

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



Phase I Final Report October 1999

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Florida Department of Transportation Contract No. BB-854

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

**Final Report
October 1999**

Introduction

Massive numbers of wildlife roadkills have occurred on the section of U.S. Highway 441 across Paynes Prairie State Preserve (Franz and Scudder, 1977; Smith, 1996). The high levels of wildlife mortality have adversely affected wildlife populations, created human safety concerns, and detracted from the beauty of the prairie. This research project was designed to determine the effectiveness of a wildlife barrier/underpass system. This phase of the project was designed to determine the level of pre-construction wildlife mortality and to determine how many and what types of animals use the existing culverts.

Methods

Road surveys consisted of a researcher walking the entire 3.2 km (2 mile) length of the road during each sampling unit (sampling unit = 24 hours). A 3-day sampling period was conducted each week. This consisted of a researcher going out on day 1 and marking all dead animals found, and on days 2 and 3 recording all roadkills. Thus 104 randomized sampling units per year were sampled during the year-long study (2, 24-hr sampling units x 52 weeks). The survey schedule is presented in Table 1.

The area surveyed consisted of the entire road surface (north and southbound lanes) and extended 3-4 m onto the grassy shoulders (1 pass on each side of the road). The median also was surveyed (1 pass) on foot, or mountain bicycle. The road was divided into 100-m sections, for a length of 3.2-km. The first section was located on the north rim of the prairie at the first private driveway (see Fig. 1).

Surveys were conducted at first light and all live and dead animals were recorded. Dead animals were marked with spray paint so that they were not counted more than once. The paint used was both lead and toluene-free (Forestry Suppliers, Jackson, MS). Locations

of all animals also were recorded, e.g., north or southbound lane, right-of-way, median, and 100-m section.

Freshly killed, undamaged specimens were collected (GFC Permit # WS98348), preserved, and deposited in the Florida Museum of Natural History at the University of Florida (see Appendix A for a list of specimens collected).

Funnel traps were installed in the northern and southern box culverts to capture amphibians, reptiles, and small mammals. In the southern culvert, ten equally spaced hardware-cloth traps were placed along the sides (Fig. 2). Four floating screen funnel traps were installed in the northern box culvert which was inundated during the first 9 months of the study. Ten hardware cloth traps were set in the northern culvert once water levels had receded. The two culverts in the center of the prairie were completely inundated throughout the study and no traps were placed there.

The trapping schedule coincided with road surveys. However, to assure adequate sampling, the trapping period included an additional 2 sampling units (48 hours- for a total of 5 trap-days per week). All animals captured (excluding venomous snakes) were marked, measured, weighed, and released. Age and sex of animals was determined whenever possible. A sand track station (1.8 m long by 1 m wide) was maintained in the center of the southern, dry culvert. The track station was monitored during the trapping schedule. A TrailMaster Active Infrared monitor and camera (Goodson and Associates, Inc., Lenexa, KS) were installed at the center of the southern culvert to monitor animal use of culverts throughout the year.

Nighttime observations were conducted as a supplement to road surveys. The purpose of these surveys was to examine the proportion of animals that successfully cross the road versus the number attempting to cross the road. Florida Department of Transportation conducted traffic counts at the north rim of the prairie for one 24 hr period per month for the course of the study. Traffic data are presented in Appendix B.

Environmental data was recorded in two locations along the roadway. Air and water temperature, relative humidity, and barometric pressure were measured with computer data loggers (Onset Computer Corporation, Bourne, MA).

Results

A total of 3,365 dead animals (1,333 frogs; 29 alligators; 374 turtles; 1 lizard; 1,291 snakes; 265 birds; and 72 mammals) were counted from August 19, 1998 through August 13, 1999 (Table 2). This total includes all dead animals observed during the study (3 days per week x 52 weeks). The greatest number of kills was recorded in July 1999 (Fig 3). The green tree frog (*Hyla cinerea*) was the most commonly observed species (13.8% of total), followed by Florida banded water snake (12.7%), southern leopard frog (11.5%), and green water snake (6.2%). These five species represented more than 50% of the total number of animals killed.

The mean number of kills per 24-hour sampling period was 17.3 (sdev = 15.5; range = 0 - 79). Monthly means ranged from 8.0 through 44.8 and were highest in July and August 1999 (Fig. 4). Most carcasses were located in the outside lanes (55.5%) or bicycle lanes (21.7%), followed by the inside lane (13.0%) (Table 3). Very few were found in the median (1.5%), grassy right-of-way (4.6%), and centerline (3.7%). Most carcasses were located in sections 4-6, on the north rim of the prairie, but large numbers of kills also occurred in sections 19-28 (Fig. 5).

Twenty-nine species were documented using the existing north and south box culverts (Table 4). Funnel trap captures included 50 animals in 3,950 trap-days (1.0% capture success). Most captures (76%) occurred between March and August. Tracks of nine-banded armadillo (*Dasypus novemcinctus*), river otter (*Lutra canadensis*), opossum (*Didelphis virginianus*) and raccoon (*Procyon lotor*) often were observed in the dry southern culvert. These four species also were repeatedly photographed with the motion sensor camera. Three small mammals, rice rat (*Oryzomys palustris*), hispid cotton rat (*Sigmodon hispidus*), and round-tailed muskrat (*Neofiber alleni*), used the dry culvert.

Although nighttime surveys were conducted, animals were not observed in sufficient numbers to estimate the success rate of animals attempting to cross the road. The first nighttime survey was conducted on September 21, 1998 following 35 mm of rainfall. Two eastern cottonmouths (*Agkistrodon piscivorous*) were observed on the right-of-way; however, no movement across the road was observed over a two-hour period (from 2200 – 2400 hrs). Two additional night surveys were conducted on 3 and 20 February 1999 (from 2200 – 2430 hrs). On 3 February several southern leopard frogs were seen on the southbound traffic lanes and grassy right-of-way. No movement across the road was observed. No live animals were observed during the 20 February night survey. On 15 March and 17 April surveys were conducted from 2000-2300 hrs. No live animals were observed during these surveys. Night surveys also were conducted on 12, 13, and 14 June (from 2100-2330 hrs). Several freshly killed eastern mud snakes (*Farancia abacura*), pig frogs (*Rana grylio*), southern leopard frogs, and eastern cottonmouths were observed. Live animals encountered included two pig frogs, a leopard frog, and one eastern cottonmouth. The eastern cottonmouth attempted to enter the northbound outside lane, but retreated after several vehicles nearly ran over it.

During daylight hours, live animals found on the right-of-way included eastern cottonmouth, southern leopard frog and American alligator (*Alligator mississippiensis*); however, these animals were not observed attempting to cross the road. A red fox (*Vulpes vulpes*), Florida box turtle (*Terrapene carolina*), and common snapping turtle (*Chelydra serpentina*) were observed successfully crossing the road. A round-tailed muskrat was seen attempting to cross the road at 0700 hrs in May. The muskrat darted across both northbound lanes to the median before returning to the northbound right-of-way.

Table 1. Field schedule for the pre-construction survey. Surveys consisted of a researcher going out on day 1 and marking all dead animals found, and on days 2 and 3 recording all roadkills.

Week	Dates	Week	Dates
1	August 19-21, 1998	27	February 16-19, 1999
2	August 27-29, 1998	28	February 21-23, 1999
3	September 3-5, 1998	29	March 3-5, 1999
4	September 9-11, 1998	30	March 11-13, 1999
5	September 17-19, 1998	31	March 14-16, 1999
6	September 23-25, 1998	32	March 23-25, 1999
7	September 29- October 1, 1998	33	March 30- April 1, 1999
8	October 6-8, 1998	34	April 8-10, 1999
9	October 12-14, 1998	35	April 12-14, 1999
10	October 21-23, 1998	36	April 18-20, 1999
11	October 27-29, 1998	37	April 27-29, 1999
12	November 2-4, 1998	38	May 6-8, 1999
13	November 11-13, 1998	39	May 9-11, 1999
14	November 19-21, 1998	40	May 18-20, 1999
15	November 22-24, 1998	41	May 23-25, 1999
16	December 3-5, 1998	42	June 2-4, 1999
17	December 8-10, 1998	43	June 7-9, 1999
18	December 17-19, 1998	44	June 16-18, 1999
19	December 22-24, 1998	45	June 24-26, 1999
20	December 29-31, 1998	46	June 29 - July 1, 1999
21	January 5-7, 1999	47	July 5-7, 1999
22	January 10-12, 1999	48	July 15-17, 1999
23	January 17-19, 1999	49	July 20-22, 1999
24	January 28-30, 1999	50	July 26-28, 1999
25	February 4-6, 1999	51	August 4-6, 1999
26	February 7-9, 1999	52	August 11-13, 1999

Table 2. Vertebrate roadkills on U.S. 441 at Paynes Prairie from August 19, 1998 through August 13, 1999.

Taxa	Scientific Name	Common Name	Number
Frogs			
	<i>Acris gryllus</i>	cricket frog	1
	<i>Bufo terrestris</i>	southern toad	11
	<i>Hyla cinerea</i>	green treefrog	463
	<i>Hyla cinerea?</i>		5
	<i>Hyla sp.</i>	unidentified hylid	77
	<i>Hyla squirella</i>	squirrel treefrog	2
	<i>Rana catesbeiana?</i>	Bullfrog	1
	<i>Rana grylio</i>	pig frog	259
	<i>Rana grylio?</i>		22
	<i>Rana sp.</i>	unidentified ranid	40
	<i>Rana sp.?</i>		2
	<i>Rana utricularia</i>	southern leopard frog	387
	<i>Rana utricularia?</i>		39
	<i>Scaphiopus holbrookii</i>	Eastern spadefoot toad	1
		unidentified frog	23
		Subtotal:	1,333
Crocodylians			
	<i>Alligator mississippiensis</i>	American alligator	29
Turtles			
	<i>Apalone ferox</i>	Florida softshell	5
	<i>Chelydra serpentina</i>	common snapping turtle	26
	<i>Kinosternon bauri</i>	striped mud turtle	140
	<i>Kinosternon bauri?</i>		1
	<i>Kinosternon sp.</i>		26
	<i>Kinosternon sp.?</i>		2
	<i>Kinosternon subrubrum</i>	eastern mud turtle	30
	<i>Pseudemys floridana</i>	peninsula cooter	36
	<i>Pseudemys nelsoni</i>	Florida redbelly turtle	26
	<i>Pseudemys sp.</i>		2
	<i>Sternotherus odoratus</i>	musk turtle	66
	<i>Sternotherus odoratus?</i>		1
	<i>Terrapene carolina</i>	Florida box turtle	2
	<i>Trachemys scripta</i>	yellowbelly slider	8
		unidentified turtle	3
		Subtotal:	374
Lizards			
	<i>Ophisaurus ventralis</i>	eastern glass lizard	1

Snakes

<i>Agkistrodon piscivorus</i>	eastern cottonmouth	205
<i>Agkistrodon piscivorus?</i>		1
<i>Crotalus adamanteus</i>	eastern diamondback	2
<i>Coluber constrictor</i>	southern black racer	1
<i>Coluber constrictor?</i>		1
<i>Elaphe guttata</i>	red rat snake	5
<i>Elaphe obsoleta</i>	yellow rat snake	8
<i>Farancia abacura</i>	eastern mud snake	60
<i>Nerodia fasciata</i>	Florida banded water snake	427
<i>Nerodia fasciata?</i>		2
<i>Nerodia floridana</i>	Florida green water snake	210
<i>Nerodia floridana?</i>		1
<i>Nerodia sp.?</i>		1
<i>Nerodia taxispilota</i>	brown water snake	1
<i>Opheodrys aestivus</i>	rough green snake	2
<i>Regina alleni</i>	striped crayfish snake	142
<i>Regina alleni?</i>		1
<i>Seminatrix pygaea</i>	black swamp snake	131
<i>Storeria dekayi</i>	Florida brown snake	19
<i>Storeria dekayi?</i>		1
<i>Tantilla relicta</i>	peninsula crowned snake	2
<i>Thamnophis sauritus</i>	peninsula ribbon snake	55
<i>Thamnophis sirtalis</i>	eastern garter snake	6
<i>Thamnophis sp.</i>		1
Unidentified snake		6
	Subtotal:	1,291

Birds

<i>Agelaius phoeniceus</i>	red-winged blackbird	1
<i>Anhinga anhinga</i>	anhinga	3
<i>Ardea herodias</i>	great blue heron	4
<i>Bubulcus ibis</i>	cattle egret	9
<i>Casmerodius albus</i>	great egret	1
<i>Ceryle alcyon</i>	belted-kingfisher	1
<i>Ceryle alcyon?</i>	belted-kingfisher	1
<i>Coccyzus americanus</i>	yellow-billed cuckoo	1
<i>Cathartes aura</i>	turkey vulture	2
<i>Dendroica coronata</i>	yellow-rumped warbler	41
<i>Dendroica coronata?</i>	yellow-rumped warbler	3
<i>Dendroica palmarum</i>	palm warbler	2
<i>Dumetella carolinensis</i>	gray catbird	3
<i>Falco sparverius</i>	American kestrel	1
<i>Falco sparverius?</i>	American kestrel	1
<i>Fulica americana</i>	American coot	8
<i>Gallinago gallinago</i>	common snipe	2

<i>Gallinula chloropus</i>	common moorhen	19
<i>Geothlypis trichas</i>	common yellowthroat	18
<i>Geothlypis trichas?</i>	common yellowthroat	2
<i>Ixobrychus ixilis</i>	least bittern	22
<i>Melospiza georgiana</i>	swamp sparrow	17
<i>Melospiza georgiana?</i>	swamp sparrow	1
<i>Mimus polyglottos</i>	northern mockingbird	1
<i>Otus asio</i>	eastern screech owl	1
<i>Phalacrocorax auritus</i>	double-crested cormorant	1
<i>Pluvialis squatarola</i>	black-bellied plover	1
<i>Porzana carolina</i>	sora	2
<i>Quiscalus major</i>	boat-tailed grackle	8
<i>Quiscalus major?</i>	boat-tailed grackle	1
<i>Rallus elegans</i>	king rail	3
<i>Rallus limicola</i>	Virginia rail	2
<i>Sialia sialis</i>	eastern bluebird	1
<i>Spizella passerina</i>	chipping sparrow	3
<i>Sayornis phoebe</i>	eastern phoebe	1
<i>Tachycineta bicolor</i>	tree swallow	4
<i>Thryothorus ludovicianus</i>	Carolina wren	3
<i>Zenaida macroura</i>	mourning dove	1
	unidentified bird	69
	Subtotal:	265

Mammals

<i>Canis familiaris</i>	domestic dog	2
<i>Dasyus novemcinctus</i>	nine-banded armadillo	3
<i>Didelphis virginianus</i>	opossum	11
<i>Neofiber alleni</i>	round-tailed muskrat	18
<i>Neofiber alleni?</i>		1
<i>Lasiurus sp.</i>	red bat	1
<i>Myotis cryptans</i>		1
<i>Oryzomys palustris</i>	rice rat	1
<i>Odocoileus virginianus</i>	white-tailed deer	2
<i>Peromyscus gossypinus</i>	cotton mouse	1
<i>Peromyscus gossypinus?</i>		2
<i>Procyon lotor</i>	raccoon	19
<i>Sigmodon hispidus</i>	hispid cotton rat	3
<i>Sylvilagus sp.</i>	rabbit	1
	unidentified rodent	6
	Subtotal:	72

Grand Total: 3,365

Table 3. Location of kills on the road surface, right-of-way, and median of U.S. 441 at Paynes Prairie. Surveys were conducted from August 19, 1998 through August 13, 1999. The data presented represent the two 24-hour samples collected each week throughout the course of the study.

Location	Northbound	Southbound	Median
Right-of-way	60	23	
Bicycle lane	198	196	
Outside lane	448	562	
Centerline	24	43	
Inside lane	90	147	
Median			28
Total:	820	971	28

Table 4. Vertebrates documented using existing culverts under U.S. 441 at Paynes Prairie from August 19, 1998 through August 13, 1999.

Scientific Name	Common Name	Qty	Capture/Observation Method
North Culvert			
<i>Amphiuma means</i>	two-toed amphiuma	3	funnel trap
<i>Kinosternon bauri</i>	striped mud turtle	1	funnel trap
<i>Nerodia fasciata</i>	Florida banded water snake	7	funnel trap
<i>Nerodia floridana</i>	green water snake	1	Funnel trap
<i>Pseudemys floridana</i>	peninsula cooter	1	floating funnel trap
<i>Pseudemys nelsoni</i>	Florida redbelly turtle	1	floating funnel trap
<i>Rana grylio</i>	pig frog	11	funnel trap
<i>Regina alleni</i>	crayfish snake	1	funnel trap
<i>Siren intermedia</i>	lesser siren	5	funnel trap
<i>Siren lacertina</i>	greater siren	1	floating funnel trap
<i>Sternotherus odoratus</i>	musk turtle	2	floating funnel trap
South Culvert			
<i>Agkistrodon piscivorous</i>	eastern cottonmouth	1	funnel trap
<i>Amphiuma means</i>	two-toed amphiuma	1	funnel trap
<i>Apalone ferox</i>	Florida softshell turtle	1	funnel trap
<i>Canis latrans</i>	coyote	1	tracks
<i>Dasyus novemcinctus</i>	nine-banded armadillo	*	tracks; photos
<i>Didelphis virginianus</i>	opossum	*	tracks; photos
<i>Elaphe guttata</i>	red rat snake	1	funnel trap
<i>Kinosternon bauri</i>	striped mud turtle	4	funnel trap
<i>Kinosternon subrubrum</i>	eastern mud turtle	1	funnel trap
<i>Lutra canadensis</i>	river otter	*	tracks; photos
<i>Lynx rufus</i>	bobcat	1	tracks
<i>Neofiber alleni</i>	round-tailed muskrat	2	tracks
<i>Nerodia fasciata</i>	Florida banded water snake	3	funnel trap
<i>Odocoileus virginianus</i>	white-tailed deer	1	tracks
<i>Oryzomys palustris</i>	rice rat	2	funnel trap
<i>Procyon lotor</i>	raccoon	*	tracks; photos
<i>Rana utricularia</i>	southern leopard frog	3	funnel trap
<i>Seminatrix pygaea</i>	black swamp snake	1	funnel trap
<i>Sigmodon hispidus</i>	hispid cotton rat	4	funnel trap
<i>Thamnophis sauritus</i>	eastern ribbon snake	1	funnel trap

* Multiple tracks and photographs recorded for these species.

Appendix A
Specimens Deposited in the Florida Museum of Natural History

Species:	Specimen #:
<i>Nerodia fasciata</i>	218336
<i>Nerodia fasciata</i>	218337
<i>Seminatrix pygaea</i>	218338
<i>Nerodia fasciata</i>	218339
<i>Nerodia fasciata</i>	218340
<i>Regina alleni</i>	218341
<i>Farancia abacura</i>	218342
<i>Chelydra serpentina</i>	218343
<i>Nerodia floridana</i>	218344
<i>Farancia abacura</i>	218345
<i>Nerodia floridana</i>	218346
<i>Rana utricularia</i>	218347
<i>Agkistrodon piscivorous</i>	218348
<i>Nerodia floridana</i>	218349
<i>Nerodia fasciata</i>	218350
<i>Nerodia fasciata</i>	218351
<i>Pseudemys floridana</i>	218352
<i>Nerodia fasciata</i>	218353
<i>Kinosternon bauri</i>	218354
<i>Rana grylio</i>	218355
<i>Farancia abacura</i>	218356
<i>Farancia abacura</i>	218357
<i>Chelydra serpentina</i>	218358
<i>Agkistrodon piscivorous</i>	218359
<i>Storeria dekayi</i>	218734
<i>Storeria dekayi</i>	218735
<i>Seminatrix pygaea</i>	218736
<i>Seminatrix pygaea</i>	218737
<i>Nerodia floridana</i>	218738
<i>Thamnophis sauritus</i>	218739
<i>Agkistrodon piscivorous</i>	12134
<i>Farancia abacura</i>	12135
<i>Nerodia floridana</i>	12136
<i>Nerodia floridana</i>	12137

Appendix B.
Monthly traffic counts (number of cars in a 24-hr period) for U.S. Highway 441
across Paynes Prairie, Alachua County, Florida*

Month	Northbound	Southbound	Total
September 1998	5394	5564	10958
October	5547	5649	11196
November	6952	7036	13988
December	5533	6582	12115
January 1999	6160	6191	12351
February	5624	5549	11173
March	5669	5592	11261
April	5840	7436	13276
May	5913	5825	11738
June	5803	5845	11648
July	5675	5625	11300
August	6556	6709	13265
Total:	70666	73603	144269

*data were collected by the Florida Department of Transportation.

References

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.

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.

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Phase II Post-Construction

Final Report

July 2002

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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 hybrid carcasses, and we decided it was better to rigorously sample three highway sections rather than to underestimate hybrid mortality over the entire study length. In the results that follow, hybrid 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 sphenoccephala*) were captured in culvert funnel traps in July 2002, presumably as they 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 sphenoccephala*; 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			
<i>Bufo terrestris</i>	Southern Toad	78	7
<i>Gastrophryne carolinensis</i>	Eastern Narrow-mouthed Toad	218	4
<i>Hyla cinerea</i>	Green Treefrog	135	101
<i>Hyla</i> sp.	Unidentified Treefrog	1153	763
<i>Hyla squirella</i>	Squirrel Treefrog	13	7
<i>Rana</i> sp.	Unidentified Ranid	12	5
<i>Rana sphenocephala</i>	Southern Leopard Frog	12	6
<i>Scaphiopus holbrookii</i>	Eastern Spadefoot	7	-
Unidentified frog		19	6
		1647	899
Crocodylians			
<i>Alligator mississippiensis</i>	American Alligator	1	-
		1	0
Turtles			
<i>Chelydra serpentina</i>	Snapping Turtle	2	2
<i>Kinosternon bauri</i>	Striped Mud Turtle	2	-
<i>Kinosternon</i> sp.	Unidentified Mud Turtle	1	-
<i>Pseudemys nelsoni</i>	Florida Red-bellied Turtle	2	1
		7	3
Lizards			
<i>Anolis</i> sp.	Unidentified Anole	1	1
<i>Ophisaurus</i> sp.	Unidentified Glass Lizard	2	2
<i>Ophisaurus ventralis</i>	Eastern Glass Lizard	1	1
		4	4
Snakes			
<i>Agkistrodon piscivorus</i>	Cottonmouth	1	-
<i>Coluber constrictor</i>	Eastern Racer	4	4
<i>Diadophis punctatus</i>	Ring-necked Snake	2	1
<i>Elaphe guttata</i>	Cornsnake	2	2
<i>Elaphe obsoleta</i>	Yellow Ratsnake	16	5
<i>Farancia abacura</i>	Red-bellied Mudsnake	8	7
<i>Lampropeltis triangulum</i>	Milksnake	1	-
<i>Nerodia fasciata</i>	Southern Watersnake	21	18
<i>Nerodia floridana</i>	Florida Green Watersnake	3	2

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

Scientific Name	Common Name	Count for all sections	Count for sections 3 to 30
<i>Didelphis virginianus</i>	Virginia Opossum	15	1
<i>Lutra canadensis</i>	River Otter	1	1
<i>Odocoileus virginianus</i>	White-tailed Deer	3	1
<i>Oryzomys palustris</i>	Rice Rat	25	17
<i>Peromyscus gossypinus</i>	Cotton Mouse	2	1
<i>Procyon lotor</i>	Raccoon	5	-
<i>Sigmodon hispidus</i>	Hispid Cotton Rat	2	1
<i>Sylvilagus palustris</i>	Marsh Rabbit	2	1
<i>Sylvilagus</i> sp.	Unidentified rabbit	1	1
<i>Urocyon cinereoargenteus</i>	Gray Fox	1	1
Unidentified bat		5	2
Unidentified mammal		7	3
		<hr/>	<hr/>
		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
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
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
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 through 5 March 2002.

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

Scientific Name**Common Name****Snakes (n = 11)**

<i>Agkistrodon piscivorus</i>	Cottonmouth
<i>Coluber constrictor</i>	Eastern Racer
<i>Diadophis punctatus</i>	Ring-necked Snake
<i>Elaphe guttata</i>	Cornsnake
<i>Elaphe obsoleta</i>	Yellow Ratsnake
<i>Farancia abacura</i>	Eastern Mudsnake
<i>Nerodia fasciata</i>	Southern Watersnake
<i>Nerodia floridana</i>	Florida Green Watersnake
<i>Storeria dekayi</i>	Dekay's Brownsnake
<i>Thamnophis sauritus</i>	Eastern Ribbonsnake
<i>Thamnophis sirtalis</i>	Common Gartersnake

Mammals (n = 12)

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

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

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

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

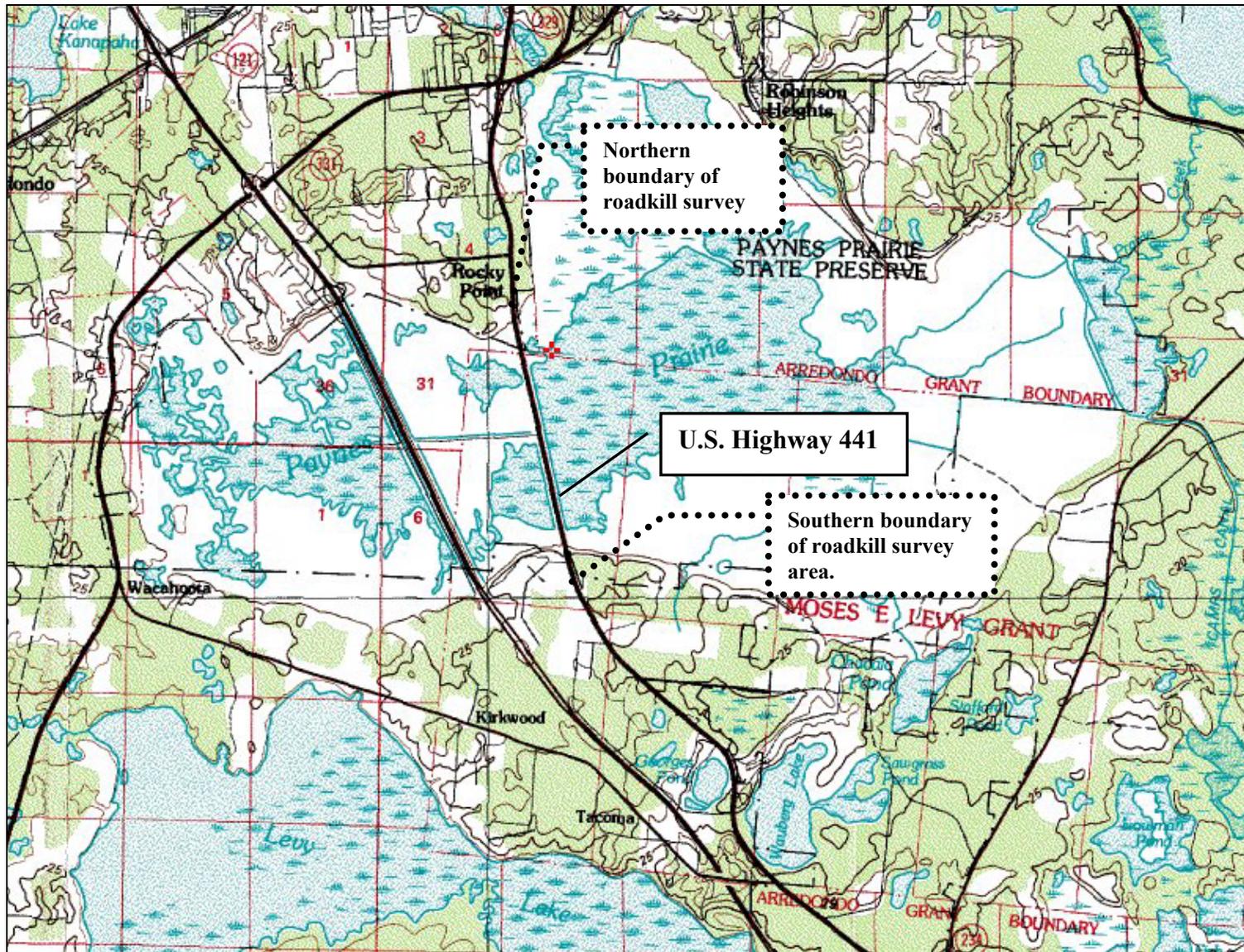


Figure 1. Survey study area on U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida.

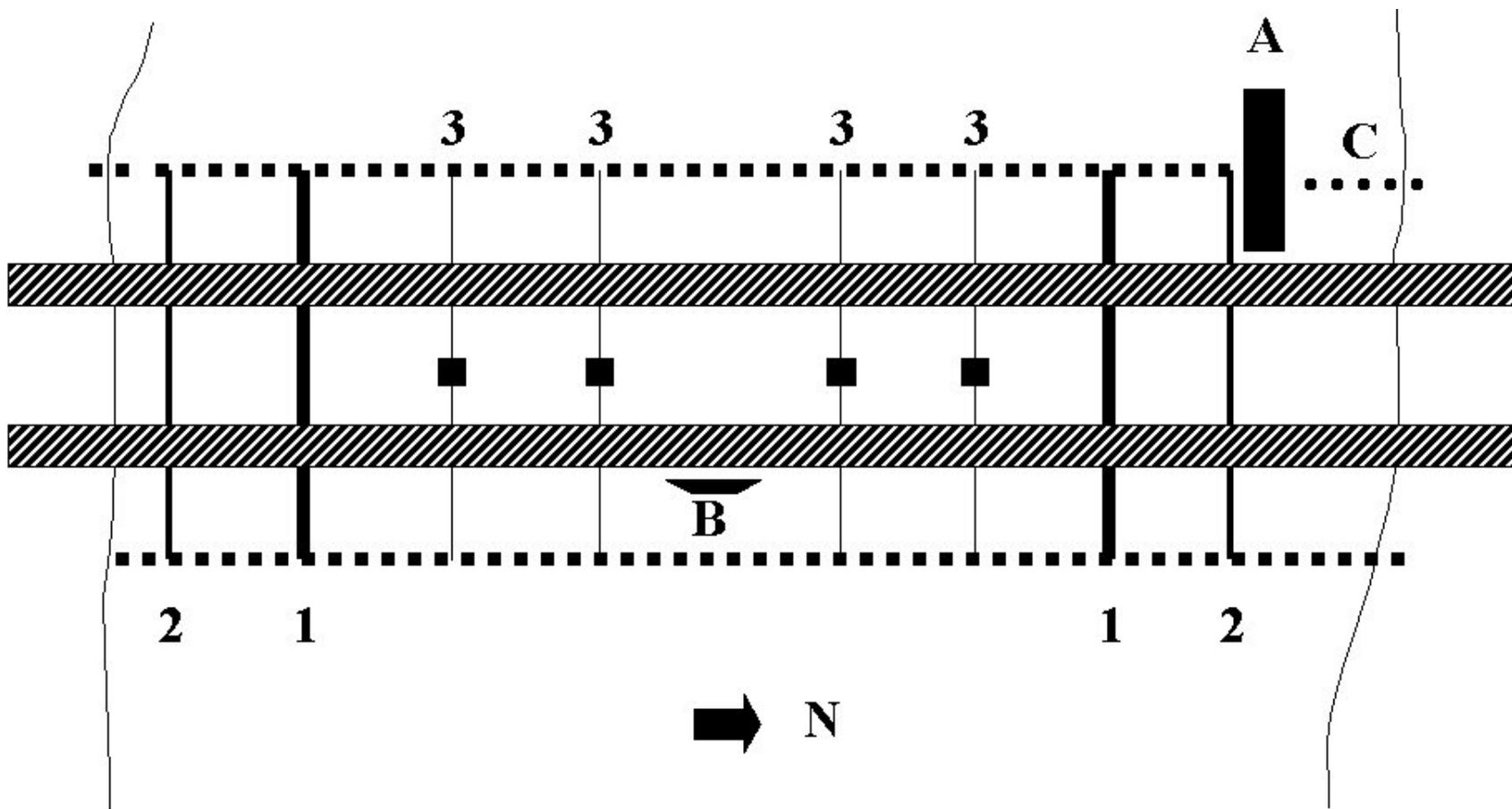


Figure 2. Schematic representation of US Highway 441 (diagonal hatching) across Paynes Prairie State Preserve. The road is bordered by a concrete barrier wall (square line) and underlain by 8 culverts: (1) wet 2.4 x 2.4 m box culverts; (2) dry 1.8 x 1.8 m box culverts; (3) 0.9 m rounded culverts. Light 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).

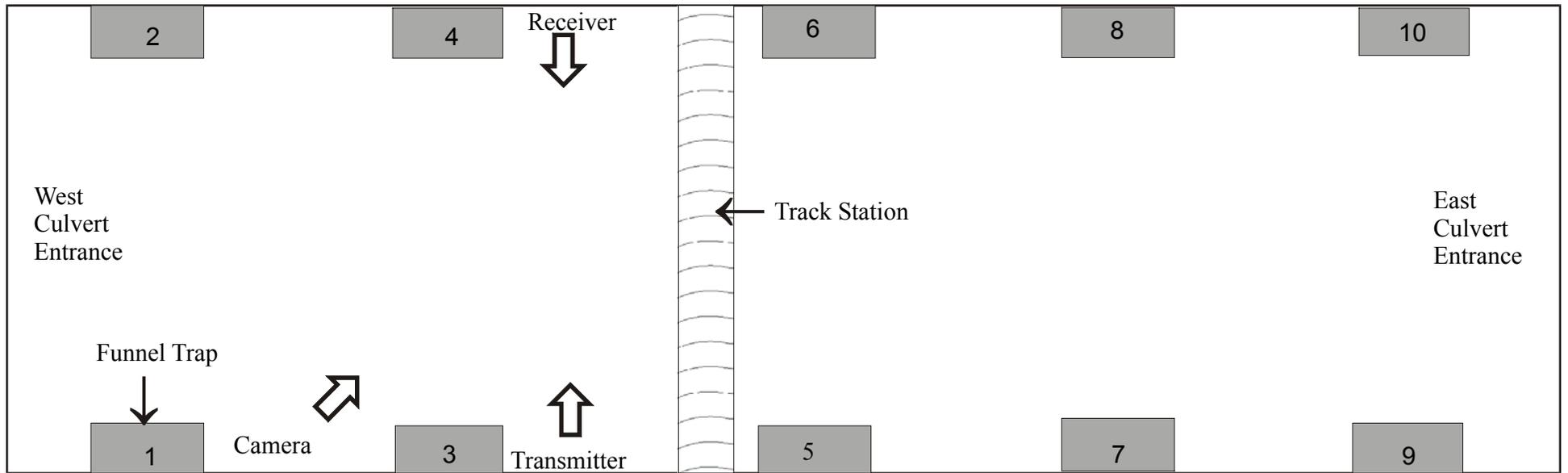


Figure 3. Diagram of a box culvert illustrating the location of funnel traps, track station, and motion sensor camera. U.S. Highway 441 at Paynes Prairie, Alachua County, Florida.

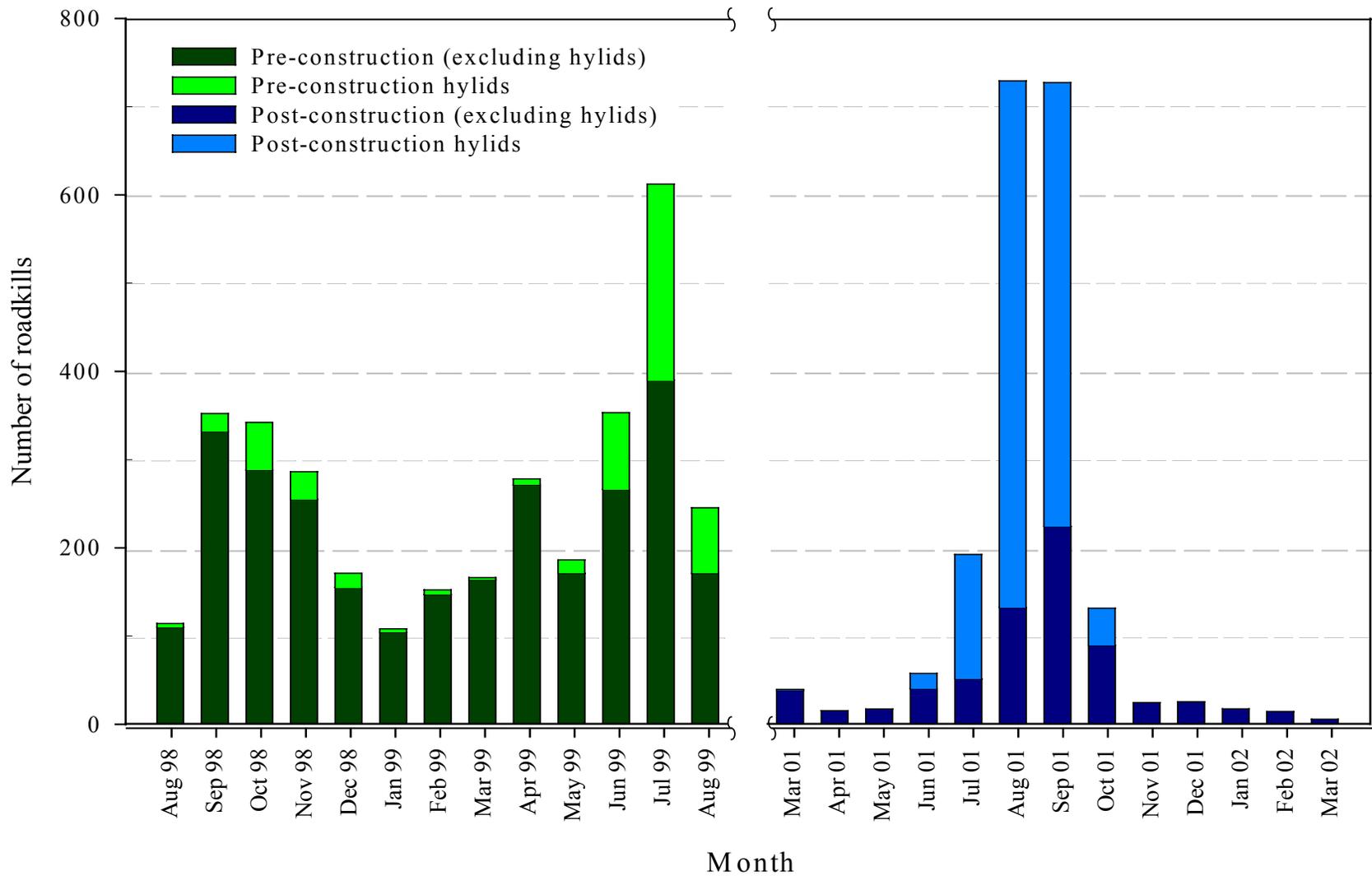


Figure 4. Monthly roadkill totals on U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida Florida one-year prior to and after construction of the ecopassage.

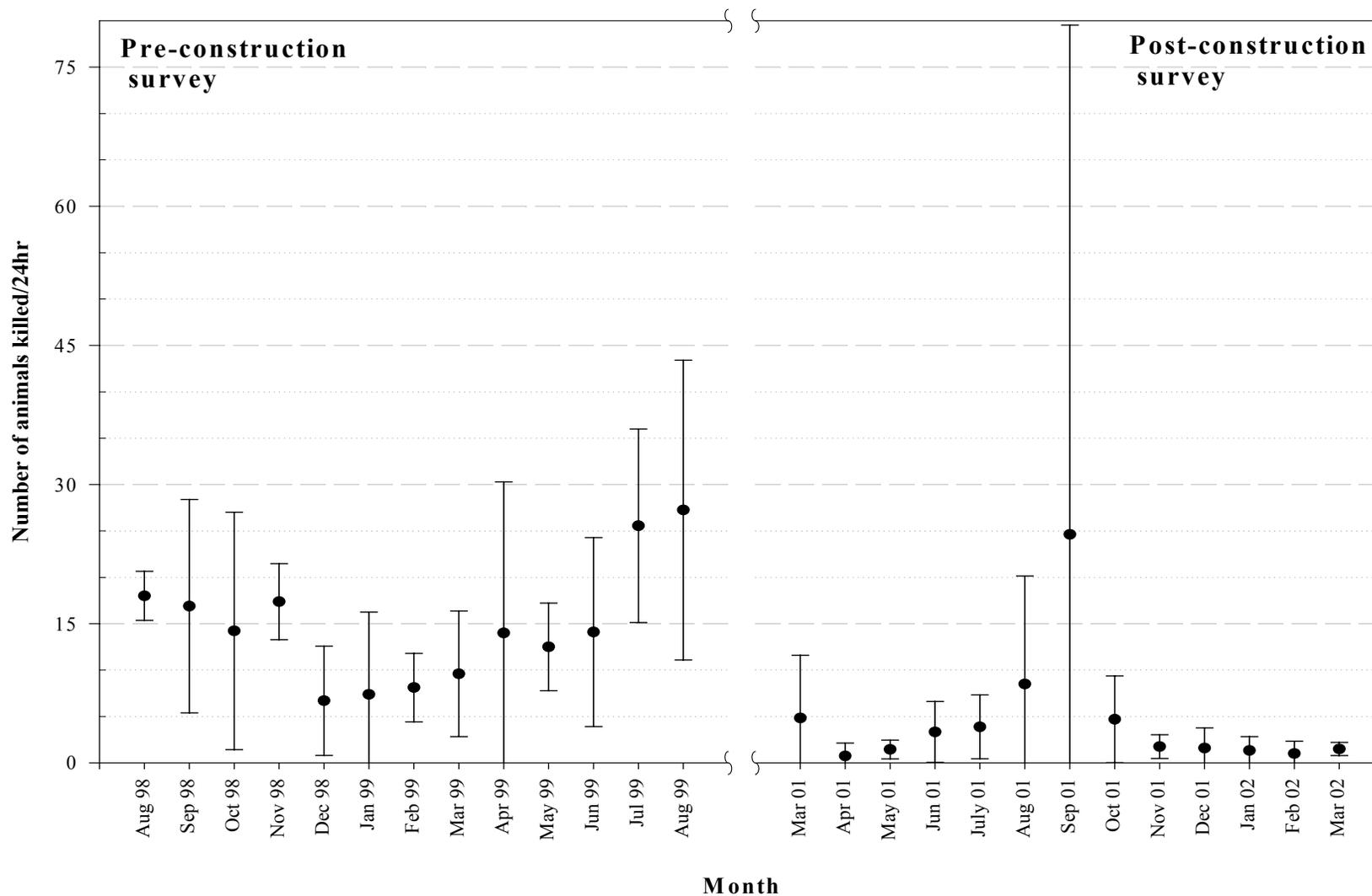


Figure 5. Mean number of roadkills per 24-hour period, exclusive of hylid treefrogs, on U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida one-year prior to and after construction of the ecopassage. One standard deviation is expressed by the error bars. The large number of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

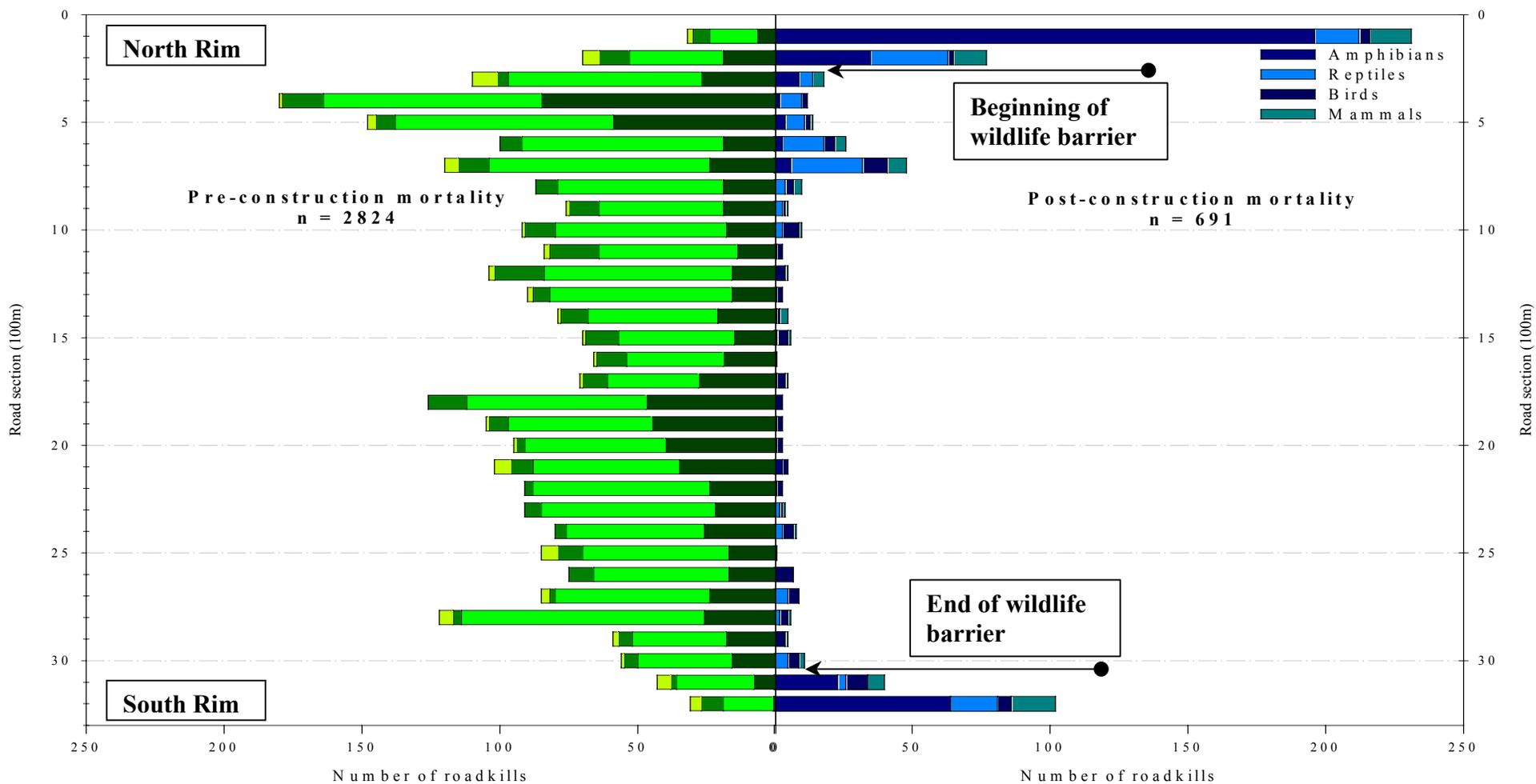


Figure 6. Number of roadkills, excluding hylid treefrogs, per 100 m-section of U.S. Highway 441 across Paynes Prairie State Preserve, Alachua County, Florida. The survey area commenced at the first private drive on the north rim of the prairie (section 1) and extended 3.2 km to the first private driveway 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*).