Documenting Trends in Yellowstone's Beaver Population: A Comparison of Aerial and Ground Surveys in the Yellowstone Lake Basin

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Introduction

The beaver *(Castor canadensis)* is a keystone species that can affect ecosystem structure and dynamics beyond its own immediate requirements for food and space (Novak 1987) and thus may be of particular interest to researchers and managers of wildland ecosystems. This species is sometimes erroneously portrayed as missing from Yellowstone National Park, but the historical record contradicts this. Although there has been relatively little research or monitoring of beaver during the park's nearly 130-year history, earlier records (Warren 1926; Jonas 1955; Fullerton 1980; Houston 1982) provide information on beaver activity and distribution from the early 1900s until the 1980s (Consolo Murphy and Hanson 1993).

In 1988–1989, the senior author initiated a sampling survey to document the presence and distribution of beaver in the park and develop a monitoring scheme to assess changes in the status of the species over time. This was a ground survey similar to that most recently undertaken by Fullerton in 1979–1980 (Fullerton 1980). Beavers typically, but not always, construct large lodges built of sticks and mud, anchored most often on the banks of a lake or river, particularly on river bends where the water deepens or at the confluence of two streams. Beavers sometimes use dens in river banks rather than (or in addition to) constructed lodges. Beavers also cut woody vegetation, which is often consolidated and stored in a floating mat, called a cache, anchored to a lodge or located on the water surface near where a beaver colony winters (Jenkins and Busher 1979; Novak 1987). Lodges augmented with freshly cut trees and stems with stripped branches or newly placed mud, new food caches, bank dens, fresh slides down a bank, and recently built dams are also signs of current beaver activity easily observed in autumn, as the animals are then at the height of activity constructing lodges, repairing dams, and caching food for the winter.

Ground surveys were completed by one or two persons who hiked to lakes and along suitable riparian corridors of the park, recording signs of current beaver activity, including lodges, food caches, dams, bank dens, felled trees, stripped stems, beaver trails, and canals. Biologists recommended that beaver surveys be repeated at five-year intervals to build a database on trends in the number and distribution of colonies over time (Consolo Murphy and Hanson 1993), and the senior author and her field assistants did repeat the survey as planned in 1994 (Consolo Murphy and Tatum 1994).

In 1996, Doug Smith, a newly arrived park biologist, was able to obtain funds to conduct the park's first near-complete autumn aerial count of beaver colonies with food caches (Smith et al. 1997). His method was to survey watercourses, ponds, and lakes of suitable gradient from a fixed-wing Supercub plane, flying at an altitude of 100 to 175 feet at an air speed of 55 to 65 mph (Hay 1958; Payne 1981), a widely used survey technique. Every river system in the park was surveyed once, and repeat overflights were often used to census beaver colonies in high-density habitats. Lodges and food caches are easily visible in the fall from slow-flying aircraft after deciduous plants have shed their leaves and before snow and ice form on water surfaces. Smith repeated this survey in 1998 and recommended continuation of aerial surveys at two- to three-year intervals to monitor beaver distribution in the park (Smith 1998).

Since a third iteration of the ground survey was due to be completed in 1999, the park biologists with previous experience surveying beaver decided to compare efforts and techniques in order to build a long-term, affordable monitoring strategy for this species in the park. Some studies have found ground surveys to be more accurate in finding and censusing beaver in non-mountainous terrain, and this may be so in the park as well (Robel and Fox 1992), but they may be prohibitively costly in survey time and dollars. Aerial surveys of late-season food caches are easily conducted and cost-effective (Swensen et al. 1983; Robel and Fox 1992) but are not believed to document the presence of all bank-denning beaver nor those associated with an atypical cache pattern. We compared the effectiveness of the two methods by conducting both a ground survey and an aerial survey in the autumn of 1999 in an area of high-density beaver occupation: along the upper Yellowstone River from the southern park boundary to Yellowstone Lake.

Study Area

The Yellowstone River and its tributaries drain the eastern half of the park. The Yellowstone flows into the southeastern portion of the park (the Thorofare region) and meanders north-northwest for about 26 km (16 mi) to Yellowstone Lake along a mostly flat gradient. The inlet to Yellowstone Lake is a large, marshy delta that supports extensive tall willow communities *(Salix* spp.). Previous ground and aerial surveys have shown that several dozen beaver colonies are generally located in this corridor. Smith (1998) calculated the density of beaver colonies here as 0.35 per km (1.5 per 2 mi) of river surveyed, one of the two highest-density areas of occupation across Yellowstone National Park (the other being an 8.6-km stretch of the Madison River). The survey area included an estimated 9.54 km of streambank and lakeshore in the Yellowstone River delta, 1.97 km in nearby sloughs or ponds, and 19.25 km of streambank upriver along the Yellowstone and the lower reaches of its tributaries (Figure 1), for a total of 30.77 km.

Results

The ground survey of this study area was conducted on three days: September

14 and October 2–3, 1999. On September 14, two ground crews of two persons each initiated the survey from Trail Creek at the tip of Yellowstone Lake's Southeast Arm. One crew (including the senior author) departed via canoe, crossed the arm, and proceeded up the Yellowstone River for approximately 3.2 km, beyond which the upstream current of the river precluded progress. At a number of spots, the crew beached the canoe and searched from the ground, hiking through the dense willow patches. The second crew surveyed on foot between Trail Creek and the Yellowstone River upstream from the delta; initial plans to proceed all the way upriver to the park boundary at Thorofare were delayed due to an injury suffered by one member of this ground crew. Another two-person team thus completed the survey upstream of Cabin Creek in early October. Ground survey crews located a total of 17 active colonies: 13 lodges with food caches, two bank dens with food caches, and two lodges with freshly cut stems, mud, or other signs of current activity but no obvious food cache present (Figure 1). Ten of the colonies were within the Yellowstone River–Beaverdam

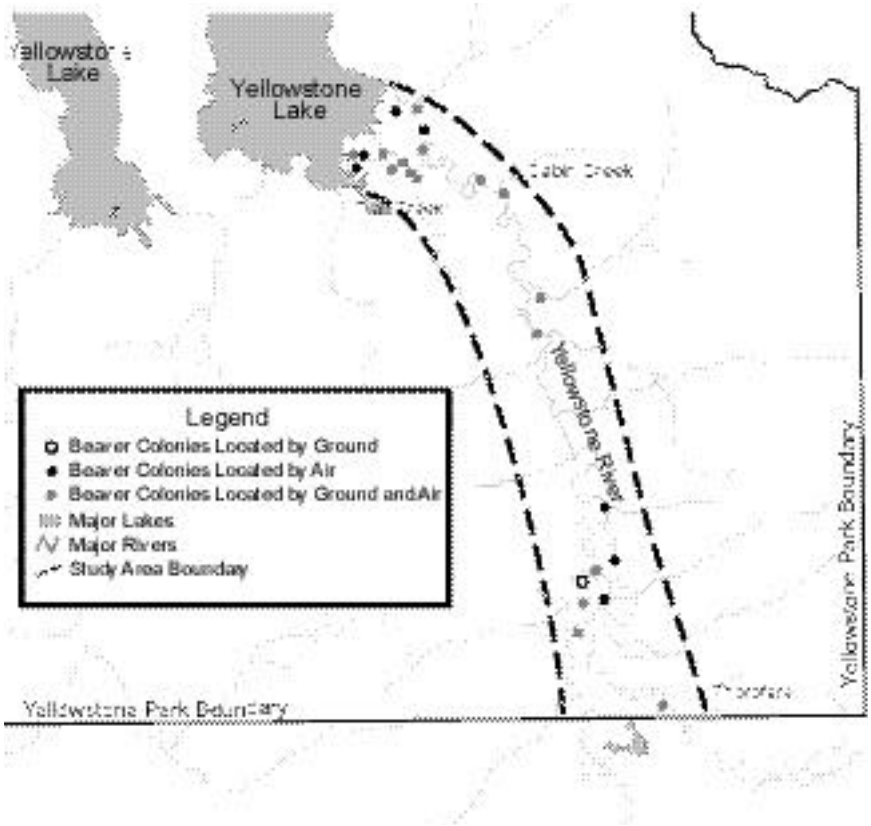

Figure 1. Study area from Yellowstone Lake upstream along the Yellowstone River to the park's southern boundary, and active beaver colonies found by ground survey, aerial survey, and both methods in September–October 1999.

Creek delta area, and seven were upstream of Cabin Creek. The ground survey took eight 10-hour person-days, since safety concerns compelled us to pair observers traveling in the backcountry by either foot or canoe. Total cost was $1,270 in personnel; equipment was already available for general park purposes.

The aerial survey was conducted on October 25, 1999, by one observer (the junior author) in addition to the contract pilot, flying in a Supercub at an average speed of 55–65 mph from 100 to 175 feet above the river and its main tributaries between the delta and the park boundary. (It was part of a parkwide survey flight.) They observed a total of 23 active beaver colonies in the study area. All of the aerial observations were of lodges or bank dens with caches; 14 of the colonies were within the delta and nine were upstream of Cabin Creek (Figure 1). The aerial survey took 1.5 hours of flight time at a cost of $115 per hour plus the salary of the park biologist observer, for a total cost of $212.

Comparison of Techniques

The ground and air observers co-located 16 active colonies: one was located only by the ground crew and seven were located only by the aerial observers, for a total of 24 colonies active within the study area in autumn of 1999. Using a capture/recapture double-count model, the probability of detecting an active colony was 94% by aerial survey and 69% by ground survey. The lower level of detection by ground observers was due to several reasons, none of which were unexpected, especially in this area. All the beaver colonies within the study area were associated with willow communities. The large expanse of flat, marshy habitat present in the Yellowstone River delta is extremely challenging to survey effectively from the ground. The tall willows block visibility and impede safe passage. Even upriver along the Yellowstone, there are extensive willow habitats that are time-intensive and risky to survey; crews were ever alert to the possibility of encountering moose or bears, particularly, in the thick vegetative cover. Also, scattered across the delta are small streams, backwaters, and ponds that are difficult to visit in an efficient manner; it is ideal country to survey from aircraft.

All four of the colonies not seen by ground observers within the delta were some distance from the shore of Yellowstone Lake or the main course of the Yellowstone River, in areas not effectively covered by ground crews. Of note, although two of the colonies within the delta called "active" by ground crews were not recorded as having food caches on September 14, they were recorded as having both an active lodge and cache during the aerial survey. This could be a result of the beavers not having yet begun to actively cache food in mid-September, or because caches are not always visible to ground crews, depending on how closely they can see a lodge; crews tried not to approach too closely lest beavers be disturbed during the survey.

Upstream from the delta, three colonies along the Yellowstone River were seen from the air but not by ground crews, due to the latter having exhausted their ability to cover the area effectively within a reasonable period of time. One colony observed from the air, near the confluence of the north fork of Cliff Creek and the Yellowstone River, was in an area noted by ground observers to have an

abundance of sign but no evident lodge or cache; ground crews may have missed it, or it may been constructed after the ground survey occurred. The one colony found by ground observers but not seen from the air was a lodge near the river's confluence with the south fork of Escarpment Creek. Ground observers described the lodge as concealed within early-season flood debris. It had no food cache anchored to it, though a very large one was just upstream around the next river bend; during the October 3 survey the ground crew did observe a large beaver swimming between the two sites. This points out one of the situations where ground surveys may be more effective at finding beaver colonies that are hard to see from the air. Another situation that occurs in the park, but not in this study area, is one in which beaver colonies occupy less-typical habitats—particularly streams or lakes without willows, aspens, or cottonwoods. In these settings, such as ground crews observed at Heart Lake in 1999, beavers may rely on other foods such as pond lilies *(Nuphar polysepalum)* or submerged aquatic plants. A food cache, if present, may not be visible from the air.

Summary

Aerial surveys should not be construed as providing a complete count of beaver lodges and caches. However, the results of this survey indicate that, for most park purposes, aerial surveys have a high probability of detecting active beaver colonies in the autumn when beaver are most active and likely preparing to overwinter in the observed location. In comparison, a yearly ground survey is more costly and, at least in difficult-to-survey terrain, less likely to document as high a percentage of the existing beaver colonies (Table 1). In general, we find that aerial surveys are a cost-effective method to survey for trends in the number and distribution of beaver colonies that exist across Yellowstone National Park. Since the park's current budget and work plans call for biennial beaver survey flights, periodic ground surveys can help test the efficiency of flights to monitor colonies, especially in marginal or atypical beaver habitats. Ground survey data may augment the data from aerial counts, especially in areas where beavers are likely to bank-den or overwinter without building visible food caches. Ground surveys also permit observers to better view animal behavior and appreciate the

Table 1. A comparison of ground and aerial survey costs and results from the 1999 study.

Results Compared	Ground survey	Aerial survey
Number of beaver colonies found	17	23
Number not found by other method	1	7
Detection probability	17 of 24 (69%)	23 of 24 (94%)
Time required (10-hr person-days)	8.0	0.188
Cost of survey	$1,270	$212 w/o ferry time

extent of beaver cutting, construction, and habitat alteration that occurs in specific sites as a result of the animal's periodic presence and withdrawal. Since Yellowstone lacks data on relationships between the numbers of active lodges or food caches and the beaver population, we suggest that further research to estimate the average size of the beaver colonies in various park habitats would be of benefit to resource managers, interpreters, and others.

Acknowledgments

We thank Ryan Eisfeldt, Sharit Koser, Tom Zieber, Deb Guernsey, and Susan Chin for conducting ground surveys and/or completing data analysis and mapping. Pilot Roger Stradley was instrumental in completing a safe, successful aerial survey. Dan Reinhart and other Yellowstone biologists and rangers accompanied ground crews during surveys, providing an added measure of safety, and provided necessary logistical support and equipment to access the Yellowstone backcountry.

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