THE EFFECTS OF DEER BROWSING ON THE UPLAND HARDWOODS REPRODUCTION OF THE EDWIN S. GEORGE RESERVE, MICHIGAN

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I. Introduction

Much has been written about the habits and life history of the whitetailed deer (Odocoileus virginianus borealis Miller), our foremost American game animal. His large size, widespread distribution, adaptability, and sporting qualities combine to make him an animal well worth further attention. The tendency to quickly overpopulate suitable areas and to reduce or destroy the vegetation of his range by overbrowsing are problems perplexing many game managers. Determining the carrying capacity of the range is an important beginning step along with analyzing food preferences and requirements. Steps must then be taken to reduce the deer population or to improve the range.

The University of Michigan is fortunate in possessing a splendid outdoor laboratory of 1268 acres, close by, that is complete with its own deer herd, for study by zoologists, foresters, game managers, and other interested persons. This area, known as the Edwin S. George Reserve, has been under constant supervision for the past twenty years and much valuable information on deer productivity and yield has been obtained. "Conservationists the country over are interested in facts now being ascertained concerning the George Reserve deer herd - its rate of increase, the relationship between it and its food supply, and its seasonal behavior." (Museum Bulletin) The resident biologist, F. N. Hamerstrom, in collaboration with the custodian, Laurence Camburn, is currently conducting a study on the reproductive capacities of the deer and much

useful data is also being compiled on weights, ages, and herd composition. Carroll Smithson and John Brasch, Wildlife Management students, carried on studies in 1946-47 based on deer herd composition and habitat preferences, respectively.

Investigations still need to be made on the food preferences and nutritional requirements of whitetails in the southern hardwoods regions.

In their natural food habits, deer are dainty, random, tip browsers - a twig here and a leaf there. They move along in an apparently thoughtless, unsystematic manner sampling the vegetation. "No plant is too small for their attention; and with differences in acceptability according to season and circumstances, almost everything that grows is eaten." (Forbes et al, 1941) Cook (1946) found that even on a block as small as one-half acre, deer did not forage everywhere but restricted their travels to certain well defined paths. The pattern of use was determined at least in part by the presence of such obstructions as brush piles, stone heaps, brambles, as well as by location of trails coming into the clearing from the forest. In consequence, arbitrary samplings such as strip counts, are of rather limited use. At certain seasons, deer eagerly sought out and fed upon the plants they liked best, so only rarely did an individual escape. Seedlings were not as much sought after as sprouts, probably due to a chemical or nutritive difference.

When deer are artificially confined to an area and allowed to multiply unmolested by predation and hunting, it

can readily be seen that the carrying capacity of the range would soon be exceeded. O'Roke and Hamerstrom (1948) found evidence that the George Reserve herd tended to become self limiting after it developed an overpopulation and that it became apparent before damage to the vegetation had reached its peak. They state that the Reserve in its present condition could support its present 25-30 deer per section for many years and could undoubtedly have supported an even larger herd if there had not been so large an overpopulation in the early thirties.

The summer carrying capacity of deer range is relatively large and the winter carrying capacity is relatively small. The Reserve herd does not have the freedom of unlimited range during critical winters so unusually heavy pressure was brought to bear upon the woody vegetation when the deer population was at its peak around 1933.

The writer is interested in the differential effect of deer browsing on the oak-hickory reproduction and is attempting to gather the data in the form of a growth study on selected plots.

Old residents familiar with the area say that "deer damage" became evident about 1935 but within the past four or five years they have noticed a gradual improvement of the understory. Dr. Hamerstrom, in describing the recent change, suggested that cutting back the herd to about 50-60 deer since 1941 probably aided the vegetation in makihg a comeback. "Oak reproduction is still being severely damaged and seedlings of maple and hickory are destroyed almost as soon as they appear." Even to the casual observer the "deer line" is obvious on the red cedar (Juniperus virginiana), and the smooth sumac (Rhus glabra) inside the fence is nowhere near as

high as that growing just a few feet away but protected from the deer. A little closer survey might reveal that red osier dogwood (Cornus stolonifera) and hazel (Corylus americana) are not as easy to locate on the Reserve as they are in adjoining woodlots. Much less obvious but worth of further study is the possibility of measuring the damage done to hardwood reproduction previously mentioned. Also, it may be shown that some plants benefit by deer overbrowsing their competitors and "releasing" them.

When mention is made of browse damage, there is a tendency to assume that growth is stunted or reproduction reduced. Mann (1933) however, found that moderate browsing of aspen sprouts actually stimulated better growth. When the deer eat the terminal buds, lateral growth is stimulated and usually increases the amount of browse. Lateral branching and new sprouts from the root collar appear to result in reduction of height growth. Krefting (1941) noted that logging and fires tend to increase shrubby growth.

Since deer reproduce annually and forests reproduce only in long-time cycles, it is evident that some tree species may be harmed long before the damage is apparent even to the trained eye. Adolph Murie (1941) noted in his moose studies on Isle Royale that "those species eaten the year round are apt to suffer before seasonal foods, other factors being equal. Complete utilization of a range composed of a varied vegetation is generally not possible without harmful effects to some species. Plant species are not uniform in palatability nor are they uniform in abundance. Therefore, the palatable, less abundant species may be almost extirpated before a few abundant species making up the bulk of the food supply are at all damaged. Depletion

of the range may set in long before the bulk of the food supply has begun to be utilized."

Management of the Reserve herd by harvesting the surplus was begun in 1933-34 and has been carried on ever since in an attempt to match the population with the carrying capacity of the range. As a result of these removals, nothing spectacular in the way of destruction of the vegetation is to be expected, other than that brought about by their selective habits of feeding. Establishment of experimental exclosures within the Reserve, planned for the near future, may provide the necessary information on food preferences and give more concrete data on the pressure brought to bear on individual species. Dixon (1934), in his study on California mule deer, stated that in any deer food study you cannot get free natural food preferences unless the full complement of food plants is present and grazing is excluded.

A restatement of the purpose or objective of this study seems to be in order at this point. The author is assuming that (a) some changes in the vegetation have been brought about by the presence of the deer on this tract of land and, (b) these changes have been quantitative rather than qualitative (species composition). The available evidence substantiates the assumption that while the species are found on both sides of the fence, there is a noticeable difference in the condition and abundance of those species. An attempt will be made to determine the influence of browsing on height growth rates for the dominant upland hardwoods by a comparison with selected adjacent unbrowsed woodlots outside the George Reserve.

PLAINFIELD

GREGORY

UNADILLA

WILLIAMSVILLE LAKE

GRAND TRUNK

TOWN 1 NORTH — RANGE 3 EAST

ANDERSON LAKE

PINCKNEY

BENTLEY LAKE

SCHOOL LAKE

BARBER LAKES

PUTNAM

TOWN 1 NORTH — RANGE 4 EAST

Description of the George Reserve:

Location: The Edwin S. George Reserve, a 1268 acre tract, is located about four and a half (4½) miles west of Pinckney, Michigan, in the southwest corner of Livingston County. It is approximately 24 miles northwest of Ann Arbor.

Physiography: The area is characterized by many glacial features - outwash plains, eskers, kames, kettleholes, and typical rolling terrain. Physiographers state that it lies on the north edge of an interlobate morainic region. The lowland paralleling the north fence is the Pinckney channel through which the Huron River flowed to the south and west before the last glacier blocked its path and diverted it into its present channel. Huge blocks of ice buried under tons of debris eventually melted leaving kettle holes and low areas. The meltwater flowing between these blocks deposited an enormous amount of material from the face of the glacier and built up an esker-like formation, one-half mile long, known locally as the "hogsback". This knife-edge ridge extends to the southwest from the northeast corner of the Reserve in what was probably the original drainage direction. The Big Swamp is on the south side of the "esker" and numerous potholes and spur ridges lie to the north. In the north central part of the area is a high level outwash plain of about 50 acres that has about the same elevation as the "esker". Scattered throughout the southwestern and western parts of the Reserve are hills and knolls which may represent kames.

The lowest elevations (below 900') are occupied by marshes and swamps, and the highest elevations (above 975') are the crests of hills, the esker, and the outwash plain. The rest of the area lies between 925' and 975'. (See Fig. 6)

The soils of the Reserve, according to the Soil Survey Division, (USDA.1938) are in the Miami-Kewaunee soil area, gray-brown podzolic soils, and are varied and erratic in distribution. Nearly all the lowlands are covered with soils composed of peats, or mucks, to what is thought to be a considerable depth. The fields and hills are covered with mineral soils: Bellefontaine sandy loam, Plainfield sandy loam, and Coloma loamy sand. Some patches of Miami loam are found in the eastern, southern, and western parts of the area.

The oak-hickory association occurs almost wholly on the Bellefontaine sandy loam, which is porous and permits water to drain readily. It has a porous, gravelly substratum and stones occur throughout the soil. According to local standards, the soil is of medium fertility, but well suited for woodlots, especially on the steeper slopes.

The accompanying soil map (Fig. 4) should not be interpreted as having sharp lines of demarcation between the soil types, but rather that they show general soil characteristics. Since almost all the major study areas were located on sandy loams, it was felt that a detailed survey of the soils would be unnecessary. In one instance, for the George Reserve Annex, a detailed map drawn up by the Soil Conservation Service was available.

Drainage is good to excessive for the uplands by runoff or by filtering through the sandy soils. The water table is close to the elevation of the lowlands so parts of the Reserve (marshes and swamps)

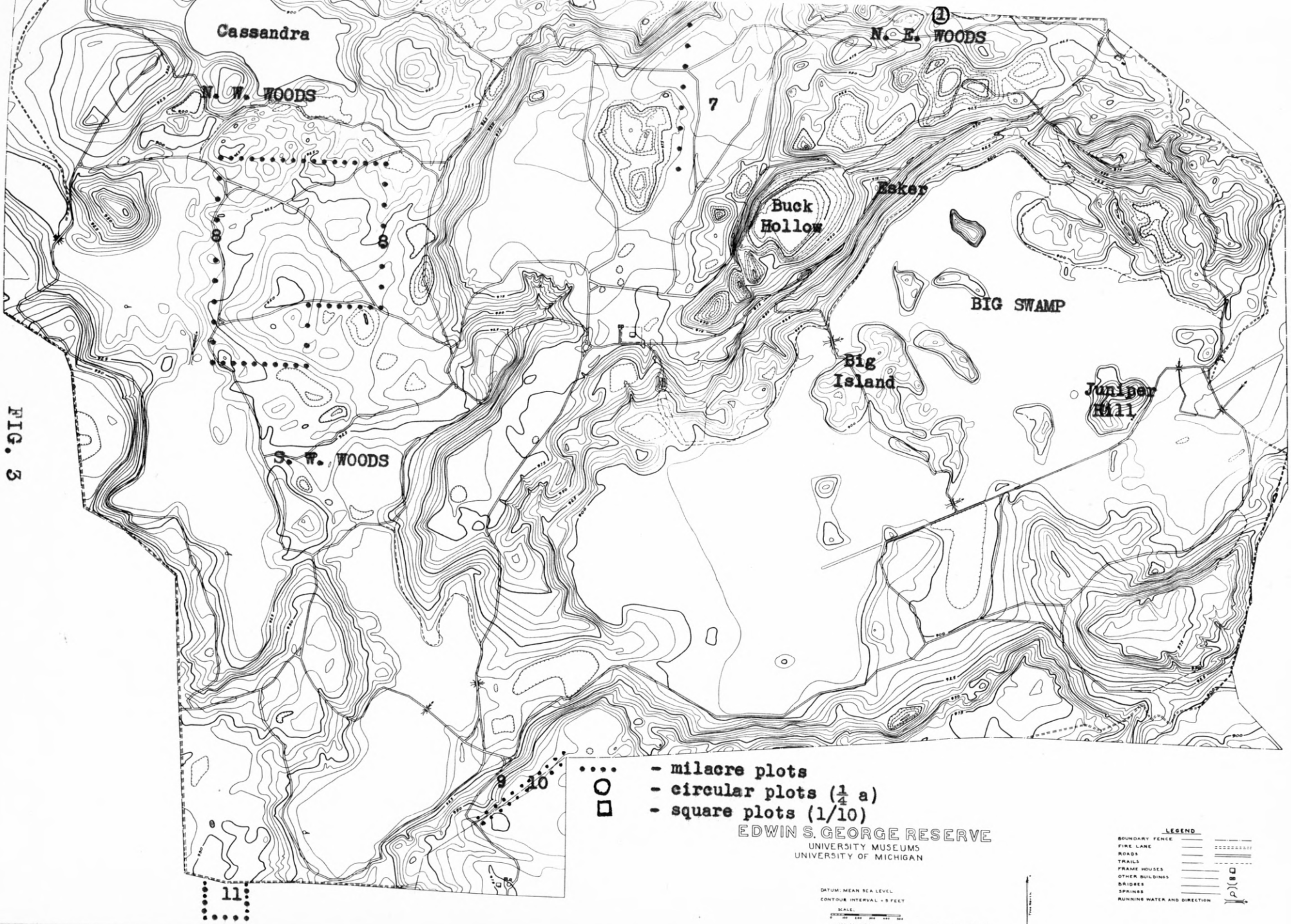
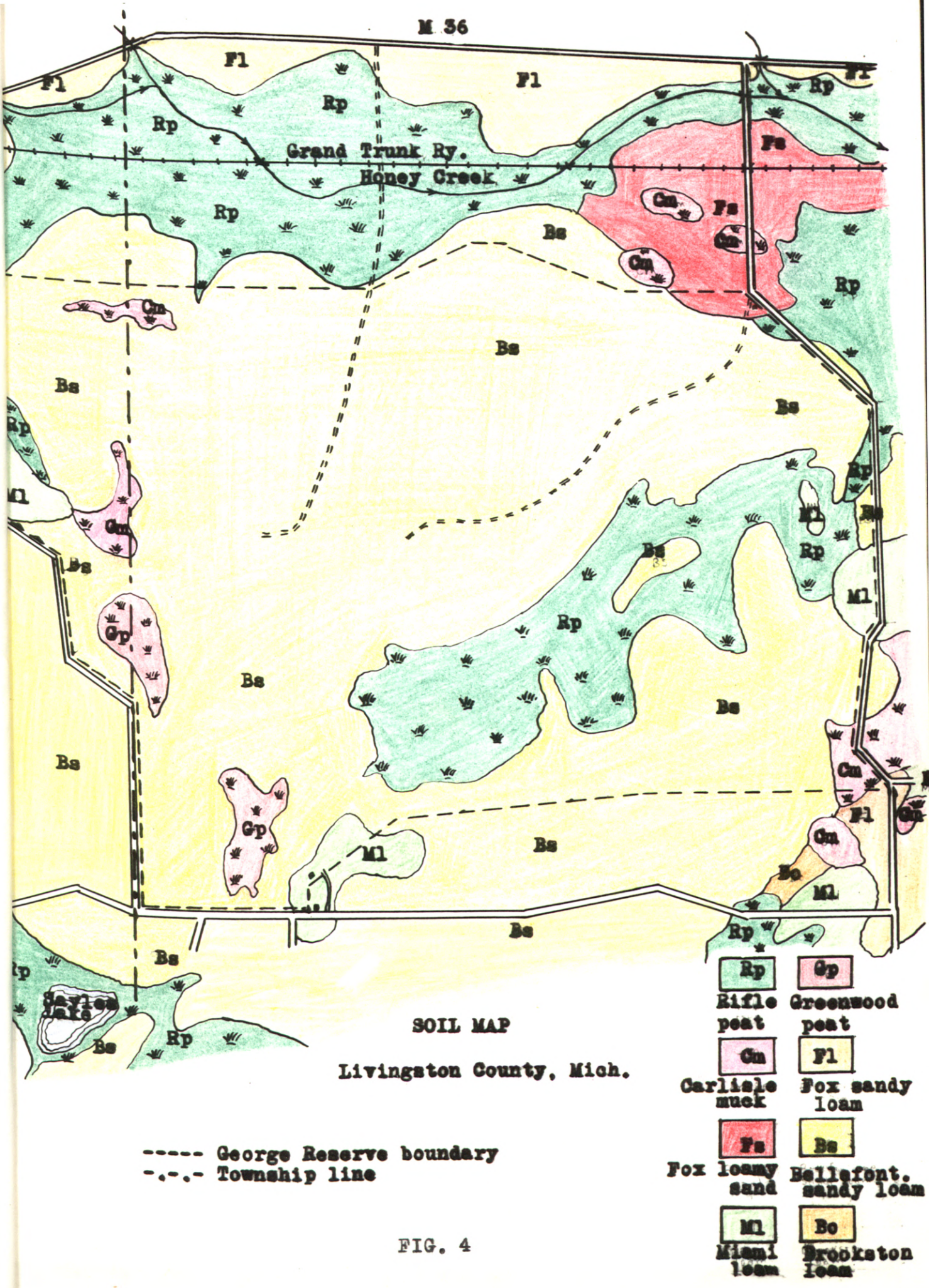

Cassandra
N. W. WOODS
N. E. WOODS
S. W. WOODS
Buck Hollow
Esker
BIG SWAMP
Big Island
Juniper Hill
7
8
8
9
10
11
- milacre plots
- circular plots (1/4 a)
- square plots (1/10)
EDWIN S. GEORGE RESERVE
UNIVERSITY MUSEUMS
UNIVERSITY OF MICHIGAN
DATUM: MEAN SEA LEVEL
CONTOUR INTERVAL = 5 FEET
SCALE
JAN 28, 1953
JOHN RUSKIN, ENGR.
PAUL F. HICKIE
LEGEND
BOUNDARY FENCE
FIRE LANE
ROADS
TRAILS
FRAME HOUSES
OTHER BUILDINGS
BRIDGES
SPRINGS
RUNNING WATER AND DIRECTION

FIG. 3

are under water at all times. There are four springs on the area which indicates the presence of hardpan under part of the Reserve. There is some drainage into Honey Creek to the north. The old outlet in the southwest corner was blocked when the Patterson Lake Rd. was built in 1872 and a tile line was installed to carry the overflow into the Big Swamp, but that appears to be non-functional now. There aren't any natural lakes or streams on the Reserve but there is a 3 acre pond, and the area is probably typical of the rolling moraine topography of southern Michigan.

The climatic conditions prevailing in Livingston County are those characteristic of central Michigan; fairly cold winters and mild summers. The average annual rainfall is 28.9" and under normal conditions is well distributed throughout the year, the heaviest rainfall occurring during the growing season from April to September. The average snowfall of 29" is rather light compared to that in other sections of the state. The mean annual temperature is 46.6° F. Prevailing winds are southwesterly throughout the year.



SOIL MAP

Livingston County, Mich.

FIG. 4

COVER MAP
OF THE
EDWIN S. GEORGE RESERVE
UNIV. OF MICH.
MAPPED AND DRAWN
BY
John Brasch
MARCH 1948
SCALE
0 1000 ft.
LEGEND ATTACHED

N

FIG. 6

	Porous Soils P	Nonporous Soils A	Rock Outcrops R	Seepage BS	Stagnant B	Seepage MS	Stagnant M	Floodplain F	Transition Belts E
1	Bare Soil	Bare Soil	Bare Rock	Saturated Soil or Water	Water	Saturated Soil or Water	Water	Bare Soil	Same as Corresponding Water or Dry land Type.
2			Crustose Lichens		Submerged Vegetation		Same as B2		do.
3			Foliose Lichens and Moss		Floating Vegetation		Same as B3		do.
4	Moss and Annuals	Same as P4	Same as P4	Sphagnum Sedge mat	Same as BS4	Emergent Aquatics	Same as MS4	Annuals	do.
5	Grass and Other Perennials	Same as P5	Same as P5	Sphagnum Sedge and Heath	Same as BS5	Emergents and Sedge-Grass	Same as MS5	Same as A5	do.
6	Mixed Herbaceous	Same as P6	Same as P6	Predominantly Heaths	Same as BS6	Same as P6	Same as P6	Same as P6	Same as P6
7	Shrubs	Shrubs	Shrubs	Swamp Shrubs	Same as BS7	Same as BS7	Same as BS7	Same as P7	Same as P7 or BS7
8	Intolerant Trees	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8
9	Mid-tolerant Trees	Same as P9	Same as P9	Same as P9	Same as P9	Same as P9	Same as P9	Same as P9	Same as P9
10	Tolerant Trees	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10

Physiographic Conditions - Exponential Letters

o - Outwash
d - Dunes
k - Kettle Hole
l - Calcareous
g - Igneous Rock
s - Shale
m - Glacial Drift
b - Loess

"Same as" - Ecological equivalent not necessarily identical species.

Disturbance Effects - Sub Letters

d - Drained
p - Pastured
e - Eroded
c - Cropped
f - Flooded
y - Cutover
x - Burned
a - Wild Animal Grazing and Browsing
b - Blowdown

Timber Size and Stocking

/ Scattered — 4" to 6" DBH
// Medium — 4" to 12" DBH
/// Dense — Etc.

Shrub Density

— Scattered
= Medium
≡ Dense

Form 6579 ML

Vegetation: A rough division of the vegetation can be made on the basis of topography - (a) dry uplands, (b) moist lowlands.

(a) Dry uplands comprise about 3/4 of the Reserve and are 1/3 woodland and 2/3 grassland. The woodland areas are covered by an oak-hickory forest that appears to be a stable pre-climax on poor, well drained soils. There is about 320 acres of woods occurring in patches of 1 to 125 acres over the area. They cover the hilltops, slopes and kettleholes - all areas not suitable for clearing for cultivation. An understory of hazel, witch hazel, sassafras, oak and hickory reproduction, and black cherry is found in varying degrees of density throughout the woodlots. The fields and pastures were retired from use in 1928 and are now being invaded along their boundaries by oak and hickory, and elsewhere by junipers, sumac, and blackberry. Some of the fields still have stands of timothy, alfalfa, and wild grasses also.

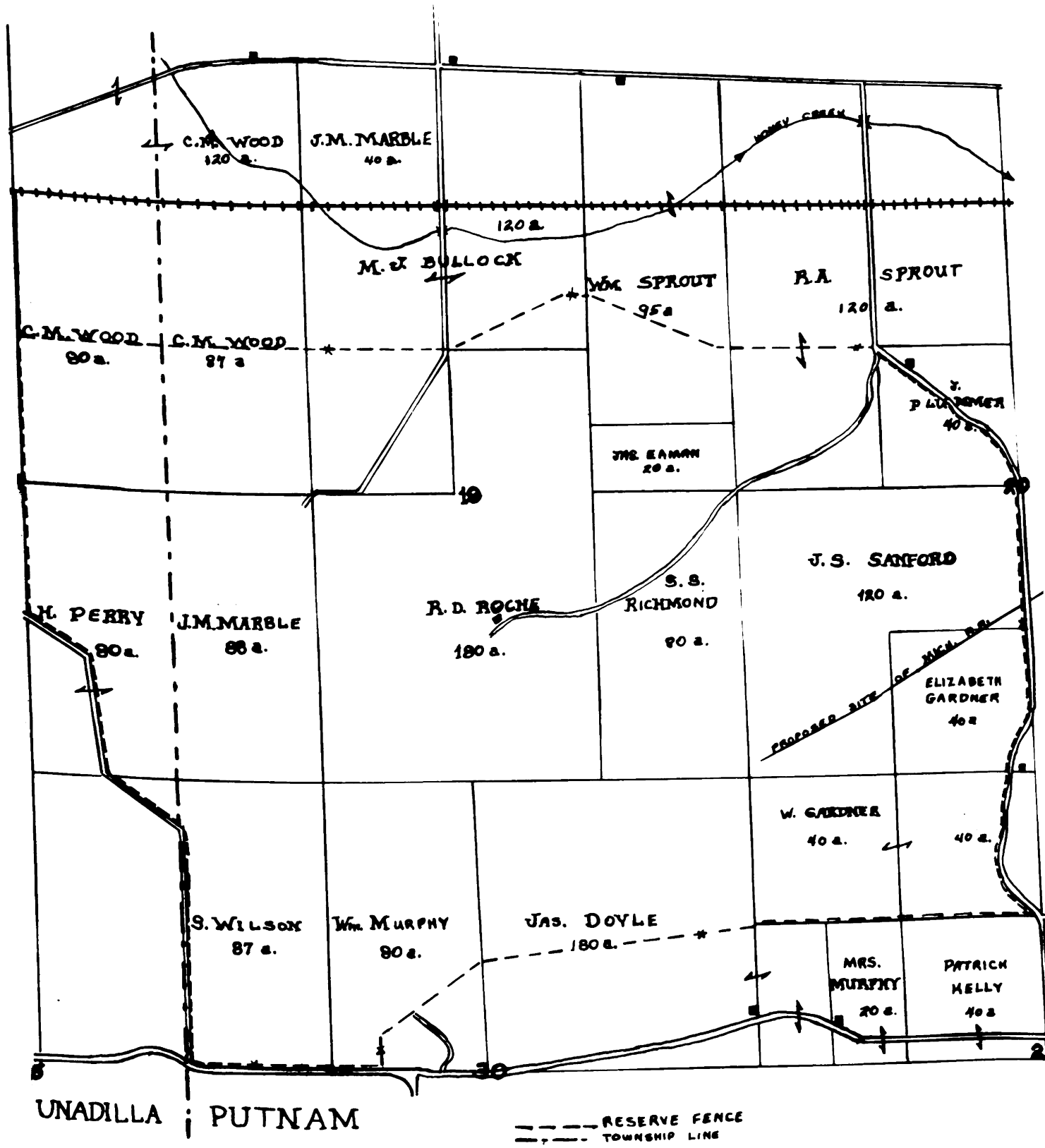
"Over most of the level areas and gentler slopes, well developed leaf litter, and leaf mold are present. On the steeper slopes large patches of bare soil alternates with pockets and depressions of well formed leaf accumulations. The greater part of the litter is rather dry or only moderately moist, but its lower layers mix with the sandy loam beneath to form a compact but friable and aerated mold or humus. Over most of the woods the combined litter and mold are probably 4-8" deep. Fallen twigs, branches, and trunks accumulate undisturbed in all of the wooded areas. The density of tree stand, density and composition of undergrowth, and amounts of down timber and leaf mold vary considerably within any one and from one to the other of the several wooded tracts.

There is little relation between the soil type and the vegetation

of the uplands. The oak-hickory forest occurs indiscriminately on Bellefontaine and Miami soils and evidently was once present on at least part of the areas occupied by Plainfield and Coloma soils.

Cultivation, grazing, cutting of timber, fire, and the rough topography of the Reserve have caused the elimination of many of the stages of succession. Upland areas have been cleared of timber and cultivated so close to the remaining trees that shrub zones are almost non-existent. The transition between swamplands and woodlands is abrupt, consisting at most of a narrow belt of hydrophytic shrubs. The poor soil and good drainage, will, at least for a very long time, prevent the development of the theoretical beech-maple climax forest cover." (Rogers 1938). There is one mature beech tree in the N.E. woods near Sta. 1.

(b) Moist lowlands are occupied by tamarack and poison sumac, or hardwood (maple-birch-elm) swamps; marshes of grasses, sedges, ferns, and shrubs; and two sphagnum-leatherleaf bogs.



PLAT OF LAND OWNERSHIP OF PRESENT EDWIN. S. GEORGE RESERVE AND ADJACENT FARMS, AS OF 1875.

FROM "ATLAS OF LIVINGSTON CO., MICH."

FIG. 7

ST HISTORY:

The following information was obtained from the custodian, old sidents, and other persons familiar with the past history of the rea, by J. Speed Rogers in 1938, and by the author in 1948. A study f old records in the county courthouse at Howell and of old volumes the Michigan Historical Society Collection at Ann Arbor also threw me light on past ownership, boundaries, and notes on the wildlife d vegetation as far back as 1833.

Much logging was done about 1900 and many of the larger and better rees were removed. Again in 1918 a lot of cutting was done in the rthwest woods when all the "red" and white oaks a foot or more in ameter were sold. At the same time some tamaracks were taken from e Big Swamp and no cutting has been done there since then. Farming ractices, at the time the Reserve was set aside, included pasturing e woodlots and brushy lowlands but wasn't as intensive as before 1900. here were about a dozen farms with cultivated fields, woodlots, orchards, astures, and waste wetlands included in the purchase. After 1900, the rosion of the fields in the southern and eastern parts caused a shift rom cultivation to pasturing and the grassy slopes of the uplands roughout the Reserve were also pastured.

There haven't been any fires on the area since 1926 when a fire ept over the southwest corner and as far east as the edge of the Big amp. Another fire occurred before that in the fields in the northwest rner.

ST HISTORY OF THE AREA NORTH OF THE RESERVE:

The two woodlots outside the fence where the major control plots e located were originally part of the main woodlots inside the fence.

The southern boundaries of the N.E. woodlot were 20 chains south of the present north fence until 1928 when Col. George bought the "square 40" that includes the Big Cassandra, from Loy McClear. Mr. McClear, who still owns the piece outside, lives across the road on Highway 36. Now 56 years of age, he told the writer that he bought the property from M. J. Wood in 1914. Mr. Wood had "bought it up from the government" so it has had only two owners. In 1918 Mr. McClear had a contract to cut all the 12" oaks he could find in his woods and that was done. No hickory was cut because there was none, although he thinks quite a bit has come in since then. After selling the 40 to Col. George, McClear has limited cuttings on his own property to a few oaks (1939-40) which he sold, and several more that were cut for fence posts during the winter of 1946-47. Pasturing has been limited to 70 sheep that were turned in during the summer months of 1938, and to 12 of his neighbor's cows that got through the fence last summer. A grass fire that started along the railroad in 1938 got as far as the edge of the woods.

The N.E. woodlot was recently purchased by the University of Michigan and the fields that comprise the balance of the 40 acres are to be cultivated. Ben White, who has lived at Anderson for 27 years, pastured two horses and 7 or 8 cows there in 1947 and says that no one else has ever pastured livestock there within the span of his memory. The grass fire of 1938 also got into this woodlot for a short distance but didn't reach the larger trees. As with the S.E. woodlot this area was once part of the same woodlot inside the fence - extending southward for about 10 chains in one parcel of land. Between 1928 and 1947 when Mrs. Crain sold the land to the University, some cuttings were made. Philip Sprout, nephew of Mrs. Crain, told me that a dozen

black oaks were taken out in 1942 on the east edge of the woodlot. Before that, very little cutting was done - just damaged trees for firewood.

Some of the general history of the area may be gotten from old books in the Michigan Historical Society Library. One such volume, (Chapman Bros. 1891), dealing with biographies of prominent citizens, contained the following excerpts:

> ". . Indians and wild animals abounded and venison was easy to procure (1836)." "...country was very wild and the shy denizens of the forest had not yet learned to fear man. Mr. Bush frequently went out before breakfast and killed a deer." "...There were plenty of deer, wolves, and many are the bears that our subject has shot. Deer were seen in droves as commonly as sheep are now." Reference was frequently made to the "heavy timber" and "oak openings".

PRESENT CONDITIONS:

In 1927-28, Col. Edwin S. George purchased and fenced the area as a game preserve. Two years later he gave it to the University of Michigan for use as a natural history reserve. It is administered by the Museum of Zoology and a custodian and resident biologist live on the area.

In March, 1928, Col. George purchased four does and two buck whitetail deer from the Cleveland Cliff Company on Grand Island, Michigan and released them in the enclosure. He stated: "As they were all aged deer we naturally assumed that the four does were bred and probably dropped fawns the following May or June."

Paul Hickie, first biologist on the area, described the rapid growth of the deer herd in "Six Deer Produce 160 in Six Years" (Mich. Cons.1937) "Deer didn't appear especially common until the fall of 1931 when small groups were seen in the evenings, and some browsing became noticeable near the trails bordering the marshes and swamps. Deer browsing became more apparent in the winter of 1932-33 on red-osier dogwood, sumac, and junipers." ". . It became apparent that a reliable estimate of the population was necessary so on December 9, 1933 a deer drive was conducted." The total count was 160 - quite an investment in 6 years from 6 deer! It was felt that despite the presence of errors, the count was fairly close and accurate enough for all practical purposes. A comparison with the figures used in the Breeding Potential Tables (Aldo Leopold - Game Management, 1933, table 45b) showed a close approximation, or a theoretical herd of 168 deer. These results gave them concrete evidence that management practices would have to be put into effect immediately. Good evidence had been furnished that if the

herd continued to increase as it had in the past, the yearly totals would have been somewhat as follows:

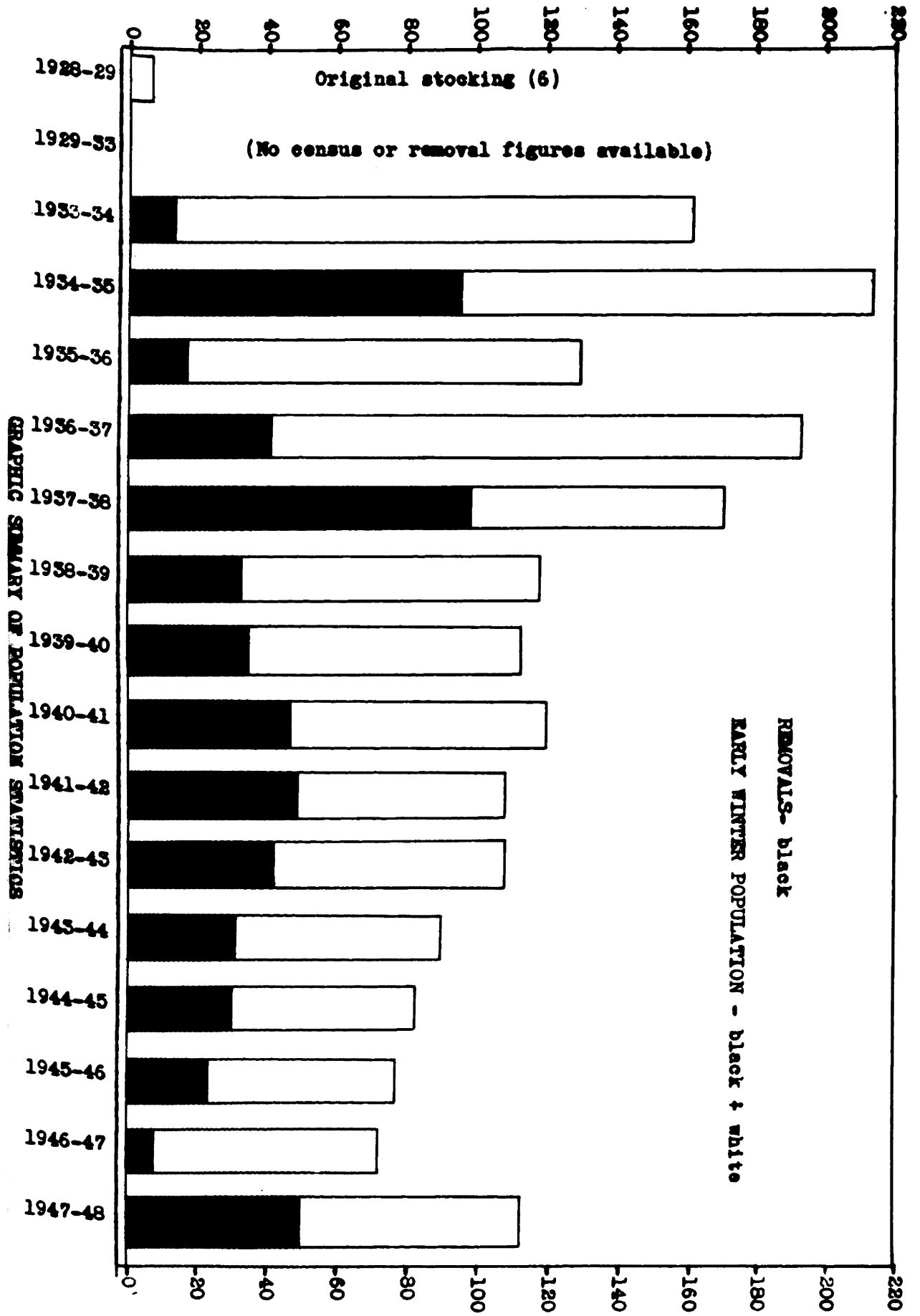
1934 - 272
1935 - 440
1936 - 712
1937 - 1152 (almost one deer per acre, or six times as much as is regarded as an extremely heavy population)

a reduction in the herd by shooting was begun and while the numbers haven't been kept as low as they should have been to prevent all inroads on vegetation, it remains for the most part in good condition.

Thus Hickie summarizes the first six years experience with deer on this controlled tract and gives a good indication why deer irruptions have occurred in dozens of localities to the detriment of the range, and ultimately the deer.

Thirteen years have elapsed since then and perhaps the best summary of the entire history of the herd is the recent article by O'Roke and Hamerstrom. They have contrasted the later history of the herd with the first six years in their work on productivity and yield. They state that the rapid increase during the early years was due to the original animals being adults and they estimated the annual increase, based on the total herd, at the rate of about 60%. Their study further shows that the rate of increase has not been maintained (average 44%) and that it has varied widely from year to year (1942-43 .. 104.1% 1937-38 .. 11.9%) The following chart (Fig. 8) was prepared from their figures and brought up to date by the writer. The February 1948 census figures were used along with removal records kept by Mr. Laurence Sumburn, custodian, who kindly consented to let me use them.

EARLY WINTER POPULATIONS AND REMOVALS



EARLY WINTER POPULATIONS AND REMOVALS

FIG. 8

WORK OF OTHER INVESTIGATORS

Many authorities have studied deer browse from the standpoint of food preferences and nutritional requirements. A few have approached a study of deer food habits with a view toward management of the environment to improve the carrying capacity. Since the environment of the George Reserve is to undergo only natural successional changes, management measures are all directed toward control of the herd. Control of the herd, in turn, is based upon the carrying capacity of this enclosure. Carrying capacity is dependent upon the kind and amounts of vegetation available for the deer to eat so the silvicultural effects of browsing must be clearly understood.

I. Relating Directly to Deer and Their Food Habits:

Maynard (et al, 1935) in their New York studies, listed various browse species by relative preference as "best liked," "readily eaten" or "poorly eaten". Balsam, although readily eaten, was proven worthless as a winter food. The terms "palatable" and "unpalatable" were used to distinguish between the types of browse utilized by Michigan deer, by Davenport (1944) Hard maple, although very palatable to deer, proved to be an inadequate diet. One factor was brought out early in their experiments, that their estimates of available browse, and consequently carrying capacity, had been low in almost every instance; therefore, estimated populations based on browsed conditions are probably low also.

II. Relating to Vegetation:

"The fruit crops (acorns, beechnuts) of southern Vermont are favored fall feeding grounds" (Foote 1945). He also notes that hardwood sprout growth is much used by deer after a fire or after cutting operations.

Leopold (1943) states that deer irruptions on the Kaibab caused loss of a large part of the deer food without any gain in deer. Cook and Hamilton (1942) reported that central New York deer sampled almost every species of tree and shrub. Hosley and Liebarth (1935) noted that north central Massachusetts deer browsed at least 62 different plant species in winter. They found that red maple was the most important browse species and that the extent of browsing on hardwoods apparently was proportional to the abundance of these species in the stand where the feeding was done. "Overbrowsing may deter natural succession and favor growth of inferior species."

Bartlett (1938) says that since deer in southern Michigan are not forced to yard in winter, carrying capacity of the land is increased. The larger variety of deciduous plants and production of more food annually also helps alleviate browse damage. Repeated browsing decreases the annual production of food until the tree dies, or matures and natural self pruning also may kill some lower branches of trees which had been in reach of the deer.

The recent publication of the Wisconsin Conservation Department, "A History of Wisconsin Deer" (Swift 1946) describes the damage to tree plantations and natural reproduction. "Damage to tree plantations is more noticeable and far easier to determine than damage to the natural growth of the forest, but the latter might prove the greater loss." Some foresters working in areas of high populations, consider deer damage as serious or even more so than fire damage. Where the damage is light, enough trees may grow out of reach to result in a satisfactory stand. Seedlings and young trees may pull through if not browsed too often or too heavily, although they will be retarded and deformed.

Frontz and Clepper (1931) found that practically every woody plant, both native and introduced, is at present browsed by deer to a greater or lesser degree. They have pointed out sections where natural forest reproduction has been set back scores of years, solely by overbrowsing. Perhaps the most complete study on the silvicultural effects of browsing that came to my attention was by Pearce (1937) on Adirondack forest types. He concluded that "deer may enable red spruce to assume dominance by selective browsing on its competitors. In old growth stands the composition of the understory is changed due to browsing of certain species in the undergrowth. This influence is cumulative."

In North Carolina, Schilling (1938) reported that general food preferences were sprout growth of trees and shrubs, seedling growth of trees and shrubs, and weeds and grasses. In over-populated sections neither black nor white oak becomes established readily because the acorns are "especially delectable". Older specimens (4 or 5') will withstand moderate use. Sassafras is far too palatable to exist long in the browse level. Dogwood, which is very palatable, is held back to the sprouting stage under heavy use. When tender shoots become lignified, the deer feed on less palatable and more abundant species.

II. TECHNIQUES

Selection of Areas:

The dominant upland hardwoods, white and black oaks, and shagbark hickory, comprise about 90% of the entire forested area of the Reserve. Any factors affecting the reproduction of these three species will exert a major influence on the future forest types. Reproduction is gaining a foothold in fields retired from cultivation so study plots were selected in the woods and along old field borders.

There is a scarcity of information in the literature pertaining to methods of gauging browse damage, so existing techniques were utilized and modified to meet the needs of this study.

Since an attempt was being made to isolate deer damage as the major biotic factor, a comparison was sought between adjacent browsed and unbrowsed woodlots, and between the reproduction coming in on old fields retired from use 20 years or more, outside and in. In order to reduce the problem to a simple comparitive study, it was necessary to eliminate as many variables affecting growth as possible. Soils, moisture conditions, slopes, exposures, past and present use (cultivation, grazing, cutting, fire) climate, species composition, density of stand (crown cover, basal area), and wildlife species and numbers were the variables that could be eliminated from consideration by the careful selection of the study plots. Slopes and exposures were compared by estimate, and climate may be assumed to have an equal effect on plots situated less than a mile apart and often within 10' of each other. Past and present use, discussed previously, were similar enough to warrant comparison on an equal basis. There were local variations in abundance of certain tree species but the overall species composition

was the same for all woodlots. The final consideration, density of crown cover, was determined by ocular estimate; when the sample plots had approximately equal crown cover, light would not be a variable in the establishment and growth of reproduction.

The necessity for careful selection of the pairs of plots in the wooded areas indicated that 1/10 and 1/4 acre quadrats were the most suitable. Milacre plots (6.6' x 6.6') were chosen for sampling the reproduction along field borders where a 100% sample was impossible and impractical. The plots were made along a line one-half a Gunter's chain (33') in from the wooded field borders and one chain (66') apart along the transect. The end of the chain was chosen as the center of the plot and two sticks (6.6' long) were used to define the quadrat boundaries. All woody vegetation was counted, identified as to species, heights measured, and ages computed on a 10% sample basis. White oak reproduction occurred so infrequently in the plots that all specimens (100%) were aged.

Along the north fence of the Reserve it is possible to select adjacent browsed and unbrowsed wooded plots for the fence cuts right through woodlots that were formerly continuous. (See air photo). Elsewhere roads or fields separate the wooded areas and make the elimination of variables more difficult.

Two 1/4 acre circular plots (radius 58.88') were set up in the N.E. woods (Sta. 1 and 2), one on each side of the fence, andwere selected primarily on the basis of similarity of crown cover. Lack of suitable data on reproduction in five subplots at Station 1 caused me to select Stations 5 and 6 in more open areas in the N.E. woods. Here again crown cover was the primary consideration and 1/10 acre plots were made.

A third pair of plots (Sta. 3 and 4) were set up on the west edge of the N. E. woods in clearings and represented mainly invasion of old fields, consisting chiefly of black oak and juniper reproduction. The last comparison of adjacent plots was made along the south fence near the gate. (Sta. 9 and 10). Fourteen milacre plots, a chain apart, were laid off along a line, one-half chain away from the fence. Again shade was not a factor and all growth represented reproduction that has started since 1928, inside, and 1936, outside the fence. Prior to 1936, the outside field had been used as an alfalfa hay field and the custodian's horses were pastured there until 1947.

When it became evident that the larger plots (Sta. 1-6) were yielding insufficient data for a statistical comparison, Dr. S. A. Graham suggested the use of line plots in many areas both on the Reserve and on the Reserve Annex across the road, and in the adjoining Fresh Air Camp woods. Cain and Penfound (1938) have noted that "although uniformity in sampling method is desirable when comparisons are to be made, it is probably good to sacrifice rigid uniformity of all samples for the sake of assuring the adequacy of each sample, hence the occasional use of different sizes as the stand requires."

South of the Cassandra is an irregularly shaped field (about 36 acres) whose perimeter is 80 chains long. It is bounded on three sides by woods and on the fourth by an old fence boundary of mature oaks and hickories. Reproduction is establishing itself along all margins so a transect was run in the manner previously described for milacre plots. All woody vegetation was recorded as to species, height, number and age (10% sample).

To get data that might be compared to that above, it was necessary

to go over to the Reserve Annex on the south side of Patterson Road, across from the southwest end of the Reserve. This land, purchased in 1928 has remained idle as long as the fenced in Reserve, and represents conditions as nearly alike as can be found in this area. The soils, surveyed by the Soil Conservation Service at Howell, were the same as the sandy loams found on the wooded parts of the Reserve. Milacre plots in the manner described above were laid out along the east, west, and south edges of the field near the Red Barn, on the old Doyle property. Observation and age samples were also made in the Fresh Air Camp woods along the south shore of Sayles Lake, and in the old Gardner property across the road from the southeast fence. No plots were taken.

Several factors influenced the techniques used and brief mention may be made here. The study was carried on for only one semester and field work and observations are thus limited. Pacing instead of a tape was used to measure distances since all field work was carried on by one person and it was obviously impractical to do it any other way. The success of a study involving ages of seedlings and saplings will depend to some extent upon the number of records. Since the policy of the Reserve governing board is to leave the area virtually undisturbed, and some of the plots were located on private property, it was deemed advisable to make only the barest minimum of cuttings.

Heights were measured up to 10' with a steel ruler, and with an Abney level over 10'. Diameters over 2" were obtained by using a diameter tape. An ocular estimate of average crown diameters was made and checked frequently by pacing.

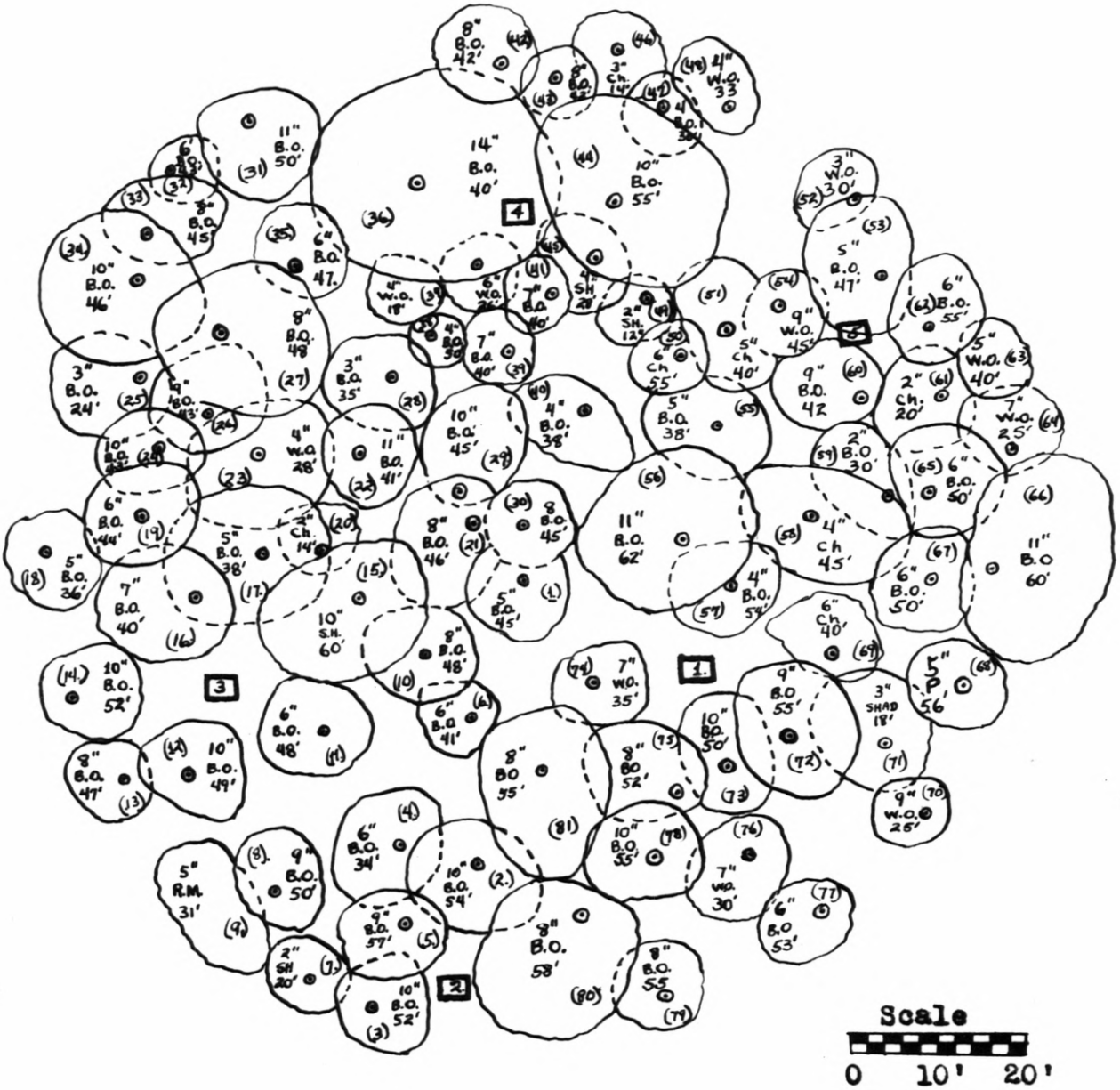
Large trees were aged by using an increment borer, a foot from the ground and always on the same side of the tree (north) for uniformity. Seedlings and saplings were aged by ring counts. As all specimens were cut off at the ground level, no factor was added to the ring count for age to that point. Any error thus introduced would be the same for all plots and wouldn't affect the trend of the height curves. A sharp knife to smooth the cut surfaces, and a hand lens (9 or 10x) made it possible to age the specimens in the field. Moistening the cut surface with water or kerosene usually made the structural features more prominent. Some difficulties are encountered in counting growth rings - some species have nearly indiscernible rings, other may form false or extra rings, or rings may be missing at some point on the stump. With suppressed or slow growing trees, it is easy to overlook the less conspicuous layers.

Beckwith (1942) noted that the age of woody shrubs and seedlings can be determined by counting groups of winter bud scars, or branch scars. With sumac, the age of the parent plant was found to be accurately computed by counting the number of dead branches, or their remaining scars, beginning at the base of the shrub and progressing to the end of one of the branches. A stub is left for every year's growth. Staghorn sumacs up to 16 years old were measured in this manner and found to check with ring counts made in the usual way.

Identification was made by reference to winter buds, bark, and wood characteristics. A check with older trees nearby often helped verify identification. Texts used were Sargent, Billington, Muenscher, and Harlow.

PLOT ONE

N. E. Woods, George Reserve



Legend:

50' - height of tree

(2) - number of tree

8" - diameter (D.B.H.)

[2] - milacre subplot

- crown outline

B.O. - black oak

W.O. - white oak

S.H.- shagbark hickory

R.M. - red maple

P. - poplar

FIG. 9

SAMPLE PLOT DATA

PLOT NO. One SHEET One DATE May, 1940 OBSERVER L. Pengelly

LOCATION AND DESCRIPTION ¼ acre circular plot, N. E. woods in George Reserve near north fence

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

NO.	SPECIES	DBH 0.1"	NO. LOGS	TOTAL HEIGHT	CROWN LENGTH	CROWN WIDTH	CROWN COND.	CROWN CLASS	REMARKS
1	Bl. oak	6"		45'		12'			
2	"	10"		64'		16			
3	"	10		62		11			
4	"	6		34		13			
5	"	9		57		12			
6	"	6		41		10			
7	Hickory	3		30		10			
8	Bl. oak	9		50		11			
9	Red maple	5		31		14			
10	Bl. oak	10		48		14			
11	"	6		48		13			
12	"	10		49		12			
13	"	8		47		10			
14	"	10		52		12			
15	Hickory	10		60		18			
16	Bl. oak	7		40		16			
17	"	5		38		20			
18	"	6		36		12			
19	"	6		44		13			
20	Cherry	2		14		10			
21	Bl. oak	8		46		14			
22	"	11		41		12			
23	Wh. oak	4		28		18			
24	Bl. oak	10		43		12			
25	"	3		24		14			
26	"	9		43		13			
27	"	8		48		20			
28	"	3		35		15			
29	"	10		42		14			
30	"	8		45		11			
31	"	11		50		16			
32	"	6		43		9			
33	"	8		45		14			

FORM 6792

SAMPLE PLOT DATA

PLOT NO. One SHEET Two DATE _____ OBSERVER _____

LOCATION AND DESCRIPTION _____

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

No.	Species	DBH 0.1"	No. Logs	Total Height	Crown				Remarks
					Length	Width	Cond.	Class	
34	Bl. oak	10"		46'		20'			
35	"	6		47		11			
36	"	14		40		30			
37	"	4		18		9			
38	"	4		50		9			
39	Wh.oak	6		26		10			
40	Bl. oak	4		38		13			
41	"	7		40		8			
42	"	8"		42		12			
43	"	8		42		9			
44	"	10		55		26			
45	Hickory	4		28		12			
46	Cherry	3		14		12			
47	Bl.oak	4		30		9			
48	Wh.oak	4		33		11			
49	Hickory	2		12		9			
50	Cherry	6		55		9			
51	"	5		40		13			
52	Wh.oak	3		30		9			
53	Bl.oak	5		47		14			
54	Wh.oak	9		45		10			
55	Bl. oak	5		38		13			
56	"	11		60		16			
57	"	4		54		12			
58	Cherry	4		45		16			
59	Bl. oak	2		30		11			
60	"	9		42		12			
61	Cherry	2		20		12			
62	Bl.oak	6		55		13			
63	Wh.oak	5		40		9			
64	"	7		25		12			
65	Bl. oak	6		50		13			
66	"	11		60		22			

FORM 6792

SAMPLE PLOT DATA

PLOT NO. One SHEET three DATE _____ OBSERVER _____

LOCATION AND DESCRIPTION _____

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

NO.	SPECIES	DBH 0.1"	NO. LOGS	TOTAL HEIGHT	CROWN LENGTH	CROWN WIDTH	CROWN COND.	CROWN CLASS	REMARKS
67	Bl.oak	6"		50'		12'			
68	Poplar	5		66		12			
69	Cherry	6		40		12			
70	Wh.oak	9		25		10			
71	Amelanchier	5		18		14			
72	Bl.oak	9		55		15			
73	"	10		60		18			
74	Wh.oak	7		35		12			
75	Bl.oak	8		62		14			
76	Wh. oak	7		50		11			
77	Bl. oak	6		53		11			
78	"	10		55		14			
79	"	8		65		18			
80	"	8		58		16			
81	"	8		65		12			

Reproduction

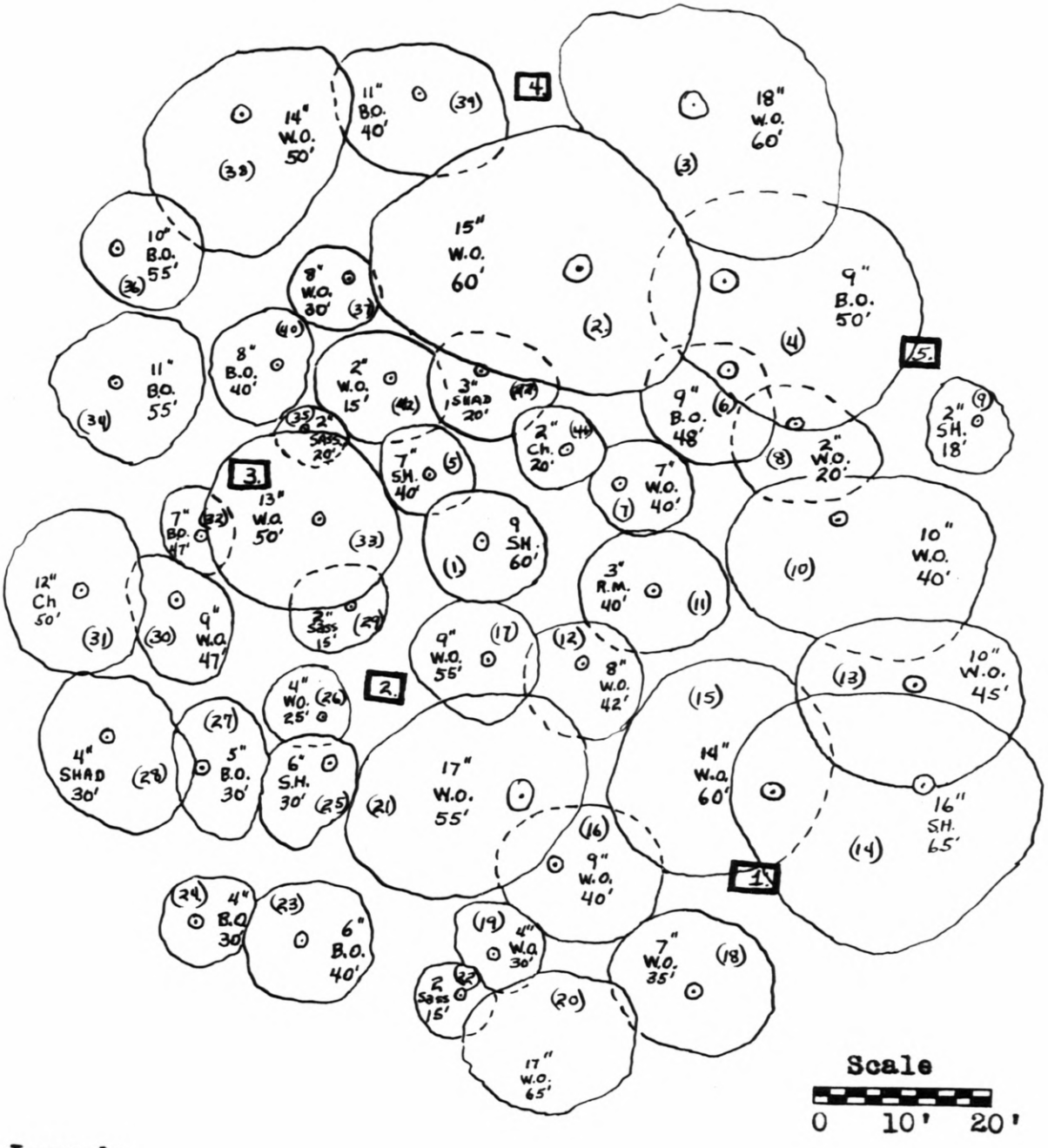
Subplot 1	Cherry	abundant	4 stems in milacre plot
2	Cherry	common	2 " " " "
3	Cherry	abundant	5 " " " "
4	Sassafras	scarce	only 2 in ¼ acre plot
5	Cherry	scarce	1 stem in milacre plot

A thorough check of the plot revealed only two small clumps of juniper (J. horizontalis), two stems of sassafras about 2' high, and a good distribution of cherry reproduction.

FORM 6792

PLOT TWO

The N. E. Woods, outside of Reserve



Legend:

50' - height of tree

(2) - number of tree

8" - diameter (D.B.H.)

2 - milacre subplot

- crown outline

B.O. - black oak

W.O. - white oak

S.H. - shagbark hickory

Sass.- sassafras

Shad-- Amelanchier

Ch - cherry

FIG. 10

SAMPLE PLOT DATA

PLOT NO. Two SHEET One DATE May 1948 OBSERVER L. Pengelly

LOCATION AND DESCRIPTION ¼ acre circular plot outside of George Reserve fence in N.E. woodlot

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

No.	Species	DBH 0.1"	No. Logs	Total Height	Crown Length	Crown Width	Crown Cond.	Crown Class	Remarks
1	Sh. hick.	9"		60'		15'			
2	Wh. oak	15		60		35			
3	"	10		60		28			
4	Bl. oak	9		50		30			
5	Hickory	7		40		14			
6	Bl. oak	9		48		16			
7	Wh. oak	7		40		12			
8	"	8		20		16			
9	Hickory	8		18		11			
10	Wh. oak	10		40		26			
11	Red maple	5		40		18			
12	Wh. oak	8		42		14			
13	"	10		45		22			
14	Hickory	16		65		34			
15	Wh. oak	14		60		24			
16	"	9		40		20			
17	"	9		55		16			
18	"	7		55		20			
19	"	4		30		11			
20	"	17		65		20			Just outside plot.
21	"	17		55		25			
22	Sassafras	8		15		10			
23	Bl. oak	6		40		15			
24	"	4		30		10			
25	Hickory	6		30		12			
26	Wh. oak	4		25		10			
27	Bl. oak	5		30		15			
28	Shad	4		30		18			
29	Sassafras	2		15		12			
30	Wh. oak	9		47		14			
31	Cherry	12		50		17			
32	Bl. oak	7		47		10			
33	Wh. oak	13		50		32			

FORM 6792

SAMPLE PLOT DATA

PLOT NO. Two SHEET Two DATE _____ OBSERVER _____
LOCATION AND DESCRIPTION _____

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

NO.	SPECIES	DBH 0.1"	NO. LOGS	TOTAL HEIGHT	CROWN LENGTH	CROWN WIDTH	CROWN COND.	CROWN CLASS	REMARKS
34.	Bl. oak	11"		55'		18'			
35.	Sassafras	2		20		8			
36.	Bl. oak	10		55		14			
37.	Wh. oak	8		30		11			
38.	"	14		50		24			
39.	Bl. oak	11		40		19			
40.	"	9		40		11			
41.	Cherry	2		20		10			
42.	Wh. oak	2		15		15			

REPRODUCTION

Subplot No.	Species	Class	Remarks
1.	Red maple	common	Three sprouts in milacre plot
	Black oak	common	Two seedlings (under 6')
2.	Hickory	abundant	Two saplings occupying 50% of plot
	Wh. oak	common	Three sprouts " 30% " "
3.	Gray dogwood	abundant	Dense stand covering entire plot
4.	Black oak	common	Two saplings occupying 40% of plot
	Hickory	scarce	One sapling six feet tall
	Cherry	scarce	Two seedlings occupying 10% of plot
5.	Black oak	common	Three sprouts occupying 40% of plot
	Cherry	common	Two saplings " 60% " "
	Hickory	scarce	One seedling " 5% " "

Nearly all available space was occupied by some form of tree or shrub reproduction well distributed over the ¼ acre plot. Black oak, white oak hickory, red maple, sassafras, cherry, gray dogwood, and a few clumps of Rubus were the principal species coming in.

FORM 6792

Stations 5 and 6, N. W. woods

Heavier cutting operations in the past have opened up the N.W. woods on both sides of the fence, considerably more than was the case with Stations 1 and 2.

Only 11 trees with a D.B.H. greater than 2" were recorded but several large trees along the east and south edge of the quadrat cast considerable shade. Plot 6 had 32 trees over 2" D.B.H. and on the whole receives less light than Plot 5.

	Inside Reprod.	Outside Reprod.	Inside Mature	Outside Mature
Black oak	99	54	6	5
White oak	1	3	0	1
Hickory	3	41	2	7
Sassafras	3	6	3	2
Low Juniper	10	0	0	0
Aspen	0	12	0	0
Red Maple	0	2	0	9
Cherry	45	6	0	6
Gray dogwood	0	35	0	0
Witch Hazel	0	1	0	0
Elm	0	0	0	2
	161	160	11	32

Despite the presence of a greater number of mature trees (32-11), the plot outside the fence had an equal number of stems of reproduction (160-161), a greater variety of species (9-6), and there appear to be significant differences in the numbers of the more desirable species. The apparent advantage in favor of black oak reproduction

SAMPLE PLOT DATA

PLOT NO. Five SHEET One DATE May 1948 OBSERVER L. Pengelly

LOCATION AND DESCRIPTION N. W. woods in George Reserve, between Cassandra and north fence, 1/10 acre square plot.

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

No.	Species	DBH 2"up	No. Logs	Total Height	Crown Length	Crown Width	Crown Cond.	Crown Class	Remarks
35	Red Oak	4"		20'		12'			
48	Bl. oak	2		10		9			
52	Red oak	8		20		10			
	"	8		20		12			
68	Bl. oak	8		50		40			
69	Hickory	14		50		20			
64	"	3		15		10			
79	Sassafras	4		25		14			
	"	4		25		14			
93	"	3		18		8			
102	Black oak	8		50		18			
		(under 2")	REPRODUCTION						
1	Cherry			3					
2	"			2½					
3	"			½					
4	"			1					
5	"			1½					
6	Bl. oak			6					
7	"			7					
8	Wh. oak			1					16 years old
9	Juniper								
10	Cherry			½					
11	"			3					
12	Bl. oak			½					8 years old
13	"			1					15 " "
14	Bl. oak	3 stems		½					8 " "
15	Cherry	8 stems		1					
16	"			1					
17	"			½					
18	"			½					
19	Bl. oak			3					

FORM 6792

SAMPLE PLOT DATA

PLOT NO. Five SHEET Two DATE _____ OBSERVER _____

LOCATION AND DESCRIPTION _____

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

Reproduction (cont'd)

NO.	SPECIES	DBH	NO. LOGS	TOTAL HEIGHT	CROWN				REMARKS
					LENGTH	WIDTH	COND.	CLASS	
20	Bl oak			3'					
21	"			½					
22	"			1					
23	Cherry	2 stems		1					
24	"			1½					
25	"			1					
26	Hickory			½					6 years old
27	Cherry			2					
28	Bl. oak			1					
29	"			1					9 " "
30	"			½					
31	Cherry			1					
32	"	6 stems		1					
33	"	2 "		1					
34	"	dead		4					
36	Hickory			½					9 " "
37	Bl. oak			2					
38	"			½					
39	"	6 stems		1½					16 " "
40	"	2 "		½					6 " "
41	"			1½					18 " "
42	"	3 "		1½					
43	Cherry			1½					
44	Bl. oak			5					
45	"			4					
46	"	3 "		1½					
47	"	3 "		½					
49	"			½					8 years old
50	"	2 "		½					
51	"			½					
53	Cherry	5 "							
54	Bl. oak	7 "		½					
55	Cherry			½					

FORM 6792

SAMPLE PLOT DATA

PLOT NO. Five SHEET Three DATE _____ OBSERVER _____

LOCATION AND DESCRIPTION _____

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

Reproduction (cont'd)

NO.	SPECIES	DBH O.T. under	NO. LOGS	TOTAL HEIGHT	CROWN LENGTH	CROWN WIDTH	CROWN COND.	CROWN CLASS	REMARKS
56	Cherry			1½'					
57	Bl. oak			1½					15 years old
58	Cherry			2					
61	Juniper			¼					
62	"			½					
63	Cherry			2					
65	"			1					
66	Bl. oak	5 stems		1½					
67	"	3	"	1					
68	Juniper			2					20 years old
69	Bl. oak	6	"	1½					
70	Hickory			½					8 " "
71	Bl.oak			¾					7 " "
72	"	3	"	1					
73	"	3	"	2					
74	Cherry			3					
75	Bl.oak			3					
76	"	6		6					
77	"			2					
78	Cherry	3	"	1½					
80	Sassafras			3					
81	"			3					
82	"			3					
83	Cherry	3 stems		1					
84	Bl. oak			3					
85	"			4					25 years old
86	"	2	"	½					
87	"	4	"	1½					
88	"			¼					
89	Cherry			4					
90	"	8	"	3					
91	Bl.oak	6	"	1					9 " "
92	Juniper	3	"	½					

FORM 6792

SAMPLE PLOT DATA

PLOT NO. Five SHEET Four DATE _____ OBSERVER _____

LOCATION AND DESCRIPTION _____

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

Reproduction (cont'd)

NO.	SPECIES	DBH O.B.	No. LOGS	TOTAL HEIGHT	CROWN LENGTH	CROWN WIDTH	CROWN COND.	CROWN CLASS	REMARKS
94	Bl. oak	under 5 stems		1'					10 years old
95	Cherry			½					
96	"			4					
97	Juniper	6	"	1½					(low juniper)
98	Bl.oak			1					
99	"			½					
100	"	2	"	½					6 years old
101	"	3	"	½					

FORM 6792

(99-54) inside is minimized by consulting the age and height curves (Fig 13). The black oak reproduction outside the fence is larger, not deformed, and generally younger.

Stations 3 and 4, located along the north fence in an old field were little influenced by shade. Many factors favoring reproduction in Station 3 were noticed but here again the differences in height growth and form were apparent. There is unusually heavy deer pressure in this plot (3), due to topographic features - steep slopes and marshes influence their travel lanes along the fence through this study area. Only three species were found inside the fence, mainly black oak with a few low junipers and hickories. Every specimen was browsed heavily and ring counts indicate marked suppression. Outside in the open field much low juniper and black oak reproduction is coming in. The luxuriant spread of the juniper attests to land misuse in the past but it also shows that it has never been browsed. The black oak seedlings and saplings are all straight, well-formed specimens and conform to the normal growth curves for that species.

The data obtained in the milacre plots in Stations 7 and 8 was used in preparing the growth curves for the various species, and Station 11 outside the Reserve yielded comparable data for unbrowsed areas. For convenience in comparing milacre data Stations 7 and 8 were added together (92 plots) and the plots in Station 11 were multiplied by a factor to raise them to 92. It is easily seen that many errors can be introduced in this manner but no conclusions will be attempted, merely an objective comparison as to relative numbers and species composition.

SAMPLE PLOT DATA

PLOT NO. Six SHEET One DATE May 1948 OBSERVER L. Pengelly

LOCATION AND DESCRIPTION North of Cassandra in Loy McClear's woodlot, adjacent to George Reserve north fence.

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

NO.	SPECIES	DBH 5" up	NO. LOGS	TOTAL HEIGHT	CROWN				REMARKS
					LENGTH	WIDTH	COND.	CLASS	
2.	Sassafras	2"		20'		12'			
5	Hickory	2		30		8			
8	Wh.oak	10		40		20			
21	Bl.oak	3		11		9			
31	Hickory	3		15		10			
32	"	3		18		10			
39	Red maple	3		20		12			
48	Elm (2)	12		45		18			
49	Hickory	2		18		8			
54	Cherry	3		25		16			
55	Bl.oak	14		60		25			
58	Red maple	4		30		20			
59	Bl.oak(2)	6		50		18			
	"	3		35		16			
63	Red maple	2		20		10			
64	Red maple	4		25		12			
	"	2		20		9			
73	"	3		30		12			
78	"	3		24		12			
81	Cherry	3		20		9			
82	"	4		25		15			
84	"	2		20		13			
86	Bl.oak	2		12		8			
88	Hickory	2		18		10			
93	Red maple	4		35		16			
94	Hickory	2		20		8			
96	Hickory	3		20		8			
108	Sassafras	3		20		10			
109	Cherry	3		15		8			
112	"	3		30		16			
117	Red maple	3		18		13			

FORM 6792

SAMPLE PLOT DATA

PLOT NO. Six SHEET Two DATE _____ OBSERVER _____

LOCATION AND DESCRIPTION _____

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

Reproduction

NO.	SPECIES	DBH Over 1"	No. Logs	TOTAL HEIGHT	CROWN LENGTH	CROWN WIDTH	CROWN COND.	CROWN CLASS	REMARKS
1	Bl. oak	under 1"		1'					dead, 14 years old
3	Sassafras			5					12 years old
4	Bl. oak			2					
6	Sassafras			10					
7	Aspen			1					
9	Hickory	2 stems		1					
10	Wh. oak	3	"	10					
11	Bl. oak			10					
12	Hickory			6					9 years old
13	"			2					
14	"			8					
15	"	4	"	10					
16	"			4					9 " "
17	"			2					7 " " (rabbit
18	Bl. oak			6					10 " " damage)
19	"			3					
20	Hickory			12					
22	"			12					
23	Bl. oak	4	"	6					
24	"			3					
25	"	2	"	6					
26	"	5	"	4					
27	"			6					
28	Hickory			12					
29	"			5					
30	Bl. oak	4	"	8					
33	"			4					
34	Hickory			5					
35	"			10					
36	Bl. oak			6					
37	Hickory			8					
38	Bl oak			4					8 years old (rabbit damage)
40	Red maple			8					

FORM 6792

SAMPLE PLOT DATA

PLOT NO. Six SHEET Three DATE _____ OBSERVER _____

LOCATION AND DESCRIPTION _____

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

Reproduction (cont'd)

NO.	SPECIES	DBH	No. LOGS	TOTAL HEIGHT	CROWN				REMARKS
					LENGTH	WIDTH	COND.	CLASS	
41	Hickory	under 2"		7'					
42	Cherry			8'					
43	Bl.oak			1					9 years old
44	"			3					
45	Cherry			1					
46	Bl.oak			1					
47	Aspen			7					
60	Hickory			5					
61	"			3					
62	Bl.oak			2					
63	Hickory			5					
66	"			3					
67	"			6					
69	Sassafras	2	6 stems	2					
61	Hickory			2					
62	"	2	"	7					
65	"	2	"	3, 3					
66	"	2							Rabbit damage
67	"	"	"	6,3					
68	Bl.oak			6					
69	Aspen	3	"	6,4,3					
70	Bl.oak	2	"	3,4					
71	Aspen	4	"	6					
72	Bl.oak			4					
73	Red maple			20					
74	Aspen	2	"	3					" "
75	Hickory			2					
76	"			12					
77	Cherry	2	"	10					
79	Bl.oak	2	"	8					
80	"			7					
83	"			4					
85	"			5					

FORM 6792

SAMPLE PLOT DATA

PLOT NO. Six SHEET Four DATE _____ OBSERVER _____

LOCATION AND DESCRIPTION _____

NOTE: LOGS RECORDED IN LOGS AND HALF LOGS TO 8" TOP DIAMETER.
CROWN CONDITION CLASSES RECORDED BY NUMBER. 1-EXCELLENT, 2-FEW DEAD TWIGS SCATTERED THROUGH CROWN AND FOLIAGE SLIGHTLY OFF COLOR, 3-THIN CROWN, SOME DEAD BRANCHES IN CROWN, FOLIAGE OFF COLOR, LEAVES SMALLER THAN NORMAL, 4-DEFINITELY DECADENT OR DYING, 5-DEAD

Reproduction (cont'd)

NO.	SPECIES	DBH	NO. LOGS	TOTAL HEIGHT	CROWN				REMARKS
					LENGTH	WIDTH	COND.	CLASS	
87	Sassafras	under 2"		8'					
89	Dogwood	25	stems	6					Cornus paniculata
90	Aspen			6					
91	Hickory			8					
92	"			3					
95	Bl.oak			10					
96	Hickory			6					
98	Witch hazel			6					
99	Hickory			10					
100	Bl.oak	2	stems	10					
101	Hickory			10					
102	Bl.oak			4					
103	Sassafras			4					
104	Cherry			3					
105	Hickory			10					
106	Bl. oak	2	stems	6, 8					
107	"	4	"						Rabbit damage
110	Dogwood	10	"	5					
111	Bl.oak			3					
113	Bl/oak	6	"	1					
114	Cherry			3					
115	Bl.oak			6					
116	Hickory			8					

FORM 6792

The Stations (9 and 10) along the south fence near the gate provided little data but significant differences. The only reproduction encountered inside the fence were four badly deformed hickories. Since the hill slopes down into the Reserve, it was not unexpected that there were no seedlings gaining a foothold outside the fence. Twelve foot cherry trees, ten foot red cedar, and an abundance of miscellaneous reproduction has covered the field since it was taken out of cultivation 12 years ago. The bare slope inside the fence contrasts sharply with the variety and form of new growth on the outside that has been subjected to livestock grazing and is eight years younger than the Reserve (Sta. 9).

	Station 7 & 8 (92 plots)	Station 11 (outside)
Black oak	64	36
White oak	1	6
Hickory	30	24
Smooth sumac	75	18
Staghorn sumac	0	42
Red cedar	2	0
Cherry	10	18
Aspen	7	0
Elm	0	6
Red dogwood	0	102 stems
Apple	0	12
Butternut	0	6

	Station 9 (12 plots)	Station 10 (outside)
Elm	0	7
Hickory	4	0
Smooth sumac	0	20
Cherry	0	5

DISCUSSION:

"The young tree tends to develop precisely like compound interest. When it has plenty of light, water, and nutrients, the limiting factor is its own inability to use them. Every new leaf and shoot proceeds to serve as capital to produce more leaves and shoots... a form of geometrical progression." (Baker)

A typical height growth curve under optimum conditions consists of a concave curve at the lower end where growth is just beginning. Inadequate leafage is the limiting factor and may be brief in intolerant trees or long with tolerant species. Normally the curve then becomes almost a straight line as the leaf area increases and efficiently utilizes all of the growth factors available. Later the upward trend ceases, primarily as an expression of the difficulty of supplying water to the topmost twigs. This curve may be depressed at any point by a change in available growth factors, or change in conditions of growth. The problem of deer browsing may be seen to affect height growth by reducing the leaf area, removing terminal

leaders, and forcing the seedling to use all available nutrients to replace lost parts. If the tree can grow beyond the reach of the deer, little damage will result from occasional browsing on the lower branches since few large trees utilize all their leafage with 100% efficiency. The mechanical damage to seedlings and saplings by trampling, and rubbing of antlers has not been considered in this study but may destroy a measurable portion of reproduction if the herd reaches large proportions once more. Also the large amounts of acorns and other fruits eaten by deer represents a loss of considerable potential reproduction.

GRAPHS:

The average growth curves (Fig. 11-15) are based on data accumulated from all the plots rather than separate curves based on individual plots. Heights were taken to the nearest foot and plotted against age which was taken in five year intervals for convenience in handling. The figures in parentheses indicate the number of samples taken and are included to show the amount of weighting necessary in drawing a curve to represent average growth for the species. An analysis of the individual species growth curve can be attempted if the data is adequate and in some cases further material would have been desirable. (Mention will be made in the individual analysis for the species.)

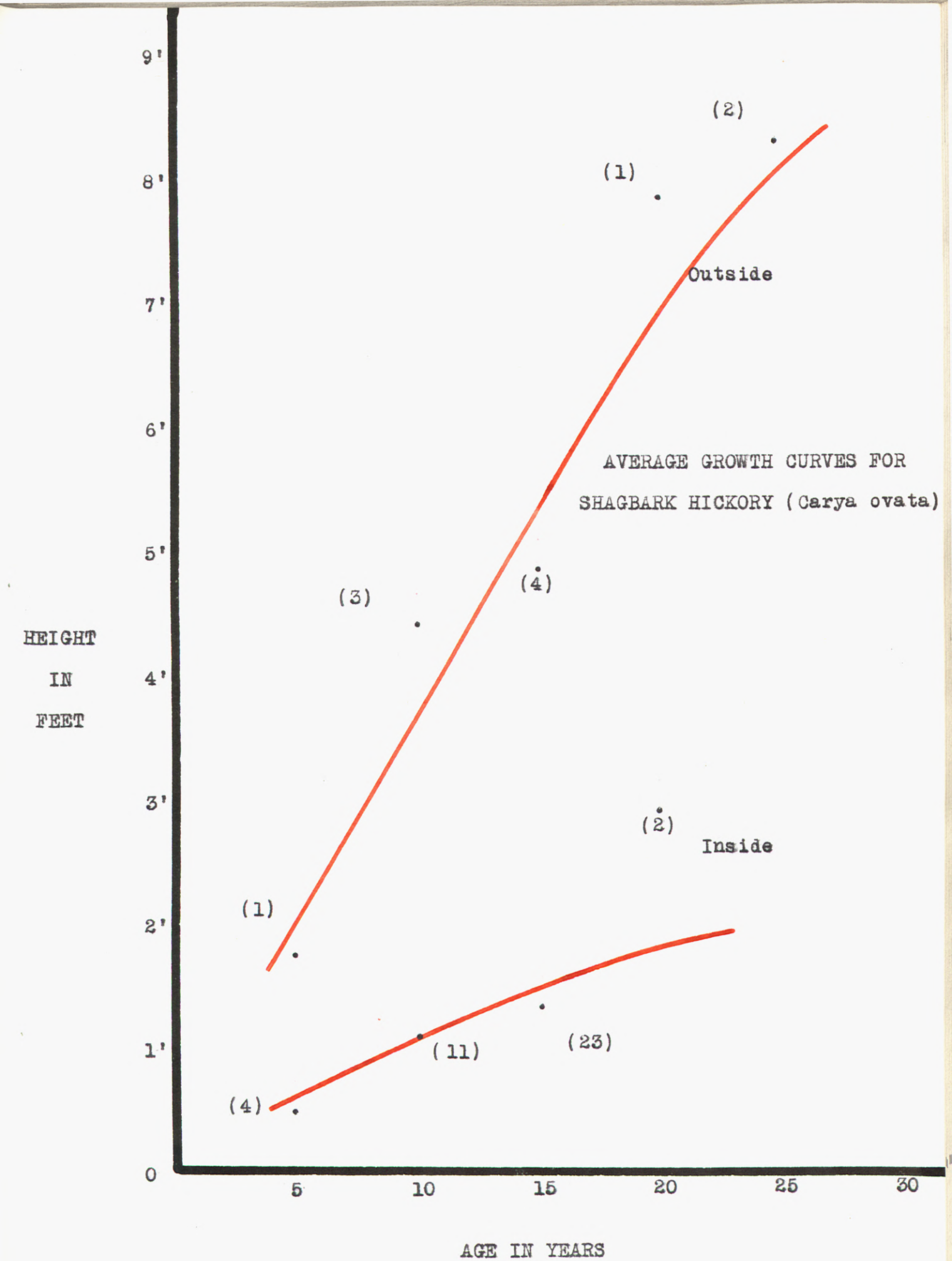

9'
8'
7'
6'
5'
4'
3'
2'
1'
0
HEIGHT IN FEET
(2)
(1)
Outside
AVERAGE GROWTH CURVES FOR
SHAGBARK HICKORY (Carya ovata)
(3)
(4)
(2)
Inside
(1)
(11)
(23)
(4)
5
10
15
20
25
30
AGE IN YEARS

FIG. 11

SHAGBARK HICKORY:

The growth curves for shagbark hickory (Fig 11) were based on 55 specimens, 40 inside and 15 outside the Reserve. All of the specimens encountered inside were aged because they were often badly deformed and all showed evidence of at least slight damage so that age was impossible to estimate. A great abundance of hickory reproduction was found outside the Reserve but since they were straight and undamaged, a smaller sample of cuttings was made so as not to destroy potential sound trees. It may be safely assumed that additional cuttings of these even-height saplings would yield similar growth data.

Since hickory is slow growing and tolerant as a seedling, no great differences in height will be noticeable in the early ages. It reproduces by seed every two or three years but great quantities of seed are destroyed by rodents, and deer eat the tiny seedlings "as fast as they appear". The snow cover in winter and thick humus layer in spring probably conceals many seedlings that are overlooked except under intensive investigation. More samples of the 0-5 year seedlings from both sides of the fence would have given a better picture of early growth. From five years on, the hickory outside the Reserve grew more rapidly, as is typical with intolerant trees, probably reaching its maximum growth early in life and then slowly decreasing in annual growth. The same species on the Reserve under similar conditions, except for the mechanical damage of browsing, grows very slowly up to two feet and 20-25 years of age. No saplings under 15' were encountered; the middle height class seems to have been eliminated, especially in the areas under consideration. Many

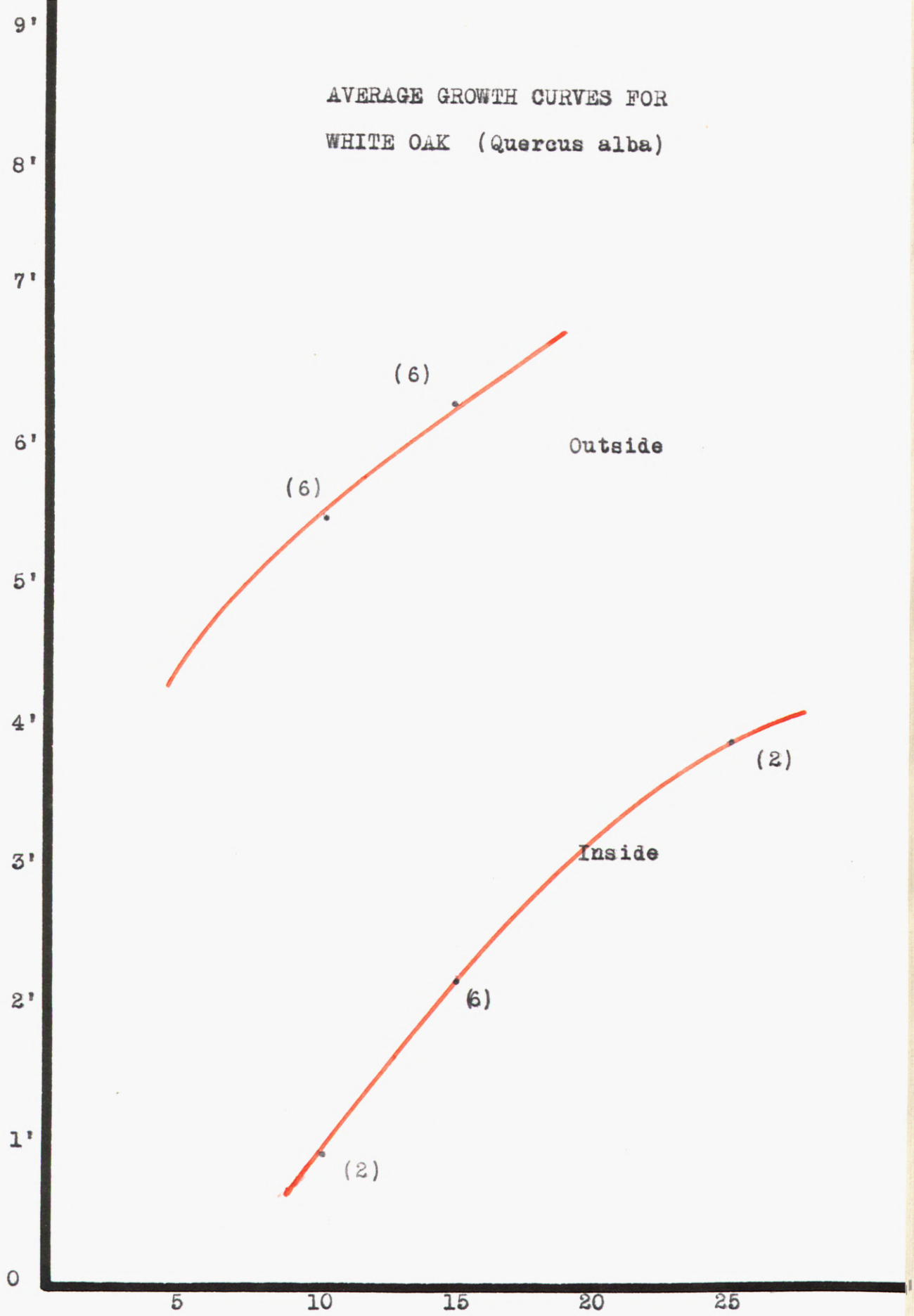

AVERAGE GROWTH CURVES FOR
WHITE OAK (Quercus alba)
HEIGHT IN FEET
9'
8'
7'
6'
5'
4'
3'
2'
1'
0
(6)
(6)
Outside
(2)
Inside
(6)
(2)
5
10
15
20
25
AGE IN YEARS

FIG. 12

dead specimens were noted and were usually those badly deformed. Light or moderately browsed specimens seem to resist browsing fairly well as they continue to live, although almost all growth is lateral.

Hickory planted at Saginaw Forest reached 2.6' after 10 years of growth as compared to 3' outside and 1' inside the deserve.

WHITE OAK:

Very little white oak reproduction occurred in the plots on the deserve so every specimen was aged (100%). Not enough samples were obtained for a statistically accurate growth curve but the plotted curves are fairly significant. Browsed specimens did not seem to resist damage very well. Lateral branching, while pronounced, was less than in the other hardwood species and every sample showed stem rot, indicating a short existence even for the reproduction that has gained a foothold (Fig. 12).

The trend of the curves is similar which may seem incompatible with a statement that white oak does not resist browsing damage. Additional data may alter the trend of the curves and an extension beyond 25 years may show a disappearance of white oak inside.

Records of white oak grown from seed in deep fresh clay loam at Saginaw Forest shows saplings to be 8.3' tall at 18 years of age. By interpolation from the growth curves on Fig. 12, white oak outside the deserve would be about 6½' tall and those on the inside would be 3' tall. At 15 years of age... (1) Saginaw 5.2' (2) Outside 6' (3) Inside 2-1/4'.

White oak is a prolific seeder with fruit maturing in one season. Occasionally they may skip seasons and since the seeds germinate in

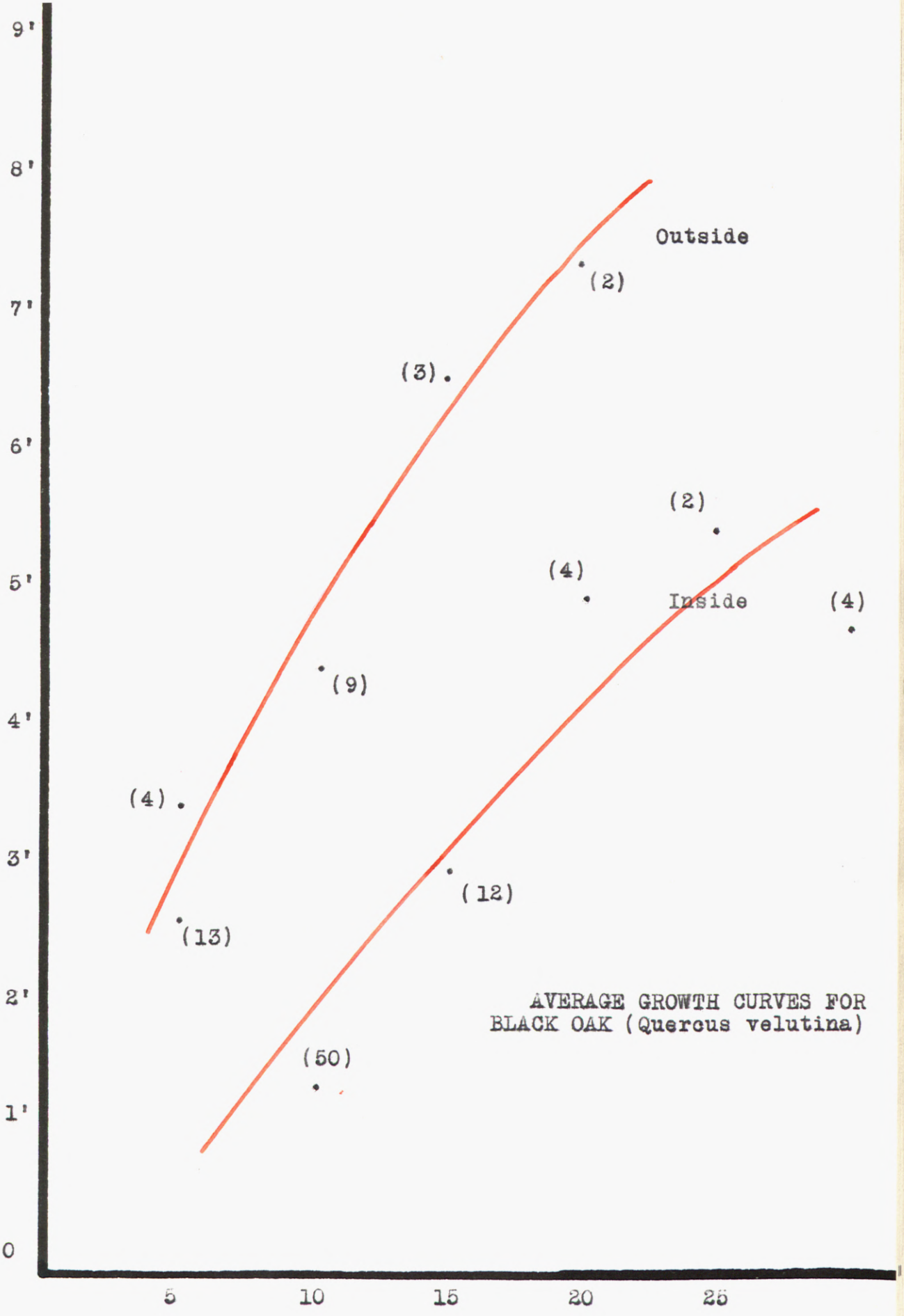

9'
8'
7'
6'
5'
4'
3'
2'
1'
0
HEIGHT IN FEET
Outside
(2)
(3)
(9)
(4)
(13)
(2)
(4)
Inside
(4)
(12)
(50)
AVERAGE GROWTH CURVES FOR
BLACK OAK (Quercus velutina)
5
10
15
20
25
AGE IN YEARS

FIG. 13

the fall, a great amount of loss due to freezing is expected. The seedlings are not fast growers, are of intermediate tolerance, and grow more tolerant with age. Again rodents destroy great quantities of the seeds and the deer make the acorns provide the bulk of their diet during the fall months. Loss of leaf area due to removal of both twigs and new leaves, tends to depress the curve of seedling growth (Fig 12).

BLACK OAK:

Over one hundred specimens of black oak saplings and seedlings were ring counted, measured, and plotted to give the resulting average growth curves (Fig 13). More specimens were taken than was the case with the other study species because of the great abundance of this oak.

Black oak is a persistent sprouter but good seed years are infrequent and often no acorns are born for several years. There seems to be a difference of opinion as to whether deer pass up the black oak fruit because it is bitter (Dixon 1934) or that they pay little attention to what we call bitterness in their choice of food (Van Dersal 1940). The George Reserve deer do browse the woody growth of the black oaks and the growth curves (Fig 13) seem to indicate that while the height growth is suppressed, it does follow the same general trend as for undamaged saplings, and will eventually "escape" the deer. Unfortunately no growth figures for black oak are available at Saginaw Forest for comparison. Browsing deforms black oak by promoting lateral growth but unless it is unusually severe, butt rot

and dead specimens are not common.

Beckwith (1942) found that "red and black oaks were established in old fields 3-5 years after the date of last cultivation." They are intolerant as a tree, not a climax type, and slower growing than red oak. They can stand dense shade as seedlings which probably accounts for their abundance in the oak-hickory types in this area. Many of the specimens aged on the Reserve showed wider growth rings for the past 3-4 years which may be interpreted as release from overbrowsing coincident with the cutting back of the herd starting in 1940-41.

INDICATOR SPECIES:

In addition to the three hardwoods previously studied, it was felt advisable to investigate several other species that are not as abundant but preferred by deer at one season or another. Not all species could be studied adequately for statistical purposes but observations and samples were made to test the feasibility of selecting an indicator species. Since hardwoods grow so slowly and damage is often too great when it becomes apparent, game managers have found it advisable to find a species that grows quickly and shows damage very soon after it begins. The value of such knowledge is evident for then control measures can be taken before irruptions take place with subsequent depletion of the range.

Pearce (1937) found that witch-hobble(Viburnum alnifolium) was 'a key species, an indicator plant that 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 though heavily browsed."

Perhaps an intensive growth study of fast growing, widespread shrubs and an investigation of the preferences and requirements of deer in this region will yield a similar key species for use in the management of the George Reserve deer herd. Key species may have to be selected for all four seasons of the year.

A partial list was suggested by Dr. F. N. Hamerstrom, based on his observations of changes that have occurred on the area since he has lived there (1941). Smooth sumac, red cedar, buckthorn, red osier dogwood, gray dogwood, sassafras, tamarack, elm, poplar, red maple, witch hazel, yellow birch, and hazelnut were suggested by him as possibilities for further study. The difficulty in making accurate comparisons with specimens obtained outside the sample plots prevented the accumulation of any amount of data but samples were taken as they were encountered during the study.

Actual observations of deer feeding on various browse species were made but were too few and of too short duration to be included as evidence of preference or seasonal need. The observations did serve to substantiate statements as to their general habits of browsing and factors influencing them.

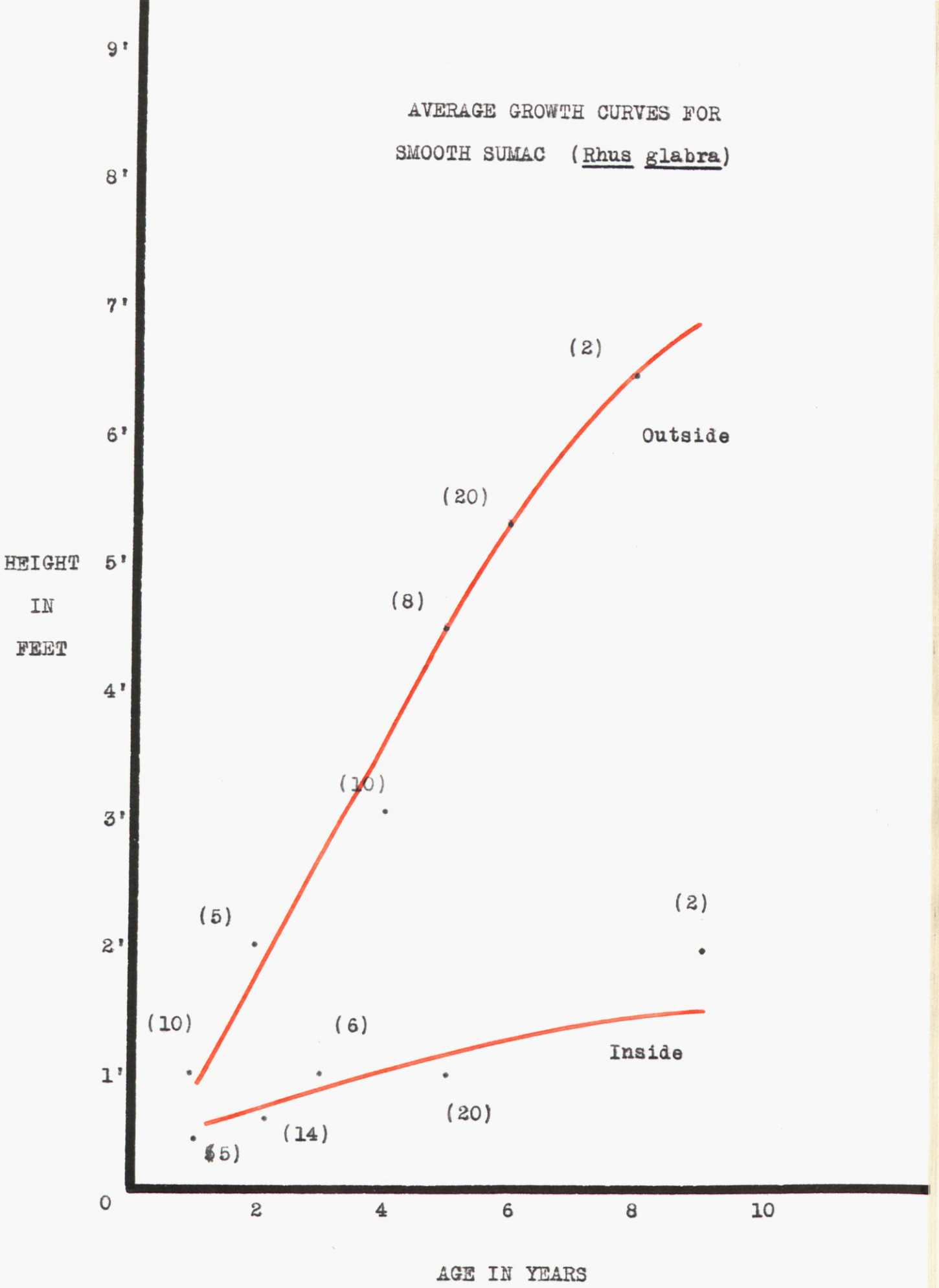

AVERAGE GROWTH CURVES FOR
SMOOTH SUMAC (Rhus glabra)
HEIGHT IN FEET
9'
8'
7'
6'
5'
4'
3'
2'
1'
0
2
4
6
8
10
AGE IN YEARS
Outside
Inside
(2)
(20)
(8)
(10)
(5)
(2)
(10)
(6)
(20)
(14)
(5)

FIG. 14

SMOOTH SUMAC:

This shrub, although less common in Michigan than staghorn sumac, was the only one encountered on the Reserve. Original survey notes refer to staghorn sumac on the present Reserve, but may be an error in identification. Large patches of smooth sumac occur near the airport, along the east fence, along Fishhook Marsh and elsewhere throughout the cleared slopes.

The method of aging, previously described, was employed, with occasional ring counts to insure accuracy. Generally speaking, the sumac found growing outside the Reserve grows about one foot per year to a maximum height of 12-14'. Then it dies and in some areas is being replaced by more tolerant gray dogwood. Samples were taken on the George Reserve Annex, the old Elizabeth Gardner property across from the east fence (now owned by the University) and between the east road and the fence. Inside the fence the deer browse back each year's new growth so that comparitively little gain in height is made. Some stems escape, probably due to the law of average, and others in inaccessible places were observed to be growing at a fairly normal rate.

An expanded age scale was used in computing the average growth curve for smooth sumac because of its quick growth and short life. It is readily seen that the deer seek it out as soon as it breaks the surface of the ground.

CEDAR:

Juniper, because of its persistent foliage, and close grown symmetrical form is very quick to show browse damage. In some

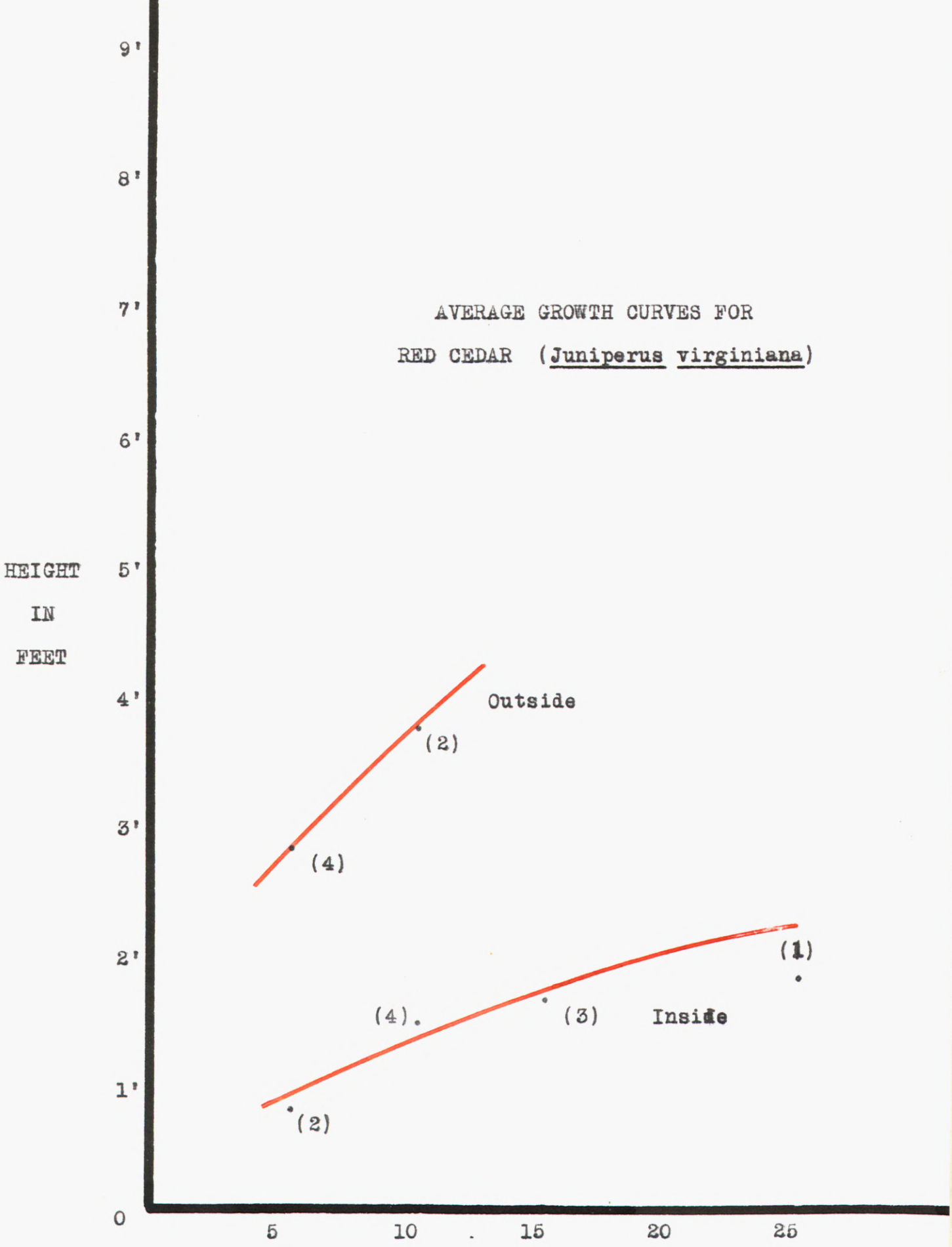

AVERAGE GROWTH CURVES FOR
RED CEDAR (Juniperus virginiana)
HEIGHT IN FEET
9'
8'
7'
6'
5'
4'
3'
2'
1'
0
Outside
(2)
(4)
(1)
(4).
(3)
Inside
(2)
5
10
15
20
25
AGE IN YEARS

FIG. 15

instances the deer have stripped off all foliage to a height of 6' and left a 1 or 2' plume at the top. A few saplings were broken but, despite the heavy and repeated browsing, only the smaller seedlings were dying as a result of the pressure. Most of the red cedar is found on old fields and in the more open woodlots for they are very intolerant. Inside the fence they are a sorry sight - whole patches of reproduction, notably along the south fence, are browsed almost to the point of extinction. Few specimens have escaped browsing to some degree no matter how widespread they are. During the winter all trails led to them. A doe was observed feeding late one afternoon in January along the east fence. Despite zero temperature and a strong wind, she browsed leisurely, spending two or three minutes at each red cedar and low juniper (J. communis var depressa), and gradually worked her way along the side of the hill. In fifteen minutes she did not browse anything but juniper despite the presence of sumac and black oak seedlings.

East of the Reserve on State-owned land are thousands of red cedars of all sizes covering abandoned agricultural land. Their perfectly symmetrical form indicates that they have grown free from browsing by sheep or deer and the growth figures obtained seemed to substantiate this. No trees larger than four feet were cut due to the difficulty in cutting a smooth surface for aging with the available equipment. The samples made showed even, wide growth rings in contrast to the compressed and contorted rings noted inside.

Many large specimens of low juniper were heavily browsed and were dead or dying. No ages were taken or comparisons made although abundant samples for comparison are available north of the fence near Station 4.

MISCELLANEOUS:

Only one clump of red osier dogwood was found on the Reserve - along the fire trail near the swamp in the southeast corner. (Fig. 37). Deer find it very palatable which probably accounts in part for its scarcity inside the boundaries. Another factor tending to prevent it from ever becoming abundant is its habit of reproducing by sending out shoots, and this process is very slow, especially early in its life. The samples taken inside averaged 6 years of age and were 3' tall. Samples taken on the Reserve Annex and in Loy McClear's woodlot (east boundary) were 5' tall at an average age of 3 years.

Witch hazel is found both in and out of the Reserve and may indicate several things. It appears to be more abundant in than out. The few samples aged showed nothing significant and no browse damage was ever noted. In the winter, deer tracks were seldom, if ever, found near witch hazel. Apparently deer do not find it palatable and are not forced by starvation to eat it. It is "poorly eaten" in New York (Maynard et al 1936). Is it more abundant inside or does lack of other reproduction make it more conspicuous? If it is more abundant, then it might follow that the deer, by overbrowsing its competitors, have allowed it to assume dominance in the understory.

Elm is eagerly consumed and many deformed specimens attest to the deer's preference for it. Eight specimens, selected at random outside, averaged 3-1/2' at 8 years of age. Five similar specimens inside at 8 years of age averaged only 10" in height. South of the Reserve fence (Sta. 10) many elm seedlings are establishing themselves in the old field. Experimental exclosures will be constructed soon inside the Reserve and it is to be hoped that plots containing elm reproduction will be studied in this manner.

Cantrall (1942) wrote "sassafras, apparently unpalatable to the deer, is at present spreading to other parts of the woods." Regarded by some as a "weed tree" it is rapidly restocking abandoned farm lands by seeds as well as by root sprouts. Samples taken did not indicate any difference in growth rate in or out of the Reserve and may suggest that the deer do not browse it. However, additional data may lend weight to the opposite view held by some, that deer do browse sassafras. The southwest woodlot would be the best place for a study of this kind.

Black cherry is abundant in the woodlots and may be "released" by lack of competition due to deer holding back more tolerant species. They do nibble on the new growth of seedlings as was witnessed in mid-April but it is possible that this light pruning effect actually stimulates growth. No samples were aged.

SUMMARY:

Abandonment of cultivation and permitting vegetation to return to the Reserve, coupled with elimination of cutting, grazing, and fire, have undoubtedly helped to conserve the natural resources of the area. The introduction of the deer herd and its subsequent domination had an opposite effect on the vegetation and allied fauna. Most of these changes have been so recent, in terms of long range successional modifications, that the Reserve will unquestionably be further altered, either toward climax vegetative types or by retrogression. With the deer herd at or near the carrying capacity of the range, it is unlikely that they will act to modify succession greatly. It is also unlikely that natural succession will change the cover to such an extent that the range will be no longer suitable for wildlife, especially an adaptable animal like the whitetail.

CONCLUSIONS:

1. A tree grows in height only through new growth from its topshoot. Destruction of the topshoot by browsing suppresses height growth and causes deformities.
2. Relatively light pruning by deer may stimulate growth and is not so destructive to range as is excessive use and trampling by livestock.
3. Hardwoods over six feet tall provide very little browse.
4. No two woods are ever precisely alike but food habits studies utilizing exclosures should provide valuable information on deer food preferences and seasonal requirements.

5. Prevention of fires and cuttings has halted increased growth of succulent vegetation and other shrubby growth suitable for deer food.

6. While the present population of 25-30 deer per section does not appear to be taxing the carrying capacity of the Reserve, it might prove impossible to attempt reforestation on a similar area with that number.

7. Damage on the Reserve is spread over a larger area due to milder climate and presence of more food in southern hardwood forests. Data on carrying capacity is probably not applicable further north where deer are forced to yard.

8. The deer on the Reserve browse hardwoods all year round, with the lightest pressure coming during the summer when there is a greater variety of browse present.

9. An average herd of 127 deer annually may be expected to consume upwards of 160 tons of browse. Much of this is oak and hickory reproduction.

10. The Reserve cannot be sacrificed to the deer herd; their numbers must be controlled to match carrying capacity.

11. Lack of oak and hickory reproduction within the woodlots due to browsing may be changing the composition of the understory. Witch hazel, cherry, and sassafras seem to be more abundant inside than out.

12. White oak does not resist browse damage as well as black oak and hickory, and shows a greater incidence of butt rot and early kill.

13. Damage other than by browsing may be trampling, antler damage, eating seeds (acorns, nuts), and release of undesirable species which may grow and crowd out or prevent establishment of desirable species.

14. The three dominant hardwoods showed suppression of height growth due to overbrowsing.

15. Estimated populations based on browse conditions are probably low. Therefore, it is desirable to discover key or indicator species to judge current condition of range before damage is too great.

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SCIENTIFIC NAMES

1. Abies balsamea.....balsam fir
2. Acer rubrum.....red maple
3. Betula lutea.....yellow birch
4. Carya glabra.....pignut hickory
5. Carya ovata.....shagbark hickory
6. Cornus paniculata.....panicled dogwood
7. Cornus stolonifera.....red-osier dogwood
8. Corylus americana.....American hazel
9. Fagus grandifolia.....beech
10. Hamamelis virginiana.....witch hazel
11. Juglans cinerea.....butternut
12. Juniperus communis var. depressa.....low juniper
13. Juniperus virginiana.....red cedar
14. Larix laricina.....tamarack
15. Picea rubra.....red spruce
16. Pinus resinosa.....red pine
17. Populus tremuloides.....quaking aspen
18. Prunus serotina.....black cherry
19. Quercus alba.....white oak
20. Quercus borealis var. maxima.....red oak
21. Quercus velutina.....black oak
22. Rhamnus alnifolia.....alder buckthorn
23. Rhus glabra.....smooth sumac
24. Rhus typhina.....staghorn sumac
25. Rhus Vernix.....poison sumac
26. Sassafras officinale.....sassafras
27. Ulmus americana.....American elm
28. Vaccinium canadense.....low bush blueberry
29. Viburnum alnifolium.....witch hobble

Fig. 16 Heavily browsed smooth sumac along east end of Edwin S. George Reserve.

Fig. 17 Same as Fig. 16. Contrast normal growth outside of fence with that utilized by deer.

Fig. 18. Smooth sumac stems, both are six years old. The one on the left grew on the Reserve and the other was growing outside.

Fig. 19. Red maple buds and twigs are readily eaten in winter. Little reproduction can be found on the Reserve but an occasional windthrow brings browse within the reach of the deer.

Fig. 20. No intermediate sizes of aspen are to be found along the edge of the birch-maple-elm swamp. Black oak and juniper reproduction are invading this abandoned field but are heavily browsed each year.

Fig. 21. This two foot white oak "seedling" is eighteen years old. The repeated destruction of terminal leaders causes lateral branching, and ultimately kills the tree.

Fig. 22. Shagbark hickory is readily deformed by browsing but will recover if not too severely damaged. Left- 20 years old (in), Right- 9 years old (outside).

Fig. 23. The persistent leaves of white oak are eaten by deer in the winter.

Fig. 24. These white oak seedlings were subject to heavy pressure when other food sources were buried under the snow. They were found on the north end of the airport along the edge of the woods.

Fig. 25. Three deer beds in the lee of a low juniper bush. Note browsed red cedars in background. Junipers and tamarack are the only conifers on the Reserve and both species are used in winter.

Fig. 26. The red pine plantation*near the N. E. gate provide shelter in winter and are moderately browsed. Antler damage is responsible for the condition of this specimen. *(Planted - 1928)

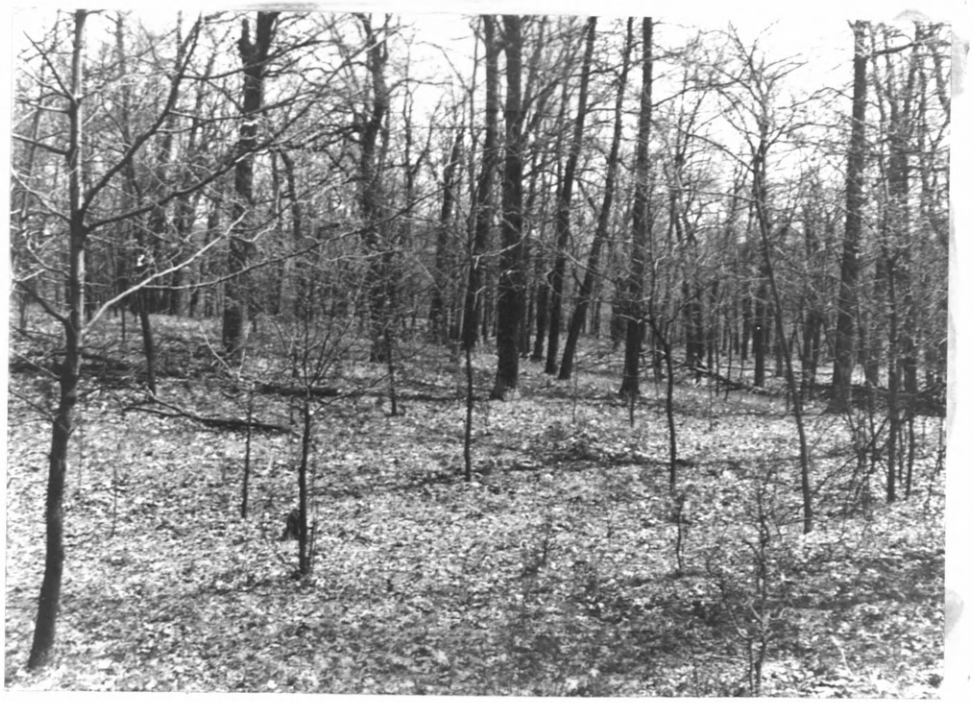


Fig. 27. Plot 5 in N. W. woods, George Reserve. Some reproduction is coming in but many species are inferior and growth of valuable species is suppressed.

Fig. 28. Plot 6 in Loy McClear's woods adjacent to Plot 5. Both photographs were taken from the same spot. Note difference in form and abundance of understory.

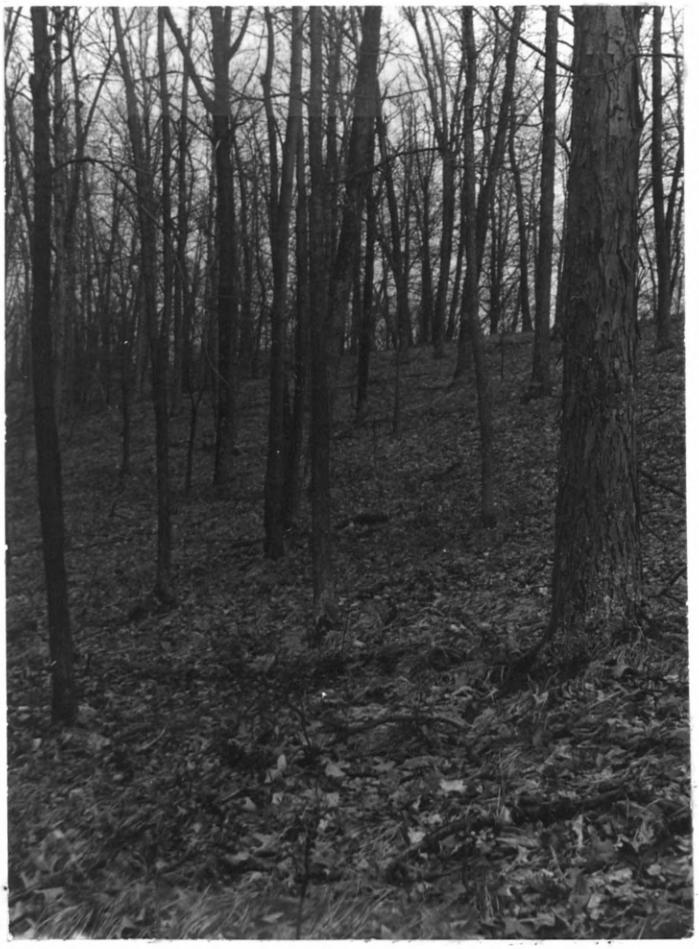


Fig. 29 Plot 1 in N. E. woods, George Reserve. Only cherry reproduction seems to be gaining a foothold.

Fig. 30. Plot 2 outside of fence in N. E. woods. White oak, black oak, cherry, hickory, sassafras, dogwood, and red maple reproduction is well established.

Fig. 31. Rows of mature oaks and hickories mark the boundaries of old fields.

Fig. 32. Invasion of old fields by oak and hickory reproduction, east edge of Cassandra 40. Mature junipers are browsed as high as 6 feet.

Fig. 33. Plot 1 showing almost complete absence of undergrowth. Three fawns were observed feeding on new growth cherry leaves (right center) in mid-April.

Fig. 34. Photograph of Plot 2, taken from inside the George Reserve. Profusion of shrubs is mainly witch hazel and gray dogwood.

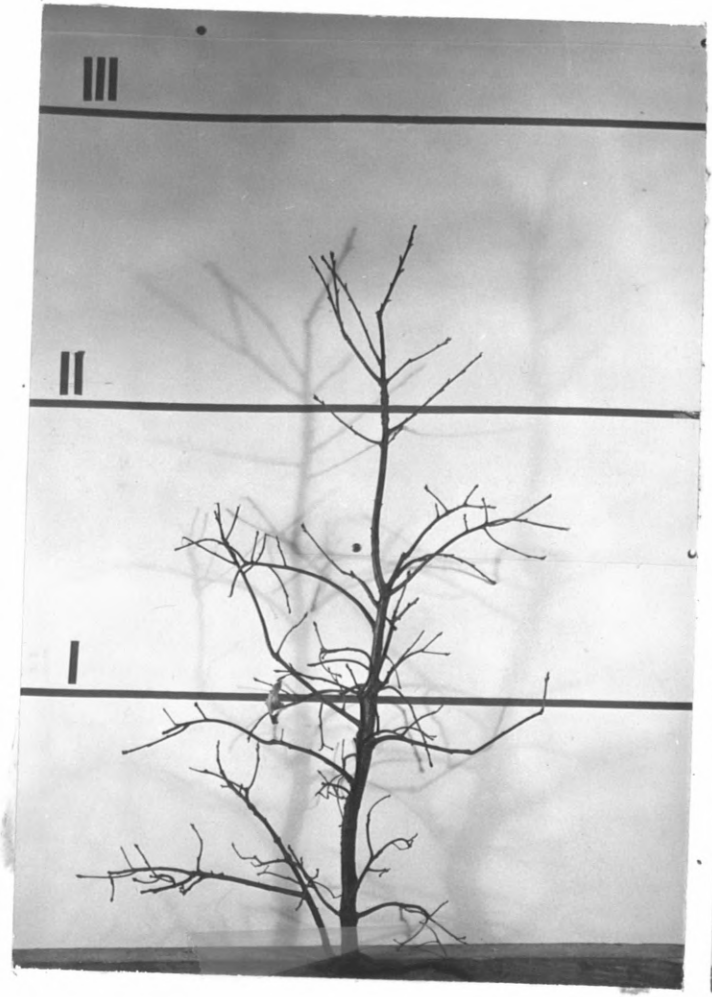
Fig. 35. Deer damage many trees by rubbing the velvet off their antlers in the fall. The damaged red maple in the foreground and other hardwoods in the pole stage provide little food during critical winter periods.

Fig. 36. Dead leaves on this windthrown black oak were consumed as high as the deer could reach. A difference in chemical composition may account for the preferences shown in many instances.

Fig. 37. Red-osier dogwood may be scarce due to its palatability. Under heavy pressure it is held back to the sprouting stage.

Fig. 38. Uneven aged, mixed hardwoods at the University of Michigan Fresh Air Camp across the road from the George Reserve. This ungrazed woods has been retired from use since 1928, the date the Reserve was purchased. Reproduction of almost all the major hardwoods and shrubs can be found here in varying stages of development.

Fig. 39. The Reserve is fairly typical of the rolling moraine country of southern Michigan. Shown above is one of the many small leatherleaf bogs north of the esker.



Black Oak Sapling - 7 years

OUTSIDE

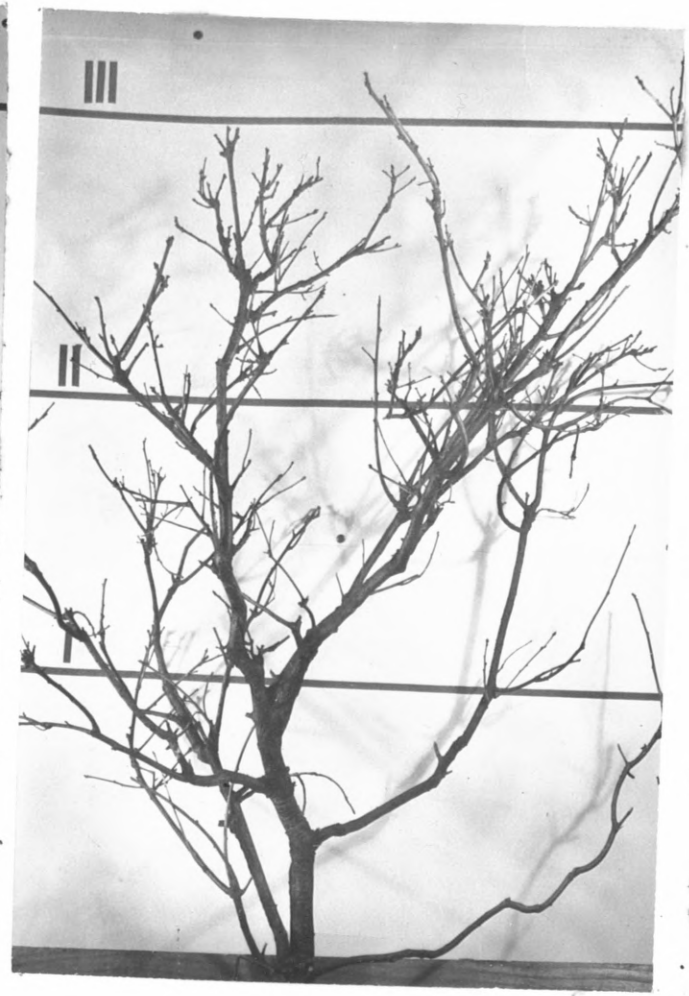
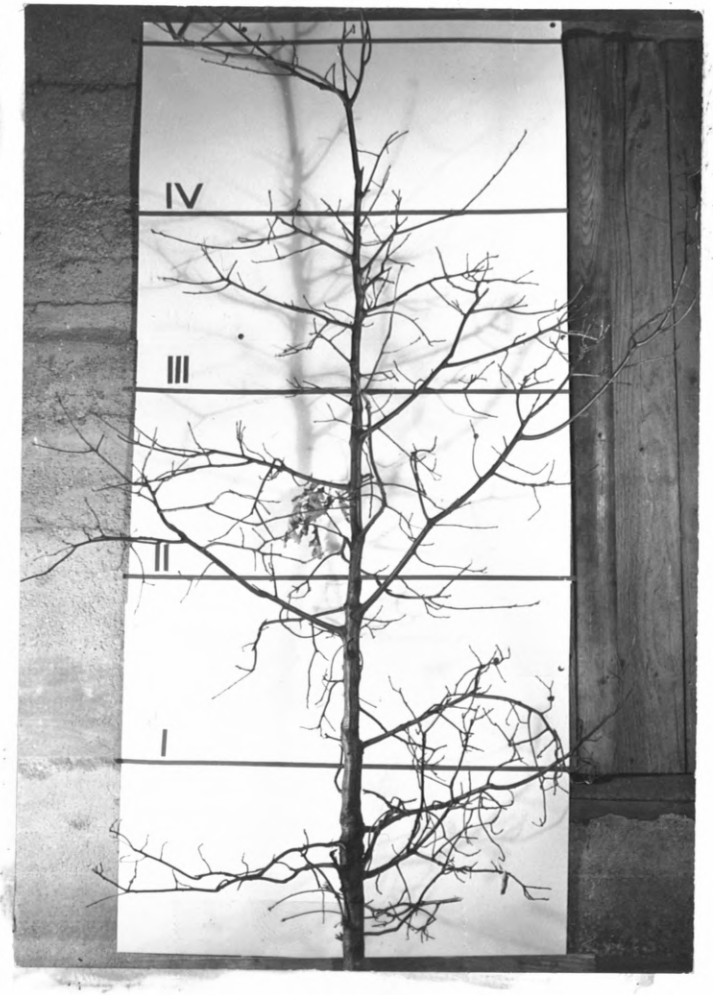


Fig. 40

28 years
INSIDE



12 years

OUTSIDE