood, and the means of its removal is within his reach, he has reason to rejoice that his soil was so constituted as to be preserved from the effects of the improvidence of his forefathers, who would have worn out any land not almost indestructible. The presence of acid, by restraining the productive powers of the soil, has in a great measure saved it from exhaustion; and after a course of cropping which would have utterly ruined soils much better constituted, the powers of our acid land remain not greatly impaired, though dormant, and ready to be called into action by merely being relieved of its acid quality. A few crops will reduce a new acid field to so low a rate of product, that it scarcely will pay for its cultivation; but no great change is afterwards caused, by continuing scourging tillage and grazing, for fifty years longer. Thus our acid soils have two remarkable and opposite qualities, both proceeding from the same cause: they can neither be enriched by manure, nor impoverished by cultivation, to any great extent. Qualities so remarkable deserve all our powers of investigation; yet their very frequency seems to have caused them to be overlooked; and our writers on agriculture have continued to urge those who seek improvement to apply precepts drawn from English authors, to soils which are totally different from all those for which their instructions were intended.

CHAPTER VIII.

THE MODE OF OPERATION BY WHICH CALCAREOUS EARTH INCREASES THE FERTILITY AND PRODUCTIVENESS OF SOILS.

PROPOSITION 3. *The fertilizing effects of calcareous earth are chiefly produced by its power of neutralizing acids, and of combining putrescent manures with soils, between which there would otherwise be but little, if any, chemical attraction.*

PROPOSITION 4. *Poor and acid soils cannot be improved durably, or profitably, by putrescent manures, without previously making them calcareous, and thereby correcting the defect in their constitution.*

It has already been made evident that the presence of calcareous earth in a natural soil causes great and durable fertility. But it still remains to be determined, to what properties of this earth its peculiar fertilizing effects are to be attributed.

Chemistry has taught that silicious earth, in any state of division, attracts but slightly, if at all, any of the parts of putrescent animal and vegetable matters.* But even if any slight attraction really exists when this earth is minutely divided for experiment in the laboratory of the chemist, it cannot be exerted by silicious sand in the usual form in which nature gives it to soils; that is, in particles comparatively coarse, loose, and open, and yet each particle impenetrable to any liquid, or gaseous fluid, that might be passing through the vacancies. Hence, silicious earth can have no power, chemical or mechanical, either to attract enriching manures, or to preserve them when actually placed in contact and intermixed with them; and soils in which the qualities of this earth greatly predominate, must give out freely all enriching matters which they may have received, not only to a growing crop, but to the sun, air, and water, so as soon to lose the whole. No portion of putrescent matter can remain longer than the completion of its decomposition; and if not arrested during this process, by the roots of living plants, all will escape in the form of *gas* (the latest products of decomposition,) into the air, without leaving a trace of lasting improvement. With a knowledge of these properties, we need not resort to the common opinion that manure *sinks* through sandy soils, to account for its rapid and total disappearance.†

Aluminous earth, by its closeness, mechanically excludes those agents of decomposition, heat, air and moisture, which sand so freely admits; and therefore clay soils, in which this earth predominates, give out manure much more slowly than sand, whether for waste or for use. The practical effect of this is universally understood—that clay soils retain manure much longer than sand, but require much heavier applications to show as much effect early, or at once. But as this means of retaining manure is altogether mechanical, it serves only to delay both its use and its waste. Aluminous earth also exerts some chemical power in attracting and combining with putrescent manures, but too weakly to enable a clay soil to become rich by natural means. For though clays are able to exert more force than sand in holding manures, their closeness also acts to deny admittance beneath

* Davy's Agr. Chem. page 129.

† Except the very small proportions of earthy, saline and metallic matters that may be in animal and vegetable manures, the whole balance of their bulk (and the whole of whatever can feed plants,) is composed of different elements which are known only in the forms of *gases*—into which manures must be finally resolved, after going through all the various stages of fermentation and decomposition. So far from sinking in the earth, these final results could not be possibly confined there, but must escape into the atmosphere as soon as they take a gaseous form, unless immediately taken up by the organs of growing plants. It is probable that but a small portion of any dressing of manure remains long enough in the soil to make this final change; and that nearly all of it is used by growing plants, during previous changes, or carried off by air and water. During the progress of the many changes caused by fermentation and decomposition, every soluble product may certainly sink as low as the rains penetrate; but it cannot descend lower than the water, and that, together with the soluble manure, will be again drawn up by the roots of plants. One exception, however, seems probable. Should the soil need draining, to take off water passing beneath the surface, the soluble manure may be carried off by those springs; and this supposed result receives strong confirmation from the complete loss of fertility which is often observed in spots over sub-soil that is oozy in wet seasons, but which have been kept under tillage, without being drained. We are as yet but little informed as to the particular changes made, and the various new substances successively formed, and then decomposed, during the whole duration of putrescent manures in the soil—and no field for discovery would better reward the investigations of the agricultural chemist. For want of this knowledge we proceed at random in using manures, instead of being enabled to conform to any rule founded on scientific principles; nor can we hope, without such knowledge, so to manage manures with regard to their fermentation, the time and manner of application, mixing with other substances, &c., as to enable the crops to seize every enriching result as soon as it is produced, and to postpone as long as possible the final results of decomposition—which ought to be the ends sought in every application of putrescent manure.

the surface to the enriching matters furnished by the growth and decay of plants. And therefore, before being brought into cultivation, a poor clay soil would derive scarcely any benefit from its small power of combining chemically with putrescent matters. If then it is considered how small is the power of both silicious and aluminous earths to receive and retain putrescent manures, it will cease to cause surprise that such soils cannot be thus enriched, with profit, if at all. It would indeed be strange and unaccountable, if earths and soils thus constituted *could be* enriched by putrescent manures alone.

Davy states that both aluminous and calcareous earth will combine with any vegetable extract, so as to render it less soluble, (and consequently not subject to the waste that would otherwise take place,) and hence "that the soils which contain most alumina and carbonate of lime, are those which act with the greatest chemical energy in preserving manures." Here is high authority for calcareous earth possessing the power which my argument demands, but not in so great a degree as I think it deserves. Davy apparently places both earths in this respect on the same footing, and allows to aluminous soils retentive powers equal to the calcareous. But though he gives evidence (from chemical experiments) of this power in both earths, he does not seem to have investigated the difference of their forces. Nor could he deem it very important, holding the opinion which he elsewhere expresses, that calcareous earth acts "merely by forming a useful earthy ingredient in the soil," and consequently attributing to it no remarkable chemical effects as a manure. I shall offer some reasons for believing that the powers of attracting and retaining manure, possessed by these two earths, differ greatly in their degrees of force.

Our aluminous and calcareous soils, through the whole of their virgin state, have had equal means of receiving vegetable matter; and if their powers for retaining it were nearly equal, so would be their acquired fertility. Instead of this, while the calcareous soils have been raised to the highest condition, many of the tracts of clay soil remain the poorest and most worthless. It is true that the one labored under acidity, from which the other was free. But if we suppose nine-tenths of the vegetable matter to have been rendered useless by that poisonous quality, the remaining tenth, applied for so long a time, would have made fertile any soil that had the power to retain the enriching matter.

Many kinds of shells are partly composed of gelatinous animal matter, which, I suppose, must be chemically combined with the calcareous earth, and by that means only is preserved from the putrefaction and waste that would otherwise certainly and speedily take place. Indeed, the large proportion of animal matter which thus helps to constitute shells, instead of making them more perishable, serves to increase their firmness and solidity. When long exposure, as in fossil shells, has destroyed all animal matter, the texture of the calcareous substance is greatly weakened. A simple experiment will serve to separate, and make manifest to the eye, the animal matter which is thus combined with and preserved by the calcareous earth. If a fresh-water muscle-shell is kept for some days immersed in a weak mixture of muriatic acid and water, all the calcareous part will be gradually dissolved, leaving the animal matter so entire, as to appear still to be a whole shell—but which, when lifted from the fluid which supports it, will prove to be entirely a flaccid, gelatinous, and putrescent substance, without a particle of calcareous matter being left. Yet this substance, which is so highly putrescent when alone, would have been preserved in combination with calcareous matter, in the shell, for many years, if exposed to the usual changes of air and moisture; and if secured from such changes, would be almost imperishable.

Calcareous earth has power to preserve those animal matters which are most liable to waste, and which give to the sense of smell full evidence when they are escaping. Of this, a striking example is furnished by an experiment which was made with care and attention. The carcass of a cow, that was killed by accident in May, was laid on the surface of the earth, and covered with about seventy bushels of finely divided fossil shells and earth, (mostly silicious,) their proportions being as thirty-six of calcareous, to sixty-four of silicious earth. After the rains had settled the heap, it was only six inches thick over the highest part of the carcass. The process of putrefaction was so slow, that several weeks passed before it was over; nor was it ever so violent as to throw off any effluvia that the calcareous earth did not intercept in its escape, so that no offensive smell was ever perceived. In October, the whole heap was carried out and applied to one-sixth of an acre of wheat—and the effect produced far exceeded that of the calcareous manure alone, which was applied at the same rate on the surrounding land. No such power as this experiment indicated (and which I have since repeated in various modes, and always with like results) will be obtained, or expected from clay.

Quick-lime is used to prevent the escape of offensive effluvia from animal matter; but its operation is entirely different from that of calcareous earth. The former effects its object by "eating" or decomposing the animal substance, (and nearly destroying it as manure,) before putrefaction begins. The operation of calcareous earth is to moderate and retard, but not to prevent putrefaction; not to destroy the animal matter, but to preserve it effectually, by forming new combinations with the products of putrefaction. This important operation will be treated of more fully in a subsequent chapter.

The power of calcareous earth to combine with and retain putrescent manure, implies the power of fixing them in any soil to which both are applied. The same power will be equally exerted if the putrescent manure is applied to a soil which had previously been made calcareous, whether by nature, or by art. When a chemical combination is formed between the two kinds of manure, the one is necessarily as much fixed in the soil as the other. Neither air, sun or rain, can then waste the putrescent manure, because neither can take it from the calcareous earth, with which it is chemically combined. Nothing can effect the separation of the parts of this compound manure, except the attractive power of growing plants—which, as all experience shows, will draw their food from this combination as fast as they require it, and as easily as from sand. The means then by which calcareous earth acts as an improving manure are, *completely preserving putrescent manures from waste, and yielding them freely for use.* These particular benefits, however great they may be, cannot be seen very quickly after a soil is made calcareous, but will increase with time, and, with the means for obtaining vegetable matters, until their accumulation is equal to the soil's power of retention. The kind, or the source, of enriching manure, does not alter the process described. The natural growth of the soil, left to die and rot, or other putrescent manures collected and applied, would alike be seized by the calcareous earth, and fixed in the soil.

This, the most important and valuable operation of calcareous earth, then gives nothing to the soil; but only secures other manures, and gives *them* wholly to the soil. In this respect, the action of calcareous earth in fixing manures in soils, is precisely like that of *mordants* in "setting" or fixing colors on cloth. When alum, for example, is used by the dyer for this purpose, it adds not the slightest tinge of itself—but it holds to the cloth, and also to the otherwise fleeting dye, and thus fixes them per-

manently together. Without the mordant, the color might have been equally vivid, but would be lost by the first wetting of the cloth.

Thus, reasoning *a priori*, from that chemical power possessed by calcareous earth which is wanting to both sandy and clayey earths, would lead to the conclusion that calcareous earth serves to combine putrescent matters with the soil in general; and the known results of fertility being therein so fixed, might serve for the like proof, even without the other course of reasoning. There is still another proof of this combination being formed, which is obtained by a chemical process, but which is so simple that no chemical science is requisite to make the trial.

If a specimen of any naturally poor soil, after being dried and reduced to powder, be agitated in a vessel of water, (as a common drinking glass,) and then allowed to stand still, the coarser silicious sand will subside first, the finer sand next, and last the clay. In this manner, and by pouring off the lighter parts, before their subsidence, it is very easy to separate with sufficient accuracy the sand from the clay. But if a specimen of a good rich *neutral soil* be tried in that manner, it will be found that the fine sand and the clay and putrescent matter hold together so closely that they cannot be separated by mere agitation in water. Then take another sample of the same soil, and pour to it a small quantity of diluted muriatic acid; and though no effervescence is produced, (the lime not being in the form of carbonate,) the acid will take away the lime, or destroy its combination with the other earths, so that the sand and the clay may then be separated by agitation in water, as perfectly and easily as in the case of the poorest soils. This difference between good and bad soils, (whether light or stiff,) or those naturally rich and those naturally poor, cannot escape the observation of the young experimenter; and the cause can be no other than what I have supposed. This then serves as the third mode of proof of the important position, that calcareous earth (or lime in some other form) not only combines with vegetable and animal matters, but also serves (as a connecting link) to combine these matters with the sand and clay of the soil.

The next most valuable property of calcareous manures for the improvement of soil is their *power of neutralizing acids*, which has already been incidentally brought forward in the preceding chapter. According to the views already presented, our poorest cultivated soils contain more vegetable matter than they can beneficially use; and when first cleared, they have it in great excess. So antiseptic is the acid quality of poor wood-land, that before the crop of leaves of one year can entirely rot, two or three others will have fallen; and there are always enough, at any one time, to greatly enrich the soil, if the leaves could be rotted and fixed in it at once.

This alleged antiseptic effect of vegetable acid in our soils receives strong support from the facts established with regard to *peat soils*, in which vegetable acids have been discovered by chemical analysis; and though the peat or moss soils of Britain differ entirely from any soils in eastern Virginia, (except that of the great Dismal Swamp, almost the only peat bog known,) still some facts relating to the former class may throw light on the properties of our own soils, different as they may be. Not only does vegetable matter remain without putrefaction in peat soils and bogs, and serve to increase their depth by regular accretions from the successive annual growths, but even the bodies of beasts and men have been found unchanged under peat, many years after they had been covered.* It is well known that the leaves of trees rot very quickly on the rich lime-stone soils of the western

* See Aiton's Essay on Moss Earth, republished in Farmers' Register, vol. v., p. 462.

states, while the successive crops of several years' growth, in the different stages of their slow decomposition, may be always found on the acid woodland of lower Virginia.

The presence of acid in soils, by preventing or retarding putrefaction, keeps the vegetable matter inert, and even hurtful on cultivated land; and the crops are still further injured by taking up this poisonous acid with their nutriment. A sufficient quantity of calcareous earth, mixed with such a soil, will immediately neutralize the acid, and destroy its powers; and the soil, released from its baneful influence, will be rendered capable, for the first time, of using the fertility which it really possessed. The benefit thus produced is almost immediate; but though the soil will show a new vigor in its earliest vegetation, and may even double its first crop, yet no part of that increased product is due to the direct operation of the calcareous manure, but merely to the removal of acidity. The calcareous earth, in such a case, has not made the soil richer in the slightest degree, but has merely permitted it to bring into use the fertility it had before, and which was concealed by the acid character of the soil. It will be a dangerous error for the farmer to suppose that calcareous earth can enrich soil by direct means. It destroys the worst foe of productiveness, and uses to the greatest advantage the fertilizing powers of other manures; but of itself it gives no fertility to soils, nor does it furnish the least food to growing plants.*

These two kinds of action are by far the most powerful of the means possessed by calcareous earth for fertilizing soils. It has another however of great importance—or rather two others, which may be best described together as the *power of altering the texture and absorbency of soils*.

At first it may seem impossible that the same manure can produce such opposite effects on soils as to lessen the faults of being either too sandy or too clayey—and the evils occasioned by both the want and the excess of moisture. Contradictory as this may appear, it is strictly true as to calcareous earth. In common with clay, calcareous earth possesses the power of making sandy soils more close and firm—and in common with sand, the power of making clay soils lighter. When sand and clay thus alter the textures of soils, their operation is altogether mechanical; but calcareous earth must have some chemical action also in producing such effects, as its power is far greater than that of either sand or clay. A very great quantity of clay would be required to stiffen a sandy soil perceptibly, and still more sand would be necessary to make a clay soil much lighter—so that the cost of such improvement would generally exceed the

* Perhaps it may be considered that there are exceptions to the above doctrine in the well established fact that certain plants will not grow well, if at all, in soils containing so little lime as to be classed as acid soils, no matter how rich they may be made for the time by putrescent manures. Among trees, locust, papaw, and hackberry have been already named as plants of this kind; and red clover is as remarkable among grasses for requiring lime in the soil. Sainfoin is still more remarkable, and cannot be produced to profit, even if it will live, except on a highly calcareous soil. Lime then is certainly a *specific manure* for these plants; that is, lime promotes their growth in a remarkable and peculiar degree, and they can scarcely live without a considerable quantity in the soil. Still it may be doubted whether it is that they require the lime *as food*, or for some other unknown purpose, no less indispensable. Except as to sainfoin, (of which I have no practical experience,) a moderate proportion of lime in a soil, such as will merely make it neutral, seems to add as much vigor to the growth of the plants named, as if it be given in ten-fold quantity. This would seem to contradict the supposition of the lime serving as food, though it may be as indispensable to these plants as is their food. It is certain that dung, or other rotten vegetable matter, acts as food to all crops which it benefits; and therefore it is, that, in every case of its use and benefit, a large quantity will always produce effects perceptibly better than a small quantity.

benefit obtained. Much greater effects on the texture of soils are derived from much less quantities of calcareous earth, besides obtaining the more valuable operation of its other powers.

Every substance that is open enough for air to enter, and the particles of which are not absolutely impenetrable, must absorb moisture from the atmosphere. Aluminous earth, reduced to an impalpable powder, has strong absorbing powers. But this is not the form in which such soils can act—and a close and solid clay will scarcely admit the passage of air or water, and therefore cannot absorb much moisture except by its surface. Through sandy soils, the air passes freely; but most of its particles are impenetrable by moisture, and therefore these soils are also extremely deficient in absorbent power. Calcareous earth, by rendering clay more open to the entrance of air, and closing partially the too open pores of sandy soils, increases the absorbent powers of both. To increase that power in any soil, is to enable it to draw supplies of moisture from the air, in the driest weather, and to resist more strongly the waste by evaporation of light rains. A calcareous soil will so quickly absorb a hasty shower of rain as to appear to have received less than adjoining land of different character; and yet if observed in summer, when under tillage, some days after a rain, and when other adjacent land appears dry on the surface, the part made calcareous will still show the moisture to be yet remaining, by its darker color. All the effects from this power of calcareous manures may be observed within a few years after their application—though none of them so strongly marked, as they are on lands made calcareous by nature, and in which time has aided and perfected the operation. These soils present great variety in their proportions of sand and clay; yet the most clayey is friable enough, and the most sandy firm and close enough, to be considered soils of good texture; and they resist the extremes of both wet and dry seasons, better than any other soils whatever. Time, and the increase of vegetable matter, will bring those qualities to the same perfection in soils made calcareous by artificial means, as they are in soils made calcareous by nature.

The subsequent gradual accumulation of vegetable or other putrescent matter in the soil, by the combining or fixing power of calcareous earth, must have yet another beneficial effect on vegetation. The soil is thereby made darker in color, and it consequently is made warmer, by more freely absorbing the rays of the sun.

Additional and practical proofs of all the powers of calcareous earth will be furnished, when its use and effects as manure will be stated. I am persuaded, however, that enough has already been said both to establish and account for the different capacities of soils for improvement by putrescent manures. If the power of fixing manures in soils has been correctly ascribed to calcareous earth, that alone is enough to show that soils containing that ingredient, in sufficient quantity, must become rich; and that aluminous and silicious earths mixed in any proportions, and even with vegetable or other putrescent matter added, can never form other than a sterile soil.

CHAPTER IX.

ACTION OF CAUSTIC LIME AS MANURE. CLASSIFICATION OF MANURES.

The object of this essay is to treat only of calcareous earth (as before defined) as a manure, and not of pure lime, nor of manures in general. Still the nature of that which is properly my subject is so intimately connected with some other kinds of manures, and is so liable to be confounded with others which act very differently, that frequent references to both classes have been and will be again necessary. To make such references more plain and useful, some general remarks and opinions will now be submitted, as to the peculiar modes of the operation of various manures, and particularly of lime.

Until now I have been careful to say as little as possible of *pure* or *quick lime*, for fear of my meaning being mistaken, from the usual practice of confounding it with calcareous earth; or of considering both its first and later operations as belonging to one and the same manure. The connexion between the manures is so intimate, and yet their actions so distinct, that it is necessary to mark the points of resemblance as well as those of difference.

My own use of quick or caustic lime as a manure has not extended beyond a few acres; and I do not pretend to know any thing from experience of its first or caustic effects. But Davy's simple and beautiful theory of its operation carries conviction with it, and in accordance with his opinions I shall state the theory, and thence attempt to deduce its proper practical use.

By a sufficient degree of heat, the carbonic acid is driven off from shells, lime-stone, or chalk, and the remainder is pure or caustic lime. In this state it has a powerful decomposing power on all putrescent animal and vegetable matters, which it exerts on every such substance in the soils to which it is applied as manure. If the lime thus meets with solid and inert vegetable matters, it hastens their decomposition, renders them soluble, and brings them into use and action as manure. But such vegetable and animal matters as were already decomposed, and fit to support growing plants, are injured by the addition of lime; as the chemical action which takes place between these bodies forms different compounds, which are always less valuable than the putrid or soluble matters were, before being acted on by the lime.*

This theory will direct us to expect profit from applying caustic lime to all soils containing much unrotted and inert vegetable matter, as our acid wood-land when first cleared, and perhaps worn fields, covered with broom-grass; and to avoid the application of lime, or (what is the same thing) to destroy previously its caustic quality by exposure to the air, for all good soils containing soluble vegetable or animal matters, and on all poor soils deficient in inert, as well as in active nourishment for plants. The warmth of our climate so much aids the fermentation of all putrescent matters in soils, that it can seldom be required to hasten it by artificial means. To check its rapidity is much more necessary, to avoid the waste of manures in our lands. But in England, and still more in Scotland, the case is very different. There, the coldness and moisture of the climate greatly retard the fermentation of the vegetable matter that falls on the land; so much so that, in certain situations, the most favorable to such results, the vegetable cover is

* Davy's Agr. Chem. Lect. vii.

increased by the deposit of every successive year, and forms those vegetable soils which are called *moor*, *peat*, and *bog* lands. Vegetable matter abounds in these soils, and sometimes it even forms the greater bulk for many feet in depth; but it is inert, insoluble, and useless, and the soil is unable to bring any useful crop, though containing vegetable matter in such great excess. Many millions of acres in Britain are of the different grades of peat soils, of which almost none exist in the eastern half of Virginia. Upon this ground of the difference of climate, and its effects on fermentation, I deduce the opinion that *caustic lime* would be serviceable much more generally in Britain than here; and indeed that there are very few cases in which the caustic quality would not do our arable lands more harm than good. This is no contradiction to the great improvements which have been made on many farms by applying lime; for its caustic quality was seldom allowed to act at all. Lime is continually changing to the carbonate of lime; and, in practice, no exact line of separation can be drawn between the transient effects of the one, and the later, but durable improvement from the other. Lime powerfully attracts the carbonic acid of which it was deprived by heat, and that acid is universally diffused through the atmosphere (though in a very small proportion,) and is produced by every decomposing putrescent substance. Consequently, caustic lime, when on land, is continually absorbing and combining with this acid; and, with more or less rapidity, according to the manner of its application, is returning to its former state of mild calcareous earth. If spread as a top-dressing on grass lands—or on ploughed land, and superficially mixed with the soil by harrowing—or used in composts with fermenting vegetable matter—the lime is probably completely carbonated, before its causticity can act on the soil. In no case can lime, applied properly as manure, long remain caustic in the soil. Thus most applications of *lime* are, in effect, simply applications of *calcareous earth* but acting with greater energy and power at first, in proportion to its quantity, because more finely divided, and more equally distributed.

Some account of the mode of using burnt lime in lower Virginia by many farmers who cannot as well avail themselves of cheaper means to render their lands calcareous, and the effects produced, will be given in a subsequent part of this essay.

By adopting the views which have been presented of the action of calcareous earth, and of lime, as manures, and those which are generally received as to the modes of operation of other manures, the following table has been constructed, which may be found useful, though necessarily imperfect, and in part founded only on conjecture. The various particular kinds of manures are arranged in the supposed order of their power, under the several heads or characters to which they belong; and when one manure possesses several different modes of action, the comparative force of each is represented by the letters annexed—the letter *a* designating its strongest or most valuable agency, *b* the next strongest, and so on as to *c* and *d*.

PROPOSED CLASSIFICATION OF MANURES.

Substances which act as manures are either

<i>Alimentary</i> , or serving as food for plants—as	{ Feathers, hair, woollen rags, Pounded bones, (b) All putrescent animal and vegetable substances, as dung, Stable and farm-yard manures, (a) Straw, (a) Green crops ploughed in, and dead grass and weeds left on the surface. (a)
<i>Solvent</i> of alimentary manures—as	{ Quick-lime, (a) Potash and soap lie? (a) Wood ashes not drawn? (d) Paring and burning the surface of the soil. (a)
<i>Fixers, or Mordants</i> —serving to combine with or set other manures in soils—as	{ Calcareous earth, including Lime become mild by exposure, (a) Chalk, (a) Lime-stone gravel, (a) Wood ashes, (b) Fossil shells, (or shell marl,) (a) Marl (a calcareous clay,) (a) Old mortar and lime cements.
<i>Neutralizing acids</i> —as	{ All calcareous manures, (b) Quick-lime, (b) Potash and soap lie, (b) Wood ashes. (c)
<i>Mechanical</i> , or improving by altering the texture of soil—as	{ All calcareous manures, (c) Marl, (b) Clay, Sand, Fermenting vegetable manures, (b) Green manures, (b) Unfermented litter. (b)
<i>Stimulating</i> —as	{ Nitre? Common salt? (b)
<i>Specific</i> , or furnishing ingredients necessary for particular plants—as	{ Sulphate of lime, or gypsum, (for clover,) Gypseous earth, (or green-sand earth,) for clover. Calcareous manures (for clover) Phosphate of lime, (for wheat) in Bones, (a) and Drawn ashes, (a) Salt, for asparagus. (a)

AN
ESSAY
ON
CALCAREOUS MANURES.

PART SECOND—PRACTICE.

CHAPTER I.

INTRODUCTORY AND GENERAL OBSERVATIONS ON MARL AND LIME. REMARKS ON THE EXPERIMENTS TO FOLLOW.

PROPOSITION 5. *Calcareous manures will give to our worst soils a power of retaining putrescent manures, equal to that of the best—and will cause more productiveness, and yield more profit, than any other improvement practicable in lower Virginia.*

THE theory of the constitution of fertile and barren soils, has now been regularly discussed. It remains to show its practical application, in the use of calcareous earth as a manure. If the opinions which have been maintained are unsound, the attempt to reduce them to practice will surely expose their futility; and if they pass through that trial, agreeing with and confirmed by facts, their truth and value must stand on impregnable ground. The belief in the most important of these opinions, (the incapacity of poor soils for improvement, and its cause,) first directed the commencement of my use of calcareous manures; and the manner of my practice has also been directed entirely by the views which have been exhibited. Yet in every respect the results of practice have sustained the theory of the action of calcareous manures; unless indeed there be claimed as exceptions the injuries which have been caused by applying too heavy dressings to weak lands; and also the beneficial effects of proper practice being found to exceed in degree what the theory seemed to promise.

My use of calcareous earth as manure has been almost entirely confined to that form of it which is so abundant in the neighborhood of our tide-waters—the beds of *fossil shells*, together with the earth with which they are found mixed. The shells are in various states—in some beds generally whole, and in others reduced nearly to a coarse powder. The earth which fills their vacancies, and serves to make the whole a compact mass, in most cases is principally silicious sand, and contains no putrescent or valuable matter, other than the calcareous.* The same effects might be expected from calcareous earth in any other form, whether chalk, lime-stone gravel,

* From later observation I have formed the opinion that the coloring matter of blue marls is vegetable extract, chemically combined with the calcareous matter, of which opinion the grounds will be stated hereafter. But still the amount of this vegetable admixture is too small to have much appreciable effect as food for plants; and, practically, the general position assumed above may yet be considered as altogether true.

wood ashes, or lime—though the two last have other qualities besides the calcareous. During the short time that lime can remain *quick* or *caustic*, after being applied as manure, it exerts (as before stated) a solvent power, sometimes beneficial and at others hurtful, which has no connexion with its subsequent and permanent action as calcareous earth.

These natural depositories of fossil shells are commonly, but very improperly, called *marl*. This misapplied term is particularly objectionable, because it induces erroneous views of this manure. Other earthy manures have long been used in England under the name of marl, and numerous publications have described their general effects, and recommended their use. When the same name is given here to a different manure, many persons will consider both operations as similar, and perhaps may refer to English authorities for the purpose of testing the truth of my opinions, and the results of my practice. But no two operations called by the same name can well differ more. The process which it is my object to recommend, is simply *the application of calcareous earth in any form whatever, to soils wanting that ingredient*, and generally being quite destitute of it; and the propriety of the application depends entirely on the knowing that the manure contains calcareous earth, and what proportion, and that the soil contains none. In England, the most scientific agriculturists apply the term *marl* correctly to a *calcareous clay* of peculiar texture; but most authors, as well as mere cultivators, have used it for any smooth soapy clay, which may or may not have contained, so far as they knew, any proportion whatever of calcareous matter. Indeed, in most cases, they seem unconscious of the presence as well as of the importance of that ingredient, by their not alluding to it when attempting most carefully to point out the characters by which marl may be known. Still less do they inquire into the deficiency of calcareous earth in soils proposed to be marled—but apply any earth which either science or ignorance may have called *marl*, to any soils within a convenient distance—and rely upon the subsequent effects to direct whether the operation shall be continued or abandoned. Authors of the highest character, (as Sinclair and Young, for example,) when telling of the practical use and valuable effects of marl, omit giving the strength of the manure, and generally even its nature—and in no instance have I found the ingredients of the soil stated, so that the reader might learn what kind of operation really was described, or be enabled to form a judgment of its propriety. From all this, it follows that though what is called *marling* in England may sometimes (though very rarely, as I infer,) be the same chemical operation on the soil that I am recommending, yet it may also be either applying clay to sand, or clay to chalk, or true marl to either of those soils; and the reader will generally be left to guess, in every separate case, which of all these operations is meant by the term *marling*. For these reasons, the practical knowledge to be gathered from all this mass of written instruction on marling will be far less abundant than the inevitable errors and mistakes. The recommendations of marl by English authors, induced me very early to look to what was here called by the same name, as a means for improvement. But their descriptions of the manure convinced me that our marl was nothing like theirs, and thus actually deterred me from using it, until other and more correct views instructed me that its value did not depend on its having “a soapy feel,” or on any admixture of clay whatever.

Nevertheless, much valuable information may be obtained from these same works, on calcareous manure, or on marl, (in the sense that term is used among us)—but under a different head, viz., *lime*. This manure is generally treated of with as little clearness or correctness, as is done with marl;

but the reader at least cannot be mistaken in this, that the ultimate effect of every application of lime must be to make the soil more calcareous; and to that cause solely are to be imputed all the long-continued beneficial consequences, and great profits, which have been derived from liming. But excepting this one point, in which we cannot be misled by ignorance or want of precision, the mass of writings on lime, as well as on calcareous manures in general, will need much sifting to yield instruction. The opinions published on the operation of lime are so many, so various, and so contradictory, that it seems as if each author had hazarded a guess, and added it to a compilation of those of all who had preceded him. For a reader of these publications to be able to reject all that is erroneous in reasoning, and in statements of facts—or inapplicable, on account of difference of soil, or other circumstances—and thus obtain only what is true, and useful—it would be necessary for him first to understand the subject better than most of those whose opinions he was studying. Indeed it was not possible for them to be correct, when treating (as most do) of *lime* as one kind of manure, and every different form of the *carbonate of lime* as so many others. Only one distinction of this kind (as to operation and effects) should be made, and never lost sight of—and that is one of substance, still more than of name. Pure or quick-lime, and carbonate of lime are manures entirely different in their powers and effects. But it should be remembered that the substance that was *pure lime* when just burned, often becomes *carbonate of lime* before it is used, (by absorbing carbonic acid from the atmosphere,)—still more frequently before a crop is planted—and probably always before the first crop ripens. Thus, it should be borne in mind that the manure spoken of as lime is often at first, and always at a later period, neither more nor less than calcareous earth; that lime, which at different periods is two distinct kinds of manure, is considered in agricultural treatises as only one; and to calcareous earth are given as many different names, all considered to have different values and effects, as there are different forms and mixtures of the substance presented by nature.

But, however incorrect and inconvenient the term *marl* may be, custom has too strongly fixed its application for any proposed change to be adopted. Therefore, I must submit to use the word *marl* to mean beds of *fossil shells*, notwithstanding my protest against the propriety of its being so applied.

The following experiments are reported, either on account of having been accurately made and carefully observed, or as presenting such results as have been generally obtained on similar soils, from applications of fossil shells to nearly six hundred acres of Coggins Point farm (made before 1830.) It had been my habit to make written memoranda of such things; and the material circumstances of these experiments were put in writing at the time they occurred, or not long after. Some of the experiments were, from their commencement, designed to be permanent, and their results to be measured as long as circumstances might permit. These were made with the utmost care. But generally, when precise amounts are not stated, the experiments were less carefully made, and their results reported by guess. Every measurement stated, of land or of crop, was made in my presence. The average strength of the different marls used was ascertained by a sufficient number of analyses; and the quantity applied was known by measuring some of the loads, and having them dropped at regular distances. At the risk of being tedious, I shall state every circumstance supposed to affect the results of the experiments; and the manner of description, and of reference, necessary to use, will require a degree of attention that few readers may be disposed to give, to enable them to derive the full

benefit of these details. But, however disagreeable it may be to give to them the necessary attention, I will presume to say that these experiments deserve it. They will present practical proofs of what otherwise would be but uncertain theory—and give to this essay its principal claim to be considered truly instructive and useful.

When these operations were commenced, I knew of no other experiments having been made with fossil shells, except two, which had been tried long before, and were considered as proving the manure to be too worthless to be resorted to again.

The earliest of these old experiments was made at Spring Garden, in Surry, about 1775, by Mr. Wm. Short, proprietor of that estate. The extent marled was eight or ten acres, on poor sandy land. Nothing is now known of the effects for the first twenty-five or thirty years, except that they were too inconsiderable to induce a repetition of the experiment. The system of cultivation was doubtless as exhausting as usual at that time. Since 1812, the farm has been under mild and improving management generally. No care has been taken to observe the progress either of improvement or exhaustion on the marled piece; but there is no doubt that the product has continued for the last fifteen years better than that of the adjacent land. Mr. Francis Ruffin, the present owner of the farm, believed that the product was not much increased in favorable seasons: but when the other land suffered, either from too much wet, or dry weather, the crop on the marled land was comparatively but slightly injured. The loose reports that have been obtained respecting this experiment are at least conclusive in showing the long duration of the effects produced.

The other old experiment referred to was made at Aberdeen, Prince George county, in 1803, by Mr. Thomas Cocke. Three small spots (neither exceeding thirty yards square,) of poor land, kept before and since generally under exhausting culture, were covered with this manure. He found a very inconsiderable early improvement, which he thought altogether an inadequate reward for the labor of applying the marl. The experiment, being deemed of no value, was but little noticed until after the commencement of my use of the same manure. On examination, the improvement appeared to have increased greatly on two of the pieces, but the third was evidently the worse for the application. For a number of years after making this experiment, Mr. Cocke considered it as giving full proof of the worthlessness of the manure. But more correct views of its mode of operation, induced by my experiments and reasoning, induced him to recommence its use; and no one has met with more success, or produced more valuable early improvement.

Inexperience, and the total want of any practical guide, caused my applications, for the first few years, to be frequently injudicious, particularly as to the quantities laid on. For this reason, these experiments will show what was actually done, and the effects thence derived, and not what better information would have directed as the most profitable course.

The measurements of corn that will be reported were all made at the time and place of gathering. The measure used for all except very small quantities was a barrel, holding five bushels when filled level, and which being filled twice with ears of corn, well shaken to settle them, and heaped, was estimated to make five bushels of grain; and the products will be reported in *grain*, according to this estimate. This mode of measurement will best serve for comparing results; but in most cases it is far from giving correctly the actual quantity of dry and sound grain, for the following reasons. The common large soft-grained white corn was the kind cultivated, which was always cut down for sowing wheat before the best

matured was dry enough to grind, or even to be stored for keeping; and when the ears from the poorest land were in a state to lose considerably more by shrinking. Yet, for fear of some mistake occurring if measurements were delayed until the crop was gathered, these experiments were measured when the land was ploughed for wheat in October. The subsequent loss from shrinking would of course be greatest on the corn from the poorest and most backward land, as the most defective and unripe ears would always be there found. Besides, every ear, however imperfect or rotten, was included in the measurement. For these several reasons, the actual increase of product on the marled land was always greater than will appear from the comparison of quantities measured; and from the statements of all such early measurements, there ought to be allowed a deduction, varying from 10 or 15 per cent. on the best and most forward corn, to 30 or 35 per cent. on the latest and most defective. Having stated the grounds of this estimate, practical men can draw such conclusions as their experience may direct, from the dates and amounts of the actual measurements that will be reported. Some careful trials of the amount of shrinkage in particular experiments will be hereafter stated.

No grazing had been permitted on any land from which experiments will be reported, since 1814, (or since being cleared, if in forest at that time,) unless the contrary shall be specially stated. The cropping had also been mild, during that time, though previously it was the usual exhausting three-shift and grazing course.

CHAPTER II.

EFFECTS OF CALCAREOUS MANURES ON ACID SANDY SOILS, NEWLY CLEARED.

Proposition 5—continued.

As most of the experiments on new land were made on a single piece of twenty-six acres, a general description or plan of the whole will enable me to be better understood, as well as to be more concise, by references being made to the annexed figure. It forms part of the ridge or high table land lying between James river and the nearest stream running into Powell's creek. The surface is nearly level, but slightly undulating. The soil in its natural state very similar throughout, but the part next to the line B C

somewhat more sandy, and more productive in corn, than the part next to A D; and, in like manner, it is lighter along A e, than nearer to D f. The whole soil, a gray sandy acid loam, not more than two inches deep at first, resting on a yellowish sandy sub-soil, from one to two feet deep, when it changes to clay. Natural growth mostly pine—next in quantity, oaks of different kinds—a little of dogwood and chinquapin—whortleberry bushes throughout in plenty. The quality of the soil better than the average of ridge lands in general, but yet quite poor. Judging from experience of adjoining grounds and similar soil, this land would have produced as its early and best crop, and under the best treatment, about 12 bushels of corn to the acre, well ripened and fully shrunk. And if thereafter kept under ordinary culture and management, the products would have gradually and speedily sunk to 5 bushels to the acre. Being still less suitable to wheat, that crop would have been scarcely worth being sown on the land in its best natural state, (when the product might be 6 bushels,) and certainly not at all after a few years of the usual downward progress. The effects of putrescent manures were very transient, as on all such poor lands.

Experiment 1.

The part B C g h, about eleven acres, grubbed and the trees cut down in the winter of 1814-15—suffered to lie three years with most of the wood and brush on it. February, 1818, my earliest application of marl was made on the smaller part B C m l, about $2\frac{1}{2}$ acres. Marl, containing 33 per cent. of pure calcareous earth, and the balance silicious sand, except a very small proportion of clay; the shelly matter finely divided. Quantity of marl to the acre, one hundred and twenty-five to two hundred heaped bushels. The whole space B C g h coultured, and planted in its first crop of corn in 1818. This was my earliest experiment of calcareous manures.

Results. 1818. The corn on the marled land evidently much better—supposed difference, forty per cent.

1819. In wheat. The difference as great, perhaps more so—particularly to be remarked from the commencement to the end of the winter, by the marled part preserving a green color, while the remainder was seldom visible from a short distance, and in the spring stood much thinner, from the greater number of plants killed during the winter. The line of separation very perceptible throughout both crops.

1820. At rest. During the summer marled all B C g h, at the rate of five hundred bushels, without excepting the space before covered, and a small part of that made as heavy as one thousand bushels, counting both dressings. The shells now generally coarse—average strength of the marl, 37 per cent. of calcareous earth. In the winter after, ploughed three inches deep only, as nearly as could be; which however, shallow as it was, made the whole new surface yellow, by bringing the barren sub-soil of yellow sand to the top. One of my neighbors, an intelligent and experienced farmer, who saw the land when in this state, pronounced that I “had ruined the land for ever, by ploughing and turning the soil too deep.”

Results continued, 1821. In corn. The whole a remarkable growth for such a soil. The oldest (and heaviest) marled piece better than the other, but not enough so to show the dividing line. The average product of the whole supposed to have been fully twenty-five bushels of ripe and good corn to the acre.

1822. In wheat—and red clover sowed on all the old marling, and one or two acres adjoining. A severe drought in June killed the greater part

of the clover, but left it much the thickest on the oldest marled piece, so as again to show the dividing line, and to yield, in 1823, two middling crops to the scythe—the first that I had known obtained from any acid soil, without high improvement from putrescent manures.

1823. At rest—nothing taken off, except the clover on *B C m l*.

1824. In corn—product seemed as before, and its rate may be inferred from the actual measurements on other parts, which will be stated in the next experiment, the whole twenty-six acres being now cleared, and brought under like cultivation.

Experiment 2.

The part *e f n o*, cleared and cultivated in corn at the same times as the preceding—but treated differently in some other respects. This had been deprived of nearly all its wood, and the brush burnt, at the time of cutting down—and its first crop of corn (1818) being very inferior, was not followed by wheat in 1819, because promising too little product to pay for the cost of the crop. This gave two years of rest before the crop of 1821—and five years rest out of six, since the piece had been cut down. As before stated, the soil rather lighter on the side next to *o e*, than *n f*.

March, 1821. A measured acre near the middle, covered with six hundred bushels of calcareous sand, containing 20 per cent. of calcareous earth, the upper layer of another body of fossil shells.

Results. 1821. In corn. October—the four adjoining quarter acres, marked 1, 2, 3, 4, extending nearly across the piece, two of them within, and two without the marled part, measured as follows:

Not marled, No. 1,	$6\frac{1}{8}$	} average to the acre $22\frac{1}{2}$ bushels of grain.
Do. No. 4,	$5\frac{1}{8}$	
Marled, No. 2,	$8\frac{1}{2}$	} average $33\frac{1}{4}$ bushels.
Do. No. 3,	$8\frac{1}{8}$	

The remainder of this piece was marled before sowing wheat in 1821.

1823. At rest.

1824. In corn—distance $5\frac{1}{2}$ by $3\frac{1}{4}$ feet, making 2436 stalks to the acre. October 11th, measured two quarter acres very nearly coinciding with Nos. 2 and 3 in the last measurement. The products now were as follows:

No 2 brought 7 bushels $3\frac{1}{4}$ pecks,	} average 31.2½
or per acre, - - - 31.1	
No 3 brought 8 bushels, - - 32	
Average in 1821, - - - - 33.1	

Experiment 3.

The part *e f g h* was cut down in January, 1821, and the land planted in corn the same year. The coulturing and after-tillage very badly executed, on account of the number of whortleberry and other roots. As much as was convenient was marled at six hundred bushels, 37 per cent. and the dressing limited by a straight line. Distance of corn $5\frac{1}{2}$ by $3\frac{1}{4}$ feet—2262 stalks to the acre.

Results. 1821. October—on each side of the dividing line, a piece of twenty-eight by twenty-one corn hills measured as follows:

No. 1, 588 stalks, not marled, 2 bushels, equal to 7 bushels 3 pecks the acre.
No. 2, 588 stalks, marled, $4\frac{1}{4}$ 16 bushels $2\frac{1}{2}$ pecks.

1822. In wheat, the remainder having been previously marled.

1823. At rest. During the following winter it was covered with a second dressing of marl at 250 bushels, 45 per cent., making 850 bushels to the acre altogether.

1824. In corn. Two quarter acres, chosen as nearly as possible on the same spaces that were measured in 1821, produced as follows:

No. 1 made 8 bushels, 2 pecks, or to the acre, 34 bushels.
The same in 1821, before marling, 7.3 $\frac{1}{4}$

Increase, - - - - - 26.0 $\frac{3}{4}$

No. 2 made 7 bushels, 2 $\frac{1}{2}$ pecks, or to the acre, 30.2
The same in 1821, after marling, 16.2 $\frac{1}{2}$

Increase average, - - - - - 13.3 $\frac{1}{2}$

The second dressing of marl, or the larger quantity, had but little effect in making the increase of crops greater than in 1821. The difference was caused mainly by the greater length of time since the clearing of the land.

1825. The whole twenty-six acres, including the subjects of all these experiments and observations, were in wheat. The first marled piece, in Exp. 1, was decidedly the best—and a gradual decline was to be seen to the latest. I have never measured the product of wheat from any experiment, on account of the great trouble and difficulty that would be encountered. Even if the wheat from small measured spaces could be reaped and secured separately, during the urgent labors of harvest, it would be scarcely possible afterwards to carry the different parcels through all the operations necessary to show exactly the clean grain derived from each. But without any separate measurement, all my observations convince me that the increase of wheat, from marling, was at least equal to that of corn, during the first few years, and certainly greater afterwards, in comparison to the product before using marl.

It was from the heaviest marled part of Exp. 1, that soil was analyzed to find how much calcareous earth remained in 1826, (page 50.) Before that time the marl and soil had been well mixed by ploughing to the depth of five inches. One of the specimens of this soil then examined consisted of the following parts—half an inch of the surface, and consequently the undecomposed weeds upon it, being excluded.

1000 grains of soil yielded

769 grains of silicious sand moderately fine,
15 finer sand,

784

8

calcareous earth, from the manure applied,
180 finely divided gray clay, vegetable matter, &c.
28 lost in the process.

1000

This part, it has been already stated, was originally somewhat lighter than the general texture of the remainder of the land.

Experiment 4.

The four acres marked A D n o were cleared in the winter of 1823–4. The lines *p q* and *r s* divide the piece nearly into quarters. The end nearest A *p o* is lighter, and best for corn, and was still better for the first crop, owing to nearly all that half having been accidentally burnt over. After twice coultering, marl and putrescent manures were applied as follows; and the products measured, October 11th, the same year.

s q not marled nor manured—produced on a quarter acre, (No. 4.) of soft and badly filled corn,

	Bush.P.
3 bushels, - - - - - or per acre	12.
<i>q r</i> and <i>r p</i> , marled 800 bushels (45 per cent.) by three measurements of different pieces—	
Quarter acre (No. 1.) 5 bushels, very nearly, or per acre	19.3½
Eighth (No. 2) 2.3¼ } average }	22.2
Eighth (No. 3) 3.1¼ } 24.1½ }	27.
<i>s t</i> manured at 900 to 1100 bushels to the acre, of which,	
Quarter acre (No. 5) with rotted corn stalks, from a winter cow-pen, gave 5.2½ - - - - -	22.2
Eighth (No. 6) with stable manure, 4.1½ - - - - -	35.2
Eighth (No. 7) covered with the same heavy dressings of stable manure, and of marl also, gave 4.2	36.
<i>p w</i> , marled at 450 bushels, brought not so good a crop as the adjoining <i>r p</i> at 800.	

The distance was 5½ by 3¼ feet. Two of the quarter acres were measured by a surveyor's chain, (as were four other of the experiments of 1824,) and found to vary so little from the distance counted by corn rows, that the difference was not worth notice.

1825. In wheat, the different marked pieces seemed to yield in comparison to each other, proportions not perceptibly different from those of the preceding crop—but the best not equal to any of the land marled before 1822, as stated in the 1st, 2d and 3d experiments.

1827. Wheat on a very rough and imperfect summer fallow. This was too exhausting a course (being three grain crops in the four shift rotation,)—but was considered necessary to check the growth of bushes that had sprung from the roots still living. The crop was small, as might have been expected from its bad preparation.

1828. Corn—in rows five feet apart, and about three feet of distance along the rows, the seed being dropped by the step. Owing to unfavorable weather, and to insects and other vermin, not more than half of the first planting of this field lived—and so much replanting of course caused its product to be much less matured than usual, on the weaker land. All the part not marled (and more particularly that manured) was so covered by sorrel, as to require ten times as much labor in weeding as the marled parts, which, as in every other such case, bore no sorrel. October 15th, gathered and measured the corn from the several spaces, which were laid off (by the chain) as nearly as could be, on the same land as in 1824. The products so obtained, together with those of the previous and subsequent courses of tillage, will be presented below in a tabular form, for the purpose of being more readily compared.

On the wheat succeeding this crop, clover seed was sown, but very thinly, and irregularly. On the parts not marled, only a few yards width received seed, which the next year showed the expected result of scarcely any living clover, and that very mean. On the marled portions, the growth of clover was of middling quality. Was not mowed nor grazed, but seed gathered by hand both in 1830 and 1831.

1832. Again in corn. It was soon evident that much injury was caused to the marled half *q p o n*, by the too great quantity applied. A considerable proportion of the stalks, during their growth, showed strongly the marks of disease from that cause, and some were rendered entirely barren. A few stalks only had appeared hurt by the quantity of marl in 1828. On the lightly marled piece, *w p*, and also on *w t*, where the heaviest marling

was accompanied by stable manure, there appeared no sign of injury. The products of the three successive crops were as follows:

MARKS.	DESCRIPTION.	PRODUCTS OF GRAIN PER ACRE.		
		1st course.	2d course.	3d course.
		1824. October 11.	1828. October 15	1832. October 26
		Bush. pecks	Bush. pks.	Bush. pks.
<i>s q</i>	Not marled or manured,	12	21 1	17 3½
<i>q r 1</i>	Marled at 800 bushels,	19 3½	28 1½	28
<i>r p 2</i>	The same,	22 2	31 0½	27 3
<i>r p 3</i>	The same,	27		
<i>s t 5</i>	Cow-pen manure only, 900 to 1100 bushels,	22 2	25 2	more than <i>s q</i>
<i>s t 6</i>	Stable manure only, 900 to 1100 bushels,	35 2	29	28 1
<i>w t 7</i>	Marl and stable manure, both as above,	36	33 2	37 3½
<i>w p</i>	Marled at 450 bushels,	Less than <i>r p</i> (800)	Equal to <i>r p</i>	31 3

An accidental omission prevented the measurement of *s t 5*, in 1832.

This experiment has been made with much trouble, and every care bestowed to ensure accuracy. Still several causes have operated to affect the correctness of the results, and to prevent the comparative products showing the true rate of improvement, either from the marl or the putrescent manure. These causes will be briefly stated.

1st. The quantity of marl (800 bushels) on *q r* and *r p* is nearly double the amount that ought to have been used; and this error has not only increased the expense uselessly, but has served to prevent the increase of product that would otherwise have taken place. This loss is proved by the gradual increase, and at last the greater product of *w p*, marled at only 450 bushels.

2d, The comparative superiority of all the marled ground to *s q*, not marled, is lessened by this circumstance: most of the large logs, as well as all the small branches, were burnt upon the land, when it was cleared in 1824, before the experiment was commenced; and the ashes have durably improved a spot where each of these large fires was made on *s q*, but have done no good, and perhaps have been injurious, to the marled pieces that were made sufficiently calcareous without the addition of ashes. At least, the good effect of ashes, on spots, is very evident in *s q*, and has helped somewhat to increase all its measured products, and no such benefit has been visible on the marled parts.

3rd. The quantity of putrescent manure applied to *s t* (900 to 1100 bushels) was much too great both for fair experiment and profit; and the excess of quantity, together with the imperfectly rotted state of the stable manure, has given more durability to the effect, than is to be expected from a more judicious and economical rate of manuring on such land when not marled. For these several reasons, it is evident that far more satisfactory results than even these would have been obtained, if only half as much of either marl or manure had been applied.

There are other circumstances to be considered, which, if not attended to, will cause the comparative increase or decrease of product in this experiment to be misunderstood. It is well known that poor land put under tillage immediately after being cleared, as this was in 1824, will not yield near as much as on the next succeeding course of crops. This increase,

which depends merely on the effects of time, operates independently of all other means for improvement that the land may possess; and its rate, in this experiment, may be fairly estimated by the increase on the piece *s q* from 1824 to 1828. The increase here, where time only acted, was from 12 to 21½ bushels. But as the corn gathered here was always much the most imperfectly ripened, and would therefore lose the most by shrinking, I will suppose eight bushels to be the rate of increase from time, and that so much of the product of all the pieces should be attributed to that cause. Then to estimate alone the increased or diminished effects of marl, or manure on the other pieces, eight bushels should be deducted from all the different applications, and the estimate will stand thus:

	1821.	1828.	Deduct for time.	Increase.	Decrease	
	B. P.	B. P.	B.	B.P.	B. P.	
<i>q r</i> 1	19 3½	28 1½	8	0 2	—	From 800 bushels of marl.
<i>r p</i> 2	22 2	24 1½	8	—	1 1½	800 bushels of marl.
<i>r p</i> 3	27					
<i>s l</i> 5	22 2	25	8	—	5 2	1000 bush. cow-pen manure
<i>s l</i> 6	35 2	29	8	—	14 2	1000 bush. stable manure.

Even the piece covered with both marl and stable manure (*w t*) shows according to this estimate a diminished effect equal to 10½ bushels; which was owing to the marl not being able to combine with, and fix, so great a quantity of manure, in addition to the vegetable matter left by its natural growth of wood. The piece *w p*, marled at 450 bushels alone, has shown a steady increase of product at each return of tillage, and thereby has given evidence of its being the only improvement made in such manner as both judgment and economy would have directed.

After the crop and measurement of 1832, it was inferred that the separate products of such small spaces could no longer be relied on, owing to the mixture of the surfaces of adjacent parts, necessarily caused by tillage. Therefore the previously omitted parts were marled before the next course of crops came round.

CHAPTER III.

EFFECTS OF CALCAREOUS MANURE ON ACID CLAY SOILS, RECENTLY CLEARED

The two next experiments were made on another field of thirty acres of very uniform quality, marled and cleared in 1826 and the succeeding years. The soil is very stiff, close, and intractable under cultivation—seems to contain scarcely any sand—but, in fact, about one-half of it is composed of silicious sand, which is so fine, when separated, as to feel like the finest flour. Only a small proportion of the sand is coarser than this state of impalpable powder. Aluminous earth of a dirty fawn color forms nearly all of its remaining ingredients. Before being cleared of the forest growth, and ploughed, the soil is not an inch deep; and all below, for many feet, is apparently composed of the like parts of clay and fine sand. This is decidedly the most worthless kind of soil, in its natural state, that our district furnishes. It is better for wheat than for corn, though its product is contemptible in every thing. It is difficult to be made wet, or dry—and therefore suffers more than other soils from both dry and wet seasons, but

especially from the former. It is almost always either too wet or too dry for ploughing; and sometimes it will pass through both states in two or three clear and warm days. If broken up early in winter, the soil, instead of being pulverized by frost, like most clay lands, runs together again by freezing and thawing; and by March, will have a sleek (though not a very even) crust upon the surface, quite too hard to plant on without a second ploughing. The natural growth is principally white and red oaks, a smaller proportion of pine, and an under-growth of whortleberry bushes throughout.

Experiment 5.

On one side of this field a marked spot of thirty-five yards square was left out, when the adjoining land was marled at the rate of five hundred to six hundred bushels, (37 per cent.,) to the acre. Paths for the carts were opened through the trees, and the marl dropped and spread in January, 1826, and the land cleared the following winter. Most of the wood was carried off for fuel: the remaining logs and brush burnt on the ground, as usual, at such irregular distances as were convenient to the laborers. This part was perhaps the poorer, because wood had previously been cut here for fuel; though only a few trees had been taken, here and there, each winter, for a long time past.

Results, 1827. Planted in corn the whole recent clearing of fifteen acres—all marled, except the spot left out for experiment: broken up late and badly, and worse tilled, as the land was generally too hard, until the season was too far advanced to save the crop. The whole product so small, that it was useless to attempt to measure the products. The difference would have been only between a few imperfect ears on the marled ground, and still less—indeed almost nothing—on that not marled.

1828. Again in corn—as well broken and cultivated as usual for such land. October 8th—cut down four rows of corn running through the land not marled, and eight others, alongside on the marled—all fifty feet in length. The rows had been laid off for five and a half feet—but were found to vary a few inches—for which the proper allowance was made, by calculation. The spaces taken for measurement were caused to be thus small by a part of the corn having been inadvertently cut down and shocked, just before. The ears were shelled when gathered; and the products, measured in a vessel which held (by trial) 1-80th of a bushel, were as follows:

On land not marled,	
4 rows, average 5 feet, and 50 in length, (500 square feet)	13½ measures,
or to the acre, - - - - -	7¼ bushels.
On adjoining marled land	
4 rows, average 5 feet 1½ inches by 50 feet=512 square feet,	25¾ measures,
or to the acre, - - - - -	13½ bushels.
4 next rows, 5 feet 4½ inches by 50=537 square feet,	27½ measures,
or to the acre, - - - - -	14 bushels.

1829. In wheat.

1830. At rest—the weeds, a scanty cover.

1831. In corn. October 20th—measured by the chain equal spaces, and gathered and measured their products. The corn not marled was so imperfectly filled, that it was necessary to shell it, for fairly measuring the quantity. The marled parcels, being of good ears generally, were measured as usual, by allowing two heaped measures of ears, for one of grain.

On land not marled,	
363 square yards made - - - - -	3 gallons,
or to the acre, - - - - -	5 bushels.

On marled land, close adjoining on one side,
 363 square yards made rather more than 6 gallons—to the acre, 10 bushels.
 363 square yards on another side, made not quite 8 gallons,
 or to the acre, - - - - - 12 bushels.

The piece not marled coincided with that measured in 1828, as nearly as their difference of size and shape permitted—as did the last named marled piece, with the two of 1828. The last crop was greatly injured by the wettest summer that I have ever known, which has caused the decrease of product exhibited in this experiment—which will be best seen in this form :

		Product of grain to the acre.	
		1828—October 18.	1831—October 20
Not marled, - - -	-	7 bushels 1 peck.	- 5 bushels.
Marled, (averaged,) - - -	-	13 " 3 "	- 11 "

Experiment 6.

The remainder of the thirty acres was grubbed during the winter of 1826-7—marled the next summer at five hundred to six hundred bushels the acre; marl 40 per cent. A rectangle (A) 11 by 13 poles, was laid off by the chain and compass, and left without marl. All the surrounding land supposed to be equal in quality with A—and all level, except on the sides E and B, which were partly sloping, but not otherwise different. The soil suited to the general description given before; no material difference known or suspected between the land on which 5th experiment was made and this, except that the latter had not been robbed of any wood for fuel, before clearing. The large trees (or all more than ten inches through,) were belted, and the smaller cut down in the beginning of 1828, and all the land west of the line *ef* was planted in corn. As usual, the tillage bad, and the crop very small. The balance lying east of *ef*, was coultured once, but as more labor could not be spared, nothing more was done with it until the latter part of the winter, 1829, when it was broken by two-horse ploughs, oats sown and covered by trowel ploughs—then clover sown, and a wooden-tooth harrow passed over to cover the seed, and to smooth down, in some measure, the masses of roots and clods.

Results, 1829. The oats produced badly—but yielded more for the labor required than corn would have done. The young clover on the marled land was remarkably good, and covered the surface completely. In the unmarled part, A, only two casts through had been sown, for comparison, as I knew it would be a waste of seed. This looked as badly as had been expected.

1830. The crop of clover would have been considered excellent even on good land, and was most remarkable for so poor a soil as this. The strips sown through A, had but little left alive, and that scarcely of a size to be observed, except one or two small tufts, where I supposed some marl had been deposited by the cleaning of a plough, or that ashes had been left, from burning the brush. The growth of clover was left undisturbed until after midsummer, when it was grazed by my small stock of cattle, but not closely.

1831. Corn on the whole field. October 20th, measured carefully half an acre (10 by 8 poles) in A, the same in D, and half as much (10 by 4) in E. No more space could be taken on this side, for fear of getting within the injurious influence of the contiguous woods. No measurement was made on the side B, because a large oak, which the belting had not killed, affected its product considerably. Another accidental circumstance prevented my being able to know the product of the side C, which however was evidently and greatly inferior to all the marled land on which oats and clover had been raised. This side had been in corn, followed by wheat, and next (1830) under its spontaneous growth of weeds. The corn on each of the measured spaces was cut down, and put in separate shocks—and on Nov. 25th, when well dried, the parcels were shucked and measured, before being moved. We had then been gathering and storing the crop for more than fifteen days—and therefore these measurements may be considered as showing the amount of dry and firm grain, without any unusual deduction being required for shrinkage.

								Bushels.	Pecks.
A (half acre)	made	7 $\frac{1}{2}$	bushels of ears,	or of grain to the acre,	7	1			
D (half acre)		16 $\frac{3}{4}$	-	-	-	-	-	16	3
E (quarter acre)		11	-	-	-	-	-	22	

The sloping surface of the side E, prevented water from lying on it, and therefore it suffered less, perhaps not at all, from the extreme wetness of the summer, which evidently injured the growth on A and D, as well as of all the other level parts of the field.

1832. The field in wheat.

1833. In clover, which was grazed, though not closely, after it had reached its full growth.

1834. Corn, a year earlier than would have been permitted by the four-shift rotation. The tillage was insufficient, and made still worse by the commencement of severe drought before the last ploughing was completed, which was thereby rendered very laborious, and imperfect withal. The drought continued through all August, and greatly injured the whole crop of corn.

Results continued. October 22d. Marked off by a chain half an acre within the space A (8 by 10 poles) as much in D, and a quarter acre (10 by 4 poles) in each of the other three sides C, B, and E, having each of the last four spaces as near as could be to the outlines of the space A. The products carefully measured (in the ears) yielded as follows:

A, not marled,	yielded	6 bush.	0 $\frac{1}{2}$ peck of grain, to the acre.
D, marled,	"	19 "	3 $\frac{1}{2}$ "
E, do.	"	20 "	1 "
C, do.	"	20 "	2 "
B, do.	"	20 "	1 $\frac{1}{2}$ "

In comparing these products with those of the same land in 1831, stated above, it should be remembered that the corn formerly measured was dry, while that of the last measurement had yet to lose greatly by shrinking. As after early gathering, the corn from the poorest land of course will lose

most by drying, and as the ears on A were generally very defective and badly filled, if the measurement had been made in the sound and well dried grain of each parcel, the product of A could not have exceeded one-fourth of that of the surrounding marled land, and probably was less.

But though these differences of product present the improvement caused by marling in a striking point of view, this close and stubborn soil at best is very unfit for the corn crop; and its highest value is found under clover, and in wheat on clover, of which some proofs will be found in the next experiment. The first crop of clover, however, after marling, has not since been equalled.

My subsequent distant residence prevented my observing this field when under any matured crop, until in 1842, when in wheat. The growth on the unmarled space was certainly not more than one fourth as much as that of the surrounding ground.

Experiment 7.

Another piece of land of twenty-five acres, of soil and qualities similar to the last described, (Exp. 5 and 6,) was cleared in 1818, and about six acres marled in 1819, at about three hundred and fifty bushels. The course of cultivation was as follows:

1820—Corn—benefit from marl very unequal—supposed to vary between twenty-five and eighty per cent.

1821. Wheat—the benefit derived greater.

1822. At rest.

1823. Ploughed early for corn, but not planted. The whole marled at the rate of six hundred bushels (40 per cent.) again ploughed in August, and sown in wheat in October. The old marled space more lightly covered, so as to make the whole nearly equal.

1824. The wheat much improved.

1825 and 1826, at rest.

1827. Corn.

1828. In wheat, and sown in clover.

1829. The crop of clover was heavier than any I had ever seen in this part of the country, except in some very rare cases of rich natural soil, where gypsum was used and acted well. The growth was thick, but unequal in height, (owing probably to unequal spreading of the marl,) standing from fifteen to twenty-four inches high. The first growth was mowed for hay, and the second left to manure the land.

1830. The clover not mowed. Fallowed in August, and sowed wheat in October, after a second ploughing.

1831. The wheat was excellent, almost heavy enough to be in danger of lodging. I supposed the product to be certainly twenty bushels, perhaps twenty-five, to the acre.

As it had not been designed to make any experiment on this land, the progress of improvement was not observed with much care. But whatever were the intermediate steps, it is certain that the land, at first, was as poor as that forming the subjects of the two preceding experiments in the unimproved state, (the measured products of which have been given,) and that its last crop was at least four times as great as could have been obtained, if marl had not been applied. The peculiar fitness of this kind of soil for clover after marling, and the supposed cause of the remarkable heavy *first* crop of clover, will require further remarks, and will be again referred to hereafter.

CHAPTER IV.

THE EFFECTS OF CALCAREOUS MANURES ON ACID SOILS REDUCED BY CULTIVATION.

Proposition 5—continued.

My use of marl has been more extensive on impoverished acid soils than on all other kinds, and has never failed to produce striking improvement. Yet it has unfortunately happened that the two experiments made on such land with most care, and on which I relied mainly for evidence of the durable and increasing benefit from this manure, have had their effects almost destroyed by the applications having been made too heavy. These experiments, like the 4th and 6th, already reported, were designed to remain without any subsequent alteration, so that the measurement of their products, once in every succeeding rotation, might exhibit the progress of improvement under all the different circumstances. As no danger was then feared from such a course, marl was applied heavily, that no future addition might be required; and for this reason, I have to report my greatest disappointments exactly in those cases where the most evident success and increasing benefits had been expected. However, these failures will be stated fairly, and as fully as the most successful results; and they may at least serve to warn from the danger of error, if not to show the greatest profits of judicious marling.

It should be observed that the general rotation of crops pursued on the farm, on all land not recently cleared, was that of four shifts, (corn, wheat, and then the land two years at rest and not grazed,) though some exceptions to this course may be remarked in some of the experiments to be stated.

Experiment 8.

Of a poor sandy acid loam, seven acres were marled at the rate of only ninety bushels (37 per cent.) to the acre; laid on and spread early in 1819.

Results, 1819. In corn—the benefit too small to be generally perceptible, but could be plainly distinguished along part of the outline, by comparing with the part not marled.

1820. Wheat—the effect something better—and continued to be visible on the weeds following, until the whole was more heavily marled in 1823.

Experiment 9.

In the same field, on soil as poor and more sandy than the last described, four acres were marled at one hundred and eighty bushels, (37 per cent.) March 1818. A part of the same was also covered heavily with rotted barnyard manure, which also extended through similar land not marled. This furnished for observation, land marled only—manured only—marled and manured—and some without either. The whole space, and more adjoining, had been heavily manured five or six years before by summer cow-pens, and stable litter—of which no appearance remained after two years.

Results, 1819. In corn. The improvement from marl very evident—but not to be distinguished on the part covered also by manure, the effect of the latter so far exceeding that of the marl as to conceal it.

1820. In wheat. In 1821 and 1822, at rest.

1823. In corn— $5\frac{1}{2}$ by $3\frac{1}{4}$ feet. The following measurements were made

on adjoining spaces on October 10th. The shape of the ground did not admit of larger pieces, equal in all respects, being measured, as no comparison of products had been contemplated at first, otherwise than by the eye.

			Bush.	Quarts.
From the part not marled, 414 corn-hills made 75 quarts—				
or per acre,			13	26
Marled only, 414	-	-	100	18
Manured only, 490	-	-	105	15
Marled and manured, 490	-	-	130	20

The growth on the part both marled and manured was evidently inferior to that of 1819. This was to be expected, as the small quantity of calcareous earth was not enough to fix half so much putrescent manure; and, of course, the excess was as liable to waste as if no marl had been used.

Experiment 10.

Twenty acres of sandy loam, on a sandy sub-soil, covered in 1819 with marl of about 30 per cent. average proportion of calcareous earth, and the balance silicious sand—at 800 bushels to the acre. This land had been long cleared, and much exhausted by cultivation; since 1814 not grazed, and had been in corn only once in four years; and, as it was not worth sowing in wheat, had three years in each rotation to rest and improve by receiving all its scanty growth of weeds. The same course has been continued from 1819 to 1832, except that wheat has regularly followed the crops of corn, leaving two years of rest in four. This soil was lighter than the subject of any preceding experiment, except the 9th. On a high level part, surrounded by land apparently equal, a square of about an acre (A) was staked off, and left without marl—which that year's work brought to two sides of the square (C, D and E.)

Results, 1820. In corn. October 13th, three half acres of marled land were measured, and as many on that not marled, and close adjoining, and produced as follows :

<i>Not marled.</i>			<i>Marled.</i>		
	Bush	Pecks.		Bush.	Pecks.
Half acre in A,	7	1	adjoining in C,	12	3
The same in A,	7	1	" " D,	13	3 $\frac{3}{4}$
Half acre in B,	7	2 $\frac{1}{2}$	" " E,	15	0 $\frac{1}{2}$

The average increase being 12 $\frac{1}{2}$ bushels of grain to the acre, nearly 100 per cent. as measured, and more than 100 if the defective filling, and less matured state of the corn not marled, be considered. The whole would have lost more by shrinkage than is usual from equal products.

1821. The whole in wheat; much hurt by the wetness of the season. The marled part more than twice as good as that left out.

1822 and 1823. At rest. A good cover of carrot weeds and other kinds had succeeded the former growth of poverty grass and sorrel, and every appearance promised additional increase to the next cultivated crop. November, 1823, when the next ploughing was commenced, the soil was found to be evidently deeper, of a darker color and firmer, yet more friable. The two-horse ploughs with difficulty (increased by the cover of weeds,) could cut the required depth of five inches, and the slice crumbled as it fell from the mould-board. But as the furrows passed into the part not marled, an immediate change was seen, and even *felt* by the ploughman, as the cutting was so much more easy, that care was necessary to prevent the plough running too deep—and the slices turned over in flakes, smooth and sleek from the mould board, like land too wet for ploughing, which however was not the case. The marling of the field was completed at the same rate, (800 bushels,) which closed a third side (B) of the marked square. The fourth side was my neighbor's field.

1824. In corn. The newly marled (on B) showed as early and as great benefit as was found in 1820 on C and D—but yet was very inferior to the old, until the latter was 10 or 12 inches high, when it began to give the first known evidence of the very injurious effects of using this manure too heavily. The disease thus produced became worse and worse, until many of the plants had been killed, and still more were so stunted as to leave no hope of their being otherwise than barren. The effects will be known from the measurements which were made as nearly as could be on the same ground as the corresponding marks in 1820, and will be exhibited in the table, together with the products of the succeeding rotations. Besides the general injury suffered here in 1824, there were one hundred and three corn hills in one of the measured quarter acres (in C,) or more than one-sixth, entirely barren, and eighty-nine corn hills in another quarter acre (D.) In counting these, none of the missing hills were included, as these plants might have perished from other causes. This unlooked for disaster diminished the previous increase gained by marling, by nearly one-half; and the damage has since been still greater, at each successive return of cultivation until some years after 1832.

Just before planting the crops of 1832, straw and chaff very imperfectly rotted by exposure, and which contained no admixture of animal manure, were applied at the rate of 800 bushels the acre to half the square without marl (A, 1) and to the adjacent parts of the marled land. The vegetable manure showed but slight benefit, until after all the worst effects of excessive marling had been produced; and the later operation of the manure served barely to prevent a still farther diminution being exhibited by the land injured by marl.

MARK	DESCRIPTION.	PRODUCT IN SHELLED CORN PER ACRE.			
		1st course	2d course	3d course	4th course
		1820. Oct. 13.	1821. October 16.	1828. October 13.	1832. October 19.
		Bush. pk.	Bush. pecks.	Bush. pecks.	Bush. pecks.
A	Not marled	11 2	16 1	11 3½	9 3
A 1	After manuring,				16 3
B	Not marled until 1823,	15 1	28	19 2	not measured.
C	Marled in 1819—manured with chaff, &c. in 1832.	25	19 2	15	18
D		27 3½	20	19	19 ½
E		30 1	not measured	not measured.	not measured.

The crops of wheat were throughout less injured by the excess of marl than the corn.

For the crop of 1828, ploughed with three mules to each plough, from six to seven inches deep—seldom turning up any subsoil, (which was formerly within three inches of the surface,) and the soil appearing still darker and richer than when preparing for the crops of 1824. The ploughing of the square not marled (A) no where exceeded six inches; yet that depth must have injured the land, as I can impute to no other cause the remarkable diminution of product, through four courses of the mild four-shift rotation. It was evident that a still greater depth of furrow was not hurtful to the marled land. A strip across the field, in another place, was in 1828 ploughed eight inches deep for experiment, by the side of another of four inches, and the corn on the deepest ploughing was the best. Another strip was trench-ploughed twelve inches deep, without showing any perceptible difference, either of product or in the effects of damage from the excess of marl.

This square left without marl was the land previously referred to (page 27) as showing a diminished product through three successive courses of the rotation recommended by the author of 'Arator' as enriching. Since, another crop has been made and measured, and found to be still smaller than any previous. To whatever cause this continued falling off, for 16 years, may be attributed, it is at least a remarkable contradiction to the doctrine of vegetable matter serving alone to make poor land rich.

Much trouble has been encountered in attending to this experiment, and much loss of product submitted to, since its commencement, for the purpose of knowing the progress and extent of the evil caused by the excess of marl. But another portion of the field, marled as heavily in 1824, and where equal damage was expected to ensue, has been entirely relieved by intermitting the corn crop of 1828, sowing clover, which (by manuring with gypseous earth, or green-sand earth, at 20 bushels to the acre,) produced well, and which was left to fall and rot on the land. The next growth of corn on this part of the field (1832) was free from disease, and though irregular, seemed to the eye to amount to full twenty-five bushels to the acre.

After 1836, the rotation and management of this field ceased to be regular or uniform, as previously; and also, by cross ploughing, &c., during so many years, marl had necessarily become slightly diffused over the space designed to remain without marl. Therefore no more measurements were made, as they could no longer be relied on for accurate comparison. The unmarled part, even with its slight accidental gain of marl from the surrounding ground, and half the piece having also been dressed with putrescent manure in 1832, (as stated above,) is but very little improved since 1820.

Experiment 11.

The ground on which this experiment was made was in the midst of nineteen or twenty acres of soil apparently similar in all respects—level, gray sandy loam, cleared about thirty years before, and reduced as low by cultivation as such soil could well be. The land that was marled and measured was about two hundred yards distant from experiment 2, and both places are supposed to have been originally similar in all respects. This land had not been cultivated since 1815, when it was in corn—but had been once ploughed since, in November, 1817, which had prevented broom grass from taking possession. The ploughing then was four inches deep, and in five and a half feet beds, as recommended in 'Arator.' The growth in the year 1820 presented little except poverty grass, (*Aristida gracilis*,) running blackberry briars, and sorrel—and the land seemed very little if at all improved by its five successive years of rest. A small part of this land was covered with calcareous sand, (20 per cent.) quantity not observed particularly, but probably about 600 bushels.

Results. 1821. Ploughed level, and planted in corn—distance $5\frac{1}{2}$ by $3\frac{1}{2}$ feet. The measurement of spaces nearly adjoining, made in October, was as follows:

23 by 25 corn hills, not marled, (in A) made $2\frac{1}{8}$ bushels, or	} very nearly.
per acre, - - - - - $8\frac{3}{8}$	
23 by 25 corn hills, marled, (on the side B) $5\frac{5}{8}$	$22\frac{1}{8}$

1822. At rest. Marled the whole, except a marked square of fifty yards, containing the space measured the preceding year. Marl 45 per cent. and finely divided—350 bushels to the acre—from the same bed as that used for experiment 4. In August, ploughed the land, and sowed wheat early in October.

1823. Much injury sustained by the wheat from Hessian fly, and the growth was not only mean, but very irregular; but it was supposed that the first marled place (on the side B) was from 50 to 100 per cent. better than the last marled, and the last superior to the included square not marled, (A) in as great a proportion.

1824. Again in corn. The effects of disease from marling were as injurious here, both on the new and old part, as those described in experiment 10. No measurement of products made, owing to my being from home when the corn was cut down for sowing wheat.

1825. The injury from disease less on the wheat than on the corn of the last year on the latest marling, and none perceptible on the oldest application. This scourging rotation of three grain crops in four years was particularly improper on marled land, and the more so on account of its poverty.

1826. White clover had been sown thickly over forty-five acres, including this part, on the wheat, in January, 1825. In the spring of 1826,

It formed a beautiful green though low cover to even the poorest of the marled land. Marked spots, which were so diseased by over-marling as not to produce a grain of corn or wheat, produced clover at least as good as other places not injured by that cause. The square, which had been sown in the same manner, and on which the plants came up well, had no clover remaining by April, 1826, except on a few small spots, all of which together would not have made three feet square. The piece not marled, white with poverty grass, might be seen, and its outlines traced, at some distance, by its strong contrast with the surrounding dark weeds in winter, or the verdant turf of white clover the spring before.

1827. Still at rest. No grazing allowed on the white clover.

1828. In corn—the land broken in January, five inches deep. October 14th, made the following measurements:

In the square not marled, (A) 105 by 104½ feet (thirty-six square yards more than a quarter of an acre,) made one barrel of ears—

	Bushels.	pecks.
Or of grain to the acre,	9	1½
The same in 1821,	8	1½

Gain, 1 0½

Old marling (in B)—105 by 104½ feet—2¼ barrels,	22	2
The same in 1821,	22	0½

Gain, 1½

New marling, 105 by 104½ feet, on the side that seemed to be the most diseased, (D) 1½ barrels—or nearly 12 bushels to the acre.

1832. Again in corn. Since 1826, the mild four-shift rotation had been regularly adhered to. Ploughed early in winter five inches deep, and again with two-horse ploughs just before planting, and after manuring the land above the dotted line D x. The manure was from the stable yard, the vegetable part of it composed of straw, corn-stalks, corn-cobs, and leaves raked from wood-land, had been heaped in a wet state a short time before, and was still hot from its fermentation when carrying to the field. It was then about half rotted. The rate at which it was applied was about 807 heaped bushels to the acre, which was too heavy for the best net profit. The corn on the oldest marling (B) showed scarcely a trace of remaining damage, while that on D 2 (not manured) was again much injured. On the manured part, D 1, and C, the symptoms of disease began also to show early—but were so soon checked by the operation of the putrescent manure, that very little (if any) loss could have been sustained from that cause. The following table exhibits all the measured products for comparison:

MARKS	DESCRIPTION.	PRODUCT IN GRAIN, PER ACRE.			
		1st course 1821. Oct. —	2d course 1824.	3d course 1828. Oct. 14.	4th course 1832. Oct. 20.
A	{ Not marled,	8 1½	None measured, but the product of B much reduced by excess of marl, and D & C equally injured from the same cause.	Bush. pk. 9 1½	Bush. pk. 9 2½
A 1	{ Not marled & manured in 1832 }			the same	23 3 }
C	{ Marled in 1822, and manured in 1832. }				31 1½
B	{ Marled in 1821 (lightly) }	22 0½		22 2	25
D }	{ Marled in 1822 (more heavily) }			12	17 3 }
D 1 }	{ The same—and manured in 1832. }			the same	34 3 }

The products of the spaces A and B, in 1828, were not only estimated as usual from the measurement of the corn in ears, (which estimated quantities are those in the table,) but they were also shelled on the day when gathered, and the grain then measured, and again some months after, when it had become thoroughly dry. Care was taken that there should be no waste of the corn, or other cause of inaccuracy. The result showed nearly double the loss from shrinking in the corn not marled, and of course a proportional greater comparative increase of product in that marled, besides the increase which appears from the early measurement exhibited in the table. The grain of A, not marled, when first shelled, measured a very little more than the quantity fixed by estimate—made as usual by measurement of the ears, and lost by shrinking 30 per cent. The marled grain, from B, measured at first above 4 per cent. more than the estimate, and after shrinking, fell below it so much as to show the loss to be 16 per cent. The loss from shrinking in this case was greater than usual in both, from the poverty and consequent backwardness of the part not marled, and the uncommonly large proportion of replanted and of course late corn on the whole.

The two last experiments, as well as the 4th, were especially designed to test the amount of increased product to be obtained from marling, and to show the regular addition to the first increase, which the theory promised at each renewal of tillage. As to the main objects, all the three experiments have proved failures—and from the same error, that of marling too heavily. Although for this reason, the results have shown so much of the injurious effects, still, taken altogether, the experiments prove, clearly, not only the great immediate benefit of applying marl, but also its continued and increasing good effects when applied in proper quantities.

Experiment 12.

On 9 acres of sandy loam, marled in 1819 at 400 bushels, (25 per cent.,) nearly an acre was manured during the same summer, by penning cattle. With the expectation of preserving the manure, double the quantity of marl, or 800 bushels in all, was laid on that part. The field in corn in 1820—in wheat, 1821—and at rest 1822 and 1823.

Results, 1824. In corn, the second rotation after marling. The effects of the dung have not much diminished, and that part shows no damage from the quantity of marl, though the surrounding corn, marled only half as thickly, gave signs of general, though very slight injury from that cause.

Experiment 13.

Nearly two acres of loamy sand were covered with barn-yard manure, and marl, (45 per cent.,) at the same time, in the spring of 1822, and the field put in corn the same year, followed by wheat. The quantity of marl not remembered—but it must have been heavy (say not less than six hundred bushels to the acre) as it was put on to fix and retain the manure, and I had then no fear of damage from heavy dressings.

Result, 1825. Again in corn—and except on a small spot of sand almost pure, (nearly a “blowing sand,” or liable to be drifted by high winds in dry weather,) no signs of disease from over-marling were seen, then or afterwards.

CHAPTER V.

EFFECTS OF CALCAREOUS MANURES ON "FREE LIGHT LAND."

Proposition 5—continued.

The soil known in this part of the country by the name of "free light land" has so peculiar a character that it deserves a particular notice. It belongs to the slopes and undulating lands, between the highest ridges and the water courses, but has nothing of the durability which slopes of medium fertility sometimes possess. In its wood-land state it would be called rich, and may remain productive for a few crops after being cleared; but it is rapidly exhausted, and, when poor, seems as unimprovable by vegetable manures as the poorest ridge lands. In its virgin state, this soil might be supposed to deserve the name of neutral; but its productive power is so fleeting, and acid growths and qualities so surely follow its exhaustion, that it must be inferred that it is truly an acid soil.

Experiment 14.

The subject of this experiment presents soil of this kind with its peculiar characters unusually well marked. It is a loamy sandy soil, (the sand coarse,) on a similar sub-soil of considerable depth. The surface waving, almost hilly in some parts. The original growth principally red-oak, hickory, and dogwood, not many pines, and very little whortleberry. Cut down in 1816 and put in corn the next year. The crop was supposed to be twenty-five bushels to the acre. Wheat succeeded, and was still a better crop for so sandy a soil; making twelve to fifteen bushels, as it appeared standing. After 18 months of rest, and not grazed, the next corn crop, of 1820, was evidently and considerably inferior to the first; and the wheat of 1821 (which however was a very bad crop, from too wet a season) could not have been more than five bushels to the acre. In January, 1820, a piece of $1\frac{1}{2}$ acres was limed, at 100 bushels the acre. The lime, being caught by rain before it was spread, formed small lumps of mortar on the land, and produced no benefit on the corn of that year, but could be seen slightly in the wheat of 1821. The land again at rest in 1822 and '23, when it was marled, at 600 bushels, (37 per cent.,) without omitting the limed piece—and all sowed in wheat that fall. In 1824, the wheat was found to be improved by the marl, but neither that, nor the next crop of 1828, was equal to its earliest product of wheat. The limed part showed injury in 1824, from the quantity of manure, but none since. The field was now under the regular four-shift rotation, and continued to recover; but did not surpass its first crop until 1831, when it brought rather more than thirty bushels of corn to the acre (estimated by the eye,)—being five or six bushels more than its supposed first crop.

Experiment 15.

Adjoining this piece, six acres of similar soil were grubbed and belted in August, 1826—marl at 600 to 700 bushels (37 per cent.) spread just before. But few of the trees died until the summer of 1827. In 1828, planted in corn; the crop did not appear heavier than would have been expected if no marl had been applied—but no part had been left without, for comparison. 1829, wheat. 1830, at rest. 1831, in corn, and the product supposed to be near or quite thirty-five bushels, or an increase of thirty-five or forty

per cent. on the first crop. No measurement was made—but the product was estimated by comparison with an adjacent piece, which measured thirty-one bushels, and which seemed to be inferior to this piece.

The operation of marl on this kind of soil seems to add to the previous product very slowly, compared with other soils; but it is not the less effectual and profitable in fixing and retaining the vegetable matter accumulated by nature, which otherwise would be quickly dissipated by cultivation, and lost for ever.

The remarkable sandy and open texture of the soil on which the last two experiments were tried, will be evident from the following statement of the quantity and coarseness of the silicious sand contained.

1000 grains of this soil, taken in 1826 from the part that had been both limed and marled, was found to consist of

811 of silicious sand moderately coarse, mixed with a few grains of coarse shelly matter (the remains of the marl.)

158 finely divided earthy matter, part silicious, as well as aluminous, &c.

31 loss.

At the same time, from the edge of the adjoining wood-land which formed the next described experiment, 15, and which had not then been marled, a specimen of soil was taken from between the depths of one and three inches—and found to consist of the following proportions. This spot was believed to be rather lighter than the other in its natural state.

865 grains of silicious sand, principally coarse,

107 finely divided earthy matter (partly silicious,) &c.

28 loss.

CHAPTER VI.

EFFECTS OF CALCAREOUS MANURES ON EXHAUSTED ACID SOILS, UNDER THEIR SECOND GROWTH OF TREES.

Proposition 5—continued.

Not having owned much land under a second growth of pines, I can only refer to two experiments of this kind. The improvement in both these cases has been so remarkable, as to induce the belief that the “old fields” to be found on every farm, which have been exhausted and turned out of cultivation thirty or forty years, offer the most profitable subjects for the application of calcareous manures.

Experiment 16.

May 1826. Marled about eight acres of land under its second growth, by opening paths for the carts ten yards apart. Marl 40 per cent.; put 500 to 600 bushels to the acre—and spread in the course of the summer. In August, belted slightly all the pines that were as much as eight inches through, and cut down or grubbed the smaller growth, of which there was very little. The pines (which were the only trees) stood thick, and were mostly from eight to twelve inches in diameter—eighteen inches where standing thin. The land joined experiment 15 on one side; but this is level, and on the other side joins ridge woodland, which soon becomes like soil of experiment 1. This piece, in its virgin state, was probably of a nature between those two soils—but less like the ridge soil than the “free light land.” No information has been obtained as to the state of this land

when its cultivation was formerly abandoned. The soil, (that is, the depth which has since been turned by the plough,) a whitish loamy sand, on a subsoil of the same; in fact, *all was subsoil* before the ploughing, except half an inch or three quarters, on the top, which was principally composed of rotted pine leaves. Above this thin layer were the later dropped and unrotted leaves, lying loosely several inches thick.

The pines showed no symptoms of being killed, until the autumn of 1827, when their leaves began to have a tinge of yellow. To suit the cultivation with the surrounding land, this piece was laid down in wheat for its first crop, in October, 1827. For this purpose, the few logs, the boughs, and grubbed bushes were heaped, but not burnt—the seed then sowed on the coat of pine leaves, and ploughed in by two-horse ploughs, in as slovenly a manner as may be supposed from the condition of the land; and a wooden-tooth harrow then passed over, to pull down the heaps of leaves, and roughest furrows.

Results. The wheat was thin, but otherwise looked well while young. The surface was very soon again covered by the leaves dropping from the then dying trees. On April 2d, 1828, most of the trees were nearly dead, though but few of them entirely. The wheat was then taller than any in my crop—and when ripe, was a surprising growth for such land, and such imperfect tillage.

1829 and 1830. At rest. Late in the spring of 1830 an accidental fire passed over the land—but the then growing vegetation prevented all of the older cover being burnt, though some was destroyed every where.

1831. In corn. The growth excited the admiration of all who saw it, and no one estimated the product so low as it actually proved to be. A square of four (two-pole) chains, or four-tenths of an acre, measured on November 25th, yielded at the rate of thirty-one and three-eighths bushels of grain to the acre.

Experiment 17.

In a field of acid sandy loam, long under the usual cultivation, a piece of five or six acres was covered by a second growth of pines thirty-nine years old, as supposed from that number of rings being counted on some of the stumps. The largest trees were eighteen or twenty inches through. This ground was altogether on the side of a slope, steep enough to lose soil by washing, and more than one old shallow gully remained to confirm the belief of the injury that had been formerly sustained from that cause. These circumstances, added to all the surrounding land having been continued under cultivation, made it evident that this piece had been turned out of cultivation because greatly injured by tillage. It was again cut down in the winter of 1824-5. Many of the trees furnished fence-rails and fuel, and the remaining bodies were heaped and burnt some months after, as well as the large brush. In August it was marled, supposed at 600 bushels, (37 per cent.,) twice coultured in August and September, and sowed in wheat—the seed covered by trowel ploughs. The leaves and much of the smaller brush left on the ground, made the ploughing troublesome and imperfect. The crop (1826) was remarkably good—and still better were the crops of corn and wheat in the ensuing rotation, after two years of rest. On the last crop of wheat (1830) clover was sown—and mowed for hay in 1831. The growth stood about eighteen inches high, and never have I seen so heavy a crop on sandy and acid soil, even from the heaviest dunging, the utmost care, and the most favorable season. The clover grew well in the bottoms of the old gullies, which were still plainly to be seen, and which no

means had been used to improve, except such as all the land had received. Within two feet of the surface the subsoil of this land is of red clay, which probably helped its growth of clover.

CHAPTER VII.

EFFECTS OF CALCAREOUS MANURES ALONE, OR WITH GYPSUM, ON NEUTRAL SOILS.

Proposition 5—continued.

Reason would teach that applications of calcareous earth alone to calcareous soils are so manifestly useless, that no more than two experiments of that kind have been made by me, neither of which had any improving effect that could be noticed, in the twelve ensuing years during which the experiments were observed.

When calcareous manures have been applied to neutral soils, whether new or worn, no perceptible and manifest benefit has been obtained on the first crop. The subsequent improvement has gradually increased, as would be expected from the power of fixing manures ascribed to calcareous earth. But however satisfactory these general results were to myself, they are not such as could be reported in detail, with any advantage to other persons. It is sufficiently difficult to make fair and accurate experiments where early and remarkable results are expected. But no cultivator of a farm can bestow enough care, and patient observation, to obtain true results from experiments that scarcely will show their first feeble effects in several years after the commencement. On a mere experimental farm, such things may be possible; but not where the main object of the farmer is profit from his general and varied operations. The effects of changes of season, of crops, of the mode of tillage—the auxiliary effects of other manures, and many other circumstances—would serve to defeat any observations of the progress of a slow improvement, though the ultimate result of the general practice might be abundantly evident.

Another cause for being unable to state with any precision the practical benefit of marling neutral soils, arises from the circumstance that nearly all the calcareous manure thus applied by me has been accompanied by a natural admixture of gypsum; and though I feel confident in ascribing some effects to one, and some to the other of these two kinds of manure, yet this division of operation must rest merely on opinion, and cannot be received as certain by any other than him who makes and carefully observes the experiments. Some of these applications will be described, that other persons may draw their own conclusions from them.

The cause of these manures being applied in conjunction was this. A singular bed of marl lying under Coggins Point, and the only one within a convenient distance to most of the neutral soil of that farm, contains a very small proportion (perhaps about one per cent.) of gypsum, scattered irregularly through the mass, seldom visible, though sometimes and very rarely to be met with in small crystals. The calcareous ingredient on a general average, carefully made, was found to be 62 per cent. If this manure had been used before its *gypseous* quality was discovered, all its effects would have been ascribed to calcareous earth alone, and the most erroneous opinions might thence have been formed of its mode of operation.

What led me to suspect the presence of gypsum, in this bed of fossil shells, was the circumstance that throughout its whole extent, of near a mile

along the river bank, this bed lies on another earth, of peculiar character and appearance, and which, in many places, exhibits gypsum in crystals of various sizes. This earth has evidently once been a bed of fossil shells, like what still remains above; but nothing now is left of the shells, except numerous impressions of their forms. Not the smallest proportion of calcareous earth can be found, and the gypsum into which it must have been changed (by meeting with sulphuric acid, or sulphuret of iron,) has also disappeared in most places; and in others, it remains only in small quantities—say from the smallest perceptible proportion, to fifteen or twenty per cent. of the mixed mass. In some rare cases, this gypseous earth is sufficiently abundant to be used profitably as manure, as has been done, by Mr. Thomas Cocke, of Tarbay, as well as myself. It is found in the greatest quantity, and also the richest in gypsum, at Evergreen, two miles below City Point. There the gypsum frequently forms large crystals of varied and beautiful forms. The distance that this bed of gypseous earth extends is about seven miles, interrupted only by some bodies of lower land, apparently of a more recent formation by alluvion.

In the bed of gypseous marl above described, there are regular layers of a calcareous rock, which was too hard to use profitably for manure, and which caused the greatest impediment to obtaining the softer part. This rock contains between eighty-five and ninety per cent. of pure calcareous earth, besides a little gypsum and iron. It makes excellent lime for cement, mixed with twice its bulk of sand, and has been used for part of the brick-work, and all the plastering of my present dwelling house, and for several of my neighbors' houses. The whole body of marl also contains a minute proportion of some soluble salts, which possibly may have some influence on the operation of the substance, as manure or cement.

Thus, from the examination of a single body of marl, there have been obtained not only a rich calcareous manure, but also gypsum, and a valuable cement. Similar formations may perhaps be abundant elsewhere, and their value unsuspected, and likely to remain useless. This particular body of marl has no outward appearance of possessing even its calcareous character. It would be considered, on slight inspection, as a mass of gritty clay, of no worth whatever.

The last preceding paragraph presents, as in the previous editions, my earliest views of this particular bed of marl. Further information has taught that it is of the *eocone*, or more ancient formation; and that the underlying stratum, (which is usually not at all calcareous,) which I formerly named and treated of as "gypseous earth," is what geologists call "greensand," a term still less descriptive, and not at all more accurate. A full account of both of these bodies will be given in the Appendix.

This gypseous marl has been used only on sixty acres, most of which was neutral soil, and generally, if not universally, with early as well as permanent benefits. The following experiments show results more striking than have been usually obtained; but all agree in their general character.

Experiment 18.

1819. Across the shelly island numbered 3 in the examinations of soils, (page 38,) but where the land was less calcareous, a strip of three quarters of an acre was covered with muscle-shell marl, a deposit on parts of the river banks supposed to have been made by the aboriginal inhabitants. Touching this, through its whole length, another strip was covered with gypseous marl, 53 per cent., at the rate of 250 bushels.

Results. 1819. In corn. No perceptible effect from the muscle shells. The gypseous marling considerably better than on either side of it.

1820. Wheat—less difference.

1821. Grazed. Natural growth of white clover thickly set on the gypseous marling, much thinner on the muscle-shells, and still less of it where no marl had been applied.

The whole field afterwards was put in wheat on summer fallow every second year, and grazed closely the intervening year—a course very unfavorable for observing, or permitting to take place, any effects of gypsum. Nothing more was noted of this experiment until 1825, when cattle were not turned in until the clover reached its full size. The strip covered with gypseous marl showed a remarkable superiority over the other marled piece, as well as over the land which was still more calcareous by nature, and which had produced better in 1820. In several places, the white clover stood thickly a foot in height.

Experiment 19.

A strip of a quarter acre passing through rich black neutral loam, covered with gypseous marl at 250 bushels.

Results. 1818. In corn. By July, the marled part seemed the best by 50 per cent., but afterwards the other land gained on it, and little or no difference was apparent when the crop was matured.

1819. Wheat—no difference seen.

1820 and 1821. At rest. In the last summer the marled strip could again be easily traced, by the entire absence of sorrel, (which had been gradually increasing on this land since it had been secured from grazing,) and still more by its very luxuriant growth of bird-foot clover, which was thrice as good as that on the adjoining ground.

Experiment 20.

1822. On a body of neutral soil which had been reduced quite low, but was well manured in 1819 when last cultivated, gypseous marl was spread on nine acres, at the rate of 300 bushels. This terminated on one side at a strip of muscle-shell marl ten yards wide—its rate not remembered, but it was certainly thicker in proportion to the calcareous earth contained, than the other, which I always avoided laying on heavily, from a mistaken fear of causing injury by too much gypsum. The line of division between the two marls was through a clay loam. The subsoil was a retentive clay, which caused the rain water to keep the land very wet through the winter, and early part of spring.

Results. 1822. In corn, followed by wheat in 1823—not particularly noticed, but the benefits must have been very inconsiderable. All the muscle-shell marling, and four acres of the gypseous, sowed in red clover, which stood well, but was severely checked, and much of it killed, by a drought in June, when the sheltering wheat was reaped. During the next winter (by neglect) my horses had frequent access to this piece, and by their trampling in its wet state must have injured both land and clover. From these disasters the clover recovered surprisingly; and in 1824, two mowings were obtained, which, though not heavy, were better than from any of my previous attempts to raise this grass. In 1825, the growth was still better, and yielded more to the scythe. This was the first time that I had seen clover worth mowing on the third year after sowing—and had never heard of its being comparable to the second year's growth any where in the lower country. The growth on the muscle-shell marling was very inferior

to the other, and was not mowed at all the last year, being thin and low, and almost eaten out by wire-grass, (*Cynodon dactylon*.)

1826. In corn—and it was remarkable that the difference shown the last year was reversed, the muscle-shell marling now having much the best crop.

In these and other applications to neutral soils, I ascribe the earliest effects entirely to gypsum, as well as the peculiar benefit shown to clover, throughout. The later effects, and especially on grain, are due to the calcareous earth in the manure.

CHAPTER VIII.

DIgression TO THE THEORY OF THE ACTION OF GYPSUM AS MANURE. SUPPOSED CAUSE OF ITS WANT OF POWER AND VALUE ON ACID SOILS.

Proposition 5—continued.

Another opinion was formed from the effects of gypseous marl, as stated in the foregoing chapter, which may lead to profits much more important than any to be derived from the limited use of this, or any similar mineral compound—viz.: *that gypsum may be profitably used after calcareous manures, on soils on which it was totally inefficient before.* I do not present this as a fact fully established, or, even if established, of universal application; for the results of some of my own experiments are directly in opposition. But, however it may be opposed by some facts, the greater weight of evidence, furnished by my experiments and observations, decidedly supports this opinion. If correct, its importance to our low country is inferior only to the value of calcareous manures alone—which value may be almost doubled, if the land is thereby fitted to receive the wonderful benefits of gypsum and clover.

It is well known that gypsum has failed entirely as a manure on nearly all the land on which it has been tried in our tide-water district; and we may learn from various publications, that as little general success has been met with along the Atlantic coast, as far north as Long Island. To account for this general failure of a manure so efficacious elsewhere, some one offered a reason, which was received without examination, and which is still considered by many as sufficient, viz.: that the influence of salt vapors destroyed the power of gypsum on and near the sea-coast. But the same general worthlessness of that manure extends one hundred miles higher than the salt water of the rivers—and the lands where it is profitably used are much more exposed to sea air. Such are the rich neutral soils of Curle's Neck, Shirley, Berkley, Brandon, and Sandy Point, on James river, on all which gypsum on clover has been extensively and profitably used. On acid soils, I have never heard of enough benefit being obtained from gypsum to induce the cultivator to extend its use further than making a few small experiments. When any effect has been produced on an acid soil, (so far as instructed by my own experience, or the information of others,) it has been caused by applying to small spaces comparatively large quantities; and even then, the effects were neither considerable, durable, nor profitable. Such have been the results of many small experiments made on my own acid soils—and very rarely was the least perceptible effect produced. Yet on some of the same soils, after marling, the most evident benefits have been obtained from gypsum on clover. The soils on which the 1st and 10th experiments were made, (at some distance from these

experiments,) had both been tried with gypsum, and at different rates of thickness, before marling, without the least effect. Several years after both had been marled, gypseous earth (from the bed referred to, page 93,) was spread at twenty bushels the acre, (which gave four bushels of pure gypsum,) on clover, and produced in some parts a growth I have never seen surpassed. It is proper to state that such results have been produced only by heavy dressings. Mr. Thomas Cocke, of Tarbay, in the spring of 1831 sowed nearly four tons of Nova Scotia gypsum on clover on marled land, the field being a continuation of the same ridge that my 1st. 2d, 3d, and 4th experiments were made on, and very similar soil. His dressing, at a bushel to the acre, before the summer had passed, produced evident benefit, where it is absolutely certain, from abundant previous experience, that none could have been obtained before marling.

On soils naturally calcareous, I have in some experiments greatly promoted the growth of corn by gypsum, and have doubled the growth of clover on my best land of that kind. When the marl containing gypsum was applied, benefit from that ingredient was almost certain to be obtained.

All these facts, if presented alone, would seem to prove clearly the correctness of the opinion, that the acidity of most of our soils caused the inefficacy of gypsum, and that the application of calcareous earth, which will remove the acid, will also serve to bring gypsum into useful operation. But this most desirable conclusion is opposed by the results of other experiments, which, though fewer in number, are as strong as any of the facts that favor that conclusion. If the subject were properly investigated, those facts, apparently in opposition, might be explained so as no longer to contradict this opinion, or perhaps might help to confirm it. Good reasons, deduced from established chemical truths, may be offered to explain why the acidity of our soils should prevent the operation of gypsum; though it may be deemed premature to attempt the explanation of any supposed fact, before every doubt of the existence of the fact itself has been first removed.

One of the circumstances will be mentioned, which appears at first glance most strongly opposed to the opinion which has been advanced. On the poor acid clay soil, of such peculiar and base qualities, which forms the subject of the 5th, 6th, and 7th experiments, gypsum has been sufficiently tried, and has not produced the least benefit, either before marling, or afterwards. Yet the first growth of clover on this land after marling is fully equal to what might be expected from the best operation of gypsum. Now if it could be ascertained that a very small proportion of either *sulphuric acid*, or of the *sulphate of iron*, exists in this soil, it would completely explain away this opposing fact, and even make it the strongest support of my position. The sulphate of iron has sometimes been found in arable soil,* and sulphuric acid has been detected in certain clays.† I have seen, on the same farm, a bed of clay of very similar appearance to this soil, which certainly had once contained one of these substances, as was proved by the formation of crystallized sulphate of lime, where the clay came in contact with a bed of marl. The sulphate of lime was found in the small fissures of the clay, extending sometimes one or two feet in perpendicular height from the calcareous earth below. Precisely the same chemical change would take place in a soil containing sulphuric acid, or sulphate of iron, as soon as marl is applied. The sulphuric acid, (whether free or combined with iron) would immediately unite with the lime presented, and form gypsum, (sulphate of lime.) Proportions of these substances, too small perhaps to be detected by analysis, would be sufficient to form three

* Agr. Chem p 141.

† Kirwan on Manures.

or four bushels of gypsum to the acre—more than enough to produce the greatest known effect on clover—and to prevent any benefit being derived from a subsequent application of gypsum; because there being already in the soil more gypsum than could act, no additional quantity could be of the slightest benefit.

Since the publication of the foregoing part of this chapter, in the first edition, my use of gypsum, on land formerly acid, has been more extended, and the results have been such as to give additional confidence in the practice, and, indeed, an assurance of good profit, on the average of such applications. But still, as before, disappointments, either total or nearly so, in the effect of such applications, have sometimes occurred, and without there being any known or apparent cause to which to attribute such disappointment in the results.

In 1832, nine acres of the same body of ridge land above referred to, adjoining the piece on which the 1st, 2d, 3d and 4th experiments were made, and more lately cleared, were sown in clover in the early part of 1831, on wheat. The next spring, French gypsum was sown at the rate of a bushel to the acre, except on four marked adjoining squares, each about one third of an acre, one of which was left without plaster, and the others received it at the several rates of 2, 3, and 4 bushels to the acre. The whole brought a middling crop, and was mowed for hay, except the square left without gypsum, which did not produce more than half as much as the adjoining land where gypsum was applied at one bushel the acre. The products of the other pieces were slightly increased by each addition to the gypsum, but by no means in proportion to the increased quantity used; nor was the effect of the four bushels near equal to that formerly obtained, in several cases, from 20 bushels of gypseous earth taken from the river bank. Hence it seems that it was not merely the unusual quantity of gypsum applied in this earth, which produced such remarkable benefit; and we must infer that it contains some other quality or ingredient capable of giving additional improvement to clover.

Since the first publication of the foregoing passage, (in 1832,) and in accordance with the views there presented, more than 10 tons of good French gypsum has been used, in different years and with less effect, in general, than formerly, in the first few years after the marling. This general diminution, and more frequent total failures, may be owing to the longer time that the land has been marled, and, by the increase of its vegetable supplies serving as putrescent manure, the land being thereby changed from calcareous to neutral, and perhaps in some cases even approaching to being acid. If this supposition be well founded, then a repetition of the marling would not only be profitable in other respects, but would increase or restore the capacity of the soil to receive benefit from gypsum.

The following are my views of the general causes of the inertness and worthlessness of gypsum as manure, on all acid soils, and for the different and valuable results from gypsum, after the soils have been made calcareous.

I do not pretend to explain the mode of operation by which gypsum produces its almost magical benefits; it would be equally hopeless and ridiculous for one having so little knowledge of the successful practice to attempt an explanation, in which so many good chemists and agriculturists, both scientific and practical, have completely failed. There is no operation of nature heretofore less understood, or of which the cause, or agent, seems so totally disproportioned to the effect, as the enormous increase of vegetable growth from a very small quantity of gypsum, in circumstances favorable to its action. All other known manures, whatever may be the nature of their action, require to be applied in quantities very far exceed-

ing any bulk of crop expected from their use. But one bushel of gypsum spread over an acre of land fit for its action, may add more than twenty times its own weight to a single crop of clover hay.

But without pretending to account for the wonderful action of gypsum as manure, and without entertaining any confidence in any of the numerous theories heretofore presented, (not excepting the latest set forth, by Professor Liebig,) I concur in the general opinion expressed by Davy. This accurate investigator, who took nothing upon trust which could be subjected to the test of rigid experiment, pursued that mode to obtain light on this obscure subject. He found by chemical analysis, that gypsum was always present in the ashes of red clover, and in quantity, in a good crop, amounting to three or four bushels to the acre. He inferred that gypsum, thus always forming a portion of the clover plant, was essential to its healthy existence—and that it is necessary to the structure of the woody fibre of clover and other grasses. But it is enough if Davy was correct in the main opinion, that a certain though very small proportion of gypsum is an essential component part of certain plants, of which the clover tribe furnishes the most noted examples. If this be so, no matter what may be the office or function of the gypsum, the small amount necessary for the demands of the plants *must be present in the soil*, or otherwise the plants needing it *cannot live, or maintain a healthy growth*. It will follow, further, that on soils well adapted for clover in other respects, but almost totally deficient in gypsum, the application of so small a dressing as one bushel of that substance to the acre may enable a full crop of clover to grow, and twice or thrice as much as the land could have brought without this small application. Such I suppose to be the circumstances of those lands of this country on which gypsum exerts the greatest power. But in England, though clover culture is universally extended, gypsum has shown scarcely any benefit as manure, and though extensively experimented with, has not been found sufficiently operative to be brought into ordinary practice on any one farm in the kingdom. This may be accounted for by supposing the soils generally to be supplied by nature abundantly with gypsum, so that no more is required. Davy found gypsum in the soil itself of four farms, examined with this view, and in one of them the very large proportion of nearly one per cent. (See Agricultural Chemistry, Lecture vii.) But there is another and numerous class of cases in which gypsum cannot be supposed to be present, and yet when applied shows no benefit. These are the poor acid soils of lower Virginia, (and elsewhere,) and the cause of which it seems to me not difficult to explain.

However wonderful and inscrutable the fertilizing power of this manure may be, and admitting its cause as yet to be hidden, and entirely beyond our reach—still it is possible to show reasons why gypsum cannot act in many situations, where all experience has proved it to be worthless. If this only can be satisfactorily explained, it will remove much of the uncertainty as to the effects to be expected; and the farmer may thence learn on which soils he may hope for benefit from this manure—on which it will certainly be thrown away—and by what means the circumstances adverse to its action may be removed, and its efficacy thereby secured. This is the explanation that I shall attempt.

If the vegetable acid, which I suppose to exist in what I have called acid soils, is not the oxalic, (which is the particular acid in sorrel,) at least every vegetable acid, being composed of different proportions of the same three elements, may easily change to any other, and all to the oxalic acid. This, of all bodies known by chemists, has the strongest attraction for lime, and will take it from any other acid which was before combined with it, and for

that purpose, the oxalic acid will let go any other earth or metal, which it had before held in combination. Let us then observe what would be the effect of the known chemical action of these substances, on their meeting in soils. If oxalic acid were produced in any soil, its immediate effect would be to unite with its proper proportion of lime, if enough were in the soil in any combination whatever. If the lime were in such small quantity as to leave an excess of oxalic acid, that excess would seize on the other substances in the soil, in the order of their mutual attractive force; and one or more of such substances are always present, as magnesia; or, more certainly, iron and alumina. The soil then would not only contain some proportion of the *oxalate of lime*, but also the oxalate of either one or more of the other substances named. Let us now suppose gypsum to be applied to this soil. This substance (sulphate of lime) is composed of sulphuric acid and lime. It is applied in a finely pulverized state, and in quantities from half a bushel to two bushels the acre—generally not more than one bushel. As soon as the earth is made wet enough for any chemical decomposition to take place, the oxalic acid must let go its *base* of iron, or alumina, and seize upon and combine with the lime that formed an ingredient of the gypsum. The sulphuric acid left free, will combine with the iron, or the alumina of the soil, forming copperas in the one case, and alum in the other. *The gypsum no longer exists*—and surely no more satisfactory reason can be given why no effect from it should follow. The decomposition of the gypsum has served to form two or perhaps three other substances. One of them, oxalate of lime, like all salts of lime, is probably valuable as manure, but the very small quantity that could be formed out of one or even two bushels of gypsum, might have no more visible effect on a whole acre, than that small quantity of calcareous earth, or farm-yard manure. The other substance certainly formed, copperas, is known to be a poison to soil and to plants—and alum, of which the formation would be doubtful, I believe is also hurtful. In such small quantities, however, the poison would be as little perceptible as the manure—and no apparent effect whatever could follow such an application of gypsum to an acid soil. So small a proportion of oxalic acid, or any oxalate other than of lime, would suffice to decompose and destroy the gypsum, that it would not amount to one part in twenty thousand of the soil.

Why gypsum sometimes acts as a manure on acid soils, when applied in large quantities for the space, is equally well explained by the same theory. If a handful, or even a spoonful of gypsum is put on a space of six inches square, it would so much exceed in proportion all the oxalic acid that could speedily come in contact with it, that all would not be decomposed, and the part that continued to be gypsum would show its peculiar powers perhaps long enough to improve one crop. But as tillage served to scatter these little collections more equally over the whole space—or even as repeated soaking rains allowed the extension of the attractive powers—applications like these would also be destroyed, after a very short-lived, limited, and rarely profitable action.

Soils that are naturally calcareous cannot contain oxalic acid combined with any other base than lime. Hence, gypsum applied there *continues to be gypsum*—and exerts its great fertilizing power, as in the counties of Loudoun and Frederick. But even on these most suitable soils, this manure is said not to be certain and uniform in its effects, and of course more certain results are not to be looked for with us. I have not undertaken to explain its occasional failures any more than its general success, on the lands where it is profitably used in general—but only why it cannot act at all, on lands of a different kind.

The same chemical action being supposed, explains why the power of profiting by gypsum should be immediately awakened on acid soils after making them calcareous—and why that manure should seldom fail, when applied mixed with much larger quantities of calcareous earth.

CHAPTER IX.

THE DAMAGE CAUSED BY TOO HEAVY DRESSINGS OF CALCAREOUS MANURE, AND THE REMEDY.

Proposition 5—continued.

The injury or disease in grain crops produced by marling has so lately been presented to our notice, that the collection and comparison of many additional facts will be required before its cause can be satisfactorily explained. But the facts already ascertained will at least show how to avoid the danger of such injury in future, and to find remedies for the evils already inflicted by the injudicious use of calcareous manures.

The earliest effect of this kind observed was in May, 1824, on the field containing experiment 10. The corn on the land marled four years before sprang up and grew with all the vigor and luxuriance that was expected from the appearance of increased fertility exhibited by the soil, as before described, (page 84.) About the 20th of May the change commenced, and the worst symptoms of the disease were seen by the 11th of June. From having as deep a color as young corn shows on the richest and best soils, it became of a pale sickly green. The leaves, when closely examined, seemed almost transparent, afterwards were marked through their whole length by streaks of rusty red, separated very regularly by other streaks of what was then more of yellow than green, and next they began to shrivel and die downwards from their extremities. The growth of many of the plants was nearly stopped. Still some few showed no sign of injury, and maintained the vigorous growth which they began with, so as by contrast more strongly to mark the general loss sustained. The appearance of the field was such, that a stranger would have supposed that he saw the crop on a rich soil exposed to the worst ravages of some destructive kind of insects; but neither on the roots or stalks of the corn could any thing be found to support that opinion. Before the first of August this gloomy prospect had somewhat improved. Most of the plants seemed to have been relieved of the infliction, and to grow again with renewed vigor. But before that time many were dead, and it was impossible that the others could so fully recover as to produce any thing approaching a full crop for the land. It has been shown in the report of the products of Exp. 10, what diminution of crop was then sustained—and that the evil was not abated in the three succeeding courses of cultivation. Still, neither of the diseased measured pieces has fallen quite as low as its product before marling; nor do I think that such has been the result on any one acre together on my farm, though many smaller spots have been rendered incapable of yielding even so much as a grain of corn or wheat.

The injury caused to wheat by marling is not so easy to describe, though abundantly evident to the observer. Its earliest growth, like that of corn, is not affected. About the time for heading, the plants most diseased appear as if they were scorched, and when ripe will be found very deficient in grain. On very poor spots, from which nearly all the soil has been washed, sometimes fifty heads of wheat, taken together, would not furnish

as many grains of wheat. This crop, however, suffers less than corn on the same land; perhaps because its growth is nearly completed by the time that the warm season begins, to which the ill effects of calcareous manures seem confined. The injury to corn is also greater in a wet than a drier summer.

When these unpleasant discoveries were first made, two hundred and fifty acres had already been marled so heavily that the same evil was to be expected to visit the whole. My labors, thus bestowed for years, had been greatly and unnecessarily increased—and the excess, worse than being thrown away, had served to take away that increase of crop which lighter marling would have ensured. But though much and general injury was afterwards sustained from the previous work, yet it was lessened in extent and degree, and sometimes entirely avoided, by the remedial measures which were adopted. My observation and comparison of all the facts presented, led to the following conclusions, and pointed out the course by which to avoid the recurrence of the evil, and the means to lessen or remove it, where it had already been inflicted.

1st. No injury has been sustained on any soil of my farm by marling not more heavily than two hundred and fifty heaped bushels to the acre, with marl of strength not exceeding 40 per cent. of calcareous earth.

2d. Dressings twice as heavy seldom produce damage to the first crop on any soil—and never even on the after crops on any calcareous, or good neutral soil—nor on any acid soil supplied plentifully with vegetable matter.

3d. On acid soils marled too heavily, the injury is in proportion to the extent of one or all these circumstances of the soil—poverty, sandiness, and severe cropping and grazing, whether inflicted previously or subsequently.

4th. Clover, both red and white, will live and flourish on the spots most injured for grain crops by marling too heavily. Thus, in the case before cited of land adjacent to the pieces measured in experiment 10, and equally over-marled, very heavy red clover was raised in 1830, by adding gypseous earth, and which was succeeded by a good growth of corn, free from every mark of disease, in 1832.

5th. A good dressing of putrescent manure removes the disease completely, (see Exp. 11, 12, 13.) All kinds of marl (or fossil shells) have sometimes been injurious—but such effects have been more generally experienced from the dry yellow marl, than from the blue and wet.

The inferences to be drawn from these facts are obvious. They direct us to avoid injury by applying marl lightly at first, and to be still more cautious according to the existence of the circumstances stated as increasing the tendency of marl to do harm. Next, if the over-dose has already been given, we should forbid grazing entirely, and furnish putrescent manure as far as possible—or omit one or two grain crops, so as to allow more vegetable matter to be fixed in the land—apply putrescent manures—and sow clover as soon as circumstances permit. One or more of these remedies have been used on most of my too heavily marled land; and with considerable, though not always with entire success, because the means for the cure could not always be furnished at once in sufficient abundance. Other persons, who permitted close grazing, and adopted a more scourging rotation of crops, have suffered more damage, from much lighter dressings of marl than those of mine which were injurious.

But though the unlooked-for damage sustained from this cause produced much loss and disappointment, and has greatly retarded the progress of my improvements, it did not suspend my marling, nor abate my estimate of the value of the manure. If a cover of 500 or 600 bushels was so strong as

to injure land of certain qualities, it seemed to be a fair deduction, that the benefit expected from so heavy a dressing, might have been obtained from half the quantity—if not on the first crop, at least on every one afterwards. That surely is nothing to be lamented. It also afforded some consolation for the evil of the too heavy marlings already applied, that the soil was thereby fitted to seize upon and retain a greater quantity of vegetable matter, and would thereby ultimately reach a higher grade of fertility.

The cause of this disease is less apparent than its remedies. It is certain that it is not produced merely by the quantity of calcareous earth in the soil. If it were so, similar effects, shown in diseased crops, would always be found on soils containing far greater proportions of that earth. These injurious effects have not been known, to any extent, except on soils formerly acid, and made calcareous artificially: and not on either neutral or calcareous soils, even by the addition of a great excess of marl. The small spots of land that nature has made excessively calcareous, and also sandy by marl beds cropping out at the surface of cultivated fields, (as the specimen 4, page 38,) produce indeed a pale feeble growth of corn, such as might be expected from poor gravelly soils—but whether the plants yield grain, or are barren, they show none of those peculiar and strongly marked symptoms of disease which have been described. Some such places on my farm, from which great quantities of poor sandy marl had been removed for manure, and where the remainder still was of unknown depth, have been afterwards cultivated with the surrounding land: and with no more aid than the portion of the adjacent soil carried thereto necessarily by the plough, these places have gradually improved to a product equal to 12 or 15 bushels of corn per acre, and have never exhibited any mark of the marl disease.

By calculation, it appears that the heaviest dressing causing injurious consequences, if mixed to the depth of five inches, has not given to the soil a proportion of calcareous earth equal to two per cent. This proportion is greatly exceeded in our best shelly land, and no such disease is found there, even when the rich mould is nearly all washed away, and the shells mostly left. Soils of remarkable fertility from the prairies of Alabama and Mississippi have been shown (page 43) to contain from 5 to 16 per cent. of calcareous earth, all of which proportions were in the state of most minute division, and therefore most ready to produce this disease, if it could have been produced by the quantity of this ingredient. The soil of the borders of the Nile, celebrated for its exuberant fertility through thousands of successive crops, contains about 25 per cent. of carbonate of lime. (*Lyell's Geology*.) Very fertile soils in France and England sometimes contain 20 or 30 per cent. Among the soils of remarkable good qualities analyzed by Davy, one is stated to contain about 28 per cent., and another, which was eight-ninths of silicious sand, contained nearly 10 per cent. of calcareous earth. Nor does he intimate that such proportions are very rare. Similar results have been stated, from analyses reported by Kirwan, Young, Bergman, and Rozier, (page 32.) and from all the same deduction is inevitable, that much larger natural proportions of calcareous earth, than our diseased lands have received, are very common in France and England, without any such effect being produced.

From the numerous facts of which these are examples, it is certain that calcareous earth acting alone, or directly, has not caused this injury; and it seems most probable that the cause is some new combination of lime formed in acid soils only; and that this new combination is hurtful to grain under certain circumstances, which we may avoid, and is highly beneficial to every kind of clover. Perhaps it is the *salt of lime*, formed by the calcareous manure combining with the acid of the soil, which not meeting with

enough vegetable matter to combine with and fix in the soil, causes, by its excess, all these injurious effects.

CHAPTER X.

RECAPITULATION OF THE EFFECTS OF CALCAREOUS MANURES, AND DIRECTIONS FOR THEIR MOST PROFITABLE APPLICATION.

Proposition 5—continued.

From the foregoing experiments may be gathered most of the effects, both injurious and beneficial, to be expected from calcareous manures, on the several kinds of soils there described. Information obtained from statements in detail of agricultural experiments, is far more satisfactory, to the attentive and laborious inquirer, than a mere report of the general opinions of the experimenter, derived from the results. But however preferable may be this mode of reporting facts, it is necessarily deficient in method, clearness, and conciseness. It may therefore be useful to bring together the general results of these experiments in a somewhat digested form, to serve as rules for practice. Other effects of calcareous manures will also be stated, which are equally established by experience, but which did not belong to any one accurately observed experiment.

The results that have been reported confirm in almost every particular the chemical powers before attributed to calcareous manures, by the theory of their action. It is admitted that causes and effects were not always proportioned—and that sometimes trivial apparent contradictions were presented. But this is inevitable, even with regard to the best established doctrines, and the most perfect processes in agriculture. There are many practices universally admitted to be beneficial; yet there are none, which are not found sometimes useless, or hurtful, on account of some other attendant circumstance, which was not expected, and perhaps not discovered. Every application of calcareous earth to soil is a chemical operation on a great scale. Decompositions and new combinations are produced, and in a manner generally conforming to the operator's expectations. But other and unknown agents may sometimes have a share in the process, and thus cause unlooked-for results. Such differences between practice and theory have sometimes occurred in my use of calcareous manures, (as may be observed in some of the reported experiments,) but they have neither been frequent, uniform, nor important.

But in nearly all such cases of disproportion between causes and effects, in the use of marl, the manner of variation has been in the effects surpassing the anticipated power of the causes, (as previously inferred from reasoning and in advance of my practice,) and in very few, if indeed any cases, of the contrary operation, of the results falling short of what might have been inferred from the theory of the action of calcareous manures. For such variation as this, it may be that no reader will require either excuse or explanation; nevertheless it is as much due to truth that it should be stated, as if the opposite kind of difference existed.

Before my earliest trials, or practical knowledge, of the effects of marl, I was well assured that this manure would correct the acidity of poor soil, and enable it to be enriched by putrescent manures. But I was still totally at a loss to know, or to guess, how much calcareous earth would be required for that result, or how much time might be required for the sufficient

quantity to produce its full effect; and there were grounds to fear that the quantity of the manure and time for its operation, and consequently the cost compared to profit, would be much greater than after-experience has shown. If 1000 bushels of ordinary marl had been required for an acre, and 10 years time for that application to raise the product to double its previous rate, the theory of the action of calcareous manures would have been sustained. But in fact, as great effect as this has been usually produced, (in judicious and proper practice,) by measures of marl and of time less by three-fourths than those just stated. And thus, while effects have almost universally exceeded in measure the supposed power of their causes, I may safely assert that in not a single case, in the tide-water region, of a judicious application of marl or lime, has it been known that the effect fell short of what would be indicated by my theory of the action of calcareous earth as manure.

But there is still another exception, if it be one, to admit, or of apparent want of accordance between theory and practice; and unluckily, this case is of the effects falling short of the supposed power of causes. There has as yet been made but little use of lime in the region immediately above the granite ridge which forms the lower falls of our eastern rivers. But almost all the failures of lime to act that have been heard of, or of effects falling much short of what were expected and are usual, are among the few experiments which have been made within fifty miles above the granite ridge. While truth requires that the fact of these failures should be stated, I pretend not to account for them. It may be the case, and probably is, that there is a general difference of chemical constitution between even lands of like apparent texture and qualities, above and below the falls. Of the lands above, my knowledge is but slight, and founded only on general and slight personal observation, or the report and better information of practical cultivators. But judging from such uncertain lights, I would infer that the lands above the falls were much less acid than those below, even when as poor. The growth of pine and of sorrel is more scarce on lands above the falls; and gypsum often acts there on natural soils, and lime (in some known trials) has produced but slight benefit. On the contrary, gypsum is scarcely ever operative on any natural soil below the falls, (that is on none of the great body of acid soil,) and lime never fails to act on these same lands.

The most important observation to be made on the disproportion of causes and effects, in the tide-water region, is in regard to good neutral soils, and especially as to that best class known by the common name of "mulatto land." On such soils, which constitute the chief value of the best farms of James river, the applications of lime have been the most extensive, and always highly effective.

The fact that the effects of calcareous manures so generally exceed in measure the supposed power of their causes, would seem to indicate that *some other kind of action of calcareous earth as manure operates*, in addition to all those set forth in chapter viii. This I think is more than probable.

Dismissing then from further consideration such exceptions (whether real or apparent) to general rules, I will return to stating the results of applying marl as they have occurred almost without exception in my own practice, and which are confirmed by the concurrence of all known and certain testimony in regard to practical operations in the marl region of Virginia.

Under like circumstances in other respects, the benefit derived from marling will be in proportion to the quantity of vegetable or other putrescent matter given to the soil. It is essential that the cultivation should be mild,

and that no grazing be permitted on poor lands under regular tillage, and which have no supply of putrescent manure, except the grass and weeds growing on them, while at rest. Wherever farm-yard manure is used, the land should be marled heavily, and if the marl is applied first, so much the better. The marl cannot act by fixing the other manure, except so far as they are in contact, and when both are well mixed with the soil.

When I first asserted the agency and force of calcareous manures in fixing alimentary manures in soils, and maintained the great and indispensable necessity of that operation, the proposition was founded almost exclusively on reasoning, and on observation of natural soils, and not at all on practical effects experienced from applications of marl or lime. From the very nature of the case, such effects as these, however important and valuable, could not be seen at first, nor fully even in a very few years after beginning to marl, nor their extent understood and appreciated. Moreover, my earlier experience had shown so fully the incapacity of my acid or naturally poor soils to retain alimentary manures, and my labors and expenditures to apply them had been so very unprofitable, that I was not myself prepared for the full extent of the contrary operation, after marl had been applied. And though the views and estimation of such new operation have been yearly enlarging, from the experience of practical results, yet even when the last edition of this work was published, my estimate of the *fixing* value of marl fell short of what is now confidently believed, and which is every season manifest, of the greater effect and permanency, and far greater profit of alimentary manures, caused solely by the presence of calcareous earth in the same soils. Notwithstanding that the theory of the action of calcareous manures, as set forth in this essay, and published as early as 1821, made this fixing operation the first of the two most important agencies, and though that theoretical view guided my practice from the beginning, still it was not until after a long time, that gradually and slowly I fully and truly estimated the value and profit of this operation. My early and zealous efforts (before beginning to marl) to improve naturally poor lands by the vegetable and animal manures of the farm, had been so much disappointed, and the effects had been so inconsiderable as well as so fleeting, that it was long before I arrived at the conviction of the full extent of the opposite and new condition of the soil. But during latter years, the certain and profitable operation, and durable operation, of every kind of vegetable or alimentary manure, no matter how or when applied, has been made obvious; and now my estimate of value would be, that if marling had no other operation whatever than this one of making other manures much more active and durable, the profit from this one source alone would amply reward all the usual labors and expenses of marling.

On "galled" spots, from which all the soil has been washed, and where no plant can live, the application of marl *alone* is utterly useless; at least, until time and accident shall furnish some addition of vegetable matter also. Putrescent manures alone would there have but little effect, unless in great quantity, and would soon be all lost. But marl and putrescent matter together serve to form a new soil, and thus both are brought into useful action; the marl is made active, and the putrescent manure permanent. The only perfect cures, that I have been able to make, at one operation, of galls produced upon a barren subsoil, were by applying a heavy dressing of both calcareous and putrescent manures together; and this method may be relied on as certainly effectual. But though a fertile soil may thus be created, and fixed durably on galls otherwise irreclaimable, the cost will generally exceed the value of the land recovered, from the great quantity of putrescent matter required. Much of our acid hilly land

has been deprived, by washing, of a considerable portion of its natural soil, though not yet made entirely barren. The foregoing remarks equally apply to this kind of land, to the extent that its soil has been carried off. It will be profitable to apply marl to such land; but its effect will be diminished, in proportion to the previous removal of the soil. Calcareous soils, from the difference of texture, are much less apt to wash than other kinds. Within a few years after marling a field that has been injured by washing, many of the old gulleys will begin to produce vegetation, and show that a soil is gradually forming from the dead vegetables brought there by winds and rains, although no means had been used to aid this operation.

This newly acquired ability to resist the washing power of rains, is one of the most beneficial effects of marling on hilly lands. And this effect is no less certain, than it is conformable to the theory of the action of marl and to reason. On soils containing very little lime, (or none, as in naked sub-soils,) whether they be sandy or clayey, there is nothing to combine the vegetable matter with the soil, nor the different ingredients of the soil with each other. Consequently they have no cohesion, and whenever made very soft, or semi-fluid by rains, and there is any declivity, there is nothing to prevent the soil, or upper surface, being washed off by excessive rain, though falling gently. Of course, torrents of rain produce the same injurious effects much more rapidly and effectually. But when such soils have been made calcareous, a chemical combination and bond of union and coherence is formed between the lime and the putrescent or organic matter, and of both with the silicious and argillaceous parts of the soil, which combination is able to resist any but an unusual degree of the washing action of rains. Moreover, by the increase of productive power thus given, grass grows more kindly and rapidly, and by its decay the vegetable mould is continually augmented, and thereby the power of resisting washing is still more increased as the fertility of the soil is increased. This is but another aspect and operation of the power of calcareous manure in soils to fix and retain manures.

The effect of marling will be much lessened by the soil being kept under exhausting cultivation. Such were the circumstances under which we may suppose that marl was tried and abandoned many years ago, in the case referred to in page 70. Proceeding upon the false supposition that marl was to enrich by direct action, like dung, it is most probable that it was applied to some of the poorest and most exhausted land, for the purpose of giving the manure a "fair trial." The disappointment of such ill-founded expectations was a sufficient reason for the experiment not being repeated, or being scarcely ever referred to again, unless as evidence of the worthlessness of marl. Yet with proper views of the action of this manure, this experiment might at first have as well proved the early efficacy and value of marl, as it now does its durability.

When acid soils are equally poor, the increase of the first crop from marling will be greater on sandy, than on clay soils; though the latter, by heavier dressings and longer time, may ultimately become the best land, at least for wheat and for grass. The more acid the growth of any soil is, or would be, if suffered to stand, the more increase of crop may be expected from marl; which is directly the reverse of the effects of putrescent manures. The increase of the first crop on worn acid soil, I have never known under fifty per cent., and more often it is as much as one hundred; and the improvement continues to increase, under mild tillage, to three or four times the original product of the land. [See Exp. 11, page 86, and Exp. 4 and 6.] In this, and other general statements of effects, I suppose the land to bear not more than two grain crops in four years, and not to

be subjected to grazing during the other two; and that a sufficient cover of marl has been laid on for use, and not enough to cause disease. It is true, that it is difficult, if not impossible, to fix that proper medium, varying as it may on every change of soil, of cropping, and of the kind of marl. But whatever error may be made in the proportion of marl applied, let it be on the side of light dressing, (except where putrescent manures are also laid on, or designed to be laid on before the next course of crops begins) —and if less increase of crop is gained to the acre, the cost and labor of marling will be lessened in a still greater proportion. If, when tillage has served to mix the marl well with the soil, sorrel should still show to any extent, it will sufficiently indicate that not enough marl had been applied, and that it may be added to, safely and profitably. If the nature of the soil, its condition and treatment, and the strength of the marl, all were known, it would be easy to direct the amount of a suitable dressing; but without knowing these circumstances, it will be safest to give not more than 200 or 250 bushels of marl, of say 40 per cent. to the acre of worn acid soils. Twice or thrice as much might be given, safely and profitably, to newly cleared wood land, or well manured land. Besides avoiding danger, it is more profitable to marl lightly at first on weak lands. If a farmer can carry out only ten thousand bushels of marl in a year, he will derive more product, and confer a greater amount of improvement, by spreading it over forty acres of the land intended for his next crop, than on twenty; though the increase to the acre would probably be greatest in the latter case. By the lighter dressing, the land of the whole farm will be marled, and be storing up vegetable matter for its progressive improvement, in half the time that it could be marled at double the rate.

The greater part of the calcareous earth applied at one time cannot begin to act as manure before several years have passed, owing to the coarse state of many of the shells, and the want of thoroughly mixing them with the soil. Therefore, if enough marl is applied to obtain its full effect on the first course of crops, there will certainly be too much afterwards.

Perhaps the greatest profit to be derived from marling, though not the most apparent in the first few years, is on such soils as are full of wasting vegetable matter. Here the effect is mostly preservative, and the benefit and profit may be great, even though the increase of crop may be very inconsiderable. Putrescent manure laid on any acid soil, or the natural vegetable cover of those newly cleared, without marl, would soon be lost, and the crops reduced to one-half or less. But when marl is previously applied, this waste of fertility is prevented; and the estimate of benefit should not only include the actual increase of crop caused by marling, but as much more as the amount of the diminution which would otherwise have followed. Every intended clearing of woodland, and especially of those under a second growth of pines, ought to be marled before cutting down; and it will be still better, if it can be done several years before. If the application is delayed until the new land is brought under cultivation, though much putrescent matter will be saved, still more must be wasted. By using marl some years before obtaining a crop from it, as many more successive growths of leaves will be converted to useful manure, and fixed in the soil; and the increased fertility will more than compensate for the delay. By such an operation, the farmer makes a loan to the soil, at a distant time for payment, but on ample security, and at a high rate of compound interest.

Some experienced cultivators have believed that the most profitable way to manage pine old fields, when cleared of their second growth, was to cultivate them every year, until worn out—because, as they said, such land

would not last much longer, no matter how mildly treated. This opinion, which would seem at first so absurd, and in opposition to all the received rules for good husbandry, is considerably supported by the properties which are here ascribed to such soils. When these lands are first cut down, an immense quantity of vegetable matter is accumulated on the surface, which, notwithstanding its accompanying acid quality, is capable of making two or three crops nearly as good as the land was ever before able to bring. But as the soil has no power to retain this vegetable matter, it will begin rapidly to decompose and waste, as soon as exposed to the sun; and will be lost, except so much as is caught, while escaping, by the roots of growing crops. The previous application of marl, however, would make it profitable in these, as well as other cases, to adopt a mild and meliorating course of tillage.

Less improvement will be obtained by marling worn soils of the kind called "free light land," than other acid soils which originally produced much more sparingly. The early productiveness of this kind of soil, and its rapid exhaustion by cultivation, at first view seem to contradict the opinion that durability and the ease of improving by putrescent manures are proportioned to the natural fertility of the soil. But a full consideration of the circumstances will show that no such contradiction exists.

In defining the term *natural fertility*, it was stated that it should not be measured by the earliest products of a new soil, which might be either much reduced, or increased, by temporary causes. The early fertility of free light land is so rapidly destroyed, as to take away all ground for considering it as fixed in, and belonging to the soil. It is like the effect of dung on the same land afterwards, which throws out all its benefit in the course of one or at most two years, and leaves the land as poor as before. But still it needs explanation why so much productiveness can at first be exerted by any acid soil, as in those described in the 14th experiment. The causes may be found in the following statement. These soils, and also their sub-soils, are principally composed of coarse sand, which makes them of more open texture than best suits pine, and (when rich enough) more favorable to other trees, the leaves of which have no natural acid, and therefore decompose more readily. As fast as the fallen leaves rot, they are of course exposed to waste; but the rains convey much of their finer parts down into the open soil, where the less degree of heat retards their final decomposition. Still this enriching matter is liable to be further decomposed, and to final waste; but though continually wasting, it is also continually added to by the rotting leaves above. The shelter of the upper coat of unrotted leaves, and the shade of the trees, cause the first as well as the last stages of decomposition to proceed slowly, and to favor the mechanical process of the products being mixed with the soil. But there is no chemical union of the vegetable matter with the soil. When the land is cleared, and opened by the plough, the decomposition of all the accumulated vegetable matter is hastened by the increased action of sun and air, and in a short time every thing is converted to food for plants. This abundant supply suffices to produce two or three fine crops. But now, the most fruitful source of vegetable matter has been cut off—and the soil is kept so heated (by its open texture) as to be unable to hold enriching matters, even if they were furnished. The land soon becomes poor, and must remain so, as long as these causes operate, even though cultivated under the mildest rotation. When the transient fertility of such a soil is gone, its acid qualities (which were before concealed in some measure by so much enriching matter,) become evident. Sorrel and broom grass cover the land, and if allowed to stand, pines will then take complete possession, because the poverty of the soil leaves them no rival to contend with.

Marling deepens cultivated sandy soils, even lower than the plough may have penetrated. This was an unexpected result, and when first observed seemed scarcely credible. But this effect also is a consequence of the power of calcareous earth to fix manures. As stated in the foregoing paragraph, the soluble and finely divided particles of rotted vegetable matters are carried by the rains below the soil; but as there is no calcareous earth there to fix them, they must again rise in a gaseous form, after their last decomposition, unless previously taken up by growing plants. But after the soil is marled, calcareous as well as putrescent matter is carried down by the rains as far as the soil is open enough for it to pass. This will always be as deep as the ploughing has been, and somewhat deeper in loose earth; and the chemical union formed between these different substances serves to fix both, and thus increases the depth of the soil. This effect is very different from the deepening of a soil by letting the plough run into the barren sub-soil. If, by this mechanical process, a soil of only three inches is increased to six, as much as it gains in depth, it loses in richness. But when a marled soil is deepened gradually, its dark color and apparent richness are increased, as well as its depth. Formerly, single-horse ploughs were used to break all my acid soils, and even these would often turn up sub-soil. The average depth of soil on old land did not exceed three inches, nor two on the newly cleared. Even before marling was commenced, my ploughing had generally sunk into the sub-soil—and since 1825, most of this originally thin soil has required three mules, or two good horses to a plough, to break the necessary depth. The soil is now from six to eight inches deep generally, from the joint operation of marling and deepening the ploughing a little in the beginning of every course of crops; and to that depth, or very nearly, the land is now ploughed whenever preparing for corn, or for wheat on clover.

Since marling was begun, the deepening of the soil has much more generally preceded than followed the deepening of the ploughing. How destructive to the power of soil this present depth of ploughing would have been, without marling, may be inferred from the continued decrease of the crop, through four successive courses of a very mild rotation, on the spot kept without marl in experiment 10. Yet the depth of ploughing there did not exceed six inches, and depths of nine and even twelve inches were tried, without injury, on parts of the adjacent marled land.

This remarkable and valuable effect of marling, in deepening the soil, is increased in action by the sub-soil being *sandy*, which is commonly deemed the worst kind of sub-soil. Land having a clay sub-soil, which is known in common parlance as land with “a good foundation,” is almost universally prized; and that impervious sub-soil is supposed necessary to prevent the manure and the rains from sinking, and being lost. And such may be among the disadvantages, before marling, of poor land having a sandy sub-soil. But not so after marling. While the open texture of such a sub-soil permits so much of the water as is superfluous and injurious to sink and disappear, and the combined manures to sink enough to deepen the soil, (by converting barren sub-soil to productive soil,) the attractive force of the calcareous earth, for both putrescent matter and moisture, will much more effectually prevent either from being lost to the soil, than the mechanical obstruction of a clay sub-soil. Great as are the objections entertained by most farmers to sandy sub-soils, or to what they call “land without any foundation,” I would decidedly prefer such to lands having an impervious clay sub-soil—supposing both to be equally barren. The subjects of all my experiments stated as made on acid sandy loams, had also sub-soils of yellow and barren sand; and on such lands have been made my greatest and most profitable improvements by marling. However, a sub-soil (and

also a soil) more of medium texture, would no doubt have been as much better than the very sandy, as the latter was better than the very stiff and impervious clay sub-soils.

Besides the general benefit which marling causes equally to all crops, by making the soils they grow on richer and more productive, there are other particular benefits which affect some plants more than others. For example, marling serves to make soils warmer, and thereby hastens the ripening of every crop, more than would take place on the like soils, if made equally productive by other than calcareous manures. This quality of marled land is highly important to cotton, as our summers are not long enough to mature the later pods. Wheat also derives especial benefit from the warmth thus added to the soil. It is enabled better to withstand the severe cold of winter; and even the short time by which its ripening is forwarded by marling, serves very much to lessen the danger of that crop from the worst of all its diseases, the *rust*. Wheat also profits by the absorbent power of marled land, (by which sands acquire, to some extent, the best qualities of clays,) though less so than clover and other grasses that flourish best in a moist climate. Indian corn does not need more time for maturing than our summers afford, (except on the poorest land,) and can sustain much drought without injury, and therefore is less aided by these qualities of marled land. Most (if not all) the different plants of the pea kind, and all the varieties of clover, derive such remarkable benefit from marling, that it must be caused by some peculiarity in the nature of those plants. Perhaps a large portion of calcareous earth is necessary as part of their food, to aid in the formation of the substance of these plants, as well as to preserve their healthy existence.

On acid soils, without heavy manuring, it is scarcely possible to raise red clover; and even with every aid from putrescent manure, the crop will be both uncertain and unprofitable. The recommendation of this grass, as part of a general system of cultivation and improvement, by the author of '*Arator*,' is sufficient to prove that his improvements were made on soils far better than such as are general. Almost every zealous cultivator and improver (in prospect) of acid soil has been induced to attempt clover culture, either by the recommendations of writers on this grass, or by the success witnessed on better constituted soils elsewhere. The utmost that has been gained, by any of these numerous efforts, has been sometimes to obtain one, or at most two mowings, of middling clover, on some very rich lot, which had been prepared in the most perfect manner by the previous cultivation of tobacco. Even in such situations, this degree of success could only be obtained by the concurrence of the most favorable seasons. Severe cold, and sudden alternations of temperature in winter and spring, and the spells of hot and dry weather which we usually have in summer, were alike fatal to the growth of clover, on so unfriendly a soil. The few examples of partial success never served to pay for the more frequent failures and losses; and a few years' trial would convince the most ardent, or the most obstinate advocate for the clover husbandry, that its introduction on the great body of land in lower Virginia was absolutely impossible. Still the general failure was by common consent attributed to any thing but the true cause. There was always some reason offered for each particular failure, sufficient to cause it, and but for which, (it was supposed,) a crop might have been raised. Either the young plants were killed by freezing soon after first springing from the seed—or a drought occurred when the crop was most exposed to the sun, by reaping the sheltering crop of wheat—or native and hardy weeds overran the crop—and all such disasters were supposed to be increased in force, and rendered generally fatal,

by our sandy soil, and hot and dry summers. But after the true evil, *the acid nature of the soil*, is removed by marling, clover ceases to be a feeble exotic. It is at once naturalized on our soil, and is able to contend with rival plants, and to undergo every severity and change of season, as safely as our crops of corn and wheat—and offers to our acceptance the fruition of those hopes of profit and improvement from clover, with which previously we had only been deluded.

After much waste of seed and labor, and years of disappointed efforts, I abandoned clover as utterly hopeless. But after marling the fields on which the raising of clover had been vainly attempted, there arose from its scattered and feeble remains, a growth which served to prove that its cultivation would then be safe and profitable. It has since been gradually extended over all the fields. It will stand well, and maintain a healthy growth on the poorest marled land; but the crop is too scanty for mowing, or perhaps for profit of any kind, on most poor sandy soils, unless aided by gypsum. Newly cleared lands yield better clover than the old, though the latter may produce as heavy grain crops. The remarkable crops of clover raised on very poor clay soils, after marling, have been already described. This grass, even without gypsum, and still more if aided by that manure, will add greatly to the improving power of marl; but it may do as much harm as service, if we greedily take from the soil nearly all of the supply of putrescent matter which it affords.

Some other plants, less welcome than clover, are equally favored by marling. Unless both the tillage and the rotation of crops be good, green-sward (*poa pratensis*), blue grass (*poa compressa*), wire grass (*cynodon dactylon*), and partridge pea (*vicia sativa*), will soon increase so as to be not less impediments to bad tillage, or to the grain crops, than manifest evidences of an entire change in the character and power of the soil.

The power of calcareous manures is still more strongly shown in the eradication of certain plants, as has been before incidentally mentioned. Sorrel (*rumex acetosus*), is the most plentiful and injurious weed on the cultivated acid soils of lower Virginia; an unmixed growth of poverty grass (*aristida gracilis* and *a. dichotoma*) is spread over all such lands, a year after being left at rest; at a somewhat later time broom-grass (*andropogon*) of different kinds covers them completely; and if suffered to remain unbroken a few years longer a thick growth of young pines will succeed. But as soon as such land is sufficiently and properly marled, there remains no longer the peculiar disposition or even power of the soil to produce these plants. Sorrel is totally removed, and poverty grass no more is to be found, where both in their turn before had entire possession. The appearance of a single tuft of either of these plants is enough to prove that the acid quality of the soil on that spot still remains, and that either more marl, or more complete intermixture, is still wanting. Thus, the presence of either of these plants is the most unerring as well as most convenient and ready indication of a soil wanting calcareous manure. The most laborious analyses, by the most able chemists, directed to ascertain the different characters of soils in this respect, are not to be compared for accuracy to the tests furnished by either the appearance or total absence of sorrel or poverty grass. In regard to broom-grass and pines, the change is not so sudden, nor complete; but still the soil will have been made manifestly unfriendly to both. Some striking apparent exceptions to these rules have caused some persons to doubt of their correctness; when full examination of the circumstances would have confirmed my positions. I have known a mere top-dressing of marl, left for some years on a worn-out old field, to eradicate the before general growth of broom-grass, and substitute

a cover of annual weeds. Yet on other tillage land, after marling and one crop of wheat on fallow, I have seen the growth of broom-grass return, and seemingly with greater than its former vigor. But this return and vigor were but temporary, and the land is now comparatively free from this injurious weed. When soil, already filled with its seeds, is very imperfectly mixed with marl by ploughing, these is nothing to prevent the broom-grass springing from all the spots not touched by the marl, whether these spots be above or below or between unmixed masses of marl. And the growth being thin and scattered, and not covering the surface completely as formerly, will cause the separate tufts of broom-grass to be much more luxuriant, and greater impediments to tillage, than previously. But the next course of tillage will serve to mix the marl and soil completely, and remove all appearance of marl being favorable instead of destructive to broom-grass. Sorrel may often be seen growing out of the heaps of pure marl, dropped from the carts on acid land, and the heaps left thus, unspread, through a summer. But this apparent and very striking exception may be fully explained. The heaps of marl, thus left, had not as yet by any intermixture affected the original composition of the soil below; and the seeds or roots of sorrel therein were therefore free to spring and grow; and the great hardness and remarkable vital power of that plant enabled it to rise through the (to it) dead matter and great obstruction of several inches thickness of pure marl above. On examining the roots of sorrel thus growing out of marl, it will be seen clearly, and invariably, that they drew all their support from the still acid soil below, and merely passed through the marl, without drawing any thing therefrom.

CHAPTER XI.

RECAPITULATION OF EFFECTS, AND DIRECTIONS FOR PRACTICE CONTINUED.

Proposition 5—continued.

If the foregoing views may be confided in, the general course most proper to pursue in using calcareous manures may thence be deduced without difficulty. But as I have found, since the publication of the previous edition of this essay, that many persons still ask for more special directions to guide their operations, and as all such difficulties may not be entirely obviated even by the more full details now given, I will here add the following directions, at the risk of their being considered superfluous. These directions, like all the foregoing reasoning, may apply generally, if not entirely, to the use of all kinds of calcareous manures, and to soils in various regions; but to avoid too wide a range, I shall consider them as applied particularly to the poor lands of the tide-water region, and addressed to persons who are just commencing their improvement by means of the fossil shells or marl of the same region.

As the cheapest mode of furnishing vegetable matter to land intended to be marled and cultivated, no grazing should be permitted. It is best to put the marl on the grass previous to ploughing the field for corn, as the early effect of this manure is greatest when it has been placed in contact with the vegetable matter. But this advantage is not so great as to induce the ploughing to be delayed, or to stop the marling after that operation.

When the marl is spread upon the ploughed surface, it can be better mixed with the soil by the cultivation of the crop; and this advantage in some measure compensates for the loss of that which would have been obtained from an earlier application on the sod. If marl is ploughed in, it should not be so deeply as to prevent its being mixed with the soil, speedily and thoroughly, by the subsequent tillage. To make sure of equal operation, the marl should be spread regularly over the surface. From neglect in this respect, a dressing of marl is often too thin in many places to have its proper effect, and in others, so thick as to prove injurious. Hence it is, that marl-burnt stalks of corn and tufts of sorrel are sometimes seen on the same acre.

After the first year, the farmer may generally marl fast enough to keep ahead of his cultivation; and even though he should reduce the space of his tillage to one-half, it will be best for him not to put an acre in corn without its being marled. Fifty acres can generally be both marled and tilled, as cheaply as one hundred can be tilled without marling; and the fifty with marl will produce as much as the hundred without, in the first course of crops, and much more afterwards.

That rotation of crops which gives most vegetable matter to the soil, is best to aid the effects of marl recently applied. The four-shift rotation is convenient in this respect, because two or three years of rest may be given in each course of the rotation at first, upon the poorest land; and the number of exhausting crops may be increased, first to two, then to three in the rotation, as the soil advances to its highest state of productiveness.

After marling, clover should be sown, and gypsum on the clover. On poor, though marled land, of course only a poor growth of clover can be expected; but wherever other manures are given, and especially if gypsum is found to act well, the crop of clover becomes a most important part of the improvement by marling. Without clover, and without returning the greater part of the early product to the soil, the greatest value of marling will not be seen. A small proportion of the clover may be used as food for cattle; and in a few years even this small share will far exceed all the grass that the fields furnished before marling and the limitation of grazing. What is at first objected to as lessening the food of grazing stock, and their products, within a few years becomes the source of a far more abundant supply.

During the first few years of marling, but little attention can (or indeed ought to) be given to making putrescent manures, because the soil much more needs calcareous manure—and three or four acres may generally be supplied with the latter, as cheaply as one with the former. But putrescent manures cannot any where be used to so much advantage as upon poor soils made calcareous; and no farmer can make and apply vegetable matter as manure to greater profit than he who has marled his poor fields, and can then withdraw his labor from applying the more to the less valuable manure. After the farm has been marled over at the light rate recommended at first, every effort should be made to accumulate and apply vegetable manures; and with their gradual extension over the fields, a second application of marl may be made, making the whole quantity, in both the first and second marling, 500 or 600 bushels to the acre, or even more; which quantity would have been hurtful if given at first, but which will now be not only harmless, but necessary to fix and retain so much putrescent and nutritive matter in the soil.

The above injunction, that "every effort should be made to accumulate and apply vegetable manures," should not be limited, as most new improvers would be apt to do, to the mere economical use of the vegetable materials for manure furnished by the crops, and those only as prepared by being

first used as litter for animals. Not only these, but every other vegetable and putrescent material that is accessible should be saved and applied, and even without any intermediate process of preparation, and at any time of the year, and state of the fields, provided no growing or commencing crop be thereby molested. Surplus straw, not needed for food or litter, is most valuable and cheaply applied as top-dressing to clover or other grass; though it is an inconvenient and troublesome manure if immediately ploughed under. Leaves from the woods of the farm may be used most profitably in the same manner, to the full extent of the resources offered. And though the manuring operations on the Coggins Point farm have not yet been extended beyond the last named putrescent material, it is believed that other and abundant sources yet remain untried and unproductive on that and most other farms, and to use which would be but a waste of labor or money, if in advance of marling. Among the most abundant of such materials, may be mentioned marsh grasses and marsh or pond mud; and also the purchase of rich alimentary manures from towns, to be carried by land or by water carriage to much greater distances than has yet been done, or can be afforded to be done, on other lands. Even saw-dust and spent tanner's bark, which, because of their insolubility, are generally deemed of no value as manures, would form important and valuable materials for fertilization, in situations where they can be obtained cheaply and in great quantity. Mixing these or other insoluble vegetable substances with rich putrescent matters, and still more if with some alkaline matter also, would render them soluble, and convert them to food for plants.

But putting aside the consideration of all such unusual or untried resources and operations for additional fertilization, and limiting the present view merely to the ordinary materials furnished by every farm, the progress and profit of improvement by such means only, after marling, will be greater than will be at first believed by most cultivators of acid soils, not yet marled or limed. If, on such soils, the general course above advised be pursued, (and using merely the resources of the farm after marling,) the products of crops on all the marled land usually will be doubled in the first course of the rotation—often in the first crop immediately following the marling; and the original product may be expected to be tripled by the third return of the rotation. And this may be from merely applying marl in sufficient (and not excessive) quantities, and giving the land two years rest in four without grazing. But on the parts having the aid of farm-yard and other putrescent manures, and of clover, still greater returns may be obtained.

When such statements as these are made, the question naturally occurs to the reader, "Has the writer himself met with so much success, and what has been the actual result of his labors in general, in the business so strongly recommended?" This question I have no right to shrink from, although the answer to be given fully will be objectionable, from the egotism inseparable from such details, which are certainly not worth being thus presented to public notice, and which are called for only because silence on this head might be considered as operating against the general tenor of this essay. It will be sufficient here to state generally, that my average profits from marling, and the increased fertility derived from it, have not been as great as are promised above, nor such as might be expected from the most successful experiments of which the results have been reported—and for these reasons. 1st. The greater part of my land was not of soil the best adapted to be improved by marling. 2d. Having at first every thing to learn, and to prove by trial, much of my labor was lost uselessly, or spent in excessive and injurious applications. 3d. The fitness given to the soil by marl to produce clover was not found out until after that best

auxiliary to improvement ought to have been in full use. 4th. From the want of labor and capital to use both calcareous and putrescent manures, the collecting and applying of the latter were almost entirely neglected as long as there was full employment in marling. And, 5th. That general bad practical management, which I have to admit has marked all my business, has of course also affected injuriously this important branch—though in a less degree, because it was as much as possible (until about 1826,) under my personal and close attention. With all these drawbacks to complete success, I am able to state the following general results of my operations. Omitting the land on Coggins Point farm not susceptible of any considerable or profitable improvement from marling, the great body of the farm was tripled in productive power from 1818, when my first experiment was made, to 1834. Particular bodies of soil now produce four-fold the former amount without any other kind of manure; and the whole farm, including the parts least improved as well as the most, and allowing for the increase of extent of surface, will now make more than double of its best product before marling. Statements on this head, more in detail, will be given in the Appendix.

With all the increase of products that I have ascribed to marling, the heaviest amounts stated may appear inconsiderable to farmers who till soils more favored by nature. Corn yielding twenty-five or thirty bushels to the acre, is doubled by many natural soils in the western states; and ten or twelve bushels of wheat, will still less compare with the product of the best lime-stone clay land. The cultivators of our poor region, however, know that such products, without any future increase, would be a prodigious addition to their present gains. Still it is doubtful whether these rewards are sufficiently high to tempt many of my countrymen speedily to accept them. The opinions of many farmers have been so long fixed, and their habits are so uniform and unvarying, that it is difficult to excite them to adopt any new plan of improvement, except by promises of profits so great, that an uncommon share of credulity would be necessary to expect their fulfilment. The net profits of marling, if estimated at twenty or even fifty per cent. per annum, on the expense, for ever—or the assurance, by good evidence, of doubling the crops of a farm in ten years or less—will scarcely attract the attention of those who would embrace without any scrutiny, a plan that promised five times as much. Hall's scheme for cultivating corn was a stimulus exactly suited to their lethargic state; and that impudent Irish impostor found many steady old-fashioned farmers willing to pay for his directions for making five hundred barrels of corn without ploughing, and with the hand labor of two men only.

The products and profits derived from the use of marl as presented in the preceding pages, considerable as they are, have been kept down, or lessened in amount, by my then want of experience, and ignorance of the danger of injudicious applications. My errors may at least enable others to avoid similar losses, and thereby to reach equal profits with half the expense of time and labor. But are we to consider even the greatest known increase of product that has been yet gained in a few years after marling, as showing the full amount of improvement and profit to be derived! Certainly not; and if we may venture to leave the sure ground of practical experience, and look forward to what is promised by the theory of the operation of calcareous manures, we must anticipate future crops far exceeding what have yet been obtained. To this, the ready objection may be opposed, that the sandiness of the greater part of our lands will always prevent their being raised to a high state of productiveness—and particularly, that no care nor improvement can make heavy crops of wheat on such soils.

This very general opinion is far from being correct; and as the error is important, it may be useful to offer some evidence in support of the great value to which sandy soils may arrive.

We are so accustomed to find sandy soils poor, that it is difficult for us to connect with them the idea of fertility, and still less of durability. Yet British agriculturists, who were acquainted with clays and clay loams of as great value, and as well managed under tillage, as any in the world, speak in still higher terms of certain soils which are even more sandy than most of ours. For example—"Rich sandy soils, however," says Sir John Sinclair, "such as those of Frodsham in Cheshire, are invaluable. They are cultivated at a moderate expense; and at all times have a dry soundness, accompanied by moisture, which secures excellent crops, even in the driest summers."* Robert Brown (one of the very few who have deserved the character of being both able writers and successful practical cultivators) says—"Perhaps a true sandy loam, incumbent on a sound sub-soil, is the most valuable of all soils."† Arthur Young, when describing the soils of France, in his agricultural survey of that country, in several places speaks in the highest terms of different bodies of light or sandy soils, of which the following example, of the extensive district which he calls the plain of the Garonne, will be enough to quote: "It is entered about Creissensac, and improves all the way to Montauban and Toulouse, where it is one of the finest bodies of fertile soil that can any where be seen."—"Through all this plain, wherever the soil is found excellent, it consists usually of a deep mellow friable sandy loam, with moisture sufficient for any thing; much of it is calcareous."‡ The soil of Belgium, so celebrated for its high improvement and remarkable productiveness, is mostly sandy. The author last quoted, in another work describes a body of land in the county of Norfolk, as "one of the finest tracts that is any where to be seen"—"a fine, deep, mellow, putrid sandy loam, adhesive enough to fear no drought, and friable enough to strain off superfluous moisture, so that all seasons suit it; from texture free to work, and from chemical qualities sure to produce in luxuriance whatever the industry of man commits to its friendly bosom."§ Mr. Coke, the great Norfolk farmer, made on the average 24 bushels of wheat to the acre, on an estate of as sandy soil as our Southampton, (where probably a general average of two bushels could not be obtained, if general wheat culture were attempted)—and many other farms in Norfolk yielded much better wheat than Mr. Coke's in 1804, when Young's survey was made. Several farms averaged 36 bushels, and one of 40 is stated; and the general average of the county was 24 bushels.|| Yet the county of Norfolk was formerly pronounced by Charles II. to be only fit "to cut up into strips, to make roads of for the balance of the kingdom"—and that sportive description expressed strongly the sandy nature of the soil, as well as its then state of poverty.

Because certain qualities of poor clay soils (particularly their absorbent power) make them better than poor sands for producing wheat, we most strangely attach a value to the stiffness and intractability of the former. Yet if all the absorbent quality and productive power of clay could be given to sand, surely the latter would be the more valuable in proportion to its being friable and easy to cultivate. The causes of all the valuable qualities and productive power of the rich sands that have been referred to, are only calcareous and putrescent manures, and depth of soil; and if

* Code of Agriculture, p. 12.

† Brown's Treatise on Agriculture, p. 218, of "Agriculture" in Edin. Ency.

‡ Young's Tour in France.

§ Young's Survey of Norfolk, p. 4.

|| Young's Survey of Norfolk, p. 300 to 304.

the same means can be used, our now poor sands may also be made as productive and valuable. I do not mean to assert that the most highly improved sandy soils can produce as much wheat as the best clay soils; but they will not fall so far short as to prevent their being the more valuable lands, for wheat as well as other crops, on account of their being more easily cultivated, and less liable to suffer from bad seasons, or bad management.

The greatest objection to the poor sandy lands of lower Virginia, as subjects for improvement by calcareous manures, is not their excess of sand, nor yet their poverty—great as may be both these disadvantages—but it is the *shallowness* of the poor and sandy soil. The natural soil of a large portion of these lands, before cultivation, is not more than from one to two inches deep, lying on a barren sub-soil of sand. Now suppose this very shallow soil to be doubled or even tripled in fertility by marling, or a productive power of 6 or 9 bushels of corn be raised to 18 bushels, still it would be but mean land. And a long succession of annual vegetable covers to be left on the land, or a great quantity of prepared putrescent manure furnished at once, would be required to make such soil both rich and deep. If the original soil had been ten inches deep, the fertility before marling might have been but little more than on the shallowest soil. But heavy marling and deep and good tillage would have served speedily to make a rich and productive soil, approaching in value to those rich sands of Europe mentioned above.

Another large class of the poor lands of lower Virginia are the close stiff clays, of which the soil is still more shallow than the sands. Such land was described at page 77 and formed the subjects of experiments 5, 6 and 7. This is the very worst soil known before being marled, and also the most worthless of all known marled soils. And yet a three-fold product has been usually obtained on these lands by marling alone, within four or at most eight years after the application of marl. Still, this land, as well as the most sandy, wants only greater depth of soil and abundance of vegetable matter, to become fertile and valuable.

While then calcareous manures may be counted on to produce great improvement on all soils not naturally provided with them—and to show as great a *per centage* of increase on the worst as on better soils, and a remunerating profit on all—still, it will be far more profitable to marl some soils than others. Dung, or other alimentary manure in the best condition for use, increases vegetation mainly in proportion to the quantity of the manure, and without regard or proportion to the previous product of the soil. Thus, a wasteful application of dung might in a single year increase the production of an acre of very poor land, from 5 bushels to 50 bushels of corn. But calcareous manures improve production in proportion to the previous power of the soil; and if the original product be very low, the addition thereto of 100 or even 200 per cent., made on the first crops after marling, will show still but a poor product. These remarks and illustrations are designed for the instruction of those beginners who deem it important to learn on what kinds of soil to apply their marl. In more general terms I would answer, “apply it to all soils not already calcareous;” for however different may be the measure of profit, I have never known marl applied unprofitably in regard to place, if applied judiciously in manner. Of course I refer to soils having some previous productive power and some tenacity; and not to such naked sands, drifting with the winds, as are seen in parts of North Carolina, South Carolina and Georgia.

CHAPTER XII.

THE PERMANENCY OF CALCAREOUS MANURES, AND OF ALIMENTARY OR PUTRESCENT MANURES, WHEN COMBINED WITH THE CALCAREOUS.

Proposition 5—continued.

It was stated, (page 70) that the ground on which an old experiment was made and abandoned as a failure, more than sixty years ago, still continues to show the effects of marl. Lord Kames mentions a fact of the continued beneficial effect of an application of calcareous manure, which was known to be one hundred and twenty years old.* Every author who has treated of manures of this nature, attests their long duration. But when they say that they will last twenty years, or even one hundred and twenty years, it amounts to the admission that at some future time the effects of these manures will be lost. This I deny—and from the nature and action of calcareous earth, claim for its effects a duration that will have no end.

If calcareous earth, applied as manure, is not afterwards combined with some acid in the soil, it must retain its first form, which is as indestructible, and as little liable to be wasted, by any cause whatever, as the sand and clay that form the other earthy ingredients of the soil. The only possible vent for its loss, is the very small proportion taken up by the roots of plants, which is so inconsiderable as scarcely to deserve naming.

Clay is a manure for sandy soils, serving to close their too open texture. When so applied, no one can doubt but that this effect of the clay will last as long as its presence, or as long as the soil itself. Neither can calcareous earth cease to exert its peculiar powers as a manure, any more than clay can, by the lapse of time, lose its power of making sands more firm and adhesive. Making due allowance for the minute quantity drawn up into growing plants, it is as absurd to assert that the calcareous earth in a soil, whether furnished by nature or not, can be exhausted, as that cultivation can deprive a soil of its sand or clay.

But on my supposition that calcareous earth will change its form by combining with acid in the soil, it may perhaps be doubted by some whether it will be equally safe from waste under its new form. It must be admitted that the permanency of this compound cannot be proved by its insolubility, or other properties, because neither the kind nor the nature of the salt itself is yet known.† But judging from the force with which good neutral soils resist the exhaustion of their fertility, and their always preserving their peculiar character, it cannot be believed that the calcareous earth, once present, has been lessened in durability by its chemical change of form. It was contended that the action of calcareous earth is absolutely necessary to make a poor acid soil fertile; but it does not thence follow that other substances, and particularly *this salt of lime*, may not serve as well to preserve the fertility bestowed at first by calcareous earth. All that is required for this purpose, is the power of combining with putrescent matter, and thereby fixing it in the soil; and judging solely from effects,

* Gentleman Farmer, page 266, 2d Edin. edition.

† This passage is left as it stood in the first edition, before the discovery of the humic acid was known. Indeed no aid has been derived from that discovery, nor any change of language made in consequence of it, except by inserting the quotation respecting this substance, and the remarks thereon, at page 53.

this power seems to be possessed in an eminent degree by this new combination of lime. If this salt is the oxalate of lime, (as there is most reason to believe,) it is insoluble in water, and consequently safe from waste; and the same property belongs to most other combinations of lime with vegetable acid. The acetate of lime is soluble in water, and while alone, might be carried off by rains. But if it combines with putrescent matter, by chemical affinity, its previous solubility will no longer remain. Sulphate of iron (copperas) is easily soluble; but when it forms one of the component parts of ink, it can no longer be separately dissolved by water, or taken away from the coloring matter combined with it. In rich limestone soils, and some of our best river lands, in which no carbonate of lime now remains, we may suppose that its change of form to some other salt of lime took place centuries ago. Yet, however scourged and exhausted by cultivation, these soils still show, as strongly as ever, the qualities which were derived from their former calcareous ingredient. When the dark color of such soils, their power of absorption, and of holding manures, their friability, and their peculiar fitness for clover and certain other plants, are no longer to be distinguished, then, and not before, may the salt of lime be considered as lost to the soil.

But though all persons would probably admit this general proposition, that these natural qualities of good soils, including a certain degree of, or tendency to productive power, are permanent, (which is but stating in other words, that the good effects of calcareous manures are permanent—) still perhaps few would grant the possibility of permanency of effect to putrescent manures also, when added thereafter. Yet this latter proposition is as legitimate a deduction from the former, as the former proposition is from the theory which has been maintained of the action of calcareous manures. The attention of the reader is requested to the argument which will now be offered to sustain this important deduction.

We have all been trained to consider farm-yard and stable manures, dung, and all vegetable and other putrescent matters, when applied to soils, as having temporary effects only; and whether the effects lasted for but the first crop, as on acid sandy soils, or for four, six or even eight years on well constituted natural soils, still the effects were truly, as usually considered, only for a limited time, and would at some period be totally lost, and the ground so manured would return to the same state of less productiveness, as of the surrounding land, previously equal, and which had received no such manuring. Such views are almost universal; and the utmost that would be claimed by the most zealous and sanguine advocate for extending the use of such manures, would be a protracted though still limited and temporary duration of effect. And the actual results would always accord with these opinions, (and also with my theory of the action of calcareous manures,) both on good and on bad soils, before making them more calcareous. All natural soils (not excessively and injuriously calcareous,) have secured by their natural powers and facilities, and have had fixed in them, as much alimentary matter as their natural ingredient of lime could combine with. If that ingredient had been very small, the soil would be poor; if large, then the soil would be rich. But in neither case would there be power in the soil to combine with an additional supply of alimentary manure; and if such were applied, it would be exhausted and pass away, rapidly on the bad soil, and more slowly on the good; but certainly, in the end, on both.

Again, suppose the soils to be more or less exhausted by scourging cultivation. Then their actual amount of alimentary matter would have been reduced below what their respective shares of lime could combine with

and retain, under a state of nature, or of mild tillage. Then, if alimentary manures were applied, so much as was required for combination by the lime present would be as permanently fixed as if the original fertility had never been abstracted; and any additional quantity and excess of manure, not being so combined and fixed, would be totally lost in more or less time, as in the previously supposed case.

Lest these propositions may not appear, because of their novelty, perfectly clear and unquestionable to every reader, an illustration will be offered which can scarcely fail to induce their general and ready admission. Suppose a cultivator to have two fields, one of bad and poor soil naturally, and the other of the best natural quality—and both having been brought under cultivation together, and kept under the same rotation of crops and other management. Suppose further that the equal and uniform course of cropping has been such, (whether taking one or two or three grains crops to one year of rest and resuscitation,) that both fields have neither been reduced nor increased in average product, since brought under regular tillage—and that such average product, when of corn, is equal to 10 bushels per acre on the poor, and 50 bushels on the rich soil. Now, these different products are derived from the different funds of alimentary and putrescent manure originally supplied to the soil by nature, (which were just so much as the lime of each soil could combine with,) and, under the supposed degrees of exaction and relief counteracting each other under tillage, the same rates of product may be obtained for ever. And the yielding of 50 bushels by the one soil operates no more to reduce its after power of production, than the yield of the other of but one-fifth of that amount of crop. The yield from each soil, at and for the time, is certainly so much reduction of its productive power; but the recuperative power of each (to seize upon and hold to new supplies for fertilization) is in proportion to the yield; and the vegetable growth serving for manure, and atmospherical influences, during a year of rest, will continually give to the good soil the renewed power of producing again its large crop, as certainly as to the poor soil the power of still continuing to produce its small crop. It is not that the natural alimentary manure in the soil is not taken away in part, by the growth and removal of every crop—but that such waste is continually compensated by new acquisitions. And whether such new supplies of alimentary matter be furnished in part during every day, or in every year, or only during the one term of rest in the whole course of crops, the practical result is the same, of the natural or original amount of alimentary manure remaining finally undiminished.

So far as to the absolute permanency of putrescent or alimentary manures supplied by nature. Next let us see whether the same reasoning, and also experience, so far as yet obtained, do not in like manner prove the permanency of putrescent manures applied after calcareous manures. The poor soil just presented for illustration, while having its natural alimentary ingredient and its natural supply of lime thus balanced and proportioned to each other, was supposed to produce at the rate of 10 bushels of corn to the acre, and to remain at or near that rate of productive power. Suppose then marl to be applied in such quantity as would give enough calcareous earth to combine with twice as much new alimentary matter as the soil before held. Suppose further, that the soil so marled is not left to draw and store up this now needed stock of alimentary manure by its newly increased power, (and as would be done in due time, if under favorable circumstances of tillage,) but that so much putrescent manure is applied to the soil, gradually and judiciously, as can be combined with and held by the supply of calcareous earth; and that such addition of manure gives to

the soil a power to produce 30 bushels of corn. As soon as this combination is completely made, the soil is in precisely the same condition as to its newly increased rate of product of 30 bushels, as before to that of 10 bushels; and the new and larger supply of putrescent manure must be as permanent as was the natural and smaller supply.

But it is not contended that the mere application of vegetable or other putrescent manure, under such circumstances, secures the permanency of effect of all thus applied, but only of so much as can be and is combined with the calcareous earth. And many circumstances may and do usually obstruct the immediate and complete combination taking place. To ensure the perfect and full result, the intermixture of the calcareous and the putrescent matters, and in due proportions, must be perfect, and no excess of the latter remain any where in the soil; the putrescent matter must also be in the particular state of decomposition (whatever that may be) to enter into combination; and moreover there must be enough and equally diffused moisture, without which no chemical combination can take place. Now as some and probably all these conditions must necessarily be deficient in every case of applying putrescent matters to marled land, it must follow that much of the manure must remain uncombined for some length of time; and during that time is as liable to be wasted and exhausted as if in any other soil. And hence, and the more as the dressing is lavish, farm-yard and stable manure so applied must be expected to yield more for the first and second year, while the excess is wasting, than afterwards. But after this first waste and exhaustion has been suffered, whatever of the manure remains to the soils, say for the next ensuing rotation at latest, must be fully combined with and fixed in the soil, and will be permanent for all future time, under proper, judicious, and also the most profitable course of cropping. This first waste probably cannot be entirely prevented; but can be much lessened by care. And to this end, putrescent manure should not be applied heavily at once, but lightly, and repeated subsequently, and should be well scattered and equally diffused over the ground. Its subsequent decomposition being slow, and the products being gradually as well as surely presented to the lime diffused previously throughout the soil, will also tend to remove as much as possible of the manure from the condition of being fleeting and wasting, to that of being fixed and permanent.

Next let us see how far facts and experience sustain this reasoning. It is readily admitted that the time since marling was commenced in Virginia, and since correct views of the action of calcareous manures were entertained and acted on in any case, has been too short to furnish decided proofs. But so far as accurate facts can thus be referred to, they fully sustain the foregoing doctrine, not only of the permanency of calcareous manures, but also of putrescent manures in combination therewith. Some of these facts will be mentioned generally.

However in accordance with the theory of the action of calcareous manures, this absolute permanency of effect given thereby to putrescent manures was not at first counted on or expected, and was not known until it was forced on my observation by long continued results. My own practice is not only the oldest, but is all that I can refer to for proofs. And until all my marling was completed, and indeed for some time after, but little care was used by me to make and apply putrescent manures. This culpable neglect was the result of the habits caused by the disappointments and losses experienced in manuring long before. From the same ignorance and carelessness in this respect, no experiments on the durability of putrescent manures were made until long after, and then injudiciously.

Thus, in the three experiments 4, 9, and 11, the putrescent manure applied was in quantity much too great for the calcareous earth to combine with at once, even if the recent and irregular scattering of both kinds of manure had not prevented their meeting in proper proportions. For like reasons, of all the putrescent manures applied on the farm, and since larger quantities have been used, there is much more of *early* than *continued* effect. Still, so far as known and believed, there is always more or less of abiding effect, and which I infer will be permanent.

But wider scope for observation has been afforded in the increasing productiveness of all the marled lands, kept under what was deemed not too frequent tillage. Neither has the tillage been always mild, nor the rotation uniform, and latterly the grain crops have been made more frequent than before, and much more grazing permitted. Still, even where no prepared putrescent manures have ever been applied, and putrescent matters have been furnished only from the growth of the land itself during its share of rest in each course of crops, there has been a regular increase of productiveness of the grain crops, in every successive rotation. In one connected clearing, of what I found as poor forest land, now making 85 acres, the marling was commenced in 1818, and has been continued, as the successive clearings extended, to 1841. The earliest effects of the applications were always satisfactory, but they have regularly and largely increased with time. Thus, when under the last crop of corn, (in 1839,) the crop on the last finished marling, though perhaps thereby nearly doubled in product, was obviously and considerably less than that of four to six years earlier—that again as inferior to that of the marling of ten to fifteen years—and the crop on the marling of 1821 and earlier, decidedly the best of all, under circumstances otherwise equal. For the limited time of 23 years, and without any careful and accurate experiment or observation having been made for this special object, there could not well be stronger practical proof of the permanency of the vegetable manures stored up by the marl.

If we keep in mind the mode by which calcareous manure acts, its effects may be anticipated for a much longer time than my experience extends. Let us trace the supposed effects, from the causes, on an acid soil kept under meliorating culture. As soon as applied, the calcareous earth combines with all the acid then present, and to that extent is changed to the *vegetable salt of lime*. The remaining calcareous earth continues to take up the after formations of acid, and (together with the salt so produced) to fix putrescent manures, as fast as these substances are presented, until all the lime has been combined with acid, and all their product is combined with putrescent matter. Both those actions then cease. During all the time necessary for those changes, the soil has been regularly increasing in productiveness; and it may be supposed that before their completion, the product had risen from ten to thirty bushels of corn to the acre. The soil has then become neutral. It can never lose its ability (under the mild rotation supposed) of producing thirty bushels—but it has no power to rise above that product. Vegetable food continues to form, but is mostly wasted, because the salt of lime is already combined with as much as it can act on; and whatever excess of vegetable matter remains in the soil, is kept useless by acid also newly formed, and left free and noxious as before the application of calcareous earth. But though this excess of acid may balance and keep useless the excess of vegetable matter, it cannot affect the previously fixed fertility, nor lessen the power of the soil to yield its then maximum product of thirty bushels. In this state of things, sorrel may again begin to grow, and its return may be taken as notice that a new marling is needed, and will afford additional profit, in the

same manner as before, by destroying the last formed acid, and fixing the last supply of vegetable matter. Thus perhaps five or ten bushels more may be added to the previous product, and a power given to the soil gradually to increase as much more, before it will stop again for similar reasons, at a second maximum product of forty or fifty bushels. I pretend not to fix the time necessary for the completion of one or more of these gradual changes; but as the termination of each, and the consequent additional marling, will add new profits, it ought to be desired by the farmer, instead of his wishing that his first labor of marling each acre may also be the last required. Every permanent addition of five bushels of corn, to the previous average crop, will more than repay the heaviest expenses that have yet been encountered in marling. But whether a second application of marl is made or not, I cannot imagine such a consequence, under judicious tillage, as the actual decrease of the product once obtained. My earliest marled land has been severely cropped, compared to the rotation supposed above, and yet has continued to improve, though at a slow rate. The part first marled, in 1818, had only four years of rest in the next fifteen; and yielded nine crops of grain, one of cotton, and one year clover twice mowed. This piece, however, besides being sown with gypsum, (with little benefit,) once received a light cover of rotted corn-stalk manure. The balance of the same piece of land (Exp. 1.) was marled for the crop of 1821—has borne the same treatment since, and has had no other manure, except gypsous earth once, (in 1830,) which acted well. These periods of twelve and fifteen years (even though now extended to and confirmed by nine years more of experience) are very short to serve as grounds to decide on the eternal duration of a manure. But it can scarcely be believed that the effect of any temporary manure, would not have been somewhat abated by such a course of severe tillage. Under milder treatment, there can be no doubt that there would have been much greater improvement.

If subjected to a long course of the most severe cultivation, a soil could not be deprived of its calcareous ingredient, whether natural or artificial: but though still calcareous, it would be, in the end, reduced to barrenness, by the exhaustion of its vegetable matter. Under the usual system of exhausting cultivation, marl certainly improves the product of acid soils, and may continue to add to the previous amount of crop, for a considerable time; yet the theory of its action instructs us, that the ultimate result of marling, under such circumstances, must be the more complete destruction of the land, by enabling it to yield all its vegetable food to growing plants, which would have been prevented by the continuance of its former acid state. An acid soil yielding only five bushels of corn may contain enough food for plants to bring fifteen bushels—and its production will be raised to that mark, as soon as marling sets free its dormant powers. But a calcareous soil reduced to a product of five bushels, can furnish food for no more, and nothing but an expensive application of putrescent manures, can render it worth the labor of cultivation. Thus it is, that soils, the improvement of which is the most hopeless without calcareous manures, will be the most certainly improved with profit by their use.

CHAPTER XIII.

THE EXPENSE AND PROFIT OF MARLING.

Proposition 5—concluded.

At this time there are but few persons among us who doubt the great benefit to be derived from the use of marl: and many of those who ten years ago deemed the practice the result of folly, and a fit subject for ridicule, now give that manure credit for virtues which it certainly does not possess; and from their manner of applying it seem to believe it a universal cure for sterility.* Such erroneous views have been a principal cause of the many injudicious and even injurious applications of marl. It is as necessary to moderate the ill-founded expectations which many entertain, as to excite the too feeble hopes of others.

The improvement caused by marling, and its permanency, have been established beyond question. Still the improvement may be paid for too dearly—and the propriety of the practice must depend entirely on the amount of its clear profits, ascertained by fair estimates of the expenses incurred.

With those who attempt any calculations of this kind, it is very common to set out on the mistaken ground that the expense of marling should bear some proportion to the selling price of the land: and without in the least under-rating the effects of marl, they conclude that the improvement cannot justify an expense of six dollars on an acre of land that would not previously sell for four dollars. Such a conclusion would be correct if the land were held as an article for sale, and intended to be disposed of as soon as possible: as the expense in that case might not be returned in immediate profit, and certainly would not be added to the price of the land by the purchaser, under present circumstances. But if the land is held as a possession of any permanency, its previous price, or its subsequent valuation, has no bearing whatever on the amount which it may be profitable to expend for its improvement. Land that sells at four dollars, is often too dear at as many cents, because its product will not pay the expense of cultivation. But if by laying out for the improvement ten dollars, or even one hundred dollars to the acre, the average increased annual profit would certainly and permanently be worth ten per cent. on that cost of improvement, then the expenditure would be highly expedient and profitable. We are so generally influenced by a rage for extending our domain, that another farm is often bought, stocked and cultivated, when a liberal estimate of its expected products, would not show an annual clear profit of three per cent.: and any one would mortgage his estate to buy another thousand acres, that was supposed fully capable of yielding ten per cent. on its price. Yet the advantage would be precisely the same, if the principal money was used to enrich the land already in possession, (without regard to its extent, or previous value,) with equal assurance of its yielding the same amount of profit.

Nothing is more general, or has had a worse influence on the state of agriculture, than the desire to extend our cultivation and landed possessions. One of the consequences of this disposition has been to give an artificial value to the poorest land, considered merely as so much territory,

* This was in 1831, when these remarks were first printed. They are less applicable now than formerly.

while various causes have concurred to depress the price of all good soils much below their real worth. Whatever a farm will sell for fixes its value as merchandise; but by no means is it a fair measure of its value as permanent farming capital.

The true value of land, and also of any permanent improvements to land, I would estimate in the following manner. Ascertain as nearly as possible the average clear and permanent annual income, and the land is worth as much money as would securely yield that amount of income, in the form of interest—which may be considered as worth six per cent. For example, if a field brings ten dollars average value of crops to the acre, in the course of a four-shift rotation, and the average expense of every kind necessary to carry on the cultivation is also ten dollars, then the land yields nothing, and is worth nothing. If the average clear profit was but two dollars and forty cents in the term, or only sixty cents a year, it would raise the value of the land to ten dollars; and if six dollars could be made annually, clear of all expense, it is equally certain that one hundred dollars would be the fair value of the acre. Yet if lands of precisely these rates of profit were offered for sale at this time, the poorest would probably sell for four dollars, and the richest for less than thirty dollars. In like manner, if any field, that paid the expense of cultivation before, has its average annual net product increased six dollars for each acre, by some permanent improvement, the value thereby added to the field is one hundred dollars the acre, without regard to its former worth. Let the cost and value of marling be compared by this rule, and it will be found that the capital laid out in that mode of improvement will seldom return an annual interest of less than twenty per cent.—that it will more often reach to forty—and sometimes exceed one hundred per cent. of annual and permanent interest on the investment. The application of this rule for the valuation of such improvements will raise them to such an amount, that the magnitude of the sum may be deemed a sufficient contradiction of my estimates. But before this mode of estimating values is rejected, merely for the supposed absurdity of an acid soil being considered as raised from one dollar, or nothing, to thirty dollars, or more, per acre, by a single marling, let it at least be examined and its fallacy exposed.

If the reader will accompany me through some detailed estimates of values, and arithmetical calculations, in regard to the grounds of which we cannot differ, the truth of the result which I claim will be made manifest, however startling and monstrous they may appear to some persons at first glance.

Assuming as sound and unquestionable the grounds for estimating the intrinsic value of lands, as stated generally in the last paragraph, let us illustrate the position more particularly. The principle of valuation is that the land is worth to its proprietor and cultivator such sum of money as would yield in annual interest the same amount as the net annual product of the land, after paying for all labor, attention, expenses and risks. Further, to simplify the calculation, and also to suit the course of culture to the more general practice of the country, let us suppose the land in question to be cultivated under the ordinary three-shift rotation, of 1st, corn, 2nd, wheat, (or oats,) 3rd, at rest, with no grazing when the land is poor, and with but partial and moderate grazing (or mowing of clover) when improved or rich.

Then suppose a field of the poor and thin soil most common in lower Virginia, under this treatment for some years previously, to produce, on the general average, 10 bushels of corn to the acre, and 5 bushels of wheat, or its equivalent value of oats; and the value of the corn, at the barn, to be 50 cents the bushel, and of the wheat \$1. And let the joint and total

expenses of preparation, tillage, seed, harvesting, thrashing, &c., for market, (or for home use,) and of superintendence and care of both the corn and wheat or oat crops, be counted as being over and above the value of the offal (stalks, straw, &c.) of the crops, by \$10 for the two years. Then the full statement will be as follows:

First year, product in corn per acre, 10 bushels, at 50 cents	-	\$5
Second year, wheat, 5 bushels, at \$1,	- - - - -	5
Third year, no crop or profit, and no expense,	- - - - -	0
		<hr/>
Total product of the three-years' rotation,	- - - - -	\$10
Cost of cultivation, &c., of the crop,	- - - - -	10
		<hr/>

Net profit, - - - - - 00

However wretched may be the foregoing exhibition of products, it will be admitted to be abundantly liberal by all persons acquainted with lower and middle Virginia, for a very large proportion of the cultivated lands. Yet such lands might sell at prices varying from \$3 to \$6 the acre, and that without a view to their being improved, and even before calcareous manures were thought of as means for improvement. Yet the conclusion is evident, that such land, no matter what may be its then selling price, (or speculative appreciation caused by the effects of paper-money and fraudulent bank issues,) is worth not one cent for cultivation, or for the benefit of the proprietor and cultivator.

Next, suppose the land in question to be properly marled, and at the unusually heavy expense of \$7 the acre. This rate is more than double the usual expense for a full and sufficient dressing, when the marl is obtained on the farm where applied. Suppose also that the increase of products, as shown in the second course of the rotation, (beginning three years after the application,) is equal to 100 per cent. on the production previous to marling. This estimate is quite low enough, as all experience has shown. Upon such land, and so treated, this degree of increase may very often be obtained upon the first crop of the first course; and, even if no auxiliary means of enriching be afterwards used, the rate of increase will be more and more for each of sundry succeeding courses of crops thereafter. Then let us test the value of the returns by figures as before:

First year, product in corn per acre, 20 bushels, at 50 cents,	-	\$10
Second year, wheat, 10 bushels, at \$1,	- - - - -	10
Third year, clover most of it left as manure to the land, and no profit counted here,	- - - - -	00
		<hr/>

Total expenses of cultivation, &c., as before, in two years, - - 20
 10

Net product, or clear profit of cultivation in the term of three years, - - - - - \$10

This is all so much *increase of net annual product* upon the previous rate; and the amount, \$3.33 yearly, is the interest, (at 6 per cent.,) of something more than a capital of \$55. And therefore, according to these grounds of estimate, \$55 per acre is the *increase of intrinsic value* given to the land by marling alone, or \$48 the *clear gain* made by the operation, after deducting \$7 paid for the marling of the land; and this without regard to what might have been its previous intrinsic value, or its former or its present market price. The more rigidly this mode of estimate is scrutinized, the more manifestly true will be found the results. The premises assumed, in the supposed effects and profits of marling, will not be objected to

(unless as being too low) by any person who is well informed by practice and experience.

But there is one important apparent omission of a proper charge in the last statement of expenses. This is the *increase of labor* of tillage, harvesting, &c., caused by the crop being doubled in quantity. This is certainly a fair ground of charge; and, if estimated alone, would serve to reduce considerably the statement of increased net product, and consequently of increased value of land. But there were also omitted sundry items of increased production, which together would undoubtedly much more than compensate for the increase of labor in tilling a deeper and richer soil, and in harvesting, removing and preparing for sale or use, a double quantity of crop. These items of gain are, first, the additional offal, in corn-stalks, fodder and shucks, and wheat or oat straw, and chaff—second, the limited proportion of clover grazed or mowed—and third, the further gradual increase of crops, in subsequent time. Probably the first class of items alone would balance the increased expense of labor; if not, the addition of the second (the clover) certainly would be enough. And if that be doubted, the subsequent annual increase upon the first doubling of the crops (which only is estimated above) will not only furnish a fund to meet any such deficiency, but also will greatly, and beyond any calculation here attempted, augment the whole profit of marling, and consequently the intrinsic value of the land to the proprietor.

I admit the practical difficulty of applying this rule for estimating the value of land, or of its improvement, however certain may be its theoretical truth. It is not possible to fix on the precise clear profit of any farm to its owner and cultivator; and any error made in these premises is increased sixteen and two-third times in the estimate of value founded on them. Still we may approximate the truth with most certainty by using this guide. The early increase of crop from marling will, in most cases, be an equal increase of clear profit, (for the subsequent improvement and the additional offal will surely pay for the increase of labor—) and it is not very difficult to fix a value for that actual increase of crop, and thereby to estimate the value of the improvement, as farming capital.*

This mode of valuing land, under a different form, is universally received as correct in England. Cultivation there is carried on almost entirely by tenants; and the annual rent which any farm brings, on a long lease, fixes beyond question what is its annual clear profit to the owner. The price, or value of land, is generally estimated at so many "years' purchase," which means as many years' rent as will return the purchaser's money. There, the interest of money being lower, increases the value of land according to this mode of estimation; and it is generally sold as high as twenty years' purchase. My estimate is less favorable for raising the value of our lands, as it fixes them at sixteen and two-thirds years' purchase, according to our higher rate of interest on money.

But though this rule for estimating the true value of land, and of the improvements made by marling, may be unquestionable in theory, still a practical objection will be presented by the well known fact that the income and profits of farmers are not increased in proportion to such improvements, nor is there found such a vast disproportion as this rule of estimating values would show, between the profits of the tillers of poor and of rich lands. These positions are admitted to be generally well founded—but it is denied that they invalidate the previous estimates. A farmer may,

* No degree of uncertainty in the application, however, detracts from its truth. For if the annual average net profit derived from marling be considered as an *unknown quantity* (x), it is not therefore the less certain that $x \times 16\frac{2}{3}$ = the increased intrinsic value of the land.

and generally does, obtain less gross product from a large or a rich farm, than his more necessitous, and therefore more attentive and economical neighbor gets from a smaller or poorer farm, in proportion to the producing power of each; and even the same persons, when young and needy, have often made more profit according to their means, than afterwards when relieved from want, and having lands increased to a double power of production. These, and similar facts, however general, are only examples of the obvious truth, that the profits of land depend principally on the industry, economy, and good management of the cultivator; and that many a farmer, who can manage well a small or poor farm, is more deficient in industry, economy, or the increased degree of knowledge required, when possessed of much more abundant resources. In short, if these considerations were to direct or influence our estimates, we should not be comparing and estimating the value of lands, but the value of the care and industry bestowed on their management by their proprietors.

Another objector may ask, "If any poor land is raised in value, (according to this estimate,) from one dollar to thirty, by marling, would a purchaser make a judicious investment of his capital, by buying this improved land at thirty dollars?" I would answer in the affirmative, if the view was confined to this particular means of investing farming capital. The purchaser would get a clear interest of six per cent.—which is always a good return from land, and is twice as much as all lower Virginia now yields. But if such a purchase is compared with other means of acquiring land so improved, it would be extremely injudicious: because thirty dollars expended in purchasing and marling suitable land, would serve both to acquire and improve, to as high a value, five or six acres.

Estimates of the expenses required for marling are commonly erected on as improper grounds as those of its profits. We never calculate the cost of any old practice. We are content to clear wood-land that afterwards will not pay for the expense of tillage—to keep under the plough land reduced to five bushels of corn to the acre—to build and continue to repair miles of useless and perishable fences—to make farm-yard manure, (though not much of this fault,) and apply it to acid soils—without once calculating whether we lose or gain by any of these operations. But let any new practice be proposed, and then every one begins to count its cost; and that on such erroneous premises, that if applied to every kind of farm labor, the estimate would prove that the most fertile land known could scarcely defray the expenses of its cultivation.

According to estimates made with much care and accuracy, the cost of an uncommonly expensive job of marling, 4036 bushels in quantity, in 1824, amounted to \$5.35 the acre, for 598 bushels of marl. This quantity was much too great; 400 bushels would have been quite enough for safety and profit, and would have reduced the whole expense, including every necessary preparation, to \$3.50 the acre. The earth which was taken off, to uncover the bed of marl, was considerably thicker than the marl itself. The road from the pit ascended hills amounting to fifty feet of perpendicular elevation—and the average distance to the field was 347 yards. The full estimates of these operations will be presented in the next chapter.

It is impossible to carry on marling to advantage, or with any thing like economy, unless it is made a regular business, to be continued throughout the year or a specified portion of it, by a laboring force devoted to that purpose, and not allowed to be withdrawn for any other. Instead of proceeding on this plan, most persons, who have begun to marl, attempt it in the short intervals of leisure afforded between their different farming operations—and without lessening for this purpose the extent of their usual

cultivation. Let us suppose that the preparations have been made, and, on the first opportunity, a farmer commences marling with zeal and spirit. But every new labor is attended by causes of difficulty and delay, and a full share of these will be found in the first few days of marling. The road is soft, for want of previous use, and, if the least wet, soon becomes miry. The horses, unaccustomed to carting, balk at the hills, or only carry half loads. Other difficulties occur from the awkwardness of the laborers and the inexperience of their master, and still more from the usual unwillingness of his overseer to devote any labor to improvements which are not expected to add to the crop of that year. Before matters can get straight, the leisure time is at an end; and the work is stopped, and the road and pit are left to get out of order, before making another attempt, some six months after, when all the same vexatious difficulties are again to be encountered.

If only a single horse is employed in drawing marl throughout the year, at the moderate allowance of two hundred working days, and one hundred bushels carried out for each, his year's work will amount to twenty thousand bushels, or enough for more than sixty acres. This alone would be a great object effected. But, besides, this plan would allow the profitable employment of any amount of additional labor. When, at any time, other teams and laborers could be spared to assist, though for only a few days, every thing is ready for them to go immediately to work. The pit is drained, the road is firm, and the field marked off for the loads. In this way much labor may be obtained in the course of the year, from teams that would otherwise be idle, and laborers whose other employments would be of but little importance. The spreading of marl on the field is a job that will always be ready to employ any spare labor; and throwing off the covering earth from an intended digging of marl may be done when rain, snow, or severe cold has rendered the earth unfit for almost every other kind of labor.

Another interesting question respecting the expense of this improvement is, to what distance from the pit may marl be profitably carried? If the amount of labor necessary to carry it half a mile is known, it is easy to calculate how much more will be required for two or three miles. The cost of teams and drivers is in proportion to the distance travelled, but the pit and field labors are not affected by that circumstance. At present, when so much poor land, abundantly supplied with fossil shells, may be bought at from two dollars to four dollars the acre, a farmer had better buy and marl a new farm, than to move marl even two miles to his land in possession.* But this would be merely declining one considerable profit, for the purpose of taking another much greater. Whenever the value of marl shall be properly understood, and our lands are priced according to their improvement, or their capability of being improved from that source, as must be the case hereafter, then this choice of advantages will no longer be offered. Then rich marl will be profitably carted miles from the pits, and

* This statement of prices, though correct when first published, is no longer so. Some little land may yet be so low; but, in general, the prices of lands having marl have already advanced from 50 to 100 per cent. within 15 years. The lowest of the above named prices was much above the former minimum rate. The various tracts of land in James City county belonging to Mrs. Paradise's large estate, when sold some 12 or 14 years ago, brought prices that averaged only about \$1.25 the acre. Most of the lands were poor, but easily improvable, and all having plenty of rich marl. One of the tracts of that description, of 800 acres, was bought at 75 cents the acre; and after being held for three or four years, without being in any respect improved, was resold by the purchaser for \$2.50 the acre. Where marl has been actually applied, the increased intrinsic or productive value of the land always considerably exceeds the increased market price, even though the latter may be already doubled or tripled.

perhaps conveyed by water as far as it may be needed. A bushel of such marl as the bed on James river, described page 92, is as rich in calcareous earth alone, as a bushel of slaked lime will be after it becomes carbonated, and the greater weight of the first is a less disadvantage for water carriage, than the price of the latter. Farmers on James river, who have used lime as manure to great extent and advantage, might more cheaply have moved rich marl twenty miles by water, as it would cost nothing but the labor of digging and transportation.

Within the short time that has elapsed since the first publication of the foregoing passages in the first edition of this essay, the transportation of marl by water carriage has been commenced on James river, and has been carried on with more facility and at less expense than was anticipated. The farmers who may profit by this new mode of using marl will be indebted to the enterprise of C. H. Minge, esq., of Charles City, for having made the first full and satisfactory experiment of the business on a large scale.

Since the publication of the last edition, the transportation of marl by water-carriage has been carried on much more extensively. But very recently another source for obtaining calcareous manures has been opened to the farmers of lower Virginia, which they think cheaper than either transporting marl or burning shells, and they are availing of it to great extent. This is northern stone-lime, which is brought in bulk, ready slaked, and sold by the vessel load at prices varying from 8 to 10 cents the bushel. Slaked lime, even if pure, from its extreme lightness, cannot be as much to the bushel as rich marl contains of pure lime, even though the marl may have 30 per cent. of other earths. Therefore the lime is much the most costly, as marl may be procured and transported at from 3 to 5 cents the bushel. Still, the lime is so much more readily obtained in large quantities, and a farm can by that means be so much more speedily covered, that the purchase of lime is often the more desirable and also the more profitable operation of the two.

In making this improvement, more than in any other business, "time is money." Marling is usually effected by the farmer's labor, whereas the expense of liming is mostly in the purchase. By the use of water-borne marl, few farmers could dress a fourth of their tillage field in a year, whereas by purchasing lime the whole field might be limed, and the whole farm covered in one-fourth of the time required for marling. If then the lime were even thrice the cost of marl, (for equal quantities of pure lime,) it would still be the cheapest mode of improvement, because yielding its products in one-fourth of the time required for marling. The difference of amount of net product in the first crop, between an acre marled or limed, and another acre not so improved, would usually pay the cost of marling or liming the acre. Therefore, on every acre cultivated by any farmer, and not marled or limed until *after* making the crop, there is as much loss of crop suffered by the delay, as would have paid for making the improvement.

The objections to carrying marl unusual distances, admitted above, apply merely to improvements proposed for field culture. But it would be profitable, even under existing circumstances, for rich marl to be carried five miles by land, or one hundred miles by water, for the purpose of being applied to gardens, or other land kept under perpetual tillage, and receiving frequent and heavy coverings of putrescent manure. In such cases, independent of the direct benefit which the calcareous earth might afford to the crops, its power of combining with putrescent matters, and preventing their waste, would be of the utmost importance. If the soil

is acid, the making it calcareous will enable half the usual supplies of manure to be more effective and durable than the whole had been. There are other uses for marl, about dwelling houses and in towns, which should induce its being carried much farther than mere agricultural purposes would warrant. I allude to the use of calcareous earth in preserving putrescent matters, and thereby promoting cleanliness and health. This important subject will hereafter be separately considered.

Either lime or good marl may hereafter be profitably distributed over a remote strip of poor land, by means of the rail-road now constructing from Petersburg to the Roanoke [1831]; provided the proprietors do not imitate the over greedy policy of the legislature of Virginia in imposing tolls on manures passing through the James river canal. If there were no object whatever in view but to draw the greatest possible income from tolls on canals and roads, true policy would direct that all manures should pass from town to country toll free. Every bushel of lime, marl, or gypsum thus conveyed, would be the means of bringing back, in future time, more than as much wheat or corn; and there would be an actual gain in tolls, besides the twenty-fold greater increase to the wealth of individuals and the state. Wood-ashes, after being deprived of their potash, have calcareous earth, and a smaller proportion of phosphate of lime, as their only fertilizing ingredients; and both together do not commonly make more than there is of calcareous earth in the same bulk of good marl. Yet drawn ashes have been purchased largely from our soap factories, at five cents the bushel, and carried by sea to be sold for manure to the farmers of Long Island. Except for the proportion of phosphate of lime which they contain, drawn ashes are simply artificial marl—more fit for immediate action, by being finely divided, but weaker in amount of calcareous earth than our best beds of fossil shells.

The argument in support of the several propositions which have been discussed through so many chapters, is now concluded. However unskilfully, I flatter myself that it has been effectually used; and that the general deficiency in our soils of calcareous earth, the necessity of supplying it, the profit by that means to be derived, and the high importance of all these considerations, have been established too firmly to be shaken by either arguments or facts.

CHAPTER XIV.

ESTIMATES OF THE COST OF LABOR APPLIED TO MARLING.

Before we can estimate with any truth the expense of improving land by marling, it is necessary to fix the fair cost of every kind of labor necessary for the purpose, and for a length of time not less than one year. We very often hear *guesses* of how much a day's labor of a man, a horse, or a wagon and team, may be worth—and all are wide of the truth, because they are made on wrong premises, or no premises whatever. The only correct method is to reduce every kind of labor to its elements—and to fix the cost of every particular necessary to furnish it. This I shall attempt; and if my estimates are erroneous in any particular, other persons better informed may easily correct my calculation in that respect, and make the necessary allowance on the final amount. Thus, even my mistakes in

the grounds of these estimates, will not prevent true and valuable results being derived from them.

The following estimates were made in 1828, according to the prices of that year. I shall make no alteration in any of the sums, because there is no considerable difference at this time, (January 1832,) and the least alteration would make it necessary to change the after calculations founded on them. But no one estimate will suit for years of different prices. If any one desires to know the value of labor when corn (for example) is higher or lower, he must ascertain the difference in that item, and add or deduct, so as to correct the error.

Cost of the labor of a negro man in 1828.

Hire for the year, payable at the end, - - - - -	\$38 00
Food—19½ bushels of corn at 40 cents,	7 80
Add 10 per cent. for waste in keeping,	78
Meat and fish, &c.	9 00
	— \$17 58
Interest for one year on \$17 58, paid for food,	1 05
	— 18 63
Clothing—6 yards coarse woollen cloth, at 50 cents,	3 00
12 yards cotton, for summer clothes and two shirts, at 12 cents,	1 44
Blanket at \$1 50, once in two years—yearly,	75
Shoes and mending,	2 50
	— 7 19
Taxes—State, 47 cents—county 47—poor 33—road, suppose 1 dollar,	2 27
His share of expense of quarters, fuel, and sending to mill,	4 50
Nursing when sick, (exclusive of medical aid,)	1 50
	— 8 27
	\$72 09
Add 20 per cent. on the whole of the above for cost of superintendence, waste, wanton damage to stock, tools, &c., and thefts,	14 41
	—
Total expense per year,	\$86 50
Time lost—Sundays and holidays, 58 days	
Bad weather and half holidays, suppose 20	
Sickness, suppose 10	
	—
Making in all 88	
From 365, deduct 88, leaves 277 working days; which makes the cost of each working day 31¼ cents.	

The hire was fixed at the average price obtained that year for ten or twelve young men hired out at the highest bids, for field labor. According to the established custom, all the expenses of medical attendance, and loss of time from the death of a slave occurring when he is hired, are paid, or deducted from the hire by the owner, and therefore are omitted in this estimate. By supposing the slave to be hired by his employer, instead of being owned, the calculation is made more simple, and therefore more correct.

Cost of the labor of a negro woman.

Hire for the year,	- - - - -	\$12 00
Food,	- - - - -	12 95
Clothing, blanket, and shoes,	- - - - -	6 50
Taxes, quarters, fuel, mill, nursing, &c.	- - - - -	7 19
Add 20 per cent. as before, for superintendence, &c.,	- - - - -	7 73
Total yearly cost,		<u>\$46 37</u>

Suppose lost time, 100 days, leaves working days 265, at $17\frac{1}{2}$ cents for each.

Nearly all the women who are usually hired out are wanted by persons having few or no other slaves, as cooks, or for some other employment at which they are more useful than at field labor—and their price is nearer fifteen dollars in these cases. But when there is no demand for such purposes, women for field labor will not bring more than twelve dollars.

A boy of twelve or thirteen would hire for more than the foregoing estimate of the hire of a woman, but would not lose half the time from sickness and bad weather, and therefore may be supposed to cost the same per day, or seventeen and a third cents. A girl of fourteen or fifteen years, for similar reasons, may be put at the same price.

Cost of the labor of a horse.

First cost of a good work horse, \$80 00—supposed to last five years at work, makes the yearly wear,	-	\$16 00
Interest for one year on \$80 00—\$4 80—tax, 12 cents,		4 92
		<u>\$20 92</u>
20 bbls. of corn at \$2 00—3,500 lbs. of fodder at 50 cents the hundred,	- - - - -	\$57 50
Add 10 per cent. for waste in keeping,	- - - - -	5 75
		<u>63 25</u>
Interest on \$63 25, for one year,	- - - - -	\$3 79
Share of yearly expense for corn-house,	- - - - -	47
		<u>4 26</u>
Total yearly cost,		<u>\$88 43</u>

Lost time, 98 days, leaves 267 working days, at 33 cents nearly.

A mule eats less corn than a horse, but more hay, and lives longer, and may be considered as costing one-fifth less, or yearly cost, \$70 00, and daily, 26½ cents.

A tumbrel for marling, will cost when new, \$25 00

It will last two years, or (what is the same thing) if that sum will

pay for all repairs, for two years, its wear per year, is	-	\$12 50
Interest on \$25 00 for a year,	- - - - -	1 50

Cost per year,	<u>\$14 00</u>
----------------	----------------

And at 267 working days—cost per day five cents.

In the estimate of the cost of horse labor, no charge is made for attendance, because that is part of the labor of the driver, and forms part of his expense. No charge is made for grazing, because enough corn and hay

are allowed for every day in the year— and when grass is part of his food, more than as much in value is saved in his dry food. No charge is made for stable or litter, as the manure made is supposed to compensate those expenses.

It may be supposed that the prices fixed for corn, and fodder or hay, are too low for an average. Such is not my opinion. The price is fixed at the beginning of the year, when it is always comparatively low, because it is too soon for purchasers to keep shelled corn in bulk, and the market is glutted. Besides, the allowance for waste during the year's use (10 per cent.) makes the actual price equal to two dollars and twenty cents on July 1st. The nominal country price of corn in January is almost always on credit—and small debts for corn are the latest and worst paid of all. The farmer who can consume any additional portion of his crop, in employing profitable labor, becomes his own best customer. The corn supposed to be used, by these estimates, is transferred on the first of January, without even the trouble of shelling or measuring, from A. B. *corn-seller*, to A. B. *marler*, and instantly paid for. Two dollars per barrel at that early time, and obtained with as little trouble, from any purchaser, would be a better regular sale than the average of prices and payments have afforded for the last eight years.

Cost of marling, founded on the foregoing estimates of the cost of labor.

From the beginning of November, 1823, to the 31st of May, 1824, a regular force, of two horses and suitable hands, was employed in marling on Coggins Point, on every working day, unless prevented by bad weather, wet and soft roads, or some pressing labor of other kinds. The same two horses were used, without any change, and indeed they had drawn the greater part of all the marl carried out on the farm, since 1818. The best of the two was seventeen years old—both of middle size, and both worse than any of my other horses, which were kept at ploughing.

The following estimates were made on a connected portion of this time and labor, and upon my own personal observation and notes of the work, from the beginning to the end. It was very desirable to me to know the exact cost of some considerable job of marling, attended with certain known difficulties, and on any particular mode of estimating the expense; for although the same degree of difficulty, and of cost of labor, might never again be met with, still, any such estimate would furnish a tolerable rule to apply, in a modified form, to any other undertaking of this kind. These estimates may be even more useful to other persons; as they will serve generally to prove that the greatest obstacles to the execution of this improvement are less alarming, and more easily overcome, than any inexperienced persons would suppose.

Both these jobs were attended with uncommon difficulties, in the unusual thickness of the superincumbent earth, compared to that of the fossil shells worth digging, and on account of the distance, and amount of ascent, to the field. The first job was so much more expensive than was anticipated, that it may perhaps be considered as a failure—but as the account of its expense had been kept so carefully, it will be given just as if more success and profit had been obtained. This work was commenced April 14th, 1824. The bed of marl for the upper six feet of its thickness is dry and firm, though easy to dig, and rich. It has an average strength of 45 per cent., the shells mostly pulverized, and the remaining earth more of clay than sand. After being carried out, the heaps appear, to a superficial observer, to be a coarse loose sand. Below six feet, the marl became so

poor as not to be worth carrying out, and was not used except when the distance was very short. Its strength was less than 20 per cent. The bed at first was exposed on the surface, near the bottom of a steep hill-side; but as a large quantity had been taken out, and several successive cuts made into the face of the hill some years before, the covering earth was increased on the space now to be cleared, so as to vary between eight and sixteen feet, and I think averaged between eleven and twelve. The situation of the marl and road required that a clear cart-way should be made as low as the intended digging; and therefore nearly all of the earth was to be moved by a scraper, and was thrown into the narrow bottom at the foot of the hill. This earth served thus to form an excellent causeway across the valley, which made part of the road in the next undertaking. All this marl runs horizontally, and the layers of different qualities are very uniform in their thickness. The greater part of the covering earth is a hard clay, or impure fuller's earth, which was difficult to dig, and still more so for the scraper to take up and remove. Part was thrown off by shovels, and served to increase a mound made by former operations, within the circle around which the scraper was drawn.

Labor used in digging and removing earth.

4 days' labor of 9 men, at 31½ cents each,	-	-	-	-	\$11 25
4 6 women, }	} at 17½ cents,	-	-	-	5 55
4 2 boys, }					
4 1 young girl at 15, and 1 old man at 25,					1 60
1 8 oxen, (the scraper being drawn by 4 half the					
day, which then rested and grazed while the others worked					
the other half of the day,) at 15 cents each,	-	-	-	-	4 80
Add 80 cents for wear of scraper, hoes, and shovels,	-	-	-	-	80
Total, - - - - -	-	-	-	-	<u>\$24 00</u>

The price allowed for the oxen is much too high for the common work, and so much rest allowed; but they work so seldom at the scraper, that both the men and the oxen are awkward, and the labor is very heavy, and even injurious to the team.

Labor of digging and carrying out the marl.

Three tumbrels were kept at work on this job and the next, a good mule being added to the regular carting force—and no time was lost from April 20th to May 31st, except when carts broke down, (which was very often, owing to careless driving, and worse carpentry,) or when bad weather compelled this labor to stop. One man dug the marl and assisted to load; another man loaded, and led the cart out of the pit, until he met another driver returning from the field, to whom he delivered the loaded cart and returned to the pit with the empty one. Of the two other drivers, one was a boy of sixteen, and the other twelve years old—the youngest only was permitted to ride back, when returning empty. The distance to the nearest part of the work (measured by the chain) was nine hundred and two yards, and to the farthest one thousand and forty-five; adding two-thirds of the difference to the nearest for the average distance, makes nine hundred and ninety-seven yards. The ascent from the pit, by a road formerly cut

and well graduated for marling, was supposed to be twenty-five feet in perpendicular height; and every trip of the carts, going and coming, crossed a valley supposed to be fifteen feet deep, and both sides forming a hill-side of that elevation.

When only four and a half feet of the marl had been dug, a large mass of earth fell into the pit, covered entirely the remaining one foot and a half of marl, and stopped all passage for carts. To clear away this obstruction would have cost more labor than the remaining marl was worth, and therefore this pit was abandoned. This happened on May 10th, when six hundred and ninety-nine loads had been carried out, and the work done was equal to thirty-six days' work of one cart, (by adding together all the working time of each,) which was nineteen and a half loads for the average daily work of each cart, or fifty-eight for the three. The average size of the loads, by trial, was five and a half heaped bushels; and the weight, one hundred and one pounds the bushel. It was laid on at one hundred and four loads, or five hundred and seventy-two bushels the acre.

Labor employed for 699 loads, or 3844 bushels.

2 men at $31\frac{1}{4}$ cents,	-	-	-	-	62 $\frac{1}{2}$
2 boys at 19 cents,	-	-	-	-	38
2 horses at 33 cents,	-	-	-	-	66
1 mule at $26\frac{1}{2}$ cents,	-	-	-	-	26 $\frac{1}{2}$
3 carts at 5 cents,	-	-	-	-	15
Tools at 3 cents,	-	-	-	-	3
					<hr/>
Daily expense, or for 58 loads,					\$2 11
Digging and carting 699 loads at the same rate,	-	-	-	-	\$25 43
Add the total expense of removing earth,	-	-	-	-	24 00
					<hr/>
					\$49 43
Spreading at 50 cents the 100 loads,	-	-	-	-	3 50
					<hr/>
Total expense,					\$52 93
Which makes the cost per bushel,	1	25-100	cents.		
per load, ($5\frac{1}{2}$)	7				
per acre, of 572 bushels,	\$7	85			

This marl was laid on much too thick for common poor land, and one fourth of the body uncovered was lost by the falling in of the earth. If one fourth of the expense of uncovering the marl was deducted on account of this loss, it would reduce the whole expense nearly one eighth.

As soon as the carts were stopped in the work just described, they were employed in moving earth from similar marl, across the ravine. The thickness, strength, and other qualities of the marl, on both sides, are not perceptibly different. A large quantity had also been formerly dug on this side, but the land being lower, the covering earth was not more than ten feet where thickest, and the average was eight and a half or nine feet. To make room for convenient working, and a large job, an unusual space was cleared, ten to fourteen feet wide, and perhaps fifty or more long. The shape of the adjoining old pits compelled this to be irregular. The greater

part of the earth was of the same hard fuller's earth mentioned as being on the other side—and the upper part of this was still worse, being in woods, and the digging obstructed by the roots and trees.

Labor used in digging and removing the earth.

6 men	5 days, at $31\frac{1}{4}$ cents,	-	-	-	-	\$9 37 $\frac{1}{2}$
5 women	5	}	at $17\frac{1}{2}$ cents,	-	-	6 24
1 woman	1					
2 boys	5					
1 old man	2		25 cents,	-	-	50
2 girls	6		15 cents,	-	-	1 80
8 oxen, for the scraper as before, each team at rest half the day, 5 days, at 15 cents,				-	-	6 00
3 horses and carts, $1\frac{1}{2}$ days, at 38 cents,				-	-	1 71
Add for damages to scraper and other utensils,				-	-	86 $\frac{1}{4}$
Total cost of moving earth,						<u>\$27 48$\frac{3}{4}$</u>

Enough of the earth was carried by the carts to the dam crossing the ravine, to raise the road as high as the bottom of the intended pit. The balance was thrown into the valley wherever most convenient. Only a small proportion, perhaps one third, could be thrown off, without being carried away by the carts and scraper.

The loads were carried to the same field, and by the same road as from the former digging. The first hundred and ninety-one loads served to finish the piece begun before, of which the average distance was nine hundred and ninety-seven yards; all the balance was carried to land adjoining the former, eight hundred and forty-seven measured yards from the pit.

The loads were ordered to be increased to six bushels, which was as much as the carts (without tail-boards) could hold, without waste in ascending the hills; but as the loaders often fell below that quantity, I suppose the average to have been five and three fourths heaped bushels, or five hundred and eighty-one pounds.

The tumbrels were kept constantly at this work, except when some of the land was too wet, or for some other unavoidable cause of delay. All the space which the old pits occupied, and over which the road passed, being composed of tough clay thrown from later openings, and which had never become solid, was made miry by every heavy rain, and caused more loss of time, than would usually occur at that season. The same four laborers, and two horses and one mule, employed as before, and their daily work was as follows:

May 13th, began the new pit						
13th, 2 carts all the day, and 1 for 2 hours only, (afterwards otherwise employed,)	-	-	-	-	-	47 loads.
14th, 2 " half the day, then employed otherwise—(1 horse idle)	-	-	-	-	-	21
15th, 3 " " " " " " " "	-	-	-	-	-	61
16th, Sunday.						
17th, 3 " finished most distant work with	-	-	-	-	-	62
						<u>191</u>

Average distance 907 yds.

Brought forward,	- - - - -	loads 191	Average distance 847 yards.
And the same day began nearest work with	- - - - -	4	
May 18th, 3 carts for 4 hours (stopped by heavy rain,)	- - - - -	22	
19th and 20th, 3 carts at work elsewhere, on drier land.	- - - - -		
21st, 3 " again marling,	- - - - -	75	
22d, rain, no work done by horses.	- - - - -		
23d, Sunday.	- - - - -		
24th, 1 " at other work.	- - - - -		
25th, 3 " again marling,	- - - - -	74	
26th, 3 " - - - - -	- - - - -	75	
27th, 3 " - - - - -	- - - - -	72	
28th, 3 " - - - - -	- - - - -	72	
29th, 3 " (shafts of one broken and repaired,)	- - - - -	64	
30th, Sunday.	- - - - -		
31st, 3 " until rain at 4 P. M.	- - - - -	53	
		<hr/> 511	
		702	

After this stoppage, the horses were put to ploughing the corn, that the cultivation might be sufficiently advanced to use all the laborers in harvest, which began on the 11th of June. As near as I could determine by inspection, and a rough cubic measurement, about one half of the uncovered marl was then dug and carried out. As the remainder was not dug until August, when I was absent from home, I have no more correct means of ascertaining these proportions; and shall according to this supposition charge *half* the actual cost of the whole uncovering of earth, to this supposed half of the marl which formed this last operation.

The list of days' work shows that the average number of loads per day, at eight hundred and forty-seven yards, was twenty-four and a half for each cart, which made twenty-three and a half miles for the day's journey of each horse. The first four days' work finished the farthest piece, of which the average distance was nine hundred and ninety-seven yards—but this part of the work was on the nearest side of that piece, and at less than that average distance. I shall not make any separate calculation, for these hundred and ninety-one loads, but consider all as if carried only eight hundred and forty-seven yards.

The daily cost of the laboring force, 2 men, 2 boys, 2 horses, and 1 mule, was before estimated at \$2 11—which served to carry out 73½ loads, or 422 bushels. At that rate, (to May 31st,) 702 loads, or 4036 bushels, cost,	\$20 15
Add half the expense of uncovering, (half the marl still remaining not dug.)	13 74
For spreading, at 31½ cents per hundred loads,	2 18½
Total cost of 4036 bushels laid on,	<hr/> \$36 07½

Which makes the cost per bushel, 9 mills nearly.

And per acre, at 104 loads, or 598 bushels.	\$5 34½
Or, at 400 bushels, which would have been a sufficient, and much safer dressing, per acre,	\$3 57½

In 1828, at Shellbanks, Prince George county, a very poor, worn, and hilly farm, I commenced marling, and in about four months finished 120½ acres at rates between 230 and 280 bushels per acre. The time taken up in this work was five days in January, and all February and March, with

two carts at work—and from the 5th of August to the 27th of September, with a much stronger force. I kept a very minute journal of all these operations, showing the amount of labor employed, and of loads carried out during the whole time. It would be entirely unnecessary to state here any thing more than the general amounts of labor and its expense, after the two particular statements just submitted. At Shellbanks, the difficulties of opening pits were generally less, the average distance shorter, and the reduced state of the soil, and the strength of the marl, made heavy dressings dangerous. These circumstances all served to diminish the expense to the acre. The difficulties, however, at some of the pits, were very great, owing to the quantity of water continually running in, through the loose fragments of the shells; and almost every load was carried up some high hill. Taking every thing into consideration, I should suppose that the labor and cost of this large job of marling will be equal to, if not greater than the average of all that may be undertaken, and judiciously executed, on farms having plenty of this means for improvement, at convenient distances. The whole cost of this large job was as follows:

Preparatory work, including uncovering marl, cutting and repairing the necessary roads, and bringing corn (from another farm) for the teams—digging, carrying out, and spreading			
6892 loads of marl, (4½ heaped bushels only, because of the steep hills, and sometimes wet marl,) on 120½ acres,	-	8258	38
At the average rate of 57½ loads, or 259 bushels per acre, the average expense was, to the acre,	-	-	2 08
To the load,	-	3	cents and 63-100ths,
And to the bushel,	-	0	83-100ths.

When the preceding edition of this essay was published, (in 1835,) the transportation of marl by water had been but recently commenced. Since, the business has been greatly increased. But still it is badly conducted in general, and therefore is much more costly than it would be under better and proper direction. Farmers are averse to being engaged in the management of vessels, or any other business away from their farms, and therefore they have always preferred to buy the marl from vessels, even at higher prices, rather than to have it dug by their own laborers and transported in their own vessels. And this division of labor would be right in all respects if the owners of the river lighters were better managers of their business, and their hands were industrious and sober. For rich marl thus obtained and transported, the prices at the purchasers' landings have usually been from 4 to 5 cents the heaped bushel. And at these high prices, the lazy and worthless and illy provided navigators have rarely realized any profit. The highest price charged for marl, in beds on the river banks, is a half cent the bushel. Under existing circumstances, the cheapest and best mode of obtaining water-borne marl is for the farmer to also carry on the digging and the navigating. And if the several operations were properly conducted, the entire expense of water-borne marl, say 10 to 30 miles, will rarely exceed three cents the bushel when landed, and under favorable circumstances may fall short of two cents. Collier H. Minge, Esq., of Charles City, and Dr. Corbin Braxton, of King William county, who have carried on this business extensively, and for years in succession, for marling their own farms, have furnished me with careful and detailed estimates of their expenses, which have been published at length in the *Farmers' Register*, (p. 567 vol. i. and p. 691, vol. viii.) According to the estimate of Mr. Minge, the entire cost of thus procuring marl, carried 15 miles on the broad water of James river, amounted to less than two cents the heaped bushel, when landed. And

Dr. Braxton's total expense, the transportation being for eight miles on the narrow and smooth Pamunkey, was but little more than half a cent the bushel, placed at his landing. No charge was made for the marl in either case, but every other charge or expense was included. The labor and difficulties on James river, both of uncovering and digging the marl (at Coggins Point) and unloading (on a shallow creek) were unusually great; and on the Pamunkey these labors were very light. A vessel and also a mode of loading, safe in strong winds, were necessary on James river; while no such danger had to be feared, or was guarded against, on the well sheltered Pamunkey river. So much of the business in both these cases, as was conducted from home, necessarily was wanting of proper superintendence; and, no doubt, both of these undertakings suffered for that important deficiency, as in all cases where labor is on a small scale of operations, and more especially when slave labor is employed.

CHAPTER XV.

THE USE OF CALCAREOUS EARTH RECOMMENDED TO PRESERVE PUTRESCENT MANURES, AND TO PROMOTE CLEANLINESS AND HEALTH.

The operation of calcareous earth in enriching barren soils has been traced, in a former part of this essay, to the chemical power possessed by that earth of combining with putrescent matters, or with the products of their fermentation—and in that manner preserving them from waste, for the use of the soil, and for the food of growing plants. That power was exemplified by the details of an experiment, (page 60,) in which the carcass of an animal was so acted on, and its enriching properties secured. That trial of the putrefaction of animal matter in contact with calcareous earth, was commenced with a view to results very different from those which were obtained. Darwin says that *nitrous acid* is produced in the process of fermentation, and he supposes the *nitrate of lime* to be very serviceable to vegetation.* As the nitrous acid is a gas, it must pass off into the air, under ordinary circumstances, as fast as it is formed, and be entirely lost. But as it is strongly attracted by lime, it was supposed that a cover of calcareous earth would arrest it, and form a new combination, which, if not precisely nitrate of lime, would at least be composed of the same elements, though in different proportions. To ascertain whether any such combination had taken place, when the manure was used, a handful of the marl was taken, which had been in immediate contact with the carcass, and thrown into a glass of hot water. After remaining half an hour, the fluid was poured off, filtered, and evaporated, and left a considerable proportion of a white soluble salt, (supposed eight or ten grains.) I could not ascertain its kind—but it was not deliquescent, and therefore could not have been the nitrate of lime. The spot on which the carcass lay was so strongly impregnated by this salt, that it remained bare of vegetation for several years, and until the field was ploughed up for cultivation.

But whatever were the products of fermentation saved by this experiment, the absence of all offensive effluvia throughout the process sufficiently proved that little or nothing was lost, as every atom must be, when flesh putrefies in the open air; and I presume that a cover of equal thickness of clay, or sand, or any mixture of both, without calcareous earth,

* Darwin's *Phytologia*, pp 210 and 224 Dublin edition

would have had very little effect in arresting and retaining the aeriform products of putrefaction. All the circumstances of this experiment, and particularly the good effect exhibited by the manure when put to use, prove the propriety of extending a similar practice. In the neighborhood of towns, or wherever else the carcasses of animals, or any other animal substances subject to rapid and wasteful putrefaction, can be obtained in great quantity, all their enriching powers might be secured, by depositing them between layers of marl, or calcareous earth in any other form. On the borders of the Chowan, immense quantities of herrings are often used as manure, when purchasers cannot take off the myriads supplied by the seines. A herring is buried under each corn-hill, and fine crops are thus made as far as this singular mode of manuring is extended. But whatever benefits have been thus derived, the sense of smelling, as well as the known chemical products of the process of animal putrefaction, make it certain that nine-tenths of all this rich manure, when so applied, must be wasted in the air. If those who fortunately possess this supply of animal manure would cause the fermentation to take place and be completely mixed with and enclosed by marl, in pits of suitable size, they would increase prodigiously both the amount and permanency of their acting animal manure, besides obtaining the benefit of the calcareous earth mixed with it.

But without regarding such uncommon or abundant sources for supplying animal matter, every farmer may considerably increase his stock of putrescent manure by using the preservative power of marl; and all the substances that might be so saved are not only now lost to the land, but serve to contaminate the air while putrefying, and perhaps to engender diseases. The last consideration is of most importance to towns, though worthy of attention every where. Whoever will make the trial will be surprised to find how much putrescent matter may be collected from the dwelling-house, kitchen, and laundry of a family; and which if accumulated (without mixture with calcareous earth,) will soon become so offensive as to prove the necessity of putting an end to the practice. Yet it must be admitted that when all such matters are scattered about, (as is usual both in town and country,) over an extended surface, the same putrefaction must ensue, and the same noxious effluvia be evolved, though not enough concentrated to be very offensive, or even always perceptible. The same amount is inhaled—but in a very diluted state, and in small though incessantly repeated doses. But if mild calcareous earth in any form (and fossil shells or marl present much the cheapest) is used to cover and mix with the putrescent matters so collected, they will be prevented from discharging offensive effluvia, and preserved to enrich the soil. A malignant and ever acting enemy will be converted to a friend and benefactor.

The usual dispersion and waste of such putrescent and excrementitious matters about a farm house, though a considerable loss to agriculture, may take place without being very offensive to the senses, or manifestly injurious to health. But the case is widely different in towns. There, unless great care is continually used to remove or destroy filth of every kind, it soon becomes offensive, if not pestilential. During the summer of 1832, when that most horrible scourge of the human race, the Asiatic cholera, was desolating some of the towns of the United States, and all expected to be visited by its fatal ravages, great and unusual exertions were every where used to remove and prevent the accumulation of filth, which, if allowed to remain, it was supposed would invite the approach, and aid the effects of the pestilence. The efforts made for that purpose served to show

what a vast amount of putrescent matter existed in every town, and which was so rapidly reproduced, that its complete riddance was impossible. Immense quantities of the richest manures, or materials for them, were washed away into the rivers—caustic lime was used to destroy them—and the chloride of lime to decompose the offensive products of their fermentation, when that process had already occurred. All this amount of labor and expense was directed to the complete destruction of what might have given fertility to many adjacent fields—and yet served to cleanse the towns but imperfectly, and for a very short time. Yet the object in view might have been better attained by the previous adoption of the proper means for preserving these putrescent matters, than by destroying them. These means would be to mix or cover all accumulations of such matters with rich marl, (which would be the better for the purpose if its shells were in small particles,) and in such quantity as the effect would show to be sufficient. But much the greater part of the filth of a town is not, and cannot be accumulated; and from being dispersed is the most difficult to remove, and is probably the most noxious in its usual course of fermentation. This would be guarded against by covering thickly with marl the floor of every cellar and stable, back yard and stable lot. Every other vacant space should be lightly covered. The same course pursued on the gardens and other cultivated grounds would be sufficiently compensated by their increased products that would be obtained. But independent of that consideration, the manures there applied would be prevented from escaping into the air; and being wholly retained by the soil, much smaller applications would serve. The level streets ought also to be sprinkled with marl, and as often as circumstances might require. The various putrescent matters usually left in the streets of a town alone serve to make the dirt scraped from them a valuable manure; for the principal part of the bulk of street dirt is composed merely of the barren clay brought in upon the wheels of wagons from the country roads. Such a cover of calcareous earth would be the most effectual absorbent and preserver of putrescent matter, as well as the cheapest mode of keeping a town always clean. There would be less noxious or offensive effluvia than is generated in spite of all the ordinary means of prevention; and by scraping up and removing the marl after it had combined with and secured enough of putrescent matter, a compost would be obtained for the use of the surrounding country, so rich and so abundant, that its use would repay a large part, if not the whole of the expense incurred in its production. Probably one covering of marl for each year would serve for most yards, cellars, &c.; but if required oftener, it would only prove the necessity for the operation, and show the greater value in the results. The compost that might be obtained from spaces equal to five hundred acres, in a populous town, would durably enrich thrice as many acres of the adjacent country; and after twenty years of such a course, the surrounding farms might be capable of returning to the town a ten-fold increased surplus product. After the qualities and value of the manure so formed were properly estimated, it would be used for farms that would be out of the reach of all other calcareous manures. Carts bringing country produce to market might with profit carry back loads of this compost eight or ten miles. The annual supply that the country might be furnished with would produce very different effects from the putrescent and fleeting manure now obtained from the town stables. Of the little durable benefit heretofore derived from such means, the appearance of the country offers sufficient testimony. At three miles distance from some of the principal towns in Virginia, more than half the cultivated land is too poor to yield any farming profit. The surplus grain sent to market is very incon-

siderable—and the coarse hay from the wet natural meadows can only be sold to tavern-keepers, or those who feed horses belonging to other persons—and to whom that hay is the most desirable that is least likely to be eaten.

But even if the waste and destruction of manure in towns were counted as nothing, and the preservation of health by keeping the air pure were the only object sought, still calcareous earth, as presented by rich marl, would serve the purpose far better than quick-lime. It is true that the latter substance acts powerfully in decomposing putrescent animal matter, and destroys its texture and qualities so completely, that the operation is commonly and expressively called “burning” the substances acted on. But to use a sufficient quantity of quick-lime to meet and decompose all putrescent animal matters in a town would be intolerably expensive, and still more objectionable in other respects. If a cover of dry quick-lime in powder was spread over all the surfaces requiring it for this purpose, the town would be unfit to live in; and the nuisance would be scarcely less, when rain had changed the suffocating dust to an adhesive mortar. Woolen clothing, carpets, and even living flesh, would be continually sustaining injury from the contact. No such objections would attend the use of mild calcareous earth; and this could be obtained probably for less than one-fifth of the cost of quick-lime, supposing an equal quantity of pure calcareous matter to be obtained in each case. At this time the richest marl on James river may be obtained at merely the cost of digging, and its carriage by water, which, if undertaken on a large scale, could not exceed, and probably would not equal, two cents the bushel.*

The putrescent animal matters that would be preserved and rendered innocuous by the general marling of the site of a town, would be mostly such as are so dispersed and imperceptible that they would otherwise be entirely lost. But all such as are usually saved in part would be doubled in quantity and value, and deprived of their offensive and noxious qualities, by being kept mixed with calcareous earth. The importance of this plan being adopted with the products of privies, &c., is still greater in town than country. The various matters so collected and combined should never be applied to the soil alone, as the salt derived from the kitchen, and the potash and soap from the laundry, might be injurious in so concentrated a form. When the pit for receiving this compound is emptied, the contents should be spread over other and weaker manure, before being applied to the field.

Towns might furnish many other kinds of rich manure, which are now lost entirely. Some of these particularly require the aid of calcareous earth to be secured from destruction by putrefaction, and others, though not putrescent, are equally wasted. The blood of slaughtered animals, and the waste and rejected articles of wool, hair, feathers, skin, horn and bones, all are manures of great richness. We not only give the flesh of dead animals to infect the air, instead of using it to fertilize the land, but their bones, which might be so easily saved, are as completely thrown away. Bones are composed of phosphate of lime and gelatinous animal matter, and, when crushed, form one of the richest and most convenient manures in the world. They are shipped in quantities from the continent of Europe, and latterly even from this country, to be sold for manure in England. The fields of battle have been gleaned, and their shallow graves emptied for this purpose: and the bones of the ten thousand British heroes, who fell on the field of Waterloo, are now performing the less glorious, but more useful purpose of producing, as manure, bread for their brothers at home.

* Such was the case in 1833 when this part was first published; but now a half cent the bushel is the usual price charged for the best marl, as it lies in the river banks.

There prevails a vulgar but useful superstition, that there is "bad luck" in throwing into the fire any thing, however small may be its amount or value, that can serve for the food of any living animal. It is a pity that the same belief does not extend to every thing that as manure can serve to feed growing plants—and that even the parings of nails and clippings of beards are not saved (as in China) for this purpose. However small each particular source might be, the amount of all the manures that might be saved, and which are now wasted, would add incalculably to the usual means for fertilization. Human excrement, which is scarcely used at all in this country, is stated to be even richer than that of birds; and if all the enriching matters were preserved that are derived not only from the food, but from all the habits of man, there can be no question but that a town of ten thousand inhabitants, from those sources alone, might enrich more land than could be done from as many cattle.

The opinions here presented are principally founded on the theory of the operation of calcareous manures, as maintained in the foregoing part of this essay, but they are also sustained to considerable extent by facts and experience. The most undeniable practical proof of one of my positions is the power of a cover of marl to prevent the escape of all offensive effluvia from the most putrescent animal matters. Of this power I have made continued use for about eighteen months, and know it to be more effectual than quick-lime, even if the destructive action of the latter was not objectionable. Quick-lime forms new combinations with putrescent substances, and, in thus combining, throws off effluvia, which, though different from the products of putrescent matter alone, are still disagreeable and offensive. Mild lime on the contrary absorbs and preserves every thing—or at least prevents the escape of any offensive odor being perceived. Whether putrescent vegetable matter is acted on in like manner by calcareous earth cannot be as well tested by our senses, and therefore the proof is less satisfactory. But if it is true that calcareous earth acts by combining putrescent matters with the soil, and thus preventing their loss, (as I have endeavored to prove in chapter viii.) it must follow that, to the extent of such combination, the formation and escape of all volatile products of putrefaction will also be prevented.

But it will be considered that the most important inquiry remains to be answered, to wit: Has the application of calcareous manures been found in practice decidedly beneficial to the health of the residents on the land? I answer, that long experience, and the collection and comparison of numerous facts derived from various sources, will be required to remove all doubts from this question; and it would be presumptuous in any individual to offer as sufficient proof, the experience of only ten or twelve years on any one farm. But while admitting the insufficiency of such testimony, I assert that, so far, [to 1833,] my experience decidedly supports my position. My principal farm, until within some four or five years, was subject in a remarkable degree to the common mild autumnal diseases of our low country. Whether it is owing to marling, or other unknown causes, these bilious diseases have since [to 1833] become comparatively very rare. Neither does my opinion in this respect, nor the facts that have occurred on my farm, stand alone. Some other persons are equally convinced of this change on other land as well as on mine. But in most cases where I have made inquiries as to such results, nothing decisive had then been observed. The hope that other persons may be induced to observe and report facts bearing on this important point has in part caused the appearance of these crude and perhaps premature views.

Even if my opinions and reasoning should appear sound, I am aware

that the practical application is not to be looked for soon; and that the scheme of using marl in towns is more likely to be met by ridicule, than to receive a serious and attentive examination. Notwithstanding this anticipation, and however hopeless of making converts, either of individuals or of corporate bodies, I will offer a few concluding remarks on the most obvious objections to, and benefits of the plan. The objections will all be resolved into one—namely, the expense to be encountered. The expense certainly would be considerable; but it would be amply compensated by the gains and benefits. In the first place, the general use of marl as proposed, for towns, would serve to insure cleanliness, and purity of the air, more than all the labors of their boards of health and their scavengers, even when acting under the dread of approaching pestilence. Secondly, the putrescent manures produced in towns, by being merely preserved from waste, would be increased ten-fold in quantity and value. Thirdly, all existing nuisances and abominations of filth would be at an end; and the beautiful city of Richmond (for example) would not give offence to our nostrils, almost as often as it offers gratification to our eyes. Lastly, the marl, (or mild lime,) after being used until saturated with putrescent matter, would retain all its first value as calcareous earth, and be well worth purchasing and removing to the adjacent farms, independent of the enriching manure with which it would be loaded. If these advantages can indeed be obtained, they would be cheaply bought at any price necessary to be encountered for the purpose.

The foregoing part of this chapter was first published in the *Farmers' Register*, (for July, 1833,) as supplementary to the previous edition of this essay. That publication drew some attention from others to the subject, and served to elicit many important facts, of which I had been before altogether ignorant, in support of the operation of calcareous earth in arresting the effects of *malaria*, or the usual autumnal diseases of the southern states and other similar regions. These facts, together with the result of my own personal experience, extended through two more autumns, (or sickly seasons, as commonly called here and farther south,) since the first publication of these views, will now be submitted. Most of the facts derived from other persons relate to one region, the "rotten lime-stone lands" of southern Alabama; but that region is extensive, is of remarkable and well known character and peculiarities, and the evidence comes from various sources, and is full, and consistent in purport. The facts will be here presented in an abridged form. The several more full communications, from which they are drawn, may be referred to in the *Farmers' Register*, vol. i., pp. 152, 214 and 277.

The first fact brought out was that, in the town of Mobile near the Gulf of Mexico, the streets actually had been paved or covered with shells—thus presenting precisely such a case as I recommended, though not with any view to promoting cleanliness or health. The shells had been used merely as a substitute for stones, which could not be so cheaply obtained. Nor had the greatly improved healthiness of Mobile, since the streets were so covered, (of which there is the most ample and undoubted testimony,) been attributed to that cause, until the publication of the foregoing opinions served to connect them as cause and effect. This can scarcely be doubted by those who will admit the theory of the action of calcareous earth; and the remarkable change from unhealthiness in Mobile, to comparative healthiness, is a very strong exemplification of the truth of the theory. But it is not strange, when so many other causes might (and probably did) operate to arrest disease, that none should have considered the chemical operation of the shelly pavement as one of them, and still less as the one

by far the most important. The paving of streets, (with any material,) draining and filling up wet places, substituting for rotting wooden buildings new ones of brick and stone—and especially the operation of destructive and extensive fires—all, we know, operate (and particularly the last) to improve the healthiness of towns; and all these operated at Mobile, as well as shelling the streets. Neither was the shelling so ordered as to produce its best effect for health. The streets, alleys, and many yards and small vacant lots were covered, and so far the formation and evolving of pestilential effluvia were lessened. But as this was not the object in view, and indeed the chemical action of shells was not thought of, the process was incomplete, and must necessarily have been less effectual than it might have been made. The shelling ought to have been extended to every open spot where filth could accumulate—to every back yard, in every cellar, and made the material of the floor of every stable, and every other building of which the floor would otherwise be of common earth. In addition, after a sufficient lapse of time to saturate with putrescent matters the upper part of the calcareous layer, and thus to make it a very rich compound, there should have been a partial or total removal of the mass, and a new coating of shells laid down. The value of the old material, as manure, would probably go far towards paying for this renewal. If it is not so renewed, the calcareous matter cannot combine with more than a certain amount of putrescent matters; and, after being so saturated, can have no further effect in saving such matters for use, or preventing them from having their usual evil course.

The burning of towns is well known to be a cause of the healthiness of the places being greatly improved, and that such effect continues after as many buildings, or more, have replaced those destroyed by fire. Indeed this improvement is considered so permanent, as well as considerable, that the most sweeping and destructive conflagrations of some of our southern towns have been afterwards acknowledged to have proved a gain and a blessing. The principal and immediate mode of operation of this universally acknowledged cause is usually supposed to be the total destruction, by the fire, of all filth and putrescent matters; and in a less degree, and more gradually, by afterwards substituting brick and stone for wooden buildings, which are always in a more or less decayed state. But though these reasons have served heretofore to satisfy all, as to the beneficial consequences of fires, surely they are altogether inadequate as causes for such great and durable effects. The mere destruction of all putrescent matters in a town, at any one time, would certainly leave a clear atmosphere, and give strong assurance of health being improved for a short time afterwards. But these matters would be replaced probably in the course of a few months, by the residence of as many inhabitants, and the continuance of the same general habits; and most certainly this cause would lose all its operation by the time the town was rebuilt. But there is one operation produced by the burning of a town, which is far more powerful—which in fact is indirectly the very practice which has been advocated—and the effect of which, if given its due weight, furnishes proof of the theory set forth, by the experience of every unhealthy town which has suffered much from fire. If a fair estimate is made of the immense quantity of mild calcareous earth which is contained in the plastering and brick-work of even the wooden dwelling-houses of a town, and still more of those built of masonry, it must be admitted that all that material being separated, broken down, (soon or late,) and spread, by the burning of the houses and pulling down their ruins, is enough to give a very heavy cover of calcareous earth to the whole space of land burnt over. It is to this operation, in a far

greater degree than to all others, that I attribute the beneficial effects to health of the burning of towns.

I proceed to the facts derived from the extensive body of prairie lands in Alabama which rest on a substratum of soft lime-stone, or rich indurated clay marl. It was from these remarkable soils that the specimens were obtained which were described at pp. 42, 43. Some of these, indeed all that have been examined by chemical tests, of the high and dry prairie lands, contain calcareous earth in larger proportions than any soils of considerable extent in the United States that I have seen or tested. The specimens not containing free calcareous earth are of the class of neutral soils; and the calcareous earth, which doubtless they formerly contained, and from which they derived their peculiar and valuable qualities, may be supposed only to be concealed by the accumulation of vegetable matter, according to the general views submitted in chapter vii. The more full descriptions of the soils of this remarkable and extensive region before referred to render it unnecessary to enlarge much here. It will be sufficient to sum up concisely the facts there exhibited—and which agree with various other private accounts which have been received from undoubted sources of information. The deductions from these facts, and their accordance with the theory of the operation of calcareous matter, are matters of reasoning, and, as such, are submitted to the consideration and judgment of readers.

The soil of these prairie lands is very rich, except the spots where the soft lime-stone rises to the surface, and makes the calcareous ingredient excessive. In the specimen formerly mentioned, the pure calcareous matter formed 59 parts in the 100 of this "bald prairie" land. The soil generally has so little of sand, that nothing but the calcareous matter which enters so largely into its composition prevents it being so stiff and intractable, that its tillage would be almost impracticable; yet it is friable and light when dry, and easy to till. But the superfluous rain water cannot sink and pass off, as in sandy or other pervious lands, but is held in this close and highly absorbent soil, which throughout winter is thereby made a deep mire, unfit to prepare for tillage, and scarcely practicable to travel over. This water-holding quality of the soil, and the nearness to the surface of the hard and impervious marly substratum, deprive the country of natural springs and running streams; and before the important discovery was made that pure water might be obtained by boring from 300 to 700 feet through the solid calcareous rock, the inhabitants used the stagnant rain water collected in pits, which was very far from being either pure or palatable. Under all these circumstances, added to the rank herbage of millions of acres annually dying and decomposing under a southern sun, it might have been counted on, as almost certain, that such a country would have proved very unhealthy. Yet the reverse is the fact, and in a remarkable degree. The healthiness of this region is so connected with and limited by the calcareous substratum and soil, that it could not escape observation; and they have been considered as cause and effect by those who had no theory to support, and who did not spend a thought upon the mode in which was produced the important result they so readily admitted. Their testimony therefore is in this respect the more valuable, because it cannot be suspected of having any such bias.

To the time when this last publication is made, (1842,) there has been no reason to doubt the actual facts of autumnal diseases (the effects of *malaria*) being greatly lessened by even the partial use of marling; nor the inference that they would almost cease to occur, (if no mill-ponds and undrained lands remained,) if all the surface of a considerable extent of country were made calcareous, and all rapidly putrescent and otherwise

offensive matter were preserved and kept harmless by being combined with marl, applied from time to time as required. But it should be remembered that, as yet, rapid and extensive as has been the progress of marling in Virginia, there has been no instance of the greater part of any whole neighborhood of so much as a few miles in extent being marled; nor even of all the surface of any one farm; and that, therefore, we have no means of judging by experience of the full measure of benefit to be derived from such a general change of the character of the soil. The most that has yet been done any where is the marling of all the cultivated and arable land; leaving unmarled, and as much as ever the abundant sources of vegetable decomposition and of disease, all the wood-land, hill-sides, and the wet bottoms. Now, as the remaining wood-lands are generally among the poorest of our soils, that is, (according to the theory maintained,) soils incapable of combining with and retaining the products of decomposition—and as they are covered annually with leaves, which in time all rot and their gaseous products finally pass off into the air—it follows, that the lands so left are among the most fruitful of malaria. It is obvious that the remedy is but partially and inefficiently in operation, so long as from one third to one half of every farm is left unmarled, and as free as ever to evolve the agent of disease. So sure does this opinion seem to me, that I have commenced acting on it, by marling the wood-land that is not designed to be cleared for cultivation—and shall continue, as more necessary labors permit, to do so, until not an acre of the farm is left without being changed in character by calcareous earth.

It is proper to add, as an opinion founded on but limited experience as yet, that though the cases of sickness on Coggins Point farm have certainly diminished very greatly—there not being one case of late years of bilious diseases, where there were twenty formerly—still that the diseases seem to have changed in kind, and to have increased in severity and danger. Formerly, there was almost no sickness except from ague and fever, (or, very rarely, a case of mild bilious fever,) from which, though few persons escaped through the autumn, and some suffered several relapses, the attacks were rarely dangerous, and required little skill, and but a few days to cure, for that time. Bad as was this state of things, it seemed that the ague and fever acted as a safely-valve to the system, and while it seldom permitted the enjoyment of long continued robust health, it prevented the occurrence of more dangerous or fatal diseases, such as are the most common among the fewer diseases of what are deemed healthy regions. The fewer diseases of my adult negroes for the last twelve or thirteen years have been of a more inflammatory kind, and are not confined to autumn; and there have been certainly more severe and fatal diseases, and more that required medical aid, than formerly, when there was so much more of sickness of one kind, and confined to one season. In short, it seems that the diseases are no longer (or but in few cases) those of the low country and of a bilious climate, but are more like those of the upper country, which, though occurring but rarely, are generally of a more serious nature. The facts on which this particular opinion has been formed, are still too few, and of too short continuance, to attach to them much importance; and even if they were less doubtful, I have not the medical knowledge to trace these new effects back to their causes. Still, it is deemed due to candor, and to the desire for a fair and full investigation of the subject, even if making against my own views, that these opinions should be stated. There is no other subject, than this, taken in general, which more deserves and requires investigation; and in the present inchoate state of the discussion, the expression of even erroneous opinions

will not be useless, if it should serve to elicit more full or correct ones from other sources.

Nothing better than this one subject deserves investigation by medical men, acting under the direction of government. The materials for information are now abundant, in the experience and observation of the numerous farmers who have marled or limed their lands long enough to judge of the effects on health; and whether upon true or false grounds, the opinion among such persons seems now (1842) almost universal, (so far as I have heard opinions expressed,) that the prevalence of autumnal diseases, the product of malaria, has been invariably and manifestly lessened since the lands were in part marled or limed. My individual experience and observations on this point, now of nine years' more extent than when the first fruits thereof were stated in a foregoing part of this chapter, concur with the more general and loose information derived from others, in confirming my position. It sometimes happens that the very fact of an opinion being universally admitted prevents the obtaining such proofs of its truth as would certainly have been ready, if the opinion had been questioned and denied by many skeptics. And such is the state of the proposition now under consideration. Even in the few years which have passed since I first advanced the opinion that the use of calcareous manures served to improve health, that opinion has become so general, and is deemed so certain and unquestionable, by those persons who have used those manures, that but few facts can be learned of them sufficiently exact to serve as proofs; because no person has deemed it necessary to collect and preserve proofs of what none doubted. When asking for such proofs, as I have often done, of cultivators and residents in various parts of the marl region, I have rarely obtained any, except new declarations, from every person interrogated, of concurrence and entire faith in the general opinion that marling or liming had served greatly to abate the prevalence of autumnal diseases. Such general belief and confidence in an opinion so recently entertained and promulgated, cannot be altogether founded on error.

When my opinions of the beneficial operation of calcareous earth in soil, or mixed with putrescent matter, in destroying or disarming the sources of disease, were first published, and until after the last publication of the same in 1835, I had no knowledge that similar grounds had been taken by any other person. But since, in the recent publications of a French writer, M. Puvis, I have found the same general opinion expressed, and many important facts given in confirmation. However, while I gladly accept the important aid of M. Puvis' facts, as proof, I do not admit the correctness of his reasoning thereupon. Some of the former will be quoted in the following passages. For his full views, see the translations of his essays 'On Lime as Manure,' and 'On Marl,' both contained in vol. iii. of the *Farmers' Register*.

"The results of marling may be considered in a point of view more elevated, and still more important than that of the fertility which it gives to the soil; they may perhaps have much influence on the healthiness of a country where it becomes a general practice.

"Although it may not have been yet uttered by others, this opinion appears founded on strong probabilities, on strong analogies and precise facts, all of which appear to give it a sufficient certainty.

"It is known that the calcareous principle is one of the most powerful agents to resist putrefaction. It is employed to make healthy places inhabited by men and animals, in which sickness or contagion is feared; it serves to neutralize the emanations of dead bodies undergoing putrefaction; it destroys the deleterious exhalations which escape from privies, and which sometimes cause the death of those who are employed to cleanse them.

"It even seems that calcareous countries are unhealthy only when they are interspersed by marshes, or when some causes, foreign to the soil and climate, determine the unhealthiness, as in countries on the borders of the sea, where the flowing of the tide and the mingling of salt and fresh waters infect the air, by the deleterious emanations of their combination. This cause of unhealthiness is regarded as a certain fact; for salubrity is generally seen to appear whenever this mixture of waters is prevented.

"In the valleys of rivers bordered by calcareous mountains, which enclose unhealthy countries in their interior, insalubrity commences there only as the calcareous soil, which is attached to the mountain, gives place to silicious soil. In the same plain, and far from a mountain, salubrity is seen to diminish in the same proportion that the calcareous soil of the surface does; and the *communes* of Bresse, which have an abundance of marly or calcareous soils, are much more remarkable for their salubrity than those on the white lands (*terrain blanc**) While the ponds of Dombé, which are on the silicious soil, appear to be one of the greatest causes of unhealthiness, those of Bresse, which are on calcareous lands, do not show such effects in the country where they are found; so, likewise, the ponds of the country situated between the Veyle and the Reyssouze, to the north-west of Bourg, which are generally on calcareous soil, do not appear to injure the healthiness of the country in any manner.

"For the support of this system, we will also cite the ponds of Berri on calcareous soil, whose emanations have nothing unhealthy; the laying dry of the ponds of Parraçay, in the canton of Lignières, has added nothing to the healthiness of a calcareous country naturally healthy. And in the same canton, the pond of Villiers, which is said to be seven leagues in circumference, does not cause diseases on its borders. Besides, during the month of August, the water of the ponds on calcareous soil does not become blackish, as often happens in silicious ponds. The water would then be made wholesome by the calcareous principle, in the same way as their emanations.

"In fine, Dombé and Sologne, and a number of other countries are unhealthy, and subject to intermittent fevers, without being marshy; but their soil is likewise silicious, and the land moist. Puisaye, and a part of Bresse, in similar land, which contain little or no calcareous soil, have also many autumnal fevers."—(*Translation from 'Essai sur la Marne.'*)

CHAPTER XVI.

DIRECTIONS FOR THE MECHANICAL OPERATIONS OF APPLYING MARL AS MANURE.

The great deposite of fossil shells, which custom has miscalled marl, is in many places exposed to view in most of the lands that border on our tide-waters, and on many of their small tributary streams. Formerly, it was supposed to be limited to such situations; but since its value as a manure has caused it to be more noticed and sought after, marl has been found in many other places. It is often discovered by the digging of wells, but lying so deep that its value must be more highly estimated than at

* The reader of M. Puvis' essays on lime and marl, which were inserted in vol. iii., may remember that this provincial term and others (*plateaux argillo-silicieux*, &c.) were there used to designate a peculiar kind of soil, destitute of calcareous matter, stiff, intractable and poor—and which seems precisely of the character of the poor ridge lands of lower Virginia, to which calcareous manures are so peculiarly adapted.—*Translator.*

present before it will be dug for manure. From all the scattered evidences of the presence of this deposit, it may be inferred that it lies beneath nearly every part of our country between the sea and the granite ridge which forms the falls of all our rivers. It is exposed where it rises, and where cut through by the deep ravines of hilly land and by the courses of rivers—and concealed by its dips, and the usual level surface of the country. The rich tracts of neutral soil on James river, such as Shirley, Westover, Brandon, and Sandy Point, seem to have been formed by alluvion, which may be termed recent compared to that of our district in general; and in these no marl has been found, though it is generally abundant in the adjacent higher lands. Fresh-water muscle shells are sometimes found in thin layers, (from a few inches to two feet thick,) both on these lands and others—but generally near the surface, and always far above the deposit of sea shells, found under the high land. These two layers of different kinds of shells are separated by a thickness of many feet of earth, containing no shells of any kind. Muscle shells are richer than the others, as they contain much gelatinous and enriching animal matter. On this account, the earth with which muscle shells are found mixed is a rich black mould. Most persons consider these beds of muscle shells as artificially formed by the Indians, who are supposed to have collected the muscles for food, and left the shells where the fish were consumed. There are some strong reasons which may be adduced both to sustain and to oppose this opinion. But whatever may be the origin of these collections of muscle shells, it does not affect their qualities as manure for the soils in which they are found, or for others to which they may be removed.

Neither the fossil sea shells, nor the earth mixed with them, are supposed to contain any important or considerable proportion of putrescent matter—and this manure has been considered throughout this essay as being valuable *only as containing calcareous earth*. This, no doubt, is the only ingredient of any worth, in the great majority of cases. But sometimes there are other ingredients—which must be considered merely as exceptions to the general rule. One of these exceptions has already been stated, in the description of gypseous marl, (page 92;) and some others have been discovered since the publication of that statement. A kind of earth, containing a large proportion of carbonate of magnesia, as well as of carbonate of lime, has been found in Hanover county, Va. (*Farmers' Register*, vol. i.) Professor Rogers, of William and Mary College, has discovered, in many of the marls of lower Virginia, some proportion of the "green sand" of geologists, or what is itself called "marl," (another misapplication of that name,) in New Jersey, and which has there been found highly valuable as manure, though containing not a particle of the carbonate of lime, which constitutes the sole value of shells and calcareous manures in general. The formation or body of this green-sand, separate and distinct from any marl, I had discovered long before, and of which a full account will be given in a subsequent part of this essay. But however interesting may be the discovery of these different ingredients of particular bodies of marl, and however valuable they may prove as manures, still they are not to be considered as treated of in this essay under any general observations on *marl*—which observations are designed to be applied simply to manure of which the only useful ingredient is the *carbonate of lime*.

More than a hundred kinds of sea shells are found in the beds of marl, that I have worked, without counting any of very small size. Many kinds would escape common observation, and others would require the aid of a magnifying glass to be distinguished. Generally the shells, though fragile, are entire, but are much broken by the digging, and after-operations. The

white shells are rapidly reduced, after being mixed with an acid soil; but some gray kinds, as the scallop and the oyster, are so hard as to be very long before they can act as manure. Some beds, and they are generally the richest, have scarcely any whole shells, but are formed principally of small broken fragments. Of course the value of marl as a manure depends in some measure on which kinds of shells are most numerous, and their state of division, as well as upon the total amount of the calcareous earth contained. The last is however by far the most important criterion of value. The most experienced eye may be much deceived in the strength of marl; and still more gross and dangerous errors would be made by an inexperienced marler. The strength of a body of marl often changes materially in sinking a foot in depth—although the same changes may be expected to occur very regularly, in every pit sunk through the same bed. Whoever uses marl ought to know how to analyze it, which a little care will enable any one to do with sufficient accuracy. The method described, at page 35, for ascertaining the proportions of calcareous earth in soils, will of course serve for the same purpose with marl. But as more particular and minute directions may be necessary for many persons who will use this manure, and who ought to be able to judge of its value, such directions will be here given, and which any one can follow by merely applying sufficient attention and care. To perform this process will require no other chemical tests than muriatic acid and carbonate of potash, and no apparatus, except small scales and weights, a glass funnel and some blotting or very porous, printing paper—all of which may be bought at any apothecary's shop.

Directions for analyzing marl by solution and precipitation.

1st. Take a lump of marl, fossil shells, &c., large enough to furnish a fair sample of the particular body under consideration—dry it perfectly near the fire—pound the whole to a coarse powder (in a metal mortar,) and mix the whole together. Take from the mixture a small sample, which reduce to a finely divided state, and weigh of it a certain portion, say 50 grains, for trial.

2d. To this known quantity, in a glass, pour slowly and at different times muriatic acid diluted with three or four times its bulk of water—(any except limestone, or *hard* water.) The acid will dissolve all the lime in the calcareous earth, and let loose the carbonic acid, with which it was previously combined, in the form of gas, or air, which causes the effervescence, which so plainly marks the progress of such solution. The addition of the muriatic acid must be continued as long as it produces effervescence; and but very little after that effect has ceased. The mixture should be well and often stirred, and should have enough excess of acid to be sour after standing thirty or forty minutes. (So much of the acid as the lime combines with loses its sour taste, as well as its other peculiar qualities.)

The mixture now consists of 1, the lime combined chemically with muriatic acid, forming *muriate of lime*, which is a *salt*, and which is dissolved in the water—2, a small excess of muriatic acid mixed with the fluid—and 3, the sand, clay and any other insoluble parts of the sample of marl. To separate the solid from the fluid and soluble parts is the next step required.

3rd. Take a piece of filtering or blotting paper, about six or eight inches square, (some spongy and unsized newspapers serve well,) fold it so as to fit within a glass funnel, which will act better if its inner surface is fluted. Pour water first into the filter, so as to see whether it is free from any hole,

or defect; if the filtering paper operates well, throw out the water, and pour into it the whole mixture. The fluid will slowly pass through into a glass under the funnel, leaving on the filter all the solid parts, on which water must be poured once or twice, so as to wash out, and convey to the solution, every remaining particle of the dissolved lime.

4th. The solid matter left, after being thus washed, must be taken out of the funnel on the paper, and carefully and thoroughly dried—then scraped off the paper and weighed. The weight, say 27 grains, being deducted from the original quantity, 50, would make the part dissolved ($50 - 27 = 23$) 46 per cent. of the whole. And such may be taken as very nearly the proportion of calcareous earth (or carbonate of lime) in the earth examined. But as there will necessarily be some loss in the process, and every grain taken from the solid parts appears in the result as a grain added to the carbonate of lime, it will be right in such partial trials to allow about two per cent. for loss, which allowance will reduce the foregoing statement to 44 per cent. of carbonate of lime.

5th. But it is not necessary to rely altogether on the estimate obtained by subtraction, as it may be proved by comparison with the next step of the process. Into the solution (and the washings) which passed through the filter, pour gradually a solution of *carbonate of potash*. The first effect of the alkaline substance, thus added, will be to take up any excess of muriatic acid in the fluid—and next, to precipitate the lime (now converted again to carbonate of lime,) in a thick curd-like form. When the precipitation is ended, and the fluid retains a strong taste of the carbonate of potash, (showing it to remain in excess,) the whole must be poured on another filtering paper, and (as before,) the solid matter left thereon repeatedly washed by pouring on water, then dried, scraped off, and weighed. This will be the actual proportion of the calcareous part of the sample, except, perhaps, a loss of one or two grains in the hundred. The loss, therefore, in this part of the process apparently lessens, as the loss in the earlier part increases the statement of the strength of the manure. The whole may be supposed to stand then :

27 grains of sand and clay	} = 50.
21 ——— of carbonate of lime	
2 ——— of loss	

If the loss be divided between the carbonate of lime and the other worthless parts of the manure, it will make the proportion 28 and 22, which will be probably near the actual proportions.

The foregoing method is not the most exact, but is sufficiently so for practical use. All the errors to which it is liable will not much affect the reported result—unless magnesia is present, and that is not often in manures of this nature. Magnesia is never found (I believe) in the deposits of fossil shells—nor have I known of its presence in any of the earthy manures, except lime-stone, and the magnesian marl discovered in Hanover. If any considerable proportion of carbonate of magnesia should ever be present in marl tried by the foregoing method, it may be suspected by the effervescence being very slow compared to that of carbonate of lime alone; and the proportions of these two earths may be ascertained as follows. The magnesia as well as the lime would be dissolved by the *muriatic acid*, (applied as above directed,) but the magnesia would not be precipitated with the carbonate of lime, but would remain dissolved in the alkaline solution, last separated by filtering. If this liquor is poured into a Florence flask and boiled for a quarter of an hour, the carbonate of magnesia will fall to the bottom, and may then be separated by filtering and washing, and its quantity ascertained by being dried and weighed. This

part of the process may be easily added to the foregoing—but it will very rarely be required.

If desired, the proportion of silicious and aluminous earth may be ascertained, with enough truth for practical use, by stirring well these parts (minutely divided) in a glass of water, and after letting it stand a minute, for the sand to subside, pouring off the fluid into another glass. The sand will be left, and the finely divided earth and clay pass off with the water, and may be separately collected and dried on filtering paper, and weighed.

For want of attention to the only safe guide, the chemical analysis of marl, gross errors are often committed, and losses continually sustained. By relying on the eye only, I have known marl, or rather a calcareous sand, to be rejected as worthless, and thrown off at considerable cost of labor, to uncover worse marl below, in which whole shells were visible; and on the contrary, earth has been taken for marl, and used as such, which had no calcareous ingredient whatever. The best marls for profitable use are generally such as show the fewest whole shells, or even large fragments—and would be passed by unnoticed in some cases, or considered only as barren sand, or equally worthless clay. But even if such mistakes as these are avoided, every farmer using marl, without analyzing specimens frequently and accurately, will incur much loss by applying it in quantities either too great or too small.

If marl reaches the surface, or “crops out,” any where, it may be found most easily by examining the beds of streams passing through the lowest land, or deepest ravines. A few of the smallest particles of shells found there will prove that the stream passes through marl somewhere above; and a careful examination continued towards the source, will scarcely fail to discover where the bed lies. Its usual direction is horizontal, or very little inclined; and therefore if discovered any where along the sides of a narrow valley, it may generally be found by digging on the opposite side, or elsewhere not very distant at the same elevation on the hill-side; and it is always nearer the surface on swells, or the convex parts of the hill-side, than where it retreats and forms hollows. In the more level parts of the country, the marl sometimes is very near the surface of the lowest land, and yet is not visible any where. In such situations, particularly, a cheap and convenient auger may be used with much advantage in searching for marl; and it is also useful to try the depth or quality of a bed, even when its surface has been found. This tool may be made by welding a straight stem, half an inch square and six or seven feet long, to a common screw auger of about one inch and a half bore. If it has been so much worn as to be useless as a carpenter's tool, it will serve for boring in earth. A cross-piece for a handle should be fixed to slide over the stem, and be fastened by a small screw at different elevations, as most convenient. Other pieces may be added to the stem, attached by joints, so as to bore twelve or more feet deep. Dr. Wm. I. Cocke, formerly of Sussex, to whom I am indebted for this simple but useful tool, was enabled by its use to find a very valuable bed of marl which was no where visible at the surface, and which he used to great extent and advantage.

Mr. Williams Carter, of Hanover, has introduced a simple and useful improvement which greatly facilitates the use of the cheap and light auger just described. When one or more additional joints are required, (for boring to greater depth than seven or eight feet,) the process becomes much more troublesome, because of the necessity for separating and re-uniting the several joints every time the auger is drawn up to take off the earth, which has to be done for every four or five inches of depth gained. This trouble may be avoided by Mr. Carter's method. This is, to have a rough bench,

or narrow table, made of a single plank, some 7 or 8 feet long, and having legs 10 or 12 feet in length. A hole large enough for the stem of the auger to turn in freely is in the middle of the bench. As soon as a second joint is attached, the bench is set over the boring, with the hole immediately above, so that when the auger is lifted perpendicularly clear of the boring, its upper joint passes through the hole, and is held up steadily by the support of the bench above. For still greater and unusual depths, another bench with longer legs may be substituted, or a lower one placed upon and confined to the first bench. (*Farmers' Register.*) Such means as these, imperfect as they are, will be found more convenient and more operative, as well as much more cheap, than the heavy and costly augers used to search for coal.

By proper examinations marl may be found at or near the surface through a vast extent of the tide-water region of the United States, where it has not yet been noticed. But still, under most lands it probably does not approach within twenty-five or thirty feet of the surface, and if reached by digging, would be covered by water, so as greatly to increase the difficulty of obtaining it from such depths. Will these obstacles always debar from the benefit of this treasure half the great region under which it lies? I think not. Though it would be ridiculous now to propose such undertakings, it will at some future time be found profitable to descend still greater depths for good marl; and shafts will be sunk and the water and marl drawn out by horse-power or by steam engines, and the excavation carried on in the same manner as is done in coal mines. When such means shall be resorted to, it is probable that there will be but a small portion of the great tide-water region, or the region east of the granite range, in which marl may not be found sufficiently convenient for use. For example: from a mile south of Petersburg, along the line of the railway to the Roanoke, no marl had been found either by the excavations for the road, or in the much deeper wells dug long before in the vicinity of the route. The well for the water-station nine miles from Petersburg did not at all times supply enough water for the engines, and it was determined to dig one deep enough for that purpose. Disregarding the small veins of water usually reached at less than 20 feet, the digging was sunk to 50 feet, when marl was reached. Its quality at top was rather poor; but it became more and more rich, as well as of firmer consistence, (though never very hard,) until the well had been sunk to 80 feet, without reaching the bottom of the marl, or finding any other vein of water. The lower part of this marl was from 80 to 90 per cent. of carbonate of lime, as I found by several analyses. It would have served to make good lime, by burning, for cement or for manure, to be transported to a distance on the railway; besides being of more value to be used unprepared to enrich the nearer land. Though covered by 50 feet of earth, and the excavation impeded by the water from above, this marl might have been profitably raised 80 feet, or as much lower as the bed may extend. And so firm was its texture, that the excavation might have been safely enlarged gradually as it was deepened, as is done in the chalk-pits of England, so as that the digging should form a hollow cone, communicating from its apex by the narrower cylindrical well through the 50 feet of earth above to the surface. Thus though the earth might have been twice the thickness of the marl below, the greater diameter of excavation in the latter would have furnished much the greater quantity of contents. Of this most valuable deposit, found in a region before supposed destitute, and where its transportation to a long line of destitute land was so convenient, no use has been made, except of the quantity necessarily drawn up in digging this well. And this means for enriching the undertaker, and fertilizing a vast extent of surface

of acid and poor land, will probably remain totally neglected for the next fifty years. It is most probable that this same thick and rich body of marl may be found at many miles' distance on the line of rail-road, and indeed wherever the surface is in the same position relative to the granite range.

For taking up marl from any depth, greater than 16 feet, or more than two casts with the shovel will serve for, it will be better to use horse-power applied to machinery. A crane which has been used by Wm. Carmichael Esq., of Queen Ann's county, Md., will serve the purpose. His description of the crane was published in the 'Farmers' Register,' as follows:

"In your 'Essay on Calcareous Manures,' you give instructions for digging and carting marl. This method I pursued for several years, but found the labor hard on my hands, and tedious. Marl here is generally found in deep ravines or in wet grounds. My operations have been slow, from the difficulty of making firm and lasting ways, and the labor of ascending steep hills. Last winter I made a model, and this spring I built a machine for raising marl, to be worked by a horse. I have been using it to advantage, and now send you a draught of it, as it may be useful to those who have wet marl pits like mine. By means of a pump to throw off the water, pits may be worked at a considerable depth; and even if marl is dry, but lies deep, I think the crane may be used to advantage. I use two boxes, and by means of hinges and a latch the marl is discharged from the bottom. I have double blocks; the rope passes through the swoop about eighteen inches from the end, and runs down to the post which supports the swoop, and passes through it on a small roller, and in like manner through the next post to the cylinder, to which a reel is attached to increase the motion. The post which holds the swoop and the cylinder, runs on iron pins let into thimbles. The lever is in two pieces, one fastened in the cylinder with a groove at the end, into which the other is let, and secured by a sliding iron clamp. When the marl is discharged from the box, and the swoop swung round over the pit, in nautical phrase, by unshipping the end of the lever, the rope unwinds, and the box descends without moving the horse. The circle in which the horse travels ought to be twenty-one feet in diameter. The second and third posts supported by side braces.

"The cost of the machine is small, though I cannot make an exact estimate. The carpenter who did the work was hired by the day on the farm,

and was taken off with other jobs; but his bill could not exceed eight dollars. The cost of the iron work was ten, and one hundred and sixty-five feet of inch rope, at eighteen and a half cents a pound. The timber, taken from my own woods, may be estimated at five dollars. The rope I find soon wears out, and I intend to supply its place with a light iron chain.

"When the marl is uncovered, with one efficient hand in the pit and a less efficient one to discharge the boxes and drive the horse, five hundred bushels may be raised in a day. The work is not oppressive to the laborers. The teams stand on high, dry ground; no sloughs to plunge through, and no hill to climb. The swoop is turned by a small rope over the carts, and the marl immediately discharged into them. I work four carts, with two sets of oxen to each. They came out of the winter lean and weak; and now, with green clover for their food, at the distance of a half to three-quarters of a mile I draw out from four to five hundred bushels a day, and my oxen have improved. My work goes on with ease and expedition; without stoppage to mend roads, or to clear ditches."

Our beds of marl are either of a blue, or a yellowish color. The color of the first might be supposed to have some connexion with the presence of water, as this kind is always kept wet by water oozing slowly through it. But the yellow marl is also sometimes wet, though more generally dry. The blue color of marl therefore is not caused by merely the presence of water, or there would be no wet yellow marl. When both blue and yellow marl are seen in the same bed, the blue is always at bottom; and the line of division between the colors is well defined, and there is seen no gradual change of one to the other. I observed, in the year 1834, that as intense and perfect a blue color as marl has ever been known to have was given to what had been dry yellow marl, by its being used as a thick flooring for a stable yard, and kept covered with the rotting manure, and penetrated by its liquid oozings, which the marl was there placed to save. It may be inferred from this fact that blue marls have received their color from some vegetable extract, or other putrescent matter, dissolved in the water passing through the bed.

The dry marls are of course much the easier to be worked. Unless very poor, and sandy, as well as wet, all our marls are sufficiently firm and solid for the sides of the pit to stand secure, when dug perpendicularly.

Where a bed of marl is dry, and not covered by much earth, no directions are required for the pit work—except it be, that the pit should be long enough to allow the carts to descend to the bottom (when finished) and to rise out on a slope sufficiently gradual. This will prevent the necessity of twice handling the marl, by first throwing it out of the pit and then into the carts, which must be done if the pit is made too short, or its ends too steep, for the loads to be drawn out. No machine or contrivance yet known will raise marl from the bottom of a pit, or a valley, so well as a horse cart; and no pains will be lost, in enlarging the pit, and graduating the ascent out of it, to attain that object.

But it is not necessary, nor often convenient, that the carts shall descend as low as the bottom of the excavation. For the lower 6 or 8 feet of the marl to be dug, it is generally best, (after digging an area of sufficient size to the top of that part,) to take out this lower part in small pits, of about 5 feet wide to 7 or 8 in length, with perpendicular ends as well as sides. These pits may be filled with the earth removed from the next adjacent space, cleared off for another digging. If the bed be very wet, or unavoidably subject to inundation from streams swollen by heavy rains, it will be more safe to dig pits as small as the men employed can find space

to dig in and throw out from, and to sink them to 15 or 16 feet, by throwing the lower half on a table, whence another man will throw it to the level where the carts can stand to be loaded. Then each separate pit will soon be completed, and out of danger of bad weather. And if flooded before being finished, the loss of the marl, then remaining not dug, will not be important in so small an excavation.

As marl shows usually on a hill-side, but little earth has to be moved off to uncover the first place for digging. But the next, and each successive cover of earth, will be more thick, until it may be necessary to abandon that place and begin again elsewhere. But the quantity of covering earth need not be regarded as a serious obstacle, if it is not thicker than the marl below it. While that is the case, one pit completed will receive all the earth thrown from an equal space, for commencing another. When this proportion of earth is exceeded, it is necessary to carry it farther, by either wheel-barrows or scrapers, and the labor is thereby greatly increased.

For any extensive operation, it is much cheaper to take off a cover of earth twelve feet thick to obtain marl of equal depth, than if both the covering earth and marl were only three feet each. Whether the cover be thick or thin, two parts of the operation are equally troublesome, viz. to take off the mat of roots, and perhaps some large trees on the surface soil, and to clean off the surface of the marl, which is sometimes very irregular. The greater part of the thickest cover would be much easier to work. But the most important advantage in taking off earth of ten or more feet in thickness, is saving digging by causing the earth to come down by its own weight. If time can be allowed to aid this operation, the driest earth will mostly fall, by being repeatedly undermined a little. But this is greatly facilitated by the oozing water, which generally fills the earth lying immediately on beds of wet marl. In uncovering a bed of this description, for one of my early operations, where the marl was to be dug fourteen feet, and ten to twelve feet of earth to remove, my labor was made ten-fold heavier by digging altogether. The surface bore living trees, and was full of roots—there was enough stone to keep the edges of the hoes battered—and small springs and oozing water came out every where, after digging a few feet deep. A considerable part of the earth was a tough, adhesive clay, kept wet throughout, and which it was equally difficult to get on the shovels, and to get rid of. Some years after, another pit was uncovered on the same bed, and under like circumstances, except that the time was the last of summer, and there was less water oozing through the earth. This digging was begun at the lowest part of the earth, which was a layer of sand, kept quite wet and soft by the water oozing through it. With gravel shovels, this was easily cut under from one to two feet along the whole length of the old pit, and, as fast as was desirable, the upper earth, thus undermined, fell into the old pit; and afterwards, when that did not take place of itself, the fallen earth was easily thrown there by shovels. As the earth fell separated into small but compact masses, it was not much affected by the water, even when it remained through the night before being shoveled away. No digging was required, except this continued shoveling out of the lowest sand stratum; and whether clay, or stones, or roots, were mixed with the falling earth, they were easy to throw off. The numerous roots, which were so troublesome in the former operation, were now an advantage; as they supported the earth sufficiently to let it fall only gradually and safely; and before the roots fell, they were almost clear of earth. The whole body of earth, notwithstanding all its difficulties, was moved off as easily as the driest and softest could have been by digging altogether.

In working a pit of wet marl, no pains should be spared to drain it as effectually as possible. Very few beds are penetrated by veins of running water which would deserve the name of springs; but water oozes very slowly through every part of wet marl, and bold springs often burst out immediately over its surface. After the form of the pit and situation of the road are determined, a ditch to receive and draw off all the water should be commenced down the valley, as low as the bottom of the area where the carts are to stand is expected to be made; and the ditch opened up to the work, deepening as it extends, so as to keep the bottom of the ditch on the same level with the bottom of the area. It may be cheaper, and will serve as well, to deepen this ditch as the deepening of the pit proceeds. After the marl is uncovered for the full size intended for the area, (which ought to be large enough for carts to turn about on,) a little drain of four or five inches wide, and as many deep, (or the size made by the grubbing hoe used to cut it,) should be carried all around to intercept the surface or spring water, and conduct it to the main drain. The marl will now be dry enough for the carts to be brought on and loaded. But as the digging proceeds, oozing water will collect slowly; and, aided by the wheels of loaded carts, the surface of the firmest marl would soon be rendered a puddle, and next quagmire. This may easily be prevented by the inclination of the surface. The first course dug off should be much the deepest next the surface drain, (leaving a margin of a few inches of firm marl, as a bank to keep in the stream,) so that the digging shall be the lowest around the outside, and gradually rise in level to the middle of the area. Whatever water may find its way within the work, whether from oozing, rain, or accidental burstings of the little surface drain, will run to the outside, the dip of which should lead to the lower main drain. After this form has once been given to the surface of the area, very little attention is required to preserve it; for if the successive courses are dug of equal depth from side to side, the previous dip will not be altered. The sides or walls of the pit should be cut, (in descending,) something without the perpendicular, so that the pit is made one or two feet wider at bottom than top. The usual firm texture will prevent any danger from this overhanging shape, and several advantages will be gained from it. It gives more space for work—prevents the wheels running on the lowest and wettest parts—allows more earth to be disposed of, in opening for the next pit—and prevents that earth from tumbling into the next digging, when the separating wall of marl is afterwards cut away. The next upper and larger drain of the pit, which takes the surface water, will hang over the small one below, kept for the oozing water. The former remains unaltered throughout the job, and may still convey the stream when six feet above the heads of the laborers in the pit. The lower drain of course sinks with the digging. Should the pit be dug deeper than the level of the main receiving ditch can be sunk, a wall should be left between, and the remainder of the oozing water must be conducted to a little basin near the wall, and thence be baled or pumped into the receiving ditch. The passage for the carts to ascend from the pit should be kept on a suitable slope; and the marl forming that slope may be cut out in small pits, after all the balance of the digging has been completed.

If the marl is so situated that carts cannot be driven as low as the bottom, either because of the danger of flooding, or that the ascent would be too steep for sufficiently easy draught, then the area must be cut out in small pits, as before stated, beginning at the back part, and extending as they proceed, towards the road leading out of the pit.

On high and hilly land, marl is generally found at the bottom of ra-

vines, and separated from the field to which it is to be carried by a high and steep hill-side. The difficulty of cutting roads in such situations is much less than any inexperienced person would suppose. We cannot get rid of any of the actual elevation—but the ascent may be made as gradual as is desired, by a proper location of the road. The intended course must be laid off by the eye, and the upper side of the road marked. If it passes through woods, it will be necessary to use grubbing hoes for the digging. With these, the digging should be begun at the distance of four or five feet below the marked line, and carried horizontally onward to it. The earth so dug is to be pulled back with broad hoes, and laid over a width of three or four feet below the place from which it was taken. Thus the upper side of the road is formed by cutting down, and the lower side by filling up with the earth taken from above.

The annexed figure will prevent these directions being misunderstood. The straight line from *a* to *b* represents the original slope of the hill-side, of which the whole figure is a section. The upper end of the dotted part of the line is in the mark for laying off the upper side of the road. The upper triangle is a section of the earth dug out of the hill-side, and the lower triangle of the part filled up by its removal. The horizontal line is the level of the road formed by cutting in on the upper, and filling up on the lower side. After shaping the road roughly, the deficiencies will be seen, and may be corrected in the finishing work, by deepening some places and filling up others, so as to graduate the whole properly. A width of eight or nine feet of firm road will be sufficient for carting marl.

If the land through which the road is to be cut is not very steep, and is free from trees and roots, the operation may be made much cheaper by using the plough. The first furrow should be run along the line of the lower side of the intended road, and turned down hill: the plough then returns empty, to carry a second furrow by the first. In this manner it proceeds, cutting deeply, and throwing the slices far, (both of which are easily done on a hill-side,) until rather more than the required width is ploughed. The ploughman then begins again over his first furrow, and ploughs the whole over as at first, and this course is repeated perhaps once or twice more, until enough earth is cut from the upper and put on the lower side of the road. After the first ploughing, broad hoes should aid and complete the work, by pulling down the earth from the higher to the lower side, and particularly in those places where the hill-side is steepest. After the proper shape is given, carts, at first empty and then with light loads, should be driven over every part of the surface of the road, until it is firm. If a heavy rain should fall before it has been thus trodden, the road would be rendered useless for a considerable time.

These directions are mostly suited for greater difficulties than usually occur, though they are such as attended most of my labors in marling. In the

great majority of cases, there will be much less labor and care and skill required, because there will not be encountered such obstacles as high and steep hills to ascend, thick over-lying earth to remove, or wet pits and roads to keep drained.

In large operations and in dry marl, much labor of digging might be saved by slightly undermining a perpendicular body of marl, and then splitting of large masses at once, by driving in a line of wedges on the upper surface.

For hard or firm marl, narrow and heavy picks are the best digging utensils. Gravel shovels, with rounded points and long handles, are the cheapest and most effective for throwing out the marl and loading the carts, as well as for afterwards spreading the heaps on the field.

Tumbrel carts, drawn by a single horse or mule, are most convenient for conveying marl short distances. Every part of the cart should be light, and the body should be so small as only to hold the load it is intended to carry, without a tail-board. This plan enables the drivers to measure every load, which advantage will be found on trial much more important than would at first be supposed. If carts of common size are used, the careless laborers will generally load too lightly, yet sometimes will injure the horse by putting on a load much too heavy. The small sized cart-bodies prevent both these faults. The load cannot be made much too heavy; and if too light, the farmer can detect it at a glance. Where there is a hill to ascend, five heaped bushels of wet marl is a sufficient load for a horse or good mule. If the marl is dry, or the road level and firm, six bushels will be not too much, and may be put in the same carts, by using tail-boards.

Strong laborers are required in the pit for digging and loading; but boys who are too small for any other regular farm labor, are sufficient to drive the carts. Horses or mules kept at this work soon become so tractable that very little strength or skill is required to drive them.

One of the most general and injurious errors is the irregular and unequal distribution of the marl over the fields. By this error, it often happens that in the same acre there is both too much and too little marl, on many different parts. It will save much time and trouble, and ensure far greater accuracy in depositing the loads, and afterwards in spreading them, to have the field marked off slightly by a plough, in checks or squares of sizes suitable to the desired amount of the dressing. A load (or the half of a load for very light marling) should be dropped in every square, and the heap be required to be spread over that marked space precisely.

All these hints and expedients, or perhaps better plans, might perhaps occur to most persons before they are long engaged in marling. Still these directions may help to smooth away some of the obstructions in the way of the inexperienced; and they will not be entirely useless, if they serve to prevent even small losses of time and labor.

CHAPTER XVII.

THE PROGRESS OF MARLING IN VIRGINIA.

My task is at last completed. Whether I shall be able to persuade my countrymen to prize the treasures, and seize the profits which are within their reach, or whether my testimony and arguments shall be fruitless, soon or late, a time must arrive when my expectations will be realized. The use of calcareous manures is destined to change a large portion of the soil of lower Virginia from barrenness to fertility; which, added to the advantages we already possess—our navigable waters and convenient markets, the facility of tilling our lands, and the choice of crops offered by our climate—will all concur to increase ten-fold the present value of our land, and produce more farming profit than has been found elsewhere on soils far more favored by nature. Population, wealth and learning, will keep pace with the improvement of the soil; and we or our children will have reason to rejoice, not only as farmers, but as Virginians, and as patriots.

Such, as appear in the last paragraph, were the concluding words of this essay, as published in 1832, and precisely as the work had been prepared for the press several years before that publication was made. Such was then the language of hope and anticipation. It may now be both interesting and useful to examine to what extent such hopes and sanguine anticipations have been yet realized.

Every new and great improvement in agriculture has had to work its way slowly and in opposition to every possible discouragement and obstacle. It would seem that the agricultural classes were, of all classes and professions, always the least ready to receive benefit from instruction—the most distrustful of instructors and the least thankful for their services—even after the benefit is the most completely proved, and established by actual practice and unquestionable facts. The novel improvement by marling has not been an exception to this universal rule. But still, it may be confidently asserted, that no other agricultural improvement has been so rapidly extended, so widely and generally received in such short time, or has been so generally and greatly profitable to all who have availed themselves of the benefits thereby offered to their acceptance. When my first trials were made in 1818, so far as I then knew, I had no forerunner in success. For the few and small known and long abandoned experiments, and the opinions deduced therefrom, stood as warnings against, and not in the least as inducements to repetition; and the then actually proceeding use of marl, silent and unknown, but successful, had not even been heard of. A few more years served to dispel all doubts of those who had tried or could witness the results of the applications of marl. Still, ignorance of the mode of operation has not been dispelled by the knowledge of the great benefits of marl; and therefore the grossest errors of practice accompanied and greatly lessened the full advantages of the continually extending use of marl. It required but little time for all to learn and submit to the one main and simple instruction, “apply marl;” but few would consent to learn any thing else, or would believe that there was any thing else necessary to learn or to do, except merely to “apply marl.” They would not learn from any thing but their own dearly bought experience of error. And very many have thus learned, and have paid the cost to their own pecuniary interest of thousands of dollars in value—whether of delay, of

misapplied effort, or of positive loss and injury sustained by wrong practice—which the out-lay of a few shillings, and the attentive reading for a few hours, might have effectually guarded them against. And so it still goes on, and will go on, with all who are new beginners and learners, and who have not yet paid each their hundreds or thousands of dollars in loss, in preference to less than as many cents, in both money and labor, in acquiring proper instruction, and security from all such loss.

But with all such enormous drawbacks of loss, which if avoided would have doubled the actually achieved benefits, the extension of marling and liming, and the amount of benefit thence derived and realized in lower Virginia, since 1818, have had no precedent in the annals of agricultural improvement by any mode of manuring. The following extract from a more general report, recently made by the writer to the State Board of Agriculture, will present this branch of the subject in its proper aspect.

*“Marling, or manuring from beds of fossil shells.—*This mode of fertilization, now so general through all the marl region of lower Virginia, was not practised except on three or four detached farms, and that to but small extent before 1820. Some few and generally small experimental applications of marl had indeed been made by different individuals, from 15 to as far back as 45 years before; but which applications, from total misconception of the true mode of action of calcareous manures, had been deemed failures; and without exception, of course, had been abandoned by the experimenters as worthless; and the experiments had been almost forgotten, until again brought to notice, after the much later and fully successful introduction of the practice.

“Hendley Taylor and Archer Hankins, two plain and illiterate farmers, and near neighbors in James City county, were the earliest *successful* and continuing appliers of marl in Virginia. But at what time they began, and which of them was the first, I have not been able to learn, though visiting Mr. Hankins' farm for that purpose, as well as to see his marling, and making inquiries of him personally, in 1833. Mr. Taylor had then been long dead, and his improvements said to be almost lost, by the then occupant of his land. Mr. Hankins was unable to say when he and his neighbor began to try marl. He was only certain that it was before 1816. Yet, though these farms are within 12 or 15 miles of Williamsburg, to which place I had made visits once a year or oftener, yet I never heard an intimation of their having begun such practice, until some time after my own first trials in 1818. At that time, when led to the use, as I was, altogether by theoretical views, and by reasoning on the supposed constitution of the soil, as well as the known constitution of the manure, it would have been to me the most acceptable and beneficial information to have heard that any other person in Virginia had already proved practically the value of marling. The slow progress of the knowledge of the mere fact of marl having been successfully used before that time, was a strong illustration of the then almost total want of communication among farmers, as well as of their general apathy and ignorance, in regard to the means of improving their lands.*

“Much earlier than the commencement of marling in James City, the practice had been commenced, (in 1805,) in Talbot county, Maryland, by Mr. Singleton. His account of his practice is in the 4th volume of the ‘Memoirs of the Philadelphia Agricultural Society,’ dated December 31, 1817, and first published some time in 1818. But successful as was his

* See a more full account at page 108, vol. i, Farmers' Register.

practice, and also that of Mr. Taylor and Mr. Hankins, in connexion with much worse farming, it is certain that neither of these individuals had the least idea of the true action of marl; and they were indebted to their good fortune, more than to any exercise of reasoning, that they received profitable returns, and did no injury by marling. They all three applied their putrescent manures with the marl. But though this was the safest and most beneficial plan, the thus uniting them prevented the separate action and value of putrescent and calcareous manures being known, compared, and duly appreciated.

"My own application of marl, on Coggins Point farm, Prince George county, which in 1818 extended only to 15 acres, (of which but 3 or 4 were under the crop of that year,) by 1821 had been increased to above 80 acres a year, and so continued until nearly all the then arable land on that farm requiring it, (more than 600 acres,) had been covered. In 1821, my earliest publication on the subject was made. Though the facts and reasoning thus made known by that time were beginning to attract much notice, and to induce many persons to begin to marl, still it was some years later before incredulity and ridicule had generally given place to full confidence in the value of the improvement. Even at this time, when nearly 25 years of my own experience of marling and its benefits have passed, and the results are open to public notice and scrutiny, not half the persons who could marl are engaged at it, or are marling to but little purpose; and of all who are using marl, nineteen in twenty are proceeding injudiciously, without regard to the mode of operation of the manure, and therefore are either doing harm, or losing profit, almost as often, though in less degree, as doing good. At this time, however, there are scarcely any persons, however negligent in practice, who do not fully admit the great value and certain profit of applying marl wherever it is found.

"But with all the existing neglect of using this means of fertilization, and with all the still worse ignorance of or inattention to its manner of operating, there never has been a new improvement in agriculture more rapidly extended, or with such beneficial and profitable results. In Prince George county, there is not one farmer having marl on or near his land, who has not applied it to greater or less extent, and always with more or less profit—and, in most cases, largely as well as profitably. In James City county there has been perhaps the next largest as well as the oldest practice. In York county, as in James City, some of the most valuable and profitable improvements by marling have been made. And some of the farms of both counties, adjoining Williamsburg, and having the benefit of putrescent town manures, show more strikingly than any others known, the remarkable power of calcareous manure to fix the putrescent in the soil, and make them more efficient and far more durable. In Surry, Isle of Wight, Nansemond, Charles City, New Kent, Hanover, King William, King and Queen, Gloucester, and Middlesex counties, in the middle of the marl region of Virginia, marl has been already extensively applied, and the profits therefrom are annually increasing. And in other surrounding counties, worse supplied with marl, the practice has been carried on in proportion to the facilities, and to the more scanty experience and degree of information on the subject. It would be a most important statistical fact, if it could be ascertained how much land in Virginia has already been marled. The quantity however is very great; and all the land marled has been thereby increased in *net* product, on the general average, fully 8 bushels of corn or oats, or 4 bushels of wheat—and the land increased in intrinsic value fully 200 per cent. on its previous value or market price. Where the marling has been judiciously conducted, these rates of increase have been more

than doubled. From these data, might be calculated something like the already prodigiously increased values and products due solely to marling, and which will be still more increasing from year to year. If not already reached, the result *will* soon be reached, of new value to the amount of millions of dollars having been thus created. It is not designed in this hasty sketch to enter into minute details of results, nor to prescribe rules for practice, both of which have been given in other publications. The purpose here is but to state improvements and describe results in general.

"It required the improvement by marling, on originally poor and middling soils, (or liming, which in final or general results is the same thing,) to render as generally available the best and otherwise but rarely found benefits of the two kinds of vegetable manuring recommended by Taylor. When such soils have been made calcareous, by marling or liming, then, and not until then, all the benefits present and future, that his readers might have been induced to expect, may be confidently counted upon. In my own earlier practice—and Taylor had no greater admirer, or more implicit follower—I found my farm-yard manurings on acid soils scarcely to pay the expense of application, and to leave no trace of the effect after a very short time. And land, allowed to receive for its support all its vegetable growth (of weeds and natural grass) of two and a half years in every four, and the products in corn having been measured and compared, showed no certain increase in more than twenty years of such mild treatment. Since, on the same fields, farm-yard manures, in every mode of preparation and application, always tell well, both in early effect and in duration. And even the leaves raked up on wood-land, spread immediately and without any preparation as top-dressing on clover, always produce most manifest improvement, and are believed to give more *net* profit than any application of the much richer farm-yard manure, per acre, made on like land before it is marled. This utilizing and fixing of other manures, and the fitting land to produce clover, which effects of marling are in addition to all the *direct* benefit produced, would alone serve to give a new face to the agriculture of the country. Whatever may be done by clover, and almost every thing that can be done to profit by vegetable manures, on the much larger proportion of the lands of lower Virginia, will be due to the application of marl or lime.

"*Liming*.—The kindred improvement by liming began to be extensively practised on some of the best James river lands, where no marl was found, soon after the use of the latter began to extend. Who may have made the earliest and small applications of lime is not known, nor is it at all important. The earlier profitable use of lime in Pennsylvania, and the much earlier and more extended use in Britain, were known to every well-informed or reading farmer. Such a one was Fielding Lewis, of Charles City, as well as a most attentive, judicious, and successful practical cultivator and improver. He is believed to have been the earliest considerable limer, and the one who obtained the most manifest profits therefrom, and whose example had most effect in spreading the practice. Some of his disciples and followers have since, in greater rapidity and wider extent of operations, far surpassed their teacher and leader—to whom, however, they award the highest meed of praise for bringing into use, and establishing, this great benefit to the agriculture of lower Virginia. Nearly all the best soils on James river are comparatively of low level, as if of ancient alluvial formation, and have no marl, with which the neighboring higher and poorer lands are mostly supplied. Of such rich lands are the farms of Weyanoke, Sandy Point, Westover, and Shirley, &c., in Charles City, and Brandon (Upper and Lower,) in Prince George—and on all these lands, as well as

some others, lime has been largely applied. The use is extending to the lands on all the tide waters of the state; and it has recently received a new impulse from the low price at which northern stone-lime is now brought and sold. It is ready slaked, and the vessels are loaded in bulk. The lime is sold on James river at 10 cents the bushel, and even may be contracted for at 8 cents, from vessels that come for cargoes of wood, and would come empty but for bringing lime. The greater lightness and cheaper transportation of lime will enable it to be applied where marl could not be carried with profit; and with the two, there will be but little of lower Virginia which may not be profitably improved by calcareous manures."*

* Extract from "Report to the State Board of Agriculture, on the most important recent improvements of agriculture in lower Virginia, and the most important defects yet remaining," Farmers' Register, p. 257, vol. x.

AN
ESSAY
ON
CALCAREOUS MANURES.

PART THIRD—APPENDIX.

INTRODUCTORY REMARKS.

IN the foregoing exposition of theory and practice, it has been the object and effort of the author to embrace whatever seemed necessary for proof or for illustration; and to omit every thing else, lest too much of amplification or digression should weaken rather than strengthen the main positions. Thus it is believed that the foregoing chapters, as argument and proof, serve to establish the series of propositions which were at first advanced and throughout contended for. Still there remained many minor but interesting subjects more or less intimately connected with the investigation, and which well deserved more extended discussion, and the consideration of those readers who should desire to pursue farther the general object of this essay. These subjects will be treated separately in the different articles of this appendix; which may be read, it is believed, with both interest and benefit by the more inquiring class of readers; or may be passed over, by the more cursory and careless, without detriment to the arguments and facts of the preceding portion and regular body of the work.

Among the most important of the subjects to be thus treated at length, will be the remarkable and extensive deposits of gypseous earth, or greensand earth, in lower Virginia, and its action as manure—the formation of prairies, (or lands divested of trees)—and the causes of, and remedies for malaria, and its train of diseases, which serve, aided by the operation of the evil legislative policy of Virginia, so grievously to afflict this now otherwise most fortunate and highly blessed agricultural region. Various other articles will be presented, which will be but extensions of different parts of the foregoing text, and which will serve as additional proofs or illustrations of some of the positions before presented and maintained.

NOTE I.—*Extension of subject at page 54.*

PROOFS OF THE EXISTENCE OF ACID SOILS, FURNISHED BY THE RECENT RESEARCHES OF CHEMISTS.

The '*Traité de Chimie*' is a French translation, by Esslinger, of the voluminous and valuable work of the great Swedish chemist, Berzelius. The first edition of the original work, in the German language, and the French

translation of it were in the course of publication at the same time; and the first volumes of the latter were published at Paris, before the latter volumes of the original work had been sent to the press at Stockholm. The sixth volume of the French translation, from which I have translated the following extract into English, was printed in 1832. It is not known to me whether the original work is in this country [1835.]

The following passages contain the opinions of Berzelius, and of other chemists, on humin and humic acids, or as called here, *geine* and *geic acid*, and which were referred to in the quotation from Rennie, at page 54. It will be left to the reader to decide how far my views of acid soils are supported by these new opinions of chemists, founded upon chemical analyses of the substances in question. It is proper to state that this new doctrine of geic or humic acid has not passed uncontroverted. It is altogether denied by Raspail, a French chemist, and who is a later writer than Berzelius.

This article will offer scarcely any thing of interest to most readers, and is one of those which will be generally passed over. Its substance might indeed have been given more concisely, and perhaps in a more attractive form, if my object had been merely to exhibit the opinions now generally received among scientific men concerning acid in soil. But it was also designed to exhibit what was the utmost possible extent of scientific authority for this doctrine, so far as could have been known in this country when the last preceding edition of this essay was published in 1835. When my still earlier editions asserted the same doctrine, as then and now, there was not only no scientific authority for acid in soil, but all authority was opposed, either directly or indirectly.

[TRANSLATION.]

Products of putrefaction at the surface of the earth.

*Mould (terreau).—*The vegetable matters which rot at the surface of the earth, finish by leaving a blackish brown pulverulent mass, which has received the name of *mould* [humus.]

All the vegetation of a year, which dies at the arrival of winter, is converted by degrees to mould, which is mixed with the earth in which the plant grew; whence it comes that the extreme surface of the earth contains a greater or less proportion of mould, which serves for the nutriment of the succeeding growth of plants. This mould, such as it is found in the earth, is often mingled with the products of a less advanced putrefaction, or even with vegetable parts not changed, principally a great quantity of small roots. If we examine the mould, such as it is found in cultivated soils, it is found to be in a mass very much mixed; but it is always possible to extract the parts which characterize mould.

During the transformation of the vegetable matters to mould, the first portion of their mass is changed into a brownish black substance, which presents all the characters of *apotheme** when we have separated from it the unaltered *extract*, which the apotheme draws with it. The salts of such acids as are of organic origin, contained in the vegetable matter, are destroyed, so that the elements of the acid are resolved into water and carbonic acid, whilst the base is combined with the substance analogous

* What Berzelius calls apotheme is "a deposit slightly soluble in water, produced in an aqueous solution of vegetable extract during slow evaporation, and containing a larger proportion of carbon, than does an equal weight of extract."

to apotheme, which makes part of the mould. The salts of acids of mineral origin are preserved, unless they are soluble, in which case the rain carries them off. In addition, mould contains a substance but slightly soluble in water, which colors the liquid yellow, and a carbonaceous substance which is entirely insoluble, and which appears to be one of the products of a destruction, still more advanced, of organic matters.

To give an example of a completed formation of a mould of vegetable origin, I shall here state the results of an analysis to which Braconnot submitted some wheat, which had remained during many centuries in a damp vault, the issues from which were stopped up by earth, and of which the existence was forgotten, until by chance it was again discovered. The grains had preserved their form, and the brightness of their outside skin; but they were black, and were reduced by the slightest pressure to a black powder. The water with which they were boiled was colored yellow, and it left, after being evaporated, a saline mass of a brownish yellow, which burnt with slight explosion when heated, and which, besides the substance cited soluble in water, contained nitrate of potash, nitrate of lime, and a little of the muriates of potash and of lime. The nitrates were the result of the oxidation of the nitrogen contained in the gluten and vegetable albumen, and of the combination of the nitric acid thus produced, with the bases previously combined with vegetable acids. The weight of this mass soluble in water, including the salts and all the other principles, did not exceed $1\frac{1}{4}$ per cent. of the weight of the black grain. When the part insoluble in water was boiled in alcohol, a small trace of a brown substance was taken up, which remained after evaporating the alcohol, and had the consistence of wax. The mass, exhausted of its soluble parts by boiling water and alcohol, was then heated slowly with a weak solution of caustic potash, which became saturated and colored of a blackish brown; and this treatment was continued as long as new potash lie took up any thing. This substance was precipitated from the solution by an acid; it was the body similar to *apotheme* which has already been mentioned, and of which the weight amounted to $26\frac{1}{2}$ per cent. The portion of matter insoluble in the alkali preserved the same appearance. This, exposed to the action of diluted muriatic acid, yielded to it a certain quantity of lime, of oxide of iron, and of phosphate of lime. The residue was again acted on by potash, which took up a new and very large proportion of the body similar to *apotheme*. This was after that combined with lime, and resisted in that state the action of potash. This calcareous combination amounted to 42 hundredths. The 30 per cent. remaining consisted of a black carbonaceous matter, insoluble in the solvent used.

If cultivated soil is treated in the same manner, similar results will be obtained, with this difference, that the earthy matter of the soil is found mixed with the products which are obtained, whilst no soluble salts are met with, they being generally carried off by the rains.

To describe the constituent principles of mould, it is necessary to designate them by particular names. I will then call *extract of mould* the body soluble in water, and I will give the name of *geine** to the matter similar to apotheme, which constitutes the principal mass of mould. As to the coally substance insoluble in water, alcohol, acids and alkalies, I will designate it by the name of *carbonaceous* mould.

Extract of mould.—We obtain this substance by drawing it from the mould by the action of cold water, which becomes thereby colored yellow, and which leaves, after evaporation, a yellow extract of a bitter taste, and

* Or *humin*, as termed by other authors.

from which some geine is separated when it is again acted on by water. If this solution is left to evaporate spontaneously in contact with air, it becomes covered with an insoluble pellicle, and when a certain degree of concentration has been reached, the liquor becomes turbid. The solution is precipitated by the salts of tin and of lead; after the precipitation, the liquor is without color. According to Korte, the sulphuretted hydrogen gas precipitates it also. This extractive matter is contained in the water of many springs and streams. The water of the springs of Porla, in West-rogotha, contains so great a quantity that it is colored yellow. When the iron contained in this water is oxidized from the air, the extract of mould is precipitated with the oxide of iron, and the water becomes clear.

Geine.—This substance has received different names. Braconnot has given to it the name of *ulmin*, for reasons which I have exhibited and opposed in a former part of this work. Dobereiner and Sprengel gave to it the name of *acid of humus*, because it combines with the earths and alkalies. But for the same reason we might give the name of *acid* to more than the half of all vegetable bodies.

Geine does not exist in vegetable earth only; soot contains it also, and according to Braconnot, it is formed when the saw-dust of wood is exposed to the action of caustic potash. It is almost impossible to obtain geine in a state of purity. One part of geine which is met with in a natural state is in combination with bases; but when we attempt to remove these by an acid, the geine combines in part with the excess of acid, and acquires itself (in part) the property of reddening vegetable blues. Geine possesses all the properties of apotheme, and it is produced like other apothemes; that is to say, by the action of the air on dissolved extract of mould. In the natural state it does not act chemically, either like the acids or the alkalies. Nor does it have any effect on the color of vegetable blues. It is but slightly soluble in water, which it colors of a pale yellow; is still less soluble in alcohol, and insoluble in ether. Exposed to the action of heat it takes fire, burns at first with flame, then without flame like spunk, spreading a peculiar odor, something like that of burning peat. Submitted to dry distillation, it is decomposed, gives half its weight of a charcoal having a metallic lustre, of empyreumatic oil, an acid water containing acetic acid and sometimes ammonia, some carburetted hydrogen, and a little carbonic acid gas. If geine is held suspended in water, through which a current of chlorine is passed, this whitens it, and precipitates a white resin-like substance. Iodine is without action on it. If we add an acid to an alkaline solution of geine, the geine is precipitated. If the whole of the geine is not precipitated, that part which is precipitated retains in combination a small portion of the base, and leaves, when it is burnt, a small quantity of alkaline ashes. If, on the contrary, an excess of acid is poured into the alkaline solution, the liquor is discolored, and the precipitated geine strongly reddens vegetable blues, a property which cannot be removed by placing the geine on a filter, and pouring water upon it. So long as the liquor which passes through the filter contains free acid it is not colored; then it begins to be colored, and finally it dissolves as much as two-thirds of its weight of the precipitated mass. These acid properties belong in part to the geine, which owes them to the action of the alkali, and which may, in this case, be called *geic acid*; they ought to be in part attributed to a combination of the geine with the precipitated acid. According to Einhoff, it is the latter case which is really presented, and the acid cannot be carried off, but with the aid of an alkali. Sprengel, on the other hand, pretends to have freed the geine, by prolonged washing, from the muriatic acid which had served to precipitate it: and to make certain the absence of the

muriatic acid, he has mixed the washed geine with a little nitrate of silver. After evaporation to dryness, and calcination, the residue, treated by nitric acid, was dissolved, without leaving any muriate of silver. But as muriate of silver, like the other salts of silver, is reduced to a metallic state by bodies containing carbon and hydrogen, and carbon itself effects the same change when disengaged along with water, this result proves nothing. In general, in the descriptions of geine, they have attributed the properties of that which has been changed by the action of an alkali, to the geine which has not been altered. The geine which reddens vegetable blues, is the same, whatever may have been the acid which served for its precipitation. Its saturated aqueous solution is of a yellowish brown, and the combination is precipitated anew by acids, excepting the carbonic, and the sulphuretted hydrogen. Collected upon a filter, it is presented under the form of a gelatinous mass, of a taste slightly acid, astringent—and by drying, it contracts strongly, and forms clots of a deep brown, almost black, with a vitreous fracture, and which are not dissolved again in water after being once completely dried. The aqueous solution of the acid geine, is precipitated by the salts of lead, of tin, and of iron; but is not disturbed by gelatine, albumen, starch, gum, tannin, or solution of soap. According to Braconnot, it is precipitated by a mixture of the solution of gelatine and gallic acid. The dried geine is dissolved with difficulty, and incompletely, in alcohol. The solution reddens vegetable blues, whilst the part not dissolved is without this power, though it still preserves the property of combining with potash. Geine is destroyed by concentrated acids. The sulphuric acid dissolves it, taking at the same time a black color, carbonizing it, disengaging sulphurous acid gas, and leaving for residue the ordinary products which result from the action of this acid. By the addition of sur-oxide (or black oxide) of manganese, carbonic acid gas is disengaged. The nitric acid dissolves and decomposes geine, with a disengagement of nitric oxide gas, and carbonic acid gas. If the solution is evaporated to the consistence of syrup, and then mixed with water, there is precipitated a peculiar bitter substance in powder, and there are found in the solution, artificial tannin and oxalic acid.

Geine forms soluble combinations with alkalis. When an excess of geine is used, the caustic alkalis are so neutralized by this substance, that they lose their peculiar chemical action and properties. In this respect, geine agrees with gluten, vegetable albumen, the brown of indigo, the sugar of liquorice, apotheme, and other bodies not acid. During the evaporation the solution furnishes a black mass, which acquires lustre by complete drying, and splits, and is easily reduced to a powder. It is redissolved in water, its taste is weak, bitter and disagreeable. Caustic ammonia gives a like mass, soluble in water, which gives up, during evaporation, the excess of alkali employed. Geine is not dissolved always in alkaline carbonates; when it is so dissolved, these carbonates are transformed, half into *geates*, half into bi-carbonates. When the solution is boiled, the bi-carbonate is decomposed with disengagement of carbonic acid gas, and in this manner the geine drives off all the carbonic acid. If a solution of geine in carbonate of ammonia is evaporated, a residue is obtained containing neutralized geate of ammonia. The solution of geine in caustic potash, in excess, absorbs oxygen from the air, and at the end of some time, the alkali is in part carbonated.

Geine forms with the *alkaline earths* pulverulent combinations but little soluble, which have an external resemblance to geine. The best means for obtaining them is to mix a solution of the geate of ammonia, with the solu-

tion of an earthy salt; the combination of the geine with the earth is precipitated, and may be separated by filtration, from the supernatant fluid. In the humid state, these compounds are slightly soluble in water. According to the experiments of Sprengel, one part of *geate of barytes* is dissolved in 5200 parts of water, one part of *geate of lime* is soluble in 2000 parts of water, and one part of *geate of magnesia* in 160 parts of water, cold. These same compounds require for their solution, rather smaller proportions of boiling water. After having been completely dried they will no more dissolve. In the air, the base is combined in part with carbonic acid, and the carbonate which results therefrom remains in the state of mixture with a combination of geine, and of a base analogous to a supersalt. The alkaline carbonates decompose the earthy geates; they dissolve the geine, and leave the base in the state of carbonate. According to Sprengel, the *geates of lime* and *magnesia* are dissolved in the caustic fixed alkalies, and in the carbonate of ammonia. Other chemists have not arrived at the same result; and according to them, the *geate of potash*, acted on by the hydrate of lime, precipitates all the geine. The *geate of alumina* is precipitated when a solution of alum is mixed with a solution of *geate of potash*, or of ammonia. This compound is dissolved in 4200 parts of cold water. In the moist state it is dissolved easily, and in abundance, in the alkaline carbonates and hydrates, and even in ammonia. According to Sprengel, it resists the decomposing action of acids, so that it is difficult to extract from it geine exempt from alumine. A combination is obtained having an excess of alumine, by digesting a solution of the *geate of ammonia* with hydrate of alumina. * * * *

Carbonaceous mould.—The substance to which this name has been given has been but little examined. It is insoluble in alkaline liquors. Its color is a brown, almost black. Placed in contact with a body in combustion, it takes fire, and burns without flame like spunk. According to the experiments of Th. de Saussure, carbonaceous mould combines with the oxygen of the air, and forms carbonic acid gas, and when it is left a long time exposed to air and water, it becomes by slow degrees soluble in alkalies. The acids precipitate it from the alkaline solution, in the state of acid geine. When cold, the sulphuric acid has but little effect on it. According to Braconnot, the nitric acid converts it at a gentle heat to a brown liquor, in which water produces a precipitate of a chocolate color, which possesses the properties of acid geine, and is dissolved without residue in the alkalies.

Soil (terre végétale).—It is the mixture of these several substances with the upper layer of the surface of the earth, which constitutes the *vegetable earth* or *soil*, properly so called. Arable land is a bed of this soil, placed upon a bed of earth which contains no mould. Its fertility depends upon the quantity of mould which it contains. Growing plants continually diminish the quantity of geine contained in the soil; and when the plants are carried off from the soil on which they grew, which happens almost always with cultivated land, it is finally exhausted to that degree as to produce nothing. It is on this account that it is necessary to manure land. The matters discharged and left by animals, or the barn-yard manure which is used for this purpose, are by degrees converted into geine, and thus replace the matters dissipated by vegetation. Botanists, who have directed their attention to vegetable physiology, have remarked that the plants vegetate well enough without geine, until the time arrives for them to commence their sexual functions. But as soon as these are ended and the fruit begins to be developed, the plants absorb a great quantity of the

nutritive principles contained in the soil, and if these are not in the soil, the flower falls without forming any fruit. The experiments to which Th. de Saussure has submitted soil, [*terre végétale*] appear to demonstrate that the three constituent principles of mould may be converted the one to the other, under the alternately preponderating influence of air and water. Water converts to the *extract of mould* a part of the insoluble *geine* contained in the soil, and this transformation extends more and more, so that finally the greater part of the *geine* becomes soluble. In contact with the air, the dissolved matter passes again to the state of *geine*. The *carbonaceous mould* which changes a part of the air into carbonic acid, is itself changed by air into *geine* and into *extract of mould*, and it is upon this transformation that appear to depend in part the advantages derived from the tillage of the soil, which is divided by the action of the plough, and exposed to the immediate influence of the air. In this manner all the parts of the soil contribute to nutrition; whilst it is probable that the solution of the *extract of mould*, that of the *geate of lime*, and perhaps also that of the *geate of alumine*, are immediately absorbed by the roots. During a heavy rain, this solution penetrates the interior, and often to very deep beds of the sterile earth; but notwithstanding that, it is not lost to vegetable life; for the roots of trees seek it, and bring it back as matter suitable for their nourishment.

Experience has demonstrated that quick-lime and the carbonate of lime mingled with the soil, favor the vegetation produced thereon. Chemistry has not yet explained, in a satisfactory manner, the power which lime thus exerts; however, it is known that when the soil contains this alkaline earth, or, in its place, ashes only, the mould is quickly consumed, and vegetation becomes more rich in proportion. It has thence been concluded that lime acts, partly in exciting the plant to greater activity, and partly in rendering more soluble the principles of the soil, which are absorbed by the roots when dissolved in the water which the earth has imbibed. Lime is not then a true [or alimentary] manure. It contributes only to promote and hasten the absorption of the principles which serve to nourish the plant; and that lime may be serviceable, it is necessary to introduce into the soil improved by lime, materials proper to furnish new quantities of mould. The lime or alkali contained in ashes acts also in hastening the change of organic matters to mould.

It is known by experience, that gypsum also augments the fertility of the earth, especially when leguminous plants are cultivated. It is not probable that this neutral salt acts in the same manner as lime, and we are ignorant of what is its mode of acting.

Soil [*terre végétale*] possesses the property of being able to retain as much as three-fourths of its weight of water without appearing moist, and, like charcoal, it condenses atmospheric humidity. It owes this property to the *geine* which it contains, which is one of the substances that, of all known, absorbs moisture with most energy. Mould [*terreau*] can absorb double its weight of water, without appearing moist; and after being dried, it draws from the air, in less than twenty-four hours, a quantity of water, which may vary according to the humidity of the atmosphere, from 80 to 100 per cent. of its weight. This property depends upon its light and dust-like consistence; and *geine*, of which the fracture becomes vitreous from its course of chemical treatment, is deprived of this physical property, which is of the utmost importance to vegetable life. For, in consequence of this property, mould retains water in the earth and obstructs its evaporation; and it is probably this water which maintains the extremities of the roots in the state to perform their functions.

It is usual to divide soil into fertile earth, and acid earth.* The first is very common, the second presents itself but rarely. It produces nothing, unless it be mosses; it is in marshy places that it is ordinarily found. It is in general composed in the same manner as fertile earth; but whilst in the latter the geine is united with lime, and perhaps with other bases besides, it is in the acid earth combined with acids, which, according to Einhof, are the phosphoric and acetic acids. It is for this reason that it has the property of reddening vegetable blues, and that it gives, by calcination, ashes which contain phosphoric acid. To dry distillation, it yields a great quantity of an acid liquid, containing the acetate of ammonia; and when it is distilled, after having mixed it with water, a liquid product is obtained, which reddens vegetable blues, and likewise contains acetate of ammonia. In opposition to Einhof, Sprengel affirms that the acid geine is produced only for the want of bases, and that its acid action proceeds only from the geic acid which it contains, and not from the presence of a foreign acid. De Pontin has made the analysis of an acid† soil taken from the plain of Eckerud, in the government of Elfsburg, in Sweden, and found that the geine had there combined with the malic, acetic, and phosphoric acids. The dissolving of the soluble principles of the soil in boiling water, left to be deposited when the hydrate of lime was mixed therein, these acids as well as geine, so that there was found afterwards in the water only traces of the acetate and hydrate of lime. But when a current of carbonic acid gas was made to pass through this precipitate, steeped in water, the geine remained, without dissolving, in combination with the carbonate of lime produced, while there was formed a solution slightly yellowish, which left after evaporation a residue of calcareous salts. This residue was treated by alcohol, which took up a certain quantity of acetate of lime, and left a salt of lime of a gummy appearance, which was soluble in water, and possessed the properties of the malate of lime. In burning the geate of lime, and taking up the residue by muriatic acid, there was obtained a solution which when treated by ammonia gave a small precipitate of phosphate of lime. The greater part of the acid geine was dissolved in the carbonate of ammonia. Hydrate of lime was poured into the solution, which precipitated the geine without leaving in solution a salt of lime. But when after having washed the precipitate, it was calcined, and the residue treated with muriatic acid, there was obtained a solution, which, after the expulsion of the carbonic acid, gave with ammonia an abundant precipitate of the phosphate of lime. These experiments confirm those given by Einhof.

An acid soil becomes fertile when there is mixed with it lime or ashes

* It is not a little strange to say it is "*usual [dans l'usage]* to divide soils into fertile earth and acid earth," when the acid nature of any has been treated by Berzelius as a new discovery, and of which the truth is not admitted by all of those who had taken the subject into consideration. If this division had indeed been usual, there would have been no want of numerous authorities (whatever might be their value) for the acidity of soil.—TRANSLATOR.

† In the French version, this word was "*aride*," and also in the two other places where it is used below soon after. But though the context made it almost certain that this was an error of the press, and that the word should have been *acide*, I did not venture to make the alteration in a preceding edition, but merely stated in a note, the doubt, and probable grounds of error. Very lately, (1842,) I saw for the first time the German work by Berzelius, in the library of Professor J. C. Booth of Philadelphia, and by aid of his knowledge of the language, I was enabled to make sure that the error was as I had supposed. Though the book lately examined was the second edition, the extract was translated (through the French) from Berzelius' first edition, and there is no difference in the above paragraph, except that in the latter he has added the term "unfruitful" to "acid soil," [*unfruchtbare saure Dammerde*].—TRANSLATOR.

and earth, inasmuch as the soil consists principally of geine. The report of Sprengel, according to which, it [this character of soil] is produced in consequence of the absence of the bases which are found in fertile earth, is certainly true; but it does not follow from that, that it owes its acidity solely to the acid nature of the geine. The ashes of acid soil always contain a great quantity of silicæ.

NOTE II.—*Extension of subject of pages 58—61.*

ADDITIONAL PROOF OFFERED, BY THE PRODUCTION AND EXISTENCE OF BLACK WATERS, OF THE ACTION OF LIME IN COMBINING VEGETABLE MATTERS WITH SOIL.

Every person who has seen much of the different parts of lower Virginia, (to go no farther for examples,) must have remarked the dark permanent color of the waters of many streams and mill-ponds; and that others, whether when clear or when turbid, are at all times and entirely without any tinge of this peculiar coloring matter. The waters thus colored by vegetable matter are more deeply tinted at some times than at others; but are always strongly thus marked. These waters, when several feet in depth, appear to the eye quite black or very dark brown. The same if viewed in a drinking glass would appear of the color of Sherry wine, and might present some shade between the palest and deepest tints of such wine. This color has nothing of muddiness; for these waters are as clear from suspended clay or mud as any other waters not so colored in the slightest degree. In the county in which nearly all my life has been passed, Prince George, these different kinds of waters are to be seen in stronger contrast, because of their close neighborhood. All the streams which flow into Blackwater river, as well as the main stream, which that name so well describes, from its head to its outlet, are colored deeply, and it is believed without exception. On the contrary, the streams which flow into James river often rise from sources very near to some of the others, the head-springs being on opposite sides of the same dividing ridge of level table land, and in lands precisely alike. Some of these lands are of close and stiff soil, and some more sandy and quite light; but all are level, poor, and acid lands, and are mostly still under forest growth.

All persons, whether of the most or the least observant class, would concur in the opinion that this color proceeds from vegetable matter. This is obvious even in the waters of heavy rains, which when more than the level ridge lands can absorb, flow off, and are sometimes for a day or more thus passing in temporary streams to the nearest valley, or other descent. These surplus waters, while yet on the highest woodland, are colored to a greater or less depth of tint; and just as much in those which take their course towards James river, as the others which flow in the opposite direction to the Blackwater. The difference is that the former soon lose all such coloring matter, and in no case carry it to or even near James river, whilst the other waters increase in depth of color with the length of their course, or the duration of time they remain in the mill-ponds they pass through, or in the sluggish Blackwater river.

The supply of coloring matter is principally furnished by the dead and fallen leaves in the poor forest land, and is doubtless increased afterwards, both by the partial evaporation of the water, and by its dissolving still more of the soluble vegetable extract in the flat swampy grounds through which the streams flow into the Blackwater. This might indeed satisfactorily

account for these waters being *more deeply* colored than those which pass by a more rapid descent to James river. But these different circumstances do not serve at all to explain why the latter waters should soon lose, if they had it at first, the slightest trace of color.

The like circumstances are probably to be found to more or less extent in most of the counties on our tide-water rivers, as most of them have poor forest lands and some swampy streams in the interior.

As the opposite circumstances of the presence or absence of color in different waters is certainly not caused by such difference in the sources of supply, they must be caused by some subsequent action which serves to clear the waters in one locality, by combining with and taking off the dissolved coloring matter, and which action does not take place elsewhere, because there is no such efficient agent present. That agent I take to be carbonate of lime, or some other salt of lime in the soil in the one case, and which is present in quantity altogether insufficient for such action in the other case. According to the views which were presented (page 58) in regard to the power of calcareous earth to combine chemically with vegetable matter, if the colored waters should flow over soils furnished with calcareous matter, or into streams impregnated with any salts of lime, it would follow that the suspended or dissolved vegetable extract would combine with the calcareous matter of the soil in the water, and the new combination be precipitated, and be given to the soil, as manure, either immediately or remotely. This effect would be greatly aided if the streams swollen by rains actually passed in contact with and washed away exposed banks of marl. All recent rain water contains a small amount of carbonic acid, and that impregnation enables water to dissolve a proportional quantity of carbonate of lime, which is insoluble in water without this addition of carbonic acid. Therefore, in such circumstances the swollen streams and land floods would necessarily dissolve some carbonate of lime, which would be thus placed immediately and fully in mixture and perfect contact with the before dissolved vegetable coloring matter, and next must take place the combination of the two, and precipitation of the compound manure. The consequence must be, that the lands thus overflowed must be more or less enriched by every heavy rain; while the lands overflowed by the colored waters receive, or retain, nothing of soluble vegetable matter from this source, and may even lose part of what they had before received from the decay of their own growth, or other sources, by its being dissolved and carried off by such overflowing waters.

Now let us see how the actual results agree with these different causes, so far as the causes are known to exist. In the limited region particularly referred to above, the low grounds, subject to inundation by rains in a state of nature, and having beds of marl which the stream cuts through, are of much richer soil than any others, though the quantity of marl displaced by the stream (if indeed any such displacing be perceptible) would seem altogether too small in amount to produce such extent of fertilization by direct action. And it is believed, whether marl beds be so exposed or not, that the low-grounds on the streams of colorless water are always much better soils, and of more durable fertility, than those washed by colored waters. The latter soils being often swampy, are full of vegetable matter, and of course would be very productive when first drained and cultivated. But these soils are far from being among the most durable, and they are even at first, and when in best condition, very inferior lands to most low-grounds of prime quality; and the latter are always penetrated by streams, or had been sometimes covered by floods, which, however turbid at certain

times with suspended clay and mud, are never colored by vegetable extractive or soluble matter alone.

If we go farther for examples, the effects will be found to be still more striking. None of the lime-stone streams are ever colored; and their remarkable transparency, very far surpassing that of the most pure and limpid waters of the low country, show that the dissolved lime, which the mountain streams contain, serves to remove every thing of coloring matter. These lime-stone waters, and land floods from rains which also necessarily carry dissolved carbonate of lime, form the principal supply of the upper James river. But long before the waters reach the head of tide, not a particle of lime remains. The dissolved lime had been continually uniting with the suspended or dissolved vegetable matter, until no lime was left, and the precipitated compound had served to add more manure to the extensive low-grounds along the whole course of the upper James river, and which are so well known and deservedly celebrated for their great and enduring fertility and high value.

When a resident of the lower country first visits our mountain and lime-stone region, he cannot avoid observing and being forcibly impressed by the remarkable clearness of the waters. Pools and basins in the streams containing six feet depth of water, will appear to his unpractised eye as not deeper than two or three feet. And it is only by comparison, and by becoming acquainted with this really and perfectly clear lime-stone water, he learns that he had, in truth, never before seen a stream or pond of perfectly clear water. Though the dissolved matters may be in too small quantity to produce any appearance of color, they serve to impair the transparency of the water. And when any such coloring or vegetable matters are received into and intermixed with lime-stone streams, the vegetable matter is immediately combined with lime, and the compound precipitated; still leaving in the water a great excess of dissolved lime, scarcely diminished by the loss of the small part acting to clear the water of all coloring and vegetable impregnation.

From the large proportion of lime held in solution by lime-stone springs, and the streams proceeding from them, and also by rain floods passing over lime-stone soils, it must be inferred, (according to my views,) that such waters must very quickly combine with and precipitate all coloring matters, and, when not turbid with earthy matter, be as transparent as water can possibly be. Hence, the well known and remarkable transparency of such water is not directly caused (as commonly understood) by lime being contained in them—but because of the other adulterations being totally removed in combination with a part of that dissolved lime. Thus, the water is not in the least made crystalline and transparent because of what it *contains*, but because of what it has been *deprived of*. And, therefore, even after all the lime may have been precipitated, the water must retain its previous perfect transparency, unless subsequently impregnated with other coloring matter.

The additional supply of carbonic acid to water, which alone gives to it the power to dissolve or to retain in solution even the smallest proportion of carbonate of lime, is not strongly held. It is given off by the lime-stone water in its partial evaporation, and to every contact of atmospheric air; and this operation is increased by such agitation of the water as exposes a larger surface to the air. Hence, at all rapids of lime-stone streams, there is a peculiarly rapid and large deposition of carbonate of lime, let loose by the water because of the loss of the proportion of carbonic acid which before served to hold the lime dissolved in the water. This precipitation and gradual accumulation of carbonate of lime, at the rapids and

cascares of streams, is the formation called calcareous tufa or travertine, and vulgarly called "marl" in our mountain region, and which is presented in great quantity, and sometimes in enormous masses.

As lime-stone water so easily parts with the carbonic acid which enables it to hold lime in solution, it can scarcely be supposed that any of the acid remains after the water collects and remains long in the great reservoirs formed in lakes. But whether the water remains impregnated with carbonic acid, and of course with lime, or has lost both, the effect is the same, and is exhibited most strongly in the remarkable transparency of lakes so formed. Of such, I have never myself witnessed any but of Lake George, in New York. And after the long lapse of time, since my short visit to this lake, I cannot remember to what extent the transparency of its waters was asserted, or what my own personal observation ascertained. I only remember certainly that the depth of water through which very small objects were distinctly visible was very great, and that no ground was left to doubt what is generally asserted and received as true on that head.

To return to the lands and waters of Prince George county. The water left by heavy rains, standing in shallow pools on the high level woodland, and flowing off in temporary rivulets, is seen to be colored by vegetable matter even within a mile of James river, just as it is found on the other lands sloping towards the Blackwater. But in either and every known case of such discoloration being caused, it is on poor and acid land. No such effect takes place on calcareous or even neutral soil, no matter how abundantly it is provided with dead leaves or other vegetable matter. Therefore it is manifest that it is not difference of locality, but difference of soil, which causes the different effects of the surplus rain water becoming tinged, and remaining tinged with vegetable extract, or otherwise remaining colorless. And also, after the water has been so tinged, that it depends on the difference of chemical composition in the soils over which it passes, or of the streams into which it is discharged, whether the color remains or is quickly discharged. And, as already stated, this difference of action and effect depends on the absence or presence of lime in the soils or waters to which the colored excess of rain water flows.

It is only in the surplus quantity of rain water, or that which is more than the soil can absorb, that this coloring matter is *seen*. But it is not the less certain that all of the much greater quantity of water from more gentle and more frequent rains which soak into the earth, must also be more or less tinged with the coloring matter of the leaves and other dead vegetable matter through which the water passes, and must take up in passing all that is then easily soluble, and not chemically combined with some other body. Thus, every gentle and soaking rain probably carries into the soil the greater part of all the then soluble vegetable matter, and that only which is soluble is all that is then completely ready to act as food for plants. The same rain, and the subsequent chemical action of air and warmth, cause the decomposition of the before insoluble vegetable matter to recommence, and in a few days there is a renewed supply of soluble or extractive matter formed in the vegetable cover of the soil, ready to be dissolved and to be carried into the earth by the next succeeding rain.

Such is Nature's process of furnishing alimentary manure, or the food of plants, to soils. And the source of supply is unlimited; for it is principally from the atmosphere and water, and by fixing their elements, (oxygen, nitrogen, hydrogen and carbon,) that the vegetable growths of soils, and consequently all alimentary manures, are formed.

As enormous then as is the continual waste of vegetable extractive matter and manure that is caused by every heavy rain, and which is always

evident to the eye in the black waters of so many ponds and streams, all this lost fertilizing matter must be in very small proportion, compared to the greater quantity that is carried more gradually and frequently into the earth. Much the greater part of the wood-land of lower Virginia is most freely and abundantly thus supplied, not only because of the abundant sources presented in a thick layer of fallen leaves, the growth of many successive years, but also because of the very level surface of the land, which obstructs the flowing off of the surplus rain water, and the general sandy and open texture of the soil and sub-soil, which operate to absorb quickly the water and its dissolved vegetable matter. Yet it is more especially these lands that show the least remaining and abiding store of this supply of vegetable manure. The soil, or all of the upper part which shows any color from containing vegetable matter, is usually not more than two inches thick on sandy soils, and still less on the stiffest; and all the portion below, (though necessarily manured by being often soaked to a foot or more with rain-water conveying all its dissolved vegetable extract,) is entirely barren and worthless. Such results would be as inexplicable as they are wonderful, but for the reasons afforded by the doctrine of the combining and fixing powers of carbonate of lime and vegetable salts of lime; the absence of which ingredients is the sole defect in these cases, and which, when present in soils, show results of fertilization altogether the reverse of these. Where lime is present in sufficient quantity, no coloring or manuring matter is lost to the soil in the flowing off of surplus water, nor in the wasteful and profitless decomposition of the greater quantity of coloring and alimentary matter soaked into the earth.

My observation was not attracted to the cause of the existence of black waters, and this application of the facts, until nearly the close of my residence in the country, and of my opportunities for personal and accurate observation. And I am well aware, and ready to admit, that previous observations, made by mere chance and without object, are worth very little comparatively. I therefore would be glad to have the attention of other observers drawn to this point, and any facts to be elicited that will either confirm or disprove my positions. From inquiries made of persons who have had ample opportunity to observe what waters were either permanently black or without tinge of such vegetable stain, I have heard the following general statements of facts, on which my comments will be offered as the facts are presented.

Streams and ponds of black waters are rarely seen above the falls of the rivers; and are believed to be very rarely found even twenty to thirty miles above. They are never seen in the still higher lime-stone region. If this opinion be correct, then these waters are confined exclusively (as they certainly are mainly) to the region of soil of the most *acid quality*. At the distance above the falls where black waters are never found, the high land was naturally in general of good quality, and the bottom or alluvial lands, on small streams, invariably of good soil. Of course these qualities indicate more of lime in the soil; and, according to my views, also the inability of water to become black, or at least to remain colored.*

The waters of Blackwater river and its tributary streams and swamps become darker in autumn, owing to the low level of the surface at that season. This is according to sound reason; as evaporation of the solvent fluid necessarily increases the strength of the solution. But this cause is held

* The extract translated from M. Puvion's '*Essai sur la Marne*,' and introduced at page 150 of this essay, affords testimony that the facts in regard to the existence and localities of black waters in France accord strictly with the views presented in this article. He says there that, "during the month of August, the water of the ponds on calcareous soil does not become blackish, as often happens in silicious ponds."

by most persons as secondary in force to another, viz: the dropping of the leaves, and especially of the numerous black-gum trees, and their berries, at that season, on the swamps and in the streams. Of course such is the source of the coloring matter; but it would produce no notable or abiding effect, but for the want of lime both in the soil and in the water. The extensive tide swamps on the creeks of James river, are covered with a dense growth of trees, of which a large proportion are black-gums. Yet in the numerous rills trickling or oozing out of these soils, after some days of low tides, I have never observed the water to be dark, or in the least discolored. Yet the soil of these tide swamps is as much of vegetable formation as any capable of bearing trees, and is believed to be more so than the swamp lands of Blackwater river and its tributaries. Therefore it is not the abundance of dead vegetable matter in a soil, nor the quantity or kind of leaves furnished by the trees growing on it, which alone or together produce colored waters. The earthy portion of the soil of these tide marshes and swamps, small as is its amount, is not acid, but neutral, and the lime contained serves to prevent the water remaining discolored.

Yet this is not always the case on tide swamps. The waters of Pocomoke river, flowing into the Chesapeake, are black, which I presume is owing to the deficiency of lime in the water and in the surface soil of the lands from which the waters flow.

The great Dismal Swamp of Virginia and its lake, and the still more extensive swamps and lakes of North Carolina, all present black waters, and which may all be accounted for by the reasons here given.

Neither is it necessary that marl beds should be wanting to produce the effect of black waters. It is only necessary that the marl (no matter how abundant) should be so far below the surface as not to affect the overflowing waters, and that the soil of the higher lands should be generally of acid quality. Such are the lands on Blackwater river and its tributaries. And though marl was scarcely known any where there twenty years ago, it is now known to be abundant, and generally to be found, though almost always a few feet below the surface of the low lands.

Many persons who would concur with me as to the premises and results, would yet ascribe the coloring of certain waters to the more level surface of the land, and the more sluggish and stagnant state of the waters; and would suppose the absence of coloring matter in the waters of the upper country to be caused by the rapidity of the descent and of the passage of the streams. This would be a correct view, if the matter in question were the degree of *intensity* of color, instead of the *existence or entire absence* of color. It is true, and obvious, that if the colored waters which now creep and stagnate over the level lands below the falls, had as rapid a descent and free discharge as the mountain torrents, their color could not be made deeper by the long infusion of the leaves, nor by evaporation of still waters. But though the color would be much more pale, its existence would not be the less certain. The source of coloring matter, the soaking of dead leaves, &c., in rain water, is as abundant in the upper as in the lower country; and the more rapid discharge of the waters, if no other cause of clearing them operated, would not prevent their becoming and remaining colored, as generally, and, however more pale in tint, would be seen as obviously, as in the most level lands. But this is not all. Though there is almost no level land, and therefore no swamps in the hilly or still less in the mountain region, there are mill-ponds in the lower hilly country, and natural lakes in the mountain region. If there was the slightest tint of dissolved coloring matter in the streams, the waters when collected in these deep reservoirs could not fail to exhibit the color much more deeply. Yet no one such fact is known, or is believed to have existence.

NOTE III.—*Extension of the subject of page 68.*

THE STATEMENTS OF BRITISH AUTHORS ON MARL, AND THEIR APPLICATIONS OF THE NAME, GENERALLY INCORRECT AND CONTRADICTIONARY.

Custom compels me to apply improperly the name *marl* to our deposits of fossil shells. But as I have defined the manuring by this substance, which is called *marling*, to be simply *making a soil calcareous*, or more so than it was before, any term used for that operation would serve, if its meaning was always kept in view. But this term, unfortunately, is of old and frequent use in English books, with very different meanings. The existence of these differences and errors has been generally stated in the foregoing pages of this essay, and I shall here present the proofs. The following quotations will show that the term *marl* is frequently applied in Britain to clays containing no known or certain proportion of calcareous earth—that when calcareous earth is known to be contained, it is seldom relied on as the most valuable part of the manure—and that in many cases *the reader is left in doubt whether the manure has served to increase, or diminish, or has not altered materially the amount of the previous calcareous contents of the soil.*

The passages quoted will exhibit so fully the striking contradictions and ignorance generally prevailing as to the nature and operation of marl, that it will scarcely be necessary for me to express dissent in every case, or to point out the errors or uncertainty of facts, or of reasoning, which will appear so manifestly and abundantly.

1. Kirwan, on the authority of Arthur Young and the *Bath Memoirs*, [1783,] states that,

“In some parts of England, where husbandry is successfully practised, any loose clay is called *marl*: in others, *marl* is called *chalk*, and in others, *clay* is called *loam*.”—Kirwan on *Manures*, p. 4.

2. The learned and practical Miller thus defines and describes marl, in the *Abridgment of the Gardener's Dictionary*, fifth London edition, at the article *marl*:

“Marl is a kind of clay which is become fatter and of a more enriching quality, by a better fermentation, and by its having lain so deep in the earth as not to have spent or weakened its fertilizing quality by any product. Marls are of different qualities in different counties of England.”

He then names and describes ten varieties, most of them being very minutely and particularly characterized—and in only two of the ten is there any allusion to a calcareous ingredient, and in these, it is evidently not deemed to constitute their value as manures. These are “the cowshut marl” of Cheshire, which—

“Is of a brownish color, with blue veins in it, and little lumps of chalk or limestone,”—and “clay-marl; this resembles clay, and is pretty near akin to it, but is fatter, and sometimes mixed with chalk stones.

“The properties of any sorts of marls, by which the goodness of them may be best known, are better judged of by their purity and uncompoundedness, than their color: as if it will break in pieces like dice, or into thin flakes, or is smooth like lead ore, and is without a mixture of gravel or sand; if it will slake like slate-stones and shatter after wet, or will tumble into dust, when it has been exposed to the sun; or will not hang and stick together when it is thoroughly dry, like tough clay; but is fat and tender, and will open the land it is laid on, and not bind; it may be taken for granted that it will be beneficial to it.”

3. *Johnson's Dictionary* (octavo edition) defines marl in precisely the words of the first sentence of Miller, as quoted above.

4. *Walker's Dictionary* (octavo edition) gives the following definition—"Marl—a kind of clay much used for manure."

5. *A Practical Treatise on Husbandry*, (2nd edition, London 1785), which professes to be principally compiled from the experience of Evelyn, Home, and Miller, supplies the following quota.

"But of all the manures for sandy soils, none is so good as marl. There are many different kinds and colors of it, severally distinguished by many writers, but the nature is the same; they may be all used upon the same ground, without the least interference in their effect. The color is either red, brown, yellow, gray, or mixed. It may be known by its pure and uncompounded nature. There are many marks to distinguish it by; such as its breaking into little square bits; its falling easily into pieces, by the force of a blow, or upon being exposed to the sun and the frost; its feeling fat and oily, and shining when 'tis dry. But the most unerring way to judge of marl, and know it from any other substance, is to break a piece as big as a nutmeg, and when it is quite dry, drop it into a glass of clear water, where, if it be right, it will dissolve and crumble, as it were, to dust, in a little time, shooting up sparkles to the surface of the water."—p. 27.

—Not the slightest hint is here of any calcareous ingredient being necessary, or even serving in any manner to distinguish marl. But afterwards, in another part of this work, when *shell marl* is slightly noticed, it is said:

"This effervesces strongly with all acids, which is perhaps chiefly owing to the shells. There are very good marls which show nothing of this effervescence: and therefore the author of the *New System of Agriculture* judged right in making its solution in water the distinguishing mark."—p. 29.

The last sentence declares, as clearly as any words could do, that, in the opinion of the author, no calcareous ingredient is necessary, either to constitute the character, or the value of marl. And though it may be gathered from other parts of this work, that what is called marl generally contains calcareous earth, yet no importance seems attached to that quality, any more than to the particular color of the earth, or any other accidental or immaterial appearance of some of the varieties described.

The "shell marl" alluded to above, without explanation might be supposed to be similar to our beds of fossil shells, which are called marl. The two manures are very different in form, appearance, and value, though agreeing in both being calcareous. The manure called shell marl by the work last quoted from, is described there with sufficient precision, and more fully in several parts of the *Edinburgh Farmer's Magazine*,* and in the *Memoirs of the Philadelphia Agricultural Society*.† It is still more unlike marl, properly so called, than any of the substances described under that name, in the foregoing quotations. This manure is almost a pure calcareous earth, being formed of the remains of small fresh-water shells deposited on what were once the bottoms of lakes, but which have since become covered with bog or peat soil. If I may judge from our beds of muscle shells, (to which this manure seems to bear most resemblance,) much putrescent animal matter is combined with, and serves to give additional value to these bodies of shells. This kind of manure is sold in Scotland by the bushel, at such prices as show that it is very highly prized. It seems to be found but in few situations, and though called a kind of marl, is never meant when that term alone is used generally.

A much older work than either of these referred to furnishes in part the definitions and even the words used above. This is the *'Systema Agriculturae, the Mystery of Husbandry discovered'*, published in 1687; and the author or compiler of that old work was probably indebted to others still older for his description of marl. For new books on agriculture, more

* See *Farmer's Register*, vol. i., p. 90.

† Vol. iii. p. 206.

especially, have been most generally made by compiling and copying from older ones.

"Marle is a very excellent thing, commended of all that either write or practise anything in husbandry. There are several kinds of it, some *stony*, some *soft*, *white*, *gray*, *russet*, *yellow*, *blew*, *black*, and some *red*: It is of a cold nature and saddens land exceedingly; and very heavy it is, and will go downward, though not so much as lime doth. The goodness or badness thereof is not known so much by the colour, as by the purity and uncompoundness of it; for if it will break into bits like a dye, or smooth like lead-ore, without any composition of sand or gravel; or if it will slake like slate-stones, and slake or shatter after a shower of rain, or being exposed to the sun or air, and shortly after turn to dust, when it's thoroughly dry again, and not congeal like tough clay, question not the fruitfulness of it, notwithstanding the difference of colours, which are no certain signs of the goodness of the *marle*. As for the *slipperiness*, viscusness, fattiness, or oyliness thereof, although it be commonly esteemed a sign of good *marle*, yet the best authors affirm the contrary—viz: that there is very good *marle* which is not so, but lieth in the *mine* pure, dry and short, yet nevertheless if you water it, you will find it slippery. But the best and truest rule to know the richness and profit of your *marle*, is to try a load or two on your lands, in several places and in different proportions.

"They usually lay the same on the small heaps, and disperse it over the whole field, as they do their *dung*; and this *marle* will keep the land whereon it is laid, in some places ten or fifteen and in some places thirty years in heart: it is most profitable in dry, light, and barren lands, such as is most kind and natural for *rye*, as is evident by Mr. *Blti*'s experiment in his chapter of *marle*. It also affordeth not its virtue or strength the first year, so much as in the subsequent years. It yields a very great increase and advantage on high, sandy, gravelly, or mixed lands. Though never so barren, strong clay ground is unsuitable to it; yet if it can be laid dry, *marle* may be profitable on that also."

The author then proceeds to direct the mode of application more particularly; and if there were any doubt as to his total ignorance (or otherwise denial) of calcareous earth being necessary to the constitution of marl, that doubt would be removed by a subsequent sentence.

"You shall observe, (saith Markham,) that if you cannot get dry, perfect, and rich *marle*, if then you can get of that earth which is called fuller's earth, (and where the one is not, commonly the other is,) then you may use it in the same manner as you should do *marle*, and it is found to be very near as profitable."

Evelyn's *Terra, or Philosophical Discourse of Earths, &c.*, delivered before the Royal Society in 1675, has the following passage:

"Of *marle*, (of a cold sad nature, a substance between clay and chalk,) seldom have we such quantities in layers as we have of forementioned earth; but we commonly meet with it in places affected to it, and 'tis taken out of pits, at different depths, and of divers colours, red, white, gray, blue, all of them unctuous, and of a slippery nature, and differing in goodness; for being pure and immixt, it sooner relents after a shower, and when dried again, slackens, and crumbles into dust, without induration, and growing hard again. They are profitable for barren grounds, as abounding in nitre; and sometimes there has been found in *marle*, *delfs*, a vitriolic wood, which will kindle like coal."

The opinions expressed in the foregoing extracts, prove sufficiently that it was not the ignorant cultivators only, who either did not know of, or attached no importance to the calcareous ingredient in marl; and it was impossible that, from any number of such authors, an American reader could learn that either the object or the effect of *marling* was to render a soil more calcareous—or that our bodies of fossil shells resembled marl in character, or in operation as a manure. Of this, the following quotation will furnish striking proof—and the more so as the author refers frequently to the works of Anderson, and of Young, who treated of marl and of calcareous manures, in a more scientific manner than had been usual. This author, Bordley, cannot be justly charged with inattention to the instruction to be gained from books; for his greatest fault, as an agriculturist, is his

fondness for applying the practice of the Eastern Shore of England, to our lands and situation. Now, however, it is obvious which he carried to an extent that is ruinous to the farmer who should so shape his operations.

8. "I farmed in a country [the Eastern Shore of Maryland] which had due attention to manures : but having read of the application of fossil shells, I inquired where there was any in the peninsula of the Chesapeake. I found it had a grayish clay which to the eye was marl : but because it was so hard, and acids, it was given up when it ought to have been tried on the land, and it rapidly crumbled and fell to mud, in water, with some appearance of success." *Bordley's Husbandry*, 2nd ed., p. 55.

That peninsula, through which Mr. Bordley in vain inquired for marl, contained immense quantities of the fossil shells which we so improperly call by that name. But as his search was directed to *marl* as described by English authors—and not to *calcareous earth* simply—it is not to be wondered at that he should neither find the former substance, nor attach enough importance to the latter, to induce the slightest remark on its probable use as manure.

9. The *Practical Treatise on Husbandry*, among the directions for improving clay land, has what follows :

"Sea sand and sea shells are used to great advantage as a manure, chiefly for cold strong [i. e. clay] land, and loam inclining to clay. They separate the parts ; and the salts which are contained in them are a very great improvement to the land. Coral, and such kind of stony plants which grow on the rocks, are filled with salts, which are very beneficial to land. But as these bodies are hard, the improvement is not the first or second year after they are laid on the ground, because they require time to pulverize them, before their salts can mix with the earth to impregnate it. The consequence of this is, that their manure is lasting. Sand, and the smaller kind of sea weeds, will enrich land for six or seven years ; and shells, coral, and other hard bodies, will continue many years longer.

"In some countries *fossil shells* have been used with success as manure ; but they are not near so full of salts, as those shells which are taken from the sea shore : and therefore the latter are always to be preferred. Sea sand is much used as manure in Cornwall. The best is that which is intimately mixed with coral."—p. 21.

After stating the manner in which this "excellent manure" is taken up from the bottom, in barges, its character is thus continued :

"It [i. e. the sea sand mixed with coral, as it may happen,] gives the heat of lime, and the fatness of oil, to the land it is laid upon. Being more solid than shells, it conveys a greater quantity of fermenting earth in equal space. Besides, it does not dissolve in the ground so soon as shells, but decaying more gradually, continues longer to impart its warmth to the juices of the earth."

Here are described manures which are known to be calcareous, which are strongly recommended--but solely for their supposed mechanical effect in separating the parts of close clays, and on account of the salts derived from sea water, which they contain. Indeed, no allusion is made to any supposed value, or even to the presence of calcareous earth, which forms so large a proportion of these manures : and the fossil shells, (in which that ingredient is more abundant, more finely reduced, and consequently more fit for both immediate and durable effects,) are considered as less efficacious than solid sea shells—and inferior to sea sand. All these substances, besides whatever service their salts may render, are precisely the same kind of calcareous manure, as our beds of fossil shells furnish in a different form. Yet neither here nor elsewhere, does the author intimate that these manures and marl have similar powers for improving soils.

The foregoing quotations show what opinions have been expressed by English writers of reputation—and what opinion would be formed by a

... natural works, of the nature of what is so named in this part of our country. Other authors have not thought more correct than to have called themselves with precision on this subject. ... to be a *calcareous clay**—and in this correct sense by Davy, and other chemical agriculturists. Such as Sinclair also could not have been ignorant of the nature of marl—yet even they have used so little precision or care when speaking of the effects of marling, that their statements, even if correct they may be in the sense they intended them,) convey no information, and have not served to remove the erroneous impressions made by the great body of their predecessors. Knowing as Young did [see first quotation] the confusion in which this subject was involved, it was the more incumbent on him to be guarded in his use of terms so generally misapplied. Yet considering his practical and scientific knowledge as an agriculturist, his extensive personal observations, and the quantity of matter he has published on soils and calcareous manures, his omissions are more remarkable than those of any other writer. In such of his works as I have met with, though full of strong recommendations of marling, in no case does he state the composition of the soil, (as respects its calcareous ingredient,) or the proportion added by the operation—and generally notices neither, as if he viewed marling just as most others have done. These charges are supported by the following extracts and references.

10. Young's *Farmer's Calendar*, 10th London edition, page 40.—On marling. Through nearly four pages this practice is strongly recommended—but the manures spoken of, are regularly called “marl or clay,” and their application, “marling or claying.” Mr. Rodwell's account of his practice is inserted at length. On leased land he “clayed or marled” eight hundred and twenty acres with one hundred and forty thousand loads, and at a cost of four thousand nine hundred and fifty-eight pounds—and the business is stated to have been attended with great profit. At last, the author lets us know that it is not the same substance that he has been calling “marl or clay”—and that the marl effervesces strongly with acids, and the clay slightly. But we are told nothing more precise as to the amount of calcareous ingredients, either in the manures, or the soil—and even if we were informed on those heads, (without which we can know little or nothing of what the operation really is,) we are left ignorant of how much was clayed, and how much marled. It is to be inferred, however, that the clay was thought most serviceable, as Mr. Rodwell says—

“Clay is much to be preferred to marl on those sandy soils, some of which are loose, poor, and even a black sand.”

11. Young's *Survey of Norfolk*, (a large and closely printed octavo volume,) has fourteen pages filled with a minute description of the soils of that county—but without any indication whatever of the proportion, presence, or absence, of calcareous earth in that extensive district of sandy soils, so celebrated for their improvement by marling—nor in any other part of the county. The wastes are very extensive: one of them (page 385) eighteen miles across, quite a desert of sand, “yet highly improvable.” Of this also, no information is given as to its calcareous constitution.

12. The section on marl (page 402, of the same work) gives concise statements of its application, with general notices of its effects, on near

* Cleaveland's *Mineralogy*.

fifty different parishes, neighborhoods, or separate farms. Among all these, the only statements from which the calcareous nature of the manure may be gathered, are, (page 406,) of a marl that “ferments strongly with acids”—another, (page 409,) that marling at a particular place destroys sorrel—and (page 410) that the marl is generally calcareous, and that *that containing the most clay, and the least calcareous earth*, is preferred by most persons, but not by all.

13. Young’s *General View of the Agriculture of Suffolk*, (an octavo of 432 pages of close print,) in the description of soils, affords no information as to any of them being calcareous, or otherwise; yet the author mentions (page 3) having analyzed some of the soils, and reports their aluminous and silicious ingredients. Nor can more be learned in this respect, in the long account afterwards given of the “marl” which has been very extensively applied also in the county of Suffolk. We may gather however, from the following extracts, that the “marl or clay” of Suffolk is generally calcareous, but that this quality is not considered the principal cause of its value; and further, that *crag*, a much richer calcareous manure, (which seems to be the same with our richest beds of fossil shells, or marl,) is held to be injurious to the sandy soils, which are so generally improved by what is *there* called marl.

“Claying—a term in Suffolk, which includes marling; and indeed the earth carried under this term is very generally a clay marl; though a *pure, or nearly a pure clay, is preferred for very loose sands.*”—*Young’s Suffolk*, p. 186.

14. After speaking of the great value of this manure on light lands, he adds

“But when the clay is not of a good sort, that is, when there is really none, or scarcely any clay in it, but is an imperfect and even a hard chalk, there are great doubts how far it answers and in some cases has been spread to little profit.”—p. 187.

15. “Part of the under stratum of the county is a singular body of cockle and other shells, found in great masses in various parts of the country, from Dunwich quite to the river Orwell, &c.”—“I have seen pits of it to the depth of fifteen or twenty feet, from which great quantities had been taken for the purpose of improving the heaths. It is both red and white, and the shells so broken as to resemble sand. On lands long in tillage, the use is discontinued, as it is found to make the sands blow more.” [That is, to be moved by the winds.]—p. 5.

15. The *Essay on Manures*, by Arthur Young, for which the author was honored with the Bedford medal, speaks distinctly enough of the value of marl being due to its calcareous ingredient, (as this author doubtless always knew, notwithstanding the looseness of most of his remarks on this head—) but at the same time he furnishes some of the strongest examples of absurd inferences, or of gross ignorance of the mode in which calcareous earth acts as an ingredient of soil, and the proportion which soils ought to contain. These are his statements, and his reasoning thereon:

“It is extremely difficult to discover, from the knowledge at present possessed by the public, what ought to be the quantity of calcareous earth in a soil. The best specimen analyzed by Giobert had 6 per cent.; by Bergman, 30 per cent.; by Dr. Fordyce, 2 per cent.; a rich soil, quoted by Mr. Davy, in his lecture at the Royal Institution, 11 per cent. This is an inquiry, concerning which I have made many experiments, and on soils of the most extraordinary fertility. In one, the proportion was equal to 9 per cent.; in another 20 per cent.; another, 3 per cent.; and in a specimen of famous land, which I procured from Flanders, 17 per cent. But the circumstance which much perplexes the inquiry is, that many poor soils possess the same or nearly the same proportions as these most fertile ones. To attain the truth, in so important a point, induced me to repeat many trials, and to compare every circumstance; and I am disposed to conclude, *that the necessity of there being a large proportion of calcareous earth in a soil depends on the deficiency of organic* [i. e. vegetable or animal] *matter; of that organic matter which is [partly]*

convertible into hydrogen gas. If the farmer finds, by experiment, that his soil has but a small quantity of organic matter, or knows by his practice that it is poor, and not worth more than 10s., 15s. or 20s. an acre, *he may then conclude that there ought to be 20 per cent. of calcareous earth in it*; but if, on the contrary, it abound with organic matter, and be worth in practice a much larger rent, in that case his marl cart will not be called for, though there be but five per cent. or even less, of calcareous matter."—*Young's Essay on Manures*—Sect. 2.

It is scarcely necessary to show, that the opinion of calcareous matter being needed in larger quantities in proportion to the deficiency of putrescent matter, is directly opposed to the reasoning of this essay. If a poor soil were made to contain twenty per cent. of calcareous matter, by applying lime, chalk, or marl, the quantity and the expense would be so enormous as not to be justified by any possible return, and in truth, would lessen rather than increase the product of a poor soil. The fact named as strange by Young, that some rich soils contain very small, and others very large proportions of calcareous earth, is easily explained. If a natural soil contains any excess of calcareous earth, even though but one per cent., it shows that there is that much to spare after having served every purpose of neutralizing acids and combining with putrescent matter. If there were twenty per cent. more of calcareous matter, it would be useless, until met by an additional supply of putrescent matter. Young's statement that some poor soils agree precisely with other rich soils, in their contents of calcareous earth, does not necessarily contradict my doctrine that a proper proportion of calcareous earth will enable any soil to become rich, either in a state of nature, or under mild cultivation, and for the following reasons:

16. 1st. The correctness of Young's analyses may be well doubted; and if he used the then usual process for separating calcareous earth, he was obliged to be incorrect on account of its unavoidable imperfection, as has been already explained at page 36. 2d. It cannot be known positively what was the original state of fertility of most cultivated soils in England, nor whether they were subjected to exhausting or improving cultivation, for centuries before our information from history begins. 3d. Lime has been there used for a long time, and to great extent; and chalk and marl were applied as manures during the time of the Roman conquest, as stated by Pliny, (say 1700 years ago) so that it cannot be always known whether a soil has received its calcareous ingredient from nature, or the industry of man. 4th. It is known that severe cropping after liming, and also excessive doses of calcareous earth, have rendered land almost barren; of which the following extracts offer sufficient proof:—

"Before 1773, [in East Lothian,] the *out-field* did not receive any dung except what was left by the animals grazed upon it. In many cases, *out-field* land was limed; and often with singular advantage. The after management was uniformly bad; it being customary to crop the timed *out-field* with barley and oats successively, so long as the crop was worth cutting. In this way numerous fields suffered so severely as to be rendered almost sterile for half a century afterwards." *Farmer's Magazine*, p. 53, vol. xii.

"An overdose of shell marl, laid perhaps an inch thick, produces for a time large crops. But at last it renders the soil a *caput mortuum*, capable of neither corn nor grass; of which, there are too many examples in Scotland, &c. *Gentleman Farmer*, p. 378.

17. Yet the last writer (Lord Kames) elsewhere states, (at page 379,) that as much clay marl as contains 1500 bolls, (or 9000 bushels,) of pure calcareous earth to the acre, is not an overdose in Scotland.

18. "*Marl*. Of this substance, there are four sorts, rock—slate—clay—and shell marl. The three former are of so heavy a nature that they are seldom conveyed to any distance; though useful when found below a *lighter* soil. But shell marl is specifically

lighter, and consists entirely of calcareous (fish-bone, or shells of fish,) which may be applied as a top-dressing, but it will be less advantageous to use quick-lime." [This is the substance of extract 5, and there more particularly described.] "The argillaceous or red marl, is the great source of fertilization, &c."—"The soil in many cases about three hundred middling cart loads per acre, and is sometimes so thickly covered as to have the appearance of a red soiled surface."—*Sinclair's Code of Agriculture, American ed. (Hartford) p. 138.*

This account of the Lancashire improvements made by red chalk closes with the statement that "the effects are represented to be benefited in the highest degree," which is fully as exact an account of profit, or increased production, as we can obtain of any other marling. Throughout, there is no hint as to the calcareous constituents of the soil or the manure, or whether either rock, clay or slate marls, generally, are valuable for that or for other reasons; nor indeed could we guess that they contained any calcareous earth, but for their being classed with many other substances, under the general head of calcareous manures.

19. "The means of ameliorating the texture of *chalky* soils, are either by the application of clayey and sandy loams, pure clay, or *marl*."—"The chalk stratum sometimes lies upon a thick vein of black tenacious marl, of a rich quality, which ought to be dug up and mixed with the chalk."—*Code of Agriculture, p. 19.*

20. Dickson's *Farmer's Companion*.—The author recommends "argillaceous marl" for the improvement of *chalky soils*; and for sandy soils, "where the calcareous principle is in sufficient abundance, *argillaceous marl*, and clayey loams," are recommended as manures.

21. "Chalky loam. The best manure for this soil is clay, or *argillaceous marl*, if clay cannot be had; because this soil is defective principally in the argillaceous ingredient."—*Kirwan on Manures, p. 80.*

The evident intention and effect of the marling recommended in all the three last extracts, is to *diminish* the proportion of calcareous earth in the soil.

22. In a *Traveller's Notes* of an agricultural tour in England, in 1811, which is published in the third volume of the *Edinburgh Farmers' Magazine*, the following passages relate to Mr. Coke's estate, Holkham, and to Norfolk generally.

"Holkham.—The soil here is naturally very poor, being a mixture of sand, *chalk*, and flint stones, with apparently little mixture of argillaceous earth—the *subsoil, chalk or lime-stone every where*." Page 486. "As the soil of the territory [of Norfolk generally] through which I passed, seems to have a *sufficient mixture of calcareous earth naturally*, I learn they do not often lime their lands; but *clay marl* has been found to have the most beneficial consequences on most of the Norfolk soils." p. 487.

23. "In Norfolk, they seem to *value clay more than marl*, probably because their sandy soils already contain *calcareous parts*."—*Kirwan on Manures, p. 87.*

From this and the preceding quotation it would follow, that the great and celebrated improvements in Norfolk, made by marling, had actually operated to *lessen the calcareous proportion of the soil*, instead of increasing it. Or, (as may be deduced from what will follow,) if so scientific and diligent an inquirer as Kirwan was deceived on this very important point, it furnishes additional proof of the impossibility of drawing correct conclusions on this subject from European books—when it is left doubtful, whether the most extensive, the most profitable, and the most celebrated improvements by "marling" in Europe, have in fact served to make the soil *more or less* calcareous.

Most of the extracts which I have presented, are from British agriculturists of high character and authority. If such writers as these, while

glving long and (in some respects) minute statements of marl, and marling, omit to tell, or leave their readers to doubt, whether the manure or the soil is the most calcareous—or what proportions of calcareous earth, or whether any is present in either—then have I fully established that the American reader who may attempt to draw instruction from such sources, as to the operation, effects and profits of either marl or calcareous manures in general, will be more apt to be deceived and misled than enlightened.

I have now to refer to an author, whose works, well known as they may be to others, had not come under my view until after the publication of most of the foregoing extracts. Otherwise, Marshall would have been stated as an exception to the general silence of British authors as to the true and precise nature of what they treated of as *marl*. But though he has not been like others, so faulty as to leave in doubt what was the character and value of the marls of which he spoke, and the nature of their operation on the soils to which they were applied, still no other writer furnishes stronger proof of the general ignorance and disregard of the nature of marls and calcareous manures, and of their mode of operation; and even the author himself is not free from the same charge as will be shown. I shall quote more at length from Marshall, because he presents the strongest opposition to what I have stated as to the general purport of publications on marling; and also, because whatever may be their character, there is much to interest the reader in his accounts of the opinions and practices of those who have used calcareous manures longest and most extensively, although without knowing what they were doing.

In his *Rural Economy of Norfolk*, the “marls” and “clays” most used in the celebrated improvements of that county are minutely described, and the chemical composition stated, showing that both are highly calcareous. Of the “marls” or chalks, most used for manure in Norfolk, he analyzed three specimens, and one of clay, and found the proportions of pure calcareous matter as follows:

Chalk marl of Thorp-market, contained, per cent.	-	-	-	85
Soft chalk of Thorp-next-Norwich,	-	-	-	93
Hard chalk of Swaffham, almost pure,—nearly	-	-	-	100
Clay marl of Hemsby,	-	-	-	43

24. Of these he spoke previously and in general terms, thus:

“The central and northern parts of the district abound, universally, with a whitish-colored chalk marl; while the Fleg hundreds, and the eastern coast, are equally fortunate in a gray-colored clay marl.

“The first has, in all probability, been in use as a manure many centuries; there are oaks of considerable size now going to decay in pits which have obviously been heretofore in use, and which, perhaps, still remain in use, as marl-pits.

“The use of clay marl, as a manure, seems to be a much later discovery; even yet, there are farmers who are blind to its good effect; because it is not *marl*, but “*clay*,” by which name it is universally known.

“The name, however, would be a thing of no import, were it not indiscriminately applied to unctuous earths in general, whether they contain, or not, any portion of calcareous matter. Nothing is “*marl*” which is not white; for, notwithstanding the county has been so long and so largely indebted to its fertilizing quality, her husbandmen, even in this enlightened age, remain totally ignorant of its distinguishing properties; through which want of information much labor and expense is frequently thrown away.

“One man, seeing the good effect of the Fleg clay, for instance, concludes that all clays are fertile, and finding a bed of strong brick earth upon his farm, falls to work, at a great expense, to “*claying*”—while another, observing this man’s miscarriage, concludes that all clays are unprofitable; and, in consequence, is at an expense, equally ill applied, of fetching “*marl*” from a great distance; while he has, perhaps, in his own farm, if judiciously sought after, an earth of a quality equally fertilizing with that he is throwing away his time and his money in fetching.—*Marshall’s Norfolk*, vol. i., p. 16.

Yet it is remarkable, that Marshall should not have intimated whether the Norfolk soils were naturally calcareous, (as the two writers just before quoted declare,) or not; and therefore we are still left to guess whether these manures served to increase the calcareous quality of soils already possessing that quality in a high degree—or to give it to soils devoid of it before.

Other passages will now be quoted from the same, and from other similar works of Marshall's, to show the prevailing ignorance of the ingredients, and operation of the marls sometimes prized, and sometimes contemned, with as little reason in the one case as the other, by farmers in various parts of England.

25. "The principal part of his estate, however, is of a much shallower soil, not deeper than the plough goes; and its present very amazing fertility he ascribes in a great measure to his having clayed it. Indeed to this species of improvement the fertility of the Fleg Hundred is allowed to be principally owing.

"Mr. F. gave me an opportunity of examining his clay pit, which is very commodious; the uncallow is trifling, and the depth of the bed or jam he has not been able to ascertain. It is worked, at present, about ten or twelve feet deep.

"The color of the fossil, when moist, is dark brown, interspersed with specks of white, and dries to a color lighter than that of tuler's earth; on being exposed to the air, it breaks into small die-like pieces.

"From Mr. F's account of the manner of its acting, and more particularly from its appearance, I judged it to be a brown marl, rather than a clay; and, on trying it in acid, it proves to be strongly calcareous; effervescing, and hissing, more violently than most of the white marls of this neighborhood: and what is still more interesting, the Hemsby clay is equally turbulent in acid as the Norwich marl, which is brought by water forty miles into this country, at the excessive expense of four shillings a load upon the staitth; besides the land carriage. [The strength of this Hemsby clay is stated above.]

"It is somewhat extraordinary that Mr. F., sensible and intelligent as he is, should be entirely unacquainted with this quality of his clay; a circumstance, however, the less to be wondered at, as the Norfolk farmers, in general, are equally uninformed of the nature and properties of marl."—*Marshall's Norfolk*, vol. ii., page 192.

The following is a remarkable instance, in a particular district, of a clay very poor in calcareous matter, being considered and used as valuable manure, and a very rich marl equally accessible, being deemed inferior.

26. "The marl is either an adulterate chalk, found near the foot of the chalky steep of the West Downs, lying between the chalk rock and the Maam soil, partaking of them both—in truth, a marl of the first quality, or a sort of blue mud, or clay, dug out of the area of this district, particularly, I believe, on the south side of the river. This is said to have been set on with good effect; while the former is spoken of, as of less value; whereas, the white is more than three-fourths of it calcareous; while the blue does not contain ten grains, per cent., of calcareous matter."—*Marshall's Southern Counties*, p. 175.

The greater part of what are called marls in the following extract, and used as manure, contain so little calcareous earth, that whatever power they may exert, must be owing to some other ingredient. Yet, without Marshall's analysis, they would be considered to deserve the character of calcareous manures, as much as any others before named.

27. "The red earth which has been set upon the lands of this district, in great abundance, as 'marl,'—is much of it in a manner destitute of calcareous matter; and, of course, cannot, with propriety, be classed among marls.

"Nevertheless, a red fossil is found, in some parts of the district, which contains a proportion of calcareous matter.

"The marl of Croxall (in part of a stone-like, or stony texture, and of a light red color) is the richest in calcareosity; one hundred grains of it afford *thirty grains* of calcareous matter; and seventy grains of fine, impalpable, red bark-like powder."

* This marl is singularly tenacious of its calcareous matter; dissolving remarkably slowly. One hundred grains, roughly pounded, was twenty-four hours in dissolving;

"And a marl of Elford (in color and contexture various, but resembling those of the Croxall marl) affords near *twenty grains*.

"Yet the marl of Barton, on the opposite side of the Trent—though somewhat of a similar contexture, but of a darker more dusky color—is in a manner destitute of calcareosity! one hundred grains of it yielding little more than one grain—not *two grains* of calcareous matter. Nevertheless, the pit, from which I took the specimens analyzed, is an immense excavation, out of which many thousand loads have been taken.

"And the marls of this neighborhood (which mostly differ in appearance from those described, having generally that of a blood-red clay, interlayered, and sometimes intermingled with a white gritty substance) are equally poor in calcareosity.

One hundred grains of the marl of Statford (which I believe may be taken as a fair specimen of the red clays of this quarter of the district) afford little more than *two grains* of calcareous matter.* Yet this is said to be 'famous marl;' and from the pits which now appear, has been laid on in great abundance.

"I do not mean to intimate, that these clays are altogether destitute of fertilizing properties, on their first application. It is not likely that the large pits which abound in almost every part of the district, and which must have been formed at a very great expense, should have been dug, without their contents being productive of some evidently, or at least apparently good effect, on the lands on which they have been spread.

I confess, however, that this is but conjecture; and it may be, that the good effect of the marls, first described being experienced, the *fashion* was set; and the distinguishing quality being unknown, or not attended to, marls and clays were indiscriminately used."—*Marshall's Midland Counties*, vol. i. p. 152.

28. "On the southern banks of the Anker, is found a gray marl; resembling in general appearance the marl of Norfolk, or rather the fuller's earth of Surrey. In contexture it is loose and friable.

"This earth is singularly prodigal of its calcareosity. The acid being dropped on its surface, it flies into bubbles as the Norfolk marl. This circumstance, added to that of a striking improvement, which I was shown as being effected by this earth, led me to imagine that it was of a quality similar to the marls of Norfolk.

"But, from the results of two experiments—one of them made with granules formed by the weather, and collected on the site of improvement, the other with a specimen taken from the pit, it appears that one hundred grains of this earth contain no more than *six grains* of calcareous matter! the residuum a cream colored saponaceous clay, with a small proportion of coarse sand."—*Marshall's Midland Counties*, vol. i: p. 155.

The last extracts suggested a remark which ought to have been made earlier. When there is so much general ignorance prevailing among practical farmers as to what they call marl, it cannot be expected that the most intelligent writers can be correct, when attempting to record their practices. When Arthur Young, for example, reports the effects of marl in fifty different localities, as known from the practice of perhaps more than several hundred individuals, it must be inferred that he uses the term, generally, as they did from whom his information was gathered, and in very few cases, if at all, as learned by his own analyses. Therefore, it may well be doubted whether the uncertainty as to the character of marl does not extend very generally to even the most scientific writers on agriculture.

As the foregoing extract exhibits the use of "marls" destitute of calcareous earth, so the following shows, under the name of *sea sand*, a manure which is in its chemical qualities a rich *marl* (in our sense) or calcareous manure.

29. "*Sea sand*. This has been a manure of the district, beyond memory or tradition. "There are two species still in use: the one bearing the ordinary appearances of sea sand, as found at the mouths of rivers; namely a compound of the common sand and mud; the other appears to the eye clean fragments of broken shells without mixture; resembling in color and particles, clean-dressed bran of wheat.

and another hundred, though pulverized to mere dust, continued to effervesce twelve hours; notwithstanding it was first saturated with water, and afterward shook repeatedly. The Breckon stone, roughly pounded, dissolved in half the time; notwithstanding its extreme hardness.

* Lodged not in the substance of the clay, but in its natural cracks or fissures.

"By analysis, one hundred grains of the former contain about thirty grains of common silicious sea sand, with a few grains of fine silt or mud; the rest is calcareous earth mixed with the animal matter of marine shells.

"One hundred grains of the latter contain eighty-five grains of the matter of shells, and fifteen grains of an earthy substance, which resembles in color and particles, minute fragments of burnt clay or common red brick.

"These sands are raised in different parts of Plymouth Sound, or in the harbor; and are carried up the estuaries in barges; and from these on horseback, perhaps five or six miles into the country; of course at a very great expense, yet without discrimination, by men in general, as to their specific qualities. The shelly kind, no doubt brought them into repute, and induced landlords to bind their tenants to the use of them; but without specifying the sort—and the bargemen, of course, bring such as they can raise and convey at the least labor and expense. It is probable that the specimen first mentioned, is above par, as to quality: I have seen sand of a much clearer appearance, travelling towards the fields of this quarter of the country; and near Beddiford, in North Devonshire, I collected a specimen under the operation of "melling" with mould, which contains eighty grains per cent. of clean silicious sand!"—*Marshall's West of England*, vol. i., page 154.

It might be inferred from all these proofs of Marshall's knowledge of calcareous earth constituting the real value of marls, that he could scarcely miss the evident corollary to that proposition, that the valuable operation of calcareous manures is to render soils more calcareous, and that the knowledge of the nature of the manure and the soil would sufficiently indicate when the application of the one to the other was judicious or not. But the following expression of opinion (*Marshall's Yorkshire*, vol. i., p. 377) is not only strongly opposed to those deductions, but to the general purport of all his truths which I have before quoted.

30. "Nothing at present but comparative experiments can determine the value of a given lime, to a given soil; and no man can with common prudence lime any land upon a large scale, until a moral certainty of improvement has been established by experience."

If this be true, then indeed is there no true or known theory, or established precepts, for applying either lime or any calcareous manure. It amounts to saying, that every new application is a mere experiment, the result of which cannot even be conjectured from any facts previously known of other soils and other manures.

31. The next quotation, which is from an editorial article in the *Farmers' Journal* of July 38, 1823, shows that the old opinion still prevails, that marl is profitable only on sandy lands; which opinion carries with it the inference that it is the argillaceous quality, rather than the calcareous that operates. The editor is remarking on a new agricultural compilation by a Mr. Elkinson, and ridiculing the author for his solemn annunciation of the truism, (in the editor's opinion,) that "marling on sand is more useful than on clay land." The reputation of Mr. Elkinson, says the editor

"May remain undisturbed among the farmers of Lincolnshire for a long time, who may never have chanced to meet with the old proverb, or have taken a journey into the sandy district of Norfolk. We really do not know whether it be as old as Jarvais Markham or not: but we have seen the following lines in black letter:

He that marls sand, may buy land;
He that marls moss, shall have loss;
He that marls clay, throws all away!"

The editor then passes to a subject on which his admitted ignorance serves to prove that the improvement gained by marling could not be simply the making a soil calcareous—for, upon that ground, when marl has once been plentifully given, and the land afterwards worked poor, there can be neither reason nor profit in a second marling. Yet, as if the mode of operation was altogether unknown, this passage follows:

"It was once asked of the editor by a very good practical Norfolk farmer, 'whether land which had been once marled and worn out would receive the same benefit from a second marling?' It was answered, that an experiment made on one field, or on one acre, would decide the point, but conjecture led to nothing conclusive. It has often been observed that loose land, after having been marled and out-cropped, deposited its marl in the subsoil, which therefore became more retentive [of water;] and it has been suggested, that deep ploughing ought to be tried, to bring this marl again to the top. We hope that the point here in question has before now been settled by practice in both ways; though at the above period, (about 1806,) such facts had not reached the gentleman alluded to, although a very intelligent man."

The singular fact stated above, of marl, and also of lime, sinking and forming a layer below the soil, is stated by other British writers. No such result has been found in this country, so far as I am informed. Nor do I believe that it can occur, except when the calcareous matter is too abundant to form a chemical combination with the soil, or with the matters in the soil. According to my views of the manner in which calcareous earth acts, it must form such combination in the soil, to be useful—and if so combined, it cannot be separated, and sink through the soil by the force of gravity, or any other cause.

32. The next article is probably one of the latest publications on marl, yet contains as little of truth, and for its length, as much that is false and absurd, as if it had been written a century ago. It appeared (in English) in the *Quarterly Journal of Agriculture*, (for Dec. 1834,) and is there quoted from the *Magazine of Gardening and Botany*, and as written by Count Gyllenborg. As no contradictory remarks are appended by either of the editors of these highly respectable journals, it may be considered as in some measure giving their countenance to the opinions here presented.

Though the writer speaks of "acid in the land," yet the succeeding part of the sentence, which speaks of "imbibing it from stagnating water," shows that no correct or definite idea was attached to the term "acid." The entire piece is copied.

"How far marl contributes to the fertility of soils, 1st. Not materially, for it is devoid of every unctuous and saline matter. 2d. But instrumentally it promotes vegetation, by attracting the moisture, acids or oils in the atmosphere, which enrich the land. As this quality becomes stronger by burning, how wisely would the farmers act in using it after being calcined. It promotes vegetation, by destroying the acid actually in the land, or removing that which it might be in danger of imbibing from stagnating water, and hence, also, it may perhaps help to prevent a too acid disposition in the seeds. By dissolving every unctuous substance in the land, whence arises a saponaceous mixture soluble in water, and fitted to enter into the pores of vegetables. By destroying the toughness of strong soils, for, by its quickly crumbling in the air, the cohesion of a clayey soil is diminished, it is rendered easier to cultivate, and more fit to carry on the growth of plants. It gives greater solidity and firmness to loose or sandy soils; and, as before observed, it contributes to their fertility, by attracting into this dry soil the nutritive contents of the air. There are some who think that marl should not be laid on sandy soils; but experience has taught us to conclude otherwise, having observed that the most beneficial effects are produced from it on very light and sandy soils. Marl may hurt land by too long and a too plentiful use of it; for, from its calcareous quality, it much resembles lime. It soon dissolves and consumes the fat of the land—and it loosens a clayey soil, so that it becomes less retentive of moisture. Marl is, however, very different, according to its being more or less calcareous or clayey; and therefore judgment is more or less necessary to adapt it to the nature of the soil. Some have recommended it chiefly for wet and cold soils, and many farmers have observed that it is most useful when mixed with rich manures. Neither of these observations, however, seems to be correct; but a due care should be taken that this manure be adapted to the soil on which it is laid."

NOTE IV.

DESCRIPTION AND ACCOUNT OF THE DIFFERENT KINDS OF MARL, AND OF THE GYPSEOUS EARTH, OF THE TIDE-WATER REGION OF VIRGINIA.

Report to the State Board of Agriculture, by Edmund Ruffin, Member and Corresponding Secretary of the Board. 1842.

Within the last twenty-five years there have been produced from the application of calcareous manures more improvement and benefit, both agricultural and general, in lower Virginia, than from all other means and sources, numerous and valuable as have been the agricultural improvements made. And for the latter half of that time, no one agricultural subject has been treated of more at length in the publications of this state. Still, there is much required to be known; and it has very often, and not less so recently than formerly, been required of the writer, who has furnished to the press the larger part of all that has thence proceeded on this subject, to give answers to inquiries, which, however variously worded, amounted in substance to the question, "What is marl?"—or "Is my marl, (or whatever earth was so termed,) good marl, and likely to be profitable as manure?" It has therefore appeared to the writer that it would be useful to prepare something like a natural history or general and full description of the marls of lower Virginia; and also of the kindred and yet very different mineral manure, the gypseous earth, or "green-sand" earth, concerning which latter so much error and delusion have been spread and long maintained, and so little of truth or useful information derived from the sources generally respected as the highest authority.

The main difficulty in the treating of this subject is presented in the outset in the very term "*marl*," which is altogether misapplied now in this country, though not so much as it has been and perhaps still is in England. Since this general course of misapplication was set forth by the writer at length in the 'Essay on Calcareous Manures,' there have become general in this country still other misapplications of this always misapplied term. For the "green-sand" earth of New Jersey, which before had been called "marl" by illiterate farmers only, has been since received under that name by chemists and the scientific reporters of geological surveys; and thus confusion has become still "worse confounded." In the following pages, I shall be compelled, as heretofore, to yield in part to such misapplication of the term; but at the expense of some otherwise useless repetition, and frequent explanation, shall hope to avoid misleading readers as to each of the particular earths under consideration. And, in general, I shall in no case apply the term *marl* to any but a *calcareous earth*, and of which the calcareous ingredient or proportion of carbonate of lime is deemed sufficient to constitute the most important, if not indeed forming the only important or appreciable agent of fertilization; and therefore I shall not so designate either the fine clays, (not calcareous, or very slightly so,) called marl in England, or the green-sand earths of New Jersey, Delaware or Virginia, when containing very little or no carbonate of lime.

True marl, as correctly understood and described by mineralogists, is a fine calcareous clay, containing very little silicious sand, and none coarse, or separate; of firm texture—not plastic, or adhesive; does not bend under pressure, but breaks easily. It is manifest, from its laminated appearance and fracture that this true marl has been originally suspended in rapidly flowing waters, and deposited at the bottom by subsidence, when the waters became comparatively still; as when a rapid river, turbid with calcareous clay, reached a lake. Thus, from its manner of formation, such marl, however argillaceous, was of a texture very different from the almost pure.

or the most tenacious clays. The carbonate of lime also tends to preserve an open and mellow texture in true marls, disposing the lumps to readily yield and crumble, or fall to powder or to thin flakes, under atmospherical influences, which would only affect clay by making it an intractable sticky mortar when wet, or lumps of almost stony hardness when dry. Moreover, there seems good reason to believe that in true marl there is a *chemical combination* (and not merely a mixture) of the argillaceous and calcareous ingredients, induced by their suspension in water, when the particles of both were in the finest possible state of division, and most intimate intermixture, while so suspended. Besides the crumbling quality just stated, so different from clay, there is a still stronger reason for believing that the calcareous and the silicious parts of true marl are chemically combined, which is, that they cannot be separated by mechanical means, such as agitation and subsidence in water. For the suggestion that the different earthy parts of true marl are in a state of chemical combination with each other, I am indebted to the '*Essai sur la Marne*,' of M. Pavis, which work, in an abridged form, I translated and published in the third volume of the Farmers' Register. The author there also states that the marls of France are principally, if not always, of fresh-water formation, as is shown by the shells they contain being either such as belong to rivers and lakes or to the land. This is different from any thing known in lower Virginia; all our known marls, whether properly or improperly so termed, being deposits made in a former sea, and the shells being those of sea-animals.*

But though it is proper to describe that which only is truly "marl," before speaking of what is improperly so called, it is also true that there is nothing to tell of the use of any true marl in Virginia, and scarcely of its existence in the tide-water region. I have as yet seen it in but few places, and then overlying ordinary beds of fossil shells, and intermixed therewith. This marl was thus found in two of my diggings, one on Coggins Point farm and the other at Shellbanks. In both cases, though perfectly characterized, the quantity of true marl was too small to be used separately from the more calcareous and much thicker stratum of shell marl below. This true marl was in many horizontal layers, seldom more than an inch in thickness, separated by other layers, sometimes very thin, of almost pure shells

* "It may be of some interest to scientific investigators to know more particularly the shells of these marls of France. In a catalogue annexed to the original '*Essai sur la Marne*,' the author names the following shells:

In a marl sent from St. Trivier—yellowish, compact, of homogeneous appearance, and coming to pieces finely and easily in water—

Land shell—*Turbo elegans*.

River shells—*Helix fascicularis*, *Helix vivipara*, †*Helix tentacula*, †*Mya Pictorum*.

In a marl from Cuiseaux, Saône et Loire—

River shell—*Melanopside* (of Lamarck.)

In a marl from Leugny, in Yonne—

Land shell—†*Chassiliæ rideæ* (of Lamarck, and Draparnaud,) †*Helix lubrica*.

In a marl from St. Priest in Dauphiny—earthy, yellowish, very easy to crumble in water—

Land shell—†*Ambrette alongée* (of Lamarck and Draparnaud, †*Helix bispida*).

In an analogous formation of marl, in the basin of the Rhone, between Meximieux and Montluel, the *Helix striée*, a land species is found in great abundance."

M. Pavis states that among these, and among all the species of shells found in the marls of the basins of the three great rivers, Saône, Rhone and Yonne, there are no remains of sea shells. All seem to have been formed under fresh water. "But (he continues) as these marls contain land shells, often in great abundance, we must conclude, that the revolution which heaped up the marls, has been preceded by a time in which the land was not covered by water, in which the earth producing vegetables, permitted the multiplication of the species of land shells which were found in these marls."—*Essai sur la Marne*, p. 8 to p. 24, and translation in *Farmer's Register*, iii., note to p. 692.

† Living species are still found in the same region similar to those marked thus.

broken very small, with some only of the very smallest entire. The pure argillaceous marl is blue (though sometimes of buff color,) firm and compact breaks easily, but does not bend however moist, and is cut smooth by a knife, leaving a surface like that of hard soap. This marl contained, in the argillaceous part, free from the shelly parts, only 10 per cent. of calcareous matter. Several other specimens, from other localities in the same region, were about the same strength. Therefore, even if more plenty, there would seem to be no inducement to use our true marl, where the beds of fossil shells, called marl, and usually so much richer in calcareous matter, can be drawn from. But in Europe, clay marl is reported as rich as 40 to 60 per cent. of calcareous matter, and indeed richer, gradually running into lime-stone. In our lime-stone mountain region, (and especially in the places of ancient lakes and ponds, now drained or filled up, there probably may be found bodies of true or clay marl, comparing in strength as manure, and in abundance, with the valuable European deposits.

But though it is proper to know, and to bear in mind, what is understood by the term marl by mineralogists, and by the well informed English and French agricultural writers, in regard to the extensive marlings in those countries, yet it is necessary in Virginia to conform generally to the usage which gives the name of marl to all earths mixed with fossil shells; and as the term is so far improperly extended, I would carry it still farther, and make it embrace all natural calcareous earths not of stony hardness. This arrangement then would indeed include true marl, but merely as one class, and that one of the least noticeable for abundance or value of all in this country. The following scheme of classification will conform to this view, and serve to make more clear the descriptions that will follow.

Marl in this wide sense may then be first divided into the two following great classes :

1. Fine *argillo-calcareous earth*, described above as "true marl," and which is not of itself shelly, even when in alternate layers with shells, and contains no separate silicious sand, or other coarse or heavy matters which could not remain, in a finely divided state, suspended in water flowing in but a moderate current. This marl, as stated above, is abundant and rich in some parts of Europe; but so rare and inconsiderable in quantity in eastern Virginia, as to be scarcely worth naming for agricultural use.

II. The second great division is *shell-marl*, which may be again divided into the two kinds, of 1, *recent fresh-water shells*, and 2, *fossil or ancient sea-shells*, left on and covered within what is now high land, up-heaved from the former bottom of the ocean, by ancient convulsions, or other great changes of the level of the earth's surface.

1. The first of these kinds is common in some parts of Scotland, and is found also in Vermont and probably other parts of the northern states, but is not known to exist in Virginia. It is formed by the gradual accumulation of the shells of periwinkles or other small fresh-water shell-fish, at the bottoms of the small and shallow lakes in which the animals had lived. When the bottom had been raised by this accumulation, and by deposits from this and other sources, nearly to the level of the surface of the lake, water plants began to grow, and to form a new accumulation of vegetable and earthy deposits; and finally the lake was thus changed to a peat-bog, wet and miry, but free from standing water. It is under the peat, and sometimes at considerable depths, that this peculiar and very rich marl is found. It is said to be almost pure calcareous matter, and has been sold by the bushel, in great quantity for manure in Scotland.—(*Edinburgh Farmers' Magazine*.*)

2. The second is for us the only important division of shell marl, embracing all the immense body of fossil sea-shells which underlies nearly all of the tide-water or tertiary region of Virginia. This is also of two kinds designated by Professor Lyell, according to their geological age and formation, as *miocene* and *ocene*; and these have each the several agricultural varieties and sub-varieties named in the table above, and which will be hereafter described in order.

As the terms "*miocene*" and "*ocene*" are now of universal acceptance among scientific writers, and are generally understood by agricultural readers on marl, and therefore are convenient for designating the very different descriptions of marls to which they have been applied, they will be here used. If the difference between these two kinds were merely geological, or in regard to comparative ages of formation, or to the respective fossils of each, it would be useless to preserve it in writing on agriculture, however marked the difference, and however interesting, to the geologist. But there is also a difference of agricultural character and value in these two kinds of marl. In relation merely to each other, the terms *ocene* and *miocene* may be sufficiently understood as the *older* and *newer* formations. But it will not do as well to substitute the latter terms, because they are not correct generally, or in relation to other marls and geological formations. For there are some much older than the *ocene*, and others

* In the *Edinburgh Farmers' Magazine*, vol. iv. p. 153, there is an interesting article (most of which was republished in the *Farmers' Register*, vol. i. p. 90,) describing a large body of this kind of shell marl, under Kesteven peat moss, Forfar, Scotland. Most of the shells are of the water snail (*Helix patris*, Linnaeus,) others are bivalves, (generally *tellina*, animal *tethys*, Lin.) From this deposit, the proprietor had sold as much for manure as brought him £12,000 sterling, in the 12 years after its use had been begun.

much more recently formed than the *miocene*. With neither of these is it necessary to encumber this article.

The different periods of time of these two different deposites of shells were very remote from each other, and the latest of them was also very remote from the present time. In the *miocene* marl of Virginia, or later of the two, of the numerous species of shells found, there are but few kinds belonging to animals known or believed to be yet existing; and in the *eocene* marl of Virginia there are almost none that now exist, and very few that belong also to the *miocene* marls. According to the highest geological authority, the race of animals whose remains formed the latest of these deposites, were mostly extinct before the creation of man.

Although it might be more conformable to regular or scientific arrangement to commence a general description with the older and lower deposit, the *eocene* marls, yet it will better suit the purpose of agricultural instruction to reverse the order, by describing first the *miocene* marls, as the highest in the series and the first reached, and by very far the most abundant and extensively accessible, and which therefore, though usually less powerful for fertilization, are much the most important to agriculture in Virginia in general. I shall therefore proceed first to treat of the *miocene* marls, which are the only kinds known in Virginia with the exceptions of the two comparatively small districts of *eocene* marl which will be hereafter treated of in their order.

MIOCENE MARLS.

When my investigations and practical labors on this subject were commenced, more than 24 years ago, the existence of marl of any kind had been noticed in lower Virginia at but a few places, where naturally exposed along steep river banks, and where cut through by deep ravines, and thus rendered conspicuous; and the deposit was supposed to be very limited, by the few persons who had ever cast a thought upon the subject. But the attention and observation subsequently directed to the search, soon showed that the quantity was very far more extensive; and now, though not generally near the surface of the earth, nor every where accessible, it seems probable that beds of fossil shells under-lie much the greater part of all the region between the falls of the rivers and the sea-shore. Except at or near the places where exposed on the surface, as above mentioned, the overlying earth is generally 20 or 30 and even sometimes 50 feet thick. All the marl-beds appear to be nearly horizontal, and of course are the most deeply covered under the highest lands, and are most easily accessible in deep depressions. The deposit dips gently towards the east, so that it lies too deep to be visible near the sea-coast. At Norfolk, the marl has been recently reached, in boring deep for water, at 40 feet below that low surface.

The marl is formed by the deposit and gradual accumulation of sea-shells, mostly left where the animals died; and the vacancies between the shells were filled by the sand or clay, or mixtures of both, with fragments of older shells, brought by currents and deposited in what was then the sea. The remarkably perfect state of preservation of many very thin and always fragile shells, and still more the many pairs of bivalve shells that yet are found connected or in contact, prove that such shells could not have been transported, or even much agitated, by the force of the water. But other beds of marl, and also frequently the upper layers of such as have been just referred to, show as clearly the action of currents, or of water in violent and long continued motion, which served to grind down the shells

to small fragments, and which also left, in shaping the surface of the marl, the marks of whirl-pools or other violent disturbance. From such supposed causes might be expected such effects as many of the various marl-beds actually exhibit. In different places, and sometimes in the same place, the shells and their fragments are found of all sizes, and of all conditions of preservation; and intermixed, in various proportions, with such clay, or fine sand, as might be suspended in or borne by currents; so as to form beds of every degree of texture and shade of color. The shells, and their fragments, or the carbonate of lime, are in various proportions of quantity, from 10 per cent., (or even less in rare cases,) to 90 per cent. or more, of the mixture, or whole mass. In different beds, and sometimes in contiguous layers of the same bed, the shells are in every state of preservation or of decay; from that of being firm, and often entire in their calcareous structure, and the most delicate parts of their beautiful forms preserved, to that of being mostly broken down, and almost reduced to a coarse powder, and sometimes even forming a homogeneous mass of still finer particles in which the forms of but few if any shells are distinguishable. The original bright and various colors of the shells are lost, and they are nearly all white—a few of the hardest only being brown or gray. The texture of the mass also varies, from a loose sand to a firm body of almost stony hardness. The earth intermixed with the shells is generally much more sandy than clayey, and more especially in the poorer marls. Even when the admixture of earth is clay, it rarely makes the marl appear the least clayey in texture, or plastic or adhesive, because the clay is but in small proportion to the shelly matter. The color of the miocene marls is also various—generally either pale yellow or dingy white or blue, sometimes bright, but more often a dull blue, or ash color. The richest marls, of homogeneous texture, are nearly white when dry, and approach in appearance to a coarse or impure chalk. There is no true chalk known to exist in this country.

The shell marls of Virginia are confined almost entirely to the tide-water region, or the space eastward of the granite which forms the falls of all our eastern rivers. But near Petersburg (on the farm of Dr. William J. Dupuy, and other adjoining lands,) there is an exception to this general rule, the marl being found about a mile farther west, over-lapping the eastern part of the granite, and passing under a small stream which empties into the Appomattox, a mile above the lowest falls. A thick stratum has also recently been found in Richmond, above the Penitentiary, and of course above the lower falls of James river.

The only important fertilizing ingredient of the miocene marls is the carbonate of lime, or shelly matter. There may be, and probably is, some slight additional benefit sometimes, by accidental or peculiar admixtures of other substances; as, of animal matter still remaining, or of vegetable extract in blue marls, or of the oxide of iron, or of a small proportion of green-sand generally, and even of the clay or the sand respectively for soils deficient in either. But either and all of these additional matters, though giving some value as manure, are of but little importance in miocene marls, in comparison to the main and great agent of fertilization, the shelly or calcareous matter. According then to the greater or less proportion of this main ingredient, and to its state of division or readiness to be reduced to a state of minute division in the soil, may be rated the comparative values of marls for manure. In regard to the much larger proportions of green-sand in miocene marls, as asserted by other authority, some additional remarks will be hereafter submitted, in the proper order for consideration.

As might be inferred from the obvious manner of the deposition of the marl, as before stated, by waters of the sea in violent and yet varying

degrees of motion, the different horizontal layers of marl, successively deposited in the same bed, and even within a few inches of perpendicular distance of each other, sometimes exhibit remarkable differences of appearance, composition, and of value; while there is also generally as remarkable a uniformity of character of each particular layer, (though differing much in thickness at different places) throughout not only the different diggings of the same place, but sometimes for miles in extent. I have seen often, in diggings on different farms, and several miles apart, layers of marl so precisely alike, and so marked in peculiar character, that there could be no doubt of their being parts of the same deposit, made at the same time, and by the same operating natural causes. Under such circumstances, a practised eye can by comparison fix very nearly the chemical composition of similar varieties, and even more correctly, for general averages of value, than would be usually obtained from the accurate chemical analysis of one or two specimens. For the usual danger of error is, not in the chemical analysis, (which is easy enough made, and the mode very correct,) but in the selection of equal and fair specimens of marl to exhibit the average strength of the whole body excavated; which requires much more experience and accuracy than are usually exercised by most operators, and still more in regard to proprietors who send specimens of their marls to be analyzed by other persons. It is highly important to the farmer to know the strength of the marl he is using. And to this end, it is necessary that every layer should be carefully analyzed, or what is better, a specimen from an equal and continuous shaving of the whole vertical section of a digging, so as to furnish a fair average of the whole body. But after this trouble is once taken, the general result will serve for all the future diggings at the same place, and also for similar bodies more or less remote.

The layers of marls formed by shells left "in place," or where the animals died, are in general the poorest; and for this obvious reason, that all the hollows of and interstices between the shells are filled by what is mostly earth, (but mixed with more or less of shelly fragments,) and that earth is principally silicious sand. Marl so formed, will not have more than 35 to at most 40 per cent of calcareous matter, and more often only from 25 to 35. The sand or earth that would be required to fill all the hollows and chinks of a body of entire shells, of ordinary form, though touching each other at their edges and points, would necessarily be as much as 65 to 75 per cent. of the whole mass. And therefore, it is only because of, and in proportion to, the quantity of shelly particles mixed and borne along with the earth brought by currents and deposited among the whole shells, that such marl is sometimes richer than 25 to 35 per cent. in calcareous matter. The degree of admixture of shelly fragments in this filling earth, may be easily judged of by an experienced eye, and the proportion of shells and large fragments will depend much on the forms of the prevailing kinds of shells. It is easy to know the marls formed by shells left in their original place, by the state of the shells. Either the shells being whole, and especially the more fragile varieties, or the two sides of bivalve shells being found in close contact, as when the animal was living, will show clearly that the dead shells had not been agitated or borne along by currents. The beds or layers formed by removal are as easily known by the broken and finely reduced state of the shells. These marls are usually much the richest in calcareous matter; for, by the grinding operation of the currents, and the difference of specific gravity in the particles carried along, the calcareous powder and clay are deposited together, with but little silicious sand. Among the richest marls are some having whole shells in their original places, but of which the interstices are filled by such fine calcareous and clayey earth as could have been deposited only in waters nearly still. Such are

the rich marls in and about Williamsburg, and in Surry and that belt of country generally, containing 70 to 80 per cent. of carbonate of lime.

The different varieties of miocene marls which will now be more particularly described are not always separated in different beds, but sometimes form some of the different and even adjoining layers of the same bed or digging. The differences of color, &c., caused by the greater or less quantity of various accidental ingredients, however striking to the eye, are not often of much importance to the value of the marl; but only (or principally) such differences as are caused by the greater or less proportion of shelly matter, and its state of disintegration and division.

(a) *Yellow marl*.—This kind, wherever found, always forms the highest layers of the particular body. That is, if there be layers both of yellow and blue marl in the same body, the yellow is always above and the blue below, and never in the reverse position. But sometimes the yellow continues to the bottom, and sometimes the blue forms the top as well as the bottom.

Yellow marl is usually found dry; that is, having no springs or oozing waters, which are generally reached on digging lower in the body. But the lower part, where wet, is sometimes, though rarely, of the same yellowish or dingy white tint, so as to make it manifest that the color is not dependent on the degree of moisture or dryness. The yellowish tint is owing to the presence of oxide of iron, and is pale or deep, approaching sometimes to reddish brown, according to the quantity of that coloring matter.

Yellow sandy marl is the kind most abundant in Prince George county on and at some miles distance from the banks of James river, and from which some farms entirely, and others principally, in that neighborhood have been marled. It is of shells left in their original place, the filling earth being mostly of coarse sand, and the whole body poor in calcareous matter, varying in its proportion usually from 20 to 30 per cent. and rarely richer than 35 per cent. But it is of such open and loose texture, (and the more so as the sand is the more abundant,) that this marl is easily and cheaply worked, and the labor so applied is therefore often better compensated than in diggings of much richer marl. In this variety of marl, the shells are usually entire, or in large fragments, but are not firm or well preserved. In some beds, or thick layers, they are so finely reduced that the mass seems to the eye to be wholly, as it is indeed principally, a body of silicious sand. From one bed of this kind which its proprietor supposed from its appearance to be merely silicious, it was used as sand to mix in lime mortar for masonry, and it was found to serve well for that purpose. Subsequently this bed of sand was found to be enough calcareous to be used as manure; and was so used, and to such good profit, that the proprietor supposed it to be rich marl. In that opinion, however, he was mistaken, at least as to the calcareous contents.

Yellow clay marl.—But most of the richest as well as of the poorest miocene marls are yellowish. When rich, say containing proportions of carbonate of lime from 45 to 80 per cent., the marl is usually formed of shells broken down, when under the sea, to small fragments or to powder, by the grinding action of the water in violent motion, and left afterwards to settle in stiller water, according to the specific gravity. Or it is the same kind of rich and finely divided water-borne matter deposited on and filling the hollows in and between whole shells remaining in their original place. In either case, the small quantity of earth first suspended in the current, and then deposited with the finely reduced shelly matter, is mostly if not entirely clay; as silicious sand, having more specific weight, could not be suspended by

the current so long, or carried so far, before being deposited. The few rich clay marls of Prince George are of the first named variety, or composed entirely of fine fragments of shells intermixed with clay. The much richer marls in and about Williamsburg are of the other kind, there being also numerous whole shells in place, as well as the interstices being filled almost entirely by water-borne fragments, and fine powder of other shells. The other contents, making from 15 to 25 per cent. of the body, are principally of a very fine clay of pale yellow, and much less of silicious or white quartz sand, oxide of iron, and green-sand. Much of the same kind of rich marl is also in other parts of James City and York, in the lower part of Surry, and in Isle of Wight, New Kent, and King William counties, which I have seen—and probably throughout the middle belt of the marl region of Virginia. There has been little or none of these rich clay marls seen by me in the upper range of marl counties, (those next the falls of the rivers,) and not much more near to the eastern limits, or next to where the marl dips so deeply, as to disappear from the surface and is accessible only by deep digging. Perhaps observations more extended, and more accurate than mine have been, might present different conclusions.

The marls just described, when separated mechanically, (by the sieve and by carefully washing in water,) seem to consist, for the much greater part, of pure shelly matter, mostly in large or small fragments, slightly colored by brown oxide of iron, and the remainder of a very fine and apparently pure pale yellow clay. But this clay is also composed in part of finely divided carbonate of lime; and the fine shelly matter is intermixed with some silicious sand and a little green-sand. The bed of marl near Surry Court House, (which is similar to the marl at most other places thereabout,) is of this kind and general character; and from it, a large body of land has been manured with great benefit. This body of marl was reputed to be among the richest in green-sand. From a much larger sample of the marl of this bed, carefully selected by the proprietor, at my request and for my examination, an average portion taken was composed as follows:

1780 grains, separated mechanically, by the sieve and by washing in
— water, consisted of

	Carbonate of lime.	Fine argillaceous earth.	Silicious sand.	Green sand.
1036 grains of shells and coarse fragments, nearly pure, and so counted,	1036			
433 grains fine shelly fragments, &c., which consisted of	268	-	120	45
277 grains fine yellow clay, &c., which consisted of	65	212		
34 loss in the process.				
1780	1369	212	120	45

Which may be stated of parts to the hundred thus:

100 grains of marl contained of carbonate of lime,	77 grains.
Silicious or quartz sand, very pure and white,	6½ "
Green-sand	2½ "
Fine yellow clay or argillaceous earth, (and the loss in the latter process,)	13¾ "
	100 "

The richest bodies of these marls show very few shells, or even fragments, and have a homogeneous texture and appearance to the eye, like a very impure chalk or sandy clay. Such marls are in James City, New Kent, King William and Middlesex counties. The following are some of them of which I have analyzed specimens:

From King William, (Lipseonib's land)—	82	per cent. of carbonate of lime.
" " (Slaughter's land)—	88	" " "
" New Kent, (Col. Macon's land)—	88	" " "
" Middlesex, (Oaks' land) -	83	" " "

Some of very similar appearance, but still more approaching in texture to a very soft rock, from Lenoir county, N. C., and the bank of Neuse river, contained 75 per cent. of carbonate of lime. Sundry other specimens, of still more homogeneous and firm texture, from the banks of the Santee, S. C., contained about 95 per cent. Most of these marls are soft enough to be used for manure as dug from the pits; but the hardest lumps may need burning to lime. Any hard enough to need burning, and as rich as 85 per cent., will make good lime for cement, as well as for manure.

Under a peculiar combination of circumstances, the great richness of some marls operates to lessen the value of the body as manure. Rain water, when just fallen, always contains some carbonic acid, which admixture causes it to be a solvent of carbonate of lime. When rain water then can descend by percolation into rich dry marl, in its passage it dissolves some of the calcareous matter, which is again left solid, and in crystals, by the slow evaporation of the fluid. These crystals of carbonate of lime are slowly added to by every recurrence of the like causes, until the cavities of large shells, and other openings into which the water had settled, are completely filled with crystallization. If layers of marl, less pervious to water than in general, oppose the descent of the water, the crystallization forms in connected horizontal layers, separated by the thicker layers of softer marl. Such crystallized layers are found abundantly in the very rich marl at Yorktown, serving by their stony hardness to impair the otherwise great value of the manure. At Belfield, Col. Robert McCandlish's farm, a few miles higher on York river, the hollows of large shells have been filled with beautiful and brilliant crystals thus formed. In Surry also, on the land of the late William Jones, such crystallization is abundant. For such effect to be produced, there are several conditions necessary. The superincumbent earth must be of open texture, and not very thick—or rain water could not pass through. It must not be a hill-side—as the water would flow off the surface and not penetrate to the marl. And the marl must be dry—or evaporation could not take place, and of course not crystallization.

Gloucester, though one of the outside marl counties to the east, is most abundantly supplied with marl, accessible on almost every farm, whether of high or of low grounds. It is generally of the poorer yellow kind. But three marked exceptions were seen, which as such deserve to be named. One is the rich clay marl forming the north bank of Ware river on the farm of Mr. Alexander Taliaferro. Another is the general sub-soil (as it may considered from its position) of the lowest land of the farm of Mr. Jefferson Sinclair, near the mouth of Severn river. This is an almost pure body of coarse shelly powder, or fragments, seldom found larger than two or three grains in weight, and a very few shells, of as minute size, entire enough to be distinguished. This mass of shelly matter is as loose and incohesive as coarse sand, yet is tinged slightly with green by the admixture of greenish clay. A specimen analyzed contained 72 per cent. of carbonate of lime. (See more full account at page 181, vol. vi. Farmers' Register.) The third is the marl used by Capt. P. E. Tabb, and dug from beneath the low grounds on North river. It is a mass of pulverized shells, colored by red or brown oxide of iron.

(b) *Blue marl*.—This is the most common kind in the upper range, or near the western limits of the great marl deposit. Thereabouts, blue marl usually forms the whole thickness of the bed. More eastward, and lower

down the country, it sometimes forms the whole of low-lying beds, but more usually only the lower layers of a bed, of which the upper part is yellow.

Blue marl is generally such as remains "in place," or where the shells were left by the death of the enclosed animals, and the intermixed earth is mostly silicious sand; and therefore, (and not because of its color, this marl is rarely found as rich as 45 per cent., and is still more rarely equal to the yellow clay marls, though generally richer than the yellow sandy marls.

Blue marl in the bed is always wet, being made so by water slowly oozing from every part, though seldom fast any where, or showing sprugs or veins of running water. The blue color is not caused by moisture, for some yellow marls are also permanently wet,) but by vegetable extract, or other dark-colored putrescent matter, brought in the percolating water. This inference I have drawn from extensive observation of the natural beds, and also from several accurate though accidental experiments, of which the first that was observed will be here stated. A small stable yard was covered 6 to 10 inches thick with a rich dry yellow marl, for the purpose of retaining by chemical combination the juices of the putrescent manure which was to be thrown there from the stable. After remaining for this use a year or more, this flooring of marl was dug up and carried out for manure; when it was found to be changed in color to a deep and vivid blue, and precisely like the natural color and appearance of the understratum of the same body of marl, which being an open and almost pure mass of pulverized (and water-borne) fragments of shells, was readily penetrated by and always full of water. A general fact confirming this view is that all marls found lying immediately under swampy soils, full of vegetable matter, are blue. And this coloring vegetable matter in marl is not merely intermixed with, but must be held in chemical combination by the calcareous matter; and serves, according to its quantity, in blue marls, as an addition to the fertilizing power of the calcareous matter alone. The particular body of marl above referred to, the understratum of which is the most marked or vivid blue ever seen in marl, is at Shellbanks farm, Prince George, and from which I dug and applied a large quantity. The greater part, and all the richest layers seemed to be of shells broken down to a coarse powder, or of sizes less than fine gravel, through which clear water rose and passed so freely as to forbid digging to the bottom. The small quantity of clay or other earth intermixed with the calcareous earth of this marl is altogether insufficient to hold so much coloring matter; and, moreover, if the coloring matter were not *chemically* combined with the calcareous, the continued free passage of water must have dissolved and washed off any uncombined vegetable extract. This whole body of marl, both the dry and yellow lying at top, as well as the blue and wet below, was all brought and deposited by currents, as is manifest by the different layers of different specific gravity; and still more by the many intervening layers of a fine calcareous clay, (before mentioned,) which may be considered as the true marl of mineralogists, though in very small quantity. Analyses were carefully made of every different quality, and the results may be interesting as showing how much one layer may vary from the one next adjoining; and different specimens not more than a few feet apart.

Upper dry part, yellow, and loose as sand varying (by unevenness of surface) from 3 to 7 feet, contained of carbonate of lime	63 per cent.
Next layer below, brownish yellow, through which water passes,	25 "
About 12 inches lower, in the blue,	64 "
" " " " " another specimen below	73 "
Layers of clay marl, interspersed through the above	9 "

And in a subsequent digging the strength of four specimens of the blue part of the marl was as follows:

In the first foot depth of blue under-stratum	-	-	32 per cent.
In the second foot	-	-	33 "
At 3½ feet	-	-	76 "
At 4 feet, and lowest digging then effected	-	-	70 "

It may readily be inferred, from these various results, that if one or two specimens only had been analyzed, and these taken with no more care than is commonly used, that a very deceptive report might have been furnished from making even the most accurate analyses.

Conchologists and geologists, who have treated so much of marls but merely in reference to the shells they furnish, or to their geological character, speak of the blue marl as formed by shells being imbedded in a *blue clay*. But the earth is not generally a clay, nor any thing even approaching to a clay, but is mostly of silicious sand. The ordinary blue marl contains usually from three to four times as much pure silicious sand as of clay. From various specimens of two diggings in such marl, from which more than 300 acres were marled of the Coggins' Point farm, the following results were found by analysis:

Yellow marl (wet) thin layer at top, contained of carbonate of lime 24 grains. Within 24 inches of top, shelly matter finely divided, and the mass uniform dull blue color, 100 grains contained:

Carbonate of lime,	-	-	-	-	-	-	34 grains.
White silicious sand,	-	-	-	-	-	-	47
Clay, black when moist, and dark gray when dried,	-	-	-	-	-	-	19

100

Like blue marl from another pit in the same body, 100 grains contained:

Carbonate of lime,	-	-	-	-	-	-	34 grains.
Silicious sand,	-	-	-	-	-	-	52
Clay,	-	-	-	-	-	-	14

100

Of another specimen from the same, and of similar marl, 100 grains contained of carbonate of lime

-	-	-	-	-	-	-	29
At 6 feet deep, (the shell not much reduced,) carbonate of lime							44
At 13 feet deep, and one foot from bottom,							33

Some few hard lumps of conglomerated shells and earths scattered through the general mass,

73

From a digging at three-fourths of a mile distant, of marl of the same appearance and believed to be the same body as the preceding, the general average of strength, as obtained from several trials at different depths, was in 100 grains of marl, 35 of carbonate of lime. The thickness of this body, where penetrated, varied from 11 to 1½ feet; where there was a marked though not entire absence of shelly matter, and increase of silicious sand of the same blue tint. The deeper removal was stopped because of the obvious poverty, and no further examination of more than a foot or two in depth was made in this poor substratum. In but few of all the various diggings made by myself, or of others heard of, has the bottom of the marl been reached—though in many, and most generally when penetrated deeply enough, it becomes so poor as to be not worth the labor of removing. In the only known cases, when digging the marl for manure, that the bottom of the miocene was reached, the stratum below was of eocene green-sand earth, or eocene marl. In digging a well, at Shellbanks in Prince George county, my then residence, after passing through a bed of firm blue marl,

of broken (or water-worn) shells, obviously the same kind dug at another place for manure, and described at page 204, a soft brown sand was reached, apparently destitute of calcareous matter, and from which rose an abundant supply of pure and soft water to the height of 13 feet, which stood altogether in this blue marl, without its purity being affected either by the calcareous matter of the marl, or its coloring matter. The continued purity of this water is an additional proof that the blue coloring matter is chemically combined with the carbonate of lime—and the combination is a visible illustration of the manner in which marl holds to and fixes putrescent manures.

Mr. William Carmichael, of Queen Ann's county, Maryland, an intelligent agriculturist and an experienced and observant marler, is of opinion that there is a perceptible superiority of effect of blue marls over others of equal (and even greater) strength in calcareous matter. (Farmers' Register, vol. vii. p. 106.) This superiority of effect must be caused by the vegetable or other putrescent and alimentary matter being combined with the calcareous, and by its presence giving color to the blue marl. And that the blue color is thus produced is fully proved by the facts stated at page 204, and by my more general observation.

Excepting then the additional value in the vegetable extract which gives the color, there is no difference between the blue and the yellow marls, other than the difference, as of any marls of similar color, in their respective amounts of calcareous matter. And the same may be said of wet and dry marls, which are generally, but not always, distinguished by the above colors; and also of any other miocene marls, excepting for such proportion of "green-sand" as is sometimes present. But there is reason to believe that wet marls, in many cases, have lost some of their ancient strength, by the continued though very slow percolation and subsequent discharge of water through the mass. If recent rain water penetrates wet marl, it dissolves some carbonate of lime, (by means of the carbonic acid in the rain-water;) and, as the water slowly flows off, or oozes out, instead of being evaporated, the dissolved lime is washed into the nearest stream, and is lost, instead of being left, crystallized or otherwise, as in dry marl. Again—if water flows over having sulphate of iron (copperas) in solution, (which is not a very rare case,) that dissolved salt acts with the carbonate of lime to produce the decomposition of both the sulphate of iron and the carbonate of lime, and from two of their component parts to form sulphate of lime. And as this is slightly soluble in water, it must be carried off by the slowly oozing water, as long as any of these new salts remain. In this case, the carbonic acid is evolved, and the iron is precipitated—and often fills, or coats the interior of the spaces before filled by the shells which this chemical process had decomposed and removed. This effect, when produced, is seen at the upper part of the marl, where the copperas water first touches the shelly matter. In Henrico, near the western limit of the marl, there is generally over the present highest shells a body of earth of color and general appearance very similar to the marl below, and full of hollow impressions of shells, though no shelly nor even any calcareous matter now remains. In other marls, there is often seen an upper layer colored brown by this deposit of iron. Both these are different modes of the same operation; the waters charged with sulphate of iron having in the latter case decomposed and removed but part, and in the former all the calcareous matter, to some depth below the former top of the stratum of marl. The marl, in the upper part of which the shells have been thus dissolved and removed, has a decided sulphureous odor, which is left very perceptible on the hands, after handling the marl as dug; and this odor is still more

manifest in the marl when it has been dug and thrown out, and exposed some days to the weather. Such marl is within a few miles of Richmond, at Dr. Chamberlayne's and Col. C. W. Gooch's farms. It is poor in calcareous matter.

The comparative values of marls are fixed by the comparative proportions of carbonate of lime contained, other circumstances being alike; yet if these circumstances are very different, they may make a marl containing but 25 per cent. worth more than another of 50 per cent. The more finely reduced, or the more rotten the shells, the quicker the action will be, and the more profitable the marling. But all the white shells, however hard and entire when applied, are dissolved in a few years, if the soil really needs so much lime—that is, (according to my views,) if there be *acid of soil* enough to combine with the lime. But the brown or slate-colored shells seem to be insoluble and almost indestructible, and do very little good as manure. These shells are the several species of scallop (*pecten*) and of fossil oyster, (*ostrea*), and some few others, all fortunately being but in small proportion to the numerous white and softer shells. Some beds of marl, however, or layers, have mostly these hard shells, and therefore are worth very little compared to what their chemical analysis would indicate.

A list of most of the shells found in the miocene marls, and also of the eocene of Virginia, (and of which specimens are in my collection,) will be annexed to this article, for which I am indebted to the scientific knowledge and kind assistance of Mr. M. Tuomey. But as the scientific names will be of but little use to many readers, it may be useful to describe in advance a few of the most common shells, peculiar to the miocene marls, and which can scarcely be mistaken. Such are the various large scallop shells, (*pecten*), oysters, (*ostrea Virginica*, &c.)—hollow tubes, about the thickness of a large pipe-stem, and open at both ends, (*serpula*), and elliptical funnel-shaped shells having a small hole at the bottom, (*fissurella*.) These references will be enough for any person acquainted with the shells by sight, but not acquainted with their scientific names. If however even very slightly informed in the latter respect, the observer will not need any such explanations.

It is not necessary to speak otherwise than very concisely as to the practical applications and effects of miocene shell marl; for this is the kind in general use throughout lower Virginia and Maryland and to such small extent as has been used in North Carolina, and therefore the operation is well known. All the usual and general and highly beneficial effects of marl known, with but few exceptions in the limited districts of eocene marl, (hereafter to be described,) are due to the miocene marls. And of such effects, there have been numerous statements, general and particular. The operation of the eocene marls, and especially those largely mixed with "green-sand," is different, and superior; but their use has been so limited, and so few statements of effects published, that nearly all the particular results and general statements of effects yet laid before the public, in the 'Essay on Calcareous Manures' or elsewhere, have been in relation to the miocene marls.

Eocene Marl.

(c).—*Calcareous marl, containing but little green-sand.*—The existence in Virginia of the marl now known as *eocene*, was first discovered in 1819 by myself, in the south bank of James river, underlying the promontory of Coggins Point; and in the same year it was tried as manure. The texture and general appearance of this marl were obvious-

ly peculiar; and its effects as manure were soon also observed to be in some measure different from those of the other marls, which I had then used, and which were all of the kind now distinguished as miocene. At that time these terms had not been introduced, and for perhaps fifteen years afterwards, I did not so much as hear of the terms "eocene" and "miocene;" but their difference of age, appearance, and agricultural character were not therefore the less evident and obvious to my observation. The manifest difference of effects as manures was then ascribed by me to the general if not universal presence of a small proportion of sulphate of lime, or gypsum, in the eocene marl. The belief in the general presence of gypsum was very early induced by my seeing in a few places small crystals overlying and in contact with the surface of the bed of marl; and also by the apparent results of such poor attempts as I subsequently made to ascertain the presence of this substance, by means of chemical tests. Upon such imperfect tests, and to the still more imperfect knowledge and skill which I could apply to the investigation, (amounting indeed to almost nothing,) very little reliance ought to have been placed. Nevertheless, I thence inferred that there was universally present and diffused through the body of this marl a small proportion of sulphate of lime. (say one or two parts in the hundred,) and subsequent agricultural practice has supplied the confirmation, which has not yet been sought for by the superior chemical knowledge and skill of any other and late investigator. In the earliest publication of my views on calcareous manures in 1821, the *gypseous* character of this particular body of marl was affirmed, and the peculiar character of the results of the first experiments with it stated.* And in the edition of 1832 of the 'Essay on Calcareous Manures,' the general and full description of this marl was given precisely as it now stands in pages 92 and 93 of the latest edition. My still earlier discovery of and observations upon the peculiar character of the underlying bed of *gypseous* or "green-sand" earth, (which will be treated of subsequently,) led me to observe the peculiarities of the eocene marl, which being less distinctly marked, might otherwise have escaped my notice.

As stated above, it was not from any knowledge of geological theories of successive formations, and different ages and periods, of all which I was profoundly ignorant, that my opinion of the peculiar character of this marl was influenced. But judging solely from the more rotten and disintegrated state of the shells, and their entire disappearance generally, even though their calcareous material remains—and from the total difference of kind of the few shells remaining whole, or of which the shape is distinctly marked, from any others of the many shells then known to me in any other marls, I very early formed the opinion that this bed was one of the remains or ruins of a condition of the earth much more ancient than that in which the ordinary marls had been formed. I remember having stated this opinion to one of the earliest of the several geologists who at different times visited my dwelling place and my marl excavations. This was the since notorious Mr. Featherstonhaugh, to whom I pointed out this curious and to me highly interesting deposit, and requested his attention to the more modern and very different (miocene) marl lying immediately upon and in close contact with the much more ancient formation below. This remarkable feature I also showed at a later time to Professor William B. Rogers, who was much struck with the fact, and attached so much impor-

* American Farmer, vol. iii., p. 317, and also the same experiments numbered 18, 19, 20, of the present edition of 'Essay on Calcareous Manures.'

tance to it, that he has referred to it in several of his subsequent publications.

The most ready and certain mode of distinguishing eocene marl, is by reference to some of the shells belonging to this kind, and which are never found in miocene marls. There are many such; but the most common and well marked are the two following: 1st, the *cardita planicosta*, a bivalve white shell, having numerous regularly formed ridges running from the point at the hinge of the valves to the circumference of the outer or opening parts, and widening as the ridges extend—both valves alike, and having outlines approaching to circular—sometimes seen more than three inches across and the connected valves nearly two inches through, but generally of much smaller and various sizes. 2d. The *ostrea sellaformis*, or saddle oyster, a curiously and variously contorted brown and very hard bivalve shell, the larger valve of which approaches the shape and reversed curves of a saddle. This shell is sometimes found more than five inches in length. Both of these shells are abundant, especially the *cardita planicosta*, in this particular bed of eocene marl, and also in the upper part of all the other eocene marls since known elsewhere in Virginia. Without reference to these, or to some other characteristic shells, the eocene marl might not always be distinguishable by its texture or general appearance from the miocene. And even these two shells, the most abundant and characteristic of the eocene formation generally, are neither to be found in the lower layers.

For some years after the first discovery and application of this calcareous eocene marl on Coggins Point farm, it was not known to exist elsewhere. For even where then visible, and at later times used, its different character was neither known nor suspected by its proprietors. As chance furnished to me opportunities of seeing the beds, or as small specimens of the marl were sent to me for examination, I gradually came to know the greater extent of this bed. It is now known at various points in an area of about twelve miles in length, from east to west, and eight or ten miles wide, which area takes in parts of the counties of Prince George, (which has much the larger portion,) Charles City, and the lower point of Chesterfield. And in this area also is the broad bed of James river, and the lower parts of its considerable tributaries, Appomattox river, and Bailey's, Powell's, and Herring creeks. The marl is exposed to view on the southern side of James river, at the following several points: Coggins Point, Maycox, (a mile below, and the most eastern exposure known,) Tarbay, Wm. H. Harrison's farm, and Beaver Castle, all above on the river—Elbank and Hawksnest, (the most southern exposure,) on Powell's creek—the Old Court-house tract and Spring Garden farm, both on Bailey's creek, and the latter from one to two miles above the head of its tide, and three miles south of the Appomattox where opposite. The last is the most western exposure. On the northern side of the Appomattox, it is seen in the river bank at Bermuda Hundred, and north of James river, and of Herring creek, at Neston and Evelyn-ton.

Through nearly all this large area, this bed of marl preserves remarkable uniformity of appearance, texture, chemical character and composition, and even of the thickness of the stratum, and of the succession and variations of character of the several smaller layers of the general body. The bed lies nearly horizontal, but dips slightly and irregularly eastward and northward. At Coggins Point, its lower part is 10 to 12 feet above high tide, while at Maycox, a mile to the east, and at Evelyn-ton three miles north, it is lower than high tide mark. Yet not so much difference of elevation as this is seen in all the greater extension westward to Bermuda Hundred. The stratum varies from 1 foot to 10 feet thick, being thinnest

at its south-western extremity, Spring Garden, and thickest at the north-eastern, Neston and Evelyn-ton. At Coggins Point, where traced along the face of the river cliff continuously for more than half a mile, it is usually six feet thick, never more than eight, and never less than four feet, except where terminating. The general and almost uniform color is a pale dingy yellow. The few shells remaining are not perceptible without careful observation, and the whole mass, when dug down for use, is scarcely distinguishable from many common and barren sub-soils, or clay river cliffs, of like color. Two thin but continuous and separate layers of almost stony hardness extend through the whole bed. These contain from 85 to 90 per cent. of carbonate of lime, and may be burnt to excellent quick-lime for cement. The marl intervening with these hard layers is similar to them in color and general appearance; but is quite soft and mellow in handling, and in that respect differs from all other known marls. The very uniform calcareous proportion of this part is about 53 per cent.; and taking an equal section of the whole thickness of the bed, and with the greatest care to obtain a fair average sample, the strength in carbonate of lime was found to be 62 per cent. This is far less of calcareous matter than is contained by many miocene marls which show less effect than this as manure. But besides its calcareous matter, this eocene marl has some little gypsum, some kind of saline matter which cattle are fond of licking, (believed to be sulphate of alumina,) and some amount of the granules of "green-sand"—and more of this than most of the miocene marls. The other earth of this marl is mostly of yellowish clay, and composed more of argillaceous than silicious matter. I confess that all these additional ingredients, together, do not seem to me sufficient to account for the superiority which this marl exhibits as manure.

Though this peculiar kind of marl was so early known, and its value appreciated, and, though it underlies the whole of Coggins Point, yet it is covered there so deeply by the overlying earth, and is therefore so difficult to work extensively, and, moreover, is so distant from the main body of the farm, that this has not been applied to more than 65 acres, out of some 700 marled on that farm. Other proprietors have elsewhere made much more extensive applications of this marl. The peculiar effects of this kind of marl were tested with the most accuracy by Messrs. Collier H. Minge, then of Walnut Hill, and Hill Carter, of Shirley: both of whom used this marl from Coggins Point, water-borne to distances of 12 and 15 miles. Though the marl was given to them, (in the bed,) it was yet very costly in the labor of digging and transportation; and therefore they used it with strict economy, and carefully estimated the results. But highly as they both thought of, and have reported the effects,* in comparison with either lime or miocene marls, the expense and trouble were so great, that it is now considered by the most judicious farmers on the tide water rivers, that they can better afford to buy stone-lime, at its present low price, (8 to 10 cents the bushel,) than to transport marl of any kind by water.

Since the foregoing pages were written, I have learned of two farther exposures of this body of eocene marl. One is four miles north of Evelyn-ton, (in Charles City county,) where the marl was reached and penetrated by the digging of a well in 1814. At about 30 feet deep, after passing through the marl, and a layer of rock, water was reached, which rose to the top of the well, and continues to flow over, forming the only Artesian well known in this region. The other locality is in Henrico county, on Turkey Island creek, its eastern boundary, and about 8 miles

* See Farmers' Register, vol. v. pp. 189, 217, 511.

north of City Point. This marl I recognized to be the same, by a specimen recently brought me for examination. It is below the surface of swampy ground, and is colored dark gray. It is much fuller of green-sand, and indeed in that respect makes some approach to the green-sand marls of the Pamunkey, of which the nearest exposure is only 16 miles from this place. It is probable that the marl extends continuously from the one place to the other, and may be found throughout the interval by deep digging.

(c) THE GYPSEOUS EARTH OR GREEN EARTH OF JAMES RIVER.

Before proceeding to consider the next and only remaining known variety of our marls, the eocene green-sand marl, it is necessary to treat in advance and separately of the peculiar earthy compound, called "green-sand" by geological writers, of which the large admixture, and sometimes even larger proportion, gives additional value and peculiar character and action to the greater number and quantity of the eocene marls yet known. But important and valuable as may be the green-sand in itself, and necessary to be considered in connexion with the subject of eocene marl, with which it is so inseparably connected, I wish especially to avoid confounding the two earths under one name or one character; and to be understood as protesting against the prevalent error, in giving currency to which scientific writers have concurred with the unlearned cultivators, of applying to the non-calcareous green-sand earth the name of "marl," and thus adding another, and the most important one, to the previous misapplications of this wonderfully misused and misunderstood term. This misapplication is universal in New Jersey, where the green-sand earth is most abundant, and is generally very rich in its distinguishing ingredient, (usually containing 75 to 90 per cent. of pure green-sand—) and where this earth has been long, and is now extensively used as a manure, and has been found to be of great value as a fertilizer. I shall hereafter refer to both the points of resemblance and of difference (both of which are important and interesting) between this green earth of New Jersey and that of James river; but, for the present, my remarks will be confined to the latter, and its use as manure, as known principally, and indeed almost entirely, from my own observations and practical experience, there having as yet been but few trials of it made by other persons.

It was mentioned in the foregoing section, that the first notice or observation of the eocene marl on James river was induced by the previous discovery and examination of the green or gypseous earth—the latter being the universal underlying bed of the former, and connected with it in more respects than merely its subjacent position. It was my chance, or the result of habits of observation of marls and other earths, and not of any scientific knowledge or previous preparation for such investigations, which led me, in 1817, to be the first to observe this bed of green earth in the river banks of Evergreen and Coggins Point, and to trace it where visible along the intermediate ground, a distance of about eight miles. Since then, it is known to be much more extended; for it not only underlies all the eocene marl of the same neighborhood, wherever that is found, and part of the yellow sandy miocene, but also extends beyond, and is found at various places where no eocene or even miocene marl is found. The most western limit, seen after a long interval or concealed existence of this formation, is at Petersburg, where it shows in the ravines south of Poplar Lawn.

What first directed my attention to this earth was the existence in the

river bank at Evergreen, (the place of my birth, and of residence in early life,) of curiously shaped and beautiful crystals, which subsequently I learned were selenite or gypsum. The like crystals, though much smaller in size, I soon after found in different places at Coggins Point, my own farm and then residence. And, in making examinations for this purpose, I observed that wherever any gypsum could be found, it was always in a peculiar kind of earth, which, though varying much in appearance in different places and at different elevations at the same place, yet possessed characteristic marks by which it could be easily distinguished from all others. This was the earth in question. For want of any known or more appropriate name, I at first applied the term "gypseous earth" to this deposit; and though I subsequently abandoned this name in (undeserved) deference to scientific authority, and have used instead, in my later publications, the name "green-sand earth," I now believe that my original term (in reference to the more general and universal manuring qualities) was the better of the two, for reasons which will appear in the course of these remarks. And besides that "green-sand earth" is inconvenient for its length, it is not truly descriptive; for the entire granules from which the peculiar character of the earth is derived, are not green, but black superficially, or so appear; and are not what is usually understood as *sand*, but in texture are like fine and unctuous clay. Still worse is it to term the whole mass, "green-sand," as is usually done, when the pure "green-sand," even if that were properly named, may not form one fourth or even one tenth of the whole mass of earth. I therefore would prefer for the deposit, and shall use indifferently, either my first designation of gypseous earth, or the name of *green earth*, which latter is convenient, is sufficiently descriptive, and moreover affirms nothing except as to the color, which is generally manifest in the whole mass, and, if not, is certainly so in the separated and mashed granules, which distinguish the earth.

As the lower part of the river bank is mostly exposed and kept bare by the frequent washing by the waves driven by strong winds and high tides, the bed of gypseous earth can be easily traced through nearly its whole course along the river side. As thus exposed to view, it has generally a green color, most frequently intermixed and mottled with smaller streaks and spots of bright yellow. The earth, as seen firm in the bank, and with a smooth washed surface, might be supposed to be somewhat of a clay; but, on handling it, and breaking down a lump, its texture is more like sand; as indeed a large proportion of the mass is silicious sand. A very general distinguishing mark of this earth is its containing numerous hollow impressions of eocene shells, of which the forms remain perfect, though neither the shells themselves nor any portion of their calcareous substance remain, as the earth in this part, and where most generally seen, contains not a particle of carbonate of lime. Among the yellow spots there are also other small spots and streaks of reddish brown colored clay, very pure, soft and unctuous to the touch. The bright yellow clay is doubtless largely impregnated with iron, or is a true yellow ochre. Though soft within the bed, this yellow ochre hardens when exposed to the air on the outside, and even when under water. Many of the yellow spots made by this ochre, as seen on the surface of a smooth section of the bed, have a rough resemblance to the shape of sections of bivalve shells; and these contrasted with the general green ground, and, with the exception of the colors being different, give to such a section of the bank somewhat the appearance of the beautiful black marbles used sometimes for mantel-pieces, in which the white traces of what were formerly shells show throughout. In some places near to and below the beach, the earth is seen much darker colored, indeed is

almost black when moist in the bank, though more of dark green when dry. This deeper color is owing to the green granules being present in larger quantity; and generally, if not always, the lower part of the bed of earth is richer in that ingredient than the upper. The empty impressions which were formerly filled by shells are still found in penetrating below; but as the depth increases, first are seen some fragments, and then whole shells, though greatly decayed, and the parts having scarcely any coherence. Still, generally, even below, where these shells are most abundant, their quantity would not furnish as much as two per cent., and generally not one per cent., to the whole thickness of the bed; and therefore the carbonate of lime, though of course useful in proportion to its quantity, can give no appreciable addition of value to the mass as manure.

Here and there, but rarely, in the upper and dry part of this bed, crystals of gypsum are found, generally so small as to be barely distinguishable by the eye. In the lower and wet part, gypsum is never visible; but it is nevertheless believed to be always present in some proportion.

But the important and most characteristic mark of the green earth is present in the black granules called "green-sand," which give color to the mass. To ascertain the presence of these granules, let a small sample of the earth or marl supposed to contain them be dried, and then crumbled between the fingers, or, if too hard for that, by being rubbed in a mortar, not too finely and closely. Then take a pinch of the powder between the thumb and finger, and sprinkle it very thinly over a piece of white paper. If any of the separated grains appear black, (or green,) mash one of them with the moistened point of a pen-knife; and if it be "green-sand," the granule will mash like fine soap clay, and make a vivid green smear.

For greater accuracy, let the earth (or marl) be well washed by agitation in water, and pour off the pure clay and other lighter matters which will remain longer suspended in the fluid. The grains of green-sand will then be left with nothing else but the quartz or silicious sand, and moreover the former will be made more perceptible, in consequence of being cleared by the washing of any previous covering of fine clay.

My first published account of this earth was made in or about the year 1828, in the old series of the 'American Farmer.' A much more extended article "On the Gypseous Earth of James River," I afterwards published, July, 1833, in the first volume of the Farmers' Register, beginning at page 207. Though up to that time I had never so much as heard of the term "green-sand," and though I adopted and used the new and unauthorized designation of "gypseous earth," the earth in question was described so minutely and accurately that it was impossible for any intelligent and attentive reader of the article, and subsequent observer of the kind of earth in question, to mistake the subject of description. I trust that I may be pardoned for thus specifying my claim to the first discovery of this earth in Virginia, inasmuch as that merit (if it be one) would be ascribed by every otherwise uninformed reader of the first report of the geological survey of Virginia, and some other of the publications from the same source, to the author of these pieces. Upon this occasion, it would be improper to say more on this question than thus concisely and explicitly to assert my just rights.

Before proceeding to offer the more precise and more valuable information concerning this earth obtained by very recent investigations, it will be proper to state something of the progress and changes of opinion on this subject, which operated at different times either to encourage or to obstruct the use of this earth as manure.

From 1818 to 1835 inclusive, I made numerous trials, and in some cases

extensive applications of the Coggins Point gypseous earth as manure. The results of my general practice, and also of many particular experiments noted at the times when made, were reported in a communication to the Farmers' Register, commencing at page 118, vol. ix. The effects stated were very different and apparently contradictory—sometimes beneficial and profitable in a remarkable degree, but more generally of little value, or of no benefit whatever. The inferences which I drew from all my experience, (and there existed scarcely any other facts or experiments,) were that this earth as manure acted in the same manner as gypsum, though more powerfully—and in no other manner than as gypsum would under like circumstances; that like gypsum, on my land certainly, and as I inferred in our tide-water region generally, this earth had no effect whatever (unless used in excessive quantity) on any acid soils—and rarely on any other crop than clover, even when properly applied on neutral or calcareous soils; and that when naturally acid soils were made calcareous by being marled, this green earth then became generally operative thereon as a manure for clover, (and for other plants of the clover or pea tribe,) in the same manner as is usual in regard to gypsum.* And though the effects, when any were produced, were greater than those of any usual or known dressings of gypsum, and sometimes in a very remarkable degree, still the failures and disappointments were so many that I did not deem the practice worth being continued. In 1841, my son, the present occupant of the Coggins Point farm, at my request, recommenced the applications of gypseous earth, for experiment; and on the clover of this year, 1842, he has extended the dressings over more than 60 acres.† The results were, as in former years, very unequal, and for the greater space of ground covered, unprofitable, and barely if at all perceptible. But on 25 to 30 acres the benefit was remarkably great, and in some cases (of summer dressings) improvement was obvious within ten days after the application. But what was most interesting in the results was, that a clue seemed to be thereby furnished to explain the frequent previous failures of this manure, even when applied to clover growing on neutral or calcareous soil, which are the only circumstances in which it has ever been found profitable in practice. My former applications had been generally made from the upper and greener stratum of the gypseous earth, (designated in a succeeding page as *C*;) or if from the lower and blacker part, (*D*;) the digging did not penetrate more than a foot, or, at most and rarely, two feet below the before exposed outer surface. But in the recent larger operation, the digging (made on the river beach) was so much more extensive as to furnish earth from depths of three or four feet, as well as of portions nearer to and at the surface. I ascribed the remarkable differences of effect to the kind and place of the earth; inferring that the exposed parts, and all perhaps near the surface, had, by exposure to air or water, lost a large proportion of the soluble or decomposable fertilizing ingredients. As the applications had not been made with any view to this question, the experiments are not to be deemed as conclusive, and the correctness of this inference is yet to be fairly tested by future experiments. But the benefits from some of the dressings, and all of those supposed to be from the deeper digging, were so great, and so speedily produced, that renewed and strong interest was

* See these views more fully set forth in the article above referred to, and also in another on the green-sand marls of Pamunkey, at pp. 679 and 690, vol. viii. Farmers' Register.

† See the facts and results stated in two communications to Farmers' Register pp. 26, 185 and 252, vol. x.

excited in regard to this manure. The quantity applied was generally 40 bushels of the earth to the acre. And this quantity seemed, (from an accurate comparative experiment) to produce as much benefit as 200 bushels. The growth of clover was increased in degrees varying from 100 to 300 per cent. And where the application was most successful, the increase and profit were sufficient to compensate the expense, even though no further benefit shall be found than in this one crop—or that a new application shall be required and be made for every succeeding crop of clover, or once in each round of the rotation of crops.

An observation made by accident last spring led to further chemical as well as other examinations of this earth, and to important results. Upon heating a lump of it to red heat, I found that strong fumes were thereby extricated, which were almost suffocating if inhaled incautiously. The odor was manifestly sulphureous in part, and principally; but it seemed not altogether so, but to be mixed with some other, much like that of muriatic acid gas. Similar trials were made on many specimens, and all the darker and (as supposed) richer layers of the green earth at Coggins Point showed the like result. From specimens of the upper and lighter green stratum (*C*) when heated red, there was nothing of this suffocating odor produced. And it may be useful to state here, in anticipation of subjects to be hereafter more fully considered, that I subsequently found that the New Jersey green-sand earths yielded not a particle of this gaseous product.

This odor, so far as it was sulphureous, was obviously the product of the decomposition (by red heat) of sulphuret of iron—which was thus proved to be universally diffused, though invisible, through all the darker and better kinds of this earth. Sulphur would have shown like results, with a much less degree of heat; but it could not be that, because the heat sufficient to decompose sulphur (and to evolve its fumes) had no effect on the earth. I also observed that lumps of the earth after having been applied as manure, and exposed on the surface of the ground for some months, often had a smell of sulphur; and, in some cases, the same effect was exhibited in specimens taken from the diggings, and kept dry. The sulphuret of iron, if universally present, would, by its decomposition in contact with carbonate of lime, (as when on calcareous land,) form sulphate of lime, (gypsum.) This showed a source for the universal supply of that manure to some extent. Further, Mr. M. Tuomey had found sulphate of lime ready formed in specimens of wet earth which I supposed the least likely to retain that ingredient—and thus was indicated another general supply of gypsum.

The increased interest excited by these new observations, and also the new views as to the cause of the failures of most of the former applications of this manure, induced the sinking of a pit in the gypseous earth, on the river beach at Coggins Point, to the depth of 18 feet below ordinary high tide. This digging for the lower 13 feet was in a very compact and fine clay (*I*) or clay marl, as it would have been designated in England, from its texture and sensible qualities, but which contained no visible or apparent fertilizing ingredient, except a very small sprinkling of shells, and elsewhere some little sulphuret of iron in small lumps and in minute crystals, visible in a few detached spots only. The appearances promised so little of value or remuneration, (and less so as the digging was sunk lower,) that the work was suspended. But the blacker earth above (*D*) and also the clay (*E*) were carried out for experiment on clover, (May 26th,) of which the first crop had just been grazed off closely, and the cattle removed. As the season was so far advanced, and benefit so little counted on, the covering was made heavier than in the winter and early spring before (and of which

the full benefit had been already seen on the first or spring crop of clover); 100 bushels of the upper and better earth, and 150 of the clay, being applied to the acre. A good rain fell the next night; and in less than ten days there were visible and manifest beneficial effects from both kinds of earth, but better from the upper—which effects increased to fully the doubling of the growth by the first of August. The hard lumps of the compact clay soon split and crumbled when exposed to the air, and even without rain. The remarkable benefits of these applications induced the resuming of the digging, and another and much deeper pit was dug as early as the other labors of the farm permitted, and a statement will presently be made of the section thereby exposed. But previous to this, it is proper to describe another like operation, and its results, at a more interesting locality.

The same general appearance of the gypseous earth, and mostly of the poorer kind of greenish color mottled with pale yellow clay, is exhibited all along the river bank of Coggins Point and the lands above, to the Evergreen farm—interrupted only by the parts of marshy or more ancient alluvial lands; or where the stratum has been broken and concealed by the ancient land-slips which have greatly altered the original levels and form of the surface of that whole stretch of land bordering on the river and overlying the green earth formation. This operation by the land slipping and sinking continues, and some new effects are seen every year. At many places along this stretch gypsum is perceptible in the green earth, either in crystals or in powder, and sometimes, and rarely, in considerable proportion, say from 5 to 15 per cent. of the whole mass. At the upper part of the river line of the Evergreen farm, (at the mouth of Bayley's creek, and two miles below City Point,) the river bank has peculiar and remarkable features, which deserve particular notice. It was here in 1817 that I first discovered this green earth formation, and thence traced it to my own farm and then residence, Coggins Point, and elsewhere in that neighborhood.

The lower visible part of the body of green-sand earth at Evergreen is laid bare by the wasting inroads of the river, (by which it is rapidly washing away,) for 200 yards in length. The southern or upper extremity, for some 20 yards, approaches nearly in appearance to the general character of the upper stratum before described. But all the remainder is different, and much richer in the dark or green granules than generally elsewhere.

Since this article was commenced, Capt. H. H. Cocke, the present proprietor of Evergreen, at my suggestion and request, had a shaft dug for examination, which, with an extension of my own after he had ceased his operations, added to the natural and higher exposure of the section, 27 feet below the beach, and 25 below common high tide. The several strata of the whole section, and their variations, will be described in their descending order.

At top—

- 1st. Surface soil (sloping back irregularly to the table land, which is much higher,) on (2d) gravelly and sandy sub-soil, pervious to water, of various depths—lying on strata nearly all horizontal. Next,
- 10 feet of yellow sandy miocene marl.
- 8 feet of yellowish clay, (supposed eocene,) intermixed throughout with very small crystals and powder of sulphate of lime—the clay not compact or solid, but open and loose throughout. (Query: Is not this the equivalent of the eocene marl at Coggins Point, with its former shells and carbonate of lime completely changed to sulphate of lime, and the remainder dissolved and lost?)
- 5 feet of gypseous earth—the general color, green mottled and streaked with yellow ochre, and full throughout of very minute crystals of sulphate

of lime, supposed to be about 10 to 15 per cent. of the whole mass. No shells or casts seen in the part exposed by digging for examination.

7 feet of brownish mottled clay, feeling smooth and soapy, containing numerous small crystals of sulphate of lime.

9 feet very pure white clay or fuller's-earth, in horizontal layers, separated by veins of the yellow clay (or iron ochre) before mentioned, other veins of the same sometimes also inclined and crossing the horizontal veins—the outsides of the lumps of clay colored by oxide of iron. The clay all broken into irregular lumps, as if the fissures had been formed by the contraction in drying of clay soft and distended with wetness. No shells, nor appearance of them, but many pure and transparent and beautiful crystals of sulphate of lime here and there, some weighing several ounces. This stratum changing gradually into the next of

4 feet of dark bluish clay, the coloring matter being green-sand, mottled with irregular streaks of bright yellow, becoming brown below where oozing water begins to show and is reddish with sulphate of iron, or other ferruginous matter in solution. This stratum full of large and solid crystals of sulphate of lime, amounting apparently to from 25 to 35 per cent. of the whole mass—the crystals colored dark gray, because of some impurities in small grains (green-sand) being enclosed and diffused through them. No shells. This changing into the next, of

11 feet of same dark or nearly black clay, nearly uniform color, and still compact texture, and feeling smooth and soapy—with very few crystals, and much less sulphate of lime than the preceding, but many small and scattered eocene white shells, quite rotten, and, being moist, as soft as dough. The shells, mostly several kinds of very large turritellas. Fewer shells as descending. At top of the stratum some large and very perfect specimens of the *ostrea compressirostra* (!) To level of the river at common high tide.

Below high tide.

14 feet very similar to the last, the shells very few for the greater part, but increasing near the next. No crystals or other sulphate of lime visible. The green-sand granules coarser—sometimes in small lumps quite pure, or unmixed with any thing else. These granules breaking easily, though as if hard or brittle, and not like a soft soapy clay as usual—though as green as before. Many small cylindrical tubes seen, which seem to be formed on, or coated with pure green-sand in mass and green in color, and the hollows filled with black granules.

11 feet of shells lying generally close together, and serving to make the whole stratum a calcareous marl, of perhaps 30 per cent. or more of carbonate of lime—the earth filling the shells and between them being the same black earth, as rich as before in green-sand. At top, some very large and perfect shells of *ostrea compressirostra*, and another much thicker *ostrea*, not known.* The shells mostly very large *turritellæ* of different species—near bottom fewer of these and mostly *crassatella*. The shells nearly as numerous as before, at this depth, at which the digging was abandoned, at 25 feet below tide.

The whole section, from the top of the highest undoubted eocene stratum to where the digging ceased, (without any indication of being near the end,) is 61 feet—and if the clay and gypsum stratum below the

* One of these last (both valves) weighed 5 lbs. Mr. M. Tuomey, to whose much better information on this subject I ought to defer, supposes this very large and heavy shell to be an *O. compressirostra* of unusual age and growth. If so, however, it is certainly very different in appearance from that shell, as usually seen higher up in this bed, even when wider than the very thick and heavy *ostrea*.

miocene be added, which, though not certain, I believe to be eocene, there would be 69 feet. And if this and the two other lower clay strata be deducted, there will still remain 45 feet of strata exposed, all rich in green-sand, and of it 9 feet very rich also in sulphate of lime or gypsum, and 11 feet moderately rich in carbonate of lime. Such a deposit is well worth the examination of geologists and chemists, and the trial of farmers.

It was remarkable that at this place only of all the usual strata of all the then known deposits of green-sand or eocene marl in Virginia, were found exposed, the shells of the *ostrea compressirostra*—and below tide the other before unknown and very thick and heavy *ostrea*; and that at this place there has not been found a single shell of either the *ostrea sellesiformis* or *cardita planicosta*, the latter of which is so abundant through all other known eocene deposits, and the former in the calcareous eocene elsewhere. These facts seemed to indicate (as well as the general dip to the eastward,) that the strata at Evergreen are much more elevated than the same at Coggins Point—and that by digging deeper, the lower and all the strata of the former might be found at other parts of the known area (before described) of the eocene formation.

This inference added to other considerations caused to be sunk the second shaft above mentioned in the beach of Coggins Point, 130 yards distant from the first one, which by this time had been filled completely by the sand driven by storms and high tides. The digging was made at a low part of the bank, and which therefore did not show either the eocene marl or the miocene, the former of which is seen in the higher bank at a short distance, and both together at the distance of a mile. The different strata of the actual section at the new digging, taken descending from the top of the bank, were as follows:

- 1 foot, surface soil—gray loam, ancient alluvial deposit.
 - 7 feet of pale yellow clay, containing much coarse silicious sand.
 - 4 feet rounded or water-worn pebbles, of all sizes, from 4 inches through to coarse gravel, held together by enough clay and ferruginous earth to fill the interstices between the pebbles. None calcareous.
 - 2 feet of very thin layers of hard and gritty gray clay, alternating with others of coarse ferruginous sand.
 - 2 feet of poor greenish earth, more than half the surface of the section brown in spots, and indurated with oxide of iron.
- (Here should be, as elsewhere in the neighborhood, though absent at this particular locality, either one or both, the miocene marl, (*A*), and next below the eocene calcareous marl (*B*) described in the preceding pages.)
- (*C*) 9 feet of the ordinary upper layer of gypseous earth—green color, mottled with spots of bright yellow clay, (or ochre,) and some other spots of unctuous reddish brown clay. Very slight efflorescence of gypsum on the surface.
 - (*D*) 3 feet of darker and nearly uniform color, almost black, from the greater proportion of green-sand. This and the preceding, containing many impressions of shells, but no shells or fragments, and no carbonate of lime. More efflorescence of gypsum, and also on next—
 - (*D*) 3 feet of same, except that some shells are seen—and increase in the next to level of river at common high tide.
 - (*D*) 6 feet of same (next below tide—) the shells mostly *cardita planicosta*—fewer of *cytherea* and *corbula*. No *ostrea* or *turritella*. Small and slender shark's teeth (so called) in perfect preservation, the points and edges being as sharp as in teeth of the living animal.
 - (*E*) 15 feet bluish gray or lead-colored clay, (from 6 to 22 feet below tide,)

having nearly the texture of clay marl. Very compact and firm in texture—unctuous to the touch, but not adhesive or tough—does not bend to pressure, but breaks—cuts smooth, except when the edge of the knife meets parts of shells, or grains of silicious sand, which, as well as granules of green-sand, are irregularly intermixed throughout. The shells very rotten, and flattened by pressure. Sometimes in masses, or thin bands or regular layers, becoming less and less in quantity as descending, and but few seen at and below 10 feet of this stratum. Numerous particles of mica throughout. Changing gradually to next. At 12 to 13 feet of its depth, many hard lumps of sulphuret of iron. The upper three or four feet of this penetrated by numerous hollow cylinders, of an inch or more in diameter, and in every direction—obviously having been bored by shell-fish. These hollows are filled by the green earth of the stratum above, which thus makes nearly half the mass. (This clay and the layer above (*D*) were the kinds used for manure from the first opened pit.)

3 feet (22 to 25 below tide) of brownish and more friable clay, intermixing at first with the above. Green-sand much more abundant than in the preceding, and partly in very large granules.

3½ feet (25 to 28 below tide) of very smooth and firm clay, of delicate lilac color at first, but becoming paler as descending, until nearly white. Splits easily into flakes like thick slate; and still thinner laminæ show that the earth was a deposit in tranquil waters. Thin flakes (not thicker than writing paper,) and sometimes a mere powder of pure sulphuret of iron visible between many of the layers of clay, and causing them to separate easily. The upper foot of this every where penetrated by small hollow tubes, (from an eighth to the third of an inch in diameter,) which are filled by the brown and green variegated earth of the stratum above—causing a lump when cut smooth to appear like a conglomerate of differently colored marbles. Except in these borings, no green-sand deposit, and no shelly matter. The sulphuret of iron, which is through this stratum visible in powder, or thin layers, and above in small masses or lumps, is diffused through all the strata containing green sand, except the highest (*C*.) Through this and the upper gray clay (*E*) some small black pebbles seen, which appear as if formed by melting. The same found in the eocene marl. A sudden change to the next—

2½ feet (28½ to 31 below high tide) of remarkably smooth and unctuous, but firm clay of reddish brown color, (or dull brick red,) and homogeneous texture as well as color. Cuts as smooth as the best hard soap. Deposited in thin laminæ, and breaks or splits easily in straight lines both in the direction of the laminæ and lengthwise at right-angles to their direction—the grain and fracture appearing like that of rotten wood. Across these two directions, the fracture very uneven. Near the bottom of the richest green stratum (*D*) there is a barely perceptible oozing of water. All below dry, and the two last strata remarkably dry. They could not be more so if within three feet of the surface of a high knoll.

1 foot (31 to 32 below tide) of same as the last in texture, but of pale blue color.

1 foot (32 to 33 below tide) mixture of the last, in small lumps imbedded in the next, as if broken up by a violent current, and deposited in rapid water..

17 feet (33 to 49 below tide, the lowest digging,) black earth—richest in green sand (supposed to be 60 per cent) mixed with a few fragments (less than 2 per cent. on an average) of shells—mostly small, and all very rotten. Kinds, mostly of *turritella* (some of which are large,) *mytilus*, *corbula* and *crassatella*. Many small and a few large shells of *ostrea compressirostra* near top of this stratum and again near the lowest part, where the work was stopped by the water rising from below.

The whole, so far as dug, added to the before exposed bank, amounted to 66 feet of the eocene deposit, of which 49 feet was below the level of high tide. The last stratum, of which was penetrated 17 feet before the rise of spring water compelled the work to be discontinued, was manifestly the same with that at Evergreen which was even with high tide (and extending above and below,) and which was there 25 feet thick. It was a subject of much regret, after so much labor, that the still lower stratum, full of shells, could not be reached, and which probably might have been done in 8 feet more of digging. However, enough was done to show that the quantity is inexhaustible of the layers richest in green-sand, (whatever may be that degree of richness, independent of the other layers.

Besides the main object of this laborious examination by digging as low as possible, to learn more of the quality and quantity of the earth for manure, and as a matter of curiosity, there was another inducement. The whole bottom of the river across to Berkley (below the thin covering of loose and soft mud,) according to its variation of depth, must be formed of one or another of the same layers shown in this digging of 49 feet below the water level; and, of course, Harrison's Bar, which lies between the Coggins and Berkley shores, must be so formed. No earth more strongly resists the washing action of water than the gypseous earth, even when the least mixed with clay. This peculiar quality must be the cause of the existence of this bar, which presents so serious an obstacle to the navigation of the river; and it may be thence inferred what would be the degree of difficulty of its removal, and also that the removal if effected would be permanent.

Various and contradictory as had been many of the results of my experiments of the green earth as manure, there had been perfect agreement in some respects. Thus, as before stated generally, the earth has never been beneficial as manure on acid soil—but rarely on corn, and never (directly) on any other grain crops; and (on proper soils) generally and greatly beneficial on clover, and perhaps all plants of the clover and pea tribe—and the effects, when produced, have never been permanent, nor even very durable. And the effects shown in these points of agreement were nearly all the reverse of those ascribed to the New Jersey green-sand. In regard to these effects, in the absence of all certain and particular information to be obtained otherwise, I found it necessary to seek information in person. The results of my inquiries and personal examinations, in general, showed that the green-sand (called marl) of New Jersey, though agreeing in some respects with ours in action as manure, is operative generally on the greater number of soils and on most crops, and is also very durable in effect. On the other hand, much larger quantities are applied there, (usually 200 bushels, and sometimes 400 or more to the acre) than I have done with ours; and something of the more general benefit, and longer duration may perhaps be owing to that circumstance.* Whether the green-sand is indeed the principal, or a very important manuring agent, of the James river earth, or whether the other ingredients may not be still more active than its green-sand, is yet undecided.

It is indeed strange that such doubts should exist at this late day as to the manuring action and effect of this earth—and still more so that the chemical composition and ingredients of the earth should not have been long ago ascertained. Yet previous to the recent imperfect application of tests above referred to, there had been no known full or correct chemical analysis made of the earth in question; nor even any partial examination for and report of the ingredients, that was entitled to any respect for

* See report at length on the New Jersey green-sand, and its operation, at page 415 vol. x. Farmers' Register.

accuracy and fidelity. For these reasons, I engaged the valuable services of Professor C. U. Shepard, for the analyses of specimens which I selected from the different strata of the earth at Coggins Point, exposed in recent diggings, including several which had been tried as manure and had operated with remarkable power and benefit. I report of the analyses, which has been received since the preceding and subsequent portions of this article were written, will now be presented. It enables me to furnish more of what is valuable, because more certain than every thing else I could offer, or than has before been offered to the public on this subject—prominent as it has been made in the reports of the geological survey of Virginia.

New Haven, October 26, 1842.

Dear sir—The specimens of green-sand and accompanying earths have, agreeably to your request, received my particular attention; and I now proceed to apprise you of the results at which I have arrived.

Commencing with the mechanical analysis of the green-sand, I was not a little surprised to find that the green particles, when cleared by washing of a slight investment of clay, assumed the aspect of chlorite and green earth, and more rarely of grains of serpentine and fine scales of mica. The other ingredients of the earth were chiefly grains of quartz, (some of which were penetrated by chlorite,) and more rarely specks of garnet, iron pyrites, and what appeared to be yellow phosphate of lime. Fragments of shells, in a very decayed state, occur disseminated through the earth; and I detected also small teeth and bones of fishes. The proportions of the leading ingredients are very difficult to establish with precision; and after all my examinations I can only give them approximatively and within wide limits. Thus, the quartz grains may be said to constitute from 60 to 80 per cent., the chloritic and micaceous grains from 10 to 15 per cent., and the fine clay from 3 to 5 per cent.

Nothing is plainer than that the green particles possess the character here attributed to them; since they put on all the properties so common to chlorite, being sometimes in regular hexagonal plates, though usually in little granules made up of impalpable grains, which under the pestle easily separate, with an oily feel, into bright green specks. Subjected to acids and heat, it agrees with true chlorite.

The existence of such a mineral in the present formation offers nothing remarkable in a geological point of view, since it may have originated in the decomposition of chlorite slate rocks, or of veins in primitive rocks, (in which chlorite often abounds,) and in both cases iron pyrites is its common attendant. Besides, it may have been derived from the metamorphosis of pyroxene, or from amygdaloidal traps, a source of green earth very often recognized in Europe and America. Indeed, chlorite (which is but another name for green talc) is often interchanged for mica as an ingredient of primitive rocks, and is every where little prone to decomposition, being, on the whole, one of the most persistent of the simple minerals.

Neither can it be objected that its chemical constitution is incompatible with the results obtained for green earth; for here we must bear in mind, also, that it is impossible accurately to separate the green particles from the mica, serpentine and other ingredients with which they are associated.

M. Berthier found the following composition in the green grains from the green-sand of Havre (France)—

Silica	-	-	-	-	-	50.00
Protoxide of iron	-	-	-	-	-	21.00
Alumina	-	-	-	-	-	7.00
Potassa	-	-	-	-	-	10.00
Alumina	-	-	-	-	-	11.00
						99.00*

Mr. Seybert found in that of New Jersey—

Silica	-	-	-	-	-	49.83
Alumina	-	-	-	-	-	6.00
Magnesia	-	-	-	-	-	1.83
Potassa	-	-	-	-	-	10.12
Water	-	-	-	-	-	9.80
Protoxide of iron	-	-	-	-	-	21.53
Loss	-	-	-	-	-	89
						100.00†

* Geological Manual, by H. T. de la Beche, Phila., 1832, p. 255.

† American Journal of Science, vol. xvii., p. 277.

Prof. Wm. B. Rogers found in the green-sand of Virginia—

Silica	-	-	-	-	-	51.70
Protoxide of iron	-	-	-	-	-	25.20
Potassa	-	-	-	-	-	10.33
Water	-	-	-	-	-	10.
Magnesia, a trace.						

97.23*

The foregoing may be taken as a fair exhibition of the composition of the green particles in green-sand; and the following analyses may serve to show the constitution of such chlorites and mica as may be presumed to be most analogous to the green substances in the earth under consideration.

M. Vauquelin found in the green-earth of Verona—

Silica	-	-	-	-	-	52.00
Magnesia	-	-	-	-	-	6.00
Alumina	-	-	-	-	-	7.00
Protoxide of iron	-	-	-	-	-	23.00
Potassa	-	-	-	-	-	7.50
Water	-	-	-	-	-	4.00

99.50†

Dr. Thomson found in the chlorite-earth, from the highlands of Scotland—

Silica	-	-	-	-	-	48.166
Magnesia	-	-	-	-	-	2.916
Alumina	-	-	-	-	-	16.851
Oxide of iron	-	-	-	-	-	19.000
Potassa	-	-	-	-	-	6.558
Lime	-	-	-	-	-	2.675
Water	-	-	-	-	-	2.350

98.718‡

The composition of the most common silvery mica from Zinwald (Bohemia) was ascertained by M. Klaproth to be the following—

Silica	-	-	-	-	-	47.
Alumina	-	-	-	-	-	20.
Potassa	-	-	-	-	-	14.50
Ox. iron	-	-	-	-	-	15.50
Ox. manganese	-	-	-	-	-	1.75

98.75§

Having described the grounds on which I arrive at the conclusion that the green grains of this earth are chlorite, or chlorite blended with mica, and rarely specks of serpentine, I cannot but express the opinion, that as a nutritive manure the efficacy of the green particles has been greatly overrated. As these particles are very little liable to decomposition, their action, whatever it may be, must be slow, and, I should infer, nearly imperceptible. Indeed, I am rather disposed to regard its favorable operation, if indeed it has any, as flowing from a mechanical agency, after the manner of a clay, than as arising from the liberation of its potassa through chemical decomposition. Not that I would call in question the usefulness of the earth taken as a whole, for happily this is too well established. But when I find a decided content of sulphate of lime, with carbonate and phosphate of lime in addition thereto, together with distinct traces of organic matter, it appears to me unnecessary to look any farther in order to account for the phenomena in the case.

I now proceed to state my method of examination, together with the results obtained.

The specimens were kept in a dry room, exposed to air in shallow dishes, for several weeks; after which, portions free from crystals of sulphate of lime visible by the naked eye, and large fragments of shells, were heated in a platina capsule to 300°, Fah., in order to expel hygrometric moisture, and subsequently to low redness, to decompose organic matter.¶ The organic matter is very inconsiderable, and was in no instances rigidly determined.

Having ascertained by experiment that the iron-pyrites was not decomposable by tepid dilute hydrochloric acid, the following method was resorted to for the determination of

* Farmers' Register, vol. ii., p. 131.

† Shepard's Mineralogy, vol. ii., p. 225.

‡ Idem. ii., p. 225.

§ Idem. ii., p. 41.

¶ This last step was always attended with the extrication of a little sulphur.

the phosphate of lime. Two hundred grains of the triturated earth were suffered to stand (with occasional agitation) in contact with a dilute hydrochloric acid for three hours. The whole was then transferred to a filter, and the earth well washed thereon, with abundance of tepid water. The clear fluid and washings thus obtained were super-saturated with ammonia, and the precipitate subsequently digested in a warm potassic solution for the removal of the silica and the alumina. The per-oxide of iron and phosphate of lime now remaining, after being well washed, were treated with a cold, dilute acetic acid, whereby the phosphate alone was taken into solution. It was then precipitated by ammonia, dried, ignited and weighed. Having found reason to believe that the proportion of finely divided phosphate of lime was pretty uniform in the different specimens of the green-sand, I was only at the pains to determine its exact proportion in specimen No. 1.* Having ascertained how much peroxide of iron each sample contained, this amount was deducted from that yielded by the treatment of the same specimen with nitro-hydrochloric acid, (aided by gentle heat,) whereby the sulphuret of iron was decomposed. Thus the exact quantity of iron which was engaged by the sulphur (and consequently the amount of bi-sulphuret of iron) was ascertained.

The carbonate of lime was determined in the usual way, viz., by treating the first obtained solution in hydrochloric acid with ammonia, whereby the silica, alumina, peroxide of iron, and phosphate of lime were thrown down, leaving the lime and magnesia alone in a state of suspension. The former was precipitated by oxalate of ammonia, and subsequently the latter by phosphoric acid.

The sulphate of lime was ascertained by boiling a determinate quantity of the green-sand in water until the whole of this salt present was taken into solution. The clear solution was treated with chloride of barium, and the sulphate of baryta ignited and weighed. The sulphuric acid present in the earth was thus arrived at, and, by subsequent calculation, the sulphate of lime originally present was ascertained.

Sulphate of alumina (but no sulphate of iron) was found to exist, in traces, by the precipitation of alumina, occasioned on the treatment of the water boiled on the earth with ammonia. But in each case it was too inconsiderable for the determination of its proportion. Chloride of calcium (muriate of lime) was ascertained by treating the same fluid with nitrate of silver. Its proportion did not exceed that in which it exists also in common soils.

Results obtained on specimens of green-sand earth from Coggins Point, James river.

"No. 1. From 8 inches within the exposed side of a ravine, where a stream flowed by, and 15 feet from the top of the green earth."† [Middle part of stratum D, see page 218.]

Hygrometric moisture, (lost at 300°)	-	-	5.50
By heating to low redness, it lost in addition	-	-	2.03
Phosphate of lime	-	-	0.25
Carbonate of magnesia, in decided traces.	-	-	
Sulphate of alumina, in traces.	-	-	

"No. 3. Same as number 1, except from a deeper excavation.

Hygrometric moisture (lost at 300°)	-	-	4.600
By heating to low redness it lost in addition	-	-	2.200
Carbonate of lime	-	-	1.550
Bi-sulphuret of iron	-	-	3.066
Carbonate of magnesia and sulphate of alumina in traces.	-	-	
Phosphate of lime, about as in number 1.	-	-	
Sulphate of lime	-	-	0.813

"No. 6. Three feet below the river beach, [from pit, lower part of D, half a mile distant from preceding.]"

Hygrometric moisture	-	-	5.400
By heating to low redness, it lost in addition	-	-	2.060
Carbonate of lime	-	-	0.535
Bi-sulphuret of iron	-	-	2.060
Sulphate of lime	-	-	0.661
Carbonate of magnesia and sulphate of alumina in traces.	-	-	
Phosphate of lime as in number 1.	-	-	

* I will here observe that, by the process now described, it was ascertained that had the whole of the precipitate by ammonia from the hydrochloric acid solution been taken for phosphate of lime, it would have involved the error of an over estimate of the phosphate by nearly 800 per cent.

† This specimen was not thoroughly analyzed, and therefore the contents are reported but in part. The next (No. 3) was deemed the most important, and a more correct specimen of this layer, (D,) and therefore to it the examination of Prof. Shepard was especially

"No. 9. See foregoing, page 218. Having sulphuret of iron in powder, or minute crystals;" [taken from 14 feet below the beach, in *E.*]

Carbonate of lime	-	-	-	-	2.350
Bi-sulphuret of iron	-	-	-	-	5.821
Sulphate of lime	-	-	-	-	2.309
(Carbonate of magnesia not found.)					

"No. 10. Several thin layers of compressed shells. 1 to 3 inches thick," [contained in stratum *E.*]

Carbonate of lime	-	-	-	-	56.00
Phosphate of lime	-	-	-	-	0.84

No. 2. [*D*] from 4 feet lower than number 1, was examined with results similar to 1 and 3.

No. 4. [*D*] from 4 feet below beach, and half a mile from number 1, was found to be rich in sulphate of lime and to contain bi-sulphuret of iron.

No. 5. [*D*] "From another spot, and has been exposed to the weather from last winter to June on the field where applied as manure." Is richer than No. 2 or 4 in sulphate of lime, but inferior to either in bi-sulphuret of iron. It likewise affords more sulphate of alumina than any sample examined.

"No. 11. The clay at 16 to 18 feet deep;" [supposed when selected to be the poorest part of stratum *E.*]

Carbonate of lime	-	-	-	-	1.45
-------------------	---	---	---	---	------

It is rich in sulphate of lime, and has traces of sulphate of alumina, and bi-sulphuret of iron.

It is to be kept in mind that in these analyses no account is taken of such sized crystals of sulphate of lime as readily meet the eye, or of large fragments of shells, the occasional presence of both which must often essentially enhance the gypseous and calcareous contents of these samples. The proportions in which they may occur at different depths and localities can readily be determined, however, by the practical agriculturist. The same may be said of the phosphatic ingredient so far as the teeth and bones of fishes are concerned.

If we assume the average proportion of bi-sulphuret of iron in these earths to be 2 per cent., and suppose the whole of the sulphate to become oxidized, it would give rise to 2.722 per cent. of sulphuric acid; to saturate which would require 1.905 of lime, and thereby produce 4.627 per cent. of (anhydrous) sulphate of lime. But 2.722 of lime would demand 3.383 per cent. of carbonate of lime in the soil. Now in the three analyses (Nos. 3, 6 and 9) made, the bi-sulphuret of iron, by average, equals 3.649 per cent., and the carbonate of lime in the same equals but 1.478 per cent.—a quantity too small for the saturation of the acid, even after a liberal allowance is made for the increase of calcareous matter from the occasional presence of large fragments of shells.

It would therefore appear to be an obvious deduction from these inquiries, that dressings of lime, and especially of calcareous bands, like No. 10, should be employed in conjunction with the green-sand soil.

Having now replied in the best way I am able to your various inquiries, I leave it for you to make such other practical inferences from the information afforded as in your more experienced judgment it may seem to authorize— and remain, very respectfully, your obedient servant,

CHARLES UPHAM SHEPARD.

EDMUND ROFFIN, Esq, Petersburg, Va.

The specimens numbered above 1, 2, 3, were from one locality, and of earth which was used as manure for clover of this year, with effect as great as any ever known on marled land; and with no certain benefit on an adjoining space, (also in clover,) of the same soil naturally, but not marled. Numbers 4, 5, and 6, were from the pit dug in the beach, half a mile distant, apparently similar to each other, and to the preceding specimens. All these are of the dark stratum (*D*) richest in green-sand, (except the lowest, *E*.) and all before rated by me as containing 50 per cent. of the pure granules. Professor Rogers stated the same to contain 60 to 70 per cent. (See *F. Register*, vol. ii., p. 750, and 2d edition of 'Essay on Calcareous Manures,' p. 116.) Even if leaving the green-sand out of consideration, and out of the estimate of value, there would still remain enough of active manuring principles to produce a large share of all the beneficial effects which I have found from the use of this earth; and I have

requested, and was so directed. It is therefore that the contents of bi-sulphuret of iron, carbonate of lime, and sulphate of lime are not stated of No. 1, as in No. 3.—E. R.

heard of but few other applications in Virginia, other than those made on Coggins Point farm, and of none with different or better *certain* effects. With the help of surplus carbonate of lime in the soil, (furnished by nature or by previous marling or liming,) 100 bushels of this earth, averaging in strength the ingredients of these specimens analyzed by Professor Shepard, would furnish nearly 5 bushels of pure sulphate of lime (gypsum); and 40 bushels to the acre would furnish 2 bushels of sulphate of lime. Not one of these specimens contained any gypsum visible to the eye; and but one specimen (number 9) contained any visible sulphuret of iron; and therefore these ingredients may be fairly supposed to be at least as abundant in the earth dug in any considerable operation. What the green-sand or any other ingredients may do in addition, I pretend not to estimate. But so far as I have learned from my own experience and all known experience of other persons, the whole operation of this earth, when used alone, is precisely of such kind as I would anticipate from gypsum, though yielding more of benefit in measure and value. Nor should I therefore be understood as placing a low estimate on the value of the effects produced. Since seeing the effects this year, and especially since having formed the opinion that the upper and exposed parts (most generally used formerly) are comparatively worthless and should be avoided, I count on much benefit being derived from this manure, and am desirous that it shall be largely used; as my son and partner, and the sole director of our farming, proposes to do for the next year's growth of clover. Still, I am now as far as ever from believing in or expecting such great and regular benefit as would be inferred to be certain from views and statements which rest upon other authority.

It may not be useless to note another point of recent resemblance between these two manures, both of which seem so capricious and uncertain in operation in general. This year (1842) the applications of the green earth on the Coggins Point farm, whether made in the beginning of the winter preceding, in March, or in the beginning of summer, have acted more quickly and powerfully than any known before. This I had ascribed to the earth being mostly obtained from deeper excavations. But I have lately heard, from Messrs. Hill Carter and John A. Selden, both extensive and experienced and successful users of gypsum, that they have never before known the good effects of that manure to be so remarkable as in all their applications of this year.

(d.) EOCENE GREEN-SAND MARL.

Except in the lower stratum exposed in the pit recently dug at Evergreen, this peculiar valuable kind of marl has not yet been known in Virginia elsewhere than on and near the borders of the Pamunkey river; though there can be but little doubt that this or other eocene deposits are to be found elsewhere than within the limits here stated of the now known localities. It is more than probable that other rivers cut through and expose some of the eocene as well as miocene deposits; and that deep diggings would reach them also in the intervening high lands. The Pamunkey eocene marl is seen first, or most eastward, at Liberty Hall, (Mr. Waring's farm,) in King William county; and it is found on nearly every farm above, to South Wales, in Hanover, the farm of Mr. William F. Wickham, just below the junction of the North Anna and South Anna rivers, and on the farm of Mr. Williams Carter, across the Pamunkey, in Caroline county. This distance in a straight line is about 28 miles; and the very winding course of the Pamunkey serves to make the exposure

of the bed of marl show an average width of three or more miles. Throughout this area, it is found in great abundance at numerous points—though of great variety of appearance and of value at different elevations, and in very different degrees of accessibleness, or ease of working.

This marl every where has its calcareous portion (which is usually small in comparison to good miocene marls,) intermixed with a large proportion of green-sand. The calcareous earth varies from 10 to 40 per cent. at different diggings, or different layers at the same locality; and the green-sand perhaps from 20 to 40 per cent. as estimated by the eye.* In some places, the one ingredient predominates in quantity, and elsewhere the other. No one specimen has been found rich in both of these ingredients. So far as known, the remainder of the whole mass, (as in miocene marls,) is of silicious sand and clay.

Below this green-sand marl lies a bed of brownish green earth, slightly sprinkled with small eocene shells and their fragments, but which, or all the calcareous matter present, would very rarely amount to 5 per cent., and sometimes not 2 per cent. To this lower stratum is also applied the term *marl* by the proprietors, as is done in New Jersey. But this term should not be given where the calcareous earth is so small in amount as 5 per cent. Though it may be impossible to draw a precise line of demarkation, either on the banks, or to distinguish them by definition in words, still these two earths ought to be known by different terms. By *green-sand earth* or green earth, will be here understood the lower stratum, or any other having green-sand in considerable quantity, and not more than 5 per cent. of calcareous earth, if any. And I would not consider any as *green-sand marl*, that did not have as much as 10 per cent. of carbonate of lime—leaving as doubtful and debatable, such as had more than 5 and less than 10 per cent.

The Pamunkey river is very narrow and yet deep, and its high banks, or cliffs, formed generally of green-sand marl and green-sand earth, are nearly perpendicular. The remarkable power which green-sand has of resisting the washing of water, is doubtless the cause of the narrowness of this river, and of the forces of its strong ordinary tides and violent current in freshes having operated to deepen the channel, instead of wearing away the banks. Slides of the banks, or land-slips, are frequent; large masses of the upper stratum of soil breaking loose, and, with the growth of large trees, slip down the steep bank into the river, scraping clean the exposed parts of the strata in the descent. In this way, sections of the bank 40 feet or more in height are exposed more completely to view than would be done by the progress of any diggings for marl, however rapid or extensive.

The general appearance of any one of such sections, taken at one of the several exposures from one to five miles below Newcastle ferry, is as follows: At top, below the soil and ordinary sub-soil, (or diluvial earth,) of say 10 to 20 feet, there is generally, though not always, a stratum of some 4 or 5 feet of *olive colored earth*, so called, and which term is descriptive of the appearance. This earth is of a greenish brown color, contains small sharks' teeth and fishes' bones, but no shells. Its appearance so nearly resembles the marl below, that it has been sometimes dug and used instead, either from the ignorance of the conductor or the carelessness of the laborers. It is entirely worthless as manure, as has been proved by careful experiments. A well dug (to obtain water) at Piping Tree ferry, penetrated very deep into this olive earth without reaching marl. The earth thus removed was used as manure, without any benefit being produced.

* These and all others named *supposed* proportions of green-sand were written before receiving Professor Shepard's report. His analyses make it seem probable that all my guesses of such proportions were too high.

Mr. Conrade Webb informed me that on his estate in New Kent he had made very careful comparative trials of applications of this olive earth, on land with and without marling, opposite to like pieces without the olive earth; and in neither case did its application show any effect.

Next, under this olive earth, is green-sand marl; sometimes the upper part has layers full of the saddle oyster shells, in place, which also occur scattered throughout all this marl. Sometimes, as above Newcastle ferry, there are interspersed hard lumps much richer in calcareous matter than the surrounding body. The matrix in which these accidental bodies are imbedded, or the whole body when they are absent, is a dark gray marl, of nearly homogeneous texture, containing green-sand in large proportion, and very few shells or fragments. This sometimes continues down to the green-sand earth. But at and a little above the ferry, (on Mr. Carter Braxton's farm,) there occurs between them a stratum of larger shells, mostly the *cardita planicosta*, as close together as they can lie, well preserved in form, though very rotten, as all the white shells are. The shells of this layer are often stained superficially of a deep and vivid green, by the green-sand. This layer of shells lies on the brownish green earth before mentioned, having very little calcareous matter, and of which the depth is unknown, as its bottom has never been reached in any of the diggings. This layer of whole shells was not seen elsewhere.

Such is the succession of strata at the fine bank of Mr. Carter Braxton, Hanover, a little above Newcastle ferry; and specimens of the several kinds, analyzed carefully, afforded the following results of calcareous matter. The proportions of green-sand were merely guessed at by the eye, but by careful examination, and with the aid of a magnifying glass.

Upper stratum furnishing the greater proportion of all used for manure:
 100 grains contained of carbonate of lime - - - - 37 grains.
 100 grains of lower stratum only - - - - 2
 Another specimen of upper stratum, carbonate of lime - - 10
 and green-sand moderately coarse (supposed,) - - - 40

At the ferry:

100 grains of upper stratum, carbonate of lime, - - - 15
 and (supposed) of green-sand - - - - 35
 Lower stratum of same, carbonate of lime - - - - 6
 Masses of stony hardness, interspersed in same, contained of
 carbonate of lime - - - - 67
 and green-sand - - - - 3

At Mr. J. W. Tomlin's land, Hanover, about a mile below the ferry, the visible section of marl and green-sand earth together is 32 feet high, above low tide mark, and the green-sand earth making only 7 or 8 feet of the lowest part. All is eocene—as I found saddle oyster shells at the top of the light colored upper layer, next to the diluvial sandy sub-soil.* Specimens taken from different heights on this bank yielded the following proportions of carbonate of lime:

From 7 feet above low tide, 100 grains contained of carbonate
 of lime - - - - 35
 At 14 feet - - - - 31
 At 29 feet - - - - 15

Upper light-colored stratum—(not including in the specimen
 any of its few large saddle oyster shells) - - - - 6
 Thin stratum of hard shelly marl, low in the section - - 45

* This light colored upper layer is stated by the state geologist, in his report, to be miocene. See first report, of 1835, and same copied at p. 670, vol. iii., Farmers' Register.

The green-sand stratum (brownish color) of 7 or 8 feet above the water was not analyzed; but, as at all other places on this river, was evidently very poor in calcareous matter.

On the land of Mr. George W. Bassett, Hanover, about 5 miles below Newcastle ferry, the marl appears rich and of more homogeneous texture and uniform appearance than generally elsewhere. Yet it is variable, and on the average is poor in calcareous matter. However, this marl, which has been largely used by Dr. Corbin Braxton, water-borne to Chericoke, 8 miles below, has been wonderfully efficacious. Still it has not been used at all, or considered worth being applied, by its proprietor. Specimens analyzed at different times showed the following proportions of calcareous matter:

Stratum a few feet above the level of river, 100 grains contain-	
ed of carbonate of lime, - - - - -	10 grains.
And green-sand (supposed,) - - - - -	35
Another (furnished and analyzed in 1840) carbonate of lime, - - - - -	11
And green-sand, - - - - -	27
Another, from different part of same bank, carbonate of lime, - - - - -	45.50

This body was examined personally by the state geologist, and his estimate of its contents of carbonate of lime and of green-sand was 34 per cent. of each.

Over this marl is a regular stratum, perhaps 5 feet thick, of the olive earth. The marl descends to the level of the river, and therefore the green-sand earth below is not here visible.

In the river bank of Northbury, in New Kent, one of the farms of Mr. Conrade Webb, the green-sand marl presents the usual appearance, and is overlaid by the olive colored earth. To my eye this marl was rather poor in the calcareous ingredient, and, as Mr. Webb supposed, in use was often adulterated by the carelessness of overseers and laborers, by admixtures of the worthless olive earth. Still, the application as manure has had very good effect. A large quantity of this particular body has been dug and used; but it has since been abandoned, because of the greater value of and more convenient access to other more recently discovered beds, which will presently be noticed. At Northbury, as Professor Rogers supposed and reported in 1835, "the precise point was determined at which the eocene first makes its appearance above the water line" of the Pamunkey. But it has been since found at Mr. Waring's farm, about 4 miles lower, as well as at Waterloo, another part of Mr. Webb's estate, about two miles lower than the first diggings at Northbury.

By using the borer in low places, but where no sign of marl was visible on the surface, Mr. Webb has since discovered the eocene marl which will be next described, at various points in a line stretching through the middle of his large estate, and furnishing a convenient supply to each of the three farms. At several distant points, large pits have been dug, which are sunk from 16 to 20 feet deep in the solid marl, without reaching bottom or showing any change of the lower of the two kinds of marl. The pits are worked quite dry; but no marl having been dug for some time before my visit (May 1842) the pits were then all full of water to the brim, and there was but little opportunity to examine the marl, except at the upper edges, and in the heaps still remaining unspread over a part of one of the fields. However, Mr. Webb had before selected and kept for me, at my request, fair specimens in two large lumps of marl from one of the largest and deepest pits, from which my analyses were made. The one, a specimen of the upper 8 or 10 feet of depth, is full of large fragments of shells, generally very soft and much decayed, and with very few whole shells, except

those of the oyster kind. Below this stratum, the marl (as shown by the sample) has no shells or considerable fragments, is of dark gray color and homogeneous texture, like coarse sand united in a mass by barely enough of clay to serve for that purpose. This apparent texture belongs to most of the Pamunkey marls, and is caused by the shelly matter being so pulverized as to be in fact a coarse calcareous sand. The specimen of this lower stratum, of which 8 or 10 feet depth had been exposed, contained in 100 grains, 35.50 of carbonate of lime; and the upper (shelly stratum) 35. The green-sand in both kinds appeared to be in less proportion than in the marl of the river bank at Northbury, and elsewhere along the river generally. Probably there was not more than 20 per cent. at most. The upper stratum, and larger part as used, of this marl, through a line of several miles in length, is very different in appearance from all the other marls seen on the river. And it must also be different in geological age or manner of original deposition, as the shells show much difference. Very few of the *cardita planicosta* were found in the heaps of marl, (which always offer the best exhibition of shells for collection,) and those of very small size, and no saddle oysters. On the other hand, several shells were found, not observed by me at any other place; and one of them, an oyster shell of large size, of remarkable and peculiar form, and in excellent preservation, is very abundant. Though various in form, as are all the *ostreas*, this, or the more convex of its two valves, has a general peculiarity in a large and sharp hump on the back, and sometimes two such humps. Another *ostrea*, of which the shell is very thin and very convex, and the outline of the valves nearly circular, is here abundant, and as large as two inches across. No specimen of the same had ever been seen by me, except perhaps a few at Newcastle of size so small that the identity was doubtful. The striking differences of kind and of proportions of the shells at Mr. Webb's more recent diggings would be highly interesting to any person possessing that knowledge of geology, and its auxiliary science, fossil conchology, to which I have no claim, and make no pretension. I have done, however, all in my power, to increase the facilities of future competent investigators, by collecting and preserving specimens for their examination. My cabinet contain not only some of all the shells that I have found, or have been able to obtain from the several kinds of marl, but also specimens of all the marls of peculiar and marked character, with their localities accurately distinguished. And the time and the labor which I have given to making the collection, with opportunities possessed by but few other individuals, may thus serve greatly to advance the pursuits of scientific and truly competent investigators.

In the river bank of Mr. Carter Braxton's farm, immediately above the Newcastle ferry, there commences a rapid decrease of the thickness of the calcareous or marl stratum proper, which is substituted by an equal increase or rising of the under-lying green-sand earth. A little above the ferry, the marl is at least 10 feet thick; at less than a mile above, the thickness of the marl is only 5 feet; and at the next large exposure, on the adjacent farm of Mr. B. Tomlin, the marl is not more than 2 or 3 feet thick, over-lying green-sand earth marked with a few scattered and small shells, rising to nearly the full usual height of the marl, say 25 feet or more visible above the water. This was as far in regular connexion along the river as I personally examined; but I learned that still higher, the calcareous stratum almost ceases, the lower stratum of green-sand earth occupying nearly the whole visible section. The lower stratum of the body at Spring Garden, Hanover, (Mr. William H. Roane's farm,) next above, is stated in Professor Rogers' Report as containing, in 100 parts—

Carbonate of lime	-	-	-	-	-	-	-	-	4
Green-sand	-	-	-	-	-	-	-	-	46
Gypsum	-	-	-	-	-	-	-	-	3
Silica and alumina	-	-	-	-	-	-	-	-	50
									100

The next important locality of marl, and perhaps the most interesting, is South Wales, Hanover, the farm of Mr. William F. Wickham, and which is the highest point of its known existence. Here, as at the western termination of the green-sand in Petersburg, the bottom is seen, the underlying stratum being gravelly sand mixed with rounded pebbles. This marl, as seen in several places where very large excavations had been made to marl both the South Wales and North Wales farms, differs altogether in appearance, and greatly in constitution, from all the kinds below. The bed is about 10 feet thick, is generally of uniform dark (nearly black) color, except for being intermixed throughout with large fragments of white shells. At one place, the upper stratum of the marl is yellow or pale reddish instead of black, but similar in the appearance of shells. Specimens of these marls carefully selected on the places in 1840, and analyzed, gave the following results:

From South Wales, (William F. Wickham's land,) Hanover county, 100 grains of upper stratum, yellowish, consisted of

Carbonate of lime	-	-	-	-	-	-	-	-	36
Silicious sand and green-sand together	47	—	of	which	green-sand				
appeared to be one-tenth or	-	-	-	-	-	-	-	-	4.70
and silicious (or quartz) sand	-	-	-	-	-	-	-	-	42.30
Yellow clay and loss	-	-	-	-	-	-	-	-	17
100 grains blackish marl, lying below the last—									
Carbonate of lime	-	-	-	-	-	-	-	-	44
Green-sand	-	-	-	-	-	-	-	-	8
100 grains similar to the last, from a different digging—									
Carbonate of lime	-	-	-	-	-	-	-	-	32.50
Green-sand	-	-	-	-	-	-	-	-	22

From North Wales, Caroline county, Williams Carter's land,

100 grains of like blackish marl contained—

Carbonate of lime	-	-	-	-	-	-	-	-	37
Green-sand	-	-	-	-	-	-	-	-	24

These specimens, which were supposed to present a fair average of the whole body, show an unusually large proportion of carbonate of lime for the Pamunkey eocene beds, and a less proportion of green-sand. To the happy combination of the two manures, I cannot but ascribe the remarkable success of Mr. Wickham in fertilizing his land. Still, he deems the green-sand ingredient of so little worth, compared to the calcareous, that he would prefer that his marl should have had none of the former substance, provided an equal quantity of calcareous matter could be substituted.

In a former publication, I have presented at length both the facts and my opinions of the peculiar operation of the green-sand marls of the Pamunkey.* It is therefore enough to say here, that the operation of this compound manure is greater than of any quantity of either one of the two enriching materials of which it is composed. In smaller quantity than is usually applied of calcareous marl, it produced equal or greater effect, and was more especially beneficial to clover. The heaviest quantities also applied (as in the practice of Mr. Wickham,) caused no loss; though the like large quantities

* See more full statements at pp. 679 to 691, vol. viii. Farmers' Register.

of merely calcareous marl would have been certainly either wasteful of the manure, or injurious to the land.

Many specimens of these Pamunkey marls and of the lower-lying green-sand earth were subjected to a partial red heat, for the purpose of showing whether suffocating sulphureous fumes were disengaged, as was stated above (page 215) to be the case with some of the James river green-sand earth. The lower stratum (very slightly calcareous) of the Pamunkey marls, from Newcastle ferry, and at J. W. Tomlin's bank, gave out such fumes, but not so powerfully as the dark gypseous earth of Coggins Point. The next higher calcareous and green-sand stratum of J. W. Tomlin's, and the same kind at Piping Tree ferry, and the blackish marl at South Wales, all yielded these strong fumes, but in a still less degree. Sundry other specimens of calcareous green-sand marl which were thus treated, yielded no fumes. The latter results were found in specimens from the several diggings at Newcastle, (both sides of the river,) and at G. W. Bassett's bank. It may not be useless to repeat here, and thus to place in connexion with these results, that all the dark green or blackish earth (*D*) of Coggins Point gave out these suffocating fumes, and also the gray clay (*E*) below, and most powerfully—and that no such product was found from any of the very shelly bands. Thus it would seem that most generally the non-calcareous earths (or nearly non-calcareous) gave out fumes, and the calcareous not. But exceptions were found to both. And of the New Jersey green-sands, containing no carbonate of lime, six specimens were tried at red heat, of earths most esteemed for manure, and not the slightest disengagement of such fumes was produced.*

Of green-sand as an ingredient of miocene marls.

In a previous page, (199,) the presence of green-sand in miocene marls, as an important and general ingredient, was denied; and the subject then passed by, with the promise of its being subsequently resumed. Having treated of the gypseous earth and of eocene green-sand marls, of both of which green-sand forms large and important proportions, it is now most appropriate to inquire into the alleged extent and operation of this substance in miocene marls.

In 1834, Professor William B. Rogers (then a resident of lower Virginia) announced that he had discovered green-sand to be a considerable ingredient of nearly all the many ordinary miocene marls which he had examined either in place or by specimens; and from which observations he inferred the same admixture to be general as to other miocene marls; and that the proportions of green-sand so contained were large enough to form useful additions to, and in some cases the most valuable portion of the manuring ingredients of such marls, (*Farmer's Register*, vol. ii., p. 129.) At a later time, he added to like general opinions and statements the following: "In some of these deposits [marl beds in the vicinity of Williamsburg,] so large a proportion as thirty and in some specimens forty per cent. [of pure green-sand] has been found; and in cases like this, if we are to trust to the experience of New Jersey, a very marked addition to the fertilizing power of marl must be ascribed to the presence of this ingredient." (*Farmer's Register*, vol. ii., p. 747.) In a subsequent communication to the Phi-

* The New Jersey "marls" thus tried were selected by the writer from the pits of Josiah Heritage and Thomas Bee of Gloucester, and Henry Allen, Allen Wallace, J. Riley, and J. Cauley, Salem county. The same results were found as to the poorer (or less valued) overlying strata of Heritage, R. Dickenson, J. Cauley, and also of the barren green clay or subsoil. See all described in my report on the New Jersey green-sand earths, *Farmers' Register*, vol. x. p. 429.

losophical Society of Philadelphia in 1835, and again in the first report of the geological survey of Virginia, the material parts of the above statements are re-asserted, in substance, and nearly in the same words. These statements and opinions were received, when announced, as undoubted, and they have not since been questioned in any publication; nor have they since been either confirmed by any additional proof or testimony, nor have they in direct terms been modified or retracted by their author. Yet the correctness or incorrectness of the assertion of such abundance and general diffusion of green-sand in the miocene marls of Virginia is a matter of great interest—and, in its bearing on the application of marl and the rationale of its operation, of great importance to agricultural improvement. It is certain that to this day, many proprietors consider that their marls are peculiarly valuable because of the supposed large proportions of green-sand therein—such opinions being founded either on the publications, or, with still more confidence, upon the personal examinations and verbally expressed opinions of the state geologist.

My own personal examinations of marls in place, and analyses of specimens of other beds, have been very extensive; and my attention has been given especially in regard to this point to sundry specimens, including several of the particular bodies of marl which it is understood that Professor Rogers had pronounced to be very rich in green-sand—containing, say, 20 to 30 per cent. of the black granules so called. I have found some green-sand (but generally in very small proportion,) in nearly all the specimens examined particularly for this substance; and believe that Professor Rogers was correct so far as inferring that it is a very frequent ingredient. And for the first observation of this curious and interesting fact he is justly entitled to the entire credit. To such extent as green-sand is present, and according to the manner of the operation of that earth, (whatever that may be,) the green-sand in the miocene marls must be effective and useful. But whether such effect be of any distinguishable and appreciable value, or not, depends on the quantity and proportion of green-sand in the marl; and, so far as all my experience and observation enable me to judge, I cannot but believe that the above stated estimates of quantities and proportions of green-sand are greatly exaggerated, and extremely incorrect and delusive. I do not mean to assert, and cannot be expected to prove, the *negative* of the assertion of such abundance of green-sand. But, from all my means for arriving at conclusions, it is my confident belief that but few of the bodies of miocene marls in Virginia contain as much as 2 per cent. of green-sand—if even as much as 1 per cent.; and that an average proportion, throughout any considerable digging for manure, of as much as 5 per cent. of green-sand is extremely rare. The largest proportion (estimated by the eye) that I ever found was supposed to be 5 per cent.; and that was in a very peculiar marl, found at Coggins Point farm and elsewhere in that neighborhood, or rather a loose calcareous sand, which forms the over-lying layer of compact blue marl. This sand contains only about 20 per cent. of finely divided shelly matter, and the whole mass would appear, to slight observation, similar to and as poor and as loose as the deep sands of the roads through a sandy country. But few persons would have used this sand for manure—or would have dignified it by the name of marl. However, the ease with which it could be worked, and the necessity for removing it to uncover the better marl below, induced me to carry out and apply it as a second dressing to an adjacent part of a field which had been just before marled. The effects were so marked, and so superior to the single marling, that I was ready to believe that the green-sand caused the difference. The loose calcareous sand mentioned at page 201, which one of my neigh-

bors supposed (from its good effects) to be rich in calcareous earth, is precisely like mine in general appearance, and in position in the bed; and appears to have a like unusually large proportion of green-sand, which no doubt served to produce part of the benefit which was ascribed wholly to the carbonate of lime. This peculiar deposit furnishes the only cases known to me of a miocene marl being rich enough in green-sand for the benefit from the latter to be known. And even this benefit would *not* have been distinguished or suspected, but that the poverty of the earth in calcareous matter required it to be applied very heavily. The much thicker body of compact marl, lying under this poor calcareous sand, contains (by supposition) not so much as 2 per cent. of green-sand.

But it is true, that when attention was not particularly directed to green-sand, proportions not exceeding 5 or 6 per cent. might have escaped the notice of one who had handled and examined the specimens of marl, or who even analyzed them, merely with a view to their proportions of calcareous matter. But proportions so large as 40, 30, or even 20 per cent. of green-sand could not thus escape even careless and superficial observation; for even the smallest of these proportions would give a very manifest greenish or gray tint to any otherwise light-colored marl. Knowing the great uncertainty of the *guessings* at proportions of green-sand naturally intermixed with marl or other earth, I did not rely on them except as to the *absence* of any very large proportion. For more accurate testing, the clayey parts were washed off in water; in others the calcareous parts were also removed by weak acid. And for still better means of judging by comparison, I mixed together, in different known proportions, measured quantities of light-colored marl (such as are all those about Williamsburg,) and pure green-sand prepared by washing some obtained from the richest beds in New Jersey. And of such artificial compounds, examined by the eye both when dry and in powder, and wet, and also after being again dried in mass, the admixture of green-sand, even when as small as 10 per cent., was obviously more abundant than in the miocene marls reputed to be among the richest in green-sand. Under these circumstances, without denying the possible existence of such cases, it is proper to wait for and to require further proof of such large proportions as 20 to 40 per cent.

But there is much better support for my position, of the general scarcity of green-sand in miocene marls, than any proofs, positive or negative, that I can adduce, presented by Prof. Rogers himself in his 'Report of the progress of the Geological Survey' for 1837. He therein gives a tabular statement of 148 specimens selected by his assistants, and their analyses made under his own direction. It is to be presumed that so many specimens, and thus obtained, must present a fair and correct average of general quality of the marls of the region in which they were found; or at least that their contents would not be too little favorable to the geologist's preconceived opinions. The specimens were from 18 counties, viz.: Lancaster, Westmoreland, Richmond, Northumberland, King George, Mathews, Middlesex, Gloucester, King and Queen, King William, Essex, Isle of Wight, Nansemond, Elizabeth City, Surry, Prince George, James City, and Warwick. Of these 148 specimens, of one only (S. Downing's, Lancaster,) is the quantity or proportion of green-sand stated with any approach to precision. This is said to contain "10 or 12 per cent. of green-sand," and only 17 per cent. of carbonate of lime. Of five others, the green-sand would seem to be in notable quantities, but as no numbers or proportions are named, it may be inferred that the proportions were deemed less than the one just stated. These five are described as follows, in regard to this ingredient: Callahan's, Lancaster, "large grains of green-sand in considerable quantity;" Gloucester Town, "richly specked with green-sand;" Saunders', Isle of Wight, (one only of

three strata,) "considerable green-sand." Stith's, Surry, "quite richly specked with green-sand." A. C. Jones', Surry, and at Kingsmill, James City, "intermixed with green-sand." Now what proportions these descriptions designate, it is not for me to determine; but 3 or 4 per cent., at most, would abundantly serve to meet all their requisitions. There are also 7 other of the specimens named marked in less degrees by the presence of this ingredient, and which are described in this respect in such phrases as these: containing "a little green-sand"—"specked with green-sand"—"quite perceptibly specked with green-sand"—"tinged with green-sand"—and "slightly intermixed with green-sand." There remain of the list 135 other specimens, of which 48 are stated to contain of "green-sand *a trace*," (by which term chemists understand a proportion so small that its presence is barely certain,) and of the other 87 specimens no green-sand is mentioned, and therefore it may be inferred that not even "a trace" could be found.

If this list of marls and statements of their fertilizing contents had been presented by the author distinctly as a designed refutation of his previously and repeatedly published opinions of the frequent abundance and general presence in useful quantity of green-sand in miocene marls, nothing could have been more to the purpose, or more conclusive.

Nevertheless, few and rare as may be the cases in which the value and beneficial effects of marls are increased in any considerable degree by the presence of green-sand, or of any other ingredient than carbonate of lime, it is important that such auxiliary fertilizing matters should be searched for, and their absence or presence known. The great value and uniform fertilizing effects of *carbonate of lime* will be the most highly appreciated by those farmers who understand and estimate them separately and alone; without confounding the operation of that manuring earth with those of any other intermixed and unknown substances, no matter what increase of benefit such intermixture may produce in particular cases.

KNOWN SHELLS OF THE MARLS OF LOWER VIRGINIA.*

Miocene.

Astarte undulata, Say.	Crepidula aculeata, Lamarck.
" concentrica, Conrad.	" fornicata "
" vicina, Say.	Conus——?
Artemis acetabulum "	Dentalium thallus, Con.
- Arca incile, Say.	Dispotæa costata, Say.
" centenaria, Say.	- Fusus quadricostatus, Say.
" limula, Con.	" cenerus "
" idonea "	" exilis, Con.
Ballanus——?	Fissurella, ——?
Buccinum porcinum, Say.	Fasciolaria mutabilis, Con.
" obsoletum "	Gnathodon cuneatum, Gray.
" laqueatum "	Isocardia rustica, Sowerby.
" altile, Con.	Lucina divaricata, Lam.
Cardium laqueatum, Con.	" contracta, Say.
" Virginianum "	" anodonta, "
Chama congregata, Con.	" cribaria, "
" corticosa, "	" squamosa, Lam.
Corbula cuneata, "	Lithodendron lineatus, Con.
" inequale, Say.	Murex umbrifer, Con.
Crassatella undulata, Say.	Macra delumbis, "
Carditamera arata, Con.	Marginella ——?
Cardita granulata, Say.	Natica heros, Say.
Cytherea reposta, Con.	" duplicata, Say.

* I am indebted to my friend M. Tuomey for this list of the *known* tertiary shells in my collection. There are also sundry other species or varieties which are doubtful or undetermined, and therefore are not here enumerated.

Ostrea Virginiana, Gmel.
 " *subfalcata*, Con.
Oliva littorata, Lam.
Pandora crassidens.
Panopæa reflexa, Say.
Petricola centenaria, Con.
Plicatula marginata, Say.
Pecten Jeffersonius, Say.
 " *Madisonius*
 " *septemnarius* "
 " *decemnarius*, Con.
 " *Virginianus*, Con.

Pecten Clintonius, Say.
 " *eboreus*, Con.
Pectunculus subovatus, Say.
 " *pulvinatus*, Lam.
Perna maxillata, "
Pleurotoma — ?
Serpula — ?
Teredo — ?
Turritella.
Venus tridacnoides, Lam.
 " *Rileyi*, Con.
 " *alveata*, Con.

Eocene.

Cardita planicosta.
Corbula Alabamienensis, Lea,
Crassatella — ?
Ostrea sellæformis, Con.
 " *compressirostra*, Con.

Pecten Lyelli, Lea.
Panopæa oblongata, Con.
Rostellaria velata. "
Turritella Mortoni. "

Erratum in Professor Shepard's letter, p. 222, line 29, for "nutritive," read MINERAL.

NOTE V.

THE EARLIEST KNOWN SUCCESSFUL APPLICATIONS OF FOSSIL SHELLS AS MANURE.

The two old experiments described at page 70, though the only applications of fossil shells known to me previous to the commencement of my use of this manure, were not all that had been made, and, which being deemed failures, had been abandoned and forgotten. Another, within a few miles of my residence, was brought to light and notice afterwards, by an old negro, who was perhaps the only person then living who had any knowledge of the facts. After I had found enough success in using this manure to attract to it some attention, Mr. Thomas Cocke of Aberdeen was one of those who began, but still with doubt and hesitation, to use marl to some considerable extent. One of his early applications was to his garden. The old gardener opposed this, and told his master that he knew "the stuff was good for nothing, because, when he was a boy, his old master (Mr. Cocke's father) had used some at Bonaccord, and it had never done the least good." Being asked whether he could show the spot where this trial had been made, he answered that he could easily, as he drove the cart which carried out the marl. The place was immediately sought. It was on the most elevated part of a very poor field, which had been cleared and exhausted fully a century before. The marled space (a square of about half an acre) though still poor, was at least twice as productive as the surrounding land, though a slight manuring from the farm-yard had been applied a few years before to the surrounding land, and omitted on this spot, which was supposed, from its appearance, to have been the site of some former dwelling house and yard, of which every trace had disappeared except the permanent improvement of the soil usual from that cause. A close examination showed some fragments of the hardest shells remaining, so as to prove that the old man had not mistaken the spot. This, like other early applications, had been made on ground too poor for the marl to show but very slight early effect; and as only one kind of operation of any manure was then thought of, (that which dung produces,) it is not strange that both the master and servant should have agreed in the opinion that the application was useless, and that all persons who knew of

the application remained under that opinion until almost all remembrance of the experiment had been lost.

Since the printing of the previous pages in which references were made to the earliest application of marl in Virginia, I have obtained some further information thereupon, which, however imperfect, may yet be interesting. In a recent conversation (1842) with William Short, esq., now of Philadelphia, the son of Major William Short who made the experiment, he told me that he well recollected when his father's first and accidental discovery of marl was made on the Spring Garden farm in Surry, (in digging a ditch across a wet swamp,) and his sanguine and confident anticipations of deriving from its use great improvement and profit. Mr. Short further stated that he was then so young, and always so little acquainted with agriculture, that he did not know what were the precise facts in regard to the failure of his father's experiment and hopes; but he well remembers that the result was deemed an entire failure, and that it caused total disappointment.

Such a conclusion I had supposed before being so informed. I had also inferred, and no doubt correctly, that the supposed failure and truly slight benefit, and the mistaken deductions from the results, were such as have been stated. I have since written to the present proprietor of the land, Francis Ruffin, esq., to obtain the latest information concerning the results of this application, now some sixty-five years old; and the most recent effects, as learned from him, will be here stated in connexion with the earlier, which will be repeated.

It was before said (page 70) that this old marling (of about 10 acres) was done on poor sandy land, kept (as was the then universal course of tillage) under exhausting culture and close grazing for many years thereafter; that from 1812 the treatment had been lenient; and that in 1819, the superiority of the marled part was visible, and that part of the outline could be then distinctly traced. In 1834, Mr. F. Ruffin applied to this and some acres of adjoining land, pine leaves at the rate of 75 one-horse cart loads to the acre. The benefit from this vegetable cover was so much greater on the marled part, that the superior growth of the next crop of corn and of the succeeding crop of wheat, "marked out the limits of the old marling very conspicuously." The whole was sown in clover in the spring while under wheat; that on the marled part lived and stood pretty well, while nearly every plant of clover on the part not marled died in the course of the year. In 1837, the whole field was marled, without excepting the old marled part; and the whole was again littered with pine leaves. The crops of corn and wheat since have shown less improvement from these applications on the piece thus re-marled, than on the adjoining land then marled for the first time. Indeed, the recent and additional increase of corn and wheat, since re-marling has been very little. These results, early and late, are precisely such as might have been anticipated from the action of calcareous manures, and the condition of this land and its management.

Another experiment of marling, made earlier than my first, by Mr. Richard Hill, in King William county, has been heard of since the publication of the last edition, and of which the circumstances were given at length at pages 22 and 27 of vol. ix. *Farmers' Register*, to which the reader is referred. It is enough here to state, that the effects were beneficial at first; but so injurious (because of the excessive quantity) on several succeeding crops, that this trial also was deemed a failure, and the marling a source of loss; and there was no repetition of marling in that neighborhood until about 1820, when other and better views began there to be first entertained.

There was also successful and continued use of this manure in James

City county, in Virginia, made earlier than mine; and still earlier by the Rev. John Singleton, in Talbot county, Maryland. It appears that the early (though chance-directed) combination of putrescent manures with marl, in both these places, served to prove the value of the latter, and perhaps to prevent it being there also abandoned as worthless, as in the other cases. But though the application was continued, and with great success and profit, the knowledge of these facts and the example extended very slowly; and the then want of communication among farmers kept all ignorant of these practices for years, except in the immediate vicinity of the commencement of each. I have since endeavored to ascertain the time of the first applications in James City, and have been informed that it was in 1816. Mr. Singleton's, in Maryland, were begun as early as 1805. His own account of his practice (which will be annexed, as an interesting statement of the earliest profitable use of this manure,) was first published in 1818, in the 11th volume of the Memoirs of the Philadelphia Agricultural Society, (page 238.) The date of his letter is Dec. 31. 1817. My first experiment was made the following month, (Jan. 1818,) but more than a year before I met with Mr. Singleton's publication, or had heard of any application of fossil shells, except the two failures mentioned in page 70. But, however beneficial may have been found the operation of marl in Talbot and in James City, it is evident, from Mr. Singleton's letter, and from all other sources of information, that the mode of operation remained altogether unsuspected by those who used it; and this was perhaps the principal cause why the practice was so slow in spreading. It is now [1835] thirty years since the first proofs were exhibited on the land of Mr. Singleton; yet, according to the report of the geological survey of the lower part of Maryland, (submitted to the legislature of Maryland at its recent session of 1834-5,) it appears, though the value of marl is well understood, and much use of it made in Talbot county, and part of Queen Ann's county, yet that almost no use has been made of it on the other and much more extensive parts of the Eastern Shore of Maryland—and none whatever west of the Chesapeake in that state, where it is found in abundance. Such at least are the inferences from Mr. Ducatel's report, though in part drawn from indirect testimony, more than direct and particular assertions.

The slight, and almost contemptuous manner, in which marl is mentioned by so well informed an agriculturist as Taylor, as late as 1814, when his *Arator* was published, (and which remained unaltered in his 3d edition of 1817,) proves that almost nothing was then known of the value of this manure. All that seems to relate to our abundant deposits of fossil shells, or to marl generally, is contained in the two following passages:

"Without new accessions of vegetable matter, successive heavy dressings with lime, gypsum, and even marl, have been frequently found to terminate in impoverishment. Hence it is inferred, that minerals operate as an excitement only to the manure furnished by the atmosphere. From this fact results the impossibility of removing an exhausted soil, by resorting to fossils, which will expel the poor remnant of life; and indeed it is *hardly probable that divine wisdom has lodged in the bowels of the earth the manure necessary for its surface.*"—*Arator*, p. 52, 2d edition, Baltimore.

"Of lime and marl we have an abundance, but experience does not entitle me to say any thing of either."—*Id.* p. 50.

From the Rev. John Singleton, to the Hon. Wm. Tilghman.

"Your first question is, 'whether what I use be marl, or soil mixed with shells?'

"Whether it be marl or not, I will not pretend to determine, as I have seen no de-

scription of marl that answers exactly to it; but Mr. Tench Tilghman informed me he had seen a description of marl used in Scotland, exactly similar to what I use on the farm on which I reside, and which is the improved land you mention. I have not seen the account myself. However, this, and all mixtures of broken marine shells, of which there is a great variety, are now denominated marl, here. What I consider the best, and which I most use, is composed of small parts of marine shells, chiefly scallop shell, about one eighth of an inch square, or somewhat longer or smaller, with scarce any sand or soil with it: some of it seems to be petrified, and is dug up in lumps, like stone, from four or five, to forty or fifty pounds in weight, hard to break even with the edge of an axe, and will remain for years, tumbled about with the plough, before it is entirely broken to pieces, and mixed with the soil; indeed you may observe it in some parts of the bank, where the soil has been washed from it, appearing like rock stone; but if broken and pulverized a little, it effervesces very much with acids.

"I have applied it to all the soils on my farm, some of which is a cold white clay, and wet; others a light loam, and sandy. I find it useful to each kind, and manure my land all over with it, without distinction, and to advantage; putting a smaller quantity upon the looser soils. I have applied it as a top dressing on clover, and also where clover has not been sown, with a view to improving the grass, and also to be satisfied whether it would not be best for the ground, to let it lie spread on the surface, for a year before the ground was put into cultivation. But it has not answered my expectation. I could not perceive any advantage from that mode of application. I now constantly apply it to the ground cultivated in corn; carting it out in the winter and spring, and putting on from twenty to forty cart loads per acre, according to the ground, and the previous quantity that had been put on, in former cultivations, dividing each load into from four to eight small heaps, for the greater ease in spreading, according to the size of the load. Some is put on before, and some after the ground is broken up, but it is all worked into the soil by the cultivation of the corn, and it never fails of considerably improving the crop of corn, as also the ground wherever the marl is, especially in largest quantity. There is a small green moss, and black moist appearance, on the surface of the ground, when not cultivated; as you perceive about old walls, and in strong ground. Though the preceding is the common mode in which I use the marl, I do not think it the best: I mix some in my farm yard, with the farm yard and stable manure; and would prefer mixing and applying all that I use thus mixed, but for the labor of double cartage which I cannot as yet accomplish, manuring so largely as I do. I cultivate one hundred acres yearly, and constantly manure the whole of what I cultivate; employing only four carts, and four hands with the carts, which do all the manuring and carting on the farm.

"Your next question is, 'what has been my rotation of crops, and mode of cultivating, since I have used this manure?'

"Since I began to use the marl, and bend my attention to improvement by manure, I have cultivated only corn and wheat, sowing my ground in clover, and using the plaster. Instead of cultivating all my ground in corn, and sowing wheat on it as heretofore, I divided my cultivation into two parts, of fifty acres each, putting one part into corn, which I was able to accomplish manuring time enough for the corn, and making a fallow of the other part, manuring as much of it as I could accomplish before the time for sowing wheat; and disregarding, in a degree, all smaller crops, which I could not attend to, as an object, without increasing my number of hands, and interfering with the main business. I went on in this manner, till I found I could easily accomplish manuring one hundred acres and upwards, per annuo. Having got my ground to that state that I can risk making a crop without manure, I am now about discarding fallow, being able to manure my whole hundred acres time enough for cropping in the spring, by beginning to manure for the next year as soon as the spring manuring is finished. I shall in future have no wheat in fallow, but sow it after corn and other crops, from which I am satisfied I can make more from my ground than by naked fallow, which I always considered unprofitable, though you made more wheat, except for the advantage of having more time to manure.

"In saving my corn crop, I cut it up without pulling it from the stalk as usual, and cart it in all together, then husk it out, leaving the husk to the stalk: I lay these near my feeding yard, and throw them into it twice a day; this gives us a large quantity of strong healthy food for the cattle, which serves them all winter, and keeps them in good condition without any other food; makes a large quantity of excellent manure, and a fine dry feeding yard. As opportunity can be found, we cart marl, fuller's earth, clay, and any good soil that is convenient, into this yard, which being mixed with the stalks, and straw, or any thing else, penning the cattle on it through the winter and summer, instead of penning on the field, in the common way, we have a large quantity of manure to go out in the fall, and next winter; it is put into the field, in the intermediate rows, between the rows of marl, as far as it will go, and they will get mixed in the cultivation. We also convert the scouring of our ditches, the head-lands of the fields, and all waste-ground that we can, into manure, by carting litter, from the woods, yard manure, or

litter, &c., and mixing with them; so that I can nearly, or quite, now, accomplish making farm-yard and this kind of manure, sufficient to go over my whole hundred acres, annually. For the two last years, I have made more manure than I could accomplish or effect carrying out, though I have manured from ten to twenty acres more than my hundred, each year, with part marl and part farm-yard, but not the whole with both, as I hope to be able to do in future; but it will be necessary to increase my carting force to effect it, and I clearly see I can raise sufficient manure for the purpose; heretofore I have manured my corn-ground, fifty acres, with marl, and my fallow with part farm-yard manure, and part marl, as mentioned before; so that you will perceive the improvement made on my soil has not been effected by marl alone, but in conjunction with farm-yard manure, clover and plaster, and by making it a point to manure with something all the ground I put into cultivation; so that every time I cultivated a field, that field was improved, and not in any degree impoverished by the cultivation. By this means, and the Divine assistance, I have effected that improvement of my farm, which is so very striking to the observation of every person acquainted with it.

In August, 1805, in digging down a bank on the side of a cove, for the purpose of making a causeway, I observed a shelly appearance, which it struck me might improve clay soil; I took some of it immediately to the house, and putting it into a glass, with vinegar, found it effervesced very much; this determined me to try it as a manure; accordingly, in September, I carted out about eighty cart loads, and put it on a piece of ground, fallow, preparing for wheat, trying it in different proportions, at the rate of from twenty-seven to about a hundred loads per acre, and the ground was sown in wheat. I could not, myself, be satisfied that there was any difference through the winter and spring, although General Lloyd, who was viewing it with me in the spring, thought he could perceive some difference in favor of the marl; but at harvest time, the wheat, though not more luxuriant in growth, or better head, was considerably thicker on the ground; and after the wheat was taken off, the ground where the marl had been put was set with white clover, no clover being on the ground on either side of it. The next year, 1806, I discovered it in the drain into the head of the cove, which I immediately ditched, and from the ditch put out seven hundred loads, on the fallow ground. The effect, as to the wheat and clover, was the same, (this was put, for experiment, at the rate of from forty to a hundred and twenty cart-loads per acre,) though the marl was not of the same kind as the other, but more mixed with sand and surface soil, being taken from the low ground, by ditching, and all mixed together. I also tried it on corn ground, spread out as above mentioned, and found the effect immediate, as to the corn; and in the same manner as above described, as to the wheat sown on the corn ground. This induced me to persevere in the use of it, which I have done ever since, adopting the mode I mentioned before, and putting it at first from forty to seventy loads per acre, till I have now come down as low as eighteen or twenty loads per acre, going the third time over the ground with it.

NOTE VI.

FIRST VIEWS WHICH LED TO MARLING IN PRINCE GEORGE COUNTY.

(*From the Farmers' Register, Nov., 1839.*)

Among the persons who have read with interest the 'Essay on Calcareous Manures' and have received as sound the novel theory and doctrines there maintained, several have expressed their curiosity which had been excited to learn the earliest facts, or the train of reasoning, which led to the suggestion of the cause of the defect of naturally barren soils, and the remedy. Such inquiries have been made of the writer by persons of investigating and well informed minds, but of very different education and pursuits; and they were pleased to say, in regard to the concise verbal answers made to their inquiries, that they deemed the details likely to be interesting to many, and that if given to the public, they might serve better to induce the consideration and enforcement of the doctrines, than had been done by the mere arguments which had been already published, convincing as they considered the arguments to be.

Though, without these reasons and solicitations, the writer might have still refrained from touching this subject, it was not that he had not held the same opinion, and, except in his own case, would have urged the same course. It is certain, that the tracing of the steps by which any new discovery or improvement is reached, must always be interesting in proportion to the admitted importance of the results; and indeed such a statement seems almost necessary to induce the reader to accompany the author from his first premises to the remote conclusion, and which otherwise is only reached through a devious and tedious passage, and by a course of reasoning which is wanting in interest, because the application and tendency of the arguments and proofs are not seen when they are first presented. The objection which restrained the writer from before pursuing a course which he would have highly approved in others, was, that such a narrative of opinions and facts would be entirely a personal narrative, and therefore obnoxious to the charge of egotism throughout. The statement of the reasoning which led to the successful use of fossil shells on the poor lands of lower Virginia, would be incomplete if not accompanied by a narrative of early labors, and the early as well as latest results and effects. In the whole of this, there would be scarcely any thing but statements of what the writer thought, and reasoned, and performed. But the subject must be so treated, or not at all; and having consented to give the narrative, the writer will throw aside all scruples and objections, and endeavor to enter as much into detail, as he, if a reader of others' agricultural improvements and practical operations, would desire there to find.

With the beginning of the year 1813, when barely nineteen years of age, the easy indulgence of my guardian gave to me the possession and direction of my property; which consisted of the Coggins Point farm, with the necessary and yet very insufficient stock of every kind. It is scarcely necessary to add that, at my very early commencement, I was totally ignorant of practical agriculture; and such would have been the case, according to the then and now usual want of training of farmers of Virginia, even if my farming labors had been postponed to a mature age. But I had always been fond of reading for amusement, and the few books on agriculture which I had met with had been studied, merely for the pleasure they afforded, at a still earlier time of my boyhood. The earliest known of these works was an English book, in four volumes, the 'Complete Body of Husbandry,' of which I have not seen the only known copy since I was fifteen years old. This work was probably a mere compilation, and of little value or authority; but it gave me a fondness for agricultural studies, and filled my head with notions which were, even if proper in England, totally unsuitable to this country. 'Bordley's Husbandry' next fell into my hands, and its contents were as greedily devoured. This was indeed written in America, and by an American cultivator; but as he drew almost all his notions from English writers, his work is essentially also of foreign materials.

Thus prepared, I commenced farming, ignorant indeed, but not in my own conceit. The agriculture of my neighborhood, like all that I had ever witnessed, was wretched in execution, and as erroneous as well could be in system, whether subjected to the test of sound doctrine, or the improper notions which I had formed from English writers. I was right in condemning the general practice of my neighbors; but decidedly mistaken in my self-satisfied estimate of my own better information and plans.

Just about the time that my business as a cultivator was commenced, Col. John Taylor's 'Arator' was published; and never has any book on agriculture been received with so much enthusiastic applause, nor has any

other had such wide-spread early effects in affecting opinion, and stimulating to exertion and attempts for improvement. The ground had before no occupant, and therefore this work had to contend with no rival. The larger land-owners, of lower Virginia especially, had previously treated their own proper employment, and their only source of income, with total neglect; and very few country gentlemen took any personal and regular direction of their farming operations. It was considered enough for them to hire overseers, (and that class then was greatly inferior in grade and respectability to what it is now,) and to leave the daily superintendence to them entirely. The agricultural practices, and also the products, were consequently, and almost universally, at a very low ebb. The work of Taylor appeared when these evils had become manifest; and it was received with a welcome which in warmth was proportioned to the magnitude of the evil, and to the exaggeration of the promises of speedy and effectual remedy which the author made, with entire good faith no doubt, but which proved any thing but true to the great majority of his sanguine followers.

Of course, I was among the most enthusiastic admirers of 'Arator;' and not only received as sound and true every opinion and precept, but even went beyond the author's intention, (perhaps,) and applied his rules for tillage to lands of surface and soil altogether different from the level and originally rich sandy soils of the Rappahannock, where his labors and system had been so successful. However, this error was by no means confined to myself; for his other disciples fully as much misunderstood the directions, and misapplied the practices.

It was my main object to enrich my then very poor land; and for that, Taylor offered means that seemed to be sure and speedy. According to his views, it was only necessary to protect the arable land from all grazing, and thus let the vegetable cover of the land, when resting, serve as manure—to plough deep, and in ridges—to convert all the corn-stalks and other offal to manure, and plough it under, unrotted, for the corn—to put the farm under clover as fast as manured—and the desired result would be sure. I hoped at first to be able to manure, say 10 or 12 acres a year very heavily, with the barn-yard manure, and expected that such manuring would give a crop of 50 bushels of corn to the acre. The space, so enriched, when in the succeeding crop of wheat, would be laid under clover—and its acquired productiveness be made permanent, by the lenient rotation of two crops only taken from the land in four years. But utter disappointment followed. The manure was put on the poorest (and naturally poor) land; and it produced very little of the expected effect in the first course of crops, and was scarcely to be perceived on the second. Clover could not be made to live on land of this kind; and even on much better, or where more enriched, it was a very precarious crop, and which, where the growth was best, was certain to yield the entire occupancy of the ground to natural weeds after one year. The general non-grazing of the fields under grass, or rather under weeds, produced no visible enriching effect, and the ploughing of hilly land (as mine mostly was) into ridges, caused the most destructive washing away of the soil by heavy rains. These results were not speedily made manifest; and before being convinced of their certainty, I had labored for four or five years in using these means of supposed improvement of the soil, but all of which proved either profitless, entirely useless, or absolutely and in some cases greatly injurious. And even after trying to avoid the first known errors, and using all other supposed means for giving durable and increasing fertility to my worn and poor fields, at the end of six years, instead of having already achieved great improvement, I was compelled to confess that no part of my poor land was more

productive than when my labors commenced, and that on much of it, a ten-fold increase had been made of the previously large space of galled and gullied hill-sides and slopes.

When more correct opinions had been formed in after-time of the actual condition and requirements of such poor soils, it seemed an astonishing delusion, which would have been altogether ludicrous but for its serious effects, that I should have counted so much on improving such a soil, and by such means. With the exception of a small part near the river banks, (perhaps one-fifth of the then cleared and cultivated land,) which had been originally of very fine quality, and, however abused and exhausted, was still good land, the farm generally consisted of a soil of sandy loam, usually about three inches deep, and through which a single-horse plough could easily penetrate and turn up the barren and more sandy subsoil. Grazing the fields, when not under tillage, had been the regular practice; and under it very little growth was to be seen except the light and diminutive "hen's nest grass," which formed the almost universal cover of the poor fields of lower Virginia, in the intervals between tillage. Add to these circumstances of very poor and shallow soil, and barren and sandy subsoil, and almost no vegetable cover to turn under, that every field was more or less hilly, and liable to be washed by heavy rains—and the judicious reader will see nothing but false confidence and ignorance displayed in my bold adoption of Taylor's system. Nor was I convinced of my error until after nearly all the fields had been successively thrown into ridges by two-horse ploughs, and all the hilly and more slightly inclined surface had been awfully washed and gullied, by the exposure of the loose sub-soil to the action of the streams of rain-water.

While these my supposed measures of improvement were in progress, I was in habits of frequent and familiar intercourse with my oldest and best friend, and former guardian, Thomas Cocke, who resided then on his Aberdeen farm, and since and now, on Tarbay, adjoining my own land. My friend was a man for whose mind and mental cultivation I could not but entertain a very high estimation. But though all his life a practical and assiduous cultivator, and finding his greatest pleasure in his farming labors, he yet was a careless, slovenly, and bad manager, and of course an unprofitable farmer. Therefore, on this subject, I held in but light esteem the opinions which he maintained, which were opposed to my own. One of these, (and which he had first gathered from some old and ignorant, but experienced practical cultivators of his neighborhood,) was the opinion that our land which was naturally poor could not "hold manure," to any extent or profit, and therefore could not be enriched. For years I heard this opinion frequently expressed by him, and the evident inference therefrom, that the far greater part of our lands, and of the whole country, was doomed to hopeless sterility; and as often as heard, I rejected it as a monstrous agricultural heresy—as treason, indeed, to the authority of Taylor, and of every other author on agriculture whom I had read or heard of. But at last I was compelled, most reluctantly, to concur in this opinion.

What was then to be done! I could not bear the idea of pursuing the general system of the country in continuing to lessen the already small productiveness of my fields, by their course of cultivation. The whole income, and more, was required for the most economical support of a then small but fast growing family; and for any increase of income or net profit, there was no hope, save in the universal approved resort, in all such cases, of emigrating to the rich western wilderness. And accordingly such became my intention, fully considered and decided upon, and which was only prevented being carried into effect by subsequent occurrences.

Just before this time Davy's 'Agricultural Chemistry' had been published in this country; and I read it with delight, notwithstanding my then total ignorance of chemical science, and even of chemical names, except as learned by that perusal. There was one passage of this author which seemed to promise to afford both light and hope on the point in which disappointment had led me to despair. As an illustration of defects in the chemical constitution of soils, and of the remedies which proper investigation might point out, he adduced the fact of a soil "of good apparent texture," which was sterile, and seemed incapable of being enriched. The fact which struck so forcibly on my mind was presented in the following concise passage of Lect. iv. "If on washing [for analyzing] a sterile soil, it is found to contain the salt of iron, or any acid matter, it may be ameliorated by the application of quick-lime. A soil of good apparent texture from Lincolnshire, was put into my hands by Sir Joseph Banks as remarkable for sterility. On examining it, I found that it contained sulphate of iron; and I offered the obvious remedy of top-dressing with lime, which converts the sulphate into a manure."

Much the greater part of my land, and of all the land of lower Virginia, seemed to me just such as Davy described in this single and peculiar soil. It was certainly of "good apparent texture," that is, it was neither much too clayey or too sandy, nor had it any other apparent defect to forbid its being fertile in a very high degree. Yet it was and always had been sterile, and, as my experience now concurred with that of my older friend in showing, it could not be either durably or profitably enriched by putrescent manures. Could it be possible that the sulphate of iron (copperas) which Davy found in this soil, and which he evidently spoke of as a rare example of peculiar constitution, could exist in nineteen twentieths of all the lands of lower Virginia? This could scarcely be; and yet, in despair of finding other causes, I set about searching for this one.

It was not difficult, even for a reader so little instructed in chemistry, to apply the test for copperas. It was only necessary to let a specimen of the suspected soil remain soaking in pure water, until any copperas, if present, would be dissolved; then to separate the fluid by pouring off and filtration, and then to add to the fluid some of the infusion of nut galls. If copperas had been held in solution, the mixture would produce a true ink, of which the smallest proportion would be made visible in the before perfectly transparent water. But all these first attempts were fruitless, and I was obliged to conclude that the great defect, or impediment to improvement, in most of our soils, was *not* the presence of the salts of iron. But though not a salt, of which one of the component parts was an acid, might not the poisonous quality be a *pure* or *uncombined acid*? This question was raised in my mind, and the readiness produced to suppose the affirmative to be true, by several circumstances. These were, 1st, that certain plants known to contain acid, as sheep-sorrel and pine, preferred these soils, and indeed were almost confined to them, and grew there with luxuriance and vigor proportioned to the unfitness of the land for producing cultivated crops. 2nd. That of all the soils supposed to be acid which I examined by chemical tests, not one contained any calcareous earth.* 3rd. That the small proportion of my land, and of all within the range of my observation,

* I was not then aware, of the important and novel fact which I afterwards ascertained and established, and which is now fully received (with very slight acknowledgment of its source) by the geologists of this country, that *almost all the soils* on the Atlantic slope of this country, and even including nearly all limestone soils, are also entirely destitute of carbonate of lime, though that ingredient seems nearly if not quite universal in all the good soils of England and the continent of Europe.

which was *shelly*, and of course calcareous, was entirely free from pine and sorrel, and moreover was as remarkable for great and lasting fertility, as the lands supposed to be acid for the reverse qualities. Shells, or lime, would necessarily combine with, and destroy, all the previous properties of any acid placed in contact; and therefore, if acid were present universally, and acting as a poison to cultivated plants, it seemed plain enough why the shelly lands were free from this bad quality, and by its absence had been permitted to grow rich, and to continue productive. Every new observation served to add strength to this notion; and in our tide-water region generally, and even in my own neighborhood, there were plenty of subjects for observation and comparison, both in small shelly and fertile spots, and a vast extent of poor pine and sorrel-producing lands. Still, I could obtain no direct evidence of the presence of acid, either free or combined, by applying chemical tests to soils, (as was tried in many cases,) nor was there any authority in my oracle, Davy's 'Agricultural Chemistry,' nor in any other work which I had read, for supposing *vegetable* acid to be present in any soil. Though Davy adds to the supposition of the presence of the "salt of iron," "or any acid matter," it is clear from the whole context that he had in view the possible and extremely rare presence of a *mineral* acid (as the sulphuric,) and not *vegetable* acid, which my views required, and my proofs were afterwards brought to maintain. Sulphuric acid is sometimes found in certain clays, and in combination with iron is also in peat soils; but these facts have no application to ordinary soils of any country. Of course, this absence of authority would, to most inquirers, have seemed fatal to the position of an acid principle being *generally* present in the soils of Virginia, and in great quantity and power of injurious action. This was, indeed, a great obstacle opposed to the establishment of my newly-formed opinion; but it was not yielded to as insuperable. Diffident 'as I then was of any such views of my own, and holding the dicta of Davy as the highest authority, and even his omission of any position as evidence that it was untrue, or unknown, still I was not daunted, and supposed it possible that the soils of this country might vary essentially in composition in this respect, from those of England; or *barely possible* that even the great chemical philosopher might not have observed the presence of vegetable acid in the comparatively few cases of its existence in English soils. The later observations of subsequent years added much to my evidences of the existence of acid in soils; and still later and scientific investigations of chemists have served to establish that there *is* an acid principle in most soils, in the *humic* or *geic* acid. But these discoveries of chemists had not been published in 1817, (if indeed known to any) nor had my own observations reached to all the proofs which I afterwards (in 1832) published in the first edition (in book form) of the 'Essay on Calcareous Manures,' and which were still in advance of the publication of the now generally received opinions of the *geic* or *humic* acid. It must therefore, be confessed, that if I reached a correct conclusion, it was not on sufficiently established premises, and known chemical facts. However, reached it was, whether by right or by wrong reasoning; and however little supported by direct proof or authority, I was almost sure, in advance of any known experiment, first, that the cause of the unproductiveness and unfitness for being enriched of most of our lands, was the presence of acid—and secondly, and consequently, that the application of lime, or calcareous earth, would, by taking up and destroying the poisonous principle, leave the soil free to receive and to profit by enriching manures.

But even if this theoretical position had been demonstrated, still it might furnish no *profitable* practical remedy. For admitting that the application

of calcareous matters would relieve the soil of its great evil, and make it capable of receiving subsequent improvement, yet after being so relieved, the land, I supposed, would be still as poor as before, and would require all the manure, labor and time necessary to enrich any very poor soil; and these might be so expensive, that the improvement of the land would cost more than it would afterwards be worth. These considerations served to lessen my estimation of the practical utility of the theoretical truth, and to make my earliest applications of the theory to practice hesitating, and very limited in extent.

Having settled that calcareous matter was the medicine to be applied to the diseased or illy constituted soil, I was luckily at no loss to find the materials. In some of the many ravines which passed through my land, and on sundry parts of the river bank, were exposed some portions of the beds of fossil shells which underlie nearly all the eastern parts of Virginia and several other southern states; the deposit which then had obtained in this region, though improperly, and still retains the name of *marl*. I began operations in February 1818, at one of the spots most accessible to a cart. The overlying earth was thrown off, and a few feet in width of the marl exposed, in which a pit was sunk to the depth of but three or four feet. When night stopped the digging and throwing out of the marl, the slowly oozing water filled the pit; and as no proper plan of draining had been adopted, the first shallow pit was abandoned, and another opened. In this laborious and wasteful manner there was as much marl obtained as I was then willing to apply. It served to give a covering of 125 to 200 bushels per acre, to $2\frac{1}{2}$ acres of new-ground. The wood on the land had been cut down three years before, and suffered to lie and rot until cleared up for cultivation in 1818. Though poor ridge land, and of what I deemed of the most acid class of soils, still the previous treatment had given to it so much decomposed vegetable matter, that its product would necessarily be made the best which such a soil was capable of bringing. And because of the superabundance of food for plants then ready to act, this was not a good subject to show the earliest and greatest benefit of neutralizing the acid. However—notwithstanding this circumstance, and the small amount and poverty of the marl, (which contained but one-third of calcareous matter,) the improvement produced was greater and more speedy in showing than I had dared to hope for. When the plants were but a few inches high, and before I had expected to see the slightest improvement, (indeed none had been expected to show in the first year,) the superiority of the marled corn was manifest, and which continued to increase as the growth advanced. My high gratification can only be appreciated by a schemer and projector; but such a one can well imagine my feelings and sympathize in my triumph. The increase of the first crop, corn, I stated by guess, in reporting the experiment, to be fully 40 per cent., and that of the wheat which succeeded was much greater. Subsequent measurements of other products of experiments induced me to believe that I had under-rated the amount of increase in this first application. [This experiment is the first stated, and at length, at page 72 of 'Essay on Calcareous Manures,' 3d edition. Throughout this republished article, the references to the pages of the 'Essay on Calcareous Manures,' will be changed from the previous to the present edition.]

Great as had been the labor of this application, and small as its increased product, (comparing both with later operations,) the results served completely to sustain my theoretical views, and also showed the remedy for the general evil to be far more quick, and more profitable, than I had counted on. Another person would probably have despised this small

increase to the acre, if supposing the effect to be but temporary; and this all would have inferred, whether judging by comparison with all other manures known in practice, or even if by the authority of books. For the best informed of the old writers, (even Lord Kames, for example,) while claiming for the effects of marl great durability, still consider that at some period, say 20 or 100 years, the effects are to cease. But my views were not limited within any practical experience, or authority, but by my own theory of the action; and that theory taught me to infer that the benefit gained would never be lost, and that under proper cultivation, the increase of product would still more increase, instead of being lessened in the course of time. In thus fully confiding in the permanency of the improvement, I was at once convinced of the operation being both cheap and profitable. All doubt and hesitation were thrown aside, and I determined to increase my labors in marling to the utmost extent of my views. Still the want of spare labor, and the established routine of farm operations which occupied all the force, retarded my operations so much, that no more than 12 more acres (for the next year's crop) were marled in that year.

It forms an essential part of the character of an enthusiastic and successful projector, and especially an agricultural projector, to be as anxious to inform others as to profit himself. Of course I tried to bestow upon and share my lights with all my neighbors and other farmers whom my then secluded life permitted me to meet. This disposition also caused my earliest attempt at writing for even so small a portion of the public as constituted a little agricultural society of which I had induced the establishment in my neighborhood. To show my earliest opinions and statements on this subject, I will here quote the material part of a communication made to that society, and which was written in October of the year of my first experiment in 1818. I copy the extract just as it then stood, and with all its defects of form and of substance. I then shrunk in fear from the greater publicity which the press would have afforded, and had not the remotest anticipation that my first effort, then made, would lead me to the extent of intercourse since established and maintained with the public, both by writing and printing.

"We should be induced to infer from the remarks of those writers who have treated on the improvement of land, that a soil artificially enriched is equally valuable with one which would produce the same amount of crop from its natural fertility; and that a soil originally good, but impoverished by injudicious cultivation, is no better than if it never had been rich. If this conclusion be just (and the contrary has not been even hinted by them) it is in direct contradiction to the opinion of many intelligent practical farmers, with whom my own observations concur, in pronouncing that soils naturally rich, (although completely worn out,) will sooner recover by rest—can be enriched with less manure—and will longer resist the effects of the severest course of cropping, than soils of as good apparent texture and constitution, and in similar situations, but poor before they were brought into cultivation. Should the latter opinion be correct, it is of the utmost importance that the subject should be investigated; as the only conclusion that can be drawn from it is, that such land must have some secret defect in its constitution, some principle adverse to improvement: and until this is discovered and corrected, it is an almost hopeless undertaking to make a barren country permanently fertile, by means of animal and vegetable manure.

"That *inclosing** has but little effect in improving land naturally barren,

* The non-grazing system of Taylor.

is sufficiently proved by poor wood-land. This has had the benefit of inclosing for perhaps thousands of years, and is yet miserably poor. It may be said that leaves are not to be compared in value to grass or weeds; but surely leaves ought to improve as much in a thousand years, as grass or weeds in twenty. Besides, it is well known, that leaves taken from this very land, and applied elsewhere, have produced much benefit; and the advocates of inclosing must agree with me in ascribing to this cause the *natural* fertility of the most valuable land.

"As to manuring, there are but few farmers who have not, like me, experienced complete disappointment in endeavoring to improve land so little favored by nature. In the usual method of summer manuring, by movable cow-pens, the most negligent farmers give the heaviest covering, by suffering their pens to remain stationary sometimes six or eight weeks. I have known the surface in this manner to be covered an inch thick with the richest of manures, and yet, after going through the same course of crops and grazing with the adjoining unmanured land for six years, it could not be distinguished."

"If any one principle should be always found in one kind of soil, and as invariably absent in the other, we might reasonably infer that *that* was the cause of fertility or barrenness. Judging from my very limited observations, it appears evident that *calcareous earth* constitutes a part of every soil rich in its natural state, and that whenever a soil is entirely or nearly deficient, it never can become rich of itself, and if made so by heavy doses of dung, will soon relapse into its former sterility.

"Let us observe how facts coincide with this opinion. The lower part of Virginia is generally poor; narrow stripes along the rivers and smaller water courses are nearly all the high lands that are valuable, and in this class, exclusively, shells are seen so frequently, and in such abundance, that it seems highly probable that they are universally present, but so finely divided as not to be visible. When we know the change produced by calcareous earth in the color and texture of soil, and in a field of an hundred acres, all of the same dark-colored mellow soil, shells may be seen in only a few detached spots, yet we cannot but attribute the same effects to the same cause, and allow calcareous matter to be present in every part.

"The durable fertility of land which contains shells in abundance is so wonderful, that I should not dare to describe it, were not the facts supported by the best authority. The calcareous matter for ages has been collecting and fixing in the soil such an immense supply of vegetable matter, that near two centuries of almost continual exhaustion have not materially injured its value. I have seen fields on York, James, and Nansemond rivers, now extremely productive, which are said to have been under cultivation for thirty and forty years, without any aid worthy mentioning, from rest or manure.

"The same cause operates on low lands, formed by alluvion, and situated on streams accustomed to overflow. Such land is, with very few exceptions, of the first quality; and it is made so by the calcareous matter which the currents must necessarily convey from the strata of marl through which they pass; and which being intimately mixed with sand, clay, and vegetable matter, is sufficient to form the finest and deepest soil. All the rich low grounds which I have had an opportunity of observing, have marl on some of the streams which fall into them, and I have not heard of any on those few which are poor. Not a solitary instance of shells being found in poor land of any description has come to my knowledge.

"If these premises are correct, no other conclusion can be drawn from them but that a proportion of calcareous earth gives to soil a capacity for

improvement which it has not without; and it also follows, that by an application of shell-marl, the worst land would be enabled to digest and retain that food, which has hitherto been of little or no advantage." * * *

"The property of fixing manures is not more important in marl, than that of destroying acids. The unproductiveness of our lands arises not so much from the absence of food as the presence of poison. We are so much accustomed to see a luxuriant and rapid growth of pines cover land on which no crop can thrive, that we cannot readily see the impropriety of calling such a soil absolutely barren.

"From the circumstance of this soil being so congenial to the growth of pine and sorrel, (both of which are acid plants,) it seems probable that it abounds in acidity, or acid combinations, which, (although destructive to all valuable crops,) are their food while living, and product when dead. The most common forest trees are furnishing the earth with poison as liberally as food, while it depends entirely on the presence of the antidote, whether one or the other takes effect. I have observed a very luxuriant growth of sorrel on land too poor to support vegetables of any kind, from green pine brush having been buried to stop gullies; and it is well known how much land on which pines have rotted is infested with this pernicious plant. Marl will immediately neutralize the acid, and this noxious principle being removed, the land will then for the first time yield according to its actual capacity. Sorrel will no longer be troublesome; and, by a very heavy covering, I have known a spot rendered incapable of producing it, although the adjoining land was thickly set to the edge. Pines do not thrive on shelly land, whether fertile or exhausted. To this cause I attribute the great and immediate benefit I derived from marl on new-ground. The acid produced by the pine leaves is destroyed, and the soil is capable of supporting much heavier crops, without being (as yet) at all richer than it was."—*Communication to Prince George Agricultural Society.*

Before proceeding to state later experiments, and general practice and results, it will be necessary to recur to some other connected branches of the subject. The reader will pardon the apparent digression.

So well established and general has the opinion now become that this *marl* is a manure, and a most valuable one, that it may seem strange that I should have only arrived at such an opinion indirectly, by the train of reasoning indicated above. There were hundreds of persons who afterwards said, "Oh! I never doubted that marl was a good manure;" but not one of whom had been induced to try its operation. But passing by these *postponing* believers, and all others who confessedly never attached any value to this great deposit, it may require explanation why I had not learned its value from English works which treat so extensively on marl, even though I had then had access to but few of them. It was precisely because I had read attentively some of the English accounts of marl that I was deterred from using *our marl*, which agreed with it (apparently) in nothing but name. Struck with the importance attached to marl in England, I had earnestly desired to find it, and had searched for it in vain, years before the early beginning of my farming. The name induced a close examination of what was called marl here; but the "soapy feel," the absence of grit, the crumbling and melting of lumps in water, &c., which were the most distinguishing characteristics of the marl of the English writers, were in vain looked for in our shell beds—of which the earth was generally sandy, never "soapy," and of which the lumps were often of almost stony hardness, and if not, at least showed nothing of the melting disposition of the English marls. I had before this found, however, in the American edition of the 'Edinburgh Encyclopædia,' more modern

and correct views of marl, and had thereby learned to prize *calcareous matter* in general as an ingredient of soil, whether natural or artificial. But still, even admitting that the shelly portion of our marl would slowly decompose, and gradually furnish some manure to the soil, still it seemed that there was little prospect of its operating as the English marl, of such very different texture and qualities. I then supposed that the shells which had resisted decomposition, even where exposed on the surface of the beds, for centuries, would be as slow to dissolve, and to act as manure if laid upon the fields. Still, notwithstanding these grounds of objection, the general idea of the value of calcareous manures would have induced me earlier to try fossil shells, but for being *deterred* therefrom by the only actual facts then known of the use. When speaking of my thought of trying marl to my friend Mr. Cocke, he told me that it was not worth the trouble; that he (attracted merely by the name,) had made several small applications, in 1803, on soils of different kinds, and that he had found almost no visible benefit; and he had attached so little importance to the trial, that he had never thought to mention it, until induced by my remark. This communication was enough to check my then slight disposition to try marl. The old experiments of Mr. Cocke, as well as some much older, and, like his, considered worthless by the makers and almost forgotten, are stated at page 70 of this edition of 'Essay on Calcareous Manures.'

As soon as I was satisfied that I had found in marl a remedy for the general and fixed disease of our poor lands, it became very desirable to know the strength of different beds, and of the different parts of the same bed. The rules of Davy for determining the proportion of carbonate of lime were easy to apply; and having provided myself with the necessary tests and other means, I was soon enabled to analyze the specimens with ease and accuracy. This was a delightful and profitable direction of my very small amount of chemical acquirements, and served to stimulate to further study. The amount of knowledge was indeed very small—and is still so with all later acquirements added. But little as I had been enabled to learn of chemistry, the possession led me to adopt my views of the constitution of soils, and enabled me to double the product, and to much more than double the clear profit and pecuniary value of my land, in the course of a few years thereafter.

Though my own doubts as to the propriety and profit of marling had been removed by my first experiments, it was not so with my neighbors. Small applications were indeed made by two of them only, in the next year after my first trial. But either because the land had been kept too much exhausted of its vegetable matter by grazing as well as by cropping, or because the experimenters could not think of the operation of the manure as different from that of dung, or for both these reasons, it is certain that they were not encouraged by the results to persevere. They stopped marling with their first trial, until several years after, when both recommenced, then fully convinced of the benefit, and were afterwards among the largest and most successful marlers. One of these persons was the late Edward Marks, of Old Town, and the other my old friend Thomas Cocke—who, though he had led me to find the disease, could not be speedily convinced of its true nature, or of the value of the remedy. As late indeed as 1822, when he walked with me to an enormous excavation which I was then making in carrying out marl, he said to me, "In future time, if marling shall then have been abandoned as unprofitable, this place will probably be known by the name of '*Ruffin's Folly*.' " For some years, my marling was a subject for ridicule with some of my neighbors; and this was renewed, when in after-time the great

damage caused by improper applications began to be seen, and which will be described in due order.

Having had in view from the beginning the true action of marl, and fully believing that its good effects would be permanent, and even increasing with time, under a proper system of tillage, I was no more discouraged by what some deemed small profits, than I was annoyed by the incredulity and ridicule of other persons. Almost all the farms in the neighborhood, except mine, were regularly and closely grazed when not under a crop, and of course they had not stored up in the soil much either of inert vegetable matter, or its acid product. Mine had not been grazed since 1814, and had been rested two years in every four; and the poorest land three years in four. And though, in truth, no increased production had been obtained by this lenient treatment, inasmuch as the increase of acid counterbalanced the increase of vegetable food, still, when marl was applied, the acid was immediately destroyed, and the food left free to act. The effect of marling was generally shown most plainly on the first crop of corn, and the limits could be easily traced by the deep green color of the plants before they were five inches high; and the increased product of the first crop on acid soils rarely fell under 50 per cent., was most generally 100, and has been known to be 200 per cent. But even such increase was not satisfactory to many persons, until the action of marl came to be better understood, and the permanency of the effects were credited. In five or six years after my commencement, there were few if any of those of my neighbors, who had marl visible on their lands, who had not begun to apply it. And though it has been injudiciously as well as insufficiently applied since, and not one-fourth of the full benefit obtained, still the general improvement and increased products of the marl farms of Prince George have been very great. The existence of marl too, which was known at first but on a few farms in my own neighborhood, has been since discovered in many and remote parts of the county; and wherever accessible it is valued and used. The like observations will now apply to most of the other counties of lower Virginia. Wherever the effects of marling could be seen for a few years, the early incredulity not only disappeared, but most persons were even too ready to believe in marl possessing virtues to which it has no claim. Thus, ignorant or careless of its true mode of operation, they crop the marled lands more severely than before; and if they are not thereby soon reduced as low as their former state of sterility, they are made to approach it as nearly as possible, and at a sacrifice of nine-tenths of the profit from marling which a more lenient and judicious system of cultivation would have insured.

In 1819, the second year of my operations, my marling was increased to 62 acres, but most of it at too thin a rate. In 1820, only 25 acres, though at 600 heaped bushels or even more to the acre. Up to this time I had done as most other persons have, that is, attempted to marl "at leisure times," and without making it a regular employment for a certain additional force, or reducing the amount of cultivation, or of other operations on the farm. No person will ever marl to much advantage who does not avoid this error; and this year's labors showed the necessity of an alteration. The next year, two horses and carts, with the necessary drivers and pit-men, were appropriated to marling at all times when weather permitted, except during harvest, thrashing, and wheat-sowing times. Viewing marling too as the most profitable operation, except the saving of a crop already made, it was made a fixed rule of the farm that marling was to be interrupted for nothing else. My corn shift for that year was reduced in size one half—so that one half could be marled while the other was under cultivation. By

these means, I marled 80 acres this year, 1821, (and that much too heavily,) and had all the lessened corn-field on marled land. The product of the half was equal to what the whole had brought before, and I was enabled thereafter to have every field marled over in advance of its next cultivation. In 1822, the land marled was 93 acres, 100 in 1823, and 80 in 1824, which served to cover nearly all of the then cleared land requiring marling. The next three years' marling amounted respectively to 50 acres, 24 acres, and 27 acres, being principally upon land subsequently cleared and brought into cultivation. Since then, there has been no marling on the farm, except on wood-land, not yet cleared, and on small spots formerly omitted, and of which no account was taken. With the exception of such spots, (and some such still remain, because of their inconvenient position,) all the land which was not naturally calcareous, or too wet or too steep for carting on, had been marled by 1827; and none has required any additional dose, though some of the thinnest covered places had been re-marled long before that time, so as to bring them to a proper constitution.

In 1824, I first observed, (and had never before suspected such effect,) the injury caused by having marled acid soil too heavily. To show my first impressions, I will copy the words of my farm journal, written on the very day on which the discovery was fully made.

"June 13th, 1824. Observed a new and alarming disease in a large proportion of my corn; and, what makes the matter much worse, the evil is certainly caused by marling. The disease seems to have commenced when the corn was from 6 to 10 inches high, and to have stopped its growth. Its general color is a pale sickly green, and the leaves appear so thin as to be almost transparent: next they become streaked with rusty red, and then begin to die at the upper ends. Several pulled up, showed no defect, or injury from insects, among the roots. All the land marled from pits Nos. 7 and 9 (both yellow) from 1820 to 1822, is so much diseased as to promise not more than half a crop. The corn is twice as large as on the spaces left for experiment without marl, yet looks much worse; though three weeks ago its superiority in color and vigor was even more than in size. With but few exceptions, the land *newly* marled from the same pits, and the old marling from Nos. 1 and 8, (both blue,) as well as that not marled, are free from this disease. The parts most affected are those which were driest and poorest, and of course were least covered with vegetable matter. Yet though the corn on this old marling is generally so bad, it is yet evident that the land is more benefited by the manure than at first: flourishing stalks of corn, 18 to 24 inches high, are seen frequently within a few feet of those most hurt by this disease."

Subsequently, when the whole extent of injury could be seen, the following remarks were written in the journal, at the date below.

"October 15th. The damage caused by marl to this crop I suppose to be about one third of what the land would otherwise have made, judging from the present and former measurements of the same land, where experiments were made.

"Nearly all the heavy marling in Finnies, (at 800 bushels,) about 20 acres,* suffered by it; the poorest and lightest most injured, here and in Court-House field. The few rich spots escaped, as did most of the piece plastered (on the heavy marling) in 1820. The marks of this experiment were destroyed, and the superiority was not so regular as to enable me to trace the outlines of the gypseous earth—but an acre of corn might be taken which certainly was plastered, better than any other acre in the old

* See Exp. 10, p. 83, Essay on Cal. Man.

land. This at least proves that *gypsum* contained [if any] in the marl has not caused the disease. The poor land, lightly marled in 1819, showed but little of the disease, and none was found in the piece not marled, nor in any marled since the last crop [or now first cultivated since being marled.]

"In Court-House field the injury was confined to 19 acres, the poorest part of the field, which was in corn in 1821,* marled and fallowed, 1822, and in wheat 1823, corn 1824. The remainder of the old land, which had not been cropped so severely, and was covered as heavy with *blue marl*, brought a fine crop, quite free from the disease. The new ground was mostly marled very heavy (800 bushels of 45 per cent.)† and this and all my former clearings, (some marled equally heavy,) were also quite free. These facts satisfy me that it was not the quality, but the over quantity of marl which has caused the evil; and that the land which has escaped, owes its safety to its containing more vegetable matter. I forgot to state that on some of the lightest spots of South Field the wheat was much injured, though blue marl was used there.

"If I had followed my own advice to others, "to put no more marl at first than would but little more than neutralize the soil, and repeat the dressing afterwards," this evil would not have fallen on me. The present loss is not much; but it makes me expect the same on all similar land, marled as heavily. I shall endeavor to avoid it, by giving vegetable matter to the soil; either by manuring, or by allowing one or two more years of grass in the first term of the rotation. *Why* the quantity of marl applied should do harm in *any* case, is more than I can tell; but I draw this consolation from the discovery—if a certain quantity, (say 500 bushels per acre,) is too much for present use of the soil, it proves that it will combine with more vegetable matter, and fix more fertility in the soil, than I had supposed. That the second crop should be injured, and not the first, is owing to the unbroken state of the shells at first, and, by their being reduced, twice as much calcareous matter is in action after a few years."

Thus it will be seen, from these entries made at the time, that I took a correct view of this great and unlooked-for evil, and was by no means discouraged, or induced to lessen my efforts in marling. But in all after operations on poor land, the quantity was lessened from 500 and 600 bushels, (and even more of the poorest marl,) to about 300 bushels. With this alteration, the operation was continued with as much zeal as before; and also at a later time on another farm (Shellbanks) purchased afterwards, and where I marled upwards of 400 acres.

When this injury was first discovered, about 250 acres of very similar land had been marled so heavily that the like mischief was to be looked for in the next crop, and thenceforward, if not guarded against. For a more full account of this disease, and my opinions thereon, I must refer to what has been before published.‡ It is sufficient here to say that by pursuing the means there advised—in allowing more rest from grain crops, furnishing vegetable matter to the land, in its natural cover of weeds, in clover and farm-yard manure so far as the limited supply sufficed—that no very great loss was subsequently suffered, except in the field where the disease was first discovered, and which was marled in 1819. This field was too remote and inconveniently situated, to be manured from the barn-yard; and from that and other causes, (including the failure of the first seeding of clover,) that field only still shows injury from marling in the present crop (1839;)

* Exp. 11, p. 86.

† Exp. 1 to 4, pp. 72 to 77.

‡ Essay on Calcareous Manures, *ante*.

so much diminished however, that its general average product this year is fully twice as much as the land could have brought before being marled.

The results of many particular experiments made during the progress of marling this farm were stated in the 'Essay on Calcareous Manures,' and the general benefits and improved products were described in a later publication.* It is not necessary here to repeat these statements. But as this article may come under the notice of some readers who have not access to the others, the general results, as produced in the whole period of twenty-two years, from the earliest experiment to the last product, will be here very concisely and generally stated.

The many and extensive old galled parts of sloping land, wherever dressed with marl, and even without the further help of barn-yard manure, are now nearly all *skinned over* by a newly formed soil; and though such soil is still both poor and thin, and may yet long remain so, the *whole* of its present productive power is due to marling; as such galled land was before naked, entirely barren, and irreclaimable by other manures. Where much or rich putrescent matter has been also applied to galls, with or after marl, both rich and durable soil has been formed, though at great cost.

The more level parts of the old and greatly exhausted fields, and the newly cleared wood-land, (both kinds being naturally poor, thin, and acid soils,) are the only lands which have enjoyed any thing like the full beneficial effects of marling. These have been increased in product from 5 and 10 bushels of corn per acre (which may be considered the usual minimum and maximum rates,) to at least 20, and in some cases to 30 bushels, even without the aid of barn-yard manure. Where putrescent manures have been also applied, they have raised the products much higher; and these manures are now as durable and as profitable as formerly they were fleeting and profitless in effect.

The before poor and light soil which formed the greater part of the old arable lands, and which was not above three inches in depth, (and scarcely two inches when in its natural forest state,) is now seven inches or more, and requires three-horse ploughs to break it to proper depth, where the one-horse ploughs formerly would frequently reach and bring up the barren subsoil.

The fertilizing operation of marl has increased with time, even where the effects were also the most speedy, and most profitable on the first crop after the application.

The soil, which before was totally unable to support red clover, is now (except on the most sandy spots) well adapted to the growth, and capable, according to the grade of fertility, of receiving the great benefit which is offered by that most valuable of improving crops.

And generally—notwithstanding all the many and great errors committed in my marling, (for want of experience,) and of still worse general farm management—and though a considerable proportion of the old land was either but little or not at all fit to be improved by marling—and though the land added since by new clearings was all very poor, and worthless for its natural producing power—still the general annual grain products of the farm have been increased from three to four-fold, and the net profit of cultivation and the intrinsic value of the land have been increased in a still greater proportion.

* See p. 112, vol. vii. of Farmers' Register.

Addendum, 1842.

The following table of crops, with the annexed remarks and notes, will perhaps be more satisfactory than the preceding statements of general results, besides serving to bring the report down to the present time.

It is proper to premise, that after 1827 I ceased to keep a regular farm journal, and neglected even to preserve accounts of the amount of crops. Ill health and other circumstances had caused me several years before that time to withdraw much of my personal attention from my farming. In 1830, my residence was permanently removed from the farm, and thereafter my superintendence was more and more withdrawn, until it ceased entirely at the end of 1838. Hence the blanks which will be seen in this part of the table. At the close of 1838, my eldest son became the part owner and occupant, and since has been sole director of the farm. Though it was then placed in charge of a new beginner, who had every thing to learn of farming, the management has since been much improved, and consequently also the condition and production of the farm, as shown by the table.

The quantities and other facts, stated below, are taken from careful memoranda noted at the times of the occurrences, and are precise wherever presented as such, according to the best lights possessed by the cultivator. But the volume of my former journal, which embraced the transactions of 1824 to 1827 inclusive, has been lost; and for want of recent reference to it, there may be some inaccuracy in the *dates only* of operations within that time, as well as in the next few succeeding years.

TABLE OF CROPS ON COGGINS POINT FARM.

Year.	Acres sown.	Acres in wheat.	Product in bushels.	Average per acre.	Acres in corn.	Product in bushels.	Average per acre.	Acres in cotton.	Bales of cotton.	Acres in oats.	Bushels of oats.	Acres in roots, vines, &c.
1813		145	510	5 ⁵ / ₁₄	125	2250	18					
1814		110	550	5 ¹ / ₄	163	1340	8 ³ / ₁₆					
1815		78	520	6 ⁵ / ₁₂	136	1955	14 ¹ / ₁₆					
1816		104	896	8 ⁶ / ₄	144	2300	16					
1817		79	595	7 ³ / ₁₀	188	2050	10 ¹ / ₁₀					
1818	15	63	450	7 ⁶ / ₁₀	160	2670*	16 ¹ / ₁₀					
1819	62	132	1015	7 ⁹ / ₁₀	137	2000*	14 ¹ / ₁₀					
1820	25	119	1020	8 ¹ / ₁₀	164	2780*	17					
1821	80	160	1049	6 ⁶ / ₁₀	77	1775	23					
1822	93	154	1627	10 ¹ / ₁₀	114	2250*	19 ¹ / ₁₀					
1823	100	139	1475	10 ³ / ₁₀	158	3000*	19					
1824	80	194	1850	9 ¹ / ₁₀	156	3405*	21 ⁴ / ₁₀					
1825	50	195	1452	7 ⁹ / ₁₀	70	1254	17 ⁶ / ₁₀	48				
1826	24	170	1390	8 ¹ / ₁₀	138	2275*	16 ⁶ / ₁₀	70				
1827	§27	151	1366	9 ¹ / ₁₀	104	1665*	16	76	37			
1828	0	153	936	6 ¹ / ₁₀	112	1750	15 ⁷ / ₁₀	90 ¹ / ₂	55			
1829	0	134	908	6 ¹ / ₁₀	133	2300	17 ¹ / ₁₀	96				
1830	50	-	-	-	-	-	-	50 ¹ / ₂	33			
1831	0	-	-	-	-	-	-					
1832	0	-	-	-	126	2830	22 ⁵ / ₁₀					
1836	10	-	394 ^e	-	-	4415	-					
1837	0	-	2056	-	-	2620	-					
1838	0	-	2117	-	-	2070†	-					
1839	2	167	1252†	7 ¹ / ₁₀ †	190	4500	23 ¹ / ₁₀	30	600			
1840	c12	228	1942	8 ¹ / ₁₀	143	3540	24 ¹ / ₁₀	50	1000			5 ^c
1841	c32	212	2475	11 ¹ / ₁₀	146	3800	25 ¹ / ₁₀	10	200			10 ^c
1842	30	250	3377	13 ¹ / ₁₀	155	3500 ^b	22 ⁹ / ₁₀	50	1000			10 ^c

Explanatory remarks on the land and its management.

Quantity of land for cultivation (exclusive of waste parts,) at first, 472 acres; increased by new clearings to 602 by 1826; to 652 in 1832; and no more in 1842 though 30 more acres have since been cleared and tilled, because as much in 1836 converted to a permanent pasture. All the new land added by clearing was poor, and very few acres of it would have produced more than 10 bushels of corn, or 5 of wheat (without the marling) after the 3 or 4 first crops. Of course the new land added served to reduce instead of increasing the general average product per acre.

Rotation at first of three-shifts, viz.: 1 corn, 2 wheat on the richer half, 3 at rest, and after 1814 not grazed. This changed gradually to 4 shifts (by 1823) of 1 corn, 2 wheat, 3 and 4 at rest. 1820 began to fallow for wheat, in part and only in some years. In 1826 or 1827 began to sow the wheat fields generally in clover, and about 1835, to fallow a part (say one-fourth to one-third) of each clover field for wheat the year preceding the crop of corn. This changed in 1840 to a five-shift rotation, one-fifth of the arable land being in corn, two-fifths in wheat (and oats) and two-fifths in clover, or other green or manuring crops.

The crops of wheat for first six years (1813 to 1818) raised on the richer parts of each shift, making about one-half the land only; the other half being then much too poor to be sown. As these poorest parts were marled, all were sown in wheat, in their turn. Therefore, the earlier average products of wheat per acre as stated, were for the richest half of the land, while since 1822 the average is for the worst as well as the best land of each shift.

Grazing the clover fields commenced partially about 1830, and increased since. Later about 20 head of cattle and 100 of hogs on the clover during the grazing season.

The crops of hay, corn-fodder, &c., being all consumed on the farm, their products have not been estimated.

Notes on particular crops, &c.

a 1818 to '22 inclusive, 27 acres of rich embanked marsh in corn every year, which served to increase these crops, and their average—which land sunk too low after 1823 for corn, and has since been under the tide.

c In 1818, the first marling.

1828, oats on 17 acres.

1829 to 1830, a succession of bad seasons for wheat, or of crops—made much worse (as I afterwards believed,) by the land having been so long kept from being grazed and trodden by cattle.

* These crops not actually measured, but amounts otherwise estimated. All other quantities measured, unless stated otherwise.

§ The richer half of the shift only cultivated in corn this year (1821.)

§§ Marling nearly extended over all the cleared arable land requiring it, and injurious where too thick.

From 1825 to 1830 inclusive, the richest land of the farm kept under cotton, which served greatly to lessen the general products, and still more the average product per acre of the wheat crops, during that time.

|| 13,027 lbs. of cotton, net weight as sold, or 170 lbs. to the acre.

e 1836, the wheat crop nearly destroyed by rust, as was general through eastern Virginia.

† Corn crop of 1838 and wheat crop of 1839 very much lessened by the ravages of the chinch-bug.

c, c. On 26 of these acres the marling was a second application.

d The crops of oats being consumed on the farm, were never measured, but the quantities estimated by the land sown, at 20 bushels to the acre.

e The root crops, (turnips and beets,) and pumpkins and cymblins, occupied part of the most highly enriched land—all consumed on the farm, and products not estimated.

b The crop of corn of 1842 stated upon supposition, it not being half gathered when this article was prepared.

NOTE VII.

(From the Farmers' Register of Oct. 1835.)

INQUIRY INTO THE CAUSES OF THE FORMATION OF PRAIRIES, AND OF THE PECULIAR CONSTITUTION OF SOIL WHICH FAVORS OR PREVENTS THE DESTRUCTION OF THE GROWTH OF FORESTS.

Introductory remarks.

The views which will be presented in the following pages are in part founded on others which were maintained, and are considered as established in the 'Essay on Calcareous Manures'—as, for example, the doctrine of the existence and causes of acid and still more of neutral soils—the chemical power of calcareous earth to combine with and to fix vegetable or other putrescent matter in soils—and that a certain proportion of lime, in some form, is essential to every productive soil, and without which ingredient the land would be barren, and incapable of being enriched. As the repetition here of the whole train of argument by which those doctrines were sustained would be both unnecessary and improper, it may be permitted merely to refer to the work named for these positions, as premises established, and either known, or accessible to every one who may feel interest in the further extension and consideration of the same general subject, which is here designed.

The necessity of making frequent reference to a previous and avowed work, and also the having elsewhere stated the general purport of this, will prohibit the writer from presenting this continuation anonymously; which otherwise would have been preferable, both on account of the writer's connexion with the journal in which this will appear, and because the subject is one which will derive no support from its origin, being a matter of general argument resting on facts and authorities within the reach of every reader. But as these circumstances made it necessary that the piece should not be anonymous, for convenience the ordinary form of a communication to the Farmers' Register has been adopted. Whatever of opposition to editorial usage may appear in these respects, it is hoped will be sufficiently accounted for, and held excused by the existing circumstances. However confident the writer may be of the main positions which he will aim to establish in the following pages, he is sensible that he is venturing upon a new field of investigation, which is as yet unexplored—and indeed almost untouched, except by those who have paid no attention to the problem to be solved, or of others who, with better lights of science, have fallen into gross and manifest errors and mistakes. Under such circumstances, he cannot expect to avoid being misled in many particulars; and he will be gratified at having such errors corrected, and the subject fully and properly treated by any other person possessing better means for receiving information, and pursuing this interesting subject of inquiry.

General and erroneous opinions respecting the growth or absence of trees on land in a state of nature.

There exists a wide-spread and strongly marked difference between the lands of different regions of the globe, in their being covered, or not, with trees, before being subjected to cultivation. But striking and strongly contrasted as are these different aspects of parts of the earth's surface, and much as each kind, when a novel scene, has drawn forth expressions of wonder and admiration from travellers, the causes have not been sought—

indeed have scarcely attracted any attention. Yet, even if considered as a mere matter of curiosity, not likely to bring to light any thing of practical use, there is scarcely one of Nature's riddles which would seem better calculated to interest philosophical, and especially agricultural investigators. These very different kinds of garb which are worn by different regions of the earth, extend over vast spaces, and of course are accompanied with many remarkable changes both of climate and soil. It follows that there are not many persons who have been accustomed to more than one of these conditions of the face of the earth; and those who have been, were not of the class the best qualified for investigating the subject. The first European settlers of North America were, by the contrast to their native lands, the more forcibly impressed by the magnificent forests of which there seemed to be no end, and no change, except from the greater abundance of one luxuriant and gigantic growth to that of others. But this universal cover of the land, so different from any thing before known, was merely described with admiration by Europeans. No cause was sought for, or thought wanting; and they remained content with most erroneously attributing the luxuriant growth of trees to the fertility of the soil, and the want of the labors of tillage.*

The children of the early settlers grew up among forests, and they and their children, judging from all they saw, learned to consider that almost all soils, rich or poor, naturally would be covered by trees; and while falling into this error, they at least got rid of that of their forefathers, in connecting the idea of a luxuriant forest growth with great fertility. When the spread of population finally brought the latter descendants to the borders of the Mississippi, and the great prairies of the west first opened to their astonished view, this change was as great as unaccountable, and yet the cause as little sought, as that of the universal forest state had been by the first emigrants from Europe. But ignorant wonder soon ceases, and leads

* The words of the founder of Virginia, Capt. John Smith, show that the noble growth of trees which he and the other first European visitors found, gave them a very high and certainly mistaken opinion of the general fertility of Lower Virginia. "Within [the capes of Virginia,] is a cuntry that may have the prerogative over the most pleasant places knowne, for large and pleasant navigable rivers: heaven and earth never agreed better to frame a place for man's habitation, were it fully manured and inhabited by industrious people. Here are mountains, hills, plaines, valleyes, rivers, and brookes, all running most pleasantly into a faire bay, compassed, but for the mouth, with fruitful and delightsome land."—"The vesture of the earth in most places doth manifestly proue the nature of the soyl to be lusty and very rich. The colour of the earth we found in diverse places resembleth bole Armoniac, terra a sigillata, and Lemnia, fuller's earth, marle, and divers other such appearances. But generally for the most part it is a blacke sandy mould, and in some places a fat slimy clay, and in other places a very barren gravell. But the best ground is knowne by the vesture it beareth, as by the greatnesse of trees, or abundance of weeds, &c."—"Virginia doth afford many excellent vegetables, and living creatures, yet grasse there is little or none, but what groweth in low marishes: for all the cuntry is overgrowne with trees, whose droppings continually turneth their grasse to weeds, by reason of the racknesse of the ground, which would soone be amended by good husbandry. The wood that is most common is oke and walnut, many of their okes are so tall and straight that they will beare two foote and a halfe square of good timber for 20 yards long."—(*Second Booke of the True Travels, Adventures, and Observations of Captaine Iohn Smith, &c. London, 1629.*) Captain Smith was altogether unskilled in agriculture, and it may be presumed that when he spoke of the need of such rich land being "fully manured," as well as inhabited, he meant nothing more than that it should be properly cultivated—of which, manuring was deemed a general and necessary part. But this accidental (and according to his views, erroneous) expression, was much nearer the truth than the opinion of fertility being proved by the "greatnesse of trees;" for much the greater part of the land bearing the largest and most magnificent growth of oaks, pines, and other common trees, was in truth poor then, and will ever remain so, without the application of calcareous matter.

to no profitable search for causes, or for truth. The children of the first settlers of the west have grown up among prairies; and when another century shall have passed, and our frontier settlements shall have reached the base of the Rocky Mountains, it may begin to be believed there, that the forest state is rarely known to nature, and is only produced by the labors and care of man. So the Bedouin Arab thinks the world is made of naked sand—and the Shetlander's world is of wet peat.

Of course these general remarks apply to those who are acquainted only with some one region of the world, and who have not been informed of others by books, any more than by travel. Among the more learned, there has been no lack of causes assigned for these opposite appearances; but they are such as to show a strange disregard of all the requisites of sound reasoning, and of accurate investigation. Any reason that was first advanced, however insufficient, however absurd, seems to have been readily admitted, and to have passed current from one traveller, or writer, to another. Thus, to the annual fires alone has been attributed the destruction of trees, and the formation of the great prairies of the west; and this cause has been deemed sufficient by both the learned and the ignorant. The objection to it is, that all the Atlantic slope was burned over as often as the west, before the settlement of the country, and in the former (at least east of the mountains) not one acre of prairie had been produced.

Philosophical writers have maintained supposed causes of the destruction of the forests which formerly covered England, which are very plausible when considered alone. But precisely similar causes have been operating long and generally in this country, and our forests not only do not decay and die, but continue to defy every agent of injury, except the thorough use of the axe and plough. Even where long continued tillage has the most effectually eradicated the natural and original forest growth, if the impoverished land is merely let alone for thirty years, it will (in most cases) be better covered with a new growth of trees, than the utmost care could raise in England. Examples of the facts and reasoning referred to are presented in the following passage from Davy. "In instances where successive generations of vegetables have grown upon a soil, unless part of their produce has been carried off by man, or consumed by animals, the vegetable matter increases in such a proportion, that the soil approaches to a peat in its nature; and if in a situation where it can receive water from a higher district, it becomes spongy, and permeated with that fluid, and is gradually rendered incapable of supporting the nobler classes of vegetables.

"Many peat-mosses seem to have been formed by the destruction of forests, in consequence of the imprudent use of the hatchet by the early cultivators of the country in which they exist: when the trees are felled in the out-skirts of the wood, those in the interior are exposed to the influence of the winds; and having been accustomed to shelter, become unhealthy, and die in their new situation, and their leaves and branches, gradually decomposing, produce a stratum of vegetable matter. In many of the great bogs in Ireland and Scotland, the larger trees that are found in the out-skirts of them bear the marks of having been felled. In the interior, few entire trees are found; and the cause is, probably, that they fell by gradual decay; and that the fermentation and decomposition of the vegetable matter was most rapid where it was in the greatest quantity."—[*I. ec.* 4.] In Virginia no one forest tree has been known to die, or even to decline, from being exposed in the manner above described as so fatal: and such effects being produced in England would only prove that the soil was unfavorable to trees, and their life therefore feeble and sickly, and ready to yield to any new and considerable cause of injury.

The entire absence of trees for 900 miles across the Pampas between Buenos Ayres and the Andes, has been still more absurdly attributed to the winds (called *pamperos*) which often sweep across those wide plains with such violence, that no trees could withstand their power. I have seen in our forests where a hurricane had uprooted or broken off every tree of size in its course. But no wind could destroy the young and flexible under-wood; and if such winds swept the same track every year, or every month, they would not prevent it being thickly covered with young sapling trees.

The downs in England, which have not been tilled for hundreds of years, and are only valuable for sheep pasture, show no rising growth of trees. This is not held strange there, but would be supposed sufficiently accounted for by the poverty of the soil, and the (supposed) impossibility of young trees growing, even if planted on open pasture land, without any care, and where they were always exposed to the attacks of live stock. But in Virginia, no degree of poverty, no exposure to grazing, will prevent untilled land growing up in wood. Annual fires, grazing animals, and poverty, wetness or sandiness of soil, all may prevent the growth of trees, as alleged in different countries; but all these are but secondary causes which would have little or no effect, without the more powerful operation of some other and primary cause. *This cause will be found in the peculiar constitution of the soil*; and I will proceed to state my reasons for believing that the cause of the different conditions of land as to being naturally covered with trees, or not so in general is merely *the deficiency of lime in the soil, or its abundance*—the former state being friendly to forest growth, and the latter being as unfriendly. Or—in terms so general as to cover all the exceptions which will hereafter be admitted to the foregoing position—it may be stated, that the formation of prairies, &c., is caused by *the existence of such circumstances as favor the growth of grass in a far greater degree than the growth of trees*—and of all such circumstances, the abundance of calcareous matter in the soil is the most efficient.

In addressing readers residing in, or otherwise well acquainted with the Atlantic states, it is unnecessary to adduce facts to prove the general and strong disposition of the soil to produce trees, in vigor and luxuriance—to resist the labors of man for their destruction—and to return to the state of forest whenever tillage is intermitted. No untilled land will long remain naked, or in grass; and even under a regular rotation of crops, the labor of grubbing to destroy young trees is continually required on most lands, and particularly on those originally of inferior quality. Our poorest lands in lower Virginia, are generally covered with young pines in four or five years after being left without tillage, and their after-growth is as rapid and heavy as European timber growers would expect on the best lands, and with every care bestowed for that end. But it is not only to pines, (though that is the most striking case,) that this applies. In the higher and stiffer lands, where pines are rare, the springing of other young trees shows the same general tendency of the soil. If this tendency can be said to be feeble any where in lower Virginia (and it may be presumed that the same state of things exists in all the Atlantic states,) it is on the few naturally rich soils on the rivers, some of which are the only lands naturally calcareous in the country, and all of which derived their natural fertility and permanent value from possessing lime in some form as an ingredient. In the 'Essay on Calcareous Manures' proofs have been exhibited of this supposed quality of such lands,* and therefore they will not be repeated here. It has also been maintained

* Part I, chapter vii.—On neutral soils.

in the same work, and the proofs exhibited at length, that in Virginia and the Atlantic states generally there are few soils containing naturally any portion whatever of *carbonate of lime*—and all the vast region which is so peculiarly constituted in being destitute of this ingredient, is precisely that which so strongly favors the growth of trees.

Over all this great extent of country, we may suppose that the aboriginal inhabitants sent fires every year to aid their hunting. Indeed it would have been scarcely possible to avoid it, when almost the whole country was under one great forest, and the entire surface covered with dry leaves. For more than a century after the settlement of the present race of civilized inhabitants, fires passed over the wood-land almost every spring—caused either by the carelessness or design of hunters, or by the farmers to forward the growth of grass for their cattle. It required legal prohibitions, added to the general extension of tillage, and the great damage of burning fences, &c., to put a stop to this practice of burning the woods. Even in these latter times we hear of fires of tremendous fury sweeping hundreds of square miles in Maine, destroying timber, and every combustible matter on the few small farms in this yet wild region. Yet no where below the mountains, nor in any poor region, has the wood growth been destroyed—nor has an acre of prairie been thus formed, whether on land rich or poor. This is enough to prove that no violence or frequency of fires can destroy and keep down the growth of trees, unless aided by some other and more efficient agent.

The most general cause of the absence of trees.

The next position that will be assumed is, that most of the prairies, pampas, steppes and downs, which are bare of wood, though never tilled, are highly calcareous, and therefore unfriendly to the growth of trees.

The proofs necessary to maintain such wide ground, directly and absolutely, would require more of time, and labor of investigation, than the labors and life of any one individual would suffice for; therefore the facts that will be offered are considered only as specimens of the thousands which the world could furnish, and to be taken as fair samples of all, only while they remain uncontradicted by other opposing facts. No traveller having (to my knowledge) sought to learn or to report any particular information as to the constitution of such soils, or having attached any importance to the presence or absence of calcareous ingredients, I have only been able to gather indirectly from their observations the scattered testimony which will be adduced. Unfortunately no traveller has been a scientific agriculturist; and though many have been mineralogists, geologists, or chemists, they have given no attention to the constitution of the soils over which they passed, nor did any seem to consider that the composition of the soil had any bearing on its strange external features, which were the theme of their admiration. Dr. Clarke, distinguished as he deservedly was as a man of science, has told as little of the nature of the soil of the Russian steppes, as most of the least uninformed of the observers of our prairies.

Proofs—derived from the general description of prairies, pampas, steppes, &c.

Before entering more upon particulars, in addressing readers who are generally (like the writer) accustomed only to soils favorable to trees, it is proper to describe generally the features of the great regions which are bare of such growth, and which, under the different names of *prairies*, *barrens*, and *savannas* in North America, *pampas* in South America, and *steppes* in

Russia and Tartary, form a very large portion of those parts of the globe. All of these, with various grades of fertility, and many points of difference in other respects, agree in being, or having been at some time when in a state of nature, bare of trees, or nearly so, and in being clothed with grass of greater or less luxuriance.

The word "prairie" was first applied by the French colonists, and means, in their language, a *meadow*. The name therefore plainly enough designated all land covered only with grass. The name of "barrens," so strangely applied in Kentucky to very rich lands, of this kind, was owing to the resemblance of the dry grass on these lands to the broom grass which covers and grows luxuriantly on the naturally poor soils of lower Virginia, when left out of cultivation. This resemblance caused the surveyors who were sent to lay off the Virginia military lands, to reject these as barren soil, and the term then so erroneously applied to an extensive region, has still continued to be used, and even has been extended to similar lands elsewhere.

It will be most sure and satisfactory to use the language of the writers who have seen and described these regions, rather than to attempt a more general and condensed description, at the risk of changing the purport of their expressions. None of these writers, nor any that I have been able to consult, give any direct and positive testimony derived from analysis, as to the soil being supplied, or not, with calcareous ingredients. It is only from incidental observations of the nature of the rocky subsoil, the kinds of grass, &c., that any information of this kind has been indirectly gathered. All that can be said is, that such testimony, so far as it goes, is in favor of the calcareous composition of such soils generally. Such expressions as most strongly (though indirectly) support my views of the constitution of prairie soils, or show a resemblance of one of these regions to some other better known, will be put in italics.

The first extracts will be from the *Views of Louisiana*, by H. M. Breckenridge, a writer intimately acquainted with the western country, and who describes what he had travelled over and seen. The Louisiana of which this work treats includes not only the state as now bounded, but all the vast region lying west of the Mississippi, formerly held under that general name by the French and Spanish governments.

"This extensive portion of North America, has usually been described from the inconsiderable part which is occupied by the settlements, as though it were confined to the immediate borders of the Mississippi, as Egypt is to those of the Nile. By some, it is represented in general description as a low, flat region, abounding in swamps and subject to inundation; which is the same thing as if the Netherlands should furnish a description for all the rest of Europe. Others speak of Louisiana as one vast forest of wilderness:

"Missouri marches through the world of woods ;"

which is far from being the case, for excepting on the banks of this river, and that not more than one-half its course, the country through which it passes is deplorably deficient in woods. If, then, we are to describe Louisiana, not from a small district, important because already the seat of population, but from the appearance of the whole, combined in a general view, we should say, that it is an extensive region of open plains and meadows, *interspersed with bare untillable hills*, and with the exception of some fertile tracts in the vicinity of the great rivers by which it is traversed, resembling the grassy steppes of Tartary or the Saharas of Africa, but without the numerous morasses and dull uniformity of the one, or the dreary sterility of the other. The fertile tracts are chiefly to be found in the

narrow valleys of the great rivers Missouri, Mississippi, Arkansas, Red river, and some of their principal tributaries; the two largest bodies of fertile soil are the delta of the Mississippi, which is much interspersed with lakes, marshes, and sunken lands, that will require ages to reclaim, and the territory of the Missouri, as limited by the boundaries lately agreed on with the Indians, which bears a strong resemblance to the West Tennessee in some of its features.”—pp. 66, 67.

“A remarkable feature in this western side of the great valley [of the Mississippi] is its deficiency of wood, while the opposite (with the exception of some parts on the north side of the Ohio, where the woods have been burnt,) is a close and deep forest. The woods continue for a short distance up the Mississippi before they disappear, and the grassy plains begin. The banks of the Missouri are clothed with luxuriant forest trees for three or four hundred miles, after which they gradually become bare, and the trees diminish in size; at first we find thin groves of the kind of poplar called cotton wood, but of a diminutive growth, intermixed with willows; next the same tree, reduced to half its height, and resembling an orchard tree; after this a thin border of shrubbery is almost the only ornament of the margin of the river. The same thing may be said of the Arkansas and Red river.

“Taking the distance to the mountains to be about nine hundred miles, of the first two hundred, the larger proportion on the Missouri and its waters is well adapted to agricultural settlements, its soil and conveniences are equal if not superior to those of Tennessee or Illinois; this tract will include the greater part of the White and Osage rivers, the lower Missouri, and for at least one hundred and fifty miles north of this last river. The proportion of wood gradually lessens to the west, and still more to the north, with the addition that the lands become of an inferior quality. For the next three hundred miles, the country will scarcely admit of compact settlements of any great extent; the wooded parts form trifling exceptions to its general surface, and are never met with but on the margin of the rivers. We may safely lay it down, that after the first two hundred miles, no trees are found on the uplands, save stunted pines or cedars; the rest of the country consists of open plains of vast magnitude, stretching beyond the boundary of the eye, and chequered by numerous waving ridges, which enable the traveller to see his long wearisome journey of several days before him. Yet, it does not seem to me, that the soil of this tract is any where absolutely unproductive; it is uniformly covered with herbage, though not long and luxuriant like that of the plants nearer the centre of the valley; it is short and close, but more nutritious to the wild herds, than the coarse grass of the common prairie. This tract has not the dreary barrenness described by Johnson in his Tour to the Hebrides; the green carpet which covers, and the beautiful shrubberies which adorn it, afford relief to the eye. But again, it is very doubtful whether trees could be cultivated; for I observed that *the trees which by accident are permitted to grow, are but dwarfs*; the oak for instance, is not larger than an orchard tree, the plumb is nothing more than a shrub, in some places not exceeding a currant bush. There are, however, scattered over the immense waste, a number of spots which greatly surpass in beauty any thing I have ever seen to the east of the Mississippi. But there are others, again, barren in the extreme, producing nothing in the best soil but hyssop and the prickly pear.”—pp. 69, 71.

“Thus it appears, that with the exception of a belt of one hundred and fifty, or two hundred miles in width, at most, stretching from the Missouri, in a line parallel with the course of the Mississippi, across the Arkansas and Red river to the Sabine, about twice the territory of New York, but not a

tenth part of the western section of the valley, the province of Louisiana is little better than a barren waste, and that the eastern side will always contain a much greater population."—p. 72.

"This western region, it is certain, can never become agricultural; but it is in many respects highly favorable for the multiplication of flocks and herds. Those delightful spots, where the beauty and variety of the landscape might challenge the fancy of the poet, invite to the pastoral life. How admirably adapted to the interesting little animal, the sheep, are those clean smooth meadows, of a surface so infinitely varied by hill and dale, covered with a short sweet grass, intermixed with thousands of the most beautiful flowers, undeformed by a single weed.

"I confess that, to me, nature never wore an aspect so lovely as on the lonely plains of the west. From their dry and unsheltered surface, no damp and unwholesome vapors rise to lessen the elasticity of the air, or dim the brilliant blue of the heavens. So transparent is the atmosphere, that a slight smoke can be discerned at the distance of many miles, which curiously exercises the caution and sagacity of the fearful savage, ever on the watch to destroy, or to avoid destruction. And then, that sublime immensity which surrounds us; the sea in motion is a sublime object, but not to be compared to the varied scenes which here present themselves, and over which the body, as well as the imagination, is free to expatiate. The beams of the sun appeared to me to have less fierceness, or perhaps this might be owing to the cool breezes which continually fan the air, bringing upon their wings the odors of millions of flowers. The mind appears to receive a proportionate elevation, when we are thus lifted up so much higher than the centre of the valley. There was to me something like the fables of fairy land, in passing over a country where for hundreds of miles I saw no inhabitants but the buffalo, deer, the elk, and antelope: I have called it the paradise of hunters, for to them it is indeed a paradise. There are, however, some important drawbacks on the advantages of this country, even considered as a pastoral district. To the north of the Missouri, rains are extremely rare, but when they are set in, pour down in torrents, while to the south their place is chiefly supplied by heavy dews. In the dry season, which is from the month of June until the latter end of September, at a distance from the great rivers, *water is every where exceedingly scarce.* The buffalo at this time leaves the plain and seeks the rivers, and the Indians in their excursions to any considerable distance are obliged to shape their courses by some known pond, and to carry besides a quantity of water in bladders. It is possible, that wells might be sunk, but it is certain, that at this season *one may travel for days without finding a drop of water*; one may frequently pass the beds of large rivers which have disappeared in the sands, but after rains, or on the melting of the snows, impassable torrents are seen to fill their channels, and to roll down in turbid and frightful floods."—pp. 73, 75.

"The tract of country north of the Missouri is less hilly than that on the south, but there is much greater proportion of prairie. It has a waving surface, varied by those dividing ridges of streams, which in Kentucky are called *knobs*. These prairies, it is well known, are caused by repeated and desolating fires, and the soil is extremely fertile.

"The plains of Indiana and Illinois have been mostly produced by the same cause. They are very different from the savannas on the sea board, and the immense plains of the Upper Missouri. In the prairies of Indiana, I have been assured that the woods in places have been known to recede, and in others to increase, within the recollection of the old inhabitants. In moist places, the woods are still standing, the fire meeting there with obstruc-

tion. Trees, if planted in these prairies, would doubtless grow. In the islands, preserved by accidental causes, the progress of the fire can be traced; the first burning would only scorch the outer bark of the tree; this would render it more susceptible to the next, and the third would completely kill. I have seen in places, at present completely prairie, pieces of burnt trees, proving that the prairie had been caused by fire. The grass is usually very luxuriant, which is not the case in the plains of the Missouri. There may doubtless be spots where the proportion of salts, or other bodies, may be such, as to favor the growth of grass only.

"Such woods as remain are fine, but the quantity of adjoining prairie is usually too great. There are large tracts, however, admirably suited for settlements: a thousand acres or more of wood land, surrounded by as much of prairie. It is generally well watered with fine streams, and also interspersed with lakes. There is an extensive strip of land along this side of the Missouri, of nearly thirty miles in width, and about one hundred and fifty in length, altogether woods, and of excellent soil. An old gentleman, who has seen Kentucky a wilderness, informed me that the appearance of this tract is similar, with the exception of its not being covered with cane, and a forest so dark and heavy. The "Forks of the Missouri" (such is the name given to the northern angle formed by the two great rivers) daily increases in reputation, and is settling faster than any part of the territory.

"The Missouri bottoms, alternately appearing on one side or other of the river, we have already seen, are very fine for three hundred miles up, generally covered with heavy timber; the greatest part of which is cotton wood of enormous size. The bottoms are usually about two miles in width, and entirely free from inundation. The bottoms of the Mississippi are equally extensive and rich, but not so well wooded. They are in fact a continued succession of the most beautiful prairies or meadows. The tract called *Les Mamelles*, from the circumstance of several mounds, bearing the appearance of art, projecting from the bluff some distance into the plain, may be worth describing as a specimen. It is about three miles from St. Charles; I visited it last summer. To those who have never seen any of these prairies, it is very difficult to convey any just idea of them. Perhaps the comparison to the smooth green sea is the best. Ascending the mounds, I was elevated about one hundred feet above the plain; I had a view of an immense plain below, and a distant prospect of hills. Every sense was delighted, and every faculty awakened. After gazing for an hour, I still continued to experience an unsatiated delight, in contemplating the rich and magnificent scene. To the right, the Missouri is concealed by a wood of no great width, extending to the Mississippi, the distance of ten miles. Before me, I could mark the course of the latter river, its banks without even a fringe of wood; on the other side, the hills of the Illinois, *faced with limestone*, in bold masses of various hues, and the summits crowned with trees; pursuing these hills to the north, we see, at the distance of twenty miles, where the Illinois separates them, in his course to the Mississippi. To the left, we behold the ocean of prairie, with islets at intervals. The whole extent perfectly level, covered with long waving grass, and at every moment changing color, from the shadows cast by the passing clouds. In some places there stands a solitary tree of cotton wood or walnut, of enormous size, but from the distance diminished to a shrub. A hundred thousand acres of the finest land are under the eye at once, and yet, on all this space, there is but one little cultivated spot to be seen."—pp. 204,206.

"—— Nothing else was visible—not a deer, not a tree—all was prairie—a wide unbroken sea of green—where hollow succeeded hollow, and the

long grass waved on the hills with a heavy surf-like motion, until at last it was blended with the hazy atmosphere, which met the horizon. The power of sight was shut out by nothing; it had its full scope, and we gazed around until our eyes ached with the very vastness of the view that lay before them. There was a degree of pain, of loneliness, in the scene. A tree would have been a companion, a friend. It would have taken away the very desolation which hung round us, and would have thrown an air of sociability over the face of nature; but there were none. The annual fires which sweep over the whole face of the country during the autumn of every year, effectually destroy every thing of the kind. There will be no forest as long as the Indians possess these regions; for every year, when the season of hunting arrives, they set fire to the long dry grass. Once fairly on its errand, the destructive messenger speeds onward, licking up every blade and every bush; until some strip of timber, whose tall trees protect the shrubbery, by the dampness which they diffuse beneath, or some stream, stops it in its desolating path.

"The object of burning the grass is to drive the deer and elk that are roving over the broad extent of the prairies, into the small groves of timber scattered over the surface. Once enclosed within these thickets, they fall an easy prey to the hunters."—*Irving's Indian Sketches*, 1835.

The next extracts are from an article in Silliman's Journal, by W. W. McGuire, on the prairies of Alabama.

"In speaking of the prairies, the rock formation claims particular attention. It is *uniformly found below the prairie soil*, at various depths, ranging from ten to fifteen feet, and it sometimes projects above the ground. This rock is generally known by the name of *rotten limestone*; when removed for several feet on the top, and exposed to the action of the atmosphere for some time, it assumes a beautiful white color. In its soft state it is easily quarried, and blocks of almost any dimensions can be procured. It has been dressed by planes and other instruments, and used in building chimneys, some of which have stood twelve or fifteen years without injury or decay. A summer's seasoning is requisite to fit it for building. This rock has been penetrated by boring to depths varying from one hundred to five hundred and fifty feet; after the first six or seven feet, it is of a bluish or gray color, but still soft except in a few instances, where flint strata of a foot thick or more have been met with. On perforating the rock, a full supply of good water is always obtained, which uniformly flows over the top. I have heard of no constant running stream of water over this rock, except one in Pickens county, near the lower line. The superincumbent earth is for a few feet composed principally of stiff clay, of whitish color; then comes the mould of soil, which is very black—in wet weather it is extremely miry and stiff, and in dry, very hard and compact.

"Shells, such as the oyster, muscle, periwinkle, and some other kinds, are found in great quantities throughout almost all the prairies of Alabama and Mississippi; the first named being the most numerous, mixed in every proportion with the others. The oyster shells are perfectly similar to those now obtained from the oyster banks on the shores of the Atlantic. The largest beds of shells in the open prairies seem to occupy rather elevated, but not the highest places. They have probably been removed from the more elevated situations by torrents of rain. It may be that the lowest places never contained any shells; or if they did, as vegetable matter accumulates in greater quantities in low situations, they may have been thus covered. In some instances I believe they have been found in such places, several feet below the surface. They are not found in very large quantities in the timbered prairies; and indeed, so far as I have observed, where-

ever the shells are numerous, vegetation is not so luxuriant as where there is a proper admixture of the decomposed or decomposing shells and vegetable matter.

"These shells and other decomposing materials appear to have given a peculiar character to the prairie soil, which causes it to adhere so strongly to the legs of horses and to the wheels of carriages as to remain several days in travelling, unless washed or beaten off. Yet, when well broken up, at the proper season, and regularly ploughed, it remains quite mellow, producing corn and cotton equal to the best alluvial bottoms, with, so far as it has been tried, increased fertility; although, from the compact nature of the rock beneath, and the tenacity with which it retains moisture, crops are injured sometimes by rains, but seldom by drought.

"There being no opening or fissures, except above the rock, by which to convey the water directly to the channel of creeks and rivers, there are consequently *no reservoirs to contain supplies for fountains and springs*. In the winter and spring seasons the streams overflow and the land is literally submerged. In the summer and autumn *neither springs nor wells are to be found*, except below the rock; yet, notwithstanding this scarcity of water, there is seldom a lack of moisture for the purpose of vegetation. And at times when the drought is such as to produce fissures two or three inches wide, and as many feet deep, *the earth will be found quite moist at the depth of two or three inches*.

"There are open prairies of every size, from one hundred to one thousand or twelve hundred acres, mixed and interspersed in every form and mode with timbered land of all kinds; some producing only black-jack and post oak, not exceeding fifteen or twenty feet in height; others again covered with the most majestic oak, poplar, elm, hickory, walnut, pacaun, hackberry, grape-vine and cane, equal in size and beauty, I understand, to similar kinds in the Mississippi alluvions.

"The extent of this country may not be unimportant. I am informed that traces of prairie soil may be seen in Georgig, perhaps as far east as Milledgeville. It is indeed said to exist in North Carolina; but of this I have not evidence such as to warrant the assertion. That it stretches nearly five hundred miles eastward from the vicinity of the Mississippi on the west almost to Milledgeville, there is no doubt; and if it extends, as is said to be the fact, to North Carolina, it reaches four hundred or five hundred miles farther, being perhaps nine hundred or one thousand miles long, and from forty to sixty in breadth."

In addition to the foregoing extracts, several communications to the Farmers' Register, (which are before its readers,) confirm these statements, and (independent of the aid of chemical analysis, which will be referred to hereafter,) show that the prairie soils of Alabama generally are intermixed with calcareous earth, and universally underlaid with that substance in a much more pure form, yet soft enough to be penetrated by roots.* The letter of N. D. Smith, Esq., in the last number gives a like account of the underlying stratum of the prairies of Arkansas. Such is also the account of Mr. Featherstonhaugh in his geological report of that region—and in addition to the calcareous character of the underlying soft rock, he speaks (though not in very definite terms) of the black rich soil above, as being substantially calcareous.† Another similar fact in a remote locality, has recently been published. A tract of prairie land in the northwest part of Pennsylvania,

* See Farm. Reg. pp. 276, 277, 367, of vol. i.—and pp. 637, 716, 717, vol. ii, and p. 140, Essay on Calcareous Manures.

† See extract from the report at page 147, vol. iii. Farm. Reg.

lies on calcareous earth, so pure as to be converted, by being burnt, to lime of the best quality. This earth reaches to within a foot of the surface.*

The next extracts present sufficient ground for considering the steppes and prairies as belonging to the same class.

"In all parts of the river [Don] above Kasankaia, it seems to flow over a bed of chalk; and its banks, gently swelling upwards from the water, rise like the South Downs of Sussex; often disclosing the chalk, of which they consist. Farther down, and near the water's edge, low copses of wood almost always accompany its course; but they diminish as it draws nearer to Tscherchaskoy, the inhabitants of which town derive all their wood from the Volga.

"As soon as we left Kasankaia, we entered the *steppes* in good earnest, with a view to traverse their whole extent to Tscherchaskoy. These are not cultivated; yet, bleak and desolate as their appearance during winter must be, they have in summer the aspect of a wild continued meadow. The herbage rises as high as the knee, full of flowers, and exhibiting a most interesting collection of plants. No one collects or cuts this herbage. The soil, though neglected, is very fine. We passed some oaks in the first part of our journey, which had the largest leaves I ever saw."—*Clark's Travels in Russia*, p. 189.

"Leaving this encampment, we continued traversing the *steppes* in a south-westerly direction, and passed a very neat village belonging to a rich Greek, who, to our great surprise, had established a residence in the midst of these desolate plains. As we advanced, we perceived that wherever rivers intersect the *steppes*, there are villages, and plenty of inhabitants. A manuscript map at Tscherchaskoy confirmed the truth of this observation. No maps have been hitherto published in Europe which give an accurate notion of the country. A stranger crossing the Cossack territory, might suppose himself in a desert, and yet be in the midst of villages. The road, it is true, does not often disclose them; but frequently, when we were crossing a river, and believed ourselves in the midst of the most uninhabited country, which might be compared to a boundless meadow, we beheld villages to the right and left of us, concealed, by the depth of the banks of the river, below the level of the plain; not a single house or church of which would have been otherwise discerned."—p. 198.

"From Acenovkaia, we continued our route over *steppes* apparently destitute of any habitation. Dromedaries were feeding, as if sole tenants of these wide pastures."—p. 199.

Dr. Clarke, though traversing a vast extent of steppes, says very little more of them than is presented in the short quotations above. They give a clear though indirect indication of their chalky formation, and similarity to the *downs* of Sussex in England. Yet the author seems to have attached no importance to these facts, nor does he take any other notice, direct or indirect, of the nature, or chemical composition of the soil. Yet, in addition to his scientific attainments as a chemist and mineralogist, his botanical knowledge, if properly applied, would have thrown much light on this subject. I have no doubt but hereafter the character of soils, as to possessing calcareous matter abundantly, or being destitute of that ingredient, will be determined with certainty by the presence or absence of many different plants. Dr. Clarke gives a catalogue of many of the plants observed in his journey, and of them a few are stated to have been found on the steppes.

* See Farmers' Register, page 169, vol. iii.

These are copied below,* that others who have some knowledge of botany, may be able to state whether these plants are confined to calcareous soils or not. If the author had stated that sheep sorrel was a common growth of the steppes, I would at once admit, from that solitary fact, that the soil must be destitute of calcareous earth. In like manner, if the soil is highly calcareous, some of the plants which he observed there, or which may be found on the prairies, would afford as certain proof of that fact, as the presence of sorrel would of the reverse. These suggestions are thrown out for the consideration of investigators who have the knowledge and opportunities requisite to put them to use. It is a new field for botanists, which promises a sure and valuable harvest.

The next extracts, which are from Tooke's *View of the Russian Empire*, will give more full information of the steppes.

"*Arable land.*—Under this head we must reckon various tracts of land, especially, 1. Those that are kept in constant cultivation and tillage, such as are every where seen in Great and Little Russia, in the provinces bordering on the Baltic, and many others. 2. Such as are only used at times, and left quiet for a great length of time. In some regions, for instance, in Little Russia, about the Don,† &c. where they are looked upon as steppes, which if merely ploughed and then sown, would be productive; in others, for example, in Livonia, Esthonia, and Ingria, where they are rendered fertile by fire, and are called by the countrymen bush-lands.‡ On such parcels of ground, which are either allotted into particular possessions, or without a proper owner, villages might be gradually erected. In uninhabited districts these tracts are most frequent. 3. Those that are proper for agriculture, but lie totally unemployed: they wait only for industrious hands. There are still plenty of these vast tracts where millions of men might find work and profit, especially in fruitful steppes, and in numberless large forests.

"The fertility of all these tracts is very different according to the quality of the soil. In Livonia and Esthonia, from good fields they reap 8, and in successful years from 10 to 12 fold; from indifferent ground about only 3, but from better, at times 16 or even more than 20 fold. The harvests about the Don are commonly 10 fold; but towards Tomsk on the Tshumush, and in the whole region between the Oby and the Tom, many fields afford an increase of 25 to 30 fold,§ and at Krasnoyarsk the failure of a crop was never heard of; of winter corn they reap 8, of barley 12, and of oats 20 fold.||

"In Little Russia, on the Don, and in many other places, the fields are never manured, only ploughed once, just to turn up the earth, afterwards harrowed, and then sown: more culture, especially dunging, would push the

* "*Centaurea frigida*, northern knap weed—on the steppes." "*Centaurea radiata*, rayed knap weed—on the steppes near Koslof. The sheep feed on it in winter, and it is supposed to give them that gray wool so much valued by the Tartars." "*Crocus sativus*, autumnal meadow-saffron—steppes near Achmetchet." "*Geranium sylvaticum*, wood crane's bill—steppes." "*Silene quadrifida*, four-cleft catch-fly—steppes, near Perecop," "*Sisymbrium Loeselii*, Loesel's hedge-mustard—steppes near Perecop." "*Statice trigona*, three-sided lavender—in the steppes, very frequent." "*Vescia pannonica*, Pannonian vetch—steppes. "*Stipa Pennata*—in all the steppes." Many other plants are named in different parts of the work, as found in the region of steppes, but it is not certain that they were always from such soil, and therefore are not added to this list.

† The Don Kozak takes, in whatever part of the steppe he chooses, a piece fit for cultivation, and, bestows his labor upon it as long as he thinks proper or as long as its visible fertility will amply reward his labor.

‡ See Hupel Lief. and Esthl. vol. ii.

§ Pallas, vol. ii. p. 650 et seq.

|| Ibid. vol. iii. p. 6.

corn up too luxuriantly or parch it, and so hurt the harvest, as the soil is sufficiently fertile of itself. Of equal goodness is the ground in great part of Siberia; for example, on the Samara, on the Ufa in the country of the Bashkirs, here and there in the Baraba, or the Barabianian steppe, also on the Kama, whence a great quantity of corn is sent to the northern cornless dwelling-places on the Dvina and Petshora. In like manner too in the government of Isetsk the soil generally consists of a black earth, to the depth of an ell, consequently is proper for tillage, for meadow-land, and garden ground. On the Oby near Barnaul, the black earth does not indeed go very deep, *but the marly clay* that lies under it fertilizes it so much* as to make it, in some places, yield plentiful harvests, without manuring, for twenty years successively.† At Krasnoyarsk, the fields will bear no manure whatever, and yet continue fruitful for 10 or 15 years, if only suffered to lie fallow every third year.‡ When the fertility ceases, the boor takes a fresh piece from the steppe. On the Selenga, in the district of Selenghinsk, the fields are hilly, and yet will bear no manure, as it is found on repeated trials to spoil the corn.”§

Speaking of the meadow land, the same author says—

“Some steppes produce the best meadow-grass for provender, and yield seed for making artificial meadows; such as the *esparcette*, the alpine hedy-sarium, *clover*, various kinds of artemisia, pulse, star-flower plants,¶ and fine grasses that will bear any climate.”

There was good reason to believe that other plants mentioned as growing on these lands, as clover, vetches, &c. indicated a calcareous soil; but here is one mentioned, which alone is a positive and sufficient proof. *Esparcette*, which is stated as one of the natural grasses of some of the steppes, is the French name of sainfoin—and the fact of its growth, alone, proves, as well as any chemical analysis could, that all the soils bearing it are highly calcareous. Sainfoin not only delights in calcareous soils, but it will scarcely live, and cannot thrive, on any other. It is a valuable grass on chalk soils in England, which would be almost barren under grain tillage; and it has never been raised in Virginia, and indeed will scarcely produce a few feeble and scattering stalks on our best lands. The bald and least productive prairies of our western country would be the proper place for this grass.

¶ All the meadows may be reduced to these four kinds: 1. Fine productive meads that have a good black, but somewhat moist soil: these yield the greatest crops, of hay; to them belong the *luchten* [overflowed land.] 2. Dry, whereof the soil is fit for agriculture, and at times is so employed; they commonly yield a short but very nutritious hay. 3. Watery and marshy; these do not produce the best, but give a very serviceable hay in cases of scarcity in parching summers and dry places. 4. Fat steppes, where the grass in some parts grows to the height of a man: they are seldom mown.”

“*Steppes*.—This term does not properly denote low and watery places, or morasses, but dry, elevated, extensive, and for the most part uninhabited plains. Some of them being destitute of wood and water, are therefore uninhabitable; others have shrubs growing on them, and are watered by streams, at least have springs or wells, though they are void of inhabitants;

* A dark-gray earth, about a foot deep, beneath which runs a layer of clay, and is held in many places to be fine arable land.

† Pallas, vol. ii. p. 611.

‡ Ibid. vol. iii. p. 6.

§ Ibid. p. 163.

¶ Ibid. vol. ii. p. 75.

yet in these, nomadic people wander about with their herds and flocks, and thus make them, if not their constant, yet their summer residence. In many of them are seen villages. Some occupy a very large space: thus it is calculated that the steppe between Samara and the town of Uralsk* amounts in length to upwards of 700 versts; but, as every twenty or thirty versts we come to a lake or river, the Ural Kozaks traverse them when they fetch their meal from Samara. Probably hereafter several of these steppes, at least in some places, will be cultivated, if they wish to raise forests upon them.

"In regard to the soil an extreme variety prevails, either being very fruitful and proper for agriculture or for meadow-land, or indiscriminately for both. Accordingly in the steppe about the Don, the Kozaks of those parts employ themselves in agriculture, as well as in the breeding of cattle. Some of them furnish excellent pasture by their fine herbage, as the southern tract of the Isetskoi province, and the steppe of the middle horde of the Kirghistzi.† Or the soil is unfruitful: whether it be the sand, the salt, or the stone it contains that is the cause of it. Among these are to be reckoned the sandy steppe on the Irtysh near Omsk; in general we find about the mountains up the Irtysh pure arid steppes, and therefore no villages. Also the Krasno-ufimskoi, between the rivers Belaia, Kama, and Tchussovaia, towards the Ural-chain, is mostly sandy; and that on the Argoun towards the borders of China, is of a still worse soil, consisting of rocky particles and flint. The whole of the steppe along the river Kushum, towards the town of Uralsk, is described by Prof. Pallas‡ as dry, poor, saline, and unfit for any kind of agriculture, for the breed of cattle, and even for permanent inhabitants; there is not even a solitary shrub to be seen, much less any wood. In general saline spots are not unfrequent in the steppes; and here and there we also meet with salt-lakes: however, such districts may invite to camel-pasture."—pp. 81, 83.

"The steppes are frequently fired either by the negligence of travellers, or on purpose by the herdsmen, in order to forward the crops of grass; or, it may be, out of malice, as some years since the Kozaks of the Yaik did; when, having risen in rebellion, a small corps of Russian troops advancing against them, they saw themselves all at once almost entirely surrounded by the high grass on fire. Such a catastrophe often occasions great mischief; the flames spread themselves far and wide, put the dwellings of the inhabitants in imminent danger, consume the corn on the ground, and even seize on the forests. Many prohibitions under severe penalties have accordingly been issued against this practice, but they seldom have any effect.§ All the steppes may be considered as a sort of common land."—p. 84.

"The steppe of the Don and the Volga comprises the whole space between the Don, the Volga, and the Kuban, and is a large, very arid steppe, altogether destitute of wood and water; it has few inhabitants, and contains several salt-lakes and salt-plots."—"Within the confines of this steppe lies what is called the Kuman steppe"—"this, it is said, has all the appearance of a dried-up sea: it is a sandy, part clayey salt plain, without trees. Many circumstances render it probable that it might really have been the sea bottom, as the flat shores of the Caspian and Azof Seas, the shallowness of their coasts, the low situation of the steppe, the saline lakes, and the sea shells," &c.—Rees' Cyclopædia.

Of the extensive Kamyk steppe, it is said, in the same work, that "the soil consists of sand, *mud*, and clay, often mixed with sea shells."

* Formerly Yaik.

† Pallas, vol. ii. p. 75.

‡ Travels, vol. iii. p. 325.

§ See Pallas, vol. ii. p. 378.

The latter passages include under the general name of steppes, sterile deserts of altogether a different character. In like manner, some great tracts of naked sand in South America are called pampas—and some of what are called prairies, west of the Arkansas territory, are of somewhat similar general character to those described above. These are mentioned here to avoid the appearance of omitting what might be considered as opposing my positions. But these regions are altogether different from the lands properly called prairies or steppes; and have no more connexion with our subject than if they had been more properly called sandy, stony, or salt deserts.

"*Pampas*, a province in South America, in the vice-royalty of Buenos Ayres, consists of vast plains, which extend from the sea coast on the east, to that great chain which forms the beginning of the Cordilleras of Chili, about 140 leagues west from the city of Buenos Ayres. Towards the south, they stretch about 100 leagues, to a chain proceeding W. N. W. from the Atlantic. The northern boundaries are not distinctly known, but the name of Pampas is chiefly applied to the territory on the south of Buenos Ayres, Cordova, and Mendoza. These vast plains, like the steppes of Russia, having scarcely any elevation, the view, as at sea, is terminated by the horizon. They are only diversified with paths and ditches, which collect the rain waters, and which commonly end in lakes, as there is no declivity; yet there are wide tracts in which *no water is found, nor is that element pure*; and the trees are extremely rare, except a few shrubs round the lakes. Hence this region is only inhabited by a few wandering savages. The soil is generally *a black earth of little depth, and is followed by a kind of coarse chalk, so that it is difficult to form wells, as the water can scarcely pass so tenacious a substance*. The chief pasturage is clover, and in the best parts, sometimes so strong as to resist the step of a horse: it is much liked by the cattle, which, when there is water, multiply prodigiously in the pampas."—*Rees' Cycl.*

"On leaving Buenos Ayres, the first region is covered for 180 miles with clover and thistles; the second region (480 miles) produces long grass, without a weed; and the third, reaching to the base of the Cordilleras, is a grove of low trees and shrubs, in which such beautiful order is observed, that one may gallop between them in every direction."—"The climate of the pampas is subject to great differences of temperature, though the gradual changes are very regular. The winter is as cold as an English November. The summer is oppressively hot. *But the whole pampas enjoy an atmosphere as beautiful and salubrious as the most healthy parts of Greece and Italy, without their malaria*."—*Malte Brun's Geog.*

"The whole plain [nearest] to the foot of the Cordillera, is a loose sandy soil, greatly impregnated with saline matter, which is inimical to vegetation in the natural way. This immense tract is called the Traversia, or the Desert, resembling similar tracts in Africa. *When assisted by irrigation, it is the most fertile soil imaginable*."—*Malte Brun's Geog. vol. 3, p. 362, (note.) Am. Ed.*

A late traveller from Buenos Ayres to the Andes, Temple, speaks thus of the first and second regions of pampas:

"The country for leagues round is covered with thistles, which at this season are to be seen growing to the prodigious height of eight, and, in some places, ten feet: cattle which go in amongst them to seek a shade from the sun, and to feed upon the grass beneath, are completely concealed. These thistles* form almost the only fuel for the few inhabitants who are scattered

* At certain periods of the year, when the clover withers enormous thistles, ten or twelve feet high, suddenly shoot up, hem in the roads and paths, and form a dense and

over this vast wilderness: not a tree is to be seen, with the exception of a few peach trees, which have been planted in the immediate neighborhood of the huts." * * * *

"We now bade adieu to the region of thistles, through which we travelled for upwards of one hundred miles, and which, on each side of the road, extended as far as the eye could reach. At this season of the year, in consequence of these gigantic weeds being parched by the sun, the country, at a distance, had the appearance of being covered with ripe corn; but the scene was too monotonous to afford any agreeable impression. Madame de Stael, on her journey into Russia, remarks, [of the steppes,] "there is so much space that every thing is lost—" *"meme les chateaux, meme la population. On droit qu'on traverse un pays dont la nation vient de s'en aller."* Here, on the contrary, the traveller would say that he traverses a country where the nation is yet to come; for every thing exists as nature first formed it, unimproved, uncultivated, untouched." * * * *

"After leaving the region of thistles before mentioned, we travelled for about 120 miles through a country of more agreeable aspect, though not a tree as yet appeared to our view, the whole being one vast field of rich pasture. This is the true pampa of South America of which we have of late years read and heard so much in Europe." * * * *

"Innumerable herds of cattle, the progeny, it is said, of six cows and a bull imported rather more than two centuries ago from Spain, range at large over this ever verdant surface of inexhaustible luxuriance. I have been credibly informed that their numbers at the present day bear no proportion to what they were before the devastating havoc of the late civil war; still they appear to a European eye in countless multitudes, and leave the traveller no longer cause to wonder that such fine animals should, at one time, have been slaughtered in *thousands*, merely for their hides." * * *

"This noble plain, entirely covered with pasture, extends many hundred miles into the regions of Patagonia, where it is yet unexplored. M. Humboldt calculated its area at 70,000 square leagues. 'This area,' he observes, 'of the pampas of Tucuman, Buenos Ayres, and Patagonia, (they are all united,) is consequently four times as large as the area of all France.'

"No lawn was ever laid down with greater precision by the hand of man, than this vast interminable plain has been by nature. Not a stone is to be seen on its surface."—*Temple's Travels*.

"In the whole of this immense region, there is not a weed to be seen. The coarse grass is its sole produce, and in the summer, when it is high, it is beautiful to see the effect which the wind has in passing over this wild expanse of waving grass: the shades between the brown and yellow are beautiful. The scene is placid beyond description: no habitation or human being is to be seen, unless occasionally the wild and picturesque outline of the gaucho on the horizon, his scarlet poncho or cloak streaming horizontally behind him, his balls flying round his head, and as he bends forward towards his prey, his horse straining every nerve."—*Head's Rough Notes*, &c.

Nature of prairie soils, so far as ascertained by chemical tests.

After I had ascertained the truth of the novel and strange fact that scarcely any soils in Virginia, or of the other Atlantic states, of which I had

impenetrable barrier. Mr. Head remarks: "The sudden growth of these plants is quite astonishing: and though it would be an unusual misfortune in military history, yet it is really possible, that an invading army, unacquainted with this country, might be imprisoned by these thistles, before they had time to escape from them."—*Head's Notes*.

opportunity to examine specimens, contained any calcareous matter (carbonate of lime,*) it became a new subject of surprise to learn from articles which have been published in the *Farmers' Register* (pp. 276, 277, vol. i.) that many of the prairie lands of Alabama were highly calcareous according to the observations of those who judged merely from appearances. Combining this fact with my own personal experience that old cleared lands, even slightly calcareous, were much more easily kept clear of young bushes, than naturally poor and acid soils—and with what I had read of the nakedness of chalk downs in England—and the general difficulty of rearing trees in calcareous parts of Europe—all served to build up the opinion which I now aim to establish, that the abundance of calcareous earth in prairie soils was the principal, and is a sufficient cause of the absence of trees. Still there had never been an analysis made of any such soil, to my knowledge, and there was no other kind of evidence (however slight) of such quality of any prairie soils, except of a part of Alabama; and reports of the constituent parts of soils, judged solely by the eye, or by the mere close neighborhood of calcareous rocks, I knew from experience, deserved but little credit or respect. In 1834, I first obtained some such proofs from a few specimens of prairie and wood-land soils from Marengo county, Alabama, and one from Mississippi. The prairie soils were all calcareous, containing from 8 to 59 per cent. of carbonate of lime; and these were the first specimens of highly calcareous soils that I had ever examined, except from shelly spots on the banks of our tide-water rivers. The wood-land soils, like our lime-stone and other rich *neutral* soils† contained no *carbonate* of lime. Since then, other specimens have been received and examined from various parts of Alabama—and also the reports of analyses of others, made by Dr. Cooper and Dr. Gibbs of South Carolina, have been received, and have been published in this journal.‡ Most of these soils are highly calcareous. *But also some specimens of prairie soils contain not a particle of carbonate of lime.* This apparent contradiction will be considered hereafter.

It is proper to observe here that I do not extend the term *prairie* to any land bearing trees, unless of new growth, or land known to have formerly been without them. But the distinctness of this term is much impaired by its being now applied in Alabama (and perhaps elsewhere) to soils having the same peculiar texture, appearance, and sensible qualities, though covered with trees. Thus “wooded prairies” are spoken of in the pieces formerly published in this journal, and referred to in this piece.

In addition to new facts of the same kinds, for the convenience of the reader, an abridged statement will here be given of the calcareous ingredients of all the prairie soils which I have formerly examined, or which have been analyzed by other persons, and the results communicated for publication to the *Farmers' Register*: and also of other neighboring soils, sometimes improperly called “prairie,” though covered with growing trees. It is proper to observe, that my own examinations were confined to lime in one form of combination only—the *carbonate*—and that the silicious, aluminous, and vegetable ingredients, when mentioned, were judged of by the senses, and not by accurate chemical tests. My own trials and results will be given first.

Specimens of soils from Marengo county, Alabama, furnished and selected by Richard Coke, Esq. (Described more fully at page 44 of ‘*Essay on Calcareous Manures.*’

* *Essay on Calcareous Manures*, p. 34.

† *Essay on Calcareous Manures*, p. 38.

‡ See pages 715, vol. ii, and 272, vol. iii. *Farmers' Register*.

No. 1. Prairie soil of the most productive kind in Alabama—a black clay, with scarcely any sand, yet so far from being stiff, becomes too light by being tilled. Bears luxuriant crops of corn, oats, and cotton—but the last, after a few years, becomes subject to rust. Contained 8 per cent. of carbonate of lime. All this kind of soil lies on a substratum of “rotten limestone,” (specimens of which contained from 72 to 82 per cent. of carbonate of lime) and which rises sometimes to the surface, forming the “bald prairies.”

No. 2. Bald prairie soil—“comparatively poor—neither trees nor bushes grow there, and only grass and weeds before cultivation—corn does not grow well—small grain better—cotton crops soon become subject to rust.” Contained 59 per cent. of carbonate of lime. The general substratum of rotten limestone in texture and appearance, as well as in chemical character, approaches the chalk of Europe more nearly than any other earth known in the United States.

No. 3. Very rich cane brake land—a kind of prairie of a wetter nature, from the winter rains not running off freely, and the tenacious soil not permitting the superfluous water to sink through—contained 16 per cent.

No. 4. From the valley cane land—very wet through winter, but always dry in summer; after being ditched dry enough, and brings fine cotton, &c. Contained no carbonate of lime.

No. 5. From what is called the best “post oak land,” on which trees of that kind stand from two to four feet in diameter—but little underwood, and no cane—nearly as rich as the best cane land. No carbonate of lime.

No. 6. “Palmetto land,” having that plant as well as a heavy and luxuriant growth of large trees. A cold and wet soil before being brought into till, but afterwards soft and easy to till, and produces corn and cotton finely. The cane on it generally small. Soil from 4 to 10 feet deep. No carbonate of lime.

Selected by Dr. W. J. Dupuy—

No. 7. Soil from the Choctaw Prairie in Mississippi, an extensive body of fertile land. Contained 13 per cent. of carbonate of lime.

Selected and sent by Dr. R. Withers, of Greene county, Alabama—

No. 8. From Kemper county, Miss., part of a “considerable body of similar land, extending into Neshobak and Winston counties. Chocolate colored sandy loam, very friable and easily worked—produces corn and cotton well—growth, hickory, black-jack and some other oaks, principally red oak, interspersed with a few pines.” Contained no carbonate of lime.

No. 9. “Prairie soil from near Demopolis, Alabama, taken from the road near the surface. The rock here is within a few inches of the surface, and many small fragments are mixed with the soil. It is a dark calcareous mould—produces corn finely; but there is too much lime for cotton.” Contained 60 per cent. of carbonate of lime.

No. 10. Subsoil of the common “open prairie” of Greene county, taken from a foot or more below the surface. “The soil above is dark, and probably less calcareous. The rock is not more than two feet below the surface. Lime was perceptible in this specimen in powder, in detached masses, before being pounded.” Contained 50 per cent. of carbonate of lime.

No. 11. “From the southern part of Noxubee county, Miss.—taken 4 inches below the surface, of land cultivated two years. It is a prairie country, but different from ours on this side of the Tombecbe, in having the elevated parts of it, which hardly amount to hills, covered with hickory trees, interspersed with some black-jacks. Hence it is often called a “hickory barren” country. Between the timbered portions, there are long

savannas, or open prairies, which are very level and rich. This specimen was taken from one of them. It is covered with a very heavy grasscoat, very much resembling the gama grass; and some of it I know is of that species. It is at first very difficult to eradicate; but when this is once effected, the soil is as easily ploughed as other prairie soils, and produces corn very finely; say from 50 to 60 bushels to the acre. Cotton however is pre-disposed to rust at first, and probably will be more so after the undecomposed vegetable matter existing in the primitive soil becomes exhausted. Immediately on the outskirts of the hickory hammocks, where they join the open prairie, the cotton is much more disposed to rust, even the first year, and it is from such a locality that it was selected."

No. 12. "This soil is very loose and friable, and it is generally in such land that I have observed the cotton to rust most. It grows off at first more luxuriantly than in other places, but as the heat of summer comes on, begins to look scorched, sheds its shapes, then the bolls, and leaves, until nothing is left but the dead stalks. These two specimens, Nos. 11 and 12, do not effervesce perceptibly with diluted sulphuric acid, but I presume you will find them strongly impregnated with lime. There is a considerable tract of country of this kind of soil in Mississippi, and the lime-stone rock frequently shows itself near the surface. Detached masses of sand-stone are also frequently seen about the hill-sides and hickory hammocks."

Neither of the last two specimens (Nos. 11, 12,) contained any carbonate of lime. The descriptions have been quoted at length, because the facts are among those that most oppose my argument. A similar deficiency of calcareous earth was found in the four next specimens, which were sent by Capt. John Symington, U. S. A., of St. Louis.

No. 13. From a small prairie in the neighborhood of St. Louis, Missouri. Fertile, but not equal to the best prairie soils. "This is high and rolling, and consequently dry—and never subject to inundation. Specimen taken about 4 inches below the surface, and just below the fibrous grass roots."

No. 14. "From the surface of a ridge of rolling prairie, in Macoupin county, Illinois—high and dry, and never subject to inundation."

No. 15. "From Macoupin county, Illinois. Also high prairie, and never subject to inundation, but quite level, and therefore the rain water does not flow off rapidly enough. Still it cannot be called a wet soil. It is considered rich, and produces well grain of all kinds. Taken 2 feet below the surface."

No. 16. Sent by George Churchill, Esq. Sample of the soil of the "Ridge Prairie," Madison, Illinois—"taken from 4 inches below the surface, where it has never been ploughed, and three-quarters of a mile from the nearest wood-land. Surface dry and rolling."

Neither of the four last specimens contained a particle of carbonate of lime. All were very black (therefore supposed full of vegetable matter) and contained but a very small proportion of finely divided silicious earth. For any practical and useful purpose, this essential ingredient might almost be said to be entirely wanting.

No. 17. Prairie soil from Madison county, Ohio—contained no carbonate of lime.

No. 18. Prairie soil from Pickaway county, Ohio, contained a very small portion only of carbonate of lime. The amount was not ascertained precisely.

The three next, selected and sent by Jas. Deas, Esq., were all taken from different depths below the same field of "unwooded prairie," in Lowndes county, Alabama. The surface soil black.

No. 19 Taken $4\frac{1}{2}$ feet below the surface, where very fertile—stiff clay

of dark olive color when dry, and pounded for trial—very little silicious earth, and that very finely divided. Contained 11 per cent. of carbonate of lime.

No. 20. "At 1½ feet below the surface, where the soil is rather thin" [or poor]—nearly white—contained 84 per cent. of carbonate of lime.

No. 21. At 3 feet below the surface of another place, "also rather thin soil." Color darker than the preceding. Carbonate of lime, 27 per cent.

No. 22. Of the celebrated fertile alluvial soil of Red River, Arkansas, a specimen of 300 grains contained 12 grains of earthy carbonates, of which rather more than one third was found to be *carbonate of magnesia*—the remainder carbonate of lime. So far as I am informed, this is the first known fact of magnesia being found in a notable proportion in any soil in this country. It is hoped that this peculiarity of the Red River land will receive further investigation. The presence of magnesia was indicated by the very slow effervescence of the soil in acid. The separation of the two carbonates was made according to Dary's method, (directed in his "Agricultural Chemistry,") which, however, is not very accurate.

The results of analyses of prairie soils (and some which, though so called, are covered with trees,) made by Drs. Cooper, Nott, and Gibbes, will now be adduced. See the more full report. *Farmers' Register*, p. 716, vol. ii.

No. 23. Bald prairie on Big Swamp, Lowndes, Alabama. Plantation of Col. James Deas. Carbonate of lime 25 per cent.

No. 24. Slue prairie—same plantation—15 per cent.

No. 25. From plantation of Messrs. Elmore and Taylor, on Pintlala creek, Montgomery, Alabama—open prairie—taken 6 inches below the surface. Carbonate of lime 38 per cent.

No. 26. From same spot, taken 18 inches below the surface. Carbonate of lime 48 per cent.

The balance were very late examinations of Alabama soils made by Dr. R. W. Gibbes, July 1835, and published in the *Farmers' Register*, vol. vi.

No. 27. Slue prairie, (Col. Elmore's plantation)—6 or 8 inches below the surface—Carbonate of lime 26 per cent.

No. 28. Hammock prairie, carbonate of lime 22 per cent.

No. 29. Open prairie, mahogany colored, *no limestone*, and vegetable matter as much as 33 per cent.

No. 30. Hog-bed prairie, carbonate of lime 8.

No. 31. Post oak prairie, *no limestone*, and vegetable matter 38 per cent. [From the name, it is presumed that this is such wooded land as No. 5, and therefore improperly called prairie land.]

No. 32. Black slue prairie, (Moulton plantation of Dr. J. H. Taylor.) Carbonate of lime 12 per cent.

No. 33. Prairie, (scattering large post oak.) mingled with red clay. Carbonate of lime 6 per cent.—and vegetable matter 32.

No. 34. Open prairie—from a hill or ridge, 18 per cent.

No. 35. White open prairie, (Chisolm's)—from near surface—soil not more than 18 inches deep. Carbonate of lime 42 per cent. Vegetable matter 28.

Formation of prairies, &c. accounted for, and apparent exceptions to the rule explained.

My views of the manner in which prairies are formed will now be submitted.

There are some few trees, as wild or black locust, papaw, and hackberry, which thrive best on soil moderately calcareous, and will scarcely live in soils very deficient in lime. But most forest trees prefer soils having so

little lime, as to be, if not naturally poor, at least unfriendly to the growth of grass. Hence such lands are covered naturally by an unmixed growth of trees, and are almost destitute of grass. Calcareous soils are, on the contrary, favorable to the growth of grass, and unfavorable to the growth of trees, and the more so (other circumstances being alike) in proportion to the excess of lime in the soil. Supposing such a soil to have been so protected as to be covered with trees, the first passage over it of fire, which would be harmless to the more hardy growth of acid soil, would here serve to scorch and damage the trees, feeble and tender, because unnaturally placed. This effect would be the greater because such calcareous woodland would have some growth of rank grass, which, as dry fuel, would add to the violence of the fire, and to its effect. The next winter, the crippled and stunted condition of the trees would prepare them to be still more damaged by the like passage of fire, and its violence would be increased by the greater quantity of dead and dry wood, and the increased growth of grass less obstructed now by shade. Every year these circumstances would serve the more to augment the destructive power of the fires, and to diminish the power of resistance in the still living trees. In the course of time all the trees would be killed, and burnt, and then the seeds and roots after springing in vain many succeeding summers, would finally have to yield to destruction also. The surface is then covered with the growth of grass most suitable to its composition, which growth is luxuriant according to the fertility of the soil. So long as fires sweep every year over such land, the prairies can never be covered with wood; and on the contrary will be extending every year so long as there is wood which the fires can destroy, and land that will yield grass to furnish the fuel for still more extended ravages.

It may well happen also, that a soil not at all calcareous, if bordering on a prairie, would be so exposed to the power of fire, when driven in all its violence by strong winds, that its trees would be damaged, and finally killed, and the land brought likewise to the prairie state. Such land, however, would be making continual efforts to return to its more natural state of woodland; and whether under young wood, or a meager cover of grass, would, by refusing fuel, serve to check the farther extension of the ravages of fire.

This would be one means of land not calcareous being brought to the prairie state. There are two other means for the formation or extension of prairies on land not calcareous, both of which are probably more often operative. These will now be considered.

It may be inferred that the destruction of trees on calcareous soils is not so much caused by their absolute unkindliness to trees, as by their far greater suitableness for grass, which serves when dry as fuel to burn the trees. Now if any thing other than the presence of calcareous earth will produce an equally rank growth of grass, the same destructive end will be produced, and as completely in time, though perhaps with less facility and quickness. Moisture in the soil will in this manner serve as well as calcareous matter—and if the surface is only dry enough at some time in every year to permit full force to the fire, similar effects must be produced in destroying and keeping down the growth of trees. In this manner are formed the rich alluvial prairies or savannas on the great western rivers, which are covered by floods sometimes, and perfectly dry at others.

Again—a soil may be free from floods, and from all water except from the clouds, and yet without being calcareous, may be so constituted as to attract and retain moisture, with great force, and thus be very favorable to the growth of grass, and consequently to the formation of prairies. This constitution is produced when a soil is formed almost entirely of fine alu-

minous, or argillaceous earth, and decomposed vegetable matter—and this is precisely the composition of every specimen of prairie soil which I have examined, and which was not highly calcareous. Examples of some such soils are presented in the foregoing list. The soils contained very little silicious earth, and that little so fine as only to be made sensible to trial between the teeth. The ordinary mode of separating silicious from aluminous earth, by agitation in water, was quite ineffectual for the purpose. Though no *carbonate* of lime was present, it is certain that the soils were neutral*—that is, that they contained in some other combination enough lime to make fertile and absorbent soils. This, added to the quantity of finely divided vegetable mould, and to the fine clay composing nearly the whole earthy portion, forms a soil that holds water like a sponge, and must be peculiarly favorable to the growth of grass.† This alone will suffice to account for prairies being formed on such soils—even if soils so destitute of silicious parts are not (as I think to be very probable, but do not know them to be) as unfavorable to the growth of trees as are dry calcareous soils.

Practical application of the foregoing views, for the improvement and better cultivation of prairie lands.

The calcareous prairie soils, as well as all those not calcareous, are in general remarkably deficient in sand, and would be far more valuable but for this deficiency. This excess of aluminous earth (or pure clay) and not the calcareous matter, causes the remarkable and troublesome adhesiveness of these soils. Is it also not likely that to this defect of constitution is owing the great prevalence on prairie soils of the rust in cotton? It cannot be caused by the calcareous earth, as two of the specimens which were sent by Dr. Withers from land peculiarly subject to produce that disease, contained no carbonate of lime. But whether or not the *rust* is one of the evil effects of a great deficiency of sand, there are enough others, to make it very desirable to remedy this defect in soils otherwise so valuable. This might be done by the process of paring and burning the surface, as is often done in England, when a new or sod-covered field is brought from pasture into tillage. The first preparing of prairie soil for tillage, by the plough, is very laborious, and perhaps it would not be much more troublesome to pare and burn the sod. This would be the most perfect preparation for tillage; and the unrotted and redundant vegetable matter would be converted from a nuisance to a benefit; and the fine clay, burnt to brick-like particles, would form an artificial coarse sand, serving to open and cure the previous close texture of the soil. If the turf had already been conquered by tillage, burning clay in kilns, as was practised for manure in Europe, and by some in the Atlantic states, would serve the same purpose of providing a durable earthy ingredient acting mechanically like coarse sand. By paring and burning the surface of the soil, prairie lands might also be made more healthy. It is true that they are now considered generally healthy—the calcareous prairies especially. But though there may be lime enough, in most cases, to hold in combination the immense quantity of vegetable matter, still the latter must be greatly in excess in many cases; and when so, must be rapidly decomposing, after being ploughed, and evolve effluvia injurious

* Essay on Cal. Man. p. 44.

† Mould [*terreau*] can absorb double its weight of water without appearing moist; and after being dried, it draws from the atmosphere in less than twenty-four hours, a quantity of water, which may vary, according to the humidity of the atmosphere, from 80 to 100 per cent. of its weight.—*Berzelius*—quoted in Essay on Cal. Man. p. 169,

to health. If the prairie lands could by a miracle be suddenly and completely deprived of all their lime, the decomposition and waste in the air of their putrescent matter, now held combined and harmless, would make them as sickly as the western coast of Africa.

Exceptions and apparent contradictions explained.

Supposing these general causes to operate in the formation of prairie lands, the least reflection will show that their power and effects will be often greatly modified by other circumstances. It is well known that in prairie regions, the borders of rivers and small streams are generally clothed with trees. They are protected from the fires in some measure by the dampness of the earth, and because low bottoms are more sheltered from winds. The river also is a secure barrier against the flames, and therefore always guards one of its banks, at least. Even the close neighborhood of those exempted places, would diminish the violence of the flames; and spots abundantly calcareous, and lying high, might thus retain their wood growth. It would require that the flames should pass over a considerable space, and with a full supply of dry fuel, to acquire the requisite force and rapidity for producing destruction. Therefore the vicinity of the wooded banks of a river would not probably be changed from woodland to prairie, by any fires driven by winds from the river. To produce this effect, the winds which prevail in dry seasons must drive the flames towards the rivers, and downward between their forks. The existing state of things on the borders of the Mississippi and Missouri (as I have been told) accords well with this position. The north-west winds are generally dry, and blow with great violence; and wherever their direction is between the forks of streams and down their course, the prairie extends nearly or quite to the water's edge. But streams running from the opposite slope of the great valley, oppose the course and obstruct the effects of these fires—and the easterly winds, which would bear on them in like manner as to direction, are generally accompanied by rain. Therefore, in the last situation calcareous soils may retain their growth of trees, and in the former, soils well constituted to nourish and support them, may be brought to the state of poor prairie land.

If these general views are well founded, the manner in which prairies are formed can no longer be mistaken; and though a highly calcareous soil is deemed the most general and the most important means, the theory serves as satisfactorily to explain the existence of prairies on various other situations, though the soil be not calcareous.

Ancient prairie lands in the lime-stone region of Virginia

In the foregoing observations I have limited the total absence of prairies in the Atlantic states to the eastern slope from the mountains to the sea, and to all poor land even among the mountains. In the rich limestone lands of Rockbridge and Clarke counties, and perhaps on similar soils elsewhere between the Blue Ridge and Alleghany mountains, there certainly were prairies at an early period. When that part of Virginia was first settled by the present race of inhabitants, large bodies of land were covered entirely by young sapling wood, and there were other indisputable proofs that at an earlier time few trees, if any, had been there growing. But though these lands are enough impregnated with lime (in some form) to be very rich, and to be favorable to the growth of grass, they contain no car-

*bonate of lime**—and therefore the land must have been brought to the prairie state slowly and with difficulty, under the long continued operation of annually repeated fires—and their intermission for a few years was enough to enable the soil to again throw up a new growth of young trees. These appearances were so well known in Rockbridge, that some very intelligent persons, born and reared in that county, have thence inferred that the wood cover of our country was every where comparatively recent, and that at some former and not very remote time, every part of this continent had been without trees; which is an example of very erroneous reasoning from particular to general facts.

Of soils rendered barren by excess of calcareous matter—and the fertility produced on them by irrigation.

The “bald prairies” of Alabama present the only known cases in the United States of bodies of land so highly calcareous as to be thereby lessened in productiveness. This effect will increase as exhausting cultivation shall lessen the vegetable ingredients of the soil; and probably (under a continuation of such tillage) the barren spots will extend widely into what now form their fertile margins. The quantity of vegetable matter accumulated in the highly calcareous prairie soils is now so great, that a very long course of exhausting tillage will be borne before sterility can be produced. Nevertheless, however remote may be that result, its occurrence is not the less sure, if exhausting tillage is pursued. Similar to our rich prairies probably was the original state of the now poor chalk downs of England, the almost barren plains of “Lousy” Champagne in France—and some of the still more hopeless deserts of Asia and Africa. The furnishing or retaining of a sufficiency of vegetable matter would cure this kind of barrenness, and more easily will prevent its extension beyond its present limits, in our own new country. In other countries, water alone, used for irrigation, has had the effect of making highly fertile, and keeping it so, land so calcareous that it would otherwise have been altogether barren. Many facts of this kind may be gathered from the writings of travelers; but their notices are very slight, and merely incidental, as unfortunately, none who have viewed and described these lands, possessed any agricultural knowledge. Some of these passages will be quoted. In some far remote future time, perhaps the overflowing wells of southern Alabama, may be used to irrigate the excessively calcareous soils, and to retain or restore their fertility.

Denon, in his *Travels in Egypt*, (Am. Ed. vol. ii., p. 4,) when at Siut, or Lycopolis, $2\frac{1}{2}$ degrees south of Cairo, speaks thus of the Lybian range of mountains. “I found this, as I had supposed, a ruin of nature, formed of horizontal and regular strata of calcareous stones more or less crumbling, and of different shades of whiteness, divided at intervals with large mammillated and concentric flints, which appear to be the *nuclei*, or as it were, the bones of this vast chain, and seem to keep it together, and prevent its total destruction. This decomposition is daily happening by the impression of the salt air, which penetrates every part of the calcareous surface, decomposes it, and makes it, as it were, dissolve down in streams of sand, which are at first collected in heaps at the foot of the rock, and are then carried away by the winds, and encroaching gradually on the cultivated plains and the villages, change them into barrenness and desolation.” The Lybian chain of mountains which runs nearly parallel with the Nile, there ap-

* Essay on Calcareous Manures, p. 31.

proaches very close to it, and the narrow strip of fertile and irrigated land between must necessarily have been deeply though gradually covered by the same calcareous sand; (indeed the continued operation of the like causes is raising, not only the borders, but even the bed of the Nile;) yet Denon mentions particularly the high state of cultivation seen in his next day's journey up the river. It is well known that wherever the waters of the Nile have been conveyed to irrigate these sands, an astonishing degree of fertility has been the immediate consequence; and that wherever the canals for this purpose have been permitted to become dry, (often the effect of political causes on this wretched population,) there is as sure a return to the former state of naked and barren sand. There is reason also to believe (though upon slighter foundation,) that portions of the great deserts of both Asia and Africa also are excessively calcareous, and owe their sterility to that cause, combined with the general absence of water. The only direct testimony as to this character of the soil, is in the following passage from Madden's Travels. He was in the desert between Egypt and Judea. "Next day we travelled all day long without seeing a single tree, or the smallest patch of verdure, or laying our eyes on any human being."—"The soil was no longer sandy, but of a hard gravel, on which a carriage might be rolled from Salehie to Suez. At night we stopped at a well without water, and here I examined the soil, three feet below the surface; [for] two feet deep there is a superficial stratum of calcareous pebbles, and below that, a solid bed of limestone, which I believe to be the basis of the soil of all Egypt."—[p. 122, vol. ii., Am. Ed.]

"One thing is certain that wherever there is water, no matter in what part of the wilderness, there vegetation is to be found. The stopping up of the canals, and the want of irrigation, are the great causes of desolation which favor the extension of the desert. The country from San to Salehie, and probably to Suez, was formerly a cultivated country: the ruins of palaces, such as those of Zoan and that of Beit Pharoon, now in the middle of the desert, prove that the country around then must have been cultivated, and that at a very short period before our era."—*Ib.* p. 126.

Lieut. Burnes, who has recently published the very interesting account of his travels across central Asia, after describing, in various detached passages, the barren and often naked sands of the great Tartarian desert, over which he had been many weeks passing, and of the great scarcity of water even in the few wells, and the total want of it elsewhere, thus describes the approach to the river Moorghab, or Merve, and the effects of irrigation. "By the time the sun had set, we found ourselves among the ruins of forts and villages, now deserted, which rose in castellated groups over an extensive plain. I have observed that we were gradually emerging from the sand-hills, and these marks of human industry which we had now approached, were the ancient remnants of civilization of the famous kingdom of Merve, or Meroo. Before we had approached them, we had not wanted signs of our being delivered from the ocean of sand, since several flocks of birds had passed over us. As the mariner is assured by such indications that he nears land, we had the satisfaction of knowing that we were approaching water, after a journey of 150 miles [from the last habitable spot] through a sterile waste, where we had suffered considerable inconvenience from the want of it."—"This river was formerly dammed above Merve, which turned the principal part of its waters to that neighborhood, and raised that city to the state of richness and opulence it once enjoyed. The dam was thrown down about 45 years ago by Shah Moorad, a king of Bokhara, and the river now only irrigates the country in its immediate vicinity. The inhabitants cultivate by irrigation, and every thing grows in rich luxuriance"—and where the

waters have been withdrawn, as stated above, the country is again a desert, and the former habitations are tenantless ruins. Another inhabited and cultivated spot in the desert is afterwards thus mentioned. "The country around Shurukhs is well watered with aqueducts, from the rivulet of Tejend, which is a little brackish, but its waters are usefully employed in fertilizing the fields. The soil is exceedingly rich, and possesses great aptness of agriculture; the seed is scattered and vegetates almost without labor. The harvest is rich."—"The inhabitants repeat a tradition that the first of men tilled in Shurukhs, which was his garden, while Serendib or Ceylon was his house! There is not a tree or a bush to enliven the landscape."

But these speculations, however plausible, would require many additional facts and proofs, to place them on as sure ground, as I flatter myself, the earlier part of this essay has done for the cause of the formation of prairies. However interesting it may be to the inquiring mind to extend views so far upon unexplored ground, prudence admonishes that in that way I have already exceeded the proper limits of argument sustained by known and undoubted facts.

Addendum.

Since the first publication of this piece (in 1835) there have come under my notice many statements of facts serving to confirm the positions assumed, and none to oppose them. Most of these statements are of more extended observations of other prairie soils and prairie regions, which are unnecessary to recite, as they agree generally and fully with the numerous particular examples cited in the foregoing pages. Some other of such evidences, on a different branch of the subject, will be here added, in confirmation of some of the positions before presented.

It was stated above, on the authority of Denon, that the soil of part of the sandy desert of Egypt (near Lycopolis) which is encroaching on and covering the rich borders of the Nile, consists of almost pure carbonate of lime, in calcareous sand formed by the continual disintegration of the range of Lybian mountains, there close adjacent. Also, on general authority and understanding of the facts, that this calcareous sand, though forming a barren and naked desert when dry, was made fertile wherever moistened naturally or artificially, by the waters of the Nile. Other facts were stated of places which are now and have long been naked deserts of dry sand, which are known to have been formerly watered by the industry of man, and were then highly fertile. And hence my inference that, wherever watering of barren sands had induced fertility, such sands must have been highly calcareous; and that the great abundance of the calcareous ingredient is both a cause of the barrenness of such soils when dry, and of their immediate change to productiveness and subsequent great fertility, when supplied with water. If, (to suppose a case,) instead of 70 per cent. of finely divided carbonate of lime in the soil of what is now a desert, there had been but 10 per cent. of that ingredient, and all the other parts had been silicious sand and clay, it may be presumed that the land would be much less barren than it is in these highly calcareous deserts, and with a moderate share of rain might be actually and highly fertile. In Egypt rain is a very rare occurrence; and therefore, except where watered naturally or artificially from the Nile, the highly calcareous sands are without moisture, and must necessarily constitute a perfectly barren desert.

The Lybian mountains being composed of calcareous rock, continually disintegrated and blown away by the winds in fine sand, would also alone serve to prove that the vast extent of desert sand thus spread over Egypt

must be largely composed of carbonate of lime. But that is not all. Malte-Brun says—"The analysis of the mud of the Nile gives nearly one half of argillaceous earth, about *one fourth of carbonate of lime*, the remainder consisting of water, oxide of iron, and *carbonate of magnesia*." (*Universal Geography, book lx.*) This is the deposit of the overflows of the bounteous Nile, and which annually manures and preserves in the highest state of fertility, all the sands to which it is conveyed by the inundations. The same high authority furnishes some additional testimony, confirmatory of Denon's, as to the calcareous composition of soils of or near the deserts, or of rocks which by their disintegration must help to form the neighboring soil. "The mountains on the west side of the Nile seem to consist of limestone containing many shells. In those on the east side, serpentine and granite seem to form the highest ridges." "The valley leading to Cosseir [on the Red Sea] is covered with a sand partly calcareous, partly quartzose. The mountains are of limestone and sandstone." (*Un. Geog. book lx.*) "At the distance of eight miles from Cosseir the mountains suddenly change their character; a great part of them are limestone, or alabaster in strata. Here are found the debris of the *ostrea diluviana*."—"Towards the valley of Suez, the mountains are calcareous, and in several places composed of concreted shells." (*Ib. book lx.*)

The same author speaks thus of the country and desert of Barca, which is south of a part of Barbary, and north of the Zahara or great African desert. "Some call Barca a *desert*, and the interior certainly merits that name."—"The coast of Barca, once famed for its three-fold crops [as stated by Herodotus and Strabo] is now very ill cultivated; the wandering tribes of the desert allow no rest to the inhabitants, or security to their labors."—"A sandy plain at the bottom of the mountains [a part of the desert from Siwah to Andelah] presents on its surface an immense calcareous bank, which contains no traces of petrification, while the adjacent mountains are full of the remains of marine animals and shells. These are also met with here in large isolated heaps." (*Ib. book lxx.*)

Fezzan is surrounded by the desert, and seems to partake of the character of the desert in all respects, except in the close neighborhood of abundant water under-ground, and of its consequence, the exuberant fertility for which this country is celebrated. Malte-Brun says of Fezzan, "In the whole country there is no river or stream worthy of notice. The soil is a *deep sand* covering rocks, and sometimes a *calcareous* or argillaceous earth. There are numerous springs, which supply water for the purposes of agriculture. The whole of Fezzan, indeed, abounds in water at a moderate depth underground, derived, no doubt, from the rains which fall on hills more or less distant, perhaps on the confines of the desert, and though absorbed by the sand, find their level among the loose strata, across a broad extent of desert, till they become accessible in Fezzan, and impart to the country its characteristic fertility." (*Ib. book lxx.*) Though the author (or his translator) has used the word "springs," it is evident from the context that the sources of water are not what we here understand by springs, but are *wells*, requiring to be dug to reach the water to be thence drawn, and not furnishing flowing streams.

But even if there were no direct or positive evidence of these sands being calcareous, enough of indirect evidence would be presented in the well known fact that exuberant productiveness is induced wherever watering is applied. And wherever such results are stated by travellers to be produced on barren sands and in deserts, in any part of the world, it may be safely assumed that calcareous earth must form a sufficient, if not a superabundant portion of the soil. Unfortunately, no travellers through

sandy deserts and irrigated regions have been competent, and enough observant, to describe the agricultural qualities of the soils. I have not heard of there having been brought away any specimens of such remarkable soils, except in a single case; and for which one opportunity for obtaining direct proof of the ingredients we are indebted to the enlightened curiosity and investigating mind of an American lady. When I was lately (in 1842) at the Patent Office in Washington, I saw among many other collected subjects of curiosity, a small bottle labelled "Sand from the desert of Barca." It had been obtained and was presented by Mrs. Macauley, the wife of David S. Macauley, the American consul at Barca. I asked for and obtained a small portion of it, for the purpose of ascertaining its composition in regard to calcareous matter. Upon trial I found it to contain 49 per cent. of carbonate of lime! This sand is very fine, of a pale yellow color, and would offer to the eye, or to slight observation, no indication of being any thing else than almost pure silicious sand, slightly tinged by ferruginous matter.

It may seem to some readers that these speculations on sandy deserts, upon such few data furnished in positive facts, are a wide departure from the investigation of prairie soils; and that the deductions, even if established, are more curious than useful, and can lead to no practical result. But it is not so, if the lights thus obtained are properly applied. The facts here presented in connexion with others previously discussed, serve to show that the same cause, (a very large proportion of calcareous earth,) according to the existence or changes of other circumstances, may produce in soils either the highest degree of fertility, or the most complete sterility. These modifying circumstances are the presence in the soil of much putrescent matter, the accumulation of ages of repose under grass, or of abundance of water—or of the absence or great deficiency of both. It may be merely a matter of curious speculation, however correctly deduced from the positions here maintained, that it is possible, and perhaps would be profitable, merely by raising water to the surface, to bring to a state of productiveness most of the naked and burning deserts of Africa. But another deduction is not merely a matter for idle and amusing speculation, but is a most important truth, and strictly applicable to practice; which is, that the rich prairie regions of the west and south-west of the United States and of Texas, if continued to be scourged unremittingly by exhausting tillage, will finally become deserts as barren as those of Lybia and Barca.

NOTE VII.—*Extension of subject from pp. 57 and 140.*

RECENTLY OBSERVED POWERS OF CALCAREOUS EARTH, FOR INCREASING THE PRODUCTIVENESS OF LAND AND THE HEALTHFULNESS OF THE ATMOSPHERE.

It was stated at pages 103-4, that though the practical results of applications of calcareous manures conformed strictly to the theory of their action as previously laid down, yet they exceeded the measure or amount of effect which would have been anticipated from the theory alone. Since a large portion of this work has been printed, I have first heard of the discovery, by Dr. William L. Wight, of Goochland, of a before unknown property of calcareous earth, which operates to increase in an important degree its fertilizing power, and also its health-preserving power. I was favored by a mutual friend with the perusal of a rough draught of an essay in which these views were incidentally presented, and which Dr. Wight had designed for publication in a medical journal. I immediately requested him to communicate these particular and interesting views, in such form as would suit agricultural and general readers, for publication in the *Farmers' Register*. To this he assented; and I had hoped before this time to have been enabled thus to present the article entire to the public, in which case, it might here be merely referred to, as already in the possession of my readers. The communication has been received; but too late to be included in the few remaining pages of the current volume of the *Farmers' Register*, or to precede the appearance of this note; though it will appear at length in the first number of the second series of that journal.

Before stating the newly discovered powers above referred to, it is necessary to introduce them by some general statements of established or received opinions of vegetable and animal life and functions.

The atmosphere is composed mainly of oxygen and nitrogen gases, (and which two alone are deemed essential to the constitution of atmospheric air) with a very small but universally occurring admixture of carbonic acid gas. The oxygen gas (formerly termed "vital air," from its admitted quality) is that part of the atmosphere which is essential to the life of breathing animals, and which is diluted to form atmospheric air by the mixture of nitrogen gas, and also by the small and perhaps accidental, but always present carbonic acid gas, either of which alone is not only incapable of supporting life, but to breathe which is deadly, and immediate in its fatal effects. Hence it has been supposed, and it is difficult to deny the positions, that to give larger supplies of oxygen gas to the atmosphere must render it more healthful, and to increase the quantity of carbonic acid gas must render it less so. It must be admitted, however, that these deductions, though in accordance with the known and opposite qualities of these different gases, and with reason, are not sustained by the analyses which have been made of atmospheric air in various places. For if these analyses are to be entirely confided in, they would show that in all situations, the highest or the lowest, the most pure and healthy and the most pestilential and fatal to human life, the proportion of oxygen in the air is precisely the same.

By the respiration of animals, the atmospheric air is partially decomposed, and the relative amounts of its ingredients altered, at least for the time. Some of the oxygen gas of the air inhaled is retained by the lungs and given to the blood; and some nearly formed carbonic acid gas is given out from the lungs continually, and added to the atmosphere. Thus, the breathing, or the existence of animals, if acting alone, or not counteracted, would serve continually to deteriorate the purity of the atmosphere, and to render it less conducive to the support of healthy animal life.

But to this very general operation of animal life, there is as general and as operative a 'countervailing action in vegetable life. Carbonic acid gas is essential to the health and growth of plants, and serves to furnish them with a very large if not indeed their larger proportion of bulk and substance. All that part of every vegetable substance which can be converted to charcoal (or carbon) has been furnished to the plant from the atmosphere in the shape of carbonic acid gas, which is a combination of oxygen gas and carbon. The leaves of growing plants absorb this ingredient from the atmosphere, and retain and fix the carbon as part of their substance, and evolve the pure oxygen; thus taking from the air some of its poisonous ingredient, and adding to it new supplies of the purifying or health-supporting gas.*

It follows necessarily from these premises that if by any means these universal powers and continual action of plants, to absorb carbonic acid gas and evolve oxygen gas, be in any manner increased, that proportional increase must be given by the first to the growth of the plant, and by the second, proportional purification and healthiness to the atmosphere.

To these general views and positions the recent observations of Dr. Wight apply admirably. He ascertained, by a series of careful and well conducted and repeated experiments, that the diffusion of carbonate of lime in water with which plants were nourished, caused in the plants a great and remarkable increase of both the above named actions; so that they absorbed much more, in some cases a quadrupled quantity, of carbonic acid, and evolved as large an increased quantity of oxygen gas. If this be so—and the manner of the experiments stated leaves no ground to doubt the accuracy of their conduct, or of their results—then there can be no question of the following important deductions: that besides all other modes and powers of fertilizing action of lime in soil, as maintained in this essay, it also causes plants to draw from the atmosphere a very large accession of nutriment; and to increase in proportion the measure of their ordinary purification of the atmosphere. And therefore, these interesting and new observations serve to confirm and to show additional and important reasons for the operation of calcareous manures both for increasing the productiveness of lands, and of lessening the amount of disease among the residents thereon and in the vicinity.

NOTE VIII.—*Extension of subject from page 161.*

DIRECTIONS FOR BURNING AND APPLYING OYSTER-SHELL LIME.

The following directions and remarks may be useful to some of those persons to whom shell-lime will be cheaper than either marl or stone lime.

Oyster-shells are brought by vessels to the landing places of the purchasers on the James river, and sold on board usually at 62½ cents the hogshead, of 18 heaped bushels. Where fuel is plenty, the shells and dry pine wood, in alternate layers, are built up in a heap of cubical form for burning. In this manner, if judiciously executed, 12 cords of wood are sufficient to burn 100 hogsheads of shells to quick-lime. A more careful mode of burning was used by the late Fielding Lewis, of Weyanoke, which was described in an account of his farming in the *Farmers' Register*, for June, 1833, and which will be copied below, together with his mode of application;

* As this is the greatly preponderating action of vegetables, the smaller reverse operation (which takes place at night) is passed over, as unnecessary to be referred to more fully than in this manner.

which is still deemed the best for separating the particles of lime and spreading it equally over the land; and also (I will add, as another important object,) to permit the quick-lime by exposure to become again combined with carbonic acid in the shortest time.

"Close kilns, with walls of brick or stone, have not yet been used to burn oyster shells for manure; and until fuel becomes more costly than the additional transportation of the lime, it will be cheaper to use wooden kilns. What are commonly called lime kilns are merely heaps of wood and shells, built up in a somewhat cubical form, by which the burning is imperfectly performed at great expense of fuel though without much trouble. Mr. Lewis burns his shells in the following manner. A pen of sixteen or seventeen feet square, is built of round green pine logs, (notched where they lock, so as to come as close together as their form will allow,) and with a floor of similar logs, chinked with smaller pieces, so as to prevent the shells dropping through. The bottom logs of the kiln are laid on four corner blocks, of twelve inches, so as to leave a vacancy of twelve or fifteen inches between the earth and the bottom of the floor, which is to be packed closely with dry wood. The walls of the pen are raised about nine feet; and about one hundred logs of six to eight inches through (which these now put up seemed to be,) usually serve for the floor and side walls. The shells are thrown in, and in layers of different degrees of thickness, according to their order, and separated by thin layers of pine wood, cut eight feet long, and split to the usual size for fuel. The size of the last kiln burnt by Mr. L., according to his memorandum book, was as follows:

Kiln 17 feet square and 9 feet high, inside measure.

The lowest bed of shells 8 inches (he thinks it might as well have been 12 inches.)

The second bed of shells 12 inches.

third	16
fourth	20
fifth	15
sixth	6

The layers of wood between were equal, and about six inches. The kiln took one hundred hogsheads of shells, and consumed ten cords of wood in the layers, and three more of foundation or kindling wood. The kiln should be fired in calm weather; and if the wind afterwards rises, it should be kept off as much as possible by a screen of brush, or whatever may be most convenient.

The burning (in preference) is done in March, or as soon after as may be. The newly burnt shells are carted to the field as soon as they are cold enough, and deposited in small parcels of a measured heaped half bushel each, at distances of six yards. The field is previously ploughed, and marked off carefully in checks of six yards square. These small heaps of shells are immediately covered completely, but not heavily, by the surrounding earth being drawn over them with broad hoes. If a heavy rain was to catch the lime before this covering, much of it would become a wet sticky mortar, difficult to manage, and impossible to distribute equally. When secured in the heaps, the moisture absorbed from the earth will usually slake the lime in forty-eight hours. The heaps are then cut down and mixed with hoes, and carefully spread so as to cover the field very equally. The land is then well harrowed, more effectually to distribute and mix the lime with the soil. The quantity applied to the acre is about seventy bushels of the burnt and unslaked shells, which quantity is produced by burning 6 hogsheads (108 bushels) of shells; and the same, if well burnt, will swell in slacking to 125 or 130 bushels. The lime is always put on a part of the field of the fourth

year, and is put under field peas the same year. The red, or cow pea, is preferred, being considered most profitable for live stock; and as that is a late kind, it should be planted as soon as possible after the 20th of April, that the crop may mature. Two after ploughings and one slight hand weeding serve to cultivate the crop; and its product, Mr. L. thinks, though, without having made any experiment or careful estimate, usually pays the whole expense of the liming."—*F. Register*, vol. i. p. 18.

The shells sold to the farmers are obtained at the various landings on York and the lower James river and their tributaries, where oysters are opened in great quantities for sale. On some of the lands bordering the Potomac, there are much cheaper and universal sources of supply, in ancient accumulation, of shells called "Indian banks," and which are now used to burn lime from for manure for farms in the Northern Neck. Very recently there has been brought into use a new source of supply on James river. This is the young living oysters and old shells which together form entire shoals in some parts of the river, and which are raked up in mass to load the vessels. These shells are sold at 50 cents the hogshead or less. As these are mostly small and thin shells, they could more easily than ordinary shells be pulverized by a mill-stone running on its circumference, as in a tanner's bark mill; and in this manner all the rich animal matter would be preserved, which is destroyed by burning.

NOTE IX.

ON THE SOURCES OF MALARIA, OR OF AUTUMNAL DISEASES, IN VIRGINIA, AND THE MEANS OF REMEDY AND PREVENTION.

(From the *Farmers' Register* of July, 1838.)

Throughout the course of publication of the *Farmers' Register*, it has been one of the main objects of the editor to attract attention to the causes and effects of malaria, or unhealthy marsh effluvia, and to enforce his views as to the means of restraining or preventing this greatest of the evils under which the eastern half of Virginia suffers. To forward this end, every fit opportunity has been availed of; and the subject has been treated, directly and at length, or incidentally and slightly, in various articles in these volumes. But there has been found but little if any encouragement to persevere in this course. The editor has, alone, and without any certain evidence of approval of his views and his course, and certainly without any practical adoption of his recommendations, labored in this cause, which, to his understanding, demands the support of all, on considerations of economy and agricultural improvement and profit, as well as on the more important grounds of the strength or frailty of the tenure by which the people of half of our entire territory possess and enjoy health, happiness, and even life. It is under such impressions of the high importance of the whole subject, that the readers of this journal are again invited to its consideration; and, probably, for the last time, by the present writer, if there continues to be no more interest excited, and action produced, in regard to the evils existing, and which are multiplied ten-fold in power by the ignorant and careless legislation of this commonwealth.

The views of the writer on this subject were presented generally, and at some length, in an editorial article (pp. 41 to 43) in vol. v., *Farmers' Register*, on the causes of and means for preventing the formation and the effects of malaria in eastern Virginia; and also in sundry shorter incidental pas-

sages in each of all the volumes, in connexion with articles on marshes, mill-ponds, and canals, &c. But as it would be requiring too much of readers that they should either remember, or carefully refer to these various articles, a general, though slight view of the whole subject will be here presented, sustained by additional facts, which have been recently learned by personal inquiry and observation.

That the common autumnal or bilious diseases of eastern Virginia, and especially of the tide-water portion, which is most subjected to them, are principally caused by the effluvia rising from wet lands, is a matter in which all concur. The general difference between the presence of these disorders, in low, wet, or marshy countries, and their absence, or scarcity, in mountainous and dry regions, is so great, that none can mistake, or differ about, the *general* causes and effects. But from this general opinion, which is true in the main, (though having numerous and important exceptions,) there is deduced the erroneous conclusion, that these opposite general effects produced on health, in extensive regions either generally low and wet, or generally hilly and dry, are produced by these opposite natural features, and cannot be very materially altered by art; as art cannot materially alter the natural character of the land. Or, in other words, that nature has made one great region low and sickly, and another high and healthy; and that man cannot do much to counteract the law of nature in either case. Perhaps none may maintain this position, in argument, without admitting partial exceptions in numerous particular cases and localities. Indeed, every man will say that care may lessen the causes and mitigate the operation of malaria, in a sickly region, or increase both in a healthy one. But, judging from the action of both the people and their laws, which speaks more strongly than words, it may be inferred that it is a general belief that such bendings of nature from her course can be but slight, in particular cases, and scarcely worth estimating on a broad scale, or through an extensive country. In entire conformity with this supposition, it is a notorious fact that very few individuals in Virginia have done any thing considerable, or on system, to protect their dwelling places from malaria; and the government has not only done nothing for general protection, but has actually caused the worst of the existing evils, and is encouraging their continued increase and aggravation, by the fixed legal policy of the country; which permits the raising of mill-ponds, that are productive of little else than malaria and disease; and indirectly, but effectually, forbids the drainage of extensive swamps. The production and deadly effects of malaria, in eastern Virginia, for the greater part, is to be charged, not to the laws of God, but to the laws of man; which, in this respect, operate to put away or sacrifice some of the most precious of God's blessings, offered to all, to gratify the whims, or the blind and often mistaken avarice, of a few individuals. There are, doubtless, great *natural* differences as to the sickness of differently situated regions; as between the low tide-water region of Virginia, the central or hilly, and also the mountainous region. But, in their natural state, before damaged by mill-ponds and other of man's mis-called improvements, the low-country was probably less afflicted by malaria than the hilly parts now are, or may be rendered by the full extension of these injurious operations of man. This is a matter of mere supposition, and cannot possibly be subjected to the rigid test of proof by known facts. But, from reasoning, and inferences from such facts as are known, it seems most probable that some of the now most sickly counties on tide-water were, at the first settlement of the country, less sickly than the hilly and originally very healthy county of Brunswick, for example, has been in latter years.

Even the very important fact of increased and increasing sickness in this country, is entirely without support from any known written authority ; and the whole subject has been so little examined, or thought of, that to most readers the position here assumed may be entirely new. There are no statistics of health to which we can refer for proof. But general and historical facts, few as they are, if fairly considered, will suffice to place the question beyond dispute.

Before proceeding further in this part of the argument, let me remark that I am opposed in the outset, and shall be opposed throughout, by the reluctance felt by every individual to believe, or if believing, to admit, that his particular property, or place of residence, is more sickly than others, or has become more so than in former times. This self-delusion, and consequent, though perhaps undesigned effort to deceive others, is almost universal. Each man claims for his own place more healthiness than in truth ought to be admitted ; and the combined effect of all these individual claims, is to maintain that the whole country is more healthy than is true, and more so than each individual would have claimed for it, with the exception of his own farm and his own neighborhood. It is against this universal prejudice and obstruction that I have had to contend in seeking for facts, and shall have to contend in argument ; and, with such opposition, there is but small hope of maintaining my ground, or producing conviction of the soundness of my views, in the minds of those who have so prejudged the case.

One of the strongest proofs of the greater former healthiness of the low country, was the settlement of our English ancestors having been made and continued at Jamestown. It was on May 13th, when they landed ; and now, a residence on that spot, or in that region, continued for five months after that time of the year, would be fatal to half of the strangers from a northern climate, even though provided with all the comforts and necessities which a long-settled country affords, and all of which the first settlers most deplorably needed. It is true, that for some years after the first settlement, there was much sickness, and numerous deaths ; and that in fact the infant colony was more than once on the point of extinction. But these diseases and deaths do not seem, from the direct and the still stronger indirect testimony of history, to have been attributed by the sufferers to an unhealthy location ; and there were sufficient other causes for all that was suffered, in the usual and unavoidable privations of the first colonists of a new and savage country, added to the extreme improvidence and mismanagement of these settlers, and their government, as detailed in history. Even after several years had passed, and though cultivating a very fertile soil, and aided by annual supplies of food from England, and with all the resources of trade with the savages, hunting and fishing, still, want of food was one of the greatest causes of disease and death. Of course, there must have been, under any circumstances, more or less of disease caused by malaria ; and although any predisposition to such disease, naturally induced, must have been violently urged to action, and aggravated to ten-fold malignity, by hunger, intemperance, exposure of every kind, depression of spirits, and every other painful emotion of the minds of men in such desperate straits, still, even with all these aids, the prevalence of autumnal diseases, the effect of malaria, was not so conspicuous as to stamp the character of sickness on the location, or to induce even the proposition to remove the colony, or afterwards its seat of government, to a much higher or more healthy situation. The unavoidable inference seems to be, that the great sickness of the early settlers was not attributed by themselves to the climate. Yet, this was a question on which they could not possibly have been deceived. And even if most others had been deceived, by ignorance, and the want of ex-

perience of the effects of malaria, this could not have been the case with Smith, the most efficient director, and the true founder of the colony; who would have known better, not only by his general intelligence, but also by his experience of such effects, gained in his campaigns against the Turks. It may be alleged, that fear of the savages, stronger than the dread of disease, caused the choice of, and after continuance on, an unhealthy spot, because it was more easily guarded on the land-side, and perfectly accessible to ships. But spots equally favorable for defence, and on deep water, might have been selected at first, much higher up the river; and yet Jamestown and its immediate neighborhood continued to be the chief place in Virginia, after the power of the savages had been crushed, and settlements had been extended to distant and inland places. The proof of my position would be sufficiently proved by any attempt made now to settle Englishmen, just arrived, on the border of almost any of our tide-waters, and especially about the junction of the salt and fresh waters. Several such trials have been made with foreign laborers; but the first autumn was enough to put an end to each experiment, by inflicting so much disease and death as to prevent any of the foreigners remaining through another season, who could possibly move away.

There can be but little doubt also, but there was much less of autumnal diseases, or at least of violent and fatal diseases, before the revolutionary war than now. There was no such thing then, as the healthy residents leaving home in summer, as is so usual now, to spend the sickly season among the mountains, or at the north; nor does it appear that there was much suffering for want of such resources, although the climate must even then have become very far more unhealthy than in the early times of the colony.

Another striking proof of the increased tendency of the country to produce disease, even within the last sixty years, is presented by history, in the circumstances of the occupation of Yorktown by the British army in 1781, and the siege carried on by the American army; and especially in regard to the hastily-levied militia from the mountains, and other high and healthy parts of Virginia. Cornwallis chose his position first in Portsmouth, and afterwards in Yorktown, with a view to health, as well as defence, to await the arrival of reinforcements from New York. His army was concentrated at Yorktown, August 22. Washington reached Williamsburg, September 14, and the American army moved on thence to invest Yorktown, Sept. 30, and the surrender of the British army was made on Oct. 19th. Thus, both armies were exposed to the worst part of the malaria season, and the British army to the whole of it. Among the besiegers were raw militia, just raised for the occasion, from Roekbridge county, (of which portion I have been more particularly informed,) and probably from sundry others of the mountain counties. There was certainly much sickness, and especially among the British troops; but not more than is usual in camps, and especially in besieged camps, suffering all the privations incidental to the confined situation. It does not appear, from the very slight notices in history, that there was more sickness than might have been expected if the same circumstance had occurred in the hilly middle region of Virginia. Yet, if the like circumstances could occur now, it can scarcely be doubted but that every soldier, not already acclimated, and accustomed to malaria, would be made sick; and that probably half of those just brought from breathing the pure mountain air, would never return home.

Another indirect proof is presented in the great and deplorable decline of most of the lower counties of Virginia in wealth, and in the usual accompaniments of wealth, which formerly made a residence delightful in many neighborhoods in which there is nothing now left to invite any one to re-

main. It is true that other causes, political and economical, have concurred to produce this result. But the most potent of the several causes was the slow and silent, but continual and increasing warfare on the health of body and mind, made by the action of malaria. By its operation, when scarcely amounting in effect to positive and known disease, the mind is sickened even more than the body. The buoyant spirits are tamed—energy is relaxed—the keen appetite for enjoyment (which is the greater part of happiness) is lost; and the victims of malaria cease to strive, or to enjoy; and either sink into apathy and listlessness, or, urged by discontent, more than by any remains of energy, take the final step of emigration to the western wilderness.

But the upper country furnishes still stronger evidence, because of positive and unquestionable facts, to prove an increase of the product and effect of malaria. The hilly country between the falls of the rivers and the nearest mountain-range, with the exception of some comparatively small spots, on swamps and rivers, was formerly as free from this scourge as is now the mountain region. But the number and the extent of the unhealthy places have greatly increased within the memory of those now living; and some large districts have been, in particular seasons, as subject to bilious diseases, and still more to violent ones, than the tide-water region. Indeed, in very many places, universally believed (unless by the mill-owners) to be injuriously affected by the neighborhood of mill-ponds, these effects of malaria are of as regular recurrence in autumn, as on places near to any of the marshes of the low country; and are much more dangerous.

The third and highest region seems destined, notwithstanding its better defence in mountain sides and peaks, and the rarity of flat surface on which to form wide and shallow ponds, to take its turn next, as the victim of malaria. Already, in that part of the mountain region in and about Frederick county, there have been particular autumns which seemed almost pestilential. And though such cases of general and virulent disease are rare, particular cases of autumnal diseases are now frequent in many such places where they were rarely heard of thirty years ago.

These statements may be considered by some as exaggerated or unfounded—and, by others, if admitted to be true, considered as showing the want of both patriotism and policy, in the writer's thus exposing the enormous existing and still growing evils under which the country suffers. In regard to the former point, I admit, in advance, the scarcity of particular and positive facts, to serve as proofs, which is found throughout the whole subject; and that among the existing difficulties of obtaining such facts, (and still more by a single and unaided individual, who has had little opportunity to make proper researches,) I have to rely mostly upon general and loose opinions, and deductions from general facts. Hence there is much liability of mistake. But if the public can in any way be driven to the examination of this subject, and numerous individuals be excited to search for facts, whether to sustain or to oppose my views, the arrangement and presentation of such facts will serve as materials, which are now almost totally wanting, and will enable this all-important question to be hereafter properly discussed and correctly determined.

If there were no hope for relief, there would certainly be no use in exposing or dwelling upon these distresses of our people. But, though nothing yet has been done for relief, nor does it seem to have entered the imagination of our legislators, and though all they have yet done has been to add strength to the evil, still it is my confident opinion, that relief may be furnished for this sorest evil of the land, and furnished easily and profitably; and that it is perfectly within the power of man to dry up the most

fruitful sources of malaria, and to bring the whole, or very nearly the whole of Virginia, to a state as healthy as that of any other country in the world. If such a result is indeed attainable, it is worth making every possible exertion for; and nothing will induce the smallest exertion, either by the people or the government, except a full exposure of the enormity of the evil which presses upon the country.

It is not my purpose to attempt to investigate the cause and trace the mode of operation of malaria. Though worthy of every care and labor as a scientific question, it is one which as yet has entirely baffled every attempt at exposition. But though it is as yet unknown what is the chemical character of this subtle fluid, and what are the precise circumstances under which it is evolved, and what is the manner in which it exerts its baneful influence—still the main and most important points are left of no question. Thus, and in general, all persons, from the most ignorant to the most learned, agree that there is *something* which rises into the atmosphere in hot weather, from marshy ground and stagnant waters, which tends to produce the common autumnal fevers in those who are much exposed to breathing the air contaminated by this admixture.

Though I speak of malaria as an aeriform fluid, or gaseous product, it is not designed to found my argument upon the truth of that opinion. Though for convenience, as well as because inclining to the belief, malaria is here spoken of as a material aeriform product, yet, it may be also used as a term to designate the particular *condition of circumstances* produced by certain causes, which condition operates to produce and strengthen autumnal diseases. Still less do I mean to maintain that malaria, even if material, is of any one kind of gas, or any particular combination of several kinds. Besides these, there are many other common points on which the learned investigators of malaria totally disagree; and so much does each one insist upon deducing general principles from his own particular facts, (or supposed facts,) and so slightly and incorrectly have such facts been observed, that the general reader becomes lost in the contradictory positions of different instructors. Thus, judging from particular and isolated observations, with some writers, there is no condition of circumstances which will not sometimes in a warm climate produce malaria; and with others, upon equally partial and imperfect observation of other facts, the production is denied to be usually caused by any of the circumstances which are generally deemed the most certain and fruitful sources. One writer, perhaps, has known an exemption from disease in those who lived close to a stinking marsh, or a stagnant pond; and hence he denies that these are sources of malaria, and accordingly searches for them in other circumstances. Another has known the effects of malaria on troops encamped in a high defile in the mountains of Spain, where the soil was dry and stony, and no water except rapidly flowing rivulets, and the place some miles distant from the nearest marsh or lake. Hence he concludes, that even such a locality as this, in certain (unknown) circumstances, throws out abundance of malaria. Considering the circumstances under which most of the works on malaria have been written, it would be strange if they were not quite contradictory. The authors of most of them were army-surgeons and physicians, who observed the effects of malaria in some deadly region, upon soldiers not at all acclimated. Perhaps the author was confined to a garrison, or at least limited in his observations to the line of march of an invading army; and in a country to which he was totally a stranger, and among a hostile people, whose opinions he could not learn, and whose language he probably did not understand. If a physician of Lord Cornwallis' army, who had merely accompanied his march through Virginia, and been cooped up in Yorktown

during the siege, had written a treatise on the diseases of the country, he would have been better prepared to treat of them than most of those who have essayed such tasks; and he probably would have considered as a regular disease of the country the fatal "jail-fever," which swept off in numbers the absconding slaves who had joined the British army, and were crowded together in Yorktown until the surrender, and which form of disease has never been known in Virginia before, or since.

All agree that decaying and putrefying vegetable matter is one of the greatest, if not the only source of malaria. Of course, then, in addition to the sufficient abundance of the material, the circumstances most conducive to its putrefaction must be the most favorable to the production of malaria.

The presence of moisture, a certain degree of heat, and the access of air, are circumstances *essential* to putrefaction, and of course to the production of malaria; and neither can take place without the aid of all three of these things. Much moisture would be less favorable than a less quantity; and entire covering by water would, by excluding air, nearly prevent fermentation, and its consequence, the formation and escape of malaria.

It is also one of the few settled points, among scientific investigators, that malaria is very light, at least when warmed by the sun; and hence the fact known to many in this country, that those who live on the borders of marshes, and of mill-ponds, sometimes escape all injury from their exhalations, when others, who live on high hills, and at much greater distances from the sources, suffer greatly by the disease produced. Facts of this kind are numerous, and of regular annual occurrence, in Gloucester county. The whole of the wide and very level low-grounds furnish residences very healthy, compared to the tide-water region in general; though intersected in every direction by tide-waters, and though there still remains much swamp land unreclaimed, such as the whole body of low-ground was when in a state of nature. But the high, dry and hilly land, which forms the ridge of the county, is less healthy; and the highly elevated and beautiful sites of mansion-houses overlooking the low-grounds are universally sickly in autumn.

If all the facts in regard to the action of malaria were as regular and uniform as this one just stated is in Gloucester, there would be far less doubt on the subject. It is the uniform character of that county, in its high-land, low-ground, and also the water, and the long extent of each, which causes these effects to be so uniform there. Owing to causes stated in the description of the low-grounds of Gloucester, (Farmers' Register, page 178, vol. vi.) there is but little malaria evolved there; and if that, as supposed, rises by its greater levity, the regular daily sea-breeze must cause it to float towards the high-lands; and the long and regular line of ridge cannot fail to receive it, and in not very different proportions. But in most other situations, even though malaria should be produced in great quantity and with direful effects, yet these effects are so extremely irregular, in the places, the times, and the intensity of their operation, that they cannot be certainly traced to their true source; and therefore, that source may remain scarcely suspected, while it is dealing out death somewhere in almost every season. Away from the vicinity of the sea, nothing can be more irregular than the winds; yet, supposing a mill-pond to produce a regular and large supply of malaria every autumn, (though that supply is itself extremely irregular,) it depends upon the direction, force, and continuance of every change of wind, whether and where, and to what extent the malaria will produce disease. It is therefore not at all strange, nor opposed, as is thought by some, to the regular annual production of malaria or causes of sickness by each mill-pond, that the visitations of sickness, at any

one place, should be very irregular, and the difference be often totally inexplicable from any known causes, or variation of circumstances.

According to the views presented, there must be more or less malaria (or the gaseous products which, under certain conditions, form malaria,) evolved in every country where there is much vegetable matter to ferment, and sufficient warmth of climate to carry on fermentation. But, in the small quantity which is unavoidably extricated in every such temperate and fertile country, these products seem to be harmless. Perhaps a small quantity is absorbed as food by growing plants, and this aids the production of the earth. If so, this beneficial operation is made easy by another quality of malaria, which is well established as true. This is, that though it is so expanded by the sun as to rise above the lower air, still it remains on the surface of the earth in the night, after being extricated, or perhaps descends again from above, when condensed by the cold night air, and of course lies in contact, through the night, with growing plants. Hence it is, that sleeping on the ground, or in the lowest apartments, and being exposed to the night-air, invites the attacks and increases the virulence of malaria; and hence also it is, that the keeping of fires at night, even in warm weather, has been found highly useful to health, in places much subject to autumnal fevers.

Though it may then be theoretically true that every good soil, in warm or temperate climates, is throwing out malaria to a certain extent, it is only large quantities that are hurtful; and in practice, we have only, if possible, to avoid the formation of the hurtful excess of the products of fermentation. If, in lower Virginia, we can guard against the existing and increasing excess of malaria, our situation would be one of the healthiest in the world. For while we are comparatively free from the many and fatal disorders of the lungs to which the inhabitants of northern, and what are usually and improperly called *healthy* countries are peculiarly subject, we have no source of disease peculiar to our location, save this one, which, I fully believe, it is within our power to guard against.

Putrefying animal matter alone, however offensive in scent, is supposed not to produce malaria. It cannot be doubted but that decomposing vegetable matter is its source, because there is no production of it where there is no such material. Still, vegetable matter alone, or even when mixed with some putrescent animal matter, does not seem generally to produce malaria in great quantity; or with manifestly injurious effects on health. Thus, the gradual fermentation and rotting of the litter in cattle-yards, when left to stand through summer and autumn, or when the same was heaped and so left, (as was formerly the general practice in lower Virginia on all farms where manure was an object of care,) never was known to be certainly and highly injurious to the residents on the farm. Doubtless, malaria, and to an injurious extent, was always thus produced; but I have never known a sensible difference in regard to health, between years when either of the practices above-named were pursued, and when the material was carried out and applied to the fields in the spring, before fermenting. Yet, if judged by the test of some of the causes and effects as described and reasoned from by writers on malaria, one well-filled yard of litter, rotting through summer, ought to have produced enough malaria to kill half the inhabitants of the farm; and effects, in general, which would have been so disastrous, and so sure, as to leave no doubt of the cause of the evils, and of the absolute necessity of preventing their future recurrence.

But the putrefaction of vegetable matter, mixed with other things, as earth and water, and under peculiar circumstances, (though neither the precise admixture nor the circumstances are known,) produces disease to

such extent, that there is no doubting or mistaking the connexion of causes and effects. Such sure and abundant sources of malaria are the following materials: 1st, The putrid and stinking water of stagnant ponds, partially dried by the heat of summer. 2d, The mud bottoms of such ponds, or of streams reduced by drought, rich in decomposed vegetable matter, and left bare of water only in summer. 3d, Fresh-water marshes, of vegetable soil, frequently, but not regularly, covered by the tides. 4th, Fresh-water marshes, laid dry by embankments, and thereby permitted to rot away rapidly. 5th, The meeting of salt and fresh waters on land full of vegetable matter. Of these several and most important sources of malaria, I deem the third (fresh-water marshes in their natural state) to be the least hurtful; and that the sources numbered 1st, 2d, 4th, and 5th, increase in virulence in the order in which they are named. The greater evils produced by the last are universally admitted, but still by an erroneous deduction from the premises. The belt of the tide-water region of Virginia, in which the fresh water flowing down the rivers mingles with the reflux salt water from the ocean, is well known to be more subject to autumnal diseases than any other extensive space in the country. The breadth of this belt varies much in different seasons. The parts of the rivers in which the fresh and salt waters meet, and where each alternately has possession—as the tide ebbs or flows, may be but a few miles wide, and even that space is not stationary. But if the limits of this belt be fixed by the highest points to which the rivers have been known to be brackish in driest summers, and by the lowest points where they are fresh in winter, then this belt may be considered for the time as 40 or 50 miles wide, and, in length, stretching across all the tide-waters of the state. But in the much narrower space where this mingling of the salt and fresh waters usually takes place during the heat of summer, malaria acts with most intensity. Hence the general opinion, that it is simply the meeting and mingling of the fresh and salt waters which cause disease. This is not so, or but in a very slight degree. It is either the passage of fresh-water over salt-water marshes, or of salt-water over fresh-water marshes, that causes the great production of malaria, and disease. This is an important distinction, and the truth or error of the position deserves the most careful investigation. If the mere mingling of the waters were the cause of sickness, any relief for this part of the evil would be hopeless, as the waters *must* meet and mix together *somewhere*. But if it be as I suppose, the evil may be greatly restrained by works of art, or by simply preventing the unnatural accumulation of vast reservoirs of fresh water in mill-ponds, which when discharged, by breaches in the dams, or by opening the flood-gates, overflow salt-marshes, which the natural or unobstructed stream never could have covered.

Salt-water marshes, not touched by fresh-water streams, are not unhealthy to any considerable extent. This is susceptible of proof by innumerable examples in Virginia on the borders of the ocean, or of the waters of the Chesapeake bay. It is rare, however, to find a large salt-marsh attached to extensive high-land, which is not reached by some small stream; and every salt-marsh of course must sometimes be well washed and freshened by the heaviest falls of rain. Therefore all must, slightly and at some times, be prejudicial to health. These, however, are exceptions of but small practical or sensible operation.

The view here taken of the manner in which malaria is produced most certainly, and acts most injuriously, though not sustained by any known authority in this country, nor by any other precisely as stated here, is not therefore presented as original. I derived it, and thence deduced my application to this country in a modified form, from the interesting report on

the malaria of Italy, by Cautano Georgini, of which the substance was published in two different papers in the Farmers' Register, (p. 502 of vol. iv., and 460 of vol. v.) In this report the author shows, by the most conclusive argument and facts, that the irregular irruptions of sea-water over tracts of marshes, or other low-grounds, of fresh-water alluvial formation, caused the long continued and worst effects of malaria; and that by simply guarding against the entrance of sea-water, the country was restored permanently to healthiness. He says nothing of the reverse operation, the irregular floodings with fresh-water of salt-marshes. But what is produced by the one can scarcely fail to be as well produced in the other case. The mode in which the effect is produced is not attempted to be explained by the learned author quoted above; nor does any explanation seem sufficient to my mind. The rapid and abundant production of malaria may perhaps be aided, if not entirely caused, by the luxuriant cover of fresh-water plants, in the one case, being partly killed, and made ready for putrefaction, by being covered by salt water; and in the other case, in this country, by a like injurious operation on the plants peculiar to salt marshes, produced by the overflowing of fresh water. We know that certain plants flourish best in salt and wet soil, as others do in wet soil entirely free from salt; and that respectively with these different growths, the salt and the fresh marshes are heavily covered. It must follow from a sudden change in the condition, from salt to fresh, or the reverse, that the health of the entire growth must be greatly injured, and much of it subjected to death and decay.

The next most fertile source of malaria, (or perhaps what is even of greater malignity, for the small space occupied,) is presented in what is entirely the work of man—the mis-called *improvements* made by embanking and partially or entirely drying tide-marshes. The soils of these marshes, as I have ascertained by careful analyses, are composed, for about half their weight, of vegetable matter, and probably nine-tenths of their bulk is of that material, destructible by decomposition, when circumstances are favorable to that result; and drainage and cultivation produce precisely the condition which is most favorable. When covered twice every day by flood-tide, a marsh soil of this kind, though composed of the most putrescent materials, is but little subject to decomposition; because, being always thoroughly water-soaked, even when not entirely covered, and by water continually changed, the air is too much excluded, and the wetness is too much in excess, to favor the progress of decomposition. When the marsh rises so high as not to be covered by daily or frequent tides, then decomposition is more favored by the drier state of the surface, and, to a greater extent, malaria is evolved, and health injured. Hence the inference, that the higher and drier the marsh, the more it is injurious to health. But as soon as such a vegetable and putrescent soil is made nearly dry, and still more when cultivated and exposed to be penetrated by the air, decomposition proceeds under the most favorable circumstances. The soil sinks annually and rapidly, not so much by drying (as commonly supposed) as by actually rotting away; and, in a few years, it is reduced to so low a level as again necessarily to pass under the dominion and shelter of the water. The more complete the drainage, and the more perfect the management as arable or tilled land, the more rapidly is that end reached. In the progress to this end, a layer of the whole soil, of from one to three feet in thickness, will have passed off into the air in the gaseous products of putrefaction, of which enormous products, a large proportion will be malaria, and the effects produced by it on the health of some of the neighboring population are generally so evident as to leave no doubt of the source of the evil. More full details on the effects

of embankments of tide-marshes are to be found in previous articles in this work.*

The production of malaria by the last named operation, the embanking of marshes, however, is necessarily of very limited extent—and, moreover, of very limited duration. Nature soon asserts and enforces her rights; and the hopes of the improver, and the land so improved, are together overwhelmed by the reinstatement of the waters, and this source of disease is thereby cut off.

Tide-marshes, however extensive and injurious in their operation on health, still are limited to a comparatively small proportion of our broad territory. But there is another source which spreads disease over half the state, and which is entirely of artificial formation, and of which the evil effects have been becoming more and more extensive, and more and more virulent, from the early settlements of the country to this time. This widespread and generally operating source of disease and death is furnished by the numerous mill-ponds, of variable height of surface, which are now scattered over the whole face of eastern Virginia, and of which every individual case adds something to the general and enormous amount of injury to health and to life.

The law of Virginia in regard to the erection of mill-ponds, with perhaps the exception of the fence-law, is one of the most stupid, and most regardless both of private rights and general interests, of all in our code; and it is far more objectionable than the former, inasmuch as while the one merely robs individuals and destroys public wealth to an enormous amount, the mill-law permits and encourages also the destruction of health and of life throughout the whole land. It is true, unfortunately, that this opinion is not entertained by many persons; and that even with those who admit that all such mill-ponds are injurious to some extent, their estimate of the amount of evil is much below mine. It is my object to awaken the community to a sense of the enormity of the evil, and thereby to induce the commencement of measures of remedy and prevention. The universal acquiescence in this policy of our country, and the almost universal ignorance of the evils which it produces, requires strong language to enforce novel views in opposition to long established opinions. But it is confidently believed that my denunciations will be justified by reason and by facts, and by the magnitude of the existing evils.

There has long prevailed in Virginia a mania for building water-mills, which was not restrained by insufficient regular supplies of water to fill the ponds, nor by the insufficient prospect of business and of profit, even if there were no failure of water. In consequence, there have been not only erected mills on every stream barely sufficient to keep a common corn-mill in operation, but also on as many others where the water-power was either insufficient, or totally failed, during the driest season of every year. In the tide-water region, the mills for grinding wheat-flour, or any thing else for sale abroad, are limited to the falls of the rivers. All the others, (and probably there is on an average one for every square of five miles,) are merely designed to grind for toll the corn used for bread in the immediate neighborhood; and, considered merely in regard to money-cost and profit, it is most likely that half the mills in the country do not get enough toll-corn to pay for more than the costs of maintenance and repairs of their establishment. The more worthless the mill, on account of the insufficient supply of water, the more productive it necessarily is of malaria, diseases, and death. It will be difficult for me to make those who are unacquainted

* See Farmers' Register, p. 107, and 129, vol. i., and p. 41, 42, vol. v.

with our country believe that hundreds of mills have been built, and that most of them are still kept up, and many more new ones will probably yet be added to the number, which cannot yield any clear profit, above the entire cost, to the owners, independent of cost in property to the neighbors, and the cost (whatever that may be) of health and life to the country at large. Still the fact is notorious throughout lower Virginia, if it does not extend through the higher middle country. The only reason that I can conceive for so many unprofitable investments of this kind is, that many residents of the country build mills as many others raise race horses, more for amusement and excitement and to vary the monotony of their lives, than for profit. But this propensity of individuals could not have done much mischief to the country at large, but for the encouragement offered by the government. According to the law, and the long-established usage under the law, any man who desires to erect a mill, and for which it is necessary to pond the water on some of his neighbors' land, has nothing to do but to apply for an order of the county-court, by which the sheriff summons a jury to meet on the spot, to judge of and assess the damages that will be sustained by the owners of the lands designed to be covered by the pond. The jury is generally composed principally of men as ignorant and unfit for such investigations and estimates as the neighborhood can furnish—and they decide by guess as to how much land will be covered, and what damage will be sustained in the loss of the use of the land. There is no question entertained as to whether a mill is at all required by the demand of the neighbors for meal; and if the question of the effect on health is even named, it is addressed to a body entirely unacquainted with, and regardless of the whole subject. In fact the question as to health has rarely been considered in any such cases—and never duly considered. If the land that will be covered by a pond, though very rich, is then in the state of swamp, and totally unproductive, such an uninformed jury as the case is usually submitted to will be very ready to decide that such land is worth nothing, and if \$3 an acre is given as damages for the land actually to be covered by the pond, it will be deemed a liberal allowance. The court will rarely refuse to sustain the verdict of the jury.

Though the use of the land thus covered is for ever taken from the owner, or, for as long as the mill-owner may choose to keep up his pond, still the right of property is not changed. This small reservation of right, or feeble homage to justice, serves as a still further injury to the community, and is not of the least value to those to whom the right is reserved. It would be far better for all parties, if, when land was thus condemned to be covered by a mill-pond, that the damages assessed, however low and contemptible compared to the damages actually sustained, should have been deemed the purchase-money of the land, and the absolute right of property vested in the mill-owner. If this were the case now, there are many mill-ponds in Virginia which would be forthwith laid dry, even though the mills should necessarily go down; because the land covered by the ponds is now known to be worth more for cultivation than the mill is for toll. Hundreds of other mills, of greater profit and value, also, in that case, would be better supplied with water by canals than by their present ponds, by which their value as mills would be increased, to the owners and to the public, and the nuisances of the ponds be equally abated. But, as the law now stands, if a mill, which will not bring in of net rent \$50 a year, covers by its pond 500 acres of rich land belonging to other persons, the mill-owner has no interest whatever in draining the pond, because its drained bottom would belong to those persons. In any case approaching to this, and in which there would be a gain to all the individuals concerned, by draining the

pond, still it is not done, and the nuisance continues long after it is well known to be such, because there is a contest between the several owners of the pond and of the land covered by it, in regard to their respective shares of profit to be gained by emptying the pond. Many such cases still exist in Virginia; although many of the most unprofitable ponds, from proper views of economy, have been drained, and either substituted by cheaper and more efficient canals, or the mills put down entirely. An old mill-pond in Dinwiddie county, which covered 1200 acres of land, has been drawn off, and thereby an indifferent mill exchanged for a large fertile farm. This would not have been done, even if the mill was worthless, but for the ownership of the mill and the land covered by the pond falling into the same hands. There is a mill-pond now kept up in Prince George county, which is supposed to cover nearly 400 acres of land; and there are many others not much smaller, on different branches of swamps in lower Virginia. The larger the pond, in general, the greater proportion of bottom is left dry in autumn, and the more disease is therefore produced; and though the draining of such large ponds would be so much the more an object of gain, there is the less chance for its being done, because of the many separate ownerships and interests.

Almost all the mills throughout the lower part of Virginia, and also a large proportion of those in the more hilly middle county, are worked by streams which are inadequate to the daily supply of the mill and evaporation from the pond, even if the grinding is not necessarily suspended or diminished at any time. To guard against the temporary failure in dry weather, the full "head" of the pond, (or the level of water for which damages were assessed, and to which the water may lawfully be raised,) is much higher than the lowest level that will work the mill. The land covered is also usually very nearly level, so that to raise the water 10 or 15 feet at the dam, will often back the water from one to two miles up the low-grounds. If the variation between a full head of water, and the lowest level, be 5 feet perpendicular, it will often cause the uncovering of many acres of the bottom of the pond to the hot sun, and thereby furnish a most fruitful source of malaria in every such case. Rich alluvial mud, as this always is, thus exposed in hot weather, cannot be otherwise than very injurious to health; and there is not a pond-mill in Virginia, with a variable head, which has not more or less of the pond every summer thus converted to a fruitful seed-bed and nursery of disease.

Besides this, there is the not rare occurrence of the pond being entirely drawn off in summer, by the breaking of the dam, and its being suffered so to remain for weeks or months, before being again repaired and the pond filled. In this case, a double quantity of bottom is exposed to putrefaction, and fitted for the discharge of unhealthy miasma.

At all times, in ponds supplied by streams as feeble as most of those used for mills in Virginia, the water approaches to a stagnant state; and therefore of itself is a producer of malaria. In dry seasons, when unusually low, the putridity of the water of such ponds is perceptible to the sense of smell; and it must be then far from harmless.

Another, and in certain situations, the greatest evil of mill-ponds, remains to be stated. The others above-mentioned are the effects of the scarcity of the supply of water; this is from the excess, which is found in all streams, at some times, even though the most deficient at others.

To guard as much as possible against the expected scarcity of water, the mill-owner aims to hold, when rains increase the usual supply, as "full a head" as he has a right to maintain. When this supply is exceeded, as it frequently is, and greatly, if the dam be not actually broken, and the whole

emptied, in one prodigious flood, at least the flood-gates are opened widely, and a discharge made ten-fold greater than would have occurred during equal time, if the stream had not been obstructed by a dam, and had discharged as regularly as the supply was increased. It will be evident, on considering these circumstances, that water from a mill-pond, whether discharged by flood-gates, or otherwise, must be far more variable in height, and in extent of inundation on the land below, than the natural stream unobstructed by art; and still more than the stream opened and improved and its course facilitated by art. An ordinary natural stream, which might have a very uniform discharge in dry weather, and would rarely overflow its banks in wet, if dammed across for a mill, would often have its bed below the dam left almost dry; and, at rare and irregular times, would be converted to a tremendous flood, which would sweep over hundreds of acres more than the floods of the natural stream could have reached. Besides the immense damage caused to cultivated land by these floods, (and which kind of damage is rarely estimated or thought of by juries when mills are established above,) there are numerous hollows made, and filled with water, which, on the retreat of the flood, (as hasty as its inroad,) remain so many stagnant pools until made dry by evaporation. The whole land, thus covered, is saturated with water; and, from the nature of the rich alluvial soil, is throughout, as it dries, made a producer of malaria.

But the worst part of this evil, by far, is when these artificial floods of fresh-waters pass over salt-marshes—which happens in all the country in which the fresh and salt waters meet; and this combination of causes I consider the most efficient producer of disease in that part of the country, and the thing which ought most especially to be guarded against. According to the views before presented, the passage of fresh water over salt-marshes, no matter to what extent, is one of the most sure producers of malaria, and of a particularly malignant kind. The mill-ponds, alone, form other and far more extensive, if weaker sources of the poison; and by the union of the two, the mill-ponds exert all their usual bad influence above the dams, and spread ten-fold more pestilential effects below, by inundating the wide salt-marshes, which by natural streams would scarcely have been affected.

On Nansmond river there are lands already rich, and having inexhaustible supplies of the best marl, which have been sold at \$10 the acre. There are hundreds of estates in the same belt of country which cannot be sold for as much as the cost and present value of the buildings. And this otherwise fine country, so accursed by disease, owes its condition principally to the mill streams which flow into the salt tide-waters, and which are so numerous, and their sources so interlocked, that there is no spot safe, by remoteness of position, from these combined effects of mill-ponds and salt-marshes. It is therefore sufficiently evident why that otherwise finest part of the state, for agricultural improvement and profit, should stand among the lowest in both these respects. Yet this part of Virginia might be rendered both healthful and fruitful, and the delightful region which God has permitted it to be made, if man would accept and avail of his bounties by merely using half the expense for improving which has been lavished to inflict pestilence and poverty on the country.

These statements and expressions of opinion will be unpalatable, if not offensive; and perhaps may subject the writer to the charge of being willing to injure the residents of the region for whose relief in this respect he is most anxious, and of the facility and cheapness of obtaining relief, by the use of proper means, he feels most confident. If the exposure and probing of the ulcer be never so painful, let it be remembered that it is done solely for the purpose of seeking for, and applying, a sure remedy.

There is still another source of malaria, which it is necessary to touch on in connexion with the above-mentioned, though it has been already treated more fully elsewhere, and therefore will be but slightly mentioned here.*

From the vegetable matter upon the driest land, as it ferments and decays, there must be extricated more or less of the gaseous matter which, when in excess, is injurious to health. According to this view, the whole surface of the country, and especially that most heavily covered with vegetable matter, may furnish malaria. The degree of hurtfulness of this product will depend on the power of growing vegetables to feed on, and of the soil to absorb and fix in it this matter, which, according to its direction and quantity, may either enrich land, feed plants, or poison men. In earlier publications I have stated at large my reasons for believing that all the products of vegetable decomposition, on naturally poor lands, are lost to the land;† and as the ultimate results of decomposition are gaseous, or aëriform, they must go off into the air. These products constitute or cause malaria, and its injurious effects on the health of the inhabitants. But calcareous matter serves effectually to fix in the soil the enriching principles of decaying vegetable matter, until they serve as food for growing plants. Hence the deduction that a naturally poor soil, made calcareous, will no longer throw off gaseous products, or malaria, into the air; but will store it up as fertilizing manure. The sure remedy for the irregular and generally slight degree of sickness thus caused, is to marl or lime all the land that requires calcareous earth. But that remedy would not be sufficient, if mill-ponds or marshes in the neighborhood continued to send out large additional supplies of the aëriform poison.‡

The correctness of my deductions as to the very injurious effects of mill-ponds on health, will be denied on several grounds, which, so far as expected, I will anticipate as objections, and state with the answers, as follows:

Objection 1.—Admitting generally, and to some extent, the ill effects of mill-ponds in producing noxious exhalations and autumnal diseases, it does not appear that these effects can be either so great, or so sure, as is charged above. The residents on the farms nearest to mill-ponds are not always, and often not at all, more sickly than those who reside several miles distant. The house of the slave who acts as miller, is usually near the mill, and close to the pond; yet families so situated are generally as healthy as any others, and sometimes are healthy in a remarkable degree, compared to the neighborhood generally.

Answer. Near the mill-dam, or the lower end of the pond, may well be less affected by the exhalations from it, than places a mile or two more distant. That part is the deepest of the pond, and of which also the banks are steepest; and perhaps half a mile in length of the bottom of the upper and shallowest part of the pond, and of alluvial mud, might be left naked in drought, before a margin of steep hill-side of three feet width could be exposed near the mill. Further—from the greater lightness of the malaria, it will rise high in the air, and would soon be carried far away by a moderate breeze. If the wind be moderate, and steady to one direction, and still more if its course be confined to an opening by or between woods, or to a narrow valley between high hills, it may well be imagined that the poisonous air might injuriously affect persons perhaps five miles from the pond, and who would not suspect the operation of so distant a source;

* See 'Essay on Calcareous Manures,' 3d ed., chapter xv, and 'Essay on the Police of Health' commencing p. 154., vol. v., of Farmers' Register.

† Essay on Calc. Man., pp. 23, 57 and 59.

while others, close to its border, but in a different direction, or on a different level, might escape its influence.

Objection 2.—There is not enough difference in the usual or average healthiness of families the most exposed, and others the least exposed to mill-ponds, to attribute much of the effects to these causes. Whole neighborhoods, in some autumns, are very healthy, and in others very sickly, without either condition seeming to be connected with any certain and known state of the nearest mill-ponds.

Answer.—The extreme lightness of the poisonous air, and great and frequent variations in the direction, force, and continuance of the winds on which it is borne, make it generally impossible for it to be known from which particular pond or ponds the malaria rises, or where it is carried. It is most probable that the exhalations of twenty ponds, of which the most remote may be thirty miles apart, may be mingled together by the winds of a single day, and thus combine and average the effects of all. Further, if all the mill-ponds of a county furnish one half of the active and injurious malaria, and the other half is thrown off, nearly equally, by the whole surface of the land, (though some parts would receive the strongest doses, and others escape with having only the weakest,) it would be impossible to understand the mode, and estimate the intensity of operation of the known general causes; or to refer, with certainty, any one effect to its special or principal cause. Thus, a farm relieved from all malaria of its own product, by marling and by drying its mill-pond, though evidently showing the benefit in increased general healthiness, might still be sorely visited by the seeds of disease from other and remote sources, directed and concentrated by a steady wind.

Having presented these views of the origin, action and effects of malaria in this country, I can better exhibit the progress of the causes which I believe to have operated, and which are still continuing to operate, to produce the change from a healthy to an unhealthy state.

When our ancestors first reached this shore, nearly the whole country was in a state of nature. The savages had cleared for cultivation but a few fertile spots on the banks of the rivers; all the remainder of the land was under one great forest. The streams had not been obstructed by the cutting down of trees across their beds, (by which in many cases streams have since been choked, and swamps thereby formed, or greatly extended.) No dams had obstructed the free and regular course of the streams, and therefore no great artificial floods were formed. The soil not having been cultivated, was not exposed to be washed away by the rains into the rivers. The waters therefore were generally clear, instead of being generally muddy, as since all these circumstances have been changed. In this former state of things there could have been existing but few sources of malaria.

The first formation of sources by the civilized settlers, was in making ponds to supply mills. But while these were yet few in number, the constructors of course chose the best and most unfailing streams; and the ponds were also, for a long time, surrounded by dense and tall forests. Such hilly land as the margins of the ponds would certainly not be brought into cultivation while so much that was far better, and easier to till, remained unoccupied. Hence, such ponds produced but little malaria, and that little was warded off from the settlers, or taken up by the forest growth. The general wooded state of the country, also, for a long time, rendered the supplies of water more regular, and prevented the severe droughts, which would have altered greatly, as is usual now, the levels of the ponds.

The clearing, cultivation, and consequent washing of the lands of the upper country, greatly increased the muddiness, and quantity of alluvial

deposite of the rivers, and thereby increased the marshes both in breadth and in height. More mills continued to be built, and on streams worse and worse for water power, as the choice became less open, and the mill-mania began to grow; and, in the general, each successive construction of a pond was less productive of profit, and more productive of disease, than its predecessors. The number of mills not only continued to increase, and is increasing to this day, and in the oldest settled parts of this state, as well as the newest, but gradual changes also took place in the condition of the old mills which greatly increased their fitness to produce disease. By the long continued deposite of mud from the streams, and the washing of the now cleared and tilled hill-sides, the ponds became more shallow, and the waste of water by evaporation therefore became greater; while the supply was lessened, in consequence of the extended clearings of the great forest which had before covered the whole country. To remedy the increasing deficiency of water, the owners of old mills, who were not prohibited by circumstances, raised the level of their ponds; which, by increasing their surface and their contents, still more increased the daily evaporation, and also the violence of floods, and the variable height and surface of the water; all of which again combined to increase, still more than before, the product of malaria. The consideration of the progress of all these circumstances, and their bearing on each other, will serve to explain why a particular neighborhood might formerly have been healthy, though having two or three mill-ponds within or around it; and why it might gradually have become very unhealthy, in the course of time, by the malaria produced by the ponds of the same mills, or perhaps by the addition of one more pond only to the former number. But, in such cases, so gradual would be the general change, and so irregular and variable the attacks and virulence of the autumnal diseases, that the sufferers would not attribute the change, (even if they admitted it to have taken place,) in their average degree of health, to causes which had so long existed without being charged with doing mischief; and in which causes no change of condition had been observed. Add to this, that self-love makes every man reluctant to believe, and to confess, that his own farm, or his own neighborhood, has become more sickly; and the change for the worse is attributed to transient causes, until the former state of things is almost forgotten, and the present is received as if it had always been the usual condition of circumstances.

During all this time, other causes were working to produce other nurseries of disease, and impediments to agricultural products and improvement. The wet alluvial bottom-lands, bordering on small rivers and still smaller streams, were for a long time neglected, and deemed of little value, except for their fine white-oak, cypress, and other noble timber trees. These were cut down so as to fall into or across the streams, when in reach, more often than otherwise; and in consequence of such obstructions, continually increased in number for more than a century, the before open streams were choked, and the bordering low-grounds converted to swamps; and those which had been swampy at first were made still more so, by obstructing the sluggish streams, and spreading them over the whole surface, and causing that surface continually to rise by fallen trees and alluvium. But wet as are such swamps for the greater part of the year, most of the surface is dry in autumn; and the scanty water is then stagnant in numerous pools, until added to by the first heavy rain, or a flood from a mill-pond discharged above. Of course all these circumstances added enormously to the previous annual decomposition of vegetable matter, and consequent production of malaria. Such swamps as these, formed by nature and increased by art, are those on the Chickahominy, Blackwater, and many other long but

gentle streams. To form or increase their evil qualities and tendencies, the law has given full permission, and no small aid; but it positively, though indirectly, *forbids the drainage* of all such extensive swamps, and preserves them still as mere nurseries of disease. A general law for permitting and facilitating, under proper regulations, the draining of these great swamps, would be a measure which would be most beneficial, not only for improving the healthiness, but for increasing the agricultural products of the country.

But though the tendency of the general changes in the physical condition of the country was to increase the causes of autumnal diseases, there were numerous particular exceptions, in works serving to promote health. Of this kind were the opening and straightening of the choked channels of small rivers, and many large streams, in the hilly country, where there was enough descent to enable each individual proprietor of flooded low-ground to relieve it by operations confined to his own land. The effectual drainage of much land of this kind has produced so much benefit to health as in many cases to balance and even exceed the increasing pestiferous effects of the neighboring mill-ponds. Such facts would be taken by most persons as proofs that the increase of mill-ponds had not increased disease. Such benefits have been produced by the gradual draining of the extensive low-ground of Gloucester, which in its former and natural swampy state must necessarily have been an abundant source of malaria. This change, together with other circumstances stated in the recent description of that part of the country, has operated to render the Gloucester as free from bilious disorders as any part of the tide-water region—save the adjoining county of Matthews.* The remarkable general state of healthiness of all these very low lands at present, as well as the exceptions and evident causes of the exceptions, furnish the most clear and important evidence of the truth of the position, that mill-ponds and floods of fresh-water discharged over salt-marshes are the great sources of malaria in Virginia. As stated formerly,† there are but few fresh-water streams discharged on salt-marshes in these two counties, and not a pond-mill on the low-grounds, nor indeed in the whole county of Matthews, save one on its border nearest the high-land. The facts presented here alone will prove the great and certain benefit to be obtained by even a partial and imperfect avoidance of the action, separate and combined, of these two greatest sources of malaria.

But although the general and average degree of sickness may have been, and certainly is, much lessened of late years by the better drainage of very many of the smaller swamps—the introduction and increase of more perfect tillage, which includes better drainage of arable land—and, still more by far, by the now extensive applications of marl and lime—yet it would be a great and dangerous error thence to infer that the mill-ponds and the still remaining irreclaimable swamps had become less injurious to health. Their malignant effects are not only not lessened in the slightest degree, but must continue to increase with time, as long as the present destructive legal policy of Virginia remains. The growing beneficial operation of the other and opposite influences, have indeed served to neutralize, counteract, and even (in the most thoroughly marled districts) to greatly overbalance the continually increasing disease-producing operation of the mill-ponds and swamps; but not to prevent its existence or power. The greatly beneficial operation of calcareous manures especially in improving health, (which operation has been so fully treated of in preceding parts of this work as

* See the facts and reasons stated more fully at p. 179 and 190, in vol. vi. of *Farmers' Register*

† The same p. 190.

to be unnecessary to enlarge more upon here—) instead of blinding us to the unabated though more concealed effects of remaining sources of malaria, should urge the more strongly, and encourage every effort, to destroy all such sources. For if the mere counteraction of opposite influences has so much improved the healthiness of a large portion of lower Virginia, it may be safely inferred, that the removal of the remaining sources of disease, and leaving the beneficial influences to operate freely and absolutely, instead of merely by counteraction, would serve to make this region as healthy, in general, as any part of our whole country.*

The most important part of this subject is the consideration of the remedies for the evils described. But although the means available for this end in my opinion are ready, cheap, and sure, still it is needless at present to argue in their favor at great length. Unless the people are aroused to a proper sense of the evils under which the country suffers, no regard will be paid to the consideration of proper remedies; and if the former object can be gained, the latter will then necessarily follow.

The most important of these remedies, and of which the proper use, I maintain, will remove nearly all the existing sources of malaria, and make lower and middle Virginia healthy, will be merely here stated concisely and distinctly.

1st. To prevent the continuance of any mill-ponds of very uncertain supply, and variable "head," or height of water.

2d. To furnish to the land-floods, of streams swollen by rains or by any mill-ponds still left, the quickest and best possible discharge to tide-water by open canals, so as to prevent the fresh-waters passing over any salt-marshes.

3d. To drain the great flat swamps; all of which require a continued canal to be extended from the lowest out-let up to the head of the supply of water, in the most effective course, and on a general plan, through the lands of many different proprietors. The drainage of lands so situated is effectually forbidden by the existing laws; as there is no power to act, unless all the proprietors concur in every particular of the execution and expense of the drainage; which is obviously impossible.

4th. To refrain from embanking from the tide any marshes of the usual putrescent and perishable soil.

5th. To apply marl or lime to all lands needing calcareous manures, and on which they can be furnished at not too great cost for even such great improvement of soil and product as would certainly be obtained in all such cases.

The two last means of prevention are altogether within the power of individuals, and will be used, or not, according to the views of different individuals as to the agricultural profit to be expected from such operations.

The three first-named means of remedy would each require the action of the legislature, to enable them to be used to any considerable extent.

The necessity for a general plan being authorized by law for inducing and compelling combined operations to drain swamps on long and sluggish streams, though merely for agricultural improvement and profit, is already evident to most intelligent farmers; and perhaps nothing is now wanting to procure such legislation but the proper exertion of some of the individuals who are most interested on the subject.†

The giving free vent to land-floods, also, by wide and straight canals, and

* This paragraph is an addition to this article, as it was first published in 1838. The only other changes made, are the correction of a few verbal inaccuracies, and the marks of references to this Essay being made to suit the present instead of the previous edition.

† See *Farmers' Register*, vol. i., pp. 232, 386, 518, 733, 734.

preventing them, by dikes, from overflowing the salt-marshes, though a kind of work requiring public money as well as legal authority, still may be hoped for, when the necessity of the measure shall have been made evident.

But there is no such prospect of success as to the most important reform needed, in the putting down of all fever-breeding mill-ponds; and he who will venture to advocate this general measure will be regarded, by most of those whom he aims to serve, as more an enemy than a friend to their interests, and more deserving to be treated as a lunatic, than to be respected as a judicious advocate for valuable public improvements. It is not in the vain hope of now enforcing my views by extended argument, but to offer explanations, and thereby prevent misconstruction, on some particular points, that some further remarks will now be offered.

Even if the public mind had been prepared for a full legal reformation of the policy of mill-ponds, and for the laying dry all such as are nuisances to health, there would be no accompanying necessity for injuring the private interests of mill-owners, nor of causing material loss or inconvenience to the customers of the mills. In the first place, in justice to the vested rights of the millers, (however unjust to others, and injurious to the public may have been the original creation of their rights,) I would advocate full compensation being made for every sacrifice of value in their ponds, which should be required and compelled for the general benefit. But *not more* than full compensation for all value thus destroyed should be granted; and many of the fever-breeding ponds are really of no pecuniary value to their owners or to the public; and most others may, to greater advantage, be supplied with water by canals, instead of by ponds. Even if one-third of all the mills should be thus put down entirely, these would be such as now always fail in dry seasons; and the more permanent and regular supplies of water, which all the remaining mills would receive from the canals substituted for ponds, would render them able to furnish the whole country with meal, with regularity, certainty, and in abundance, and therefore more suitably and conveniently to the consumers, than all the mills, good and bad, now in operation. By an important innovation in the law in regard to mills, (enacted March 2d, 1826,) every owner of a mill is authorized to cut a canal through the lands of other persons, if required by the nature of the locality, so as to substitute the pond by a canal. Before this amendment of the old law, no mill-owner could effect any such improvement, unless in the rare case of his own land extending under the whole course of the desired canal. The privileges offered by this new provision have already been availed of in many cases, in Charlotte and the neighboring counties, and to great advantage in regard to health as well as to increased power to the mills, and with great value gained in the rich drained bottoms of the ponds being put under cultivation. Slowly as such lessons are usually learned, and slowly as new agricultural improvements are brought into extended use, this highly beneficial and profitable improvement cannot fail to be adopted generally in the course of time.* The main obstacle to the early and general substitution of canals for ponds, wherever the change is practicable, is the absurd legal distribution of rights in the mill-ponds and the land which they cover, as stated on a preceding page; one person being vested with the perpetual right to keep the land overflowed and worthless, while others have the right of property in that land, to be exercised only in the never-expected event of the owner of the pond drawing it off and draining the rich bottom, and that for the gain of others more than himself. Now I

* See facts and statements on this subject at p. 231, vol. v., *Farmers' Register*, pp. 1 to 3; p. 579, vol. ii.; p. 374, vol. iv.

would get rid of this absurd conflict of rights, by vesting the full property of the land covered in every mill-owner who would draw off the pond; or if he did not avail of the privilege offered, the land should be given up to its former owners, or to any one else, who would construct a canal, and thereby secure to the use of the mill an equally good supply of water-power.

Each of the several remedies proposed and stated above would alone furnish a fruitful subject for investigation and discussion. But more extended remark from this source is as yet uncalled for. Other persons, having better practical information, and thereby prepared to confirm or to disprove the positions here assumed, are invited to aid in the discussion. Let the truth be made known, on whichever side it may be found; and should all facts and deductions presented serve to show that the present system greatly needs reformation, and to awaken the public to the importance of the object, then will be the suitable and propitious time to ask attention to remedies proposed for the then acknowledged evils, inflicted by the action or permission of the government. Whenever the legislature is prepared to act decisively on this whole question, there will be before them a subject for the "internal improvement" of Virginia far more important in beneficial results than the roads and canals which have cost millions of dollars to the treasury; and yet which will be cheaper, compared to the profit to be certainly counted on, than the most humble or contemptible job for private objects, which has yet been carried through by public expenditure, and as a public improvement.

But even under the existing law, any single individual who clearly sustains injury to health from any particular mill-pond, has now the legal power to have that particular nuisance abated, by means of suit for damages for the injury thereby sustained. It has been judicially settled that such ground of suit for damages is not prevented by any previous assessment by the first jury, nor by any lapse of time during which the mill has been standing; nor is the ground removed by the new damages awarded for injury already sustained and sued for. No matter how often damages may have been given to the plaintiff by successive verdicts, and paid by the defendant, there will continue ground to sue, and recover, as long as the pond remains, and is hurtful. It is surprising that the law, so favorable to the interests of mill-owners, and regardless of all conflicting interests and rights of other persons, should have permitted, in this particular, so much of remedy for the previous injustice and injury inflicted by the law. And it is still more surprising after legal decisions have so clearly shown the remedy, that, of so many thousands of individuals who are unquestionably suffering every autumn from the neighborhood of stagnant mill-ponds, so few should have availed themselves of the offered means of relief.

If the importance of this general subject were duly appreciated, its investigation would become an object of the care, and be conducted at the expense of government. If the legislature of Virginia (for example) would institute a "General Board of Health," or "Commission of Sanitary Police," for the purpose of investigating the subject of malaria thoroughly, and of reporting the sources and proper remedies, the body of evidence which would be collected, and the after-results, might be made worth many millions of increased pecuniary value to the state, besides the far greater benefit to be produced to the health, the physical and moral qualities, and the general happiness of the people. At any possible cost of such an investigation, and of the system of measures founded thereon, the public improvement and benefit produced thereby would exceed the expenses a hundred-fold.

Note X.—Extension of subject from page 150.

A MACHINE PROPOSED FOR RAISING MARL.

The machine which will be described below is used at Fortress Monroe for raising sand from the fosse to fill the ramparts; and has been found by experience to be the best contrivance of all which have been tried for that operation, and for which an immense amount of labor was necessary in constructing the defences of the fortress. Precisely the same manner of operation is required for raising marl from deep pits, and there can be no doubt of this being a more effective machine for that purpose than any heretofore applied. The force applied is the weight of the laborers, on the principle of the tread-mill, which is the most effective manner in which the power of men can be applied. I am indebted for the suggestion of this machine for raising marl to the observation and scientific knowledge of mechanics of my friend M. Tuomey, and also for the following description and the drawings for the engraved figures. Mr. Tuomey, when making a transient visit to the fortress, had seen the machine at work; and recently, after reading in the foregoing part of this work the remarks on the different modes of raising marl, and having witnessed some of the usual modes in practice, this machine and what he had seen of its power appeared greatly superior, whenever circumstances may require any use of machinery. Upon being thus informed, I applied to Dr. Robert Archer, U. S. A. Surgeon at Fortress Monroe, (to whom I, and through me the agricultural public, have been frequently and much indebted,) for a rough plan, and accurate statement of the dimensions of the machine, both of which he kindly furnished; and with the aid of these, Mr. Tuomey has been enabled to give such particular description and correct delineation as will serve for full instruction for the building and working of the machine.

"1. Figure 1 is a side view, in perspective.

i, i, The base, consisting of 3 pieces of scantling, each 12 feet long, and 11 inches by 5, notched on to each other about 6 inches from the end, so as to be flush on top, forming an equilateral triangle.

e, The principal post 8 feet, 8 by 6 inches, secured to the base, and braced by the braces f. Near the top of this post 2 iron sheaves or pulleys are placed, one on each side, and secured by pieces spiked over them. The chains pass over these pulleys.

f, 2 braces 11 feet long, 4 inches by 6.

h, h, Two uprights, in which the gudgeons of the wheel turn, they are bolted to the base and connected at top by the piece g, 10 feet 6 inches long, 4½ by 6 inches, which also serves as a hand-rail for the men to steady by when working on the wheel. These

uprights are further secured by cross pieces connected with the braces, and bearing in front and rear of the wheel two steps on which the men stand as they go on or off the wheel.

- w.* The wheel 4 feet in diameter, the steps $3\frac{1}{2}$ feet long 8 inches wide, made of $1\frac{1}{2}$ inch plank. The ends of the wheels are formed of two thicknesses of inch plank placed crosswise, the inside being grooved to receive the steps which are placed about 8 inches apart. The axle of the wheel is 10 feet 6 inches long and 8 inches in diameter, the portion around which the chain winds is enlarged, so as to suit the force employed on the wheel, or the weight to be raised, by nailing on strips of plank, over which a few turns of old rope may be placed to prevent the slipping of the chain.

To prevent confusion, only one crane (or arm) is represented in this figure.

The crane post is represented as turning on two iron pivots in pieces *s, s*, one bolted to the principal post *e*, and the other spiked to the base. The crane post is 6 inches square.

- a.* The crane jib, 7 feet 6 inches long 6 by 7 inches.
- b.* The strut to the jib, 8 feet 6 inches long 4 by 6 inches. Near the extremity of the jib an iron sheave is fixed over which the chain passes.
- c.* Is a three-quarter inch rod of iron secured to *u* by means of a staple, and having a hook at the other end which drops into a staple at *i*. This rod serves the double purpose of a stay and a guide, by which (when unhooked) the arm is drawn to one side for the purpose of landing the box. When fixed, as represented in the drawing, it serves to retain the crane in its proper position. When the box is raised the rod is unhooked, and by means of it the box is landed,

Figure 2 is a front view, showing the relative position of the cranes, which are represented as turned aside. The chain is seen winding around the axle. It is evident that the men must pass to the opposite side of the wheel as each box is drawn up.

- j, j.* Represent 2 views of the boxes, which are square and may be each about 21 inches every way, they will then contain nearly 6 cubic feet each. They are suspended by two pins placed a little below and to one side of the centre so as to turn over and empty themselves when a small iron pin seen at *j*, figure 2, is withdrawn. Three men can be employed to advantage at the wheel, two remaining on whilst the third gets off to land the box. Should the box not be heavy enough the diameter of the axle can be enlarged so as to make up in time what is lost in weight. Should it be too heavy for the force employed the diameter may be lessened."

The above dimensions of timbers were those of the particular machine measured by Dr. Archer; but they vary in all the machines of this kind used at the fortress. The length of the arms of course should be proportioned to the height to which the loaded buckets are to be raised. For marl, any sized timbers on hand, or logs, that are long enough, would serve for the base (*j, i*.) It is however desirable that the machine should be as

light as is consistent with strength, for the greater facility of moving it; and for strength alone, (as in all other machines,) the large size of timbers is of less importance than their being well put together. Two thick and narrow planks, firmly spiked together, and with a space left between of proper size for the sheeve to play in at the upper end, would be a cheaper substitute for the jib *a*. When carts are removing the marl at the same time it is raised, there would be much advantage gained in having the boxes of such size as to be emptied into the carts, and the measure or load of both being made the same.

TABLE OF CONTENTS.

Preface to first edition	iii
Preface to second edition	iv
Preface to third edition	vi

PART FIRST—THEORY.

Chapter I.—General description of earths and soils.

The necessity for distinguishing each, 13. Description of siliceous, aluminous and calcareous earths, 13. Guide to the chemical nomenclature of neutral salts, 14. Reasons for confining the term "calcareous earth" to carbonate of lime, 14. Magnesia, 16. Soils are formed by mixtures of earths, 16. Inaccuracy of ordinary definitions of soils, 17. Plan of nomenclature of soils proposed, 18.

Chapter II.—On the soils and state of agriculture of the tide-water district of Virginia.

General features of the district, and character of its soils, 19. Ridges, 19. Slopes, 20. River banks and alluvial lands, 20. Destructive tillage, 20. Products, 21. Slavery in connexion with the general system of agriculture, 22.

Chapter III.—The different capacities of soils for receiving improvement.

First principal propositions stated for discussion, 24. Natural fertility defined, 24. Permanency of either fertile or sterile character of different countries, or particular soils, 25. Land naturally poor not capable of being enriched by putrescent manures, 26. Opposing opinions and authorities, 26, 27. Evidence in support, 28. The degree of original fertility is the limit of profitable improvement by putrescent manures, 29.

Chapter IV.—Effects of the presence of calcareous earth in soils.

Calcareous earth not found in poor soils, 30. Its presence always accompanied by great fertility, 30. Exceptions in soils overcharged, 31. Authors have erroneously taught that calcareous soils were general, 31. Evidence of such opinions, 33, 33. Erroneous as to Virginia, 34.

Chapter V.—Results of the chemical examination of various soils.

Different modes of finding calcareous earth in soils, or to show its absence, 35. Davy's pneumatic apparatus and its operation described, 36. Proportions of calcareous earth in sundry species of rich soils, 37. Calcareous soils fertile, and poor soils not calcareous, 39. Most rich soils, and even lime-stone soils contain no carbonate of lime, 39.

Chapter VI.—Chemical examination of rich soils containing no carbonate of lime.

Rich river lands, 40. Lime-stone soils, 40, 41. Soils from Pennsylvania and New York, 41. Prairie soils of Alabama generally highly calcareous, 42.

Chapter VII.—Proofs of the existence of acid and neutral soils.

Lime in some form present in every soil, 44. Acid not considered an ingredient of soil by any writer of authority, and denied by others, 44. Proofs of the existence of acid in soil, 45. Growth of acid plants, 46. Nourished best by dead acid plants, 46. By other putrescent manures, 47. Acid poisonous to cultivated plants, 48. Disappearance of carbonate of lime in soils, and their becoming neutral, 48. All wood ashes contain carbonate of lime, 52. The recent discovery of humic acid in soils, 53. Deductions, 55. Supposed gradual and natural changes of soils from calcareous to neutral, and next to acid, 55.

Chapter VIII.—The mode of operation by which calcareous earth increases the fertility and productiveness of soils.

Siliceous and aluminous earths have no chemical power to retain putrescent manure, 58. Calcareous earth has such power and how, 59. Fertilizing power exerted in neutralizing acid, 61. And in altering the texture and absorbency of soils, 62.

Chapter IX.—Action of caustic lime as manure. Classification of manures.

Davy's theory of liming stated, 64. ^{Applied} Applied to practice, 65. Action injurious on soils generally, 65. Plan of classification of manures, 69.

PART SECOND—PRACTICE.

Chapter I.—Introductory and general observations on marl and lime.

Fossil shells, or marl, so called improperly, 67. Improper use of the term "marl" in England, 68. Lime is, in fact, generally the carbonate in operation, 69. Oldest trials of marl in Virginia, 70. Preliminary remarks on experiments, 70.

Chapter II.—Effects of calcareous manures on acid soils recently cleared.

Experiments stated, and the first and subsequent results on light loam, newly brought under cultivation, 71 to 77.

Chapter III.—Effects of calcareous manures on acid clay soils, recently cleared.

Description of the worst known class of clay soils, 77. Remarkable effects of marling on such, on clover and grain, 78 to 81.

Chapter IV.—The effects of calcareous manures on acid soils reduced by cultivation.

Marling always effective on such soils, 82. Causes of disappointment and loss, 82. Experiments showing best and worst results, the evil in heavy marling and the remedy, 82 to 88.

Chapter V.—Effects of calcareous manures on "free light land."

Peculiar character of this land, 89. Effects of marl thereon, 89. Analysis of the soil, 90.

Chapter VI.—Effects of calcareous manures on exhausted acid soils under their second growth of pines.

Experiments showing remarkable benefits from marling land in this state 90

Chapter VII.—Effects of calcareous manures alone, or with gypsum, on neutral soils.

Experiments difficult to conduct, and unsatisfactory, 92. Gypsens (eccenc) marl described 93. Experiments and their results, 93.

Chapter VIII.—Digression to the theory of the action of gypsum as manure. Supposed cause of its want of effect on acid soils.

Gypsum of no effect on acid soils 95. When operative, on neutral and calcareous soils 95. Generally operative on acid soils after marling 96. Reasons for these results 97. Illustrations 98.

Chapter IX.—The damage caused by too heavy dressings of calcareous manure, and the remedy.

The disease caused by over-marling described, 100. How prevented or removed 101. The mere quantity of calcareous earth not the cause of this disease, 102.

Chapter X.—Recapitulation of the effects of calcareous manures, and directions for their most profitable use.

Results of practice generally sustain the theory of the action of calcareous manures, 103. Less efficacious above the falls of the rivers, and more so on "mulatto land" than the theory would indicate, 104. Effect in fixing potrescent manures, 105. Less benefit on most exhausted and "galled" land, 105. Effects of marl in resisting the washing by rains, and in curing galls, 106. Benefits lessened by exhausting tillage, 106. Light dressings preferable, 107. Marling of wood-lands, 107—on "free light land," 108. Soils deepened by marling, and the mode, 109. Sandy sub-soils not objectionable, 109. Peculiar benefits of marl on certain plants—and especially on clover, 110. Eradication of sorrel and other acid plants, 111.

Chapter XI.—Recapitulation of effects and directions for practice continued.

Directions for improving by marling, 112. Prohibiting grazing, 112. The four-shift rotation suitable, 113.

Clover and gypsum, 113. Farm-yard manure, 113. Leaves, 114. Causes of results in practice on a large scale failing short of proper and available effects, 115. Value of sandy soils, 116. The thinness of soils more objectionable than sandiness or barrenness, 117. Rate of increase from marling on soils of different kinds, 117.

Chapter XII.—The permanency of calcareous manures, and of alimentary or putrescent manures when combined with the calcareous.

The effects of calcareous manures permanent, 118. Reasons for such effect, 119. Usual transient operation of putrescent manures, 119—become permanent on marled land, 120. Illustrations of such supposed operation, 120. Statement in proof, 121. The future and continued effects of calcareous manures supposed from the mode of action, 122.

Chapter XIII.—The expense and profit of marling.

Mistaken views of the value of marling, and false mode of estimating profits of improvements, 124; True value of land, and of permanent improvement of its productivity, 125. Mode of estimating the expenses of marling, 125. Water carriage of marl, 126. On canal and rail road, 131.

Chapter XIV.—Estimates of the cost of labor applied to marling.

Proper grounds for estimates of cost, 131. Cost of the labor of a negro man, 132. Woman, girl and boy, 133. Horse or mule, 133. Amount of labor of several large jobs of marling 131 to 140.

Chapter XV.—The use of calcareous earth recommended to preserve putrescent manures, and to promote cleanliness and health.

Effects of calcareous earth preventing waste of products of putrefying animal matter, 140. Cases in which this power might be especially employed, 141. In towns, for the milk and hen-beds, 142. Unfitness of quick lime for the same use, 142. Different actions of quick and mild lime on putrescent matters, 144. Supposed and also known particular results to health, from use of marl, 141. Proofs adduced in the paving with shells of the city of Mobile, 145; from the burning of it was 146; from the calcareous prairie region of Alabama, 147. Extensive changes from former sickness already produced by marling, 147. Confirmation of this doctrine, by facts in France, 149.

Chapter XVI.—Directions for the mechanical operations of applying marl as manure.

The marls of lower Virginia, 150; comparative value of different kinds, 152. Direction for analyzing, by solution and precipitation 152. Necessity for thoroughly ascertaining the value of marls, 151. Searching for concealed marl by use of the auger, 151. Deeply excavated, and suggestions for extracting it, 155. Descriptions and advantages of cranes for drawing the marl from pits, 156. Excavation of marl beds, 157. Removal of overlying earth, 158. Draining and working of a wet pit, 159. Making roads up hills, 160. The proper utensils for working in marl, 161. Carts, teams, and laborers, 161. Common error in unequal spreading of marl, 161.

Chapter XVII.—The progress of marling in Virginia.

Obstacles to the progress of all new improvements in agriculture, 162. The beginning and progress of marling, and present general state of it in Virginia, 162. Progress and effects of lading 163. Stone lime, 166.

PART THIRD—APPENDIX.

Introductory remarks - - - - - 167

Note I.—Proofs of the existence of acid soils furnished by the recent researches of chemists.

Berzelius' work on chemistry, 167. Products of putrefaction of vegetable matters, 168. Mould or humus, 168. Extract of mould, 169. Geine (or humin) and geine or humic acid, 170. Carbonaceous mould, 172. Soil, 172. Acid soils, 174.

Note II.—Additional proof offered, by the prediction and existence of black waters, of the action of lime in combining vegetable matters with soil.

Black or dark colors of waters of certain streams and mill ponds, and absence of coloring matter in others, 175. Cause of the different circumstances, the absence or presence of lime in the soils, 176. Proof and illustrations 176. Transparency of lime-stone waters, 177. The combination of coloring vegetable matter with the soil, the natural process of fertilization 178.

Note III.—The statements of British authors on marl, and their applications of the name generally incorrect and contradictory.

Proofs in quotations from Kirwan, 151; Miller, 151; Johnson and Walker, 152; Practical Treatise on Husbandry, 152; 'Systema Agriculture,' 152; Evelyn's 'Terra,' 153; Bordley 154; 'Practical Treatise,' &c. in regard to shell- and sea sand, 154; Arthur Young, 155, 156; Lord Kames 157; Sir John Suckair, 157; Dickson, 158. Norfolk and Holkham soils and marling, 158. Proofs and quotations from Marshall, 159, 192; 'Farmers' Journal,' 192; Count Gyllenburg, and late English agricultural journals, 193.

Note IV.—Description and account of the different kinds of marl, and of the gypseous earth, of the tide-water region of Virginia.

Object of the report, 194. True marl, 194. French marls, 195; Classification of marls, 196. Argillo-calcareous earth or true marl, 197. Shell-marl 197. Fresh-water shell marl, 197. Fossil shell marl, of the tertiary formation, 197. MIOCENE MARLS—General position, characters, &c. 198; comparative value, 200. Yellow sandy marl, 201; yellow clay marl, 201; crystals of carbonate of lime, 203; blue marls, 203; cause of color, 204; proportions of calcareous earth, 204. Accidental ingredients of marls, 205. Kinds distinguished by their respective shells, 207. General operation of miocene marls as manure, 207. Eocene marls—calcareous marls, containing but little green sand, 207. Their discovery, and known extent, and peculiar operation as manure, 207 to 211. GYPSEOUS EARTH of James river,—Its first discovery, and known extent, 211. Description of appearance and general character, 212; operation as manure, 214; sulphureous gas extricated from by heat 215. Description of the cliff at Evergreen, and section of same and of pit, 216. Statement of strata exposed by deep digging at Coggins Point, 218. Harrison's Bar formed of this material, 220. Effects as manure, compared with the New Jersey green-sand "marl," 220. Analysis of gypseous earth of Coggins Point, by Professor Shepard, 221. Eocene green-sand marl of Pamunkey, 225. General description, 226. Of different kinds, 227. Green-sand in miocene marls, 231. Known shells of marls of lower Virginia, 234.

Note V.—The earliest known successful applications of fossil shells as manure.

Old experiment at Bonaccord, Prince George county, 235. At Spring Garden, Surry, 236. In King William, 236. In Talbot county, Maryland, 237.

Note VI.—First views which led to marling in Prince George county.

Early erroneous opinions and practices of the author in regard to fertilization of land, 241. Mistakes discovered, 243. Indications of correct views, 244. First trials and results of opinions of marling, 245. Obstacles to the mode of improvement, 248. Errors of practice and injury therefrom, 251. Corrections and remedies, 252. General results, 253. Particular results and table of crops, &c. 254.

Note VII.—Inquiry into the causes of the formation of prairies and of the peculiar constitution of soil which favors or prevents the destruction of the growth of trees.

General and erroneous opinions on this subject, 256. Most general causes of absence of trees, 260. Proofs of positions asserted, derived from general descriptions of prairies, pampas, steppes, &c. 260, 272. Analyses of prairie soils, 272-6. Formation of prairies deduced and explained, 276. Application of the views to improvement or preservation of fertility of prairies, 278. Exceptions and apparent contradictions, 279. Ancient prairies of Virginia, 279. Soils made barren by excess of carbonate of lime, and fertilized by irrigation, 280. The sandy deserts of Asia and Africa supposed to be excessively calcareous, 280-4.

Note VII.—Recently observed powers of calcareous earth, for increasing the productiveness of land, and the healthfulness of the atmosphere.

Composition of atmospheric air, 285. Animals, in breathing, take from the purity of the atmosphere, 285. Opposite operations of plants, 285, which are greatly increased by the presence of carbonate of lime in the soil, 286.

Note VIII.—Directions for burning and applying oyster-shell lime, 286.

Note IX.—On the sources of malaria, or of autumnal diseases, in Virginia, and the means of remedy and prevention.

Mistaken opinions of the sources prevent attempts to avoid malaria, 289. The effects have increased in Virginia from the first settlement until recently, 290. Proofs, 290-2. Nature of malaria, 293. Certain causes of the production, 296. Meeting of salt and fresh waters, 296. Embankment and drying of marshes, 297. Law of mills and mill-ponds, 298. Absurd operation of, and evil effects on health, 299, 300. Discharge of floods from mill ponds over salt marshes, 301. Malaria produced from high lands, 302. Objections and exceptions considered, 302. Causes of general increase of malaria with time, 303. The causes of decrease in particular cases, 305. Means of prevention, 306. Benefit to be expected, 307. Remedy now afforded by law against mill-ponds, 308.

Note X.—A machine proposed for raising marl.

Description and figures of a machine used at Fortress Monroe for raising sand, and which it is supposed will be well adapted for raising marl, 309-11.