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SECONDARY SUCCESSION IN STANDS OF RED MAPLE—SWEET GUM—BEECH FORESTS IN RIPLEY COUNTY, INDIANA*

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The vegetation of the leached Illinoian till plain has been described in detail by Braun (1, 2) Keller (4), McCoy (5), and the progress of secondary succession in these habitats has been considered quantitatively by Potzger and Potzger (7), and in a more general way by Chapman (3). Realizing the insecure accuracy of empirical field impressions, the present quantitative study of seven stands on Illinoian till plain forests in the process of developing either from lumbering disturbance or from cleared land was undertaken.

METHODS

Stands selected have not been disturbed by grazing, so it can be assumed that reproduction followed a natural course. In all but the Reinking woods (table 1) twenty 10-meter-square quadrats were delimited by synthetic wash line with loops at ten meter intervals which could easily be slipped over wire stakes. Wooden calipers were used to make DBH. measurements of trunks. Young trees, at least three feet in height and below one inch DBH. were tabulated as index for reproduction.

LOCATION AND DESCRIPTION OF THE STANDS

Reinking woods: 55.59 A. Lumbered but not cleared, undisturbed for 36 years. It is located along highway 421 near Osgood.

Huneke woods (table 2) 8.43 A. Lumbered, not cleared. Undisturbed for 25 years.

Clyde Peetz woods (table 3) 11.1 A. Lumbered, not cleared. Undisturbed for 20 years.

Ben Fangman woods (table 4). Completely cleared but not farmed. Undisturbed for 30 years.

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Eldon Ehlors south woods (table 5) 15 A. Cleared but not farmed. Undisturbed for 23 years.

Eldon Ehlors north woods (table 6) about 15 A. Cleared, not farmed. Undisturbed for 27 years.

Versailles Park (table 7) about 10 A. Cleared and farmed. Undisturbed for 15 years.

All of the stands are located within a few miles of Versailles and Osgood.

RESULTS

The youth of all stands is indicated by small DBH. of trunks. The youngest is, of course, the Versailles Park stand (table 7). The number of dominant trees is larger and their per cent F. I. higher than in forests of more mesophytic habitats. In abundance and F. I. *Acer rubrum,* Liquidambar and *Ulmus americana* are leading all other genera. In succession following lumbering number of stems per quadrat is smaller and average diameter of stems is greater than in stands which began on cleared areas. This indicates greater progress in succession with reduced disturbance. Succession in the strictest ecological sense, i. e. by a succession of seres, is not evident in these Illinoian till plain forests. This can readily be seen from tables 1 to 7.

DISCUSSION

In habitats of the Illinoian till plain microclimate plays an important role in invasion by various species especially of *Acer saccharum,* and perhaps also has marked influence on the invasion by Liriodendron and others. This was pointed out by Chapman (3) when he says, "The species composition of the stand varied with drainage conditions." In the Versailles-Osgood area variation is apparently not sufficiently great to disturb the forest type but only to make variation in abundance of one or the other species. Potzger (6) pointed out that drainage by a few feet of cutting by a little stream in the Versailles Park region eliminated Liquidambar and *Acer rubrum* from the association and gave the climax beech-sugar maple-ash association control.

The authors agree with Chapman (3) that the forest type is not transitional but uniquely specific. However, it is crowded hard by

the climax beech-sugar maple-ash type where soil moisture becomes somewhat mesophytic. This characteristic stands out prominently as one travels westward from Osgood on highway 421. The sweet gum-red maple-beech type of forest stops "on a line" a few miles east of Greensburg as proximity to streams affords more effective drainage of the plain. It is, thus, a very fascinating forest association to study ecologically. In the seven stands included here *Acer saccharum* is almost entirely wanting in the forest association.

A striking characteristic is also the large number of species which have a F. I. above 50 per cent, differing in this respect from the climax forest for the same region, as reported by Potzger (6). Of the characteristic dominants *Acer rubrum,* Fagus, *Carya ovata* and Nyssa show a wide range of habitat tolerance, and there is good reason to suspect that varieties or ecotypes parade under the same taxonomic designation, and so offer a challenge to taxonomists for critical study.

For comparison of the stands in the process of succession with an undisturbed mature sweet gum-red maple-beech stand we have the record of the Klein woods, studied quantitatively by Keller (4) before it was lumbered a few years later. In gross features of the associates it is essentially like the stands considered in the present study.

Different types of sweet gum- red maple-beech-pin oak forests appear already in the successional stages, they are determined by greater or lesser abundance of the dominant species, even though fidelity of species within the association is very high. In terms of percentage they are: *Acer rubrum* 100, A. saccharum 70, *Carya ovata* 86, *Fagus grandifolia* 86, *Fraxinus americana* 100, Liriodendron 86, Liquidambar 100, *Nyssa sylvatica* 100, *Quercus alba* 70, *Q. palustris* 100, *Q. rubra* 70, *Ulmus americana* 100.

Soil moisture is perhaps the most important single control factor. As representative examples we refer to the Peetz woods (table 3), a poorly drained area, and the Huneke woods (table 2) on a better drained area. We note that *Acer rubrum* and Liquidambar are not affected by the degree of difference in the edaphic factor, but *Carya ovata,* Fagus, *Fraxinus americana, Quercus alba* and *Q. rubra* indicate preference for better drained soil.

In a way, secondary succession is non-existent for these till plain forests. Liquidambar and *Acer rubrum* are non-replacing immediate invaders of cut-over forests on old fields. Secondary succession in this unique forest is merely a multiplication of numbers of the dominants and reduction in abundance of the various associates. As Potzger and Potzger (7) and Chapman (3) point out, succession is a process of invasion of groups of the dominants determined by age of the stand. According to results obtained from this study the progress of succession is not greatly influenced by degree of disturbance, except that in lumbered areas more of the dominants participate from the beginning than in cleared fields, and so mature forest conditions are obtained more quickly.

SUMMARY AND CONCLUSIONS

1. The study deals with secondary succession in seven stands of sweet gum-red maple-beech-pin oak type of forest in Ripley County, Indiana.

2. Three stands began after disturbance by lumbering, three from cleared not farmed fields and one from an abandoned field.

3. Secondary succession on Illinoian till plain habitats is a process of different groups of the dominants entering the association at different time intervals which influences abundance of the various dominants but does not replace species of trees in succession of seres.

4. Sweet gum, red maple and American elm are most abundant in the young stands.

5. While in general the same forest type is evident in stands beginning after lumbering as from cleared fields succession from fields requires more time for all associates of mature forests to enter the association.

6. Difference in soil moisture (apparently) induce various types of sweet gum-red maple-beech-pin oak forest covers, determined by variation in abundance of the participating dominants.

7. Fidelity of the dominants is high in the seven stands, and more species (five to seven) have a F. I. above 50 per cent than in the climax mixed hardwoods.

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TABLE 1

Tabulation of woody species in forty 10-meter-square quadrats in the Reinking woods. Size-classes in inches.

Species	Below .1 in.	1-2	3-5	6-9	10-15	Above 15	Total stems	% F. I.
Acer rubrum	21	28	45	19	5		118	78
A. saccharum	5						5	13
Carpinus caroliniana	8	9					17	20
Carya cordiformis	2						2	3
C. glabra	4	7	3				14	20
C. ovata	13	18	20	5			56	60
Cornus florida	2	1					3	3
Fagus grandifolia	17	34	11				62	95
Fraxinus americana	14	7	24	10	2		57	75
F. nigra	1						1	3
Juniperus virginiana	1						1	3
Liriodendron tulipifera	3			1	1		5	12
Liquidambar styraciflua	2	2	9	7	2		22	40
Nyssa sylvatica	5	9	14	2	4		34	30
Populus deltoides					1		1	3
Populus grandidentata					2		2	3
Prunus serotina	8						8	5
Quercus alba		1	7	8	2		18	28
Q. bicolor		1	5	9	4		19	28
Q. palustris	1	1	10	50	36	2	100	87
Q. rubra			5	6	2		13	17
Q. velutina	1						1	3
Sassafras albidum	11			2			13	17
Ulmus americana	108	69	44	19	1		241	83

TABLE 1—(Continued)

Tabulation of woody species in forty 10-meter-square quadrats in the Reinking woods. Size-classes in inches.

Species	Below .1 in.	1-2	3-5	6-9	10-15	Above 15	Total stems	% F. I.
Aralia spinosa	4						4	3
Lindera benzoin	95						95	37
Sambucus canadensis	1						1	2
Smilax glauca	16						16	17
Viburnum dentatum var. deamii	1						1	2
V. prunifolium	1						1	2

TABLE 2

Tabulation of woody species in twenty 10-meter-square quadrats in the Woodrow Huneke woods. Size classes in inches.

Species	Below 1 inch	1-2	3-5	6-9	10-11	Total stems	% F. I.
Acer rubrum	69	71	51	12	2	204	100
Carpinus caroliniana	26	32	8			66	55
Carya ovata	22	77	44	4		169	100
Fagus grandifolia	39	49	11			138	90
Fraxinus americana	10	36	17	5		78	85
Liquidambar styraciflua	2	44	88	30		166	100
Liriodendron tulipifera				1		1	5
Morus rubra		1				1	5
Nyssa sylvatica	1	5	2			8	30
Prunus serotina				1		1	5
Quercus alba		1	2			3	10
Q. palustris	1	1	2	2		6	20
Q. rubra		4	4	5	1	14	45
Salix sp.?			1			1	5
Sassafras albidum	9	2	5	3		19	40
Ulmus americana	49	42	16	4		111	95
Aralia spinosa	1					1	5
Lindera benzoin	71					71	50
Smilax glauca	46					46	35
Vitis sp.?	9					9	20

TABLE 3

Tabulation of woody species in twenty 10-meter-square quadrats in the Clyde Peetz woods. Size-classes in inches.

Species	Below 1 inch	1-2	3-5	6-9	10-15	Total stems	% F. I.
Acer rubrum	33	92	101	68	3	297	100
Carya ovata	14	9	1	1		25	50
Fagus grandifolia	16	18	1	2		37	70
Fraxinus americana	13	12	19	5		49	70
Liquidambar styraciflua	4	13	30	23	1	70	75
Liriodendron tulipifera	5	1	4	10	1	21	45
Nyssa sylvatica	30	14	1			45	35
Quercus palustris	2	1	9	1	2	15	30
Sassafras albidum	15		3	4		22	20
Ulmus americana	18	37	15		1	71	85
Aralia spinosa	3					3	10
Corylus americana	10					10	5
Ilex verticillata	3					3	5
Lindera benzoin	34					34	55
Sambucus canadensis	1					1	5
Smilax glauca	50					50	70
Viburnum sp.?	2					2	10
Vitis sp.?	13					13	50

TABLE 4

Tabulation of woody species in twenty 10-meter-square quadrats in the Fangman woods. Size-classes in inches.

Species	Below 1 in.	1-2	3-5	6-9	Total stems	% F. I.
Acer rubrum	570	516	77	6	1169	100
Carpinus caroliniana	70	25	1		96	60
Carya ovata	6	14			20	55
Carya sp.?	2	1			3	5
Fagus grandifolia	11	1			12	30
Fraxinus americana	4	3			7	35
F. pennsylvanica	2	1			3	10
Liquidambar styraciflua	99	149	94	18	360	100
Liriodendron tulipifera	2	1			3	15
Morus rubra	2	1			3	5
Nyssa sylvatica	22	19	4		45	60
Ostrya virginiana	1				1	5
Populus tremuloides	8	4	4		16	20
Platanus occidentalis			1		1	5

TABLE 4—(Continued)

Tabulation of woody species in twenty 10-meter-square quadrats in the Fangman woods. Size-classes in inches.

Species	Below 1 in.	1-2	3-5	6-9	Total stems	% F. I.
Quercus alba	1				1	5
Q. palustris	22	32	20	5	79	25
Q. rubra	2	1			3	15
Sassafras albidum	2				2	10
Ulmus americana	101	39	2	1	143	80
Amelanchier canadensis	1				1	5
Corylus americana	336				336	70
Hamamelis virginiana	4				4	5
Ilex virticillata	245				245	50
Rhus sp.?	5				5	10
Rosa sp.?	90				90	55
Salix sp.?	32	9			41	50
Smilax rotundifolia	110				110	60
Viburnum dentaum var. deamii	35				35	45
Parthenocissus quinquefolia	15				15	25
Vitis sp.?	38				38	70

TABLE 5

Tabulation of woody species in twenty 10-meter-square quadrats in the Estol Ehlors south woods. Size-classes in inches.

Species	Below .1 inch	1-2	3-5	6-9	10-15	Above 15	Total stems	% F. I.
Acer rubrum	81	111	66	1			259	100
A. saccharum		9	3	1			13	15
Carpinus caroliniana	29	36	9		1		75	40
Carya cordiformis	4	6	2		1		13	40
C. ovata	16	20	8	1			45	65
Cornus florida	5						5	5
Fagus grandifolia	10	1	3	2			16	15
Fraxinus americana	1		1		1		3	15
Juniperus virginiana	1						1	5
Liriodendron tulipifera	7	8	3				18	15
Liquidambar styraciflua	30	45	44	1	1		121	85
Nyssa sylvatica	77	80	11	5	2		175	100
Populus grandidentata		1	1	2			4	10
Prunus serotina		1					1	5
Quercus bicolor		1	4	4			9	10
Q. palustris	2	9	13	4	3	1	32	80

TABLE 5—(Continued)

Tabulation of woody species in twenty 10-meter-square quadrats in the Estol Ehlors south woods. Size-classes in inches.

Species	Below .1 inch	1-2	3-5	6-9	10-15	Above 15	Total stems	% F. I.
Q. rubra	1	1	2	3			7	15
Sassafras albidum		3	4				7	15
Ulmus americana	39	30	21	3			93	85
U. rubra	13	5	3	2			23	45
Aralia spinosa	21	2	1				24	30
Lindera benzoin	24						24	35
Rosa sp.?	9						9	20
Sambucus canadensis	4						4	5
Smilax glauca	2						2	10
Vitis sp.?	24						24	70

TABLE 6

Tabulation of woody species in twenty 10-meter-square quadrats in the Estol Ehlers north woods. Size-classes in inches.

Species	Below .1 inch	1-2	3-5	6-9	10-15	Total stems	% F. I.
Acer rubrum	282	246	106	5		639	95
A. saccharum	1	1				2	10
Carya cordiformis		1	3	1		5	20
C. ovata	4	7	4	1		16	30
Fraxinus americana		1	2	1		4	10
Liquidambar styraciflua	28	28	34	12	1	103	90
Nyssa sylvatica	54	38	19	1		112	100
Populus grandidentata			7	2		9	15
Quercus alba	2	2		1	3	8	20
Q. palustris	7	1	13	15	9	45	90
Q. rubra	10					10	15
Ulmus americana	458	269	34	1		762	100
U. rubra	15	3				18	25
Amelanchier canadensis	1					1	5
Aralia spinosa	1					1	5
Rosa sp.?	28					28	35
Vitis sp.?	12					12	25

TABLE 7

Tabulation of woody species in twenty 10-meter-square quadrats in Versailles State Park. Size-classes in inches.

Species	Below 1 inch	1-2	3-5	Total stems	% F. I.
Acer rubrum	223	278	9	510	100
A. saccharum	1			1	5
Carpinus caroliniana	1			1	5
Cornus florida	2	1		3	5
Fagus grandifolia	1			1	5
Fraxinus americana	17			17	55
Juniperus virginiana	3	1		4	15
Liquidambar styraciflua	158	343	72	573	100
Liriodendron tulipifera	55	14	1	70	75
Nyssa sylvatica	17	4		21	35
Platanus occidentalis	4	1		5	15
Populus grandidentata	26	2		28	30
Prunus serotina	4	2	1	7	20
Quercus alba	2			2	10
Q. bicolor	3			3	10
Q. rubra	1			1	5
Sassafras albidum	5	1		6	25
Ulmus americana	5	1		6	20
Campsis radicans	545	1		546	50
Rhus glabra	11	1		12	10
Salix sp.?	63	1		64	35
Viburnum dentatum var. deamii	21			21	5
Vitis labrusca	79			79	45