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The upland hardwood forest of the Cedar-Sauk Field Station

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THE UPLAND HARDWOOD FOREST OF THE CEDAR-SAUK FIELD STATION

As forest communities develop, their composition is molded by many factors—climate, soil, available seed and subtle or catastrophic disturbance both natural and man-made. Given time, the pioneer species that colonize open ground are replaced by others more tolerant of shade and gradually a community develops composed of species suited to the soil and climate of the area and capable of reproduction within the forest environment. Such is the nature of the upland forest on the UWM Field Station.

Unless catastrophe intervenes, change in the mature forest is slow and hardly perceptible. The processes of change can only be examined by detailed studies covering relatively long intervals.

This study of forest composition and structure was designed to establish the nature of the Field Station stand relative to other forest communities in southeastern Wisconsin and to document the essential data to serve as the basis for future comparisons.

To provide data of maximum long term usefulness, the vegetation was sampled in permanently located plots. These permanent plots will be useful in habitat studies, and may also be used to document successional change in the composition and structure of the woods. To establish these plots in a regular pattern, the entire woods was surveyed using a grid with N–S and E–W lines at intervals of 165 feet. This interval results in the formation of square units of approximately one-quarter hectare. A sample plot was located at each corner of a section and marked with a numbered wood stake; 110 plots were established.

Nested circular plots were used for sampling. Trees and saplings were sampled in circles with a radius of 5.645 meters or 100 m^2 in area. Shrubs and herbs were sampled in 10 m^2 and 1 m^2 circles, respectively. The data were tabulated as density, per cent dominance, per cent density, per cent frequency, and importance value (sum of the three percentage values).

It was immediately evident that this stand is not homogeneous, but that it includes elements of upland forest and other areas of lowland, swamp forest. To facilitate analysis, the stand was divided into two discrete communities. The separation was based both on vegetational and soil differences. All samples above the 900 foot contour (feet in elevation) were considered upland forest and all samples below 900 feet were classified as lowland forest. This report describes only the upland portion of the forest.

The tree sample for the upland forest consisted of 366 trees in 69 plots. This community had a density of 212.0 trees per acre, an average basal area per tree of 71.99 $in.^2$ and a continuum index value of 2545. This high C. I. value (scale of 0 to 3000) indicates that the stand is approaching a stable or "climax" condition for

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A description of the lowland forest and shrub and herbaceous species in the upland forest are contained in a M.S. thesis entitled "The phytosociology of Beech-Maple Woods in Ozaukee County, Wisconsin"—by James Dunnum, February, 1972.

TABLE 1

DENSITY[a], RELATIVE DOMINANCE[b], DENSITY, AND FREQUENCY, AND IMPORTANCE VALUE OF TREES IN THE UPLAND FOREST

	NORTHERN SECTION[c]					*SOUTHERN SECTION*[c]				
	Density	*Percent Dominance*	*Percent Density*	*Percent Frequency*	*I.V.*	*Density*	*Percent Dominance*	*Percent Density*	*Percent Frequency*	*I.V.*
Acer saccharum	85.8	37.5	37.1	33.8	108.3	98.0	48.9	49.1	42.3	140.2
Fagus grandifolia	25.8	14.9	11.4	10.4	36.7	25.4	11.5	12.7	14.1	38.3
Fraxinus americana	22.0	14.5	9.7	23.0	37.2	14.5	14.0	7.3	12.7	33.9
Tilia americana	31.0	10.5	13.7	6.5	30.7	14.5	15.1	7.3	9.9	32.3
Ostrya virginiana	24.5	4.4	10.9	14.3	29.5	37.5	4.5	18.8	9.9	33.2
Quercus borealis	2.6	2.1	1.1	2.6	5.9	1.2	1.1	0.6	1.4	3.1
Carya ovata	28.4	13.7	12.6	11.7	38.0	1.2	0.7	0.6	1.4	2.7
Ulmus rubra	3.9	1.4	1.7	3.9	7.0	3.6	2.0	1.8	4.2	8.1
Ulmus americana	–	–	–	–	–	1.2	0.6	0.6	1.4	2.6
Prunus serotina	1.3	0.6	0.6	1.3	2.5	–	–	–	–	–
Acer rubrum	1.3	0.3	0.6	1.3	2.1	1.2	1.1	0.6	1.4	3.1
Populus tremuloides	1.3	0.3	0.6	1.3	2.1	–	–	–	–	–
Betula papyrifera	–	–	–	–	–	1.2	0.5	0.6	1.4	2.5

a) Density is the number of stems per acre.

b) Relative dominance is the percentage that each species comprises of the total stand basal area, relative density the percentage of the total stems, and relative frequency the percentage of the total number of plots in which the species is found. Importance Value (I.V.) is the sum of relative dominance, density, and frequency.

c) Northern section 31 plots and southern section 33 plots.

this region. Barring major disturbance, the stand should show only minor changes in overall composition and structure in future decades.

Thirteen species reached tree size in the upland forest (Table 1). Of these, six species comprise almost 94 percent of the total importance value (I.V.). Sugar maple (*Acer saccharum*) is the leading dominant, with an I.V. of 121.9, over 40 percent of the total. This species exerts the controlling influence over the entire upland through its numbers, its size, and its fairly uniform distribution. Of the 111 sugar maples sampled, 41 exceeded 100 square inches in basal area; the largest tree reached 580 square inches.

Secondary dominance is shared by three species: white ash (*Fraxinus americana*), beech (*Fagus grandifolia*) and basswood (*Tilia americana*). These species have importance values respectively of 35.8, 34.7, and 29.8 percent. Beech stems are present in the greater numbers, however, many are young, with basal areas less than 50 square inches, whereas well over one-half of the white ash trees have basal areas greater than 100 square inches. There are also a number of very large basswood trees present, but basswood tends to grow in clumps, thus limiting its influence to restricted areas.

Ironwood (*Ostrya virginiana*) has the second highest importance value; this species rarely reaches into the canopy and attains its importance primarily from the large number of small trees. Thus, while ironwood is important in the overall structure of the forest, it cannot be considered a dominant. Shagbark hickory (*Carya ovata*) reaches an unusually high I.V., 20.7 in this stand. Hickory is ordinarily a minor component in the typical beech-maple forest and usually attains maximum development in Wisconsin in the oak openings of south central Wisconsin (Curtis, 1959). In this stand, shagbark is restricted to a portion which has been repeatedly disturbed by selective logging.

The elms, both American and slippery, are now of minor importance. It is assumed, both from the results of other studies and from a number of dead elms still standing in the study area, that these species were formerly of much greater importance. Dutch elm disease has been the major factor in their decline.

Northern red oak (*Quercus borealis* var. *maxima*) is a minor component in the upland portion of this area, growing only in damp depressions in fairly open sites. The remaining species, black cherry (*Prunus serotina*), trembling aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*) are all shade intolerant and may be considered as transient species which cannot persist in this forest type unless disturbance creates an opening large enough to admit ample light onto the forest floor.

The sapling data emphasize the climax nature of the upland forest (Table 2). The five species which comprise 99 percent of the saplings are the same species which comprise 89 percent of the stems in the canopy. Sugar maple is again the most important with a relative density of almost 60 percent.

Beech attains a higher importance value in the sapling layer than in the tree stratum, but this is due primarily to a greater range of occurrence rather than a greater relative number of individuals. White ash loses almost half of its importance

TABLE 2

DENSITY[a], RELATIVE DENSITY[b], RELATIVE FREQUENCY AND IMPORTANCE VALUE OF SAPLINGS IN THE UPLAND FOREST

	NORTHERN SECTION[c]				*SOUTHERN SECTION*[c]			
	Density	*Percent Density*	*Percent Frequency*	*I.V.*	*Density*	*Percent Density*	*Percent Frequency*	*I.V.*
Acer saccharum	113.5	57.1	50.0	160.7	106.6	66.6	53.9	180.0
Fagus grandifolia	24.0	12.3	20.4	49.1	24.2	15.0	17.3	48.5
Fraxinus americana	6.4	3.3	7.4	16.0	6.1	3.8	3.9	11.4
Tilia americana	18.1	9.1	3.7	19.2	8.5	5.3	11.5	25.2
Ostrya virginiana	33.5	16.9	14.8	47.5	14.5	9.0	11.5	30.8
Quercus borealis	1.3	0.7	1.9	3.8	–	–	–	–
Ulmus rubra	1.3	0.7	1.9	3.8	–	–	–	–
Vitis riparia[d]	–	–	–	–	1.2	0.8	1.9	4.0

a) Density equals the number of stems per acre.

b) Relative density is the percentage of the total number of stems represented by the species and relative frequency is the percentage of the total number of plots in which the species occurs.

Importance Value (I.V.) is the sum of the percentage frequency and density times 1.5. Use of the factor 1.5 places the sapling and tree data at the same level.

c) Northern section 31 plots, southern section 33 plots.

d) Stem diameters over one inch place grape in the sapling category.

value from the tree to the sapling stage, and shagbark hickory, which has an I.V. of 20.66 in the tree stage is not represented in the sapling stage. Both species have medium shade tolerance (Baker, 1949) and are not capable of maintaining growth under a closed canopy. Ash is slightly less shade intolerant than hickory and a few individuals are able to grow to sapling size in the more open locations and by gap-phrase replacement. The average density is 184.6 saplings per acre.

During sampling it was apparent that the upland forest was not uniform in structure. One section was composed of a large number of smaller trees, while the other had fewer but larger trees. The two areas had been under different ownership and, according to the best knowledge available, had been subjected to different management.

The majority of the southern section, comprising 20 acres, had apparently suffered only minimal disturbance. Some selective logging may have taken place in the past, but presumably this was of minor importance to the integrity of the forest. Traces of an old logging road are evident. This road enters the woods from the south and extends north about three-quarters of the distance (1,000 feet) into the woods. The extreme southern edge of the woods has suffered the most disturbance. This area may have been partially cleared about the time of original settlement in the mid-1800's. In any case, the building and operation of St. Augustine road along the southern edge of the woods has kept this portion in a relatively disturbed state. My nearest samples to the road are approximately 120 feet from the right of way. Just prior to acquisition of this property by the Field Station in 1964, a few large trees, primarily basswood, were cut for sale as firewood.

The northern section of the upland forest has been subjected to greater and more continual disturbance. This portion was part of a small farm which maintained fifteen to twenty head of cattle. Apparently, the woods was used consistently to supply timber both for building and for firewood. Most recently, prior to purchase, cutting was primarily for firewood and aesthetic purposes. At the time of acquisition by the Field Station in 1964, there were no dead trees standing and the ground was completely clear of debris (Paul Matthiae, personal communication). This northern sector is laced by a number of logging roads, which are still easily followed.

When data from the northern and southern sections are examined separately, a number of differences appear. The northern section included 31 plots, had an average of 5.64 trees per plot or 225.6 trees per acre and a basal area of 13,440 square inches per acre or 59.54 square inches per tree. The southern section, with 33 plots, averaged 5 trees per plot or 200 trees per acre, and showed a basal area of 17,560 $in.^2$ per acre, and 87.8 $in.^2$ per tree.

Species composition is also different in the two areas (Table 1). Sugar maple is much more important in the southern section and shows 11 percent greater relative dominance and relative density than in the north. Although there are about 10 per cent fewer trees per acre in the southern section, the density of sugar maple is 98.0 trees per acre versus 85.8 trees per acre in the north. The same is true of ironwood which has a density of 37.5 trees per acre in the south and 24.5 in the north. The ironwood trees in the north are well distributed throughout the stand,

while in the south, this species is extremely clumped with aggregation about three times that in the north.

Unexpectedly, beech is of approximately equal importance in both areas; its distribution had been expected to be correlated more closely with sugar maple, i.e. to reach a higher density in the south. The northern section, however, has more level topography with fewer steep-sided ridges. This terrain favors development of beech rather than sugar maple since beech does not grow well on the higher ridges where water run-off is rapid and soil moisture somewhat lower.

White ash has a slightly higher importance value in the northern section where its density is about 50 percent greater than in the south. This is probably the result of the logging which removed canopy trees and thus increased light penetration.

Other presumed effects of selective logging in the northern section include the spatial distribution of basswood and the high importance of shagbark hickory. In the uncut sector, basswood consists of a few large trees fairly well distributed throughout. In the northern section, the basswoods are about twice as numerous, are much smaller in size, and are extremely clumped, with a high degree of aggregation (4.55). The older basswoods in the northern section may have been cut a number of years ago. This would have resulted in the formation of sprouts around the base of the stumps, thus increasing the number of small trees and also increasing the degree of aggregation.

The most dramatic difference is the high importance of shagbark hickory in the northern section and the very low value in the southern section. Presumably, shagbark has been severely reduced by competition in the uncut area while selective logging in the northern section has repeatedly opened the canopy and allowed this and other shade intolerant species, such as black cherry and trembling aspen, to become established and grow to maturity.

The sapling data provide some indication of the dynamics of the two sections. Sugar maple is again more important in the south, although the difference is not so marked as in the tree stratum (Table 2). This suggests that the logged area is recovering from disturbance. The absence of shagbark hickory saplings in the north may also be an indication of this recovery.The higher relative frequency of beech saplings in the northern section seems to substantiate the assumption that the more level topography of this area offers a better habitat for the beech than does the south. The higher relative frequency of ash in the north, however, is probably a result of the logging. In the southern section, ash cannot become established until a canopy tree dies and enough light is admitted to allow the seedlings to grow into saplings; therefore the occurrence of sapling-sized ash is restricted to small areas. Basswood saplings have the same clumped spatial distribution as do basswood trees but the degree of aggregation of saplings is even more pronounced, reaching a value of 7 in the northern section. Ironwood presents an enigma. Mature ironwood trees are about 50 percent denser in the southern portion of the forest; however, the density of ironwood saplings is more than twice as great in the northern section. These data suggest that ironwood, despite its high shade tolerance as a mature tree, becomes established more readily in disturbed areas. The mature trees in the southern area

are clustered in sites which had been disturbed many years ago by road and fence building. The sapling-sized ironwoods are now most abundant in locations which have been more recently disturbed by intermittent logging.

LITERATURE CITED

Curtis, J. T., 1959. The Vegetation of Wisconsin, University of Wisconsin Press. 657p.

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An annual report summarizing activities at the Field Station during 1971 and including abstracts of research projects may be obtained by writing Millicent Ficken, UWM Field Station, Route 1, Box 216, Saukville, Wisconsin, 53080. If you are not already on the mailing list for the Bulletin and wish to receive it, contact Dr. Ficken.

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