ORIGIN OF OAK STANDS ON THE SPRINGFIELD PLAIN: A LESSON ON OAK REGENERATION[1]

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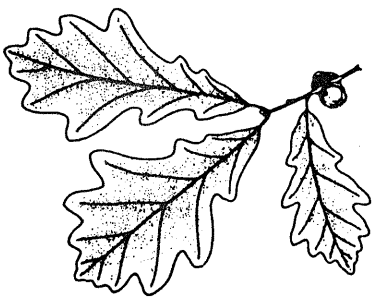

ABSTRACT.--Present-day oak stands on the Springfield Plain are commonly immature, even-aged, adequately and uniformly stocked, dominated by white or post oak and show little or no continuity with former stands. They occur for the most part on areas with a history of previous agricultural use. Oaks behave as aggressive pioneer tree species that gain early dominance of open areas which they gradually lose in one generation to more tolerant species such as sugar maple. This natural succession is hastened by partial cuttings. The open conditions under which they became established differ vastly from those prevailing after timber harvest of any kind.

The management of central hardwoods has been predicated on the assumption that proper harvest methods would assure adequate regeneration of oak immediately or within the time span that any associated site preparation remained effective. Over a half century of experience with cutting methods ranging from single-tree selection to clearcutting indicates that cutting methods do not in themselves insure the desired oak regeneration.

Widespread concern over the failure to obtain satisfactory oak regeneration in managed stands led McLintock (1979) to conclude that research on natural oak regeneration was an urgent priority in the eastern hardwood region. Sander and Clark (1971) and Merritt (1979) recognized that lack of sufficient advanced oak reproduction prior to harvest and competition with more advanced regeneration of more tolerant species were major stumbling blocks. Extensive research as exemplified by articles in the Proceedings of the 1979 John S. Wright Conference: "Regenerating Oaks in Upland Hardwood Forests" (Holt and Fisher, eds.), and of other recent hardwood conferences relate principally to the perpetuation of existing oak stands rather than to their origins.

Although regeneration of oak has proven to be difficult to obtain in managed upland forests, the many naturally occurring oak stands attest to the prolific nature of oak under certain conditions. The object of our study was to ascertain the conditions that prevailed at the time of their origin.

SPRINGFIELD PLAIN

Geologic History and Soil Associations

The Springfield Plain was chosen as a primary study area because of the prevalence of oak stands of various ages especially on the lower plain where rough terrain and low soil fertility has limited agricultural use. The Springfield Plain is a physiographic land division in central Illinois bounded on the north by the terminal moraine of the Wisconsin ice sheet, on the east by the Wabash River, on the south by the Mount Vernon Hill Country and on the west by the Illinois River (Leighton et al. 1948). Pre-Illinois ice sheets graded off the hills and filled depressions. Drift deposited uniformly over the previously glaciated area during the Illinoian glaciation gave rise to the flat till plain of the present day. Overlying loess deposits associated with the Illinois and Wisconsin glacial epochs decrease in depth from west to east (Vestal 1931). The flat till plain is dissected by well established waterways that adequately drain only the sloping land adjacent to these waterways.

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[1]A paper presented at the Fifth Central Hardwood Forest Conference held at the University of Illinois, Urbana, IL on April 15-17, 1985.

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The upland soils of the lower Springfield plain where the case histories were made belong to three soil associations as described by Fehrenbacher et al. (1967). Those of the flat till plain developed under prairie vegetation, belong to the Hoyleton-Cisne-Huey Association, are dark to moderately dark colored, well developed and are poorly drained. Soils on the slopes of dissected areas adjacent to the water ways developed under forest vegetation, belong to the Ava-Bluford-Wynose Association, are light to moderately dark colored, strongly developed and are moderately well to poorly drained. Soils on the morainal areas developed under forest vegetation, belong to the Hosmer-Stroy-Weir Association, are lightly colored, strongly developed and are moderately well to poorly drained.

Settlement and Land Use

The first settlers arrived on the Springfield Plain prior to 1800. Settlement increased with the westward extension of the National Road from Terre Haute to Vandalia and in 1830 to St. Louis. Early settlers preferred forested areas and commonly joined together to burn the woods to open up crop land and to improve grazing. Rapid depletion of organic material or humus that lowered soil fertility fostered shifting agriculture. The Springfield Plain experienced extensive timber harvesting, land clearing and burning associated with rapid settlement following the completion of the Chicago Branch of the Illinois Central Railroad and Vandalia Railroad in the 1850s. By the early 1900s most of the original forest lands were depleted of timber, cleared for crop land or periodically burned to improve forage production (Telford 1926).

Livestock production, an important livelihood during the settlement period, peaked at the turn of the present century and then rapidly declined. Increasing rail shipments of western cattle to eastern markets contributed to the decline. The dairy industry increased with the population. By 1902 Effingham had become the headquarters of a thriving dairy industry that covered much of the area of the Springfield Plain (Effingham Regional Historical Society 1968). This trend, though fluctuating, generally continued up until 1939.[3/] Thereafter, increasing specialization, commercialization and a shift of the industry to other areas of the state drastically reduced the number of dairy cows on the plain. The Grade A Milk Law approved by the Illinois General Assembly in 1939 contributed to the decline of the small dairy enterprises (State of Illinois 1956).

As a consequence of declining beef production and dairy industries, vast amounts of pasture lands, much of it unsuited for row cropping, were abandoned. In recent decades consolidation of farming operations brought on by changes in ownership, the shift to grain farming and the consolidation of row crop acreage to accommodate modern farm machinery has resulted in additional abandonment of crop land.

FIELD OBSERVATIONS AND DATA COLLECTION

Field observations were made throughout most of Illinois and in south-central Indiana; however, our principal focus was on oak stands on the Springfield Plain. Detailed case histories were prepared for selected seedling to mature stands on the lower Springfield Plain that were judged to be or to have been, prior to partial cutting, adequately stocked with oak. Present stand conditions were determined by stand inventories and past cultural practices were ascertained from field observations, aerial photographs dating back to 1938, interrogation of owners and other knowledgeable persons and research of available historical records.

Seedling and sapling stands were sampled on transects of contiguous .001-hectare (2 × 5 m) plots. All woody stems taller than .15 m were tallied by species into one-meter height classes. Total stem ages and early growth rates of 10 to 15 sample trees (covering the range of height classes) in each stand were determined from annual ring counts on cross-sections taken at heights of 0, .15 and 1.3 m.

Pole and sawtimber stands were sampled on .02-hectare, fixed-radius line plots. All trees with breast-high diameters (DBH) larger than 2.5 cm were tallied by species into 5-cm classes. The presence and abundance of smaller stems were noted by species on each plot. Total heights of 10 to 15 dominant or codominant trees (principally oak), depending on stand size, were measured. Their total ages were determined from increment borings made at a height of .3 m, or in the case of very large trees and in order to avoid butt rot, at 1.3 m.

RESULTS AND DISCUSSION

Oak stands on the Springfield Plain are typically even-aged, uniformly well-stocked, immature and show little or no continuity with former stands as would be evidenced by the presence of stumps, veterans and more tolerant species. On the contrary, they show much evidence of having arisen on former agricultural land. Stand boundaries are often delineated by cultural features relating to past land use rather than by edaphic or topographic features which have influenced species composition.

Post oak (*Quercus stellata* Wangenh.) stands characteristically occur on poorly drained soils on the flat till plain that are underlain by shallow clay pans (Hoyleton-Cisne-Huey Association) and which tend to be saturated during the spring and droughty during the summer. Shingle (*Q.*

3/G. Ablasser. An analysis of milk production in Illinois. M.S. Thesis, University of Illinois, Urbana, Illinois, 1964.

imbricaria Michx.) and blackjack oaks (Q. marilandica Muenchh.) are common associates. Shingle oak is a characteristic species on severely eroded sites. Pin oak (Q. palustris Michx.) generally occurs on the most poorly drained sites. White oak (Q. alba L.) stands are most common on well-drained soils adjacent to waterways (Ava-Bluford-Wynose Association) or on well-drained soils (Hosmer-Stroy-Weir Association) on morainal areas in the northern and western portions of the plain. Black oak (Q. velutina Lam.) and hickory (principally shagbark hickory [Carya ovata (Mill.) K. Kock] are common associates of white oak. Red oak (Q. rubra L.) is uncommon and generally restricted to small coves and north-facing slopes.

The occurrence and characteristics of present-day stands on the Springfield Plain reflect past land use. Only typical case histories (CH) will be discussed.

Pre-settlement Forest

The pre-settlement forest has been reduced to a few remnants, such as Baber Woods, a 20-hectare natural area located a few miles north of the Springfield Plain in Edgar County. The presence of long abandoned road ways and trails are evidence that sawtimber harvesting and grazing occurred in the past. Huge oaks (Quercus spp.) comprise a sparse, broken dominant canopy over an understory composed principally of sugar maple (Acer saccarhum Marsh.), many of which are in the large sawtimber class. Sapling and pole-size oak occur infrequently. The veteran oaks are steadily succumbing to the ravages of old age including lightning strikes and windthrow.

Mature Forest

The oldest oak stands encountered on the Plain originated after intensive harvesting, land clearing and burning associated with railroad construction and rapid settlement from the mid to late 1800s. Stands of this age are not common and occur on areas which because of rough terrain or other reasons were considered unsuitable for any form of agriculture other than grazing. Most have been subjected to grazing and one or more partial cuttings. Consequently, they tend to be irregularly and inadequately stocked and have broken crown canopies.

The stand described in Case History 103 is typical. This 20-acre tract occurs on soils of the Ava-Bluford-Wynose Association on rolling terrain in Effingham County. Aerial photographs taken in 1938 show a uniform crown canopy. A heavy selection cut made in the early forties removed most of the veneer-quality oak and largest black walnuts (Juglans nigra L.). Canopy openings created by this cut are shown to be filling up with hard maple on photographs taken in 1960 and 1966. White oak was the principal species in the dominant canopy in 1983 (table 1). White and black oaks accounted for 34 percent of the total stand basal area but only 10 percent of the stems larger than 2.5 cm. Sugar maple which comprised 60 percent of the stems and 28 percent of the stand basal area were largely confined to sapling and pole classes. Hickory accounted for 9 percent of the stems and 21 percent of the basal area and were quite uniformly distributed among diameter classes. Stems with diameters of less than 2.5 cm were mostly hard maple. Other species represented in this size class were hickories, white ash (Fraxinus americana L.), sassafras (Sassafras albidum (Nutt.) Nees), black cherry (Prunus serotina Ehrh.) and flowering dogwood (Cornus florida L.). Oak seedlings though absent on most plots occurred on the adjacent ungraded, grassy portion of right-of-way of Interstate 70.

The advanced stage of succession to hard maple in this mature oak stand is typical in other stands of comparable age. Partial cuttings have hastened this process--one more partial cut would eliminate oak as a major component of this stand.

TABLE 1.--Stand Table for mature oak-hickory stand with hard maple understory (Ava-Bluford-Wynose Association); Effingham County, 1983 (CH 103).

DBH Class (cm)	White Oak	Black Oak	Hickory	Sugar Maple	Elm	W. Ash, Walnut, Other	Total
			(No. of stems/ha)				
2.5-7.5		2	10	232	58		302
7.5-17.5	2	4	10	250	10	65	341
17.5-27.5	15	15	28	65		20	171
27.5-37.5	17		25	20	28	2	64
37.5-47.5	23	5	10				46
47.5-57.5	10		2			10	14
Total	67	26	85	567	96	97	938
BA(m^2)	7.3	1.2	5.2	7.0	1.4	2.9	25.0

Based on 20 fiftieth-hectare plots.

The regeneration of hickory under a sparse residual stand of black oak described in Case History 117a illustrates the inability of oak to succeed itself. This former wooded pasture on soils of the Ava-Bluford-Wynose Association in Fayette County was grazed for many years. This is evidenced by the low density stand of short-boled, broad-crowned trees on aerial photographs taken in 1938. Grazing was terminated just prior to or soon after a stave-bolt cut in 1960. A stump count indicated that about 50 white oak trees per hectare were cut. At the time of the 1983 survey the sparse residual overstory was composed almost exclusively of black oak with diameters exceeding 45 cm and ages exceeding 100 years. These residuals accounted for 39 percent of the stand basal

area but only 2 percent of the trees with diameters exceeding 2.5 cm (table 2).

Regeneration consisted principally of sapling and pole hickories which together numbered 2,148 per hectare and 76 percent of the total number of stems. The pole-sized hickories were established prior to the 1960 cut. Oak regeneration, 79 percent of it white oak, amounted to only 269 per hectare and occurred primarily in areas where the 1960 cut removed groups of trees.

The preponderance of shagbark hickory and the paucity of oak regeneration under a sparse overstory of black oak suggests that the overstory was sufficiently dense to preclude oak regeneration but not dense enough to inhibit the establishment and growth of more tolerant hickory.

The rapid encroachment of oak on an abandoned field directly adjacent to the residual black oak stand provides a sharp contrast and an insight into another aspect of oak regeneration. Aerial photographs show that the field was cultivated and grazed prior to 1938 and abandoned about 1960. A narrow band of pole-sized oak and hickory was present on the field edge adjacent to the residual stand in 1983. This stand was adequately stocked with oak alone. Black and white oaks accounted for 57 percent of the total stems larger than 2.5 cm and 100 percent of the stems in the 10 cm and larger diameter classes. White ash, hickory, sassafras, cherry and elm (Ulmus spp.) were all contained in smaller diameter classes and collectively accounted for only 12 percent of the total stand basal area of 19.4 m^2 per hectare. White ash and hickory were the most common, hard maple, elm and sassafras were less common and oaks least common in the less than 2.5-cm diameter class. The ages of dominant oaks ranged from 20 to 30 years and averaged 27 years.

TABLE 2.--Stand Table for former wooded pasture with hickory regeneration (Ava-Bluford-Wynose Association; Fayette County, 1983 (CH 117a).

DBH Class (cm)	White Oak	Black Oak	Hick-ory	Sugar Maple	Sass-afras	W. Ash, Other	Total
	(No. of stems/ha)						
2.5-7.5	150	21	1849	28	246	85	2379
7.5-17.5	49[a]		250	7		35	341
17.5-27.5	14		42				56
27.5-37.5			7				7
37.5-47.5		21					21
47.5-62.5		14					14
Total	213	56	2148	35	246	120	2818
BA(m^2)	1.3	7.0	8.1	0.2	0.5	0.7	17.8

[a]Includes 7 post oak.
Based on 8 fiftieth-hectare plots.

Pole and Small Sawtimber Stands

Pole and small sawtimber stands are common on the Springfield Plain. Characteristically they have had little or no timber cutting and consequently tend to be adequately and uniformly stocked. In all case histories of these and younger stands we have been able to establish that these stands arose on former crop land or otherwise open land. Crop land was generally grazed for a period of years before abandonment. The power of oak to encroach on abandoned farm land was brought out by elderly people interviewed in Laclede, Illinois who with a sense of awe of the forest that was engulfing them, nostalgically recalled fields and homesites known to them in youth that were now overrun by forest.

The development of an oak-hickory stand on a former wooded pasture located in Bond County on soils belonging to the Hosmer-Stroy-Weir Association is described in Case History 121. This 7-hectare site has a long grazing history dating back to at least the early 1900s and terminating about 1945. A former tenant dairy farmer recalled that this pasture consisted of "good sod" and a "scattering" of white oak trees. According to him the white oaks were cut at about the same time that grazing ceased. It was estimated from a 1938 aerial photograph and stump counts made at the time of the 1983 inventory that these pasture trees numbered about 40 per hectare. A 1949 aerial photograph shows that most had been removed. The site has remained relatively undisturbed since the cutting.

The present stand is uniformly well stocked and dominated by oaks, chiefly white oak, and hickory (table 3). Although several large sugar maple occur in an adjacent ravine, sugar maple is

TABLE 3.--Stand Table for pole oak-hickory stand on former wooded pasture (Hosmer-Stroy-Weir Association); Bond County, 1983 (CH 121).

DBH Class (cm)	White Oak	Black Oak	Post Oak	Hick-ory	Elm	Other	Total
	(No. of stems/ha)						
2.5-7.5	195	45	5	125	45	55[a]	470
7.5-17.5	279	70	35	196	50	15	645
17.5-27.5	55	55	10	175	10	15	320
27.5-37.5		5		5			10
37.5-47.5							
47.5-57.5	1						1
Total	530	175	50	501	105	85	1446
BA(m^2)	5.3	3.7	0.8	9.4	1.0	1.0	21.2

[a]Includes 50 sugar maple.
Based on 10 fiftieth-hectare plots.

represented only in the seedling class and accounted for only 3 percent of the total number of stems larger than 2.5 cm in diameter. Seedlings and saplings with diameters less than 2.5 cm of elm and hickory were well distributed throughout the stand and were much more common than those of oak.

Ages of pole-sized oak, which ranged from 22 to 38 years and averaged 29 years, are evidence that most of the oak regeneration occurred after the cessation of grazing and the removal of the pasture trees.

Regeneration in a wooded pasture north of the adjacent ravine which was still grazed in the 1970s and where the pasture trees were not removed is sparse and consists principally of elm, hickory, and black cherry.

The development of an oak stand on a former wooded pasture on poorly drained soil belonging to the Hoyleston-Cisne-Huey Association in Effingham County is described in Case History 105. Grazing ceased about 1940. At that time only a few open-grown trees per hectare remained on most of the pasture area.

The area on which the pasture trees were removed is presently occupied by an almost pure stand of pole and sawtimber sized oak. Post oak accounted for 51 percent of the trees with diameters larger than 2.5 cm and 57 percent of the stand basal area; other oaks, chiefly shingle oak, accounted for approximately 40 percent of the stems and basal area (table 4). The ages of dominant oaks in 1983 ranged from 40 to 47 years and average 43 years.

This stand is typical on poorly drained upland till plain soils with a shallow clay pan that are saturated in the spring and droughty in July and August. These areas were referred to as the post oak flats by Telford (1926).

Regeneration on the portion of pasture where the residual pasture trees were not removed is sparse and composed chiefly of species other than oak.

White oak is characteristically the most common species on abandoned farm land on soils belonging to the Ava-Bluford-Wynose Association on sloping land adjacent to waterways. The pole-small timber oak stand on a former timbered pasture adjacent to Dismal Creek in Effingham County described in Case History 115 is an example. This stand developed on a 6-hectare portion of a wooded pasture from which the pasture trees were removed in the mid to late 1920s. The present owner recalled helping his father "slick off" the pasture trees for fire wood and his boyhood chore during the 1930s of "harassing out" milk cows that occasionally strayed into the sapling oak thicket that had developed on the area. A uniformly dense stand of forest regeneration is shown on aerial photographs taken in 1938. Light fuel wood cuttings made on the fringes and in the more accessible ravines during the late 1940s or early 1950s are evident on 1953 aerial photos and suggested by the average age of 30 years in 1983 of the resulting multistemmed coppice. Grazing which was resumed in the 1960s and continued until the early 1970s may partially explain the lack of a well developed understory.

TABLE 4.--Stand Table for pole-small sawtimber mixed oak stand on former wooded pasture (Hoyleton-Cisne-Huey Soil Association); Effingham County, 1983 (CH 105).

DBH Class (cm)	Oak Species				Hickory	Ash, Other	Total
	White	Post	Black jack	Shingle			
	(No. of stems/ha)						
2.5-7.5	33	8			50	33	124
7.5-17.5	42	274	33	67	50		466
17.5-27.5	25	216	50	124[a]			415
27.5-37.5		42	8				50
Total	100	540	91	191	100	33	1055
BA(m^2)	1.7	14.7	2.8	6.1	0.6	0.1	25.9

[a]Includes 8 black oak.
Based on 20 fiftieth-hectare plots.

Stand tables based on a 1983 inventory were made for varying aspects and topographic positions. These showed so much conformity with respect to species composition and density that they were combined into an overall stand table (table 5). White oaks comprised 66 percent of the total number of stems with diameters exceeding 2.5 cm and 65 percent of the stand basal area. Black oak accounted for 16 percent of the stems and 25 percent of the basal area. Hickory, black cherry and black walnut accounted almost equally for the remaining basal area.

The age of dominant and codominant oaks ranged from 50 to 60 years and averaged 54 years in 1982. This suggests the stand became established rapidly after the pasture trees were removed and the cessation of grazing.

The contemporaries of the pasture trees removed in the 1920s are still present in the portion of the timber pasture adjacent to the homesite on which grazing continued until the early 1970s. Regeneration in this area is poor and lacking oak.

Seedling and Sapling Stands

Seedling and sapling oak stands are prevalent but often small in area. They occur frequently on unmowed right-of-ways and field edges on land taken out of production as row crop acreage was consolidated to accommodate modern farm machinery.

TABLE 5.--Stand Table for pole-small sawtimber white and black oak stand on former pasture (Ava-Bluford-Wynose Soil Association); Fayette County, 1983 (CH 115).

DBH Class (cm)	White Oak	Black Oak	Post Oak	Hick-ory	Elm	Other	Total
	(No. of stems/ha)						
2.5-7.5	50	5		48			103
7.5-17.5	345	40		67	2	30	484
17.5-27.5	274	96	24	5	2	10	411
27.5-37.5	40	30		2			72
Total	709	171	24	122	4	40	1070
BA(m^2)	18.0	6.8	0.8	1.1	0.1	0.7	27.5

Based on 20 fiftieth-hectare plots

Larger stands are found on untillable portions of pasture lands recently abandoned as the result of the shift to grain production and the elimination of livestock production on family farms.

The rapidity of forest regeneration on open pasture land is illustrated in Case History 131 which describes a recently abandoned pasture located in Effingham County on soils belonging to the Ava-Bluford-Wynose Association. This 2-hectare site has been severely eroded and gullied as a result of heavy and continuous grazing.

The only seed bearing trees on the site were 26 white oak, 2 post oak and 1 hickory which occurred singularly or in small groups. Their short boles and wide spreading crowns indicate that they developed as open-grown trees. Their large size (DBH > 50 cm) and ages suggest that the site had been grazed for more than 100 years.

The present owners had run about 15 head of cattle on this pasture continuously from 1946, when they acquired ownership, until 1975 when they discontinued livestock production. During this period pasture maintenance consisted of periodic burning and mowing to control woody vegetation. The pasture was undisturbed since abandonment until the fall of 1983 when an attempt was made to reclaim a small area with the least tree regeneration.

The distribution of trees on the area 8 years after grazing was terminated is shown in table 6. Oaks accounted for 44 percent of the total number of stems (10,246/ha) taller than .15 m and were present on 90 percent of the .001-hectare plots. Almost 60 percent of the oak regeneration was of species not represented by a seed-bearing tree on the site. Their seeds had to have been carried over distances up to 500 m. The only areas not heavily regenerating to oak were underneath the wide spreading crowns of the residual pasture trees. The large number of stems in the smallest height class suggests that regeneration was still occurring and that the stand will become overstocked by oaks alone.

Oaks commonly became established on grassy right-of-ways after the discontinuation of mowing and burning. An example of a relatively undisturbed portion of a narrow strip of tree growth that continues more or less uninterrupted for over a mile between a railroad grade and Illinois Route 37 in Effingham County is described in Case History 116. Since the completion of Route 37 in 1930 the site was kept free of tree growth except for an occasional large roadside tree until the 1960s by mowing and periodic burning as is shown on aerial photographs taken in 1938, 1953 and 1966. The results of a 1983 inventory of a 50-meter long strip of relatively undisturbed regeneration based on two parallel transects of .001-hectare plots sampling the interior of the stand are summarized in table 7. The total number of stems with diameters larger than 2.5 cm averaged 6,686 per hectare. This total was comprised of 46 percent white oak, 13 percent black oak, 34 percent hickory and 6 percent sassafras. Almost all were single stemmed. Dominant oaks averaged 10 m in height and were 17 to 20 years old.

TABLE 6.--Distribution of mixed hardwood regeneration by species and height classes on recently abandoned pasture (Ava-Bluford-Wynose Soil Association); Effingham County, 1983 (CH 131).

Height Class (m)	Oak Species						Hick-ory	Walnut	Crae-tagus	Elm	Other Species	Total
	White	Post	Black	Black-jack	Pin	Shingle						
	No. of stems/ha											
.15-0.5	559	258	54	32	161	108	495	11	140	32	119	1969
0.5-2.5	677	334	129	54	581	1129	1225	183	774	398	1033	6517
2.5-4.5	86		33	11	108	194	646	33	54	215	314	1694
4.5-6.5					11		11			22	22	66
Total	1322	592	216	97	861	1431	2377	227	968	667	1488	10246
% of Plots Stocked	41	33	12	10	46	63	66	15	59	34		99

Based on 93 mil-hectare plots.

TABLE 7.--Stand table for sapling oak-hickory stand on undisturbed railroad right-of-way; Clay County, 1983 (CH 116).

DBH Class (cm)	White Oak	Black Oak	Hick-ory	Sassa-fras	Total
	(No. of stems/ha)				
0.5- 3.5	737	53	263	316	1369
3.5- 6.5	1842	159	1157	105	3263
6.5- 9.5	316	368	790		1474
9.5-12.5	158	316	53		527
12.5-13.5	53				53
Total	3106	896	2263	421	6686
BA(m^2)	7.4	5.1	6.5	0.3	19.3
% Plots Stocked	79	42	84	32	100

Based on 19 mil-hectare plots.

Seed of all species with the exception of black oak had to have been transported across a state highway or a double-track railroad bed over distances exceeding 30 meters. The direction of this mass movement of acorns and nuts from forest to grassland suggests that small field rodents were the principal vectors.

SUMMARY AND CONCLUSIONS

All evidence from case histories, including those not reported herein, and from observations of stands throughout the Springfield Plain indicate that the present-day stands that are predominately oak occur for the most part on sites once cleared for agricultural use, most commonly pasture. These stands show little or no continuity with former stands, are even-aged and typically are adequately and uniformly stocked. The encroachment of oak on abandoned fields on the Springfield Plain is analagous to the encroachment of eastern white pine on old fields in northeastern United States described by Spalding (1899), Cheyney (1942), and Spurr and Barnes (1980).

We have observed that oaks behave as aggressive pioneer tree species that gain early dominance of grassy areas which they lose in one generation to more tolerant tree species. We do not ascribe oaks to a subclimax status on soils belonging to the Ava-Bluford-Wynose and Hosmer-Stroy-Weir soil associations.

The attributes of oak that enable it to encroach onto lightly-sodded areas are:

1. large number of heavy animal and bird dispersed acorns which can work down through grass to make contact with the soil;

2. presence of large amounts of stored food within seed that enable seedlings to quickly develop sufficient size to compete with grasses;

3. rapid development of the radicle, especially of white oaks which germinate in the fall, which enables seedlings to withstand summer droughts and to compete with shallow-rooted grasses;

4. ability to resprout and persist in grass until sufficient root development is obtained for rapid shoot growth;

5. ability to maximize height growth in full sunlight.

These are essentially those considered important for the establishment of oak seedlings in understories (Phares 1971, Sander and Clark 1971, Sander 1979, Watt 1979) and those for the establishment of eastern white pine on old fields (Spurr and Barnes 1980).

Our observations on the Springfield Plain are supported by our observations elsewhere in Illinois and in south-central Indiana where extensive even-aged oak stands apparently have similar origins. The invasion of abandoned pasture by oaks in north-central Illinois was described by Bullington (1965) and in Wisconsin by Marks (1942).

Rampant growth of multiflora rose (Rosa multiflora Thunb.), which has naturalized on uncultivated open lands throughout the Springfield Plain, and the presence of deep-rooted domestic grasses such as smooth broom and tall fescue on improved pasture will present formidable obstacles to future establishment of oak.

The conditions at the time of origin of oak stands described in the case histories are far different than those prevailing after timber harvesting of any kind. Partial cuttings which have been and continue to be commonly practiced in the central hardwood region hasten natural succession by favoring tolerant species such as sugar maple and beech. Clear cuts without control of the understory have not been much more successful in promoting satisfactory oak regeneration. Understory treatment with 2, 4, 5-T two years prior to harvest resulted in satisfactory regeneration of red oak in Wisconsin (Johnson and Jacobs 1981).

It is doubtful that any overstory manipulation, short of its complete removal without control of the competing understory species, will do much to ensure oak regeneration of desired density and uniformity. Even-aged management aimed at maintaining an unbroken crown canopy and control of the understory by judicious grazing during the latter half of the rotation or by timely herbicide treatments at rotation age would give rise to post-harvest conditions that approximate those that gave rise to natural stands on the Springfield Plain.

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