Yellowstone Science

A quarterly publication devoted to the natural and cultural resources

GYE Development Trends and Grizzlies

Archaeology Along the Yellowstone

The Value of Saving Cutthroats

Volume 9 Number 2

The Yellowstone River near Cottonwood Creek in the Black Canyon of the Yellowstone. People have always been attracted to waterways. NPS photo.

A current vision of sprawl in the Bridger Mountains near Bozeman, Montana. Photo by Tim Crawford, courtesy Greater Yellowstone Coalition.

Blurring the Lines

Archaeologist Mack Shortt tells us in this issue that research in the Black Canyon has "demonstrated intensive Precontact use of most of the Yellowstone River valley" during the past 9,000 years. Many of us find it fascinating to read about or, better yet, happen upon evidence of humans far beyond our time while out exploring in the "wilderness." Using clues dug from what's left on the land and from the often-meager, more recent, written record, researchers like Shortt "shed light on Yellowstone's cultural past." And perhaps more…Our other two features focus on two of the park's current natural resource management priorities. Vanessa Johnson documents rural residential growth in greater Yellowstone and associated concerns for wildlife—especially grizzly bears. Todd Cherry and Jason Shogren tell us people are willing to pay to control lake trout who eat native cutthroat who feed bears and other species that presumably coexisted with much earlier residents of the Yellowstone River valley.

Glimpses of how our human predecessors lived and used the land cannot tell us just how to "get it right." They do remind me that the ecosystem cannot be simply divided, on maps or in our minds, into "wild," "rural," and "urban." That resources in and outside parks cannot be easily termed "natural" or "cultural," when the relationships are so often interwoven. That future humans will, like us, struggle to balance human use against wild species' habitat needs and debate how to ensure the long-term health of the planet and our little corner of it. That we who are nature's great threat are also its great friends. Good luck to all of us.

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On the cover: Kevin Thorson (Museum of the Rockies) and a Yellowstone Institute class enrollee testing at the Ryder archaeological site on the Yellowstone River. NPS photo.
Above: A hafted knife (actual size) from the Pelican Lake camp at the LBD archaeological site. Drawing by Tah Madsen.

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Yellowstone Science is published quarterly, and submissions are welcome from all investigators conducting formal research in the Yellowstone area. Correspondence should be sent to the Editor, *Yellowstone Science*, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, WY 82190.
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Trends in Rural Residential Development in the Greater Yellowstone Ecosystem Since the Listing of the Grizzly Bear, 1975–1998

by Vanessa K. Johnson

Dennis Glick, GYC.

I shift my car into fourth gear (its highest) and gratefully breathe the cool evening air rushing through my windows. The steep hillsides framing the road are golden as the last rays of the sun play upon tall grasses flattened into cowlicks by wind and time. I glance up at a ridgetop and can almost see a grizzly and her cub searching for roots, acorns, berries, and other candies of the earth. The mother ambles along patiently while her cub frolics nearby. The fading sun gently touches the mother's fur, and her brown coat becomes a luminescent blonde that melts her into the surroundings. And there she disappears for a moment, and then for eternity. Because I'm not in Wyoming, Montana, or Idaho, the last three states in the lower 48 where grizzlies have a stronghold. I'm in California, where the last grizzly bear was shot in 1922, just outside Sequoia National Park. The only grizzlies seen here now are flying on the state flag.

In the Northern Rockies, with a combined human population nearly one-tenth that of California, there is still time to save the great bear. But how much?

Introduction

Escalating development levels on the lands surrounding Yellowstone National Park have only recently begun to attract attention, as concerns rise regarding the impacts of growth on the region's landscape and wildlife. The area surrounding Yellowstone National Park, which has come to be known as the Greater Yellowstone Ecosystem (Figure 1), represents one of the largest, most intact ecosystems in the lower 48 states. Yet many of the counties encompassed in the three states of the Greater Yellowstone Ecosystem (GYE) have some of the fastest growing populations in the U.S.

NPS photo.

This study was instigated by growing concerns about the potential impacts of such population growth and concomitant development on grizzly bear populations and their habitat in the GYE. Grizzly bears (*Ursus arctos horribilis*) were listed for protection under the Endangered Species Act in 1975. In fewer than 200 years, the great bear's population has been decimated to a mere 1 percent of its historic numbers and 2 percent of its former range in the lower 48 states, where the GYE harbors one of five remaining grizzly bear populations. Despite 25 years of federal protection, current regional trends, conditions, and projections regarding grizzly bear ecology and habitat suggest that the grizzly bears' future in the lower 48 and the GYE is still far from certain.

Historically, between 85 and 94 percent of all recorded grizzly bear mortalities in the GYE since listing have been human-caused. Substantial evidence indicates that increasing numbers of people moving into or nearer to grizzly bear habitat will mean a greater likelihood of human-caused grizzly bear mortality. Human–bear interactions are likely to become even more numerous if projected declines occur in key grizzly bear foods, such as cutthroat trout, whitebark pine seeds, and army cutworm moths. Under conditions of food scarcity, bears tend to roam more widely in search of alternative food sources, often bringing them into areas of human activity and substantially increasing the risk of human-caused death.

Grizzly bears are an umbrella species,

which means that their habitat area requirements encompass those of many other species. Ecosystems that retain their umbrella species are often the most ecologically robust, with a predominance of native species and ecological processes that operate as they have historically. The habitats utilized by grizzlies span the spectrum of natural communities present in this region, rendering grizzlies the ecological canary in the coal mine; thus successful grizzly bear recovery will likely also assure the long-term health of the GYE.

The intention of this study was to help inform grizzly bear conservation efforts by (1) developing some operational indices of private lands development in the GYE counties, (2) presenting trends, conditions, and projections on these indices, and (3) presenting some alternatives for how to better conserve habitat and minimize human–bear conflicts on private lands. This article will focus primarily on the trends found, some causal conditions, and ideas on how these trends and potential adverse consequences might be addressed.

Methods

The study area consisted of the counties encompassed in the Greater Yellowstone Ecosystem. The primary indicators initially chosen to assess county development levels were domestic water well records in Montana, domestic water well permits in Wyoming, and individual septic system permits in Idaho. Data were requested for the years 1975–1998, the period between the year the grizzly bear was listed as threatened and the year this study was initiated. However, data availability varied greatly, limiting the years, and in some cases the counties, for which trends were analyzed.

Well records and permits were chosen to indicate development trends in Montana and Wyoming because they had been tracked by state agencies for several decades. Homes built within city limits are usually connected to municipal water systems, thus well data were anticipated to most closely approximate rural development. Additionally, wells are classified according to use, so wells drilled for domestic drinking water could be isolated from wells drilled for other purposes, such as agriculture. In Idaho, water well permit data were less reliable, thus septic permits were chosen to assess rural development trends.

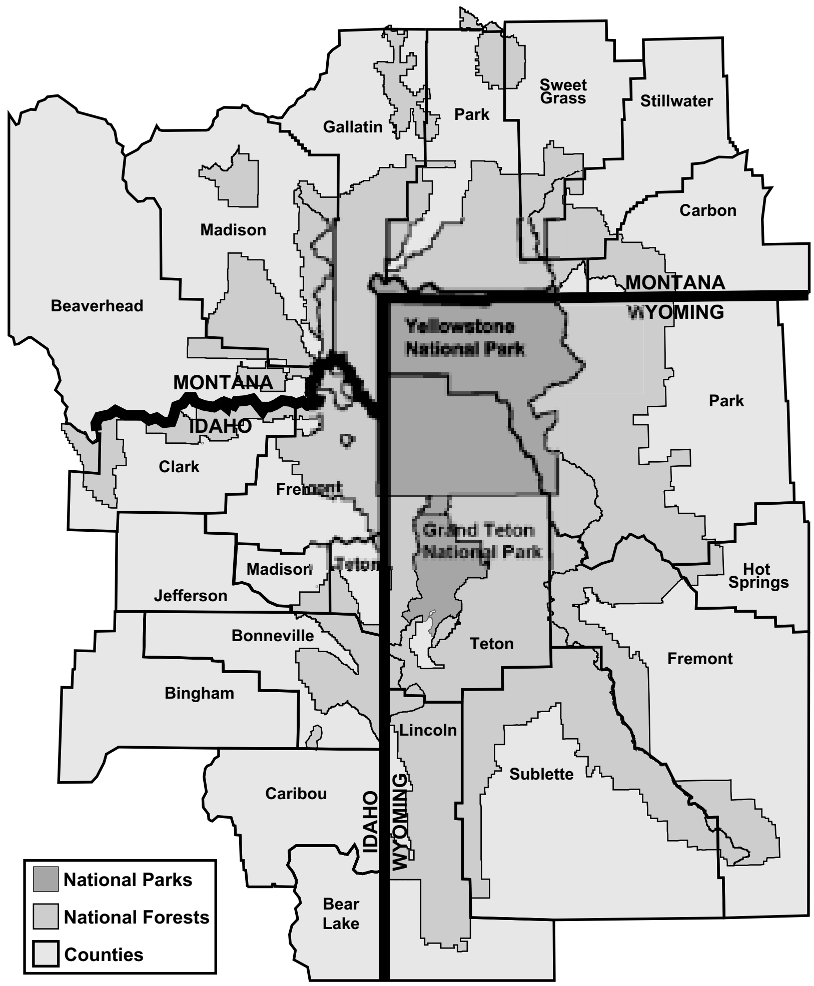

Figure 1. Counties Found Within the Greater Yellowstone Ecosystem. *Based on a map courtesy of the Greater Yellowstone Coalition.*

Research for this study unearthed development data and analyses from numerous city, state, and GYE county planning and land-use entities. These data, as well as U.S. Bureau of Census statistics, were analyzed for comparison with well and septic data trends. Finally, interviews with city, county, and private land-use planning professionals were essential to this study, both for consultation before indicators were chosen, and after data were analyzed for corroboration of the validity of the results.

It is important to note that no one indicator illustrates the complete picture of the level and location of development. Although the development indicators used in this study coincided on broad development trends, domestic well records (from Montana) were by far the most accurate statewide development level indicator, primarily due to historically consistent and stringent data collection by the state. Planning specialists concurred that domestic well permits (from Wyoming) and septic permits (from Idaho) mildly to significantly (depending on the county) underestimated development levels. In general, well or septic permits (and other housing unit indicators) cannot indicate the number of acres developed, or the amount of land approved for development but not yet built upon. And there are some inherent inaccuracies: permits may be distributed for replacement systems, and there are inevitable inconsistencies with permitting regulation and monitoring. However, there is a tremendous amount of information that can be gleaned from using numerous development indicators concurrently to assess development trends.

Table 1. A Sample of Development Totals for the 1990s.

State	County	Total developed or approved for development	Years
Idaho	Fremont	4,768 acres	1990–96
	Bear Lake	4,436 acres	1991–97
	Teton	4,203 acres	1990–97
Montana	Gallatin	9,270 acres	1993–98
	Madison	16,584 acres	1994–98
Wyoming	Teton	1,426 new house building permits	1990–98

Four Major GYE Development Trends

1. The 1990s: A Decade of Unprecedented Development

Septic permits, well records, well permits, and data gathered independently by city, county, and state planning agencies indicated that for the majority of GYE counties included in this study, the greatest residential development occurred during the 1990s. Of the three indicators analyzed (well permits, well records, and septic permits), the number of water well records in Montana GYE counties show this trend most dramatically (Figure 2). Analyses of all of the development data gathered indicated that the following GYE counties have had the most rapid recent development: Gallatin and Madison counties, Montana; Bonneville, Fremont, Jefferson, and Teton counties, Idaho; and Lincoln, Park, and Teton counties, Wyoming.

Cumulative development levels provide a poignant perspective on the additive impact of development over time. Table 1 represents a sample of development totals tallied for the 1990s. These numbers indicate that regardless of waxes and wanes in annual development levels, the cumulative impact is the permanent conversion of land from wild and agricultural open space to housing, with concurrently shrinking quantities of quality habitat available to native GYE species.

One of the greatest challenges of this study also became a great asset: the different indicators by which different planning entities measured development provided important insights into development trends. Fremont County's (Idaho) detailed residential development records well illustrate the additional information that can be discerned from different data. In the mid-1990s, Fremont County's individual septic permits (Figure 3A), subdivision acres (Figure 3B), and building permits (Figure 3C) were at their highest. However, note that the acres of land divided increased more rapidly than the number of subdivision lots in the 1990s. Fremont County's planner explained that one reason for this increase in acres developed is a growing preference for larger lots. Subdivisions built in the 1960s consisted primarily of lot sizes of about one-quarter acre. More recently, buyers have shown an increasing preference for lot sizes ranging from 5 to 15 acres.

2. "Open Space"—Is it as it Appears?

In seven GYE counties (Bear Lake and Fremont counties, Idaho; Gallatin and Madison counties, Montana; and Lincoln, Park, and Sublette counties, Wyoming), a sizable portion of private county land that appears vacant (*i.e.*, undeveloped) has already been approved for development. In other words, what may appear to be open space is not guaranteed to remain so in the future. The extent of such lands may not be insignificant. In Madison County, Montana, it was estimated that 81 percent of the lots platted for development are yet undeveloped. In Sublette and Park counties, Wyoming, approximately one-half of the lands subdivided and approved for development in the 1970s remain vacant.

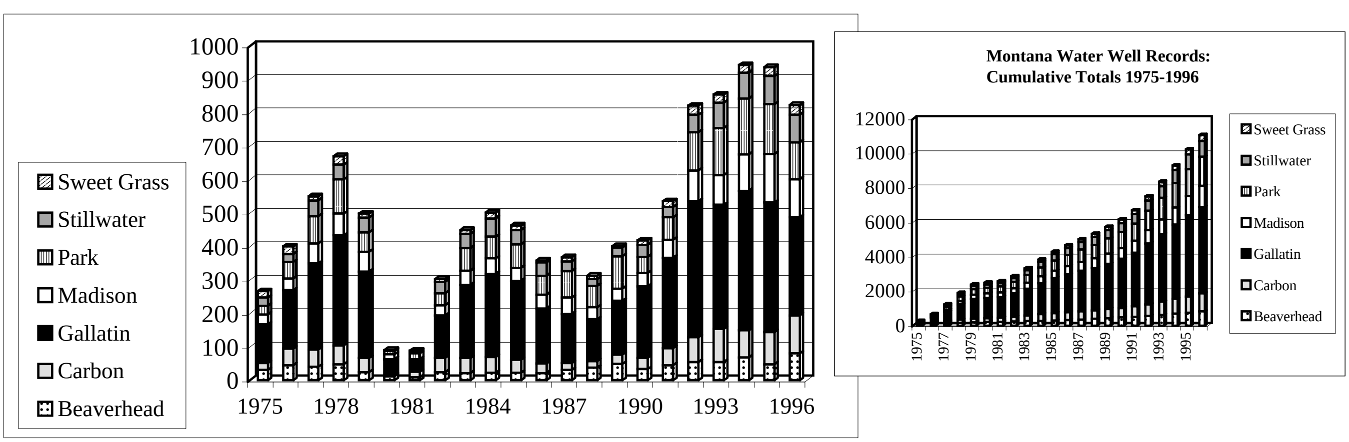

Figure 2. Domestic Well Records Issued in Montana Counties, 1975–1996.
Source: Montana Bureau of Geology and Mines, Helena, Montana.

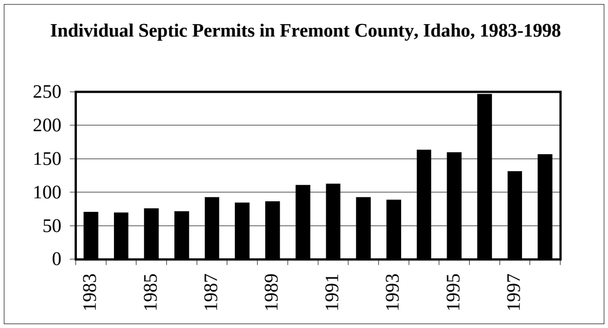

Figure 3a. *Source: District 7 Health Department, Idaho Falls, Idaho.*

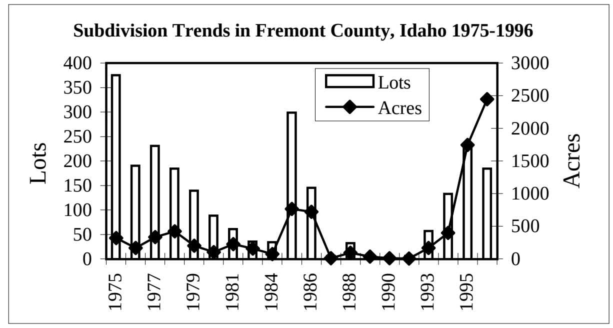

Figure 3b. *Source: Fremont County Planning and Building Department, St. Anthony, Idaho.*

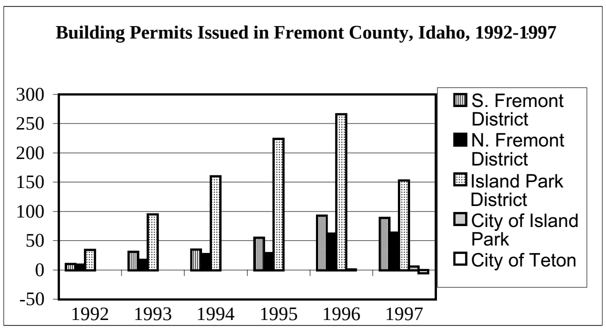

Figure 3c. *Source: Fremont County Planning and Building Department, St. Anthony, Idaho.*

Condominium construction near Grand Targhee, Idaho. Photo courtesy Greater Yellowstone Coalition.

3. Most New Development is in Rural Areas

Much of this study focused on development trends through time. But from a critical habitat perspective, *where* development is located is even more pertinent. Nearly all of the data gathered measure development in rural, unincorporated county areas, so these data by themselves indicate that the character of many rural county areas is rapidly changing because of development levels unprecedented in previous decades. Planning agencies that have compared rural and urban development also determined that more development is occurring in rural areas rather than clustering near cities and towns.

For example, Gallatin County recently concluded that "Sites slated for new residential development or commercial development tend to be large and dispersed, rather than compact and integrated into existing towns...[between 1993 and 1998] the largest fractions of new tracts created (45%) and the total area divided (57%) represent lands outside the boundaries of the [city planning zones]."[1] Similarly, Teton County, Wyoming, found that 60 percent of new development has been in unincorporated county areas, and 40 percent in incorporated towns—a ratio that has been fairly constant over the last decade and is projected to remain so. Planners in Beaverhead and Carbon counties, Montana, and Lincoln and Park counties, Wyoming, acknowledged similar trends in their planning jurisdictions.

U.S. Census Bureau data on urban and rural population growth between 1970 and 1996 also demonstrate preferential rural development in GYE counties, especially in the last two decades.[2] According to census data, the majority of Idaho and Wyoming GYE counties experienced a complete reversal in urban/rural growth patterns in the last decade. Between 1970 and 1990, growth in urban areas of Wyoming and Idaho GYE counties predominated. However, in the 1990s, this trend reversed itself, with the majority of growth occurring in rural areas. While Montana's GYE counties have shown a consistently greater proportion of urban over rural growth during the last three decades, the rural growth rate has steadily increased. Beaverhead, Carbon, and Madison counties experienced a greater than two-fold rise in annual rural growth between the 1980s and 1990s. In Gallatin County, even with the annexation of city property, the cumulative annual rural growth rate increased from the 1980s through the 1990s.

4. Waterfront Property—Prime Real Estate for People and Wildlife

According to a recent study, "the most sought after properties are often in the most ecologically sensitive areas, in particular near Jackson Hole's major waterways."[3] Similarly, ongoing research at Montana State University has so far found that homes in southern Gallatin County, Montana, were disproportionately abundant within two kilometers of aspen-cottonwood-willow habitat—*i.e.*, riparian areas. River corridors also harbor a disproportionate abundance of native wildlife and plant species. While these areas comprise a relatively small proportion of the landscape, research overwhelmingly indicates that riparian corridors contain a significant component of regional biodiversity.

The character of many rural areas is rapidly changing. Photo by Dennis Glick, GYC.

Conditions Influencing Rural Development Trends

Human Population Growth

The most apparent factor contributing to residential development trends in GYE counties is human population growth. The population of the GYE grew at an average rate of 2 percent per year between 1990 and 1996, more than twice the national average of 0.9 percent. Not surprisingly, the fastest growing counties were those found to have the greatest residential development: Teton County, Idaho, grew at 8.4 percent per year; while Carbon, Stillwater, Gallatin, and Madison counties, Montana, and Teton and Sublette counties, Wyoming, grew at rates between 13 and 24 percent per year between 1990 and 1996.[4]

Census data indicate that much of the growth in the GYE states is caused by people moving into these areas rather than by an *in situ* population increase. Idaho, Montana, and Wyoming ranked fairly low nationally for births and deaths, but ranked 11th, 23rd, and 32nd (respectively) for net domestic migration.

Socioeconomic Trends: Recreation, Income, Real Estate, Retirement, and the Economy

Population growth in the GYE (as elsewhere) is the result of a complex and dynamic nexus of economic and demographic variables. In the Northern Rockies, the myth of the Wild West, a renewed passion for wilderness recreation, retiring "Baby Boomers," technological communication advances, and favorable economic conditions are all credited with spurring population growth. Specifically, the following are contributing to the rapid growth many GYE counties are experiencing:

- an aging population, leading to an increase in retirement income;
- an influx of people from urban areas seeking a higher quality of life;
- a decline in out-migration;
- a rapid rise in non-labor income;
- skyrocketing property values in metropolitan areas, making rural housing comparatively more affordable;
- more "telecommuters," made possible by telecommunications technology and an outsourcing of services; and
- a rise in demand for tourism and recreation services.

As of 1997, more than 35 percent of total personal income in the Yellowstone region was primarily from retirement income and money earned from past investments. These income earnings are 23 percent higher than they were in the 1970s, and more than two and one-half times the total income earned from mining, logging, and agriculture.

One of the most prominent economic trends in the GYE is the declining dependence on resource extraction industries, accompanied by tremendous growth in the service industries. Between 1970 and 1995, resource extraction industries contributed just 1 percent of new personal income. Historically, the classic "boom and bust" cycles characterizing resource extraction industries have been a major factor in community population growth and decline. The diversification of GYE economies implies a greater likelihood that the population growth trends reported in this study will be less susceptible to economic "busts."

Furthermore, studies are finding that communities that safeguard their natural amenities (*e.g.*, through protecting open space) are rebounding both economically and demographically from resource extraction industry closures. A 1997 report on economic and demographic trends in the U.S. and Canadian portions of Rocky Mountain communities summarized:

> "...if it is plausible that some of the recent growth is stimulated by people's desire to live and do business in a picturesque mountain environment, then resource development at a scale and pace that destroys environmental assets is simply bad for the economy, the communities, and the quality of life of local residents. This is true whether the pressure comes from a mine that pollutes the streams, logging that scars the landscape or the sale of ranches to accommodate urban sprawl."[5]

Local conditions also influence population growth. In Jackson Hole, international exposure, lack of state income tax, and relatively low property taxes have contributed to high rates of private land development and one of the most active real estate markets in the country.

Recreation trends are also drawing people in record numbers to the GYE. Yellowstone National Park's annual visitation has risen by one million people in the last 25 years, and the current annual growth rate in visitation is nearly five times that of the previous decade (3.9% versus 0.8% in the 1980s). Increasingly, outdoor recreation is becoming a year-round activity. Winter visitation to Yellowstone, mainly via snowmobile, grew 6 percent annually between 1973 and 1995—three times the summer growth rate during this period.

Tourists, seasonal residents, and seasonal workers contribute disproportionately to population numbers in many GYE counties. In 1993, the Teton County, Wyoming, population expanded from a spring low of 19,000 to a summer high of 52,000. Growth in one segment of the population often influences growth in another. Teton County projected that growth in the permanent residential population would inevitably spur growth in services and tourism, further increasing the seasonal population needed to support the permanent population.

Anecdotal information from county planners and others working in Yellowstone area counties supports these seasonal population trends. Planners for Teton, Fremont, Bear Lake, and Clark counties, Idaho; Carbon County, Montana; and Lincoln and Sublette counties, Wyoming, told the author that while an increasing number of new homes are built for year-round rather than seasonal use, these year-round homes are increasingly occupied only seasonally.

One frustrated Montana planner commented that maintaining the status quo in subdivision regulations would still result in a "peanut-butter smear" of low-density, inefficient development across the landscape.

Challenges to Controlling Development

Planning Agency Authority.—One of the challenges to overseeing development is the limited authority of the agencies charged with monitoring development. In Montana, for example, few countywide zoning laws exist. Although county planners may operate according to a master plan, their role is only advisory; final development approval rests with county commissioners.

Regulatory Loopholes.—Regulatory loopholes further weaken planning officials' power to control development. One county planner reported that most of the subdivisions approved prior to 1986 were approved via exemptions to subdivision regulations, limiting the Board of County Commissioners' control over the level or type of development. An analysis of subdivided acreage versus acres in reviewed subdivisions in GYE counties (Figure 4) suggests that a substantial amount of development in Montana's GYE counties occurs without local oversight. Thirty percent of the land divided in Gallatin County between April 1993 and 1998 was included in certificates of survey, which are exempt from county subdivision review. Minor subdivisions (subdivisions of five or fewer lots), which comprise 40 percent of the subdivisions approved during the same period, are subject to a lesser standard of local review than major subdivisions (six or more lots).

Regulatory Changes.—Changes in local and state development regulations have helped spur building booms. Montana's subdivision regulations changed significantly in 1993. Prior to 1993, Montana properties divided into parcels larger than 20 acres were exempt from local subdivision review; the new 1993 statute raised this minimum lot size to 160 acres. Gallatin County reported that in the months leading up to the passage, there was an impressive surge in the number of applications for certificates of survey. Most of these documented lands were divided into parcels slightly larger than 20 acres, as landowners rushed to file in anticipation of the Legislature's action. Similar trends were observed in Fremont County, Idaho, when the county adopted uniform building codes.

Current regulations may yet be insufficient to stem the tide of development. One frustrated Montana planner commented that maintaining the status quo in subdivision regulations would still result in a "peanut-butter smear" of low-density, inefficient development across the landscape.

Insufficient Resources.—The pace of growth in the GYE has accelerated faster than many counties' abilities to monitor development trends. Many GYE county planning offices have few or no support staff, sparse funding, and minimal or no technological resources (*e.g.*, Geographic Information Systems mapping capability). Only a few county planning agencies have computerized databases. Some counties do not yet have full-time planners, and others do not have planning departments at all.

Difficulties with Collaborative Planning.—The lack of coordinated and standardized data collection and reporting efforts among GYE counties and states hinders monitoring efforts. Each county differs in types of data and lengths of time for which development data have been gathered. Complicating this is that each state has its own distinct development

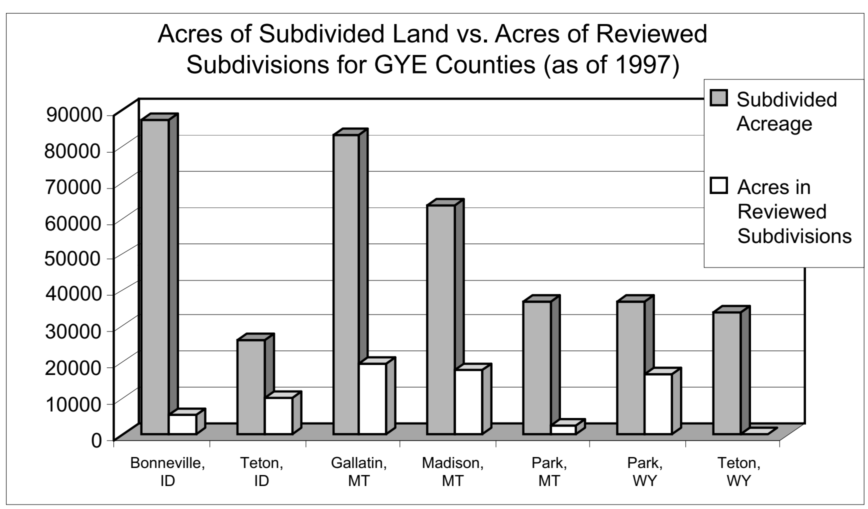

Figure 4. *Source: Greater Yellowstone Coalition.*
Note: these numbers may actually underestimate the full magnitude of unreviewed subdivisions in GYE counties (Souvigney, pers. comm., 1998).

terminology and regulations. In addition, the patchwork of public land ownership in the region impedes interagency coordination of habitat management and monitoring, especially as long-term monitoring efforts rarely receive funding priority. Administratively and politically, the region is highly fragmented. More than 25 different resource management agencies and committees hold jurisdiction over various parts of the ecosystem.

Future Growth Trends in the GYE

County and city planners of the counties with the greatest growth levels projected little to no decline in current development trends. State planning agency studies, private groups, and census estimates echoed this forecast.

Other land use specialists noted that development and growth might be leveling off. This follows the historic development patterns revealed in this study, with development rising and falling in successive decades, each growth peak higher than the last. A safer conclusion is that development could climb again under the right combination of demographic and economic variables.

Cromartie and Beale (1996) concluded that the conditions influencing elevated GYE population growth were unlikely to change soon. Trends in the desire to escape urban areas, decreasing locational constraints on services and other industries, favorable real-estate opportunities in non-urban areas, and a steady increase in recreation, tourism, and the retired portion of the population were likely to "strengthen in the coming years, increasing the supply of nonmetro newcomers, especially to high-amenity areas, and encouraging current residents to stay."[6]

Regardless of future trends, existing levels of development are here to stay. Even if development rates were to decline significantly, it would be extremely difficult, if not impossible, to reclaim the habitat that has already been effectively lost.

Alternatives for Addressing Current Trends

Identify and Prioritize Critical Habitat for Protection

Clearly, a piecemeal, opportunistic approach to land conservation will not protect the integrated network of habitats necessary to retain intact ecosystems—and the grizzlies—in the GYE. While there exist several ecosystem-wide ecological mapping and data collection efforts, no current analyses specifically identify critical grizzly bear habitat on privately held lands. Thus, planning departments and other interested groups do not have the tools to evaluate the impacts of development proposals on critical habitat. Special emphasis should be placed on identifying and prioritizing critical habitat areas on public and private lands. Areas to focus on include open space on private lands where grizzlies do or could reside, especially spring range, private lands adjacent to public lands, and linkage corridors between grizzly bear ecosystems. Public-private collaborations should be encouraged to openly share ideas, resources, and research that is relevant to such conservation efforts.

Encourage Non-Regulatory, Incentive-Based Techniques for Land Protection

Non-regulatory, incentive-based land protection alternatives such as conservation easements, land banking, and transfer or purchase of development rights are becoming among the most widely used private land conservation tools. Often, these options provide financial incentives to landowners. For example, landowners who donate conservation easements are compensated by reductions in estate, income, and, in some cases, property taxes. In addition, many federal, state, and private organizations offer financial assistance for protecting land through non-regulatory means.

Implement and Enforce Regulatory Techniques for Open Space Protection

In many GYE counties, development regulations, if they exist at all, are rarely enforced. Impressing upon communities the significance of preserving open space may convince planners and commissioners that enforcing, strengthening, or implementing master plans, zoning rules (*e.g.*, for cluster development, or for prohibiting development in critical wildlife areas), urban growth boundaries, greenways, and other methods of protecting open space are in the best long-term interests of both the wildlife and human communities of the GYE.

Outreach and Education to Prevent Human–Grizzly Bear Conflicts

More human–grizzly conflicts lead to more human-caused grizzly bear mortalities. Grizzlies have keen memories, and once they find a food source, they will likely return to it. Management actions that involve moving "nuisance" bears within the ecosystem have had only limited success. Furthermore, locations to which to move bears outside the ecosystem (*e.g.*, zoos) are limited. Increasingly, the only option for grizzlies found repeatedly on private property is death.

Garbage is the most notorious grizzly bear attractant. In areas close to or in grizzly bear habitat, where it may be too late to insulate bears from human activity, the key to minimizing human–bear conflicts is eliminating the attractants that lure bears. For example:

- encourage cities and counties to adopt sanitation ordinances, *e.g.*, requiring bear-proof garbage containers (only three areas in the GYE currently have sanitation ordinances, and enforcement is often lax);
- secure garbage in bear-proof containers (some disposal companies provide these);
- minimize quantities of food leftover in bird feeders, pet food dishes, and farm feeding areas; and
- install electric fences around fruit trees and honeybee operations.

Wildlife management agencies have limited financial resources for helping landowners implement the above measures. However, managers can provide expertise and furnish information on where to acquire items to deter bears. In addition, there are some private organizations helping to fund these efforts. As for all of the other alternatives listed above, educating landowners and land use planners on the options available for minimizing human–bear conflicts on private lands, and impressing upon them the importance of doing so, should be an essential part of all grizzly bear recovery outreach programs.

Encourage Public Land Management Agencies to Prioritize Habitat Preservation over Resource Extraction and Motorized Recreation on Public Lands

Most of the GYE is encompassed by seven national forests and Yellowstone and Grand Teton national parks. Some of these lands continue to be used for logging, oil and gas development, and motorized recreation. Growing numbers of people moving into and visiting the GYE will only increase pressures to use these areas for a variety of purposes. This means that maintaining quality habitat on public lands will acquire more significance as habitat availability and quality diminishes on private lands.

Conclusion

The underlying concern catalyzing this study was that regional trends, conditions, and projections regarding grizzly bear ecology and habitat suggest that the long-term viability of the Yellowstone grizzly bear population is uncertain. The results of this study indicate that rural residential development trends in the GYE may impede grizzly bear recovery by degrading and fragmenting current and potential grizzly bear habitat on private lands in this region. There is no "magic bullet" for ameliorating the adverse impacts of development. Preventing habitat degradation from worsening will require a multi-faceted approach involving both regulatory and non-regulatory approaches, as well as cooperation and open communication between landowners, land-use planners, wilderness and open-space advocates, and public land managers. The diversity of public and private organizations whose common goal is to protect the ecological integrity of the GYE offers tremendous potential for leveraging scarce resources, while pooling the abundance of expertise and ideas to successfully preserve enough habitat in time to keep grizzlies a living symbol of the American West.

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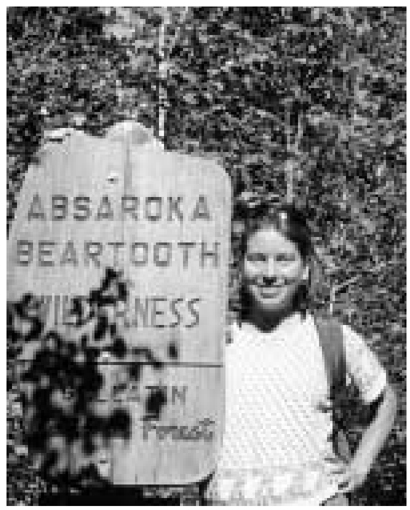

Photo courtesy Vanessa Johnson.

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This article is based on a report prepared by the author for the Sierra Club Grizzly Bear Ecosystems Project, copies of which can be obtained from them by calling (406) 582-8365. Full citations are available in the original report:

Johnson, V.K. 2000. Rural Residential Development Trends in the Greater Yellowstone Ecosystem Since the Listing of the Grizzly Bear 1975–1998. Bozeman, Mont.: Sierra Club Grizzly Bear Ecosystems Project. 73 pp.

Footnotes:

1 Gallatin County Planning Dept. 1998. *Land Division in Gallatin County, Montana 1993–1998.* Bozeman, Mont.

2 For the decennial census, the U.S. Census Bureau analyzes growth at the county level according to urban and rural areas. Urban, as applies to the GYE states, is defined as "places of 2,500 or more persons incorporated as cities, villages, boroughs, and towns, but excluding the rural portions of extended cities" or "census designated places of 2,500 or more persons." Rural is defined as "territory, population, and housing units not classified as urban." In between the decennial census, the U.S. Census Bureau publishes estimates of population growth based on birth, death, and migration rates.

3 Jackson Hole Conservation Alliance (formerly Jackson Hole Alliance for Responsible Planning), Jackson, Wyo. 1992 poster.

4 U.S. Census Bureau *in* Glick, D., and B. Alexander. 1998, in review. *Development by Default, not Design—Yellowstone Park and the Greater Yellowstone Ecosystem.* Greater Yellowstone Coalition: Bozeman, Mont.

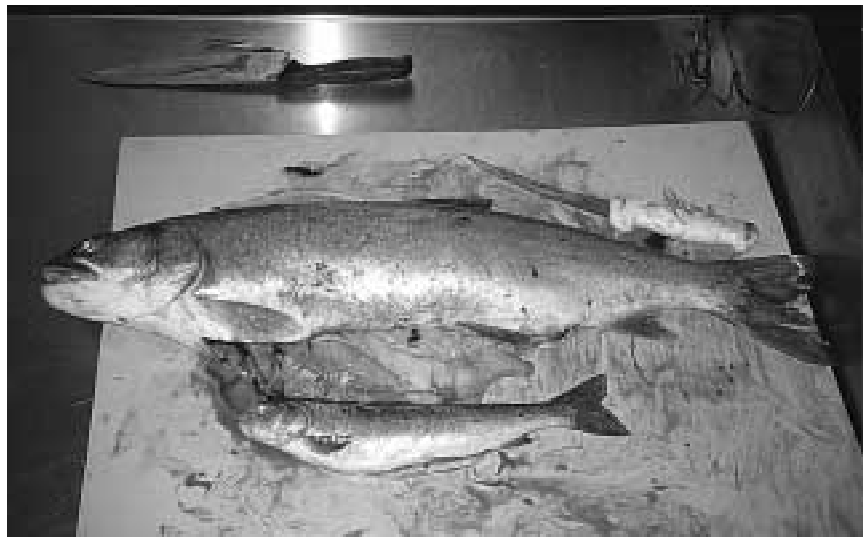
The percent population change between 1990 and 1998 also shows growth levels quite dramatically. While the percent population change among GYE counties averaged 15%, Teton County's (Idaho) population increased 59.6% between 1990 and 1998. A distant second was Teton County, Wyoming, with 26.8%, followed by Gallatin and Stillwater counties, Montana, with 23.9% and 23.5%, respectively. The percent change in population growth for these counties exceeds the 23.1% average for the Mountain West (which includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming), and far exceeds the U.S. percent population change for this time period of 8.7%.

5 Rasker, R., and B. Alexander. 1997. *The New Challenge: People, Commerce and the Environment in the Yellowstone to Yukon Region.* The Wilderness Society: Bozeman, Mont.

6 Cromartie, J., and C. Beale. 1996. Rural Population Rebounds in the 1990s. *Agricultural Outlook* (Economic Research Service/USDA). November:18–21.

Invasive Species Management for the Yellowstone Lake Ecosystem: What do Visitors Think?

by Todd L. Cherry and Jason F. Shogren



An introduced lake trout (above, 28 inches) with a Yellowstone cutthroat trout (below, 13 inches) that was removed from its stomach. NPS photo.

In 1994, an angler caught a lake trout (*Salvelinus namaycush*) in Yellowstone Lake, Yellowstone National Park, Wyoming. Judging by the size of the trout, and from subsequent data provided by the National Park Service and the U.S. Fish and Wildlife Service, biologists now believe that someone must have illegally planted lake trout in the lake at least 20 years earlier. Although lake trout inhabit at least four other lakes in Yellowstone National Park, biologists blame humans for the introduction because natural movement of this non-native species into Yellowstone Lake is improbable. Based on catch and mortality rates, biologists estimate that thousands, perhaps tens of thousands, of lake trout of several age classes, some capable of spawning, live in Yellowstone Lake (Kaeding et al. 1995).

Rivers and lakes are vulnerable to invasive fish species, and Yellowstone Lake is a prime habitat for lake trout because they thrive in cold, deep water (*Yellowstone Science* 1996). But the problem is that Yellowstone Lake is the last premier inland Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) fishery in North America. After years of work to restore the native Yellowstone cutthroat trout population back to viable levels, lake trout put this cutthroat population at risk. Experts fear the lake trout population will expand and cause a serious decline in the cutthroat population, especially juveniles (see Ruzycki and Beauchamp 1997). If left unchecked, some biologists have predicted that this voracious exotic species could reduce the catchable-size cutthroat population from 2.5 million to 250,000–500,000 within the near future (Kaeding et al. 1995).

As if putting native cutthroats at risk were not enough, lake trout also place some other native species at risk. Lake trout do not replace cutthroat in the food chain. For example, grizzly bears (*Ursus arctos*), listed as threatened under the U.S. Endangered Species Act since 1975, feed on cutthroat when they spawn in over half of Yellowstone Lake's 124 tributary streams. Researchers there have observed an adult female grizzly harvest an average of 100 fish per day for 10 days (Schullery and Varley 1995). Lake trout do not replace cutthroat in the food chain because, unlike cutthroats, they spawn in the cobble and rubble in the lake, far from many predators' reach. As Yellowstone's former Superintendent Robert Barbee has put it, "If lake trout make serious inroads on the cutthroat population, many animals will suffer, including eagles, ospreys, otters, and bears" (*Yellowstone Science* 1994). Approximately 40 other birds and mammals also eat cutthroat.

Wildlife viewing has been estimated to be the "single most important activity" for over 90 percent of park visitors (Varley and Schullery 1995). Park officials have attempted to protect the cutthroat population by netting lake trout. Netters now remove about half the spawning adult lake trout from Yellowstone Lake each year by catching them in spawning areas of the lake (see Mahony and Ruzycki 1997). Analysis suggests that the netting program of the park has cut into the lake trout population, but netting may have to continue indefinitely and be modified to avoid the bycatch of cutthroat trout, at non-trivial expense. Figure 1 illustrates how biological processes may affect visitors' experiences in Yellowstone.

This paper presents results of a survey designed to elicit visitor perceptions and their stated willingness to pay money to reduce this risk to Yellowstone cutthroat trout in Yellowstone Lake. We found the average visitor said he or she would pay an annual fee of about $11 to help fund a program to manage the lake trout problem, suggesting that the benefits of such a program would exceed current costs.

Valuing Species at Risk

The risk to Yellowstone cutthroat and grizzly bears is one example of a growing issue in species protection—the effects on species put at risk by exotic invaders. Organisms that move beyond their traditional natural ranges may have undesirable ecological and economic consequences. Scientists have documented numerous examples of exotic plants and animals causing unacceptable damages, both monetary and non-monetary. Exotic deer and livestock, for instance, have altered the structure and composition of native vegetation in the Nahuel Huapi National Park in Argentina (Veblen et al. 1992). Nile perch released into Africa's Lake Victoria have caused mass extinction of native fish, and induced water quality problems. Field bindweed is estimated to cause more than $40 million in crop damages in Kansas every year (FICMNEW 1998). Zebra mussels in the Great Lakes have led to serious biotic and abiotic effects, *e.g.*, greatly diminished phytoplantkton biomass and biofouling of human-made structures (MacIsaac 1996).

Some researchers and policymakers, including ourselves, think that understanding the economic value of reducing risks to wildlife should play a role in wildlife management strategies in Yellowstone. Cutthroat trout and the species that depend on them provide many values to society—ranging from aesthetic to financial/commercial—many of which remain unpriced by the marketplace and public sector. Wildlife may not stay within the confines of either public or private property, so many people enjoy the benefits or suffer the costs without compensation paid or received.

Some people find the gains from species protection so obvious that they need

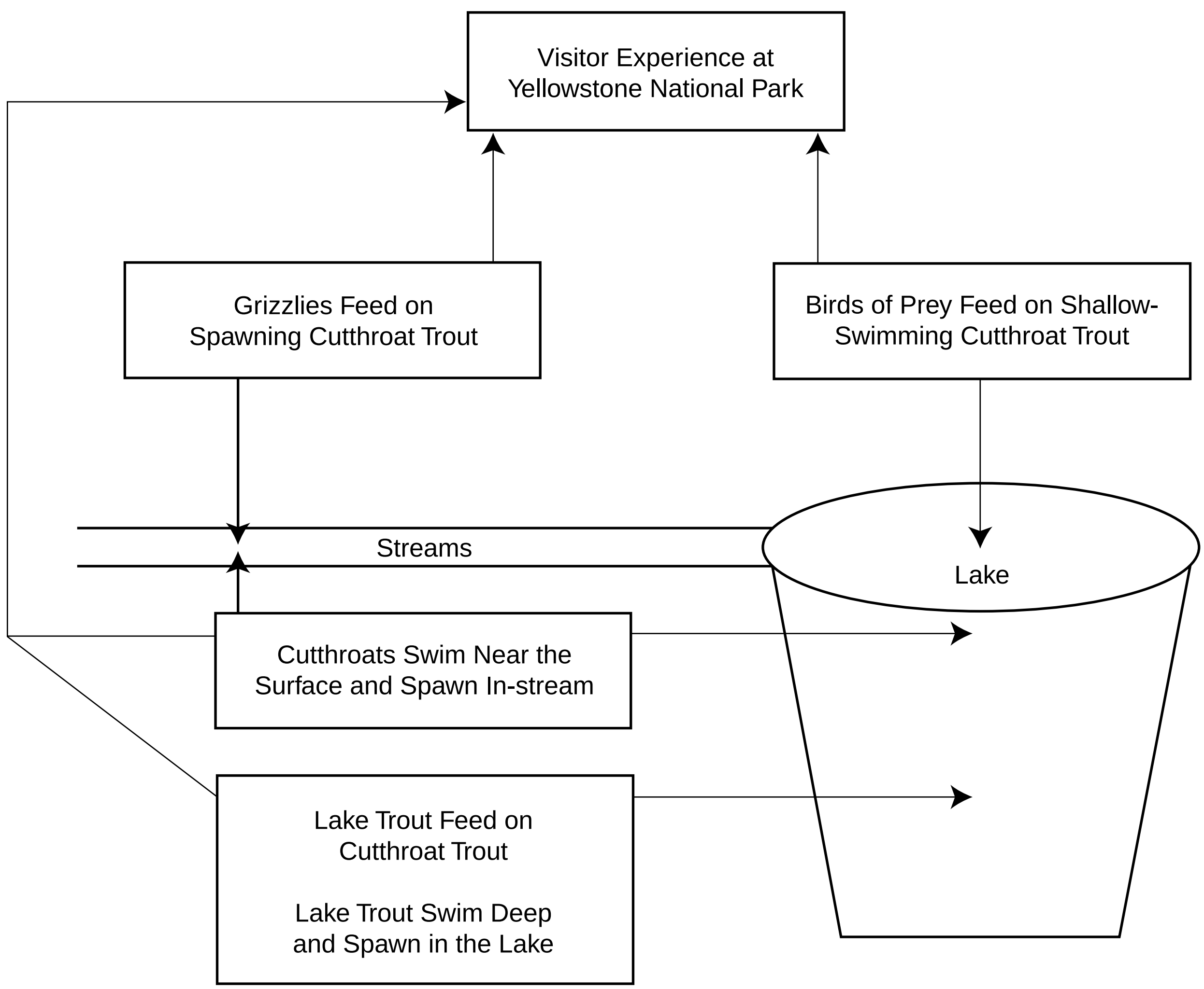


Figure 1. How Biological Processes May Affect Visitors' Experiences in Yellowstone.

not be measured. For them, the essential ecological services that indigenous species provide are so valuable that the benefits of species preservation always exceed the benefits of development (see, for example, Roughgarden 1995). Others, however, see things differently. Epstein (1995 p. 278) illustrates this point of view, stating:

> "Some people believe that it is important to develop nature to the full, to overcome poverty and to ensure prosperity; others believe that nature should be left in its original condition to the extent that is possible, even if it means a cutback in overall standards of living. It is not within the power of either side to convert the doubters to the opposite position, and coercive systems of regulation are the worst possible way to achieve uniform social outcomes in the face of social disagreement. The interconnectedness of what goes on in one place and what goes on in another cannot be presumed on some dubious theory of necessary physical linkages for all events."

People who support the goal of species protection often still want a monetary estimate of the potential benefits. They want to better understand the consequences of diverting resources from other worthwhile goals like health care, education, and policies promoting a decent standard of living. In doing so, they recognize that economics is not synonymous with financial and commercial concerns. They understand the goal of economics is to compare and balance the commercial gains from developing a resource with the benefits from its preservation. As economist Henry Hazlitt noted, "[t]he art of economics consists in looking not merely at the immediate but at the longer effects of any act or policy; it consists in tracing the consequences of that policy not merely for one group but for all groups."

But valuing species protection is a challenge due to problems of assigning economic value to goods that most people never directly use, and of the method used to estimate these values. Most economists recognize people can have preferences about protecting species and related services they will rarely ever, if at all, see or use (Krutilla 1967). The main question is how to link a monetary value with these preferences. The primary tool used to estimate use and nonuse values is contingent valuation, which provides data based on public opinion surveys that use a sequence of questions to obtain a monetary value from stated preferences. This method is highly contentious; critics argue that what people say often differs from what they actually do, complaining that hypothetical surveys elicit surrogate preferences from species protection in general, rather than for the particular species in question.

Some people also suggest that people who are simply responding to a survey might give different responses if they were facing real-life budget constraints and actually spending their own money. Researchers have found the average person often overstates his willingness to pay by a factor of two when valuing one project independently relative to valuing

Table 1. Visitor Perceptions of the Lake Trout Issue.

Question/Answer	Percent of Sample
How familiar were you with this problem?	
Well Informed	14.8%
Moderately Informed	22.4%
Barely Informed	12.4%
Not Informed at All	50.4%
How serious do you consider this problem?	
Very Serious	48.0%
Moderately Serious	30.0%
Barely Serious	11.6%
Not a Problem at All	3.6%
No Opinion	8.0%
Do you expect to visit YNP to view wildlife in the future?	
Definitely Will	45.7%
Probably Will	33.9%
I Don't Know	15.0%
Probably Will Not	4.7%
Definitely Will Not	0.8%
Do you expect to visit YNP to fish in the future?	
Definitely Will	12.3%
Probably Will	15.5%
I Don't Know	13.1%
Probably Will Not	30.6%
Definitely Will Not	28.6%
Would a decreased chance of catching cutthroat trout affect your decision to visit YNP?	
Yes	12.7%
No	87.3%
Would a decreased chance of catching lake trout affect your decision to visit YNP?	
Yes	3.6%
No	96.4%
Would a decreased chance of viewing birds of prey affect your decision to visit YNP?	
Yes	39.5%
No	60.5%
Would a decreased chance of viewing grizzly bears affect your decision to visit YNP?	
Yes	54.3%
No	45.7%

Visitors said fewer cutthroat trout would not affect future decisions to visit the park; likewise they said fewer lake trout would have no influence. But they did say that diminished wildlife viewing due to fewer cutthroats would alter their future visits. Wildlife on land and sky, not the fish in the lake, had a greater influence on the likelihood of future visits.

the same project in combination with other projects (*e.g.,* trout protection and road improvements in the park; see Hoehn and Loomis 1993). But despite the analytical difficulties associated with measuring the social value that should be placed on preserving each species, determining at least a plausible range for these values is essential if we are to make judgments about the benefits of preservation.

The Yellowstone Valuation Survey

Our survey had four sections: background, perception, valuation, and demographic. The background section informed the respondent with a short and thorough explanation of the cause and potential effects of lake trout being present in Yellowstone Lake. The perception section elicited how the respondent perceived the potential impacts of the exotic species in Yellowstone Lake, including how the possible changes would influence his or her decision to visit the park. The demographic section obtained respondent and household characteristics. The valuation section elicited the visitor's maximum willingness to pay a fee to support lake trout control measures by using a dichotomous choice format, *i.e.,* people responded either yes or no to a stated price for trout control.

Surveys were distributed in person to visitors of Yellowstone and Grand Teton national parks in three general locations: (1) the interagency visitor center in Jackson, Wyoming, (2) the Colter Bay Visitor Center in Grand Teton National Park and the Fishing Bridge Visitor Center in Yellowstone, and (3) viewing turnoffs in both Yellowstone and Grand Teton. Respondents had approximately 40 days to return the surveys. Distribution covered three days, and the closing date was fixed.

Some respondents (2.2%) chose to complete the survey on site. Two hundred and eighty-four of the 496 distributed surveys were returned within 30 days. The response rate was 57.3 percent. Note we excluded people who refused to take a survey (sometimes with emphasis), and we did not ask for the home addresses of visitors, which precluded the use of follow-up surveys.

Our target population of national park visitors is illustrated by their socio-economic and demographic attributes. The average respondent was about 47 years old, with 56 percent being male. About 10 percent of the respondents lived alone, and 60 percent of the represented households had no children. As expected, the targeted sample had relatively high education and income levels, with nearly 70 percent of the sample having four years or more of college and 53 percent earning more than $50,000 annually.

What the Visitors Think

Perception of the Problem

Table 1 shows the perceptions and attitudes of the visitors responding to our survey. With half of respondents (50.4%) indicating no familiarity with the lake trout problem, the clarity and accuracy of the description of the issue was vital. Subsequent responses, in addition to general feedback, indicate that participants understood the explanation of the problem. Nearly 80 percent of our respondents agreed that the lake trout problem was either *very serious* (48%) or *moderately serious* (30%), and responses were broadly consistent regarding the expected benefits and costs of visiting Yellowstone.

As Table 1 shows, the data suggest visitors worry less about how lake trout directly affect cutthroat trout than how they indirectly affect other wildlife that depend on cutthroats, *e.g.,* grizzly bears. Visitors said fewer cutthroat trout would not affect future decisions to visit the park; likewise they said fewer lake trout would have no influence. But they did say that diminished wildlife viewing due to fewer cutthroats would alter their future visits. Wildlife on land and sky, not the fish in the lake, had a greater influence on the likelihood of future visits.

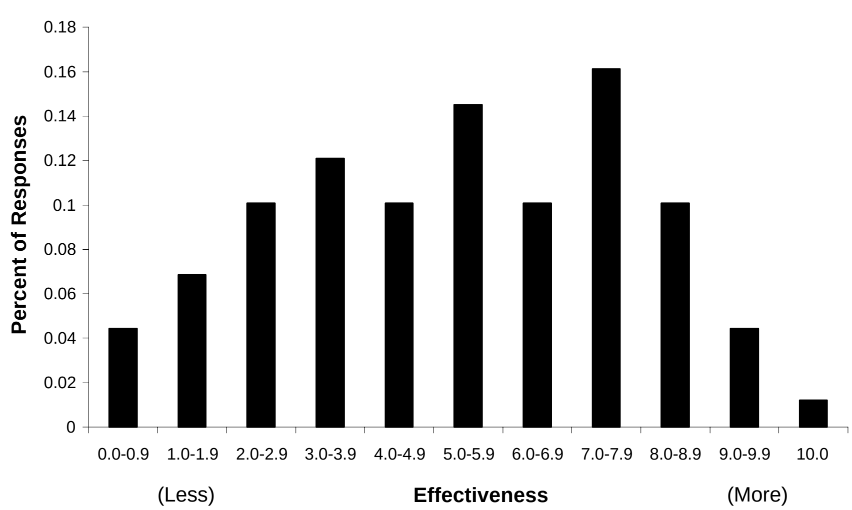


Figure 2. Perception of the Effectiveness of Lake Trout Management Efforts *(10-point scale: 0 = no effect and 10 = complete success).*

Visitors registered concern when they recognized that exotic species could indirectly affect other wildlife like grizzly bears.

Confidence in Management Efforts

A key factor in determining public support for any management program is whether people believe the efforts will result in a reasonable level of success. Since we were interested in the perception of visitors regarding management effectiveness, we did not inform respondents of past management successes or failures. Rather, we asked visitors to indicate their *a priori* beliefs on how successful a management program would be in handling the lake trout problem, using a 10-point scale. Within this scale, a 0 means the program would be *completely ineffective*, and a 10 indicates the program will be *completely successful*. Figure 2 shows that 57 percent of visitors said a program would be *at least moderately successful* (*i.e.*, selected 5 or higher) in addressing the lake trout issue. Fewer than 5 percent believed efforts would be *completely ineffective* or *completely successful*. These responses suggest that visitors generally have confidence in the ability of the National Park Service to manage the lake trout problem.

Willingness to Financially Support Management Efforts

Of the 284 returned surveys, 28 (5.6%) failed to respond to the willingness to pay (WTP) question, thereby eliminating their preferences from the WTP estimation. Sixty-eight, or 13.7 percent, responded "do not know" to the willingness to pay question, which we coded as negative responses to provide a conservative estimate. Finally, the sample was trimmed further because some respondents did not complete supplemental questions needed in the estimation process. The final sample used to estimate the mean visitor's willingness to pay had 238 observations.

Based on our regression analysis (available on request), the resulting estimate suggests that the average park visitor would pay about \$11 (\$11.16, standard deviation \$3.25) per year to fund a program to help protect the Yellowstone Lake ecosystem, which includes cutthroats, eagles, and grizzly bears. The aggregate value estimate is enlightening when placed into a management context. Park officials recently extended the current management scheme of deep netting, and substantially increased funding of deep netting to \$1 million over the next four years. The annual cost of \$250,000 includes a commercial-grade vessel and a crew solely dedicated to the thinning of lake trout numbers. Distributing the annual cost over the estimated three million visitors in calendar year 2000 would ask each visitor to pay about nine cents—less than one percent of the estimated \$11 mean. In fact, collecting the estimated WTP amount from 1 percent of the visitors, akin to collecting the estimated \$11 from only the visitors on one average July day, would cover the costs associated with the netting program. Note we are not promoting a policy to collect an extra \$11 dollars from July visitors, just that this illustrative example clearly shows that our results indicate that stated visitor benefits outweigh the cost of current policy.

Motivation for Financial Support

After stating their financial willingness to support lake trout management efforts in Yellowstone Lake, we asked respondents to explain their answer. As Table 2 shows, 20 percent of respondents indicated that preserving the natural Yellowstone Lake ecosystem was the reason for their support. This contrasts with only 5 percent of the visitors who indicated that recreation was the main reason for their support. Nearly a quarter of respondents indicated they should not be responsible for financially supporting a management program—many suggesting the entrance fee should cover any costs. Although the survey instrument apparently provided a good description of the problem, as suggested by fewer than 3 percent of respondents indicating they did not understand the problem, many respondents (22.2%) wanted additional information before pledging any financial support for management efforts. Overall, these findings suggest that environmental concerns, more than recreation, motivate visitors who supported management efforts.

Table 2. Stated Reasons for Financial Support or Non-Support of Lake Trout Management Efforts.

Reason	Percent of Respondents
Environmental reasons	20.4%
Recreational reasons	5.0%
Shouldn't have to	24.0%
Cannot afford it	14.0%
Need more information	22.2%
Don't understand	2.7%
Other	11.8%

Concluding Comment

Visitors to Yellowstone say they are willing to pay to protect the Yellowstone Lake ecosystem from lake trout—an exotic invader that puts key native species at risk, namely Yellowstone cutthroat trout and threatened grizzly bears. Using data collected from visitors to Yellowstone and Grand Teton national parks, our estimates suggest the average person says that s/he will pay about \$11 to help fund a program to manage the lake trout problem. Even if one were to halve the \$11 to placate critics of valuation surveys, the computed benefits would still substantially exceed the current costs of protecting Yellowstone cutthroat trout through a managed strategy of gill netting lake trout.

We thank the editor and staff at *Yellowstone Science* for their helpful comments, Yellowstone National Park for cooperation, and the U.S. Environmental Protection Agency EPSCOR Grant #R-826281-09-0 and Stroock Professorship for financial support. Also thanks to David Finnoff, Peter Frykblom, and Greg Parkhurst for their research support, and Hank Harlow and the University of Wyoming/NPS research station for their hospitality.

Photo courtesy Todd Cherry.

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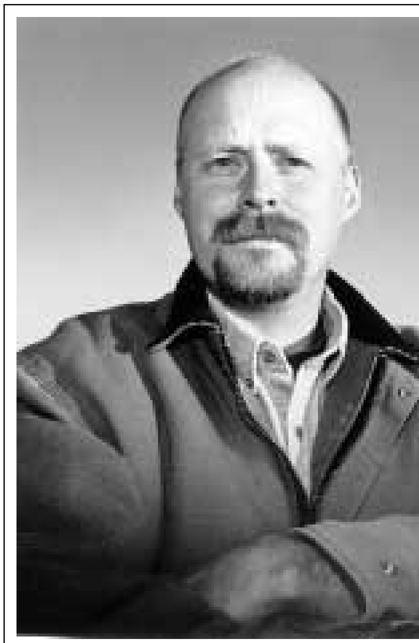


Photo courtesy Jason Shogren.

Jason Shogren is the Stroock Distinguished Professor of Natural Resource Conservation and Management, and is a professor of economics at the University of Wyoming in Laramie. His research focuses on the behavioral underpinnings of private choice and public policy, especially for environmental and natural resources. Before returning to his alma mater, *he taught at Iowa State and Yale. In 1997, Shogren served as the senior economist for environmental and natural resource policy on the Council of Economic Advisers in the White House. Currently, he serves on the Environmental Economics Science Advisory Board for the U.S. Environmental Protection Agency, and the Intergovernmental Panel on Climate Change. Governor Geringer recently appointed him to Wyoming's Environmental Quality Council. Shogren is also on the advisory committee for* Enlibra, *the Western Governors Association's new doctrine for environmental management. He was an associate editor of the* Journal of Environmental Economics and Management*, and the* American Journal of Agricultural Economics.

References

Epstein, R. 1995. *Simple Rules for a Complex World*. Harvard University Press. Cambridge, Mass.

Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) 1998. *Invasive Plants: Changing the Landscape of America. Fact Book*. FICMNEW, Washington, D.C.

Hoehn, J., and J. Loomis. 1993. "Substitution effects in the Valuation of Multiple Environmental Programs." *Journal of Environmental Economics and Management* 25: 56–75.

Kaeding, L., G. Boltz, and D. Carty. 1995. "Lake Trout Discovered in Yellowstone Lake." *The Yellowstone Lake Crisis: Confronting a Lake Trout Invasion* (J. Varley and P. Schullery, eds.). A Report to the Director of the National Park Service, Yellowstone Center for Resources, National Park Service, Yellowstone National Park, Wyo., pp. 4–11.

Krutilla J. 1967. "Conservation Reconsidered," *American Economic Review* 57, 787–796.

MacIsaac, H. 1996. "Potential Abiotic and Biotic Impacts of Zebra Mussels on the Inland Waters of North America," *American Zoology* 36: 287–299.

Mahony, D., and J. Ruzycki. 1997. "Initial Investigations Towards the Development of a Lake Trout Removal Program in Yellowstone Lake." *Wild Trout IV* (R. Hamre, ed.). Trout Unlimited and Federation of Fly Fishers, Fort Collins, Colo., pp. 153–162.

Roughgarden, J. 1995. "Can Economics Protect Biodiversity?" *The Economics and Ecology of Biodiversity Decline.* (T. Swanson, ed.). Cambridge University Press, Cambridge, England, pp. 149–154.

Ruzycki, J. and D. Beauchamp. 1997. "A Bioenergetics Modeling Assessment of the Lake Trout Impact in Yellowstone Lake." *Wild Trout IV* (R. Hamre, ed.). Trout Unlimited and Federation of Fly Fishers, Fort Collins, Colo., pp. 127–133.

Schullery, P., and J. Varley. 1995. "Cutthroat Trout and the Yellowstone Lake Ecosystem." *The Yellowstone Lake Crisis: Confronting a Lake Trout Invasion* (J. Varley and P. Schullery, eds.). A Report to the Director of the National Park Service, Yellowstone Center for Resources, National Park Service, Yellowstone National Park, Wyo., pp. 12–21.

Varley, J., and P. Schullery. 1995. "Socioeconomic Values Associated with the Yellowstone Lake Cutthroat Trout." *The Yellowstone Lake Crisis: Confronting a Lake Trout Invasion* (J. Varley and P. Schullery, eds.). A Report to the Director of the National Park Service, Yellowstone Center for Resources, National Park Service, Yellowstone National Park, Wyo., pp. 22–27.

Veblen, T., M. Mermoz, C. Martin, and T. Kitzberger. 1992. "Ecological impacts of introduced animals in Nahuel Huapi National Park, Argentina." *Conservation Biology* 6: 71–83.

Yellowstone Science. 1994. "News and Notes." Vol. 2(4).

Yellowstone Science. 1996. "Natives versus Exotics: Coming to Terms with Nonnative Species Invasions and Rates of Change (Interview with Michael Soule)," Vol. 4(4).

Museum of the Rockies Archaeological Research in the Canyons of the Yellowstone

by Mack W. Shortt

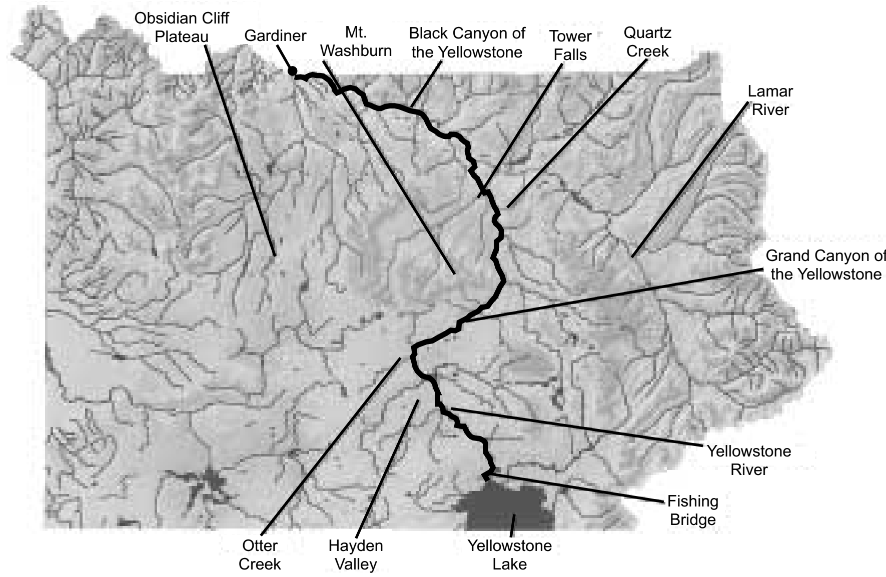


Figure 1. *An overview of the study area, showing the path of the Yellowstone River through the park from Yellowstone Lake to the town of Gardiner, Montana. Courtesy Kevin Thorson, MOR.*

For the past five years, the Museum of the Rockies (MOR) at Montana State University has been involved in an ongoing cooperative archaeology project with the National Park Service in Yellowstone National Park. Field studies, first conducted during the summer of 1996, have included a number of programs sponsored by the Federal Highways Administration, National Park Service trail realignment/rehabilitation inventories, site documentation and evaluation, and other projects related to infrastructure planning and development. The museum has also conducted archaeological site inventories in the Yellowstone River valley from its outlet at Yellowstone Lake to Gardiner, Montana. The river surveys have provided opportunities to address particular research-oriented questions concerning cultural history, Precontact[1] travel and migration, the exploitation of faunal and floral resources, site seasonality, the use of lithic raw materials, and paleoenvironmental reconstruction, *i.e.*, the use of information recovered through archaeological excavations to indicate past environments. Typically, these data sets include pollen, charcoal, tree-rings, animal bones, and plant parts and seeds.

In general terms, the Precontact Period in Yellowstone National Park and surrounding areas is divisible into a series of archaeological units (*e.g.*, phase), each possessing traits (*e.g.*, projectile point style) that distinguish them from other units. In this paper a phase assumes to represent one social-cultural group definable in space over a period of time. Subphases are divisions of phases that can be used for studying the internal variability within the phase and the relationships to both simultaneous and sequential phases. The term complex is used for a phase with unknown antecedents and descendants.

The purpose of this paper is to summarize some of our findings along the river while focusing on who was in the park and when. Past archaeological surveys, such as those done by the University of Montana at Missoula in 1958 and 1959, the State University of New York in the early 1980s, and Northwest College and the Midwest Archeological Center in the early 1990s, have included portions of the Yellowstone River. However, MOR's work is the first comprehensive site inventory of the Yellowstone River valley. To date, the Yellowstone River inventory from Fishing Bridge to Gardiner is nearly complete, with relatively small segments of the west bank of the river targeted for the upcoming 2001 field season.

Study Area

The Yellowstone River flows through diverse topographies on its journey from Yellowstone Lake to the town of Gardiner, Montana (Figure 1). It is likely that this sometimes forested, sometimes grassy valley once served as a transportation corridor for people entering the park area from the north and traveling south toward Yellowstone Lake. A total of 244 Precontact sites were recorded by the end of the 2000 field season, including sites discovered by the MOR crew and those recorded by others and subsequently revisited. Site types include large, spatially complex lithic scatters[2] and campsites measuring several hundred meters in length, small lithic scatters, finds of single artifacts, and, in the northern extreme of the study area, cairns (rock piles) and stone circles or tipi rings. Precontact sites are distributed throughout the study area. From Gardiner in the north, sites are present in relatively low numbers, and they rapidly diminish in the northern extreme of the Grand Canyon of the Yellowstone. A survey of the valley south of Tower Falls failed to record a single site above Quartz Creek. The paucity of archaeological sites in the northern end of the Grand Canyon above Tower Creek is likely due to Precontact movement around the shoulders of Mount Washburn toward Hayden Valley rather than through the canyon itself, which would have been extremely difficult. This hypothesis will be tested this summer by an inventory of portions of the Grand Canyon, and in subsequent years by an archaeological survey of Yellowstone's northern ungulate winter range. South of the Grand Canyon of the Yellowstone, Precontact sites increase in frequency, size, and complexity. These characteristics are especially true from the area south of Otter Creek in Hayden Valley to the outlet of Yellowstone Lake, where 176 sites (73% of all sites) are located.

Precontact peoples were attracted to all sections of the Yellowstone River by an abundance of exploitable resources and the convenient travel route by which it was possible to access the park interior, including the Obsidian Cliff Plateau, Yellowstone Lake, and other known trail systems. Obsidian source analyses of many artifacts collected from sites in the Black Canyon of the Yellowstone and from Hayden Valley to Yellowstone Lake indicate that over 95 percent of specimens tested derive from the Obsidian Cliff Plateau. It is not surprising that Obsidian Cliff volcanic glass dominates the obsidian stone tools found along the Yellowstone River, as these sites are relatively close to the premier obsidian source (Obsidian Cliff Plateau). "Foreign" obsidian from Idaho, southwestern Montana, the Grand Teton National Park area, and other sources in Yellowstone help archaeologists to document the movements of regional peoples who would have replenished their tool kits when in the vicinity of those stone sources.

Prehistoric Use

The archaeological sites found along the Yellowstone River demonstrate that nearly all segments of the river valley were utilized during the Precontact Period; however, many questions regarding cultural and temporal affiliation remain. Although the dating of archaeological sites by reference to projectile point styles is not always appropriate (not all points represent classic types that are easily assigned to cultures and time period), it does provide a general framework for understanding the relative temporal range of the use of the Yellowstone River during the Precontact Period. Figure 2 thus illustrates the frequencies of Yellowstone River projectile point types that are assignable to particular Precontact Periods. Those points from the Late Precontact Period (Table 1), dating from 1,600 to possibly 200 years before the present (BP), are those in the first four columns from the left. Included are six specimens assigned to the First Blood Subphase representing a Late Precontact Numic (thought to be prehistoric Shoshone) occupation of the project area from possibly 800 to 200 years BP. A more intensive occupation of the Yellowstone River valley is manifested by 11 specimens identified as Tower Junction Subphase projectiles. These corner notched, often barbed arrow points are roughly contemporaneous with other late Precontact forms, such as those in the Todd Phase east and south of Yellowstone. Black Canyon Subphase points, representing local Avonlea Phase occupations that date from 1,600 to 1,200 years BP are relatively uncommon. This is interesting because Avonlea sites are common in northern Montana, Alberta, and Saskatchewan.

If the number of projectile points recovered during survey activities is indicative of the intensity of occupation, then it appears that the Yellowstone River valley system was most intensively utilized during the Middle Precontact Period. The human use of the Yellowstone River valley has fluctuated in intensity through time. It is probable that environmental changes (warming, drying, cooling, increased moisture) created more or less favorable conditions for people and local plants and animals. The Lamar Valley Subphase and Hayden Valley Complex points are numerous. These represent, respectively, regional expressions of the Pelican Lake Phase (3,000 to 1,600 years BP) and the McKean Complex (4,500 to 3,000 years BP). Hayden Valley Subphase components are well-represented where ground surfaces of the

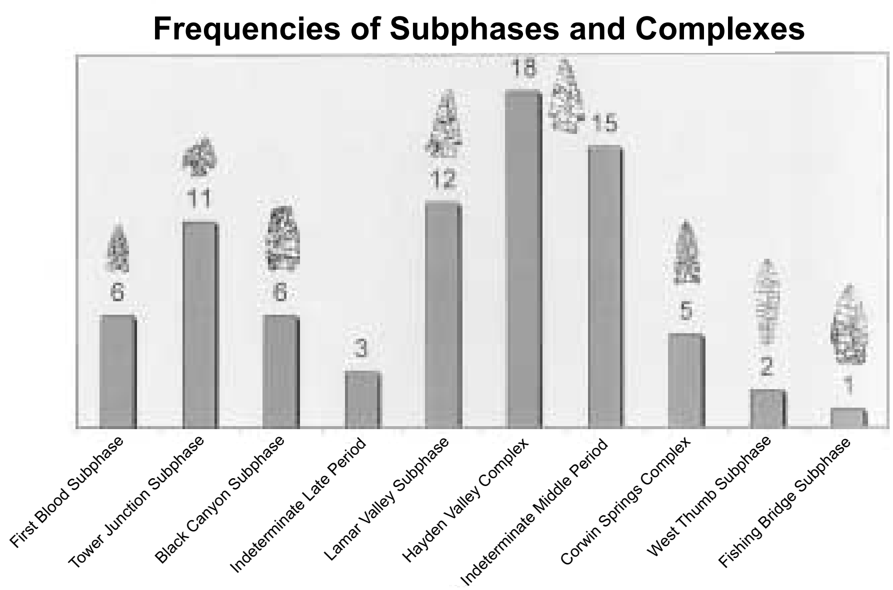


FIGURE 2. *Numbers of projectile points for each cultural group/time. It is assumed that relative numbers of these diagnostic artifacts can be used as proxy data for intensity/duration of occupation. Points in the indeterminate categories are fragmentary and cannot be identified specifically, but because of their size and flaking can be assigned to the relative time period. Courtesy Kevin Thorson, MOR.*

Table 1. Yellowstone National Park Precontact Archaeological Sequence

Late Precontact Period (ca. 1,600 to 200 years BP)
- First Blood Subphase (Ahvish Phase) (800 to 200 years BP)
- Tower Junction Subphase (Uinta Phase) (1,600 to 800 years BP)
- Black Canyon Subphase (Avonlea Phase) (1,600 to 1,200 years BP)

Middle Precontact Period (ca. 7,750 to 1,300 years BP)
- Antonsen Subphase (Besant Phase) (1,800 to 1,300 years BP)
- Lamar Valley Subphase (Pelican Lake Phase) (3,000 to 1,600 years BP)
- Hayden Valley Complex (McKean Complex/Hanna Phase) (4,500 to 3,000 years BP)
- Corwin Springs Complex (Mummy Cave Complex) (7,750 to 4,500 years BP)

Early Precontact (Paleoindian) Period (ca. 11,500 to 7,750 years BP)
- West Thumb Subphase (9,000 to 7,750 years BP)
- Fishing Bridge Subphase (9,500 to 8,500 years BP)
- Windust/Cascade Complex (10,000 to 9,000 years BP)
- Agate Basin/Hell Gap Complexes (10,000 to 9,500 years BP)
- Clovis Complex (11,500 to 10,000 years BP)

appropriate age are visible in exposed river benches and terraces. The frequency of sites of this age suggests a considerable increase in resource harvesting and occupancy along the Yellowstone River relative to earlier periods. The Corwin Springs Complex points represent the regional subphase of the Mummy Cave Complex in Yellowstone National Park. Their low frequency relative to those of the Hayden Valley Complex reflects, in part, natural processes that have removed ancient surfaces or so deeply buried them that they are not found by archaeological inventories. The West Thumb and Fishing Bridge subphases include early Precontact Period lanceolate and stemmed forms found during examination of museum collections. These are not discussed in this paper.

In addition to undertaking extensive inventory studies along the Yellowstone River, the museum crew conducted test excavations at five sites recorded in the Black Canyon of the Yellowstone during the survey program. These excavations were initiated as part of a site assessment program aimed at recovering archaeological deposits threatened annually by spring runoff. The need for such a program became apparent during early season flooding in 1996 and 1997, when resultant erosion created an excellent opportunity for assessing the depth, age, and extent of the archaeological deposits at each site. The MOR crew hoped to encounter well-separated, stratified deposits often missing at archaeological sites elsewhere in Yellowstone National Park. Of the five sites tested, two are discussed here.

Ryder Site

The first site investigated was the Ryder site, located on the south side of the Yellowstone River in its Black Canyon. During the initial inventory program there in 1996, the crew visited a large site associated with a well-defined river terrace that had undergone extensive terrace edge erosion. Large segments of the terrace had slumped and exposed quantities of fire-cracked rock, faunal remains, stone flakes, and a variety of formal stone tools including projectile points, bifaces (knives), scrapers, and expedient flake tools. Fire-cracked rock in this context is evidence of eroded hearths and roasting pits. Lithic material types were varied and included brown and red Madison Formation cherts, chalcedonies, obsidian, and a limited number of quartzite and basalt artifacts.

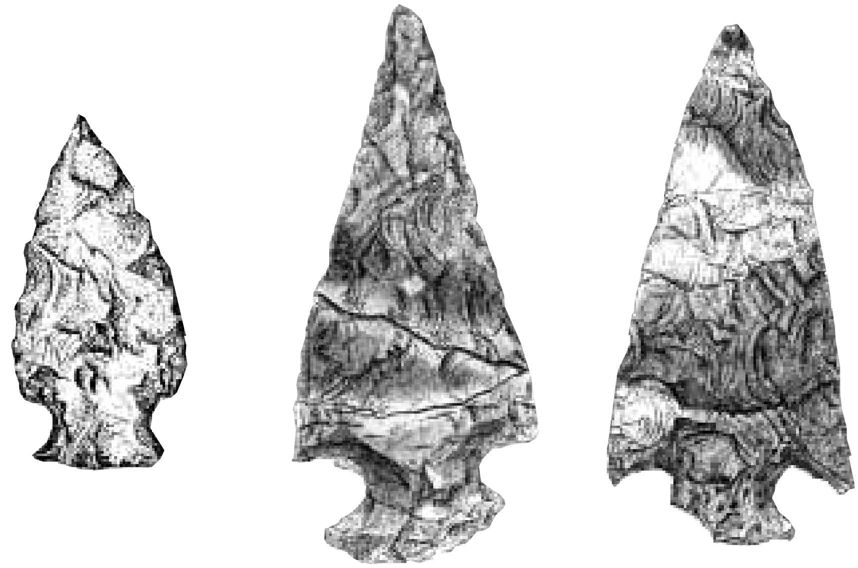
In July 1997, the museum crew returned and established a small excavation block over the part of the terrace that was actively eroding and slumping into the river. Excavation exposed a stratigraphic profile consisting of a series of buried soil horizons and associated artifact assemblages. Fire-cracked rock features, faunal remains, and a variety of stone tools characterized each level. The uppermost buried soil, located only a few centimeters below the ground surface, did not contain any cultural materials. It did, however, yield a significant number of faunal specimens, one of which provided a radiocarbon age of 190+/-40 years BP. It is likely that this soil represents a stable landscape prior to the last major depositional event along the river near the end of the Little Ice Age (525–150 BP), a period of colder temperatures and increased precipitation.

At a depth of roughly 70 centimeters below the surface, crew members exposed a mixed Black Canyon Subphase/First Blood Subphase component associated with a thick, buried soil horizon. Cultural materials include scattered fire-cracked rock, hearth-like features, side-notched and tri-notched projectile points, bifaces, scrapers, flake tools, and, for the second time in Yellowstone National

NPS photo.

Doug Mitchell excavating at the Ryder site. The light layer represents overbank flood deposits, while the dark zone contains remains of the Precontact campsites.

Park, prehistoric pottery. A preliminary analysis of 96 sherds indicates that they fit into the range of variation for Intermountain Ware. Two radiocarbon dates were subsequently secured for the mixed component; 630+/-70 years BP and 930 +/-60 years BP. Mammalian species identified in the faunal record include bison, elk, pronghorn, and a very large number of skeletal fragments identified as mountain sheep. Of significance was the presence of three fetal sheep bones that suggest a late spring to early summer occupation of the site. Pollen and charcoal analysis indicated that sagebrush, spruce, pine, and Douglas-fir were used as fuel sources by the site's inhabitants.



A projectile point and two hafted knives (actual size) from the Pelican Lake camp at the LBD site. The knives are manufactured out of stone from the Hellroaring Creek drainage. Drawings by Tah Madsen.

Continued excavation at the Ryder site exposed a third, more deeply buried soil horizon that yielded several fragmentary Lamar Valley Subphase (or Pelican Lake Phase) projectile points and other tool forms. In addition to a diverse lithic assemblage larger and more complex than the later First Blood/Black Canyon component, this occupation is characterized by a considerable amount of fire-cracked rock and a zooarchaeological assemblage representing a relatively wide variety of mammals. Species identified in the faunal assemblage from the Lamar Valley component at the Ryder site include bison, elk, hare, marmot, pronghorn, and mountain sheep. The pollen record indicates that Douglas-fir, willow, and aspen grew in the vicinity of the site and were likely used as fuel sources. One faunal specimen subsequently provided a radiocarbon age of 2,370+/-60 years BP.

Like many of the sites in the Black Canyon of the Yellowstone, the deepest cultural deposits identified at the Ryder site consist of what are likely Hayden Valley Complex or McKean Complex materials. Although projectile points were not recovered *in situ*, a small number of points typical of the McKean Complex were collected from the river bottom and from eroded lumps of soil. The lowest buried soil horizon from which these materials are thought to derive contained small quantities of debitage, faunal remains, and fire-cracked rock. Fortunately, a radiocarbon age of 3,220+/-50 years was secured on a piece of animal bone from the soil horizon, supporting an assignment of these materials to the McKean Complex. Pollen studies undertaken on soil samples taken during excavation suggest that a well-developed riparian community that included alder and pine surrounded the site. In contrast to the later components, Douglas-fir was not as abundant.

In the end, the Ryder site investigations allowed the crew to assess a portion of the site that would have eroded and slumped into the river during the summer or following spring. The subsequent collection of archaeological and paleoenvironmental data provided information regarding three Precontact components: an early Hayden Valley Complex occupation followed by a much heavier, intensive use of the site area by Lamar Valley Subphase (Pelican Lake Phase) peoples, and finally, near the end of the Little Ice Age, utilization of the site area by Precontact Native American peoples, who used it as a springtime campsite where a variety of mammalian species were put to use. Stratified sites such as this allow us to study how different people used the same space and resources at different times.

As an aside, recent test excavations conducted last August at the LBD site (named for Dr. Leslie B. Davis of the MOR) on the opposite side of the Yellowstone River revealed a stratigraphic profile similar to the Ryder site. The crew identified a mixed Tower Junction Corner-Notched/Black Canyon (or Avonlea) component, a Lamar Valley (or Pelican Lake) component, and what also appears to be a Hayden Valley (McKean) component. Comparative analyses between these sites will certainly help us to synthesize and better understand middle- to late-Precontact occupations in the canyon system.

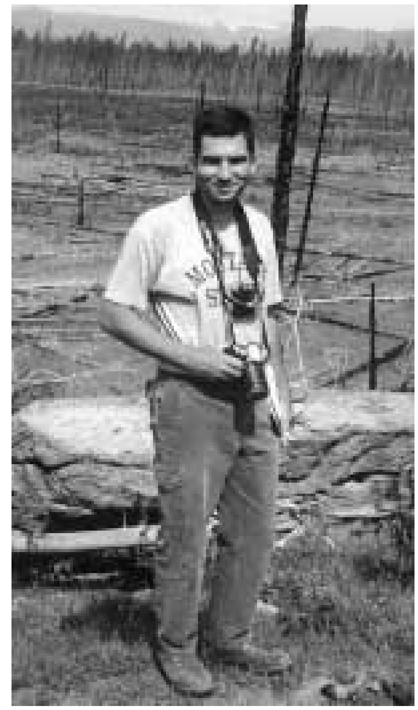
BOKR Site

In the summer of 1999, the Museum of the Rockies crew returned to the BOKR site (named for Dr. Brian O. K. Reeves, professor emeritus of the University of Calgary), a large campsite on the north side of the Yellowstone River in the Black Canyon. Like the Ryder site in 1997, the aim was to conduct assessment-oriented excavations on those portions of the site undergoing erosion. First recorded during the 1996 field season, the BOKR site was heavily damaged by flood-level waters in 1996 and 1997. Subsequent annual snow melt and runoff have continued to erode archaeological deposits onto the sandy river bottom. In addition to lithic debris and the occasional stone tool, large concentrations of fire-cracked rock were observed on the beach between the terrace edge and river channel. These concentrations represent completely eroded roasting pits and hearths. Roasting pits were often used like crock pots to slow cook high carbohydrate plant remains. Excavations revealed a stratigraphic profile consisting of silty overbank sediments overlying a thick deposit of dark brown organically rich silt. Rather than a series of discrete buried soil horizons with associated archaeological components, the BOKR site consists of a single thick cultural deposit dating to the Tower Junction Subphase, approximately 1,600 to 800 years BP. The projectile points found during excavation include small, finely made corner-notched forms. Other tool types include bifaces, endscrapers, and a notched-pebble netsinker, which would have been used to help hold a fishing net in place in the river. The faunal assemblage, while not as extensive as that recovered at the Ryder site, consists of skeletal elements identified as mountain sheep and an unidentified bird species. Although the amount of fire-cracked rock exposed is suggestive of the processing of animal products, the relative lack of faunal remains may suggest that the processing of plant remains was a more important undertaking. To date, none of the bone or charcoal samples have been submitted for radiocarbon analyses. As with the data from the Ryder site, we certainly look forward to continuing our analyses of the artifactual remains from the BOKR site and incorporating the data into a regional synthesis of Tower Junction Subphase components.

Summary

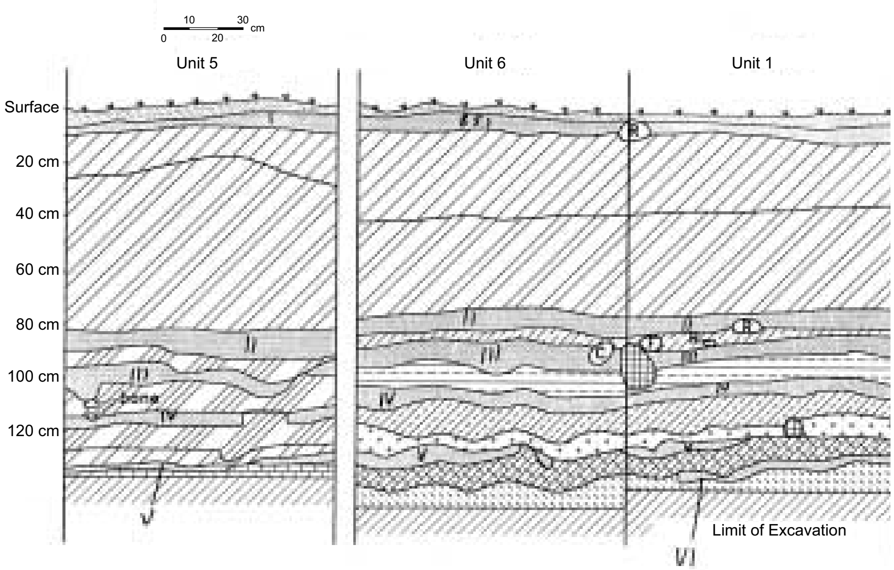
The ongoing archaeological project being conducted by the Museum of the Rockies along the Yellowstone River has demonstrated intensive Precontact use of most of the valley. The resulting archaeological record is extensive and suggests that at least 9,000 years of Precontact time is represented. In relative terms, the projectile point data suggest that the heaviest use of all parts of the river, from the town of Gardiner to the outlet of Yellowstone Lake, occurred during the Middle Precontact Period (from 4,500 to 1,600 years BP). Use of the valley system continued into the Late Precontact Period from approximately 1,600 to 200 years BP. Subsequent excavations at five of the sites, two of which were briefly discussed in this paper, revealed well-stratified buried soil horizons with associated middle- to late-period archaeological components. Archaeological data germane to the study of resource exploitation, cultural history, and paleoenvironmental reconstruction has and will continue to shed light on Yellowstone's cultural past, determining who was in the park at what time—the past is the first step to understanding Yellowstone's archaeology.

I would like to thank Dr. Leslie Davis of the Museum of the Rockies, Dr. Ann Johnson of the Branch of Cultural Resources in Yellowstone, and Dr. Brian "Barney" Reeves for their ongoing support and guidance, and Devon Finley for her assistance in the production of this article.



NPS photo.

Mack Shortt was born in Calgary, Alberta, Canada. He received a B.A. and an M.A. in archaeology from the University of Calgary, and has worked in the field of archaeology since 1989, in areas such as the boreal forests of northern Alberta, the Rocky Mountains in Alberta and British Columbia, the Alberta Plains, and the Siksika Nation. From 1993 to 1996 and in 1998 he worked on the Glacier National Park Archaeology Project for the Museum of the Rockies. Since 1996, he has worked for the Museum of the Rockies in Yellowstone National Park—his favorite place in the world.



Bank profiles of test units 1, 5, and 6 at the BR site showing six (I–VI) different campsites in this location. These distinct campsites are separated by overbank sand and silt deposits. Unit I has two crosshatched rodent holes. NPS graphic.

Footnotes

[1] Precontact is perhaps more politically correct than the term "prehistoric." Both terms are used to mean that time before the coming of the Europeans.

[2] Lithic scatters are Precontact sites identified by the flake debris left from manufacture and repair of stone tools. Campsite is also a generic term for a Precontact site, and may also contain hearths, pottery, archaeological bone, and other materials.

Commercial Film Company Cited for Resource Violations

On February 27, 2001, a weekly television show in the Seattle area broadcast an episode entitled "A Winter in Yellowstone." The show featured a segment in which the host walked off the boardwalk in a Yellowstone thermal basin, dug a hole, and placed a piece of chicken in it. He was later shown to be digging up what appeared to be the same piece of chicken, cooked from the ground's heat. Although King TV, the production company, maintained that this was done to demonstrate the hot and dangerous temperatures in geyser basins, the park viewed it as demonstrating the old practice of attempting to cook food in thermal areas. Most of the filming in January occurred with an NPS monitor present, but this stunt was not originally scripted and was conducted at a time when the monitor was absent. Officials from Yellowstone contacted the company and came to an agreement. The company has apologized publicly, and has emphasized the safety and resource damage aspects of the stunt in a statement on their web site and on a short segment that will appear in an upcoming edition of the weekly show. The company was also cited under 36 CFR for violating the terms of their filming permit and for digging up mineral resources, fined $150, and placed on a "full monitoring" probation for any filming they conduct in the park over the next two years.

Yellowstone Superintendent Announces Retirement

Yellowstone National Park Superintendent Michael V. Finley announced his retirement from the National Park Service, effective in late-May 2001. Finley has been superintendent since November 1994. Finley leaves his position for a new challenge as president of the Turner Foundation in Atlanta, Georgia.

Finley, a 32-year veteran with the National Park Service, began his career as a seasonal firefighter in Yellowstone. He was a major influence in establishing the Yellowstone Park Foundation, whose purpose is to protect, preserve, and enhance Yellowstone National Park by raising money to fund important projects and programs that are beyond the financial capacity of the National Park Service.

Finley's successor will be selected by the NPS, subject to the approval of the Secretary of the Interior. Since the Yellowstone position is a designated member of the federal career Senior Executive Service, a pool of previously qualified and competitive candidates is available to be named to the position.

Wyoming Bans Salt Baiting

The 2001 Wyoming State Legislature recently passed a bill that will ban salt baiting of wildlife. The law does not prohibit ranchers from placing salt for their livestock, nor does it prohibit black bear baiting. For many years, some hunters and outfitters have placed salt licks just outside the border of Yellowstone in the Bridger-Teton and Shoshone national forests to lure trophy bull elk. In fact, more than 20 salt sites have been identified just outside park boundaries, and land satellite and aerial photographs taken by the U.S. Geological Survey reveal even more illegal salt sites.

Sixth Biennial Scientific Conference on the Greater Yellowstone Ecosystem

From October 8 to 10, 2001, the Sixth Biennial Scientific Conference on the Greater Yellowstone Ecosystem, "Yellowstone Lake: Hotbed of Chaos or Reservoir of Resilience," will be held at the Mammoth Hotel in Yellowstone. The conference will focus on a central feature of the Greater Yellowstone Ecosystem's landscape, Yellowstone Lake, where submerged hot springs and spires emerge atop the Yellowstone caldera and rare plants and evidence of prehistoric peoples erode at the mercy of wind, waves, and modern footsteps. The conference is interdisciplinary in nature, and includes presentations on geology, wildlife, human history, archaeology, and recreational use around the lake. Conference attendance is open to all, and participants will include scientists, park employees, students, park cooperating organizations, tribal members, and other interested individuals. Registration and lodging information will be posted as it becomes available on the conference's web site, at *www.nps.gov/yell/technical/conference.htm.*

Yellowstone Becomes Catch-and-Release Only for Native Fish

Beginning with the 2001 fishing season, all native sport fish species in Yellowstone will be placed under catch-and-release-only fishing rules. The native species affected by this change are the cutthroat trout and its several subspecies, Montana grayling, and mountain whitefish. These rules are in response to the increased threats to native fish from invasive introduced organisms such as lake trout, whirling disease, and New Zealand mud snails. Most of the park's native fishes have been under catch-and-release-only fishing rules since the early 1970s. The recent changes primarily affect fish populations in Yellowstone Lake, its tributaries, and the upper Lamar River. Non-native species, such as brook, brown, rainbow, and lake trout, are not affected by this rule.

In addition, the opening date of the fishing season on Yellowstone Lake will return to its historic date of June 15 for the 2001 fishing season. From 1998 through 2000, Yellowstone Lake's opening date was moved forward to June 1 in an attempt to give anglers a greater chance of catching non-native lake trout, but monitoring showed that during the early June period, anglers caught several thousand cutthroat trout for every lake trout caught. Because of incidental hooking mortality of released fish, this negated the positive impact of the angler catch of lake trout.

Note

An attribution for a figure in the article in *Yellowstone Science* 9(1) "*Pilobolus*: A Fungus that Grows in Yellowstone" was omitted. Figure 2 was adapted from a figure by Robert Page that originally appeared in: Page, Robert M. 1962. Light and the asexual reproduction of *Pilobolus*. *Science* 138: 1238–1245.