The Effectiveness of Wildlife Barriers and Underpasses on U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida

Phase II
Post-Construction

Final Report

July 2002

Prepared by:

William J. Barichivich and
C. Kenneth Dodd, Jr.

Principal Investigator and Contact:

C. Kenneth Dodd, Jr.
Florida Caribbean Science Center
7920 NW 71st Street
Gainesville, FL 32653-3071
ken_dodd@usgs.gov
(352) 378-8181 x339

Florida Department of Transportation Contract No. BB-854

The Effectiveness of Wildlife Barriers and Underpasses on U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida

Post-Construction Survey: Final report

July 2002

EXECUTIVE SUMMARY

- One thousand nine hundred and ninety-two vertebrates were found dead on US Highway 441 on the rims of the prairie and across Paynes Prairie State Preserve from 14 March 2001 through 5 March 2002. Sixty-five percent of the count total was hylid treefrogs, which readily crossed the concrete barrier and associated overhanging lip.

- Excluding birds and hylid treefrogs, 2411 road kills were recorded in the study area eventually bordered by the ecopassage in the 12 months prior to construction, whereas only 157 animals were killed during the post-construction surveys in this same area. Limiting the analysis to the prairie basin within the survey area, mortality was reduced 64.2 % with birds and hylid treefrogs included, 90.1 % with hylid treefrogs excluded, and 93.5 % with both birds and hylid treefrogs excluded.

- Approximately 65% of the non-hylid road kills occurred in the 400 m section of road beyond the extent of the ecopassage (that is, in sections 1, 2 and 31, 32) where there were no barriers to the highway right-of-way.

- Sixty-four percent of the wildlife kills observed along the ecopassage (sections 3-30) occurred in five of the 28 sections, that is, at the cattle gate access (section 7) and along the type-A fence of the southbound lanes bordering private property adjacent to sections 3-6.

- The 24-hour kill rate during the post-construction survey was 4.7 (SD = 16.1; range = 0-160) compared with 14.1 (SD = 10.6; range = 1-48) during the pre-construction survey.

- Fifty-one vertebrate species, including nine fish, were detected using the eight culverts/ underpasses after the construction of the ecopassage. Prior to the construction of the ecopassage, 28 vertebrate species were observed in the four existing culverts. Capture success improved by an order of magnitude, that is, from 0.014 captures/trapnight during the pre-construction survey compared to 0.138 captures/trapnight during the post-construction survey.

- Trespass is facilitated by overhanging vegetation, road access, and the construction of the type-A fence. Additional problems resulted from siltation, waterholes, and human access. These problems can be corrected using design modifications and by routine, periodic maintenance.

INTRODUCTION

Large numbers of animals have been reported killed on the section of U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida, since it was constructed in the early 1920's (Beck, 1938; Carr, 1940, 1974; Hellman and Telford, 1956; Kauffeld, 1957; Franz and Scudder, 1977; Smith, 1996; Smith and Dodd, 1999, ms). High levels of wildlife mortality for nearly 8 decades may have adversely impacted animal populations adjacent to the roadway by serving as a continuous drain on animal numbers. In addition, the many animals attempting to cross the road (particularly alligators, large turtles, and medium-sized mammals) created human safety concerns as motorists collided with crossing animals or attempted to avoid them. Animal carcasses detracted from the beauty of the prairie and sometimes caused the road surface to become slick, creating an additional motorist safety hazard.

In 1996, the Florida Department of Transportation proposed constructing a wildlife barrier/ underpass system (termed an ecopassage) to ameliorate the effects of the road on wildlife populations. The ecopassage system consists of a concrete wall located parallel to, and ca. 9.1 m from, the roadway. The wall is 1.1 m high with a 15.2 cm overhanging lip, and interconnects with 8 culverts (2 2.4 x 2.4 partially submerged box culverts; 2 1.8 x 1.8 usually dry box culverts; 4 round culverts 0.9 m in diameter) which allow passage of water and wildlife underneath US Highway 441. Funds for the project were secured in 1998. Photographs and details of the design are found at: http://www.fcsc.usgs.gov/Amphibians_and_Reptiles/Paynes_Prairie_Project/paynes_prairie_project.html.

In mid-1998, the U.S. Geological Survey was contracted to conduct a study to assess the effectiveness of the ecopassage. The first phase of the project (18 August 1998 to 13 August 1999) determined the level of pre-construction wildlife mortality, and how many and what types of animals used the existing four box culverts. The results of that study confirmed significant mortality on the road and adjacent right-of-way (Smith and Dodd, 1999, ms), although some animals were shown to use the existing culverts to successfully traverse the highway. Construction of the new ecopassage system was completed in February 2001. The post-construction phase of the USGS study began on 14 March 2001 and continued until 5 March 2002. Herein, we provide the results of Phase II of the project. The study was designed to assess the efficacy of the ecopassage by measuring post-construction levels of wildlife mortality and extent of culvert use. Based on our findings, we provide suggestions concerning modifications in the construction design and the need for regular maintenance of the ecopassage.

METHODS

General survey methods were similar to those employed during the pre-construction phase of data collection (see Smith and Dodd, ms, as appended to this report). The road was divided into 32 100-m sections for a total one-way length of 3.2 km. Section 1 was located on the north rim of the prairie at the first private driveway, and Section 32 was located on the south rim at the first private drive (Fig. 1). There were no barriers to wildlife entry onto the highway right-of-way in Sections 1, 2, 31, and 32; a type-A fence bordered the highway adjacent to private property along the southbound lanes of Sections 3 to 6. The remainder of the highway was bordered by the ecopassage.

Surveys consisted of observers walking the 3.2 km (2 mile) length of the road one time in each direction on each sampling occasion. Both the north and southbound lanes of the entire road surface, extending 3 to 4 m onto the grassy shoulders, and the entire median between the north and southbound lanes, were surveyed.

A sampling period consisted of 3 consecutive 24-hr sampling units, with one sampling period scheduled each week. The actual start day was chosen randomly using Julian calendar days. On day 1 (first sampling unit), researchers marked all dead animals found throughout the study site. On days 2 and 3 (sampling units 2 and 3), all road kills that had accumulated in the previous 24-hours were recorded. Thus, the sampling protocol called for 104 sampling units per year (2, 24-hr sampling units x 52 weeks). The survey schedule for the post-construction phase of the project is presented in Table 1.

Road kill surveys began at first light and all live and dead animals were recorded. Dead animals were marked with Day-Glo orange spray paint so that they were not counted more than once. The paint was free of lead and toluene (Forestry Suppliers, Jackson, MS). Locations of all animals were recorded, that is, whether the animal was in the north or southbound lane, the right-of-way, the median, and in which 100-m section it was found. Freshly killed, undamaged specimens were collected (GFC Permit #WS98348 and #WS01511), preserved, and deposited in the Florida Museum of Natural History at the University of Florida. Beginning 5 September 2001, our sampling protocol was adjusted so that treefrogs (Family Hylidae) were counted only in the southbound lanes of three randomly selected sections (3, 14, and 23). We made this change because of the large volume of morning commuter traffic in addition to associated safety

concerns. The large volume of traffic quickly obliterated hylid carcasses, and we decided it was better to rigorously sample three highway sections rather than to underestimate hylid mortality over the entire study length. In the results that follow, hylid totals are thus for the entire 3.2 km survey area from 14 March to 4 September 2001, but only for the 3 100-meter sections from 5 September to the end of the survey.

The eight culverts that underlie Highway 441 also were monitored for wildlife use. Culverts were numbered one to eight from north to south (Fig. 2). Wire screen-mesh funnel traps were installed in the four box culverts to sample amphibians, reptiles, and small mammals. In both 1.8 m x 1.8 m box culverts (1 & 8), ten additional square hardware-cloth funnel traps were placed flush with the sides of the culverts (Fig. 3). Ten floating screen funnel traps were installed in the remaining two 2.4 m x 2.4 m box culverts (2 & 7) in the center of the prairie. The latter two culverts were inundated throughout the study and the traps were monitored until the culverts became unsuitable for sampling because of high water levels or the presence of alligators. Each of the four newly-installed 0.9 m diameter culverts (3, 4, 5, & 6) were sampled using two commercial crayfish traps (Lee Fisher, Inc., Tampa, FL) placed in each centrally-located light box, for a total of four traps per culvert.

The trapping schedule coincided with the road surveys, although it was adjusted to include two additional sampling units in order to ensure comprehensive sampling; thus, all culverts were sampled five nights per week. All animals captured, excluding venomous snakes and rodents, were marked, measured, weighed and released. The age and sex of animals was determined whenever possible.

A sand track station (1.8 m long by 1.0 m wide) was maintained in the center of the northern, dry culvert (number 1) (Fig. 3). TrailMaster TM1500 Active Infrared monitors and cameras (Goodson and Associates, Inc., Lenexa, KS) were installed at the center of the north and south culverts (1 & 8) to record the use of these culverts by larger vertebrates (Fig. 3). To be recorded, an animal had to pass through the infrared light beam; thus, animals less than ca. 30 cm (12 in) were not recorded. The track station and cameras were monitored five days per week, weather and water conditions permitting.

Environmental data were recorded on the south rim of the prairie. Air temperature, rainfall, relative humidity, and barometric pressure were measured with automated data loggers (Onset Computer Corporation, Bourne, MA).

RESULTS

Live Animals on Roadway

Only 13 vertebrates (exclusive of birds) were observed on the highway during the year-long post-construction survey: 7 frogs (2 *Gastrophryne carolinensis*, *Hyla* sp., 2 *Hyla cinerea*, *H. squirella*, *Rana sphenocephala*); 1 turtle (*Kinosternon bauri*); 3 lizards (*Anolis sagrei, Eumeces laticeps, Ophisaurus ventralis*); 1 snake (*Nerodia fasciata*); 1 mammal (*Canis latrans*).

Road mortality

A total of 1992 dead vertebrates (1647 frogs; 1 alligator; 7 turtles; 4 lizards; 149 snakes; 101 birds; 83 mammals) were counted during the post-construction phase of the study (Table 2). This total includes all of the dead animals observed during 152 road kill surveys over the entire

3.2 km study area, including the 400 m sections (1, 2 & 31, 32) beyond the extent of the concrete barrier wall. Most post-construction mortality was recorded in August and September (729 & 727, respectively, or 132 & 224 if hylid treefrogs are excluded; Fig. 4). Approximately 65% of road kills, excluding hylid treefrogs, occurred in the 400 m surveyed beyond the extent of the ecopassage where no barrier of any type exists (sections 1, 2 and 31, 32; Table 3, Fig. 6). A total of only 240 dead animals were counted within the prairie basin. Approximately one third of the wildlife mortality observed on the prairie basin resulted from bird kills (n = 82; Table 2). Most (64%) of the remaining carcasses counted on the roadway were found in sections adjacent to the type-A fence (n = 62; section 3-6) and in front of the cattle gate (n = 39; section 7).

Mortality increased on the north rim of the prairie outside the area bordered by the barrier wall during the post-construction phase of the survey (Table 3). Most non-hylid mortality resulted from deaths of Eastern Narrow-mouthed Toads (*Gastrophryne carolinensis*) during September 2001 (203 of 308 [66%] recorded kills). Mortality on the south rim of the prairie outside the area bordered by the barrier wall decreased during the post-construction phase of the survey. Unlike the north rim, mortality on the south rim resulted mostly from kills of Southern Toads (*Bufo terrestris*) and was more evenly spaced throughout the year. Increased levels of mortality during the post-construction survey may be related to the falling water levels on the prairie, thus causing amphibians to move to more terrestrial habitats.

Hylid treefrogs (n = 1301) accounted for 65.3% of road kills counted throughout Phase II of the study. However, this total drops to only 194 if counts are limited to Sections 3, 14, and 23 (see Methods). For comparison, 149 hylids were counted in these three highway sections during the

pre-construction phase of the study. Most treefrogs could not be identified to species because of the extent of body damage, although Green Treefrogs (*Hyla cinerea*, n = 135) accounted for at least 10.4 % of the hylids. The second most abundant species found dead on the highway was the Eastern Narrow-mouthed Toad (10.9 %; n = 218). The results are somewhat misleading, however, in that 162 Eastern Narrow-mouthed Toads (*Gastrophyrne carolinensis*) were counted on a single day (6 September 2001) in the northbound lane in section 1 (on the prairie rim) where there are no barriers to entry onto the roadway.

DeKay's Brownsnakes (*Storeria dekayi*; n = 54) and Southern Watersnakes (*Nerodia fasciata*; n = 21) were the most commonly killed snakes (Table 2). Most DeKay's Brownsnakes also were killed on the north and south prairie rims (n = 28). However, this small, semi-fossorial species also may have colonized the road right-of-way, based on the number killed (n = 26) rather evenly distributed across the prairie basin. Most Southern Watersnakes were killed within the prairie basin (81%), but the relatively large percentages killed in front of the cattle gate (33%; section 7) and type-A fence (19%; sections 3 – 6) suggest a bias resulting from opportunistic trespass rather than a failure of the wildlife barrier per se.

Because of the ability of hylids to trespass the barrier system (that is, they easily climb the barrier wall and associated vegetation to access the roadway), they have been excluded from further analyses of road mortality. Without hylids, the mean number of vertebrate kills per 24-hour sampling period was 4.7 (SD = 16.1; range = 0 - 162). Monthly means ranged from 0.75 to 24.6 vertebrates killed per 24-hr period, and were highest in August and September (Fig. 5). Most carcasses were located in the outside lanes (46.5%) and bicycle lanes (28.5%), followed by

the inside lane (11.1%) and grassy right-of-way (9.9%, Table 4). Very few animals were found in the median (3.6%) and centerline (0.4%) (Table 4).

Wildlife mortality in the northbound lanes was 1.75 x that of southbound lanes (Table 4). This finding could result from the large volume of traffic moving toward Gainesville during the very early morning hours, when nocturnal and crepuscular animals were still active. In the late afternoon, when motorists working in Gainesville return to their homes south of the Prairie, fewer animals were likely to be active during the heat of the day and thus encountered on the highway. Alternatively, some animals may have been moving in a particular direction at a certain time of the year, such as when juvenile frogs disperse after metamorphosis. For example, large numbers of juvenile Southern Leopard Frogs (*Rana sphenocephala*) were captured in culvert funnel traps in July 2002, presumably as the dispersed away from drying wetlands. We are currently examining data on individual species to see if other such patterns exist.

Culvert use

Fifty-one vertebrate species were documented using the culverts during post-construction monitoring (Table 5). We recorded 1046 captures during 7580 trap-nights (13.8 % capture success) in funnel traps. Most captures occurred from mid-June to early July, when large numbers of juvenile Southern Leopard Frogs (*Rana sphenocephala*; 40.5%) passed through culvert 8. Captures of Rice and Hispid Cotton Rats (*Oryzomys palustris* and *Sigmodon hispidus*, respectively) were most numerous in the dry culverts (especially culvert 1) during the summer (Table 6). Tracks of Nine-banded Armadillo (*Dasypus novemcinctus*), River Otter (*Lutra canadensis*), Virginia Opossum (*Didelphis virginianus*), and Raccoon (*Procyon lotor*) often were observed in the dry north culvert (1). These four species were repeatedly photographed with the motion sensor cameras. Two species previously undocumented from the culverts, the Marsh

Rabbit (*Sylvilagus palustris*) and American Alligator (*Alligator mississippiensis*), also were photographed in culvert 1. Photographs of vertebrates passing through culverts 1 and 8 are presented in Appendix A.

New (0.9 m diameter) culvert use

Culverts 3 to 6 were installed during the construction of the ecopassage. Culvert 4 was usually wet, whereas the other round culverts (3, 5, 6) were dry or wet depending on prairie water levels. These smaller culverts often contained considerable amounts of water, and appeared to be used readily by fishes and small mammals. Amphibians and reptiles were captured or observed less often (Table 6), although a few individuals apparently traversed the culverts for considerable distances. Because of the small diameter of these culverts and their often wet environs, we were unable to use motion cameras or track stations to monitor culvert use. Other vertebrate species may have used the culverts and not been captured in the specialized traps.

DISCUSSION

Overall, we recorded a 41 % reduction in traffic-related wildlife mortality between pre- and post-construction survey periods. This figure includes all vertebrate taxa and a considerable (12.5%) area outside the explicit area covered by the ecopassage on the north and south rims of the prairie basin. Excluding climbing and flying species such as treefrogs and birds, and limiting the area to the prairie basin directly adjacent to the concrete barrier wall, the effect of the ecopassage was much more pronounced. In the 12 months prior to ecopassage construction, 2411 road kills were recorded in the study area, whereas only 157 animals were killed during the post-construction surveys. Thus, limiting the analysis to the survey area within the prairie basin, mortality was reduced 64.2 % with birds and hylids included, 90.1 % with hylids excluded, and 93.5 % with both birds and hylids excluded.

Road-related mortality was greatest during the late summer months in both surveys, and this pattern is consistent with the results from the most systematic previous survey (Franz and Scudder, 1977). Snake, turtle, ranid frog, and alligator mortality declined dramatically with the construction of the ecopassage, yet treefrog mortality appears to have increased. The apparent increase in mortality likely resulted from differences in sampling protocols between the pre- and post-construction surveys, although the counts were not greatly different when data from only the three continuously sampled road sections were examined. The apparent increase also might result from differences in water levels between pre and post construction surveys. During the period of high water in the prairie basin during part of the pre-construction survey, hylids may have been less likely to migrate than they did when water receded during the drought associated with much of the post-construction survey. However, the large number of hylids killed on the road indicates that some animals likely will be killed on US 441, regardless of the barrier design. At this time, we can think of no effective way to reduce hylid or avian mortality.

In addition to a decrease in road-related mortality of most vertebrates, we observed an increase in culvert use by many species. Capture success rose from 0.014 captures per trap night during pre-construction sampling to 0.138 captures per trap night during post-construction sampling. The increase was most pronounced in the number of individual amphibians using the culvert, where capture success increased from 0.006 to 0.085 captures/trapnight. Additionally, the number of species using the culverts increased from 28 to 42 (excluding fish in the wet culverts), and was most apparent in the number of amphibian species using the culverts (from 5 to 13 species).

A pronounced reduction in the number of animals killed on US Highway 441 and an increase in culvert use by many species might be considered the best indication of a successful ecopassage design. The huge decline in the number of ranid frogs killed on the highway, combined with an increase in the use of culverts by these species, provides the best example of the effectiveness of the wall-culvert system to prevent mortality while allowing passage under the highway.

The combined wall and culvert system on US 441 reduced wildlife mortality of most taxa, especially the larger non-flying species, yet permitted movement from one side of the highway to the other for many taxa. The number of individuals killed on US 441 decreased with little to no change in observed culvert activity, however. We suggest that even if pre- and post construction culvert use remained similar for most taxa (e.g., most animals rarely moved across the highway through the culverts), movements through culverts by at least a few individuals should be sufficient to maintain genetic exchange between the north and south sides of the highway, while at the same time significantly decreasing highway-related deaths for the vast majority of populations adjacent to the road.

RECOMMENDATIONS

Wildlife mortality decreased substantially on US Highway 441 across Paynes Prairie State Preserve after construction of the Paynes Prairie ecopassage, although trespass has not been prevented completely. However, the wall-culvert design was effective in reducing and, in some cases, nearly eliminating highway-related mortality and yet allowed for the passage of some individuals under this very busy highway. There may be no way of completely eliminating

highway-related mortality of some species, especially species capable of jumping over (e.g., deer), climbing up (hylid treefrogs), or flying over (e.g., birds) the concrete barrier wall.

During the course of spending long hours observing wildlife behavior, and after examining patterns of mortality on US Highway 441 across Paynes Prairie, certain problems have been identified (Appendix B). In order to ameliorate them on the Prairie, and in order to prevent similar problems should the Paynes Prairie ecopassage model become the FDOT prototype to reduce mortality on other busy highway stretches across wetlands, we make the following suggestions:

1. **Vegetation**. USGS personnel observed small mammals, snakes, and treefrogs climbing the vegetation immediately adjacent to the barrier wall. Thus, the vegetation formed an avenue of access to the roadway's right-of-way. Undoubtedly, some of the animals killed on the roadway crossed the barrier wall and its associated overhang in this manner. Vegetation hanging over the wall from the right-of-way and growing up along the wall from the canal bank must be removed at prescribed intervals, especially during the growing season, to minimize such trespass.
2. **Road Access**. USGS personnel documented a significant peak in the numbers of animals killed on the roadway where the right-of-way is accessed near the cattle gate along the southbound lanes at the northern side of the prairie (section 7). Although some attempt has been made to reduce access to the right-of-way by prairie animals, further efforts are required.

3. **Type A Fence**. Despite attempts to bury the type-A fence into the ground along the north prairie rim, significant trespass still occurs in this area. Some of the trespass undoubtedly results from animals going under the fence inasmuch as the underside of the fence is easily exposed due to sheet erosion. Burying galvanized metal or aluminum flashing to a depth of 20 cm (8 in) could significantly decrease access to the roadway by small species of snakes and turtles. Clearly, this problem needs careful attention.
4. **Human Access**. Although not perceived as a problem during ecopassage construction, post construction surveys revealed a great amount of public interest in the wall. In particular, people began pulling off Highway 441, parking, and walking along the wall looking for animals, particularly alligators. Although illegal, many people began feeding alligators, resulting in a decrease in fear of these large reptiles toward humans, an association of humans with food presentation, and possibly an increase in aggressiveness among resident alligators. Public access created problems for both highway and wildlife safety. The FDOT has erected a setback fence away from the wall, and local law enforcement officers have vigorously cracked down on people who park on the right-of-way. These combined efforts appear to have eliminated the problem. In any case, regulating public access must be considered during the planning stage when designing future ecopassage projects around the state.
5. **Siltation**. Some culverts receive significant amounts of water sheet flow during heavy rainfall and during periods of high water. As a result, silt and mud accumulates on the floor of the culverts. Unless periodically removed, this mud will eventually diminish the area available for wildlife passage, and may even clog the culvert completely. Periodic

removal of silt and mud will be necessary in some of the culverts under US Highway 441.

6. **Waterholes**. Significant waterholes were excavated at the entrance of most of the culverts. Invariably, an alligator took up residence in the pools, and may even have reworked the pools to some extent to fit their requirements. A large pool at the entrance to a culvert, particularly if occupied by an alligator, could discourage movement through the culvert. Animals exiting in such a pool also could be subject to an increased chance of predation. As such, waterholes should be filled in if possible, and landscaped in such a manner as to discourage formation.

FURTHER ANALYSES

1. We plan to analyze the data on water levels and the other environmental variables to determine if they influenced counts of animals killed on the highway.
2. We will assess capture data, by species, within culverts to determine if captures were evenly distributed, and to determine how many individuals of each species used culverts.
3. We will assess directional data to determine migratory patterns, if any.
4. We will compare monthly counts, by species, of the pre- and post-construction surveys

Table 1. Sampling schedule during the post-construction survey. Surveys consisted of researchers marking all dead animals found on day 1, and recording all roadkills observed during the previous 24 hours on days 2 and 3.

Week	Dates	Week	Dates
1	March 14-16, 2001	27	September 13-15, 2001
2	March 19-21, 2001	28	September 19-21, 2001
3	March 27-29, 2001	29	September 25-27, 2001
4	April 3-5, 2001	30	October 2-4, 2001
5	April 11-13, 2001	31	October 9-11, 2001
6	April 17-19, 2001	32	October 16-18, 2001
7	April 23-25, 2001	33	October 22-24, 2001
8	May 1-3, 2001	34	October 28-30, 2001
9	May 9-11, 2001	35	November 6-8, 2001
10	May 15-17, 2001	36	November 11-13, 2001
11	May 21-23, 2001	37	November 19-21, 2001
12	May 30 - June 1, 2001	38	November 28-30, 2001
13	June 6-8, 2001	39	December 6-8, 2001
14	June 12-14, 2001	40	December 11-13, 2001
15	June 17-19, 2001	41	December 21-23, 2001
16	June 27-29, 2001	42	December 27-29, 2001
17	July 5-7, 2001	43	December 30-31, 2001
18	July 8-10, 2001	44	January 10-12, 2002
19	July 19-21, 2001	45	January 16-18, 2002
20	July 22-23, 2001	46	January 23-25, 2002
21	August 2-4, 2001	47	January 31-February 2, 2002
22	August 9-11, 2001	48	February 7-9, 2002
23	August 12-13, 2001	49	February 10-11, 2002
24	August 20-22, 2001	50	February 19-21, 2002
25	August 29-31, 2001	51	February 21-26, 2002
26	September 4-6, 2001	52	March 3-5, 2002

Table 2. Vertebrate roadkills on U.S. 441 at Paynes Prairie State Preserve from 14 March 2001 through 5 March 2002. Nomenclature of amphibians and reptiles follows Crother et al. (2000).

Scientific Name	Common Name	Count for all sections	Count for sections 3 to 30
Frogs			
Bufo terrestris	Southern Toad	78	7
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad	218	4
Hyla cinerea	Green Treefrog	135	101
Hyla sp.	Unidentified Treefrog	1153	763
Hyla squirella	Squirrel Treefrog	13	7
Rana sp.	Unidentified Ranid	12	5
Rana sphenocephala	Southern Leopard Frog	12	6
Scaphiopus holbrookii	Eastern Spadefoot	7	-
Unidentified frog		19	6
		1647	**899**
Crocodilians			
Alligator mississippiensis	American Alligator	1	-
		1	**0**
Turtles			
Chelydra serpentina	Snapping Turtle	2	2
Kinosternon bauri	Striped Mud Turtle	2	-
Kinosternon sp.	Unidentified Mud Turtle	1	-
Pseudemys nelsoni	Florida Red-bellied Turtle	2	1
		7	**3**
Lizards			
Anolis sp.	Unidentified Anole	1	1
Ophisaurus sp.	Unidentified Glass Lizard	2	2
Ophisaurus ventralis	Eastern Glass Lizard	1	1
		4	**4**
Snakes			
Agkistrodon piscivorus	Cottonmouth	1	-
Coluber constrictor	Eastern Racer	4	4
Diadophis punctatus	Ring-necked Snake	2	1
Elaphe guttata	Cornsnake	2	2
Elaphe obsoleta	Yellow Ratsnake	16	5
Farancia abacura	Red-bellied Mudsnake	8	7
Lampropeltis triangulum	Milksnake	1	-
Nerodia fasciata	Southern Watersnake	21	18
Nerodia floridana	Florida Green Watersnake	3	2

Scientific Name	Common Name	Count for all sections	Count for sections 3 to 30
Opheodrys aestivus	Rough Greensnake	1	-
Seminatrix pygaea	Black Swampsnake	12	10
Storeria dekayi	DeKay's Brownsnake	54	26
Thamnophis sauritus	Eastern Ribbonsnake	3	2
Thamnophis sirtalis	Common Gartersnake	12	7
Unidentified snake		9	5
		149	**89**
Birds			
Bubo virginianus	Great Horned Owl	1	1
Cardinalis cardinalis	Northern Cardinal	4	-
Ceryle alcyon	Belted Kingfisher	1	1
Charadrius vociferus	Killdeer	3	2
Cistothorus palustris	Marsh Wren	2	2
Coccyzus americanus	Yellow-billed Cuckoo	2	2
Dendroica coronata	Yellow-rumped Warbler	5	3
Dendroica palmarum	Palm Warbler	4	3
Dumetella carolinensis	Gray Catbird	1	1
Falco sparverius	American Kestrel	1	-
Gallinago gallinago	Common Snipe	2	2
Gallinula chloropus	Common Moorhen	5	5
Geothlypis trichas	Common Yellowthroat	2	2
Ixobrychus exilis	Least Bittern	7	7
Melospiza georgiana	Swamp Sparrow	3	2
Mimus polyglottos	Northern Mockingbird	4	3
Otus asio	Eastern Screech-owl	1	1
Passerculus sandwichensis	Savannah Sparrow	5	4
Passerina cyanea	Indigo Bunting	1	1
Quiscalus major	Boat-tailed Grackle	5	4
Quiscalus quiscula	Common Grackle	1	1
Sayornis phoebe	Eastern Phoebe	1	1
Tachycineta bicolor	Tree Swallow	1	1
Thryothorus ludovicianus	Carolina Wren	1	1
Toxostoma rufum	Brown Thrasher	2	2
Tyto alba	Barn Owl	2	2
Zenaida macroura	Mourning Dove	1	1
Unidentified bird		33	27
		101	**82**
Mammals			
Blarina carolinensis	Southeastern Short-tailed Shrew	1	-
Canis familiaris	Domestic Dog	1	1
Canis latrans	Coyote	2	-
Dasypus novemcinctus	Nine-banded Armadillo	10	2

Scientific Name	Common Name	Count for all sections	Count for sections 3 to 30
Didelphis virginianus	Virginia Opossum	15	1
Lutra canadensis	River Otter	1	1
Odocoileus virginianus	White-tailed Deer	3	1
Oryzomys palustris	Rice Rat	25	17
Peromyscus gossypinus	Cotton Mouse	2	1
Procyon lotor	Raccoon	5	-
Sigmodon hispidus	Hispid Cotton Rat	2	1
Sylvilagus palustris	Marsh Rabbit	2	1
Sylvilagus sp.	Unidentified rabbit	1	1
Urocyon cinereoargenteus	Gray Fox	1	1
Unidentified bat		5	2
Unidentified mammal		7	3
		83	**33**
Total		**1992**	**1110**

Table 3. Pre- and post- construction highway-related mortality on US Highway 441 in sections bordered and not bordered by the concrete barrier wall. Sections 1, 2, 31, and 32 had no barriers to highway access by wildlife; sections 3 to 30 were bordered by the concrete barrier wall. * is the total without birds.

Sections	Pre-construction mortality	Pre-construction mortality w/o hylids	Post Construction mortality	Post Construction mortality w/o hylids
1 and 2	163	102	601	308
3 to 30	3100	2648	1111	240
		2411*		157*
31 and 32	102	74	280	143
Total	3365	2824	1992	691

Table 4. Location of wildlife kills (excluding hylid treefrogs) on the road surface, right-of-way, and median of U.S. 441 at Paynes Prairie State Preserve, Alachua County, Florida. Surveys were conducted from 15 March 2001 through 5 March 2002. The data presented represents the two 24-hour sampling units (2 & 3) collected weekly throughout the study.

	Location	**Northbound**	**Southbound**	**Median**	**Total**
Amphibians	Right-of-way		1		1
	Bike lane	89	15		104
	Outer lane	136	38		174
	Centerline				0
	Inner lane	5	8		13
	Median			2	2
	Total	230	62	2	294
	Location	**Northbound**	**Southbound**	**Median**	**Total**
Reptiles	Right-of-way	12	20		32
	Bike lane	17	20		37
	Outer lane	22	44		66
	Centerline				0
	Inner lane	10	12		22
	Median			3	3
	Total	61	96	3	160
	Location	**Northbound**	**Southbound**	**Median**	**Total**
Birds	Right-of-way	8	7		15
	Bike lane	7	5		12
	Outer lane	1	3		4
	Centerline		1		1
	Inner lane	5	6		11
	Median			10	10
	Total	21	22	10	53
	Location	**Northbound**	**Southbound**	**Median**	**Total**
Mammals	Right-of-way	4	2		6
	Bike lane	3			3
	Outer lane	7	4		11
	Centerline	1			1
	Inner lane	7	8		15
	Median			5	5
	Total	22	14	5	41
	Lane total	334	194	20	548

Table 5. Vertebrates observed in culverts under U.S. Highway 441 across Paynes Prairie, Alachua County, Florida, 14 March though 5 March 2002.

Scientific Name	Common Name
Fish (n = 9)	
Ameiurus nebulosus	Brown bullhead
Elassoma sp.	Pygmy sunfish
Etheostoma fusiforme	Swamp darter
Fundulus chrysotus	Golden topminnnow
Gambusia holbrooki	Mosquitofish
Heterandria formosa	Least killifish
Lepisosteus platyrhincus	Florida gar
Lepomis gulosus	Warmouth
Lepomis macrochirus	Bluegill
Salamanders (n = 2)	
Amphiuma means	Two-toed Amphiuma
Siren lacertina	Greater Siren
Frogs (n = 11)	
Acris gryllus	Southern Cricket Frog
Bufo terrestris	Southern Toad
Gastrophryne carolinensis	Narrow-mouthed Toad
Hyla cinerea	Green Treefrog
Hyla femoralis	Pine Woods Treefrog
Hyla squirella	Squirrel Treefrog
Rana catesbeiana	American Bullfrog
Rana clamitans	Green Frog
Rana grylio	Pig frog
Rana sphenocephala	Southern Leopard Frog
Scaphiopus holbrooki	Eastern Spadefoot
Crocodilians (n = 1)	
Alligator mississippiensis	American alligator
Turtles (n = 4)	
Apalone ferox	Florida Softshell
Kinosternon baurii	Striped Mud Turtle
Pseudemys nelsoni	Florida Red-bellied Turtle
Sternotherus odoratus	Stinkpot
Lizards (n = 1)	
Anolis carolinensis	Green Anole

Scientific Name	Common Name
Snakes (n = 11)	
Agkistrodon piscivorus	Cottonmouth
Coluber constrictor	Eastern Racer
Diadophis punctatus	Ring-necked Snake
Elaphe guttata	Cornsnake
Elaphe obsoleta	Yellow Ratsnake
Farancia abacura	Eastern Mudsnake
Nerodia fasciata	Southern Watersnake
Nerodia floridana	Florida Green Watersnake
Storeria dekayi	Dekay's Brownsnake
Thamnophis sauritus	Eastern Ribbonsnake
Thamnophis sirtalis	Common Gartersnake
Mammals (n = 12)	
Blarina carolinensis	Southeastern Short-tailed Shrew
Dasypus novemcinctus	Nine-banded Armadillo
Didelphis virginianus	Virginia Opossum
Lynx rufus	Bobcat
Lutra canadensis	River Otter
Myotis austroriparius	Southeastern Bat
Neofiber alleni	Round-tailed Muskrat
Oryzomys palustris	Rice Rat
Peromyscus gossypinus	Cotton Mouse
Procyon lotor	Raccoon
Sigmodon hispidus	Hispid Cotton Rat
Sylvilagus palustris	Marsh Rabbit

Table 6. Vertebrates documented using culverts under U.S. Highway 441 at Paynes Prairie State Preserve from 14 March 2001 through 5 March 2002. Rice rats (*Oryzomys palustris*) and Hispid cotton rats (*Sigmodon hispidus*) were combined because of the uncertain identification involved in some observations. Culverts 1, 2, 7, and 8 were present prior to the ecopassage construction; culverts 3-6 were added during construction. If a number is provided, the number of animals was counted based on trap captures. Because the number of different animals passing through a culvert based on photo or track identifications cannot usually be determined, only the method of observation is noted; in most cases (*), many photos were taken of such animals throughout the study.

Scientific Name	Common Name	Number or Method of Observation
Culvert 1 (1.8 m x 1.8 m)		
Agkistrodon piscivorus	Cottonmouth	4
Alligator mississippiensis	American Alligator	photo*
Anolis carolinensis	Green Anole	incidental sighting
Blarina carolinensis	Southeastern Short-tailed Shrew	6
Bufo terrestris	Southern Toad	9
Coluber consrictor	Eastern Racer	1
Dasypus novemcinctus	Nine-banded Armadillo	photo; tracks*
Didelphis virginianus	Virginia Opossum	photo*
Elaphe guttata	Cornsnake	1
Lynx rufus	Bobcat	photo
Gastrophryne carolinensis	Narrow-mouthed Toad	3
Hyla cinerea	Green Treefrog	4
Lutra canadensis	River Otter	photo; tracks*
Neofiber alleni	Round-tailed Muskrat	1
Nerodia fasciata	Southern Watersnake	4; incidental sighting
Nerodia floridana	Florida Green Watersnake	2
Oryzomys palustris/ *Sigmodon hispidus*	Rice rat/ Hispid Cotton Rat	173; photo*
Peromyscus gossypinus	Cotton Mouse	2
Procyon lotor	Raccoon	photo; tracks*
Rana sphenocephala	Southern Leopard Frog	14
Storeria dekayi	DeKay's Brownsnake	1
Sylvilagus palustris	Marsh Rabbit	photo; tracks*
Thamnophis sauritus	Eastern Ribbonsnake	4
Thamnophis sirtalis	Common Gartersnake	1
Culvert 2 (2.4 m x 2.4 m)		
Ameiurus nebulosus	Brown Bullhead	1
Alligator mississippiensis	American Alligator	incidental sighting
Elassoma sp.	Pygmy Sunfish	5
Gambusia holbrooki	Mosquitofish	12

Scientific Name	Common Name	Number or Method of Observation
Heterandria formosa	Least Killifish	1
Lepisosteus platyrhincus	Florida Gar	3
Pseudemys nelsoni	Florida Red-bellied Turtle	1
Rana sphenocephala	Southern Leopard Frog	12
Culvert 3 (0.9 m diameter)		
Agkistrodon piscivorus	Cottonmouth	incidental sighting
Apalone ferox	Florida Softshell	incidental sighting
Hyla cinerea	Green Treefrog	incidental sighting
Lepisosteus platyrhincus	Florida Gar	4
Nerodia fasciata	Southen Watersnake	1
Oryzomys palustris/ Sigmodon hispidus	Rice rat/ Hispid Cotton Rat	29
Peromyscus gossypinus	Cotton Mouse	3
Rana sphenocephala	Southern Leopard Frog	incidental sighting
Storeria dekayi	DeKay's Brownsnake	incidental sighting
Culvert 4 (0.9 m diameter)		
Alligator mississippiensis	American Alligator	6; incidental sighting
Ameiurus nebulosus	Brown Bullhead	1
Amphiuma means	Two-toed Amphiuma	1
Apalone ferox	Florida Softshell	3
Diadophis punctatus	Ring-necked Snake	incidental sighting
Hyla cinerea	Green Treefrog	incidental sighting
Hyla squirella	Squirrel Treefrog	incidental sighting
Lepisosteus platyrhincus	Florida Gar	1
Lepomis gulosus	Warmouth	16
Lepomis macrochirus	Bluegill	2
Nerodia fasciata	Southern Watersnake	incidental sighting
Rana grylio	Pig Frog	incidental sighting
Sternotherus odoratus	Stinkpot	1
Siren lacertina	Greater Siren	2
Culvert 5 (0.9 m diameter)		
Agkistrodon piscivorus	Cottonmouth	incidental sighting
Hyla cinerea	Green Treefrog	incidental sighting
Hyla squirella	Squirrel Treefrog	incidental sighting
Lepisosteus platyrhincus	Florida Gar	2
Nerodia fasciata	Southern Watersnake	incidental sighting
Oryzomys palustris/ Sigmodon hispidus	Rice rat/ Hispid Cotton Rat	19
Peromyscus gossypinus	Cotton Mouse	2
Rana sphenocephala	Southern Leopard Frog	incidental sighting

Scientific Name	Common Name	Number or Method of Observation
Siren lacertina	Greater Siren	1
Culvert 6 (0.9 m diameter)		
Amphiuma means	Two-toed Amphiuma	2
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad	incidental sighting
Hyla cinerea	Green Treefrog	incidental sighting
Lepisosteus platyrhincus	Florida Gar	1
Lepomis gulosus	Warmouth	1
Lutra canadensis	River Otter	incidental sighting
Neofiber alleni	Round-tailed Muskrat	1
Nerodia fasciata	Southern Watersnake	incidental sighting
Oryzomys palustris/ Sigmodon hispidus	Rice rat/ Hispid Cotton Rat	20
Rana catesbeiana	American Bullfrog	1
Rana grylio	Pig Frog	1
Culvert 7 (2.4 m x 2.4 m)		
Agkistrodon piscivorus	Cottonmouth	incidental sighting
Alligator mississippiensis	American Alligator	incidental sighting
Elassoma sp.	Pygmy Sunfish	21
Etheostoma fusiforme	Swamp Darter	1
Fundulus chrysotus	Golden Topminnnow	1
Gambusia holbrooki	Mosquitofish	88
Heterandria formosa	Least Killifish	19
Hyla cinerea	Green Treefrog	incidental sighting
Nerodia fasciata	Southern Watersnake	incidental sighting
Rana sphenocephala	Southern Leopard Frog	85
Culvert 8 (1.8 m x 1.8 m)		
Acris gryllus	Southern Cricket Frog	incidental sighting
Agkistrodon piscivorus	Cottonmouth	3
Alligator mississippiensis	American Alligator	incidental sighting
Blarina carolinensis	Southeastern Short-Tailed Shrew	4
Bufo terrestris	Southern Toad	36; incidental sighting
Dasypus novemcinctus	Nine-banded Armadillo	photos; tracks*
Didelphis virginianus	Virginia Opossum	photos*
Elaphe obsoleta	Yellow Ratsnake	1
Farancia abacura	Red-bellied Mudsnake	incidental sighting
Gastrophryne carolinensis	Narrow-mouthed Toad	7; incidental sighting
Hyla cinerea	Green Treefrog	34; incidental sighting
Hyla femoralis	Pine Woods Treefrog	1

Scientific Name	Common Name	Number or Method of Observation
Hyla squirella	Squirrel Treefrog	6
Kinosternon baurii	Striped Mud Turtle	2, incidental sighting
Myotis austroriparius	Southeastern Bat	incidental sighting
Neofiber alleni	Round-tailed Muskrat	4; tracks*
Nerodia fasciata	Southern Watersnake	incidental sighting
Oryzomys palustris/ *Sigmodon hispidus*	Rice rat/ Hispid Cotton Rat	19
Procyon lotor	Raccoon	photos; tracks*
Rana clamitans	Green Frog	1; incidental sighting
Rana sphenocephala	Southern Leopard Frog	424; incidental sightings
Scaphiopus holbrooki	Eastern Spadefoot	1

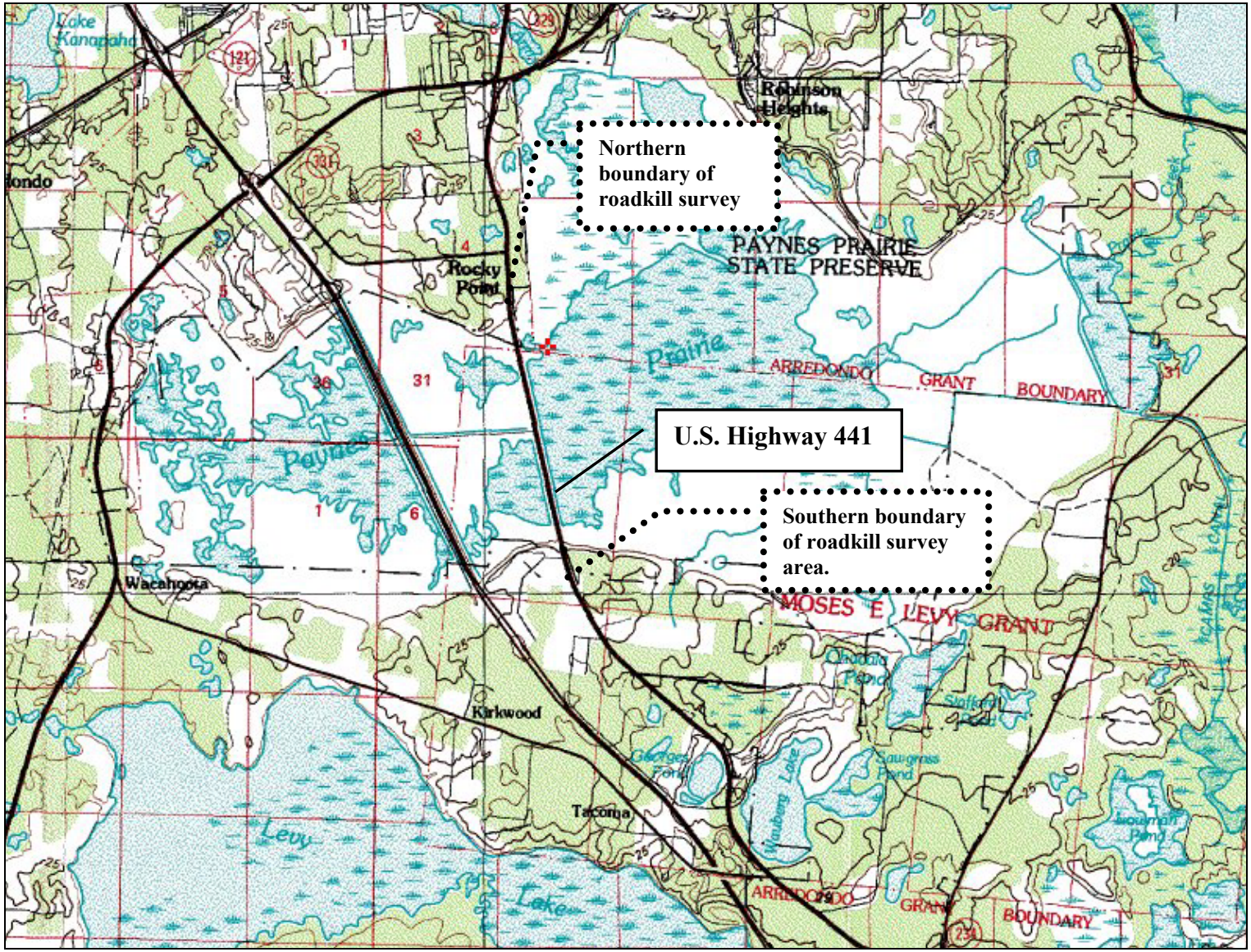

Figure 1. Survey study area on U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida.

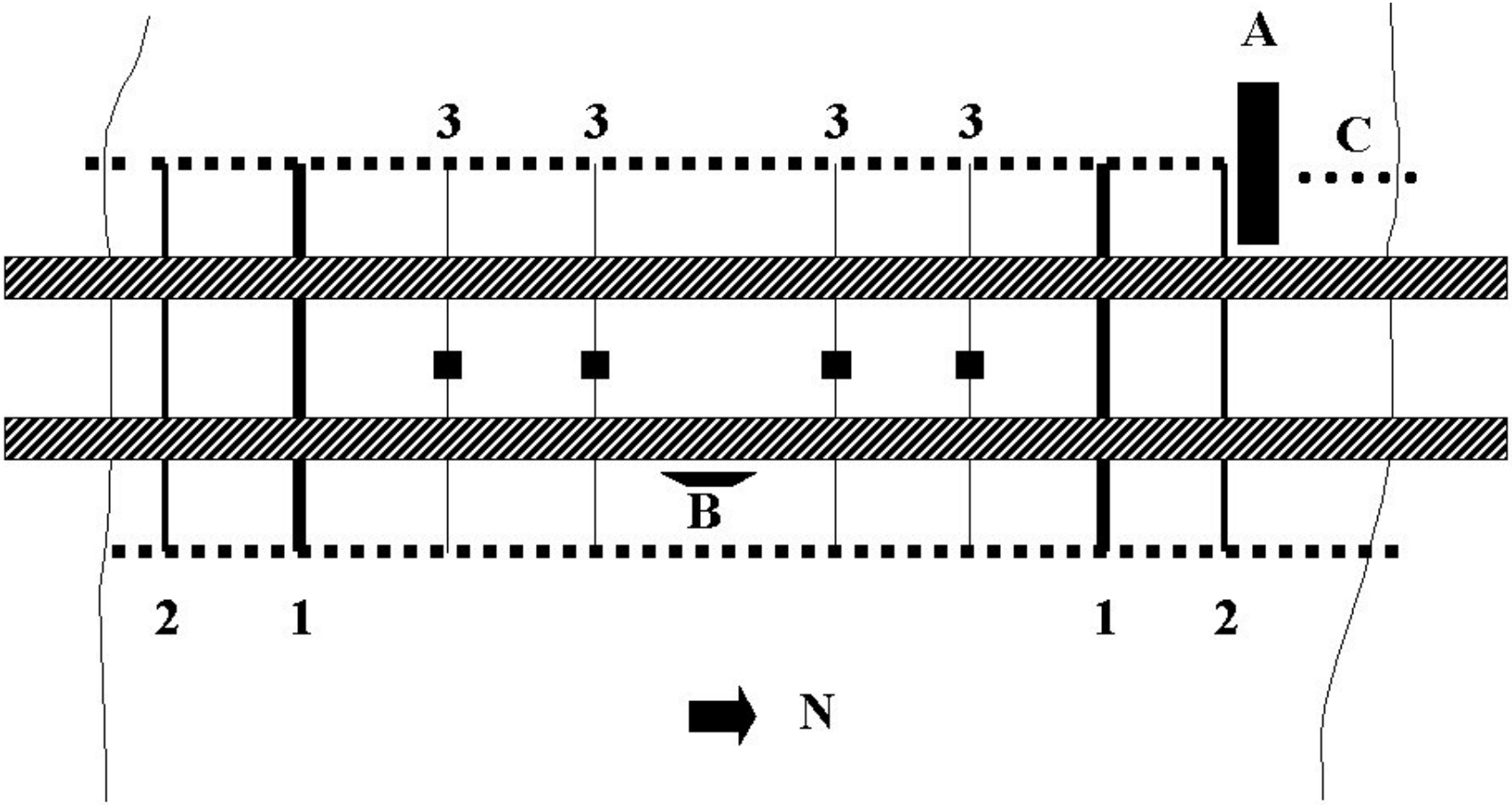

Figure 2. Schematic representation of US Highway 441 (diagonal hatching) across Paynes Prairie State Preserve. The road is bordered by a concrete barrier wall (square line) and underlain by 8 culverts: (1) wet 2.4 x 2.4 m box culverts; (2) dry 1.8 x 1.8 m box culverts; (3) 0.9 m rounded culverts. Light boxes (squares) occur midway across the road in the small culverts to allow light. An access road enters on the southbound lane near the northern prairie rim (A), and a visitor turn out is located at B. A type-A fence borders private property along the southbound lanes on the north prairie rim (C).

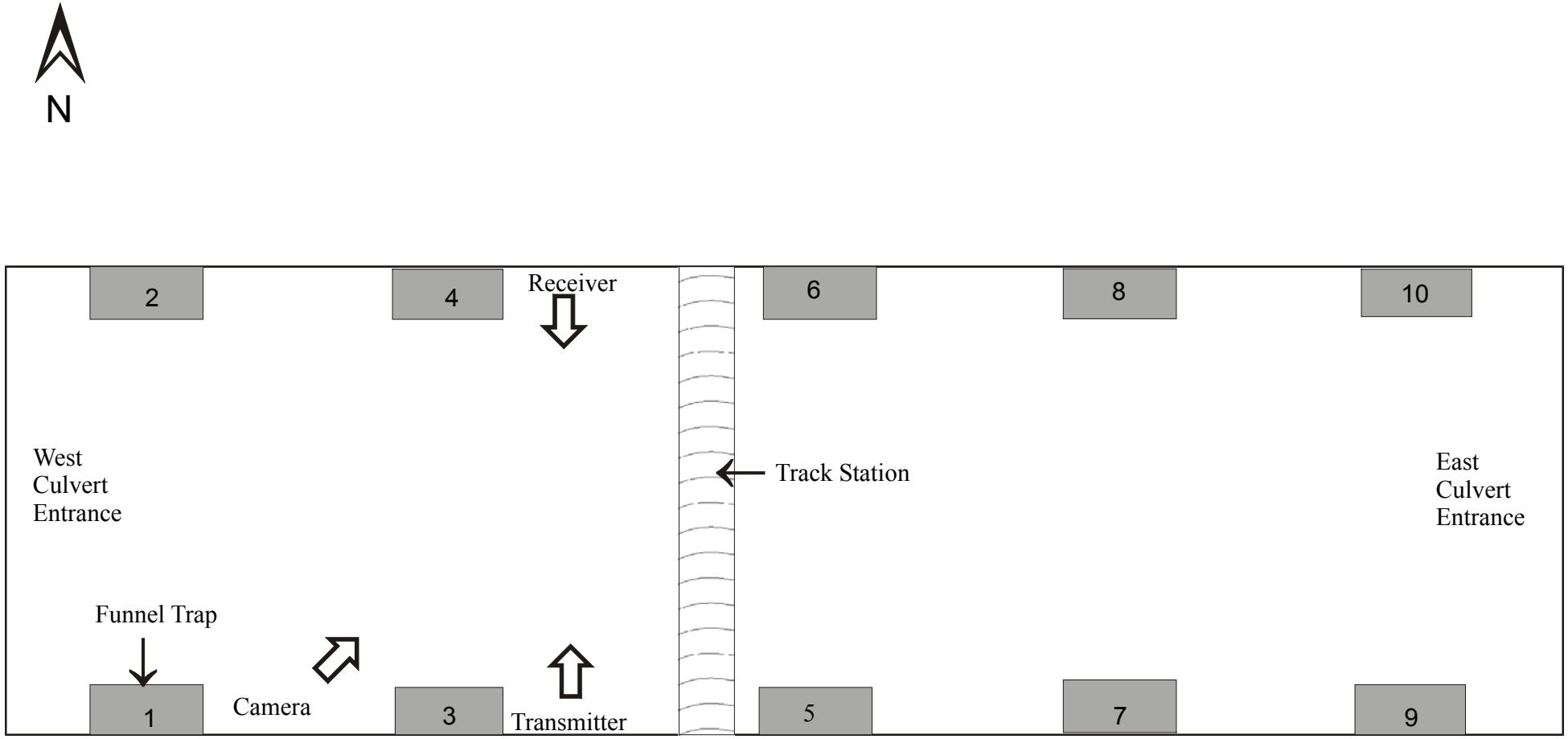

Figure 3. Diagram of a box culvert illustrating the location of funnel traps, track station, and motion senor camera. U.S. Highway 441 at Paynes Prairie, Alachua County, Florida.

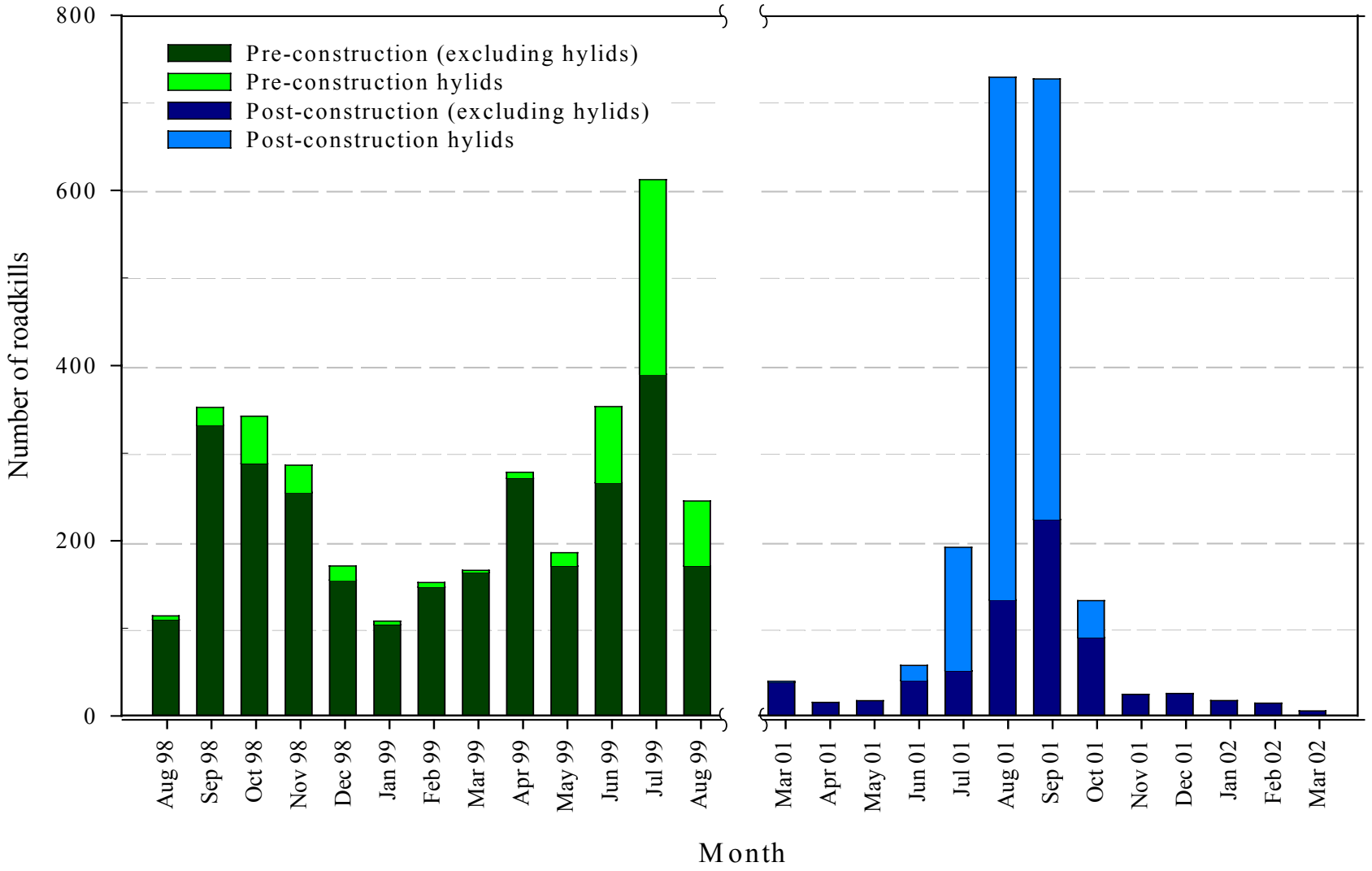

Figure 4. Monthly roadkill totals on U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida Florida one-year prior to and after construction of the ecopassage.

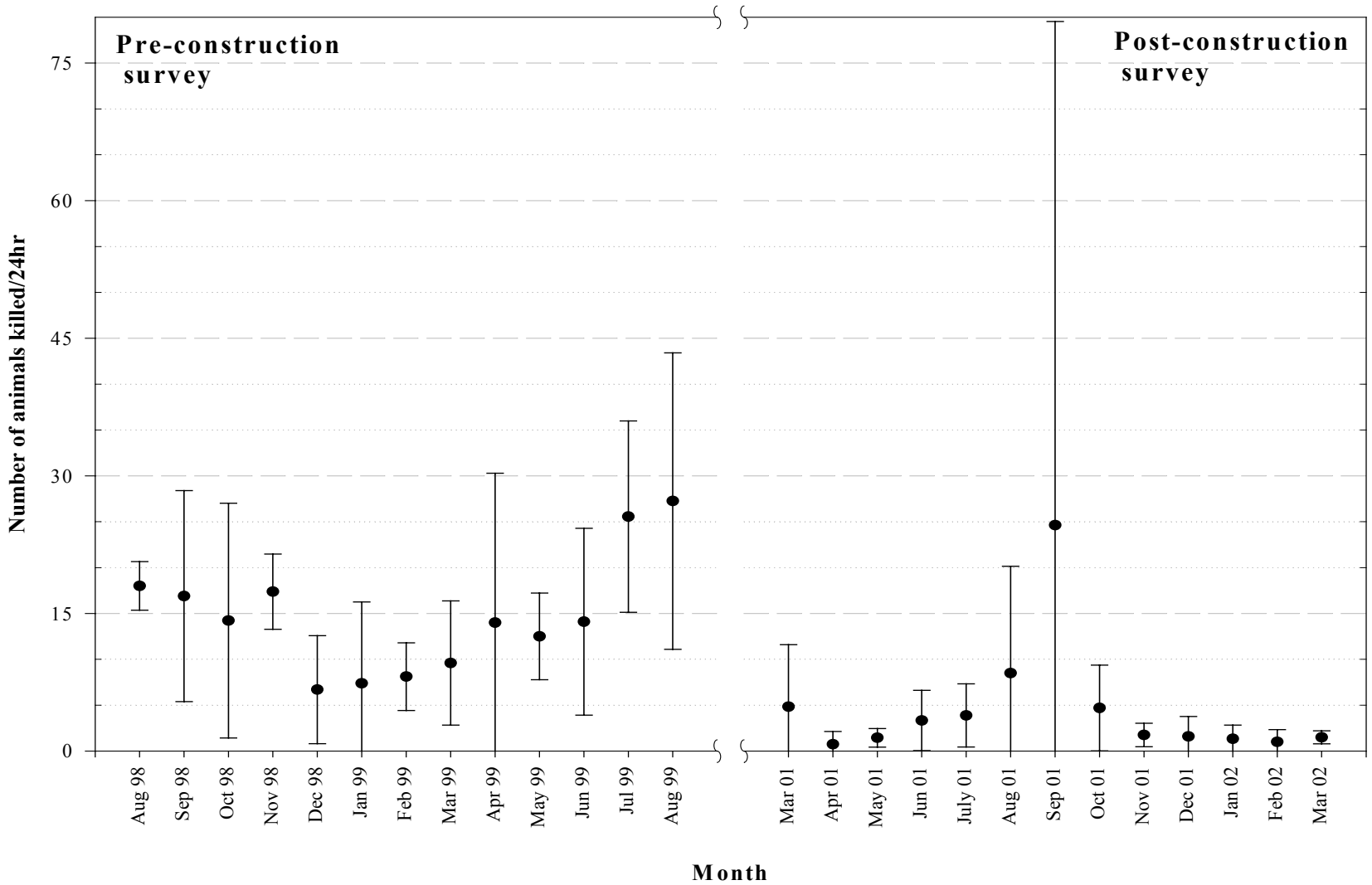

Figure 5. Mean number of roadkills per 24-hour period, exclusive of hylid treefrogs, on U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida one-year prior to and after construction of the ecopassage. One standard deviation is expressed by the error bars. The large number of kills recorded in September 2001 results from a single day during which 162 Eastern Narrow-mouthed Toads were killed.

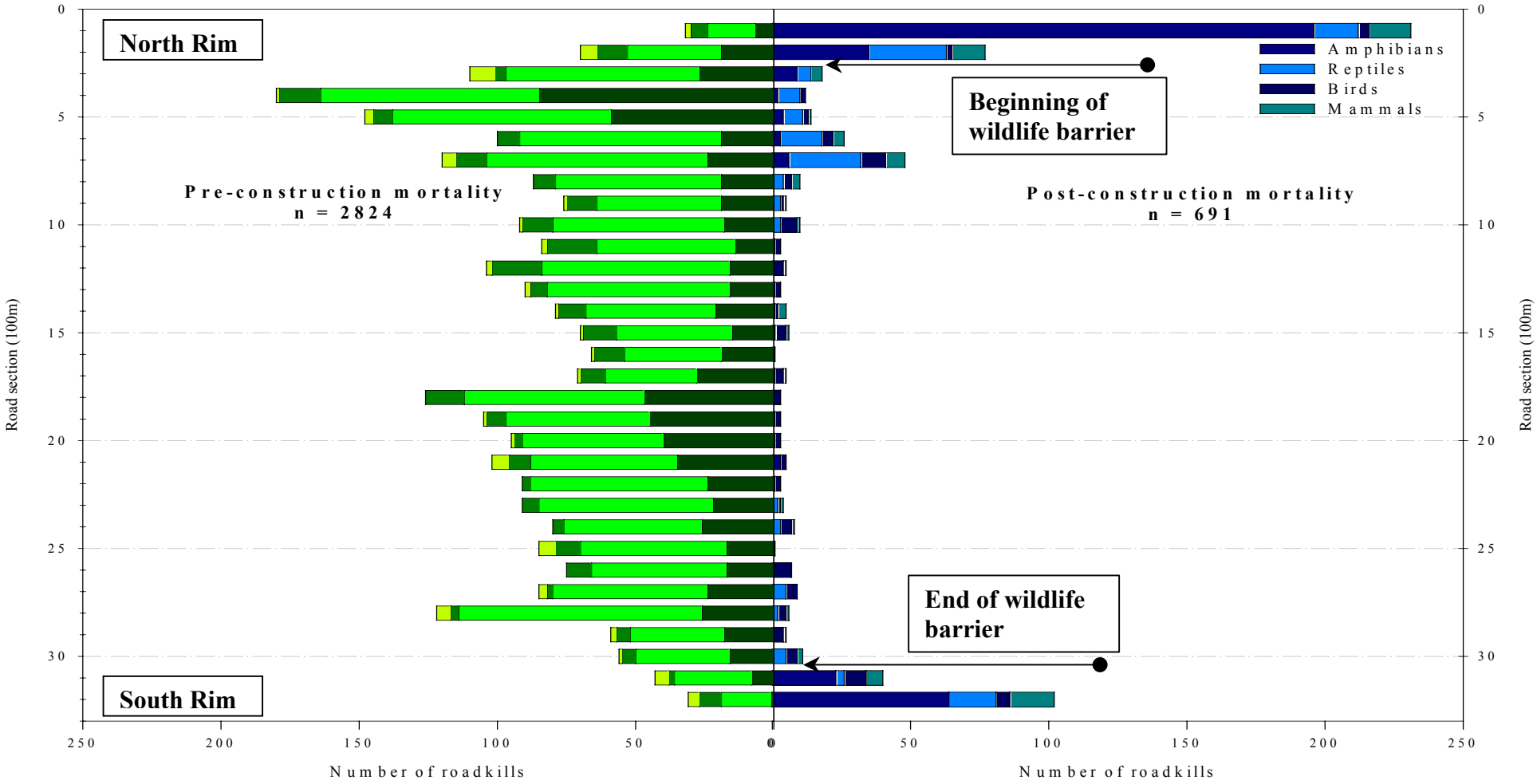

Figure 6. Number of roadkills, excluding hylid treefrogs, per 100 m-section of U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida. The survey area commenced at the first private drive on the north rim of the prairie (section 1) and extended 3.2 km to the first private driveway on the south rim (section 32). Pre-construction data were collected from 18 August 1998 through 13 August 1999, and post-construction data were collected from 14 March 2001 to 5 March 2002. The wildlife concrete barrier adjacent to the roadway extends from section 3 to section 30.

LITERATURE CITED

Beck, W. M. 1938. Notes on the reptiles of Payne's Prairie, Alachua County, Florida. Florida Naturalist 11:85-87.

Carr, A. F. 1940. A contribution to the herpetology of Florida. University of Florida, Biological Science Series 3: 1-118.

Carr, A.F. 1974. The Reptiles. Time-Life Books, New York.

Crother, B. I. (Ed.). 2000. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. SSAR Herpetological Circular No. 29, 82 pp.

Franz, R. and S.J. Scudder. 1977. Observations of snake movements on a north Florida highway. Unpublished Report. Florida State Museum. University of Florida. Gainesville, Florida.

Hellman, R.E., and S.R. Telford. 1956. Notes on a large number of red-bellied mudsnakes, *Farancia a. abacura*, from northcentral Florida. Copeia 1956:257-258.

Kauffeld, C. 1957. Snakes and snake hunting. Hanover House, Garden City, New York.

Smith, D. 1996. The direct and indirect impacts of highways on the vertebrates of Payne's Prairie State Preserve. State of Florida Department of Transportation. FL-ER-62-96.

Smith, L.L. and C.K. Dodd, Jr. 1999. Determination of the Effectiveness of Wildlife Barriers and Underpasses on U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida. Unpublished progress report to FDOT, USGS project #BB-854.

Smith, L.L. and C.K. Dodd, Jr. ms. Wildlife mortality on U.S. Highway 441 across Paynes Prairie, Alachua County, Florida. Florida Scientist, submitted (4/26/02).

Appendix A. Photographs of wildlife using 1.8m x 1.8m box culverts under U.S. Highway 441 across Paynes Prairie taken with Trailmaster 1500 Active Infrared monitors and cameras.

American Alligator
(*Alligator mississippiensis*)

River otter
(*Lutra canadensis*)

Bobcat
(*Lynx rufus*)

Marsh rabbit
(*Sylvilagus palustris*)

Southeastern Bat
(*Myotis austroriparius*)

Raccoon
(*Procyon lotor*)

Appendix B. Photographs of areas recommended as needing improvement.

Sigmodon hispidus climbing vegetation along wall.

Type-A fence adjacent to southbound lane of U.S. 441.

Cattle gate near north rim of Paynes Prairie.

Vegetation growing against wall.

Passersby feeding American Alligators (*Alligator mississippiensis*).