

Growth and Development of Hardwood Seedlings

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Thirty years ago, the Indiana Forest Classification Act, which provided certain tax benefits to woodland owners who excluded domestic livestock from their woods, was enacted. Woodlands entered under this law provide excellent places for the study of the changes that take place in the protected woods. To the botanist, the ecologist, and the forester these protected woods are field laboratories in which plant populations can be studied.

Twenty years ago, a woodland management project was started by the Purdue Agricultural Experiment Station. A series of permanent sample plots were established in some of Indiana's classified and protected woods. One of the objectives was to study the regeneration of the woods following the removal of livestock. As part of the general study, milacre quadrats permanently marked and systematically distributed over the plot, were established.

Previous reports (1) have already shown that the condition of a woods, recognized as a stage of decadence, at the time livestock are excluded, will influence the natural regeneration. The composition of the overhead stand, seed production and dissemination, with all its variables, and the condition of the seedbed, ground cover, etc., all exert an influence. No attempt is being made to show how each influence acts on the tree seedlings but simply to show the results of the action of all site factors in terms of tree seedling establishment and growth under woods conditions.

Remeasurements of the quadrats were made annually for the first 10 year period (1931-1940) and periodically during the period 1941-1950. Although several hundred thousand measurements of tree seedlings have been recorded for the permanent sample plots, this paper presents a selected sample of the results from one woods which has been protected from livestock grazing and fire for 25 years.

Because of the great changes which take place from year to year in the current crop of newly germinated tree seedlings, only those seedlings which survived one season were located, mapped and tagged on each quadrat. It was impossible to get a record of all the seedlings that came into the quadrats. Some seedlings came into the quadrats and died before the annual remeasurements were made while others came in after the annual measurements had been taken.

Seedlings under 6 inches in total height were counted on each quadrat at each remeasurement period and those seedlings over 6 inches in total height were tagged. The development of each tagged tree was followed for 20 years or until the seedling died.

The part of the woods in which the quadrats are located is stocked with 70 trees per acre 6 inches or more in diameter. There are 14 trees, 6 to 10 inches in diameter and 56 are from 11 to 30 inches in

diameter. The species present are shagbark hickory (*Carya ovata*), bitternut hickory (*Carya cordiformis*), red oak (*Quercus rubra*), bur-oak (*Quercus macrocarpa*), black oak (*Quercus velutina*), sugar maple (*Acer saccharum*), silver maple (*Acer saccharinum*), American elm (*Ulmus americana*), slippery elm (*Ulmus fulva*), beech (*Fagus grandifolia*), and basswood (*Tilia glabra*). In other parts of the woods, other hardwood trees of seed bearing size such as white ash (*Fraxinus americana*), black ash (*Fraxinus nigra*), white oak (*Quercus alba*), and walnut (*Juglans nigra*), are present.

At the time the quadrats were established the ground cover consisted principally of herbaceous vegetation such as clearweed (*Pilea pumila* L.), sedge (*Carex* sp.), and bluegrass (*Poa pratensis* L.). During the past 20 years most all of the clearweed and blue grass have disappeared and only a scattering of sedge can be found in the more open portions of the woods. The woods, in 1931, was classified as a transition stage woods (1), with only a few scattered hawthorn (*Crataegus*), elm, and black cherry present.

Results

Complete records of sample quadrats are shown in Tables 1, 2 and 3. All of these quadrats are located within the boundaries of a half-acre permanent sample plot.

The quadrat shown in Table I is partly shaded by the canopy of the overhead stand. Two tree seedlings, both under six inches in height, were present when the quadrat was established in 1931. Apparently the black cherry seedling tagged in 1932 was one of the two present in 1931. Basswood and black ash were next to come into the area. Each year some seedlings under six inches in height were recorded and gradually a few seedlings were added to the permanent record. The quadrat record shows how the height growth of seedlings varies from year to year. Some seedlings may be cut off by rodents or be killed back, as illustrated by the black cherry and hophornbeam in the quadrat. Some species come into the area and remain for a comparatively short period of time.

It is apparent from the record that in 1950 basswood seedlings were competing with black ash, black cherry, and hophornbeam. Even though more sugar maple seedlings came into the quadrat than any other species, not one was present in the quadrat in 1950. Hickory and oak, the dominant species in the overhead stand were not represented in the quadrat. At no time during the 20-year period did an oak seedling appear in the quadrat.

The quadrat shown in Table II is located in a partially shaded place where the only competition would come from the overhead stand. Seedlings of hawthorn (*Crataegus*), American elm, slippery elm, and black cherry (*Prunus serotina*) were tagged in 1931 when the quadrat was established. In addition one red maple and one black ash (*Fraxinus nigra*) seedling were present. A few prickly ash were present but they gradually died out.

TABLE II. Tree Seedlings—A Record of their Establishment and Growth on a 1/1000 Acre Quadrat

Species	Reproduction—over 6" in total height											
	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1945	1950
Slippery Elm	14	20	26	28	33	30	35	38	42	42	—	—
Slippery Elm	13	18	34	51	59	75	87	102	120	137	180	216
American Elm	7	12	13	13	19	29	34	39	27	38	—	—
American Elm	7	10	13	14	14	18	26	23	16	20	—	—
American Elm	11	18	24	24	21	29	30	38	38	44	48	—
American Elm	15	18	25	32	32	38	44	47	48	52	52	—
American Elm	10	12	13	14	17	—	—	—	—	—	—	—
Basswood	7	10	—	—	—	—	—	—	—	—	—	—
Black Cherry	7	8	10	11	14	15	18	28	31	14	—	—
Crataegus or Hawthorn	18	18	24	31	34	37	31	40	42	26	76	120
Crataegus or Hawthorn	36	36	42	47	50	56	70	84	92	103	—	—
Crataegus or Hawthorn	36	40	49	49	54	57	64	72	75	79	72	72
Crataegus or Hawthorn	40	42	51	64	70	73	74	80	85	93	98	120
Slippery Elm	—	9	10	11	17	19	24	13	15	10	—	—
Red Oak	—	—	—	7	8	9	9	12	12	10	6	4
Red Oak	—	—	—	7	7	7	10	3	Dead	—	—	—
Basswood	—	—	—	—	8	12	19	29	31	30	30	25
Basswood	—	—	—	—	8	15	18	30	36	39	39	42
Red Oak	—	—	—	—	8	9	12	10	9	7	7	—
Basswood	—	—	—	—	—	—	15	17	21	23	24	—
Red Oak	—	—	—	—	—	—	11	7	4	5	—	—
Shagbark Hickory	—	—	—	—	—	—	—	7	7	5	6	—
Totals in	13	14	13	15	18	17	19	20	19	19	12	7
Numbers Present	13	14	13	15	18	17	19	20	19	19	12	7

Reproduction under 6"
Number of Seedlings

Species	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940
Sugar Maple	1	3	3	3	3	3	4	1	2	1
Basswood	4	5	10	6	2	1	1	1	2	
Black Ash	1		2	1						
Black Cherry			1							
Shagbark Hickory				1						
Bitternut Hickory						1				1
Slippery Elm										2
Totals	6	8	16	11	5	5	5	2	4	

The record shows how persistent can be the *Crataegus*. Three of the four *Crataegus* have persisted for 20 years compared to only one of the seven elm. The composition of the quadrat shows very little change during the 20-year period. Although red oak is represented in the composition of the quadrat, the growth and development of the seedlings are unsatisfactory. Rodents repeatedly cut back the red oak. The record of the one red oak (1934 to 1950) is representative of the way the species seems to develop under woods conditions. This quadrat record is very much like that secured in many other woods where species like hawthorn and elm do survive when woods are grazed. The severe competition for space that these species give to the newly germinated seedlings of oak, maple and ash makes their establishment less probable.

The quadrat record shown in Table III is similar to the others except that only one seedling was tagged in 1931 and neither *Crataegus* nor elm were present. Basswood is the dominant species in this quadrat. During the 20-year period more basswood seedlings started growth and more of them survived and were present in 1950, than any other species. The record of seedlings under 6 inches in total height gives a total of 32 basswood and 24 sugar maple. Only one sugar maple seedling was tagged and this one was present for only 5 years (1940-1945). Apparently the basswood seedlings recorded in 1933, 1934 and 1935 were later tagged as established seedlings. The record of the seedling in and establishment of basswood is typical of its growth in many woods. It appears to be an invader of dense sod cover and of other ground cover of less density.

The black ash seedling present in 1931 had a very interesting height growth record. Such a height growth record is characteristic of black ash when it is competing with other hardwoods. The one seedling that became established in 1935 shows better height growth and appears to be growing well in competition with basswood.

Summary

The examples shown in the tables could be multiplied many times. They would show variations in the regeneration patterns as they occur from place to place in the natural woods. However, these quadrat records do show that natural regeneration is a slow process and that during the early period of growth, many seedlings make very little height growth. Seedlings also appear to be very tolerant of shade and competition. It is also apparent that reproduction takes place periodically and that environmental factors work to favor one species and not another. In some places a species seems to take over the area while in other places the same species may become temporarily established and then lose out in competition with others.

It is also apparent that the early invaders of the protected woods are not necessarily those that will constitute the overhead stand of the future. A mere tally of seedlings at any one time may be misleading because a large number of trees during the early stages of growth

is not an assurance that the composition of a well stocked stand of young trees will be like that of the seedling or sapling stage. The character of the reproduction below 6 inches in height often varies considerably from year to year. The species predominantly in evidence one year may have almost disappeared and an entire new crop of seedlings, sometimes of a different species, may occupy this height class the following season. Some species are only temporarily in abundance.

Seed production, dissemination, establishment and growth of tree seedlings in the protected woods are cyclic. Certainly the whole process is influenced by local conditions of site. Each quadrat studied shows a distinct pattern of growth and development. One can read into the quadrat regeneration records a partial explanation of the way our hardwood species occur in the woods, as single trees or in groups and having survived the years of competition for a place in the woods, eventually the mixed hardwood stand is established.

Literature Cited

1. DENUYL, D., O. D. DILLER, R. K. DAY. 1938. The development of natural reproduction in previously grazed farmwoods. Purdue Univ. Agricultural Exp. Sta. Bul. 431.