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Creation of bunchgrass, sagebrush, and perennial grassland habitats within a semi-arid agricultural setting: Implications for small mammals

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ABSTRACT

Native habitats of the semi-arid intermontane grasslands and shrub-steppe rangelands of the Pacific Northwest of North America are disappearing owing to agricultural, urban, and recreational development. A major small mammal occupying these habitats is the montane vole (*Microtus montanus*), along with the deer mouse (*Peromyscus maniculatus*), northwestern chipmunk (*Neotamias amoenus*), house mouse (*Mus musculus*), and two less common species at risk. To help restore these native habitats and small mammals, we tested three hypotheses (H) that non-crop habitats of native bunchgrasses, sagebrush (*Artemisia tridentata*), and perennial grasslands (alfalfa and mix of forage grasses) would: (H_1) establish in an agricultural setting, (H_2) conserve small mammal species, and (H_3) limit vole damage to tree fruit production in orchards. Linear habitats of these non-crop treatments, *within* a semi-arid agrarian setting in south-central British Columbia, Canada, were sampled for all vascular plants and small mammals from 2006 to 2010. Mean abundance of bunchgrasses declined after the second year owing to competition from orchard herbs, but sagebrush and pasture grasses became well established, thereby partially supporting H_1. Alfalfa established initially but then declined potentially owing to consumption by voles. Conservation of the three major small mammal species, but not less common species, partially supported H_2. Alfalfa and pasture grasses provided optimum habitat for montane voles, but their high numbers did not result in feeding damage to tree fruit production, thereby supporting H_3. Creation of non-crop habitats *within* as well as *adjacent* to agricultural settings should become a major endeavour to restore native habitats, enhance small mammal populations, and maintain biodiversity.

1. Introduction

The semi-arid intermontane grasslands and shrub-steppe rangelands of the interior Pacific Northwest of North America provide habitats for many terrestrial wildlife species. This ecological zone extends from the northwestern United States (US) into southern British Columbia (BC), Canada. There is less than 10% of these semi-arid landscapes that have not suffered some degree of habitat losses owing to agricultural (including cattle grazing), urban, and recreational developments (Harper et al., 1993; Fleischner, 1994; Pearson et al., 2001). The quandary of what constitutes natural, climax, and degraded states within various successional and disturbance regimes, for example, is particularly troublesome in rangeland management. Vegetation dynamics of rangelands have been recently reviewed in terms of restoration and conservation goals with respect to threshold concepts (Bestelmeyer, 2006) and the equilibrium and non-equilibrium paradigms (Briske et al., 2003).

Perennial grassland habitats in the semi-arid Okanagan and Similkameen valleys of southern BC include native bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith), Idaho fescue (*Festuca idahoensis* Elmer), rough fescue (*F. scabrella* L.), needle and thread grass (*Hesperostipa comata* (Trin.&Rupr.) Barkworth), and big sagebrush (*Artemisia tridentata* Nutt.). These habitats may also be abandoned croplands ("old fields") such as forage fields and orchards that are in various states of recovery after abandonment. There is a diverse group of terrestrial small mammals occupying these various habitats, and include the montane vole (*Microtus montanus* Peale), deer mouse (*Peromyscus maniculatus* Wagner), northwestern chipmunk (*Neotamias amoenus* J.A. Allen), and house mouse (*Mus musculus* L.). Two additional species considered at risk are the Great Basin pocket mouse (*Perognathus parvus* Peale) and the western harvest mouse (*Reithrodontomys megalotis* Baird) that occupy big sagebrush habitats and perennial grasslands (Sullivan and Sullivan, 2008).

The montane vole is distributed throughout the central cordilleran region of western North America (Banfield, 1974; Sera and Early, 2003). Native bunchgrasses, sagebrush, and perennial grasslands in dry

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valley bottoms are preferred habitats of this microtine (Pearson et al., 2001; Sullivan et al., 2003). *M. montanus* could be considered a "keystone" species of semi-arid perennial grasslands, similar to species of *Microtus* elsewhere (Delibes-Mateos et al., 2011; Rodriguez-Pastor et al., 2016). Voles are important prey for the majority of small and medium-sized carnivores including owls, raptors, and mustelids (Hanski et al., 1991). These microtines may also interact dramatically with vegetation by hindering natural succession processes in grassland and forest ecosystems (Ostfeld and Canham, 1993).

The two generalist species, *P. maniculatus* and *N. amoenus*, occupy a wide range of habitats, including old fields, sagebrush, ponderosa pine (*Pinus ponderosa* Dougl.), and tree fruit orchards (Sutton, 1992; Sullivan and Sullivan, 2006). The house mouse, when at high abundance levels, is usually associated with farmland crops and stored grains (Banfield, 1974; Wilson and Reeder, 2005). All of these small mammals are an important component of biodiversity because they are prey for many avian and mammalian predators (Martin, 1994; Butet and Leroux, 2001), feed on various plant parts and seeds (Hayward and Phillipson, 1979), and by these feeding activities, distribute seeds and fungal spores essential to plant regeneration (Maser et al., 2008). Small mammals may also have roles as zoonotic and ecto-parasitic hosts (Gratz, 1988).

Conservation of native plant species and overall diversity of vegetation in both crop and non-crop areas would seem essential to maintenance of habitats for small mammals in these semi-arid agricultural landscapes. A diverse mosaic of crop and non-crop habitats associated with farmland helped conserve species of vascular plants (Freemark et al., 2002). In addition, the importance of non-crop habitats as refuges for plant species that are indicative of natural regional vegetation was reported by Jobin et al. (1997) and Boutin and Jobin (1998). Non-crop habitats are typically associated with edges of agricultural lands and include various linear units such as field margins, hedgerows, and riparian zones, as well as non-linear units such as set-asides (Marshall et al., 2002; Tattersall et al., 2002). Sullivan et al. (2012) reported on the utility of various linear habitats on edges of apple (*Malus domestica* Borkh.) orchards for maintaining the overall small mammal community in a semi-arid agricultural landscape. Bates and Harris (2008) concluded that increasing the area of non-crop habitats would benefit small mammal populations more than improving organic vs. conventional management regimes. Similarly, Gomez et al. (2011) and Coda et al. (2015) reported on the positive attributes of border non-crop habitats for small mammals in agroecosystems in central Argentina. A potential concern, if non-crop habitats generate relatively high populations of small mammals, is the dispersal of such species (e.g., *Microtus* spp.) from high-quality habitat into adjacent crop fields (Briner et al., 2005; Sullivan and Sullivan, 2009).

To our knowledge, there are no studies of semi-arid non-crop habitats being created *within* agricultural settings. We ask if non-crop habitats could be created *within* agro-ecosystems and be as beneficial to small mammals as those on the borders of farmland? Thus, we tested the hypotheses (H) that (H_1) the non-crop habitats of native bunchgrasses, sagebrush, and perennial grasslands could be successfully established in apple orchards, (H_2) these habitats would help conserve small mammal species in these dry environments, and (H_3) relatively abundant populations of *M. montanus* occurring in potentially high-quality habitat would not damage tree fruit production in orchards.

2. Materials and methods

2.1. Study areas and experimental design

This study was located in a 0.45-ha 12-year-old McIntosh apple orchard in Prairie Valley, Summerland, British Columbia (BC), Canada (49°34′ N; 119°40′ W). Tree spacing was 3 m × 4.5 m. The orchard was mowed in alleys and sprayed with Roundup® herbicide for weed control along tree rows 3 to 4 times per growing season. No other chemicals were applied. Common herbaceous species in the orchard included quackgrass (*A. repens* L. Beauv.), orchard grass (*Dactylis glomerata* L.), annual blue-grass (*Poa annua* L.), Kentucky bluegrass (*P. pratensis* L.), mountain brome (*Bromus marginatus* Nees ex Steud.), downy brome (*B. tectorum* L.), perennial ryegrass (*Lolium perenne* L.), common dandelion (*Taraxacum officinale* Weber), white clover (*Trifolium repens* L.), shepherd's purse (*Capsella bursa-pastoris* (L.) Medik.), lamb's quarters (*Chenopodium album* L.), great mullein (*Verbascum thapsus* L.), prickly lettuce (*Lactuca serriola* L.), fleabane (*Erigeron canadensis* (L.) Cronquist), and tall tumble-mustard (*Sisymbrium altissimum* L.). Shrubs or trees in perimeter hedgerows on two sides of the orchard included red-osier dogwood (*Cornus sericea* L.), Nootka rose (*Rosa nutkana* C. Presl.), snowberry (*Symphoricarpos albus* Duhamel), Virginia creeper (*Parthenoscissus quinquefolia* L.), Douglas maple (*Acer glabrum* Torr.), choke cherry (*Prunus virginiana* L.), and tower poplar (*Populus canescens* (Aiton) Sm.). Hedgerows formed border habitats between adjacent orchards or old fields.

In preparation for testing the various non-crop habitats in an orchard environment, every second tree row (70 m in length) was removed and these units were divided into 12 sites that were each 35 m in length and 2 m wide with a tree row between each set of sites. This configuration provided a completely randomized design with three replicate sites of four different treatments of non-crop vegetation. Sites were contiguous at one end of each rectangular unit, and hence for plants were reasonably independent from a statistical perspective. Sites were separated by 9 m that included an intact tree row and two alleys composed of grass and mowed 4–5 times each summer. To provide control (conventional orchard) conditions, two additional treatments of 35-m long sites within tree rows had regular herbicide and no herbicide applications. There were three randomly located replicates of each of these treatments for an overall design of 3 replicates x 6 treatments = 18 treatment sites.

2.2. Non-crop habitat treatments

As a preparation for seeding and/or planting of non-crop vegetation, experimental sites were sprayed with Roundup® herbicide at 2.2 kg a.i./ha in late April 2006 and then rotovated to remove remnant vegetation cover, prior to planting and seeding in early May 2006. The six treatments were: (1) native bunchgrasses, (2) sagebrush, (3) alfalfa, (4) pasture grasses, (5) no herbicide along tree rows thereby maintaining orchard herbaceous cover, and (6) herbicide along tree rows eliminating vegetation cover. The relative compositions and planting or seeding densities in each replicate site of the non-crop treatments were (1) 70% bluebunch wheatgrass, 25% Idaho fescue, and 5% needle and thread grass (in 125-ml plugs and 10-cm diameter pots) planted at four plants per m^2; (2) sagebrush (in 15-cm pots) planted at one plant per m^2; (3) alfalfa at 3.33 kg/site; (4) a mix of pasture grasses consisting of 25% timothy (*Phleum pretense* L.), 25% tall fescue (*Festuca arundinacea* Schreb.), 20% orchardgrass, 20% Kentucky bluegrass, 6% creeping red fescue (*Festuca rubra* L.), and 4% ryegrass was applied at 3.33 kg/site. Native grasses and sagebrush were from Wild West Plant Nursery, Okanagan Falls, BC, and Sagebrush Nursery, Oliver, BC. Alfalfa and pasture seed mixes were from Quality Seeds West, Langley, BC, Canada.

Non-crop treatment sites were irrigated initially for 30–60 min each day to help establish seeded and planted non-crop vegetation; thereafter, these sites were not irrigated so as to simulate semi-arid conditions. All apple trees were irrigated for 30–60 min daily during summer periods. Bunchgrasses and sagebrush sites were manually weeded at least twice a summer (2006 and 2007) in an attempt to keep potentially competitive orchard herbs at a minimum.

2.3. Vegetation

Three 1 m × 1 m plots for sampling species of non-crop vegetation and associated orchard herbs were randomly located in each site. A