Vegetation of Loess Bluff Ravines in the Jackson Purchase Region of Kentucky

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Abstract: Forest vegetation of some loess bluff ravines in the Jackson Purchase Region of Kentucky was sampled. A total of 27 tree species comprised the mixed mesophytic association with *Acer saccharum*, *Fagus grandifolia* and *Liquidambar styraciflua* as the dominants. This assemblage of species agrees with that reported for the loess bluffs over 100 years ago. Basal area averaged 27.2 m^2/ha; density 289.5 trees/ha; and diversity (H') ranged from 3.01-3.52. Species similarity was stronger between the forests of the loess bluffs and those of the Appalachians, but especially the dissected Illinoian till plains, than to adjacent communities on thin loess. Disjuncts from Braun's Mixed Mesophytic Forest Region, *Tilia heterophylla* and *Magnolia acuminata*, and the composition of loess bluff forests relative to other forests in the Jackson Purchase tend to support the refugial nature of the loess bluff ravines.

INTRODUCTION

The forests of the loess bluffs of the Jackson Purchase Region of Kentucky were first given attention over 100 years ago (DeFriese 1880, 1884, Loughridge 1888). Those writers described the bluff forests as "some of the most variable of the original forest growth" and their lists of tree species pointed to a vegetational and floristic distinctiveness unlike other sections of the Jackson Purchase. According to the 1820 General Land Office Survey, the vegetation of the Jackson Purchase was a mixture of oak-hickory (Bryant and Martin 1988) and extensive barrens (Dicken 1935). Exceptions included bottomland hardwoods (Bryant 1990), swamps, and forests of the loess bluffs. It was because of mixed mesophytic forest communities of the bluffs that Braun (1950) included the Jackson Purchase in her Western Mesophytic Forest Region rather than Oak-Hickory.

The loess bluffs of the Jackson Purchase are the northern extension of a long belt of silty upland soils along the east side of the Mississippi River bottoms that run from southwestern Kentucky to Louisiana (Bennett 1921). Crowley's Ridge is a cut-off outlier of these bluffs, but on the west side of the river in Missouri and Arkansas (Bennett 1921, Braun 1950).

Loughridge (1888) recognized the vegetational similarities between the bluff forests of Kentucky and those in Tennessee, Mississippi, and Louisiana. Braun (1950) noted the gradual change in vegetational composition of the bluffs along the length of their N-S gradient with northern species dropping out and southern species entering. A unifying characteristic was the occurrence of cane, *Arundinaria gigantea*, throughout the length of the bluffs. Its presence led to the name "cane hills" for various portions of the bluffs (Loughridge 1888, Davis 1923). Because of grazing and other disturbances, cane has virtually disappeared from the uplands (Shull 1921, Heineke 1987) and few intact forest remnants exist.

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Recent floristic surveys of the loess bluffs in Kentucky (Wilson 1976, Bryan 1977, Grubbs and Fuller 1991) have shown the flora to be distinct from adjacent areas, however contemporary vegetational studies are lacking. To the south, in Tennessee (Braun 1950, Miller and Neiswender 1987a, b, 1989, Miller and Holyfield 1986); in Mississippi (Caplenor 1968); in Louisiana (Brown 1972, Delcourt and Delcourt 1974, 1975); and on Crowley's Ridge (Clark 1977) there have been more detailed vegetational studies.

The purpose of this study was to determine the structure and composition of the vegetation for the least disturbed ravines of the Kentucky loess bluffs; to compare these to other forest communities in the Jackson Purchase and elsewhere; and to assess the biogeographical significance (Braun 1950, Delcourt and Delcourt 1974) of these bluff ravines.

THE ENVIRONMENT

The loess bluffs, from 30-60 meters in height, arise abruptly along the eastern side of the Mississippi River floodplain in Ballard, Carlisle, Hickman and Fulton Counties (Davis 1923). Except for dissection by Mayfield Creek, Bayou deChien and Obion Creek, the bluffs are contiguous in western Kentucky (Figure 1). The loess deposits are of Pleistocene origin and cover Tertiary and Cretaceous sands and gravels (McFarland 1943). Numerous ravines, known locally as "gulfs", form trenches throughout (Davis 1923). The loess is deepest near the Mississippi River and thins to the east.

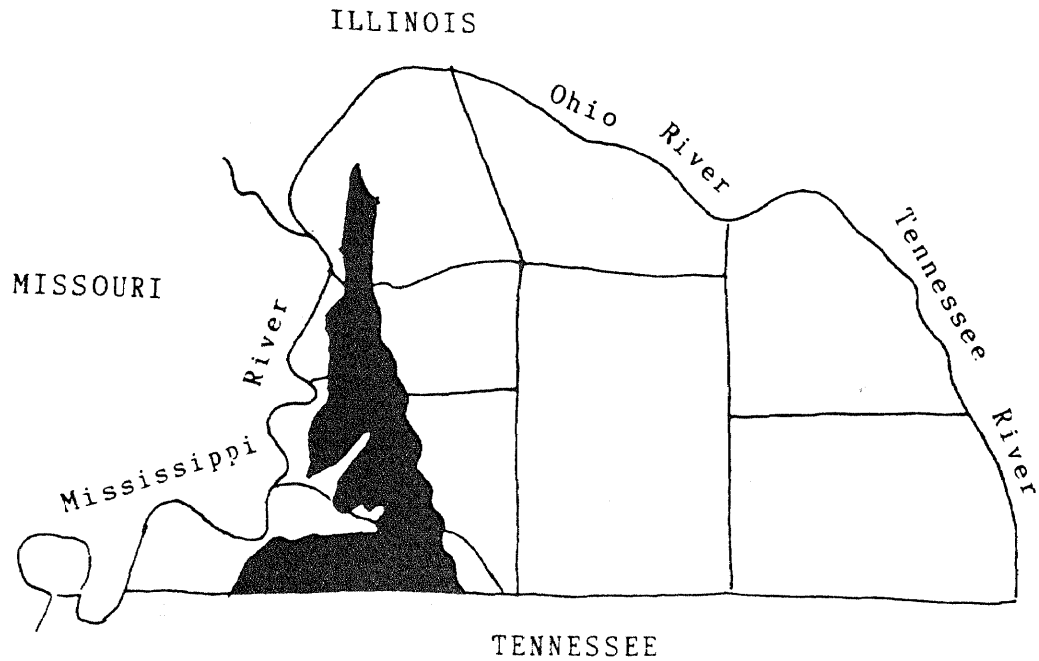

Figure 1.—The location of the loess bluffs (blackened area) in the 8 county Jackson Purchase Region of Kentucky (after Davis 1923).

Memphis silt loan is the primary soil type on the deep loess (Soil Conservation Service, unpub.). This soil is typical of areas of steep relief and tends to have a deep water table. The loess is highly fertile calcareous silt and because of this much of the land adjacent to the bluffs has been converted to agriculture (Grubbs and Fuller 1991). Throughout the 4 counties, erosion has removed several meters of loess on steep side slopes uncovering previously buried coastal plain sediments (Soil Conservation Service, unpub.).

The climate of the Jackson Purchase Region is humid and temperate. The average annual precipitation is 132 cm and the mean annual temperature is 14 c (Newton and Sims 1987).

METHODS

Vegetation of selected loess bluff ravines was sampled as one part of a broader study of the Jackson Purchase vegetation. Visits were made to potential study sites in each of the 4 counties in the cane hills section of the Purchase (Davis 1923). Two sites, one in Carlisle and one in Fulton Counties, that had been floristically studied by Bryan (1977) were selected for the most intensive sampling. Two other sites, one in Ballard and another in Fulton County, were quantitatively sampled. Stands varied from 3-5 ha in size (Bryan 1977).

Vegetation was sampled in 0.04 ha circular plots, randomly spaced throughout each stand. Over 20% of the 198 plots taken in the 4 counties were from little disturbed forests on the bluffs. All woody individuals $\geq$10 cm dbh were measured in each plot. Tree data were analyzed to relative frequency (RF), relative density (RD), and relative dominance (RDo). These values were summed to give an importance value (IV) for each species. Density (trees/ha), basal area (m^2/ha), and species diversity (H') (Magurran 1988) were calculated. Coefficient of similarity follows Bray and Curtis (1957).

Notes on seedlings, saplings and shrubs were made for each plot. Because of the intensive floristic analyses of the bluffs (Wilson 1976, Bryan 1977, Grubbs and Fuller 1991) and the listing of characteristic species (Heineke 1987), less attention was given to the herbaceous layer.

RESULTS AND DISCUSSION

A total of 27 tree species was recorded from the sampling plots of the loess bluffs. In general, vegetation differences among sampling sites were mainly in the relative importance of major species rather that in floristic composition. For that reason a composite table for all stands is presented (Table 1).

In terms of IVs, the leading tree species were sugar maple (*Acer saccharum*, IV 54.11), beech (*Fagus grandifolia*, IV 51.45), and sweetgum (*Liquidambar styraciflua*, IV 41.86). These three accounted for >53% of the density and >56% of the basal area in the ravines (Table 1). Other major canopy and subcanopy associates were white oak (*Quercus alba*), tulip poplar (*Liriodendron tulipifera*), black walnut (*Juglans nigra*), slippery elm (*Ulmus rubra*), hophornbeam (*Ostrya virginiana*), white ash (*Fraxinus americana*), and white basswood (*Tilia heterophylla*). Braun (1950) considered white basswood to be an indicator species for the mixed mesophytic forest. Here it and cucumber magnolia (*Magnolia acuminata*) are disjuncts at the western edge of their ranges (Little 1970). Although cucumber magnolia was of minor importance, Bryan (1977) recognized it as a loess bluff indicator.

In addition to hophornbeam, other commonly encountered understory trees and shrubs included *Cornus florida*, *Asimina triloba*, *Cercis canadensis*, *Hydrangea arborescens*, *Lindera benzoin*, *Styphylea trifoliata*, and *Aralia spinosa*. The seedling/sapling strata were composed of the canopy

Table 1.—The number of trees/ha (N), relative frequency (RF), relative density (RD), relative dominance (RDo), and importance values (IV) of the tree species of the loess bluffs of the Jackson Purchase of Kentucky

	N	RF	RD	RDo	IV
Acer saccharum	78.5	15.54	27.07	11.50	54.11
Fagus grandifolia	33.2	11.92	11.46	28.07	51.45
Liquidambar styraciflua	42.3	10.36	14.63	16.87	41.86
Quercus alba	13.4	5.18	4.63	8.84	18.65
Liriodendron tulipifera	17.6	5.70	6.10	6.12	17.92
Ulmus rubra	14.1	6.74	4.88	3.04	14.66
Ostrya virginiana	15.5	6.74	5.37	0.82	12.93
Juglans nigra	7.8	4.15	2.68	5.48	12.31
Fraxinus americana	11.3	4.66	3.90	2.64	11.20
Carya cordiformis	5.7	3.63	1.95	3.01	8.59
Tilia heterophylla	7.8	2.59	2.68	3.29	8.56
Sassafras albidum	8.5	4.15	2.93	0.75	7.83
Quercus muehlenbergii	5.7	3.63	1.95	1.28	6.86
Quercus velutina	3.5	2.07	1.22	2.60	5.89
Celtis occidentalis	5.7	2.07	1.95	0.98	5.00
Carya glabra	4.9	2.07	1.71	0.92	4.70
Carya ovata	2.8	2.07	0.98	0.21	3.26
Robinia pseudoacacia	2.2	1.04	0.73	0.85	2.62
Quercus rubra	1.4	1.04	0.49	0.99	2.52
Cornus florida	2.2	1.04	0.73	0.09	1.86
Paulownia tomentosa	1.4	0.52	0.49	0.40	1.41
Nyssa sylvatica	0.7	0.52	0.24	0.65	1.41
Acer negundo	0.7	0.52	0.24	0.30	1.06
Magnolia acuminata	0.7	0.52	0.24	0.20	0.96
Prunus serotina	0.7	0.52	0.24	0.03	0.79
Morus rubra	0.7	0.52	0.24	0.02	0.78
Asimina triloba	0.7	0.52	0.24	0.02	0.78
Totals	289.5	100.03	99.97	99.97	299.97

species, especially sugar maple. Wilson (1976) listed 447 taxa and Bryan (1977) 307 taxa of vascular plants for the loess bluffs. Over 18% of the 889 taxa reported for Hickman County were from loess or rich moist woods (Grubbs and Fuller 1991).

Most portions of the bluffs have experienced various degrees of disturbance, however, the forest remnants sampled were little disturbed as judged by their coefficients of determination (100r^2 82-92) (Schmelz and Lindsey 1965). All species were native except for princess tree (*Paulownia tomentosa*). Wilson (1976) listed princess as a characteristic species for Sandy Branch in Carlisle County.

Tree species composition of these forest remnants compares favorably to what was reported over 100 years ago (DeFriese 1880, 1884, Loughridge 1888). The forests on the damp white-sandy soils [loess] near Columbus, Kentucky included "white oak, liriodendron, black and red oaks, white

walnut, ash, considerable sugar maple, hickory, sweetgum, black gum, elms, pawpaw, and redbud" (DeFriese 1880). Loughridge (1888) noted that the original forests included, "oaks (white, chinquapin, black and spanish), hickory, walnut, tuliptree, basswood, elm, beech, pawpaw, sweet and black gum, large sassafras and a dense undergrowth of cane".

Tree density varied from 217-400 trees/ha and averaged 289.5. The average basal area was 27.2 m^2/ha with the maximum of 31.5 m^2/ha. Those values are within the range of such characteristics in other mixed mesophytic forests (Martin 1992, Held and Winstead 1975). Species diversity (H') for the combined sample was 3.66 but for individual stands ranged from 3.01 - 3.52. Those values are comparable to those found for all-deciduous mixed mesophytic forests (Monk 1967, Bryant 1988, Martin 1992). The contributions of several species to the community is reflected by an equitability of .77 which agrees with equitability >.50 for mixed mesophytic forests (Martin 1992).

Throughout their N-S length, the loess bluffs are situated between the swamps and bottomland hardwoods of the Mississippi River floodplain to the west and the oak-hickory uplands to the east (Davis 1923). Caplenor (1968) concluded that the mixed hardwood forests of the deep loess in Mississippi were composed of species from the Mixed Mesophytic, Western Mesophytic, bottomland hardwood and the Southern mixed hardwood forests. Miller and Neiswender (1987a, b) found the bluff forests to be somewhat distinct from adjacent communities. Loughridge (1888) noticed that the characteristic vegetation of the bottoms extended to the uplands because of the loess deposits. Sweetgum was the only important tree species in both the bottomland hardwoods and loess bluffs (Bryant 1990, Miller and Neiswender 1989).

Miller and Neiswender (1987a, b) found greater similarity between the forests of the Chickasaw Bluffs and the Appalachians of east Tennessee than to adjacent communities on thin loess. Coefficients of similarity between the bluff forests of the Purchase and the sugar maple-basswood-tuliptree and beech-sugar maple communities of the Lilley Cornett Woods (Martin 1975) in eastern Kentucky were ≈ 48% each. The similarity to the old growth composite for Lilley Cornett Woods (Muller 1982) was >49%. These similarities are about the same as reported by Caplenor (1968) and Miller and Neiswender (1987a, b, 1989).

Braun (1950) observed that the loess bluffs may show stronger vegetational similarities to the forests on the dissected glacial deposits in the Illinoian Drift Area than to the Appalachians. Indeed, similarities between the loess bluffs and the dissected Kansan (Bryant 1978) and Illinoian Drift (Jackson and Allen 1969, Held and Winstead 1976, Bryant 1988, unpub.) of Kentucky, Indiana and Ohio ranged from 41-61%. The average similarity for the 15 stands that were compared to the bluffs composite was >54%. These somewhat higher values seem to support Braun's (1950) observations and may give support for her placing the Jackson Purchase in the transitional Western Mesophytic Forest rather than the Oak-Hickory.

The phytogeographical significance of the loess bluffs, especially the Tunica Hills near their southern terminus, was mentioned by Braun (1950) but given emphasis by Delcourt and Delcourt (1975). Braun (1950) interpreted the mesophytic communities of the loess bluff ravines to be Tertiary relics. On their maps, Delcourt and Delcourt (1981) showed there to be refugial areas of mixed hardwood forests along the bluffs that dated from 40,000 yr. B.P. These communities were relics persisting from the late Pleistocene migrations (Delcourt and Delcourt 1975, 1981).

Mesic species, beech, sugar maple, and basswood, collectively accounted for <1% of the trees in the 1820 General Land Office Survey of the Jackson Purchase (Bryant and Martin 1988). Oaks and hickories were the major species in that survey totalling 72% of the trees. The low percentages for the mesic members seem to indicate their limited or confined distribution in the Purchase. The percentage occurrences (RD) for each of the 27 tree species in the loess bluff ravines were compared to their collective RDs in 63 other upland and lowland survey stands in the Jackson

Purchase (Bryant unpub.). The presence of 12 species, sugar maple, beech, sweetgum, black walnut, basswood, slippery elm, hophornbeam, bitternut hickory, white ash, sassafras, hackberry and chinquapin oak, in the bluff ravines relative to other habitats was highly significant ($p > .001$, z-test). A thirteenth species, cucumber magnolia, was confined to the bluffs. Six other species, white oak, black oak, shagbark hickory, pignut hickory, dogwood and blackgum, were significant for their lack of importance in the bluff ravines relative to other habitats ($p > .001$, z-test). The near confinement of a number of these mesic species in the Jackson Purchase to the bluff ravines may support to their refugial nature (Braun 1950, Delcourt and Delcourt 1975, 1981, 1983, Heineke 1987) as may the presence of disjuncts (Little 1970).

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