Article 44

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The Return of the Beaver

They're back. Beavers were extirpated from many watersheds by the early 1900s due to heavy trapping pressures and habitat disturbance. Beaver populations, however, have soared in the past two decades in response to less trapping, fewer predators, and reintroduction efforts by state wildlife agencies.

Population statistics illuminate this remarkable recovery. By the early 1900s, the North American beaver population had dwindled to about 100,000. Since then, it has recovered to an estimated level of six to 20 million individuals. The recovery may not be fully complete. Some wildlife biologists estimate that some 60 to 400 million beavers were present in North America prior to the advent of the fur trade (Naiman *et al*., 1986). During the recovery, beavers have expanded their range and returned to many watersheds where they had long been absent. Indeed, some wildlife biologists believe that due to relocation programs, the beaver currently has a greater range than before Europeans arrived on the continent (Clements, 1991).

This adaptable mammal can now be found across most of North America, and is a common sight in many urbanizing watersheds (Figure 1). It is no longer unusual to see beavers or their dams in such unlikely places as downtown Washington, D.C., suburban Detroit, or a new subdivision in Portland. Indeed, increased efforts to protect stream valleys, parks, creek buffers, greenways, wetlands, floodplains, riparian forests and other natural areas in urban watersheds also help to reserve prime beaver habitat.

While the return of the beaver is welcome, it has many implications for the urban watershed manager. First, the beaver is considered a "keystone species" because it fundamentally influences the ecology of headwater streams and adjacent riparian areas. In natural areas, for example, researchers have found that beavers can directly alter up to 40% of the small streams and rivers in the landscape, and an impressive 15% of the forest cover (Hammerson, 1994; D'Eon *et al.*, 1995). Their activities increase the retention of sediment and organic matter. The network of dams and pools created by beavers also has a profound impact on the water quality and ecology of streams.

As a consequence, urban watershed managers are now faced with a series of questions about beavers after an absence of many generations. How will beavers alter the narrow belts of urban riparian forest? Will they play a positive or negative role in fishery habitat? In what manner will they change the water quality of urban streams?

On a more pragmatic level, the engineering works of the beaver often conflict with the plans of humans. Complaints about blocked culverts, flooding, inundation, and tree damage have sharply increased as beaver and human habitat overlap. What techniques can be applied to minimize beaver problems? Can a beaver problem ever be truly eliminated? Lastly, is it possible to reconcile the concerns of angry landowners, wildlife lovers and animal rights activists in an effective management plan?

In this article, we explore the implications of the return of the beaver, beginning with a review of its fascinating natural history and its impact on headwater streams. A range of management techniques for countering beaver problems are then assessed. In most cases, these techniques have had limited effectiveness, i.e., they can reduce beaver damages but seldom can

Table 2: Beaver Biology and Life History (Olson *et al.*, 1994)

Mating Behavior	Pair for Life
Size at Maturity	40-60 lbs
Territory	Approximately 1/2 square mile. Territorial marking with scent glands.
Living Arrangements	Family colonies
Dispersal	Leave to establish new territory within 5-10 miles at around age 2
Food Sources	Bark of trees and shrubs as well as softer vegetation
Litters	2-4 young per litter
Distribution	Not found in Arctic, arid Southwest, Florida, nor Atlantic Coastline

reduce beaver populations. As a result, watershed managers may need to educate residents on how to co-exist with this adaptive mammal.

The Natural History of Beaver

The size of beavers makes them quite noticeable in an urban setting where large wildlife is often absent. In fact, beavers are the largest rodents in North America and can weigh as much as 60 pounds. The beaver's broad flat tail is used for both underwater maneuvering and to slap water to warn others of oncoming danger.

Like many rodents, beavers are quite fecund, reproducing at an average of three to four kits per litter. Kits are born in late spring (see Table 1). At two years of age, juvenile beaver leave the parental lodge just before the birth of a new litter, often migrating as far as five to 10 miles away. In some cases, tagged beavers have been recorded roaming as far as 100 miles to establish new territory.

The migration of the juvenile beavers is usually dictated by the availability of food and territory and this dispersal is also known to be the leading cause of beaver mortality. New territories are established from May to July which coincides with the increased number of reported beaver problems.

Beavers chew trees for food and to provide themselves with the building materials for dams and lodges. Strictly vegetarian, the beaver diet consists of the bark from aspens, willows, alders, poplars, and birch trees, as well as softer aquatic vegetation such as sedges and grasses. Beavers must continually gnaw on trees, not only for food and building materials, but also to wear down their two huge front teeth.

Dam building is an instinctual reaction of beavers to the sight or sound of running water and provides the beavers a stable body of water, deep enough that it will not freeze to the bottom in winter (D'Eon *et al.*, 1995). Beaver dams also provide a handy conduit to transport downed trees.

The resulting pond from beaver dams also provides an effective refuge from predators. In larger streams and rivers where water fluctuations are not as drastic, beavers generally do not build dams.

Beaver Influence on Stream and Riparian Ecology

The impact of a beaver pond on stream ecology is most strongly felt on second to fifth order streams, as shown in Table 2. Excellent reviews can be found in Hammerson (1994) and Olson and Hubert (1994), although it should be noted that nearly all the research has been drawn from rural and wilderness settings.

In general, a beaver pond tends to shift a stream from a running water ecosystem to more of a shallow lake environment. Locally, the beaver ponds trap sediments and organic matter, and increase algal productivity. Beaver ponds help retain and store small floods, but the dams can washout during extreme floods and thereby increase downstream flood damage. The dams often raise the local water table, and create a greater connection with the floodplain. Beaver activity breaks the forest canopy, but the ponding water often kills other trees whose roots cannot tolerate inundation. These conditions, in turn, favor the growth of riparian tree species such as alders and willows, which are a preferred food source for the beaver. The patches, edges and dead standing trees can result in three-fold increase in songbird species (Medin and Cleary, 1990) and can dramatically enhance amphibian and mammal habitat as well (Olson and Hubert, 1994).

Figure 1: Distribution Map Showing Beaver Range in North America (Rue, 1981)

Beaver dams function very much like a stormwater pond, and exert a similar influence on downstream water quality. For example, Maret (1987) found that beaver pond complexes in Wyoming stream sharply reduced total suspended solid concentrations, and reduced phosphorus and nitrogen by 20 to 50%. Beaver ponds are usually an effective buffer, and tend to increase the pH of water. At the same time, beaver ponds increase downstream water temperature which can adversely affect trout populations at lower elevations and lati-

Table 2: Local or Downstream Changes Caused by Beaver Dams (Hammerson, 1994)

1. Storage of precipitation, gradual release during dry weather
2. Reduced current velocity
3. Increase in wetted surface area of channel by several orders of magnitude
4. Increased water depth
5. Higher elevation of the local water table
6. Decrease in amount of forest canopy
7. Loss of habitat for species that depend on live deciduous trees
8. Enhanced or degraded fish habitat and fisheries
9. Creation of habitat for species that prefer ponds, edges, and dead trees
10. Shift of aquatic insect taxa within pond to collectors and predators, and away from shredders and scrapers
11. Increase in aquatic insect emergence, per unit length of "stream"
12. Increase in algal productivity
13. Increased trapping of sediment and decreased turbidity
14. Favorable conditions for willow and alder
15. Increased movement of carbon, nitrogen, and other nutrients into stream
16. Reduced stream acidity (i.e., higher pH)
17. Lower oxygen levels in the spring and early summer due to decomposition
18. Increased resistance to ecosystem perturbation

tudes. In addition, decomposition and microbial action occurring within the beaver pond typically lowers the dissolved oxygen content downstream. The aquatic insect community often becomes less diverse both within and below beaver ponds, with running-water species being replaced by pond taxa (Smith *et al.*, 1991).

The effects of dams are not temporary. Even though the construction looks a little shoddy in comparison to a stormwater pond, a typical dam and lodge complex is maintained for about 10 years before it is typically abandoned (Hammerson, 1994). The beaver dams slow the flow of water, minimizing soil erosion and scouring. In some cases beaver dams help restore drought areas by raising the water table and creating lush meadows (Stuebner, 1994).

Beaver Problems

Beaver damage is not trivial. D'Eon *et al.* (1995) has estimated that beaver damage in North America exceeds 100 million dollars every year.

Beavers are fairly impressive loggers. It has been estimated that a single family of beavers can consume the equivalent of about an acre of dense trees each year (D'Eon *et al.*, 1995). This rate of consumption can have a major impact on any suburban stream buffer, landscape, park or open space. The impact is particularly acute in suburban areas since most forest areas consist of relatively small forest fragments.

Tree damage was only one of two frequently reported beaver problems from homeowners. A frustrated homeowner cited that the backyard of her residential area had become a wetland, attracting mosquitoes to the area. Beavers are also suspected of transmitting *Giardia*, a parasite that can be transplanted to humans by drinking water infested with it. One report even indicated a case of an attacking beaver in Fairfax County, Virginia. The beaver was accused of allegedly snapping at a woman's ankles and lurching at dogs.

But by far and away, the greatest damage associated with beavers is the ponding behind the dam, flooding when the dam is breached, or blockage of culverts. The 500 respondents in the North American beaver survey reported road flooding as the primary type of damage caused by beavers. Culvert blockage, damage to standing timber, and flooding of land were also rated highly by respondents (Table 3).

Table 3: Types & Percentages of Beaver Problems Reported (D'Eon *et al.*, 1995)

Type of Damage	% of Repondents
Road Flooding/Damage	71%
Culvert Blockage/Damage	82%
Damage to Standing Timber	48%
Flooding of Land	57%

Like a stormwater engineer looking for an ideal retrofit site, beavers love road culverts. With relatively little work, the beaver can plug up the culvert, and quickly back water up to form a pond. The culvert can no longer convey runoff from large storm events, in-

Table 4: Beaver Management - Methods and Success Rates (D'Eon *et al*. 1995)

	Always Successful	Sometimes Successful	Never Successful
Removal of Beavers by:			
Trapping	34%	65%	1%
Shooting	18%	78%	4%
Live-Trapping/Relocating	10%	62%	28%
Dam Destruction by:			
Explosives	22%	71%	7%
Manually	12%	69%	19%
Control Water Levels by:			
Barriers/Grills	5%	79%	16%
Syphons/Pipes	6%	82%	12%
Prevention by:			
Bridges vs. Culverts	12%	76%	12%
Oversized Culverts	4%	77%	19%
Road Design	6%	75%	18%

creasing the probability that the road will be flooded or the earthwork washed out.

Management Options

Wildlife biologists have employed kill-traps, live-traps, poison, guns, sterilization, electric fences, dynamite, drain pipes, fences and other contraptions to eliminate or discourage beavers. None of these methods, however, has proven to be completely effective, although some are clearly better than others. The North American Survey conducted by D'Eon *et al*. (1995) asked 500 beaver experts about their experience with these management techniques, and a condensed summary of the results are provided in Table 4. Some of the more effective methods are profiled below:

Kill-Trapping

The rules and regulations vary and consultation with your state wildlife agency is advisable before trapping. In some areas, licensed trappers are allowed to harvest if a nuisance becomes apparent and the problem is documented. Another advantage to trapping is that it is probably the cheapest management option. Many trappers are willing to do it for free if the price of pelts is high.

In addition, trapping was reported as the most frequently used method (94% of respondents) that had the highest effectiveness. Nearly all (99%) of respondents in a survey indicated it was sometimes or always effective (D'Eon *et al*., 1995). One should keep in mind that since juvenile beavers disperse each year to find prime sites, it is likely that a problem area will be recolonized frequently. Experts recommend that trapping be systematically done on an annual basis.

One additional issue to consider is that for every resident that wants to get rid of a beaver, there are many others that enjoy their presence or are ethically opposed to trapping. Thus, it is often difficult to obtain consensus to support a trapping program in many suburban communities.

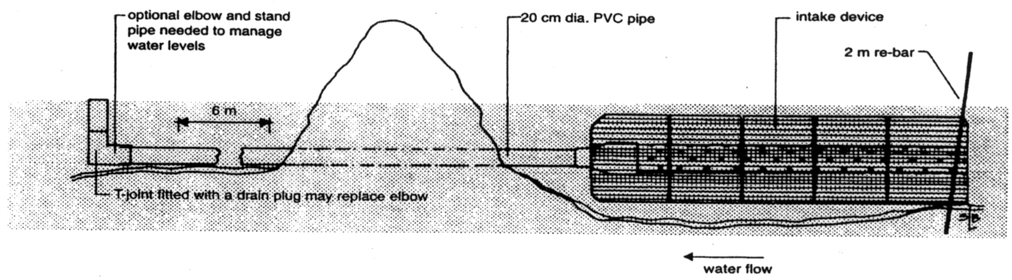
Live-Trapping

While live-trapping and subsequent relocation of nuisance beavers is a more humane approach, this option is plagued with problems. One of its major flaws is that this approach requires considerable effort and cost. Additionally, beaver densities in many parts of the nation are already high. With acceptable habitats becoming saturated, few state wildlife agencies are willing to allow relocation.

As was the case with regular trapping, live-trapping must be performed repeatedly to solve the problem due to recolonization. A survey of the effectiveness of live-trapping found only 41% of beaver managers use the option, and only 10% rate it as "always successful" (D'Eon *et al*., 1995).

Tree Protection

Individual trees can be effectively protected by placing a three-foot collar of hardware cloth or heavy wire mesh loosely around the base of the tree. A drawback of fencing is that it cannot prevent trees from



The Clemson Beaver Pond Levelers frustrate beavers by continually lowering the water level behind the dam. A key feature is the protective mesh near the intake that prevents beavers from plugging intakes.

Figure 2: Clemson Beaver Pond Leveler (D'Eon *et al.*, 1995)

dying due to rising water levels. Hammerson (1994) and D'Eon *et al*. (1995) report that deer repellents may also work in some conditions, but the odor may be objectionable for some landowners. This is probably the most effective strategy for the suburban homeowner that seeks to protect a landscaping investment, but is often too costly and impractical to do on a larger scale.

Water Level Control

The majority of beaver problems are created by rising water levels caused by the dam or plugging of a road culvert. The simple and cool approach of dynamiting the dam into smithereens seldom works, unless all beavers are trapped or removed. Beavers are quite industrious, and can repair the breach in a matter of days or weeks. The survey indicated only a modest success rate when dams were destroyed. Dynamite was found to be more effective than manual removal of beaver dams (Table 4).

An alternative approach is to drain the pond by installing a pipe under the dam (or through a clogged culvert). This approach is simple and can work fairly well if the intake is well protected. Otherwise, beavers will try to plug it up with mud and wood to restore water levels, so protective measures are essential. One reported incident involved an industrious beaver that outsmarted an engineer by plugging up every half- inch hole in a perforated pipe.

D'Eon *et al.* (1995) reviews a handful of pipe schemes to control water levels and the one of the most effective appears to be the Clemson Beaver Pond Leveler (see Figure 2). The idea behind the pond leveler is to keep the rise in water table at a minimum by using pipes to continually drain the pond. This simple mechanism requires the installation of 20 cm diameter PVC pipe through a dam with an attached multi-hole intake device guarded by fencing. This method requires little maintenance and is widely used. A step-by-step construction of another kind is listed in Table 5.

Table 5: Pond Leveler Assembly Instructions (Hammerson, 1994)

Step 1	Assemble perforated and unperforated PVC pipe, caps, steel fence posts.
Step 2	Inspect pond and dam to find the deepest and closest invert to the downstream channel for breachpoint.
Step 3	Breach the dam with two foot wide slot at breachpoint with fork.
Step 4	Extend perforated pipe into pond, connect to perforated pipe within the slot, connect to underwater flexible pipe within stream.
Step 5	Level PVC pipe to achieve positive drainage, secure to fence posts driven into pond and stream bottom.
Step 6	Allow beavers to repair the slot.
Step 7	Monthly inspection to clear any obstructions.

The Clemson pond leveler was tested at 50 beaver ponds in the southeastern United States and was never plugged by beavers. It is easy to fabricate and install, and costs less than $400 per unit. It can be used for culvert protection as well. (The only down side may be frustrated beavers!).

Other Management Methods

Sterilization is a long-term management method and a more humane option. However, one should keep in mind that sterilization doesn't keep the beavers from chewing trees or creating water level problems. Sterilization can also be costly since most experiments have been done on individual beavers.

Although it may be too late in some cases, it is often wise to consider preventative planning measures. *The Beaver Handbook* also provides survey information on such practices. For example, almost 90% of respondents who built bridges rather than culverts reported high success levels. Again, cost may be a factor in selecting between options. Site selection, road design and larger culverts were also fairly effective, with success rates varying from 81 to 86%.

Conclusion

It looks like the beavers are here to stay. A realistic beaver management program should account for at least some beaver activity since you really can't keep the rodents from breeding. Consequently, population control is a necessity in all management programs. Harvesting and sterilization are two ways to control beaver populations. Tree protection and water level control devices should be employed along with population control methods.

Watershed management requirements should determine the appropriate choice between methods. Cost may also be an important factor. For example, fencing trees may be good for areas with a few trees, but this method would be too costly to utilize in a thick forest. Choosing the management option best suited to the beaver problem is essential for an effective program. As an example, the water control devices won't do any good if your beaver problem is tree loss.

Urban watershed managers should always consult state resource agencies on wildlife management laws. Most states have strict hunting regulations governing trapping and beaver dam demolition laws. Resources like *The Beaver Handbook* are also valuable sources of management guidance.

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