Fall 1987

Three decades of change in three Southeastern Wisconsin woodlots

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ABSTRACT

Three upland woodlots in southeastern Wisconsin, originally sampled by the Plant Ecology Lab of UW-Madison in 1949, were resampled in 1981. In general, red and white oaks were being replaced by more shade-tolerant species. Two of the sites, Zirbe's Woods and Petrifying Springs Woods, appear headed for complete domination by sugar maple. Thompson Woods, where maple was absent, was at an earlier successional stage. In Thompson Woods, basswood and white ash were becoming dominant.

INTRODUCTION

Despite the numerous investigations of the upland forest communities of southern Wisconsin, our understanding of successional trends in this region is still incomplete. It has been complicated by the fact that the original forests have been fragmented into isolated woodlots subjected to increasing levels of disturbance (e.g., cutting, burning, grazing, trampling) (Sharpe, et al. 1986). New species have also been added to the flora as others (e.g., American elm Ulmus americana) have been eliminated. The result is that few high quality sites remain to answer basic questions concerning rates and directions of compositional dynamics. Long-term data are a particularly scarce, but invaluable, source of information.

In 1946, the Plant Ecology Laboratory (PEL) of the Botany Department of the University of Wisconsin-Madison initiated an attempt to survey the entire vegetation of Wisconsin in order "... to learn the geographical limits, species compositions, and as much as possible of the environmental relations of the communities comprising that vegetation" (Curtis, 1959). Throughout the next decade, 1420 of the most representative stands were studied, encompassing all of the state's major plant communities. The records of these surveys are on file in the PEL office at UW-Madison.

Three of these sites were upland woodlots in southeastern Wisconsin (PEL #'s 1101, 1102, and 1103), surveyed in 1949 (Table 1). As with other stands, they were chosen by the PEL because they were relatively large and showed minimal evidence of disturbance. In 1981, in the course of investigating the invasive characteristics of the European buckthorn (Rhamnus cathartica) (Leitner, 1985), I re-sampled these three sites. This report provides an update on these three stands and documents changes that have occurred in tree species composition over 30 years.

Table 1. Locations of the three study sites.

Woodlot	Dates Sampled	Size	Location
Zirbe	July 11, 1949	4.42 ha	Racine Co.
(PEL 1101)	July 6, 1981		Caledonia Twp.
			Franksville USGS quad.
			T4N R22E S9 NW1/4 SW1/4
Thompson	July 12, 1949	3.15 ha	Kenosha Co.
(PEL 1102)	May 22, 1981		Somers Twp.
			Racine S. USGS quad.
			T2N R22E S13 SW1/4 NW1/4
Petrifying Springs	July 12, 1949	13.64 ha	Kenosha Co.
(PEL 1103)	July 7, 1981		Somers Twp.
			Racine S. USGS quad.
			T2N R22E S11 NW1/4 SW1/4

The three study sites are located in Racine and Kenosha Counties. The natural vegetation in these counties consisted of a mosaic of prairie, oak savanna, and denser oak woods, with more mesic upland forests of sugar maple (Acer saccharum) and American beech (Fagus grandifolia) in northeastern Racine. The tension zone, that transition area separating the prairie-forest floristic province in southwestern Wisconsin from the northern hardwoods province in the northeast, is usually considered to pass through northeastern Racine County. Figure 1 is a synthesis of various county, state, and regional vegetation maps (Goder, 1956; Curtis, 1959; SEWRPC, 1963; Stearns and Kobriger, 1975; and Finley, 1976), showing the distribution of the original plant communities and the locations of the three sites (Table 1).

METHODS

Because of the tremendous number of sites studied, and the enormous amount of time required, the PEL investigators discarded the traditional quadrat survey method in favor of plotless sampling techniques (random-pairs and quarter methods) (Cottam and Curtis, 1949, 1955, 1956). Their results included densities, basal areas (i.e., dominance), and an importance value for each species in the tree stratum.

Since my primary intent was to study an individual species in a smaller number of stands (28), my sampling technique was necessarily more detailed. I thus used the modified line-transect method (Lindsey, 1955). After locating the approximate areas of the 1949 surveys from the written PEL descriptions, USGS quads, and aerial photos, I entered each woodlot about 10 m to avoid edge effect and ran two parallel, 100m apart, transects along the long axis of the woods. Quadrats were established at 25 m intervals, each including a series of nested

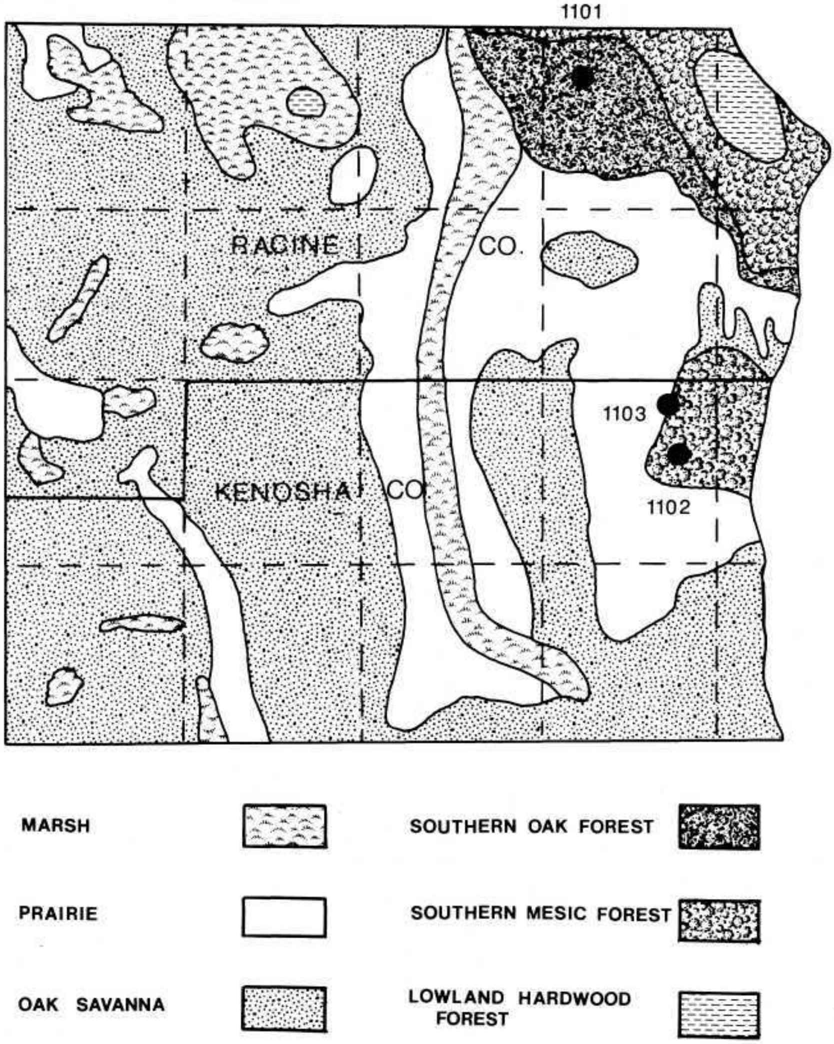


Figure 1. Locations of the three study sites (1101 = Zirbe's Woods; 1102 = Thompson Woods; 1103 = Petrifying Springs Woods) in relation to the presettlement vegetation of Racine and Kenosha counties.

plots for sampling different strata. Woody vegetation was arbitrarily divided into three strata: trees (woody stems > 10 cm diameter at breast height (dbh)); shrubs (woody stems > 1 m tall and < 10 cm dbh); and seedlings (woody stems < 1 m tall). Different plot dimensions were sampled for each stratum (trees: 10 x 25 m; shrubs: 10 x 2.5 m; seedlings: 1 x 2.5 m). For each plot and stratum I tallied number of stems per species, while diameters were measured for trees and percent cover estimated for shrubs and seedlings. Diameters were later converted into basal areas. The number of quadrats and the number of transects employed varied from stand to stand, depending on the size and shape of the woodlot and on a subjective determination of adequate coverage.

Vegetational data for each woodlot, recorded by stratum and species, included numbers of individuals, occurrence by plot, and either dbh for trees or percent cover for shrubs and seedlings. For comparison with the PEL data, the tree stratum is emphasized here. These values were used to calculate absolute density, frequency, and dominance, which were then relativized (Curtis and McIntosh, 1951; Lindsey, 1956). Data for each species were summarized by woodlot and stratum according to an artificial importance value, which is the mean of the sum of the relative density, relative frequency, and relative dominance.

The continuum index (CI) (Curtis, 1959) is a synthetic scale that reflects a stand's composition, and indicates the phytosociological relationship of one stand to another. It ranges from 300 to 3000 and is based on species importance values multiplied by species adaptation values. It indicates the degree to which a stand is composed of shade-tolerant tree species. Thus, the more mesic the component species, the higher the CI. I calculated indexes for each of the stands, for both 1949 and 1981. In addition, I divided each stand's trees into diameter size-classes. By considering each size-class as a "stand", and calculating importance values as before, I determined a continuum index for each class. This enabled me to examine changes occurring within each woodlot.

RESULTS

Zirbe's Woods

Zirbe's Woods is a relatively undisturbed southern mesic stand in northern Racine County, owned by the Zirbe family since 1942. The old Green Bay Trail once passed through the woods. It is bounded by the Zirbe farm on the south, crop fields on the east and west, and new housing to the north.

In July of 1949, this stand was characterized by the Plant Ecology Lab (PEL #1101) as "good; very little cutting; much reproduction." This is much the situation today. The only sign of disturbance I noticed was an old farm road through the southern end. According to Mrs. Zirbe, in 1902 a "cyclone" took many of the larger trees. At the south end a large clone of Lily-of-the-Valley (*Convallaria majalis*) has become established.

Table 2. Stand dynamics of tree species in Zirbe's Woods from 1949 to 1981. Density, in stems/ha; Basal Area in m^2/ha; R.I. = relative importance, percent of total importance value of the stand contributed by each species.

Species	1949			1981			Net Change		
	Density	Basal Area	R.I.	Density	Basal Area	R.I.	Density	Basal Area	R.I.
Tilia americana	161.8	3.81	23.67	227.3	10.34	32.31	65.5	6.53	8.64
Fraxinus americana	208.0	6.81	31.47	124.1	5.31	20.86	-83.9	-1.50	-10.61
Quercus rubra	23.2	3.26	7.37	56.8	7.28	16.26	33.6	4.02	8.89
Acer saccharum	30.9	1.42	4.13	77.9	3.01	14.57	47.0	1.59	9.44
Quercus alba	38.5	4.06	10.30	10.5	1.83	4.37	-28.0	-2.23	-5.93
Carya cordiformis	15.3	0.16	2.33	19.0	1.18	3.70	3.7	1.02	1.37
Juglans nigra	15.3	0.37	1.83	6.3	0.78	2.55	-9.0	0.41	0.72
Ostrya virginiana	61.8	0.89	7.93	8.4	0.11	2.35	-53.4	-0.78	-5.58
Quercus macrocarpa	---	---	---	2.1	1.18	1.83	2.1	1.18	1.83
Prunus serotina	15.3	0.57	2.60	2.1	0.11	0.65	-13.2	-0.46	-1.95
Crateagus sp.	---	---	---	2.1	0.02	0.56	2.1	0.02	0.56
Ulmus americana	30.9	0.66	4.50	---	---	---	-30.9	-0.66	-4.50
Ulmus rubra	15.3	0.85	3.00	---	---	---	-15.3	-0.85	-3.00
Totals	616.3	22.87	100.13	536.8	30.31	100.01	-79.5	7.44	
Continuum Index		1972			2103				

Most of the woods is underlain by Morley silt loam (2-6% slopes), except for a small intrusion of Blount silt loam (1-3%) near the northwest corner. Topography is nearly level, with a slight rise from north to south. An intermittent stream crosses the woods at the north end.

The 1949 survey (Table 2) showed dominance by white ash (Fraxinus americana), followed by basswood (Tilia americana), white oak (Quercus alba), and ironwood (Ostrya virginiana). Today, the most important species is basswood, with white ash, red oak (Quercus rubra), and sugar maple (Acer saccharum) as subdominants. A single American beech (Fagus grandifolia) was located outside of a plot near the southwest corner, with a number of saplings associated.

The increases in the importance of basswood (23.67% to 32.31%) and sugar maple (5.13% to 14.57%) have resulted in an increase in the stand continuum index from 1972 to 2103. Stand basal area has increased by 7.44 m^2 ha, although overall density decreased by 79.5 stems/ha. Most of the change in basal area is due to diameter growth in basswood, red oak, and sugar maple. The decreased density is the result primarily of fewer ash, ironwood, elm, and white oak stems. In 1981, the average size of basswood stems was only 8.8" (22.30 cm) dbh; in 1949, these individuals were too small to be counted in the tree stratum.

Size-class profiles of the entire woodlot (Fig. 2) show Acer saccharum and Tilia americana to be particularly prominent in the smaller categories where Quercus alba is noticeably absent. Figure 3 points out the increase in shade-tolerant species in the smaller classes. Sugar maple also dominated the shrub layer.

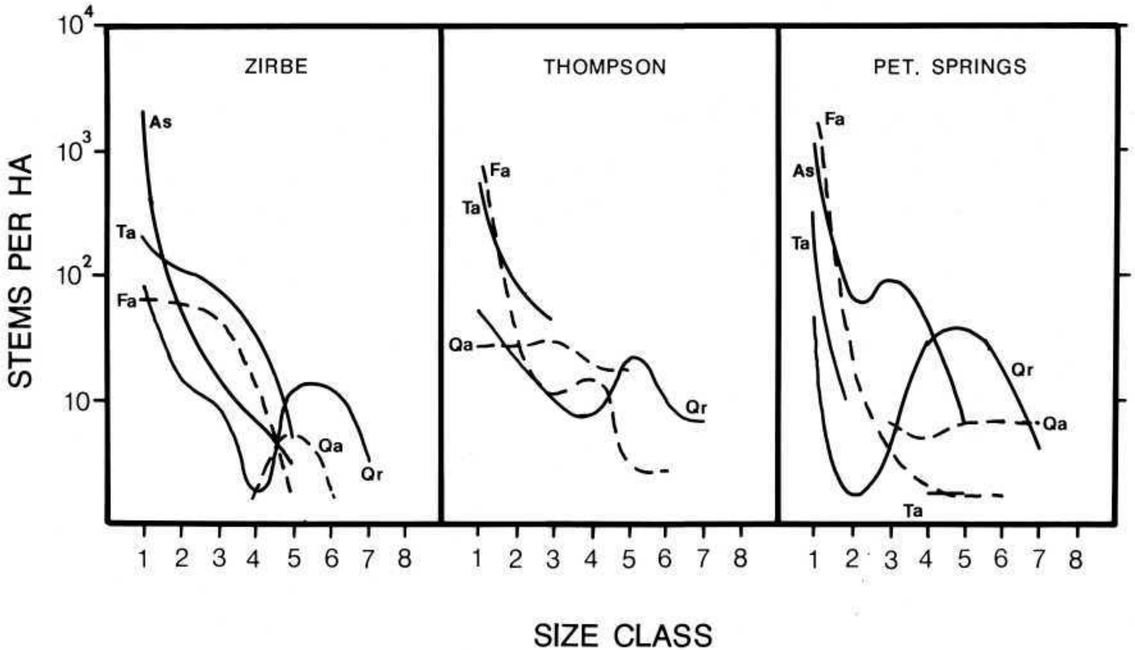
Thompson Woods

Thompson Woods is a relatively undisturbed dry-mesic forest remnant that was sampled in 1949 by the Plant Ecology Lab (PEL #1102). It is bordered by an old field on the north and a crop field on the east. To the west are new residences, and the south half of the woods has been taken by houses and lots where woodpiles indicate some light cutting. The north half (the area of concern in this study) showed little indication of any disturbance. A single diagonal footpath was noted. Topography is level, and soils are entirely Morley silt loam (2-6% slopes).

Table 3. Stand dynamics of tree species in Thompson Woods from 1949 to 1981. Density, in stems/ha; Basal Area in m^2/ha; R.I. = relative importance, percent of total importance value of the stand contributed by each species.

Species	1949			1981			Net Change		
	Density	Basal Area	R.I.	Density	Basal Area	R.I.	Density	Basal Area	R.I.
Quercus alba	59.8	2.70	14.37	100.0	7.05	23.58	40.2	4.35	9.21
Quercus rubra	115.0	12.34	37.47	80.0	8.96	23.29	-35.0	-3.38	-14.18
Tilia americana	69.0	2.82	16.33	126.6	3.72	20.56	57.6	0.90	4.23
Fraxinus americana	64.4	4.19	17.33	70.0	4.03	16.13	5.6	-0.16	-1.20
Ulmus rubra	32.2	0.84	7.40	23.3	0.62	5.04	-8.9	-0.22	-2.36
Ostrya virginiana	---	---	---	6.7	0.30	4.87	26.7	0.30	4.87
Carya cordiformis	---	---	---	10.0	0.15	2.83	10.0	0.15	2.83
Prunus serotina	13.8	0.26	3.03	6.7	0.29	2.16	-7.1	-0.03	-0.87
Juglans nigra	---	---	---	3.3	0.52	1.53	3.3	0.52	1.53
Quercus macrocarpa	4.6	0.84	2.03	---	---	---	-4.6	-0.84	-2.03
Crateagus sp.	9.2	0.07	1.90	---	---	---	-9.2	-0.07	-1.90
Totals	368.0	24.06	99.86	446.6	25.64	99.99	78.6	1.58	
Continuum Index	1761			1779					

Figure 2. Size-class - log density profiles of the major tree species for the three study sites in 1981. Size class '1' represents saplings (2.5-9.9 cm dbh); all others are in increments of 10 cm dbh. As = Acer saccharum; Fa = Fraxinus americana; Qa = Quercus alba; Qr = Quercus rubra; Ta = Tilia americana.



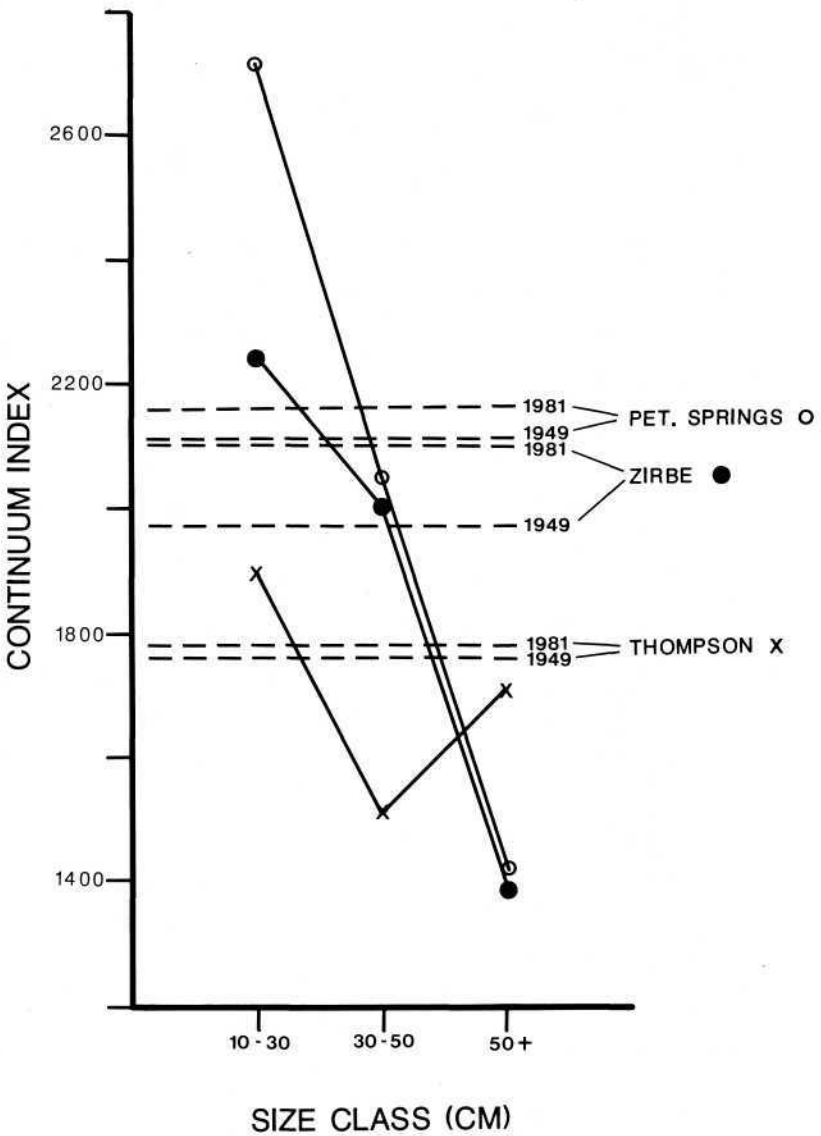


Figure 3. Changes in continuum index by size class for the three sites. Dashed lines represent overall stand CI.

In 1981, white (Quercus alba) and red oak (Q. rubra) were nearly equal co-cominants in the tree stratum, with basswood (Tilia americana) and white ash (Fraxinus americana) contributing a more mesophytic element (Table 3). Sugar maple (Acer saccharum) was absent from all three strata. Gray dogwood (Cornus racemosa) and chokecherry (Prunus virginiana) dominated the shrub layer while white ash was the most important seedling species.

The 1949 PEL study described the site as "...ash-oak in good condition, with some cutting of oaks." Their survey listed red oak, white ash, basswood, and white oak as the leading dominants (Table 3). Thirty-two years have brought about an increase in the importance of white oak and basswood at the expense of red oak and white ash. The latter may reflect selective cutting of the red oaks and ash mortality; several large (circa 20" dbh), dead ash stems were noticed. Overall stand density has increased by 79 trees/ha, although basal area was only slightly greater. Despite these changes, the continuum index increased only minimally (1761 to 1779).

Figure 2 shows both Fraxinus americana and Tilia americana to be at high densities in the smaller classes, but, because of the complete absence of Acer saccharum from the stand, the trend towards increasing mesophytism is much slower and less direct than in the other two sites (Fig. 3).

Petrifying Springs Woods

Petrifying Springs Woods is part of Petrifying Springs County Park, a large rural park administered by Kenosha County. Located in the north section of the park, the stand is completely encircled by a park road and Highway A. Topography ranges from nearly level to rolling; several intermittent streams flow north to south through the woods. Soils are Morley silt loam (2-6%; 6-12%; 12-20%; and 20-30% slopes). The only sign of disturbance was a network of foot paths maintained by park personnel.

The site was surveyed by the Plant Ecology Lab in July of 1949 (PEL #1103), at which time the condition of the stand was described as "excellent; not very brushy," a situation holding today, except perhaps for an increase in shrub density. Sugar maple (Acer saccharum), white oak (Quercus alba), and red oak (Q. rubra) were the dominant trees, followed by white ash (Fraxinus americana) and basswood (Tilia americana) (Table 4). There has been little change in thrity-two years, save that white oak and red oak have switched rankings. The stand continuum index has increased (2110 to 2158), although probably not significantly. Overall density increased slightly (by 24.1 trees/ha); this may be due to large increases in the number of maple and red oak stems which offset fewer white oaks. For the same reason, basal area increased 4.52 m^2/ha.

Breakdown of composition by size-class reveals the high densities of three species (sugar maple, white ash, and basswood) in the smaller categories (Fig. 2). The 10-30 cm class has the highest continuum index among the three sites (Fig. 3).

Table 4. Stand dynamics of tree species in Petrifying Springs County Park Woods from 1949 to 1981. Density, in stems/ha; Basal Area in m^2/ha; R.I. = relative importance, percent of total importance value of the stand contributed by each species.

Species	1949			1981			Net Change		
	Density	Basal Area	R.I.	Density	Basal Area	R.I.	Density	Basal Area	R.I.
Acer saccharum	155.4	6.19	37.23	197.6	9.69	39.36	42.2	3.50	2.13
Quercus rubra	54.6	6.93	20.80	77.6	11.93	28.88	23.0	5.00	8.08
Quercus alba	71.4	9.27	26.07	32.9	6.05	15.84	-38.5	-3.22	-10.23
Fraxinus americana	25.2	2.02	7.77	25.9	1.48	7.03	0.7	-0.54	-0.74
Tilia americana	16.8	0.89	4.93	14.1	0.71	4.56	-2.7	-0.18	-0.37
Ostrya virginiana	4.2	0.08	1.03	7.1	0.07	2.59	2.9	-0.01	1.56
Prunus serotina	4.2	0.05	1.00	2.4	0.05	0.89	-1.8	0.00	-0.11
Ulmus americana	---	---	---	2.4	0.02	0.86	2.4	0.02	0.86
Crateagus sp.	4.2	0.05	1.00	---	---	---	-4.2	-0.05	-1.00
Totals	335.9	25.48	99.83	360.0	30.00	100.01	24.1	4.52	
Continuum Index		2110			2158				

DISCUSSION

The three sites appear to be different stages in the development of mesic forests. Their pattern of species replacement resembles the first generation mesic stands described by Peet and Loucks (1977) in southern Wisconsin, except for the minor status of Ulmus rubra. The low importance of elms may be related to Dutch elm disease; however, I found no elm snags to indicate this as a cause of decline. Dominance by Quercus rubra, possibly of post-fire origin, is giving way to more shade-tolerant Tilia americana, Fraxinus americana and, in two sites, to Acer saccharum. The results strongly suggest that both Zirbe's and Petrifying Springs will become more mesophytic as the older oaks die and the maples achieve dominance. The question is whether Thompson will also converge towards maple-domination. The opening of the canopy by the deaths of several of the mature ashes and the removal of oaks may have retarded the natural course of succession by maintaining more zeric conditions beneath the canopy. Basswood and ash likely represent a transition stage, but one that may be of long duration because of drier site characteristics, or simply a lack of a readily-available maple seed source. This is where future monitoring would be beneficial.

In the background of these studies, though, a larger problem remains. Will these woodlots survive in such a state as to warrant further investigation?

Petrifying Springs Woods seems safe. It is under public ownership within a park, and it is physically buffered by surrounding woods. Zirbe's and Thompson, on the other hand, suffer from being exposed on all sides to natural elements such as sun and wind, and from the vicissitudes of private ownership in a rapidly developing area. Even if the tracts are not actually destroyed for houses, increased local disturbance is likely, making future species composition partly under the control of human use rather than a strictly natural process.

LITERATURE CITED

Cottam, G., and J. T. Curtis. 1949. A method for making rapid surveys of woodlands by means of pairs of randomly selected trees. Ecology 30: 101-104.

Cottam, G., and J. T. Curtis. 1955. Correction for various exclusion angles in the random pairs method. Ecology 36: 767.

Cottam, G., and J. T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology 37: 451-460.

Curtis, J. T. 1959. The Vegetation of Wisconsin. Univ. of Wisconsin press, Madison, WI.

Curtis, J. T., and R. P. McIntosh. 1951. An upland forest continuum in the prairie-forest border region of Wisconsin. Ecology 32: 476-496.

Finley, R. W. 1976. Original vegetation cover of Wisconsin. USDA, Forest Service, North Central For. Exp. Sta., St. Paul, MI Map.

Goder, H. A. 1956. Pre-settlement vegetation of Racine County. Trans. Wisc. Acad. Sci., Arts & Lett. 45: 169-176.

Leitner, L. A. 1985. An alien shrub in a changing landscape: The European buckthorn (Rhamnus cathartica L.) in southeastern Wisconsin. Ph.D. Dissertation, Dept. of Biol. Sci., Univ. of Wisc.-Milwaukee.

Lindsey, A. A. 1955. Testing the line-strip method against full tallies in diverse forest types. Ecology 36: 485-495.

Lindsey, A. A. 1956. Sampling methods and community attributes in forest ecology. Forest Sci. 2: 287-296.

Peet, R. K., and O. L. Loucks. 1977. A gradient analysis of southern Wisconsin forests. Ecology 58: 485-499.

Sharpe, D. M., F. Stearns, L. A. Leitner, and J. R. Dorney. 1986. Fate of natural vegetation during urban development of rural landscapes in southeastern Wisconsin. Urban Ecology 9: 267-287.

SEWRPC (Southeastern Wisconsin Regional Planning Commission). 1963. The natural resources of southeastern Wisconsin. Planning Rep. No. 5, Waukesha, WI.

Stearns, F., and N. Kobriger. 1975. Environmental status of the Lake Michigan region. Vol. 10. Vegetation of the Lake Michigan drainage basin. Argonne Nat. Lab., Argonne, IL.