Supplemental Information for the Gopher Frog 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 Boyd Blihovde

From: Boyd_Blihovde@fws.gov
To: Imperiled
Cc: Turner, Bill
Subject: Gopher Frog Review
Date: Tuesday, February 08, 2011 5:33:42 PM

I'm sorry this is late. I did not attach the gopher frog file because I did not find any dramatic errors or lack of information.

The team of reviewers were very thorough and well written when completing the Gopher Frog recommendations. Although I do not agree with a finding that lists the Gopher Frog as "not threatened" (as there review does) I am comfortable with the methods used and the literature search was complete. I understand that the new listing procedures require this new recomendation for each State listed species, and as long as the State of Florida remains consistent, I am confident that species will be managed effectively in Florida if standards such as those used by IUCN are followed. Again, I am not happy with a decrease in protection or fundamental resources for the gopher frog but I agree with the reviewers that places like Ocala National Forest provide a slight level of species survival assurance, and hopefullly long term that will remain true.

Thanks,

boyd blihovde
Deputy Refuge Manager
Chassahowitzka National Wildlife Refuge Complex
1502 SE Kings Bay Drive
Crystal River, FL 34429

Peer review #2 from John Palis

From: john palis
Sent: Wednesday, January 19, 2011 12:29 PM
To: Turner, Bill
Subject: capito report comments submission

Hi Bill,

Here's my two cents. I didn't comment on verbage in my review, but there is an odd sentence in the biological review document that implies invertebrates not only eat capito eggs and tadpoles, but also "a variety of vertebrates, such as wading birds and snakes." They must be referring to forms of MACROinvertebrates that I don't know exist. :) When all the reviews are in, how/where can I access them?

Thanks. -- John

Peer review of "Biological Status Review for the Gopher Frog (*Lithobates capito*)" by John G. Palis (January 2011)

Using the most current occurrence data available, and working within the constraints of State of Florida listing criteria, the 5-member Gopher Frog biological review group (BRG) concluded that the Gopher Frog does not meet the requirements for designation as a threatened species in Florida. Florida Fish and Wildlife Conservation Commission (FWC) staff further recommend that the Gopher Frog no longer be listed as a Species of Special Concern. As requested, I reviewed the biological status review of the Gopher Frog and have the following comments.

The BRG appeared to put considerable thought and effort into preparing their biological status review of the gopher frog. The review document is well organized and generally well written. Supporting data are organized in tabular form and assumptions made by the group are provided. Considering the constraints of the listing criteria, it is difficult to disagree with the conclusion of the BRG that the Gopher Frog does not warrant listing by the state of Florida as a threatened species. However, I do see a potential flaw in the Geographic Range analysis and I question the premise that population trends over a ten-year period or during three generations of any species under consideration are sufficient to determine a species' conservation status.

The FWC listing guidelines appear to ignore historic population declines of species under consideration for listing. Although I consider this is a serious flaw in the listing process, I have no further comment as it is beyond the scope of the review requested of me.

A recent review of the status of the Gopher Tortoise in Florida concluded that it warrants listing as a state-threatened species. Therefore, it is difficult to conceive how the Gopher Frog, a species having a more restricted range than its primary upland host, the Gopher Tortoise, can be less endangered than the Gopher Tortoise. This is especially perplexing given the Gopher Frog's biphasic life history requirements for both suitable breeding non-breeding habitat in close proximity.

The BRG estimated the extent of occurrence of the Gopher Frog in Florida as 80,440 km^2 based on the total area of the 37 inhabited counties. Recognizing that these counties include habitat types unsuitable for Gopher Frogs, the BRG restricted estimated area of Gopher Frog occupancy within these 37 counties to 8992 km^2 based on GIS analysis. The estimated area of occupancy was based on 2003 land-cover class estimates of both upland and wetland habitat types deemed suitable for gopher frogs. However, it is not specifically stated whether or not juxtaposition of wetland and upland habitat types was considered in this analysis. This is *critically* important because, without appropriate breeding habitat, even the best-managed, otherwise suitable upland habitat has no value to gopher frogs. If juxtaposition of suitable upland and wetland habitats was not considered, I recommend re-analysis of estimated area of occupancy incorporating proximity of breeding and non-breeding habitat.

The BRG may also consider using an alternate means of estimating of area of occupancy. Using the 2 km maximum distance Gopher Frogs are known to migrate from breeding sites, a circular area of occupancy around each breeding site of 6.28 km^2 can be inferred. This, of course, assumes equal upland habitat suitability in every direction from a breeding site. This simple assumption if often not met as a result of nearby unsuitable habitat whether it is natural (e.g., floodplain forest associated with a perennial stream) or anthropogenic (e.g., a shopping mall). However, for illustrative purposes, we will assume all breeding ponds are equally distributed in the landscape a minimum of 4 km apart, and that all upland around each breeding site is suitable for habitation by Gopher Frogs.

It is not possible to determine the number of extant Gopher Frog breeding sites in Florida based on the biological status review. Apparently, the best estimate of the BRG is “far more than 200 breeding ponds in Florida.” Although equally subjective, I think 300 Gopher Frog breeding ponds in Florida is a fair assumption. Multiplying 6.28 km^2 by 300 yields an estimate of 1884 km^2 of Gopher Frog habitat in Florida. This is less than the 2000 km^2 threshold for a threatened species.

Given that Gopher Frog breeding sites are often clustered in the landscape, the area of occupied upland around each wetland in the cluster would be less than that of isolated breeding sites evenly distributed in the landscape. Therefore, the actual area of Gopher Frog occupancy in Florida may be even less than my rough estimate of 1884 km^2. In summary, I suspect that the area of occupancy, as determined by the BRG, is likely an over-estimate and should be recalculated.

Although I intuitively agree with the assessment of the BRG that the Gopher Frog is not *immediately* threatened with extirpation in Florida, I feel strongly that the species’ historic loss of habitat and reduction in range, the continued loss of habitat on private lands, and the degradation of habitat on conservation lands resulting from inappropriate management be accounted for by the FWC. Concern regarding the species’ status in Florida is further justified by the fact that most of the data/information summarized in the biological status review table was based on estimate, inference, and suspicion, not hard data. Based on the biological status review, it is apparent that *little is actually known regarding the conservation status of the Gopher Frog in Florida*. Unless a future assessment demonstrates that the Gopher Frog is secure as a breeding species in Florida, I recommend retaining some level of legal protection by the state of Florida or inclusion of the Gopher Frog on a “watch” list.

Peer review #3 from Dr. Steve Godley

From: Steve Godley
To: Imperiled
Cc: Turner, Bill; Enge, Kevin
Subject: RE: Gopher frog Draft BSR Report
Date: Monday, February 21, 2011 11:26:04 AM
Gopher Frog BSR Peer Review

I concur with the finding of the Biological Review Group (BRG) that the gopher frog (*Lithobates capito*) does not meet any of the FWC criteria for listing included in the definitions in Rule 68A-27.001(3).

However, the modeled Area of Occupancy (8,992 km^2), based on a GIS analysis of potential habitat (Stys 2010) as proposed in the BSR, most likely grossly over-estimates the true area of occupancy for this species in Florida. First, this estimate includes 283.7 km^2 of open water, marshes and wet prairies; given the breeding requirements (small, isolated, fishless wetlands and ponds) and patchy distribution of this species (see below) , 1/100th to 1/1,000th of this acreage is probably a better estimate. Secondly, the 8,992 km^2 is about 66% of the estimated Area of Occupancy for the gopher tortoise (Enge et al. 2006), yet Godley (1992) provided some comparative data indicating the gopher frogs are seemingly absent or rare from a majority of sites with tortoises, at least in central Florida (I acknowledge that gopher frogs use refugia other than gopher tortoise burrows). Kent and Snell (1994) collected 15 gopher frogs from 155 excavated tortoise burrows at a scrub site (with breeding ponds nearby; pers. obs.) in Orange County, but Witz et al. (1991) found none in 1,019 burrows in a Hernando County sandhill (no potential ponds nearby). Mushinsky and McCoy (1991, Vertebrate Species Composition of Selected Scrub Islands on the Lake Wales Ridge of Central Florida, FGFWFC Final Report NG87 - 149) intensively sampled 16 scrubs on the Lake Wales Ridge and detected gopher frogs at only 6 (37.5%); in contrast, gopher tortoises occurred at 15 of the same scrubs. More recently, I (December 2003, IMC's Mine-wide Gopher Tortoise and Burrow Commensal Management Plan, submitted to the FWC) summarized the results of excavating 12,266 active and inactive tortoise burrows from 42 sites on Mosaic (fka IMC) lands in Polk, Hillsborough, Manatee and Hardee Counties between 1989 – 2003: 6,448 tortoises and 38 species (N = 2,234 individuals) of burrow associates were collected. Gopher frogs (N = 286) occurred at 19 (45%) of the sites, numerically accounted for 12.8% of the burrow associates, and were found in 2.3% of the excavated burrows. On a per acreage basis, gopher frogs were detected at 33.7% of the 31,254 acres sampled, and at sites where they were present, the ratio was 1 gopher frog per 36.8 acres. In my experience, the Mosaic landscape represents good to excellent gopher frog habitat with thousands of suitable breeding ponds and management that favors tortoises and frogs.

J. Steve Godley
Director Emeritus / Senior Principal
Cardno ENTRIX
3905 Crescent Park Drive, Riverview, FL 33578

Peer review #4 from Dr. Bruce Means

From: D. Bruce Means [mailto:means@bio.fsu.edu]
Sent: Tuesday, January 25, 2011 2:17 PM
To: Turner, Bill
Subject: RE: Biol Status Rev of Pine Barrens Treefrog

Greetings, Bill,

Thanks for the kind words about Ryan. My two sons are the apples of my eye, and I am so proud of them. Attached please find my comments for the Biological Status Review for the Gopher Frog. Basically, I find that it is a complete and good review and I only have one comment about sentence structure.

Best regards,
--Bruce

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22 January 2011

Bill.Turner@MyFWC.com
Biological Status Review of the
Gopher Frog, *Lithobates capito*

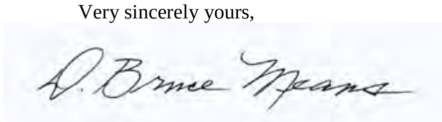
Dear Bill,

I have carefully reviewed the Biological Status Review of the Gopher Frog and can find no substantive changes that I would recommend. The Gopher Frog committee did a good and thorough job.

I have just one comment about sentence construction to make. Under Threats, paragraph 3 (on page 5), line 7 & 8, I'd change the sentence to read, "Invertebrates and a variety of vertebrates such as wading birds and snakes, can significantly impact population recruitment...."

Other than that, I heartily approve of the text and its content.

Very sincerely yours,



D. Bruce Means, Ph. D.
President and Executive Director

Peer review #5 from Betsy Roznik

From: Betsy Roznik
To: Imperiled
Subject: Review for gopher frog draft BSR report
Date: Tuesday, February 15, 2011 11:59:00 PM
Attachments: Gopher Frog Final Draft BSR_comments-EAR.doc

Hello,

I have completed my review of the draft biological status report for the gopher frog. In general, I found the information contained in the report to be thorough and accurate, and I agree with most of the interpretations of the data. Please see the attached report for my specific suggestions, which I have added using the track changes tool. I do, however, have two larger concerns that were not addressed in the draft report.

First, gopher frogs are burrow commensals of gopher tortoises. Because gopher tortoises are proposed to be listed as Threatened, it seems appropriate that any species (such as the gopher frog) that strongly relies on tortoise burrows to also be listed as Threatened. I realize that dependency on another Threatened species is not one of the IUCN criteria, but tortoise burrows are an essential habitat requirement for gopher frogs. Although gopher frogs have been reported to use other types of underground refuges, burrow selection has not been studied, and the frequency of use of other refuge types is unknown and should not be overstated. At my study sites in Ocala National Forest, gopher frogs used tortoise burrows as their permanent refuges, but they sometimes used other types of refuges temporarily while traveling to and from breeding ponds. This suggests that tortoise burrows are more important than other types of refugia, but this needs to be studied in further detail. Regardless, gopher frogs are strongly dependent on gopher tortoises and would likely disappear in areas where tortoises decline steeply or become extirpated.

Second, I am concerned about the information that was used to determine the area of gopher frog occupancy throughout the state. To address this sub-criterion, a GIS analysis was used to predict potential habitat for the gopher frog (by B. Stys, FWC). I was not able to evaluate this model fully because the details of the analysis were not available (e.g., how land cover classes were chosen, how breeding ponds were identified, whether these ponds were buffered by surrounding upland habitat, and if so, by how much, etc.). These details are a necessary part of the biological status report because they are not available in a public outlet that is accessible. Also, the assumptions of this model should be explained clearly. I disagree with the assumption that the area of potential habitat is equal to the area of occupancy, and there is an extensive body of literature available in peer-reviewed journals on this topic. In my experience, such GIS analyses vastly overpredict areas of habitat suitability and actual occupancy. This may be especially true for the gopher frog, which requires a combination of highquality habitat that is actively managed with fire, and high densities of gopher tortoise burrows. We know that sandhill is the land cover class most likely to support large, permanent populations of gopher frogs. According to the report, the amount of potential sandhill habitat is 1,903 km2, which is just below the 2,000 km2 threshold. However, the actual amount of sandhill used by gopher frogs is presumably less that that, in part due to habitat degradation (such as inappropriate habitat management) and a lack of tortoises. This report acknowledges that a large amount of potential gopher frog habitat on public and private lands is fire-suppressed (at least 61%), and persistence of gopher frog populations on these lands is unknown. For these reasons, the area of sandhill occupied by gopher frogs is likely less than 2,000 km2; I strongly suggest erring on the side of caution by scoring the area of occupancy as < 2,000 km2. This would mean that the gopher frog would meet two sub-criteria (low area of occupancy, and continued decline) necessary to warrant listing as a Threatened species under the geographic range criterion.

For these two reasons, I believe that the gopher frog should be listed as Threatened. I would be happy to discuss this further, and I would also be happy to evaluate the GIS model if provided with the details of the analysis. (I am experienced in GIS and spatial analysis.) Regardless of the review group's final decision on the status of the gopher frog, the concerns I have outlined above should be addressed directly in the report and supported with appropriate literature. Please let me know if I can assist in any way, including reviewing a revised draft of the report.

Sincerely,

Betsy Roznik
PhD Candidate
School of Marine and Tropical Biology
James Cook University
Townsville, QLD 4811
Australia

Biological Status Review
for the
Gopher Frog
(*Lithobates capito*)

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 September 1, 2010. Public information on the status of the gopher frog 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), Thomas Ostertag (FWC), Rick Owen (Florida Department of Environmental Protection), and David Printiss (The Nature Conservancy) (Appendix 1). In accordance with rule 68A-27.0012 Florida Administrative Code (F.A.C), the BRG was charged with evaluating the biological status of the gopher frog using criteria included in definitions in 68A-27.001(3), F.A.C. 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 from the biological assessment that the gopher frog did not meet any of the criteria for designation as a Threatened species. FWC staff recommends that the gopher frog not be listed as a threatened species and be removed from the State Species of Special Concern list.

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

BIOLOGICAL INFORMATION

Taxonomic Classification – Two subspecies of gopher frog were formerly recognized in Florida, the Florida gopher frog (*Rana capito aesopus*) and the dusky gopher frog (*R. c. sevosa*). The latter subspecies was thought to occur west of the Apalachicola River (Conant and Collins 1991). However, Young and Crother (2001) analyzed allozyme data that showed no genetic divisions among populations of *Rana capito*, except for the population in southern Mississippi, which they recommended elevating to specific status by resurrecting *Rana sevosa* (Goin and Netting, 1940), the dusky gopher frog. Frost et al. (2006) removed New World frogs from the genus *Rana* and placed them in *Lithobates*, so the current name for the species occurring in Florida is the gopher frog (*Lithobates capito*).

Life History and Habitat Requirements – Information on the species has been summarized by Jensen and Richter (2005). The gopher frog primarily inhabits areas with well-drained sandy soils that support gopher tortoise (*Gopherus polyphemus*) populations (Wright 1932, Franz 1986, Blihovde 2006, Roznik 2007). During the non-breeding season, the gopher frog is generally associated with longleaf pine (*Pinus palustris*)–xeric oak (*Quercus* spp.) sandhills but also occurs in upland pine forest, scrub, xeric hammock, mesic and scrubby flatwoods, dry prairie, mixed hardwood-pine communities, and a variety of disturbed habitats (Enge 1997). Gopher frogs extensively use gopher tortoise burrows for underground retreats (Wright 1932, Carr 1940, Franz 1986) but also use southeastern pocket gopher (*Geomys pinetis*) burrows, mouse burrows, crayfish burrows, hollow logs, stump holes, root mounds, broken limbs, crevices, dead vegetation, and clumps of grass (Wright and Wright 1949, Gentry and Smith 1968, Lee 1968, Godley 1992, Richter et al. 2001, Nickerson and Celino 2003, Blihovde 2006, K. Enge, FWC, pers. commun. 2010). Underground retreats in uplands are important for avoiding predation and desiccation, and frogs would be unlikely to survive droughts without them (Blihovde 2006). Furthermore, underground retreats are essential for the survival of newly metamorphosed gopher frogs, which experience high predation rates when they are above ground, and are more vulnerable to desiccation than adults (Roznik and Johnson 2009a). Gopher frogs breed in temporary or semipermanent, shallow, fishless ponds with an open canopy and emergent vegetation, including depression marshes, basin marshes, wet prairies, dome swamps, upland sandhill lakes, sinkhole ponds, borrow pits, and ditches (Godley 1992; Jensen and LaClaire 1995; Enge 1997; K. Enge, FWC, pers. commun. 2010).

Gopher frogs will travel up to 2 km to a breeding pond (Franz 1986), typically during heavy winter and spring rains. The breeding season is usually September–April (Palis 1998; Branch and Hokit 2000; Blihovde 2006; S. Morrison, The Nature Conservancy, pers. commun. 2010), but frogs potentially can breed during any month of the year during heavy rains, although summer breeding is probably more common in southern Florida because winter frontal systems are weaker (Godley 1992, Jackson 2004). A female apparently deposits only a single egg mass containing a mean of 1,200–2,200 eggs (*see* Jensen and Richter 2005). Egg masses are attached to vegetation, and tadpoles transform in 3–7 months (Godley 1992, Palis 1998). Newly metamorphosed frogs leave their natal pond and spend most of their life in the surrounding uplands (Roznik and Johnson 2009b. Males apparently become reproductively mature at 1.5 years and females at 2 years (*see* Jensen and Richter 2005).

Population Status and Trend – There is no quantitative information, but the population is assumed to have declined as the human population in Florida has increased and converted suitable habitat to urban, agricultural, and other land uses. Based on the lack of recent activity at many historic breeding sites, Franz and Smith (1999) concluded that gopher frog populations had declined east of the Apalachicola River in the last 20 years (1975–95), particularly in coastal counties and in South Florida where most of the human population is concentrated. However, Franz and Smith (1999) considered the species to still be common on protected lands along the central spine of the Peninsula north of Lake Okeechobee. Franz and Smith (1999) compiled records from 258 localities in 45 counties in the peninsula. During surveys in 1990–95, they found gopher frogs at only 3 of 63 historical sites visited but found 83 new sites in 19 counties, including 4 new county records. Of the 12 counties for which Franz and Smith (1999) found no records, there have been recent records for 2 counties, Gilchrist and Hamilton (Tucker and Handrick 2006; K. Enge, FWC, unpubl. data). In the past 12 years (since 1998), gopher frogs have been recorded in 26 counties: Alachua, Baker, Citrus, Clay, Columbia, Gilchrist, Glades, Hernando, Highlands, Lake, Leon, Levy, Manatee, Marion, Martin, Orange, Osceola, Pasco, Polk, Putnam, Sarasota, Seminole, St. Lucie, Sumter, Taylor, and Volusia (museum and Florida Natural Areas Inventory [FNAI] records; K. Enge, FWC, unpubl. data). None of these counties is west of the Apalachicola River, because there have not been recent surveys in those counties; however, records in the 1990s exist for Calhoun, Okaloosa, Santa Rosa, Walton, and Washington counties (museum and FNAI records). Surveys in 2006–10 recorded gopher frogs in 118 ponds on 20 public conservation lands (K. Enge, FWC, unpubl. data). Of the 63 ponds where gopher frogs were found from July 2009 through June 2010, 50 represented new ponds (K. Enge, FWC, unpubl. data). Many public lands were not surveyed, such as Avon Park Air Force Range, where Franz et al. (1998) found 11 gopher frog breeding ponds. Surveys for gopher frogs on public lands typically document multiple breeding ponds, such as 20 ponds on Eglin Air Force Base

(Palis and Jensen 1995) and 21 ponds on Camp Blanding Military Reservation (Hipes and Jackson 1996). At the Ordway–Swisher Biological Station, Franz (1986) marked 100 gopher frogs at tortoise burrows over a 16-month period.

Geographic Range and Distribution – The gopher frog occurs in the southeastern Coastal Plain from southeastern Alabama to North Carolina, with disjunct populations in central Alabama and the Cumberland Plateau in Tennessee (*see* Jensen and Richter 2005). The gopher frog historically occurred throughout Florida except for the Everglades region (Fig. 1), and Florida represents the largest portion of the total global range of the species (Jensen and Richter 2005).

Quantitative Analyses – We are not aware of a population viability analysis for the gopher frog. However, we believe that it is unlikely that the species will become extinct within the next 100 years based upon the large acreage of suitable habitat contained in conservation lands throughout Florida, its adaptability to some habitat alteration, and the increased security of gopher tortoise populations because of its new Threatened status (*see* Enge et al. 2006) and concomitant Gopher Tortoise Management Plan (Gopher Tortoise Management Plan Team 2007). The only factor that might change this scenario would be catastrophic die-offs from disease, but the isolated nature of many populations should keep them protected from disease vectors.

BIOLOGICAL STATUS ASSESSMENT

Threats – The greatest threat to gopher frogs is loss and alteration of xeric upland habitats resulting from commercial and residential development, silviculture, agriculture, and mining (Jensen and Richter 2005). Intact xerophytic upland ecosystems inhabited by gopher frogs have suffered severe losses in Florida, including longleaf pine-dominated sandhill as well as scrub habitat on the ridges of central and coastal Florida (Means and Grow 1985, Myers 1990, Kautz, 1998, Enge et al. 2006). Losses have been especially severe along the highly developed coastal ridges of both southeastern and southwestern Florida, as well as the central ridges that have been mined, converted to

Fig. 1. Locality records from museums, FNAI, and the literature for the gopher frog.

Comment [BR1]: Over what time period do these records represent?

agriculture, and more recently developed (Jackson 2004). Because of their vagility, gopher frog populations can persist in fragmented landscapes, even when breeding ponds occur in unsuitable upland habitat. Gopher frogs do not require intact native ground cover, and dense populations can occur in pastures containing gopher tortoise burrows. For example, 97 gopher frogs were observed using 261 tortoise burrows in an abandoned pasture in Green Swamp West, Pasco County (M. Barnwell, Southwest Florida Water Management District, pers. comm. 2010). The most cited management concerns for gopher frogs are altered fire regimes, resulting in the encroachment of hardwoods and shrubs in the upland habitat, and the loss of gopher tortoise or pocket gopher populations that provide the primary source of upland shelters (Godley 1992, Greenberg et al. 2003, Jensen and Richter 2005, Blihovde 2006, Roznik 2007). Newly metamorphosed gopher frogs emigrating from ponds in Ocala National Forest selected fire-maintained habitat that was associated with an open canopy, few hardwood trees, small amounts of leaf litter, and large amounts of wiregrass (*Aristida stricta*); this habitat contained higher densities of gopher tortoise and small mammal burrows used as refuges (Roznik and Johnson 2009b). At these same sites, adult gopher frogs also selected fire-maintained habitat over forest that had been fire-suppressed (Roznik and Johnson 2009c). Altered fire regimes have resulted in canopy closure and unnatural shading of the grassy ground cover, which provides food for gopher tortoises and the frog's invertebrate prey base. Silvicultural practices can degrade upland habitat and impact gopher frog populations. Gopher frog larvae were found in <7% of 444 ponds sampled on forest industry lands (Wigley et al. 1999). On commercial forest lands in the Panhandle, dense stands of sand pine (*Pinus clausa*) are often planted in sandhill habitat. Gopher frog larvae were found in only 1 of 85 ponds sampled in a Sand Pine plantation on private land, whereas they were found significantly more often in ponds in an adjacent Longleaf Pine forest on Apalachicola National Forest (Means and Means 2005).

Comment [BR2]: This statement needs to be supported with references and should also be qualified; although gopher frogs can tolerate some fragmentation, it depends on the distances between suitable habitats and what lies between them.

Degradation and destruction of wetlands also affect gopher frogs that rely on these ponds for breeding. Exclusion and suppression of fire from wetlands often leads to degradation of breeding ponds through shrub encroachment, peat buildup, and increased evapotranspiration shortening hydroperiods (LaClaire 2001). Coverage of grassy emergent vegetation decreases, and peat buildup may acidify the water past tolerance levels (Smith and Braswell 1994). Land managers often use fire lines to exclude prescribed fire from dry wetlands to prevent problems with smoke management or muck fires, particularly if the wetlands are associated with wildland urban interface (Bishop and Haas 2005). Erosion from adjacent unpaved roads can lead to siltation and sedimentation of ponds, and runoff from paved roads can pollute ponds with petrochemicals and other toxic substances to frogs (LaClaire 2001). Pond degradation also results from garbage dumping and off-road vehicle (ORV) use (Means and Means 1998, LaClaire 2001). Use of ORVs in pond basins can cause direct mortality of tadpoles and adults, and it can affect habitat quality by altering pond contours, herbaceous vegetation, and hydrology (LaClaire 2001). Loss of herbaceous vegetation decreases cover for tadpoles from predators and can discourage reproduction, because egg masses are attached to stems of herbaceous vegetation (*see* LaClaire 2001). Large tires of ORVs may break the organic hardpan beneath a pond, causing water to drain out and shortening the hydroperiod (LaClaire and Franz 1990). The hydrology of many of Florida's depression marsh wetlands may already have been significantly influenced by anthropogenic-caused impacts related to groundwater withdrawals (R. Owen, Florida Department of Environmental Protection, pers. commun. 2010). North Florida has already undergone extreme shifts in groundwater potentiometric levels (i.e., "groundwater contours") (Grubs and Crandall 2007). The hydrologic impact has been documented for the first time across regional hydrologic divides between the Suwannee River and St. Johns River water management districts, and there are numerous examples across the entire state where groundwater withdrawals are significantly shifting the historic directional flow of localized groundwater supplies (R. Owen, Florida Department of Environmental Protection, pers. commun. 2010). State regulators and governing water management districts have been forced to plan for future losses of ground water and even develop written recovery strategies, as mandated by legislative law, because of significant damaging groundwater losses (http://www.swfwmd.state.fl.us/waterman/swuca/). Some ephemeral wetlands are independent of ground water or surface aquifer water, but other wetlands are being impacted by hydrological alterations related to groundwater withdrawal (Guzy et al. 2006). Groundwater withdrawal can shorten hydroperiods or even eliminate ephemeral wetlands, and climate change may be affecting the amount of winter precipitation in peninsular Florida. Long-term droughts may have caused some populations to disappear because of insufficient population recruitment.

The introduction of fish may play a role in population declines of certain anurans breeding in normally fish-free wetlands. Eastern mosquitofish (*Gambusia holbrooki*) are often introduced into isolated wetlands for mosquito control purposes, and even these small fish may have significant negative effects on gopher frog tadpoles (Gregoire and Gunzburger 2008). A far more serious threat, however, is the stocking of game fish (*Lepomis* spp. and *Micropterus* spp.) into ponds used by gopher frogs, or the introduction of predaceous fish into formerly fish-free wetlands during natural flooding events. Invertebrates can significantly impact population recruitment by feeding on eggs and tadpoles (Richter 2000), and a variety of vertebrates, such as wading birds and snakes. Seventy-five percent of 32 metamorphs leaving a natal pond were killed by North American racers (*Coluber constrictor*), common garter snakes (*Thamnophis sirtalis*), or mammals (Roznik and Johnson 2009a). The long distances sometimes traveled by gopher frogs to breed, or following metamorphosis, can make them susceptible to highway mortality. A metamorph leaving a natal pond moved 691 m before being killed, and 3 of 32 metamorphs were killed by vehicles on lightly traveled dirt roads (Roznik and Johnson 2009a) that they apparently used as migration corridors (Roznik and Johnson 2009b).

A chytridiomycete fungus (*Batrachochytrium dendrobatidis*), or *Bd*, has been implicated as a primary or suspected cause of disease epidemics and subsequent population declines of amphibians in many parts of the world, but chytrid fungus is not known to be responsible for any amphibian die-offs in the Southeast US. None of 18 gopher frog tadpoles examined from Florida and Georgia tested positive for *Bd* (Rothermel et al. 2008). Ranaviruses are likely a greater threat to amphibians, particularly tadpoles, than *Bd* in North America (Gray et al. 2009a, b). A die-off of hundreds of ranid tadpoles, including gopher frogs, in 2 ponds in Withlacoochee State Forest, Hernando County, was apparently caused by an unnamed *Perkinsus*like (or alveolate) microorganism (Davis et al. 2007, Rothermel et al. 2008). A newly identified mesomycetozoan pathogen, *Anuraperkinsus emelandra*, has been the cause of massive ranid tadpole mortalities in 10 states, including a 2003 die-off of almost all tadpoles at the only known breeding pond of the federally endangered dusky gopher frog (http://www.nwhc.usgs.gov/disease_information/amphibian_malformation_and_decline/index.jsp).

Statewide Population Assessment – Findings from the BRG are included in Biological Status Review Information tables.

LISTING RECOMMENDATION

The BRG found the gopher frog did not meet any of the criteria for listing as a threatened species. Staff recommends that the gopher frog not be listed as a threatened species.

SUMMARY OF THE INDEPENDENT REVIEW

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Peer review # 6 from Dr. Katie Greenberg

From: Katie Greenberg
To: Imperiled
Cc: Turner, Bill
Subject: Re: Gopher frog Draft BSR Report
Date: Wednesday, January 26, 2011 12:09:07 PM
Attachments: RedListGuidelines.pdf
Guidelines for Application of IUCN Red List Criteria at Regional Levels Version 3 0.pdf
IUCN reg-guidelines v 3 1.pdf
Readable Version of the Listed Species Rule.doc
Gopher Frog Final Draft BSR 12-9-10.docx
RWC Gopher Frog Final Draft BSR kt edits 1-26-10.docx
Roznik&Johnson&Greenberg-TerrestrialMovementsRcap_FEAM 2009.pdf
SWGP-FWC-05044-FINAL-5-22-08.doc

Hi Bill - Hope you're well.

I'm attaching the gopher frog draft report with my (few) comments and edits embedded using track changes. Mainly I thought the report could benefit from a more thorough discussion of potential impacts of climate change, and plans for monitoring potential gopher frog population declines due to climate change or from other sources.

Overall the report looks really good - thorough, and well written! I'm also attaching a couple of references that you might find useful (or not!). One is a final report I submitted to you back in 2008, but I never was clear as to whether it was published as you've done with my final reports in the past. If it was, I'd really appreciate it if you could send me the citation (and report) or link (if it was online); if not, here it is!

Thanks for the opportunity to review this - it was informative, and a pleasure to review

- Katie
Katie Greenberg
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Biological Status Review
for the
Gopher Frog
(*Lithobates capito*)

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 September 1, 2010. Public information on the status of the gopher frog 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), Thomas Ostertag (FWC), Rick Owen (Florida Department of Environmental Protection), and David Printiss (The Nature Conservancy) (Appendix 1). In accordance with rule 68A-27.0012 Florida Administrative Code (F.A.C), the BRG was charged with evaluating the biological status of the gopher frog using criteria included in definitions in 68A-27.001(3), F.A.C. 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 from the biological assessment that the gopher frog did not meet any of the criteria for designation as a Threatened species. FWC staff recommends that the gopher frog not be listed as a threatened species and be removed from the State Species of Special Concern list.

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

BIOLOGICAL INFORMATION

Taxonomic Classification – Two subspecies of gopher frog were formerly recognized in Florida, the Florida gopher frog (*Rana capito aesopus*) and the dusky gopher frog (*R. c. sevosa*). The latter subspecies was thought to occur west of the Apalachicola River (Conant and Collins 1991). However, Young and Crother (2001) analyzed allozyme data that showed no genetic divisions among populations of *Rana capito*, except for the population in southern Mississippi, which they recommended elevating to specific status by resurrecting *Rana sevosa* (Goin and Netting, 1940), the dusky gopher frog. Frost et al. (2006) removed New World frogs from the genus *Rana* and placed them in *Lithobates*, so the current name for the species occurring in Florida is the gopher frog (*Lithobates capito*).

Life History and Habitat Requirements – Information on the species has been summarized by Jensen and Richter (2005). The gopher frog primarily inhabits areas with well-drained sandy soils that support gopher tortoise (*Gopherus polyphemus*) populations (Wright 1932, Franz 1986, Blihovde 2006, Roznik 2007). During the non-breeding season, the gopher frog is generally associated with longleaf pine (*Pinus palustris*)–xeric oak (*Quercus* spp.)

sandhills but also occurs in upland pine forest, scrub, xeric hammock, mesic and scrubby flatwoods, dry prairie, mixed hardwood-pine communities, and a variety of disturbed habitats (Enge 1997). Gopher frogs extensively use gopher tortoise burrows for underground retreats (Wright 1932, Carr 1940, Franz 1986) but also use southeastern pocket gopher (*Geomys pinetis*) burrows, mouse burrows, crayfish burrows, hollow logs, stump holes, root mounds, broken limbs, crevices, dead vegetation, and clumps of grass (Wright and Wright 1949, Gentry and Smith 1968, Lee 1968, Godley 1992, Richter et al. 2001, Nickerson and Celino 2003, Blihovde 2006, K. Enge, FWC, pers. commun. 2010). Underground retreats in uplands are important for avoiding predation and desiccation, and frogs would be unlikely to survive droughts without them (Blihovde 2006). Gopher frogs breed in temporary or semipermanent, shallow, fishless ponds with an open canopy and emergent vegetation, including depression marshes, basin marshes, wet prairies, dome swamps, upland sandhill lakes, sinkhole ponds, borrow pits, and ditches (Godley 1992; Jensen and LaClaire 1995; Enge 1997; K. Enge, FWC, pers. commun. 2010).

Gopher frogs will travel up to 2 km to a breeding pond (Franz 1986), typically during heavy winter and spring rains. The breeding season is usually September–April (Palis 1998; Branch and Hokit 2000; Blihovde 2006; S. Morrison, The Nature Conservancy, pers. commun. 2010), but frogs potentially can breed during any month of the year during heavy rains; summer breeding is probably more common in southern Florida because winter frontal systems are weaker (Godley 1992, Jackson 2004). A female apparently deposits only a single egg mass containing a mean of 1,200–2,200 eggs (*see* Jensen and Richter 2005). Egg masses are attached to vegetation, and tadpoles transform in 3–7 months (Godley 1992, Palis 1998). Newly metamorphosed frogs leave their natal pond and spend most of their life in the surrounding uplands. Males apparently become reproductively mature at 1.5 years and females at 2 years (*see* Jensen and Richter 2005).

Population Status and Trend – There is no quantitative information, but the population is assumed to have declined as the human population in Florida has increased and converted suitable habitat to urban, agricultural, and other land uses. Based on the lack of recent activity at many historic breeding sites, Franz and Smith (1999) concluded that gopher frog populations had declined east of the Apalachicola River in the last 20 years (1975–95), particularly in coastal counties and in South Florida where most of the human population is concentrated. However, Franz and Smith (1999) considered the species to still be common on protected lands along the central spine of the Peninsula north of Lake Okeechobee. Franz and Smith (1999) compiled records from 258 localities in 45 counties in the peninsula. During surveys in 1990–95, they found gopher frogs at only 3 of 63 historical sites visited but found 83 new sites in 19 counties, including 4 new county records. Of the 12 counties for which Franz and Smith (1999) found no records, there have been recent records for 2 counties, Gilchrist and Hamilton (Tucker and Handrick 2006; K. Enge, FWC, unpubl. data). In the past 12 years (since 1998), gopher frogs have been recorded in 26 counties: Alachua, Baker, Citrus, Clay, Columbia, Gilchrist, Glades, Hernando, Highlands, Lake, Leon, Levy, Manatee, Marion, Martin, Orange, Osceola, Pasco, Polk, Putnam, Sarasota, Seminole, St. Lucie, Sumter, Taylor, and Volusia (museum and Florida Natural Areas Inventory [FNAI] records; K. Enge, FWC, unpubl. data). None of these counties is west of the Apalachicola River, because there have not been recent surveys in those counties; however, records in the 1990s exist for Calhoun, Okaloosa, Santa Rosa, Walton, and Washington counties (museum and FNAI records). Surveys in 2006–10 recorded gopher frogs in 118 ponds on 20 public conservation lands (K. Enge, FWC, unpubl. data). Of the 63 ponds where gopher frogs were found from July 2009 through June 2010, 50 represented new ponds (K. Enge, FWC, unpubl. data). Many public lands were not surveyed, such as Avon Park Air Force Range, where Franz et al. (1998) found 11 gopher frog breeding ponds. Surveys for gopher frogs on public lands typically document multiple breeding ponds, such as 20 ponds on Eglin Air Force Base (Palis and Jensen 1995) and 21 ponds on Camp Blanding Military Reservation (Hipes and Jackson 1996). At the Ordway–Swisher Biological Station, Franz (1986) marked 100 gopher frogs at tortoise burrows over a 16-month period.

Geographic Range and Distribution – The gopher frog occurs in the southeastern Coastal Plain from southeastern Alabama to North Carolina, with disjunct populations in central Alabama and the Cumberland Plateau in Tennessee (*see* Jensen and Richter 2005). The gopher frog historically occurred throughout Florida except for the Everglades region (Fig. 1), and Florida represents the largest portion of the total global range of the species (Jensen and Richter 2005).

Quantitative Analyses – We are not aware of a population viability analysis for the gopher frog. However, we believe that it is unlikely that the species will become extinct within the next 100 years based upon the large acreage of suitable habitat contained in conservation lands throughout Florida, its adaptability to some habitat alteration, and the increased security of gopher tortoise populations because of its new Threatened status (*see* Enge et al. 2006) and concomitant Gopher Tortoise Management Plan (Gopher Tortoise Management Plan Team 2007). The only factor that might change this scenario would be catastrophic die-offs from disease, but the isolated nature of many populations should keep them protected from disease vectors.

BIOLOGICAL STATUS ASSESSMENT

Threats – The greatest threat to gopher frogs is loss and alteration of xeric upland habitats resulting from commercial and residential development, silviculture, agriculture, and mining (Jensen and Richter 2005). Intact xerophytic upland ecosystems inhabited by gopher frogs have suffered severe losses in Florida, including longleaf pine-dominated sandhill as well as scrub habitat on the ridges of central and coastal Florida (Means and Grow 1985, Myers 1990, Kautz, 1998, Enge et al. 2006). Losses have been especially severe along the highly developed coastal ridges of both southeastern and southwestern Florida, as well as the central ridges that have been mined, converted to

Fig. 1. Locality records from museums, FNAI, and the literature for the gopher frog.

agriculture, and more recently developed (Jackson 2004). Because of their vagility, gopher frog populations can persist in fragmented landscapes, even when breeding ponds occur in unsuitable upland habitat. Gopher frogs do not require intact native ground cover, and dense populations can occur in pastures containing gopher tortoise burrows. For example, 97 gopher frogs were observed using 261 tortoise burrows in an abandoned pasture in Green Swamp West, Pasco County (M. Barnwell, Southwest Florida Water Management District, pers. comm. 2010). The most cited management concerns for gopher frogs are altered fire regimes, resulting in the encroachment of hardwoods and shrubs in the upland habitat, and the loss of gopher tortoise or pocket gopher populations that provide the primary source of upland shelters (Godley 1992, Greenberg et al. 2003, Jensen and Richter 2005, Blihovde 2006, Roznik 2007). Newly metamorphosed gopher frogs emigrating from ponds in Ocala National Forest selected fire-maintained habitat that was associated with an open canopy, few hardwood trees, small amounts of leaf litter, and large amounts of wiregrass (*Aristida stricta*); this habitat contained higher densities of gopher tortoise and small mammal burrows used as refuges (Roznik and Johnson 2009b). Altered fire regimes have resulted in canopy closure and unnatural shading of the grassy ground cover, which provides food for gopher tortoises and the frog's invertebrate prey base. Silvicultural practices can degrade upland habitat and impact gopher frog populations. Gopher frog larvae were found in <7% of 444 ponds sampled on forest industry lands (Wigley et al. 1999). On commercial forest lands in the Panhandle, dense stands of sand pine *(Pinus clausa*) are often planted in sandhill habitat. Gopher frog larvae were found in only 1 of 85 ponds sampled in a sand pine plantation on private land, whereas they were found significantly more often in ponds in an adjacent Longleaf Pine forest on Apalachicola National Forest (Means and Means 2005).

Comment [chg3]: A more recent report for this study was submitted to FWC in 2008; I'll attach FYI. I'm not sure if this was ever published (online or hard copy); if it was I'm not aware of it.

Degradation and destruction of wetlands also affect gopher frogs that rely on these ponds for breeding. Exclusion and suppression of fire from wetlands often leads to degradation of breeding ponds through shrub encroachment, peat buildup, and increased evapotranspiration shortening hydroperiods (LaClaire 2001). Coverage of grassy emergent vegetation decreases, and peat buildup may acidify the water past tolerance levels (Smith and Braswell 1994). Land managers often use fire lines to exclude prescribed fire from dry wetlands to prevent problems with smoke management or muck fires, particularly if the wetlands are associated with wildland urban interface (Bishop and Haas 2005). Erosion from adjacent unpaved roads can lead to siltation and sedimentation of ponds, and runoff from paved roads can pollute ponds with petrochemicals and other toxic substances to frogs (LaClaire 2001). Pond degradation also results from garbage dumping and off-road vehicle (ORV) use (Means and Means 1998, LaClaire 2001). Use of ORVs in pond basins can cause direct mortality of tadpoles and adults, and it can affect habitat quality by altering pond contours, herbaceous vegetation, and hydrology (LaClaire 2001). Loss of herbaceous vegetation decreases cover for tadpoles from predators and can discourage reproduction, because egg masses are attached to stems of herbaceous vegetation (*see* LaClaire 2001). Large tires of ORVs may break the organic hardpan beneath a pond, causing water to drain out and shortening the hydroperiod (LaClaire and Franz 1990). The hydrology of many of Florida's depression marsh wetlands may already have been significantly influenced by anthropogenic-caused impacts related to groundwater withdrawals (R. Owen, Florida Department of Environmental Protection, pers. commun. 2010). North Florida has already undergone extreme shifts in groundwater potentiometric levels (i.e., "groundwater contours") (Grubs and Crandall 2007). The hydrologic impact has been documented for the first time across regional hydrologic divides between the Suwannee River and St. Johns River water management districts, and there are numerous examples across the entire state where groundwater withdrawals are significantly shifting the historic directional flow of localized groundwater supplies (R. Owen, Florida Department of Environmental Protection, pers. commun. 2010). State regulators and governing water management districts have been forced to plan for future losses of ground water and even develop written recovery strategies, as mandated by legislative law, because of significant damaging groundwater losses (http://www.swfwmd.state.fl.us/waterman/swuca/). Some ephemeral wetlands are independent of ground water or surface aquifer water, but other wetlands are being impacted by hydrological alterations related to groundwater withdrawal (Guzy et al. 2006). Groundwater withdrawal can shorten hydroperiods or even eliminate ephemeral wetlands, and climate change may be affecting the amount of winter precipitation in peninsular Florida. Long-term droughts may have caused some populations to disappear because of insufficient population recruitment.

Comment [chg4]: I'd like to see a paragraph specifically on how climate change might alter breeding pond hydrology (hydroperiod and timing; water temperature) and upland habitat conditions (fire return and intensity), and potential effects on gopher frog populations. I'd also like to see a section on how the FWC will monitor these conditions and gopher frog populations so that FWC can be poised to manage for potential population declines.

The introduction of fish may play a role in population declines of certain anurans breeding in normally fish-free wetlands. Eastern mosquitofish (*Gambusia holbrooki*) are often introduced into isolated wetlands for mosquito control purposes, and even these small fish may have significant negative effects on gopher frog tadpoles (Gregoire and Gunzburger 2008). A far more serious threat, however, is the stocking of game fish (*Lepomis* spp. and *Micropterus* spp.) into ponds used by gopher frogs, or the introduction of predaceous fish into formerly fish-free wetlands during natural flooding events. Invertebrates can significantly impact population recruitment by feeding on eggs and tadpoles (Richter 2000), and a variety of vertebrates, such as wading birds and snakes. Seventy-five percent of 32 metamorphs leaving a natal pond were killed by North American racers (*Coluber constrictor*), common garter snakes (*Thamnophis* *sirtalis*), or mammals (Roznik and Johnson 2009a). The long distances sometimes traveled by gopher frogs to breed can make them susceptible to highway mortality. A metamorph leaving a natal pond moved 691 m before being killed, and 3 of 32 metamorphs were killed by vehicles on lightly traveled dirt roads (Roznik and Johnson 2009a) that they apparently used as migration corridors (Roznik and Johnson 2009b).

A chytridiomycete fungus (*Batrachochytrium dendrobatidis*), or *Bd*, has been implicated as a primary or suspected cause of disease epidemics and subsequent population declines of amphibians in many parts of the world, although chytrid fungus is not known to be responsible for any amphibian die-offs in the Southeast. None of 18 gopher frog tadpoles examined from Florida and Georgia tested positive for *Bd* (Rothermel et al. 2008). Ranaviruses are likely a greater threat to amphibians, particularly tadpoles, than *Bd* in North America (Gray et al. 2009a, b). A die-off of hundreds of ranid tadpoles, including gopher frogs, in 2 ponds in Withlacoochee State Forest, Hernando County, was apparently caused by an unnamed *Perkinsus*like (or alveolate) microorganism (Davis et al. 2007, Rothermel et al. 2008). A newly identified mesomycetozoan pathogen, *Anuraperkinsus emelandra*, has been the cause of massive ranid tadpole mortalities in 10 states, including a 2003 die-off of almost all tadpoles at the only known breeding pond of the federally endangered dusky gopher frog (http://www.nwhc.usgs.gov/disease_information/amphibian_malformation_and_decline/index.jsp).

Statewide Population Assessment – Findings from the BRG are included in Biological Status Review Information tables.

LISTING RECOMMENDATION

The BRG found the gopher frog did not meet any of the criteria for listing as a threatened species. Staff recommends that the gopher frog not be listed as a threatened species.

SUMMARY OF THE INDEPENDENT REVIEW

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.
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February 2010

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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 ($\leq$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

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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.

Acknowledgments

We are grateful to Scott Cardiff, Charlotte Cowan, Bob Gilbreath, Alex Pries, and Coral Wolf for assistance with field sampling and data management. We also thank John Bridges for facilitating our fieldwork, Peg Margosian for providing GIS data and advice, and Steve Orzell for identifying plant species. Becky Hylton and Dave Nelson provided advice on aerial survey logistics, and Romke Sikkema and Ray Meyers skillfully piloted the airplanes.

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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

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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

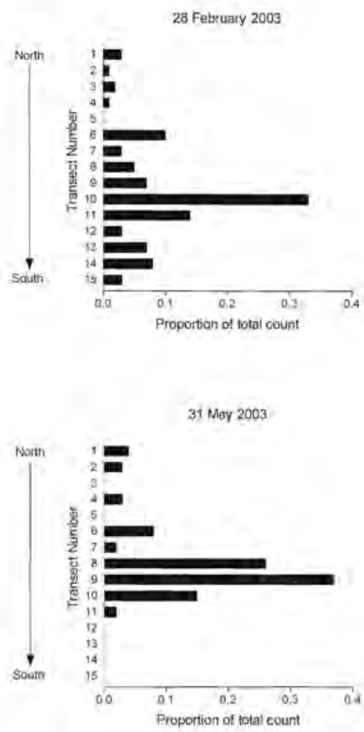

Figure 1. Distribution of wading birds counted along 15 transects during aerial surveys at Avon Park Air Force Range.

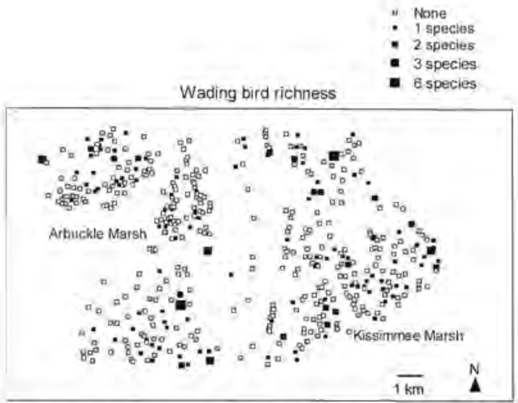

Figure 2. Species richness of wading birds in depression marshes ($n = 459$) at Avon Park Air Force Range, July 2002-February 2003 based on ground surveys of wetlands.

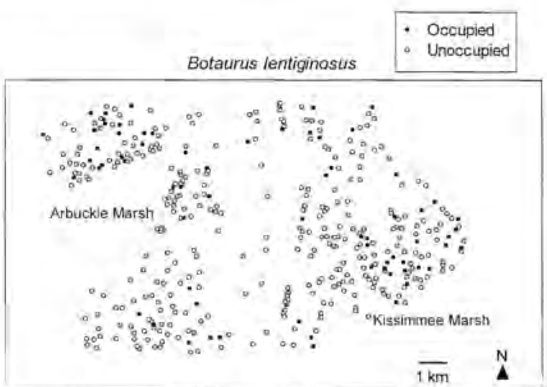

Figure 3. Patterns of patch occupancy for American bitterns (*Botaurus lentiginosus*) at Avon Park Air Force Range, October 2002-February 2003. Each circle indicates the location of a depression marsh ($n = 394$).

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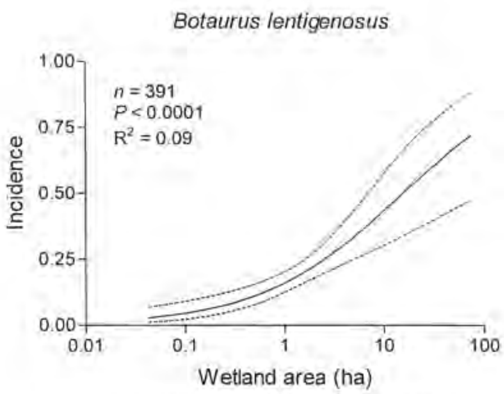

Figure 4. Relationship between wetland size and the probability of wetland occupancy by American bitterns (*Botaurus lentigenosus*). The incidence curve is based on predicted probabilities from a logistic regression model. Dotted lines indicate a 95% confidence envelope for the predicted values. The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

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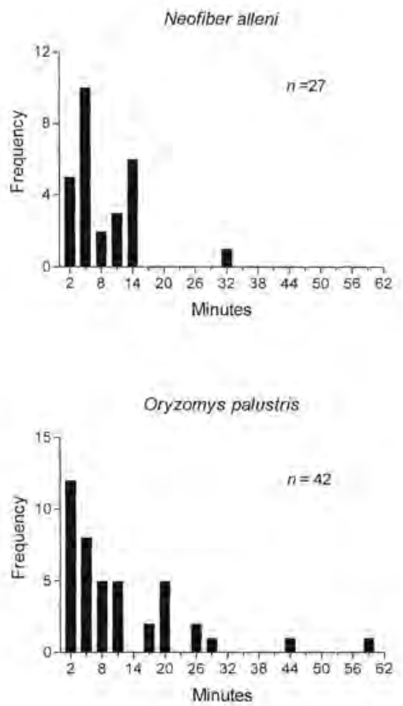

Figure 5. The amount of time until the first sign of occupancy was encountered for round-tailed muskrats (*Neofiber alleni*) and marsh rice rats (*Oryzomys palustris*) during wetland surveys. The sample size refers to the number of depression marshes with sign of occupancy.

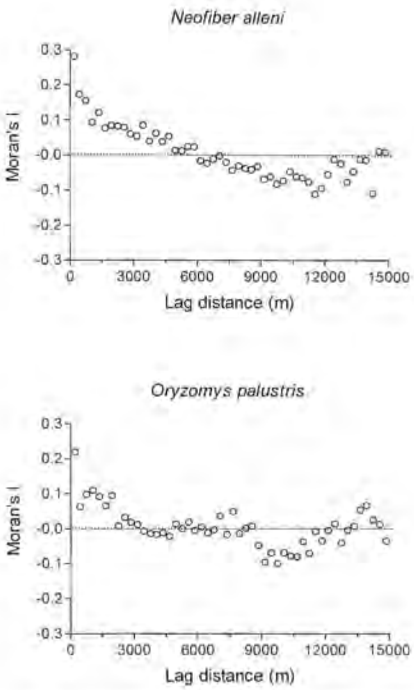

Figure 6. Isotropic indicator correlograms for wetland occupancy by round-tailed muskrats and marsh rice rats. The correlograms indicate the degree of spatial autocorrelation in occupancy patterns across a range of spatial scales. Positive values at small lag distances indicate that nearby wetlands have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

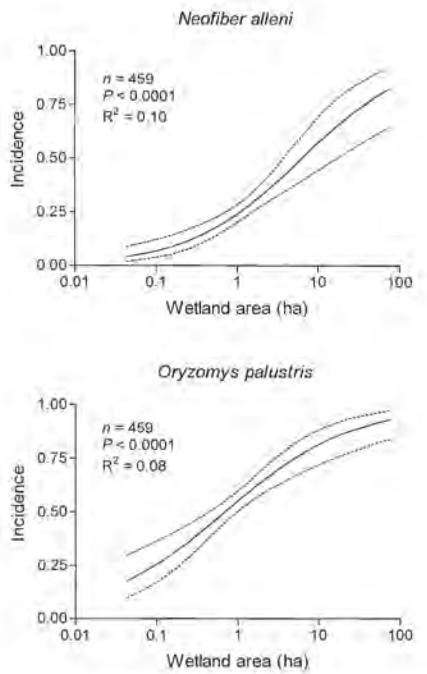

Figure 7. Relationship between wetland size and the probability of wetland occupancy by round-tailed muskrats (*Neofiber alleni*) and by marsh rice rats (*Oryzomys palustris*). The incidence curves are based on predicted probabilities from logistic regression models. Dotted lines indicate 95% confidence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

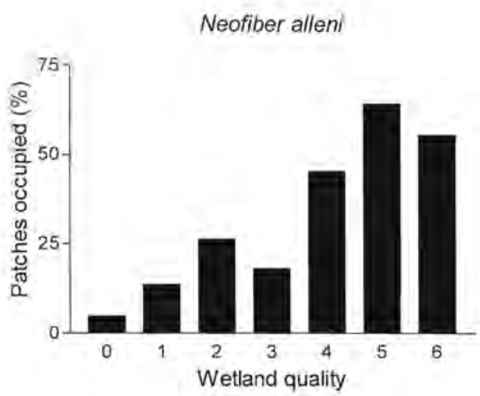

Figure 8. Relationship between habitat quality and occupancy of wetlands by round-tailed muskrats. Quality is a rank based on the coverage of plant zones in which maidencane is a dominant or codominant species.

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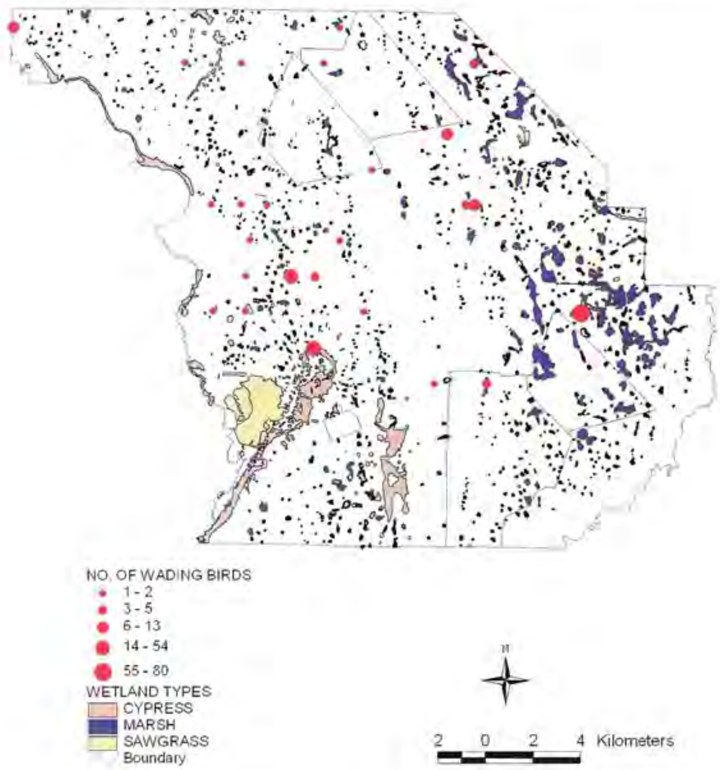
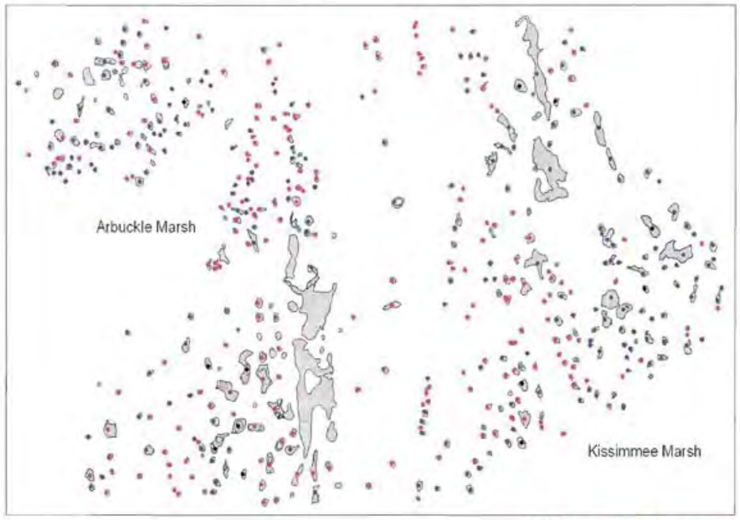
Appendix 1. Spatial distribution of wading birds from aerial survey at APAFR on 31 May 2003.



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 Gopher frog BSR draft report that was sent out for peer review

Biological Status Review
for the
Gopher Frog
(*Lithobates capito*)

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 September 1, 2010. Public information on the status of the gopher frog 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), Thomas Ostertag (FWC), Rick Owen (Florida Department of Environmental Protection), and David Printiss (The Nature Conservancy) (Appendix 1). In accordance with rule 68A-27.0012 Florida Administrative Code (F.A.C), the BRG was charged with evaluating the biological status of the gopher frog using criteria included in definitions in 68A-27.001(3), F.A.C. 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 from the biological assessment that the gopher frog did not meet any of the criteria for designation as a Threatened species. FWC staff recommends that the gopher frog not be listed as a threatened species and be removed from the State Species of Special Concern list.

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

BIOLOGICAL INFORMATION

Taxonomic Classification – Two subspecies of gopher frog were formerly recognized in Florida, the Florida gopher frog (*Rana capito aesopus*) and the dusky gopher frog (*R. c. sevosa*). The latter subspecies was thought to occur west of the Apalachicola River (Conant and Collins 1991). However, Young and Crother (2001) analyzed allozyme data that showed no genetic divisions among populations of *Rana capito*, except for the population in southern Mississippi, which they recommended elevating to specific status by resurrecting *Rana sevosa* (Goin and Netting, 1940), the dusky gopher frog. Frost et al. (2006) removed New World frogs from the genus *Rana* and placed them in *Lithobates*, so the current name for the species occurring in Florida is the gopher frog (*Lithobates capito*).

Life History and Habitat Requirements – Information on the species has been summarized by Jensen and Richter (2005). The gopher frog primarily inhabits areas with well-drained sandy soils that support gopher tortoise (*Gopherus polyphemus*) populations (Wright 1932, Franz 1986, Blihovde 2006, Roznik 2007). During the non-breeding season, the gopher frog is generally associated with longleaf pine (*Pinus palustris*)–xeric oak (*Quercus* spp.) sandhills but also occurs in upland pine forest, scrub, xeric hammock, mesic and scrubby flatwoods, dry prairie, mixed hardwood-pine communities, and a variety of disturbed habitats (Enge 1997). Gopher frogs extensively use gopher tortoise burrows for underground retreats (Wright 1932, Carr 1940, Franz 1986) but also use southeastern pocket gopher (*Geomys pinetis*) burrows, mouse burrows, crayfish burrows, hollow logs, stump holes, root mounds, broken limbs, crevices, dead vegetation, and clumps of grass (Wright and Wright 1949, Gentry and Smith 1968, Lee 1968, Godley 1992, Richter et al. 2001, Nickerson and Celino 2003, Blihovde 2006, K. Enge, FWC, pers. commun. 2010). Underground retreats in uplands are important for avoiding predation and desiccation, and frogs would be unlikely to survive droughts without them (Blihovde 2006). Gopher frogs breed in temporary or semipermanent, shallow, fishless ponds with an open canopy and emergent vegetation, including depression marshes, basin marshes, wet prairies, dome swamps, upland sandhill lakes, sinkhole ponds, borrow pits, and ditches (Godley 1992; Jensen and LaClaire 1995; Enge 1997; K. Enge, FWC, pers. commun. 2010).

Gopher frogs will travel up to 2 km to a breeding pond (Franz 1986), typically during heavy winter and spring rains. The breeding season is usually September–April (Palis 1998; Branch and Hokit 2000; Blihovde 2006; S. Morrison, The Nature Conservancy, pers. commun. 2010), but frogs potentially can breed during any month of the year during heavy rains, although summer breeding is probably more common in southern Florida because winter frontal systems are weaker (Godley 1992, Jackson 2004). A female apparently deposits only a single egg mass containing a mean of 1,200–2,200 eggs (*see* Jensen and Richter 2005). Egg masses are attached to vegetation, and tadpoles transform in 3–7 months (Godley 1992, Palis 1998). Newly metamorphosed frogs leave their natal pond and spend most of their life in the surrounding uplands. Males apparently become reproductively mature at 1.5 years and females at 2 years (*see* Jensen and Richter 2005).

Population Status and Trend – There is no quantitative information, but the population is assumed to have declined as the human population in Florida has increased and converted suitable habitat to urban, agricultural, and other land uses. Based on the lack of recent activity at many historic breeding sites, Franz and Smith (1999) concluded that gopher frog populations had declined east of the Apalachicola River in the last 20 years (1975–95), particularly in coastal counties and in South Florida where most of the human population is concentrated. However, Franz and Smith (1999) considered the species to still be common on protected lands along the central spine of the Peninsula north of Lake Okeechobee. Franz and Smith (1999) compiled records from 258 localities in 45 counties in the peninsula. During surveys in 1990–95, they found gopher frogs at only 3 of 63 historical sites visited but found 83 new sites in 19 counties, including 4 new county records. Of the 12 counties for which Franz and Smith (1999) found no records, there have been recent records for 2 counties, Gilchrist and Hamilton (Tucker and Handrick 2006; K. Enge, FWC, unpubl. data). In the past 12 years (since 1998), gopher frogs have been recorded in 26 counties: Alachua, Baker, Citrus, Clay, Columbia, Gilchrist, Glades, Hernando, Highlands, Lake, Leon, Levy, Manatee, Marion, Martin, Orange, Osceola, Pasco, Polk, Putnam, Sarasota, Seminole, St. Lucie, Sumter, Taylor, and Volusia (museum and Florida Natural Areas Inventory [FNAI] records; K. Enge, FWC, unpubl. data). None of these counties is west of the Apalachicola River, because there have not been recent surveys in those counties; however, records in the 1990s exist for Calhoun, Okaloosa, Santa Rosa, Walton, and Washington counties (museum and FNAI records). Surveys in 2006–10 recorded gopher frogs in 118 ponds on 20 public conservation lands (K. Enge, FWC, unpubl. data). Of the 63 ponds where gopher frogs were found from July 2009 through June 2010, 50 represented new ponds (K. Enge, FWC, unpubl. data). Many public lands were not surveyed, such as Avon Park Air Force Range, where Franz et al. (1998) found 11 gopher frog breeding ponds. Surveys for gopher frogs on public lands typically document multiple breeding ponds, such as 20 ponds on Eglin Air Force Base (Palis and Jensen 1995) and 21 ponds on

Camp Blanding Military Reservation (Hipes and Jackson 1996). At the Ordway–Swisher Biological Station, Franz (1986) marked 100 gopher frogs at tortoise burrows over a 16-month period.

Geographic Range and Distribution – The gopher frog occurs in the southeastern Coastal Plain from southeastern Alabama to North Carolina, with disjunct populations in central Alabama and the Cumberland Plateau in Tennessee (*see* Jensen and Richter 2005). The gopher frog historically occurred throughout Florida except for the Everglades region (Fig. 1), and Florida represents the largest portion of the total global range of the species (Jensen and Richter 2005).

Quantitative Analyses – We are not aware of a population viability analysis for the gopher frog. However, we believe that it is unlikely that the species will become extinct within the next 100 years based upon the large acreage of suitable habitat contained in conservation lands throughout Florida, its adaptability to some habitat alteration, and the increased security of gopher tortoise populations because of its new Threatened status (*see* Enge et al. 2006) and concomitant Gopher Tortoise Management Plan (Gopher Tortoise Management Plan Team 2007). The only factor that might change this scenario would be catastrophic die-offs from disease, but the isolated nature of many populations should keep them protected from disease vectors.

BIOLOGICAL STATUS ASSESSMENT

Threats – The greatest threat to gopher frogs is loss and alteration of xeric upland habitats resulting from commercial and residential development, silviculture, agriculture, and mining (Jensen and Richter 2005). Intact xerophytic upland ecosystems inhabited by gopher frogs have suffered severe losses in Florida, including longleaf pine-dominated sandhill as well as scrub habitat on the ridges of central and coastal Florida (Means and Grow 1985, Myers 1990, Kautz, 1998, Enge et al. 2006). Losses have been especially severe along the highly developed coastal ridges of both southeastern and southwestern Florida, as well as the central ridges that have been mined, converted to

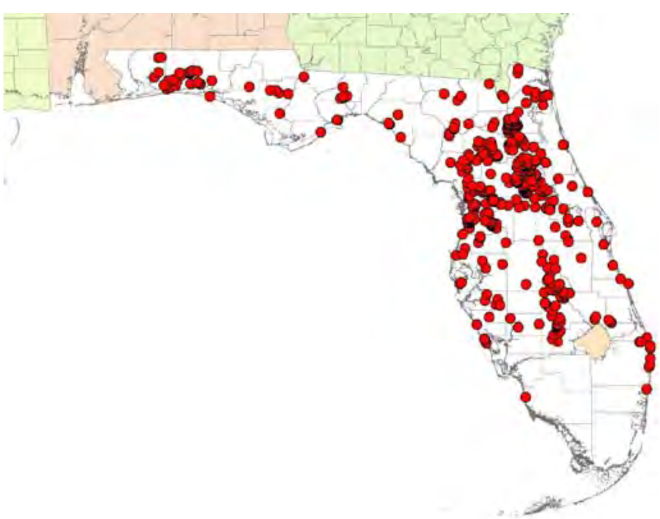


Fig. 1. Locality records from museums, FNAI, and the literature for the gopher frog.

agriculture, and more recently developed (Jackson 2004). Because of their vagility, gopher frog populations can persist in fragmented landscapes, even when breeding ponds occur in unsuitable upland habitat. Gopher frogs do not require intact native ground cover, and dense populations can occur in pastures containing gopher tortoise burrows. For example, 97 gopher frogs were observed using 261 tortoise burrows in an abandoned pasture in Green Swamp West, Pasco County (M. Barnwell, Southwest Florida Water Management District, pers. comm. 2010). The most cited management concerns for gopher frogs are altered fire regimes, resulting in the encroachment of hardwoods and shrubs in the upland habitat, and the loss of gopher tortoise or pocket gopher populations that provide the primary source of upland shelters (Godley 1992, Greenberg et al. 2003, Jensen and Richter 2005, Blihovde 2006, Roznik 2007). Newly metamorphosed gopher frogs emigrating from ponds in Ocala National Forest selected fire-maintained habitat that was associated with an open canopy, few hardwood trees, small amounts of leaf litter, and large amounts of wiregrass (*Aristida stricta*); this habitat contained higher densities of gopher tortoise and small mammal burrows used as refuges (Roznik and Johnson 2009b). Altered fire regimes have resulted in canopy closure and unnatural shading of the grassy ground cover, which provides food for gopher tortoises and the frog's invertebrate prey base. Silvicultural practices can degrade upland habitat and impact gopher frog populations. Gopher frog larvae were found in <7% of 444 ponds sampled on forest industry lands (Wigley et al. 1999). On commercial forest lands in the Panhandle, dense stands of sand pine *(Pinus clausa*) are often planted in sandhill habitat. Gopher frog larvae were found in only 1 of 85 ponds sampled in a Sand Pine plantation on private land, whereas they were found significantly more often in ponds in an adjacent Longleaf Pine forest on Apalachicola National Forest (Means and Means 2005).

Degradation and destruction of wetlands also affect gopher frogs that rely on these ponds for breeding. Exclusion and suppression of fire from wetlands often leads to degradation of breeding ponds through shrub encroachment, peat buildup, and increased evapotranspiration shortening hydroperiods (LaClaire 2001). Coverage of grassy emergent vegetation decreases, and peat buildup may acidify the water past tolerance levels (Smith and Braswell 1994). Land managers often use fire lines to exclude prescribed fire from dry wetlands to prevent problems with smoke management or muck fires, particularly if the wetlands are associated with wildland urban interface (Bishop and Haas 2005). Erosion from adjacent unpaved roads can lead to siltation and sedimentation of ponds, and runoff from paved roads can pollute ponds with petrochemicals and other toxic substances to frogs (LaClaire 2001). Pond degradation also results from garbage dumping and off-road vehicle (ORV) use (Means and Means 1998, LaClaire 2001). Use of ORVs in pond basins can cause direct mortality of tadpoles and adults, and it can affect habitat quality by altering pond contours, herbaceous vegetation, and hydrology (LaClaire 2001). Loss of herbaceous vegetation decreases cover for tadpoles from predators and can discourage reproduction, because egg masses are attached to stems of herbaceous vegetation (*see* LaClaire 2001). Large tires of ORVs may break the organic hardpan beneath a pond, causing water to drain out and shortening the hydroperiod (LaClaire and Franz 1990). The hydrology of many of Florida's depression marsh wetlands may already have been significantly influenced by anthropogenic-caused impacts related to groundwater withdrawals (R. Owen, Florida Department of Environmental Protection, pers. commun. 2010). North Florida has already undergone extreme shifts in groundwater potentiometric levels (i.e., "groundwater contours") (Grubs and Crandall 2007). The hydrologic impact has been documented for the first time across regional hydrologic divides between the Suwannee River and St. Johns River water management districts, and there are numerous examples across the entire state where groundwater withdrawals are significantly shifting the historic directional flow of localized groundwater supplies (R. Owen, Florida Department of Environmental Protection, pers. commun. 2010). State regulators and governing water management districts have been forced to plan for future losses of ground water and even develop written recovery strategies, as mandated by legislative law, because of significant damaging groundwater losses (http://www.swfwmd.state.fl.us/waterman/swuca/). Some ephemeral wetlands are independent of ground water or surface aquifer water, but other wetlands are being impacted by hydrological alterations related to groundwater withdrawal (Guzy et al. 2006). Groundwater withdrawal can shorten hydroperiods or even eliminate ephemeral wetlands, and climate change may be affecting the amount of winter precipitation in peninsular Florida. Long-term droughts may have caused some populations to disappear because of insufficient population recruitment.

The introduction of fish may play a role in population declines of certain anurans breeding in normally fish-free wetlands. Eastern mosquitofish (*Gambusia holbrooki*) are often introduced into isolated wetlands for mosquito control purposes, and even these small fish may have significant negative effects on gopher frog tadpoles (Gregoire and Gunzburger 2008). A far more serious threat, however, is the stocking of game fish (*Lepomis* spp. and *Micropterus* spp.) into ponds used by gopher frogs, or the introduction of predaceous fish into formerly fish-free wetlands during natural flooding events. Invertebrates can significantly impact population recruitment by feeding on eggs and tadpoles (Richter 2000), and a variety of vertebrates, such as wading birds and snakes. Seventy-five percent of 32 metamorphs leaving a natal pond were killed by North American racers (*Coluber constrictor*), common garter snakes (*Thamnophis sirtalis*), or mammals (Roznik and Johnson 2009a). The long distances sometimes traveled by gopher frogs to breed can make them susceptible to highway mortality. A metamorph leaving a natal pond moved 691 m before being killed, and 3 of 32 metamorphs were killed by vehicles on lightly traveled dirt roads (Roznik and Johnson 2009a) that they apparently used as migration corridors (Roznik and Johnson 2009b).

A chytridiomycete fungus (*Batrachochytrium dendrobatidis*), or *Bd*, has been implicated as a primary or suspected cause of disease epidemics and subsequent population declines of amphibians in many parts of the world, but although chytrid fungus is not known to be responsible for any amphibian die-offs in the Southeast. None of 18 gopher frog tadpoles examined from Florida and Georgia tested positive for *Bd* (Rothermel et al. 2008). Ranaviruses are likely a greater threat to amphibians, particularly tadpoles, than *Bd* in North America (Gray et al. 2009a, b). A die-off of hundreds of ranid tadpoles, including gopher frogs, in 2 ponds in Withlacoochee State Forest, Hernando County, was apparently caused by an unnamed *Perkinsus*like (or alveolate) microorganism (Davis et al. 2007, Rothermel et al. 2008). A newly identified mesomycetozoan pathogen, *Anuraperkinsus emelandra*, has been the cause of massive ranid tadpole mortalities in 10 states, including a 2003 die-off of almost all tadpoles at the only known breeding pond of the federally endangered dusky gopher frog (http://www.nwhc.usgs.gov/disease_information/amphibian_malformation_and_decline/index.jsp).

Statewide Population Assessment – Findings from the BRG are included in Biological Status Review Information tables.

LISTING RECOMMENDATION

The BRG found the gopher frog did not meet any of the criteria for listing as a threatened species. Staff recommends that the gopher frog not be listed as a threatened species.

SUMMARY OF THE INDEPENDENT REVIEW

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	Species/taxon:	Gopher Frog
Biological Status Review Information Findings	Date:	11/18/10
	Assessors:	Enge, Johnson, Ostertag, Owen, Printiss
	Generation length:	4 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]	Causes of reduction have not ceased (c)	S	N	
(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 16.0% increase in human population since 2000 and acquisition of conservation lands. Loss of suitable habitat in the past 12 years is <30%.	S	N	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]	<30% population size reduction because human population projected to increase by 16.5% in next 10 years, 47.6% of potential habitat is on conservation lands, and species can survive in some altered habitats	S	N	Zwick and Carr (2006), 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. 80,440 km^2 (37 counties)	E	N	
(b)2. Area of occupancy < 2,000 km^2 (772 mi^2)	8,992 km^2	E	N	GIS analysis of potential habitat by B. Stys (FWC)
AND at least 2 of the following:				
a. Severely fragmented or exist in ≤ 10 locations		S	N	

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	See Sub-criterion A3
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	>10,000 mature individuals	S	N	Palis and Jensen (1995); Hipes and Jackson (1996); Franz et al. (1998); Palis (1998); Franz and Smith (1999); FNAI and museum records; K. Enge, unpubl. data
(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	Uncertain if there will be a 10% decline in the next 12 years	S	N	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	>10,000 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	8,992 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	No PVA		N	

Initial Finding (Meets at least one of the criteria OR Does not meet any of the criteria)	Reason (which criteria are met)
Not Threatened	
Is species/taxon endemic to Florida? (Y/N)	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)
Not Threatened	

1	Species/taxon:	Gopher Frog
2	Date:	11/18/10
3	**Biological Status Review Information** Regional Assessment 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	Not Threatened

Additional notes – Generation length is defined as the average age of parents of the current cohort (estimated at 5 years), which is greater than the age at first breeding and less than the age of the oldest breeding individual. Franz (1986) estimated that it took gopher frogs 3.8 years to attain the maximum size observed at the Ordway–Swisher Biological Station. In a mark-recapture study of the closely related dusky gopher frog in Mississippi, the minimum age of sexual maturity was 4–6 months for males and 24–36 months for females, and annual population turnover was apparently high (Richter and Seigel 2002). Only 13.6% of 301 marked frogs were captured in more than 1 breeding season; the average number of breeding seasons for a frog was 1.2, although 1 frog bred 5 times (Richter and Seigel 2002). Richter et al. (2003) estimated maximum longevity of the dusky gopher frog to be 6–10 years but thought most adults did not live longer than 4–5 years. Based upon this information, we will infer a mean generation length of 4 years.

Sub-criterion A2. – We assume that the gopher frog population has declined as the human population in Florida has increased and converted suitable habitat to urban, agricultural, and other land uses. Florida's human population increased by 23.5% from 1990 through 2000 and by 16.0% from 2000 through 2009. Florida loses 182 ha (450 acres) of forest and 166 ha (410 acres) of farmland to development every day (Bouvier and McCloe Stein n.d.). Actual estimates of gopher frog populations do not exist, but we suspect that loss and degradation of habitat would not have resulted in a $\geq$ 30% population decline within the past 12 years, particularly considering Florida's programs for purchasing public conservation lands (e.g., Preservation 2000 and Florida Forever). See Population Status and Trend section for past and present occurrence information. On most public lands, suitable upland habitat for the gopher frog is managed by controlled burning, and these public lands probably have extant populations. However, gopher frogs were documented in the Panacea Unit of St. Marks National Wildlife Refuge in 1978 but apparently no longer occur there, despite suitable upland habitat and wetlands (Dodd et al. 2007). Inexplicable population declines or extinctions are a cause for concern and indicate that such events could occur elsewhere. Apparent population declines or extirpations may be related to several years of unsuitable weather for breeding or population recruitment (or to unknown factors), but populations may reappear. For example, calling gopher frogs have been monitored from 1 station (choruses from 2 breeding ponds can be heard) on the Lake Wales Ridge in Polk County since 1993, and the number of nights frogs were heard calling ranged from 4 to 35 annually. However, no gopher frogs were heard calling from 2006 through 2009, but frogs were again heard in 2010 (S. Morrison, The Nature Conservancy, pers. commun. 2010). The gopher frog is currently not hunted for food or pets (Enge 2005). Massive die-offs of gopher frog adults and tadpoles from pathogens could contribute to future population declines (see Threats section).

Sub-criterion A3. – Three generations from 2010 as the present would be 2022. Florida's population is projected to increase by 16.5% by 2020 and by 24.4% by 2025 (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 frog populations. 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. Increased groundwater withdrawal shortening the hydroperiod of ephemeral wetlands used as breeding ponds may also impact frog populations. Of the potential habitat identified using GIS analysis, 47.6% is in conservation lands (B. Stys, FWC, pers. commun. 2010), and presumably gopher frog populations will continue to persist on most of these lands, particularly the larger parcels. However, just because land is protected does not mean that it is properly managed. 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 gopher frog populations to continue to persist on fire-suppressed public and private lands lands is unknown. 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).

Sub-criterion B1. – The extent of occurrence was calculated by adding up the land area of the 37 counties in which gopher frogs have been reported since 1990 (museum and FNAI records; K. Enge, FWC, unpubl. data). The extent of occurrence is 80,440 km^2 (31,058 mi^2).

Sub-criterion B2. – A GIS analysis of potential habitat for the species identified 8,992 km^2 (3,462 mi^2) of potential habitat (B. Stys, FWC, pers. commun. 2010), which we will assume is equivalent to the area of occupancy. The major FWC 2003 land-cover classes that comprised the potential habitat were pinelands (3,428 km^2; 1,323.6 mi^2), sandhill (1,903 km^2; 734.6 mi^2), dry prairie (1,254 km^2; 484.0 mi2), mixed pine-hardwood forest (874 km^2; 337.6 mi^2), shrub and brushland (627.0 km^2; 242.1 mi^2), xeric oak scrub (159.8 km^2; 61.7 mi^2), sand pine scrub (145.8 km^2; 56.3 mi^2), open water (143.7 km^2; 55.5 mi^2), and freshwater marsh and wet prairie (140.0 km^2; 54.0 mi^2), and unimproved pasture (139.6 km^2; 53.9 mi^2). The amount of potential habitat just on conservation lands, which is 4,280 km^2 (1,653 mi^2) (B. Stys, FWC, pers. commun. 2010), is over twice the threshold for listing. Well-managed sandhill habitat is considered the most favorable natural habitat for both gopher tortoises and commensal gopher frogs. Potential habitat just in the sandhill landcover class (1,903 km^2; 734.6 mi^2) almost meets the threshold for area of occupancy.

Criterion C – Because females lay only a single egg mass, counts of egg masses are a good index of the number of breeding females in the population. At 2 ponds in Conecuh National Forest, Alabama, a maximum of 160–180 egg masses were counted in each pond during 1 year (Jensen et al. 2003). Gopher frog populations apparently have an equal sex ratio (Palis 1998); thus, over 300 adult frogs used each of these ponds. At a 1.2-ha pond on Eglin Air Force Base, Florida, 301 unmarked adult frogs were captured during 1 breeding season (Palis 1998). We suspect that most ponds are not used by this many frogs, and the number of adult frogs in a population will vary annually depending upon the number of frogs recruited into the population and mortality rates. In some years, there is no population recruitment from some ponds (Greenberg 2001, Richter and Seigel 2002). Since 1990, at least 200 breeding ponds have been found during surveys on 7 public lands: Apalachicola National Forest, Avon Park Air Force Range, Camp Blanding Military Reservation, Chassahowitzka WMA, Eglin Air Force Base, Ocala National Forest, and Rock Springs Run State Reserve. If an average of 50 frogs bred in these ponds, these 7 public lands would contain 10,000 adult gopher frogs. There are far more than 200 breeding ponds in Florida. During a survey in northern Florida in 2006–10, gopher frogs were found using 118 ponds (K. Enge, FWC, unpubl. data).

Sub-criterion C2. – Ocala National Forest has at least 70 gopher frog breeding ponds, and this subpopulation probably contains >1,000 adults. Prolonged droughts could result in extreme population fluctuations of adults, but we think it is unlikely that the fluctuations would be the scale of on an order of magnitude.

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.

To be inserted later