Yellowstone Science

A quarterly publication devoted to the natural and cultural resources

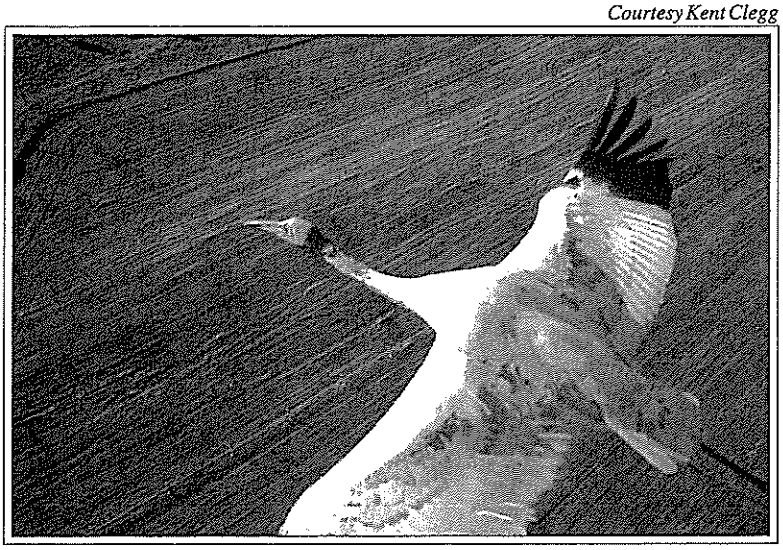
What's Up With Whooping Cranes

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....

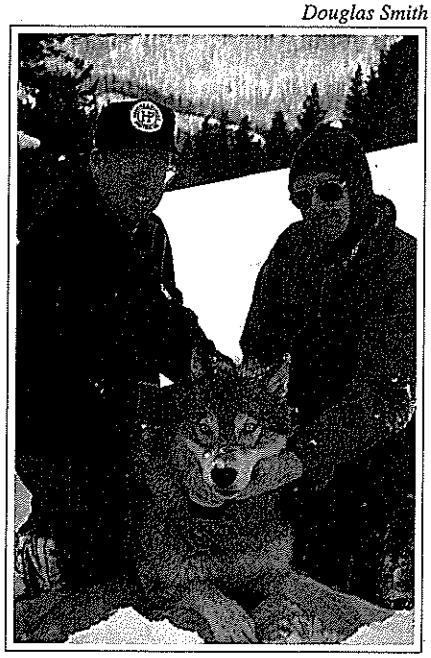
Readers, what potential gems are deep in *your* winter stores? SCM

Yellowstone Science

A quarterly publication devoted to the natural and cultural resources

Volume 7 Number 1 Winter 1999

Table of Contents



Douglas Smith

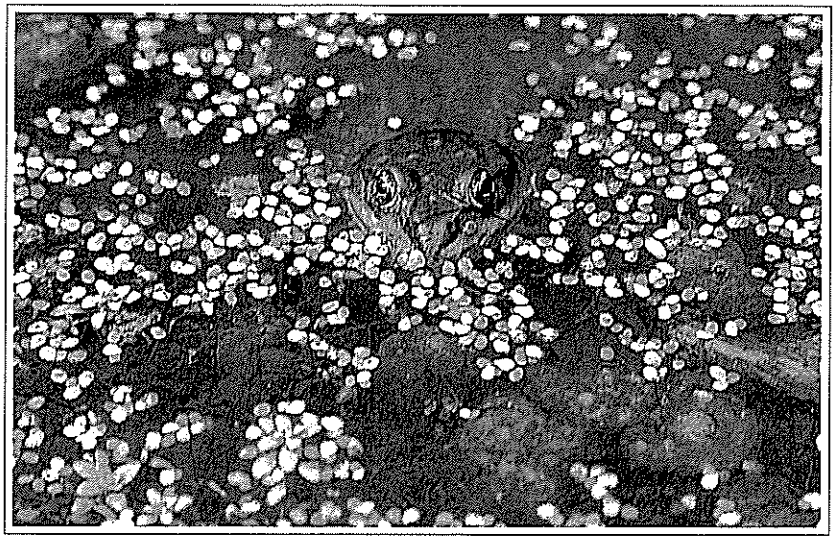
Editor
Sue Consolo-Murphy
Associate & Design Editor
Sarah Broadbent
Assistant Editor
Tami Blackford
Assistant Editor
Renée Evanoff
Printing
Artcraft Inc.
Bozeman, Montana

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.

Yellowstone Science is published quarterly, and submissions are welcome from all investigators conducting formal research in the Yellowstone area. Correspondence should be sent to the Editor, *Yellowstone Science*, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, WY 82190.
The opinions expressed in *Yellowstone Science* are the authors' and may not reflect either National Park Service policy or the views of the Yellowstone Center for Resources.

Support for *Yellowstone Science* is provided by the Yellowstone Association for Natural Science, History & Education, a non-profit educational organization dedicated to serving the park and its visitors. For more information about the Yellowstone Association, including membership, write to P.O. Box 117, Yellowstone National Park, WY 82190.
Yellowstone Science is printed on recycled paper with a linseed oil-based ink.

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.

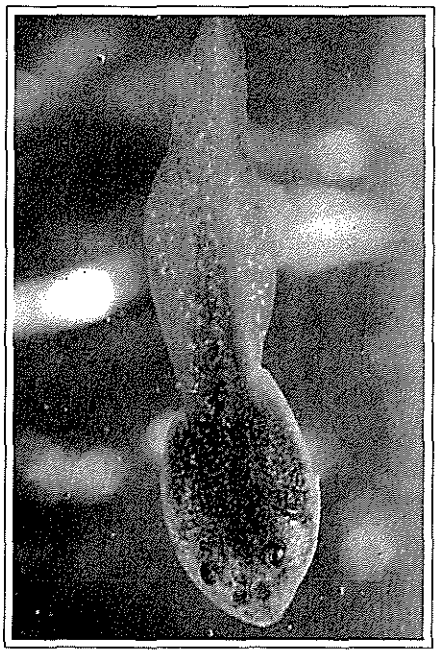
How are the amphibians of Yellowstone faring? The work of past and current researchers and many observers indicates that along with some good news there are also reasons for concern and many unanswered questions.

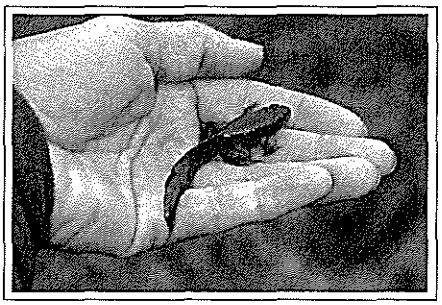
Early Investigations

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





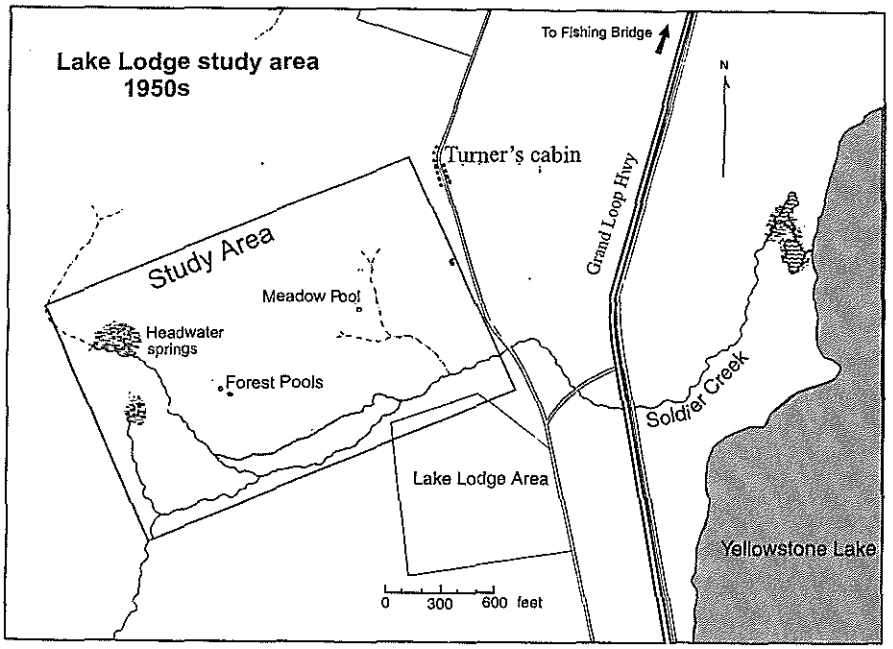


Figure 1. (Map) Turner's spotted frog study area in the 1950s, less than one mile south of Fishing Bridge junction. Far left: Columbia spotted frog (Rana luteiventris). *Above left: Tadpole. Just after hatching, tadpoles are dark in color. Older tadpoles are brownish-green with gold flecks or speckles. 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 1/2-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-

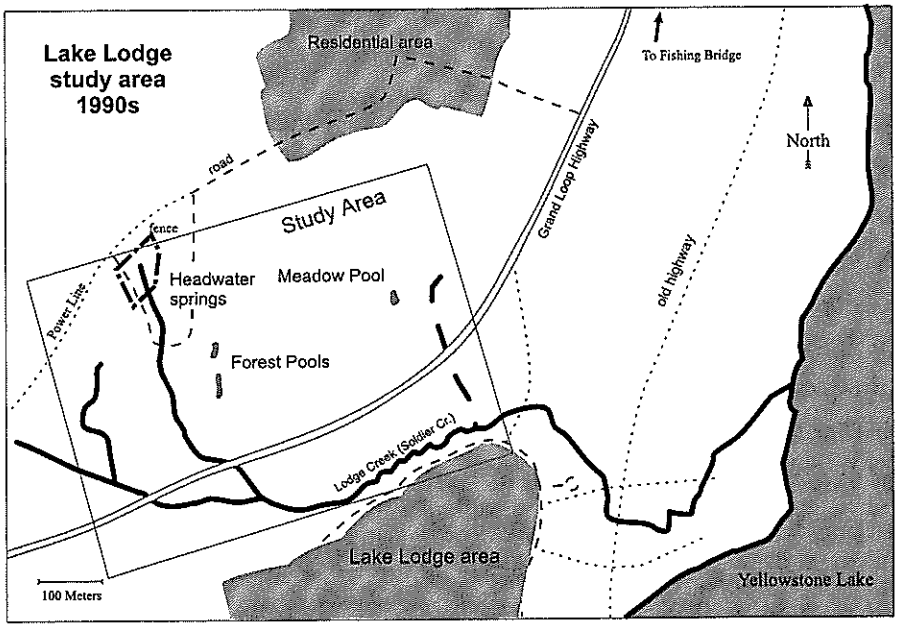


Figure 2. The Lake Lodge study area in the 1990s. The Grand Loop Road has been shifted to the west, and a water pumping system for Lake Lodge developments has been installed at the headwater springs of the east fork of Lodge Creek [formerly Soldier Creek].

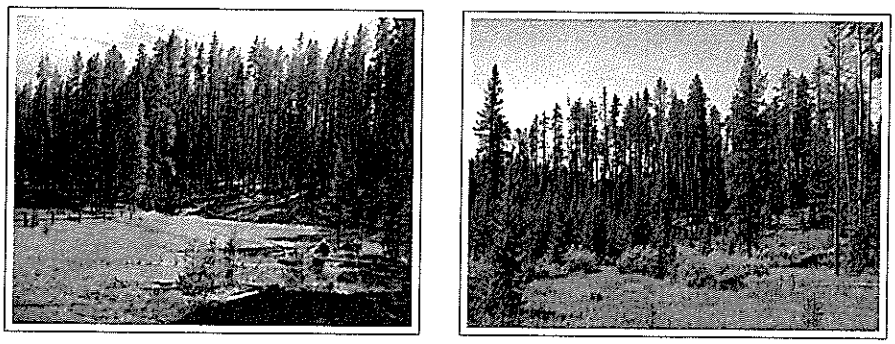


Figure 3. Far left: Lodge Creek's headwater springs in 1955 (Photo by F.B. Turner). Near left: The headwater springs in 1993. The area was developed for water extraction in the 1980s.

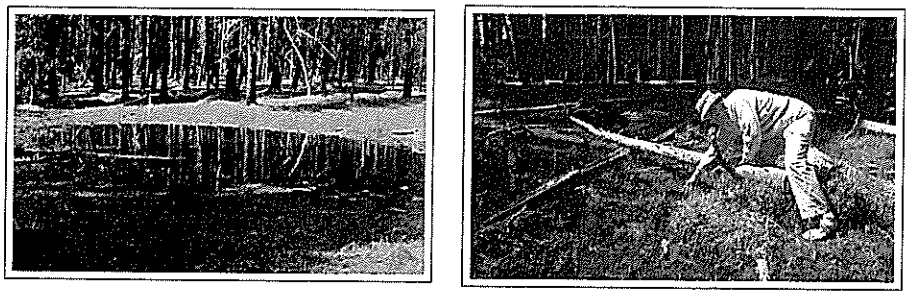


Figure 4. Far left: A pool in the forest east of upper Lodge Creek used by spotted frogs for breeding. Photo taken in 1955 by F.B. Turner. Near left: Turner in 1991 at the same forest pool. Spotted frogs still use this pool for breeding.

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

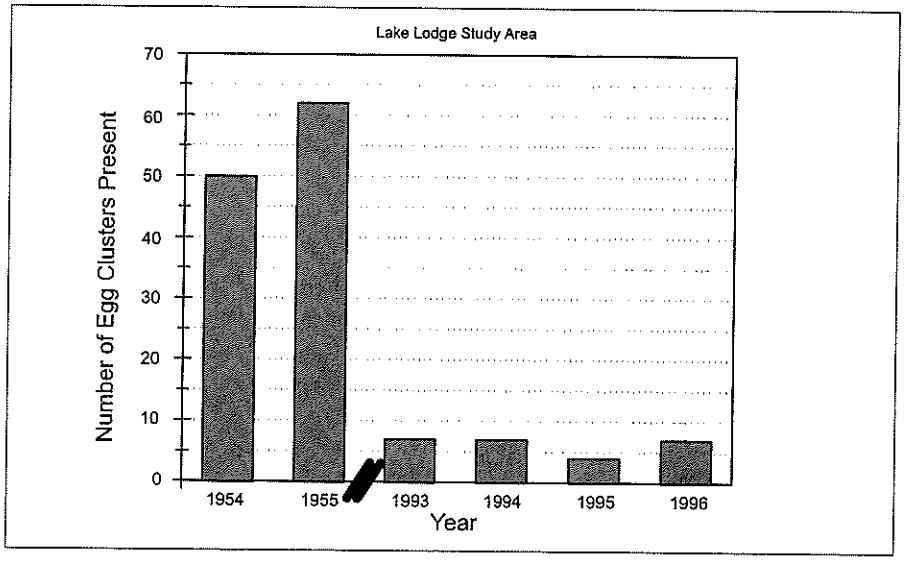
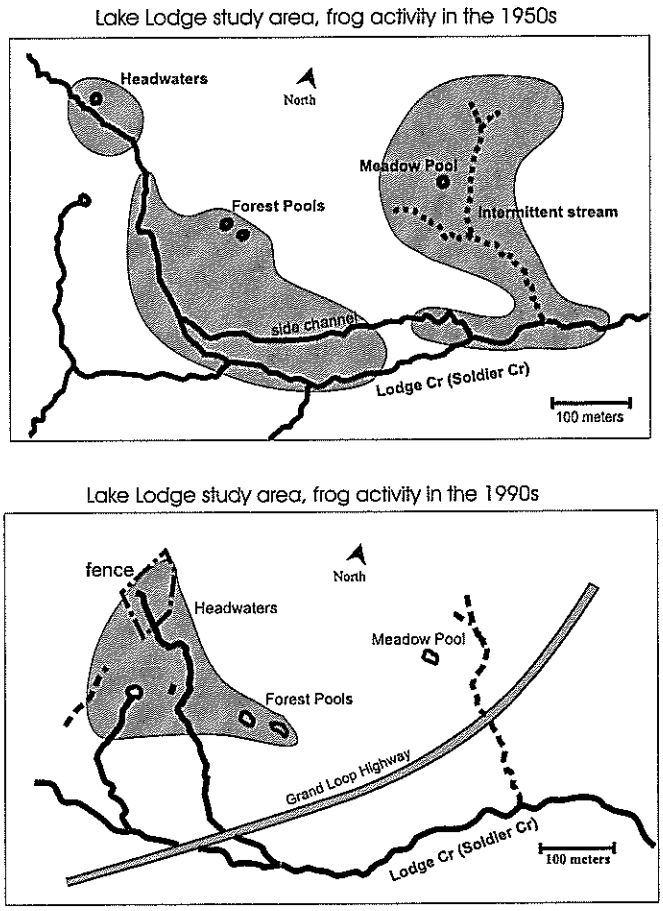


Figure 5. The number of egg clusters in the 1950s far exceeded that in the 1990s.

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.



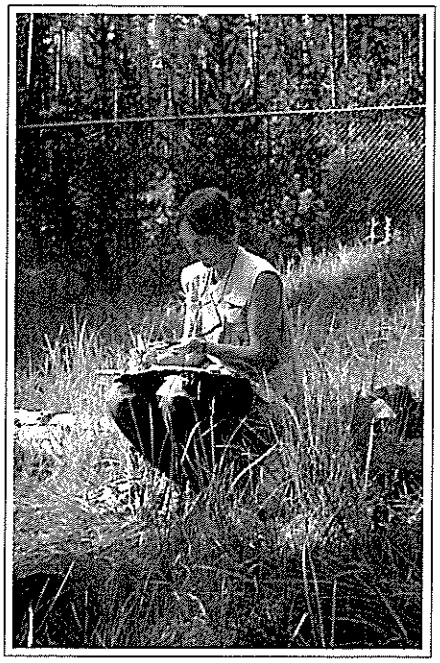
Figures 6 and 7. In the 1950s, frog activities centered on three main areas (indicated with shading), each including breeding, foraging, and wintering habitat. In the 1990s, most frog activity was limited to one main area.

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

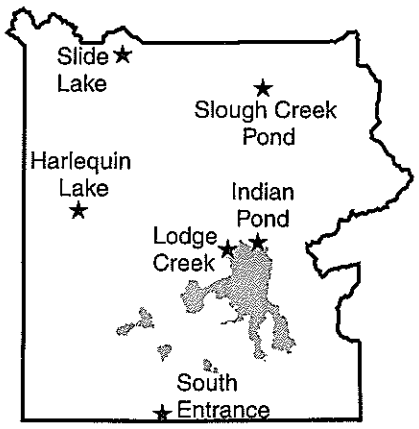
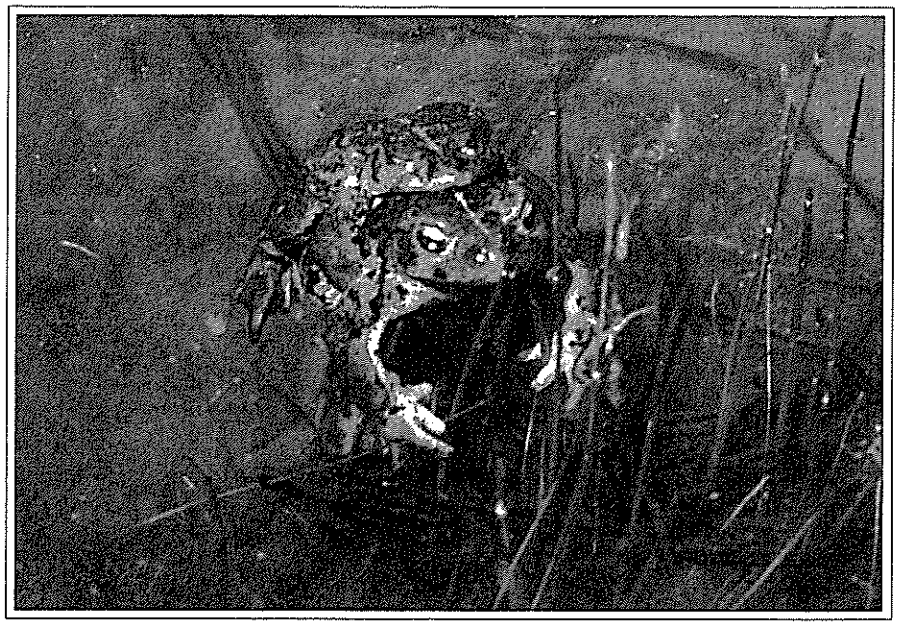


Figure 8. Six breeding sites monitored since 1991. Each site hosts two to four amphibian species.



*Boreal toad (*Bufo boreas boreas*), subspecies of the western toad. Bumpy skin with large elongated glands behind the eyes, stocky body, short legs, blunt head, size ranges from 0.5 to 5 inches long. Olive-green, brown, or gray or brown, usually with a light stripe through the middle of the back. Distinctive musky odor. Males have a dark thickened area on the upper surface of the thumbs. Calling during breeding or when handled is a soft, birdlike chirping, produced intermittently and irregularly. Breeds in Yellowstone in shallow areas of ponds, lakes, river backwater channels, and slow streams, often in water with a mild thermal influence and almost always with relatively high conductivity and high pH. Toad skin is toxic but ravens have learned how to kill toads and consume only their insides. Adults range widely across meadows and forests and overwinter in burrows or cavities.*

park. In 1991, moved into action by reports of amphibian declines from numerous colleagues, I (Charles Peterson) collaborated with Koch and Corn to initiate investigations of the status of Yellowstone amphibians.

Our first task was to refer to a database, compiled by Koch while a student at Idaho State University (ISU), which includes all known records for amphibians in the greater Yellowstone ecosystem: museum records, field observations from scientific literature and unpublished studies, and sighting records from the park and other sources. From the database, and with the help of Yellowstone resource managers, we selected six amphibian breeding sites in the park where amphibians still existed for a pilot monitoring program (Fig. 8). Since 1991, these have been surveyed three or more times per year to record species occurrence, to observe life history characteristics, and to learn about annual variation in reproduction.

A number of other amphibian projects have taken place in the past few years. Since 1993, the Herpetology Laboratory of ISU has conducted surveys and reported amphibian and reptile occurrence in several areas where management activities were planned, including roadside zones along 95 miles of park roads slated for widening and possible realignment. Steve Hill and Robert Moore of Montana State University (MSU) surveyed many ponds for amphibians in Yellowstone's northern range in 1993. Hill also conducted research for his M.S. degree on the population ecology and natural history of tiger salamanders at Ice Lake. In 1995, *Amphibians and Reptiles of Yellowstone and Grand Teton Parks* was published, providing a field guide for amphibians in all their life stages as well as a summary of information from previous studies. Through a volunteer-based backcountry amphibian atlas project started in 1997, we are beginning to document amphibian occurrence in remote areas of the park where no one has previously looked for amphibians or reptiles. ISU graduate student Jeremy Hawk is investigating relationships among disease-causing bacteria and water chemistry at boreal toad breeding sites. Wendy Roberts, a researcher at MSU, is investigating how tadpoles may influence the productivity and structure of pond ecosystems.

From these various studies and efforts, we have learned much about the natural history, habitat associations, distribution, and status of Yellowstone's native amphibians. The good news is that three species appear to be widespread and locally common to abundant (Fig. 9). Boreal chorus frogs loudly announce their existence in May and June at many park wetlands, and we frequently find their tadpoles. Columbia spotted frogs in all their life stages are often encountered during surveys as well as by hikers, and they are probably the park's most abundant amphibian. The blotched tiger salamander appears to have a rather spotty distribution, but is very common in the pothole lakes of the northern range. Although historical and recent records for salamanders are much fewer than those for chorus frogs and spotted frogs, this is likely influenced by the relative difficulty of finding them. Adult salamanders spend most of their time underground, and their larvae are often concealed in

aquatic vegetation.

The news is less rosy for another amphibian. Boreal toads are widespread in distribution across the ecosystem but relatively rare in most areas. While metamorphosing toads are abundant at a few breeding sites such as the one near Yellowstone's South Entrance, our surveys have turned up few new breeding sites. Amphibian surveyors infrequently encounter adult and juvenile toads. The scarcity of toads appears to be a significant change from the past. Forty years ago, Fred Turner and Charles Carpenter, researching in Yellowstone and Grand Teton respectively, both characterized toads as common. Although the evidence for declines is largely anecdotal because quantitative historical data are lacking, toads appear to be substantially less widespread and abundant than they were formerly. Boreal toads (or closely related species) have suffered declines across the species' former range in the western United States. Populations in Colorado and southern Wyoming are candidates for listing under the Endangered Species Act. The reasons for the widespread decline of toads are not understood; no single cause capable of explaining the declines has been identified.

There are rare records in the ecosystem of two other species, the northern leopard frog and the spadefoot "toad" (which is toad-like but not a true toad). Leopard frogs have never been documented in Yellowstone, but they are rarely seen in Grand Teton National Park and breeding populations were recorded there in the 1950s. Just two records exist for spadefoots in Yellowstone; one of these is from 1889. So much of Yellowstone remains to be surveyed for amphibians that finding unlikely and unexpected species still exists as a tantalizing possibility. The discovery of one particular amphibian here, however, would not be received as good news. Bullfrogs have been introduced in many areas of the western United States, with very negative consequences for the native amphibians on which they prey.

Declining Amphibians?

The number and distribution of chorus frog and spotted frog observations are initially reassuring but tell us little about possible trends. Recalling our experience at Lodge Creek where historical quantitative data fortunately exist, is it possible that significant reductions in population sizes have occurred but we can't perceive them? Given that nearly every species of the genus *Rana* in western North America has experienced local or regional declines in recent years, what if spotted frogs are just starting to decline here in Yellowstone? How long would it take to notice such a decline? How serious is the suspected decline of boreal toads in greater Yellowstone, and is the decline intensifying?

Answering these questions is important for Yellowstone National Park and also may be essential to understanding the causes of declines and their relative importance elsewhere. After nearly a decade of investigations, it appears that multiple causes are at work—there is not likely to be a primary cause, as was the case with declining raptorial birds and the pesticide DDT. Several hypotheses for amphibian declines are on the table, including: increased mortality from excessive ultraviolet radiation due to ozone thinning; diseases and immune system failures; climate change affecting critical aspects of breeding and larval development; widespread effects of pesticides and other chemicals; and unnatural levels of predation or other problems resulting from introduced animals such as nonnative trout and bullfrogs. Identifying the locations and rates of amphibian population decline would help clarify the relative importance of these potential causes and may lead to the identification of new hypotheses, perhaps even to finding an unexpected primary cause.

Amphibian populations are notorious for their fluctuations, making the determination of trends dauntingly difficult. Researchers have variously reported that 20 to 100 years of monitoring reproduction might be necessary to understand whether a particular population is truly declining. Recapture rates have to be quite high to produce population estimates that are accurate enough to make useful comparisons. There are seldom enough resources to monitor an area with

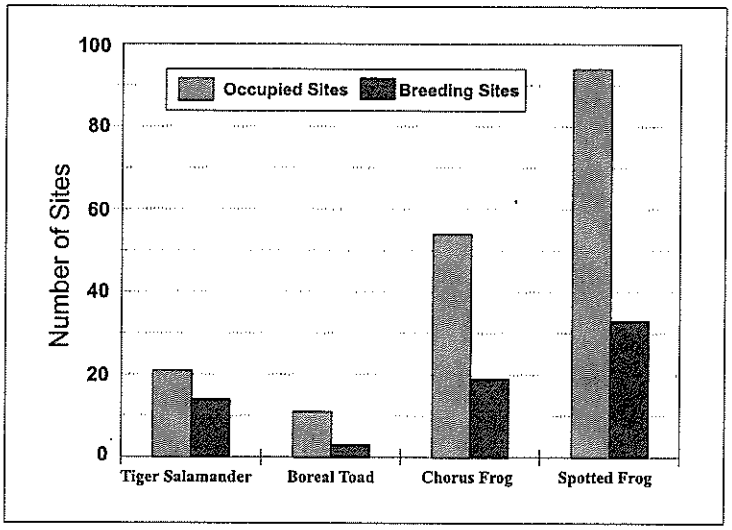


Figure 9. Number of occupied and confirmed breeding sites located during surveys for amphibians and reptiles along 95 miles of Yellowstone National Park roads, including the sections Tower to Northeast Entrance, Tower to Canyon, Mammoth to Madison, Madison to Biscuit Basin, and Arnica Creek to Little Thumb Creek.

Blotched tiger salamander (Ambystoma tigrinum melanostictum).

the detailed approach applied at the Lake Lodge study area, where we studied a population throughout the active season across its range. In addition, the handling and marking of many individuals entails some risk to the health of amphibian populations.

Recommendations for Studying and Conserving Yellowstone's Amphibians

Grappling with these questions, and with a sense of urgency inspired by documented amphibian declines elsewhere, we think that there are four main tasks on which to concentrate. First, systematic amphibian surveys of the park and adjacent public lands are needed. These should include revisiting all sites with historical records and systematic sampling of representative areas on a sub-watershed basis. From such surveys, we can determine if changes in distribution have occurred, map current species distributions, determine if there are areas where amphibians are scarce or missing, and better define habitat associations.

Second, we need to expand monitoring efforts. The past eight years of monitoring six Yellowstone sites have been very valuable for learning about monitoring techniques, variability in observation rates, and many aspects of Yellowstone amphibian life histories. We are currently analyzing the data for specific information about possible changes or trends in relative abundance. But to understand if amphibians are declining or not in the park, the number of monitored areas needs to be larger, probably on the order of 20 to 40 sites chosen randomly from a variety of suitable and marginal habitats. Rather than focusing on single breeding sites, monitoring should encompass complexes of potential habitat, thus allowing for spatial shifts in breeding sites that may occur when environmental conditions change. The target of this kind of monitoring is species presence, reproduction, and recruitment (survival of the young as evidenced by the presence of juveniles). With a sufficient number of well-distributed monitoring areas, we would be able to perceive if populations are disappearing or increasing in number, providing the basis for recognizing park-wide trends in amphibian abundance.

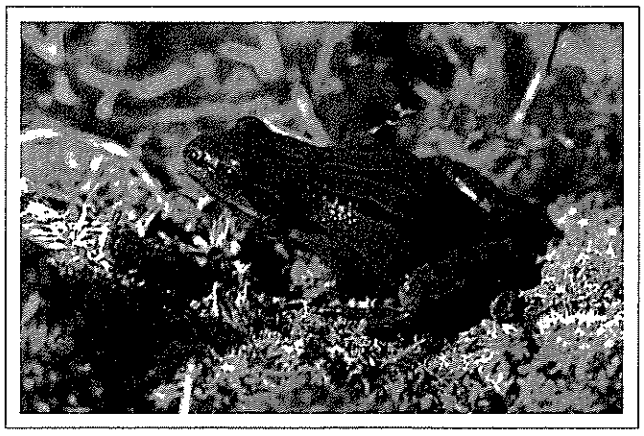
A third emphasis of amphibian conservation should be to track the fate of populations in areas where management issues exist—such as in the vicinity of the park's developed areas, near roadside ponds and sewage treatment areas where exposure to pollutants is possible, and during habitat or wildlife restoration projects involving wetland and aquatic areas. Surveys and monitoring should be conducted before, during, and after management actions that may affect amphibian populations. Concern for and awareness of amphibians is higher now in Yellowstone than ever before, and sincere attempts have been made to obtain information and incorporate it in planning. If combined with follow-up monitoring and the application of lessons from one project to another, this adaptive management approach could contribute significantly to the conservation of amphibians and their environments (including other animals). Insights garnered from successes as well as failures could be useful far beyond Yellowstone's borders.

Finally, the number and scope of natural history studies and research projects should expand. Recent advances in genetics, microbiology, amphibian diseases, and population biology are providing tools that can greatly advance the understanding of amphibians in their natural environments.

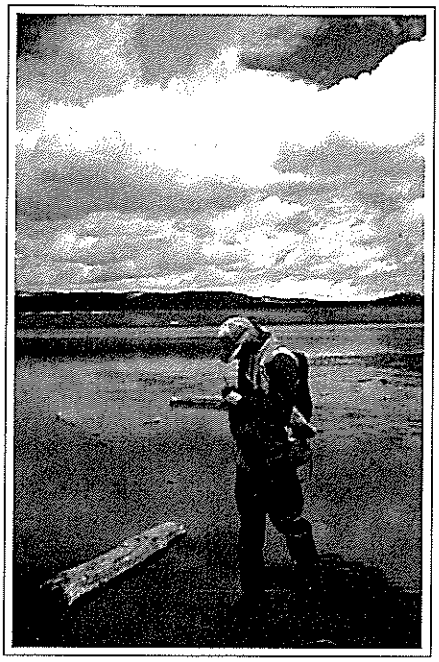
Amphibians in the Yellowstone Landscape

Among Yellowstone's assortment of magnificent mammals and birds, amphibians are admittedly easy to overlook—few tourists ask where they can see a spotted frog or listen to chorus frogs! Nevertheless, when you investigate wet and muddy areas at the right times, the park seems to pulse with amphibian life. A visit on a warm, early June evening to the mouth of Pelican Creek will astound you with a tremendous concert, produced by large numbers of Yellowstone's tiniest adult vertebrate, the boreal chorus frog. On a walk around a pond on a sunny July day, you may see scores of spotted frogs, flashing bright salmon color from the undersides of their hind legs as they leap into the water. When boreal toads metamorphose, the ground at some sites is literally blanketed by vigorous toadlets, barely the size of a fingernail. On rainy summer nights, some people have witnessed mass migrations of hundreds or thousands of tiger salamanders on the move from breeding pools.

What does this abundance of amphibian life mean for the Yellowstone ecosystem? Larval amphibians, which consume algae, detritus, and tiny invertebrates, exist in such large numbers in some ponds that they may alter the pond community structure. When they metamorphose and emerge from the ponds, amphibians provide one of the few biotic mechanisms for moving energy and nutrients from eutrophic water bodies to the terrestrial environment. Adult amphibians consume an enormous variety and amount of invertebrates (mainly insects) during the active season. In turn, larval and adult amphibians provide prey for a large array of animals, including aquatic predaceous insects, snakes, fish, birds, mammals, and other amphibians. Amphibian body



Boreal chorus frog (Pseudacris maculata).



Chuck Peterson monitoring spotted frogs and boreal toads at Indian Pond.

size, which is larger than most insects and smaller than most rodents, means that amphibians occupy an important link in the food chain. As ectotherms, amphibians are extraordinarily efficient in converting energy into biomass, which then becomes available to predators; in fact they are more than ten times more efficient than birds and mammals in converting the food they consume into growth.

The reported world-wide declines of amphibian populations is often portrayed as a symptom of declining environmental health, with alarming connotations for human health. But reductions in the diversity and abundance of amphibians also have grave implications and direct, immediate consequences for many other wildlife species. The "silence of the frogs" (a phrase coined by the *New York Times Magazine* in 1992) is a silence heavy with foreboding. May it not descend on Yellowstone.

It's Just a Frog...

"Kermit!" shouted a high childish voice, and we knew the roadside wetland we were scouting held at least one frog. A distant moose was instantly forgotten as the young tourist's family gathered around to share her delight in observing the tiny creature with the fearless wide-eyed gaze and mysterious powers of transformation.

Acknowledgments

The number of park personnel who have helped with amphibian studies is impressive—amphibians have more friends than expected! We especially thank those whose consistent support and interest has been the backbone of recent research and monitoring efforts: Stu Coleman, Craig McClure, Dave Price, Dan Reinhart, and John Varley. Reinhart's help was an essential ingredient in the Lake Lodge spotted frog project. Many Yellowstone people joined in field work or reported observations, including Roger Andrascik, Denise Culver, Karen Kitchen, Tom Oliff, Rick Swanker, Jim Sweaney, Jennifer Whipple, and McClure, Price, Reinhart and their staffs. Lee Whittlesey assisted in archival research. Mary Hektner, Beth Kaeding, Ann Rodman, and John Sacklin incorporated amphibians in planning and data compilations. We are grateful to those who facilitated permits, accommodations, and logistics, including Rene Farias, Bob Lindstrom, Terry McEneaney, and Jim Owen.

Ted Koch's inspired scholarship, field work, and infectious energy have been central to recent advances in understanding, conserving, and appreciating Yellowstone's amphibians. Paul Stephen Corn was instrumental in setting up initial investigations and has been a consistent source of assistance and information. Fred Turner, besides providing inspiration from his early work, made two trips to Yellowstone to advise us. We are indebted to our dedicated volunteers: especially Char and Dave Corkran, Marc Hanna, and Roger Harm. Merlin Hare provided invaluable assistance with computers, equipment, and graphics.

Funding for the Lake Lodge research and for monitoring and surveys was provided by the American Natural History Museum; IUCN/SSC Declining Amphibian Populations Task Force; Idaho State University; National Fish and Wildlife Foundation; Northwest Scientific Association; University of Wyoming National Park Service Research Center; and Yellowstone National Park.

Suggested Reading

Corn, P.S. 1994. What we know and don't know about amphibian declines in the West. Pages 59-67 *in* W.W. Covington and L.F. DeBano (coordinators). Sustainable ecological systems: implementing an ecological approach to land management. Fort Collins, Colo.: USDA Forest Service Rocky Mountain Forest and Range Exp. Sta. Gen. Tech. Rep. RM-247.

Koch, E.D. and C.R. Peterson. 1995. Amphibians and reptiles of Yellowstone and Grand Teton National Parks. Univ. of Utah Press. 188pp.

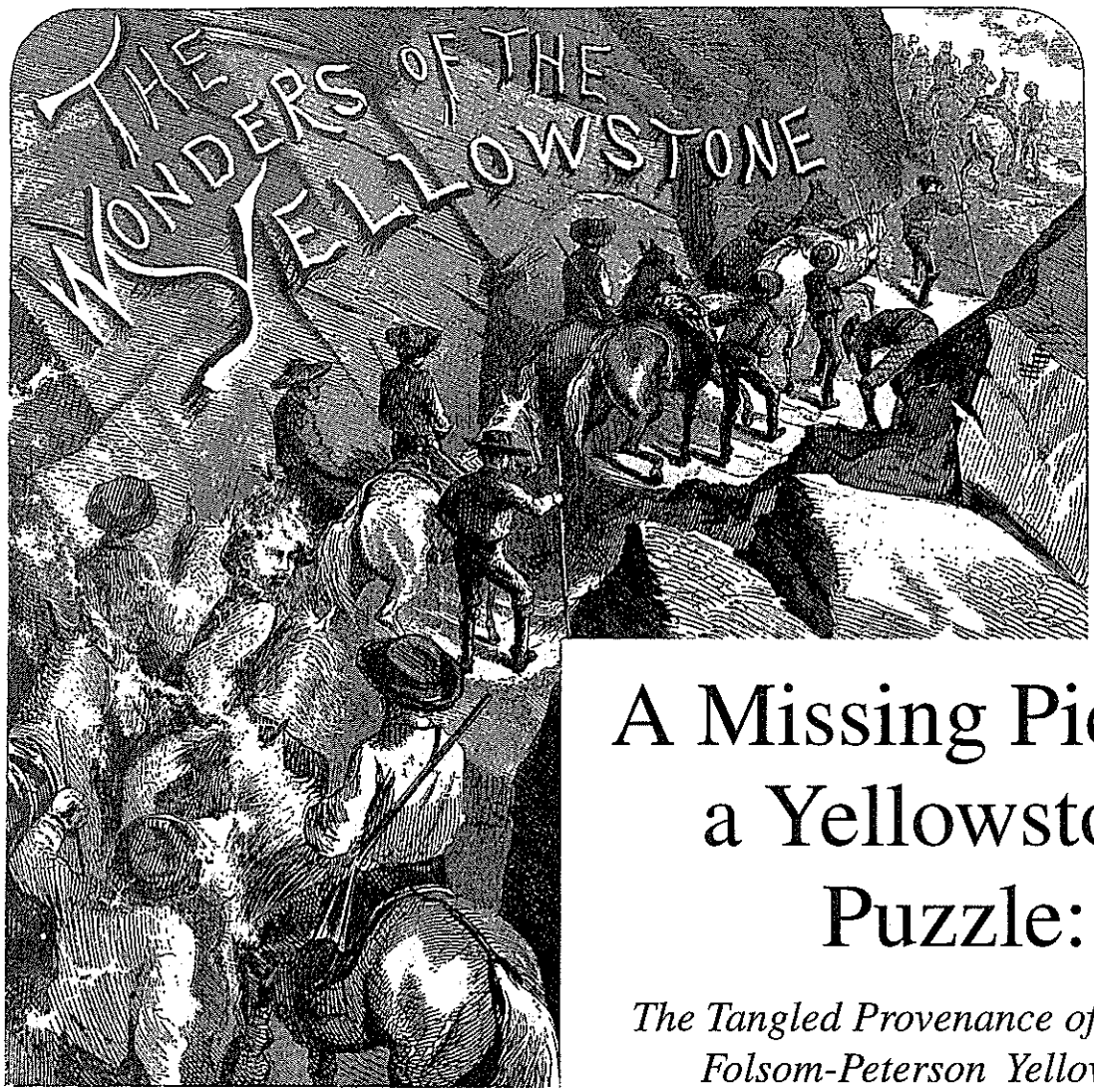
Licht, L.E. 1975. Comparative life history of the western spotted frog, *Rana pretiosa*, from low- and high-elevation populations. Can. J. Zool. 53(9):1254-1257.

Phillips, K. 1994. Tracking the vanishing frogs: an ecological mystery. Penguin Books, N.Y. 244pp.

Stebbins, R.C. and N.W. Cohen. 1995. A Natural History of Amphibians. Princeton Univ. Press. 316pp.

Turner, F.B. 1960. Population structure and dynamics of the western spotted frog, *Rana p. pretiosa*. Baird & Girard, in Yellowstone Park, Wyoming. Ecol. Monographs 30(3):251-278.

Debra Patla is a research associate of Idaho State University. She has been conducting amphibian research, surveys, and monitoring in greater Yellowstone since 1993, including completion of her M.S. research project on the Lake Lodge spotted frogs. Dr. Charles Peterson is professor of zoology in the Department of Biological Sciences at ISU. He also serves as curator of herpetology at the Idaho Museum of Natural History, Pocatello, and as a co-chair of the IUCN/SSC Declining Amphibian Populations Task Force for the Rocky Mountains. Chuck has been investigating amphibians and reptiles in the ecosystem for the past ten years. Debra and Chuck come to work unintentionally disguised as fishermen with waders, nets, and fishing vests, always ready for an impromptu discussion about amphibians with tourists who ask "How many did you catch?"



A Missing Piece of a Yellowstone Puzzle:

The Tangled Provenance of the Cook-Folsom-Peterson Yellowstone Expedition Diary

by Kim Allen Scott

The definitive exploration of Yellowstone National Park began in 1869 with the journey of three friends, Charles W. Cook, David E. Folsom, and William Peterson, who visited the region on their own to investigate its rumored wonders. Two subsequent expeditions in 1870 and 1871, undertaken with official government support, completed the scientific reconnaissance of Yellowstone and laid the foundation for its establishment as a national park in 1872. The men who participated in the latter two explorations had both the desire and the means to publicize their discovery narratives to a wide audience, but fire, neglect, and mishandling have all combined to somewhat obscure the record of the Cook-Folsom-Peterson journey.[1] This essay will attempt to unravel the complicated story of their expedition chronicle, identify what may very well be the earliest draft of the manuscript extant, and present for the first time a section from the draft that had been omitted when Cook attempted to reconstruct the original composition in 1922.

Folsom, an engineer employed by the mining hydraulic works at Diamond City, Montana, and his two friends, Cook and Peterson, began their exploration of Yellowstone on September 6, 1869. For the next four weeks they traversed the country, measuring the waterfall at the head of the Grand Canyon, visiting the northern shore of Yellowstone Lake, and lingering in the Lower Geyser Basin, all the while recording their observations in a memoranda book. Upon their return during the winter of 1869–70, Cook and Folsom apparently collaborated on preparing for publication a narrative from their diary. A writer named Clark, who had met Cook the previous year in Diamond City, requested a copy of their manuscript and permission to seek out a publisher. Cook mailed the article, but in spite of Clark's best efforts, several of the nation's leading magazines rejected the story, allegedly due to the skepticism of the editors over some of the phenomena

described.[2] Clark finally convinced the proprietors of the Western Monthly, a Chicago, Illinois, literary periodical, to accept the piece in the spring of 1870, but the resulting publication belies the allegations that eastern editors found the descriptions of the country too incredible to repeat.

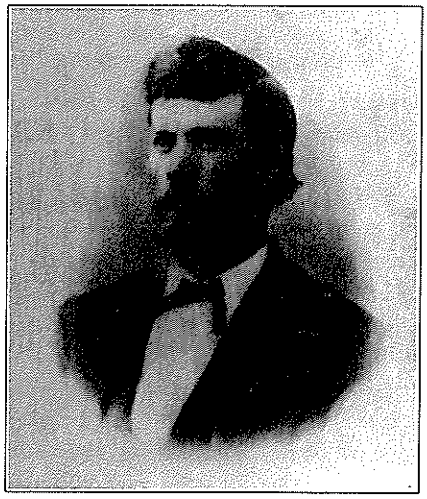
"The Valley of the Upper Yellowstone" appeared in the June 1870 edition of the Western Monthly under the byline of Charles W. Cook.[3] Comparing the heavily edited text with what has survived of the submitted manuscript[4] shows that the Western Monthly editors restricted most of their paring to the grammatical voice, rather than the substance of the report. Cook and Folsom had originally written the text with an introduction in the first person past tense to describe their preparations for the trip, but then abruptly changed to a combination of present and past tense voice once they embarked from Diamond City on September 6. To further confound readers the original manuscript began to refer to all three participants only by their initials; "C" or "Cap" for Charles Cook, "B" for William Peterson, and "D" for David Folsom, so that it was unclear who was telling the story. To clarify the story's narrative continuity, the Western Monthly altered the manuscript to read entirely from the point of view of one person, a writer they assumed to be Charles W. Cook. Other textual alterations in the Western Monthly article had more to do with relevancy than credulity. Cook, Folsom, and Peterson all shared the frontiersman's dislike for native peoples, and the two encounters the party had with Shoshoni Indians during their journey were described in language that did little to advance their chronicle of exploration. Western Monthly apparently chose to omit these portions in order to focus on the article's main thrust of describing the countryside.

Although Cook and Folsom might have been dismayed at having their text substantially altered when it appeared in print, they just as likely felt secure that their accomplishment in setting forth the first comprehensive description of the Yellowstone country would win them lasting fame. Folsom later recalled providing the original diary memoranda book and a map he had prepared to Henry D. Washburn[5] and other members of the exploration party being formed in the late summer of 1870, but he could not have known that by so doing he would help obscure the record of his own group's efforts. When the published results of the Washburn-Langford-Doane expedition began to appear in 1871, no mention was made of the 1869 reconnaissance by Cook, Folsom, and Peterson. The reserve stock of the June 1870 issue of the Western Monthly, along with the original manuscript, burned in a fire which consumed the publisher's Chicago headquarters on September 4, 1870. As a result, only the issues of the magazine which had been sent to subscribers survived, and any demand for extra copies generated by subsequent explorations of the park simply could not be met.[6]

Although it is not at all clear what became of the memoranda book they had carried on the expedition,[7] both Cook and Folsom kept incomplete duplicate copies of their literary effort. Folsom donated his copy of the Western Monthly to the infant Montana Historical Society, in hopes that the scarce magazine would at least be preserved, but again fire intervened to obscure the record. All of the precious documents gathered by the Society burned in the disastrous Helena, Montana, fire of January 9, 1874, including Folsom's contribution.[8] The explorers made no further attempt to publish the piece, and by 1894, when Nathaniel P. Langford decided to reprint the Western Monthly article in pamphlet form, he erroneously assumed that his personal copy of the magazine was the only one extant.[9] Langford's reprint, a limited edition of 500 copies, attempted to set the record straight regarding the importance of the 1869 journey, and graciously recognized the Cook-Folsom expedition as contributing to the establishment of the park in 1872.[10] Unfortunately Langford chose to credit the article to Folsom alone, probably because the two had become well acquainted over the years.[11] When Langford's version was reprinted in 1904 he once again credited the authorship to Folsom.[12]

However, that same year another writer took up the matter with a resolve to reprint the original text of the joint diary. Before accepting an appointment on the faculty of Montana Agricultural College in 1904, Victor K. Chesnut, a chemist and botanist for the United States Department of Agriculture, had been in the state preparing reports on indigenous poisonous plants.[13] During his investigations in 1903, Chesnut happened to call at the sheep ranch of Charles W. Cook near Unity, Meagher County, Montana. Cook, a spry 64 years old, took a liking to the botanist and during their visits he described his 1869 trek through the park. Perhaps Cook thought Chesnut's ties to the academic world would help result in the long-delayed publication of the original manuscript he and Folsom had prepared 33 years earlier, because he turned over his only copy of the document to Chesnut for transcribing. Chesnut took the handwritten pages back to his office in Bozeman where he carefully typed a verbatim copy and then, on February 23, 1904, he took the transcript to Helena, Montana, where he introduced himself to David E. Folsom. By that time Folsom had become somewhat embittered by the twisted fate of the diary's publication history. He told Chesnut he felt that Langford in particular had plagiarized his work in the latter's 1871 articles in Scribner's and gave no credit to the ear-

George Mueller



Above: Charles W. Cook. Left: Illustration from "The Wonders of the Yellowstone," Scribner's Monthly 2(1):May 1871. This article told of the Washburn–Langford–Doane expedition in 1870, which had much more publicity than the Cook–Folsom–Peterson expedition the previous year.

Above: Superintendent Albright, Charles Cook, and Anne Anzer of the National Editorial Association during the 50th anniversary ceremony of the park's establishment. Right and following page: Missing pages from the diary.

lier expedition.[14] Folsom became excited by the possibility of publishing the original piece in its entirety and carefully went over the transcript Chesnut left with him, making corrections based on his own version of the manuscript. He mailed the corrections to Chesnut with a copy of Langford's 1894 pamphlet, indicating where the page breaks occurred in the Western Monthly's version of the story so that the missing portions at the end of Chesnut's transcript could be replaced with the exact wording which had been published in 1870.

Folsom's hopes of seeing the original narrative in print proved groundless because Chesnut never got around to publishing the manuscript. Lacking historical training and pressed by other official duties, Chesnut laid aside his transcription for the balance of his tenure at Bozeman. In 1907, he left for Washington, D.C., where he took a new job with the USDA.[15] He never returned the manuscript to Cook and apparently soon forgot all about the matter. Cook's handwritten original remained in Chesnut's old office for another nine years until, on the afternoon of October 20, 1916, it was consumed by a conflagration that gutted the Chemistry building on the MSC campus.[16] Once again fire had intervened to destroy the record of the Cook-Folsom-Peterson expedition, but fortunately Chesnut had retained the transcript he had prepared in 1903.

In 1922, grand preparations were underway to observe the 50th anniversary of Yellowstone National Park's founding, and 82-year-old Charles Cook had been approached by his son-in-law, Lewistown, Montana, attorney Oscar O. Mueller, to participate in the observance by again attempting to publish the long-neglected record of the expedition. Cook, of course, could not amplify the Western Monthly version without his handwritten manuscript. After Cook told him about Chesnut's involvement, Mueller wrote the botanist at Washington to see what had happened to the document. "I was very much surprised...to learn that the Folsom-Cook [manuscript account] of their historic trip was not deposited in the Montana Historical Library," Chesnut wrote back to Mueller, "I should have sent it there myself but when I left Bozeman in 1907 or 1908 I turned it over to [Montana Agricultural College] President James M. Hamilton together with a typewritten copy to be sent to the library. The [manuscript] was not complete but Mr. Cook could find no more at that time."[17] Mueller, thinking half a loaf would be better than none, pressed Chesnut for a copy of his transcription, corrected by Folsom: "...I have decided to have you send me a typewritten copy of the copy of the manuscript you have, as it may be a long time in locating the others here in Montana, if [that is even] possible...Mr. Cook has no [other] copy of the manuscript and your copy may be the only means of receiving [the] same."[18]

While Chesnut set his wife to copying the precious transcription in his possession, Mueller doggedly pursued the trail of the original draft. He tried contacting James Hamilton to find out if he still had the document. When no reply came he confronted Hamilton in a Lewistown hotel lobby but Mueller reported years later that "all I could get out of him was evasive answers."[19] Chesnut tactfully attempted to backpedal, pointing out that he did not distinctly remember giving the document to Hamilton. He suggested Mueller contact Professor Edmund Burke, Chesnut's former office mate at Bozeman, but that inquiry only confirmed the likelihood that the 1916 chemistry building fire had consumed Cook's original manuscript.[20]

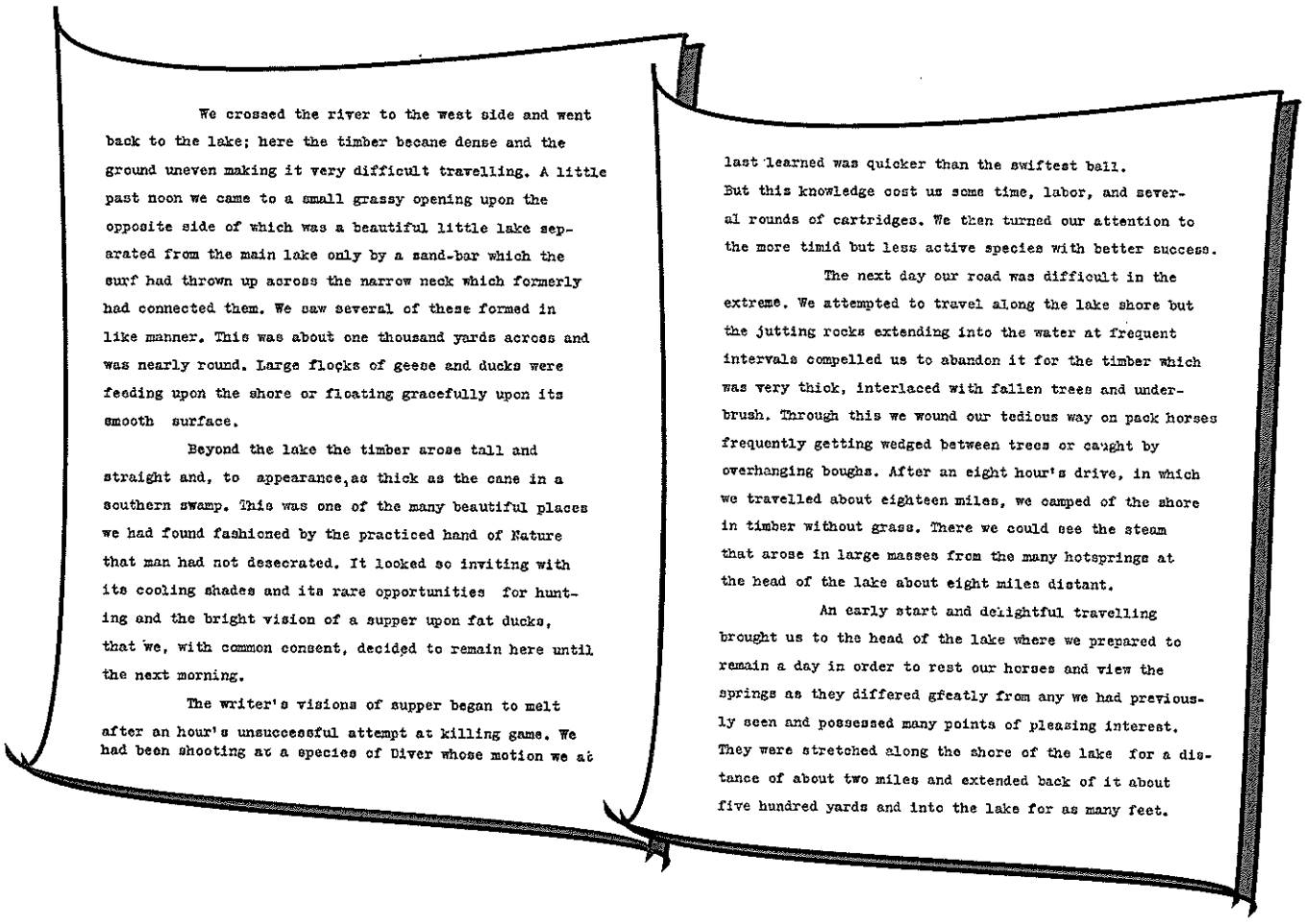
Once Oscar Mueller had possession of the typed transcript prepared by Chesnut's wife, he realized the goal of publishing the complete text could still not be achieved. Chesnut's transcript, as corrected by Folsom, consisted of only 29 pages, ending just as the explorers made plans to leave Lake Yellowstone on the afternoon of September 25, 1869; it had none of the important description of the party's journey through the Lower Geyser Basin. Eager to help Mueller now that his incomplete transcription appeared to be the earliest surviving copy of the manuscript, Chesnut made the following deduction in a letter to the attorney:

The original manuscript was given, so Mr. Folsom told me, to General Washburn. I wonder what became of that? Mr. Folsom must have had a copy of the amplified diary, however, in making his corrections on the copy I sent him! Possibly he then had the original. I have written to his son to find out the facts of the case.[21]

While Mueller continued to press his father-in-law Cook to search his house for the missing pages of the manuscript and also wrote to David Folsom Jr., Chesnut rifled through his own files in Washington to see if he could find any pages of the original manuscript. "I have come across a page or two of the manuscript I got from Mr. Cook," he wrote Mueller on May 14, 1922. "It is in what I take to be his own handwriting and it covers the trip around the lake, but it does not give the most interesting part."[22] Chesnut went on to explain that he had made a photographic copy of the leaves and attempted to transcribe them but had temporarily misplaced the typescript.

Mueller must have been too preoccupied with preparing for the semi-centennial observance at the park and tracking down David Folsom Jr.[23] to complete the manuscript because Chesnut's discovery seems not to have made an immediate impression. Almost a month later Mueller responded:

> Every bit of this that can be produced will be of assistance to me in getting the Diary completed and hope you can send me a copy. I can then with the assistance of everything available get Mr. Cook to complete it, but at his age and over half a century having elapsed, will need all the notes possible to be secured



We crossed the river to the west side and went back to the lake; here the timber became dense and the ground uneven making it very difficult travelling. A little past noon we came to a small grassy opening upon the opposite side of which was a beautiful little lake separated from the main lake only by a sand-bar which the surf had thrown up across the narrow neck which formerly had connected them. We saw several of these formed in like manner. This was about one thousand yards across and was nearly round. Large flocks of geese and ducks were feeding upon the shore or floating gracefully upon its smooth surface.

Beyond the lake the timber arose tall and straight and, to appearance, as thick as the cane in a southern swamp. This was one of the many beautiful places we had found fashioned by the practiced hand of Nature that man had not desecrated. It looked so inviting with its cooling shades and its rare opportunities for hunting and the bright vision of a supper upon fat ducks, that we, with common consent, decided to remain here until the next morning.

The writer's visions of supper began to melt after an hour's unsuccessful attempt at killing game. We had been shooting at a species of Diver whose motion we at last learned was quicker than the swiftest ball. But this knowledge cost us some time, labor, and several rounds of cartridges. We then turned our attention to the more timid but less active species with better success.

The next day our road was difficult in the extreme. We attempted to travel along the lake shore but the jutting rocks extending into the water at frequent intervals compelled us to abandon it for the timber which was very thick, interlaced with fallen trees and underbrush. Through this we wound our tedious way on pack horses frequently getting wedged between trees or caught by overhanging boughs. After an eight hour's drive, in which we travelled about eighteen miles, we camped of the shore in timber without grass. There we could see the steam that arose in large masses from the many hotsprings at the head of the lake about eight miles distant.

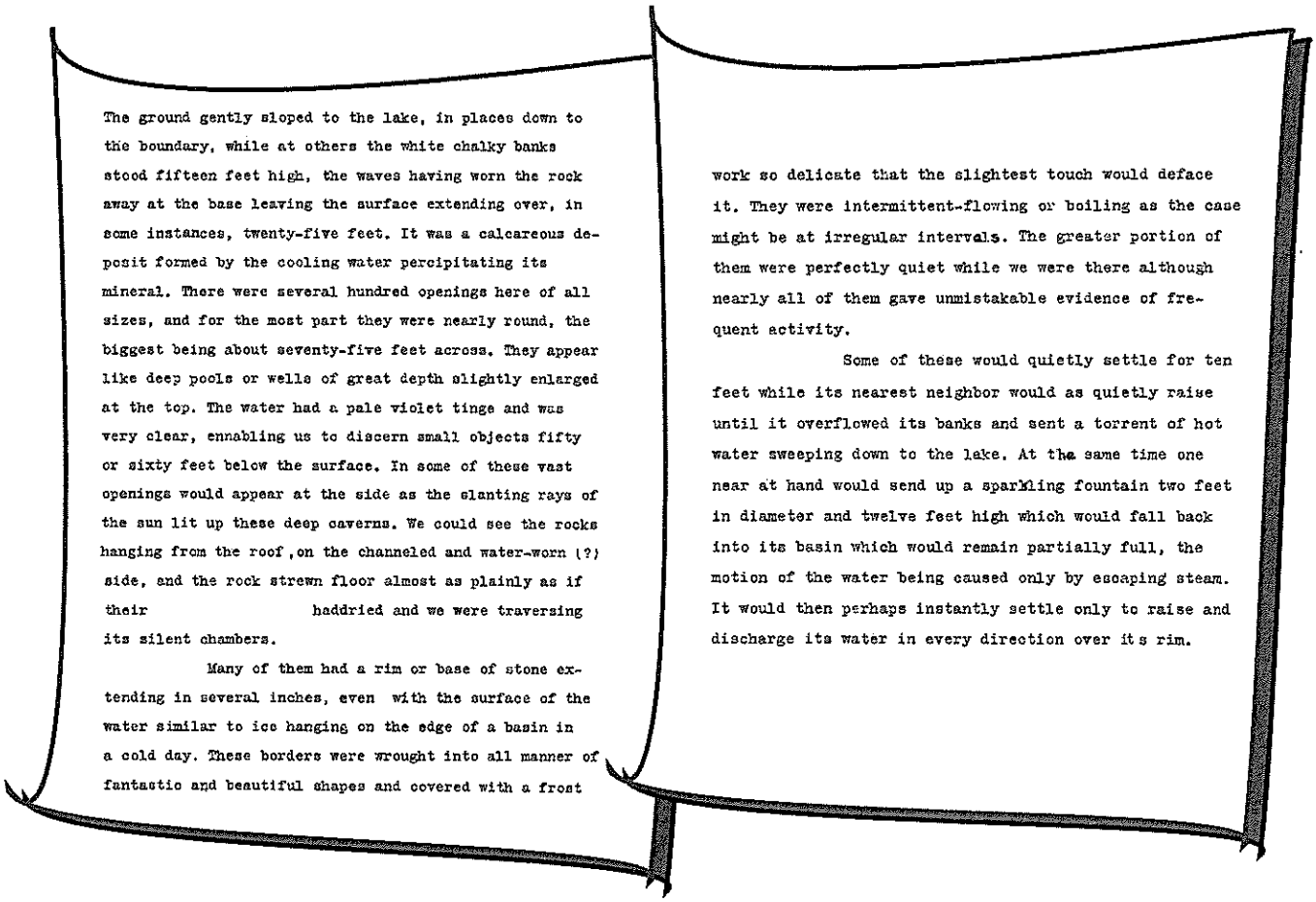
An early start and delightful travelling brought us to the head of the lake where we prepared to remain a day in order to rest our horses and view the springs as they differed greatly from any we had previously seen and possessed many points of pleasing interest. They were stretched along the shore of the lake for a distance of about two miles and extended back of it about five hundred yards and into the lake for as many feet.

in order to be sure that it is accurate. I would like to know whether or not you are absolutely sure you did not get all of the Diary from Mr. Cook?[24]

Mueller may not have immediately realized that the leaves Chesnut had found continued the narrative beyond the point where his own transcript ended. The pages that Chesnut had found described the portion of the route through September 28, describing in more detail their investigations of the lake shore up to the West Thumb. In any event, Mueller continued to work with Cook to both prepare a new manuscript for publication and to arrange for Cook's participation in the park's semi-centennial celebration on July 16, 1922. When he finally got a reply from David Folsom Jr., Mueller unhappily reported to Chesnut, "I have received from Mr. David Folsom Jr. a copy of the diary, but [it] is identical to the one that you sent me and presumably a copy from the copy you sent Mr. Folsom Sr. [in 1904.]"[25] Chesnut felt moved to explain himself when he sent Mueller a photograph of the first handwritten page he had found. "No, I am sure that I didn't get all of the [manuscript] from Mr. Cook," he wrote. "There must be some at his house and I hope Mrs. Mueller will be able to locate it. It is very difficult to read this particular piece that I found, so it was on that account that it was not copied. I haven't been able to decipher it all yet."[26]

For some reason, Victor Chesnut never sent the original leaves he had found to Oscar Mueller and only mailed the attorney a negative photographic copy of the first page, which consisted of 191 words describing the explorers' decision to remain at the lakeshore on the night of September 25, 1869. Mueller assumed this to be the last vestiges of the original he would be able to locate, and turned it over to Charles Cook, who completed the reconstructed chronicle by referring to the Western Monthly for all the information from September 26 to the end of the journey on October 10, 1869. Mueller seemed satisfied with his transactions with Chesnut, probably because he believed the latter's contacts with Yellowstone National Park Superintendent Horace Albright and concessionaire Jack Ellis Haynes had finally secured his father-in-law the recognition he deserved as a member of the first comprehensive exploration of the park.[27]

Mueller submitted Cook's final compilation of the diary to Haynes on September 13, 1922. Initially Mueller thought the Montana Historical Society would publish it and only wanted Haynes to proof the manuscript, but Haynes convinced the attorney to let him print it in the Haynes Bulletin, a house organ of very limited circulation.[28] The "Reconstructed Diary of the Cook-Folsom Expedition in 1869 to the Yellowstone Region" appeared serially in four consecutive issues of the Haynes Bulletin beginning in December 1922, with a preliminary statement by Cook that explained how the chronicle had been mishandled in the past.[29] But again circumstances would rob the old explorer of widespread recognition for his achievement. After



The ground gently sloped to the lake, in places down to the boundary, while at others the white chalky banks stood fifteen feet high, the waves having worn the rock away at the base leaving the surface extending over, in some instances, twenty-five feet. It was a calcareous deposit formed by the cooling water percipitating its mineral. There were several hundred openings here of all sizes, and for the most part they were nearly round, the biggest being about seventy-five feet across. They appear like deep pools or wells of great depth slightly enlarged at the top. The water had a pale violet tinge and was very clear, ennabling us to discern small objects fifty or sixty feet below the surface. In some of these vast openings would appear at the side as the slanting rays of the sun lit up these deep caverns. We could see the rocks hanging from the roof, on the channeled and water-worn (?) side, and the rock strewn floor almost as plainly as if their haddried and we were traversing its silent chambers.

Many of them had a rim or base of stone extending in several inches, even with the surface of the water similar to ice hanging on the edge of a basin in a cold day. These borders were wrought into all manner of fantastic and beautiful shapes and covered with a frost work so delicate that the slightest touch would deface it. They were intermittent-flowing or boiling as the case might be at irregular intervals. The greater portion of them were perfectly quiet while we were there although nearly all of them gave unmistakable evidence of frequent activity.

Some of these would quietly settle for ten feet while its nearest neighbor would as quietly raise until it overflowed its banks and sent a torrent of hot water sweeping down to the lake. At the same time one near at hand would send up a sparkling fountain two feet in diameter and twelve feet high which would fall back into its basin which would remain partially full, the motion of the water being caused only by escaping steam. It would then perhaps instantly settle only to raise and discharge its water in every direction over its rim.

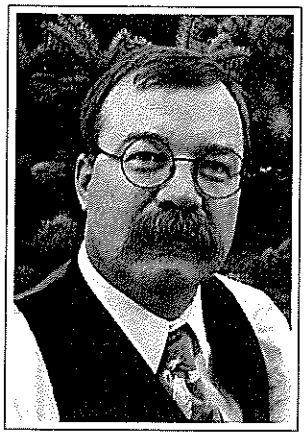
Haynes had published the piece, the Montana Historical Society made other plans for their 1923 edition of Contributions and more than 40 years would pass before the exploration chronicle would again appear in print.

In 1965 park historian Aubrey L. Haines turned his attention to the Cook-Folsom-Peterson expedition record. Having access to all the previous published versions and a recently discovered reminiscence credited to William Peterson, Haines masterfully attempted to unravel the complicated story of the exploration narrative by interlocking passages from the four published versions, their supplemental text, and the Peterson reminiscence. Although Haines had access to a typescript of Folsom's version of the diary up to September 25, 1869, it had no substantial differences from Cook's text in the Haynes Bulletin[30]. When Haines' book, The Valley of the Upper Yellowstone, appeared in print, it seemed as if the last word on the Cook-Folsom-Peterson expedition had been said[31].

However, in 1979 a small collection of papers from the files of Victor K. Chesnut were donated to the Special Collections department of the Montana State University Library. The accession contained all of the letters Chesnut had received from Oscar Mueller, the 1904 transcript that David E. Folsom had corrected, supplemental notes, the photograph of the first faded leaf, and, most importantly, four additional pages of transcription that Chesnut had deciphered from the original leaves discovered during his 1922 search through his files. He had misplaced them when he sent the photographed page to Mueller, and after the Haynes Bulletin published Cook's reconstruction Chesnut probably thought no more about them.[32] The additional text, some of which was included or paraphrased in the 1870 Western Monthly article, appears here for the first time and includes the expedition's detailed description of the West Thumb geyser basin:[33]

The tangled provenance of the Cook-Folsom-Peterson expedition diary is an unfortunate case of editorial omission, well-intentioned mishandling, and fiery demise. The discovery of this additional puzzle piece may not be the last word, however, since the location of the memoranda book the men actually carried on their journey has yet to be accounted for, along with those faded leaves that Victor Chesnut neglected to return to Charles Cook in 1922.

Kim Allen Scott is Special Collections Librarian and University Archivist for Montana State University, Bozeman. He earned an M.A. in History from the University of Arkansas in 1986 and a Master of Library Science from the University of Texas at Austin in 1990. His publications include works on printing history and the Civil War. His current position has exposed him to a wealth of primary source materials dealing with the history of Yellowstone National Park. He is particularly interested in records which document the park's military administration. Scott was pleased recently to show the Chesnut transcription to historian Aubrey Haines, who confirmed the document's authenticity.



Kim Allen Scott.

Notes

1. William T. Jackson, "The Cook-Folsom Expedition of the Upper Yellowstone, 1869." Pacific Northwest Quarterly 32, 2 (1941): 321-322. It must be said here that scholarship since the appearance of Jackson's article has helped clarify the role of the expedition in establishing Yellowstone National Park, but the expedition narrative itself has continued to suffer from its checkered publication history.

2. C. W. Cook, "Preliminary Statement to the Cook-Folsom Diary." Haynes Bulletin, December 1922, 3-4.

3. C. W. Cook, "The Valley of the Upper Yellowstone." Western Monthly, July 1870, 60-67.

4. "Copy of Diary of the Folsom-Cook Expedition in 1869 To The Yellowstone National Park, Amplified at Diamond City, Montana by D. E. Folsom." Victor K. Chesnut papers, Collection 1268, Merrill G. Burlingame Special Collections, Montana State University, Bozeman. This 29-page typescript bearing handwritten marginalia and corrections, is on 9 ½ x 7 ½"-laid finish paper bearing the watermark "Old Berkshire Mills 1903." Two unnumbered prefatory sheets, titled "V.K. Chesnut Conversation at Helena Montana February 23 [190]4 with D. E. Folsom of White Sulphur Springs, Montana" accompany the manuscript.

5. "V.K. Chesnut Conversation at Helena Montana February 23 [190]4 with D. E. Folsom of White Sulphur Springs, Montana." Victor K. Chesnut papers, Collection 1268, Merrill G. Burlingame Special Collections, Montana State University, Bozeman. In this statement Folsom recalled giving the map to Walter De Lacy and the diary to Washburn. Handwritten notations in the Washburn diary, currently owned by Mr. Lee Parsons of Indianapolis, Indiana, confirm that Washburn had access to the diary, and Nathaniel P. Langford wrote in 1894 that both information and "a map" was provided to his group before the 1870 expedition. See: Nathaniel P. Langford, The Cook-Folsom Expedition of the Upper Yellowstone in the year 1869 (N. P. Langford: St. Paul, Minn., 1894): 4.

6. William Turrentine Jackson, "The Early Exploration and Founding of Yellowstone National Park," (Ph.D Dissertation; University of Texas at Austin, 1940): 139.

7. Langford confirmed in his 1894 pamphlet the receipt of the documents, but never mentioned returning them. By the time he published his own reminiscence in 1905, Langford dropped mention of the documents entirely. See: Nathaniel P. Langford, Diary of the Washburn expedition to the Yellowstone and Firehole rivers in the year 1870 [St. Paul? Minn., c1905]: iii-xxi.

8. Vivian Paladin and Jean Baucus, Helena, An Illustrated History (Norfolk, Va.: Donning Co., 1983): 29.

9. Nathaniel P. Langford, The Cook-Folsom Expedition of the Upper Yellowstone in the year 1869 (N. P. Langford: St. Paul, Minn., 1894): 8. Orrin and Lorraine Bonney have concisely described the true circumstances of the Western Monthly fire and the distribution of the Cook article. See: Orrin H. Bonney and Lorraine Bonney, Battle Drums and Geysers (Chicago: Swallow Press, 1970): 394-395.

10. Nathaniel P. Langford, The Cook-Folsom Expedition of the Upper Yellowstone in the year 1869 (N. P. Langford: St. Paul, Minn., 1894): 8.

11. There is hearsay evidence that the slight to Cook's authorship was intentional. Oscar Mueller, who married Cook's daughter Josephine in 1915, maintained that Langford still harbored a grudge against his father-in-law because Cook had publicly criticized the Washburn-Langford-Doane expedition for abandoning Truman Everts in the Yellowstone country during their 1870 journey. However, the criticism, if it appeared in a Montana newspaper, has not been located. See: Oscar O. Mueller, letter to Victor K. Chesnut, February 18, 1922. Victor K. Chesnut papers, Collection 1268, Merrill G. Burlingame Special Collections, Montana State University, Bozeman.

12. David E. Folsom, "The Folsom-Cook Exploration of the Upper Yellowstone in the Year 1869," Contributions to the Montana Historical Society, vol. 5 (1904): 349-369.

13. Who was Who in America, Volume 1 (Chicago: A.N. Marquis Company, 1943): 215.

14. Victor K. Chesnut, "The V.K. Chesnut Conversation at Helena, Montana, February 23, 1904, with D. E. Folsom of White Sulphur Springs, Montana." Manuscript in the Victor Chesnut papers, Collection 1268, Merrill G. Burlingame Special Collections, Montana State University, Bozeman.

15. Who was Who in America, Volume 1 (Chicago: A.N. Marquis Company, 1943): 215.

16. "Flames Destroy Science Hall at MSC-Gasolene Burner Cause-Loss Heavy," The Weekly Courier (Bozeman, Montana), October 25, 1916, 12.

17. Victor K. Chesnut, letter to Oscar O. Mueller, December 11, 1921. Original letter in the possession of George D. Mueller of Lewistown, Montana.

18. Oscar O. Mueller, letter to Victor K. Chesnut, December 15, 1921. Victor K. Chesnut papers, Collection 1268, Merrill G. Burlingame Special Collections, Montana State University, Bozeman.

19. Oscar O. Mueller, letter to Merrill G. Burlingame, November 4, 1957. Merrill G. Burlingame papers, Collection 2245, Merrill G. Burlingame Special Collections, Montana State University, Bozeman. In Hamilton's defense it should be pointed out that his manuscript history of Yellowstone National Park cites only the known sources of the Cook-Folsom expedition diary. If Hamilton had received the manuscript from Chesnut in 1904 he doubtless would have used it. See: James M. Hamilton, " History of Yellowstone National Park, previous to 1895" typescript circa 1947, Merrill G. Burlingame Special Collections, Montana State University, Bozeman.

20. Victor K. Chesnut, letter to Oscar O. Mueller, February 12, 1922. Original letter in the possession of George D. Mueller of Lewistown, Montana.

21. Victor K. Chesnut, letter to Oscar O. Mueller, February 12, 1922. Original letter in the possession of George D. Mueller of Lewistown, Montana.

22. Victor K. Chesnut, letter to Oscar O. Mueller, May 14, 1922. Original letter in the possession of George D. Mueller of Lewistown, Montana.

23. David E. Folsom had died in Stanford, California on May 18, 1918. His copy of the manuscript became the property of his son.

24. Oscar O. Mueller, letter to Victor K. Chesnut, June 10, 1922. Victor K. Chesnut papers, Collection 1268, Merrill G. Burlingame Special Collections, Montana State University, Bozeman.

25. Oscar O. Mueller, letter to Victor K. Chesnut, July 7, 1922. Victor K. Chesnut papers, Collection 1268, Merrill G. Burlingame Special Collections, Montana State University, Bozeman.

26. Victor K. Chesnut, letter to Oscar O. Mueller, July 4, 1922. Original letter in the possession of George D. Mueller of Lewistown, Montana.

27. Oscar O. Mueller, letter to Victor K. Chesnut, August 10, 1922. Victor K. Chesnut papers, Collection 1268, Merrill G. Burlingame Special Collections, Montana State University, Bozeman.

28. Oscar O. Mueller, letter to J. E. Haynes, September 13, 1922. Jack Ellis Haynes and Haynes, Inc. Records, Collection 1504, Merrill G. Burlingame Special Collections, Montana State University, Bozeman.

29. Charles W. Cook, "Preliminary Statement to the Cook-Folsom Diary," Haynes Bulletin (December 1922): 7-8; "Reconstructed Diary of the Cook-Folsom Expedition in 1869 to the Yellowstone Region," Haynes Bulletin (December 1922):8, (January 1923): 1, 9, (February 1923): 8 (May 1923):7-8.

30. This version, donated to the library at Yellowstone National Park, had been provided by David S. Folsom, the explorer's grandson, on September 24, 1940. Folsom had transcribed the document from a pencil-written original which remains in the family's possession.

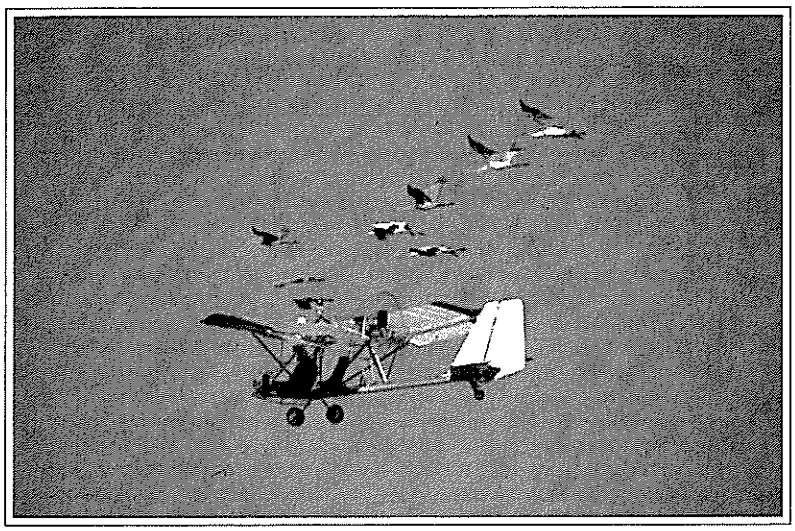
31. Aubrey L. Haines, ed., The Valley of the Upper Yellowstone: an exploration of the headwaters of the Yellowstone River in the year 1869 / as recorded by Charles W. Cook, David E. Folsom, and William Peterson. (Norman: University of Oklahoma Press, [1965]).

32. The four pages in the Chesnut papers include two identical carbon copies, indicating that Chesnut had copied them with the intention to send them on to Mueller and other interested parties but had, indeed, misplaced them until it was too late for their inclusion in Cook's reconstructed diary in the 1923 Haynes Bulletin.

33. The typescript has been lightly edited with spelling corrections and punctuation additions.

Yellowstone Science Interview: Kent Clegg

The Pied Piper of Whooping Cranes



Kent Clegg grew up on a ranch in southeastern Idaho and, while still in high school, began working at Gray's Lake National Wildlife Refuge, where he first encountered whooping cranes, perhaps the most endangered bird in North America. Since then, he has continued working with a variety of wildlife monitoring and management projects while still ranching and farming. Clegg visited with the editor during a visit to Yellowstone in July 1998. When asked whether, compared to ranching, he would describe wildlife research as a vocation or a hobby on the side, he laughed, "I'm not sure which—neither of them pay very well!" He commented that although "sometimes people think there's either one or the other and they can't coexist, I've always found it an interesting challenge to be able to put the two together."

A Most Endangered Bird

YS: Am I right in that we have just the two species of cranes here in North America, sandhills and whoopers?

KC: Right. There are subspecies of the sandhill, the Greater, the Lesser, and the Canadian Sandhill.

YS: And the sandhills have never been threatened or endangered?

KC: Not as a species. Sandhills in Mississippi almost became extinct before conservation efforts to restore them began.

YS: Can you briefly summarize for us the status of whooping cranes? They've been endangered for a long time.

KC: In the 1940s, the whooping crane population consisted of 15 or 16 individual birds that migrated from Texas to the Northwest Territories of Canada. Basically, all the whooping cranes existing today came from that group of 15 birds. There are currently about 180 birds in the wild flock migrating from Texas to Canada each year.

The balance are either in captive propagation centers or in a group that has been released in Florida and now consists of about 65 birds. The flock in Florida was created to ensure a second population of whooping cranes in the event of a disaster with the original flock. It has been successful to a certain extent; however, to date no young have been produced. The birds have paired and put down nests but have never laid eggs.

The total population of whooping cranes is about 360 individual birds.

YS: What was it that endangered whooping cranes in the first place—hunting?

KC: Hunting and the loss of habitat around the turn of the century contributed largely to their decline in numbers. A lot of wetlands were drained, which is the primary habitat for whooping cranes.

YS: Are they susceptible to disease at all?

KC: Like any species there is a risk of disease. There are concerns about tuberculosis in whooping crane populations, but there have been no known die-offs of cranes from tuberculosis.

YS: What do whooping cranes eat?

KC: Anything and everything! For the most part, invertebrates and tubers on plants. In this flyway they feed mostly on corn produced specifically for the cranes and other waterfowl by national wildlife refuges. During the summer they feed in natural habitats like Slough Creek, where we have observed them feeding heavily on salamanders and even water snakes. Whooping cranes tend to be more aquatic by nature than sandhills.

YS: How big does a whooping crane get?

KC: They stand about 5 feet tall with a wing span of about 7 feet. The weight is surprising—only about 13 to 15 pounds.

YS: When you were younger and first got involved with whooping cranes, the fostering parenting experiment [*in which eggs were taken from the nests of whooping cranes in Canada and placed under nesting sandhill cranes in hopes that sandhills would raise the "foster" offspring to inhabit this flyway*] was going on at Gray's Lake; it obviously did not succeed.

KC: It didn't succeed in the fact that for some reason they never did pair and mate. It is thought they were imprinted too strongly on sandhills and that they didn't recognize their own species. They were raised by sandhills and were dispersed all over the Rocky Mountain area, and so they never really associated with each other, except on the wintering grounds for short periods of time. The project was successful getting birds to migrate back and forth, which was one of the objectives. That project was discontinued in the late 1980s because of high mortality and the fact that they never reproduced.

YS: How many birds actually were produced as a result of the foster parent experiment?

KC: Two hundred and eighty-nine eggs were put under sandhill cranes over a 13-year period, with only 89 of those surviving to migrate south. The mortality was high and can be attributed to many things: behavior, predation by animals, possibly because a chick wasn't able to communicate with the parents properly. For whatever reason, the mortality was unusually high. Of the ones that did survive, there were a number lost to powerline strikes in Colorado.

YS: What's the mating behavior of whooping cranes—at what age do they mate, and where does it occur?

KC: Whooping cranes usually pair and mate when they are three to five years of age and some even later than that—five to seven, although you will see some actually start hanging out together at two and three years old. They are thought to mate for life, providing they are successful in raising young together. They are extremely territorial and will come back to defend the same territory year after year.

YS: Whooping cranes can live to be quite old, can't they?

KC: The average life span is estimated to be 25 to 30 years, and yet, in captivity, one has lived to 82 years of age! Some of the birds from the foster program lived 18 to 20 years. Part of our research deals with trying to overcome the mortality experienced during the first year of a crane's life, which will increase their average life span a great deal.

Developing a New Technique

YS: At what point did you establish some formal research relationships—I understand you have worked with the Whooping Crane Recovery Team and have permits from the U.S. Fish and Wildlife Service?

KC: In 1994 Jim Lewis, who was the Whooping Crane Coordinator, and I met and talked over the possibility of doing a research project which would consist of training cranes to follow an ultralight aircraft. I had raised a number of sandhills over the years and had an idea that they would follow an airplane. Jim secured the necessary federal permits and helped initiate the project as a co-investigator on the research.

In 1994, we raised six sandhill cranes and took them on local flights around the valley to determine if they would follow the airplane. Once we proved that the cranes would follow the airplane we began the permit process necessary to make a migration from Idaho to New Mexico. We used sandhill cranes as surrogates for the endangered whooping cranes to see if a migration was possible and to work out some of the bugs. In 1995, we did the first migration from Grace, Idaho, to Bosque Del Apache National Wildlife Refuge in New Mexico; it took us 11 days to make the migration. We started with 11 birds, but one of them turned back and disappeared the first day—it later ended up back at the ranch. Two others were killed by golden eagles while in flight behind the airplane. We arrived in New Mexico with eight sandhill cranes. Unfortunately, two of them were killed during the sandhill crane hunt a few days after arriving. The next spring, the survivors returned to Idaho on their own without any assistance from us. We repeated the same process again in 1996 to further develop our technique and to work out more of the migration details.

Then this past year, 1997, we applied for permits and received approval from the recovery team/USFWS to raise and migrate a small group of whooping cranes.

YS: Your birds were born in captivity, but it was at a very young age that they were brought to your ranch and at least somewhat weaned into the wild?

KC: We hatched them at the Patuxent Wildlife Research Center in Laurel, Maryland. They were kept there for the first 15 days because of Patuxent's expertise and facilities. They were then flown to Idaho to be reared on the ranch and trained to follow the airplane. While raising the young whooping cranes, we spent about four to six hours a day out in the fields exposing them to the environment just as they would if they were wild cranes. As soon as they started feeding, I would leave them there alone to take care of themselves. They soon became content to be with each other and did not require my presence to survive. We monitored them from a distance so as to not be seen. That was part of the process which enabled us to release them into the wild and have them survive.

We also raised a group of sandhill cranes that were integrated with the whooping crane chicks just before fledging. We did this to allow the whooping cranes time to develop a social dominance before being released at the end of the migration with 10,000 wild sandhills cranes.

YS: To clarify, you mentioned you are

Young whooping cranes following Clegg on his Idaho ranch. All photos courtesy Kent Clegg.

not doing a reintroduction. The purpose of your research was...?

KC: The purpose of our research is to develop a technique for reintroducing birds into areas where they no longer exist. There are many things that need to be learned before an actual reintroduction can take place. The first is to determine if birds can be raised wild enough to survive. Second, can a migration be taught to young cranes, and will they follow the migration route in subsequent years? Third, will they act like normal cranes, and will they eventually pair and reproduce?

Our primary objective is to develop a technique that will answer those three questions. If we are successful, it is conceivable that it may be used with any number of endangered species around the world. Just in the case of cranes alone, half of the 15 different species are endangered. The Japanese, the Russians, and many others are looking to this project in hopes of finding a way to help conserve their cranes.

YS: Let's talk about your plane, the ultralight. This was a skill and a hobby you had prior to being involved with the cranes. You didn't learn this skill because of them.

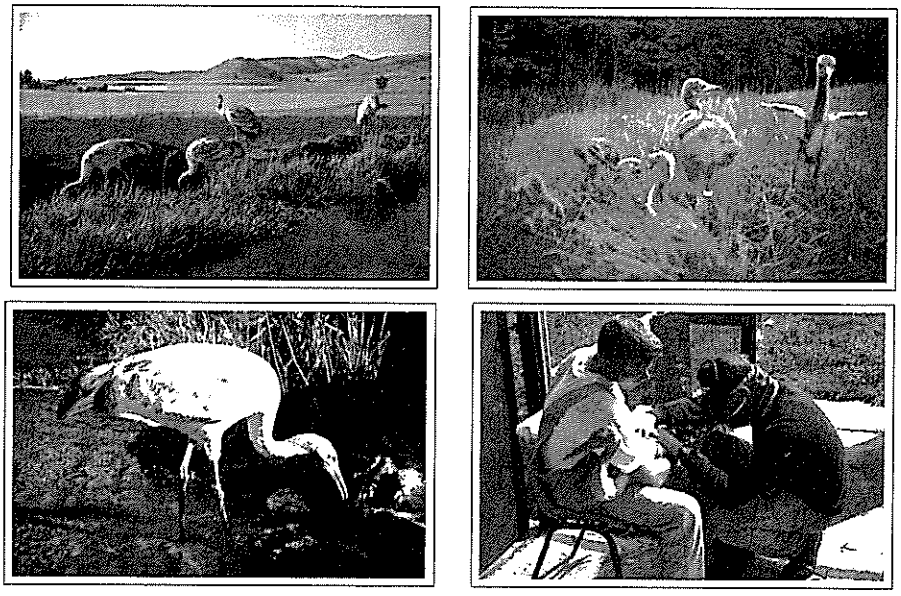
KC: No, not at all. I learned to fly when I was just a kid. My dad was a private pilot and had several small aircraft over the years. I used to fly with him all the time, and he taught me the basics of flying. I bought my first ultralight from a neighbor. He had built and flown it a few times before crashing it. I brought it home, reassembled it, and then taught myself to fly—but I wouldn't recommend that to anybody! The first time I took off, I nearly hyperventilated before getting back on the ground. With no one else there to land the plane, that is not a good thing.

I did eventually get a private pilot's license. I used ultralights on different projects before the whooping cranes. I used one counting and hazing swans on the Henry's Fork, and also used one doing aerial photography for local farmers monitoring fertilizer applications.

YS: How fast does this plane go? How high up do you fly when you're leading the cranes?

KC: The average flight speed with the cranes is about 35 mph, although at times we calculated ground speed at 59 mph. Of course, that is with a tail wind pushing the plane and the birds along. The plane I fly is called a Dragonfly and is made by Moyes Microlite in Australia. The plane was shipped to Florida and assembled there. After doing all the test flights, the plane was disassembled and shipped to Idaho. The plane was designed to pull gliders and hang-gliders and has a very low stall speed, which is necessary for flying with the cranes.

On average, we fly about 1,500–2,500 feet above the ground. It takes us a while to get up to that altitude. Often we use thermals to help us climb and to save energy. As we cross the Continental Divide near Price, Utah, we are at about 10,000 feet MSS. It is impressive from that altitude to look at the mountains and valleys below and then at the birds off your wing tips and know that you are part of a unique migration.



Above and below left: Whooping cranes feeding. Top right: Young whoopers stretch their wings. Below right: A young captive crane is checked over prior to being released from a pen.

Heading South for the Winter

YS: Back to 1997...so you led the whoopers you had raised back to wintering grounds at Bosque Del Apache National Wildlife Refuge in New Mexico. Tell us about the journey.

KC: The migration took us nine days to go from Idaho to New Mexico. We left Idaho with four whooping cranes and eight sandhill cranes and arrived with all but one sandhill that was fatally injured during the trip. One of the whooping cranes was attacked by a golden eagle near Price, Utah, and was trailered the rest of the way.

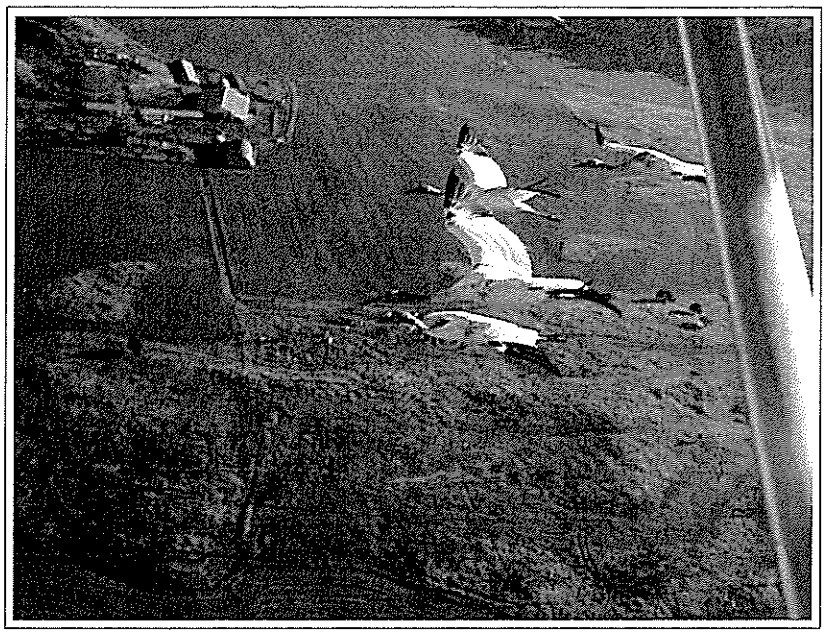
YS: Obviously you have to put down somewhere along the way. Is that a function of your exhaustion level, the birds getting tired, or a little bit of both?

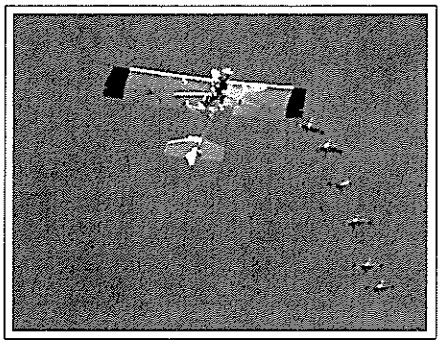
KC: Both. We'd try to stay in the air as long as possible and get as much distance as we could out of each flight. We'd have about three hours of fuel on board and can cover about a hundred miles in that amount of time. Often we had to land because the birds were tired due to unavoidable encounters with golden eagles, head winds, and climbing over mountains. We have also run low on fuel a time or two and had to land.

YS: How did you figure out where you were going to stop every night?

KC: Our stops are not planned. We try and get as much distance as we can each day and then camp where ever we end up that night. We only need about 300 feet to land and take off, which does not limit us too much.

We've found farmers and ranchers to be the most hospitable, so we looked for hay fields and pastures in which to land. We did land on a golf course once and were met with by a hostile police depart-





Above: Whooping cranes following Clegg in his ultralight plane. Left: View of whoopers in flight.

ment and had to leave.

YS: Other than that one incident, you've never had a landowner deny you permission to stay?

KC: No. In fact, most people were fascinated with the fact that a plane drops out of the sky with a bunch of birds following it. Everybody has been very nice and helpful, some even put us up for the night. We had a ground crew following along with portable pens and our necessary ground equipment.

YS: The birds are penned up at night when you're on this journey?

KC: We penned the birds at night to protect them from predators and to avoid having them wander off in an unfamiliar area. We were also concerned about golden eagles attacking the young cranes. We had incidents on two of the migrations where cranes were attacked by golden eagles and injured or killed.

YS: Are there ground predators that go after them?

KC: Few predators will challenge a full grown crane. They will often hang around large flocks and pick off the injured or sick. Coyotes will occasionally rush a large roost of cranes at night, catching the unsuspecting crane.

YS: Are your birds marked to help you keep track of them?

KC: Each bird has a radio transmitter attached to a leg band. There are two types of transmitters. One is conventional and emits a signal that can be picked up with a hand-held receiver. The other is a satellite transmitter that sends a signal to a satellite which is relayed to a computer giving us the latitude and longitude of each bird. It all *sounds* good as long as it is working. However, we have a lot of problems with the cranes breaking off the antennas, making them useless.

YS: It sounds like there were great opportunities to educate people along the flight to New Mexico.

KC: Not just along the migration. It's one of the few projects that I have been associated with that seems to capture the imagination and interest of the general public. I think it is a great way to educate and make people aware of the need for conservation.

YS: When you ended your journey that fall, at Bosque Del Apache, what was your reception?

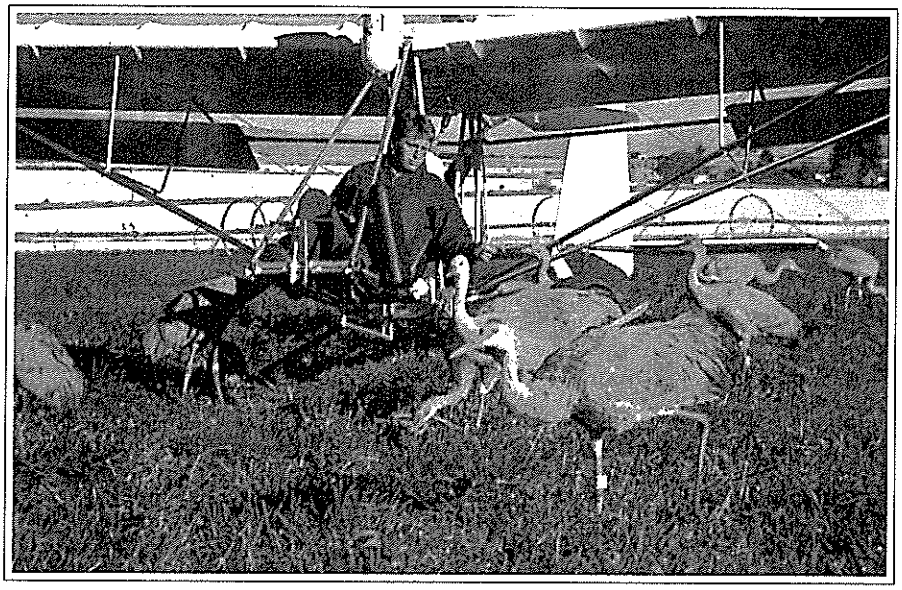
KC: We were surprised by the number of people who were there when we arrived. Because it is a research project and we did not want the birds to associate with people, we had not allowed the media and others to be around while raising or migrating the birds. It was a nice climax after making the 800-mile migration to see so many people there in support of our efforts.

Returning to Greater Yellowstone

YS: Two birds from this experiment, the winter of 1997–98, ended up in Yellowstone National Park. How did that transpire?

KC: Two of the four whooping cranes survived the winter to migrate north in the spring. The other two were killed by predators during the winter. We suspect one of them was killed by a bobcat because we found the remains buried in the ground, which is typical of cats. The other time, we found only feathers and the transmitter, and coyotes in the area. There are a large number of predators on the refuge, so releasing captive-reared cranes into a wild environment will have a certain amount of mortality.

We feel that it has been successful considering that 8 of the 11 cranes released into the wild this year survived the winter to migrate north. All six sandhills and the two whooping cranes migrated back north into Colorado in early March and, after spending six weeks in Colorado, migrated on north, ending up in Wyoming. The two whooping cranes were found in separate locations and in poor habitat. Both were caught with the intent of locating them into a habitat that would ensure their survival and also determine if they would return to specific summer sites in subsequent years. Once the birds were captured we ran into strong opposition from both state and federal agencies that did not want whooping cranes in their state or region. Basically, we were not allowed to release the birds. Fortunately, Yellowstone Park agreed to a re-



Clegg on the ground in his ultralight plane surrounded by whooping cranes.

lease which saved the birds from ending up in a zoo.

YS: Although you originally did have permits from the states to do your migration.

KC: I work under a federal permit that allows me to work with whooping cranes. We are required to also have state permits to work with cranes that may end up in a particular state. As a private contractor, it sometimes seems as though you need a permit to hold a permit. I apparently did not have the proper permit to transport the cranes from Wyoming back to Idaho. Again, it was fortunate for the birds' sake and for the sake of science that we were allowed to bring the two whooping cranes here to Yellowstone Park.

YS: Somewhat unfortunately, perhaps, they're both females, right?

KC: According to blood tests they are both females. The only way to tell the sex of a whooping crane is through a blood test, and the tests indicate they are both females.

YS: For the last eight to ten summers we have had one or two whooping cranes from the foster flock that have showed up in Yellowstone. Is there any chance that these birds might meet up someday and possibly mate?

KC: One of the cross-fostered whooping cranes summers at Red Rocks, Montana; the other summers here in the park in Bechler Meadows. We were able to get the ultralight cranes to associate with the cross-fostered cranes during the winter in New Mexico.

There is a slim possibility that the birds could mate provided they are of the opposite sex. We are not completely sure on the sex of the older cross-fostered birds. At any rate, they do not pair until they are 3 to 5 years of age, so it will be a while before that could happen. Getting them to survive to that age is our main objective right now.

Post-interview note: The two whooping cranes were released in the Slough Creek area on May 1, 1998. As a result of human activity in that area it was decided that it would be better to relocate the birds to a more remote part of the park.

Catching a flighted bird is always easier said than done. Three unsuccessful attempts were made to capture both cranes. In mid-July one of them was caught and moved to the Bechler Meadows area. It readily joined with an old cross-fostered whooping crane that has been coming to the park for several years. In late September, both ultralight cranes and the cross-fostered whooping crane migrated to Teton Basin, which is a typical staging area in the fall for cranes. The two ultralight cranes joined back together after being separated for about two months. They remained in the valley for nearly a week before leaving. Both cranes were found in New Mexico but were in separate locations. One returned to the Bosque Del Apache NWR while the other was seen near Farmington, New Mexico, in early November 1998, and was seen near Wilcox, Arizona in January 1999.

Prognosis for the Future

YS: Given that these are one of the most, if not *the* single most endangered bird in North America, people are still concerned about its overall prognosis. To sum up, the chances for recovery in this flyway are not good?

KC: Not with the opposition of the states. The reason we have pushed so hard to do the research here is that we feel like this flyway has specific characteristics that increase the chance of success with this technique. The cranes in the Rocky Mountains are funneled up and down the Rockies in a very concentrated flyway. The wintering area is a narrow strip of agricultural lands along the Rio Grande River, which concentrates thousands of birds. Consequently, we stand a better chance of associating and manipulating crane behavior there than anywhere else. Twenty years of research has been conducted here in this flyway during which time a lot has been learned. We are using that information and new ideas to develop a new and better reintroduction technique.

YS: And your personal involvement with whooping cranes seems a little bit up in the air?

KC: Up in the air is one way to put it, I guess—we're grounded right now! It has been a personally rewarding experience and probably one that not too many will ever have the opportunity to do. It has been disappointing to be stopped by politics and bureaucracy, especially when the technique has so much promise. Personally, I feel there are still a lot of unknowns and many things yet to discover before we can really make a difference in the ultimate recovery of whooping cranes.

YS: Do you plan to write up your results?

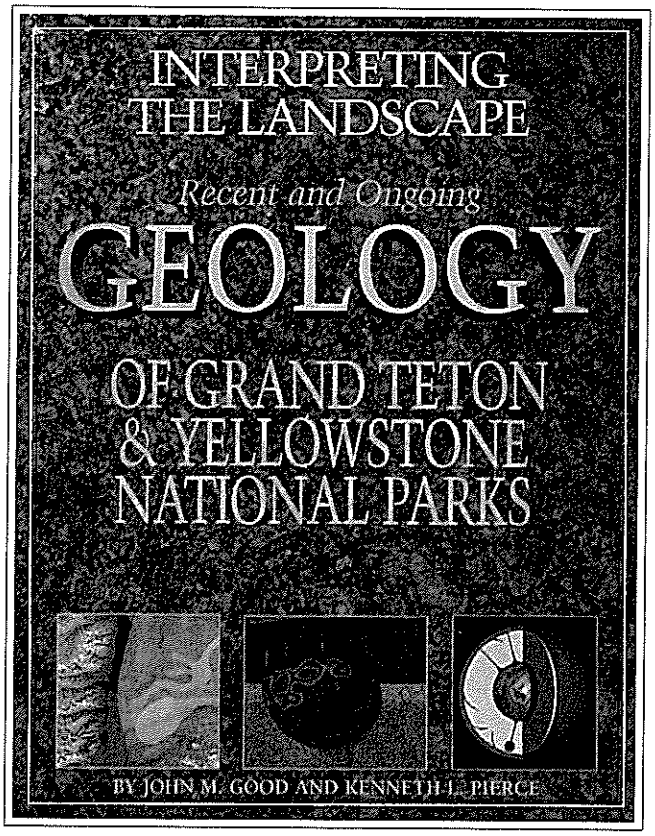
KC: We write an annual report that is sent to interested parties and contributors.

YS: We'll look forward to seeing that.

Book Review

Interpreting the Landscape of Grand Teton and Yellowstone National Parks: Recent and Ongoing Geology, *by John M. Good and Kenneth L. Pierce, Grand Teton Natural History Association, Moose, Wyoming, 1996, 58 pages. $12.95 (softcover).*

Reviewed by Neysa Dickey



If there were only one word allowed to describe this book it might be "contrasts." Pierce brings his strong background in geology to the effort while Good's interpretive skills breathe life into rock-hard concepts. They succeed in sharing their knowledge of and excitement about the geologic past, present, and future of this unique area.

"This book is aimed at growing numbers of interested, better informed visitors to Grand Teton and Yellowstone who want to learn about the youngest mountain range in the Rocky Mountain chain, one of the largest mountain ice fields in the lower forty-eight states, mountain lakes, and the sources of heat in geyser basins." The authors know their subject and the target audience, and generally hit the mark. But their task is not an easy one; explaining geologic theories, especially of the Yellowstone and Grand Teton area, never is!

Yet in less than 60 pages, these co-authors manage to fill the reader with images of mountain-building, caldera formation, the Yellowstone Hot Spot, glaciations, and the resultant geologic landscape of today.

The concepts covered, such as convection cells, exsolution, and the complexities of multiple glaciations and nearly infinite faulting, could be intimidating for the average reader, but the active language, full of color and analogies, helps save the day. Chapter Two, "A Flight of Fancy," gives a real feel for the time and place through the eyes of a high-flying eagle. Phrases early-on such as "flowing liquid fire," "violent gaseous currents," "rolling masses of incandescent, hot ash," and "the gun was loaded and cocked," keep even a novice reader anxious for more.

By contrast, the reader is tossed back and forth from quite technical and complex language, ideas, or graphics to wonderful metaphors, simplified explanations, or understandable drawings. Chapter Six, "Tracking the Yellowstone Hotspot," begins with a clear analogy: the Earth an egg, the crust its shell, the yolk its core, and so on. It continues to say that the deepest drill hole in America is only six miles deep, leaving the next part unexplained; that is, how do we know the mantle extends about 2,000 miles or that the crust is generally 25 miles thick?

The next chapter, "Building the Yellowstone Ecosystem," with its "busy" map showing "boundaries of neotectonic fault belts" and "lesser and reactivated Holocene" fault types, requires the reader to slow down, flip pages, and seek out the glossary frequently. Later, we're lost in stream flow and diverging terraces of the Bighorn Basin, then rescued by a clear word-picture of a tiny boat (Billings, Montana) afloat on the surface of a hot swell.

Another "saving" sentence, one that hits the reader like a two-by-four on the forehead, is found earlier, on page 16. We are wading through "hydrothermal features, heat flow, seismicity, earthquakes, gravity, and historical altitude change" to show evidence consistent with a "large, partly molten magma body at shallow depth that extends northeast of the caldera rim." We continue through low-density rocks, low seismic velocities, hot-but-not-molten-rocks, and emerge to the perfect summary: "Thus we see that Yellowstone's fires are only banked, not out."

Other comparisons move us along comfortably: likening the eruption of the Lava Creek Tuff to a shaken bottle of carbonated water, the "...north end of the Teton range was like a ship's prow, separating ice streaming to the south from that to the west;" viewing a glacier as a conveyor belt; and "That's a geological rocket!" referring to the uplift rate at LeHardy Rapids. Geology comes alive.

Humor inserts its smiling face, too. In discussing the unique properties of water comes, "This is why ice floats on lakes and gin." And, yes, even poetic language coaxes us to enjoy that often-dreaded subject—geology! In dealing with snow, ice, and glaciers, "The crystals (snow-

flakes) are so delicate a baby's breath melts them or the sweep of your hand sends thousands dancing from your car roof."

At times, the language approaches "slang" and may hinder the message. "Miles of streams man [sic] hasn't messed with..." might be gentler on the mind's ear as "humans haven't tampered with..." It would seem more appropriate in a book like this to avoid anthropomorphism and personal opinion, too. In writing about how adaptable lodgepole pine forests are to sterile rhyolitic and silicic soils the authors state, "Their adaptability is why you see so many miles of boring forest along Yellowstone roads." Boring? And towards the end of the book: "We know beavers were splashing happily and munching willows..." Splashing? A certainty. Happily? Well...

The bulk of hardcore science throughout the book is supported, whether by referring to the research work of Pierce and Morgan concerning the hotspot or turning our minds to the convincing evidence of seismic studies. The frequent summaries, glossary, index, and selected additional reading list all help to clarify or substantiate the authors' words. With that said, then, it is unfortunate that this book didn't receive the high quality of proofreading, binding, and design factors it deserves. There are many typographical and occasional grammatical errors. Other items range from tiny glitches (inconsistences in the diagrams on page 11) to distracting, inaccurate references (on page 24, we are referred to a map on pages 20–21 when it is actually on pages 22–23; page 34 text refers us to Figure 9.8 when 9.7 is meant instead).

Although this book isn't intended to go into details of the particular features of the Yellowstone-Grand Teton landscape, an explanation of the formation of the Grand Canyon of the Yellowstone River, a critical chunk of the geologic mosaic, seems to be missing. It could come on page 33 as the authors talk about glaciers. "In early Pinedale time before the Yellowstone Plateau was ice-covered, ice from the Beartooth uplands flowed southward up the Grand Canyon of the Yellowstone River, then ice-free. This advancing ice front dammed the Yellowstone River creating ancestral Hayden Lake whose silts, sands and gravel form the rolling, grassy hills of Hayden Valley today." Or perhaps it belongs on page 46, with the relating of torrential flooding of the Yellowstone River's Black Canyon and Yankee Jim Canyon. Instead, we lack the connections of glacial dams, Hayden Lake, and flooding to the formation of the Grand Canyon, one of the area's primary features.

Still, the strong points of *Interpreting the Landscape* far outweigh its weaknesses. The authors have captured the excitement of this geologic story—the realization that volcanic events forming Yellowstone and Grand Teton national parks weren't just projects of millions of years, but a sequence of explosions and flows on a short time scale; that it all required a heat source much larger and younger than ever before imagined; that in hours (most likely), more than 240 cubic miles of Lava Creek Tuff lay within and around the caldera, and that thermal features, waterfalls, lakes, rivers, plants, and animals, so much a part of the Yellowstone story, all are dependent on the area's geology.

Return to page 1. Read the goal of their efforts. "We describe the geologic events and processes that created the landscape we see today, the stage that defines play and players." Yes, gentlemen, you do and you do it well.

Neysa Dickey has served in six national parks and two regional offices since she began her NPS career in 1975. She came to Yellowstone in 1994 as Canyon District Naturalist, where she and her staff regularly explain Yellowstone's geology to thousands of curious park visitors. She has written and edited articles for a number of newsletters and Park Service publications. ❄

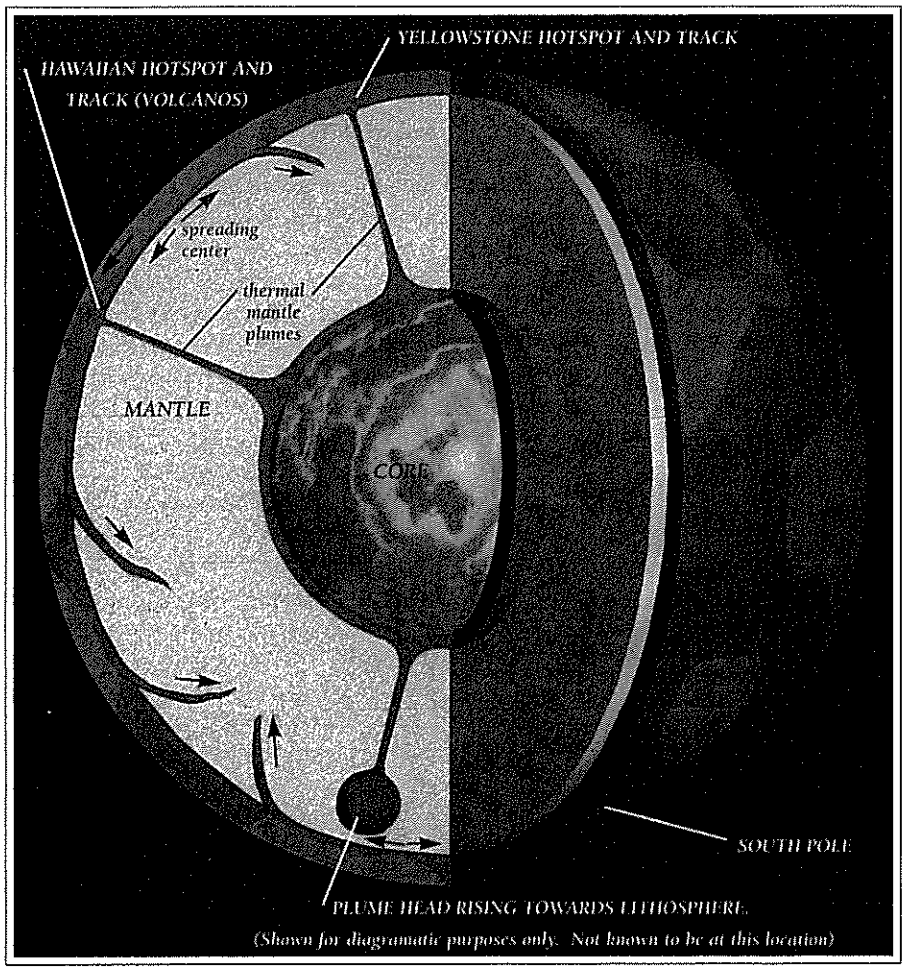
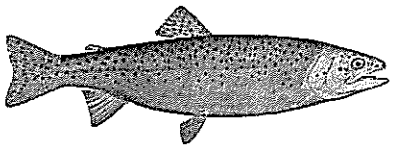


Illustration on page 17 in Interpreting the Landscape of Grand Teton and Yellowstone National Parks: Recent and Ongoing Geology.

Whirling Disease Found in Yellowstone



During the 1998 field season, staff from Yellowstone's Aquatic Resources Center confirmed the presence of whirling disease in the park. In recent years, the disease, caused by a parasite that attacks the cartilage of young fish, has been found in streams around the park, but previous sampling efforts had not indicated its presence within Yellowstone. In three separate tests, native cutthroat trout taken from near Clear Creek, a major spawning tributary to Yellowstone Lake, tested positive for whirling disease. The affected fish are unable to feed normally, which often results in the victim being more subject to predation, starvation, and premature death. Biologists will test additional cutthroat trout from in and around Yellowstone Lake during the summer of 1999 to learn more about the extent of the disease.

NAS Begins Review of Natural Regulation Policy

In 1998, Congress requested the National Academy of Sciences (NAS) to initiate a comprehensive and objective review of the so-called "natural regulation" policy in Yellowstone. A budget of $500,000 was allocated for the task, estimated to take two years, and 12 scientists were named to serve on the group. An initial visit to Yellowstone took place in January 1999; subsequent field trips to the park and visits with academicians are planned during the course of the committee's investigation. The policy, initiated after a major review of wildlife management in the national parks was completed in 1963, has often been criticized by game and range managers. The committee members are expected to review voluminous amounts of research, particularly related to the ecology of Yellowstone's northern range.

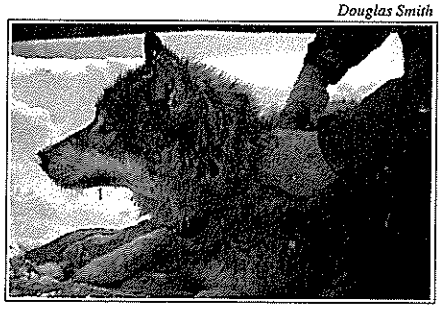
Legislation Gives NPS New Mandate for Research

On October 13, 1998, Congress passed an omnibus bill that provided for a number of improvements to National Park Service (NPS) programs. Title II of the act provides "clear authority and direction for the conduct of scientific study in the National Park System and to use the information gathered for management purposes; to ensure the appropriate documentation of resource conditions...to encourage others to use the NPS for study to the benefit of park management as well as broader scientific value...and to encourage the publication and dissemination of information derived from studies...."

The legislation directs the Secretary of Interior to undertake a program of inventory and monitoring to establish baseline resource conditions in the national park system, to be coordinated with other federal information collection efforts. Information concerning the nature and specific location of resources that are endangered, threatened, rare, and commercially valuable, and objects of mineral, paleontological, or cultural patrimony may be withheld unless determination is made that disclosure "would not create unreasonable risk of harm, theft, or destruction of the resource or object...."

Wolf Monitoring Continues to Show Success

Douglas Smith



Biologists successfully captured and radio-collared 24 wolves from 7 packs in and near the park since January. The goal, as in previous years, was to capture and radio-collar 30 to 50 percent of the pups in each pack and replace or install collars on the two lead adults in each pack. This will ensure continued monitoring of up to 11 wolf groups or packs that have become reestablished in the greater Yellowstone area. The capture operation is a part of a monitoring plan approved in 1995. During this year's helicopter-darting, a female pup, one of a litter of 10 born last spring to the Rose Creek pack, was injured and had to be euthanized on January 17. In a fluke accident, the animal was hit directly on the hind leg bone by a capture dart, causing a compound fracture of the tibia. Before the decision was made to euthanize the animal, the wolf was examined by two veterinarians who felt that there was low likelihood the animal would avoid infection, be successfully treated, and be able to be returned to the wild after treatment, especially during the winter months when wolves tend to move long distances through heavy snow. Since wolves were reintroduced into Yellowstone in 1995, 69 animals have been captured and radio-collared without any previous injuries.

Fifth Biennial Science Conference to Focus on Alien Species

"Exotic Organisms in Greater Yellowstone: Native Biodiversity Under Siege" is the theme of the Fifth Biennial Science Conference on the Greater Yellowstone Ecosystem, to be held October 11–13, 1999, in Mammoth Hot Springs. The conference series provides a forum for researchers, managers, and other interested persons to discuss scholarly work and professional resolution to issues that affect Yellowstone's resources. Potential topics for presented papers and panel discussions include: defining exotic or alien species; environmental history of non-native resources; effects of alien species on native resources and human experiences; biocontrols and other management techniques; and ethical considerations in managing exotic organisms. Abstracts will be accepted through March 15, 1999. For more information contact Joy_Perius@nps.gov or call (307) 344-2209.