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A Phytosociological Description of a Remnant Bottomland Hardwood Forest in Denton, Texas

LLELA Research Note 5
June 2003

This *Note* is a corrected version of the essay that appeared in the November 1999 issue of the *Texas Journal of Science* (Vol 51(4):309-316). Although it does not describe a site at LLELA, it is important for regional comparisons and forest restoration work, which is why it is included as a *LLELA Research Note*. The raw data is also available for research or study on the LLELA website.

A Phytosociological Description of a Remnant Bottomland Hardwood Forest in Denton, Texas

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ABSTRACT

A remnant bottomland hardwood forest near Denton, Texas, was surveyed in order to describe its phytosociological composition. Hackberry, cedar elm, and green ash dominate the site with respect to basal area, density, and frequency in the forest. Importance values for these three dominant species are 33%, 27%, and 11%, respectively. Cluster analyses of plot metrics indicate a patchy forest. Many trees were found to be well over 200 years old, indicating that the forest predates any significant Anglo settlement. These results indicate that the forest may be classified as transitional old-growth of the hackberry-elm-ash forest type. Because of its unique status as a relatively intact north Texas bottomland hardwood forest, the data obtained from this site can be used for comparisons with other bottomland forests, and as a guideline for future restoration efforts throughout the northwestern region of the southern bottomland forests.

INTRODUCTION

The bottomland hardwood ecosystem in Texas prior to European settlement once extended over 6.5 million hectares; it is estimated that less than 40% of this original extent still remains (Frye 1986), with only a few small and isolated patches of old growth scattered amongst the floodplains of the eastern third of the state. Intact bottomland hardwood forests are among the list of endangered ecosystems in the United States; in the past 50 years, losses of these forest have at times been greater than 120,000 ha per year (MacDonald et al. 1979, as cited in King 1996). This survey was undertaken in order to analyze and classify a remnant bottomland forest, the results of which can be used to assist future ecological management and restoration of these disappearing ecosystems (Shear et al. 1996; Michener 1997).

SITE LOCATION

The site is a bottomland hardwood forest of approximately 93 ha, lying within the Cross Timbers and Prairies physiogeographic province of north-central Texas. The forest is located at UTM coordinates 682045 W and 3684420 N (Zone 14), along the banks of the Elm Fork of the Trinity River approximately 10 km northeast of downtown Denton in Denton County. It is located within the Lewisville Lake Wildlife Restoration Area, which is owned and managed by the U.S. Army Corps of Engineers.

The forest lies on the Elm Fork's floodplain. The site is covered by a layer of silty clay loam, classified by the USDA as Ovan clay, a soil type most often found on the floodplains of major regional streams (Ford & Pauls 1980). This series resides within the family of fine, montmorillonitic, thermic Udic Chromusterts soils. Both the permeability and the surface runoff of the soil are reported as slow (Ford & Pauls 1980).

METHODS

A grid of 128 100 m^2 circular plots was laid out and sampled using standard forestry metrics, including diameter at breast height (dbh), density, and frequency of occurrence. At total of 972 trees were sampled within the plot areas.

For determination of age, 24 individuals of hackberry, 13 individuals of green ash, and 4 individuals of bur oak through all size classes were randomly selected for increment boring. After obtaining the dbh of each tree, a 16 inch increment borer with a 0.2 inch diameter was drilled into the tree at breast height to obtain a core sample. The rings on each core sample were double counted in the field. The cores were then replaced in the hole and covered with a dab of mud to prevent insect or fungal intrusion into the tree's bole.

Phytosociological importance values for each species were calculated for the forest through an averaging of relative dominance (basal area per unit area sampled), density, and frequency of occurrence values. Linear regression was performed on age class and dbh data for the three species chosen for age class analysis. Regression was tested at an ? =0.05, and descriptive statistics were also generated in order to obtain 95% confidence limits. Cluster analyses were used to determine the relative similarity of the individual plots. K-Means clustering was used for specified cluster designation, the complete linkage joining algorithm was

used in order to maximize differences between plot distance values, percent disagreement distance algorithm was used for categorical (presence/absence) data, and City-block distance algorithm was used for continuous data in order to minimize the effects of extreme values.

RESULTS

This forest contains at least 24 different tree species, the most common of which include sugar hackberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*), eastern cottonwood (*Populus deltoides*), bur oak (*Quercus macrocarpa*), American elm (*Ulmus americana*), cedar elm (*Ulmus crassifolia*), and slippery elm (*Ulmus rubra*). In the understory, common trees include hawthorn (*Crataegus* spp.), box elder (*Acer negundo*), Eve's necklace (*Sophora affinis*), and bois d'arc (*Maclura pomifera*). Table 1 lists all tree species encountered in the forest.

Table 2 gives the importance values of each tree species found within sampling plots. Hackberry and cedar elm dominate this forest with respect to basal area, density, and frequency in the forest; hackberry had an importance value of 32.55%, while cedar elm had an importance value of 26.63%. Green ash had an importance value of 11%. Table 3 gives the total basal area, number of trees per hectare, and frequency of plot occurrence for each tree species. Snag density was found to be 57 standing dead trees per hectare. These results indicate that the forest may be classified as a hackberry-elm-ash forest type (Nixon 1986).

The regression analysis for the age to dbh relationship demonstrated a positive linear relationship between age and size for hackberry and green ash. For hackberry, $y = 1.7015x + 7.4975$ ($R2 = 0.68$, $p<0.0001$); for green ash, $y = 1.0175x + 14.597$ ($R2 = 0.7088$, $p=0.0003$). The small sample size for bur oak prevented the use of linear regression; estimates were derived instead using an average ring-to-diameter ratio of 2.3 years per cm of diameter. Allometric formulae for these species are summarized in Table 4.

Cluster analysis of the presence and absence of the different tree species by plot and the analysis of plot metrics demonstrated that the forest is highly patchy in terms of both species composition and association. At the 50% relative dissimilarity level, there were 14 different classification clusters, indicating that plot species composition varies extensively across the sampled areas. Many spatially adjacent plots were not clustered together in the results of 5 category K-Means clustering, further demonstrating the patchy distribution of the forest's tree species. The highly patchy nature of this forest is a classic characteristic of natural mature and old growth forests, especially on floodplains.

DISCUSSION

The results of our analysis indicate that the forest is dominated by hackberry, cedar elm, and green ash, and is likely to remain so well into the future. These three species are able to tolerate relatively prolonged periods of inundation and are shade tolerant, attributes that have helped them survive and propagate in the closed canopy and in the frequently flooded environment beside the Elm Fork. Hackberry and cedar elm occurred throughout most of the size classes (except for the very large ones); this evidence of recruitment indicates that these species are replacing themselves and remaining as the "climax" community. The extreme size (and likely

old age) of many individual trees within the forest indicates that conditions for their growth have existed for at least 150-250 years; the forest itself could be many centuries older.

The presence of numerous oak, pecan, and black walnut seedlings, paired with the sizable amount of mature bur and Shumard oaks located in the forest, may indicate a maturation of the floodplain soils underlying the forest, a condition that might lead to the oak-hickory community that is often found in old growth bottomland hardwood stands. The hypothetical movement of this forest to such a community is an event that would occur over hundreds of years and be subject to several factors including extent and duration of hydroperiods (flooding, rain, etc.). The presence of Lake Ray Roberts upstream will eliminate many of the flood cycles that have contributed so much to the current structure of the site; without the flood events which were so common, the water table underlying the forest should stabilize. Indication that this is already happening comes from the black walnuts, which are found in drier soils than hackberry, cedar elm, and green ash. The current distribution of bur oak, with large trees located on drier river-front sites and numerous seedlings readily apparent throughout the forest, also points to a changing water table, as bur oaks cannot withstand prolonged periods of inundation. Without the competitive advantage provided by past flood events, the aspect of this forest may change from a hackberry/elm/ash forest to one dominated by a combination of bur and Shumard oaks and black walnuts, which are representative of classic old-growth and late successional bottomland hardwood forests (Hodges 1997).

The results of the cluster analysis indicate a forest with a patchy distribution. Respective tree species tend to occur in clumped distributions; this is likely a result of seed dispersion and the site's topography. Because of the forest's general lack of vertical relief, elevation changes of 0.25-0.5 m may drastically alter the species present at that location. Lower areas are more inclined to support forested wetlands or maintain soil inundation for longer periods of time, thus affecting the size and species of trees present. In addition, the understory vegetation present at various sites is heavily reliant upon the level of soil moisture and inundation.

These findings are consistent with trends in bottomland forest ecology and succession as noted by Nixon (1986), Nixon et al. (1990), Hodges (1997), and Kellison & Young (1997). Based on descriptive forest classification systems, we have determined that the forest as a whole may be classified as transitional old-growth (Oliver & Larson 1990). Several smaller stands within this forest may be classified as true old-growth, based on species composition, age/size classes, and stand structural features. Because of its unique status as a relatively intact North Texas bottomland hardwood forest, the forest can be used as a baseline for comparisons with other similar forests in the area.

ACKNOWLEDGMENTS

Funding to support this research was provided in part by the City of Denton. Thanks to Mr. Bill Lynch for graciously providing his time and knowledge of local natural and cultural history, as well as for providing access to the site through his land. Additional thanks to two anonymous reviewers who helped improve the quality of this manuscript.

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Table 1. Tree and large shrub species encountered in the relict bottomland forest.

Species	**Common Name**
Acer negundo	Box elder
Broussonetia papyrifera	Paper mulberry
Bumelia lanuginosa	Chittamwood
Carya illinoensis	Pecan
Celtis laevigata	Hackberry
Cornus drummondii	Rough-leaf dogwood
Crataegus spp.	Hawthorn
Diospytos virginiana	Common persimmon
Fraxinus pennsylvanica	Green ash
Gleditsia triacanthos	Honey locust
Juglans nigra	Black walnut
Juniperus virginiana	Eastern red cedar
Maclura pomifera	Bois d'arc
Morus rubra	Red mulberry
Platanus occidentalis	American sycamore
Populus deltoides	Eastern cottonwood
Quercus macrocarpa	Bur oak
Quercus shumardii	Shumard oak
Salix nigra	Black willow
Sophora affinis	Eve's necklace
Ulmus alata	Winged elm
Ulmus americana	American elm
Ulmus crassifolia	Cedar elm
Ulmus rubra	Slippery elm

Table 2. Importance values of sampled tree species.

Species	Common Name	Relative Dominance	Relative Density	Relative Frequency	Importance Value
Celtis laevigata	Hackberry	30.50	39.92	27.25	32.55
Ulmus crassifolia	Cedar elm	34.28	23.46	22.14	26.63
Fraxinus pennsylvanica	Green ash	8.68	12.14	12.17	11.00
Snags		5.19	7.51	12.65	8.45
Quercus macrocarpa	Bur oak	14.89	2.37	5.35	7.54
Maclura pomifera	Bois d'arc	2.06	2.26	3.65	2.66
Bumelia lanuginosa	Chittamwood	1.74	1.95	4.14	2.61
Juglans nigra	Black walnut	0.43	2.67	3.65	2.25
Crataegus spp.	Hawthorn	0.42	2.47	2.43	1.77
Carya illinoensis	Pecan	0.25	1.54	1.95	1.25
Acer negundo	Box elder	0.26	1.44	0.73	0.81
Morus rubra	Red mulberry	0.09	0.72	1.46	0.76
Quercus shumardii	Shumard oak	1.04	0.31	0.49	0.61
Sophora affinis	Eve's necklace	0.05	0.51	0.73	0.43
Ulmus americana	American elm	0.09	0.41	0.49	0.33
Broussonetia papyrifera	Paper mulberry	0.02	0.11	0.24	0.12
Gleditsia triacanthos	Honey locust	0.01	0.11	0.24	0.12
Ulmus rubra	Slippery elm	0.00	0.10	0.24	0.11
Sum		**100**	**100**	**100**	**100**

Table 3. Summary results of forest composition survey based on plot analysis.

Species	**Common Name**	**Dominance (m^2/ha)**	**Density (stems/ha)**	**Frequency (# of plots)***
Celtis laevigata	Hackberry	10.34	303	112
Ulmus crassifolia	Cedar elm	11.62	178	91
Fraxinus pennsylvanica	Green ash	2.94	92	50
Snags		1.76	57	52
Quercus macrocarpa	Bur oak	5.05	18	22
Maclura pomifera	Bois d'arc	0.70	17	15
Bumelia lanuginosa	Chittamwood	0.59	15	17
Juglans nigra	Black walnut	0.14	20	15
Crataegus spp.	Hawthorn	0.14	19	10
Carya illinoensis	Pecan	0.08	12	8
Acer negundo	Box elder	0.09	11	3
Morus rubra	Red mulberry	0.03	5	6
Quercus shumardii	Shumard oak	0.35	2	2
Sophora affinis	Eve's necklace	0.02	4	3
Ulmus americana	American elm	0.03	3	2
Broussonetia papyrifera	Paper mulberry	0.00	1	1
Gleditsia triacanthos	Honey locust	0.00	1	1
Ulmus rubra	Slippery elm	0.00	1	1
Sum		33.89	759	411

* total number of plots = 128

Table 4. Age estimation formulae for hackberry, green ash, and bur oak derived through regression analysis of dbh and age information. +/- indicates 95% confidence limits.

Species	**Formula to estimate age**	**95% confidence limits**
Celtis laevigata	age = (1.7015*dbh) + 7.4975	+/- 0.03*dbh
Fraxinus pennsylvanica	age = (1.0175*dbh) + 14.597	+/- 0.23*dbh
Quercus macrocarpa	age = 2.3*dbh	+/- 0.38*dbh