FINAL REPORT

FEDERAL AID GRANT NO. T-18-P-1

ASSESSMENT OF ECOLOGICAL DISTURBANCE TO A CROSS TIMBER HABITAT

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

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FINAL REPORT

State: Oklahoma **Grant Number:** T-18-P-1

Grant Program: State Wildlife Grants

Grant Name: Assessment of Ecological Disturbance to a Cross Timbers Habitat

Grant Period: 1 June 2004–31 May 2007

A. Abstract:

The Cross Timbers forest (dominated by *Quercus stellata* and *Q. marilandica*) is one of the largest ecosystem types in Oklahoma, but little is known of the impact of disturbance on plant composition and wildlife of special concern. In 2003, a tornado severely damaged a portion of the Cross Timbers forest at the Tallgrass Prairie Preserve in Osage County, Oklahoma. To assess the effects of the tornado, we established a 14.55-ha permanent plot divided into 1,448 10m x 10m modules encompassing damaged forest and adjacent undamaged forests and grasslands. The spatial location of each tree in the plot was recorded as was the degree of damage sustained from the tornado. In 2004, 2005, and 2006 we resampled the plot and counted the number of basal and epicormic sprouts present on each tree. We also established five transects (two of undisturbed grasslands and three of damaged Cross Timbers) to assess effects on understory vegetation. We also surveyed the bird community in 2004, 2005, and 2006. We found that while *Q. marilandica* sustained significantly greater damage and rates of mortality than did *Q. stellata* following the tornado, it also produced more sprouts and thus seems to be reestablishing more quickly post disturbance. We found no significant difference in species richness between the understory transects, although there were significant differences in species composition. Survey of the bird community showed an increase in species richness in the damaged areas throughout the three years of monitoring. Fire is another important disturbance in the Cross Timbers forests. We collected 150 cross-sections from downed trees throughout the plot. We used dendrochronological techniques to reconstruct the fire history of the area. We estimated a fire return interval of 1.35 years between 1947 and 1992 with most fires occurring in the early spring.

B. Objectives:

To examine the influence of a severe 2003 tornado, on a Cross Timbers forest in the Tallgrass Prairie Preserve, Osage county, with particular focus on forest structure, tree demography, regrowth, bird communities, and disturbance history, and to reconstruct the fire history using dendroecological techniques.

C. Need:

Oklahoma's rich biological heritage is derived, to a large extent, from the State's diversity of habitats. In particular, Oklahoma's grasslands and forests each have characteristic suites of species, many of which are of concern for conservation (Oklahoma Department of Wildlife Conservation 2005) and game interests. In many parts of the state, forests and grasslands can coexist in the same landscape—yet the reasons why one piece of land becomes a forest and another piece of land becomes a grassland is unclear. Sometimes the distinction is due to underlying soil or bedrock patterns (Johnson and Risser 1972, Roe 1998, Hoagland et al. 1999) or climate (Stadler et al. 1992), yet at other times the distinction may be due to disturbance history (Penfound 1962, Abrams 1992). However, because most kinds of natural disturbance are rare (in human lifespans, but not necessarily those of trees) and unpredictable, they are difficult to study.

In the evening of 8 May 2003, a tornado (F3 on the five-point Fujita scale) tracked through the southwestern part of the Nature Conservancy's Tallgrass Prairie Preserve. While much of the storm path covered grasslands, with little or no sign of destruction, the tornado ripped through about 500 meters of Cross Timbers. Digital photographs of the damage are available at www.okstate.edu/artsci/botany/tornado/. A total of 570 trees were killed and another 401 damaged by the tornado.

In most studies of windstorms, the outcome is clear: the disturbed area will revert back to forest (Glitzenstein and Harcomb 1988, Peterson and Picket 1995, Everham and Brokaw 1996, Held et al 1998, England et al. 2000, Peterson 2000). However, in the Cross Timbers, it is possible that disturbance may change forests into grasslands or it may change the composition of the forest. The Cross Timbers is dominated primarily by two tree species blackjack oak (*Quercus marilandica*) and post oak (*Quercus stellata*), but little is known of the processes or disturbances that allow for the co-dominance of these two species.

These potential effects of windstorms have important implications for wildlife. For example, increasing cover of prairie can benefit obligate grassland birds [e.g. Greater Prairie Chicken (*Tympanuchus cupido*), Henslow's Sparrow (*Ammodramus henslowii*)] and lepidopterans (Rattlesnake Master Borer Moth (*Papaipema eryngii*), Regal Fritillary (*Speyeria idalia*), Iowa Skipper (*Atrytone arogos* ssp. iowa)). The creation of long-standing snags can influence populations of cavity-nesting birds such as the Red-Headed Woodpecker (*Melanerpes erythrocephalus*) (Pogue and Schnell 1994). The Northern Bobwhite (*Colinus virginianus*) and Painted Bunting (*Passerina cirus*) typically are associated with the prairie/forest interface and may benefit from thickets. The long-term presence of logs or snags may strongly impact the small mammal and reptile communities.

We examined effects of tornado and fire disturbance on a Cross Timbers habitat and its associated avian wildlife of special concern (Oklahoma Department of Wildlife Conservation 2005).

D. Approach:

Tree response

We established a 14.55-ha permanent plot in the Tallgrass Prairie Preserve in August 2003, approximately three months after the tornado. The plot included damaged and undamaged forest areas as well as immediately adjacent grasslands. We divided the plot into 1,448 10-m x 10-m modules (100 m^2) and set rebar at each corner of the module. Every 50 m, we capped the rebar with an aluminum Surv-Kap® (Surv-Kap, Tucson, AZ) with the coordinates permanently stamped in it. The intervening rebar were capped with plastic caps with the coordinates written in permanent marker. The permanent plot contains 681 grassland modules (no trees present) and 621 forest modules (at least one tree present). One hundred forty-six modules were not included in the study because damaged trees were bulldozed to allow access to utility lines and the boundary fence.

In each module, except anthropogenically disturbed areas, we identified, numbered and tagged each tree > 2.5 cm diameter at breast height (dbh) and recorded its diameter at breast height (dbh), spatial coordinates, status (dead or alive), and damage type. For smaller trees (saplings), we affixed numbered tags with wires.

In summers 2004 and 2005, we counted the number of basal sprouts (separately for those less than and greater than 50 cm in height) and the number of epicormic sprouts originating <2 m from the ground for each individual tree.

In fall 2006, we established a 20-m wide transect (2 modules wide, columns 15 and 16 on the site map; Figure 1) running north south through the study area and counted the number of basal sprouts (again separately for those less than and greater than 50 cm in height) and measured dbh for all trees in the transect.

To analyze sprouting response following the disturbance we performed a Mann-Whitney test to test the null hypothesis that the number of sprouts per tree between the two dominant species, *Q. stellata* and *Q. marilandica*, following the 2003 tornado were equal with respect to stem status (dead, damaged, and undamaged). We modeled the effect of tree size on number of sprouts for the two dominant species for dead, damaged, and undamaged stems in Poisson regressions. We used Kruskal-Wallis test to examine if number of sprouts was dependent on stem status within each species. We performed analyses for Mann-Whitney Test and Kruskal-Wallis Test in SPSS 14.0 for Windows and the Poisson regression analysis in R 2.3.0 for Windows.

Understory vegetation

We established five transects (two in undisturbed grasslands; three in tornado-damaged Cross Timbers). Each transect consisted of 10 contiguous square meter quadrats. In each quadrat, we estimated the cover of each vascular plant species.

Fire history

We cut disks out of 150 dead trees at 30 cm above the base during June and July 2004 to

examine fire history using dendrochronology techniques. We processed and cross-dated the disks. We developed the fire chronology and analyzed the medium fire return interval and the Weibull medium fire interval (WMI) for all fire events and, separately, for moderate-scaled fires, defined as single fires recorded by > 10% of total samples, including non fire-scarred disks, in the fire year, using the fire history analysis software, FHX2 (Grissino-Mayer 2001)). Fire return intervals are rarely normal distributed. Therefore, WMI is considered to be less biased than mean fire interval as an estimate of central tendencies in fire. FHX2 tested Goodness-of-fit for the normal distribution and the Weibull distribution separately using the Kolmogorov-Smirnov (K-S) test. We created a graph of fire chronology using FHX2 and analyzed fire return intervals after 1947 only due to sample size constraints.

Bird community

We surveyed the bird community in the Cross Timbers study site in 2004, 2005, and 2006. We conducted four 5-minute variable circular plot (VCP) point counts (Ralph et al. 1993, PRBO 2004) within the tornado impacted area (points 1 through 4), a nearby non-impacted area (points 5 through 8), and the nearby grassland (points 9 through 12) within the 14.55-ha permanent plot. We conducted surveys three times: in late May, mid-June, and early July; all surveys were run at least two weeks apart.

E. Results and Discussion:

Some the results, as indicated below, are presented in Appendix A, a M.S. thesis by Fumiko Shirakura titled "Tornado damage and fire history in the Cross Timbers of the Tallgrass Prairie Preserve, Oklahoma."

Tree response

Patterns of Damage and Mortality

See Chapter 2 in Appendix A for a complete report of the damage and mortality patterns of the study site.

Sprouting Response

Poison regressions showed species of *Quercus* strongly affected the number of sprouts. The stem status (dead, damaged and undamaged), tree size, species x stem status interaction and tree size x stem status interaction also significantly influenced the number of basal and epicormic sprouts for the two species. Dead or damaged *Q. marilandica* were associated with a significantly greater number of sprouts than undamaged *Q. marilandica* (Fig. 2 and 3). With the exception of epicormic sprouts for undamaged stems, *Q. marilandica* sprouted more than *Q. stellata* (Figures 2 and 3). Stems of intermediate tree size were better sprouters than larger or smaller sizes, except for undamaged stems of both species. *Q. marilandica* was severely damaged by the 2003 tornado and lost 34% of its basal area. However, tradeoffs in windstorm susceptibility versus resprouting ability may allow coexistence of the long-lived *Q. stellata* and

short-lived *Q. marilandica* as dominant species and are potentially important in the dynamics of the Cross Timbers.

Understory vegetation

There were no significant differences in species richness between disturbed and undisturbed areas. However, species composition differed substantially (CCA Monte Carlo test, $p < 0.001$). Species that occurred more frequently in disturbed areas include a number of annuals specializing on sandy soil (Table 2). Presumably, those species were already represented in the seed bank, and the disturbance triggered their germination.

Big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and switchgrass (*Panicum virgatum*) (host plants of the Iowa skipper, the Otoe skipper (*Hesperia ottoe*), and the dotted skipper (*Hesperia attalus*), respectively) remained frequent in both damaged and undamaged areas. Thus, tornado disturbance is unlikely to impact these species. We did not find *Eryngium yuccifolium* in our study site, so we were unable to assess how the tornado affected the larval host plant for the Rattlesnake Borer moth. Similarly, we did not find violet species and therefore cannot assess the effects of the tornado on the regal fritillary. We did not encounter the prairie mole cricket in the study area, although we were in the area during the times they should have been calling.

Fire History

See Chapter 3 of Appendix A for a complete report of the fire history of the study site.

Bird community

In 2006, 39 bird species were counted at all 12 points. In the non-impacted Cross Timbers forest, 29 species were recorded of which the field sparrow (*Spizella pusilla*) and the blue-gray gnatcatcher (*Polioptila caerulea*) were the most abundant. In the tornado-impacted forest, there were 24 species. In this habitat type, the most common species also were the field sparrow and the blue-gray gnatcatcher. We recorded 22 species in the grassland, where the dickcissel (*Spiza americana*), the grasshopper sparrow (*Ammodramus savannarum*), and the eastern meadowlark (*Sturnella magna*) were the most abundant species. A total of 51 species were recorded in 2006 the survey. From 2004 to 2005, the species richness and the Shannon Diversity Index increased for the impacted forest and decreased for the continuous forest (Table 3). Relative to each other, the two forested habitats were roughly equivalent in terms of diversity; however, the grassland habitat consistently had lower comparative diversity .

A partial canonical correspondence analysis (pCCA) was performed on the summed abundance of each bird species for the 2004 and 2005 surveys. The year of the survey and the season of the survey were used in the analysis as covariables to factor out their effects on the placement of species relative to the three habitat groupings in the ordination space. The analysis indicated that the species from the two forested habitats shared many of the same species. A fairly continuous gradient of species exists linking the two forest habitats (Figure 4). The grassland habitat, however, is quite different from either forested habitat and appears in the ordination diagram as a distinct habitat type. One interpretation of a species placement in the

ordination diagram is the degree of habitat specialization. Species located closer to the center of the diagram can be considered habitat generalists while those located toward the periphery show higher habitat specificity.

Of the avian species of concern (Oklahoma Department of Wildlife Conservation 2005), we did not encounter red-headed woodpeckers in the survey. However, the tornado resulted in the formation of snags, which could possibly serve as nest trees in the future. We did not encounter greater prairie chickens, and given the large quantity of woody plants (dead and alive) in the region, they are unlikely to be benefited unless massive future fires remove the woody plants. Henslow's sparrows were found but were too infrequently encountered for us to draw solid conclusions about the impact of the tornado. Painted buntings were quite frequent in the tornado-damaged areas and are likely to be favored by open forests with large quantities of downed limbs. Northern bobwhites were found in abundance in both impacted and non-impacted forests and are thus likely not to be affected by tornado disturbance.

Management recommendations

Disturbance is clearly an important component of the Cross Timbers ecosystem. The two disturbance types analyzed here (tornado and fire) seem to have played an important role historically in maintaining the Cross Timbers as we see them today. For Cross Timbers managers it is important to recognize that such disturbances, when they occur, are a natural part of the ecosystem and should not be subjected to artificial clean up. Theoretically, in the absence of disturbance, the sturdier and longer lived post oak should eventually replace the shorter lived blackjack oak. However, blackjack oak's ability to quickly regenerate (compared to post oak) after disturbance seems to have assured its co-dominance in the Cross Timbers ecosystem. It seems here that disturbance, and the succession that follows is helping to maintain Cross Timbers tree species. Removing snags or brush piles formed from tornado or other wind disturbances, not only removes important habitat for cavity-nesting birds and a number of other wildlife species, but may also alter succession which could affect the ultimate forest composition. This in turn could have long-lasting consequences, negatively affecting both plant and wildlife species.

We also have shown that fire has played an important and, perhaps, frequent role in Cross Timbers history. Yet fire suppression in some areas may be negatively impacting Oklahoma's Cross Timbers species. In areas where fires have become infrequent or where the forests have become too fragmented for fires to spread, prescribed fire should be used to maintain the dynamics of this ecosystem.

F. Significant Deviations:

Because the price of soil analysis increased substantially and advantages of doing a soil analysis were negligible given the time elapsed since the disturbance, we deleted the soil analysis from our approach. Instead, we felt it very important to understand the disturbance history of the stand to place our forest dynamics in a broader context. Therefore, we added the fire-history

component to our approach.

G. Costs:

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K. Literature Cited:

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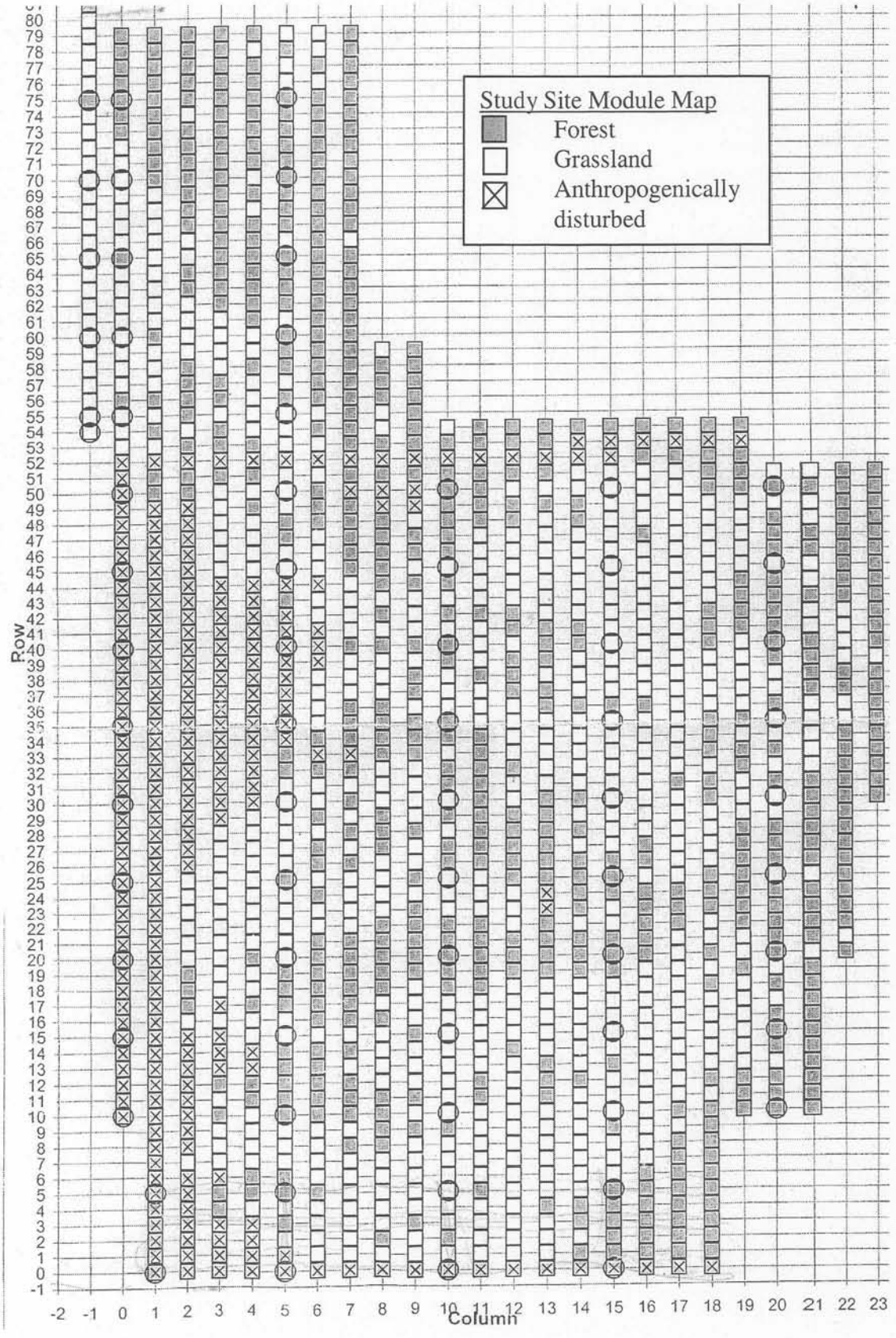
Study Site Module Map
Forest
Grassland
Anthropogenically disturbed
Row
Column

Figure 1

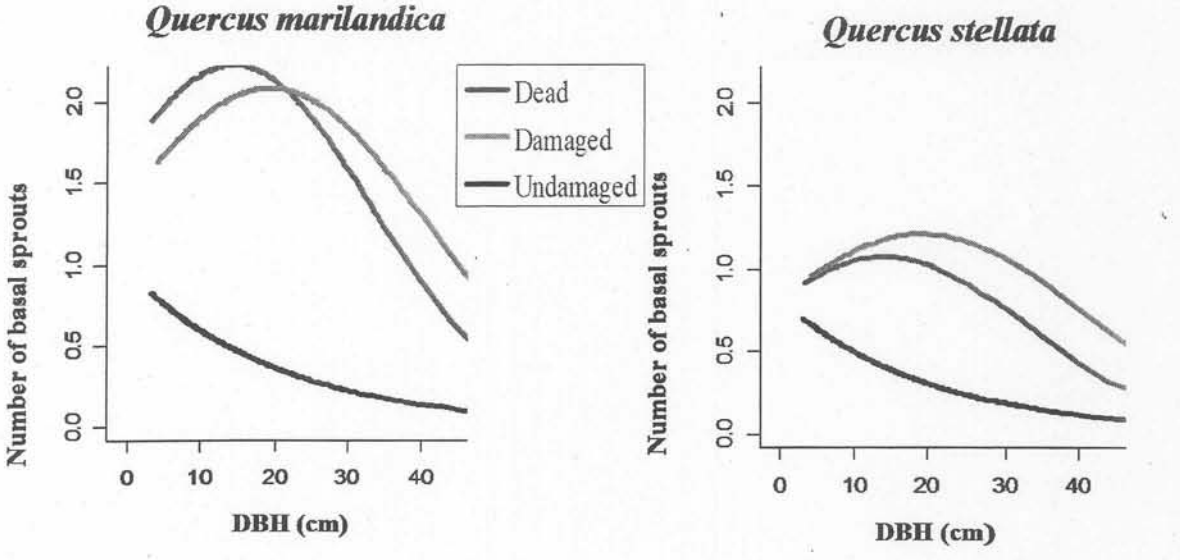

Fig.2. Poisson regressions showing relations between number of basal sprouts and DBH for *Q. marilandica* and *Q. stellata* with respect to dead, damaged, and undamaged stems. Explanatory variables included DBH, species, species x dead, DBH x dead, DBH^2 x dead, species x stem status (dead, damaged, and undamaged), DBH x stem status, and DBH^2 x stem status.

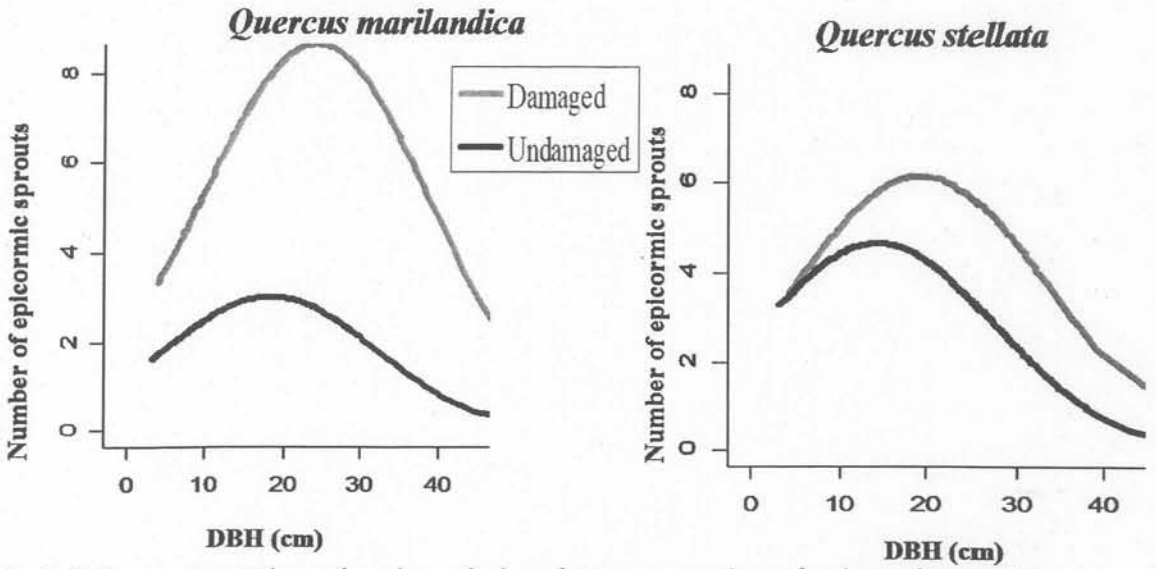

Fig.3. Poisson regressions showing relations between number of epicormic sprouts and DBH for *Q. marilandica* and *Q. stellata.* Explanatory variables included DBH, DBH^2, species, species x DBH, species x stem status (dead, damaged, and undamaged), and DBH x stem status interactions, and DBH2 x stem status.

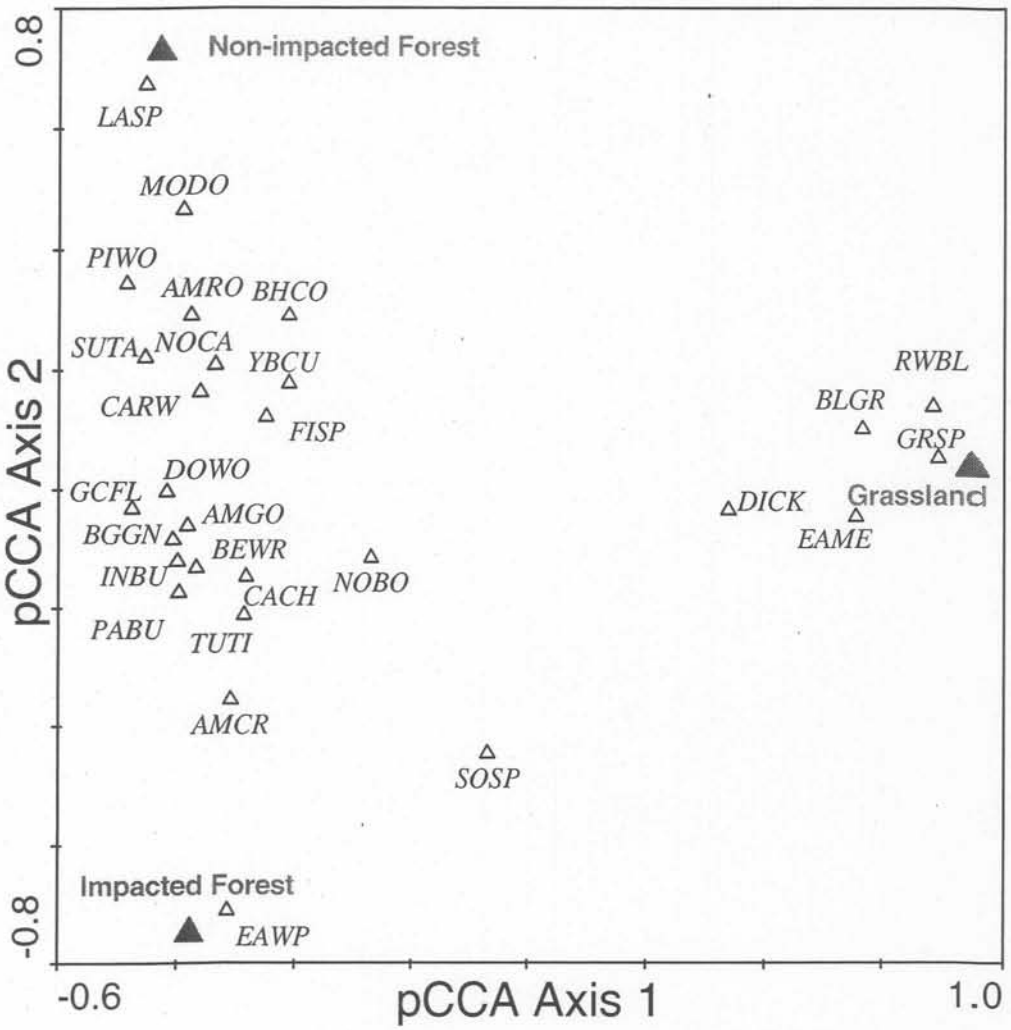

Fig. 4. The result of a pCCA of the 2004 and 2005 bird survey results given the month and year of sampling as covariables. The eigenvalues for the first and second axes were 0.548 and 0.103 respectively. A key to the species abbreviations is given in Table 3.

Table 1. Occurrence of sprouts of *Quercus marilandica* and *Quercus stellata* in the study site in 2004 and 2005.

Epicormic sprouts

	Quercus marilandica	*Quercus stellata*
2004 damaged	1276.4	225.7
2004 undamaged	232.3	94.2
2005 damaged	1078.0	1003.0
2005 undamaged	492.9	691.7

Basal sprouts<50cm high

	Quercus marilandica	*Quercus stellata*
2004 damaged	257.8	100.0
2004 undamaged	68.3	64.0
2005 damaged	309.1	86.5
2005 undamaged	84.6	61.8

Basal sprouts>50cm high

	Quercus marilandica	*Quercus stellata*
2004 damaged	452.7	45.9
2004 undamaged	57.2	13.2
2005 damaged	359.5	67.2
2005 undamaged	36.6	6.5

Table 2. Frequency of understory plant species (in percent) in damaged and undamaged areas. Bold-faced numbers indicate species with significantly greater frequency in the indicated area (chi-squared, $p < 0.05$).

	Frequency in damaged area	Frequency in undamaged area
Ambrosia psilostachya	87.1	66.7
Schizachyrium scoparium	54.8	**95.2**
Dichanthelium oligosanthes	54.8	**85.7**
Ruellia humillis	51.6	**85.7**
Artemisia ludoviciana	29.0	**66.7**
Erigeron strigosus	48.4	38.1
Sporobolus compositus	29.0	**61.9**
Rudbeckia hirta	**67.7**	0.0
Sorghastrum nutans	19.4	**71.4**
Andropogon gerardii	22.6	**66.7**
Elymus virginicus	29.0	**57.1**
Panicum virgatum	25.8	47.6
psuedo acalypha	**54.8**	0.0
Vernonia baldwinii	38.7	19.0
Oxalis dillenii	32.3	28.6
Bromus japonicus	38.7	14.3
Kummerowia stipulacea	38.7	14.3
Croton sp	29.0	28.6
Bouteloua curtipendula	9.7	**52.4**
Lespedeza procumbens	9.7	**47.6**
Strophostyles leiosperma	19.4	33.3
Croton monanthogynus	32.3	9.5
Paspalum setaceum	29.0	14.3
Daucus pusillus	25.8	14.3
Carex bushii	19.4	23.8

Table 3. Bird species list for the 2004 and 2005 surveys. Species are included that were also only observed during a fly-over event.

Species	Common Name	Abbrev.	2004	2005	Total
Corvus brachyrhynchos	American Crow	AMCR	12	18	30
Carduelis tristis	American Goldfinch	AMGO	7	3	10
Turdus migratorius	American Robin	AMRO		5	5
Tyto alba	Barn Owl	BANO		1	1
Hirundo rustica	Barn Swallow	BARS	2		2
Ceryle alcyon	Belted Kingfisher	BEKI	1		1
Vireo bellii	Bell's Vireo	BEVI		2	2
Thryomanes bewickii	Bewick's Wren	BEWR	5	5	10
Polioptila caerulea	Blue-gray Gnatcatcher	BGGN	18	30	48
Molothrus ater	Brown-headed Cowbird	BHCO	22	19	41
Guiraca caerulea	Blue Grosbeak	BLGR		2	2
Cyanocitta cristata	Blue Jay	BLJA	3		3
Colinus virginianus	Northern Bobwhite	NOBO	6	17	23
Poecile carolinensis	Carolina Chickadee	CACH	9	13	22
Thryothorus ludovicianus	Carolina Wren	CARW	1	7	8
Petrochelidon pyrrhonota	Cliff Swallow	CLSW	5	1	6
Chordeiles minor	Common Nighthawk	CONI	1	3	4
Geothlypis trichas	Common Yellowthroat	COYE	2	1	3
Spiza americana	Dickcissel	DICK	108	56	164
Picoides pubescens	Downy Woodpecker	DOWO	3	4	7
Sialia sialis	Eastern Bluebird	EABL	11	5	16
Tyrannus tyrannus	Eastern Kingbird	EAKI		1	1
Sturnella magna	Eastern Meadowlark	EAME	22	14	36
Sayornis phoebe	Eastern Phoebe	EAPH		1	1
Sturnus vulgaris	European Starling	EUST	1		1
Contopus virens	Eastern Wood-pewee	EAWP		4	4
Spizella pusilla	Field Sparrow	FISP	62	55	117
Ardea herodias	Great Blue Heron	GBHE		1	1
Myiarchus crinitus	Great Crested Flycatcher	GCFL	2		2
Ammodramus savannarum	Grasshopper Sparrow	GRSP	18	13	31
Quiscalus mexicanus	Great-tailed Grackle	GTGR	1		1
Ammodramus henslowii	Henslow's Sparrow	HESP		2	2
Passerina cyanea	Indigo Bunting	INBU	4	7	11
Charadrius vociferus	Killdeer	KILL	3		3
Chondestes grammacus	Lark Sparrow	LASP	2		2
Zenaida macroura	Mourning Dove	MODO	2	5	7
Cardinalis cardinalis	Northern Cardinal	NOCA	19	9	28
Stelgidopteryx serripennis	Northern Rough-winged Swallow	NRWS	1		1
Passerina ciris	Painted Bunting	PABU	21	11	32
Dryocopus pileatus	Pileated Woodpecker	PIWO	1	3	4
Progne subis	Purple Martin	PUMA		1	1

Agelaius phoeniceus	Red-winged Blackbird	RWBL	5	4	9
Melospiza melodia	Song Sparrow	SOSP		3	3
Accipiter striatus	Sharp-shinned Hawk	SSHA		1	1
Tyrannus forficatus	Scissor-tailed Flycatcher	STFL	1	2	3
Piranga rubra	Summer Tanager	SUTA	10	1	11
Baeolophus bicolor	Tufted Titmouse	TUTI	7	6	13
Cathartes aura	Turkey Vulture	TUVU	1		1
Sitta carolinensis	White-breasted Nuthatch	WBNU	1		1
Coccyzus americanus	Yellow-billed Cuckoo	YBCU	8	2	10
	Total		414	338	752

APPENDIX A

M.S. thesis by Fumiko Shirakura:

Tornado damage and fire history in the Cross Timbers

of the Tallgrass Prairie Preserve, Oklahoma