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WOODY SPECIES COMPOSITION OF HABITATS USED BY OCELOTS (*LEOPARDUS PARDALIS*) IN THE TAMAULIPAN BIOTIC PROVINCE

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The northern limit of the distribution of the endangered ocelot (*Leopardus pardalis*) occurs within the Tamaulipan Biotic Province (TBP) of southern Texas (Blair, 1950; Tewes and Everett, 1986; U.S. Fish and Wildlife Service, 1990). Ocelots occur predominantly in isolated fragments of dense thornshrub communities (Navarro, 1985; Tewes, 1986; Laack, 1991; Caso, 1994) characteristic of the Matamoran District of the TBP (Blair, 1950). These dense thornshrub communities compose a unique ecosystem found only in the Lower Rio Grande Valley (LRGV) of southern Texas and northeastern Mexico (Jahrsdoerfer and Leslie, 1988). Over 95% of these native thornshrub communities in the LRGV have been altered for agricultural and urban development (Jahrsdoerfer and Leslie, 1988). Tewes and Everett (1986) designated <1% of southern Texas as supporting the dense thornshrub cover type used by ocelots. The loss and fragmentation of dense thornshrub communities is the primary threat to the persistence of the ocelot population in the TBP (Tewes and Everett, 1986; U.S. Fish and Wildlife Service, 1990). The establishment of the LRGV National Wildlife Refuge in 1979 focused the efforts of private organizations and state and federal agencies on acquiring, maintaining, and restoring native thornshrub communities for vertebrate species of management concern (Jahrsdoerfer and Leslie, 1988). Techniques for germinating thornshrub species (Vora, 1989) and restoring ocelot habitat (Young and Tewes, 1994) have been evaluated. However, data regarding woody species composition in habitats used by ocelots are lacking (Tewes and Miller, 1987).

Our objective was to quantify woody species composition of habitats used by ocelots in the LRGV of southern Texas and in Tamaulipas, in northeastern Mexico. Quantification of woody species composition of known ocelot habitat is necessary to restore unused sites adjacent to occupied or potential habitat. Increasing ocelot habitat and establishing corridors of habitat through restoration is recommended to assist the recovery of the endangered ocelot population (Tewes and Miller, 1987; U.S. Fish and Wildlife Service, 1990; Young and Tewes, 1994).

Data were collected from October 1993 to January 1995 on three sites in the TBP where previous studies had been conducted on the resident population of ocelots. Laguna Atascosa National Wildlife Refuge (LANWR; 26°13′N, 97°22′W) is approximately 32 km east of Harlingen in Cameron County, Texas. The climate is subtropical with a mean annual precipitation of 96 cm and with a mean annual temperature of 23°C (National Oceanic and Atmospheric Administration, 1993, 1994). Topography is flat with slopes <1% (Williams et al., 1977). San Francisco Ranch (26°35′N, 97°36′W) is approximately 5 km north of San Perlita in Willacy County, Texas. Data were collected only in the La Perlita and El Jardin conservation easement tracts. Mean annual precipitation and mean annual temperature were

-Woody species by presence (P) or ab-) within dense thornshrub communities[1] by ocelots on Laguna Atascosa National Wildlife Refuge (LANWR), Cameron County, Texas; San Francisco Ranch (SFR), Willacy County, Texas; and Los Ebanos Ranch (LER), Tamaulipas, Mexico, October 1993 to January 1995.

Scientific name	LANWR	SFR	LER
Abutilon hypoleucum	A	A	P
Acacia cornigera	A	A	P
Acacia farnesiana	P	P	A
Acacia rigidula	P	P	A
Achatocarpus nigricans	A	A	P
Aloysia gratissima	P	P	A
Amyris madrensis	P	P	A
Amyris texana	P	A	A
Asclepias curassavica	A	A	P
Ayenia sp.	A	A	P
Borrichia frutescens	P	A	A
Bastardia viscosa	A	P	A
Bernardia myricaefolia	A	P	A
Bromelia sp.	A	A	P
Bumelia celastrina	P	A	A
Bumelia laetevirens	A	A	P
Bursera simaruba	A	A	P
Caesalpinia mexicana	A	A	P
Callicarpa acuminata	A	A	P
Capsicum annuum	P	P	P
Castela texana	P	P	A
Celtis iguanaea	A	A	P
Celtis pallida	P	P	P
Citharexylum berlandieri	P	A	A
Cnidoscolus multilobus	A	A	P
Condalia hookeri	P	P	P
Cordia boissieri	P	A	A
Croton humilis	P	A	P
Croton sp.	A	A	P
Croton sp.	A	A	P
Dalea thyrsiflora	P	P	A
Diospyrus texana	P	P	A
Duranta repens	A	A	P
Ericameria austrotexana	P	P	A
Eupatorium azureum	P	A	A
Eupatorium odoratum	P	P	P
Ficus sp.	A	A	P
Forestiera angustifolia	P	P	P
Gouania lupuloides	A	A	P
Guaiacum angustifolium	P	P	A
Guazuma ulmifolia	A	A	P
Hamelia patens	A	A	P
Ipomoea sp.	A	A	P
Isocoma drummondii	P	A	A
Jatropha dioica	P	A	A
Karwinskia humboltiana	P	A	P
Koeberlinia spinosa	A	P	A
Lantana horrida	P	A	A
Leucaena pulverulenta	A	A	P
Leucophylum frutescens	P	A	A
Lycium berlandieri	P	A	A
Malpighia glabra	P	A	A
Maytenus texana	P	A	A
Mimosa malacophylla	A	A	P
Opuntia engelmannii	P	A	A
Opuntia leptocaulis	P	P	A
Opuntia sp.	A	A	P
Parkinsonia texana	A	P	A
Paullinia sp.	A	A	P
Phaulothamnus spinescens	P	P	A
Phoebe tampicensis	A	A	P
Physalis sp.	A	A	P
Pithecellobium dulce	A	A	P
Pithecellobium flexicaule	P	P	P
Pithecellobium pallens	P	P	P
Prosopis glandulosa	P	P	A
Prosopis reptans	P	A	A
Pseudoabutilon lozanii	P	P	A
Randia rhagocarpa	P	A	P
Salvia ballotaeflora	P	A	A
Sabal texana	A	A	P
Sapindus saponaria	A	A	P
Schaefferia cunefolia	P	P	A
Senna sp.	A	A	P
Sida sp.	A	A	P
Solanum triquetrum	P	A	A
Solanum verbascifolium	A	A	P
Stemmadenia sp.	A	A	P
Trixis inula	P	P	A
Triumfetta sp.	A	A	P
Xylosoma flexuosum	A	A	P
Yucca treculeana	P	A	A
Zanthoxylum fagara	P	P	P
Ziziphus obtusifolia	P	P	A
Unknown[2]	A	A	P
Unknown[3]	A	A	P
Unknown[4]	A	A	P
Unknown[5]	A	A	P
Unknown[6]	A	A	P

TABLE 1—Continued.

[1] Thornshrub communities of the Tamaulipan brushland (Jahrsdoerfer and Leslie, 1988) characterized as optimal cover types for ocelots (Tewes and Everett, 1986).

[2] Family Acanthaceae

[3] Family Bignoniaceae

[4] Family Euphorbiaceae

[5] Family Malpighiaceae

[6] Family Sterculiaceae

TABLE 2—Wo
thornshrub con
County, Texas (
1993 to June 19

Common
Amargosa
Barbados cher
Berlandier fid
Berlandier wol
Berlandier cro
Black persimm
Blackbrush ac
Blue eupatori
Blue sage
Border palove
Brasil
Cenizo
Chilipiquin
Colima
Coma
Coyotillo
Crucifixion th
Crucita
Desert olive
Desert yaupo
Drummond g
Dwarf screw-l
Ebano
False broomv
Granjeno
Guayacan
Honey Mesq
Huisache
Leather stem
Leatherleaf
Lotebush
Mexican bas
Mexican oli
Mexican tor
Mexican trix
Nightshade
Pseudoabuti
Sea ox-eye
Snake-eyes
Spanish dag
Tasajillo
Tenaza
Texas torch
Texas randi
Texas lanta
Texas prick
Thyrsus dal
Whitebrusl

[1] Using t
[2] Thornsl
as optimal
[3] Relative

TABLE 2—Woody species composition and relative cover measured[1] along 20-m line transects within dense thornshrub communities[2] used by ocelots on Laguna Atascosa National Wildlife Refuge (LANWR), Cameron County, Texas (n = 80 transects); and San Francisco Ranch (SFR), Willacy County, Texas (n = 46), October 1993 to June 1994.

Common name	Scientific name	Relative cover (%)[3]	
		LANWR	SFR
Amargosa	*Castela texana*	1.98	1.61
Barbados cherry	*Malpighia glabra*	0.06	0.00
Berlandier fiddlewood	*Citharexylum berlandieri*	9.41	0.00
Berlandier wolfberry	*Lycium berlandieri*	0.43	0.00
Berlandier croton	*Croton humilis*	2.54	0.00
Black persimmon	*Diospyrus texana*	0.61	0.11
Blackbrush acacia	*Acacia rigidula*	0.09	0.02
Blue eupatorium	*Eupatorium azureum*	0.23	0.00
Blue sage	*Salvia balloteaeflora*	1.33	0.00
Border paloverde	*Parkinsonia texana*	0.00	0.41
Brasil	*Condalia hookeri*	3.55	0.82
Cenizo	*Leucophylum frutescens*	2.70	0.00
Chilipiquin	*Capsicum annuum*	0.10	0.03
Colima	*Zanthoxylum fagara*	4.86	5.97
Coma	*Bumelia celastrina*	2.59	0.00
Coyotillo	*Karwinskia humboldtiana*	2.25	0.00
Crucifixion thorn	*Koeberlinia spinosa*	0.00	4.48
Crucita	*Eupatorium odoratum*	9.63	7.36
Desert olive	*Forestiera angustifolia*	6.67	4.74
Desert yaupon	*Schaefferia cunefolia*	0.51	0.02
Drummond goldenweed	*Isocoma drummondii*	0.97	0.00
Dwarf screw-bean	*Prosopis reptans*	0.10	0.00
Ebano	*Pithecellobium flexicaule*	2.01	0.08
False broomweed	*Ericameria austrotexana*	0.82	0.38
Granjeno	*Celtis pallida*	17.47	14.73
Guayacan	*Guaiacum angustifolium*	0.07	0.16
Honey Mesquite	*Prosopis glandulosa*	8.21	27.14
Huisache	*Acacia farnesiana*	0.09	0.22
Leather stem	*Jatropha dioica*	0.16	0.00
Leatherleaf	*Maytenus texana*	0.44	0.00
Lotebush	*Ziziphus obtusifolia*	2.68	2.02
Mexican bastardia	*Bastardia viscosa*	0.00	0.24
Mexican olive	*Cordia boissieri*	0.44	0.02
Mexican torchwood amyris	*Amyris madrensis*	2.86	0.02
Mexican trixis	*Trixis inula*	2.08	0.06
Nightshade	*Solanum triquetrum*	0.05	0.00
Pseudoabutilon	*Pseudoabutilon lozanii*	0.05	0.09
Sea ox-eye	*Borrichia frutescens*	0.06	0.00
Snake-eyes	*Phaulothamnus spinescens*	5.91	23.70
Spanish dagger	*Yucca treculeana*	0.10	0.00
Tasajillo	*Opuntia leptocaulis*	0.02	0.01
Tenaza	*Pithecellobium pallens*	1.86	0.14
Texas torchwood amyris	*Amyris texana*	0.10	0.00
Texas randia	*Randia rhagocarpa*	0.43	0.00
Texas lantana	*Lantana horrida*	0.65	0.00
Texas prickly pear	*Opuntia engelmannii*	0.18	0.00
Thyrsus dalea	*Dalea thyrsiflora*	0.07	0.06
Whitebrush	*Aloysia gratissima*	2.66	4.05

[1] Using the line intercept method (Chambers and Brown, 1983; Bonham, 1989).

[2] Thornshrub communities of the Tamaulipan brushland (Jahrsdoerfer and Leslie, 1988) characterized as optimal cover types for ocelots (Tewes and Everett, 1986).

[3] Relative cover (%) = ($\bar{X}$ percent cover of a species/sum of $\bar{X}$ percent cover values for all species) × 100.

67.5 cm and 21°C, respectively (National Oceanic and Atmospheric Administration, 1993, 1994). Topography is flat with slopes <2% (Turner, 1982). Los Ebanos Ranch (23°27'N, 97°48'W) is adjacent to the Gulf of Mexico in Tamaulipas, in northeastern Mexico. Mean annual precipitation and mean annual temperature were 92.7 cm and 25°C, respectively (Pennington and Sarukhan, 1968; González, 1990). Topography is flat with elevations ranging from 0 to 30 m (Detenal, 1987).

Long-term studies on the resident population of ocelots at each study site provided justification for sampling specific dense thornshrub tracts. Intensive monitoring of radiocollared ocelots at LANWR from 1982 to 1995 documented that ocelots used dense thornshrub communities almost exclusively to open habitat types (Tewes, 1986; Laack, 1991; Shindle, 1995; L. L. Laack, pers. comm.). Radiotelemetry studies conducted from 1983 to 1995 on San Francisco Ranch documented that movements of ocelots were restricted primarily within the boundaries of the La Perlita and El Jardin dense thornshrub tracts (Navarro, 1985; D. B. Shindle, pers. obs.). On Los Ebanos Ranch from 1991 to 1995, radiotelemetry locations and direct observations of ocelots occurred more frequently in dense thornshrub than more open habitat types (Caso, 1994; A. Caso, pers. comm.).

Woody species composition within dense thornshrub communities with documented use by ocelots was sampled along line transects (20 m long, 160 m apart) with random starting points. Percent cover of woody plants was measured along the entire length of transect using the line intercept method described by Chambers and Brown (1983) and Bonham (1989). Woody canopy measurements included all woody species >0.5 m tall occurring along each transect, as cover of this height could conceal an ocelot (Tewes, 1986; Bothma et al., 1994). The total length of the separate canopy intercepts by each species was calculated for each transect. Percent cover of each species by transect was determined by dividing the total canopy intercept of a species by the transect length. Because all species could not be identified along each transect at Los Ebanos Ranch, an accurate measure of percent cover of each species was not calculated for this site. However, representative specimens of unidentified species at Los Ebanos Ranch were collected and later identified to document woody species presence.

Mean percent cover for each species on the southern Texas sites was determined by adding the transect intercept values for each species and dividing by the number of transects on each site (Chambers and Brown, 1983). Percent relative cover of a species was calculated because the vegetation had overlapping canopies. Percent relative cover of a species by site was determined by the percent cover of a species divided by the sum of the percent cover value for all species.

Scientific and common names for woody species identified on the southern Texas sites follow Lonard et al. (1991) and Everitt and Drawe (1993). Scientific names for woody species identified on Los Ebanos Ranch follow González-Medrano (1972).

Similarity of woody species composition between sites was quantified using Jaccard's index which is based on the presence-absence relationship of species (Mueller-Dombois and Ellenberg, 1974; Janson and Vegelius, 1981). A more rigorous comparison of the two proximate sites in southern Texas was made using Spatz's modification of Jaccard's index (Mueller-Dombois and Ellenberg, 1974). This index combines both quantitative and qualitative properties of communities by incorporating quantitative values (e.g., relative cover) of a species common to both areas or unique to each area (Chambers and Brown, 1983).

Woody species composition was sampled as part of a broader quantification of dense thornshrub communities used by ocelots (Shindle, 1995), therefore, the sample size requirements for each site were determined according to estimated population means and variances for structural features of woody vegetation estimated from preliminary sampling. An a posteriori determination of required sample sizes based on species-area curves revealed that the number of transects at LANWR (n = 80) and San Francisco Ranch (n = 46) adequately sampled the species composition at both sites. The last 20% of transects sampled at LANWR and San Francisco Ranch documented only two and one additional species, respectively. A species-area curve for Los Ebanos Ranch could not be constructed because specific identification of woody plants could

not be made along each transect. However, the intensity of our sampling effort at LANWR, San Francisco Ranch, and Los Ebanos Ranch (3.11, 3.78, and 4.78 ha/transect, respectively) justifies the examination of all results.

Forty-five woody species were documented along transects (n = 80) in dense thornshrub communities used by ocelots at LANWR (Table 1). Predominant woody species were granjeno (*Celtis pallida*), crucita (*Eupatorium odoratum*), Berlandier fiddlewood (*Citharexylum berlandieri*), honey mesquite (*Prosopis glandulosa*), and desert olive (*Forestiera angustifolia*) (Table 2).

Twenty-eight woody species were documented along transects (n = 46) in dense thornshrub communities used by ocelots at San Francisco Ranch (Table 1). Predominant woody species were honey mesquite, snake-eyes (*Phaulothamnus spinescens*), granjeno, crucita, colima (*Zanthoxylum fagara*), and desert olive (Table 2). Fifty-one woody species were documented along transects (n = 23) in dense thornshrub communities used by ocelots at Los Ebanos Ranch (Table 1).

The degree of similarity in woody species composition (Jaccard's index) of dense thornshrub between LANWR and San Francisco Ranch, between LANWR and Los Ebanos Ranch, and between San Francisco Ranch and Los Ebanos Ranch, was 49.0%, 12.9%, and 11.3%, respectively. The degree of similarity in woody species composition and relative cover (Spatz's index) of dense thornshrub between LANWR and San Francisco Ranch was 17.6%.

Five species (granjeno, crucita, Berlandier fiddlewood, honey mesquite, and desert olive) accounted for >50% of the total relative cover at LANWR, whereas only two species (honey mesquite and snake-eyes) accounted for >50% of the total relative cover at San Francisco Ranch. Predominant shrub species common to the southern Texas sites included granjeno, snake-eyes, crucita, desert olive, colima, whitebrush (*Aloysia gratissima*), brasil, and lotebush (*Ziziphus obtusifolia*). The aforementioned species composed 53% and 63% of the total relative cover at LANWR and San Francisco Ranch, respectively. Eight woody species common to all three sites were chilipiquin (*Capsicum annuum*), granjeno, brasil (*Condalia hookeri*), crucita, desert olive, ebano (*Pithecellobium flexicaule*), tenaza (*P. pallens*), and colima.

The composition and relative cover data collected during this study, knowledge of germination and restoration techniques (Vora, 1989; Young and Tewes, 1994), and quantified structural characteristics of thornshrub communities used by ocelots (Shindle, 1995) provide guidance for public and private landowners involved in restoring ocelot habitat through revegetative efforts in southern Texas. Whereas many factors dictate the selection of species for a specific site (Vora, 1989; Young and Tewes, 1994), these data provide justification for restoring selected woody species.

Similarity indices suggested that the three dense thornshrub communities used by ocelots were not highly similar in terms of woody species composition and relative cover (Chambers and Brown, 1983). However, based on the predominant species common to LANWR and San Francisco Ranch, the selection of granjeno, snake-eyes, crucita, desert olive, colima, whitebrush, brasil, and lotebush would be justified for restoration. The presence of granjeno, crucita, desert olive, colima, and brasil at Los Ebanos Ranch provides further justification for selecting these species.

We do not infer that woody cover by species, as opposed to the structural cover and prey base supported by woody species, is the only critical component of ocelot habitat. However, if budgetary and logistical constraints limit the diversity of woody species selected for restoration of ocelot habitat, the dominance of the aforementioned species in areas of ocelot use justifies their selection over less common woody species. The reestablishment of these dominant woody species should facilitate, through natural succession, recovery of the necessary physical and biological components of ocelot habitat. The reestablishment of thornshrub species may accelerate ocelot use of an area, but a minimal structural density (>85% vertical cover), canopy height (>2 m), and canopy coverage (>97%) must be achieved before an area is characterized as suitable for ocelot use in southern Texas (Shindle, 1995).

Resumen—La perdida del habitat es la principal amenaza sobre la persistencia del ocelote (Leopardus pardalis) en la provincia biotica Tamaulipeca, ademas de que dicho felino es considerado en peligro de extincion. Los habitats de arbustivas, utilizados por el ocelote, fu-

eron determinadas en el Sur de Texas y Noreste de Mexico. Dentro de dichos habitats, se indetificaron las especies arbustivas que se podian utilizar en futuras restauraciones de habitats del ocelote. Para lo cual, muestreamos 3 sitios mediante transectos lineales y comparamos la composicion y cobertura en todos los sitios. Encontramos que la composicion relative de especies de arbustivas y cobertura de todos los sitios no fueron similares (dando un valor de indice de similaridad de <49.0%). Sin embargo, la base de seleccion de 8 especies de arbustivas dominantes afines o comunes a los sitios de Texas y el Noreste de Mexico, podria ser una justificante para futuros esfuerzos de restauracion.

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