Thirty Years of Growth Records in Donaldson's Woods

James D. Barton
Newfane, Vermont 05345
and
Damian V. Schmelz
Saint Meinrad College
St. Meinrad, Indiana 47577

Introduction

Donaldson's Woods, now dedicated as a Nature Preserve, is an 80-acre remnant of original mixed woods forest (3) in Spring Mill State Park, Lawrence County, Indiana. During the summer of 1984 the third 10-year study was made of 19.6 acres of all trees 4-in. d.b.h. and over as measured by diameter tape. In 1954 (1) a 37 × 18 ft. two dimensional map was constructed showing the position, diameter and basal area of each tree. Data on each tree in 1964 (2) and 1974 (4) were recorded directly on the 52 map sections (each 31 × 67 in.) in the field; trees new to the lowest size-class were added to the map, and trees that had died were deleted.

Methods

In preparation for the latest study the first author entered all previous data on Donaldson's Woods onto computer, which generated 11 × 17 in. map sections and comprehensive field data sheets. These were used in the field to record 1984 data. Tree-by-tree comparison on new and old map sections corrected some inaccuracies in the data of the previous studies. George Parker, Purdue University, Paul MacMillan, Hanover College and Mark Kurzendoerfer, Mater Dei High School, Evansville, assisted in the field.

For each 10-year study density and basal area were calculated for each species and each 4-inch size-class. Relative density and relative basal area for each species were averaged to give an importance value. Analysis of these attributes reveals changes and suggests trends in composition, distribution and dominance.

Data are now being converted to metric units for future analyses. Maps, data and computer program will be housed with both authors for future studies.

Lowest-Size-Class

The composition of an undisturbed old growth forest and species dominance are determined mainly throughout the higher size-classes. Significant changes can be detected not only by the rate of growth and survival among the larger trees but also by the number of accessions and deaths in the lowest size-class (4.0-7.9 dbh). These data (Table 1) show that the total number of trees has declined through each decade, by 37% over the 30 years from 1118 to 704. The number of new trees increaed from 145 to 195 (34%); however, the number dying also increased from 130 to 246 (89%). Sugar maple[1] has continued to be the most prolific; nearly half of all trees in this size-class are this species. Through every decade it has shown more accessions than deaths. Second in numbers, beech decreased through each decade, by 48% over the 30 years from 374 to 196. White and green ashes rank a distant third. The pattern observed previously continued for the oaks and the hickories: poor representation, few accessions in the first 20 year and none at all in the last 10 years, high mortality.

Mortality

Much of the mortality among the higher size-classes was due to windthrow, but also there were many trees standing dead from causes unknown. Shading and competi-

TABLE 1. Total number, accessions and deaths of trees in the six-inch size-class, 1954-84.

Species	Total				New			Died		
Qa	79	55	24	7	4	1	0	21	27	20
Fg	374	315	255	196	23	20	30	33	26	50
As	347	367	329	332	81	73	116	11	45	76
Co/Cl	41	35	19	6	1	2	0	7	16	11
Qr	6	2	3	0	0	1	0	1	0	3
Ns	39	28	25	20	2	4	5	10	4	13
Ar	63	57	42	34	1	4	7	8	7	8
Cg	43	32	24	4	5	1	0	15	8	19
Fa/Fp	55	58	56	50	13	12	17	8	10	26
Qv	0	0	0	0	0	0	0	0	0	0
Lt	4	3	0	3	0	0	3	0	1	0
Ov	30	29	26	31	3	6	9	4	7	8
Cc/Ct	5	6	2	1	1	0	0	0	4	1
Cf	20	23	14	13	5	2	5	8	10	8
Others	12	9	6	7	0	2	3	4	4	3
Total	1118	1019	825	704	145	128	195	130	169	246
Per Acre	57.0	52.0	42.1	35.9	7.40	6.53	9.95	6.63	8.62	12.6

tion undoubtedly were responsible for the very high mortality in the lowest size-classes. The bridle trail of previous decades has been removed and is no longer a factor. Whatever mortality might be expected in a stand such as this, the number of deaths continued to increase in nearly every size-class (Table 2). Almost twice as many trees died during the third decade (413) as during the first (219), and the basal area sum lost during the third decade (325.1) was 81% more than that lost during the first decade (179.8). Of all deaths (413) in the last 10 years 60% (246) were in the 6-in. size-class, and more than half (126) of those were beech/maple. However, the 41 trees in the 22-in. class and larger that died in the last 10 years were oaks or hickories. The basal area loss by the oaks and hickories was 79% (258.3) of the total lost (325.1), and more than one third (133.7) was from white oak.

TABLE 2. Number of trees and their actual basal area sums lost by death for all size-classes of white oak, red and black oaks, all hickories, beech and maple, and all other species combined.

	Qa						Qr, Qv					
	Number			B.A.			Number			B.A.		
Size Class	1964	1974	1984	1964	1974	1984	1964	1974	1984	1964	1974	1984
6	21	27	20	4.12	5.30	3.93	1	0	3	0.20	0	0.59
10	8	8	21	4.31	4.36	11.5	1	2	3	0.54	1.09	1.64
14	8	8	8	8.55	8.55	8.55	3	2	7	3.21	2.14	7.48
18	3	3	5	5.30	5.30	8.84	3	0	8	5.30	0	14.1
22	1	8	4	2.64	21.1	10.6	1	2	4	2.64	5.28	10.6
26	2	3	7	7.37	11.1	25.8	3	1	6	11.1	3.69	22.1
30	4	4	8	19.6	19.6	39.3	0	0	1	0	0	4.91
34+	5	7	4	31.5	44.1	25.2	0	0	0	0	0	0
Total	52	68	77	83.4	119.4	133.7	12	7	32	23.0	12.2	61.4
Per Acre	2.65	3.47	3.88	4.26	6.09	6.82	0.61	0.36	1.63	1.17	0.62	3.13

TABLE 2.—Continued

	Co, Cl, Cg, Cc, Ct						Fg, As					
	Number			B.A.			Number			B.A.		
Size Class	1964	1974	1984	1964	1974	1984	1964	1974	1984	1964	1974	1984
6	22	28	31	4.32	5.50	6.09	44	71	126	8.64	13.9	24.7
10	5	8	12	2.72	4.36	6.54	6	8	18	3.27	4.36	9.82
14	4	2	12	4.28	2.14	12.8	0	3	2	0	3.21	2.14
18	1	2	8	1.77	3.53	14.1	3	2	0	5.30	3.53	0
22	3	3	2	7.92	7.92	5.28	0	0	0	0	0	0
26	3	2	5	11.1	7.37	18.4	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
34+	0	0	0	0	0	0	0	0	0	0	0	0
Total	38	45	70	32.1	30.8	63.2	53	84	149	17.2	25.0	36.6
Per Acre	1.94	2.30	3.57	1.64	1.57	3.22	2.70	4.29	7.60	0.88	1.28	1.87

TABLE 2.—Continued

	Others						Total					
	Number			B.A.			Number			B.A.		
Size Class	1964	1974	1984	1964	1974	1984	1964	1974	1984	1964	1974	1984
6	42	43	66	8.24	8.44	13.0	130	169	246	25.5	33.2	48.3
10	16	5	15	8.73	2.73	8.18	36	31	69	19.6	16.9	37.6
14	5	4	5	5.34	4.28	5.34	20	19	34	21.4	20.3	36.4
18	1	1	2	1.77	1.77	3.53	11	8	23	19.4	14.1	40.6
22	0	1	0	0	2.64	0	5	14	10	13.2	37.0	26.4
26	0	0	0	0	0	0	8	6	18	29.5	22.1	66.4
30	0	1	0	0	4.91	0	4	5	9	19.3	24.5	44.2
34+	0	0	0	0	0	0	5	7	4	31.5	44.1	25.2
Total	64	55	88	24.1	24.8	30.0	219	259	413	179.8	212.3	325.1
Per Acre	3.27	2.81	4.49	1.23	1.27	1.53	11.2	13.2	21.1	9.17	10.8	16.6

Growth and Change

Stand density decreased through each decade, by 15% during the 30 years from 119.5 to 101.9 (Table 3). From 1954 to 1964 11.2 trees per acre died (Table 2), but only

TABLE 3. Density and basal area per acre by size classes for all species combined, 1954-84.

	Density/Acre				Basal Area/Acre			
Size Class	1954	1964	1974	1984	1954	1964	1974	1984
6	57.0	52.0	42.1	35.9	11.2	10.2	8.26	7.05
10	20.8	23.1	24.6	24.4	11.3	12.6	13.4	13.3
14	11.4	12.1	11.3	12.0	12.2	13.0	12.1	12.9
18	11.2	9.59	9.08	8.16	19.8	16.9	16.0	14.4
22	7.91	8.32	7.55	6.79	20.9	22.0	19.9	17.9
26	5.87	6.28	6.53	6.22	21.6	23.1	24.1	23.0
30	3.27	3.78	4.18	4.85	16.0	18.5	20.5	23.8
34+	1.94	2.04	2.45	3.52	12.3	12.9	15.4	22.2
Total	119.5	117.2	107.9	101.9	125.3	129.2	129.7	134.6

7.4 trees per acre grew into the 6-in. size-class (Table 1). During 1964-74 13.2 trees were lost; 6.5 were new. From 1974 to 1984 21.1 trees were lost; 9.9 were new. Although mortality increased for all size-classes (Table 2), density has decreased over the 30 years only in size-classes 6, 18 and 22. Growth of surviving trees moved a larger number from these into the next higher classes. Average stem diameter increased from 11.5 in. (1954) to 11.9 (1964) to 12.4 in. (1974) to 13.4 in. (1984). Basal area per acre increased through each decade, by 7.4% over the 30 years from 125.3 to 134.6. Subtracting out the basal area of those trees that died during each decade (Table 2), the survivors added 13.1 square feet of basal area per acre in the first decade, 11.3 during the second and 21.5 during the third.

White oak continues to be the single most important (V_3) species in the woods, but it continues to decline steadily in all attributes (Table 4). It now ranks third in density,

TABLE 4. Comparison of species attributes 1954-84 and net gain (+) or loss (−) of density and basal area.

	Density per Acre (D_2)				Relative Density (D_3)			
Species	1954	1964	1974	1984	1954	1964	1974	1984
Qa	27.1	24.6	20.9	17.8	22.7	21.0	19.4	17.5
Fg	27.2	26.4	24.8	24.8	22.8	22.5	23.0	24.3
As	22.9	27.0	27.6	30.6	19.2	23.0	25.6	30.0
Co/Cl	8.11	7.50	6.33	4.69	6.79	6.40	5.87	4.60
Qr	4.74	4.23	4.08	2.81	3.97	3.61	3.78	2.76
Ns	4.95	4.29	3.72	3.27	4.14	3.66	3.45	3.21
Ar	4.95	4.54	4.03	3.78	4.14	3.87	3.73	3.71
Cg	4.90	4.18	3.47	1.84	4.10	3.57	3.22	1.81
Fa/Fp	4.29	4.44	4.29	4.03	3.59	3.79	3.98	3.95
Qv	3.38	3.32	3.06	2.70	2.83	2.83	2.84	2.65
Lt	1.94	1.89	1.73	1.89	1.54	1.61	1.60	1.85
Ov	1.53	1.48	1.33	1.58	1.28	1.26	1.23	1.55
Cc/Ct	1.48	1.38	1.07	0.82	1.24	1.18	0.99	0.80
Cf	1.02	1.17	0.71	0.66	0.85	1.00	0.66	0.65
Others	0.97	0.82	0.77	0.66	0.81	0.70	0.71	0.65
Totals	119.5	117.2	107.9	101.9				

TABLE 4.—Continued

	Basal Area per Acre (B_2)				Relative Basal Area (B_3)			
Species	1954	1964	1974	1984	1954	1964	1974	1984
Qa	62.0	61.2	59.2	59.4	49.5	47.4	45.6	44.1
Fg	10.9	11.9	13.1	16.2	8.70	9.21	10.1	12.0
As	6.88	9.08	10.5	13.2	5.49	7.03	8.08	9.82
Co/Cl	10.3	10.1	9.44	8.29	8.22	7.82	7.28	6.16
Qr	8.30	8.45	9.24	8.32	6.62	6.54	7.12	6.18
Ns	3.13	2.93	2.67	2.48	2.50	2.27	2.06	1.84
Ar	1.90	1.81	1.80	1.81	1.52	1.40	1.39	1.35
Cg	3.45	3.28	3.12	2.51	2.75	2.54	2.40	1.87
Fa/Fp	2.53	2.82	2.90	3.21	2.02	2.18	2.23	2.39
Qv	7.86	8.99	9.37	9.77	6.27	6.69	7.22	7.26
Lt	5.44	5.76	5.77	6.89	4.34	4.46	4.45	5.12
Ov	0.30	0.29	0.26	0.31	0.24	0.22	0.20	0.23
Cc/Ct	1.67	1.76	1.64	1.46	1.33	1.36	1.26	1.09
Cf	0.20	0.23	0.14	0.13	0.16	0.18	0.11	0.10
Others	0.55	0.56	0.61	0.59	0.44	0.43	0.47	0.44
Totals	125.3	129.2	129.7	134.6				

TABLE 4.—Continued

Species	Importance (V_3) 1954	1964	1974	1984	% Change 1954-84 D_2	B_2
Qa	36.1	34.2	32.5	30.8	−34.3	− 4.19
Fg	15.8	15.9	16.6	18.2	− 8.8	+48.6
As	12.4	15.0	16.8	19.9	+33.6	+91.9
Co/Cl	7.50	7.11	6.56	5.38	−42.2	−19.5
Qr	5.30	5.08	5.45	4.47	−40.7	+ 0.24
Ns	3.32	2.96	2.76	2.52	−33.9	−20.8
Ar	2.83	2.64	2.56	2.53	−23.6	− 4.74
Cg	3.42	3.06	2.81	1.84	−62.4	−27.2
Fa/Fp	2.80	2.98	3.10	3.17	− 6.07	+26.9
Qv	4.55	4.90	5.03	4.96	−20.1	+24.3
Lt	2.94	3.04	3.02	3.48	− 2.58	+26.6
Ov	0.76	0.74	0.72	0.89	+ 3.27	+ 3.33
Cc/Ct	1.28	1.27	1.12	0.94	−44.6	−12.6
Cf	0.50	0.59	0.38	0.38	−35.3	−35.0
Others	0.62	0.56	0.59	0.54	−32.0	+ 7.27
Totals					−14.3	+ 7.42

but it still dominates by basal area. Growth has been good, almost offsetting the heavy loss of large stems (Table 2).

Sugar maple is second and beech third in importance, and their gains have been steady through the 30 years. Sugar maple has been the most abundant species for the last 20 years; it ranks third, behind beech, in basal area at this time.

Other species which impact the woods and impress the visitor with their large stems include red and black oaks, the several hickories and tulip. All of these are declining in number. Black oak and tulip have gained slightly in basal area; the rest have decreased. Mortality is high; new 6-in. trees are few to none.

Trend

The kind of changes recognized in 1964 and seen again in 1974 were evident once more in 1984. Beech and maple have lost considerably more trees than all the oaks and hickories combined, but the oaks and hickories lost six times as much basal area. Of the trees 20-in. and larger which have died during the 30 years 95% were among the oaks and hickories. In the lowest size-class only sugar maple more than replaced deaths by new trees. Beech is abundant, and only a few other mesic species are reproducing and growing into the lowest size class. The trend seems to be from an oak-hickory-tulip dominant stand to one which is more of mixed mesophytic nature with beech and maple dominating.

Literature Cited

1. Lindsey, A.A., J.D. Barton, Jr., and S.R. Miles. 1958. Field efficiencies of forest sampling methods. Ecology 39:428-444.
2. Lindsey, A.A. and D.V. Schmelz. 1965. Comparison on Donaldson's Woods in 1964 and its 1954 map of 20 acres. Proc. Indiana Acad. Sci. 74:169-177.
3. ______. 1970. The forest types of Indiana and a new method of classifying midwestern hardwood forests. Proc. Indiana Acad. Sci. 79:198-204.
4. Schmelz, D.V., J.D. Barton, and A.A. Lindsey. 1975. Donaldson's Woods: Two Decades of Change. Proc. Indiana Acad. Sci. 84:234-243.

Note

[1]Ar *Acer rubrum*, As *Acer saccharum*, Cc *Carya cordiformis*, Cg *Carya glabra*, Cl *Carya laciniosa*, Co *Carya ovata*, Ct *Carya tomentosa*, Cf *Cornus Florida*, Fg *Fagus grandifolia*, Fa *Fraxinus americana*, Fp *Fraxinus pennsylvanica*, Lt *Liriodendron tulipfera*, Ns *Nyssa sylvatica*, Ov *Ostrya virginiana*, Qa *Quercus alba*, Qr *Quercus rubra*, Qv *Quercus velutina*, and others are *Carpinus caroliniana*, *Celtis occidentalis*, *Juglans nigra*, *Morus rubra*, *Tilia americana*, *Ulmus americana*, *Ulmus rubra*, *Ulmus thomasi*.