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Bulletin of the New York State
College of Forestry at Syracuse University

Vol. X, No. 2
October, 1937

THE EFFECT OF DEER BROWSING ON CERTAIN WESTERN ADIRONDACK FOREST TYPES

By

John Pearce



Roosevelt Wildlife Bulletin

VOLUME 7

NUMBER 1

Published by the Roosevelt Wildlife Forest Experiment Station at the
New York State College of Forestry, Syracuse, N. Y.

SAMUEL N. SPRING, *Dean*

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Errata

The following errors were made by the printer in making the final changes in the text.

Page 39. Put period after "Forest" in legend for Fig. 20.

Page 49. "School" should be capitalized in legend for Fig. 25.

Inside back cover. Put comma after "Jul" in first line.



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Fig. 1. Old log chewed by deer. Piseco Lake region. Photograph by M. T. Townsend.



Fig. 2. Composted horse manure heap upon which deer had chewed extensively, Huntington Forest. Photograph by C. E. Johnson.

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By

JOHN PEARCE, *Collaborator*

*Roosevelt Wildlife Forest Experiment Station,
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INTRODUCTION

This study was inaugurated for the purpose of obtaining definite information relative to the quantitative effect of animal browsing on the future character of the timber stand. The silvicultural effect of browsing must be clearly understood before the inhabitation of forests by herbivorous animals can be made compatible with most other forest uses. Studies to this end are indispensable to intelligent forest-use planning.

The writer has attempted to present, primarily, the result of preliminary browsing investigations made in an area embracing two common western Adirondack forest types, i. e., the swamp and the spruce flat. This area had been previously cut over and subjected to deer yarding. Consideration has also been given to "preferences" shown by deer for the woody species encountered, the apparent ability of these species to withstand the adverse effect of browsing, and the initial attempt to name an indicator or key species, which reflects the general intensity of deer browsing. Since this paper is but the outgrowth of a thesis submitted by the author as a requirement for the Master of Forestry degree in silviculture at the New York State College of Forestry, it is not contended that final information is offered on any of the phases mentioned. The revised thesis material is herewith presented as a basis for further studies of a similar nature that are needed by foresters, biologists and wildlife technicians. The field data were obtained by methods which will have some degree of general usefulness. While this technique is treated at length, it will serve chiefly as a starting point for other investigators who seek to measure the influence of browsing on stand composition.

Certain drawbacks to the completeness of this study are acknowledged. Principally, the fact that the number of deer responsible for the browsing tabulated in the type studies is not known. Ignorance of this figure, however, is of less consequence in silvicultural studies on stand composition than in game management work. Future refinements of the procedure will undoubtedly call for studies on stands of known density influenced by known numbers of deer. An area which has been under close observation over a period of years also is desirable in order that the fullest possible history may be presented.

The white-tailed deer under consideration, *Odocoileus virginianus borealis* Miller, is the sub-species native to the Adirondacks. Its general browsing habits differ but slightly from those of other sub-



Fig. 3. Heavily browsed mountain holly. Sucker Brook yard. September, 1934.



Fig. 4. Heavily browsed red maple. Note instances of pronounced lateral growth following terminal browsing.



Fig. 5. Illustrating how inconspicuous hardwood browsing may be, even though fairly severe. Sucker Brook yard. September, 1934.



Fig. 6. White pine with terminal and laterals repeatedly browsed. Sucker Brook yard. July, 1934.

species in the East, although sharp differences may be found in the food chosen by the same sub-species inhabiting other sections of the country. This fact must be recognized at the outset in order to avoid confusion from seemingly contradictory statements in the literature. "Browsing" as used in this paper means "the feeding on browse," which Dixon (1934) defines as "shoots, twigs, leaves and fruits of woody plants."

Reconnaissance work was carried out in June, 1934, to locate a suitable study area in the Cranberry Lake territory. During this period an examination was made of the forest about the State Ranger School, Cranberry Lake proper, Peavine Swamp, and a considerable area between Big Deer and Clear ponds (Map 1). These areas contained several types, including virgin, old-cut, new-cut, and burned-over forest, in a wide assortment of conditions. All of these supported deer. However, the effect of deer browsing was most sharply defined in the well-drained swamp type and in the lower sections of spruce flat type, which were heavily cut about ten to twenty years ago. Consequently, this study is limited mainly to these two types of forest growth. The locality finally selected lies along Sucker Brook about two and one-half miles east of Cranberry Lake from Barber Point and is hereafter referred to as the Sucker Brook Deer Yard. Deer used this area as a wintering ground for several years. Detailed examination of the area was made in September, 1934, by the author, with the aid of Mr. Paul Zimmer as tally man. The data were gathered by recording the tree and shrub tally on milacre (one-thousandth acre) plots taken at regular intervals throughout the main portion of the yard. The common and scientific names of the trees mentioned in this report correspond with those of Sudworth (1927); of the shrubs, Rehder (1927). Only the common names appear in the text proper, but the corresponding scientific names appear at the end of the report on page 54.

I wish to express my gratitude to the New York State College of Forestry for enabling me, by means of a graduate fellowship, to pursue the field research and subsequent analysis of data connected with this study. For valued assistance, courtesies or constructive criticism I am grateful to the following: Miss H. Ruth Merrill, Secretary of the Roosevelt Wildlife Forest Experiment Station; Prof. James F. Dubuar, Director of the State Ranger School at Wanakena; Messrs. T. R. Phillips and O. W. Oja of the Huntington Forest at Newcomb and Mr. Wilford A. Dence of the faculty. I am particularly indebted to Prof. E. F. McCarthy, also of the faculty, for his many kindnesses and helpful counsel.

HABITS OF WHITE-TAILED DEER TENDING TO INFLUENCE FOREST GROWTH

Certain habits attributed to the normal life history of the deer have a direct bearing on the findings. Much has been written on the subject by many able naturalists and it would be beside the point to present a thorough review of their work at this time. However, a brief summary of several pertinent browsing habits will undoubtedly prove helpful.

Seasonal Changes in Diet and Range.—The autumnal change in the diet of deer from herbaceous plants to browse is induced chiefly by cold weather withering the succulent material. Coincident with snowfall comes a reduction of the daily range, which reaches greatest restriction during yarding periods enforced by deep snows. However, the actual diminution of the range may not be as great as is sometimes thought. The normal range of the white-tailed deer throughout the year is less extensive than that of most large mammals. Seton (1909) places it at less than any other species of native big game. Leopold (1933) sets it at about five miles.

During extended yarding periods young trees may be subjected to considerable damage, particularly when the deer are confined for two or three months. Obviously the damage is more uniformly scattered during open winters when deer yard only for short periods.

The term "yard" has not been standardized for all parts of the country. The eastern usage of the word generally means the immediate vicinity to which deer are confined in heavy snows—an area, or occasionally several closely connected areas, used by a band of deer. Townsend and Smith (1933) define a yard as being, typically, a swampy area and its adjacent slopes.

Deer herds indicate a strong desire to remain on a definite range: they oftentimes continue to inhabit heavily-used, over-browsed areas rather than travel to easily accessible areas for better feed. Several individuals have noted this peculiar phase of deer nature: Pearson (1925), the Pennsylvania Board of Game Commissioners (1930), Clepper (1931) and Ruhl (1932) have all remarked on it. The hidden factors which cause such seemingly illogical habits are significant, but beyond the scope of this investigation. This has a direct bearing on the use of deer yards, however, inasmuch as yards are frequently used season after season in spite of the greatly reduced food supply. The only over-browsed areas encountered were former yards.



Fig. 7. Snowshoe rabbit skull. Note efficient upper incisors.



Fig. 8. Skull of Adirondack buck. Note lack of upper incisors.



Fig. 9. Twigs bitten off by deer and rabbits. Those bitten off by rabbits are on the right in A and B. Compare these with the knife cutting on the right in C.



Fig. 10. Typical rabbit damaged red spruce. Note that the top, being out of ordinary reach, was not damaged while the lateral branches were greatly affected. Oswegatchie River, near Ranger School. June, 1934.

Browsing Procedure of Deer.—A very pronounced characteristic of deer is their unmethodical manner of feeding upon a plant. At the first browsing they seldom strip, completely, shrubs or saplings over one or two feet in height. Their method of feeding has a certain daintiness which led Caton (1880) to comment on the "delicacy" of their feeding habits. Toumey (1928) and Townsend and Smith (1933) used the term "selective" to describe deer browsing. These remarks have been borne out by my own observations on deer feeding in several localities. Frequently they eat a few twigs or leaves at one point, stop and glance around, proceed rather nervously for a few steps, take a few more bites and move on—even when in no way alarmed. Consequently, plants are less affected and better able to continue growth than would be the case if heavily browsed. The accumulative effect of the light feeding damage over a wide area tends to prolong the life of the plants. As a result a deer herd may be supplied with food for a longer period of years.

Uncertain Tastes Developed by Deer.—The uncertain choice of food by deer is sometimes a factor to be considered in the forest. Schenck (1909) says that the greatest damage is done to the rare species of plants which seem to arouse the curiosity of deer. Shepard (1934) mentions cases of European deer peeling spruce bark—the reason being attributed to faulty diet. As an extreme example of what may be attractive to deer, Job (1915) cites an established instance where thirty-eight deer died on a preserve from eating poisoned mice. Rutledge (1931) sums up the situation, paradoxically, by saying that it is "much harder to discover what a deer will not eat, than what it will."

The inconsistency with which deer feed on any one species of plant is even more surprising than their taste for strange food. Investigations by Clepper (1931) in Pennsylvania indicate that many species of browse plants are usually more attractive to deer if grown on recently burned lands than browse of the same species grown on unburned lands. Tree planting experience in the same state lend weight to the idea that trees planted in fertilized nurseries are more attractive to deer than those reproduced naturally on unfertilized soil. This seemingly is due to the higher mineral content in plants grown on newly burned or fertilized areas. Coville (1929) reports a case where deer apparently showed a decided preference for western yellow pine, *Pinus ponderosa*, grown from Black Hills seed to that grown from seed from some other sections. Chemical variation in

the different stocks was advanced as a theory for the choice. Mitchell and Hosley (1936) cite an example of a definite increase in browsing due to increased nitrogen content brought on by fertilizing. Clepper (1936) mentions investigations made by Prof. G. S. Perry, which indicate that increased mineral salts are found in forest soils following silvicultural thinnings. This may account for the well known deer preference for sprout growth.

Sociability of Deer.—Deer congregate in loosely organized groups after the rutting season. Each group, averaging from five to twenty individuals in the Adirondacks, usually remains together until spring. Feeding proceeds with the whole group much the same as with solitary individuals. An average area is covered several times, and a network of trails is established before overbrowsed conditions become general. The existence of these trails in the yards become increasingly useful as the snow gets deeper and the deer grow weaker.

A METHOD FOR MEASURING THE INFLUENCE OF DEER BROWSING ON THE COMPOSITION OF YOUNG STANDS

In considering methods of gauging browsing influence on forest growth one should bear in mind the wide diversity of natural stands. The minute differences of two areas in the same forest type only serve to emphasize the greater variation between separate types. It is not likely, therefore, that one method can be used in another section without deviation. The method used in this study is described in detail because there is a scarcity of such information in forestry literature.

Sampling.—A statistical summary, comprising the quantity, status and species of plants of the area, is the first requisite of a quantitative browsing study. Obviously a 100 percent tally of all vegetation on even a small deer yard would be a formidable task and not in accord with present day knowledge of sampling procedure. Therefore, in order to arrive at a sound representation of the woody growth on the area it was considered best to use sample plots. In order to minimize errors in personal variation these plots were of uniform size and spacing. The "quadrat-at-interval" method of Clements (1905), which is frequently called the "line-plot system," was chosen as the most efficient means to this end. For convenience, thousandth

acre plots were adopted. These were taken along cruise lines run at right angles from an established baseline (see sketch p. 23). This system included samples within the spruce flat type as well as the swamp type. The cruise lines were one-half a Gunter's chain (33 feet) apart. The plots were located 33 feet apart and forward of the half-chain point along these lines. The distance between the plots was established by pacing, while two straight poles, 79.2 inches in length, were used for laying off the sides of the plots. A tape measure could be used to check the diagonal distance of 112.005 inches.

Tallying.—While it must be acknowledged that each plant species probably has some ecological influence on every other associated species, nevertheless in dealing with a study of forest types it is obvious that the major influences affecting tree species are the main factors to consider. The influence to be considered in this particular study concerns deer browsing, therefore the data is limited to the species of woody plants that affect the composition of the stand. In certain areas herbaceous plants may be sufficiently abundant to have a decided effect on woody plants, but that is not the case in the Sucker Brook yard.

A specially designed form was used for tallying. The information contained thereon is outlined below:

A. Hardwood tree species

1. Browsed

a. Dead

(1) Height class and number times browsed back (leaders) while alive

b. Alive

(1) Height class and number times browsed back (leaders)

2. Unbrowsed

a. Dead

(1) Height class

b. Alive

(1) Height class

3. Escaped

a. Dead

b. Alive

B. Softwood tree species

1. Browsed

a. Dead

(1) Height class and number times browsed back (leaders) while alive

b. Alive

(1) Height class and number times browsed back (leaders)

2. Unbrowsed

a. Dead

(1) Height class

b. Alive

(1) Height class

3. Escaped

a. Dead

b. Alive

C. Shrub species

1. Alive

a. Degree of abundance

(1) Sparse

(2) Common

(3) Abundant

b. Degree of browsing

(1) Light

(2) Moderate

(3) Heavy

c. Height class

2. Dead

a. Abundance as above

b. Browsing sustained while alive

(1) Light

(2) Moderate

(3) Heavy

c. Height class

3. Escaped

a. Alive

b. Dead

Specimens in the escaped class are not listed as browsed or unbrowsed. This classification was omitted because of the general impossibility of stating, after the lapse of a few growing seasons, the extent of browsing previous to escaping. Large trees were not tallied because the majority of them were culls which had only slight influence on the young growth in the two types.

Explanation of Terms Adopted for Sample Plot Tallying.—

Height Classes

INCHES IN		INCHES IN	
CLASS	HEIGHT	CLASS	HEIGHT
1-foot	1—12	5-foot	49—60
2-foot	13—24	6-foot	61—72
3-foot	25—36	Escaped	73—
4-foot	37—48		

It is practically impossible to state at what height a tree will be absolutely safe from tip browsing, because many factors must be considered. The possibility of deer "riding down" trees by straddling them to get at the tops, the presence of large rocks, heavy snow weighing down the crowns, and packed and drifted snow—all permit the browsing of an occasional escaped tree at an abnormal height. Yarding sites in the Adirondacks are protected, ordinarily, from the wind force necessary to pack snow firmly enough to support deer. Heavily-crusting snow usually occurs for short periods only. The escaping point was established by computing the lowest average height at which trees in the district were free of tip browsing. This was accomplished by determining the highest point at which browsing had occurred on escaped trees, found along several random lines. Care was taken to do this on areas which obviously had been browsed well during the time required for the trees to escape. The standard height as adopted (6 feet) is about the same as that arrived at by Hosley (1931), Bailey (1933) and others. Mr. A. V. S. Pulling, Assistant Superintendent of the Upper Mississippi Wildlife Refuge, however, in a personal letter states that he has seen trees "much browsed" at seven feet, and some as high as nine feet where hard-packed snow occurred in Wisconsin.

Degree of Browsing. The approximate intensity of browsing sustained on plants, including trees and shrubs, was classified arbitrarily as (1) light, (2) moderate and (3) heavy. The following is a description of the three classes:

LIGHT BROWSING—Damage so slight that it may be overlooked. Little effect is apparent on the plants.

MODERATE BROWSING—The plant visibly, but not seriously affected. A somewhat trimmed effect is apparent.

HEAVY BROWSING—Plant critically affected; decided interference with height growth. An excessively trimmed appearance frequently noticed.

Degree of Abundance. An approximation is necessary where exact counts cannot be applied readily to the stems on a plot; for example, clumped shrubs which fork from low stems. It so happened that a loose classification fitted the requirements of this study—three degrees of abundance were adopted as standards for the work. These are described as:

SPARSE—One to six single stems, or a clump of about six stems per milacre.

COMMON—Seven to twelve single stems, or not more than three clumps each of about six stems per milacre.

ABUNDANT—Over twelve single stems, or more than three small clumps per milacre.

Those who would have a more definite count of the shrubs may criticize this system. But it is not simple to devise one, especially after moderate or heavy browsing has caused profuse sprouting of a species which suckers or layers easily (See Fig. 23).

Recording Terminal Browsing. Evidence of deer browsing on woody stems usually remains for several years. Due to this fact it was possible to determine definite years of yard occupancy. This was done by making growth-ring counts immediately below the browsed ends and comparing these with the subsequent growth resulting from the buds below the breaks.

By close examination also it was possible to state at least the minimum number of times the terminal buds of unescaped trees had been browsed. Since the regular increment of additional height becomes a critical factor in young stands which must grow beyond a certain point to escape perennial damage, the determination of shoot browsing is important. The ease and accuracy with which this "browsing back" can be determined depend upon the tree species browsed and the time elapsed since the feeding. The "number of times browsed" as herein used, refers to the apparent number of times the original leader (or the subsequent shoots assuming the lead) had been turned aside from regular growth by browsing deer. If based on visible evidence the minimum always will be the recorded number of browsings. For example, a shoot appears to have been broken off but once, although the stem is possibly more than a year old, and an older break is not visible. Again, evidence cannot be recorded unless the work is definitely attributed to deer. Rotting of browsed stubs is a common cause of uncertainty on this score.

Maples, and other opposite-budded species, are exceptionally favorable specimens for collecting data on old browsing. In the winter when such species lose their tips the sections back to the first pair of buds die. In the following spring each bud of the pair develops into a branch forming a Y-shaped crotch with the browsed dead stub in the center. The age of the crotch may be determined during subsequent years by ring counts of a section near its base. It often happens that a series of such crotches may be traced out when each succeeding crotch is browsed, provided the stubs in the crotches remain to be identified as deer damage. Alternately budded species were somewhat less adapted to such studies, although on most stems it was possible to distinguish several browsings. When this type of shoot is broken the nearest bud generally develops into a new leader which grows at a slight angle to the stem. A zig-zag appearance is thus produced when such a branch has been browsed repeatedly for several years. When the little stub disappears, only the angle in the twig or branch, and a slight disconformity in the bark mark the former break. This evidence is less conspicuous in later years than is the "crotching" mentioned in connection with opposite budded species. In either type of budding, the confirmed habit of the deer to feed only on the growth of the previous season, unless very hard-pressed, is a distinct help in ascertaining the dates of old damage. The browsing dates of such softwoods as white pine, tamarack and balsam can be determined in a similar manner. In these species a lateral branch frequently grows upright from the first whorl below the break to replace the lost terminal. Sometimes the most promising lateral is browsed before it is wholly upright. The effect of this check is actually equal to a browsing of the leader.

Distinguishing Between Deer and Rabbit Browsing. Except in rare cases the ends of deer-browsed twigs can be differentiated from those clipped off by rabbits. Rabbits have an efficient set of upper and lower incisor teeth while deer have no upper incisors (Fig. 8); the former gnaw off twigs while the latter hold them against their upper jaws and break them off over the lower incisors. Therefore the ends of twigs severed by deer are nearly square across but quite rough (often with hanging shreds of bark and wood) while those severed by rabbits are slanting but relatively clean and smooth (Fig. 9).

THE INFLUENCE OF DEER BROWSING IN THE SUCKER BROOK YARD

Description and History of the Yard. The sketch map opposite this page shows the principal features of the Sucker Brook yard. Roughly, this yard comprises about a square mile of irregularly outlined swamp land hemmed in by an esker (paralleling Sucker Brook) and slope formations—the latter supporting a spruce flat forest type. These features combined with the excellent cover make an attractive yarding ground for deer. Figure 12 illustrates the general aspect of the cut-over spruce flat type. A small remnant of swamp growth appears in the foreground; the esker in the left background. The area was cut some thirty years ago for softwood (red spruce and white pine) saw logs; then in 1918 and again in 1923 for pulp (spruce and balsam fir). The second pulp operation included all softwoods down to five inches in diameter—virtually a clear cutting in the swamp. However, in the spruce flat type all the merchantable hardwood was removed, in addition to the pulp wood, leaving a very scattered stand of advanced reproduction and culled old growth. Both types seeded in rapidly and a heavy stocking of young growth was the result. This growth provided excellent winter deer browse.

Mr. Warren Guinup, a local resident, states that deer have never been more than moderately abundant here in the winter time, the average population being from 8 to 12 deer. They make very little use of the area in the summer—a number of old work trails and haul roads serve as runways in crossing the yard.

Description of Forest Cover Types in the Yard. The literature dealing with Adirondack forest types is confusing because several authors have used different names for essentially the same types. The most widely used type designations appear to be those of Pinchot (1898) and Graves (1899). Their classification is used for this study, although we are concerned with only two of the four types originally described; namely, swamp and spruce flat. These may be described briefly as follows:

SWAMP TYPE—Low flats with wet soil (bogs not separated from drained swamps). Red and black spruce, balsam, tamarack, soft maple and white pine are characteristic species.

SPRUCE FLAT TYPE—Level and rolling "flats" bordering lakes, streams and swamps; soil fresh and frequently moist. Red spruce, yellow birch, red maple, white pine, hemlock, occasional sugar maple and balsam are the characteristic species.

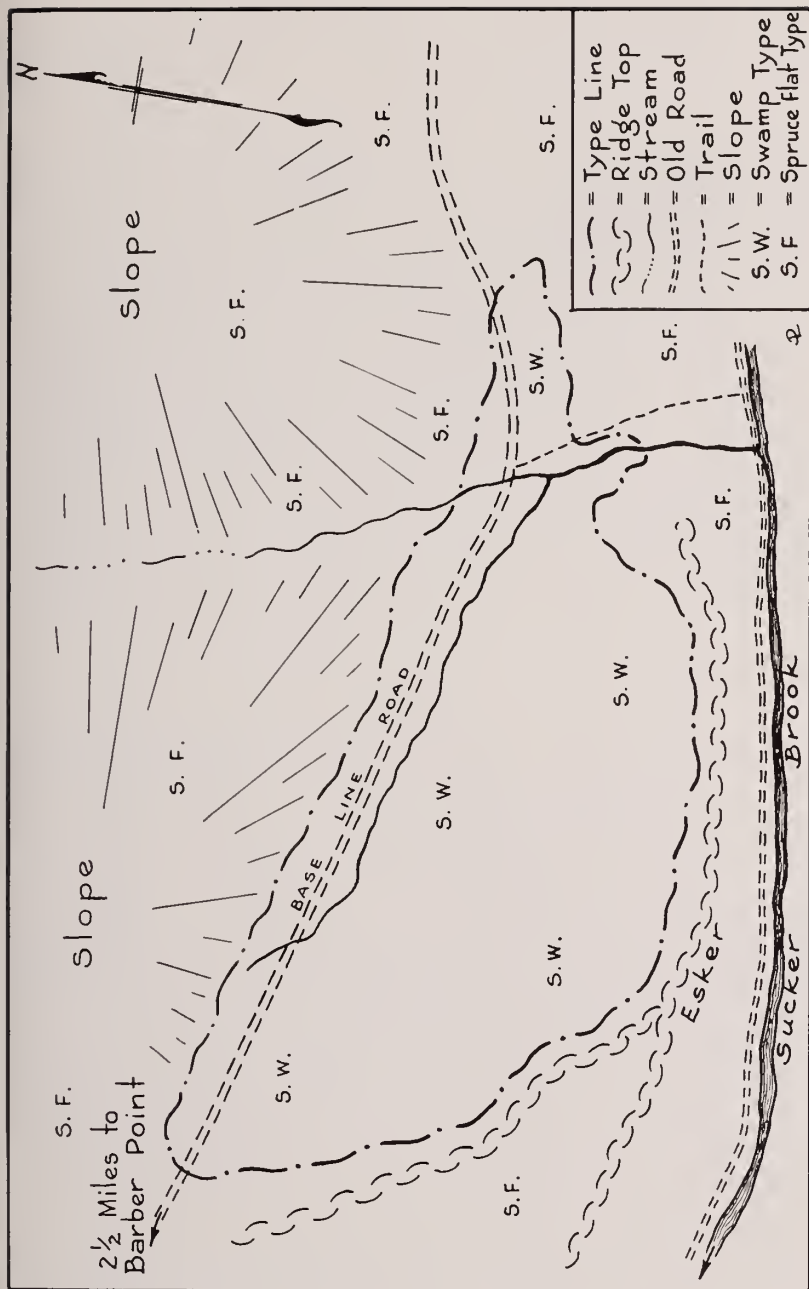


Fig. 11. Sketch map of the Sucker Brook yard showing location of the two types and other features.

In reality, the basis of separation is topographical location. The terms "swamp" and "spruce flat" have been used widely because of their convenience, but they are misleading since they may be assigned to areas which do not conform to the mental pictures suggested by the names themselves. The swamp type may be well timbered and without standing water, while the spruce flat may be quite hilly. According to authoritative information the 1923 pulp cutting left the swamp with only an advance reproduction for cover. This was composed primarily of red spruce, red maple, and balsam, which had become established, chiefly since the 1918 cutting. However, by 1934, a total of some thirteen tree species and fifteen shrub species were represented, but the three principal species of the reproduction, dating from 1918-1923, had strengthened their numbers so that they continued to predominate. These predominant species were present in the following ratios: red spruce, 11; red maple, 11; balsam, 3.

The spruce flat of Pinchot and Graves (*op. cit.*) covers two distinct zones which usually may be seen by traveling up the slope from the swamp type. Red maple and balsam are found commonly at the edge of the spruce flat, but as the ascent is continued—first the balsam, then the red maple tend to drop out, to be replaced by beech and sugar maple at a somewhat higher elevation. The sample plots for this type were located where red maple is still common, but beech and balsam are scattered and sugar maple is so rare that it appeared only once in the tally. A small series of plots included in the analyses were taken at Curtis Pond, about three quarters of a mile east of Sucker Brook, in essentially the same situation. Unlike the swamp type studied, the spruce flat has an overstory, composed mostly of scattered birch culls. The overstory was rather open, as may be seen from Figure 12, and this resulted in an abundant reproduction on all sides. Red spruce, yellow birch and red maple predominated by a great majority and were found in the ratios of about 7 red spruce to 6 red maple to 4 yellow birch.

ANALYSES OF SAMPLE PLOT DATA

Swamp Type. *Stand Composition in the Swamp Type Studied.* Since the .430 milacre plots represent .430 of an acre, theoretically the total tally per species was .43 of the per acre stand figures. Thus computed there were 12,955 trees per acre in the stand. The probable numerical distribution of this stock, by species, is shown in Table 1, which gives a general idea as to the composition of the stand at the



Fig. 12. General view of the Sucker Brook yard at its southern extremity. Esker in left background. Remnant of swamp type vegetation may be seen in the foreground. September, 1934.



Fig. 13. View of spruce flat reproduction on the esker beneath the overstory of scattered culls. September, 1934.



Fig. 14. Old growth swamp type virgin timber. Note lack of undergrowth. Across the Oswegatchie River from the Ranger School. June, 1934.



Fig. 15. Typical old growth spruce flat. Photograph by R. T. Hatt.

time of tallying. However, the distribution of the principal species—red spruce and red maple—among the plots, is indicated in a chart (Figure 16). This chart shows graphically how many times each

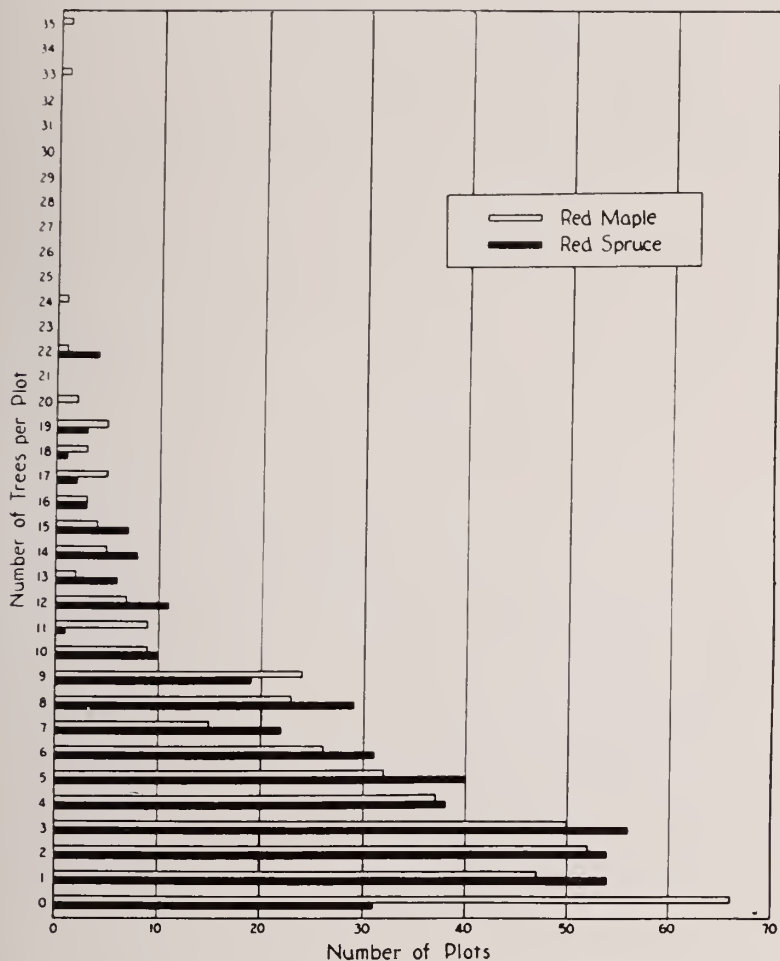


Fig. 16. Distribution of frequency classes of chief swamp species among sample plots.

frequency class (number of a particular species per plot) occurred for the tally as a whole. A total of 399 plots contained spruce; 364 plots contained red maple. An expression of the general distribution may be given by applying Gleason's (1920) Frequency Index which is used to measure frequency incidence in plant ecology.

$$\begin{array}{r}
 \text{FI} = \frac{\text{No. quadrats containing the species}}{\text{No. of quadrats taken}} \\
 \text{Red Spruce} - \frac{399}{430} \text{ or } .928 \text{ or FI of } 93 \\
 \text{Red Maple} - \frac{364}{430} \text{ or } .846 \text{ or FI of } 85
 \end{array}$$

Table 1 and Figure 16, as well as the high FI of both species, indicate that these two species are generally distributed.

TABLE 1. PROBABLE STOCKING PER ACRE OF THE TREE SPECIES IN THE SUCKER BROOK YARD. BASED ON 430 MILACRES IN THE SWAMP TYPE AND 168 MILACRES IN THE SPRUCE FLAT TYPE.

Species	Type	
	Swamp	Spruce Flat
	No. of Trees	No. of Trees
Maple, Red.....	4,965	4,067
Birch, Yellow.....	1,085	2,482
Ash, Mountain.....	137	113
Beech.....	23	298
Maple, Striped.....	.....	101
Maple, Sugar.....	2	6
Cherry, Pin.....	7	60
Cherry, Black.....	2	24
Aspen, Trembling.....	5	.....
Birch, Gray.....	2	.....
Spruce, Red.....	5,135	4,558
Balsam.....	1,285	54
Pine, White.....	230	54
Tamarack.....	21	.....
Hemlock.....	5	60
Spruce, Black.....	51	.....
Totals.....	12,593	11,877

Considering the preponderance of the maple and spruce which comprise 76.8 per cent of the stand, any important influence in the yard affects one or both species. Obviously the other species have

scarcely enough numerical strength to compete successfully for predominance. However, it must not be construed that the remainder is to be ignored because of its unimportance. The condition of the browsed maples reflects more or less the condition of all the species that were competing with red spruce (except for a few black spruce). This fact is described further in the subsequent discussion.

Distribution of the Deer Browsing. According to my findings in the swamp type plots 97.9 per cent of the red maples six feet or under in height (Table 3) had been browsed by deer. Two and one-half per cent or only 102 trees per acre sustained no browsing. These percentages and those following, which concern browsed and unbrowsed trees, were calculated without including "escaped" trees (those over six feet in height). It is impossible to tally with reliable accuracy the amount of browsing sustained by this class of trees before reaching the 6-foot height. However, due to the few escaped maples per acre the error introduced is small.

One browsing will not materially affect red maple, so it might be well to consider how the damage has been distributed among the six height classes. The result of my field studies shows that all the browsed trees over four feet in height had sustained at least three terminal leader browsings, but as the trees neared the escaping point, the total of such browsings showed material increases. For the 5-foot class the average tree was browsed 4.2 times; for the 6-foot class, 4.6, whereas the general average was approximately 2.5 for all six classes. Only one live maple on the entire 430 plots had reached the height of six feet without being browsed. Furthermore, 75 per cent of the unbrowsed maples were in the three lower height classes. These had the most hazardous heights yet to pass before escaping.

TABLE 2. PERCENTAGE OF PRINCIPAL SPECIES BROWSED. BASED ON NUMBER OF TREES IN UNESCAPED CLASSES ONLY, AND ONLY FOR SPECIES TALLYING 50 OR MORE IN THESE CLASSES.

Species	Type	
	Swamp	Spruce Flat
	Per cent Browsed	Per cent Browsed
Yellow Birch.....	99.1	98.1
Red Maple.....	97.9	96.6
Balsam Fir.....	89.0	.....
White Pine.....	85.7	.....
Mountain Ash.....	81.3	.....

Only four red spruce, or 00.2 per cent of the tally, had been browsed. This is equivalent to 9.3 trees per acre, in contrast to 4,774 trees per acre, or 97.9 per cent of the red maples that had been browsed. The unbrowsed spruce class contained 4,116 trees per acre (99.8 per cent of the tally for the species) in comparison to the 102 maples per acre that had escaped browsing by deer. The escaped maple class affords another interesting comparison. After sixteen years the total live escapes for the maple was 32 on the plots or 77 trees per acre; while for the spruce it was 334 on the plots or 777 per acre. If the question should arise in the reader's mind as to whether this might be due to a difference in growth rates, attention is called to the following discussion on growth and also to Table 4. He will then note that the *undisturbed* growth of red maple was much faster than that of the red spruce.

These facts illustrate the situation regarding red spruce and red maple. However, as previously stated 11 other tree species, representing 23.4 per cent of the tally, were found in this type. These minor species, when sufficiently abundant in the tally to be significant, average nearly the same as the red maple for amount of browsing sustained. Yellow birch in fact was even more thoroughly browsed (99.1 per cent) than red maple. Balsam, white pine and mountain ash, the others of any consequence (see Table 2), all sustained more than 80 per cent browsing, with the first two being nearer 90 per cent. Thus the deer have kept in check not only the red maple but the other competitors of the spruce as well.



Fig. 17. Red spruce outgrowing red maples subjected to perennial browsing. Transition from swamp to spruce flat type. Sucker Brook yard. July, 1934.



Fig. 18. Red spruce holding its own against browsed maples, edge of swamp type. Sucker Brook yard. July, 1934.

Pearce, John

TABLE 3. NUMBER AND PERCENTAGE OF BROWSED AND UNBROWSED TREE SPECIES IN SWAMP AND SPRUCE FLAT. EXCLUSIVE OF ESCAPES.

Species	Swamp			Spruce Flat		
	No. Trees	Per cent Browsed	Per cent Un-browsed	No. Trees	Per cent Browsed	Per cent Un-browsed
Maple, Red.....	2,047	97.9	2.1	607	96.7	3.3
Birch, Yellow.....	459	99.1	.9	416	98.1	1.9
Ash, Mountain.....	59	81.3	18.7	19	100.0	.....
Beech.....	10	100.0	.....	38	94.7	5.3
Maple, Striped.....	.....	.....	.....	17	94.1	5.9
Maple, Sugar.....	1	100.0	.....	1	100.0	.....
Maple, Mountain....	1	100.0	.....	4	100.0	.....
Cherry, Black.....	1	100.0	.....	3	100.0	.....
Cherry, Pin.....	3	33.3	66.7	10	90.0	10.0
Aspen, Trembling...	2	100.0	.....	.....	.....	.....
Birch, Gray.....	1	100.0	.....	.....	.....	.....
Spruce, Red.....	1,874	.2	99.8	561	.5	99.5
Balsam.....	653	89.0	11.0	9	88.9	11.1
Pine, White.....	77	85.7	14.3	9	100.0	.....
Tamarack.....	4	100.0	.....	.....	.....	.....
Spruce, Black.....	17	.....	100.0	.....	.....	.....
Hemlock.....	2	100.0	.....	10	100.0	.....

TABLE 4. SUMMATION OF GROWTH STUDIES
Red Spruce

Type	No. Trees	Total Height Feet	Total Age Years	Av. Height	Av. Age
Swamp.....	38	150	528	4.5	14.5
Spruce flat.....	10	89	143	8.9	14.3

Red Maple
Escaped

Swamp.....	26	364	389	14.0	14.2
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Browsed

Type	Average Times Browsed	No. Trees	Av. Height	Av. Age
Swamp.....	5	53	4.2	13.0

Comparison of Growth Rates.—The value of the above facts becomes more significant when we consider the different growth rates of red maple and red spruce. The comparison reveals that deer browsing may be called, appropriately, the most "significant variable" which affects the growth of red maple in the type. Red maples which had escaped showed an average annual growth of .93 feet as compared to .31 feet for red spruce. Individual trees showed surprising extremes. For example, a 17-year old one-foot red maple, apparently, had been browsed three times. If unbrowsed, the tree would have showed a height of between seventeen and twenty feet (Table 4). The three- and four-foot browsed red maples were frequently ten, twelve and even fourteen years of age. An unbrowsed maple ordinarily escapes in from five to eight years at the most in this type.

The Change in Stand Composition due to Browsing.—A material change in the stand composition is a consequence of deer browsing in this type. Instead of an area dominated by hardwoods we find an increasing dominance of red spruce. This reversal of expected conditions is remarkable in that the hardwoods, with the abundance and growth rates prevailing, might logically be expected to thoroughly dominate the stand. Studies by several authors show why this expectation is reasonable. McCarthy and Belyea (1920), Preston (1918), Meyers (1929) and Westveld (1931) have all demonstrated or otherwise described the aggressiveness of northern hardwoods in contrast to the slower-growing red spruce. Yet, in this case, the latter has established itself in a dominant position, not because of an inimical site for the hardwoods, but rather because of the damage suffered from deer browsing. A most significant point in this discussion is the fact that in order to favor spruce the hardwoods must be checked until the spruce crowns begin to interlock at the bottom. When this occurs the hardwood seedlings are thereafter shaded out. The situation illustrates on a small scale the same process that Leopold (1936) describes for many German coniferous forests where large deer herds are maintained on what was originally mixed-wood forests.

TABLE 5. SHRUB ABUNDANCE AND AMOUNT OF BROWSING ON
SAMPLE PLOTS
Swamp Type

Species	Abundance	No. Plots	Percentage Browsed			Percentage Un-browsed
			Heavy	Moderate	Light	
Shad Bush.....	Sparse	17				
	Common	6				
	Abund.	1	20.9	29.3	45.6	4.2
Blueberry.....	Sparse	36				
	Common	19				
	Abund.	....	16.4	50.8	32.8	....
Mt. Holly.....	Sparse	58				
	Common	36				
	Abund.	24	88.9	6.7	4.4	....
Labrador Tea.....	Sparse	2				
	Common	....			
	Abund.	....	....	50.0	....	50.0
Wild Raisin.....	Sparse	25				
	Common	39				
	Abund.	22	62.9	31.3	5.8	....
Meadow Sweet....	Sparse	5				
	Common	2				
	Abund.	2	....	11.1	44.5	44.4
Witch Hobble....	Sparse	7				
	Common	5				
	Abund.	1	53.8	46.2	....	....
Raspberry.....	Sparse	2				
	Common	2				
	Abund.	....	0.0	50.0	25.0	25.0
Honeysuckle.....	Sparse	11				
	Common	13				
	Abund.	....	75.0	16.7	8.3	....
Willow.....	Sparse	3				
	Common	7				
	Abund.	....	10.0	20.0	70.0	....
Viburnum sp.....	Sparse	1				
	Common	....			
	Abund.	....	....	....	100.0	....
Blackberry.....	Sparse	1				
	Common	1				
	Abund.	....	....	50.0	50.0	....
Alder.....	Sparse	3				
	Common	....			
	Abund.	....	....	....	66.7	33.3
Skunk Currant....	Sparse	6				
	Common	3				
	Abund.	....	....	....	100.0	....
Chokeberry.....	Sparse	18				
	Common	22				
	Abund.	10	42.0	46.0	10.0	2.0
Total.....	.....	410				

The Place of the Shrubs in the Swamp Type.—Due to the lesser importance of shrubs in the stand little has been said concerning them. While occurring on 95 per cent of the plots (Table 5), generally they were either sparsely or only commonly represented. They must occur abundantly, at least, in order to have any pronounced effect on the tree growth in the plots. Each species was browsed to some extent and generally shrubs were as frequently browsed as the hardwood tree species.

When shrubs are abundant in regenerating stands used by deer, the tree species are often subjected to less damage.

The Area as a Sample of Others in the Region.—In closing this analysis of the swamp type, mention is made once more that the particular area selected is not unique. While it does show the influence of more sharply defined deer browsing than in many other places, the fact remains that a number of similar situations about Cranberry Lake were subjected to much the same influence. The proportion of the species present may change. For example, in some parts of Forsaith's Bog (near lower Sucker Brook) balsam replaced the red maple as chief competitor of the red spruce. But here, as in the Sucker Brook yard, deer were feeding on the other species and neglecting the spruces.

Spruce Flat Type. *Stand Composition.*—In the spruce flat type, 93.3 per cent of the stand (reproduction only) was composed of red maple, red spruce and yellow birch, while the remaining 6.7 per cent was made up of ten species. In analysing the type the three principal species will be given greatest consideration because of their predominance. As in the swamp type, the remaining species align themselves with the maple and birch as competitors of the spruce. In Table 1 the total stand per acre for each species is computed by using the 168 milacre plots as a basis. Figure 19 gives a graphic representation of the distribution of each species according to the number of times each plot frequency class occurs. The following results are obtained when the data for the three main species are expressed by Gleason's Frequency Index (*op. cit.* page 25).

SPECIES	FREQUENCY INDEX	
Red Spruce	96.4	(96)
Red maple	77.3	(77)
Yellow birch	57.2	(57)

These frequency indices reveal that red spruce is very well distributed over the type, but that each of the two hardwoods is some-

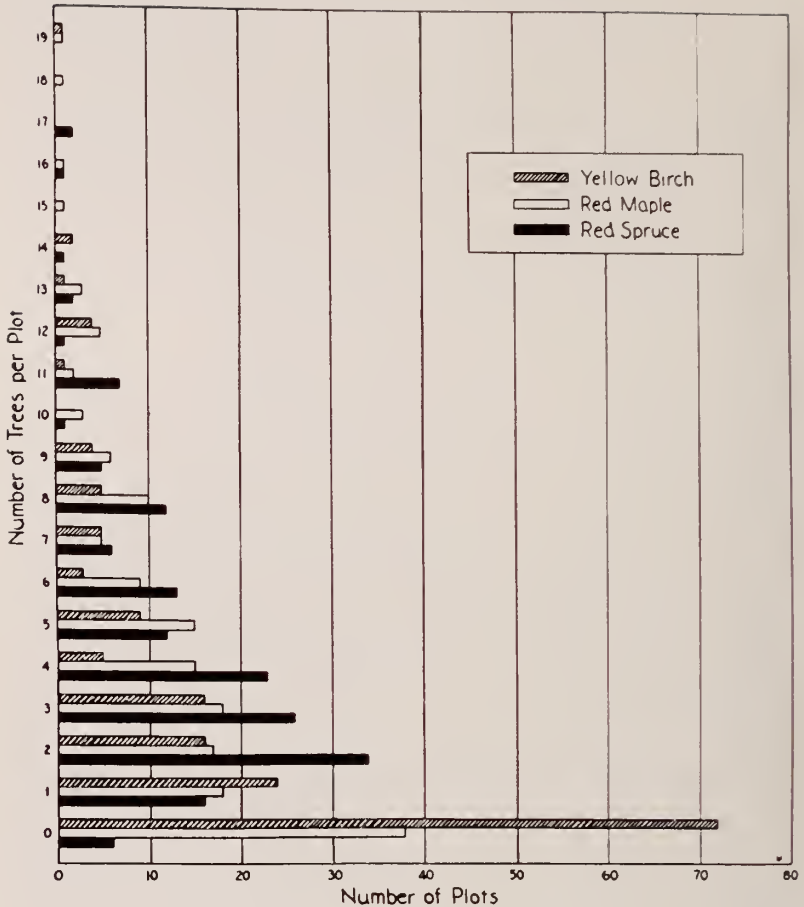


Fig. 19. Distribution of frequency classes of chief spruce flat species among sample plots.

what less general in occurrence. This might lead some to believe that the spruce was subject to less competition, and therefore the deer influence was even more pronounced than in the swamp type. However, there are apparently other factors operating against the spruce, that were absent in the swamp.

Distribution of Browsing.—Approximately the same degree of browsing on the principal species prevailed in this type as in the swamp type. Red maple was browsed in 96.7 per cent of the tally (Table 3), yellow birch, 98.1 per cent and spruce only 00.5 per cent. The browsing on the maple decreased slightly, while on the birch it remained about the same. This is perhaps due to the occurrence of more concentrated yarding in the swamp type.

TABLE 6. SHRUB ABUNDANCE AND AMOUNT OF BROWSING SUSTAINED ON SAMPLE PLOTS

Spruce Flat Type

Species	Abundance	No. Plots	Percentage Browsed			Percentage Unbrowsed
			Heavy	Moderate	Light	
Blueberry.....	Sparse	31				
	Common	21				
	Abund.	....	44.3	46.1	9.6	.....
Leather Leaf.....	Sparse	2				
	Common	2				
	Abund.	....	....	.....	....	100.0
Raspberry.....	Sparse	6				
	Common	6				
	Abund.	....	....	25.0	50.0	25.0
Mt. Holly.....	Sparse	2				
	Common	7				
	Abund.	3	91.7	8.3	....	.....
Labrador Tea.....	Sparse	1				
	Common	1				
	Abund.	....	....	.....	50.0	50.0
Honeysuckle.....	Sparse	2				
	Common	6				
	Abund.	2	80.0	20.0	....	.....
Hardhack.....	Sparse	2				
	Common	1				
	Abund.	....	33.3	66.7	....	.....
Sweet Gale.....	Sparse	2				
	Common	1				
	Abund.	....	....	.....	100.0	.....
Shad Bush.....	Sparse	2				
	Common	1				
	Abund.	....	66.7	.....	33.3	.....
Witch Hobble.....	Sparse	8				
	Common	9				
	Abund.	5	95.5	4.5	....	.....
Blackberry.....	Sparse	1				
	Common	2				
	Abund.	....	....	66.7	33.3	.....
Wild Raisin.....	Sparse	1				
	Common	1				
	Abund.	....	50.0	50.0	....	.....
Skunk Currant....	Sparse	1				
	Common	....			
	Abund.	....	100.0	.....	....	.....
Total.....	.....	129				

A summary of browsing sustained showed that the average live maple, within the 6-foot class, was 3.2 feet high and had been browsed 2.9 times. The yellow birch was smaller and yet the averages—1.5 feet for height and 1.7 times for browsing—compare favorably with similar figures in the swamp type. Probably the tendency of yellow birch to produce a profusion of new sprouts when a stem is browsed, rather than to grow persistently from buds of the browsed shoot, is partly responsible for the low average height. Table 3 shows that all the other species competing against the spruce sustained thorough browsings, although their numbers in each case was rather limited.

Shrubs in the Spruce Flat Type.—In Table 6 the column marked "abundance" shows that the shrub distribution in the spruce flat was considerably lighter than in the swamp plots (see Table 5). Only 77 per cent of these plots as compared to 93 per cent of the swamp plots contained them. All species of any consequence, numerically, had been browsed, although deer passed less time in this type than they did in the swamp type during yarding periods.

Comparison of Growth Rates in the Two Types.—Red maple and red spruce each showed an increase in the percentage of escapes in the spruce flat. This was especially true of the spruce which escaped in 26.6 per cent, as against 15 per cent, of the total cases recorded. Only 15.5 per cent of the maple escaped, but this was a substantial gain over the 1.7 per cent in the swamp type plots. It may be inferred that the growth was better. The younger spruce were less affected by the difference in site than the older ones, due to the naturally slower start spruce makes in early years. In the swamp the average height of spruce, under six feet, was slightly greater than in the spruce flat; yet the flat showed many more escapes. On the average those under six feet in the swamp were older than those on the better site. Due somewhat to the slow growth rate of the yellow birch its average height was much lower than that of the maple. McCarthy and Belyea (1920) found that red maple grows nearly twice as fast in the region as yellow birch. The slower growth of the latter, its unfavorable reaction to browsing and its special appeal to deer (see discussion on Preferences, page 43) undoubtedly are responsible for the almost complete failure to escape. Thus the influence of deer in the cut-over spruce flat regeneration continues to be a highly significant variable which favors spruce. By reason of the fact that fewer spruce are usually found, and hardwoods grow



Fig. 20. Cedars with dead lower limbs, Rich Lake, Huntington Forest
 Photograph by C. E. Johnson.



Fig. 21. "Escaping" red maples. The stems are badly crooked (upper right)
 due to heavy browsing. These points frequently become breaking points in
 later years. Cut-over land, opposite Ranger School, June, 1934.



Fig. 22. Witch hobble heavily browsed by deer.



Fig. 23. Heavily browsed witch hobble. Peavine Swamp. July, 1934.

more rapidly in this type, it is concluded that the latter are even more effective here in curbing the spruce, unless checked by some such factor as browsing.

THE INFLUENCE OF DEER BROWSING IN OTHER FOREST TYPES OF THE CRANBERRY LAKE REGION

Although time was too limited to permit intensive investigations in other forest types, fragmentary observations were made from June to September, 1934, in burns and old growth. Most of these areas were burns varying in age from about 10 to 25 years. While these observations lack the support of quantitative data they will, at least, pave the way for further study. They also will be helpful for comparative purposes.

Browsing in Burns. The burns observed were in three different age groups. The oldest, which occurred during the disastrous fire season of 1908, is scattered throughout the region. It has been restocked with a variety of mixed woods, and is interesting from the standpoint of deer browsing. The influence of deer browsing here was chiefly on poorly stocked low quality sites. The normal succession after burning was much retarded on such browsed sites, due to the slower rate of growth. Another burn near Barber Point, Cranberry Lake, originated just prior to 1916. The original forest was of the spruce flat type (mixed wood growth) but after a moderate burn it was restocked with a dense stand of hardwoods, which afforded abundant browse for several years. By the summer of 1934 this area provided poor rather than good browsing. The maximum browsing possibilities, occurred several years ago when the heavy regeneration of soft maple and yellow birch was within reach of the deer, and the herbaceous plants as well as the temporary shrubs were still present. Now tree growth has not only escaped, but has closed over in the crown. As a result ground cover has been killed and the growth of reproduction has been prevented. This course of events is the general rule on well-stocked northern hardwood stands, but is less acute in aspen, pin cherry or oak-hickory successions that grow more openly. The Bear Mountain (Cranberry Lake) burn of 1923, which covered steep, rocky terrain again illustrates the additional difficulty encountered by forest regeneration, particularly when browsed by deer and rabbits. Here, despite an abundance of seed trees that provided heavy restocking, the growth

was shrubby in many places. This stunted condition was the result of a poor site and browsing. More favorable sites in the same burn showed numerous escaped trees.

Browsing in Old Growth Types. The extent to which deer influence the forest cover in old growth depends largely upon the character of the mature stand. For example, deer naturally can exert little influence in a stand of dense virgin spruce with practically no undergrowth (Fig. 14). On the other hand old growth hardwood and "blowdown" openings in softwood stands provide a variety of browse plants because more light reaches the forest floor.

The control of witch hobble is one of the most conspicuous results of deer browsing on old stands—particularly in virgin-growth spruce flat and hardwood types—such as occur about Cranberry Lake. When uncontrolled this shrub prevents red spruce from coming in as an understory or advance reproduction, by virtue of the shade its wide leaves produce. While not always evident from casual observation, nevertheless witch hobble is frequently checked by deer browsing, particularly when the damage occurs in several successive years (figs. 23 and 24). The end growth on the old stems as well as the new shoots are browsed; the plants are thus less able to spread by layering or normal fruiting.

A striking instance of widespread damage to witch hobble was noted in the virgin timber directly east of the Ranger School forest. It was evident that until the past six or eight years extensive growth had occurred without undue deer browsing. But it is apparent that since that time repeated browsing on most of the plants has made severe inroads on once thriving patches.

Certain old growth hardwood stands comprising beech, yellow birch and sugar maple revealed a widespread, accumulative effect of deer feeding. While deer had repeatedly browsed the reproduction of the birch and maple they had neglected that of beech. Additional data on this phenomenon occurs later, under "preference" discussions, where it is stated that the maple and yellow birch were very acceptable to deer, while beech co-existing with them was generally neglected. This selection may, and sometimes does, result in an undergrowth of beech. A similar process goes on in all old growth reproduction where there is differential browsing among species.

These very generalized observations emphasize the slight but none the less real and widespread influence exerted by deer inhabiting nearly all types of forest growth. This fact has been ignored frequently in the past.

BROWSE CHOSEN BY DEER IN THE CRANBERRY LAKE REGION

Factors Influencing Browse Choice. Planned forest practices require an understanding of the choice exerted by browsing deer in regenerating stands. This need has been pointed out by several authors, and in U. S. Senate, Congressional report (1931). Bartlett and Stephenson (1929) recommended that experiments be carried out for the purpose of determining which species of second growth are the most satisfactory browse. Such information should be used with caution when applying the choice of browse in one locality to that of another range. Experienced investigators soon appreciate that factors, as yet, little understood, cause changes in choice of the same plants in different localities.

The term "preference" is not an apt one for describing the degree of acceptance of a given plant. Apparently it is used for want of a better one. Although objection to the word "preference" appears to be "hair-splitting" to some, the opposition to its use is valid, because continued choice of a species does not necessarily indicate "preference" in its strictest sense. Most investigators, however, assume that a species reflects, in all probability, the true "preference" when *consistently* chosen. Consequently the word has been accepted widely as a descriptive term of plant attractiveness to deer. It is used herein on the same basic assumption. There is, however, need for continual caution—in using the term and in making field studies—because food preferences of deer are difficult to determine. Whether the problem is approached from a study of stomach contents, by observation on a feeding individual or examination of the browsed vegetation, errors peculiar to the particular method tend to affect the results. Some of the more confusing factors influencing the opinion of the observer in naming the *apparent* choice of browse are listed as follows:

1. Disappearance of the less hardy but highly preferred species after a few years of relatively light browsing.
2. The acceptance of species not particularly preferred, due to concentrated population, or in winter to isolation.
3. Unexplained variation in deer tastes for the same browse species on different ranges.
4. Abundance of the staple browse species over the whole area. (When there is a scarcity of staple species those less preferred are sometimes eaten readily.)

5. The habit of deer in sampling nearly everything of an edible nature.

6. The individual tastes of certain deer.

7. Age or type of browse. Age and rate of growth result in differences in palatability. Sprout growth was chosen rather than normal woody growth. Even more refinement is noticeable in large budded species, for the buds are taken before the sprout growth. Sometimes there is a strong tendency to take the terminal buds of side branches on older trees and to neglect the remainder of the branch. Large trees felled to provide deer food were sparingly utilized in the early winter months of 1935 at the Huntington Forest. The preference for sprouts over top material also is noticeable on areas where logging has occurred consecutively for more than one winter and where sprout growth and newly cut tops are available.

The existing vegetation is used as a basis for analysis in studies of deer browse preference. Careful consideration has been given to these factors. Pulling (*op. cit.*, p. 19) has rightly called some of these "hidden variables."

Discussion of Browsed Species.—The apparent preferences for the trees (Table 3) and for the shrubs (Tables 5 and 6) on the area are based upon the percentages of the total tally browsed. The tables merely indicate the actual conditions. They are subject to the above-mentioned variables in some cases. The predominant species in each type were abundant enough to furnish a significant tally, but the limited data of the remaining species were supplemented by published records—especially where such information was considered important from the standpoint of managing the forest. For example, Clepper (1931) has prepared an extensive list in connection with the browsing preference in Pennsylvania woodlands. These areas were over-populated, however, in many cases, so that the listed preferences differ in some respects from those in normally populated areas. Maynard, *et al* (1935) give a preference list based primarily upon confined animals and, in addition, include analyses of the nutritive value of the various plants. The following discussion of the trees and shrubs of the two types studied is presented by species, or groups of species.

Maples.—The red maple was the only species of sufficient abundance in the sample plot data to warrant definite conclusions. Judging from the small amount left unbrowsed on the plots and its heavy utilization generally in the Cranberry Lake region, red

maple may be considered a winter staple for deer there. Striped, mountain and sugar maples were rather thoroughly browsed, but these species were poorly represented on the plots. These were also heavily utilized on several other areas in the Adirondacks. Maynard and his associates (1935) found maples, in general, to be good deer browse, but red maple was listed as being "readily eaten," yet not "best liked." However, their nutritional experiments (*loc. cit.*) showed this species to be an excellent deer food and capable of bringing the animals through the winter in good condition. Other writers also have found that the maples were readily accepted by deer in other parts of the East.

Yellow Birch.—Based on the plot data, yellow birch heads the preferred species list; the amount browsed totalled 98.6 per cent for both types. It appears to be quite generally utilized by deer throughout the Cranberry Lake country. I have been told by people from various sections of the East that the same choice prevails in other places. Maynard (*op. cit.*) classes yellow birch as a "best liked" species and because of its high palatability and food value lists it with red maple as a food for maintaining deer in healthy condition during the winter.

Beech.—As stated previously, beech apparently is less appealing to deer than the other common hardwoods of the region. The reason is not evident, but taste or the toughness of the twigs may account for its unattractiveness. Certainly, anyone who has attempted to break a beech stem realizes how much more difficult it is to break than a maple or birch twig. Deer appear to use the species during the stress of yarding conditions, for the tally (Table 3) shows that in the spruce flat type a total of 36 out of a possible 38 trees were browsed. This is in marked contrast to beech neglected in old growth located away from yards. Maynard (*op. cit.*) found that beech had little attraction to the confined deer.

Mountain Ash, Pin Cherry, Black Cherry and Aspen.—With the exception of the mountain ash, only a few specimens of each were found on the plots. As a matter of fact less than a hundred mountain ash trees were tallied for both types. This species is subject to considerable browsing in the yards and furthermore many trees are girdled by deer feeding on its bark. As a result of this damage, mature mountain ash are usually scarce about deer yards.

Black cherry and pin cherry were not especially singled out by deer in the region. However, under yarding influence they appeared

to be acceptable. While Clepper (1931) reports black cherry heavily browsed in Pennsylvania, this is not always the case. My personal observations in northwestern sections of the State were that areas of heavy deer concentration often showed very little use of this species. Black cherry leaves are known to be toxic to cattle, under certain conditions, but I did not find any record of deer being poisoned from this source. According to Chesnut (1898) and Gress (1935) the wilted or otherwise freshly damaged leaves, when eaten, give off a cyanic gas that results in paralysis of the lungs.

The aspens (large-toothed and trembling) were browsed very sparingly by deer in the region. With the exception of occasional feeding on vigorous unligified sprouts, slight damage was noted. Maynard considers this species as "poorly eaten," and Pulling (in correspondence) regards it as of little attraction. But I have seen sprouts extensively browsed on several areas in Pennsylvania forests. Mr. Odell Julander, of the United States Forest Service, has stated that the aspens are considered as the key species for the summer range of the Kaibab National Forest deer. The Kaibab Deer Investigating Committee (1924), Pearson (1925) and MacDonald (1934) found it well utilized, while McAtee (1936) referred to it as one of the better browse species.

Balsam.—Balsam presents a peculiar case in regard to its food value and choice by deer. This tree appears to be a choice food; furthermore, it is eaten so commonly in yards that many observers do not hesitate to call it a winter staple. However, Brandreth (1929) states that deer will die on a straight diet of it. Spiker (1933) cites examples of deer that apparently died from starvation although there was balsam browse in their stomachs. In May, 1927, I examined approximately two dozen deer skeletons and carcasses in a dense thicket of spruce and balsam near High Falls on the Oswegatchie River. These animals were trapped by deep snow during the previous winter with only spruce and balsam available for food. While the balsam had been heavily browsed, the available supply was by no means exhausted. Apparently the spruce was not browsed at all. Spiker (1933) says that in one observed case deer preferred white cedar and hemlock to balsam. Maynard and his colleagues finally produced conclusive proof (1935) that balsam really is a starvation ration for deer. Although the animals readily accepted the balsam they were not maintained in

good health. When unsupplemented, they lost weight rapidly and finally died. This illustrates how an apparent choice may be very confusing.

Northern White Cedar.—Northern white cedar undoubtedly is the choice coniferous browse of deer. But it is not common in all sections of the western Adirondacks. Bartlett and Stephenson (1929) list it as a staple in Michigan yards. According to Maynard (*op. cit.*) this species is highly preferred and capable of supporting deer throughout the winter because of its high nutritional value.

The line of dead branches on the lower part of cedars which fringe many northern lakes and ponds is a much debated phenomenon. The sharp demarcation between live and dead twigs and the uniform height are characteristic features of this line. No less an authority than Merriam (1884) attributes this condition to deer browsing. Many guides and hunters still accept this theory. Johnson (1927), however, offers convincing proof that it must be due to some other factor. As check I made a critical comparison of browsed cedar twigs with the dead branches of cedars forming the "line" about certain lakes in the Huntington Forest and I have concluded that Johnson's theory is correct. Characteristically, deer browse cedar rather completely, yet the finest twigs on dead branches of many cedars which compose this "line" are often intact (see Fig. 20).

Eastern Hemlock.—Hemlock was really too scarce in the sample plots to have any significance. However, it is an important browse plant in some parts of the region. Ehrhart (1936) points out that heavy browsing occurs on it in the Allegheny National Forest, a section where hemlock greatly outnumbers all other conifers. Maynard (1935) credits it with fair nutritional values.

Red Spruce.—The sample plot data indicates that red spruce is very unpalatable to deer. This conclusion is upheld by statements of several authors: Brandreth (1929) states "deer do not like it" and Spiker (1933) says that deer "seldom use it for food." In at least one instance spruce (unspecified) is reported as an important browse plant in New England (Hosley, 1936). However in some sections exotic and western species of spruce appear to be more acceptable than red. The Pennsylvania Board of Game Commissioners (1930) list certain of these species as being eaten more than the red; Burnham (1928) expresses a similar thought. I have

found Norway spruce in sections of northwestern Pennsylvania subjected to frequent deer damage, but generally to a lesser extent than the associated tree species. The average deer population per square mile in this region is several times that of the Adirondacks.

Other Conifers.—The sample plot tally indicates that in most cases white pine and larch are eaten by yarding deer. The white pine alone is represented by an appreciable tally. It escaped browsing in only eleven out of a total count of eighty-six trees under six feet in height. Clepper (1931) records white pine as being heavily browsed and larch lightly browsed.

Deer Preference for Shrubs.—Some shrubs appear to be highly preferred for browse. Summaries of shrub preference for the swamp and spruce flat types in the Sucker Brook yard appear in Tables 5 and 6. A discussion on the principal shrub species follows. The information is based on plot data, general observations made during the field work and supplementary references to the literature.

Witch Hobble.—This is probably the most generally utilized woody plant, particularly in old growth types, in the entire region. Deer feed on it during the dormant season, but I have noticed that before the advent of deep snow, only the large terminal buds are likely to be taken. Under the more stringent conditions of late winter most of the growth of the previous season is usually eaten. Since this plant is associated with shaded conditions characteristic of old growth forest, only a few were found on the sample plots.

Mountain Holly.—This species appears to have quite definite site requirements not generally found outside of the swamp type. It was widely distributed through the swamp type of the Sucker Brook yard. This plant usually sustained moderate to heavy browsing (95.6 per cent) and was an important browse source for deer.

Wild Raisin, Chokeberry and Honeysuckle.—These species, although not so abundant as mountain holly, were scattered through the swamp type and were moderately to heavily browsed. (In other regions I have found all of them browsed extensively.) Published data on the use of these species as deer browse are very meagre.

Blueberry.—The low bush blueberry was quite generally but only lightly or moderately browsed. Ordinarily, when a certain plant species has a high percentage of browsed stems the damage will be either heavy or moderate. Tables 5 and 6 reveal that in the



Fig. 24. Witch hobble heavily browsed after a period of light utilization. Ranger School forest. July, 1934.



Fig. 25. Very light-browsed witch hobble. Ranger school forest. March, 1935.

case of the blueberry only about 22 per cent was heavily browsed despite the fact that damage was noted on each of the 103 milacre plots inhabited by the species. Under the system used blueberries are perhaps the least satisfactory of all species to classify for browsing. The indication is, therefore, that this plant is not reliable as a staple. A deep cover of snow at critical periods may account in part for the light browsing.

Other Shrubs Encountered.—This group includes shad bush, willow, speckled alder, raspberry, blackberry and sweet gale. Most of these were too scarce to have any significance in regard to local preference studies. However, none was refused completely by deer. Usually shad bush, the only common species in this group was browsed lightly. (See tables 5 and 6.)

Deer evidently went to considerable trouble to get buds of the staminate aments of several speckled alder bushes located near the Ranger School in March, 1935; other parts of the shrub were neglected.

REACTIONS TO BROWSING DAMAGE NOTED AMONG SPECIES ON THE SAMPLE PLOTS

In certain sections more definite information concerning browse species in second growth stands is needed. Leopold (1933) recognized the need for such knowledge in order to coordinate game management with silvicultural practices. Various authors have described the reaction of certain species of woody plants to browsing. Mann (1932) says that some species of trees and shrubs show increased vigor when browsed. On the other hand, the Pennsylvania Board of Game Commissioners (1930) reports that several species, such as mountain ash and rhododendron, die when persistently browsed. Also the influence of browsing on the form of the tree has been considered. Hill (1917) believes there is no relationship between browsing injury and the common deformities of western yellow pine. Mougín (1931) in his paper on forest browsing by domestic animals states that such activities sometimes result in trunk damage that renders the trees subject to fungi attacks.

Factors Influencing Effect of Browsing Damage.—The determination of browsing resistance is rather involved. Accordingly certain factors which complicate the study of plant reactions to browsing will be discussed before the recorded reactions of the various species are considered. To begin with, it is usually impossible

to state definitely the cause for death of a browsed tree. Likewise, we do not know whether browsing impairs or actually increases the vigor of certain trees or whether this response is in proportion to the browsing sustained. Again, a host of other elusive variables enter into the problem.

It is obvious that browsed trees are more susceptible to disease and insect attack than unbrowsed ones. But consideration must be given to a number of other factors such as (1) exposure to excessive sunlight or frost (2) the presence of too much or too little moisture and (3) the type of browsing. The following list shows a few species which have persisted for several years in spite of heavy, perennial browsing. It is based on the number of times browsed and the percentage of living browsed woody plants on the sample plots. Only those well represented in the tally are considered.

TREES	SHRUBS
Yellow Birch	Mountain Holly
Red Maple	Witch Hobble
White Pine	Wild Raisin
	Shad Bush

Maples (sugar, mountain, striped), hemlock, skunk currant, chokeberry, willow and honeysuckle have withstood browsing fairly well in other sections and some of these may be more hardy than those listed above. For the swamp type six times as many browsed balsams died in the few years preceding the investigation as unbrowsed. As explained previously the significance of these figures in regard to browsing in general, cannot be definitely stated, but indications point to a low "browsing resistance."

The form and growth of red maple, as illustrated by Figure 4, may be affected for several years, if not permanently. Whenever groups of red maple escape after heavy browsing the escaping point is marked by a knot of dead stubs or an irregularity in each stem (Fig. 21). Some of these eventually suffer from decay at the old escaping point, while others develop sharp angles or are broken by snow and wind. Although white pine persists in spite of heavy browsing, it suffers considerably in form during the early years (Fig. 6)—this handicap may last for many years. Additional damage may result from butt rot at the base of the dead browsed stubs.

When heavily browsed, some species, such as yellow birch, exhibit strong tendencies to sprout from the root collar. Certain species, such as red maple, apparently put the excess vigor from the browsed branches into shoots. Mountain holly becomes very compact and hedge-like when heavily browsed, but when an opportunity occurs to escape it has plenty of vigor to throw out several shoots. When wild raisin has been heavily browsed for several years it usually forms abnormally dense clumps. This indicates that browsing encourages the growth of sprouts from the root system. The reaction of witch hobble is discussed under a different heading. Experiments may eventually provide more exact knowledge, when the variables are controlled or measured and clipping is done mechanically to simulate browsing.

Witch Hobble as a Key Species.—An important outgrowth of preference of browse and browse resistance studies is the selection of what has been termed a key species. That is, an indicator plant which will reflect by its own state the general intensity of browsing on an area. An ideal key species should have the following qualifications:

1. Common to all parts of the feeding ground.
2. Availability when needed by deer.
3. Capable of reflecting various degrees of browsing by its reaction to damage.
4. Stability as a food. Used habitually until the supply is exhausted—not a “tid-bit.”
5. Ability to survive although heavily browsed.

The seasonal change in deer diet, with respect to the western Adirondacks, obviously eliminates the possibility of finding a key species applicable at all seasons of the year. Therefore, consideration is given to a woody species that can be used to gauge only critical winter season browsing.

No other species encountered in the field, either tree or shrub, conforms to the requirements listed so well as witch hobble. This plant is generally distributed throughout the Adirondack forest. However, it is absent in most swamps, certain heavily cut areas and young burns. The other qualifications are well met. It is especially useful in demonstrating several intensities and stages of browsing (figs. 22, 23 and 24). Specimens which have sustained very little browsing produce long slender laterals, while constantly browsed stems become stunted and have a knotty appearance. A normal

witch hobble has buds or branches on the stem occurring several inches to about a foot apart. When a bud is eaten the stem dies back the entire distance to the next bud. Figure 24 illustrates heavy browsing succeeded by a period of light browsing, followed again by heavy browsing. In general, it was observed that when little browsing occurred on witch hobble, damage was correspondingly light on other woody species. Conversely, where heavily damaged witch hobble occurred, a general increase was noted in the browsing sustained.

SUMMARY AND CONCLUSIONS

1. At present western Adirondack deer usually browse woody growth during the dormant season only. This of course includes a portion of the fall and spring.

2. Evidence of deer browsing on young trees generally remains for several years. The date such damage occurred usually can be determined by careful examination of living specimens, often after a lapse of six or more years.

3. Deer do not usually browse on the leaders of trees six feet or over in height.

4. Deer feed on practically every woody plant except spruce, when in yards of the western Adirondacks.

5. Deer may enable red spruce to assume dominance by selective browsing on its competitors. This is especially true in drained swamp type where hardwoods, especially red maple and yellow birch, outgrow it ordinarily.

6. When red spruce is not dominant, as in most spruce flat regeneration, stand composition is nevertheless influenced because of damage to competitors.

7. In old-growth stands the composition of the understory is changed due to browsing of certain species in the undergrowth. This influence is cumulative.

8. Red maple, yellow birch, mountain holly and witch hobble have special appeal for deer in the western Adirondacks.

9. Red maple, yellow birch, mountain holly and wild raisin are particularly resistant to repeated browsing. Apparently balsam and mountain ash are not.

10. Witch hobble is the most satisfactory key species or indicator for the general degree of browsing sustained in old growth of western Adirondack forests.

SCIENTIFIC NAMES OF THE TREES¹ AND SHRUBS²
MENTIONED IN THE TEXT WHICH WERE
ENCOUNTERED IN THE FIELD

Trees

Aspen, Trembling.....	<i>Populus tremuloides</i> Michx.
Balsam	<i>Abies balsamea</i> (L.) Miller
Beech	<i>Fagus grandiflora</i> Ehrhart
Birch, Gray.....	<i>Betula populifolia</i> Marsh.
Birch, Yellow.....	<i>Betula lutea</i> Michx.
Cedar, White.....	<i>Thuja occidentalis</i> L.
Cherry, Black.....	<i>Prunus serotina</i> Ehrhart
Cherry, Pin.....	<i>Prunus pennsylvanica</i> Linnaeus fil.
Hemlock	<i>Tsuga canadensis</i> (L.) Carriere
Maple, Mountain	<i>Acer spicatum</i> La Marck
Maple, Red	<i>Acer rubrum</i> L.
Maple, Striped.....	<i>Acer pennsylvanicum</i> L.
Maple, Sugar.....	<i>Acer saccharum</i> Marsh.
Pine, White	<i>Pinus Strobus</i> L.
Spruce, Black.....	<i>Picea mariana</i> (Miller) Britton, Sterns, and Poggenberg
Spruce, Red	<i>Picea rubra</i> Link
Tamarack	<i>Larix laricina</i> (Du Roi) Koch

Shrubs

Alder, Speckled	<i>Alnus incana</i> Moench.
Blackberry, Mountain ...	<i>Rubus alleghemensis</i> Porter
Blueberry, Sour-top.....	<i>Vaccinium canadense</i> Kalm.
Chokeberry	<i>Aronia melanocarpa</i> Elliott
Hardhack	<i>Spiraea tomentosa</i> L.
Honeysuckle, Fly	<i>Lonicera oblongifolia</i> Hook
Labrador Tea.....	<i>Ledum groenlandicum</i> Oed.
Leather Leaf	<i>Chamaedaphne calyculata</i> Moench
Meadow-sweet	<i>Spiraea latifolia</i> Borkh.
Mountain Ash	<i>Sorbus americana</i> Marsh.
Mountain Holly.....	<i>Neuopanthus mucronata</i> Trel.
Raspberry, Red	<i>Rubus idaeus</i> L.
Shad Bush.....	<i>Amelanchier canadensis</i> Med. ³
Skunk Currant.....	<i>Ribes glandulosum</i> Grauer
Sweet Gale.....	<i>Myrica Gale</i> L.
Viburnum	<i>Viburnum</i> sp. ⁴
Wild Raisin.....	<i>Viburnum cassinoides</i> L.
Willow, Bebb's	<i>Salix Bebbiana</i> Sarg.
Witch Hobble.....	<i>Viburnum alnifolium</i> Marsh.
Yew, Canada	<i>Taxus canadensis</i> Marsh.

¹ From Sudworth (1927). ² From Rehder (1927). ³ A few specimens of *A. laevis* Wieg., were found in the tally. They were included as shad bush. ⁴ Probably *V. opulus*.

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Map 1: The Cranberry Lake region, including the Sucker Brook deer yard and other points mentioned in the report. Adapted from U. S. Topographic map, Cranberry Lake quadrangle. Scale—1 inch = 1 mile.

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