YELLOWSTONE SCIENCE

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Yellowstone Beavers

The Language of Heaven and Hell

Changing Values at Fishing Bridge

NPS PHOTOS

Clockwise from top left: A beaver just under the bank in Soda Butte Creek. Abyss Pool, a hot spring in the West Thumb Geyser Basin. Fishing Bridge in its current fish-watching state.

Something in the Water

ONE WEEKEND THIS SUMMER, I watched my two young children lie on their bellies on a small bridge, watching for fish swimming below them. They would get so excited when they spotted one, determinedly pointing it out and describing to the rest of us just where it was, wanting to be sure we saw it too. There is something mysterious and magical about water and the things that live in it. In Yellowstone, water enhances scenic vistas, provides habitat for many species, and shapes the park's geothermal wonders. We peer out and down into it, hoping for a glimpse of something that connects us to another world, if only for a moment.

In this issue, we are pleased to have had Doug Smith and Dan Tyers document beaver surveys in Yellowstone and a U.S. Forest Service reintroduction effort that took place north of the park in the Absaroka-Beartooth Wilderness. Beavers dispersing from newly established colonies there are finding some areas on the park's northern range where willow have recently grown taller, offering enough food and building materials for beavers to settle.

In "Between Heaven and Hell," Michael Barton explores the use of religious language in early descriptions of Yellowstone National Park. Naturally, early visitors to the area used words and experiences from their own culture to express their feelings about the park, which ranged from fear and disgust to amazement and delight. Many place names still reference religious terminology, such as Abyss Pool above. An abyss is a deep or bottomless place. In biblical literature, the word abyss generally refers to a pit, the underworld, the deepest ocean floor, or to hell.

Paul Schullery's article describes the changes at Fishing Bridge as it went from a place of "hog-heaven" fishing to one with a new tradition of fish watching. This example showcases how National Park Service management has responded over time to changing values. Judging by the large number of people who use Fishing Bridge for fish watching today, it is not just children who take joy in spying something in the water.

We hope you enjoy the issue.

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Submissions are welcome from all investigators conducting formal research in the Yellowstone area. To submit proposals for articles, to subscribe, or to send a letter to the editor, please write to the following address: Editor, *Yellowstone Science*, P.O. Box 168, Yellowstone National Park, WY 82190.
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on the cover:
One of the beavers reintroduced to the Absaroka-Beartooth Wilderness.
USFS/Dan Tyers photo.

NPS/JIM PEACO

A beaver in Yellowstone at Soda Butte Creek near its confluence with the Lamar River, January 2005.

FEATURES

DEPARTMENTS

News & Notes

Volunteer Ralph Taylor Receives Hartzog Award

On July 18, 2008, Linda Young, Yellowstone's Chief of Interpretation, presented the George B. Hartzog, Jr., Award for the National Park Service (NPS) Intermountain Region to Mr. Ralph Taylor at the Old Faithful Visitor Center.

One of the most prestigious awards given by the NPS, this award recognizes outstanding contributions to the NPS by individuals, organized groups, or park volunteer programs. The intent of the award is to distinguish those individuals who give of their skills, talents, and time beyond the normal call of duty.

For 21 years, Ralph Taylor has volunteered in Yellowstone each summer, focusing on protecting the park's geothermal features. Ralph works in the Old Faithful area, observing and studying geysers and hot springs, educating visitors, and promoting visitor enjoyment and understanding of the geothermal features in six geyser basins.

Ralph arrived in Yellowstone as a visitor in 1966. He was enthralled by the park's geothermal features and became an avid "geyser gazer." After he retired from a position as an electrical engineer with Cincinnati Milacron Company, Ralph became a summer VIP (Volunteers-in-Parks) in Yellowstone beginning in 1986. His primary task has been to clean litter from more than 80 geothermal features and scrub out graffiti from the bacterial mats in the Upper, Midway, and Lower geyser basins. He uses "a very long pole with a slotted kitchen spoon" to remove coins and other debris. Ralph and others are concerned about the best way to pass on the skills of safe and effective cleaning of these very fragile features.

Ralph is responsible for documenting geyser activity for 35 geothermal features by deploying and maintaining scientific data loggers, then downloading and analyzing the data. Staff at the Old Faithful Visitor Center use Ralph's analyses to predict eruptions of certain geysers, explain eruption patterns to visitors, and incorporate possible geyser eruptions into daily interpretive walks and talks. This data has also shown the effects of earthquakes thousands of miles away. The sensors in Yellowstone reflected activity within one to two hours from occurrence after the 2002 earthquake in Denali National Park, Alaska. In the winter months, data is recorded and sent to Ralph to analyze and prepare for his next summer trip to Yellowstone.


NPS

Volunteer Ralph Taylor received the George B. Hartzog, Jr., Award in July for his outstanding contributions to the National Park Service. He helps protect the park's geothermal features.

Awards Presented at IGBC 25th Anniversary Celebration

On June 21, 2008, the Interagency Grizzly Bear Committee (IGBC) recognized many people for their contributions to the grizzly bear recovery effort. Awards were presented at the IGBC 25th Anniversary Celebration held near Seeley Lake, Montana.

The IGBC consists of representatives from the USDA Forest Service, the National Park Service (NPS), the U.S. Fish and Wildlife Service (USFWS), the Bureau of Land Management, and representatives of the state wildlife agencies of Idaho, Montana, Washington, and Wyoming. In the interest of international coordination and cooperation, the Canadian Wildlife Service is also represented. The IGBC was formed in 1983 to help ensure the recovery of viable grizzly bear populations and their habitat in the lower 48 states. Prior to its establishment, decisions about grizzly bear recovery were often problematic when they conflicted with jurisdictional boundaries between federal and state agencies. The inclusion of high-level administrative staff with agency decision-making authority and funding support to IGBC was a significant turning point for grizzly bear recovery.

Award recipients included authors and editors of the previous issue of *Yellowstone Science,* 16(2), which focused on Yellowstone grizzly bears: U.S. Geological Survey wildlife biologists Chuck Schwartz and Mark Haroldson of the Interagency Grizzly Bear Management Team, for Scientific Leadership; NPS wildlife biologist Kerry Gunther, for On-the-Ground Leadership; NPS naturalist Paul Schullery, for Communications Leadership; and Chris Servheen, USFWS Grizzly Bear Recovery Coordinator, for Significant Accomplishment. For a list of other award recipients, visit the IGBC website at http://www.igbconline.org/IGBC25FinalProgram.pdf.

Centennial Challenge Provides $700,000 to Yellowstone

The Yellowstone Park Foundation has raised more than $700,000 in private funding for four 2008 National Park Service Centennial Challenge projects. As a result of the Yellowstone Park Foundation's fundraising efforts, Yellowstone has been awarded matching federal funds to be used toward these projects.

The purpose of the NPS Centennial Challenge is to improve, through federal investment and private charitable contributions, the value and natural beauty of America's national parks in anticipation of the 100th anniversary of the National Park System in 2016. In response to the President's Centennial Challenge, Congress appropriated $24.6 million this year to be matched by donations for programs and projects that will further NPS centennial goals and help prepare parks for another century of preservation, conservation, and enjoyment.

Yellowstone's 4 projects are among 110 at 76 national parks that are receiving matching grants this year. The projects, designed to help American youth, national park visitors, researchers, and scientists understand and protect Yellowstone, include:

- *The Greater Yellowstone Science Learning Center (http://www.greateryellowstonescience.org).* This website is designed to integrate the work of the park, academic, and scientific communities in collaborative efforts to gather and use information to better protect and manage places like Yellowstone. A grant from Canon U.S.A. to the Yellowstone Park Foundation is being matched by $115,000 in federal funds.
- *The protection and preservation of more than 40,000 priceless artifacts in Yellowstone's Heritage and Research Center.* A grant from Canon U.S.A. to the Yellowstone Park Foundation is being matched by $79,528 in federal funds.


NPS, YNP, YELL 125424-1

Long-time Yellowstone park ranger Dale Nuss.

- *A scientific study on Yellowstone Lake's microbial biodiversity.* This groundbreaking research will be aimed at documenting environmental relationships between many identified and previously unidentified microbial species, including those living in the depths of Yellowstone Lake. A grant from the Gordon and Betty Moore Foundation to the Yellowstone Park Foundation is being matched by $459,000 in federal funds.
- *The "Inspiring Future Yellowstone Stewards: No Child Left Inside" initiative.* This initiative is designed to help better connect school-age children with the natural world by giving them first-hand experiences with the outdoors. It includes special programs for visiting school groups and underserved youth in the Yellowstone region, and enhances the park's Junior Ranger and Young Scientist programs. A grant from the Toyota U.S.A. Foundation to the Yellowstone Park Foundation is being matched by $80,230 in federal funds.

The Yellowstone Park Foundation (http://www.ypf.org) has been Yellowstone National Park's official fundraising partner organization since 1996. The Foundation has raised $50 million in contributions from individuals, foundations, and corporations to support more than 150 park projects.

Passing of Dale Nuss

On June 20, long-time Yellowstone park ranger Dale Nuss passed away at the Montana Veterans Home in Columbia Falls, Montana, where he had been a resident since 2004.

Dale Hudson Nuss was born in Kansas City, Missouri, on August 31,1925. His father worked at Pahaska Teepee near the East Entrance to Yellowstone National Park. He spent his childhood summers there and often traveled into the park with Camp Trails, the boys' summer camp his father operated.

Dale served with the U.S. Army Air Corps in Europe during World War II, flying numerous missions over Germany. After the war, Dale attended Colorado State University and worked as a seasonal fire control aid and park ranger in Yellowstone from 1947 to 1952. He met Bunny, his wife and life companion in Yellowstone in 1952. After working at Shenandoah National Park, he returned to Yellowstone as a permanent employee in 1953, and remained there until his retirement in 1980.

During his long career in Yellowstone, Dale served as district ranger at West, South, and North districts, as assistant chief ranger, and as a specialist in forestry, fire, and bear management. He was involved in most aspects of park management, including the elk and bison programs, which he supervised. He developed and designed A-frame cabins that replaced tent-frames and log patrol cabins. Four A-frame cabins still stand as a continuing monument to Dale's innovation.

He loved his family, his wife, and his friends more than he could show and his love of animals and nature were immeasurable. Through his sometimes gruff exterior, there was probably not one request that he did not honor.

YS

The Beavers of Yellowstone

Douglas W. Smith and Daniel B. Tyers

PHOTO BY ANDREA EASTER-PILCHER

LITTLE HAS BEEN PUBLISHED about beavers in Yellowstone National Park (YNP) despite their central importance in Euro-American exploration of the West. Beaver fur was the most sought-after pelt during the fur trade and fueled most North American exploration. The hunt for new trapping grounds led parties through what is now YNP. Further, the quirky and interesting life history of the beaver, its engineering skill (second only to humans), and its effects on biodiversity make the lack of scientific study in YNP a notable omission. The fur trade reduced beaver populations across the West and likely in the Yellowstone area by the time the park was established in 1872, but the park was never considered prime beaver habitat due to the lack of extensive aspen stands, a key beaver food. No reliable pre-park population estimates exist, but journals from the late 1800s indicate beavers were present in places where they are not currently found: Pelican Creek, the upper Lamar, and Gardner's Hole. Ernest Thompson Seton observed a beaver colony in Yancey's Hole in 1897 and the present meadows there were probably created as beaver meadows (old beaver ponds that drained and grew into a lush grassland), but there is no sign of beavers there today.

In 1921 and 1923, Edward Warren surveyed portions of the northern range for beavers and produced the first published account of beavers in the park (Warren 1926). What Warren found might be called the beaver heyday for the northern range. Beavers were common and they were cutting aspen, which was much more abundant on the northern range in the 1920s than it is now. The objective of this short beaver history is to take you through the few and sporadic surveys conducted between Warren and the present, when population counts are done every other fall. But before we get into the Yellowstone story, some background on beavers is necessary.

Beaver Biology

Beavers are choosy generalists; they can eat many different foods but prefer only a few. Aspen is their most preferred food and beavers go to great trouble to cut and eat it. After aspen, beavers prefer willow and cottonwood. Beavers produce more young and have higher population densities when these foods are abundant, and there is some data to support the idea that they do slightly better when aspen is plentiful, but this is far from settled. Next in beaver preference is a long list of deciduous tree species such as birch, oak, and maple, and shrubs such as dogwood, mountain maple, and beaked hazel. Last on the list are conifers; their sappy, resinous bark is not sought after by beavers except when nothing else is available. Harlequin Lake near Madison Junction is a good example of a place where beavers use lodgepole pine. Alder is widespread and grows along many YNP stream courses and is commonly cut by beavers, but how much alder they eat is not well understood. Beavers commonly cut it for building material, but there is some debate over whether they are cutting it for food as well. Research in western Montana found that beavers used small alder stems during the late fall when they were storing ("caching") food for winter, suggesting some alder consumption (A. Easter-Pilcher, personal communication, University of Montana–Western) even though it is loaded with tannins that reduce its palatability. But some researchers have found that beavers actually use the less edible alder to cap their food cache, as the top portion

NPS/DOUG SMITH

This beaver lodge in Harlequin Lake near Madison Junction shows use of lodgepole pine (green) in the food cache.

NPS/DOUG SMITH

A typical beaver food cache in Yellowstone, with canals that allow water access to willow stands.

is frozen in ice and unusable. Regardless, it is well known that beavers construct dams and lodges out of alder, but they often use it with the bark on, whereas other woody vegetation is used after the bark is consumed.

During the growing season beavers shift from eating bark (the cambium layer) to eating primarily the herbaceous, succulent vegetation on shore, including willow and aspen leaves. They tend to cut wood and eat the bark before herbaceous plants come up in the spring and after they die off in the fall. They store wood in a food cache in the water near their burrows or lodges, as beavers do not hibernate and are active all winter. Existence below the ice in this totally dark environment (called subnivean living) is fascinating but beyond the scope of this article. Aquatic vegetation is another key food for beavers. Water lilies, which are rich in starch, are available all winter because they have a tuberous root that grows in the bottom mud of ponds. Harlequin and Heart lakes and some ponds in the Bechler area that are used by beavers have abundant water lilies.

It is an odd sight seeing a beaver graze on shore. Designed for swimming, with their haunches above their forelimbs, beavers do not seem like they should be able to walk. Running is even more difficult for them. They appear to gallop but look like they are about to roll over at any moment. They would clearly rather amble along and not have to run anywhere. Their clumsiness on land makes them vulnerable to terrestrial predators because their only defense is to escape into the water; that is why they dig extensive canal systems around their habitations. Some good examples of these canals can be found in the Willow Park area. The water around their dwelling serves as a moat, protecting them from nearly all predators. Their lodges are so sturdy that bears have a hard time digging through them; several attempts have been seen in the park, none successful. Nocturnal and crepuscular (primarily active at twilight), beavers have a keen sense of smell and acute hearing but poor eyesight. Wolves patrol some beaver ponds nightly, waiting for a beaver to forage too far from the water. When a beaver detects danger while swimming, it slaps its tail on the water to warn any beavers on land, who then flee to the water. Colony members can identify each other by tail slaps, and the tail slaps of kits (young beavers), who are inexperienced at assessing danger, are often ignored. This tail slapping is often the first thing you hear when you approach a beaver pond, unless the beavers are habituated to humans.

The term "busy as a beaver" comes from their obsession with damming flowing water and creating ponds. For example, a beaver that was being held overnight in Doug Smith's basement dug at the corner of its cage when a toilet was flushed upstairs and water ran through the pipes. When the water stopped, the beaver did too. They can be so zealous at damming that they flood trees they could use as food.

Life History and Population Ecology

Called cooperative breeders, beavers, wolves, and other mammals that live in family groups represent less than 2% of all mammalian species. Beavers are territorial and colonies typically start when two dispersing beavers of the opposite sex find a vacant location upon which to build a lodge. They will readily settle old, unoccupied colony sites, and may prefer them because much of the major structural work has already been completed, but the forage in previously occupied sites is often poor. If the current is too strong they may live in burrows or bank dens without making any dams.

Beavers typically breed monogamously each year (there are some exceptions), producing a litter of one to nine kits (averaging two to four). Their colonies can grow quickly, sometimes reaching 14 beavers, but in North America the average size is about six, which usually includes one or two young from the current year and one or two from the previous year (yearlings). Many beavers disperse at two years, but this depends on the availability of nearby vacant territories. Some beavers live 10–15 years in the wild, making them a fairly long-lived rodent. They also grow to be North America's largest rodent (the

capybara in South America is the only larger rodent in the world). Their life history strategy, combined with their lodge building and food storage, has made them adaptable and resilient, and enabled them to settle most of North America, from the southeast United States to above the Arctic Circle. Their range is limited only by their need for adequate water and enough woody vegetation for their structures and winter food storage. They sometimes use sagebrush for construction in Yellowstone (see the colony along Glen Creek and near Golden Gate); beaver use of corn stalks has been reported in the Midwest.

Given their preference for aspen and its positive influence on their productivity, beaver populations can exhibit a boom-bust cycle. Aspen, a sun-loving, early successional species, comes in after disturbances and can grow into lush forests, but once cut it takes time to regenerate. Beavers move along waterways into aspen stands and cut them for winter food almost exclusively until the only remaining trees are beyond safe reach of the water. Their boom-bust population ecology has been especially evident in Michigan, Minnesota, and Wisconsin, where beavers expanded in record numbers when vast tracts of aspen came in after the extensive pine forests were clear-cut. The 210 square miles of land in Minnesota that became Voyageurs National Park after having been logged by Boise-Cascade had abundant aspen growing in it and more than 500 beaver colonies in 1986. (YNP, with about 3,600 square miles, had only 127 colonies in 2007.) At Apostle Islands National Lakeshore in Wisconsin, where beavers have no predators, Smith has seen them travel more than 300 meters on land to cut an aspen tree. On Isle Royale National Park in Lake Superior, where wolves are abundant and beavers make up a significant part of their diet, beavers cut every aspen tree within about 40 meters of the water, then switch to birch until it is gone, then the colony goes extinct. Most of the aspen cut by beavers there did not regrow due to heavy moose browsing, so aspen stands along streams converted to white spruce, a tree moose do not eat, nor do beavers. At some sites the aspen trees grow back and the cycle repeats itself, causing the boom-bust swings.

Beavers subsisting on willow may not exhibit this boom-bust cycle because they are less capable of suppressing its growth (Boyce 1974). This may be due to the hardiness of willow, which withstands beaver cutting well, but it is also probably partly due to the lower beaver densities in colonies subsisting on willow than on aspen. This aspect of beaver ecology has important ramifications for beavers in Yellowstone. While Warren found beavers commonly using aspen on the northern range, recent parkwide surveys seldom find an aspen cut by beavers (Fullerton 1980, Smith et al. 1997). Virtually all of the beavers living in Yellowstone today subsist on willow (Figure 1); some use aquatic plants, others use lodgepole pine, but aspen is not used because there is very little available. Aspen accessible to beavers was cut and has not re-grown. Cottonwood is occasionally cut, but it is not a significant food source for beavers in YNP.

Virtually all of the beavers living in Yellowstone today subsist on willow...

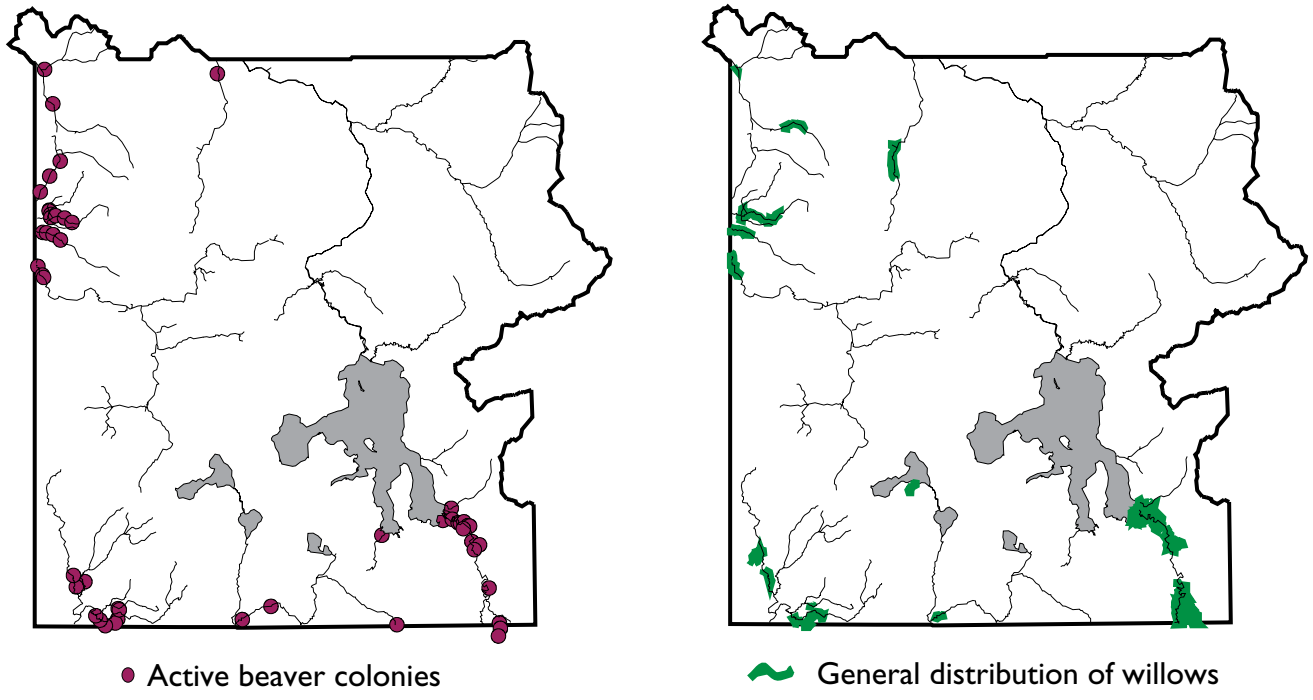

Figure 1. Locations of active beaver colonies and general distribution of willows, 1996. Willow data from the Yellowstone Spatial Analysis Center.

YNP Beaver Surveys, 1921–2007

Warren. When Warren surveyed parts of the northern range for beavers in 1921 and 1923 (Warren 1926), he found 25 and 9 colonies, respectively (Figure 2). As he walked and rode horseback, he photographed and wrote detailed accounts of many of these colonies, most of which were cutting and using aspen. One large colony existed within view just south of the main road at a point just east of the Lava Creek bridge; another was next to the highway near the Yellowstone River bridge just east of Tower. Today it is virtually impossible to tell that beaver colonies with abundant aspen ever existed at these locations.

Jonas. In 1953 a graduate student at Montana State University, Robert Jonas, repeated the Warren survey, extended it to other areas of the park, and included beaver sightings by other people in his report (Jonas 1955). Like Warren, Jonas did a ground survey, walking or riding stream courses. Jonas, who found no beavers where Warren had found them, cited three reasons for the decline: (1) lack of preferred food (e.g., aspen), (2) poor water conditions, and (3) silting in of the beaver ponds. He considered the primary factor to be "lack of preferred food," meaning that aspen had declined significantly. He found northern range beaver sites that had not been documented by Warren (Figure 2), but he concluded that beavers had declined overall, aspen had declined, and that elk browsing prevented aspen regeneration, reducing the possibility of beaver recolonization. Jonas also located beaver sites elsewhere in the park that had not been previously recorded, including the southeast arm of Yellowstone Lake along the Yellowstone River Delta, Hayden Valley, and the Snake, Gibbon, Firehole, and Madison rivers.

Consolo Murphy. In 1988 and 1989, park biologist Sue Consolo Murphy conducted surveys to document the presence and distribution of beavers in the park. Beavers were surveyed during two August overflights and on the ground mainly from August to October (Consolo Murphy and Hanson 1993). This survey improved the park's reporting system so that more information on beaver sightings and sign was recorded. Consolo Murphy found 71 active lodges parkwide, which she considered a conservative estimate (Figure 2). She suggested that many northern range colonies were "ephemeral," with some locations supporting just one colony that moved around over a period of years. She hypothesized that "beavers may move between the Gardner River and nearby ponds and lakes (such as Slide Lake)." She classified at least 13 streams or stream

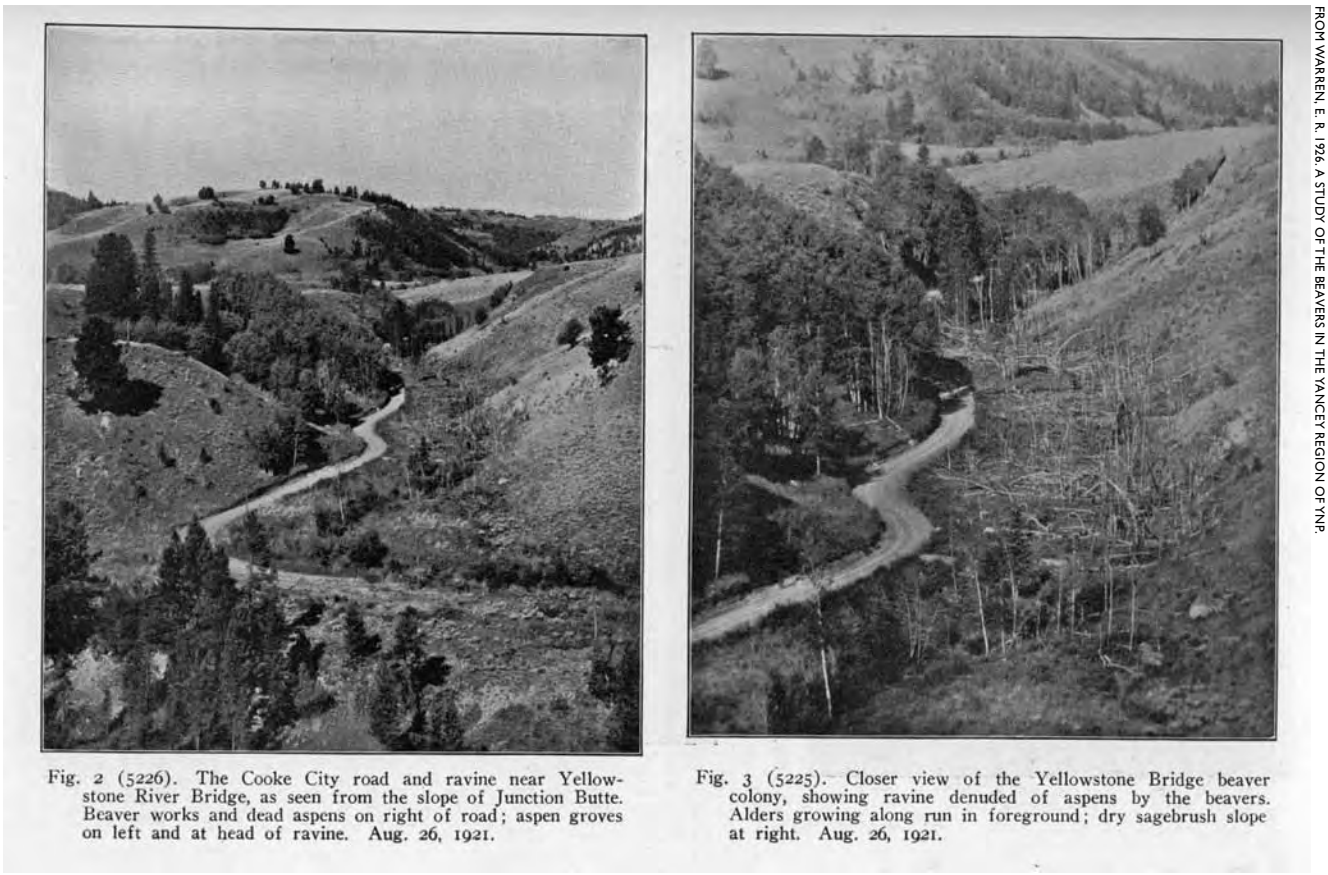

Fig. 2 (5226). The Cooke City road and ravine near Yellowstone River Bridge, as seen from the slope of Junction Butte. Beaver works and dead aspens on right of road; aspen groves on left and at head of ravine. Aug. 26, 1921.

Fig. 3 (5225). Closer view of the Yellowstone Bridge beaver colony, showing ravine denuded of aspens by the beavers. Alders growing along run in foreground; dry sagebrush slope at right. Aug. 26, 1921.

FROM WARREN, E. R. 1926. A STUDY OF THE BEAVERS IN THE YANCEY REGION OF YNP.

These 1921 photos from Warren's report show the Yellowstone Bridge beaver colony's use of aspen. Jonas found no beaver and little evidence of aspen here in 1953. Today, it is virtually impossible to tell that beaver and aspen ever existed here.

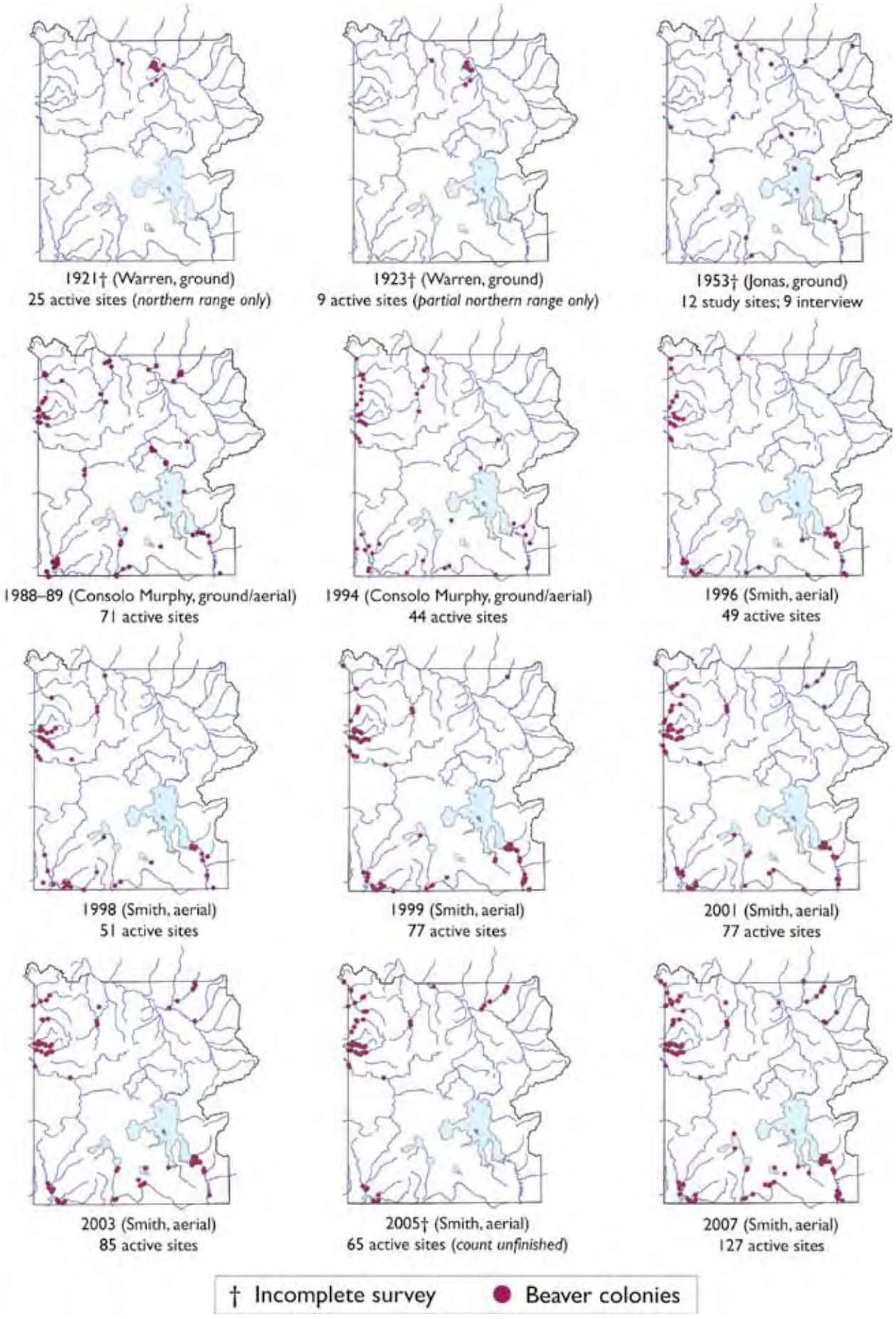

Figure 2. Maps of Yellowstone beaver surveys, 1921–2007. Note: data from these surveys are not precisely comparable because of the different census techniques and objectives used in each study.

segments in the northwest, southwest, and southeast portions of the park as high quality beaver habitat. Colonies with persistent activity were usually associated with either willow or aspen, and at some sites with aquatic vegetation.

In 1994, Consolo Murphy conducted a follow-up sampling survey. She looked for beavers during a September 9 overflight and during ground surveys that mainly took place from August 15 to November 15 (Consolo Murphy and Tatum 1995). The results were similar to and reaffirmed those of the previous survey; 44 lodges were classified as active.

Smith. In 1996, Smith began the first of seven parkwide aerial surveys conducted during the fall. In the summer beavers may wander alone and leave sign over a wide area, sometimes overlapping with beavers from a nearby colony or dispersing to a new territory. In the fall they begin centralizing their activity around a lodge and building a food cache. Counts made in the fall when the beavers are more settled in their behavior have become the accepted approach (Baker and Hill 2003).

Smith followed the standard technique used by other beaver researchers. Close ground inspection is probably the most accurate survey method, but covering an area as large as Yellowstone is most efficiently done from aircraft. The aerial surveys took from 12 to 14 hours of total flying time spread out over six or seven surveys. To assess the accuracy of aerial counts, Dan Tyers of the Gallatin National Forest and Smith have been comparing them against ground counts outside the park for about 10 years. Each year that Smith surveys the beaver colonies by air, Tyers surveys a subset of the same areas on the ground on the Gallatin National Forest. Although preliminary, the results indicate that ground counts are only a little better than aerial counts, but this finding will surely vary by location. In 1999, Smith and Consolo Murphy compared ground and aerial beaver counts in southeast Yellowstone and found the results to be approximately equal (Consolo Murphy and Smith 2002).

For each aerial survey, Smith flew the entire park, usually during October, looking for lodges with a cache and other signs of beaver presence, such as mud on lodges, peeled sticks that glint white in the sun, and freshly maintained dams with brimming water levels. Counting hundreds of colonies in Minnesota, Wisconsin, and Michigan, Smith found that beavers typically build one cache per family. However, the incidence of two-cache colonies is higher in Yellowstone, where he has found three or four 2-cache colonies per year, especially on the west side of the park. This phenomenon is ripe for further investigation because some inspections from the ground indicate that this may actually be two colonies close to each other (A. Easter-Pilcher, University of Montana–Western).

The first year, pilot Roger Stradley of the Gallatin Flying Service and Smith looked for beaver colonies on all the creeks, rivers, and lakes in the park that have low gradient. (A gradient >4% is typically too steep for beavers to be able to dam.) They found 49 active colonies, all of them in places where they had been recorded on previous surveys. They found only one colony (Slide Lake) on the northern range, the lowest tally for this area of any survey since 1921 (Table 1 and Figure 2). They found no use of aspen anywhere in the park and the cutting of cottonwood in only two places (two trees in Lamar Valley and two on the Gardner River). They were able to identify three areas of concentrated beaver occupation (or "hubs" as Stradley called them): the Yellowstone River Delta south of the southeast arm of Yellowstone Lake, Bechler and its many streams and rivers, and the drainages north of West Yellowstone (Figure 2).

NPS/DOUG SMITH

Beaver density in the Yellowstone River Delta is the highest in the park and rivals high densities elsewhere in North America.

In the three surveys from 1999 through 2003, the count of beaver colonies stabilized, indicating [Smith and Stradley] had probably achieved maximum efficiency and were getting a relatively accurate parkwide count.

Table 1. Number and locations of active Yellowstone beaver colonies, 1996–2007. Data from Smith fall aerial surveys.

Location	Number of Active Colonies						
	1996	1998	1999	2001	2003	2005	2007
Northwest							
Campanula/Gneiss/Duck Creek	7	6	7	8	10	15	16
Cougar Creek	4	7	11	9	3	4	5
Maple Creek[1]	-	-	-	-	4	6	7
Fan Creek	0	0	0	0	0	2	5
Bacon Rind Creek	0	0	0	0	1	1	3
Gallatin River	2	2	5	6	1	7	7
Harlequin Lake	0	1	1	1	1	1	1
Grayling Creek	3	0	1	6	5	5	5
Madison River	3	3	3	3	1	2	1
Southwest							
Bechler River	1	0	3	2	3	3	1
Boundary Creek	2	2	1	3	7	0	6
Falls River	0	2	3	6	3	2	6
Mountain Ash/Proposition Creeks	7	6	6	1	0	3	1
Other Bechler	0	1	1	0	1	0	2
Southeast/Southcentral							
Snake River	3	2	4	4	3	*	3
Yellowstone River Area	15	14	23	17	21	*	29
Heart Lake Area	0	0	0	0	6	*	2
Basin/Otter/Moose Creeks	*	*	*	*	0	0	7
Other							
Glen Creek	0	0	0	0	1	*	1
Chipmunk Creek	0	0	2	0	0	*	1
Slough Creek	0	0	1	3	6	9	6
Grouse Creek	1	0	0	0	1	*	1
Outlet Creek	0	1	0	0	0	*	1
Shoshone	0	1	1	1	0	*	0
Slide Lake	1	1	0	0	0	*	0
Willow Park	*	2	4	3	4	4	6
Hayden Valley	0	0	0	1	0	*	0
South Lewis Lake Area	0	0	0	2	2	*	0
Lamar Valley	0	0	0	1	1	*	3
Yellowstone River	0	0	0	0	0	1	0
Elk Creek	0	0	0	0	0	0	1
Total	**49**	**51**	**77**	**77**	**85**	**65**	**127**

[1]For years 1996–2001, Maple Creek data was tabulated under Campanula/Gneiss/Duck Creek or Cougar Creek.

*Not censused

Beaver density in the delta area was the highest in the park, and rivaled high beaver densities elsewhere in North America. These beavers were living entirely on willow in the winter; no aspen was observed. The wide willow expanse of the delta provides enough habitat to support about 15 beaver colonies in only about a two-mile stretch along the Yellowstone River. The delta's wetland area enables beavers to occupy places off of the main river channel, but that is still a very high density.

Although they found no colonies in Willow Park during that first survey in 1996, they have found two to six colonies there in every survey since, indicating that they were probably missed the first time. Being the observer in the back of the plane, Smith remembers well the first survey. After hours of flying and counting colonies he was somewhat green, as they say, from so much circling in an airplane at low altitude. This is a key issue for any aerial survey: observer fatigue or, as some say, "stop before the puking point."

In the three surveys from 1999 through 2003, the count of beaver colonies stabilized, indicating they had probably achieved maximum efficiency and were getting a relatively accurate parkwide count. In 2005, early ice prohibited the completion of the count, but in 2007 the count significantly increased (Table 1). Smith speculates that beavers dammed more areas because long-term drought in the park reduced water levels on several streams, making them easier for beavers to dam. Beavers could better handle the normally high-flow creeks found in mountainous Yellowstone that usually blow dams out. New colonies and dams were discovered across main-stem streams like Cougar, Maple, Slough, and Hellroaring creeks due to diminished flows. In the Midwest where gradients are low, drought decreases beaver numbers because habitats dry up, whereas more water creates new habitats. The reverse may be true on the high gradient streams of Yellowstone.

All of the colonies found were amid willow rather than aspen. In fact, mapping willow distribution against beaver distribution showed a strong association between them (Figure 1). The other notable finding was that beavers made a dramatic comeback on the northern range, from one colony in 1996 to 10 in 2005. After years of stunted growth, in the late 1990s willows increased in stature in many areas across the northern range and this resurgence is correlated with the increased number of beaver colonies there. Most of these colonies were along Slough Creek, but new colonies were also recorded elsewhere, including a spot on Elk Creek that, according to Jonas, had not been occupied since the early 1900s. Importantly, none of the sites reported by Warren or Jonas were occupied from 1996 through 2007.

USFS/DAN TYERS

Beavers were packed into the Absaroka-Beartooth Wilderness by horse and mule.

Absaroka-Beartooth Wilderness Beaver Reintroduction

The rapid re-occupation of the northern range with persistent beaver colonies, especially along Slough Creek, occurred because Tyers of the Gallatin National Forest released 129 beavers in drainages north of the park (*see sidebar*). In a remarkable and ingenious project that took place from 1986 to 1999, Tyers arranged to have "problem" beavers that were caught live by Montana Fish, Wildlife and Parks staff sent to Gardiner, Montana. Dan packed them in via horse and mule, a skilled packing job for sure, to release at sites on the Gallatin National Forest (Figure 3). Some of these beavers moved downstream into YNP.

Beaver have been present on the northern range of YNP since the 1920s, as documented by Warren, Jonas, and Consolo Murphy, and by occasional sightings and observations of sign as Consolo Murphy described, but there were few places of persistent beaver occupation until the late 1990s. This was probably because there was too little of the woody vegetation that beavers need for food and building materials. In the late 1990s, these necessities were offered by some northern range willow stands that had grown taller, and reintroduced beavers dispersing out of newly established colonies found areas that they could settle. Beavers found places to live in areas where willow was recovering, primarily along Slough Creek, but also in other areas. Lamar Valley now has three beaver colonies.

Beaver re-occupation of the northern range could have eventually occurred from the opposite direction. Beavers existed along the Yellowstone River downstream of the park during the

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Absaroka-Beartooth Wilderness Beaver Reintroductions, 1985–Present

Dan Tyers

PHOTOS USFS/DAN TYERS

ALTHOUGH BEAVER have been continuously present along the Yellowstone River north of Gardiner, a cursory investigation in 1985 found no of evidence of beaver populations in the Absaroka-Beartooth Wilderness, USDA Forest Service, Gardiner Ranger District. Consequently, a reintroduction effort was considered. Procedurally, returning a species to designated wilderness requires that four criteria be met: (1) the species is not present and therefore not capable of repopulating without intervention, (2) suitable habitat exists, (3) humans can be implicated in the extirpation, and (4) the species has a limited opportunity to return to the area by natural means.

Suitable habitat is obviously abundant in the study area. At a minimum, the three primary drainages (Hellroaring, Buffalo Fork, and Slough Creek) have extensive and robust willow stands. When I surveyed these areas during the summer and fall of 1985, I found plentiful and widely distributed dams and lodges that had apparently been abandoned many years before. This evidence of prior activity matched archived reports and maps found in district files. However, these surveys did not reveal any contemporary activity.

I conducted the surveys by walking the banks of all areas likely to support beaver: Eagle Creek, Bear Creek, Hellroaring, Buffalo Fork, Slough Creek, the upper reaches of the Stillwater, Soda Butte Creek, and the Clarks Fork. These occurred predominantly in the Absaroka-Beartooth Wilderness, but included several adjacent drainages in associated watersheds.

I also interviewed current and former sheepherders, outfitters, and Montana Fish, Wildlife and Parks (MTFWP) employees who had knowledge of the area's history. All agreed that beaver had been well-established in the study area and there was a general consensus that the population was robust until the 1940s or 1950s. They cited very determined trapping, a tularemia epidemic, and a general decline of willow stand condition due to drought and moose and elk browsing as possible reasons for the observed beaver decline. Many of the interviewees could recall specific dams and lodges they had seen in the backcountry, or at least general areas of activity. Some described dams that were noteworthy in size and the amount of water impounded, and some named trappers who had persistently removed beaver from the area. Others recalled seeing dead beaver floating in ponds, which they interpreted as evidence of disease. However, no one in 1985 could provide definitive evidence of current beaver activity in the study area.

Based on these findings, the Forest Service determined that the criteria had been met to warrant a reintroduction effort. MTFWP Region 3 personnel, principally Mike Ross and Harry Whitney, assisted the project by live-trapping beavers when responding to complaints from property owners. Complaints generally involved beaver cutting shade-trees, plugging culverts or irrigation ditches, or flooding fields. MTFWP has also assisted the project by putting a

Transporting beaver into Buffalo Fork on pack-stock. Above left: beaver did not immediately run off after being released from cages. Above right: beaver cages on ice at Charlie White Lake.

moratorium on beaver trapping in Absaroka-Beartooth drainages that extend into the park.

For humanitarian reasons and to help ensure that beaver stayed in the release areas, the trapping efforts targeted family groups. Beaver separated from family groups are more likely to leave release sites, presumably in search of family members. In addition, beaver were released only in late summer or early fall because they might be more inclined to stay in the area when they needed to prepare structures and food caches for winter.

Each beaver was transported in a specially designed cage which had a block of ice placed on top and was then wrapped in canvas, keeping the animal cool, wet, and sheltered. Also, pack-stock are less skittish about carrying a live animal when they cannot see it. All of the 129 trapped beaver survived the handling and transit to release areas in seven drainages between 1986 and 1999. They were transported to locations within the Absaroka-Beartooth using pack-stock and to the release site outside of wilderness by vehicle.

Since the reintroductions began, about 15 to 20 miles of stream have been surveyed annually to record active and inactive lodges, dams, and caches. These inventories have charted the expansion of the population into what we believe is nearly all suitable areas within the study area. From 2000 to 2007, we typically located 20 to 30 lodges each year. During the 2007 survey, we found 16 primary areas and 27 active lodges. With the study area now nearly saturated, it is likely that natural displacement of juveniles and intra-specific competition have resulted in dispersal within the study area, as well as downstream into Yellowstone National Park (YNP).

To assess the possible survival and dispersal of the reintroduced beaver, 10 instrumented animals (4 in 1998 and 6 in 1999) were released into an area about three miles north of the YNP boundary that did not have an existing population. Although the sample size was very small and the batteries had failed in all transmitters by the fall of 2000, these animals provided some insights into the fate of the larger population. At least 5 of the 10 animals survived until their transmitters failed. Four of these survivors stayed in the willow stand where they were released and the fifth beaver established in a willow stand about one mile away. Two other beavers, one found in the release meadow and the other about 10 miles away, were alive when their first winter after release began but did not survive until spring. Neither showed signs of predation. The other three beavers could not be located the spring following their release. However, the search was limited to the Gallatin Forest and it is presumed that these three beavers relocated into the Lamar and Yellowstone drainages downstream in the park.

The reintroduction effort has clearly been successful. Beaver are currently established in nearly all areas that had been identified as formerly occupied. Now the project affords opportunities to assess the effects of beaver on riparian areas in the headwaters of the Yellowstone River. For example, in partnership with the USDA Forest Service Remote Sensing Applications Center, remote imagery will be used to determine changes in the amount of standing water, willow canopy, and riparian footprint since the project began. Other research is comparing sites with perennially active lodges to sites with ephemeral lodges to determine what characterizes locations where beaver are able to persist long-term in this environment. Annual stream-side surveys will continue to be used to monitor beaver colony locations.

Beavers were also packed in by sled and transported by truck.

Figure 3. Beaver reintroduction release sites in and near the Absaroka-Beartooth Wilderness, 1986–99.

beaver decline in the park, and in time they would have found their way upstream. This has probably already happened; there are new colonies along the Yellowstone River above the Black Canyon, and on Elk Creek near Garnet Hill just up from the Yellowstone River. The Yellowstone River serves as a beaver highway, with a constant flow of immigrants looking for a suitable place to settle.

Beaver-Aspen-Willow Relationships

A key finding of recent beaver surveys is their lack of aspen use. Warren documented significant use of aspen on the northern range, Jonas noted some use but much reduced on the northern range, and Consolo Murphy and Smith reported very little parkwide. Beavers currently living in Yellowstone are subsisting on willow where previously it appears they subsisted on aspen and willow. Elk may have affected this beaver-aspen-willow condition or state, as some ecologists call it.

Beaver ponds, whether full or drained, provide ideal habitat for willow, which seeds best on wet, mineral substrate. Full ponds create excellent hydrologic conditions for willows and they respond with lush growth. Eventually when beaver ponds drain, the wet soil left behind is ideal for seeds to grow and establish new willows, repeating the beaver cycle and creating a positive feedback loop.

One group of researchers has hypothesized that the loss of beavers on the northern range has led to greater stream incision and reduced opportunity for willows to establish; water runs faster and straighter, cutting more deeply into the substrate when beaver dams are not present to impede water flow and create floodplains of mineral substrate. They maintain that the beaver-aspen-willow state that existed on the northern range in the 1920s was replaced by an elk-grassland state, possibly as a result of wolf extermination affecting elk numbers and behavior. Further, they postulate that the restoration of the wolf that began in 1995 is not enough to restore the beaver-willow state because of the dramatic changes that have occurred in stream morphology and functioning due to the loss of beavers (Wolf et al. 2007).

Beaver populations that rely primarily on willow may not cycle in a boom-bust fashion like they do when their primary food is aspen. Willow is a hardy shrub that readily resprouts after being clipped by beaver and some studies have found beavers unable to suppress willow growth (Boyce 1974). Beavers also tend to move to different feeding sites from year to year, which allows willow to recover. Hence, once established in stands of willow, beavers seem able to exist in stable numbers for years and possibly decades unless something else, like ungulate browsing, alters the cycle.

Conclusion

In addition to benefiting many insects, fish, birds, amphibians, reptiles, and mammals, the beaver's creation of aquatic habitats provides favorable hydrologic and light conditions for plant species. Chuck Peterson of Idaho State University believes beaver ponds are critical habitats for boreal chorus frogs. Beavers have been reintroduced in other western states as a way to restore degraded riparian areas (Baker and Hill 2003).

In Yellowstone, surveys that took place from the 1920s to the present show that beaver numbers have fluctuated and colonies have shifted locations, but beavers are distributed throughout the park and activity is abundant in the southeast, southwest, and northwest corners of the park, where habitat is most suitable. A decline in beaver numbers on the northern range that took place between the 1920s and the 1950s was likely caused by a decline in aspen and willow there. The U.S. Forest Service reintroductions of beaver that took place north of the park from 1986 to 1999 along with recent willow recovery in some areas hastened re-occupation of the northern range with persistent beaver colonies. Park staff will continue to perform biennial aerial surveys to monitor beaver population status and trend.

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NPS/DOUG SMITH

Beaver colonies on the park's northern range increased from one in 1996 to ten in 2005, most of them along Slough Creek.