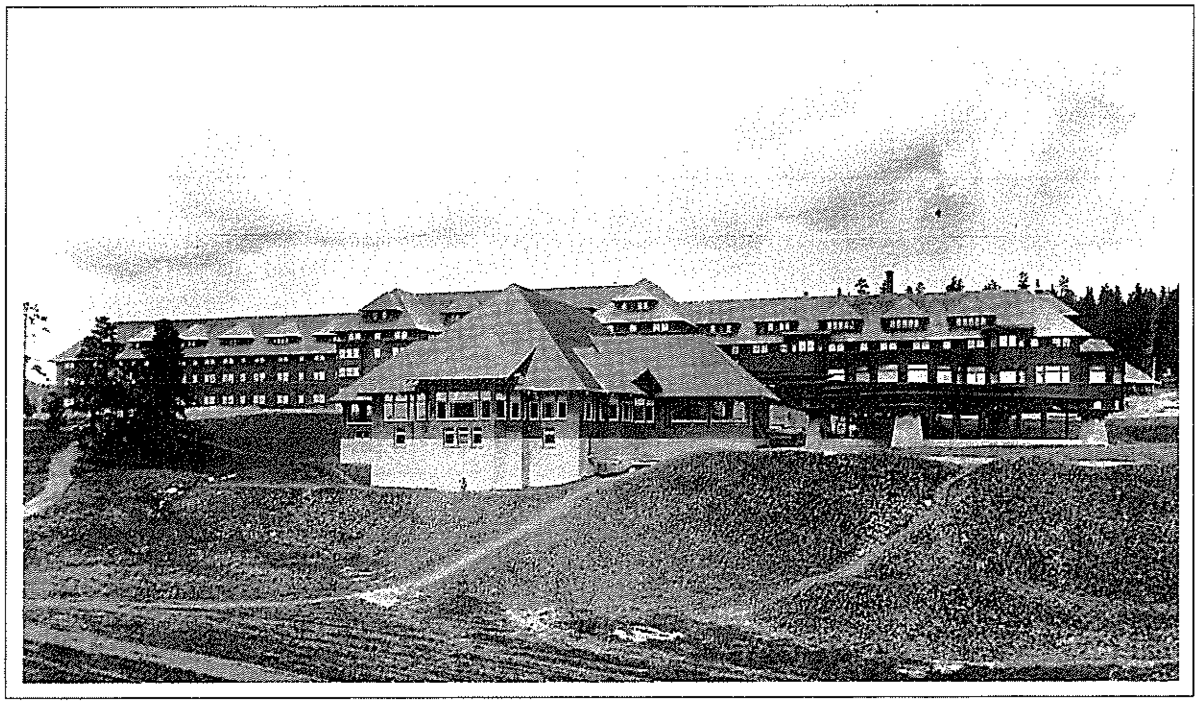
Yellowstone Science

A quarterly publication devoted to the natural and cultural sciences

Yellowstone Lake in Change
Litter Invertebrates and Fire
Roads and Culture
Bison Planning

Volume 4 Number 2



Canyon Hotel, 1914

The Cultural Component

If a representative sample of the American public were asked. "Who works in Yellowstone National Park?" it seems certain that the most common answer, perhaps the only answer, would be "rangers." We like to think that if those asked had seen *Yellowstone Science*, they'd also say "scientists," but even if they know that both rangers and scientists work here, they quite literally don't know the half of it. While the ranger has always been an important symbol of the national parks, and admitting even that rangers play an amazing variety of roles in the parks (from fire fighting to public education to emergency medicine), it is part of the irony of the Yellowstone experience that historically it has depended even more on people the visitors never saw or heard of.

At least half of the park's budget goes to maintenance of the elaborate, historic, and ever-aging infrastructure of the park: roads, trails, buildings, and all the other conveniences that both facilitate and complicate our experience of the park's wild setting.

Through Eric Sandeen's review essay of a newly published history of the park's road system (page 10), we are introduced to perhaps the single most important element in the average visitor experience here. Yellowstone's road system was laid out a century ago by a few foresightful engineers to whose esthetic sensitivities we owe much of the pleasure of a park visit. They understood more than construction techniques; they understood landscapes, and how to move people through them in a way that would make the most of the experience. Through studies like Culpin's, and essay's like Sandeen's, we are reminded that Yellowstone is truly a cultural landscape as well as an ecological one, and that something as seemingly mundane as a strip of pavement is in fact a powerful force in defining our relationship with nature.

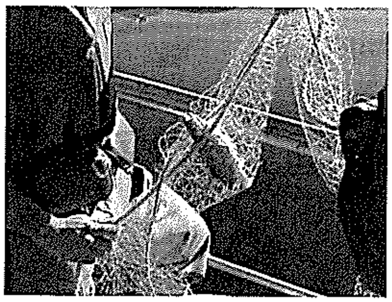
PS

Yellowstone Science

A quarterly publication devoted to the natural and cultural sciences

Volume 4 Number 2 Spring 1996

Table of Contents



On the cover: The Corkscrew bridge near Sylvan Pass in 1913 captures the spirit of the more leisurely pace in early park travel as it reveals changing esthetics in road design. See the review essay on Yellowstone's road history beginning on page 10. NPS photo.

Above: Gillnetting may become the most effective way to contain the lake trout that threaten Yellowstone Lake's cutthroat trout population. See the interview with Bob Gresswell beginning on page 4.

Yellowstone Science is published quarterly, and submissions are welcome from all investigators conducting formal research in the Yellowstone area. Editorial correspondence should be sent to the Editor, *Yellowstone Science*, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, WY 82190.

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.

Terrestrial Litter Invertebrate Communities in Yellowstone National Park

by Tim A. Christiansen

Invertebrates comprise a major portion of the faunal density contained within forest and sagebrush habitats. Generally, vertebrates comprise less than 0.2 percent of the fauna in most ecosystems. Invertebrate communities include species of insects, spiders, mites, millipedes, pillbugs, centipedes, round worms, and pseudoscorpions. Invertebrates comprise a vast amount of fauna species within the litter environment, that complex habitat that covers the soil. Litter consists of dead leaves, twigs, logs, fungus, bacteria, small mammals, and many species of invertebrates. The litter helps to provide nutrients to the soil as well as provide cover to hold moisture in the soil.

Invertebrates can directly and indirectly influence many aspects of a forest and sagebrush ecosystem. This influence includes almost every process (i.e., nutrient cycling, decomposition, seed dispersal, etc.) in forest and sagebrush ecosystems and every life stage of dominant and subordinate species of forest and sagebrush vegetation. Without insects and other invertebrates, current patterns of plant reproduction, growth, death, organic material decomposition, and nutrient cycling would not exist.

Following the fires of 1988, my colleagues and I studied insect communities in burned and unburned forest sites and sagebrush sites across the park.

A total of 134 litter invertebrate species were found in forest stands, and 60 invertebrate species in sagebrush habitats. The majority of these species were mites (*Acari*) and springtails (*Collembolla*). The majority of species

An older pine stand. These stands usually contained lower diversity of litter invertebrates than younger-aged stands.

found in forest stands were different than invertebrate species found in sagebrush habitat.

Lodgepole pine stands in Yellowstone National Park contained a higher forest litter diversity than found in several other lodgepole pine forest sites located in Wyoming. We measured diversity by using the Shannon-Wiener Diversity Index, a commonly used measure of the diversity of a ecological setting. This index seldom goes above 5.00, with an average range of 1.50 to 4.50. Thus, an index of 3.65 is an ecosystem that is above average in terms of species numbers, and the density of those species is fairly high. A number below 1.50 (as is found in many of the Yellowstone National Park sagebrush areas) indicates a low number of species.

The Shannon-Wiener Diversity Index in Yellowstone National Park averaged 3.65, whereas diversity in south-central Wyoming was 2.96, and 2.73 in the southeastern corner of Wyoming. Diversity in sagebrush was 1.21 for Yellowstone National Park, as compared to a diversity of 0.62 in south-central Wyoming. Thus, the park contains some of the higher litter invertebrate diversities found in either forest or sagebrush sites in Wyoming.

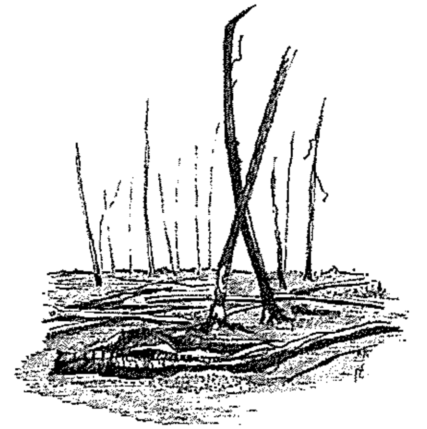
Habitat stage (that is, the plant community's age since its last fire) and habitat condition (such as the density of the trees or other vegetation) are important to the invertebrate community. Forest-floor invertebrate diversity was lower in tree stands that contained above-average densities of tree seedlings. Higher invertebrate diversity was found in middle-aged forest stands that contained higher than average densities of mature trees. Diversity was generally greater in middle-aged stands (30- to 60-year old pine stands) than in stands that were older than 60 years. Noninsect diversity (i.e., mites, spiders, centipedes, and millipedes) was higher than insect diversity in lodgepole pine stands.

Standing dead tree density influenced invertebrate diversity. Tree stands that contained large amounts of standing dead trees (such as those killed by fire, insects, or disease) contained lower invertebrate diversity than stands that had few standing dead trees. Lodgepole pine stands that contained high amounts of fallen trees supported higher litter invertebrate density.

Preliminary analysis indicated that a minimum criteria of habitat herbaceous cover (which includes shrubs, trees, and

Renee Evanoff

A studied forest stand, adjacent to a burned pine stand, the type used as a reference site for diversity and fire studies.



A burned pine stand, representative of those used in the fire study.

Above: A sagebrush site like that was used as a reference site in both the diversity and the fire studies.

Below: A fire-disturbed sagebrush site, typical of a site two years after the 1988 fires.

grasses), tree seedling density, litter, and number of logs were necessary to support high densities of mites and springtails.

What species were found, and where?

Mites and springtails comprised the majority of both species and density of forest-floor and sagebrush-floor invertebrates. Mite density was significantly higher in forest stands that contained a minimum of 40 percent herbaceous cover, 10 pine seedlings per square meter, 45 grams litter per square meter, and 14 logs per hectare. Springtail density was higher in stands containing at least 50 percent herbaceous cover, 10 pine seedlings, 50 grams litter per square meter, and at least 12 logs per hectare.

Millipedes are important litter decomposers in coniferous forests. These invertebrates were found in higher densities in stands containing at least 100 grams of litter per square meter. A large amount of log debris was required to maintain millipede density.

Ants are important in a forest ecosystem. Ants help spread seeds, break up soil crusts, and create pores in soils for better water penetration into the soil. Ant density was higher in pine stands that contained at least 70 grams of litter per square meter.

Diversity and density of litter invertebrates in sagebrush habitats increased with an increase in percent herbaceous cover. Sagebrush shrub density was important for invertebrate diversity. Areas with few shrubs supported fewer species and contained lower litter invertebrate density than areas with higher shrub densities.

What were the effects of fire?

Fire can influence litter invertebrate communities in both forest stands and in sagebrush habitats. Forest and sagebrush litter habitats were severely damaged during the 1988 fires. Diversity declined 63 percent in severely burned forest stands and had only slightly increased two years after the fire. Density declined 77 percent in severely burned stands. Sagebrush invertebrate communities were almost wiped out from the fire. Diversity declined 90 percent, whereas density declined 94 percent in severely burned sagebrush areas. Neither invertebrate diversity nor invertebrate density in sagebrush areas had increased significantly two years after the fire.

The invertebrate predator:prey ratio fell from 1:24 to 1:7.9 in burned forest stands as compared to unburned stands, whereas the ratio increased from 1:4.5 to 1:5.8 in burned sagebrush areas as compared to unburned sagebrush areas. Thus, severe fire events are a strong influence on forest-floor and sagebrush litter invertebrate communities.

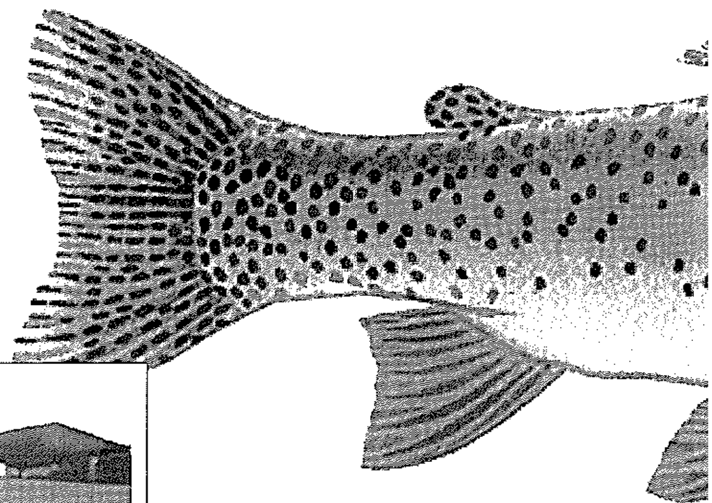
What can we conclude about Yellowstone's invertebrates?

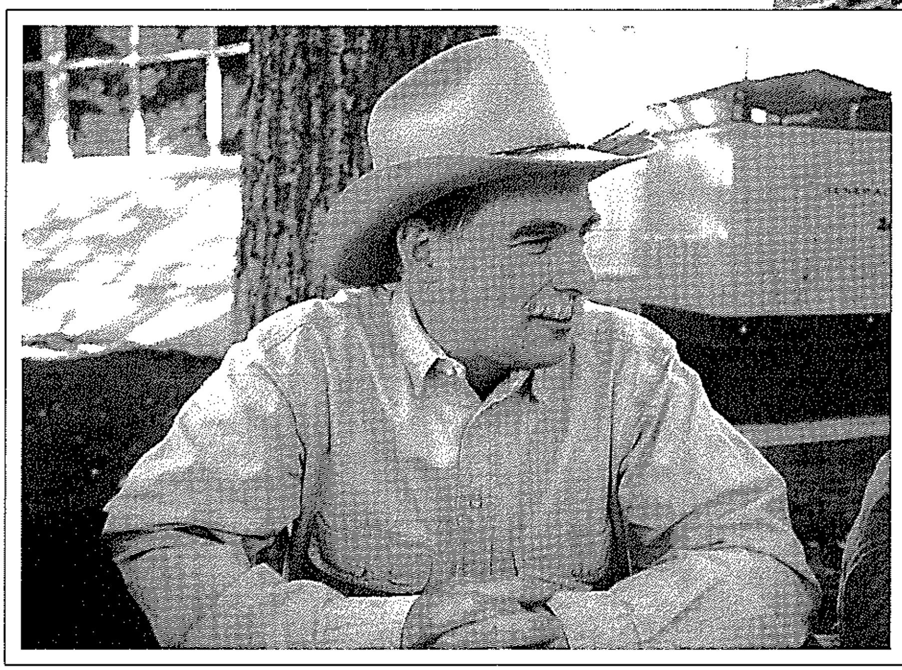
Several conclusions can be made about the forest-floor and sagebrush litter invertebrate communities in Yellowstone National Park. Yellowstone contains a higher litter invertebrate biodiversity than several other areas in Wyoming. Sagebrush habitats are as important as forest stands for the preservation and study of invertebrate biodiversity within the park system.

Fires can, obviously, disrupt invertebrate communities. A major question is how long before invertebrate communities can be considered stable after a major disruption. Also, the role of litter invertebrate communities is not well known in either forest or sagebrush systems. More information is necessary on both invertebrate habitat requirements and the role invertebrates play in ecosystems.

Tim Christiansen recently completed a post-doctoral fellowship in the Division of Forestry at West Virginia University. He is currently working on several technical manuscripts based on the research summarized in this article, as well as a volume on the ants of Yellowstone.

Yellowstone Lake and Change





What can natural history tell us about the fate of the Yellowstone Cutthroat?

Robert Gresswell has been studying and working on Yellowstone Lake for more than 20 years, first as a fisheries biologist with the U.S. Fish and Wildlife Service, and more recently as an adjunct assistant professor at Oregon State University. A member of the special lake trout workshop held early in 1995 to deliberate on the lake trout crisis, Bob has published many important articles and reports on the Yellowstone cutthroat trout. This interview, conducted last September, provided us with an opportunity to invite Bob to expand on the ideas and information presented at that workshop, and more especially on the results of his own recent research.

YS: Of course the big issue these days with the Yellowstone cutthroat trout is the much- publicized illegal introduction of lake trout in Yellowstone Lake. You've worked on Yellowstone Lake for more than 20 years now, and must be one of the most widely published Yellowstone Lake researchers now active. How would you characterize what is going on there?

BG: Well, speaking as someone who tries to be an eternal optimist, it's hard to view that situation optimistically. The recent population modeling work we've done makes me even more of a pessimist. The results of this summer's [*1995*] sampling and the angler catch suggest that the lake trout are well established in the lake and their population seems to be expanding quite rapidly. Perhaps the best that we might be able to do is maintain persistance of Yellowstone cutthroat in the system. I think that we have to try, and the sooner that we get to work on it, the sooner we begin to move, the better.

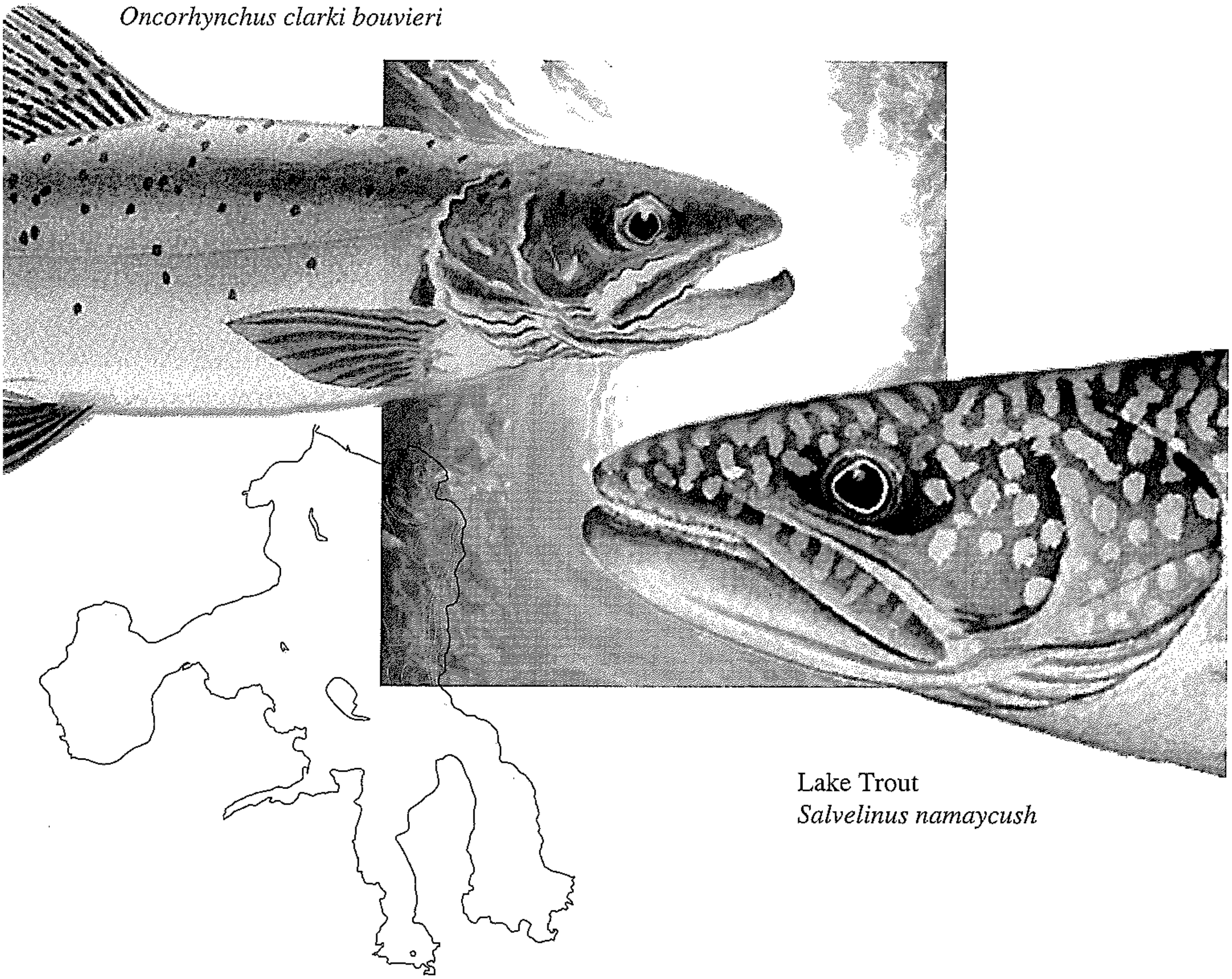
YS: Do we know enough to do that well?

BG: Even in the absence of better information we have to act while the lake trout population is still expanding. At the same time, there are a lot of information gaps that we'll need to work on, to improve our ability to reduce lake trout numbers.

YS: How much can we hope to reduce them?

BG: First, it's important to acknowledge

Cutthroat Trout
Oncorhynchus clarki bouvieri



Lake Trout
Salvelinus namaycush

that there is no way that we're going to be able to remove them completely. But with enough intervention, we might be able to stabilize the situation at a point where the lake trout population is low and the cutthroat population can be maintained.

YS: Tell us more about the modeling that you've been involved in.

BG: Our primary interest is the interaction of the juvenile lake trout with both the adult and juvenile cutthroat trout. Our understanding of their food habits, based solely on the scientific literature, suggests to us that the lake trout might actually compete with both the juvenile and the adult cutthroat trout.

YS: The juvenile lake trout would compete with the juvenile cutthroat trout for zooplankton?

BG: Right. But they might also compete with the adult fish.

YS: How?

BG: At this point we're not sure exactly where these young lake trout are going to hang out in Yellowstone Lake. If they have more of a littoral existence, that is if they live in shallow water and near the shore, then they could become a direct competitor with the adult cutthroats. The adult cutthroats don't eat many small fish, and so the juvenile lake trout aren't going to provide them with a significant food source, but there is a possibility that there will be substantial overlap of preferred foods.

The models are designed to predict consequences of certain scenarios, and when you ask the model to predict what will happen when the cutthroat trout get this double whammy—of competition at all ages, and from another species that will eventually grow up and prey heavily on them—the model goes into some wild oscillations.

YS: As you know, there are people who are skeptical of wildlife models. The criticisms are usually aimed at the answers that the models provide, because they're just predictions and aren't certain. But what you're saying is that the model you're using doesn't give you definitive answers; it suggests the places where you should look first for problems.

BG: Yes, it's called qualitative modeling. This is not a quantitative population model, the kind that we hear the most about, where you put some numbers in and you crunch them and you get some numbers out. This type of analysis is totally dependent on the interaction that occurs among groups of organisms.

YS: Can you summarize that in a non-technical way?

BG: Think of it this way. Organisms can act either positively or negatively on each other, or there is no interaction. In any system, you have different levels of interaction, from the levels where the interactions are simple to those where they become more complex and less predictable, which is what happens as you add predators to the system. And so what we tend to see in these ecological systems—and this is one of the things that we need to understand better in Yellowstone Lake—is that one consequence of added predator-prey links is increased oscillations that slow the recovery from disturbance.

YS: Models concerned with system stability and its relationship to system complexity have been a hot topic among ecologists for quite a while. How does this apply in Yellowstone Lake?

BG: Well, with loop analysis, you're not going to get a final prediction of how many lake trout there will be, or at what level they're going to stabilize. What you do is focus on whether the system is going to be stable. If you can develop a set of scenarios, then you can ask the model to experiment with different scenarios; by changing various aspects of the interactions you can watch how that system reacts. And that is why I say this competition between cutthroat trout and lake trout is so important. New competition changes things dramatically in the system, and so we ought to know, or at least not just be guessing, about what that will mean in the long run. And that is where this model is very useful, because you can learn a lot about the potential changes, and not have to wait 20 years.

YS: Of course there are more than cutthroat trout and lake trout in the lake. Not much has been said about what might happen to the other fish species.

BG: I think that may actually be the worst part about it. If the lake trout acts as a generalist predator, and is able to prey on all the other species, then it isn't dependent upon the cutthroat. That means that if cutthroat numbers go down, the lake trout just switches prey. Doing that, it can maintain itself at a higher level and higher density than it can if it's feeding just on cutthroat trout.

YS: We know something about the natural history of all those other fishes, including the non-native ones. Can't we predict anything about which ones the lake trout is liable to favor right off?

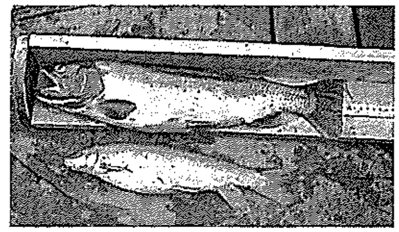
BG: It's hard to say, because of the thermal stratification issue.

YS: Explain thermal stratification.

BG: Well, the lake trout are very sensitive to temperature; they're rarely found at much above 60°F. Each year, the lake stratifies, meaning that from top to bottom there are three different temperature zones. The warmer upper waters are called the epilimnion, the middle zone of rapidly decreasing temperature is the thermocline, and the bottom zone, called the hypolimnion, is a broad deep area of water ranging from 34° to 48° F. After the lake stratifies in early summer, lake trout move down below the thermocline to the hyperlimnion and stay there. But they do make feeding forays up through the thermocline and into the epilimnion and shoreline areas looking for food.

The lake is usually only stratified from mid-July through mid-September, so you're talking about a 60- to 90-day period during which the lake trout are distinctly separated from the cutthroats that favor the warmer, shallower water. The early-season angler harvest this year clearly showed that the lake trout were in the shallower water for a while between ice-out and the advent of thermal stratification, and then just disappeared from the harvest as they moved down below the thermocline. Redside shiners and lake chubs hang around in the shallower lagoon areas of the lake, and the juvenile lake trout might go after them there. Although big lake trout don't usually enter shallow water except during spawning, the scientific literature suggests they will if food is scarce.

YS: That leaves the long-nosed sucker, another non-native, as a potential prey species.



Cutthroat trout (above) and long-nosed sucker from Yellowstone Lake.

BG: The long-nosed sucker would certainly be a prime candidate in the deeper water during the summer.

But the other thing that is very worrisome about this whole situation is that its effects don't just involve the different fish species and how they will deal with each other. When you talk to the people who work in places where cutthroat were present and lake trout were introduced on top of them, the cutthroat virtually disappeared—not completely in all cases, but statistically they might as well have been gone. If that happens here in Yellowstone, we can hardly imagine all the ramifications.

YS: Imagine a few of them for us.

BG: Start with the vertebrates. What will happen to the mammals that depend upon those fish?

YS: Nothing good, it appears. The grizzly bears have spent the last 25 years readjusting to feeding on the cutthroat spawners, and the trout have become a significant food source.

BG: I think the effects on the avian predators may be even greater. There is a whole community of birds that moves into the Yellowstone Lake area during the breeding season, and without the cutthroat, reproductive success may plummet. A really important thing that we have to realize is that the lake trout will not replace or substitute for the cutthroat as prey for all these birds.

YS: We're already hearing casual talk about the lake trout as a "replacement" for the cutthroat trout, from people who don't know much about trout natural history; they somehow think that one fish is the same as another, but the differences are profound in this case. We know that the lake trout won't be available to any of the birds except maybe the cormorant, which dives very deep. Lake trout spawn in deep water during the late fall, so they won't replace the cutthroat trout spawning runs that the bears and other mammals feed on in the lake's tributary streams. Lake trout aren't the same as cutthroat trout, and they won't serve as an ecosystem replacement species.

BG: I think it's really important to get that message across. For one thing, the fishermen will be quick to grasp what it means to the future of fishing. Those thousands of people who fish Yellowstone Lake now don't have the equipment to fish for lake trout, and probably aren't interested in trying.

YS: It's a completely different kind of fishing.

So far, we've mostly been talking in generalities about how lake trout and other species might interact. But you've spent half your life studying the specifics of the life history of these cutthroat trout, and that natural history has a lot of implications here.

BG: We have found it useful to imagine the cutthroat trout in Yellowstone Lake as a complex metapopulation.

YS: A what?

BG: A metapopulation is essentially a group of subpopulations that interact but are isolated enough in reproduction that they develop distinct characteristics. There is some genetic exchange between these subpopulations over time, and they might blink on and off as the habitat blinks on and off.

YS: How do subpopulations appear?

BG: By adapting to the specific habitats in spawning tributaries and different parts of the lake. Because cutthroat trout return to spawn in the same stream in which they were born, over time members of the individual subpopulations must adapt to conditions in the specific tributary they use for spawning. One study done on homing behavior in Yellowstone Lake took place in Arnica Creek. About 25 percent of the fish that were marked returned to Arnica Creek to spawn. None of them went anywhere else. It wasn't a big study—only about 600 fish—but all the spawners returned to Arnica Creek.

Another kind of homing is adult homing, where we're looking at repeat spawners. You mark them as they come into a stream the first time and see if they come back in subsequent years. That is how we know there is about one or two percent straying to different streams. On the other hand, we can't even be positive about that one or two percent. For all we know, the true straying rate is closer to zero; just because they enter the stream doesn't mean they stay and successfully spawn. For example, salmon do what's called "proofing" a stream, which means they might swim up the stream, kind of check it out, and then swim back down and eventually end up in another stream to spawn.

YS: So, the subpopulations of cutthroat trout in Yellowstone Lake—are they identified solely through where they go to spawn, or do some of the spawners from several streams end up congregating in one part of the lake and get identified also as a subpopulation in that way?

BG: When we analyzed different spawning runs and looked at the timing of the spawning from location to location, certain characteristics, such as the size and aspect of the drainage, accounted for two-thirds of the variation in when the fish moved into the stream to spawn. So that would suggest that these fish are keying into hydrological characteristics of a specific drainage basin. We would expect something like that; it's intuitively sensible. On the other hand, those same two characteristics also explained about two-thirds of the variation in the size of the fish, and this was somewhat harder to understand. It's more complicated than that. You see, when you talk about aspect in a more or less circular lake basin, you're not only talking about the orientation of the stream drainage, but also the location of the stream in the lake basin. It was obvious, however, that it wasn't directly related to stream size, the biggest fish were not found in the biggest streams or vice versa. Hydrology is important, but so is the location of the stream along the lakeshore. When we examined data from the lake, we found that fish size differed from one place to another. Further analysis showed that size and growth were linked to differences in general productivity in different parts of the lake.

So even when they're in the lake, it appears that there are *lake* subpopulations of this meta population that kind of hang out together. There is some tagging data from the 1950s that support that interpretation. The fish displayed a good bit of loyalty to an area of the lake, just as they did to their spawning stream. The integrity of the individual subpopulations, that is the extent to which they are devoted to one area, seems highest in the arms of the lake and in West Thumb.

We need to know more about that, and we now have some potential new techniques for learning more. We've been working with Jerry Smith at the University of Michigan on using the microchemistry of the otolith, a small bone in the fish's head. Smith has discovered that when the otolith is forming in the fish, it develops a permanent chemical "fingerprint" that can be identified with the stream where the fish hatched. If we can work out the technique, suddenly we have a situation where every fish we capture can be traced to its stream of origin.

YS: For more than half a century, Yellowstone Lake was operated like a huge trout factory. Millions of eggs and fish were removed, and many other fish were moved around in the lake and elsewhere in the park. This raises the question of how much we have already altered these subpopulations. Not only did we overharvest them for decades, we tinkered with them genetically by scrambling the spawn. Is there any way we can track that and figure out how much change we caused?

BG: Intuitively it seems we may have lost components of the metapopulation that may never come back; the whole idea of chaos theory is that where you get to depends on where you start, and Yellowstone Lake has never before been like it is now, so how can we expect it to restore itself completely to some past state?

Besides that, the environmental conditions are always different. We now have a new non-native predator—the lake trout—with great potential for changing things. And even before the lake trout got there, there were the other non-native fish introduced. For all we know, there was once a Yellowstone cutthroat trout subpopulation that lived in the shallow lagoons but they were excluded by all the non-native minnows that we introduced in the early 1900s.

But I also think there is tremendous

resilience in the metapopulation. When you consider that we are now approaching 40 years since the hatchery was closed, and remember that the lake's powerful selective forces are based on things we didn't affect much, such as hydrology and prey base and the lake's physical characteristics, it would seem that the trout populations would sort themselves out.

YS: So even if the metapopulation and the subpopulations aren't identical to what they would have been if we hadn't interfered so much the past 100 years, they're still cranking along in a viable wild system?

BG: Something like that.

YS: Back to the variations that the lake cutthroats display: you've stressed the complexity of the system. Can you give an example?

BG: A really obvious one is the outlet stream: the Yellowstone River itself. Those fish had to develop a mirror image of the spawning behavior of the fish that spawn in tributary streams, because adults actually go *down*stream to spawn, and the young fry swim back *up*stream to get to the lake. That's just the opposite of what all the other cutthroat trout in Yellowstone Lake do; all the others go upstream to spawn, and downstream to the lake.

But I think that Pelican Creek and the upper Yellowstone River probably provide the most complex examples of all. When you look at the whole Yellowstone Lake basin, with dozens of spawning streams, you see everything from tiny streams less than a kilometer long to big streams like Pelican Creek, to real rivers like the Yellowstone above and below the lake. The larger ones, like Pelican Creek, especially, and also the upper Yellowstone, are so much more complex. They have many tributaries of their own, and large, diverse basins. For example, my guess is that there are fluvial [*river-dwelling*] populations in the upper Yellowstone that have very little contact with Yellowstone Lake, just like there are trout in the river below the lake that never leave the river. There are probably all kinds of combinations of fish spending different versions of their life history in that upper Yellowstone River basin.

The same with Pelican Creek. We found some incredibly complex things going on there when we were tagging fish during the spawning runs. We had more fish coming out than we had going in, and they weren't all just two-inchers making their first trip down to the lake. We had sub-adult fish, 13 and 14 inches long, coming out of Pelican Creek in the spawning season; these were fish that had never spawned. Those fish had probably been living in the creek several years, and were making their first trip out to the lake. We also saw fish going up into Pelican Creek that weren't mature. They showed no sign of being ready to spawn. Maybe they were going up there just to prey on young cutthroat, or some other species.

One of the most unusual situations around the lake is what's happened at Sedge Creek. Sedge Creek is a tributary that has been isolated from Yellowstone Lake for about 8,000 years by a thermal area that acts as a barrier between the lake and the creek. Genetic studies of the trout in Sedge Creek show that it's like they all came out of a stamp mill. They're identical, no genetic variation at all. The population geneticists would say that that's a prescription for extinction, because if any random event threatened them, there would be no flexibility to deal with it and they'd perish. Well, that may be true, but in the meantime they've been highly selected for exactly the habitat they're in.

One of the things that is interesting about all of this is that even when you look at the Yellowstone cutthroat trout across its whole range, there isn't much genetic variability. For years people have argued that "a Yellowstone cutthroat is a Yellowstone cutthroat is a Yellowstone cutthroat." Yet there is a lot of variation in their life history, depending upon what they have had to adapt to, including all the things we've talked about: hydrology, food, chemistry, and so on. Yellowstone cutthroats just haven't been separated from each other long enough to display the genetic variability measured by the most commonly used analytical techniques.

Westslope cutthroats, on the other hand, have a tremendous amount of genetic variability, possibly because during the Pleistocene they were divided up into small isolated pockets here and there. That didn't happen to the Yellowstone cutthroat.

YS: The young cutthroats in the lake are an important part of this story, because of their unusual vulnerability. For 10,000 years or so, they didn't have to worry much about being preyed upon by a bigger fish, and now suddenly they do, and they're not prepared for it. Can you explain how that works?

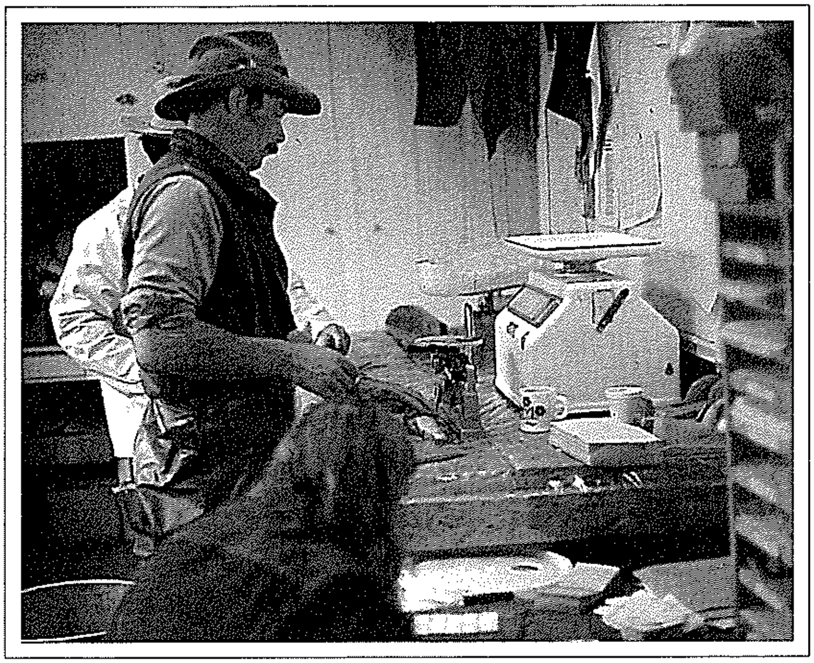
BG: In general, a month or two after they hatch in the tributary streams, the young larval cutthroat trout leave the gravel and move back to the lake. Once they enter the lake, the majority of them move into open and deep water areas, where they feed primarily on crustaceans and zooplankton. As they grow older and mature, they need larger food items in order to support this growth, so they begin to move into the more productive littoral [*shallow*] zones of the lake. They still feed on plankton, but aquatic insect larvae and adults become much more prominent in their diet.

YS: At what size do the cutthroat trout switch from eating zooplankton and start taking aquatic invertebrates?

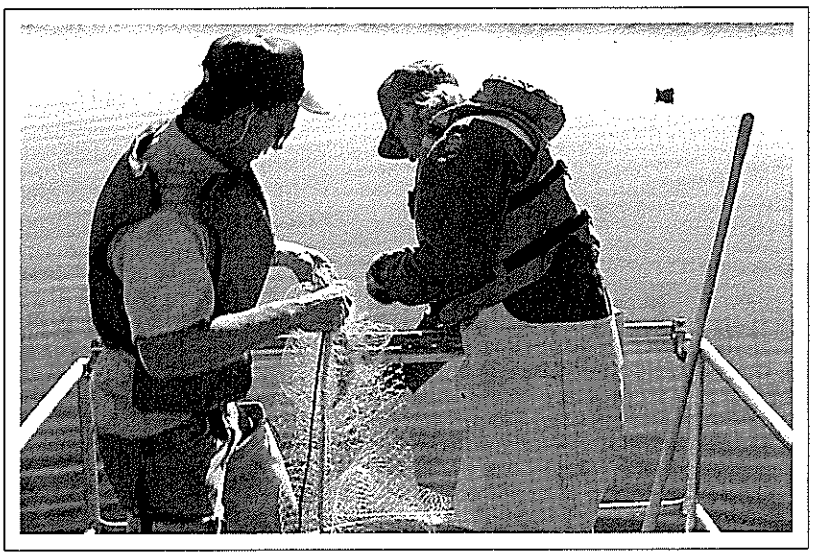
BG: Somewhere between 13 and 14 inches, which is why the 13-inch maximum size regulation works on Yellowstone Lake. If they had picked 14 inches as the maximum size limit, there would have been too many fish harvested because there would have been too many available.

By the way, food habit studies have shown another interesting variation in the lake's cutthroat trout populations. In some of my research, we looked at the percent of the littoral zone in various areas of the lake versus the size of the fish in those areas. We found a positive relationship; the areas of the lake with different proportions of shallow water had different size of fish. Where the water temperatures were higher and the water was shallower, the fish were larger. People had suspected that, and they attributed it to angling pressure, but we demonstrated that it wasn't due to angling pressure. It's just one of those interesting dimensions of the lake ecosystem, that it doesn't produce uniform-size trout everywhere.

YS: Back on the subject of the lake trout, this new method of tracing the cutthroat trout raises an interesting question. Could the chemical analysis of the otolith in the lake trout in Yellowstone Lake tell us where they're from?



Bob Gresswell conducting analysis on cutthroat trout at the U.S. Fish and Wildlife Service laboratory at Yellowstone Lake.



Jeff Lutch and Rick Swanker pulling gillnets on Yellowstone Lake. Photos courtesy of Fish and Wildlife Service, Yellowstone Fisheries Assistance Office.

Cutthroat trout spawning at Clear Creek in the park. It is these massive movements of trout into dozens of Yellowstone Lake tributaries that make the fish available and important to many species of predators.

BG: Presumably, if you gave the analyst samples of all the waters in the region from which the lake trout might have come, it could.

YS: Considering all these things we know about the various subpopulations of cutthroats in Yellowstone Lake, can you give us some examples of how those variations will play out in the lake trout situation?

BG: The cutthroat trout that are focused on the lake throughout their life history, in all aspects, may be most vulnerable to predation by the lake trout. On the other hand, things probably won't be as bad for cutthroat trout that live in tributary streams of the lake: part of their lives are going to be more protected because the lake trout don't generally go into the streams. All of the cutthroat trout will be affected by predation to some extent, but in subpopulations in places like the Yellowstone River, Pelican Creek, Arnica Creek, and Beaver Dam Creek, they may do better.

On the other hand, regardless of our model predictions, it appears that if you go in and hit those mature lake trout hard in the lake, like with gillnetting, you can reduce their numbers and reproduction, and it will be good for the cutthroats.

YS: So far, most talk about control of the lake trout has centered on a regular gillnetting program that will concentrate on lake trout. Now that we've had a second season to study the situation, do you see other things that might help with that reduction?

BG: The model suggests that we ought to think a little more seriously about food habits of both species and determining where the lake trout are spawning and ways to interrupt that spawning. It's not clear yet how we can do that, but I think that the first thing we need to do is find out what the adult lake trout are eating: what species do they eat, and at what time of year. Then we need to find out where they're spawning and when.

YS: How do we find that out?

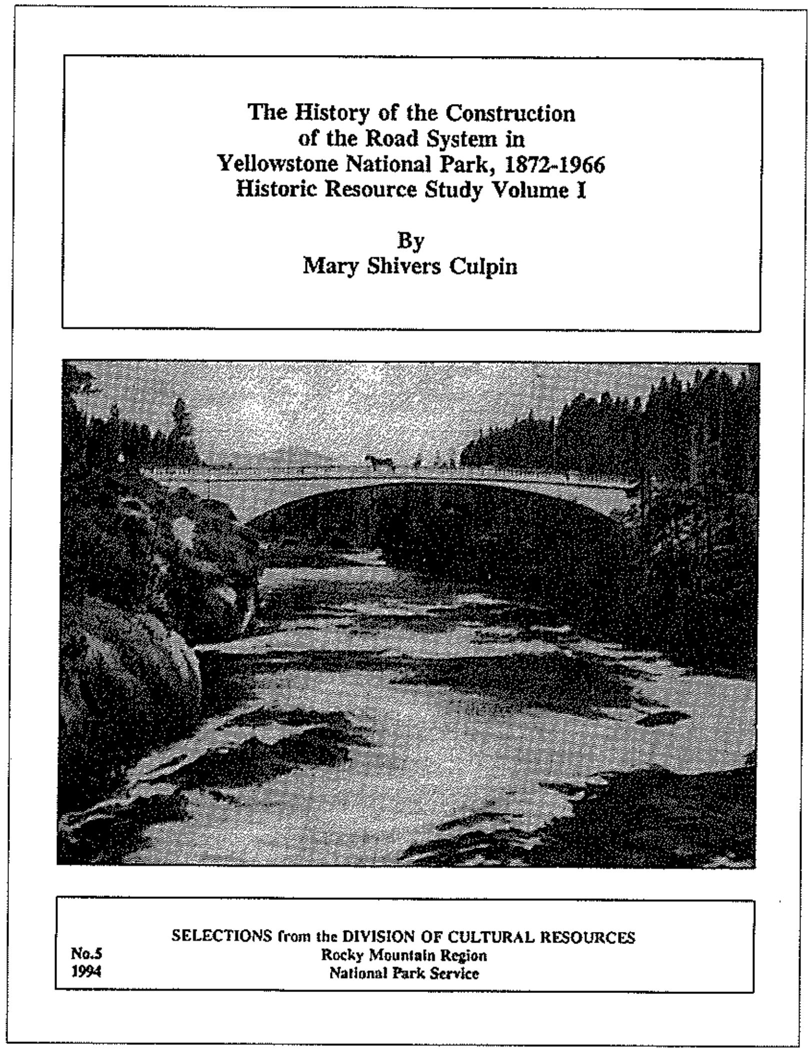
BG: One technique would use what are called "Judas fish:" lake trout that you capture and attach radios to and release. They'll lead you to the spawning areas.

Review Essay

A History of Yellowstone's Roads

by Eric Sandeen

The History of the Construction of the Road System in Yellowstone by Mary Shivers Culpin. U.S. Dept. of Interior, National Park Service, Rocky Mountain Region, 1994, 530 pages.



The History of the Construction of the Road System in Yellowstone National Park, 1872-1966
Historic Resource Study Volume I

By
Mary Shivers Culpin

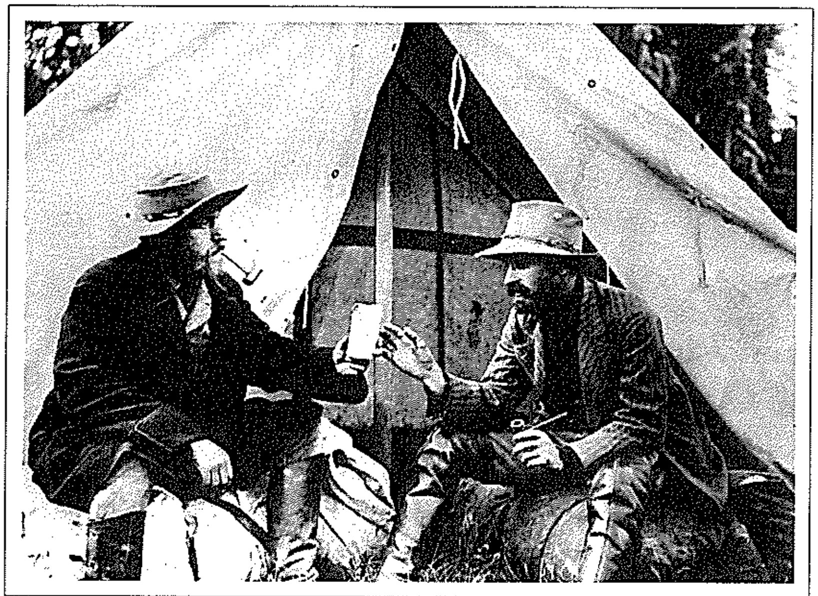
SELECTIONS from the DIVISION OF CULTURAL RESOURCES
Rocky Mountain Region
National Park Service
No.5
1994

The History of the Construction of the Road System in Yellowstone began as a response to the Federal Highway Administration's multi-decade construction project in Yellowstone National Park. This hefty volume was intended as a management tool for park personnel, even though it was commissioned only to meet the compliance needs of the National Historic Preservation Act. In that sense, this is an expansive document, which, through the scope of terrain that it surveys and the detail of its point of view, attempts to create a basic resource for those interested in historic preservation, cultural and natural landscapes, ecology, and park development.

In another sense, however, the volume retreats from a level of interest to which it does not feel that it can lay claim. Academic historians, Mary Shivers Culpin informs us, might be put off by the necessary repetition of a government report. While her work will probably not be required reading for seminars, I want to pay special attention in this review to ways in which her work connects with broader cultural concerns—a wider landscape, if you will—especially at the end of the nineteenth century. I wish to suggest that the viewpoints of those of us in universities who look at cultural landscapes complement the day-to-day outlook of "practitioners" who are at work "in the field." To play with a metaphor: it is worth considering how we can create something like an ecology of concern, using specific sites such as Yellowstone as common terrain.

Culpin's work describes the development of the road system from the creation of the park to the implementation of the Mission 66 program in the 1950s (aimed at upgrading park services and facilities). She then returns to examine the history of particular road segments, paying particular attention to the Grand Loop. Finally, she includes the nomination of the Grand Loop as a National Historic District and surveys some management issues. Historic bridges were photographed and documented according to the ongoing Historic American Engineering Record (HAER) project (page 481), but these photographs and drawings are not included in the volume. The volume does contain useful photographs of Yellowstone, however, along with two historic maps. This is a government report and shows clearly the template of those who commissioned the work.

Culpin is right: there is repetition here, but there are also enough details in this lengthy work to keep any park *aficionado* occupied. Park administrative history, the placement and condition of roads and



Lt. Dan Kingman, United States Corps of Engineers, early pioneer of park roadbuilding esthetics, and Lt. R.C. Stivers, 9th Infantry, 1885.

trails, the function of the Army Corps of Engineers and other entities, and the steady inundation of tourists are all dealt with in sufficient detail in Culpin's work. Since I am not an historian of the park, the specifics of Culpin's account are beyond my criticism; I would merely note that what she says correlates well with the standard accounts of the development of Yellowstone.

Of more general interest is her account of the development of a landscape esthetic within the governmental agencies responsible for opening this remarkable territory "for the benefit and enjoyment of the people," as Congress had proclaimed in 1872. If the reader wishes to explore the larger issue of the visual presentation of the park to visitors, Culpin assists by focusing our gaze onto the road system, the most obviously intrusive imposition of the human order within Yellowstone. The road and trail system in Yellowstone expanded very quickly—to more than 100 miles by 1878—but these corridors through the wilderness were used as passageways to what the first superintendent called "scenic and interesting views." Ruts incised by heavy vehicles and then widened by wagons of different wheel bases, tree stumps at roadside, vandalized signs (reported as early as 1879), and the dual curses of mud and dust clearly delineated the discomfort of travel from the invigorating promise of tourism. The focus during the early years had been on the construction of the roads themselves. Through the work of two men, Lieutenants Dan Kingman and Hiram Chittenden of the Army Corps of Engineers, attention was drawn to the view from the road, the presentation of the natural wonders of the nation's first national park to the eye of the tourist.

In 1883, the Corps of Engineers began supervising the construction of roads and Lt. Kingman gradually reshaped the human landscape of Yellowstone. The roads, he concluded, "should have something of the solid, durable, and substantial quality that usually characterized the works constructed by the national government" (page 26). The park should be protected from "mammoth hotels," "the race course," "the drinking saloon and gambling table," and "the noise and smoke of the locomotive" so that it would belong to the whole people (page 27).

His successor, Hiram Chittenden, continued this good work over two tours of duty in the park, extending into the early part of this century. He supervised the clearing of dead timber within 100 feet of roadways, the placement of signs and mileage posts on major roadways, the positioning of guardrails "at the most precarious points," and the alignment of slopes and cuts. Thus he hoped that the roads would "themselves be made one of the interesting features of this most interesting place" (page 49). He was also an

Road Crews on Mt. Washburn, 1903. All photos courtesy Yellowstone Park Archives.

effective advocate of the construction budget, which, he informed his superiors, was intended for an area as large as the state of Connecticut.

According to Culpin, Kingman and Chittenden influenced the following 1918 policy statement of Franklin Lane, the Secretary of the Interior, concerning construction and improvements within the newly formed National Park System:

> In the construction of roads, trails, buildings, and other improvements, particular attention must be devoted always to the harmonizing of these improvements with the landscape. This is a most important item in our program of development and requires the employment of trained engineers who either possess a knowledge of landscape architecture or have a proper appreciation of the aesthetic value of park lands. All improvements will be carried out in accordance with a preconceived plan developed with special reference to the preservation of the landscape, and comprehensive plans for future development of the national parks on an adequate scale will be prepared as funds are available for this purpose (page 87).

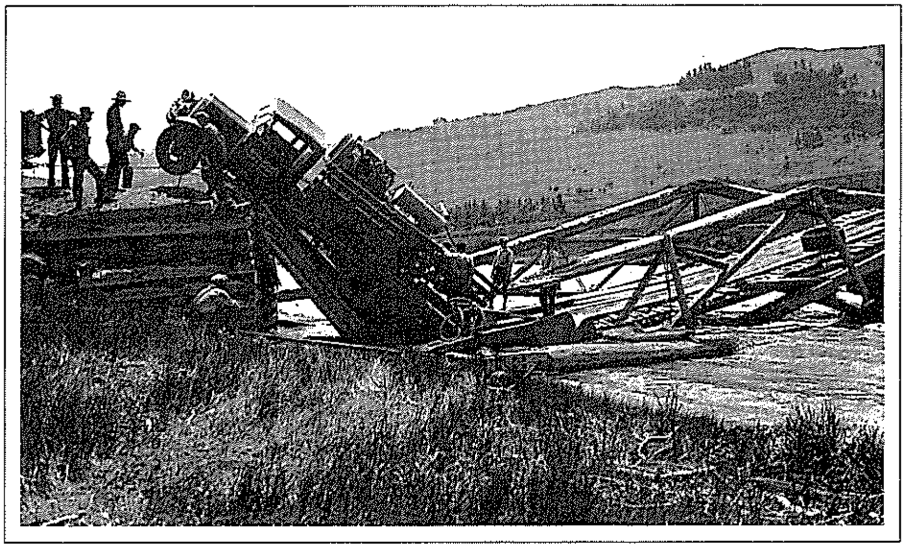
This proclamation occurred at an important moment. Automobiles had begun to enter the park in 1915 and were poised for a new invasion after the conclusion of World War I—visitorship rose from slightly more than 62,000 in 1919 to more than 100,000 during the 50th anniversary year of 1922. The race was on.

At the same time, two important figures, Horace Albright, who became superintendent of the park in 1919, and Stephen Mather, the first director of the National Park Service, began to exert their enormous influence. These are well-studied careers, which I will not attempt to rehearse here (Culpin, too, wisely leaves these extraordinary personalities off stage and deals with them through their administrative decisions).

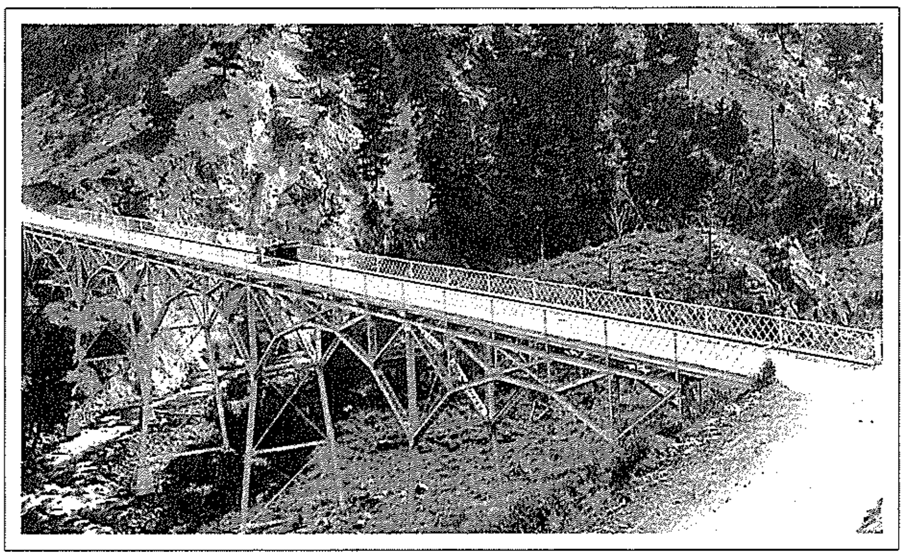
Through Mather we can see the overwhelming impact that the automobile has had on Yellowstone. The development of good road systems outside the parks had by 1922 made the park roads seem substandard. The Park-to-Park Highway movement, which encouraged tourists to pioneer the road between, say, Yellowstone and Crater Lake, promised more road-weary families who would be accustomed to viewing scenery at speed and would not tolerate traffic jams or the unseemly jostling of worn-out roadbeds. Mather looked down the road and saw what was coming. Against the phalanx of approaching headlights, his argument focused on the preservation of a Yellowstone experience that was anachronistic, that encouraged people to step out of the twentieth century and, if not into the forest primeval, then at least into a more relaxed tourism that predated the internal combustion engine:

> The automobile should revolutionize the park tour, just as it changed travel conditions everywhere and turned into memories cherished methods of seeing and doing things. However, the old atmosphere of the Yellowstone is still to be enjoyed, not perhaps on the roads, certainly only a few hundred yards distant, where the trails take their winding course through the forests (page 110).

The view from the road, the necessary veneer of exurban detritus at roadside, the willful immersion into the primitive environment that lay beyond (if only people could be coaxed away from the



Above: The Lamar River Bridge broken by overload, 1932. Below: Gardner River Bridge, 1917.



road)—these basic themes of twentieth-century tourism were established early on.

Superintendent Albright improved the view from the road. Starting in 1919, "vista cuts" were made at roadside, to further enhance the experience of the windshield tourist (page 110). Shortly thereafter, he began tidying up the roadside. Through his chief of landscape engineering, Daniel Hull, he ordered that "any new barrow pits, sprinkling stations, and telephone and electric service lines should be placed in the least noticeable positions. In the past, most of these services had been placed in the 'easiest' location, without regard to the effect on their landscape" (page 113). He encouraged Stephen Mather to rule in 1921 that no new roads would be built in Yellowstone, so that all resources could be directed to the existing system, but still, appropriations for improvements languished and the roads began to deteriorate.

John D. Rockefeller, Jr. entered the park in 1924. Already he was at work on his legendary acquisition of land assembly in the Tetons, south of Yellowstone. His practiced vision, softened by the delicate historic recreation at Colonial Williamsburg and civilized by his donations to the restoration of Versailles, spotted the most visible eyesore immediately: the stubble and fallen timber by the side of the road. While he acquired the land that would become the best viewing platform for Grand Teton National Monument, he also contributed money to his new friend Albright for the removal of trees and underbrush in Yellowstone (page 129).

In 1926, responsibility for Yellowstone roads passed to the Bureau of Public Roads, a sign of the increasing national concern for a highway network and, Albright complained, a sure indication that construction costs would rise. Between that year and the beginning of World War II, road traffic would increase fivefold (page 152).

A fascinating subject, which bears further investigation, is tourism within the park during the Great Depression. The New Deal story is more familiar and, in all likelihood, more significant for the road system that Culpin is studying. "It was during these years of extensive road reconstruction and bridge building that the National Park Service wrote stringent specifications for special landscape features such as masonry guardrails, wooden guardrails, and stone paving. The specifications covered the materials, construction, and treatment of the features" (page 148). But during the early part of the Depression, when times were notoriously tough, visitorship actually rose 5% (page 143). It is clear what Albright saw in this. Parks would exert "a strong influence for stabilization and good citizenship." "[I]n a time of anxiety and restlessness, they were immensely useful to large numbers of people" (page 143). For a student of American culture, the value-laden words "citizenship," "anxiety," "restlessness," and "useful" beg for exploration from the tourist's point of view.

Another explosion of tourist interest detonated quickly after World War II: from about 350,000 visitors in 1946 to more than 825,000 only a year later. By 1953 the park was so overrun that Bernard DeVoto advocated closing Yellowstone because of the "nationally disgraceful situation" regarding support and maintenance (page 175). The Mission 66 process initiated by the Park Service may have turned attention to the historically underfunded road system, but it also produced the transplanted superhighway interchange at the Old Faithful junction with the Grand Loop. Culpin allows herself an editorial comment against this disorienting concrete merry-go-round, the park's most intrusive feature.

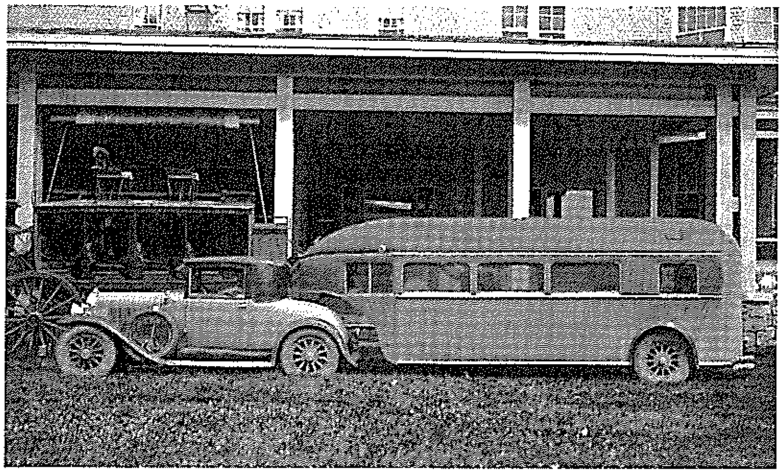
Even my brief overview of a massively detailed work indicates that the story of the roads is intertwined with the experience of the tourist, the development of a reading of the landscape (both by the tourist and by park administrators), and the construction of a relentlessly technological culture surrounding the park. In other words, the park quickly became a cultural text, important both for what it said about nature and culture and for what it was seen to argue against—the urban, or increasingly suburban, world of the vast majority of tourists who visited what one popular writer has called the last refuge.

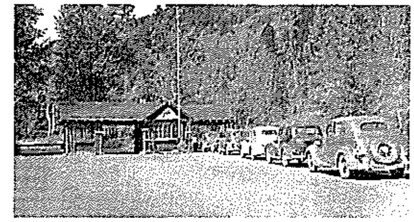
The text of Yellowstone has most frequently been written according to the Anglo-American inscription that begins in the 19th century. Thus we have the history of explorers, scientists, and photographers, so well chronicled by such eminent historians as William Goetzmann and critiqued by cultural historians like Peter B. Hales. The ecological literature regarding Yellowstone is also immense and, in the terms that I am using, could be read in individual historic contexts, as projections of contemporaneous visions of historical development and American destiny.

Yellowstone has been seen as valuable cultural terrain. John B. Jackson, one of the most prominent proponents of cultural landscape study, summarizes the importance of Yellowstone with a statement and a question: "First it was the mining lands which were officially recognized as possessing distinct characteristics of their own; then it was land suited to irrigation, then forests, until much of the American landscape became a composition not only of political units but of natural environments. And was it not this new kind of definition of land that inspired the creation in 1872 of Yellowstone National Park?"(*American Space*, page 27). For Roderick Nash this is not a rhetorical question. In *Wilderness and the American Mind* he portrays Congress as forming the national park only after assurances that the terrain had no higher economic use.

Such debates over cultural and economic value—and the representation of natural space as either a presence or an absence—are extensive and endlessly fascinating. However, I would like to put the articulation of Yellowstone as a cultural text into conversation with theories about what was occurring in vastly different locations in American culture. The point of view that I am taking owes a debt to Alan Trachtenberg's book, *The Incorporation of America*, which draws together phenomena from both West and East into a study of a consolidating American culture at the end of the nineteenth century.

Culpin's work gives us enough clues to see how such a larger realm might be formed. Occasionally, one of her sources will make an explicit comparison to this broader world. For example, Lt. Kingman advocates a good road system and ex-





Cars lined up to be checked in at the East Entrance checking station, 1929. Left, a "house car" at Mammoth Hotel August 26, 1930.

cludes road houses and race courses because he does not want "a sort of Coney Island" (page 27) to invade the park. Culpin takes pains to differentiate this landscape aesthetic from Central Park, another New York reference. The better connection with the East may not be through theories of landscape gardening. Frederick Law Olmstead or Andrew Jackson Downing had well-articulated systems of domesticated nature based on the English garden. Yellowstone is not Kew Gardens, or Central Park, for that matter. The better connection may be through conceptions of tourism and leisure that developed during the last quarter of the nineteenth century, in which special spaces were designated as compensatory realms to escape from an increasingly industrialized, alienating world. Yellowstone is the opposite of Coney Island, perhaps, because they represent two variations on a common cultural theme.

The better reference may not be the stereotypical urban area of Manhattan, but the federal city, Washington, D. C. Here again, Culpin's material leads the way. In her Historic District Nomination for the Grand Loop, she points out that:

> Before the turn of the century, there was no national road system only road systems within states, and a few state-built public roads. The Federal Government had been responsible for the roads in Washington, D. C., the roads to government posts (which in most cases were no more than trails), roads on military reservations, and for building the road system in Yellowstone National Park (page 488).

We are thus encouraged to revisit the subject of nineteenth-century road conditions. Here is one eyewitness report:

> Nearly all of the streets were dirt roadways. Where these were improved they were rudely covered with gravel, from which, in dry weather, clouds of dust arose with the breezes or from the passing vehicles, and many of the streets were almost impassible in times of heavy rains. The few that were improved with a more durable surface....were paved with the roughest sort of cobble or other irregularly shaped stones, destructive alike to the vehicles which traveled upon them, and to the nerves of those by whom those vehicles were occupied (quoted in John Reps, *Monumental Washington*, page 56).

The author was commenting on Washington roads during the year of the founding of Yellowstone, 1872. It is nonsensical to equate Washington with the Yellowstone experience. But it is instructive, I think, to compare development of a landscape aesthetic in one national epitome area (Yellowstone) with the formulation of a civic aesthetic in the federal Capitol as it approached its centennial year, 1900. Why not begin with roads, not just the surfaces themselves and the technologically based experience of traversing them, but also the view from that sometimes unstable platform and the values that were to be learned from these vistas? The development of the Mall, the removal of a rail line from the front of the Capitol building, the debates within congressional committees concerning appropriations (and what is appropriate) may have interesting resonances in the history of the western park.

One more, equally broad, connection deserves exploration, although I have only a small space to mention it here. This is the figure of the engineer, which becomes important in the park with the Kingman/Chittenden duo and which emerges as a new form of western hero in American popular culture (not to mention American legislative history in the western states) in the late nineteenth century. Those interested in that topic could turn to Cecilia Tichi's *Shifting Gears* for an introduction. Those blazing a trail through this particular terrain will be rewarded with a new vista on the subject of management, a work loaded with assumptions about the value of nature and the function of technology to bring it to productive use.

Culpin's intent is that this volume be a management tool. I would like to suggest that the broad community who read works like Culpin's consider ways in which linkages in the current day can be made that parallel those I have suggested for times past. Does the meaning of roads in Yellowstone have anything to do with the construction of a bridge/road to another national epitome area, Ellis Island, for example? Does the web that these Yellowstone roads represent also connect public interests and private, local meaning with national memory? All of us travel these roads, and shouldn't all of us talk about the view from this thoroughfare?

Eric J. Sandeen
American Studies Program
University of Wyoming

Alternative Fuel Tested for Risks as Bear Attractant

NPS photos

Almost all of Yellowstone's 3 million or so annual visitors travel through the park in vehicles powered by a conventional internal combustion engine fueled with gasoline or diesel fuel. An estimated 7.6 million gallons of these fuels are used in the park, with potential effects on plant and animal communities, including humans. Yellowstone's Maintenance Division, in cooperation with the Montana Department of Natural Resources and Conservation and the U.S. Department of Energy's Pacific Northwest and Alaska Regional Bioenergy Program, is participating in a pilot project to evaluate the use of 100 percent rape ethyl ester (biodiesel) as a low-pollution alternative to diesel fuel in environmentally sensitive areas. Many visitors probably saw the biodiesel pickup truck used last summer by Maintenance Foreman Jim Evanoff.

Biodiesel is a vegetable oil derivative with several advantages over fossil fuels: it is biodegradable (important in the case of oil spills), contains negligible levels of sulfur (unlike fossil fuels, which contribute significantly to acid rain), emits fewer hydrocarbons and particulates than fossil-based fuels, and is derived from renewable resources.

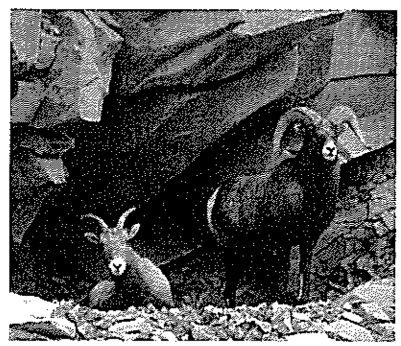
However, the vegetable base of the fuel causes concern in areas with wildlife that might be attracted to its odors, as both grizzly and black bears are quickly attracted to human foods and cooking odors in Yellowstone. As a result of these concerns, tests were conducted using the park's experimental vehicle, to determine if raw biodiesel fuel or its emissions were bear attractants.The tests, undertaken by Yellowstone bear-management personnel Mark Biel, Kerry Gunther, and Hopi Hoekstra, took place at Washington State University's captive bear facility in Pullman, Washington. As part of the tests, bears were exposed to ambient air and to odor from raw biodiesel fuel, raw diesel fuel, deer meat/dog food, biodiesel exhaust, and diesel exhaust. Of five captive grizzly bears and five captive black bears tested, all displayed a "significant non–attraction response" (they were disinterested) to ambient air, and a "significant attraction and investigation response" (they were interested and wanted to check it out) to deer meat/dog food. All bears were indifferent to biodiesel fuel diesel fuel, but many showed a "significant agitation/aggression response" to biodiesel exhaust and diesel exhaust. Grizzly bears reacted more strongly to the exhaust than did black bears.

The investigators concluded that there was "no statistical evidence that bears were attracted to biodiesel fuel or biodiesel exhaust any more than they might be to diesel fuel and diesel fuel exhaust. They recommended, however, that both experimentation and monitoring of biodiesel vehicles continue.

Northern Yellowstone Wildlife Working Group Research Reports

At the autumn meeting of the Northern Yellowstone Wildlife Working Group held in Gardiner, Montana, Montana State University (MSU) Dr. Carl Wamboldt reported on results of a multi-year study of sagebrush and ungulate habitat selection. Although there are three subspecies of big sage as well as black sage on the Northern Range, mule deer preferred mountain big sage; the black sage was least preferred, although it is high in protein and is highly digestible. Preference appeared to be related to the presence of secondary compounds, such as terpenoids, which influence browsing of the forage plants by making the plants less palatable to ungulates. Severe winters tended to reduce the preference differences of the ungulate browsers, which included elk as well as mule deer.

MSU graduate student Kristen Legg presented a progress report on her study of bighorn sheep in the Tom Miner-Point of Rocks area north and west of Yankee Jim Canyon. Her comparison of pellet transects to similar transects run in 1975 indicates an apparent shift from sheep use to elk use of steep grassy upper slopes in her study area. None of her radio-collared animals moved into Yellowstone National Park; most moved from winter ranges in her study area northward into the Hyalite Basin area. During monitoring flights, she and/or pilot Bill Chapman also reported seeing as many as 60 non-native mountain goats in the Tom Miner-Hyalite area.

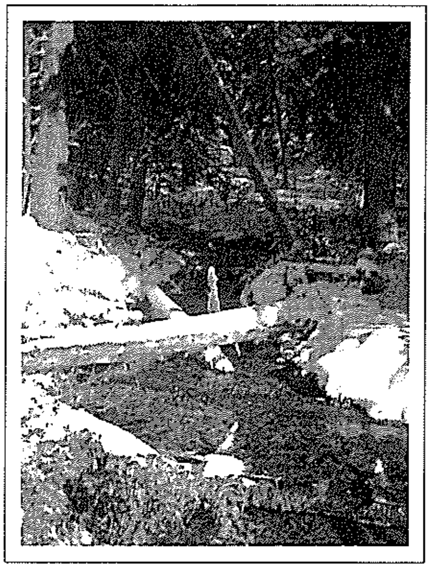


Gallatin National Forest staff reported that fall horseback surveys and drive-by counts were suggestive of a decline in moose numbers since the fires of 1988. Some moose are still being harvested by hunters, but moose permits were reduced following 1988.

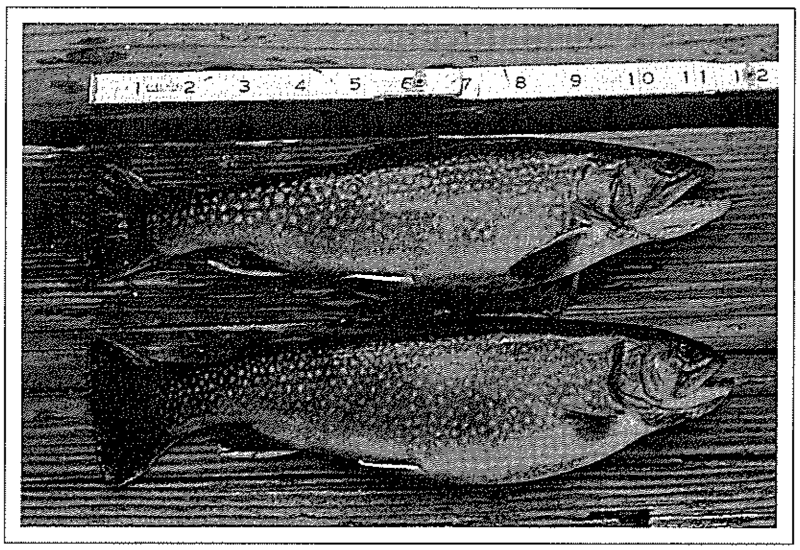
National Biological Service researcher Peter Gogan, whose mule deer study on the Northern Range was previously reported on in *Yellowstone Science* (Summer 1993), reported that deer radiocollared on the Northern Range outside of Yellowstone National Park summered as far away as Shoshone Lake, Bechler Meadows, Cooke City, and areas southwest of West Yellowstone, Montana.

Non-native Brook Trout Confirmed in Soda Butte Creek

Soda Butte Creek, which flows into Yellowstone National Park near the park's Northeast Entrance, is frequently in the news because of the past effects of mining activity in its headwaters and because of possible threats to this tributary of the Lamar River from proposed mining activity. A recently completed study of the headwaters of Soda Butte Creek, just outside the park, has added another worry for those concerned with the fate of this beautiful but troubled stream. The study revealed the presence of non-native brook trout (*Salvelinus fontinalis*) in water where native Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) have long been considered a species of special concern by managers.



The upper Soda Butte Creek site where non-native brook trout (below) were found.



The study, "Soda Butte Drainage Reconnaissance Fish Survey 1994," was prepared by Gallatin National Forest Fisheries Biologist Scot Shuler and published in January 1995. It was a partnership project of Shoshone and Gallatin National Forests, the Wyoming Game and Fish Department, the Montana Department of Fish, Wildlife and Parks, and the U.S. Fish and Wildlife Service Fisheries Assistance Office in Yellowstone National Park.

Because genetically pure Yellowstone cutthroat trout occupy only about eight percent of their historic range in the west, they are designated a "sensitive species" by the U.S. Forest Service and a "species of special concern" by the Montana Department of Fish, Wildlife and Parks. The status of the Yellowstone cutthroat trout has been in the news lately because of the threat to the last remaining large population of them, in Yellowstone Lake, where lake trout (*Salvelinus namaycush*) have recently been discovered.

Though there have been occasional reports of brook trout in Soda Butte Creek for at least 20 years, including some in Yellowstone National Park, this study, which summarized recent electrofishing results, provides the first scientific confirmation of their presence. No brook trout were found in any of the tributaries that were sampled (Woody, Republic, and Hayden creeks, and Guitar Lake); the brook trout were all in Soda Butte Creek itself. The report suggests two possible sources of origin for the brook trout. They may have been intentionally introduced by someone, or they may have entered the drainage during spring snowmelt runoff, when high water in the divide area between Soda Butte Creek and the Clarks Fork might allow passage of fish.

The report also points out that another non-native fish, westslope cutthroat trout (*Oncorhynchus clarki lewisi*), have recently been identified in Soda Butte Creek. This also is a troubling finding, because while the brook trout might outcompete the native Yellowstone cutthroat trout in the Soda Butte Creek drainage or move downstream into the Lamar River, the westslope cutthroat trout could interbreed with the native trout. Shuler recommended additional monitoring and study to keep track of both of these incursions.

Third Biennial Rocky Mountain Anthropological Conference, September 18-20, 1997

The Third Biennial Rocky Mountain Anthropological Conference will be held September 18-20, 1997, at the Holiday Inn in Bozeman, Montana. According to the conference organizers, "interested individuals are encouraged to organize forums as a possible alternative to symposia, to enable thoughtful, focused, and more open discussion of carefully delineated themes/topics." Please contact the organizers (below) for information about organizing a forum. The organizers encourage the participation of individual researchers from all areas of anthropological study pertaining to the Rocky Mountains, and researchers in related fields addressing issues of past environmental conditions are also welcome. The deadline for symposium or forum proposals is March 15, 1997. Other deadlines and information will be announced.

For more information, contact Ken Cannon, NPS Midwest Archeological Center, Federal Building, Room 474, 100 Centennial Mall North, Lincoln, NE 68508-3873 or (402) 437-5392 ext. 139, FAX402-437-5098),email: ken_cannon @nps.gov; or Jack Fisher, Department of Sociology, Montana State University, Bozeman, MT 59717 (406-994-5250, FAX406-994-6879),email:isijf@msu. oscs.montana.edu.

Trumpeter Swans Killed

Yellowstone's bird biologist, Terry McEneaney, has been working cooperatively for several years with private landowners, organizations, and state wildlife managers to restore a population of trumpeter swans in the Paradise Valley of Montana. Swans have been purchased using donated monies and placed on private lands with suitable habitat along the Yellowstone River south of Livingston, about 45 miles north of Yellowstone. Although the released birds have their wings clipped, restricting flight, the clipped birds have successfully nested, and their offspring augment the population of wild trumpeter swans that now exists in the greater Yellowstone area. On December 2, 1995, four swans (two wing-clipped adults and two wild adults) were killed in Paradise Valley by a hunter. Although the birds have never been listed as threatened or endangered under the Endangered Species Act, they cannot be legally hunted in the ecosystem. Bruce Reid of Livingston, Montana, was apprehended and has yet to be tried on charges of shooting the wild swans. However, Reid, who claimed to have mistaken the swans for snow geese, paid $2,500 restitution to the Trumpeter Swan Recovery Fund for killing the two birds. Restitution monies were used to purchase two adult trumpeter swans and four cygnets, and the birds were placed on the Call of the Wild Ranch. As of February 1996, there were 33 trumpeter swans (20 adults and 13 cygnets) in Paradise Valley.

Alice Siebecker

Bison Research and Management Continue While Long-Range Plans are Prepared

Efforts to reach agreement on a long-range plan to manage bison in and outside Yellowstone National Park continue, as an interagency team strives to have a draft plan and Environmental Impact Statement (EIS) released for public comment in November 1996. In the past decade bison from Yellowstone have increased in number, and some of the animals have increasingly migrated, primarily in winter, outside park boundaries. State and federal agency representatives are addressing various issues, including public safety, property damage, and potential disease transmission from bison to cattle. Concern over the length of time it was taking to reach agreement prompted the state of Montana to file a lawsuit against the federal agencies, including the NPS, in 1995. A final plan and EIS to guide the management of bison that migrate from the park into Montana is expected by May 1, 1997, with a Record of Decision issued by July 1, 1997, as outlined in a settlement agreement approved by a federal court judge.

Meanwhile, the park is involved in several intensive bison management and research activities. Under an Interim Bison Management Operating Plan approved in November 1995 park rangers assist with bison control outside the north and west boundaries when requested by the Montana Department of Livestock. This winter, cooperative activities included regular monitoring and reporting of bison outside park boundaries, hazing bison back into the park, and shooting of bison outside the park. Mary Meagher, of the NBS Yellowstone Field Station, continues to monitor bison numbers and movements parkwide as part of her long-term ecological studies. From aerial observations throughout this winter, she estimated the park's bison population at between 3,500 and 4,000 animals. She believed that her highest winter count, of 3,398 bison in December 1995, was not a good indication of bison numbers parkwide, and more recent surveys were even less reliable, due to bison breaking their social bonds and scattering geographically. As of March 23, her records indicated that 355 bison had been removed outside the park's west boundary, and 20 bulls had been removed outside the north boundary; an additional bull was shot outside Gardiner, Montana, by a landowner concerned about the bison threatening his stock. Carcasses were donated to Native American tribes around the region.

A Draft Interim Bison Management Plan and Environmental Assessment (EA), outlining operational plans for the period until a longer-range program is in place, was released for public comment from December 20, 1995, to February 2, 1996. The park received 260 comments on the proposed action, which called for capture of bison migrating outside the north and west boundaries. Bison captured on the northern boundary, at facilities built at the NPS service area on Stephens Creek, would be sent to slaughter. Bison exiting the park in the Eagle Creek-Bear Creek areas near Jardine, Montana would only be monitored. Bison captured in the West Yellowstone area would be field-tested for brucellosis. Those animals of either sex that showed seropositive results, along with seronegative pregnant females, would be sent to slaughter. Other animals captured outside the west boundary would be released. Public comments have been analyzed and a decision on the interim proposal is expected by the end of April.

A pilot study of the epidemiology and pathogenesis of brucellosis in wild bison was initiated last summer by the Animal and Plant Health Inspection Service (APHIS), the National Biological Service (NBS), the Montana Department of Fish, Wildlife and Parks (MDFWP), and the NPS. Researchers implanted vaginal transmitters in ten radio-collared bison cows on the park's northern range. The transmitters were designed to indicate calving or abortion in pregnant females. All ten cows appeared pregnant and none had calved as of April 2, 1996; however, all but one of the transmitters had fallen out, indicating failure of this application of the vaginal transmitter technique. Researchers plan to continue monitoring bison throughout the calving period in April and May, then take additional samples from the cows and their calves. Researchers will then assess results of the pilot study and determine future study plans.

Numerous state and federal agencies continue to participate in the Greater Yellowstone Interagency Brucellosis Committee. Their stated goal is to protect and sustain the existing free-ranging elk and bison populations in the Greater Yellowstone Area (GYA) and protect the public interests and economic viability of the livestock industry in Wyoming, Montana, and Idaho. Toward this end, their mission is to facilitate the development and implementation of brucellosis management plans for elk and bison in the GYA. The NPS representative on the executive committee of the GYIBC is Dr. Dan Huff from the Intermountain Field Office in Denver. Representatives on the technical committee are Wayne Brewster from Yellowstone and Dr. Robert Schiller from Grand Teton National Park. The GYIBC hopes to proceed with development and implementation of programmatic plans to deal with the elimination of brucellosis in the GYA.

The NPS has committed approximately $900,000 over fiscal years 1996-1998 from servicewide Natural Resource Preservation Program (NRPP) funds for bison research and the building of capture facilities to manage bison. Research emphasis will be focussed on these topical questions: 1) the ecology of the brucella organism in the wild, and a risk assessment of its effects on wild ungulates, 2) testing new vaccines for biosafety and efficacy in wild bison, and 3) bison ecology. More information about bison and brucellosis studies will be forthcoming in future issues.

World Heritage Committee Calls Yellowstone "Endangered"

The World Heritage Committee, an international panel of conservationists from countries that signed the World Heritage Convention treaty in 1973, met in Yellowstone in September 1995. After touring the ecosystem and listening to concerns expressed by various citizens and organized groups, the Committee voted to add Yellowstone to a list of endangered natural and cultural sites that are "of universal value to mankind." Their decision was based on both ascertained and potential dangers. Among the general issues of concern were plans for the New World Mine site near the park's northeastern corner, potential development of geothermal systems outside the park, and growing numbers of park visitors.

A special area of focus related to the proposed gold, silver, and copper mine near Cooke City, Montana, including impacts on water quality in the Yellowstone River and its tributaries; associated impacts on aquatic invertebrates and fisheries; groundwater quality; long-term alteration of wildlife habitat; and increased road access; human use; and occupation of the area from the park's northeast entrance to Cody, Wyoming. The U.S. Forest Service and the Montana Department of Environmental Quality have been working on an environmental impact statement for several years; a draft plan is expected later this year.

In-park Training Focuses on Visitor Use Management

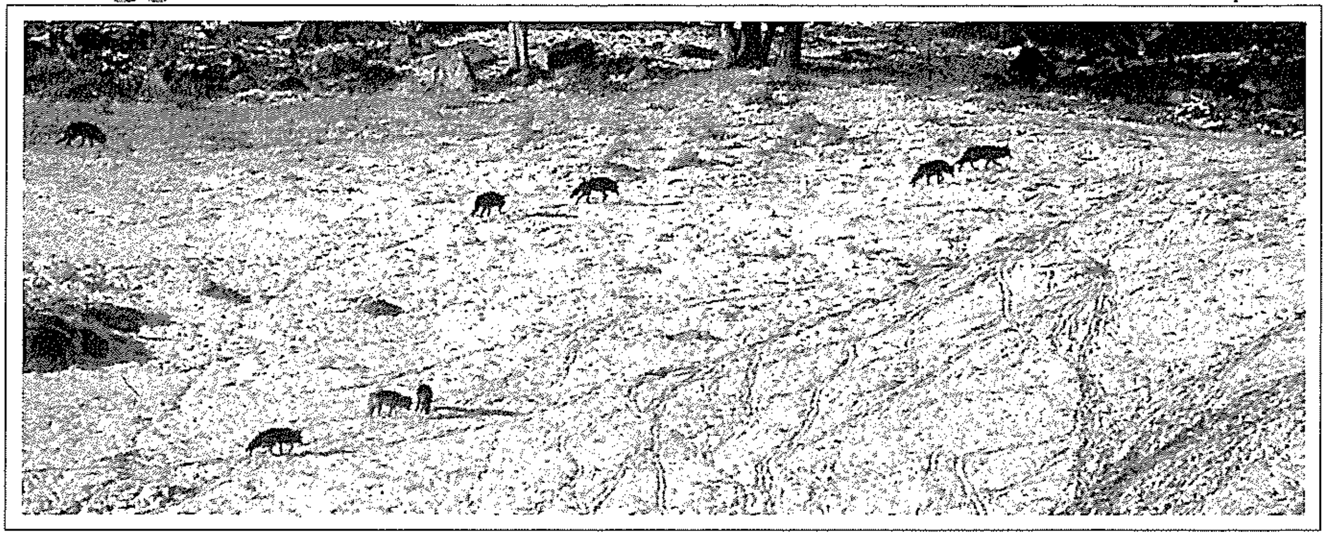
About 80 persons attended Yellowstone's Tenth Annual Resource Management Workshop, held January 24-26, 1996, in Mammoth Hot Springs. This year's theme was "Visitor Use: Impacts and Management." Guests included professors Gary Machlis, Steven McCool, and Bob Manning, who talked of "Understanding the Visitor" and "Perspectives on Carrying Capacity"; Wayne Freimund and Marilyn Hof, who have tested an NPS visitor use management process at Arches National Park; and Dave VanCleve, who described four case studies in management of visitors and resources in the California state parks. The workshop, sponsored by Yellowstone's Division of Resource Management Operations and Visitor Protection, brings together employees representing all park divisions as well as guest researchers and managers from other parks, forests, state agencies, and academia.

More Wolves Released in Yellowstone

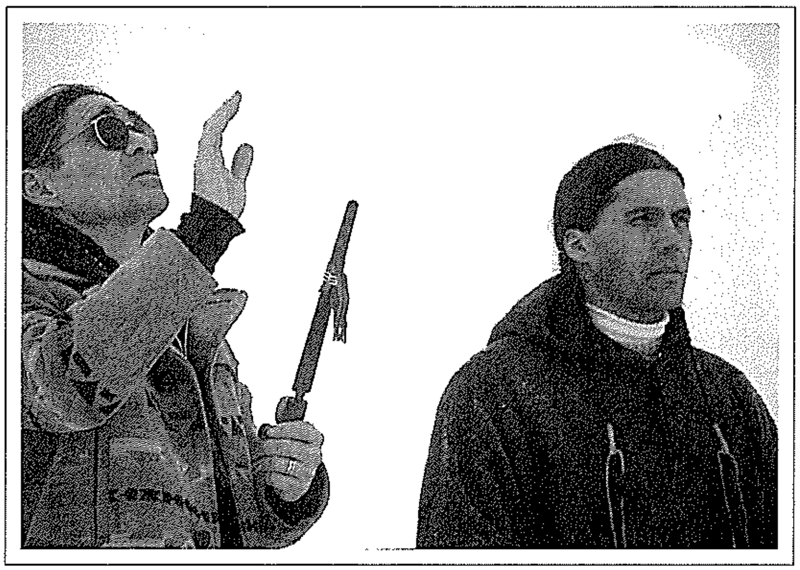
In early April 1996, 17 wolves—11 females and 6 males, ranging from 72 to 130 pounds in size and from nine months to five years in age—were released into Yellowstone to join wolves already roaming the ecosystem. The wolves, originally from six different packs in British Columbia, had spent about ten weeks in acclimation pens prior to being released.

Six wolves from the same pack—two males and four females—penned near Nez Perce Creek, in the Firehole River Valley in central Yellowstone, were freed

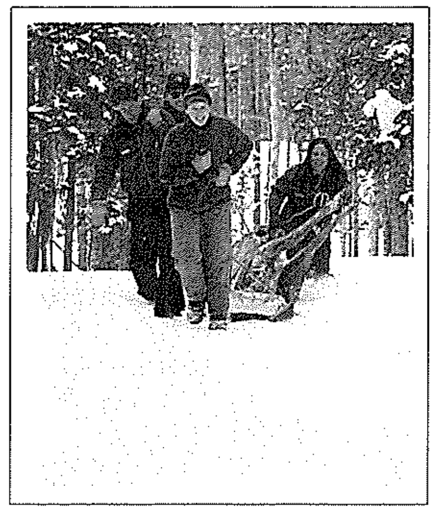
NPS photos



Rose Creek Pack, in the Lamar Valley, October 23, 1995.

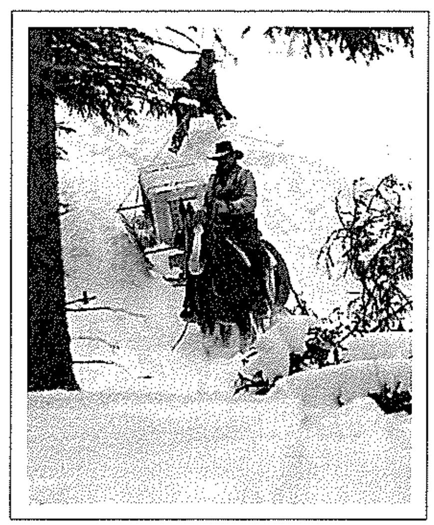


Scott Frazier (left), a Sioux-Crow, and John Potter, an Ojibwa, during a prayer ceremony where they sang morning songs of welcome for the arrival of the new wolves.



Volunteer Carrie Schaefer and park employees Carol Tepper, Les Brunton, and Mark Biel taking a carcass to the Nez Perce wolves on March1.

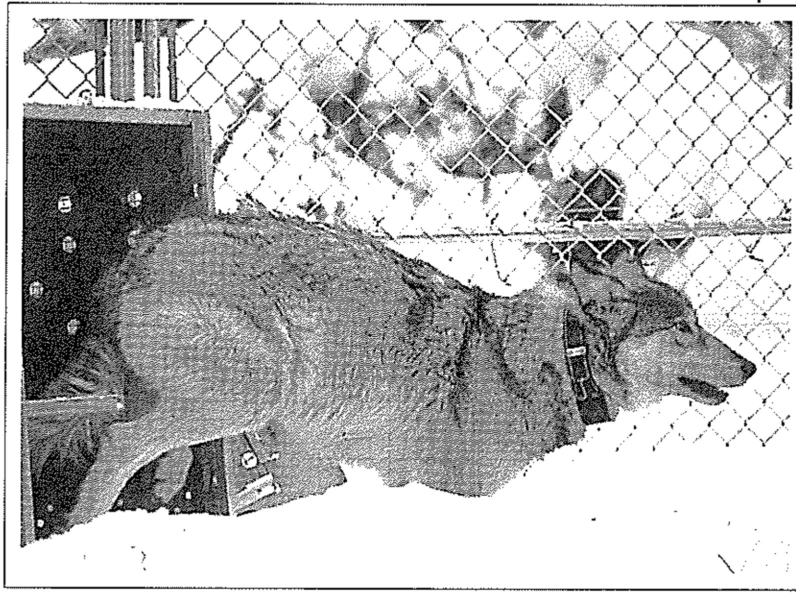
Mike Phillips (left), John Cook (center), NPS Intermountain Field Area director, and Dan Huff (right), assistant field director for Natural Resources /Science, at the Rose Creek pen.



Park wrangler Wally Wines on horseback and chief park ranger Dan Sholly on skis hauling a wolf to the Rose Creek pen.

when biologists cut a hole in their pen on April 1. The next day, the female wolves had all exited the pen and moved eastward toward the Yellowstone River, while the males stayed put. Within several days, all the wolves had left the pen, but the females continued moving northeast and left the park; the males apparently lost their trail along the river and moved north. By April 23, the wolf pack was still scattered; the alpha female was located near Nye, Montana, and the female pups were east of Red Lodge, Montana. The alpha male and a male pup were located in Paradise Valley, north of Gardiner, Montana. Biologists were monitoring the situation, in the hope that the pair would reunite, and leaving open the possibility that capture efforts would be undertaken to bring the alpha female and others from her pack back into the park.

NPS photo



Rose Creek female leaving the crate upon arrival in Yellowstone.

A male, a female, and her three female pups had been penned at Rose Creek. An opening was cut in their pen in April and—similar to what happened during the 1995 releases—the wolves took their time in vacating their temporary enclosure. By April 14, biologists confirmed that the newly-named Druid Peak pack had finally left the acclimation pen; they were moving generally northward at last report.

Since wolves released in 1995 have established territories on the northern range, animals in two other pens were transported to other parts of the park for release. Project biologists believed that relocating the wolves just prior to their release would accomplish the goals of soft release and decrease the likelihood that these wolves would immediately conflict with established packs in northern Yellowstone. Wolves mate from late February through early March, so the release of all penned wolves was scheduled prior to the onset of denning activity that might occur, typically from late April to May.

The pair held on Blacktail Deer Plateau was released on a service road near Lone Star Geyser, southeast of Old Faithful, on April 5, 1996. The wolves were located near the release site several times following their release. Both wolves were located on April 13 near Old Faithful and they seemed to be in good condition. However, during a routine monitoring flight on the afternoon of April 14, biologists received a mortality signal from the radio-collared female wolf, #36. She was spotted south of Old Faithful and appeared to be dead; the male wolf was located near the carcass of the female wolf. On April 15, project biologists searched the area and retrieved the carcass of wolf #36. A necropsy of the animal indicated that she was carrying six pups, and had died of thermal burns. The male wolf from the Blacktail pen was located in the south-central part of the park.

Four wolves—an adult pair and a younger male and female—from the Crystal Creek pen were moved to the northern end of the Firehole Valley on April 11. The wolves, renamed the Chief Joseph Pack, were temporarily placed in the Nez Perce pen, which had been vacated on April 3 by the pack of wolves held there all winter. On April 15, the pack was several miles west of the pen and had apparently successfully killed an elk. By April 23, the young male remained in the Firehole Valley, and the other wolves were west of Hebgen Lake feeding on a moose.

The wolves released in 1996 augment the existing population that has roamed wild for the past year. Fourteen wolves were released in 1995, and nine pups were born to two packs. Wolf #10, a male originally penned at Rose Creek, was killed by Chad McKittrick near Red Lodge last April. (McKittrick was found guilty of killing an endangered animal and sentenced to six months incarceration and ordered to pay $10,000 restitution if and when he is able.) In December, #22, a male pup from the Rose Creek Pack, was killed by a vehicle on the park's northeast entrance road.

Four wolf mortalities have occurred thus far in 1996. As mentioned earlier, #36 was found dead on April 14. On January 11, wolf #3, a yearling male from the Crystal Creek Pack, was spotted on a ranch at Dry Creek near Emigrant, Montana. On January 12, Animal Damage Control (ADC) agents found a sheep carcass that had been killed by a wolf. Based on the final rule for management of reintroduced wolves and upon consultation with USFWS and NPS staff, ADC recaptured the wolf and returned him temporarily to the Rose Creek pen. On January 25, #3 was released in Pelican Valley, approximately 60 airline miles from Dry Creek. The wolf stayed in the center of the park for a few days, but on February 3, he was back at the ranch. Another sheep had been attacked, and the responsible agencies decided that, under the circumstances, the wolf's removal was the most plausible action to benefit the wolf recovery program. On February 5, #3 was shot and killed by agents from ADC. Defenders of Wildlife planned to work with the landowners to compensate them for their livestock loss.

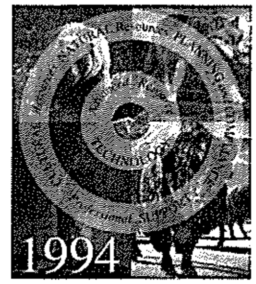
Wolf #12, a large adult male—but not the alpha—from the Soda Butte Pack, spent January exploring south along the Absaroka Mountains. On February 11, the wolf was found dead approximately 20 miles northwest of Pinedale, Wyoming. The carcass was shipped to the USFWS's National Forensics Laboratory in Ashland, Oregon, for further examination; investigators disclosed that the wolf had been shot. The USFWS has offered a $2,000 reward for information leading to the identification and conviction of the person(s) responsible. Information can be given anonymously. Anyone with information about the wolf's death may contact Special Agent Roy Brown in Lander, Wyoming, at (307) 322–7607, any other USFWS special agent, or any law enforcement agent with the Wyoming Game and Fish Department.

On March 30 biologists discovered that #11, a subadult female who had dispersed from the Soda Butte Pack, had been shot near Meeteetse, Wyoming. On April 15, the U.S. Attorney's Office announced that Jay M. York, an employee of the Deseret Ranch near Meeteetse, had pled guilty to illegally taking the endangered wolf. Mr. York was fined $500. The incident occurred during calving season on the ranch, when some 23 calves had already been lost to snow and cold weather conditions. Ranch managers were concerned about the number of coyotes they were seeing, and about the potential for coyote depredation on the newborn calves, so they decided to shoot any coyotes found in the calving pasture. York had seen two coyotes in the pasture on morning of March 30 and stepped out of his truck to shoot them. As a third animal came into view, York sighted in his rifle and shot it. Upon inspecting the animal he had shot, he believed it to be a wolf, and found it to be ear-tagged. York reported the killing that day, and both he and his employer were "very cooperative throughout the investigation" conducted by the USFWS, and the Wyoming Game and Fish Department.

The wolf mortalities are unfortunate but not unexpected; restoration of a wolf population in the ecosystem continues to progress well. Three wolves from six originally in the Crystal Creek Pack remain generally in the Lamar and or Pelican valleys; winter visitors reported seeing them chase and feed on elk. Throughout the winter, these wolves had also killed at least eight coyotes, according to researchers. The Rose Creek Pack spends most of its time in the Slough Creek-Hellroaring areas. The alpha female and her seven surviving pups were joined by #8 (a young male formerly of the Crystal Creek Pack) last autumn; he is now the alpha male. The Soda Butte Pack ranges along the northern front of the Beartooth Mountains and in upper Slough Creek in and outside the park. Perhaps most exciting is the news that wolf #2, a male formerly from the Crystal Creek Pack, paired with #7, a female originally penned at Rose Creek. They are the first naturally-forming wolf pack in Yellowstone in more than 60 years. The pair has been observed mating, and could have a litter of pups born this spring. Project biologists have decided to name this pack in honor of the late biologist, Aldo Leopold, who, in 1944, called for restoring wolves to Yellowstone. Other packs will be named based on geographic areas once they establish territories.

Annual Report Available for 1994

YELLOWSTONE CENTER
FOR RESOURCES



ANNUAL REPORT

The Yellowstone Center for Resources has produced an annual report for its activities in calendar year 1994. The 100-page document highlights efforts to study and protect natural and cultural resources through reports by various staff specialists and interdisciplinary resource teams established to focus on specific priority assignments. Highlights from 1994 include the discovery of non-native lake trout in Yellowstone Lake, the growth of the park's cultural resource management staff and program, discovery of Eocene plant fossils during reconstruction of the East Entrance Road, and initiation of wolf restoration to Yellowstone. Some copies are still available by contacting the Yellowstone Center for Resources at (307) 344–2203.

HEARTFELT THANKS

to all the readers who have donated to support the printing of *Yellowstone Science*. Rising costs of paper and printing make it imperative that we try to become more cost-effective and self-sufficient in these times of budget-cutting. Readers still wishing to donate may send contributions to:

The Yellowstone Association
P.O. Box 117 - *Yellowstone Science*
Yellowstone National Park, WY 82190