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# Are linear habitats in agrarian landscapes source areas of beneficial or pest rodents?

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ABSTRACT

This study tested the hypotheses that populations of the montane vole *Microtus montanus* (a potential pest species) and deer mouse *Peromyscus maniculatus* (a potential beneficial species) in linear habitats will be (i) positively related to the type of vegetation (abundance and diversity of vascular plants) within and adjacent to those habitats; and (ii) correlated with population changes and productivity (reproductive performance, recruitment, and survival) in nearby apple (*Malus domestica*) orchards. Population dynamics of *M. montanus* and *P. maniculatus* were measured by intensive live-trapping from 2003 to 2006 in replicated hedgerows, riparian strips, and nearby orchards, in southern British Columbia, Canada. Hedgerows were borders between orchards, orchards and old fields, as well as orchards and natural forest. Contrary to hypothesis (i), *M. montanus* and *P. maniculatus* populations were not positively related to vegetation type within linear habitats and their adjacent crop and non-crop areas. Mean abundance and diversity of vegetation attributes were similar among linear habitats. Hypothesis (ii) was not supported for *M. montanus* populations in linear habitats since they did not correlate with population changes in nearby apple orchards, during a peak year in abundance. Populations of *P. maniculatus* were similar in abundance and other demographic variables among the linear habitats and apple orchards, and hence hypothesis (ii) was supported for this species.



## 1. Introduction

A major conservation objective of non-crop areas is to provide habitat for a variety of small mammal species and their predators including birds of prey (Tattersall et al., 2000; Butet and Leroux, 2001). Non-crop linear habitats include hedgerows, field margins, riparian zones along streams, and other field boundary delineations such as ditches and roadsides (Marshall et al., 2002; Tattersall et al., 2002). Terrestrial small mammals are common inhabitants of these areas (Butet and Leroux, 2001) and distribute beneficial mycorrhizal fungi and seeds for tree regeneration in woodlands and along hedgerows, and consume invertebrates, plants, and their seeds (Buckner, 1966; Golley et al., 1975). However, species of *Microtus* and *Clethrionomys* may become pests by feeding on crops such as alfalfa (*Medicago sativa* L.), cereals, and orchard trees (Byers, 1984; Wood, 1994; Jacob, 2003).

Populations of some species of voles tend to have cyclic fluctuations in abundance in northern latitudes with a peak every 3–5 years and these periods may be interspersed with annual fluctuations in abundance (Krebs and Myers, 1974; Taitt and Krebs, 1985). Montane voles (*Microtus montanus* Peale) and meadow voles (*M. pennsylvanicus* Ord.) are the most common microtine species affecting tree fruit production in western North America (Sullivan and Hogue, 1987). A second major species associated with these orchard agroecosystems is the deer mouse (*Peromyscus maniculatus* Wagner), a rodent with generalist dietary and habitat requirements (Banfield, 1974; Sullivan et al., 2004). Recent reports suggest that *P. maniculatus* may be valuable consumers of weed seeds, and hence directly beneficial to crop production (Westerman et al., 2005).

Thus, this study was designed to test the hypotheses that populations of *M. montanus* and *P. maniculatus* in linear habitats (hedgerows and riparian strips) will be (i) positively related to the type of vegetation (abundance and diversity of vascular plants) within the linear habitats and their adjacent crop and non-crop areas; and (ii) correlated with population changes and productivity (reproductive performance, recruitment, and survival) in nearby apple orchards.

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## 2. Materials and methods

This study was located in Prairie Valley, Summerland, British Columbia (BC), Canada (49°34′N; 119°40′W). Our linear habitat 'hedgerows' were borders between (i) adjacent orchards, (ii) orchards and old fields, and (iii) orchards and natural ponderosa pine (*Pinus ponderosa* Dougl.) forest; as well as (iv) 'riparian strips'. Vegetation along hedgerows was composed primarily of shrubs and some herbs. Hedgerows were usually up to 2 m wide and at least 100 m in length. The riparian habitats were located along a 3-km long year-round flowing stream which bisected Prairie Valley.

Apple orchards were 6- to 7-year-old Royal Gala cultivars in spacings of 0.5–1 m × 3–4 m and 10–30-year-old McIntosh and Red Delicious cultivars at spacings of 3–4 m × 5 m. Common herbaceous species in apple orchards included orchard grass (*Dactylis glomerata* L.), annual blue-grass (*Poa annua* L.), mountain brome (*Bromus marginatus* Nees ex Steud.), common dandelion (*Taraxacum officinale* Weber), white clover (*Trifolium repens* L.), and perennial ryegrass (*Lolium perenne* L.). These orchards were mowed in alleys and sprayed 3–4 times per growing season with Roundup® herbicide for weed control along tree rows. Orchard sites were each 4–7 ha in area.

Old fields were abandoned hay fields or orchards (with trees removed) composed of crested wheatgrass (*Agropyron cristatum* L.), quack grass (*Agropyron repens* L.), downy brome (*Bromus tectorum* L.), diffuse knapweed (*Centaurea diffusa* Lam.), and some minor herbaceous species such as yellow salsify (*Tragopogon dubius* Scop.). These sites were each 2–3 ha in area.

The natural forest habitats were composed of ponderosa pine as the major tree species with understory herbs such as arrow-leaved balsamroot (*Balsamorhiza sagittata* Nels & Macbr.), bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith), diffuse knapweed, downy brome, and sporadic shrubs such as big sagebrush (*Artemisia tridentata* Nutt.) and rabbitbrush (*Chrysothamnus nauseosus* (Pall.) Britt.).

The study had a completely randomized design with three replicate sites of each of the four types of linear habitats and the apple orchards. The 15 sites (five habitat types × three replicates) were selected on the basis of availability of intact hedgerows with nearby riparian strips and apple orchards. Orchard sites were the size of typical farming operations in the Okanagan Valley of BC. All sites were far enough apart (0.12–1.00 km) to be statistically independent.

### 2.1. Vegetation

Two 25 m transects, consisting of five 5 m × 5 m plots were systematically located along each linear habitat following the method of Stickney (1980). Each plot contained three sizes of nested sub-plots: a 5 m × 5 m plot for sampling trees, a 3 m × 3 m sub-plot for sampling shrubs; and a 1 m × 1 m sub-plot for sampling herbs. A visual estimate of percentage cover of the ground was made for each species height class combination within the appropriate nested sub-plot. These data were then used to calculate a crown volume index ($m^3$/0.01 ha) for each plant species. The product of percentage 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 a 0.01-ha base to produce the values given for each species and layer (herbs, shrubs, and trees). Sampling was done in June–July 2003. Species richness, species diversity, and structural diversity were calculated for these data.

### 2.2. Vole and deer mouse populations

Vole and deer mouse populations were sampled at 4-week (summer) and 4–6-week (winter) intervals from April 2003 to March 2006. One trapping grid (1 ha), with 49 (7 × 7) trap stations at 14.3 m intervals, and one Longworth live-trap at each station were located in each of two orchard sites, with a third orchard site that had an irregular-shaped 1 ha grid. Each hedgerow and riparian strip had seven trap stations at 14.3 m intervals with four Longworth live-traps at each station. Additional traps were added to stations when required to sample high numbers of animals. Traps were supplied with whole oats and carrot, with 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 sessions.

All voles and deer mice captured were ear-tagged with individually numbered tags, and released at point of capture (Krebs et al., 1969). Seasons were defined as summer (April–September) and winter (October–March) periods. Thus, there were three summer and three winter periods that had at least five trapping sessions. We used mass at sexual maturity to infer age classes of animals. The percentage of sexually mature animals was used to determine the mass limitations for juveniles and adults assuming that juveniles were seldom, if ever, sexually mature, and that at least 50% of the adults were sexually mature in their lowest mass class. *M. montanus* (juvenile = 1–26 g, adult ≥ 27 g) and *P. maniculatus* (juvenile = 1–20 g, adult ≥ 21 g) were classified as juvenile or adult by body mass. All handling of animals was in accordance with the principles of the Animal Care Committee, University of British Columbia.

Trappability and population density were measured to compare the abundance of *M. montanus* and *P. maniculatus* in the different habitats. Population densities were estimated by the Jolly-Seber (J–S) model (Seber, 1982) with small sample size corrections (Krebs, 1991). Measurements of recruitment, number of successful pregnancies, and early juvenile survival were derived from the sample of animals captured in each trapping session and then summed for summer periods. A pregnancy was considered successful if the female was lactating during the period following the estimated time of birth of a litter. Early juvenile survival was an index relating recruitment of young into the trappable population to the number of lactating females. A modified version of this index was the number of juvenile animals at week $t$ divided by the number of lactating females caught in week $t - 4$. Mean survival rates per 28 days for summer and winter periods were estimated from the J–S model.

### 2.3. Statistical analyses

A one-way analysis of variance (ANOVA) (Zar, 1999) was used to determine the effect of linear habitat type on mean crown volume index, mean species richness and diversity, and mean structural diversity of the herb, shrub, and tree layers. A repeated-measures (RM) ANOVA was conducted to test for differences among linear habitats for the demographic variables of mean abundance, mean number of recruits, mean number of successful pregnancies, mean early juvenile survival, and mean J–S survival for populations of *M. montanus* and *P. maniculatus*. Data not conforming to properties of normality and equal variance were subjected to various transformations to best approximate the assumptions required by an ANOVA (Zar, 1999). Mauchly's *W*-test statistic was used to test for sphericity (independence of data among repeated measures; Littel, 1989; Kuehl, 1994). For datasets that were correlated among years, the Huynh–Feldt (H–F)