Yellowstone Science

A quarterly publication devoted to the natural and cultural resources

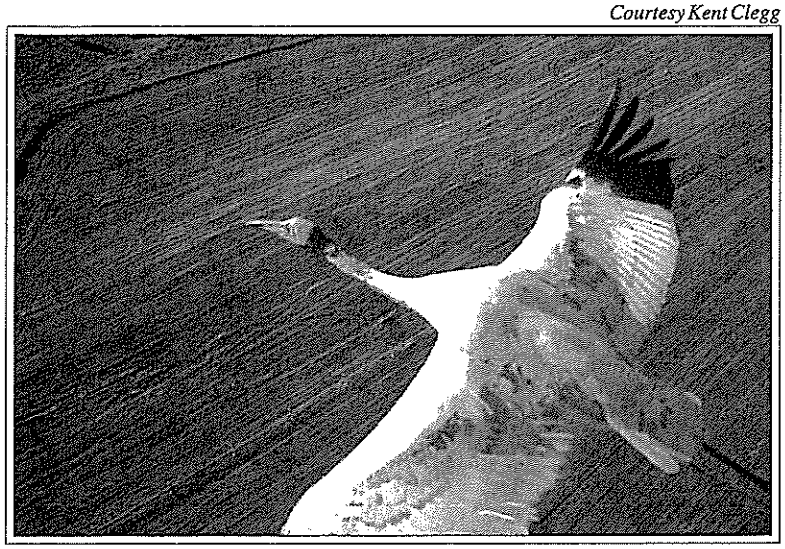
What's Up With Whooping Cranes

Found: Missing Pages of History

Amphibians in Yellowstone

Volume 7 Number 1

Courtesy Kent Clegg



Dear Field Diary...

I seem to be falling into a pattern of "spring cleaning" my office each January after the holidays, as I ease back into the work routine. These last few years, the major task is to discard (recycling in the environmentally appropriate manner, of course) or file all the amassed journal articles, theses, and letters that crossed my desk in the previous twelve months. All of them I *meant* to read, but they were lost in what a former superintendent once called "the Eocene of my in-box." Buried in the swamp was also my own field notebook, *fairly* up-to-date.

During this latest flurry of reorganization, I found myself thinking about two of the features in this issue. Archivist Kim Allen Scott takes us along on a trail of discovery that leads to some of the long-missing words describing the park's exploration by Folsom and Cook. Non-history buffs may underestimate the value of such record in giving the readers of today and the future added detail and a sense of the Yellowstone that was in 1869.

Coming from a completely different discipline, biologists Deb Patla and Chuck Peterson point out how, without the detailed notes and maps left by a researcher from the 1950s, they could not have understood substantial changes that have occurred in the intervening years in the habitat and the population of spotted frogs near Yellowstone Lake. They implore other scientists to *keep those field notes!* The future scientific value of today's measurements, maps, and observations is unpredictable.

These features compel me to once again catch up on my own backlogged data, maps, and notes from ongoing observation of beavers in the park, and to store it somewhere easy for future curious readers to find. Maybe, just maybe, it will be of use to someone, someday....

Readers, what potential gems are deep in *your* winter stores? SCM

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On the cover: Columbia spotted frog, see story on page 2; left: whooping crane in flight, see story on page 18; above: 125 lb yearling wolf from the Crystal Creek Pack with Bob Hawkins and Carter Niemeyer, see story page 25.

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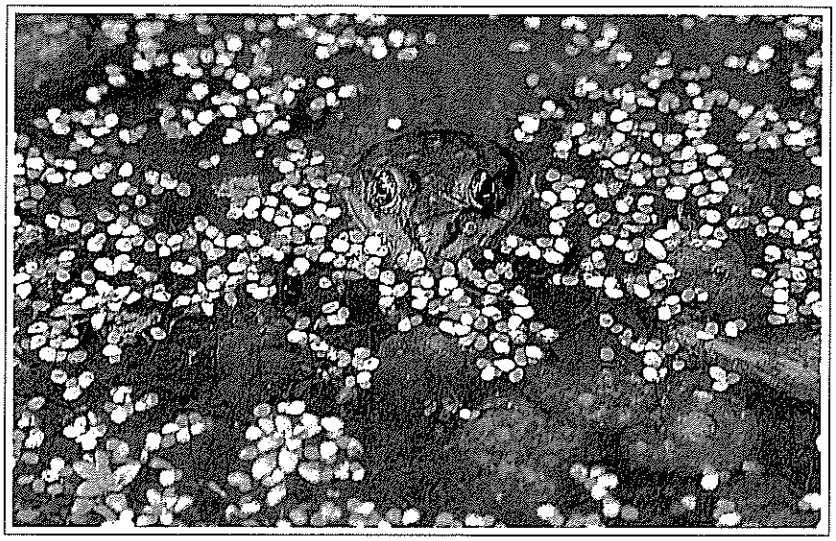
Are Amphibians Declining in Yellowstone National Park?



by Debra A. Patla and Charles R. Peterson

Following a June thunderstorm, the meadow we are walking through is dotted with tiny pools, the water-filled hoof prints of bison. A quick movement at the edge of one catches our attention. Groping in the muddy water, we find a small spotted frog. A bison footprint pool is just about perfect for a frog's need to hide and moisten its skin while traversing or foraging in an open meadow. We are bemused by the idea that with a history stretching back 200 million years, frogs must have similarly taken refuge in the footprints of dinosaurs and mammals long vanished from the earth.

Since the late 1970s, researchers have noted declines and disappearances of amphibian populations in many places around the world. Although a large number of these declines and local extinctions reflect the widespread destruction and pollution of natural habitats, others have occurred in areas generally considered pristine. Mountainous regions of the western United States, including national parks and wilderness areas, host an unexpectedly large share of amphibian declines. Substantial declines of formerly common species have been noted in southern Wyoming, the Colorado Rockies, the Sierra Nevada, and other remote protected areas.

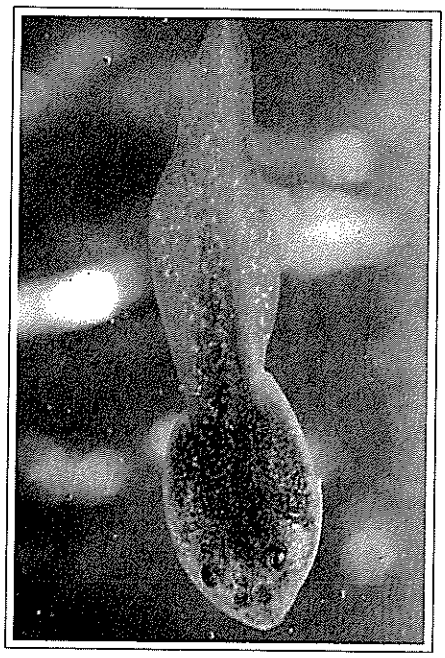
How are the amphibians of Yellowstone faring? The work of past and current researchers and many observers indicates that along with some good news there are also reasons for concern and many unanswered questions.

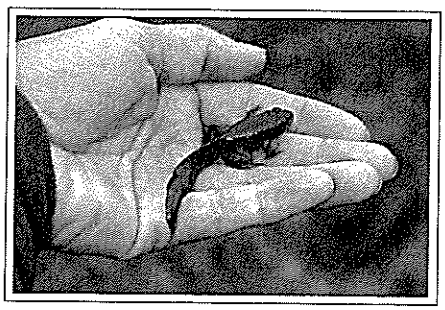
Early Investigations

Knowledge about Yellowstone amphibians was scant until the early 1950s, when a herpetology student from the University of California at Berkeley, Frederick B. Turner, began work as a ranger naturalist. During his summers in Yellowstone, Turner made detailed observations, museum collections, illustrated accounts, and a checklist of the park's amphibians and reptiles. He found that, despite low species diversity (only four species were present), amphibians were widespread and abundant in many areas.

In 1952, when Turner was assigned to work at Fishing Bridge, he realized that an exciting research opportunity existed just outside his cabin doorstep. Scores of spotted frogs, ranging in size from barely one inch to three inches long, occupied the large meadow northwest of Lake Lodge. The frogs apparently gathered to breed in a shallow pool formed by snowmelt and rain showers, then dispersed into the meadow, and finally disappeared. Where did these frogs go, how long did they live, how fast did they grow, what did they eat, and what ate them? How did they survive the harsh climate? Few people had examined these questions in detail for natural populations of amphibians, and no one had attempted it in Yellowstone. Turner took up the challenge.

For the next three summers (1953–55) Turner lived an intense double-life. In between shifts as ranger naturalist, he searched for frogs in a 70-acre study area in the meadow and forests around Soldier Creek, now known as Lodge Creek (Fig. 1). He marked each frog with a unique pattern of toe-clipping to distinguish it from other frogs and recorded its size, sex





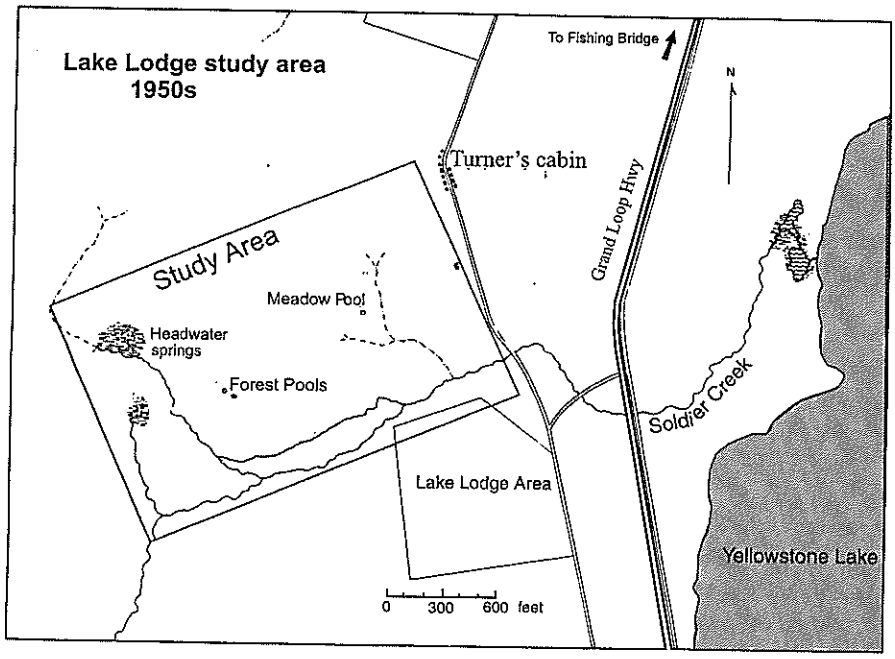


Figure 1. (Map) Turner's spotted frog study area in the 1950s, less than one mile south of Fishing Bridge junction. Far left: Columbia spotted frog (Rana luteiventris). *Above left: Tadpole. Just after hatching, tadpoles are dark in color. Older tadpoles are brownish-green with gold flecks or speckles. The tail is about twice as long as the body. Above middle: An exceptionally large spotted frog metamorphs resembles the adult in dorsal color and body shape, but has varying amounts of tail or tail stub until the tail is completely resorbed. Size ranges from 0.5 to 1.0 inches, snout-vent length. Large numbers of metamorphs are sometimes found at the edge of breeding pools. Above right: Adult spotted frog. A frog with bumpy skin, rather pointed snout, and large hind feet with webbed toes. Adults range in size from 1.8 to 3 inches long. The back is brown or dull green with irregular, blotchy dark spots that sometimes have light centers and a light-colored jaw stripe from snout to front leg. Underside of hind legs and lower abdomen of most adults is salmon or orange colored, sometimes very bright. Males have a dark, thick callous on the thumbs. All photos courtesy Debra Patla and Charles Peterson.*

(adult males are distinguished by a callous on the thumbs), and precise location of capture. By the end of 1955, Turner had captured almost 1,700 frogs and recaptured 900 of them at least once.

From this painstaking work, the natural history of the Lake Lodge population emerged, forming the basis for much of what is known about this species, now named the Columbia spotted frog. In May or early June, a portion of the adult population gathered to breed at three pools: one in the meadow, one in the forest, and one at the creek's headwater springs. Eggs were deposited in clusters about the size of a softball, a gelatinous mass that floated at the surface of the pools' shallow water, enclosing 200 to 800 eggs. In 12 to 21 days, hatchlings, just 0.4 inches long, uncurled and emerged from the egg clusters. The tadpoles grew and developed at variable rates among the three pools (which differed in water temperature) until they reached a maximum length of 2.5–3.0 inches.

In about 60 days, the total length of tadpoles started to shrink as the wonderfully strange set of transformations known as metamorphosis occurred. Hind legs developed and enlarged. Then front legs appeared, popping fully developed through the skin, first the left leg and then the right. Tails were resorbed gradually. The small round mouths, used for scraping and sucking in tiny food particles, were replaced by gaping jaws. Internally, the intestines of the tadpoles (mainly vegetarians) transformed into the shortened gut of carnivores, and lungs developed to replace gills. In late August to mid September, froglets just over ½-inch long emerged from the pools, prepared for terrestrial life. These tiny creatures had to find their way to suitable sites where they would join juvenile and adult frogs in a hibernation that lasted until May.

It took years of growing for the frogs of the Lodge Creek area to reach their adult size. Turner determined that males probably bred for the first time when they were four years old, while females first attempted to reproduce when they were five or six years old. Like many other

ectothermic ("cold-blooded") animals, the frogs continued growing after reaching maturity, but very slowly. Females eventually outgrew the males, attaining a length of almost three inches (measured from tip of the snout to end of the backbone) and weighing up to 2.6 oz. Males grew to less than 2½ inches long and about 1 oz in weight. Based on growth rates, Turner estimated that males lived as long as 10 years, and females 12 to 13 years. These characteristics turned out to be distinctive: a later study in British Columbia revealed that spotted frogs living near sea level matured in two years and seldom lived beyond three or four years. For spotted frogs, Yellowstone's winters translate into long lives! Although many Yellowstone predators, including trout, garter snakes, bears, mink, coyotes, cranes and herons, ravens, hawks, and even owls consume frogs or tadpoles, in the Lake Lodge area Turner found a "fortuitous absence of predators."

Some of Turner's most valuable discoveries related to the length, timing, and patterns of movements exhibited by the frogs. In spring, frogs migrated from overwintering zones along Lodge Creek and its headwater springs. Adult frogs ready to breed traveled to pools in the forest and meadow, covering 600–1,400 feet in a few days time, even when the ground was still partially covered by snow. Some non-breeding and juvenile frogs also migrated, probably somewhat later in spring. They moved to wet or moist meadows, ephemeral pools and streams, and small seeps or puddles in the forest or forest clearings. As upland areas dried out in mid or late summer, all frogs migrated back to permanent water sources provided by Lodge Creek and its springs in preparation for winter.

Some frogs in Turner's sampled population used the same areas at the same time each year, showing strong site fidelity. Others appeared to follow such a pattern for a year or two, and then suddenly shifted to another area. Some frogs apparently stayed within a few feet of the wintering site while others traversed the study area, reaching habitat zones separated by 2,000 feet of straight-line distance in a single summer. Turner defined "activity ranges" (similar to a home range, but including seasonal movements) for 86 frogs, based on the area outlined by five or more captures of the same frog at different periods of the summer. These activity ranges varied greatly in size, from 2,500 to 36,000 square feet. The variation in size of activity range was not related to sex or age class; it varied according to the portion of the study area where the frog lived and in the relative proximity of breeding, foraging, and wintering habitat components.

Turner's findings were very important to the study of natural amphibian populations. In addition to providing rich details about life history of spotted frogs, his work revealed the complexity underlying the relationship of frog populations to the physical setting. Like much larger animals but at a different scale, frogs roamed the landscape, seeking out different habitats in different seasons, displaying a set of patterns within the population as well as considerable individual variation. Turner earned a Ph.D. for this work in 1957 and published his manuscript on the Lake Lodge spotted frog population in 1960. Engaged in teaching and herpetological research in California and Nevada, Turner ended his studies in Yellowstone.

Return to Yellowstone

Fred Turner returned to his study area in 1991, at the request of herpetologists Chuck Peterson (Idaho State University), Ted Koch (U.S. Fish and Wildlife Service), and Steve Corn (Biological Resource Division of the U.S. Geological Survey). In the light of known and suspected amphibian population declines around the world in the 1970–80s, Turner's study acquired a new and pressing relevance. Many researchers were finding that frogs were missing from places where they had formerly flourished. Would Turner find this as well?

Turner's first impression was one of great surprise, as he struggled to reconcile the landscape with his memories of 40 years ago (Fig. 2). In the intervening years, a new road had been constructed and now cut directly across Turner's former study area. The cabin where he had spent the summers was gone without a trace. The northern edge of the meadow was rimmed by new housing and maintenance buildings. At Lodge Creek's headwaters, the wetland had almost disappeared behind a screen of encroaching lodgepole pines (Fig. 3). The former wet-

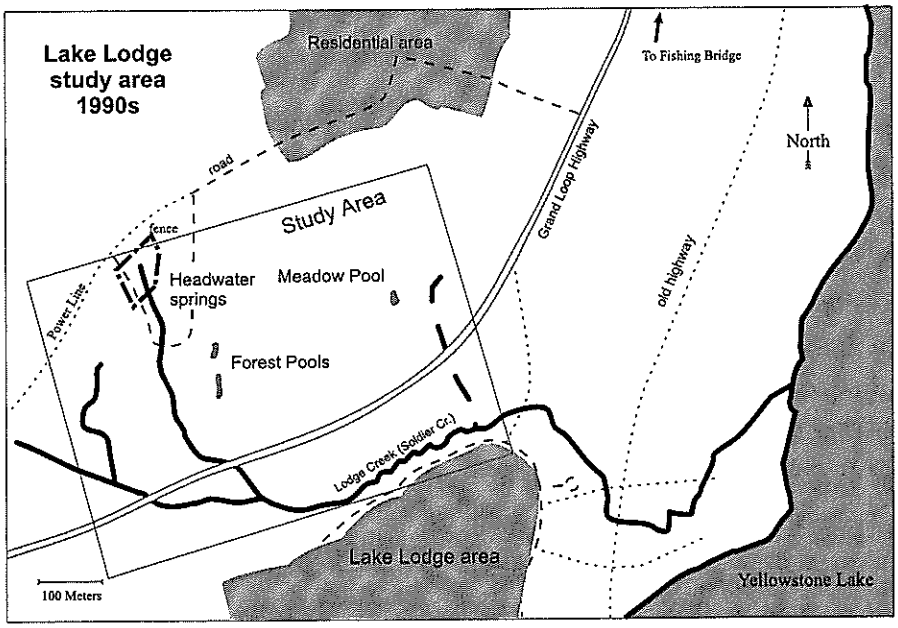
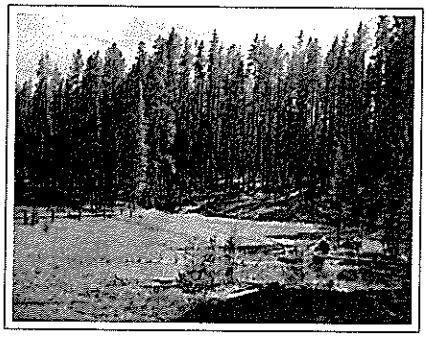


Figure 2. The Lake Lodge study area in the 1990s. The Grand Loop Road has been shifted to the west, and a water pumping system for Lake Lodge developments has been installed at the headwater springs of the east fork of Lodge Creek [formerly Soldier Creek].



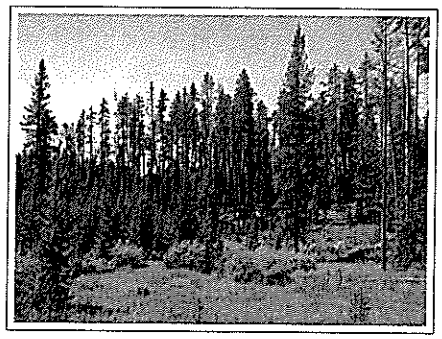


Figure 3. Far left: Lodge Creek's headwater springs in 1955 (Photo by F.B. Turner). Near left: The headwater springs in 1993. The area was developed for water extraction in the 1980s.

Figure 4. Far left: A pool in the forest east of upper Lodge Creek used by spotted frogs for breeding. Photo taken in 1955 by F.B. Turner. Near left: Turner in 1991 at the same forest pool. Spotted frogs still use this pool for breeding.

land area was penetrated by a road and encircled by a tall chain-link fence. Nevertheless, Lodge Creek still followed approximately the same course to Yellowstone Lake. The pools that had been used by frogs in the meadow and the forest were still there, too (Fig. 4).

And the spotted frogs? Yes, still there! There were tadpoles in the pools and adult frogs along streams and springs, but in nowhere near the abundance that Turner recalled. Was this an accurate impression? Had the frog population truly declined? And if so, why?

Retracing Turner's Steps

To answer these questions, in 1993 we began a study replicating Turner's work. Employing the methodology used by Turner, we caught, measured, and marked frogs, and mapped their locations and movements; we observed frog breeding, tadpole development, and seasonal shifts of the population. Taking advantage of modern technology, we also radiotracked the movements of some adult frogs through the use of miniature transmitters. At the end of three summers, we compared the data sets from the years 1953–55 and 1993–95. Employing computers to sort and analyze data and a geographical information system to map the area, we came to deeply appreciate the labor of Turner's original work, accomplished with few of the tools available today.

The new data indicated that the spotted frog population had indeed declined substantially. The numbers dropped from an estimated 1,200–1,850 frogs in the 1950s to about 225–400 frogs in the 1990s, based on mark-recapture population estimates for both data sets. Reproductive effort also dropped drastically, judging by the numbers of egg clusters (Fig. 5). Comparing the years 1955 and 1995, the number of egg clusters dropped from 62 to 4, a decline of 94 percent. Because female spotted frogs probably lay a single clutch every two to three years, the numbers of egg clusters indicates the number of breeding females in any given year and can be used to extrapolate roughly the number of adult females in the population. In the 1990s, with the number of egg clusters averaging about eight, the reproductive female population size was probably fewer than 25 frogs.

Reproductive success and recruitment were very poor in the 1990s, despite a variety of weather conditions. After the formal study ended in 1995, we continued monitoring and found that the population contained almost no juvenile frogs from 1995 to 1997. The future of this

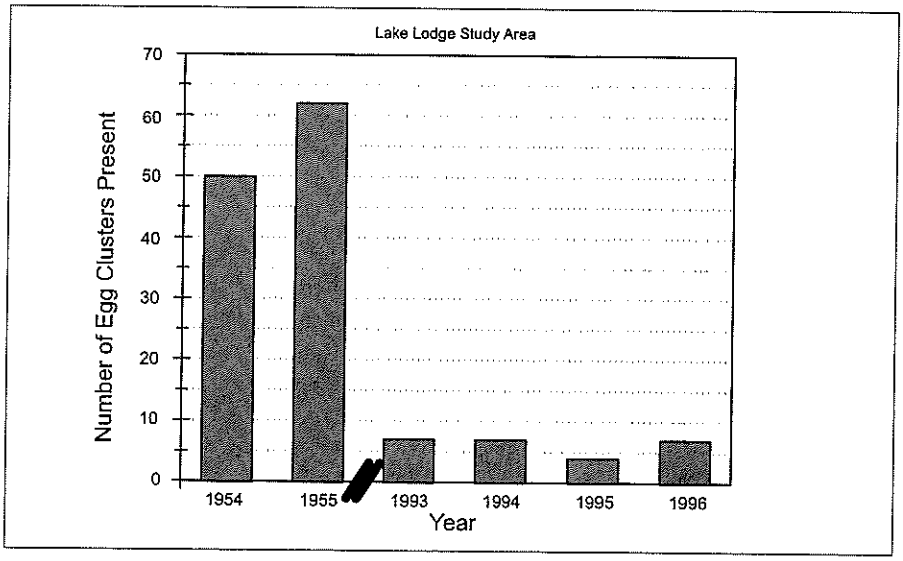
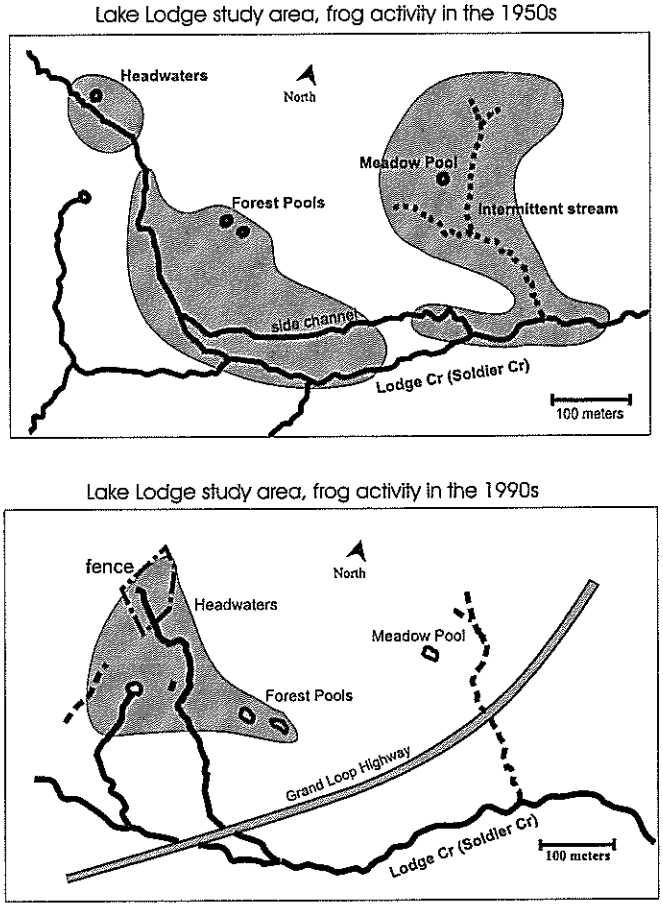


Figure 5. The number of egg clusters in the 1950s far exceeded that in the 1990s.

population looked bleak. Rescue apparently arrived with the wet and relatively warm summer of 1997. Large numbers of tadpoles occupied the forest pool, with plenty of water to last through metamorphosis. To our great delight, it looked as though the population had an excellent chance of staging at least a limited recovery. Our one concern was that the metamorphosing and newly transformed frogs would suffer high mortality from trampling if the horses in the surrounding pasture came to graze or drink at the critical time. We turned to Lake Resource Manager Dan Reinhart, who had been an invaluable source of advice and assistance throughout the research project. Dan responded immediately, and by mid-July the frog nursery was safely behind a simple post-and-cable barrier. Happily, there followed the successful transformation and survival of a bumper crop of spotted frogs. Scores of froglets found their way to the old wintering areas at the spring and survived their first winter; the "class of 1997" was abundantly evident around Lodge Creek headwaters in the summer of 1998.

Despite this good news, a recovery to population levels of the early 1990s is probably the most we can expect. Changes in the Lodge Creek area, including the loss of the important headwater spring breeding area and the apparent abandonment of the meadow pool, indicate that recovery to the robust levels of the 1950s is highly unlikely.



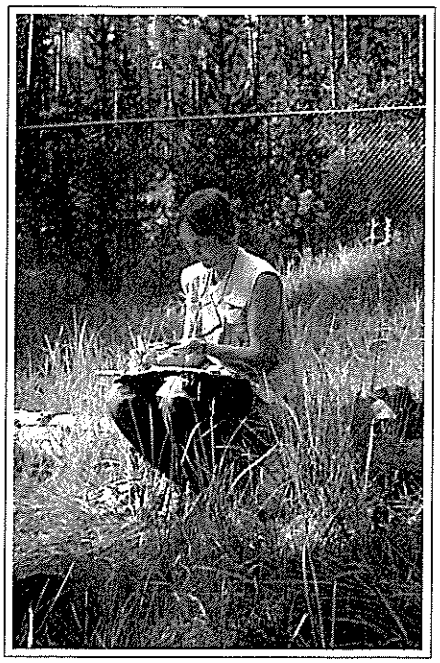
Figures 6 and 7. In the 1950s, frog activities centered on three main areas (indicated with shading), each including breeding, foraging, and wintering habitat. In the 1990s, most frog activity was limited to one main area.

What Happened at Lake Lodge?

A data gap of 40 years is a discouraging obstacle, and from the first we realized that identifying the precise cause of the population decline was not possible. Nevertheless, detailed knowledge of conditions and habitat use patterns preceding the substantial decline provided an extraordinary advantage compared to information available about most other suspected amphibian population declines. Nearly all historical data about amphibian populations are strictly limited to observations at breeding sites, which reflect only a portion of the population and a short part of the lives of individuals. We searched for clues about what happened at Lodge Creek by examining spatial relationships of the frog populations in the 1950s and the 1990s, comparing distribution and movement patterns.

In the 1990s, there were fewer frogs nearly everywhere in the study area, but the population also was more clumped, with most of the frogs occupying one portion of the study area and only minimally present at, or absent from others. The findings seemed paradoxical at first. The majority of frogs in the 1990s were clustered in the most obviously disturbed area, around the headwater springs where the underwater pumping system installed in the 1980s had led to diminished wetlands and surface water. The situation became clearer as we realized that the former Lodge Creek "population" could be understood as consisting of three overlapping subgroups (Fig. 6), each including the three basics of spotted frog habitat: breeding, summer foraging, and overwintering. In the years between the two study periods, these three subgroups had apparently combined into one, in the upper reaches of Lodge Creek (Fig. 7). The change in distribution represented a spatial retreat from former strongholds of the population along Lodge Creek and in the eastern meadow. The annual pulse of frogs dispersing into the meadow and back again to Lodge Creek that had attracted Turner's attention in 1953 was reduced to a trickle.

The reconfiguration of occupied frog habitat probably relates to habitat modifications and losses since the 1950s. First, the new road constructed in the 1970s likely presented a source of mortality and movement barrier for frogs trying to migrate between summer habitat in the meadow and overwintering sites along Lodge Creek. Second, installation of the elevated roadbed and culverts may have negatively affected foraging and wintering sites as well as up- and downstream



Debra Patla measuring a spotted frog at the Lake Lodge study area.

movements. Third, the water pumping system at the headwater spring may have changed the hydrology of Lodge Creek in unfavorable ways, such as reducing stream flow below critical levels during drought years, stranding and freezing frogs during their hibernation. Finally, the pumping reduced summer and winter habitat at the headwater spring and eliminated a pond that had provided an important breeding site.

Because of these changes, the frogs' remaining habitat use pattern involved breeding at the forest pools, foraging in areas upstream of the highway, and wintering in the springs at the head of Lodge Creek. Although feasible, this pattern represented a substantial loss in carrying capacity compared to the past, potentially explaining the decline in frog numbers.

Although it is difficult to assess the relative significance of these habitat changes along with other factors potentially contributing to a population decline, it seems clear that human-caused changes in the area over the past 40 years have had impacts on important habitat components. The story of the Lake Lodge frogs is a poignant example of the toll that expanding human development may take on populations of animals, even within the sanctuary of national parks.

Lessons From Lake Lodge

From this then-and-now study, we have learned several important lessons about amphibian conservation. First, populations must be viewed in the context of the local landscape, with each dependent on a complex set of spatial requirements. A pond, however rich in tadpoles and frogs, may be only one portion of the set of features and conditions that enable a population to persist. Wintering and foraging areas and migration routes must also be adequate. A diversity and redundancy of habitat features enables the population to survive variable weather and changing environmental conditions.

Second, finding amphibians in disturbed areas does not necessarily indicate that the animals "like" the new conditions, or that they are highly tolerant of disturbance. Exhibiting the site fidelity that has been noted in many amphibian species, a few survivors may remain faithful to established patterns of habitat use. (One study found that frogs kept returning each spring to the parking lot that had replaced their breeding pool, and they were still coming back five years after the pool was gone.) It can be very difficult for human observers to envision former conditions and habitat use patterns after topography and vegetation have been altered.

Related to this idea is the realization of how limited we are in judging amphibian abundance in the absence of historical information. If Turner's study had never taken place, we would perceive the Lake Lodge area to be a fairly good place for frogs, supporting consistent breeding and reliably providing us with observations during monitoring visits. Knowing that this is in fact a relict or "ghost" population in terms of its past abundance has disturbing implications for our ability to recognize amphibian declines in areas without previous records.

Another lesson is that development has costs that are not usually considered. Even though developed areas in national parks are limited in number, their expansion and zones of influence may affect resident wildlife, including entire populations with long local histories and unique characteristics. For how many decades or even centuries did spotted frogs migrate across the area now divided by a busy road? If the Lake Lodge population disappears entirely, who knows what has been lost in terms of genetics and ecology? While Yellowstone and other parks have made large advances in planning and seeking to minimize the negative effects of development, the fact remains that very little is known about the many areas that are altered by road expansion, construction of new facilities, changes in human use, or restoration projects. This is particularly true because development often proceeds in bit-by-bit fashion with no single project appearing to be very important. Cumulative effects may eventually become obvious, but only if memories or written records persist.

Finally, a lesson important to share with fellow scientists: keep those field notes! Archive *all* your raw data in a safe place where future investigators can find them. Our study replicating Turner's work would have been impossible without access to his detailed notes.

The Status of Yellowstone Amphibians

From Turner's field notes we learned that boreal toads and boreal chorus frogs, as well as spotted frogs, have apparently declined in the Lodge Creek study area since the 1950s. Is this distressing situation representative of Yellowstone National Park? Have spotted frogs and other species declined, even in non-developed areas? Are declines occurring now?

Like other researchers, we find questions about abundance and trends the most difficult to answer. Even in America's oldest and most celebrated national park, information about species occurrence, distribution, and abundance is scarce. With regard to amphibians, Yellowstone's historical information consists of a spotty collection of opportunistic sighting records and Turner's work of the 1950s.

More survey and research of Yellowstone amphibians has been conducted in the past few years than in the whole history of the park. This work reflects increased levels of concern about amphibians both inside and outside the