Supplemental Information for the Florida Pine Snake

Biological Status Review Report

The following pages contain peer reviews received from selected peer reviewers, comments received during the public comment period, and the draft report that was reviewed before the final report was completed

March 31, 2011

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Peer review #1 from Dirk Stevenson

From: Dirk Stevenson
To: Imperiled
Cc: Enge, Kevin
Subject: FL pine snake review
Date: Friday, December 24, 2010 4:08:11 PM

I am writing to comment on the status review of the Florida Pine Snake. I do indeed agree with the staff decision to delist the Florida Pine Snake for the same reasons discussed in the review. Also, as mentioned in the document, pine snake populations occur in a very wide diversity of sandy pine upland habitats, including disturbed habitats (e.g., oldfields) and sites lacking pocket gophers (although the
presence of pocket gophers likely enhances population health). It is my opinion that this status review is thorough, complete, and accurate, and includes reasonable and appropriate assumptions and conclusions that do justify the decision to delist this species.

Thank you,

Dirk Stevenson

(Please note, I am reviewing this as an independent species expert, **not** as an employee of Project Orianne)

Dirk J. Stevenson
Director of Inventory & Monitoring
The Orianne Society
Indigo Snake Initiative
414 Club Drive
Hinesville, GA 31313

Peer review #2 from Dr. Lora Smith

From: Lora Smith
To: Imperiled
Subject: Re: Florida pine snake Draft BSR Report
Date: Thursday, February 03, 2011 11:40:41 AM
Attachments: BSR_FPS_lls_comments.docx

Dear Dr. Haubold,

I have attached my comments on the FWC Biological Status Review for the Florida pine snake. Thank you very much for the opportunity to comment on this review.

Sincerely,

Lora Smith
--
Lora L. Smith, PhD
Associate Scientist
Joseph W. Jones Ecological Research Center
3988 Jones Center Dr.
Newton, Ga 39870

The Biological Status Review for the Florida pine snake included a thorough review of published data on this species, as well as relevant literature/knowledge on other species of large upland snakes. The parameter estimates used in the habitat and population viability models were conservative, which seems like a sound approach. Given the details outlined in the review, I am surprised that FWC staff decided to over-ride the recommendations of the review team and delist the species. My specific comments/concerns about the status review are as follows:
Under the Quantitative analyses section:

- Did the PVA models only consider potential habitat north of Lake Okeechobee? Given the spotty distribution of the species south of the Lake, this might provide a slightly more conservative estimate than including all potential habitat.

Under the Listing recommendation section:

- Since FWC staff concede that there will be continued declines in Florida pine snake populations, it seems irresponsible to cite the "lack of sufficient data to predict the magnitude of the declines" as a justification for delisting. In my opinion, data in the review suggest that the species should remain listed as threatened until we have data on the magnitude of the declines. We have information that indicates that snake populations can decline rapidly (e.g., southern hognose, eastern king snake in portions of Florida, and Florida pine snakes at Ordway Preserve) and that some populations have declined on protected areas (king snakes on Paynes Prairie State Preserve and the Savannah River Site, Florida pine snakes on the Ordway Preserve). I think the species warrants continued protection as a threatened species in Florida.

- Given projections for state budget shortfalls in Florida (and at the federal level), how likely is it that land management funds will remain stable? Also, if in fact, only 54% of state managed land fell within the recommended fire return interval in 2009 and 2010, this cannot bode well for sandhill specialists like the Florida pine snake.

Thank you for the opportunity to provide comments on the review.

Sincerely,

Lora L. Smith, Ph.D.
Associate Scientist
Joseph W. Jones Ecological Research Center
3988 Jones Center Drive
Newton, GA 39870
lora.smith@jonesctr.org

Peer review #3 from Dr. Robert Zappalorti

From: RZappalort@aol.com
To: Imperiled
Cc: lrfranz08@gmail.com; mmccort@herpetologicalassociates.com; lsmith@jonesctr.org; gabriel.miller@myfwc.com
Subject: Re: Re: Florida Pine Snake - a Vulnerable, Species of Special Concern
Date: Thursday, January 27, 2011 6:13:21 PM
Attachments: RTZ"s Florida Pine Snake Review Comments to FWC 2011.pdf
RTZ"s Florida Pine Snake Review Comments to FWC 2011.wpd

Elsa M. Haubold, Ph.D.
Leader, Species Conservation Planning Section
and Caly Murphy, Assistant Listed Species Coordinator
Florida Fish and Wildlife Conservation Commission
620 S. Meridian Street, MS:2A,
Tallahassee, Florida 32399-1600

Dear Dr. Haubold and Ms. Murphy:

Attached please find my comments and suggestion for the Biological Status Review of the Florida Pine Snake. It is in Word Perfect and PDF format. I do not use Word, but the Word Perfect file will open as a Word document. I hope the FWC finds my suggestions and recommendations informative and useful.

Thanks for the opportunity to comment on this important issue.

Sincerely,

Robert T. Zappalorti
Executive Director/President
HERPETOLOGICAL ASSOCIATES, INC.
575 Toms River Road, Route 571
Jackson, New Jersey 08527

Herpetological Associates, Inc. - Environmental Consultants
- Plant and Wildlife Specialists -
Phone: 732- 833-8600 Fax: 732-928-9257; E-mail: RZappalort@aol.com
575 Toms River Road Jackson, New Jersey 08527

January 26, 2011

Elsa M. Haubold, Ph.D.
Leader, Species Conservation Planning Section
and **Caly Murphy**, Assistant Listed Species Coordinator
Florida Fish and Wildlife Conservation Commission 620 S. Meridian Street, MS:2A, Tallahassee, Florida 32399-1600

Re: Florida Pine Snake - a Vulnerable, Species of Special Concern.

Dear Dr. Haubold and Ms. Murphy:

I'm writing this letter in support of the recommendation made by the Biological Review Group members: Kevin Enge, Steve Johnson, Richard Owen, Thomas Ostertag and David Printiss, to keep the Florida pine snake (*Pituophis melanoleucus mugitus*), as a "Species of Special Concern," because I disagree with the Florida Fish and Wildlife Conservation Commission's decision to remove it from the state list of vulnerable species. There are several reasons for my objections to remove it which are detailed below. I argue herewith, that not only should the snake remain on Florida's "Species of Special Concern" list, but my personal observations suggest that the species may actually be on the decline throughout its known range in Florida.

My Background and Qualifications

While most of my research deals with northern herpetological species, I have 20-years of experience observing Florida's herpetofauna as well. I, along with several colleagues such as, Joanna Burger, PhD, Rutgers University; Michael Gochfeld (PhD, MD- UMDNJ-Robert Wood Johnson Medical School); Howard K. Reinert, PhD, College of New Jersey; Michael Torocco, MS, PA Regional Manager, Herpetological Associates, Inc. (hereafter HA); Dave Schneider, Southern NJ Regional Manager, HA; Matthew McCort, Northern NJ Regional Manager, HA; have studied the ecology and behavior of snakes in general and the northern pine snake in particular over the past 35-years.

Additionally, I have studied the Florida pine snake for the past 15-years. I lived in Marion County, Florida between 2004 - 2010, and observed Florida pine snakes and eastern indigo snakes (*Drymarchon couperi*), both live and road killed, in several Florida counties (e.g., Citrus, Franklin, Gulf, Hernando, Highlands, Leon, Marion, Polk, and Wakulla).

Between 1974 and 1977, I served as Associate Curator of Herpetology and Education, at the Staten Island Zoological Society in New York. The responsibilities of this position included curatorial administration, in-house lecturing, teaching, scientific and popular writing, herpetological research, inventory of zoo specimens, zoo exhibit planning, assist zoo veterinarian with animal care, scientific collection, public relations, education programs, film-making and wildlife photography. Between 1964 and 1974, I was a Reptile Keeper at the Staten Island Zoo and reported directly to my mentor, the late Carl F. Kauffeld, Zoo Director and Curator of Reptiles.

In 1977, I founded Herpetological Associates, Inc. (HA), an environmental consulting company that specializes in the conservation biology of threatened and endangered plants and wildlife species. HA also conducts environmental monitoring, wildlife assessments, habitat evaluations and designs management plans for plants and wildlife. We also conduct adverse impact analysis, assess development projects and design mitigation plans. I and my staff have conducted over 350 herpetological surveys for a variety of clients and sometimes provided expert testimony.

I have authored or co-authored 36 peer reviewed publications. I'm also a published wildlife photographer. Many of my photographs have appeared in books and magazines, including Florida Wildlife Magazine and National Geographic. I have served as a consultant to the Endangered and Nongame Species Program, Division of Fish and Wildlife (NJDEP), the Division of Coastal Resources, the New Jersey Pinelands Commission, the Trust for Public Land, the Pinelands Preservation Alliance, the NJ Conservation Foundation and The Nature Conservancy.

I have been invited to lecture and be a guest speaker at numerous museums, zoos and universities from 1964 to 2010 such as: All Florida HERP Conference, Gainesville, Florida, Taiwan Normal University - Republic of China, New York University, Trenton State College, University of Western North Carolina, Rutgers University, Trenton State Museum, Morris Museum, Staten Island Museum, Staten Island Zoo, Philadelphia Zoo, Atlanta Zoo, Taipei Zoo, Taiwan, Republic of China, New Jersey Audubon Society, National Audubon Society, New York Herpetological Society, Connecticut Herpetological Society, Florida Herpetological Society, Georgia Herpetological Society, North Carolina Herpetological Society, All Florida Herpetological Conference, The Nature Conservancy, the Society for the Study of Amphibians and Reptiles (SSAR), the University of Georgia - Savanna River Ecology Laboratory Site (SREL) and the National Zoo, Washington, D.C.

I am a "Life Member" of the New Jersey Academy of Science, the SSAR and the Gopher Tortoise Council. I'm also listed as a "Qualified Bog Turtle Surveyor and Trapper" by the US Fish and Wildlife Service.

Specific Northern Pine Snake Research

While working at the Staten Island Zoo, my colleagues and I began studies on the pine snake in New Jersey (see: Zappalorti, R.T., E.W. Johnson, and Z. Leszczynski 1983. The Ecology of the Northern Pine Snake (*Pituophis melanoleucus*), (Daudin - Reptilia, Serpentes, Colubridae), in Southern New Jersey, with special notes on habitat and nesting behavior. Bulletin, Chicago Herpetological Society 18:57-72). I also co-authored a preliminary management plan for pine snakes for the NJDEP, Division of Fish and Wildlife (Frier and Zappalorti 1983, Zappalorti and Golden 2006). Additionally, I have observed pine snakes throughout their range in the eastern United States, which includes North Carolina, South Carolina, Georgia and Florida.

In 1985 I began collaborating with Dr. Joanna Burger, and together we have studied and published northern pine snakes papers ever since (1986 to 2011). Our studies were conducted both in the laboratory and the field. Jointly, we have internationally published more scientific papers on the northern pine snake than any other person or group (see the bibliography in this document). Dr. Burger and I have studied habitat use, mating, nesting behavior, movements and home range, hibernation behavior and the effect of incubation temperature on egg/neonate development, among several other topics. We have studied their behavior and ecology on private non-profit wildlife sanctuaries and on state protected lands. Our hibernation research on northern pine snakes is probably the longest continuous snake study in the U.S. We, and colleagues, have monitored the same hibernacula since 1986, which continues today. Therefore, I feel qualified to comment upon and make recommendations to the FWC on the status of the Florida pine snake.

Introduction

The Biological Review Group (BRG), members concluded that the Florida pine snake met sub-criterion A3 (A population size reduction of at least 30% projected or suspected to be met within the next 3 generations). The BRG projected a population size reduction of at least 30% in Florida pine snake populations within the next 3 generations (24 years), based upon: a projected 32% increase in Florida's human population by 2035, with only 24 % of the pine snake's potential habitat being on public conservation lands, altered fire regimes on public and private lands, a continuing backlog of fire-suppressed habitats, suspected population declines in pocket gopher populations, and the species' susceptibility to habitat fragmentation and residential development (i.e., mortality from vehicles, landowners and pets). However, after careful consideration and deliberation, FWC staff did not agree with the BRG member's information which supports a 30% projected decline in Florida pine snake populations over the next 24 years. Furthermore, the FWC went ahead and recommended delisting the Florida pine snake. I'm in agreement with the recommendations of the BRG to keep the Florida pine snake (*Pituophis melanoleucus mugitus*), as a "Species of Special Concern." I strongly disagree with the Florida Fish and Wildlife Conservation Commission's preliminary decision to remove it from the state list of vulnerable species because of the following reasons.

Reasons for Florida Pine Snake Declines

The Florida Fish and Wildlife Conservation Commission (hereafter FWC), suggested that there is ample habitat available on protected public and NGO lands for the Florida pine snake population to survive. In spite of all the protected lands in Florida, based upon my observations the Florida pine snake population has declined in some highly developed areas and/or in disturbed habitat types over the past 15-years. Especially in the eastern Panhandle (Tallahassee -

Jacksonville regions), in the central region (Gainesville - Ocala regions), and the south-central Lake Wales Ridge in the Florida Peninsula.

There are many reasons for pine snake declines throughout the historic and current known range (Conant and Collins 1991). However, the FWC suggests that Florida has plenty of large tracts of suitable public land throughout the state. While some of these public lands already have known pine snake populations, other large tracts of federal and/or state lands only have small, relict populations or may lack pine snakes altogether. Why do large upland forest areas such as Apalachicola National Forest, Tate's Hell WMA, Osceola National Forest and WMA, and portions of Ocala National Forest appear to only have minimal Florida pine snake populations?

These public lands are managed by prescribed burning for longleaf pine forest to some degree, are large enough, have suitable forest types and habitat structure, have ample prey resources and limited fragmentation by roads and highways. Does this paucity of viable Florida pine snake populations in certain areas suggest that purchasing, protecting and managing habitat by prescribed burning may not be enough to ensure the long-term survival of the species? While I agree that more habitat management is needed on existing protected lands, it is not clear why some Florida pine snake populations have gradually declined.

Case in point, several HA staff members and I have been spending an average of one to two-weeks a year in the Apalachicola National Forest area, usually in April or May. HA's field survey teams were able to locate, capture, observe or photograph a total of **89** species and sub-species of amphibians and reptiles over the 23-year study period (i.e., American alligator, 14 species of turtles, 8 forms of lizards, 38 kinds of snakes, 8 types of salamanders and 20 species of frogs and toads). Even though HA knows how to find snakes in general and pine snakes in particular (Zappalorti and Torocco 2002), we have only found 21 live Florida pine snakes, 3 DOR's and one shed skin in the Apalachicola National Forest, Tate's Hell WMA, and/or at TNC's Apalachicola Bluffs and Ravines Preserve over the past 23-years (see **Table 1**).

According to Franz (2005) and Miller (2008), Florida pine snakes are fossorial, spending much of their time in underground retreats, primarily in the tunnels and burrows of the southeastern pocket gopher (*Geomys pinetis*). This could be a possible reason why they are not more frequently detected in their habitat, but if there is a viable population in a forest area, specimens should be observed basking in the morning by experienced field herpetologists. Pine snakes are large diurnal serpents and spend the early morning basking and the rest of the day foraging on the surface or in stump-holes, in mammal burrows or their tunnels. Just like indigo snakes, they shed their skin on the surface, so shed skins should be found in areas where there is suitable habitat for pine snakes. Pine snakes often use old tree stump holes as refugia (Burger et al 1988).

Table 1. Herpetological Associates Florida Pine Snake Observations over a 13-Year period from Various Counties in Florida (* Indicates that a Photo is Available**).**

Date	County	Snake's Activity	Alive	Dead on Road	Number of Snakes
March 1997	Wakulla	_ Crawling	1*	---	1
April 2000	Polk	n/a	---	1 _	1
April 2000	Highlands	_ Concealed	1*	---	1
May 2002	Franklin	n/a	---	1 _	1
April 2004	Marion	_ Crawling	1*	---	1
June 2005	Marion	n/a	---	1 _	1
May 2008	Citrus	_ Shed Skin	1	---	1
May 2008	Liberty	n/a	---	1 _	1
September 2008	Hernando	_ Partially Concealed	1*	---	1
April 2009	Liberty	_ Arrested Crawl	1*	---	1
April 2009	Liberty	Shed Skin	1	---	1
May 2010	Liberty	n/a	---	1_	1
June 2010	Citrus	n/a	---	1_	1
	8		**7**	**6**	**13** Pine Snakes or their sign

Among the threats to pine snakes in Florida are habitat loss and fragmentation from commercial and residential development, but silviculture, agriculture and mining should not be ignored as additional threats. Longleaf pine-dominated sandhill, scrub pine-oak habitat on the ridges of central Florida, and along both coasts have also suffered serious habitat losses (Means and Grow 1985, Myers 1990, Kautz 1998, Enge et al. 2003).

The historic information provided by the Biological Review Group was very interesting and should provide some valuable insight for the FWC staff. They point out that: "Pine snakes once occurred along the Atlantic Coastal Ridge as far south as Miami (Duellman and Schwartz 1958, Florida Museum of Natural History record from 1980), but urban development in southeastern Florida might have eliminated populations south of Martin County (museum and FNAI records)."

I also agree with the BRG when they state: "Altered fire regime in sandhill habitat and resulting hardwood encroachment presumably creates less favorable habitat conditions for pine snakes." While pine snake populations can coexist with some agricultural development, they do not do well in tree farm pine plantations because of the monotypic conditions and removal of tree stumps. On the other hand, pine snakes thrive in abandoned grassy fields where they find cover from the grasses and ample small mammal prey (Zappalorti, personal observations). I also agree with the BRG, when they state that: "Stumpwood removal may affect pine snake subpopulations by decreasing underground habitat structure (Means 2005); this may be particularly detrimental in areas where pocket gophers are absent."

Comments About Quantitative Analyses

The Biological Review Group and the FWC used two population viability analysis models for the Florida pine snake (Root and Barnes 2005). One model considered "all potential habitat identified," and the other model only used "potential habitat occurring on conservation lands." Under the baseline parameters, the FWC concluded that there was 0% risk of extinction and/or a 20% population decline over the next 24-years for both models.

I'm troubled by depending upon "models" to predict the theoretical survival of a large, top predator snake species. The problem with using models is the mathematics depends upon arbitrary numbers, formulas or assumptions which are not true to real life conditions that the Florida pine snake populations face daily within their natural habitat. In other words, the baseline parameters of the mathematical models do not account for all the combined threats, both natural and anthropogenic, in the formulas. The models depend upon theoretic abundance set at a hypothetical 0.2 individuals occurring per hectare, and a distance of 1.2 km set to identify discrete populations, thus producing an estimate of 495 populations for the "conservation lands model," and an estimate of 343 populations for the "all potential habitat model."

The "conservation lands model," theoretically had more populations because the "all potential habitat identified lands" were fragmented by road boundaries and development, instead of being connected by corridors or protected habitats. It is likely that more pine snakes will survive on larger tracts of protected sandhill forests, than on un-managed, fragmented poor habitats on private, unprotected lands. However, this would only be true if the protected land were properly managed and free of paved, gravel or sand roads and had minimal human disturbances. The other thing that the models do not consider, or take into account, is the large seasonal home ranges that pine snakes are known to have (**Table 2**).

Based upon data from a 2009 radio-tracking study of 20 adult pine snakes, home ranges in the New Jersey Pine Barrens varied from 71-acres to 967-acres. The greatest distance between any two of the tracking points was about 5-kilometers (3-miles), with an average distance of 2.3-kilometers (standard error of 2.4 km, Zappalorti et al. 2009). This means that in the normal course of radio-tracking pine snakes for one year, no snake was found more than about 5-kilometers away from any other location within its seasonal home range. In other words, an adult pine snake may not move more than 5-kilometers from any point within its seasonal activity home range. Most pine snakes tended to avoid unsuitable, highly developed land, especially if they had to cross paved roads. These observations are similar to those made with bull snakes (*Pituophis catenifer sayi*, Kapfer et al 2010).

Likewise, HA collected activity home range data on 16 of the same radio-tracked northern pine snakes in 2010. The size of pine snake seasonal activities ranged from 69.52-acres to 1104.99-acres (91.35-hectares to 407.77-hectares). Of the 16 radio-tracked pine snakes, 11 had home ranges greater than 100-hectares, whereas four snakes from the sample had home ranges larger than 200-hectares. One adult male had a home range of 407.77-hectares (see **Table 2** below).

By extrapolating the home range size of northern pine snakes, and comparing it with the Florida pine snake results of Franz (2001 and 2005) and Miller et al (2008), one can see that pine snakes need large tracts of undisturbed natural habitat in which to thrive and survive (Zappalorti et al 2009 and 2010). In reality, there are very few protected federal, state or NGO lands in Florida, where large populations of Florida pine snakes occur, that are undisturbed, have properly managed sandhill and/or grassland habitats, are free of paved or gravel roads, and have minimal human disturbances. Eglin Air Force Base, the Nokuse Plantation, TNC's Apalachicola Bluffs and Ravines Preserve, and the Joseph W. Jones Ecological Research Center, in Newton, Georgia are all good examples of highly suitable Florida pine snake habitat.

Table 2. Minimum Convex Polygon (MCP) in Acres and Hectares and Kernel Activity Range (Both 50% and 90 % Isopleth) Home Range Sizes for 16 Radio-tracked Northern Pine Snakes in the New Jersey Pine Barrens in 2010.

HA Snake Field ID Number	Sex	Number of Relocations	Minimum Convex Polygon		50% Kernel Home Range Isopleth		90% Kernel Home Range Isopleth	
			Acres	Hectares	Acres	Hectares	Acres	Hectares
2006.08	F	53	291.40	117.93	104.06	42.11	449.78	182.02
2006.16	M	66	302.29	122.33	194.91	78.88	607.52	245.85
2006.19	F	55	69.52	28.13	66.75	27.01	225.73	91.35
2006.29	F	40	583.95	236.31	265.10	107.28	874.46	353.88
2006.34	M	50	311.67	126.13	120.47	48.75	469.43	189.97
2006.41	M	32	88.48	35.81	87.93	35.58	289.48	117.15
2006.108	M	51	299.60	121.24	153.44	62.09	517.69	209.50
2007.05	F	28	55.77	22.57	74.80	30.27	266.18	107.72
2007.07	F	59	511.66	207.06	196.73	79.61	705.02	285.31
2007.09	M	31	684.12	276.85	226.49	91.66	719.27	291.08
2007.10	M	59	201.57	81.57	87.56	35.43	348.50	141.03
2007.11	M	69	307.22	124.33	174.42	70.59	513.68	207.88
2007.14	M	61	473.34	191.55	182.45	73.83	638.18	258.26
2008.02	M	33	1104.99	447.17	250.53	101.39	1007.61	407.77
2008.03	F	59	350.31	141.76	133.93	54.20	502.24	203.25
2009.13	M	55	114.81	46.46	107.22	43.39	353.17	142.92
N=16	**6m:10f**							

Most federal and state lands are multi-human use habitats that are crisscrossed with paved and sand roads for a variety of commercial and public uses (e.g., tree farming and harvesting, stump removal, camping, horse-back riding, cattle grazing, hunting, fishing and off road vehicle use). These many land use activities inadvertently kill Florida pine snakes (and many other reptiles and amphibians). While these multi-human commercial and recreational activities are all necessary and legitimate uses of public lands, the direct and secondary adverse impacts upon snakes and other wildlife is often ignored by fish and game, and forest timber managers (Gibbons et al 2000). These combined human use impacts, in conjunction with natural predators, directly effect Florida pine snake populations along with many other species of reptiles and amphibians (Cox and Kautz 2000, Golden et al 2009, Burger and Zappalorti 2011). Another model formula that was used to predict Florida pine snake survival rates was set at 50% for juveniles and 65% for adults. Additionally, the fecundity for adults was set at 0.83, which is one-half of the average clutch size (5.6 eggs), multiplied by 85% of the female population breeding annually, and multiplied by a 35% survival rate of eggs to Year 1. This information produced a population growth rate of 1.0465. Once again this is all speculation based upon model formulas.

In my opinion, these predicted population estimates are to high. There have been very few studies done on the survival rate of hatchling snakes. The one that is available shows a 60% loss of hatchling within their first year of life (Fukada 1978 and 1960). Along with Joanna Burger, we have documented the loss of free-roaming hatchling, juvenile and adult northern pine snakes from the New Jersey Pine Barrens from various causes over a 45-year period as shown in **Table 3** below.

The Biological Review Group members calculated that Florida pine snakes will decline by 30% in Florida over the next 24-years. In contrast, the FWC concluded that the decline would only be 20%. I suggest that even a 20% decline in the Florida pine snakes population is too much of a loss. Shouldn’t all of the known obvious, and subtle combined threats be considered when removing a protected species from a state’s list? Many scientists have warned that the main threats to wildlife biodiversity in general is critical habitat loss, coupled with fragmentation, degradation, wonton killing, natural predation and road kills (Wilcove et al., 1998, Cox and Kautz 2000, Golden et al 2009, Zappalorti et al 2008, 2009, and 2010, Burger and Zappalorti 2011).

Reptiles, as a group have been largely ignored in conservation biology (Gibbons et al., 2000), yet they are strongly affected by habitat loss. Franz (1992 and 2005) suggested that Florida pine snake populations are declining, and felt that habitat loss was the most likely factor. **Table 3** below, shows many of the reasons why Florida pine snakes could be killed in the wild (Burger and Zappalorti 2011, Zappalorti, personal observations and **Table 1**).

Back in the late 1970's, 1980's, 1990's and 2000's eras, I have personally seen the loss of critical pine snake habitat throughout many counties in Florida. As an example of pine snake decline in the wild, HA is currently conducting a long-term study in Ocean County, New Jersey (Portions of **Table 3** are based on this study). In the Fall of 2006, HA had 40 adult pine snakes (26 shifted within their natural habitat and 14 non-shifted specimens from the same population). Each snake was injected with a micro-chip (Pit Tag) and surgically fitted with a radio-transmitter for identification and long-term monitoring purposes (Reinert and Cundall 1986, Reinert 1992).

Table 3. Predation and Causes of Death to Pine Snakes in New Jersey (after Burger et al. 1988, 2007, Burger and Zappalorti 2011, and Zappalorti, unpublished data). For snakes that were killed by predators on the forest surface, the number of confirmed kills by bird and mammal predators are given (Predation on hibernacula, nests or snakes [a]).

Cause of Death or Types of Predation	Snakes in Winter Dens	Snakes or Eggs in Nest Chambers	Snakes on Surface
Years of Observations	**1986 - 2000**	**1976 - 1991**	**1965 - 2010**
Number of years studied	**20**	**15**	**45**
Scarlet snake (*Cemophora coccinea*)	0	2	0
Eastern Kingsnake (*Lampropeltis getula*)	0	1	2
Short-tailed shrew (*Blarina brevicauda*)	2	0	0
Eastern Coyote (*Canis latrans var*)	1	8	10
Striped skunk (*Mephitis mephitis*)	4	1	0
Red fox (*Vulpes fulva*)	2	10	2
Red squirrel (*Tamiasciurus hudsonicus*)	1	0	1
Red-Tailed Hawk (*Buteo jamaicensis*)	0	0	12
Human Poaching	43	80	---
Sand Road Kills	---	---	4
Paved Road Kills	---	---	180
Off-road Vehicles in Nesting Areas	---	10	---
Number of Nests Churned-Up	---	37	---
Forest Fire	1	---	6
14	**54**	**149**	**217 (n - 420)**

a = A hibernacula could have been destroyed one year by predators, and then used by snakes in subsequent years.

The radio-tracking study began with 40 snakes in the Spring of 2007. By the Fall of the 2007 field season, 13 were dead from various causes and 27 snakes remained alive. In the Spring of 2008, one new snake was added to the sample to compensate for mortality suffered the previous season, so 28 adult pine snakes were radio-tracked. By the end of the 2008 field season, 4 more were dead from various causes and 24 remained alive. In the Spring of 2009, one new snake was added and 25 adult pine snakes were radio-tracked. By the end of the 2009 field season, 6 more snakes were dead from various causes and one had gone missing, while 18 remained alive. Finally, by the end of our radio-tracking study in 2010, only 16 pine snakes remained alive. Over a 5-year monitoring period, 27 free-roaming pine snakes from one population were lost from predation, road kill and other causes. **Table 3** above shows the various causes of pine snake mortality in their natural habitat.

If a decline of 27 adults from one monitored pine snake population is used as an example, this loss could be magnified to other pine snake meta-populations throughout the New Jersey Pine Barrens. Clearly, there are many combinations of threats which affect the overall abundance and survivorship of pine snakes in southern New Jersey. Then the FWC could extrapolate these combined threats and conditions to the state of Florida, where there are even more snake predators and a much larger human population. Based upon the 2009 U. S. Census Bureau data for Florida, the human population is 18,537,969 people, therefore the threats to wildlife in general and the Florida pine snakes in particular, are much more significant. With all the habitat loss, an increased human population and even more natural predators, this leads to a reduced population scenario for Florida pine snakes. Thousands of acres of important sandhill habitat have already been lost over the past 35-years from various and numerous development projects and new highway construction.

It is my opinion that the FWC should consider the combined increase of some mammalian predators such as black bear, coyote, fox, skunk, nine-banded armadillo, feral hogs, dogs and cats. Additionally, indigo snakes, king snakes, black racers, coachwhips and scarlet snakes are all predators to Florida pine snakes (or their eggs), especially hatchlings in their natural habitat (Burger et al 1992, Burger and Zappalorti 2011, Zappalorti, personal observations). Then add the increasing problem of fire ants to the list of predators upon egg-laying snakes and other reptiles. Fire ants attack and kill snakes or other egg-laying reptiles and birds when they are hatching.

Additionally, most adult people drive motor vehicles and ATV's, on paved or dirt roads causing snake and wildlife mortality (Andrews and Gibbons 2005, 2006 and 2009). Finally, illegal collection of Florida pine snakes for the pet market should be added to the negative impacts; therefore one can see that the future is not bright for the Florida pine snake, or other rare wildlife species in Florida (Dodd and Seigel 1991; Himes et al, 2006, Wilcove et al., 1998, Cox and Kautz 2000, Golden et al 2009, Zappalorti et al 2008, 2009, and 2010, Burger and Zappalorti 2011).

Listing Recommendation

The FWC staff, considered the Biological Review Group's findings and assumptions for the criterion of A3, but could not project a 30% decline in Florida pine snakes in the next 24 years. Instead, the FWC calculated that Florida pine snakes would only decline by 20% in Florida over the next three generations and found this loss acceptable. I suggest that even a 20% decline in the Florida pine snakes population is too much of a loss. Just because the initial projections of increases in Florida's human population by Zwick and Carr (2006) have not been met, there are still 18,537,969 people living in the state of Florida. Without being listed, or not having proper habitat protection and specific management plan, and with that many humans living in the state, Florida pine snake populations are destined to dwindle.

Another major contributing problem and cause of pine snake declines in Florida is highway and road mortality (e.g., Florida Turnpike, I-95, I-75, I-275, I-10, I-4, SR-19 and the Suncoast Parkway) along with other state and county roads inadvertently kill snakes and other wildlife. I have personally found 6 dead on road (DOR) Florida pine snake since 1997 (**Table 1**). Some drivers go out of their way to run over snakes. There are many new roads being built to accommodate new residential and commercial developments throughout the state of Florida. Moreover, there are more cars and trucks on older existing paved roads.

There is also a movement in many rural townships to pave old railroad right-of-ways, sand roads and/or horse trails, which would only serve to increase DOR snakes as they attempt to cross these roads while moving about within their seasonal home range. Paved roads also cause fragmentation of important pine snake habitat and tend to isolate their meta-populations (Fitch 1949; Kauffeld 1957; Rudolph and Burgdorf 1997; Rudolph et al. 1998; and Andrews et al., 2006, 2007 and 2009).

As a conservationist, I wonder how the FWC can accept even a 20% loss of the Florida pine snake population, while knowing there are insufficient data to predict the magnitude of the decline? Florida pine snakes (and many other rare species), suffer from habitat loss and fragmentation due to human population increases along with many other threats to its survival. In contrast, I strongly recommend that the Florida pine snake should be kept as a "Species of Special Concern." Additionally, more research should be done on this species in order to better understand its current distribution, learn what the true population size is, identify the locations of population strongholds, and what the reproductive status is in areas that have highly suitable habitat.

Discussion

I truly believe that the Florida pine snake is not a common species in its selected upland sandy habitat. Archie Carr (1940), considered the Florida pine snake to be "not common." Dick Franz (1992), claimed that some herpetologists thought that pine snakes had seriously declined in the last 20-years. Even the FWC knows that there are "no quantitative studies of population trends for this species."

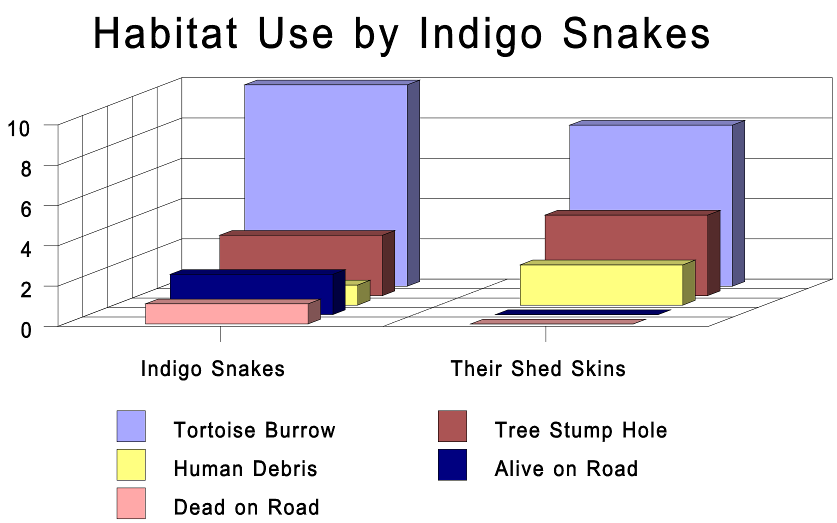
As an example, snake studies at the Ordway-Swisher Biological Station in Putnam County, documented 16 adult Florida pine snakes found between 1983 and 1991. However, only 4 more pine snakes have been found since then, thus suggesting a major decline in the population. Dick Franz (2005), suggested the decline was possibly related to a series of severe regional droughts, but pine snakes are efficient burrowers and are highly adapted to long-term dry conditions. Their western relatives, bull snakes (*Pituophis catenifer sayi*), live in dry prairies and deserts, so I disagree that drought was the cause of the Florida pine snake decline at Ordway.

Combined, there are 464 confirmed Florida pine snake records from museum collections, the Florida Natural Areas Inventory, and from the literature of which 295 are historic records. There are105 records from the 1990's era and only 64 are from the 2000's era, which suggests a noticeable decline. The FWC staff suggested that Florida pine snakes are probably more common than observational data suggest, because they spend about 80% of their time underground (Franz 2005). However this important survival behavior has no bearing on how common they really are in their habitat. Remaining underground just demonstrates how pine snakes avoid excessive heat and predators.

While Florida pine snakes may spend a good portion of their active season hidden underground, in contrast 16 radio-tracked northern pine snakes were observed 993 times at active season relocation points. These 16 pine snakes were observed underground only 36% of the time. The same snakes were observed concealed under surface objects (e.g., hollow logs, leaf litter and human debris), at 26% of their relocations. Whereas 38% of all other relocations were of pine snakes visible on the surface in the process of foraging, eating, drinking, basking, mating, shedding and/or resting (Zappalorti et al 2008, 2009, and 2010, Burger and Zappalorti 2011).

The FWC staff also argued that "if enough time is spent in the field or driving roads in suitable habitat, pine snakes are often detected." As an example, they used 20 pine snake records from Eglin Air Force Base collected between 1993 and 1998 (Printiss and Hipes 1999). The reason so many pine snakes were seen at Eglin Air Force Base is because it happens to be one of the largest tracts of suitable habitat which is ideal for pine snakes and other wildlife. Eglin AFB covers 464,000-acres in Santa Rosa, Okaloosa, and Walton counties. It is also contiguous with the 55,000-acre Nokuse Plantation, which also has a Florida pine snake population. Therefore it's a poor example and unfair for the FWC staff to compare Eglin's habitat conditions with other large tracts of land elsewhere in Florida that does not have the same habitat conditions. Additionally, much of Eglin is closed to the general public and the roads are clearly less traveled than some of FWC's wildlife management hunting areas.

An appropriate example of suitable Florida pine snake habitat is the 49,000-acre Citrus Tract of the Withlacoochee State Forest. The combined size of all its holdings is 157,315-acres. The forest is managed for longleaf pine and wire grass with frequent prescribed fires. Both Florida pine snakes and indigo snakes have been confirmed within the Withlacoochee State Forest by the FWC and by my colleagues and I. Between 2004 and 2010, my colleagues and I spent over 2,500 person hours searching for indigo snakes, which included random opportunistic searching and road cruising. This effort resulted in sighting 31 indigo snakes and/or their sign. This includes indigo snake shed skins counted within 5-meters of a gopher tortoise burrow or stump hole (**Figure 1**). Even though we spent 2,500-person hours searching for snakes, we only captured or observed 3 Florida pine snakes during the same study. Why? Are indigo snakes more common than Florida pine snakes? Are indigo snakes, mammals and birds of prey killing and eating pine snakes? In my opinion, these questions should be answered before removing Florida pine snakes from the "Species of Special Concern" list.


Habitat Use by Indigo Snakes
10
8
6
4
2
0
Indigo Snakes
Their Shed Skins
Tortoise Burrow
Tree Stump Hole
Human Debris
Alive on Road
Dead on Road

Summary

How can the FWC accept even a 20% to 30% loss of the Florida pine snake population along with the loss and fragmentation of their habitat due to human population increases, while knowing there are insufficient data to predict the magnitude of the decline? In my opinion, the FWC does not have enough scientific evidence to delist the Florida pine snake at this time.

In contrast, I strongly recommend that the Florida pine snake should remain listed as a "Species of Special Concern" in the state of Florida. Additionally, more research should be done on this species in order to better understand its true population size and status in areas that have suitable habitat. If it is delisted, the constant loss of critical habitat and road mortality will be the main causes for the Florida pine snake population's decline.

Thank you for the opportunity to comment on this important conservation issue. If you have any questions, or need additional information, please do not hesitate to call upon me.

Sincerely yours,

Robert T. Zappalorti
Executive Director/President

HERPETOLOGICAL ASSOCIATES, INC.

c:
- Joanna Burger, Rutgers University
- Howard Reinert, College of NJ
- Walter Bien, Drexel University
- Dave Schneider, HA
- Matt McCort, HA
- Mike Torocco, HA

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Peer review #4 from Gabe Miller

Sent: Monday, February 14, 2011 2:02 PM
To: Imperiled
Subject: Opinion on Listing Recommendation for Florida Pine Snake_Gabe Miller

I have attached a Word document providing my opinions on the listing recommendations set forth for Florida Pine Snakes.

Gabe Miller
Wildlife Biologist/Project Coordinator
Dept. of Land and Environment
Prairie Island Indian Community
5636 Sturgeon Lake Rd, Welch, MN 55089

Opinion on Listing Recommendation for Florida Pine Snakes: Florida's Imperiled Species

The Biological Review Group determined that Florida Pine snakes qualify to be listed as a threatened species in Florida under sub-criterion A3 of the new listing criteria. However, decision makers have decided, based on speculation and conjecture, to delist Florida Pine Snakes despite the evidence presented by the Biological review Group based on the scientific method. I disagree with the decision to delist Florida Pine Snakes given the reasons implied in the Listing Recommendations section of the Biological Status Review.

My first reason for favoring listing is in regards to the population assessment data. Florida pine snakes are a tricky species to attempt estimates of populations due to their secretive nature and the lack of real data on survival rates of the various life stages. It was not clear (I could not find a section on Florida Pine Snakes in Root and Barne, 2005) if the numbers from the quantitative analyses section in the Biological Status Review were based on real data or if the numbers used were a "best- guess" of the true survival of the whole Florida population? Predators, fire ants, anthropogenic factors (land development, road mortality, etc.), and other causes may be taking a larger toll than what was implied in this analysis? Lack of real data and using best-guess numbers, even conservative ones, may lead us to a false conclusion about true survivorship. I believe there may be too much potential error in trusting such numbers. Due to a lack of objective data in the population assessment, it can be argued either way whether or not to list a species; the most responsible and ethical choice in this debate would be to err on the side of caution and retain listing the species.

Florida Pine Snakes exhibit some specialist tendencies such as high use of underground refugia (~80% of time), structures that typically exist in minimally-disturbed settings and are virtually absent in developed areas. Telemetry data suggested avoidance of highly disturbed/developed areas (paved roads and rights-of-way, center-pivot irrigated agricultural fields, urban centers), preferring native landscapes, and naturalized disturbed areas harboring these resources. Also, Florida Pine Snakes only occur in sandhill uplands, habitats most desirable for and at highest risk of land development (we know this to be very true in Florida). Specialist species require special attention and Florida Pine Snakes fall under this categorization. I would argue the potential detriment to this species if delisting occurs based on conjecture and we find ourselves in the future in need of immediate action to save the species, which would be more expensive and laborious than taking preventative measures now to ensure perpetuation.

I would also like to specifically address the speculative arguments made in favor of delisting:

1. **Human population in Florida is not increasing to the projected 32% by 2035**: population growth may have slowed, but may resurge in the near future due to economic upturn or other factors.
2. **Not enough data on future loss of habitat from development**: lack of data should assert even more impetus on the need to preserve a high risk habitat expected to be at an increased risk of development especially when considering the needs of a specialist species!
3. **Fire backlog**: though staff believes the backlog is not as severe as initially thought, it can be argued that, due to future budgetary constraints, burning frequency may decrease and therefore, the increase the burning backlog.

In conclusion, I reiterate that I do not agree with the decision to delist Florida Pine Snakes, but agree with the original Biological Review Group decision to maintain a listing of threatened under their conclusions provided in sub-criterion A3. It is agreed that the species is and will continue declining (as it is even accepted by those who favor delisting), but to choose to delist based on the debate of a specific reduction % that was calculated from dubious numbers and speculation is risky. I suggest a more cautious approach in favor of the species; as a decline in Florida Pine Snakes is accepted and the decision of listing incites debate, I favor listing the species as Threatened in the state of Florida until ample data deems otherwise.

Thank you for the opportunity to evaluate this review. I hope that my comments will convince you of the need for Florida Pine Snakes to remain on Florida's list of threatened species.

Sincerely,

Gabriel J. Miller
Wildlife Biologist/Conservation Coordinator
Prairie Island Indian Community
5636 Sturgeon Lake Rd
Welch, MN 55089

Letters and emails received during the solicitation of information from the public period of September 17, 2010 through November 1, 2010

Email from Mark Fredlake

From: Fredlake Mark J Civ 23 WG DET 1 OL A/CEVN
To: Imperiled
Subject: Surveys of Sensitive Species on Avon Park Air Force Range: Sherma n"s fox squirrel, gopher frog, Florida mouse, Florida pine snake, Burrowi ng owl, etc.
Date: Monday, November 01, 2010 3:35:56 PM
Attachments: CHAP_7_APAFR_TortReport_2009.docx
Wetland Assessment 2002-2003.pdf
BUOW data.xlsx
BO observations.jpg

I am currently reviewing our files to determine if we have any information regarding the 61 species under review. I currently have found several reports of interest:

AVON PARK AIR FORCE RANGE PROJECT: DISTRIBUTION AND ABUNDANCE OF SENSITIVE WILDLIFE SPECIES AT AVON PARK AIR FORCE RANGE FINAL REPORT PROJECT RWO-169 DECEMBER 1998 authors: Richard Franz , David Maehr, Alton Kinlaw, Christopher O'Brien, and Richard D. Owen
This report contains information regarding population levels of the following species: Florida mouse: found commonly in well-drained soils through APAFR, in oak scrub and scrubby flatwoods. Live trapping effort yielded 274 captures of Florida mouse in 8160 trap nights, spread over a 16 month period.

Sherman's fox squirrel: Found in both native and planted pine stands, Sherman's fox squirrels prefer slash pine plantations over native long-leaf stands in APAFR. Population of fox squirrel for plantations in APAFR (7948 hectares) was estimated in the range of 433 to 867.

Florida gopher frog: documented in eleven breeding sites in APAFR mostly in the southern portion of the Bombing Range scrub ridge. Six to ten dry ponds were identified as potential breeding sites during wet seasons.

The report also documents the occurrence on APAFR of Florida pine snake based on one record along old Bravo Road, APAFR.

I suspect you probably have a copy of this report in your files. Nevertheless it can be downloaded from: http://aquacomm.fcla.edu/1072/1/OCRFranz%2C_R._1998.pdf

A second report (**BASELINE AQUATIC FAUNAL SURVEY OF AVON PARK AIR FORCE RANGE, FLORIDA: Fishes, Mollusks, and Crayfishes** PROJECT RWO-157. July 2000, Authors: Leo G. Nico, James D. Williams, and Holly N. Blalock-Herod) contains no information relevant to the special status species under review.
It can be downloaded from:

http://aquacomm.fcla.edu/1288/1/OCRNico%2C_L._2000.pdf
The third report: (**Population Survey and Monitoring of the Gopher Tortoise (*Gopherus polyphemus*) at Avon Park Air Force Range.** ANNUAL REPORT. October 2008 - September 2009 Authors: Betsie Rothermel, Ph.D. Traci Castellón, Ph.D. February 2010 Archbold Biological Station) contains some locations of Gopher Frog and Florida Pine

CHAPTER SEVEN (COMMENSUAL SPECIES) EXCERPT FROM:
POPULATION SURVEY AND MONITORING OF THE GOPHER TORTOISE (*GOPHERUS POLYPHEMUS*) AT AVON PARK AIR FORCE RANGE. ANNUAL REPORT. October 2008 - September 2009

Authors:
Betsie Rothermel, Ph.D.
Principal Investigator

Traci Castellón, Ph.D.
Post-doctoral Research Fellow
February 2010

Archbold Biological Station
P.O. Box 2057
Lake Placid, FL 33862
(863) 465-2571 (phone); (863) 699-1927 (fax)
brothermel@archbold-station.org

CHAPTER 7
COMMENSAL, MORTALITY, AND DISEASE MONITORING

Observations of Commensal Species

An additional objective of our research at APAFR was to document and gather data on Gopher Tortoise burrow commensals, especially for species of conservation concern (e.g., the Eastern Indigo Snake, *Drymarchon couperi*). In total, we encountered at least 11 species of vertebrate commensals since fieldwork began in March 2009 (Table 7). Observations were derived from examination of tortoise burrows using the video scope, records from field cameras with motion sensors located outside burrow entrances, and other opportunistic encounters. Commensals were observed inside tortoise burrows at 30 sites, and included 26 anurans (12 Gopher Frogs, one unidentified treefrog, and 13 unidentified anurans), six snakes (one Eastern Coachwhip, three Eastern Diamondback Rattlesnakes, one Pine Snake, and one Eastern Indigo Snake), and one unidentified mouse (possibly a Florida Mouse, *Podomys floridanus*).

Other vertebrates that were observed entering or exiting burrows included Eastern Cottontails at eight sites, Eastern Spotted Skunks at six sites, Nine-banded Armadillos at five sites, unidentified mice (Family Cricetidae, possibly the Florida Mouse) at nine sites, and a Hispid Cotton Rat at one site (Table 7). Two bird species (Bachman's Sparrow and Eastern Towhee) were also observed foraging in front of, entering, and leaving three different burrows. One Eastern Indigo Snake was also observed while driving along Frostproof Road.

Table 7. Observations of commensal species obtained from burrow scoping activities, motion-sensor field cameras and opportunistic sightings. Species, habitat type and UTM locations are provided. Habitats include the scrub stratum (Scrub) and the flatwoods and pine plantation strata (FW & PL).

Species	Habitat	GPS Northing	GPS Easting
Frogs and Toads	FW&PL	3066118	463999
Order Anura	FW&PL	3056124	476147
	FW&PL	3063795	462598
	FW&PL	3055430	484694
	FW&PL	3048967	467312
	Scrub	3064155	461833
	Scrub	3063997	471771
	FW&PL	3046819	468667
	Scrub	3064217	461853
	FW&PL	3046812	468546
	Scrub	3063968	471957
	Scrub	3064181	472290
	Scrub	3048791	474287
Treefrog	Scrub	3049025	474458
Family Hylidae			
Gopher Frog	Scrub	3060890	472404
Rana capito	Scrub	3054510	474003
	Scrub	3048157	474347
	Scrub	3059387	472678
	Scrub	3053088	474309
	FW&PL	3055451	484575
	Scrub	3054760	475692
	Scrub	3048278	474332
	Scrub	3048274	474490
	Scrub	3046769	474355
	Scrub	3049130	474690
	Scrub	3047054	474238
Eastern Coachwhip	Scrub	3064573	472035
Coluber (formerly *Masticophis*) *flagellum*			
Eastern Indigo Snake	Scrub	3060890	472404
Drymarchon couperi	FW&PL	3067011	459803

Pine Snake	Scrub	3056513	474555
Pituophis melanoleucus			
Eastern Diamondback Rattlesnake	Scrub	3057414	474260
Crotalus adamanteus	Scrub	3057484	474413
	FW&PL	3057080	473331
Eastern Towhees	Scrub	3060683	472265
Pipilo erythrophthalmus	Scrub	3060744	472560
Bachman's Sparrow	Scrub	3064570	472159
Aimophila aestivalis			
Nine-banded Armadillo	Scrub	3061106	472168
Dasypus novemcinctus	Scrub	3060890	472404
	Scrub	3060683	472265
	Scrub	3064574	472035
	Scrub	3060744	472560
Mouse	Scrub	3064261	472038
Family Cricetidae	Scrub	3061106	472168
	Scrub	3060486	472518
	Scrub	3060890	472404
	Scrub	3060824	472382
	Scrub	3060683	472265
	Scrub	3060744	472560
	Scrub	3064570	472159
	Scrub	3064574	472035
	Scrub	3060792	472092
Hispid Cotton Rat	Scrub	3061106	472168
Sigmodon hispidus			
Eastern Cottontail	Scrub	3061106	472168
Sylvilagus floridanus	Scrub	3060486	472518
	Scrub	3060890	472404
	Scrub	3060824	472382
	Scrub	3060683	472265
	Scrub	3064570	472159
	Scrub	3064574	472035
	Scrub	3060792	472092

Eastern Spotted Skunk	Scrub	3061106	472168
Spilogale putorius	Scrub	3060486	472518
	Scrub	3060890	472404
	Scrub	3060824	472382
	Scrub	3064570	472159
	Scrub	3064574	472035

Project Title: Wetland Assessment in a Landscape Context on Avon Park Air Force Range: Surveys for Wading Birds and Round-tailed Muskrats (*Neofiber alleni*)

Annual Report

Report Period: 1 July 2002 - 30 June 2003

Contract Number: UPN 01013122

Authors: Robert L. Schooley and Lyn Branch, Department of Wildlife Ecology & Conservation, University of Florida, Gainesville, FL 32611

Submitted: 30 June 2003

Background

Extensive loss and degradation of wetlands are among the most pervasive impacts by humans on the environment in Florida (Frayer and Hefner 1991). Diverse taxa depend on these declining habitats, and wetlands are the most highly ranked ecological communities in Florida, after coastal strands, for importance in supporting wildlife of conservation concern (Millsap et al. 1990). The most obvious effects of wetland loss and degradation are reductions in habitat amount and quality. Furthermore, wetland species may exhibit a metapopulation structure (Sjögren-Gulve and Ray 1996, Joly et al. 2001, Fedriani et al. 2001) in which subpopulations occur in relatively discrete patches of suitable habitat, experience repeated extinction and colonization events, and are connected by inter-patch dispersal (Hanski 1999). Hence, wetland loss further fragments already naturally patchy wetland systems, increases wetland isolation, and may affect dispersal success and regional persistence of metapopulations. Moreover, the functional connectivity (Wiens 1996) of wetlands may be decreased due to modifications of the terrestrial habitat matrix that hinder movements of organisms among wetlands. Understanding how landscape context affects wetland quality is a key step in assessing their value as wildlife habitat.

There also is a conspicuous lack of knowledge regarding the importance of small, isolated wetlands for wetland-associated species. Small wetlands (<4 ha) may be critical for maintaining adequate landscape connectivity for species with a metapopulation spatial structure (Gibbs 1993, Semlitsch and Bodie 1998), but empirical data for evaluating this proposition are sparse. For most wetland species, we also are uninformed whether there is a minimum critical patch size required for occupancy, and how such a size might correspond to existing wetland regulations (Kaiser 1998, Semlitsch and Bodie 1998).

The Avon Park Air Force Range (APAFR) contains >24,000 acres of wetlands. The relative use of these wetlands by different vertebrate species is unknown. APAFR has diverse upland plant communities (Bridges 2000) and assorted land uses, including military training, forestry, cattle grazing, and recreation. APAFR is one of the largest tracts of federal land in south-central Florida, and thus it is a key conservation area. Overall, APAFR is an ideal location for investigating the effects of natural landscape heterogeneity and land management on the distribution of wetland species.

This project is focusing on the use of wetlands by wading birds and round-tailed muskrats (*Neofiber alleni*). These species were selected because they use the landscape at different spatial scales (Birkenholz 1963, Haig et al. 1998) and should provide complementary perspectives regarding landscape effects on APAFR wetlands. Moreover, wading birds are state and federally listed in categories ranging from 'Species of Special Concern' to 'Endangered' and *Neofiber* is listed as a Species of Special Concern (Humphrey 1992) because of presumed statewide population declines due to wetland losses (Lefebvre and Tilmant 1992).

Project Objectives

1) Obtain baseline data for assessing the potential impacts of military operations on wetland conditions and connectivity as indicated by the focal species.

2) Provide information on the distribution and abundance of wading birds and round-tailed muskrats and the characteristics of their wetland habitats at APAFR.

3) Develop and test a predictive habitat model for round-tailed muskrats.

4) Provide recommendations concerning management and future research directions for wetlands at APAFR.

Main activities during this year

1) Designed a sampling protocol for aerial surveys of wading birds at APAFR.

2) Conducted three aerial surveys of wading birds.

3) Completed ground surveys of 459 wetlands for habitat characteristic and occupancy by wading birds, round-tailed muskrats, and marsh rice rats (*Oryzomys palustris*).

4) Initiated livetrapping and movement studies of round-tailed muskrats and marsh rice rats.

5) Created a spatially accurate GIS map layer for all of the wetlands for which we conducted ground surveys.

Methods

Aerial surveys of wading birds: distribution patterns and habitat correlates

We designed our aerial surveys after the Systematic Reconnaissance Flights (SRF) that are used for monitoring wading birds in the Florida Everglades. The SRF approach has been effective in relating the distribution and abundance of wading birds to hydrological patterns (Russell et al. 2002) and to nutrient enrichment (Crozier and Gawlik 2002). In general, evenly spaced transects following lines of latitude are flown at a low altitude in a fixed-wing aircraft, and two observers on opposite sides of the airplane count all birds observed within a predetermined strip width. We established 15 transects across the entire APAFR that were separated by 1.5 km and flown in a Cessna 172 in alternating directions (west-to-east and east-to-west) at an altitude of 250 feet (76 m). Each of the two back-seat observers counted birds in a 150-m strip. Hence, for each transect we sampled a 300-m combined strip, which resulted in a 20% sample of the total area (300 m out of 1500 m). For comparison, the Everglades SRF are flown on transects separated by 2 km at an altitude of 200 ft. (60 m) using 150-m strips for a 15% sample of the area (Crozier and Gawlik 2002, Russell et al. 2002).

Each observer recorded the number of individuals of each species seen within the viewing strip into a microcassette recorder. The potential species included wood storks (*Mycteria americana*), great egrets (*Ardea alba*), white ibis (*Eudocimus albus*), great blue herons (*Ardea herodias*), sandhill cranes (*Grus canadensis*), and 'small white herons'. This last group mainly consisted of cattle egrets (*Bubulcus ibis*) and perhaps an occasional snowy egret (*Egretta thula*). For each observation, we also recorded the longitude along the transect using an onboard GPS system. Thus, we have spatial locations for all observed wading bird individuals or groups.

For analysis, we will divide the study area into 2.25-km^2 cells. The flight transects pass through the center of the cells. Various predictor variables will be measured for each cell and correlated with the number of individuals of each species per cell and the total number of individuals per cell (Crozier and Gawlik 2002, Russell et al. 2002). The explanatory variables will include the total area of wetland habitat, diversity of wetland types, density and median size of wetlands, perimeter-to-area ratios for wetlands, cover of matrix habitat, distance to major rivers and lakes, and land use (including percent of each cell within an active bombing range). We will also aggregate the cells into larger cell sizes (e.g., 4.5-km^2, 9-km^2) and repeat the analyses. This multi-scale approach should help to identify particular spatial scales at which wading birds are responding most strongly to their environment. Insights from this type of analysis should be valuable for designing future monitoring programs for wading birds at APAFR.

We flew a practice flight on 14 February 2003 (2.7 hours total flight time) and conducted our first regular survey on 28 February 2003 (2.8 hours). Unfortunately, we were not given final clearance for the survey flight from the Air Force until <24 hours before takeoff. This late notification caused us to lose our regular pilot (that we used for the practice flight), and forced us to use a substitute pilot. Due to some miscommunication with the new pilot, our survey transects were not flown on the correct latitudes. Hence, the flight on 28 February must be considered a preliminary survey, and we will only report some summary statistics for counts of wading birds. We conducted another survey on 31 May 2003 (2.8 hours) following the correct flight path. The May survey was completed toward the end of the period when shallow wetlands dry out, and thus it provides a useful contrast with the February survey when most wetlands still held water.

Statistical analyses of the wading bird counts will be performed after we finish creating a spatially referenced GIS map layer of wetlands for the entire APAFR. We currently have one for the southern half of the study area only (see below).

Ground surveys of wetlands

We focused our sampling of wetlands on the southern half of APAFR because it contains most of the landscape-scale variation in plant communities and land use found within APAFR. Moreover, we detected a higher occupancy rate for *Neofiber* in the southern half of the APAFR during our preliminary surveys in the spring-summer of 2002.

Wetland-level variables

We recorded habitat characteristics of each wetland during our surveys. Our methodology is designed to allow for rapid assessment without detailed vegetation measurement. Such procedures allowed us to sample a large number of wetlands, and they should be useful for future monitoring of wetland conditions.

We visually estimated the percent of each marsh covered by different plant zones (≤ 4) and measured traits of those zones: dominant species, cover, height of emerged plants, and water depth. For each marsh, we also recorded the substrate type, percent of marsh with water, presence of trees and shrubs, and the upland plant communities in the immediate neighborhood.

Wetland mammals and wading birds

We surveyed marshes for round-tailed muskrats and for marsh rice rats by searching for their lodges, feeding platforms, and feces. Because rice rats are more of a generalist species with an omnivorous diet (Wolfe 1982) compared to the relatively specialized and herbivorous muskrats, we expected that rice rats would have a higher occupancy rate than that of muskrats. This wider distribution might enable us to detect impacts on rice rats from military operations or other management that are not revealed for the more sparsely distributed muskrat.

Initially, we surveyed the entire marsh for sign of the two mammal species. We always began the searches in the plant zones where we were most likely to find muskrat or rice rat lodges. To facilitate a more rapid survey method, we recorded how much time it took until positive sign (a lodge) was first encountered in occupied marshes. We used these data to set a standardized maximum search time for marshes.

Based on conditions of lodges, we classified muskrat and rice rat sign within wetlands as either current use (Y) or past use (P). For this report, we calculated occupancy rates using all sign (i.e., marshes classified as Y or P). We present occupancy patterns for all surveys conducted between 1 July 2002 and 15 February 2003.

We also recorded the species and number of wading birds observed in wetlands during our ground surveys. Most species were seen during our initial approach to the marshes. One exception was the American bittern (*Botaurus lentigenosus*), which is a secretive bird that prefers wetlands with thick vegetation (Riffell et al. 2001). Bitterns typically were seen only when they were flushed from dense plant cover at a short distance (<20 m) during our walking surveys.

Landscape context

We obtained UTM coordinates for the center of each surveyed wetland using a hand-held global positioning system (Garmin GPS 76). These units had WAAS (Wide Area Augmentation System) correction and typically provided estimated accuracies of <5 m. We will use these spatial coordinates in preliminary analyses of wetland connectivity.

A more complete analysis of landscape context and connectivity will incorporate information on plant communities and land use from GIS layers for the APAFR. Because the current GIS map layer for plant communities (and wetlands) is not geo-rectified, and the project for updating the plant layer is substantially behind schedule, it is necessary that we piece together the spatial data layers required for our analysis of landscape context effects. We plan to use the new landscape association map based on Bridges (2000) as a base vegetation map. To this layer, we will add our surveyed marshes and other wetland types (e.g., cypress stands, sawgrass, hardwood swamps). We created a spatially accurate map layer of these wetlands by using low-altitude aerial photographs from 1999 to move wetlands from the current GIS plant community map to their correct positions. In addition, we identified a number of marshes that were not on the current GIS plant community map. We added these to our map layer by digitizing in ArcView (using the aerial photographs) or by delineating the marsh boundaries in the field with a GPS unit. We will add additional map features in the future, including pine plantations that are currently being digitized by Peg Margosian, and any spatially referenced data available on cattle grazing, fire history, and military activities.

Preliminary analyses

Spatial autocorrelation in ecological data can lead to false conclusions about relationships (Lichstein et al. 2002). We calculated correlograms based on Moran's I to evaluate potential autocorrelation in the occupancy patterns of *Neofiber* and *Oryzomys*. Correlograms display the degree of correlation in variables in space across a range of scales. We used indicator correlograms, which are simply correlograms based on binary data (presence and absence).

We examined the relationship between wetland area and the probability of occupancy by round-tailed muskrats, rice rats, and American bitterns using logistic regression. We $\log_{10}$-transformed wetland area prior to analyses. We present incidence curves that include the predicted probabilities of occupancy and 95% confidence envelopes on these estimates.

We used multiple logistic regression models to evaluate the ability of several wetland-level traits to predict occupancy of wetlands by *Neofiber* and *Oryzomys*. In the models, we included wetland area, wetland perimeter, substrate type, and some measure of habitat quality as explanatory variables. For *Neofiber*, we used a single variable for quality that was a ranking based on the coverage of plant zones with maidencane (*Panicum hemitomon*) as a dominant or codominant species. The presence of a plant zone with dense, emergent maidencane may be an important variable for predicting wetland occupancy by muskrats because it is a preferred species for food and lodges (Birkenholz 1963, Franz et al. 1998). *Oryzomys* seems to prefer several plant species for lodge building, including pickerelweed (*Pontederia cordata*), sand cord grass (*Spartina bakeri*), and soft rush (*Juncus effusus*). We included these three variables in models as binary variables (presence or absence of zone dominated by the species).

Livetrapping of muskrats and rice rats

We initiated livetrapping efforts aimed at *Neofiber* to determine whether future work on movement behavior would be feasible. *Neofiber* is considered a difficult species to capture. For instance, Bergstrom et al. (2000) reported only one capture in >800 trap nights.

We designed a small platform (30.5 x 61 cm) made of plywood with three adjustable legs made of PVC pipes to use in the shallow marshes where the muskrats occur. The adjustable legs allowed us to quickly change the height of the platforms when water levels changed. We attempted to keep the platforms level with the water surface. On each platform, we placed one Tomahawk live trap (15 x 15 x 40 cm) baited with apple slices. The trap was placed near the back of the platform so that there was a small platform area in front of the trap opening where a muskrat could sit and feed on additional apple bait. We placed platforms and traps near active lodges or natural platforms when possible. Our trap design was also suitable for capturing rice rats.

For all captured animals, we recorded their age, sex, and reproductive status. Beginning in June, we marked muskrats with PIT tags (Schooley et al. 1993) and rice rats with ear tags.

Results and Discussion

Wading birds

Aerial Surveys

We counted a total of 410 wading bird individuals during our survey on 28 February 2003 and 230 on 31 May 2003 (Table 1). Hence, we expect there will be substantial seasonal variation in the number of wading birds foraging at APAFR. For comparison, Crozier and Gawlik (2002) counted an average of 323 individuals in a wet year, and 804 in a dry year, on a similar-sized study area (WCA 2A in the northern Everglades; 42,206 ha).

During both of our surveys, white ibis were the most numerous species (Table 1). This result is not surprising because white ibis typically occurred in relatively large groups (15 – 80 individuals). We counted more wood storks in May compared to February, even though fewer wading birds were observed overall (Table 1). The wood storks might have been attracted to wetlands that still had water, but in which some drying had occurred, because foraging wood storks require receding water levels that concentrate prey (Bancroft et al. 1992).

The total number of individuals varied considerably among transects (Fig. 1). In both surveys, there was a peak between transects 8 and 11. There was a striking absence of wading birds on the four most southern transects during the May survey (Fig. 1). Overall, there was much spatial variation in the counts (Appendix 1), which we will be able to correlate to landscape characteristics.

Ground surveys

We observed wading birds in 121 of 459 (0.26) marshes. The number of species in any one marsh ranged from 0-6 (Fig. 2). The 12 species detected in decreasing incidence were the

American bittern (n = 70 marshes), great egret (n = 39), great blue heron (n = 29), sandhill crane (n = 15), cattle egret (n = 12), white ibis (n = 8), wood stork (n = 5), little blue heron (*Egretta caerulea*, n = 5), green heron (*Butorides virescens*, n = 2), tricolored heron (*Egretta tricolor*, n = 2), snowy egret (n = 1), and rail (*Rallus* sp., n = 1). The species richness of wading birds was positively related to wetland size (X^2 = 29.31, P = 0.0001, R^2 = 0.19) but not to wetland perimeter (X^2 = 0.02, P = 0.8966).

Other water birds that we observed included the mottled duck (*Anas fulvigula*), hooded merganser (*Lophodytes cucullatus*), double-crested cormorant (*Phalacrocorax auritus*), anhinga (*Anhinga anhinga*), pied-billed grebe (*Podilymbus podiceps*), and greater yellowlegs (*Tringa melanoleuca*).

American bitterns are difficult to survey due to their preference for dense cover and ability to stay well hidden. Surveys of bitterns during the breeding season rely on broadcasting recorded vocalizations to elicit responses (Riffell et al. 2001). Our sightings of flushed birds during walking surveys also should provide useful data on incidence because we typically search all of the dense plant zones. American bitterns are migratory and we first observed an individual during surveys on 7 October 2002. Hence, we calculated an estimate of patch occupancy restricted to the 394 marshes surveyed after the 'arrival date'. American bitterns occurred in 70 (0.18) marshes, had a patchy distribution (Fig. 3), and their probability of occupancy was related to wetland area (Fig. 4). Wetland area and vegetation density were the most important explanatory variables for bitterns on their breeding range (Riffell et al. 2001).

Wetland mammals

Wetland traits

Many of the shallow depression marshes at APAFR are small (median = 0.92 ha), but there is a large amount of variation in wetland size (Table 2). The distribution of wetland area was skewed with a long right tail. Most of the wetlands were filled with water (Table 2) during our ground surveys, although many of these dried out completely in late March to May 2003. Water depths are typically only 20 – 40 cm in most plant zones (Table 2), but water levels fluctuate widely on short time scales in response to rain events. Wetland organisms must be adapted to this sort of environmental variability. Most of the surveyed wetlands had a mucky substrate, contained trees, had trees along their edges (including escaped slash pines from nearby plantations), and about half had shrubs along their edges (Table 3).

Sampling effort and search time

For round-tailed muskrats, we surveyed 106 marshes from 7 August to 12 November 2002 in which we recorded the amount of time required to find positive sign in occupied marshes (n = 27). Two observers were present for most (87%) of these surveys; 3-5 observers were present for the remainder. In most of the marshes (96%), the first sign was encountered in <15 min (Fig. 5). The one marsh that required 32 min was 3.2 ha and had a thick coverage of maidencane and pickerelweed. For marsh rice rats, we surveyed 98 marshes from 4 September to 12 November 2002 in which we recorded the amount of time required to find positive sign in occupied marshes (n = 42). Again, two observers were present for most (86%) of the surveys, and 3-5 observers were present for the rest. In most of the marshes (95%), the first sign was encountered in <30 min (Fig. 5). The two marshes that required >30 min were >1 ha and had thick plant cover. We concluded that a 30-min search was adequate to determine whether these two mammal species were present in most marshes. Hence, we restricted most additional surveys to 30 min, but extended the search time up to 60 min for large marshes with exceptionally dense plant cover.

From 1 July 2002 to 15 February 2003, we conducted surveys of 459 marshes for the presence of muskrats and rice rats. This sampling effort not only exceeds our proposed effort for this project (225 patches), it also greatly surpasses the sample sizes for most previous studies of patch occupancy by mammals (e.g., Franz et al. 1998, Forys and Humphrey 1999, Hanski 1999, Fedriani et al. 2002). Overall, at least two observers searched most wetlands (97.6%), and often there were 3-4 observers (54.1%). We generally used ≥4 observers for larger marshes (>2.5 ha).

Wetland occupancy: round-tailed muskrats and marsh rice rats

As expected, the occupancy rate of marshes (n = 459) was substantially lower for round-tailed muskrats (0.26) than for marsh rice rats (0.55). Muskrats not only occurred in fewer wetlands, they also had a more patchy distribution on a broad scale (Appendices 2 and 3). In particular, muskrats were nearly absent from the southwest portion of the study area south of Arbuckle Marsh and west of Van Eeghen Road.

The xeric scrub ridge in the center of the study area contained only a few, isolated marshes. Round-tailed muskrats occupied none of these wetlands (Appendix 2). Hence, the scrub ridge might separate our study area into two relatively independent patch networks for *Neofiber*. In contrast, marsh rice rats occurred in several of the wetlands imbedded in the scrubby area (Appendix 3).

The distribution of both muskrats and rice rats exhibited positive spatial autocorrelation at fine scales (<1.5 km), but the pattern was stronger for the muskrats (Fig. 6). Such results can be due to autocorrelation of environmental variables related to occupancy, or to spatial dynamics of the species independent of measured variables. In either case, our logistic regression results must be considered preliminary. Our final analyses will include an evaluation of whether we need to statistically control for broad-scale spatial trend (with trend surface analysis) and for fine-scale autocorrelation (with autoregressive models).

The occupancy of wetlands was positively related to wetland size for round-tailed muskrats and for marsh rice rats (Fig. 7). Because of differences in overall occupancy rates and the shapes of the incidence curves, the point where the probability of occupancy was ≥50% differed substantially for the two species (muskrats = 6.2 ha, rice rats = 0.7 ha). Interestingly, wetland area did not explain a large amount of the variance for either mammal species (Fig. 7).

Of the four wetland-level variables that we evaluated for predicting occupancy of *Neofiber*, habitat quality was the most important (Table 4, Figure 8). In fact, the importance of wetland area was marginal when included in the model with habitat quality. The model with only quality explained 29% of the overall variation, whereas a model with area and quality explained 32%. This outcome is at odds with current ideas on spatially structured metapopulations, in which patch area is assumed to be a key determinant of occupancy (Hanski 1999).

For *Oryzomys*, wetland area was an important predictor variable (Table 5). Habitat quality, as indexed by the presence of *Juncus*, *Spartina*, and *Pontederia*, was also related to occupancy (Table 5). The logistic regression model that included wetland area and the three indicator species explained 20% of the overall variation in occupancy.

For both mammal species, there was a fair amount of unexplained variance that may be related to variables not used in our preliminary models, including other wetland traits, isolation, land use, and landscape context. Moreover, we should be able to refine our measures of habitat quality for future analyses.

Livetrapping of muskrats and rice rats

In March 2003, the capture success of *Neofiber* was 6.9% (19 captures/276 trapnights), and the capture success of *Oryzomys* was 5.8% (16/276). In June 2003, the capture success of *Neofiber* was only 1.6% (8 captures/513 trapnights), and all of the captures were of the same individual. The seasonal decline in capture success for *Neofiber* coincided to a general lack of activity in the shallow depression marshes; we found no fresh muskrat lodges during May or June. *Neofiber* must burrow in other areas during the periods when wetlands are dry and when early summer rains refill the wetlands. The capture success of *Oryzomys* in June was 6.2% (32/515), so we initiated movement experiments with them aimed at determining their ability to locate and orientate toward wetlands while dispersing (Zollner 2000).

Potential effects of land use

We will evaluate the potential influences of military activities and other land uses on wetland quality, landscape connectivity, and vertebrate distribution patterns at APAFR. Our general analytical approach will be to develop correlative habitat models using environmental variables (e.g., wetland size, wetland quality, isolation, matrix habitat), and then to ask whether additional variation in patterns of distribution and abundance can be explained by land use. The degree that we can incorporate different types of land use as predictor variables in our statistical models for wading birds and marsh mammals will depend on the availability of spatially referenced data. Ideally, we plan to examine levels of military activity, current and past grazing pressures, fire histories, and planting of pine plantations. Moreover, we will evaluate whether roadside ditches might serve as movement corridors for *Neofiber* and *Oryzomys* indirectly by comparing models of landscape connectivity that either include or exclude these linear elements in the calculation of wetland isolation.

The most significant finding of our preliminary analysis is the importance of habitat quality of wetlands in determining distribution patterns of *Neofiber*. Wetland size may matter, but quality matters more. Therefore, land use could influence wetland occupancy not only by affecting the nature of matrix habitat and wetland connectivity, but also by directly affecting the habitat quality of the wetlands. For instance, cattle grazing could influence the cover of maidencane in marshes via herbivory and trampling, or road building and pine planting could alter hydrological patterns and the vegetation of wetlands. Finally, the round-tailed muskrat currently occurs in marshes throughout much of Echo, Charlie, and OQ ranges at APAFR. Therefore, any substantial changes in activities and land use within these areas could potentially influence the distribution and network-level persistence of this patchily distributed mammal.

Main activities for next year

1) Conduct six additional aerial surveys of habitat use by foraging wading birds at APAFR.

2) Resurvey 459 wetlands for habitat characteristics and for the presence of wading birds, round-tailed muskrats, and marsh rice rats.

3) Continue livetrapping of round-tailed muskrats and marsh rice rats and conduct studies to obtain data on movement behavior, space use, and inter-wetland dispersal.

4) Conduct statistical analysis for (a) distribution patterns of wading birds, and (b) predictive models of patch occupancy for muskrats, rice rats, and American bitterns.

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Table 1. Aerial counts of wading birds on 15 transects at APAFR. We sampled 20% of the study area during the surveys. 'Small white herons' are primarily cattle egrets.

	28 February 2003		31 May 2003	
Species	Count	%	Count	%
Wood stork	8	1.95	21	9.13
White ibis	276	67.32	167	72.61
Great egret	51	12.44	31	13.48
Great blue heron	17	4.16	8	3.48
'Small white heron'	56	13.66	3	1.30
Sandhill crane	2	0.49	0	0.00
TOTAL	410		230	

Table 2. Continuous environmental variables measured at 459 wetlands surveyed from 3 July 2002 – 15 February 2003. The traits are potential explanatory variables for predictive habitat models.

Variable	Mean	SE	Median	Minimum - Maximum
Area (ha)	1.92	0.22	0.92	0.04 – 73.79
Perimeter (m)	535.4	27.1	376.0	94.0 – 6832.0
Water cover (%)	88.57	1.07	100	0 – 100
Mean water depth (cm)	22.3	0.62	22.8	0 – 80.8
Water depth of deepest zone (cm)	36.8	0.91	35	0 - 115

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Table 3. Categorical environmental variables measured at wetlands surveyed from 3 July 2002 – 15 February 2003 at APAFR.

Variable	No. of wetlands	%
Substrate		
Mucky	387	84.3
Sediment	69	15.0
Other	3	0.6
Trees in wetland		
Present	275	60.0
Absent	183	40.0
Trees along wetland edge		
Present	337	73.6
Absent	121	26.4
Shrubs along wetland edge		
Present	215	46.9
Absent	241	53.1

Table 4. Logistic regression analysis of occupancy of shallow marsh wetlands ($n = 459$) by round-tailed muskrats (*Neofiber alleni*). The model includes four patch-level variables. Wetland area was log-transformed. Significance was based on a Type III analysis.

Source of variation	d.f.	X^2	***P***
Wetland area	1	2.42	0.1194
Wetland perimeter	1	0.97	0.3253
Habitat quality	1	82.16	**0.0001**
Substrate	1	0.79	0.3745

Table 5. Logistic regression analysis of occupancy of shallow marsh wetlands ($n = 459$) by marsh rice rats (*Oryzomys palustris*). The model includes six patch-level variables. Wetland area was log-transformed. Significance was based on a Type III analysis.

Source of variation	d.f.	X^2	***P***
Wetland area	1	19.96	**0.0001**
Wetland perimeter	1	1.07	0.2998
Juncus	1	9.37	**0.0022**
Spartina	1	26.96	**0.0001**
Pontederia	1	5.25	**0.0220**
Substrate	1	0.51	0.4742

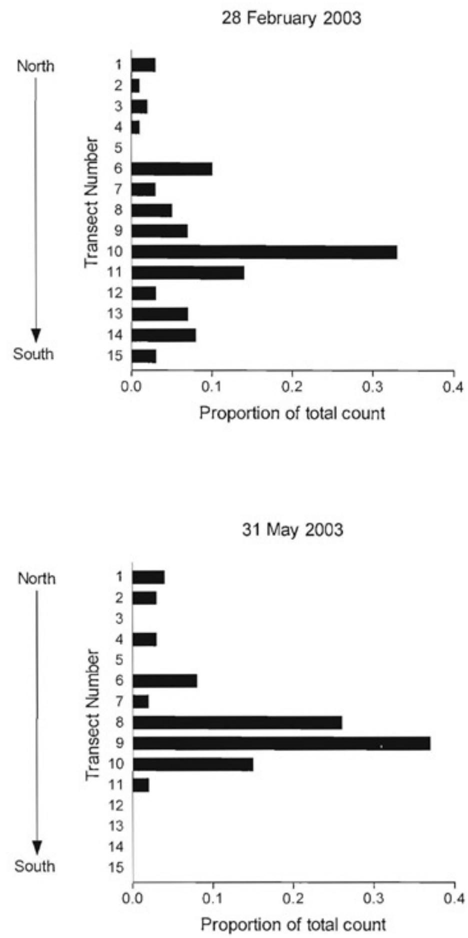

Figure 1. Distribution of wading birds counted along 15 transects during aerial surveys at Avon Park Air Force Range.

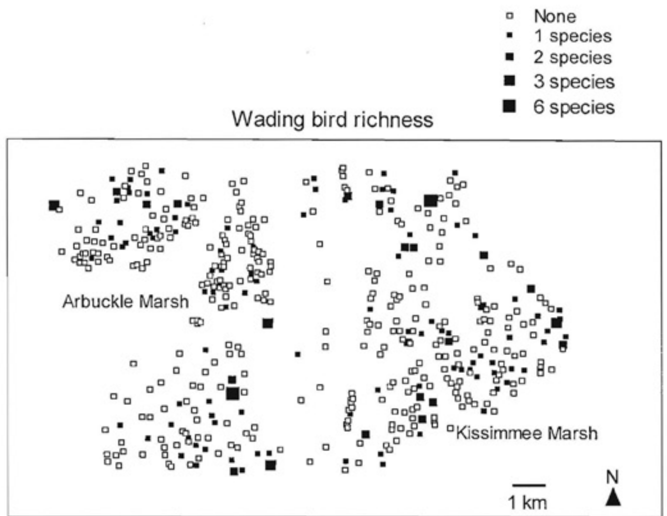

Figure 2. Species richness of wading birds in depression marshes (n = 459) at Avon Park Air Force Range, July 2002-February 2003 based on ground surveys of wetlands.

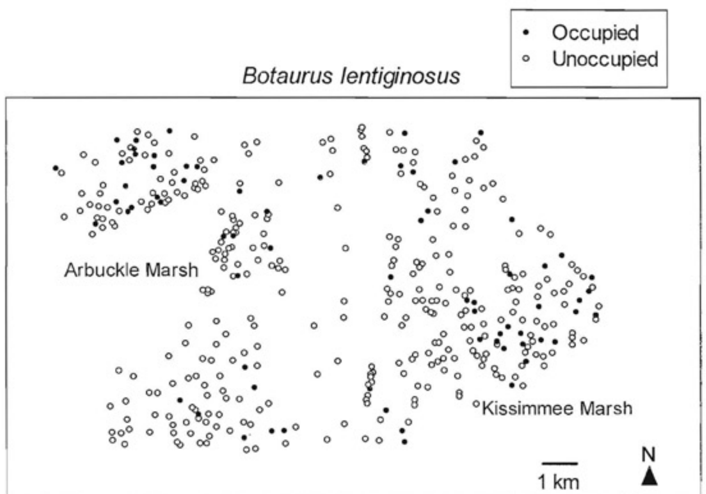

Figure 3. Patterns of patch occupancy for American bitterns (*Botaurus lentiginosus*) at Avon Park Air Force Range, October 2002-February 2003. Each circle indicates the location of a depression marsh (n = 394).

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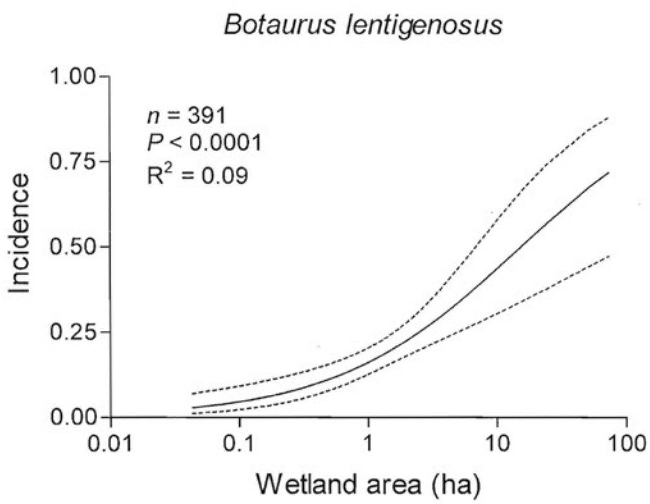

Figure 4. Relationship between wetland size and the probability of wetland occupancy by American bitterns (*Botaurus lentigenosus*). The incidence curve is based on predicted probabilities from a logistic regression model. Dotted lines indicate a 95% confidence envelope for the predicted values. The X-axis is on a $\log_{10}$ scale.

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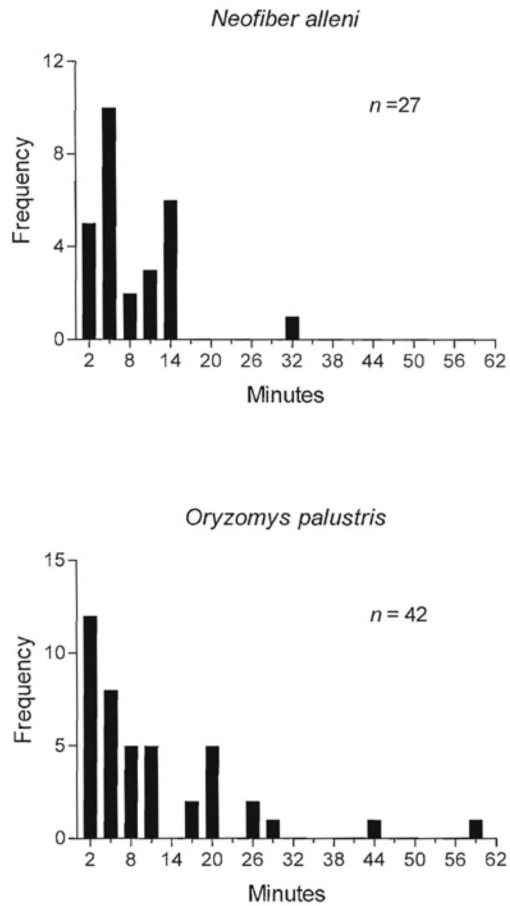
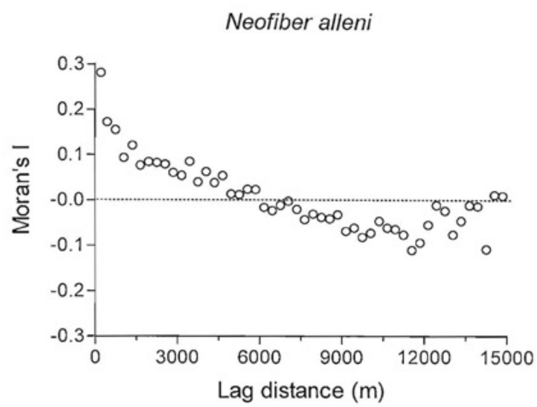


Figure 5. The amount of time until the first sign of occupancy was encountered for round-tailed muskrats (*Neofiber alleni*) and marsh rice rats (*Oryzomys palustris*) during wetland surveys. The sample size refers to the number of depression marshes with sign of occupancy.



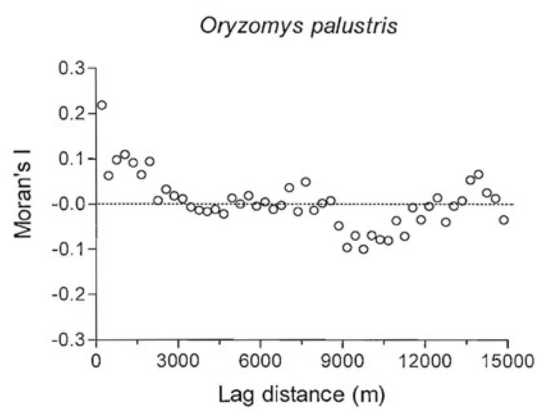


Figure 6. Isotropic indicator correlograms for wetland occupancy by round-tailed muskrats and marsh rice rats. The correlograms indicate the degree of spatial autocorrelation in occupancy patterns across a range of spatial scales. Positive values at small lag distances indicate that nearby wetlands have similar values (if a marsh is occupied then the neighboring marshes tend to be occupied).

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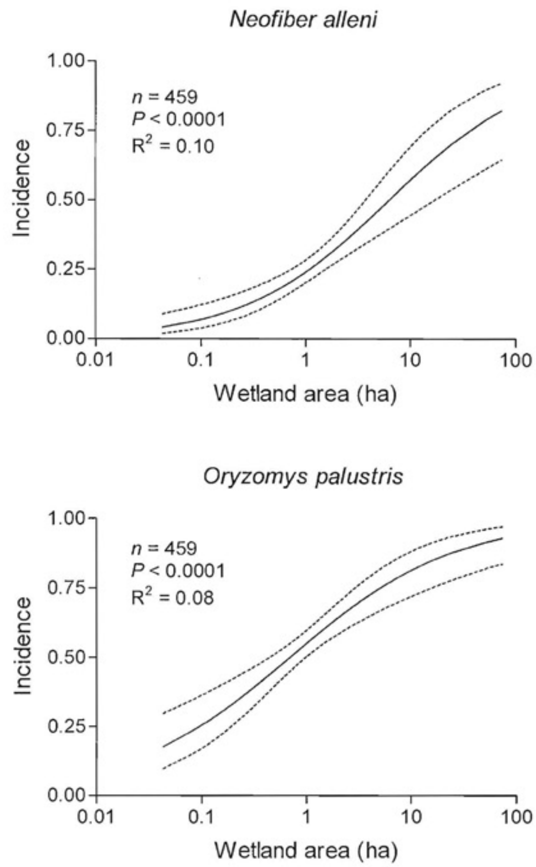

Figure 7. Relationship between wetland size and the probability of wetland occupancy by round-tailed muskrats (*Neofiber alleni*) and by marsh rice rats (*Oryzomys palustris*). The incidence curves are based on predicted probabilities from logistic regression models. Dotted lines indicate 95% confidence envelopes for the predicted values. The X-axes are on a $\log_{10}$ scale.

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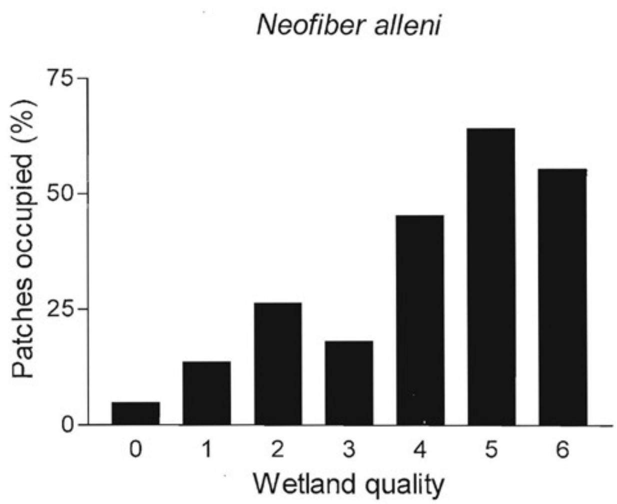

Figure 8. Relationship between habitat quality and occupancy of wetlands by round-tailed muskrats. Quality is a rank based on the coverage of plant zones in which maidencane is a dominant or codominant species.

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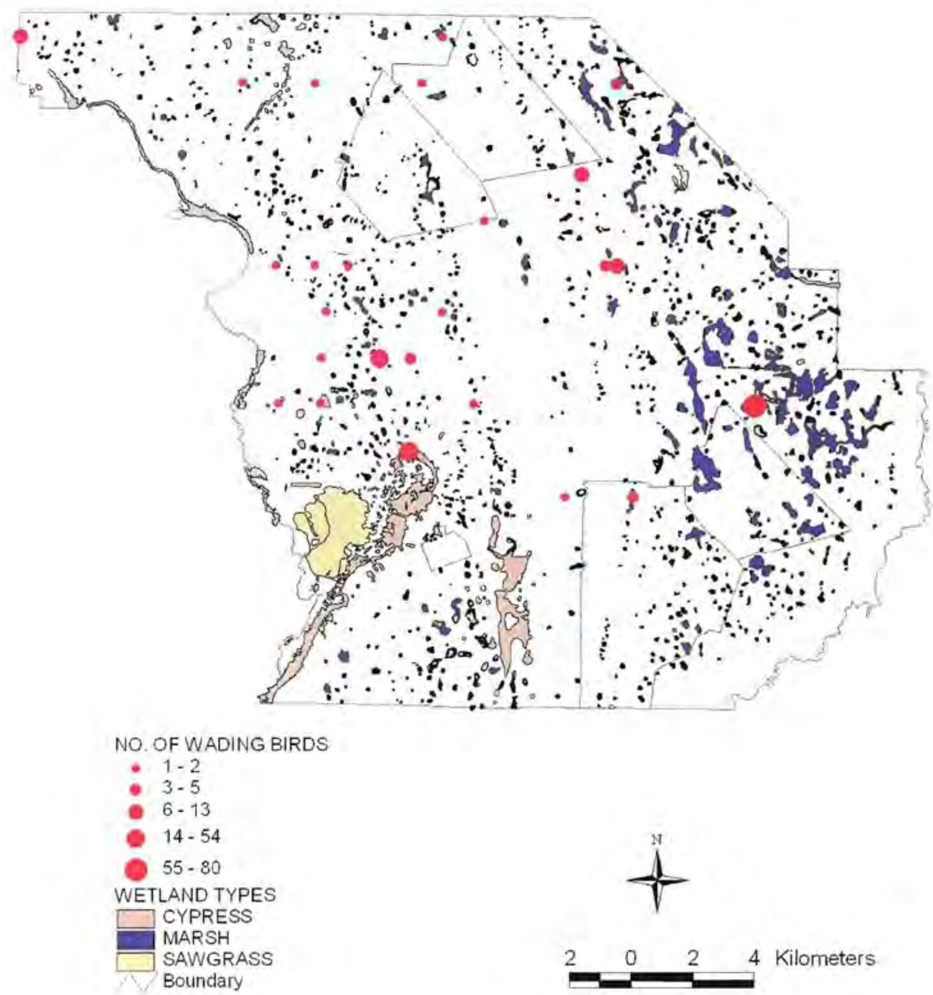
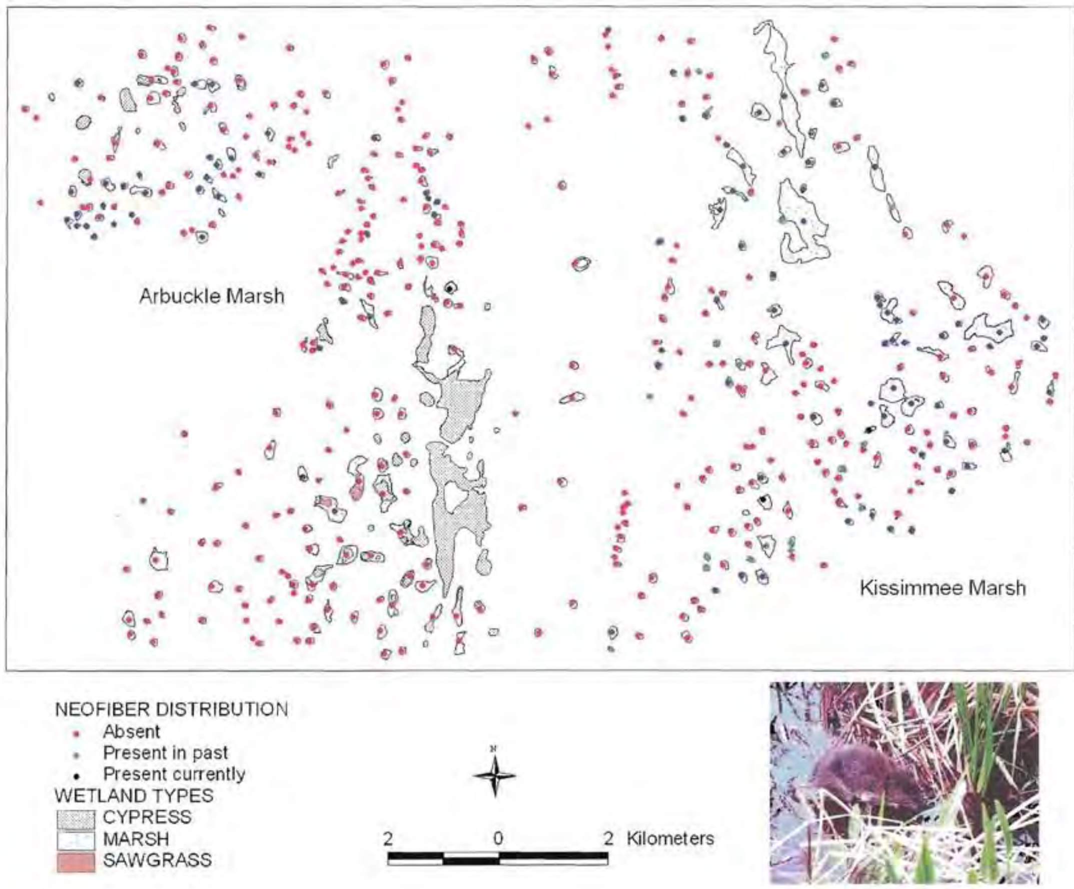
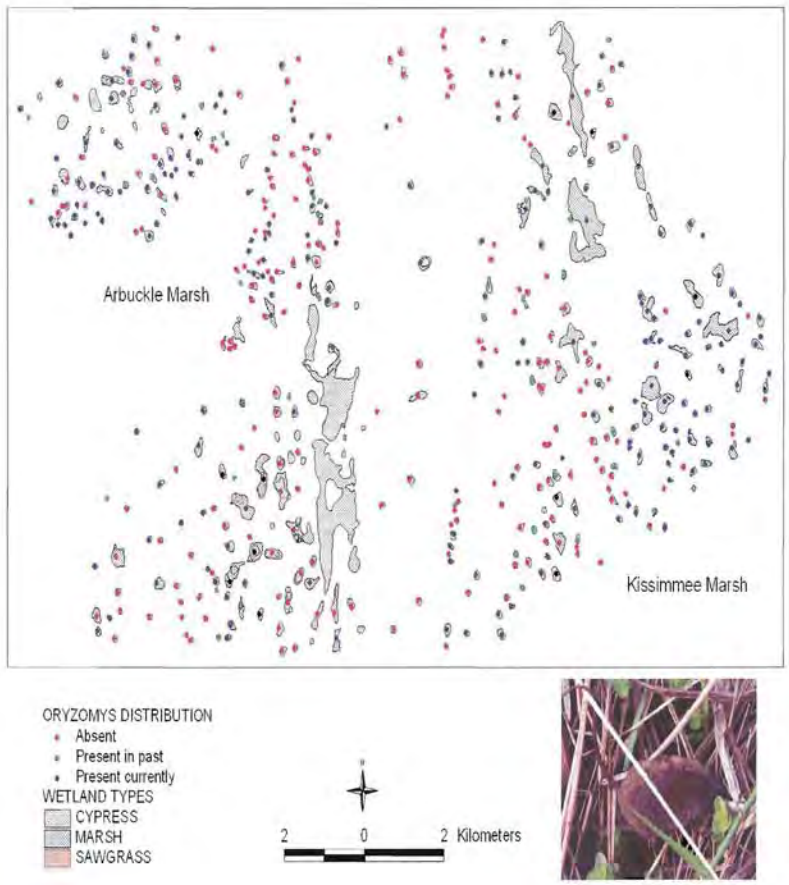
Appendix 1. Spatial distribution of wading birds from aerial survey at APAFR on 31 May 2003



Appendix 2. Distribution patterns of round-tailed muskrats at Avon Park Air Force Range, 2002-2003.



Appendix 3. Distribution patterns of marsh rice rats at Avon Park Air Force Range, 2002-2003.



Copy of the Florida pine snake BSR draft report that was sent out for peer review

Biological Status Review for the Florida Pine Snake (*Pituophis melanolucus mugitus*)

EXECUTIVE SUMMARY

The Florida Fish and Wildlife Conservation Commission (FWC) directed staff to evaluate all species listed as Threatened or Species of Special Concern as of 1 September 2010. Public information on the status of the Florida pine snake was sought from September 17 through November 1, 2010. The 5-member biological review group (BRG) met on November 18, 2010. Group members were Kevin Enge (FWC lead), Steve Johnson (University of Florida), Rick Owen (Florida Department of Environmental Protection), Thomas Ostertag (FWC), and David Printiss (The Nature Conservancy) (Appendix 1). In accordance with rule 68A-27.0012 F.A.C, the BRG was charged with evaluating the biological status of the Florida pine snake using criteria included in definitions in 68A-1.004 and following protocols in the *Guidelines for Application of the IUCN Red List Criteria at Regional Levels (Version 3.0)* and *Guidelines for Using the IUCN Red List Categories and Criteria (Version 8.1)*. Please visit http://myfwc.com/docs/WildlifeHabitats/Imperiled_EndangeredThreatened_FinalRules.pdf to view the listing process rule and the criteria found in the definitions.

The BRG concluded that the Florida pine snake met sub-criterion A3 (A population size reduction of at least 30% projected or suspected to be met within the next 3 generations). The BRG projected a population size reduction of at least 30% in Florida pine snake populations within the next 3 generations (24 years) based upon: a projected 32% increase in Florida's human population by 2035, only 24% of the pine snake's potential habitat being on public conservation lands, altered fire regimes on public and private lands, a continuing backlog of fire-suppressed habitats, suspected population declines in pocket gopher populations, and the species' susceptibility to habitat fragmentation and residential development (i.e., mortality from vehicles, landowners, and pets). After careful consideration and deliberation, staff does not agree that the information supports a 30% projected decline in Florida pine snake populations over the next 24 years and recommends delisting the Florida pine snake.

This work was supported by a Conserve Wildlife Tag grant from the Wildlife Foundation of Florida.

BIOLOGICAL INFORMATION

Taxonomic Classification – The Florida pine snake (*Pituophis melanoleucus mugitus* Barbour, 1921) is 1 of 3 currently recognized subspecies of the pine snake (Crother 2008). It intergrades with the black pine snake (*P. m. lodingi*) in Escambia County, Florida (Mount 1975, Franz 1992).

Life History and Habitat Requirements – Information on the Florida pine snake has been summarized by Franz (1992), Ernst and Ernst (2003), Franz (2005), and Miller (2008). The Florida pine snake prefers habitats with well-drained, sandy soils and moderate to open canopy cover (Franz 1992, Ernst and Ernst 2003). In Florida, pine snakes are most common in sandhill habitat, but they also are found in scrub habitat, xeric hammock, scrubby flatwoods, and mesic pine flatwoods and dry prairies with dry soils (Allen and Neill 1952, Enge 1997, Franz 2005). During a telemetry study in northern peninsular Florida, 69% of observations were in sandhill (i.e., high pine), followed by ruderal habitats (i.e., pastures, former orange groves, and old hay fields), xeric hammock, and lake edge (Franz 2005). During a telemetry study in southwestern Georgia, pine snakes used habitats relative to their availability within their home ranges, but at a landscape level, they selected (in order of preference) mixed pine-hardwood forests, pine regeneration plots and plantations, scrub/shrub or fallow land, agricultural fields or wildlife food plots, urban areas (rural farms, barns or other buildings), hardwood forest, natural pine forest, and aquatic habitat (Miller 2008). Florida pine snakes are fossorial, spending ca. 80% of their time in underground retreats, primarily burrows of the southeastern pocket gopher (*Geomys pinetis*) (Franz 2005, Miller 2008). Other retreats used are stumpholes, mole runs, and burrows of gopher tortoises (*Gopherus polyphemus*), nine-banded armadillos (*Dasypus novemcinctus*), and mice (Franz 2005, Miller 2008). Florida pine snakes are diurnally active and occasionally climb into shrubs and small trees (Franz 2005). Pine snakes primarily feed on pocket gophers, other rodents, and rabbits, but they also eat ground-dwelling birds and eggs (Allen and Neill 1952, Ernst and Ernst 2003, Franz 2005, Miller 2008). Pine snakes are adept at excavating the sand plugs of pocket gopher burrows to access their runways (Franz 2001, 2005). The pine snake lays an average of 8.7 eggs (n = 111) (Ernst and Ernst 2003), but 4 clutches of the Florida subspecies ranged from 4 to 8 eggs (mean 5.6) (Neill 1951, Franz 2005). Mammals, birds, and snakes have been reported preying upon pine snakes, primarily smaller individuals, and their eggs (Ernst and Ernst 2003).

Population Status and Trend – Carr (1940) considered the Florida pine snake to be "not common." Franz (1992) claimed that some herpetologists thought that pine snakes had seriously declined in the last 20 years. However, there are no quantitative studies of population trends for this species. At the Ordway-Swisher Biological Station in Putnam County, more than 16 adult snakes were found between 1983 and 1991 but only 4 snakes since then, suggesting a major decline in the population that was possibly related to 2 severe regional droughts (Franz 2005). Of 464 records from museums, Florida Natural Areas Inventory (FNAI), and the literature, 105 records were from the 1990s and 64 from the 2000s. Pine snakes are probably more common than observational data suggest because they spend about 80% of their time underground (Franz 2005). If enough time is spent in the field or driving roads in suitable habitat, pine snakes are often detected. For example, there are 20 pine snake records from Eglin Air Force Base in 1993–98, mostly from persons involved in surveys for rare species (Printiss and Hipes 1999).

Geographic Range and Distribution – The Florida pine snake occurs in the extreme southeastern United States from southwestern South Carolina westward to Mobile Bay in southern Alabama, and south into Florida, exclusive of the Everglades (Conant and Collins 1991, Ernst and Ernst 2003). There are few records south of the southern end of Lake Okeechobee (Fig. 1).

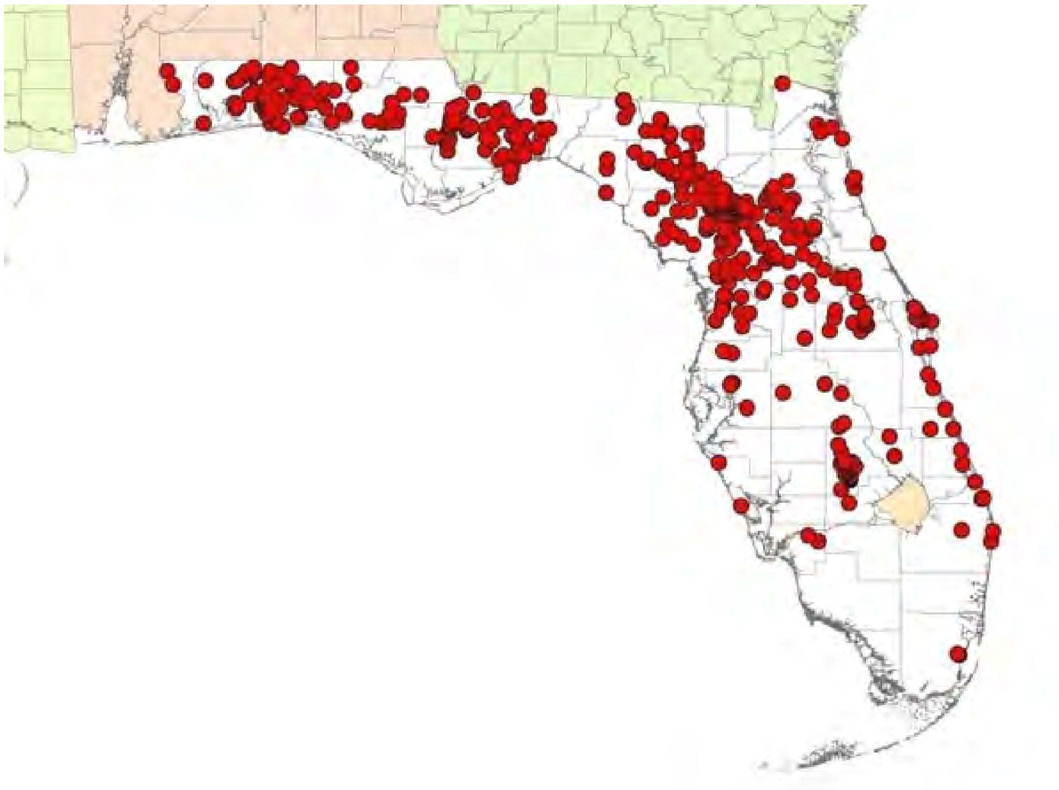


Fig. 1. Locality records from museums, FNAI, and the literature for the Florida pine snake in Florida.

Quantitative Analyses – Two population viability analysis models have been run for the Florida pine snake in Florida (Root and Barnes 2005). One model considered all potential habitat identified and the other model only potential habitat occurring on conservation lands. Under the baseline parameters, there was 0% risk of extinction or 20% population decline over the next 100 years for both models. The initial abundance was set at a conservative 0.2 individuals/ha, and a distance of 1.2 km was set to identify discrete populations, producing 495 populations for the conservation lands model and 343 populations for the all potential habitat model. The conservation lands model had more populations because populations were fragmented by property boundaries instead of being connected by habitat on private lands. Juvenile survival was set at 50% and adult survival at 65%. Fecundity for adults was set at 0.83, which is one-half of the average clutch size (5.6 eggs), multiplied by 85% of the female population breeding annually, and multiplied by a 35% survival rate of eggs to Year 1. This information produced a population growth rate of 1.0465.

BIOLOGICAL STATUS ASSESSMENT

Threats – Enge et al. (2003) provided descriptions of sandhill habitat and threats to its wildlife community. By 1987, 88% of Florida's sandhill habitat had been lost (Kautz et al. 1993), and scrub habitat has also experienced serious losses (Enge et al. 2003). It is estimated that >97% of the original longleaf pine (*Pinus palustris*) ecosystem has been converted to agriculture, pine plantations, and urban areas (Noss et al. 1995). From 1985–89 to 2003, 15.5% of Florida's sandhill habitat, 12.4% of its scrub habitat, and 9.2% of its pinelands were converted to other uses, primarily urban or other developed uses (Kautz et al. 2007). Shrub and brushland, a semi-natural cover type often used by pine snakes, lost 36.3% of its acreage to intensive human uses (Kautz et al. 2007). Franz (1992) suspected population declines in the Florida pine snake were due to excessive collecting, road mortality, and habitat loss. In New Jersey, the six greatest threats to northern pine snakes (*P. m. melanoleucus*) were identified as habitat loss and fragmentation, illegal collection, predation from natural and subsidized predators, road mortality, fire suppression and habitat change, and off-road vehicle use (Golden et al. 2009). The greatest threat to pine snakes in Florida is probably habitat loss and fragmentation resulting from commercial and residential development, silviculture, agriculture, mining, and roads. Longleaf pine-dominated sandhill as well as scrub habitat on the ridges of central Florida and along both coasts have suffered serious losses (Means and Grow 1985, Myers 1990, Kautz 1998, Enge et al. 2003). Pine snakes once occurred along the Atlantic Coastal Ridge as far south as Miami (Duellman and Schwartz 1958, Florida Museum of Natural History record from 1980), but urban development in southeastern Florida might have eliminated populations south of Martin County (museum and FNAI records). Altered fire regime in sandhill habitat and resulting hardwood encroachment presumably creates less favorable habitat conditions for pine snakes, although they will use xeric hammocks. Presumably, pine snakes do poorly in dense pine plantations, particularly sand pine (*Pinus clausa*) plantations on former sandhill sites in the Panhandle. Pine snake populations can coexist with some agricultural development, and snakes may thrive in abandoned fields. Stumpwood removal may affect pine snake subpopulations by decreasing underground habitat structure (Means 2005); this may be particularly detrimental in areas where pocket gophers are absent.

Pine snakes are large and conspicuous, and populations in subdivisions are threatened by road mortality and killing by residents and domestic pets (Jordan 1998). Large, slow-moving snakes are highly susceptible to road mortality (Andrews and Gibbons 2005); in eastern Texas, populations of large snakes were 50% less abundant up to 450 m from roads than they were 850 m from roads (Rudolph et al. 1999). However, pine snakes may avoid crossing major highways abutting their home ranges (Miller 2008). Because of their association with pocket gophers, pine snake populations might be expected to decline in response to declines in pocket gopher populations, such as from pest control programs. Pocket gopher populations have apparently declined in Alabama, Georgia, and to a lesser extent, Florida (Georgia Department of Natural Resources 2008, Miller et al. 2008); a subspecies of pocket gopher in Florida is now extinct (Humphrey 1992). However, Florida pine snake populations occur in areas where pocket gophers are absent. Collection of pine snakes for pets presumably decreased when they were listed as a Species of Special Concern; commercialization was prohibited and a personal possession limit of one snake was imposed. Later, commercialization was permitted for "albino" (i.e., amelanistic and leucistic) individuals. The threat to wild populations would be unknown, if collection and commercialization of normal-looking specimens were permitted again. Florida pine snakes cannot be collected in large quantities because of their fossorial nature and dispersed distribution. Unlike northern pine snakes, which are threatened by illegal collection in New Jersey (Golden et al. 2009), they do not have communal hibernacula and oviposition sites. Plus, there is less demand for the less vividly marked Florida subspecies, although there is a market for amelanistic, leucistic, and patternless specimens (K. Enge, FWC, pers. commun. 2010).

Statewide Population Assessment – Findings from the BRG are included in Biological Status Review Information tables. The BRG concluded that the Florida pine snake met sub-criterion A3 (a population size reduction of at least 30% projected or suspected to be met within the next 3 generations). The BRG projected a population size reduction of at least 30% within the next 3 generations (24 years) based upon: a projected 32% increase in Florida's human population by 2035, only 24% of the pine snake's potential habitat being on public conservation lands, altered fire regimes on public and private lands, a continuing backlog of fire-suppressed habitats, suspected population declines in pocket gopher populations, and the species' susceptibility to habitat fragmentation and residential development (i.e., mortality from vehicles, landowners, and pets).

LISTING RECOMMENDATION

FWC staff, including herpetologists and fire management experts, carefully considered the biological review group findings and assumptions for criterion A3 and could not project a 30% decline in Florida pine snakes in the next 24 years. Staff considered the fact that initial projections of increases in Florida's human population by Zwick and Carr (2006) have not been met. Staff expects the future human population growth rate to be lower than initially projected as well. Although loss of pine snake habitat and fragmentation due to population increases reasonably can be expected to cause Florida pine snake declines, there are insufficient data to predict the magnitude of the decline. Staff believes that the backlog of fire-suppressed pine snake habitat is not as severe as assumed by the BRG. Staff's interpretation of the State of Florida Land Management Uniform Accounting Council (2010) report on the number of acres reported burned in the appropriate fire return interval is different than what the BRG concluded. For example, 54% of all state managed lands and 86% of FWC managed lands were within the fire return interval in 2009-10. There are likely other similar examples in other land management agencies. Considering all of this information, staff does not project a 30% decline in Florida pine snake populations in the next 24 years (3 generations), although some lower level of decline will probably occur. Because of these considerations, staff recommends that the Florida pine snake be delisted in Florida.

SUMMARY OF THE INDEPENDENT REVIEW

To be added after the peer review.

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Biological Status Review Information Findings	Species/taxon: Date: Assessors: Generation length:	Florida Pine Snake 11/18/10 Enge, Johnson, Ostertag, Printiss, Owen 8 years		
Criterion/Listing Measure	Data/Information	Data Type*	Criterion Met?	References
*Data Types - observed (O), estimated (E), inferred (I), suspected (S), or projected (P). Criterion met - yes (Y) or no (N).				
(A) Population Size Reduction, ANY of				
(a)1. An observed, estimated, inferred or suspected population size reduction of at least 50% over the last 10 years or 3 generations, whichever is longer, where the causes of the reduction are clearly reversible and understood and ceased[1]		S	N	Franz (2005), Kautz et al. (2007)
(a)2. An observed, estimated, inferred or suspected population size reduction of at least 30% over the last 10 years or 3 generations, whichever is longer, where the reduction or its causes may not have ceased or may not be understood or may not be reversible[1]	<30% population size reduction because only 23.5% increase in human population since 1990 and acquisition of conservation lands. From 1985–89 to 2003, 15.5% of sandhill, 12.4% of scrub, 9.2% of pinelands, 36.3% of shrub and brushland, 11.3% of upland forest, 25.4% of dry prairie, and 10.8% of coastal strand were converted to other land uses, often urban or other developed uses.	S	N	Franz (2005), Kautz et al. (2007), U.S. Census Bureau
(a)3. A population size reduction of at least 30% projected or suspected to be met within the next 10 years or 3 generations, whichever is longer (up to a maximum of 100 years) [1]	Florida's population is projected to increase by 31.7% in the next 25 years, but this won't necessarily result in an equivalent destruction of pine snake habitat. However, only 24% of the potential habitat is in conservation lands, and upland habitats favored by this species are particularly in demand for development. This is a large-bodied species with a relatively large home range whose subpopulations decline in response to habitat fragmentation and residential development, suffering mortality from vehicles, landowners, and pets. Continued altered fire regimes (timing, intensity, fire-return interval, and season) and lack of fire management on public and private lands will likely result in future population declines. Suspected declines in pocket gopher populations will probably continue, affecting those pine snake subpopulations that rely on pocket gophers for underground retreats and food.	S	Y	Rudolph et al. (1999), Andrews and Gibbons (2005), Zwick and Carr (2006); Miller et al. (2008); State of Florida Land Management Uniform Accounting Council (2010); D. Printiss and R. Owen, pers. commun.; GIS analysis of potential habitat by B. Stys (FWC)

(a)4. An observed, estimated, inferred, projected or suspected population size reduction of at least 30% over any 10 year or 3 generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased or may not be understood or may not be reversible.[1]	<30% population size reduction (see A2 and A3)	S	N	Zwick and Carr (2006)
[1] based on (and specifying) any of the following: (a) direct observation; (b) an index of abundance appropriate to the taxon; (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat; (d) actual or potential levels of exploitation; (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.				
(B) Geographic Range, EITHER				
(b)1. Extent of occurrence < 20,000 km^2 (7,722 mi^2) OR	ca. 76,800 km^2 in 38 counties (since 1990)	E	N	
(b)2. Area of occupancy < 2,000 km^2 (772 mi^2)	19,984 km^2	E	N	GIS analysis of potential habitat by B. Stys (FWC)
AND at least 2 of the following:		S	N	
a. Severely fragmented or exist in ≤ 10 locations				
b. Continuing decline, observed, inferred or projected in any of the following: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent, and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals		P	Y	
c. Extreme fluctuations in any of the following: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals		S	N	
(C) Population Size and Trend				
Population size estimate to number fewer than 10,000 mature individuals AND EITHER	>30,000 mature individuals based on a mean home range size of 58 ha and the amount of potential habitat	S	N	Franz (2005), Miller (2008), GIS analysis of potential habitat by B. Stys (FWC)
(c)1. An estimated continuing decline of at least 10% in 10 years or 3 generations, whichever is longer (up to a maximum of 100 years in the future) OR		S	Y	See Sub-criterion A3
(c)2. A continuing decline, observed, projected, or inferred in numbers of mature individuals AND at least one of the following:		P	Y	See Sub-criterion A3
a. Population structure in the form of EITHER		S	N	
(i) No subpopulation estimated to contain more than 1000 mature individuals; OR				
(ii) All mature individuals are in one subpopulation		O	N	

b. Extreme fluctuations in number of mature individuals		S	N	
(D) Population Very Small or Restricted, EITHER				
(d)1. Population estimated to number fewer than 1,000 mature individuals; OR	>30,000 mature individuals	S	N	See Criterion C
(d)2. Population with a very restricted area of occupancy (typically less than 20 km^2 [8 mi^2]) or number of locations (typically 5 or fewer) such that it is prone to the effects of human activities or stochastic events within a short time period in an uncertain future	19,984 km^2	E	N	See Sub-criterion B2
(E) Quantitative Analyses				
e1. Showing the probability of extinction in the wild is at least 10% within 100 years	0% risk of extinction within 100 years	E	N	Root and Barnes (2005)

Initial Finding (Meets at least one of the criteria OR Does not meet any of the criteria)	Reason (which criteria are met)
Threatened	A3
Is species/taxon endemic to Florida? (Y/N)	
If Yes, your initial finding is your final finding. Copy the initial finding and reason to the final finding space below. If No, complete the regional assessment sheet and copy the final finding from that sheet to the space below.	
Final Finding (Meets at least one of the criteria OR Does not meet any of the criteria)	Reason (which criteria are met)
Threatened	A3

1	**Biological Status Review Information** Regional Assessment	Species/taxon:	Florida Pine Snake
2		Date:	11/18/10
3		Assessors:	Enge, Johnson,Ostertag, Owen, Printiss
4			
5			
6			
7			
8	Initial finding		
9			
10	2a. Is the species/taxon a non-breeding visitor? (Y/N/DK). If 2a is YES, go to line 18. If 2a is NO or DO NOT KNOW, go to line 11.		No
11	2b. Does the Florida population experience any significant immigration of propagules capable of reproducing in Florida? (Y/N/DK). If 2b is YES, go to line 12. If 2b is NO or DO NOT KNOW, go to line 17.		No
12	2c. Is the immigration expected to decrease? (Y/N/DK). If 2c is YES or DO NOT KNOW, go to line 13. If 2c is NO go to line 16.		
13	2d. Is the regional population a sink? (Y/N/DK). If 2d is YES, go to line 14. If 2d is NO or DO NOT KNOW, go to line 15.		
14	If 2d is YES - Upgrade from initial finding (more imperiled)		
15	If 2d is NO or DO NOT KNOW - No change from initial finding		
16	If 2c is NO or DO NOT KNOW- Downgrade from initial finding (less imperiled)		
17	If 2b is NO or DO NOT KNOW - No change from initial finding		
18	2e. Are the conditions outside Florida deteriorating? (Y/N/DK). If 2e is YES or DO NOT KNOW, go to line 24. If 2e is NO go to line 19.		
19	2f. Are the conditions within Florida deteriorating? (Y/N/DK). If 2f is YES or DO NOT KNOW, go to line 23. If 2f is NO, go to line 20.		
20	2g. Can the breeding population rescue the Florida population should it decline? (Y/N/DK). If 2g is YES, go to line 21. If 2g is NO or DO NOT KNOW, go to line 22.		
21	If 2g is YES - Downgrade from initial finding (less imperiled)		
22	If 2g is NO or DO NOT KNOW - No change from initial finding		
23	If 2f is YES or DO NOT KNOW - No change from initial finding		
24	If 2e is YES or DO NOT KNOW - No change from initial finding		
25			
26	Final finding		Threatened

Additional information – Generation length is defined as the average age of parents of the current cohort, which is greater than the age at first breeding and less than the age of the oldest breeding individual. No demographic data are available for the pine snake. Florida pine snakes may reach sexual maturity in 3 years (Franz 1992), and a northern pine snake lived up to 23 years in the wild (*see* Golden et al. 2009). A Florida pine snake marked as an adult was recaptured 4–5 years later (D. Franz, pers. commun. 2010). We infer a mean generation length of 8 years.

Sub-criterion A2. – We assume that the Florida pine snake population has declined as the human population in Florida has increased and converted suitable habitat to urban, agricultural, and other land uses. According to the U.S. Census Bureau, Florida's human population increased by 23.5% from 1990 through 2000 and by 16.0% from 2000 through 2009. From 1985–89 to 2003 (a period of 14–18 years), 15.5% of Florida's sandhill habitat, 12.4% of scrub, and 9.2% of pinelands were converted to other uses, primarily urban or other developed uses (Kautz et al. 2007). Other habitats used by Florida pine snakes experienced the following conversion to other land uses: shrub and brushland 36.3%, upland forest 11.3%, dry prairie 25.4%, and coastal strand 10.8% (Kautz et al. 2007). Actual estimates of Florida pine snake populations do not exist, but we suspect that loss and degradation of habitat would not have resulted in a >30% population decline within the past 24 years, particularly considering Florida's programs for purchasing public conservation lands (e.g., Preservation 2000 and Florida Forever). Prescribed fire is used by most public land managers to manage many of the habitats used by Florida pine snakes. Unlike some sandhill species, the Florida pine snake apparently tolerates fire-suppressed sandhill habitat and will use xeric hammock and mixed pine-hardwood forests (Franz 2005, Miller 2008), although the presence of more open habitats in the vicinity are probably necessary. Collection for pets is probably not a significant threat because of its fossorial habits.

Sub-criterion A3. – Three generations from 2010 would be 2034. Florida's population is projected to increase by 31.8% by 2035 (Zwick and Carr 2006). The exact relationship between human population increase and habitat loss is unknown. Much of the population increase could occur in urban areas, and residential development in suburban and rural areas may not eliminate snake populations. Although pine snakes use human-altered habitats (Franz 2005, Miller 2008), populations decline in habitats that have been fragmented by roads or residential developments. This is a large-bodied species with a relatively large home range that suffers mortality from vehicles, landowners, and pets. Of the potential habitat identified using GIS analysis, 76% is on private land (B. Stys, FWC, pers. commun. 2010). Both public and private lands will continue to experience habitat degradation from altered fire regimes (timing, intensity, fire-return interval, and season) (D. Printiss, The Nature Conservancy, pers. commun. 2010), leading to future population declines. There are ca. 900,000 ha (2.2 million acres) of fire-dominated natural communities on all publicly managed state lands, and ca. 336,000 ha (830,000 acres) were reported to have been prescribe burned in fiscal year 2009–10 within the fire interval necessary to maintain optimal habitat conditions (State of Florida Land Management Uniform Accounting Council 2010). This means that 61% of fire-dominated communities are being fire suppressed. This trend of backlogged, fire-suppressed communities has occurred each year all the way back to the mid-1970's when state agencies in Florida first began using fire as a management tool, and these backlogged acres, on average, are not decreasing (R. Owen, Florida Department of

Environmental Protection, pers. commun. 2010). Because of this downward trend, the available optimal habitat for upland species is projected to continue to decrease on the very lands that were meant to conserve them. The ability of Florida pine snake populations to continue to persist on fire-suppressed public and private lands is unknown. Suspected declines in pocket gopher populations (Miller et al. 2008) will probably continue, affecting those pine snakes that rely on pocket gophers for underground retreats and food. In a GIS analysis conducted by Cox and Kautz (2000), 12 public conservation lands have enough habitat to support over 200 adult snakes, assuming a population density of 1 snake/20 ha. The BRG was split regarding whether a 30% population decline will occur in 3 generations; 2 of 5 members suspected the decline would be <30% because populations can persist in ruderal habitats and efforts are being made to restore degraded sandhill habitat. For example, a 3-year multi-state sandhill ecological restoration project will enhance restoration on public and private lands by providing additional resources to meet sandhill restoration goals, significantly increasing the quality and quantity of habitat for wildlife species on 6,740 ha (16,655) acres of sandhill habitat in Florida by 2012 (http://myfwc.com/wildlifelegacy/fundedprojects/GrantDetails.aspx?ID=215). Another project will completely or partially restore 539 ha (1,333 acres) of sandhill and scrub habitats to benefit wildlife on Apalachee Wildlife Management Area (WMA), Big Bend WMA, Guana River WMA, and Lake Wales Ridge Wildlife and Environmental Area by 2012 (http://myfwc.com/wildlifelegacy/fundedprojects/GrantDetails.aspx?ID=229). Florida pine snake populations will also benefit from management of public lands for red-cockaded woodpeckers (Picoides borealis) and gopher tortoises (Gopher Tortoise Management Plan Team 2007).

Sub-criterion B1. – Historically, the extent of occurrence of the Florida pine snake was the entire state, exclusive of the Everglades and Florida Keys (110,210 km^2; 42,552 mi^2). There are museum, FNAI, and literature records from 38 counties since 1990. The total land area of these 38 counties is ca. 76,800 km^2 (29,650 mi^2), which is a conservative estimate of the current extent of occurrence.

Sub-criterion B2. – A GIS analysis of potential habitat for the species identified 19,983 km^2 (7,716 mi^2) of potential habitat (B. Stys, FWC, pers. commun. 2010), which we assume is equivalent to the area of occupancy. The FWC 2003 land-cover classes that comprised the potential habitat were pinelands (8,939.8 km^2; 3,451.7 mi^2), improved pasture (3,364.8 km^2; 1,299.2 mi^2), sandhill (3,080.4 km^2; 1,189.4 mi^2), shrub and brushland (2,658.1 km^2; 1,026.3 mi^2), sand pine scrub (785.4 km^2; 303.2 mi^2), xeric oak scrub (592.6 km^2; 228.8 mi^2), dry prairie (356.4 km^2; 137.6 mi^2), unimproved pasture (148.0 km^2; 75.1 mi^2), and coastal strand (122.1 km^2; 47.1 mi^2). Only pinelands, shrub and brushland, dry prairies, and pastures with dry soils were included as potential habitat. A continuing population decline is suspected because of continuing habitat loss and degradation, but there is no evidence of extreme fluctuations, and we do not consider the range of the species to be severely fragmented because of its tolerance of many disturbed habitats.

Criterion C. – No data on population densities exist for the Florida pine snake, but 2 telemetry studies have provided information on home range sizes. In Putnam County, Florida, 3 males had home ranges of 32.5–138.7 ha (mean 73.3 ha), whereas 3 females had home ranges of 10.6–16.9 ha (mean 13.5 ha) (Franz 2005). Home ranges of the 3 males did not overlap, whereas the home ranges of all 3 females overlapped each other and at least 1 male. In southwestern Georgia, 8 males had home ranges of 25.7–156.8 ha (mean 70.1 ha), and 4 females had home ranges of 18.6–80.7 ha (mean 37.5 ha) (Miller 2008). The mean home range size of both sexes combined was 57 ha in Florida and 59.2 ha in Georgia. These studies were conducted on protected lands with presumably good habitat and pine snake populations. Obviously, populations may not be as dense on all conservation lands or private lands. If we assume that all potential habitat (1,998,413 ha) is occupied by snakes, home ranges do not overlap, and home range size is 157 ha (the largest home range size found during the 2 studies), then the total population in Florida would be 12,729 adult snakes. This is equivalent to 0.006 snakes/ha. If we use the mean home range size of 58 ha, then the total population would be 34,455 adult snakes (density of 0.17 snakes/ha).

Appendix 1. Biological Review Group Members Biographies

Kevin M. Enge received his M.S. in Wildlife Ecology and Conservation from the University of Florida and B.S. degrees in Wildlife and Biology from the University of Wisconsin–Stevens Point. He is currently an Associate Research Scientist in the Reptile and Amphibian Subsection of the Wildlife Research Section, Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission (FWC). He has worked for FWC since 1989, serving as a nongame survey and monitoring biologist and the Herp Taxa Coordinator. He has conducted numerous surveys of both native and exotic amphibians and reptiles, and he has published >60 scientific papers and 25 reports.

Steve A. Johnson received his Ph.D. from the University of Florida and M.S. and B.S. degrees from the University of Central Florida. He is an Assistant Professor of Urban Wildlife Ecology at the University of Florida, and he holds a teaching and extension position in the Department of Wildlife Ecology and Conservation, Gulf Coast Research and Education Center. His area of expertise is natural history and conservation of amphibians and reptiles, especially those using isolated wetlands, and he has >60 publications.

Richard D. Owen received his M.S. and B.S. in Biology from the University of Central Florida. He is currently a District 2 Environmental Specialist for the Department of Environmental Protection, Florida Park Service specializing in aquatic systems and prescribed fire management at 40 north Florida state parks. He has over 22 years of vertebrate survey and monitoring experience in the southeastern United States. His area of expertise is natural history and distribution of Florida's amphibians and reptiles. He has been involved with over 30 publications on amphibians and reptiles.

Thomas E. Ostertag received his M.S. in Biological Sciences from the University of West Florida and B.S. degrees in Anthropology and Biological Sciences from Florida State University. He is currently the Listed Species Conservation Ecologist in the Species Conservation Planning Section of the Division of Habitat and Species Conservation, FWC. His areas of expertise are the ecology of ephemeral ponds and fire ecology. He has published several papers on the effects of fire in upland pine ecosystems.

David Printiss received B.S. in Biological Sciences from Florida State University. He is currently the Northwest Florida Program Director for The Nature Conservancy and is responsible for management and restoration of over 30,000 acres across 12 preserves. As a Conservancy Field Zoologist, he has surveyed nearly all conservation lands in northern Florida in order to provide rare species and natural community inventories and management plans. Although much of his current work is related to natural community restoration, his early training was in herpetology, and he co-authored many survey and management recommendation reports when he worked for the Florida Natural Areas Inventory.

APPENDIX 2. Summary of letters and emails received during the solicitation of information from the public period of September 17, 2010 through November 1, 2010.

No information about this species was received during the public information request period.

APPENDIX 3. Information and comments received from independent reviewers.