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Oak island dynamics in Southeastern Wisconsin

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OAK ISLAND DYNAMICS IN SOUTHEASTERN WISCONSIN

Much of the dry to dry-mesic oak forest in southeastern Wisconsin was savanna prior to European settlement. Settlement brought a decrease in the frequency and the extent of fire, one agent responsible for maintenance of savanna; as a result, the oak savanna, or oak opening, gradually changed to oak forest (Curtis, 1959). Invading tree species created a sub-canopy beneath the original oaks, and the understory changed in structure and species composition, adapting to the more mesic conditions brought about by the closed canopy.

Settlement also resulted in geographic isolation of the oak forests by conversion of surrounding land to agricultural fields and pastures.

The occurrence of oak forests as vegetation islands on the landscape prompted this study, the objective being to describe species composition in the oak forests and to relate the findings to the theory of island biogeography (MacArthur and Wilson 1967). Comparatively little work has been done in application of island biogeography theory to terrestrial forest islands; the formulation and development of the theory was based largely on studies of birds on oceanic islands.

My study of southeastern Wisconsin oak forests, in 1977-78, also had as an aim the identification of urban cultivars, (plants cultivated in cities) if any, that were colonizing the oak woodlots (Mudrak, 1978). The increasingly mesic conditions of the forests appeared conducive to colonization by cultivars, since most are derived from species native to floodplains and bottomlands.

METHODS

Fifteen oak islands were chosen for study; they ranged in size from 2.3 to 32.4 hectares. Trees, shrubs, and ground layer species were sampled in each island, using a linear series of nested quadrats (Levenson, 1976). Stem counts were made in the overstory and shrub layers. In the ground layer, herbaceous cover was estimated, while woody seedlings were counted to provide data on reproduction.

In each stand importance values were calculated for all tree species. These values were multiplied by species adaptation numbers to determine the position of each stand on the continuum (stand continuum index).

The Shannon diversity index calculated for each stand (Pielou, 1975) combines the number of individuals (equitability) with species richness (the number of species present).

RESULTS

The oak forests of southeastern Wisconsin are dominated by bur oak *(Quercus macrocarpa),* black cherry *(Prunus serotina),* red oak *(Quercus borealis),* and white oak *(Quercus alba)* (Table 1). Bur oak and white oak are the major species in size classes greater than 42 cm dbh, although they are not restricted to those classes. Contrary to expectation, bur oak had a greater importance value (12.5) than white oak (3.5) in the shrub layer. I had not expected bur oak to reproduce so successfully under a closing canopy.

Island biogeography theory maintains that species diversity and species richness increase with an increase in island size. In my study this occurred, for the woody species, only in those islands larger than approximately eight hectares and then the trend was not statistically significant (Fig. 1).

The great range of species richness and diversity in the smaller islands may have resulted from more environmental variability produced by the greater edge effect in small islands. The selection of 2.3 hectares as the minimum size for my islands was based on the work of Levenson (1976), who found that beech-maple islands less than 2.3 hectares in area were dominated by the tree species and environmental conditions typical of the forest edge. In oak islands, the more open canopy and the well-drained soils may result in a wider forest edge.

The oak forest islands were not colonized significantly by woody species commonly found as cultivars in urban settings. Red cedar *(Juniperus virginiana)* was found in three of the fifteen study sites. In one site, all red cedars present occurred in a line and were found near long-abandoned building foundations. Presumably, they were planted by a former owner. Red cedar at the other two sites could possibly have been established by seed dispersal from urban or suburban plantings. Birds and, probably some mammals, use the seeds of red cedar for food, but there have been no studies documenting bird transport of red cedar seed.

Other cultivars, more common in mesic and wet-mesic forests in southeastern Wisconsin, are probably limited here by relatively xeric conditions. Hawthorn *(Crataegus* spp.) was not listed by Curtis (1959) as present in either southern dry or dry-mesic forest or in oak openings. However, hawthorn occurred in 53% of my stands. Hawthorn is readily disseminated by birds and probably invaded the oak openings after fires ceased. Establishment seems favored by disturbance such as grazing and, since hawthorn is rarely browsed by cattle it survived the pasturing that was widespread in these woodlots. The absence of hawthorn from the communities examined by Curtis may be a function of stand selection; only stands lacking in recent disturbance were selected for his studies. Species of the genus *Crataegus* hybridize readily and have produced a complex of many forms difficult to identify. Both native and European species and their hybrids expanded rapidly throughout the midwest following settlement.

Box elder *(Acer negundo)* is near the northern limit of its range in southeastern Wisconsin, where it was originally restricted to streamsides and bottomlands. The trees found in five of my study sites probably escaped from cultivation in nearby homesteads or villages. Box elder was valued for rapid growth and

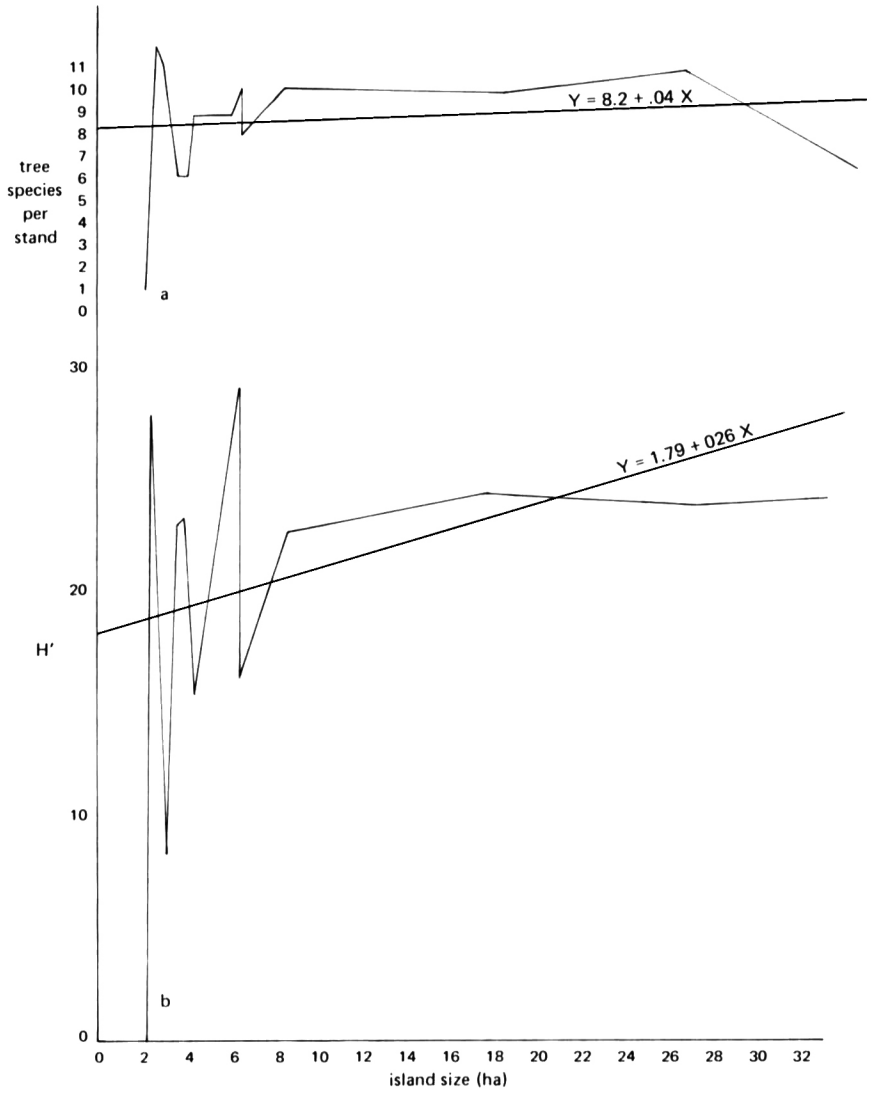

Fig. 1 (a) Species richness and (b) Shannon-Weiner diversity index (H') as a function of island size.

relatively dense shade. Wind-dispersed seeds make long-range colonization by this species possible.

Despite widespread planting of black locust *(Robinia pseudoacacia)* in the area no individuals were found in these oak islands.

CONCLUSIONS

The oak forests of southeastern Wisconsin appear relatively consistent in species composition and probably have shown little change in this regard since European settlement, perhaps because they were originally forest islands in a prairie matrix and remain as islands in an agricultural setting. Elimination of periodic fire permitted the oak savanna to develop into oak forest. Apparently the degree of separation between islands and the xeric nature of the sites restrict invasion by exotic species established as cultivars in nearby villages and farmsteads.

Neither tree species richness nor tree species diversity could be predicted from island size, substantiating the belief that colonization and extinction dynamics differ appreciably between oceanic and terrestrial islands. Local seed sources are available for a limited number of adapted species and distance from seed source appears more important than island size.

In the oak forest islands, the edge effect appears to extend further into the stand than in the beech-maple forests studied by Levenson (1976); apparently an oak island requires a minimum size of approximately seven to eight hectares to prevent domination by edge species.

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Table 1. Woody species importance values for all oak islands (Mudrak, 1978)

Stands listed according to continuum index from dry to dry-mesic

Species according to Climax adaptation value	Mills woods	Union Grove #1	Union Grove #2	Milw. Co. Park	Dominski woods	Highway 36	Muir Ski Trail	Nelson woods
Cornus mas						3.4		
Cornus racemosa		3.1	1.2			1.3		1.6
Crataegus Spp.			1.2	25.2		6.1		
Juniperus virginiana		1.3						
Acer negundo			3.8		12.8	3.6		
Populus tremuloides		1.3		1.2				
Quercus macrocarpa	100.0	57.8	24.5	27.9	14.7	11.8	25.3	
Quercus velutina								4.0
Prunus serotina		13.1	37.9	6.4	19.4	21.7	18.4	46.6
Quercus alba			9.7		25.5	12.7	7.1	26.6
Carya ovata		22.2	8.5	7.1	2.4	12.3	15.2	
Populus grandidentata				1.4				
Quercus borealis			7.0	22.6	25.1	14.3	22.2	11.7
Fraxinus americana						1.5		
Tilia americana				3.3		1.5		
Ulmus rubra		1.3	1.2			9.7	10.6	9.4
Carya cordiformis				0.7				
Ostrya virginiana				4.4				
Acer saccharum								
Stand continuum index	300	659	887	922	1001	1137	1195	1224

a) Species present in only one stand: *Cornus alternifolia, Prunus virginiana, Morus rubra, Juglans nigra, Carpinus caroliniana* and *Fagus grandifolia.*

Table 1 continued.

Species according to Climax adaptation value	Paris woods	Austin woods	Bell School	Oster woods	Bartz #2	Minooka Park	Section 20
Cornus mas					2.1		
Cornus racemosa					3.1		
Crataegus sp.	1.1	2.6	1.7	1.2		2.1	
Juniperus virginiana	1.8						
Acer negundo		6.5			2.5		
Populus tremuloides						1.2	
Quercus macrocarpa	14.9	8.4	5.6	1.6	15.6		
Quercus velutina			4.0				
Prunus serotina	16.5	18.1	21.1	34.0	17.9	9.8	3.4
Quercus alba	19.4	34.2	10.7	24.6		15.0	26.6
Carya ovata	24.8	1.9	15.5		10.7	15.7	8.6
Populus grandidentata	0.7		3.7				1.0
Quercus borealis	16.8	13.9	33.3	32.9	26.8	5.8	10.1
Fraxinus americana	5.2					0.7	
Tilia americana		4.3		1.2			2.6
Ulmus rubra		7.6					0.8
Carya cordiformis	8.0					3.6	
Ostrya virginiana		4.7		2.7	18.3	27.6	29.7
Acer saccharum				1.8	3.0	15.8	6.0
	1253	1257	1279	1317	1401	1929	1947