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REPORT
ON THE
NATAL FORESTS.

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REPORT

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NATAL FORESTS.

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E R R A T A.

- p. 9, line 3 from bottom, for "cleaving" read "clearing."
- p. 14, line 1 from bottom, for *Cathastrum Capense* read "*Olinia cymosa*."
- p. 16, line 7, for "area of the reserve" read "area of the forests in the reserve."
- p. 16, line 7, for (*Widdringtonia cupressoides*) read (*Callitris Natalensis*).
- p. 17, line 10, for "Onai" read "um-Nqai (*Elæodendron velutinum*)."
- p. 17, line 12, *dele* "*Celastrus peduncularis*."
- p. 18, line 10, for "Bey" read "Berg."
- p. 19, line 3, for "*Celastrus peduncularis*" read "*Elæodendron velutinum*."
- p. 20, line 9, for "*A. Horrida, A. Kraussinia*" read "*A. horrida, A. Kraussiana*."
- p. 21, line 8 from bottom, for "*Anastrabe integrima*" read "*Anastrabe integerrima*."
- p. 21, line 11 from bottom, for "*Orchipeda dregei*" read "*Orchipeda Dregei*."
- p. 23, line 11 from bottom, for "the forests on Crown land" read "the Timber forests on Crown land."
- p. 23, line 6 from bottom, for "co-relation" read "correlation."
- p. 29, line 10 from bottom, for "the practice of burning the grass in summer, which leaves the ground unprotected" read "the practice of burning the grass late in winter, which leaves, during the following season, the ground unprotected."
- p. 30, line 14, for "Prof. J. R. Seeley" read "Prof. H. G. Seeley."
- p. 37, line 3, for "Dr. Hector" read "Sir James Hector."
- p. 38, footnote (b). Add: These figures include the State reserves only. In 1887, according to Dr. Schlich, there were 52,222 sq. miles of reserved forests, 15,854 sq. miles of protected forests, and 17,664 sq. miles of unclassified forests under the control of the Forest Department. The total area of the forests is, excluding Native States, about 220,000 sq. miles, of which half belong to the Government.
- p. 47, line 4, for "strong" read "stony."
- p. 47, line 6, for "1495" read "1497," and for in "Natal that Vasco de Gama" read "in South Africa that Vasco da Gama."
- p. 49, line 13, for "Kurr" read "Kurz."
- p. 54, line 11, for "which" read "whom."
- p. 63, line 18, for (*Pteroxylon utila*) read (*Pteroxylon utile*).
- p. 63, line 25, for (*Elæodendron visceum*) read (*Elæodendron croceum*).
- p. 63, line 8 from bottom, for "Zwarthout (*Celastrus peduncularis*)" read "um-Nqai (*Elæodendron velutinum*)."
- p. 67, line 3 from bottom, for "8,739,400" read "873,950."
- p. 86, line 10, for "from" read "by."
- p. 88, line 17, for "poorly regions" read "poorly wooded regions."
- p. 110, line 16, for "*Gardenia Rothmania*" read "*Gardenia Rothmannia*."
- p. 118, line 14 from bottom, for "*Bridelia micrantha*" read "*Briedelia micrantha*."
- p. 132, line 17, for "*Swietenia Mahogoni*" read "*Swietenia Mahagoni*."

REPORT ON THE NATAL FORESTS,

By H. G. FOURCADE, ASSISTANT CONSERVATOR OF FORESTS, ON SPECIAL DUTY,
DATED MARITZBURG, 3RD DECEMBER, 1889.

The Honourable the COLONIAL SECRETARY.

SIR,—

I have the honour to submit, for the information of His Excellency the Governor, the following Report on the Natal Forests.

The instructions contained in your letter No. 442, 1883, dated March 15, 1889, may be summarized as directing me (1) to report on the condition of forests on Crown and Trust lands, making suggestions for their conservation, improvement, and extension ; (2), to report on the feasibility of creating artificial forests of indigenous and exotic trees, and of meeting from these the demand for timber for railway purposes ; (3), to report on the suitability of indigenous timber for railway purposes ; and (4), to consider the question of the establishment of a Forest Department in the Colony, and to furnish a scheme for its organisation.

The question of the utility of a Forest Department involves that of the general utility of forests, and I have dwelt at some length on this point.

This Report is divided into six sections, dealing successively with (1) the Natal Forests ; (2), their utility ; (3), protective measures ; (4), the management of forest ; (5), Plantations ; (6), the organisation of works and staff.

Much of the more technical matter has been relegated into appendices, which include a descriptive list of the Natal woods, the results of mechanical tests, a Note on the manufacture of Railway sleepers, and other special information.

I should prefer to revise the proofs of this Report myself, as the figures and the botanical names in the text require careful verification.

The forests of Natal may be divided, with reference to their nature and distribution, into High Timber forest, Thorn Bush, and Coast forest, found respectively in the Upland, Midland, and the Coast regions. The High Timber forests are situated in a belt along

the Drakensberg, forming patches mostly on south slopes, at an elevation of from 3,500 to 6,000 feet, where the mean yearly temperature ranges from 52° to 59° . The Upright Yellowwood (*Podocarpus Thunbergii*) reaches its greatest development in this zone, but occurs mixed with numerous other species. The Thorn Bush consists chiefly of various species of Mimoseæ, *Acacia Natalitia* and *A. Kraussiana* being the most common. It is spread over very wide areas, mostly in the basins of the Tugela and of the Umkomanzi, at an altitude of from 3,500 to 1,000 feet, below which it intermingles with the Coast forest. In this region, the mean annual temperature ranges from 59 to 67° . The Coast forest predominates below 1,000 feet where the climate becomes sub-tropical, and the mean annual temperature ranges from 67° to 71° . It is composed of a great variety of low trees, among which the Waterboom (*Eugenia cordata*) and the Flaterown (*Albizia fastigiata*) are characteristic species.

Map I. shows the distribution of the different classes of forest, but patches of High Timber forest may be found, out of the upland region of the map, wherever the altitude is sufficient.

FORESTS IN POLELA DISTRICT.—The largest timber forests of Natal are situated in the south-western portion of the Colony, towards the Transkeian border. In the division of Polela, there are about 10,000 acres of forest on Crown Land and some 5,000 more on Native locations, which still contain large quantities of valuable timber.

The Xumeni forest was the first examined. It is bounded to the south by the Dumadezwa location, occupied by the Memela tribe, and covers about 1,200 acres of south and south-westerly slopes, at an altitude of 4,000—4,500 feet. The climate is temperate, frosts are prevalent in winter and thunderstorms in summer. The soil is light, moist, and consists largely of humus. The underlying rock (Maritzburg shale) protrudes in many places, and detached boulders are scattered over the surface. The prevailing species is the Upright Yellowwood (*Podocarpus Thunbergii*), which alone constitutes the greater portion of the standing stock. Other trees are the Natal Mahogany (*Kiggeluria Dregeana*), the Stinkwood (*Ocotea bullata*), the Wild Chestnut (*Calodendron Capense*), the Saffraan (*Elæodendron croceum*), the Camdeboo Stinkwood (*Celtis Kraussiana*), and the Onderbosch (*Cryptocarya sp.*) The surface growth, composed of nettles and ferns, does not contain many young plants of valuable species. On entering the forest the great scarcity of saplings is at once apparent; large quantities have been taken by the Kafirs of the adjoining location for wattles to build their huts with, or as kraalwood or firewood. In the upper portion of the forest, a steep declivity has been denuded of undergrowth to such an extent that the soil has been washed away round the large trees, which now seem to grow out of a sheet of rock, and if these trees were now felled, that portion of the forest which they occupy would disappear entirely.

The quantity of mature timber that has been taken from the forest cannot be considerable, as there is still an abundant supply of Upright Yellowwood of large dimensions, averaging nearly 3 feet in diameter, and much Stinkwood and Natal Mahogany of fair quality. Sneezewood is scarce. Though the slopes which the forest covers are generally steep, it appears that most of the timber could be extracted. There is very little spare Crown Land in the vicinity, a circumstance that would render the working difficult. The forest is accessible from the main road to Polela, and the produce could be transported easily. The ruling rates to Richmond are 30 to 40 shillings for loads of 800 running feet. Yellowwood was formerly delivered at the saw pits for £4 or £4 10s. a load, when the license was one pound a saw per month. For sawing, Kafirs are paid 12 to 15 shillings a load, cut into scantlings or planks. Hard woods are cut at the same rates, but the load is reduced to 600 feet. Natives for felling receive 10 to 15 shillings a month, and food worth 7 or 8 shillings. The Native locations in the neighbourhood could supply a large amount of cheap labour.

The edge of the forest is very broken; mealie gardens extend from the Dumadezwa Location all along the forest-line, and some of the clearings have even been made right into the heart of the forest. Thousands of heads of cattle are said to be regularly driven each winter into the forest for shelter, causing much damage to the undergrowth.

In the adjoining location, No. 4 Upper Umkomanzi, there are about 500 acres of forest, in detached patches, of a character similar to that of the Xumeni. Much of it covers banks too steep for working.

The road to Polela passes through the south-western corner of location No. 2, Upper Umkomanzi, not far from two or three strips of forest spread along the north banks of a tributary of the Umkomanzi River. These forests contain about 650 acres; they are fringed with mealie gardens which have crept in wherever the ground was not too steep for cultivation. Unless any further clearing or cutting is prevented, the forest will have disappeared within a few years.

The Mahutywa Forest is situated a mile west of Polela, just outside the location No. 2, Upper Umkomanzi. Its extent is about 800 acres, and the mean altitude 4,500 feet. It covers the northern side of a valley intersected by minor kloofs. With the exception of a main ridge and of a flat terrace near the river at the bottom, the ground is too steep for convenient working. The soil is light and deep, but stony in the steep places. Maritzburg shale forms the underlying rock. The forest has been partially worked and there are no trees of great size. The principal species are the Outeniqua and Upright Yellowwoods, the Camdeboo Stinkwood, the Sneezewood, the Wild Chesnut, the Natal Mahogany, the White Ironwood (*Toddalia lanceolata*), the White Pear (*Apodytes dimidiata*), *Euclea lanceolata*, *Plectronia* spp., *Kraussia lanceolata*, *Royena lucida*, *Gardenia Rothmannia*, *Olea verrucosa*, *Elæodendron* spp., *Celastrus* spp., *Dombeya*

rotundifolia, *D. natalensis*, *Cryptocarya* spp., *Halleria lucida*, *Schmidelia africana*, with some smaller species such as *Myaris inæqualis*, *Cluytia* sp., *Heteromorpha arborescens*, *Leucosidea sericea*, &c.

A sample area, selected to represent the average of the forest, was found to cover 2.92 acres. 59 trees measured within were estimated to contain 3,842 cubic feet of sound logwood, and the standing stock per acre consisted of :

6 Outeniqua Yellowwood ...	...	603 cubic feet.
7 Camdeboo Stinkwood ...	...	426 "
2 Sneezewood ...	...	114 "
2 Wild Chesnut ...	...	105 "
2 Natal Mahogany ...	...	41 "
2 Other Woods ...	...	81 "
—		—
21 trees, containing		1,370 "

This yield per acre compares favourably with that of the best Cape forests, but it is greatly exceeded in other parts of the Polela district.

The Mahutywa forest is being destroyed rapidly by the Natives. The young growth has already been entirely cleared for wattles. Troops of Native women appear to be constantly cutting and removing timber for firewood without let or hindrance. The firewood is made up into bundles and carried to the adjoining location, the path to which should be closed if the forest is to be preserved. At the foot of the forest, mealie gardens eat into the boundary everywhere, and all the forest ground that is not too steep is gradually cleared for cultivation. Inside the forest, Natives fell large trees for firewood by burning round the roots, and the fire usually spreads some distance round if the bush is dry. Grass fires have also caused much damage in the western end of the forest.

There are two forests towards the Polela River, with an area estimated at 1,750 acres, in which sawing was formerly carried. Nearer to the Umkomaas, there is also a patch of forest about 500 acres in area, covering south-eastern slopes in the kloof below Colvill's Hill, and surrounded by mealie gardens wherever cultivation is practicable. These forests resemble the Mahutywa, excepting that stinkwood is now found in some abundance, probably owing to the greater elevation (5,000—5,500 feet).

FORESTS BEYOND DRONK VLEI.—Returning towards the Coast, several forests are met with in the valley of the Umzimkulu. The Hlabeni Forest is situated about two miles East of the river, between the farm "Dudwick" and Location No. 1, Upper Umkomanzi. A flat-topped hill is crowned by rocky cliffs, from the foot of which the forest spreads downwards on south slopes, generally steep, and in some places almost inaccessible. The area is about 15,000 acres, and the mean altitude 4,500 feet. The chief timber trees are the Upright and Outeniqua Yellowwoods, Stinkwood, Bogabog

(*Xylosma Monospora*), and Sneeze-wood (*Pteroxylon Utile*). Here, as almost everywhere else in Natal, the absence of young stock is striking. The best timber has been cut out, and the forest so damaged in other respects that it will probably be found best to close it for a number of years.

The country between the Gwangwane River, which forms the boundary of Griqualand East, and the Umzimkulu River is richly wooded. The Gwangwane Forest, situated on Crown Land, is the largest and most important in this region. It is a truly magnificent forest; indeed, for its size, the finest that I have yet seen in South Africa, and the nearest approach to a pure forest of yellowwood. The trees are well grown and regular, average between three and four feet in diameter and a hundred in height, and consist chiefly of Upright Yellowwood, mixed with a few Outeniqua Yellowwoods, Stinkwoods, Wild Chesnuts, and White Ironwood. In the lower portion, the standing stock per acre may be estimated at 10,000 cubic feet, consisting of 25 Yellowwoods, containing 9,000 cubic feet, and 8 other trees containing 1,000 cubic feet. An excellent feature is the presence of a young growth of yellowwood, partly in the pole stage. At present, the forest is only reached by a road from Griqualand East, and the quantity of timber felled in it has been small. The destruction of young trees by natives has also been slight, but the forests nearer Dronk Vlei being now almost cleared of wattles and poles, it will increase rapidly if it is not checked. There are few natives near the forest, and in consequence, few mealie gardens along the edge.

The Gwangwane forest forms part of the East end of a piece of land reserved in the centre of location No. 1. The area is about 2,200 acres, the altitude 4,500 to 5,000 feet, and the aspect south. Much of the ground is flat or gently sloping, and nearly the whole of the forest could be worked without any difficulty. The soil is very moist, deep, and rich, and covered with a luxuriant growth of ferns and grasses. The climate appears to be mild, and the remarkably straight growth of the trees, indicates that the intervening high ridge between the Umzimkulu and the Gwangwane, affords effectual protection from easterly gales.

The Umbani forest, and one or two other patches, covering together some 1,500 acres, are also situated in the reserve surrounded by location No. 1, but nearer the Umzimkulu, and on steeper ground than the Gwangwane, which they resemble in point of richness, though the yield of yellowwood would be much less. These forests have not been worked because they are difficult of access.

Nearly 4,000 acres of virgin forest are found on the location itself. Five or six patches covering about 2,600 acres are grouped together near the north-western boundary, some of them possibly on Crown Land. Their distance from native settlements has served to shield them from destruction, and they are yet practically intact. South of the Gwangwane forest occurs a small piece covering some 250 acres of steep south slopes.

East of the Umzinkulu River, there are again many patches of forest scattered about on steep hillsides, the aggregate area of which may be reckoned at 1,200 acres. The Ini forest, forming the principal patch, is reported to be rich in yellowwood but difficult to get at, and it has, like the others, remained untouched.

The number of Natives in Location No. 1 seems to be comparatively small, and most of the huts are clustered away from the forests, at the eastern end, near Dronk Vlei. The forests in the location have not suffered severely from recent fires, and the damage sustained from wattle-cutting and cultivation has been considerably less than the average elsewhere.

Between Location No. 1 and Location No. 3 to the south, the Umkazini forest, about 1,200 acres in area, has been reserved. The hillside which it covers overlooks the Gwangwane River and slopes rapidly with a south-western aspect; altitude, 4,500 feet. The forest was poor at the best of times; and as it has been worked considerably, there remains very little timber of value. Both Yellowwoods, Sneezewood, Natal Mahogany, or Zwartbast are still found, but the trees are inferior and scarce. At the time of my visit, quantities of poles and spars were being cut for the Trappist Missionaries at Dronk Vlei—it was stated by permission of the Government—and removed along a large slip path penetrating far into the forest.

The Crown forests in the division of Polela are placed under the supervision of Mr. G. A. Jackson, who is allowed 25 per cent. of the collections. The amounts thus received are too small to warrant any patrolling of the forest, and Mr. Jackson cannot be expected to do more than issue licenses. It would be simpler to collect forest revenue through Magistrates if enough is not spent on supervision to make it effective.

FORESTS IN THE IXOPO DIVISION.—In the division of Ixopo there are three supervisors of Crown forests, Messrs. Surridge, Simons, and Howes, who also receive 25 per cent. on collections. The high timber forests only cover some 1,600 acres in the two reserves in charge of Mr. Howes, and 400 acres in Location No. 5, in charge of Mr. Surridge; the rest is Thorn bush. All these forests are situated in the valley of the Umkomanzi, west of the river. They are not nearly so valuable as those in the Polela division. Yellowwood is comparatively scarce, and more plentiful trees are the Wild Chesnut, the Bogabog, and the Beukenhout (*Myrsine melanophleos*) near the edges. In Location No. 5, forest destruction seems to have been severe, and the seven or eight small patches that have been left in the valley of the Lufafa, a tributary of the Umkomanzi, are very considerably damaged. The altitude is here 3,500—4,000 feet, and the aspect south.

FORESTS IN ALFRED COUNTY.—The Forests in Alfred County are, next to those at Polela, the most valuable in Natal.

The Ingeli Forest extends for five miles along the south-eastern slopes of a spur of

the Zuurberg range, the top of which forms the boundary of Griqualand East. Its area may be estimated at 3,500 acres. Portions of the forest have been cut off and included in adjoining farms : Mr. Quicke's on the eastern side, and Mr. Clark's on the western. From the foot of the forest, the ground stretches to the south in undulating plains, watered by numerous streams issuing from the forest ; but as this land has been alienated almost to the edge, the forest is now hemmed in between private farms, and future working will have to be carried under difficulties. The forest is steep in the upper portions and in some of the kloofs that take their rise there. Here and there the vegetation has become stunted, and the ground poor, on account of former injudicious working. The principal timber trees are : Upright and Outeniqua Yellowwood, Stinkwood, Sneezewood, Camdeboo Stinkwood, Bogabog, Natal Mahogany, Assagai, Essenhout (*Ekebergia capensis*), *Popowia Caffra*, *Olea verrucosa*, *Mimusops obovata*, *Toddalia lanceolata*, *Gardenia Rothmannia*, *Kraussia lanceolata*, *Clerodendron glabrum*, *Royena lucida*, and *Zanthoxylum capense*. Smaller trees are *Halleria lucida*, *Cryptocarya* spp. *Plectronia ventosa*, *Strychnos* sp., and *Burchellia capensis*.

The Ingeli must have once been a magnificent forest, perhaps equalling the Gwangwane in richness. It is deplorable to see how ignorant and ruthless working has contrived to ruin a large portion. The quantity of timber formerly obtained, large as it was, and probably greatly exceeding that for which the Government received any consideration, does not give a measure of the destruction effected. Irregular working is essentially wasteful, and it has proved the curse of many South African forests ; a result by no means surprising if we realise the nature of the process. The woodcutter of old used to roam through the forest to choose a tree, and damaged many or even felled a few before he could find one to suit his convenience. The tree selected was felled high and crowned low, the finest marketable piece of timber being taken, and the rest, often amounting to more, left to rot in the forest. Then, to make a sawpit, the straightest trees, in the most promising stage of growth, that could be found sufficiently near, were felled and dragged together. More destruction followed, after the log had been sawn : a forked tree was selected ; the forked branches cut out to make a sledge, and the trunk abandoned. A slip path was next required to remove the sawn wood piled on the sledge to the nearest main path, and to make it broad enough for a span of oxen many young trees had to be cut. When slipping the wood down steep places, a young tree was tied behind the sledge, its crown of foliage acting as a brake, and for every steep portion of the path the process had to be repeated. Other young trees were also cut along the path and thrown across to facilitate the slipping. When the main paths became cut up or muddy, deviations involving the cleaving of more young trees were freely made. Sometimes, as in the Ingeli, the main paths were made wide enough to take ox-wagons into the centre of the forest. The finest trees were gradually cut out

whenever they could be easily extracted, and the kloofs and other steep places remained almost untouched. In those portions that were worked, the young growth was continually destroyed or damaged. Kafis, by cutting wattles and other small wood, and cattle by browsing, helped to prevent it from making any headway, so that it has now completely disappeared in some places, leaving inferior old trees, the refuse of former woodcutters, to cover the crop of rubbish on the ground. A considerable quantity of timber has been left in the less accessible places, and much of it could be worked without endangering sensibly the chances of recovery of the forest. At present, there is very little work carried on. Since 1883, when the Natal forests were closed, it has consisted chiefly of the removal of old logs that had been left by former woodcutters, but now that felling is resumed under Proclamation No. 24, 1888, wagonwood is taken in increasing quantities. The main road from Harding to Kokstad passes close to the eastern end of the forest, and it would not be difficult to improve the branch road that skirts the foot.

The Stinkwood Bush is a patch of forest within a mile to the south, formerly rich in Wagonwood and Stinkwood, as its name implies, but now considered "cut out."

A fine forest, known as the Impetyne, is situated about five or six miles further south. Crown land still surrounds it on every side, but farms are being rapidly taken up, and no time should be lost in reserving enough land for convenient working. The area is about 1,800 acres, the mean altitude 5,000 feet, and the aspect south. Much of the forest clothes the sides of steep gorges at the head of the basin of the Umtamvuna River; its shape is irregular. The configuration of the ground affords shelter from easterly gales. As only a few loads of timber have been cut, the forest is still very rich in Upright Yellowwood and Stinkwood. In a sample area 1.63 acres in extent, 58 trees, containing 11,423 cubic feet of log wood, were measured. The growth was fairly average, excepting in the case of Stinkwood, many logs of which had been cut in the vicinity, so that about double the estimated yield of this species would more nearly represent the average for the whole forest. The standing stock per acre deduced from the measurements was:

26 Upright Yellowwood	...	...	6,186 cubic feet
5 Stinkwood	...	...	560 "
3 Bogabog	...	...	153 "
2 Other species	...	...	109 "
<hr/>			
36 trees, containing			7,008 "

It is interesting to compare this yield with that of Cape forests. Taking the whole of the Knysna forests, the standing stock per acre averages nearly:—

6 Yellowwood	...	...	300 cubic feet
4 Ironwood	...	...	80 "
2 Stinkwood	...	...	70 "
6 Other woods	...	...	160 "
<hr/>			
18 trees			610 "

In the virgin Gouna forest, the yield of 182 acres in the three sections designated as "Red Els VII," "Knysna River I.," and "Klein Kop I.," was, per acre, 31 trees, containing 1,081 cubic feet. In the Main Forest, where all the best timber has been cut out long since, the yield in one typical section: "Petrus Brand, 1885," was, per acre, 15 trees, containing 361 cubic feet. In the sections "Portland I.," "Eiland II.," and "Beer Vlei I.," situated in forests less exhaustively worked, the yield of 162 acres was per acre 22 trees, containing 634 cubic feet. The comparatively stunted coast forests give, in the typical section "Groot Brak II.," only 10 trees, containing 172 cubic feet, per acre. Taking the whole of the sections that were open in 1888, the average yield of 2,758 acres which they covered, was per acre 15 trees, containing 468 cubic feet. But allowing for timber that had already been removed over part of the same ground during the year preceding, and for the greater richness of some of the remainder of the forest in the less accessible places, the standing stock at present in the Knysna forest may be averaged as above.

The principal kinds of timber found in the Impetyne forest are, in addition to Upright, Stinkwood and Bogabog, which comprise over 90 per cent. of the standing stock, Sneezewood, Saffraan, Hard Pear, Ironwood and Beukenhout. I did not see a single specimen of the Outeniqua Yellowwood. The extraction of the timber is difficult over the greater portion of the forest, and the produce has to be removed over several miles of broken country before it can reach the nearest wagon-road, but using steep gradients, a forest-road might be made at a reasonable cost. There are no Natives located or squatting in the immediate neighbourhood, and wattle cutting has been moderate. I am, however, informed that large troops of cattle are driven into the forest in winter; the damage which they cause is very apparent in the upper portions.

Both the Ingeli and the Impetyne forests are placed under the supervision of Mr. J. Furniss, who is paid £24 per annum for his services. Mr. Furniss deserves praise for his efforts to stem their destruction by Natives; he has succeeded in getting rid of the mealie gardens which are so obnoxious a feature elsewhere, and there is no reason to believe that their eradication throughout the Natal forests would be a matter of any great difficulty.

North of the Impetyne, there exists a small forest about 500 acres in extent, which from being situated near the sources of the Umtamvuna, and against the boundary of Griqualand East, not far from Fort Donald, was formerly held to belong to the Cape Government. A dispute between the Xesibe and Natal Kafirs, led to the appointment, in 1883, of a Commission to settle the boundary. From the position of a beacon placed by Dr. Sutherland, when part of the Pondo territory was taken over by Sir Walter Currie, it was found that the forest in question belongs to Natal.

Nearer the coast, the timber forests are less numerous and of a more stunted character. In the valley of the Umgonieza river, a forest of the same name covers some 300 acres. At the upper end, about 20 acres have been cut off by the boundary line of the farm "Zumat." I was informed that most of the remainder had been recently surveyed for Mr. N. Hoyea. Licenses were formerly issued for working in this forest, but yellowwood is scarce and wagonwood was principally cut.

Three Native locations have been laid out against the Natal boundary. In the Umkombeza or Tom Fyn's, and the Macale locations, there are perhaps 800 acres of low bush in tributary kloofs of the Umtamvuna. In the Maxolo location situated further south, near the coast, some kloofs running to the sea are wooded over 800 acres or more. Near the mouth of the Umtamvuna itself, there is a comparatively good forest, the extent of which may be estimated at 500 acres. All these forests are more or less stunted, and gradually pass into the ordinary coast forest.

Large quantities of wattles are said to be cut in the locations, and I was informed that whole wagon loads of wattles, cut in the Umtamvuna forest, are often taken beyond Harding. There was no supervision of any kind at the time of my visit, but it appears that Mr. H. Lugg, of Murchison, has been recently appointed to supervise the forests in the newly created Lower Umzimkulu Division.

The total area of the timber forests in Alfred County may be estimated at 6,600 acres on Crown land, and 1,600 acres on Native locations.

FORESTS IN ALEXANDRA COUNTY.—East of the Umzimkulu river, there are some timber forests on the back hills, of which Mr. Bru de Wold has nominal charge. The largest is the Dimbunkulu, situated in the location near St. Faith's, and about 2,000 acres in area; it covers south and south-west slopes in the valley of Umzumbi, west of the river. The most noticeable woods are the Upright Yellowwood, Black Ironwood and Milkwood. The trees are sometimes large, and the forest clean; in other places the growth is low and scrubby. There are no roads near the forest, and much of it is inaccessible for purposes of working.

Natives in the location cut wattles and firewood freely, but very few licenses seem to have been issued. There is no effective protection. Native constables employed at Dumisa, are occasionally told off to patrol the forest, but I do not think that they can be depended upon. Mealie gardens fringe every accessible portion, and year by year fires and clearings further reduce the wooded area. Natives are accustomed to drive troops of cattle into the forest in winter. Hunting parties are said to be frequent. The locations near the forest contains good grazing ground, and is thickly populated by Umpotyane's and Mabiya's people.

About three miles to the south-east, there is also a small piece of forest on Crown land, called the Mehlamanyama, which is about 500 acres in extent, and similar in nature to the preceding ; only the trees are generally more stunted, and the undergrowth tangled and thorny. Mealie gardens are numerous along the edge.

In addition to the above, there are many small patches of Crown forest, varying from 50 to 200 acres in area, scattered along the south slopes of the Inhlogozi hills.

FORESTS IN PIETERMARITZBURG COUNTY.—Returning towards the Drakensberg, the forests in Pietermaritzburg, Weenen, and Klip River Counties, were successively examined.

In Pietermaritzburg County, the forest belt extending from the Karkloof to the Umkomanzi is almost entirely included in private farms. Some of the private forests, notably those at the Karkloof, are of large size ; their area was estimated at over 80,000 acres by the Forest Commission of 1880. In the Native locations, there are less than 10,000 acres, while on Crown land, there are only a few small patches situated on spurs of the Drakensberg, which altogether do not cover much more than 1,000 acres.

The wooded area in the Zwaartkop location was estimated at 8,000 acres in 1880. Little remains of what must have once been a noble forest. Clumps and isolated trees scattered over an area much larger than that actually wooded, remain to testify to the destruction that has been wrought of late years. The forest has been attacked from every side but the top, where it follows the steep crests of the hills. Below, the edge is so broken and irregular that it appears from a distance as if lacerated into shreds. In this portion, masses of stumps may be seen between straggling patches of bush. Clearings have been made right into the heart of the forest, and what remains has been left by the Natives only on account of the steepness of the ground, making cultivation difficult. These forests are generally situate on south slopes, easily accessible from the Native settlements in the location. The altitude varies from 4,750 feet to 3,800 feet. The rainfall on the wooded range of hills is said to be unusually heavy, and the forests should be preserved if only on account of their great regulating influence on the flow of water. The principal timber trees seen were Yellowwood, Stinkwood, Sneezewood, White Ironwood, White Pear, Wild Chesnut, Camdeboo Stinkwood, Natal Mahogany, Bogabog and Benkenhout. There does not appear to be any kind of supervision exercised over these forests.

The largest patch of forest over which the Crown has control is that at Fort Nottingham, in the Lion's River Division. It is situated on the Nottingham Town lands, and circles, at 5,000 feet altitude, the South and West slopes of a flat topped hill, in a belt two miles long, but so narrow that the area does not exceed 350 acres. To the East, it joins Mr. Mackenzie's forest. The principal timber trees are : Upright and Outeniqua Yellowwood, Sneezewood, Bitter Almond, Red Pear, Camdeboo Stinkwood, and Wild Chesnut ;

there seems to be neither Stinkwood nor Ironwood ; Yellowwood occurs sparingly, but Sneezewood is fairly abundant. The forest has been much cut out in former years by Boers, and more recently by the several garrisons that were stationed at Fort Nottingham. It appears that large quantities of Sneezewood, which burns readily even when green, have been cut by the latter for fuel. Many portions of the forest have been overworked and now stand almost irretrievably ruined. Natives are not numerous in the neighbourhood ; the nearest location is that at Impenhla. In consequence, wattle cutting has remained moderate, and mealie gardens have not recently encroached on the forest. Mr. F. E. Shaw, who is paid £12 per annum to supervise this forest, has succeeded in preventing any serious destruction during the last few years. There is evidence that forests have considerably decreased in the neighbourhood. I was informed by Mr. Mackenzie that many Sneezewood stumps had been dug out, to quite eight hundred yards outside his own forest. On Capt. Grantham's map of 1861, forests are marked at Spienkop and Kamsberg, where now only a few isolated trees remain to show their former position. The Nottingham settlers, only two in number, are said to exercise a right to cut timber and firewood for their own use free of charge, and it is not certain that any timber could be sold to others, and revenue derived from the forest. Sneezewood might still be worked here profitably. The distance from the railway is only 8 miles, the cost of transport to the Nottingham Road Station is about ten shillings a load, and the price of Native labour one pound a month and rations.

FORESTS IN WEENEN COUNTY.—The High Timber Forests in the County of Weenen were estimated by the Forest Commission of 1880 to cover 6,400 acres on Crown land and a like extent on Native locations. I am of opinion that these estimates reduced by one-half would now be more accurate. Whether it is that the estimate of 1880 was too high, or that denudation has been very rapid since, cannot be ascertained definitely.

Above the farm Meshlynn, there are a few small forests near the sources of the Mooi River, but none of them of great extent, nor easy of access.

The Hlatikulu Forest is one of the largest in this county. It is situated on a rocky hill of the watershed between the Bushman's River and the Mooi River. The extent is about 600 acres, the altitude 5,500 to 6,000 feet, the aspect south, and the average declivity one in two or three. It forms a level belt in a fan-shaped basin, hollowed in the sandstone of the country, and draining into the Mooi River. The ground is moderately rich and damp ; and rocky in many places, or strewn with large boulders of sandstone. Its steepness would prevent the removal of much timber otherwise than by hand after sawing in the forest itself. The climate is cold, and frosts are prevalent in winter ; thunderstorms come from the east, misty rains from the south, and easterly gales are common. The principal trees are Hard Pear (*Cathastrum Capense*),

which forms the greater portion of the standing stock, Upright Yellowwood, growing stunted, and only found sparingly, Gnai, Red Pear, Zwartbast, and Benkenhout; Ironwood is very scarce. There is no Outeniqua Yellowwood, Stinkwood, Sneezewood, or Spokewood (*Cryptocarya*). The quantity of Hard Pear may be estimated at 400 cubic feet to the acre. Hard Pear is an exceedingly useful and durable wood, and its abundance gives a special value to this forest. Young trees are not plentiful, though saplings of Upright Yellowwood and Zwartbast are conspicuous. The timber cut in this forest is said by wagonmakers to be harder and tougher than the average. As a rule, trees on rocky hillsides grow more slowly, and the wood is stronger and more durable, than that in the case of those of lowland forests, with naturally deeper and richer soil. The Hlatikulu forest is not easily reached from the roads leading to Estcourt and Weston, which themselves are of the roughest description. The cost of transport to either town is about two pounds for a load of 800 feet; but it could be reduced to thirty shillings with continued work. The Crown land suitable for grazing has been much reduced in extent during the last four years. There still remained at the time of my visit a small piece under the forest; but most of it has been recently sold to Mr. R. Whittaker, and the future working of the forest will have to depend on the consent of the surrounding proprietors. Wagonwood was formerly cut on a large scale under the one pound a month system, and, with the exception of Hard Pear, there now remains very little useful timber. The forest is supposed to be in charge of one Saponze, a Native. Saponze states that he was placed at the forest by Mr. Wheelwright, the former Magistrate, to prevent people cutting without permits. He could not say that he had seen a permit for the last three or four years, though wattles, poles, and kraalwood appear to have been cut largely since that time. I believe that the chief destruction has been effected by this Native, who has mealie gardens in bush ground recently burnt by himself, and still full of charred stumps for a hundred yards and more from the present limit of the forest. Numbers of Natives are said to be constantly removing firewood; they cut timber trees down, and use the wood after it has become dry in the forest. I myself saw several Hard Pear trees that had been recently cut for the purpose. The Natives are accustomed to drive for game in this forest, and bucks are almost extinct.

Within a mile of the Hlatikulu, but on the north slopes of the hill, near the summit, there is another piece of forest 40 acres in extent, at most. It contains the species prevailing in the larger forest, but the trees grow more stunted owing to the exposition. Though practically inaccessible, it should be included in the Hlatikulu Reserve if it is found that it is not situated within the location that stretches across the valley of the Bushman's River.

Table Mountain is about 8 miles to the north of Hlatikulu. Near the top, on the south side, there is a small strip of scrub composed chiefly of *Greyia*, and *Leucosidea*, and at a lower elevation (between 5,500 and 6,000 feet), several small forests in depressions of the hillside. The veldt between is dotted with sugar bush trees (*Protea Hirta*), some of them of considerable size. A detachment of the Natal Mounted Police, stationed at Ulundi, protects this forest, and two others, some distance to the north-west, but included in the same Crown Reserve. The total area of the reserve does not probably exceed 300 acres.

In the Zikali location, the forests are numerous but all of small size ; they occupy deep gorges in the north flanks of the Drakensberg Mountains, which here reach their highest elevation between Cathkin Peak (10,357 feet) and Mont aux Sources (11,170 feet) the culminating point of South Africa. The country is very rugged, and the grandeur of the scenery is not surpassed in Natal. From Mont aux Sources, the Tugela leaps down some two thousand feet, to form the highest waterfall in the world. The most accessible forests have been cut out, or nearly so, and Kafir cultivation and wattle-cutting have served to damage the greater number. The timber trees belong to the species found at Hlatikulu, but Stinkwood occurs again up to the Lobonjo River, a tributary of the Tugela. A characteristic tree of this region is the mountain cypress (*Widdringtonia cupressoides*), which forms isolated forests or clumps at high altitudes.

A remarkable feature of the Drakensberg country, more particularly between the Hlatikulu and the Tugela Valley, consists in the powerful erosion of the soil by the summer downpours. The hillsides are scored with torrential ravines, *dongas*, as they are called in Natal, of comparatively recent formation, which go far to disfigure the country and reduce the value of the land for agricultural purposes. Dongas are not found in normal conditions, and their spread is always related to the destruction of bush and herbage. It is probable that the burning of the veldt, by which grass and bush are kept down, is the principal cause of their formation.

In the division of Klip River the extent of the Crown forests may be estimated at 8,000 acres. There are no Native locations. Mr. G. L. Coventry is the Government supervisor, and receives £36 a year for his services. The most densely wooded region is that along the Drakensberg, from the Tugela falls to a few miles beyond the Olivier's Hoek Pass ; the forests are, however, scattered and limited to south slopes and deep gorges. The most important kinds of timber are Hard Pear, White Ironwood, Zwartbast, Beukenhout, and Wittehout (*Ilex Capensis*). Yellowwood does not grow to a large size. Isolated sugar bush trees are dotted plentifully between the forests ; they occur from the Hlatikulu, but reach their greatest development in the higher portion of the Tugela Valley. Their diameter reaches a foot or more, but the trunk is so twisted and gnarled that it would be useless for any other purpose than firewood ; the bark might be of use for tanning.

Some of the frontier forests are easily reached from the Free State, and it is reported that the inhabitants of Harrismith district formerly obtained wood from this source. The practice does not seem to have died out altogether ; a case recently tried before the Resident Magistrate at Ladysmith resulted in a conviction.

A few of the grazing leases contain forests, and none should be sold before ascertaining whether it includes any.

The next cluster of forests is found north of Van Reenen's Pass, partly on the Crown Lot "Nolens Volens ;" they are situated on steep south and south-east slopes, at from 5,000 to 5,500 feet altitude. The principal kinds of timber noted in these were : Hard Pear, Beukenhout, Zwartbast, Upright and Outeniqua Yellowwood, Onai, White Pear, Red Pear, Ironwood, Kamdeboo Stinkwood, Wild Chesnut, White Ironwood, Assagai, Natal Mahogany, *Celastrus peduncularis*, *Chilianthus sp.*, *Plectonia spinosa*, and *Halleria lucida*. *Buddlea salviaefolia* and *Leucosidea sericea* are abundant along the edge of the forests. *Greyia Sutherlandi* is a conspicuous low tree on rocky cliffs at high elevations. Most of the ground near the forests is too steep or stony to admit of cultivation, and mealie-gardens are few in number. Part of the forest has been entirely denuded of young timber through wattle cutting and cattle grazing. Beyond "Nolens Volens," it remains doubtful whether the belt of forest is not confined within the boundaries of the farms "Brakwall" and "Roslyn." The total area of the forests on this point is about 1,000 acres, but part may be situated on private lands.

Between these forests and the Biggarsberg, private farms are continuous ; they have been surveyed almost up to the Natal boundary, and the few wooded kloofs that may be seen are all situated on private property.

At the Biggarsberg, there are about 1,000 acres of forest, in four or five pieces. One forest covering about 300 acres, is situated near the farm "Ombekend ;" it does not contain any large timber, but I found that poles had been cut surreptitiously a short time before ; the species are mainly the same as those found in the forests near Van Reenen's Pass.

Between the farm "Cundycloigh" and the Berg, two small forests, together 500 acres in area, have suffered much damage at the hands of former woodcutters. Quite half of the one nearest the Drakensberg has been burnt out by successive fires in recent years, and the remainder has been ruined by irregular working. I was informed that only last winter, it was set on fire by some Free State Boers to drive out the game. The other forest, near the road to Nelson's Kop is larger, but not protected any better, and unlicensed cutting is said to be frequent and free.

FORESTS IN NEWCASTLE DIVISION. — Nearly 9,000 acres of Crown forest are found in the Division of Newcastle. They are mostly situated in kloofs or south-east slopes of the Drakensberg, or on spurs jutting from the main chain,

between the Biggarsberg and Mueller's Pass, where the Incandu and Ingagani Rivers take their rise. At the head of the basin of the Ingagani each small valley consists of comparatively flat ground, surveyed into a farm, surrounded by a semicircle of mountains partly covered with forest. Above the farm "Schietnek" four or five small pieces form some 200 acres of forest; but the steepness of the ground has precluded its working.

Above Stellalie Hoek, a forest of 700 acres is situated in a kloof running to the south. The ground is rocky and very steep; but timber is worked near the entrance to the gorge.

In the next valley, that above Bamboos Hoek, so called from clumps of *Bey* bamboo (*Arundinaria tessellata*, Munro) found at 6,000 feet, there are 500 acres of forest in scattered patches, containing good timber. Though the ground is steep, the greater portion could be worked.

Further north, the valley of which the farm "Marsden Ash" occupies the centre, is larger than the preceding; the forests scattered on the surrounding mountains, principally on the spur to the north, cover about 2,000 acres, and consist of scattered patches, the largest of which are not more than 200 or 300 acres in area. Some contain very fine timber, and may eventually pay to work when the country is opened up more than it is at present.

From the last valley, the ground forms a massive plateau, the edge of which is wooded in several places. Above the farm "Normandien" a forest of a thousand acres, covering south and south-east slopes, contains some fine timber. Yellowwood here attains a larger size than is usually the case in the Drakensberg. Part of the forest is included in "Normandien," and it will be expedient to lay out the boundary line to prevent encroachments on either side. Above this forest, at the foot of the next terrace, is another strip of 200 acres, containing a considerable quantity of Upright Yellowwood. The altitude of the upper forest is about 6,000 feet, that of the lower from 5,000 to 5,500 feet.

From one half to one third of the area of the leased lot "Havelock," containing 2,680 acres, is clothed by the Ulumbe forest, at the head of the Incandu River, but much of it is too steep for working.

About five miles to the south-east, there is a forest of 500 acres, on south slopes overlooking the farm Buffel's Hoek, which could be worked without much difficulty.

Other small forests are dispersed above the farm Tuifel Hoek, a few miles north-east of Mueller's Pass; but further north, the country is found almost entirely devoid of timber, till the Inkwelo is reached.

The principal species of trees found in the Newcastle forests enumerated above, are the following:—Upright and Outeniqua Yellowwood, Wild Chesnut, Camdeboo Stink-

wood, Hard Pear, Red Pear, Assagai, Natal Mahogany (*Kiggelaria Africana*), White Ironwood, *Phoberos Zeyheri*, *Olea verrucosa*, *O. Capensis*, *Euclea Natalensis*, *Ekebergia Capensis*, *Euclea undulata*, *Cathastrum Capensis*, *Celastrus peduncularis*, *C. buxifolius*, *C. acuminatus*, *C. undatus*, *Elæodendron* spp., *Myrsine* spp., *Ilex Capensis*, *Cryptocarya* spp., *Clerodendron glabrum*, *Plectronia Mundtiana*, *Plectronia ventosa*, *Hippobromus alata*, *Zanthoxylum Thunbergii*, *Celtis* spp., *Schmidelia Africana*, *Schmidelia* sp., *Royena lucida*, *Buddleia salviaefolia*, *Halleria lucida*, *Myaris inæqualis*, *Trimeria alnifolia*, *Rhus* spp., *Rhamnus prinoides*, *Burchellia Capensis*, *Grewia occidentalis*, *Ficus* spp., *Leucosidea sericea*, *Heteromorpha arborescens*, *Brachylæna discolor*, *Dovyalis rhamnoides*, *Cluytia* sp., and *Scutia Commersonii*. Outside the forests the principal trees met with are :—*Acacia Horrida*, *Acacia* spp., *Salix Capensis*, along streams, *Protea hirta*, *P. lanceolata*, and *Greyia Sutherlandi*.

Mr. W. H. Bierbaum is paid £36 a year to supervise these forests, but their extent and distribution does not allow of the work being done efficiently by one man. However there is at present very little wood cut in the forests, and the destruction from other causes appears to be slight. Mr. Bierbaum is himself a woodcutter, and thus has to check his own work, which is a very bad arrangement in principle. A practice that is carried to the detriment of the revenue consists in cutting a number of trees down under a wagonwood license, taking a small piece from each, and removing the remainder under a drywood license, which costs twelve times less. Before the appointment of Mr. Bierbaum, wood stealing was very prevalent, and many well worn wagon roads and slip-paths remain to show that large quantities of timber were illicitly removed over the border. But illicit felling decreased as the quantity of serviceable timber within reach grew less; and it almost died out with increased supervision. The Mounted Police formerly patrolled the forests to prevent their destruction, but the practice has been discontinued.

The majority of the forests in the Newcastle division appear to be situated on grazing leases. It is not clear whether the timber they contain can be sold to other persons than the lessees. Should any of the leases be sold, it would be well to ascertain beforehand whether they contain any of the forests.

In the northernmost point of Natal, near the Transvaal border, there is a Crown Reserve, including the Inkwelo and the Majuba mountains. A kloof running south from the Inkwelo is partly wooded, and the forest spreads on the hill side at 5,500 feet altitude, covering some 600 acres. The trees are very stunted, and the undergrowth tangled. The principal species are those found in the rest of the Drakensberg forests, but there is very little yellowwood or indeed serviceable timber of any kind. Along the kloofs, *Ilex Capensis* and several species of *Myrsine* are abundant. Mr. A. H. Trow receives £36 a

year to supervise this forest and another, situated at Long Krantz, near the Drakensberg, which is very difficult to work in. A small revenue is derived from the sale of wattles to Natives. These two forests are the last of the Upland belt.

THORN BUSH.

The Thorn Bush of Natal is spread over vast areas in the Midland region, at an altitude of from 1,000 to 3,000 feet. It is densest at the lower elevations, and a belt of grass country almost entirely separates it from the Heavy Timber Forests. Towards the Coast, however, it merges gradually into the Coast Forest. It chiefly consists of various species of *Mimosæ*, of which *Acacia Natalitia*, *A. Horrida*, *A. Kraussinia*, *A. Caffra*, and *A. Arabica* are the most noticeable. The distribution of Thorn Bush is shown in Map I., and the Report of the Forest Commission of 1880 gives the total area covered by Thorn Bush as 196,000 acres on Crown Land, and 1,645,000 acres on Private Lands, but these figures appear to include Coast Forest, which would form an appreciable of the whole. The clearing of Thorn Bush for firewood or for Native cultivation has been very extensive of late years. The continually recurring grass fires arrest the growth of young plants, and the forest is seldom known to recover. Large areas may often be seen that are thickly studded with minute *Mimosa* plants, which would grow into a forest if protected from the grass fires. The Thorn Forests are usually ill defined and consist often of isolated trees or clumps thickly distributed over a large stretch of country.

COAST FORESTS.

With the exception of those in the Lower Umzimkulu Division, nearly the whole of the Coast Forests are situated on private property. It appears that surveyors have not hitherto considered coast forest to be any forest within the meaning of their instructions, and it has been freely alienated, but what remains should be preserved as far as circumstances will permit. The Coast Forest is still extensive, but much of it has been cleared for planting. Nearly the whole of the cultivated land in the Coast districts consists of cleared bush ground. This extensive denudation is said by old settlers to have somewhat altered the climate, causing a greater aridity and more irregularity in the weather. Yellowwood and wagonwood were formerly cut in many of the coast forests; but few good timber trees are now left. The coast forest is generally low, the average height varying from 30 to 60 feet. It contains a great variety of trees, the wood of some of which is of great value. The principal species found are the following:—*Popowia Caffra*, *Niebuhreria triphylla*, *Rawsonia lucida*, *Doryalis rhamnoides*, *Trimeria alnifolia*,

Garcinia Gerrardi, *Hibiscus tiliaceus*, *Cola Natalensis*, *Dombeya Natalensis*, *D. rotundifolia*, *D. Dregeana*, *D. Burgessiae*, *Erythroxyton emarginatum*, *E. pictum*, *Acridocarpus Natalitius*, *Sphedamnocarpus galphimifolius*, *S. pruriens*, *Calodendron Capense* (Wild Chesnut), *Zanthoxylum Capense* (Knobthorn), *Z. Thunbergii*, *Toddalia lanceolata* (White Ironwood), *T. Natalensis*, *Ochna arborea* (Rooihout), *O. atropurpurea*, *Balsamea africana*, *Turraea heterophylla*, *T. obtusifolia*, *Melia Azedarach* (Syringa, introduced), *Ekebergia Meyeri* (Essenhout), *Trichilia Natalensis*, *T. Dregeana*, *Apodytes dimidiata* (White Pear), *Celastrus buxifolius*, *Putterlickia verrucosa*, *Elæodendron capense*, *E. confertiflorum*, *Scutia indica*, *Schmidelia africana*, *S. natalensis*, *S. decipiens*, *Hippobromus alata* (Paardepis), *Sapindus oblongifolius*, *Dodonea viscosa*, *Ptæroxylon utile* (Sneezewood), *Bersama lucens*, *Rhus lævigata* (Red Currant), *R. longifolia*, *Loxostylis alata*, *Odina caffra* (Kafir Plum), *Sclerocarya Caffra*, *Milletia Caffra* (Umzumbeet), *M. Sutherlandi*, *Erythrina Caffra* (Kafir boom), *E. latissima*, *E. Humei* (small Kafir boom), *Dalbergia armata*, *D. obovata*, *Baphia racemosa*, *Calpurnia lasiogyne*, *Schotia brachypetalata*, *Dichrostachys nutans*, *Acacia Arabica*, *A. Natalitia*, *A. Gerrardi*, *A. Kraussiana*, *Albizzia fastigiata* (Flat Crown), *Rhizophora mucronata* (Mangrove), *Bruguiera gymnorhiza* (Mangrove), *Weihea Madagascariensis*, *Combretum Gueinzii*, *C. Kraussii*, *C. Sonderi*, *Eugenia cordata* (Waterboom), *E. albanensis*, *E. capensis*, *Barringtonia racemosa*, *Memecylon* sp., *Heteropyxis natalensis*, *Homalium rufescens*, *Gerrardina foliosa*, *Cussonia spicata*, *C. umbellifera* (Cabbage-wood), *Burchellia capensis* (Wild Pomegranate), *Randia Kraussii*, *Gardenia globosa*, *G. citriodora*, *G. Thunbergia*, *Oxyanthus* spp., *Kraussia pavettoides*, *Triculysia* sp., *Alberta magna*, *Plectronia obovata* (Quar), *P. ventosa*, *Pavetta* spp., *Psychotria Eckloniana*, *Brachylaena discolor*, *Tarchonanthus camphoratus*, *Mæsa alnifolia*, *M. rufescens*, *Myrsine melanophleos* (Beukenhout), *Sideroxylon inerme* (White Milkwood), *Labourdonnaisia discolor*, *Mimusops obovata* (Red Milkwood), *M. Caffra*, *Chrysophyllum natalense*, *Rouena* spp., *Euclea natalensis*, *E. lanceolata*, *Maba natalensis*, *Schrebera alata*, *Olea foveolata* (Bastard Ironwood), *Olea laurifolia* (Black Ironwood), *Olea verrucosa* (Olivewood), *Rauwolfia Natalensis*, *Orchipeda dregei*, *Tabernaemontana ventricosa*, *T. Thouarsii*, *Nuxia congesta*, *Chilianthus arboreus*, *Buddleia salviaefolia*, *Strychnos Atherstonii* (Chaka's-wood), *S. Umbanda*, *S. Mackenii*, *S. spinosa*, *Cordia caffra*, *Ehretia hottentotica*, *Halleria lucida*, *Anastrabe integrima*, *Vitex* sp., *Clerodendron glabrum*, *Avicennia officinalis* (White Mangrove), *Colpoon compressum*, *Euphorbia grandidens*, *E. antiquorum*, *Bridelia micrantha*, *Cyclostemon natalense*, *C. argutus*, *Antidesma venosum*, *Macaranga capensis*, *Gelonium africanum*, *Excoecaria elliptica*, *E. africana* (Umtambooti), *E. reticulata*, *Celtis Kraussiana* (Camdeboo Stinkwood), *Trema guineensis*, *Chaetachme Meyeri*, *Ficus* spp., *Podocarpus elongatus* (Outeniqua Yellowwood), *Podocarpus Thunbergii* (Upright Yellowwood). Particulars about these species, and those found in the Upland and Midland regions, are given in Appendix I.

GENERAL.—The following table of the extent of the Natal forests is reproduced from the Report of the Forest Commission of 1880 :—

COUNTRY OR DIVISION.	HEAVY TIMBER FORESTS.		LOW FORESTS.	
	Crown Lands.	Private Lands and Locations.	Crown Lands.	Private Lands and Locations.
	Acres.	Acres.	Acres.	Acres.
Newcastle	4,000	2,000	—	—
Klip River	6,000	—	—	100,000
Upper Tugela	2,500	2,500	—	—
Weenen	6,400	6,400	10,000	300,000
Umsinga	—	100	—	120,000
Upper Umkomaas	—	12,000	5,000	25,000
Pietermaritzburg	—	90,000	—	80,000
Umvoti	—	14,000	10,000	400,000
Victoria	—	—	10,000	200,000
Durban	—	—	1,000	160,000
Alexandra	—	—	40,000	60,000
Alfred	6,000	—	100,000	100,000
Ixopo	8,000	6,000	20,000	100,000
<hr/>				
Total ...	32,900	133,000	196,000	1,645,000

The estimate of the extent of High Timber Forest is apparently too low in the case of Newcastle and Ixopo, and too high for Weenen County. My own estimates give 39,750 acres as the total area of the forests on Crown land, and 17,200 as that of the timber forests in Native locations, but such estimates are entirely guesswork and give at best only a very rough approximation. The former estimates must have been very much out, in some cases ; and nothing can be inferred from them about the rate of diminution of the forests ; but there is strong evidence that both timber forests and low forests have decreased considerably since 1880. The principal causes of destruction at work have been (a) fires, (b) cutting of wattles, poles, and kraalwood, (c) cutting of firewood, (d) clearing for cultivation, (e) licensed felling, (f) unlicensed felling, (g) grazing of cattle. I will consider their effect when treating of the measures required to be taken in order to conserve the Natal Forests. And before doing this, it will be best to discuss whether the forests are worth preserving or not.

ON THE UTILITY OF THE FORESTS.

The expediency of conserving forests must primarily depend on their degree of utility. Some of the beneficial functions of forests might readily escape notice if not pointed out, and I will devote the present section of this report to a short exposition of the subject. Few people would deny that forests play an important part in the economy of nature, that they add to the beauty of scenery and prove of great service to man. But it is not always that these advantages can be estimated in pounds, shillings, and pence, and the sense of their utility, taken alone, has seldom been sufficient to prevent the destruction of forests, even by civilised races. To a certain extent, the clearing of woodland is a legitimate process—it may transform a barely habitable forest region into a fertile and populous country. Unfortunately denudation has seldom been kept within due bounds, and historic instances show that, in the words of Clavé, the prosperity of not a few countries has gone along with the forests that covered them.

The beneficial functions of a forest are mainly climatic and economic. There are also other attributes of minor importance which may be noticed first. I refer to the ornamental nature of forests, and to the protection which they afford to game.

WOODLAND SCENERY.—No landscape is complete without woods and water. The disfigurement of a country by the destruction of its forests has always been denounced by those few to whom beautiful scenery is something more than stone and water and timber. Even from a purely monetary point of view, scenery is to be valued. A bleak and arid country, such as Natal would be without trees, is not conducive to permanent settlement, and therefore retains less wealth than one that is attractive and picturesque.

FORESTS AND GAME.—Many of the forests of Western Europe own their preservations through feudal times to that of game. In England forests have been set apart for game ever since Saxon times, and in English legal phraseology the essential characteristic of a forest is that of being a game preserve. Manwood says :—" A forest must always have beasts of venery abiding in it, otherwise it is no forest " ; and Blackstone defines a forest as " wastegrounds belonging to the king, replenished with all manner of chase or venery, which are under the king's protection for the sake of his recreation and delight." Game may easily be protected together with forests, and no doubt there are sportsmen to be found still who would hold this a sufficient motive for preserving forests.

FORESTS AND RAINFALL.—The distribution of rainfall primarily determines that of forests. Timber belts everywhere follow zones of heavy rainfall, a co-relation well marked in warm countries, such as India and Australia. At the Cape, the principal forest regions of Knysna and the Amatolas, with the Cedar Bergen and Table Mountain, also formerly wooded, are seen to coincide with the four wettest regions, where the rainfall exceeds 30 inches. It is probable that in Natal, the rainfall over the timber belt at the foot of the Drakensberg, is greater than along the coast, though I find that Dr. Mann advanced a contrary opinion.

Once established, forests appear to exert a reflex action on the distribution of rain. By cooling moist air and increasing its humidity, they induce a greater local rainfall. Observations on this point are not numerous. At Cinq-Franchées, in France, Mathieu observed that the rainfall measured in 1866-68, at three points not far apart (one inside a forest, another on the edge, and the third outside), varied respectively as the numbers 1,000, 957, and 853. Fautrat and Sartiaut give the results of double observations of the rainfall at Halette, from February to July in one year, as 192.5 mm. in the forest, against 177 mm. outside. The difference appears to be greater in warm than in cold countries, though a great deal also depends on the meteorological character of the rainfall: whether it is induced by cyclones or by secondaries. An increase of the rainfall can only be apparent locally, or in a country of which forests cover a large proportion. In most cases, it would be masked by the greater irregular or cyclical variations from year to year.

But if forests do not materially augment the rainfall, they unquestionably regulate it, promote the frequency of showers, and control the flow of water, which, on the whole, is a preferable effect. In most countries, certainly in Natal, a simple increase in the intensity of rain would be an evil. Forty inches of rain poured down rapidly, will leave a smaller supply in the soil than twenty falling moderately. Torrential rains wasted in flooding the rivers may do some good at times, but frequent soaking rains are better. If forests are a means of reducing the proportion of floodwaters, they give the advantages of an increased rainfall without the attendant evils.

EROSION OF THE SOIL.—In mountain regions, the destruction of forests causes the formation of torrents and ravines. Torrential action is essentially identical in all its varied forms, and consists of the bringing down of soil and stones by the rain waters. Ravines or *dongas* feed torrents, which in turn give rise to torrential rivers. From the appearance of a river we may judge of the degree of torrentiality to which it is subject. When the banks are clothed with vegetation to the water's edge, or green islands in the centre are covered with old trees, great stability and steadiness of flow may be inferred; on the contrary, signs of erosion and shoals of gravel in the stream indicate a slight degree of torrentiality; at an aggravated stage, the water may be seen straggling through beds of pebbles; dividing into branches with unstable courses. A typical torrent can be made out to consist of a fan-shaped hollow basin in which the waters are collected, joined by a narrow gorge to a spreading bed of deposit, the average slope decreasing throughout. The erosion of the ground takes place over the whole basin, but ceases at the gorge, where the material is simply borne along by the water; finally, the washings become deposited from the foot of the gorge downwards.

The erosion of the ground in the torrent basin is caused by sudden heavy rains such as those of thunderstorms. The rain loosens the ground by impact*, the particles of soil

*Hail has been observed to be especially destructive in this respect.

round each stone get washed away, and the stones, becoming loose, follow ; the muddy water collects into streamlets charged with materials which by their friction help to gutter the ground ; it then forms surging streams full of mud and stones, which plough up the bed, undermine and eat away the banks, and end in flooding the rivers below. In time, the mountain side appears scored with innumerable ravines and becomes transformed into a barren waste devoid of vegetation or water. The more the ground becomes cut up, the greater the rate of destruction. This is due to the continual spread of the bared surface subject to rapid erosive action, and to the fact that a larger amount of solid material borne along by the water increases its destructive power in proportion. The evil may thus attain in a small number of years—as I will show it has been the case in some parts of Southern Europe—a magnitude which might have at first been thought preposterous.

ACTION OF FORESTS ON THE SOIL.—A very different effect may be observed when rain falls over a forest (a) the rain itself, though more frequent, is less intense ; (b) a large proportion of the water, averaging fully one quarter of the total amount*, is retained by the tree-tops with their vast expanse of foliage, and restored to the atmosphere by evaporation ; the trunks and the undergrowth help to retain some of the water (c) When the rain at length reaches the ground, the saturated vegetation serves still to break the shock of heavy showers, and to keep the water dispersed over the surface, where it is imbibed slowly by the spongy humus which is capable of absorbing an immense quantity. If we could see a section of a wooded slope, it would show a layer one or two feet thick of decayed leaves and humus, in which the fibrous rootlets form a close matting ; this layer is capable of holding twice its weight of water.† The roots also break up the sub-soil, increasing its porosity and causing the storage of moisture, out of the reach of direct evaporation.

In this manner, the forests store immediately by far the greater part of the rainfall, and yield it little by little, trickling in water of perfect fluidity, instead of forming swollen streams charged with mud and gravel. Where they have not been destroyed, strips of forest are usually found distributed along the banks of streams, and between the mountains and the valleys, in such a way that nearly all the water that falls over a tract of mountain country must trickle through some portion of the barrier of forest soil, acting both as a reservoir and a filter, before it can reach the nearest watercourse. The cause of this remarkably useful distribution of forests is simple enough. Trees thrive best where they can get most moisture, if the drainage remains sufficient. Thus, in plantations the

*Bavarian observations show that the tops of high trees retain 25 to 30 per cent. of the rainfall ; while Marshal Vaillant found that in the forest of Fontainebleau the proportion amounted to 30 per cent. in summer, and 50 per cent in winter, or 40 per cent. throughout the year.

†According to De Gasparin, the humus of forests, with a density of 1.225 can retain 1.99 of its weight of water. It follows that each foot of humus could store a sheet of water equal to 29 inches of rainfall.

growth may be doubled or trebled by irrigation, and Hartig, experimenting in a beech forest, finds that the amount of wood produced is related to the current of liquid passing up the stems, which itself depends on the quantity of moisture available in the ground. So that, where forests cannot spread over the whole of a tract of country, they may be found only at the foot of slopes, as it is there that most water flows over the surface, and that the ground is best protected from dessicating influences.*

Even if in very heavy rains the forests can only keep back the bulk of the mountain waters during a few hours, they yet prevent floods by allowing a large quantity of the valley waters to run down, before the mountain waters, already diminished in proportion to the storage power of the forests, can reach the lower levels.

ACTION OF GRASS AND BUSH.—Grass and bush have in a lesser degree the same controlling effect over the flow of water, but experience has shown that grass alone cannot serve to check completely torrents and floods. Neither are bushes sufficient for the purpose, for the hygroscopic layer which gives such a value to the natural forests, does not form under. Still both grass and bush consolidate the soil, and, covering often a large area compared with that of the forests, they very powerfully help the action of the latter. And where forests cover only a portion of the mountains, it is only by a judicious preservation of both grassland and forest, effected by regulating the grazing in the one and cutting in the other, that the evils following denudation can be reduced to a minimum.

TORRENTIAL ACTION IN OTHER COUNTRIES.—This protective power of vegetation was first clearly pointed out by the French Engineer, Surell, in a remarkable work**. A large technical literature has since resulted from the considerable attention which the subject has perforce attracted in France, Switzerland, Germany, and North Italy, where the destruction of the forests in some districts has been fraught with disastrous consequences. In the south of France the damage became so great towards the middle of the present century, that since 1860 very large sums of money have been spent, to avoid greater loss, in the work of checking torrents and reforesting their basins; and in 1880, it was estimated that the

* This great affinity of forests for moisture explains why the Natal forests are distributed on south and south-east slopes of considerable steepness. The amount of water received and retained on slopes with that aspect is greater than on any other; because (a) the evaporation is less than on any other aspect, especially the north, facing the sun. (b) The bulk of the rain comes from the south-east and drives at some inclination, so that slopes with that aspect will receive most water. For instance over a low hill with sidesloping at 1 in 2, rain driving at an inclination of 2 in 1 from the south would deposit 1·4 times more water on a south than on a north slope. With slopes at 1 in 3, the proportion would reach one and two-thirds. To put it otherwise, with a rainfall of 40 inches, the effect will be equivalent in the first case to a vertical fall of 47 inches on the south slopes, and 33 on the north; in the second case, the respective numbers would be 50 and 30. (c) A vapour-laden currents of air deflected upward by a mountain chain will part with some of its moisture on the windward flanks, owing to the dynamic cooling resulting from its expansion at a level of diminished pressure, and Natal, sloping rapidly from the Drakensberg to the Indian Ocean, is favoured in this respect.

In the Knysna region, the distribution of forests also illustrates strikingly the action of the several causes mentioned. The Outeniqua range, the forests and the coast all run east and west, within a narrow zone; the mountains cause an increased rainfall on the coast flanks on which alone are any forests found; then the action of the sun and the westerly rains cause the forests to prevail on south and west slopes, at a level of 500-2,000 feet, where the climate is otherwise adapted to the species that are found.

** Etudes sur les Torrents des Hautes Alpes. Paris, 1841.

completion of the works required for the purpose, in the Alps, the Cévennes and the Pyrenees would cost 148 millions of francs in works and 72 more to acquire land, or a total of nine millions sterling.

The rapid slope of Dauphiny and Provence from the mountains to the sea, and their warm climate causing sudden heavy rains, naturally expose these provinces to torrential action. At first the clearing of woodland proceeded so slowly that for centuries neither the want of timber nor torrential evils were seriously felt. Throughout the middle ages the country remained well wooded and famed for its fertility, both in the lowlands and the hills. Even so late as 1789, Arthur Young writes that "about Barcelonnette and in the highest parts of the mountains, the hill pastures feed a million sheep, besides large herds of cattle," and he adds—"with such a soil and such a climate, we are not to suppose a country barren because it is mountainous. The valleys I have visited are in general beautiful." Other contemporary writers and local tradition agree in showing that a century ago the ravages of torrents in Provence and Dauphiny were still too insignificant to deserve notice. Some portions of the same province have since become ruined and depopulated through this cause. Out of a total area of 1,710,000 acres, the department of the Lower Alps possessed, in 1852, 245,000 acres of cultivated land, against only 183,000 in 1862, the difference of 62,000 acres having been swept away by torrents during the interval of ten years. In the same interval the population decreased by 7,500. Between 1846 and 1876 there are no data of the extent of cultivation destroyed, but the population decreased from 157,000 to 136,000. In the department of the High Alps, the population, that had increased by 11,000 from 1805 to 1840, decreased during the next thirty years from 130,500 to 119,000 in 1876. Not only has much of the land of both departments been rendered absolutely barren, but villages in the torrent basins have also been engulfed, crumbling away with the ground, and roads and bridges destroyed frequently. Many forcible pictures have been drawn of the state of degradation which the country had reached towards the middle of the present century. And yet, within the memory of the same generation, those bare hill-sides that stood parched and desolate, cut up to the rock by networks of ravines, had been many of them covered with fine forests and without a single torrent. The destruction had proceeded at such a continually increasing rate that, quoting the words of an official report in 1853, "unless prompt energetic measures are taken, the time may be reckoned when the French Alps will have become nothing but a desert waste Each year will aggravate the evil, and in half a century, there will be in France a few ruins more and a department less." It became a question whether the Alps should be reclaimed or given up to the ever encroaching torrents; which ended in laws being passed in 1860 and 1864, prescribing the extensive works of restauration on which millions have already been spent.

The influence of vegetation on the flow of water suggested an efficacious remedy. It has been found, beyond question, that (a) the presence of forest on a soil prevents the

formation of torrents there, (b) the destruction of forests leaves the ground a prey to torrents, (c) the torrents disappear with the recrudescence of vegetation. In numerous cases, torrential actions had become so powerful that it was found necessary to attack the evil by auxiliary means in addition to reforestation, and the works that are now undertaken in France for the purpose of checking torrents consist of (a) reforestation, (b) turfing, and preservation of grassland, (c) dyking the torrent beds.

The distribution of the planting and grassing, over the torrent basin, is a matter of great importance, requiring careful study ; the best results are often secured by adopting a distribution of a natural character. If done judiciously, the work has the effect of reducing the volume of the flood waters and depriving them of solid material. Where it is necessary to consolidate the banks and beds of ravines till forests have gained a footing, this is done by erecting, across the bed, weirs of masonry, stonework, wickerwork or fascines, according to the nature and importance of the torrent or ravine. These barriers retain the gravel and stone, and break the speed of the water so much that it will take twelve hours to descend from the summit of a mountain to the base where formerly it took but thirty minutes. A weir is usually first erected at the outlet of the torrent gorge, then as soon as it becomes silted up, another is constructed just above the mass of deposit, and so on, till the ultimate feeders are reached. In the latter, the weirs are constructed of live willow stakes and twigs or fascines of osiers, which, by taking root, consolidate permanently the débris, and are found most efficacious. When the work is completed, the torrent beds have become shaped in steps, and the water flows evenly in the centre of the course, in a series of reaches and cascades. The banks are then planted, and in a few years the forests above have progressed sufficiently to completely stifle the torrents ; all that is further required is to preserve the trees and herbage ; it would have resulted in a great saving to have done this from the first. How effectual is the mode of extinction of torrents now adopted may be inferred from the fact cited by Costa de Bastelica, that over the torrent of Sainte-Marthe, which was formerly noted for its violence, and carried away every bridge that had been thrown across it, a simple footbridge two feet above the level of the stream can resist the greatest floods that now occur.

Torrential action is apparently more powerful in warm countries with sudden heavy rains, than in cold countries where the rain is less intense, if more frequent. In England, the rain is well spread over the year, and the general slope of the country is not very rapid ; consequently grasslands seem almost sufficient to prevent floods and the wasting away of the soil with all its evil consequences. On the contrary, warmer countries such as France, Spain, Italy, Switzerland, and Austria, have invariably suffered through torrential action following extensive denudation. According to Marsh, (*) four-tenths of the area of the Ligurian provinces of Italy have been washed away, or rendered incapable of cultivation in consequence of the felling of the woods.

*The Earth, as modified by Human Action, p. 256.

TORRENTIAL ACTION IN NATAL.—During later geological times, torrential action has been extremely powerful in Natal, and it is chiefly by the agency of water that the mountains have been shaped and the river valleys formed. By degrees, the spread of vegetation, at first doubtful, became more assured as the surface of the ground became eroded into forms of greater stability, and the meteorological influences decreased in intensity; and eventually vegetation assumed and retained the upper hand. This indicates one of the reasons why vegetation, dependent for its spread on its capacity to resist denudation, is now so well fitted for the purpose.

The physical conditions of Natal are in many respects similar to those of the South of France, and equally favourable to the formation of torrents. We have the same sudden heavy rains falling over a hilly country sloping rapidly from the mountains to the sea; and there are unmistakeable signs that in Natal an outbreak of torrentiality is at present in an incipient stage. Floods are not unknown; those of April, 1856, February, 1866, and recently that of January, 1886, are reported to have been very destructive. And ravines, locally known as *dongas*, are already a conspicuous feature of many parts of the country. Possibly *dongas* do not yet incommode farming to any serious extent; but it should be borne in mind that one of their attributes is to spread at a continually increasing rate, and that, even now, this rate, though it is yet small, is by no means insensible. Each one of the hundreds of *dongas* which I have seen in Natal appeared to me of recent formation; and whenever any definite information could be got from old residents or Natives, I found this to be the case. Some of the ravines known to have made their first appearance only a few years back have now attained a depth of ten or twenty feet, and a greater width. The head of the Tugela Valley has been very much cut up by the summer showers, and *dongas* there extend for miles; the Tugela itself has every characteristic of a torrential river. When following the coast, the rivers of the Colony, crossed near their mouth, look as if they were streams of silt and *débris* as much as streams of water.

The diminution of the forests, and the practice of burning the grass in summer, which leaves the ground unprotected and liable to be loosened by rain and cattle precisely when the violent thunderstorms occur, are sufficient causes to account for the increased guttering of the land. Indeed, the experience of other countries makes it necessary to explain why in Natal, with causes so potent, the effects are not already greater. The destruction of forests and of herbage has been severe only within a comparatively recent period. The Hottentot races which, a few centuries back, peopled South Africa were neither pastoral nor agricultural, and their numbers remained small, so that the natural conditions of the country were but slightly interfered with; and it is only with the advent of more destructive races and their great increase in late years, that vegetation began to

be checked and that eventually the erosion of the ground was manifested, at first in an insignificant and protracted manner, then by degrees in a more and more rapid form. At present, the mantle of verdure which covers the mountains still acts as a powerful brake on torrential action, but if we are to allow what remains of forest to be destroyed, and the mountain grasslands to be burnt and grazed indiscriminately, the ruin of much of the land will become a matter of years, and perhaps it would not then be feasible to spend millions in redeeming it. While it is in our power to avert such consequences, we should profit by the experience that has been so dearly bought elsewhere, and not neglect to adopt any reasonable protective measures. Besides being cheaper, it is also better to preserve natural forests than destroy them to substitute plantations which take centuries to acquire the deep layer of humus and the surface growth which give such a peculiar climatic value to the natural forest.

Torrential action at the Cape is also manifest, though in a milder form than in Natal. In a recent report published in the *Cape Government Gazette*, Prof. J. R. Seeley writes, speaking of the Cape: "When, too, land has been denuded of its timber, the water sweeping over the country carries away the ground which should have been under cultivation. This process is going on to an extent of which few people have any conception, and the result is that land is being destroyed in a wholesale way, for it is not merely the breaking up of the land which is so serious, but that a line of drainage is created deep beneath the surface of the country."

INFLUENCE OF FORESTS ON WATER SUPPLY.—In a forest country, the minor streams appear in striking contrast dried up or perennial, according to whether they issue from a forest or from the open, though the drainage areas and the rainfall may be equal in both cases. This connection between forests and the volume of water delivered by springs is a matter of common observation, established by innumerable instances, of which there is no need to give any examples. Evidence on this point may be found in Marsh's work on "The Earth as Modified by Human Action." M. Comte-Granchamps estimates that in coniferous forests of the Loire and the Alps, the normal delivery of a water-course is increased by 229 cubic feet daily for each acre reforested in its basin, and by 57 cubic feet for each acre grassed. If the springs decrease their flow as the forests are destroyed, the rivers which they feed must also shrink in volume. In 1873, G. Wex proved in an able and exhaustive work that the volume of water delivered by the five principal rivers of Central Europe—namely the Danube, the Rhine, the Elbe, the Vistula, and the Oder—has in each case decreased continually for a long period of years, and he ascribes this effect to a corresponding diminution of forests. Commissions appointed in Austria and in Russia to report on this work confirmed the conclusions arrived at by the author, and the Russian Commission adds that the Volga has also diminished in volume in consequence of the cutting down of the great forests on the Ural Mountains.

The conservation of forest and bush in the drainage area of reservoirs is thus of great importance ; this point should not be overlooked in connection with the water supply of Maritzburg and Durban.

UTILISATION OF WATER.—IRRIGATION.—The regularity of the water supply of a country is very desirable, for the value of each stream depends upon its normal, not its total, delivery, whether the water be applied for irrigation, or as a source of power or for mining or industrial purposes. Forests, by their great regulating effect on the water supply, may thus often render irrigation possible, and serve better for the purpose than costly dams. The difficulties that beset irrigation in this country are precisely those that are removed by using a forest-regulated water supply. "Irrigator," writing recently in the *Natal Witness*, states that they are the following : "1. That the rivers are not to be depended upon to yield a supply of water during the winter months sufficient for irrigating large acreages. 2. The making of dams across them to enable the water to be led out of them would, except in exceptional places, be a very expensive undertaking, with a great probability of their being swept away when the great rushes of water occur during the summer months. 3. The watercourses taken out from the streams would, for the most part, have to traverse the sides of more or less hills, and these would be entirely filled up by the washings brought down from the slopes during the heavy summer rains." The dams themselves would also become filled with washings. At the Cape, the large Beaufort West reservoir, constructed in 1880, with a capacity of 572 million gallons, for irrigation purposes, is said to be silting up so rapidly as to become useless in a limited number of years.

Now that the influence of forests on the flow of water has been explained, it will be patent that their destruction would increase all these difficulties and that their extension would have a contrary effect.

The subject of irrigation is of great and growing interest not only in Natal, but throughout South Africa. In countries placed in similar conditions of climate, such as India, or Italy and most other Mediterranean countries, irrigation is looked upon as a necessity ; agriculture has become almost entirely dependent on its use, and the works for the purpose have reached an immense development.

The conclusion of a paper read by Mr. B. E. Fernow of the U. S. Department of Agriculture, at the 1889 meeting of the American Association, applies with much force to some parts of South Africa : "A rational management of the water capital of the world in connection with the agricultural use of the soil will become the economic problem of the highest importance, as the necessity for increased food production calls for intensive methods. . . . While with one hand we pay exorbitant prices in land and wasted energy to get the plains reforested, and that with poor success, with the other hand we offer a premium for forest destruction in mountains by leaving them without proper

administration. And now we propose to establish irrigation systems, neglecting to provide first for those conditions which assure a regulated water supply, namely, by forest preservation." This paper led to the appointment of a Committee to urge the importance of these matters on the President and Congress of the United States and on the Premier and Parliament of Canada.

FORESTS AND RIVERS.—Torrents cause floods and the silting up of navigable rivers and of their estuaries. Sometimes, the sand is brought down to the sea, forming sand-banks at the mouth, which are spread along the coast by currents and wave action, filling harbours and channels to the detriment of navigation. Thus an increased discharge of sand from the mouth of the Umlazi or that of the Umkomanzi, could only tend to aid the formation of the Durban sand-bar, though other more powerful causes acting contrariwise might mask the effect. In the same way, the denudation of the Umzimkulu basin which is now in active progress, cannot tend to improve the estuary at Port Shepstone.

EFFECT OF FORESTS ON WIND.—Not only do forests shield the ground from the destructive action of water, but they also often prevent injurious effects of the wind. Acting as windbrakes, they protect adjacent cultivated land from the dessicating effect of hot winds. Instances are recorded of arid tracts rendered cultivable by the planting of protective belts and conversely the destruction of forests has doomed some fertile regions to sterility.* Planters along the coast are well aware of the value of fringes of forest in protecting tea and coffee plantations. Forests also protect sandy soil from wind action. Sand drifts on the south-western coast of France, and on the Baltic coast, which formerly buried villages and fields, and proved locally as great a scourge as torrents were in the south of France, have now been effectively arrested by plantations of Cluster pine, and a great extent of land reclaimed for agriculture. The French Landes which consisted of low-lying sand wastes, marshy and fever stricken, have been converted into productive districts ; the extent of land thus reclaimed by forest culture is estimated by Bagneris at 4,000 square miles, or over one-fifth of the area of Natal. Conversely, in Sologne, the destruction of forests on sandy ground has transformed one of the most fertile provinces of medieval France into a sterile and unhealthy region. At the Cape, about four square miles of a belt of sand running from False to Table Bay, across the isthmus over which the railway had to pass, have been successfully reclaimed by mixed plantations of *Acacia saligna*, *Hakea suaveolens*, *Pinus pinaster* and *P. pinea*.

SANITARY INFLUENCE OF FORESTS.—The power of forests to increase the salubrity of the atmosphere is held, by Italian observers, to have been proved. Forests seem to

*Vide Marsh, L.c., pp. 157-165.

destroy miasmata by a chemical action, probably oxidation by the oxygen and the ozone which they generate. This effect is well marked in the case of Eucalypts, which have rendered salubrious certain fever-stricken districts of Italy ; but perhaps Eucalypts owe their virtue to the volatile antiseptic oil which they contain. Dr. Cleghorn gives it that "no point has been more clearly established than the salubrious and fertilising effect of forest clothing on the climate of India. It has been the subject of much inquiry, and has been affirmed and demonstrated in reports from many districts." According to Dr. H. Rogers, the cutting down of forests has been found to affect seriously the healthiness of Mauritius.

CLIMATIC INFLUENCE OF FORESTS. — It is a matter of common observation that forests are more damp than the open land. Ebermayer finds that the excess in the humidity of the air of Bavarian forests amounts to 5·7, 9·3, 5·2, and 5·2 per cent. respectively in the four seasons of the year beginning with spring. Over a forest it averages 13 per cent. according to Fautrat, and Tissandier's balloon observations show that the difference is still very marked 2,500 feet above. The shaded soil of a forest being less heated * and better protected by a cool and still stratum of air, **also remains more moist than the open land. The loss from direct evaporation in a forest averages only one-third (one-half in winter and one-fifth in summer) of that in land outside ; and if the forest soil be covered with moss and decayed leaves, the proportion is even doubled.

If forests lose little moisture by direct evaporation from the soil, they exhale through foliage an immense quantity of vapour into the atmosphere. Schleiden and other observers have come to the startling conclusion that a wood exhales more moisture than the rainfall could have supplied. †The quantity thus evaporated varies with the difference in temperature between the soil and the atmosphere, the humidity of the soil and the leaf surface.†† It is less with evergreen trees than with deciduous, though the latter lose their activity in winter.

But unless water were generated by the trees themselves, infiltration, trickling, and final loss by evaporation must in their sum balance the rainfall. Possibly, the evaporation from trees has been over-estimated ; for Cailletet has shown that a plant may absorb moisture directly from the atmosphere when the supply in the soil becomes inadequate.

*Bavarian observations give a difference of 7° 5 Fahr. in summer, which becomes hardly appreciable in winter, the mean difference for the year being 3° 4 Fahr.

**The diffusion of moisture in perfectly still air is extremely slow, and wind is usually the most potent factor in determining evaporation.

†From observations by Hartig and Burger, it results that oak coppice may exhale, in a year, vapour corresponding to 57 inches of rainfall ; with beech, even more.

††Klauprecht estimates that, weight for weight, leaves of Scotch Fir evaporate 3·5 times less moisture than those of the common oak, but Risler arrives at a smaller difference. According to Lawes and Gilbert, the evaporation throughout the year, in England, is distributed thus :—

Evergreen Trees.				Deciduous Trees.			
January to April	...	23	per cent.	...	8	per cent.	
May to August	...	52·5	"	...	56	"	
September to December	...	24·5	"	...	36	"	

for its requirements. *It is possible also that a portion of the moisture given out by the leaves is restituted to the soil otherwise than as rain, and that, just as in a Wardian case, a limited quantity of moisture is taken up again and again. The water that is exhaled by foliage cannot all be lost by evaporation into the atmosphere, otherwise the resulting fall in temperature, in forests, would be greater than that observed. Moisture may be continually streaming down from the boughs to be absorbed in part by the hygroscopic soil of forests, and it will be seen that the distribution of temperature and the air circulation are such as to cause this effect.**

According to Ebermayer, the mean temperature of the air in woodland is 1° to 1.7° Fahr. less than that outside, the difference being 3.0° in spring, 3.8° in summer, 1.1° in autumn, and insensible in winter. At the level of the crowns the mean temperature is about 0.5° less than that of the outside air, and 1.1° more than that of the air at the foot of the trees ; in summer this last difference reaches 3.9° . These mean differences show that the cooling effect of a forest in the day time is greater than the warming effect at night. In July at midday (for Europe) the forest air is 8° cooler than that outside, and in August during the afternoon 7.1° . At night it is warmer by 4.4° in July, and 3.7° in August.

The distribution of temperature affects the air currents. In the day time, the cool air of the forest flows outward and spreads over the open land ; as it becomes heated it rises and flows back over the tree tops, where it is cooled by the leaves and gradually sinks back to the surface of the forest. This circulation cools the adjoining land, prevents to some degree its dessication, and carries the moisture exhaled by the leaves down to the surface, where it is absorbed in part by the hygroscopic soil.

At night, the conditions are reversed. The cold and dense air outside now streams in along the surface, and rises as it gets heated, to be cooled again by contact with the leaves, and finally flow back over the tree tops to the open. It would seem that the forest soil will thus be deprived of the moisture which it had gained in the daytime. But, at night, the differences in temperature being small, the circulation is slow in proportion ; then the evaporation from the leaves becomes much reduced : and the cool and moist air flowing in from outside, where it is often depositing dew, will rather add if anything to the humidity of the forest soil. The air circulation at night will thus keep the adjacent land somewhat warmer, and may sometimes serve to prevent frost.

The reduction of temperature in forests is due to : (a) The great radiating power of foliage, which keeps the surface cooler than bare or partially protected soil. (b) The absorption by the leaves of radiation which becomes stored in the wood and can be

* This would explain how it is that some trees seem to grow out of bare rock and derive their nourishment from the small portions of soil accumulated in the crevices.

** Risler comes to the general conclusion that the final loss from evaporation is less in a forest than in pasturage, and does not exceed 0.04 inch a day in a fir forest with moist soil and plenty of sunlight.

liberated again by combustion. (c) The maintenance of a mantle of vapour which acts, as Tyndall first pointed out, as a screen. (d) The cooling due to evaporation, great in summer but small in winter.

The increase and regulation of rainfall is due to the reduction of temperature and increase of humidity over a large area. According to Abercromby, clouds will form over rivers and forests when failing to form over the open plains, and at a more intense stage there may be "cloud everywhere and rain only over the rivers and forests."

Thunderstorms, which are of such frequent occurrence in Natal, appear to be caused by great uprushes of vapour resulting from large differences of temperature in adjoining masses of air, and there are indications that forests, by regulating temperature and humidity, serve to moderate their violence. Abercromby (Weather p. 289) gives a chart of the distribution of hailstorms in the department of the Loiret, in France, during the thirty years, 1836-65, from which it is seen that the villages outside the forest area suffer severely, "while those inside the forest enjoy almost complete immunity from destructive hailstorms." Abercromby says also that "the forest seems to act, in fact, as a breakwater against which the violence of the storms expends itself for a time until it can gather fresh force. . . . The wind circulation of thunderstorms is always confined to the low strata of the atmosphere only. . . . When the lower clouds meet such an obstacle as a forest, or even a mountain, eddies are formed. The masses of cloud come back on themselves, and seem to be repelled and dispersed by the forest. When the clouds have succeeded in passing the obstacle, their force is exhausted, and they only precipitate rare or inoffensive hail, and do not regain their intensity for some time afterwards."

Having now discussed the various physical effects of forests, we may see that vegetation in general—of which forests are the most intensified form—constitutes the natural protection of the earth from meteorological influences, and it is evident that climatic effects of some moment must result from extensive denudation; the temperature will increase, and the extremes of cold and heat become more divergent; the aridity becomes greater and the rainfall, and especially the water supply, more irregular; floods occur, and torrential action tends to regain full scope. In this manner, portions of Western Asia, North Africa and South Europe, which were once populous and fertile, have become waste and arid. More recently, and nearer Natal, the destruction of forests had such marked effects on the climate and salubrity of Mauritius that it was judged necessary to reforest extensively in order to restore the island to its former condition*; while at Zanzibar, as I was told by Sir John Kirk, extensive denudation has been

*A Report by Dr. H. Rogers "On the Effects of the cutting down of the Forests on the Climate and Health of Mauritius," issued in 1871, and a paper read by Dr. R. Meldrum before the Scottish Meteorological Society in July, 1866, supply interesting details. Meldrum estimates that 70,000 acres, or one-sixth of the area of the island, were denuded of timber during the 10 years 1852-62.

followed by a much diminished rainfall and a greater aridity. It is probable that the increasing aridity of South Africa is due to the same cause (*).

ECONOMIC UTILITY OF FORESTS.—SUPPLY OF TIMBER.

It is often assumed that the forests of the globe are of such vast extent that we have no need to fear any diminution in the supply of timber for many a year, and that a *laissez faire* attitude would be attended by evil results of no great magnitude. But there is reason to fear that such a view is fallacious. The forests of civilized countries, which are alone sufficiently accessible to provide cheap timber for exportation, have nearly all suffered a very considerable decrease within historical or even recent times, and it would appear that the continually increasing demand for timber can only be met by a continually increasing rate of destruction. It has been proved beyond doubt that some two thousand years ago Europe was densely clothed with forests, the proportion of which has now decreased to a quarter of the land surface. Marsh shows that in both Northern and Southern Europe there are many names of places etymologically indicative of woods which no longer exist. According to Chalmers there are, on the maps of Scotland, a thousand names of places derived from forests which have since disappeared. Roman writers tell us of the great Hyrcinian forest which in Cæsar's time covered the greater part of Central Europe, and was computed to be sixty days' journey long and nine broad. Gaul was then almost continuously wooded; in 1750, Mirabeau estimated the woodlands of France at seventeen million hectares; in 1860 they were reduced to eight million. Even so late as the eleventh century Adam of Bremen writes of Denmark, which is now almost treeless, as *horrida sylvis*. Asia Minor, Greece, Spain, Italy, the Canary Islands, possessed once magnificent forests, of which there remain nothing more than a few rare vestiges. At present, most of the forests of Europe are subjected to sound systematic treatment, but there is evidence to show that the destruction of forest in Russia and some of the other Continental countries still proceeds at no inconsiderable rate. Many of the forests cannot be protected by the State, because they are private property. This explains why, in France, the extent of woodland, which reached 22,687,710 acres in 1874, is reduced to 20,740,914 acres in 1882**. In Russia, the forests which covered 527,426,510 acres in 1872 were reduced to 425,564,842 in 1881**, a decrease of 20 per cent. in nine years.

In the United States, the forests, estimated to have covered, two centuries ago, 95 per cent. of the whole area, now barely cover 25 per cent. Their destruction is still very rapid. Forest fires destroy on an average over ten million acres a year. In the Census

* *Vide J. C. Brown's Hydrology of South Africa, and Water Supply of South Africa.*

** *Agricultural Returns, 1888.*

year 1880, the number of fires returned was 2,983, and they burned over 10,274,089 acres of forest.*

Interesting figures have been recorded for New Zealand. Dr. Hector estimates that the forests, which covered 20,370,000 acres in 1830 had become reduced to 15,296,000 acres in 1860, and to 12,131,000 acres in 1873. With regard to other British Colonies, the returns published by the Colonial Office in 1878 show that out of thirty-eight Colonies there were only four in which the forests were not stated to be decreasing. In most cases, as in Canada, the timbered area was reported to be diminishing rapidly.

The following statistics, embracing the available information to date, may prove of interest in connection with the subject of timber supply :—

	Total Area in Acres.	Wooded Area in Acres.	Remarks.
Russia	1,244,367,351*	425,564,842 (a)	in 1881
Norway	76,716,965*	19,167,200 (a)	in 1875
Sweden	100,298,502†	44,850,550 (a)	in 1886
Austria	69,596,034†	24,150,213 (a)	in 1887
Hungary	83,205,120†	22,514,450 (a)	in 1879
Germany	133,441,960‡	34,353,743 (a)	in 1883
Turkey	88,684,800	3,506,000 (d)	...
Spain	125,584,400	7,526,400 (c)	...
France	130,557,281‡	20,740,914 (a)	in 1882
Italy	70,787,236§	10,266,310 (a)	av. '73-83
Great Britain	56,786,199‡	2,560,700 (b)	in 1888
Switzerland	10,231,537	1,790,518 (c)	...
Greece	12,380,411	1,733,504 (c)	...
Portugal	22,926,273	1,146,312 (c)	...
Belgium	7,275,916‡	1,208,875 (a)	in 1880
Holland	7,827,442†	560,512 (a)	in 1886
Denmark	9,347,443†	507,016 (a)	in 1881

The total area of Europe is about 3,800,000 square miles, and forests cover nearly one-fifth of the land surface.

**Tenth Census of the United States*, Vol IX., p. 491. It is considered that the estimate is too low as "many towns, and even counties in which forest fires are known to have occurred in the year 1880, made no return whatever, and the returns of other counties were excluded," and it "at least does not exaggerate the annual loss inflicted upon the country by forest fires." The causes of the fires are classified thus :

Improving pasturage	197	Coal pits	9
Clearing land	1,152	Lightning	32
Locomotives	508	Indians	56
Hunters	628	Prospectors	10
Camp fires	72	Travellers	2
Smokers	35	Spontaneous combustion	2
Malice	262	Woodcutters	3
Prairie fires	12	Carelessness	3

* Exclusive of lakes.

† Exclusive of lakes and rivers.

‡ Including lakes and rivers.

§ Including lakes.

(a) *Statistical Abstract for Foreign Countries*, 1889.

(b) *Agricultural Returns*, 1888.

(c) *Encycl. Brit.*, 9th edition.

(d) *Report, Supt. Cape Forests*, 1882.

Asia covers 1,700,000 square miles. The extent of the forests is not definitely known, but may be estimated at between one-fourth and one-fifth of the total area. The following figures give the wooded area in some of the countries :—

	Total Area.	Wooded Area.
Siberia ...	4,824,570 square miles	2,800,000 square miles (a)
British India ...	868,314 „	46,213 „ (b)
Asia Minor ...	196,000 „	10,860 „ (c)
Cochinchina ...	21,600 „	3,075 „ (c)

North America has a total area of 7,400,000 square miles, and the forests, covering about one-sixth of the surface, are distributed as follows :—

	Total Area.	Wooded Area.
United States	3,501,400 square miles (d)	875,000 square miles (e)
Canada—		
Nova Scotia	21,731 „	14,000 „ (f)
Ontario and Quebec	337,955 „	145,200 „ (f)
New Brunswick	27,322 „	9,400 „ (f)
Prince Edward's Isl.	2,133 „	272 „ (f)
British Columbia		
and Vancouver	390,344 „	171,900 „ (f)
Newfoundland	42,000 „	726 „ (f)

The area of South America is about 6,500,000 square miles. Brazil being very densely wooded, the proportion of forest may reach between one-half and one-third of the total area.

In Australasia, with a total area of over 3,000,000 square miles, the proportion of forests is not known, except in the following cases :

	Total Area.	Wooded Area.
New South Wales	311,000 square miles	129,200 square miles (g)
South Australia	903,690 „	3,100 „ (g)
Victoria	88,198 „	40,000 „ (g)
Tasmania	26,215 „	13,000 „ (g)
New Zealand	105,000 „	19,000 „ (g)

(a) Rough estimate from data by Prince Kropotkin in *Encycl. Brit.*, 9th edition.

(b) In 1883. Composed of 29,371 sq. miles of first class reserves, and 16,842 sq. miles of second class reserves. Eventually, a portion of the latter will be given up for cultivation, and the remainder added to the first-class reserves.

(c) Report, Supt. Cape Forests, 1882.

(d) Exclusive of lakes and rivers; including Alaska.

(e) According to Dr. Brown in *The Forester*. The total area is not given in the Report on the United States forests by Professor Sargent, which is the standard source of information on North American forests, but it seems that Dr. Brown's estimate is too high.

(f) Command Paper, C 2,197, of 1878.

(g) Command Paper, C 2,197, of 1878.

In Africa, with a total area of nearly 10,000,000 square miles, the proportion covered by forests is not known, excepting in the following cases :—

	Total Area.	Wooded Area.	
Algeria	258,300 square miles	8,250 square miles	(a)
Tunis	45,700 "	1,125 "	(b)
Cape Colony	221,310 "	550 "	(c)
Natal	17,800 "	220 "	(d)

Though the forests of the World possibly cover between one-fourth and one-fifth of the total land surface, it would be wrong to expect that if those of North America and the Baltic, which supply half the world with lumber, should become exhausted, other forest regions will be opened up as the demand progresses, and that the present low prices would be thus maintained. Few other countries besides Canada, the United States, Russia, and Scandinavia afford the same unrivalled facilities for water carriage and cheap working. The expense of land carriage from the great Siberian forest will remain prohibitive, while the Brazilian and Central African forests could only yield a large supply of hard woods, which cannot be worked and brought to markets at the price of soft woods. In Europe, large timber is indeed getting more scarce year by year, and had it not been for the extended use of iron for many purposes, the deficiency would already have been felt keenly. As it is, timber is now required to be cut in localities more and more remote, or more difficult of access ; and the expense of bringing it down to markets is steadily increasing and must soon affect the prizes. And in consequence of the fact that timber does pay to grow in those countries whence we derive our supply, considerations of self-interest will eventually prevent the retention by them of forests larger than will serve to meet their home requirements. There seems no escape from the conclusion that timber must needs become scarcer and dearer. Whether the forests are conserved or allowed to be destroyed, the result is the same : a reduction of the present rate of supply. This would have possibly happened already, were it not that the greater portion of the forests of North America and the Baltic are in private hands, that the temptation to realise a capital which does not pay the lowest current rate of interest is irresistible to individual owners, and that State interference would be resented owing to the magnitude of the interests at stake. But all this points to one conclusion, which is that timber-growing will become more and more profitable, and that it behoves us to take this consideration into account. Many industries would be fostered by cheap and plentiful timber, a possible interruption of extra colonial supplies would not affect us, and the greater part of some £180,000 now being paid out of Natal every year for timber and woodenware of all kinds would be retained in the country ; and this without detriment to any branch of productive activity.

(a) Report, Supt. Cape Forests, 1882.

(b) Encycl. Brit., 9th edition.

(c) Including Transkei.

(d) Excluding thorn and coast forest, which cover 2,700 square miles.

PROTECTION OF THE FORESTS.

The limited extent of the Natal forests makes it all the more necessary to protect them ; we have so little wood that we cannot afford to waste any. So that one of the primary aims of a well-considered scheme of forestry must be the conservation of the forests, especially the timber forests, which are the most valuable both from an economic and a climatic point of view. It is now recognised that State intervention has to be resorted to for the purpose. The work of forestry is of such a protracted nature, requiring to be carried uniformly from generation to generation to ensure the best results, that it falls within the province of the State, which alone is fitted to undertake it on a large scale. Forests should be looked upon as a trust which the Government holds for the general benefit. They have, as Tassy points out, a character of collective utility, not only in regulating the influence of the atmosphere upon the soil, but also as a source of material products ; and owing to the great disproportion between their utility and money value, the interest of an individual owner to preserve them is much less than the general interest. Experience teaches that individuals cannot be depended upon to maintain the forests of a country and keep up the supply of timber, and that the alienation of forests means their ruin sooner or later, if not their entire disappearance.

Some of the European countries have been engaged for a century or more in the work of reclaiming forest estates, which they had blindly allowed to be frittered away. In some cases, it has been at first a tedious work ; but out here we have, at any rate, the advantage of being able to profit by the experience that has been already gained, often at no small cost. The broad principles of forestry, based as they are on natural laws, remain the same all the world over, and do not require much modification to be adapted to special needs. And besides, during the last few years, the introduction of systematic treatment in the forests of the Cape Colony, which resemble ours in many respects, has been productive of lessons which may help to smooth away some of the difficulties that would otherwise have been encountered here at the start.

The conservation of forests is not the only object of forestry, and it is not attained, as some would suppose, by reducing the supply of timber. On the contrary, the yield of systematically managed forests is increased notably, and the largest possible regular supply of timber is derived after a few years. The work of forestry may be said to combine (a) conservation of existing forests ; (b) their most profitable management ; (c) the creation and management of artificial forests. The chief aim is to steadily improve the conditions of each forest, and to never cut more than the annual production, by natural or artificial means, will justify. Sir Dietrich Brandis, late Inspector General of Forests to the Government of India, gives in a few words a summary of the requisite work :
 “ Forest management which aims at these objects requires the following measures as

essential conditions of success : First, effective protection ; second, a good system to secure the regeneration of forests either naturally by self-sown seedlings or coppice shoots, or artificially by planting, sowing, or other cultural operations ; third, good lines of communication to facilitate protection, the working of the forest and the export of produce ; and fourth, well considered and methodically arranged plans of working."

SURVEY AND DEMARKATION OF THE CROWN FORESTS.

Before the protection and management of forests can be undertaken, it is necessary to survey and demarkate the forest lands that are to be reserved. Protection can only be rendered effective after a good forest boundary has been established and disputes or rights of usage settled. A sharp distinction is wanted between waste Crown land, or private or Trust property, and land that is subject to a forest *régime*. For purposes of management, a knowledge of the extent, figure, situation, and condition of the forests is essential, and it is best gained by surveys based on the demarkation work. It has been shown again and again that very little good is done in managing the forests of a new country until their demarkation is taken in hand. In the same way that farms have to be laid off for agriculture, forest reserves are required to be demarkated for forest work. These reserves should be made to include, as far as circumstances will permit of—

1. Land covered with forest.
2. Land required for protecting and working the forests.
3. Belts of land, along hill ranges, on which forests are needed to protect the soil against erosion and to control the flow of water, or on which it is required to regulate the grazing for the same reasons.
4. Sanddrifts where their spread may become injurious.
5. Land required for reforestation.

Land reserved under the second head may be required for the following purposes (a) the depasturing of cattle employed in transporting or in hauling timber, (b) to provide easy access or retain a right of way to the several portions of the forest, (c) the location of saw mills, (d) the protection of the forest from fires by making it possible to burn a fire belt all round, and to rectify irregular boundaries, which expose a long vulnerable line to fires and winds, (e) to facilitate supervision and prevent encroachments or depredations. Bare mountain slopes overlooking forests should also be reserved under this category. Generally, it is evident that if forests are allowed to become hemmed in by private farms, the possibility of working them will have to depend upon the goodwill of the surrounding proprietors, who would be in a position to use the produce for their own benefit, to the exclusion of the Government and the public.

The third category would consist of land (a) in a zone along the crests of hills, (b) on steep slopes, say of 1 in 1 and over, (c) on which streams take their rise,

(d) forming torrent basins or the banks of ravines. It might often be possible to make this land serve for the protection and the working of the forests, as well as for protecting the soil.

The forest land classed in the first three categories, will principally be found distributed in a belt along hill ranges so that an imaginary line may be drawn, taking in all the ground that should have been kept to provide a suitable zone of protection. When contending with private rights and encroachments, the notion of the line will afford great help in deciding what lands to reserve. All the land required in connection with forests will usually be taken inside the line. In the portions that are found to be squatted upon, the cultivation will probably be nomadic and of little value, and illegal as well ; so that it may be summarily stopped after the standing crop is reaped, or else ground below given in exchange. To meet cases in which it is found imperative to include private lands in Forest Reserves, the provisions of Law No. 16, 1872, "for authorizing the taking of Lands for undertakings of a Public Nature," should be made applicable to Forest lands.

This reservation of Crown Lands in the forest belt need not be detrimental to agriculture. The mountain regions that would be affected by the measure are not suitable for anything else than grazing, and by allowing grazing within certain limits, and at a moderate charge, it is possible to give to stock farmers almost every advantage that they would have derived from the purchase of the lands. Besides, the total area to be reserved would only form a fraction of the extent of the Crown land that still remains unsold.

To save time and expense, survey, demarkation, and settlement should be combined in one operation ; and in order to ensure efficiency and unity of method, a single surveying party should undertake the whole of the work, proceeding uninterruptedly with it till its completion.

The degree of accuracy and detail required in the surveys and the demarkation will naturally depend on the importance of the forest. In low forest, it will be sufficient to place corner beacons and survey the boundary of the reserve. For timber forests, topographical surveys are required, and the boundary of the reserve should be laid out distinctly on the ground, by means of line beacons placed on the top of the ridges intersected by the boundary line, or on other prominent points, but seldom more than two or three hundred feet apart. The beacons should preferably be built of stone ; but where stones are not procurable, posts of wood, or mounds of earth, or interrupted trenches may serve instead. The corner beacons should be "not less than three feet in diameter at the base and three feet in height, and constructed of stone" to meet the requirements of Law No. 39 of 1888. When the boundary line passes through forest, it should be cleared broad enough to remain conspicuous for many years.

The survey of the forest area may be conducted in the following manner: A secondary triangulation, with stations 4 to 6 miles apart, is based on the nearest sides of the chain of triangles of Major Morris' survey. The topographical points and the boundary beacons of each reserve are then connected with the secondary triangulation. Finally, the topography is filled in by plane tabling or some other suitable method. There is a purely graphical, and on that account, a very expeditious, special method of topographical surveying which, as it is accurate enough in hilly ground, may be used with advantage for forest work in Natal. The boundary line of each reserve should be surveyed as it is run along, in order to give additional data for the topography. A convenient instrument to use for the purpose consists of a transit theodolite fitted with stadia wires, or a vertical micrometer, by means of which distances may be measured without chaining.

The position of the different points in forest surveys should be specified by means of rectangular co-ordinates, taking a near trigonometrical station as origin, and the meridian and a perpendicular to it as axes. Co-ordinate surveying is compulsory at the Cape, and the advantages of the method are too well known to require notice.

The principal features that should be laid down on forest maps are the following—(a) the boundary line of each reserve, (b) the wooded perimeter, (c) the configuration of the ground, shown by shading or by sketched contours, (d) the watercourses and ridgelines, (e) roads, fences, and buildings. The scale will vary according to the importance of the forest and the proposed mode of exploitation. For working plans of forests that are required to be sectioned, a scale of 8 inches to the mile will be found convenient. For those of forests that can only be worked irregularly, a scale of 4 inches to the mile will be generally sufficient; and for general plans 2 inches to the mile is a suitable scale.

Owing to the scattered distribution of the Natal forests, their survey will often involve that of a large tract of country, but the expense could be materially reduced by combining, in forest districts, such surveys with the secondary triangulation of the Colony which is now carried, and by apportioning the cost between each work. If the surveys are carried independently, the same ground will have to be traversed twice, and the cost will increase in proportion. In the forest districts, nearly all the stations of the secondary triangulation would have to be visited again with instruments; and thus the cost of the one survey would not be much less than the cost of both, if carried together.

CONSTITUTION OF FOREST RESERVES.—The course followed at the Cape in establishing Forest Reserves is adaptable to Natal. After three months' publication of a notice declaring the situation and the boundaries adopted, each demarkated area is proclaimed a Forest Reserve, unless the declaration is restrained by a judicial order.

The sections of the Cape Forest Act of 1888, which regulate the procedure are the following :—

- “4. Prior to the publication hereafter in the *Gazette* of any notice declaring an area to be a demarcated forest, copies of a plan of such forest and of the report of the person employed to carry out the demarcation, shall be deposited for public inspection in the office of the Civil Commissioner of the Division in which the forest is situated, and the Commissioner shall cause notice to be given once a month for a period of three months in the *Gazette*, and in some newspaper circulating in the Division of the intention to publish the said notice of declaration of demarcation.
- “5. In case no court of competent jurisdiction shall during a period of three months in the last Section mentioned, make on the application of any person interested any order restraining such declaration, or in case of such restraint, if such court shall within a period to be fixed by such order of restraint, decide against the objector or alter the limits of demarcation, the said notice of declaration fixing the limits of demarcation as originally fixed or as altered, as the case may be, shall be published, and thereupon the area to be so limited shall become a demarcated forest.”

Sections 3 to 17 of the Madras Forest Act, of 1882, deal at greater length with the reservation of forests, but the provisions in this respect are essentially similar to the preceding.

Where they exist, prescriptive rights or servitudes should be bought up, or commuted by a division of the land ; for otherwise, as it has been found in India and at the Cape, as well as in European countries, they would interfere seriously with the management, and especially the protection of the forests. This happens chiefly when the rights are exercised in respect to grazing or to the cutting of small timber and firewood. The working of mature timber can be regulated so as to save the forest from deterioration, but the destruction of the re-growth, which cannot be checked so easily, speedily consigns it to ruin. The demarkating officer should be empowered to effect any convenient settlement of such rights as may exist, subject to executive sanction. In some cases an amicable arrangement may not be arrived at, and to meet this contingency the Forest Law should provide for the redemption of servitudes, by making it lawful for the Crown to demand the division by arbitration of any Crown forest subject to servitudes or joint ownership.

I should recommend the closure of the timber forests pending the establishment of reserves. The work of demarkation would claim the undivided attention of a forest department during the first year of its existence, and besides it is best not to decide upon the treatment to be adopted in each forest before it is surveyed. Some of the forests

require to remain closed for a number of years in order to establish a re-growth, while others should be cleared of a surplus of mature timber which they contain, either by felling in sections or irregularly over the whole area, according to local circumstances. The distribution of foresters is also affected by the mode of working, and had better remain in abeyance for a time. It would cause no real inconvenience to close the forests. At present there is very little wood sold from the Crown forests, and no wood trade to speak of; the principal kinds of timber are not allowed to be cut, and from January, 1883, to May, 1888, the issue of licenses was entirely suspended without any serious injury of private interests following.

A difficulty met in connection with the reservation of forests arises from the persistent way in which some land surveyors alienate forest contrarily to their instructions. They may sometimes be incapable of deciding what lands to reserve, but more frequently they are disposed to enhance the value of the farms which they lay out by including forest. This tendency has resulted both here and at the Cape in a more than trifling diminution of forests, and it does not seem easy to repress; but surveyors should be made to realise that forest property does not differ essentially from any other, and that its unlawful disposal is an offence that requires to be dealt with severely. A strict enforcement of the instructions prohibiting the survey of forest lands could not be looked upon as a hardship, for it would only serve to do away with the preference which applicants for land may now give to those surveyors whose notions of forest are the most lax. Still, on the whole, it is not advisable to place too much reliance on the capacity of surveyors in this respect, and a preferable course would be to dispose of as little Crown land as possible, pending the constitution of forest reserves.

Most of the forests in the Division of Newcastle are situated on leased lands; and to establish Forest Reserves, it will be necessary to give to the lessees a year's notice that it is intended to alter the boundaries of their leases. Where grass lands are included in the reserves, the grazing may be leased from year to year, whenever it is not required for working the forest, and the revenue now derived from land leases could be maintained from grazing leases; at present the lands are used only for pasturage, so that the change would simply be one of tenure.

In Native locations, the principal forests could be thrown into reserves managed for the benefit of the Native Trust, and the remainder classed as undemarkated forest. An exception should be made in the case of some of the forests on Location No. 1, Upper Umkomanzi, in which the principal Crown forests have been so badly cut off that a satisfactory reserve cannot be formed without infringing on the location land. I should recommend, as a way out of the difficulty, that an equitable exchange be arranged of some of the Crown land adjoining the location for some of the location land. It could be done without inconvenience to the Natives, who are not settled near the forests; and

if the Native Trust can agree to an arrangement of this kind, the Government would obtain a block of forest sufficiently large to warrant the working of timber on a large scale and the construction of roads for its removal. This would give employment to the Natives and prove of benefit to the district generally.

When the forests have been demarkated, the next step is to secure their effectual protection. Many causes of destruction have to be guarded against ; chiefly fires, cattle, depredations, and abusive cuttings.

PROTECTION FROM FIRE.

Forest fires seldom originate inside a forest. In the majority of cases they are due to grass burning outside. When the grass is rank and dry and the wind violent, the fire is driven into the trees near the edge and the forest may become ignited. In other cases, the forest is burnt purposely by Natives, in order to drive out game or to clear land for cultivation. Those fires that originate inside a forest are also usually kindled by Natives, either wantonly, as by hunting parties, or to clear glades where cultivation may be carried without the help of fencing, or to fell trees for firewood. A favourite Native method of felling trees consists in kindling a fire round the roots, which is allowed to smoulder till the tree comes down. However, fires lighted within a forest are seldom so dangerous as those lighted outside, owing to the greater calmness of the air inside, and to the want of grass sufficiently rank to burn in a blaze reaching the crowns of high trees.

It is only during the winter months that grass fires spread to the forests. When the wind is favourable and the ground moist, as it generally is towards the end of summer, the grass may be burnt with impunity if proper precautions are taken.

In order to minimise the destruction of forests by fires, a protective belt should be burnt round each forest, in April or May, as soon as the grass becomes readily inflammable. Native cultivation should be absolutely prohibited, and Native hunting parties should not be allowed in demarkated forests. Where the forests are worked, no tree should be allowed to be felled within forty yards of the edge, so as to prevent the formation of gaps, and avoid accumulations of dry crowns and rubbish which would form vulnerable points along the edge, through which the fires might enter the forest and reach worked portions full of dry wood, with disastrous consequences. A clean boundary is characteristic of an evergreen forest, and in Natal there is a sharp transition from the grass land to the forest. It is important that this boundary should be preserved unbroken. If it is broken, the brushwood and dry trees of the burnt portions burn more fiercely the next season, and scorch another broader belt ; and so on, till the forest edge is driven to shady kloofs and steep south slopes, naturally too damp to allow of the spread of fire. Fires have in this manner caused a large diminution of the forests of South Africa. The disastrous conflagration which extended, in 1869, from George to Humansdorp at the Cape, or that which destroyed, a few months back, the once magnificent Katberg

forest, show that the destruction of a large proportion of the former South African forests may be due to this cause, provided that the burning has been carried during a sufficiently long period of time. All trace of a forest would become quite obliterated in half a century or less, and the ground as strong and barren as the adjoining veldt. The practice of grass-burning has been carried on for centuries by the pastoral Natives of Natal : in 1495, grass-fires were already so prevalent in Natal that Vasco de Gama gave it the name of *Terra de fume*. We are beginning to reap the fruits of this continual burning. The aridity that is settling over South Africa need not be ascribed to any other cause ; and, as I have pointed out, the consequent erosion of the ground is becoming a conspicuous feature of South African scenery.

Belts of deciduous trees have been found of service in India and in France to arrest the spread of forest fires, as might be tried experimentally as a border to some of our forests. The kinds preconised are Oaks and Poplars ; but Wattles, which destroy the grass under, may prove equally serviceable in Natal.

PROTECTION FROM CATTLE.

The exclusion of cattle is a necessary condition in the management of demarkated forests. Cattle, especially goats and sheep, nibble the seedlings and young trees, and it is only thorny or inaccessible portions that are proof against their attacks. The destruction of forests abandoned to indiscriminate sheep or goat grazing is certain and merely a question of time. When the old trees perish the forest ceases to exist if the seedlings have been destroyed as they sprang up and there is no young growth to replace the old timber. Though it may at first appear difficult to believe that the forests can be thus destroyed over large areas, examples have been recorded from all parts of the world (*), and whenever forest conservation is aimed at, special measures are adopted against destruction by cattle. Oxen are not so destructive as goats or sheep, and under certain conditions a limited number may be allowed to graze inside a demarkated forest. They are useful in keeping the grass down, and thereby lessening the risk of forest fires. When the grass is plentiful, oxen seldom browse the young plants ; this consideration should be taken into account in determining the pasturage allowable in demarkated forests. But even oxen cannot be allowed in the sections of the forest where regeneration is taking place, and pasturage is thus inadmissible in a forest, worked by the method of *jardinage*, where trees of all ages grow side by side. Pigs are supposed to be rather useful than otherwise. Game would be injurious when too plentiful, but this is seldom the case. The exclusion of cattle cannot be satisfactorily effected except by natural or artificial barriers.

* The forests of the High Alps have been destroyed by the pasturing of flocks, and many other European forests have suffered severely from the same cause. Prof. Sargent (*Tenth Census, U.S.*, vol. ix, p. 579) reports that cattle are threatening the destruction of the mountain forests of California. Mr. A. F. Mummery (*Nature*, March 28, 1889), gives cases of large forests on the Caucasus destroyed by cattle. Darwin (*Journal of a Naturalist*, p. 584), shows how the forests of St. Helena disappeared in consequence of the introduction of goats, and adduces a similar instance for the island of Juan Fernandez. Darwin also gives (*Origin of Species*, p. 56), an instructive account of the searching manner in which cattle destroy and keep down young forest growth.

In the vicinity of roads and other exposed places, fences, or ditches, or stone walls, are useful. In the Eastern Province of the Cape, the fencing of the forests is being undertaken on a large scale. Wire fences, with sneezewood posts are used; the cost averaging only £25 a mile.

DESTRUCTION BY NATIVES.

Natives alone have perhaps been as destructive to the forests as fires and cattle put together. They have industriously cut out nearly all the young trees from the majority of the Natal forests for wattles—of which they use an immense number—for poles, for kraalwood, or for firewood. I find that fully a thousand wattles are required on an average for the construction of each hut. Taking the number of huts in Natal at 91,789,* and the life of each to average thirty years, it may be computed that over three million sticks, mostly young trees, are destroyed annually for the purpose of providing wattles. The young timber trees are taken first, because they grow straight and make the best wattles. Large quantities of small timber are also cut surreptitiously by the Natives for making cattle kraals, which need to be renewed every few years, and as firewood, for which large trees are considered unsuitable owing to the greater amount of labour that would be requisite. The result is that most forests are now absolutely denuded of young growth—this constitutes, in fact, the most striking characteristic of a Natal forest. I have wandered in some for half an hour or more before I could find a young plant, of any useful timber species, capable of taking the place of the standing trees. With sawyers cutting the large timber, natives cutting the young trees, and cattle destroying the rest of the vegetation, it is not surprising that the forests in which work has been carried on should have failed to recover, and become “cut out” and converted into a tangle of inferior trees and thorny scrub, except in the less accessible kloofs and krantzies. The life of any forest in which the young trees are destroyed as they spring up is necessarily limited to the life of the full-grown timber, and it may be shortened at any time by a wholesale destruction of old trees either for timber or from natural causes, such as unusual droughts or storms, or the spread of an insect enemy.

It is thus indispensable that wattle-cutting should cease in demarkated forests, but how to achieve this result in a satisfactory manner, is a problem not without difficulty. Primitive races like the Kafirs are slaves to ancestral custom, to even a greater degree than civilized men, and it would be idle to expect that mere legislative enactments would suffice to alter their habits and induce them to build huts of stone or sod.

The simplest way of meeting this difficulty will be to provide wattles, from other sources than Crown forests, by establishing small plantations of Australian wattles at each forest station. *Acacia decurrens*, var. *dealbata* is the best wattle for the purpose. This variety is hardier and a better coppicer than var. *mollissima*; it can be grown easily.

* Report of the Natal Native Commission, 1881-82, p. 40.

thrives almost anywhere, and reproduces itself as freely as could be desired. It would be part of the duty of each forest guard to make and maintain one of these plantations, so that the outlay would be moderate, and I am convinced that plantations of an area sufficient to provide a supply of wattles equal to that at present obtained from the Crown forests would, if properly managed, not only be self-supporting, but also pay handsomely, and contribute a not inconsiderable sum towards the cost of forest protection. Each acre planted could be cut over every two years and would yield wattles enough for eight huts, every year; this should give a money return exceeding largely the cost of cultivation and of maintenance.

Bamboo might also be tried for hut building. In South Asia, it is the staple material for the purpose. Some species grow with marvellous rapidity and may prove more generally useful than the Australian wattles, if the Natives can be induced to use them; but at first they should be tried only experimentally. Kurr enumerates among other Asiatic bamboos used for building purposes: *Bambusa vulgaris*, Wendl. *B. Balcooa*, Roxb., *B. Tulda*, Roxb., *B. arundinacea*, Roxb., *Gigantochloa aspera*, Kurz, *G. atter*, Kurz, *G. maxima*, Kurz, and *Dendrocalamus Hamiltoni*, Nees. *D. Strictus*, Nees, is another useful species. There is a Natal species *Arundinaria tessellata*, Munro, the Berg bamboo, which ascends to 6,500 feet, and might be tried for culture at high elevations.

Special facilities, such as the distribution of seed at a nominal cost, could be given to those natives who may wish to grow wattles themselves, but it is not to be expected that this course, alone, would prove sufficient, at any rate for a long time to come.

Some of the trees in the wattle plantations would be reserved to bear seed, and a supply of timber suitable for poles and kraalwood would be obtainable in a few years; but in many places natives might build their cattle kraals of stone, and dispense with kraalwood altogether.

The cutting of wattles will have to be continued in both demarkated and undemarkated forests till a sufficient supply is derivable from the forest stations, but it should be regulated and limited to species not reserved as timber trees.

Natives should not be allowed to cut firewood in a demarkated forest without a license, and the issue of licenses should be dependent upon the supply of Thorn and sugar bush in the vicinity. They may be permitted to remove dry wood that can be got without cutting, but they should not be allowed to take an axe into the forest except with special permission. At present, they are in the habit of felling for firewood any convenient tree, whether it may be useful for timber or not. The tree is left in the forest till it has become dry, and it is then cut up and removed. Where the forests are worked there is no difficulty about firewood, as the dry crowns and wastewood provide an abundant supply.

Another potent cause of destruction that will have to be checked consists in the native practice of forest cultivation. The forest soil is naturally rich and mellow, and for ages, the Natives have been accustomed to make their mealie gardens by clearing a portion of forest and planting it with crops. In a few years the land became exhausted, and a fresh piece of forest was cleared. Recently, however, the forests on the plains having nearly disappeared from this and other causes, some of the mealie gardens had to be made elsewhere; but most of the forests may still be seen fringed with mealie gardens, which fasten parasitically upon them and eat away into the boundary from every side, till there are only a few patches left on ground too steep or stony for cultivation.

This rude system of cultivation is the commonest among primitive races, and still prevails in many parts of the world. It is as ancient as it is general, and probably was the earliest mode of agriculture practised by man, being the easiest to races wanting implements, such as are used in the agriculture of the present day.

One of the advantages of a demarkated forest is that it opposes a fixed front to encroachments of this kind; whereas the forest edge itself becomes of too fleeting a nature if it is adopted as the protective line. Inside the demarkated line, no cultivation should be allowed except by special permission; and when the forest is demarkated, notice to quit should be given, in terms of Section 4 of the Squatter's Rent Law of 1884, to the squatters found inside of the line adopted.

LEGISLATIVE MEASURES NECESSARY.

A Law should be passed to provide for the better protection of forests. Many forest offences cannot be dealt with adequately under Common Law, and the want of special legislation would be seriously felt. At present, the only enactments that relate to the Natal forests are various Proclamations issued under Ordinance No. 4, 1853, namely, those dated 24th September, 1853, 1st March, 1867, and 26th September, 1882. The preservation of forests has not been, and cannot be enforced with their aid. They are meagre and unsatisfactory in the extreme, deal with certain offences, omit others equally serious, and contain no provision to meet a single essential condition of forest management. They have been worse than useless, because they have been allowed to remain a dead letter, while legalising many ruinous practices, by omission, if not by commission. Considering the rapid rate of destruction of the forests, and the almost total absence of convictions for forest offences, it must be conceded that the various measures that have been taken in the past have not been successful, and are not suitable to present circumstances. Past attempts to protect forests have failed because of the want of proper laws and of proper supervision. Stringent laws are required for forest protection. In India, the first legislation was too lax and did not succeed; the forest laws had to be strengthened from time to time, till the Madras Act of 1882 was passed and found effective. The Cape Forest Act of 1888, based on the Madras Act, is proving very useful and marks an

important advance in the forestry of South Africa. Forest laws may be thought irksome at first, but they are none the less necessary if forests are to be preserved. The following are the chief points that would have to be dealt with in a Forest Law for Natal.

FOREST TENURE AND DEMARKATION.—A distinction requires to be drawn between demarkated and undemarkated forest ; the first includes areas that have been surveyed or beacons off and proclaimed in the *Gazette* ; the second includes Commonages or Native Locations, or any vacant Crown land on which trees are growing, or land on which the Crown retains a right to the timber. Demarkated forests are intended to be strictly conserved ; undemarkated forests to be protected as circumstances may dictate. The course to be followed in establishing forest reserves should be indicated in the Law. It may be similar to that adopted at the Cape, of which I have already given details.

Demarkated forest should be declared inalienable. This is a provision, adopted in most countries, which would effectually prevent encroachments and render invalid any of the slicing which surveyors affect. The State, being the best forest proprietor, would assure by this means the future of the forests, and serve the best interests of the country. There should be clauses to free both demarkated and undemarkated forest from the accruing of any future rights or servitudes, and to bar prescription. The want of such provisions makes it possible for people to systematically plunder the forest during thirty years, and then set up prescription or claims which it is not possible to disprove. At the Knysna, a large tract of country containing over 5,000 acres of forest was lost in 1886 through prescription. It is manifestly unfair to apply to Crown lands which cannot be looked after closely, the principle of prescription, however judicious it may be for private property, and in the same way servitudes and rights should not apply.

Servitudes and rights being incompatible with the proper management of a forest, there should also be a clause to provide for the extinction of such rights or servitudes by arbitration, and to empower the Government, in other cases, to make rules to provide for the manner in which such rights shall be exercised.

The operation of the laws that relate to Crown land should be confirmed, extended, modified, or excluded, as the case may be, in their application to forest land. Both demarkated and undemarkated forest should be declared "public lands" within the meaning of the "Grass Burning Law," No. 21, 1865 ; and the provisions of Ordinance No. 2, 1855, "to prevent unlicensed squatting and to regulate the occupation of land by Natives," should apply ; also those of the Squatter's Rent Law, 1884. The exclusion of cattle being essential, demarkated forest should be exempted from the servitude of outspan under the Outspan Law, 1870, and excluded from the operation of Sec. 8 of the Pound Law No. 25, 1874, according to which cattle cannot be impounded off Crown land. The provisions of the Main Roads Construction Law, 1870, should be declared not to apply to

demarkated forest, so far as they relate to the cutting or removal of wood, timber, or other forest produce. Crown land is now excluded from the operation of the Fencing Law, 1887, but any demarkated forest should be declared to be liable to be brought under the Law, by Proclamation. The adjoining landowners would be affected only as if the demarkated forest had been alienated.

On Crown land, Native Locations, Commonages, or Outspans, there should be free access for the purpose of working any Crown forest situated within or beyond. On Native Locations and Commonages the rights of grazing should be limited as to time, and subject to the payment of an equitable fee.

The Land Clauses Consolidation Law, 1872, should be incorporated with the Forest Act, under Clause 5, to render the provisions relating to the taking of land for public purposes applicable to areas where it is required to preserve forests, or to make forests or plantations or works of a like character. Such resumption to be subject to compensation in the manner provided by the Law.

It should be lawful to declare by Proclamation, where it is in the public interest to do so, that any part of any forest, whether Crown or private, is to be preserved (1) for the maintenance and regulation of a water supply ; (2) for the fixation of sanddrifts, or the protection of roads, bridges, railways, and other lines of communication ; and to make regulations for the purpose of conserving such forest, with regard to (1) the clearing of the land ; (2) the felling of wood ; (3) the firing of the vegetation ; (4) the use of the pasturage.

Provision should be made to bring, upon application by the owner, any forest or plantation belonging to private persons, or municipal or other bodies, under the operation of the Act, in so far as its provisions may apply.

In order to facilitate demarkation in those cases where the boundaries of farms are disputed, Law No. 39, 1888, "to remedy Defects in Surveys of Land," should be made applicable to forest land, and the authorised Demarkating Officer should rank as a licensed land surveyor for the purposes of this Act. The Demarkating Officer should have power to enter upon lands for purposes of survey, and to take materials for erecting and preparing signals or beacons.

FOREST OFFENCES.—In undemarkated forest, the cutting of trees or removal of forest produce, and the firing of the forest, wilfully or through negligence, should be punishable offences. In demarkated forest the penalties would be more severe, and the offences would consist, as in the Cape Forest Act, of : — (a) Damaging, cutting, or removing any reserved tree. (b) Cutting, damaging, or removing any firewood, wattles, saplings, or other forest produce, contrarily to such regulations as may be proclaimed (c) Kindling, or aiding and abetting in kindling a fire in consequence of which forest produce is burnt or in danger of being burnt. (d) Leaving, without taking precautions

against its spread, any fire which the same person has kindled or assisted or abetted in kindling. (e) Damaging, altering, or removing any beacon, fence, or gate.

Minor forest offences in demarkated forest, for which lighter penalties are applicable, would consist of :—(a) Clearing, cultivating, or breaking up for cultivation any land. (b) Shooting, destroying, capturing or pursuing game or fish. (c) Firing the forest through negligence. (d) Contravening any of the proclaimed Forest Regulations. The punishments of special offences, such as counterfeiting or altering marks, stamps or licenses used or issued by the Forest Department, or bribing a forest officer, or, being a forest officer, accepting a bribe, should also be provided for.

FOREST OFFICERS.—Forest officers should have police powers by virtue of their office ; also authority to impound cattle trespassing within Crown forests, to seize any tree, timber, forest produce, axe, or saw, in respect of which there is evidence that a forest offence has been committed, and to arrest without a warrant any person reasonably suspected of having been concerned in any of the graver forest offences, whenever there is presumption that such person would not otherwise appear to answer the charge.

Conservators and such other forest officers as may be appointed for the purpose, should be given petty judicial powers of a special nature. Conservators are usually Justices of the Peace by virtue of their office, but the powers thus conferred are not found sufficient in dealing with forest offences, and it is desirable that they should have summary jurisdiction in respect of petty offences. The forests are often situated twenty or thirty miles or more from the nearest Magistrate's Office, and it would be a manifest incongruity to waste a couple of days and compel the attendance of witnesses, to prosecute a man who may have cut in the forest a sapling valued at a few pence. What is wanted is some such power as that which Road Magistrates at the Cape exercise under Ordinance 28, of 1846 ; and immunity from an imputation of compounding for felony when fines are inflicted for minor offences and breaches of the Regulations. Section 55 of the Madras Forest Act, provides that "Any Forest Officer specially empowered in this behalf may accept from any person reasonably suspected of having committed any forest offence other than an offence under Section 50, or Section 52, a sum of money by way of compensation for the offence which may have been committed ; and where any property has been seized as liable to confiscation, may release the same on payment of the value thereof as estimated by such officer.

"On the payment of such sum of money, or such value, or both, as the case may be, to such officer, the accused person, if in custody, shall be discharged, the property seized shall be released and no further proceedings shall be taken against such person or property." Similar legislation was at first rejected in India, but since being passed it has worked beneficially. There should be a free right of appeal in all such cases, before the Resident Magistrate.

MARKING OF TIMBER.—The stamping of timber should be made compulsory in the neighbourhood of demarkated forest. In each district, the Government marks used for felled and other timber would be registered by the Conservator, at the Magistrate's Office ; and the marks used by owners or occupiers of any forest situated within five miles of a demarkated forest, registered by them. Forest or police officers should be entitled to seize or detain, pending enquiry, any unstamped timber in course of conveyance within five miles of a demarkated forest, when satisfactory proof of ownership cannot be given. Firewood and other small timber which cannot be stamped, would be removed from the Crown Forests under a permit, and from private forests within the five miles limit, under a pass. Compulsory stamping would not interfere seriously with private owners, the majority of which use stamps for their own advantage.

SPECIAL CLAUSES.—The provisions of the following clauses in the Cape Forest Act may be found useful to adopt here :—

28. No forest officer shall, as principal or agent, trade in timber or forest produce, or be or become interested in any lease or mortgage of any forest, or in any contract for working any timber or produce, whether in demarkated or undemarkated or private forest.

32. In case of the fraudulent removal of trees, timber, or other forest produce, the restitution of the property so removed, or its value, to be fixed by the Court, shall be ordered in addition to the fines and damages adjudged.

In case of unauthorised establishments, buildings, enclosures, huts, kraals, or standing crops within forest limits, the Court shall fix the period within which such buildings, huts, kraals, or crops shall be removed, and the places put into their former condition.

In case such removal shall not have been effected within the prescribed period, all buildings, huts, kraals, or crops found in the forest shall become the property of the Crown, and the Forest Department shall dispose of them as may be most beneficial to the forest.

35. When in any proceedings taken under this Act, a question arises as to whether any timber or forest produce is the property of the Crown, such timber or forest produce shall be presumed to be the property of the Crown until the contrary is proved.

REWARDS FOR DETECTION OF FOREST OFFENCES.—A share of the fines imposed for any forest offence should be awarded to the informer, other than a forest officer, who may have supplied such information as to lead to the conviction of an offender. As an administrative measure, some forest officers should be empowered to also offer rewards for the detection of offenders under the Forest Law. Rewards may seldom have the desired effect of bringing offenders to justice, but they are very useful in deterring others, and by allowing a small sum for this purpose much destruction may be avoided.

MANAGEMENT OF THE FORESTS.

The object of forest management is to utilize forests to their greatest advantage, by :—

1. Regulating the cuttings so as to provide a sustained yield of timber.
2. Securing natural reproductions from the cuttings themselves.
3. Steadily improving the condition of the forest, while attaining a maximum production of timber.

The quantity of timber that is added in a year to the standing stock is termed the yearly increment of a forest. It is obvious that according to whether the quantity of timber cut from a forest is greater or smaller than the annual increment, the standing stock will decrease or increase ; and that the annual increment, which corresponds to the normal interest derived from a sum of money, may be cut each year without impoverishing the forest.

Though the annual increments per acre may become comparatively steady for a number of years between the stages of young and mature timber, there is a certain age at which the average of all previous increments reaches a maximum, corresponding to the greatest yield of wood which the forest is capable of returning each year.

A forest should be left to reach a stage of greatest utility before being worked. Absolutely this happens at the time of maturity, when the largest timber that can be grown without danger of being unsound is obtained, for the larger a log the more varied the uses it can be put to and the less waste. But there is a limit, not very remote, beyond which the increase in value of the timber ceases to compensate for the delay of the return, the most advantageous rate of profit being derivable at the limit.

The number of years thus fixed upon to elapse between two successive crops of timber in the same stage of growth on the same land, is termed the *rotation*. The rotation forms a cycle embracing one complete series of the various cultural operations needed from the time of production of a tree to the time of its being cut down. An "economic rotation" is designed to secure the most useful produce, while a "financial rotation" aims at returning the highest rate of profit.

LENGTH OF THE ROTATION.—Whether it is preferable for the State to adopt long rotations, in order to provide the most useful timber, or on the contrary, financial rotations because they are the most profitable has long been a moot point among economists. The great majority of the older writers contend that large timber being indispensable to the welfare of many industries, and the State alone being fitted to grow large timber, it is clearly the duty of the State to assure a permanent supply—the indirect benefits gained being held to more than compensate for the smaller rate of interest derived in long rotations. Of late years how-

ever, the financial rotation is finding more favour in the eyes of foresters. Large timber, on account of the more extended use of iron for shipbuilding and in engineering structures, it is not now so indispensable as it was formerly, and unless it is much more useful than small timber, there is no advantage in growing it. In South Africa large timber is still less necessary than in Europe, certainly not sufficiently so to warrant its production at a comparative loss. The larger trees found in our native forests are invariably cut up into small lumber, and the interests of the country would be served best by providing cheap rather than large timber. Where timber does not increase sensibly in value or utility, per unit of volume, from the time it becomes large enough to be cut into lumber, the maximum return is given by reaping it at that time ; for the rate of profit would otherwise steadily diminish for ever afterwards, since the yearly acre increment cannot vary widely. For instance, assuming that the yearly acre increments remain constant, and that the wood does not increase in value per unit of volume, as it becomes larger, and using a $3\frac{1}{2}$ per cent. rate of interest in calculating the cost, to the Government, of deferred returns, it is found that the present value of the prospective returns increases rapidly with the length of the rotation up to a maximum at 29 years, after which it steadily decreases, being reduced to half in the 78th year. Now, the normal value of the timber is only reached when it has become convertible into lumber, and as this usually happens after 29 years, any further lengthening of the rotation would decrease the rate of profit.

The experience of sawyers shows that, to be convertible into lumber, trees should have reached a diameter of 18 inches near the base ; and taking into account the greater waste in small logs, the most useful and convenient size would be a diameter of 24 inches. There are other reasons which make it desirable to aim at producing timber of the latter size : (a) the trees in the best managed forest cannot be made to grow quite regularly, but by adopting a mean diameter of 24 inches, even the smaller trees will probably be large enough to be utilized ; (b) the greatest mean acre increment per year will be approached, if not reached ; (c) trees of medium growth, like those of our native forests, would have an age of from 80 to 120 years when reaching the larger dimension, and would be fertile enough to ensure natural reproduction by seed. European trees do not begin to seed abundantly before 50 to 80 years, according to the species, and it is under old trees that the best young growth is found.

The length of the rotation to be adopted will vary according to the rate of growth of the trees and the mode of treatment. The rate of growth is not well known, but a few measurements of the growth of native trees taken at Knysna since 1882, which I publish in Appendix V., go to show that the rate of growth of Yellowwood and Stinkwood may be averaged at 0.21 inches in diameter per annum. At this rate, trees from 18 to 24 inches would require for their growth 86 to 115 years. But it is quite likely that in Natal the

rotation may be shorter, because (1) trees appear to grow here faster than they do at the Knysna, perhaps owing to the heavier rainfall in the Natal forest region; (2) the measurements were taken in a virgin forest where the growth would be sometimes almost stationary, and always slower than that of forest cultivated in accordance with suitable methods of forestry.

FORMATION OF SERIES.—The sustained yield of which a forest is capable, may be determined in each case according to either the area, or the volume of the standing stock. If we take area as our basis, the forest may be divided into as many sections as there are years in the rotation, and we may cut over one of these sections each year. The portion of forest thus included in one working cycle is termed a *Series*. When basing the annual yield on volume, the rotation may be subdivided into equal *periods* of 10 or 20 years, and corresponding *blocks* of forest assigned to each, one block being worked over during one period and the whole *Series* during the rotation. The standing stock on the block which is to be worked first, is estimated and its volume divided by the number of years in the period; the quotient gives the number of cubic feet that may be cut during each year of the period; and this cutting may be spread over various areas according to cultural requirements.

There are cases in which it is necessary to limit the working of a forest to the selection of mature trees. The yield may then be sufficiently limited by being expressed in the number of trees to be cut yearly in the forest.

CULTURAL TREATMENT.—The forests of the country having been divided into a number of *Series*, and their survey effected, the mode of treatment of each *Series* has to be decided. There are two ways in which trees may be reproduced; by seed as in *High Forest*, or by shoots or suckers from the stumps, as in *Coppice*. *Coppice* is unsuited for the production of large timber, and there is no place for the system in our native forests. It is however adapted to plantations designed to supply wattles and poles and in these equal areas may be cut over each year as soon as the plants reach the required size. In *High Forest*, the principal modes of treatment are the *method of thinnings* and the *Selection method* or "*Jardinage*."

METHOD OF THINNINGS.—This method aims at ensuring a complete natural sowing of the ground, and continually fostering the growth of the timber. These results are achieved by making in each portion of the forest, instead of a single cutting at maturity, a succession of cuttings of different character, at various periods of the rotation. These cuttings are classed as *regeneration cuttings* and *improvement cuttings*, the first being designed to ensure reproduction, and the second to improve the growth of the young timber.

Regeneration cuttings are generally three in number. In dense forests, the *primary cutting* opens the continuous leaf-canopy just enough to admit sunlight but preserve

shelter, causing the seeds to germinate and a crop of seedlings to appear. The *secondary cutting* is made to remove superfluous trees when, after a few years, the crop of seedlings is complete, and it becomes necessary to give them more light. The *final cutting* removes the remaining timber when the young plants cover the whole surface and have reached the thicket stage.

Improvement cuttings, consisting of *cleanings* and *thinnings* now step in. Cleanings are made with the object of removing in the young growth the inferior species which might otherwise gain the upper hand to the detriment of the valuable species. Thinnings are afterwards made periodically to improve the growth of the more promising trees. At first, it is best to leave the trees crowded, as the boles then become straight and cleaned of their lower branches. But after a time, usually when the crop has reached the low pole stage, towards the age of forty years in European forests, the struggle between the individual plants would become injurious and thinnings may be begun; they are made every ten years at first and every twenty as the trees approach maturity, or more frequently with fast growing species, but in every case it is essential that they should be made moderate enough to preserve a continuous leaf canopy to the forest.

The method of thinnings turns natural agencies to the best account, and is considered the most advanced that can be applied to the management of forests. It is adapted to all species, gives the best returns in timber, as regards both quantity and quality, and ensures speedy and certain natural reproduction and constant improvement of the produce. But it requires for its application very great care and skilful operators; otherwise it may give unsatisfactory results.

A somewhat allied method known as "*tire et aire*" used to be in vogue in Europe. In this system "equal areas of forest were cut over successively in the order in which they followed on the ground, a fixed number of trees were reserved per acre, and the young crops that came up were left to themselves and grew untouched for the whole length of the rotation adopted." *

SELECTION METHOD OR JARDINAGE.—Following Parade's definition, "*Jardinage* consists in taking, here and there, the oldest trees, those decaying, damaged, or dry, and others in good growth but needed for local requirements. In this mode of working . . . the principle followed is never to take many trees at once on the same spot, and to spread as much as possible the *jardinage* over the whole forest."** To prevent damage to the young growth, *jardinage* should be carried in successive sections of the forest, returning over the same portion only every ten or twenty years.

Jardinage is inferior to the method of thinnings, but of more certain and easy application in this country. It imitates closely the action of Nature by removing one by one those trees that would have first disappeared had they been left to fall from natural

* Bagneris, *Elements of Sylviculture*, p. 23.

** Lorentz et Parade, *Culture des Bois*, 6me ed. p. 294.

causes. The result is an aggregation of trees of all sizes and ages, many of which are hampered in their growth by the taller ones, and for this reason the quantity of the produce is less than with properly conducted thinnings, and the quality is worse. The frequent working of each portion of the forest is a cause of injury to the young growth, and the large areas over which the fellings are spread each year make supervision difficult. Nevertheless, *jardinage* has its advantages. It renders regeneration certain, and retains the association of the different species better than any other method. "It ought to be maintained in all forests where protection of, or shelter to, other parts is the chief object, and wherever regeneration is uncertain, difficult, or too slow to enable us to obtain it with certainty in a regular and complete manner in a given space of time. The same rule holds good for forests of very small extent.

"As far as protection is concerned, this method should be employed whenever there is reason to fear landslips, avalanches, and the formation of torrents, or where the wind is violent and always blowing, as at the higher limit of vegetation, on mountain ridges, &c.

Regeneration becomes difficult and uncertain when the climate is extreme or the soil infertile. The climate may be extreme in itself (higher limit of vegetation), or from the absence of shelter (mountain passes, ridges, edges of the forest). The soil is unfertile from its nature (rock, scattered blocks, stones) or owing to a steep gradient (wherever one cannot walk with a sure step). These circumstances may co-exist, and result in a stock that is seldom complete and generally more or less broken up by gaps. They are found in about half the hill forests of conifers under the administration of the Forest Department.

In all these circumstances, the existence of constant leaf canopy is imperatively demanded, and to maintain this the action of nature, which gets rid of the trees one by one, has to be imitated. In a word, the selection method must be employed, only the trees must be removed when they are still capable of furnishing useful material."*

I have quoted Bagneris to show that there are few Natal forests which do not present some of the conditions which make *jardinage* compulsory. Our forests consist mainly of small patches on steep slopes, and their distribution makes it important to conserve them for the regulation of the water supply. There is only one proper method of treating such forests, and that method is a careful *jardinage*. Other methods may be adapted to the larger and more level forests, but the regeneration of South African forests is in general so uncertain and irregular that much care would be needed in their application; the method followed at the Cape, in which heavy fellings are made in small sections of the forests, would be unsafe to adopt in Natal, wherever the young growth has been destroyed by Natives and cattle, as it might mean the ruin of the forest. Close fellings also create a source of danger from fires by allowing accumulations of dry crowns and

* Bagneris, *Elements of Sylviculture*, p. 102.

waste wood on some spots. I am of opinion that all the forests which it is proposed to open should be worked by *jardinage* for a number of years, till a young growth has re-established itself; the method could then, whenever there are no special reasons for maintaining *jardinage*, be gradually changed to one of thinnings, simplified in some respects, by effecting the appropriate cultural operations needed to convert an irregular high forest into one of graduated age-classes. In the meantime I shall recommend an application of *jardinage* to the Natal forests in the manner following:—

1. The forests having been surveyed, are grouped into Series small enough to be conveniently supervised by one Forest Guard as they become worked; the extent ranging from 4,000 acres downwards, according to the distances between the individual forests.

2. Those Series in which it cannot be expected that working would cover the cost of the extra supervision that would be needed should be closed, and remain closed till they can be profitably worked. This applies to Series formerly overworked and laid waste, such as the majority of the Drakensberg forests.

3. Each Series which it is decided to work is divided into twenty sections, the area of each being made slightly larger or smaller than the average, according to the density of the forest. The sections should be preferably limited by natural boundaries.

4. Following a regular order, each section is successively worked during the corresponding year, and the whole forest is gone over in twenty years.

5. Before fellings can be commenced, the quantity of standing stock in each section is estimated, and one-fifth of the volume is to constitute the limit of the fellings allowable. The yield thus reckoned will be above the annual increment if the forest is overstocked, or below it if the forest is poor, and will tend to bring the forest to a normal condition.

6. In selecting the trees to be marked for felling each year, dry trees, windfalls, waste logs, fungus-bearing trees,* and trees with badly broken crowns should be first taken. The complement will be yielded by mature trees; in the case of Yellowwood and Stinkwood by trees over 24 inches in diameter at three feet from the ground, and for other species by trees not less than 18 inches in diameter. The most mature trees ought to be selected first, and care should be taken to spread the fellings judiciously over the whole section, so as to avoid the clearing of many trees on one spot, and the consequent formation of injurious gaps in the canopy of the forest. Where the forest is tolerably regular, it may become possible to limit the fellings to a certain number of trees, instead of a number of cubic feet. The work would thereby be simplified, and fraud rendered more difficult.

* Trees once attacked by fungi, the fructification of which appears on the surface, are never known to recover. An interesting account of some of the researches of Hartig, Ebermayer, Thuemen, and Rostob, on the subject of diseases of forest trees is given in Prof. Marshall Ward's *Timber and some of its diseases*, London, 1889.

No tree should be marked for felling within 40 yards of the edge of the forest, as it is required to leave a protective fringe against the destructive action of winds and fires. Left alone, the boundary becomes clean and hardened as it were against external influences. On the contrary, gaps are created if trees are felled, and there being no protection from the one side, the young growth may not thrive. It has been shown that the observance of this rule is also required for protection against fires.

It is of extreme importance that the annual yield arrived at for each section should not be exceeded on any account. *Jardinage* in which fellings become excessive, does not differ materially from the ordinary irregular working which so speedily brings about the ruin or degradation of a forest. When the fellings exceed the increment, the forest wastes away; the marketable timber disappears, and the young growth thins and does not recover. Glades make their appearance and the forest may fall into ruins. This has been the fate of some of the "cut out" South African forests.

Adopting the method proposed, very few sound trees would be taken in forests that have been overworked, and the bulk of the produce would be limited to damaged trees and wastewood; but most often the receipts would not cover the additional expenditure that the opening of this forest would involve, and the forest had better remain closed.

ANNUAL YIELD.—The annual yield would vary considerably according to the character of the forest. Judging from sample areas, and adopting a rotation of 100 years, the annual yield by volume would reach 100 cubic feet per acre in the Gwangwane forest, 70 cubic feet in the Impetyne forest, 14 cubic feet in the Mahutywa forest. At Knysna it would only average 6 cubic feet, and in some of our overworked forests probably still less. By proper management, the steady annual yield of yellowwood forests should reach 70 to 30 cubic feet per acre, according to the fertility of the ground. Comparing with European figures, in Baden the annual yield of mixed forests averages 51·8 cubic feet per acre.* According to Burckhardt, the mean annual increment of normally stocked forests 100 years old is in Germany, in cubic feet per acre, neglecting thinnings, 70·9 to 40·0 for oak, and 105·6 to 42·9 for spruce; and figures for other European forests do not diverge much from these.

FELLING SEASON.—Which is the best season for felling timber has long been a vexed question, some pretending that summer felled timber is the most durable, but the majority preferring to fell trees in winter, when the deciduous kinds are leafless. Winter felled timber sometimes contains less sap than that felled in summer, but the difference is seldom considerable. Bauschinger† has shown that in timber tested within three months of felling, the winter felled timber is 25 per cent. stronger than the summer felled, but the difference disappears after a long time of seasoning. There is in Natal a prevalent belief

* Sir D. Brandis, *Notes on Forest Management in Germany*, London, 1888, p. 3.

† W. C. Unwin. *The Testing of Materials of Construction*, London, 1888, p. 400.

that timber felled about June-July is the most durable ; and it is very probably so, since the air is then both dry and cold, a combination of favourable circumstances. Hartig attributes the greater durability of the winter felled timber to the fact that it has time to dry on the outside before the atmospheric influences become favourable to the development of the various fungi of rot, the spores of which, though plentiful, remain dormant in the cold of winter.* At the Cape, the felling season adopted begins in March, and ends in June or July, according to the species.

However, the time of felling influences the strength and durability of timber much less than the mode and length of seasoning, and, in many countries, it is determined by circumstances having no reference to the quality of the timber produced. Considerations of labour and transport often cause, as in many parts of Germany, spring and summer felling to be preferred. In Natal, transport is usually possible from October to May in each year, and the felling season might conveniently be taken from the middle of September to the end of December, the wood being prepared and removed during the remaining months of summer and autumn.

MARKING OF TIMBER FOR FELLING.—In each section which it is proposed to open, the forest-guard, assisted by one or two natives, would mark during the close season the trees that are to be cut during the subsequent felling season. This selection of trees is a delicate and important operation, which requires to be done at leisure and with care. The work of each guard should be arranged so as to provide ample time for the purpose—one or two months—during the close season.

To facilitate the selection of trees, the section is sub-divided into a number of narrow plots, by means of small staff lines cut or blazed through the forest, and with the help of any natural features or existing paths. Where they are used alone, the staff lines are cut parallel and at intervals of from 40 to 80 yards, according to the density of the forest. Each plot is then examined in succession, and the trees are selected, marked, measured, and numbered consecutively, with numbers either stamped or painted on the blazed bark; the diameter is taken to the nearest two inches, at three feet from the ground in the case of seedlings, or at three feet from the stump in the case of shoots ; and the length of serviceable wood is estimated to the nearest five feet. The diameter may be conveniently taken with tapes graduated to give the girth of one side and the corresponding diameter of the other. When including trees below the normal dimensions, the guard should state what defect makes it allowable. Particulars of each tree are entered in a "section book" kept by the guard.

The cubic contents may be derived from the small table given in Appendix VI., the volume of a squared log being taken to be equal to half of that of a cylinder with a diameter equal to that measured at three feet from the ground, and a height equal to the

* *Nature*, March 28, 1889, p. 513.

serviceable length. This gives a volume equal to about 60 per cent. of the actual volume of the round log, leaving a margin of 40 per cent. for bark and waste in squaring.

ISSUE OF LICENSES.—When the felling season opens, licenses may be issued by the forest guard for those trees that are marked, measured, and numbered. A license book is required for the purpose. It should contain a round number of licenses, each numbered and the number repeated on a counterfoil which forms a duplicate of the license, kept for reference. Suitable forms should be printed on the licenses, for entering particulars of each tree granted and of the manufactured wood subsequently stamped. An abstract of the conditions under which it is granted should also be included on the license. Licenses are often roughly handled during a long period, and should be printed on tough paper, such as bank-post. As a rule, licenses should not be issued for less than one hundred cubic feet of wood.

LICENSE RATES.—I should recommend the adoption of the following scale for the valuation of standing timber for sale. The contents of the squared timber having been arrived at by deducting 40 per cent. from the contents of the round log, the following charges should be made for each cubic foot :—

Umzimbeet (*Millettia Caffra* and *M. Sutherlandi*), 1s. 6d.

Sneezewood (<i>Pteroxylon utila</i>)	}	1s.
Stinkwood (<i>Ocotea bullata</i>)		
Hard Pear (<i>Olinia cymosa</i>)		
Assagai (<i>Curtisia faginea</i>)		
White Pear (<i>Apodytes dimidiata</i>)		

Red Pear (<i>Scolopia Ecklonii</i>)	}	10d.
Natal Mahogany (<i>Kiggelaria Dregeana</i> and <i>K. Africana</i>)		
Saffraan (<i>Elæodendron visceum</i>)		
Rood Els (<i>Cunonia Capensis</i>)		
White Milkwood (<i>Sideroxylon inerme</i>)		
Red Milkwood (<i>Mimusops obovata</i>)		

Bitter Almond	}	6d.
Quar (<i>Plectronia obovata</i>)		
Ironwood (<i>Olea laurifolia</i>)		
Beukenhout (<i>Myrsine melanophleos</i>)		

White Ironwood (<i>Toddalia lanceolata</i> and <i>T. Natalensis</i>)	}	4d.
Upright Yellowwood (<i>Podocarpus Thunbergii</i>)		
Outeniqua Yellowwood (<i>Podocarpus elongatus</i>)		
Kamdeboo Stinkwood (<i>Celtis rhamnifolia</i>)		
Wild Chesnut (<i>Calodendron Capense</i>)		
Essenhout (<i>Ekebergia capensis</i> and <i>E. Meyeri</i>)		
Paardepis (<i>Hippobromus alata</i>)		
Wittehout (<i>Ilex Capensis</i>)		
Zwarthout (<i>Celastrus penduncularis</i>)		
Vlier (<i>Nuxia floribunda</i>)		

Bogabog (*Xylosma monospora*)
Other woods.

Under the present regulations, the charge for wagonwood is three pounds for a wagon load of 600 running feet; which is at the rate of one shilling and two pence halfpenny for each cubic foot. The tariff proposed is therefore more moderate than the present.

ADVANTAGES OF THE METHOD.—It is far preferable to sell individual trees as they stand, than to allow woodcutters to remove from the forest a certain number of cubic feet of manufactured wood on payment of a certain fee. In the first case, the whole of a tree becomes the property of the woodcutter, and it is naturally his interest to remove as much of it as he can. In the case of payments by results, the interest of the woodcutter is very different : he will take in each tree the choicest piece of timber, abandoning the rest. Trees will be felled high and crowned low, and the logs squared wastefully, sometimes even rejected altogether, if better are subsequently found. Again, when the logs are cut up, only the best pieces are claimed, the remainder being left sometimes on account of very slight defects. The pieces that are left will then decay and become useless in a few years. It requires some experience of South African forests to form an idea of the waste that can be induced in this manner. Speaking of South Africa generally, I should say that the result of the system still in force in Natal, has been that for every load of wood accounted for, six or eight have been taken out, and a dozen more wasted unnecessarily, by the former bushcutters.

It may be said, that in buying individual trees, the woodcutter has no guarantee that he will get sound timber in return for the license-fees which he has paid. But, as a rule, woodcutters are good judges of timber and seldom buy trees at a loss. Then the valuation of the timber can be made very moderate, and if there may occur exceptional cases in which individual trees do not contain the quantity of timber paid for, it would be very seldom that, taking all the trees on one license, or better still, all the trees felled by him in the season, the woodcutter would lose by a remeasurement. At the Cape, remeasurements are optional, but they are seldom asked for, and as they involve much work, done to the detriment of other more important duties, it is preferable to dispense with them, taking care that the valuations are moderate. To check these, and also to see that the marking work has been correctly performed, a forest officer should remeasure, in each section, at least 5 per cent. of the trees marked by the guard.

An exception should be made for Stinkwood. This is a wood which is often unsound at the heart, and cuts up wastefully ; the woodcutter should therefore be entitled to ask for the remeasurement of logs of this species, and the forest guard would in such cases, re-estimate the contents of the serviceable timber that could have been derived from all the Stinkwood logs on the license, and make good the difference to the licensee.

SECOND CLASS TIMBER.—When timber is sold at a fixed rate per cubic foot, only a portion is utilised, the good trees that may be easily extracted being taken, and the others left. In order to increase the yield and improve the condition of the forest, all the inferior or badly situated trees should be sold at reduced rates. At the Cape, this is accomplished by marking certain trees at half rates, but such a course is not necessary, since it is sufficient, and more effectual too, to grant at half price the trees that remain after the best

have been taken. The percentage of timber to be removed before the reduced rates can come into operation should be decided in each case, and beforehand, by the forest officer who revises the work of the guard ; it may vary from four-fifths to one-half, but should the experience derived in working the section show that the proportion adopted was too high, it may be modified by the Conservator. The timber removed under reduced rates would consist principally of : (a) crooked or short trees not capable of yielding long timber ; (b) twisted trees ; (c) trees containing only a small proportion of sound wood ; (d) trees overestimated in the marking ; (e) trees so situated as to cause exceptionally increased cost of extraction.

When this second return is squeezed out of the forest, a residuum will be left, consisting of trees not removable at a profit. In some cases it would be well to fell a few of these, in order to disencumber the reserved stock, if it can be done at a small cost.

FOREST REGULATIONS.—A licensing system must needs be adopted, where, as in South Africa, the trade in native timber is too small to permit of the disposal of all the trees marked in a section, to tenderers, or by contract or auction. One of the drawbacks of such a system is the facility with which it lends itself to fraud, unless it is carried in a careful and systematic manner. Practical details are of much importance in this respect ; they are usually embodied in forest regulations, dealing with minor points such as I shall proceed to indicate. The holder of a license, who contravenes such regulations, should be liable to forfeiture of his license and of the wood not previously removed. This is a sufficient provision for their enforcement, if all the more serious offences are amenable to special forest legislation.

PRODUCTION OF LICENSE.—No woodcutting party should be allowed into the forest without a license, and, before any tree can be felled, the license should be presented to the forest guard, unless it has been issued by him.

The woodcutter or his deputy should produce his license, if called upon, at the forest, by a forest officer or any other person specially authorised thereto under the Forest Law ; or when he requires manufactured wood to be stamped. If the license has been mislaid, a duplicate, on which the quantity of wood already stamped is stated, could be obtained from the issuer.

FELLING AND REMOVING TIMBER.—The trees should be cut close to the ground. Not only is a saving of timber effected, but in the case of Stinkwood, Assagai, and other species that are regenerated freely by shoots or suckers, this becomes an essential condition for the production of healthy coppice-shoots capable of taking the place of the trees cut down.

There is no need to extract the crowns of trees felled in the sections ; it would be quite sufficient to reduce them with the axe, because they do not impede the growth of young plants, become converted into humus, and their presence affords protection from cattle.

In felling or removing timber, the woodcutter should take reasonable care not to damage other trees, or the young growth. When it becomes necessary to cut down other trees than those granted on the license, the woodcutter should first get the guard to mark them. The holder of the license should be held liable to pay for the young trees damaged through carelessness or neglect at the following rates : (a) for trees above three feet in girth, double the license-fees ; (b) for trees between three and thirty-six inches in girth, at the rate of the license-fee on a cubic foot, for each three inches in girth ; (c) for trees less than three inches in girth, the license-fee on one cubic foot of the species.

When poles and spars are required to be placed in the slip-path, the guard may, upon application, authorise the cutting for the purpose, free of license, of species not enumerated in the schedule of license-fees.

STAMPING OF MANUFACTURED WOOD.—The forest guard should enter on the license, on each occasion, particulars of the manufactured wood stamped by him, and repeat these on the counterfoil of the license-book, so that the quantity of wood already marked on each license may be readily known. The correct registration of manufactured wood being one of the best checks on wood stealing, forest guards who should fail to account correctly for wood delivered by them, should be held as guilty or negligent (as the case may be) as if they had not accounted correctly for moneys received. The forest guard should not be at liberty to stamp more than an excess of 15 per cent. of manufactured wood, on the quantity granted on the license, without reference to the Conservator or his deputy, unless a new license is taken out for the excess.

The cubic contents of manufactured wood may be readily derived from the small table in Appendix VI. ; and “Hoppus’ measurer” is convenient to use for pieces of unusual dimensions.

SAW PITS AND WORKPLACES.—Trees should be removed to the workplace or saw pit specified on the license. One workplace is usually sufficient for each section ; their multiplication should be avoided on account of the increased difficulty of supervision that would result. Saw pits in the forest are only allowable in exceptional circumstances, as when the ground is very steep and the slipping of logs not practicable. The removal of timber in the log is easier than that of manufactured wood, wherever the gradients allow of slipping ; and it prevents the considerable damage to the forest that would result from the clearing of workplaces for each few trees, the digging of pits, and the scattering of sawdust, chips, and refuse, over the ground, which hinder, for many years, the growth of trees on such spots.

The timber required for sawpits may be granted by the forest guard, free of charge ; only inferior trees and trees of species not specially reserved, being allowed to be taken for the purpose.

TIME ALLOWED FOR WORKING.—The time allowed for working must be restricted, to avoid the endless confusion that would otherwise result. Some such rules as the following would meet the case : Firewood licenses to hold good for a period of one week from the date of issue, and licenses for poles and spars during one fortnight. With timber licenses, the trees may be felled within three weeks and removed within two months of the date of issue. For special reasons, such as the prevalence of bad weather during the period, a week's extension for felling, and a month's extension for removal, could be granted by the issuer of the license, at his discretion. The timber ought to be removed from the saw pits within two months of the date of expiration of the license, but if the quantity exceeds 800 cubic feet, a week more may be allowed for each additional 100 feet. In every case, however, timber not removed from the workplaces a week before the opening of the next felling season should be forfeited and resold as wastewood.

Each holder of a license should be entitled to take sixteen oxen to the forest and graze them on any adjacent Government ground until his license is completed, provided the time does not exceed one month.

UTILIZATION OF COLONIAL PRODUCE.—This constitutes an important problem of forest management in this country. In every case, it is judicious to conserve the natural forests at any moderate cost, on account of the indirect benefits derived ; but whether they can be opened and worked at a profit will depend upon the degree of success in utilizing the produce to the best advantage. Owing to the small density of the population, and the want of a wood cutting class, it will be naturally difficult to sell all the timber that it would be desirable to remove each year.

Now that the native woods have been proved practically to be generally superior to the imported kinds, it is the duty of the Government to encourage their more extended use. The Government being the largest consumer of timber in the country, could facilitate to no small degree the successful working of the Natal forests, by adopting for public works the use of colonial woods, in preference to the imported kinds, whenever they can be obtained at an equal cost. The Natal forests are very limited in extent and the Government alone could consume the greater portion of the timber that is required to be felled each year, by using *Colonial woods for railway sleepers*.

There are at present $257\frac{1}{4}$ miles of railway line open in Natal ; the sidings have a length of about 30 miles and the authorised extensions of 110. So that at least $397\frac{1}{4}$ miles of permanent way will be required to be maintained in a near future ; the average number of sleepers per mile, is stated to be 2,112 on straight sections, with more for sharp curves, and may be averaged at 2,200, giving a total number of sleepers of 8,739,400 for the whole of the system (less a few iron sleepers). The average life of a sleeper is reported to be 7 years ; and the quantity wanted for renewals will in time reach 124,850,

at the least ; assuming that the larger size of sleepers 7ft. x 10in. x 5in. will be used for the heavy rails now required, the quantity of wood consumed annually would be about 303,380 cubic feet.

Yellowwood is the most abundant of our woods, and upon its suitability for railway sleepers depends the capability of our forests to supply a sufficient number of sleepers for industrial working. To ascertain the value of Colonial woods for railway purposes, the Cape Government sent, in 1883, about one hundred sleepers, mostly Yellowwood, to be tested in England ; the best professional opinion was obtained on the wood, and is recorded in Papers A. 1. 84, which contain Reports by Sir Charles Gregory, Consulting Railway Engineer to the Cape Government ; Mr. H. Wakefield, Inspecting Engineer ; Messrs. John Bland & Co., and R. Lander & Co. ; Mr. C. Besley, Inspector of Timber for the Great Western Railway Company, and Mr. E. E. Niblett. These reports, all the material points of which are reproduced in Appendix III., prove conclusively that Yellowwood, properly impregnated, furnishes an excellent and lasting sleeper, much superior to the ordinary Baltic sleeper. Its chief merits are, that it can be impregnated more easily and thoroughly than most other woods, and therefore rendered more lasting, and that it can hold rail fastenings, or resist the spreading action of the rails about twice as well as Baltic Fir, a property of great value where heavy gradients and sharp curves make the life of a sleeper depend sometimes more upon the resistance of the tissue of the wood, than even upon its durability. Yellowwood has all the qualities that a good sleeper wood should possess, and practical men consider that it is not only suitable for railway sleepers, but also not excelled by any of the other pine woods in use.

Other woods were also tested in England at the same time, and there is reason to believe that the great majority of species of Colonial timber are suitable for making sleepers by careful preparation. Yellowwood is one of the softest and weakest of our woods, and it may be taken that other woods with better mechanical properties would answer equally well, when properly prepared, as far as strength and durability are concerned. Some of our woods are unquestionably so durable, that they could be safely used without any preparation. Thus, Stinkwood may be reckoned to last at least twelve years, while Sneezewood and Hard Pear would certainly outlast in their natural state any creosoted pine wood.

The very satisfactory results arrived at in testing Yellowwood for railway purposes had for effect to remove much of the prejudice that existed at the Cape against the use of Colonial woods for public works. In 1884, a Select Committee was appointed to consider the whole question and make practical recommendations. It reported that "in order to utilise Colonial Timber for Railway Sleepers, on a scale at all commensurate with our future requirements, it is absolutely necessary to subject the wood to some preservative process so as to prolong the life of the Sleepers," and recommended "the

establishment of the necessary works at the Knysna, to season, prepare and store sleepers, and such timber as can be advantageously utilised on the Public Works of the Colony, while contracts should be entered into for the supply and delivery of Sleepers at the Knysna works above referred to."

Works were established at the Knysna during the ensuing year; they have progressed since and proved very successful. The following extract from the last Report of the Superintendent of the Sleeper Factory shows what was done in 1888 :—

"The total number of sleepers purchased during the year amounted to 126,900. Of these, 86,900 were obtained from Government forests, and 40,000 from private forests. 94,380 sleepers were creosoted and shipped to the Railway Department. The number of sleepers remaining in stock on the 31st December last was 94,900. The total sum expended in this district during the year amounted to £20,084. Tenders for sleepers were called for in February, and contracts were offered at from 500 sleepers upwards, thus enabling the woodcutters themselves to take contracts. The smallest contracts offered in the previous year were for 1,000 sleepers. Fifty tenders were accepted, amounting to 97,000 sleepers. Subsequently, an increased supply of timber having been made available in the Government forests, the contractors agreed to supply a further quantity of 20,000 sleepers. It was also arranged to work 15,000 sleepers departmentally. The total supply, therefore, for the financial year 1888-89 amounted to 132,000 sleepers. A considerable number of private forest sleepers received were delivered by contractors who purchased their timber from private forest proprietors. If a sufficient supply of timber were made available in Government forests this should not occur, on account of the lesser price paid for sleepers from private forests. The supply of sleepers is almost entirely dependent on hand labour. Out of the supply of 132,000, only 20,000 were sawn by machinery. There seems to be every probability that the supply of from 100,000 to 120,000 sleepers can be obtained yearly, provided that a sufficient quantity of yellow-wood is made available for felling in the Government forests. With the exception of a few sleepers of witte els no sleepers were supplied of the other varieties of timber authorised to be used for sleepers, and, although the license on ironwood was reduced to 1d. per cubic foot, the contractors were not induced to supply sleepers of this timber, owing to the greater cost of working. I see no prospect of further reducing the working expenses of the factory, and any difference appearing in the cost of the sleepers delivered to the Railway Department will depend on the cost of the creosote and the freight on the sleepers. The creosoting plant has up to the present time worked very satisfactorily, and is maintained in thorough repair and working order. Arrangements were made for obtaining 15,000 sleepers from the reserve forests at Gouna, and for working the Government saw-mill departmentally. 12,000 of these sleepers were delivered at the factory by

the end of the year. The sleepers were worked within the contract price paid by the Government. The license fees paid to the Forest Department for the timber amounted to nearly 10d. per sleeper on the sound sleeper produced."

The price paid for sleepers 7' x 10" x 5", containing 2.43 cubic feet, varied from 2s. 9d. to 3s., delivered at the Port.

If in Knysna it is found possible to manufacture and prepare railway sleepers of native wood, within the necessary limits of price, the same result should be achieved here with at least equal facility, for we have better advantages in Natal for the successful prosecution of the work than there exist at Knysna.

In the first place, imported sleepers can be landed in Cape Town for less than they can be landed in Durban; the excess of freight may not be much, but it leaves a slightly greater margin for the production of a native wood sleeper at an equal price. Then, at Knysna, native labour costs 2s. 6d. or 3s. a day, and the sleepers must not only be brought overland to the port at a cost of from 5d. to 9d. each, but have also to be shipped and landed in Cape Town or Port Elizabeth, at a cost of about 1s. each; while in Natal, native labour only costs 1s. a day, the transport rates are not heavier in the season, and the sleepers may be ridden direct to the line of railway. Again, there is evidence to show that the creosoting process now followed at the Knysna may be replaced advantageously by impregnation with chloride of zinc. Chloride of zinc is fast superseding creosote in Europe, as it preserves a sleeper almost equally well at a much smaller cost. At Knysna, the cost of creosoting sleepers averages 1s. 8d. each, but by using chloride of zinc, a saving of at least 10d. per sleeper could be effected. With these comparative facilities, there is every prospect that the manufacture of sleepers from native woods could be made a success.

In Natal, the small imported sleepers, 6' 9" x 9" x 4½", containing 1.90 cubic feet, are stated (Report of the General Manager of Railways for 1887) to cost 4s. 1d. each. Sleepers 7" x 10" x 5" (which are the dimensions of those cut at the Knysna), containing 2.43 cubic feet each, are now ordered for use with the heavier rails. Their corresponding cost would be 5s. 2d. each. I am now informed that the cost of the last few shipments of small sleepers has been 5s. each, which corresponds to a cost of 6s. 5d. for the larger sleepers.

PREPARATION OF WOOD.—I would recommend the establishment of suitable works at Maritzburg, which is the most convenient centre for the purpose, to season, prepare and store sleepers of native wood; these works to form part of the Railway workshops and to be placed under the management of the Railway Department. The manufacture and preparation of railway sleepers is discussed in Appendix III., where may be found details of the principal recognised processes of impregnation now in use. Creosote and chloride of zinc are the most commonly used preservative substances, and the same machinery

may be used for either. I consider that the chloride of zinc process is the most suitable for Natal, on account of its efficacy and small cost, but it may be changed to creosoting without altering the works if it is judged necessary to try creosoting for purposes of comparison. It is not likely, however, that creosoting would meet with much favour; it is a dangerous process; the creosote has to be brought out in special vessels; and the stacked timber becomes highly inflammable; while with chloride of zinc, the wood is rendered incombustible and the salt may be brought out as ordinary cargo. The superiority of the chloride of zinc process over creosoting is still greater in Natal than in Europe, on account of the saving in freight, half a pound of chloride of zinc answering the purposes of ten pounds of creosote.

The machinery required would consist of a cylinder in which the wood is placed, iron store tanks for the chloride of zinc solution, a steam engine fitted with air and forcing pumps, a boiler with mountings, wagons, rails, and other fittings. The cost of machinery with a cylinder 60 feet long and 6 feet in diameter was estimated at £1,349, delivered in London, by Messrs. Cowans and Sheldon and Co., of Carlisle, in 1884. At Knysna the total cost of the works, comprising buildings, machinery, fittings, &c., has been between two and three thousand pounds. The machinery includes an adzing machine and additional steam engine for adzing the sleepers to suit the tilt of the rails. 225 sleepers are treated in the cylinder at each charge, and the cylinder may be charged three or four times a day.

Works of this kind are very convenient to prepare timber used in public works of every kind, and the cylinder should be large enough to take the largest pieces of timber required to be treated; otherwise, a cylinder of smaller dimensions and machinery of less cost would be sufficient for the preparation of sleepers alone.

I do not think Durban would be as convenient a centre to place these works at, as Maritzburg, on account of the increased average cost of transport that would result. Most of the forests from which timber may be derived are nearer Maritzburg than Durban, and Maritzburg is a more central station to distribute the sleepers from.

CONTRACTS FOR SLEEPERS.—After the forests have been sectioned and are ready for working, contracts should be entered into for the supply of sleepers, whether from Crown or private forests. The same price may be given in both cases. Each tender should be for not less than 500 sleepers, and the price paid should not exceed the cost of imported sleepers delivered at Maritzburg, less the cost of preparation. Probably the full price would have to be paid at first, on account of the novelty of the undertaking, but it might be gradually lessened as the work progresses.

By entering into small as well as large contracts, wood cutters are enabled to tender and competition becomes more effective. Separate tenders should be called:

1. For the supply and delivery of Hard woods, not requiring to be prepared.
2. For the supply and delivery of Soft woods, requiring to be impregnated.

The species of wood accepted at the Cape for sleepers are : Outeniqua and Upright Yellowwood, Wit Els, Rooi Els, Hard Pear, Vlier, White Pear, Saffraan, and Ironwood. Owing to the greater difficulty in working other woods, and partly to their greater value as wagonwoods, Yellowwood has hitherto constituted 97 per cent. of the timber supplied. Stinkwood is not mentioned, because though very acceptable as a sleeper, it usually commands too high a price for the purpose.

It is difficult to arrive at an estimate of the quantity of timber that could be cut in the Natal forests, without injury to their conditions. More than three-fourths are private forests which I have not seen. The Commission of 1880 reports that the total extent of timber forests was then 165,900 acres. These forests should yield quite a sufficient number of sleepers for industrial working, even in their present impoverished conditions. In the Mahutywa forest, the best for its size that I know of in South Africa, the yield would reach about 15 or 20 sleepers to each acre, without injury to the forest, but the richness of most other forests would bear no proportion to these figures. The proper course would be to first call for tenders early each year, so as to find out the quantity of native wood procurable during the year ; and then to order the balance from abroad if the supply does not come up to the requirements of the Railway Department.

Though private enterprise should be solicited as much as possible in procuring sleepers of native wood, there would be much advantage to work the forests between the Umzimkulu and the Gwangwane departmentally, or rather by a system of piece-work and contracts under Government supervision. These forests cover about 7,000 acres ; their systematic working by the Government would simplify the management to an important degree, and a minimum regular supply of timber would be assured each year. Of course, the work need not be authorized before the forests are surveyed, and the annual yield of timber and the cost of working ascertained carefully.

No licenses would be issued for these forests. The trees to be felled should be marked and measured so as not to exceed the yield, but the numbering and the section books may be dispensed with. Then (a) the felling should be done by piece work, or contract, under the supervision of the guard ; (b), tenders should be called for slipping and riding the wood ; (c), the sawing work should be done departmentally, with the help of portable machinery.

The contractor for the slipping would be required to extract a certain proportion (to be agreed upon beforehand) of the timber to be felled ; he should then get a bonus equal to half the license fees on the quantity which he removes in excess ; and finally the trees which he cannot be induced to slip out should be sawn on the spot, by piece work, and the sleepers carried out by natives to the nearest slip path.

The advantages derived from the working of these forests by the Government would consist generally of (a) the simplification of the work, whereby all the evils of the

licensing system would be avoided, and a large block of forest could be supervised almost as easily as if it were closed for working, one guard being sufficient for the purpose ; (b), the regular supply of a large number of sleepers, and the facility of procuring any special pieces of timber required for public works ; (c), a thorough working of the forest, such as could not be attained in selling trees one by one ; (d), the saving that would be effected in working systematically on a suitable scale.

The fine Gouna forest, at the Knysna, is worked successfully on a similar plan, and the cost of the sleepers produced is less than that of sleepers bought from contractors. In the scheme which I propose, the work would not be purely departmental, as the felling, slipping and riding would be performed by contract, and only part of the sawing by the Government. I am not sure that private enterprise could be depended upon for working the Crown forests thoroughly, and where it is possible to utilise them successfully, by exercising some small amount of Government interference, it would be unwise not to do so.

There is evidence that Yellowwood, which is a very porous wood, though of considerable strength, may be impregnated sufficiently by simple immersion in a solution of chloride of zinc. If this proves to be the case, there would be no difficulty in working the yellowwood in some of the remote forests ; one or two immersion tanks in the neighbourhood would then be all that is required for the preparation, and it would be possible to send the sleepers to the nearest point of the railway system, instead of Maritzburg. In the Newcastle forests, for instance, simple immersion might prove of great value in promoting a sleeper industry. The sleepers would have to be immersed at least a fortnight, in cement tanks ; then left to dry for a month before use.

The Coast forests are nearly all in private hands, but they might be made to yield a considerable supply of sleepers. At Umzimkulu, there are forests not far from Port Shepstone, in which a large number of sleepers might be cut and shipped to Durban for preparation. The timber of Coast forests is of small size and would yield few square sleepers, but I have shown in Appendix III., how this difficulty is usually got over by allowing a greater proportion of wane edge when the width of the sleeper is increased in sufficient proportion to give at least the same strength and all the advantages of a square sleeper.

WOOD DEPOT.—To obviate the difficulty which is often experienced in procuring seasoned timber for public works, at short notice, it would be useful to establish a small timber depot, either at one of the forests where the manufacture of sleepers is carried under Government control, or at the central factory where the wood is prepared, to season and store sawn timber and logs that may be required from time to time by the Railway Department, the Colonial Engineer's Department, or the Harbour Board at Durban.

MINOR FOREST PRODUCE.—This is a source of revenue that should not be neglected. In India the sale of barks, gums, resins, &c., and firewood yields an important proportion of the receipts. The results of analyses of Natal barks given in Appendix IV., show that some of our forest species should be valuable for tanning purposes. The barks of other species are reputed by Natives to possess valuable medicinal properties, a few of which are indicated in the List of Natal trees forming Appendix I. Some of our woods, such as Ironwood and Quar, make excellent charcoal, and charcoal burning may become a profitable industry. A small shipment which I had prepared in 1884 was used in the Salt River workshops and declared far superior to the imported article, probably owing to the greater density of the South African woods that may be used for the purpose.

The cutting of firewood should be limited, if possible, to dry wood not serviceable as timber. Green firewood ought only to be taken when there is not enough dead wood, and the cutting should be limited to species that are not specially reserved by the Forest Law. The present tariff need not be modified ; it stands thus :

- (a) Cutting firewood in Crown Forests per wagon load, sixteen shillings ; per cart load, six shillings.
- (b) Collecting dead wood, per wagon load, five shillings ; per cart load, two shillings.

GRAZING.—The extent of Crown land reserved near some of the Natal forests is not sufficient for their working ; which may prove very inconvenient. There is no remedy, but the evil may be palliated to a certain extent by declaring Native reserves and Locations liable to a servitude of grazing, for cattle employed in the working of the Crown or Trust forests, in the same way that they are now liable to the servitude of outspan : provided that an equitable payment, regulated by tariff, be made to the Natal Native Trust, in return for the privilege. Commonages should also be turned to account in a similar manner. At the Cape, the Forest Act fixes a charge of one penny per day per head of cattle, and a limit of five days, for the depasturing of cattle on any commonage under the control of a Municipality, or Village, or other Board of Management.

Where, as in some of the Drakensberg forests, the grazing land included in reserves would exceed the present requirements, the grazing of cattle should be allowed at a certain charge per head, per month ; or, when it is more convenient, the grazing may be let by the area, for periods of one year, as in the present system of Grazing leases.

ROADS AND TRANSPORT.—A good system of forest roads is an important condition of forest management. When constructing new roads in forest districts, the forest requirements should be taken into account. Roads are now required to provide access to the forests between the Umzimkulu and the Gwangwane, and to those near the sources of the Umtamvuna. Forest roads are made narrow, and with heavy gradients (1 in 8 to 1 in 10 in difficult places), on the score of economy.

It is not sufficient to construct roads ; they must also be kept in good order. The best and cheapest way to maintain them consists in repairing at once the smallest damage, and it is necessary to authorise the forest guard to hire natives for the purpose, whenever the roads become damaged, and to supply him with a small stock of the tools required for working.

A clause in the Forest Law should provide for the establishment of rights of way over private property, by arbitration or otherwise.

SUPERVISION OF THE FORESTS.—To carry out the protection and management of the native forests, a staff of forest guards will be required ; they should be chosen among working men of a superior class, and receive salaries varying from £8 to £12, according to their grade. Each forest guard ought to provide himself with a horse, but should be supplied with uniforms, and allowed quarters, garden land, and grazing for a limited number of head of cattle. His duties would be to patrol the forests which he is placed in charge of, to report the forest offences that come under his notice and prosecute the offenders, to issue licenses, to collect and pay in forest revenue, to keep the necessary forest books and send in returns, to mark sections, stamp timber ; to assist in making and repairing roads, fences and plantations, in the surveys and demarkation, and generally in all work connected with the Forest Department. Forest guards should have police powers under the Forest Law, and authority to impound cattle trespassing within Crown forests ; they cannot be allowed to engage in farming or in any other occupation outside their duties.

In the Cape Colony, the buildings for forest guards have usually been made of wood, but it is found that more substantial and convenient houses may be built of raw brick at a not much greater cost ; and the wooden houses are now gradually replaced by raw brick or sod houses. The forest-guard is expected to assist in the construction of his quarters. The cost of each house averages £50.

The proper location of the forest stations is a matter of importance, determined by the extent of the forests, the amount of work, the position of the nearest centres, &c. The supervision may become defective owing to the insufficiency of the staff, or to the bad arrangement of the ranges. The extent of the ranges would vary from 4,000 acres downwards. If all the Natal forests were worth opening, more than a dozen guards would be required, but at present about eight may prove sufficient. They should be distributed thus :—

1. Umtamvuna and Border Forest. Extent of range, 2,500 acres.
2. Ingeli forest, 3,800 acres.
3. Forests between the Gwangwane and the Umzimkulu, 7,350 acres.
4. Forests near Dronk Vlei, 4,400 acres.
5. Forests near Polela, 4,200 acres.
6. Forests near the sources of the Tugela, 6,000 acres.
- 7, 8. Forests in Newcastle Division, two guards for 9,000 acres.

The other forests should be all closed for the present. Their protection may provisionally be entrusted to supervisors, as in the present system. These supervisors should be paid about £24 a year ; their duties would consist in protecting the forests and reporting and prosecuting forest offences. They should not be allowed to issue licenses except for dry firewood. The following forests may be protected in that manner :—

1. Mount Prospect. 2. Hlatikulu. 3. Fort Nottingham. 4. Lower Umzimkulu. 5. Dimbunkulu. 6. Alexandra County.

The Hlatikulu forest contains much Hard Pear, which it might be profitable to cut for sleepers. In this case another forest guard would be required there in place of a supervisor.

Some of the remaining closed forests might be placed in charge of the Natal Mounted Police. Detachments of this force are often stationed near the forests, and if their services can be made available for the purpose, the forests would probably be better protected than they could be by supervisors. The Natal Mounted Police have already charge of some forests near Ulundi.

Generally, it should be the duty of every Magistrate, Justice of the Peace, Police or Forest or other officer, to report and repress forest offences.

GAME PROTECTION.—Forest guards can afford valuable help in this respect. Game should be protected in the reserves not only *per se*, but also on account of the damage done to the forest by abusive hunting. Native hunting parties are especially destructive ; they are often followed by forest fires and other offences. The Forest Department should have control of the shooting within the forest boundaries, and none would be allowed without permission. Forests which are demarkated and protected, constitute very useful preserves for game, and it is instructive to see how at the Knysna, where the forests have been protected longest of any in South Africa, there are still elephants, buffaloes, and a large variety of other game, to be found side by side with a considerable population. Where protection has not extended, as in Kaffraria and Natal, elephants and buffaloes have long since disappeared, and other game is becoming very scarce. The provisions of the Forest Law relating to game need only apply to demarkated forest, as it is neither expedient nor possible to enforce them elsewhere.

PISCICULTURE.—The Forest Department may sometimes be able to undertake, as in France and Germany, fish culture in the forest streams. The forests are generally distributed about the headwaters of the principal streams of the country, and specialists give it that it is best to stock streams from their source. The introduction of trout and salmon in some of the Cape rivers was lately contemplated by the Forest Department there, and in the absence of a special staff, it is the most convenient and effective arrangement. There is some reason to fear that in Natal, valuable species of cold climates, such as salmon, cannot find a congenial home in the warm waters of the country, but if they do, it will be in the cooler streams of the forests, where the temperature is least, owing to the altitude and the shelter.

FOREST METEOROLOGY.—The forest stations scattered over the country, would be convenient as meteorological stations. Observations taken in towns are not seldom unsatisfactory, owing to artificial conditions, and those secured at different points of the country, by a set of intelligent observers, subject to regular supervision, would be of much value. The want of data regarding the meteorology of the upper districts of Natal is seriously felt whenever any information is required concerning the climate. In this respect, Natal is behind most other portions of South Africa.

NATIVE LOCATIONS.—The management of the forests on native locations would be generally similar to that of the forests on Crown Land, with the difference that they would be managed for the benefit of the Native Trust. The more important forests would be demarkated and the remainder classed as undemarkated forest. Usually, the forest guards in charge of Crown forests could also supervise those on locations, and I am of opinion that separate appointments need not be made. The Native Trust might contribute towards the salary of each forest guard who would perform the dual duties, in proportion to the relative extent of the Crown and Location forests in his range.

THORN BUSH.—The diminution of Thorn forests may be ascribed to the firing of the grass, as it prevents the growth of the young plants that would have replaced those cut down. The prohibition of burning over certain areas, might thus have the effect of allowing the growth to recover in time. Mr. R. Topham states, in the Report of the Forest Commission of 1880, that twenty-five years would be required, and adds: "I form this opinion from a good example that has been under my care, and properly protected for fifteen years. In 1864, it was three-quarters of an inch in diameter, and thirty inches high: it now (July, 1879) has three stems together, diameter (three feet from the ground) 18 inches." Elsewhere the Commission reports that "Instances are on record that where plantations of the ordinary *Mimosa*, laid out artificially by sowing the seed in cultivated lands, and protected from grass fires, attained growths of seven inches in diameter, and the heights of ten or fifteen feet in ten years. The yield of an acre of ground in that time being about fifty tons, would be worth about £50 as ordinary colonial fuel." The bark of most of the species of *Acaciæ* is valuable for tanning, and should not be wasted when the trees are cut down for firewood. Licenses should be issued at the different Magistrate's Offices, where there are no forest guards or supervisors, for cutting green firewood in thorn bush, and the license fee should not be less than ten shillings a load. The Thorn Bush could best be protected by the detachments of the Natal Mounted Police stationed over the country, who could prevent unlicensed felling, the clearing of bush for cultivation, and the firing in some cases.

COAST FOREST.—There is very little Coast forest on Crown land. Its management can be simplified and would consist of: (a) the survey of each reserve; (b) the cutting of the trees over one foot in diameter, on one-fortieth of the area each year. The growth

of the species composing Coast forest appears to be generally more rapid than that of the species in timber forests, and as besides the trees do not attain large dimensions, the rotation may be short. The protective measures applicable are the same as those for High Timber forests, but they would be carried more or less thoroughly according to circumstances. The Coast reserves should be placed in charge of supervisors till they can be taken over by forest guards and opened at a profit. At present, one supervisor between the Umzimkulu and the Umtamvuna would be perhaps sufficient.

PLANTATIONS.

After the first year, devoted to saving what is left of the Natal forests, the work of afforestation should become the main object of a Forest Department in Natal. In the meantime, land could be secured and all the necessary arrangements made for an active start the following season.

For the same reasons which make it desirable that forests should be managed by the State, it is also expedient that the Government should carry the work of planting, without relying on private enterprise to the same end, even partially. The system of fostering tree planting by premiums or remission of taxes, has never been found to work in practice. Only very high premiums have any effect, the work is done badly, without unity of method, and the results are questionable. Then once the forest is created, there is no more guarantee that it will be maintained than in the case of Native forests. Still, the Government may encourage and facilitate tree planting, by arranging for the distribution of seeds and plants from convenient centres, at a nominal cost.

This is done, at the Cape, by distributing seeds and plants from the Government nurseries; but here, it would be preferable to arrange for their distribution from the Durban and Maritzburg Botanic Gardens, which are more readily accessible to the public, and where a larger selection might be more easily kept without interfering, as it would in the Government nurseries, with the main work of re-foresting. But there are valuable species that could only thrive in a climate colder than that of Maritzburg, and for which a station at a greater altitude is required; the difficulty could be met by adopting Sir Theophilus Shepstone's excellent suggestion to create a third garden up country; or else, a simple nursery attached to one of the Government plantations up country might suffice for the purpose.

The choice of the species to be planted will be influenced by the requirements, the climate, and the soil.

At the outset, a much vexed question presents itself: whether it is better to propagate indigenous, or exotic, trees. Some contend that exotic trees never form a true forest

capable of freely regenerating and perpetuating itself by natural means. This appears to be an extreme view, only true of species introduced from a dissimilar climate. When the climatic conditions are favourable, exotic trees may become acclimatised ; that is to say that if the species is not already fully adapted to the climate and the soil, it produces a better fitted variety, after a number of generations. Natural reproduction by self-sown seedlings is the test of acclimatisation ; thus the *Syringa*, though not indigenous to the country, reproduces itself freely, and is found apparently wild in some parts of South Africa.

If we want to plant trees for their climatic effect, there is no doubt that it is preferable to use native species, which have taken ages to adapt themselves to the circumstances and climate of the country, and fulfil at present their function better than any substituted foreign species possibly could. Though even then, a plantation will take centuries to produce that thick carpet of hygroscopic soil which gives so great a value to the natural forest ; and the conservation of the latter will thus be of greater general utility than the creation of even a larger area of artificial forest.

But if we want to grow trees for the sake of timber, there is no advantage in restricting our choice to the native species. Many exotic species have already been found by experience to be admirably suited to the country or its climate, while among our woods, few have been proved to be of sufficiently fast growth to be cultivable at a profit, and their culture should, at first, be undertaken on an experimental scale only.

The native kinds of wood that should be tried in plantations are : Outeniqua Yellowwood, Stinkwood, White Pear, Hard Pear, and Sneezewood. Outeniqua Yellowwood appears to be of moderately fast growth, and as a lumber-wood, it is the best we have. The other woods are all harder. Stinkwood is an exceedingly valuable species, of fast growth, and reproducing itself freely both from seed and shoots or suckers ; the wood is adapted to almost every use. White Pear is a hard close-grained wood also of fast growth, much sought for wagonwood. Hard Pear and Sneezewood do not appear to be of very slow growth, and both yield hard woods, almost indestructible, that are highly esteemed in South Africa.

INFLUENCE OF CLIMATE ON THE DISTRIBUTION OF TREES.—In introducing exotic, or even indigenous, trees, in new regions, it is essential to choose species suited to the climate. The influence of climate, on trees, is much greater than that of soil, and many species which will thrive in almost any soil and with varying supplies of moisture, can only grow in a zone with certain definite conditions of temperature. There is for each species a central climate where it flourishes best, the fertility of the soil and the supply of moisture being otherwise equal ; as it recedes from this central climate, either through changed latitude or elevation, it becomes gradually more stunted and scarce ; and finally disappears beyond certain limits which determine the geographical and altitudinal range

of the species. Thus the common Oak which in England reaches its best development in Sussex and in Hampshire, dwindles down to little more than a shrub in North Africa or on the mountains of Scotland ; the decline being due in the one case to excessive heat and in the other to extreme cold. In Natal *Pinus insignis* is of comparatively slow growth at low elevations ; and *P. Austriaca* and other trees of cold climates grow stunted even so high up as Howick. Some Gums which thrive exceedingly well in the Midlands cannot grow in the Drakensberg. Again, *Cupressus macrocarpa* thrives better, at high elevations, than *C. Lusitanica*, while the reverse is the case at low altitudes.

The distribution of mean temperature over a country is influenced by latitude and by altitude. Temperature decreases rapidly as we ascend from sea-level, so that if we wish to eliminate the effect of altitude in comparing temperatures observed at stations differing in height we must reduce the observations to sea-level. The rate of decrease varies considerably in different countries and localities. Ferrel (*) gives values of this rate ranging from 0.450°C in Mexico to 0.720°C in Hong Kong, but these are extreme cases, and a mean of 0.552°C per 100 metres, or 3.03° Fahr. per 1,000 feet, represents, accurately enough for practical purposes, the average decrease of temperature with altitude over the globe.

Map III., taken, in part, from Scott's *Meteorology*, shows the course of the isothermal lines for mean temperatures of 50° , 60° , 70° and 80° . Now, adopting a normal rate of decrease of 3° Fahr. per 1,000 feet, we may find what the mean temperature would be at any altitude along each of these lines, and the following table gives some of the values :

Line marked :	Mean Temperature			
	At sea level.	at 3,333ft.	at 6,667ft.	at 10,000ft.
80°	80°	70°	60°	50°
70°	70°	60°	50°	
60°	60°	50°		
50°	50°			

Thus, along the isotherm for 70° , which crosses Natal, the mean temperature is 60° at 3,333 feet, and 50° at 6,667 feet. If we know the geographical and altitudinal range of any tree, we may see, by inspection, which is the mean temperature which it affects. And if we know also the distribution of temperature over Natal, we can tell what zone is the most suitable for the growth of the species. The Table forming Appendix VIII. gives, for some exotic species, the altitudinal range which would correspond, in Natal, to their natural habitat.

The distribution of temperature over Natal cannot be derived from the few direct observations that have been hitherto taken. But the heights of a great number of points are known ; and using a decrease of 1.5° Fahr. for an increase of 1° in latitude, and a

* *Recent Advances in Meteorology*, Washington, 1886, p. 180.

MAP SHOWING THE AVERAGE LAND ELEVATION IN NATAL.

Plate III.

ISOTHERMAL LINES SHOWING THE MEAN TEMPERATURE FOR THE YEAR REDUCED TO SEA LEVEL.
Plate IV.

ISOTHERMAL LINES SHOWING THE PROBABLE MEAN TEMPERATURE OF NATAL FOR THE YEAR.

decrease of 3° per 1,000 feet altitude—which agree best with South-east African observations—we may get for each point, in the absence of more direct data, an approximation to the temperature, which cannot be very inaccurate in a small stretch of country like Natal. In this manner, the isothermal lines shown on Map IV., have been deduced from the configuration of the ground shown on Map II.

Map II. shows the average height of the land, in Natal. It was constructed by plotting all the reliable observations of altitude that could be got. The heights of many points were given accurately by the railway surveys, and by Major Morris' trigonometrical survey; the heights of other points were found by correcting the barometrical observations available, including those of Major Grantham and Dr. Sutherland, in proportion to the error shown by observations of the same series, at points of which the height has since been fixed by survey. From a knowledge of the topography, the average heights of the different portions were then deduced. They are shown on the map by contour lines giving the mean elevation every thousand feet.

The Durban observations of temperature for 1884-1888, give a mean value of 69.7° Fahr. reduced to 70.4° at sea level. The Maritzburg observations taken from 1858 to 1866 by Dr. Mann, give a mean of 64.6° reduced to 70.8° at sea level at Durban. A mean of 70.6° has been taken to represent, for Natal, the mean temperature at sea level in the latitude of Durban.*

The distribution of temperature, derived from this value, is sketched in Map IV. The isothermal lines here represent actual, not reduced temperatures as in Map III. above. But for places of known height, it would always be preferable to reckon the mean temperature independently, with the aid of the data given. Comparing Maps I. and IV., it may be seen that the distribution of forests nearly follows that of temperature, the coast region being limited by the isotherm for 67° and the Midland region by that for 59° .

The isothermal lines for 70° , shown on Map III., cross the countries which have a mean annual temperature equal to that of Natal, and where corresponding climates will be found at corresponding elevations; it is to these countries that we must chiefly look to, to find trees suitable for Natal. In the northern hemisphere, the curve for 70° cuts both coasts of North America near the 30th parallel, bending inland towards the central plateau; then crosses the Atlantic, follows the coast regions of Morocco, Algeria, and Tunis; thence across the Mediterranean to Syria; inflecting northward, it crosses Central Asia along the 37th parallel, re-descending to 29° Lat. to leave the coast of China and pass south of Japan. In the southern hemisphere, the corresponding curve, leaving Natal, touches the southern point of Madagascar, and cuts the centre of the Australian continent at 24° Lat.; in South America, the West coast is crossed at 14° Lat., and the curve then descends along the Andes, to leave the East coast near 30° Lat.

* It is to be regretted that longer series of meteorological observations should not exist in Natal. The latter Maritzburg (Botanic Gardens) observations have been taken without standard instruments or methods, so that they are useless for purposes of comparison; the exposure of the thermometers is defective, and would probably affect the readings to a considerable extent.

The zone, the centre of which is thus marked, has for its extreme polar limits the isotherm of 50° , near which only those trees that grow at sea level may be planted with some chance of success in the highest mountain regions of Natal. There is no real tropical limit; along the 80° curve, those species which naturally ascend to several thousand feet may still succeed in the coast region here; but beyond, the difference in altitude of corresponding climates would become very great. Thus, mountain species of the colder zones and coast species of the warmer, could not succeed in Natal. For instance, it becomes apparent that Teak, which grows in India up to 3,000 feet, could only be grown, on the Natal coast, in conditions corresponding to those of the very verge of its habitat in India, and with small chance of success. Teak requires a mean temperature of 75 to 81° , with a rainfall of over 50 inches, while here, the mean temperature only reaches, in Durban, 70° and the rainfall 41 inches.

The forest vegetation along the belts indicated, is so rich and varied that I have confined myself to a mere enumeration of the more noticeable species to be found in each region, which forms Appendix VII. This "Note" may serve as a guide for the selection of species to experiment with in the future, and detailed information about each, may be found in Sir F. von Mueller's *Select Extra-tropical Plants readily eligible for Industrial Culture and Naturalization*, a work very useful to the planter of exotic species.

CHOICE OF EXOTIC SPECIES.—The cultivation of a large number among the great mass of species which may prove adapted for forest culture in Natal, would be not only unmanageable, but also quite unnecessary. In Europe, half a dozen kinds of Conifers and a dozen of hardwoods supply, with the exception of showy cabinet woods, such as can only grow in the tropics, a sufficient variety of timber for all practical purposes. A sufficient number of valuable species have now been successfully introduced in Natal to dispense with the necessity of conducting risky experiments on a large scale, if we wish to undertake plantation work. Other less well known species may be tried from time to time, but it is unlikely that we shall ever discover timber trees preferable to the principal Gums of Australia or Pines of the northern hemisphere.

The timber requirements of a country should determine the kinds of trees to be planted. Statistics show that more than nine-tenths of the timber used in the world is derived from Coniferæ. Their resinous timber can be obtained in convenient sizes and straight logs; it is easily worked, moderately durable, and can be grown rapidly enough. Hardwoods, on the contrary, are too heavy and difficult to work, to be used extensively for ordinary purposes. The cultivation of Conifers should therefore be the main object of a comprehensive scheme of planting, aiming at general utility. Hardwoods are, however, also required, and it is often only on account of their great scarcity that they are not used in the place of soft woods. In Australia, where hardwoods form the bulk of the forests, they are used more extensively than elsewhere, but that they are not sufficient for

all purposes is shown by the fact that New South Wales and Victoria alone import a million's worth of soft woods, on an average, every year. I consider that the culture of a relative proportion of hardwoods larger than is warranted by the present consumption, but still moderate, would not be injudicious ; for instance, a proportion of three or four times more pine-wood than hardwood might be observed.

The best conifers to grow are Pines and Cypressess. *Pinus insignis* has been found to be the fastest growing conifer, not only in Natal, but wherever it has been tried in temperate climates : at the Cape, in Australia, on the Nilgiris in India, and in California ; the timber is reported to be quite as good as that of many of the ordinary species of pine,* and there appears to be no reason why it should not be grown as the dominant species in Natal pine plantations.

The best hardwoods for profitable culture are undoubtedly the Gums of Australia, Some are of extremely rapid growth and produce strong and durable timber of great economic utility. Foremost among their number ranks the Blue Gum, a tree that has been now successfully introduced in most of the temperate countries in the world. Sir F. von Mueller writes in his *Atlas of the Eucalypts of Australia* : " The rearing of forests of our Blue Gum-tree can be accomplished more cheaply and more easily than that of almost any other tree, while the return is twice or three times earlier than that of the most productive Pine or Oak forests. . . . It is not too much to assert that among rather more than one thousand different species of trees indigenous in Australia, *E. globulus* takes the first position in importance, and among its own kinds it is the Prince of Eucalypts."

The Conifers, Gums, and other woods recommended for industrial culture are noticed in Appendix VII.

SELECTION OF LAND.—There is no common elevation at which many kinds of Conifers and of Gums can be planted. To grow both best, it will be necessary to procure land at different altitudes : at about 5,000 feet for conifers, and at about 3,000 feet for Gums. Hence there should be two classes of plantations, which may be designated Pine plantations or Gum plantations, according to the dominant species, though neither need consist exclusively of Gums or Pines.

Other favourable conditions that should be sought in land destined for planting are the following :—

1. A copious rainfall.—In the absence of observations, this is indicated by the growth of the native timber forests. These become comparatively stunted as we travel northward, beyond the south-eastern crests of the plateau shown by the contour line for 4,000 feet in Map II. The best regions thus indicated are the Ingeli, and parts of the Ixopo, Polela, and Lion's River Divisions. On the high land further up country, such as the Biggarsberg, the rainfall is probably much scantier, because the intervening hills

* The properties of the wood are given in Appendices II. and VII.

forming the south watershed of the Tugela despoil the damp air driven inland of much of its moisture, beforehand, by dynamic cooling; the greater aridity of the northern districts is moreover well known.

2. Hilly ground with a favourable aspect.—South and south-eastern slopes are the best for forest vegetation, as they receive and retain the most moisture. Hills have the advantage, besides, of securing drainage—often an important factor in determining the growth of trees.

3. Good soil.—As regards forests, the physical properties of a soil are of greater importance than its composition, and deep, hygroscopic soil, moderately fertile, is preferable to rich, shallow soil.

4. Proximity to markets.—The cost of transport of timber from the forest to a market exceeds, as a rule, its standing value in the forest, and as the cost of transport is reduced, the standing value of a crop of timber increases rapidly. Timber is more bulky in proportion to its value than any other produce, and considerations of transport are of even greater importance in forestry than in farming. For this reason, it is preferable to make plantations in Natal, not far from a line of railway. In India, plantations are made in this way, at intervals of 80 miles, along some of the lines, and in the Cape Colony and the United States a similar plan has been adopted. When suitable Crown land is not available, private lands should be repurchased for planting purposes. It would be false economy to restrict planting to Crown land, because in Natal the purchase of land would increase the final cost of planting only by a small fraction, while it may be the means of largely augmenting the returns. Thus, of two plantations, one on Crown land on the Biggarsberg, and the other on purchased land, say in the Lion's River division, the second should be expected to return a better interest on the outlay than the first, on account of the faster growth of the timber. In Europe, it is customary to reserve for planting, only the barren mountain lands that are unfit for agriculture, but this choice is in a great measure due to the fact that the plantations are undertaken mainly for climatic purposes, the interests at stake being large enough to warrant the execution of works to this end; land is also far more valuable than it is here, and therefore a more important factor in determining the cost of a plantation. By purchasing private lands, the advantage may result, that buildings are available and less delay is experienced in starting work.

The extent of each plantation should be not less than two thousand acres, as this is a convenient size for a forest managed according to the rotation principle, and to give sufficient work to one head forester entrusted with the execution of the planting. It may be greater, with advantage, and I should not recommend that more than two plantations, one of Conifers and one of Gums, be undertaken to start with; each can be made as large as necessary, and it is preferable to organise work on a large scale at one

or two places, than to pother ineffectually on many points at once. By concentrating the work a great saving will result in many details as well as in the management. Attempts have often been made to combine the supervision and management of native forests with a system of planting, by forest guards, but the results have been of the poorest order. It is best to adopt a division of labour, and keep the plantation work quite separate, and entrusted to separate agents.

Taking into account the circumstances of the Colony, I should say that it would be reasonable to plant out annually an area of five or six hundred acres. Once the area to be planted each year is decided upon, it should be adhered to without modification, until the first section planted is fit to be felled ; a regular yield for succeeding years, and the future of the forest then become assured. Before commencing planting, the ground should be surveyed and a working plan drawn, showing the limits of each year's work and the roads to be made. The working plan should be very carefully considered before being adopted, as once the work is begun any departure would give future trouble in the management. Its aim should be to create a forest composed of trees of graduated age-classes, disposed in the most advantageous manner for working, for removing the produce, and from a cultural point of view. There are certain rules relative to the location of cuttings in natural forests, which also apply to plantations.

In each Series, every tree being subject to the same rotation, it is necessary to choose for planting, species which do not differ too widely in their rates of growth. The species grown side by side should also be capable of thriving together, which is not always the case. Trees that are naturally associated should be mixed in plantations. Thus *Cupressus macrocarpa* is best mixed with *Pinus insignis*, and some of oaks, pines and cypresses may be usefully associated. Many trees of the first importance are seldom found together, but with some discrimination it is possible to group species that are the most likely to thrive in company. For instance, if there are to be three Series in the Pine plantation, and one in the Gum plantation, the first Pine Series might consist of American fast growing conifer and deciduous trees : *Pinus insignis*, *Cupressus macrocarpa*, *Chamæcyparis Lawsoniana*, *Catalpa speciosa*, *Liriodendron tulipifera* and *Populus monilifera* ; the second Series, of slower growing trees such as *Pinus Cedrus*, var. *Deodara*, *P. excelsa*, *P. Canariensis*, *P. Massoniana*, *Quercus alba*, *Q. robur*, var. *pedunculata*, retaining *Populus monilifera*, to help, with the oaks, to minimize the risk from fires ; and the third Series, of trees, also moderately fast-growing, but preferring a warmer climate, such as *Pinus longifolia*, *P. Pinaster*, *P. -Pinea*, *P. Halepensis*, with *Quercus cerris*, *Q. alba*, *Q. robur*, var. *pedunculata* and *Populus monilifera*, as a protection against fires. The Eucalypt Series may consist of the principal Gums : *Eucalyptus globulus*, *E. amygdalina*, *E. diversicolor*, *E. Leucoxydon*, *E. longifolia*, *E. marginata*, *E. obliqua*, *E. robusta* and *E. rostrata*. It would be well to try whether some of the naturally

associated Conifers such as *Araucaria Cunninghami*, *A. Bidwilli* and *Dammara robusta*, do not grow fast enough for mixed culture.

PRODUCTION OF WOOD.—In the case of Gums, the rate of growth may be ascertained accurately, as there are sufficiently old plantations of the kind in Natal. Mr. Topham's plantations near Maritzburg may be taken to be a fairly average one. The oldest plot, 40 acres in area, is 17 years old and consists of mixed *Eucalyptus globulus*, *E. longifolia* and *E. rostrata*, the rate of growth of each appearing not to differ widely. The trees are planted 12 feet apart, so that there are 302 to the acre; they average 4 feet 10 inches in girth at three feet from the ground, and 115 feet in height. Adopting the form factor of 0.450, deduced from Mr. D. E. Hutchins from measurements in plantations on the Nilgiris*, the contents of each tree average 96.3 cubic feet and the standing stock per acre 29,083 cubic feet, representing a yearly increment of 1,711 cubic feet per acre. The weight of a cubic foot of *E. globulus* (dry wood with bark) averages 40 lbs., equal to 56 cubic feet per ton, according to Mr. Hutchins, and the average density of the wood of the other species differs so little that it may be taken as being the same. The annual increment in tons of dry wood per acre is thus 30.5 tons, and this is a marvellous rate of growth. Individual trees even greatly exceed this rate, one specimen of the *E. longifolia*, 17 years old, being 12 feet 6 inches in girth at three feet from the ground, and 115 feet in height. In India, the rate of growth of *E. globulus* averages in seven plantations on the Nilgiris 11.24 tons of dry wood per acre, per year.

We may take a yearly acre increment of 1,000 cubic feet to represent the average growth, in Natal, of the faster growing Gums. This growth corresponds to an increase in diameter of about an inch a year, when the trees are planted 12 feet apart, a rate which is exceeded at Howick and elsewhere.

Data respecting the growth of *Pinus insignis* are insufficient to make it possible to form a conclusion as to the average rate of growth. Individual trees, partially isolated, grow at Howick at the average rate of nearly 6 inches in girth a year, attaining a height of 45 feet in 10 to 12 years.

MONEY RETURNS.—From a financial point of view, a forest or plantation may be regarded as capital returning an annual yield of wood, in the same way that a sum of money produces interest. The highest return is secured by adopting the rotation which gives a highest prospective value to the forest, this consisting of the present value of all sums receivable in the future, less the present value of all sums expended or to be expended.

Taking the case of a plantation of mixed Gums, 2,500 acres in extent, and adopting for the calculation of present value, a rate of interest of three and a half per cent., which is the current cost, to Government, of money borrowed, the outlay will consist of the sum of :

* D. E. Hutchins, *Report on measurements of the growth of Australian trees on the Nilgiris*, Madras, 1883, p. 15.

A. The present value of the land, at £1 per acre, including buildings, it will amount to £2,500.

B. The capitalized value at $3\frac{1}{2}$ per cent. of the cost of cultivation in perpetuity. If the period be n years, the n th part of the area will be planted every year, and if the cost be £4 per acre (including the total cost of management, works, nurseries, &c.) the yearly expenditure will be £10,000/ n , representing an initial outlay of £285,714/ n . This is assuming that on account of the shortness of the period, or imperfect acclimatization, natural reproduction will not take place, and the cost of re-planting will have to be incurred in perpetuity.

C. The capitalized value of the cost of maintenance in perpetuity; this may be estimated at 2s. per acre of the total area, per year, representing a capital value of £7,143.

The total capitalized value S , of all present and future outlay is therefore :

$$S = £9,643 - £285,714/n,$$

the actual values for different rotations being :

$n=25$ years	..	...	...	$S=£21,072$
30 „	...	...	...	19,167
35 „	...	...	...	17,806
40 „	...	...	...	16,785
45 „	...	...	...	15,992
50 „	...	...	...	15,357
55 „	...	...	...	14,838
60 „	...	...	...	14,405

From the n th year, when all the n compartments are stocked, the plantation will yield in perpetuity 1,000 cubic feet per acre per year—that is, 2,500,000 cubic feet—one-fifth being deducted for tops and branches, leaves 2,000,000 cubic feet of logwood, which barked and squared would yield 1,000,000 cubic feet of marketable wood. Owing to the proximity to markets, this should be worth at least sixpence per cubic foot, standing.* The revenue from the n th year would thus amount to £25,000, representing a capital of £714,286, the present prospective value R of which is, at $3\frac{1}{2}$ per cent., for different rotations :—

$n=25$ years	...	...	...	$R=£287,731$
30 „	...	...	...	254,500
35 „	...	...	...	214,286
40 „	...	...	...	180,429
45 „	...	...	...	151,929
50 „	...	...	...	127,929
55 „	...	...	...	107,714
60 „	...	...	...	90,643

* In Australia, at Melbourne, the wood of gums is worth from one shilling and sixpence a cubic foot, upwards.

To this must be added the prospective value of thinnings, estimated to yield 80 cubic feet per acre from the twelfth year, worth 0.1s. the cubic foot ; giving from the twelfth year 200,000 cubic feet a year, worth £1,000 ; or a capital value of £28,571, and a present value of £18,908. Thus, after the twelfth year, thinnings may almost pay the interest on the outlay incurred on the plantation.

I do not pretend that these figures will be realised in practice, and they have been given chiefly as an example of the financial conditions of a plantation. However, the result is remarkable, because it has been arrived at by using the at present most probable data. It often seems in the nature of an estimate to be unreliable ; but in the case of our Gum plantation we may double the cost of production and halve the returns, and yet find a wide margin between revenue and expenditure. I have no hesitation in saying that the cultivation of Eucalypts would repay much more than the outlay. In Europe, forests barely return three per cent. on their cost, or their value ; but here the conditions are quite different : the land has a smaller value, the species proposed to be planted grow much faster, and the produce has a greater market value. The growth of trees generally, in Natal, is indeed not surpassed by that in any other part of the world, that I am aware of ; and South Africa, being one of the most poorly regions in the world, with a rapidly increasing population, markets close at hand will always be found for a large quantity of timber.

Comparing the estimated returns on outlay that are given above, for a Gum plantation, we see that a short rotation is the most profitable. As with timber from the native forests, large pieces of timber from plantations would not command in South Africa a much greater price than smaller logs suitable for cutting into lumber of small dimensions. Taking into consideration the greater loss arising in cutting up small logs, the maximum usefulness is attained when they reach a diameter of 2 feet ; which, for Gum plantations, means a period of 25 years. To allow for the risk of destruction by fires, &c., it will be preferable to adopt a period of 35 years ; which can be done at the end of 25 years' when the whole series will have been planted, by cutting over only $\frac{1}{35}$ th of the area every year, instead of $\frac{1}{25}$ th.

By lengthening thus the rotation, other advantages follow : a kind of reserve fund is provided to meet sudden large demands for timber ; and the smaller trees which are always found in the most regular growth, will have become large enough to be converted into any ordinary lumber. It is true that the yield will now vary, but it will vary uniformly, increasing progressively with the demand. The timber will become gradually larger, more serviceable, and of better quality ; and possibly the trees will be old enough to secure natural reproduction from the second period. In a country destitute of timber, it is admissible to begin, in this manner, on a financial rotation and gradually work up to a rotation giving the maximum return in timber.

CROWN LAND FOR PLANTING.—Though the planting work ought to be centralised at a couple of points to begin with, other pieces of Crown land should be reserved in suitable spots to provide for future afforesting on a larger scale, as the country becomes more densely populated, and its resources increase in proportion. And when the work on the Native forests and on the Gum and Pine plantations has become fairly organized, it would be well to start a small plantation in the Coast districts, more as an experimental station than as a source of revenue, where important plants of the tropics may be tried on an industrial scale.

METHODS OF PLANTING.—The most approved methods for the formation of plantations and forest nurseries are described in Bagneris' *Elements of Sylviculture*; and a pamphlet by Mr. J. S. Lister on *Tree planting in the Cape Colony* embodies the results of special experience in the fine Western Province plantations. It would be out of place, in a preliminary Report of this kind, to enter into details of plantation work. Generally, planting is to be preferred to sowing *in situ*, and a nursery is required, in each plantation, for raising the plants. Planting is the more certain process and not more expensive if the plants are put out young enough. It is now admitted that the younger the plants the greater the chances of success, and at the Cape, trees are usually planted when they reach a height of four to six inches. Transplanting before planting out, is useful with most species, as it causes the formation of a good bunch of roots which render the plant hardy. The nursery requires to be made in good ground not too rich, and a stream should be close at hand for watering the plants. The soil should be well cultivated and cleaned, which is conveniently done by raising a crop, of mealies or potatoes, that requires hoeing and weeding. A fence is necessary round the nursery, if not round the plantation. The making of nurseries will imply an additional outlay during the first year; or else the planting may be made less than in the succeeding years.

PLANTATIONS OF INDIGENOUS TREES.—The culture of indigenous trees is at present too uncertain in its results to be undertaken on the same scale as that of some exotics. It will be useful for regularising the forest boundary in every demarkated forest. Glades and tongues of grass land running into the forest are numerous enough to afford work for many years to come; but the planting should at first be limited to that which may be done by forest-guards whenever leisure serves, and only a small expenditure should be allowed for the purpose.

In addition, a Series may be formed near one of the forest stations, for the culture of the indigenous species that have been recommended as being specially valuable, namely, Outeniqua Yellowwood, Stinkwood, White Pear, Hard Pear, and Sneezewood. But the work should be deferred until the exotic plantations are organized.

ORGANIZATION OF STAFF.

To carry out the measures which I have recommended for the protection, management, and extension of the native forests, and the formation of plantations, it would be necessary to create a Forest Department. There should be appointed a properly qualified Conservator of Forests to direct the whole. The Conservator being the immediate adviser of Government on forest matters, should have his headquarters at the seat of the Government. Maritzburg is besides conveniently situated as an administrative centre for the Crown forests. At first the Conservator should initiate the executive work, but the proper controlling of the whole system will afterwards require his undivided attention. A clerk would be required in the Conservator's office to take charge of it when the Conservator is travelling or engaged in field work, to keep accounts and generally do part of the office work.

The next most important selection is that of the forest-guards. Upon their efficiency will in a great measure depend the proper working of the department, and no pains should be spared to secure suitable persons. The guards should be picked men, inured to outdoor life, and capable of being entrusted with not only the execution but also the control of details; they should receive special consideration at the hands of the Government, and promotion to different classes at enhanced salaries should be held up as a reward of long and zealous service. I have already given the number and distribution of the guards that are required for the Crown forests, and sketched the nature of their duties. Between the guards and the Conservator, a District Officer, at a salary of say £250, would be required to execute many works that forest-guards may not be fitted to undertake. This officer should have a knowledge of surveying, and his most important work during the first period of the existence of a Forest Department would consist of surveys and demarkation, conjointly with the Conservator.

At each plantation, a Superintendent is wanted to take charge of the work. These officers should have a knowledge of farming, but it is not necessary that they should have any knowledge of forestry. Men of sufficient skill to undertake extensive works unaided cannot be found here at a moderate salary, and it is better to employ men who realise that they need guidance, rather than any who may wish to apply notions of their own which may lead to doubtful results.

SUMMARY.

Having now examined the principal matters connected with Natal forestry, I will end with a summary of the conclusions which I have arrived at:

1. The Natal Forests, more particularly the Timber forests, have been shown to be well worth preserving, whether from an economic or climatic point of view; and the Government alone is competent to undertake the work.

2. The condition of the forests is, for the most part, lamentable, and the result of past abuses ; their destruction is proceeding apace, and the following measures are recommended to ensure their preservation and utilisation to the best advantage.

(a) The survey and demarkation of the principal forests.

(b) Their protection from fires, from depredations, from destruction by Natives or cattle, by means of suitable measures such as the clearing of fire belts, the establishment of small Wattle plantations, the prohibition of wattle cutting and cattle grazing, with the aid of proper supervision and special legislation.

(c) The closure of the forests pending survey, demarkation and settlement.

(d) The adoption of sound methods of forestry to secure a steady yield, improvement of the forest, and most profitable management.

(e) The utilization of Colonial woods for railway sleepers.

3. Plantations of conifers and hard woods, designed to supply the future requirements of the country, can be made profitably along railway lines in the Upland and the Midland districts.

4. The most urgent work of a Forest Department in Natal would be to save what is left of the Native forests, and plantation work should be deferred till it can be undertaken without detriment to the progress of survey and demarkation.

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- (b) Their protection from fires from depredations, from destruction by Natives or cattle, by means of suitable measures such as the clearing of the belts, the establishment of small *Wauke* plantations, the prohibition of waste cutting and cattle grazing, with the aid of proper supervision and special legislation.
- (c) The closure of the forests pending survey, demarcation and settlement.
- (d) The adoption of sound methods of forestry to secure a steady yield, improvement of the forest and most profitable management.
- (e) The utilization of Colonial woods for railway sleepers.

3. Plantations of conifers and hard woods, designed to supply the future requirements of the country, can be made profitably along railway lines in the Uganda and the Midland districts.

4. The most urgent work of a Forest Department in Natal would be to save what is left of the Native forests, and plantation work should be deferred till it can be undertaken without detriment to the progress of survey and demarcation.

H. G. FOURCADE.

APPENDIX I.

LIST OF TREES INDIGENOUS TO NATAL.

In this enumeration, I have followed, for the sequence of the orders and genera, the 'Genera Plantarum' of Bentham and Hooker, and retained for the orders their numbers in that work.

A catalogue of this kind can only be rendered tolerably complete gradually during a period of years, and the present collection of notes taken during the last few months is necessarily wanting in many respects, but it is given in order to provide some source of information about the Natal woods.

The forests were visited by me during last autumn and winter, when very few flowering specimens could be collected for determination. In the Drakensberg forests, many trees were identified from a previous knowledge of the species. In other cases, the determinations were made by comparison with specimens in the Government Herbarium at Durban, and I should like to record my indebtedness to Mr. J. M. Wood, A.L.S., Curator of the Durban Botanic Gardens, for allowing me unrestricted access to the Government Herbarium, and giving me the full benefit of his unrivalled knowledge of the Natal flora.

Some of the genera of Natal plants have not been worked out in a full manner by botanists; and most of the species of *Acacia*, *Celtis*, *Ficus*, and *Cryptocarya* could not be determined.

With the exception of two well-known woods that were not identified, all doubtful or undetermined species have been uniformly excluded.

V.—ANONACEÆ.

1. *Popowia Caffra*, Harvey & Sonder.

Guatteria Caffra, Sond., *Flora Capensis*, vol. I., p. 9.

South Coast Forests, ascending to 3,500 feet at the Ingeli.

A large tree with dense foliage, fairly abundant. Wood not used.

XII.—CAPPARIDEÆ.

2. *Niebuhria triphylla*, Wendland.

Fl. Cap., vol. I., p. 60. Pappe, *Sylva Capensis*, p. 1.

Dutch: *Witboschhout*.

Uitenhage, Eastern Province, Kaffraria, Natal Midlands and Coast, to the Transvaal.

A handsome small tree; diameter 9-15 inches, height 20 feet. Bark greenish, even. Wood light, moderately soft, tough, adapted for felloes, agricultural implements, the lining of furniture, &c.

N. nervosa, Hochst. *N. rosmarinoides*, Sond. *N. pedunculosa*, Hochst. (*Boscia Caffra*, Sond.) and *N. Woodii*, are allied species found chiefly in the Coast forests.

XV.—VIOLARIEÆ.

3. *Alsodeia* sp.

Port Shepstone to South Western Drakensberg.

A small tree, attaining a diameter of 15 inches; coppicing moderately. Wood not used.

XVII.—BIXINEÆ.

4. *Rawsonia lucida*, Harvey & Sonder.

Fl. Cap. vol. I., p. 67.

A small tree found in the Coast forests.

5. *Scolopia Zeyheri*, Harvey.

Phoberos Zeyheri, Arnott, *Fl. Cap.*, vol. I., p. 68. *Sylv. Cap.* p. 2.

Dutch : *Wolverdoorn, Doorn Peer*.

Knysna and the Eastern Province to the North Drakensberg ; in mountain forests.

A tree 40-50 feet high, armed with strong spreading spines 2-4 inches long. Bark light brown-grey, thin, even. Wood very heavy, hard, strong, moderately elastic, close-grained and satiny ; annual rings irregular ; medullary rays very fine and close ; pores white, small, numerous ; colour light red tinged with yellow ; suitable for furniture and millwork ; used for felloes and axles.

6. *Scolopia Ecklonii*, Harvey.

Phoberos Ecklonii, Arnott, *Fl. Cap.*, vol. I., p. 68. *Sylv. Cap.*, p. 2.

Red Pear. Dutch : *Rooi Peer*.

Knysna and the Eastern Province to the North Drakensberg ; in mountain forests and steep ravines.

A tree 40-60 feet high, and 2-3 feet in diameter. Bark thick ; brown-grey and even in young trees, black and fissured in old trees. Wood heavy, hard, strong, moderately elastic, close grained ; annual rings irregular ; medullary rays fine, very close ; pores small, regularly distributed ; colour pale red-brown ; used for axles, felloes, and spokes, and suitable for millwork.

Scolopia Gerrardi, Harvey, is a small species found by Gerrard in mountain forests near the Nonoti River. *Fl. Cap.*, vol. II., p. 584.

7. *Xylosma monospora*, Harvey.

Thesaurus Capensis, tab. 181.

Bogabog. Kafir : *u-Veto*.

South Drakensberg forests ; very common.

A much branching, spreading tree, with dense foliage, 60-70 feet high, 2-3 feet in diameter, coppicing freely. Wood yellowish, not very durable, seldom used.

8. *Dovyalis rhamnoides*, Harvey.

Fl. Cap. vol. I., p. 69. *Sylv. Cap.* p. 2.

Dutch : *Zuurbesjes, Weinbesjes, Appelkoos*. Kafir : *um-Nyezane*.

Knysna, Eastern Province, Natal Upland Region, to the Transvaal.

A large shrub or small tree, attaining a height of 20-35 feet, and a diameter of 2-3 feet. Branches spreading, armed with spines 1-2 inches long ; foliage soft pale green. Bark light brown or greyish, thin, cracked longitudinally. Wood heavy, hard, moderately strong, elastic, very close grained and compact ; medullary rays very fine and close ; pores very small, not numerous, irregularly distributed ; colour white, tinged with yellow or brown ; used for yokes and other wagonwood, and for rural implements.

Fruit small, edible, with an acidulous taste, making excellent preserve.

9. *Aberia Caffra*, Hooker fil. & Harvey.

Fl. Cap. vol. II., p. 584. *Sylv. Cap.* p. 48.

Kei-apple.

Eastern Province, Kaffraria, and Natal.

A small thorny tree resembling *Dovyalis rhamnoides* ; cultivated for hedges. Fruit edible, the size of a small apple.

10. *Trimeria alnifolia*, Planchon.

Fl. Cap. vol. I., p. 69.

Dutch : *Wilde Moerbe, Groot blaar Yzerhout*. Kafir : *i-Dhlebelendhlovu*.

Knysna, Eastern Province, Kaffraria, throughout Natal, to the Transvaal.

A small tree 25-30 feet high, 6-10 inches in diameter. Bark yellowish grey, thin, even. Wood heavy, moderately hard, strong, moderately elastic, close grained and compact ; smaller medullary rays very fine and close ; pores small, irregularly distributed ; colour white to pale yellow-brown ; used for wagonwork.

11. *Kiggelaria africana*, Linnæus.*Fl. Cap.* vol. I., p. 71. *Sylv. Cap.* p. 3.Dutch: *Spiekhout*. Kafir: *i-Mfayenkomo*.

From the Cape Western Province to the Natal Upland Region and the Transvaal.

A large tree 2-3 feet in diameter, 50-80 feet high. Bark yellowish grey, thin, even or angular. Wood moderately heavy and hard, not strong, elastic, compact; annual rings obscure; medullary rays fine and close, the smaller ones obscure; pores small, numerous, distributed singly or in short radial lines; colour pink, tinged with brown; fairly durable, but not much used.

12. *Kiggelaria Dregeana*, Turczaninow.*Fl. Cap.*, vol. I., p. 71.Natal *Mahogany*. Dutch: *Vaterland Rooihout*. Kafir: *isi-Kali*.

Knysna, Eastern Province, Kaffraria, and South Drakensberg. Not scarce.

A large tree, 2-3 feet in diameter, 50-60 feet high, with a straight trunk and compressed crown, coppicing moderately. Bark thin, yellow-grey in some trees, black and rough in old trees. Wood moderately heavy and hard, not very strong, close-grained and compact; rings not apparent; medullary rays close, moderately fine; pores small; colour pink, tinged with yellow; takes a handsome polish, and is esteemed for cabinet-work and furniture.

K. ferruginea, E. & Z., *Fl. Cap.*, vol. I., p. 72, appears to be merely a variety.

XXVII.—GUTTIFERÆ.

13. *Garcinia Gerrardi*, Harvey.*Gamboge tree*.

A small tree with dark green foliage found in Umvoti County. The gamboge of commerce is derived from several species of the same genus.

XXXI.—MALVACEÆ.

14. *Hibiscus tiliaceus*, Linnæus.*Paritium tiliaceum*, St. Hilaire, *Fl. Cap.* vol. I., p. 177.Kafir: *um-Lolwa*.

A widely dispersed species. Pondoland and Natal Coast; also found in the Mozambique District, Upper Guinea, India, and Polynesia. Grows near the sea shore.

A shady tree, 1-1½ feet in diameter, 20-30 feet high. Bark yellowish white, thick, fibrous, even. Wood moderately heavy, hard, moderately strong, elastic, coarse grained, compact; annual rings ill defined; medullary rays fine and close; pores moderately large, numerous, regularly distributed; colour, the heartwood dull green streaked with black, the sapwood white; fairly durable, suitable for planks, and may be used by wheelwrights.

The inner bark yields a strong fibre used for rough ropes, and suitable for textile purposes and paper manufacture.

Largely planted in the streets of Durban.

XXXII.—STERCULIACEÆ.

15. *Cola Natalensis*, Oliver.

A small tree found in the Coast region. The Cola nut, which forms an important article of commerce along the West Coast of Africa, is derived from a species of the same genus.

16. *Dombeya Natalensis*, Sonder.*Fl. Cap.* vol. I., p. 221.Kafir: *i-Bunda*.

Coast and South Drakensberg.

A small straight tree 1 foot in diameter. Bark grey-brown, very thin, smooth, wood light, moderately hard and compact; medullary rays close, fine, not conspicuous; pores small, numerous, distributed in short radial lines; colour pale yellow or brown; not used

17. *Dombeya rotundifolia*, Harvey.

Fl. Cap. vol. I., p. 221.

Kafir: *Hlebehlo*.

Coast and South Drakensberg, Transvaal.

A tree 1-2 feet in diameter, coppicing moderately. Bark grey, very thin, even. Wood heavy, hard, close grained and compact; annual rings obscure; medullary rays fine, distant, with smaller rays very fine and close; pores distributed chiefly in short radial lines; colour white tinged with yellow; not used.

18. *Dombeya Dregeana*, Sonder.

Fl. Cap. vol. I., p. 221. *Thes. Cap.* tab. 89.

Eastern Province, Kaffraria, and Natal Coast.

Dombeya Burgessiae, Gerrard, *Thes. Cap.* tab. 137-138, is another species, with the habit of *Sparmannia africana*, found in Klip River and Zululand.

XXXIII.—TILIACEÆ.

19. *Grewia occidentalis*, Linnæus.

Fl. Cap. vol. I. p. 225. *Sylv. Cap.* p. 3.

Dutch: *Kruysbesjes*. Kafir: *i-Klolo*.

A large shrub or small tree, usually branching from near the base. Bark grey-brown, thin, smooth. Wood moderately heavy and hard, strong, moderately elastic, close grained, even; rings irregular; medullary rays fine and close; pores small, irregularly distributed; colour white or pale yellow; suitable for turner's work, and used by the Natives for assegai handles.

Fruit eaten by the Natives.

XXXIV.—LINEÆ.

20. *Erythroxylon emarginatum*, Schum. & Thon.

E. Caffrum, Sond. *Fl. Cap.* vol. I., p. 223.

A small tree or large shrub, found in the Coast and Midland regions. *E. Coca*, a Peruvian species, is largely used in South America as a nervous stimulant.

E. pictum, E. Meyer, is another species, found in the Coast region.

XXXVI.—MALPIGHIACEÆ.

21. *Acridocarpus Natalitius*, Jussieu.

Fl. Cap. vol. I., p. 231. *Thes. Cap.* tab. 19.

Kafir: *u-Mabope*.

Coast region; margins of woods. A small tree 15-20 feet in height.

22. *Sphedamnocarpus galphimiæfolius*.

Acridocarpus galphimiæfolius, Jussieu, *Fl. Cap.* vol. I., p. 232.

A small tree found in the Coast region and in the Transvaal.

S. pruriens, Planchon (*Acridocarpus pruriens*, Jussieu), *Fl. Cap.* vol. I., p. 232, is another species also found in the Coast region and in the Transvaal.

XXXIX.—RUTACEÆ.

23. *Calodendron capense*, Thunberg.

Fl. Cap. vol. I., p. 371. *Sylv. Cap.* p. 6.

Wild Chestnut. Dutch: *Wilde Kastanje*. Kafir: *um-Baba*.

Swellendam, Knysna, Eastern Province, Kaffraria, and Natal : Coast and Drakensberg ; also found near the Zambesi and in Central Africa ; ravines and mountain forests.

A large and handsome tree, 2-3 feet in diameter, 40-60 feet high, deciduous. Bark grey, thin, even. Wood light, moderately hard, strong, moderately elastic, compact ; annual ring irregular ; medullary rays moderately fine, distant, conspicuous ; pores moderately small, numerous, grouped in small clusters, and in radial and concentric series ; colour white ; used for yokes ; and suitable for planking and, if prepared, for railway sleepers.

Fruit resembling a chestnut, but bitter and not edible.

24. *Zanthoxylum capense*, Harvey.

Fl. Cap. vol. I., p. 446. *Sylv. Cap.* p. 7.

Knobthorn. Dutch : *Knopjesdoorn*, *Pardepram*. Kafir : *um-Nungumabele*.

Mossel Bay, Knysna, Eastern Province, Kaffraria, Natal Coast, Drakensberg, to the Transvaal.

A tree 1-2 feet in diameter, 20-40 feet high. Young twigs covered with short spines. Bark light brown, thin, thickly studded with conical protuberances one inch and more in height. Wood heavy, hard, strong, close grained, compact ; annual rings marked by thin white bands ; medullary rays very fine, close, not conspicuous ; pores very small, numerous ; colour light yellow ; used for yokes, axles, and various implements.

Annual rings average 0.078 inches, corresponding to a yearly increase in girth of 0.49 inches.

Fruit (*Wild Cardamon*), has a hot pungent taste, and is prescribed for flatulency and paralysis, according to Dr. Pappe. The bruised leaves have a strong and peculiar smell, and are used by the Natives for disinfecting milt-ziek meat. The bark of the root is one of the favourite remedies for snake bite, and in decoction for tape worms ; used also for syphilis according to Andrew Smith.

25. *Zanthoxylum Thunbergii*, De Candolle.

Fl. Cap. vol. I., p. 446.

Knobthorn. Dutch : *Knopjesdoorn*. Kafir : *um-Nungumabele*.

George and Knysna to Natal Coast, Drakensberg, and the Transvaal.

A small tree 12-18 inches in diameter, 30-40 feet high. Bark grey, thin, studded with flattened conical protuberances tipped with a spine. Wood very heavy, hard, strong, moderately elastic, very close grained and compact ; medullary rays fine and close ; pores very small, evenly distributed ; rings irregular ; colour light yellow ; not very durable, and seldom used.

Bark of the root used as a remedy for snake bite.

Known from *Z. capense*, of which it may be merely a variety, by the armed petioles and nerves of the compound leaves.

26. *Toddalia lanceolata*, Lamarck.

Vepris lanceolata, A. Jussieu, *Fl. Cap.* vol. I., p. 447. *Sylv. Cap.* p. 7.

White Ironwood, *Bastard Sneezewood*. Dutch : *Wit Yzerhout*, *Hoenderspoor*.

Kafir : *um-Zana*.

George, Knysna, Eastern Province, Kaffraria, Natal Coast, Drakensberg, to the Transvaal. Common in most forests.

A tree 1½-2½ feet in diameter, 30-40 feet high, coppicing moderately. Bark reddish brown or grey, thin, even. Wood heavy, hard, very strong, not elastic, close grained ; annual rings irregular ; medullary rays very fine and close ; pores small, arranged in short radial lines ; colour white or pale yellow ; used for axles, spokes, and other wagon-wood, and for ploughs ; not very durable.

T. Natalensis, Sonder, *Fl. Cap.* vol. I., 447, is another species, very similar in aspect, found in the Eastern Province and the Natal Coast.

27. *Clausena inæqualis*, Oliver.

Myaris inæqualis, Presl, *Fl. Cap.* vol. I., p. 444. *Sylv. Cap.* p. 7.

Kafir : *um-Nukambiba*.

George and Knysna, Eastern Province, Kaffraria, Natal Coast, Midland and Upland regions, to the Transvaal; also found in Upper Guinea. Common as an undershrub of most forests.

A small tree 6-9 inches in diameter, 15-20 feet high, coppicing moderately. Bark dark brown, thin, even or wrinkled longitudinally. Wood heavy, moderately hard, strong, moderately elastic, very close grained and compact; annual rings irregular; medullary rays very fine, close; pores small; colour white.

The leaves contain a strongly scented volatile oil, which renders them inflammable. The bark of the root is used by the Natives as a remedy for tape worms.

XLI.—OCHNACEÆ.

28. *Ochna arborea*, Burchell.

Fl. Cap. vol. I., p. 149. *Sylv. Cap.* p. 8.

Redwood, Cape Plane. Dutch: *Rooihout.* Kafir: *um-Hlezane.*

Knysna, Eastern Province, Kaffraria, Natal Coast, Delagoa Bay and the Transvaal.

A small tree 6-10 inches in diameter, 20-40 feet high, with a crooked stem and sparse foliage; coppicing moderately. Bark rich brown, thin, very smooth to the touch, exfoliating in scales, leaving a clean surface marked with patches not unlike those of the Plane tree. Wood very heavy and hard, strong, tough, very close grained and compact; annual rings irregular; medullary rays moderately broad, distant, not conspicuous; pores very small, irregularly distributed; colour pale red; used for spokes, and is not excelled, for axe and tool handles, by any other South African wood; very suitable for ordinary engraving, and most suitable for wood type according to Messrs. C. & A. Young.

29. *Ochna atropurpurea*, De Candolle.

Fl. Cap. vol. I., p. 448.

Eastern Province, Kaffraria, Basutoland, Natal Coast, and Midlands.

A small tree 9-12 inches in diameter, 30-40 feet high, with dense foliage and a stem usually crooked; coppicing moderately. Bark brownish grey, even, thin. Wood not used.

XLII.—BURSERACEÆ.

30. *Balsamea africana*.

Protium africanum, Harvey. *Fl. Cap.* vol. II., p. 592.

Kafir: *umu-Mbu.*

A tree with ash-like foliage, found in the Coast forests.

XLIII.—MELIACEÆ.

31. *Turræa heterophylla*, Sm.

Fl. Cap. vol. I., p. 245.

Coast region and Kaffraria.

A small deciduous tree. Bark reddish-brown, very thin, smooth. Wood heavy and hard, close grained and compact; medullary rays not apparent; pores small, not numerous, irregularly distributed; colour yellow; not used.

T. obtusifolia, Hochstetter, is a smaller species also found in the Coast region and Kaffraria. *Fl. Cap.* vol. I., p. 245.

32. *Melia Azedarach*, Linnæus.

Fl. Cap. vol. I., p. 245.

Syringa.

South Asia and Australia, Upper Guinea and Cape de Verd islands. Introduced and partly naturalised in many parts of South Africa.

A tree, 30-40 feet high, with a straight cylindrical trunk, Bark grey, wrinkled. Wood moderately light and soft; medullary rays moderately thin, not numerous; pores unequal, large or moderately small, distributed partly in concentric patches of white tissue; colour, the heartwood not unlike that of mahogany, the sapwood, yellowish white; generally serviceable and durable, but seldom used in Natal.

The seeds yield a bitter oil, which is used in India for lighting, as an anthelmintic, and externally in rheumatism, &c. The bark is astringent and tonic.

33. *Ekebergia capensis*, Sparmann.

Fl. Cap. vol. I., p. 247; *Sylv. Cap.* p. 6.

Essenwood. Dutch: *Essenhout.* Kafir: *um-Nyamati.*

George and Knysna, Eastern Province, Kaffraria, Natal Coast and South Drakensberg.

A large tree, 2-4 feet in diameter, 50-80 feet high, with dense foliage. Bark, brown grey, thin, cracked in squares. Wood light, soft, moderately strong and elastic, rather open grained; medullary rays fine and close; pores moderately small, distributed irregularly or in short radial lines; colour white; used for furniture, beams, planks, wagonwork and other purposes, and suitable for the manufacture of railway sleepers; not durable.

34. *Ekebergia Meyeri*, Presl.

Trichilia Ekebergia, E. Meyer, *Fl. Cap.* vol. I., p. 246. *Sylv. Cap.* p. 5.

Essenwood. Dutch: *Essenhout.* Kafir: *um-Qwehle.*

Zitzikama to Natal Coast forests.

A large tree, 2-3 feet in diameter, 50-80 feet high, with a straight cylindrical trunk and an ample crown, much resembling *E. capensis*. Bark brown-grey, moderately thick, cracked or even. Wood light, soft, not strong, moderately elastic, open grained; rings obscure; medullary rays fine and close intersected by broader concentric bands of white tissue; pores moderately small, distributed irregularly or in short radial lines; colour white, tinged with red; used for boards and other purposes; suitable for railway sleepers.

Bark poisonous, used by the Natives, in small doses, as an emetic.

35. *Trichilia Dregeana*, E. Meyer.

Fl. Cap. vol. I., p. 246. *Thes. Cap.* tab. 76.

A tree found in the Coast forests.

T. Natalensis, Sonder, *Fl. Cap.* vol. I., p. 246, is another species, also found in the Coast forests.

XLV.—OLACINEÆ.

36. *Apodytes dimidiata*, E. Meyer.

Fl. Cap. vol. I., p. 235. *Sylv. Cap.* p. 4.

White Pear. Dutch: *Wit Peer.* Kafir: *um-Dakane.*

Western Province, George and Knysna, Eastern Province, Kaffraria, Natal Coast, and Transvaal.

A tree 1-3 feet in diameter, 40-70 feet high. Bark greyish white, thick, smooth, marked in patches and rings by parasitic lichens. Wood heavy, hard, strong, moderately elastic, very close grained and compact; rings obscure; medullary rays fine, very close; pores small, irregularly distributed; colour greyish; fairly durable, preferred by wagon-makers to any other wood for felloes; "a good useful wood for all the larger kinds of engraving, wood type, posters, &c," according to Messrs. C. & A. Young.

XLVI.—ILICINEÆ.

37. *Ilex Capensis*, Sonder & Harvey.

Fl. Cap. vol. I., p. 473. *Sylv. Cap.* p. 12.

Dutch: *Wittehout.*

Western Province, Knysna, Eastern Province, North Drakensberg to the Transvaal; mountain forests, along watercourses, and in ravines.

A small tree. Bark grey, thin, even or wrinkled. Wood light, soft, moderately strong and elastic, resembling beech in grain; rings apparent in some specimens; medullary rays distinct, unequal. Moderately broad; pores very small; colour white; used for furniture, railway sleepers, and brake blocks.

Annual rings average 0·14 inches in width, corresponding to an annual increment in girth of 0·85 inches.

XLVII.—CELASTRINEÆ.

38. *Cathastrum Capense*, Turczaninow.

Fl. Cap. vol. I., p. 526.

Bastard Saffraan, Hard Pear. Kafir : *um-Tumyalele*.

Eastern Province, North and South Drakensberg. Not scarce.

A large tree 2-3 feet in diameter, 50-70 feet high. Bark yellow brown or dark, thick, cracked irregularly. Wood heavy, hard, moderately strong and elastic, close grained and compact ; with well-defined concentric wavy bands of soft tissue ; medullary rays very fine, close ; pores small, numerous, irregularly distributed ; colour white or pale yellow, tinged with pink ; used for wagonwood.

39. *Celastrus acuminatus*, Linnæus.

Fl. Cap. vol. I., p. 454. *Sylv. Cap.* p. 8.

Silkbark. Dutch ; *Zydebast.* Kafir : *um-Nama*.

Western Province, Knysna, Eastern Province, North Drakensberg ; in mountain forests.

A small tree 9-18 inches in diameter, 20-30 feet high. Bark dark brown, thin, even. Wood very heavy, hard, strong, very close grained and compact, with close and narrow concentric bands of white tissue ; medullary rays very fine and close ; pores very small, irregularly distributed ; colour pale pink tinged with brown ; suitable for turner's work and engraving.

This species is easily known from a curious peculiarity of the leaves and bark, which show numerous fine white silky threads when they are broken.

40. *Celastrus buxifolius*, Linnæus.

Fl. Cap. vol. I., p. 459. *Sylv. Cap.* p. 9.

Cape Town to the Drakensberg and the Transvaal, in some one of its numerous varieties.

A small spiny tree 6-9 inches in diameter, 10-15 feet high. Bark light brown, thin, the surface even, exfoliating in pulverulent shreds. Wood heavy, hard, strong, tough, close grained, with close concentric lines of soft tissue ; medullary rays very fine and close ; pores very small ; annual rings not apparent ; colour reddish brown or yellow ; suitable for tool handles, engraving, turnery, &c.

41. *Celastrus undatus*, Thunberg.

Fl. Cap. vol. I., p. 457. *Sylv. Cap.* p. 8.

Dutch : *Kolko doorn*.

Eastern Province and North Drakensberg.

A small tree 1-1½ feet in diameter, 20-25 feet high. Bark grey, thin, even. Wood very heavy, hard, close grained and compact ; used for wagonwork and other purposes.

42. *Pterocelastrus variabilis*, Sonder.

Fl. Cap. vol. I., p. 462. *Sylv. Cap.* p. 9.

Dutch : *Kershout.* Kafir : *i-Tywina*.

Swellendam, Knysna, Eastern Province, Kaffraria, South Drakensberg.

A tree 1-2 feet in diameter, 30-40 feet high. Bark dark red-brown or black, thick, granular. Wood heavy, hard, close grained and compact ; with concentric bands of white tissue, moderately fine and distant ; colour pink to red ; used for schamels and other wagonwood, for posts ; and is an excellent firewood ; moderately durable.

The wood, and especially the roots, are permeated with a kind of resin which cause them to burn readily, hence the Dutch name ; this resin is used by Natives for cementing assegai heads to the shafts. The bark contains tannic acid.

43. *Putterlickia verrucosa*.*Celastrus verrucosus* E. Meyer, *Fl. Cap.* vol. I., p. 453.

A small thorny tree with a warty crooked stem ; found in the Eastern Province and in the Natal Coast, Midland and Upland regions.

44. *Elæodendron croceum*, De Candolle.*Fl. Cap.* vol. I., p. 468. *Sylv. Cap.* p. 10.Dutch : *Saffraanhout*. Kafir : *um-Bomvane*.

Knysna, Eastern Province, Kaffraria, South Drakensberg.

A tree 2-3 feet in diameter, 40-60 feet high, seldom straight. Bark yellow-brown, moderately thick, even, with a resinous crust of a gamboge yellow colour under the periderm. Wood heavy, hard, strong and tough, close grained, durable, marked with close concentric lines of white tissue ; rings not apparent ; medullary rays very fine and close ; pores very small ; colour light brown, tinged with red ; used for foretongues, schamels, draaiboards, aftertongues and other wagonwood ; excellent for the large size of wood type, posters, and bold engraving generally, according to Messrs. C. & A. Young ; the crooked stems give very good boat knees.

The bark is astringent, and is used at the Cape for tanning sole leathers. The roots are used by Kafir witch-doctors, according to Smith.

45. *Elæodendron velutinum*, Harvey.*Thes. Cap.*, tab. 186.Kafir : *um-Nqai*.

North and South Drakensberg ; common in most forests.

A large tree 2-3 feet in diameter, 40-50 feet high, with a compressed crown and a channelled trunk. Bark dark-grey or black, the inner bark red ; moderately thin, even, rugose. Wood very heavy, hard, very strong, not elastic, close grained and compact, with well defined wavy concentric bands of white tissue ; medullary rays very fine and close ; pores very small, irregularly distributed ; colour pale-red brown ; used for beams, planks, yokes, and other purposes.

The pounded leaves are used by Natives as a remedy for worms in cattle.

E. capense, Ecklon & Zeyher, *Fl. Cap.* vol. I., p. 468, is a smaller species found from Swellendam and George to the Natal Coast region.

E. confertiflorum (*Mystroxydon confertiflorum*, Tulasne, *Fl. Cap.* vol. I., p. 469) is another small species found in the Coast forests, and in the Eastern Province and the Transvaal.

XLIX.—RHAMNEÆ.

46. *Zizyphus mucronata*, Willdenow.*Fl. Cap.* vol. I., p. 475. *Sylv. Cap.* p. 12.Dutch : *Buffelsdoorn*. Kafir : *um-Pafa*.

Eastern Province, Natal, and the Transvaal ; also found in Upper and Lower Guinea, Nileland and Mozambique.

A small thorny tree 1-1½ feet in diameter, 20-25 feet high. Bark reddish brown, thin, even or moderately rough. Wood hard, heavy, close grained and compact ; medullary rays very fine and close ; pores small, very few ; colour yellow, tinged with red ; chiefly used for wagonwork.

According to Smith, Kafirs use the root and the leaves in scrofula, and a decoction of the root for lumbago.

47. *Rhamnus prinoides*, L'Héritier.*Fl. Cap.* vol. I., p. 477.Dogwood. Dutch : *Hoenderpis*. Kafir : *u-Nyanya*.

Swellendam, George and Knysna, Eastern Province, Kaffraria, Drakensberg, Orange Free State, and Transvaal.

A small tree 20-25 feet high, 6-10 inches in diameter. Bark dark brown, thin,

smooth. Wood moderately heavy and hard, close grained and compact; annual rings irregular; medullary rays fine and close; pores very small, united by oblique patches of white tissue; colour pale yellow.

Used by Kafir witch-doctors.

The barks of many species of the genus possess cathartic properties; immense quantities of that of *R. Purshiana* are gathered in the Oregon forests and sold under the name of *Cascara sagrada*.

48. *Scutia indica*, Brongniart.

Scutia Commersoni, Brong., *Fl. Cap.* vol. I., p. 477. *Sylv. Cap.* p. 7.

Dutch: *Katdoorn*. Kafir: *um-Sondezo*.

Western Province, Eastern Province; Coast, Midland, and Upland regions of Natal.

A large shrub or small tree, armed with recurved thorns. Bark greyish, thin, wrinkled longitudinally. Wood moderately heavy and hard, compact; medullary rays extremely fine and close, not distinct; pores moderately large, numerous, distributed singly or in short radial lines; colour pale brown; not used.

49. *Phylica paniculata*, Willdenow.

Fl. Cap. vol. I., p. 482.

A small tree found in the Eastern Province and Natal.

LI.—SAPINDACEÆ.

50. *Schmidelia africana*, De Candolle.

S. melanocarpa, Arnott, et *S. leucocarpa*, Arn., *Fl. Cap.* vol. I., p. 238.

Kafir: *in-Qala*.

Coast and Drakensberg forests; also found in Abyssinia.

A small tree 1-1½ feet in diameter, 30-40 feet high, with a sparse head and a stem seldom straight, coppicing moderately, deciduous. Bark brown, thin, even. Wood moderately heavy, hard, very strong, moderately elastic, close grained, with faint concentric rings of white tissue; annual rings obscure; medullary rays very fine and close; pores very small, regularly distributed; colour pale citron-yellow or brown; not used.

S. Natalensis, Sonder, *Fl. Cap.*, vol. I., p. 239, and *S. Dregeana*, Sonder, *Fl. Cap.*, vol. I., p. 239, are small trees found in the Coast forests.

S. decipiens, Arnott, *Fl. Cap.*, vol. I., p. 239, *Sylv. Cap.*, p. 4, is another species, with thin white bark and hard close-grained wood, found in the Coast forests, and also in Knysna, the Eastern Province, and Kaffraria.

51. *Hippobromus alata*, Ecklon & Zeyher.

Fl. Cap., vol. I., p. 241. *Sylv. Cap.*, p. 5.

Dutch: *Paardepis*. Kafir: *u-Qume, u-Dwiya*.

Coast, Midland, and Upland regions, Natal; Knysna, Eastern Province, and Kaffraria.

A tree 1-1½ feet in diameter, 30-50 feet high. Bark brown, thin, even or rugose. Wood very heavy and hard, very strong, moderately elastic, close grained; annual rings irregular; medullary rays very fine and close; pores very small and numerous; colour—the heartwood brown, the sapwood white tinged with brown; used for wagonwork and other purposes.

The wood and leaves contain a strongly scented resinous or oily substance, which renders them readily inflammable. The wood is used by Natives in preparing love charms, and, according to Smith, the leaves for ophthalmia and syphilis.

52. *Sapindus oblongifolius*, Sonder,

Fl. Cap., vol. I., p. 240.

A small tree found in the Coast forests.

S. capensis, Sonder, *Fl. Cap.*, vol. I., p. 240., is another species also found in the Coast forests. Kafir : *um-Zinkawu*, *Masibele*.

53. *Dodonæa viscosa*, Linnæus.

Fl. Cap. vol. I., p. 242.

Coast forests ; also found in Upper Guinea, Nile land, and Mozambique. "The wood is used for engraving and in turnery, also for tool handles and walking-sticks. The leaves have a sour and bitter taste, and the plant from this circumstance is called in Jamaica Switch Sorrel" (*Moloney : Forestry of West Africa*, p. 303).

54. *Pteroxylon utile*, Ecklon & Zeyher.

Fl. Cap. vol. I., p. 243, *Thes. Cap.* tab. 17., *Sylv. Cap.*, p. 5.

Sneezewood. Dutch : *Nieshout*. Kafir : *um-Tati*.

Eastern Province, Kaffraria, Natal Coast and South Drakensberg.

A tree of the first economic importance, 2-3 feet in diameter, 30-50 feet high, with a straight trunk and a dark green head. Bark yellow-grey, thick, fissured longitudinally in old trees. Wood extremely heavy and hard, exceedingly strong, tough, not elastic, close grained, permeated with an oily substance, extremely durable in contact with the ground, easily split ; annual rings irregular ; medullary rays extremely fine, close ; pores very small, numerous ; colour pale yellow tinged with red ; used for fencing posts, for piles of bridges and jetties, for trucks, and various other purposes.

Sneezewood is one of the best woods in the world, ranking with Greenheart (*Nectandra Rodiei*) in point of strength and durability, and, in marine works, it resists equally well the attacks of the *Teredo navalis*, though Mr. R. H. Hammersley-Heenan finds that, at Port Elizabeth, neither Sneezewood nor Greenheart or Jarrah are entirely proof against the *Teredo*, *Cheluria terebrans*, and *Limnoria terebrans*. It burns readily, even when green.

55. *Greyia Sutherlandi*, Hooker & Harvey.

Fl. Cap. vol. II., p. 308., *Thes. Cap.* tab. I.

Dutch : *Baakhout*. Kafir : *in-Dalu*.

Upland region ; 5,000 feet altitude.

A small crooked tree found in rocky places and on the edge of forests, at high elevations along the Drakensberg and some of the outlying spurs. Bark ashen or dark, thick, rough, rent longitudinally. Wood light, soft, very weak, elastic, porous, reticulated ; medullary rays moderately broad, conspicuous, distant ; pores moderately small, irregularly distributed ; colour pale pink tinged with brown ; used by Natives for carving, but of little value.

56. *Bersama lucens*.

Natalia lucens, Hochstetter, *Fl. Cap.* vol. I., p. 369.

A small tree found in the Coast forests.

LIII.—ANACARDIACEÆ.

57. *Rhus lævigata*, Linnæus.

Fl. Cap. vol. I., p. 514. *Sylv. Cap.* p. 13.

Red Currant. Dutch : *Bosch Taai Bosch*. Kafir : *isi-Hlakoti*.

Western Province, Knysna, Eastern Province, Natal Coast ; in forests and on stony ground.

A tree 1-2 feet in diameter, 40-50 feet high. Bark grey-brown, thin, wrinkled. Wood hard, heavy, strong and tough ; medullary rays fine and close ; pores small, not numerous, distributed chiefly in short radial groups ; colour—the heartwood ruby red, the sapwood yellow or mottled with brown.

58. *Rhus lucida*, Linnæus.

Fl. Cap. vol. I., p. 517. *Sylv. Cap.* p. 13.

Dutch : *Taai Bosch*. Kafir : *in-Hlokotyanebomvu*.

Western Province, Knysna, North Drakensberg.

A small shrubby tree. Bark light brown, thin, cracked in squares. Wood extremely heavy, very hard, extremely strong, not elastic, close grained, compact; rings obscure; medullary rays fine and close; pores small, irregularly distributed; colour reddish brown. Bark of root and branches astringent, used for tanning.

59. *Rhus longifolia*, Sonder.

Fl. Cap. vol. I., p. 522.

Kafir: *isi-Fuce, um-Hlutiwezinga*.

Coast and South Drakensberg; along the edges of forests and in exposed situations; thriving in poor soil.

A large tree 2-3 feet in diameter, 40-50 feet high. Bark reddish grey, thin, even or cracked. Wood moderately heavy and hard, moderately strong and elastic, compact, satiny; medullary rays moderately fine, close; pores small, regularly distributed; colour purplish or grey tinged with red, the heartwood dark; used for beams, rafters, planks, &c.; not very durable in water or in contact with the ground.

Milky juice from the bark used by Natives as a depilatory.

R. lancea, Linnæus fil., *Fl. Cap.* vol. I., p. 514, is a little tree with the habit of a willow, found in the Western Province, Eastern Province, and Natal. Kafir: *in-Hluti*.

60. *Loxostylis alata*, Sprengel.

Fl. Cap. vol. I., p. 524.

A small tree found in the Eastern Province, Kaffraria, and the Natal Coast forests.

61. *Odina caffra*.

Harpephyllum caffrum, Bernh., *Fl. Cap.* vol. I., p. 525. *Thes. Cap.* tab. 125.

Sylv. Cap. p. 14.

Kafir Plum. Dutch: *Kaffer Pruim*. Kafir: *um-Gwenya*.

Eastern Province, Kaffraria and Natal Coast; in woody ravines.

A large tree 2-3 feet in diameter, 30-50 feet high. Bark dark brown, thick, rough. Wood moderately heavy and hard, strong, moderately elastic; rings obscure; medullary rays close and fine, red; pores moderately small, irregularly distributed; colour pale red; takes a handsome polish, and used for furniture, planking, beams, rafters, &c.; heartwood fairly durable, but sapwood does not withstand exposure.

62. *Sclerocarya Caffra*, Sonder.

Fl. Cap. vol. I., p. 525.

A tree found in the Coast forests and the Transvaal. Kafir: *um-Gani*. Used by Natives for their utensils, and for aperient medicine.

LVIII.—LEGUMINOSÆ.

63. *Milletia Caffra*, Meisner.

Fl. Cap. vol. II., p. 211. *Sylv. Cap.* p. 14.

Kafir: *um-Sibiti*.

Kaffraria and Natal Coast.

A tree 30-40 feet high, attaining 2-3 feet in diameter, often branching from near the ground. Bark grey or dark, thin, rugulose or cracked longitudinally. Wood extremely heavy and hard, very strong, not elastic, close grained and compact, permeated with an oily substance, durable in contact with the ground; annual rings not apparent; medullary rays fine and close; pores moderately small, not very numerous; colour—the heartwood dark brown, the sapwood yellow; used occasionally for spokes, and by Natives for sticks and implements; has been found superior to *lignum-vitæ* for bearings of light machinery.

Kafirs use the beans as a vermifuge (*Pappe*).

Milletia Sutherlandi, Harvey, *Fl. Cap.* vol. II., p. 211, is an allied species found towards Pondoland by Dr. Sutherland. "A magnificent tree, 70-90 feet high, 3 feet or more in diameter."

64. *Erythrina caffra*, Thunberg.*Fl. Cap.* vol. II., p. 236. *Sylv. Cap.* p. 15.*Kafirboom.* Dutch : *Kafferboom.* Kafir : *um-Sinsi.*

Coasts of Eastern Province, Kaffraria and Natal.

A small tree, attaining 3-4 feet in diameter, 30-60 feet high. Bark grey, thin, even, fibrous. Wood extremely light and soft, very weak, elastic, brittle, coarse grained and spongy, resembling pith; annual rings obscure; medullary rays distant, broad, conspicuous; pores large, not numerous; colour white or bluish grey; used occasionally for rough boards and brake-blocks. Pappe states that canoes and troughs are made from the hollowed trunk, and that the wood is employed instead of cork for fishing nets, and for making shingles.

E. latissima, E. Meyer. *Fl. Cap.* vol. II., p. 238 (*E. Sandersoni*, Harv. *Thes. Cap.* tab. 61) is a scrubby tree found in Kaffraria and the Natal Coast region.

E. Humei, E. Meyer. *Fl. Cap.* vol. II., p. 237, is another species found in the Coast regions of the Eastern Province, Kaffraria, and Natal. Kafir : *um-Sinsana*; "small Kafirboom." According to Smith, the roots are used by the Natives in scrofula.

65. *Dalbergia obovata*, E. Meyer.*Fl. Cap.* vol. II., p. 265.Kafir : *um-Zungulo.*

Kaffraria and Natal Coast forests.

A small tree. Bark brown, thin, even. Wood hard and heavy, compact; medullary fine and close, intersected by irregular transverse bars of white tissue; pores moderately large, very few, irregularly clustered; colour pale yellow tinged with brown; not used.

D. armata E. Meyer, *Fl. Cap.* vol. II., p. 265, is another species, sometimes spiny, found in Pondoland and near the Natal Coast.

66. *Baphia racemosa*.*Bracteolaria racemosa*, Hochstetter, *Fl. Cap.* vol. II., p. 268, *Thes. Cap.* tab. 20.Kafir : *isi-Fiti.*

Coast forests.

A small tree. Bark dark brown, very thin, smooth. Wood very heavy and hard, close grained and compact; with very close and fine concentric bands of white tissue, broken and not conspicuous; medullary rays very fine; pores small, not numerous; colour light yellow; not used.

67. *Calpurnia lasiogyne*, E. Meyer.*Fl. Cap.* vol. II., p. 267.Kafir : *isi-Pane.*

Coast forests.

A small tree. Bark yellow brown, thin, wrinkled. Wood heavy, hard, compact; medullary rays very fine and close, intersected by numerous short oblique patches of white tissue; pores small, not numerous, irregularly distributed; colour light brown; not used.

68. *Schotia brachypetalata*, Sonder.*Fl. Cap.* vol. II., p. 274. *Thes. Cap.* tab. 32.Kafir : *um-Xamo.*

A small tree, sometimes blossoming from the trunk or large branches, found in the Coast forests.

69. *Dichrostachys nutans*, Benth.*Fl. Cap.* vol. II., p. 278.Kafir : *u-Munga.*

A small tree, armed with short axillary spines, found in the Coast forests and in the Transvaal.

70. *Acacia arabica*, Willdenow.

Fl. Cap. vol. II., p. 281.

Coast and Midland region ; also found in Mozambique, Nileland, Upper and Lower Guinea and South West Asia.

One of the "Mimosa" trees. Wood moderately heavy and hard, durable, largely used in India for wheels, knees and planks of boats, agricultural implements and railway sleepers. Yields part of the gum arabic of commerce, the best for medicinal and technical purposes. The pods are used for making ink and for tanning ; when young they can be given as fodder to cattle. The bark contains 13 per cent. of a white tannin on the trunk and 19 per cent. on the branches, and is valuable for tanning and dyeing (*Procter*).

71. *Acacia horrida*, Willdenow.

Fl. Cap. vol. II., p. 281. *Sylv. Cap.* p. 17.

Dutch : *Doornboom*. Kafir : *u-Munga*.

Common throughout the Cape. North Drakensberg ; in barren localities.

A small thorny tree, 1-1½ feet in diameter, 20-25 feet in height. Bark dark grey or black, thick, rough, cracked. Wood heavy, hard, moderately strong, elastic ; annual rings irregular ; medullary rays moderately fine, close ; pores moderately small, forming white concentric bands ; colour pale brown or yellow ; much used in the interior for building purposes ; suitable for common furniture.

Gum acaciæ exudes from the bark of both the trunk and branches. The bark is very astringent and is useful for diarrhœa, dysentery, &c. (*Pappe*) ; used for tanning, but gives a red leather.

72. *Acacia Natalitia*, E. Meyer.

Fl. Cap. vol. II., p. 281.

Kafir : *u-Munga*.

One of the "Mimosa" trees. Bark yellow brown, thick, rough. Wood moderately heavy, hard, moderately strong, elastic ; annual rings not apparent ; medullary moderately broad, close ; pores moderately large, mostly united by concentric bands of white tissue ; colour white or pale yellow ; not durable exposed to the weather.

Other Natal Acaciæ found in the Coast and Midland regions, but mostly shrubby, are :—

A. hirtella, E. Meyer, *Fl. Cap.* vol. II., p. 281.

A. caffra, Willdenow, *Fl. Cap.* vol. II., p. 282.

A. Kraussiana, Meisner, *Fl. Cap.* vol. II., p. 283.

A. pennata, Willdenow, *Fl. Cap.* vol. II., 283.

A. spinosa, E. Meyer, *Fl. Cap.* vol. II., p. 283.

A. n. sp. (Wood No. 3528), Kafir : *um-Kamba*, found in the North Drakensberg.

73. *Aibizzia fastigiata*, Oliver.

Zygia fastigiata, E. Meyer, *Fl. Cap.* vol. II., p. 285.

Flat Crown. Kafir : *um-Hlandhloti*.

Coast forests ; also a native of Senegambia.

A tree 1-3 feet in diameter, 20-30 feet high, with a spreading flattened crown. Bark grey or dark, thick, even. Wood light, soft, not strong, compact, satiny ; medullary rays fine and close ; pores large, regularly distributed, not numerous ; colour—the heartwood light golden yellow, the sapwood blueish white ; preferred by Natal wagonmakers to any other wood for naves of wheels.

On the West Coast of Africa the Natives prepare a sauce from the seeds by maceration. (*Moloney*).

LVII.—ROSACEÆ.

74. *Leucosidea sericea*, Ecklon & Zeyher.*Fl. Cap.* vol., p. 289.Kafir: *um-Tyityi*.

Common along the margins of the Drakensberg forests.

A low tree 12-18 inches in diameter, densely leafy, coppicing moderately. Bark dark brown, scaly or fissured. Wood light, soft, not strong, very elastic, compact; annual rings obscure; medullary rays fine and close; pores small, numerous, regularly distributed; colour red brown; readily ignited and esteemed for firewood.

Natives use the bark as an astringent medicine (*Harvey*).

LIX.—SAXIFRAGEÆ.

75. *Cunonia Capensis*, Linnæus.*Fl. Cap.* vol. II., p. 307. *Sylv. Cap.* p. 17.*Red Els.* Dutch: *Rooi Els*.

Western Province, Knysna, Eastern Province, Kaffraria, and South Drakensberg; in moist shady places and mountain ravines.

A tree 1½-2 feet in diameter, 20-50 feet high. Bark dark brown or black, rugose, cracked. Wood moderately light and soft, compact; annual rings irregular; medullary rays fine and close, obscure; pores small, numerous, regularly distributed; colour rich red; takes a very handsome polish and makes superior furniture; durable in the water and used for the construction of mills and for wagonwood.

LXII.—HAMAMELIDEÆ.

76. *Trichocladus crinitus*, Persoon.*Fl. Cap.* vol. II., p. 325. *Sylv. Cap.* p. 18.Dutch: *Onderbosch*.

Very plentiful as an undershrub in the forests of Knysna; found more sparingly in those of the Eastern Province, Kaffraria, and Natal.

A small tree 6-9 inches in diameter, 10-15 feet high. Bark brown black, smooth. Wood heavy, hard, strong and elastic, tough, close grained; not used.

LXV.—RHIZOPHOREÆ.

77. *Rhizophora mucronata*, Lamarck.*Fl. Cap.* vol. II., p. 513. Kafir: *um-Hluma*.

Natal Coast; forming tangled thickets on muddy seashores and in estuaries; also found in Mozambique and the West Coast.

A littoral tree 15-20 feet high, easily known by its numerous roots jutting from the stem above water level. Bark black, moderately thick, rugose. Wood heavy and hard, tough, close grained, reticulated; medullary rays moderately broad; durable but seldom used; takes a fine polish when old, and is suitable for cabinet work.

Bark astringent, used for tanning.

78. *Bruguiera gymnorhiza*, Lamarck.*Fl. Cap.* vol. II., p. 514.

One of the mangroves. A littoral tree 12-15 feet high, found on the Natal Coast.

79. *Weihea Madagascariensis*.

A small tree growing near the sea (*Gerrard*).

LXVI.—COMBRETACEÆ.

80. *Combretum Kraussii*, Hochstetter.*Fl. Cap.* vol. II., p. 510.*Bush Willow.* Kafir: *um-Dubu*.

Coast Region ; near streams and in forests.

A tree 1-1½ feet in diameter, 30-40 feet high. Bark dark brown, very thin, smooth. Wood heavy, hard, strong, moderately elastic, compact ; annual rings irregular ; medullary rays very fine and close ; pores moderately large, numerous, distributed irregularly or in short oblique lines ; colour bright yellow ; liable to dry rot, and gets worm-eaten.

Other species of *Combretum* found in the Coast forests are :—

C. glomeruliflorum, Sonder, *Fl. Cap.* vol. II., p. 509.

C. Gueinzii, Sonder, *Fl. Cap.* vol. II., p. 509.

C. Sonderi, Gerrard, *Fl. Cap.* vol. II., p. 511.

LXVII.—MYRTACEÆ.

81. *Eugenia cordata*.

Sizygium cordatum, Hochstetter. *Fl. Cap.* vol. II., p. 521.

Waterboom. Kafir : *um-Doni*.

Coast region ; in swampy ground and near streams ; growing stunted on dry hill-lands.

A tree 2-3 feet in diameter, 30-50 feet in height, with a trunk usually short, but exceptionally 37 feet without a branch. Bark dark red brown, thick, fibrous, even. Wood moderately heavy, hard, moderately strong and elastic ; rings obscure ; medullary rays fine and close ; pores moderately small, numerous, distributed regularly or in short radial lines ; colour light red to pale chocolate brown ; durable and used for beams, rafters, boat planking, and occasionally for felloes ; suitable for millwork.

Mr. W. Bazley states that a waterwheel of this wood, 22 years old, is yet quite sound.

82. *Barringtonia racemosa*, Roxburgh.

Fl. Cap. vol. 2., p. 523.

A tree found in the Coast forests.

83. *Olinia cymosa*, Thunberg, var. *acuminata*.

Fl. Cap. vol. II., p. 520. *O. Capensis*, Klotzch, *Sylv. Cap.* p. 18.

Hard Pear. Dutch : *Harde Peer*, *Drakensberg*. Kafir : *Satyobe*.

Mountain forests of the Drakensberg.

A tree 2-3 feet in diameter, 50-60 feet high. Bark yellow brown, thin, smooth, exfoliating in scales. Wood heavy, hard, strong, moderately elastic, close-grained, compact ; medullary rays very fine and close ; pores small, numerous ; colour pale brown ; durable, and used for posts and for wagonwood.

There are several distinct varieties of this tree. *Var. intermedia* has a dark, rough bark, and yields a wood with a handsome wavy grain, very durable, used for railway sleepers, telegraph posts, and furniture, but it appears to be confined to the Knysna region. One variety is found in Lower Guinea and Nileland.

84. *Heteropyxis Natalensis*, Harvey.

Thes. Cap. tab. 128.

A low tree found in the Coast forests.

LXXI.—SAMydACEÆ.

85. *Homalium rufescens*, Benth.

Blackwellia rufescens, Harvey. *Fl. Cap.* vol. I., p. 72.

A small tree found in the Coast forests.

86. *Gerrardina foliosa*, Oliver.

A densely leafy small tree found at 800 feet altitude at Port Shepstone, and 2,000 feet at Inanda. Scarce. Wood not used.

LXXX.—UMBELLIFERÆ.

87. *Heteromorpha arborescens*, Chamisso & Schlechtendal.*Fl. Cap.* vol. II., p. 542.Kafir : *um-Bangandhlala*.

George, Eastern Province, Kaffaria, North and South Drakensberg.

A small tree 9-15 inches in diameter, 15-20 feet high, coppicing freely and growing from cuttings. Bark grey brown, thick, annular, exfoliating transversely in thin coriaceous sheets. Wood heavy, moderately hard, moderately strong and elastic, close grained and compact; medullary rays fine, distant; pores very small, united by oblique bands of white tissue; colour white tinged with brown; used for fencing posts.

Bark used by Natives for colic and scrofula; also as a vermifuge for horses (*A. Smith*).

LXXXI.—ARALIACEÆ.

88. *Panax Gerrardi*, Harvey.

A low tree found at Ingoma, Natal, by Gerrard.

89. *Cussonia* sp.*Cabbage wood*. Kafir : *um-Singa*.

North Drakensberg; near the margins of forests.

A small tree, 1-1½ feet in diameter, 20-25 feet high. Bark yellow grey, thick, rough, fissured longitudinally. Wood very light, soft, very weak, elastic, coarse grained; annual rings obscure; medullary rays moderately broad and distant, conspicuous; pores moderately large, regularly distributed; colour white tinged with grey or blue; of little value, and not used.

Other species of *Cussonia* are : *C. spicata*, Thunberg, *Fl. Cap.* vol. II., p. 568, found in the Eastern Province, Kaffaria, and Natal; and *C. umbellifera*, Sonder, *Fl. Cap.* vol. II., p. 370, a tree 1-1½ feet in diameter, 30-40 feet high, found in the Coast region.

LXXXII.—CORNACEÆ.

90. *Curtisia faginea*, Aiton.*Fl. Cap.* vol. II., p. 570. *Thes. Cap.* tab. 124. *Sylv. Cap.* p. 19.*Assagai*. Dutch : *Assegaihout*.

Western Province, Knysna, Eastern Province, Kaffaria, and Drakensberg.

A tree 1-2½ feet in diameter, 40-60 feet high. Bark dark brown or black, thick, rugose, craggy in old trees. Wood heavy, hard, moderately strong and elastic, close grained, compact, fissile; annual rings obscure; medullary rays moderately fine and close; colour red; used for disselbooms, axles, schamels, draaiboards, aftertongues, but principally for spokes, for which purpose it is preferred by wagonmakers to any other wood.

Bark astringent, used for tanning.

LXXXIV.—RUBIACEÆ.

91. *Burchellia Capensis*, R. Brown.*Fl. Cap.* vol. III., p. 2. *Sylv. Cap.* p. 20.*Wild Pomegranate*. Dutch : *Buffelshoorn*.

Swellendam, Knysna, Eastern Province, Kaffaria, Natal Coast, Zululand.

A small tree 9-18 inches in diameter, 12-15 feet high. Bark brown, thin, even. Wood very hard, close grained; not used.

92. *Randia Kraussii*, Harvey.*Fl. Cap.* vol. III., p. 7. *Thes. Cap.* tab. 33.

A small tree found in the Coast forests.

93. *Gardenia globosa*, Hochstetter.*Fl. Cap.* vol. III., p. 5. *Thes. Cap.* tab. 5.

Kafir : isi-Qoba, Qobomhlazi.

Coast region.

A low tree. Bark grey brown, thin, even. Wood very heavy and hard, close grained and compact; medullary rays fine and close, obscure; pores very small, numerous, regularly distributed; colour light grey-brown; not used.

94. *Gardenia Thunbergia*, Linnæus.*Fl. Cap.* vol. III., p. 6. *Sylv. Cap.* p. 20.Dutch : *Wilde Katjepiering*.

Eastern Province, Natal Coast; also found in Mozambique, Central Africa, Nileland, and Upper and Lower Guinea.

A small tree 6-9 inches in diameter, 20 feet high. Bark grey, even. Wood heavy hard, strong and tough, close grained; "used for making tools, clubs, kerries, yokes, axles, felloes, ploughs, and also fit to engrave upon" (*Pappe*).

95. *Gardenia Rothmania*, Linnæus, fil.*Fl. Cap.* vol. III., p. 6. *Sylv. Cap.* p. 2.Dutch : *Wilde Katjepiering*. Kafir : *Xelegengane*.

Swellendam, Knysna, Eastern Province, and South Drakensberg.

A tree 1-1½ feet in diameter, 30-50 feet high, coppicing moderately. Bark light brown, moderately thin, cracked superficially in squares. Wood heavy, hard, strong, tough, close grained; rings not apparent; medullary rays fine; pores small; colour yellowish or pale brown tinged with red; used for axles, felloes and other wagonwood, for tools, and by Natives for making spoons and other utensils.

G. citriodora, Hooker, *Fl. Cap.* vol. III., p. 5, is a smaller species found in the Coast forests.

96. *Oxyanthus Gerrardi*, Sonder.*Fl. Cap.* vol. III., p. 3.

A low tree found in the Coast forests.

O. Natalensis, Sonder, *Fl. Cap.* vol. III., p. 3, and *O. latifolius*, Sonder, *Fl. Cap.* vol. III., p. 4, are two allied species, both also found in the Coast forests.

97. *Kraussia lanceolata*, Sonder.*Fl. Cap.* vol. III., p. 23. Kafir : *Sanyana*.

Coast and South Drakensberg.

A small tree 6-9 inches in diameter, 20 feet high, with a compressed head. Bark light brown or dark, the surface pulverulent. Wood heavy, moderately hard, close grained, compact; annual rings narrow; medullary rays fine; pores small; colour white or reddish; not used.

Other species found in the Coast region are :—

K. pavettoides, Harvey, *Fl. Cap.* vol. II., p. 22; a small tree 10-20 feet high.*K. floribunda*, Harvey, *Fl. Cap.* vol. II., p. 22. Kafir : *i-Kweza*.*K. coriacea*, Sonder, *Fl. Cap.* vol. II., p. 23.98. *Alberta magna*, E. Meyer.*Fl. Cap.* vol. III., p. 16. *Thes. Cap.* tab. 45.

A small tree, with the aspect of *Myrsine melanophleas*, found in the Eastern Province, Pondoland, and the Natal Coast region.

99. *Plectronia obovata*.

Canthium obovatum, Klotzch, *Fl. Cap.* vol. III., p. 16. *Mitrastigma lucidum*, Harvey, *Thes. Cap.* tab. 22. *Canthium pyrifolium*, Klotzch, *Sylv. Cap.* p. 22.

Quar. Kafir : *Xululembile*.

Knysna, Eastern Province, South Drakensberg.

A small tree 12-18 inches in diameter, 30-50 feet high, with a trunk usually channelled and ribbed. Bark dark grey or black, moderately thick, rugose. Wood very heavy and hard, very strong and tough, very close grained, compact; medullary rays very fine and close; pores very small, numerous; colour yellow or light reddish brown; used for fencing posts; quite suitable for ordinary engraving according to Messrs C. & A. Young.

Annual rings average 0.08 in., corresponding to a yearly increase in girth of 0.5 inches; observed increase, Knysna, 0.6 inches.

100. *Electronia ventosa*, Linnæus.

Fl. Cap., vol. III., p. 17. *Sylv. Cap.* p. 21.

Dutch: *Schaapdrolletjes*. Kafir: *um-Vutwamini*.

Western Province, Knysna, Eastern Province, Drakensberg; in woods and ravines.

A small tree 6-10 inches in diameter, 20-30 feet high. Bark grey, thin, even or granular. Wood very heavy, hard and strong, very close grained, compact; medullary rays very fine and close, not conspicuous; pores very small, numerous; colour pale brown; used for felloes; the fruit is edible but insipid.

101. *Electronia Mundtiana*, Pappe.

Fl. Cap. vol. III., p. 17. *Sylv. Cap.* p. 21.

Dutch: *Klip Ess.* Kafir: *Sandulane*.

Western Province, Knysna, North Drakensberg.

A small tree 6-12 inches in diameter, 30-40 feet high, coppicing moderately. Bark light grey, thin, smooth. Wood heavy, hard, strong, moderately elastic, close grained, compact; annual rings irregular; medullary rays very fine and close; pores small, irregularly distributed; colour white, tinged with brown; used for disselbooms and fencing posts.

102. *Electronia spinosa*, Klotzch.

Fl. Cap. vol. III., p. 18. *Sylv. Cap.* p. 22.

Kafir: *isi-Pambato*.

Eastern Province and Natal Coast.

A small tree 8-12 inches in diameter, 15-20 feet high. "Bark thin, grey. Wood fine grained, heavy, yellowish" (*Pappe*).

P. Gueinzii (*Canthium Gueinzii*, Sond. *Fl. Cap.* vol. III., p. 16), *P. pauciflora*, Klotzch, *Fl. Cap.* vol. III., p. 18., and *P. ciliata*, Sonder, *Fl. Cap.* vol. III., p. 18, are other Natal species, of a more shrubby habit.

103. *Psychotria Eckloniana*, F. von Mueller.

Grumilea Capensis, Sonder, *Fl. Cap.* vol. III., p. 21. *Grumilea cymosa*, E. Meyer, *Sylv. Cap.* p. 22.

Knysna, Eastern Province, and Natal Coast. A tree 9-18 inches in diameter, 20-30 feet high. "Bark ash coloured, thin. Wood citron yellow, hard, tough, and useful for many purposes" (*Pappe*).

LXXXVII.—COMPOSITÆ.

104. *Brachylæna discolor*, De Candolle.

Fl. Cap. vol. III., p. 117.

Kafir: *i-* or *um-Pahla*.

Eastern Province, Natal Coast, Delagoa Bay.

A small tree 1-1½ feet in diameter, 30-35 feet high. Bark dull drab, thin, even, the surface soft and pulverulent. Wood heavy, hard, extremely strong, not elastic, tough; annual rings obscure; medullary rays very fine and close; pores small, numerous, distributed chiefly in short radial lines; colour yellow tinged with brown, the thin

sapwood yellowish white ; durable exposed to the weather ; used for axles, foretongues, spokes ; excellent for boat timbers, as it stands in water even better than Red Milkwood, though it does not hold nails so well.

"The Dutch prepare an alkali from the ashes, for the manufacture of soap" (Gerrard).

Allied species of a shrubby habit are : *B. elliptica*, Lessing, *Fl. Cap.* vol. III., p. 116 (*isi-Duli*), and *B. racemosa*, Lessing, *Fl. Cap.* vol. III., p. 116.

105. *Tarchonanthus camphoratus*, Linnæus.

Fl. Cap. vol. III., p. 118. *Sylv. Cap.* p. 23.

Cape Colony, Kaffraria, Natal South Coast.

A small tree 6 inches in diameter, 10-15 feet high. "Bark brownish grey, much rugged. Wood close, heavy ; looking handsome when polished, and useful in the manufacture of musical instruments and joiner's fancy work. The leaves when fresh have a peculiar smell resembling camphor ; they are chewed by the Mahommetans, smoked by the Hottentots, and employed in the form of infusion or tea, as antispasmodic tonic, and resolvent" (Pappe).

C.—MYRSINEÆ.

106. *Mæsa alnifolia*, Harvey.

Thes. Cap., tab. 129.

A small tree found in the Coast forests of Natal and Kaffraria.

M. rufescens is an allied species.

107. *Myrsine melanophleas*, R. Brown.

Sylv. Cap. p. 24.

Dutch : *Boekenhout*. Kafir : *isi-Qalabahlati*.

Swellendam, Eastern Province, Natal Coast and Drakensberg ; also found in Upper Guinea ; common in most forests, near the margins.

A tree 1-2 feet in diameter, 40-60 feet high, with a straight cylindrical trunk. Bark light grey, thick, even, often studded with small lenticels. Wood moderately heavy and hard, moderately strong and elastic, rather brittle, not durable exposed to the weather ; annual rings obscure ; medullary rays broad, conspicuous ; pores small, numerous, distributed chiefly in short radial lines ; colour white, the medullary rays light red brown ; used for yoke-keys, various wagonwork, furniture, and poles for roofing.

CI.—SAPOTACEÆ.

108. *Chrysophyllum Natalense*, Sonder.

Kafir : *in-Tongana*.

A moderately large tree 30-40 feet high, found on the North Coast.

109. *Sideroxylon inerme*, Linnæus.

Sylv. Cap. p. 24.

White Milkwood. Dutch : *Wit Melkhout*.

Western Province, Knysna, Eastern Province, Natal South Coast ; in ravines and near the sea shore.

A tree 1-2 feet in diameter, 20-30 feet high. Bark grey brown, moderately thick, rough, craggy or fissured longitudinally. Wood very heavy and hard, strong, moderately elastic, close grained and compact ; annual rings not apparent ; medullary rays very fine and close, intersected by close narrow bands of white tissue ; pores very small, united by short oblique or radial patches of white tissue ; colour yellow ; very durable in contact with the ground and in water ; used for fencing posts, boat building, and millwork.

110. *Labourdonnaisia discolor*, Sonder.

A tree found in the Coast forests.

111. *Mimusops obovata*, Sonder.
Sylv. Cap. p. 24. *Thes. Cap.* tab. 44.
Bush Milkwood. Kafir : *ama-Setole*.

Eastern Province and Natal Coast ; in forests.

A tree $1\frac{1}{2}$ -2 feet in diameter, 20-25 feet high. Bark dark grey, thin, the surface cracked in squares. Wood heavy, hard, strong, moderately elastic, close grained and compact ; annual rings not apparent ; medullary rays very fine and close, intersected by fine, close, concentric bands of white tissue ; pores small, very few ; colour pink ; used for felloes, axles, and various wagonwork, but not equal to the Red Milkwood of the seashore.

112. *Mimusops Caffra*, Sonder.
Red Milkwood. Kafir : *um-Yagiya*.

Coast region ; near the sea beach and the edge of estuaries.

A tree attaining 2 feet in diameter and 35 feet in height, with a trunk seldom straight. Bark dark grey, thin, wrinkled longitudinally. Wood heavy, hard, moderately strong and elastic, close grained and compact ; medullary rays very fine and close, intersected by very close narrow bands of white tissue ; pores very small, not numerous, distributed chiefly in small radial lines ; colour red ; durable in water and exposed to the weather ; excellent for wagonwork and especially for boat and ship building.

CII.—EBENACEÆ.

113. *Royena lucida*, Linnæus.
Sylv. Cap. p. 25.
Dutch : *Zwartbast.* Kafir : *um-Timatane*.

Western Province, Knysna, Eastern Province, Drakensberg, Orange Free State. Common in all the mountain forests.

A small tree 9-12 inches in diameter, 12-20 feet high, with a stem seldom straight. Bark black, thin, smooth. Wood moderately heavy and hard, moderately strong, elastic, close grained ; annual rings irregular ; medullary rays very fine and close, with minute transverse bars of white tissue ; pores very small, not numerous ; colour white or streaked with purplish grey ; occasionally used for wagonwork.

Other species of *Royena* are :—

R. cordata, E. Meyer. A small tree found in the Eastern Province and the Drakensberg, by river sides and in mountain forests.

R. villosa, Linnæus. A tree 12 inches in diameter, 30 feet high, with long patent branches, found in the Eastern Province and the Natal Coast Region.

R. hirsuta, Linnæus. A shrubby species found at the Cape and in the Drakensberg.

R. pallens, Thunberg. A small tree 9-12 inches in diameter, 20-40 feet high, with a crooked stem and dark grey, thin, smooth bark ; margins of woods in the Coast region and in the Drakensberg ; also found in the Eastern Province, Knysna, Namaqualand, the Kalihari Region, and West Tropical Africa.

R. nitens, Harvey, and *R. glandulosa*, Harvey.

114. *Euclea lanceolata*, E. Meyer.
Sylv. Cap. p. 26.
Dutch : *Bosch Gwarri.* Kafir : *um-Tyepisana*.

Knysna, Eastern Province, Kaffraria, South Drakensberg, Transvaal, Namaqualand.

A tree 1-2 feet in diameter, 40-60 feet high. Bark black, moderately thin, rough, the surface cracked irregularly or in squares. Wood heavy, hard, strong, compact, and close grained ; rings obscure ; medullary rays very close and fine, with ladder-like transverse bars of white tissue ; pores small, not numerous, arranged in short radial lines ; colour pale red ; not used.

A decoction on the bark of the root is used by Natives as a purgative (*A. Smith*).

115. *Euclea natalensis*, A. De Candolle.Kafir : *i-Dungamuzi*.

Coast forests and Drakensberg.

A small tree 1-1½ feet in diameter, 30-45 feet high. Bark dark grey or black, thin, cracked. Wood heavy, hard, strong, not elastic; annual rings irregular; medullary rays very fine; pores large, not numerous, distributed in short radial lines; colour white tinged with brown, sometimes mottled with dark patches; not used.

E. multiflora, Hiern, and *E. daphnoides*, Hiern, are two other Natal species.

116. *Maba Natalensis*, Harvey.A shrubby small tree found in the Coast forests. *Thes. Cap.* tab. 110.

CIV.—OLEACEÆ.

117. *Schrebera alata*, Welwitsch.*S. Saundersiæ*, Harvey, *Thes. Cap.* tab. 163.

A tree 1-2 feet in diameter, 30-40 feet high, with light green foliage and smooth grey bark, found in the Coast forests.

118. *Olea verrucosa*, Lamarck.*Sylv. Cap.* p. 27.Ironwood, Coast Assagai. Dutch : *Olyvenhout*. Kafir : *um-Quma*.

Coast and Drakensberg forests; also found from Capetown to the Orange River; common.

A tree 12-18 inches in diameter, 20-40 feet high. Bark grey or black, thick, slightly fissured, sometimes marked with black streaks, proceeding from fissures or wounds, due to a parasitic fungus. Wood extremely heavy, very hard, very strong, moderately elastic, very close grained and compact; annual rings obscure; medullary rays very fine and close; pores very small, distributed irregularly or in short radial lines; colour—the heartwood red brown, the sapwood white tinged with red; used for disselbooms, yoke-keys, and other wagonwood, and for teeth in mill wheels.

119. *Olea laurifolia*, Lamarck.*Sylv. Cap.* p. 27.Ironwood. Dutch : *Yzerhout*.

Knysna, Eastern Province, Kaffraria, Natal Coast, and Drakensberg; reaching its greatest development in the Knysna region, where it constitutes about one-eighth of the timber in the forests.

A large tree 2-4 feet in diameter, 60-90 feet high. Bark grey, thick, even or wrinkled. Wood very heavy and hard, very strong, not elastic, close grained; annual rings irregular; medullary rays very fine, close; pores small, white, very numerous, distributed in short radial lines; colour—the heartwood dark brown or grey, the thin sapwood white tinged with yellow; used for disselbooms, axles, foretongues, schamels, draaiboards and aftertongues of wagons, for piles of jetties, bridges, telegraph poles, and railway sleepers; the heartwood is durable in contact with the ground, but the sapwood decays rapidly.

120. *Olea foveolata*, E. Meyer.*Sylv. Cap.* p. 27.Bastard Ironwood, Black Ironwood. Dutch : *Yzerhout*. Kafir : *um-Qumaswele*.

Knysna, Eastern Province, and Natal Coast forests.

A tree 9-12 inches in diameter, 25-35 feet high. Bark light grey, thick, even, studded with large lenticels. Wood very heavy and hard, very strong, not elastic, close grained; annual rings irregular; medullary rays very fine and close; pores white, numerous, arranged radially in groups of two or three; marked with irregular concentric patches of white tissue; colour pale brown; used for wagonwood.

CVI.—APOCYNACEÆ.

121. *Rauwolfia Natalensis*, Sonder.Kafir : *um-Hlambamasi*.

Coast region ; in damp ground.

A tree attaining 2 feet in diameter and 40-50 feet in height. Bark yellow grey, thick, even. Wood light, soft, not strong, moderately elastic ; annual rings irregular ; medullary rays fine ; pores moderately small, distributed in short radial lines ; colour grey tinged with brown ; used for planks for inside work ; not so fissile as yellowwood ; not durable exposed to the weather.

122. *Orchipeda Dregei*.*Piptolœna Dregei*, Harvey. A large tree growing in swamps of the Coast region.123. *Tabernœmontana ventricosa*, Hochstetter.A small tree of the Coast region. *T. Thouarsii* is another species.

CVIII.—LOGANIACEÆ.

124. *Nuxia floribunda*, Benth.*Sylv. Cap.* p. 30.*Vlier*.

Knysna, Eastern Province, and Natal.

A tree 1-2 feet in diameter, 40-50 feet high ; larger specimens often hollow and defective. Bark thin, yellowish white, the surface pulverulent. Wood heavy, hard, close grained and compact ; medullary rays fine ; pores very small, distributed chiefly in short radial groups ; colour—light yellow tinged with pink ; used for felloes, and schamels of wagons.

N. congesta, R. Brown, is a smaller species, with heavy close grained wood, found in Natal and Upper Guinea.

125. *Chilianthus arboreus*, Burchell.*Sylv. Cap.* p. 30.

Western Province, Knysna, Natal Coast.

A small tree 8-10 inches in diameter, 20-25 feet high. Wood very heavy, hard, and tough ; not used.

C. dysophyllus, A. De Candolle, is another Coast species.126. *Buddlea salviæfolia*, Lamarck.*Sylv. Cap.* p. 31.Dutch : *Saliehout*. Kafir : *i-Lotyane*.

Knysna, Eastern Province, Natal Coast and Drakensberg.

A small tree 9-12 inches in diameter, 15-20 feet high. Bark brown, very thin, even, exfoliating in small soft elliptical scales. Wood heavy, hard, strong, elastic, close grained and compact ; annual rings broad, irregular ; medullary rays fine, moderately close or distant ; pores small, white, very numerous, distributed chiefly in short radial lines ; colour—the heartwood brown, the sapwood pale yellow ; quite suitable for the bolder kinds of engraving, also excellent for wood-type, according to Messrs. C. & A. Young.

127. *Strychnos Atherstonei*, Harvey.*Thes. Cap.* tab. 164. *Atherstonea decussata*, Pappe, *Sylv. Cap.* p. 29.Cape Teak, Chaka's wood. Dutch : *Kajatenhout*. Kafir : *um-Kangele*.

Eastern Province and Natal Coast.

A tree 1-1½ feet in diameter, 20-25 feet high. Bark grey brown, very thin, smooth or wrinkled. Wood heavy, hard, strong, moderately elastic, rather coarse grained, marked with short wavy bands of porous white tissue, arranged radially ; rings not apparent ;

medullary rays fine and close ; pores very large, regularly distributed, filled with soft cellular tissue ; colour pale yellow brown ; not durable, as it is liable to dry rot, and gets worm-eaten ; used for staves, but seldom for other purposes.

128. *Strychnos spinosa*, Lamarek.

Brehmia spinosa, Harvey.

Kafir : *um-Hlala*.

Eastern Province, Kaffraria, Natal Coast, Madagascar, West and Central Africa.

A small tree with angular spreading spiny branches. Wood heavy, hard, compact ; medullary rays fine and close ; pores small, not numerous, irregularly distributed ; colour light brown. Fruit edible.

S. Mackenii, Gerrard, mss. Kafir : *um-Gulugulu*, and *S. Umbanda*, are two other species also found in the Coast region.

CXII.—BORAGINEÆ.

129. *Cordia caffra*, Sonder.

Kafir : *um-Novunovu*.

A small tree found in the Coast forests. Bark light brown, thin, smooth. Wood moderately heavy and hard, compact ; medullary rays moderately large, intersected by irregular concentric bands of white tissue ; pores very few, moderately large ; colour light brown.

130. *Ehretia Hottentottica*, Burchell.

A small tree found in the Eastern Province and the Natal Coast region.

CXV.—SCROPHULARINEÆ.

131. *Halleria lucida*, Linnaeus.

Sylv. Cap. p. 29.

Kafir : *i-Minza*.

Western Province, Knysna, Eastern Province, Natal Coast forests, and Drakensberg.

A small much-branched tree, 8-12 inches in diameter, 20-30 feet high. Bark brown, very thin, fissured longitudinally. Wood heavy, hard, very strong, moderately elastic, close grained, liable to check in drying ; annual rings obscure ; medullary rays fine, distant ; poles small ; colour white tinged with yellow ; used by Natives for assagai-handles.

132. *Anastrabe integerrima*, E. Meyer.

Kafir : *isi-Pambato*.

A small tree found in the Coast region.

CXXV.—VERBENACEÆ.

133. *Clerodendron glabrum*, Sonder.

Kafir : *um-Qwaqwana*.

Coast forests and Drakensberg.

A small tree. Bark yellow brown, thin, the surface pulverulent. Wood moderately heavy and hard, moderately strong, elastic, close grained, compact ; medullary rays fine ; pores small, numerous, distributed irregularly or in short radial lines ; colour white tinged with red-brown.

134. *Avicennia officinalis*, Linnaeus.

White Mangrove.

A littoral evergreen tree found from the coasts of South Asia to that of Natal, and in Australia and New Zealand. Wood compact, fibrous.

CXLIII.—LAURINEÆ.

135. *Cryptocarya* sp.*Underbush.* Kafir : *um-Xaleba*.

Drakensberg forests.

A small tree 6-18 inches in diameter, the stem seldom straight. Bark brown, thin, exfoliating in papery sheets. Wood very heavy and hard, very strong and tough, very close-grained and compact; annual rings irregular; medullary rays very close and fine, with transverse bars of white tissue; pores small, not numerous; colour light brown, tinged with red; used for spokes; fruit edible.

136. *Cryptocarya* sp. (Wood No. 766.)Kafir; *Xoboti*.

A small tree, 12-18 inches in diameter. Bark brown or dark grey, moderately thin, smooth, exfoliating in thin papery sheets. Wood heavy, hard, close grained and compact, strong and tough; annual rings obscure; medullary rays very fine and close; pores small, regularly distributed; colour pale yellow. Fruit edible but insipid.

C. sp. (Wood No. 1402), Kafir : *um-Tungwa*, is found in the South Drakensberg forests.

C. sp., Kafir : *um-Ncatyane*, is another species growing in the North Drakensberg forests.

137. *Ocotea bullata*.*Oreodaphne bullata*, Nees. *Sylv. Cap.* p. 31.*Stinkwood.* Dutch : *Stinkhout*.

From the Cape Peninsula to Zululand, reaching its greatest development at Knysna, the Zitzikama, and Kaffraria; in Natal it occurs in the South Western forests and the Drakensberg as far north as the Lobonjo River, at an altitude of 3,500-4,500 feet; prefers damp rich soil.

A large evergreen tree of the first economic importance, 3-5 feet in diameter, 60-90 feet high, with a tapering trunk, often hollow in old trees. Bark dark brown rugged and scaly in old trees; grey, smooth, moderately thin, in young trees. Wood heavy, hard, very strong, moderately elastic, tough, lustrous, with a fetid smell when freshly cut, durable in contact with the ground; medullary rays fine, close; pores moderately small, numerous, regularly distributed; colour usually dark brown, as in the Black Stinkwood of commerce, grey or pale golden yellow in other varieties and in sapwood; takes a fine polish, and makes very handsome furniture; used for planks, beams, furniture, doors, and door and window frames, for every description of wagonwood except spokes, for railway sleepers, &c.

Bark astringent, used for tanning.

Stinkwood is one of the most important of South African trees, ranking with the Oak of Europe, and the Teak of Indian forests; its timber is procurable in conveniently large sizes, but the demand appears to exceed the supply. The culture of this species, though it has not hitherto been attended with much success, should engage the attention of a Forest Department in Natal; the young plants do not seem to thrive outside the forest, but this difficulty would probably be overcome by seeking carefully the necessary conditions of growth.

The young plants are very hardy in the forest but are intolerant of shade and remain dwarfed if deprived of sunlight. The seed keeps badly and should be sown soon after gathering. Stinkwood is a good coppicer, and a tree of moderately fast growth; the growth averages 0.60 inches in girth a year at Knysna in the natural forest, but in open situations it is more rapid, and averages 0.95 inches in clearings.

CXLIV.—PROTEACEÆ.

138. *Protea hirta*.*White Sugarbush.* Kafir : *isi-Qulaba*. *isi-Hlunga*.

North Drakensberg; mountain slopes, and ridges between forests.

A small tree 8-12 inches in diameter, 12-18 feet high. Bark black, thick, rugose. Wood light, soft, coarse grained, reticulated; annual rings not apparent; medullary rays broad, conspicuous, distant; pores very small, irregularly distributed; colour pale brown streaked with pink; used for firewood.

Bark astringent, rich in tannin.

139. *Protea lanceolata*, E. Meyer.

Sugar-bush. Kafir: *isi-Qalaba*.

North Drakensberg; mountain slopes, and ridges between forests.

A small tree. Bark black, thick, rugose. Wood light, soft, coarse grained, reticulated; annual rings not apparent; medullary rays broad, conspicuous, distant; pores small, irregularly distributed; colour white or pale yellow, the medullary rays dark brown; used for firewood.

Bark astringent, containing tannin.

140. *Faurea saligna*, Harvey.

A small tree found in the Upland region.

CXLIX.—SANTALACEÆ.

141. *Colpoon compressum*, Bergius.

Osyris compressa, A. De Candolle, *Sylv. Cap.* p. 34.

Dutch: *Bergbast*, *Pruimbast*, *Nantekara*.

Western Province, Knysna, Umzimkulu, North Drakensberg.

A small tree 6-10 inches in diameter, 12-15 feet high, with a compressed head. Bark grey, thin. Wood heavy, close grained; suitable for tanning and fancy work.

The leaves and the bark are rich in tannin, and form a superior tanning material, suitable for the lighter kinds of leather.

142. *Osyris Abyssinica*, Hochstetter.

A small tree resembling *Colpoon compressum*, from which it is known by the alternate leaves.

CLI.—EUPHORBIACEÆ.

143. *Euphorbia antiquorum*, Linnæus.

An arborescent *Euphorbia* found in the ravines of the Coast region. *E. grandidens*, is another species, attaining a height of 30 feet.

144. *Bridelia micrantha*, Planchon.

Kafir: *um-Hlahlamakwaba*.

Coast forests. A tree attaining 2 feet in diameter and 50 feet in height. Bark grey brown, thin, even. Wood light, soft, moderately strong and elastic, satiny; annual rings irregular; medullary rays fine and close; pores moderately small, irregularly distributed; colour pale yellow or brown; used for house-building, for boat-building and for posts; durable in water and in contact with the ground.

One of the best of Coast woods according to Mr. Bazley.

145. *Phyllanthus myrtaceus*, Sonder.

A tree found in the Coast forests.

146. *Cyclostemon Natalense*, Harvey.

Thes. Cap. tab. 200.

Kafir: *um-Kiwane*.

A tree found in the Coast forests. *C. argutus*, Mueller Arg., is another species.

147. *Antidesma venosum*, E. Meyer.

Harv. *Thes. Cap.* tab. 169.

Kafir : *um-Tyongi*.

A tree found in the Coast forests.

148. *Croton sylvaticum*, Hochstetter.

A small tree found in the Coast forests.

149. *Cluytia* sp.

Kafir : *Hloluti, um-Sipane*.

Drakensberg forests ; common as an undershrub.

A shrub or small tree 12 inches in diameter, with a stem seldom straight. Bark brown, thin, rimpled. Wood very heavy and hard, strong, close grained ; medullary rays very fine and close ; pores small ; colour—the heartwood brown, the sapwood yellow ; used for disselbooms of wagons.

150. *Macaranga Capensis*.

Mappa Capensis, E. Meyer. A small tree of the Coast forests.

151. *Gelonium Africanum*.

Ceratophorus Africanus, Sonder. A tree with ashen-white chinked bark, found in the Eastern Province and all Natal.

152. *Excoecaria Africana*, Mueller, Arg.

Spirostachys Africanus, Sonder.

Kafir : *um-Tomboti*.

A small tree of the Coast forests, exuding an acrid milky juice. Wood very heavy, extremely hard, very strong, close grained and compact, agreeably scented ; medullary rays very fine and close ; pores small, not numerous ; colour brown ; used for gunstocks.

153. *Excoecaria integerrima*.

Sclerocroton integerrimus, Hochst.

A small tree found in the Coast forests. Bark grey brown, thin, even. Wood moderately heavy and hard, compact ; medullary rays very fine and close ; pores moderately small, not numerous, distributed irregularly or in short radial groups ; colour, pale brown.

E. reticulata, Muller Arg. and *E. sp.* (Wood No. 991) are two other species, also growing in the Coast forests.

154. *Claoxylon Capense*, Baillon.

A small tree of the Coast forests.

CLIII.—URTICACEÆ.

155. *Celtis Kraussiana*, Bernhardi.

Dutch : *Kamdeboo Stinkhout*. Kafir : *um-Vumvu*.

Coast forests ; common.

A large tree 2-3 feet in diameter, 50-60 feet high. Bark yellow grey, thick, even, pitted. Wood moderately heavy and hard, strong, moderately elastic, rather brittle ; annual rings obscure ; medullary rays fine, close ; pores moderately small, numerous, irregularly distributed ; colour pale yellow tinged with brown ; becomes brittle when dry ; seldom used on that account ; suitable for railway sleepers.

156. *Celtis Burmanni*.

Dutch : *Kamdeboo Stinkhout*. Kafir : *um-Vumvu*.

South Drakensberg.

A large tree 2-3 feet in diameter, 50-60 feet high. Bark grey, thick, pitted. Wood moderately heavy and hard, rather brittle when dry; medullary rays moderately broad; pores small, irregularly distributed; colour light brown; suitable for railway sleepers.

157. *Celtis rhamnifolia*, Presl.

Sylv. Cap., p. 35.

Dutch: *Kamdeboo Stinkhout*.

Western Province, Knysna, Eastern Province, Natal.

A large tree 2-3 feet in diameter, 50-60 feet high. Wood yellowish white; used for planks, yokes, and staves; suitable for railway sleepers.

Two other species of *Celtis* are found in the North Drakensberg forests.

158. *Trema guineensis*.

Sponia guineensis, Schumacher.

Pigeonwood.

Coast forests; abundant in old cane fields.

A tree 1-2 feet in diameter, 20-30 feet high. Bark ashen, moderately thin, even. Wood very light, soft, not strong, moderately elastic, satiny; annual rings broad, obscure; medullary rays fine and close; pores moderately large, not very numerous, regularly distributed; colour silvery white; used for inside work, but bad to saw, and not durable exposed to the weather.

159. *Trema orientalis*.

Sponia orientalis.

Kafir: *um-Vangazi*.

A small tree of the Coast forests. Wood moderately light and soft, compact; medullary rays moderately fine; pores moderately small, distributed chiefly in short radial groups; colour light yellow tinged with red.

160. *Chaetachme Meyeri*, Harvey.

Kafir: *um-Kovoti*.

Coast forests. A large thorny tree 2-3 feet in diameter, 40-50 feet high, densely leafy. Bark grey-brown, moderately thick, even or slightly fissured, the surface pulverulent. Wood heavy, moderately hard, moderately strong and elastic, close grained, compact; medullary rays fine and close, intersected by close concentric bands of soft tissue; pores small, irregularly distributed; colour citron yellow.

161. *Ficus Natalensis*.

Urostigma Natalense, Miquel.

Wild Fig. Kafir: *um-Tombe*.

Drakensberg and Coast forests.

A tree 12-18 inches in diameter, 30-50 feet high, often growing parasitically on other trees. Bark grey brown, thin, smooth, fibrous. Wood very light and soft, very weak, elastic, porous, with alternate concentric layers of soft and firm tissue; medullary rays fine and close; pores moderately large and numerous, irregularly distributed; colour white or grey tinged with brown; makes rough boards, but decays rapidly if exposed to the weather.

Grows readily from cuttings; the fibres of the bark are used by Natives for making rough ropes.

Other species of *Ficus* are: (*Urostigma Thunbergii*, Miquel) found from the Cape Western Province to Natal, (*Sycomorus hirsuta*, Sonder) growing in the Coast region, and (*Sycomorus Capensis*, Miquel) found from Knysna to Natal; but this genus has by no means been worked out in Natal.

SALICINEÆ.

162. *Salix Capensis*, Thunberg.*Sylv. Cap.*, p. 35.*Cape Willow.* Dutch: *Wilgeboom.* Kafir: *um-Yezana.*

North Drakensberg, Free State, Orange River; along streams, common.

A small tree attaining 1½-2 feet in diameter and 15-20 feet in height. Bark brown, thick, craggy. Wood light, soft, compact, satiny; annual rings broad; medullary rays very fine and close; pores small, numerous, regularly distributed; colour purplish white; used occasionally for rafters, but liable to become worm-eaten.

The slender twigs are used for the manufacture of baskets (*Pappe*).

CLXV.—CONIFERÆ.

163. *Callitris Natalensis*, Endlicher.*Berg Cypress.*

North Drakensberg; forming isolated forests or clumps at high altitudes.

A small tree, resembling *C. cupressoides*, Schrader, of which it may be merely a variety.

164. *Podocarpus elongata*, L'Héritier.*Sylv. Cap.*, p. 37, *P. pruinosis*, E. Mey., l.c. p. 38.*Outeniqua Yellowwood, Bastard Yellowwood.* Dutch: *Geelhout.* Kafir: *um-Koba.*

Knysna, Eastern Province, Kaffraria, Natal, Zululand; also found on the mountains of Abyssinia at 6,000 feet; reaching its greatest development in the Knysna region, where it constitutes about one-fifth of the timber in the forests; in Natal it is scarce in the Coast forests, more abundant in those of the Drakensberg, but nowhere nearly so plentiful as *P. Thunbergii*.

A very large tree of the first economic importance, 80-120 feet high, usually 3-4 feet in diameter but attaining exceptionally a girth of 27 feet or more, with a straight cylindrical trunk 40-80 feet under branches. Bark rich brown, moderately thin, even, exfoliating in scales leaving clean smooth patches. Wood light, soft, moderately strong, elastic, fissile, not resinous. Annual rings irregular; medullary rays fine and close, not conspicuous; pores absent; colour pale yellow brown; used for planks, beams, rafters, battens, furniture, railway sleepers and many other purposes; durable exposed to the weather, but not in contact with the ground, unless impregnated with antiseptic substances.

The wood is not so hard as that of the Upright Yellowwood, but it is at least equally strong, more elastic, and less brittle; and considerably stronger than Baltic Fir, while equally elastic; it can be impregnated with antiseptic fluids more easily and thoroughly than that of resinous conifers. The growth is more rapid than that of the Upright Yellowwood, and averages 2·0 inches in girth a year in Natal plantations.

P. pruinosa, Zeyher, is a synonym, and *P. Meyeriana*, Endlicher, is probably a variety.

165. *Podocarpus Thunbergii*, Hooker.*Sylv. Cap.* p. 37.*Upright Yellowwood.* Dutch: *Regte Geelhout.* Kafir: *um-Sunti.*

Western Province, Knysna, Eastern Province, Natal, Zululand; forming one third of the timber in the forests of the Knysna region, and more than one-half of that in the Natal forests; in Natal, it is scarce in the Coast region, and reaches its greatest development in the South Drakensberg at an elevation of 3,500-4,500 feet.

A large tree of the first economic importance, 2-4 feet in diameter, 80-100 feet high, the larger specimens often hollow and defective. Bark light brown, thin, channelled, stripping longitudinally. Wood light, soft, moderately strong and elastic, fissile, not resinous; annual rings irregular; medullary rays fine and close, not conspicuous; pores absent; colour pale yellow tinged with brown; used for planks, beams, rafters, battens,

naves of wagons, staves, railway sleepers, and various other purposes; withstands exposure to the weather, but not durable in contact with the ground, unless impregnated with antiseptic substances.

The wood is harder and finer grained than that of Outeniqua Yellowwood, and more suitable for furniture, but one is not readily known from the other. It is stronger than Baltic Fir, and takes creosote better than any resinous kind of pinewood. Yellowwood of both kinds is very suitable for the manufacture of railway sleepers, and at Knysna over 100,000 are cut and creosoted annually; it yields excellent flooring boards, wearing much better than pine, makes capital ceilings, takes a handsome polish, and is otherwise vastly superior to deal in strength and appearance. One of the objections that workmen have against its use is that it splits readily and requires to be bored for nailing. Split into staves, it is used for the manufacture of vats, tubs, and small casks. Yellowwood requires much care in seasoning to prevent splitting and decay, and should be seasoned in the shade, or cut up soon after felling.

The growth averages 0.72 inches in girth a year in the natural forest at Knysna, and 0.48 inches in the poorer portions; in plantations in Natal it reaches an average of 1.18 inches.

There are two varieties of *P. Thunbergii*; var. *falcata*, which preponderates in Natal, has long sickle-shaped leaves; while in var. *latifolia*, which is that found in Knysna, the leaves are shorter and quite straight, but the young plants of both varieties are very alike, and the barks do not differ.

P. falcata, R. Brown, is a synonym of var. *falcata*, and *P. latifolia*, R. Brown, of var. *latifolia*.

166. RED IVORY.

Kafir; *um-Nini*.

A small tree found in the Coast region. Bark light brown, thick, rough. Wood extremely heavy and hard, very strong, not very elastic, close grained and compact; annual rings obscure; medullary rays very fine and close; pores small, distributed singly or in short radial lines; colour light coral red, the thin sapwood nearly white; takes a handsome polish and is prized for fancy work and turner's work.

167. BITTER ALMOND.

Kafir: *Dumizulu*.

A large tree found in the forests of the North and South Drakensberg. Bark brown, thick, rugged. Wood heavy and hard, strong, moderately elastic, close grained; medullary rays moderately fine and distant; pores small, disposed chiefly in short radial lines; colour red brown; used for felloes and other wagonwood.

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APPENDIX II.

MECHANICAL TESTS OF NATAL WOODS.

A number of experimental tests have been made in connection with the examination of the principal and other Natal woods. Through the courtesy of the Hon. D. Hunter, General Manager of Railways, and the co-operation of Messrs. W. Milne, Locomotive Superintendent, and W. Butterton, District Engineer of Maintenance, I was enabled to make use, for this purpose, of the testing appliances in the Railway workshops at Durban.

The experiments are not so complete as I should have desired. Many of the woods collected could not be identified from the foliage alone; others were excluded as belonging to new or doubtful species; and some that had been left with collectors were not received in time for use. Nevertheless, the tests include nearly all the Natal woods of the first importance, and may prove useful for reference.

Mr. W. Bazley, of Port Shepstone, kindly made at my request a collection of Coast woods which, unfortunately, could not be fully utilised because the specimens of foliage that had been collected along with the pieces of wood were lost in transmission, and though duplicates were subsequently received, it became necessary to exclude some woods the determination of which admitted of doubt.

The surplus material has been cut up for distribution in pieces of a convenient size, of which it is intended to deposit complete sets in the Durban Museum, the Maritzburg Museum, and the South African Museum in Capetown.

The constants required by engineers in determining the resistance of materials in a structure are as follows:—

1. The *density* or heaviness. The density is related to the other properties of a wood; it also gives a near approximation to the relative fuel value, and is in direct proportion to the cost of transport.
2. The *hardness* or resistance to abrasion—related to the cost of working.
3. *Coefficients of elasticity*, or resistance to stretching and bending.
4. *Limits of elasticity*, beyond which a wood retains a permanent set after the load is removed.
5. *Breaking stresses* measuring resistance to rupture, such as those to cross breaking and to crushing.

These properties, together with the durability, mainly determine the uses that a wood may be put to. Though capable of being expressed numerically, it is not easy to assign the values that the several coefficients should have in a wood used for a definite purpose. Numerical data, however, have been obtained for the principal woods of the world; they are comparable with those arrived at for the Natal woods, and we may, by inspection of the tables, rank any of our woods with a corresponding known wood the uses of which have been found out by long experience.

For this reason, and also for convenience in working, metrical units have been used throughout the experiments. The vast majority of researches on the strength of wood have been made by American, German, and French observers, whose results, some of which are added to the table of averages, would not otherwise be readily comparable. But for general convenience, another table of averages for the Natal woods is given in British measure.

The exotic timbers for which data are given comprise, in addition to well-known woods, some of the species recommended, in Appendix VII., for planting in Natal.

For many applications, lightness in a material is as essential as strength, and in order to show readily how the woods tested combine these qualities, the different species have been arranged in order of their density in the following tables:

TABLE OF AVERAGES.

Species.	Density.	Relative Hardness 0-10.	Co-efficient of elasticity.	Modulus of rupture. kgms. per sq. cm.	Crushing load, kgm. per sq. cm.
<i>Red Ivory</i> ...	1.18	10.0	1252	986	956
<i>Milletia Caffra</i> ...	1.15	9.0	1714	1183	1030
<i>Olea verrucosa</i> ...	1.14	7.7	1085	918	681
<i>Rhus lucida</i> ...	1.12	6.5	1253	1121	978
<i>Pteroxylon utile</i> ...	1.09	8.0	1520	1530	1129
<i>Olea foveolata</i> ...	1.01	7.0	1613	979	708
<i>Cluytia</i> sp. ...	1.01	5.8	—	—	—
<i>Scolopia Zeyheri</i> ...	1.00	5.1	906	895	503
<i>Hippobromus alata</i> ...	0.99	6.5	1005	831	615
<i>Sideroxylon inerme</i> ...	0.99	7.0	973	806	441
<i>Olea laurifolia</i> ...	0.97	6.8	1484	1073	763
<i>Celastrus acuminatus</i> ...	0.97	6.0	—	—	—
<i>Elæodendron velutinum</i> ...	0.96	6.0	1375	1082	724
<i>Zanthoxylum Thunbergii</i> ...	0.94	6.1	1139	803	505
<i>Bitter Almond</i> ...	0.93	5.0	786	748	532
<i>Ochna arborea</i> ...	0.92	6.6	—	—	524
<i>Curtisia faginea</i> ...	0.92	6.0	1115	683	524
<i>Toddalia lanceolata</i> ...	0.91	5.8	1244	968	617
<i>Halleria lucida</i> ...	0.91	4.6	1145	938	600
<i>Mimusops obovata</i> ...	0.91	5.3	844	862	462
<i>Cathastrum Capense</i> ...	0.90	5.4	761	641	554
<i>Olinia cymosa</i> ...	0.89	5.2	744	818	594
<i>Euclea natalensis</i> ...	0.89	4.4	1270	813	484
<i>Heteromorpha arborescens</i> ...	0.87	2.9	888	597	381
<i>Dovyalis rhamnoides</i> ...	0.87	4.2	618	537	365
<i>Brachylæna discolor</i> ...	0.86	5.0	1292	1110	829
<i>Combretum Kraussii</i> ...	0.85	5.4	1038	796	513
<i>Mimusops Caffra</i> ...	0.85	5.0	881	670	511
<i>Apodytes dimidiata</i> ...	0.84	4.6	1025	833	581
<i>Scolopia Ecklonii</i> ...	0.84	5.0	849	700	398
<i>Plectronia Mundtiana</i> ...	0.83	4.5	908	753	589
<i>Buddlea salviaefolia</i> ...	0.81	4.4	670	767	495
<i>Clausena inæqualis</i> ...	0.80	4.0	1044	789	584
<i>Trimeria alnifolia</i> ...	0.79	4.0	909	835	508
<i>Acacia horrida</i> ...	0.79	4.2	698	578	427
<i>Ocotea bullata</i> ...	0.78	4.3	1187	945	649
<i>Strychnos Atherstonei</i> ...	0.78	4.7	806	708	521
<i>Chætachme Meyeri</i> ...	0.78	4.4	826	558	429
<i>Royena lucida</i> ...	0.77	4.0	668	657	424
<i>Rhamnus prinoides</i> ...	0.77	3.8	—	—	—
<i>Celtis Kraussiana</i> ...	0.76	4.0	1200	832	554
<i>Hibiscus tiliaceus</i> ...	0.76	4.2	698	671	421
<i>Schmidelia africana</i> ...	0.75	4.2	1146	961	571
<i>Grewia occidentalis</i> ...	0.73	3.4	1001	856	603
<i>Myrsine melanophleas</i> ...	0.72	3.1	1024	633	434
<i>Acacia Natalitia</i> ...	0.70	5.0	593	599	371
<i>Eugenia cordata</i> ...	0.70	4.1	785	500	379
<i>Clerodendron glabrum</i> ...	0.69	3.0	521	623	386
<i>Rhus longifolia</i> ...	0.68	2.8	1085	640	441
<i>Scutia indica</i> ...	0.65	2.8	—	—	—
<i>Odina caffra</i> ...	0.65	3.0	884	758	502

TABLE OF AVERAGES (continued).

Species.	Density.	Relative Hardness 0-10.	Co-efficient of elasticity.	Modulus of rupture. kgms. per sq. cm.	Crushing load, kgms. per sq. cm.
<i>Kiggelaria africana</i> ...	0.65	2.7	651	457	410
<i>Ekebergia capensis</i> ...	0.64	2.6	780	528	388
<i>Protea hirta</i> ...	0.64	2.7	—	—	—
<i>Calodendron Capense</i> ...	0.62	2.7	855	753	430
<i>Ilex Capensis</i> ...	0.61	2.4	749	511	413
<i>Leucosidea sericea</i> ...	0.61	2.8	323	415	356
<i>Protea lanceolata</i> ...	0.61	2.5	—	—	—
<i>Briedelia micrantha</i> ...	0.59	2.6	976	466	505
<i>Podocarpus Thunbergii</i> ...	0.59	2.6	812	448	497
<i>Albizia fastigiata</i> ...	0.57	2.8	—	—	287
<i>Salix Capensis</i> ...	0.56	2.5	—	—	—
<i>Ekebergia Meyeri</i> ...	0.54	2.5	896	497	378
<i>Rauwolfia Natalensis</i> ...	0.53	2.3	726	491	454
<i>Natal Sleeper</i> (<i>Pinus picea</i>) ...	0.49	2.0	632	360	314
<i>Podocarpus elongata</i> ...	0.47	2.4	655	538	395
<i>Cussonia</i> sp. ...	0.46	2.1	548	286	267
<i>Trema guineensis</i> ...	0.45	2.3	739	465	381
<i>Greyia Sutherlandi</i> ...	—	2.2	308	286	209
<i>Ficus Natalensis</i> ...	0.41	1.9	417	317	276
<i>Erythrina caffra</i> ...	0.26	1.0	219	179	129

PROPERTIES OF SOME EXOTIC TIMBERS.

Species.	Vernacular Name.	Density.	Co-efficient of Elasticity.	Modulus of Rupture.	Crushing load kgms. per sq. cm.	Authority.
<i>Condalia ferrea</i> ...	Ironwood ...	1.30*	1143	905	803	Sharples.
<i>Guaiacum sanctum</i> ...	Lignum-vitæ... ..	1.14*	863	787	737	Do.
<i>Eucalyptus siderophloia</i>	Ironbark ...	(1.10)	1372	1284	715	Unwin.
<i>E. marginata</i> ...	Jarrah ...	(1.01)	499	651	504	Do.
<i>E. Globulus</i> ...	Blue Gum ...	(0.95)	1433	923	543	Do.
<i>Carya alba</i> ...	Hickory ...	0.84*	1390	1200	626	Sharples.
<i>Quercus Robur</i> ...	British Oak ...	...	1033	830	702	Unwin.
Do. (var. pedunculata)	Do.	0.81	978	649	...	Wertheim.
Do. (var. sessiliflora)	Do.	0.87	921	566	...	Do.
Do. do.	Do.	0.73	893	749	...	Sebert.
Do. do.	Do.	0.80	781	862	...	Dufaure.
Do. do.	Do.	0.74	625	562	...	De Lapparent
<i>Quercus alba</i> ...	American White Oak	0.75*	971	905	511	Sharples.
<i>Swietenia Mahogoni</i> ...	Mahogany ...	0.73*	1062	993	666	Do.
<i>Tectona grandis</i> ...	Teak (Indian)	...	1687	1090	844	Unwin.
Do. do. ...	Do. (Burmah)	0.65	1250	1080	...	De Lapparent
<i>Fraxinus Americana</i> ...	American White Ash	0.65*	1015	860	471	Sharples.
<i>Cupressus macrocarpa</i> ...	...	0.63*	1073	1052	...	Do.
<i>Pinus sylvestris</i> ...	Baltic Red Wood	0.60	564	248	...	Wertheim.
<i>P. rigida</i> ...	Pitch Pine ...	0.52*	581	740	356	Sharples.
<i>Pinus picea</i> ...	Spruce ...	0.49	632	360	314	Natal Tests.
<i>Pinus ponderosa</i> ...	Yellow Pine...	0.47*	887	720	377	Sharples.
<i>Chamæcyparis Lawsoniana</i>	...	0.46*	1217	888	466	Do.
<i>Pinus insignis</i> ...	...	0.46*	979	740	418	Do.
<i>Liriodendron tulipifera</i> ...	Tulip ...	0.42*	926	656	372	Do.
<i>Catalpa speciosa</i> ...	...	0.42*	822	633	408	Do.
<i>Populus monilifera</i> ...	Cottonwood ...	0.39*	994	769	353	Do.
<i>Pinus Strobus</i> ...	White Pine ...	0.39*	851	626	389	Do.

In the column of densities, the figures between brackets are not taken from the source given in the last column ; and those marked with an asterisk refer to absolutely dried wood.

TABLE OF AVERAGES. BRITISH MEASURE.

Species.		Weight of a cubic foot. lbs.	Relative Hardness, 0-10	Co-efficient of elasticity. Tons per square inch.	Modulus of rupture. Tons per square inch.	Crushing load. Tons per square inch.
<i>Red Ivory</i>	...	73.7	10.0	795	6.26	6.07
<i>Milletia Caffra</i>	...	71.8	9.0	1088	7.51	6.54
<i>Olea verrucosa</i>	...	71.2	7.7	689	5.83	4.32
<i>Rhus lucida</i>	...	69.9	6.5	796	7.12	6.21
<i>Pteroxylon utile</i>	...	68.0	8.0	965	9.71	7.17
<i>Olea foveolata</i>	...	63.0	7.0	1024	6.22	4.50
<i>Cluytia sp.</i>	...	63.0	5.8	—	—	—
<i>Scolopia Zeyheri</i>	...	62.4	5.1	575	5.68	3.19
<i>Hippobromus alata</i>	...	61.8	6.5	638	5.28	3.91
<i>Sideroxylon inerme</i>	...	61.8	7.0	618	5.12	2.80
<i>Olea laurifolia</i>	...	60.6	6.8	942	6.81	4.85
<i>Celastrus acuminatus</i>	...	60.6	6.0	—	—	—
<i>Elæodendron velutinum</i>	...	59.9	6.0	873	6.87	4.60
<i>Zanthoxylum Thunbergii</i>	...	58.8	6.1	723	5.10	3.21
<i>Bitter Almond</i>	...	58.0	5.0	499	4.75	3.38
<i>Ochna arborea</i>	...	57.4	6.6	—	—	3.33
<i>Curtisia faginea</i>	...	57.4	6.0	708	4.34	3.33
<i>Toddalia lanceolata</i>	...	56.8	5.8	790	6.15	3.92
<i>Halleria lucida</i>	...	56.8	4.6	727	5.96	3.81
<i>Mimusops obovata</i>	...	56.8	5.3	536	5.47	2.93
<i>Cathastrum Capense</i>	...	56.2	5.4	483	4.07	3.52
<i>Olinia cymosa</i>	...	55.6	5.2	472	5.19	3.77
<i>Euclea natalensis</i>	...	55.6	4.4	806	5.16	3.07
<i>Heteromorpha arborescens</i>	...	54.3	2.9	564	3.79	2.42
<i>Dovyalis rhamnoides</i>	...	54.3	4.2	392	3.41	2.32
<i>Brachylæna discolor</i>	...	53.7	5.0	820	7.05	5.26
<i>Combretum Kraussii</i>	...	53.1	5.4	659	5.05	3.26
<i>Mimusops Caffra</i>	...	53.1	5.0	559	4.25	3.24
<i>Apodytes dimidiata</i>	...	52.4	4.6	651	5.29	3.69
<i>Scolopia Ecklonii</i>	...	52.4	5.0	539	4.44	2.53
<i>Plectronia Mundtiana</i>	...	51.8	4.5	577	4.78	3.74
<i>Buddlea salviæfolia</i>	...	50.6	4.4	425	4.87	3.14
<i>Clausena inæqualis</i>	...	49.9	4.0	663	5.01	3.71
<i>Trimeria alnifolia</i>	...	49.3	4.0	577	5.30	3.23
<i>Acacia horrida</i>	...	49.3	4.2	443	3.67	2.71
<i>Ocotea bullata</i>	...	48.7	4.3	754	6.00	4.12
<i>Strychnos Atherstonei</i>	...	48.7	4.7	512	4.50	3.31
<i>Chætachme Meyeri</i>	...	48.7	4.4	524	3.54	2.72
<i>Royena lucida</i>	...	48.1	4.0	424	4.17	2.69
<i>Rhamnus prinoides</i>	...	48.1	3.8	—	—	—
<i>Celtis Kraussiana</i>	...	47.4	4.0	762	5.28	3.52
<i>Hibiscus tilaceus</i>	...	47.4	4.2	443	4.26	2.67
<i>Schmidelia Africana</i>	...	46.8	4.2	728	6.10	3.63
<i>Grewia occidentalis</i>	...	45.6	3.4	636	5.44	3.83
<i>Myrsine melanophleas</i>	...	44.9	3.1	650	4.02	2.76
<i>Acacia Natalitia</i>	...	43.7	5.0	377	3.80	2.36
<i>Eugenia cordata</i>	...	43.7	4.1	498	3.17	2.41
<i>Clerodendron glabrum</i>	...	43.1	3.0	331	3.96	2.45
<i>Rhus longifolia</i>	...	42.4	2.8	689	4.06	2.80
<i>Scutia indica</i>	...	40.6	2.8	—	—	—
<i>Odina caffra</i>	...	40.6	3.0	561	4.81	3.19

TABLE OF AVERAGES. BRITISH MEASURE (*continued*).

Species.	Weight of a cubic foot. lbs.	Relative Hardness, 0-10.	Co-efficient of elasticity. Tons per square inch.	Modulus of rupture. Tons per square inch.	Crushing load. Tons per square inch.
<i>Kiggelaria africana</i> ...	40·6	2·7	413	2·90	2·60
<i>Ekebergia capensis</i> ...	40·0	2·6	495	3·35	2·46
<i>Protea hirta</i> ...	40·0	2·7	—	—	—
<i>Calodendron Capense</i> ...	38·7	2·7	543	4·78	2·73
<i>Ilex Capensis</i> ...	38·1	2·4	475	3·24	2·62
<i>Leucosidea sericea</i> ...	38·1	2·8	205	2·64	2·26
<i>Protea lanceolata</i> ...	38·1	2·5	—	—	—
<i>Briedelia micrantha</i> ...	36·8	2·6	620	2·96	3·21
<i>Podocarpus Thunbergii</i> ...	36·8	2·6	516	2·84	3·16
<i>Albizzia fastigiata</i> ...	35·6	2·8	—	—	1·82
<i>Salix Capensis</i> ...	35·0	2·5	—	—	—
<i>Ekebergia Meyeri</i> ...	33·7	2·5	569	3·16	2·40
<i>Rauwolfia Natalensis</i> ...	33·1	2·3	461	3·12	2·88
<i>Natal Sleeper</i> (<i>Pinus picea</i>) ...	30·6	2·0	401	2·29	1·98
<i>Podocarpus elongata</i> ...	29·3	2·4	416	3·42	2·51
<i>Cussonia</i> sp. ...	28·7	2·1	348	1·82	1·70
<i>Trema guineensis</i> ...	28·1	2·3	469	2·95	2·42
<i>Greyia Sutherlandi</i> ...	—	2·2	196	1·82	1·33
<i>Ficus Natalensis</i> ...	25·6	1·9	265	2·01	1·75
<i>Erythrina caffra</i> ...	16·2	1·0	139	1·14	0·82

METHODS ADOPTED.

The methods adopted in the Natal tests were generally similar to those followed in the admirable series of experiments conducted at the Watertown Arsenal by Mr. S. P. Sharpley for the United States Government, the results of which are recorded in Prof. Sargent's *Report on the Forests of North America* (Tenth Census U.S., Vol. IX.).

SPECIMENS TESTED.

The specimens used were mostly cut in May or June 1889, then stacked and seasoned for some months in a well-ventilated shed in Durban, before testing in January-February 1890; they were thus seasoned eight months on an average, and the seasoning was more thorough than would usually be the case in the same interval. Dry pieces of Stinkwood, Ironwood, and White Pear from the Knysna forests, and of Flat-crown from Victoria County, were also tested.

With few exceptions, the results obtained do not give a measure of the properties of timber of the best quality. The material disposable was too limited in quantity to admit of a selection, and much of it was cut from small trees scarcely mature. For each species, the pieces of wood procured from each locality recorded in the tables were cut from the same tree, and the results of the various tests are thus comparable.

DETERMINATIONS OF DENSITY AND HARDNESS.

Timber retains a very variable proportion of water, according to the mode and length of seasoning; and to have an accurate meaning, the density determinations should be made on pieces dried artificially till they cease to lose weight, but it would have been difficult to adopt this method, and the density of the air-dried wood was alone taken.

The specimens used for the purpose were made exactly 4 centimeters square and 32 centimeters long; they were weighed and the density calculated. The results are given in Table I.

STRESS-STRAIN DIAGRAMS FOR TRANSVERSE STRESSES —

The determinations of relative hardness were made by comparing each of the woods with those forming the following scale :—

1. *Erythrina caffra* (*Kafirboom*).
2. *Pinus picea* (Pinewood of N.G.R. sleepers).
3. *Odina Caffra* (*Kafir Plum*).
4. *Royena lucida* (*Zwartbast*).
5. *Brachyæna discolor* (*um-pahla*).
6. *Elæodendron velutinum* (*um-Nqai*).
7. *Olea foveolata* (*Bastard Ironwood*).
8. *Pteroxylon utile* (*Sneezeewood*).
9. *Millettia Caffra* (*um-Simbiti*).
10. Red Ivory.

The specimens forming this scale were so selected as to make the corresponding numbers represent, approximately, the relative resistance to small indentations of uniform size.

TRANSVERSE TESTS.

The transverse tests were made with a simple form of lever-testing machine constructed for the purpose at the Railway workshops. The specimens used were planed exactly 4 centimeters square, and cut of a sufficient length to give the necessary bearing on the supports ; these were shod with iron plates slightly rounded on the edge and set 1 meter apart.

The loads were applied carefully and gradually by means of a screw, and transmitted by an interposed lever to a rod, 12 millimeters in radius, guided horizontally by a slide exactly midway between the supports. The pressure at any moment was registered by spring balances, and the deflections by a scale on the slide. The deflections were read for successive loads of 50 kilograms. When the load reached 200 kilograms, it was removed and a reading of the set taken. Pressure was again applied and the deflections, for loads of 250 kilograms and more, read, until the specimen failed. When the limit of elasticity was approached or exceeded, the deflections were not read before they ceased to increase sensibly with time.

The formula used in calculating the coefficient of elasticity was $E = \frac{W l^3}{4 \Delta b h^3}$, l , b , h , being the length, breadth, and depth of the bar in millimeters, W , the load in kilograms. The deflection Δ selected, was that for a load of 100 kilograms, except in cases when the limit of elasticity was reached with a smaller load.

The formula used in calculating the modulus of rupture was $R = \frac{3 W l}{2 b h^2}$, l , b , h , being taken in centimeters, and W , in kilograms.

The diagrams in Plate V. show the behaviour of some of the principal Natal woods under transverse pressure. The loads applied are indicated by the ordinates from each small circle, and the deflections by the corresponding abscissæ, a different origin being used for each curve. When the limit of elasticity is exceeded, the deflections cease to be proportional to the loads, and the curve departs from an approximately straight line. The last test within the limit of elasticity is shown by a larger circle. These diagrams show that the elasticity of the different specimens varies considerably less than their resistance to rupture.

CRUSHING TESTS.

The crushing tests were made by means of a 20-ton Tangye's hydraulic testing machine, on specimens 4 centimetres square and 32 centimeters long (8 diameters). The test pieces were placed horizontally between the platforms of the machine, and pressure was applied until they failed. The pressure was registered by a manometer. The results are given in Table III.

GENERAL.

The properties of each kind of wood vary considerably with the density and length of seasoning :

- a. The hardness increases with the density and with the length of seasoning.
- b. The strength, both crushing and transverse, increases nearly in proportion to the density and by thorough seasoning, it may be increased by one-fourth.
- c. The coefficient of elasticity increases with the density, but only slightly with the length of seasoning.
- d. For the same sectional dimensions, the greater the length, the smaller the crushing stress and the modulus of rupture.

TABLE I.—DENSITY DETERMINATIONS.

Species.		Office number.	Locality.	Density.	Average.	Weight of a cubic foot, lbs.
BIXINEÆ—						
5. <i>Scolopia Zeyheri</i> <i>Wolvedoorn</i>	...	1	North Drakensberg.	0.92	1.00	62.4
		2	ditto	1.03		
		3	ditto	1.00		
		4	ditto	0.99		
6. <i>Scolopia Ecklonii</i> <i>Red Pear</i>	...	5	ditto	0.84	0.84	52.4
		6	ditto	0.83		
		7	ditto	0.85		
		8	ditto	0.84		
8. <i>Dovyalis rhamnoides</i> <i>Zuurbesjes</i>	...	9	ditto	0.86	0.87	54.3
		10	ditto	0.87		
10. <i>Trimeria alnifolia</i>	...	11	ditto	0.82	0.79	49.3
		12	ditto	0.72		
		13	ditto	0.73		
		14	ditto	0.87		
11. <i>Kiggelaria africana</i> <i>Spiekhout</i>	...	15	ditto	0.66	0.65	40.6
		16	ditto	0.66		
		17	ditto	0.61		
		18	ditto	0.65		
MALVACEÆ—						
14. <i>Hibiscus tiliaceus</i>	...	19	Port Shepstone.	0.71	0.76	47.4
		20	ditto	0.76		
		21	ditto	0.75		
		22	ditto	0.82		
TILIACEÆ—						
19. <i>Grewia occidentalis</i> <i>Kruisbesjes</i>	...	228	North Drakensberg.	0.76	0.73	45.6
		229	ditto	0.69		
RUTACEÆ—						
23. <i>Calodendron capense</i> <i>Wild Chestnut</i>	...	23	ditto	0.64	0.62	38.7
		24	ditto	0.61		
		25	ditto	0.61		
		26	ditto	0.62		
25. <i>Zanthoxylum Thunbergii</i> <i>Knobthorn</i>		27	ditto	0.98	0.94	58.8
		28	ditto	0.95		
		29	ditto	0.99		
		30	Port Shepstone.	0.89		
		31	ditto	0.89		
		32	ditto	0.91		
26. <i>Toddalia lanceolata</i> <i>White Ironwood,</i> <i>Bastard Sneezewood</i>	...	33	North Drakensberg.	1.02	0.91	56.8
		34	ditto	1.01		
		35	ditto	1.04		
		36	Port Shepstone.	0.79		
		37	ditto	0.81		
		38	ditto	0.80		

TABLE I.—DENSITY DETERMINATIONS (*continued*).

Species.	Office number.	Locality.	Density.	Average.	Weight of a cubic foot, lbs.
27. <i>Clausena inæqualis</i> ...	39	North Drakensberg	0.77	0.80	49.9
	40	ditto	0.83		
OCHNACEÆ—					
28. <i>Ochna arborea</i>	41	Port Shepstone	0.90	0.92	57.4
<i>Rooihout, Cape Plane</i>	42	ditto	0.97		
	43	ditto	0.94		
	44	ditto	0.88		
MELIACEÆ—					
33. <i>Ekebergia capensis</i> ...	49	ditto	0.65	0.64	40.0
<i>Essenhout</i>	50	ditto	0.65		
	51	ditto	0.65		
	52	ditto	0.61		
34. <i>Ekebergia Meyeri</i> ...	45	ditto	0.51	0.54	33.7
<i>Wild Syringa</i>	46	ditto	0.53		
	47	ditto	0.55		
	48	ditto	0.59		
OLACINEÆ—					
36. <i>Apodytes dimidiata</i> ...	53	ditto	0.76	0.84	52.4
<i>White Pear</i>	54	ditto	0.78		
	55	ditto	0.84		
	56	ditto	0.86		
	251	Knysna	0.94		
	252	ditto	0.82		
	253	ditto	0.87		
ILICINEÆ—					
37. <i>Ilex Capensis</i>	57	North Drakensberg	0.59	0.61	38.1
<i>Wittehout</i>	58	ditto	0.60		
	59	ditto	0.63		
CELASTRINEÆ—					
38. <i>Cathastrum Capense</i> ...	230	ditto	0.89	0.90	56.2
<i>Bustard Saffraan</i>	231	ditto	0.91		
	232	ditto	0.91		
	233	ditto	0.90		
39. <i>Celastrus acuminatus</i> ...	60	ditto	0.97	0.97	60.6
<i>Silkbark, Zybast</i>					
45. <i>Elæodendron velutinum</i>	247	Port Shepstone	0.97	0.96	59.9
<i>um-Ngai</i>	248	ditto	0.95		
	249	ditto	0.96		
	250	ditto	0.95		
RHAMNEÆ—					
47. <i>Rhamnus prinoides</i> ...	61	North Drakensberg	0.78	0.77	48.1
<i>Dogwood</i>	62	ditto	0.76		

TABLE I.—DENSITY DETERMINATIONS (*continued*).

Species.		Office number.	Locality.	Density.	Average.	Weight of a cubic foot, lbs.
48. <i>Scutia indica</i> ...	...	63	North Drakensberg	0.66	0.65	40.6
<i>Katdoorn</i>		64	ditto	0.63		
SAPINDACEÆ—						
50. <i>Schmidelia africana</i> ...	...	65	ditto	0.73	0.75	46.8
		66	ditto	0.77		
		67	ditto	0.74		
51. <i>Hippobromus alata</i> ...	...	68	ditto	1.02	0.99	61.8
<i>Paardepis</i>		69	ditto	0.98		
		70	ditto	0.97		
		71	ditto	1.01		
54. <i>Pteroxylon utile</i> ...	...	72	Port Shepstone	1.09	1.09	68.0
<i>Sneezeewood</i>		73	ditto	1.05		
		74	ditto	1.12		
		75	ditto	1.11		
ANACARDIACEÆ—						
59. <i>Rhus longifolia</i> ...	...	78	ditto	0.63	0.68	42.4
		79	ditto	0.71		
		80	ditto	0.70		
58. <i>Rhus lucida</i> ...	...	81	North Drakensberg	1.13	1.12	69.9
		82	ditto	1.11		
61. <i>Odina caffra</i> ...	...	83	Port Shepstone	0.67	0.65	40.6
<i>Kafir Plum</i>		84	ditto	0.68		
		85	ditto	0.62		
		86	ditto	0.61		
LEGUMINOSÆ—						
63. <i>Milletia Caffra</i> ...	...	87	ditto	1.13	1.15	71.8
<i>Umsimbiti</i>		88	ditto	1.17		
		89	ditto	1.18		
		90	ditto	1.13		
64. <i>Erythrina caffra</i> ...	...	91	ditto	0.25	0.26	16.2
<i>Kafir boom</i>		92	ditto	0.27		
		93	ditto	0.27		
		94	ditto	0.26		
72. <i>Acacia Natalitia</i> ...	...	95	ditto	0.75	0.70	43.7
		96	ditto	0.68		
		27	ditto	0.67		
71. <i>Acacia horrida</i> ...	...	98	North Drakensberg	0.79	0.79	49.3
		99	ditto	0.76		
		100	ditto	0.81		
73. <i>Albizzia fastigiata</i> ...	...	104	North Coast	0.60	0.57	35.6
<i>Flat Crown</i>		105	ditto	0.51		
		106	ditto	0.55		
		107	ditto	0.61		

TABLE I.—DENSITY DETERMINATIONS (*continued*).

Species.	Office number.	Locality.	Density.	Average.	Weight of a cubic foot, lbs.
ROSACEÆ—					
74. <i>Leucosidea sericea</i> ...	226	North Drakensberg	0.60	0.61	38.1
	227	ditto	0.62		
COMBRETACEÆ—					
80. <i>Combretum Kraussii</i> ...	108	Port Shepstone	0.86	0.85	53.1
<i>Bush Willow</i>	109	ditto	0.87		
	110	ditto	0.83		
	111	ditto	0.85		
MYRTACEÆ—					
81. <i>Eugenia cordata</i> ...	112	ditto	0.70	0.70	43.7
<i>Waterboom, Umdoni</i>	113	ditto	0.69		
	114	ditto	0.72		
	115	ditto	0.70		
LYTHRARIÆ—					
83. <i>Olinia cymosa</i> ...	116	North Drakensberg	0.86	0.89	55.6
<i>Hard Pear</i>	117	ditto	0.89		
	118	ditto	0.91		
	119	ditto	0.89		
UMBELLIFERÆ—					
87. <i>Heteromorpha arborescens</i>	234	ditto	0.91	0.87	54.3
	235	ditto	0.83		
ARALIACEÆ—					
89. <i>Cussonia</i> sp ...	120	ditto	0.47	0.46	28.7
<i>Cabbage wood</i>	121	ditto	0.44		
CORNACEÆ—					
90. <i>Curtisia faginea</i> ...	122	ditto	0.89	0.92	57.4
<i>Assagai</i>	123	ditto	0.92		
	124	ditto	0.92		
	125	ditto	0.94		
RUBIACEÆ—					
101. <i>Plectronia Mundtiana</i>	126	ditto	0.80	0.83	51.8
<i>Klip Els</i>	127	ditto	0.81		
	128	ditto	0.86		
	128	ditto	0.85		
COMPOSITÆ—					
104. <i>Brachylæna discolor</i> ...	130	Port Shepstone	0.91	0.86	53.7
	131	ditto	0.96		
	132	ditto	0.78		
	133	ditto	0.78		
MYRSINÆ—					
107. <i>Myrsine melanophleas</i>	134	North Drakensberg	0.70	0.72	44.9
<i>Beukenhout</i>	135	ditto	0.67		
	136	ditto	0.72		
	137	Port Shepstone	0.74		
	138	ditto	0.74		
	139	ditto	0.77		

TABLE J.—DENSITY DETERMINATIONS (*continued*).

Species.	Office number.	Locality.	Density.	Average.	Weight of a cubic foot, lbs.
SAPOTACEÆ—					
109. <i>Sideroxylon inerme</i> ...	140	Port Shepstone	0.98	0.99	61.8
<i>White Milkwood</i>	141	ditto	0.96		
	142	ditto	1.00		
	143	ditto	1.02		
111. <i>Mimusops obovata</i> ...	144	ditto	0.90	0.91	56.8
<i>Red Milkwood</i>	145	ditto	0.89		
	146	ditto	0.92		
	147	ditto	0.94		
112. <i>Mimusops Caffra</i> ...	148	ditto	0.89	0.85	53.1
<i>Coast Red Milkwood</i>	149	ditto	0.90		
	150	ditto	0.76		
	151	ditto	0.86		
EBENACEÆ—					
113. <i>Royena lucida</i> ...	152	North Drakensberg	0.77	0.77	48.1
<i>Zwartbast</i>	153	ditto	0.74		
	154	ditto	0.80		
114. <i>Euclea natalensis</i> ...	155	ditto	0.89	0.89	55.6
	156	ditto	0.90		
	157	Port Shepstone	0.90		
	158	ditto	0.88		
	159	ditto	0.89		
OLEACEÆ—					
118. <i>Olea verrucosa</i> ...	160	North Drakensberg	1.05	1.14	71.2
	161	ditto	1.06		
	162	ditto	1.05		
	244	Port Shepstone	1.25		
	245	ditto	1.22		
	246	ditto	1.23		
119. <i>Olea laurifolia</i> ...	163	Knysna	0.99	0.97	60.6
<i>Ironwood</i>	164	ditto	1.00		
	165	ditto	0.95		
	166	ditto	0.94		
120. <i>Olea foveolata</i> ...	167	Port Shepstone	1.00	1.01	63.0
	168	ditto	1.02		
	169	ditto	1.01		
	170	ditto	1.00		
APOCYNACEÆ—					
121. <i>Rauwolfia Natalensis</i> ...	171	ditto	0.51	0.53	33.1
	172	ditto	0.54		
LOGANIACEÆ—					
126. <i>Buddleia salviæfolia</i> ...	173	North Drakensberg	0.84	0.81	50.6
<i>Saliehout</i>	174	ditto	0.80		
	175	ditto	0.79		

TABLE I.—DENSITY DETERMINATIONS (*continued*).

Species.	Office number.	Locality.	Density.	Average.	Weight of a cubic foot, lbs.
127. <i>Strychnos Atherstonei</i> ...	176	Port Shepstone	0.79	0.78	48.7
<i>Cape Teak, Chaka's</i>	177	ditto	0.77		
<i>wood</i>	178	ditto	0.78		
SCROPHULARINEÆ—					
131. <i>Halleria lucida</i> ...	179	North Drakensberg	0.85	0.91	56.8
	180	ditto	0.97		
	181	ditto	0.90		
VERBENACEÆ—					
133. <i>Clerodendron glabrum</i>	182	ditto	0.69	0.69	43.1
	183	ditto	0.67		
	184	ditto	0.72		
LAURINEÆ—					
137. <i>Ocotea bullata</i> ...	185	Knysna	0.70	0.78	48.7
<i>Stinkwood</i>	186	ditto	0.77		
	187	ditto	0.76		
	188	Natal	0.79		
	189	ditto	0.85		
	190	ditto	0.84		
PROTEACEÆ—					
138. <i>Protea hirta</i> ...	191	North Drakensberg	0.65	0.64	40.0
<i>White Sugar bush</i>	192	ditto	0.64		
139. <i>Protea lanceolata</i> ...	193	ditto	0.65	0.61	38.1
<i>Sugar bush</i>	194	ditto	0.58		
EUPHORBIACEÆ—					
144. <i>Briedelia micrantha</i> ...	195	Port Shepstone	0.59	0.59	36.8
	196	ditto	0.62		
	197	ditto	0.56		
149. <i>Cluytia</i> sp. ...	224	North Drakensberg	1.00	1.01	63.0
	225	ditto	1.02		
URTICACEÆ—					
155. <i>Celtis Kraussiana</i> ...	191	Port Shepstone	0.79	0.76	47.4
<i>Kamdeboo Stinkwood,</i>	199	ditto	0.74		
<i>Umvumvu</i>	200	ditto	0.77		
	201	ditto	0.76		
158. <i>Trema guineensis</i> ...	202	ditto	0.48	0.45	28.1
	203	ditto	0.41		
	204	ditto	0.47		
160. <i>Chætachme Meyeri</i> ...	205	ditto	0.80	0.78	48.7
	206	ditto	0.78		
	207	ditto	0.77		
161. <i>Ficus Natalensis</i> ...	208	ditto	0.39	0.41	25.6
<i>Wild Fig</i>	209	ditto	0.41		
	210	North Drakensberg	0.42		
	211	ditto	0.41		

TABLE I.—DENSITY DETERMINATIONS (*continued*).

Species.	Office number.	Locality.	Density.	Average.	Weight of a cubic foot, lbs.
SALICINEÆ—					
162. <i>Salix Capensis</i>	212	North Drakensberg	0.58	0.56	35.0
<i>Cape Willow, Wilgeboom.</i>	213	ditto	0.55		
CONIFERÆ—					
164. <i>Podocarpus Thunbergii</i> ,	214	ditto	0.60	0.59	36.8
<i>var falcata</i>	215	ditto	0.59		
<i>Upright Yellowwood</i>	216	ditto	0.60		
	217	ditto	0.57		
	218	ditto	0.57		
165. <i>Podocarpus elongata</i> ...	210	ditto	0.46	0.47	29.3
<i>Outeniqua Yellowwood, Bastard Yellowwood</i>	220	ditto	0.46		
	221	ditto	0.48		
	222	ditto	0.47		
	223	ditto	0.47		
166. <i>Red Ivory</i>	236	Port Shepstone	1.16	1.18	73.7
	237	ditto	1.17		
	238	ditto	1.20		
	239	ditto			
167. <i>Bitter Almond</i>	239	North Drakensberg	0.91	0.93	58.0
	240	ditto	0.93		
	241	ditto	0.97		
	242	ditto	0.90		
168. <i>Natal Railway Sleeper</i> <i>(Pinus picea)</i>	254	Baltic	0.50	0.49	30.6
	255	ditto	0.42		
	256	ditto	0.62		
	257	ditto	0.48		
	258	ditto	0.44		
	259	ditto	0.44		
	260	ditto	0.45		
	261	ditto	0.54		

TABLE II.—BENDING TESTS ON

No.	Species	Locality	Co-efficient of elasticity	Modulus of rupture	Deflection in millimeters			
					50	100	150	200
1	...	...	...	...	...	...	...	...
2	...	...	...	...	...	...	...	...
3	...	...	...	...	...	...	...	...
4	...	...	...	...	...	...	...	...
5	...	...	...	...	...	...	...	...
6	...	...	...	...	...	...	...	...
7	...	...	...	...	...	...	...	...
8	...	...	...	...	...	...	...	...
9	...	...	...	...	...	...	...	...
10	...	...	...	...	...	...	...	...
11	...	...	...	...	...	...	...	...
12	...	...	...	...	...	...	...	...
13	...	...	...	...	...	...	...	...
14	...	...	...	...	...	...	...	...
15	...	...	...	...	...	...	...	...
16	...	...	...	...	...	...	...	...
17	...	...	...	...	...	...	...	...
18	...	...	...	...	...	...	...	...
19	...	...	...	...	...	...	...	...
20	...	...	...	...	...	...	...	...
21	...	...	...	...	...	...	...	...
22	...	...	...	...	...	...	...	...
23	...	...	...	...	...	...	...	...
24	...	...	...	...	...	...	...	...
25	...	...	...	...	...	...	...	...
26	...	...	...	...	...	...	...	...
27	...	...	...	...	...	...	...	...
28	...	...	...	...	...	...	...	...
29	...	...	...	...	...	...	...	...
30	...	...	...	...	...	...	...	...
31	...	...	...	...	...	...	...	...
32	...	...	...	...	...	...	...	...
33	...	...	...	...	...	...	...	...
34	...	...	...	...	...	...	...	...
35	...	...	...	...	...	...	...	...
36	...	...	...	...	...	...	...	...
37	...	...	...	...	...	...	...	...
38	...	...	...	...	...	...	...	...
39	...	...	...	...	...	...	...	...
40	...	...	...	...	...	...	...	...
41	...	...	...	...	...	...	...	...
42	...	...	...	...	...	...	...	...
43	...	...	...	...	...	...	...	...
44	...	...	...	...	...	...	...	...
45	...	...	...	...	...	...	...	...
46	...	...	...	...	...	...	...	...
47	...	...	...	...	...	...	...	...
48	...	...	...	...	...	...	...	...
49	...	...	...	...	...	...	...	...
50	...	...	...	...	...	...	...	...

TABLE II.

BENDING TESTS ON BARS OF NATAL WOODS.

TABLE II.—BENDING TESTS ON

Species.	Office number.	Locality.	Co-efficient of elasticity.	Modulus of rupture.	DEFLECTION, IN MILLIMETERS,				
					50	100	150	200	0 (set)
BIXINEÆ—									
5. <i>Scolopia Zeyheri</i> ...	144	North Drakensberg	857	848	5.5	11.4	17.1	25.4	3.0
<i>Wolvedoorn.</i>	145	ditto	957	937	5.2	10.2	15.7	23.6	3.0
	148	ditto	904	900	5.8	10.8	16.0	25.6	3.4
6. <i>Scolopia Ecklonii</i> ...	109	ditto	828	666	5.7	11.8	18.0	27.4	2.1
<i>Red Pear.</i>	110	ditto	986	811	4.8	9.9	15.0	21.7	1.5
	111	ditto	734	623	6.0	13.3	20.8	31.2	2.9
8. <i>Dovyalis rhamnoides</i>	165	ditto	618	537	7.9	17.6	28.7	65.8	16.5
<i>Zuurbesjes.</i>									
10. <i>Trimeria alnifolia</i> ...	181	ditto	976	858	5.0	10.0	15.0	21.6	1.4
	182	ditto	842	813	6.1	11.6	17.3	24.6	1.3
11. <i>Kiggelaria africana</i>	114	ditto	763	572	6.4	14.3	23.1	36.2	3.0
<i>Spiekhout.</i>	115	ditto	531	263	9.2	24.6	...	...	...
	116	ditto	660	537	7.4	15.7	25.0	38.0	4.9
MALVACEÆ—									
14. <i>Hibiscus tiliaceus</i> ...	66	Port Shepstone	707	668	6.9	15.9	25.7	39.8	5.0
	67	ditto	588	773	8.3	18.1	29.6	48.0	7.5
	68	ditto	800	572	6.1	14.0	23.0	40.5	6.1
TILIACEÆ—									
19. <i>Grewia occidentalis</i>	169	North Drakensberg	1017	893	4.6	9.6	14.1	21.0	1.2
<i>Kruisbesjes.</i>	170	ditto	986	820	5.0	9.9	15.0	22.0	1.6
RUTACEÆ—									
23. <i>Calodendron Capense</i>	117	ditto	751	683	6.5	13.0	20.5	31.0	1.9
<i>Wild Chesnut.</i>	118	ditto	957	804	4.8	10.2	16.0	23.0	1.0
	119	ditto	857	771	5.6	11.4	17.7	26.5	1.8
25. <i>Zanthoxylum Thun-</i>	140	ditto	1285	729	3.9	7.6	12.0	17.7	1.6
<i>bergii</i> ...	141	ditto	1375	947	3.7	7.1	10.9	15.2	1.1
<i>Knobthorn.</i>	64	Port Shepstone	921	694	4.6	10.6	16.0	24.3	2.2
	65	ditto	976	844	4.0	10.0	15.0	22.0	1.5
26. <i>Toddalia lanceolata</i>	134	North Drakensberg	1684	1134	3.0	5.8	8.3	11.2	0.6
<i>White Ironwood,</i>	135	ditto	1356	1041	3.9	7.2	11.1	16.1	1.2
<i>Bastard Sneezewood.</i>	48	Port Shepstone	1039	797	3.9	9.4	14.0	21.0	1.6
	49	ditto	896	900	6.0	10.9	16.0	22.1	1.2
27. <i>Clausena inæqualis</i> ...	157	North Drakensberg	1039	858	5.0	9.4	14.0	19.1	1.1
	158	ditto	1050	720	4.6	9.3	14.2	19.7	1.0
MELIACEÆ—									
33. <i>Ekebergia capensis</i>	102	Port Shepstone	787	443	6.0	12.4	20.0	...	...
<i>Essenhout.</i>	103	ditto	834	579	5.9	11.7	18.0	28.9	2.2
	104	ditto	718	562	6.6	13.6	21.6	33.9	2.9
34. <i>Ekebergia Meyeri</i>	106	ditto	800	581	6.4	13.2	22.0	37.3	5.1
<i>Wild Syringa.</i>	107	ditto	1285	567	3.8	8.5	14.0	28.9	5.0
	108	ditto	602	342	8.1	19.6	...	...	...

BARS OF NATAL WOODS.

UNDER A LOAD, IN KILOGRAMS, OF								Breaking load.	Remarks.	Office number.
250	300	350	400	450	500	550	600			
36.9	55.8	89.1	...	...	...	...	...	362	Broke with long fibrous splinters.	144
34.8	48.8	82.6	...	...	...	...	...	400	Oblique fracture at corner.	145
34.7	51.5	85.0	...	...	...	...	...	384	Square break tension side; split in axis.	148
43.0	...	...	...	...	...	...	...	284	Long oblique fracture.	109
30.3	43.6	...	...	...	...	...	...	346	Ditto.	110
49.2	...	...	...	...	...	...	...	266	Short break tension side; split in axis.	111
...	...	...	...	...	...	...	...	229	Deflections 113 min. before fracture; failed from splinter at corner.	165
31.7	46.2	85.0	...	...	...	...	...	366	Broke with long splinters.	181
33.7	45.5	...	...	...	...	...	...	347	Failed from large splinter at corner.	182
...	...	...	...	...	...	...	...	244	Failed from splinter at corner.	114
...	...	...	...	...	...	...	...	112	Specimen cross-grained; broke at knot.	115
...	...	...	...	...	...	...	...	229	Long oblique fracture tension side; split in axis.	116
62.5	...	...	...	...	...	...	...	285	Broke at knot on one side.	66
83.2	145.0	...	...	...	...	...	...	330	Slipped from bearings and split at end.	67
...	...	...	...	...	...	...	...	244	Fibrous short break.	68
29.7	46.1	96.0	...	...	...	...	...	381	Deflected 123 mm; fine splinters.	169
29.9	48.0	...	...	...	...	...	...	350	Failed from splinter at corner.	170
50.0	...	...	...	...	...	...	...	292	Broke at corner.	117
32.0	46.0	...	...	...	...	...	...	343	Short break tension side; split in axis.	118
38.9	63.0	...	...	...	...	...	...	329	Broke with large splinters.	119
25.7	44.0	...	...	...	...	...	...	310	Broke at knot.	140
21.4	30.2	43.0	75.0	...	...	...	...	404	Broke with short fibrous splinters.	141
35.4	...	...	...	...	...	...	...	296	Failed from splinter at corner.	64
35.6	54.0	109.0	...	...	...	...	...	360	Wood green; failed from splinter at corner.	65
15.0	19.4	25.2	38.9	68.1	...	...	...	484	Broke with fine splinters.	134
22.9	31.3	43.0	61.9	...	...	...	...	444	Ditto.	135
28.5	42.0	...	...	...	...	...	...	340	Failed from splinter at corner.	48
30.7	45.6	70.6	...	...	...	...	...	384	Ditto.	49
27.7	40.0	75.0	...	...	...	...	...	366	Broke in short fine splinters.	157
30.0	40.6	...	...	...	...	...	...	307	Specimen cross-grained; broke short.	158
...	...	...	...	...	...	...	...	189	Broke short at middle.	102
...	...	...	...	...	...	...	...	247	Broke at corner.	103
...	...	...	...	...	...	...	...	240	Failed from splinter at corner.	104
...	...	...	...	...	...	...	...	248	Broke with fine splinters.	106
...	...	...	...	...	...	...	...	242	Crushed at centre bearing.	107
...	...	...	...	...	...	...	...	146	Broke short at middle.	108

TABLE II.—BENDING TESTS ON

Species.	Office number.	Locality.	Coefficient of elasticity.	Modulus of rupture.	DEFLECTION, IN MILLIMETERS,				
					50	100	150	200	0 (set)
OLACINEÆ—									
36. <i>Apodytes dimidiata</i>	58	Port Shepstone	1177	928	4.7	8.3	13.2	19.2	0.9
<i>White Pear</i> ...	59	ditto	1007	802	4.7	9.7	15.0	21.7	1.6
	60	ditto	996	806	4.7	9.8	14.1	21.0	1.3
	61	ditto	921	797	4.3	10.6	16.0	23.8	1.6
ILICINEÆ—									
37. <i>Ilex Capensis</i> ...	120	North Drakensberg	888	572	5.5	11.6	19.7	33.1	5.3
<i>Wittehout.</i>	121	ditto	610	450	8.0	17.6	31.0	...	...
CELASTRINEÆ—									
38. <i>Cathastrum Capense</i>	131	ditto	775	771	6.2	12.6	18.7	26.8	2.1
<i>Bastard Saffraan.</i>	132	ditto	763	684	6.2	12.8	19.4	29.1	4.0
	133	ditto	746	469	6.5	13.1	20.0	...	...
45. <i>Elæodendron velutinum</i> ...	82	Port Shepstone	1252	1041	3.9	7.8	12.3	16.8	1.2
<i>um-Ngai</i>	83	ditto	1437	1031	3.4	6.8	11.0	15.7	1.0
	84	ditto	1436	1174	3.4	6.8	10.0	13.4	0.4
SAPINDACEÆ—									
50. <i>Schmidelia Africana</i>	146	North Drakensberg	1191	1022	4.2	8.2	12.3	16.6	0.4
	147	ditto	1110	935	4.6	8.8	13.0	17.6	0.6
	149	ditto	1136	926	4.2	8.6	12.4	17.0	0.6
51. <i>Hippobromus alata</i> ...	142	ditto	957	919	5.1	10.2	15.0	20.6	0.7
<i>Paardepis.</i>	143	ditto	986	762	5.0	9.9	14.8	21.1	1.1
	150	ditto	1073	813	4.8	9.1	13.8	19.1	1.0
54. <i>Pteroxylon utile</i> ...	33	Port Shepstone	1550	1512	2.9	6.3	8.9	11.8	0.2
<i>Sneezeewood.</i>	34	ditto	1458	1376	2.9	6.7	9.8	13.0	0.4
	35	ditto	1656	1648	2.8	5.9	8.9	11.9	0.3
	36	ditto	1415	1584	3.4	6.9	9.9	13.0	0.2
ANACARDIACEÆ—									
59. <i>Rhus longifolia</i> ...	1	ditto	921	698	5.2	10.6	16.5	23.2	2.1
	2	ditto	1206	640	4.0	8.1	13.7	21.1	2.1
	3	ditto	1236	562	3.9	7.9	12.9	17.6	1.5
	4	ditto	976	661	4.6	10.0	15.0	21.8	1.7
58. <i>Rhus lucida</i> ...	178	North Drakensberg	1221	1134	4.3	8.0	11.3	14.9	0.3
	179	ditto	1285	1109	3.9	7.6	11.5	15.7	0.6
61. <i>Ocotea Caffra</i> ...	17	Port Shepstone	834	762	6.2	11.7	17.8	24.9	2.1
<i>Kafir Plum.</i>	18	ditto	1017	771	6.2	9.6	11.2	26.2	2.2
	19	ditto	842	701	6.4	11.6	17.1	23.7	1.3
	20	ditto	842	797	6.0	11.6	16.8	24.0	1.4
LEGUMINOSÆ—									
63. <i>Milletia Caffra</i> ...	50	ditto	1656	926	3.0	5.9	8.1	10.8	0.3
<i>Umsimbiti.</i>	51	ditto	1993	1045	2.4	4.9	7.0	9.6	0.3
	52	ditto	1550	1369	3.4	6.3	8.7	11.2	0.3
	53	ditto	1656	1390	2.9	5.9	9.0	11.6	0.3

BARS OF NATAL WOOD; (continued).

UNDER A LOAD, IN KILOGRAMS, OF								Breaking load.	Remarks.	Office number.
250	300	350	400	450	500	550	600			
26.2	34.6	58.7	...	...	...	...	...	396	Broke with large splinters.	58
30.8	46.5	...	...	...	...	...	...	342	Broke with fine splinters.	59
29.7	43.1	...	...	...	...	...	...	344	Split from knot at corner.	60
36.5	58.6	...	...	...	...	...	...	340	Broke with long fine splinters.	61
...	...	...	...	...	...	...	...	244	Broke at corner.	120
...	...	...	...	...	...	...	...	192	Long oblique fracture.	121
38.1	57.3	...	...	...	...	...	...	329	Failed from splinter at corner.	131
42.7	...	...	...	...	...	...	...	292	Shattered on tension side.	132
...	...	...	...	...	...	...	...	200	Split from tension side.	133
23.3	30.0	40.8	66.2	...	...	...	...	444	Wood not seasoned; broke with short splinters.	82
24.0	29.4	36.0	60.2	...	...	...	...	440	Ditto	83
17.0	21.3	27.1	35.8	49.0	79.0	...	...	501	Ditto	84
22.0	30.0	43.8	64.6	...	...	...	...	436	Broke with long splinters.	146
23.5	31.5	44.1	...	...	...	...	...	399	Failed from splinter at corner.	147
21.8	28.8	38.4	...	...	...	...	...	395	Broke with fine splinters.	149
27.9	38.0	52.0	...	...	...	...	...	392	Shattered on tension side.	142
27.6	37.0	...	...	...	...	...	...	325	Long oblique fracture to axis.	143
26.6	33.4	...	...	...	...	...	...	347	Failed from splinter at corner.	150
14.3	17.1	20.6	23.2	27.9	34.4	42.7	55.8	645	Broke with long fine splinters.	33
16.0	19.8	23.2	28.6	35.8	47.0	64.6	...	587	ditto	34
14.9	17.6	20.5	23.8	28.3	32.9	39.2	48.7	703	66.8 mm. deflection for 650 kgms.; broke with long fine splinters.	35
15.9	18.9	22.1	25.9	30.1	35.3	41.6	53.2	676	70.5 mm. deflection for 650 kgms.; sapwood compression side; broke with long fine splinters, and split in axis.	36
36.2	...	...	...	...	...	...	...	298	Broke with large splinters.	1
42.0	...	...	...	...	...	...	...	273	Ditto.	2
45.0	...	...	...	...	...	...	...	240	Ditto.	3
29.3	...	...	...	...	...	...	...	282	Oblique fracture.	4
18.3	22.3	27.0	31.0	35.5	...	...	...	484	Long oblique fracture from corner.	178
20.0	24.7	30.0	35.1	42.5	...	...	...	473	Large flake tension side.	179
39.6	80.0	...	...	...	...	...	...	325	Long oblique fracture at one end.	17
40.5	78.8	...	...	...	...	...	...	329	Broke with large splinters.	18
38.6	...	...	...	...	...	...	...	299	Ditto.	19
34.6	63.7	...	...	...	...	...	...	340	Ditto.	20
13.2	16.0	18.6	...	...	...	...	...	395	Failed from splinter over knot at corner.	50
11.6	14.4	17.2	20.6	...	...	...	...	446	Sapwood on compression side; failed from splinter at corner.	51
13.8	16.6	19.9	23.0	27.8	33.0	43.0	...	584	Sapwood tension side; failed at knot in middle.	52
14.6	17.2	20.7	25.0	29.8	34.2	39.3	...	593	Half sapwood; failed from splinter at corner.	53

TABLE II.—BENDING TESTS ON

Species.	Office number.	Locality.	Co-efficient of elasticity.	Modulus of rupture.	DEFLECTION, IN MILLIMETERS,				
					50	100	150	200	0 (set)
64. <i>Erythrina caffra</i> ... <i>Kafirboom.</i>	21	ditto	233	216	20.9	...	...	...	...
	22	ditto	156	138	31.3	...	...	...	...
	23	ditto	207	173	23.5	...	...	...	...
	24	ditto	279	190	17.5	...	...	...	...
72. <i>Acacia Natalitia</i> ...	196	Port Shepstone	574	633	8.5	17.6	29.8	49.7	10.0
	197	ditto	610	504	8.0	16.7	30.6	55.1	12.6
	198	ditto	595	659	8.2	16.9	28.6	45.0	8.0
71. <i>Acacia horrida</i> ...	187	North Drakensberg	698	684	7.0	14.8	23.0	36.8	5.5
	188	ditto	740	572	6.6	14.0	24.0	38.4	6.6
	189	ditto	618	478	7.9	14.9	25.3	40.5	8.5
ROSACEÆ—									
74. <i>Leucosidea sericea</i>	151	ditto	323	415	15.1	33.0	58.0	...	...
COMBRETACEÆ—									
80. <i>Combretum Kraussii</i> <i>Bush Willow.</i>	93	Port Shepstone	1097	816	4.1	8.9	13.6	20.7	2.5
	94	ditto	1050	785	4.2	9.3	14.8	24.0	3.0
	203	ditto	967	797	5.1	10.1	15.2	21.0	2.0
MYRTACEÆ—									
81. <i>Engenia cordata</i> ... <i>Waterboom, Um-</i> <i>doni.</i>	9	ditto	957	591	5.1	12.1	19.8	35.2	5.2
	10	ditto	536	328	9.0	18.2	...	...	...
	11	ditto	807	537	5.9	12.1	21.2	41.3	9.2
	12	ditto	842	546	5.8	13.1	24.4	47.5	11.2
LYTHRARIÆ—									
83. <i>Olinia cymosa</i> ... <i>Hard Pear.</i>	160	North Drakensberg	834	930	6.0	11.7	17.0	23.1	1.0
	161	ditto	665	691	7.4	14.7	23.0	36.1	4.8
	162	ditto	734	832	6.8	13.3	19.6	26.6	1.7
UMBELLIFERÆ—									
87. <i>Heteromorpha arbo-</i> <i>rescens...</i>	175	ditto	888	595	6.2	11.0	17.8	30.7	2.9
	176	ditto	888	600	6.0	11.0	17.9	28.7	3.3
ARALIACEÆ—									
89. <i>Cussonia sp.</i> ... <i>Cabbage Wood.</i>	194	ditto	622	338	7.9	15.7	...	...	...
	195	ditto	474	234	10.3	...	...	...	...
CORNACEÆ—									
90. <i>Curtisia faginea</i> ... <i>Assagai.</i>	112	North Drakensberg	1039	579	4.7	10.7	17.4	26.3	3.1
	113	ditto	1191	787	4.1	9.0	14.0	20.8	1.7

BARS OF NATAL WOODS.

UNDER A LOAD. IN KILOGRAMS, OF								Breaking load.	Remarks.	Office number.
250	300	350	400	450	500	550	600			
...	...	...	...	...	...	...	...	92	Square break tension side ; split in axis.	21
...	...	...	...	...	...	...	...	59	Square break tension side ; oblique fracture compression side.	22
...	...	...	...	...	...	...	...	74	Short break tension side ; split in axis.	23
...	...	...	...	...	...	...	...	81	Ditto	24
93.0	...	...	...	...	...	...	...	270	Deflected 193 mm.; large fibrous flake tension side.	196
...	...	...	...	...	...	...	...	215	Large fibrous flake tension side.	197
80.0	...	...	...	...	...	...	...	281	Deflected 117 mm.; large fibrous flake tension side.	198
56.1	...	...	...	...	...	...	...	292	Shattered and split in axis.	187
...	...	...	...	...	...	...	...	244	Long oblique fracture.	188
...	...	...	...	...	...	...	...	204	Shattered tension side.	189
...	...	...	...	...	...	...	...	177	Long oblique fracture.	151
28.0	46.6	...	...	...	...	...	...	348	Crushed at centre bearing ; failed from splinter at corner.	93
33.8	60.2	...	...	...	...	...	...	335	Coarse fibrous splinters.	94
29.7	52.2	...	...	...	...	...	...	340	Deflected 90 mm. ; coarse fibrous splinters.	203
...	...	...	...	...	...	...	...	252	Oblique fracture tension side.	9
...	...	...	...	...	...	...	...	140	Broke at knot.	10
...	...	...	...	...	...	...	...	229	Square break tension side ; oblique fracture compression side.	11
...	...	...	...	...	...	...	...	233	Double oblique fracture.	12
29.8	37.0	47.8	...	...	...	...	...	397	Failed from large splinter at corner.	160
57.7	...	...	...	...	...	...	...	295	Failed from splinter at corner.	161
34.6	47.9	70.0	...	...	...	...	...	355	Large flakes tension side.	162
101.5	...	...	...	...	...	...	...	254	Broke with short splinters.	175
70.0	...	...	...	...	...	...	...	256	Ditto	176
...	...	...	...	...	...	...	...	144	Broke short in middle.	194
...	...	...	...	...	...	...	...	100	Ditto	195
...	...	...	...	...	...	...	...	247	Short fibrous fracture tension side.	112
31.0	42.9	...	...	...	...	...	...	336	Shattered tension side.	113

TABLE II.—BENDING TESTS ON

Species.	Office number.	Locality.	Coefficient of elasticity.	Modulus of rupture.	DEFLECTION, IN MILLIMETERS,				
					50	100	150	200	0 (set)
RUBIACEÆ—									
101. <i>Plectronia Mundtiana—Klip Els.</i>	163	ditto	996	703	5.0	9.8	15.1	21.0	1.9
	164	ditto	821	804	6.4	11.9	17.0	24.0	2.0
COMPOSITE—									
104. <i>Brachylæna discolor</i>	25	Port Shepstone	1039	926	5.0	9.4	14.2	19.4	1.2
	26	ditto	1550	1256	3.2	6.3	9.0	12.0	0.4
	27	ditto	1163	1038	4.9	8.4	12.8	17.0	1.1
	28	ditto	1415	1219	3.1	6.9	9.9	13.5	0.6
MYRSINÆ—									
107. <i>Myrsine melanophleas ... Beukenhout.</i>	77	North Drakensberg	888	581	5.1	11.0	18.2	29.7	3.6
	78	ditto	872	668	5.8	11.2	17.7	26.0	2.3
	41	Port Shepstone	1191	684	4.1	9.1	14.0	20.1	1.6
	42	ditto	814	562	6.6	12.0	19.7	33.7	5.2
	43	ditto	1356	668	3.6	7.8	14.0	22.7	1.0
SAPOTACEÆ—									
109. <i>Sideroxylon inerme White Milkwood.</i>	199	ditto	787	691	6.2	12.4	22.0	37.0	6.0
	200	ditto	864	797	5.7	11.3	18.6	29.0	4.7
	201	ditto	1268	930	3.6	7.7	11.9	16.2	1.0
111. <i>Mimusops obovata Red Milkwood.</i>	91	ditto	849	937	5.5	11.5	19.0	30.4	3.3
	92	ditto	842	818	5.9	11.6	19.0	29.9	3.2
	202	ditto	842	832	5.7	11.6	17.9	26.5	1.7
112. <i>Mimusops Caffra ... Coast Red Milkwood.</i>	13	ditto	769	726	5.2	12.7	18.8	25.8	2.2
	14	ditto	857	691	5.5	11.4	18.8	27.8	4.2
	15	ditto	1191	703	3.8	8.2	12.9	22.1	2.2
	16	ditto	707	572	6.6	13.8	22.1	35.3	4.6
EBENACEÆ—									
113. <i>Royena lucida ... Zwartbast.</i>	137	North Drakensberg	698	710	7.0	14.0	22.0	38.0	6.2
	138	ditto	646	698	7.6	15.1	24.2	37.8	4.9
	139	ditto	660	562	7.4	14.8	24.9	40.8	4.7
114. <i>Euclea natalensis ...</i>	54	Port Shepstone	1479	820	3.1	6.6	9.2	13.0	0.5
	55	ditto	1356	809	3.8	7.2	10.7	14.0	1.1
	56	ditto	1628	1064	3.2	6.0	9.1	12.1	0.9
	57	North Drakensberg	618	558	7.6	15.8	27.0	53.0	12.0
OLEACEÆ—									
118. <i>Olea verrucosa ...</i>	136	ditto	713	720	6.8	13.7	20.9	30.6	2.9
	5	Port Shepstone	1395	1035	3.5	7.0	10.4	14.1	0.4
	6	ditto	1252	970	3.7	7.8	11.6	15.3	0.6
	7	ditto	1028	945	4.8	9.5	14.3	19.2	0.9
	8	ditto	1039	919	4.9	9.4	14.2	20.3	2.1

BARS OF NATAL WOOD (*continued*).

UNDER A LOAD, IN KILOGRAMS, OF								Breaking load.	Remarks.	Office number.
250	300	350	400	450	500	550	600			
31.5	...	...	...	...	...	...	...	300	Shattered tension side.	163
33.4	50.0	...	...	...	...	...	...	343	Broke short tension side ; split in axis.	164
25.6	47.0	52.8	...	...	...	...	...	395	Split from tension side.	25
15.6	19.5	25.0	33.2	46.1	66.4	...	...	536	Broke with small splinters.	26
21.8	28.6	36.7	52.2	...	...	...	...	443	Ditto	27
16.7	21.0	29.1	36.6	54.6	73.5	...	...	520	Ditto	28
...	...	...	...	...	...	...	...	248	Broke short at middle.	77
43.7	...	...	...	...	...	...	...	285	Square break tension side ; oblique fracture compression side.	78
32.2	...	...	...	...	...	...	...	292	Long oblique fracture tension side ; split in axis.	41
...	...	...	...	...	...	...	...	240	Broke at knot.	42
35.0	...	...	...	...	...	...	...	285	Square break tension side ; split in axis.	43
61.2	...	...	...	...	...	...	...	295	Large flake tension side.	199
43.0	66.0	...	...	...	...	...	...	340	Ditto	200
21.6	28.2	42.6	...	...	...	...	...	397	Split from tension side to axis.	201
44.8	79.5	139.0	...	...	...	...	...	400	Wood not seasoned ; slipped from bearings.	91
46.1	73.0	...	...	...	...	...	...	349	Wood not seasoned ; fibrous splinter at corner.	92
36.5	52.0	100.5	...	...	...	...	...	355	Long splinters at corner.	202
35.5	48.2	...	...	...	...	...	...	310	Specimen cross grained ; oblique fracture on one side.	13
45.0	...	...	...	...	...	...	...	295	Shattered on tension side.	14
38.0	...	...	...	...	...	...	...	300	Short splinters.	15
...	...	...	...	...	...	...	...	244	Square breaks tension side and compression side ; split between.	16
67.0	144.0	...	...	...	...	...	...	303	Specimen cross grained ; oblique fracture.	137
60.1	...	...	...	...	...	...	...	298	Oblique fracture from corner.	138
...	...	...	...	...	...	...	...	240	Failed from splinter at corner.	139
17.8	25.0	...	...	...	...	...	...	350	Broke short tension side.	54
18.1	25.6	...	...	...	...	...	...	345	Failed from crack in compression side.	55
17.6	22.1	30.3	48.8	...	...	...	...	454	Crushed on compression side ; splinters tension side.	56
...	...	...	...	...	...	...	...	238	Wood not seasoned ; failed from splinter.	57
43.0	57.6	...	...	...	...	...	...	307	Specimen cross grained ; oblique fracture.	136
18.6	24.6	32.1	42.4	...	...	...	...	442	Failed from large splinter at corner.	5
20.6	26.7	37.0	53.0	...	...	...	...	414	Ditto	6
26.0	34.7	39.0	...	...	...	...	...	403	Shattered tension side.	7
25.5	29.8	36.6	...	...	...	...	...	392	Broke with short splinters.	8

TABLE II.—BENDING TESTS ON

Species.	Office number.	Locality.	Coefficient of elasticity.	Modulus of rupture.	DEFLECTION, IN MILLIMETERS,				
					50	100	150	200	0 (set)
119. <i>Olea laurifolia</i> ... <i>Ironwood.</i>	127	Knysna	1526	1045	3.6	6.4	9.3	12.5	0.6
	128	ditto	1458	1059	3.5	6.7	9.8	13.2	0.6
	129	ditto	1575	1151	3.3	6.2	9.0	12.0	0.6
	130	ditto	1375	1038	4.0	7.1	10.4	14.0	0.8
120. <i>Olea foveolata</i> ...	79	Port Shepstone	1601	1059	3.0	6.1	9.2	12.8	0.5
	80	ditto	1713	1031	2.6	5.7	9.0	12.1	0.5
	81	ditto	1526	848	3.5	6.4	9.8	12.9	0.6
APOCYNACEÆ—									
121. <i>Rauwolfia Natalensis</i>	29	Port Shepstone	763	492	6.2	12.8	21.2	33.9	3.6
	30	ditto	673	527	7.6	14.5	22.8	36.2	5.0
	31	ditto	729	494	6.9	13.4	21.6	36.1	5.8
	32	ditto	740	450	7.1	13.2	21.4	...	...
LOGANIACEÆ—									
126. <i>Buddleia salviæfolia</i>	166	North Drakensberg	740	804	6.9	13.2	19.5	28.6	2.5
<i>Saliehout.</i>	167	ditto	577	696	8.4	16.9	25.8	37.6	3.4
	168	ditto	693	802	7.0	14.1	21.4	30.2	2.0
127. <i>Strychnos Ather-</i>									
<i>stonei</i> ...	37	Port Shepstone	702	591	7.3	13.9	23.0	34.6	5.0
<i>Cape Teak, Chaka's</i>									
<i>wood.</i>	38	ditto	821	736	6.6	11.9	19.1	28.4	2.4
	39	ditto	842	825	6.0	11.6	17.9	26.4	1.8
	40	ditto	857	680	6.0	11.4	17.2	25.0	1.5
SCROPHULARINEÆ—									
131. <i>Halleria lucida</i> ...	154	North Drakensberg	1191	952	4.6	8.2	11.9	16.6	1.0
	155	ditto	1122	928	4.5	8.7	13.0	18.0	1.0
	156	ditto	1122	935	4.5	8.7	13.0	18.2	1.0
VERBENACEÆ—									
133. <i>Clerodendron gla-</i>									
<i>brum</i> ...	184	ditto	471	633	10.9	20.7	33.4	56.6	9.4
	185	ditto	574	649	8.6	17.0	27.4	44.0	5.5
	186	ditto	519	586	9.0	18.8	31.6	50.6	8.0
LAURINEÆ—									
137. <i>Ocotea bullata</i> ...	122	Natal	1221	1038	3.7	8.0	11.6	15.1	0.3
<i>Stinkwood.</i>	123	ditto	1110	1059	4.7	8.8	12.8	16.8	0.6
	124	ditto	1252	1247	3.9	7.8	11.4	15.9	0.5
	125	Knysna	1191	698	4.5	8.2	12.1	16.8	0.9
	126	ditto	1163	684	4.4	8.4	12.4	16.7	1.0
EUPHORBIACEÆ—									
144. <i>Briedelia micrantha</i>	85	Port Shepstone	996	347	4.9	11.8	...	...	...
	86	ditto	976	469	5.1	10.0	16.7	...	...
	87	ditto	957	581	4.7	10.2	15.8	22.7	1.6

BARS OF NATAL WOODS.

UNDER A LOAD, IN KILOGRAMS, OF								Breaking load.	Remarks.	Office number.
250	300	350	400	450	500	550	600			
15.7	18.9	23.0	28.8	...	..	...	...	446	Failed from splinter at corner.	127
16.9	20.6	26.1	34.9	43.8	...	...	...	452	Split in axis.	128
15.1	19.0	23.8	33.0	45.4	...	...	...	491	Broke with short splinters.	129
18.0	23.0	30.6	42.1	...	...	...	...	443	Shattered tension side.	130
16.0	20.6	25.2	33.2	46.8	...	...	...	452	Failed from splinter at corner.	79
15.9	20.1	26.0	34.2	...	...	...	...	440	Specimen cross grained; failed at knot.	80
16.4	20.3	28.9	...	...	...	...	...	362	Failed from splinter at corner.	81
...	...	...	...	...	...	...	...	210	Square break tension side; double oblique fracture compression side; wood brittle.	29
...	...	...	...	...	...	...	...	225	Square fracture, across.	30
...	...	...	...	...	...	...	...	211	Broke short at middle.	31
...	...	...	...	...	...	...	...	192	Ditto	32
42.0	58.5	...	...	...	...	...	...	343	Long oblique fracture from corner.	166
53.5	...	...	...	...	...	...	...	297	Deflected 105 min.; long oblique fracture.	167
42.5	64.2	...	...	...	...	...	...	342	Deflected 109 min.; failed from splinter at corner.	168
55.4	...	...	...	...	...	...	...	252	Cross grained; oblique fracture near one end.	37
44.3	74.6	...	...	...	...	...	...	314	Broke with small flakes on tension side.	38
37.2	58.8	..	...	...	...	...	...	352	Broke with short splinters.	39
35.8	...	...	...	...	...	...	...	290	Failed from splinter at corner.	40
22.3	31.9	44.7	82.0	...	...	...	...	406	Crushed at centre bearing; broke with fine splinters.	154
23.2	33.5	50.8	...	...	...	...	...	396	Ditto	155
23.9	34.0	56.3	...	...	...	...	...	399	Ditto	156
107.7	...	...	...	...	...	...	...	270	Failed from splinter at corner.	184
91.2	...	...	...	...	...	...	...	277	Divergent oblique fractures tension side; split in axis.	185
104.0	...	...	...	...	...	...	...	250	Long oblique fracture.	186
19.1	23.0	28.8	35.2	...	...	...	...	443	Long oblique fracture.	122
21.3	26.0	32.9	41.0	52.0	...	...	...	452	Ditto	123
20.1	25.1	30.1	37.5	46.6	57.3	...	...	532	Square break tension side; oblique fracture compression side.	124
22.1	...	...	...	...	...	...	...	298	Long oblique fracture.	125
21.2	...	...	...	...	...	...	...	292	Ditto.	126
...	...	...	...	...	...	...	...	148	Broke at knot.	85
...	...	...	...	...	...	...	...	200	Specimen cross grained; oblique fracture.	86
...	...	...	...	...	...	...	...	248	Long oblique fracture.	87

TABLE II.—BENDING TESTS ON

Species.	Office number.	Locality.	Coefficient of elasticity.	Modulus of rupture.	DEFLECTION, IN MILLIMETERS,				
					50	100	150	200	0 (set)
URTICACEÆ—									
155. <i>Celtis Kraussiana</i> ...	98	ditto	1526	874	2·7	6·4	10·0	14·0	0·7
<i>Kamdeboo Stink-wood, Umvumvu.</i>	99	ditto	1136	816	3·8	8·6	13·6	19·8	1·9
	100	ditto	1122	820	4·2	8·7	13·3	18·9	1·7
	701	ditto	1017	818	4·8	9·6	15·2	22·1	3·0
158. <i>Trema guineensis</i> ...	44	ditto	842	469	5·8	13·3	24·5	...	...
	45	ditto	888	460	5·5	12·8	24·1	...	...
	46	ditto	549	464	9·2	17·8	28·8	...	...
	47	ditto	678	459	7·2	17·1	29·0	...	...
160. <i>Chætachme Meyeri</i>	95	ditto	763	504	6·4	13·3	22·2	34·3	3·8
	99	ditto	939	649	5·2	11·9	20·8	35·8	6·6
	97	ditto	775	520	6·3	14·4	25·0	39·5	5·0
161. <i>Ficus Natalensis</i> ...	192	ditto	514	361	9·6	19·0	32·3	...	...
	193	ditto	542	389	9·1	18·0	29·0	...	...
	190	North Drakensberg	287	234	17·0	...	...	...	...
	191	ditto	326	286	15·0	31·3	...	...	...
CONIFERÆ—									
164. <i>Podocarpus Thunbergii</i> , var. <i>falcata</i>	73	ditto	746	469	6·1	13·1	21·2	...	...
<i>Upright Yellow-wood.</i>	74	ditto	921	537	5·1	10·6	17·2	24·4	1·2
	75	ditto	775	434	6·2	12·6	19·5	...	...
	76	ditto	807	352	6·6	12·1	...	...	...
160. <i>Podocarpus elongata</i>	69	ditto	602	572	8·2	16·2	27·0	46·2	6·0
<i>Outeniqua Yellow-wood, Bastard Yellowwood.</i>	70	ditto	602	537	7·9	16·2	27·1	42·1	4·8
	71	ditto	698	537	7·0	14·9	23·1	36·5	3·5
	72	ditto	718	504	6·8	15·0	24·6	44·0	6·3
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166. <i>Red Ivory</i> ...	62	Port Shepstone	1252	1165	3·6	7·8	11·2	15·6	1·0
	63	ditto	1252	806	3·8	7·8	11·2	16·0	0·8
167. <i>Bitter Almond</i> ...	152	North Drakensberg	912	806	5·2	10·7	16·7	24·0	2·4
	153	ditto	660	691	7·3	14·8	22·9	34·2	4·5
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168. <i>Natal Railway Sleeper</i> ...	204	Baltic	493	312	9·9	21·4	...	...	...
<i>(Pinus picea).</i>	205	ditto	525	270	9·5	18·6	...	...	...
	206	ditto	683	356	7·0	14·3	25·6	...	...
	207	ditto	751	363	6·5	13·0	20·5	...	...
	208	ditto	592	398	8·3	16·5	28·9	...	...
	209	ditto	660	338	7·4	16·0	...	...	...
	210	ditto	763	459	6·9	12·9	19·8	...	...
	211	ditto	592	382	8·2	16·5	27·9	...	...

BARS OF NATAL WOOD (*continued*).

UNDER A LOAD, IN KILOGRAMS, OF								Breaking load.	Remarks.	Office number.
250	300	350	400	450	500	550	600			
19.1	25.7	44.1	...	...	...	...	...	373	Crushed at centre bearing ; failed from fibrous splinter at corner.	98
27.9	43.0	...	...	...	...	...	...	348	Broke with coarse splinters.	99
27.9	41.4	...	...	...	...	...	...	350	Ditto	100
30.4	43.7	...	...	...	...	...	...	349	Specimen cross grained ; oblique fracture.	101
...	...	...	...	...	...	...	...	200	Crushed at centre bearing.	44
...	...	...	...	...	...	...	...	200	Crushed at centre bearing ; square break tension side ; split in axis.	45
...	...	...	...	...	...	...	...	198	Ditto	46
...	...	...	...	...	...	...	...	196	Crushed at centre bearing.	47
...	...	...	...	...	...	...	...	215	Large flake tension side.	95
67.7	...	...	...	...	...	...	...	277	Short fracture at middle.	96
...	...	...	...	...	...	...	...	222	Specimen cross grained ; shattered tension side.	97
...	...	...	...	...	...	...	...	154	Shattered ; large splinters,	192
...	...	...	...	...	...	...	...	166	Broke short at middle.	193
...	...	...	...	...	...	...	...	100	Ditto	190
...	...	...	...	...	...	...	...	122	Ditto	191
...	...	...	...	...	...	...	...	200	Specimen cross grained ; oblique fracture.	73
...	...	...	...	...	...	...	...	229	Failed from large splinter at corner.	74
...	...	...	...	...	...	...	...	185	Specimen cross grained ; split obliquely.	75
...	...	...	...	...	...	...	...	150	Failed at knot, tension side.	76
...	...	...	...	...	...	...	...	244	Square break tension side ; split in axis.	69
...	...	...	...	...	...	...	...	229	Ditto	70
...	...	...	...	...	...	...	...	229	Failed from splinter at corner.	71
...	...	...	...	...	...	...	...	215	Square break tension side ; split in axis.	72
20.4	25.1	30.5	37.6	46.5	...	...	...	497	Split from knot tension side.	62
20.4	25.2	...	...	...	...	...	...	344	Long oblique fracture along fibres.	63
32.1	48.0	...	...	...	...	...	...	344	Failed from splinter at corner.	152
46.0	...	...	...	...	...	...	...	295	Long oblique fracture.	153
...	...	...	...	...	...	...	...	133	Broke near knot at side.	204
...	...	...	...	...	...	...	...	115	Broke from knot near end.	205
...	...	...	...	...	...	...	...	152	Large flake tension side.	206
...	...	...	...	...	...	...	...	155	Long oblique fracture.	207
...	...	...	...	...	...	...	...	170	Oblique fracture.	208
...	...	...	...	...	...	...	...	144	Ditto	209
...	...	...	...	...	...	...	...	196	Ditto	210
...	...	...	...	...	...	...	...	163	Ditto	211

TABLE III.—RESISTANCE TO LONGITUDINAL CRUSHING.

Species.	Office number.	Locality.	Crushing weight Kilograms.	Remarks.
BIXINEÆ—				
5. <i>Scolopia Zeyheri</i> ...	1	North Drakensberg	8,230	Failed 9 cm. from end.
<i>Wolvedoorn</i>	2	ditto	7,870	Crushed at middle.
6. <i>Scolopia Ecklonii</i> ...	3	ditto	7,010	Crushed 9 cm. from end.
<i>Red Pear</i>	4	ditto	5,740	Crushed at middle.
8. <i>Dovyalis rhamnoides</i>	5	ditto	5,840	Crushed on one side near middle.
<i>Zuurbesjes</i>				
10. <i>Trimeria alnifolia</i> ...	6	ditto	8,130	Crushed at middle.
11. <i>Kiggelaria africana</i>	7	ditto	6,350	Crushed 12 cm. from end.
<i>Spiekhout</i>	8	ditto	6,760	Sheared obliquely near end.
MALVACEÆ—				
14. <i>Hibiscus tiliaceus</i> ...	9	Port Shepstone...	7,270	Crushed near middle.
	10	ditto	6,200	Sheared obliquely near end.
TILIACEÆ—				
19. <i>Grewia occidentalis</i> ...	127	North Drakensberg	9,650	Triple flexure.
<i>Kruisbesjes</i>				
RUTACEÆ—				
23. <i>Calodendron Capense</i>	11	ditto	6,650	Crushed near middle.
<i>Wild Chesnut</i>	12	ditto	7,110	Ditto.
25. <i>Zanthoxylum Thun-</i>	13	ditto	9,190	Sheared obliquely near end.
<i>bergii—Knobthorn</i>	14	Port Shepstone...	6,960	Failed at middle.
26. <i>Toddalia lanceolata</i> ...	15	...	10,970	Crushed near end and at middle.
<i>White Ironwood,</i>				
<i>Bastard Sneeze-</i>	16	...	10,010	Crushed at middle.
<i>wood</i>	17	...	8,630	Split in axis.
27. <i>Clausena inæqualis</i> ...	18	North Drakensberg	9,350	Crushed at middle.
OCHNACEÆ—				
28. <i>Ochna arborea</i> ...	19	Port Shepstone...	8,630	Crushed at middle.
<i>Rooihout, Cape</i>	20	ditto	8,130	Ditto.
<i>Plane</i>				
MELIACEÆ—				
33. <i>Ekebergia Capensis</i> ...	23	ditto	6,100	Sheared obliquely near end.
<i>Essenhout</i>	24	ditto	6,300	Crushed at middle.
34. <i>Ekebergia Meyeri</i> ...	...	ditto	5,940	Crushed near middle.
<i>Wild Syringa</i>		ditto	6,150	Ditto.

TABLE III—RESISTANCE TO LONGITUDINAL CRUSHING (*continued.*)

Species.	Office number.	Locality.	Crushing weight Kilograms.	Remarks.
OLACINÆE—				
36. <i>Apodytes dimidiata</i> ... <i>White Pear</i>	25	Port Shepstone...	8,280	Crushed at middle; de- flected diagonally.
	26	ditto	9,240	Crushed at middle.
	27	ditto	8,830	Sheared obliquely 4 cm. from end.
	140	Knysna	10,470	Sheared obliquely near centre.
	141	ditto	9,650	Sheared obliquely 12 cm. from end.
ILICINÆE—				
37. <i>Ilex Capensis</i> ... <i>Wittehout</i>	28	North Drakensberg	6,600	Sheared obliquely 5 cm. from end.
CELASTRINÆE—				
38. <i>Cathastrum Capense</i> <i>Bastard Saffraan</i>	128	ditto	8,730	Triple flexure.
	129	ditto	8,990	Crushed at centre.
45. <i>Elæodendron velutin- um—um-Nqai</i>	137	Port Shepstone...	10,670	Crushed at corner 12 cm. from end; split to end.
	138	ditto	12,090	Sheared obliquely at end.
	139	ditto	11,990	Sheared obliquely 11 cm. from end.
SAPINDACEÆ—				
50. <i>Schmidelia africana</i>	29	North Drakensberg	9,140	Sheared obliquely 5 cm. from end.
51. <i>Hippobromus alata</i> ... <i>Paardepis</i>	30	North Drakensberg	9,810	Crushed 3 cm. from end; split to end.
	31	ditto	9,860	Crushed 9 cm. from end.
54. <i>Pteroxylon utile</i> ... <i>Sneezeewood</i>	32	Port Shepstone...	19,100	Sheared obliquely at middle; split in axis.
	33	ditto	17,570	Crushed in middle; split in axis.
	34	ditto	17,520	Sheared near end; split in axis.
<i>Greyia Sutherlandi</i> ...	35	North Drakensberg	3,350	Specimen not seasoned; crushed obliquely 2 cm. from end.
ANACARDIACEÆ—				
59. <i>Rhus longifolia</i> ...	36	Port Shepstone...	6,740	Crushed at middle.
	37	ditto	7,420	Sheared obliquely 7 cm. from end.
58. <i>Rhus lucida</i> ...	38	North Drakensberg	15,640	Long oblique fracture; sheared fibres.
61. <i>Odina caffra</i> ... <i>Kafir Plum</i>	39	Port Shepstone...	8,130	Crushed near middle.
	40	ditto	7,930	Sheared obliquely 3 cm. from end.

TABLE III.—RESISTANCE TO LONGITUDINAL CRUSHING (*continued.*)

Species.	Office number.	Locality.	Crushing weight Kilograms	Remarks.
LEGUMINOSÆ—				
63. <i>Milletia Caffra</i> ...	41	ditto	17,070	Split from corner.
<i>Umsimbiti</i>	42	ditto	18,550	Sheared obliquely near end.
	43	ditto	13,820	Defective specimen; shattered along axis.
64. <i>Erythrina caffra</i> ...	44	ditto	2,220	Crushed at end.
<i>Kafirboom</i>	45	ditto	2,120	Ditto.
	46	ditto	1,830	Crushed at middle.
72. <i>Acacia Natalitia</i> ...	47	ditto	5,940	Crushed 10 cm. from end.
71. <i>Acacia horrida</i> ...	48	North Drakensberg	6,350	Crushed near middle; deflected diagonally.
	49	ditto	7,320	Crushed at middle.
73. <i>Albizia fastigiata</i> ...	50	North Coast ...	4,570	Sheared obliquely 2 cm. from end and crushed at 10 cm.
<i>Flat crown</i>	51	ditto	4,675	Sheared obliquely 10 cm. from end.
	51a	ditto	5,080	Crushed at middle.
	51b	ditto	4,065	Crushed 7 cm. from end.
ROSACEÆ—				
74. <i>Leucosidea sericea</i> ...	126	North Drakensberg	5,690	Crushed 10 cm. from end; developed intersecting "Cooper lines"
COMBRETACEÆ—				
80. <i>Combretum Kraussii</i>	52	Port. Shepstone...	7,870	Crushed and crumpled at centre.
<i>Bush Willow</i>	53	ditto	8,530	Crushed 10 cm. from end, with intersecting "Cooper lines."
MYRTACEÆ—				
81. <i>Eugenia cordata</i> ...	54	ditto	5,890	Crushed 11 cm. from end.
<i>Waterboom, Umdoni</i>	55	ditto	6,200	Crushed at middle.
	56	ditto	6,100	Triple flexure.
LYTHRARIÆ				
83. <i>Olinia cymosa</i> ...	57	North Drakensberg	9,040	Sheared obliquely 6 cm. from end.
<i>Hard Pear</i>	58	ditto	10,320	Crushed at middle and at 2 cm. from each end.
	59	ditto	9,140	Sheared obliquely 5 cm. from end.
UMBELLIFERÆ—				
87. <i>Heteromorpha arborescens</i>	130	ditto	6,100	Double flexure; crushed at 3 and 25 cm; split between.
ARALIACEÆ—				
89. <i>Cussonia</i> sp. ...	60	ditto	4,270	Crushed 11 cm. from end.
<i>Cabbage wood</i>				

TABLE III.—RESISTANCE TO LONGITUDINAL CRUSHING (*continued.*)

Species.	Office number.	Locality.	Crushing weight Kilograms.	Remarks.
CORNACEÆ—				
90. <i>Curtisia faginea</i> ... <i>Assagai</i>	61	ditto	9,350	Sheared obliquely 9 cm. from end.
	62	ditto	7,110	Crumpled along wavy fibres.
	63	ditto	8,680	Crushed 13 cm. from end; deflected diagonally.
RUBIACEÆ—				
101. <i>Plectronia Mundtiana</i>	64	ditto	9,450	Crushed at 12 cm. from end.
<i>Klip Els</i>	65	ditto	9,400	Crushed at 10 cm. from end.
COMPOSITÆ—				
104. <i>Brachylæna discolor</i>	66	Port Shepstone...	11,940	Crushed at 14 cm. from end.
	67	ditto	14,530	Crushed at 9 cm. with intersecting "Cooper lines" from corner.
	68	ditto	13,310	Double flexure.
MYRSINÆÆ—				
107. <i>Myrsine melanophleas</i>	69	North Drakensberg	5,330	Crushed 12 cm. from end.
<i>Beukenhout</i>	70	ditto	7,060	Crushed at end and at 8 cm.
	71	Port Shepstone...	7,270	Crushed at end.
	72	ditto	8,130	Double flexure, 3 & 12 cm.
SAPOTACEÆ—				
109. <i>Sideroxylon inerme...</i> <i>White Milkwood</i>	73	ditto	7,370	Crushed near centre; deflected diagonally.
	74	ditto	6,600	Crushed near centre.
	75	ditto	7,220	Crushed near end.
111. <i>Mimusops obovata</i> ... <i>Red Milkwood</i>	76	ditto	7,520	Wood not seasoned; crushed near end.
	77	ditto	7,320	Ditto; crushed near centre.
	78	ditto	7,320	Ditto; crushed near centre.
112. <i>Mimusops Caffra</i> ... <i>Coast Red Milkwood</i>	79	ditto	7,870	Failed 11 cm. from end.
	80	ditto	8,940	Failed near centre.
	81	ditto	7,720	Crushed near middle.
EBENACEÆ—				
113. <i>Royena lucida</i> ... <i>Zwartbast</i>	82	North Drakensberg	6,710	Crushed 12 cm. from end.
	83	ditto	6,860	Crushed near middle.
114. <i>Euclea natalensis</i> ...	84	ditto	5,780	Sheared obliquely & crumpled on one side 6 cm. from end.
	85	ditto	6,300	Crushed near middle.
	86	Port Shepstone...	9,240	Crushed near end.
	87	ditto	9,650	Crushed near middle and 5 cm. from end.
OLEACEÆ—				
118. <i>Olea verrucosa</i> ...	88	North Drakensberg	7,620	Crushed near end.
	89	ditto	8,130	Crumpled on one side near end; split in axis.
	135	Port Shepstone...	13,620	Crushed at centre.
	136	ditto	14,220	Sheared obliquely at centre.

TABLE III.—RESISTANCE TO LONGITUDINAL CRUSHING (*continued*).

Species.	Office number.	Locality.	Crushing weight Kilograms.	Remarks.
119. <i>Olea laurifolia</i> ... <i>Ironwood</i>	90	Knysna ...	12,500	Sheared obliquely 5 cm. from end.
	91	ditto	11,940	Ditto, 12 cm. from end.
	92	ditto	12,190	Ditto, at end.
120. <i>Olea foveolata</i> ...	93	Port Shepstone ...	10,460	Sheared obliquely at end.
	94	ditto	12,190	Double flexure; shattered 7 cm. from end.
APOCYNACEÆ—				
121. <i>Rauwolfia Natalensis</i>	95	ditto	7,260	Failed at middle.
LOGANIACEÆ—				
126. <i>Buddlea salviæfolia</i>	96	North Drakensberg	7,720	Double flexure.
<i>Saliehout</i>	97	ditto	8,130	Crushed at middle & at end.
127. <i>Strychnos Atherstonei</i>	98	Port Shepstone...	8,230	Crushed at middle & at end.
<i>Cape Teak, Chaka's wood</i>	99	ditto	8,430	Triple flexure.
SCROPHULARINÆ—				
131. <i>Halleria lucida</i> ...	100	North Drakensberg	9,600	Sheared obliquely 12 cm. from end.
VERBENACEÆ—				
133. <i>Clerodendron glabrum</i>	101	ditto	6,250	Crushed 8 cm. from end.
	102	ditto	6,100	Crushed 10 cm. from end.
LAURINÆ—				
137. <i>Ocotea bullata</i> ... <i>Stinkwood</i>	103	Knysna ...	8,030	Crushed 9 cm from end; deflected diagonally.
	104	ditto	8,130	Crushed at end.
	105	ditto	9,350	Sheared obliquely, 12 cm. from end.
	106	Natal ...	11,940	Ditto.
	107	ditto	12,500	Sheared obliquely at end.
	108	ditto	12,300	Sheared in 3 places near middle.
EUPHORBIACEÆ—				
144. <i>Briedelia micrantha</i>	109	Port Shepstone ...	7,720	Sheared obliquely 2cm. from end.
	110	ditto	8,430	Ditto 1 cm. from end.
URTICACEÆ—				
155. <i>Celtis Kraussiana</i> ... <i>Kamdeboo Stinkwood Umvuvu</i>	111	ditto	8,580	Crushed at middle.
	112	ditto	9,140	Double flexure; crushed on 1 side 6cm. from end.
158. <i>Trema guineensis</i> ...	113	ditto	6,100	Crushed 7 & 14 cm. from end.
160. <i>Chaetachme Meyeri</i> ...	114	ditto	7,620	Sheared obliquely 2 cm. from end.
	115	ditto	6,100	Double flexure; crushed at 5 & 21cm. from end.
161. <i>Ficus Natalensis</i> ...	116	ditto	5,430	Sheared obliquely 8cm. from end.
	117	North Drakensberg	3,400	Crushed 6cm. from end.

TABLE III.—RESISTANCE TO LONGITUDINAL CRUSHING (*continued*).

Species.	Office number.	Locality.	Crushing weight Kilograms.	Remarks.
CONIFERÆ—				
164. <i>Podocarpus Thunbergii</i> <i>var. falcata</i> .— <i>Up-right Yellowwood</i>	118	ditto	7,720	Sheared obliquely at end.
	119	ditto	8,130	Crushed 6 cm. from end; split to end.
	120	ditto	7,620	Sheared obliquely 13 cm. from end.
	121	ditto	8,330	Crushed 9 cm. from end.
165. <i>Podocarpus elongata</i> <i>Outeniqua Yellowwood, Bastard Yellowwood</i> ...	122	ditto	6,300	Sheared obliquely 13 cm. from end.
	123	ditto	6,250	Crushed 12 cm. from end.
	124	ditto	6,250	Crushed at end.
	125	ditto	6,500	Crushed near middle.
166. <i>Red Ivory</i> ...	131	Port Shepstone ...	14,220	Split along axis.
	132	ditto	16,360	Crushed 14 cm. from end; shattered to end.
167. <i>Bitter Almond</i> ...	133	North Drakensberg	8,280	Sheared obliquely at knot 5 cm. from end.
	134	ditto	8,730	Crumpled on one side, 8 cm. from end.
168. <i>Natal Railway Sleeper</i> (<i>Pinus picea</i>)	142	Baltic ...	5,690	Crushed 10 cm. from end.
	143	ditto	5,380	Crushed 7 cm. from end.
	144	ditto	4,780	Crushed 10 cm. from end.
	145	ditto	4,270	Crushed 12 cm. from end.

APPENDIX III.

NOTE ON THE PREPARATION OF WOOD AND THE MANUFACTURE OF RAILWAY SLEEPERS.

I.—SEASONING OF TIMBER.

Trees contain 20 to 60 per cent. of water, 15 to 20 per cent. of which is permanently retained by timber dried at ordinary temperatures, and constitutes the "hygrometric water." Seasoning effects the removal of the superfluous water, and may be hastened by artificial means. In natural seasoning, timber loses one-fifth to one-seventh of its weight; sometimes as much as one-third before it is perfectly dry. The time required for thorough seasoning may vary from 3 years with sawn resinous woods, or 4 years with hardwoods 4 inches thick, to 10 years with hardwood logs 2 feet thick. Timber shrinks during seasoning, and much more in a direction transverse to the fibres, especially along the annual rings, than longitudinally. A plank of Oak or Yellowwood may shrink in width one-twelfth, and one of Pine or Stinkwood one-thirtieth to one-fortieth. It is this shrinkage that causes the heart shakes (radial) and cup shakes (along the rings) which often detract so much from the value of timber.

Girdling is sometimes practised to hasten seasoning, particularly with Teak trees in India; it consists in cutting a ring through the bark and the sapwood of a tree. After several days or weeks, or even months, according to the species, the tree dies if the sapwood has been completely severed, and it is then allowed to stand till the wood is dry. Teak trees in Burmah are left standing for one or two or three years, in order to get the timber sufficiently dry to float. Girdling has many disadvantages: (a) the heart shake is increased in dead trees left standing exposed to the wind; (b) the wood becomes brittle and liable to be shattered in the felling; (c) the increased hardness of the wood renders the cutting up more laborious; (d) the risks from fires are increased; (e) the risk of damage from wood-boring insects is great; (f) it is inapplicable to some kinds of wood, which decay unless they are converted into lumber soon after felling; (g) the delay, of 2 or 3 years, required may often prove inconvenient. Against these drawbacks: (a) the weight of the wood may be reduced by one-fifth, and the cost of transport lessened in proportion; (b) woods heavier than water when green, may become sufficiently dry to be floated along streams; (c) the durability of some kinds of woods is said to be increased by the process—but it is doubtful whether the durability becomes greater than when timber is carefully seasoned in the ordinary manner.

A preferable method consists in not crowning the felled trees before the foliage is dry; while green, the leaves assist in removing the superfluous sap. Deciduous trees are sometimes felled when the new leaves come out; these open out completely after and draw off a proportion of the sap.

The barking of logs promotes very powerfully their dessication. Uhr, comparing the loss of weight of oak logs, barked and unbarked, found that four months after felling, the barked logs had lost 39·62 per cent. of their weight, while the unbarked logs had lost only 0·98 per cent. Another advantage resulting from the barking or squaring of logs is that timber so treated becomes less readily attacked by xylophagous insects.

The steeping of logs in water, for a fortnight or more, soon after felling, is another means of extracting a portion of the sap, and accelerating the seasoning.

Logs should generally be barked or squared within a fortnight of the time of felling; and the sooner removed from the forest the better, but they should be kept sheltered from the action of the sun. Squared timber is less liable to split than round timber; sawn

timber less than squared timber. The splitting of timber being caused by unequal shrinkage in a radial direction and along the rings, may be avoided, in great part, by sawing the logs through the heart; or by making a longitudinal cut, from the surface to the heart, which relieves the superficial tension and opens up steadily as the log dries.

Sawn timber should be stacked in a dry place, sheltered from sunshine and high winds. The seasoning shed or yard should be floored or paved and well drained, as otherwise "stack rot" may result from the piling of timber on damp soil. The mode of stacking should be such as to allow of a free circulation of air all round each piece, while resisting warping.

2.—PRESERVATION OF TIMBER.

The decay of timber is generally due to the growth of the *mycelium* of various fungi which derive their nutriment from the tissues of the wood; it is also aided by bacteria. An excess of moisture is favourable to the development of "wet rot," and warm and stagnant air to that of "dry rot." Timber is most lasting when kept constantly dry and freely ventilated, while alternations of dryness and wetness are the most unfavourable conditions.

Protection from decay is afforded by seasoning and ventilation, and by coatings of oil-paint or tar applied when the wood is dry, but impregnation with antiseptic substances that prevent the spread of the fungi of rot is a more effectual method.

The various processes which have been adopted from time to time for the preservation of timber are mainly the following:—

a. *Creosoting.*

This consists in impregnating timber with the oil of tar called *creosote*. The cut up timber, which must be sufficiently dry, is packed on small wagons that are run along a light line of rails into a long cylinder, the headpiece of which is then closed and made air-tight. The air inside is exhausted by means of an air-pump; the highest vacuum is reached after half-an-hour's pumping, but a longer interval is required to make the wood give up all the air it contains. The creosote is next admitted and allowed to be forced in by the pressure of the atmosphere, the air-pump being kept going to prevent the accumulation of air, in the upper part of the cylinder as it becomes filled up, which by penetrating into the pieces of wood near the top would render these incapable of absorbing the creosote. The creosote is usually heated to a temperature of 100° to 120° by coils of pipes placed in the reservoir, through which a current of steam is passed, in order to render it fluid enough to penetrate the wood freely, but in a warm climate this precaution is unnecessary. When the cylinder is nearly full, the supply of creosote is cut off, but the air pump is left to work a little longer. More creosote is then forced in by means of a force-pump, until a pressure of 120 to 150 lbs. per square inch is registered. This pressure is maintained from two to sixteen hours, according to the kind of wood and the degree of saturation required. When the impregnation is sufficient, the creosote is run off, the lid of the cylinder opened, and the wagons drawn out.

Creosote is a product of the distillation of coal tar. Coal tar yields about one-fourth of volatile oils, which can again be separated into lighter oils containing benzine, and heavier oils containing carbolic acid. The latter constitute the raw creosote of commerce. The proportion of carbolic acid in coal-tar is about 3 per cent.; in creosote it should be at least 8 or 10 per cent. for purposes of impregnation, but it is frequently very much less in some of the creosote used for the impregnation of sleepers for export, and unsatisfactory results follow. A simple method of testing creosote consists in shaking a portion, with a 10 per cent. solution of caustic soda, in a graduated glass tube, and allowing the mixture to settle. The carbolic acid combines with the alkali in the solution, and the volatile oils float in a layer on the surface. The diminution in volume of the latter indicates the quantity of carbolic acid which they contained. Creosote is one of the best substances used for impregnation. Apart from its antiseptic qualities, due to the carbolic acid which it contains, it fills the pores of the wood with a bituminous substance that excludes both air and moisture; it resists the lixiviating action of water better than metallic salts; and, unlike the latter, which render wood somewhat more brittle, it rather increases if anything the strength of soft woods. Creosoting, when properly performed, about doubles the life of a sleeper.

The quantity of creosote usually forced into wood is:

For railway sleepers, telegraph poles, and construction on land, 8 lbs. or .8 galls. per cubic foot.

For piles, jetties, and other marine works, 10 lbs. or 1 gall. per cubic foot.

Oak does not readily take up more than 2 or 3 lbs. of creosote, and teak more than $1\frac{3}{4}$ per cubic foot.

According to Molesworth, the relative absorbing power of timber, Memel pine being assumed = 1, is : elm = 1.35 ; yellow pine = 1.15 ; beech = .4 ; English oak = .34. And the results of the Cape "tests of Yellowwood for Railway purposes" reduced to yellow pine = 1.15 give : Outeniqua Yellowwood = 2.60 ; Upright Yellowwood = 2.44 ; "dry open grained Baltic sleeper" = 2.20 ; white pear = 1.08.

b. Chloride of Zinc process.

The impregnation of timber with a solution of zinc chloride is effected in the same apparatus, and in the same manner as with creosote ; but steaming up to 150° may take place if the wood is not already well seasoned ; after which, the liquid that has collected at the bottom of the cylinder is drawn off, and the exhaustion of the air, commenced. The pressure used in Germany for impregnation with chloride of zinc is usually 112 lbs. to the square inch.

The solution consists of one part of the commercial chloride of zinc solution to 50 parts of water. Formerly the proportion adopted was 1 in 30, but it was found that the iron spikes became corroded. The commercial zinc solution contains 25 per cent. of metallic zinc, equal to 52.4 per cent. of chloride. It is diluted to the proper strength for impregnation with the aid of densimeters graduated from 1.000 to 1.100.

The quantity of zinc chloride taken up is about .2 lb. per cubic foot for oak, and .5 lb. per cubic foot for beech and pine-wood. Drying the wood before pickling is not necessary.

The pneumatic process with zinc chloride gives results almost equal to creosoting, while its cost is only from one-half to one-third. This process is regarded with increasing favour, and in Germany it is now the one most largely followed for the impregnation of railway sleepers.

c. Boucherie's process.

The timber is impregnated with a 1 per cent. solution of copper sulphate, placed in a tank 30 to 40 feet from the ground, giving a pressure of 13 to 17 lbs. per square inch. A watertight cap is fitted on one end of the log to be treated, and the solution from the tank being introduced by means of a flexible tube, drives out the sap through the log and takes its place. This process can only be applied to timber freshly cut and with the bark left on. It has been chiefly used for the impregnation of telegraph poles of round wood. The quantity of sulphate taken is about .3 lb. per cubic foot.

d. Pneumatic sulphate of copper process.

The apparatus used is similar to that required for creosoting. The impregnating fluid consists of a 2 per cent. solution of copper sulphate, 1.5 to 1.8 galls. of which are forced per cubic foot, equal to .30 to .36 lb. of sulphate. The solution is usually heated to 120° , and a pressure of 60 to 120 lbs. per square inch maintained for at least half-an-hour. To test the result, a 9 per cent. solution of potassium ferrocyanide is used ; a drop of this reagent placed on the wood should give it a red stain ; a pink stain denotes that the impregnation is not sufficient.

e. Hot immersion.

The wood is kept for two hours in tanks containing a 2 per cent. solution of copper sulphate, heated by means of steam pipes to 140° ; the impregnation is only effected to a small depth.

f. Kyanizing.

This consists in impregnating the wood with a solution of mercuric chloride (corrosive sublimate), of a strength of 0.66 per cent. The quantity of the salt taken up is .066 lb per cubic foot. Mercuric chloride is the best antiseptic known, but the difficulties in the way of its application, resulting from the fact that the solution cannot be placed in vessels of common metals, and its great cost, make other substances to be preferred for the preservation of timber.

g. Payne's process.

The wood is impregnated first with a strong solution of ferrous sulphate, then with a solution of barium sulphate ; the wood is rendered incombustible, but a slow destruction of its fibres appears to take place.

h. Carbonization (*Ravazé's process*).

The apparatus used consists of a tube 26 feet long, 2 feet in diameter, lined with fire bricks, through which a flame is drawn by a chimney built at one end. Sleepers are drawn through the tube by means of an endless chain; they take fire and give part of the heat required in the process. The speed of the chain is regulated to allow the sleepers to come out thoroughly carbonized, which takes about 2 minutes. The burning sleepers are extinguished by a jet of water when they come out.

A modification of this process consists in plunging the sleepers that come out of the tube into a tank of coal tar heated at 170° to 190° . The tar penetrates readily into the heated wood, and each sleeper absorbs about 4.4 lbs. during the two hours it is left immersed; 900 to 1,200 sleepers may be treated in a day, and the results are said to be uniformly favourable.

3.—RAILWAY SLEEPERS.

Railway sleepers are placed in conditions very unfavourable for durability: they are subjected to constant alternations of dryness and wetness which induce decay; and they have, besides, to bear heavy pressures that destroy the cellular tissue of soft woods, even with the use of chairs, and also lateral pressures tending to loosen the spikes.

To resist these influences, the wood of sleepers should possess the following qualities:—

- a. Sufficient resistance to compression, since the wood has to bear pressures of 250 to 300 lbs. per square inch, under the rail, though less when chairs are used.
- b. The fibres should be close and the tissue homogeneous.
- c. Durability when exposed to alternate damp and dryness; either in the natural state or after impregnation.
- d. A moderate density—otherwise the sleepers become unwieldy and difficult to pack; sufficient toughness to resist splitting by the spikes; and sufficient elasticity to resist rupture when the sleepers are badly packed.

The timber should be of good quality and free from such defects as cracks, rotten spots, and weak knots. Heartwood that has become discoloured is considered inferior wood.

The trees from which sleepers are cut, should not be less than 12 inches in diameter, but they may be of any larger size. Branchwood is also frequently used.

In order to obtain sleepers at a moderate cost, many Continental railway companies admit several classes. In the *Report of the U. S. Commissioner of Agriculture for 1884*, are given the following data relative to the sleepers used by the Compagnie du Nord (France):

Beech sleepers for gauge 4.9 feet; length 8.5 feet; consisting of:—

- (a) Square sleepers: breadth 9.5 inches; depth 5.5 inches.
- (b) Other shapes of sleepers:

(Only four per cent. of the above kinds are accepted which measure so low as 8.7 to 9.0 inches in width.)

These partly round sleepers have all the advantages of square sleepers. The dimensions are increased sufficiently to give an equal strength. The under side is flat, and gives a bearing surface at least equal to, and usually greater than, that of the square sleeper. When the upper surface is round, it is adzed to receive the rails, but too long a bearing is not sought, as it gives sleepers a tendency to rock. The sleepers often contain a large proportion of sapwood, but sapwood impregnated is found to be quite as durable as the heartwood, on account of the greater quantity of preservative substance which it takes up.

Several important advantages result from the use of such sleepers :

1. The cost of production is reduced.
2. The waste in cutting is much less : not 25 per cent., instead of 50 per cent. ; and thus *the yield of sleepers may be increased by one-half.*
3. Small trees that cannot give square sleepers may often be cut into partly round sleepers. The Natal Coast forests, particularly those at Umzimkulu, consist mainly of small trees, and would give few square sleepers, but they might be made to yield a large supply of partly round sleepers.

Besides Yellowwood, all the other Colonial woods that fulfil the conditions required in a sleeper should be accepted for the purpose. In selecting these woods, the results of mechanical tests given in Appendix II. would be of service. Most of the Colonial woods that are suitable for sleepers are either too hard or too fissile to allow of the driving of spikes without boring, and it would generally be necessary to bore holes for the spikes about half their diameter, and quite through.

By using sleepers of Yellowwood or of other Native woods with a cellular tissue less compressible than that of Baltic Fir, the use of chairs may be dispensed with, and yet the resistance to the enlargement of the gauge increased. The chairs that are now used cost over a shilling each, and about seventeen hundred thousand will have been laid on the lines now constructed or authorised, if their use is adhered to.

Metal sleepers have been tried under a variety of shapes, but none have proved entirely successful. They destroy elasticity, and, on account of their deficiency in bulk, do not possess the stability of a wooden sleeper ; they are also more difficult to place and to pack. It does not seem that at present the prospects of the metal sleeper are such as to seriously affect those of the wooden sleeper.

4.—TESTS OF YELLOWWOOD.

The following extracts give the chief points of information contained in the "*Papers and Correspondence with reference to the Testing of Yellowwood for Railway Purposes*" (Cape Town, 1884) referred to at p. 68. The tests were all performed in England.

p. 9. Mr. S. Aitken (John Bland & Co., Cardiff), to the Agent-General : "I have now the pleasure to hand you 'Report on Native Sleepers' as experimented upon by me, for the purpose of ascertaining :

- 1st. Whether they would take creosote, and
- 2nd. Whether in such quantities as would justify my recommending them for Railway work.

I am happy to say that I can give you the most positive answer in the affirmative on both points. Indeed, I may say, the capacity of the wood for absorbing the oil has far exceeded my expectations, and I have no hesitation in saying that either of the specimens submitted will make an excellent and lasting sleeper. I consider them superior to any Baltic sleepers you can get, and, if properly operated upon, you have an article in your own hands that will be found efficient and economical, supposing they can be readily and cheaply cut in the forests. Whilst on this part of the matter, I may say, these samples have been submitted to the Great Western Railway Company's Inspector, who has had the inspection of their creosoted timber for 30 to 40 years, and also to our own out-door manager, a practical man of similar experience, and they both agree with my estimate of the value of any and all of the sleepers, which they say could not possibly be better, and they regard them as much superior to Baltic redwood. I must now direct your attention to the accompanying statistics, which I have put in simple and complete form, not troubling you with *details* of the experiments, but simply giving you the *results*. The five different sorts have each been operated upon in the first instance, all together, so that each has been subjected to precisely the same conditions. The figures require very little explanation, but simply and broadly put, the result is that E, the least absorbent sleeper,

takes the same as yellow pine, and all the rest more than double, and this, too, under the same pressure, and at the same time and in the same cylinder as the yellow pine longitudinals. Letters A, B, F, M, as you see, very readily absorb the oil—as readily as a dry Baltic open-grained sleeper. You will probably like my opinion as to the relative value of the five different sorts. They are all good—good enough for any railway work whatever, but I think the best are A [Upright Y.W] and B [Outeniqua Y.W.], then F [Colonial Fir] and M [Colonial Fir], and after that E [White Pear]. This, of course, is but an opinion, but I am under the impression that the softer-natured wood will wear better and not split so much. Letters A and B partake considerably of the nature of yellow pine, which, though very soft, is undoubtedly the best wood for railway work.”

“7 feet 10 by 5.—Cape Sleeper—Native Wood.

Mark.	No.	Weight Clear.	Weight Creosoted.	Yellow Creosote To load 50 feet.
A	1	102 lbs.	139 lbs.	74
B	5	101 „	141 „	80
E	9	154 „	171 „	34
F	10	135 „	175 „	80
M	13	124 „	158 „	68

These results were obtained from an exhaustion of air for 30 minutes, and afterwards a pressure of 120 lbs. per square inch, applied for nine hours.

The sleepers were put into the cylinder with a charge of Yellow Pine longitudinals for the Great Western Railway, into which 35 gallons of creosote was forced. The absorbing capacity, therefore, of the sleepers was equal in that which took the last oil letter E, and about double in letter M, and more than double in letters A, B, and F. They have all, even letter E, taken considerably more than is absolutely necessary or customary.

By contract with a *dry open-grained* Baltic sleeper, one of letter A (No. 2), under another experiment absorbed 68 gallons to the load—exactly the same as the Baltic Fir.”

p. 19. Sir Charles Gregory to the Agent General. Forwarding a report of Mr. H. Wakefield, “with a statement of the experiments tried by him, which I think are sufficient for present purposes, and which are in favour of the Colonial wood, and although the small amount of deflection before fracture is a defect in the Colonial wood which would make it unfit for many structural purposes, and it would not be a bar to its use as a sleeper if kept properly packed up.”

p. 19. The results of the creosoting by Messrs. R. Lander & Co., of some Cape sleepers treated for 5 hours under a pressure of 100 lbs. per square inch, are stated to have been as follows :

A. Upright Yellowwood.	Absorbed 14.9 lbs. per cubic foot
B. Outeniqua Yellowwood.	„ 14.2 „ „
E. White Pear.	„ 6.5 „ „

in reference to which Messrs. R. Lander & Co. report :

“The 3 pieces marked A, as you will see, have taken the largest quantity of creosote, and the 3 pieces marked B have taken nearly an equal quantity. Both these qualities, we should consider, would make useful sleepers if well dried before being creosoted.

The 3 pieces marked E you will see have taken very little creosote, being a very close grained hard, and we think a timber that would not be so durable, and would be more easily split in fastening the rails than any of the others.

Having no knowledge of the durability of the different examples in the climate in which they are grown and to be used, we cannot with any certainty give an opinion as to the wear (or value there, but from what we can see of the timber we certainly think it should, if properly prepared and creosoted, be equal to Baltic redwood, if not considerably more durable.”

p. 23. Report from the Mr. H. Wakefield to Sir Charles Gregory :

" *Cape Government Railways. Experiments with Native Wood Sleepers.*"

Experiment No. 1. Weight required to draw a dog spike from each sleeper :

				Tons. Cwt.	
A. Upright Yellowwood required	...	3	5	}	Dog spikes $1\frac{1}{6}$ square, $4\frac{1}{2}$ in. long, all holes bored with $\frac{5}{8}$ in. auger.
B. Outeniqua "	...	3	5		
F. Colonial Fir "	...	2	10		
M. Colonial Fir "	...	2	5		
Baltic Fir "	...	1	10	}	

Experiment No. 2. Resistance to spreading action of rail by a steady pull, one dog spike to each side of rail :

				Tons. Cwt.	
A. Upright Yellowwood	...	3	10	}	With these weights the rail commenced to spread and the out- side spike began cut- ting into the timber.
B. Outeniqua "	...	3	15		
F. Colonial Fir "	...	3	15		
M. Colonial Fir "	...	3	0		
Baltic Fir "	...	2	0	}	

Experiment No. 2a. Two dog spikes outside and one inside of rail. In all the three following experiments, the inside spike drew by the canting of the rail, otherwise a greater resistance would have been shewn :

					Tons. Cwt.
A. Upright Yellowwood stood	...	...	...	4	10
B. Outeniqua "	...	...	...	4	0
M. Colonial Fir "	...	...	...	3	5

Experiment No. 2b. Spreading action against rail with one holding down bolt and fanged clip each side of rail and ordinary washer under head of bolt :

A. Upright Yellowwood, with a strain of 4 tons 5 cwt. bent outside bolt and drew rail from under the inside clip fang, sinking into timber $\frac{3}{8}$ in. bolt bending in centre $\frac{1}{4}$ in.

B. Outeniqua Yellowwood, with bolts and clips same as A, with a strain of 5 tons 10 cwt. bent outside bolt in centre $\frac{1}{4}$ in. and partially fractured it in the thread, outside clip fang sunk into timber $\frac{3}{8}$ in. owing to canting by rail. Baltic Fir with bolts and clips, same as A, with a strain of 2 tons 15 cwt., broke outside bolt in the thread.

2 Dog spikes were driven into each of the Native Wood sleepers, and also into one of the Baltic sleepers side by side, or $4\frac{1}{2}$ in. centres, and no signs of splitting were shown in any of the sleepers ; holes were bored with $\frac{5}{8}$ in. auger.

Experiment No. 3. Action of clip-washers with fangs :

A. Upright Yellowwood. Bottom washers did not cut in as in the Baltic Fir ; top washers harder to draw into timber, the fangs making clean cuts instead of tearing the wood ; washers with back fangs easiest to draw in.

B. Outeniqua Yellowwood the same as A. apparently harder, fangs of clips scarcely cutting into the wood at all.

M. Colonial Fir. Bottom washers show marks in sleepers, top washers pulled down rather more than other specimens of wood, apparently softer but very tough.

F. Colonial Fir. Two bolts broke pulling in the lower side, bottom washers 3 inches square, did not cut in both clip washers, very hard to screw up, clip washers pulled very slightly into timber bolt, fractured at thread before they could be pulled tightly up as in the ordinary timber. Clip washers drew more easily into A than F.

In the creosoted Baltic Fir Timber, one sleeper of which was tried, fangs tore away the wood and fractured the fibres more decidedly than in the Colonial Wood.

Experiment No. 4.—To try the strength of each kind of sleeper by placing a flat bar of iron $4\frac{1}{4}$ in. wide on the sleeper, and dropping a monkey upon the flat bar, shewing the indentation after each blow.

Weight of Monkey 17 cwt. Drop Four Feet.

	1st 6 ton.	2nd 6 ton.	3rd 6 ton.	4th 6 ton.
A. Upright Yellowwood ...	$\frac{1}{64}$ in.	$\frac{1}{32}$ in.	$\frac{1}{32}$ in.	$\frac{1}{32}$ in.
B. Outeniqua ...	$\frac{1}{64}$ in.	$\frac{1}{32}$ "	$\frac{1}{32}$ in.	$\frac{1}{16}$ "
F. Colonial Fir ...	$\frac{1}{64}$ "	$\frac{1}{16}$ "	$\frac{1}{32}$ "	$\frac{1}{16}$ "
M. Colonial Fir ...	$\frac{1}{16}$ "	$\frac{1}{64}$ "	$\frac{1}{32}$ "	$\frac{1}{16}$ "
Baltic Fir ...	$\frac{1}{16}$ "	$\frac{1}{32}$ "	$\frac{1}{16}$ "	$\frac{3}{32}$ " split at the end.

Drop Seven Feet.

	1st 6 ton.	2nd 6 ton.	3rd 6 ton.	4th 6 ton.
A. Upright Yellowwood ...	$\frac{1}{32}$ in.	$\frac{1}{16}$ in.	$\frac{3}{32}$ in.	$\frac{1}{8}$ in.
B. Outeniqua ...	$\frac{1}{32}$ "	$\frac{1}{16}$ "	$\frac{3}{32}$ "	$\frac{1}{8}$ "
F. Colonial Fir ...	$\frac{1}{64}$ "	$\frac{1}{32}$ "	$\frac{1}{16}$ "	$\frac{3}{32}$ "
M. Colonial Fir ...	$\frac{1}{32}$ "	$\frac{1}{16}$ "	$\frac{1}{8}$ "	$\frac{1}{16}$ " Broke under the iron plate from the blows.
Baltic Fir ...	$\frac{1}{8}$ "	$\frac{1}{16}$ "	$\frac{1}{16}$ "	$\frac{1}{4}$ " split at the end.

Experiment No. 5. Taking the strength of timber by Hydraulic Press, an iron plate in front of ram, 10 in. x 7 in., bearings 3 ft. 8 in. apart :

A. Upright Yellowwood stood before cracking 11 tons 10 cwt., bending $1\frac{1}{4}$ in. long, sloping crack extending about 18 inches.

B. Outeniqua Yellowwood stood before cracking 7 tons 10 cwt., bending 1 in. appearance of fracture generally similar to A.

F. Colonial Fir stood before cracking 10 tons, bending $1\frac{1}{4}$ in. long sloping fracture, starting near a larger knot.

M. Colonial Fir stood before cracking 5 tons, bending 2 ins., the fracture being nearly straight across and extending about 10 ins., rather short grain close to a knob.

Baltic Fir stood before cracking 11 tons, bending 3 in., straight crack side away from ram extending about half way through.

Experiment No. 6. Dog spikes driven into sleepers without boring 1 ft. 5 in. from the end :

A. Upright Yellowwood. Slightly split on bottom side 5 inches each side of dog spike.

B. Outeniqua Yellowwood. No signs of splitting top side ; timber driven out by point of dog spike on the bottom side of the sleeper.

F. Colonial Fir split top side for a length of $3\frac{1}{2}$ in. towards the end and $4\frac{1}{2}$ in. into the rail bed, bottom side $3\frac{1}{2}$ in. towards the end, $4\frac{1}{2}$ in. towards the centre.

M. Colonial Fir. No sign of split on top side towards the end, 1 in. into the rail bed on bottom side about 1 inch each side of the point of dog spike on bottom side."

Mr. H. Wakefield remarks, with reference to the foregoing, "that as regards holding power of bolts, clips, spikes, and fastenings, and the resistance of the rail beating into the sleeper, the Colonial sleepers show very satisfactory results. In resistance to breaking force the experiments show that the Colonial sleepers do not bend so much before fracture as the Baltic sleepers. . . . Taking, however, into consideration all the other good points of the Colonial wood sleepers, and bearing in mind that the sleepers are bedded in the ground, I do not anticipate any prejudicial results will occur in practice owing to the deficiency of elasticity as compared with Baltic Fir sleepers shown in the experiment."

p. 37. Mr. C. Besley, G. W. Ry. Inspector, to Mr. S. Aitken :—"Having witnessed the experiments made by you with the red wood sleepers, I must say that I never saw during my 30 years' service with the Great Western Railway Company a more successful experiment with timber under the process of creosoting.

"That the wood you have experimented upon will readily absorb creosote, both under ordinary and extreme pressure, is borne out by the fact of its having freely absorbed a quantity of creosote sufficient for all practical purposes. I am very much inclined in favour of the closer grained wood [Yellowwood], from the fact of its being so much like American Pine, which the Great Western Railway Company have universally adopted for their permanent way for the past half-century.

"The coarser grained wood [Colonial Fir] seems to contain a large amount of sap, and take after the nature of Baltic red pine, although either of these woods, when thoroughly creosoted, are well adapted for railway purposes ; but I cannot help thinking that in actual use the fine grained wood would be less likely to throw off in evaporation a lesser quantity of creosote than the more sappy wood, therefore adding very much to its lasting qualities."

p. 38. Mr. E. E. Niblett to Mr. S. Aitken :—"That this kind of wood will with proper machinery absorb creosote thoroughly is proved by the fact that the oil (in almost every case) having penetrated through the whole substance of the wood particularized in the pieces Nos. 1 [Upright Y.W.], 5 [Outeniqua Y.W.], and 9 [White Pear]. The pieces Nos. 10 and 13 [Colonial Fir], being of a coarser grain and apparently containing in the pores, especially near the heart, a gummy or resinous substance which in a measure has acted with a resisting force against the more freely absorbing nature of the closer grained wood. Respecting the relative durability of the wood experimented upon, I am strongly of opinion that the more closely grained wood, when impregnated thoroughly with creosote, would be less likely in actual work to throw off in evaporation (or exposure to the elements) a lesser quantity of creosote than the coarser grained wood, and therefore all the preserving qualities of the oil most essential to its nature would be retained in the wood, thereby resisting the absorption of any external moisture with which it might be brought in contact.

"There is another reason, too, why I think the closer grained wood, after being creosoted, would be more lasting than the coarser grained wood ; that is because the former resembles in its nature American Pine, whereas the latter seems to take more after the nature of Memel or Dantzig Pine."

p. 39. Mr. S. Aitken, to the Commissioner's Office : "I am quite convinced that the sleepers of *Native wood creosoted* will be found superior—I may say greatly superior—to any you have imported from England, and in this opinion I am quite confirmed by that of the practical men whose reports I have left with you."

The other portions of the collection of reports from which extracts have been made deal chiefly with business matters, and do not contain any additional information relative to the suitability of Yellowwood and other Colonial woods for railway sleepers.

APPENDIX IV.

It was intended to give here the results of the examination of some tannin barks yielded by Natal trees, but the work could not be completed, because some special chemicals, required for the tannin determination (using a modification of Löwenthal's method) and procured from Europe through a firm in Maritzburg, were found to be of a different quality to that ordered, and had to be returned as unsuitable for even approximate analyses.

The barks for which it was intended to determine the percentage of tannin were the following :—

1. Various species of *Acacia*.
2. *Elæodendron croceum* (Saffraan).
3. *Ocotea bullata* (Stinkwood).
4. *Curtisia faginea* (Assagai).
5. *Rhizophora mucronata* (Mangrove).
6. *Rhus longifolia*.
7. *Rhus lucida* (Taaibosch).
8. *Plectronia obovata*.
9. *Protea hirta* (Sugar bush).
10. *Protea lanceolata*.
11. *Eugenia cordata* (Waterboom).
12. *Colpoon compressum* (Bergbast).

all of which afford strong indications of the presence of tannic acid.

APPENDIX V.

MEASUREMENTS OF THE RATE OF GROWTH OF INDIGENOUS TREES.

The following measurements were taken between 1882 and 1889 at the Knysna, on trees in the natural forest; the growth would probably have been more rapid had it been aided by thinnings, and there is little doubt that the rates of growth observed would be exceeded in plantations.

GOUNA FOREST.

OCOTEA BULLATA. *Stinkwood.*

No. 1—November, 1882 ; girth 63in.			
February, 1889	64 $\frac{3}{4}$;	growth 1 $\frac{3}{4}$ in. in 75 months.	
8—November, 1882	28 $\frac{1}{2}$.		
February, 1889	32 $\frac{3}{8}$;	4in. in 75	„
34—August, 1885	24 $\frac{1}{3}$.		
February, 1889	27	2 $\frac{1}{4}$ in. in 42	„
31—December, 1886	25 $\frac{5}{8}$.		
February, 1889	26 $\frac{1}{2}$;	1in. in 26	„
46—October, 1887	50.		
February, 1889	52 ;	2in. in 16	„
47—October, 1887	12 $\frac{1}{8}$.		
February, 1889	12 $\frac{7}{8}$;	$\frac{3}{4}$ in. in 16	„

Aggregate growth, 12 $\frac{1}{2}$ in. in 250 months.

Mean yearly increase in girth, 0·60in.

PODOCARPUS THUNBERGII, var. LATIFOLIA. *Upright Yellowwood.*

No. 4—December, 1883 ; girth 32in.			
February, 1889	35 $\frac{5}{8}$;	growth 3 $\frac{5}{8}$ in. in 62 months.	
14—July, 1885	15 $\frac{1}{4}$.		
February, 1889	16 $\frac{3}{4}$;	1 $\frac{1}{2}$ in. in 43	„
16—July, 1885	41 $\frac{1}{2}$.		
February, 1889	43 $\frac{1}{4}$;	1 $\frac{3}{4}$ in. in 43	„
27—December, 1886	33 $\frac{7}{8}$.		
February, 1889	35 $\frac{1}{2}$;	1 $\frac{5}{8}$ in. in 26	„
35—May, 1887	25 $\frac{1}{4}$.		
February, 1889	26 $\frac{1}{2}$;	1 $\frac{1}{4}$ in. in 21	„
36—May, 1887	16 $\frac{1}{2}$.		
February, 1889	17 $\frac{1}{2}$;	1in. in 21	„
37—May, 1887	22 $\frac{3}{4}$.		
February, 1889	23 $\frac{3}{8}$;	1 $\frac{1}{8}$ in. in 21	„
39—October, 1887	23.		
February, 1889	25 ;	2in. in 16	„
40—October, 1887	33.		
February, 1889	33 $\frac{1}{2}$	$\frac{1}{2}$ in. in 16	„
43—October, 1887	31 $\frac{1}{2}$.		
February, 1889	32 $\frac{1}{4}$;	$\frac{3}{4}$ in. in 16	„

Aggregate growth, $17\frac{1}{2}$ in. in 285 months.
Mean yearly increase in girth, 0.72 in.

PODOCARPUS ELONGATA. *Outeniqua Yellowwood.*

No. 10—December, 1883 ; girth $29\frac{3}{4}$ in.

February, 1889	„	$34\frac{1}{2}$;	growth $4\frac{3}{4}$ in. in 62 months.
17—August, 1885	„	$19\frac{2}{3}$;	
February, 1889	„	$20\frac{5}{8}$;	„ 1 in. in 42 „
18—August, 1885	„	$21\frac{3}{4}$;	
February, 1889	„	$22\frac{3}{4}$;	„ 1 in. in 42 „
19—August, 1885	„	$24\frac{1}{4}$;	
February, 1889	„	$25\frac{3}{4}$;	„ $1\frac{1}{2}$ in. in 42 „
45—October, 1887	„	$25\frac{5}{8}$;	
February, 1889	„	$26\frac{1}{2}$;	„ $\frac{7}{8}$ in. in 16 „

Aggregate growth, $8\frac{1}{2}$ in. in 162 months.
Mean yearly increase in girth, 0.60 in.

CURTISIA FAGINEA. *Assagai.*

No. 3—November, 1882 ; girth $35\frac{1}{2}$ in.

February, 1889	„	38 ;	growth $2\frac{1}{2}$ in. in 75 months.
20—July, 1885	„	27.	
February, 1889	„	28 ;	„ 1 in. in 43 „
41—October, 1887	„	23.	
February, 1889	„	$23\frac{1}{2}$;	„ $\frac{1}{2}$ in. in 16 „

Aggregate growth, 4 in. in 134 months.
Mean yearly increase in girth 0.36 in.

OLEA LAURIFOLIA. *Ironwood.*

No. 15—July, 1885 ; girth $28\frac{1}{6}$ in.

February, 1889	„	31 ;	growth $2\frac{7}{8}$ in. in 43 months.
22—August, 1885	„	$24\frac{1}{4}$;	
February, 1889	„	$25\frac{3}{8}$;	„ $1\frac{1}{8}$ in. in 42 „
40—October, 1887	„	$13\frac{1}{8}$;	
February, 1889	„	$13\frac{1}{2}$;	„ $\frac{3}{8}$ in. in 16 „
44—October, 1887	„	$18\frac{1}{8}$;	
February, 1889	„	$19\frac{1}{2}$;	„ $1\frac{3}{8}$ in. in 16 „

Aggregate growth, $5\frac{5}{8}$ in 117 months.
Mean yearly increase in girth, 0.59 in.

APODYTES DIMIDIATA. *White Pear.*

No. 6—November, 1882 ; girth $23\frac{1}{4}$ in.

February, 1889	„	29	growth $5\frac{3}{4}$ in. in 75 months.
9—March, 1883	„	$24\frac{1}{4}$;	
February, 1889	„	$25\frac{5}{8}$;	„ $1\frac{3}{8}$ in. in 71 „
11—March, 1884	„	12.	
February, 1889	„	$15\frac{1}{8}$;	„ $3\frac{1}{8}$ in. in 59 „
25—November, 1886	„	$23\frac{7}{8}$;	
February, 1889	„	$25\frac{3}{4}$;	„ $1\frac{7}{8}$ in. in 27 „
50—October, 1887	„	$8\frac{1}{4}$;	
February, 1889	„	$9\frac{1}{2}$;	„ $\frac{3}{4}$ in. in 16 „

Aggregate growth, $12\frac{3}{8}$ in. in 248 months.
Mean yearly increase in girth, 0.62 in.

CELASTRUS PEDUNCULARIS. *Zwartbast.*

No. 5—December, 1883 ; girth $22\frac{1}{2}$ in.

July, 1885	„	$24\frac{1}{10}$;	growth $1\frac{1}{2}$ in. in 19 months.
13—July, 1885	„	$12\frac{1}{4}$;	
February, 1889	„	$14\frac{5}{8}$;	„ $1\frac{7}{8}$ in. in 43 „

Aggregate growth, $3\frac{1}{2}$ in. in 62 months.
Mean yearly increase in girth, 0.68 in.

PLECTRONIA OBOVATA. Quar.

No. 21—August, 1885 ; $23\frac{3}{4}$ in.
February, 1889 ; $25\frac{1}{2}$ growth $1\frac{1}{2}$ in. in 42 months.

28—December, 1886 ; $21\frac{5}{8}$
February, 1889 ; $23\frac{1}{4}$ „ $1\frac{1}{8}$ in. in 26 „

Aggregate growth $3\frac{3}{8}$ in. in 68 months.

Mean yearly increase in girth, 0·60in.

CUNONIA CAPENSIS. Red Els.

No. 29—December, 1886 ; $26\frac{1}{2}$ in.

February, 1889 ; $27\frac{1}{2}$ growth 1in. in 26 months.

Mean yearly increase in girth, 0·46in.

MYRSINE MELANOPHLEOS. Beukenhout.

No. 30—December, 1886 ; $27\frac{3}{4}$ in.

February, 1889 ; $29\frac{1}{2}$ growth $1\frac{1}{4}$ in. in 26 months.

Mean yearly increase in girth, 0·80in.

NUXIA FLORIBUNDA. Vlier.

No. 32—December, 1886 ; $37\frac{1}{2}$ in.

February, 1889 ; $39\frac{1}{2}$ growth 2in. in 26 months.

Mean yearly increase in girth, 0·92in.

EKEBERGIA CAPENSIS. Essenwood.

No. 33—December, 1886 ; $47\frac{3}{8}$ in.

February, 1889 ; 49 growth $1\frac{1}{8}$ in. in 26 months.

Mean yearly increase in girth, 0·75in.

OLINIA CYMOSA, var. INTERMEDIA. Hard Pear.

No. 34—May, 1887 ; $33\frac{3}{4}$ in.

February, 1889 ; 36 ; growth $2\frac{1}{4}$ in. in 21 months.

Mean yearly increase in girth, 1·17in.

ELÆODENDRON CROCEUM. Saffraan.

No. 49—October, 1887, $18\frac{1}{8}$ in.

February, 1889, $18\frac{3}{8}$ growth $\frac{1}{2}$ in. in 16 months.

Mean yearly increase in girth, 0·38in.

MAIN FOREST.

Since writing the above, Mr. J. Cooper, Acting Conservator of Forests, Knysna, has kindly procured at my request the following measurement of trees in the Main Forest at Knysna, and I take the opportunity to add these to the foregoing. The Stinkwood trees measured, and some of the others, were left standing in a clearing made along the Main Forest road, and received thus more sunlight than those situated in the adjoining forest ; hence the rates of growth are in general greater than those for the Gouna forest, and approximate more closely to those that would be obtained in plantations :—

OCOTEA BULLATA. Stinkwood.

No 1—March, 1882 ; girth 25 in.
January, 1890 ; „ $34\frac{1}{2}$; growth $9\frac{1}{2}$ in. in 94 months.

6—October, 1885 ; „ $37\frac{1}{2}$ „
January, 1890 ; „ $40\frac{1}{4}$ „ $2\frac{3}{4}$ in. in 51 „

7—December, 1886 ; „ 30.
January, 1890 ; „ 33 „ 3in. in 37 „

8—December, 1886 ; girth $32\frac{1}{2}$.			
Janaary, 1890 ;	36 ;	growth $3\frac{1}{2}$ in. in 37 months.	
9—December, 1886 ;	20 $\frac{1}{2}$.		
January, 1890 ;	23 $\frac{3}{4}$	3 $\frac{1}{4}$ in. in 37	„
10—December, 1886 ;	23.		
January, 1890 ;	25	2in. in 37	„
11—December, 1886 ;	27 $\frac{1}{2}$.		
January, 1890 ;	30 $\frac{1}{4}$	2 $\frac{3}{4}$ in. in 37	„
12—December, 1886 ;	33.		
January, 1890 ;	36 $\frac{3}{4}$	3 $\frac{3}{4}$ in. in 37	„
13—December, 1886 ;	16 $\frac{1}{2}$.		
January, 1890 ;	19 $\frac{1}{4}$	2 $\frac{3}{4}$ in. in 37	„
15—December, 1887 ;	34.		
January, 1890 ;	34 $\frac{1}{2}$	$\frac{1}{2}$ in. in 25	„
21—December, 1887 ;	27 $\frac{3}{4}$.		
January, 1890 ;	29 $\frac{1}{4}$	1 $\frac{1}{2}$ in. in 25	„
23—December, 1887 ;	30 $\frac{3}{2}$.		
January, 1890 ;	31 $\frac{3}{4}$	1 $\frac{1}{4}$ in. in 25	„
24—December, 1887 ;	32.		
January, 1890 ;	33 $\frac{3}{4}$	1 $\frac{3}{4}$ in. in 25	„
25—December, 1887 ;	34 $\frac{1}{2}$.		
January, 1890 ;	38	3 $\frac{1}{2}$ in. in 25	„
Aggregate growth, $41\frac{1}{4}$ in. in 529 months.			
Mean yearly increase in girth, 0.95in.			

PODOCARPUS THUNBERGII, var. LATIFOLIA. *Upright Yellowwood.*

No. 3—December, 1882 ; girth 29 in.			
February, 1888 ;	32 $\frac{1}{4}$	growth $3\frac{1}{4}$ in. in 62 months.	
14—December, 1887 ;	23.		
January, 1890 ;	24 $\frac{1}{2}$	1 $\frac{1}{2}$ in. in 25	„
19—December, 1887 ;	10.		
January, 1890 ;	10 $\frac{3}{4}$	$\frac{3}{4}$ in. in 25	„
29—December, 1887 ;	24.		
January, 1890 ;	24 $\frac{3}{4}$	$\frac{3}{4}$ in. in 25	„
30—December, 1887 ;	29.		
January, 1890 ;	29 $\frac{3}{4}$	$\frac{3}{4}$ in. in 25	„
31—December, 1887 ;	14.		
January, 1890 ;	14 $\frac{1}{2}$	$\frac{1}{2}$ in. in 25	„
Aggregate growth, $7\frac{1}{2}$ in. in 187 months.			
Mean yearly increase in girth, 0.48in.			

PODOCARPUS ELONGATA. *Outeniqua Yellowwood.*

No. 33—December, 1887 ; girth 40 in.			
January, 1890 ;	42 ;	growth 2in. in 25 months.	
35—December, 1887 ;	42 $\frac{3}{4}$.		
January, 1890 ;	44 $\frac{1}{4}$	1 $\frac{1}{2}$ in 25	„
Aggregate growth, $3\frac{1}{2}$ in. in 50 months.			
Mean yearly increase in girth, 0.84in.			

CURTISIA FAGINEA. *Assagai.*

No. 20—December, 1887 ; girth $15\frac{1}{2}$ in.			
January, 1890 ;	17	growth $1\frac{1}{2}$ in. in 25 months.	
27—December, 1887 ;	17 $\frac{1}{2}$.		
January, 1890 ;	18	$\frac{1}{2}$ in. in 25	„
Aggregate growth, 2in. in 50 months.			
Mean yearly increase in girth 0.48in.			

OLEA LAURIFOLIA. Ironwood.

No. 16—December, 1887 ; girth	31½ in.		
January, 1890 ;	32	; growth ½ in. in 25 months.	
26—December, 1887 ;	17.		
January, 1890 ;	18½	„ 1½ in. in 25	„
32—December, 1887 ;	36½.		
January, 1890 ;	38½	; „ 2 in. in 25	„
34—December, 1887 ;	23.		
January, 1890 ;	24⅞	; „ 1⅞ in. in 25	„
Aggregate growth, 3·05 in. in 100 months.			
Mean yearly increase in girth, 0·37 in.			

APODYTES DIMIDIATA. White Pear.

No. 5—March, 1883 ; girth	29 in.		
January, 1890 ;	31½	; growth 2½ in. in 82 months.	
Mean yearly increase in girth, 0·37 in.			

ILEX CAPENSIS. Wittehout.

No. 17—December, 1887 ; girth	29 in.		
January, 1890 ;	31¾	; growth 2¾ in. in 25 months.	
Mean yearly increase in girth, 1·32 in.			

MEASUREMENTS TAKEN IN NATAL PLANTATIONS.

By the courtesy of Mr. Dering Stainbank, I was enabled to take the following measurements of the average growth of some thousands of indigenous trees that have been planted on his estate at Bellair. The soil is sandy, not rich.

PODOCARPUS THUNBERGII. Upright Yellowwood.

Sample Plot No. 1.—Planted in 1876 with seedlings raised from seed sown in 1875.

No. 1—girth	10½ in. ;	height	12 feet.
2	11¼ "	"	13 "
3	11½ "	"	13 "
4	13¼ "	"	14 "
5	10½ "	"	12 "
6	12 "	"	16 "
7	11¾ "	"	14 "
8	13 "	"	16 "
9	7 "	"	13 "
10	10 "	"	15 "
11	14 "	"	15 "
Average	11·34 "	"	13·9 "
Mean yearly increase in girth, 0·87 "			

Sample Plot No. 2.—Planted in December, 1875.

No. 1—girth	15½ in. ;	height	15 feet.
2	10½ "	"	10 "
3	8½ "	"	11 "
4	9 "	"	12 "
5	11¼ "	"	14 "
6	12¾ "	"	15 "
Average	11·25 "	"	12·7 "
Mean yearly increase in girth, 0·80 "			

Sample Plot No. 3.—Containing about 150 trees. Planted in December, 1875.

Average girth, 10 in. ; height, 15 feet.

Mean yearly increase in girth, 0·71 in.

Sample Plot No. 4.—In plantation containing about 2,000 trees of the species.
Planted in October, 1885.

Average girth, 7in. ; height, 11 feet.

Mean yearly increase in girth, 2·33in.

Ditto for the four plots, 1·18in.

PODOCARPUS ELONGATA. Outeniqua Yellowwood.

Sample Plot No. 1.—Planted in March, 1885.

No. 1—girth 9 in. ; height 10 feet.

2 " 8 " " 10 "

3 " $8\frac{1}{2}$ " " 10 "

4 " $10\frac{1}{2}$ " " 12 "

5 " $7\frac{1}{2}$ " " 10 "

Average " 9·10 " " 10·4 "

Mean yearly increase in girth, 2·02in.

Sample Plot No. 2.—Planted in 1878.

No. 1—girth $14\frac{1}{2}$ in ; height 20 feet.

2 " 17 " " 19 "

3 " 12 " " 18 "

4 " $15\frac{1}{2}$ " " 22 "

5 " $16\frac{3}{4}$ " " 20 "

6 " $8\frac{1}{4}$ " " 10 "

7 " $10\frac{1}{2}$ " " 16 "

Average " 13·5 " " 17·9 "

Mean yearly increase in girth, 1·23in.

Sample Plot No. 3.—Containing about 125 trees. Planted February, 1886.

Average girth 5in. ; height 12 feet.

Mean yearly increase in girth 1·36in.

Ditto for the three plots, 1·54in.

Maximum Individual increments.—1 tree planted October, 1886, girth, 12 inches ; height, 18 feet. Mean yearly increase in girth, 4·0 inches.

TODDALIA LANCEOLATA. White Ironwood.

Sample Plot No. 1. Planted March, 1885. Average girth, 6 inches ; height, 10 feet. Mean yearly increase in girth, 1·31 inches.

Sample Plot No. 2. Planted in 1878. Average girth, $11\frac{1}{2}$ inches ; height, 13 feet. Mean yearly increase in girth, 1·04 inches.

Sample Plot No. 3. Planted October, 1886. Average girth, $4\frac{3}{4}$ inches ; height, 10 feet. Mean yearly increase in girth, 1·58 inches ; ditto for the three plots, 1·31 inches.

CALODENDRON CAPENSE. Wild Chesnut.

Sample Plot No. 1. In plantation containing about 100. Planted February, 1886. Average girth, $1\frac{3}{4}$ inches ; height, 8 feet. Mean yearly increase in girth, 0·48 inches.

Sample Plot No. 2. In plantation containing about 200. Planted February, 1886. Average girth, 2 inches ; height, 8 feet. Mean yearly increase in girth, 0·55 inches ; ditto for the two plots, 0·51 inches.

APODYTES DIMIDIATA. White Pear.

Sample Plot No. 1. Planted October, 1885. Average girth, 4 inches ; height, 9 feet. Mean yearly increase in girth, 1·00 inches.

Sample Plot No. 2. Planted October, 1885. Average girth, $8\frac{1}{4}$ inches ; height, 16 feet. Mean yearly increase in girth, 2·06 inches ; ditto for the two plots, 1·53 inches.

ODINA CAFFRA. Kafir Plum.

Sample Plot No. 1. Planted October, 1885. Average girth, $8\frac{3}{4}$ inches ; height, 12 feet. Mean yearly increase in girth, 2·19 inches.

Sample Plot No. 2. Planted October, 1886. Average girth, $9\frac{1}{4}$ inches ; height, 12 feet. Mean yearly increase in girth, 3·08 inches ; ditto for the two plots, 2·63 inches.

MILLETIA CAFFRA. *Umsimbiti.*

Growth rapid, but branches almost from the ground when isolated, and measurements are misleading. Exceptionally: No. 1. Planted October, 1886. Girth, 18 inches; height, 12 feet. Mean yearly increase in girth, 6.00 inches.

ALBIZZIA FASTIGIATA. *Flat crown.*

No. 1. Planted 1879. Girth, $36\frac{1}{2}$ inches. Mean yearly increase in girth, 3.65 inches.

MIMUSOPS OBOVATA. *Bush Milkwood.*

Sample Plot No. 1. Planted October, 1885. Average girth, $3\frac{1}{2}$ inches; height, 10 feet. Mean yearly increase in girth, 0.87 inches.

The trees in the plantations were raised from seed and planted the following season, except with *Podocarpus elongata*, the seed of which takes two years to germinate.

ABSTRACT.

Number of Trees.	Species.				Locality.	Aggregate number of months.	Mean Yearly increment in girth.
IN NATURAL FOREST :							
1	Ilex Capensis	...	...	...	Main Forest	25	1.32
1	Olinia cymosa, var. intermedia	...	...	...	Gouna	26	1.17
1	Nuxia floribunda	...	...	...	Ditto	26	0.92
14	Ocotea bullata	...	...	...	Main Forest	529	0.95
6	Ditto	...	...	...	Gouna	250	0.60
1	Myzoina melanophlebos	...	...	...	Ditto	26	0.80
1	Ekebergia Capensis	...	...	...	Ditto	26	0.75
2	Podocarpus elongata	...	...	...	Main Forest	50	0.84
5	Ditto	...	...	...	Gouna	162	0.60
10	Podocarpus Thunbergii, var. latifolia	...	...	...	Ditto	285	0.72
6	Ditto	...	...	...	Main Forest	187	0.48
2	Celastrus peduncularis	...	...	...	Gouna	62	0.68
2	Plectronia obovata	...	...	...	Ditto	68	0.60
5	Apodytes dimidiata	...	...	...	Ditto	248	0.62
1	Ditto	...	...	...	Main Forest	82	0.37
4	Olea laurifolia	...	...	...	Gouna	117	0.59
4	Ditto	...	...	...	Main Forest	100	0.37
2	Curtisia faginea	...	...	...	Ditto	50	0.48
3	Ditto	...	...	...	Gouna	134	0.36
1	Cunonia Capensis	...	...	...	Ditto	26	0.46
1	Elæodendron Croceum	...	...	...	Ditto	16	0.38
IN PLANTATIONS :							
1	Albizzia fastigiata	...	...	...	Bellair	120	3.65
	Odina Caffra	...	...	...	Ditto	...	2.63
	Podocarpus elongata	...	...	...	Ditto	...	2.02
	Apodytes dimidiata	...	...	...	Ditto	...	1.53
	Toddalia lanceolata	...	...	...	Bellair	...	1.31
1	Ditto	...	...	...	Howick	264	2.00
	Podocarpus Thunbergii	...	...	...	Bellair	...	1.18
3	Ditto	...	...	...	Howick	396	0.73
	Calodendron Capense	...	...	...	Bellair	...	0.51

APPENDIX VI.

MEASUREMENT OF TIMBER.

The contents of a round log may be obtained by measuring the diameter in the middle, and calculating the volume of a cylinder of the same diameter and height. But tables are oftener used for the same purpose. For standing trees, the height of which can only be estimated accurately to the nearest 5 feet, a small table such as the one given below, is quite sufficient. It is usual to allow 40 per cent. on logs measured in the middle, for bark and waste in squaring; and 50 per cent. on trees measured at the butt-end, in order to deduct an additional 10 per cent. for taper.

Table II. gives readily the contents of a number of pieces of wagonwood and other timber of ordinary sizes. For pieces of unusual dimensions, "Hoppus' measurer" may be used.

I.—TABLE SHEWING THE CONTENTS IN CUB. FT. OF ROUND LOGS.

Diameter in inches.	LENGTH IN FEET.									
	5	10	15	20	25	30	35	40	45	50
12	4	8	12	16	20	24	27	31	35	39
14	5	11	16	21	27	32	37	43	48	53
16	7	14	21	28	35	42	49	56	63	70
18	9	18	27	35	44	53	62	71	80	88
20	11	22	33	44	55	65	76	87	98	109
22	13	26	40	53	66	79	92	106	119	132
24	16	31	47	63	79	94	110	126	141	157
26	18	37	55	74	92	111	129	147	166	184
28	21	43	64	86	107	128	150	171	192	214
30	25	49	74	98	123	147	172	196	221	245
32	28	56	88	112	140	168	195	223	251	279
34	32	63	95	126	158	189	221	252	284	315
36	35	71	106	141	177	212	247	283	318	353
38	39	79	118	158	197	236	276	315	354	394
40	44	87	131	175	218	262	305	349	393	436
42	48	96	144	192	241	289	337	385	433	481
44	53	106	158	211	264	317	370	422	475	528
46	58	115	173	231	289	346	404	462	519	577
48	63	126	188	251	314	377	440	503	565	628
50	68	136	205	273	341	409	477	545	614	682
52	74	147	221	295	369	442	516	590	664	737
54	80	159	239	318	398	477	557	636	716	795
56	86	171	257	342	428	513	599	684	770	855
58	92	183	275	367	459	550	642	734	826	917
60	98	196	295	393	491	589	687	785	884	982

To get the squared contents of round logs measured in the middle take 60 per cent. of result from table.

To get squared contents of standing trees measured at 6ft. from the ground, take half of result from table.

For trees above 60 inches in diameter, take four times the contents of a tree of same length and half the diameter.

II.—TABLE SHEWING CONTENTS IN CUB. FT. OF MANUFACTURED WOOD.

DESCRIPTION.	SIZES.			NUMBER OF PIECES.								
				100	200	300	400	500	600	700	800	900
Sleepers ...	10"	5"	7'	243	486	729	972	1215	1458	1701	1944	2187
Planks ...	12"	1"	20'	167	333	500	667	833	1000	1167	1333	1500
Ditto ...	12"	3"	20'	500	1000	1500	2000	2500	3000	3500	4000	4500
Long spokes	3"	2½"	30"	13	26	39	52	65	78	91	104	117
Short spokes	3"	2¼"	22"	10	19	29	38	48	57	67	76	86
Naves ...	12"	12"	16"	112	223	335	447	559	670	782	894	1005
Ditto ...	14"	14"	16"	152	304	456	608	760	913	1065	1217	1369
Felloes ...	5"	3½"	27"	27	55	82	109	137	164	191	219	246
Axles ...	8"	5"	6'	167	333	500	667	833	1000	1167	1333	1500
Draai boards	5"	5"	4½'	79	156	234	312	391	469	547	625	703
Yokes ...	3½"	3½"	6'	51	102	153	204	255	306	357	408	459
Schamels ...	8"	5"	4½'	125	250	375	500	625	750	875	1000	1125
Fore tongues	10"	5"	4½"	156	313	469	625	781	938	1094	1250	1406
After tongues	5"	3½"	4½"	55	109	164	219	273	328	383	437	492
Long wagons	5"	3½"	14'	170	340	510	680	851	1021	1191	1361	1531
Disselbooms	5"	3"	11'	115	229	344	458	573	687	802	917	1031
Cart naves ...	10"	10"	12"	58	115	173	230	288	345	403	460	518
Cart spokes...	2½"	2"	26"	8	15	23	30	38	45	53	60	68
Cart felloes...	3"	3"	24"	15	30	45	60	75	90	105	120	135
Cart axles ...	6"	3½"	6'	88	175	263	350	438	525	613	700	788
Cart dissel-booms	3½"	3½"	15'	11	21	32	43	53	64	74	85	96

To get the contents of a number of pieces, add together the contents corresponding to each figure of the number.

EXAMPLE : Wanted the contents of 241 Sleepers.

For 200 486 c. ft.

„ 40 97 „

„ 1 2 „

0 0 4 2 3 2 0 3

Total for 241	585 c.ft.
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585 c.ft.

APPENDIX VII.

NOTE ON THE FOREST VEGETATION OF COUNTRIES CONTAINING TREES ELIGIBLE FOR ACCLIMATIZATION IN NATAL, WITH SHORT NOTICES OF THE PRINCIPAL SPECIES RECOMMENDED FOR PLANTING.

Following the isotherm of 70°, first in the northern, then in the southern hemisphere, the forest vegetation of the countries in a zone of which it forms the centre, with a climate corresponding in some parts to that of Natal, will be successively examined.

United States. The United States may be divided into an Atlantic and a Pacific region by a line drawn along the Eastern base of the Rocky Mountains. In the Atlantic region, vast forests are found between the Appalachian ranges and the sea, where the rainfall averages from 40 to 50 inches. Pines generally predominate along the coast, and deciduous trees in the Mississippi basin and over the Western Atlantic plains. Among the hardwood trees, the most important are, *Quercus alba* (white oak), which often forms half of the forest growth; *Q. macrocarpa* (burr oak), *Q. coccinea* (scarlet oak); *Q. rubra* (red oak); *Q. virens* (live oak), an evergreen chiefly developed along the Gulf coast, and in North Mexico at an altitude of 6—8,000 feet; *Q. prinoides* (chestnut oak); *Acer saccharinum* (sugar maple), predominating to the north; *A. dasycarpum* (soft maple); *A. rubrum* (red maple); *Fraxinus americana* (white ash), ranging over nearly the whole of the region; *F. viridis* (green ash); *F. pubescens* (red ash); *Castanea vesca* var. *americana* (chestnut); *Betula papyrifera* (white birch), and *B. lutea* (yellow or gray birch), both common trees of the northern forests; *Carya alba* (hickory), an important tree with a wide range; *Juglans cinerea* (butternut); *J. nigra* (black walnut); *Ulmus Americana* (American elm); *U. racemosa* (rock elm); *Fagus ferruginea* (beech); *Tilia Americana* (basswood); *Liriodendron tulipifera* (tulip); *Magnolia grandiflora* (big laurel), and *Nyssa sylvatica* (black gum), both Southern trees; *Machura aurantiaca* (Osage orange); *Robinia Pseudacacia* (locust); and *Gleditschia triacanthos* (honey locust).

Of the coniferous trees in the same region, *Pinus Strobus* (white pine), is the most important, if not the most widely distributed, species. In the Southern States, *P. palustris* (long leaved pine), *P. mitis* (yellow pine), *Taxodium distichum* (cypress), and *Chamæcyparis sphaeroidea* (white cedar), rank next in importance, while in the colder Northern States, they are replaced by *Abies balsamea* (balsam fir), *Picea nigra* (black spruce), *Picea alba* (white spruce), *Abies canadensis* (hemlock), *Larix Americana* (tamarack), and *Thuja occidentalis* (arbor-vitæ). *Juniperus Virginiana* (red cedar) is widely distributed in both northern and southern States.

The forests in the Pacific region are separated from those of the Atlantic region by the intervening country of the Great Basin, where trees are very scantily distributed. The most important and widely spread species is the red fir (*Pseudotsuga Douglasii*), found from sea-level to 10,000 feet, often in almost pure forests. Other conifers of the coast region are *Sequoia sempervirens* (redwood)—a very large tree forming dense forests, *Picea Sitchensis* (tideland spruce), and *Abies grandis*. Found more to the south are: *Pinus Sabiniana*, the digger pine of the foothills, *P. insignis* (Monterey pine) *P. muricata* (Obispo pine), *Cupressus macrocarpa* (Monterey cypress) *Chamæcyparis Lawsoniana* (Port Orford Cedar), and *Cupressus Goveniana*.

In the mountain zone, *Sequoia gigantea* (Big tree), found at 4-8,000 feet, attain a colossal size. The other conifers are *Picea Engelmanni* (white spruce), the principal tree of the central Rocky Mountains, found at 5-11,500 feet, *Libocedrus decurrens* (white cedar), occurring at 3-8,500 feet, *Thuja gigantea* (red cedar), below 5,200 feet. *Pinus monticola*, at 7-10,000 feet, *P. flexilis*, at 4-10,000 feet, *P. Jeffreyi*, at 6-8,000 feet, *P. Murrayana*, at 6-9,000 feet, *Abies magnifica*, at 4,900-8,000 feet, *A. bracteata*, at 3-6,000 feet, and *A. concolor*, at 3-9,000 feet. The deciduous trees of the region are *Quercus*

agrifolia (Coast live oak), *Q. Kelloggii* (black oak) and *Q. densiflora* (chestnut oak); on the Rocky Mountains they are represented by the cottonwood (*Populus tremuloides*) and some small oaks (*Quercus undulata*, var. *Gambelii*, *Q. Emoryi*, and *Q. grisea*).

In the Great Basin, a stunted juniper and a small pine (*Pinus monophylla*) are the only characteristic trees.

Detailed information about the trees of the United States may be found in the *Report on the Forests of North America* by Prof. C. S. Sargent, Washington, 1884. (Vol. IX: Tenth Census, 1880.)

Mexico. The climate is similar to that of Natal, the mean temperature ranging from 70° to 50° according to elevation. A number of the species found in Texas and California extend to the northern plateau. Among the hardwoods, *Swietenia Mohagoni* (Mahogany) deserves special notice, and *Hymenaea Courbaril* yields very strong and elastic timber. The oaks are represented chiefly by *Quercus Castanea* (chestnut oak), *Q. agrifolia*, *Q. Skinneri*, and *Q. Sideroxylon*. Other noticeable trees are *Morus celtidifolia* and the evergreen *Ulmus crassifolia*. Conifers predominate between 5,000 and 13,000 feet; the principal species are *Pinus tenuifolia*, forming dense forests at 5,000 feet, *P. Teocote*, *P. religiosa* (Organel Fir), *P. Pseudo-Shobus*, *P. Pinceana*, *P. leiophylla*, *P. patula*, *P. Ayacahuite*, *P. Hartwegii*, *P. cembroides* (swamp pine), *Cupressus Lindleyi*, *C. Benthami*, and *Taxodium mucronatum*, the Montezuma cypress, forming extensive forests.

Atlantic Islands. In Bermuda, the pencil cedar (*Juniperus Bermudiana*) is a noticeable tree. In the Canary Islands, conifers are represented by *Pinus Pinea*, *P. Canariensis*, and *Juniperus Cedrus*; in the Azores, by *Pinus Pinea* and *Juniperus brevifolia*. *Persea Teneriffæ* is a large tree found in both groups and in Madeira.

Mediterranean Region. In northern Africa, some fine forests are found on the Atlas mountains of Morocco and Algeria; they consist principally of *Pinus Halepensis* (Aleppo pine), *Quercus Suber* (cork oak), *Pinus Cedrus* (Atlas cedar), and *Callitris quadrivalvis* (Atlas cypress). Associated with these species are: *Quercus castaneifolia*, *Q. ilex* var. *Ballota*, *Pinus Pinaster* (Cluster pine) and *P. Pinsapo*. Other Algerian trees are: *Quercus Mirbeckii* (zeen), *Q. coccifera* (kermes oak), *Pistacia Lentiscus* (mastic tree), *P. Terebinthus*, *P. Atlantica*, *Ceratonia siliqua* (carob), *Olea Europæa* (olive), *Laurus nobilis* (laurel), *Castanea sativa* (chestnut), *Salix alba* (silky willow) *S. Babylonica* (weeping willow) and *Buxus sempervirens* (Box).

Oaks and pines are the most important forest trees of Southern Europe. In the cooler zone, *Quercus robur*, the British Oak, forming the two varieties *pedunculata* and *sessiliflora*, extends from Spain and the south of France to Greece and Turkey, and supplies most of the oak timber used for construction. *Fagus sylvatica*, the beech, *Fraxinus excelsior*, the ash, *Castanea sativa*, the chestnut, *Acer platanoides*, the Norway maple, and *Ulmus campestris*, the elm, are the most important associated trees.

The warmer zone is characterized by *Olea Europæa*, the olive. The principal conifers are *Pinus Halepensis* (Aleppo pine), found from Portugal to the Taurus, *P. Pinaster* (cluster pine) extending to Greece, *P. Finea* (stone pine), reaching Asia Minor, and *P. Laricio*, the Corsican pine, found, in some of its numerous varieties, from Spain to the Taurus, and as far north as the Danube, and *P. Pinsapo* limited to Spain and North Africa. The oaks are mostly of evergreen species: *Quercus Suber*, the cork oak, forms very valuable forests in southern provinces of Catalonia, and *Q. occidentalis*, an allied species, replaces it in the littoral zone. In Spain, *Quercus Ilex* (Holly oak) and *Q. Tozza* are associated with the cork oak and *Pinus Pinaster*. *Quercus Cerris* (Turkey oak) is a valuable species found from France to South Western Asia, reaching its greatest development in Turkey. Other Eastern oaks are *Q. Ægilops*, the Valonia oak of Turkey and *Q. macrolepis*, one of the Valonia oaks of Greece. Other trees are *Castanea sativa*, the chestnut, found all over south-eastern Europe, *Celtis Australis* (lotus-tree), with the same range, *Fagus sylvatica* (beech), extending to the south of Corsica, where it is associated with the Corsican pine, *Buxus sempervirens* (Box), attaining its largest size in Turkey, but widely distributed, and *Ceratonia siliqua*, the carob-tree, found but sparingly.

Descriptions and particulars of the trees of the Mediterranean region may be found in Mathieu's *Flore Forestière*.

South Western Asia. In Asia Minor, the principal forests are found on the Taurus. The wild olive (*Olea Europæa*), covers the hills, between forests of pines (*Pinus Halepensis*, *P. Pinaster*, *P. Pinea*, *P. Cilicica*, the Cilician silver fir, *P. Orientalis*, the Sapindus fir) and oaks (*Quercus Ilex*, var. *Ballota*, *Q. Ægilops*, and *Q. infectoria*). Other

trees are *Liquidambar orientalis*, the Box (*Buxus sempervirens*), the Chesnut (*Castanea sativa*) the Elm (*Ulmus campestris*), Junipers (*Juniperus communis*, *J. excelsa*, and *J. foetidissima* which extends to Armenia) the Poplar (*Populus alba*) and the Yew (*Taxus baccata*).

In Syria, the central mountains of the Lebanon are wooded. Up to a height of 1,600 feet, characteristic trees are *Ceratonia siliqua* (carob) and *Pinus Pinea*; *Melia Azedarach* (Syringa) and *Ficus Sycamorus* are also found, but the great mass of vegetation is scrubby. Between 1,600 and 3,200 feet, there are *Fontanesia phyllioides*, *Acer Syriacum*, and dwarf hard leaved oaks. Between 3,700 and 4,200 feet *Pinus Brutia* is common. The zone between 4,200 and 6,200 feet is characterised by *Cupressus sempervirens*, the Cypress, and *Pinus Cedrus*, the cedar of Lebanon; with which are associated *Ostrya carpinifolia* (Hop Hornbeam), *Quercus Mellul*, *Q. cerris* (Turkey Oak), *Q. subalpina*. *Pinus Cilicia* the Cilician silver fir, occurs sparingly. Next come Junipers: *Juniperus excelsa*, *J. drupacea* and *J. rufescens*. Above this zone there are only a few stunted oaks and junipers. The mean temperature at Beyrouth, at sea level, is 68° F., so that the climate is similar to that of Natal.

Persia, which comes next within the belt examined is said to be poorly wooded, but there are some oaks, the beech (*Fagus sylvatica*), the elm (*Ulmus campestris*), the walnut (*Juglans regia*), the plane (*Platanus orientalis*), the sycamore (*Acer pseudo-platanus*), the ash (*Fraxinus excelsior*), the yew (*Taxus baccata*), the Box (*Buxus sempervirens*), Junipers (*Juniperus communis*, *J. excelsa* and *J. Phœnicia*), the chesnut (*Castanea sativa*), the Black Mulberry (*Morus nigra*), poplars (*Populus alba*, and *P. tremula*), willows (*Salix Babylonica*, *S. fragilis*, *S. alba* and *S. triandra*). Few trees peculiar to the country have been described.

Himalayan Region. This extends from the Hindu-Kush in Afghanistan to Assam, along the Himalayan range. A great belt of forest country called the *Teria* stretches along the southern spurs of the Himalayas. In the Himalayan region, the Deodar (*Pinus Cedrus*, var. *Deodara*), a variety of the cedar of Lebanon, is the most valuable tree; it forms forests, sometimes pure, at 3-12,000 feet, in the mountains of Afghanistan, Kashmir, the North West Himalaya and Western Tibet. Ranking next are *Pinus excelsa* ("Kail" or Bootan pine), often associated with the deodar at 5-12,000 feet, and *Pinus longifolia*, the "chir," which forms gregarious forests at 2,000-9,000 feet. Other Himalayan conifers are *Pinus Webbiana* (King pine) found at 7-13,000 feet, *P. Pindrow*, at 8-12,000, *P. Smithiana*, at 6-11,000, *P. Brunoniana*, at 8-10,500, *P. Gerrardiana*, the Nepal nut-pine, at 10-12,000, *P. Griffithii*, the Himalayan Larch, at 8-12,000, *Cupressus torulosa*, the Nepal cypress, at 4,500-8,000, *Juniperus communis*, found up to 14,000 feet, *J. recurva*, at 7,500-15,000, *J. Wallichiana* and *Taxus baccata*, the common yew.

Non-coniferous trees are *Cœrela Taona*, the Toon, found up to 8,000 feet, *Dalbergia Sissoo* (Sissoo) extending to Afghanistan, found up to 5,000 feet, *D. latifolia* (Blackwood) *Quercus dilatata*, found from the Himalayas to Afghanistan, at 4,500-10,000 feet, *Q. incana*, found at 3-8,000 feet, *Q. lancifolia*, *Q. semecarpifolia*, the largest oak of India, found up to 10,000 feet, *Q. Ilex* (Holly oak), also up to 10,000 feet, *Q. squamata*, *Q. annulata*, a large Nepal evergreen, *Fraxinus floribunda*, the Nepal ash, found at 5-11,000 feet, *Ulmus Wallichiana*, an elm at 3,500-10,000 feet, *Michelia excelsa*, up to 7,000 feet, associated with several other species of the genus, *Hloptelea integrifolia*, the elm of India, *Populus alba*, found at 4-10,000 feet, *P. ciliata*, with the same range, *P. nigra*, found up to 12,500 feet, *Juglans regia* (walnut), and *Pyrularia edulis*, a large tree found in Nepal Khasia and Sikkim.

At the base of the Himalayan forests, and up to 3,000 feet, there are, from Assam to the Sutlej, principally in the great Ganges Valley, forests of *Sál* (*Shorea robusta*), the chief gregarious tree of India. *Ficus elastica*, the Assam Rubber-tree, grows in rocky valleys of the Himalayas, with a moist tropical atmosphere.

Some of the most valuable trees of India are found in a tropical zone where the mean temperature exceeds 80°; particularly the teak (*Tectona grandis*), satinwood (*Chloroxylon Swietenia*), Sandalwood (*Santalum album*), red sandalwood (*Pterocarpus Santalinum*), and the various kinds of ebony (*Pterocarpus*). Other noticeable trees are *Cupressus lusitanica*, the cedar of Goa, planted largely in Portugal, *Melaleuca leucadendron*, the Cajaput tree, *Melia Azedarach*, the Syringa, and *Terminalia Catappa*.

The best sources of information about Indian trees are Sir D. Brandis' *Forest Flora of North-West and Central India*, and Mr. J. S. Gamble's *Manual of Indian Timbers*.

China. The forests of China are very imperfectly known. Those on the mountains

of Tibet are composed mainly of Himalayan species. In China Proper, *Pinus Kämpferi* (Chinese larch), *P. Massoniana*, *P. Fortunei*, *Ginkgo biloba*, *Juniperus Chinensis*, and *J. sphaerica*, are among the principal conifers; and among the principal non-coniferous trees are: *Quercus serrata*, which extends to Nepal and Japan, *Q. cornea*, *Fraxinus Chinensis* (Chinese ash), *Ulmus parvifolia* (an evergreen elm), *Morus alba*, (white mulberry), *Populus nigra* (black poplar), *P. tremula* (aspen), *Castanea sativa* (chestnut), *Cedrela Chinensis*, *Cinnamomum Camphora* (camphor tree), *C. Cassia*, *Liquidambar Formosana*, *Sophora Japonica*, *Sterculia monosperma*, *Diospyros Kiki* (date plum), and *Buxus sempervirens* (Box).

Japan is well wooded, and the forests contain a great variety of valuable trees. Foremost among these is the magnificent Japanese cedar (*Cryptomeria Japonica*). Other conifers are: *Pinus Massoniana*, the most common tree of the country; *P. polita*, forming large forests in the mountain ranges; *P. densiflora* (Amakutsu), *P. stenolopsis*, found up to 7,000 feet; *P. parviflora*; *P. Aleutica*, found with *P. tonga* and *P. polita* at 6-7,000 feet, *P. Jeroensis*; *P. leptolepis*, the "Karamatsu" or Japanese Larch, found up to 9,000 feet; *P. firma* and *P. Tsuga*, both found in North Japan, the latter at 6-9,000 feet; *Cupressus obtusa*, the "Hinoki," found at 1,200—4,200 feet; *Ginkgo biloba*; *Juniperus Chinensis*; *Podocarpus macrophylla*, the "Inumaki;" *Cephalotaxus drupacea*, a kind of Yew; and *Sciadopitys verticillata*, the curious umbrella fir. Among the non-coniferous trees are: *Zelkova acuminata*, the "Keaki" which yields perhaps the best timber in Japan, and is found at 3,500—10,000 feet; *Quercus cuspidata*, a fine oak; *Q. glauca*, the "Kashi"; *Q. glabra*; *Q. dentata*; *Q. serrata*, which extends to Nepal; *Castanea sativa* (chestnut); *Juglans cordiformis*; *J. Sieboldiana*; *Prunus Pseudo Cerasus*; *Populus Sieboldii*; *P. tremula* (aspen); *Ulmus campestris* (elm); *Fagus Sieboldii*, the Japan beech; *Acer palmatum*, one of the many species of maple indigenous to Japan; *Morus alba*, var. *Japonica* (mulberry); *Salix Babylonica*, extending to West Asia; *Buxus sempervirens*, still more more widely distributed; *Cinnamomum Camphora* (camphor tree), found in Southern Japan; *Sophora Japonica*; *Ailanthus glandulosa*; *Thuyopsis dolabrata*; *Diospyros Kaki*, the date plum; *Pawlonia imperialis*; and *Catalpa Kämpferi*.

Australia. Eucalypti and Acaciæ compose four-fifths of the forests of Australia and Tasmania. In Australia we may distinguish between an eastern and a western forest region, separated by the vast central desert tracts.

The eastern region will include Tasmania, the south-western corner of South Australia, and the littoral zone between the coast and the great dividing range that runs at 40 to 200 miles from the coast, through Victoria, New South Wales, and Queensland. The mean temperature is, at Hobart, in Tasmania, 54°, at Melbourne 57°, at Sydney 62·7°, at Brisbane 69°, and probably reaches 80° towards Cape York. The rainfall is from 20 to 40 inches in the littoral portion of Victoria, 40 to 65 in that of New South Wales, and 30 to 130 in that of Queensland.

Eucalypts reach their greatest development in the cooler parts of this region, that is, along the coasts of Victoria and New South Wales. The more important kinds are—*Eucalyptus amygdalina* (White or Peppermint Gum), a giant tree found from South Australia to New South Wales; *E. obliqua*, the most gregarious of all Eucalypts, known as "Stringy Bark" in Tasmania, and as the "Messmate Tree" from South Australia to Queensland; *E. Globulus*, the Blue Gum of Victoria and Tasmania; *E. rostrata*, the Red Gum of Southern Australia; *E. leucoxylon*, the Iron Bark of Victoria, South Australia, and New South Wales; *E. robusta*, the Swamp Mahogany of New South Wales; *E. longifolia*, the Woolly Butt of New South Wales and Victoria; *E. Gunni*, ascending to Alpine elevations in Victoria, Tasmania, and New South Wales; *E. corynocalyx*, the Sugar-gum of South Australia and North-western Victoria; *E. melliodora*, the yellow box of Victoria; *E. polyanthema*, the red box of South-eastern Australia; *E. paniculata*, the White Ironbark of New South Wales; *E. punctata*, the Leather Jacket of New South Wales; and *E. resinifera*, the Red Mahogany of Southern Queensland and New South Wales. Less important species found over the same region are—to the south *E. macrorrhyncha*, the Stringy Bark of Victoria and New South Wales; *E. goniocalyx*, extending from Cape Otway to the southern portion of New South Wales; *E. viminalis*, *E. Siberiana*, and *E. Stuartiana*, all three indigenous to the south-eastern portion of Australia; and *E. pauciflora*, found in New South Wales, Victoria, and Tasmania. More to the north are—*E. eugenioides*, a Stringy bark of Victoria and New South Wales; *E. piperita*, another Stringy bark of New South Wales and Gippsland; *E. Saligna*, the

Blue Gum of New South Wales; *E. pilularis*, the Black Butt of Southern Queensland, New South Wales, and Gippsland; *E. siderophloia*, the White Ironbark, *E. hæmastoma*, one of the White Gums, and *E. hemiphloia*, the Box, all three found in New South Wales and South Queensland; *E. corymbosa* the Bloodwood; and *E. maculata*, the Spotted Gum of N. S. Wales and Queensland. Among the Acaciæ, *Acacia melanoxylon*, the Blackwood of South-eastern Australia, attains a large size; *A. decurrens* the black wattle of Victoria and N. S. Wales, and *A. pycnantha*, the golden wattle of Victoria and S. Australia, yield bark valuable for tanning. The Casuarineæ or She Oaks are spread from the Coast to the far interior, *Casuarina quadrivalvis*, *C. suberosa*, and *C. torulosa*, being the principal species in South-eastern Australia. Other trees are *Angophora intermedia* and *Fagus Cunninghami*, found also in Tasmania. In Tasmania, the Huon pine (*Dacrydium Franklini*), the beech (*Fagus Cunninghami*), and the celery pine (*Phyllocladus rhomboidalis*), are valuable species.

In East Queensland, which forms the northern half of the eastern region, the climate is warm and humid. A characteristic feature is the occurrence of conifers, including *Araucaria Cunninghami*, the Moreton Bay pine, found between 14° and 32° S. Lat., *Dammara robusta* (Kauri), with a smaller range, from 18° to 26°; *Araucaria Bidwilli*, *Podocarpus elata*, *Callitris verrucosa*, *C. Parlatorei*, and *C. Macleyana* towards the south; and *C. columellaris*, on bare Coast tracts towards the north. The principal Eucalypts are—*Eucalyptus tereticornis*, the Red Gum, and *E. botryoides*, the Bastard Mahogany, both found from East Queensland to Gippsland; *E. crebra*, the narrow-leaved Ironbark of N. S. Wales and Queensland; *E. microcorys*, one of the Stringy barks, with the same range; and *E. Raveretiana*, the Grey or Iron Gum. Less important species are *E. citriodora*, the Scented Gum; *E. Baileyana* and *E. Planchoniana*, both found in South Queensland; *E. triantha*, the White Mahogany of N. S. Wales and Queensland; *E. melanophloia*, the silver-leaved Ironbark, with the same range; *E. platyphylla*; *E. terminalis*, the Bloodwood of North Queensland; *E. populifolia*, one of the Box Gums; and *E. Abergiana*, both also found in North Queensland. The principal other non-coniferous trees are—*Tristania conferta* and *Cedrela Australis* (red cedar), *Casuarina torulosa*, *C. tenuissima*, *Flindersia Australis*, *F. Oxleyana* (yellowwood), *Syncarpia laurifolia* (turpentine tree), and *Angophora subvelutina*, all extending to N. S. Wales. *Grevillea robusta*, *Gmelina Leichartii*, *Ulmus parvifolia* (an evergreen elm) and *Melaleuca leucadendron*, have a more northern range, but the last species extends so far south as 34° Lat.

The western region extends from 20° to 35° S. Lat., in Western Australia. The climate is very dry except to the south-west, where the principal forests are situated, and the rainfall attains in a few places 40 inches. Perth has a mean temperature of about 70°. The great majority of the trees are Eucalypts, *Eucalyptus marginata*, the Jarrah, being the most abundant, as well as the most valuable, species. Then come *E. diversicolor* (Karri), *E. viminalis* (white gum), *E. loxophleba* (York gum), *E. calophylla* (red gum), *E. gomphocephala* (Tooart) and *E. cornuta* and *E. occidentalis*, the Yate trees. Of minor importance are *E. ficifolia*, *E. Salmonophloia*, and *E. Doratoxylon* (spear wood) found in sterile districts. Among other species may be mentioned *Acacia leiophylla*, valued for its bark, *Casuarina Fraseriana*, growing in sterile tracts, and *Callitris columellaris*, the cypress pine, abounding on sandy wastes to the north.

In Central and North Australia, the country is generally destitute of trees; there are large stretches covered with low scrub, composed of minor species of Acaciæ or Eucalypts, such as *Eucalyptus oleosa*, one of the "Mallee" trees, but very few timber forests. The climate is extremely dry and arid, except on the north coast, where the rainfall is from 50 to 70 inches. Among the larger Eucalypts are *E. microtheca*, widely dispersed over the inland regions, and *E. salubris*, the Gimlet wood of West and Central Australia. Smaller species are *E. phænicea*, found in Carpentaria and Arnhem's Land, and *E. tessellaris*, extending to Queensland. Other noticeable trees are *Melaleuca leucadendron* and *Melia Azedarach*, two Indian species found in North and East Australia; *Casuarina equisetifolia*, the Beefwood of North Australia; *C. Decaisnea*, a large species of Central Australia; and *C. glauca*, the widely distributed Desert She Oak.

Australia trees and their timbers are described in J. E. Brown's *Forest Resources of South Australia*, and in Sir F. von Mueller's *Eucalyptographia*.

New Zealand. The climate of New Zealand is generally colder than that of Australia. The mean temperature of the north island is 57°, and that of the south island 52°. At Auckland, the mean temperature is 59°, with a rainfall of 43 inches; at Wellington

55° and 52 inches, and at Dunedin, 50° and 35 inches, respectively. New Zealand trees could thus only thrive in the coldest parts of the Natal upland region. The principal species are conifers. Besides *Dammara australis*, the Kauri pine of the north island, the largest and most valuable are—*Podocarpus Totara* (Totara), *P. spicata* (Matai), *P. ferruginea* (black pine), *Podocarpus ducryoides* (white pine), *Dacrydium cupressinum* (red pine—the most common tree of the country), the Manao (*D. Kirkii* and *D. Golensoi*), *Libocedrus Doniana* (Kawka), *L. Bidwilli* (Pahautea), and *Phyllocladus trichomanoides* (Teuekaha). The more important non-coniferous trees are different kinds of Tawai, or Birch (*Fagus fusca*, *F. Menziesii*, and *F. Solandri*) the Puriri (*Vitex littoralis*), the Pohutukawa (*Metrosideros tomentosa*), the Rata (*M. robusta* and *M. lucida*), the several kinds of Maire (*Olea Cunninghami*, *O. apetalata*, and *Eugenia Maire*), the Kawhai (*Sophora tetraptera*) and the Manuka (*Leptospermum ericoides*.)

The timbers of New Zealand are described in T. Kirk's *Forest Flora of New Zealand*.

Polynesia. In New Caledonia alone, there are 183 species of trees, described by Sebert in his *Notice sur les Bois de la Nouvelle Calédonie*, the most important being: *Araucaria Cookii*, *A. Rulei*, *Dammara lanceolata*, *D. Moorei*, *D. ovata*, several small species of *Podocarpus*, the widely dispensed *Casuarina equisetifolia*, several other species of the same genus, *Chrysophyllum Wakere*, *Pancheria ternata*, *Geissos racemosa*, *Montrouzieria sphaeroflora*, *Calophyllum inophyllum*, *C. montanum* *Flindersia Fournieri*, *Euphorbia Cleopatra*, *Spermolepsis gummifera*, and *Albizia granulosa*. The forest flora, of New Caledonia presents a curious affinity to that of Natal, 44 genera out of 125 being common (1).

Other Polynesian trees of note are: *Araucaria excelsa* (Norfolk Island Pine), *Dammara macrophylla*, found in the Santa Cruz Archipelago, *D. obtusa*, in the New Hebrides, and *D. Vitiensis*, in Fiji. Several kinds of Sandalwood are very valuable: *Santalum Austro Caledonicum*, in New Caledonia, *S. Yasi*, in Fiji, and *S. Freycinetianum*, in the Sandwich Islands.

South America. Following the line indicating a mean temperature of 70° at sea-level, the countries to be examined are Peru, Bolivia, North Argentine and South Brazil. The great mountain chain of the Andes runs north and south from the Pacific coast, and an Andine region may be separated from an Atlantic region by a line drawn along the eastern base of the Andes. The first includes the greater part of Peru, Bolivia and North Chili. Important conifers are found in the Andes of Chili; the mean temperature of their habitat being probably about 50° so that they could only be introduced in the coldest parts of Natal. The principal species are: *Araucaria imbricata*, and *Fitzroya Patagonica*, both extending to Patagonia, *Podocarpus Chilina*, *P. nubigena*, *P. andina*, *Libocedrus tetragona*, and *L. Chilensis*. Non-coniferous trees are, in Chili, *Fagus Dombeyi* (an evergreen beech), *F. procera* (Reulé), and *F. obliqua* (Roble), the last two deciduous, *Laurelia aromatica*, found in South Chili, associated with *L. serrata*, *Quillaja saponaria*, *Adenostemum nitidum*, *Myrtus Lumal* and *M. Meli*, both of which are trees of South Chili, and *Salix Humboldtiana*, extending to Patagonia. The pods of *Cesalpinia brevifolia* and the bark of *Persea lingue* are much valued for tanning. In Peru, there are vast forests of which very little is known, but yielding many products of economic importance, such as Cinchona bark and Coca. The best forests of Cinchonas occur in moist warm valleys with a mean temperature of from 53° to 66°. *Cinchona officinalis*, *C. Calisaya*, and *C. succirubra* are the principal species. Coca consists of the leaves of *Erythroxylon Coca*, of which more than £600,000 in value are collected annually.

The vast forests of Brazil, which cover an area half the size of Europe, are distributed chiefly in the tropical basin of the Amazons, where the climate is considerably warmer than that of Natal. Towards the south, however, there are still some valuable species, including *Araucaria Brasiliensis*, *Cedrela Brasiliensis*, and *C. Veloziana*; and among the non-coniferous trees, *Dalbergia miscolobium* and *D. nigra*, which supply a portion of the Jacaranda or Palissandre wood, with *Jacaranda mimosifolia*, *J. Braziliensis* and *J. obtusifolia*. *Maclura Mora* and *Pircunia dioica* are also trees of the Atlantic region. Plants of special economic importance are the wax palm (*Copernicia*

(1). The genera are: *Acacia*, *Albizia*, *Avicennia*, *Blackwellia*, *Bridelia*, *Bruguiera*, *Canthium*, *Carissa*, *Catha*, *Celastrus*, *Chrysophyllum*, *Claoxylon*, *Cordia*, *Croton*, *Cunonia*, *Cussonia*, *Elæodendron*, *Eugenia*, *Euphorbia*, *Ficus*, *Garcinia*, *Gardenia*, *Guetarda*, *Hibiscus*, *Ilex*, *Maba*, *Metrosideros*, *Myrsine*, *Olea*, *Panax*, *Phyllanthus*, *Pittosporum*, *Podocarpus*, *Rhizophora*, *Rhus*, *Schmidelia*, *Sponia*, *Stereulia*, *Stillingia*, *Syzygium*, *Tabernaemontana*, *Terminalia*, *Trichilia*, *Ximenia*; they include 81 species.

cerifera), which yields wax and fibre of a value of £250,000 annually, and several tannin producing shrubs or small trees: *Acacia Cebil* and *Aspidosperma Quebracho*, found in North Argentine.

South Africa. Nearly all the more valuable species that are found in the Cape Colony are also found in Natal, and a list of the Natal trees having been given elsewhere, it is not necessary to refer to these again.

PRINCIPAL SPECIES RECOMMENDED FOR PLANTING.

Catalpa speciosa, Warder. Central Mississippi region, U.S.A.; borders of streams and swamps in rich bottom lands. A tree 3 to 6 feet in diameter, 60 to 100, or exceptionally 140, feet high. Wood light, soft, not strong, coarse-grained, compact, very durable in contact with the ground; colour brown, the sapwood lighter; density, 0.42; largely used for railway sleepers, fencing poles, &c., and for furniture and cabinet-work. (*Sargent*). Cultivated from seed, cuttings, and layers. Growth very rapid. Suitable for planting between 3,000 and 6,000 altitude. The allied *C. bignonioides*, Walter, suitable for coast planting, is a smaller tree, but its growth is equally rapid and the wood equally durable.

Chamæcyparis Lawsoniana, Parlatores. Oregon and Californian coast, U.S.A.; in low situations and rich moist soil; associated with the yellow fir and hemlock. A large tree of the first economic value, 5-13 feet in diameter, and 140-190 feet high. Wood light, hard, strong, very close-grained, compact, satiny, easily worked, very durable in contact with the ground, permeated with scented resin, and taking a beautiful polish; colour light yellow or almost white, the thin sapwood very similar; density, 0.46; largely manufactured into lumber, and used for interior finish, flooring, railway sleepers, fencing poles, matchwood, and in ship and boat-building; the resin is strongly diuretic and a powerful insecticide (*Sargent*). Suitable for planting between 4,700 and 6,000 feet altitude.

Cupressus macrocarpa, Hartweg. *Monterey Cypress*. Californian coast near Monterey; on granite rocks. A tree 4-6 feet in diameter, 50-65 feet high. Wood heavy, hard, strong, rather brittle, very close grained, compact, satiny and taking a beautiful polish, scented, easily worked, very durable in contact with the ground; colour, clear bright brown, streaked with red and yellow, the thin sapwood light yellow; density, 0.63; very beautiful and valuable as a cabinet-wood (*Sargent*). This is one of the quickest growing of all conifers, even in poor dry soil. Suitable for planting between 4,000 and 6,000 feet altitude.

Eucalyptus amygdalina, Labillardière. *Giant Gum*. Victoria, New South Wales, and Tasmania, ascending to 4,000 feet elevation. One of the largest trees of the world, attaining exceptionally 470 feet in height and 70 feet in girth. Of very rapid growth in sheltered moist soil. According to Mueller, the wood is very fissile, and well adapted for shingles, palings, rails, for house-building, hoops for wagons, for the keelson and planking of ships, and for other purposes, but it is not a strong wood, nor very lasting. Density, 0.89. The leaves contain over 3 per cent. of the volatile Eucalyptus oil, and the tree is, in consequence, of great hygienic value. In South Africa, the growth of *E. amygdalina* approaches that of the Blue Gum. Suitable for planting between 2,500 and 6,000 feet altitude.

Eucalyptus diversicolor, F. Mueller. The *Karri* of South-west Australia. A tree of extremely large size, exceptionally 400 feet in height and 20 feet in diameter, found in rich valleys not more than thirty miles inland. Wood very durable, and excellent for many purposes, now generally preferred to Jarrah for marine works on account of its greater strength and elasticity, though not so easily worked. Also used, according to Sir F. von Mueller, for ship and boat planks, masts, &c., and adapted for shafts, spokes, felloes, and fence rails. Density, 0.98 (air-dried wood). The growth though fairly rapid, is surpassed by that of some other Eucalypts. Suitable for planting between 1,000 and 4,500 feet altitude.

Eucalyptus Globulus, Libillardière. The *Blue Gum* of Victoria and Tasmania. A tree of very large size, attaining a height of 350 feet. Growth rapid in humid stations. Wood of a rather pale colour, hard, heavy, strong and durable, more twisted than that of

E. obliqua, *E. amygdalina*, and many other fissile kinds ; the transverse strength is about equal to that of English oak. Used for heavy scantlings in house-building, for ship-building, for carriage-building, for telegraph-poles, and for planking for bridges and jetties ; formerly largely used for railway sleepers and for structures in water, but the wood of *E. rostrata* is now preferred for these purposes (*F. Mueller*). Density, 0.845 to 1.096 (air dried). Plantations of Blue Gum have been found, in Italy and elsewhere, to be of great hygienic value in fever-stricken districts. Introduced at the Cape in 1828 by Sir Lowry Cole from Mauritius. Suitable for planting between 2,000 and 4,500 feet.

Eucalyptus Leucoxydon, F. v. Mueller. The *Ironbark-tree* of Victoria and some parts of South Australia and New South Wales. A large tree, exceptionally 200 feet high. Wood heavy, very hard, tough, very strong and durable ; colour pale reddish-brown ; density 0.91 ; used for wheelwork, shafts, poles, railway sleepers, in ship-building for treenails, topsides and the stock of rudders, in mining work, and for other purposes. The bark is rich in kino tannin, yielding up to 22 per cent. when fresh, but is only available for inferior leather. Suitable for planting between 1,000 and 3,500 feet.

Eucalyptus longifolia, Link. The *Woolly Butt* of Extra-tropic East Australia. A large tree, exceptionally 200 feet high. Wood, heavy, durable ; used for fuel and by wheelwrights, but often traversed by kino-sediments. Dry bark contains 8.3 per cent. tannic, and 2.3 per cent. gallic acid (*Procter*). Suitable for planting between 1,500 and 3,500 feet.

Eucalyptus marginata, Smith. The *Jarrah* of South Western Australia. A large tree 100 feet high ; exceptionally 11 feet in diameter, and 150 feet high ; thriving in a variety of soils and situations, but not in hot and dry stations ; found in a belt within 50 miles of the coast ; naturally associated with *E. calophylla*. Wood heavy, moderately hard, easily worked, extremely durable, and taking a beautiful polish ; density 1.010 (air dried) ; used for jetties, underground work, telegraph poles, railway sleepers, ship-building, flooring, rafters, shingles and for furniture. Jarrah ranks with Live Oak, Teak, and Greenheart, as one of the most durable and generally serviceable timbers extant. Growth much less rapid than that of the Blue Gum. Suitable for planting between 1,000 and 2,500 feet.

Eucalyptus obliqua, L'Héritier. The *Stringy Bark* of Tasmania and *Messmate* of Victoria. A very large tree, attaining a height of 300 feet, and a diameter of 10 feet, found chiefly on mountain ranges. The most gregarious of all Eucalypts, according to Sir F. von Mueller. Wood heavy, moderately hard, easily worked, and very fissile, but not very durable underground ; light coloured ; density 0.82 ; supplies a large portion of the ordinary sawn hardwood timber for rough building and for work not to be sunk underground, nor requiring great strength or elasticity ; split into fence-rails, palings and shingles (*Mueller*). Growth rapid. Suitable for planting between 2,000 and 4,500 feet.

Eucalyptus robusta, Smith. The *Swamp Mahogany* of New South Wales. A large tree attaining a height of 100 feet and a diameter of 4 feet, preferring wet localities. Wood heavy, moderately strong, but rather brittle, durable, not attacked by insects ; colour light red ; density 0.82 ; used largely for posts, joists and sleepers ; also for ship-building and wheelwright's work. Growth rapid. Suitable for planting between 1,000 and 3,000 feet.

Eucalyptus rostrata, Schlechtendal. The *Red Gum* of Southern Australia. Found in moist ground with a clayey subsoil ; also on river flats in the interior of the Australian continent ; will thrive in ground periodically inundated, or slightly saline. A large tree 100 feet high, exceptionally 14 feet in diameter and 250 feet high. Wood heavy, hard, strong and extremely durable, either above or under ground or in water ; colour dark reddish brown ; density 0.83 ; used for railway sleepers, telegraph poles, posts, piles, bridge planks, culverts, in shipbuilding, and for felloes. Growth more rapid than that of *E. marginata*, but slower than that of *E. Globulus*. Suitable for planting up to 3,000 feet.

Liriodendron tulipifera, Linnæus. The *Tulip* of the United States. One of the largest and most valuable trees of the Atlantic region ; 90 to 190 feet high, 6 to 12 feet in diameter. Wood light, soft, not very strong, rather brittle, fine grained and compact, easily worked ; colour light yellow or brown ; sapwood thin ; density 0.423 ; largely sawn into lumber, and used for building, for bridges, furniture, carriage building, shingles, in boat building, and for other purposes (*Sargent*). Difficult to transplant. Growth rapid. Suitable for planting up to 5,000 feet.

Pinus Canariensis, C. Smith. The *Canary Pine*, forming forests at 4,000—6,000 feet in the Canary Islands. A tree 60-70 feet high. Wood moderately heavy, resinous, durable, and not readily attacked by insects. Suitable for planting between 4,000 and 6,000 feet.

Pinus Cedrus, Linnæus, var. *Deodara*. The *Deodar* of the Himalayan mountains, found at 3,000—12,000 feet. A large tree 5-7 feet in diameter, 150 feet high, reaching exceptionally a diameter of 10 feet and a height of 200 feet. One of the most valuable timbers of India. Wood light, compact, rather close grained, long fibred, very resinous, strongly and agreeably scented, very durable even if exposed to the weather; colour light yellow; largely used for construction, bridges, and boat building. Grows best in a humid clime. Suitable for planting between 1,000 and 6,000 feet. The Cedar of Lebanon is a variety of this species.

Pinus excelsa, Wallich. The *Bhotan Pine* of the Himalayas, occurring from 5,000 to 12,000 feet, and found in abundance at 6,000-8,000 feet. A tree 150 feet high. Wood soft, close-grained, resinous, easily worked; colour white; among Himalayan Pine-woods, it ranks for durability next to the Deodar; yields a fragrant resinous turpentine. Suitable for planting between 2,500 and 5,000 feet.

Pinus Halepensis, Miller. The *Aleppo Pine*. South Europe and North Africa. A tree attaining 80 feet, and a diameter of 4-5 feet. Wood white, the heart yellowish brown; density 0.53 to 0.87 (air dried); used in construction, for sleepers, for boat building, for common furniture, and largely for packing cases; yields a peculiar turpentine. Thrives best in sandy coast lands. Growth moderately rapid. Suitable for planting up to 5,000 feet.

Pinus insignis, Douglas. The *Monterey Pine*. Californian coast; sandy soil near the sea shore; rare and local but now widely cultivated in California for shelter and ornament. A tree 2-3 feet in diameter, 80-100 feet high. Wood light, soft, not strong, rather brittle, close grained, compact, resinous; colour light brown, the thick sapwood nearly white; density 0.46; used locally for fuel and also for boat-building (*Sargent*). Growth very rapid. Suitable for planting between 4,000-5,500 feet.

Pinus longifolia, Roxburgh. Common on the Himalayas, between 2,000 and 7,000 feet. A tree 60 to 100 feet high; diameter 3-4 feet. Wood resinous; the red variety compact, straight fibred; used for construction, boat-building, &c.; the white variety often twisted, open in the grain, and generally inferior; yields tar and turpentine. Suitable for planting up to 3,500 feet.

Pinus Pinaster, Solander. *Cluster Pine*. South Europe in sandy coast lands. 2-3 feet in diameter, 50-70 feet high. Wood soft, coarse-grained, resinous; colour white or reddish; density 0.52-0.77 (air dried); used in ship-building for minor purposes, for construction, railway sleepers, telegraph poles, posts, planks, beams, &c.; yields a large quantity of turpentine. Growth moderately rapid. Suitable for planting between 1,000 and 5,300 feet.

Pinus Pinea, Linné. The *Stone Pine*. Mediterranean region, thriving best in deep moist soil. A tree 2-3 feet in diameter, 60-80 feet high. Wood soft, coarse-grained, resinous; colour white or reddish; density 0.52—0.77 (air-dried); used for house and ship-building and for rough furniture. Growth moderately rapid. Suitable for planting between 1,000 and 4,000 feet.

Populus monilifera, Aiton. *Cottonwood*. Atlantic region of the United States; low moist lands and borders of streams. A large tree 4-8 feet in diameter, 70-150 feet high. Wood light, soft, close-grained, compact, liable to warp in drying; colour dark brown, the thick sapwood nearly white; density 0.39; largely used in the manufacture of paper pulp, for packing cases, fence boards, and fuel (*Sargent*). Growth rapid. Suitable for planting between 500 and 6,000 feet.

Quercus Cerris, Linnæus. *Turkey Oak*. South Europe and South-west Asia. A tree 2-4 feet in diameter, 80-100 feet high. Wood strong, heavy, hard, liable to warp, not fissile; colour brown tinged with red, the thick sapwood lighter; density 0.86—1.00 (air dried); used for ship-building, and by wheelwrights, cabinetmakers, turners and coopers, but considered inferior to that of *Q. robur*. Suitable for planting between 2,500 and 3,500 feet.

Quercus alba, Linnæus. *White Oak*. Atlantic region of North America; found in all soils; a large tree 4-8 feet in diameter, 75-150 feet high. Wood strong, very heavy, hard; tough, close-grained, requiring careful seasoning, durable in contact with the ground; colour brown, sapwood lighter; density 0.75; largely used in construction,

ship-building, and cabinetwork, and for casks, machinery, spokes, naves, beams, plough handles, agricultural implements, railway sleepers, fencing, flooring, and basket material (*Sargent*). Bark contains 8 per cent. tannin. Growth more rapid than that of *Q. robur*. Suitable for planting from 500 to 6,000 feet.

Quercus Robur, Linnaeus, var. *pedunculata*. The *British Oak*. Europe and Western Asia; plains and valley bottoms. A large tree 4-8 feet in diameter, 70-120 feet high. Wood strong, heavy, hard, very tough, durable; colour light brown, the sapwood white; density 0.65 to 0.91 (air dried); largely used in construction, ship-building, and planks, and for cabinetmaker's and joiner's work. Introduced at the Cape about 1656 from Holland, and now acclimatized. Growth moderately rapid. Suitable for planting between 2,500 and 6,000 feet. *Q. robur* var. *sessiliflora*, the Durmast Oak, is another important variety.

APPENDIX VIII.

ALTITUDINAL RANGE, FOR NATAL, OF SOME EXOTIC TREES. (1)

	COAST. 0-1000	MIDLANDS. 1000-3500	UPLANDS. 3500-6000 feet
<i>Acacia decurrens</i> , var. <i>mollissima</i> ...	...	2000-3500	3500-6000
<i>Acacia decurrens</i> , var. <i>dealbata</i> ...	...	1000-3500	3500-6000
<i>Acacia melanoxylon</i> ...	...	...	...
<i>Acer saccharinum</i> ...	...	2000-3500	3500-6000
<i>Acer dasycarpum</i> ...	...	1500-3500	3500-6000
<i>Araucaria Cookii</i> ...	0-1000	...	...
<i>Araucaria Cunninghamii</i> ...	0-1000	1000-3000	...
<i>Araucaria excelsa</i> ...	...	1000-2500	...
<i>Araucaria Rulei</i> ...	0-1000	...	...
<i>Callitris columellaris</i> ...	0-1000	1000-3000	...
<i>Callitris verrucosa</i> ...	0-1000	1000-3500	...
<i>Carya alba</i> ..	...	1000-3500	3500-6000
<i>Castanea vulgaris</i> ...	...	2000-3500	3500-6000
<i>Castanea vulgaris</i> , var. <i>americana</i> ...	...	...	4000-6000
<i>Casuarina equisetifolia</i> ...	0-1000	...	...
<i>Catalpa bignonioides</i> ...	0-1000	1000-2000	...
<i>Catalpa speciosa</i> ...	...	3000-3500	3500-6000
<i>Cedrela Taona</i> ...	0-1000	1000-3500	3500-4700
<i>Cedrela Australis</i> ...	0-1000	1000-3000	...
<i>Ceratonia siliqua</i> ...	0-1000	1000-2000	...
<i>Chamæcyparis sphæroidea</i> ...	0-1000	1000-3500	3500-6000
<i>Chamæcyparis Lawsoniana</i> ...	...	...	4700-6000
<i>Cinchona Calisaya</i> ...	...	...	3500-6000
<i>Cinchona cordifolia</i> ...	...	...	4500-6000
<i>Cinchona officinalis</i> ...	...	...	4500-6000
<i>Cinchona succirubra</i> ...	...	...	4500-6000
<i>Cinnamomum camphora</i> ...	0-1000	1000-2000	...
<i>Cupressus Benthani</i> ...	...	...	5000-6000
<i>Cupressus macrocarpa</i> ...	...	...	4000-6000
<i>Cupressus obtusa</i> ...	...	...	4500-6000
<i>Cupressus lusitanica</i> ...	0-1000	1000-3000	...
<i>Cupressus sempervirens</i> ...	...	...	4000-6000
<i>Cupressus torulosa</i> ...	...	1500-3500	3500-5000
<i>Cryptomeria Japonica</i> ...	...	...	3500-6000
<i>Dalbergia Sissoo</i> ...	0-1000	1000-1700	...
<i>Dammara lanceolata</i> ...	...	1000-2000	...
<i>Dammara robusta</i> ...	0-1000	1000-2000	...
<i>Eucalyptus amygdalina</i> ...	...	2500-3500	3500-6000
<i>Eucalyptus Baileyana</i> ...	0-1000	...	...
<i>Eucalyptus botryoides</i> ...	...	1000-3000	...
<i>Eucalyptus calophylla</i> ...	...	1000-2500	...
<i>Eucalyptus corynocalyx</i> ...	...	...	3000-4300
<i>Eucalyptus diversicolor</i> ...	...	1000-3500	3500-4500
<i>Eucalyptus Globulus</i> ...	...	2000-3500	3500-4500
<i>Eucalyptus Gunni</i> ...	...	...	3500-6000
<i>Eucalyptus Leucoxylon</i> ...	...	1000-3500	...
<i>Eucalyptus longifolia</i> ...	...	1500-3500	...
<i>Eucalyptus marginata</i> ...	...	1000-2500	...
<i>Eucalyptus microtheca</i> ...	0-1000	1000-3000	...
<i>Eucalyptus obliqua</i> ...	...	2000-3500	3500-4500
<i>Eucalyptus robusta</i> ...	...	1000-3000	...
<i>Eucalyptus rostrata</i> ...	0-1000	1000-3000	...

(1). These heights are given for the latitude of Durban. 500ft. should be added for each degree north and 500ft. deducted for each degree south, of Durban.

APPENDIX VIII.—ALTITUDINAL RANGE, FOR NATAL, OF SOME
EXOTIC TREES (*continued*).

				COAST.	MIDLANDS.	UPLANDS.
				0—1000	1000—3500	3500—6000 feet
Eucalyptus siderophloia	...	...	...	...	1000—3500	...
Eucalyptus tereticornis	...	...	...	0—1000	1000—3000	...
Eucalyptus viminalis	...	...	...	...	...	3500—6000
Fagus ferruginea	...	...	...	...	1000—3500	3500—6000
Fagus sylvatica	...	...	...	...	...	5800—6000
Ficus elastica	...	...	...	0—500	...	...
Fraxinus excelsior	...	...	...	...	...	5000—6000
Fraxinus floribunda	...	...	...	...	2000—3500	3500—6000
Fraxinus Americana	...	...	...	...	1000—3500	3500—6000
Gleditschia triacanthos	...	...	...	500—1000	1000—3500	3500—6000
Juglans cinerea	...	...	...	...	3000—3500	3500—6000
Juglans regia	...	...	...	...	3000—3500	3500—6000
Juglans nigra	...	...	...	700—1000	1000—3500	3500—6000
Juniperus Bermudiana	...	...	...	...	2000—3500	3500—6000
Juniperus brevifolia	...	...	...	...	...	3500—6000
Juniperus excelsa	...	...	...	...	2000—3500	3500—6000
Juniperus flaccida	...	...	...	...	...	5000—6000
Juniperus recurva	...	...	...	...	...	4000—6000
Juniperus Virginiana	...	...	...	0—1000	1000—3500	3500—4700
Larix Griffithii	...	...	...	...	...	5000—6000
Libocedrus decurrens	...	...	...	...	...	6000
Libocedrus tetragona	...	...	...	...	...	5000—6000
Liriodendron tulipifera	...	...	...	0—1000	1000—3500	3500—5000
Magnolia grandiflora	...	...	...	0—1000	1000—2000	...
Maclura aurantiaca	...	...	...	...	2000—2700	...
Melia Azedarach	...	...	...	0—1000	1000—3500	3500—4000
Melaleuca leucadendron	...	...	...	0—1000	1000—3500	...
Nyssa sylvatica	...	...	...	500—1000	1000—3500	3500—6000
Olea Europæa	...	...	...	...	1000—3500	...
Pinus Brunoniana	...	...	...	...	...	4700—6000
Pinus Canariensis	...	...	...	...	...	4000—6000
Pinus Cedrus	...	...	...	...	...	4000—6000
Pinus Cedrus, var. Deodara	...	...	...	...	1000—3500	3500—6000
Pinus Cilicica	...	...	...	...	...	4000—6000
Pinus Coulteri	...	...	...	...	...	5000—6000
Pinus Cubensis	...	...	...	0—1000	1000—2000	...
Pinus densiflora	...	...	...	...	...	4300—5500
Pinus excelsa	...	...	...	...	2500—3500	3500—5000
Pinus Halepensis	...	...	...	0—1000	1000—3500	3500—5300
Pinus insignis	...	...	...	...	...	4000—5500
Pinus Laricio	...	...	...	...	...	4500—6000
Pinus longifolia	...	...	...	0—1000	1000—3500	...
Pinus Massoniana	...	...	...	...	...	4300—5500
Pinus mitis	...	...	...	0—1000	1000—3500	3500—6000
Pinus palustris	...	...	...	0—1000	1000—3500	...
Pinus Pinaster	...	...	...	...	1000—3500	3500—5300
Pinus Pindrow	...	...	...	...	...	5000—6000
Pinus Pinea	...	...	...	...	1000—3500	3500—4000
Pinus ponderosa	...	...	...	...	...	3500—6000
Pinus religiosa	...	...	...	...	...	4000—6000
Pinus rigida	...	...	...	...	...	3500—6000
Pinus Sabiniana	...	...	...	...	...	4000—6000

APPENDIX IX.

TIMBER IMPORTS, NATAL.

1.—RETURN OF BOARDS AND PLANKS IMPORTED INTO THE COLONY FOR 10 YEARS, FROM 1880 TO 1889, INCLUSIVE (1).

Year.	Quantity cubic feet.	Value. £
1880	679,762	39,036
1881	902,627	54,947
1882	1,177,326	71,830
1883	448,739	26,844
1884	438,348	24,506
1885	212,812	10,740
1886	324,045	15,672
1887	710,719	34,883
1888	1,333,742	68,175
1889	2,503,779	138,981
Total	8,731,899	485,614

2.—RETURN OF BOARDS AND PLANKS IMPORTED DURING THE 10 YEARS 1880-1889; CLASSIFIED ACCORDING TO COUNTRIES.

Imported from	Quantity cubic feet.	Value. £
Sweden	6,809,092	360,788
United States	1,216,557	68,110
United Kingdom...	420,978	29,768
Cape Colony	81,263	7,578
Holland	60,820	3,687
Canada and British Columbia	54,088	2,886
India, Burmah, and Singapore	51,496	10,055
Germany	19,614	882
St. Thomas (North America)...	5,964	356
Australia	5,506	879
Mauritius	4,467	499
Delagoa Bay, Quillimane, and Inhambane	902	69
Pondoland	586	38
Brazil	464	7
Madagascar	120	12
Total	8,731,899	485,614

(1) Including "Deals and Timber, unmanufactured," and "Boards and Planks."—Does not include Railway Sleepers and other "Public Stores."

3.—RETURN OF WOODENWARE OF ALL KINDS IMPORTED DURING THE 10 YEARS 1880-1889. (1).

Year.	Value. £
1880	17,258
1881	17,715
1882	23,838
1883	10,990
1884	9,330
1885	5,326
1886	5,091
1887	14,224
1888	30,695
1889	30,987
Total ...	165,454

4.—RETURN OF CABINET AND UPHOLSTERY WARE IMPORTED DURING THE 10 YEARS 1880-1889.

Year.	Value. £
1880	58,321
1881	42,343
1882	47,468
1883	29,698
1884	24,088
1885	18,852
1886	15,155
1887	26,625
1888	54,505
1889	116,840
Total	433,895

5.—RETURN OF CARTS AND CARRIAGES IMPORTED DURING THE 10 YEARS 1880-1889.

Years.	Value.
1880-1889	£146,533

(1). Including "Boats," "Houses and Frames," "Poles and Spars," "Oars," and "Woodenware of all kinds."

APPENDIX X.

[*Revised Extract from Minute Paper No. 830, on the subject of Diminished Rainfall in Victoria County—attached to Forest Report by direction of His Excellency.*]

HONOURABLE COLONIAL SECRETARY.

The connection between forests and rainfall in Natal is a wide subject that cannot be treated exhaustively without special study and more data than are at present available. The rainfall fluctuates from year to year in an apparently irregular manner, but in reality it is governed by cycles with regular periods. My friend Mr. D. E. Hutchins, who has made a study of the variation of the weather of South Africa in cycles, finds a close connection between solar energy, as indicated by Sunspots, and the rainfall.* He also traces secondary cycles, one with a period of 9·5 years, which he terms the "Storm Cycle," from its association with violent gales and numerous shipwrecks, the other with a period of 12·5 years, which he terms the "Mitigation Cycle." Droughts prevail at the Sunspot minima every 11·11 years (Wolf's Sunspot period), unless masked by a coinciding wave of the "Storm Cycle," or of the "Mitigation Cycle." These three cycles give, in the opinion of Mr. Hutchins, a complete key to the South African weather, and the character of the seasons since 1884, particularly last year's severe drought, have been successfully foretold by their use. The "Storm Cycle" is the most prominent feature of the Capetown rainfall, while the "Mitigation Cycle" governs more powerfully the rains of the Eastern Province. I have sketched the diagram attached, which seems to indicate a close connection between the waves of rainfall observed by Mr. Wilkinson, at Ottawa, and the three cycles discovered by Mr. Hutchins. Many years' observations will be required before these cycles can be established on a firm basis, and the influence of each ascertained exactly by suitable mathematical processes (harmonic analysis).

Two sources of discrepancies tend to mask the probable correlation between various cycles and the rainfall: First, the calendar year often cuts the rainy season, and late rains one year may show a dry year followed by a wetter year, though the rainfall in the two rainy seasons may have been nearly the same. Second, the rain gauges may not measure accurately the rainfall over a large tract of country, the precipitation being influenced by locality and shelter.

Though the rainfall fluctuates in waves, the diagram shows clearly a steady diminution of their level. Taking two equal periods of eight years, similar in character as regards the waves of rainfall, namely, those connected with the "sunspot cycle" above, a diminution of mean level from 39·0 inches during 1871-78 to 30·8 inches during 1882-89, is observed to have taken place. This diminution does not appear to be due to cyclical variation, because (1) Two corresponding periods have been chosen for comparison; (2) Using all the other complete South African observations, for similar periods, which I have at present with me, no such severe diminution of rainfall is perceivable elsewhere:

Station.	Period.	Mean Rainfall.	Period.	Mean Rainfall.	Excess of former rainfall in percentage of the latter.
Ottawa	... 1871-78	39·0	1882-89	30·8	+ 26·6
Do.	... 1871-77	40·7	1882-88	31·7	+ 28·4
Capetown Royal Observatory...	1871-77	26·8	1882-88	29·3	- 8·5
Graaff-Reinet	... 1871-77	16·1	1882-88	15·3	- 5·2
Grahamstown	... 1871-77	28·2	1882-88	30·3	- 6·9
Aliwal	... 1871-77	26·0	1882-88	23·4	- 11·1
Maritzburg	... 1871-77	38·4	1882-88	38·3	0·0
(using Gardenscliffe observations for some of the years.)					

* D. E. Hutchins. *Cycles of Drought and Good Seasons in South Africa*, Wynberg, 1889.

1 wave of rainfall recurring at intervals of 12.5 years (Hutchins' "cyclical mitigation").

1 wave of rainfall recurring at intervals of 9.5 years (Hutchins' "storm cycle").

3 waves of rainfall recurring at intervals of 11.1 years (Wolf's "sunspot cycle"):
1. Hutchins' "sunspot rains." 2. Hutchins' "lag rains."

Resulting waves of rainfall.

It may be seen that there are considerable variations of the rainfall in other parts of South Africa, but none nearly so great as that observed at Ottawa, and I cannot but think that the serious diminution in late years of the rainfall of Victoria County is due primarily to the clearing, since 1860, of some 35,000 acres of forest, for coffee and sugar planting.

There are not many reliable observations of the influence of forests on rainfall. In 1867, Dr. E. Ebermayer introduced the use of double stations, one inside a fully stocked forest, the other at some distance outside, both being placed in similar conditions of altitude, aspect, soil, &c. During the last few years the use of these double stations has been extended in Germany and France. The recently available Prussian observations, ** which I did not get in time for insertion in my Forest Report, show the following increase of rainfall in the forest stations over those of the open country, in per cent. of the rainfall of the latter.

Between sea-level and 328 feet altitude	...	...	...	1.25 per cent.
Between 328 and 556 feet altitude	...	...	...	14.2 " "
Between 1,969 and 2,297 feet altitude...	...	...	...	19 " "
Between 2,297 and 2,625 feet altitude...	...	...	...	43 " "

These figures have been arrived at from observations taken at sixteen pairs of stations during periods of from four to eleven years. They appear to show that the forests have little influence on the rainfall near sea level, and that their influence becomes considerable with increased altitude in mountainous countries.

At Nancy, in France, the results of seven years observations made at a pair of stations 1,247 feet in altitude, show a mean increase of 16 per cent. in the rainfall over the forests.

The action of forests has also been investigated by Swedish observers. I have not the figures before me, but they show that in Scandinavia the influence of forests on the rainfall is much less than in Germany.

It is probable that the power of the forests to increase rainfall is much greater in warm than in cold countries. The increase of rainfall over forests is due chiefly to the lowering of the temperature in their vicinity. Beech woods in Bavaria reduce the temperature by 8.4° in July, while increasing it by 2.1° in January. The effect being most marked in summer, it is probably considerably greater in tropical or semi-tropical climates. A second cause consists of the mechanical action of masses of trees, which break the air currents and induce precipitation. Both causes would act more powerfully, with increased elevation, and this may explain why the excess of rainfall over forests is found to increase with altitude. Conversely, the rains induced by low lying atmospheric disturbances, such as thunderstorms and "secondaries," would be affected more powerfully by the forests than the rains due to "cyclones," and Abercromby observes this to be the case. The Natal rains being caused by thunderstorms and "secondaries" chiefly, it may be expected that the forests here exercise a powerful influence on the rainfall.

A third result of denudation, consisting in the increase of radiation from a bared surface, also helps to reduce the condensation of vapour. On a coast region such as the littoral zone of Victoria County, the increased temperature and radiation due to denudation, would probably serve to buoy up over the heated belt, a considerable proportion of the clouds from the sea that condense only 15 or 20 miles inland.

I am inclined to the belief that these three causes are quite sufficient to account for the serious diminution of the rainfall of Victoria County that has followed the destruction of its forests.

(Signed) H. G. FOURCADE.

Durban, February 11th, 1890.

** See Dr. Schlich's *Manual of Forestry*, vol. I. p. 41.

It may be seen that there are considerable variations of the rainfall in other parts of North Africa, but none nearly so great as that observed at Omdurman, and I cannot but think that the serious diminution in late years of the rainfall of Victoria County is due primarily to the clearing, since 1860, of some 35,000 acres of forest for coffee and sugarcane plantations.

There are not many reliable observations of the influence of forests on rainfall. In 1867, Dr. H. Ebermayer introduced the use of double stations, one inside a fully stocked forest, the other at some distance outside, both being placed in similar conditions of altitude, aspect, soil, &c. During the last few years the use of these double stations has been extended in Germany and France. The recently available French observations, which I did not get in time for insertion in my Forest Report, show the following increase of rainfall at the forest stations over those of the open country, in per cent. of the rainfall at the latter:

Between sea-level and 328 feet altitude	1.25 per cent.
Between 328 and 556 feet altitude	1.42 "
Between 556 and 827 feet altitude	1.9 "
Between 827 and 1,100 feet altitude	4.3 "

These figures have been arrived at from observations taken at sixteen pairs of stations during periods of from four to eleven years. They appear to show that the forests have little influence on the rainfall near sea level, and that their influence becomes considerable with increased altitude in mountainous countries.

At Bannoy, in France, the results of seven years' observations made at a pair of stations 1,115 feet in altitude show a mean increase of 16 per cent. in the rainfall over the forests.

The action of forests has also been investigated by Swedish observers. I have not figures before me, but they show that in Scandinavia the influence of forests on the rainfall is much less than in Germany.

It is probable that the power of the forests to increase rainfall is much greater in warm than in cold countries. The increase of rainfall over forests is due chiefly to the lowering of the temperature in their vicinity. Forest woods in Bavaria reduce the temperature by 3.4° to 5° in July, while increasing it by 3.1° to 5° in January. The effect being most marked in summer, it is probably considerably greater in tropical or semi-tropical climates. A second cause consists of the mechanical action of masses of trees, which break the air currents and induce precipitation. Both causes would not more powerful with increased elevation, and this may explain why the excess of rainfall over forests is found to increase with altitude. Conversely, the rains induced by low lying mountain ranges, such as the Apennines and "secondaries," would be affected more powerfully by the forests than the rains due to "cyclones," and Abernethy observes this to be the case. The lateral rains being caused by thunderstorms and "secondaries," clouds may be regarded that the forests there exercise a powerful influence on the rainfall.

A third cause of denudation, consisting in the increase of radiation from a bare surface, also helps to reduce the condensation of vapour. On a coast region such as the zone of Victoria County, the increased temperature and radiation due to the denudation would probably serve to dry up over the forest belt, a considerable proportion of the moisture which in sea that condenses only 15 or 20 miles inland.

I am inclined to believe that these three causes are quite sufficient to account for the serious diminution of the rainfall of Victoria County that has followed the destruction of its forests.

(Signed) H. G. FORDGATE

Durban, February 11th, 1890.

LOAN PERIOD 1

LOAN PERIOD 1	2	3
4	5	6

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