BEAVER:

Water resources and riparian habitat manager

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Introduction

Beaver can be an asset or a liability, depending on their compatability with human interests and activities in a particular situation. Management of beavers cannot be either total protection or reduction, but a discretionary harvest where conflict occurs or protection where habitat enhancement for multiple uses is needed (Hine 1962).

This publication describes the beneficial aspects of beaver as a tool to enhance water resources and riparian habitat through proper management techniques, and provides management guidelines to minimize damage problems where conflicts with human interests and activities occur. Beaver management practices preserve existing land uses while maintaining benefits provided by enhanced water quality, wildlife habitat, livestock grazing, recreation, and aesthetic values.

Natural resource managers, farmers, ranchers, private conservation organizations, landowners, and others interested in public and private land management have long recognized the importance of maintaining healthy riparian habitat, especially in the arid West. Proper management of riparian habitat and other aquatic ecosystems improves water quality and quantity, enhances wildlife habitat, increases forage production and quality for livestock, increases aesthetic values, and provides opportunities for recreation.

Beavers play an important and cost-effective role in maintaining and enhancing riparian and aquatic ecosystems for multiple uses (Stuebner 1994). The benefits from beaver activity in an aquatic ecosystem, primarily through dam construction, include:

1. elevation of water tables that enhance riparian vegetation development to trap eroded silt from adjacent lands,
2. reduction of stream water velocity and increase of sediment deposition to reduce streambank and channel erosion,
3. improvement of water quality as riparian vegetation intercepts nutrient and chemical contamination in runoff water,
4. improvement of water storage and stabilization of stream flows throughout the summer and droughts,

5. protection of downstream croplands and urban developments from floods by upstream storage structures,
6. enhancement of fish habitat in streams by increasing water depth and production of aquatic invertebrates,
7. improvement of habitat for waterfowl, big game, game and nongame birds, and other wildlife through vegetative development, and
8. increase in forage production, shelter, and water for domestic livestock.

In addition, the resulting diversity and production of riparian vegetation improves aesthetic values and provides areas for consumptive and non-consumptive uses of wildlife resources (Munther 1981; Wood River Resource Conservation and Development District 1989; Collins 1993; Boddicker undated).

However, beavers can be a nuisance to agriculture and urban development in the lower reaches of watersheds. Conflicts between beavers and humans often occur on private property where beaver dams can do serious damage by flooding roads, hay meadows, pastures, and croplands. Damming of culverts and irrigation ditches impairs agricultural operations. Beaver cutting of ornamental trees and shrubs on residential property is costly (Hine 1962; Clements 1991; Collins 1993).

Sometimes, beaver overuse preferred woody species such as aspen and cottonwoods along streams and cause the decrease of tree diversity (Yeager and Rutherford 1957). Human health can also be at risk because beaver are amplification hosts of *Giardia duodenalis* and contaminate surface waters downstream from their dams by shedding *Giardia* cysts throughout the year (Monzingo and Hibler 1987).

Historical Background

Early exploration of western North America was largely due to the search for beavers by trappers. Size estimates of pre-European beaver populations in North America were 60-400 million animals or the equivalent of 10-60 animals per mile of stream and river (Naiman et al. 1986). During the early 1800's, beaver pelts for hats and garments brought many trappers to the wilderness. Beaver populations during this period were nearly eliminated by the fur trade, and the subsequent quantity and quality of riparian habitat declined (Parker et al. 1985).

In the 1900's many western states implemented protective laws to enhance beaver populations (Grasse and Putnam 1955; Rue 1964). Restocking across North America began in the early 1900's by live-trapping and relocating problem animals to stream headwaters (Grasse and Putnam 1955). Today, population size estimates are 6-12 million animals, a fraction of the original numbers (Naiman et al. 1986).

In Wyoming, early settlement and economic development also began with the first fur trappers around 1820. By 1860, the beaver was nearly extinct due to intensive trapping. Legislative protection from 1899 to 1919 and reintroduction by the Wyoming Game and Fish Department promoted the recovery of beaver (Collins 1993).

The beaver was classified as a protected animal in Wyoming until 1958 when the Wyoming Game and Fish Department reclassified it as a furbearer. Today, beavers occupy only one third of their original range in Wyoming. Yet, between 5,000 and 10,000 beaver are harvested annually and provide more than one-quarter million dollars in revenue to the state from license sales, trapper expenditures, and other costs (Collins 1993). Undoubtedly, beaver trapping provides significant economic gains and recreation in Wyoming.

Biology and Life History

The beaver is North America's largest rodent. Adults weigh more than 50 pounds and exceed 40 inches from the tip of the snout to the tip of the tail. Beavers in excess of 100 pounds have been reported (Grasse and Putnam 1955). The beaver ranges throughout North America except on the peninsula of Florida, on the Arctic tundra, and in southwestern deserts (Allen 1983).

Figure 1. Beaver are common herbivores in aquatic ecosystems of North America (Photo by Thomas Collins).

BODY STRUCTURE

Beavers are aquatic animals capable of staying under water for as long as 15 to 20 minutes. Their broad, flat tails serve as rudders and propellers, and their webbed hind feet are specialized for swimming (Grasse and Putnam 1955). The ears are small, but the beaver has a keen sense of hearing. Their ears are valvular and close under water (Grasse and Putnam 1955). The nostrils also close under water.

The teeth of the beaver grow constantly throughout its life. The chisel-shaped incisors are kept sharp by the constant wearing action (Grasse and Putnam 1955).

The beaver's tools are very simple: four incisors and two front feet (Richard 1983). The beaver digs with its front feet and throws dirt with its hind legs. It can carry mud with its front feet and legs while walking on the hind legs.

The very soft and dense under fur of the beaver is protected by long, coarse guard hairs. Oil is applied and rubbed into the fur all over the body to make it water repellent. The oil is obtained from two sacs, one on each side of the uro-genital opening.

COLONIES

Beavers live in family groups called colonies (Busher et al. 1983; Buech 1985). A family of beavers or colony occupies a pond or stretch of stream in common, uses a common food supply, and maintains a common dam or dams (Bradt 1938). A colony often consists of an adult pair, the young of the year (kits), and the young of the previous year (yearlings) (Hodgdon and Lancia 1983). Typical families comprise 19 to 64 percent of the colonies (Bradt 1938; Hodgdon 1978). However, this typical family is one of many possible combinations (Buech 1985; Busher 1987).

The average number of beavers in a colony is about five or six but can be 12 or higher (Hodgdon 1978; Svendsén 1980a). The typical range is four to eight animals (Buech 1985; Hodgdon 1978; Busher et al. 1983).

The colony is organized around the adult female. She is the alpha member of the family in dominance encounters. She emerges from the lodge first (93% of time), and she leads the colony in lodge maintenance, food cache building, and dam maintenance (Hodgdon and Larson 1973; Hodgdon and Lancia 1983).

The maximum known age of beavers is 16.5 years (Novak 1977). Mortality is high in the first few years of life; only 9 percent of the population may exceed 4.5 years (Novak 1977). An annual mortality of about 30 percent is common among 2.5-year-old and older beaver (Bergerud and Miller 1977).

DIET

The beaver is strictly herbivorous (vegetarian). It is best known for cutting and eating the bark of trees, but its diet is more varied (Buech 1985). During summer, the beaver eats the bark of deciduous trees and shrubs and substantial amounts of non-woody material, such as aquatic plants, grasses, sedges, rushes, and water lilies (Grasse and Putnam 1955; Northcott 1971; Svendsén 1980b; Belovsky 1984). Forbs and grasses can be 50 percent of the summer diet (Collins 1976a).

In the Arctic, leaves and growing tips of willows were the main food during July and August. The remaining 10 months food was willow bark (76%), popular (14%), and alder (10%) (Aleksiuk 1970a). This diet is probably similar to the diet of beavers in high mountain areas of Wyoming. At lower elevations, beavers in Wyoming probably consume more forbs and grasses.

The food habits of the beaver suggest that the animal is a fastidious generalist (Jenkins and Busher 1979; Buech 1985). In order of preference, the beaver eats aspen, willow, cottonwood, alder, and red osier dogwood most frequently (Hall 1960; Easter-Pilcher 1987; Allen 1983; Masslich et al. 1988), but the diet of beavers depends on the foods that are available. Tamarisk is used as food along the Colorado River in Arizona (Hensley and Fox 1948) and is probably important food along rivers in Wyoming where tamarisk has invaded.

CACHES

Beaver caches are stored, submerged food piles for winter (Swenson and Knapp 1980). In fall, colonies build food caches of tree and shrub branches. Aspen, cottonwood, or willow or a combination of two or three of these are usually used in Wyoming (Grasse and Putnam 1955).

Willow is preferred, but the beaver substitutes other food where willow is not available. Along the Tongue River in Montana, willow composed 50 to 90 percent of the food in caches, cottonwood was second, and boxelder was common (Swenson and Knapp 1980). Tree cutting and food-cache construction peak in fall (Bown 1980; DeByle 1985). Food caches are placed near the lodge and in as-deep-as-possible water (Grasse and Putnam 1955). The food is dragged into a pile and additional material is stacked on top. As the material becomes soaked, the whole mass sinks. At the time of freezing, only a few twigs may extend above the surface of the water. Slough (1978) stated that beavers first form a raft and then place other material under the raft. The raft gradually becomes waterlogged and sinks beneath the surface. Mostly cuttings of aspen and willow but also low-preference food items are used. Some materials seem to be selected to submerge and secure the raft.

The relative size and number of food caches are indices of colony size (Grasse and Putnam 1955; Easter-Pilcher 1987; Osmundson 1990). An adult beaver requires 1.5 to 4.0 pounds of bark and twigs daily (Grasse and Putnam 1955; DeByle 1985).

During summer, food is abundant and beavers grow rapidly. But during winter, food is limited to cached supplies, and the beaver grows little or not at all (Aleksiuk and Cowan 1969). Aleksiuk (1970b) reported that beaver tails function as a fat storage area for use during winter. Beavers lower their metabolic expenditures during winter to conserve fat.

Colonies on streams that do not become ice covered may not cache, so cache counts on lower elevation streams in Wyoming are not accurate estimates of beaver abundance. Collins (1976a) found that 30 percent of colonies that were not ice bound during the winter did not cache food in northwestern Wyoming.

BEHAVIOR

Beavers spend daylight hours in the seclusion of their lodges or dens. They are active at night and during dawn and dusk (Grasse and Putnam 1955; Hodgdon and Lancia 1983).

Tail slapping is a primary warning signal to colony members on land or in shallow water to move to deep water (Hodgdon and Lancia 1983). Vocal communication among beavers is limited (Hodgdon and Lancia 1983). Kits are most vocal, but vocalization seems to have little survival value for beavers (Novakowski 1969).

BREEDING

The beaver breeds once each winter; breeding season lasts from late January to early March and peaks in mid-February (Hodgdon and Hunt 1966; Bergerud and Miller 1977; Buech 1985). Only the adult pair in a colony reproduces. Mostly 2.5-year-old and older females breed, but no more than one female per colony breeds (Novak 1977).

Couples mate in the water under the ice in mid winter (Grasse and Putnam 1955) and are believed to be monogamous for life (Svendsén 1980a; Buech 1985). Busher (1987) found that females do not have litters every year, and nonbreeding females may attach themselves to a colony (Novak 1977).

YOUNG

An uncommon trait of other large mammals is the beaver's long parental care (Buech 1985). The youngsters' period of development and association with their parents and other kin is typically two years.

Gestation is about 107 days (Wilsson 1971; Buech 1985). Litters of one to eight kits are born in late spring, May and June (Grasse and Putnam 1955; Hodgdon and Hunt 1966; Bergerud and Miller 1977). The usual litter size is two to four kits (Leege and Williams 1967; Hodgdon 1978; Svendsén 1980a; Buech 1985; Busher 1987; Kafcas 1987). The average number of kits at the time of emergence from the lodge is 2.3 (Busher 1987).

Litter size varies with the age and weight of the female, quantity and quality of food, and severity of winter (Yeager and Rutherford 1957; Pearson 1960; Rutherford 1964; Hodgdon and Hunt 1966; Henry and Bookhout 1969; Boyce 1974; Buech 1985). Productivity of kits is highest for females of five to 13 years old. Reproduction is density dependent with an inverse relation between litter size and colony size (Payne 1984). Because the number of kits increases as harvest rates increase (Kafcas 1987), reproductive rates are greatest among highly exploited populations.

At birth, a kit weighs about one pound (Buech 1985). Kits are fully furred with open eyes, and their incisors are erupted. All family members participate in the care of kits (Svendsén 1980a). Within two weeks, kits begin to eat herbaceous vegetation brought to the lodge by the adults (Wilsson 1971; Buech 1985). At two months, near the end of July and early August, kits are weaned and leave the lodge to forage on their own. By fall, they range almost as far from the lodge as older family members (Buech 1985). By the time of ice formation, kits weigh 10 to 16 pounds (Buech 1985).

However, kits seldom venture on land or participate in lodge maintenance or construction of food caches (Hodgdon 1978). Second-year offspring (yearlings) participate in construction (Buech 1985). Reproduction by yearlings is density dependent (Payne 1984). Few, if any, yearlings produce young when greater than 40 percent of potential colony sites are occupied.

DISPERSAL

Two-year-old beavers leave the colony in late spring in search of mates (Leege and Williams 1967; Leege 1968). They depart shortly before the new litter of kits arrives (Grasse and Putnam 1955). During dispersal, they move as many as 1.4 miles per day (Hodgdon 1978; Buech 1985). Most dispersal is by water, but some is over land. Dispersal coincides with increased runoff from snowmelt or spring rains (Allen 1983).

Dispersing two-year-old beavers usually move five to ten miles and sometimes farther (Hebbard 1958; Leege 1968). Moves of more than 100 miles have been reported (Grasse and Putnam 1955; Hebbard 1958; Allen 1983).

During dispersal, a young beaver attempts to locate a mate who may be an unpaired adult, an unrelated two-year-old, or in some cases a sibling (Buech 1985). It is generally assumed that mortality of two-year-olds during dispersal is substantial (Buech 1985). The causes are trapping, predation, and disease. Dispersal seems to control population sizes of the beaver (Payne 1984).

A common migration pattern is movement from high-elevation public land to private holdings downstream where beaver structures can flood crops, pastures, and roads and interrupt irrigation and stock-watering systems (Leege 1968).

TERRITORIALITY

Beavers of a colony are highly territorial. Colonies have distinct, nonoverlapping territories (Allen 1983). A colony delineates its territory and prevents further colonization of an area with scent (castoreum) mounds (Aleksiuk 1969; Svendsén 1980a; Hodgdon and Lancia 1983). Both sexes release castoreum from two castor glands in the anal area. Occasionally a colony constructs a large mound where scent is deposited, but most often the scent is deposited on small piles of mud carried from the stream bottom to the territorial boundary.

Scent mounds at the water's edge consist of mud, grass, and other debris (Beuch 1985). Mounds are placed most frequently at the perimeter of territories and near activity centers. Beavers urinate on the mounds and deposit castoreum in the process. Castoreum deposition is not always on mounds; sometimes deposition sites are bare ground totally unmanipulated by beavers (Collins 1976a).

All family members that are older than one year scent mound (Hodgdon 1978). Scent mounding is strongest in spring (Hodgdon 1978; Svendsén 1980a). Scent mounds deter transient beavers from establishing themselves in the territory (Muller-Schwarze and Hickman 1980) and communicate among beavers from adjacent colonies and the floating population. Males do more scent marking than females (Hodgdon and Lancia 1983). Collins (1976a) observed that the magnitude of marking territorial boundaries was related to the extent of encounters by beavers with individuals from neighboring colonies or transients.

The length of the territory of a beaver colony can exceed one mile but generally extends about 0.25-mile above and below the primary pond (Buech 1985). This corresponds to a home range of about 0.5-mile (Allen 1983).

DENSITIES

The density of beavers is regulated by territories (Payne 1984), and the density of territories is limited by energy (food). Beaver colonies may change territories over years, particularly if food becomes limiting (Buech 1985). A beaver colony may establish several lodges or bank dens in one territory.

Densities of beavers average one to two colonies per mile on streams with suitable habitat (Smith 1950; Nordstrom 1972; Boyce 1974; Bergerud and Miller 1977; Busher 1987; Bown 1988; Allen 1983), but can be reduced by intense harvest (Kafcas 1987).

Habitat

"Beaver may be exceeded only by man in their abilities to alter the environment" (Clements 1991). Most beaver colonies in the mountainous West are on streams that flow through or are adjacent to aspen or willow (DeByle 1985). The abundance of beaver colonies is determined by the quality of the habitat. Usually, the maintenance of a beaver colony requires a minimum of 0.5-mile of stream channel.

FOOD AND CONSTRUCTION MATERIAL

The construction of dams and canals earned the beaver the title of Nature's Number One Engineer (Grasse and Putnam 1955), but its most distinctive activity is the cutting of trees and shrubs. One beaver can cut 200 to 300 trees per year. About 200 aspens support one beaver for one year (DeByle 1985). Approximately 90 percent of all cutting of woody material is within 100 feet of the water's edge (Allen 1983, Belovsky 1984), but cutting can extend to 600 feet from the water (DeByle 1985).

An adequate and accessible supply of food must be present for the establishment

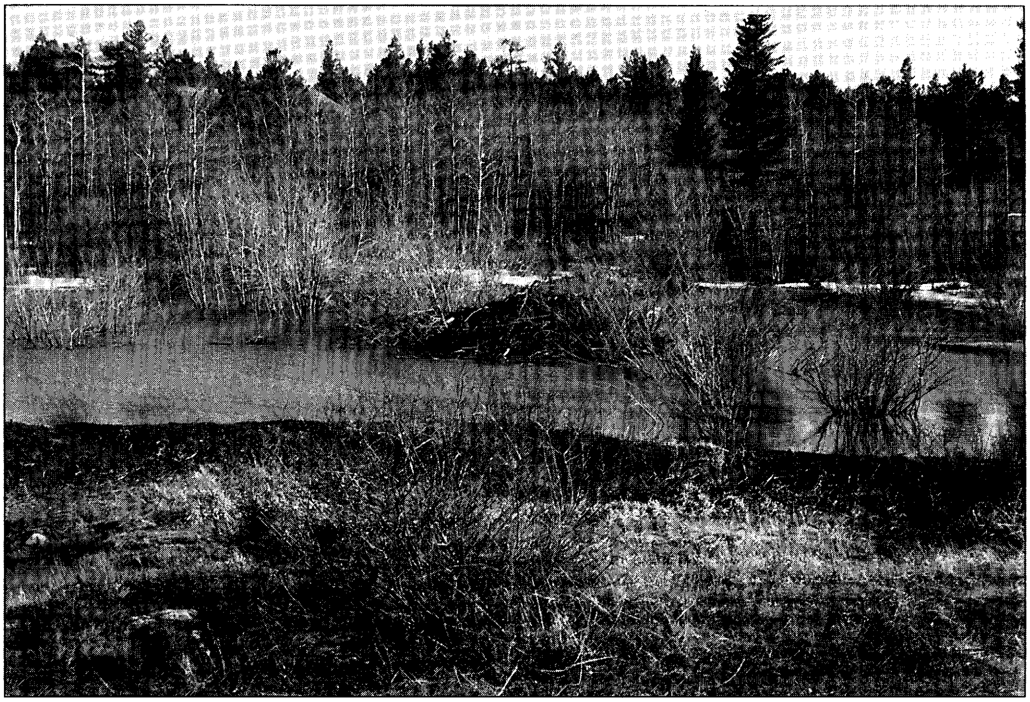

Figure 2. Characteristics of good beaver habitat include adequate water, accessible foods such as aspen and willow, and a wide valley with low channel gradient. This relatively recent beaver pond and lodge was built in high-quality habitat (Photo by Wayne Hubert).

of a beaver colony (Allen 1983). Several studies revealed that the presence of hardwood vegetation on shorelines is positively correlated with the presence of beavers. Aspen are particularly important in mountain areas (Slough and Sadlier 1977). Suitable food should be within 100 feet of the water (Belovsky 1984; Liedholt et al. 1989).

Beavers can overuse their food resources which leads to population decline (Bergerud and Miller 1977). Aspen abundance is the most significant factor of beaver density in many areas of the Rocky Mountains. Beaver populations must be regulated in many areas to preserve aspen communities. Preservation of aspen is important to several wildlife species—deer, moose, elk, porcupines, and woodland birds (Slough and Sadlier 1977).

At newly occupied ponds, beaver preferentially fell aspens of less than three inches in diameter (Hall 1960; Basey et al. 1988). A compound in the bark of larger aspen trees and in sprouts deters their use by beavers (Basey et al. 1990).

WATER

Beavers require a permanent, relatively constant water flow (Grasse and Putnam 1955; Allen 1983; Buech 1985). A stream flow of 0.5 cubic feet per second seems to be near the minimum (Muchmore 1975). They may attempt to colonize intermittent streams but abandon them when flows become inadequate.

VALLEY WIDTH

Narrow canyons with little or no riparian vegetation and steep channel slopes are not considered suitable habitat for the beaver. Valley widths of greater than 150 feet are most suitable (Allen 1983), but the animals seem to prefer small watersheds in the Rocky Mountains (Retzer et al. 1956).

A flat floodplain allows construction of shallow lateral canals leading to food supplies. Canals longer than 450 feet have been observed, but most are shorter than 75 feet. Canals serve the same purpose as secondary dams; they facilitate the transport of food and construction material and extend the swimming range of beaver. They are dug to where winter food is to be cut (Grasse and Putnam 1955).

CHANNEL GRADIENT

Channels with gradients of greater than 15 percent are seldom occupied; the optimum stream gradients are less than 3 percent (Smith 1950; Retzer 1955; Retzer et al. 1956; Hodgdon and Hunt 1966; Shelton 1966). In a study in Colorado, 68 percent of the colonies were in valleys with less than 6 percent channel slope, 28 percent in 7-12 percent, 4 percent in 13-14 percent, and none was at greater than 15 percent (Allen 1983). Beaver can build dams on steep segments of side channels; but many such dams wash out during high water in spring (Smith 1950).

ELEVATION

Beavers are not limited by altitude. In Colorado, they occur as high as timberline in riparian areas with willows (Retzer et al. 1956).

CYCLES

Beaver populations along any stretch of stream are not stable. They move in, establish a series of dams and lodges, harvest the aspens and willows within the reach of the inundated areas, and depart when supplies are exhausted (DeByle 1985). Tree regrowth is not fast enough to sustain the population.

Beavers often move into a drainage and use aspens 200-300 feet from the stream (depending on slope). Ultimately the animals eliminate their food and building material and leave. Subsequently, sedimentation of the ponds causes a transition to marsh-meadow habitat. During the absence of beavers, aspens regenerate and eventually provide suitable food and building material for beavers.

Because they sprout after cutting and grow rapidly, willows are more tolerant of beavers and are better than aspens for sustaining stable populations along low-gradient stream reaches (Hall 1960). Use of aspen is not believed to be on a sustained yield basis; beavers consume the local aspens and move on (Hall 1960). Call (1966) stated that aspen-supported beavers in southeastern Wyoming approximated a 30 year cycle, but many of the ponds that he studied still have stable water levels and have not filled with sediment. However, Smith (1980a, 1980b) stated that some aspen-supported beaver complexes may not have boom-and-bust cycles or that cycles of 75-150 years may occur in southwestern Wyoming. Collins (1976a) found sites occupied by beavers in northwestern Wyoming that have been used continuously for over 50 years.

DAMS

The sight and sound of flowing water releases dam-building behavior in beaver. Suitable locations for dams are limited by channel gradient, channel erosion, and the magnitude of variation in stream flows. Beavers build dams of whatever material is available—tree branches, sagebrush, rocks, bottles, or tin cans. Anything that can be dragged, floated, or rolled may be used (Grasse and Putnam 1955; Richard 1983).

In the mountainous West, aspens and willows are used for food and dam construction (DeByle 1985). On high-gradient streams, aspens are better than willows for the construction of dams.

Beaver dams are of every conceivable shape and size. The sizes of dams vary a great deal with a maximum height of four to six feet (Call 1960). Usually, one dam is built to impound water around the lodge and to cover the food cache. This is called the primary pond (Grasse and Putnam 1955; Richard 1983). The primary dam and pond are built downstream from the food supply so that food and construction material can be carried downstream with the current. Many secondary dams may be built. They function to improve transportation and extend the swimming range of the beaver (Grasse and Putnam 1955). When dams are washed out by high water in spring, beavers rebuild dams; the first dam reconstructed is for the lodge or primary pond (Smith 1950).

When building ponds, beaver drag branches by the thick end and prune them to prevent entanglement (Richard 1983). They roll logs and place them at a right angle to the stream.

There is a definite sequence and seasonality to construction (Buech 1985). If the colony moves, it does so either before the kits are born or after the kits are somewhat independent, April and May or August and September (Buech 1985). Beavers without young may move any time between April and September (Buech 1985). If lodges and dams already exist in the new location, beavers refurbish existing structures (Buech 1985). Otherwise, the beavers build dams and lodges. Dam repair is crucial behavior released by the sound or sight of running water (Wilsson 1971; Hartman 1975; Buech 1985).

The most important features of beaver habitat are the dams and resulting ponds with the associated canals. Because ponds and canals are the primary refuges from predators, beavers usually remain close to ponds. Beavers use ponds and canals to transport food and building materials from where they are available to where food is to be stored or to where the material is used for construction. Beavers construct food caches in the ponds during fall.

LODGES AND DENS

Beaver dwellings are of two types, lodges and bank dens. Lodges and bank dens provide escape, a place for resting, thermal cover, and cover for young (Allen 1983). Lodges have higher air temperatures than the outside environment (Buech et al. 1989). The air temperature in lodges may be above freezing when it is below zero outside. This enables beavers to use environments that would otherwise be physiologically unsuitable. Beaver lodges also serve as a barrier to predators.

When the primary dam is complete, beavers begin construction of the lodge (Buech 1985). Lodges are built of debarked sticks and mud. The removed bark is eaten. Beavers prefer lodge sites surrounded by water. The floor of the lodge is about four inches above the water level. Lodges are in the deep portion of the channel of the primary pond where the water does not freeze to the bottom. Lodges are built with several underwater entrances.

If a stream is too large for beaver to dam, they will construct bank dens or lodges along the banks. Along large rivers, such as the Snake, Green, and Colorado rivers, beavers are forced to build bank dens or lodges on the bank (Hensley and Fox 1948; Collins 1976a; Brazell and Workman 1977). Rocky substrates or highly erosive banks can limit bank-dwelling beaver.

Dens in the banks of large streams and rivers are built along deep channels with steep banks. There is one entrance at or slightly below the water level. The tunnel extends several feet into the bank and upward to an expanded chamber above water level. Small holes serve as air vents. Bank dens are constructed on sunny banks that face east or south. The diameter of most openings is about 18 inches; openings are immediately above the fall water level. Most bank dens have two or more underwater entrances (Dieter and McCabe 1989). Most dens are submerged by high water (Brazell and Workman 1977). There is evidence that some colonies build two bank dens, one accessible at normal water levels and one higher up the bank for use during high water (Dieter and McCabe 1989). Beavers prefer ungrazed banks for den sites because the vegetative cover reduces exposure to predators (Dieter and McCabe 1989). Bank dens do not provide the warmth of lodges (Buech et al. 1989).

Beavers are absent from sizable portions of rivers in Wyoming because of swift water and an absence of suitable den sites during high and low water (Collins 1976b). Colonies abandon sites when water levels drop or rise too much. In Wyoming, lack of suitable habitat for winter dwellings along larger streams is a major factor limiting beaver population size.

Influence On Water Quality and Riparian Systems

Beaver dams alter hydrology, channel morphology, biochemical pathways, and the productivity of a stream system (Naiman et al. 1986). On headwater streams of Wyoming, beavers are beneficial. Ponds store substantial volumes of water which percolates through the soil into the riparian area and into the stream.

Beaver ponds benefit riparian and aquatic ecosystems in many ways by:

1. creating and expanding wetlands,
2. elevating water tables and improving vegetation development with subirrigation,
3. enhancing forage and cover for livestock and wildlife,
4. improving watershed stability,
5. reducing high flows and downstream flooding,
6. providing more constant summer flows through water storage,
7. retaining sediment and organic matter,
8. increasing aquatic invertebrate production,
9. increasing total aquatic productivity, and
10. enhancing recreation such as fishing, hunting, and viewing wildlife (Retzer et al. 1956; Smith 1980a).

WATER QUALITY

"Beaver dam complexes clearly improve the quality of water flowing through them . . ." (Parker 1986). Sediment storage is the primary means by which beaver ponds alter water quality of streams.

In southwestern Wyoming, beaver dams affect movement of sediment and nutrients within streams in two ways: (1) trapping of sediment above dams causes settling of particles, and (2) a reduction of maximum water velocity decreases bank erosion and contribution of nutrients (Parker et al. 1985). The reestablishment of beavers in Current Creek, Wyoming, reduced sediment transport from 33 to four tons per day (Brayton 1984; Parker 1986).

Most young ponds have sand and gravel bottoms (Rasmussen 1940), but sediment accumulates over time. Silt and organic debris in ponds can be from a few inches to more than six feet thick (Rasmussen 1940; Call 1966). Naiman et al. (1986) found that 17 dams per mile retained 7,000 cubic yards of sediment per dam.

Sediment accumulation also influences the biochemical carbon cycling in stream systems (Ford and Naiman 1988) and can lead to methane production. Energy entering beaver ponds in the form of leaves and branches from terrestrial plants is much greater

Figure 3. Beaver ponds improve water quality by storing sediment. This drained pond illustrates the magnitude of sediment deposition (Photo by Wayne Hubert).

than energy produced from algae and aquatic plants within the ponds (Hodkinson 1975). More than 50 percent of the energy contributed to beaver ponds may be assimilated into the sediment (Hodkinson 1975).

Beaver ponds retain organic matter in the stream systems and thereby allow the organic matter to be processed into fine size fractions in headwater tributaries (Bilby and Likens 1980; Naiman et al. 1986; Bilby 1981).

There is definite warming of streams during the summer as water passes through either large ponds or a series of ponds (Evans 1948; Adams 1953; Hale 1966). The activity of bacteria on organic matter in beaver ponds can consume oxygen as water passes through, thereby reducing dissolved oxygen levels. A loss of dissolved oxygen has been observed in streams as they passed through beaver ponds due to increased bacterial activity and higher water temperatures that hold less dissolved oxygen (Adams 1953; Smith et al. 1991).

There are also changes in nitrogen and phosphorus levels within stream systems that contain beaver ponds. Since nitrogen and phosphorus adsorb to clay, trapping of sediment in beaver ponds reduces nitrogen and phosphorus levels within streams (Maret 1985; Maret et al. 1987). Subsequently, beaver ponds serve as sinks for nutrients that contribute to eutrophication (Francis et al. 1985).

Where low nitrogen levels limit biological production in high-elevation streams, beaver ponds can enhance nitrogen conversion and cycling to improve biological production (Naiman and Melillo 1984). In one area of previously low nitrogen levels, stream sections accumulated 1000 times more nitrogen after modification by beaver ponds. In streams with beaver ponds, more nitrogen is fixed by sediment-dwelling organisms (Francis et al. 1985), and long-term stable cycles in nitrogen storage and release are enhanced. Overall, beaver ponds enhance biological productivity of headwater areas.

Parker (1986) reported that stream water below beaver pond complexes had 50 to 75 percent less suspended solids, 20 to 65 percent less total phosphorus and total Kjeldahl nitrogen, and 20 to 25 percent less nitrate nitrogen. Beaver ponds can also lead to higher pH and reduced acidic conditions (Driscoll et al. 1987; Smith et al. 1991). This has a positive effect on streams where highly acidic runoff from adjacent forested lands is a problem.

Concentrations of dissolved metals in stream water can be altered by beaver ponds. Iron and manganese are elevated, whereas aluminum declines as water flows through beaver ponds (Smith et al. 1991).

Skinner et al. (1984) found that stream-water quality in grazed systems was influenced by beavers in Wyoming. Beaver ponds trap coliform bacteria and influence concentrations of bacteria in water.

A parasite of warm-blooded mammals called *Giardia* occurs in beavers and can be transferred to humans in pond and stream water (von Oettingen 1982). In the Rocky Mountain region, *Giardia* can be present in beaver colonies throughout the year and can contaminate downstream waters with cysts (Monzingo and Hibler 1987). Beavers shed cysts in their feces, can become infected as kits, and remain infected. Waterborne outbreaks of Giardiasis have been seen in Aspen, Colorado, and other locations in the Rocky Mountains (von Oettingen 1982). Beavers have been implicated in several of these outbreaks.

RIPARIAN HABITAT

Beavers have been the single most influential factor affecting the overall state of riparian landscapes in some areas (Parker 1986). Beaver ponds increase the surface area of water several hundred times (Naiman et al. 1986) and thereby enhance the overall aquatic and riparian system.

Beaver ponds store water that subsequently is stored in the bank and floodplain. Bank storage is the percolation of water into the floodplain. This increases the water table, enhances summer flows, adds cold water during summer, and causes more even stream flow throughout the year (Knudsen 1962; Parker et al. 1985).

The storage of water in beaver ponds during spring runoff and after summer storms reduces downstream flooding and the damage from rapid increases in stream flows (Parker et al. 1985).

Figure 4. Beaver play a dominant role in the development of riparian habitat by increasing the surface area of water (Photo by Wayne Hubert).

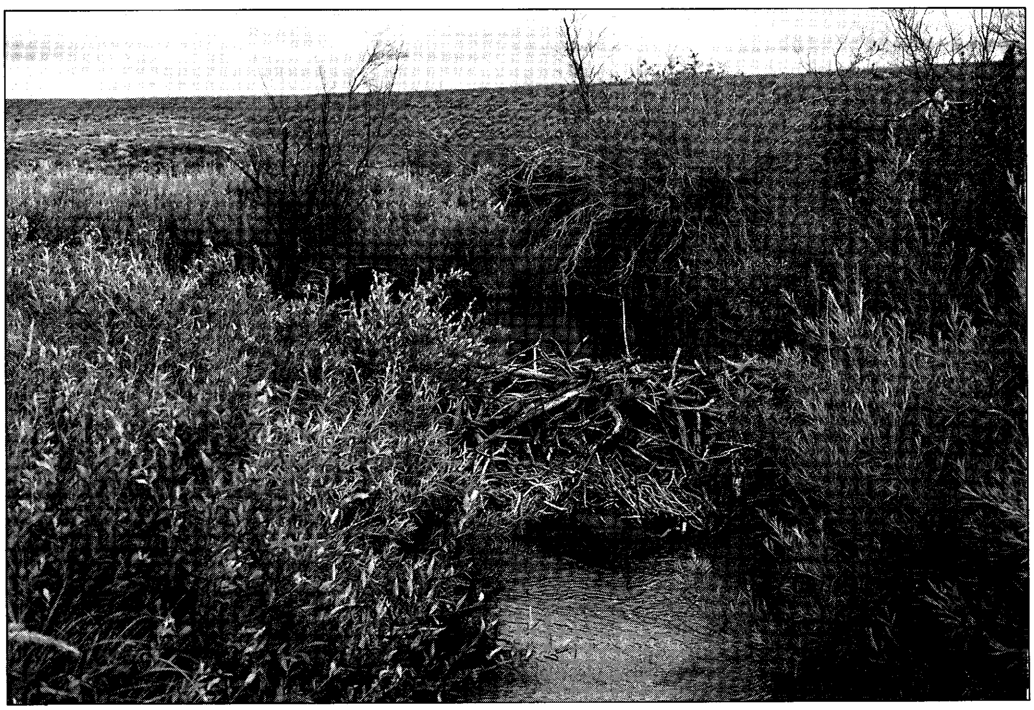

Figure 5. Beaver ponds enhance vegetation growth by increasing the amount of groundwater for use by riparian plants (Photo by Rich Olson).

Beaver ponds also reduce the channel gradient and thereby lessen bank erosion. Reduction of the channel gradient in Current Creek, Wyoming, reduced bank erosion during high flows (spring runoff), which was the primary contribution of sediment into the stream (Maret et al. 1987; Parker 1991). "Beaver dams can be thought of as continually-renewed, erosionally-resistant substrates" because they reduce water velocity and hence decrease potential erosion (Parker 1986, 1991).

Raising the water table enhances the growth of riparian vegetation and stabilization of banks (Parker 1986). Heavy dependence by beavers on willows in some areas can result in the removal of willow from the riparian community and can impair the stability of beaver populations (Aleksiuk 1969).

Interactions With Wildlife

Dam building creates habitats that are important for several species of wildlife, particularly fishes, waterfowl, and browsing animals (Jenkins and Busher 1979). It was estimated that 75 percent of all wildlife species in the sagebrush steppe of Wyoming are dependent on riparian habitat that is enhanced by beavers (Smith 1982).

FISH

In general, beavers are beneficial to trout (Rasmussen 1940). Beaver ponds alter stream habitat for trout in several ways:

1. the bottom substrate changes from gravel and rubble to silt,
2. water velocities decrease,
3. ice conditions become less severe,
4. the area of aquatic habitat increases and provides more living space and cover for trout, and
5. water temperature extremes lessen (Gard 1961).

Overall trout biomass (standing stock) is greater and the average size of trout is greater in stream sections with ponds (Patterson 1951; Hale 1966).

Beaver ponds are indispensable for maintaining trout habitat in rocky, short, high-gradient streams (Salyer 1935). Beavers create trout habitat where none would exist in small streams. An example of this is the Pole Mountain Recreation Area in southeastern Wyoming where the brook trout fishery depends on the continued existence of beaver ponds (McDowell 1975). However, suitable spawning areas seem to be limiting natural reproduction of brook trout in many ponds (McDowell 1975; Johnson et al. 1992).

In the Rocky Mountains, spreading and slowing of icy water in high-gradient streams tends to warm the water and thereby increases food production and growth of trout (Knudsen 1962; Duncan 1984). Beaver ponds also produce a greater standing stock of benthic organisms than adjacent streams (Rabe 1970, Call 1970). Beaver dams

Figure 6. Brook trout tend to be abundant in active beaver ponds (Photo by Richard Grost).

stabilize and maintain flows and create uncommon habitat in streams, especially deep pools that provide valuable overwintering areas and refuges during very low flows (Liedholt et al. 1989).

Brook trout and cutthroat trout tend to be most abundant in streams with active beaver ponds but are generally absent in streams with only abandoned ponds (Neff 1957). The presence of suitable spawning habitat in the form of riffles in an inflowing stream or spring with gravel in the pond is the primary influence on the size structure of brook trout in Wyoming beaver ponds (Johnson et al. 1992; Rabe 1970). Surface area of the pond is the primary influence on standing stock (Winkle et al. 1990); as surface area increases standing stock decreases.

It is generally believed that beaver dams are barriers to trout movement (Salyer 1935; Reid 1952; Rupp 1954; Hale 1966). However, some studies indicate that trout not only can pass over dams during high water (Adams 1953) but also can cross upstream and downstream through most beaver dams during all seasons (Gard 1961).

Beaver dams generally cause no significant changes in water quality that would adversely affect trout in the Rocky Mountain region (Gard 1961). Although dissolved oxygen levels can be reduced in beaver ponds (Salyer 1935; Rasmussen 1940; Rupp 1954), in the Rocky Mountain region it is usually not reduced enough to affect trout. Beaver ponds also raise water temperatures by slowing and spreading the water and by the removal of shade (Salyer 1935; Patterson 1950, 1951; Rupp 1954), but water temperatures downstream from beaver dams seldom exceed the tolerable high temperature for trout in the Rocky Mountain region (Rasmussen 1940; Gard 1961).

Beaver ponds alter the winter habitat for trout in streams. Beaver ponds are continuously capped with several inches of ice and overlaid with snow during the winter, therefore anchor ice does not form in these ponds. In portions of streams without beaver ponds, the stream can freeze almost solid on cold nights, ice can build up behind dams formed by the ice, and the substrate can be substantially disturbed by the ice and the drastic changes in water velocities as the ice dams melt during the day and release the impounded water (Gard 1961). Furthermore, no supercooling of water occurs during winter in beaver ponds (Gard 1961), but temperatures below the freezing point of water can occur in stream reaches without beaver dams. Beaver ponds also produced deep pools that are important as winter habitat for trout (Rasmussen 1940; Chisholm 1985).

The presence of beaver ponds in headwater streams affects fish habitat by greatly increasing the volume of water, providing deep pools during low or intermittent stream flow, and increasing the variety of fish habitat (Hanson and Campbell 1963). The effects on warmwater fishes can be an increased variety and abundance of species and a greatly increased standing stock (Rupp 1954; Hanson and Campbell 1963).

BIRDS

Densities and species of birds increase because of beaver activities. Beaver-pond ecosystems provide important habitats for nongame breeding birds. Shrub biomass, shrub height, and shrub canopy cover are higher at beaver pond sites. These features, in addition to ponded water, enhance habitat for birds (Medin and Clary 1990). Total bird density in beaver-pond habitat can be three times greater than in adjacent riparian habitat without beaver ponds. Species richness and diversity are also higher.

Ponds provide nesting and brooding habitat for ducks and geese (Neff 1957; Call 1966). In Wisconsin, 333 ponds produced 115 duck broods and 764 ducklings (2.3 ducklings/pond/year; average pond size was 3.5 acres). Birds also use ponds for feeding and resting during spring and fall migrations (Knudsen 1962). Trumpeter swans, sandhill cranes, and Canada geese have been observed to nest on beaver ponds in the Jackson Hole area of Wyoming.

FURBEARERS AND NONGAME MAMMALS

Muskrats are attracted to beaver ponds, especially old ponds that are still occupied by beavers (Grasse and Putnam 1955; Neff 1957; Call 1966). Muskrats used 80 percent of beaver ponds assessed in Wisconsin (Knudsen 1962).

Minks are also attracted to beaver ponds. They use muskrats and trout as prey (Grasse and Putnam 1955). Minks used 58 percent of the ponds studied in Wisconsin (Knudsen 1962).

Figure 7. Beaver ponds create nesting and brooding habitat for waterfowl (Photo by Rich Olson).

Otters use abandoned ponds. Otters used 31 percent of the ponds in Wisconsin (Knudsen 1962).

A study in Idaho revealed three times more small mammals in beaver-pond habitat than in adjacent areas of riparian habitat (Medin and Clary 1991). The dense and structurally more complex vegetation of the beaver-pond ecosystem produced food and cover that support higher populations of small mammals.

BIG GAME

Big game benefit from enhanced forage production and cover in riparian zones due to the subirrigation and stabilized stream flow from beaver ponds (Grasse and Putnam 1955).

In some areas, beaver cut aspen and other browse species that might otherwise be used by big game (Grasse and Putnam 1955). For example, moose feed in and around beaver ponds, but beaver can compete with moose for food (Collins 1976a; Shelton and Peterson 1983).

In Wisconsin, 86 percent of assessed beaver ponds were used by deer (beds and browse) and 10 percent were used by black bears (tender vegetation used as food) (Knudsen 1962).

Interactions With Livestock

In many areas of Wyoming, overgrazing by domestic livestock and big game animals in riparian areas degrades habitat conditions for beaver. Introduction of beavers into these areas can improve habitat conditions for livestock and wildlife. However, extensively damaged riparian areas must first have a stabilized stream channel and established riparian vegetation before they become suitable for the introduction of beavers (Collins 1993).

On the other hand, proper livestock grazing management in riparian pastures can improve plant vigor and permit more desirable plant species to compete effectively with undesirable species, thus enhancing habitat for beaver. Lower livestock stocking rates, shorter grazing periods, and more rest between grazing periods are examples of management to enhance riparian wildlife habitat (Chaney et al. 1990).

BENEFICIAL ASPECTS OF BEAVERS

Beavers improve riparian habitat for livestock by enhancing subirrigation of adjacent land through elevated water tables and creating and expanding wetland areas (Collins 1993). Elevated water tables from beaver dam construction increase forage production for livestock grazing, enhance growth of woody vegetation that provides

Figure 8. Beaver ponds attract livestock by providing forage, shelter, and water sources (Photo by Wayne Hubert).

shelter for livestock, and create additional direct water sources for livestock (Apple 1985; Steubner 1992; Stabler 1985; Boddicker undated; Collins 1993).

Water stored in beaver pond complexes delays the discharge of spring runoff for a longer time during the growing season and thus, extends the time of available water for direct use by livestock (Stabler 1985). Additional sources of water for livestock also improve the grazing distribution and reduce localized grazing pressure across pastures and thus, improve range condition, and enhance efficient use of available forage (Boddicker undated).

In some situations, beavers stimulated production of understory herbaceous vegetation by opening up overstory canopy cover by cutting down deciduous trees for lodge and dam construction and for food supplies (Munther 1981). When canopy cover is removed by beaver, additional sunlight reaches the ground surface and stimulates greater production of herbaceous forage for livestock. Collins (1993) reported that livestock graze new aspen suckers that appeared after beavers cut mature aspens. Under these circumstances, livestock are attracted to these areas, and grazing distribution can be significantly altered by beaver activity.

Some deciduous shrubs, such as willows, are vulnerable to livestock grazing during certain periods of the grazing season. In late fall, when herbaceous vegetation ceases to grow and becomes dormant, livestock become attracted to lush riparian forage. Beaver ponds can then create partial or complete barriers to livestock and thus, protect vulnerable riparian plant species from heavy grazing. In such cases, a plant species, such as willow, continues to prosper in a plant community exposed to heavy grazing because of beaver-created isolation from livestock with flooding. If beavers are eliminated and the water level recedes, these plants are once again vulnerable to livestock grazing (Munther 1981).

EFFECTS OF HEAVY LIVESTOCK GRAZING

Livestock are attracted to riparian areas because of succulent forage, easy accessibility, shade, a generally reliable water supply, and a more favorable microclimate than that of surrounding terrain (Skovlin 1984). In some cases, heavy livestock grazing is responsible for deteriorated riparian habitat. When herbaceous vegetation in adjacent upland areas is depleted, livestock tend to concentrate in riparian areas. Deteriorated riparian areas are extremely sensitive to improper livestock grazing. Even riparian areas in good condition are susceptible to damage by concentrations of livestock when the season of use, duration, and intensity of grazing are improper (Chaney et al. 1990).

Improper livestock grazing in riparian areas can decrease water quality, reduce herbaceous and woody vegetation, increase soil compaction, accelerate erosion, and cause physical streambank damage (Thomas et al. 1979). Excessive herbage removal raises stream water temperatures, increases erosion and sedimentation, and raises water evaporation rates, which harm fisheries and riparian resources. Soil compaction decreases water infiltration rates, increases erosion from higher runoff velocities, and reduces vegetative production. Physical damage to banks from excessive hoof impact can increase erosion and sedimentation, accelerate channel widening, and decrease stream depths. Woody riparian vegetation may suffer from the rubbing effects, trampling, and browsing of excessive livestock densities.

On riparian sites where extensive tree-cutting occurs due to high beaver populations, added grazing pressure from heavy livestock use may prevent aspen regeneration. This combination of high populations of beavers and heavy livestock grazing may prevent or retard the reestablishment of aspen and other woody vegetation necessary for future beaver occupancy.

RECOMMENDATIONS FOR LIVESTOCK MANAGEMENT

If livestock grazing causes the deterioration of riparian habitat, management should assist beavers in improving the habitat quality. Grazing management should include the following goals: (1) retain sufficient herbaceous stubble height (4-6 inches) to maintain plant vigor; (2) avoid late-season grazing shifts to woody riparian plants; (3) provide streambank protection; and (4) maintain sufficient plant cover to aid in trapping sediment from runoff.

Grazing and habitat management that improves riparian habitat must be commensurate with the unique conditions of each site, including watershed and stream conditions, riparian and upland vegetation, terrain, class and kind of livestock, and the management capability of the livestock operator (Chaney et al. 1990). These circumstances occur in an infinite number of variations in riparian areas throughout Wyoming. No single grazing-management or habitat-improvement plan will suit all sites.

The following grazing regime and habitat improvement options should be considered for improvement of deteriorated riparian areas due to livestock grazing (Chaney et al. 1990):

1. **Designate pastures with riparian areas as separate units with individual management objectives and strategies.** Pastures with riparian areas can be integrated with adjacent pastures in a rest rotation, two or three pasture deferred rotation, or a simple deferred grazing plan to provide adequate rest and protection from overuse by livestock. Such a grazing regime allows different periods of extended rest that suit the condition of the riparian area in the pasture. Alternate seasons of grazing also can be incorporated in the specific management of the riparian area. Each riparian area is unique and requires specific management.
2. **Use fences or herding to keep livestock out of riparian areas until vegetation and streambanks recover.** Where water is required for livestock, water gaps can be constructed to limit livestock access to the riparian area. Herding helps livestock acquire learned behavior to select nonriparian sites for resting, feeding, bedding, etc. In some cases, livestock operators select livestock breeds that prefer grazing on upland to grazing in riparian sites.

3. **Control the timing of grazing to keep livestock off streambanks when they are most vulnerable to damage and coincide with the physiological needs of target plant species.** To avoid soil compaction and to minimize damage to streambanks, let livestock graze only when riparian soils are dry.
4. **Add more rest to the grazing cycle to increase plant vigor, allow streambanks to heal, or encourage more desirable plant species composition.** In riparian pastures, more rest between grazing periods will improve plant vigor and permit more desirable plant species to compete effectively with undesirable species that are favored by intense heavy grazing.
5. **Limit grazing intensity to a level that maintains desired species composition and vigor.** Lower stocking rates and shorter grazing periods improve plant vigor and provide a competitive edge to desirable plant species.
6. **Change the type of livestock to obtain better animal distribution through herding.** When herded, sheep tend to cover more ground during grazing activities compared to cattle. Changing from cattle to sheep improves the grazing distribution when herded and thus reduces grazing pressure on riparian areas.
7. **Initiate range improvement practices on adjacent upland areas to draw livestock off riparian areas.** Salting, placement of mineral blocks, water development, prescribed burning, shade trees, fertilization, rotobeating, thinning sagebrush with tebuthiuron, and a host of other treatments to upland plant communities attract livestock to upland and away from riparian areas.
8. **Permanently exclude livestock from riparian areas in poor condition that have poor recovery potential when there is no practical way to protect them while grazing adjacent uplands.** Deteriorated riparian areas are more sensitive to improper livestock grazing than areas in good condition. Damage from grazing deteriorated riparian areas can be severe, long lasting and, in some cases, irreversible.

The condition of riparian habitat in Wyoming varies from site to site depending on a number of physical (draining/diverting water, filling, excavating, etc.), chemical (runoff from fertilizers, herbicides, pesticides, etc.), and biological (grazing, exotic plant introductions, etc.) factors that influence these systems. Beavers can enhance these ecosystems. However, they also can be detrimental at high population levels. Any recovery plan for a riparian area must address both the management of livestock and the control of beaver population levels to prevent the return of degraded conditions (Collins 1993).

Management With Beavers

WATERSHED RESTORATION

Riparian habitat on public lands in the arid West has become scarce. In southwestern Wyoming, 80 percent of the riparian habitat has been lost due to accelerated streambank erosion and lowered water tables.

In southwestern Wyoming, beavers were reintroduced in a gully-cut stream system to restore eroded stream banks, enhance riparian areas, and improve water quality (Smith 1981, 1982, 1983; Brayton 1984; Randall 1985; Maret 1985; Parker 1986; Maret et al. 1987). Willows had been extirpated and streambank erosion was extensive. The creeks contributed a heavy silt load to the Flaming Gorge Reservoir.

Beavers were reintroduced to the watershed and aspen were delivered to them because large building material for stable dams was not present. Dams that were subsequently constructed trapped sediment, reduced stream velocity, elevated the water table, and reduced the effects of seasonal fluctuations in the water table. The dams encouraged the growth of willows and riparian plants, stabilized the banks, and improved riparian and aquatic habitat. Beaver dams reduced sediment transport by 90 percent in some sections of the streams.

Land use practices along the stream influenced the effect that beavers had on the system. For example, Current Creek carried 34 ounces of sediment in every 100 cubic feet of water from public land. After flowing five miles through private land with well developed riparian habitat and beaver dams, the solids load was reduced 90 percent (Smith 1981). However, the solids increased 110 percent when the stream flowed through half a mile of highly grazed pasture with poor riparian features. Concentrations of suspended solids increased even further to 112 ounces per 100 cubic feet over the next two miles on public land with poor riparian conditions.

During high flows (spring runoff), suspended solids, phosphorus, and nitrogen were reduced in water flowing through beaver ponds thereby improving water quality. Suspended sediments in beaver ponds trapped phosphorus and nitrogen and significantly improved water quality (Maret 1985; Maret et al. 1987). The beaver ponds had less effect in summer because of lower flows, but sediment transport and erosion were substantially less during summer. Downstream from the complex of dams, bank and channel erosion persisted, and suspended solids, phosphorus, and nitrogen levels in the stream increased.

TRANSPLANTING STRATEGIES

Trapping and transplanting beavers to suitable, unoccupied habitat is a viable option for enhancing water resources and riparian habitat. In marginal habitat, beavers can provide immediate benefits to riparian areas. However, occupation of marginal habitat is often short-lived because beavers commonly disperse to more suitable areas (Collins 1993). The ideal situation for successful transplanting is to relocate beaver in areas where beavers were removed by trappers (Wood River Resource Conservation and Development District 1989).

Several factors must be considered for a successful transplant. The habitat must be evaluated for its potential support of beavers. Relocated beavers cut and use many trees for dam construction during the first two years after the transplant. In marginal habitat, structurally sound trees may be transported to the release site for the beavers. However, providing young trees for food and building materials requires considerable effort (Wood River Resource Conservation and Development District 1989). This approach can be successful in marginal habitat when conducted simultaneously with vegetation treatment to improve willow and aspen densities throughout the drainage (Collins 1993).

Aspens of four to five inches in diameter and four to eight feet lengths are ideal for beavers. Transported tree branches with these specifications should be placed next to the stream. Beavers generally will cut woody material within 100 feet of the pond edge, but they can travel up to 600 feet to obtain building material (Wood River Resource Conservation and Development District 1989).

An evaluation of a potential area for transplanted beavers must address nuisance problems to adjacent landowners in the event the animals move to other sites. Beavers do not always remain where they are released, even if the site provides optimum habitat. Two-year-old beavers commonly disperse to other areas causing damage problems that require control efforts.

Informing upstream and downstream landowners of targeted sites for transplant of beavers is recommended. Owners of adjacent land and local wildlife resource managers must cooperate for a successful transplant. A cooperative evaluation of habitat quality and potential adverse effects of beavers is important for planning transplants (Wood River Resource Conservation and Development District 1989; Collins 1993).

Trapping and transplanting should be performed by an experienced trapper in cooperation with local Wyoming Game and Fish Department personnel. Captured beavers should be weighed, sexed, and aged (adult, yearling, kit) to ascertain the composition of the transplanted assemblage. To assure the identification of released animals, all captured beaver should be ear-tagged. This information helps monitor the future success or failure of transplants (Collins 1993).

Optimum times for transplanting beavers are during the principal dam-building period, late summer or early fall (August-October). Beavers that are transplanted during this time are less likely to desert the area (Wood River Resource Conservation and Development District 1989). Yearlings and adult males can be transplanted any time between 1 May and 30 September. However, after 30 September at higher elevations winter may arrive before transplanted beavers have an opportunity to construct a dam and cache food supplies (Collins 1993).

The best strategy is to transplant three to five beavers from the same colony that includes a breeding pair (Wood River Resource Conservation and Development

Figure 9. Trapping and transplanting of beaver to unoccupied areas can be used to enhance water resources and riparian habitat (Photo by Thomas Collins).

District 1989). Adult or yearling beavers should be transplanted in male-female pairs. If all males or all females are transplanted, they will probably disperse to other areas in search of mates. Adult females should not be transplanted until after kits are weaned (August) or the kits should be transplanted with the females (Collins 1993).

Animals should be transplanted to a site at a sufficient distance from their home colony to reduce chances of returning due to homing instincts. This problem is especially significant when adult pairs are separated (Collins 1993).

MANAGEMENT OF TRANSPLANTS

In new colonies, beavers should not be harvested for at least three years if food is adequate. This allows sufficient time for the establishment of a viable population (Wood River Resource Conservation and Development District 1989).

On sites with marginal habitat, livestock grazing should be avoided for one to two years. This deferral allows time for riparian plant communities to adjust to beavers. When livestock grazing on beaver-transplant sites is resumed, a rest-rotation or deferred grazing system that benefits riparian vegetation must be implemented (Wood River Resource Conservation and Development District 1989). The grazing management practices and habitat improvement options suggested by Chaney et al. (1990) should be followed.

Longevity of a beaver colony depends on habitat quality, size of a colony's home range, and carrying capacity of the habitat. When a colony establishes a large home range in optimum habitat, the site may be occupied for many years (Collins 1993).

Management of the transplanted beaver colony must be implemented to avoid habitat degradation and eventual abandonment of the area by the beavers. A population that exceeds the carrying capacity of a habitat depletes the resources and disperses to other areas. Abandoned ponds eventually fill with silt and become wet meadows. Under natural conditions and over time, trees and shrubs establish themselves and make the site again suitable for beaver colonization. The length of this occupancy-abandonment-succession cycle is highly variable and ranges from a few years to several decades (Collins 1993).

Unregulated livestock grazing of wet meadows that become established after beaver abandon an area can delay beaver re-colonization. If grazing is severe, preferred trees and shrubs may not reestablish themselves and restoration of beaver habitat does not occur (Collins 1993).

Where multiple beaver colonies occupy the same drainage, previously abandoned sites may be re-colonized before sufficient time for rejuvenation has passed. Accumulated habitat degradation in this instance can result in abandonment of the entire drainage (Collins 1993).

Population management should extend over an entire drainage because beavers rapidly occupy all suitable habitat. Management after transplant should focus on controlling beaver populations so that some habitat in the drainage remains unoccupied (Collins 1993).

Managing Beaver Damage

DESCRIPTION OF THE PROBLEM

Most of the damage by beavers is from dam building, bank burrowing, tree cutting, or flooding. Beavers commonly use mud, rocks, sticks, fence posts, tree limbs, corn stalks, and other types of vegetation to build dams. These same materials are used to plug drain pipes, irrigation gates, culverts, canals, ditches, bridges, and other structures in water impoundments (Miller 1983; Wade and Ramsey undated).

In urban areas, beavers cause damage by cutting or girdling ornamental trees or shrubs, burrowing into yards or walkways adjacent to streams or rivers, and flooding roadways and walkways. Shade trees and ornamental trees in parks, golf courses, and urban greenbelts often are severely damaged when beaver populations are high. On urban lakes and ponds, the burrowing by beavers often destroys styrofoam and other flotation materials that support docks and boat houses.

In rural areas, beavers often cause flooding of roads, pastures, croplands, and timberlands by damming drainage ditches and canals, plugging drain pipes, and building dams on small streams. Livestock watering ponds often attract beavers where

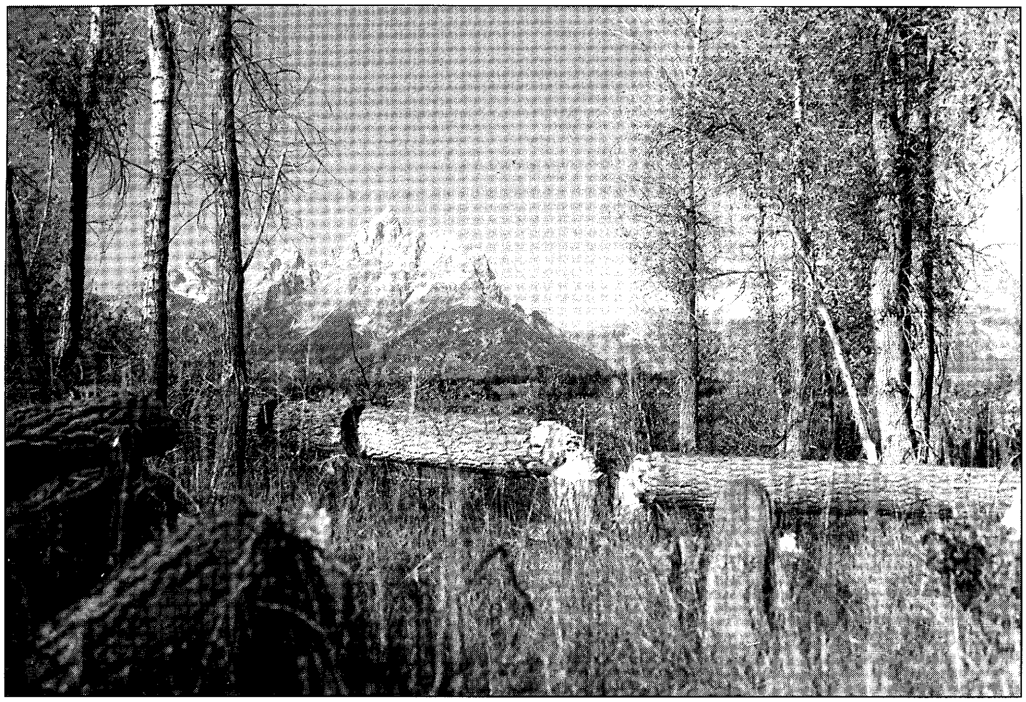

Figure 10. Beaver can damage trees in riparian areas that provide wildlife habitat, shelter for livestock, and aesthetic values (Photo by Thomas Collins).

burrowing into the banks or earthen dams frequently causes washouts that can destroy the ponds. Fields of sorghum, corn, soybeans, and other agricultural crops adjacent to streams and ponds are often used extensively as food sources by beaver (Wade and Ramsey undated).

Beaver ponds and areas flooded by beaver dams provide optimum conditions for mosquito production. In urban areas, this situation reduces the effectiveness of mosquito control. In rural areas, additional mosquito production may do significant harm to livestock and humans (Wade and Ramsey undated).

On a nationwide scale, a conservative estimate of costs from beaver damage is around $75 million per year (Miller 1983). This includes damage to crops, forests, roads, pastures, and rural and urban properties.

Beaver damage can be intensive, such as one or two beavers damming a culvert or drain pipe causing flooding of roads or crops, or extensive, where several beaver colonies in a flatland area cause flooding over several hundred acres. The extent of damage depends on when the property owner or land manager recognizes a problem and starts a damage control effort. Damage control should begin as soon as a problem develops. When beaver colonies are well established over a large contiguous area, management becomes difficult and costly.

Extremely difficult damage control arises when the neighbor of a landowner with damage from beavers refuses to cooperate with management of the beaver populations.

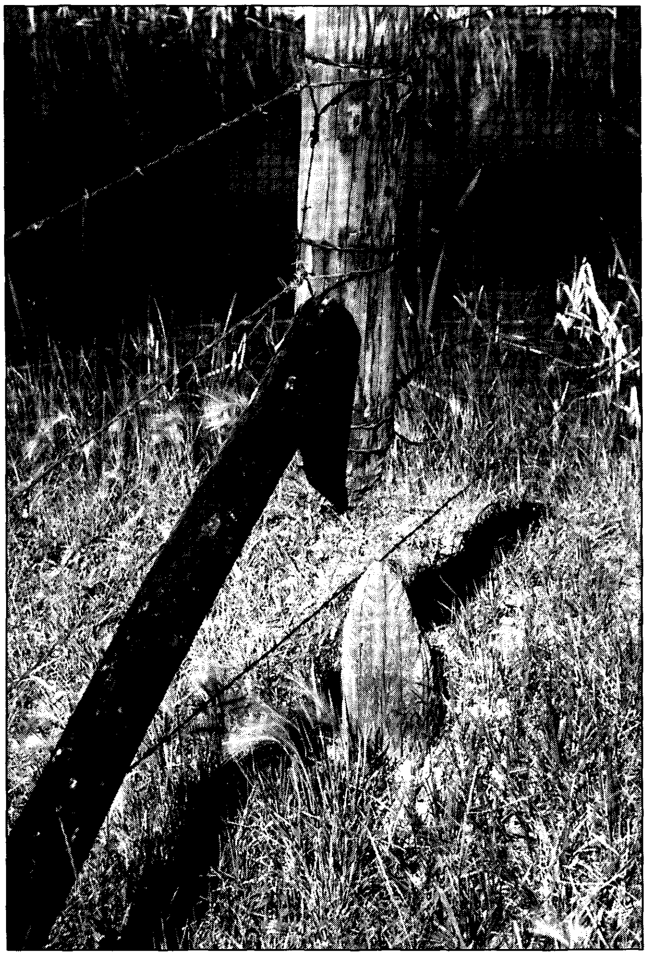

Figure 11. Obvious beaver damage of a unique form (Photo by Rich Olson).

In this case, damage control on the affected lands becomes difficult because of periodic reinvasion by beavers from the adjacent land (Miller 1983).

Identifying beaver damage is usually not difficult. The presence of dams, dammed culverts, bridges, or drain pipes that flood lands, forests, roads, or crops indicate the work of beavers. Cut-down or girdled trees and burrows in pond or reservoir levees also confirm damage by beavers. Sometimes the removal of sticks, logs, mud, and debris from dammed culverts or drain pipes to reduce water levels for trapping is very difficult (Miller 1983).

Dam repair is a compelling force in beavers who perceive any water flowing through a structure as a leak that must be fixed. The sound of running water is a strong stimulus that elicits repair behavior from beavers. The sight or sound of escaping water is an additional stimulus that reinforces repair. Any water level control structure that (1) produces a sound of running water, (2) produces the appearance of escaping water, (3) produces the feel of escaping water, and (4) is accessible to beaver will elicit repair (Buech 1985).

Before damage control is implemented, the degree of damage and cost of control should be evaluated against the benefits from the presence of beavers. Examples of such benefits include fur values, recreational trapping, water storage in beaver ponds, and habitat for waterfowl and other wildlife (Wade and Ramsey undated). If damage control is necessary, several possible approaches can be considered. Non-lethal techniques are preferred over lethal methods to reduce or eliminate problem beavers.

LEGAL STATUS

In Wyoming, the beaver is classified as a furbearer and licensed trappers may trap beavers during trapping seasons. However, beavers who flood meadows, dam irrigation systems, or construct dams or ponds that are dangerous to livestock on privately owned lands or on state lands may be killed immediately by the landowner, lessee of state lands, or employee of the landowner or lessee or an agent of the landowner or lessee (Wyoming Game and Fish Department 1989).

DAMAGE PREVENTION AND CONTROL TECHNIQUES

Exclusion Methods

Ornamental trees or shrubs are often damaged by beavers, especially when yards are near streams, rivers, or ponds. Beaver cut down or feed on trees in urban or rural yards at night. A single tree or shrub can be protected from damage by fencing or wrapping with hardware cloth or a similar stiff material. Chicken wire is usually too light unless well staked. The hardware cloth must be at least 30 inches tall and have no larger than two-inch mesh.

This technique is feasible for a few trees or shrubs in private yards, small parks, and golf courses in suburban areas. But it is too costly and impractical in large areas or shelterbelts, especially where beaver damage is extensive (Collins 1993; Saskatchewan Parks and Renewable Resources undated; Wade and Ramsey undated).

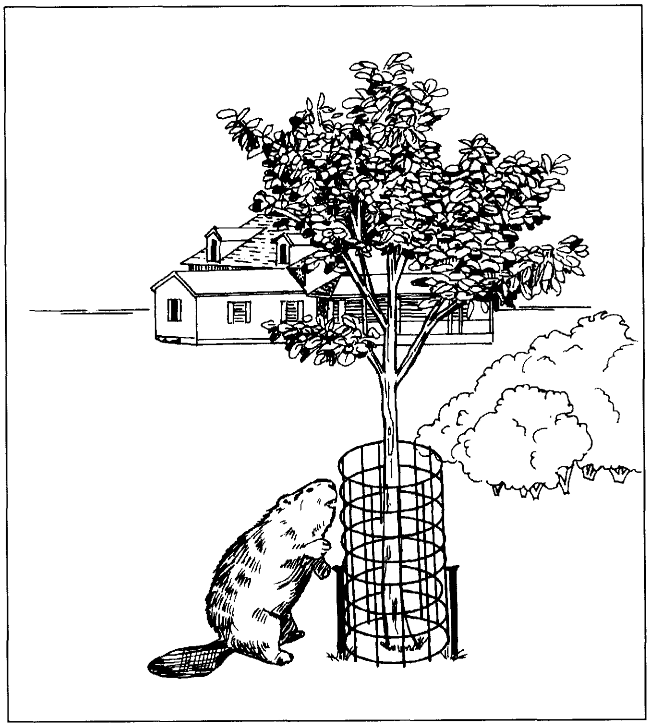

Figure 12. Stiff hardware cloth can be used to protect a single tree or shrub from beaver damage (Illustration courtesy of Saskatchewan Environment, Wildlife, and Resource Management Branch).

Culverts are especially susceptible to beaver problems because they produce the sound, sight, and feel of escaping water, and are accessible to beavers. Damming of culverts by beavers may be curtailed using various methods.

A wire-mesh protector can be made from concrete reinforcement wire that is rolled together and fastened to extend at least 12 feet from the end of the culvert. The cylindrical wire mesh should be placed **over** the end of the culvert and not inside to prevent beavers from flattening this end. Light rods should be welded at two positions inside the cylinder (at three feet and nine feet) to further hold the protector in a cylindrical shape. The end of the wire protector in the pond is wired closed to prevent entry of beavers. Four metal stakes hold this device in place in the pond. Periodic maintenance is required, however, to keep the protector effective. If the protector freezes in the ice during winter, it may collapse under the pressures of ice breakup in the following spring (Saskatchewan Parks and Renewable Resources undated).

Another device that protects culverts from damming is the culvert protector-cleaner. This device can be built for most sizes of culverts and requires little maintenance. It is constructed by welding rods of three-quarter-inch rebar across a looped chain. Rods are spaced approximately four inches apart. This protector should extend at least six feet from the bottom of the culvert on the stream

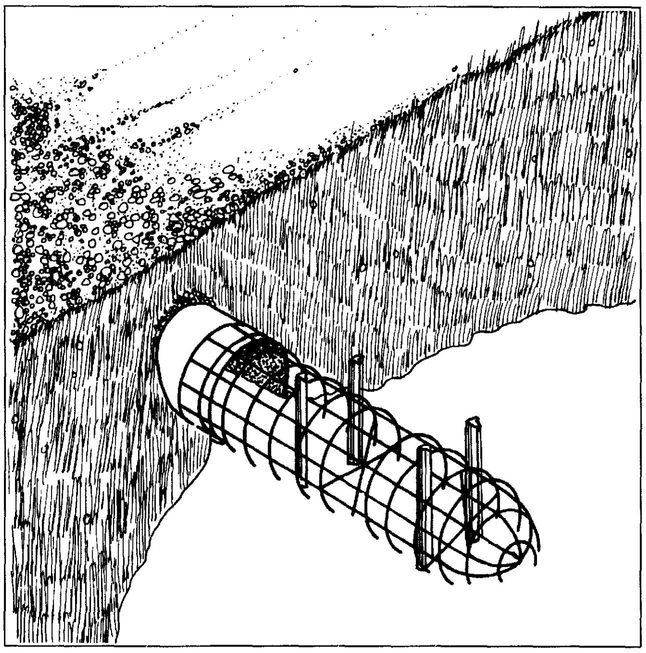

Figure 13. A wire-mesh culvert protector is one method of reducing damming by beavers (Illustration courtesy of Saskatchewan Environment, Wildlife, and Resource Management Branch).

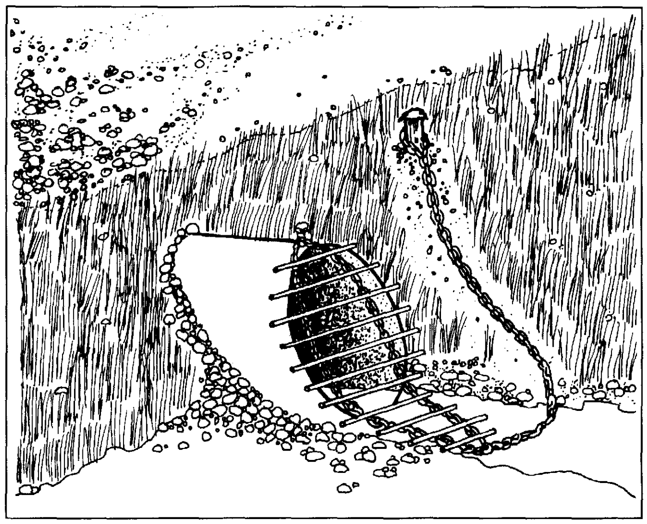

Figure 14. The culvert protector-cleaner prevents damming by beavers and is easily cleaned by attaching the tail chain to a vehicle bumper and pulling it up to the road (Illustration courtesy of Saskatchewan Environment, Wildlife, and Resource Management Branch).

bed and have a tail chain or cable attached to the lower end. The upper end is held against the culvert by a bolt that is placed through the top of the culvert. The culvert must be cut on an angle to allow the device to lie on a slope. The end of the tail chain is looped back and attached to a stake at the side of the road grade. When beavers pile mud and sticks on this protector, they can be easily removed by attaching the tail chain to a vehicle bumper and pulling it up onto the road. This device is best used on roadways that cross major streams where beavers frequently travel (Saskatchewan Parks and Renewable Resources undated).

To reduce the sound, sight, and feel of escaping water from culverts, a short elbow can be attached on the intake end of the culvert and oriented to face down and have a grate over the opening for cleaning. The immediate area of the elbow should be dug out with a backhoe or other heavy equipment to create a deep hole directly below the intake end of the elbow. An alternative to a grate is the complete enclosure of the intake end with wire mesh, staking material, or a pile of rocks. However, beavers may start repairing the outlet end of the pipe by plugging the pipe directly, extending the dam to include the outlet pipe, or building a new dam below the outlet. In this case, the outlet pipe can be elbowed similarly to the intake end, extended, grated, or fenced.

Another technique to reduce damming of culverts is to cover the intake end of the culvert with a sheet of plywood so that the lower edge is just below the water surface. This eliminates the appearance of escaping water from the upstream side, although the water is still flowing freely through the culvert underneath the water surface. This technique reduces the flow rate of water through the culvert, creates too small a hole for beaver to enter the culvert, reduces the sound of water running out the culvert, and eliminates visual cues on the pond surface that water is escaping. However, this approach requires periodic checking and adjustment when water levels increase or decrease (Buech 1985).

Cleaning plugged culverts is time consuming. Laramie (1963) described a method using a vehicle-mounted winch to pull a short log through the culvert to remove the plug. In this example, a concrete reinforcement rod is used to thread a rope through the plug. The rope is then attached to the winch cable and pulled back through the plug. A log slightly smaller than the culvert diameter is attached to the cable at its center, then winched through the culvert outlet to pull the plug and log through the culvert and clear the opening. This process can be repeated as necessary to remove the entire plug. If a mud plug remains, a small diameter tree can be winched through the culvert like a cleaning brush. Another technique to remove plugged culverts is the use of a portable, gasoline-powered water pump to hydraulically remove plugs from culverts (Buech 1985).

Cultural Methods

Techniques that discourage establishment of colonies or encourage beavers to abandon existing habitat are commonly referred to as "cultural methods." These methods are generally not effective because beavers usually alter or modify their aquatic habitat extensively over time. With the possible exception of eliminating food sources and aquatic habitat, most cultural practices have no significant effect on beavers. However, several techniques can be tried (Miller 1983).

Clearing land to remove food sources has met with only limited success. If building materials are in short supply, complete removal of the remaining woody vegetation can be effective along ditches, canals, streams, ponds, and reservoirs in sparsely forested areas. In some cases, shorelines can be densely planted to conifers to shade out competing hardwood vegetation (Buech 1985). Another alternative approach is clearing woody vegetation from shorelines and planting agricultural crops no closer than 100 yards from streams and ponds (Wade and Ramsey undated). However, this technique may result in severe riparian habitat degradation and detrimental impacts to aquatic resources if applied to riparian areas with unstable soils. This approach is also in opposition to nonpoint source pollution control philosophy.

The most widely used but least effective method of altering aquatic habitat is removing dams or lodges (Buech 1985). Typically, dams, lodges, or both are removed or partially destroyed either manually or with dynamite. Beavers respond by repairing a dam or lodge by the following day. Removal is most successful during the initial building period if dams and lodges are destroyed simultaneously. Removal of building materials far enough from the site to discourage further re-use of previous materials can be effective. Daily destruction of dams or lodges in marginal habitat may persuade beavers to abandon an area. However, this may cause a colony or individual beavers to move to another site where they may become more troublesome (Miller 1983). If beavers are abundant, they continually re-invade suitable habitat despite dam and lodge destruction.

In some cases, beavers are needed to maintain a water supply, but their pond size must be regulated to prevent excessive flooding. Installing drains can temporarily maintain water levels at tolerable limits and reduce the sound and sight that trigger dam repair in beavers. Several drain designs reduce water levels in beaver ponds despite the presence of the animals.

One technique, a water-level-control pipe, is simple to build and can be used for many years with little maintenance. To construct a water-level-control pipe, one end of a polyethylene pipe (18 feet long and eight inches in diameter) is plugged with a fitted piece of wood. The section of pipe in the beaver pond is perforated by drilling several one-inch diameter holes in a series along eight feet of the pipe. The pipe is placed through the beaver dam at an appropriate vertical position to drain excess water from the pond. The perforated end of the pipe should extend well into the deep water of the pond. A four to six foot extension of the pipe beyond the dam on the downstream side is usually adequate to prevent beaver repair. Extensions can be added to the downstream side if necessary. This device is most suitable for small ponds (Saskatchewan Parks and Renewable Resources undated).

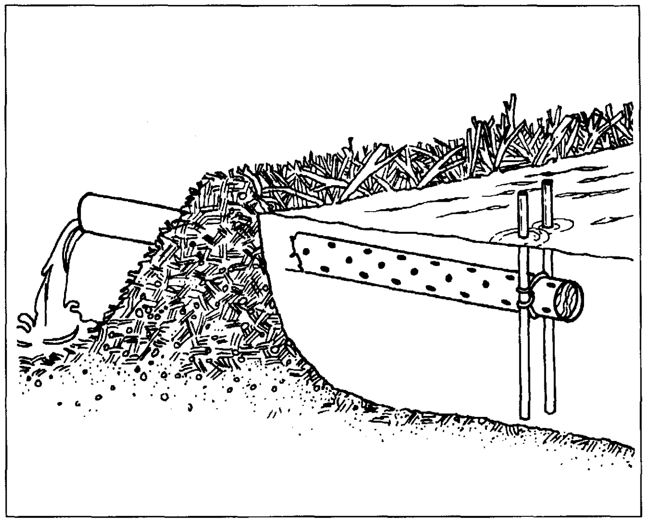

Figure 15. This water-level-control pipe maintains water levels at tolerable limits to prevent excessive flooding (Illustration courtesy of Saskatchewan Environment, Wildlife, and Resource Management Branch).

A three-log drain system can be effective and constructed inexpensively with three logs and sheet metal (Buech 1985). Square wooden pipes with solid tops and sides with slatted bottoms or a perforated PVC pipe (16 to 24 feet long) with a cap on the inlet end can be used in place of logs (Laramie 1963). The three logs are held together with sheet metal and placed through the dam so that one end is laid on the upstream side of the dam at the bottom of the pond and the other end extends beyond the dam on the downstream side. The outlet end of the pipe should extend far enough beyond the dam on the downstream side to discourage beaver from extending their dam to cover the outlet end. The height of the outlet end determines the water level in the beaver pond.

Even these drain designs can be plugged by beavers where beaver populations are high. Guenther (1956) described a fencing arrangement called a "beaver baffler" that consists of two parallel lines of woven wire fence about three feet apart that extend 15 to 20 feet below the dam, through the dam, and to a distance of 30 to 40 feet upstream in one to three feet of water. Woven wire cross sections are installed inside the fenced lane to block beaver that enter the lane from beneath the fence. Posts are placed along the woven wire fence to hold it to the bottom of the pond.

Other water control structures such as spillways, adjustable overflow structures, drop tubes, and whistle tubes produce stimuli that trigger dam repair in beavers (Buech 1985). These can be modified to reduce beaver dam repair.

Spillways with or without an apron produce the sound, sight, and feel of escaping water and stimulate beavers to build a dam across the spillway entrance. Adjustable overflow structures control water levels through placement boards, called stop-logs, placed in a channeled framework inside the dam. These stimulate beavers to plug the overflow with sticks and mud at full pool and at drawdown (Buech 1985). Both of these structures can be modified to reduce the stimuli of escaping water by installing a vertical baffle off the leading edge of the overflow or spillway so that escaping water would be invisible from the water surface on the upstream side. Baffle height and length should be sufficient to prevent a view of the escaping water and access by beavers to the spillway or overflow. Also, a gradual decline from the spillway or overflow edge to the pool rather than a vertical drop over the edge reduces the noise of escaping water. Beaver access to the spillway or overflow edge can be restricted by staking or fencing the area in front of the baffle far enough away so that water cannot be felt passing through the barrier (Buech 1985).

Drop-tubes are typically L-shaped and the horizontal segment is beneath the dam and a vertical segment is attached at or near the intake end of the horizontal portion. Constructed with culvert sections or concrete, water drops down the vertical segment and its height controls the water level. Drop-tubes produce all the stimuli that trigger repair. One solution to eliminate beaver from plugging the intake and outlet ends of a drop-tube is to add two successive 90-degree elbows to the intake, thereby creating an inverted "J" pattern. The intake end under the water surface can be covered with a removable grate. Reynolds and Lewis (1976) reported that this modification eliminated the appearance of escaping water and thus, somewhat discouraged beavers. If the sound of escaping water still attracts beavers, a length of pipe can be installed between the 90-degree elbows to move the intake far enough from the vertical tube to reduce the association between the two tubes. If problems still persist, beaver access can be restricted by fencing, staking, caging, or enclosing the intake inside a pile of rocks (Buech 1985).

Whistle tubes resemble drop-tubes except that the vertical segment does not function as a drop-tube outlet but holds removable boards or stop-logs of varying length to regulate water level. Water flows from the bottom of a beaver pond into the horizontal segment to the top of the stop-log in the whistle tube and then down the other half of the vertical tube to the outlet. The vertical tube is placed in the earthen dam to provide access for the placement of stop-logs of varying lengths. This water-level regulator is fairly successful at reducing beaver problems at full pool. However, at drawdown, the whistle tube acts like a straight culvert and elicits beaver repair. This can be modified by installing an elbow at the intake end of the whistle tube and fencing or enclosing the end in a pile of rocks (Buech 1985).

Any of the described water-level regulating methods has an added advantage of encouraging native wetland plant development on exposed mudflats, which improves habitat conditions for waterfowl and other aquatic wildlife. In some situations, exposed mudflats can be seeded to Japanese millet, barnyard grass, or a variety of other beneficial plant species that provide food and cover for waterfowl and other wildlife (Wade and Ramsey undated).

Repellents

No chemical repellents are specifically registered for use on beavers. However, several researchers in past years tested promising repellents. Most were either non-effective, not registered for use on beavers, environmentally unsafe, or not practical. Of those repellents, some were marginally successful (Miller 1983; Collins 1993; Wade and Ramsey undated).

Huey (1956) found that 10 percent trinitrobenzene-aniline in acetone and arochlors reduced damage to valuable ornamental trees and shrubs. The deer repellent "Magic Circle" was somewhat promising although further testing was not conducted. Buech (1985) mentions that a repellent called "Ropel" whose active ingredient is denatonium saccharide, has been advertised as curtailing cutting or feeding on vegetation by beavers.

Other repellents such as light and noise devices have little or no lasting effect on beaver repair behavior (Guenther 1956; Collins 1993). Buech (1985) had little success with wind-activated wolf silhouettes and wolf feces to prevent beavers from plugging culverts. However, Guenther (1956) reported temporary success by hanging burlap bags covered with scent from natural predators (bear, cougar) on beaver dams. In this case, beavers temporarily avoided the area until the scent dissipated.

Johnson et al. (1976) tried electrically charged wires across dam breaks, but the system was easily shorted out and subsequently unsuccessful. Others reported some success with electric fences when the charged, noninsulated fence wire was attached to a frame on floats (Buech 1985). This system stopped beavers at all structures, but damage continued when the electric fence was removed.

Peterson (1979) suggested creating and maintaining artificial scent mounds at vacant problem sites to falsely advertise occupation. This technique may be effective but is costly in materials and labor.

Toxicants and Fumigants

No toxicants or fumigants are currently registered by the U.S. Environmental Protection Agency for use on beavers (Miller 1983; Buech 1985). There has been some research to develop effective toxicants on captive beavers. However, none of these chemicals has been tested in the field to insure environmental safeness or practicality (Buech 1985). Research revealed that some fumigants kill captive beavers in burrows, and some baits kill captive beavers. There is a definite need to develop toxic baits that are selective, readily acceptable to beavers, and easy to use (Wade and Ramsey undated).

Trapping

A variety of traps are suitable for capturing beavers. These include the Hancock and Bailey livetraps, leghold traps, conibear-type traps, and wire cable snares. In many situations, trapping is the most effective, practical, and environmentally safe method of control. Trapping effectiveness depends on the trapper's knowledge of beaver habits, the ability to read beaver sign, the use of proper traps for each situation, and the correct trap placement. Where beaver are common and not exposed to previous trapping, this technique can be successful. With additional experience and expertise, a trapper can become proficient in removing problem beavers.

Livetrapping is easy when only a few problem beavers exist. Before livetrapping, acceptable release sites must have been identified where the transplanted beavers will not cause additional damage. Also, beavers will not remain in areas unless there is suitable materials for food and dam building and an adequate water supply. Moving beavers into areas with existing populations causes intense intraspecific competition and migration to other areas (Wade and Ramsey undated).

Figure 16. Livetrapping is an alternative to remove problem beavers (Photo by Thomas Collins).

The Hancock and Bailey livetraps, commonly used for livetrapping, are expensive, cumbersome, bulky, and hard to conceal. The Bailey livetrap is used exclusively for underwater sets in less than a foot of water. The Hancock trap is commonly set on steep banks facing the water. This trap has powerful springs that may pose a danger to people and domestic animals. However, both traps are readily visible due to their size and location of the set. Because many people are opposed to trapping, strong local support for beaver control is necessary before livetrapping can be effective. In many cases, livetrapping and transplanting beavers may not be a reasonable economic or biological damage control method (Wade and Ramsey undated).

Leghold traps capture beavers, but their use requires knowledge and skill. The size and jawspread of these traps should not be smaller than a Number 4 longspring or coilspring trap and should be in good mechanical condition. Leghold traps require the use of a weight and slide lock wire or other mechanism to ensure rapid drowning of trapped beavers.

Placement of leghold traps is important for trapping success. These traps are usually placed slightly under water at the shoreline and the pan, jaws, and springs are lightly covered with leaves or mud. There must be a cavity under the pan to allow release of the jaws when a beaver steps into the trap. Traps should be placed slightly off-center on the beaver trail or run to ensure capture by the hind foot. When leghold traps without drowning sets are used, beavers commonly escape.

Leghold traps in bank dens or feeding burrows are especially effective for trapping young beavers. This set can be placed under water at the edge of the hole where beavers turn upward to enter the burrow. Castoreum scent or freshly cut cottonwood, ash, or willow can be used as bait to attract beavers to leghold sets. Scent or bait is especially helpful around scent mounds and on slides down the bank or dam. To increase trapping success, several sets can be made in slides and runs near dams and feeding areas (Wade and Ramsey undated).

One of the most effective traps is the Size 330 Conibear-type trap (Miller 1983; Wade and Ramsey undated). Designed primarily for underwater use, this trap is commonly used by professional beaver trappers. Conibear-type traps kill a beaver instantly. It is equally effective in deep and shallow water. The size, effectiveness, mobility, and capability to kill beavers quickly make it an effective management tool. Only one trap per site generally is necessary and thus, reduces the need for extra traps. When tripped, it exerts tremendous pressure and impact. Care must be taken when setting and placing these traps to avoid personal injury.

A variety of sets can be made with Conibear traps such as dam sets, slide sets, lodge sets, bank den sets, run or trail sets, under-log/dive sets, pole sets, sets under the ice, deep water sets, drain pipe sets, and others depending on the trapper's ingenuity. In most ponds, beavers are trapped easily with sets on dams or in lodges or bank dens, and in runs, dives, or slides where the animals enter the water from feeding areas. In shallow ponds, beavers commonly swim along the pond bottom in areas called runs. These runs are used for traveling from lodges or dens to dam sites or feeding areas. The bottoms of these runs are good locations for setting Conibear traps.

Underwater runs can be located by wading the pond and using a good stake or walking staff to locate the deep areas. In older beaver ponds, runs and lodges or den entrances are commonly scoured out to a depth of two to three feet in the pond bottom.

Another effective technique of using Conibear-type traps is to break out a portion of the dam during the morning, allow water levels to lower all day through the break, and set the Conibear-type trap near the break during that evening. Beavers usually repair a break in a dam during the evening hours after sunset. Traps that are set when the dam is breached often end up above the water level by evening or are tripped or blocked by debris flowing through the break. The best sets at a broken dam are traps located 12-18 inches in front of the dam in moving water with stakes and debris placed on both sides of the trap to guide beavers into the trap jaws.

Riedel (1988) reported that wire-cable snares are very effective for taking beavers in South Dakota. Snares are versatile, quick to set up, easy to use, and do not scare or spook beavers. This technique is effective where beaver slides enter the water, at den entrances, in feeding areas, on land or water trails, or where beavers dive under logs or other obstructions (Wade and Ramsey undated).

The disadvantages of using snares include unnecessary suffering of animals and the potential probability of capturing other non-targeted wildlife species. In Wyoming, snares may not be advisable where threatened and endangered wildlife species or other protected species, such as the river otter, may occur.

Shooting

Generally, the time spent trying to shoot problem beavers is better spent on trapping. Shooting rarely eliminates problem beavers (Miller 1983; Buech 1985). Because beavers rapidly become wary when hunted with firearms, this technique usually is only partially successful. Their nocturnal habits and the difficulty in hitting swimming beavers are additional factors that make shooting a marginally successful control technique (Buech 1985).

However, the most common technique used to shoot beavers is to sit quietly in a hiding spot next to the pond and shoot individual swimming animals during early morning and evening. Beavers are most active from late afternoon to shortly after daybreak, depending on the time of year. During the day, beavers retire to the lodge or bank den until late afternoon (Wade and Ramsey undated).

Another common shooting technique is to lower pond water levels and shoot beavers as they leave den entrances. When beaver dams are removed, water levels drop and leave den entrances exposed (Wade and Ramsey undated). In some cases, trained dogs are used to flush beavers from bank dens and lodges where they are shot upon emerging (Buech 1985). Depending on the range, either a high-powered rifle or a shotgun with large shot is effective. Low-power .22 caliber rimfire rifles and small birdshot in shotguns are not adequate for killing beavers.

Other Techniques

Frightening techniques are seldom successful because beavers are wary of humans and restrict their activities to nighttime hours when harassed. In almost all cases, these methods do not force beavers to leave already established habitat and do not prevent future damage (Wade and Ramsey undated).

Some chemicals inhibit reproduction in captive beavers. However, there is no known method to administer a reproductive inhibitor in wild beavers. Extensive research and testing is required to develop methods to apply chemical reproductive inhibitors to wild populations. An additional problem is to get chemical reproductive inhibitors for this purpose registered by the U.S. Environmental Protection Agency (Wade and Ramsey undated).

In some cases of extensive and repeated damage, almost every kind of imaginable method has been tried. These include dynamiting lodges during mid-day to using snag-type fish hooks in front of dams, road culverts, and drain pipes (Miller 1983). Although they may kill a few beavers, such techniques rarely eliminate damage. In many cases, nontarget wildlife species are killed in the process.

Beaver damage can be severe and cause extensive economic losses in some situations. However, landowners with beaver problems often overestimate the number of beavers in a pond and the difficulty of control (Collins 1993). Beaver colonies, like other populations of wildlife, build to a certain level above the carrying capacity of the habitat before colony members colonize adjacent suitable habitat. Beavers are territorial. More than eight to 13 beavers in any particular pond are rare, and most often the numbers range from four to eight. Older and larger ponds with adequate food supplies are more likely to support higher beaver numbers (Miller 1983).

Likewise, a good trapper with a dozen traps can successfully trap all the beavers in a particular pond in a week of trapping. Where it is legal to trap in lodges and bank dens, a good trapper can remove every beaver from a pond if dams are kept broken and water continually flows from the pond on a nightly basis.

As with any animal damage management situation, nonlethal methods should be tried first to alleviate damage. If these are unsuccessful and economic losses by beavers are high, then lethal methods of control can be considered as a last alternative.

Summary and Recommendations

Beavers play a key role in riparian habitat management by increasing and improving water quality and quantity, fish and wildlife habitat, forage quantity and quality for livestock grazing, recreational opportunities, and aesthetic values for nonconsumptive resource use. Where conflicts with human interests occur, beavers can be a liability. Each site occupied by beavers calls for different management with a multitude of physical, chemical, biological, and social constraints. Therefore, management has to be specific for each site where beavers prevail.

Unlimited beaver populations can be detrimental to riparian habitats. Likewise, removing beavers completely from an area can eliminate a natural component of an ecosystem that is important to many species of animals and plants. Management cannot embrace total protection or reduction of beaver populations, but discretionary management that promotes adequate harvest where conflict occurs or protection where habitat enhancement is needed for other multiple uses.

Proper beaver management is an emotional and difficult issue for natural resource managers, farmers, ranchers, and others who are interested in the aesthetic values of riparian habitats. Beaver management should be used to enhance water resources and riparian habitat according to site-specific management objectives. Landowners should consult local representatives of the University of Wyoming Agricultural Extension Service and Wyoming Game and Fish Department for assistance in developing management plans for beavers on their land.

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