# PATCH STUDIES IN THE STABILITY OF NON-DIVERSITY: DENNSTAEDTIA, SOLIDAGO, SPIRAEA, KALMIA

John P. Anderson Jr., and Frank E. Egler

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## Introduction

This paper is a Progress Report on the relative stabilities of four one-species-predominant "Patches" of a fern, a forb, a low shrub and a tall shrub, of Dennstaedtia punctilobula, Solidago rugosa, Spiraea latifolia, and Kalmia latifolia -- not on the stability of a complex Vegetation composed of many plant-communities. It is based on both observations and experimentation that go back for several decades. The study is part of the long-term low-tech low-cost research at Aton Forest, an 1100-acre area in the beech-birch-maple-hemlock Zone of northwestern Connecticut; and does not emulate the ecolometric overkill now fashionable in ecological journals ("Physics Envy in Ecology" Ecol. Soc. of Amer. Bull. 67(3):233-234. 1986). Furthermore, the study goes beyond the successional "patch dynamics" that seems to be currently emerging, which current approach is a rediscovery of the Cover Type coincidences, fully understood by Henry A. Gleason, Carl O. Sauer and others seven decades ago, subsequently lost under several epistomologic enthusiasms. This present Patch study focuses upon specific small areas up to 10 m. across, that play their partial roles in the complex wholes of total Vegetation, an example of top-down ecosystemic research, from wholes to parts (not the reverse). (The Latin nomenclature is that of Gleason's 3-volume "Illustrated Flora of the Northwestern United States and Adjacent Canada", 1952.

I. Basic Conceptualization. In the philosophy of the science, this study aims:

- To reduce where feasible the known, multi-species plant-community in nature to predominantly one-species "parts" or "Patches" by top-down thinking;
- To observe, monitor, describe, study and experiment with these one-species-predominant parts; for their stability, their peripheral expansion into other plant-communities or other one-species Patches (which expansion is clearly non-stability on the part of the invaded community, the combination of the two communities being one expression of "diversity); or for the instability of the Patch by peripheral contraction (as by invasion of other plants); or by autotoxicity, forming "fairy rings"; or by overall

invasion (Relay Floristics) by other plant-communities or by one-species populations;

- To evaluate the role of allelopathy, with or without competition for space and nutrients;
- To accept interferences and accidents of nature, which are thus turned into "natural experiments", which may or may not require readjustments in the study;
- To integrate, lastly, the knowledge of a one-species-predominant community into a better understanding of the nature of many-species plant-communities, bio-communities and ecosystems.

II. History of the Idea. While working for his doctorate under George E. Nichols in 1934-36, Egler came in one day after sitting thinking and dozing in a large Patch of overmature Rhus typhina near Yale, and excitedly told his professor that the community under the Rhus was precisely the same set of herbs as in the open weedy field outside the Patch, that there was no Rhus-correlated invasion by young "pioneer" trees; and that where the Rhus was deteriorating from old age, this supposedly later Rhus-shrub stage was actually being "succeeded" by the "younger" old-field stage! Nichols' dogmatic reply was one that did not accept either such exceptional successional behavior, or further such student observations.

Two decades later, Egler visited the Audubon Nature Center, Greenwich, Conn., met their summer staff member William A. Niering, and saw a patch of Viburnum lentago. The end result was "A shrub community of Viburnum lentago, stable for twenty-five years" (Ecology 36(2):356-360. 1955). A fifth-decade update, by William A. Niering, Glen Dreyer, John P. Anderson Jr., and Frank E. Egler has been completed (Ecology 113(1):23-27. 1986).

At Aton Forest, over one hundred plant taxa occurring in Patches are under long-term observation. Some are not proving significantly stable, especially under recent heavy deer-grazing, but mice and rabbits are also critical factors. (Amongst other related publications, see "Botanical studies in the stability of non-diversity: Cornus racemosa", Conn. Bot. Soc. Newsletter 10(3):1. 1982. And "Botanical studies in the stability of non-diversity: Taxus canadensis", Third Intern. Symposium on Environmental Concerns in Rights-of-way Management, Feb. 15-18, 1982, San Diego. 1984 [Miss. State Univ., 39762].) The subject is obviously of great practical importance in silviculture, range management, naturalistic landscaping, and R/W Vegetation Management, as well as in academic Ecosystem Science.

III. Methodology. If research in long-stable Patches appears to have been neglected, it is understandable if not excusable. The study is not amenable to the short-term quickie research of Mr. Grant Swinger. The methods are not rigid and elegant, but

flaccid yet risible with attractive and unexpected opportunities.

- Pick a small area, a good "sample" in the judgment of an experienced field person, young or old (but not of a just-graduated technician).
- Interpret the area with regard to its origins:
  - A. The species: clonal, seedlings, root age, past browsing, etc.
  - B. The non-Patch species: are they
    1. Antecedents (older than the Patch species)?
    2. Concomitants (same age as the Patch species)?
    3. Subsequents (younger than the Patch species)?
- "Purify" the Patch, by rootkilling or otherwise removing all the species you arbitrarily decide are "alien" to your intents. (Remember that the herbicide industry sells chemicals as "control", and sells more if they do not rootkill -- a kind of planned obsolescence of the treatment, like using a cheap paint on a house.) This purification itself may take several years.
- Sample the Patch for detailed data on composition and abundance, by permanent plots, transects, or lines. There is no single standard methodology, suited for all species in all areas.
- Monitor the Patch thru the years and decades as to overall expansion (in decimeters, not millimeters), contraction, overall invasion (change, not Clementsian "succession"), internal decay (fairy rings), autotoxicity, etc.
- Manage or not-manage the Patch thru the years as unanticipated events arise, and ad hoc decisions must be made, e.g.:
  1. If overridden by a dense vine, like grape or Japanese honeysuckle.
  2. If affected by fire, flood, drouth, wind, insects.
  3. If grazed out, as by deer, or a neighbor's cow, or if a well-meaning person interferes.
  4. If an adjacent tree overshades it, or a rootsuckering shrub or tree invades from below.

IV. Prepare Reports. At initiation of the project, and at suitable intervals thereafter, indicate changes or non-changes involving:

- Composition (minor and accessory species that may be present).
- Structure with respect to height, type of branching, etc.
- Peripheral behavior with adjacent plant-communities, and with species of them (always pointing to further research) on the physico-chemical nature of the phenomena observed, especially with respect to competition for space and nutrients, and to allelopathy).

- Internal behavior, as regards newly invading taxa. Herein lies the very essence of Patch Stability, or Instability.

## I. DENNSTAEDTIA PUNCTILOBULA 1946-1987

Dennstaedtia punctilobula, the non-evergreen Hay-scented Fern, is and is increasingly, an important component of our regional vegetation in New England, New York and Pennsylvania. It commonly covers significant portions of land, either mixed with other plant species, or more frequently as a single-species patch.

At Aton Forest, Dennstaedtia cover in the forested areas is now estimated at up to 25% of the local (50-acre units) vegetation cover; it is less important in the non-forested managed Herblands and Shrublands, to 5% of the cover, but it is increasing even there. Due to its clonal nature, this native fern tends to form a dense rhizomatous sod.

The fern has increased tremendously within the last twenty-five years, in full sunlight and under hardwoods and pine. It is absent under Hemlock. In the total vegetation it seems destined to increase still more. The increase is related to its unpalatability to deer, its aggressiveness in the browse-outs by deer, and to its apparent allelopathy which seems to prevent invasion by all other potential predominants, herbs shrubs and trees (except Rubus idaeus, thinly appearing in a few sunny areas). In 40 years, no clone has been observed to decay or disintegrate.

Elsewhere on Aton Forest, a few large down and decaying tree trunks may be playing a significant role in the future plant-community complex. All small tree trunks (to 45 cm., ca. 18 in., in dm.) are submerged in Dennstaedtia fronds almost year-round. A few larger trunks remain free of such a cover, and after suitable decay, ca. 25 years, may become a seed bed for trees. Paper Birch, Yellow Birch, Black Birch, Red Maple and White Ash have been found in such a microsite. Other species can be expected. Such large down-trunks are rare in Connecticut forests that are lumbered and fuelwood-collected; and thus this significant silvicultural factor in forest regeneration is likely to go unnoticed. Approximately 70 such prostrate tree trunks are under long-term study at Aton Forest.

Location and History. The Patch is located at the north edge of the field called Far North, in Lot C-47 (1757 Town Map), and was originally part of the brushy border of the hayfield. The field was mowed from 1926 thru 1944. It was not mowed from then on, but has been kept free of trees and tall shrubs since 1946 by the selective spot-use of herbicides.

Creation and Enlargement of the Patch. In 1946 there was a 4 m. wide strip of dense shrubs and young trees immediately south of the bounding E-W stone wall. It contained the usual mixture of species: Red Oak, Sugar Maple, Red Maple, Striped Maple, White Ash, Black Cherry, Paper Gray and Black Birches, a few White Pines and Hemlocks; Tall Blueberry, Low Blueberry, Winterberry, Lyonia, Arrowwood, Low Juniper, and perhaps others. In 1946, 1947 and 1948 this brush was treated to spot-spraying with chlorophenoxy herbicides. (See various publications by FEE.) By that time not only had the woody plants been rootkilled, but the herbicide-resistant probably-allelopathic Dennstaedtia was observed as becoming predominant at this spot. It was decided to make it a study Patch.

To mark the Patch, a line of 15 stones was laid down by FEE, ca. one m. apart and 23 m. long, on May 31, 1949. Remeasurements were taken on March 30, 1973, by FEE and Happy Kitchel Egler, with no new stone-line (data on file), showing that the entire Patch had not only remained compositionally stable, but had moved southward from 2.7 to 3.6 m. (aver. 3.2 m.), averaging 0.13 m./yr. Both 1949 and 1973 lines were "wavy" in the sense that each seemed to consist of the fronts of two circular clones that had already merged. If so, there was no apparent phenotypic difference between the two clones. This phenomenon occurs commonly at Aton Forest and elsewhere in northwest Connecticut.

A second line of bordering stones was laid down on May 10, 1981, by JPA and FEE. Again the entire Patch had remained stable, and the line had moved southward from 1.22 m. to 2.5 m. (aver. 1.7 m.), averaging 0.22 m./yr.

The Patch was restudied by JPA and FEE on June 18, 1985. By this time, Dennstaedtia clones had consolidated in the forest north of the stone wall and westward for ca. 60 m., carpeting the forest floor. Fifteen 1949-1981 transects were again measured, and shown to have moved southward (into further sunlight) from 1981 to 1985 from 0.6 m. to 1.14 m. (aver. 0.84 m.), averaging 0.21 m./yr. There was no 1985 line of stones.

Also on June 18, 1985, data on: composition and structure, behavior, and the adjacent herbaceous communities were taken (now on file), from which the following summaries are drawn.

According to policy, as the clonal Patch has moved southward, any established trees and shrubs that seemed destined to be Antecedents to the Patch have been rootkilled, since it is the primary intention of the research to test for newly invading "subsequent" woody plants. From 1946 to 1965 this rootkill was accomplished by spot-spraying with phenoxy herbicides. In 1965, use of phenoxy was stopped because certain species always had been resistant to it. From 1965 to 1979 such plants were cut close to

the ground with a pruning shears, with the assumption that competition and allelopathy would be effective. It was, if one so pruned two or three times a year. In 1979, stub-spraying with picloram was initiated; and the few remaining such woody plants now occurring in the Dennstaedtia are considered to be "misses", related to previous deer- or rodent-browsing. To date, there has been no obvious invasion by new tree or shrub seedlings, tho such seedlings do occur in adjacent non-Dennstaedtia communities.

Composition and Structure. The Dennstaedtia Patch, as a plant community, appears physiognomically as a pure single-species population. There are no other herbaceous species that are apparent, even as one stands only a few feet away. Nonetheless the fern occupies only 95 to 99% of the total mass, the few other species being small, low, and of no functional dominance. No sporeling ferns have been found.

In the section of the Patch studied and measured between 1949 and 1981, the most common (i.e., occurred in at least 25% of the transects) species found (still comprising 1% or less of the Cover) were: Carex spp. (2 sterile unidentified taxa), Rumex acetosella, Potentilla canadensis, Rubus flagellaris, grasses (small, sterile, unidentified), Maianthemum canadense (the most frequent), Rubus hispidus, and Solidago rugosa. Woody plant species (not yet rootkilled) occurred in only 8 out of 15 transects (75.4 m. of total length), for a total of 14 stems: Acer saccharum (5 stems), Quercus borealis (4), Carpinus caroliniana (2), Acer rubrum (1), Fagus grandifolia (1), and Amelanchier arborea (1).

The Marginal Belt. In autumn it has been noticed that all the fronds at the margin of the Patch bend away from the Patch and seemingly blanket out the adjacent low herbs of the Herbland. In spring after growth has started, there is an obvious 15-25 cm. band where the low herbs appear weakened and depauperate. It can be assumed that such an effect facilitates the extension of the Dennstaedtia rhizomes into this band.

Furthermore, in that new part of the Patch dating only from 1981-1985, there is a distinctly greater, but still minor amount of the Herbland plants, implying that it takes 5 years or more for the overrolling Dennstaedtia to eliminate them. The most common such species (still comprising 5% or less of the total Cover) were: Rubus hispidus, Rubus flagellaris, Potentilla canadensis, Carex spp., Rumex acetosella, and Quercus borealis. Other forbs occurred in 8 out of 15 transects (12.8 m. total length) for a total of 12 stems: Acer saccharum (3), Acer rubrum (3), Quercus borealis (2), Betula papyrifera (2), Prunus serotina (1), and Viburnum recognitum (1). Heavy fern growth would probably kill the small plants.

This poor survival and decline of woody species and the sudden reduction in other species Coverage which occurs immediately at the advancing edge of the fern suggests not only that Dennstaedtia punctilobula is a strong competitor in our regional vegetation, but is likely to be allelopathic, as various other studies have indicated.

Behavior. A conspicuous deer trail crossed the Patch at one place from 1981 to 1984. In the winter of 1980-81 about 10% of the area had been chewed up by mice, and short sections of the fern stipes could be raked together using one's hand. Several holes 8 inches deep had been dug (skunks?). Within the fern Patch over the years Whitetail Deer have occasionally pawed at the fern in early and late winter. Over the three years of 1983-85, this pawing has increased and intensified. In spring 1985, such scratches occurred in 13 of 15 transects between the 1949 and 1981 stone-lines. (None occurred between the 1981 and 1985 stone-lines), covering 18% of those transects, which seemed a fair approximation for this entire section of the patch. These scratches, which are oval-shaped, vary from 1.0 to 2.0 sq. m. in size, and are usually bare soil, with nearby piles of fern duff several inches deep. By summer new fern fronds were seen in some, but often where spots have been deeply scratched down to the soil, grasses sedges or Potentilla seeded in sparingly. In the 1985-86 and 1986-87 winters, no pawing occurred. By July 1986, in walking thru the dense fern fronds, no bare soil whatever was seen. In April 1987 new fern fronds were unrolling in almost all the pawed places. Neither these nor other animal effects have yet altered or permanently changed the continuity or stability of the Dennstaedtia Patch.

In a different Dennstaedtia Patch in northern Lot C-46, about 100 ft. in dm., Rubus strigosus (wild Red Raspberry) was first noticed in 1975, occupying less than 5% coverage. Since then, it has maintained this status, neither decreasing nor increasing in Coverage.

Adjacent Vegetation. The old-field vegetation beyond the 1985 Patch boundary was inventoried for plant species and abundance in a two-meter strip parallel to the Patch. Abundant species were: Anthoxanthum odoratum, Solidago rugosa, Lycopodium obscurum, Vaccinium angustifolium, Rubus flagellaris, Rubus hispidus, and Potentilla canadensis. Few or rare species included: Anaphalis margaritacea, Rumex acetosella, Festuca ovina, Panicum sp. (sterile), Quercus borealis, Carpinus caroliniana, Acer rubrum, Amelanchier arborea, Acer pensylvanicum, Acer saccharum, and Viburnum recognitum. Trees and a few shrubs can and do invade this Herbland, but not the shrubland of V. angustifolium. Such woody plants have from time to time been cut and treated with herbicides since 1946, in another project.

Future Trends. There is no indication as yet, after 38 years, that any seedplant or other fern does or can invade the Patch, either peripherally by vegetative means or scatteringly by isolated propagules. It can be assumed that some rhizomatous or rootsuckering plant might invade, but none has been observed so far.

As a stable spreading clone that, helped by deer, outcompetes adjacent herbaceous species and communities, and in terms of the multi-community vegetational mosaic of Aton Forest, this Patch can be said to be contributing to an inter-community instability of that total Vegetation.

Conclusions. Dennstaedtia is high in esthetic appeal, excellent in preventing soil erosion, probably cannot withstand trampling by livestock, without forage or edible-fruit value for wildlife, with unknown insect populations, and forms a cover which prevents the development of seedling forest reproduction. Dennstaedtia is one plant that exemplifies the principle that in small-scale natural one-species predominant community-level non-diversity, there can be a significant stability.

## II. SOLIDAGO RUGOSA

The strongly rhizomatous Solidago rugosa, best called the Rugose-leaved Goldenrod, is one of the easier to recognize in spring and summer in its vegetative state. It is also one of the most abundant thruout the northeastern states in Zones "below" spruce and fir, in sunlight forming solid stands, with other herbs taking very minor roles. It gives every evidence of being a relatively stable one-species-predominant herbaceous community. If young trees are also part of the Initial Floristic Composition (IFC), these soon overtop, and thin out the Solidago. On the other hand, this goldenrod is not part of the typical forest understory of the beech-birch-maple-hemlock Zone.

In the entire acreage of Aton Forest, it is estimated that Solidago rugosa (SR) occurs in 1-5% of its herb stratum. For 1926, the species is not recollected as being of vegetational significance in mowed fields and pastures. From 1946 to the mid-1950s, this plant was sprayed with phenoxy herbicides (in order to maintain a "grassland"). That treatment produced a kill-to-ground in spring. When the foliage "hardened" by midsummer, the spraying merely twisted the leaves. Thru those years, the total amount of SR was increasing by rhizomatous spread. In the 1960s, an intensive effort was made to remove it by "pulling". A steady tug would pull up a section of the horizontal rhizome. Later in the season there would be a satisfying addition of 5-8 new radiating rhizomes of 3-6 in. lengths. By count, thousands of such stems were pulled, in an effort completely to eradicate SR from about

4 acres, plus other smaller infestations. Obviously, pieces of rhizomes were always left in the soil, for the next year's growth was always plentiful. Within 2-3 years, the stand would become solid again. It was noticed however, that nowhere in the fields were SR seedlings found (tho they did occur in an experimental Bare Soil Project). Then it was decided to "live with it". Then it was found (by 1985) that SR does not appear to extend uphill on dry infertile thinly covered Upper Slopes, nor does it invade already existing Spiraea, Dennstaedtia, Vaccinium angustifolium, Onoclea, or Festuca turf (where developed on lower moister areas). It also does not invade areas that are mowed in a thrice-a-year, 5-foot-wide, mile-long transect (begun in 1947). SR will also dominate where shaded much of the day by tall adjacent forest.

Creation of the Patch. For reasons indicated above, and in order to concentrate attention at one particular spot, a study Patch was established June 19, 1985, partially under the crown of an isolated large Red Oak (which blew down in hurricane Gloria September 27, 1985), in the Aton Forest research area of C-46, known as Headquarters, section Eta. This area had been pastured until 1926; mowed until 1945; then treated with phenoxy herbicides until 1965, and with picloram since 1978. The Patch boundaries are located by four permanent field-stone markers, one at the base of the above-mentioned oak. Two transects were laid out (40 cm. wide), perpendicular to each other (E. 25 deg. N. and N. 25 deg. W.), dividing the elliptical Patch into quarters.

The Patch diameters are 6.45 and 3.70 m. The transects extended 0.6 m. beyond the Patch, into Herbland on three sides. The circumference is smooth and broadly elliptical. Altho this area has been under observation for many years, this is the first time that detailed measurements and other data have been collected. Ash and oak seedlings had previously been abundant.

Composition and Structure. The Patch is 99% Solidago rugosa. There is an abundance of Maianthemum canadense under the Solidago, which is the only truly associated species. There remained in 1985 several suppressed-and-browsed Quercus borealis and Fraxinus americana stems, shorter than the Solidago, scattered thruout the Patch.

The 6.45 m. transect contained: Maianthemum canadense, Gentiana andrewsii, Asters simplex var. simplex, lateriflorus, sagittifolius, and undulatus (all frequent in the surrounding herblands), Narcissus 'King Alfred', Aralia nudicaulis, Fraxinus, Quercus, Prunus serotina, and a large Kalmia latifolia at the tree-end of the transect.

The 3.70 m. transect contained: Maianthemum canadense, Convallaria majalis, Narcissus 'King Alfred', Aster undulatus,

Rubus flagellaris, Quercus, Prunus serotina, Prunus virginiana, and Fraxinus.

A marginal not-dense Solidago belt occurs around the Patch, varying from 0.3 to 0.8 m. in width (except for 20% of the Patch edge at the east, which abuts another Patch of Solidago). SR is still dominant, but other species include: Achillea millefolium, Potentilla canadensis, Rubus flagellaris, Anthoxanthum odoratum, Solidago graminifolia, Fragaria virginiana, Asters simplex var. simplex, laterifolius, sagittifolius, and undulatus, Rumex acetosella, Carex sp. (sterile, small), Gentiana andrewsii, Quercus and Fraxinus. This marginal belt is viewed as the most recent expansion of the clone into the "thinner" plant-community of section Eta. It is interesting to note the occurrence of a few species more common at the forest edge, particularly Aralia, Gentiana, and Convallaria (which spreads by seedlings and rhizomes), which herbs are rarely in the surrounding sunny mixed non-SR herbland. This is a situation implying an ecosystemic affinity of the dense and shady SR vegetation with the Forest Edge, rather than with large open sunny areas.

Adjacent Vegetation. Beyond the Patch, Solidago is spotty, or rare. Other species vary considerably in coverage from place to place. The most abundant are: Anthoxanthum odoratum with Agrostis alba, Agropyron repens, Dactylis glomerata, Carex spp., Uvularia perfoliata, Poa pratensis, Maianthemum canadense, Potentilla canadensis, Achillea millefolium, Aster spp. (as above), Solidago graminifolia, Rubus flagellaris, and browsed Fraxinus, Quercus and Prunus.

Future Trends. On the basis of past experience with SR elsewhere on Aton Forest, no retreat of the Patch boundaries is expected, nor any decadence within a Patch. Gradual enlargement is possible, barring unusual drouths. On the other hand, an unanticipated critical event has already occurred, with the hurricane-felling of the tree that partially shaded the area. This event will significantly change the mixture of herb and leaf litter on the ground, as well as the concomitant moisture, light and chemical conditions.

Conclusion. The small oaks and ashes still remaining within this Patch are considered to be Antecedent to the dense SR, not yet rootkilled. They will be closely watched to see if they die thru competition/allelopathy/browsing. If the rise above the Solidago, they will be rootkilled. The blowdown left a snag 7 feet tall. The tree was already weakened by Polyporus sulfureus. The Patch will thus be deprived of future falls of acorns directly upon it. The autumns of 1985, 1986, and 1987 were exceptionally heavy acorn-years, and the moist spring of 1986 an exceptionally successful germination year, yet no new seedlings appeared either in the Patch or in the vicinity from other trees

(tho seedlings were abundant on the roadsides where covered by road sand). By the spring of 1987, deer and rodents had eaten most of the acorns. A large oak grows 50 feet to the northeast, and a large ash 50 feet to the north, so that invasions by fruits of both are expected. The Patch is ideally located to test for the stability or instability of an essentially pure colony of this densely growing goldenrod, especially under an invasion of tree fruits that are well supplied with initial food for substantial seedling growth.

## III. SPIRAEA LATIFOLIA

Spiraea latifolia (SL), the native Meadowsweet, is one of the most common and aggressive shrubs of the original pre-1926 hayfields of Aton Forest, growing eventually to 2-2.5 m. in height, rhizomatous, with woody pencil-sized rhizomes, ca. 6-8 cm. below the surface, and up to 1 m. or more in length. It does best in full sunlight; becomes rare in open young forests, and is totally absent under the full canopy of Beech, Yellow Birch, Sugar Maple, Hemlock, Black Cherry and White Ash. In de-shrubbed and de-treed old-fields, it becomes increasingly abundant. Most of the increase seems to be due to the slow increase of distant vegetative sprouts, competing with the herbs and animals, tho Spiraea is only very lightly browsed by deer. New SL seedlings in the Herbland have not been identified (another project). They are however, known to occur on bare soil (another project). Eventually (after 30-40 years), and if "concomitant" and "antecedent" woody plants are rootkilled, Spiraea becomes a dense cluster of whipstem shoots, from which one-species-predominant community most other species have disappeared. To date, no invading (Clementsian) Relay of any tree or taller shrub has been observed. The present project was designed to test the long-term stability, and the expansion (i.e., an instability at the multi-community level) of one specific Spiraea Patch, as supplemented by observations of many other such stands at Aton Forest.

Location and History. The Spiraea Patch is located on a Midslope of Woodchuck Hill, in 1926 a 7-acre hayfield in Lot C-47 (of the original Proprietor's Map of the Town of Norfolk, 1757). The field was mowed from 1927 thru 1944. From 1946 thru 1965, undesired trees and shrubs were spot-treated with chlorophenoxy herbicides, followed by a very large new incursion of the herbicide-resistant Red Maple. From 1966 thru 1978 various physical methods of removal were unsuccessfully tried. Stub treatments with picloram (liquid and pellets) were effectively begun in 1978, and are continuing. Certain seedling trees and shrubs do newly invade, but not according to the ecological literature. Spiraea latifolia and Vaccinium angustifolium are the two chief shrubby invaders of the Herbland under recent management practices. Observations on many acres since 1946 already indicate

that physiognomically pure stands of Spiraea are remarkably stable, with no internal die-back as yet.

Creation of the Patch. In the southern part of Woodchuck Hill, Spiraea is predominant on about one acre. From this material a spot was subjectively chosen that appeared to be a single circular clone, of tall dense old growth, with no trees and other shrubs, surrounded by less tall and less dense Spiraea. Other spots in the field are similarly tall and dense.

On June 20, 1985, a circular surrounding "trench", 0.6 m. wide, was cut with a pruning shears; and the ca. 500 stubs (mostly Spiraea) treated (2 hrs.) with picloram. (See Phytologia 57(3):177-181, and citations in it.) Results of this treatment are awaited. Personal "misses" will be stub-treated. By September 1987, no movement thru and by the soil-solution has affected nearby plants. Once the bio-effects of Tordon have ceased (sometimes up to 4 years), continuing studies will be initiated on the original clone, and on its extensions outward, if any, into the Herbland.

Composition and Structure. Data taken by JPA and FEE on May 6, 1986, provide the following information:

In gross vertical and horizontal structure of stems and foliage, the Spiraea is distinctive. The stems are clearly clumped, with many stems in small areas 10-30 cm. across, and very few stems in between the clumps. Vertically, the foliage is dense in the upper third. In the middle third, the stems are relatively bare of foliage. The lower third reveals another surge of leafy shoots. These could probably perpetuate the Patch in the event of such as mowing, are probably supported by photosynthates produced in the upper foliage, but doubtfully produce enough photosynthates in that lower shade to justify their present existence.

The Patch is essentially circular, with 4 diameters of 5.9, 6.1, 6.8 and 6.8 m. respectively. It is crossed by two 20-cm.-wide transects, extending N-center-south, and W-center-E, providing four radii or spokes for separate data-gathering. There was an obvious segregation between (a) a central uniform core, and (b) a marginal perimetric belt 0.0 to 1.0 meter wide (as in the Dennstaedtia and Solidago Patches) transitional to the outside Herbland (see section below).

(a) The Central Core was 99%-plus Spiraea (119 stems in the 4 plots) in terms of stem density, biomass, coverage, and other measurable parameters. Accessory species were limited to Steironema ciliatum (48 stems in the 4 plots) and one very depauperate Lycopodium clavatum. There were no other woody plants.

(b) The Perimetric Belt (looked upon as a relatively recent centrifugal clonal expansion) showed a decided admixture of old-field plants. Spiraea maintains its status with 90-99% of the mass. Other plants comprise a total of 1 to 10% (usually closer to 1%). Listed alphabetically: Achillea millefolium, Agropyron repens, Agrostis alba, Anaphalis margaritacea, Anthoxanthum odoratum, Aster sagittifolius, Carex spp. (sterile), Danthonia spicata, Festuca rubra, Polytrichum commune, Potentilla canadensis, Rubus flagellaris (rooted outside the Patch), Rubus hispidus, Solidago graminifolia.

Behavior. Spiraea latifolia is a low-shrub growing densely in clonally spreading patches, or as sparsely scattered stems from old rootstocks. Dense grass covers or Festuca and Agrostis seem to retard the proliferation of Spiraea for at least one or two decades. The solid clumps are apparently topping out at heights of 2 m. or slightly more. The flowering tops rise some 15-30 cm. above the general foliage level, and thus become conspicuous in their season. The entire clone is slightly dome-shaped, with no flowering stalks at the outer margins. The doming may be in part due to the younger age of peripheral stems, and in part to light deer-browsing. Deer do no enter into the center of the clone.

The Adjacent Herbland. The surrounding Midslope Herbland (a separate project) by data from this Patch study, is an admixture of all the herbs mentioned above. Among the graminoids, Agrostis has been the most abundant, but Anthoxanthum and Danthonia are increasing. Carex spp. occur in small amounts. Potentilla and Rubus flagellaris are seasonally flowering aspects. Anaphalis, with its fairy rings forming and breaking thru the years, is conspicuous. Pinus, Juniperus, Amelanchiers arborea and laevis, Vacciniums augustifolium and corymbosum, and Prunus serotina seedlings do occur, but rarely, and need be removed, so far, at 10 or more year intervals.

Future Trends. Altho stands of Spiraea appeared in this field soon after the last mowing in 1944, they must have been mowed for many years previously. They were mixed with 75 kinds of woody plants, which Vegetation Management practices eventually removed. There is no evidence whatsoever at this time of any invading autogenic (Clementsian) Relay of another shrub, or any tree, under the Spiraea of this patch. The Patch, and surrounding areas, will be watched closely for evidence of any trend to another community.

Conclusion. Development of one-species-predominant dense clones of Spiraea latifolia seems to be a natural situation in sunny areas when and where trees and other shrubs do not occur, by coincidence or by human management. There is no vertical layering in the community, except for a few small herbs. After almost 40

years of extensive observation, there is no evidence of any invading Relay of another woody species.

## IV. KALMIA LATIFOLIA

Kalmia latifolia, the Mountain Laurel, is the most common single-shrub species in the once-pastured landscape of Aton Forest. It was present in the original pre-1750 forests of Indian times, tho in unknown but undoubtedly variable, quantities. It was probably less abundant in the Midslope forests than just below the hickory-covered "southern" Summits, with their ground cover of Carex pensylvanica. It does not occur under old hemlock stands. (neither does anything else.)

The next 200 years can be referred to as the Cattle Era, with or without sheep. Laurel is unpalatable to cows, and becomes increasingly abundant, eventually crowding out the cattle, who graze out most other trees shrubs and herbs (but not White Pine, Pasture Juniper and Hemlock, hence those common Cover Types of this Zone on the face of New England until recently). In the late 1920s, the laurel pasture was one of the commonest plant-communities, dominating on ca. 50% of the present Aton Forest, both as open pastures and as an understory under non-hemlock forests, being the accumulations of maybe two centuries, for laurel resprouts after cutting by the farmer. In those times Visibility was often not more than 30 feet and trail-cutting thru it was a laborious exercise.

By 1965, a remarkable change was first noticed, a change which is still continuing. Visibility is increasing. Today one can see thru the trees for 300 feet, where before there was an impassable laurel tangle from the ground up. Laurel foliage has largely disappeared at mid-heights from 18" aboveground, up to 7 feet, above which the original dense foliage remains. (In northeastern Maryland we have seen the entire lower foliage of laurel lost, apparently in correlation with the extreme shade of the upper laurel canopy, but that is not the critical factor here.

In the forest, Laurel is a layering species, forming sprawling clones, helped by falling trunks and weighted ice- and snow-covered branches. In the open, Laurel is a single shrub, neither layering nor clonally spreading. Seedlings are known to occur, even abundantly, in the crevices of open new rocky slopes (southeastern Connecticut) or on the abandonment of run-down hayfields. Today the total Laurel stratum at Aton Forest varies from 5% to 20% per 50-acre "Lot". In 1925, it had been 20-40% or much more.

Location and History. The Kalmia latifolia Patch here studied is located in the northwest section of Aton Forest, in the

southeast part of Lot C-16-2, in an area which we believe to have been pastured (never ploughed) almost continuously since the early 1800s, and not abandoned until the early 1970s. It is now mostly forested, with a mixture of northern hardwoods, Hemlock and White Pine, of Beech, Yellow Birch, Sugar Maple, Red Maple, White Ash, Black Cherry and Red Oak, with an unusually dense and almost continuous understory of Kalmia.

Creation of the Patch. There are many places that had been considered suitable for a permanent Kalmia Patch, areas of 20 or more meters across, and covered with uniformly dense tall laurel. On the other hand, it now appears that deer-browsing has affected and will be affecting all such areas more extensively in the near future, with remaining tall slender stems themselves then vulnerable to snow-weight and ice-weight damage, so that special consideration is essential.

The present Patch was found and chosen by JPA because it included one unusual single non-layering 11-stem shrub, probably over 100 years old, which for some reason was left uncut when the pasture was last rejuvenated by shrub-cutting. It is 7 m. tall, 7.5 to 9.1 m. in diameter, with essentially no understory foliage, thru which one can walk with ease (contrary to much of the adjacent laurel). The ground is 95% covered with oak leaves, with 5% low herbs, with a few small tree seedlings.

This single shrub is surrounded on 3 sides by other tall high-canopied Laurels, forming a Patch 12.8 x 17 m. in size, with no concomitant trees (which would have been removed in this 1985-creation of the Patch), with very few associated tall shrubs, no low-shrub layer, almost no ground cover, and no (Clementsian) Relay of invading trees, even tho a complete canopy of trees surrounds the Patch. The land has not been pastured since. The Patch is judged to be a one-species-predominant shrub community, that has already resisted tree invasion for an estimated 100 years.

Composition and Structure. On June 25, 1985, JPA and FEE charted and gathered data on this Patch (on file). Every laurel stem was located and measured. All other woody plants were similarly treated. Ground cover was also detailed. The major trees of the adjacent forest were located and diameters taken. Laurel formed essentially a complete canopy. Other tall shrubs formed less than 5% of the coverage of that layer, including only Amelanchier arborea/laevis, Viburnum recognitum, and Vaccinium corymbosum. There was one 5-cm.-dm. dead ash.

There was no low-shrub layer. The 5% ground cover included the following: Arisaema triphyllum, Dennstaedtia punctilobula (barely invading the Patch on the east), Lycopodia annotinum complanatum and obscurum, Mitchella repens, Polytrichum commune, and Trientalis americana. Among shrubs, only a few small

Vaccinium corymbosum were present. Several small Red Maples, Red Oaks, and Black Cherries gave no evidence of growing into trees. A few small Laurel seedlings occurred in a moss patch. About 50% of the Patch was overshadowed by the high branches of surrounding trees.

Adjacent Forest. This forest, extending in all directions, is composed of the customary beech-birch-maple-hemlock-pine, with Red Oak, White Ash, Black, Yellow and Paper Birches. Adjacent to the Kalmia Patch were one oak, 5 Red Maples, and 2 pines. Laurel formed essentially a complete tall-shrub cover above 3 m.; about 50% coverage at 2-3 m. height; 15% coverage at 1-2 m. and below 1 m. less than 5%. Visibility varied to distances of 3-5 m. Dennstaedtia was predominant locally. Other common plants were Vaccinium corymbosum, Vaccinium angustifolium, Hamamelis virginiana, Acer pensylvanicum, and Osmunda claytoniana (not here a moist-soil species).

Conclusions. Kalmia latifolia is a native evergreen, attractively flowering State-protected species that has greatly increased during the last two centuries due to cattle-grazing; and that is now decreasing due to increased deer-browsing. It can be, and in the landscape can produce, tall dense Patches (akin to chaparral, maquis, et al.) which restrict the growth of other plants, hinders advance tree reproduction of importance to timber-harvesting and fuelwood-production, provides no fruits or nuts for wildlife, tho it does provide cover. Academically, it provides a challenging and fascinating opportunity to study the stability of non-diversity, with respect to one essentially pure shrub-cover, which may have started by chance and coincidence and not by paradigmatic edapho-climatic determinism.

The present Patch, established in 1985, is considered to have started a century ago, and will be reported upon periodically in the future. As with current legal easements for preserving open-space recognized by the Internal Revenue Service, these study-Patches are considered to be established "in perpetuity", in the public interest, for study of developmental changes on the site.