

EFFECTS OF DISTURBANCE ON SPECIES COMPOSITION IN
TWO CENTRAL INDIANA FOREST STANDS

By

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INTRODUCTION

Very little is known about changes in natural vegetation at the time scale of 100-200 years, which coincides with the length of time since European settlement of the central United States. An accurate assessment of rates of vegetation change in natural systems for this interval can be used as a "benchmark" against which to measure changes in disturbed systems.

In this study, I compared species attributes from different time periods in Ginn Woods, an undisturbed forest stand. I also evaluated the effects of disturbance upon species composition by comparing contemporary data from Ginn Woods with data from the Cooper Memorial Woodland Area, a forest stand disturbed by grazing and browsing activities of herbivores. Both stands occur on similar soils and experience similar climatic conditions. Thus, any historical changes in vegetation will probably result from different histories of use, rather than from some underlying environmental differences between the sites.

METHODS

Data Sources

Raw data for the 1822 vegetation were obtained from microfilm copies of original General Land Office (GLO) survey notes. The GLO survey was based on the township and range system in which townships were divided into 36 sections, each one mile square (Leitner and Jackson, 1981). Surveyors used "witness trees" to mark each section corner. These trees were identified

by species and diameter. They also noted species and diameter of trees at quarter sections along the section line (every 1/4 mile). After determining the locations of the Ginn and Cooper Woods regions on the original survey, data on species and diameter were transcribed from the microfilm copy. This GLO surveying method is assumed to be an objective random sample of the forest of a particular land area, although some surveyors appeared to have been biased to a degree (Bourdo, 1956).

The 1967 raw data were taken from an unpublished survey by W.B. Crankshaw, who listed species and diameter for 50 sample plots in the woods. These data included 1,988 individual trees, each of whose diameter was converted to metric units. The data were then sorted by species, summarized by plot, and entered into computer programs to generate size-class distributions and Gini coefficients (described below).

Data concerning current species composition in the Cooper area were provided by an unpublished survey performed by Crankshaw in 1987.

Data Analysis

Data for both stands from 1822 and for Ginn Woods from 1967 were organized according to species and size, and were used to determine such characteristics as density, basal area, and importance value for each species. Density is simply the number of individuals per species. Basal area (BA) is calculated by using diameter to measure cross-sectional area of a tree. Both density and basal area were then converted to relative percentages for each species. Importance value (IV) for each

species was determined by summing relative density (RD) and relative basal area (RBA) and dividing by two. Once calculated, these numbers were used to determine changes in species composition from 1822 to 1967.

Tree diameters from the 1967 data were used to determine Gini coefficients of inequality (Weiner and Solbrig, 1984; Weiner, 1985) for individual species, as well as for all species combined in Ginn Woods. The Gini coefficient (G) is a measure of size hierarchy, or "inequality," representing the degree to which any size measure (here, tree diameter) is concentrated in a small fraction of a population. This coefficient seems to be preferable to other measures of size-class structure such as skewness, coefficient of variation, and kurtosis (Weiner and Solbrig, 1984). The value of G can range from 0 when all individuals are equal (i.e., no hierarchy) to a theoretical maximum of 1.0 when all individuals but one have a value of 0 (i.e. maximum hierarchy; Weiner and Solbrig, 1984). Coefficients for each species were compared to determine if significant differences between species size-class distributions existed. Gini coefficients were determined using a Turbo-PASCAL program (Dixon et al., 1987), which calculated 95% confidence intervals using the bootstrap method of Efron (1982). The Gini coefficient (Gini, 1912) is based on the Lorenz curve, an economic measure of concentration of wealth (Lorenz, 1905).

RESULTS AND DISCUSSION

Comparison of 1822 and 1967 Vegetation

In 1822, the both areas were dominated largely by American beech (Fagus grandifolia). In Ginn Woods, this species accounted for 51.4% of the total density (Table 1). The remaining 48.6% was composed of a fairly even distribution among ten other species. Importance values, which combine density and basal area, also indicated the dominance of beech, which had an IV of nearly 50%.

In the Cooper area, beech shared dominance with white oak (Quercus alba). Shagbark hickory (Carya ovata) and slippery elm (Ulmus rubra) were also relatively important (Table 2).

By 1967, dominance in Ginn Woods had shifted from beech to sugar maple (Acer saccharum). Sugar maple had an IV of nearly 48%, and the IV for beech had dropped to less than 10% (Table 3). Also, the total number of species present had increased nearly three-fold to 31. Importance values calculated by McClain in 1985 also conveyed continued sugar maple dominance. Once the dominant tree in parts of Indiana, American beech's decline in importance is perhaps a result of lowering of the water table precipitated by clearing adjacent forest land for agriculture (Cain, 1935).

Today, Cooper Woods is dominated by white oak and bur oak (Quercus macrocarpa), with some sugar maple, ash, and elm (Crankshaw, personal communication). Beech may have been lost from this stand for the same reasons as speculated for Ginn

Woods. Cooper Woods differs considerably from Ginn Woods in that sugar maple seems to be much less prevalent. It is likely that sugar maple dominance has been reduced by past grazing. Longer-term studies will be necessary to determine if sugar maple can regain dominance following the cessation of grazing.

Size-class Distributions

Gini coefficients for the six most dominant species in Ginn Woods in 1967 indicated significant differences ($P < 0.05$) in size-classes between sugar maple and all other species and between basswood (Tilia americana) and beech (Table 4). The G for sugar maple (0.396) is significantly higher than for the other species. This higher G indicates a greater "inequality" in the size-class distribution; i.e., a larger representation of smaller trees. For other species, G is lower, implying a lesser inequality (or more even distribution among size classes).

Size class distributions (Fig. 1) indicate that most species, especially sugar maple (Fig. 1b), have been successfully reproducing. The abundance of trees in the smaller size classes suggests that seedlings have established. Some of the species, including Ulmus rubra (Fig. 1f) demonstrated a lower proportion of younger stems, which may imply poor reproduction. However, longer term studies would be required to determine if these less common species are having trouble reproducing. Overall, the combination of young stems and seed-producing sugar maple trees indicates that Ginn Woods will continue to be dominated by this species. Importance values calculated by McClain (1985) for the northern portion of the woods reinforce the hypothesis that sugar

maple will maintain dominance, with American beech continuing to be the second most important species.

Size class distribution for the Cooper area was not differentiated

CONCLUSIONS

Ginn and Cooper woods had similar species compositions at the time of settlement (1822). Both have since changed considerably, but not in the same way and not as a result of the same forces. Changes in Ginn Woods (decline of beech and increase in sugar maple) are probably attributable to conversion of surrounding land from forest to agriculture. This land-use conversion may have altered aspects of the physical environment (e.g., water table depth) to such an extent that beech was no longer tolerant of site conditions.

By contrast, changes in Cooper are due to a much less subtle influence; namely, the use of the woods by cattle. Sugar maple is a very palatable species and likely suffered from grazing pressure. Thus, other species such as white oak, are dominant.

TABLE 1

Species attributes for Ginn Woods in 1822. Data are from the original General Land Office Survey notes.

<u>Species</u>	<u>D</u>	<u>BA(m²)</u>	<u>RD</u>	<u>RBA</u>	<u>IV</u>
Fagus grandifolia	19	2.13	51.4	46.0	48.7
Quercus alba	3	1.13	8.1	24.4	16.2
Carya ovata	2	0.32	5.4	6.9	6.2
Fraxinus americana	3	0.18	8.1	3.9	6.0
Aesculus glabra	3	0.09	8.1	1.9	5.0
Celtis occidentalis	1	0.34	2.7	7.3	5.0
Ulmus rubra	1	0.29	2.7	6.3	4.5
Ostrya virginiana	2	0.02	2.7	0.4	2.9
Acer saccharum	1	0.10	2.7	2.2	2.4
Quercus rubra	1	0.02	2.7	0.4	1.6
Carpinus caroliniana	1	0.01	2.7	0.2	1.4
	<u>37</u>	<u>4.63</u>	<u>100</u>	<u>100</u>	<u>100</u>

TABLE 2

Species attributes for Cooper Woods in 1822. Data are from the original General Land Office Survey notes.

<u>Species</u>	<u>D</u>	<u>BA(m²)</u>	<u>RD</u>	<u>RBA</u>	<u>IV</u>
Fagus grandifolia	8	0.87	28.6	22.1	25.4
Quercus alba	4	1.16	14.3	29.4	21.9
Ulmus rubra	4	0.58	14.3	14.7	14.5
Carya ovata	3	0.38	10.7	9.6	10.2
Fraxinus americana	2	0.26	7.1	6.6	6.8
Quercus rubra	1	0.20	3.6	5.1	4.4
Quercus velutina	1	0.20	3.6	5.1	4.4
F. pennsylvanica	2	0.16	3.6	4.1	3.8
Ostrya virginiana	2	0.01	7.1	0.03	3.7
Acer saccharum	1	0.07	3.6	1.8	2.7
Morus rubra	1	0.05	3.6	1.3	2.4
	<u>28</u>	<u>3.94</u>	<u>100</u>	<u>100</u>	<u>100</u>

TABLE 3

Species attributes for Ginn Woods in 1967. Data are from
W.B. Crankshaw (unpublished).

<u>Species</u>	<u>D</u>	<u>BA(m²)</u>	<u>RD</u>	<u>RBA</u>	<u>IV</u>
Acer saccharum	224.9	12.31	46.57	49.36	47.97
Fagus grandifolia	45.3	1.93	9.38	7.75	8.56
Tilia americana	35.8	2.02	7.41	8.10	7.76
Fraxinus americana	34.8	1.58	7.21	6.35	6.78
Ulmus rubra	24.3	0.68	5.03	2.73	3.88
Populus deltoides	7.4	0.99	1.53	3.99	2.76
Celtis occidentalis	14.2	0.40	2.94	1.61	2.28
Aesculus glabra	13.0	0.35	2.69	1.40	2.04
Acer nigrum	10.0	0.50	2.07	1.99	2.03
Quercus bicolor	4.4	0.69	0.91	2.74	1.82
Carya ovata	6.9	0.51	1.43	2.04	1.74
Carpinus caroliniana	12.3	0.11	2.45	0.43	1.44
Ulmus americana	10.5	0.16	2.17	0.64	1.40
Prunus serotina	5.9	0.34	1.22	1.37	1.30
Acer saccharinum	3.4	0.46	0.70	1.84	1.27
Carya cordiformis	5.4	0.35	1.12	1.40	1.26
Fraxinus nigra	6.4	0.20	1.32	0.81	1.06
Other*	22.7	1.46	4.70	5.86	5.28
	<u>482.9</u>	<u>24.93</u>	<u>100</u>	<u>100</u>	<u>100</u>

* Species with importance values < 1.0, in alphabetical order:
Acer negundo, Asimina triloba, Crataegus spp., Gymnocladus
dioica, Juglans nigra, Liriodendron tulipifera, Ostrya
virginiana, Platanus occidentalis, Quercus alba, Q. macrocarpa,
Q. rubra, Q. velutina, Ulmus crassifolia, U. thomasii

TABLE 4

Differences in Gini coefficients for tree species
prevalent in Ginn Woods. Pairs marked with an
asterisk differ significantly ($P < 0.05$)

	Ulmus	Fraxinus	Fagus	Tilia	Acer
Ulmus	---	.020	.046	.003	.077*
Fraxinus		---	.027	.016	.058*
Fagus			---	.043*	.031*
Tilia				---	.074*
Acer					---

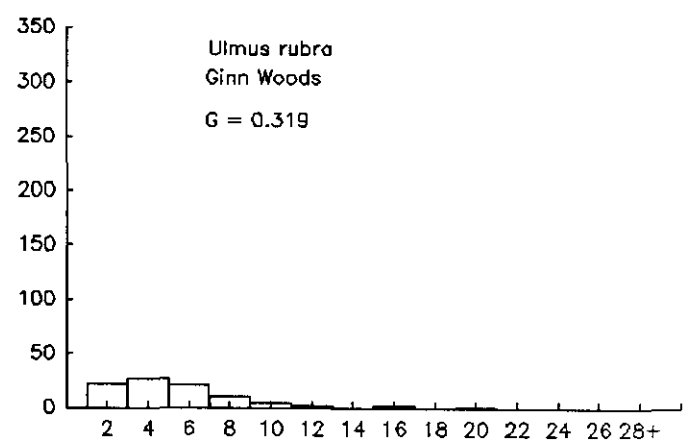
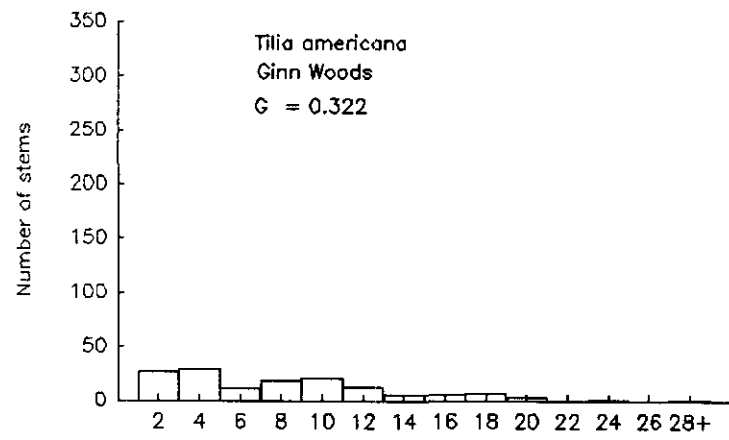
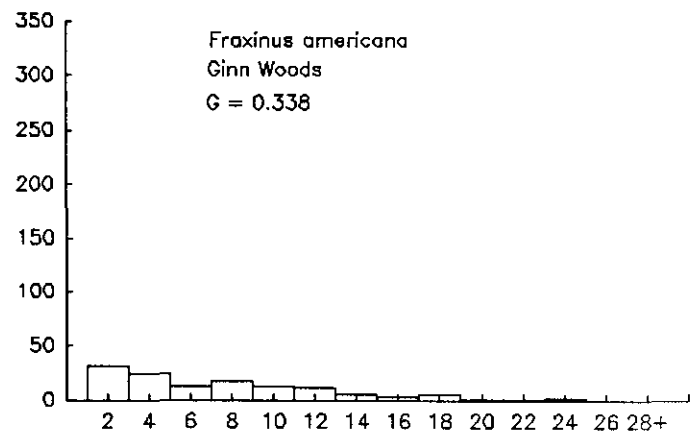
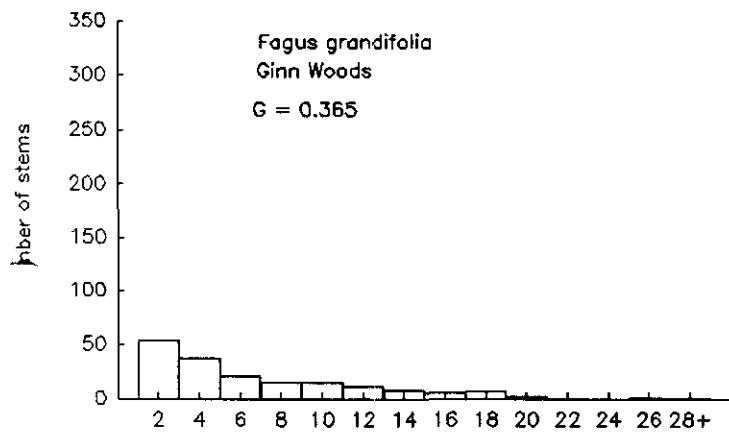
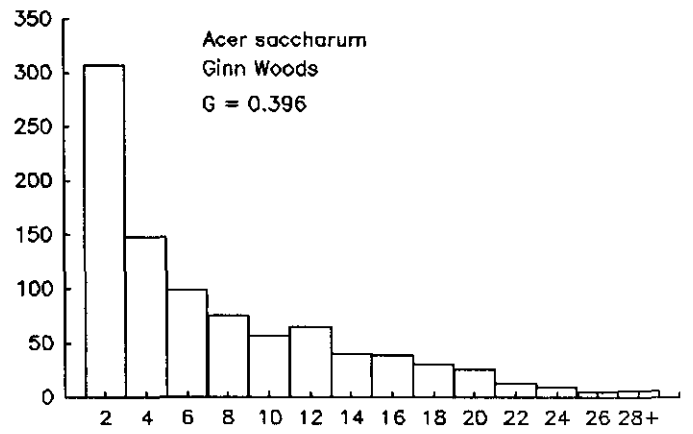
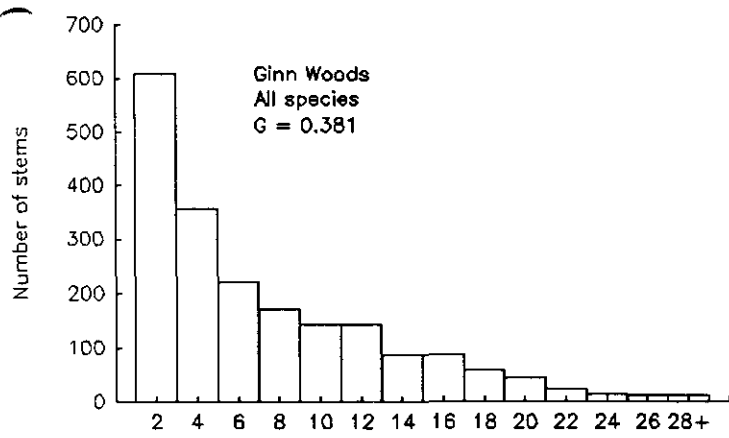


Figure 1. Size-class distributions and Gini coefficients for selected tree species in Ginn Woods (1967).

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