Species composition and classification of forest vegetation at the John T. Nickel Family Nature and Wildlife Preserve, Cherokee County, Oklahoma

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The deciduous forests of Oklahoma are situated in a unique biogeographic position on the western fringe of the eastern deciduous forest. In this study, we describe the forest associations from a site in the Oklahoma Ozarks. Thirty-nine tree species were recorded from fifty plots. Tree species with the highest importance values were *Pinus echinatus*, *Quercus marilandica*, *Q. velutina*, *Q. stellata*, **and** *Q. rubra*. **Based on interpretation of Non-metric Multidimensional Scaling results, five forest vegetation associations were identified:** *Carya cordiformis - Q. stellata*, *P. echinata - Q. stellata, P. echinata - Q. velutina, Q. alba – Q. rubra,* **and** *Q. marilandica - Q. velutina*. **© 2012 Oklahoma Academy of Science.**

INTRODUCTION

The upland forests of Oklahoma represent the westernmost extension of the eastern deciduous forest of North America. Although it is well known that forests in the Ozark Plateau and Ouachita Mountains of eastern Oklahoma are more species rich then forests and woodlands in western and central Oklahoma (Rice and Penfound 1959), there are few quantitative studies from that area. The objective of this research is to analyze patterns of tree species composition and richness in an Ozark forest of Oklahoma.

The Ozark Plateau is a subregion of the Interior Highlands and covers central and southern Missouri, northern Arkansas and northeastern Oklahoma (Hunt 1974). Vegetation of the region is predominantly *Quercus-Carya* forest with extensive stands of *Quercus-Carya-Pinus* (Kuchler 1966). Braun (1950) described the forest vegetation of the Ozark Plateau as consisting of *Quercus* species on xeric slopes, and *Acer saccharum* and other mesophytic species predominating on mesic slopes. Forest cover in the region is locally interrupted by prairie openings and limestone glades (Ware et al. 1992).

Although lacking in Oklahoma, analyses of Ozark forests have been conducted in Arkansas (Read 1952; Soucy et al. 2005) and Missouri (Kucera and Martin 1957; Rochow 1972; Zimmerman and Wagner 1979; Nigh et al. 1985; Ware et al. 1992). There is some consensus between these reports that three major forest types occur in the Ozarks; bottomland, mesic north-facing slope, and xeric south-facing slopes.

Rochow (1972), for example, sampled 75 plots in a gradient analysis of forest composition in central Missouri. Three forest vegetation associations were identified; upland oaks, mesic coves and slopes, and bottomlands. Of the 35 tree species encountered, *Quercus alba, Q. muehlenbergii, Q. rubra*, and *Acer saccharum* were the most frequent. *Acer nigrum* (not present in Oklahoma), *A. saccharum, Carya cordiformis, Juglans nigra, Q. muehlenbergii, Q. rubra*, and *Tilia americana* were dominant species in the mesic cove association; *C. alba, C. texana, Q. alba*, and *Q. velutina* in the upland oak association; *Celtis occidentalis, Platanus occidentalis*, and *Ulmus americana* in the bottomland forest association.

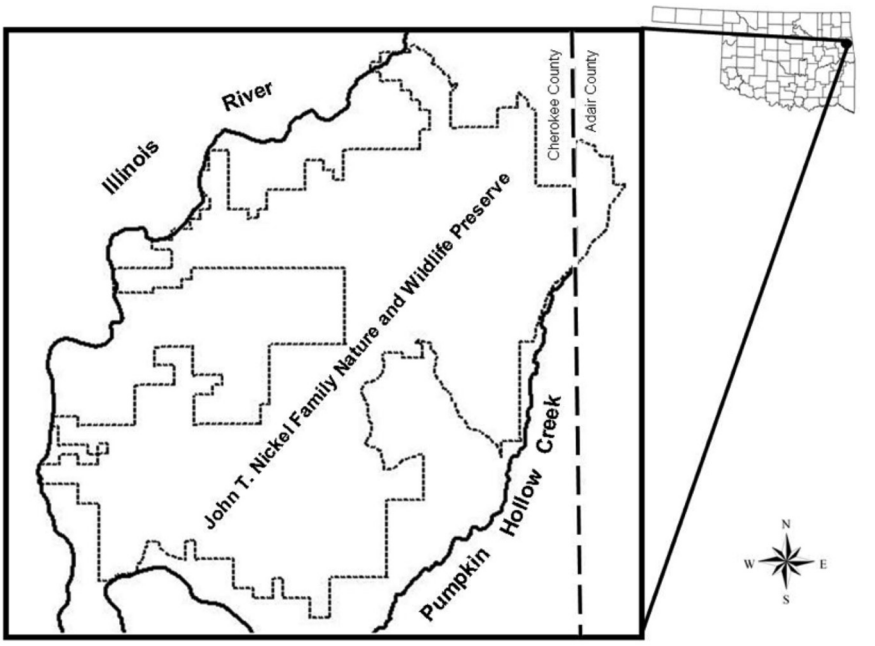

Figure 1. Location of The Nature Conservancy's J. T. Nickel Family Nature and Wildlife Preserve in the Ozark Plateau, Cherokee County, Oklahoma.

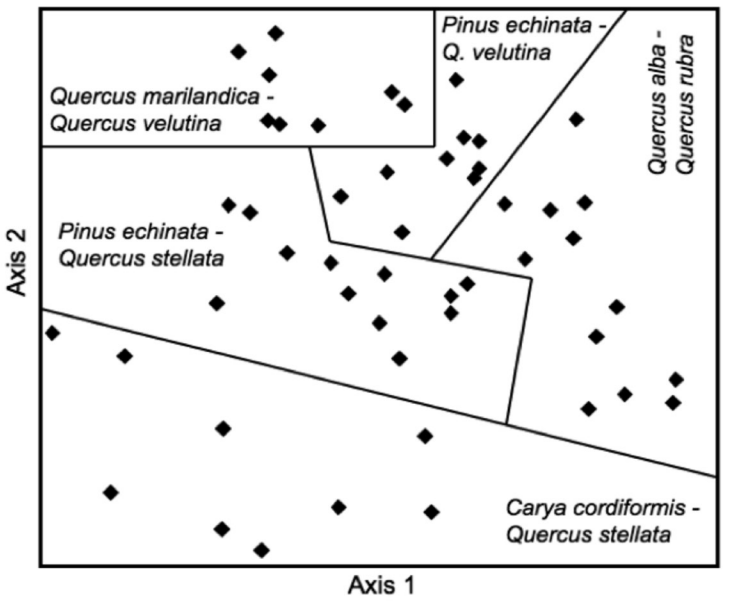

Figure 2. Non-metric multidimensional scaling plot of forest stands at The Nature Conservancy's J. T. Nickel Family Nature and Wildlife Preserve, Cherokee County, Oklahoma.

Zimmerman and Wagner (1979) also described three forest types; bottomland, protected slope, and exposed south-facing slope. Of the 34 tree species listed, *Ulmus rubra* and *P. occidentalis* were the dominant bottomland species; *A. negundo* and *C. cordiformis* were secondary species. *Cornus florida, Q. alba*, and *Q. velutina* were listed as dominant species on protected slopes, and *Juniperus virginiana* and *Q. muehlenbergii* characterized exposed south-facing slope. Ware et al. (1992) also described three "groups" of vegetation based on an analysis of 81 sites; *C. texana, Q. alba*, and *Q. velutina* predominated on xeric sites, *P. occidentalis* was the dominant tree in bottomland and streamside stands, and *A. saccharum, J. virginiana, Q. muehlenbergii*, and *T. americana* characterized mesic stands.

Prior to the work of Rice and Penfound (1959), there were no quantitative studies of forest composition in the Oklahoma Ozarks. Information on Ozark forest composition came from descriptive studies, such as Bruner (1931) and Blair and Hubbell (1938). These authors listed the predominant upland tree species as *C. alba*, *C. texana*, *Quercus falcata*, *Q. marilandica*, *Q. stellata*, and *Ulmus alata. Pinus echinata* was reported as locally abundant. Common understory species included *Amelanchier arborea, Crataegus crus-galli, Vaccinium arboreum, V. pallidum,* and *Viburnum rufidulum. Acer saccharum*, *C. cordiformis*, *Morus rubra, Nyssa sylvatica, Q. muhlenbergii*, and *Q. alba* predominate on steep north facing slopes and ravines, with *C. florida, Frangula caroliniana*, and *Ostrya virginiana* in the understory. *Acer saccharinum*, *Betula nigra, Lindera benzoin*, *P. occidentalis*, and *U. americana* are frequent in bottomland forests.

Rice and Penfound (1959) collected the quantitative data from the Oklahoma Ozarks in a statewide analysis of the upland forests. Of the 21 stands sampled and 30 species encountered in the Ozarks, *Q. marilandica* and/or *Q. stellata* were the dominant species, and *C. texana* and *Q. velutina* were secondary forest constituents (Rice and Penfound 1959). In Cherokee County, the location of the present study, Rice and Penfound sampled five plots, in which *Quercus* species were the most prevalent. *Quercus marilandica*, *Q. stellata*, and *Q. velutina* were the dominant species in 4 of the plots, and *Q. alba* and *Q. shumardii* predominated in the fifth plot.

The objective of this study was to analyze the woody species composition of a forested location in the Ozark Plateau forest of Oklahoma. Given that the study area is situated in the western Ozarks, one possible outcome of our investigation is that fewer species will be encountered than in studies elsewhere in the region. This assumption is predicated on the trend of decreasing species in the eastern deciduous along any east to west gradient. In addition to species richness, do the Ozark forest of Oklahoma exhibit similarities in species composition and topo-edaphic relationships as described above?

STUDY AREA

Vegetation sampling was conducted at John T. Nickel Family Nature and Wildlife Preserve (JTN [and 36.09°N to 35.98°N and 94.92° W to 94.78°W]), a facility of The Nature Conservancy in Cherokee County. The JTN was established in 2000 to protect and restore 6,070 hectares of Ozark forest and woodland habitat (The Nature Conservancy 2006). The climate is Subtropical Humid (Cf) (Trewartha 1968). Summers are warm (mean July temperature = 26.9°C) and humid, and winters are relatively short and mild (mean January temperature = 2.7°C). Mean annual precipitation is 122 cm (Oklahoma Climatological Survey 2009).

The surface geology is predominantly Mississippian limestone and chert (Johnson 2008). Soils at the site belong to either the Sallisaw-Elsah-Staser Association (deep, gravelly or loamy, nearly level to sloping soils on floodplains and benches) or the Clark-Baxter-Locust Association (deep, stony and cherty, very gently sloping to

steeply sloping on timbered uplands) (Everett 1970). Elevation ranges from 184 to 381 m above sea-level.

Potential natural vegetation at JTN was mapped pine by Duck and Fletcher (1943) as oak-hickory. Previous landowners had converted the broad valley bottoms and level uplands to pastures of *Schedonorus phoenix*, which was cut for hay. Since acquisition, The Nature Conservancy has initiated a program of ecological restoration consisting of the reintroduction of fire and eradication of *S. phoenix*. The management goal is to recreate a mosaic of grassland, woodland and forest vegetation as described by authors such as Beilman and Brenner (1951) as existing in the Ozarks prior to extensive Euro-American settlement.

METHODS

Forest vegetation was sampled at fifty randomly selected locations throughout the JNT using 20 m x 20 m plots. Diameter-at-breast height (DBH) was recorded for stems greater then 2.54 cm. Basal area (BA) was calculated for each species in each plot using the formula Area=$\prod r^2$. Relative Basal Area (RBA) was calculated as the percentage of basal area contributed by individual species. Density (D) was defined as the number of stems for each species occurring in a plot. Relative density (RD) was calculated as percentage of total density contributed by individual species. Frequency was defined as the number plots in which a species occurred and relative frequency (RF) was calculated as the percentage of total density contributed by an individual species. The values for RBA, RD, and RF were summed into an importance value (IV) for each species and were used to evaluate a species contribution to stand composition. Nomenclature follows the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS 2012).

Importance values for each species (39) from each plot (50) were compiled into a species-plot matrix for multivariate analysis. Non-metric Multidimensional Scaling (NMS) was select to analyze patterns of species composition. NMS is an ordination method used for data that are non-normal ecological data (McCune and Grace 2002). In addition, NMS does not assume a linear relationship among variables. NMS in PC-Ord (MjM Software Design: Version 4) was used for the analysis. The Sorensen distance measure with a random starting configuration was selected for NMS. There were 15 runs with real data and 30 with randomized data. The final stress was 13.48 for 4-dimensional solution and stability was 0.0001 for 76 iterations.

RESULTS AND DISCUSSION

A total of 39 tree species were encountered in 50 plots (Table 1). Nine species belonged to the genus *Quercus* and six in *Carya*. *Acer* was the only other genus with more than one species. *Castanea pumila* var. *ozarkensis*, a species that experienced a precipitous decline in abundance as a result of the chestnut blight and is now of conservation concern, was found in only one plot. Read (1952) reported the occurrence of *Castanea pumila* var. *ozarkensis* coincided with cherty soils, which was the case at JTN. Braun (1950) also encountered *Castanea pumila* var. *ozarkensis* at Dripping Springs (now Natural Falls) State Park and reported it as an understory species.

The number of species per plot ranged from 3 to 13 (mean = 7.1), which exceeds the number of tree species reported in previous studies in the Ozark region: Rice and Penfound (1959), n=30; Rochow (1972), n=35; Zimmerman and Wagner (1979) n=34; Braun (1950), n=20 and Kucera and Martin (1957), n=16.

Five of the 39 tree species scored importance values greater than 25 (Table 1): *P. echinatus* (45.6), *Q. marilandica* (32.7), *Q. velutina* (31.5), *Q. stellata* (26.8), and *Q. rubra* (26.6). Thirty species (77%) scored an IV > 10. Despite a high IV, *P. echinata* occurred in only 20 (40%) plots. Only five species

Table 1. Summary data for woody plants in 50 plots sampled in Cherokee County, Oklahoma. BA = basal area (m^2), RBA = relative basal area, FRQ = frequency, RF = relative frequency, DEN = total number of stems, MSTM = average density/plot, RD = relative density, and IV = importance value.

Species	BA	RBA	FRQ	RF	DEN	RD	IV
Pinus echinata	434.95	29.66	20	5.6	198	10.36	45.61
Quercus marilandica	236.38	16.12	23	6.44	194	10.15	32.71
Quercus velutina	186.91	12.74	34	9.52	177	9.26	31.53
Quercus stellata	125.2	8.54	27	7.56	205	10.72	26.82
Quercus rubra	150.3	10.25	26	7.28	175	9.15	26.68
Quercus alba	119.2	8.13	28	7.84	163	8.53	24.5
Carya cordiformis	54.74	3.73	23	6.44	167	8.73	18.91
Cornus florida	26.45	1.8	29	8.12	131	6.85	16.78
Ostrya virginiana	26.1	1.78	10	2.8	103	5.39	9.97
Carya texana	17.62	1.2	17	4.76	60	3.14	9.1
Cornus drummondii	1.56	0.11	9	2.52	70	3.66	6.29
Ulmus alata	4.85	0.33	16	4.48	20	1.05	5.86
Carya alba	12.35	0.84	11	3.08	16	0.84	4.76
Quercus falcata	17.29	1.18	7	1.96	23	1.2	4.34
Sassafrass albidum	0.95	0.06	7	1.96	21	1.1	3.12
Quercus shumardii	11.8	0.8	5	1.4	13	0.68	2.89
Quercus muehlenbergii	5.75	0.39	6	1.68	15	0.78	2.86
Carya ovata	4.16	0.28	5	1.4	17	0.89	2.57
Acer rubrum	3.99	0.27	3	0.84	25	1.31	2.42
Amelanchier arborea	0.16	0.01	6	1.68	12	0.63	2.32
Tilia carolina	4.41	0.3	5	1.4	11	0.58	2.28
Carya glabra	3.36	0.23	4	1.12	16	0.84	2.19
Acer saccaharum	6	0.41	4	1.12	12	0.63	2.16
Cercis canadensis	2.21	0.15	4	1.12	16	0.84	2.11
Carya illinoensis	3.92	0.27	5	1.4	6	0.31	1.98
Quercus macrocarpa	1.5	0.1	5	1.4	8	0.42	1.92
Juniperus virginiana	0.15	0.01	3	0.84	7	0.37	1.22
Morus rubra	0.23	0.02	3	0.84	2	0.1	0.96
Juglans nigra	1.91	0.13	2	0.56	3	0.16	0.85
Robinia pseudoaccacia	0.41	0.03	1	0.28	10	0.52	0.83
Vaccinium arboreum	0.02	0	2	0.56	2	0.1	0.67
Frangula caroliniana	0.13	0.01	1	0.28	4	0.21	0.5
Nyssa sylvatica	0.13	0.01	1	0.28	4	0.21	0.5
Lindernia benzoin	0.02	0	1	0.28	3	0.16	0.44
Platanus occidentalis	1.39	0.09	1	0.28	0	0	0.37
Diospyros virginiana	0.08	0.01	1	0.28	1	0.05	0.34
Castanea pumila var. *ozarkensis*	0.01	0	1	0.28	1	0.05	0.33
Viburnum rufidulum	0.01	0	1	0.28	1	0.05	0.33

occurred in 50% or more of the plots: *Q. velutina* (34 plots), *Cornus florida* (29), *Q. alba* (28), *Q. stellata* (27), and *Q. rubra* (26).

The species composition reported for JTN is consistent with previous reports from the Ozark Plateau of Oklahoma. At Dripping Springs, Braun (1950) reported 20 woody species, of which *Quercus marilandica* was dominant in uplands, and *Q. alba, Q. stellata,* and *Carya* sp. were secondary consitutents. *Quercus alba* and *Q. rubra* were the most important canopy species in mesic ravine at Dripping Springs.

Rice and Penfound (1959) recorded 30 species in Cherokee, only nine fewer than JTN. *Quercus stellata, Q. marilandica, Q. velutina* and *Q. shumardii* had the highest mean IVs in their study, though none of these species occurred at all sites sampled. *Pinus echinata* occurred in a higher percentage of sites at JTN than in the Rice and Penfound (1959) data. In both the Braun and Rice and Penfound, the lower number of species reported is most likely due to the smaller sample size.

We recognized five forest vegetation associations based on interpretation of the NMS results: *Carya cordiformis - Q. stellata, P. echinata - Q. stellata, P. echinata - Q. velutina, Q. alba – Q. rubra,* and *Q. marilandica - Q. velutina.* The association names represent the species with the highest IVs in that category. In addition, we used species composition to assigned each JTN forest association to one of the three topo-edaphic (bottomland, mesic north-facing slope, and xeric south-facing slope) categories derived from the combined work of Rochow (1972), Zimmerman and Wagner (1979), and Ware et al. (1992). For example, the *Carya cordiformis - Q. stellata* forest association, which consisted of nine plots, corresponds to the bottomland type. The *Carya cordiformis - Q. stellata* forest association had the highest species richness (n=30). *Ostrya virginiana* was the only other species to score an I.V >10 in this association. Woody species found exclusive to this vegetation type were *Diospyros virginiana, Frangula caroliniana, Juglans nigra, Lindera benzoin*, and *Platanus occidentalis*.

The *Q. alba - Q. rubra* forest association corresponds with the mesic north-facing slope and consists of 12 plots and 21 species and was the only association to include *Nyssa sylvatica* and *Viburnum rufidulum*. *Acer saccharum* was found only in *Q. alba - Q. rubra* and the *Carya cordiformis - Q. stellata* forest associations and thus straddles the bottomland and mesic categories.

The xeric category included the *P. echinata - Q. stellata, P. echinata - Q. velutina, Q. marilandica - Q. velutina* forest associations. The *P. echinata - Q. stellata* forest association consisted of 12 plots and 23 species and the *P. echinata - Q. velutina* forest association 9 plots and 24 species. *Vaccinium arboreum* was found only in the xeric forest associations. *Acer rubrum, Morus rubra*, and *Tilia americana* are mesic forest species that occurred in *P. echinata - Q. velutina* plots.

The *Q. marilandica - Q. velutina* consisted of 8 plots and 21 species. The only occurrence of *Castanea pumila* var. *ozarkensis* was a plot in this association. *Carya alba, C. cordiformis, C. texana, Cornus drummondi, C. florida, Q. alba, Q. marilandica, Q. rubra, Q. velutina*, and *Ulmus alata* were the only species to occur in all five forest associations.

CONCLUSIONS

Contrary to expectations, the species richness at the JTN exceeded that of sites in the Ozarks of Arkansas and Missouri, as well as other sites in Oklahoma. Disparities in sampling design and intensity might explain these differences. For example, Braun (1950) sampled only two points at one location in Oklahoma. Rice and Penfound (1959) sampled 21 sites in the Oklahoma Ozarks, only 5 were in Cherokee County. Regarding species composition, the dominant upland tree species at JTN were the same as Rice and Penfound (1959): *Quercus stellata, Q. marilandica,* and *Q. velutina.* The most distinct difference was the higher abundance of *Pinus echinata* than at other Ozark location

(Rochow 1972; Zimmerman and Wagner 1979; Ware et al. 1992). Notable speices absent from our dataset but present in Rochow (1972) and Zimmerman and Wagner (1979) were Carya ovalis and Fraxinus quadrangulata, although both have been reported from Cherokee County (Hoagland et al. 2012). Finally, topo-edaphic in Oklahoma closely parallel those in other portions of the Ozarks.

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