INFLUENCE OF THE EASTERN COTTONTAIL ON TREE REPRODUCTION IN SUGAR MAPLE-BEECH STANDS OF SOUTHERN MICHIGAN

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

JOHN BEATTY MATHIES

1967

ABSTRACT

INFLUENCE OF THE EASTERN COTTONTAIL ON TREE REPRODUCTION IN SUGAR MAPLE-BEECH STANDS OF SOUTHERN MICHIGAN

by John Beatty Mathies

The study objective was to examine the cottontail rabbit as an influent on tree reproduction in an old-growth and a second-growth woodlot located near East Lansing, Michigan. Within each woodlot, four areas were selected that gave a range of the rabbit pressure observed in the woodlots. A total of 1472 seedlings of eight species was sampled by random strip transects within each area. These plants were measured in the fall and winter for height, age, and prior rabbit utilization. These same plants were subsequently rechecked in the spring for the current winter's utilization and mortality.

The 1965-1966 winter study period was mild and became an important factor in reducing the use by rabbits in both woodlots below that anticipated.

The winter utilization of the tree seedlings was examined to determine the percent of seedlings utilized by the cottontail prior to, and during, the study. Species preferences were similar in both woodlots. American beech, elm, and American basswood were preferred. Sugar maple and black cherry appear to be moderately accepted, whereas bitternut hickory, white ash, and northern red oak were non-preferred. Area preferences appeared to be directly related to the amount of available low ground cover.

Past utilization on all species was similar in both woodlots, instead of decreasing in the old-growth woodlot

as might be expected. This is apparently due to additional food and cover available in the agricultural areas adjacent to the woodlot. In addition, use by rabbits in the second-growth woodlot was not as localized as in the old-growth woodlot. This may indicate a more suitable habitat for rabbits in the former area. Since the cottontail has definite preferences for species and areas, rabbit utilization could be an important factor in the height growth of the seedlings in these woodlots.

Sugar maple was the most common species found in both woodlots, and an intensive study was conducted to determine its response to rabbit utilization. Each plant was classified into one of three utilization categories by the number of times each plant had been browsed. The growth rates indicated that the utilized plants in the old-growth woodlot were taller than unused seedlings of the same age. The reverse was apparent in the second-growth woodlot. Based on the average age of the seedlings, it appears that rabbit utilization, on a per year basis, is lower in the old-growth than the second-growth woodlot. The implication is that sugar maple may respond according to the amount of utilization per unit time. At low levels of use, it is stimulated to greater growth whereas the reverse is true at higher levels of use.

Sugar maple may therefore be a good indicator for estimating total rabbit utilization in sugar maple-beech woodlots similar to the study woodlots.

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By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Forestry

1967

ACKNOWLEDGEMENTS

I am grateful to the following individuals for assistance throughout this study.

To Dr. L. W. Gysel, of the Fisheries and Wildlife Department, for guidance in the selection of the study areas, furnishing trapping data, and for valuable review and criticism of the ecological portions of the study.

To the following members of the Forestry Department: to Dr. R. K. Hudson, for advice and suggestions concerning the format of the dissertation; to Dr. J. W. Wright, for advice concerning the design of the field data collection; to Mr. D. J. Gerrard, for the invaluable assistance given concerning all statistical problems, and for the use and modification of a computer program which aided considerably in the sugar maple analysis; and finally to Dr. G. Schneider, under whom this study was undertaken, for guidance and advice throughout the development of the study, and for critical reviews and discussions during the preparation of the dissertation.

I am indebted to Michigan State University for financial aid in the form of a teaching assistantship in the Department of Forestry, and for providing needed supplies during the two years of the dissertation preparation.

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INTRODUCTION

The interactions between plants and animals have become an important field of ecological study. As man continually changes his environment, the disruption that is often created merely emphasizes his interdependence with the rest of the biotic community. The consequences of these disturbances are usually not recognized as being detrimental unless an adverse economic effect results. Man than attempts to correct his errors by, hopefully, restoring the ecological balance.

Under pristine conditions, the Beech-Maple climax forest region encompassed a large portion of the Deciduous Forest Formation of the Lake States area (Braun, 1950).[1/] A large part of this formation has been almost entirely removed or destroyed by logging and agricultural practices since the early 1600's. Approximately 0.1 percent of the original beech-maple area remains in a relatively undisturbed condition (Shelford, 1963). These stands are commonly small in size, and the animal constituents have been considerably altered. Certain species, such as the wolf, mountain lion, and elk have been eradicated; while other species, such as the whitetail deer and red fox, have invaded or increased in importance.[2/]

1/ Common and scientific names of all plant species are given in the Appendix, Table 25.

2/ Common and scientific names of all animal species are given in the Appendix, Table 26.

The Eastern cottontail is one species that has apparently adapted by increasing its range and density as the continuity of the forest canopy changed. This has been postulated from the facts presently known about the habitat requirements of the species (Lord, 1963; Fay and Chandler, 1955). This study examines the extent of cottontail utilization of forest tree reproduction in two contrasting sugar maple-beech stands in southern Michigan. Whereas the one area is a relatively undisturbed, old-growth stand, the other is a young, second-growth stand. Based on past and current utilization, the rabbit's preferences for tree species and area are determined, and resulting ecological implications are discussed.

REVIEW OF LITERATURE

The literature concerning rabbit use of woody vegetation is both extensive and repetitive. The rabbit was first recognized as a farm, nursery, and orchard pest; and most of the articles prior to 1910 dealt with damage to agricultural crops. Damage to forest tree reproduction has only become important in studies since the early 1900's. The initial forest-oriented studies were primarily tabulations of the vegetation used by the rabbit (Aldous, 1936; Cox, 1936; Hendrickson, 1938; Smith, 1940; Trippensee, 1938). Todd (1927) listed seventy-one plant species used by the cottontail rabbit. He determined this by following their tracks in winter and listing the species and portions of the plant utilized. His list contained thirty-one tree species but no indication was given of food preferences or the effect of use on the plants. Blair (1936) listed foods eaten by a captive Florida marsh rabbit for plants taken from its habitat. Seton (1929) stated that ninety-nine percent of the flora of the United States could be utilized by the cottontail rabbit. Lantz (1907) supports this statement although he was considering arborescent plants only. It would appear that any list of plants used by the rabbit is of minor importance. (Perhaps the plants not used would be more important!)

About 1940 the emphasis shifted to food preference and numerous studies were made (Aldous, 1947; Allen, 1939; Cook and Robeson, 1945; deVos, 1964; Dice, 1945; Dodds, 1960; Gammon et al., 1960; Lord, 1963; Pearce and Reineke, 1940;

Sweetman, 1949). Dalke and Sime (1941) determined food preferences from over thirteen hundred direct observations of feeding in Connecticut. They found seventy species of trees and shrubs utilized to some extent, with two species, gray birch and red maple, receiving the greatest amount of use. Although the method of preference determination was not stated, the listing of preferred foods differed from those receiving the greatest use, indicating unequal availability. Food preference varied during the two years of the study, but no reason was given for this difference.

Hough (1949) studied the browsing of both the cottontail rabbit and whitetail deer in a Pennsylvania hardwood forest. Rabbits were more discriminating in their browsing than the deer. All species were browsed approximately equally by deer but a preference for certain species was apparent for the rabbit. The rabbit preference was: 1) red maple, 2) beech, 3) sugar maple, and 4) black cherry. A series of four inclosures were established to determine the effects of three types of browsing pressure on the vegetation. The increase in tree seedlings per acre was greatest when both rabbits and deer were excluded rather than if deer alone were excluded. The increase was large enough for the author to conclude that rabbits were more active than the deer in controlling tree reproduction. Hough stated that overpopulations of either deer or rabbits were harmful to the vegetation.

The rabbit apparently turns to woody vegetation when the herbaceous vegetation, forming its summer diet, becomes

unattractive (frozen or decayed) or unavailable due to scarcity, snow depth, or ice coverage (Sweetman, 1944). When any of these conditions occur, the twigs and bark of woody plants become the primary winter food source (Allen, 1939). Nutrition apparently is a factor here since the consumption of woody vegetation involves more intensive digestive processes (Madson, 1963; Trippensee, 1938). Sweetman (1944) found that the amount of injury incurred by woody vegetation was directly proportional to snow cover. This would indicate that weather, particularly snow depth, is an important factor to be considered when determining the cause and effect of winter use of forest reproduction by the rabbit.

Numerous investigators have determined that most rabbit winter utilization occurs on hardwood species. While no agreement on the order of preference exists, there is general accord on preferred species compared to non-preferred species. Table 1 indicates the general rabbit preference for trees commonly found in the sugar maple-beech forest region.

A few authors have noted winter rabbit utilization of conifers. Trippensee (1938) noted heavy damage on Corsican pine (probably Austrian pine) and Scotch pine with moderate damage to Eastern red cedar. Dice (1945) reported damage on several pine and spruce species. The comparison of hardwood damage to conifer damage appears to be related to the habitat requirements of the cottontail. Allen (1939) gave the

habitat preference as follows: 1) cutover oak-hickory brush areas, 2) lowland brush thickets, and 3) young conifer stands. Lord (1963) found that the cottontail prefers an area with low ground cover rather than an open area, and Gysel (1957) determined that the amount of use was directly related to the rabbit's preference for low ground cover.

Table 1. General rabbit preference of tree species commonly found in the sugar maple-beech forest region[a/]

Preferred species	Non-preferred species
American basswood	Eastern cottonwood
American beech	Shagbark hickory
American elm	Sycamore
Black cherry	White ash
Black oak	White oak
Black walnut	Yellow poplar
Gray birch	
Ironwood	
Northern red oak	
Quaking aspen	
Red maple	
Sassafras	
Sugar maple	

a/ Dalke and Sime, 1941; Gammon et al., 1960; Hough, 1949; Lord, 1963; Pearce and Reineke, 1940; Sweetman, 1944

There are also indications that the rabbit has intraspecific preferences as well as interspecific preferences. Moore (1940) found that planted seedling stock was utilized to a greater extent than natural regeneration. He postulated that this was due to the greater volume of growth made available by the planted seedling. Perhaps the nutritional content of the plant is also a factor. Sweetman (1949) found that succulent growth was more attractive to foraging

rabbits than old woody stems. He also found a preference for sucker or sprout growth over normal seedlings. Because browsed plants often remain within reach of the rabbits for a longer time, the same plants may be utilized for several years. These plants are subject to clipping until they grow out of reach or obtain a minimum diameter of one-half inch for portions of the plant still within reach of the rabbits (Dice, 1945). The damage to larger plants is usually restricted to the removal of the bark. Although it may occur at any season, barking is more prevalent during severe winters and/or high rabbit populations (deVos, 1964; Miller, 1965). On small plants, the rabbit commonly cuts the stem near the base and then eats toward the tip of the cut material (Hutchison and Kotok, 1942). Derr and Mann (1959) found that the damage often occurred on the stem about one-eighth inch above the ground level.

Few investigators actually reported on the ecological effects of rabbit utilization upon the forest. Scholz (1964), in a northern red oak stand, found that protected seedlings averaged seventy inches in height, while unprotected seedlings averaged fifty-four inches in height at ten years of age. The total effect was to retard tree growth one or two years and reduce tree height. Scholz suggests that the rabbit damage is cyclic in nature, being more severe during population peaks. The plants recover quickly, despite the amount of use, between the population highs. In contrast, Gammon et al. (1960) found that the average height of northern red oak seedlings remained relatively unchanged, due primarily

to rabbit browsing.

Another rabbit influence which has received little study is the extent of plant mortality. The rabbit may be the cause for the scarcity of certain native shrubs. Sharp (1957) found that seedling shrubs were often killed by excessive rabbit browsing within two years following their germination. Geis (1954), in a study of black oak in southern Michigan, found cottontail damage on eighty-nine percent of 212 plants examined. The damaged trees had:

1) a slower rate of height and stem diameter growth
2) an increase in main limbs and dead main limbs per tree
3) a higher incidence of heart rot
4) their annual growth utilized for several years on many of the trees

As a consequence of this disturbance, Geis proposed that rabbit damage may be an important factor in the survival and perpetuation of oak as a dominant species in the stand. Similar results were found by deVos (1964), who studied the snowshoe hare in Ontario and found forty-four tree species browsed to some extent. He concluded that the hare may affect the plant composition of a forest stand. This is accomplished through the food preferences of the rabbit, resulting in a differential survival of the species in the stand.

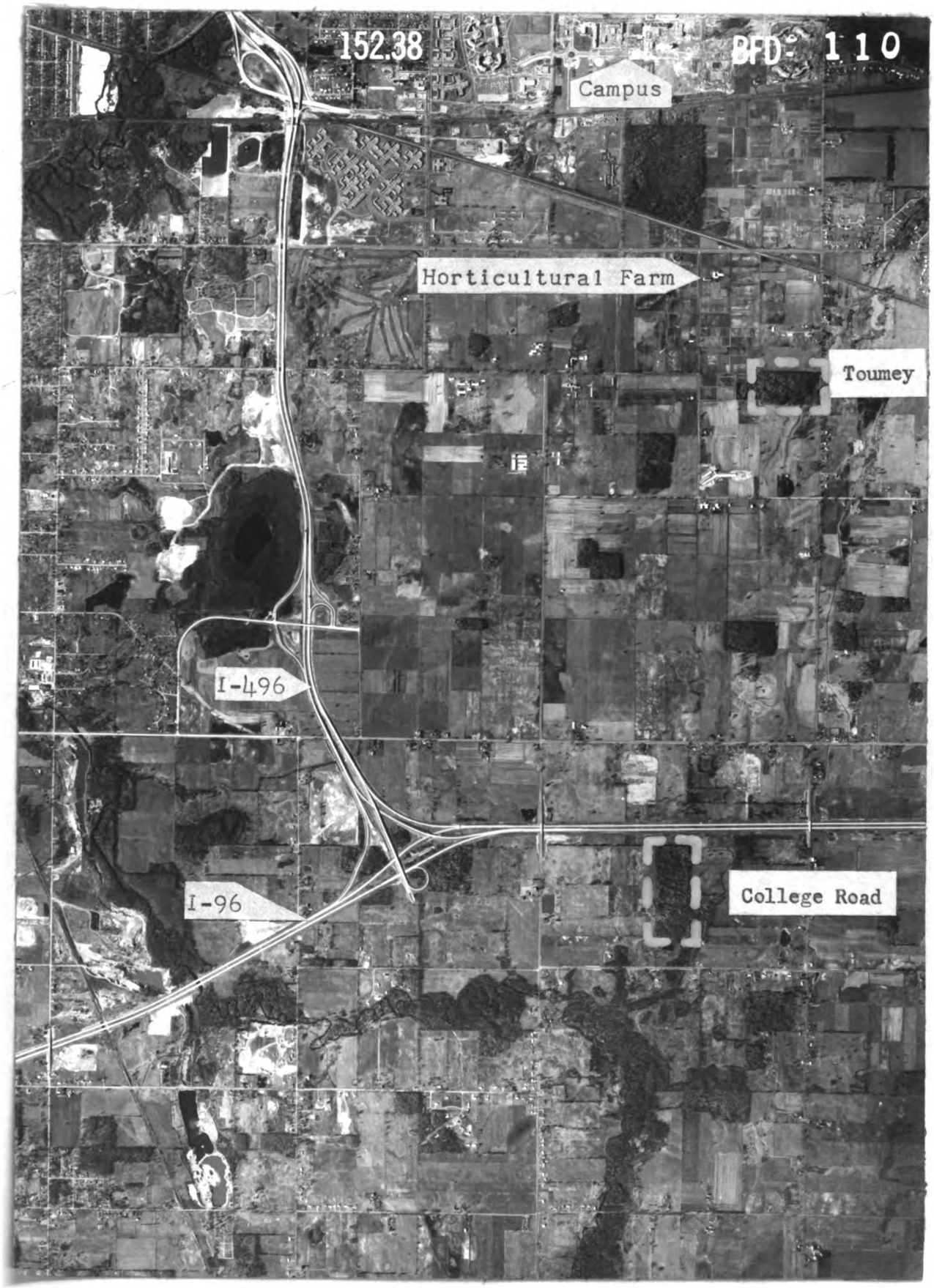
DESCRIPTION OF GENERAL AREAS

The study was conducted in two woodlots within five miles of the Michigan State University campus at East Lansing, Michigan (Figure 1). The first of these, Toumey Woodlot, was acquired by the University in 1939. It is a relatively undisturbed, old-growth sugar maple-beech stand, one of the few remnant stands of this forest type in the area. The fifteen acre stand is located in the NE 1/4 of the SE 1/4 of Section 30, T 4N, R 1W, Michigan Meridian in Ingham County, Michigan. The stand has not been grazed, burned, or logged (except for removal of a few dead and dying trees for firewood) during the known single ownership which was established in 1852. The area is presently surrounded by agricultural crops on the west, pastures on the north and south and a county road on the east. The stand is being maintained as undisturbed as possible for continuing forest research.

The second area, the College Road Woodlot, is located about one and one-half miles south of Toumey Woodlot. It is a second-growth sugar maple-beech stand with ample evidence of recent selective logging throughout the area. The history of this forty-three acre stand is unknown, but it has probably been grazed and there are indications of past wildfires in the area. This woodlot is located in the SW 1/4 of Section 6, T 3N, R 1W, Michigan Meridian in Ingham County, Michigan. The area is presently bounded by an interstate highway on the north, and by agricultural crops on the remaining sides.

Figure 1. Aerial photograph of the general study area and location of Toumey and College Road Woodlots

(Scale: 1 inch = 3000 feet; April 9, 1964)


152.38
BFD- 110
Campus
Horticultural Farm
Toumey
I-496
I-96
College Road

Study areas

Toumey Woodlot.--Four areas were selected in this woodlot as representative of the range of winter utilization by the cottontail rabbit. Two of the areas having low use were located along the north and south borders of the woodlot (Figure 7). The woodlot edge paralleling the north area, and adjacent to a pasture, was relatively open. Protective ground cover within the north area was noticeably sparce, with a few dead trees on the ground. The south area afforded more suitable cover than the north due to the remnants of an old wooden fence, and the high grass cover in the adjacent unused pasture. A small abandoned triangle of land is located between the woodlot and the present fence at one end of the south area and provided additional cover for the south area.

The other two areas chosen represented locations of intensive rabbit utilization as evidenced by the high degree of browsing in both the blowdown and the swamp areas. The swamp created an oblong opening which was surrounded by a relatively dense herbaceous plant cover during the summer. In winter, this provided some cover, as did a few old blowdowns within the area. The sample area was located along the northwest edge of the swamp within 150 feet of a small stand of planted red pine. In 1964, several dead and dying American elms were felled and left on the southeast edge of this intermittent swamp.

The blowdown area was the result of a local windstorm,

which occurred in September, 1959. Both uprooted trees and broken stems created an opening approximately a quarter acre in size. Common elderberry rapidly invaded the site and apparently provided a highly suitable habitat for the cottontail since it became a center of rabbit activity during subsequent winters.

College Road Woodlot.--The four areas selected in this woodlot were comparable to those in Toumey Woodlot (Figure 8). The north area was located adjacent to an old clearcut area presently covered with a dense stand of staghorn sumac. Whereas few actual tree stems were found on the ground, several brush patches offer nearby protective rabbit cover. An abandoned cornfield and a small plantation of Scotch pine are within 300 feet of the area.

The south area was located near the eastern boundary of the woodlot proper. A wire fence parallel to this area provided some protective rabbit cover. The woodlot area east of this fence was heavily logged and only a few scattered young or cull trees were left standing. A dense cover of herbaceous and shrub vegetation dominated the ground cover and tree reproduction was sparce. Brush piles, created primarily by logging slash, were found throughout the area.

The swamp area was located on the northwest edge of the swamp and had less downed logs than found in Toumey Woodlot. The sapling segment of the tree reproduction was more dense than any other area. The area was within 200 feet of an abandoned cornfield and a patch of staghorn sumac.

The blowdown area was apparently an old logged area with subsequent blowdowns along the perimeter. Most of the merchantable material was removed but several piles of tops and cull logs were left. A dense herbaceous ground cover predominated over the area, with grass cover along an old logging skid road.

Climate

The climate is considered strongly continental with relatively variable temperatures. Normal daily air temperatures range from a maximum of 84°F. to a minimum of 12°F. Extremes of 102°F. and -25°F. have been recorded at the East Lansing station.

Total precipitation averages 31 inches a year, with an average of 23.1 inches occurring during the study period of September through May. The precipitation is fairly evenly distributed through the year, with lows of 1.8 and 1.7 inches in January and February respectively, and highs of 3.7 and 3.3 inches in May and June respectively. Average snowfall is 55 inches a year and occurs normally between October 20 and May 1. The extremes in total snowfall were experienced in 1904-1905 when 18 inches fell, and in the 1925-1926 winter with 84 inches.

Winds are generally moderate to mild, averaging seven miles per hour annually, with west and northwest winds prevailing during the winter and more variable winds, generally southerly, during the summer. The average growing season is 146 days, with a recorded range of 106 days minimum to 195

days maximum (Baten and Eichmeier, 1951; Barrett, 1962).

Physiography

The area is characteristic of the glacial deposits throughout the region. The reconstructed history of the area begins with a Tertiary Peneplain which was uplifted and then eroded over a long period of time. Several periods of glaciation followed, and the present depth of the glacial drift is around 300 feet in the general area of the study, with the elevation averaging 800 to 900 feet above sea level. The topography is gentle with rolling hills and little stream dissection. Drainage is to the west, through the Red Cedar and Grand Rivers to Lake Michigan (Barrett, 1962; Leverett, 1917).

Soils

The soils are predominately well-drained mineral soils of the Gray-brown Podzolic great soil group. In Toumey Woodlot, Hillsdale and Spinks loams are found through most of the woodlot, with Conover silt loam predominating in the low swamp area (Schneider, 1966). College Road Woodlot differs in that the primary soil type is Miami loam, changing to Spinks loam in the blowdown area, and Conover loam in the south and swamp area.[3/]

3/ Tri-county soil survey, Soil Conservation Service, East Lansing, Michigan. Personal communication, 1966.

Biotic factors

Although the cottontail rabbit was the animal studied, other animals are commonly found within the woodlots. Evidences from tracks, scat, trapping results, and direct observations indicate that the following mammals inhabit the study areas:

Shorttail shrew	Fox squirrel
White-footed mouse	Woodchuck
Meadow vole	Racoon
Southern bog lemming	Opossum
Starnose mole	Red fox
Eastern chipmunk	Whitetail deer

FIELD PROCEDURES

The study of four selected areas within Toumey Woodlot began in Fall, 1965. Four additional areas within College Road Woodlot were chosen in March, 1966. As far as possible, these were similar to corresponding areas in Toumey Woodlot in tree seedling composition and extent of previous rabbit utilization.

Initial reconnaissance of both woodlots indicated that species density was too low to be effectively sampled by use of permanent mil-acre plots. Therefore, a series of random strip transects were established, oriented parallel to the border of each area where possible. Since the blowdowns were circular in outline, they were sampled by random strip transects passing through the center of the blowdown area. Depending upon species frequency, from five to twelve strip transects were established in each area, with the average size being two feet by fifty feet. All species were sampled as they occurred throughout each transect except for sugar maple in Toumey Woodlot. Because of the great abundance of sugar maple throughout this woodlot, randomly selected strips of thirty consecutive mil-acre quadrats were established to insure that a representative sample of each study area was indeed obtained. These quadrat strips were also parallel to the adjacent forest border, and each quadrat was located with a small wooden stake. Where present, a suitable number of sugar maple were sampled in each mil-acre plot, with the plants nearest the investigator

selected upon entering the plot.

A total of 1472 plants of eight species were sampled in both woodlots. Each plant was marked with a strip of yellow, plastic coated, adhesive tape. The species symbol and sample number were written on each tape with a black felt tip marker. The tag was placed within two inches of the base of the tree to minimize the experimental effects on the rabbits, as snow and dead leaves would help cover the tags.

All trees sampled were measured for height, age, and amount of winter use by rabbits. A maximum height of 150 centimeters was used to limit the sampling to the size normally used by the cottontails (Geis, 1954; Pearce and Reineke, 1940). Height of the present live leader was recorded to the nearest centimeter. Age was determined by either counting the actual terminal bud scars, or estimating those portions where bud scars were not discernable. Previous use by rabbits was recognizable from other mammal use by the characteristic 45° angle of shearing and smooth face of the cut (Scholz, 1964; Todd, 1927). The utilized stems are persistent for several years after they have been clipped and the samples were divided into three levels of rabbit use: 1) not used, 2) used once, and 3) used more than once.

The areas were examined at one or two week intervals during the winter to determine the extent of rabbit use occurring throughout the study period. The final field work in both woodlots was completed in June, 1966. Each plant was rechecked for winter use and mortality resulting from rabbit use.

RESULTS AND DISCUSSION

Stand description

The amount of cover has been found to influence the habitat favored by the cottontail (Allen, 1939; Gysel, 1957; Lord, 1963; Miller, 1965). During the winter months, the available rabbit cover in a deciduous forest is often difficult to define. The general description of each woodlot was previously discussed. In addition, tree density and species composition were sampled to aid in the description of each woodlot area.

Stand density.--For convenience, this will be termed the "overstory" and includes all trees over one inch d.b.h. (diameter at breast height). Although this is a broad classification, it serves as an overall description of the present stands.

Toumey Woodlot has been the subject of a continuing ecological study since 1940. The woodlot has been subdivided into sixty-foot square compartments and an inventory has been completed on all stems one inch d.b.h. and over (Schneider, 1966). Total stand density in 1965 is shown in Table 2. This is an old-growth stand typical of the few remnant sugar maple-beech stands in this area. Stand density is high, with basal area per acre between 113 and 193 square feet.

The College Road Woodlot has not previously been studied. The overstory density was determined by examining

three randomly selected plots in each area of the woodlot using the variable plot method and a ten-factor prism (Grosenbaugh, 1958). This information is summarized in Table 2.

Table 2. Basal area per acre of all trees one inch d.b.h. and over, Toumey and College Road Woodlots, 1965-1966

Woodlot	Area	Basal area per acre
Toumey a/	North	193
	South	160
	Swamp	118
	Blowdown	113
	Average	157
College Road b/	North	60
	South	110
	Swamp	90
	Blowdown	57
	Average	79

a/ Based on 100 percent inventory.
b/ Based on averages of three variable plots.

As can be seen, the College Road Woodlot is considerably less dense than Toumey Woodlot. In fact, the densest area sampled in College Road Woodlot has three square feet of basal area per acre less than the least stocked area found in Toumey Woodlot. This second-growth woodlot has had a considerable volume of its merchantable sawtimber removed.

The remaining stems are thus small and the majority of the stand's basal area is therefore in the small sawtimber size class. A few scattered large cull trees, often beech, are also present.

Overstory composition.--Species composition in Toumey Woodlot is primarily sugar maple, with some beech and elm distributed throughout. Although a total of twenty-two tree species occur in the woodlot, only eight appear in any abundance.

The College Road Woodlot contains much less sugar maple than Toumey Woodlot for all areas except the south. Sugar maple comprises but one-half as much basal area as found in Toumey Woodlot; whereas three species, white ash, black cherry, and elm have twice as much basal area as in Toumey Woodlot. This woodlot is younger and the species composition includes a greater number of the less typical species which are commonly found in the successional stages (Shelford, 1963).

Climatic influence

Several authors have noted that the amount of rabbit use of woody vegetation varies with the depth of snow, or the severity of the winter (Allen, 1939; Dice, 1945; Dodds, 1960). To examine this climatic influence, the weather during the study period was compared to the average weather conditions for the past six years. All weather data is from the Horticultural Farm located on the Michigan State University campus at East Lansing, Michigan (U. S. Weather Bureau,

1960-1966). This station is located about one-half mile from Toumey Woodlot and two and one-half miles from College Road Woodlot.

The air temperature data are presented in Table 3. In general, the 1965-1966 winter, though considered mild, had temperatures below average in November, January, April and May. The temperatures in December and March were notably higher than the averages for those months. The late winter and early spring period is often the most important to rabbit survival. The rabbits normally go into the winter with a layer of fat, and this source of energy is depleted as the winter progresses. As the winter of the study was relatively mild, the amount of rabbit utilization observed in the woodlots was apparently reduced.

Total precipitation and snowfall data are shown in Table 4 and Figure 2, respectively. Precipitation was 44 percent higher than the average, with a total precipitation for the study period of 22.10 inches as compared to the past six-year average for that time period of 15.38 inches. The only month having considerably less than average total precipitation was January. Conversely, snowfall was less than expected for all months except January. Total snowfall was 16.7 inches compared to the average of 28.1 inches, a 41 percent reduction. A most significant weather factor influencing rabbit browse was the amount of snowfall in the late winter and early spring period. The premature decline in measurable snow depth, two months earlier than usual, greatly contributed to the reduced rabbit use observed on

Table 3. Average monthly air temperatures during 1960-1966 and deviations for the 1965-1966 study period at the Horticultural Farm, East Lansing, Michigan

Month	Average temperature (°F.)			Average maximum (°F.)			Average minimum (°F.)		
	1960-1966	1965-1966	Deviation from average	1960-1966	1965-1966	Deviation from average	1960-1966	1965-1966	Deviation from average
September	63.3	63.2	-0.1	74.7	74.2	-0.5	51.9	52.3	+0.3
October	52.8	50.8	-2.0	63.8	60.3	-3.5	41.6	41.2	-0.4
November	41.4	40.6	-0.8	49.9	49.1	-0.8	32.8	32.0	-0.8
December	26.2	34.1	+7.9	33.2	40.2	+7.0	19.2	28.0	+8.3
January	21.0	19.9	-1.1	28.4	27.8	-0.6	13.5	12.0	-1.5
February	24.1	25.6	+1.5	32.5	33.6	+1.1	15.7	17.6	+1.9
March	34.7	38.6	+3.9	43.2	47.7	+4.5	26.2	29.4	+3.2
April	45.8	44.3	-1.5	56.6	54.1	-2.5	35.0	34.5	-0.5
May	59.0	53.0	-6.0	71.3	64.1	-7.2	46.7	41.8	-4.9
Average	40.9	41.1	+0.2	50.4	50.1	-0.3	31.4	32.1	+0.7

Table 4. Average monthly total precipitation and snowfall during 1960-1966 and deviations for the study period 1965-1966, at East Lansing, Michigan

Month	Total precipitation			Monthly snowfall			Maximum snow depth		
	1960-1966	1965-1966	Deviation from average	1960-1966	1965-1966	Deviation from average	1960-1966	1965-1966	Deviation from average
	-inches-								
September	2.72	4.78	+2.06	--[a]	--	--	--	--	--
October	1.34	1.50	+0.16	T[b]	--	--	T	--	--
November	1.58	2.97	+1.39	0.8	T	-0.8	3.0	T	-3.0
December	1.11	3.40	+2.29	7.2	6.2	-1.0	7.0	6.0	-1.0
January	1.17	0.43	-0.74	5.4	6.5	+1.1	8.0	4.5	-3.5
February	0.85	0.81	-0.04	7.8	4.0	-3.8	12.0	4.0	-8.0
March	2.07	2.95	+0.88	4.4	T	-4.4	6.0	T	-6.0
April	2.38	3.26	+0.88	2.5	--	-2.5	6.0	--	-6.0
May	2.16	2.00	-0.16	--	--	--	--	--	--
Totals	15.38	22.10	+6.72	28.1	16.7	-11.4			

a/ None recorded
b/ Trace recorded

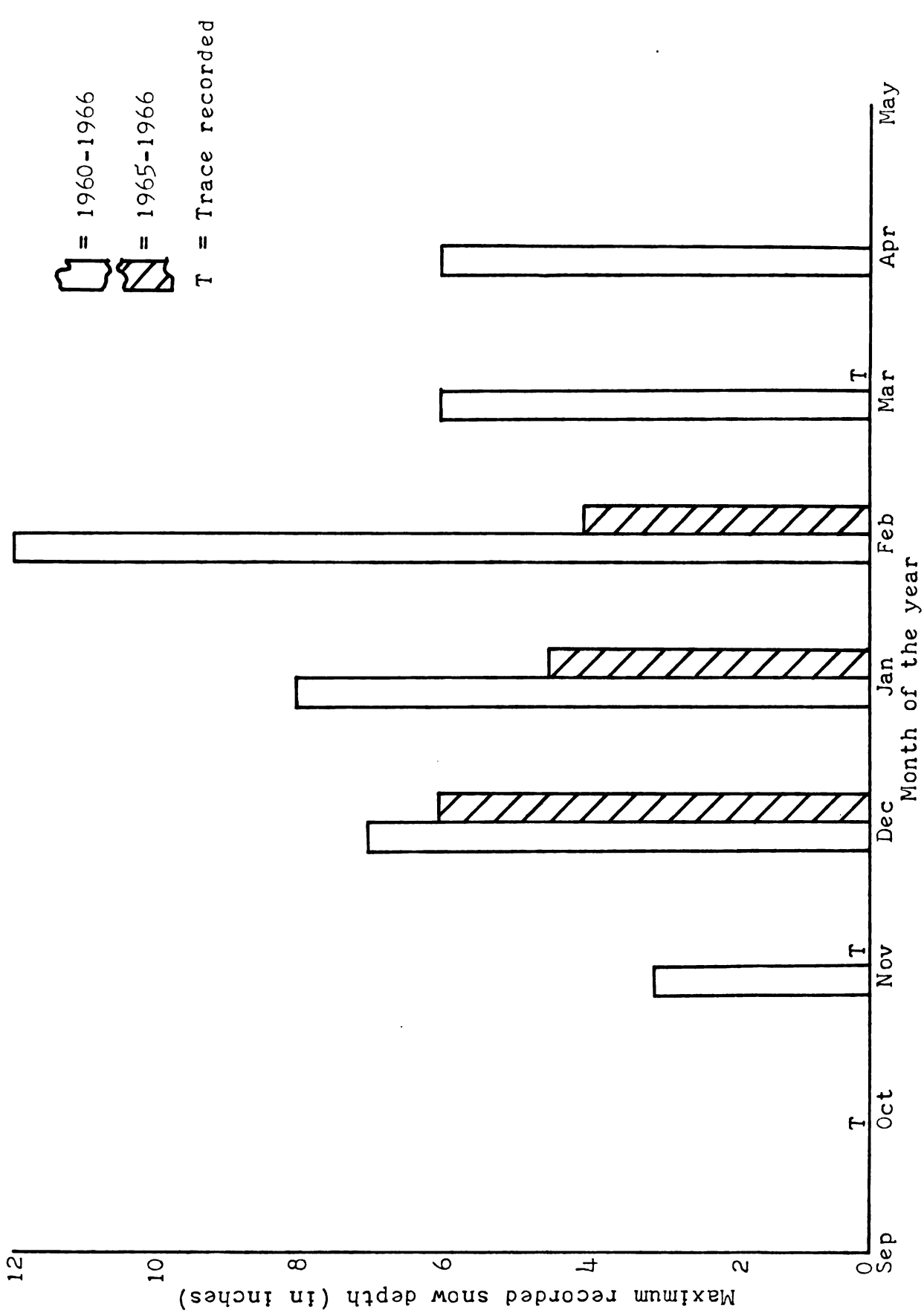


Figure 2. Monthly maximum snow depth during 1960-1966 and for the study period 1965-1966 at East Lansing, Michigan

the study areas (see Table 6).

Rabbit population

While no information on the rabbit population exists for the College Road Woodlot, trapping studies have been occasionally conducted in Toumey Woodlot since 1958.4/ Fall trapping was for periods of up to one month in August, November, and December; whereas spring trapping was conducted in April and May. Both wooden and woven-wire box traps, baited with corn, were used. Prior to each animal's release, sex and age information were taken and the animal was tagged with aluminum ear tags if it had not been trapped previously.

Success varied considerably over the six-year period. A maximum of fifteen different individuals was trapped in the Fall of 1964; the minimum of zero trapped occurred several times prior to this same date. However, the reliability of cottontail trapping data has been severely criticized in recent work (Eberhardt et al., 1963). For this reason the data has been used to indicate general trends only. The rabbit population in Toumey Woodlot was relatively stable in 1958 and 1959, and appears to have been increasing since 1963.

Available food (tree seedlings, 10 to 150 cm. in height)

One measure of available food is the density of vegetative reproduction in the area. To determine the density of the tree seedling reproduction, five mil-acre

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4/ Gysel, L. W. Personal communication, 1966.

plots, representative of the average stand conditions, were randomly established in each woodlot area and the total number of stems by species were recorded for plants within the above height restriction. The average species densities per acre by woodlot area are shown in Table 5.

The same species occur in both woodlots, but in varying amounts within each area. An analysis of variance indicates that the total species density is not significantly different between either the woodlots as a whole, or for the four areas sampled within Toumey Woodlot (Table 13). The areas selected in College Road Woodlot are also similar except for the south area. It appears that this significance is perhaps due more to the lower species density found in the blowdown area rather than the higher density in the south. Therefore, with this one exception, study plots within and between both woodlots are similar when total tree seedling density is considered.

This similarity, however, does not hold when individual tree species density is examined. An analysis of variance revealed a significant difference between woodlots when the density of sugar maple and the collective density of all other species is compared (Table 14). Toumey Woodlot is composed primarily of sugar maple with a scattering of other species. Although sugar maple is also the most common species in College Road Woodlot, it has a significantly lower density of sugar maple and a higher density of all other species. This indicates a change in species composition of

Table 5. Number of tree seedlings per acre (10 to 150 cm. in height), available as rabbit food within areas of Toumey and College Road Woodlots, 1966[a/]

Woodlot	Area	Species density (in thousands per acre)								Area Totals
		Sugar maple	Bitternut hickory	White ash	American beech	Black cherry	Northern red oak	American basswood	Elm	
Toumey	North	26.2	0.2	--[b/]	--	--	0.2	--	--	26.6
	South	24.2	0.2	0.2	--	--	1.4	0.2	6.8	33.0
	Swamp	31.2	0.2	0.4	--	3.2	0.2	--	0.2	35.4
	Blowdown	36.2	0.4	0.6	--	1.0	--	--	1.0	39.2
	Average	29.4	0.3	0.3	--	1.1	0.4	0.1	2.0	33.6
College Road	North	8.2	3.2	1.6	--	7.0	0.4	2.4	10.8	33.6
	South	36.0	1.0	0.4	--	0.4	--	--	2.2	40.0
	Swamp	6.8	0.8	1.4	0.6	6.4	0.8	--	10.4	27.2
	Blowdown	6.6	--	--	--	--	--	--	3.2	9.8
	Average	14.4	1.2	0.9	0.2	3.4	0.3	0.6	6.6	27.6
Species average		21.9	0.8	0.6	0.1	2.2	0.4	0.3	4.3	30.6

a/ Based on five representative mil-acre plots in each area
b/ Not present in sample

the tree reproduction between the young second-growth College Road Woodlot and the old-growth Toumey Woodlot.

Previous utilization of vegetation

The number of utilized plants found in the woodlot is an indication of the winter rabbit pressure, and this factor is directly related to the amount of use an area receives. An attempt to evaluate these conditions is summarized in Table 6, which shows the percent of previously utilized tree seedlings found in each study area. This percentage is indicative of the total use observed during a period of years in which the evidence is persistent. The value may be slightly misleading since the damaged stems do not remain on the plant for a constant period of time before either decay, healing, or mechanical disturbance removes the evidence. However, if it can be assumed that these effects are found equally in all the woodlot areas, then the trend of percent utilization can be compared for each area. The areas vary in their intensity of utilization with the greatest amount of use having occurred in the blowdown area of Toumey Woodlot. While utilization varies from 0 to 100 percent, the average previous use observed for all areas and species was 68.8 percent.

It should be noted that the extent of observed utilization in each area of Toumey Woodlot differed noticeably from similar areas in College Road Woodlot. Two areas that differed considerably were the north and the blowdown areas in College Road Woodlot. Some of these differences may be

Table 6. Tree seedling (10-150 cm. in height) utilization by the cottontail rabbit previous to and during the study period, Toumey and College Road Woodlots, 1965-1966

Woodlot	Area	Period	Percent utilization by species								Area average
			Sugar maple	Bitternut hickory	White ash	Amer. beech	Black cherry	Northern red oak	American basswood	Elm	
Toumey	North	Prev.	25.0	55.6	72.7	94.1	25.0	25.0	50.0	84.6	42.2
		Curr.	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0	0.6
	South	Prev.	59.0	71.4	55.1	100.0	46.7	47.8	66.7	84.4	60.0
		Curr.	1.0	0.0	2.0	0.0	13.3	17.4	0.0	3.1	4.3
	Swamp	Prev.	83.0	80.0	60.0	100.0	92.3	40.0	--	67.7	78.6
		Curr.	0.0	0.0	0.0	0.0	0.0	0.0	--	3.2	0.6
	Blow-down	Prev.	95.0	--[a]	60.0	--	95.8	--	--	100.0	93.9
		Curr.	2.0	--	0.0	--	8.3	--	--	0.0	3.1
	Average	Prev.	65.5	69.7	58.7	95.5	68.0	43.8	60.0	78.2	66.5
		Curr.	0.8	0.0	1.3	4.5	8.0	12.5	0.0	2.6	2.3
College Road	North	Prev.	84.0	69.0	30.8	100.0	83.3	100.0	90.5	100.0	85.3
		Curr.	9.0	3.4	7.7	0.0	16.7	18.8	9.5	40.6	17.1
	South	Prev.	67.0	43.8	0.0	100.0	57.1	50.0	--	90.0	63.7
		Curr.	2.0	6.2	0.0	0.0	0.0	0.0	--	0.0	2.1
	Swamp	Prev.	67.0	37.5	61.1	100.0	71.9	37.5	100.0	81.1	68.1
		Curr.	3.0	0.0	0.0	0.0	3.1	12.5	0.0	8.1	3.5
	Blow-down	Prev.	55.0	--	--	100.0	0.0	--	--	66.7	56.2
		Curr.	5.0	--	--	0.0	0.0	--	--	5.6	5.0
	Average	Prev.	68.2	56.6	50.0	100.0	66.7	76.9	91.3	89.1	71.1
		Curr.	4.8	3.8	1.9	0.0	3.7	15.4	8.7	23.2	8.0
Species averages		Prev.	66.9	61.6	55.1	96.9	67.4	58.6	81.8	85.0	68.8
		Curr.	2.8	2.3	1.6	3.1	6.2	13.8	6.1	15.5	5.2

[a] Not present in sample

due to the selection of the areas. The north area in College Road Woodlot provided more available cover than did the corresponding Toumey Woodlot north area, and was also adjacent to a dense staghorn sumac thicket. It is therefore possible that the rabbit population was higher there than anticipated, resulting in greater previous use. On the other hand, the blowdown area had less previous use than the comparable blowdown in Toumey Woodlot. Here, a dense grass and herbaceous plant cover apparently has resulted in a very low density of tree reproduction (see Table 5). During the winter, when the annual plant cover has been flattened, suitable rabbit cover is considerably reduced.

Cottontail tree species preferences.--An analysis of rabbit preferences for tree species was performed, based on previous utilization, with species preference compared by ranking percent use within each area (Table 7). Species preferences are significantly different (see Table 15), with only three of the eight species sampled preferred by the cottontail, when based on a mean rank value of 4.08. These were American beech, elm, and American basswood, in that order. Two species appeared to be intermediate in preference. These were sugar maple and black cherry. The remaining three species appeared to be avoided to some extent by the cottontail. In descending order, these were bitternut hickory, white ash, and northern red oak.

A paired "t" test was performed to see if the preferences varied between the two woodlots. The only species

Table 7. Cottontail rabbit species preference by woodlot and area, 1965-1966

Woodlot	Area	Preference ranking for species[a]								
		Sugar maple	Bitternut hickory	White ash	American beech	Black cherry	Northern red oak	American basswood	Elm	
Toumey	North	7	4	3	1	7[b]	7	5	2	
	South	5	3	6	1	8	7	4	2	
	Swamp	3	4	6	1	2	7	--	5	
	Blowdown	3	--[c]	4	--	2	--	--	1	
	Average	5	3	7	1	4	8	6	2	
College Road	North	5	7	8	2	6	2	4	2	
	South	3	6	7	1	4	5	--	2	
	Swamp	5	7½	6	1½	4	7½	1½	3	
	Blowdown	3	--	--	1	4	--	--	2	
	Average	5	7	8	1	6	4	2	3	
Species total		34	31½	40	8½	37	35½	14½	19	220
Mean rank		4.25	5.26	5.72	1.21	4.63	5.92	3.63	2.38	4.08

a/ Species are ranked, from 1 to 8, for each woodlot area by the percent utilization of each species occurring within that area. A rank of 1 indicates the highest percent utilization and successive numbers indicate decreasing preference

b/ Split ranks are given for tied values. Example: Toumey north area has three species with 25 percent utilization, the split rank is the sum of the preadjusted ranks divided by the number of tied species, or (6 + 7 + 8) ÷ 3 = 7 for this area.

c/ Not present in sample; ranking is only for those species which are present.

that differed significantly between the two woodlots was bitternut hickory. This species was preferred to a greater extent in Toumey Woodlot than in College Road Woodlot. Although the other species had a wide range in preference values between woodlots, the differences were not significant.

Species preference was not directly related to seedling density. However, because sugar maple occurs in such great abundance, it comprises the greatest percentage of the cottontail diet for the eight species sampled in the woodlots, although it is but a moderately preferred species.

Cottontail woodlot area preferences.--To determine if certain areas were preferred over others, the areas were ranked by the amount of use each species received. The results, in Table 8, and evaluated by analysis of variance in Table 16, show a significant difference in the utilization occurring between the eight areas sampled. Three areas appeared to be preferred over the rest when based on a mean rank value of 4.00. These were the Toumey blowdown area, College Road north area, and the Toumey swamp area in that order. Three areas used moderately were the College Road swamp area, Toumey south area, and the College Road south area. The final two areas appeared to be avoided more than any other area. These were the Toumey north area, and the College Road blowdown area. This difference in area preference is apparently related to the amount of low ground cover in the immediate area where the use occurred (see pages 12 through 14).

Table 8. Cottontail rabbit area preference by tree species utilized in both woodlots, 1965-1966

Species	Toumey Woodlot				College Road Woodlot				
	North	South	Swamp	Blowdown	North	South	Swamp	Blowdown	
Sugar maple	8	6	3	1	2	4½ [b]	4½	7	
Bitternut hickory	4	2	1	-- [c]	3	5	6	--	
White ash	1	5	3½	3½	6	7	2	--	
American beech	7	3½	3½	--	3½	3½	3½	3½	
Black cherry	7	6	2	1	3	5	4	8	
Northern red oak	6	3	4	--	1	2	5	--	
American basswood	4	3	--	--	2	--	1	--	
Elm	4	5	7	1½	1½	3	6	8	
Area average	8	6	3	1	2	5	4	7	
Area total	41	33½	24	7	22	30	32	26½	216
Mean rank	5.12	4.19	3.43	1.75	2.75	4.29	4.00	6.63	4.00

a/ Woodlot areas are ranked from 1 to 8, for each species, by the percent utilization on the areas where that species is present. A rank of 1 indicates the woodlot area with the highest percent utilization for that species, with successive numbers indicating decreasing preference.

b/ Split ranks are given for tied values. Example: Sugar maple has two areas with 67 percent utilization, the split rank is the sum of the preadjusted ranks divided by the number of tied areas, or (4 + 5) ÷ 2 = 4½ for this species.

c/ Not present in sample; ranking is only for those areas with this species present.

Utilization of sugar maple.--The most common species found in both woodlots was sugar maple. One hundred randomly selected seedlings were sampled in each woodlot area for height, age, amount of rabbit use, and mortality. A summary of the results is given in Table 9.

To determine the response of sugar maple to rabbit utilization, an analysis of covariance was computed to determine if the height-to-age ratio was correlated to the amount of winter use (Table 10). Three use categories were used: 1) not used, 2) used once, and 3) used more than once. The analysis for Toumey Woodlot indicates that for the average of the four areas sampled, the growth rates for the three use categories are not the same. This probably indicates the site difference in the woodlot. However, when each area within the woodlot is considered separately, the growth rates for the three use categories are constant within each area. The effect of use can then be determined by the difference among the regression lines and is indicated in Table 10. The north area of Toumey Woodlot does not differ among the various use categories. This was also the area with the least amount of use of any area sampled. As winter use rates increase, the difference in growth is more easily detectable among the three use categories. At about fifty percent use within a woodlot area, this difference in the growth rates is statistically significant. For the woodlot areas that had different regressions, an analysis of covariance was used between pairs of use categories to determine

Table 9. Sugar maple data summary for both woodlots from November, 1965 to June, 1966

Woodlot	Area	Number sampled	Average height	Average age	Evidence of previous use			Current use	Mortality
					Not used	Used once	Used > once		
			-cm.-	-years-	-percent-			-percent-	-percent-
Toumey	North	100	39.1 ± 21.4	10.1 ± 4.8	75.0	19.0	6.0	0.0	7.0
	South	100	41.1 ± 25.2	9.2 ± 4.0	41.0	36.0	23.0	1.0	0.0
	Swamp	100	51.6 ± 27.9	7.5 ± 4.0	17.0	35.0	48.0	0.0	0.0
	Blowdown	100	56.4 ± 33.3	5.3 ± 1.8	5.0	18.0	77.0	2.0	9.0
	Average	400	47.1 ± 28.1	8.0 ± 4.4	34.5	27.0	38.5	0.8	4.0
College Road	North	100	32.1 ± 21.5	6.1 ± 3.5	16.0	35.0	49.0	9.0	0.0
	South	100	34.1 ± 22.4	6.6 ± 3.5	33.0	23.0	44.0	2.0	0.0
	Swamp	100	56.0 ± 27.3	6.4 ± 2.2	33.0	32.0	35.0	3.0	0.0
	Blowdown	100	38.9 ± 29.7	4.4 ± 2.0	45.0	22.0	33.0	5.0	0.0
	Average	400	40.3 ± 28.8	5.9 ± 3.0	31.8	28.0	40.2	4.8	0.0
Sugar maple average		800	43.7 ± 27.8	6.9 ± 3.9	33.1	27.5	39.4	2.8	2.0

Table 10. Analysis of covariance for sugar maple reproduction by amount of use category, 1965-1966

Woodlot	Area	Non-parallelism[a]		Difference among regressions[b]	
		Value	Probability	Value	Probability
			-percent-		-percent-
Toumey	North	0.2654	>.10	1.2653	>.10
	South	1.9766	>.10	3.3009	.025<P<.05
	Swamp	1.4572	>.10	11.8087	<.001
	Blowdown	1.5265	>.10	7.8491	<.001
	Average	6.4889	.001<P<.005	397.8048	<.001
College Road	North	9.9003	<.001	0.5719	>.10
	South	25.6822	<.001	18.7454	<.001
	Swamp	2.1294	>.10	1.1822	>.10
	Blowdown	6.3492	.001<P<.005	4.4507	.01<P<.025
	Average	52.0346	<.001	0.9040	>.10

a/ Nonparallelism tests the slopes of the regression lines for all use categories. Significance means that the lines are not parallel

b/ Difference among regressions is meaningful only when non-parallelism is non-significant. If the lines are parallel, this test indicates whether the regression lines differ in amplitude

where the significance was in the system. Although the alpha level is not 0.05 percent in doing this, the results are used to indicate the amount of significance attributable to each comparison (Table 17). In general, there was little growth difference between the unused plants and the plants used once. The greatest height change occurred between the plants used more than once and the other two categories.

In the College Road Woodlot, only the swamp area had a constant growth rate for the three use categories. It was similar to the north area of Toumey Woodlot in that the height-to-age relationship indicated no difference in amplitude among the regression lines. In general, the growth rates, for each woodlot area, were stable for all use classes in Toumey Woodlot, while no consistency was shown for the College Road Woodlot. The second-growth woodlot was much more variable in the height-to-age relationship as well as in the overstory composition and continuity.

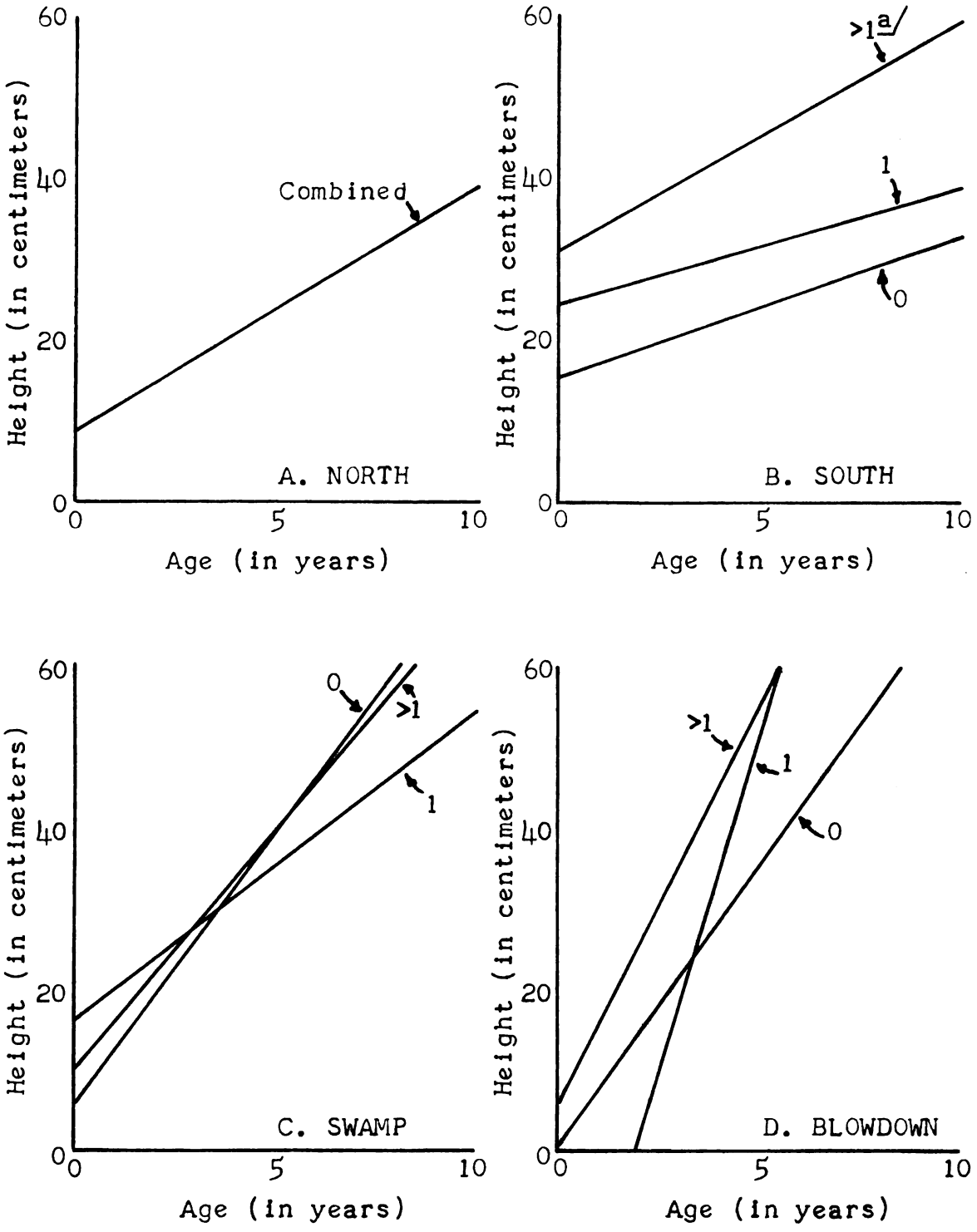
A linear regression analysis was conducted to plot the regressions for each woodlot area, with the regression analyses corresponding to the significant categories as determined by the analysis of covariance in Table 10. The results are shown in Table 11 and Figures 3 and 4.

In general, the rabbits in Toumey Woodlot appear to be utilizing the rapidly growing seedlings more than the older or slower-growing seedlings (see Figure 5 and Table 9). Two alternatives are possible: either the rabbits occupy the more productive tree growth sites, or the plant utiliza-

Table 11. Linear regressions for sugar maple reproduction, by use categories, in Toumey and College Road Woodlots, 1965-1966

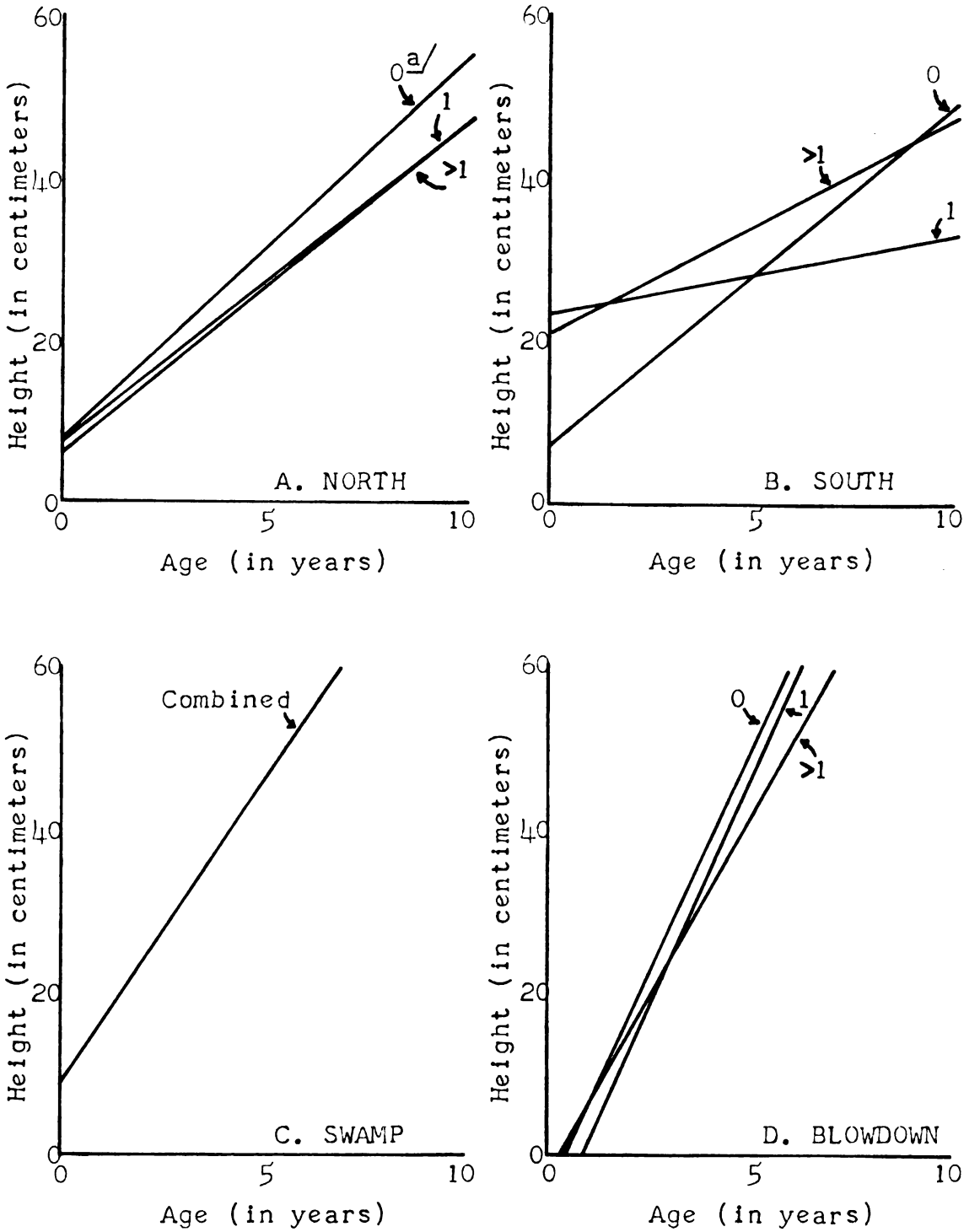
Woodlot	Area	Degree of use a/	Degrees of freedom	Regression F Value	Probability (percent)	Regression coefficient b/	Regression formula Y = a + bX	
							"a" value	"b" value
Toumey	North	All	98	82.3125	<.001	0.4565	8.6130	3.0285
	South	0	39	2.4216	>.10	0.0585	15.8816	1.6908
		1	34	2.1395	>.10	0.0592	24.6262	1.4354
		>1	21	22.9952	<.001	0.5227	31.0993	2.8842
	Swamp	0	15	8.0215	.01<P<.025	0.3484	5.1807	6.8270
		1	33	37.8685	<.001	0.5343	15.9520	3.9356
		>1	46	47.1543	<.001	0.5062	9.5798	5.9896
	Blow-down	0	3	5.2128	>.10	0.6347	0.2000	7.0000
		1	16	24.2436	<.001	0.6024	-32.1111	16.6914
		>1	75	36.3557	<.001	0.3265	4.8932	10.0723
College Road	North	0	14	1.8575	>.10	0.1171	6.8529	4.8235
		1	33	10.5516	.001<P<.005	0.2423	6.6276	4.0321
		>1	47	72.9775	<.001	0.6083	6.0533	4.0935
	South	0	31	16.9818	<.001	0.3539	6.6642	4.2347
		1	21	0.3571	>.10	0.0167	23.4602	0.9588
		>1	42	8.6702	.005<P<.01	0.1711	21.0687	2.6384
	Swamp	All	98	55.9162	<.001	0.3633	7.9283	7.5553
	Blow-down	0	43	35.0097	<.001	0.4488	-5.2723	10.9249
		1	20	15.3783	<.001	0.4347	-9.4439	11.2688
		>1	31	6.7068	.01<P<.025	0.1779	-3.4466	8.9826

a/ 0 = not used; 1 = used once; and >1 = used more than once
b/ The percent of the variance that can be accounted for by the regression line



a/ 0 = not used; 1 = used once; >1 = used more than once

Figure 3. Linear regressions for sugar maple in each study area in Toumey Woodlot, 1965-1966



a/ 0 = not used; 1 = used once; >1 = used more than once

Figure 4. Linear regressions for sugar maple in each study area in College Road Woodlot, 1965-1966

tion by the rabbit results in a stimulation effect on the seedlings themselves.

The first alternative is probably not a factor since both the greatest and least amount of utilization occur on the same soil type within six hundred feet of each other.

The second alternative is more difficult to ascertain. Theoretically, if site and heredity factors are similar in an area, all trees should be growing at approximately the same rate. Therefore, potential rabbit use can have one of three effects on a tree seedling. If the rabbit's utilization of sugar maple is truly random, there could actually be a stimulation effect on the plant. On the other hand, if the rabbits did indeed select the faster growing seedlings, then equal growth rates would reflect a detrimental impact since they would have been growing at an even faster rate if not utilized by the cottontail. If the seedlings did not respond at all, then the utilized plants would show a reduced growth rate and height at the same age as the unused seedlings.

In Toumey Woodlot, the north, south, and blowdown areas are all on predominately the same soil type, so that tree growth rates should be similar on the basis of site alone. The blowdown area has a higher plant growth rate than either the north or south areas, the result of increased light and reduced competition. The swamp area also has a high tree growth rate, apparently due to a better water supply during the growing season. The data indicates that the growth rates are not significantly different among the

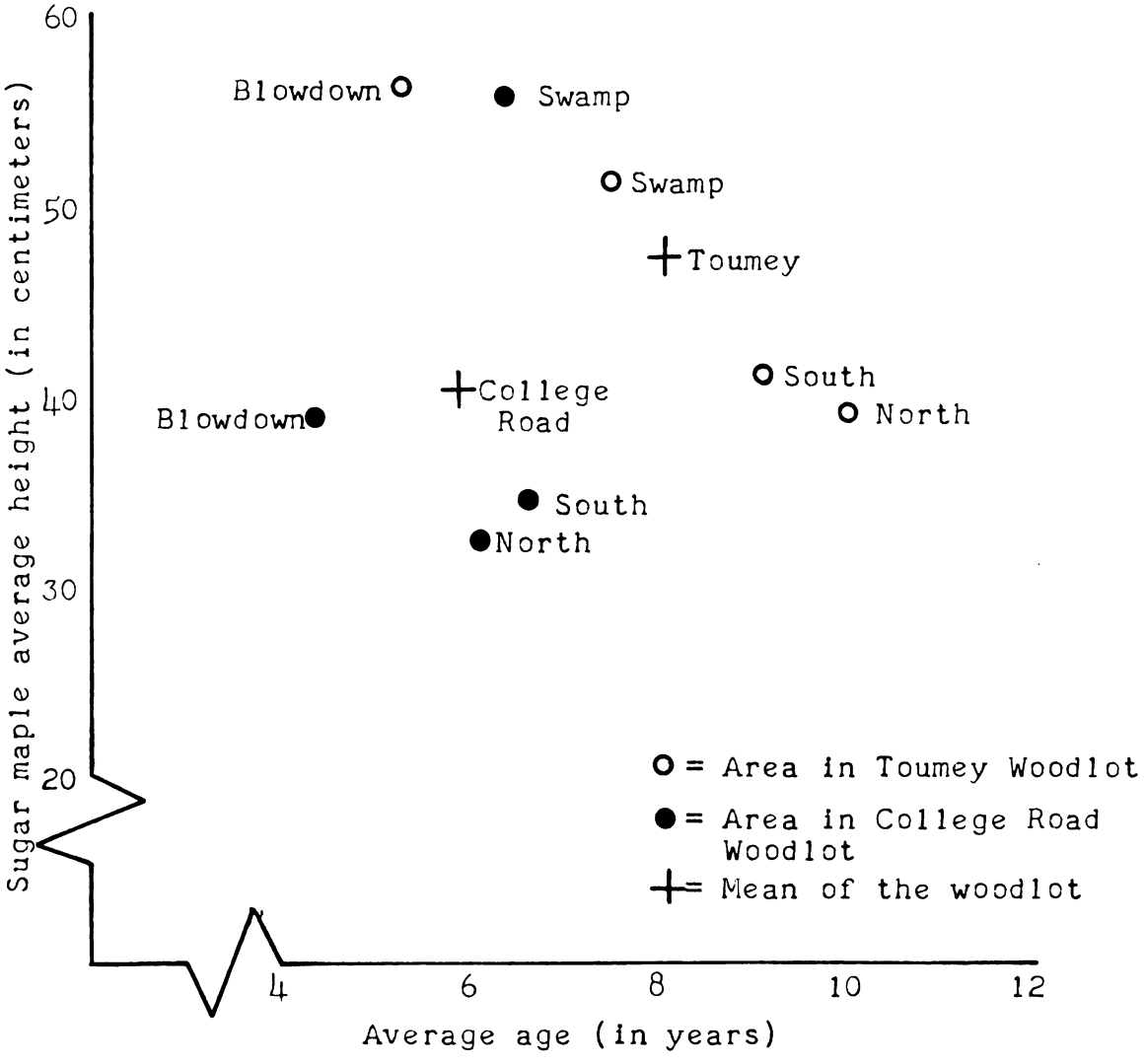


Figure 5. Sugar maple height-to-age relationship in Toumey and College Road Woodlots, 1965-1966

used and unused seedlings, but the used plants are taller than the unused seedlings at the same age. This can apparently be attributed to two factors operating in this woodlot. The rabbits appear to select the more rapidly growing seedlings, and this utilization subsequently results in a stimulation of the seedling growth. However, the reverse of this occurs in the College Road Woodlot, since the utilized seedlings are shorter and are growing at a reduced rate when compared to the unused seedlings.

Implications of sugar maple utilization.--Numerous studies have shown that seedling growth and survival are influenced by many factors such as:

1. Seedling density
2. Seedling age
3. Overstory competition
4. Soil fertility
5. Water availability
6. Microenvironmental conditions
7. Species vigor
8. Biotic influences

Any one or a combination of these factors could result in the height-to-age differences observed in the two sampled woodlots.

I propose that the cottontail may be an important biotic influence in woodlots such as those examined. It is known that the cottontail will re-use the same seedlings (Sweetman, 1949). The number of sugar maple utilized by the cottontail was nearly identical in the two woodlots sampled. Based on current seedling utilization (Table 6), it appears that cottontail pressure is lower in the old-growth woodlot

than in the second-growth woodlot. If this is in fact true, then it appears that the amount of use per unit time is lower in the old-growth than the second-growth woodlot. This also appears to be true for seedlings which may not be re-used, and is indicated by the older age of the seedlings in the old-growth woodlot. If the seedlings are used randomly by the cottontail, then the same reduced utilization per unit time is indicated by the similar utilization and older age of seedlings in the old-growth stand. When the linear regression analysis is considered, it appears that cottontail use has resulted in greater growth of the utilized seedlings in the old-growth woodlot, whereas the reverse was observed in the second-growth woodlot.

From these observations, the proposed relationship for sugar maple response to rabbit use is shown in Figure 6. A similar relationship has been observed in range management for browsing by domestic animals (Sampson, 1952). There would appear to be a threshold level of utilization where sugar maple growth is not different from an unused seedling. For Toumey Woodlot, the apparent location is to the left of the threshold level, resulting in a stimulation of seedling growth. College Road Woodlot would be located on the right of the graph, producing a detrimental effect on seedling growth. Although this effect would vary in degree for different sites, it is possible that this type of rabbit influence would occur in other similar woodlots.

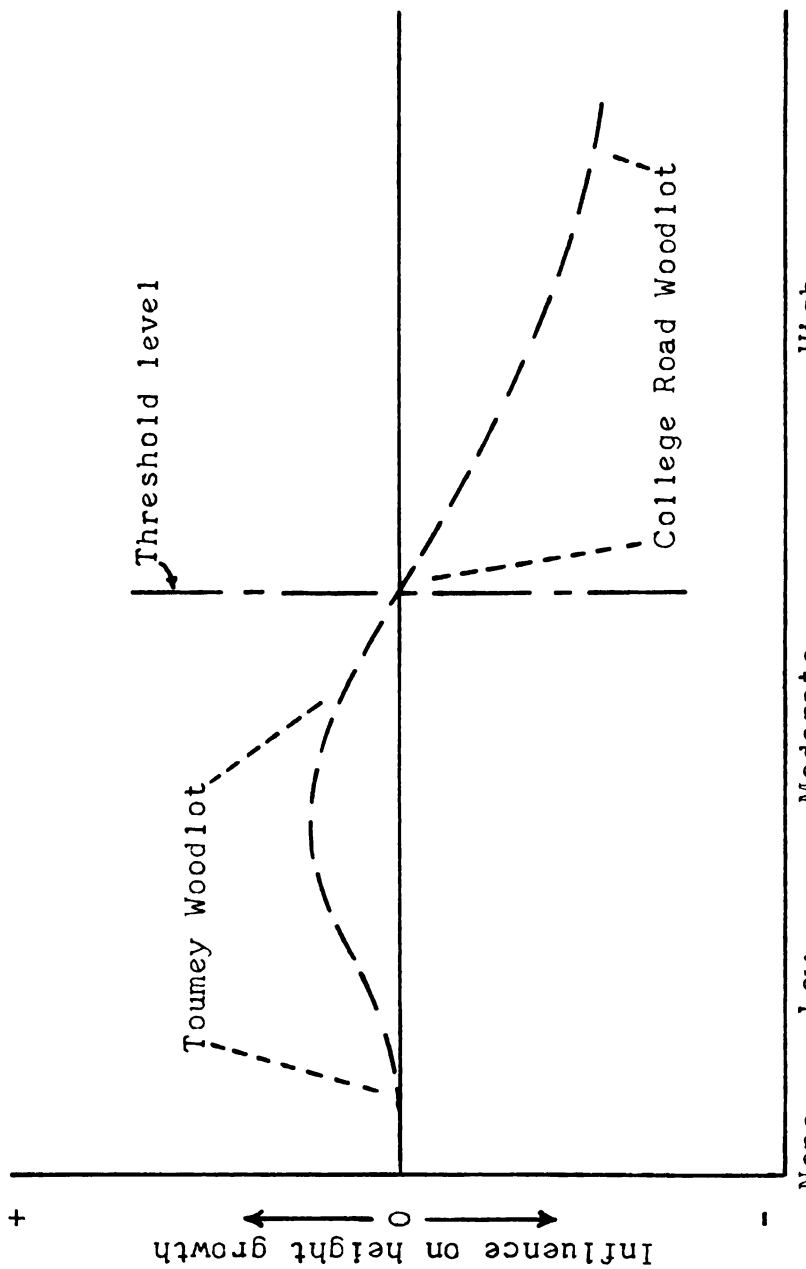


Figure 6. Theoretical relationship of sugar maple response to the amount of rabbit utilization a plant receives

Sugar maple may thus be a good indicator of winter rabbit pressure in a woodlot of this type. Although over half of the trees sampled were sugar maple, the percent utilization by the cottontail (Table 6) closely approximates the average use for its respective area and is the only species of the eight sampled that is not significantly different from the area average. Other factors support the choice of sugar maple, such as the low to moderate preference for sugar maple (neither avoided or overly preferred), longevity in the available height class (oldest average age of the eight species sampled), and ease of obtaining sufficient samples.

Utilization of associated species.--In addition to sugar maple, seven other species were sampled in the two woodlots. The results are summarized in Tables 18 through 24 in the Appendix. Stocking levels for these species were low and therefore insufficient data were available to perform an analysis similar to that completed for sugar maple. In general, data for these species supported the sugar maple results. Only one species differed greatly, that being northern red oak. Although this species was the youngest in age and shortest in height of the eight species sampled, it was both older and taller in College Road Woodlot than in Toumey Woodlot, the reverse of all other species. The oak was also much more preferred by the cottontail in College Road Woodlot than in Toumey Woodlot. It is possible that this reversal in the height-to-age relationship is an

expression of the same theory postulated for sugar maple. Since the oak was the least preferred of any species in Toumey Woodlot, there would be minimal stimulation from rabbit use. In contrast to this, the oak in College Road Woodlot received moderate use and may have resulted in greater growth. However, the reduction in height of the northern red oak appears even greater than can be accounted for by just age reduction alone. It may also indicate that this species is perhaps more sensitive to damage than the other species sampled.

The elm also differed slightly from the generally observed pattern. The age was about equal in both woodlots but the height was shorter in Toumey Woodlot. The amount of use, both previous and current, was much greater in College Road Woodlot. This is also possibly explained by the stimulation effect noted earlier.

Current utilization of vegetation

The utilization of tree seedlings that occurred during the study period by the cottontail is shown in Table 6 as the current use. In all cases, the current use is less than the total previous use. Utilization ranged from 0 to 40.6 percent of the sample when each species is considered separately within the specific woodlot areas. This compares with a range of 0 to 100 percent for previous use. Species averages for all areas range from a minimum of 1.6 percent utilization for white ash to a maximum of 15.5 percent for the elm. This compares to a previous use of 55.1 percent

for white ash as the minimum, and 96.9 percent for American beech as the maximum. The areas also vary when all species sampled within each area are combined. Two areas in Toumey Woodlot, the north and the swamp areas, had minimal utilization of 0.6 percent while the College Road north area had the maximum of 17.1 percent utilization. This area had noticeably more utilization, over three times as great as the next highest area. This compares to a minimum previous utilization of 42.2 percent in the Toumey north area, and a maximum of 93.9 percent in the Toumey blowdown area.

Of interest here is the question: can the rate of utilization experienced during any one current winter be used as an estimate of the rabbit pressure within that area?

One approach involves determining an average rate of utilization experienced on the area during previous years, and then comparing the current winter's utilization to this previous use average. This estimate is made by dividing the average age of the plants into the total percent of utilization. It is recognized that many variables are not taken into consideration in obtaining the average utilization for a species. Some of the more important variables are:

1. Varying populations of rabbits
2. Unequal availability of food species
3. Differences in the volumes utilized by species
4. Variable weather conditions during previous years
5. Agricultural practices on adjacent lands
6. Competition with other species for the same foods

Therefore, while the average utilization is only a guide, it does reflect the annual use experienced over the

period that the plants have been present on the area. These estimates were calculated and compared to the current utilization experienced in the combined woodlot areas (Table 12). All species received significantly less than the average annual utilization for the current 1965-1966 winter as determined by Chi square analysis. Only two species were within ten percent of the average annual utilization, all remaining species having less than half their respective averages. This supports the conclusions of the climatic data by indicating a mild winter with little demand for woody vegetation. It is interesting to note the species preferences as determined by the average annual utilization. These values compare favorably with those indicated by the mean rank values determined previously in Table 7. This would further imply that the age of the reproduction is an important consideration in determining the species preference.

Secondly, it is proposed that by observing the amount of browsing on several key plant species, a man in the field would be able to estimate the pressure or number of rabbit "use-days" occurring within an area. This approach would involve a random sampling of a suitable number of each key species for cottontail utilization, and determining the average height and age of each species. To obtain such an estimate of rabbit pressure, the following would need to be determined:

1. The parameters which would affect the use of a species, such as snow depth, temperature, unequal availability of tree species, age differences, growth differences, and adjacent cover.

Table 12. Expected utilization per year for tree seedlings by species, and species preference of the cottontail rabbit, 1965-1966

Species	Total previous utilization a/	Average age b/	Previous utilization per year	1965-1966 use	Deviation from expected	Preference rank	
						Prev. use per year	Species preference c/
	-percent-	-years-		-percent-			
Sugar maple	66.9	6.94	9.6	2.8	-71	8	4
Bitternut hickory	61.6	4.06	15.2	2.3	-85	4	6
White ash	55.1	5.28	10.4	1.6	-85	7	7
American beech	96.9	5.16	18.8	3.1	-84	1	1
Black cherry	67.4	4.96	13.6	6.2	-54	6	5
Northern red oak	58.6	3.95	14.8	13.8	- 7	5	8
American basswood	81.8	4.73	17.3	6.1	-65	2	3
Elm	85.0	5.12	16.6	15.5	- 7	3	2

a/ Derived from Table 6

b/ Derived from Tables 9 and 18 through 24

c/ Derived from mean ranks of Table 7

2. The number of species to sample.
3. Which reproduction species give the most reliable index of use.

Ecological implications

I. The composition of the overstory has an important influence on the seedling composition within a stand. It is recognized that seed production, germination requirements, and tolerance levels vary between species. It should also be recognized that the biota can significantly influence tree seedling composition. The present study was not extensive enough in either time or area to fully examine this influence, but it appears that the cottontail has had an effect on past tree seedling composition. The two dominant tree species of the study areas, sugar maple and beech, reflect this influence. Although sugar maple comprises 10 to 80 percent of the overstory in each study area, the reproduction ranges from 25 to 98 percent of all tree seedlings. In all areas, the percent of seedling reproduction is greater than the overstory percent for sugar maple. In contrast to this, American beech comprises a lower segment of the seedling reproduction than found in the overstory in all the woodlot areas. The species preference analysis indicates that beech was the most preferred species, while sugar maple was fourth preferred out of the eight species sampled (see Table 7).

II. The change from a second-growth to an old-growth woodlot is an important influence on the cottontail. As the stand matures, the available rabbit cover is often reduced

and as a consequence rabbit populations are diminished. This was not found in comparing the two woodlots in this study. The average percent damage in the old-growth woodlot was within five percent of the second-growth woodlot (see Table 6), indicating that the total utilization is roughly similar. The percent use is an index of the rabbit pressure per unit time, and it is possible that the populations and/or pressures in the two woodlots are similar. This leads to the question: what factors allow the rabbit pressure to be maintained in the old-growth woodlot at a level similar to the second-growth woodlot? It would appear that food and cover are primary considerations. Associated with the reduction of rabbit cover in an old-growth woodlot is a similar loss in available food, primarily in the herbaceous plants utilized by the cottontail (Moseby, 1963). If both the food and cover are reduced within the old-growth woodlot, then these limitations are being met by the adjacent lands providing sufficient food and cover to maintain a higher rabbit pressure. If winter cover is not limiting, the consequence would be an increased winter utilization of woody vegetation in the old-growth woodlot, such as was found in Toumey Woodlot. This woodlot is surrounded on three sides by either agricultural crops or pastures, as well as planted conifers on the woodlot edge, a swamp and the blowdown area; all of which probably contribute to the available food and cover requirements of the cottontail.

It is postulated that the break-up of the forest continuity is exemplified by the maintenance of a greater rabbit pressure throughout the life of small isolated forest stands. This appears to be one of the more important biotic changes that can be attributed to man's interaction with the pristine sugar maple-beech climax forest.

SUMMARY AND CONCLUSIONS

This study examined the biotic interactions between the Eastern cottontail and tree reproduction under two sugar maple-beech stands in southern Michigan during the winter of 1965-1966. Toumey Woodlot, an old-growth stand, was selected as being typical of the remnant stands of this type. In contrast, College Road Woodlot was a second-growth stand with evidence of much greater disturbance than Toumey Woodlot.

Factors considered in determining the cottontail influence in these areas were: the climate during the study period, available estimates of the rabbit populations, tree reproduction and overstory densities, and the current as well as past rabbit utilization of sugar maple reproduction and seven other associated tree species.

Stand description

Analysis showed that species abundance and stand density were different between the two woodlots. Toumey Woodlot is primarily composed of sugar maple and beech, with twenty other tree species, of which only six are common, scattered throughout the woodlot. Basal area per acre was higher in the old-growth woodlot, with the densest area sampled in the second-growth having a lower basal area than the least dense area in the old-growth woodlot. College Road Woodlot is composed primarily of sugar maple, along with considerable amounts of elm and white ash. It has had a

considerable portion of the merchantable timber removed, and the majority of the stand's basal area is in the pole and small sawtimber size classes.

Climatic influence

The 1965-1966 winter was mild. Temperatures were generally higher than normal, total precipitation for the September to May period was 44 percent above the six-year average, but snowfall was 41 percent below the average. Snow depth attained a maximum of six inches in December, with measurable snow depth also observed in January and February. The decline in the snow depth was two months earlier than expected, and was considered an important factor in the low amount of browsing observed in the woodlots.

Available food (tree seedlings, 10 to 150 cm. in height)

The density of tree seedlings was used as a measure of woody vegetation available as food for the cottontail. Although the same tree species occur as reproduction in both woodlots, their density has been altered. While the total seedling density remains the same for both woodlots, the old-growth woodlot has lost a large number of its less common tree species, and this void has been occupied by additional sugar maple.

Previous utilization of vegetation

The percentage of utilized tree seedlings is an indication of the winter rabbit pressure, influenced by the winter weather severity. Both woodlots have experienced

similar previous utilization, with an average of approximately 69 percent of all sampled tree seedlings having been utilized prior to the study.

A. Cottontail tree species preferences. Based on previous rabbit utilization, the following species preferences were observed:

Preferred	Accepted	Non-preferred
American beech	Sugar maple	Bitternut hickory
Elm	Black cherry	White ash
American basswood		Northern red oak

These preferences were consistent in both woodlots except for bitternut hickory. This species was preferred more in the old-growth than the second-growth woodlot. While individual species preference was not related to the available food, the total species utilization within an area would be more closely related to the available food. Sugar maple would comprise the bulk of the cottontail diet in both woodlots.

B. Cottontail woodlot area preferences. The blowdown and swamp areas of Toumey Woodlot had much greater previous use than the other two areas sampled in that woodlot. The use in the second-growth stand wasn't as localized as in the old-growth woodlot, indicating that it provides an over-all environment more conducive to rabbit use than the old-growth woodlot.

Two areas were noticeably avoided. The north area in Toumey Woodlot apparently lacked suitable ground cover. The

College Road blowdown area similarly had a minimal ground cover during the winter period and was used less frequently than any area in this woodlot. The amount of winter ground cover apparently is an important influence of the rabbit population utilizing the area.

C. Utilization of sugar maple. Whereas the utilized seedlings in College Road Woodlot have a reduced growth rate compared to the unused seedlings, those in Toumey Woodlot were taller than unused seedlings of the same age. If the rabbit utilization of sugar maple is truly random, then the utilized sugar maple appear to be stimulated to produce more growth than an unused seedling. The opposite would be true if the cottontail actually selected the faster growing seedlings. If equal growth rates occur for both used and unused seedlings, then this would indicate a reduction of the potential growth of the utilized seedlings.

D. Implications of sugar maple utilization. It appears that sugar maple responds proportionately according to the amount of browsing the plant receives. At low to moderate levels of use, sugar maple is stimulated and produces greater growth than it does without any use. At more intensive levels of use, the effect is detrimental and either death or a reduced growth rate results.

Sugar maple appears to be a good indicator of the winter browsing pressure in a woodlot. Compared to the other species sampled, it remained within reach of the rabbits for a longer period of time, thus providing a longer

record of use. It also was the only species sampled that gave an accurate estimate of total utilization within the woodlot areas.

Current utilization of vegetation

About five percent of all tree seedlings sampled were utilized during the 1965-1966 winter. This winter had less than average use and supports the general belief that winter severity influences the amount of utilization of woody vegetation. Species utilized to the greatest extent were elm and northern red oak. These preferences are not the same as indicated by the data for previous utilization. While species abundance varies from year to year, this may also indicate that food preferences vary from year to year. There is also a possibility that the age of the tree seedlings is an important consideration in determining species preferences.

Ecological implications

The two predominant species of this forest type give an indication that the cottontail may have an influence on seedling composition. Sugar maple is forming an increasing proportion of the seedling density while beech reproduction is decreasing. Beech was the most preferred species in the woodlots while sugar maple was moderately preferred.

The change from a second-growth to an old-growth stand also has an influence on the cottontail. As a stand approaches the climax type, the available food and cover is often reduced. In an extensive stand of this forest type,

this would normally result in a reduced rabbit population and/or pressure. It may be that in small isolated stands such as Toumey Woodlot, it is the adjacent areas that provide sufficient food and cover to compensate for the loss within the woodlot. This would then permit an increased winter pressure on the woodlot by the cottontails from the adjoining areas.

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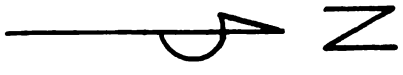
APPENDIX

Figure 7. Aerial photograph of Toumey Woodlot, and location of study areas
(Scale: 1 inch = 130 feet; Jan. 12, 1965)



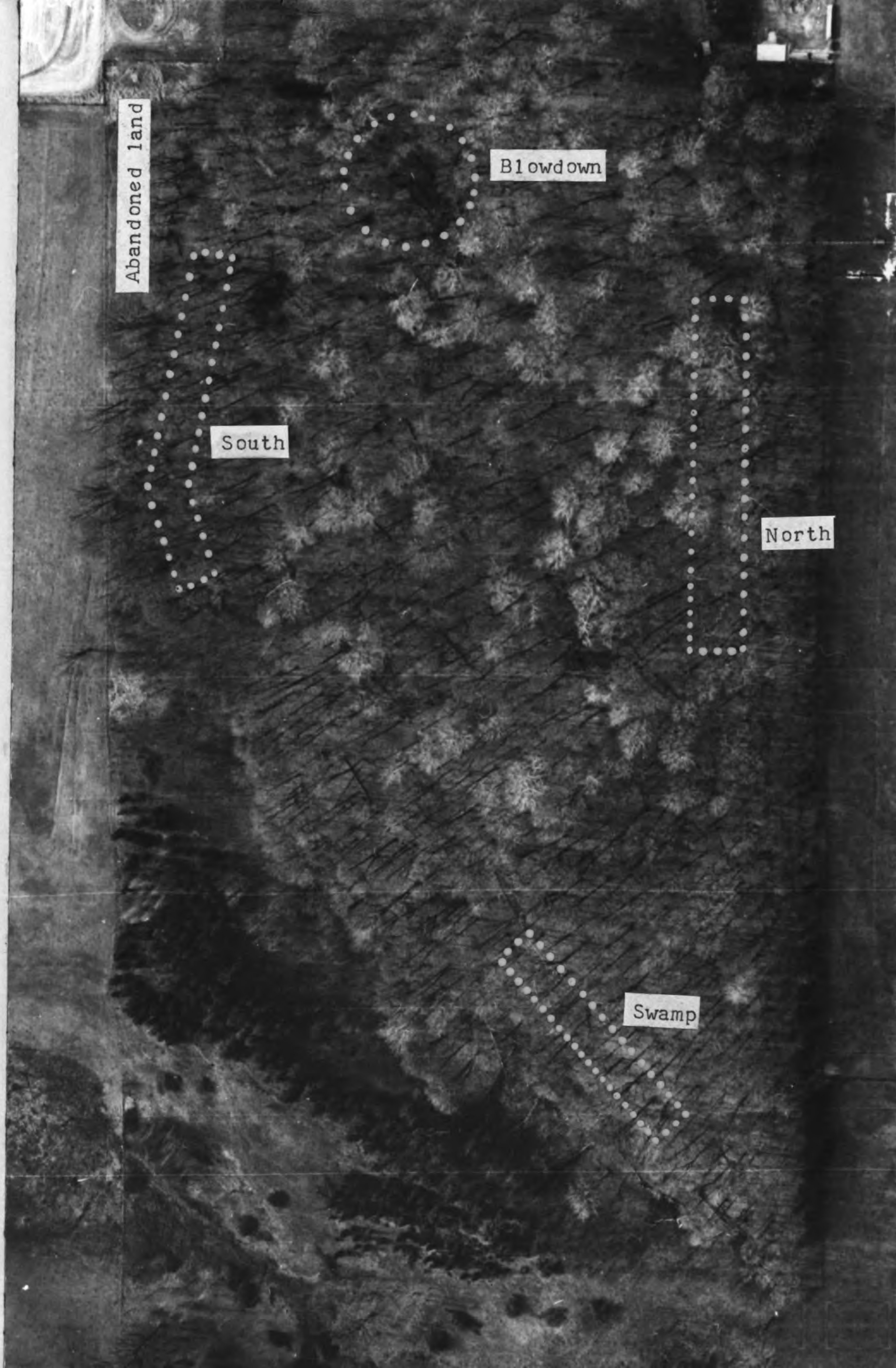

Abandoned land
Blowdown
South
North
Swamp

Figure 8. Aerial photograph of College Road Woodlot and location of study areas
(Scale: 1 inch = 210 feet; Jan. 12, 1965)


Swamp
Blowdown
South
North

Table 13. Analysis of variance for total seedling density in Toumey and College Road Woodlot areas, 1966

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability (percent)
Density	7	3301.6	471.657	1.6714	>.10
Woodlots	1	348.100	348.100	1.2336	>.10
Toumey[a/]					
N = rest	1	322.017	322.017	1.1412	>.10
S = rest	1	61.633	61.633	0.2184	>.10
Sw = rest	1	36.100	36.100	0.1279	>.10
College Road					
N = rest	1	236.017	236.017	0.8364	>.10
S = rest	1	1540.833	1540.833	5.4603	.025<P<.05
Sw = rest	1	756.900	756.900	2.6823	>.10
Error	32	9030.0	282.188		
Total	39	12331.6			

a/ N = north, S = south, and Sw = swamp area within the woodlot

Table 14. Analysis of variance for seedling density by species groups in Toumey and College Road Woodlot areas, 1966

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability (percent)
		SUGAR MAPLE			
Density	7	5816.775	830.968	3.9617	.001<P<.005
Woodlots	1	2265.025	2265.025	10.7987	.001<P<.005
Toumey[a]					
N = rest	1	70.417	70.417	0.3357	>.10
S = rest	1	300.833	300.833	1.4343	>.10
Sw = rest	1	62.500	62.500	0.2980	>.10
College Road					
N = rest	1	256.267	256.267	1.2218	>.10
S = rest	1	2861.633	2861.633	13.6431	<.001
Sw = rest	1	0.100	0.100	0.0005	>.10
Error	32	6712.000	209.750		
Total	39	12528.775			
		ALL OTHER SPECIES			
Density	7	2948.775	421.254	5.2822	<.001
Woodlots	1	837.225	837.225	10.4981	.001<P<.005
Toumey					
N = rest	1	91.267	91.267	1.1444	>.10
S = rest	1	90.133	90.133	1.1302	>.10
Sw = rest	1	3.600	3.600	0.0451	>.10
College Road					
N = rest	1	984.150	984.150	12.3404	.001<P<.005
S = rest	1	202.800	202.800	2.5430	>.10
Sw = rest	1	739.600	739.600	9.2740	.001<P<.005
Error	32	2552.000	79.750		
Total	39	5500.775			

[a] N = north, S = south, and Sw = swamp area within the woodlot

Table 15. Analysis of variance for species preference of the cottontail in Toumey and College Road Woodlots, 1965-1966

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability (percent)
Species	7	131.326	18.7609	6.9948	<.001
Error	46	123.378	2.6821		
Total	53	254.704			

Table 16. Analysis of variance for area preference of the cottontail in Toumey and College Road Woodlots, 1965-1966

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability (percent)
Species	7	73.360	10.4800	3.2700	.005<P<.01
Error	46	147.424	3.2049		
Total	53	220.784			

Table 17. Analysis of covariance for sugar maple reproduction in Toumey and College Road Woodlots, paired by use categories, 1965-1966

Woodlot	Area	Comparison [a]	Non-parallelism [b]		Difference between regressions [c]	
			Value	Probability	Value	Probability
				-percent-		-percent-
Toumey	North	0 = 1	0.4535	>.10	0.2228	>.10
		1 = >1	0.0889	>.10	2.7782	.05<P<.10
	South	0 = 1	0.4510	>.10	4.5099	.025<P<.05
		1 = >1	2.0937	>.10	0.1605	>.10
	Swamp	0 = 1	3.4740	.05<P<.10	0.5439	>.10
		1 = >1	0.0069	>.10	19.8136	<.001
	Blowdown	0 = 1	0.2132	>.10	3.0946	.05<P<.10
		1 = >1	2.7211	>.10	14.4293	<.001
College Road	North	0 = 1	0.1684	>.10	0.2340	>.10
	Swamp	0 = 1	3.2189	.05<P<.10	1.1257	>.10
		1 = >1	4.0601	.025<P<.05	5.6015	.01<P<.025

[a] 0 = not used; 1 = used once; and >1 = used more than once

[b] Non-parallelism tests the slopes of the regression lines for the use categories in the comparison. Significance means that the lines are not parallel

[c] Difference between regressions is meaningful only when non-parallelism is non-significant. If the lines are parallel, this test indicates whether the regression lines differ in amplitude

Table 18. Bitternut hickory data summary for both woodlots from November, 1965 to June, 1966

Woodlot	Area	Number sampled	Average height	Average age	Evidence of previous use			Current use	Mortality
					Not used	Used once	Used > once		
			-cm.-	-years-	-percent-			-percent-	-percent-
Toumey	North	9	41.0 ± 36.8	5.9 ± 2.8	44.4	22.2	33.3	0.0	0.0
	South	14	45.4 ± 36.7	4.8 ± 3.8	28.6	21.4	50.0	0.0	0.0
	Swamp	10	70.0 ± 30.8	5.5 ± 3.3	20.0	70.0	10.0	0.0	0.0
	Blowdown	0	---[a]	---	--	--	--	--	--
	Average	33	51.7 ± 36.2	5.3 ± 3.3	30.3	36.4	33.3	0.0	0.0
College Road	North	29	50.6 ± 33.3	4.0 ± 1.1	31.0	31.0	37.9	3.4	0.0
	South	16	19.8 ± 10.4	2.8 ± 1.6	56.2	37.5	6.3	6.3	0.0
	Swamp	8	19.1 ± 11.6	1.8 ± 0.9	62.5	37.5	0.0	0.0	0.0
	Blowdown	0	---	---	--	--	--	--	--
	Average	53	36.6 ± 29.9	3.3 ± 1.5	43.4	34.0	22.6	3.8	0.0
Bitternut hickory average		86	42.4 ± 33.1	4.1 ± 2.5	38.4	34.9	26.7	2.3	0.0

[a] Not present in sample

Table 19. White ash data summary for both woodlots from November, 1965 to June, 1966

Woodlot	Area	Number sampled	Average height	Average age	Evidence of previous use			Current use	Mortality
					Not used	Used once	Used > once		
			-cm.-	-years-	-percent-			-percent-	-percent-
Toumey	North	11	64.9 ± 33.5	7.7 ± 3.5	27.3	36.4	36.4	0.0	0.0
	South	49	51.8 ± 28.9	4.6 ± 3.2	44.9	44.9	10.2	2.0	2.0
	Swamp	10	69.0 ± 38.2	7.2 ± 3.5	40.0	20.0	40.0	0.0	0.0
	Blowdown	5	44.6 ± 14.6	3.8 ± 0.7	40.0	0.0	60.0	0.0	0.0
	Average	75	55.5 ± 30.6	5.3 ± 3.4	41.3	37.3	21.4	1.3	1.3
College Road	North	13	48.3 ± 24.0	6.3 ± 1.7	69.2	23.1	7.7	7.7	0.0
	South	3	37.0 ± 20.0	5.7 ± 0.6	100.0	0.0	0.0	0.0	0.0
	Swamp	36	33.8 ± 20.0	4.8 ± 1.5	38.9	41.7	19.4	0.0	0.0
	Blowdown	0	---a/	---	--	--	--	--	--
	Average	52	37.6 ± 21.7	5.2 ± 1.6	50.0	34.6	15.4	1.9	0.0
White ash average		127	48.2 ± 28.6	5.3 ± 2.8	44.9	36.2	18.9	1.6	0.8

a/ Not present in sample

Table 20. American beech data summary for both woodlots from November, 1965 to June, 1966

Woodlot	Area	Number sampled	Average height	Average age	Evidence of previous use			Current use	Mortality
					Not used	Used once	Used > once		
			-cm.-	-years-	-percent-			-percent-	-percent-
Toumey	North	17	65.7 ± 26.2	4.9 ± 1.8	5.9	23.5	70.6	5.9	0.0
	South	1	86.0 ± 0.0	8.0 ± 0.0	0.0	0.0	100.0	0.0	0.0
	Swamp	4	87.8 ± 30.3	6.8 ± 1.5	0.0	0.0	100.0	0.0	0.0
	Blowdown	0	---a/	---	--	--	--	--	--
	Average	22	70.6 ± 27.2	5.4 ± 1.9	4.5	18.2	77.3	4.5	0.0
College Road	North	2	63.5 ± 5.0	7.0 ± 1.4	0.0	0.0	100.0	0.0	0.0
	South	1	9.0 ± 0.0	3.0 ± 0.0	0.0	100.0	0.0	0.0	0.0
	Swamp	6	36.7 ± 28.4	4.2 ± 1.0	0.0	66.7	33.3	0.0	0.0
	Blowdown	1	76.0 ± 0.0	4.0 ± 0.0	0.0	0.0	100.0	0.0	0.0
	Average	10	43.2 ± 28.7	4.6 ± 1.6	0.0	50.0	50.0	0.0	0.0
American beech average		32	62.0 ± 30.1	5.2 ± 1.8	3.1	28.1	68.8	3.1	0.0

a/ Not present in sample

Table 21. Black cherry data summary for both woodlots from November, 1965 to June, 1966

Woodlot	Area	Number sampled	Average height	Average age	Evidence of previous use			Current use	Mortality
					Not used	Used once	Used > once		
			-cm.-	-years-	-percent-			-percent-	-percent-
Toumey	North	8	26.1 ± 4.1	4.8 ± 0.7	75.0	25.0	0.0	0.0	0.0
	South	30	53.3 ± 28.7	5.6 ± 3.1	53.3	30.0	16.7	40.0	0.0
	Swamp	13	76.5 ± 33.2	4.7 ± 2.2	7.7	30.8	61.5	0.0	0.0
	Blowdown	24	57.4 ± 36.0	4.6 ± 2.1	4.2	20.8	75.0	20.8	0.0
	Average	75	55.7 ± 32.9	5.0 ± 2.5	32.0	26.7	41.3	22.7	0.0
College Road	North	6	31.0 ± 10.6	4.7 ± 1.8	16.7	16.7	66.7	16.7	0.0
	South	14	41.4 ± 12.6	5.6 ± 2.2	42.8	21.4	35.7	0.0	0.0
	Swamp	32	38.9 ± 23.9	4.8 ± 1.6	28.1	34.4	37.5	3.1	0.0
	Blwodown	2	10.5 ± 2.1	2.0 ± 0.0	100.0	0.0	0.0	0.0	0.0
	Average	54	37.6 ± 20.5	4.9 ± 1.9	33.3	27.8	38.9	3.7	0.0
Black cherry average		129	48.1 ± 29.7	5.0 ± 2.3	32.6	27.1	40.3	14.7	0.0

Table 22. Northern red oak data summary for both woodlots from November, 1965 to June, 1966

Woodlot	Area	Number sampled	Average height	Average age	Evidence of previous use			Current use	Mortality
					Not used	Used once	Used > once		
			-cm.-	-years-	-percent-			-percent-	-percent-
Toumey	North	4	28.5 ± 25.0	5.0 ± 4.8	75.0	0.0	25.0	0.0	0.0
	South	23	21.7 ± 6.5	3.0 ± 1.3	52.2	34.8	13.0	17.4	0.0
	Swamp	5	34.8 ± 5.5	4.2 ± 1.6	60.0	20.0	20.0	0.0	0.0
	Blowdown	0	---[a]	---	--	--	--	--	--
	Average	32	24.6 ± 10.9	3.4 ± 2.1	56.2	28.1	15.6	12.5	0.0
College Road	North	16	32.3 ± 24.3	4.7 ± 2.0	0.0	31.2	68.8	25.0	0.0
	South	2	38.5 ± 21.9	5.5 ± 2.1	50.0	50.0	0.0	0.0	0.0
	Swamp	8	22.9 ± 7.6	4.3 ± 1.8	62.5	25.0	12.5	12.5	0.0
	Blowdown	0	---	---	--	--	--	--	--
	Average	26	30.2 ± 20.2	4.6 ± 1.9	23.1	30.8	46.1	19.2	0.0
Northern red oak average		58	27.1 ± 15.9	4.0 ± 2.1	41.4	29.3	29.3	15.5	0.0

a/ Not present in sample

Table 23. American basswood data summary for both woodlots from November, 1965 to June, 1966

Woodlot	Area	Number sampled	Average height	Average age	Evidence of previous use			Current use	Mortality
					Not used	Used once	Used > once		
			-cm.-	-years-	-percent-			-percent-	-percent-
Toumey	North	4	48.0 ± 24.5	6.8 ± 4.3	50.0	0.0	50.0	0.0	0.0
	South	6	64.0 ± 43.0	6.3 ± 4.0	33.3	33.3	33.3	0.0	0.0
	Swamp	0	---[a]	---	--	--	--	--	--
	Blowdown	0	---	---	--	--	--	--	--
	Average	10	57.6 ± 36.1	6.5 ± 3.9	40.0	20.0	40.0	0.0	0.0
College Road	North	21	35.1 ± 21.1	3.9 ± 1.2	9.5	23.8	66.7	9.5	0.0
	South	0	---	---	--	--	--	--	--
	Swamp	2	37.0 ± 31.1	4.5 ± 3.5	0.0	50.0	50.0	0.0	0.0
	Blowdown	0	---	---	--	--	--	--	--
	Average	23	35.2 ± 21.2	4.0 ± 1.4	8.7	26.1	65.2	8.7	0.0
American basswood average		33	42.0 ± 28.0	4.7 ± 2.6	18.2	24.4	57.6	6.1	0.0

[a] Not present in sample

Table 24. Elm data summary for both woodlots from November, 1965 to June, 1966[a/]

Woodlot	Area	Number sampled	Average height	Average age	Evidence of previous use			Current use	Mortality
					Not used	Used once	Used > once		
			-cm.-	-years-	-percent-			-percent-	-percent-
Toumey	North	13	45.2 ± 20.6	5.4 ± 2.7	15.4	53.8	30.8	0.0	0.0
	South	32	60.2 ± 32.2	5.9 ± 3.3	15.6	34.4	50.0	3.1	6.2
	Swamp	31	61.2 ± 26.8	3.6 ± 1.3	32.2	19.4	48.4	3.2	6.4
	Blowdown	2	47.5 ± 40.3	3.5 ± 0.7	0.0	0.0	100.0	0.0	0.0
	Average	78	57.8 ± 28.6	4.8 ± 2.7	21.8	30.8	47.4	2.6	5.1
College Road	North	64	40.9 ± 18.8	5.6 ± 1.3	0.0	1.6	98.4	75.0	0.0
	South	10	32.4 ± 17.6	5.6 ± 3.6	10.0	60.0	30.0	0.0	0.0
	Swamp	37	32.2 ± 18.0	4.8 ± 1.3	18.9	24.3	56.8	5.4	0.0
	Blowdown	18	58.2 ± 32.8	4.9 ± 2.2	33.3	38.9	27.8	5.6	0.0
	Average	129	40.1 ± 23.4	5.3 ± 1.7	10.9	17.8	71.3	39.5	0.0
Elm average		207	46.8 ± 26.9	5.1 ± 2.2	15.0	22.7	62.3	25.6	1.9

a/ Includes both American elm and Slippery elm

Table 25. Common and scientific names of plants discussed in the text[a]

Common name	Scientific name
American basswood	Tilia americana
American beech	Fagus grandifolia
American elm	Ulmus americana
Austrian pine	Pinus nigra var. austriaca[b]
Bitternut hickory	Carya cordiformis
Black cherry	Prunus serotina
Black oak	Quercus velutina
Black walnut	Juglans nigra
Chestnut	Castanea dentata
Common elderberry	Sambucus canadensis
Eastern cottonwood	Populus deltoides
Eastern red cedar	Juniperus virginiana
Gray birch	Betula populifolia
Hawthorn	Crataegus spp.
Ironwood	Ostrya virginiana
Northern red oak	Quercus rubra
Quaking aspen	Populus tremuloides
Red maple	Acer rubrum
Sassafras	Sassafras albidum
Scotch pine	Pinus sylvestris
Serviceberry	Amelanchier spp.
Shagbark hickory	Carya ovata
Staghorn sumac	Rhus typhina
Sugar maple	Acer saccharum
Sweet gum	Liquidambar straciflua
Sycamore	Platanus occidentalis
White ash	Fraxinus americana
White oak	Quercus alba
Yellow birch	Betula alleghaniensis
Yellow poplar	Liriodendron tulipifera

a/ From Little, E. L. 1953. Check list of native and naturalized trees of the United States. U. S. Dept. Agr., Handbook 41, 472 pp.

b/ Wright, J. W., Personal communication, 1966

Table 26. Common and scientific names of all animals discussed in the text[a]

Common name	Scientific name
Eastern chipmunk	Tamias striatus
Eastern cottontail	Sylvilagus floridanus
Elk	Cervus canadensis
Florida marsh rabbit	Sylvilagus palustris
Fox squirrel	Sciurus niger
Meadow vole	Microtus pennsylvanicus
Mountain lion	Felis concolor
New England cottontail	Sylvilagus transitionalis
Opossum	Didelphis marsupialis
Racoon	Procyon lotor
Red fox	Vulpes fulva
Shorttail shrew	Blarina brevicauda
Snowshoe hare	Lepus americanus
Southern bog lemming	Synaptomys cooperi
Starnose mole	Condylura cristata
White-footed mouse	Peromyscus leucopus
Whitetail deer	Dama virginiana
Wolf	Canis lupus
Woodchuck	Marmota monax

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a/ From Hall, E. R. and K. R. Kelson, 1959. The mammals of North America, Volumns I and II, Ronald Press, New York, 1162 pp.

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