DEBRIS PILES, SMALL MAMMAL PREY, and COVER:

CREATION of MARTEN HABITAT

on CLEARCUTS

Annual Report 2009-10
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OKANAGAN INNOVATIVE FORESTRY SOCIETY
c/o Terrafor Resources Ltd.
9304 Aberdeen Road
Coldstream, B.C.
Canada, V1B 2K5



Applied Mammal Research Institute
11010 Mitchell Avenue,
Summerland, B.C.
V0H 1Z8

Principal Investigator:

Dr. Thomas P. Sullivan
sullivan@telus.net

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1.0 EXECUTIVE SUMMARY

This annual report outlines the results of the third year of a 5-year study designed to provide habitat for marten (*Martes americana*) in newly harvested clearcuts and subsequent managed stands through time. Installation of coarse woody debris (CWD) treatments was completed and monitoring activities initiated in the 2007-08 fiscal year. A major objective of the Okanagan Innovative Forest Practices Association (IFPA) is to maintain marten in the forested landscape. Removal of the forest cover by clearcut harvesting has been viewed as a negative effect on marten in terms of loss of thermal and security cover. A major question is: Could post-harvest debris piles on cutblocks act as "middens" for marten, both initially after harvest, and as the new forest develops? Such middens may provide den sites and rest sites as well as be sources of small mammal prey.

Habitat selection by marten appears to be determined by the availability of appropriate food (small mammal prey) and access to nesting and resting sites, particularly in the winter. These attributes are essential for population maintenance. Marten are very dependent upon subnivean sheltered sites. Voles (genera *Microtus* and *Myodes*), notably red-backed voles (*M. gapperi*), are primary food items of marten. Resting sites and den sites are associated with large snags, live trees, and downed hollow logs, underground access (especially in winter), and in human-made slash piles. CWD plays a large role in providing resting sites. While controversy exists over the importance of CWD to small mammals, many studies suggest CWD provides important microhabitat for foraging and cover attributes for these species. Provision of debris piles and windrows on clearcuts, and subsequently in young forests, may provide habitat for small mammal prey and marten.

The overall objective is to manage the habitat and prey base (small mammals) of marten in managed forest stands to meet the intent statements in the Okanagan Shuswap LRMP (Section 7.1.ii): The focus of the program will be to evaluate various timber harvesting, regeneration, stand tending, and other forest management activities. Long-term objectives include: 1) Assess configurations of CWD in debris piles, windrows, and dispersed patterns across harvested sites for the small mammal prey base and use by marten; and 2) Assess debris piles adjacent to OGMAs vs. pine stands, where this pattern occurs in the experimental design.

The project is installed at three study areas: 1) the Aberdeen Plateau (Tolko Industries Ltd.), 2) China Valley (Federated Cooperatives Ltd.), and 3) Upper Trout Creek, Summerland (Gorman Bros. Lumber Ltd.). These areas had ongoing harvesting of MPB-salvage stands and associated site preparation activities in 2006 and 2007. Each of these three areas constitutes a regional replicate, with three site replicates in each area, for a total of 9 site replicates. The experimental design is a randomized complete block with 3 replicates each of: (a) CWD dispersed uniformly over each unit (control); (b) CWD distributed into several small piles (2-3 piles per ha); (c) CWD distributed into windrows, connecting to a forest edge or riparian area; and (d) uncut old-growth/mature forest.

The dispersed treatments were reasonably similar in mean total volume (range of 135 to 212 m^3/ha), as would be expected after clearcut harvesting and dispersion of debris over the area of each cutblock. Similarly, the forest treatments ranged from 125 to 180 m^3/ha of mean total volume of dispersed CWD. The mean total volume of piles increased from China Valley (673 m^3) to Aberdeen (1458 m^3) to a large increase at Trout Creek (5536 m^3). The mean volume of debris in windrows also followed this pattern. Understory vegetation was generally similar among treatments in terms of crown volume index of herbs and shrubs, with mean total species diversity of vascular plants being higher in the CWD treatments than forest.

Mean total abundance of small mammals per ha was similar among treatments at Aberdeen and China Valley, but significantly different at Trout Creek. The piles and windrows had higher overall abundance than the dispersed CWD and forest treatments in all three years. Mean abundance of red-backed voles was higher in the piles, windrows, and forest treatments than dispersed CWD treatment at Trout Creek in all years as well, and this pattern was somewhat evident at Aberdeen as well. Populations of deer mice (*Peromyscus maniculatus*) either showed no difference among treatments, or were at higher numbers in the forest and windrows in 2007 at Aberdeen, but showed no differences in subsequent years. Mean abundance of northwestern chipmunks (*Tamias amoenus*) was similar among treatments at Aberdeen, but significantly different among treatments at China Valley and Trout Creek. The long-tailed vole (*Microtus longicaudus*) was common at Trout Creek, but not at the other two study areas in either year. This vole was at significantly higher numbers in the piles and windrows than the other two treatments in 2007, with a similar pattern in 2008 and 2009. This observation may have particular relevance to seedling feeding damage since this vole routinely feeds on newly planted trees.

Results of snow tracking showed of variety of mammalian species observed at or near the CWD treatments. In December 2009, marten tracks were recorded in the uncut forest sites at all three study areas, as well as at piles at China Valley and in the dispersed treatment at Trout Creek. Weasel tracks were common and most frequent at the debris pile and windrow sites at each area in all years. Coyote, wolf, fox, and bobcat tracks were observed in this second year's survey at the three study areas. Snowshoe hare, deer, moose, and red squirrel were the major herbivores to visit the CWD treatments. Snow-track transects in early-, mid-, and late winter in subsequent years will determine the relative habitat use patterns, over successional time, of marten and other mammalian species in the study.

The principal investigator for this project is Dr. Thomas P. Sullivan with research associates include Pontus M.F. Lindgren, M.Sc., Douglas B. Ransome, Ph.D., and Druscilla S. Sullivan, M.Sc.

2.0 BACKGROUND and RATIONALE

2.1 Introduction

A major objective of the Okanagan Innovative Forest Practices Association (IFPA) is to maintain marten (*Martes americana*) in the forested landscape. Removal of the forest cover by clearcut harvesting has been viewed as a negative effect on marten in terms of loss of thermal and security cover (Hargis et al. 1999; Snyder and Bissonette 1987). Within forest stands, marten appear to use cone middens of red squirrels as den sites and rest sites because of their thermal properties (Buskirk et al. 1988), and potentially as congregation sites for small mammal prey (Buskirk 1984; Buskirk and Ruggiero 1994), although this premise is controversial (Pearson and Ruggiero 2001). A major question is: Could post-harvest debris piles on cutblocks act as "middens" for marten, both initially after harvest, and as the new forest develops? Such "middens" would provide cover and potentially a source of small mammal prey.

The above practical interest is bolstered by the well-known status of the marten as an indicator species for biodiversity in forest management deliberations in many areas (Koehler et al. 1975, Thompson 1991, Thompson and Harestad 1994, Watt et al. 1996, Adamowicz and Condon 1997, Beaudette 2000, Proulx and Banci 2000), and by research priorities expressed by BC wildlife and habitat managers (Stordeur 1986, Blood 1988, Hatler 2002). Although it is generally understood that landscape features are potentially important in broad-scale consideration of marten habitat (Bissonette et al. 1989, Eastman et al. 1991, Buskirk and Ruggiero 1994, Chapin et al. 1998, Hargis et al. 1999, Proulx 2001), the specification of "managed forest" in this project indicates a focus on practices at the stand level. The overall concept is to rely less on reserves and more on providing habitat attributes and conditions that may hasten and increase marten use of second growth forests (Lofroth and Steventon 1990, Buskirk 1992, Sturtevant et al. 1996, Lieffers and Woodard 1997).

A detailed literature review (Hatler et al. 2004) demonstrated an increasing interest and research focus on marten/habitat relationships since the early 1980s, particularly as related to forestry, providing some important new perspectives on marten/forestry relationships. However, that research has not provided a very clear and practical path for habitat managers to follow. Specifically, researchers have not yet been able to make clear distinctions between what may be considered ideal and what is demonstrably required to meet particular objectives, and have not bothered to find out what practices (in local social, economic, and administrative environments) are actually possible. Qualification and management of habitat and prey base (small mammals) in managed forest stands will meet the intent statements in the Okanagan Shuswap LRMP Section 7.1.ii; the focus of the program will be to evaluate various timber harvesting, regeneration, stand tending, and other forest management activities.

To this end, two important principles guiding habitat management for marten are:

1) Identifying, monitoring, and ultimately providing for marten foraging opportunities is an important focus for this project.
2) The area of practice with the apparently greatest current potential to provide for marten habitat needs at the stand level is in the management of coarse woody debris (CWD).

Abundance and diversity of forest floor small mammal communities serve as ecological indicators of significant change in forest structure and function. The necessity for habitat complexity, including levels of CWD, must be emphasized as a requirement for conservation of the diversity inherent in forests (Carey and Harrington 2001). Measurements of small mammal population parameters can be used as bioindicators of effective forest management. Selecting bioindicator species that are particularly associated with mature forest types, such as the deer mouse and red-backed vole, helps determine the effect of landscape changes resulting from forest management practices (Pearce and Venier 2005). Studies of the spatial and temporal effects of forest practices on indicator populations are required to determine the sustainability of these practices (Pearce and Venier 2005).

Forest floor small mammals are widespread across temperate forest ecosystems and have a variety of functions, including prey for many predators (Martin 1994; Carey and Johnson 1995), distribution of beneficial mycorrhizal fungi (Maser et al., 1978; Ure and Maser, 1982), and consumers of plants and plant products (Buckner 1966; Sullivan et al., 1990). The southern red-backed vole (*Myodes gapperi*), in particular, is an important indicator species of "old forest conditions" (Raphael, 1988; Nordyke and Buskirk, 1991). This microtine commonly inhabits late successional coniferous and deciduous forests across temperate North America (Merritt 1981), and hence is a good candidate species for evaluation of the development of "old forest" structural attributes in young stands.

Arboreal small mammals also fulfill an important ecological role. Northern flying squirrels (*Glaucomys sabrinus*) consume primarily the fruiting bodies of ectomycorrhizal fungi (Fogel and Trappe 1978; Maser et al., 1978; Waters and Zabel, 1995). Red squirrels (*Tamiasciurus hudsonicus*) consume these fruiting bodies as well but are less dependent upon them than *G. sabrinus* (Smith 1981; Currah et al. 2000). Ectomycorrhizal fungi have developed a mutualistic symbiotic relationship essential to growth and health of all species in the economically important Pinaceae family (*Abies*, *Larix*, *Picea*, *Pinus*, *Pseudotsuga*, and *Tsuga*; Maser et al., 1978; Maser and Maser, 1988; Molina et al., 1999). These sciurids play an important role in dispersing spores of ectomycorrhizal fungi when they defecate. This process forms new mycorrhizal colonies enhancing growth and health of trees (Maser et al. 1986; Cazares et al. 1999). This dispersal is especially important for young tree growth in early seral stages (Molina et al., 1999).

In addition, the snowshoe hare (*Lepus americanus*) is considered a keystone species in the boreal and temperate forests of North America (Hodges 2000; Boutin et al. 2003). This leporid has a 9- to 11-year fluctuation in abundance (Keith 1963) and

represents the main prey for many of the vertebrate predators in northern forests, such as Canada lynx (*Lynx canadensis)*, coyotes (*Canis latrans*), and great horned owls (*Bubo virginianus*). Loss of snowshoe hares from northern forest ecosystems would likely lead to elimination of these predators (Boutin et al. 2003). Thus, it is not surprising that small mammals are considered major "indicator species" of sustainable forest management in boreal and temperate ecological zones (Carey and Harrington 2001; Sullivan et al. 2001; Pearce and Venier 2005).

While controversy exists over the importance of coarse woody debris (CWD) to small mammals (Tevis 1956; Barry et al. 1990; Gyug 1994; Mills 1995; Moses and Boutin 2001) many studies suggest CWD provides important microhabitat for foraging and cover attributes for these species. However, no studies have systematically manipulated CWD levels into "debris piles" and "windrows" as a means of providing habitat for small mammals and a variety of terrestrial carnivores, including marten. In the 1990s, there was some interest in the use of post-harvest debris piles to act as potential: 1) cover and resting sites, and 2) source of small mammal prey. Some preliminary work in the Okanagan (Gyug 1994) was done on this subject and suggested that debris piles were used by various wildlife species, but no experimental design and monitoring was conducted. In general, as discussed by Hatler et al. (2004), there has been a dearth of follow-up monitoring of habitat management projects and studies. We need a sound experimental design with sufficient replicates (ideally n=3) to provide a comprehensive database for small mammal prey and marten responses to treatments.

2.2 CWD and Marten

Canopy cover is a significant habitat requirement for marten (Koehler et al. 1975; Soutiere 1979; Taylor and Abrey 1982; Hargis and McDullough 1984; Wynne and Sherburne 1984; Bateman 1986; Baker 1992; Lofroth and Steventon 1990; Lofroth 1993; Potvin 1998; Huggard 1999; Bull and Blumton 1999; Fuller and Harrison 2000; Harrison et al. 2000; Potvin et al. 2000; Proulx 2001; Smith and Schaefer 2002; Bowman and Robitaille 2005; Bull et al. 2005) along with CWD (Koehler et al. 1975; Buskirk et al. 1989; Lofroth and Steventon 1990; Eastman et al. 1991; Martin and Barrett 1991; Baker 1992; Bissonette and Sherburne 1993; Lofroth 1993; Thompson and Curran 1995; Paragi et al. 1996; Watt et al. 1996; Chapin et al 1997; Huggard 1999; Bull and Heater 2000; Payer and Harrison 2000; Proulx 2001; Bowman and Robitaille 2005; Bull et al. 2005). Paragi et al. (1996) found marten of the Alaskan taiga at highest density where there was little canopy cover but high abundance of CWD and abundant meadow voles (genus *Arvicola*) in the autumn. Canopy closure of <30% was acceptable to marten where there was high spruce budworm mortality associated with abundant young stems and plenty of CWD (Chapin et al. 1997). Bull and Heater (2000) suggest CWD, along with trees with brooms, are required for viable marten populations. They determined that 7% of resting sites are in hollow logs or slash piles and 6% of post-natal sites are in slash piles.

CWD is important for providing marten with resting and den sites (Beavais and Buskirk 1984; Wynne and Sherburne 1984; Stordeur 1986; Buskirk et al. 1988; Buskirk

et al 1989; Taylor and Buskirk 1994; Chapin et al. 1997; Jones et al. 1997; Raphael and Jones 1997; Ruggiero et al. 1998; Bull and Heater 2000; Adair et al. 2000; Wilbert et al. 2000; Bull 2002) particularly at lower temperatures after recent heavy snow (Wilbert et al. 2000). Once snow cover is complete, Spencer (1987) found all resting sites were subnivean. Openings in the snow caused by small live spruce and fir become more important as snow depth increases (Corn and Raphael 1992). Marten are known to use the openings in the snow created by the logs that make up the CWD. Fuel reduction via scattering of logs does not produce subnivean access so would not enhance marten populations (Bull and Blumton 1999) as would CWD piles (Grindal et al. 2000; Bull 2002). The greater the amount of cover, volume, log layers, and less decayed logs and root masses in the CWD the more likely marten will use the piles (Corn and Raphael 1992). Raphael and Jones (1997) found marten would use slash piles if other resting and den sites were scarce but these were used less in the winter. Gyug (1994) suggested that windrows may be more effective than debris piles in creating small mammal and therefore marten habitat. On the other hand, Lisgo et al. (2002) found that female short-tailed weasels used piles of logging residue on 3-year-old aspen cutblocks more than expected. These authors concluded that abundance of red-backed voles as a food source in these piles explained their attractiveness to weasels. Keith and Cary (1991) found that 81% of weasel population fluctuation was determined by *Microtus, Myodes, and Peromyscus* populations.

The subnivean spaces also provide access to prey items (Stordeur 1986; Sherburne and Bissonett 1994; Thompson and Curran 1995; Suter and Schielly 1998; Bull 2002). In non-snow conditions, the general ground level structure provided by CWD is lacking in second growth forests (40-60 years old) and may contribute to reduced marten prey populations (Thompson and Curran 1995). Bissonette and Sherburne (1993) believe support of prey species is the major contribution by CWD to marten populations.

Fisher habitat requirements, including mature forest and appropriate den sites, appear similar to those of marten (Bull et al. 2001).

2.3 CWD and Small Mammal Prey

Many studies suggest CWD provides important microhabitat for foraging and cover attributes for these species (Gunderson 1959; Miller and Getz 1977; Thomas 1979; Maser et al. 1979; Schlegl-Bechtold 1980; West et al. 1980; Maser and Trappe 1984; Pruitt 1984; Bartels et al 1985; Getz 1985; Harmon et al. 1986; Doyle 1987; Hayes and Cross 1987; Graves et al. 1988; Poole and Graf 1996; Tallmon and Mills 1994; Carey and Johnson 1995; McMillan and Kaufman 1995; Freedman et al 1996; Suter and Schielly 1998; Bunnell et al. 1999; Loeb 1999; Steel et al. 1999; Wilson and Carey 2000; Mengak and Guynn 2003) as well as general travel and escape routes for many small mammals (Barry and Francq 1980). CWD helps retain moisture on drier sites (Carey and Johnson 1995) and may mitigate micro-habitat changes resulting from clearcutting.

At the stand level, Bowman et al. (2000) found no relationship between the abundance of small mammals and decay class or number of logs. Species diversity of small mammals was found to be similar (Loeb 1999) on unsalvaged vs salvaged areas and was highest in forest stands with < 33% blowdown vs stands with up to 66% blowdown (Pauli et al. 2006). However, abundance of small mammals was highest on the unsalvaged plots (Loeb 1999) and varied according to species at the various levels of blowdown (Pauli et al. 2006).

A thorough study by Craig (2002) identified the complexities of variables involved in relating CWD and small mammal abundance. Vegetation cover, ecosystem, climate, seral stage, amount of disturbance, scale of investigation, and species under investigation are all factors which may ameliorate or exaggerate the effects of CWD on a site (Craig 2002).

2.4 Feeding Damage to Seedlings

The problem of feeding damage to forest plantations herbivorous small mammals has a long history in temperate and boreal ecosystems of North America. Voles of the genera *Microtus* and *Myodes* are considered the major mammalian species affecting coniferous and deciduous tree plantations (Sartz 1970; Radvanyi 1980; Bergeron and Jodoin 1989; Sullivan et al 1990). Populations of some species of voles tend to have cyclic fluctuations in abundance in northern latitudes (Krebs and Myers 1974; Taitt and Krebs 1985). It is primarily during overwinter periods when high populations of these microtines feed on plantation trees. Voles feed on bark, vascular tissues (phloem and cambium), and sometimes roots of trees. Direct mortality may result from girdling and clipping of tree stems.

Abundance of *Microtus* populations and degree of damage is usually highest in early successional habitats that develop after forest harvesting by clearcutting (Hansson 1989; 1991; Sullivan and Sullivan 2001; Sullivan et al. 2001) and in old fields (perennial grasslands) undergoing deforestation (Bergeron and Jodoin 1989; Ostfeld and Canham 1993; Ostfeld et al. 1997). Grasses, herbs, and shrubs in these habitats provide food and cover for voles (Batzli 1985; Ostfeld 1985). In terms of conservation and sustainability of temperate forests, feeding damage may limit regeneration of appropriate tree species in certain forest ecosystems, become costly to reforest these stands in time for Free Growing Status, decrease net productive forested area, and result in loss of Mean Annual Increment.

Microtus occur frequently on forested areas harvested by clearcutting, up to almost 10 years after logging, and are positively associated with high amounts of CWD. Conversely, the red-backed vole appears to decline in abundance within 1 or 2 years after clearcut logging in western North America. Clearcutting of forests yields relatively homogeneous early-successional habitats. Alternative harvesting practices such as group seed-tree and patch-cutting systems produce heterogeneous habitat patterns compared with clearcutting, and may favour red-backed voles. As discussed in section 2.3, both *Microtus* and the red-backed vole may be positively associated with high

amounts of CWD. Thus, this aspect of plantation establishment, and potential feeding damage to seedlings from voles, needs to be addressed in the project.

3.0 OBJECTIVES

3.1 Overall Objective

The overall objective is to manage the habitat and prey base (small mammals) of marten in managed forest stands to meet the intent statements in the Okanagan Shuswap LRMP (Section 7.1.ii): The focus of the program will be to evaluate various timber harvesting, regeneration, stand tending, and other forest management activities.

3.2 Long-term Objectives

1) Assess configurations of CWD in debris piles, windrows, and dispersed patterns across harvested sites for the small mammal prey base and use by marten and other mammalian species.

2) Assess debris piles adjacent to OGMAs vs. pine stands, where this pattern occurs in the experimental design.

4.0 PROJECT AREAS and DESIGN

4.1 Project Areas

The project is located at three areas: Upper Trout Creek (Gorman Bros. Lumber Ltd.) in the Bald Range (mapsheet 82E 071) 25 km west of Summerland, B.C. in the upper Interior Douglas fir (IDF_{dk}) and Montane Spruce (MS_{dm}) biogeoclimatic zones. The China Valley area (Federated Coop) is in the Fly Hills Resource Management Zone (mapsheet 82L 073), 25 km west of Salmon Arm in the upper Interior Douglas fir (IDF_{dk}) and Montane Spruce (MS_{dm}) subzones, and lower Interior Cedar Hemlock (ICH_{dk}) subzone. The third project area (Tolko Industries Ltd.) is on the Aberdeen Plateau (mapsheet 82L 015), 22 km southeast of Vernon, B.C. in the upper IDF_{dk} and MS_{dm} subzones.

The Upper Trout study area (Appendix 1) is located in mixed Douglas fir *Pseudotsuga menziesii* - lodgepole pine *Pinus contorta* mature and old-growth forests in the Bald Range, 25 km west of Summerland in south-central British Columbia ($49^0$40'N; $119^0$53'W). Clearcut harvesting of lodgepole pine, with dispersed (uniform) and aggregated (group) seed-tree reserves of Douglas fir, began in this area in the mid-1970s in response to an outbreak of MPB. Topography ranges from hilly to rolling hills at 1300 to 1520 m elevation. The upper IDF and the MS have a cool, continental climate with cold winters and moderately short, warm summers. The average temperature is below 0^0C for 2-5 months, and above 10^0C for 2-5 months, with mean annual precipitation ranging from 30 to 90 cm. Open to closed mature forests of Douglas fir cover much of the IDF zone, with even-aged post-fire lodgepole pine stands

at higher elevations. The MS landscape has extensive, young and maturing seral stages of lodgepole pine, which have regenerated after wildfire. Hybrid interior spruce *Picea glauca* x *P. engelmannii* and subalpine fir *Abies lasiocarpa* are the dominant shade-tolerant climax trees. Douglas fir is an important seral species in zonal ecosystems and is a climax species on warm south-facing slopes in the driest ecosystems. Trembling aspen *Populus tremuloides* is a common seral species and black cottonwood *Populus trichocarpa* occurs on some moist sites (Meidinger and Pojar 1991).

The China Valley and Aberdeen Plateau (50 8' N; 119 12'W) project areas (Appendix 1) are located in similar forest types as Upper Trout with the addition of the Interior Cedar Hemlock (ICH_{dk}) subzone at China Valley.

4.2 Experimental Design

The experimental design is a randomized complete block with 3 replicates each of:

(a) CWD dispersed uniformly over each unit (control)
(b) CWD distributed into several small piles (average of 2-3 piles per ha)
(c) CWD distributed into windrows, connecting to a forest edge or riparian area, and (d) uncut old-growth/mature forest (units J, K, and L).

Replicate block	Study area	Year started	Treatment – Debris Piles (CWD) Control dispersed	Piles 2/ha	Windrows ≥ 100 m
(1) *n*=3	Trout Creek	2006	(A)	(B)	(C)
(2) *n*=3	China Valley	2006	(D)	(E)	(F)
(3) *n*=3	Aberdeen Plateau	2006-07	(G)	(H)	(I)

	Trout Creek (2006) *n*=3		China Valley (2006) *n*=3		Aberdeen Plateau (2006-07) *n*=3	
CP-unit	204-2	24.2 ha	990-3	69.3 ha	381-A20	39.8 ha
	204-7	14.0	990-6	59.7	380-A9	41.6
	203-5	32.1	108-6	51.2	392-LL1001	40.1

4.3 Installation of Treatments

All timber harvesting was targeted at lodgepole pine salvage after or impending MPB attack at all three project areas. Harvesting system was clearcut with reserves of Douglas fir and some spruce as variable retention units. The CWD treatments were

installed in October 2006 at the Trout Creek area where debris piles and windrows were created during processing of cut timber, followed by some specific site preparation work with a caterpillar tractor. Costs for these treatments were borne by the Okanagan Innovative Forest Practices Association (IFPA) as incremental silviculture expenses through Gorman's. Debris piles and windrows averaged 2-3 m in height and 5-8 m in diameter or width.

At China Valley, CP 990-3 and 990-6 were harvested in 2005, whereas CP 108-6 was harvested in autumn 2006. Debris piles and windrows were installed at these sites using an excavator and backhoe, as site preparation treatments, during September and October 2006. Costs were again covered by IFPA through Federated Coop. Debris piles and windrows were smaller at China Valley averaging 1-2 m height and 2-3 m in diameter for debris piles with similar heights and widths for windrows.

At Aberdeen Plateau, the three CP 394 units were harvested in January-February 2007 with installation of treatments in March 2007. Completion of site preparation work was done in August 2007. However, our sampling regime commenced in June 2007, with accommodation of the site preparation work, and hence was concurrent with the other two project areas. Size of debris piles and windrows was similar to the China Valley project area.

5.0 METHODS

5.1 Measurement of CWD in Dispersed, Debris Piles, and Windrows

In the dispersed treatments, downed wood volumes were measured using the line-intersect method of Van Wagner (1968):

$$\text{Volume } (V) = \pi^2 \times \sum d^2 / 8 \times L$$

where: d = diameter of each piece encountered
L = Length of transect

On the assumption that the debris piles can be represented by a spherical dome, their volume was determined using the formula:

$$V = 1/3\ \pi h^2(3R_c - h) = 1/6\ \pi h(3r^2 + h^2)$$

where: d = the diameter at the base of the dome
r = is the radius of the base

R_c = is the Radius of Curvature. $= \dfrac{(r^2 + h^2)}{2h}$

h = height from the ground level to the top of the dome

On the assumption that the windrows can be represented by an elliptical segments, their volume was determined using the formula:

$V = \pi r h l/2$

where: r = is the radius of the base
h = height from the ground level to the top of the windrow segment
l = is the length of the windrow segment

5.2 Understory Vegetation

Understory vegetation was sampled on three 25-m transects, each consisting of five 5-m x 5-m plots, in each of the 9 treatment units at a project area. Each plot contained three sizes of nested subplots: a 5-m x 5-m subplot for sampling trees, a 3-m x 3-m subplot for sampling shrubs; and a 1-m x 1-m subplot for sampling herbaceous species, mosses and lichens. These layers were subdivided into height classes: 0-0.25, 0.25-0.50, 0.50-1.0, 1.0-2.0, 2.0-3.0, and 3.0-5.0 m. A visual estimate of percentage cover of the ground was made for each species height class combination within the appropriate nested subplot. Total percentage cover for each layer was also estimated for each subplot. These data were then used to calculate crown volume index (m^3/0.01 ha) for each plant species (Stickney 1980). The product of percent cover and representative height gives the volume of a cylindroid which represents the space occupied by the plant in the community. Crown volume index values were then averaged by species for each plot size and converted to 0.01-ha base to produce a tabular value given for each species and layer. Sampling was done in July-August 2007 at China Valley and Trout Creek, and at all three study areas in July-August 2008 and 2009. Plant species were identified in accordance with (Parish et al. 1996). Species richness, species diversity and structural diversity were also calculated for these data.

5.3 Small Mammal Prey Populations

Forest floor small mammals were sampled at 4-week intervals from May to October 2007, 2008, and 2009. Each treatment stand had a trapping grid (1 ha) with 49 (7 x 7) trap stations at 14.3-m intervals with one Longworth live-trap at each station. Traps were supplied with whole oats, and cotton as bedding. Traps were set on the afternoon of day 1, checked on the morning and afternoon of day 2 and morning of day 3, and then locked open between trapping periods. Forest floor small mammal species sampled by this procedure included the southern red-backed vole, meadow vole (*Microtus pennsylvanicus*), long-tailed vole (*M. longicaudus*), heather vole (*Phenacomys intermedius*), deer mouse (*Peromyscus maniculatus*), northwestern chipmunk (*Tamias amoenus*), montane shrew (*Sorex monticolus*), masked shrew, and short-tailed weasel (*Mustela erminea*) (Sullivan et al. 2000, 2001; Sullivan and Sullivan 2001).

Abundance estimates were derived from the Jolly-Seber (J-S) stochastic model (Seber 1982). Reliability of Jolly-Seber estimates declines when few tagged animals are captured (Krebs et al. 1986). Therefore, minimum number of animals known to be

alive (MNA) (Krebs 1966) was also be calculated as a precautionary measure and to indicate lower limits of the Jolly-Seber estimates. MNA estimates were used for first and last trap sessions. All statistical tests were based on Jolly-Seber estimates for the reasons indicated by (Jolly and Dickson 1983). Standards are per:

Resources Inventory Committee Publications
Standards for Components of British Columbia's Biodiversity No. 31
Inventory Methods for Small Mammals: Shrews, Voles, Mice & Rats (Version 2.0)

3.7.1 Recommended Method: Mark Recapture
3.7.2 Objectives of Surveys
3.7.3 Open vs. closed populations
3.7.4 Models of estimation and methods of analysis
3.7.5 Recommended Models
3.7.6 Office Procedures
3.7.7 Sampling Design
3.7.8 Sampling Effort
3.7.9 Equipment
3.7.10 Field Procedures

Data will be housed with NRIN in the format of Inventory Methods for Small Mammals (Version 2.0).

5.4 Monitoring of Marten and Other Mammalian Species

The two primary variations of snow-track surveys are track counts and track trailing. Track counts are generally the more quantitative, with the premise being that the importance and/or attractiveness of particular habitats or features can be inferred by the relative frequency of animal occurrence at or near them. For most of the marten track count studies (Bowman and Robitaille 1997, Gyug 1988, Thompson et al. 1989), animal track crossings are counted along pre-determined transects and data are standardized by dividing the number tallied by the product of transect distance x elapsed time since last snowfall (usually expressed as tracks/km-day, although the time unit varies from half-days (12 hour periods) to a week in the studies cited. Track trailing, on the other hand, simply involves locating tracks of a study species individual, following (and/or backtracking) it's trail, and recording its movements and behaviour in relation to particular habitat features (Corn and Raphael 1992, Gyug 1994, Huggard 1999, Therrien 2000, Ozoga and Harper 1966).

Snow-tracking was conducted within the four treatment stands (CWD evenly distributed, piled, windrowed, and uncut forest) replicated three times at each of the three study areas (4 treatments x 3 reps x 3 study areas = 36 experimental units) following the provincial standards for snow-tracking outlined within the Resources Information Standards Committee (RISC) manual titled Inventory Methods for Marten and Weasels (British Columbia Ministry of Environment, Lands and Park, 1998). While this manual is specific for marten and other weasels, the snow tracking methodology is

very similar to that used for other animals, including medium sized carnivores (British Columbia Ministry of Environment, Lands and Park, 1999) and ungulates (D'Eon et al., 2006). Therefore, the snow-tracking methodology outlined below was used to document all animal activity (including red squirrel, snowshoe hare, coyote, red fox, lynx, ungulates, marten, etc.) and is best described as a biodiversity sample rather than one that focuses on mustelids only.

Snow-tracking was conducted along systematically located and permanently marked, straight line transects that provide good coverage of each individual experimental unit (see Appendix 2 for the location of all transects in the three study areas). Timing of samples depends on snow conditions. Ideally, sampling should take place three days after a fresh snowfall. All 12 experimental units at a given study area were sampled within the same week. However, different weather conditions experienced at our three widely separated study areas resulted in different timing of samples among the three study areas. All animal tracks were identified continuously along a given transect length. In addition, approximate distance to habitat features such as CWD piles, windrows, and forest edges were noted for any furbearer observations. Time since the last snowfall was accounted for by dividing the number of tracks by the number of 12 or 24 hour periods since the last snowfall. Results are reported as number of tracks per km (per 12 or 24 hour period) for each of the study areas for each of the 2007-08 and 2008-09 winters. These data can be used to compare relative habitat use among our four treatment sites at a given study area each year.

Standards are per:

Resources Inventory Committee Publications
Standards for Components of British Columbia's Biodiversity No. 24
Inventory Methods for Marten and Weasels (Version 2.0)
Section 3.4.2 Snow tracking

Resources Inventory Committee Publications
Standards for Components of British Columbia's Biodiversity No. 25
Inventory Methods for Medium-sized Territorial Carnivores, Coyote, Red Fox, Lynx, Bobcat, Wolverine, Fisher & Badger (Version 1.0)
Section 3.5.1 Snow tracking

Resources Inventory Committee Publications
Standards for Components of British Columbia's Biodiversity No. 33a
Ground-based Inventory Methods for Ungulate Snow-track Surveys (Version 1.0)
Section 1.0 Snow tracking

5.5 Statistical Analysis

For these first years (2007-2009) of sampling, a one-way randomized block analysis of variance (ANOVA; Model III) (Zar 1999) was used to determine the effect of debris pile treatments on abundance of the major small prey species and mean crown

volume index of herbs and shrubs, and species richness and diversity of vascular plants. In subsequent years, a repeated measures analysis of variance (RM-ANOVA) will be used to determine the effect of treatments on the incidence of marten, short-tailed and long-tailed weasels, coyote, lynx, red squirrel, snowshoe hare, and other mammalian species. This same analysis will be used to evaluate the effect of these treatments on mean total abundance, species richness, and species diversity of small mammal prey species, as well as mean abundance of red-backed vole, *Microtus*, and other rodent species populations. This RM-ANOVA will also be used to determine effects of treatments on mean crown volume index of herbs, shrubs, and trees, mean total species richness, total species diversity, and total structural diversity of the herb, shrub, and tree layers. Duncan's multiple range test (DMRT) was, and will be, used to compare means among treatments. Differences are considered significant if $P \leq 0.05$ for all comparisons.

6.0 RESULTS

6.1 Coarse Woody Debris Treatments

Mean total volumes of coarse woody debris in the dispersed, pile, windrow, and forest treatments are listed in Table 1. The dispersed treatments were reasonably similar in mean total volume (range of 135 to 212 m^3/ha), as would be expected after clearcut harvesting and dispersion of debris over the area of each cutblock. Similarly, the forest treatments ranged from 125 to 180 m^3/ha of mean total volume of dispersed CWD. The mean total volume of piles increased from China Valley (673 m^3) to Aberdeen (1458 m^3) to a large increase at Trout Creek (5536 m^3) (Table 1). Mean total volume of windrows was somewhat similar at China Valley (1084 m^3) and Aberdeen (1488 m^3). The mean total volume of windrows (6742 m^3) at Trout Creek was much larger (4.5 to 6.2 times) than the other two study areas (Table 1).

6.2 Understory Vegetation

In 2007 at China Valley, mean volume, species richness, and species diversity of herbs was similar among treatments (Table 2). Mean volume and species richness of shrubs also followed this pattern. However, mean species diversity of shrubs was significantly ($F_{3,6}$=6.25; P=0.03) different among treatments. A similar pattern occurred for mean total species diversity of herbs, shrubs, and trees ($F_{3,6}$=9.07; P=0.01), with no difference in mean total species richness (Table 2).

In 2007 at Trout Creek, mean species diversity of herbs ($F_{3,6}$=6.69; P=0.02) and mean species richness of shrubs ($F_{3,6}$=8.47; P=0.01) were significantly different among treatments (Table 2). Mean total species richness ($F_{3,6}$=11.89; P<0.01) and species ($F_{3,6}$=9.60; P=0.01) of vascular plants were significantly different among treatments, with the dispersed CWD and forest treatments having higher (DMRT; P=0.05) richness than the piles and windrows. For total species diversity, the three CWD treatments were higher (DMRT; P=0.05) than the forest, and this pattern occurred at China Valley as well (Table 2).

In 2008 at Aberdeen and China Valley, species richness of vascular plants was variable among treatments with higher (P<0.05) richness in the forest than other treatments at Aberdeen, and the converse true at China Valley (Table 3). This latter pattern was evident for shrub species richness at the Trout Creek study area in 2008 (Table 3).

In 2009, these same patterns were prevalent, except at China Valley where there was variable responses in vegetation attributes, and at Trout Creek that had consistently similar responses among treatments (Table 4).

6.3 Small Mammal Prey Populations

In terms of individual species, mean abundance of red-backed voles was significantly higher in the piles, windrows, and forest treatments than dispersed CWD treatment at Trout Creek in 2007 ($F_{3,6}$=12.59; P<0.01) and 2008 ($F_{3,6}$=18.19; P<0.01) (Fig. 1). In 2009, mean abundance of this closed-canopy specialist was highest in the windrows than other treatments (Table 7). Red-backed voles at Aberdeen also tended to follow this pattern (Tables 5-7; Fig. 1). The converse was true at China Valley, possibly owing to the smaller debris load treatments and one year older successional stage.

Mean total abundance of small mammals per ha was similar among treatments at Aberdeen and China Valley, but significantly (P<0.01) different at Trout Creek in all years. The piles and windrows had higher (DMRT; P=0.05) overall abundance than the dispersed CWD and forest treatments at Trout Creek (Tables 5-7; Fig. 2).

The long-tailed vole was common at Trout Creek, but not at the other two study areas (Fig. 3). This microtine was at significantly ($F_{3,6}$=7.68; P=0.02) higher numbers in the piles and windrows than the other two treatments in 2007, tended to follow this trend in 2008, and significant again in 2009 (Tables 5-7). This observation may have particular relevance to seedling feeding damage since this vole routinely feeds on newly planted trees.

Populations of deer mice either showed no difference among treatments, or were at higher ($F_{3,6}$=8.62; P=0.01) numbers in the forest and windrows at Aberdeen in 2007, but not 2008 nor 2009 (Fig. 4). Mean abundance of northwestern chipmunks was similar among treatments at Aberdeen, but significantly different among treatments at China Valley in 2007 ($F_{3,6}$=5.28; P=0.04) and 2008 ($F_{3,6}$=11.16; P<0.01), but not in 2009 (Fig. 5). This same pattern also occurred at Trout Creek in the first two years, but not in 2009 (Fig. 5). More chipmunks (DMRT; P=0.05) generally appeared in the CWD treatments than forest at these two study areas (Tables 5-7).

6.4 Monitoring of Marten and Other Mammalian Species

Permanent snow-track transects were installed at all study areas in January 2008 and these are illustrated in Appendix 2. Totals of 5.145 km, 6.800 km, and 9.075 km

were established at the Aberdeen, China Valley, and Trout Creek study areas, for a grand total of 21.02 km of transects.

Results, to date, showed a variety of mammalian species observed at or near the CWD treatments in 2008 and 2009 (Tables 8 to 12). In 2009, marten tracks were recorded in the uncut forest sites at all three study areas, as well as at piles at China Valley and in the dispersed treatment at Trout Creek. Weasel tracks were common and most frequent at the debris pile and windrow sites at each area in all years. Weasel tracks were common and most frequent at the debris pile and windrow sites at each area. In addition, coyote, wolf, fox, and bobcat tracks were observed in this second year's survey at the three study areas. Snowshoe hare, deer, moose, and red squirrel were the major herbivores to visit the CWD treatments. Snow-track transects in early-, mid-, and late winter in subsequent years will determine the relative habitat use patterns, over successional time, of marten and other mammalian species in the study.

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Table 1. Mean (*n*=3 replicate sites) ±SE total volume (m^3) of coarse woody debris (CWD) on the dispersed, pile, windrow, and forest treatments at each of the three study areas.

	Dispersed (m^3/ha)	Piles (m^3)	Windrows (m^3)	Forest (m^3/ha)
Aberdeen				
CWD	145.59 ± 25.24	1458.69 ± 426.56	1488.65 ± 289.72	132.85 ± 26.46
China Valley				
CWD	135.15 ± 19.67	673.20 ± 19.47	1084.32 ± 403.93	124.83 ± 17.45
Trout Creek				
CWD	212.91 ± 38.47	5536.88 ± 1999.92	6742.32 ± 1628.63	179.63 ± 42.94

Table 2. Mean (*n*=3 replicate sites) ± SE crown volume index (m^3/0.01 ha), species richness, and diversity measurements of herbs, shrubs, and total vegetation on the dispersed, pile, windrow, and forest treatments at China Valley and Trout Creek in 2007. Columns of mean values with different letters are significantly different by DMRT. *P* values in bold are significant.

					Analysis	
	Dispersed	Piles	Windrows	Forest	$F_{3,6}$	*P*
China Valley						
Herbs						
Volume (m^3/0.01 ha)	2.50 ± 1.24	5.73 ± 2.81	4.98 ± 0.67	0.54 ± 0.17	3.24	0.10
Species richness	6.78 ± 2.72	9.56 ± 1.28	9.33 ± 0.19	5.56 ± 0.97	2.11	0.20
Species diversity	1.43 ± 0.53	2.24 ± 0.06	2.04 ±0.10	1.98 ± 0.19	1.55	0.30
Shrubs						
Volume (m^3/0.01 ha)	2.13 ± 0.89	4.93 ± 1.64	5.71 ± 1.58	42.83 ± 19.61	3.50	0.09
Species richness	5.44 ± 0.62	9.11 ± 0.44	7.78 ± 0.22	6.78 ± 1.72	3.80	0.08
Species diversity	1.67 [a] ± 0.12	1.94 [a] ±0.11	2.16 [a] ± 0.07	1.03 [b] ± 0.42	6.25	**0.03**
Total						
Species richness	13.67 ± 3.20	19.78 ± 1.98	18.33 ± 0.51	17.33 ± 2.71	3.67	0.08
Species diversity	2.35[a] ± 0.35	2.87 [a] ± 0.18	2.86 [a] ± 0.25	1.62 [b] ± 0.37	9.07	**0.01**
Trout Creek						
Herbs						
Volume (m^3/0.01 ha)	1.74 ± 0.34	0.73 ± 0.37	0.56 ± 0.28	5.95 ± 2.97	2.78	0.13
Species richness	7.00 ± 0.38	3.33 ± 0.88	3.44 ± 1.25	4.89 ± 2.31	2.13	0.20
Species diversity	1.80 [a] ± 0.23	0.92 [b] ± 0.24	0.92 [b] ± 0.32	1.01 [b] ± 0.43	6.69	**0.02**
Shrubs						
Volume (m^3/0.01 ha)	0.55 ± 0.11	0.24 ± 0.06	0.18 ± 0.06	1.51 ± 0.76	2.66	0.14
Species richness	6.56 [a] ±0.80	4.00 [b] ± 0.84	4.00 [b] ± 0.67	4.56 [b] ± 0.56	8.47	**0.01**
Species diversity	2.33 ± 0.22	1.63 ± 0.33	1.83 ± 0.26	1.50 ± 0.03	3.18	0.11
Total						
Species richness	15.33 [a] ± 1.45	8.44 [b] ± 1.87	8.67 [b] ± 1.76	14.22 [a] ± 2.54	11.89	**<0.01**
Species diversity	2.78 [a] ± 0.35	2.16 [a] ± 0.09	2.35 [a] ± 0.17	1.22 [b] ± 0.20	9.60	**0.01**

Table 3. Mean (*n*=3 replicate sites) ± SE crown volume index (m^3/0.01 ha), species richness, and diversity measurements of herbs, shrubs, and total vegetation on the dispersed, pile, windrow, and forest treatments at Aberdeen, China Valley and Trout Creek in 2008. Columns of mean values with different letters are significantly different by DMRT. *P* values in bold are significant.

					Analysis	
	Dispersed	Piles	Windrows	Forest	$F_{3,6}$	*P*
Aberdeen						
Herbs						
Volume (m^3/0.01 ha)	1.00 ± 0.29	2.21 ± 1.03	3.79 ± 0.80	8.14 ± 4.55	1.45	0.32
Species richness	8.89^{b} ± 1.06	7.33^{b} ± 1.07	8.33^{b} ± 1.00	15.89^{a} ± 1.06	13.99	**<0.01**
Species diversity	2.34^{ab} ± 0.16	2.01^{b} ± 0.18	1.71^{b} ±0.16	2.85^{a} ± 0.31	4.93	**0.05**
Shrubs						
Volume (m^3/0.01 ha)	0.74 ± 0.14	0.92 ± 0.21	1.11 ± 0.34	16.95 ± 10.49	2.41	0.17
Species richness	8.00^{b} ± 0.96	7.56^{b} ± 1.31	6.56^{b} ± 0.29	10.33^{a} ± 0.88	8.46	**0.01**
Species diversity	2.56 ± 0.18	2.20 ±0.18	2.09 ± 0.16	2.01 ± 0.38	1.10	0.42
Total						
Species richness	20.78^{b} ± 1.06	17.44^{b} ± 2.86	17.56^{b} ± 0.40	31.56^{a} ± 1.98	18.63	**<0.01**
Species diversity	3.03^{a} ± 0.14	2.74^{b} ± 0.15	2.65^{b} ± 0.03	1.51^{c} ± 0.16	75.54	**<0.01**
China Valley						
Herbs						
Volume (m^3/0.01 ha)	12.88^{a} ± 7.13	22.07^{a} ± 5.89	17.39^{a} ± 1.98	1.03^{b} ± 0.18	4.83	**0.05**
Species richness	9.44^{ab} ± 2.08	13.11^{a} ± 0.89	11.78^{a} ± 0.62	5.78^{b} ± 0.97	5.50	**0.04**
Species diversity	2.01 ± 0.31	2.35 ± 0.14	2.08 ±0.05	1.86 ± 0.24	0.76	0.56
Shrubs						
Volume (m^3/0.01 ha)	9.68 ± 3.61	11.73 ± 2.61	12.97 ± 2.44	40.15 ± 12.14	4.04	0.07
Species richness	6.89 ± 0.48	10.33 ± 0.33	9.56 ± 0.62	7.00 ± 1.86	3.78	0.08
Species diversity	1.69 ± 0.15	2.20 ± 0.33	2.25 ± 0.09	1.26 ± 0.42	2.78	0.13
Total						
Species richness	21.00^{b} ± 2.85	28.56^{a} ± 1.24	27.11^{a} ± 1.28	14.78^{c} ± 1.85	14.36	**<0.01**
Species diversity	2.87^{a} ± 0.07	2.87^{a} ± 0.13	3.11^{a} ± 0.20	1.88^{b} ± 0.34	6.46	**0.03**

	Dispersed	Piles	Windrows	Forest	Analysis	
Trout Creek					$F_{3,6}$	P
Herbs						
Volume (m^3/0.01 ha)	15.70 ± 3.64	8.89 ± 2.48	4.62 ± 1.83	7.04 ± 7.02	1.77	0.25
Species richness	9.33 ± 2.22	7.44 ± 1.72	7.11 ± 1.28	2.83 ± 2.50	1.48	0.31
Species diversity	1.64 ± 0.41	1.30 ± 0.19	1.54 ± 0.16	0.55 ± 0.55	0.80	0.54
Shrubs						
Volume (m^3/0.01 ha)	2.28 ± 0.24	1.37 ± 0.26	0.93 ± 0.28	1.94 ± 0.56	3.91	0.07
Species richness	7.89^a ±1.47	7.56^a ± 0.48	6.56^a ± 1.68	3.84^b ± 0.17	4.77	**0.05**
Species diversity	2.48 ± 0.35	2.48 ± 0.21	2.35 ± 0.45	1.64 ± 0.17	3.13	0.11
Total						
Species richness	20.00 ± 3.86	17.67 ± 2.04	17.44 ± 2.70	9.67 ± 3.67	1.76	0.25
Species diversity	2.51 ± 0.52	2.39 ± 0.11	2.82 ± 0.18	1.57 ± 0.12	3.47	0.09

Table 4 . Mean (*n*=3 replicate sites) ± SE crown volume index (m^3/0.01 ha), species richness, and diversity measurements of herbs, shrubs, and total vegetation on the dispersed, pile, windrow, and forest treatments at Aberdeen, China Valley and Trout Creek in 2009. Columns of mean values with different letters are significantly different by DMRT. *P* values in bold are significant.

					Analysis	
	Dispersed	Piles	Windrows	Forest	$F_{3,6}$	*P*
Aberdeen						
Herbs						
Volume (m^3/0.01 ha)	8.02 ± 2.69	8.55 ± 3.12	11.47 ± 3.27	12.14 ± 6.79	0.20	0.89
Species richness	8.78^b ± 0.78	8.22^b ± 1.74	9.33^b ± 1.58	14.33^a ± 1.35	4.92	**0.05**
Species diversity	0.57^b ± 0.04	1.60^a ± 0.25	1.80^a ±0.24	1.91^a ± 0.47	9.74	**0.01**
Shrubs						
Volume (m^3/0.01 ha)	2.17 ± 0.36	2.71 ± 0.97	3.02 ± 0.54	19.11 ± 10.25	2.53	0.15
Species richness	9.67^a ± 0.19	8.11^a ± 0.73	6.78^b ± 0.49	10.22^a ± 0.49	25.52	**<0.01**
Species diversity	2.84 ± 0.04	2.25 ±0.05	2.31 ± 0.14	2.19 ± 0.41	1.50	0.31
Total						
Species richness	23.00^b ± 0.51	20.66^b ± 2.60	20.11^b ± 2.02	29.89^a ± 2.02	8.61	**0.01**
Species diversity	3.25^a ± 0.13	2.98^a ± 0.21	2.88^a ± 0.28	1.56^b ± 0.16	13.12	**<0.01**
China Valley						
Herbs						
Volume (m^3/0.01 ha)	13.20^a ± 5.80	16.31^a ± 1.36	16.81^a ± 1.35	1.35^b± 0.14	5.58	**0.04**
Species richness	9.78^a ± 2.44	14.22^a ± 0.73	11.00^a ± 1.07	5.33^b ± 0.96	5.60	**0.04**
Species diversity	1.66 ± 0.40	2.50 ± 0.22	2.17 ±0.15	1.79 ± 0.29	1.38	0.34
Shrubs						
Volume (m^3/0.01 ha)	15.66^b ± 4.82	19.15^b ± 6.14	20.94^b ± 2.21	42.74^a ± 3.63	5.85	**0.03**
Species richness	8.11^b ± 0.62	11.67^a ± 0.38	11.11^a ± 0.22	7.56^b ± 1.28	7.35	**0.02**
Species diversity	1.86^b ± 0.09	2.30^a ± 0.18	2.32^a ± 0.03	1.49^c ± 0.29	5.49	**0.04**
Total						
Species richness	23.22^b ± 3.26	31.22^a ± 1.47	27.78^a ± 0.49	17.78^c ± 1.12	10.93	**<0.01**
Species diversity	2.89^b ± 0.16	3.55^a ± 0.19	3.35^a ± 0.09	1.66^c ± 0.46	13.29	**<0.01**

	Dispersed	Piles	Windrows	Forest	Analysis	
Trout Creek					$F_{3,6}$	P
Herbs						
Volume (m^3/0.01 ha)	11.89 ± 3.56	8.03 ± 1.40	6.20 ± 3.87	6.46 ± 3.23	0.57	0.66
Species richness	9.56 ± 1.28	9.22 ± 1.78	9.00 ± 2.04	5.22 ± 2.41	2.09	0.20
Species diversity	1.72 ± 0.42	1.44 ± 0.09	1.61 ± 0.27	1.19 ± 0.48	0.42	0.75
Shrubs						
Volume (m^3/0.01 ha)	1.72 ± 0.17	1.37 ± 0.23	0.82 ± 0.22	2.55 ± 1.11	1.61	0.28
Species richness	8.56 ±1.55	7.56 ± 0.29	7.33 ± 0.67	5.11 ± 0.80	3.89	0.07
Species diversity	2.51^a ± 0.31	2.52^a ± 0.15	2.66^a ± 0.11	1.72^b ± 0.05	9.18	**0.01**
Total						
Species richness	22.44 ± 2.79	21.00 ± 1.68	22.00 ± 2.91	15.22 ± 3.00	3.65	0.08
Species diversity	2.76 ± 0.46	2.59 ± 0.04	2.99 ± 0.43	1.18 ± 0.24	4.45	0.06

Table 5. Mean (*n*=3 replicate sites) ±SE abundance per ha of the major small mammal prey species and totals on the dispersed, pile, windrow, and forest treatments at each of the three study areas in 2007. Columns of mean values with different letters are significantly different by DMRT. *P* values in bold are significant.

Study area + species	Dispersed	Piles	Windrows	Forest	Analysis	
					$F_{3,6}$	*P*
Aberdeen						
Red-backed voles	4.11 ± 0.91	9.79 ± 0.47	9.43 ± 1.79	8.63 ± 2.64	3.46	0.09
Deer mice	0.27[b] ± 0.07	0.53[b] ± 0.29	1.20[a] ± 0.46	1.87[a] ± 0.55	8.62	**0.01**
Chipmunks	7.65 ± 1.15	7.01 ± 1.04	8.22 ± 2.11	5.62 ± 1.31	0.67	0.60
Long-tailed voles	0.33 ± 0.24	2.27 ± 1.79	0.53 ± 0.24	0.00 ± 0.00	1.18	0.39
Total	13.49 ± 0.19	20.27 ± 2.86	20.65 ± 0.43	16.92 ± 2.60	2.28	0.18
China Valley						
Red-backed voles	2.13[b] ± 0.98	1.27[b]± 0.79	0.60[b] ± 0.60	17.91[a] ± 2.56	47.15	**<0.01**
Deer mice	5.85 ± 1.36	5.72 ± 2.53	7.44 ± 0.50	2.07 ± 1.29	1.58	0.29
Chipmunks	7.80[a] ± 3.07	8.25[a] ± 2.41	9.91[a] ± 2.35	1.73[b] ± 0.75	5.28	**0.04**
Long-tailed voles	0.27 ± 0.18	1.07 ± 0.97	1.20 ± 0.80	0.27 ± 0.27	0.47	0.71
Total	18.45 ± 2.78	20.77 ± 4.97	23.35 ± 2.96	22.64 ± 0.69	1.55	0.30
Trout Creek						
Red-backed voles	1.33[b] ± 0.58	9.23[a] ± 1.91	10.28[a] ± 2.34	9.02[a] ± 2.53	12.59	**<0.01**
Deer mice	9.02 ± 2.32	5.64 ± 1.02	6.14 ± 2.98	10.30 ± 2.98	2.23	0.19
Chipmunks	5.38 ± 0.31	9.99 ± 1.27	6.48 ± 0.34	2.46 ± 1.13	9.72	**0.01**
Long-tailed voles	1.72[b] ± 0.74	11.92[a] ± 4.16	9.37[a] ± 2.10	0.00[b] ± 0.00	7.68	**0.02**
Total	19.33[b] ± 1.65	35.96[a]± 2.24	32.28[a] ± 1.21	21.94[b] ± 3.48	12.68	**<0.01**

Table 6. Mean (*n*=3 replicate sites) ±SE abundance per ha of the major small mammal prey species and totals on the dispersed, pile, windrow, and forest treatments at each of the three study areas in 2008. Columns of mean values with different letters are significantly different by DMRT. *P* values in bold are significant.

Study area + species	Dispersed	Piles	Windrows	Forest	Analysis	
					$F_{3,6}$	*P*
Aberdeen						
Red-backed voles	4.91 ± 2.44	6.67 ± 1.83	8.93 ± 2.30	12.11 ± 6.52	0.69	0.59
Deer mice	0.89 ± 0.11	0.66 ± 0.33	1.22 ± 0.67	0.78 ± 0.11	0.47	0.71
Chipmunks	3.22 ± 0.55	4.00 ± 0.84	6.86 ± 1.07	1.93 ± 0.93	4.41	0.06
Long-tailed voles	0.33 ± 0.33	0.55 ± 0.40	2.11 ± 0.87	0.22 ± 0.22	3.05	0.11
Total	11.02 ± 2.38	14.00 ± 3.75	22.02 ± 3.06	16.26 ± 8.02	0.96	0.47
China Valley						
Red-backed voles	0.22^{b} ± 0.22	0.44^{b} ± 0.44	0.11^{b} ± 0.11	12.79^{a} ± 3.29	15.82	**<0.01**
Deer mice	8.96 ± 1.26	6.44 ± 2.21	8.16 ± 1.86	1.22 ± 0.91	3.66	0.08
Chipmunks	8.82^{a} ± 1.46	8.28^{a} ± 1.72	11.07^{a} ± 1.00	2.11^{b} ± 0.87	11.16	**<0.01**
Long-tailed voles	0.11 ± 0.11	0.11 ± 0.11	0.22 ± 0.22	0.00 ± 0.00	0.40	0.76
Total	20.67 ± 2.89	19.50 ± 4.57	22.33 ± 0.68	16.23 ± 2.07	1.38	0.34
Trout Creek						
Red-backed voles	0.84^{b}± 0.33	8.86^{a} ± 3.58	16.29^{a} ± 2.83	7.01^{a} ± 1.30	18.19	**<0.01**
Deer mice	7.54 ± 0.48	4.82 ± 1.58	6.00 ± 0.93	4.63 ± 1.33	1.91	0.23
Chipmunks	8.16^{a} ± 1.24	15.23^{a} ± 0.93	10.11^{a} ± 1.42	1.56^{b} ± 0.11	25.50	**<0.01**
Long-tailed voles	1.17 ± 0.38	8.88 ± 1.62	6.30 ± 2.24	0.00 ± 0.00	2.22	0.19
Total	21.36^{b} ± 2.28	39.62^{a} ± 2.82	36.91^{a} ± 2.80	14.66^{b} ± 0.55	27.11	**<0.01**

Table 7. Mean (*n*=3 replicate sites) ±SE abundance per ha of the major small mammal prey species and totals on the dispersed, pile, windrow, and forest treatments at each of the three study areas in 2009. Columns of mean values with different letters are significantly different by DMRT. *P* values in bold are significant.

Study area + species	Dispersed	Piles	Windrows	Forest	Analysis	
					$F_{3,6}$	*P*
Aberdeen						
Red-backed voles	0.67 ± 0.51	2.22 ± 0.59	3.22 ± 1.06	11.52 ± 4.62	3.42	0.09
Deer mice	1.44 ± 0.87	2.44 ± 0.68	1.45 ± 0.62	0.78 ± 0.22	1.68	0.27
Chipmunks	10.81[a] ± 0.68	11.72[a] ± 1.51	12.04[a] ± 1.39	3.22[b] ± 1.18	9.58	**0.01**
Long-tailed voles	0.66[b] ± 0.33	1.11[b] ± 0.22	2.33[a] ± 0.51	0.00[b] ± 0.00	8.47	**0.01**
Total	13.92 ± 1.57	17.61 ± 1.82	19.27 ± 1.63	15.74 ± 4.21	0.64	0.62
China Valley						
Red-backed voles	0.00[b] ± 0.00	0.11[b] ± 0.11	0.00[b] ± 0.00	11.90[a] ± 1.74	45.39	**<0.01**
Deer mice	12.61 ± 3.15	9.30 ± 0.35	14.12 ± 4.05	2.33 ± 1.57	3.63	0.08
Chipmunks	12.08 ± 3.68	11.37 ± 2.55	11.71± 1.26	3.45 ± 1.47	2.78	0.13
Long-tailed voles	0.78 ± 0.29	0.22 ± 0.22	0.33 ± 0.19	0.00 ± 0.00	2.19	0.19
Total	26.69 ± 5.98	22.46 ± 3.42	27.06 ± 2.94	17.79 ± 2.74	1.27	0.37
Trout Creek						
Red-backed voles	1.05[c] ± 0.68	4.09[b] ± 0.70	9.89[a] ± 2.70	3.97[b] ± 1.16	13.96	**<0.01**
Deer mice	8.33 ± 2.01	8.47 ± 1.81	5.60 ± 0.30	5.62 ± 0.75	1.35	0.34
Chipmunks	10.75 ± 1.43	13.22 ± 5.23	14.95 ± 1.03	2.77 ± 0.98	3.25	0.10
Long-tailed voles	0.33[b] ± 0.19	5.12[a] ± 1.68	4.78[a] ± 1.38	0.00[b] ± 0.00	8.78	**0.01**
Total	20.58[b] ± 0.74	34.73[a] ± 2.32	35.55[a] ± 1.14	12.42 [c]± 1.73	44.00	**<0.01**

Table 8. Mean (*n*=3 replicate sites) number of tracks per km of transect per 12 hours, mid-January to early February 2008 sample period, in the four CWD treatments of dispersed, piles, windrows, and forest at each of the three study areas.

Study area and treatment													
Aberdeen	Squirrel	Flying squ	Hare	Deer	Moose	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.00	0.00	0.00	0.03	0.09	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Piles	0.00	0.00	0.00	0.00	0.11	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Windrows	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00
Windrow, row only	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Windrow - open areas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00
Uncut	2.00	0.00	0.30	3.20	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00
China Valley	Squirrel	Flying squ	Hare	Deer	Moose	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.00	0.00	0.00	0.00	1.63	0.71	0.56	0.00	0.54	0.00	3.00	0.00	0.00
Piles	0.00	0.00	0.00	0.88	0.44	0.42	0.00	0.00	0.00	0.00	4.64	0.00	0.44
Windrows	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	1.11	0.00	4.07	0.00	0.00
Windrow, row only	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.98	0.00	6.62	0.00	0.00
Windrow - open areas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28	0.00	0.95	0.00	0.00
Uncut	7.50	0.00	1.45	1.97	0.00	0.00	1.47	0.00	0.00	0.00	7.90	0.00	0.00
Trout Creek	Squirrel	Flying squ	Hare	Deer	Moose	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.00	0.00	0.00	0.04	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piles	0.07	0.00	0.03	0.32	0.37	0.00	0.03	0.00	0.00	0.07	0.19	0.00	0.00
Windrows	0.05	0.00	0.00	0.06	0.09	0.00	0.00	0.06	0.05	0.05	0.14	0.00	0.00
Windrow, row only	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.09	0.38	0.00	0.00
Windrow - open areas	0.10	0.00	0.00	0.10	0.17	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Uncut	0.34	0.00	4.67	6.99	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 9. Mean (*n*=3 replicate sites) number of tracks per km of transect per 12 hours, late March 2008 sample period, in the four CWD treatments of dispersed, piles, windrows, and forest at each of the three study areas.

Study area and treatment													
Aberdeen	Squirrel	Flying squ	Hare	Deer	Moose	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	1.08	0.00	0.66	0.00	0.00	2.15	0.00	0.00	0.64	0.00	1.08	0.00	0.00
Piles	0.00	0.00	1.57	0.00	0.00	1.90	0.00	0.00	0.00	0.00	0.78	0.00	0.00
Windrows	0.00	0.00	2.90	0.00	0.00	2.27	0.00	0.00	0.00	0.00	0.76	0.00	0.00
Windrow, row only	0.00	0.00	6.84	0.00	0.00	1.67	0.00	0.00	0.00	0.00	1.67	0.00	0.00
Windrow - open areas	0.00	0.00	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uncut	141.84	0.00	53.16	2.38	0.00	0.00	1.79	0.00	1.59	0.00	3.37	1.15	0.00
China Valley	Squirrel	Flying squ	Hare	Deer	Moose	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.47	0.00	0.72	1.30	0.37	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piles	0.15	0.00	0.00	0.21	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00
Windrows	0.00	0.00	0.31	4.94	0.00	2.38	0.00	0.00	0.15	0.00	1.76	0.00	0.00
Windrow, row only	0.00	0.00	0.00	3.81	0.00	3.67	0.00	0.00	0.30	0.00	0.33	0.00	0.00
Windrow - open areas	0.00	0.00	0.52	5.71	0.00	1.47	0.00	0.00	0.00	0.00	3.28	0.00	0.00
Uncut	8.97	0.00	1.74	1.01	0.24	0.25	0.24	0.25	0.00	0.00	0.25	1.21	0.00
Trout Creek	Squirrel	Flying squ	Hare	Deer	Moose	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.00	0.00	0.00	0.77	0.13	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piles	0.34	0.00	0.11	0.24	0.36	0.80	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Windrows	0.11	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.55	0.00	0.00
Windrow, row only	0.35	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	1.30	0.00	0.00
Windrow - open areas	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uncut	1.79	0.00	10.83	4.87	1.96	0.00	0.08	0.00	0.00	0.00	0.48	0.00	0.00

Table 10. Mean (*n*=3 replicate sites) number of tracks per km of transect per 12 hours, mid-January 2009 sample period, in the four CWD treatments of dispersed, piles, windrows, and forest at each of the three study areas.

Study area and treatment														
Aberdeen	Squirrel	Flying squ	Hare	Deer	Moose	Wolf	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.07	0.00	0.24	0.00	0.13	0.20	0.58	0.00	0.34	0.00	0.00	0.13	0.00	0.00
Piles	0.36	0.00	4.05	0.00	0.12	0.00	1.44	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Windrows	0.28	0.00	1.00	0.00	0.00	0.37	0.19	0.19	0.18	0.00	0.00	0.00	0.00	0.00
Windrow, row only	0.00	0.00	2.06	0.00	0.00	0.90	0.21	0.00	0.56	0.00	0.00	0.00	0.00	0.00
Windrow - open areas	0.52	0.00	0.35	0.00	0.00	0.00	0.17	0.35	0.00	0.00	0.00	0.00	0.00	0.00
Uncut	9.39	0.00	19.38	1.49	0.51	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.14	0.00
China Valley	Squirrel	Flying squ	Hare	Deer	Moose	Wolf	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	1.52	0.00	0.05	0.00	0.00	0.00	0.82	0.00	0.22	0.00	0.00	0.05	0.00	0.00
Piles	0.99	0.00	0.09	0.00	0.00	0.00	1.03	0.00	0.13	0.00	0.00	0.32	0.00	0.00
Windrows	1.20	0.00	0.00	0.00	0.00	0.00	0.93	0.05	0.00	0.00	0.00	0.31	0.00	0.00
Windrow, row only	1.79	0.00	0.00	0.00	0.00	0.00	1.72	0.09	0.00	0.00	0.00	0.57	0.00	0.00
Windrow - open areas	0.48	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uncut	1.03	0.00	2.02	0.00	0.00	0.00	0.07	0.15	0.00	0.00	0.00	0.22	0.45	0.00
Trout Creek	Squirrel	Flying squ	Hare	Deer	Moose	Wolf	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.56	0.00	0.00	1.15	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.67	0.00	0.00
Piles	0.61	0.00	0.46	1.20	0.00	0.08	0.08	0.00	0.12	0.00	0.00	1.49	0.00	0.00
Windrows	0.11	0.00	0.35	0.00	0.00	0.07	0.11	0.00	0.00	0.00	0.00	0.46	0.00	0.00
Windrow, row only	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00
Windrow - open areas	0.00	0.00	0.56	0.00	0.00	0.11	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uncut	4.12	0.00	28.49	17.21	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00

Table 11. Mean (*n*=3 replicate sites) number of tracks per km of transect per 12 hours, March 2009 sample period (to be completed), in the four CWD treatments of dispersed, piles, windrows, and forest at each of the three study areas.

Study area and treatment														
Aberdeen	Squirrel	Flying squ	Hare	Deer	Moose	Wolf	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00
Piles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Windrows	0.74	0.00	0.00	0.25	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.00
Windrow, row only	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00
Windrow - open areas	0.46	0.00	0.00	0.46	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00
Uncut	2.37	0.00	16.83	0.00	0.20	0.00	0.00	0.00	0.30	0.10	0.00	0.10	0.00	0.00
China Valley	Squirrel	Flying squ	Hare	Deer	Moose	Wolf	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.18	0.00	0.00
Piles	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Windrows	0.15	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.08	0.19	0.00	0.43	0.00	0.00
Windrow, row only	0.30	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.15	0.33	0.00	0.30	0.00	0.00
Windrow - open areas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00
Uncut	0.24	0.00	0.86	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	3.82	0.25	0.00
Trout Creek	Squirrel	Flying squ	Hare	Deer	Moose	Wolf	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00
Piles	0.00	0.00	0.00	0.34	0.00	0.00	0.96	0.00	0.00	0.91	0.00	0.61	0.00	0.00
Windrows	0.28	0.00	0.11	0.00	0.00	0.00	0.25	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Windrow, row only	0.65	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Windrow - open areas	0.00	0.00	0.16	0.00	0.00	0.00	0.18	0.00	0.00	0.16	0.00	0.00	0.00	0.00
Uncut	0.57	0.00	52.48	11.81	2.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00

Table 12. Mean (*n*=3 replicate sites) number of tracks per km of transect per 12 hours, December 2009 sample period (to be completed), in the four CWD treatments of dispersed, piles, windrows, and forest at each of the three study areas.

Study area and treatment														
Aberdeen	Squirrel	Flying squ	Hare	Deer	Moose	Wolf	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.10	0.00	1.16	0.18	0.03	0.00	0.07	0.00	0.00	0.00	0.00	0.17	0.00	0.00
Piles	0.79	0.00	1.24	0.34	0.15	0.00	0.28	0.05	0.05	0.15	0.00	0.27	0.00	0.00
Windrows	0.09	0.00	2.30	0.22	0.05	0.05	0.36	0.00	0.00	0.00	0.00	0.68	0.00	0.00
Windrow, row only	0.00	0.00	3.78	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	1.09	0.00	0.00
Windrow - open areas	0.17	0.00	1.57	0.35	0.09	0.09	0.37	0.00	0.00	0.00	0.00	0.45	0.00	0.00
Uncut	19.63	0.00	5.49	0.00	0.00	0.00	1.23	0.00	0.00	0.00	0.00	0.30	0.20	0.00
China Valley	Squirrel	Flying squ	Hare	Deer	Moose	Wolf	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.00	0.00	0.36	0.00	0.24	0.00	0.19	0.00	0.00	0.00	0.00	0.59	0.00	0.00
Piles	1.89	0.00	0.41	0.06	1.05	0.00	0.07	0.00	0.00	0.08	0.00	0.86	0.04	0.00
Windrows	0.95	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.59	0.00	0.00
Windrow, row only	0.94	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.69	0.00	0.00
Windrow - open areas	0.80	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00
Uncut	1.54	0.00	1.36	0.63	0.93	0.00	0.06	0.00	0.00	0.00	0.00	1.11	0.69	0.00
Trout Creek	Squirrel	Flying squ	Hare	Deer	Moose	Wolf	Coyote	Fox	Bobcat	Lynx	Cougar	Weasel	Marten	Fisher
Dispersed	0.28	0.00	0.00	1.36	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Piles	0.50	0.00	0.10	3.78	0.11	0.00	0.00	0.00	0.03	0.00	0.00	0.71	0.00	0.00
Windrows	0.25	0.00	0.08	1.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.00
Windrow, row only	0.40	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00
Windrow - open areas	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uncut	0.79	0.00	4.46	7.37	0.28	0.00	0.00	0.05	0.00	0.20	0.00	0.00	0.13	0.00

Figure 1. Mean number (*n*=3) of red-backed voles at the China Valley, Aberdeen, and Trout Creek study areas in 2007-2009.

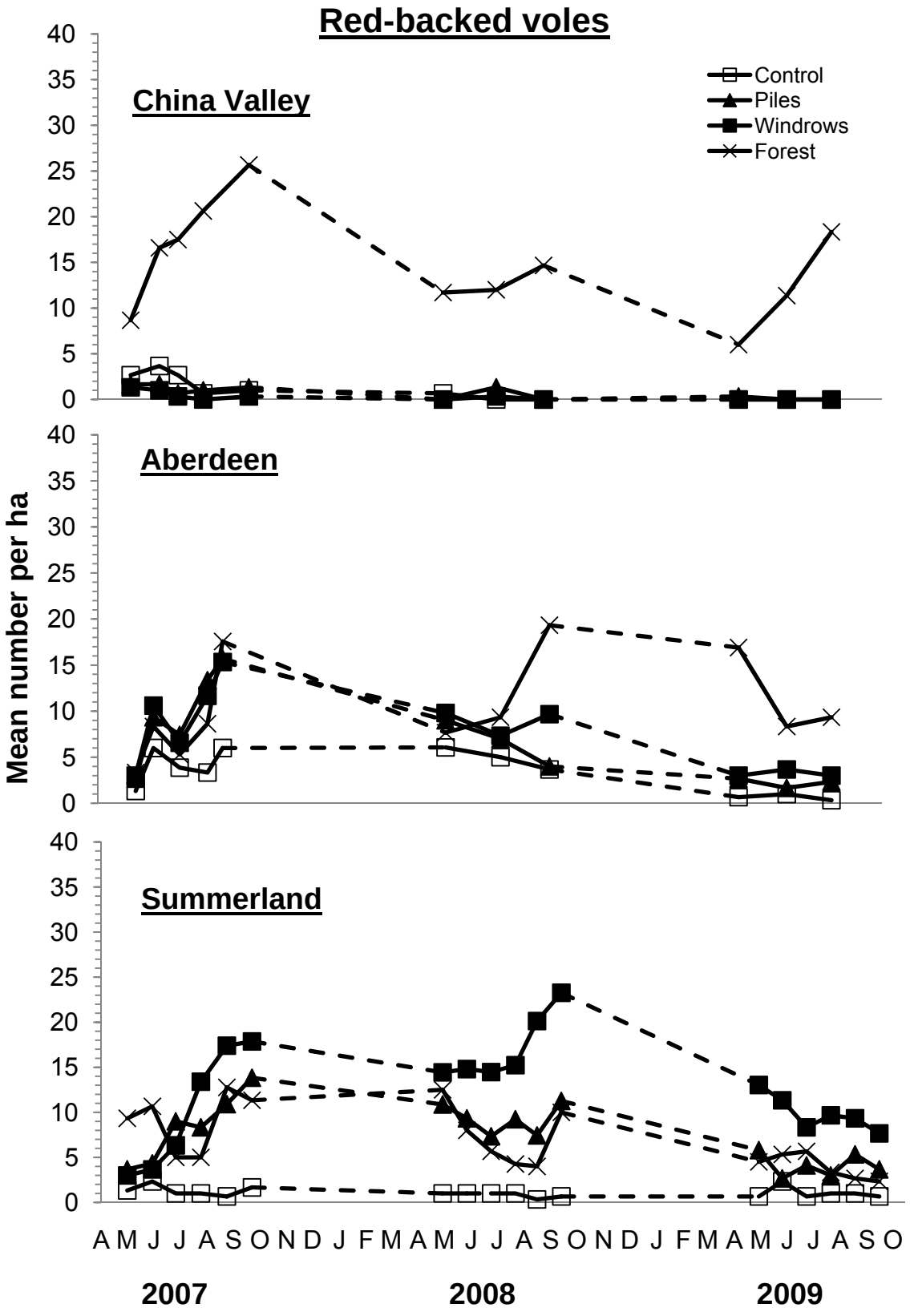


Figure 2. Mean number (*n*=3) of total small mammals at the China Valley, Aberdeen, and Trout Creek study areas in 2007-2009.

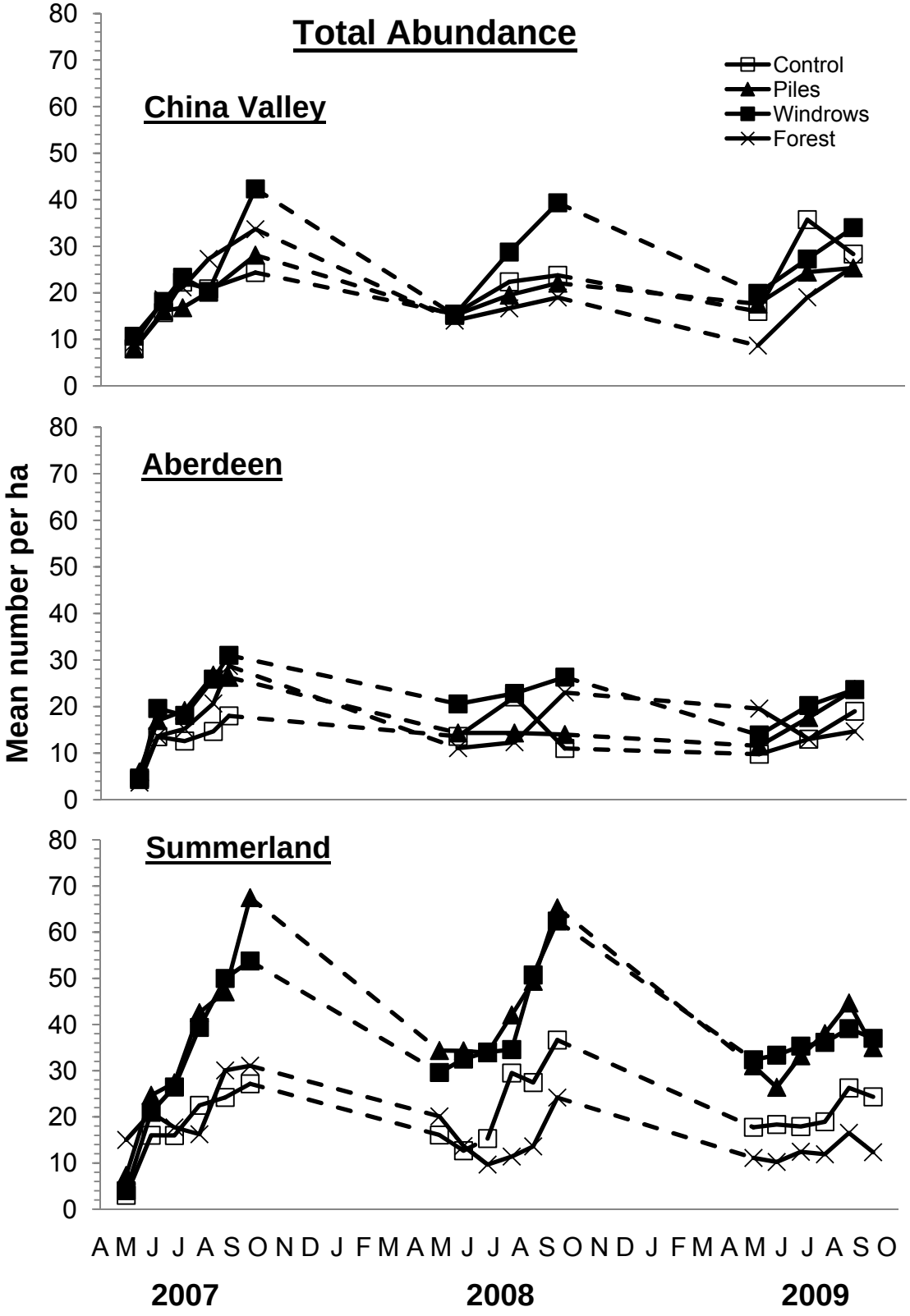


Figure 3. Mean number (*n*=3) of long-tailed voles at the China Valley, Aberdeen, and Trout Creek study areas in 2007-2009.

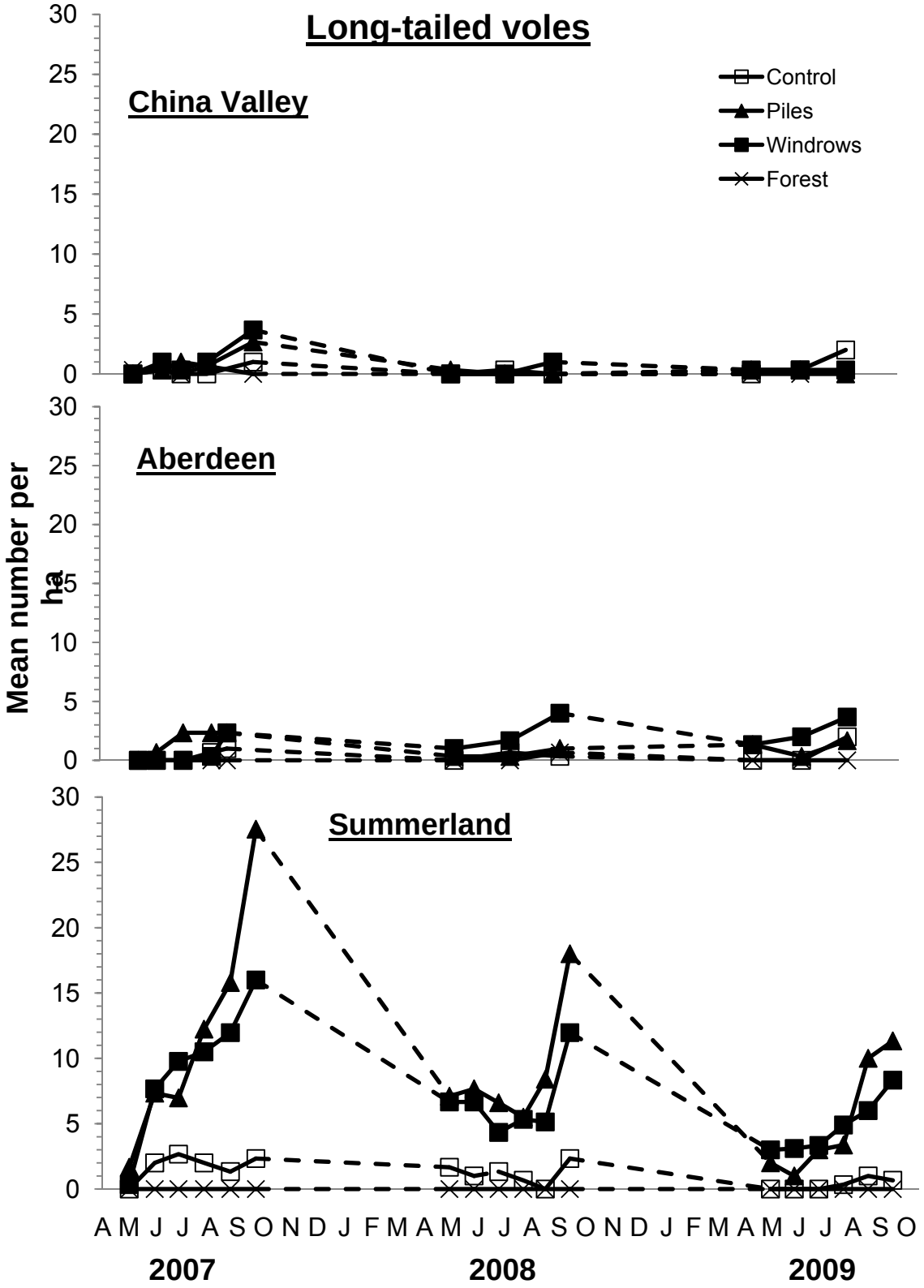


Figure 4. Mean number (*n*=3) of deer mice at the China Valley, Aberdeen, and Trout Creek study areas in 2007-2009.

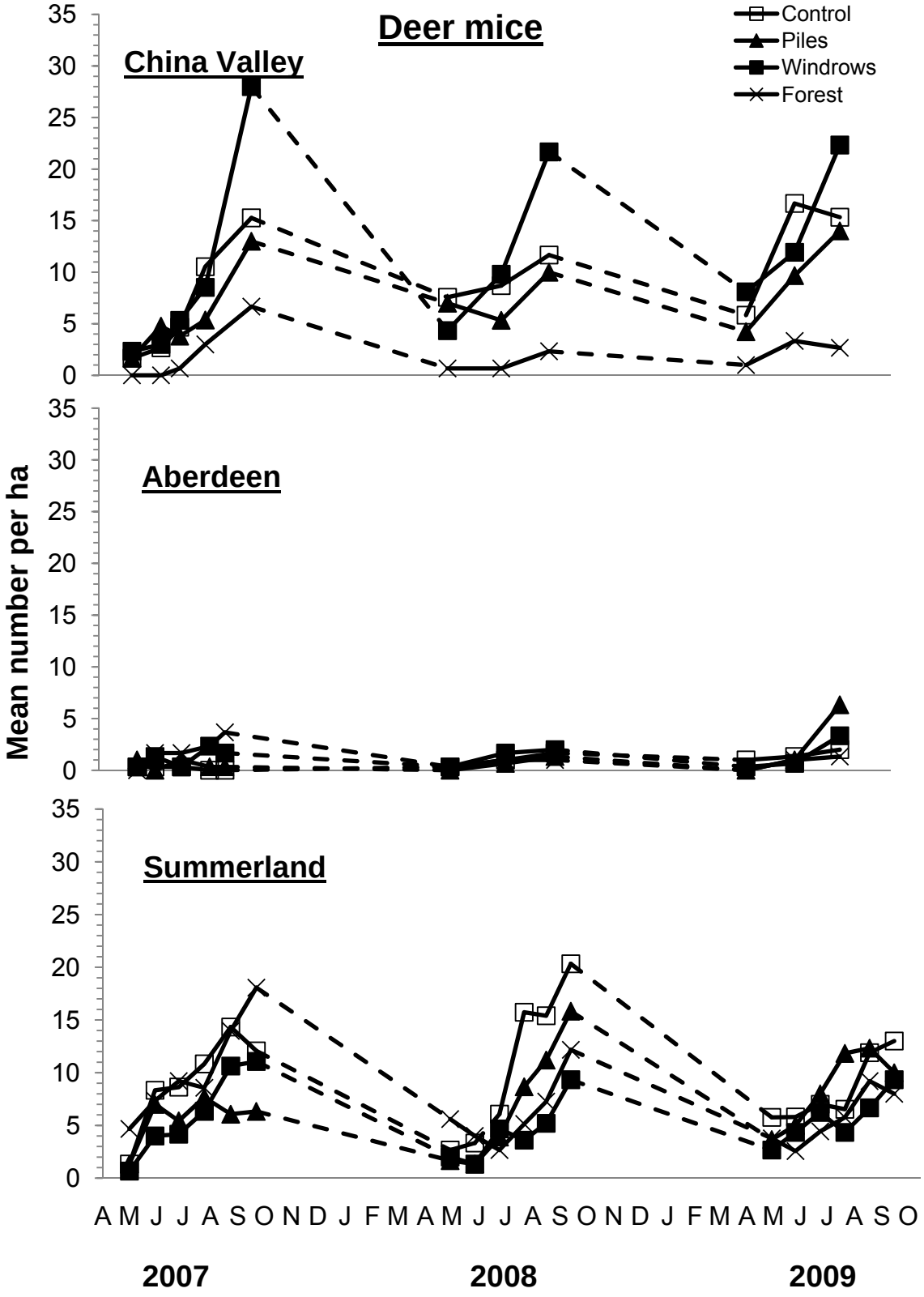


Figure 5. Mean number (*n*=3) of chipmunks at the China Valley, Aberdeen, and Trout Creek study areas in 2007-2009.

