NEW HAMPSHIRE BEAVER ASSESSMENT

2015

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EXECUTIVE SUMMARY

Native Americans maintained a well-calculated balance between beaver populations and man for centuries. The importance of beavers to the livelihood and culture of native North Americans was paramount. When western civilization nearly wiped out beavers in Europe, then successfully proceeded to do the same in North America, the existence of beavers was seriously endangered across the continent. Native American respect for beavers was replaced by European greed over a 300-year period. Conservation-minded individuals and state agencies began beaver recovery efforts during the early 1900s. The return of beavers to most of North America was a miraculous wildlife management achievement. Today, the value of beavers as wetland habitat engineers, ecosystem managers, and sources of outdoor enjoyment far outweighs their economic worth. Beavers are a highly valued furbearer resource in New Hampshire and across North America.

In keeping with our agency mission, beavers must be managed for the benefit of other wildlife species, their habitats, and all generations of New Hampshire residents to come. Our beaver management mission is to create stable beaver populations in balance with their habitat for the benefit of wetland wildlife species and humans through proper population monitoring, harvest management, and damage control. New Hampshire's beaver management goals are to (1) maintain sustained beaver populations within suitable habitat, (2) monitor the beaver harvest, (3) minimize beaver damage complaints, (4) increase public awareness and knowledge of the benefits of beavers and their habitat, and (5) provide opportunities to use and experience beavers.

The purpose of this assessment is to provide a comprehensive overview of the current state of knowledge pertaining to beaver biology, habitat, history, damage control, resource and economic value, population management and provide direction for future management. It also serves as an information and education resource for anyone seeking answers to questions concerning beaver life history and past, present, and future beaver management in the state.

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Taxonomy

Only two species of beavers exist in the world. The North American beaver (*Castor canadensis*) is a member of the Order Rodentia, Family Castoridae, and Genus *Castor*. The similar-looking Eurasian beaver (*C. fiber*) is found in portions of Europe and Asia. North American and Eurasian beavers are so closely related that they probably should be regarded as a single species separated only by geography (Wilsson 1968).

Fossil records of beavers began in the Oligocene Epoch of the Cenozoic Era, Tertiary Period, about 65 million years ago. Several evolutionary lineages developed including the burrowing Miocene beaver (*Paleocastor*) which dug corkscrew-shaped underground passages. Another lineage led to giant beavers (*Castoroides*) that were the size of bears in North America during the Pleistocene Epoch. Fossil remains of these Pleistocene beavers were discovered in Bucks, Montgomery, and Monroe counties, Pennsylvania (Rhoads 1903). Castorid beavers have been restricted to the Northern Hemisphere throughout their evolutionary history (Vaughan 1978).

Twenty four subspecies of beavers in North America have been identified (Hall 1981). Range wide gene pool mixing of some subspecies occurred in areas where beavers were extirpated, then reintroduced. Relocations and beaver subtype mixing may have completely eliminated some subspecies (Baker and Hill 2003).

Common names of the North American beaver include beaver, American beaver, Canadian beaver, and el Castor. The word *beaver* comes from the old English word *beofor*. Some Indian tribes in Canada, interpret the word *beaver* to mean *little people* (Hill 1982).

Distribution and status

The beaver was the motivating influence in the exploration and conquest of the North American continent. During the 1700s and 1800s, beaver numbers were low or near extinction across their North American range (Novak 1987). Before human-induced change in distribution occured, beavers were thought to occupy all areas of North America where food and water resources were suitable for winter survival (Bryce 1904). Beaver numbers were estimated between 60-400 million prior to European settlement (Seton 1929).

Figure 1. North American distribution of beavers depicted by shaded area. Map was created by Deems and Pursley (1978), then modified by Hill (1982).

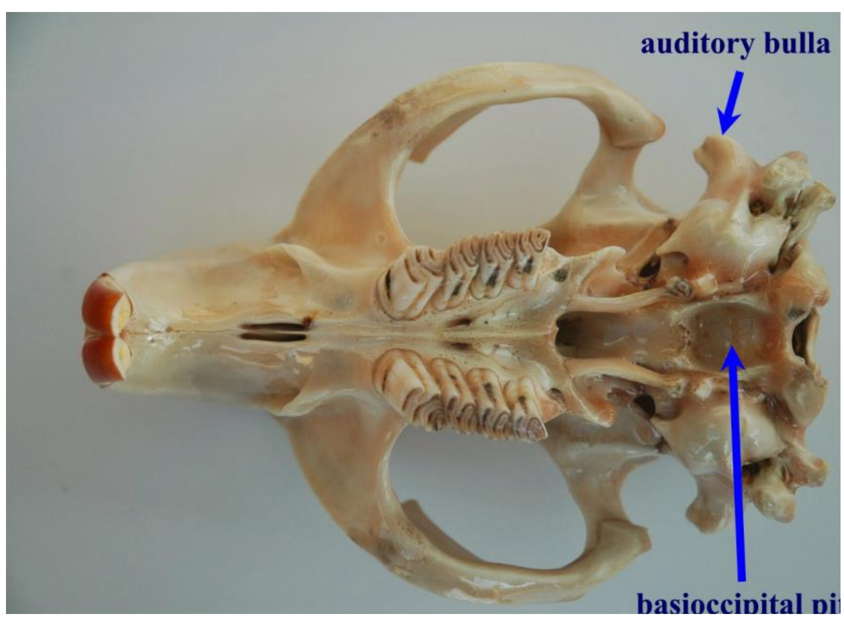
Today beavers are associated with wetlands, slow-flowing waterways in or near forests, and with watercourses in some North American agricultural areas (Deems and Pursley 1983, Fig. 1). Food and water availability limit beaver distribution across its range. In Alaska and Canada, beavers are absent north of the tree line. They are also absent from peninsular Florida, portions of the Midwest, and arid regions of the southwestern United States. Beavers occur in northern Mexico along several northern rivers within the state of Sonora, approximately 200 km from the United States border (Gallo-Reynoso et al. 2002).

During European colonization of the New World, beaver pelts were an important commodity to the effort, including those who settled in the area now known as New Hampshire. Up to the early part of the 19th century, beaver hats were manufactured in Boscawen as part of the local economy. Unregulated harvest during the 18th and 19th centuries lead to low to absent beaver presence during the early 20th century. However, beavers within Coos County were found to be present and soon to be abundant. In response to low beaver abundance in much of the southern portion of the state, New Hampshire Fish and Game Department trapped beavers in Coos County and relocated the captured animals to southern areas of the state. These efforts occurred periodically from the late 1920s through 1940. The reintroduction efforts were successful and today beaver are found statewide and abundant throughout their range.

Physical description

The beaver is the largest rodent in North America with adults averaging 14-29 kg (30-65 lbs). Total body lengths of 89-135 cm (35-53 in) and tail lengths of 24-45 cm (10-18 in) are common (Doutt et al. 1977). Compared to the larger rear half of its body, beavers have a disproportionately smaller head and front shoulders.

Beaver skulls are strongly built in a compact manner supporting powerful muscles and teeth. Orange colored incisor teeth grow continuously throughout life. The rear side of the incisors is softer and wears more easily; while the enameled portion is harder and wears slowly creating a beveled chisel-like edge. This sharp, continuously formed edge is used to cut trees and peel bark. The width of individual incisors is normally > 5 mm (3/16 in). When distinguishing beaver damage from other rodent damage, this tooth-mark width can be used to help identify the nuisance animal (Hill 1982). The hypsodont cheek teeth grow only through the deposition of cementum at the bases of the roots. The dental formula for beavers is I 1/1, C 0/0, P 1/1, M 3/3 = 20 (Doutt et al 1977). Premolars are deciduous and are replaced at about 11 months (Cook and Maunton 1954). Aunique basioccipital pit and long auditory bulla that extend upward and outward (Fig. 2) distinguish beaver skull's from other rodents (Jones and Manning 1992).



Beavers are semi aquatic and possess physical features that make them well adapted to a water environment and to the dark, humid enclosed spaces of their burrows and houses. Out of water, beavers appear hump-backed and are clumsy walkers. In water, beavers are sleek and torpedo-shaped. They propel themselves with large, powerful hind webbed feet. On the hind feet, the second inside toe has a moveable split nail that is used for grooming. Their front feet are not webbed, but are dexterous, heavily-clawed, and well-suited for digging. While swimming, the front feet are held against their chest. Swimming speeds in excess of 2 m/sec (4.5 mi/hr) have been recorded (Wilsson 1971). Their flattened scale-covered tail aids in maneuverability while swimming. Beavers also use their tails to balance themselves on land (Rue 1964), signal danger (Wilsson 1971), store fat for the winter (Aleksiuk 1970*a*), and exchange heat (Aleksiuk 1970*a*; Cutright and McKean 1979).

Beavers have dense pelage consisting of a protective layer of guard hairs and a thick layer of underfur, providing insulation and a waterproof barrier. Fully-grown guard hairs are 5-6 cm (2.0-2.4 inches) long, while underfur is 2-3 cm (0.8-1.2 inches) at maximum length (Obbard 1987). Guard hairs are black to reddish in color and are about 10 times the diameter of the underfur, giving the pelt a coarse appearance (Hill 1982). Guard hair density and length is greatest along the back. Individual hairs of the underfur are extremely dense and wavy, giving the pelt a downy softness. The color of the underfur is black to gray. Beavers have one annual molt, occurring during the summer.

A multitude of beaver pelt color patterns exist, ranging from blond to nearly black. Beavers often have variable pelt coloration within and among populations. During fur grading, however, eastern U.S. beaver pelts normally fall into the dark color category (Obbard 1987). Coloration of an individual guard hair is usually consistent throughout its length. Underfur of the pelt may be dark gray to chestnut in color on the back. Like guard hairs, underfur color becomes lighter along the sides and ventral area. Albino beavers are extremely rare, but have been documented (Ontario Ministry of Natural Resources, unpublished report).

The eyes, nose, and mouth are valvular, closing when beavers dive underwater. Beavers have transparent eyelids (nictitating membranes) which protect their eyes while swimming under water. These structures protect the eye surface from suspended abrasive particles in the water. The location of the eyes near the top of the skull and midway between the nose and skull base allows beavers to see above the water while swimming. These adaptations enable beavers to swim with minimal exposure above the water surface. Beavers have small eyes and nearsighted vision. Nearsightedness is a possible advantageous adaptation to its nocturnal lifestyle. Beavers have a keen sense of smell and acute hearing for detecting food and danger.

Beavers have fur-lined lips that close behind the incisors, allowing them to cut and carry sticks underwater. Two specialized structures enable beavers to open their mouths while gnawing underwater or carrying branches without danger of taking water into their lungs. The epiglottis is positioned above the soft palate allowing the efficient transfer of air from the nasal passages to the trachea, but not allowing panting or mouth breathing (Cole 1970). Another structural specialization is the elevated rear portion of the beaver's tongue that fits tightly against the palate. Except when swallowing, the tongue blocks the passage to the pharynx (Cole 1970).

The digestive system of beavers is adapted to utilize cellulose. Beavers are hind-gut fermenters (Baker and Hill 2003). Digestion is enhanced by an unusual cardiogastric gland in the stomach, a glandular digestive area, and a large tri-lobed cecum containing beneficial microorganisms (Vispo and Hume 1995). Beavers maximize the nutritional value of woody plants by consuming only the bark. They can digest

32% of available cellulose by microbial action in the cecum (Buech 1984). A beaver's small intestine is relatively long, suggesting a high absorption capability (Vispo and Hume 1995).

Beavers practice coprophagy (consumption of feces). They consume soft green excrement directly from the cloaca. The fecal material is chewed, reingested, and passed quickly through the digestive system (Buech 1984). This practice is believed to improve digestive efficiency and has been observed as early as 10 days of age (Wilsson 1971).

Beavers can remain submerged under water for as long as 15 minutes (Irving and Orr 1935). They have the ability to exchange as much as 75% of the air in their lungs, as compared to only 15% for humans, and can tolerate high concentrations of carbon dioxide in their lungs (Rue 1964). When held underwater, beavers do not drown from water inhalation into their lungs like most mammals. Carbon-dioxide narcosis gradually occurs, but water never enters the lungs. Gilbert and Gofton (1982) reported a reduced heart rate in beavers while they were diving (67 beats/minute) as compared to when they were swimming (125 beats/minute).

The reproductive organs of both sexes are internal and lie in front of a common anal cloaca containing castor and anal glands (Svendsen 1978). The cloaca is a single opening serving as the urinary and bowel exit point, the male and female sex organ covering, and the castor and anal gland secretion port. Beavers comb oil produced by the anal glands into their fur to waterproof it (Walro and Svendsen 1982). Ducts from the castor glands join the urethra. Urine washes the exudates from within the castor glands producing castoreum (Svendsen 1978). Beavers frequently expel castoreum and anal gland secretions into the cloaca. Both have strong, pungent odors that are used for scent communication.

Some external beaver characteristics can be used to differentiate sexes. Females nearing parturition or during lactation have 4 pectoral mammae, easily visible on the chest. Male beavers have bacula that increase in size with age (Friley 1949). The sex of live beavers and unskinned carcasses can be determined by palpation for the baculum which is positioned anterior to the anal cloaca (Svendsen 1978). When carefully palpated, presence or absence of a baculum is an accurate sexing method for beavers (Osborn 1955).

Reproduction

Beavers breed over a longer period of time (November-March) in warmer southern regions of North America than in colder northern areas (Miller 1948, Henry and Bookhout 1969, Wigley et al. 1983). Female beavers mate for life, but males are sometime polygamous (Hill 1982). In Pennsylvania, beavers mate during January-March (Brenner 1964). Mating occurs in bank dens, lodges, or in water.

The gestation period was commonly thought to last 90-100 days in both North American and European beavers. However, the gestation period is now considered to be 105-107 days in European beavers (Wilsson 1971, Doboszynska and Zurowski 1983) and about 100 days in North American beavers (Woodward 1977, Wigley et al. 1983). In Pennsylvania, females give birth to precocial young during April and May (Brenner 1960). Young beavers (kits) are born fully furred and able to walk and swim within 4 days (Wilsson 1971). Average weights of newborns have been reported at 335-495 g (12-17 oz; Shadle 1930, Bradt 1939). Most kits weigh about a pound at birth, but may be smaller in large litters.

Sexual maturity in beavers is generally reached between 1.5 and 3.0 years of age. There are no reports of female kits (<12 months old) breeding in captivity or the wild. With some regional variation, beavers can reach sexual maturity as yearlings (1.5-2.0 years old), averaging 21 months of age (Henry and Bookhout 1969, Wigley et al. 1983). Brenner (1964) did not find sexual maturity among yearling beavers in northwestern Pennsylvania and very little breeding (24%) among 2-year-old adults. He estimated the age of beavers based on weight and pelt size. In northeastern Ohio, Henry and Bookhout (1969) determined age based on tooth eruption, basal closure, and cementum annuli counts and found that 40% of yearlings and 78% of 2-year-old beavers had ovulated.

Habitat quality and nutritional plane has been related to age at first breeding (sexual maturity), age of dispersal, and litter size (Huey 1956, Gunson 1970). Beavers tend to breed at younger ages and have greater reproductive potential in areas of good or excellent food quality and habitat conditions, particularly those containing aspen. Body size, rather than age, is more closely correlated to sexual maturity and first breeding (Gunson 1970).

Beaver population density with respect to habitat availability and exploitation may relate to age of sexual maturity. Parsons and Brown (1979) noted that reproduction in yearlings may cease where >40% of suitable beaver habitat is occupied by established colonies. Boyce (1974) surmised earlier sexual maturity in exploited beaver populations in Alaska. He noted decreased age at first breeding and smaller average body size at maturity among heavily exploited populations.

In a review by Hill (1982), he noted a pattern of sexual maturity at age 1.5 to 2 at middle range latitudes, provided food conditions were favorable, some exploitation or predation occurred, and there was room for some range expansion. However, he observed inconsistency in the pattern at northern and southern range limits, where breeding was delayed until age 2.5 or more.

Pregnancy rates among age groups vary. However, pregnancy rates usually increase to about age 4 and remain high among older age groups except in extremely old individuals (Henry and Bookhout 1969). Pregnancy rates in 2.5- and 3.5-year olds are influenced by population structure within colonies and the extent of dispersal. Gunson (1970) believed that there was less dispersal in good-quality habitats and therefore less breeding among young adults in colonies containing older dominant pairs.

Beaver fecundity is density dependent (Gunson 1970, Boyce 1974, Payne 1984*a*). Consequently, in areas where regulated trapping is practiced, we would expect greater reproductive potential. In an unharvested beaver population, Payne (1984*b*) found an average of 1.8 kits per female, while females in harvested colonies averaged 2.9 kits (Payne 1984*a*). In addition to the extent of exploitation, litter size is influenced by food quality and availability.

One litter each year is produced by each family's breeding female (Novak 1977, Wigley et al. 1983). Brenner (1964) estimated litter size in northwestern Pennsylvania at 5.5 per pregnant female, ranging from 1 to 9 embryos. Doutt et al. (1977) listed an average litter size of 4 for Pennsylvania beavers, but likely based their estimate on U.S. regional or national averages. Other than a small section of northwestern Pennsylvania, statewide beaver litter size information is lacking. The sex ratio at birth is 1:1. Variation from this even sex ratio is likely a result of the random fertilization process or sampling differences.

Mortality

In the wild, most beavers do not live more than 10 years, but captive beavers may live to 21 years (Hill 1982). Today, humans are the main predator of beavers. Historically, wolves (*Canis lupus*) filled this predatory role. Timber wolves are the only predator reported to have any significant impact on beaver populations (Potvin et al. 1992). Other mammalian predators including coyotes (*Canis latrans*), river otters (*Lontra canadensis*), bobcats (*Felis rufus*), mink (*Mustela vison*), and bears (*Ursus* spp.) often prey on juvenile beavers, but have little influence on population dynamics. Habitat conditions that force beavers to forage farther away from water may cause increased predation rates. As food supplies dwindle near the water's edge, beavers are forced to spend more time on land to seek food. Beavers are most vulnerable to predation on land. Other than wolf predation, no study has shown that beaver populations have declined as a result of predatory loss.

Prenatal mortality caused by resorption of the fertilized egg or abortion of the embryo can be substantial. Most embryonic deaths occur early in the pregnancy. Reported preimplantation losses ranged from 3.8-38.2% and postimplantation mortality of embryos was an additional 2.7-17.2% (review by Hill 1982). Although not well documented, severe climatic conditions may cause excessive prenatal losses (Harper 1968).

Mortality from birth through the first two years is minimal. Gunson (1970) estimated a 2.7% mortality rate for kits during their first summer. Novak (1977) found that kit mortality from birth to the first winter was not significant. Losses in the kit as well as the yearling age classes are minimal (Cook 1943, Shelton 1966). The safety afforded by life in a family group appears significant.

Mortality of young beavers that disperse from their parental family group can be substantial. Weaver (1986) reported a 44% mortality of dispersing beavers in Mississippi. He surmised that dispersal into unsuitable or marginal habitats may have decreased their chance of survival. Bergerud and Miller (1977) estimated a combined mortality rate of 46% for kits, yearlings, and 2-year-olds and only 12% for those older than 3 years. Mortality rates are highest during the first 2-3 years of life and lowest between the ages of 5 and 9 years (Gunson 1970). Payne (1984*b*) reported mortality rates of 4% for beavers 0.5-1.5 years old and 40% for 1.5-2.5 year olds in regularly-trapped areas. In areas previously trapped out, he reported mortality rates of 0% for 0.5-1.5 year olds, 60% for those 1.5-2.5 years old, and 25% for beavers older than 2.5 years. He also found no difference in mortality between sexes. Gunson (1970) estimated that only 3-6% of beavers survive to age 10 and 1% to age 20.

Beavers appear to be less affected by diseases than many other species. However, tularemia, caused by the bacterium *Francisella tularensis*, can cause massive die-offs during local epizootics. During the winter of 1951-52, Knudsen (1953) estimated 10,000-15,000 beaver deaths from a tularemia outbreak in Wisconsin. Water-borne type B tularemia (*F. t.* biovar *palaearctica*) commonly occurs in both beavers and muskrats (Baker and Hill 2003). Type B tularemia is not fatal to humans and occurs in only 5-10% of human infections. Type A tularemia (*F. t.* biovar *tularensis*) can affect beaver populations, but is also of particular concern to humans since this type is a life-threatening disease. Tularemia in beavers causes fluid build-up in the thoracic and abdominal cavities, stomach and intestine inflammation, and small white to gray areas of necrotic tissue on the liver, spleen, kidneys, and mesenteric lymph node (Davidson 2006).

Parasites infrequently occur in beavers and do not appear to control beaver numbers. However, if they occur in very large numbers and are associated with tissue damage, parasites can cause mortality. Beavers are hosts for several ectoparasites including ticks (*Ixodes banksi*) and beaver beetles (*Platypsyllus castoris* and *Leptinillus validus*) that eat dandruff (Gibson 1957). Endoparasites including several species of nematodes, trematodes, and coccidians have been found in beavers (Miller and Yarrow 1994).

Some species of *Giardia*, protozoan parasites, are carried by beavers, but do not appear to severely affect them. Especially in dense populations, beavers can carry and spread waterborne *Giardia* spp. cysts as well as microsporidia species (Fayer et al. 2006). *Giardia lamblia* is an intestinal parasite in beavers that can cause human health problems in water supply systems.

Non-predatory mortality sources include starvation, unusual weather events, and accidents. . Malnutrition, starvation, or mortality can result from lack of a sufficient winter food store (Gunson 1970). Mid-winter snowmelts and violent spring breakups can destroy lodges and occupants or drown a large number of beavers (Hakala 1952, Boyce 1974). Accidental deaths from falling trees are generally rare, but occur occasionally. Highway accidents caused by motor vehicles are not common, but can be significant in high traffic areas.

Food Habits

Beavers in North America consume many different species of both woody and herbaceous plants. Leaves, twigs, bark of trees and shrubs, and leaves and stems of aquatic herbaceous vegetation are eaten by beavers. They are generalized herbivores, but have seasonal food preferences. Trembling aspen (*Populus tremuloides*) is the beaver's most preferred woody food across its range. In Pennsylvania, Brenner (1962) found that beavers utilized 95% of aspen and 18% of red maple (*Acer rubrum*) available within food quadrats. Red maple was the second-most preferred beaver food. Other common tree species include willow (*Salix* spp.), other maples (*Acer* spp.), oak (*Quercus* spp.), birch (*Betula* spp.), alder (*Alnus* spp.), and white pine (*Pinus strobus*). Tree cutting may occur during any season, but most woody species foraging occurs in late autumn and as cached food during the winter. Brenner (1960) estimated daily consumption of woody foods at about 559 g (20 oz).

When available, aquatic vegetation may be preferred over woody plants. Jenkins (1981) found that water lilies (*Nymphaea* spp.) with their thick fleshy rhizomes were preferred over woody vegetation during all seasons in Massachusetts. Other aquatic, herbaceous foods include burreed (*Sparganium* spp.), St. Johnswort (*Hypericum* spp.), duck potato (*Sagittaria* spp.), duckweed (*Lemna* spp.), pondweed (*Potamogeton* spp.), water weed (*Elodea* spp.), and sedges (*Carex* spp.) (Collins 1976, Brooks et al. 1993). If present in adequate amounts, aquatic vegetation can provide enough winter food and result in no or very little tree cutting or food caching of woody material (Jenkins 1981).

Upland herbaceous foods are also consumed by beavers. In Mississippi, Roberts and Arner (1984) used stomach analysis to assess food habits. They found that beavers consumed 42 species of trees, 36 genera of herbaceous plants, 4 types of woody vines, and many species of grass. Included in the types of forb species found were rice cutgrass (*Leersia oryzoides*), golden club (*Orontium aquaticum*), giant cane (*Arundinaria tecta*), poison ivy (*Toxicodendron radicans*), soybean (*Glycine max*), and pondweed.

Beavers can inhabit and sometimes thrive in areas where preferred foods are uncommon or absent (Jenkins 1975). They have subsisted in some areas by feeding on coniferous trees, which are generally considered a poor quality food source (Brenner 1962). In south-central Alaska, beavers were observed feeding on discarded Chinook salmon carcasses on three separate occasions between 1999 and 2004 (Gleason et al. 2005). This foraging behavior may be fairly common in Alaskan streams and rivers to take advantage of a seasonally abundant protein source.

Behavior

Some of the most detailed behavioral studies conducted on beavers were completed by Wilsson (1968, 1971). Comparing the behaviors of young European beavers (*Castor fiber*) raised in isolation with wild beavers raised under normal environmental conditions, he was able to distinguish innate from learned behaviors among these animals. Beaver activities such as moving materials, digging, building dams and lodges, manipulating food, and creating food caches were behaviors that involved little or no learning. Young beavers could transport building materials at 14 days and place sticks in holes by 23 days. At 2 months of age, beavers could dig burrows and make channels. Wilsson's (1971) controlled experiments showed that beavers over 1 year of age will build a dam wherever there is a sound of running water. Beavers built dams on a cement floor against a loudspeaker that played the sound of running water (acoustic stimuli). He concluded that beavers attempted to minimize the sound of running water and that this was clearly innate behavior. He also observed the beaver behaviors were typical of most rodents. He noted that beavers do not lick, even during grooming. The development of other beaver behavior patterns is described in Table 1.

Beavers will become aggressive if provoked by lunging forward and biting their adversary. Prior to lunging, beavers will usually make hissing sounds and sometimes exhibit tooth sharpening behavior (Wilsson 1971). Captured adult beavers often display both hissing and tooth sharpening behavior when approached. The placement of foreign castoreum upwind from a lodge often elicits investigation, hissing, and tail slapping as beavers emerge in the evening. This response to foreign castor prompted early trappers to use castoreum as bait (Hill 1982).

Building behavior

Dam building in a stream is usually located at a narrow spot where water runs between two or more obstructions such as stones, logs, or debris. Beavers place peeled logs or sticks parallel to the current. Once sticks are anchored across the stream, mud, rocks, and leaves are carried to the upstream side of the dam. As water levels rise, beavers add crisscrossed layers of sticks held together with more mud, detritus, vegetation, and rocks. Water begins to pool, stream velocity decreases, and sediment settles on the new pond bottom. An increase in the amount of surface water provides beavers with expanded, safe access to more trees. Beavers dig channels to facilitate transport of felled trees. They continuously repair leaks in the dam. Within 1-2 years, water-stressed trees and shrubs die, allowing more sunlight to reach the water surface.

Table 1. Development of beaver behavior patterns (from Wilsson 1971).

Behavior pattern	Age at first performance
Locomotion	
Walking	A few hours
Swimming on the surface	4 days
Diving and swimming underwater	12 days
Fully-developed ability to stay underwater	2 months
Feeding	
Gnawing bark and leaves	4 days
Handling twigs and stalks	14 days
Grasping twigs between 5th digit and the other digits	29 days
Peeling bark	33 days
Cutting and felling small trees	2-5 months
Collection of food stores under water	6 months
Eating leaves in an adult beaver fashion	12 months
Care of fur	
Grooming with forepaws and combing with split nail	4 days
Fully developed grooming	19 days
Mutual grooming within the family group	30 days
Fully developed ability to keep the fur water repellent	60 days
Digging	
Scratching/shoveling/pushing earth with family group	14 days
Shoving, pushing and packing	45 days
Digging a temporary nest	60 days
Digging a tunnel system	1 year
Building of lodges, dams and winter stores	
Carrying and pushing sticks at random	14 days
Dragging	16 days
Placing sticks in holes	23 days
Lodge building	4-5 months
Dam building	6-7 months
Protection against enemies	
Hissing	1 day
Leaping aside	3 days
Seeking protection in the water	10 days
Tail slapping	1 month
Social and territorial behavior	
Exploratory behavior	1 day
Tail wagging	6 days
Aggressive tendencies, wrestling	30 days
Territorial marking	5 months

Beavers build lodges for shelter and a safe location to raise young. Wilsson (1971) discovered beavers only build a lodge when they have become accustomed to their surroundings and have used the building site for sleeping for some time. He also found that locating the lodge building site was a learned behavior. There are two types of beaver lodges: island and bank-types. Island-type lodges are dome-shaped structures made of sticks and logs plastered with mud. Bank lodges may not be dome-shaped, but are also constructed with mud-plastered sticks and logs. All lodges and bank dens have at least two entrances and may have four or more (Miller and Yarrow 1994). Rising waters activate lodge and dam building, while low water encourages channel dredging and lodge entrance improvement. Young beavers do not assist with dam or lodge construction until their second autumn of life (Wilsson 1971). Construction and repair work is primarily a female task. Beavers within a colony may occupy several bank dens or lodges. McNeely (1995) provided an excellent description of beaver den and lodge construction along streams and rivers in his Missouri beaver manual. He noted that beavers often select a high bank or take advantage of soil-holding tree roots to dig a den. Two or three underwater entrances to a den are common. A hollowed-out living chamber inside of the bank den is located 1-2 feet above the water level. Sometimes the digging of the hollowed chamber results in a cave-in of the bank. Beavers thatch over these holes with mud and sticks. These mounds are referred to as *bank lodges* and often extend over the bank. Well-maintained mud and stick thatch freezes solid during the winter and provides excellent shelter and protection from predators.

Winter food caches (feed beds) are built during the fall to provide a winter food supply. As a rule, beavers do not create a food cache until they have built or renovated a lodge in the autumn (Wilsson 1971). Food caches usually consist of tree and shrub branches piled underwater outside of the den entrance, providing access under the ice surface throughout the winter. Beavers eat the outer, nutritious cambium layer of these stored branches and use the inner hardwood for dam and lodge construction. Young of the year do not typically fell trees or assist with food cache construction until their second autumn (Wilsson 1971).

Movements

Bergerud and Miller (1977) identified four distinct types of beaver movements. They included local movements between ponds within a family group territory, yearling wandering, dispersal of 2-year-olds to establish new family units, and movement of adults who lost their mates.

Movement around the lodge and pond are primarily nocturnal. Feeding and dam construction mostly occurs at dusk and after dark. Peak activity outside of the lodge is greatest just before dark and in the early morning hours after daybreak. Beavers appear to take advantage of stream currents by traveling further upstream to retrieve materials for dam and lodge construction and foraging than they do downstream (Boyce 1981).

Dispersal is important in reducing population pressures and social stress. It also may be the primary means of preventing inbreeding and the primary mechanism of population expansion. Beavers typically disperse after their second year to establish new colonies. Both sexes may remain transient until they settle with an unpaired beaver. At times, a beaver will build a dam and lodge that may help attract a mate.

Young adults leaving their parental family unit to establish new family groups can travel substantial distances. Dispersal movements of 82 km (51 mi) have been documented (Beer 1955), but generally average 5-6 miles from the natal family group. More interestingly, relocated beavers in Wisconsin travelled an average 7.4 km (5 mi) from their release points (Knudsen and Hale 1965). However, long distance movements of 238 km (148 mi; Hibbard 1958) and 241 km (150 mi; Libby 1957) have been documented for transplanted beavers.

Communication

Beaver tail slapping behavior is thought to warn family members of danger. Tail slapping may not always be a danger signal. Doutt et al. (1977) reports tail slapping can be a diving aid by tipping the body down, with extra propulsion. Interestingly, frightened beavers commonly submerge without creating ripples in the water and without tail slapping (Doutt et al. 1977).

Wilsson (1971) observed five types of beaver vocalization. Outside of the lodge, beavers mainly used one specific kind of vocalization named the *whistling call*. When beavers wished to contact colony members from a distance they make a high frequency whistling sound that can barely be heard by the human ear. Wilsson (1971) noted that the whistling call was often heard in newly-caught young. Hodgdon and Lancia (1983) described two additional vocalizations outside of the lodge: hissing and growling.

Inside the lodge, four types of contact vocalizations were identified by Wilsson (1971). Young beavers whimpered like small children or made a clacking sound when improperly handled. Adults inside the lodge made highly variable, high and low-pitched squeaks when seeking social contact. While feeding, beavers often used a high-pitched whine as another beaver approached. As the distance between the two beavers decreased, the whine became aggressive in tone. Vocalizations that had broad variation were thought to express the mood of the animal.

Scent marking is a highly developed form of communication in beavers. Both sexes have a pair of castor glands, used for olfactory communication, and a pair of anal glands, used for both communication and to give fur water repellency (Novak 1987). The smell of castoreum stimulates territorial behavior among group members. It also plays a role in pair formation (Wilsson 1971). Castor and anal gland secretions are deposited on scent mounds made of piles of mud and debris. Scent mounds are usually placed on or near lodges, dams, and trails within 1 m of water (Baker and Hill 2003). Beavers of all ages create scent mounds. Males place the most scent marks (Hodgdon and Lancia 1983). In Pennsylvania, scent marking occurs throughout the year, and is most intense during late winter and spring (Brenner 1960).

Population dynamics

The number of beavers occupying an area largely depends on habitat and mortality. Beaver colony density increases with the degree of stream channel splitting, available winter food cache materials, and the diversity of vegetation types (Boyce 1981). Although natural predation and disease can sometimes affect beaver numbers, regulated trapping is the primary mortality source where harvest is permitted. Sign of active beavers is obvious even to inexperienced individuals. Confined to watercourses, their movements and behavior are relatively predictable. Thus, beavers can be vulnerable to overharvest.

The beaver's vulnerability to harvest can result in local population eradication. Unrestricted trapping efforts are routinely directed to high-quality habitats. Consequently, mortality from trapping is typically greater in high-quality habitats and less in low-quality habitats (Gunson 1970). Adults seem to be more susceptible than kits or yearlings to winter trapping (Payne 1975).

Long-term shifts in beaver populations in response to changes in harvest and habitat conditions have been documented. Novak (1987) observed a decline in Ontario's beaver harvest during the 1920s to the mid-1930s due to probable overharvest. As a result of proper management, beaver numbers and harvest steadily increased until about 1970. The plotted harvest line was relatively smooth during increasing and decreasing phases (Fig. 3). When beaver populations were at or near saturation levels, the plotted harvest line became saw-toothed. Novak explained that this effect was not a result of rapidly fluctuating populations, but more likely the result of economic and climatic factors influencing the ability or desire of trappers to harvest beavers. A beaver population decline attributed to deteriorating food conditions was reported by Aleksiuk (1970*b*) in Canada's MacKenzie Delta. He observed a population decline of about 20% per year for 4 years.

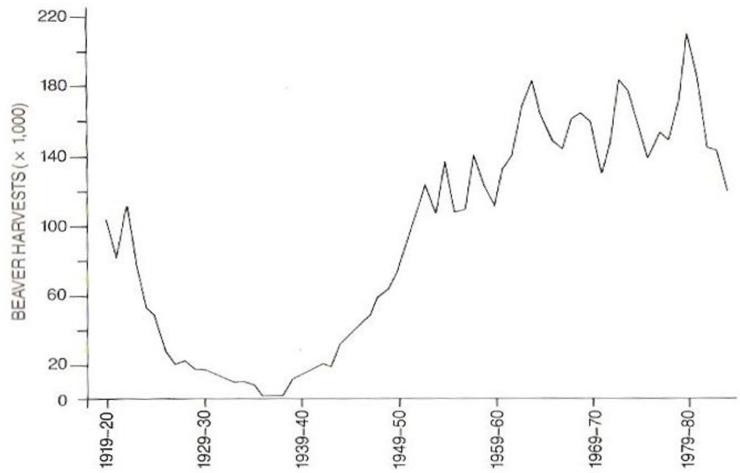


Figure 3. Beaver harvest in Ontario from Novak (1987).

There is no evidence that beaver populations are cyclic. The number of active colonies in an area varies annually. Extreme weather patterns such as drought conditions or severe flooding can decimate a beaver population. Disease outbreaks such as tularemia can also decrease a population for several years (Labzoffsky and Sprent 1952, Knudsen 1953). Favorable habitat conditions developed over time can revive a beaver population in a relatively short period.

Social/Spatial organization

A beaver colony is defined as a group of beavers occupying a common pond or stretch of stream, using a common food supply, and maintaining a common dam or dams (Bradt 1938). Although the term *colony* normally describes a collection of families, it has traditionally been used to characterize a family group of beavers. The terms *colony* and *group* are used interchangeably in reference to beavers sharing common food, shelter, and waterways. Beaver groups or colonies are actually closed, extended-family units. A typical beaver group in mid-winter consists of an adult pair, 2-3 yearlings, 2-4 kits from the previous spring litter, and occasionally one or more 2.5 year olds (Hill 1982). Most colonies consist of 4-8 beavers that are related to one another (Miller and Yarrow 1994). Gunson (1970) found that the number of beavers in a colony was greater in better quality habitats. Also, he found that the number of beavers in a colony appeared to be regulated by variations in litter size and in the frequency of dispersal of immature animals. Lone beavers and mated pairs taking up a new residence away from their parental colonies are sometimes referred to as single colonies and pair colonies (Payne 1975).

Home range is greatly influenced by the water system where the beaver colony lives. Colony members typically show territorial defense of their lodge and pond, resisting all outsiders (Miller and Yarrow 1994).

The social structure of a beaver colony tends to inhibit sexual maturity of the young. Normally, only the dominant female comes into estrus and breeds. Similarly, the dominant male may prohibit young males in the colony from breeding. Thus, beavers normally become sexually mature after leaving the parental colony (Wilsson 1968).

If good habitat with a sufficient food supply exists, less dispersal and larger colonies will likely result. Lower fecundity would occur under these favorable conditions (Boyce 1974). Likewise, limited food supplies or poor habitat often cause more rapid dispersal of juveniles resulting in breeding at an early age. In a Saskatchewan study area of inferior habitat, Gunson (1970) found high survival of kit beavers during the first few months of life, movements of entire family groups into and out of the study area, and emigration of yearlings from parental colonies in their second summer of life (Gunson 1970).

The spatial distribution of beaver colonies depends on the home range shape and size of their members. Research has not precisely defined a beaver's home range and territory. However, colonies do not share feeding areas, winter food caches, dens, lodges, or ponds with members of another family group. Brooks (1977) found two lake shore family groups that lived only 0.3 km (0.2 mi) apart, but used feeding areas in opposite directions. Home ranges of adjacent family units are usually separated by unoccupied habitat (Baker and Hill 2003).

Home range size and configuration depend on a beaver's sex, age, social position within the family group, habitat type, and seasonal limitations (Baker and Hill 2003). Females with kits tend to limit their distance from the lodge or den, while males range over a larger area. As the young become more independent, home ranges of adults may increase. Ice development confines winter movements resulting in smaller home ranges. In Manitoba, Wheatley (1997) found home ranges were smaller during winter months than summer/fall month home ranges. Beaver families have been reported to occupy 0.6-1.3 km (0.4-0.8 mi) of stream throughout much of their range (Novak 1987). Brooks (1977) reported that an average family occupied 2.5 km (1.6 mi) of shore habitat. A colony's home range size is likely a function of habitat suitability. In the Soviet Union, Semyonoff (1951) found that families of Eurasian beavers in the best habitat occupied 0.5-0.7 km (0.3-0.4 mi) of stream and were separated by about 150-200 m (490-650 ft) of neutral zone between family groups. In medium habitat, family units occupied 1 km (0.6 mi) of stream with 0.5-1.0 km (0.3-0.6 mi) separation. In inferior or poor river habitat, families were spaced 5-10 km (3-6 mi) apart.

SECTION 2: HABITAT

In North America, beaver ponds and dams number in the millions. No other animal besides humans has bestowed such a dramatic impact on the environment. Beavers are often credited with the ability to create their own habitat. Although they are dependent upon growth of plant life for food, beavers do create their own escape cover and shelter.

Prior to European settlement in North America, beavers diversified the landscape by providing wetland patches in a primarily forested region (Hill 1982). These patches of wetland created a highly productive system due to the abundance of water and nutrients. Native Americans used abandoned, sediment-rich, beaver ponds for growing crops because of the soil's high fertility (Hilfiker 1991). Beaver wetlands provide habitat diversity by creating temporally shifting patches of flooded trees and shrubs, aquatic emergent plants, open water, and edge. These habitat features support diverse types of wildlife as well as many rare wetland plants and animal species.

Habitat description

Beavers can survive in areas with poor food conditions, but cannot survive for long in waterways with seasonally fluctuating water levels or swift current. They avoid rocky streams or lakes with rocky shores. Large lakes with excessive wave action are often found to have beaver absent. Flood-prone areas with widely fluctuating water levels are avoided. Preferred sites include ponds, small lakes with muddy bottoms, and slow-moving streams. Beavers will reside in artificial ponds, reservoirs, and drainage ditches if nearby food is available.

Suitable habitat for beavers must contain all of the following: 1) stable aquatic habitat providing adequate water depth, 2) channel gradient of less than 15%, and 3) quality food species present in sufficient quantity (Williams 1965). In the northern beaver range, beavers need adequate forage for construction of a winter food cache, herbaceous vegetation for summer feeding, and a body of water of sufficient depth and size to contain a food cache and provide escape cover from terrestrial predators (Boyce 1981).

Beavers exist in three main types of aquatic systems: 1) beaver ponds created by constructing dams across streams, 2) edges of existing lakes or large ponds, and 3) within large rivers and streams where water flow is too strong to build a lasting dam. Beavers dig bank dens in areas where the water current is strong or where woody material is scarce. Conical-shaped lodges are constructed on low-flow streams, lakes, and ponds. Beavers will live in close proximity to humans as long as basic habitat requirements are met (Rue 1964).

A habitat suitability index model for beavers used to evaluate existing or potential habitat was developed by Allen (1982). Significant habitat variables were identified and optimal levels were quantified. Aquatic habitat cover types used in the model included palustrine (herbaceous, shrub, and forested wetlands), riverine, and lacustrine. The habitat survey area was a 200 m (656 ft) band around the water source and included the water surface for water systems ≤ 8 ha (20 ac) in size. The following habitat conditions rank highest in suitability for beaver habitat in the model:

- ≤ 6% stream gradient
- small water fluctuations that have no effect on burrow or lodge entrances
- 40-60% tree/shrub canopy closure
- 100% of trees in the 2.5-15.2 cm (1-6 in) dbh size class
- 40-60% shrub crown cover
- ≥ 2 m (6.6 ft) average height of shrub canopy
- ≥ 50% of woody vegetation dominated by aspen, willow, or alder
- lake surface dominated by yellow and/or white lily (*Nymphaea* spp.)
- ratio of lake shoreline length to lake area ≥3 using diversity index formula (see model)

Habitat variable scores can be used to calculate life requisite (water and food) values by cover type using the equations provided in the model.

Ecological and environmental benefits

Beavers occupy complex roles in their interrelationships with habitat, wildlife, and humans. The beneficial and detrimental impacts are often a reflection of human perception of how these interrelationships affect human interests.

Beaver wetlands are important to humans and their environment. Wetlands created by beavers are beneficial to soil conservation, water resources, ground water discharge, water quality improvement, consumptive and non-consumptive outdoor experiences, aesthetic beauty, and habitat creation for native wildlife, fish, and plant species. Conversely, beaver activities have led to significant timber, agricultural, infrastructural, and homeowner damage.

Soils

The value of the beaver's contribution toward protecting and conserving soils is poorly understood and may never be fully appreciated (Hill 1982). Beaver ponds serve as basins for the entrapment of streambed silt and eroding soil. Sediment particles fall out of the water column and settle on the pond bottom as a result of decreased stream velocity. Aquatic and early successional plants become established in the newly-deposited sediment. Conditions then become favorable for flood plain stabilization by more permanent woody vegetation. During flood conditions, beaver wetlands slow and effectively decrease floodwater scour, preventing washing of sediment downstream (Arner and Jones 2009).

Water

Beaver impoundments effectively trap and store water. If numerous dams are well-distributed, they have the effect of holding most precipitation near where it falls or melts and fill the soil to saturation (Hill 1982). The water is then released gradually by downhill gravitational pull and laterally through underground seepage. Eventually, the water finds its way to feeder streams and larger streams. Beaver pond complexes act as sponges, absorbing water during wet periods and releasing it slowly during dry periods (Arner and Jones 2009). This regulated water flow is valuable as protection from flood damage and as a water source during drought conditions.

Acidic streams benefit from beaver impoundments. In acidic watersheds, beaver ponds provide some degree of purification through water pooling. Beaver ponds also provide the essentials for early plant succession within degraded watersheds (Hill 1982).

Organic materials such as leaves, branches, and other plant structures accumulate within the increased surface area of the beaver pond, providing forage and cover for aquatic invertebrates.
Naiman et al. (1986) reported 2,000-6,500 m^3 of sediment retained by a dam ranging 4-18 m^3 in volume. In Quebec, Naiman and Melillo (1984) observed a 1,000-fold increase in nitrogen after beavers impounded a stream. They also observed a reduction in nitrogen from outside the system and an increase in nitrogen fixation. Beaver impoundments increase carbon inputs, methane fluxes, and hydrogen sulfide emissions (Johnston and Naiman 1987). As a result, the ecosystem efficiency for the utilization and storage of organic inputs (stream metabolism index) increases (Naiman et al. 1988).

The aquatic invertebrate community structure changes when a beaver impoundment is created. Running-water invertebrate taxa are replaced by pond taxa, primarily in response to finer sediments and a decrease in current speed (Naiman et al. 1988). Beaver ponds also influence community function by increasing the absolute importance of invertebrate collectors and predators, while decreasing the relative importance of invertebrate shredders and scrapers (McDowell and Naiman 1986). Total density and biomass in ponds may be 2-5 times greater than those of running water sites, ranging from 11,000-73,000 organisms/m^2 and from 1-11 g/m^2, depending upon the season (Naiman et al. 1988).

Fish

Beaver impoundments are generally beneficial to fish. Ponds created by beavers provide conditions favorable for higher plankton and other micro-organism production that serve as rearing units for small fish and deep water for protection during the winter (Denney 1952). In areas of extremely cold waters, beaver ponds are beneficial to trout fisheries, but are harmful where water temperatures become excessively warmed (Knudsen 1962).

Wildlife

Highly-productive wetland habitats created by beavers have been shown to benefit a wide variety of wildlife species including waterfowl (Beard 1953; Renouf 1972; Hepp and Hair 1977; Ringelman 1991), a broad range of other avian species (Reese and Hair 1976, Prosser 1998), and aquatic furbearers (Dubuc et al. 1990). The major benefit of beaver wetlands is the creation of standing water, edge, and plant diversity, all within close proximity to one another (Hill 1982). Habitat types supporting beavers are extremely diverse. However, the actual habitat created by beavers is often very similar. Without beavers, many areas would be less attractive to other wildlife.

Many avian species benefit from some stage of beaver activity (Reese and Hair 1976). Active beaver ponds provide valuable nesting, feeding, and migratory habitat for waterfowl (Beard 1953, Renouf 1972, Grover and Baldasarre 1995). Wetland-dependent songbirds may use various stages of beaver ponds depending on their foraging and nesting requirements.

Ecosystem

Beaver ponds and beaver browsing affect soil fertility, water chemistry, plant succession, and the rate of plant growth (Wilde et al. 1950). Environmental conditions surrounding active beaver ponds are constantly changing. These shifting conditions are dependent upon pond age and size, successional status, substrate, hydrologic characteristics, and resource inputs and have both spatial and temporal components (Naiman et al. 1988). Since all beaver ponds along a stream are not identical habitat, ecosystem parameters do not remain spatially constant. Naiman et al. (1988) used the example of one pond that may be predominantly a bog (due to local hydrology and topography) with one rate of primary production and another pond that may be an emergent marsh with a different rate of production. The connecting stream riffle may have completely different primary productivity.

Active beaver ponds progress through natural plant succession over time. As beaver numbers and food supplies change, temporal shifts in the density and diversity of beaver habitats occurs. Beaver pond succession occurs over a period of about 20-30 years, starting from dam construction on a forested stream, to the increase in open water and loss of wooded cover, and to the eventual invasion of emergent vegetative species (Naimen et al. 1988). Within this timeframe, beaver pond succession appears to be unidirectional and fairly predictive. Once beavers abandon a pond, succession becomes highly unpredictable, depending on multiple factors including topography, hydrology, soil structure and composition, and vegetative community assemblages (Naimen et al. 1988). Mud flats quickly become dense mats of sedges (Carex spp.) and grasses. These beaver meadows prevent soil erosion, but are short-lived in coarse, sandy soils (Wilde et al. 1950). However, in peat or muck soils, humic acid in the sedimentation inhibits decay and prolongs plant succession (Ives 1942).

Prosser (1998) defined four stages of beaver pond succession based on beaver activity and initial conditions. Her beaver pond successional stages were new-forested, new-open, old-active, and abandoned. She found that, in general, more plant food resources for birds were present in older beaver ponds (old-active and abandoned) than in new-forested ponds. Higher plant abundance also appeared as a trend in the older successional stages. Animal food resources were present in most successional stages. The natural multi-successional composition of beaver ponds in Pennsylvania offer nesting and brood-rearing habitat for an array of wetland-dependent avian species. She noted that management of beavers should not be attempted without considering the effects to all species. Overall, new-forested and old-active ponds were used most frequently by waterfowl adults and broods, whereas old-active and abandoned ponds provided habitat for less common species such as the American bittern (*Botaurus lentiginosus)* and Virginia rail (*Rallus limicola*).

SECTION 3: MANAGEMENT HISTORY

Historical events

Native Americans as well as many European and Asian hunting tribes maintained high regard for beavers. The Crow Indian tribe believed in the reincarnation of man into the form of a beaver (Allred 1986). Therefore, the beaver deserved special respect, since any beaver could be a deceased relative or friend. The Cherokees believed it was the beaver which created the continents by dredging them up from the primeval seas. Thus, they recognized the beaver as a great engineer. Asian tribes developed a form of social life called “beaver economy” by some Russians (Wilsson 1968).

Almost every part of a beaver’s body was used by Native Americans Wilsson (1968). The flesh was considered a delicacy and the fat was used as a treatment for frostbite. Castoreum was considered an effective cure for practically every physical ailment. The skin was used to make clothes, rugs, moccasins, stockings, rope, and many other items. The dead were wrapped in beaver skins. To give a skin to anyone as a present was a sign of special friendship. Native Americans regarded the beaver as a holy animal, often entering into their religious legends. For centuries, various tribes and families had their own beaver grounds and preserved a well-calculated balance between beaver populations and man.

The first economic interest in beavers by Europeans and Asians was based on its medicinal importance (Wilsson 1968). The fur was always highly valued, but the insatiable demand for castoreum sparked increased beaver taking. Unlike Native American cultures, western civilization commonly believed that nature provided a never-ending source of goods.

By the 1600s, the top hat became a symbol of distinction in the royal courts of Europe. Top hats were made of felt produced from wool or fur. The finest felt was made of beaver fur. In 1638, King Charles I of England was rumored to have said “nothing but beaver stuff or beaver wool shall be used in the making of hats (Allred 1986).” Because the beaver hat was a status symbol in Europe, the supply of European beavers was quickly exhausted. The species suffered near-extinction with a few remnant populations surviving in southern Norway and small portions of Germany, France, Poland, and Russia (Wilsson 1968). The world market then turned to North America to supply beaver skins and castoreum.

Based on records compiled by Wilsson (1968), organized attempts to establish a fur trade between Europe and North America began in the early 1600s. Stations for handling beaver pelts were established in French Canada, including one in Quebec in 1604 and another in Montreal in 1611. The Montreal station developed rapidly and became a main trading center. An event that significantly advanced the fur trade occurred in 1670 when the Hudson's Bay Company, founded by the British, acquired control over large areas of land in exchange for exploration of the Northwest Passage. When the governor of French Canada tried to take over the Hudson's Bay Company, competition between the English and the French led to open war.

After peace was restored, the fur trade expanded rapidly and lasted for decades. Most trading stations could supply 20,000 beaver skins per year. Beaver skins represented about two thirds of total export value of all goods. Beaver pelts became a medium of exchange. Exchange rate in trade was based upon a blanket-sized beaver. A large beaver bought 1/10 of a gun; ½ pound of gun powder; 2 lbs. of shot; ½ lb. beads; one hatchet; or 1/12 of a wool blanket (Allred 1986).

In the mid-1700s, the Hudson's Bay Company was exporting more than 200,000 beaver skins per year to Europe. An estimated 500,000 beavers were taken annually in North America during peak demand (Wilsson 1968). Most skins were sold at auctions in London to hat makers. Beaver hats were extremely popular during that period. By the end of the 1800s, beavers had been extirpated over most of the continent.

Beaver felt hats were very popular and important to European men's fashion for more than 300 years. Selling beaver pelts to Europe was New York City's first business (Sterba 2002). Beavers were so important to the economy of New York City that two beavers appear on the city's official seal. Similarly, the beaver is a national symbol of Canada and a key influential force in shaping the history of North America.

Silver (1974) compiled historical accounts of New Hampshire's Game and Furbearers. Silver (1974) reports New Hampshire's history heavily involved the harvest of beavers as part of the early colonization economy. Beavers were found to be numerous during the 1700s with considerable harvest pressure during the 1800s. Unregulated harvest caused declining beaver populations, in turn the New Hampshire legislature closed beaver harvest seasons in 1905. By 1915 the beaver population was reported to be estimated at 240. During the time period of 1920 through 1940 beavers were live trapped by New Hampshire Fish & Game staff in Coos County and relocated to southern counties. By 1940, New Hampshire's beaver population was reported to have increased to 7,000. By 1955 beavers were reported to have reached carrying capacity.

In 1939, the New Hampshire Legislature gave the Director of the New Hampshire Fish & Game Department the authority to open a beaver trapping season in Coos County during any part of March and April. The authority came with the following statements; upon written complaint that beaver were polluting a water supply or doing substantial damage to property, or upon his own motion, if he felt that the animals were detrimental to fishing, hunting or lumbering. Acting upon recommendations from Department staff, the Director declared an open season from March 15 to April 1, 1940.

The first season (1940), after 35 years of closure, resulted in a total of 369 beavers taken by 57 trappers. The following year (1941), a two week season was more successful with over a thousand beaver taken from Coos County. The department closed the season in 1942 as it was believed the previous two years take had stabilized the Coos County population. Meanwhile, beaver populations increased rapidly in some sections of southern counties. This population increase lead to farm land, highway, and woodland damage.

The entire State was opened to beaver trapping in 1943. Though, 1947 and 1949 were reported to have no open trapping season. Beaver trapping resumed in 1950 and continues today. Over the time frame of 1950 to 2014 the beaver trapping season length has been modified to fit management needs.

Harvest

The re-opening of the beaver season in 1940 was the beginning of a lasting tradition for many trappers. The historical rebirth of beaver trapping and the restoration of beaver populations was a huge wildlife management success story for New Hampshire. As beaver populations grew, trappers quickly realized the economic and social benefits of beaver trapping. A regulated harvest is not only important in sustaining a healthy beaver population, but also minimizing conflicts with humans.

Attempting to achieve the goals of fair chase, equal/ample opportunity, and rewarding trapping experience, along with reducing the risk for repeated extirpation, regulations were established and modified as beaver populations changed in number and in distribution across New Hampshire.

During the onset of beaver trapping, mandatory beaver pelt tagging was used to account for the total annual beaver harvest. The pelt tagging practice was in operation from 1939 to the mid-1980s. During this time, successful trappers were required to have each pelt tagged by a Conservation Officer. A per tag fee was collected, however, the price per tag varied through the years. Pelt tagging provided an accurate harvest inventory as well as an opportunity for trappers and Department personnel to interact.

Harvest data is currently collected through a mandatory annual trapper report. Information reported on the form includes: town, Wildlife Management Unit (WMU), number of traps set, number of nights trapped, and the number of animals taken.

Historical beaver harvests indicate the 1943 through 1955 beaver take varied yearly from a low of 529 to a high of 2,014, variation was reported to be mostly due to varying weather conditions. For comparison reasons, the 2012-13 beaver trapping season reports 2,473 beavers taken.

SECTION 4: DAMAGE MANAGEMENT

Habitat modification by beavers is often very beneficial to many forms of wildlife. However, when beaver habitat changes conflict with human objectives, the damage impact usually outweighs any habitat benefits (Miller and Yarrow 1994). Beaver damage can be severe and costly. As human populations expand into more rural areas, nuisance beaver conflicts will likely increase in New Hampshire. Human tolerance of beaver problems is partially dependent upon the type and severity of damage and partially upon an individual's level of wildlife appreciation. The lack of knowledge and expertise of many urban and suburban landowners to understand and sometimes solve nuisance animal problems on their own increases the likelihood of damage complaints (Flyger et al. 1983). Killing individual problem beavers and controlled harvests of beaver populations are often the most effective means of damage control. However, lethal methods of dealing with nuisance animals can generate controversy among landowners who appreciate and attempt to attract wildlife (San Julian 1983).

Damage types

The most common types of beaver nuisance complaints include flooding, burrowing, gnawing, damming, and public health concerns. Southwick Associates (1994) surveyed 42 states and 6 Canadian provinces to assess the status of beaver damage and management issues. They found that flooding damage was the most severe and of most concern to wildlife agencies and the public throughout the United States and Canada.

By far, the flooding effects of beaver-created blockages in or around streams, ditches, culverts, drainage pipes, bridges, and other waterway structures constitute the most common and costly damage. Miller and Yarrow (1994) noted that some road ditches, culverts, and drainage pipes have been obstructed so heavily by beavers that explosives were needed to remove the compacted debris. The structures had to be replaced. They also reported that some bridges had to be destroyed because of beaver dam construction.

In agricultural areas, pastures, and row-crop fields adjacent to streams or drainages containing woody riparian buffers are sometimes flooded by beaver dams. Cornfields planted near rivers, large streams, wetlands, and lakes are susceptible to damage from beavers. Beaver damage usually coincides with ear development on the stalk and may continue through harvest. Clean angular cut stalks are conclusive for beaver damage (Anonymous 2001). Beaver will often drag the stalk to their lodge, near water, or adjacent to some other kind of cover before they begin to feed.

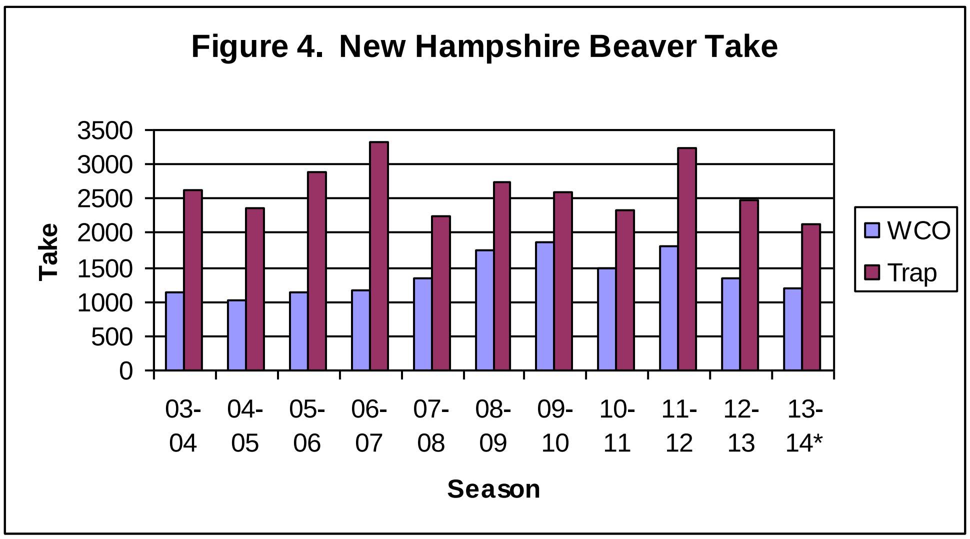
Timber damage by beavers can be significant. Flooding caused by beaver dam construction can be significant in areas of flat terrain along stream bottoms. If root systems remain inundated for more than one growing season, a proportionally larger number of trees will die (Hill 1982). Beavers frequently gnaw bark from large hardwoods and do not fell the tree. Bite wounds may only occur on a portion of the trunk, but still subject the tree to disease and subsequent rot.

Damage to trout fisheries can be serious where low-gradient streams or marginal trout habitat exist. Harmful effects of beaver ponds on trout include elevated water temperature on shallow, slow-moving streams reducing available oxygen, destruction of spawning areas and eggs from siltation, reduction in some species of aquatic insects fed on by trout, and barriers to trout movement created by beaver dams (Denny 1952, Hakala 1952).

Less common complaints are sometimes the most costly. Reservoir dams and levees are occasionally selected by beaver for den sites. Significant burrowing often occurs. Repair costs can be substantial. Continued flooding and burrowing has even caused train derailments (Miller and Yarrow 1994). Beavers occasionally feed on garden vegetables, wander through residential properties, and flood septic systems. They have also been blamed for contaminating public drinking water with the intestinal parasite *Giardia* *lamblia* (Miller 1983). Although, it is highly unlikely that beavers are the cause of drinking water contamination (Woo and Paterson 1986).

Economic impact

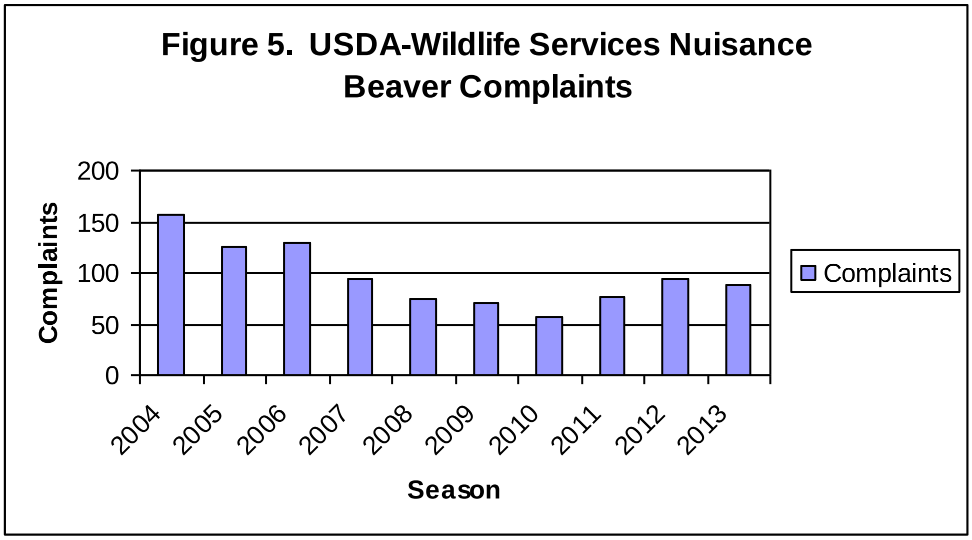
In the early 1980s, the annual cost of beaver damage in the United States was $75-100 million (Miller 1983). Over a 40-year period in the southeastern U.S., Arner and Dubose (1982) estimated total economic loss caused by beavers at $4 billion. In New York during 1993, property damage was estimated at $5.5 million at 2,113 sites (New York State Department of Environmental Conservation 1996). Plus, an additional $330,000 was spent to handle the complaints. No dollar estimate of beaver damage has been compiled for New Hampshire. However, beavers removed as part of nuisance beaver complaints by licensed Wildlife Control Operators (WCOs) averaged 1,391 during the past 11 years (Fig.4).



*2013-14 incomplete due to late data submittals

Damage monitoring

We have the ability to monitor beaver damage complaints from USDA-Wildlife Services records. USDA – Wildlife Services reports an average of 97 beaver complaints over a ten year period from 2004 to 2013 (Fig. 5). It is unclear whether this trend reflects, greater landowner tolerance of beaver damage, decreased damage reporting or direct contact with a Wildlife Control Operator.



Damage control

An annual regulated beaver harvest may be the most practical and prudent approach to controlling damage problems. Populations are reduced by citizen participation at no expense to the public (Hill 1976). The percentage of jurisdictions using the most common beaver control methods in the U.S. and Canada include trapping (100%), dam removal (90%), shooting (84%), water flow device installation (84%), snaring (76%), and relocation (59%) (Southwick Associates 1994).

Exclusion and preventive measures

Fencing out beavers from individual trees, ponds, or lakes is costly, but is an effective preventive measure. Trees near waterways may be protected by enclosing the bottom 3 ft (1 m) of each tree trunk with heavy woven wire mesh, hardware cloth, or sheet metal (Miller and Yarrow 1994). Fencing large areas is usually very expensive and not practical. Erecting a fence around culverts, drainpipes, and water control devices can sometimes prevent damage, but can also promote damage. Beavers may use fencing as material for dam building (Miller and Yarrow 1994).

Several practices have shown some promise in preventing damage. Eliminating food sources such as trees and woody vegetation near beaver habitat may discourage beaver use of an area. Miller and Yarrow (1994) found that daily destruction of dams and removal of dam construction material may cause a colony or individual beaver to move to another site. Dam removal using explosives after beaver numbers are reduced within an impoundment is also effective.

When properly installed, a beaver pipe (Arner 1963) or other structural device to control beaver pond water levels will prevent flood damage and occasionally cause beavers to move to another area. If beavers do not move from the area, these structures prevent beavers from controlling water levels as long as they do not become plugged with mud and debris. If beavers can detect the sound of running water or current flow near the water control device, they will quickly and instinctively plug the source of water drainage (Wilsson 1971). All water control devices installed in beaver dams should be constructed in such a way that water intake occurs without noticeable current flow or running water sound. Behavior patterns of beavers must be considered when designing or installing any water level control device.

Capture and removal methods

Regulated trapping is probably the most effective method of permanently removing nuisance beavers from an area. Four basic trap types are used for beavers including foothold traps, cage traps, body-gripping traps, and cable devices. When correct sizes and types are used properly, these trapping devices meet best management practices (BMP) criteria for beavers in the United States (Association of Fish and Wildlife Agencies 2007*a*). The purpose of the BMP program was to scientifically evaluate traps and trapping systems used for capturing furbearers in the United States (Association of Fish and Wildlife Agencies 2007*b*). BMP research provided guidance to trappers in selecting and using trapping devices meeting international animal welfare standards. Through extensive research and field-testing, BMP work also provided information to help trappers increase trap efficiency, selectivity, practicality, and safety.

Foothold and body-gripping traps are the most common devices used to trap beavers. When used in submersion sets only, foothold traps of sizes commonly designated in 2009 equipment catalogs as number 11, 1.5, 1.65, 1.75, 2, 3, 4, and 5 fulfilled BMP requirements. Body-gripping trap sizes commonly designated as 220, 280, 330, and 440 also passed BMP evaluation. Numeric foothold and body-gripping trap sizes are not standardized and may vary by manufacturer. Beaver trapping techniques using foothold and body-gripping traps are described in great detail by Baker and Dwyer (1987) and Miller and Yarrow (1994). In Alabama, Hill (1976) found that 2-3 body-gripping traps set for about 2 weeks in a colony during each of two years effectively eliminated beavers.

Suitcase-type cage traps may be used in locations and in weather conditions where other traps are less effective. Hancock and Bailey cage traps met BMP criteria for beavers in the United States (Association of Fish and Wildlife Agencies 2007*a*). These traps are large, cumbersome, and expensive, but hold animals alive and allow for release. Apples and corn are effective baits when making sets with this trap type (de Almeida 1987).

Using cable devices (cable restraints and snares) can be a very cost-effective method of capturing beavers. Snaring equipment costs much less than conventional trapping equipment and can be easier to use in many situations (Miller and Yarrow 1994). Not all cable device configurations are suitable for live restraint. Devices with small cable diameter and non-relaxing locks should only be used in submersion or under-ice sets. The Association of Fish and Wildlife Agencies (2007*a*) established cable device guidelines for beaver that meet BMP testing criteria. Techniques for snaring beavers are described in Weaver et al. (1985) and Baker and Dwyer (1987). Where live capture is desired, cable restraints are preferable to cage traps because they can be more easily and safely carried, handled, and set (Hill 1982). If a nuisance beaver area can be saturated with snares and/or restraint devices, the catch per unit effort and expense will often match that of other capture methods.

A variety of other control methods have been attempted to remove or decrease beaver populations. Shooting can be an effective beaver control method where firearms can be used safely. In situations where beavers have become significant pests, night hunting using spotlights and motor boats has been productive (Hill 1982). Gordon and Arner (1976) used orally-administered chemosterilants to attempt to reduce fecundity of beavers. The controlled experiments used two types of estrogen compounds and resulted in suppressed spermatogenesis in treated males and reduced ovulation in females. Effective methods of treating beavers with chemosterilants in the wild were not established. Brooks et al. (1980) found that sterilization was effective in reducing fecundity in Massachusetts beavers. However, behavior and family integrity were altered producing undesirable results. Trained, mixed-breed dogs have been used in Alabama to aid in removing beavers from drained pond complexes (Hill 1982). After dams were removed by hand or with explosives, the trained dogs were very effective at flushing beavers out of lodges and exposed bank dens. Beavers could then be caught alive or shot.

In urban settings, beavers passing through yards or swimming near houses will generally leave on their own. They can be chased into the nearest drainage ditch or waterway, if necessary. De Almeida (1987) noted that beavers can be caught by chasing them into an open area and covering them with a garbage can. The lid is slid underneath and the can inverted. The beaver then can be relocated away from the area, if desired.

SECTION 5: RESOURCE AND ECONOMIC VALUES

The value of regulated beaver trapping is difficult to quantify. For most trappers, there is no single motive driving participation. Recreation, challenge, outdoor experience, and similarly-phrased reasons are identified as primary motivators (Bailey 1981, Boddicker 1981, Marshall 1981, Samuel and Bammel 1981). Income from trapping is less important to trappers, but fur values profoundly affect trapper numbers, trapping effort, and harvest for most furbearer species (Erickson and Sampson 1978, Erickson 1981).

Beaver trapping provides income and an outdoor lifestyle for a small number of New Hampshire residents. However, a strong interest in beaver trapping has persisted since the re-opening of a beaver trapping season in 1940. Today, beaver trapping remains a very popular activity among licensed New Hampshire residents and a benefit to beaver populations, and to society. Hill (1982) described the benefits of beaver trapping as unique opportunities to experience tending a trapline, processing fur, reading animal tracks and sign, and learning and teaching woodsmanship. The habitat created by beavers also provides suitable conditions for waterfowl hunting and other furbearer trapping. Hill (1982) noted that some people removed from rural environments often do not understand relationships among wild animals and their habitats. These people may not accept consumptive use of any animal in a way that causes its death. However, most people that have lived in close association with rural settings look at furbearer populations and their perpetual existence, rather than the fate of each individual. Trapping is a valuable endeavor. Most trappers agree that the anticipation of tending a trapline is a very enjoyable and pleasant experience.

Beavers are economically important as both a nuisance species and a source of income. Prepared pelts have monetary value and are considered marketable commodities. The commodity value of the annual beaver harvest is important and provides an additional reason why we need to manage this furbearer for sustained use.

Beaver fur has been utilized in various styles of garments over the years, ranging from traditional long hair to sheared and dyed garments (Bosma 2003). Fashions are unpredictable, but drive the world demand for pelts. World markets for beaver pelts frequently fluctuate and correspondingly change the price paid for pelts at local markets. Proper pelt handling and preparation as well as pelt primeness, size, and characteristics determine prices paid.

Beaver pelt values over the past 33 years are depicted in Table 2. The average New Hampshire beaver pelt was worth $17.69 during that period. Pelt values were reported to be relatively high during the late 1970s and declined during the early 1980s. When adjusted for inflation, prices from the 1990s till present day remain lower than those of the 1980s. The total value of beaver pelts averaged $58,117 annually, with an inflation-adjusted mean of $94,183 annually. During 2013-2014, the average value of beaver pelts in New Hampshire was more than $41,000 annually, notably lower than the inflation adjusted average.

Pelt primeness is extremely important to trappers, fur buyers, and garment manufacturers. Primeness occurs when the guard hair and underfur has reached its maximum length, density, and finest texture, when the hair has matured with seemingly no pigmentation produced, and when the flesh surface of the pelt appears devoid of hair root pigmentation (Worthy et al. 1987). Stains (1979) noted that the roots of new hair growth move toward the skin's outer surface. The volume of blood that nourishes the fully-grown, new hair decreases resulting in a light-colored hide. The hair on unprime pelts is rooted deeper into the hide and is fed by more blood in the surrounding tissue. The inner (skin) side of unprime pelts appears gray or blue in color. If an unprime skin is shaved or sanded to reduce its thickness, the underfur roots may be cut off, causing the hair to fall out. This circumstance makes pelt primeness extremely important to fur manufacturers.

Normally, beaver grow new fur during the spring and fall. The spring molt replaces winter pelage. Fall shedding replaces the summer coat. Some hair replacement can occur throughout the year, but in much less volume when compared to spring and fall coat changes (Stains 1979).

Timing of harvest is an important factor when determining the price paid for beaver pelts. Bosma (2003), a senior fur grader for the North American Fur Auctions, noted that early caught beavers have blue or slate-blue leather and in most cases, have under wool on the fur side that has not grown to maximum potential. In general, beavers caught under the ice have "prime" fur developed to their maximum potential, both on the fur and leather sides. Late season or spring beavers will show dark shadowing on the leather sides around the legs or back area. This shadowing is the first indication of going "past" or "off" prime. He also warned that spring beavers tend to have a higher incidence of scars and bite marks due to territorial disputes.

Using proper trapping equipment and good set methods will reduce the chance of damage to beaver pelts. Beavers should be killed quickly to avoid damage to fur caused by the trapping device (Hall and Obbard 1987). Beaver pelts sometimes show body-gripping trap or snare damage. Body-gripping traps generally do not damage the skin. However, the trigger or dog can rub the surface guard hairs off of the pelt. If the rub is not too large, it will likely be overlooked (Bosma 2003). Improper use of snares can turn a perfectly good beaver pelt into a damaged one. Snare marks that show as a thin red line on the leather side is a bad sign (Bosma 2003). If the leather fibers are broken down, the fur is not held in by the leather. Hair slippage can occur. Snare marks that show a thin white line on the leather side generally cause no fur-dressing problems.

Table 2. Beaver pelt values in New Hampshire during 1980-2013.

Year	Annual harvest	Average pelt price ($)[a]	2013 inflation-adjusted mean pelt price ($)	Total estimated value ($)	2013 inflation-adjusted total value ($)
1980	4,267	23.08	65.25	98,482	278,422
1981	3,355	16.86	43.21	56,565	144,970
1982	3,043	11.32	27.33	34,447	83,165
1983	2,840	14.17	33.14	40,243	94,118
1984	4,150	19.24	43.14	79,846	179,031
1985	4,161	22.52	48.76	93,706	202,890
1986	4,258	24.28	51.61	103,384	219,755
1987	4,099	48.08	98.6	197,080	404,161
1988	3,637	17.58	34.62	63,938	125,913
1989	3,098	17.39	32.67	53,874	101,212
1990	2,589	8.83	15.74	22,861	40,751
1991	3,372	11.29	19.31	38,070	65,113
1992	2,059	7.49	12.44	15,422	25,614
1993	3,612	17.52	28.25	63,282	102,039
1994	5,901	13.19	20.73	77,834	122,328
1995	4,048	17.79	27.19	72,014	110,065
1996	4,752	13.92	20.67	66,148	98,224
1997	3,975	23.37	33.92	92,896	134,832
1998	3,784	9.38	13.41	35,494	50,743
1999	3,122	11.78	16.47	36,777	51,419
2000	2,652	14.43	19.52	38,268	51,767
2001	3,935	14.72	19.36	57,923	76,182
2002	2,015	9.98	12.92	20,110	26,034
2003	2,626	14.06	17.8	36,922	46,743
2004	2,366	15.94	19.66	37,714	46,516
2005	2,875	23.56	28.1	67,735	80,788
2006	3,329	21.26	24.57	70,775	81,794
2007	2,252	20.39	22.91	45,918	51,593
2008	2,756	20.12	21.77	55,451	59,998
2009	2,603	15.98	17.35	41,596	45,162
2010	2,337	19.41	20.74	45,361	48,469
2011	3,229	20.2	20.92	65,226	67,551
2012	2,473	22.59	22.92	55,865	56,681
2013	2,123	19.78	19.78	41,993	41,993
33-yr avg:	3,285	17.69	28.67	58,117	94,183

[a]Pelt prices were based on NH Trappers Association fur sale records.

Proper pelt handling and preparation is often not considered when *average* pelt prices are quoted. However, the care used to properly prepare fur for sale is reflected in the price paid. When handling beavers in the field during the winter, you should not lay them on a bare ice surface (Hall and Obbard 1987). Placing harvested beavers in a burlap bag or other container will minimize guard hairs from being pulled or damaged. Beavers caught in body-gripping traps should be pulled from the water by a forelimb, rather than by the trap to prevent guard hair rubbing or loss. Care should also be taken when beavers are frozen to the trap or ice surface. A common error when boarding beaver pelts is stretching them into unnatural shapes. All beavers should be stretched into an oval, conforming to its natural shape (Hall and Obbard 1987).

The most commonly used technique for determining the size of a beaver pelt is to sum its length and width. Pelt prices are largely based on what size category a pelt falls under. Size categories under common use are listed in Table 3 (Obbard 1987).

Table 3. Standard trade name and size for beaver pelts (Obbard 1987).

Trade name		English dimensions (in)	Metric dimensions (cm)
XS -	extra small (cub or kit)	<42	<107
S -	small	42-47	107-119
M -	medium	47-51	119-130
LM -	large medium	51-55	130-140
L -	large	55-60	140-152
XL -	extra large	60-65	152-165
XXL -	blanket	65-70	165-178
XXXL -	super blanket	>70	>178

The sale of beaver castor, oil glands, and beaver meat can provide additional income for trappers when handled properly.

SECTION 6: POPULATION MANAGEMENT

Having the maximum amount of information available to manage a beaver population is always desirable. Population and habitat information such as number of animals, productivity, amount and distribution of suitable habitat, carrying capacity, and harvest level needed to stabilize populations are among the most useful for proper management.

Harvest management

A reasonably accurate count of the annual harvest is the minimum information on which to base beaver management decisions (Hill 1982). Without this critical harvest information, the agency has no measure of the current state of beaver management, nor where it will go in the future. Annual harvest management and monitoring is essential for safeguarding and sustaining this important furbearer resource.

In order to properly manage beaver populations, the New Hampshire Fish & Game Department must have the flexibility and authority to regulate the harvest in response to changing trapping pressure and local population needs. Beavers are vulnerable to overharvest because of their confinement to watercourses, easily-learned behavior and movement patterns. If harvest is too intense, beaver populations cannot offset this loss through reproduction. They have a relatively slow rate of reproduction and delayed sexual maturity. Entire local populations can be eliminated in one season of intensive trapping.

In general, harvest levels reflect the status of the beaver population. The number of beavers harvested can fluctuate widely on an annual basis for many reasons. In the past, the following beaver harvest management parameters influenced trapper take in New Hampshire:

1. Season dates and length
2. Mandatory written landowner permission
3. Pelt price
4. Weather conditions

In Missouri, Erickson (1981) examined the statewide beaver harvests in relation to pelt value, season length, pelt value of other furbearers, temperature-indexed season length, snow-indexed season length, and beaver damage complaints. Among these variables, only season length significantly accounted for annual variation in the beaver harvest.

Wildlife agencies in northeastern North America have established seasons ranging from 45-187 days during mid-October through the end of April. Beaver season length and timing of the season vary considerably among northeastern jurisdictions. Trapping pressure and winter weather conditions are key considerations when establishing beaver seasons.

Adults are more susceptible than kits or yearlings to winter trapping (Payne 1975). Both adult males and females are equally vulnerable to harvest. The vulnerability of kits to trapping is related to trapping distance from the lodge (Payne 1975). Wilsson (1971) observed kit activity concentrated in and around the lodge for more than one year. Kits did not repair dams or help construct a winter food cache. Payne (1975) believed that kits were very susceptible to harvest within 9 m (30 ft) of the lodge.

Current harvest trends

With the advent of Furbearer Management Regions in 2007 (Fig. 6), harvest data is reported at the town and Wildlife Management Unit level. Wildlife Manage Units are assigned to specific Furbearer Management Regions. These assignments allow New Hampshire Fish and Game staff to monitor and track changes to populations and trapping effort (Fig. 7).

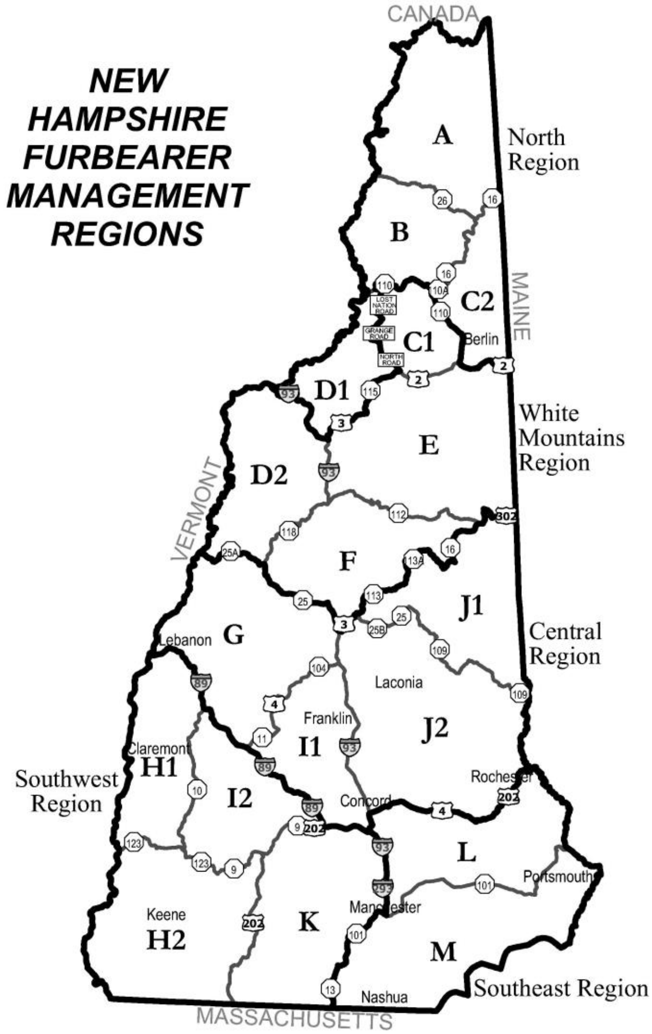
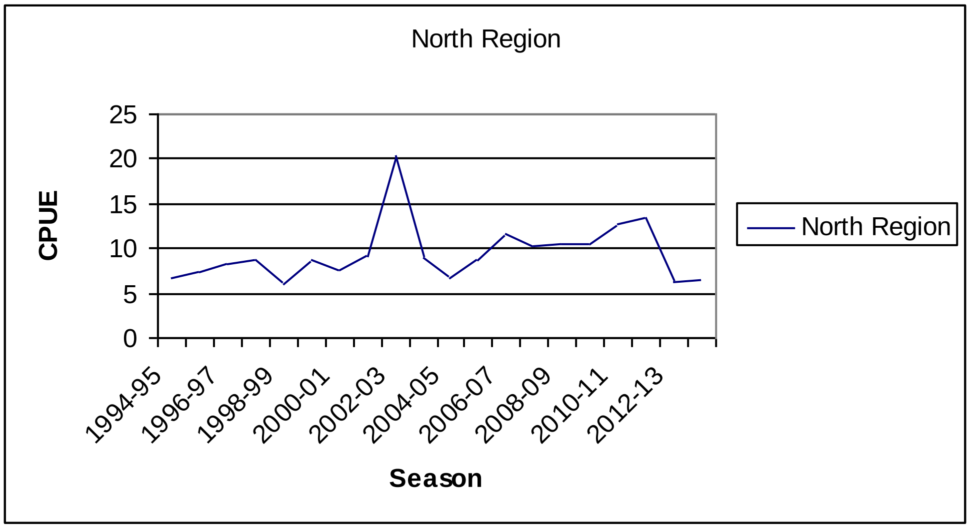


Figure 6. New Hampshire Furbearer Management Regions.

Figure 7. Beaver Take Per Region Trend.

North Region: A,B,C2,D1



White Mountain Region: C1,D2,E,F

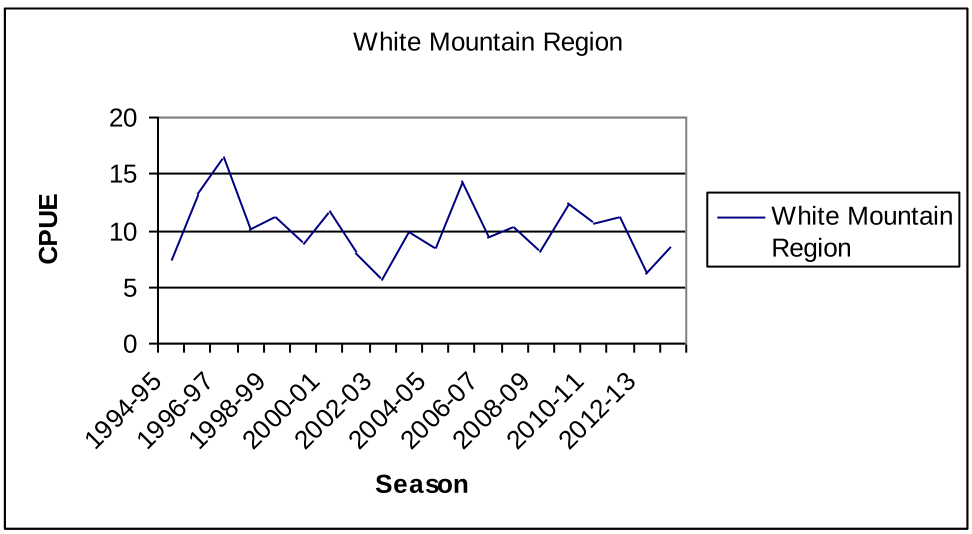
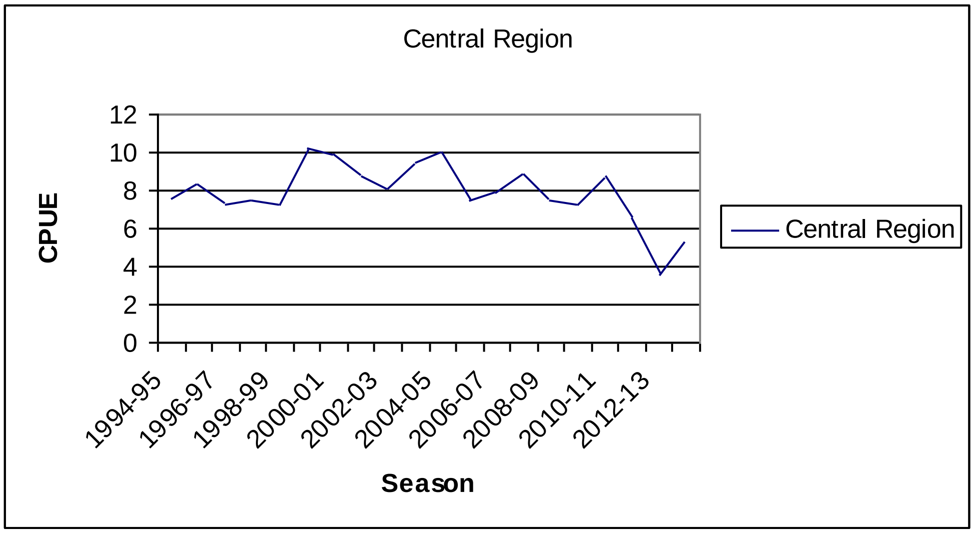


Figure 7. Beaver Take Per Region Trend. Continued

Central Region: G,I1,J1,J2



Southwest Region: H1,H2,I2,K

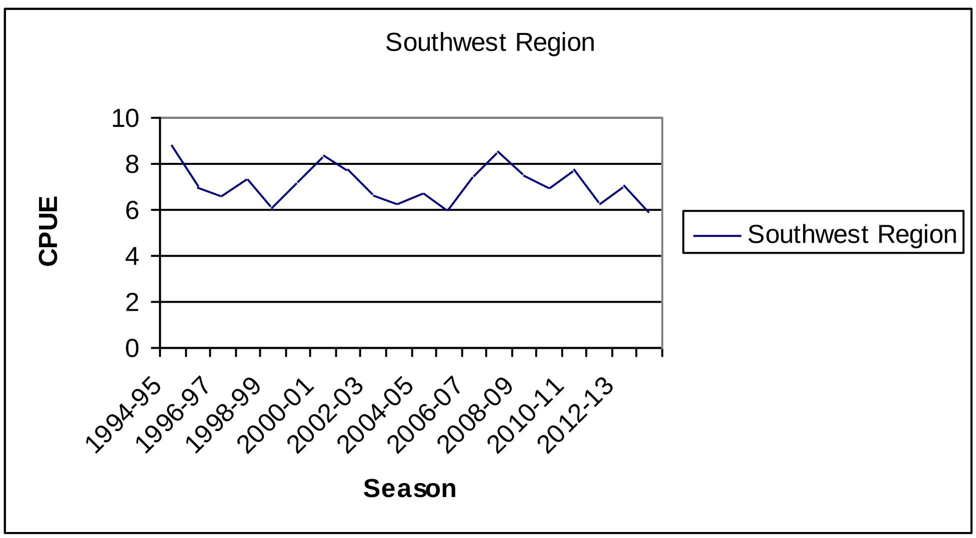
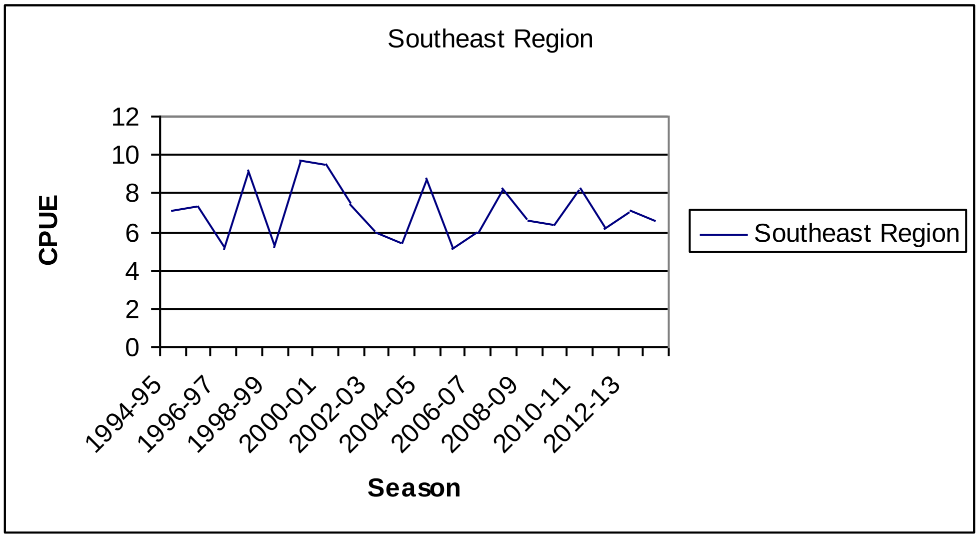


Figure 7. Beaver Take Per Region Trend. Continued

Southeast Region: LM



Population modeling

Population growth is controlled by the number of animals added to the population and the number removed from the population. Given the hypothetical scenario of unlimited, suitable habitat and no mortality, beaver populations can quickly increase. If we begin with two adult beavers and assume sexual maturity at age 2 and average litter size of 4, we can create a simple population growth model (Table 4). After 10 years with no mortality, the population grew from 2 to 608 beavers. Excluding the first year, the average population increase over this period is approximately 60% per year.

Table 4. Hypothetical growth of a beaver population experiencing no mortality, beginning with two adults, and assuming first reproduction at age 2 and litter size of four.

	Year										
Age Class	0	1	2	3	4	5	6	7	8	9	10
Adults (>2 yrs old)	2	2	2	2	6	10	14	26	46	74	126
2 year olds	0	0	0	4	4	4	12	20	28	52	92
1 year olds	0	0	4	4	4	12	20	28	52	92	148
Kits	0	4	4	4	12	20	28	52	92	148	252
Total	2	6	10	14	26	46	74	126	218	356	608
Annual increase (%)	-	300	66	40	86	77	61	70	73	63	71

Compared to many other rodents, beavers have relatively low natality, low mortality of young, high parental care, prolonged behavioral development, and high adult longevity in the absence of harvest (Hodgdon and Lancia 1983). Limiting factors that slow or stop beaver population growth include excessive harvest, limited food and water resources, weather and temperature extremes, intrauterine loss, and mortality from disease, natural predation, and accidents. Controlling the beaver population levels through annual harvest will minimize loss from most other sources.

Beaver population densities are usually expressed as the number of individuals per linear unit in well-defined watercourses or per area unit where wetlands are spread widely. The number of individuals in a population is estimated from colony counts. However, Baker and Hill (2003) warned that unless estimates of the average colony size are based on local data and not from general literature, calculated population sizes are meaningless. The practice of multiplying the number of colonies by a general, average number of individuals per colony to derive a population estimate adds false precision to the estimate.

Estimates of beaver colony size are difficult to obtain, but are important when setting harvest quotas (Novak 1987). In Pennsylvania, Brenner (1962) counted beavers in three active lodges using a night spotting scope. He later partially dismantled the same lodges and counted the beavers as they exited. Both methods produced the same colony count. In the Rocky Mountains, Hay (1958) drained beaver ponds and used smoke to drive beavers from their lodges in order to count them. Trappers were used by Payne (1982) to completely trap out beaver colonies to determine average colony size. Novak (1977) developed a formula using age and reproductive data from trapped beavers to calculate a mean family size. Swenson et al. (1983) modified the equation by adding estimates of fecundity for each age class of beavers. Estimating mean colony size from age and reproductive data of harvested beavers may be the most feasible method available.

Pennsylvania used a model to stabilize a beaver colony and found the removal rate may have been inaccurate. An average harvest of 1.5 beavers per active colony of 6 beavers may not have been achieved statewide to annually stabilize colony size, since population estimates increased throughout the 14-year monitoring period. The 25% harvest rate used was less than that recommended by most researchers. Harvest rates necessary to stabilize beaver populations depend on habitat conditions. In excellent Ontario habitat, Novak (1977) recommended a 43% harvest rate. Other investigators reported 20-25% in Newfoundland (Payne 1984), 32% in Ohio (Henry and Bookhout 1969), and 25-70% in the U.S. rocky mountain region (Yeager and Rutherford 1957). However, Novak (1987) suggested using a 30% harvest rate to stabilize beaver populations regardless of habitat type in Ontario. An annual harvest rate of 2 beavers per active colony of 6 (33%) might have more effectively stabilized colony size.

Trapping effort is largely dependent upon the strength of the fur market (pelt prices). Many other factors likely influence harvest success such as weather, season length, and trapper experience. Sufficient, but not excessive, annual harvest is essential for successful beaver management. Pelt prices must be high enough to maintain interest among beaver trappers. As long as beaver pelt prices remain relatively constant and at reasonable levels, we can effectively use trapping as a beaver management tool.

SECTION 7: MANAGEMENT CONSIDERATIONS

Based on current knowledge of beaver life history and management, specific needs or strategies required to fulfill objectives, goals, and ultimately beaver management needs can be identified. New Hampshire's overall beaver management mission, has been, and is to maintain stable beaver populations in balance with wetland habitat for the benefit of wetland wildlife species and human users through proper population monitoring, harvest management, and damage control. The goals of New Hampshire's beaver management are to (1) maintain sustained beaver populations within suitable habitat, (2) monitor the beaver harvest, (3) minimize beaver damage complaints, (4) continue public awareness and knowledge of the benefits of beavers and their habitat, and (5) provide opportunities to use and experience beavers. Objectives identify the necessary steps to achieve each of the five goals. Strategies consisting of actions help us to attain each objective.

Population status and trend monitoring

Annual beaver population monitoring is necessary to maintain numbers at levels in balance with their habitat and at levels accepted by the public. General beaver population status information should continue to be obtained from annual Wildlife Control Operator (WCO) and mandatory trapper harvest reports. In addition, beaver densities should be monitored within each Furbearer Management Region to determine population stability. Beaver monitoring methods currently used in New Hampshire focuses on indices to produce population trends.

Beaver relocation

Trapping and transferring beavers has been used to create new populations or augment small populations during the early 1900s. Although beaver relocations have occurred in New Hampshire and continue to be allowed by Wildlife Control Operators, the success of this practice has never been evaluated. Research in other states has shown relocated beavers are known to travel great distances from the release site (Hibbard 1958). Hibbard (1958) recorded a 238 km (148 mi) dispersal movement in North Dakota after trap and transfer. However, average dispersal distances were 6.4-14.6 km (4-9 mi) among beavers released in streams (Hibbard 1958, Knudsen and Hale 1965, Berghofer 1961). In potholes and ponds Knudsen and Hale (1965) observed average movements of only 3.2 km (2 mi). This finding led researchers to recommend that nuisance beavers be moved to ponds and lakes without outlets.

Dispersal distances and survival of relocated beavers depends upon habitat suitability, timing of release, sex, age, number released, family composition, predation, and disease (Baker and Hill 2003). Despite questionability of survival, it is recognized a small number of New Hampshire landowners have expressed interest in releasing beavers onto their property. Administrative rules permit relocations of beavers deemed a nuisance.

Beaver populations on Department owned lands

The ecological and environmental benefits of beavers and the habitat they create are desirable on all New Hampshire Fish and Game lands. Where possible, we should continue to manage beaver populations on public lands for maximum wildlife benefit while recognizing potential impacts, and allowing mitigation thereof, to abutting private property.

As part of the Department's state game land planning process, we should integrate beaver habitat needs into our plans when feasible. Beaver colony establishment and long term food supply can be augmented through habitat planning. Integrating beaver forage management into the state game lands planning process will not only benefit area beaver populations, but also a host of other wildlife species.

Beaver harvest monitoring

Before beaver trapping regulatory changes can be proposed, the Department needs to evaluate beaver harvest and capture per unit effort derived from Annual Trapper Reports and Wildlife Control Operator Reports.

Damage management

The Department should attempt to minimize beaver damage complaints through proper beaver population management and landowner educational efforts. Complaints should be addressed promptly. Relocation or elimination of problem beavers may be necessary, but cultural methods should be considered by landowners first. If landowners can wait until the legal beaver season starts, many trappers would likely welcome the opportunity to remove problem beaver. Landowner-Trapper cooperation and communication is critical to developing the best solution for the beaver damage circumstances. Landowners have the option to hire a WCO in situations where they are unable to wait for the open trapping season. The WCO furbearer report should be conducted annually to continue to monitor the frequency of beaver damage complaints. The Department should also continue public outreach with respect to dealing with beaver damage complaints.

Outreach and consumptive use

In order to increase public awareness of the benefits of beavers and their habitat, the Department should continue cooperation with University of New Hampshire Cooperative Extension in advising landowners how to manage beaver colonies on private land to promote the environmental benefits of beavers and their habitat. A current publication could continue as a brochure. Development of a Wildlife Journal article describing how to manage beaver populations for maximum longevity and beaver habitat for maximum wildlife use may be beneficial to the endeavor. Regulated beaver trapping is important not only for protecting private property and assuring public safety, but also for protecting and prolonging wetland habitat. The Department should permit regulated trapping of beaver, on an annual basis, under a sustained harvest supported by science-based data. Trapping should continue as it provides many benefits to society as well as to beaver populations themselves.

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