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A TWENTY-YEAR RECORD OF UNDERSTORY VEGETATIONAL CHANGE IN A VIRGIN PENNSYLVANIA FOREST

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Abstract. The understory vegetation in a 4,080-acre tract of virgin hemlock-hardwood forest on the Allegheny National Forest in northwestern Pennsylvania was studied over a 20-year period by means of color and black-and-white photographs taken at 5-year intervals from 1942 to 1962. The declines which took place in the understory were believed to be caused by browsing by the resident white-tailed deer population. The deer herd, under very light hunting pressure, has depleted the browse supply and damaged advance reproduction of hemlock and hardwoods, preventing understory recovery during the 1942-62 period. Unless relieved, this continued browsing of the understory vegetation will eventually reduce and endanger the scientific and educational value of the area.

INTRODUCTION

In the late 1930's the Federal Government purchased a large tract of timberland from the United States Leather Company, owners of the Central Pennsylvania Lumber Company. A portion of this tract, situated at the headwaters of the East Branch of Tionesta Creek in McKean and Warren Counties, Pennsylvania, contained an old-growth forest of virgin hemlock-hardwoods, known as the Tionesta area. On July 31, 1940, this area of 4,080 acres was dedicated as the Tionesta Natural and Scenic Area of the Allegheny National Forest. Under the terms of this dedication, the area is to be reserved from timber management and other commercial uses, and used for scientific study and for the education, inspiration, and enjoyment of the public. Since it is one of the few sizable remnants of virgin forest between the Adirondacks and the Smokies, its maintenance in a natural condition is essential.

FIG. 1. Virgin hemlock-beech forest in the valley of the East Branch of Tionesta Creek, showing dense understory of striped maple, beech, and other tree regeneration, mixed with shrubby growth of witch hobble. Photograph taken on May 25, 1934.

Portions of the Tionesta Natural and Scenic Area and the adjacent virgin forest to the north have been described by Hough (1936) and by Hough and Forbes (1943). In 1930 this hemlock-hardwood forest had an understory of tolerant advance-growth reproduction mixed with herbaceous and shrubby growth. The most abundant shrub was witch hobble (*Viburnum alnifolium*). The shining club moss (*Lycopodium lucidulum*), the shield fern (*Dryopteris spinulosa*), the wood sorrel (*Oxalis acetosella*), and the partridge berry (*Mitchella repens*) made up most of the herbaceous understory. A typical stream-bottom site is shown in Fig. 1.

STUDY OF UNDERSTORY CHANGES

A photographic study of permanent quadrats in the Tionesta Natural and Scenic Area was planned in 1941 to determine possible changes in the understory vegetation resulting from natural mortality of the overstory and biotic factors, such as deer browsing, in this virgin forest.

Methods

In June and early July 1942 a transect of 21 milacre quadrats was established. Beginning at the north boundary of the Scenic Area and extending 3¼ miles to the south boundary of the Natural Area, the transect included plateau, upper-slope, middle-slope, and stream-bottom sites. Each quadrat was placed at a safe distance (about 2 chains) from the right-of-way of the Pennsylvania Gas Company's tri-county pipeline. This precaution proved its worth when the pipeline right-of-way was widened in 1945. To mark reference points along the pipeline and at the quadrat corners, inconspicuous hemlock branch knots, weathered from old dead and down trees, were used. An angle-iron stake was used to mark a point 6.6 ft south of the southeast quadrat corner. This marking system held up well during the 20-year period.

Each milacre quadrat was photographed when it was established, both in black-and-white and in color. At that time a 5-ft scale stick marked in feet was placed at the northeast corner of the quadrat. A portable wooden frame 6.6 by 6.6 ft was used to enclose and delineate the quadrat during photographing. Photographs were made at 5-year intervals, at about the same season of the year, to obtain a 20-year record (Figs. 2 and 3). In addition to the milacre photographs, a stand picture was taken from the same photopoint. If any large-scale tree mortality was evident at the time of the 5-year observations, repeat photographs of the stand were made.

At the end of the first 5-year period (1947) it was found that the black-and-white photographs, supplemented by the 35-mm color transparencies, were adequate for: (1) identifying tree, shrub, and herbaceous species of living plants; (2) identifying browsing damage to stems in 1942 and 1947; (3) checking the changes in height growth of established tree seedlings; and (4) recording the entrance of new tree or herbaceous growth during the past 5-year period. The progress in decay of dead limbs on the milacre could also be noted.

In 1962, 20 years after the study was begun, the following information was tabulated for each of the 21 milacre quadrats: tree, shrub, and herbaceous species present in 1942 and at subsequent 5-year examinations; origin (seed-

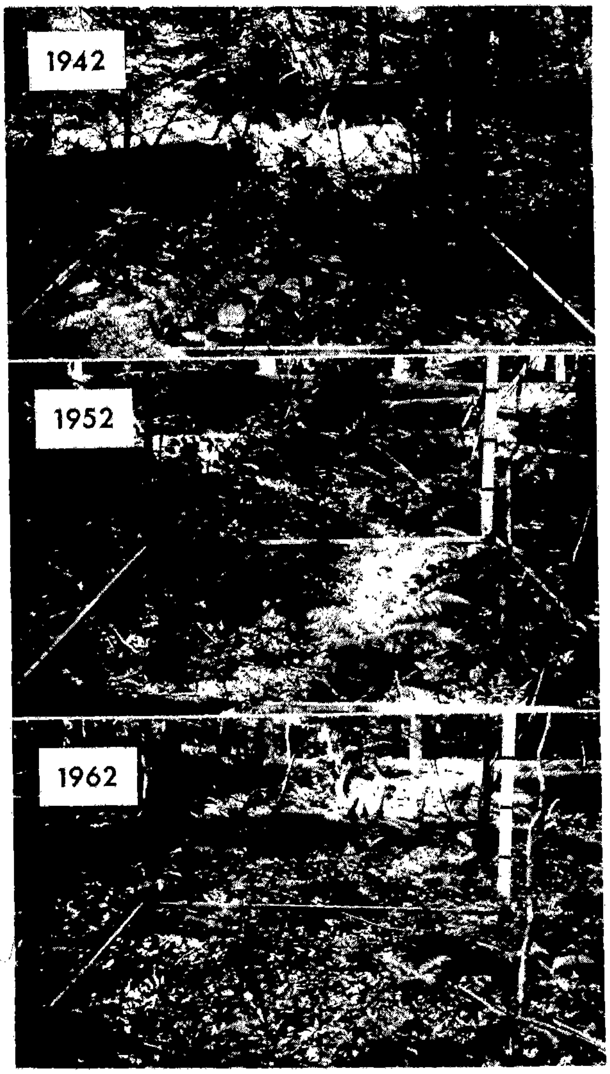

FIG. 2. Views of milacre no. 13 in valley bottom of the West Branch of Fork Run, Tionesta Natural Area, showing remnants of witch hobble (shrub with orbicular leaves in left center) and browsed understory of eastern hemlock seedlings in 1942. Note change to ferns and herbaceous growth in 1952 and 1962 photographs.

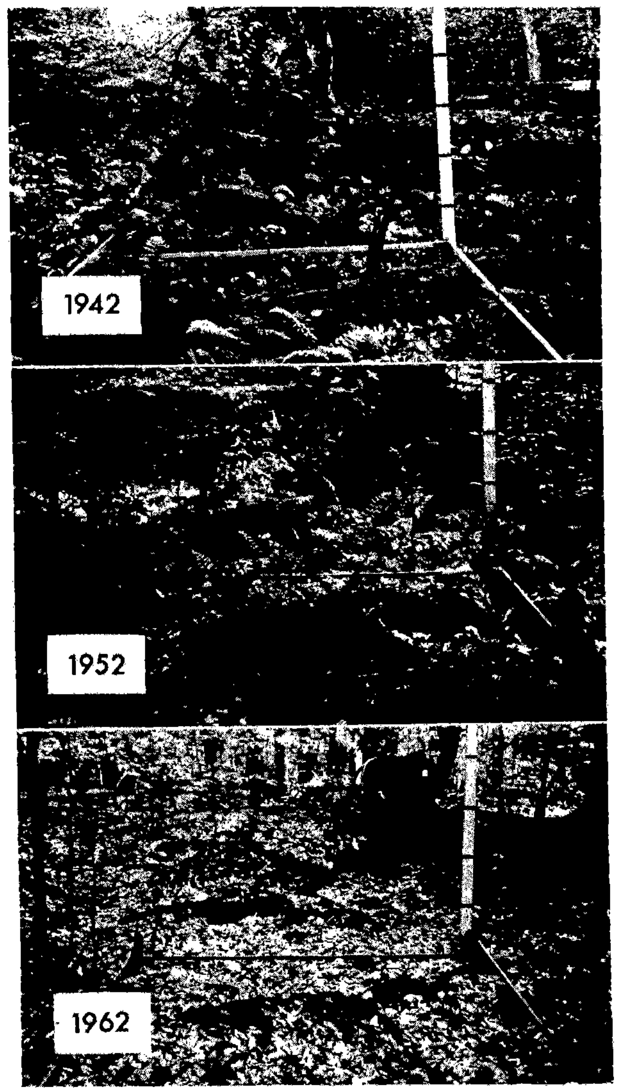

FIG. 3. Three views of milacre no. 11 on plateau between Cherry Run and Fork Run drainages, showing changes in background due to windthrows and decay of remains, and a decrease in lesser vegetation on quadrat from 1942 to 1962.

TABLE I. Summary of understory trend classes by togographic locations, at 5-year intervals after start of study, based on ocular estimates from Kodachrome photographs

Photo date	Understory trend class[1]	Number of milacres, by topographic location					Percentage of total
		Plateau (basis 5)	Upper slope (basis 6)	Middle slope (basis 6)	Lower slope (basis 4)	All (basis 21)	
	0	3	3	4	1	11	52
1947	−	2	2	2	3	9	43
	+	0	1	0	0	1	5
	0	1	3	2	1	7	33
1952	−	3	3	3	3	12	57
	+	1	0	1	0	2	10
	0	3	1	1	0	5	24
1957	−	1	4	4	3	12	57
	+	1	1	1	1	4	19
	0	2	2	0	0	4	19
1962	−	1	3	6	3	13	62
	+	2	1	0	1	4	19

[1]Understory trend classes are: 0=no change since 1942.
−=decrease since 1942.
+=increase since 1942.

ling, sprout, or sucker), estimated dbh or total height, and numbers of all tree regeneration present; signs of deer browsing; topographic location, forest association, and stand conditions or changes in canopy on or near the milacre; and notes on the microrelief, rockiness, and limb or bole debris on each milacre. These detailed data are not presented.

Changes in the status of the understory vegetation of each milacre during each 5-year period were determined from the photographs and scored in one of three classes: (1) no change from that present in 1942; (2) a decrease since 1942; and (3) an increase since 1942. The color photos were found to provide the best basis for this scoring of trends. A stereo viewer was used to compare the 1942 photo with the later photos.

Results

Change in the amount of understory compared to the 1942 base condition increased with succeeding 5-year periods (Table I). Decrease in understory was much more common than increase.

The milacres that were scored as decreasing in understory vegetation outranked all other classes in 1952, 1957, and 1962, and were high (43%) in 1947. Lower and middle slopes, in particular, suffered declines compared with 1942.

Despite this tendency for the total tree, shrub, and herbaceous understory to become progressively less at each 5-year period, certain milacres were scored as increasing in total understory since 1942. The milacres that showed increases were relatively few but were found at certain periods on all topographic locations (Table I). Such increases were usually slight, since a small amount of growth, even of herbaceous plants, was enough to contrast markedly with that found on most milacres in 1942. Such increase in understory was chiefly due to increase of beech seedlings and root suckers in numbers and size.

DEER AND UNDERSTORY VEGETATION

The effects of whitetail deer browsing in the understory vegetation of this tract were observed by the author during the 7-year period 1935-42. It was evident that heavy browsing was killing the understory hemlock (*Tsuga canadensis*) and was greatly reducing the vigor of the witch hobble in the Cherry Run and Fork Run valleys of the Tionesta Area. By 1942 it was difficult to find remnants of the former dense understory of witch hobble, and nearly all regeneration of hemlock between 1 ft and 5 ft high was dead as a direct result of deer browsing. This study was established too late to show the most rapid period of decline in tree reproduction and shrubby growth as the deer population expanded in the 1930's. The results indicate, however, that there has been no recovery of the former hemlock and witch hobble understory during the 1942-62 period.

The detailed record shows that remnants of eastern hemlock advance-growth seedlings and heavily browsed stems of witch hobble were present in 1942 but had all died by 1952. A shift in browsing is indicated from the preferred but non-available forage species to the available but less palatable beech seedlings and root suckers.

In mature stands of hemlock-hardwoods the building-up of an understory of advance tree reproduction is a long process (Hough 1937, Hough and Forbes 1943). Stems of hemlock, beech, and sugar maple in virgin stands are often suppressed for long periods and may take 50-100 years to reach small-sapling sizes. If at any time during this period the advance reproduction is heavily and repeatedly browsed, the smaller stems will be weakened and mortality may be heavy.

Of the shrub species, only the winter holly berry (*Ilex monticola*) sometimes exceeded the reach of adult deer. Though deer browsing has been found to be beneficial as a natural means of lower-branch pruning of understory conifers in the Adirondacks (Webb 1957), no such benefits were found in the Tionesta Area: here practically all the deer-pruned hemlocks died. Horn-rubbing by adult deer to remove the velvet has also been noted on sapling-size trees on these milacres, and several such badly scarred trees died during the 20-year period.

Because of its location near the center of the Allegheny National Forest, good cover of large timber, few roads, and proximity to large sawlog cuttings made by the Central Pennsylvania Lumber Company, the Tionesta Natural and Scenic Area was, and still is, a natural refuge for deer during the winter months. Most of the damage to the understory during the winter seasons following 1935 was due to continued browsing on weakened vegetation by an excessive deer herd (McCain 1941). If continued indefinitely, such constant pressure on the forest understory could prevent the establishment of advance growth of the climatic climax tree species. It could result eventually in changing the existing climax forest into a secondary successional stage, as the older elements of the overstory drop out with age and comparable species in the smaller-size classes are not present to replace them. Admittedly, such a change would take place very slowly; and many people might deny that the white-tailed deer had any part in this process.

Any attempt to maintain a limited tract of forest in a natural condition is subject to the hazards of a man-caused build-up of herbivorous animal populations in the large surrounding area. This upsetting of the natural balance could not occur if the entire Allegheny Plateau were in its original virgin condition. However, logging, extermination of predators, reintroduction of the white-tailed deer on game refuges, and protection of this species by game laws, have resulted in large deer populations and consequent hazards to tree growth. Unless some way is found to keep animal populations, such as deer, in balance in this particular forest stand, the objectives of scientific study, public education, and historic value will inevitably be lost.

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EFFECT OF PRUNING THE PARENT ROOT ON GROWTH OF ASPEN SUCKERS[1]

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Abstract. Various portions of the root systems of bigtooth aspen (*Populus grandidentata*) suckers were severed, and the subsequent height and radial growth of stems were measured. Aspen vegetative regeneration is heavily dependent on the parent roots for at least 25 years following initial suckering. The distal portion of the parent root contributes more to sucker growth than does the proximal. New roots at the base of suckers contribute little during the first 6 years, then become progressively more important with age, and by 25 years account for about half of annual stem growth.

INTRODUCTION

Following disturbances such as clearcutting or fire, aspen (*Populus tremuloides* Michx. and *P. grandidentata* Michx.) forests of North America regenerate largely by vegetative suckering from residual root systems of the previous stand (reviewed by Strothmann and Zasada 1957, Slabaugh 1958, Graham, Harrison, and Westel 1963). Rapid initial growth of these root suckers is evidence of a large dependency upon foods which were stored in the parent roots. Continued rapid growth indicates that the large, well-developed parent roots serve significantly in water and nutrient absorption for some time.

Zahner and Crawford (1965) discuss the clonal character and structure of aspen stands, including the phenotypic similarities in growth of adjacent stems which have arisen from the same parent root system. DeByle (1964) recently traced underground connections among stems in clones of bigtooth aspen (*P. grandidentata*), and showed that even at early ages, 6 years following suckering, the number of stems functionally interconnected through the parent roots is not large. He found each clone composed of both individual stems and groups of interconnected stems; the interconnected groups varied in size from 2 to 10 stems. By dye translocation, DeByle found approximately one-third of the stems in bigtooth aspen clones growing independently, not connected by the parent root to other stems in the same clone. After several vegetative generations following fires and cutting, it is not surprising that many suckers occur as individual trees, or in groups of only two or three, developed on fragments of older root systems.

As young suckers develop, the cambium and secondary vascular system aligns with that portion of the parent root immediately on the distal side of the sucker from the original location of the parent tree (Brown 1935). Diameter growth of the parent root in this region is nearly equal to that of the stem just above the root, with the result that the root on the distal side of the sucker becomes greatly enlarged, while that on the proximal side grows slowly. At the base of each sucker, varying numbers of new roots develop within a few years, and these gradually become the major root system for individual stems (Fig. 1). However, the old parent root remains alive and functioning for at least 40 to 50 years (DeByle 1964).

This study is an evaluation of the relative importance

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