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ABSTRACT

The forest communities of Crowley's Ridge in Arkansas were surveyed by sampling 22 selected stands which met predetermined criteria. The Importance Value (I.V.) for each woody species over one decimeter, diameter breast height (dbh), was derived from the combined values of relative density, relative dominance by basal area (B.A.), and relative frequency. Young trees under one decimeter, dbh, were assigned to three height classes from which frequency, density, and stratification data were derived.

White Oak-Red Oak-Hickory is the general forest type. Its subdivisions: Oak-Hickory-Pine Forest, Mixed Oak-Hickory Forest, and White Oak-Beech Forest are advocated for practical field references. They are defined by these quantitative values: Density (trees/ha), mean distance (M), mean area occupied (M^2), and mean basal area (M^2/ha). The forest subdivisions correlate with contrasts in topography and soils.

A level of importance of tree species was based on the number of times each ranked in the top five within a stand, according to I.V. and B.A. *Quercus alba, Fagus grandifolia, Pinus echinata, Quercus stellata, Liriodendron tulipifera, Quercus velutina,* and *Ulmus rubra* were top level species.

Reproductive vitality, habitat tolerances, and successional patterns are suggested from analyses of important tree species and forest community types.

INTRODUCTION

Crowley's Ridge is a unique geological anomaly (Call, 1891; Fisk, 1944) whose aspects of topography and vegetation justify its position as a distinct physiographic province of Arkansas (Foti, 1974) and in the lower Mississippi floodplain. Preliminary studies (Clark et al, 1974) show that its existing forests are of a White Oak-Red Oak Type and bear a significant resemblance to the pre-settlement forests. This study defines the forest community types, implies successional patterns of important tree species, documents reproductive vitality, and notes habitat tolerances.

METHODS

Twenty-two stands were selected for survey and analysis along Crowley's Ridge from Helena, Arkansas, to the Arkansas-Missouri border. The criteria for selection were that the stand (1) be at least six hectares in size, (2) show a uniformity of composition, and (3) be apparently free from grazing and commercial lumbering for at least 20 years. Trees were sampled by the quarter method (Cottam and Curtis, 1956) at points with 15-meter intervals. An average of 48 trees per stand were encountered, the number varying from 24 to 82 trees. Tree diameters were measured at 1.4 meters above ground for tree diameters exceeding one decimeter. Data summary for these trees included number of trees per hectare (density), mean area occupied per tree, average basal area (B.A.) per hectare per tree species, mean distance between trees, relative density (value of 100), relative dominance by basal area (100), and relative frequency (100). The last three values were combined (300) to give the importance value (I.V.) for each species (Curtis and McIntosh, 1951; Cain et al, 1956) (Table 1). Trees under one decimeter dbh, i.e. saplings, were sampled by 0.0004 hectare quadrats (one milacre) and classified by three summary size classes: less than 0.5 meter tall; 0.5-2.0 meters tall; and more than 2.0 meters tall. Relative values for frequency and density of each species were computed for each size classification. Young trees under 0.5 meters in height are regarded as seedlings.

FOREST TYPES AND THEIR DISTRIBUTION

The general classification of the white oak-red oak-hickory forest is based on canopy composition studies (Clark et al, 1974). This study also suggests that these subdivisions have practical use as field references: oak-hickory-pine type; mixed oak-hickory type; and white oak-beech type. Oak-hickory-pine forests and white oak-beech forests are contrasting types of a mesic forest which correlate with certain combinations of soil and topography. Significant differences in soil parent material from one region of the ridge to another and a deeply dissected topography, allowing for abrupt changes in habitat over short distances, are accompanied by shifts in forest constituents. The mixed oak-hickory forest is best regarded as a transitional type between the two. It has been largely destroyed by agricultural practices and its pure form is difficult to define.

A pleistocene loess mantle covers the southern portion of the ridge, diminishes in depth toward the north and disappears at the ridge tops. Thereafter it covers the low flanks. The ridge summits consist of Tertiary sands and gravels. The white oak-beech forest coincides with the loess to the south. The oak-hickory-pine forest follows the irregular outcroppings of the droughty soils to the north. Mixed oak-hickory is expressed best on the high hogbacks to the south. The physical structure of the major subdivisions of the white oak-red oak-hickory forest is compared quantitatively in Table 2. The values for mixed oak-hickory forest are arbitrary averages of the other two.

The basal area value is the space covered by stems with no regard to height or form. The lower basal area per hectare of the oak-hickory-pine forest fails to express the potential high yield of shortleaf pine with its tall, slender form, small taper of the trunk, and the small fraction of limbs. Likewise, the contrast in bole length between cove and upland trees of the white oak-beech forest is not expressed.

OAK-HICKORY-PINE FOREST

White oak *(Quercus alba)* is dominant and disappears only in the low flat floodplains. Its I.V.:68, and shortleaf pine *(Pinus echinata)* I.V.:58, show their dominance. Their high basal areas per hectare (7 and 6, respectively) represent the prevalent cover. Post oak *(Q. stellata)*, I.V.:34, and black oak *(Q. velutina)*, I.V.:31, are major constituents whose combined B.A. per hectare is two-thirds that of shortleaf pine. Black hickory *(Carya texana)*, sweet gum *(Liquidambar styraciflua)*, mockernut hickory *(C. tomentosa)*, and beech *(Fagus grandifolia)*, have I.V.'s ranging from 19 to 11. Black hickory and beech populations consist of a few large trees while mockernut hickory and sweet gum are more numerous but of smaller diameters.

The most common tree associates with I.V.'s between five and ten are blackjack oak *(Q. marilandica)*, Shumard's oak *(Q. Shumardii)*, shagbark hickory *(C. ovata)*, southern red oak *(Q. falcata)*, northern red oak *(Q. rubra)*, and black gum *(Nyssa sylvatica)*.

The understory is dominated by sparse populations of small trees and shrubs with frequencies near 25 percent. Farkleberry *(Vaccinium arborea)* and shadbush *(Amelanchier arborea)* are dominant and commonly attended by flowering dogwood *(Cornus florida)*. Hercules' club *(Aralia spinosa)*, and red buckeye *(Aesculus pavia)*. Strong populations of winged sumac *(Rhus copallina)* are found on narrow, open hogbacks and as faltering pioneer relicts under closing canopies. Farkleberry is an indicator species of the oak-hickory-pine understory community. Here, shadbush has its maximum growth but diminishes in frequency and importance in the white oak-beech communities. The importance of ironwood falls by ten times compared to its role in the white oak-beech forest, but it is still regarded as a prevalent understory member.

The prevalent woody ground layer species are deerberry *(Vaccinium stamenium)*, lowbush blueberry *(V. vacillans)*, poison ivy *(Rhus radicans)*, greenbriar *(Smilax glauca)*, muscadine grape *(Vitis rotundifolia)*, summer grape *(V. aestivalis)*, and virginia creeper *(Parthenocissus quinquefolia)*.

WHITE OAK-BEECH FOREST

White oak with an I.V. of 71 and beech with I.V.:54, dominate all other species. Black oak, I.V.:27, and mockernut hickory, I.V.:20, are conspicuous members of the community and their combined I.V.'s with that of white oak and beech account for 57% of the I.V. total. An additional 20% is represented by five trees whose I.V.'s range between 14 and 10: sweet gum, northern red oak, ironwood *(Ostrya virginiana)*, tulip poplar *(Liriodendron tulipifera)*, and southern red oak. Trees with I.V.'s between 10 and 5, ranked in descending order, are sugar maple *(Acer saccharum)*, sassafras *(Sassafras albidum)*, black gum, white ash *(Fraxinus americana)*, and American elm *(Ulmus americana)*. Ironwood and paw paw *(Asimina triloba)* dominate the understory by number and occupied space. Low shrubs are commonly absent with only wild hydrangea *(Hydrangea arborescens)*, red buckeye, and spicebush *(Lindera benzoin)* occurring sparsely in this strata among heavy populations of tree saplings.

REPRODUCTION AND SUCCESSION

An analysis of the apparent stratification of these forest communities reveals pertinent information about the dynamic state of

TABLE 1. The Level of Importance of the Tree Species Based on the Number of Times Each Ranked in the Top Five Within a Given Stand According to I.V.

	level of importance					I.V. RANGE
	1	2	3	4	5	300-0
Quercus alba	10	6	3			138-0
Fagus grandifolia	3	4	3	3		129-0
Pinus echinata	3	2		1		131-0
Quercus stellata	2		2	1	1	70-0
Liriodendron tulipifera	2			1		74-0
Quercus velutina	1	3	5	1	1	72-0
Ulmus rubra	1			1		94-0
Carya texana		2			1	52-0
Carya tomentosa		1	2	4	1	68-0
Quercus rubra		1	1	1	2	50-0
Ostrya virginiana		1		1	2	40-0
Acer saccharum		1			1	32-0
Ulmus americana		1				28-0
Liquidambar styraciflua			2	2	3	38-0
Quercus falcata			1	1	1	32-0
Carya cordiformis			1	1	1	29-0
Carya ovata			1			42-0
Platanus occidentalis			1			29-0
Nyssa sylvatica				1	2	22-0
Juglans nigra				1		20-0
Acer rubrum				1		25-0
Fraxinus americana					2	27-0
Quercus Shumardii					1	25-0

TABLE 2. Structure of Crowley's Ridge Forests. 22 Stands

	Oak-Hickory-Pine (6)	White Oak-Beech (10)	Mixed Oak-Hickory (6)
Mean Area (M^2)	74.1	60.1	67.1
Mean Distance (M)	4.9	5.3	5.1
Density (Trees/ha)	397.3	375.6	386.5
Mean B.A. (M^2/ha)	23.4	29.8	26.6

species ontogeny, population growth, and community interaction.

White oak proliferates well in all forest types considered here, but reaches its greatest seedling populations and I.V. in the white oak-beech forests. Its constant, high representation in all community strata means reliable acorn crops and a suitable habitat for fall germination.

Beech seedling populations are low except where beech is dominant. An average of 1.6 thousand seedlings per hectare are established under beech canopies.

Shortleaf pine reproduces only in the oak-hickory-pine forests. Even-aged populations of seedlings occur at an average of 3.4 thousand per hectare. None are present in strata above 0.5 meters where shortleaf pine is dominant. Saplings above 2 meters, at an average of 40 per hectare, and seedlings at a rate of 400 per hectare below 0.5 meters are present in stands where white oak is dominant. It is not represented in the 0.5-2.0 meter strata.

Four hickories are major constituents of the forest communities and are separated by habitat or stage of succession. Mockernut and shagbark may overlap with bitternut on the low slopes and well-drained bottoms, but bitternut is most prevalent were red elm *(Ulmus rubra)*, beech, sugar maple, and black walnut *(Juglans nigra)* are dominant. There, it produces 400 seedlings per hectare. Black history shows its greatest reproduction rate in communities where shortleaf pine and/or post oak are dominant. Mockernut hickory shows its highest reproductive vitality with an average of 4.5 thousand seedlings per hectare where black oak is dominant. Its seedling populations decline with shortleaf pine and/or white oak dominants. Further decline is recorded in stands where beech is dominant. Shagbark hickory follows mockernut in succession and is regarded as a species of advanced communities.

Winged elm *(Ulmus alata)*, red elm, and american elm represent a progression from dry to moist sites, respectively. They are minor members of the tree communities because of the low number attaining status in the high canopy. Winged elm has a 100% frequency in all strata where post oak, shortleaf pine, black oak, or white oak are the dominants. It reaches the canopy only in open pine or post oak communities. Red elm seedling populations are high where light penetration of the canopy is great and where black oak is the dominant tree. In low moist slopes and high floodplains it follows tulip poplar, sugarberry *(Celtis laevigata)*, white walnut *(Juglans cinerea)*, and sassafras into the community. American elm is associated with the loessial soils or their outwash in white oak-beech forest and persists on floodplains or high sites altered by advanced plant succession.

Post oak reproduces sporadically and seedlings or saplings are found where it, along with shortleaf pine and white oak, are dominant on dry, excessively drained, or disturbed ridges. Post oak as a canopy tree in white oak-beech forests shows no reproductive vitality and is considered a relict species of an earlier drier condition.

Black oak reproduces well in all upland sites and its highest seedling production coincides with pine and white oak as codominants. Its populations decline where post oak and/or white oak is dominant. It is replaced by white oak in community succession.

Northern red oak is a shade tolerant species which follows white oak into a relatively advanced and maturing community. It is found as a reproducing member only where white oak and black oak are the first and second dominants, respectively.

Southern red oak's highest importance values and reproductive vitality are in stands dominated by post oak, shortleaf pine, white oak, and black oak. Its recognized variety, cherrybark oak *(Quercus falcata, var. pagodaefolia)* (Tucker, 1976) occupies sites of greater available moisture. A common associate is northern red oak.

Tulip poplar, sassafras, and sycamore *(Platanus occidentalis)* are pioneer species which appear after disturbances in a community. Selective- and clear-cutting in white oak-beech forests stimulate regeneration of tulip poplar and sassafras. Mud slides are also conducive to their invasion as well as for cucumber magnolia *(Magnolia acuminata)* and white walnut. All respond to disruption of streams but sycamore invades closest to the main force of the stream where recent alluvium is exposed to light. Sweet gum's greatest reproduction is associated with dry sites of the oak-hickory-pine forest and old fields of the white oak-beech forest.

Initial studies of the white oak-beech forest type in the St. Francis National Forest suggest that clear-cutting is a type of major disruption enhancing the advance of pioneer species such as tulip poplar, sassafras, and winged elm. Qualitative aspects of the original composition are retained with a predominance of white oak, black oak, red elm, and mockernut hickory.

DISCUSSION

Call (1891) observed that many sections of Crowley's Ridge were still practically untouched in 1889 and stood "in their original vigor." His notations located pine on the sandy, top levels of the ridge with the conspicuous absence of tulip poplar. These specific records add credence to the assumption that the oak-hickory-pine forest represents an edaphic climax as dryness disallows alteration of habitat by forest communities sufficient to support a beech-maple climax forest. This forest occupies about one-fourth of the ridge area and correlates closely with the disjunctive distribution pattern of the Brandon-Lexington soil association. Its topography renders it inaccessible and its droughtiness has discouraged agricultural utilization. Therefore, it is used as commercial timberland, natural areas, and as pasture land on the less severe slopes.

The oak-hickory-pine edaphic climax forest and the beech-maple forest establish a baseline by which extant and extinct Crowley's Ridge forests can be compared on a habitat and successional gradient. The white oak-beech classification is descriptive of the present status of the forests once occupied by a beech-maple climax community. A reversal of conditions favorable to the steady state of the beech-maple climax were brought about by lumbering practices, burning, and pasturing. Reversion to an earlier successional stage reduced the status of beech below white oak and promoted the increase of a number of subordinate species such as black oak and mockernut hickory. Sugar maple as a canopy tree was reduced to a minor role below that of sweet gum, northern red oak, tulip poplar, southern red oak, and ironwood. It reaches into the high canopy with an I.V. of 7 where white oak is dominant. Sugar maple rarely appears in oak-hickory-pine forests but is a constant part of the low canopy size classifications in the white oak-beech forest. Its reproductive vitality and distributional frequency indicate the directional trend toward reinstatement of the original climax forest.

These studies reinforce the assumption that the pristine beech-maple forest encircled Crowley's Ridge and extended to its top with the appropriate topography, soils, and ecosystem development. Firm support is given this supposition by Call's (1891) delineation of the range of beech. He described it as having an erratic distribution on Crowley's Ridge proper, being on ridge tops to the south, none on ridge tops north of Jonesboro, but occurring at the base or off the base of the ridge in the immediate lowlands on both sides from Helena to the Missouri border. Beech appeared to be less common in the St. Francis bottoms, more common along the west flank, and reached its greatest abundance and size in the second bottoms of the Cache River in Craighead and Greene Counties.

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