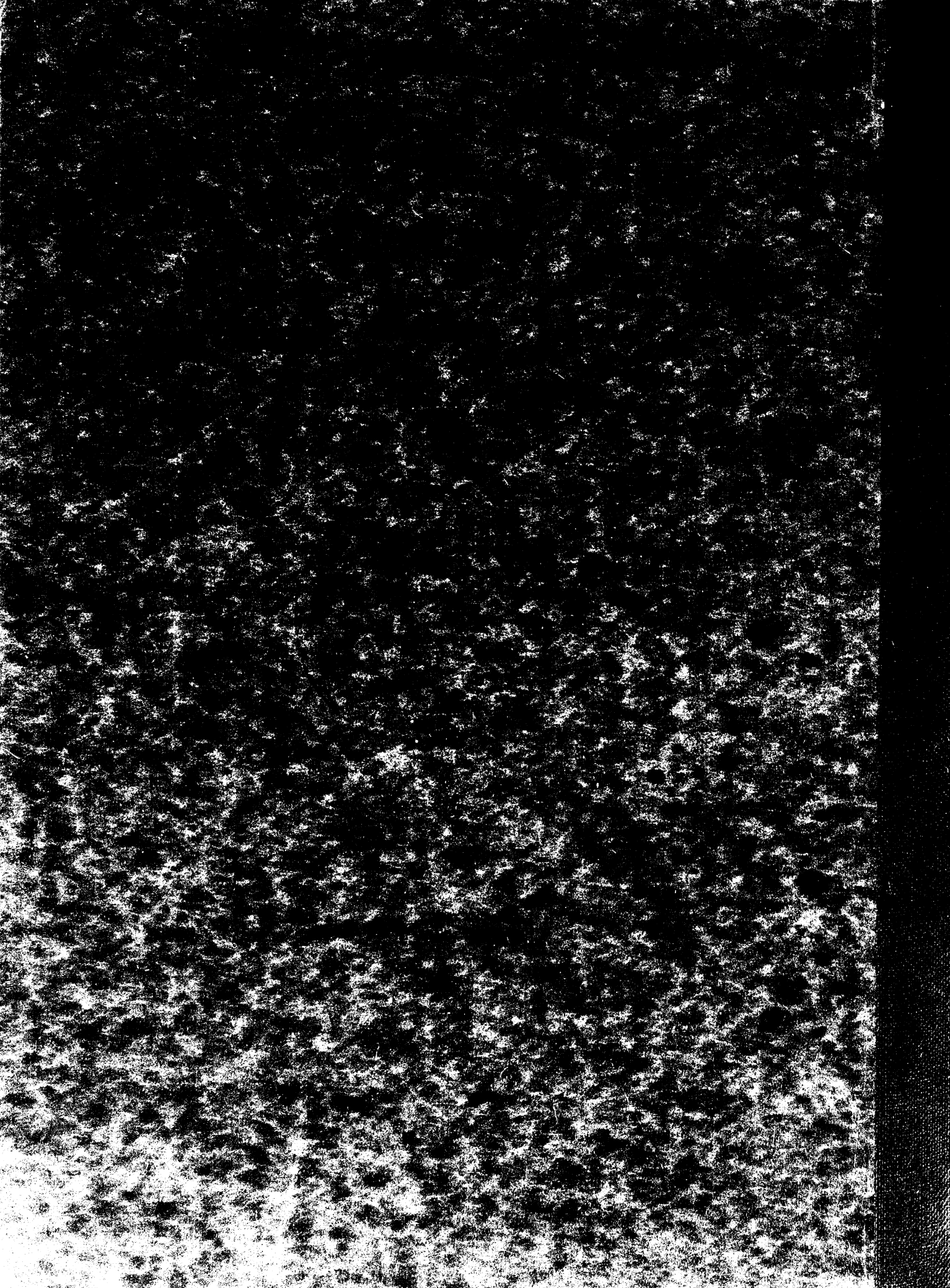
Youngberg, Chester T
Natural reproduction after grazing in the Stinchfield woods as affected by crown density and soil conditions. 1947.



NATURAL REPRODUCTION AFTER GRAZING IN THE STINCHFIELD WOODS AS AFFECTED BY CROWN DENSITY AND SOIL CONDITIONS

BY

CHESTER T. YOUNGBERG

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF FORESTRY IN THE UNIVERSITY OF MICHIGAN

ANN ARBOR, MICHIGAN

MAY, 1947

ACKNOWLEDGEMENT

The author wishes to gratefully acknowledge the valuable assistance offered by various people. He is especially grateful to Professor L. J. Young for suggesting the problem and for advice on collection and organization of the data. Gratitude is also due Professor W. W. Chase for suggestions on literature, Professor D. V. Baxter for information concerning pathological problems, Professor Frank Murray for furnishing maps and offering advice and suggestions in the field, Professor M. W. Senstius, of the Department of Geology, for aid and instruction in the mechanical analysis of soil samples, and J. L. Leedy, Professor of Botany, Wheaton College, Illinois, for taking the photographs used in this text.

C. T. Y.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

In the Central States one of the important forestry problems is in connection with the extensive grazing of farm woodlands. It is estimated that in the corn belt counties of Indiana (12) 83.6 per cent of the farm woods are grazed. One has but to drive through the agricultural areas of southern Michigan to see that the majority of farm woodlots have lost any semblance of the thrifty appearance of a well stocked stand. Many of them are open parks and near the final stages of decadence.

These farm woodlots are no longer capable of producing forest products. Farm woodlands have been a good source of fuelwood, fence posts, rough timbers, staves, lumber and veneer. If they are to continue to produce any quantity of these products these woodlots will have to be closed to grazing. The question then arises, how long will it take for these woodlots to recover to a thrifty condition. This depends on the stage of decadence and on various site conditions, soil moisture being one of prime importance.

With these thoughts in mind, we can appreciate or evaluate better this study of natural reproduction after grazing in the Stinchfield Woods.

FORAGE VALUE OF WOODLAND

"A thrifty farm woods makes a poor pasture; if pastured it soon becomes a poor woods." (4). This statement is a good summary of the conditions so common in the farm woods in the Central States. It is a well known fact that there is less forage by weight produced in woodland than in open pasture and that it is less palatable and less nutritious than forage produced on open pasture.

In a study made in southern Wisconsin (1) it was found that renovated and untreated pastures produced 11.6 and 5.3 times as much forage per acre, respectively, as woodland pasture. It was found that the clearing and renovation of one acre would provide enough forage to replace the amount produced by 11.5 acres of woodland and that one acre of cleared, untreated land will produce as much forage as 5 acres of wooded land.

In another study made in northern Indiana hardwoods (14) it was found that, under prevailing grazing practices, the actual forage production in farmwoods was insufficient to maintain animal weights over a six months season. With continued grazing the carrying capacity was lowered further.

Two studies made in Ohio (17, 22) revealed that woodland forage was 22 per cent less nutritious than forage produced in open pasture. This was due to the fact that 38 per cent less carbohydrates were produced in woodland for-

age. This lower carbohydrate production is also the reason for the lesser degree of palatability of woodland forage.

Soil Conservation Service agronomists in southern Minnesota (3) found that it takes from 3.5 to 9 acres of woodland pasture, depending on density, to support one cow; while on renovated pasture it takes only from .75 to 1.4 acres, and on ordinary blue grass pasture it takes from 1.4 to 2.3 acres to support one cow.

EFFECTS OF GRAZING

In the Indiana farmwoods studied (12) four stages of decadence of grazed woodlands were established. These stages are:

1. Early stage - crown density 80 per cent or more; absence of sod cover; absence of trees in the sapling stages.
2. Transition stage - crown density less than 80 per cent; sod cover beginning to form as canopy opens up.
3. Open park stage - crown density over 50 per cent; sod cover present; frequent stagheadedness.
4. Final stage - crown density less than 50 per cent; complete sod cover; most trees of merchantable quality gone; only culls remaining.

In the area under consideration 84 per cent of the farm woodlots were being pastured and 50 per cent of these were incapable of producing any appreciable yield of forest products.

A study of the effects on grazing on woodlands will readily reveal the reasons for the loss of yield. These effects may well be divided into three groups: The effects on the site, the effects on growth, and the effects on reproduction.

EFFECT ON SITE. The effects of grazing on the site

are directly responsible for some of the effects on growth and reproduction. As grazing in woodlands progresses all of the seedlings, herbaceous plants, shrubs and saplings gradually disappear. As a result there is a freer movement of wind through the stand and litter and duff are blown away to a certain extent. As the crown opens up the destruction of litter becomes more complete. Along with this destruction of litter and duff comes compacting of the soil by the trampling of livestock. The compactness of the soil and the absence of sufficient litter and duff lower the porosity of the soil. This in turn results in a lower water holding capacity in the soil and increased run off and erosion. As the canopy opens up, and the saplings and shrubby undergrowth disappear, a sod cover begins to form. Eventually a complete sod cover is formed. With increased opening up of the stand and compacting of the soil, soil temperatures are increased. Due to the increased wind movement and higher temperatures in the stand relative humidity becomes lower.

Grazing upsets the biological balance within a stand, with a resultant increase in noxious insects. All of these factors have direct bearings on growth and reproduction.

EFFECT ON GROWTH. Grazed woodlots show an annual loss in basal area and total number of trees. This is true even if none of the trees are cut out due to the loss in vigor and increase of disease in the remaining stand. Litter and

duff are important in maintaining rapid growth, by keeping the soil fertile and conserving soil moisture. This benefit is lost in the grazed woodlot. Stagheadedness and the exposure of roots by trampling are other important factors in lowering growth rates. Trees in grazed woodlots are highly susceptible to both heart-rotting and sap-rotting fungi (5). Reduced growth rates leave the stand open to attack by weakly parasitic fungi.

In a five year study of maple syrup production (11) it was found that production was 35 per cent higher on ungrazed woodlots than on grazed woodlots. This higher production was closely correlated with a higher rate of growth in the ungrazed woodlot.

EFFECT ON REPRODUCTION. It hardly needs to be stated that with grazing all reproduction disappears, with the exception of unpalatable species. Of the environmental factors affecting the establishment of natural reproduction in grazed woods, soil moisture is the principal limiting factor. The critical moisture conditions so common in grazed woodlots are caused by the presence of a sod cover, absence of litter and duff, absence of shrubby undergrowth, soil compactness, and a higher rate of evaporation caused by freer passage of wind through the stand. In a study made in Indiana (16) it was found that during July and August the moisture content of the soil was higher in open pasture than in grazed woodland. During good seed

years germination may be high, but mortality may also be 100 per cent during the hot dry summer.

The absence of sufficient litter and duff upsets the carbon-nitrogen ratio in the soil, with a resultant loss or lowering of seed production due to the slow rate at which reserve carbohydrates are built up.

In addition to the loss of fertility and low soil moisture, soil temperatures are increased where the soil is compacted and litter and duff are absent. These factors make germination and survival of seedlings highly improbable. In the absence of litter and duff, the nut species do not have the necessary protective covering for seed storage over winter.

Finally, with the ultimate formation of a sod cover, seed germination becomes almost impossible, especially with the heavy-seeded species like oak and hickory. If they do germinate, the root competition from the sod cover would probably prevent their survival.

STINCHFIELD WOODS

LOCATION AND HISTORY OF TRACT. Stinchfield Woods, which is a part of Sections 11, 12 and 14, T1S R4E, Dexter Township, Washtenaw County, Michigan, is a part of the forest properties of the School of Forestry and Conservation of the University of Michigan. Its purchase was made possible by a grant of $10,000 by Mrs. Charles Stinchfield for the establishment of a memorial to her husband and his father who were both Michigan lumber men (6). The original purchase was of 320 acres, over two-thirds of which was in old fields and the remainder in second growth oak-hickory.

The oak-hickory area had been heavily grazed by sheep, which are considered to be the most destructive of livestock. Present day evidence indicates that the greater part of the area was in the open park stage of decadence, with a complete sod cover over the entire area and a crown density of approximately .5.

The cuttings that have been made since the exclusion of livestock have been in the nature of improvement and salvage cuttings.

GEOLOGY OF THE AREA. The U. S. Geological Survey (19) classifies the Stinchfield Woods area as a kame. It is part of the interlobate moraine of the Huron-Erie Lobe.

Veatch (21) classifies the area as a Sandy Hills Land Type. This type is characterized by broad, long slopes, sharp ridges, knobs and basins, and alternating slopes and swells, producing an irregular billowy topography. The soils, as well as the topography are variable.

The soil is classified as a Bellefontaine sandy loam, which is characterized by being moderately stony, with a reddish, sandy and stony, friable clay subsoil and a coarse, pervious substratum (21). There is much variation in the soils of the Stinchfield area, as is shown by the analysis of soil samples taken from different parts of the area.

WEATHER. The mean annual precipitation of this area is approximately 28 inches. Two to three week drouths are common in May and June and there is a tendency toward dry, hot summers (24). These weather conditions are important factors in the consideration of the establishment of natural reproduction.

TYPE OF STUDY. Since the area under consideration had not been grazed since 1925, it was felt that the number of small saplings present would give the best indication of the establishment of reproduction. On some of the better soil types the smaller individuals of the large saplings have become established since the exclusion of livestock. Therefore they were also included in

the tally. Seedlings were also tallied, since survival of seedlings over the summer gives a good indication of the return of the stand to its normal climatic, physiographic and biotic conditions.

The line plot method of cruise was used. The lines were run 5 chains apart and plots were taken 5 chains apart (Fig. 1). The small and large saplings were tallied on $\frac{1}{4}$ acre plots and a tally of seedlings was taken on milacre quadrats at the same point. Crown density was noted on these plots.

Soil samples were taken on plots varying in density of reproduction in order to determine the relationship between the water-holding capacity of the soil and the establishment of reproduction. These samples were taken at depths from 18 - 24" in the A_1 horizon. The Bouyoucos method of mechanical analysis was used on these samples.

Ring counts were made to determine how long after the exclusion of livestock reproduction became established.

The data for this study were collected during the fall of 1946. A check was made in the spring of 1947 to determine to what extent rodents had been active in destroying seed.

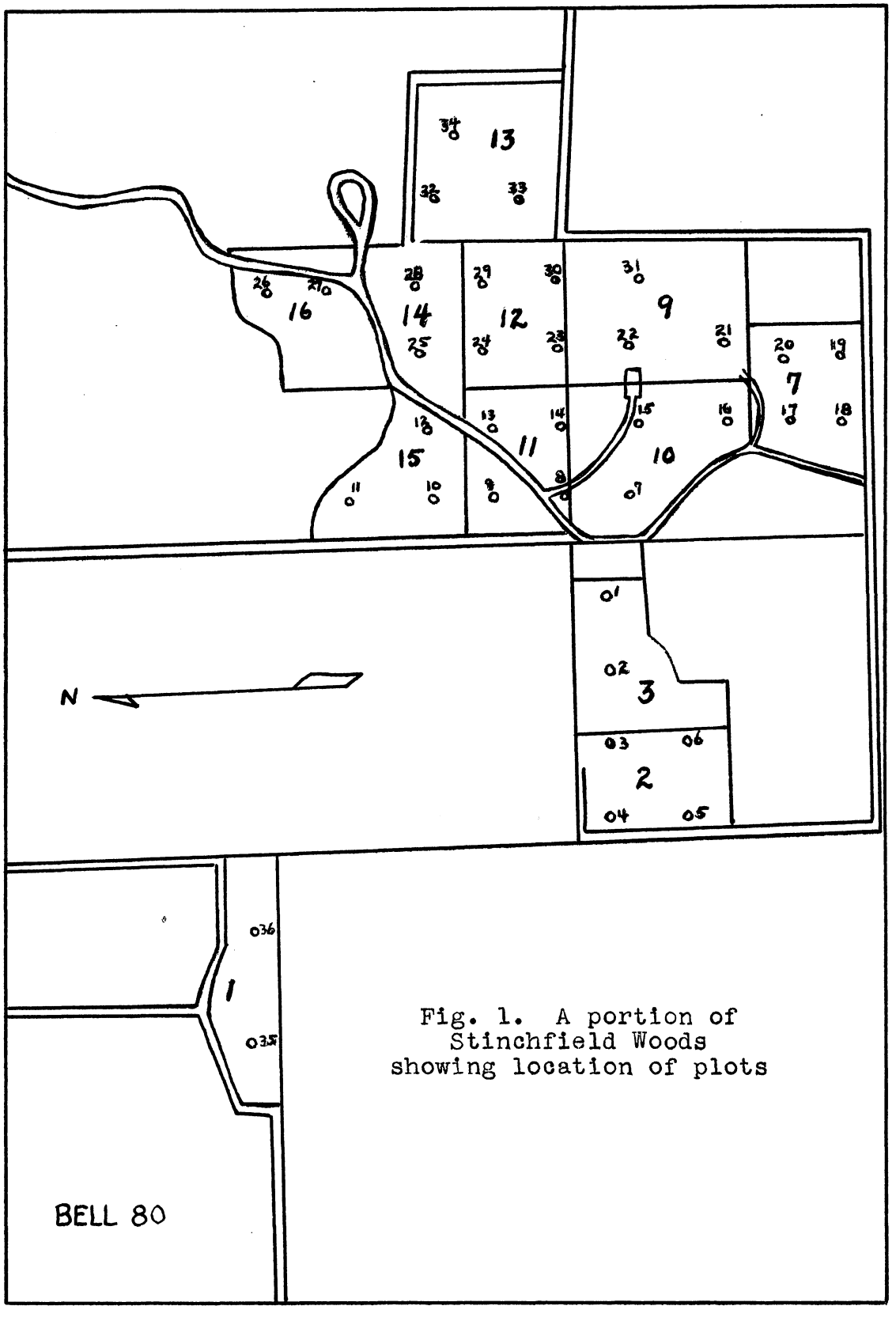


Fig. 1. A portion of Stinchfield Woods showing location of plots

NATURAL REPRODUCTION IN THE STINCHFIELD WOODS

As was stated before, soil moisture is the principal limiting factor in the satisfactory regeneration of previously grazed woodlands. The various factors affecting soil moisture are the degree to which the crown is opened up, which in turn determines the extent of sod cover, the disappearance of shrubby growth, which allows freer passage of wind through the stand, the disappearance of litter and the compacting of the soil.

The length of time required for a stand to return to a normal condition is determined by the stage of decadence to which it has deteriorated. A stand which is in the early stage of decadence will return to normal with satisfactory reproduction of the type species in a relatively short time. A stand which has deteriorated to the open park stage of decadence requires a long period of time to return to a normal condition. It usually involves a sub-climax stage with intolerant species being in abundance and eventually bringing about conditions that make it possible for the type species to reproduce and become established again.

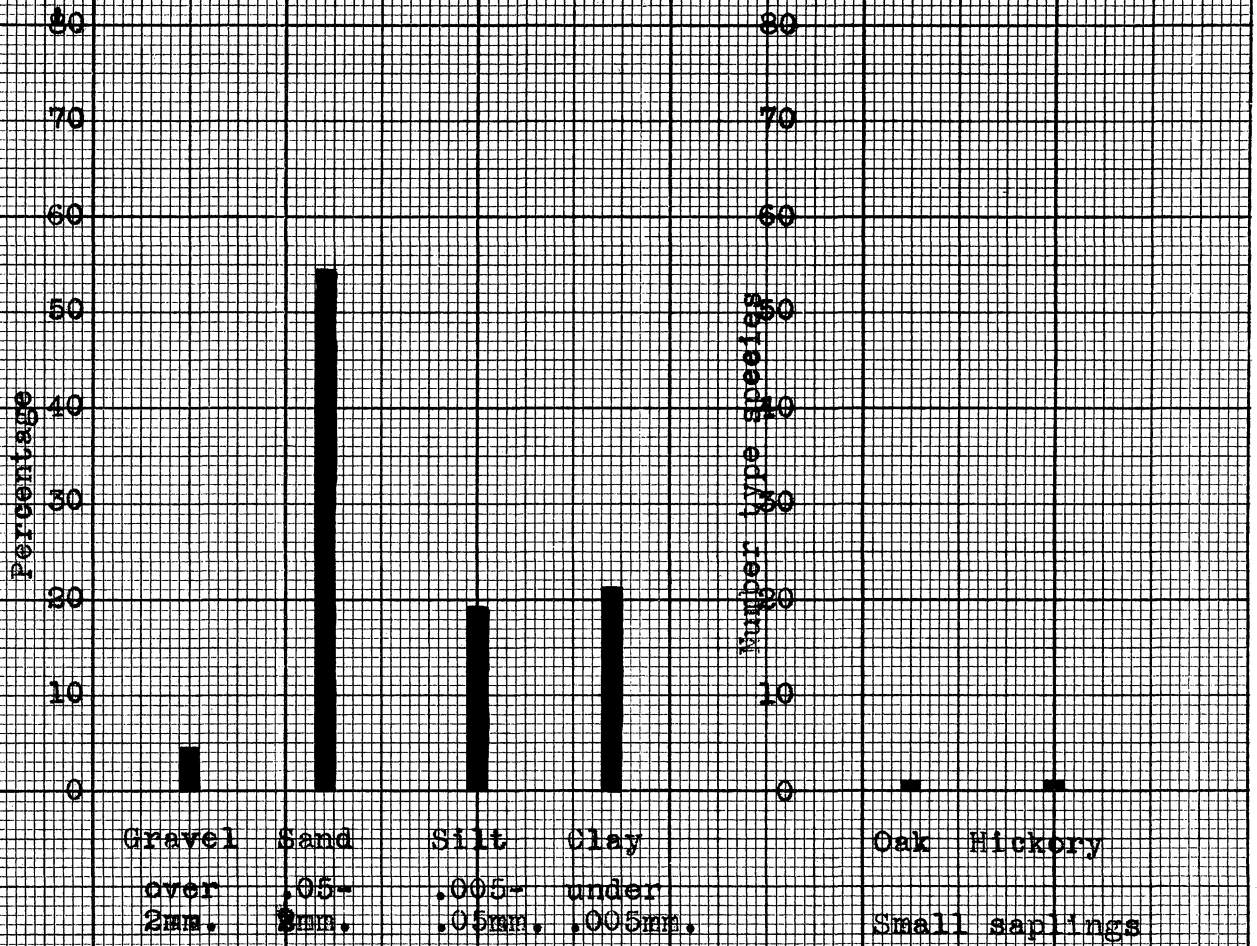
The following tables show to what extent natural reproduction has become established on the area under consideration. These tables are supplemented with discussions of factors affecting the establishment on specific plots.

TABLE 1. LOT NO. 2 - 4 PLOTS

Species	Seedlings	Small Saplings	Large Saplings
Quercus alba	40	5	1
Sprouts		14	
Quercus borealis var. maxima	12	3	
Sprouts		2	
Quercus velutina	1	6	3
Carya glabra		10	15
Carya ovata	6	2	3
Fraxinus americana	5	34	5
Ulmus americana		2	1
Prunus serotina		67	5
Sassafras variifolium	17	78	11
Populus grandidentata		3	1
Cornus florida		2	
Juniperus virginiana		3	

This lot shows evidence of having been in the open park stage of decadence with the crown density being .5 on two plots and .6 on the other two. Heavy sod is prevalent on all plots. Black cherry and sassafras are the most abundant species in the small sapling class. White ash small saplings are most abundant on plot 3 which is adjacent to Lot no. 3, on which white ash is the most abundant species. Two white ash seed trees are also located on Lot no. 3. The hickory small saplings are mostly of seed origin, becoming established under cover. The oak is primarily of sprout origin.

Fig. 2 shows the relationship of crown density to the establishment of type species. The clay content of the soil is favorable to good moisture conditions, but the open condition of the crown canopy, with the resultant



Crown density .5

Fig. 2. The relationship of crown density and soil to the reproduction of type species on Plot 4.

sod cover, and absence of litter has made conditions unfavorable for the establishment of the type species.

On plots 3 and 5 the sod cover is beginning to break up under the shade of the saplings that have become established. The majority of seedlings of type species are found on these two plots.

TABLE 2. LOT NO. 3 - 2 PLOTS

Species	Seedlings	Small Saplings	Large Saplings
Quercus alba	1		3
Quercus borealis var. maxima	5		
Quercus velutina	1		
Sprouts		3	1
Carya glabra	2		1
Carya ovata		5	2
Fraxinus americana	23	72	7
Prunus serotina		59	21
Sassafras varifolium	21	19	1
Crataegus sp.		6	

This lot also shows evidences of having been in the open park stage of decadence. White ash and black cherry are the most abundant in the small sapling class. Cutting in this lot has been done to favor the establishment of white ash. Ash, being a light-seeded species, has been able to become established in the openings where the sod cover is heavy. It has also become established under the cover of other species. The sod cover on this lot is gradually breaking up under the shade of the dense stand

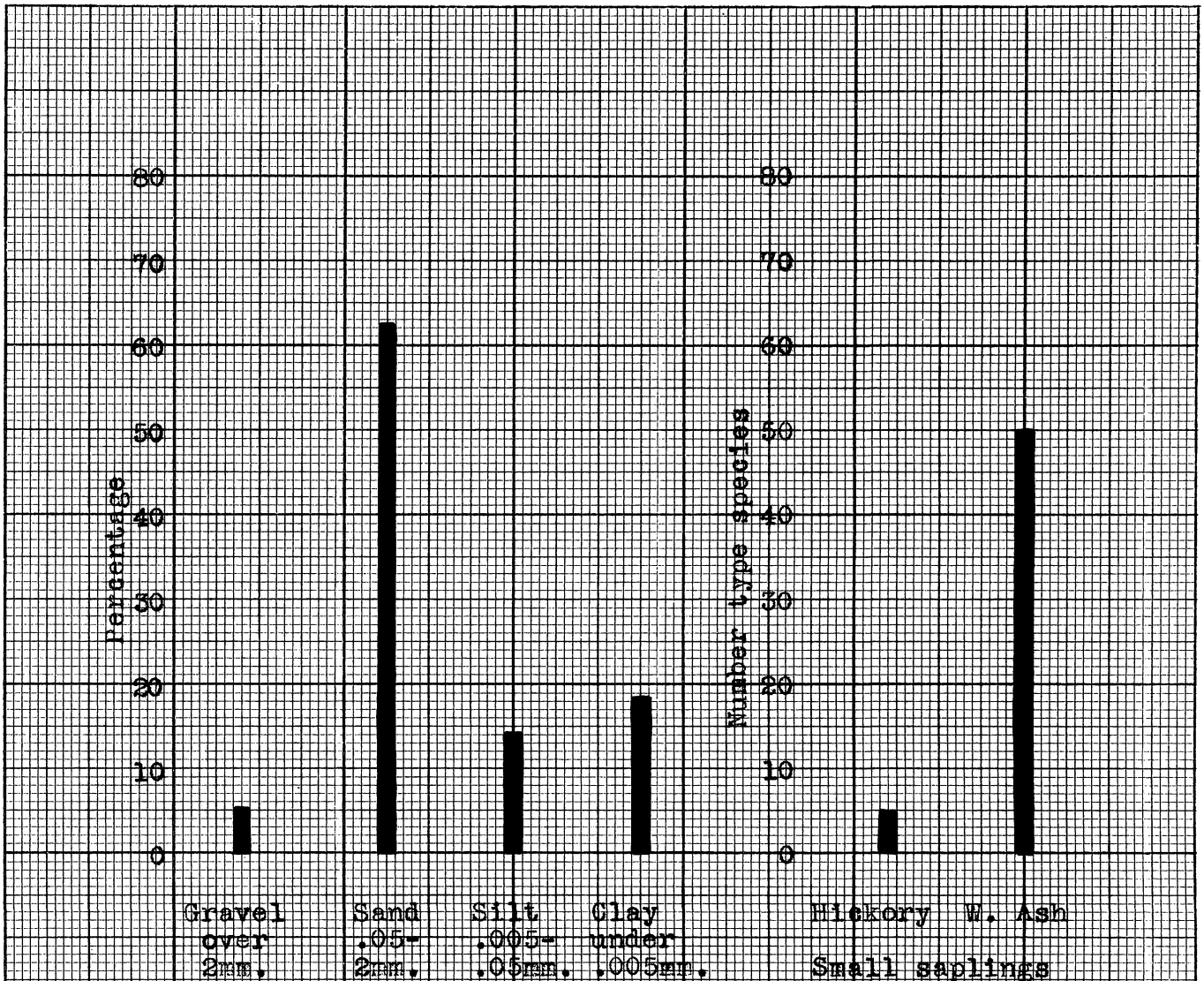
of saplings.

Reproduction of white ash is best in small openings where moisture is good. This is substantiated by Fig. 3. This plot was located near the bottom of a pothole and the majority of the ash is in the open portion of the plot. The hickory, which is of seed origin, is under cover where the sod cover is not heavy. Ash is considered a type species on this plot since cuttings have been made to favor it.

TABLE 3. LOT NO. 7 - 3 PLOTS

Species	Seedlings	Small Saplings	Large Saplings
Quercus alba		1	
Sprouts		6	5
Carya glabra		4	2
Prunus serotina	14	90	17
Sassafras variifolium	20	130	10
Crataegus sp.		4	

The west half of this lot seems to have been in the open park stage of decadence and the east half in the final stage of decadence. The crown densities on plots 17 and 18 are .5 and .6 respectively. The crown density is below .5 on plots 19 and 20. On these latter two plots the reproduction is primarily sassafras with some black cherry. The reproduction of type species is confined to plots 17 and 18. The hickory is of seed origin and the oak primarily from sprout origin.



Crown density .5

Fig. 3. The relationship of crown density and soil to the reproduction of type species on Plot 2.

The sod cover is beginning to break up on plot 18.

TABLE 4. LOT NO. 9 - 3 PLOTS

Species	Seedlings	Small Saplings	Large Saplings
Quercus alba	4	4	2
Sprouts		13	
Quercus borealis var. maxima	4	3	1
Sprouts		2	
Quercus velutina	2	3	
Carya glabra	1	7	10
Sprouts		5	7
Carya ovata		1	2
Fraxinus americana		7	6
Cornus florida		7	1
Prunus serotina	6	76	4
Sassafras variifolium	8	16	3
Juniperus virginiana		6	

This lot was also in the open park stage of decadence. The crown density on plot 31 is .5 and on plots 21 and 22 is .6. The eastern half of this lot is more open and may have been in the final stage of decadence. Most of the reproduction on this portion of the lot is sassafras and the sod cover is still heavy. The majority of oak and hickory seedlings and small saplings were tallied on plots 21 and 22. The hickory saplings are of seed origin and the oak is primarily of sprout origin with a few from seed origin. Black cherry is abundant on these plots. The sod cover is beginning to break up on the western portion of the lot.

TABLE 5. LOT NO. 10 - 3 PLOTS

Species	Seedlings	Small Saplings	Large Saplings
Quercus alba	2	5	4
Quercus borealis var. maxima	7	1	
Quercus velutina	2	1	
Carya glabra	2	3	11
Carya ovata		1	
Fraxinus americana	11	29	12
Prunus serotina	7	56	2
Sassafras variifolium	12		
Cornus florida	2	15	
Juniperus virginiana		2	1

This lot was also in the open park stage of decadence. The crown density on plot 15 is .5 and on plots 7 and 16 is .6. Black cherry is the most abundant species in the small sapling class over the entire lot. White ash is most abundant on plot 7, being found primarily in openings in a small pothole or depression. The sod cover is beginning to break up and seedlings of the type species are becoming established in spots where the sod is breaking up.

TABLE 6. LOT NO. 11 - 4 PLOTS

Species	Seedlings	Small Saplings	Large Saplings
Quercus alba	12	28	12
Sprouts		6	4
Quercus borealis var. maxima	2	3	
Quercus velutina	5		
Carya glabra	3	30	40
Sprouts		3	8
Carya ovata		5	1
Prunus serotina	2	120	24
Cornus florida	1	7	2
Sassafras variifolium	30	22	1
Amelanchier canadensis		1	
Crataegus sp.		18	
Juniperus virginiana		1	
Fraxinus americana		3	4

This lot shows evidence of having reached only the transition stage of decadence, although the crown density of plot 8 is only .5. The crown density on plot 14 is .7 and on plots 9 and 13 is .8. Although black cherry is the most abundant species in the small sapling class, the establishment of the type species has been quite satisfactory (Figs. 4 and 6). The majority of the small saplings of the type species were tallied on the two plots having crown densities of .8. These were primarily of seed origin, both in the oak and hickory. There was very little sod and a good heavy layer of litter and duff on these plots.

A comparison of Figs. 5 and 6 would seem to indicate that crown density is the most important factor affecting

Fig. 4. Successful establishment of type species on Lot no. 11.

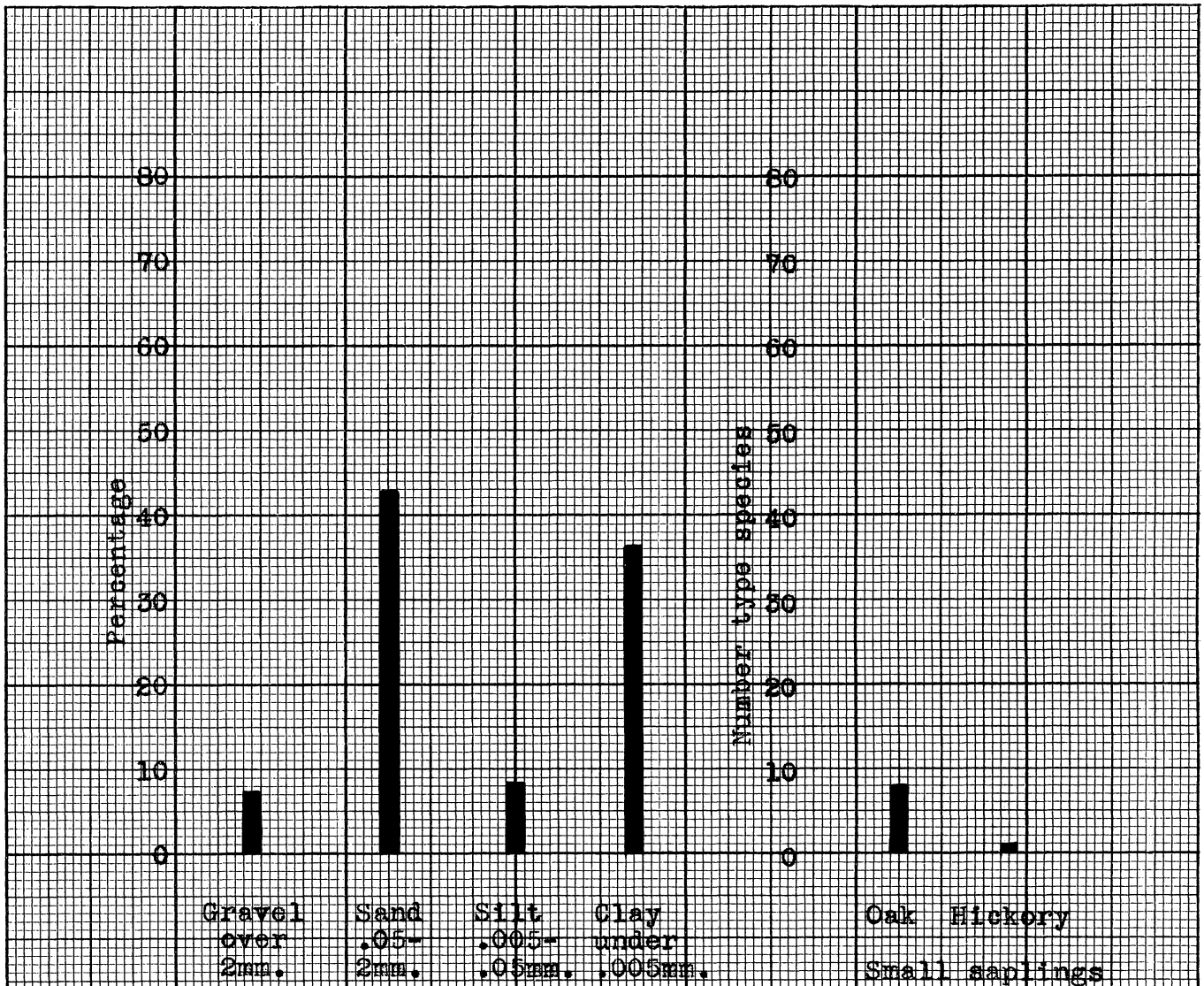
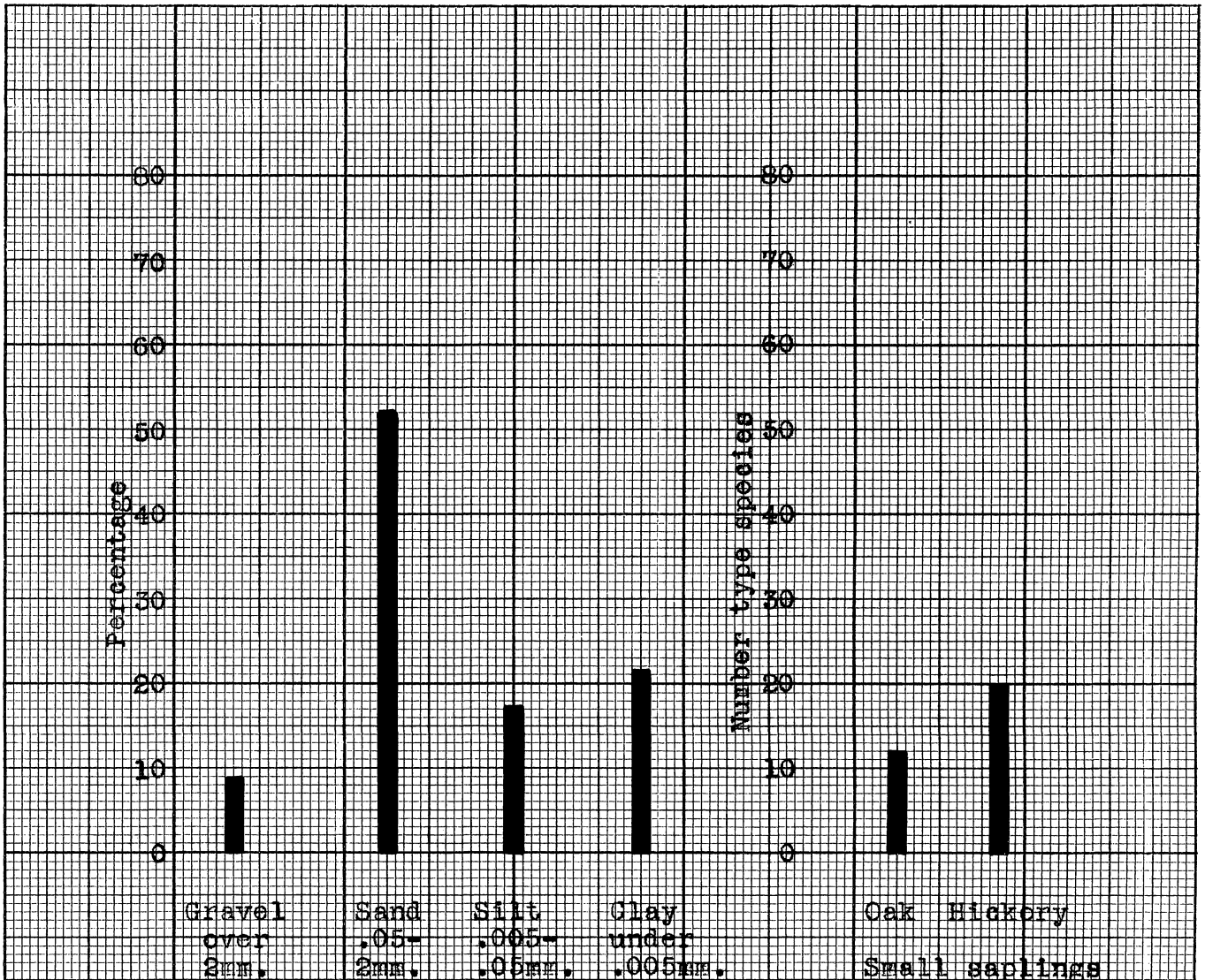


Fig. 5. The relationship of crown density and soil to the reproduction of type species on Plot 8.



Crown density .8

Fig. 6. The relationship of crown density and soil to the reproduction of type species on Plot 9.

the successful establishment of the type species. Although the soil sample from plot 8 showed a clay content 15 per cent higher than the soil sample from plot 9, only seven small saplings of the type species were tallied on plot 8, while thirty-two were tallied on plot 9. Crown density would then seem to be the deciding factor.

Ring counts showed the age of the small saplings of the type species to be from 10 to 15 years. From this we can see that it took from 5 to 10 years for the type species to become established. This can probably be considered the length of time required for the soil to return to some degree of normalcy under the more favorable conditions found on this lot.

TABLE 7. LOT NO. 12 - 4 PLOTS

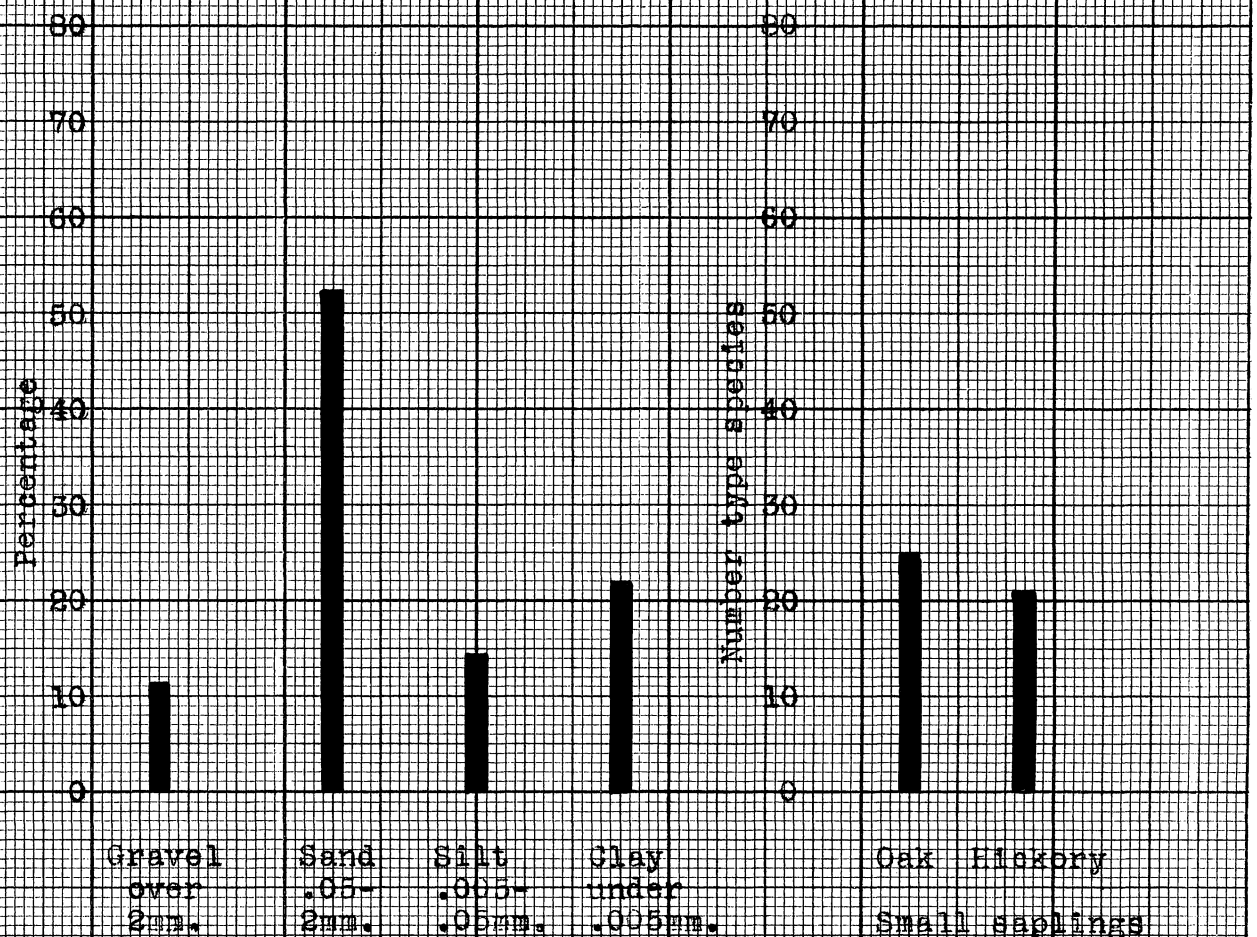
Species	Seedlings	Small Saplings	Large Saplings
Quercus alba	8	35	15
Sprouts	4	21	14
Quercus borealis var. maxima	4	2	
Quercus velutina	7		
Sprouts		12	7
Carya glabra	6	40	54
Sprouts		5	23
Carya ovata		3	3
Ulmus americana		2	
Populus grandidentata		1	
Prunus serotina	7	42	19
Sassafras variifolium	4	11	3

The larger portion of this lot was in the transition

stage of decadence. The southeast portion of it (plot 30) was in either the open park stage or final stage of decadence, probably the latter. The crown density on plot 30 is .5 and the sod cover is heavy. The average D.H.B. for trees on this plot is 4". The oak and hickory saplings, both small and large, are primarily of sprout origin and growth is poor. Only the intolerant species are becoming established.

The crown density of plot 29 is .7. The white oak on this plot is of sprout origin, while the black oak and hickory are of seed origin.

Plots 23 and 24 have a crown density of .8 and here again, as on Lot 11, the establishment of the type species has been quite satisfactory. Most of the oak and hickory are of seed origin although about 25 per cent of the white oak is of sprout origin. Here again crown density seems to be the determining factor, although the texture of the soil is favorable to good moisture conditions (Fig. 7).



Crown density .8

Fig. 7. The relationship of crown density and soil to the reproduction of type species on Plot 24.

TABLE 8. LOT NO. 13 - 3 PLOTS

Species	Seedlings	Small Saplings	Large Saplings
Quercus alba	4	6	5
Sprouts		16	16
Quercus borealis var. maxima		2	
Quercus velutina	5	13	13
Carya glabra	1	33	48
Carya ovata	1	6	4
Cornus florida		1	
Populus grandidentata			10
Prunus serotina	4	31	8
Sassafras variifolium	1	7	

The northern portion and the portion of the lot bordering on Lots 12 and 14 seem to have been in the transition stage of decadence; and the southern portion, especially the southeastern portion of the lot, was in the open park or final stage. Although no plots were taken on this portion of the lot it was noted that black cherry and sassafras are the most abundant species in the small sapling class. On the three plots tallied the crown density is .7. Most of the trees on these plots were in the large sapling and small pole classes and the average height was 25'.

Fig. 8 shows that crown condition and soil conditions on plot 32 are both favorable to reproduction of the type species. The hickory and black oak are of seed origin and the white oak is of sprout origin. This is also true on the other two plots tallied. The small saplings

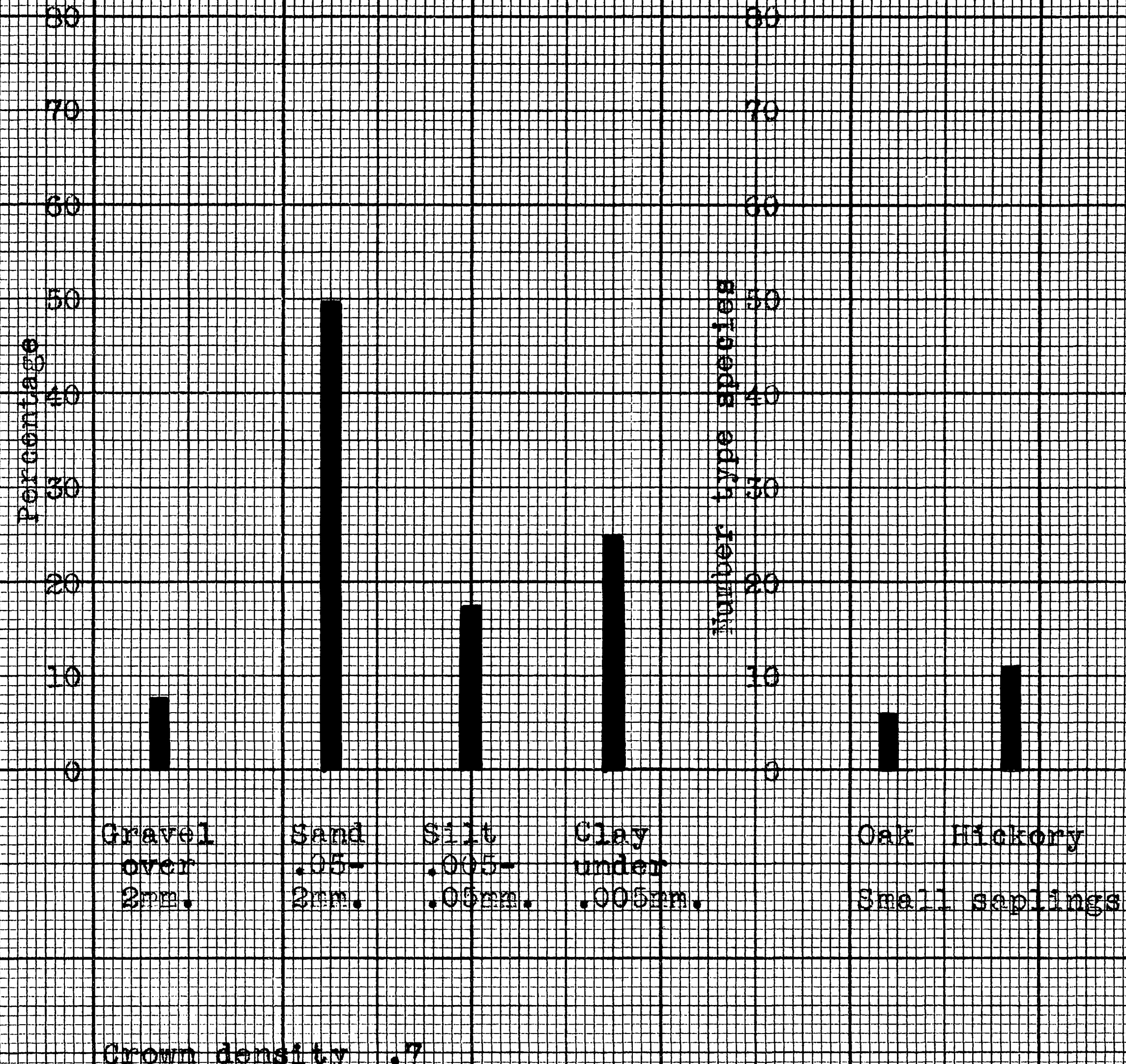


Fig. 8. The relationship of crown density and soil to the reproduction of type species on Plot 32.

of hickory on plot 32 are from 10 to 15 years old. From this we can conclude that it took from 5 to 10 years for the type species to become established again. All of the aspen tallied on Lot 13 was tallied on this plot. The mortality of aspen is high where it is overtopped by oak and hickory.

TABLE 9. LOT NO. 14 - 2 PLOTS

Species	Seedlings	Small Saplings	Large Saplings
Quercus alba		20	10
Sprouts		17	9
Quercus velutina	5	8	1
Carya glabra		16	18
Carya ovata			1
Populus grandidentata		2	7
Prunus serotina		21	5
Sassafras varifolium	10	25	4

Evidence seems to indicate that this lot was in the transition stage of decadence. Both plots on this lot have crown densities of .7; the reproduction and establishment of the type species has been successful. Approximately half of the white oak small saplings are of sprout origin. The remainder of the white oak and the black oak and hickory are of seed origin. These small saplings of the type species are located primarily under cover, with the black cherry and sassafras in the openings.

TABLE 10. LOT NO. 15 - 3 PLOTS

Species	Seedlings	Small Saplings	Large Saplings
Quercus alba	4	4	4
Sprouts		15	6
Quercus borealis var. maxima	1		
Quercus velutina	1		
Carya glabra	1	13	25
Carya ovata		4	2
Prunus serotina	3	58	1
Sassafras variifolium	9	41	
Amelanchier canadensis		2	
Crataegus sp.		15	
Fraxinus americana		1	

This lot was also in the open park stage of decadence. Plots 10 and 12 have crown densities of .6 and plot 11 has a crown density of .5. The sod cover is still heavy over most of the lot. As is to be expected under these conditions, black cherry and sassafras are most abundant in the small sapling class. Most of the hickory was tallied on plot 10 and it is of seed origin, coming up under cover. All of the white oak saplings are of sprout origin and many of them are dying off at the tops.

Fig. 9 indicates an unfavorable crown density condition and a low clay content of the soil on plot 12. These conditions account for the lack of establishment of type species on the plot.

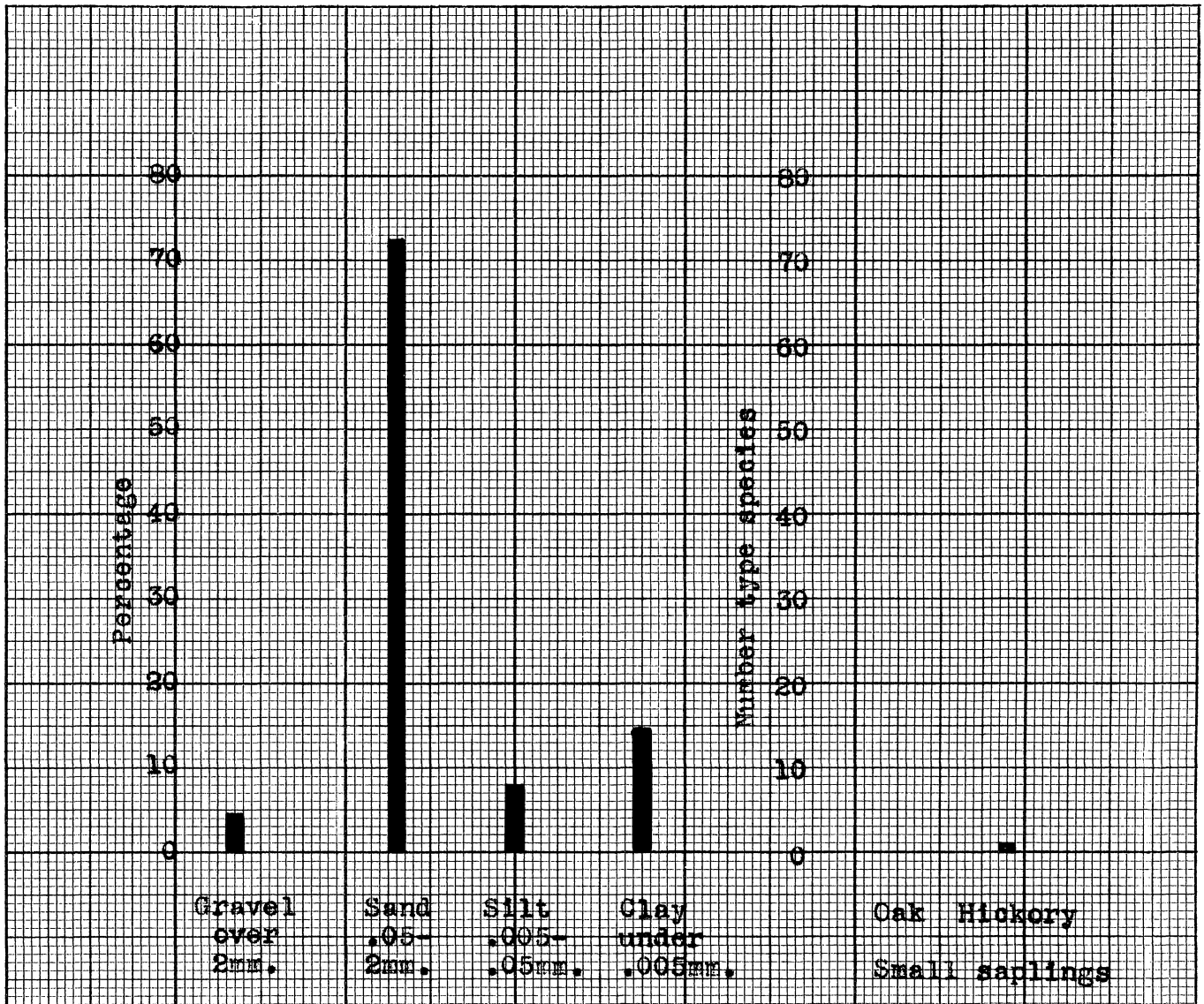


Fig. 9. The relationship of crown density and soil to the reproduction of type species on Plot 12.

TABLE 11. LOT NO. 16 - 2 PLOTS

Species	Seedlings	Small Saplings	Large Saplings
Quercus alba sprouts		5	4
Carya glabra		5	15
Prunus serotina	9	52	9
Populus grandidentata	2		
Sassafras varifolium	5	3	
Crataegus sp.	2		

This lot was in the final stage of decadence. Plots 26 and 27 have crown densities of .4 and .5 respectively. Black cherry is the most abundant species in the small sapling class. The white oak is all of sprout origin.

TABLE 12. LOT NO. 1 - BELL 80 - 2 PLOTS

Species	Seedlings	Small Saplings	Large Saplings
Quercus alba	4	8	3
Quercus borealis var. maxima	1		
Quercus velutina	10	5	4
Carya glabra	2	2	4
Cary ovata	1	3	
Fraxinus americana		3	
Prunus serotina		25	1
Sassafras varifolium	4	17	3
Juniperus virginiana		1	

Indications are that this lot was in the transition stage of decadence. The crown density on both plots is .7. Both the oak and hickory small saplings are of seed origin, and the survival of seedlings on two quadrats is fairly satisfactory.

RODENT ACTIVITY. One factor that has not been touched upon in the discussion thus far, is the activity of squirrels. This factor might be considered as an unknown. It is well known that squirrels destroy acorns and hickory nuts, but to what extent they have prevented or retarded the natural reproduction of type species is not known. The fact that not much white oak reproduction is of seed origin might be due to the fact that squirrels are especially fond of the sweet acorns of white oak.

Evidence of considerable squirrel activity was noted throughout most of the hardwood section of the Stinchfield Woods. Most of the activity had been on hickory nuts. There is a possibility that it may have been a good seed year for hickory and not so good a seed year for oak.

Fig. 10. A heavily grazed portion of the Peach Mountain Tract. Note the open park-like appearance.

Fig. 11. Natural reproduction on a portion of the original Stinchfield Woods twenty-one years after the exclusion of livestock.

PEACH MOUNTAIN TRACT

This tract, which is a recent addition to the original Stinchfield tract, has not been grazed for approximately three years. No systematic cruise was made of this area, but a general survey of present conditions was made and 21 random plots were tallied.

The majority of the area is in the open park (Fig. 10) or final stages of decadence. A small portion of the area, bounded on the north by the Stinchfield Woods Road and on the south by an old fence line (which is an extension of the north boundary of Lot 33 of the original Stinchfield tract) is in better condition than the portion to the south. The portion to the south of this old fence line is composed primarily of large saplings and small poles of sprout origin. Growth is very slow and rot and canker are very common on the hickory.

On 21 milacre quadrats 8 black cherry seedlings, one hickory and 2 black oak seedlings were tallied. There are very few small saplings and these are all of sprout origin, except for 8 cherry and 4 sassafras.

With conditions as they are on this tract we can expect that there will be a long subclimax stage of sassafras and cherry which will eventually bring about conditions that will make it possible for the type species to become established once again.

CONCLUSIONS

In looking over the data gathered for this study, we find that the establishment of type species following the exclusion of livestock, has been best on parts of Lots 11, 12 and 13, and on Lot 14. A check of the charts showing the relationship of crown density and soil to the reproduction of the type species would seem to indicate that crown density is the most important single factor affecting this reproduction. On plots where the crown density is not below .7 the establishment of the type species has been generally satisfactory. This is due to the fact that there has been no heavy sod cover and there has been a good supply of litter and duff, resulting in better soil moisture and seed bed conditions for the heavy-seeded type species. Where both crown density condition and clay content of the soil are favorable, the establishment of oak and hickory has been exceptionally good (Fig. 7). The survival of oak and hickory seedlings has been better on these lots than on most of the others (Tables 6 and 7).

The oak and hickory started to become established under these more favorable conditions about 5 years after the exclusion of livestock.

Where the crown density was below .7 establishment of the type species has been unsatisfactory. Black cherry

and sassafras are the most abundant species on these lots. In some spots the sod is beginning to break up and more litter and duff is remaining on the soil because there is not the free passage of wind through the stand that there once was. Conditions are becoming more favorable for the reproduction and establishment of the type species on these spots, and oak and hickory seedlings are beginning to appear.

In the portions of the stand that had reached the final stage of decadence (parts of Lots 7, 9 and 13) conditions are still critical, with sassafras the most abundant species. The crowns are still open and the sod cover is still heavy. White ash is becoming established on Lot 3 and parts of Lots 2 and 10. It is especially abundant in openings where its growth is satisfactory. Where it is growing under cover it is being attacked by the oyster-shell scale.

As a summary statement, we can say that crown density, as determined by the stage of decadence to which a stand has deteriorated, is the chief factor affecting the reproduction of heavy-seeded species. Where the crown density has gone below .7 in such a stand a long period of time will be required for the stand to return to a normal condition.

RECOMMENDATIONS

Heavily grazed oak-hickory woodlands in which the crown density is below 70 per cent are not capable of reproducing to the type species in a reasonable period of time. If they are to be used for continued production of forest products some treatment will have to be given them.

Breaking up the sod by plowing or discing has been suggested. It is doubtful whether this will help in oak-hickory stands, since insufficient leaf litter is retained to provide proper seed storage and seed bed conditions. Furrows plowed at right angles to the wind might improve the situation by catching and holding more leaf litter and offering protection to seedlings that may become established.

In order to cut down the free passage of wind through the stand and hasten the return to normalcy, it may be advisable to plant a windbreak on the windward sides of the stand. This is especially true on smaller farm woodlots. A fast growing coniferous species is most suitable for this purpose.

These measures will only help to hasten the return of the stand to a normal condition. In order to obtain a satisfactory yield from a woodlot that has reached the open park stage of decadence, it will be necessary to carry on an artificial planting program.

On better hardwood sites underplanting with hardwoods will probably be successful. Underplanting with sugar maple has been quite successful on portions of the Stinchfield area. On poorer sites underplanting with pine, or clearcutting and planting pine is the best plan. White pine is the best species for underplanting since it is more tolerant than other species used in this region. For planting on clearcut areas, white pine, red pine, Scotch pine and ponderosa pine are satisfactory. Pines make satisfactory growth in the young stages, but tend to stagnate and become more susceptible to disease in the later stages. This condition may be remedied by heavy enough thinnings, made as soon as a satisfactory growth rate is not maintained. If ponderosa pine is used care should be used in obtaining seed from a race that is resistant to the globose gall rust (Cronartium cerebrum) since oak is the alternate host for this rust.

The use of pines on deteriorated sites may hasten the establishment of hardwoods and the faster rate of growth maintained by the pines will produce a quicker yield of forest products.

Any cuttings made in a previously grazed woodlot should be improvement or salvage cuttings. In stands that are in the early or transition stages, cuttings should not lower the crown density below 70 per cent.

Finally, it may be necessary to control the activity

of rodents during the critical period of regeneration of the previously grazed woodlot.

APPENDIX

COMMON AND TECHNICAL NAMES OF TREES*

Common name	Technical name
Ash, white	Fraxinus americana
Aspen	Populus grandidentata
Cedar, southern red	Juniperus virginiana
Cherry, black	Prunus serotina
Dogwood, flowering	Cornus florida
Elm, American	Ulmus americana
Hawthorn	Crataegus spp.
Hickory, pignut	Carya glabra
Hickory, shagbark	Carya ovata
Maple, sugar	Acer saccharum
Oak, black	Quercus velutina
Oak, red	Quercus borealis var. maxima
Oak, white	Quercus alba
Pine, ponderosa	Pinus ponderosa
Pine, red	Pinus resinosa
Pine, Scotch	Pinus sylvestris
Pine, white	Pinus strobus
Sassafras	Sassafras variifolium
Shadbush	Amelanchier canadensis

*Taken from Harlow, Wm M. and E. S. Harrar. Textbook of Dendrology.

BIBLIOGRAPHY

1. Ahlgren, H. L., M. R. Wall, R. J. Muckenrin and J. M. Sund. 1946. Yields of forage from woodland pastures on sloping land in southern Wisconsin. Jour. Forestry. 44:709-711.
2. Anonymous. (Undated). Elements of forestry with special reference to Illinois. Illinois Dept. of Conservation.
3. Anonymous. 1944. Forestry Handbook. U. S. Dept. Agr., Soil Conservation Service, Upper Mississippi Region.
4. Anonymous. 1941. Protect hardwood stands from grazing. U. S. Dept. Agric. Leaflet No. 86.
5. Baxter, D. V. 1943. Pathology in Forest Practice. John Wiley and Sons Inc. New York.
6. Baxter, D. V. and L. J. Young. 1946. Glimpses of Saginaw Forest, Eber White Woods, and Stinchfield Woods. University of Michigan, School of Forestry and Conservation. Ann Arbor, Michigan.
7. Chandler, R. F. Jr. 1940. The influence of grazing upon certain soil and climatic conditions in farm woodlands. Jour. Amer. Soc. Agron. 32:216-230.
8. Cheyney, E. G. 1942. American Silvics and Silviculture. University of Minnesota Press.
9. Chittenden, A. K. 1927. Forest planting in Michigan. Mich. State College Agric. Exp. Sta. Bul. 163.

10. Chittenden, A. K. and P. W. Robbins. 1930. The farm woodlot in Michigan. Mich. State College Agric. Exp. Sta. Bul. 196.

11. Dambach, C. A. 1944. Comparative productiveness of adjacent grazed and ungrazed sugar maple woods. Jour. Forestry. 42:164-168.

12. Day, R. K. and D. Den Uyl. 1932. The natural regeneration of farm woodlands following the exclusion of livestock. Purdue Univ. Agric. Exp. Sta. Bul. 368.

13. Den Uyl, D. 1945. Farm woodlands should not be grazed. Jour. Forestry 43:729-732.

14. Den Uyl, D. and R. K. Day. 1934. Woodland carrying capacity and grazing injury studies. Purdue Univ. Agric. Exp. Sta. Bul. 391.

15. Den Uyl, D., O. D. Diller and R. K. Day. 1938. The development of natural reproduction in previously grazed farmwoods. Purdue Univ. Agric. Exp. Sta. Bul. 431.

16. Diller, O. D. 1937. Soil moisture content during critical periods in the regeneration of previously grazed farm woodlands. Jour. Forestry. 35:399-402.

17. Diller, O. D. 1937. The forage cover in heavily grazed woods in northern Indiana. Jour. Amer. Soc. Agron. 29:924-933.

18. Harlow, W. M. and E. S. Harrar. 1941. Textbook of Dendrology. McGraw Hill Book Co. Inc. New York.

19. Russell, I. C. and F. Leverett. 1915. Geological Atlas of the United States. Ann Arbor Folio. U. S. Geol. Survey.

20. Toumey, J. W. and C. F. Korstian. 1946. Foundations of Silviculture. John Wiley and Sons Inc. New York.

21. Veatch, J. O. 1941. Agricultural land classification and land types of Michigan. Mich. State College Agric. Exp. Sta. Bul. 231.

22. Welton, F. A. and V. H. Morris. Woodland pasture. Jour. Forestry 26:794-796.

23. Wilson, F. G. 1929. The farm timberlot. Wisconsin Agric. Exp. Sta. Bul. 407.

24. Young, L. J. 1921. Forest planting in southern Michigan. Jour. Forestry. 19:131-138.