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## Habitat characteristics and selection by ornate box turtles in the Sandhills of South Dakota

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**ABSTRACT.**—The ornate box turtle (*Terrapene ornata* Agassiz) is a species of greatest conservation need in South Dakota. Habitat loss through agricultural development and fragmentation is the main threat to the species throughout its range, which extends from Wisconsin and northern Indiana through the central Great Plains, and from southern South Dakota to Arizona, northern Mexico, and the Gulf Coast of Texas. The objectives of this study were to determine the ornate box turtle's preferred vegetation characteristics (microhabitat) compared to the available habitat (macrohabitat) on the Pine Ridge Reservation, South Dakota Sandhills region, during 2010–2011. In both years, using a modified Robel pole method, we determined that turtles selected microhabitat with greater visual obstruction readings (VORs) than those within the random available macrohabitat ( $P < 0.01$ ), with means of 22 cm and 15 cm, respectively. Higher VOR values indicate greater vegetation height and/or density. Canopy cover results showed that ornate box turtles exhibited high selection ( $P < 0.01$ ) for sand sagebrush (*Artemisia filifolia* Torr.) coverage (38%) but selected lower cover than available within the macrohabitat for total grasses (37%), total forbs (19%), and bare ground (14%). Shrubs, such as sand sagebrush, are an important component of box turtle microhabitat, as they facilitate thermoregulation by providing cool areas during the summer and favorable hibernation sites during the winter. Shrub coverage is highly recommended for consideration when developing habitat management plans that aim to increase or sustain ornate box turtle populations in the Sandhills ecological type.

**RESUMEN.**—La tortuga (*Terrapene ornata* Agassiz) es una especie de gran importancia para la conservación en el estado de Dakota del Sur. La pérdida de hábitat, producto del desarrollo de la agricultura y la fragmentación del hábitat, es la principal amenaza de la especie a lo largo de su rango de distribución, la cual se extiende desde Wisconsin y el norte de Indiana, a través de las Grandes Llanuras (Great Plains) del sur del estado de Dakota hasta Arizona, el norte de México y la Costa del Golfo de Texas. El objetivo de este estudio fue determinar las características de la vegetación (microhábitat) que prefiere la tortuga *Terrapene ornata*, en comparación con el hábitat (macrohábitat) disponible en la Reserva de Pine Ridge, en la región de las dunas de Dakota del Sur, durante los años 2010 y 2011. Con base en el método de polo de Robel modificado, encontramos que durante ambos años, las tortugas *Terrapene ornata* eligieron el microhábitat con mayores lecturas de obstrucción visual (VOR, por sus siglas en inglés), comparado con el macrohábitat aleatorio disponible ( $P < 0.01$ ), con medias de 22 cm y 15 cm, respectivamente. Valores más altos de VOR indican mayor altura y/o densidad de vegetación. Los resultados de la cobertura de dosel, mostraron que las tortugas *Terrapene ornata* mostraron mayor predilección ( $P < 0.01$ ) por Artemisia de arena (*Artemisia filifolia* Torr.), con una cobertura del 38%, pero eligieron valores de cobertura más bajos que los disponibles dentro del hábitat para el total de los pastos (37%), de las plantas herbáceas (19%) y suelo descubierto (14%). Los arbustos, tales como la Artemisia de arena, son un componente importante del microhábitat de *Terrapene ornata*, ya que facilitan la termorregulación, al proporcionar áreas frescas durante el verano, y sitios favorables a la hibernación durante el invierno. La cobertura de arbustos es altamente recomendable en el desarrollo efectivo de planes de gestión de hábitats, que sean benéficos para el incremento o sustento de las poblaciones de la tortuga *Terrapene ornata*, en los hábitats de dunas.

Habitat loss mainly through agricultural development and fragmentation has been the greatest threat to the ornate box turtle (*Terrapene ornata* Agassiz) throughout its range (Bowen et al. 2004, Redder et al. 2006). Although the ornate box turtle is not a listed species nor a candidate of concern under the

Endangered Species Act of 1973, in South Dakota its status is listed as imperiled (Redder et al. 2006). Nevertheless, South Dakota does not provide legal protection for the species. The ornate box turtle has a distribution throughout the Southern and Central Great Plains and primarily prefers grasslands associated with

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sandy soils. Converse and Savidge (2003) reported on nonhibernating activity level of the ornate box turtle as related to vegetation structure and associated microhabitat. Active turtles in the study selected bare ground and forb cover, whereas sedentary turtles selected more shrub and litter cover. Vegetation height (cm) showed no differences between active and non-active turtles. Most available literature reports on the demography of the ornate box turtle and contains limited information on quantitative habitat assessments (Redder et al. 2006).

Ornate box turtles have been documented primarily in the Sandhills of southwestern South Dakota by Over (1923), but they occur throughout the Sandhills on the Northern Great Plains. Carr (1952) reported that ornate box turtles range across the southern portion of South Dakota from Iowa to Wyoming. Currently, these turtles are found in the Sandhills region in south central and western South Dakota (Ballinger et al. 2000, Kiesow 2006). During the past several years in our surveys within the South Dakota Sandhills, several additional ornate box turtles were documented, which prompted a survey and initiation of a study in 2010. The objectives of our study were (1) to examine habitat selection of ornate box turtles, (2) to determine the vegetative structure (height-density) and canopy cover of selected habitat, and (3) to develop management guidelines based on our findings.

#### STUDY AREA

This study was conducted approximately 12.9 km south of Scenic, South Dakota, and 1.6 km east of the Pine Ridge Indian Reservation. A detailed description of the study site is not provided because ornate box turtles are collected for sales and pets. Well-developed wind-blown sands form dunes that extend into the Sandhills Region of Nebraska (USDA–NRCS 2010). Elevation is approximately 860 m. Average annual precipitation at Scenic is 39.6 cm over a 55-year period (HPRCC 2017). The monthly precipitation (over 12 months) ranged from 21.4 cm to 61.5 cm. Average monthly temperatures ranged from a winter low of  $-6.8^{\circ}\text{C}$  to a summer high of  $22.3^{\circ}\text{C}$ .

The soil features of the greater study area are sandy textured with slopes of 3% to 30%, and the area is described as Sands Ecological Type (USDA–NRCS 2010). Soils are well

drained and formed in eolian sand or sandy alluvium. The surface layer is 7.6 cm to 45.7 cm and the subsurface layers are loamy fine sand to sand. Some areas have patterns of rill and gully from limited water flow of rain and snow. Dominant grasses of the study area include prairie sandreed (*Calamovilfa longifolia* [Hook.] Scribn.), needle and thread (*Hesperostipa comata* [Trin. & Rupr.] Barkwort), blue grama (*Bouteloua gracilis* [Willd. ex Kunth] Lag. ex Griffiths), and hairy grama (*Bouteloua hirsuta* Lag.). Common forbs included Cuman ragweed (*Ambrosia psilostachya* DC.) and slim-flower scurfpea (*Psoraleidium tenuiflorum* [Pursh] Rydb.). The most common shrub is sand sagebrush (*Artemisia filifolia* Torr.). Plant nomenclature follows USDA–NRCS (2018). The area currently receives light to no grazing by livestock during the summer.

#### METHODS

Ornate box turtles were located by searching throughout the habitat during the active season, from the end of April through mid-October in both years of the study (2010–2011). In addition, dogs specifically trained to locate turtles were used during the survey periods. Twenty-five turtles (10 males, 14 females, and 1 juvenile) were fitted with radio transmitters (Advanced Telemetry Systems, Inc., Isanti, MN) attached to the back of the carapace during 2010 and 2011 (Higa et al. 2012). Ornate box turtles were located weekly with a 3-pronged antenna (3-element folding Yagi antenna). All turtles were stationary during data collections. Handling of animals was approved by the IACUC at Black Hills State University (Higa et al. 2012).

Microhabitat measurements were collected at approximately 2-week intervals for each year from May through October. We used a modified Robel pole with alternating 1.27-cm white and gray bands (Uresk and Benzon 2007, Uresk and Mergen 2012). Bands were numbered beginning with 0 (white band) at the bottom of the pole, and the zero band was placed at the soil surface. A visual obstruction reading (VOR) was recorded at a distance of 4 m from the pole in 4 cardinal directions at each Robel station. For each VOR, the lowest visible band was recorded. Canopy cover was estimated for total grass, forbs, and shrubs, including cactus, yucca, sand sagebrush, silver sage, litter, and bare ground (Daubenmire

TABLE 1. Visual obstruction readings (VORs) by Robel pole band number (1.27 cm wide) over a 2-year period at ornate box turtle–selected habitat and random available habitat in the Sandhills of South Dakota. Standard errors are in parentheses.

Year	Sample size	Visual obstruction <sup>a</sup>	
		Turtle-selected habitat	Random habitat
2010	185	17.7 (0.8)*	10.9 (0.4)
2011	112	17.2 (0.9)*	12.2 (0.5)
2010 + 2011	297	17.5 (0.6)*	11.4 (0.3)

<sup>a</sup>Robel pole bands (1.27 cm wide).

\*Significant difference,  $P < 0.01$ .

1959). Estimates of canopy cover were collected at turtle-selected habitat and at each of the 4 cardinal directions at a 10-m stratified random available habitat. For analyses, all data were averaged as site means, one for the turtle location and one for the 10-m stratified random distances within the available habitat (VOR and canopy cover).

Ten habitat variables were evaluated: total grass, total forbs, total shrubs, cactus, yucca, sand sagebrush, silver sagebrush, total vegetation, litter, and bare ground. VOR and canopy cover data were analyzed at turtle locations and at stratified random locations with SPSS (2003). Paired  $t$  tests were used to compare each attribute between ornate box turtle–selected habitat and stratified random distances for available habitat by sample period. Two-sample  $t$  tests were used to compare between years (SPSS 2003). Statistical inferences were made at  $P = 0.05$  for all comparisons unless actual  $P$  values are presented.

## RESULTS

### Visual Obstruction Readings

VOR height-density of vegetation over the 2-year period was greater ( $P < 0.05$ ) at turtle-selected habitat than within random available habitat (Table 1). Years combined showed a greater VOR at turtle locations ( $P < 0.01$ ) than within the available habitat—17.5 (22.2 cm) bands and 11.4 bands (14.5 cm), respectively. VORs among the turtle-selected habitat showed no differences between years.

VOR varied over a 6-month (May–October) sampling season ( $P < 0.05$ ) for turtle-selected habitat compared to random available habitat measured at stratified random points (Fig. 1,

Table 2). Turtle selections ranged from a low of 10.9 bands (13.8 cm) in October to a high of 18.9 bands (24 cm) in July. Ornate box turtle habitat varied from a low VOR of 6.4 bands to 13.5 bands in May and July, respectively. The turtles clearly selected for greater VORs than found in random habitat throughout the summer sampling periods ( $P < 0.05$ ).

### Canopy Cover

Overall, ornate box turtles showed a high preference ( $P < 0.01$ ) for sand sagebrush canopy cover (38%) compared to that found in random available habitat (8%) (Table 3, Fig. 2). Turtles selected lower cover for total grass (37%), total forbs (19%), and bare ground (14%) ( $P < 0.01$ ) compared to the same cover values in random available habitat, which were 50%, 24% and 20% cover, respectively (Table 3).

Throughout the seasons, turtles preferred lower grass cover compared to random sites ( $P < 0.01$ ) from June through September (Table 4, Fig. 1). Turtles selected sites with a lower forb cover (Table 4). Canopy cover of forbs for turtle-selected sites ranged from 15% to 24% from May through October, while random available habitat ranged from 13% to 27%. Sand sagebrush canopy cover was highly selected by box turtles ( $P < 0.01$ ) over other existing cover within the habitat for all 6 months. Ornate box turtles clearly selected for sand sagebrush when compared to available sand sagebrush within the habitat (Fig. 2). Turtles used litter variably throughout the season and exhibited a preference for litter ( $P < 0.05$ ) from July through September (Table 4). Selection of bare ground by ornate box turtles was generally lower than available bare ground within the habitat among months (Table 4, Fig. 2). Bare-ground cover selected by turtles ranged from 8% to 29%, while available bare-ground cover ranged from 15% to 29%. Turtles selected significantly less bare ground ( $P < 0.05$ ) during June and August.

## DISCUSSION

The ornate box turtles in this study are located in a sands ecological type that extends from South Dakota through Nebraska (USDA–NRCS 2010). These turtles generally prefer open grasslands and shrubby sites within the

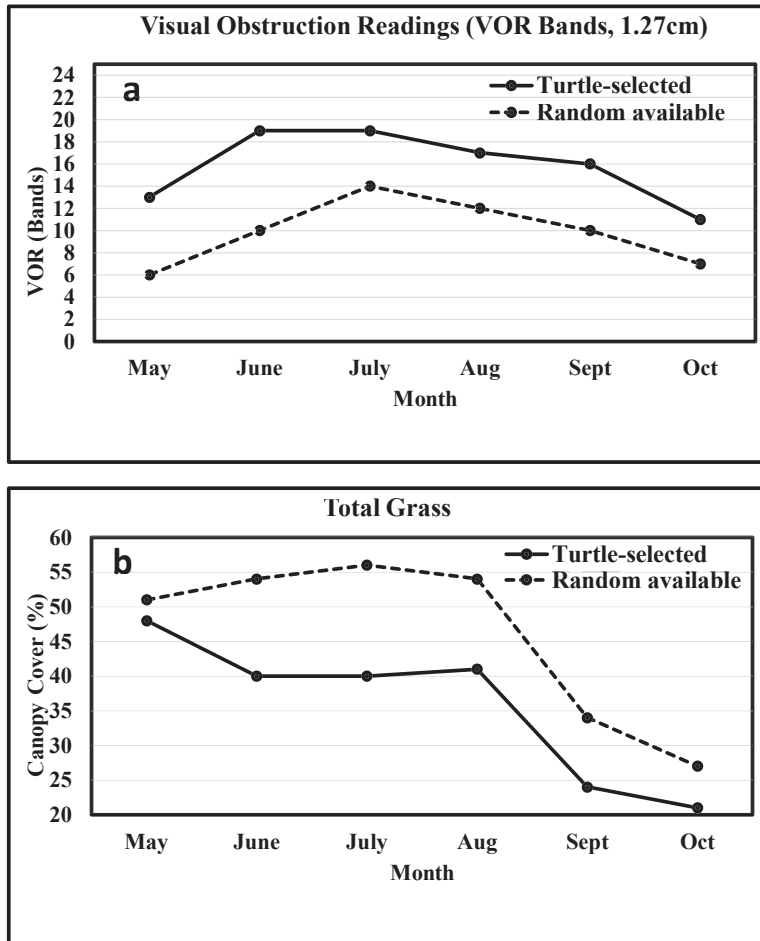


Fig. 1. (a) Visual obstruction readings (VOR bands, 1.27 cm) for ornate box turtle–selected habitat versus random available habitat from May through October. (b) Canopy cover (%) of total grass depicting ornate box turtle–selected habitat versus random available habitat over a 6-month period in the Sandhills of South Dakota.

TABLE 2. Mean visual obstruction readings (VORs) at ornate box turtle–selected habitat and random available habitat by month for a 6-month sampling period over 2 years (2010–2011) in the Sandhills of South Dakota. Standard errors are in parentheses.

Locations	Month	Visual obstruction <sup>a</sup>	
		Turtle-selected habitat	Random habitat
5	May	13.2 (1.6)*	6.4 (1.3)
53	June	18.8 (1.5)*	10.0 (0.6)
102	July	18.9 (1.0)*	13.5 (0.5)
72	August	17.4 (1.1)*	11.5 (0.6)
48	September	16.0 (1.5)*	10.2 (0.7)
17	October	10.9 (1.5)*	7.3 (0.9)

<sup>a</sup>Robel pole bands (1.27 cm wide).  
\*Significant difference,  $P < 0.05$ .

TABLE 3. Canopy cover (%) at ornate box turtle–selected habitat and random available habitat in the Sandhills of South Dakota. Means and standard errors (in parentheses) are given for 2 years combined ( $n = 297$ ).

Category	Canopy cover (%)	
	Turtle-selected habitat	Random habitat
Total grass	36.8 (1.8)*	49.8 (1.3)
Total forbs	19.2 (1.4)*	23.6 (1.0)
Total shrubs	40.3 (2.3)*	8.6 (0.7)
Cactus	0.6 (0.4)	0.8 (0.2)
Yucca	0.9 (0.5)	0.3 (0.1)
Sand sagebrush	37.5 (2.3)*	7.6 (0.7)
Silver sagebrush	0.8 (0.3)	0.8 (0.2)
Total vegetation	79.1 (1.6)*	71.2 (1.1)
Litter	59.2 (2.1)*	54.6 (1.5)
Bare ground	14.3 (1.4)*	19.9 (1.0)

\*Significant difference,  $P < 0.01$ .

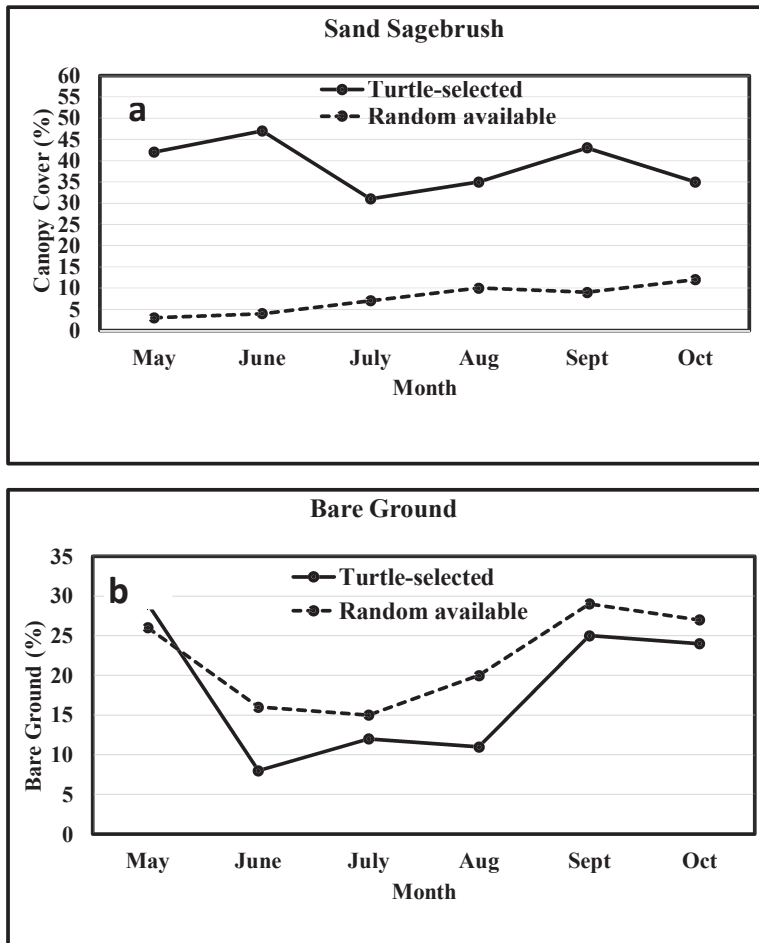


Fig. 2. (a) Canopy cover (%) of sand sagebrush for ornate box turtle–selected habitat compared to random available habitat from May through October. (b) Bare ground cover (%) of ornate box turtle–selected habitat compared to random available habitat over a 6-month period in the Sandhills of South Dakota.

Sandhills (Converse and Savidge 2003). Converse and Savidge (2003) reported that ornate box turtles in the Nebraska Sandhills also had a strong relationship to the amount of shrub cover used but did not define plant species. Ornate box turtles were common on our study area and highly selected sand sagebrush for cover. The habitat characterized at this study area in the sands ecological type is considered excellent for increasing or sustaining ornate box turtle populations.

Historically, the area has been under heavy grazing by livestock as indicated by the dominant plant species. Sand sagebrush and Cuman ragweed are abundant and they increase under heavy grazing (USDA–NRCS 2010). Prairie

sandreed with needle and thread, blue grama, and hairy grama are common throughout the study area. Other plants, such as sand blue-stem and little bluestem, are rare but are generally considered abundant for this ecological site (USDA–NRCS 2010). Currently, the area receives limited livestock grazing with short periods of rest.

Livestock grazing has been used as a tool for wildlife habitat management for many years (Severson 1990, Severson and Urness 1994). Ornate box turtle habitat can be manipulated with a high degree of control by livestock grazing for desired habitat conditions (Uresk 2012, USDA–NRCS 2018). Sand sagebrush and Cuman ragweed are common in the study

TABLE 4. Mean comparison between ornate box turtle–selected habitats and random available habitat (canopy cover [%], standard error in parentheses) by category and month over 2 years (2010–2011) in the Sandhills of South Dakota.

Category	No. of locations	Month	Canopy cover (%)	
			Turtle–selected habitat	Random habitat
Total grass	5	May	47.5 (6.1)	50.6 (7.4)
	53	June	39.9 (4.0)*	54.1 (2.4)
	102	July	40.4 (3.2)*	56.4 (2.3)
	72	August	41.2 (4.0)*	53.5 (2.7)
	48	September	23.7 (3.7)*	34.2 (2.6)
	18	October	20.7 (5.1)	26.6 (4.9)
Total forbs	5	May	15.0 (<0.1)	13.0 (3.4)
	53	June	15.6 (3.3)*	21.7 (1.8)
	102	July	24.0 (2.7)	26.9 (1.8)
	72	August	18.5 (2.9)*	25.6 (2.1)
	48	September	15.3 (3.2)	19.8 (2.1)
	18	October	16.6 (4.8)	15.0 (3.1)
Sand sagebrush	5	May	42.0 (18.8)*	2.6 (1.7)
	53	June	46.6 (5.9)*	3.9 (5.2)
	102	July	31.1 (3.9)*	7.4 (1.1)
	72	August	34.7 (4.6)*	9.6 (1.6)
	48	September	43.1 (5.7)*	8.8 (1.6)
	18	October	35.4 (0.7)*	11.5 (3.3)
Litter	5	May	41.0 (13.3)	47.5 (9.5)
	53	June	37.8 (5.2)	31.4 (3.3)
	102	July	67.1 (3.5)*	59.6 (2.6)
	72	August	71.9 (3.5)*	63.6 (2.7)
	48	September	48.3 (4.7)*	57.2 (3.2)
	18	October	61.6 (6.5)	53.5 (4.1)
Bare ground	5	May	29.0 (13.9)	25.9 (5.7)
	53	June	8.3 (2.7)*	16.2 (1.9)
	102	July	12.2 (2.2)	15.4 (1.5)
	72	August	11.1 (2.5)*	20.4 (2.2)
	48	September	25.4 (4.6)	29.4 (2.6)
	18	October	23.7 (7.4)	26.8 (4.7)

\*Significant at  $P < 0.01$ .

area and may require heavy grazing for several years to promote these plant species. Once desired habitat conditions are established, they can be maintained at light to no grazing to increase or sustain ornate box turtle populations. Fire, mowing, and spraying are additional options but are very expensive and may not be practical.

During both years, ornate box turtles selected habitat with greater VORs than those of available habitat. Turtles preferred shrubs and sand sagebrush and avoided grass, forbs, and bare ground within the available habitat. Litter was an important habitat component for the ornate box turtle during July through September. The extremely high preference for sand sagebrush strongly suggests that a decrease in this shrub species would result in negative impacts on ornate box turtles. Converse and Savidge (2003) reported that ornate box turtles used areas of more shrub and litter cover, but

these observations were not consistent over years in the Nebraska Sandhills.

#### Management Implications

Ornate box turtles consistently preferred VORs for optimal microhabitat at 18 bands (23 cm). Sand sagebrush provided most of the visual obstruction at turtle locations. Optimum conditions for ornate box turtle management would require the following canopy cover: sand sagebrush (38%), total grass (37%), total forbs (19%), and bare ground (14%). Ornate box turtles do not prefer open areas when they move within their habitat type. Maintaining or achieving these guidelines would be beneficial and effective in conservation of the ornate box turtle. Shrub coverage is highly recommended for consideration when developing management plans that aim to increase or sustain ornate box turtle populations in the Sandhills ecological type.

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