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August 1997

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Strategic Environmental Research and Development Program

Species Profile: Gopher Frog (*Rana capito* spp.) on Military Installations in the Southeastern United States

by John G. Palis
Richard A. Fischer, WES

Prepared for Headquarters, U.S. Army Corps of Engineers

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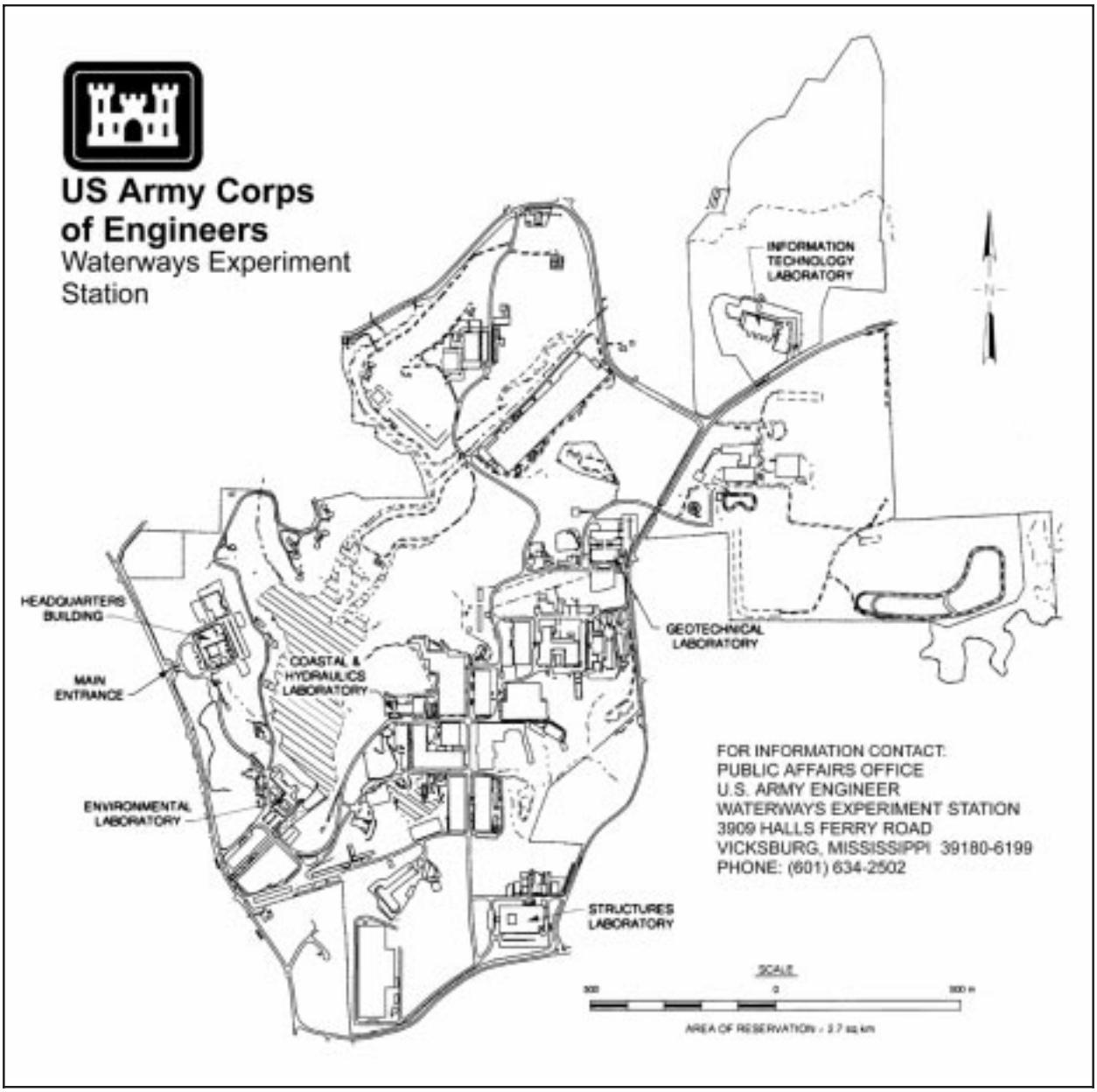

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Preface

The work described herein was authorized by the Strategic Environmental Research and Development Program (SERDP), Washington, DC. The work was performed under the SERDP study entitled "Regional Guidelines for Managing Threatened and Endangered Species Habitats." Dr. John Harrison was Executive Director, SERDP.

This report was prepared by Mr. John G. Palis, Jonesboro, IL, and Dr. Richard A. Fischer of the Natural Resources Division (NRD), Environmental Laboratory (EL), U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS. Portions of this report were taken from The Nature Conservancy's Element Stewardship Abstract (ESA) titled "Species Stewardship Summary; *Rana capito*" prepared by Mr. Palis. The ESA was prepared under contract with the U.S. Army Construction Engineering Research Laboratories (CERL), Natural Resources Division, Champaign, IL, for a document titled "Integrated endangered species management recommendations for Army installations in the southeastern United States: Assessment of Army-wide guidelines for the red-cockaded woodpecker on associated endangered, threatened, and candidate species."

Mr. Chester O. Martin, EL, and Ms. Ann-Marie Trame, Land Management Laboratory, CERL, were Principal Investigators for the regional guidelines work unit. Dr. Richard A. Fischer, EL, managed and coordinated preparation of species profiles for this study. Report review was provided by Dr. Alvin Braswell, North Carolina State Museum of Natural Science; Mr. Mark Bailey, Alabama Natural Heritage Program; Dr. C. Kenneth Dodd, National Biological Service, Gainesville, FL; Mr. John B. Jensen, Florida Natural Areas Inventory; and Messrs. Richard W. McWhite and Bruce Hagadorn, Natural Resources Branch, Eglin Air Force Base, Florida. WES technical review was provided by Mr. Martin and Dr. Wilma A. Mitchell, EL.

This report was prepared under the general supervision of Dr. Michael F. Passmore, Chief, Stewardship Branch, NRD, EL; Dr. Dave Tazik, Chief, NRD, EL; and Dr. John Harrison, Director, EL.

At the time of publication of this report, Dr. Robert W. Whalin was Director of WES.

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Species Profile: Gopher Frog
(*Rana capito spp.*)

Photo by John G. Palis

Taxonomy

Class	Amphibia
Order	Anura
Family	Ranidae
Genus/species	*Rana capito capito, R. c. sevosa, R. c. aesopus*
Other Common Names	None Known

Description

The gopher frog (*Rana capito* spp.) is a medium-sized stocky frog with a relatively large head and short legs. Its snout-vent length (SVL) may be up to 112 mm (4.4 in.), and its weight ranges from 47 to 151 g (1.6 to 5.3 oz) for adult males and gravid females, respectively (Palis 1995b). The skin ranges from smooth to warty in texture and from creamy-white to gray or brown in color. The dorsum and sides are dotted with dark brown or black spots and blotches of various sizes and shapes. A pair of prominent raised folds (dorsolateral folds) lie along either side of the back. The venter is white, cream, or yellowish and is typically spotted or mottled with dark pigment; there is often a yellowish wash in the groin area.

The egg mass of the gopher frog is typically fist size and slightly oblong to nearly spherical in shape. Tadpoles are yellowish-green to olive-green with scattered, relatively large, diffuse black spots on the upper body, tail musculature, and fin. They attain a total length of 84 mm (3.3 in.) before transformation (Wright and Wright 1949) and SVL of 26 to 38 mm (1.0 to 1.5 in.) at metamorphosis (Phillips 1995). However, Semlitsch et al. (1995) found larger metamorphs (range of sizes not given). Metamorphs weigh 3.0 to 5.5 g (0.1 to 0.2 oz) (Palis 1995b).

The call of the gopher frog is a loud snore-like vocalization that lasts up to 2 sec and carries nearly 0.4 km (0.25 mile) (Wright and Wright 1949). However, the gopher frog also will call frequently while submerged, and these calls are not audible at distances >10 m (33 ft) (Jensen et al. 1995).

Similar Species

The gopher frog is most likely to be confused with the southern leopard frog (*Rana utricularia*), with which it is sympatric, and the closely related crawfish frog (*Rana areolata*), which inhabits the Mississippi River drainage from Louisiana northward into Illinois and Indiana. The southern leopard frog has a pointed snout and fewer, widely scattered dorsal spots. The dorsal spots of the crawfish frog are encircled by white borders.

Eggs of gopher frogs and leopard frogs can be distinguished by size of the embryo. In Louisiana, gopher frog embryos range from 1.7 to 2.2 mm (0.07 to 0.09 in.) in diameter, whereas leopard frog embryos range from 1.4 to 1.8 mm (0.05 to 0.07 in.) in diameter (Volpe 1958). In western Florida, gopher frog embryos are 2.9 to 3.8 mm (0.11 to 0.15 in.) in diameter, and leopard frog embryos are 2.0 to 2.4 mm (0.08 to 0.09 in.) in diameter (Palis, unpublished data). Leopard frog egg embryos are dark black, whereas those of gopher frogs are gray to gray-black. Gopher frog egg masses are typically larger than those of the leopard frog (Palis 1995a). They are firmer to the touch and are generally deposited at the surface of deeper water than are leopard frog eggs (M. A. Bailey, Personal Communication, 1996).

Positive identification of larval gopher frogs is also difficult because they closely resemble those of the southern leopard frog. However, as with eggs, fresh hatchlings can be distinguished on the basis of size (Palis 1995a). In western Florida, hatchling gopher frog tadpoles are 11.9 to 12.7 mm (approximately 0.5 in.) in total length, whereas southern leopard frog hatchlings range from 7.3 to 7.9 mm (approximately 0.3 in.) total

length. Tail depth also differs between hatchlings of the two species. Hatchling gopher frog tadpoles have a deeper tail fin (3.1 to 3.4 mm, approximately 0.1 in.) than southern leopard frogs (1.5 to 1.9 mm, approximately 0.06 in.). Larger tadpoles of the two species can be distinguished with limited reliability. Unlike gopher frog tadpoles, southern leopard frog tadpoles often have a light line on each side of the head near the mouth. In North Carolina, the origin of the dorsal fin of gopher frogs lies in front of the spiracle, whereas in southern leopard frogs it lies behind the spiracle (A. Braswell, Personal Communication). This characteristic is unreliable in panhandle Florida (Palis 1995a).

The only other species within the range of the gopher frog that has a similar call is the river frog (*Rana heckscheri*). The river frog, however, breeds in blackwater streams and lakes (K. Dodd, Personal Communication, 1996) during the summer months (P. Moler, Personal Communication, 1996).

Status

Until its recent elevation to species status, the gopher frog was considered a subspecies of *Rana areolata*. Three subspecies of gopher frog are currently recognized: The dusky gopher frog (*Rana capito sevosa*), Carolina gopher frog (*R. c. capito*), and Florida gopher frog (*R. c. aesopus*).

Legal designation

Federal. Two subspecies are classified as "Species of Concern" (SOC), and one subspecies is classified as a candidate (C) for listing as Threatened by the U.S. Fish and Wildlife Service.

Rana capito capito (Carolina gopher frog): SOC
Rana capito aesopus (Florida gopher frog): SOC
Rana capito sevosa (Dusky gopher frog): C

State. The gopher frog is state listed as endangered in Mississippi (L. LaClaire, Personal Communication, 1995), threatened in Florida (Moler 1992, Wood 1992) and Alabama (Means 1986), and a Species of Special Concern in North Carolina (A. Braswell, Personal Communication, 1996). It is not listed in Louisiana, Georgia, or South Carolina.

Distribution and numbers

The gopher frog inhabits xeric upland pine communities of the Southeastern Coastal Plain from the southern half of the North Carolina coastal plain (Beaufort County) to southern Florida (Collier County on the west coast, Broward County on the east coast) and westward to Tangipahoa Parish, Louisiana (Martof et al. 1980, Conant and Collins 1991, Godley 1992) (Figure 1). The Carolina gopher frog inhabits Georgia north of the

Altamaha River into North Carolina (Conant and Collins 1991). The range of the Florida gopher frog extends from central Georgia (south of the Altamaha River), throughout the upper two-thirds of peninsular Florida and in the Florida panhandle to the Apalachicola River (Franz and Smith 1993). The dusky gopher frog is found west of the Apalachicola and Chattahoochee rivers in Florida and Georgia, through the Gulf Coastal Plain of Mississippi and Alabama, to the Florida parishes of Louisiana (Altig and Lohoefner 1983, The Nature Conservacy (TNC) 1995) (Figure 1). However, the geographic limits of the gopher frog still are not well-defined (C. K. Dodd, Personal Communication, 1996).

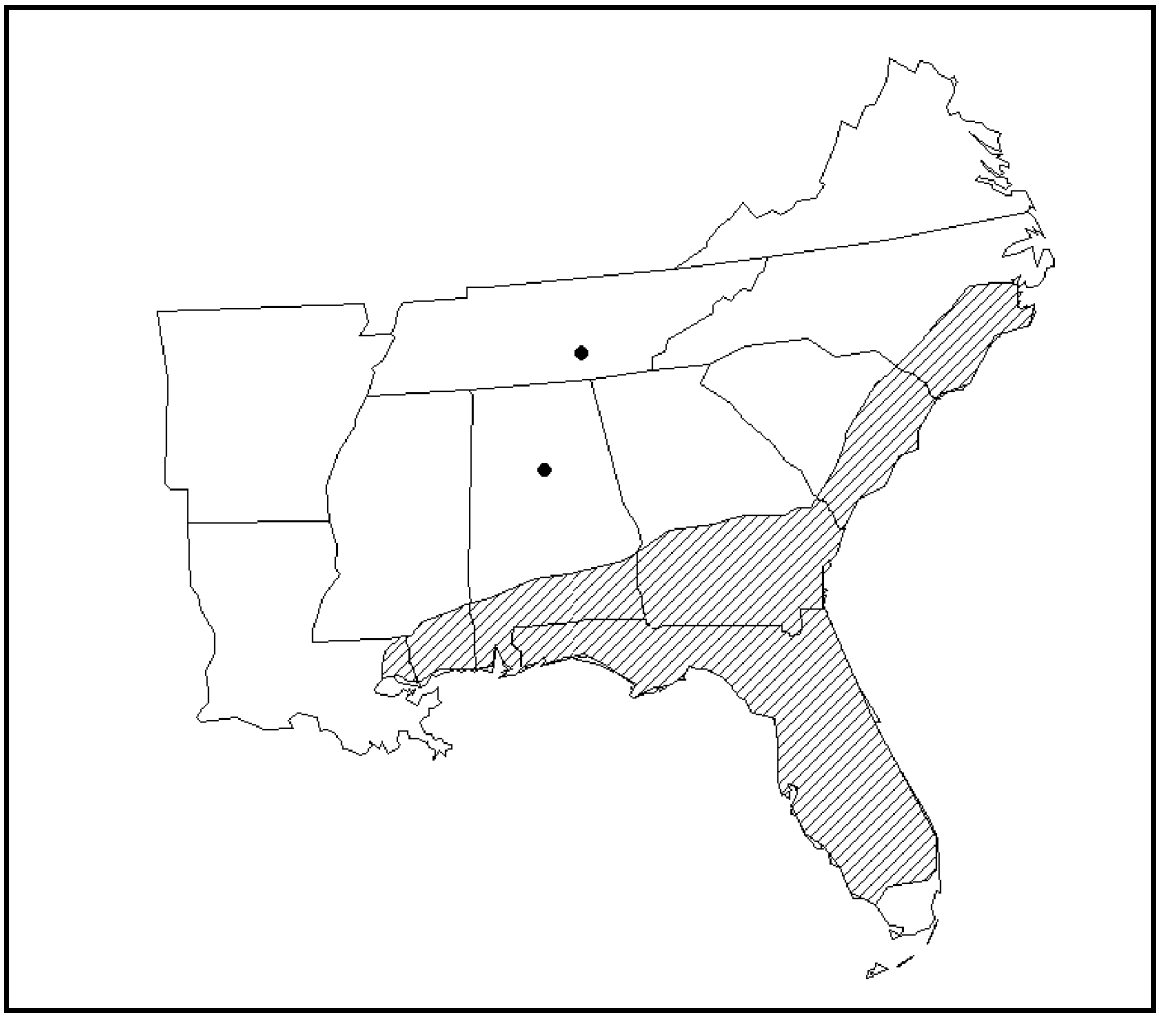

Figure 1. Distribution of gopher frogs in the southeastern United States

The gopher frog also occurs outside the coastal plain in Shelby County, Alabama (Bailey 1991), and Coffee County, Tennessee (Arnold Air Force Base). With the exceptions of Shelby County, Alabama; Coffee County, Tennessee; North Carolina; and most of South Carolina, the gopher frog occurs within the range of the gopher tortoise (Conant and Collins 1991).

The gopher frog may be extirpated in Louisiana (Seigel and Doody 1992) and is known to be from only one breeding site in Mississippi (DeSoto National Forest) (R. Seigel, Personal Communication, 1995). The gopher frog still occurs at seven breeding sites in Alabama (M. Bailey, Personal Communication). In Florida, it still occurs at 79 sites east of the Apalachicola River (Franz and Smith 1993) and breeds in at least 27 wetlands west of the Apalachicola River (Palis 1995a); many of these wetlands occur on Eglin Air Force Base (AFB), Florida (Palis 1995b). The gopher frog is known to be from five sites in Georgia: Fort Benning, Fort Stewart, McIntosh County, Baker County, and Charton County (Seyle, unpublished data). The species occurs at two widely separated sites (Savannah River Ecology Laboratory and Santee Coastal Reserve) in South Carolina (S. Bennett, Personal Communication, 1995), and still breeds at 11 sites in North Carolina (Braswell 1993).

Military Installations

See Table 1.

Table 1
Known Status of Gopher Frogs on Military Installations in the Southeastern United States

State	Installation	Status on Installation
FL	Eglin Air Force Base (AFB)	Documented Onsite; *R. c. sevosa*; largest known concentration of reproductive sites for the dusky gopher frog subspecies. Nineteen breeding sites are known in Okaloosa County, six in Walton County, and one in Santa Rosa County (Palis 1995b).
	Camp Blanding	Documented Onsite (Paul A. Johnson, Florida Army National Guard; Personal Communication 1996).
	Avon Park AFB	Documented Onsite
	Naval Air Station (NAS) Jacksonville	Documented Onsite; Rodman Bombing Target area approximately 60 miles south of NAS Jacksonville (Sandra Maynard, Natural Resources Manager, NAS Jacksonville; Personal Communication 1996).
	NAS Cecil Field	Potential
GA	Fort Stewart	Documented Onsite (TNC 1995)
	Fort Gordon	Documented Onsite
	Fort Benning	Documented Onsite
MS	Camp Shelby	Occurs in Desoto National Forest adjacent to installation

(Continued)

Table 1 (Concluded)		
TN	Arnold AFB; Arnold Engineering and Developement Center	Documented Onsite: This is a disjunct population just recently discovered. First record for state of Tennessee and most inland record for species. Breeds in Sinking Pond (162 ha (400 acres)) on installation (Miller and Campbell 1996).
NC	Fort Bragg	Documented Onsite; population status uncertain (A. Braswell, Personal Communication, 1996).
	Camp Lejeune	Documented Onsite (Leblond et al. 1994); habitat for the species is fairly extensive and in relatively good condition on parts of the base (A. Braswell, Personal Communication, 1996).
	Military Ocean Terminal Sunny Point	Documented Onsite; population is stable, but area hydrology is threatened by a proposed limestone quarry on adjacent property (A. Braswell, Personal Communication, 1996).

Life History and Ecology

Activity

Post-larval gopher frogs are terrestrial and inhabit the relatively cool, moist tunnels of burrowing animals such as the gopher tortoise (*Gopherus polyphemus*) or oldfield mouse (*Peromyscus polionotus*) (Gentry and Smith 1968, Lee 1968, Franz 1986). Gopher frogs also take shelter within hollow stumps and in holes beneath logs, trees, and stumps (Wright and Wright 1949). The species is generally nocturnal at which time it can sometimes be observed at the mouths of tortoise burrows. Gopher frogs apparently maintain a small home range during nonbreeding seasons. According to Wright and Wright (1949), gopher frogs will range "some distance from their burrows in foraging at night." However, activity outside the burrow is not confined exclusively to nighttime, as gopher frogs have been observed foraging on the surface during the day (Einem and Ober 1956; C. K. Dodd, Personal Communication, 1996).

Gopher frogs migrate between seasonal habitats; one gopher frog in Florida moved 2 km (1.2 miles) between breeding and nonbreeding habitats (Franz et al. 1988). Migration to and from breeding sites is positively correlated with rainfall and rising air temperatures (Bailey 1990, Palis 1995b).

Reproduction and development

The gopher frog is a winter and early spring breeder throughout most of its range, much of which is associated with very heavy rains. In Louisiana, Dundee and Rossman (1989) delineated the calling period as December through March. In the panhandle of Florida, gopher frogs typically reproduce from January through April (Bailey 1991, Palis 1995a), although breeding has been observed following tropical storms during October

and November at Eglin AFB, Florida (Palis 1995b). Bailey (1991) also observed reproduction in southern Alabama during late fall (September and October) following heavy rains associated with hurricanes. Godley (1992) suggested that gopher frogs breed most often in the summer months in peninsular Florida. However, Dodd (Personal Communication, 1996) has heard gopher frogs calling during the winter in the Ocala National Forest. Gopher frogs typically breed between February and April in North and South Carolina, but have been heard calling in every month of the year in South Carolina (S. Bennett, Personal Communication, 1995).

Egg masses are laid within a range 0 to 20 cm (mean of 4.5 cm) or 0 to 7.9 in. (mean of 1.8 in.) of the surface, in water 33 to 78 cm (13 to 31 in.) deep, typically attached to vertical stems of graminaceous emergent vegetation (Palis 1995b, Phillips 1995). Egg masses may also be attached to branches of St. John's-wort (*Hypericum* spp.) or myrtle-leaved holly (*Ilex myrtifolia*) (Palis 1995b). When attachment structures are not present, eggs may be deposited on the bottom in shallow water (M. A. Bailey, Personal Communication, 1996). Although egg masses may contain up to 6,000 eggs, they usually contain 1,000 to 2000 eggs (Palis 1995b; M. A. Bailey, Personal Communication, 1996).

The larval period in captivity is approximately 5 months (Volpe 1958). In the wild, however, the larval period can range from 3 to 7 months (Semlitsch et al. 1995, Palis 1995b). In north-central Florida, gopher frogs metamorphose when a length of 35 to 40 mm (1.4 to 1.6 in.) (SVL) is reached (Franz 1986). At one site, 23 metamorphs averaged 43 $\pm$ 2.9 mm (Semlitsch et al. 1995). Two years are required for gopher frogs to attain the minimum size of sexual maturity (70 to 75 mm, or 2.8 to 3.0 in. SVL) (Franz and Smith 1993). Smaller tadpoles are more susceptible to predation by notonectids and dragonfly nymphs than larger tadpoles (Cronin and Travis 1986, Travis et al. 1985).

Food habits

Tadpoles are herbivorous, while post-larval gopher frogs eat invertebrates and other frogs, including toads (Godley 1992).

Habitat Requirements

Plant communities used by gopher frogs

The principal habitat of the gopher frog is longleaf pine (*Pinus palustris*)-turkey oak (*Quercus laevis*) sandhill. In Florida, it is also known to inhabit xeric to mesic longleaf pine flatwoods, sand pine (*P. clausa*) scrub, xeric oak hammock, and ruderal successional stages of these natural communities (Godley 1992). Braswell (1993) reported that gopher frog habitat in North Carolina consisted of sandhill and mesic pine flatwoods. Because the gopher tortoise does not occur in North Carolina, he assumed that gopher frogs used

Gopher frog breeding pond; Eglin Air Force Base, FL
(Photo by Richard A. Fischer)

crayfish and rodent burrows, and stumpholes, for retreats. According to Braswell (Personal Communication, 1996), far too little is known about the overall habitat requirements of this species, especially during high-stress times such as drought.

Breeding

Gopher frogs typically breed in circular or near-circular, ephemeral to semipermanent graminoid-dominated wetlands that lack large predatory fish (Moler and Franz 1987, Bailey 1991, Palis 1995a). These depressional wetlands typically range in size from 0.12 to 33.5 ha (0.3 to 83 acres) (Palis 1995a). Florida populations often utilize sinkhole and cypress ponds, and depressional marshes (LaClaire and Franz 1991, Godley 1992). In Georgia, the Carolina gopher frog breeds in cypress ponds, pine savanna ponds, Carolina bays, and borrow pits (Williamson and Moulis 1979, Gibbons and Semlitsch 1991, Braswell 1993). At Eglin AFB, Florida, mean depth of breeding ponds was approximately 60 cm (2 ft); mean water temperatures for 3 years were 15 to 18.5 °C (59 to 65 °F); and mean pH was approximately 4.4 (range 3.3 to 5.8) (Palis 1995b). Gopher frogs also have been observed breeding in ditches and borrow pits (Means 1986), and have been heard calling from a recently refilled, normally permanent wetland following an extreme drought (Franz 1991). A new breeding site in Conecuh National Forest, Alabama, is in a borrow pit (M. A. Bailey, Personal Communication, 1996). TNC (1995) cautioned that although borrow pits are used for breeding (e.g., Fort Stewart, Georgia), it is unknown if these breeding populations experience successful reproduction and maintain viable populations.

Dominant emergent graminaceous vegetation in breeding sites typically includes maidencane (*Panicum hemitomon*), other panic grasses (*Panicum* spp.), bluestem (*Andropogon* spp.), yellow-eyed grasses (*Xyris* spp.), pipewort (*Eriocaulon compressum*), beakrushes (*Rhynchospora* spp.), and spikerushes (*Eleocharis* spp.). Most breeding sites have a small component of woody vegetation such as St. John's-wort, myrtle-leaved holly, and slash pine (*P. elliottii*) that is typically restricted to the edge.

Critical or essential habitat

High-quality habitats include several wetlands within xeric upland pine-dominated communities. Based on the maximum distance an adult gopher frog was known to travel between reproductive and nonreproductive habitat (2 km or 1.2 miles; Franz et al. 1988), each breeding site should be surrounded by at least 12 km^2 (4.6 $miles^2$) of terrestrial habitat (this will vary with the amount of available habitat). Braswell (Personal Communication, 1996) suggested that this recommendation could lead to the exclusion of potential frog habitat. Instead, he recommended managing larger areas of good terrestrial habitat that have potential multiple breeding sites until more is known about the species. A suite of wetlands guards against extirpation at any one breeding site, since animals can immigrate from nearby wetlands. The minimum viable population size needed to sustain a population of gopher frogs is not known.

Impacts and Cause of Decline

Threats to the continued existence of the gopher frog throughout most of its range are closely linked to those that threaten the gopher tortoise (Bailey 1991, Godley 1992) and oldfield mouse. Within the range of the gopher tortoise, gopher frogs most often use tortoise burrows as diurnal retreats (Godley 1992). Thus, impacts to gopher tortoise habitat can, in turn, harm gopher frog populations. The greatest threat to gopher tortoise populations is habitat destruction—chiefly fire suppression and the subsequent conversion of the open, longleaf pine sandhill community to dense monocultures of sand or slash pine. Poaching of random individuals also may be suppressing recovery of the gopher tortoise (Auffenburg and Franz 1982).

Fire suppression

Gopher tortoise density can decline as much as 80 percent when fire is excluded for 8 or more years (Diemer 1989). Gopher tortoise densities are linked with the availability of forage, which consists of forbs and grasses (Diemer 1989). Therefore, reduction of groundcover vegetation resulting from shading by closed-canopy pine plantations or leaf litter accumulation due to fire suppression can depress gopher tortoise numbers. Because the oldfield mouse, which creates burrows that gopher frogs seek for shelter, also occurs in open, graminoid-dominated habitats (e.g., sandhill and oldfields; Webster et al. 1985), its numbers also decrease with a reduction of the groundcover.

On Fort Stewart, Georgia, the creation of firebreaks has been detrimental to breeding gopher frogs. These firebreaks are often placed in the wetland ecotone (e.g., cypress/ tupelo ponds occurring in upland ecosystems) and subsequently alter pond hydroperiods, provide connections with other wetland systems allowing introduction of predatory fish, and alter/destroy the herbaceous component of the pond margins (TNC 1995). Some of these firebreaks have held enough water to make them attractive to female gopher frogs

for egg-laying. However, these fire breaks typically dry before the breeding ponds do and strand the eggs or larvae before they reach metamorphosis (TNC 1995).

Mechanical site preparation

Mechanical site preparation (e.g., roller chopping) destroys openings to subterranean burrows, which may result in entrapment of inhabitants. Although gopher tortoises are able to dig out from occluded burrows in deep sandy soils (Diemer and Moler 1982), they may be entrapped by soils with greater clay content (Diemer 1992). It seems unlikely that gopher frogs could exhume themselves from occluded burrows since they do not excavate their own burrows. Thus, unless they co-occur with tortoises in their burrows, they may become entombed when a site is mechanically disturbed.

Predation

Because gopher frog tadpoles are palatable to fishes (LaClaire and Franz 1991), the introduction of predatory fishes (e.g., *Lepomis* or *Micropterus*) into gopher frog breeding sites can render them unsuitable. Jensen (Personal Communication, 1996) suggested there is evidence that mosquitofish (*Gambusia holbrookii*) nip at and eat hatchling tadpoles.

Off-road vehicles and sandy roads adjacent to ponds

Gopher frog breeding sites are often degraded by off-road recreational vehicle (ORV) use or by sand roads that pass through or adjacent to the ponds. Vehicular traffic disrupts pond floor microtopography and eliminates herbaceous vegetation. The tires used on ORVs may break the organic hardpan that lies below the pond floor. It is this hardpan that prevents water from draining into the sand below the wetland (LaClaire and Franz 1991). Breaking the hardpan could result in a shorter hydroperiod and thereby make some wetlands unsuitable for gopher frog reproduction. Loss of herbaceous vegetation from ORV usage could also discourage gopher frog reproduction, since egg masses are attached to stems of herbaceous vegetation (Bailey 1990, Palis 1995b). Off-road vehicle use can also contribute to direct mortality of tadpoles and adults (Jensen, Personal Communication, 1996). Erosion of unpaved roads lying adjacent to breeding sites may result in an influx of sedimentation from surrounding uplands during rainstorms. Introduction of sediment is exacerbated by emplacement of wing ditches that divert water from roads into ponds (M. A. Bailey, Personal Communication, 1996). On Eglin AFB, Florida, Palis (1995b) suggested prohibiting vehicular use (except for emergency and natural resource enhancement) within 50 m (164 ft) of upland wetland depressions, particularly gopher frog breeding sites. Roads that pass near or through wetlands should also be closed or rerouted.

Military Training (from Trame, in preparation)

Mechanized training

Mechanized military training can alter natural plant communities through impacts to soils and, subsequently, cause soil erosion. Intense use of tactical land vehicles (both tracked and wheeled) can cause extensive soil disturbance. In flatwoods, this can lead to ponded areas and restricted subsurface water flow. Ruts provide new microenvironments that are drier or wetter than the natural moisture level, and this may allow invasion of the community by plants that otherwise would not occur. Longleaf pine sandhills are highly susceptible to gully erosion if training activities are sustained, intensive, or occur on sloped terrain. All these impacts can lead to a disruption of breeding and movement by gopher frogs.

Bivouacs

Military bivouacs, which involve a combination of vehicle and non-mechanized trampling, represent a serious source of soil compaction and related impacts. Upland soils with high sand content will not suffer a great deal of compaction. Even frequently used bivouac sites may retain ground cover and pine regeneration if the soils are resistant to compaction (A. Trame, Personal Communication). However, sustained high levels of trampling can ultimately eliminate vegetation, which can lead to erosion into adjacent wetlands.

Fertilization

Fertilizer that is used in erosion control projects on installations may significantly impact wetlands. The additional nutrients may move with the groundwater through sandy soils and enter adjacent wetlands used by breeding gopher frogs.

Fire

Military training can impact native plant communities and threatened, endangered, and sensitive species (TES) by fragmenting the fuel sources needed to carry fire over large areas. Native groundcover, especially grasses, are essential fuel sources that allow large areas to burn. Bunchgrasses are frequently eliminated in bivouac sites, assembly areas, and tank maneuver areas through direct destruction or soil compaction. Areas that do not burn undergo a change in species composition; sites become increasingly shaded through time; and the natural community is ultimately lost.

A potential beneficial effect of military training activities is the reintroduction of fire resulting from activities such as live arms firing and use of incendiary devices. The frequency of ignition on military installations, especially in high hazard impact areas, often produces a fire regime over large areas at a frequency that resembles presettlement natural fire return intervals. This encourages a mosaic burn pattern and enhances

conditions for the fire-adapted species, including those associated with flatwoods (Gulf Engineers and Consultants, Inc., and Geo-Marine 1994; LeBlond et al. 1994).

Management and Protection

Fire

The most appropriate form of management for maintenance of intact xeric longleaf pine-dominated uplands and ephemeral and semipermanent wetlands is to mimic natural disturbance processes such as lightning-season fire (Palis 1995b). Seasonality of fire is an important consideration in a prescribed fire plan. Historically, fire was ignited by lightning, most often between May and September (Robbins and Myers 1992). Many components of the ground cover flora, such as wiregrass (*Aristida stricta*), flower profusely only after lightning-season fire (Robbins and Myers 1992). Furthermore, lightning-season fires are outside the reproductive period of gopher frogs throughout much of its range and thus may not interfere with movements of the species to and from breeding sites. TNC (1995) suggested that for Fort Stewart, Georgia, fires should be prescribed prior to October, when frogs are moving into breeding ponds. Caution must be exercised when reintroducing fire at fire-suppressed sites. Unnaturally high fuel loads, a consequence of fire exclusion, could endanger longleaf pine if a lightning-season fire is ignited without first reducing the fuel load with cool-season fire(s). At Eglin AFB, Florida, Palis (1995b) suggested that the area within a 2-km (1.2-mile) radius of each gopher frog breeding site should be a priority for periodic burning, as gopher frogs may disperse up to this distance from breeding ponds.

Lightning-season fire may also be important to the maintenance of larval gopher frog habitat. Wetlands used by gopher frogs for reproduction are characteristically dry or partially dry during the lightning season. A fire passing through these sites when dry would consume herbaceous vegetation and possibly kill woody vegetation. Elimination or suppression of woody vegetation is important in maintaining the open, graminaceous character typical of most gopher frog breeding ponds. In addition, fire releases nutrients bound in plant material. This release of nutrients results in a flush of primary productivity that would be available to herbivorous gopher frog tadpoles the following winter.

Silviculture

Clearcutting should be replaced with selective timber harvest and natural regeneration enhanced by fire, particularly lightning-season fire. If offsite species such as slash or sand pine have been planted, they should be removed and the site replanted with longleaf pine at naturally occurring densities. Mechanical preparation of the soil should be avoided. TNC (1995) suggested providing a buffer zone of 2 km around known breeding ponds to eliminate potential activities that may impact water quality to breeding sites.

Habitat restoration and population recovery

Gopher frog recovery is directly linked with the ability to preserve existing habitat and restore degraded habitat. Given the drastic decline in the extent of longleaf pine-dominated communities (Ware et al. 1993), elevation of gopher frog populations above present levels is unlikely. However, experimental restoration of a degraded xeric upland longleaf pine sandhill is being conducted by The Nature Conservancy in Florida (G. Seamon, Personal Communication, 1995). Alvin Braswell (Personal Communication, 1996) is experimenting with construction of breeding sites and the stocking of gopher frog larvae in North Carolina, and the U.S. Department of Agriculture Forest Service is attempting to eliminate introduced predatory fishes from two gopher frog breeding sites in Conecuh National Forest, Alabama (M. A. Bailey, Personal Communication, 1996). Should these efforts prove successful, reintroduction of gopher frogs onto historic sites where extirpated may be feasible on a larger scale.

Stewardship activities aimed at restoring and/or maintaining the ecological integrity of mesic longleaf pine-turkey oak sandhill and associated ephemeral and semipermanent wetlands will help preserve extant populations of gopher frogs. Because gopher frogs are sensitive to human-induced alteration of their habitat (Bailey 1991, Godley 1992), perpetuation of existing populations will require preservation of relatively undisturbed xeric longleaf pine-dominated uplands, and graminaceous, fish-free ephemeral to semipermanent wetlands. At least 12 km^2 (4.6 $miles^2$) of terrestrial habitat surrounding each breeding site is probably needed to sustain each breeding population. Long-term perpetuation of a viable population of gopher frogs will presumably require protection of a larger area of terrestrial habitat encompassing a suite of alternative breeding sites (Travis 1994).

Inventory and Monitoring

Census methods

Prior to initiation of field work, potential gopher frog habitat can be delineated on 7.5 minute U.S. Geological Survey topographic maps, aerial photographs, and/or county soil surveys (Palis 1995b). Gopher frog breeding activity can be monitored by diurnal surveys for egg masses in known and potential breeding sites. Determination of the number of egg masses deposited by each female is needed to provide an indication of the size of the adult breeding population based on egg mass counts. Female gopher frogs appear to deposit only one egg mass (Palis 1995b) unless interrupted while depositing (J. Jensen, Personal Communication, 1996). Egg mass surveys should be conducted several days after heavy rains during the breeding season. Surveying consists of slowly wading through the wetland and visually investigating vegetation to which eggs are commonly attached. Egg masses are most readily located on overcast, windless days.

Bailey (Personal Communication, 1996) suggested that it is critical to wear polarized sunglasses while conducting surveys. Palis (1995b) stressed the importance of multiple-year surveys for assessing the presence or absence of gopher frogs. Hydrologic conditions may differ among years, and sites not used for breeding one year may be used the following year if suitable conditions exit.

Nocturnal vocalization surveys can also be performed during conditions conducive to frog calling activity, which is usually during or following rains when air temperatures are above 7 °C (45 °F). Caution must be exercised when conducting aural surveys, however, as gopher frogs can produce muted calls from underwater that are audible only at distances less than 10 m (Jensen et al. 1995). To avoid missing submerged calling males, vocalization surveys should be conducted at the pond edge at various points around the pond.

On rainy nights when frogs are moving to and from breeding sites, they can often be encountered crossing roads. Gopher frogs are readily trapped at night at the mouth of tortoise burrows with screen funnel traps, Sherman traps, or bucket traps. Burrow trapping is most successful outside the breeding season since animals abandon upland habitats during the breeding period (Franz 1986).

Drift fences[1] provide an effective means of capturing gopher frogs around breeding ponds. A total of 269 gopher frogs was captured during one breeding season at a drift fence in southern Alabama (Bailey 1990). On Eglin AFB, Florida, approximately 300 adult gopher frogs were captured at one site (Palis 1995b). At a site in South Carolina, however, fewer than 10 adults per year were captured at breeding sites during a 25-year period (Semlitsch et al. 1995). Presently, there are no standards for assessing occurrence based on the number of animals captured at a drift fence, number of egg masses observed, or the number of larvae captured at a breeding site.

A positive means of identifying live gopher frog tadpoles is needed rangewide to facilitate surveying and monitoring, although this is difficult and may be unreliable. Also, a better understanding of the impacts of human-caused disturbances on gopher frogs might be obtained by implementing drift fence surveys at locations throughout their range representing various degrees of disturbance.

[1] A drift fence with pitfall receptacles is a structure often used to capture reptiles and amphibians. The structure typically consists of fence material (e.g., aluminum flashing) partially buried in the ground in a linear fashion, with pitfall receptacles (e.g., 19.925-ℓ (5-gal) bucket, coffee can) buried flush with the ground and against the fence material.

Monitoring programs

A. Braswell (Personal Communication, 1996) annually monitors selected sites in North Carolina for breeding activity. R. Seigel (Personal Communication, 1995) has a student monitoring a gopher frog population in Mississippi.

Current research

Construction of breeding ponds and establishment of new populations by introducing tadpoles is being attempted in North Carolina.

Surveys of potential breeding sites and remnant upland pine communities are needed to better define the present distribution of the gopher frog. Additional demographic data are needed to improve man's knowledge of the life history of this species, particularly factors that limit population size (e.g., egg, larval, and metamorph survivorship; density-dependent larval growth rates; competition with other species; burrow availability). The species' response to human-induced habitat disturbance and altered fire regimes needs study. Finally, terrestrial habitat use and population densities may be determined through radiotelemetry or mark/ recapture techniques, respectively.

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13. ABSTRACT ***(Maximum 200 words)***

The gopher frog (*Rana capito*) is a rare frog of the Southeast. Currently, three subspecies are recognized; one is a candidate species for listing as Threatened or Endangered by the U.S. Fish and Wildlife Service, and the other two are former candidates now unofficially considered "Species of Concern." Gopher frogs inhabit xeric upland pine communities of the Southeastern Coastal Plain from the southern half of the North Carolina coastal plain to southern Florida and westward to eastern Louisiana. The principal habitat of the gopher frog is longleaf pine-turkey oak sandhill, but it also inhabits xeric to mesic longleaf pine flatwoods, sand pine scrub, and xeric oak hammock. Gopher frogs typically breed in circular or near-circular, ephemeral to semipermanent graminoid-dominated wetlands found within these communities. The gopher frog has been documented on several military installations in the Southeast. This document is one of a series of "Species Profiles" being developed for threatened, endangered, and sensitive species inhabiting southeastern United States plant communities. The work is being conducted as part of the Department of Defense (DoD) Strategic Environmental Research and Development Program (SERDP). The report is designed to supplement information provided in plant community management reports for major United States plant communities found on military installations. Information provided on the gopher frog includes status, life

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history and ecology, habitat requirements, impacts and cause of decline, management and protection, and inventory and monitoring.

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