VEGETATION DEVELOPMENT ON A STRIP-MINED AREA IN SOUTHERN ILLINOIS

WILLIAM C. ASHBY
Southern Illinois University, Carbondale

ABSTRACT.—The floristic composition and vegetative characteristics of a strip mine planted to black locust and to shortleaf pine in Perry County of southern Illinois were examined. The understory cover was denser under black locust, which had more typically mesic forest species. The sparser ground cover under pine included numerous old-field species. Both areas gave early evidence of succession to a forest rich in oaks.

The thousands of acres of strip-mine lands in the central United States carry a great diversity of vegetation (Brewer and Trimer, 1956; Verts, 1957; Limstrom, 1960). This results from a variation in management and planting practices on the "new" land by mine operators, from differential survival and growth of planted species, and from the extent of natural plant invasion. Black locust has been recommended to comprise 25 to 50 percent of a species mixture for strip-mine plantings on poor sites because of its beneficial effects on associated species and on the soil (Boyce and Merz, 1959; Boyce and Neebe, 1959; Limstrom, 1960). Its fast growth is often offset by repeated attacks of the locust borer. Shortleaf pine is desirable for wood products and erosion control. The present study reports the species naturally occurring under plantings of these two overstory species and thus serves as a record of a stage in the natural succession on the study areas. Differences in the present understory vegetation appear to have been brought about by the environmental modifications under the two plantations, emphasizing the importance of autogenic factors in succession.

Vegetation has been related to environment by the formulation: Vegetation is a function of the regional climate, parent material, relief or topography, and organisms potentially able to invade, all operating in the context of time. The study areas have been available for plant occupancy for 25 years, and no consistent differences in regional climate, parent material, or relief were observed between them. The floral and faunal factors can be considered essentially uniform. Both areas, surrounded by strip-mined lands, or roads, appear to be equally within the effective range of plant propagule dissemination or animal migration for the species found in the general vicinity. Possible differences between the black locust and the pine, such as perching preferences for birds carrying seed from fruit eaten earlier, would accentuate the role of cover type on subsequent development of vegetation. Those differences observed and reported here appear rather to be a resultant of the effects of the original plantation trees on the environments, particularly on the soil nutrient levels (Baker and Ashby, 1963). The total effect appears to be cumulative, with the black lo-

cust areas more shaded at the ground surface as a result of vigorous growth of the ground layer, and with more evident animal activity.

Materials and Methods

The present study areas were stripped in 1935 as part of the Fidelity Mine of the United Electric Coal Co. in Perry County about four miles west of DuQuoin, Illinois. In 1938 and 1939 black locust (*Robinia pseudoacacia*) and shortleaf pine (*Pinus echinata*) were planted in separate adjacent areas. Eight years later two adjacent one-half acre experimental plots in each overstory area were further underplanted with nine tree species (Mather et al., 1947). The black locust (many riddled by locust borer) then averaged about 22 feet in height with 1,200 survivors from the original 2700 trees per acre. The shortleaf pine averaged less than six feet in height with about 700 remaining from the original 1200 per acre.

By 1962-63 further mortality and growth of the remaining trees had taken place. Approximately 400 black locust and 650 pine trees per acre remained. Although the locust had sprouted, it continued to show damage from locust borer and the pine from tip moth and other causes. Many of the pines appeared to have low vigor. There were some resultant open places. On the other hand, localized areas in both the black locust and the pine had enhanced coverage from the growth of those underplanted trees which survived and from natural tree invasion. The canopy was closed over much of both areas. The crowns of both the black locust and the shortleaf pine were, however, relatively light. Total basal area based on diameter measurements at breast height (DBH) for all size classes of all species ranged from 65 to 70 square feet per acre for the one locust and the two pine plots, to 95 square feet per acre for the second locust plot. The plantation pine constituted over 90% of the basal area, and the locust 70% or more in those plantations.

Collections of all naturally invading plant species were made in both overstory areas from the summer of 1962 to that of 1963. The usual procedure was to walk along a ridge through one given overstory, return along the flat-bottomed troughs, repeat the first direction along a second ridge, and so forth. The slopes were checked for new species from both the troughs and the ridges. The ridges trended north-south, ranging from 2 to 20 feet in height with an average about 10 feet, and the crests ranged from 50 to 150 feet apart, usually with a trough 5 to 50 feet wide. For the most part the slopes were steep, somewhat slumped from the angle of repose, and could be walked up with some difficulty. The parent material was a silty clay with rocky phases and a pH value of approximately 7 in most areas sampled. Drainage appeared to be internal. Temporary impoundments in local low-lying areas supported willows and associated herbaceous species. These areas, and other fully open areas, were not used for collection sites.

As a rule a specimen for each species reported was taken, pressed, and deposited in the Southern Illinois University Herbarium. Exceptions were a few common species collected

TABLE 1.—Species Present in the Strip Mine Areas West of DuQuoin, Illinois.

A. Species found only in the black locust plantation.

Herbaceous—*Allium canadense* Wild Garlic, *Ampelamus albidus* Climbing Bluevine, *Arctium minus* Common Burdock, *Arisaema dracontium* Green Dragon, *Asplenium platyneuron* Ebony Spleenwort, *Bromus commutatus* Bromegrass, *Chenopodium album* Lamb's Quarters, *Erechtites hieracifolium* Fireweed, *Geranium carolinianum* Carolina Cranesbill, *Muhlenbergia sp.* Muhly Grass, *Oxalis dillenii* Yellow Woodsorrel, *Poa compressa* Canada Bluegrass, *Polygonatum canaliculatum* Solomon's Seal, *Polygonum convolvulus* Black Bindweed, *Ranunculus abortivus* Small-flowered Buttercup, *Rumex crispus* Curly Dock, *Solidago sp.* Goldenrod, *Sphenopholis obtusata* Prairie Wedgegrass, *Spiranthes sp.* Ladies'-tresses Orchid, *Taraxacum officinale* Common Dandelion, *Teucrium canadense* Wood Sage, *Viola missouriensis* Missouri Violet, *Viola rafinesquii* Johnny-jump-up.
Trees—*Celtis occidentalis* Hackberry, *Quercus alba* White Oak.

Fifteen additional species noted as present 8 years after the plantations were established (Mather, et al., 1947) and not found in 1963 were: Aster, *Erigeron sp.*, *Lactuca*, Mullein, *Myosotis virginiana*, *Oxalis stricta*, *Parietaria pensylvanica*, Plantain, Ragweed, *Rumex acetosella*, *Solanum carolinense*, *S. dulcamara*, Sweet Clover, Raspberry, and White Ash.

B. Species found in both the black locust and the shortleaf pine plantations.

Herbaceous—*Acalypha gracilens* Slender Three-seeded Mercury, *Apocynum sibiricum* Dogbane, *Botrychium virginianum* Rattlesnake Fern, *Eupatorium rugosum* White Snakeroot, *Galium aparine* Cleavers[1], *Geum canadense* White Avens, *Geum vernum* Spring Avens, *Phytolacca americana* Pokeweed[1,2], *Sanicula canadensis* Short-styled Snakeroot, *Triodanis perfoliata* Venus' Looking-glass.
Shrubs and Vines—*Campsis radicans* Trumpet Vine, *Parthenocissus quinquefolia* Virginia Creeper[1], *Rhus radicans*, Poison Ivy, *Rubus flagellaris* Dewberry[1,2], *Vitis aestivalis* Summer Grape[2].

Trees—*Acer negundo* Box-elder, *Morus rubra* Red Mulberry[1], *Platanus occidentalis* Sycamore[2], *Populus deltoides* Cottonwood[1,2], *Prunus serotina* Wild Black Cherry[1], *Quercus imbricaria* Shingle Oak, *Quercus rubra* Red Oak, *Robinia pseudoacacia* Black Locust, *Ulmus alata* Winged Elm, *Ulmus americana* American Elm[1,2], *Ulmus rubra* Slippery Elm.

C. Species found only in the shortleaf pine plantation.

Herbaceous—*Allium vineale* Field Garlic *Ambrosia artemisiifolia* Small Ragweed, *Andropogon virginicus* Broomsedge Grass[2], *Antennaria sp.* Everlasting[2], *Aster pilosus* Aster[2], *Brachyelytrum erectum* Short Husk Grass, *Cassia fasciculata* Partridge Pea, *Cassia nictitans* Wild Sensitive Plant, *Cirsium sp.* Thistle, *Convolvulus sp.* Bindweed[2], *Crotalaria sagittalis* Rattlebox, *Daucus carota* Wild Carrot, *Desmodium sp.* Tick Trefoil, *Erigeron annuus* Common Fleabane, *Euphorbia corollata* Flowering Spurge, *Gnaphalium obtusifolium* Sweet Everlasting, *Melilotus officinalis* Yellow Sweet Clover, *Panicum boscheuche* Panic Grass, *Pycnanthemum flexuosum* Mountain Mint, *Setaria lutescens* Yellow Foxtail Grass, *Solanum nigrum* Black Nightshade, *Solidago ulmifolia* Elm-leaved Goldenrod, *Solidago sp.* Goldenrod, *Sonchus oleraceus* Common Sow-thistle.

Shrubs and Vines—*Rhus copallina* Shinning Sumac, *Rhus glabra* Smooth Sumac.
Trees—*Diospyros virginiana* Persimmon, *Juniperus virginiana* Red Cedar, *Pyrus sp.* Crabapple, *Salix nigra* Black Willow[2].

[1] Species noted as present in the black locust plantation eight years after planting (Mather, et al., 1947).

[2] Species noted as present in the shortleaf pine plantation eight years after planting. Five additional species listed then which were not found in 1963 were: *Asclepias verticillata*, *Lactuca sp.*, *Lepidium sp.*, Mullein, and *Oenothera sp.*

from one area and not duplicated from the other, or inadvertently omitted from both. They are reported as sight records. Nomenclature followed Mohlenbrock and Voigt (1959).

Results and Discussion

The ground cover was denser and taller in the areas originally planted to black locust. One walked through knee-high herbs over much of the area. In contrast, the ground cover was scanty over much of the pine stand, with a pine needle carpet generally evident. In mid July, 1963, an ecology class found 8 species on single plots of the bottom, ridge, east- and west-facing slopes under the black locust overstory. These averaged 60 plants which totaled 90 grams dry weight per square meter. The bottom had the densest vegetation. Equivalent average values for the pine area were 41 plants of 14 species weighing 28 grams. These values suggest the vegetational relationships of the two areas.

The floristic analysis is given in Table 1. Woody plant invaders were about half as numerous as the herbaceous. In terms of their usual ecological relationships, the species for the two areas differed. Those under the black locust, such as green dragon, Solomon's seal, and Missouri violet were typical of mesic forested areas. Herbs such as white snakeroot and avens formed large masses of ground vegetation. Under the pine were species more typical of old fields such as aster, small ragweed, broomsedge, wild carrot, sumac, and persimmon. Growth of these species under the pine was limited, generally with scattered individuals. An exception was sweet clover which formed occasional patches in open areas within the pine.

Twenty-five species were distinctive to the black locust and 30 to the pine, with 26 species common to both. A United States Forest Service planting record in 1947, 8 years after the original plantations were established, noted volunteer plants present at that time. Fifteen of those species were found in 1963. Ten were in both plantations and five in the pine only. None remained distinctive under the black locust. Twenty were not found at all in 1963. Of these, fifteen had been noted for the locust and five from the pine areas. These figures suggest a lesser modification of the environment by pine in the years from 1947 to 1963.

Strip mining usually proceeds rapidly and disturbs large areas at a time. Perry County had been cleared to a great extent for agriculture. Remaining upland wooded areas have an oak-hickory cover (Voigt and Mohlenbrock, in press). Forests of the mesic ravines include tulip tree (*Liriodendron tulipifera*) and ash (*Fraxinus sp.*), while cottonwood, elm, hackberry, sycamore and willow are often found along streams.

The naturally invading tree species which reached canopy size in the locust areas included approximately one each per acre of hackberry, sycamore (the largest tree 14.9 inches DBH), wild black cherry, and American elm, a very low number which would not serve to establish a stand. To be sure, part of the area had the underplanted hardwoods, many of which survived and would appear to constitute the next tree

generation where planted (Boyce and Neebe, 1959, p. 9; Limstrom, 1960, p. 55; Casteel, 1963). The general picture, however, was that the black locust had been sufficiently closed to eliminate nearly all natural tree regeneration. The subsequent invasion by those tree species listed in Table 1 may ultimately be more successful.

In the pine area three invading tree species of canopy size were found — cottonwood, sycamore, and, adjacent to as well as in the temporarily inundated bottoms, willow. One of 8 cottonwoods on the two half-acre plots was 18.4 inches DBH. Half of the cottonwoods were in troughs and the others either on the slopes or the ridges. All three sycamores were on the ridges. The other 3 canopy species of the black locust areas were not found under the pine. The underplanted hardwoods showed better survival but less good growth than in the black locust. In general, the pine site appeared to have been more open for establishment of canopy trees than the locust site. Even so, the cottonwood and sycamore fall far short of forming a canopy, and other species including shrub size oaks appear to be the advance guard of the naturally invading next tree generation.

The ultimate origin of most of the invading species can be explained by bird or wind distribution. More difficult to explain at present are species such as buttercup, violets, and oaks. Squirrels were not observed on the study areas. Hickories and walnuts were not found. A good explanation for the rather numerous young oaks in all areas is not presently available. Verts (1959) on another study area in Perry County found scanty evidences of squirrels on strip-mined lands. His areas included patches of remaining oak woods.

The second ingredient of invasion, a suitable habitat, differs for the two areas. Test species on the two soils in pot culture showed a highly significantly greater growth on the soil from the black locust than from the pine area (Baker and Ashby, 1963). This difference was eliminated by fertilizing with nitrogen at 200 pounds per acre on an elemental nitrogen basis. This would be equivalent to approximately 400 pounds per acre of a high analysis fertilizer such as urea. Nodules were found on the black locust roots. The greater nitrogen nutrient capital of the black locust soil would be a major factor favoring the growth of virtually all species. Actually, herbaceous legumes (*Cassia, Crotalaria, Desmodium*) were relatively much more important in the pine, though still sparse except for the localized patches of sweet clover in openings.

The essentially continuous mat of pine needles would be a deterrent to establishment of some species. Another factor difficult to evaluate is the more abundant animal life, evidenced by ground-hog holes and ant hills, in the black locust areas. Whether the animal life and the vigorous undergrowth are both responses to a common factor or whether one can be assigned as cause and the other effect was not determined.

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