# MOVEMENTS OF LARGE SNAKES (*DRYMARCHON*, *MASTICOPHIS*) IN NORTH-CENTRAL FLORIDA

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Abstract: *Little is known concerning home range and activity of large terrestrial snakes. During the course of an inventory of a large biological preserve in north-central Florida, 5 individuals of Drymarchon and Masticophis were tracked from 49 to 322 days. A single eastern indigo snake had a home range of 100–185 ha depending on estimator, whereas the coachwhips used smaller home ranges that varied individually and by season. We provide information on ecdysis, feeding activity, and retreat sites for the 5 tracked individuals; these are the first such data on free-ranging coachwhips. Gopher tortoise and small mammal burrows were important retreat sites for both species, particularly during ecdysis. Both species frequented uplands habitats, with coachwhips using longleaf pine/xeric oak sandhills and former pastures, and the eastern indigo snake preferring upland mixed pine and hardwoods. Although sample sizes are small, these results, coupled with data on the movements of other upland species, suggest that large terrestrial snakes require substantial amounts of contiguous habitat in order to maintain populations.*

*Key Words:* Telemetry, movement, home range, snakes, *Drymarchon couperi*, *Masticophis flagellum*, sandhills

Conserving wide-ranging terrestrial vertebrates has become a central objective of landscape-level planning to protect biotic diversity, especially in states such as Florida that are experiencing increasing loss of undeveloped and unfragmented natural habitats. To date, most studies have focused attention on charismatic vertebrates, such as Florida panthers (*Puma concolor coryi*), black bears (*Ursus americanus*), and scrub jays (*Aphelocoma coerulescens*), whose populations are dwindling from habitat loss, fragmentation, and associated threats. There is often a tacit, if not explicit, assumption in the protection of wide-ranging mammals and birds that if sufficient habitat can be set aside and managed for these umbrella species, then other rare but uncharismatic species and common inhabitants also will benefit (Caro and O'Doherty, 1999). Undoubtedly this may be true in some cases, but the assumption is often untested or has proven inaccurate for many species (Schwartz, 1999; Andelman and Fagan, 2000; Caro et al., 2004), such as large terrestrial snakes, that inhabit southeastern communities.

Very little is known concerning the population structure and habitat requirements of most large terrestrial snakes inhabiting the southeastern Coastal Plain, with the exception of the large pit vipers, genus *Crotalus* (e.g., Timmerman, 1995; Timmerman and Martin, 2003; Waldron, 2005). Snakes of the genera *Drymarchon*, *Pantherophis* (=*Elaphe*), *Lampropeltis*, *Masticophis*,

and *Pituophis* likely were abundant prior to European settlement, but often circumstantial evidence suggests that certain species within these genera are declining (Moler 1992a; Ernst and Ernst, 2003; Mirarchi et al., 2004; Krysko and Smith, 2005). With increasing loss and fragmentation of habitat to development (Kautz, 1993, 1998), it becomes critically important to understand the spatial requirements of these species if they are to be maintained as functional components of remaining natural communities.

During the course of inventorying a large tract of land in north-central Florida from 1986 to 1988, one of us (CKD) had the opportunity to track the movements of several large terrestrial snakes (*Drymarchon*, *Masticophis*). These observations begin to delineate the amount of habitat necessary to maintain a large terrestrial snake community, despite the small sample size, when coupled with previous work on *Pituophis* (Franz, 2005) and *Pantherophis* (Franz, 1995) in the same area. Our objective is to present these data in the hopes of stimulating more comprehensive work, and the publication of existing data, on large snakes.

The eastern indigo snake (*Drymarchon couperi*) is protected by federal and state laws, and is the largest snake in North America. Although one of the main threats to this species is habitat loss (Lawler, 1977; Moler, 1992b; Stevenson et al., 2003), most of what is known concerning this snake's habitat use and requirements is found in unpublished, non peer-reviewed, and largely inaccessible agency reports (Steiner et al., 1983; Moler, 1985; Layne and Steiner, 1996; Hyslop et al., 2006). The snake is a diurnal, actively foraging euryphagous predator, and individuals may be active throughout the year (Bartlett and Bartlett, 2003; Ernst and Ernst, 2003).

The coachwhip (*Masticophis flagellum*) is perhaps the second largest North American snake (at least in length) and, like the eastern indigo snake, it is a diurnal, actively foraging predator (Ernst and Ernst, 2003). To date, there have been no studies of the home range and habitat requirements of the coachwhip in the eastern United States, leading Ernst and Barbour (1989: 64) to state "This [lack of knowledge] is unfortunate since its habitat is being rapidly degraded or destroyed, and the coachwhip could disappear from some areas before we come to know it well." The availability of life history data on coachwhips has not increased substantially since 1989.

MATERIALS AND METHODS—*Description of study area*—Snakes were tracked on the Ordway-Swisher Biological Station (Ordway) in Putnam County, Florida. The Ordway consists of ca. 4,364 ha of mixed uplands and wetlands managed jointly by the University of Florida and The Nature Conservancy (Fig. 1). The preserve lies on the southern edge of Trail Ridge within the Interlachen Karstic Highland. Nine major communities have been identified on the preserve. Uplands consist mostly of sandhills, xeric hammocks, and a mixed upland forest undergoing succession from open fields to forest. Wetlands consist of the Mill Creek system (a series of interconnected red water eutrophic lakes and swamp forest) and isolated clear water oligotrophic lakes and depression marshes. These communities are interspersed in a complex mosaic pattern throughout the preserve, and the sandhills community, in particular, is managed using prescribed fire on a rotational schedule. Additional details on the Ordway and its associated communities are found in Eisenberg and Franz (1995) and Dodd and Franz (1995).

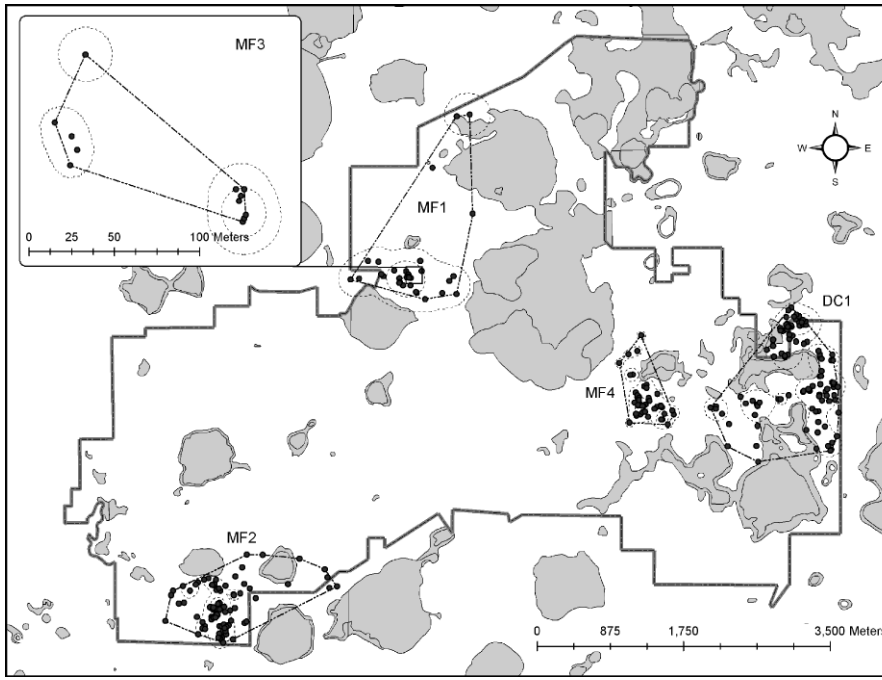


FIG. 1. Map showing the ranges of telemetered *Drymarchon* and *Masticophis* at the Ordway-Swisher Biological Station, Putnam County, Florida. The shaded areas indicate the extent of ponds, wet prairies, and other major wetlands on the preserve. The small dotted circles indicate 95% and 50% kernels.

*Telemetry*—An adult eastern indigo snake (*Drymarchon couperi*) and 4 eastern coachwhips (*Masticophis flagellum*) were collected opportunistically by hand during a general inventory of the herpetofauna of the Ordway. Prior to surgery for transmitter implantation, snakes were measured to the nearest mm for snout-vent (SVL) and total length (TL), weighed to the nearest g, and sex was determined by a cloacal probe (Table 1). AVM SB2 implant transmitters fitted with whip antennas (AVM Instrument Company, Livermore, CA) were surgically placed into the coelomic cavity; transmitters weighed 28 g. General surgical procedures followed Reinert and Cundall (1982). Prior to release, snakes were held for several days to ensure healing without medical complications. The snakes were then released in the morning at the location where they had been originally captured. Tracking began the next day ca. 24 hours after release.

Snakes generally were tracked daily, mostly in the morning hours, until transmitters began to fail. At each tracking event, the snake's location, activity, retreat site, habitat, and weather conditions upon location were recorded. Locations were plotted directly on 1:200′ aerial black and white sectional maps available from Putnam County. These maps were based on overflights in 1985, and the resolution was such that individual trees, road junctions, changes in vegetation and other landmarks could be accurately pinpointed. Snake locations were plotted in the field based on triangulation between nearest observable landscape features. Later, the annotated hardcopy aerial orthographs were scanned and stored in TIFF (Tag Image Format File) format. These images were then georeferenced in ArcMAP 9.1 using a second-order polynomial function and a minimum of six control points. The hand-plotted locations of each snake were manually digitized from the georeferenced images into individual shape files within an ArcGIS geodatabase.

In order to determine home ranges, activity centers and habitat use, we analyzed each shape file with the Animal Movements Extension (Hooge and Eichenlaub, 1997) in ArcView 3.1

TABLE 1. Descriptive statistics and data on home ranges of *Drymarchon* (DC1) and *Masticophis* (MF1-4) tracked on the Ordway-Swisher Biological Station, Putnam County, Florida. MCP = minimum convex polygon.

| | | | | | | | | | | Overall Range Estimate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Individual | SVL (mm) | TL (mm) | Body Mass (g) | Sex | Start | End | Days at large | Obs. | N obs w/o movement | MCP (ha) | 95% Kernel (ha) | 50% Kernel (ha) |
| DC1 | 1105 | 1334 | 450 | m | 5/6/1986 | 3/24/1987 | 322 | 258 | 138 | 185.30 | 99.85 | 7.10 |
| MF1 | 1850 | 2348 | 892 | m | 5/20/1987 | 7/8/1987 | 49 | 47 | 15 | 171.28 | 111.36 | 15.56 |
| MF2 | 1410 | 1852 | 486 | m | 5/20/1987 | 1/5/1988 | 230 | 177 | 71 | 128.80 | 30.39 | 3.20 |
| MF3 | 1215 | 1632 | 340 | f | 11/24/1987 | 3/28/1988 | 125 | 94 | 77 | 0.48 | 0.36 | 0.06 |
| MF4 | 1285 | 1681 | 420 | f | 4/20/1989 | 7/4/1989 | 75 | 66 | 14 | 40.57 | 30.07 | 4.36 |

(Environmental Systems Research Institute, Redlands, CA). We calculated minimum convex polygons (MCP) and 95% fixed kernels using all radiolocations, and 50% fixed kernels to identify core activity areas. Home ranges and activity centers were determined from data collected throughout the tracking period, but small sample size precluded more detailed analyses by sex or season. Habitat use was determined by clipping a land classification layer (available from the Ordway) to the extent of the home ranges and activity centers and summarizing the area of habitat within each layer.

RESULTS—Daily tracking began in spring (late April to May) for the eastern indigo snake (♂) and three coachwhips (2 ♂, 1 ♀), and extended from 49 to 322 days (Table 1). The fourth coachwhip (♀) was tracked for 125 days throughout fall of 1987 until early spring 1988. Home range estimates based on MCP and kernel density are in Table 1. Throughout this paper, we follow Gregory and co-workers (1987: 377) as defining a snake's home range as "the area covered by an animal in the course of its normal daily activities during a specified time period."

*DC1*—This adult eastern indigo snake's home range extended over a considerable portion of the eastern section of the Ordway, and varied between 100 and 185 ha depending on the estimator (Table 1). Most of his time was spent in mixed pine (*Pinus palustris*)-hardwood (*Quercus* sp.) uplands adjacent to clear water lakes, along whose margins he frequently foraged during the warmer months (Table 2). During the winter, he took up residence on a longleaf pine/xeric oak sandhill east of a wetland complex, and remained there in a series of adjacent gopher tortoise (*Gopherus polyphemus*) burrows until he was recaptured in spring 1987. The 50% kernel (7.1 ha) largely reflects concentrated winter activity in this relatively small area. Although he had been observed frequently (Table 3) and appeared in good condition on 9 March, he was found to have cutaneous lesions over much of his body when recaptured on 23 March 1987. He was treated at the University of Florida College of Veterinary Medicine, but subsequently died of the infection.

DC1 was found in 104 different locations during the tracking period. Within a 24-hr period, he moved a mean of 175 m (range 11–987, N = 119). He shed at least 7 times between May 1986 and March 1987 at intervals ranging from ca. 2 weeks to 2 months. When shedding, he remained in a single location, usually a gopher tortoise burrow, from 8 to 20 days (mean = 12.3). Shedding-related inactivity was longest during the cooler months and immediately after transmitter implantation (Table 2). DC1 was observed using a wide variety of cover and retreat sites (Table 2), particularly gopher tortoise burrows and burrows of the Florida mouse (*Podomys floridanus*) that frequently intersect tortoise burrows (Jones and Franz, 1990). DC1 often returned to previously used burrows and stump holes.

DC1 was frequently observed (N = 83 times) while diurnally foraging and, during cool periods, basking. In the open, the snake constantly moved his snout back and forth across the ground while tongue flicking. He often appeared alert to his surroundings, including the observer's approach, and

TABLE 2. Activity and retreat sites of *Drymarchon* (DC1) and *Masticophis* (MF1-4) tracked on the Ordway-Swisher Biological Station, Putnam County, Florida.

| | | | | Location | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Individual | Times Seen | Shedding | Feeding | *Podomys* or other burrow | *Dasypus* burrow | *Geomys* burrow | *Gopherus* burrow | on ground, exposed | under brush | under log | under thick ground cover | arboreal | stump hole | human dwelling or debris |
| DC1 | 83 | 7 (a.) | 4(e.) | 13 | 3 | 1 | 35 | 48 | 21 | 2 | 2 | | 5 | 6 |
| MF1 | 27 | 1 (b.) | none | 8 | 1 | | 6 | 21 | 3 | | 2 | | | |
| MF2 | 65 | 5 (c.) | 2(f.) | 21 | | 6 | 21 | 54 | 4 | 2 | 1 | 3 | | |
| MF3 | 9 | none | none | 3 | | 5 | 4 | 5 | 1 | | | 1 | | |
| MF4 | 42 | 2 (d.) | 3(g.) | 9 | | 2 | 4 | 19 | 12 | 1 | 3 | | | |

[a] 5/11-26, 7/28-8/4, 8/17-26, 10/8-16, 11/10-20, 12/10-30, 1/20-2/6.
[b] 5/30-6/6.
[c] 6/9-13, 7/13-17, 8/8-14, 9/11-17, 10/23-11/03.
[d] 5/15-22, 6/26-7/3.
[e] *Crotalus adamanteus* (eating 7/17), lg unident anuran (eating 9/22), *Bufo terrestris* (chase 11/21), *Coluber constrictor* (eating 12/10).
[f] *Eumeces laticeps* (chased 7/28), *Sigmodon hispidus* (attacked 10/4).
[g] *Rana capito* (chased 5/10), unknown (5/29, 6/6).

TABLE 3. Habitat use of *Drymarchon* (DC1) and *Masticophis* (MF1-4) tracked on the Ordway-Swisher Biological Station, Putnam County, Florida. MCP = minimum convex polygon.

| | | Habitat Use (%) Within Home Range | | | | | |
|---|---|---|---|---|---|---|---|
| Snake | | Former Pasture | Longleaf Pine/ Xeric Oak | Pine Flatwoods | Upland Mixed Pine/Hardwoods | Wetlands and their Margins | Other |
| DC1 | MCP | | 4.4 | | 62.5 | 33.1 | |
| | 95% Kernel | | 18.1 | | 68.7 | 13.2 | |
| | 50% Kernel | | 45.7 | | 54.3 | | |
| MF1 | MCP | 12.2 | 60.9 | 6.2 | 8.5 | 11.4 | 0.8 |
| | 95% Kernel | 31.2 | 34.8 | 13.0 | 1.6 | 17.7 | 1.6 |
| | 50% Kernel | 58.8 | 41.2 | | | | |
| MF2 | MCP | 5.4 | 48.0 | 24.5 | 5.0 | 17.1 | |
| | 95% Kernel | 11.4 | 83.8 | 0.3 | | 4.5 | |
| | 50% Kernel | | 100 | | | | |
| MF3 | MCP | 33.8 | 66.2 | | | | |
| | 95% Kernel | 49.0 | 51.0 | | | | |
| | 50% Kernel | | 100 | | | | |
| MF4 | MCP | | 45.0 | | 45.2 | 9.8 | |
| | 95% Kernel | | 59.6 | | 39.8 | 0.6 | |
| | 50% Kernel | | 98.3 | | 1.7 | | |

twice he was spooked when pileated woodpeckers (*Dryocopus pileatus*) flew directly overhead, although the birds never came close to him. On other occasions, however, he appeared oblivious to the observer's presence, and sometimes made physical contact with the observer before turning and moving away rapidly.

DC1 was observed eating or tracking prey on 4 occasions (Table 2), including a 60–70 cm TL eastern diamondback rattlesnake (*Crotalus adamanteus*). On one other occasion, he appeared to have eaten recently, based on a noticeable bulge in his body. No interactions with other eastern indigo snakes were observed.

*MF1*—This large adult male coachwhip frequented a mostly old pasture and a longleaf pine/xeric oak sandhills community, and was found in 31 different locations. Within a 24-hr period, he moved a mean of 323 m (range 8–1170, N = 31). He used one main area extensively (Fig. 1), but from 1 July to 5 July 1987, he made a single long-distance movement to the north (160–1170 m/day, daily mean 634 m). During this time, he skirted a large wetland complex to the east (Fig. 1). He was last tracked to a gopher tortoise burrow and observed in good condition on 7 July; his ultimate fate is unknown. Only one shedding event took place, and lasted 7 days; no predation attempts were observed.

*MF2*—MF2 primarily used a longleaf pine/xeric oak sandhill south of the Mill Creek wetland complex, making occasional forays into a hammock on the

south side of a large red water lake (Table 3). Although MF2 ranged widely (MCP, Table 1), he concentrated his activity in the direct center of his range (95% and 50% kernels, Table 1). Within a 24-hr period, he moved a mean of 188 m (range 2–983, N = 104). This snake shed 5 times during tracking at roughly monthly intervals; each shedding event lasted 4–11 days (mean 6.2). He was observed to chase a broadhead skink (*Eumeces laticeps*) 3 m up a large live oak tree (*Q. virginiana*) in a mesic hammock, and he later caught and consumed a cotton rat (*Sigmodon hispidus*). MF2's transmitter failed on 5 January. It was removed, and the snake was released, after a short recuperation period, at the point of last capture.

*MF3*—This snake was the only animal tracked exclusively during the winter months, hence her small home range (Table 1, Fig. 1) and the small number of different locations (11) at which she was found. She spent all her time in former pasture and adjacent longleaf pine/xeric oak sandhills, and her range was entirely within the home range of MF1 (Table 3, Fig. 1). Within a 24-hr period, she moved a mean of 20 m (range 2–110, N = 14). MF3 confined her activity mainly to subterranean burrows, and she sometimes was tracked as she moved along pocket gopher (*Geomys pinetis*) burrows, perhaps in response to the observer's approach. She spent considerable time in individual burrow systems (to 28 consecutive days), and reused previous locations throughout the tracking period. Even in winter, however, she was occasionally observed basking adjacent to a burrow. No shedding or feeding events were recorded. The transmitter was removed on 29 March, and the snake was released shortly thereafter.

*MF4*—This female coachwhip was found at 45 different locations, and appeared to roam over a smaller area than the male coachwhips. However, her 95% and 50% kernel estimates were very similar to MF2 (Table 1). She used mostly longleaf pine/xeric oak habitats, occasionally venturing into the fringes of the upland mixed pine/hardwoods that surround many of the larger wetlands on the Ordway preserve (Table 3). Within a 24-hr period, she moved a mean of 176 m (range 5–484, N = 50). She shed twice during the telemetry study (both requiring 7 days of inactivity), and was observed chasing a gopher frog (*Rana capito*) on one occasion. Twice she was observed with large bulges indicating that she had recently fed. Her transmitter failed, terminating further observations, shortly after she shed on 4 July.

*Coachwhip behavior*—All coachwhips were active diurnally, and there was no indication movements took place at night. When approached, coachwhips were generally alert and watching the observer, usually with the anterior one quarter to one third of the body raised vertically off the ground. On the Ordway, the anterior portions of the body of coachwhips are dull uniform black, making them difficult to observe in thick vegetation that burns every 2–4 years; the snakes' heads blended in very well with charred branches, and the

tan to brown bodies are difficult to see under the surface litter. Retreat sites included gopher tortoise and many types of mammal burrows. Snakes were frequently observed entering or watching from Florida mouse burrows (Table 2), including the 'escape' burrow exiting gopher tortoise burrows (see diagrams in Jones and Franz, 1990). On the surface, snakes were usually in shady habitats, rather than in direct sunlight.

Discussion—There are many different factors that may influence the size and shape of snake home ranges, including prey and cover availability, biophysical requirements, the locations and quality of retreat sites, and landscape features. Likewise, activity and movements are influenced by sex, size of snake, the presence of conspecifics, ecdysis, reproduction, and other factors (Gibbons and Semlitsch, 1987; Gregory et al., 1987). Although our small sample size precludes detailed analyses, our observations provide a basis for more detailed studies of these large terrestrial species. At least for the eastern indigo snake, such studies are underway (Stevenson et al., 2003; Breininger et al., 2004; Hyslop et al., 2006).

Four of the five snakes tracked in this study had large home ranges, whereas the fifth snake, tracked only during the cool winter months, stayed within a small area. Restricted home ranges during winter or cool months are not uncommon in terrestrial snakes (Moler, 1985; Hyslop et al., 2006). Likewise, snakes routinely restrict movements during ecdysis (reviewed by Gregory and co-workers, 1987), as they become particularly vulnerable because they cannot see until the old skin sloughs. Sloughing has been reported to occur relatively frequently in *Drymarchon* (Moler, 1992b; Hyslop et al., 2006); Georgia *Drymarchon* appear to be inactive (7–21 days) for similar durations as in Florida (10–14 days, Moler, 1992b; 8–20 days, this study). There are no comparable data for free-ranging *Masticophis flagellum*.

A mean MCP estimate of 185 ha for the male eastern indigo snake is within the range reported in Florida (23–281 ha in the Gulf Hammock region of north Florida, N = 5, Moler, 1985; mean = 118 ha, range 65–300 ha, in eastern Florida, R. Bolt, personal communication) but considerably less than at the northern portion of its range in southeastern Georgia (mean = 510 ha, range 140–1528 ha, N = 31, Hyslop and co-workers, 2006). In confirmation with the observations of others (Ernst and Ernst, 2003; Stevenson et al., 2003), DC1 used a variety of habitats, particularly the upland xeric oak and pine hammocks surrounding wetlands and the margins of wetlands, and retreat sites, especially the burrows of the gopher tortoise. He preyed upon or chased a variety of vertebrates, and he repeatedly visited certain retreats.

We are unaware of any published studies on the movements of *Masticophis flagellum* in eastern North America with which to compare our results. In California, Secor (1995) mapped activity ranges of 6 coachwhips using re-sightings and trackings of marked snakes, and reported that this species used a mean of 53.4 ha during a single field season. The only telemetry study of *Masticophis* involved *M. taeniatus* in Utah. Two females were tracked for 6 and

16 days to oviposition sites, and moved up to 361 m from release point before eliminating the ingested transmitters (Parker and Brown, 1972). In general, coachwhips in north-Florida were extremely active during the warmer months, moved frequently, and used a wide-variety of retreat sites, especially gopher tortoise and small mammal burrows. They are a snake of the dry uplands in north Florida, but will enter hammocks, mesic flatwoods, and even wetland communities for short periods of time, presumably during foraging (Dodd and Franz, 1995; Enge, 1997; Dyer, 2004).

*Protecting habitat for large snakes*—Our results and those of our colleagues (Franz, 1995, 2005; Timmerman, 1995) suggest that large snakes need large amounts of habitat in order to continue as functional components of upland north-central Florida ecosystems. Even more disturbing, perhaps, is the propensity of some snakes to move long straight-line distances (5–8 km in *Drymarchon*, Hyslop et al., 2006; > 1 km within a short period of time in *Masticophis*, this study). Franz (1995) noted that *P. guttatus* and *P. obsoletus* tended not to maintain home ranges, but instead wandered over extensive areas of the Ordway (> 15 km in *P. guttatus* and >17 km in *P. obsoletus*). Movements over large areas of fragmented habitats undoubtedly expose such snakes to increased road mortality and likelihood of adverse human contact (Bonnet et al., 1999; Andrews and Gibbons, 2006). In addition, simulation models suggest that the area/edge relationship influences eastern indigo snake habitat occupancy and mortality (Breininger et al., 2004). In effect, the more edge there is in relation to protected habitat, the less likely large snakes can be maintained within the area.

Eastern indigo snakes were considered a Priority 1 species for monitoring at the large John F. Kennedy Space Center (KSC) in east-central Florida because of their vulnerability to extinction and the potential for their conservation to assist in the maintenance of faunal integrity (Breininger et al., 1998). Based on simulations of this population, Breininger and co-workers (2004: 309) later concluded that "the greatest benefit might be to begin to conserve snake populations in the largest upland systems that connect other large reserves while keeping edge/area ratios low." Based on the results of telemetry studies at KSC, Ordway, Archbold Biological Station (Layne and Steiner, 1996), elsewhere in Florida (Moler, 1985), and at Fort Stewart, Georgia (Hyslop et al., 2006), we suggest that the only way to maintain viable populations of some of the largest snakes in the Southeast will be by protecting large contiguous sections of unfragmented habitat. Whether that will be possible, either as an end to itself or in conjunction with the protection of other wide-ranging species, remains to be determined, in light of Florida's ever decreasing natural areas.

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