CHANGES IN TREE COMPOSITION OF TWO FORESTRY PLOTS IN A NORTHERN HARDWOOD FOREST IN MICHIGAN FROM 1934-1980.

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ABSTRACT

Tree composition of two forestry plots was studied in a northern hardwood forest in Michigan from 1934-1980. One plot had been selectively thinned from 1934-1954; the other plot was unmanipulated (control). Sugar maple was the leading dominant in both plots. Basswood was second most dominant in the thinned plot and beech was second most dominant in the control plot. As sugar maple increased in importance, beech and ironwood decreased in importance. Sugar maple may limit beech and ironwood due to more successful competition for resources. Basswood decreased in importance after conclusion of cutting in the thinned plot which may relate successful growth of basswood to canopy holes left after cutting.

Both plots decreased in diversity from 1934-1980. Big-toothed aspen, white birch, red oak and possibly basswood are only present as large trees in the canopy and are expected to leave the forest as these large trees die (no successful reproduction due to shading out of seedlings).

Density decreased as basal area increased for the control plot. Density and basal area decreased due to cutting in the thinned plot (1934-1954); density increased from 1954-1980 to approximately 3/4 of the original density before cutting in 1934. As the thinned plot matures density is expected to decrease.

INTRODUCTION

Most areas of hardwood vegetation in the northern portion of the lower peninsula of Michigan were at one time lumbered. Many areas were also burned, and some areas pastured or cultivated (Gates, 1926). The forests of this region today are results of natural re-forestation after the last disturbance. These secondary-growth hardwoods have good potential for marketable wood yields if managed carefully. This includes thinning to remove species detrimental to the marketable species and selective cutting of the marketable species to increase space for smaller tree growth.

To study the long range effects of thinning on stand improvement, two experimental forestry plots were set up in 1934 near the University of Michigan Biological Station, (NE 1/4 of SE 1/4 of SW 1/4) section 28, Munro Township, Cheboygan County, Michigan (45 35' N. Lat., 84 41' W. Long.). One plot was selectively thinned every five years and the other was unmanipulated and used as a control. Neither stand had much commercial value and the thinnings should not be considered commercial, even though the wood removed was used as fuel. The trees were cut to improve the condition of the residual stand. Large, limby, defective trees, undesirable lumber species and small trees either defective or in clumps were cut. (Original Forestry Data). Total trees removed ~~(ha)~~ from the thinned plot from 1934-1954 include: Sugar maple (*Acer saccharum* Marsh.)--169; beech (*Fagus grandifolia* Ehrh)--25; white birch (*Betula papyrifera* Marsh.)--24; basswood (*Tilia americana* L.)--41; red oak (*Quercus borealis* Michx. f.)--2; ironwood (*Ostrya virginiana* (Mill) K. Koch)--89; striped maple (*Acer pensylvanicum* L.)--7. Trees in both plots were measured ~~in~~ five year increments from 1934 to 1954. The purpose of this study is to examine trends in vegetation structure and composition over time from the original

1934-1954 data to new data from re-measurement of the plots in 1980.

METHODS

The thinned plot is .405 ha in area (one acre--208 ft. X 208 ft. square) and the control plot is .202 ha in area (one-half acre--208 ft. X 104 ft. rectangle). The plot boundries were originally established with posts in the corners of each plot. These posts are still present and were used in 1980 to sight in the plot boundries. The plots are seperated by an unmanipulated "isolation strip" approximately 20m wide. Both plots are located on similar topography-a level terrace below a north facing slope, on a land point extending into Douglas Lake. Slope change is minimal between the two plots.

All trees greater than 2.5cm (1.0 in.) diameter at breast height (dbh) were individually tagged and numbered in both plots in 1934. Trees reaching the 2.5cm and greater dbh class ~~in~~ the five year intervals the trees were measured ~~in~~ were additionally tagged. New tags were put on many trees in 1959 due to ingrowth of old tags. Each tree was individually counted and measured (dbh) in each five-year interval from 1934-1954. From 1934-1949 the diameters were measured with forester's calipers. In 1954 and 1980 the diameters were measured with a dbh tape.

Due to lack of available time it was impractical to re-measure all trees in the plots in 1980. Each forestry plot was subsampled using circular plots of 0.04 ha area (circle diameter--11.28m). The circular plots were randomly ~~fitted~~ within the boundries of the forestry plots so that no overlap occured with adjacent circles and no circle areas were outside of the original boundries (as determined by corner posts). Five circular sample plots were ~~fitted~~ within the .405 ha thinned ~~forestry~~ plot and three circular sample plots were fitted within the .292 ha control forestry plot. All trees 2.5cm dbh and larger were recorded (as in 1934-1954). All area figures were converted to hectares (ha).

Density (stems/ha), relative density, basal area (m^2/ha) and dominance were calculated for each tree species for all years of measurements. Species Importance Values (Curtis and McIntosh, 1951) were also calculated, based on the sum of relative density and dominance divided by two. Importance Values for all species in a plot sums to 100. Simpson's Diversity Index (Simpson, 1949) was calculated for each plot for 1934, 1954 and 1980.

The majority of interpetation of data will involve the years 1934, 1954 and 1980, with some supplements from the years inbetween 1934 and 1954.

Botanical nomenclature follows Gleason and Cronquist (1963).

RESULTS

Sugar maple was the leading dominant in both the thinned and control plots for all years studied (Table 1) with a maximum importance value of 63.39 in the 1954 thinned plot and a minimum value of 51.76 in the 1934 control plot. Basswood was the second leading dominant in all years in the thinned plot and beech was the second leading dominant in all years in the control plot. Beech values in the thinned plot were low and basswood values in the control plot were likewise low.

Importance values for the five most dominant species in each plot are graphed in Figure 1. In the thinned plot sugar maple values have decreased since 1949 while ironwood values have increased greatly. Since the last thinning cut (1954) beech values have increased and basswood and white birch values have decreased. In the control plot sugar maple values have continuously increased from 1939 and beech values have continuously decreased. In a five-year interval where sugar maple values decreased (1934-1939), beech values increased. Beech values increased in this interval due to an increase in beech basal area (7.19 m^2/ha in 1934 to 7.88 m^2/ha in 1939) corresponding to a decrease in sugar maple basal area (8.09 m^2/ha in 1934 to 8.02 m^2/ha in 1939). In all subsequent five-year intervals sugar maple values increased and beech values accordingly decreased. Ironwood values steadily decreased from 1949 in the control plot; white birch values changed little and basswood values increased gradually from 1949.

Pin cherry (*Prunus pensylvanica* L. f.) was present only in 1934, in the control plot. Striped maple and elm sp. (*Ulmus* L. sp.) were no longer present in the control plot in 1980 (or elm sp. in the thinned plot in 1980). Hemlock (*Tsuga canadensis* (L.) Carr.) was present for the first time in 1980, in the thinned plot. Some species are believed to have presence in the canopy as a result of rapid growth while the canopy was still open after the last major lumbering operation (not selective cutting). These species increase in basal area but remain close to constant or decrease in density. Species demonstrating this pattern include big-toothed aspen (*Populus grandidentata* Michx.), white birch, red oak, and possibly basswood (Tables 2 and 3). (Best examples were in the control plot due to cutting in the thinned plot). Average tree size (cm^2) for seven species in the control plot from 1934-1980 is shown in Table 4. Average tree size increases 9.6 times (x) from 1934-1980 for big-toothed aspen; 11.6x for white birch; 16.1x for red oak; and 22.1x for basswood. More characteristically mesic species (Curtis, 1959) increase in much smaller multiples: Sugar maple 3.5x; ironwood 3.5x; and beech 2.3x. This indicates big-toothed aspen, white birch, red oak and possibly basswood are maximizing growth (basal area) of already present large trees while sugar maple, ironwood and beech are increasing gradually in growth but with increased numbers of individuals (successful reproduction).

Total tree densities decrease greatly in the control plot from 1934-1980 (Fig. 2). Before cutting in 1934 the thinned plot density was similar to the control plot density. Each five-year selective cut decreased total density in "step fashion" until 1954. After 1954 density of the thinned plot increases greatly. By 1980 density increased to approximately 3/4 of the original pre-cut density in 1934.

Total tree basal areas increase from 1934-1944 and 1949-1980 in the control plot (Fig. 3). Total basal area from 1944-1949 decreased, due specifically to a large decrease in beech basal area (8.03 m^2/ha in 1944 to 5.83 m^2/ha in 1949). The thinned plot basal area remained low from 1934-1954, with apparently similar rates of increase of basal area between the five-year cutting intervals. After 1954 basal area in the thinned plot increased greatly.

Diversity index values decrease in both plots from 1934-1980. In the control plot the values decrease from .60 in 1934 to .51 in 1954 to .45 in 1980. In the thinned plot the values decrease from .63 in 1934 to .54 in 1954 to .53 in 1980. The selective cutting does not appear to have affected diversity values of the thinned plot.

DISCUSSION

The high importance values of sugar maple demonstrate this species dominance of both the thinned and control plots. (INSERT) Basswood may have gained dominance in the thinned plot due to ability to rapidly grow up to holes in the forest canopy, which would have resulted from the selective cutting. Decrease of basswood after 1954 may be due to closing of the canopy as tree size of dominants increase. Basswood importance values in the control plot remain low,

(INSERT)

(INSERT) - Sugar maple seems unaffected by selective cutting, increasing in value while being cut (1934-1949). Beech seems directly affected by cutting, decreasing in value from 1939-1954.

TABLE 1. Importance values of species in thinned and control forestry plots in 1934, 1954 and 1980.

Species	Thinned			Control		
	1934[1]	1954	1980	1934	1954	1980
Acer saccharum	57.98	63.39	62.20	51.76	56.27	58.57
Fagus grandifolia	7.94	2.43	3.35	24.29	17.71	16.07
Tilia americana	11.91	17.36	13.68	3.34	3.96	6.66
Betula papyrifera	9.83	8.78	6.12	4.94	6.27	5.93
Ostrya virginiana	9.53	4.20	11.09	11.57	12.44	5.54
Quercus borealis[2]	.29	.47	.23	.50	.86	2.95
Acer pensylvanicum	.84	.62	.70	1.40	.19	
Ulmus sp.	.34	.58		.93	.84	
Fraxinus americana	1.35	2.18	2.28			
Tsuga canadensis			.36			
Populus grandidentata				.53	1.47	4.29
Prunus pensylvanica				.72		

[1] Tree data from 1934 and 1954 are computed for the thinned plot following the thinning cuts of those years. No data was available for individual tree species prior to the 1934 initial cut (initial cut removed 322 trees).

[2] Analysis of values of less important trees must be made with caution due to possible inflated or deflated values in 1980. Circular plots in 1980 may have failed to include species and individuals which would have been included in whole-tree sampling from 1934-1954.

TABLE 2. Density (stems/ha) of trees in thinned and control forestry plots in 1934, 1954 and 1980.

Species	Thinned 1934	Thinned 1954	Thinned 1980	Control 1934	Control 1954	Control 1980
Acer saccharum	906.88	736.37	1290	1517.22	1329.42	774.69
Fagus grandifolia	54.36	19.77	70	247.11	153.21	108.29
Tilia americana	202.63	163.09	130	103.78	49.42	33.32
Betula papyrifera	180.39	86.49	55	123.55	74.13	33.32
Ostrya virginiana	190.27	71.66	335	434.90	350.89	91.63
Quercus borealis	4.94	2.47	5	14.83	9.88	16.66
Acer pensylvanicum	22.24	9.88	25	49.42	2.94	
Ulmus sp.	4.94	4.94		19.77	9.88	
Fraxinus americana	27.18	27.18	30			
Tsuga canadensis			10			
Populus grandidentata				4.94	2.94	8.33
Prunus pensylvanica				19.77		

TABLE 3. Tree basal areas (m^2/ha) in thinned and control forestry plots in 1934, 1954 and 1980.

Species	Thinned			Control		
	1934	1954	1980	1934	1954	1980
Acer saccharum	8.29	8.51	14.80	8.09	10.45	14.83
Fagus grandifolia	1.75	.43	.79	7.19	6.36	7.33
Tilia americana	1.56	2.81	5.26	.48	1.25	3.40
Betula papyrifera	1.17	1.37	2.39	.93	2.02	2.91
Ostrya virginiana	1.00	.28	1.27	1.11	1.65	.83
Quercus borealis	.04	.10	.05	.08	.28	1.45
Acer pensylvanicum	.04	.05	.03	.16	.05	
Ulmus sp.	.05	.10		.20	.27	
Fraxinus americana	.14	.27	.77			
Tsuga canadensis			.05			
Populus grandidentata				.16	.64	2.60
Prunus pensylvanica				.12		

TABLE 4. Size of the average tree (cm^2) in 1934, 1954 and 1980 for selected species in control plot, and increase in size (multiplication) from 1934-1980.

Species	Average Tree Size 1934	1954	1980	Size Increase
Tilia americana	46.35	252.9	1020.4	22.1
Quercus borealis	53.9	283.4	870.4	16.1
Betula papyrifera	75.3	272.5	873.4	11.6
Populus grandidentata	323.9	2176.9	3121.3	9.6
Acer saccharum	53.3	78.6	191.4	3.5
Ostrya virginiana	25.5	47.0	90.6	3.5
Fagus grandifolia	290.9	415.1	676.9	2.3

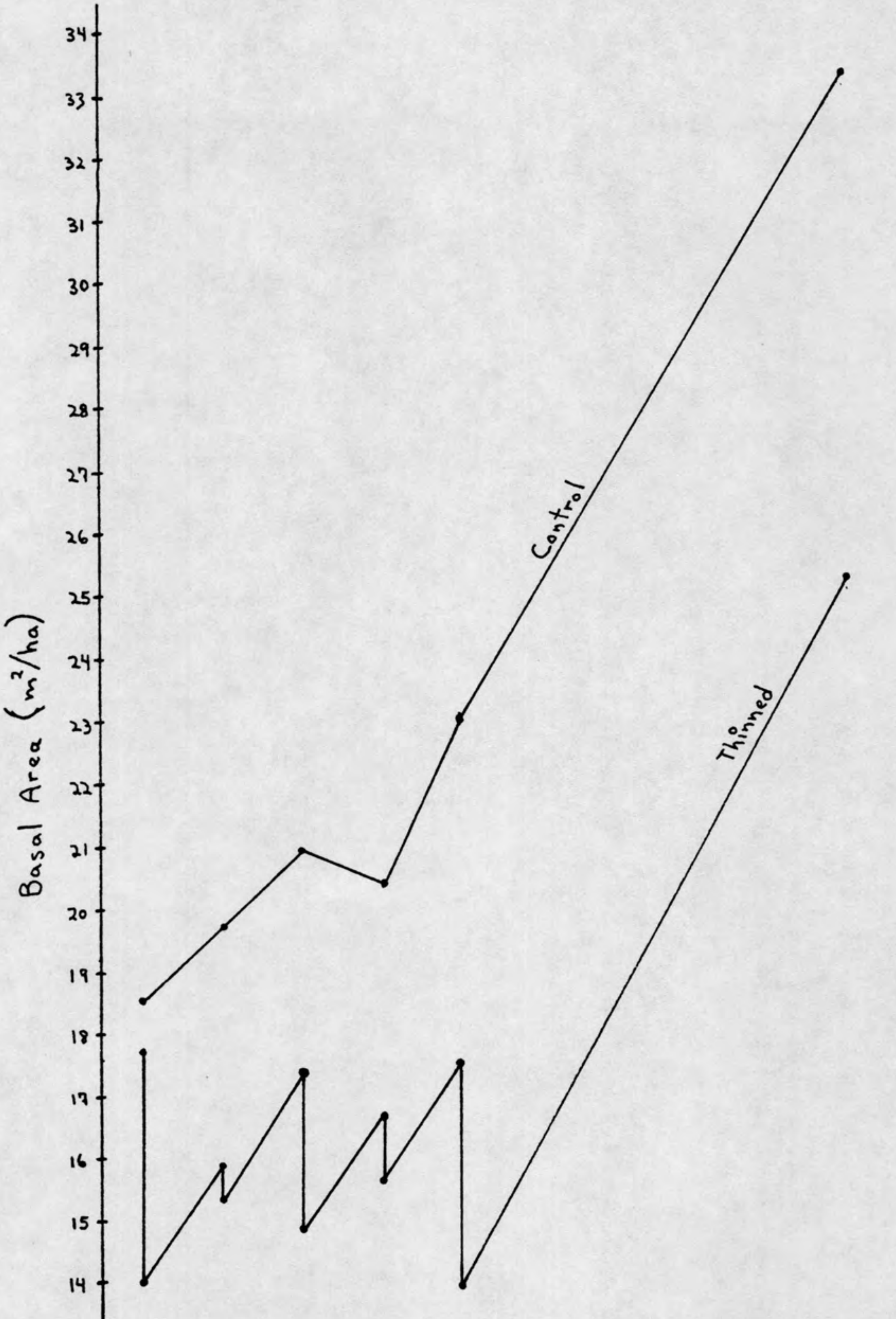

FIG. 3. Total tree basal areas for thinned and control forestry plots from 1934-1980. Vertical decreases in thinned plot per five year interval from 1934-1954 designate basal arealosses due to selective cutting.

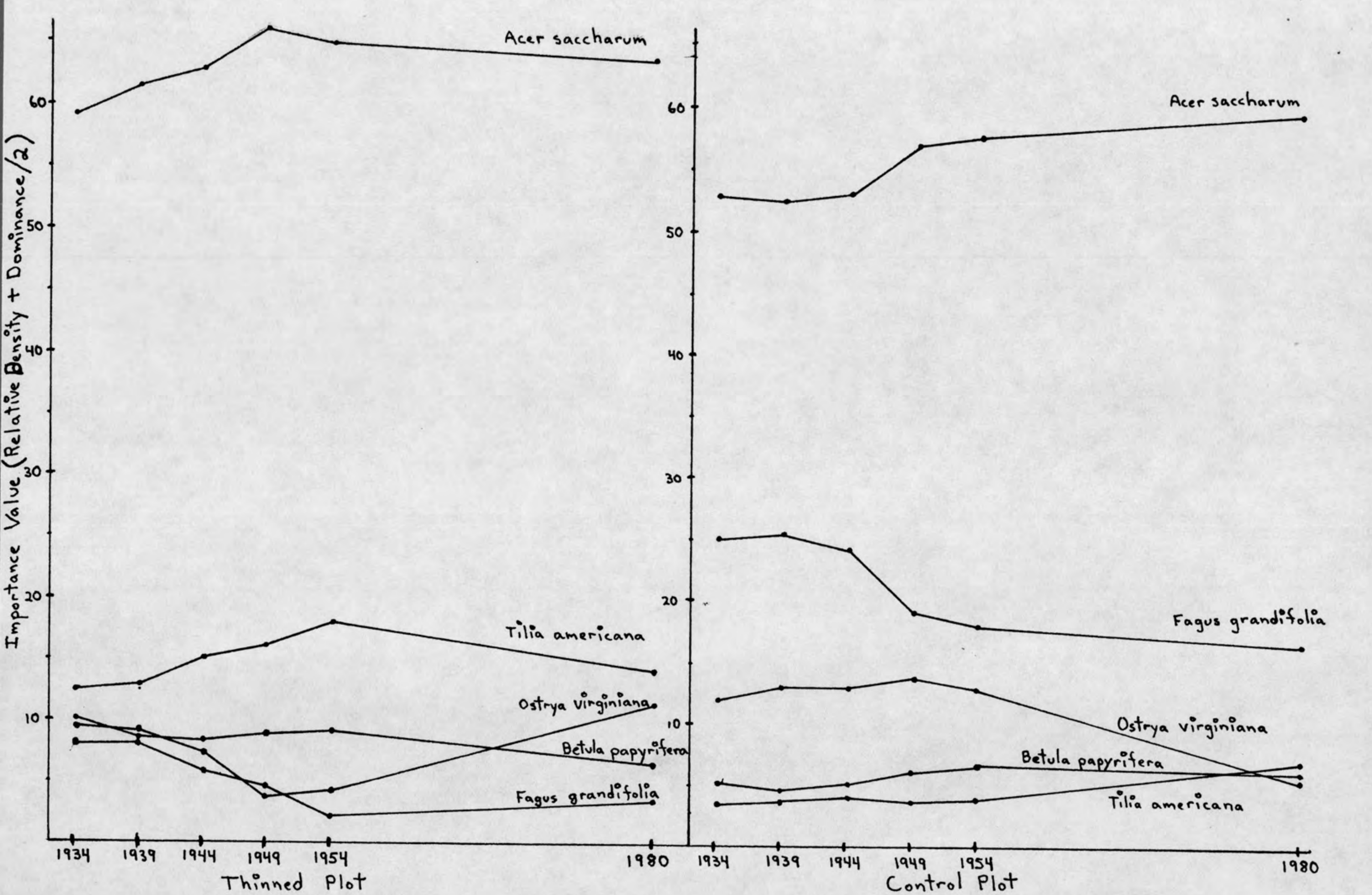

Fig. 1. Importance Values for five leading dominants in thinned and control forestry plots from 1934-1980.

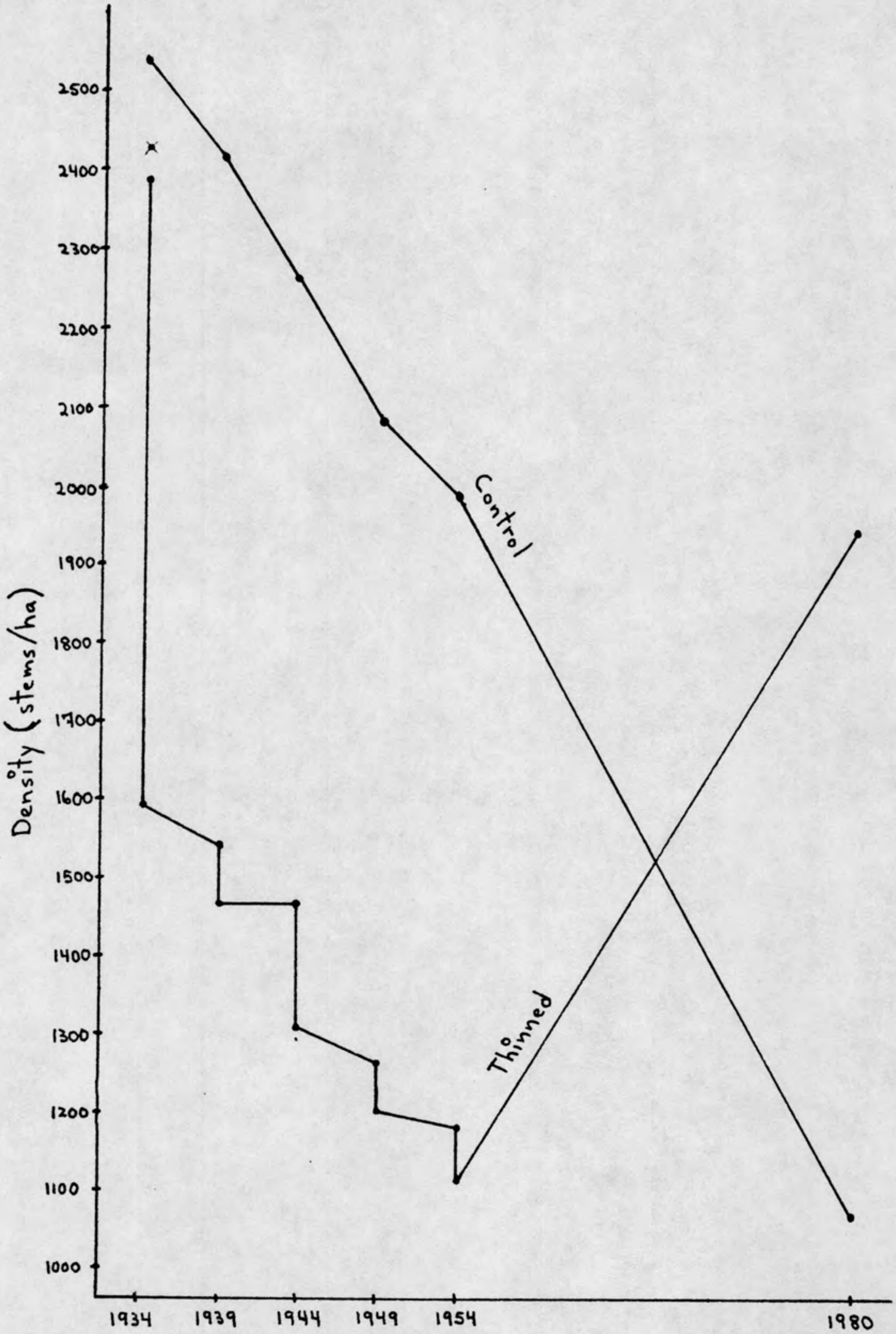

FIG. 2. Total tree densities for thinned and control forestry plots from 1934-1980. Vertical decreases in thinned plot per five year interval from 1934-1954 designate density losses due to selective cutting.

possibly indicating basswood is normally restricted in the canopy, increasing in dominance only with disturbance such as selective cutting. Ref. <u>Silvics</u> of Trees of N. Am.

Sugar maple dominance may limit success of other potentially dominant species. In the thinned plot ironwood and beech decrease in importance as sugar maple increases (1934-1949). As sugar maple begins to decrease after 1949, ironwood shows an immediate increase and beech an increase after 1954. Both continue increasing in importance to 1980 as sugar maple continues to decrease. In the control plot beech also increases or decreases in importance according to sugar maple, and ironwood decreases in importance as sugar maple increases. This possibly indicates that sugar maple increases dominance at the expense of beech and ironwood. The limiting factor may be competition; sugar maple may be more successful in competition for available resources than beech or ironwood. Beech and ironwood therefore lose out over time. Sugar maple will probably never become dominant enough to exclude beech and ironwood from the forest. Beech and ironwood will probably remain low in importance and fluctuate in dominance with sugar maple fluctuations (barring major disturbance).

Decreases in diversity for both plots indicate certain species are losing out as the forest matures and other species exert increased dominance. Pin cherry probably disappeared after 1934 due to this. The status of elm sp. and white ash (<u>Fraxinus</u> <u>americana</u> L.) is difficult to determine. These species may also leave as dominance of the major species increases. Species represented only by large trees in the canopy are also expected to leave as the forest matures and these large trees die. These species cannot reproduce in heavy shade (no growth beyond seedling stage--seedlings may be present due to root sprouting or use of food reserves in seeds). Big-toothed aspen, white birch, red oak, and possibly basswood (basswood may be able to remain by colonization of windthrow mounds or other natural disturbances) may leave the forest by these means. Hemlock (present 1980), often a dominant or co-dominant of northern mesic coniferous-hardwood forests (Brown and Curtis, 1952), may increase as the forest matures towards a mesophytic climax.

Density is expected to continue decreasing in the control plot as the trees mature, and basal area is expected to increase for some time. Density in the thinned plot is currently increasing after selective cutting but is expected to eventually attain a decreasing pattern as in the control plot (with maturation of the thinned plot).

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