

Preliminary Survey of Leopard Frogs in Glen Canyon National Recreation Area

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Abstract. Collection records and published reports indicate that the northern leopard frog (*Rana pipiens*) was formerly widely distributed along the Colorado River corridor in the area that is now Glen Canyon National Recreation Area. This species has experienced serious declines over much of its range in western North America. We report on a newly discovered population along the Colorado River in Glen Canyon National Recreation Area, and two new populations in tributaries of Lake Powell. Recent surveys suggest that the river site supports the sole remaining leopard frog population between Glen Canyon Dam and Lake Mead. This population is vulnerable because of its small size (80–100 individuals), its isolation, and because of possible effects from planned increased high flows from Glen Canyon Dam.

Key words: Amphibian decline, Colorado River, conservation, *Rana pipiens*.

Recent reviews and conferences have focused attention on serious declines of anuran amphibians from Australia to North and South America (Barinaga 1990; Blaustein and Wake 1990; Wyman 1990; Tyler 1991; Blaustein 1994a). In western North America, populations of frogs (*Rana* spp.) and toads (*Bufo* spp.) have suffered significant declines (Hayes and Jennings 1986; Fellers and Drost 1993; Corn 1994). Despite speculation and an increasing number of careful studies (e.g., Bradford et al. 1993; Carey 1993; Blaustein 1994b), the cause of many of the declines remains an enigma.

The northern leopard frog (*Rana pipiens*) and related species (*R. chiricahuensis*, *R. onca*, *R. yavapaiensis*) are among the North American species that have experienced serious declines (Corn and Fogleman 1984; Clarkson and Rorabaugh 1989; Bishop and Petit 1992). Northern leopard frogs were formerly widespread and abundant across much of the western United States and Canada.

Since the 1970's, however, declines of northern leopard frogs have been reported from Arizona, Colorado, Wyoming (Hammerson 1982; Corn and Fogleman 1984; Clarkson and Rorabaugh 1989; Vial and Saylor 1993) and large areas in Canada (Bishop and Petit 1992; Vial and Saylor 1993). Clarkson and Rorabaugh (1989) surveyed 13 sites in Arizona that previously supported northern leopard frog populations but did not find the species at any of the sites.

In 1992, National Park Service personnel found leopard frogs at Horseshoe Bend on the Colorado River in Glen Canyon National Recreation Area (GLCA). They had previously found small numbers of frogs in two tributaries of Lake Powell, also within GLCA. Based on these discoveries, we proposed an intensive survey for leopard frogs along the Colorado River in GLCA. Our objectives were to (1) survey the Horseshoe Bend site and assess the population size and condition of the frogs there, (2) search the remainder of the Colorado River corridor from Glen Canyon Dam to Lees Ferry and the tributary canyons of Lake Powell for additional leopard frog populations and potential leopard frog habitat, and (3) compare the current distribution of leopard frogs in the area with reconstructed distributions from historical records.

Methods

We searched published literature and unpublished agency reports for information on leopard frogs in the Glen Canyon area. In addition, we examined 7.5-minute U.S. Geological Survey maps and color aerial photographs of the area to locate springs, marshes, and tributary streams that might provide suitable habitat for frogs. Fieldwork on the river had three components: (1) census and habitat survey of the Horseshoe Bend site; (2) surveys by boat along the river corridor from the base of Glen Canyon Dam to Lees Ferry to search for additional potential leopard frog habitat; and (3) searches on shore for leopard frogs at all sites having suitable habitat (see Fig. 1).

We searched wetland areas adjacent to the shore by carefully walking along and through all wetland habitat while looking for frogs sitting or jumping along the water's edge or in adjacent marsh or meadow vegetation. Leopard frogs are relatively conspicuous and are usually found sitting out in the open. We also turned boulders and logs to look for frogs or other amphibians hiding underneath. We searched areas of still or slowly flowing water for tadpoles, which we captured with a dip net and examined and identified in the hand. We

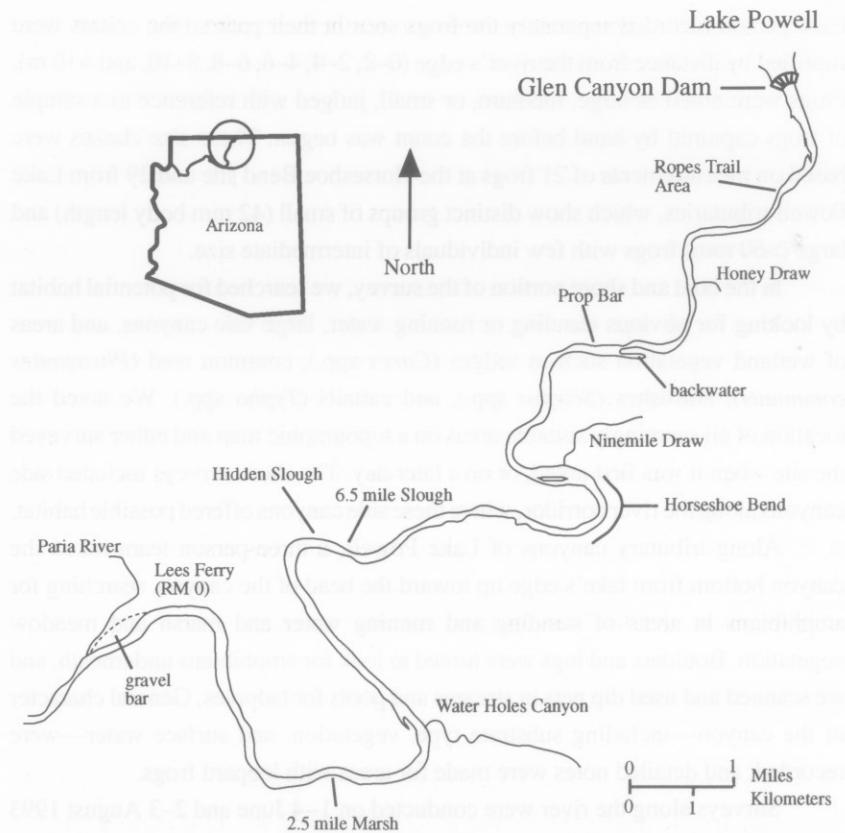


Fig. 1. The Colorado River in Glen Canyon National Recreation Area, from Glen Canyon Dam to Lees Ferry, indicating areas intensively searched for leopard frogs (*Rana* sp.) in 1993. The one site where frogs were found was Horseshoe Bend.

recorded body length (snout-urostyle) and general condition for all frogs captured. We recorded a general description of the habitat at each site that supported leopard frogs, including basic topography of the area, type and size of surface water (if any), and dominant plant species. We began surveys well upriver of apparently suitable leopard frog habitat and continued downriver beyond the last frogs seen and the last areas of apparently suitable habitat.

On the second survey of the Horseshoe Bend site, a three-person crew conducted a careful census of the frogs by walking slowly through the habitat in a line perpendicular to the river. The crew stayed abreast of each other, approximately 2 m apart, while sweeping the ground ahead with a staff or large branch.

Each person recorded separately the frogs seen in their path so the counts were stratified by distance from the river's edge (0–2, 2–4, 4–6, 6–8, 8–10, and >10 m). Frogs were noted as large, medium, or small, judged with reference to a sample of frogs captured by hand before the count was begun. These size classes were based on measurements of 21 frogs at the Horseshoe Bend site and 29 from Lake Powell tributaries, which show distinct groups of small (42 mm body length) and large (>60 mm) frogs with few individuals of intermediate size.

In the boat and shore portion of the survey, we searched for potential habitat by looking for obvious standing or running water, large side canyons, and areas of wetland vegetation such as sedges (*Carex* spp.), common reed (*Phragmites communis*), bulrushes (*Scirpus* spp.), and cattails (*Typha* spp.). We noted the location of all seemingly suitable areas on a topographic map and either surveyed the site when it was first noted, or on a later day. The shore surveys included side canyons along the river corridor, where these side canyons offered possible habitat.

Along tributary canyons of Lake Powell, a three-person team hiked the canyon bottom from lake's edge up toward the head of the canyon, searching for amphibians in areas of standing and running water and marsh and meadow vegetation. Boulders and logs were turned to look for amphibians underneath, and we scanned and used dip nets in streams and pools for tadpoles. General character of the canyon—including substrate type, vegetation, and surface water—were recorded, and detailed notes were made for areas with leopard frogs.

Surveys along the river were conducted on 1–4 June and 2–3 August 1993 to allow for seasonal variation in numbers or activity among the frogs and to obtain information on the phenology of the frogs in this area. Tributaries of Lake Powell were searched on 4–5 August. Total time spent actively searching for amphibians was 105 person-hours: 57 person-hours over 4 days on the first week; 25 person-hours on 2 different days during the second week; and 23 person-hours searching tributary canyons of the lake.

Results

Previous Records

Before the discovery of the population described here, the only recent (subsequent to dam construction) report of leopard frogs from the Colorado River corridor below Glen Canyon Dam was from Cardenas Marsh, 114 km below Lees Ferry (Tomko 1975; Miller et al. 1982). Biologists working at Cardenas Marsh in

1992 and 1993 did not find any frogs at this site, however, and recent sediment deposits have resulted in marked drying of the marsh (M. K. Sogge, unpublished data). From this we conclude that this population of frogs has been lost. Leopard frogs are not otherwise known from the entire reach of the Colorado River from Glen Canyon Dam to Lake Mead (Miller et al. 1982; C. Pinnock, 1993, personal communication). In the Lake Mead area, leopard frogs are widely distributed, but a substantial number of these frogs may be nonnative—descended from introduced individuals (Schwartz et al. 1978).

In the region of the Colorado River above Glen Canyon Dam, leopard frogs were formerly common (Woodbury 1958). There were a few reports of leopard frogs from pools along the main course of the river, but most occurrences were in tributary streams from at least Trachyte Creek near Hite, Utah, downriver to Warm Creek (Table). Most of the sites above the dam were inundated by the creation of Lake Powell (Table). Leopard frog populations persist, however, along some of the tributary streams of the lake (J. Spence, Glen Canyon National Recreation Area, personal communication).

Horseshoe Bend Site

We surveyed the Horseshoe Bend area on 2 June and 2 August. The shoreline on both sides of this sharp bend in the river were scanned from the water, and we searched the stretch from river mile (RM) –8.6 to –9.4 on foot (RM 0 is at Lees Ferry; negative RM values indicate upstream distances). Leopard frogs were restricted to the area from about RM –8.9 to –8.75 L. Habitat for the frogs is centered on a small, spring-fed stream and marsh perched above river level at the foot of a large talus slope. The pool and marsh area contains meandering, interconnected, U-shaped channels, about 0.5 m deep with a thick silt bottom. Tall, dense vegetation fringing these channels consists of *Carex*, *Phragmites*, *Scirpus*, and *Typha*. The pool-marsh area drains to a boulder and cobble shallows area along the river, which has two additional pools just above river level. The lower pools are small and shallow, 4–5 m across and up to 10 cm deep. The pools have a moderate amount of green algae and rooted *Chara*. Sparse vegetation around the pools and scattered across the low boulder bar consists of small *Carex* sp., *Juncus* spp., *Polypogon semiverticillata* (= *Agrostis viridis*) and watercress (*Rorippa nasturtium-aquaticum*). *Carex*, *Juncus*, and other elements of this wetland vegetation extend along the river's edge both upstream and downstream from the spring area for a total distance of approxi-

Table. Historical locations of northern leopard frogs (*Rana pipiens*) along the Colorado River through Glen Canyon National Recreation Area and Grand Canyon National Park.^a

Location ^b	Source	Date	Present status ^c	Notes
Lower Trachyte Creek	Woodbury	1958	Flooded	1,050 m elevation
Below mouth of Ticaboo Creek	Woodbury	1958	Flooded	
River mile -109	Woodbury	1958	Flooded	In small side
River mile -101.5	Woodbury	1958	Flooded	
Lower Long Canyon	Woodbury	1958	Flooded ^d	
Hole-in-the-Rock	Woodbury	1958	Flooded	In pond on river
Hidden Passage	Woodbury	1958	Flooded	
Rainbow Bridge Canyon				
Below Rainbow Bridge	Eaton	1935	Flooded	1,525 m elevation
Above Rainbow Bridge	AES	1936	Unknown	
Rock Creek	Woodbury	1958	Flooded	
West Canyon Creek	Woodbury	1958	Flooded	
Lower Kane Creek	Woodbury	1958	Flooded	River mile 40.6
Padre Creek	Woodbury	1958	Flooded	Numerous near mouth (of creek)
Warm Creek	Woodbury	1958	Flooded	Near mouth of creek
Cardenas Marsh	Tomko	1975	Extirpated?	Not seen during field work in 1991-93

^aMost records are from surveys conducted by the American Exploration Society from 1936 to 1938 and from a survey conducted by the University of Utah in 1957-58 before the construction of Glen Canyon Dam (Woodbury 1958).

^bSites are listed from upriver to downriver. River mile references are from Woodbury (1958) and are based on Lees Ferry = 0.

^cFlooded means the site was inundated by Lake Powell.

^dOriginal site flooded. Population still present in upper canyon (J. Spence, Glen Canyon National Recreation Area, 1993, personal communication).

mately 200 m. The leopard frogs at the site also use, to a lesser extent, the adjacent band of grasses, goldenrod (*Solidago* sp.), and other herbaceous species on drier ground just upslope from the marsh vegetation. Estimated total area of marsh and adjacent habitat for frogs is 0.3 ha.

On 2 June we counted approximately 60 leopard frogs, primarily in marsh vegetation along the river and along two small streams that drain the spring and the pool-marsh area. The frogs were identified as northern leopard frogs by the conspicuous white halo surrounding the large dorsal dark spots, complete white lip stripe, unbroken dorsolateral folds, and light-colored, unmarked posterior surface of the thighs. No specimens were taken, but photos are on file at the Colorado Plateau Research Station in Flagstaff, Arizona, and at the GLCA offices in Page, Arizona. The June count was not complete, but based on the proportion of the marsh that was thoroughly searched, we estimated that approximately 80 to 100 frogs were in the available habitat. These ranged from juvenile (transformed last year) to adult.

All observed frogs were active and alert. We captured and measured 15 frogs, and these individuals appeared healthy, with clear eyes and skin and no unusual outward appearances. Body length (snout-urostyle) of most of the measured sample fell into small (30-40 mm) and large (60-70 mm) size classes, with few intermediate (Fig. 2). One 42-mm-long individual was probably the same age as the 30-40-mm size class, so the only distinctly intermediate frog was one individual that measured 54 mm. Based on this, we recorded frogs of less than 40 mm as small, those greater than 40 and less than 60 mm as medium-sized, and those greater than 60 mm as large.

We noted several leopard frog tadpoles in the deep channels of the upper pool. One individual measured had a body length (snout-vent) of 24 mm, and a total length (including tail) of 54 mm. All tadpoles were approximately the same size and were presumed to be from eggs produced during spring 1993.

On 2 August we counted 81 leopard frogs at the Horseshoe Bend site, including 29 large, 3 medium, and 49 small frogs. We surveyed 185 m of shoreline (up- and downstream from the marsh), encompassing the entire area where frogs had been seen in previous visits. The width of suitable habitat over most of this length was 10-12 m. Upslope, suitable habitat was limited by hot, dry ground and dense brush. On the up- and downstream ends, the area suitable for frogs was apparently limited by the lack of open marsh vegetation, as woody cover extended to the edge of the water.

Most of the frogs noted in the August count were immediately adjacent to the river. Of the frogs not along the river, most were along the outflow stream below the spring pool or around a marshy overflow area just upriver of the spring outflow. The high river level at the time of this second survey (19,500 cfs) seemed to have crowded the frogs into this narrow area. Whereas most of the

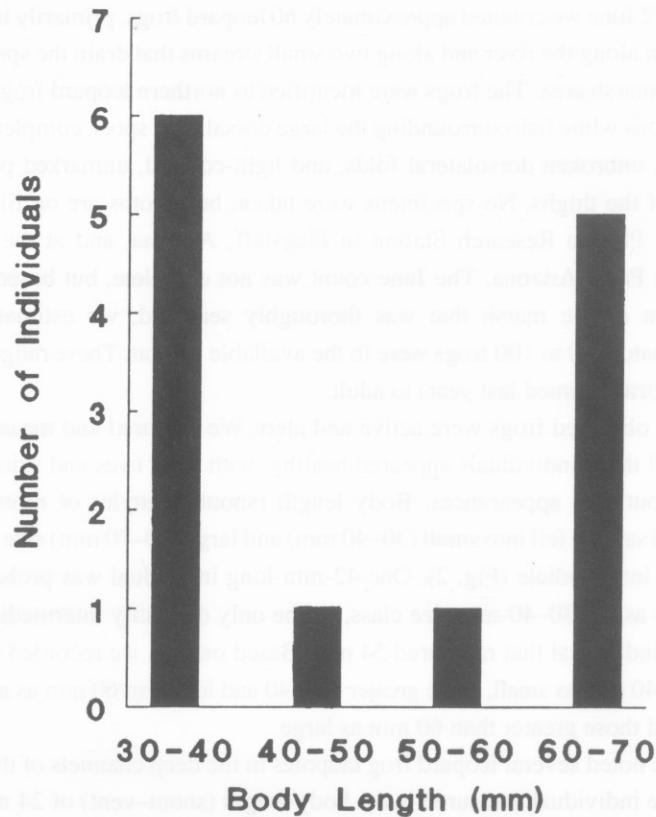


Fig. 2. Size (snout-urostyle) distribution of a sample of 13 northern leopard frogs (*Rana pipiens*) caught at Horseshoe Bend on the Colorado River in Glen Canyon National Recreation Area in June 1993. The 30-40 mm size class represents 1-year-old frogs.

marsh vegetation was inundated, the grassland and desertscrub vegetation upslope from the river at this level were dry and hot. At the lower levels of the river that prevailed during the June count, the areas of marsh vegetation and moist ground were broader, and the frogs were distributed over a greater area.

Large and small frogs also showed different distribution patterns in relation to the river's edge (Fig. 3). Eighty percent of the small frogs were in the 2-m band immediately adjacent to the river. Large frogs, in contrast, were more evenly distributed across the different bands. This difference was significant (χ^2 test of homogeneity comparing the distribution of large and small frogs; $\chi^2 = 11.72$, $P < 0.025$, $df = 4$).

Other Areas

During the 2-week survey, we searched all areas that seemed to offer potential habitat for leopard frogs from the base of Glen Canyon Dam (RM -15.6) downstream to Lees Ferry and the Paria River. No leopard frogs were found at any of these sites. Specific areas searched are listed in the Appendix; detailed descriptions of the sites and results of our surveys are given in Drost and Sogge (1993*¹).

Surveys on Lake Powell were limited to the Bowns Canyon and Ribbon Canyon tributaries to the lake. We found scattered northern leopard frogs in

¹Asterisk indicates unpublished material.

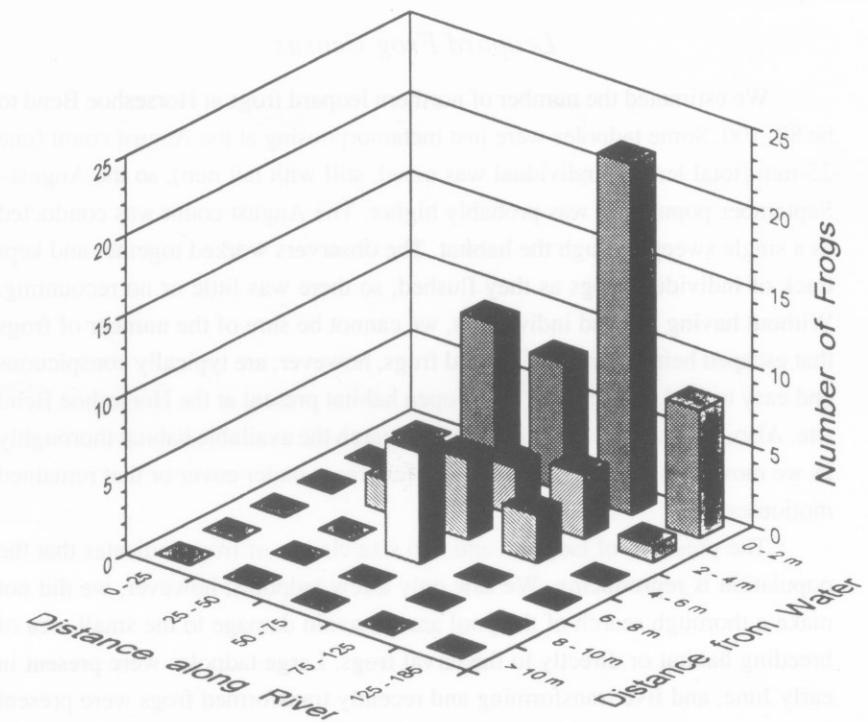


Fig. 3. Distribution of small (30-40 mm) and large (>60 mm) leopard frogs (*Rana* sp.) with respect to river's edge at Horseshoe Bend along the Colorado River in Glen Canyon National Recreation Area. From 0 to 2 m is adjacent to the water, and greater than 10 m is farthest upslope.

Bowns Canyon in parts of the stream and in streamside vegetation from about 1 km up from the lake to at least 2 km farther upstream. We counted 35 juvenile, subadult, and adult frogs, plus 3 large leopard frog tadpoles in the stream at the upper end of the area searched (2.5–3 km upstream from the lake). Most of the frogs found in Ribbon Canyon were in a large plunge pool in a hanging garden alcove at the head of the north arm of the canyon 2 km above the lake. At the time of our survey, the pool was approximately 20 × 40 m and as deep as 1.5 m. Nine large and 28 small northern leopard frogs were counted in the pool. The small frogs were recently transformed and ranged in length from 24 to 31 mm. Nine large tadpoles were observed—6 alive and 3 dead. Cause of death could not be determined.

Discussion

Leopard Frog Census

We estimated the number of northern leopard frogs at Horseshoe Bend to be 80–100. Some tadpoles were just metamorphosing at the August count (one 25-mm [total length] individual was noted, still with tail nub), so the August–September population was probably higher. The August count was conducted as a single sweep through the habitat. The observers worked together and kept track of individual frogs as they flushed, so there was little or no recounting. Without having marked individuals, we cannot be sure of the number of frogs that escaped being counted. Leopard frogs, however, are typically conspicuous and easy to find, particularly in the open habitat present at the Horseshoe Bend site. Also, we made a concerted effort to search the available habitat thoroughly as we moved through it, and we found few frogs under cover or that remained motionless.

The presence of tadpoles and two size classes of frogs indicates that the population is reproducing. We saw only a few tadpoles; however, we did not make a thorough search of the pool area to avoid damage to the small area of breeding habitat or directly to the larval frogs. Large tadpoles were present in early June, and five transforming and recently transformed frogs were present in early August. Reported larval periods of leopard frogs in this region range from 70 to 90 days (Stebbins 1951; Corn 1981), so mating and egg-laying probably occurred during April or early May (in surveys in 1994, egg masses were noted in March and April).

Conservation Concerns

The northern leopard frogs at the Horseshoe Bend site are apparently a highly isolated remnant population. Other than the 1970's record at Cardenas Marsh, this is the only recent report of northern leopard frogs along the Colorado River corridor's 300-mile course from northern Arizona to Lake Mead. Three intensive multiyear studies were conducted along the river corridor in the last 15 years; most were associated with Glen Canyon Environmental Studies and centered on the wetland areas along the river including Cardenas Marsh. No other leopard frog populations were found.

Historical collections and observations indicate that northern leopard frogs formerly existed as scattered populations along the Colorado River through southern Utah and northern Arizona. The construction of Glen Canyon Dam radically altered the river system both up- and downstream of the dam. Above the dam, the river and its tributaries were inundated for more than 250 km along the river. Below the dam, the river was changed from a warm, heavily silt-laden stream with a highly seasonal flow, to a much colder stream with a highly-regulated, nonseasonal flow. These changes affected northern leopard frog distribution and numbers by eliminating river populations above the dam and by isolating the populations that persisted in tributary streams above lake level. Downstream, the physical barrier presented by the dam and the cold temperature of the river water have combined to isolate the population at Horseshoe Bend. The dam presents an absolute barrier to any interaction with populations in Lake Powell tributaries, and the cold water probably prevents significant dispersal from the Horseshoe Bend population.

Is an isolated population like the one at Horseshoe Bend worth serious concern and management attention? Although there are still scattered populations of northern leopard frogs in southern Utah (such as the populations in Lake Powell tributaries), there is serious concern about the status of the species in Arizona. In addition to the losses reported by Clarkson and Rorabaugh (1989), recent surveys in northern Arizona have failed to find any northern leopard frogs. The northern leopard frog is currently a candidate for the Arizona state list of threatened wildlife (Arizona Game and Fish Department 1988), and southwest populations of the species have recently been proposed for addition to the federal candidate list of threatened and endangered species. In light of widespread declines of the species, both locally and regionally, a healthy population definitely merits attention.

Several other aspects of the Horseshoe Bend site are also of specific conservation concern. The spring-fed marsh habitat of the site is unique in the Glen Canyon area and is rare along the Grand Canyon stretch of the river. The site supports plant species that are rare along the central Colorado River corridor, including one grass species (rice cutgrass, *Leersia oryzoides*) not found anywhere else in Glen Canyon and Grand Canyon.

The greatest immediate threat to the Horseshoe Bend site is from planned "habitat maintenance" flows from Glen Canyon Dam, which are intended to limit bank erosion downstream and achieve a more normal pattern of sediment transport along the river. At the moderately high river levels present during the August survey (20,000–21,000 cfs), the lower pools at the Horseshoe Bend site were inundated, and most of the marsh area was at or barely above river level. At the much higher habitat maintenance flows planned for 1995 (45,000 cfs or greater), the river would wash over most or all of the frog habitat. This may directly or indirectly kill most of the frogs at the site. Tadpoles are restricted to the lower pools and marsh and, at a minimum, the projected high flows would sweep all of the tadpoles downstream and eliminate the current year's recruitment. Many of the frogs may also be swept into the cold waters of the main channel where they would be vulnerable to fish. High flows would probably also degrade the habitat at the site by stripping or drowning marsh vegetation and altering the slope that supports the marsh.

A proposed alternative management action for Glen Canyon Dam is to release warm water from the surface of Lake Powell, rather than the cold bottom water currently released. The resulting rise in the temperature of the river water may benefit some of the warmwater-adapted endangered fish species. This action might benefit the leopard frog population as well, allowing the frogs to use additional shore habitat immediately along the river and perhaps to disperse to other sites in the warmer river waters.

The Colorado River in this region has been profoundly altered and is subject to extensive management. This management must balance many often-conflicting demands and mandates, ranging from power production to limiting or mitigating negative effects of dam operations on physical, cultural, and biological resources, including endangered species. The marsh site at Horseshoe Bend—and the populations of northern leopard frogs and other species that it supports—must be added to this complex mix of demands. Within the context of the other physical, biological, and economic considerations in the management of the river, all reasonable efforts should be taken to protect this unique site.

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²Asterisk indicates unpublished material.

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Appendix. Areas Surveyed for Northern Leopard Frogs

Areas surveyed on foot for northern leopard frogs (*Rana pipiens*) in the Glen Canyon National Recreation Area during 1993. River sites are areas along the Colorado River between Glen Canyon Dam and Lees Ferry; lake sites are areas off Lake Powell. River mile (RM) references are based on Lees Ferry = 0; negative values indicate upstream site. Survey week 1 was 1-4 June; week 2 was 2-5 August.

River sites

1. Ropes Trail area (RM -14.3 R; week 1)
2. Honey Draw (RM -13.2 L; week 1)
3. Backwater above Prop Bar (RM -12.2 L; week 1)
4. Ninemile Draw (RM -9.6 L; week 1)
5. Horseshoe Bend area (RM -8.6 to -9.4 L; weeks 1 and 2)
6. 6½-mile Marsh (RM -6.5 R; weeks 1 and 2)
7. Hidden Slough (RM -6.2 R; weeks 1 and 2)
8. Water Holes Canyon (RM -3.8 L; week 2)
9. 2½-mile Marsh (RM -2.5 L; week 2)
10. Lees Ferry (shoreline and small tributary stream, above boat ramp, RM -0.2 R; week 2)
11. Lees Ferry (boulder-gravel bar just upstream of mouth of Paria River, RM +0.2 R; weeks 1 and 2)
12. Lower Paria River (Paria River N of road at Lees Ferry; week 1)

Lake sites

1. Bowns Canyon (tributary of Lake Powell, RM -78 R; week 2)
2. Ribbon Canyon (tributary of Lake Powell, RM -69 L; week 2)