Post Wind Damage Survey of Herbaceous Level in Bendix Woods Nature Preserve, St. Joseph County, Indiana

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The Bendix Woods Nature Preserve, an old growth beech-sugar maple-black maple forest, is located in western St. Joseph County, ca. 19 km west of South Bend, Indiana. This report is part of a larger study (5) initiated in the spring of 1981 to assess the damage caused when consecutive windstorms on July 5 and 9, 1980 extensively damaged about 25 percent of the preserve area.

Two previous papers (2,5) describe the historical and physical features of the preserve area as well as the flora and community parameters of the canopy/small tree levels of the forest community.

One additional objective of our study is to provide base line data for continuing studies of the forest recovery process. This report presents the data for 100 random, circular, permanent herbaceous level plots established in May, 1981 and resurveyed in the springs of 1982 and 1983.

Methods

The coordinates for 100 herbaceous quadrat sites (Table 1) were selected using a random numbers table. Two sets of three sequential numbers were obtained from the table. The first set determined the distance in meters west of the southeast corner post of the preserve. The second set determined the distance north. If the grid point was outside of or within 20 m of the edge of the preserve, a new set of numbers was drawn. Since the western boundary of the preserve was not clearly defined by a fence or trail, the western limit was set at 400 m west which corresponds to the western edge of the old growth forest. The numbers were plotted on the preserve base map in the sequence they were drawn.

Plots were located in the field by pacing from known reference points, i.e. the marked corners of the 50 m square quadrats being established for canopy inventory (5). Plots initially located in a trail were moved 2 m in the compass direction of the trail's nearest edge. All plots were at least 1.5 m from the edge of a trail. Each plot was marked by a 1.9 cm by 61 cm galvanized iron pipe driven in the center of the plot.

The plots were established and inventoried during the period May 18 through 28, 1981. In addition, a determination of the disturbance status of the plot was made using three categories, 1) undisturbed, 2) disturbed in July, 1980 windstorms, and 3) disturbed by a neary trail or recent windthrow that occurred before 1980 (See Status Column in Table 1). Plots were inventoried by using an L shaped rod placed in a cork in the top of the pipe. The length of the rod (0.6 m) defined the radius of the plot. All herbaceous species and woody species less than one meter tall within the radius were recorded. The number of individuals was recorded for tree species and two herbaceous species (*Phytolacca americana* and *Impatiens pallida*). The plots were

TABLE 1. *Location and disturbance category of 100, 1.2 m diameter plots in Bendix Woods Nature Preserve, St. Joseph County, Indiana. (1)*

Plot		Distance		Plot		Distance		Plot		Distance	
#	S	W	N	#	S	W	N	#	S	W	N
1	U	138	106	2	D1	267	172	3	D1	358	96
4	U	364	159	5	D1	194	133	6	U	355	231
7	D1	287	236	8	D2	353	259	9	U	278	146
10	D1	275	223	11	U	319	80	12	D1	354	72
13	D1	359	135	14	D1	227	177	15	U	321	37
16	D1	353	93	17	U	273	30	18	D1	280	312
19	U	135	140	20	D1	360	146	21	U	245	69
22	D1	273	291	23	D1	261	232	24	D2	281	181
25	U	322	158	26	U	246	76	27	U	396	179
28	U	247	135	29	D1	369	80	30	D1	265	304
31	D1	282	214	32	D1	277	246	33	U	151	99
34	D1	343	111	35	U	133	123	36	D1	163	46
37	U	349	187	38	D1	336	240	39	U	107	108
40	U	369	206	41	D1	352	96	42	D1	253	154
43	D2	164	80	44	D1	345	71	45	D1	279	250
46	D1	173	133	47	D1	251	159	48	U	87	91
49	U	114	62	50	U	47	21	51	U	312	269
52	U	253	30	53	U	366	105	54	U	47	46
55	U	246	27	56	U	41	76	57	D1	305	197
58	D1	302	176	59	U	254	110	60	U	371	226
61	U	117	61	62	D1	280	233	63	D1	310	210
64	D2	322	131	65	D2	212	90	66	U	67	86
67	U	128	60	68	U	384	204	69	D1	335	235
70	U	227	84	71	D2	302	139	72	D1	266	238
73	D1	265	135	74	U	323	235	75	U	113	109
76	D2	259	127	77	U	356	171	78	D1	346	75
79	U	305	265	80	U	352	159	81	D1	321	224
82	U	161	149	83	D1	356	145	84	D1	231	173
85	D1	269	268	86	U	339	96	87	U	392	127
88	U	168	120	89	U	298	33	90	U	334	145
91	U	294	242	92	U	233	103	93	D1	221	109
94	D1	264	292	95	D2	147	65	96	U	329	66
97	U	391	240	98	D2	108	105	99	U	334	211
100	D2	123	40								

1. Distance is measured in meters from the southeast corner post of chainlink fence. The W and N are the distances west and north of corner post. Plots are marked with 1.9 X 61 cm galvanized pipe driven in center of plot. The S under Plot refers to disturbance category: U-no recent disturbance, D1-plot impacted by 1980 windthrows, and D2-plot near trail or other evidence of disturbance.

inventoried again in the fall of 1981, twice in the spring of 1982 (April 22-30 and May 18-24) and twice in the spring of 1983 (May 4-10 and May 27-June 2).

Results and Discussion

Eighty two taxa were recorded within the 100 random plots. Since species distinctions were not made for four genera of tree species, *Acer*, *Ulmus*, *Fraxinus* and *Prunus*, the eighty two taxa represent 73 percent of the species reported for the preserve (2). A majority of the species not included in the random samples were either relatively rare within the preserve or had a limited distribution. In general, the distribution of plots resulted in the sample containing most of the topographic, soil and community variation within the preserve as well as nearly equal numbers of plots in disturbed and undisturbed areas.

Table 2 presents the frequency data for all species present in five percent or more of the plots. (A complete list of species and their frequencies may be obtained from the senior author or Indiana Division of Nature Preserves.) Species are listed in descending order of the 1982 frequency values calculated from total (100 plots) presence data.

TABLE 2. *Frequency values for taxa in 100 random, circular, permanent plots in Bendix Woods Nature Preserve in western St. Joseph County, Indiana. Data collected in the springs of 1981, 1982 and 1983. Species with values less than 5 percent are not included.*

	Frequency (%)[1]								
	All			U			D1		
Species	81	82	83	81	82	83	81	82	83
Galium aparine	95	98	85	94	99	88	97	95	80
Dicentra canadensis	82	78	76	80	74	78	82	82	75
Claytonia virginica	28	78	69	40	92	80	12	62	55
Dicentra cucullaria	63	71	88	64	66	82	57	70	92
Acer saccharum	55	70	57	52	72	50	55	67	62
Impatiens pallida	54	66	70	30	36	44	75	97	97
Erythronium americanum	11	49	43	8	50	44	15	47	40
Isopyrum biternatum	42	44	43	40	44	44	45	47	45
Parthenocissus quinquefolia	38	42	47	38	46	48	35	40	47
Dentaria laciniata	10	35	36	14	42	50	0	25	15
Smilacina racemosa	29	34	34	34	40	38	20	25	27
Erigenia bulbosa	7	29	25	10	36	32	5	17	12
Viola pensylvanica	28	28	30	34	34	36	17	17	20
Ulmus sp.	19	27	35	16	26	28	25	30	45
Viola canadensis	21	22	23	24	24	24	17	20	22
Arisaema atrorubens	18	22	26	20	18	22	15	25	27
Osmorhiza claytoni	19	21	30	18	18	22	15	15	37
Lindera benzoin	19	19	19	18	20	18	15	15	15
Floerkea proserpinacoides	21	19	25	26	24	32	10	10	12
Carya cordiformis	21	19	17	22	18	16	20	17	15
Asarum canadense	11	18	20	18	26	26	5	12	17
Phlox divaricata	18	17	23	24	20	30	15	17	20
Asimina triloba	14	16	21	12	12	18	7	12	17
Euonymus obovatus	9	14	10	10	16	14	10	15	7
Polygonatum pubescens	10	13	13	6	10	12	12	12	10
Sanicula trifoliata	10	12	14	16	18	16	2	5	10
Prunus sp.	4	11	9	2	8	10	7	10	5
Hydrophyllum appendiculatum	10	11	10	4	6	8	20	20	15
Trillium grandiflorum	8	10	8	10	10	8	7	12	10
T. flexipes	3	7	5	6	12	8	0	2	2
Phytolacca americana	11	7	10	0	0	0	25	17	25
Caulophyllum thalictroides	4	7	5	4	6	4	5	7	7
Osmorhiza longistylis	7	6	9	8	6	4	7	7	17
Podophyllum peltatum	5	5	5	6	6	6	5	5	5
Geranium robertianum	7	5	6	4	2	2	12	10	12
Circaea quadrisulcata	6	5	9	10	6	10	2	5	7
Stylophorum diphyllum	5	4	4	0	0	0	10	7	7
Phryma leptostachya	4	4	8	6	4	8	0	5	7
Hydrophyllum canadense	4	4	5	8	8	8	0	0	2
Fagus grandifolia	10	4	9	14	4	12	7	2	7
Carex albursina	3	4	5	0	0	0	7	10	12
Tovaria virginiana	2	3	5	4	2	6	0	5	5
Geum canadense	2	2	5	2	2	2	2	2	10

1. The abbreviations above the columns represent: U-undisturbed plots, D1-plots in 1980 windthrow area, All-all the data from the 100 plots and the numbers below a subheading are the last two digits of the year of inventory.

Values for 1982 and 1983 are based on the combined results of both early and late spring surveys, whereas 1981 values are based on a single mid- to late spring inventory supplemented by a partial late fall survey. Since the 1981 inventory period extended past the normal senescence dates for *Claytonia virginiana, Erigenia bulbosa, Erythronium americanum* and *Dentaria laciniata*, their 1981 values are too low. The visible presence of corms of *Dicentra* sp. during the fall 1981 inventory enabled us to correct the spring values and calculate accurate frequency values for these two early spring species.

In addition to total frequency values, the table contains the frequency values for undisturbed plots (50 plots) and plots within the area damaged by the July, 1980 windstorms (Disturbed, 40 plots). Plots in the latter category range from being located under windthrown tops to no physical disturbance of plot but canopy above the plot is gone. None of the random plots are located on a fresh windthrow mound or within a pit but a few plots are on older windthrow mounds within the new windthrow area. The remaining ten plots are in areas of past disturbance or near trails. Since one objective is to assess the impact of the July, 1980 storms, these plots are not used in comparison of disturbed and undisturbed areas.

The ranking of the top twenty species in Table 2 varies from year to year, particularly between disturbed and undisturbed plots. *Galium aparine* has the highest frequency value for both total plots and undisturbed plots for all three years but ranks behind *Impatiens pallida* in disturbed plots in 1982 and 1983. *Impatiens* ranks tenth in the undisturbed plots. Most spring ephemerals have high frequencies and dominate the top ten species in Table 2 although *Dentaria laciniata* has a lower rank in disturbed plots. Two other ephemerals, *Erigenia bulbosa* and *Floerkea proserpinacoides* have considerably lower frequencies in disturbed versus undisturbed plots. *Phytolacca americana*, a summer species, is not present in undisturbed plots but ranks in the top 20 species in disturbed plots.

If cover data had been collected, *Galium aparine* would have a lower ranking in all categories and years since it does not form the extensive, dense early spring colonies like *Dicentra* sp., *Isopyrum* and *Impatiens pallida*. The decision not to collect cover data may have resulted in the loss of important information. Rogers (6), in a study of the effects of an extremely warm and dry early spring on herbaceous flora, found no significant differences in number of species or frequency values but did find significant differences in cover values. The limited time we had available to establish and inventory the plots in 1981 was the major reason we decided not to collect cover data. We have not been able to inventory the plots in less than two days and usually the inventory periods were separated by one to several days. We have observed over the past three springs, fairly rapid changes in cover within periods as short as three days.

Levenson (3) included Bendix Woods as one of 21 stands he sampled in a study of the herbaceous level of the beech-maple forest region. Since his data were collected in mid-summer, none of the spring ephemerals was included. His table for Bendix Woods lists 45 species, including three species not found in our plots. One of these species, *Mitella diphylla*, was not located by us. Four species, *Impatiens pallida, Parthenocissus quinquefolia, Acer saccharum* and *Viola pensylvanica*, had frequency values of 50 or greater and the first two accounted for 63 percent of the total stems. Beyond his top five species, there were considerable differences between species rankings in the two sets of data.

The major change in the herbaceous layer in the windthrow areas has been the explosive growth of the *Impatiens pallida* population. We visited the windthrow area in September, 1980, two months after the storms, and the abundant growth of *Impatiens* was evident in much of the area. One other herbaceous species, *Phytolacca*

americana, appeared to be increasing in the damaged areas. This was the main reason we decided to collect density data for these two species when we established and inventoried the plots in May, 1981. For all sampling periods except September, 1983, the density of *Impatiens* was significantly greater in the disturbed areas of the preserve although the individual plot values were more variable than in undisturbed plots. Some of the disturbed plots had so much debris on them, only a few species or individuals were present.

Throughout the windthrow area, *Impatiens pallida* seedlings form dense stands by late April although germination is not complete until May. The large cotyledons effectively cover most of the available space and, as the stems elongate and leaves expand, the *Impatiens* canopy forms dense shade. The plants mature rapidly and begin flowering by mid June and continue until frost. Plants usually reach maximum size by late July with some stems more than 2 meters tall and the population forms a dense thicket over large areas. This is the major reason we did not attempt to inventory the plots in mid-summer.

The maximum stem count for *Impatiens* was 345 stems in a plot. Our field observations indicate that mortality is high from germination to maturity. At first, germinating individuals replace many of the dying individuals until peak density is reached in early May, then there is a decline in numbers to maturity. The April density values in Table 3 are prior to peak density and the May, 1982 values are after peak density. The early May 1983 values probably record peak density and the effects of mortality are shown by the decline in late May. The summer of 1983 was hot and dry and the stand never reached the robustness of 1981 or 1982. We did not do a summer inventory but the early fall inventory, completed before a frost, indicates that few individuals survived.

The dramatic increase in size of the *Impatiens* population must be due to a soil seed bank or some dispersal mechanism other than the explosive capsule. It is not one of the ant dispersed species as are many of the other forest floor herbs (1). Since *Impatiens* does occur fairly frequently and in low but constant numbers in the undisturbed plots, there is probably a fairly good seed pool in most areas of the forest. Levenson (3) reported *Impatiens* densities more than double our highest average values for undisturbed plots. Since his plots appear to have been located in the windthrow and adjacent areas, the initial population density of *Impatiens* may have been higher

TABLE 3. *Density values for* Impatiens pallida *for Bendix Woods Nature Preserve based on date from 100, 1.2 m diameter, permanent plots surveyed in the springs of 1981, 1982 and 1983.*

Sampling dates:	Density (#/m^2) Total Avg. 95% conf.	Undisturbed Avg. 95% conf.	Disturbed Avg. 95% conf.
1981			
May 18-24	13.0 6.7-19.6	1.4 0.4-2.3	29.9 14.8-45.0
1982			
Apr 22-30	18.5 11.1-25.9	1.9 0.7-3.2	39.2 23.1-55.2
May 18-24	24.0 15.8-32.2	2.9 0.7-5.1	51.6 34.8-68.3
1983			
May 4-10	27.2 18.0-36.4	3.3 1.1-5.5	59.1 40.4-77.8
May 27-Jun 2	21.7 15.2-28.1	3.1 1.1-5.0	46.1 33.9-58.3
Sep 21-26	0.4 0.1-0.8	.02 0.0-.05	1.1 0.3-1.8

than our data would indicate. No data on seed production was obtained in either disturbed or undisturbed areas.

One of our objectives is to obtain base line data to study forest regeneration in the preserve. Therefore, we tallied the number of tree seedlings in each plot. The density values for the five species with highest values are presented in Table 4. No clear seedling response to the windthrow disturbance by any of the tree species is indicated by the data or field observations. *Acer* seedling frequency and density values are the highest for all tree seedlings and are distantly followed by *Ulmus* and *Carya cordiformis*. *Acer* ranks in the top ten frequencies in the herbaceous layer and *Ulmus* is in the top 20.

As stated earlier, the fall 1983 inventory was made because St. Joseph County experienced one of the hottest and driest summers on record. Based on the data in Table 4, the impact on tree seedlings was slight except for *Prunus serotina*. The *Prunus* data may be wrong since the seedlings may have lost their leaves earlier than normal and were not recorded.

Chi Square, Cole's and Poole's point correlation association coefficients (4) were calculated for 1982 and 1983 data for all species pairs that occurred in ten or more plots i.e. species with total frequency values of 10 or larger in Table 2. Fifteen species had chi square values that were significant at the 95 percent level for both 1982 and 1983. Three taxa, *Acer, Dentaria* and *Floerkea*, had three or more associations. *Viola canadensis* was negatively associated with *Floerkea* and positively associated with *Ulmus*

TABLE 4. *Density values for tree seedlings less than one meter tall in 100 random, 1.2 m diameter plots in Bendix Woods Nature Preserve, St. Joseph County, Indiana.*

		Density Values (#/m^2)							
		Spring						Fall	
Species		1981		1982		1983		1983	
(1)	(2)	Avg.	SE	Avg.	SE	Avg.	SE	Avg.	SE
Acer saccharum	A	1.68	0.27	3.96	0.56	1.92	0.32	1.29	0.21
	U	2.01	0.48	5.04	0.87	2.05	0.53	1.22	0.31
	D	1.06	0.21	1.94	0.41	1.81	0.45	1.39	0.33
Asimina triloba	A	0.12	0.03	0.26	0.10	0.15	0.04	0.19	0.05
	U	0.11	0.04	0.30	0.18	0.14	0.06	0.18	0.07
	D	0.07	0.04	0.11	0.05	0.07	0.04	0.13	0.06
Carya cordiformis	A	0.23	0.05	0.22	0.05	0.20	0.05	0.18	0.05
	U	0.27	0.08	0.25	0.08	0.21	0.07	0.21	0.08
	D	0.20	0.07	0.18	0.06	0.13	0.05	0.13	0.06
Prunus serotina	A	0.04	0.02	0.15	0.06	0.13	0.05	0.0	0.0
	U	0.02	0.02	0.14	0.09	0.14	0.07	0.0	0.0
	D	0.08	0.05	0.13	0.07	0.07	0.05	0.0	0.0
Ulmus rubra	A	0.28	0.07	0.37	0.07	0.43	0.08	0.28	0.06
	U	0.21	0.10	0.39	0.11	0.27	0.07	0.21	0.08
	D	0.38	0.13	0.35	0.09	0.68	0.17	0.40	0.11

1. *Acer saccharum* includes *A. nigrum*. *Ulmus rubra* may include a few *U. americana*. Other species present in small numbers are: *Celtis occidentalis, Fagus grandifolia, Fraxinus* sp., *Liriodendron tulipifera, Quercus rubra* and *Tilia americana*.

2. The letters in column represent: A-all plots, U-undistrubed plots and D-plots in July 1980 windthrow area. The row to the right of number: Avg.-average number per square meter and SE-standard error of mean.

rubra. The remaining four taxa have simple positive associations, *Polygonum pubescens* with *Arisaema atrorubens* and *Asarum canadense* with *Sanicula trifoliata*.

Acer seedlings are positively associated, in both years, with *Claytonia virginiana, Erythronium americanum, Parthenocissus quinquefolia* and *Ulmus* sp.. *Ulmus* is a common canopy associate with beech and maple in Bendix Woods and its association with maple at the forest floor should be expected. The other species are common members of the mesic forests in northern Indiana, particularly beech-maple forests.

Floerkea proserpinacoides is positively associated with *Smilacina racemosa, Erigenia bulbosa* and *Dentaria laciniata*. *Dentaria* is positively associated with *Erigenia* also. Both *Dentaria* and *Floerkea* are negatively associated with *Isopyrum biternatum*. *Isopyrum* forms dense robust colonies and few other species are found in the same quadrats. Also, our observations of spring flowering indicate that the flowering periods of the above positively associated species only slightly overlap whereas *Isopyrum* overlaps all of them.

Summary

One hundred, 1.2 m diameter permanent plots were established and inventoried in Bendix Woods Nature Preserve in May 1981. Only species presence was recorded for a majority of the herbaceous and shrub species. Number of individuals was recorded for all tree seedlings less than one meter tall and for two herbaceous species, *Impatiens pallida* and *Phytolacca americana*.

Species with frequency values greater than 50 percent were: *Galium aparine, Dicentra canadensis, D. cucullaria, Claytonia virginica, Impatiens pallida* and *Acer* sp. *Impatiens pallida* had the greatest population growth, size and numbers, response to the opening of the canopy by the July 1980 wind storms. *Impatiens* population densities averaged 59 individuals per m^2 in the disturbed area in early May, 1983. Maple had the greatest density among the tree seedlings with elm a distant second.

The chi square test was used to determine siginificant species associations. *Isopyrum biternatum* was the only species that was negatively associated with four other species at the 5 percent level. Two of the species involved, *Dentaria laciniata* and *Floerkea proserpinacoides*, were positively associated with each other and several other species.

Acknowledgments

We are grateful for grants-in-aid provided by Indiana Academy of Science and Indiana University at South Bend. Computer time and servies of the IUSB Computer Center are gratefully acknowledged. We thank the Indiana Division of Nature Preserves and the St. Joseph County Parks and Recreation Board for permission to use Bendix Woods Nature Preserve and park facilities.

Literature Cited

1. Beattie, A. J. and D. C. Culver. 1981. The guild of myrmecochores in the herbaceous flora of West Virginia forests. Ecology 62: 107-115.
2. Blodgett, T. D. and V. L. Riemenschneider. 1983. Vascular plants of Bendix Woods Nature Preserve, St. Joseph County, Indiana. Proc. Ind. Acad. Sci. 92: 375-378.
3. Levenson, J. B. 1973. The herbaceous stratum of the beech-maple forest: A community structure analysis. M.A. thesis, Indiana State University, Terre Haute. 134p.
4. Poole, R. W. 1974. An introduction to quantitative ecology. McGraw-Hill, New York. 532p.
5. Riemenschneider, V. and T. D. Blodgett, 1983. Full tally inventory of 4 + cm woody

individuals in Bendix Woods Nature Preserve, an old growth beech-maple forest. Proc. Ind. Acad. Sci. 92: 207-211.
6. Rogers, R. S. 1983. Annual variability in community organization of forest herbs: Effect of an extremely warm and dry early spring. Ecology 64: 1086-1091.