Evaluation of Techniques for Initial Restoration of Ocelot Habitat

John H. Young[1], *Caesar Kleberg Wildlife Research Institute, Campus Box 218, Texas A&M University-Kingsville, Kingsville, TX 78363*

Michael E. Tewes, *Caesar Kleberg Wildlife Research Institute, Campus Box 218, Texas A&M University-Kingsville, Kingsville, TX 78363*

Abstract: As a result of agricultural, urban, and industrial development of native thorn-shrub communities in the Lower Rio Grande Valley, <1% of south Texas supports habitat for the endangered ocelot (*Felis pardalis*). We evaluated techniques that could facilitate restoration of ocelot habitat. Texas ebony (*Pithecellobium flexicaule*), granjeno (*Celtis pallida*), lotebush (*Ziziphus obtusifolia*), and whitebrush (*Aloysia gratissima*) seedlings were planted in 3 4-ha plots at Laguna Atascosa National Wildlife Refuge, Cameron County, Texas. Mean stem height did not differ ($P > 0.05$) among species for the clipped-weeded, clipped-non-weeded, and control treatments. All species of seedlings planted in 60-cm tall plastic shelters grew taller than seedlings planted in 30-cm plastic shelters ($P < 0.01$). Control granjeno seedlings had lower survival than the non-weeded 30-cm shelter and the weeded and non-weeded 60-cm shelter treatments ($P < 0.01$). Whitebrush seedlings planted in 60-cm shelters had higher survival ($P < 0.01$) than unsheltered seedlings. Plastic 30-cm and 60-cm tall shelters enhanced growth and survival of thorn-shrub species and may shorten seedling establishment periods. Consequently, shelters can accelerate reestablishment of ocelot habitat.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 48:336–342

The only documented resident ocelot populations in the United States resides in the Lower Rio Grande Valley (LRGV) of Texas where native thorn-shrub communities provide the ocelot its preferred habitat (Tewes and Everett 1986). Since 1920's, however, more than 95% of the native thorn-shrub communities in the LRGV have been converted to agricultural, urban, or industrial

[1] Present address: Wildlife Habitat Council, 1010 Wayne Avenue, Suite 920, Silver Spring, MD 20910.

uses (Collins 1984, Jahrsdoerfer and Leslie 1988). Destruction of native thorn shrub has resulted in decreased density and diversity of wildlife species and plant communities in general in the LRGV (Jahrsdoerfer and Leslie 1988) despite efforts by private organizations and state and federal agencies to acquire tracts of abandoned farm and pasture land for endangered and economically important species. Strategic restoration of habitat tracts and corridors may benefit the recovery of the endangered ocelot and converting selected tracts to native thorn-shrub communities is a management priority. However, establishment of thorn-shrub seedlings in LRGV is limited by 2 dominant factors: environmental stresses and biotic factors (herbivores, insects, and diseases). Our goal was to evaluate and identify techniques that facilitate establishment of ocelot habitat (native thorn-shrub communities) on post-agricultural land.

Funding, equipment, and logistical support for this study was generously provided by Laguna Atascosa National Wildlife Refuge, U.S. Fish and Wildlife Service. Additional funding was provided by the Caesar Kleberg Wildlife Research Institute. We appreciate the assistance provided by S. P. Thompson, L. L. Laack, A. Guidera, and several other field assistants. Editorial comments were provided by F. S. Guthery and P. A. Moody.

Methods

Three 4-ha post-agricultural fields on Laguna Atascosa National Wildlife Refuge (LANWR), Cameron County, Texas, were selected for planting. Soils for these areas are Laredo silty clay loam and Olmito silty clay (Williams et al. 1977:25–33). Planting areas were located ≥60 m from available wildlife cover to minimize predation of unprotected seedlings by herbivores. Previous experimental plantings at the refuge showed that a distance of 60 m was sufficient to reduce seedling predation (Robert Bluett, pers. commun.).

Thorn-shrub species planted included whitebrush (N = 350/replicate), granjeno (N = 350/replicate), Texas ebony (N = 250/replicate), and lotebush (N = 210/replicate). All species were selected because of their importance in providing food, cover, and nesting structure for a variety of wildlife species.

Seedlings with <10 cm of top growth were not planted. Planting occurred in February 1991 and the initial stem height and number of stems were measured in March. A branch was defined as a stem from the trunk of the seedling ≥2.5 cm long. Stem height and survival were measured monthly thereafter. Number of stems was recorded in March and October 1991 and February 1992.

Fields were plowed to a depth of 15–20 cm and disced twice before planting in February 1991. Seedlings were planted using a chisel-type tree planter pulled by a tractor. Seedlings were planted in rows with 2 m between plants and 4 m between rows. Plantings covered 1.5 ha of the 4-ha fields. Whitebrush, granjeno, and lotebush seedlings were assigned to 7 different treatments in each field; Texas ebony seedlings were assigned to all but the clipping treatments in each field. Treatments were as follows: (1) 30-cm plastic shelter, weeded (30 W); (2)

30-cm plastic shelter, not weeded (30 NW); (3) 60-cm plastic shelter, weeded (60 W); (4) 60-cm plastic shelter, not weeded (60 NW); (5) clipped, weeded (CW); (6) clipped, not weeded (CNW); and (7) control (i.e., no shelter, clipping or weeding conducted). Shelters were straight tubes about 8 cm in diameter and made of translucent plastic.

One hundred Texas ebony, granjeno, and whitebrush, and 60 lotebush seedlings were covered using 30-cm and 60-cm tall plastic shelters. A 50-cm wooden stake and plastic ratchet strip were used to stabilize each shelter. Shelters were pushed 3–5 cm into the soil to reduce predation from rodents. Shelters were removed for monthly measurements and were returned into the soil once measurements were recorded.

Hand shears were used to remove 50% of the terminal buds on each plant during May and September 1991. Seedlings clipped included whitebrush (N = 100), granjeno (N = 100), and lotebush (N = 60).

Fifty Texas ebony, granjeno, and whitebrush and 30 lotebush seedlings in the 30-cm and 60-cm shelters and the clipped treatment were weeded with the herbicide glyphosate. All herbaceous species within a 0.5-m radius of designated seedlings were sprayed in May and October. Glyphosate was applied with a hand sprayer and mixed at a ratio of 14.3 g/liter water. Weeds growing inside shelters were not removed because they have minimal adverse effect on seedling growth (Davies and Pepper 1989).

Texas ebony seedlings were not included in the clipping treatments because of slow growth rates. We used 30 lotebush seedlings in each treatment instead of 50 because we were unable to obtain a sufficient amount of seedlings from the nursery.

All seedlings were examined for signs of browsing when monthly measurements were taken. A seedling was considered browsed if the stem or leaf bases had an upward, angular cut and the cut appeared recent.

Differences in survival (%) were determined in February 1992 for seedlings in each treatment. Percent survival was defined as the proportion of the number of seedlings in each treatment surviving to February 1992 to the total number of seedlings planted in each treatment in February 1991. Differences in height and stem diameter were tested on treatment means from March 1991 and February 1992. Differences in mean number of stems produced were tested with data from 1991 (March, October) and 1992 (February). A one-way analysis of variance with $N = 3$ was used to test for treatment differences. Treatment means were compared by Tukey's HSD test (Peterson 1985).

Results

Survival

Treatments affected 12-month survival for Texas ebony ($P = 0.0527$), granjeno ($P = 0.0182$), lotebush ($P = 0.0402$) and whitebrush ($P = 0.0234$) seedlings (Table 1). Generally, seedlings in shelters survived at higher rates than unshel-

Table 1. Percent seedling survival for 4 thorn shrub species planted at Laguna Atascosa National Wildlife Refuge, Cameron County, Texas, 12 months after planting (March 1991–February 1992). Treatments were as follows: (1) 30-cm plastic shelter, weeded (30W); (2) 30-cm plastic shelter, not weeded (30NW); (3) 60-cm plastic shelter, weeded (60W); (4) 60-cm plastic shelter, not weeded (60NW); (5) clipped, weeded (CW); (6) clipped, not weeded (CNW); and (7) control.

		Treatment								
		Shelter height (cm)								
		30		60		Clipped				
Species	*n*	W	NW	W	NW	CW	CNW	Control	P[a]	MSE[a]
Texas ebony[b]	3	91AB	93A	91AB	82AB			76B	0.0527	3.7268
Granjeno	3	91AB	95A	94A	94A	83AB	82AB	78B	0.0182	3.4272
Lotebush	3	84A	84A	83A	80A	56A	57A	57A	0.0402	7.6611
Whitebrush	3	86AB	87AB	88A	90A	63B	63B	53B	0.0234	7.8484

[a]Mean square error and *P* value for ANOVA F-statistic comparison of percent seedling survival.
[b]Percentages in a row not sharing the same letter were different ($P < 0.1$) using Tukey's HSD test.

tered seedlings (80%–95% vs. 53%–83%), and weeding did not improve survival of seedlings in shelters ($P > 0.1$). Clipping and clipping plus weeding did not improve survival in comparison with the experimental controls ($P > 0.1$).

Stem Height

No treatment differences in mean stem height occurred following planting in March 1991 for Texas ebony ($P = 0.3567$) and lotebush ($P = 0.6458$) seedlings (Table 2). However, a difference in mean stem height occurred among granjeno ($P = 0.0491$) seedlings in March 1991. Treatments affected 12-month heights of Texas ebony, granjeno, lotebush, and whitebrush ($P = 0.0001$) seedlings. Generally seedlings in shelters grew taller than unsheltered seedlings. Texas ebony and whitebrush seedlings in 60-cm shelter treatments grew taller ($P < 0.05$) than seedlings in the 30-cm shelter treatments.

Stem Number and Stem Diameter

No significant difference in number of stems produced occurred among treatments for Texas ebony ($P = 0.4576$), granjeno ($P = 0.2425$), lotebush ($P = 0.2028$), or whitebrush ($P = 0.3958$) seedlings in March 1991 (Table 3). The number of stems produced by lotebush and whitebrush seedlings were similar among treatments in October 1991 ($P = 0.4853$, $P = 0.5927$) and February 1992 ($P = 0.0879$, $P = 0.3768$). However, Texas ebony and granjeno seedlings differed in number of stems produced among treatments in October 1991 ($P = 0.0442$, $P = 0.0025$) and February 1992 ($P = 0.0412$, $P = 0.0015$) (Table 3).

Treatments did not affect mean stem diameter for all species except Texas ebony ($P = 0.0068$). Mean stem diameter of Texas ebony seedlings in the 30 W,

Table 2. Mean stem height (cm) for 4 thorn shrub species initially measured in March 1991 and mean stem height for surviving seedlings in February 1992 planted at Laguna Atascosa National Wildlife Refuge, Cameron County, Texas. Treatments were as follows: (1) 30-cm plastic shelter, weeded (30W); (2) 30-cm plastic shelter, not weeded (30NW); (3) 60-cm plastic shelter, weeded (60W); (4) 60-cm plastic shelter, not weeded (60NW); (5) clipped, weeded (CW); (6) clipped, not weeded (CNW); and (7) control.

		Treatment								
		Shelter height (cm)								
		30		60		Clipped				
Species	*N*	W	NW	W	NW	CW	CNW	Control	P[a]	MSE[a]
Texas ebony[b]	3	16.66A	16.97A	17.51A	16.89A	—	—	16.01A	0.3567	0.4809
Granjeno	3	19.63AB	19.74AB	20.57A	19.43AB	17.91AB	18.30AB	16.27B	0.0491	0.8335
Lotebush	3	16.71A	17.29A	17.85A	16.85A	16.33A	15.54A	14.81A	0.0665	0.6274
Whitebrush	3	26.34A	27.11A	26.82A	27.25A	25.77A	26.01A	25.35A	0.6458	0.8474
Texas ebony	3	34.82B	35.19B	56.21A	56.12A	—	—	12.85C	0.0001	1.8103
Granjeno	3	26.53B	26.43B	36.46A	35.43AB	8.56C	10.11C	10.34C	0.0001	1.9952
Lotebush	3	24.18A	24.99A	34.38A	34.41A	7.89B	8.01B	7.02B	0.0001	2.2446
Whitebrush	3	44.90B	45.00B	72.95A	69.04A	19.00C	20.43C	17.92C	0.0001	2.6460

[a]Mean square error and *P* value for ANOVA F-statistic comparison of mean stem height.
[b]Monthly means in a row not sharing the same letter were different ($P < 0.5$) using Tukey's HSD test.

Table 3. Mean number of stems for 4 thorn shrub species in March 1991 and mean number of stems of surviving seedlings in October 1991 and February 1992 planted at Laguna Atascosa National Wildlife Refuge, Cameron County, Texas. Treatments were as follows: (1) 30-cm plastic shelter, weeded (30W); (2) 30-cm plastic shelter, not weeded (30NW); (3) 60-cm plastic shelter, weeded (60W); (4) 60-cm plastic shelter, not weeded (60NW); (5) clipped, weeded (CW); (6) clipped, not weeded (CNW); and (7) control.

		Treatment								
		Shelter height (cm)								
		30		60		Clipped				
Species	*N*	W	NW	W	NW	CW	CNW	Control	P[a]	MSE[a]
Texas ebony[b]	3	1.15A	1.10A	1.15A	1.19A	—	—	1.16A	0.4576	0.0342
Granjeno	3	2.08A	2.08A	2.35A	2.04A	2.03A	2.07A	2.07A	0.2425	0.0898
Lotebush	3	3.41A	3.79A	3.50A	3.84A	3.05A	3.98A	2.95A	0.2028	0.3036
Whitebrush	3	1.66A	1.70A	1.47A	1.38A	1.68A	1.41A	1.42A	0.3958	0.1334
Texas ebony	3	4.18AB	4.17AB	4.75A	3.85AB	—	—	2.11B	0.0958	0.5940
Granjeno	3	4.56AB	4.62A	4.44AB	4.76A	2.75C	2.86C	2.04BC	0.0025	0.3547
Lotebush	3	2.48A	2.92A	2.53A	2.49A	2.20A	2.03A	1.85A	0.4853	0.3339
Whitebrush	3	7.27A	7.33A	8.31A	7.02A	5.82A	5.85A	5.98A	0.5927	1.0624
Texas ebony	3	4.22AB	4.26AB	7.18A	6.11A	—	—	2.07B	0.0412	0.9652
Granjeno	3	5.35A	5.30A	5.31A	5.31A	2.67B	2.85B	3.02B	0.0015	0.4825
Lotebush	3	2.85A	2.88A	2.42A	2.31A	2.24A	1.74A	1.84A	0.0879	0.2814
Whitebrush	3	10.19A	9.62A	11.55A	10.46A	7.68A	7.05A	8.45A	0.3768	1.4865

[a]Standard error and *P* value for ANOVA F-statistic comparison of mean number of stems.
[b]Monthly means in a row not sharing the same letter were different ($P < 0.1$) using Tukey's HSD test.

30 NW, 60 W, and 60 NW shelter treatments were 3.7, 3.8, 4.0, and 4.0 cm, respectively, whereas the experimental control averaged 3.2 cm. Data were not available for Texas ebony seedlings in the clipping treatments.

Herbivory

Herbivory of seedlings occurred during all months and ranged from a high of 8.4% in July 1991 to a low of 0.1% in February 1992. Whitebrush seedlings were depredated the least (1.8%), followed by Texas ebony (3.0%), granjeno (5.3%), and lotebush (5.6%). Browsing was highest from July through November (8.4% to 5.1%) and decreased during December through January (3.3% to 0.7%). Browsing in the first 4 months of planting ranged from 2.3% to 4.1%.

Discussion

Seedling growth and survival on post-agricultural fields would be enhanced by using 30-cm or 60-cm-tall shelters. A higher relative humidity and elevated temperature may enhance photosynthesis and explain the accelerated growth of sheltered seedlings (Davies 1985). Shelters also may protect seedlings from wind stress and herbivores, enabling plants to allocate more resources to height growth (Tuley 1983, Evans and Potter 1985, Potter 1988, Davies and Pepper 1989). Once seedlings emerge from shelters, growth rates revert to normal and basal diameter and root development increase (Tuley 1983). Reallocation of resources from height growth to diameter and root development may have resulted in stem diameters of granjeno, lotebush, and whitebrush seedlings in shelters not differing from unsheltered seedlings.

Most of the mortality in shelters was directly related to girdling of stems by rodents (probably *Peromyscus* spp.), especially in winter. Rodents were probably searching for winter dorming areas and shelters would have provided protection from predators and environmental extremes.

Survival of unsheltered seedlings was also linked to predation. Removal of photosynthetic tissue may have caused plants to allocate resources to producing new leaves instead of root development and stem growth. Clipping and browsing may have caused seedlings to reach a point where net photosynthesis was inadequate to account for growth and reduced survival (Powell et al. 1972, Sosebee 1983).

Spraying glyphosate in a larger area around seedlings or on a more frequent basis may have increased survival and growth of seedlings. Davies and Pepper (1989) suggested pushing shelters into the soil to prevent rodents from reaching seedlings. Shelters were pushed several cm into the ground when placed over seedlings in this study; however, continuous removal of shelters for monthly measurements may have allowed rodents access into shelters that were not properly returned into the soil.

Shelters may reduce the time to reestablish dense thorn shrub communities. Managers attempting to restore native thorn shrub species should consider use of shelters as a means of enhancing seedling growth and establishment. Clipping resulted in reduced growth and survival of newly transplanted seedlings and is not recommended. Weeding seedlings on a regular basis can increase growth and survival of transplanted seedlings (Evans and Young 1977, Davies and Pepper 1989).

Identification of techniques that enhance seedling survival will accelerate the reestablishment of thorn-shrub communities and may accelerate ocelot usage of this habitat type. Restoration of extensive thorn-shrub communities and corridors of habitat will facilitate dispersal and stabilization of ocelot populations.

Literature Cited

Collins, K. 1984. Status and management of native south Texas brushlands. U.S. Fish and Wildl. Serv. Ecol. Serv., Corpus Christi, Texas. 18pp.

Davies, R. J. 1985. The importance of weed control and the use of tree-shelters for establishing broadleaved trees on grass dominated sites in England. Foresty 58: 167–180.

——— and H. W. Pepper. 1989. The influence of small plastic guards, tree-shelters, and weed control on damage to young broadleaved trees by field voles. J. Environ. Manage. 28:117–124.

Evans, J. and M. J. Potter. 1985. Tree-shelters—a new aid to tree establishment. Plasticulture 68:7–20.

Evans, R. A., and J. A. Young. 1977. Weed control—revegetation systems for big sagebrush-downy brome rangelands. J. Range Manage. 30:331–336.

Jahrsdoerfer, S. E. and D. M. Leslie, Jr. 1988. Tamaulipan brushland of the Lower Rio Grande Valley of south Texas: description, human impacts, and management options. U.S. Fish and Wildl. Serv. Biol. Rep. 88(36). 63pp.

Peterson, R. G. 1985. Design and analysis of experiments. Marcel Dekker, Inc., New York, N. Y. 429pp.

Potter, M. J. 1988. Tree-shelters improve survival and increase early growth rates. J. For. 86:39–41.

Powell, J., T. W. Box, and C. V. Baker. 1972. Growth rate of sprouts after top removal of huisache [*Acacia farnesiana* (L.) Willd.] (Leguminosae). Southwestern Nat. 17:191–195.

Sosebee, R. E. 1983. Physiological, phenological, and environmental considerations in brush and weed control. Pages 27–43 *in* K. C. McDaniel, ed. Proceedings of the brush management symposium. N. M. State Univ., Las Cruces.

Tewes, M. E. and D. D. Everett. 1986. Status and distribution of the endangered ocelot and jaguarundi in Texas. Pages 147–158 *in* S. D. Miller and D. D. Everett, eds. Cats of the world: biology, conservation, and management. Natl. Wildl. Fed. Washington, D.C.

Tuley, G. 1983. Shelters improve the growth of young trees in the forest. Quartelry J. For. 77:77–87.

Williams, D., D. M. Thompson, and J. L. Jacobs. 1977. Soil survey of Cameron County, Texas. U.S. Soil Conserv. Serv. 93pp.