Boomer or Bust: Managing a Pacific Northwest Pest Species

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ABSTRACT: Mountain beaver are a primitive rodent species endemic to the Pacific Northwest and California. In Oregon and Washington, mountain beaver are managed as a pest species due to the damage they inflict to Douglas-fir seedlings as well as 10- to 15-year-old trees. Available biological information on the mountain beaver is limited, thus hampering the ability of managers to develop new tools and techniques to reduce damage. We conducted a series of studies to increase our knowledge of mountain beaver biology and the influence of environmental attributes and stand management practices on demographics. Although mountain beaver damage Douglas-fir and western red cedar seedlings, observations suggest that these tree species are not preferred forage. In one pen study, pens void of preferred vegetation (i.e., salal and sword fern) had significantly more damage than pens with additional forage. Damage did not occur when animals were allowed access to pens with preferred forage, even with increased population pressure. In addition to pen trials, we radio-collared 62 mountain beaver in 3 different harvest units, which varied in vegetation management and stand age, to assess movements and seedling damage. Home ranges were larger on the chemically prepared site with reduced forage than on the non-treated site. Although mountain beaver can inhabit older timber stands, home ranges were relatively large in such stands because of the reduced preferred forage in closed-canopy habitats (3.66 ± 1.49 ha). Once units were harvested, population size increased and home range size decreased (0.88 ± 0.27 ha). Seedling damage and reproductive success were only slightly related to available forage, which was in turn affected by site preparation. Information on home range use, habitat requirements, and the difference in carrying capacity for mountain beaver under varying site preparations, can assist managers in manipulating habitats in order to minimize colonization and reduce seedling damage. We suggest several integrated pest management strategies to minimize seedling damage by mountain beaver.

KEY WORDS: *Aplodontia rufa*, damage, forest management, home range, mountain beaver, Pacific Northwest, seedlings

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INTRODUCTION

The mountain beaver (*Aplodontia rufa*), endemic to western North America, is the only extant member of the family Aplodontidae. Although the common name suggests relationship to true beaver (Castoridae), this semi-fossorial rodent shares only the behavior of tree clipping with the stream beaver. Extending from southern British Columbia south to central California and east to the Sierra Nevada and Cascade mountains (Feldhamer *et al.* 2003), mountain beaver are typically found at lower elevations with succulent forage. In Washington and Oregon, mountain beaver are managed as a pest species due to the extensive damage inflicted on conifer seedlings and saplings. Mountain beaver are considered the single greatest cause of Douglas-fir (*Pseudotsuga menziesii*) seedling damage in western Washington (King 1958, Hooven 1977, Borrecco *et al.* 1979, Black and Lawrence 1992, Cafferata 1992).

Depending on tree size, damage by mountain beaver can cause suppression of height growth, understocked plantations, or forest regeneration delays or failures (Borrecco and Anderson 1980). The most prevalent problem is clipping of seedlings after planting (Hooven 1977, Borrecco *et al.* 1979). Stems up to 19mm can be clipped, resulting in a continual loss of trees as long as 4 years after planting (Lawrence *et al.* 1961). In addition, basal girdling of 10- to 25-year-old trees and undermining of roots in sapling stands can also occur in high-density mountain beaver areas. The only current estimate available for mountain beaver damage in the Pacific Northwest reports 121,500 ha of Douglas-fir plantations are affected (Evans 1987, Campbell and Evans 1988). Although there is available information on mountain beaver biology and management tools for minimizing damage by mountain beaver, the majority of this information is antiquated, and several areas are unaddressed. Feldhamer *et al.* (2003) noted that information on the response of mountain beaver populations to silvicultural activities, as well as a better understanding of populations in association with other habitat characteristics, can provide additional direction to management strategies to minimize damage. This paper synthesizes a series of studies conducted to assess mountain beaver populations and movements under current forest management practices, and suggests integrated pest management strategies to minimize mountain beaver damage.

IMPACT OF FOREST MANAGEMENT PRACTICES

Population Changes

Like most species, mountain beaver populations are not only influenced by available vegetation in recolonizing areas, but also by surrounding habitat for a source population, reproductive potential, and survivorship. Most of the available data on mountain beaver populations are limited to a couple of studies conducted on 8- to 20-year-old units. Populations in these regeneration sites averaged 3.4 to 4.6 mountain beaver per hectare (Lovejoy and Black 1979*b*, Neal and Borrecco 1981). Information on changes in mountain beaver populations within newly harvested units prior to planting, and the impacts of site preparation on these populations, is lacking. We conducted a series of telemetry studies to address mountain beaver populations in recent clear-cut units with different chemical site preparedness. Initial trapping was conducted to radio-collar individuals on the units to obtain home range information and population estimates. Estimates based on live trapping are biased (potentially lower), because resident animals were usually the only animals captured within their territories. When removal trapping occurs, different individuals are often captured in the same trap on subsequent days after removal of the resident. Populations were consistently lower both years on the Donovan unit (0.99 and 0.49 mountain beaver/ha), which was site prepared, and no juveniles were observed (Table 1). On the Sylvia unit, which was not site prepared, populations were larger at 2.35 and 4.81 animals/ha, and juveniles were observed in both years. Vegetation was monitored around 9 mountain beaver nests in both units, and significant variation in the amount of forbs, but not in the presence of sword fern, was observed (Arjo, Huenefeld, and Nolte, unpubl. data).

Table 1. Changes in mountain beaver populations on three harvest units in western Washington under various forest management practices.

Unit	Gender		Juvenile	Trap Type
	Male	Female		
Donovan (site prepared/); 41 acres				
Spring 2002	8	8	0	Live
Spring 2003	6	2	0	Removal
Fall 2003	3	4	-	Removal
Sylvia (not site prepared); ~20 acres				
Spring 2002	8	11	3	Live
Spring 2003	18	21	16	Removal
Fall 2003	17	8	-	Removal
Vesta; 50 acres				
Prior to harvest	7	6	-	Live
Non-sprayed				
Spring 2004	4	8	8	Live
Spring 2005	8	3	9	Removal
Sprayed				
Spring 2004	3	5	6	Live
Spring 2005	2	2	2	Removal

The authors continued the investigation of the impact of vegetation on mountain beaver populations by following a harvest unit from mature trees through harvest and planting. We documented 13 mountain beaver in the 40-year old, 20.3-ha stand prior to harvest (0.64 animals/ha). Borrecco and Anderson (1980) noted that in uncut stands, mountain beaver densities seldom exceed 4 beaver/ha. We divided the Vesta unit in half after harvest to examine the effects of site preparation on populations and home range size. Half the unit was chemically site prepared, as commonly practiced by the timber industry, and the other half was left untreated. In June 2004, 1 year after harvest, we documented 12 adults on the non-treated and 8 adults on the treated side of the unit. During the 2004 live-trapping session, we estimated that 0.6 juveniles per female occurred on the non-treated side. This estimate is potentially low, because traps were removed from 2 lactating females' core areas to prevent capture myopathy before juveniles were documented. The non-treated portion of the unit contained 0.5 juveniles per female. One of these females moved into the riparian management zone (RMZ) area (not technically in the treated unit) and biased the results slightly higher. Two years after harvest, 11 adults were captured on the non-treated side and reproduction was 1.1 juveniles per female. On the treated side, only 4 adults were captured, and reproduction averaged 0.6 juveniles per female. Site preparation removed the majority of vegetation, allowing for better visual observation by predators. The remaining adults were located in vine maple patches or slash piles, which offered good protection from predators. Populations on the Vesta site increased the year following harvest from 0.64 beaver/ha to 0.99 beaver/ha, but declined the following year to 0.74 beaver/ha (Arjo, unpubl. data). Although densities increased immediately following harvest, populations returned to pre-harvest levels 2 years after harvest.

Hacker (1992) documented mountain beaver populations in various aged stands, and she found that 1 year after trapping there was no statistical difference in densities between these units and units never trapped. In addition, she documented sex ratios skewed towards juvenile females (79%) in recently harvested units, as compared to forested units (30%). More importantly, she documented that a larger proportion (50%) of those juvenile females bred before their first year in the recently harvested unit, and no juvenile females bred in the forested units. Most literature states that mountain beaver do not reproduce until their second year (Pfeiffer 1958, Feldhamer *et al*. 2003). We have documented that in pen settings with adequate and quality forage, females are reproductively capable after 9 months of age (Arjo and Nolte, unpubl. data). Dispersing juvenile females obtain a reproductive advantage by recolonizing newly harvested units, and populations can grow exponentially when females can reproduce before age 1, compared to delaying reproduction until age 2. Larger litters were also observed in newly harvested units compared to older units, which again affected densities (Hacker 1992).

Data suggest that geographic proximity is not as important a factor as are habitat features in determining where mountain beaver recolonize (Hacker and Coblentz 1993), and availability of woody cover seems to be an important contributing factor for recolonization (Martin 1971, Neal and Borrecco 1981, Hacker and Coblentz 1993). Although mountain beaver populations are usually low in forested areas, the 5- to 15-year-old forests, termed "reprod", are favorable source habitats for mountain beaver. We have documented that reinvasion into recently harvested (or trapped) units is dependent on the availability of this reprod habitat. We used removal trapping the second year on both the Donovan and the Sylvia units to document populations and reinvasion. Four months after removal trapping, the units were trapped again (Table 1). The Sylvia unit was trapped again 7 months later because of the high population observed, and an additional 20 animals were captured.

Little reinvasion occurred in the Donovan unit compared to the Sylvia unit. The Donovan unit was surrounded mainly by older growth timber, and what little reinvasion occurred was seen on the northern end of the unit near the reprod. Sylvia, however, was surrounded on two sides by reprod and on one side by a portion of the clear-cut unit not trapped (Arjo, Huenefeld, and Nolte, unpubl. data).

Home Ranges

Literature on mountain beaver home range size is very limited. Martin (1971) documented that mountain beaver home ranges were influenced by the quality and arrangement of habitat, and they averaged 0.12 ha in a ≥8-year-old unit. Similar estimates on home ranges were documented by Neal and Borrecco (1981) on two 20-year-old seral-stage study plots (0.17 ± 0.02 ha and 0.1 ± 0.01 ha), where stand openings were important determinants of home range size and distribution. Lovejoy and Black (1979*a*) documented slightly larger home ranges (0.26 ± 0.04) on a 20-year-old unit potentially biased by trapping. Telemetry techniques have improved in the last 20 years and are less biased from trapping than are home ranges obtained. We collared and monitored 62 mountain beaver to determine home ranges and movements under various timber management practices. Although home ranges varied between units, all documented home ranges and even core use areas were larger than home ranges previously documented for mountain beaver. On the Sylvia unit where populations were dense, home ranges were small (Table 2).

Table 2. Estimated home ranges (ha), using the adaptive kernel method, for mountain beaver in western Washington on two different site-prepared harvested units.

	Males			Females		
	0	*SE*	*n*	0	*SE*	*n*
Donovan						
Total home range[a]	4.16	0.69	7	4.19	1.54	7
Total core use area	0.73	0.13	7	1.02	0.44	7
Sylvia						
Total home range	1.26	0.50	9	1.70	0.82	4
Total core use area	0.22	0.08	9	0.58	0.35	4

[a]home ranges were estimated using an adaptive kernel with the 95th percentile for home ranges and 62nd percentile for core use areas

Changes in mountain beaver home ranges, from prior to harvest through harvest and planting, have never been documented. In the Vesta unit prior to harvest, we documented large mountain beaver home ranges (3.66 ± 1.49 ha) and core use areas (0.85 ± 0.37 ha). After harvest, but prior to chemical site preparation of half of the unit, home ranges decreased to 0.88 ± 0.27 ha and core use areas to 0.16 ± 0.07 ha (Arjo, unpubl. data). Neal and Borrecco (1981) documented smaller home ranges in areas with a greater percentage of open habitat. In large openings (≥0.13 ha), mountain beaver home ranges overlapped, and vegetation consisted of grasses, forbs, and bracken fern. Sword fern (*Polystichum munitum*) is thought to be the most important food source for mountain beaver (Voth 1968). Forested areas contain plentiful sword fern, but few other forbs are available due to low light at the climax stage. After harvest, openings created in harvest units allow for establishment of early successional forbs. If sword fern were the driving factor that determined mountain beaver densities and home range size, there should be very little change to either demographic variable after harvest.

RELATIONSHIP OF ALTERNATIVE FORAGE AND TREE DAMAGE

A variety of environmental factors influence the diet selection by foraging animals. Douglas-fir does not appear to be highly preferred forage of mountain beaver, yet establishment of Douglas-fir seedlings is often difficult in areas with mountain beaver. Perhaps the most significant factor in whether a plant is harvested is the availability of alternate choices. Therefore, the more desirable the surrounding forage, the less likely tree damage to seedlings will occur. We conducted a series of pen experiments on the effects of alternative forage and competition on the clipping of tree seedlings. Three vegetation regimes were established in the habitat pens to provide variation in habitats. Outdoor pens in these trials varied in the amount of available vegetation from barren pens with no plants other than the four alder shade trees, to a more complex pen with salal (*Gaultheria shallon*), sword fern, and Oregon grape (*Berberis nervosa*), red huckleberry (*Vaccinium parvifolium*), and cat's ear (*Hypochaeris radicata*). Huckleberry and cat's ear were present in the medium regime, however, the other plants were not present. When paired mountain beaver were confined to individual pens, more damage occurred in barren pens than in the complex pens. When animals were allowed to move between the pens, and competition for forage increased, no difference was found in the amount of trees damaged. In addition, when a single pair was allowed access to all three forage regimes, no matter where the nest was located, the pair would move to the areas with preferred forage, and no difference in tree damage between the pens occurred (Arjo and Nolte, unpubl. data). Hacker (1992) documented high mountain beaver density (18.2 beaver/ha) on one site, which implies that habitat suitability, and not social factors, limits densities.

In the field, trees are planted in late winter when forbs and most forage are no longer available. Sword fern and salal may still be available, depending on site preparation. Herbicide treatments do not usually affect sword fern growth the first year, and sword fern may not be the most important food resources, but may have importance as a nesting resource (Arjo, pers. observ.). During the planting period, parturition for mountain beaver also occurs, although it does not appear that damage is related to lactating females (Arjo *et al.* 2004), as previously suggested (Voth 1968). The majority of the damage to seedlings occurs within the first 3 months after planting. After this period, other vegetation becomes available and seedling diameter is often too large for mountain beaver to clip at the base of the tree. Other factors, besides site preparation, that influence available forage can affect seedling damage. Timing of canopy closure, which results in suppression of understory vegetation, can influence damage (Neal and Borrecco 1981). Significant damage was observed in areas where no chemical site preparation occurred but where large slash piles remained. These slash piles prevented growth of vegetation, except for noxious weeds such as thistle, leaving very little mountain beaver forage other than tree seedlings. We documented that 1 female, within her core area that was entirely covered with slash, clipped 36 of the 43 trees (Arjo, unpubl. data).

MANAGEMENT TOOLS

Management strategies to reduce mountain beaver damage can fall into three categories (adapted from Borrecco 1976): 1) reduction of offending animals, either through direct control such as trapping or use of toxicants; or indirect control through habitat modification, predator management, introduction of disease, or chemosterilants; 2) decrease desirability of the crop through barrier protection (Cafferata 1992), chemical repellents (Wagner and Nolte 2001), or genetically resistant stock; and 3) provision of preferable and alternative foods. Silvicultural methods such as slash removal, site preparation (i.e., burning or herbicide), and planting larger seedling stock are used to increase the competitive advantage of the newly planted seedlings. The effects on populations and mountain beaver movements were discussed previously, and additional information on preferred mountain beaver forage is necessary. Exclusion devices such as individual tree protectors, although labor intensive, can also be effective in areas where direct population control measures are impossible to implement (Cafferata 1992). Direct control methods are the most frequent techniques employed for reducing mountain beaver populations prior to planting.

Exclusion Devices

Over 55 different barrier designs to protect tree seedlings are currently marketed. Generically known as tree protectors, protection tubes, tree guards, or tree shelters, these 55 barriers can be categorized into two groups based on wall structure: 1) tubes with open mesh walls, and 2) tubes with solid walls. Installation of tree barriers can be labor intensive, since tubes are placed on the seedlings prior to planting or with an additional crew after planting, and maintenance of the tubes is required to insure integrity. Including costs of materials, transportation, and installation of the tubed seedlings, each seedling can cost up to 40¢ (Feldhamer *et al*. 2003). Borrecco and Anderson (1980) documented a significant decrease in damage to seedlings (from 44% to 3%) with the application of tree barriers. However, even with barriers, damage to seedlings can occur. Tubes can be penetrated by mountain beaver, especially those tubes with perforations or seams that allow the mountain beaver to hold onto the plastic (Doug Runde, USDA WS NWRC, Hilo, HI, pers. commun.). Mountain beaver have also been documented to climb larger tree tubes in order to clip individual seedlings inside the tubes, as well as to undermine the tubes (Cafferata 1992).

Trapping

Trapping is the most commonly used method to reduce damage, by decreasing mountain beaver populations prior to planting. Although trapping is probably the most effective way of reducing seedling damage, trapping also has limitations. Trapping can be costly at $30-$100/ha under good conditions such as moderate slope, moderate mountain beaver populations, and a relatively slash-free site (Borrecco and Anderson 1980). A successful ballot initiative banned the use of body-gripping traps, including the conibear, in the state of Washington in 2000 and requires a 24-hour trap check, which has greatly increased costs. In addition, even after initial mountain beaver removal, trapping often has to be repeated 1-year post-planting, depending on reinvasion potential. Most trapping occurs from October through February, prior to planting, in both Oregon and Washington. Management is spread over a large block of time, due to the number of units that need to be trapped (and possibly to the limitations of the trappers– i.e., available traps and personnel). With trapping spread over such a large period of time, some units are trapped in early fall prior to dispersal and up to 5 months prior to planting. Longer periods of time between trapping and planting increase the likelihood that units can be and will be invaded and populations will become re-established. Re-trapping units 1 year after they are planted (November through April) is common. In some cases, re-trapped units can have higher populations the second year after harvest (0.88 animals/ha in Year 1 vs. 1.85/hectare in Year 2; Figure 1). Unpublished data from trapping efforts documents that an average reinvasion potential in western Washington is 1.59 mountain beaver/ha (0.66/ac).

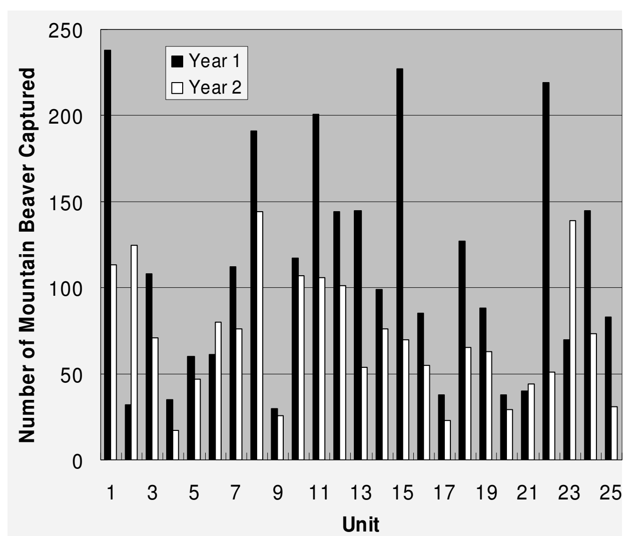

Figure 1. Mountain beaver populations in a sample of units trapped (2001-2002) and retrapped (2002-2003) in western Washington.

MANAGEMENT RECOMMENDATIONS

Black and Lawrence (1992) define animal damage as "the result of any kind of animal activity that cause economic losses by reducing or delaying forest yield". Although seedling damage can be extensive and is the most widespread form of mountain beaver damage, damaged incurred in older-aged stands can have greater economic impacts. In a 1977 survey, 44% of the respondents reported sapling damage, and of those, 23% reported damage that resulted in growth suppression or mortality (Borrecco and Anderson 1980). Considerably more time and money is invested in these older-age stands, which is why the economic loss can be far more reaching. Currently there is no one management tool that is effective in all situations to reduce damage to seedlings by mountain beaver. Although trapping is the most preferred method, it is not 100% efficacious the first year, nor is it a long-term solution. Protecting a window of time for seedlings, the first year after seedling are planted, with an integrated pest management program can offer managers a more efficacious and cost-effective strategy than those currently in use. Management techniques should be flexible and based on mountain beaver populations, terrain, and surrounding habitat. Based on research findings from several field studies, we offer a few management suggestions:

1. Trap as close to planting time in those areas with known or suspected high mountain beaver populations.
   a. Trapping after November should be more beneficial, since the majority of mountain beaver dispersal, especially for females, occurs prior to this time.
   b. Trapping during late January and early February can increase the likelihood that buffer animals are also removed from the population. Males will range further during this period for breeding opportunities.
2. Although currently cost-prohibitive for many companies, trapping a buffer zone around the units is beneficial and can slow down reinvasion.
   a. Trap at least Riparian Management Zones (RMZs) or partially into any reprod areas in close proximity to the unit.
   b. If buffer trapping is too cost-prohibitive, leaving traps in for a longer rotation along the unit edges may also pick up invading animals.
3. Remove or disassemble large slash piles, especially on the edges of units near reprod. These areas are often difficult to trap, since mountain beaver use the slash for runways, and burrow systems are few or inaccessible. In addition, leaving large slash piles from undesirable vegetation, such as vine maple, offers refugia for recolonizing mountain beaver.
4. Planters tend to avoid slash pile areas, creating natural openings in the habitat that mountain beaver favor. Increasing the openings and thus the preferred habitat can increase mountain beaver numbers, and thus increase damage. Attempt to limit natural openings by planting in these piles and in logging debris. Reduce the piles to allow greater access by planters.
5. Use barriers in areas when reinvasion potential is greatest or direct control methods were hampered.
   a. Areas with slash piles, even within the units, offer refugia for mountain beaver and are difficult to trap. These areas also offer very little forage. Protecting trees in slash areas may prevent damage, or will at least slow down damage from any remaining mountain beaver.
   b. Edges bordering on reprod need particularly close attention. These are the most vulnerable areas for mountain beaver reinvasion. Again, tree protectors may slow down or prevent damage in these vulnerable areas.
6. Although information on the effects of chemical site preparation is incomplete, there is a direct correlation of forage availability, presence of forbs (not sword fern), and home range size with tree damage. Less available forage means larger home ranges and more area covered (i.e., more trees potentially damaged) by mountain beaver. A balance between treating units to suppress grass and shrub growth, but not forbs, may offer a potential source of alternative forage for reinvading mountain beaver and therefore, decrease damage to seedlings.

No one method will work in all cases, nor may it be possible to follow some of the recommendations in every situation. Further research into the development of additional management tools to incorporate into an integrated pest management program is warranted.

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