BIODIVERSITY & FARMLAND

Diversity and Conservation of Plants and Mammals in Natural and Orchard Habitats

Biodiversity

Biological diversity (biodiversity) is the diversity of life in all its forms (plants, animals, fungi and microorganisms) and at all levels of organization (genes, species and ecosystems). A gene is the functional unit of heredity. A species is a group of interbreeding natural populations such as a robin or a dandelion. An ecosystem is a group of interacting organisms and the physical environment that they inhabit. For example, a "riparian ecosystem" includes the plants and animals living alongside and in a stream and associated wetlands. An orchard is an "agroecosystem" or "farm" composed of fruit trees, soil and associated plants and animals.

Biodiversity includes these *structural* components of genes, species and ecosystems, as well as *functional* components: the ecological and evolutionary processes through which these structural components interact with one another and with their environment. If structural biodiversity (genetic, species and ecosystem diversity) is maintained, then the diversity of ecological and evolutionary processes will probably be maintained as well.

Agriculture and Biodiversity

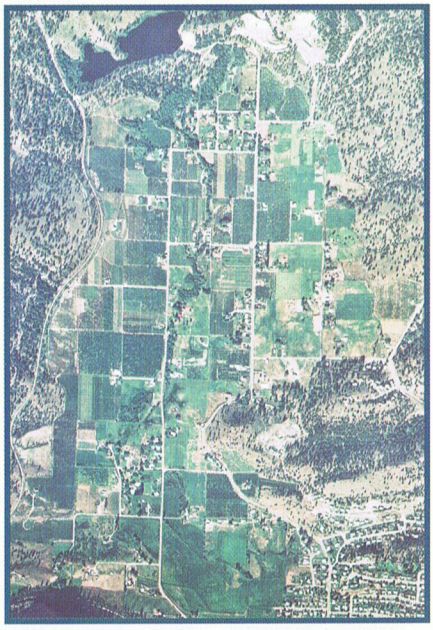
The effects of agricultural intensification on biological diversity in North America have received much attention over the past two decades. The negative impact on native species and habitats by agricultural land use, primarily by agrochemicals (pesticides and fertilizers), grazing, introductions of exotic species, and modification of natural habitats, is well documented. Agricultural landscapes that maintain mosaics of farmland habitats and remnant natural habitats of woodlots, hedgerows, shelterbelts and riparian zones may offer an opportunity to conserve biodiversity while maintaining food production.

World-wide conservation efforts have focused on protection of biodiversity in national parks and reserves. These conservation areas currently represent nearly 4% of world land area and include forests, grasslands and other natural habitats that are valuable for protection of biodiversity. Paradoxically, very little attention has been given to conservation of the biodiversity that exists in the vast managed agricultural and forest ecosystems and human settlements. These combined areas cover approximately 95% of the terrestrial environment and presumably have extensive biodiversity that has been neglected, to date. All habitats, both managed and unmanaged (natural), should be considered when managing for biodiversity across landscape mosaics.

Agricultural Landscapes

Conservation of plant species diversity and structural diversity (layers of vegetation) in both crop and noncrop areas would seem essential to maintenance of habitats for terrestrial wildlife species in agricultural mosaics. Agricultural landscape mosaics may be categorized into non-linear habitats such as field and orchard croplands, woodlots and abandoned "old fields" or set-aside. Natural grassland, shrub and forest habitats may also occur in areas surrounding a given mosaic. Linear habitats include hedgerows, field margins, riparian zones along streams and other field boundary delineations such as ditches and roadsides. Hedgerow and riparian habitats are particularly valuable for conservation of plant diversity in farming landscapes.

Terrestrial small mammals are common inhabitants of agricultural landscapes where they are an important prey source for a wide variety of avian, reptilian and mammalian predators. Small mammals also contribute to distribution of beneficial mycorrhizal fungi and seeds for tree regeneration in woodlands and along hedgerows, and they consume invertebrates and native and non-native plants and their seeds. Some species of rodents have been implicated in the transmission of diseases to humans and livestock and the depletion of stored grains and sown seeds. In addition, species of voles may feed on field crops and orchard trees. Thus, terrestrial small mammals occupy an important role in agroecosystems and may provide a measure of ecological integrity within a landscape mosaic composed of agrarian and natural habitats. In addition, some species at risk in B.C. such as the western harvest mouse and Great Basin pocket mouse may be adversely affected by agricultural land conversion in some parts of their respective ranges.



Aerial view of Prairie Valley

Project Objectives

The ability to predict a positive association between structural diversity of vegetative components and the abundance and diversity of small mammals would have considerable utility in enhancing plant and mammal conservation in agricultural landscapes. Thus, this project was located in a mosaic of natural and orchard habitats in an agrarian landscape and was designed to determine:

(1) the diversity (species diversity and structural diversity of herb, shrub and tree layers) of plant communities,

(2) the abundance and diversity of small mammal communities, and

(3) the use of structural diversity of vegetation as an index of inferred biodiversity.

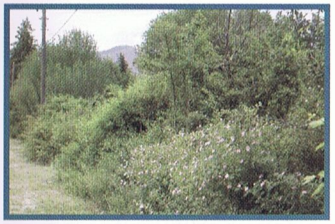
Old field habitat

Sagebrush habitat

Dwarf apple orchard

Ponderosa pine forest

Conventional apple orchard



Hedgerow

Riparian

Study Areas

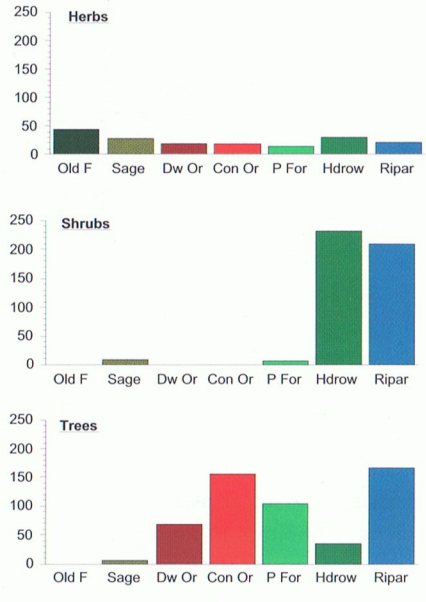
This study was located in the Okanagan Valley at the Pacific Agri-Food Research Centre and in Prairie Valley, Summerland, British Columbia, Canada. Seven habitat types were distributed over these two adjoining valleys: old field, sagebrush, dwarf orchard, conventional orchard, ponderosa pine forest, hedgerow, and riparian.

The dwarf rootstock apple orchards were Imperial/Royal Gala cultivars in spacings of 0.5-1 x 3-4 m. The conventional apple orchards were McIntosh and Red Delicious cultivars at spacings of 3-4 x 5 m. These orchards were mowed in alleys and sprayed with Roundup® herbicide for weed control along tree rows 3 to 4 times per growing season.

The hedgerows formed border habitats between adjacent orchards or orchards and old fields. Hedgerows were usually up to 2 m wide and at least 100 m in length. The riparian habitats were located along a year-round flowing stream which bisected Prairie Valley.

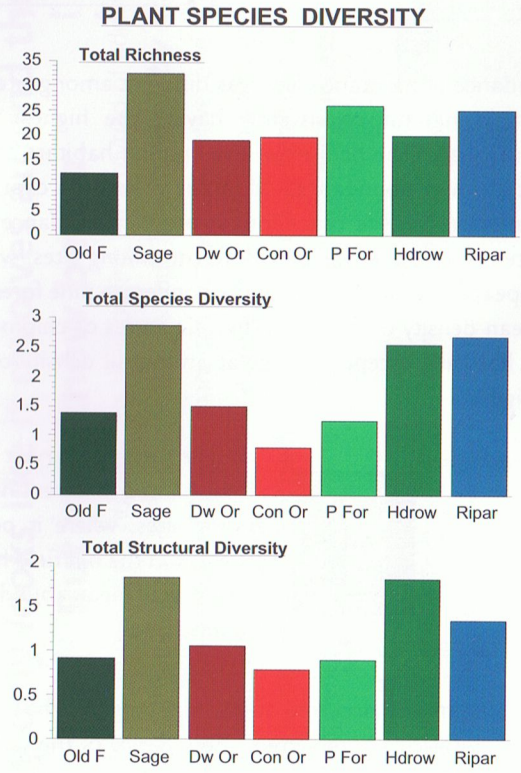
Abundance of Vegetation

Biomass of herbs was similar among habitats. However, it may be biologically significant that the abundance of herbs was 3.0 times higher in the old field than Ponderosa pine forest. Similarly, the old field had 2.2-2.4 times as much herb biomass as the two orchard sites and riparian sites.



Biomass of shrubs was different among sites. The hedgerow and riparian habitats had substantial shrub layers. Biomass of trees was different among sites. The two orchard habitats and pine forest habitat had similar tree volumes, with the conventional orchard, pine forest and riparian tree layers at the highest biomass levels. A tree layer was absent from the old field sites and of minor importance in the sage sites. As expected, apple trees were the dominant layer in both orchard sites, and ponderosa pine in the forest sites.

Species Diversity



A total of 104 species of herbs, 26 species of shrubs, and 10 species of trees was sampled in this study. Of these plant species 37.1% (52 of 140) were introduced (exotic species), primarily among herbs where 44.2% (46 of 104) were not native species. Species richness of herbs was different among sites with the sage habitat having the most herbaceous species and the riparian the least. The riparian and hedgerow sites had the most shrub species, and the riparian site had the most tree species. Total mean species richness of plants was similar among sites, but did range from a low of 12 species in the old field sites to 32 species in the sage sites.

Species diversity of herbs was similar among sites, but shrubs were different. Shrub species diversity was highest in the hedgerow and riparian sites, followed by the old field, sage and pine forest habitats. Species diversity of trees was also different among sites, with the riparian habitat having the only recorded diversity of tree species. Total species diversity of plants was highest in the sage, hedgerow and riparian sites.

Groups of plant species unique to each habitat type ranged from a low of three species in the old field and conventional orchard sites to 27 species in the riparian sites. Those habitats associated with agriculture: orchards, old fields and hedgerows; had relatively similar numbers of native and introduced plant species (total ratio 11:18) in their unique groups. The natural habitats: sage, ponderosa pine forest and riparian; had greater numbers of native than introduced species (total ratio of native to introduced species 36:8).

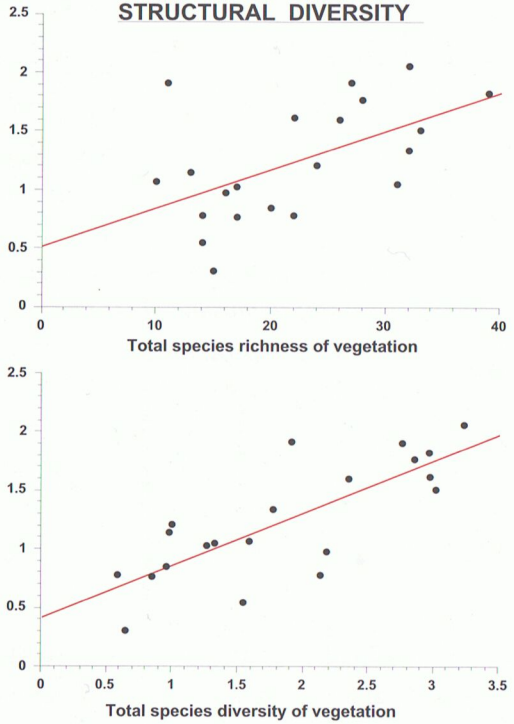
Number of vascular plant species unique to each site and the ratio of native (N) to introduced (I) species.

Layer	Old field	Sage	Dwarf orchard	Conventional orchard	Pine forest	Hedgerow	Riparian
Herbs	3	12	7	3	4	11	11
Shrubs	0	1	0	0	0	4	10
Trees	0	0	0	0	0	1	6
Total	3	13	7	3	4	16	27
N : I ratio	0:3	10:3	3:4	1:2	3:1	7:9	23:4

The contribution to the overall flora from the orchard habitats and those of agricultural origin: the old fields and hedgerows, was 29 unique species (11 native and 18 introduced) which was 39.7% (29 of 73) of the plant species unique to specific habitats. In addition, the similarity in mean total species richness among habitats was perhaps surprising with the dwarf and conventional orchards having 19.0 and 19.7 plant species, respectively, despite regular mowing of alleys and application of herbicide to tree rows 3-4 times each summer. This pattern was further supported by the general maintenance of herb species diversity in orchard sites despite the regular vegetation management regime. Although not likely to occur in intensively managed agroecosystems of annual crops, where non-crop vegetation is repeatedly reduced, the presence of these herbaceous plant species in our apple orchards contributed to the overall vegetative diversity in this landscape.

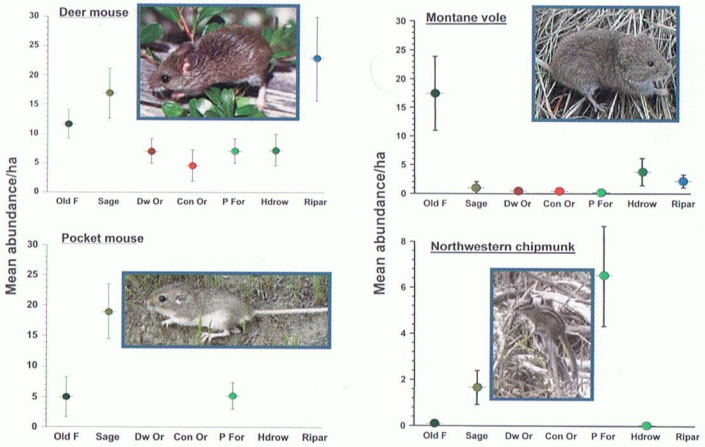
Structural Diversity

Mean structural diversity of herbs and trees was similar among sites, but shrubs were different. Structural diversity of shrubs was highest in the hedgerow and riparian sites, followed by the sage and pine forest. The old field and orchard sites had negligible or no shrub layers. Total structural diversity was different among sites, with the sage, hedgerow and riparian habitats dominating this measure of plant community structure. Structural diversity of vegetation was positively related to species richness and species diversity of vegetation.

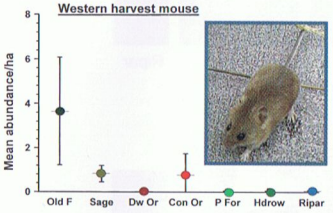


Abundance of Small Mammals

The abundance and diversity of small mammal communities were highest in those habitats where species and structural diversity of vegetation were highest, thereby providing a range of microhabitats. Abundance of deer mice was different among sites, with highest overall numbers (range of 12 to 23/ha) in the riparian, sage and old field habitats. The other four habitats had relatively similar numbers. Abundance of Great Basin pocket mice was different among sites, with highest overall numbers (19/ha) consistently occurring in the sage habitat, and with lower numbers in the old field and pine forest.

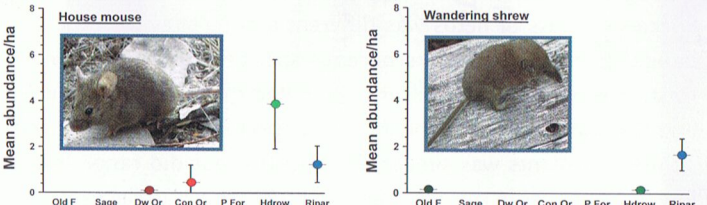


Abundance of montane voles was different among sites, with the old field habitat consistently having the highest overall numbers (17/ha). The hedgerow and riparian habitats also had voles, but at lower abundance. Montane voles were captured in very low numbers in the other four habitats. Abundance of the northwestern chipmunk was also different among sites, with this sciurid appearing predominantly in the ponderosa pine forest at an overall mean density of 7 animals/ha. Captures of chipmunks in the other habitats, except the sage at an overall density of 2/ha, were negligible.

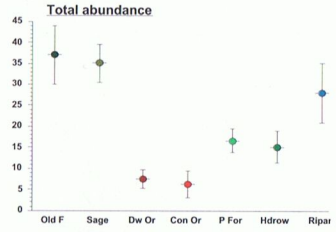


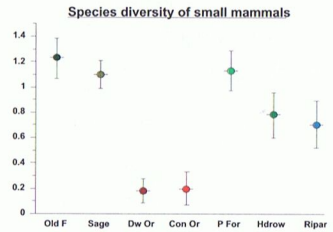
The western harvest mouse also exhibited different numbers among sites, where it occurred primarily in the old field habitats at an overall mean abundance of 4 animals/ha.

The house mouse occurred at low numbers (< 5/ha) with the hedgerow habitat clearly preferred. Abundance of the wandering shrew was different among sites, with highest overall numbers (2/ha) in the riparian habitat. There was a very minor presence (< 1 animal/ha) of this insectivore in the old field and hedgerow sites.



Total abundance of small mammals per ha was different among sites with the old field, sage, and riparian habitats supporting the most (28 – 37) small mammals. The ponderosa pine forest and hedgerow habitats had similar overall numbers (15 – 17) followed by the two orchard habitats (6 – 8).

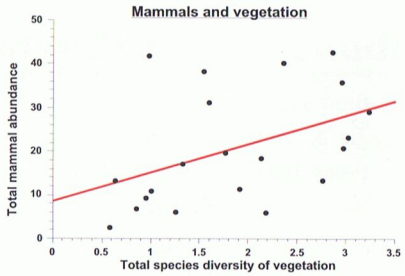


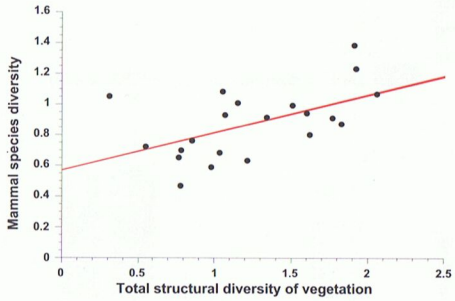


Species Diversity of Small Mammals

Species diversity of the small mammal communities was different among sites, with the old field, sage and pine forest habitats having the highest diversity measurements. Diversity of small mammals in the orchard habitats had the lowest values during most years and overall.

Total abundance of small mammals was positively related to total species diversity of vegetation. Species diversity of small mammals was positively related to total structural diversity of vegetation.





Vegetation and Habitat Diversity

This study is the first detailed investigation of species diversity and structural diversity of vascular plant communities in a mosaic of natural and orchard habitats in an agrarian landscape. This mosaic was considered typical of tree-fruit growing agricultural regions in the southern interior of British Columbia, Canada and similar dry-belt agricultural areas of the Pacific Northwest states of the U.S.A. Although scale of farming operations and size of landscape clearly vary from region to region, our seven habitat types likely represented a reasonable profile of vascular plant communities generally associated with orchard habitats.

Structural Diversity and Inferred Biodiversity

The use of structural diversity of vegetation, which includes the species composition and layers of herbs, shrubs, and trees, has been promoted as an indication of biodiversity in both managed and natural forests. This attribute of vegetation, as well as other structural features of an ecosystem, could be used as surrogates for biodiversity as well as act as indicators to monitor the success or failure of management practices designed to conserve biodiversity. This approach has received little attention, to date, in agricultural systems. However, this study provides a template for measuring structural diversity of vegetation in crop and noncrop habitats within an agrarian landscape. At least with respect to vascular plant and small mammal communities, structural diversity appeared to provide a reasonable indication of plant species richness and diversity and small mammal species diversity.

Conclusions

1. A diverse mosaic of tree fruit crop and noncrop habitats, in an agrarian landscape, seemed to conserve species of vascular plants with unique groups of natural and introduced species within each habitat;
2. Abundance and diversity of small mammal communities were positively related to species and structural diversity, respectively, of the plant communities.
3. All seven species of small mammals were recorded in one or more of the habitats within the mosaic.
4. Structural diversity of vegetation appeared to be a reasonable indicator of biodiversity (at least for plants and small mammals) and should be included in future assessments of diversity in agroecosystems.
5. Other taxa such as birds, invertebrates and nonvascular plants need to be monitored in crop and noncrop habitats for their contribution to biodiversity and relationship to structural diversity of vegetation.
6. Noncrop habitats are crucial sources of native plants and small mammals and need to be conserved, whenever possible, in agrarian landscapes.

References

Sullivan, T.P. and D.S. Sullivan. 2004. Biodiversity in an agrarian landscape: diversity of plants and mammals in natural and orchard habitats. (In review at a scientific journal).

Acknowledgements

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