Trends in wildlife habitat capacity on agricultural land in Canada, 1986-2006

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PREFACE

The Canadian Councils of Resource Ministers developed a Biodiversity Outcomes Framework[1] in 2006 to focus conservation and restoration actions under the *Canadian Biodiversity Strategy*.[2] *Canadian Biodiversity: Ecosystem Status and Trends 2010*[3] was a first report under this framework. It assesses progress towards the framework's goal of "Healthy and Diverse Ecosystems" and the two desired conservation outcomes: i) productive, resilient, diverse ecosystems with the capacity to recover and adapt; and ii) damaged ecosystems restored.

The 22 recurring key findings that are presented in *Canadian Biodiversity: Ecosystem Status and Trends 2010* emerged from synthesis and analysis of technical reports prepared as part of this project. Over 500 experts participated in the writing and review of these foundation documents. This report, *Trends in wildlife habitat capacity on agricultural land in Canada, 1986-2006*, is one of several reports prepared on the status and trends of national cross-cutting themes. It has been prepared and reviewed by experts in the field of study and reflects the views of its authors.

Acknowledgements

The authors are grateful to Warren Eilers, Robin MacKay, Luella Graham and Alex Lefebvre of Agriculture and Agri-Food Canada (AAFC) for assistance in preparation of this Agri-Environmental Indicator and to the AAFC National Agri-Environmental Health Analysis and Reporting Program (NAHARP) for support of this work. We would also like to thank the three reviewers for their helpful comments and suggestions toward an improved version of the report.

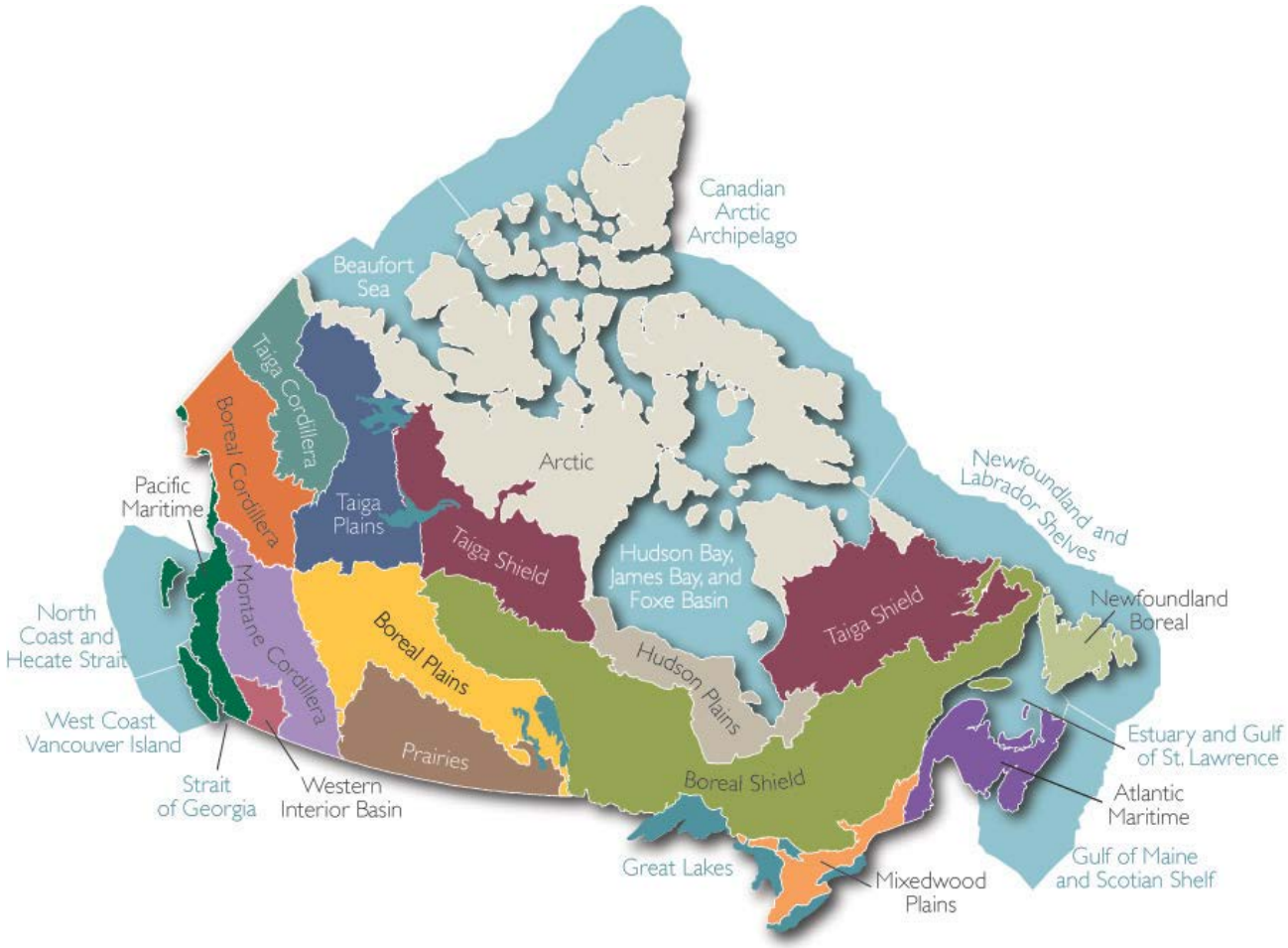
[1] Environment Canada. 2006. Biodiversity outcomes framework for Canada. Canadian Councils of Resource Ministers. Ottawa, ON. 8 p. http://www.biodivcanada.ca/default.asp?lang=En&n=F14D37B9-1

[2] Federal-Provincial-Territorial Biodiversity Working Group. 1995. Canadian biodiversity strategy: Canada's response to the Convention on Biological Diversity. Environment Canada, Biodiversity Convention Office. Ottawa, ON. 86 p. http://www.biodivcanada.ca/default.asp?lang=En&n=560ED58E-1

[3] Federal, Provincial and Territorial Governments of Canada. 2010. Canadian biodiversity: ecosystem status and trends 2010. Canadian Councils of Resource Ministers. Ottawa, ON. vi + 142 p. http://www.biodivcanada.ca/default.asp?lang=En&n=83A35E06-1

Ecological Classification System – Ecozones+

A slightly modified version of the Terrestrial Ecozones of Canada, described in the *National Ecological Framework for Canada*,[4] provided the ecosystem-based units for all reports related to this project. Modifications from the original framework include: adjustments to terrestrial boundaries to reflect improvements from ground-truthing exercises; the combination of three Arctic ecozones into one; the use of two ecoprovinces – Western Interior Basin and Newfoundland Boreal; the addition of nine marine ecosystem-based units; and, the addition of the Great Lakes as a unit. This modified classification system is referred to as "ecozones+" throughout these reports to avoid confusion with the more familiar "ecozones" of the original framework.[5]



[4] Ecological Stratification Working Group. 1995. A national ecological framework for Canada. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch. Ottawa/Hull, ON. 125 p. Report and national map at 1:7 500 000 scale.

[5] Rankin, R., Austin, M. and Rice, J. 2011. Ecological classification system for the ecosystem status and trends report. Canadian Biodiversity: Ecosystem Status and Trends 2010, Technical Thematic Report No. 1. Canadian Councils of Resource Ministers. Ottawa, ON. http://www.biodivcanada.ca/default.asp?lang=En&n=137E1147-1

Table of Contents

PREFACE I
Acknowledgements i
Ecological Classification System – Ecozones+ ii
LIST OF FIGURES IV
AGRI-ENVIRONMENTAL INDICATORS 1
INTRODUCTION 1
METHODOLOGY 1
BROAD-SCALE INTERPRETATION 3
Comparative value of land cover types used by wildlife in the Canadian agricultural landscape 3
INTERPRETATION BY ECOZONE+ 5
Atlantic Maritime Ecozone+ 5
Mixedwood Plains Ecozone+ 10
Boreal Shield Ecozone+ 16
Boreal Plains Ecozone+ 21
Prairies Ecozone+ 26
Montane Cordillera Ecozone+ 31
Western Interior Basin Ecozone+ 36
Pacific Maritime Ecozone+ 41
REFERENCES 46

List of Figures

Figure 1. Comparative value of cover types used by wildlife for breeding (top) and feeding (bottom) on agricultural land in Canada. 4

Figure 2. The percentage of agricultural land within the SLC polygons of the Atlantic Maritime Ecozone+, 2006. 5

Figure 3. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Atlantic Maritime Ecozone+ for 1986, 1996, and 2006 6

Figure 4. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Atlantic Maritime Ecozone+ in 1986, 1996, and 2006 (points and line, right axis). 7

Figure 5. Wildlife habitat capacity on agricultural land in the Atlantic Maritime Ecozone+, 1986 8

Figure 6. Wildlife habitat capacity on agricultural land in the Atlantic Maritime Ecozone+, 2006 8

Figure 7. Change in wildlife habitat capacity on agricultural land in the Atlantic Maritime Ecozone+ between 1986 and 2006 9

Figure 8. The percentage of agricultural land within the SLC polygons of the Mixedwood Plains Ecozone+, 2006. 11

Figure 9. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Mixedwood Plains Ecozone+ for 1986, 1996, and 2006 11

Figure 10. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Mixedwood Plains Ecozone+ in 1986, 1996, and 2006 (points and line, right axis). 12

Figure 11. Wildlife habitat capacity on agricultural land in the Mixedwood Plains Ecozone+, 1986. 13

Figure 12. Wildlife habitat capacity on agricultural land in the Mixedwood Plains Ecozone+, 2006. 13

Figure 13. Change in wildlife habitat capacity on agricultural land in the Mixedwood Plains Ecozone+ between 1986 and 2006 14

Figure 14. The percentage of agricultural land within the SLC polygons of the Boreal Shield Ecozone+, 2006. 16

Figure 15. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Boreal Shield Ecozone+ for 1986, 1996, and 2006 17

Figure 16. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Boreal Shield Ecozone+ in 1986, 1996, and 2006 (points and line, right axis). 18

Figure 17. Wildlife habitat capacity on agricultural land in the Boreal Shield Ecozone+, 1986. 19

Figure 18. Wildlife habitat capacity on agricultural land in the Boreal Shield Ecozone+, 2006. 19

Figure 19. Change in wildlife habitat capacity on agricultural land in the Boreal Shield Ecozone+ between 1986 and 2006. 20

Figure 20. The percentage of agricultural land within the SLC polygons of the Boreal Plains Ecozone+, 2006. 21
Figure 21. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Boreal Plains Ecozone+ for 1986, 1996, and 2006. 22
Figure 22. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Boreal Plains Ecozone+ in 1986, 1996, and 2006 (points and line, right axis). 23
Figure 23. Wildlife habitat capacity on agricultural land in the Boreal Plains Ecozone+, 1986. 24
Figure 24. Wildlife habitat capacity on agricultural land in the Boreal Plains Ecozone+, 2006. 24
Figure 25. Change in wildlife habitat capacity on agricultural land in the Boreal Plains Ecozone+ between 1986 and 2006. 25
Figure 26. The percentage of agricultural land within the SLC polygons of the Prairies Ecozone+, 2006. 26
Figure 27. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Prairies Ecozone+ for 1986, 1996, and 2006. 27
Figure 28. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Prairies Ecozone+ in 1986, 1996, and 2006 (points and line, right axis). 28
Figure 29. Wildlife habitat capacity on agricultural land in the Prairies Ecozone+, 1986. 29
Figure 30. Wildlife habitat capacity on agricultural land in the Prairies Ecozone+, 2006. 29
Figure 31. Change in wildlife habitat capacity on agricultural land in the Prairies Ecozone+ between 1986 and 2006. 30
Figure 32. The percentage of agricultural land within the SLC polygons of the Montane Cordillera Ecozone+, 2006. 32
Figure 33. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Montane Cordillera Ecozone+ for 1986, 1996, and 2006. 32
Figure 34. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Montane Cordillera Ecozone+ in 1986, 1996, and 2006 (points and line, right axis). 33
Figure 35. Wildlife habitat capacity on agricultural land in the Montane Cordillera Ecozone+, 1986. 34
Figure 36. Wildlife habitat capacity on agricultural land in the Montane Cordillera Ecozone+, 2006. 34
Figure 37. Change in wildlife habitat capacity on agricultural land in the Montane Cordillera Ecozone+ between 1986 and 2006. 35
Figure 38. The percentage of agricultural land within the SLC polygons of the Western Interior Basin Ecozone+, 2006. 37
Figure 39. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Western Interior Basin Ecozone+ for 1986, 1996, and 2006. 37

Figure 40. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Western Interior Basin Ecozone+ in 1986, 1996, and 2006 (points and line, right axis). 38
Figure 41. Wildlife habitat capacity on agricultural land in the Western Interior Basin Ecozone+, 1986. 39
Figure 42. Wildlife habitat capacity on agricultural land in the Western Interior Basin Ecozone+, 2006. 39
Figure 43. Change in wildlife habitat capacity on agricultural land in the Western Interior Basin Ecozone+ between 1986 and 2006. 40
Figure 44. The percentage of agricultural land within the SLC polygons of the Pacific Maritime Ecozone+, 2006. 42
Figure 45. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Pacific Maritime Ecozone+ for 1986, 1996, and 2006. 42
Figure 46. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Pacific Maritime Ecozone+ in 1986, 1996, and 2006 (points and line, right axis). 43
Figure 47. Wildlife habitat capacity on agricultural land in the Pacific Maritime Ecozone+, 1986. 44
Figure 48. Wildlife habitat capacity on agricultural land in the Pacific Maritime Ecozone+, 2006. 44
Figure 49. Change in wildlife habitat capacity on agricultural land in the Pacific Maritime Ecozone+ between 1986 and 2006. 45

AGRI-ENVIRONMENTAL INDICATORS

As part of the National Agri-Environmental Health Analysis and Reporting Program, Agriculture and Agri-Food Canada has developed a suite of science-based agri-environmental indicators. These were first reported in 2000 (for 1981 to 1996), updated in 2005 (for 1981 to 2001), and most recently reported in 2010 (for 1981 to 2006) (Eilers et al., 2010). Three of these indicators are presented by ecozone[+] as part of the Technical Thematic Report Series for *Canadian Biodiversity: Ecosystem Status and Trends 2010*. They are soil erosion on cropland (McConkey et al., 2011), residual soil nitrogen (Drury et al., 2011), and this report on wildlife habitat capacity.

All three of these agri-environmental indicators use data from the Canadian Census of Agriculture database. This database categorizes the agricultural landscape into four main cover types: Cropland, Pasture (broken down into Improved and Unimproved Pasture), Summerfallow, and All Other Land (All Other Land includes, for example, barnyards, woodlots, lanes, windbreaks, marshes, and bogs) (Huffman et al., 2006; Statistics Canada, 2008). The soil erosion and residual soil nitrogen Technical Thematic Reports focus on the agricultural land in production and therefore only use the first three cover types in their calculations (Unimproved Pasture is not included in the soil erosion analysis). This report, on the other hand, includes the All Other Land cover type when reporting on wildlife habitat capacity on agricultural land. The definition of "Cropland" in the soil erosion report differs from that used by the Canadian Census of Agriculture in that it includes the Census of Agriculture categories of Cropland, Improved Pasture, and Summerfallow when referring to "Cropland". For these reasons, numbers presented for the total amount of agricultural land or Cropland or proportions of different cover types for an ecozone[+] or region may differ slightly between the three agricultural reports prepared as part of the Technical Thematic Report Series for *Canadian Biodiversity: Ecosystem Status and Trends 2010*. Additional discrepancies may exist due to the methodology used to maintain anonymity of the data (see Eilers et al., 2010 for more information).

INTRODUCTION

The Wildlife Habitat Capacity on Agricultural Land Indicator provides a multi-species assessment of broad-scale trends in the potential ability of the Canadian agricultural landscape to provide suitable habitat for populations of terrestrial vertebrates.

METHODOLOGY

Wildlife habitat capacity was investigated on all land within the agricultural landscape of Canada for the years 1986, 1996, and 2006. The analysis was restricted to land reported in the Canadian Census of Agriculture (hereafter referred to as agricultural land) which included

Cropland, Summerfallow, and Pasture, as well as woodlands and wetlands reported by farmers as part of the agricultural landscape (Statistics Canada, 2008). All data were assembled and analyzed at the Soil Landscapes of Canada (SLC) polygon level which is the base unit of the Canadian Ecological Stratification Hierarchy.

Wildlife was initially linked to 31 cover types (habitats) within the Canadian agricultural landscape by constructing habitat association matrices for 588 species of birds, mammals, reptiles, and amphibians associated with agricultural land in Canada. For each species the matrices contained information on habitat use (breeding, feeding, cover, staging/migration, and wintering) and habitat value (primary, secondary, or tertiary). Primary habitat refers to land cover on which a species is dependant or is strongly preferred. Habitat was considered secondary if a species used it but was not dependant on it. Tertiary habitat is not needed, but a species is occasionally found there. Habitat values were incorporated into the analysis as modifiers to weight habitat use (primary = 1, secondary = 0.75 and tertiary = 0.25). The nested structure of habitat categories in the matrices allowed them to be rolled up to align with proportional land cover data derived from the Canadian Census of Agriculture yielding 15 habitat categories (Cereals, Winter Cereals, Oilseeds, Corn, Soybeans, Vegetables, Berries, Fruit Trees, Other Crops (potatoes, tobacco, millet, caraway, ginseng, coriander), Pulses, Summerfallow, Tame Hay, Improved Pasture, Unimproved Pasture, and All Other Land) for habitat capacity analysis. Land cover types in the All Other Land category included wetland (with margins, without margins, and open water), riparian (woody, herbaceous, and crop), shelterbelts (including natural hedgerows), woodland (with interior, without interior, plantation), idle land/old field, and anthropogenic (farm buildings, green houses, lanes). Individual species and their habitat use information were spatially linked to Census of Agriculture land cover data by rectifying distributions to SLC polygons.

For each SLC, species-specific habitat availability (SSHA) was calculated for breeding and feeding requirements, by generating a weighted average of habitat use based on the relative proportion of cover types used and the value of that habitat to the species as follows:

$$SSHA_{bf} = \sum (\%LC_b \times HUV_b) + \sum (\%LC_f \times HUV_f)$$

Where: %LC = the percentage of SLC polygon occupied by a particular land cover category used by the species and HUV = Habitat Use Value for breeding (b) and feeding (f) (primary = 1, secondary = 0.75, tertiary = 0.25).

Habitat Capacity based on breeding and feeding is the average of SSHAs per SLC polygon.

The "status" of habitat capacity on agricultural land in Canada for 1986 and 2006 was determined by generating ten categories (**Very Low**: <20, 20-30, **Low**: 30-40, 40-50, **Moderate**: 50-60, 60-70, **High**: 70-80, 80-90 and **Very High**: 90-100, >100) based on the national distribution of habitat capacity scores from all reporting SLC polygons.

Trend was determined through an analysis of Variance followed by pairwise comparison of means (Tukey's HSD) to detect significant changes ($p<0.05$) in habitat capacity for SLC polygons among years.

BROAD-SCALE INTERPRETATION

For proper interpretation, it must be noted that agricultural landscapes are dynamic, with beneficial and detrimental land cover change often happening concurrently, especially when analyzed at broader spatial scales. The nature of these changes and the resulting land cover mosaic determined the habitat capacity of the landscape and the structure of wildlife communities. Different wildlife species may have different, yet concurrent responses to land cover change. Certain species dependant on a particular habitat would be negatively affected by its loss, while other species may benefit from the newly created land cover. Also, an expanding agricultural landscape initially added natural/semi-natural land that, through time, will be brought under production. So, when assessed at broad-scales, expanding agriculture with its inherently higher natural land content, counterbalanced declining natural habitat in more established areas within the agricultural landscape. Because areas experiencing gains and losses were spatially explicit, proportional constancy of a particular land cover type (habitat) represented at broader spatial scales (nationally or ecozone[+]) did not capture the impact of habitat change on wildlife at finer scales (regionally or locally).

Comparative value of land cover types used by wildlife in the Canadian agricultural landscape

Figure 1 provides comparative breeding and feeding values of land cover types used in the habitat capacity analysis. The value of a particular land cover type was based on the number of species it supported and its habitat value to them (that is, whether it was primary, secondary, or tertiary). All Other Land (which included woodland, wetland, and riparian areas) ranked highest, followed by Unimproved Pasture (natural land for pasture); demonstrating the importance of these natural/semi-natural land cover types for wildlife. Improved Pasture, Tame Hay, and Fruit Trees ranked next but had a marked decline in their value as both breeding and feeding habitat. Cultivated lands[6] were characterized by comparatively low value for wildlife, especially in terms of breeding habitat.

The value of All Other Land is further emphasized when one considers that 75% (440) of species that use agricultural land in Canada can fulfill both their breeding and feeding habitat requirements entirely within the natural/semi-natural lands contained within this land cover category. In contrast, only 13% (79) of species can fulfill both breeding and feeding requirements on Cropland habitats.[7] When other land cover types (primarily All Other Land/Unimproved Pasture) are present in the agricultural landscape, however, the value of cultivated land for wildlife increases dramatically as 36% (203) of species utilize Cropland for a single habitat requirement (either breeding or feeding). A total of 29% (173) of species could use

[6] Cultivated land includes Summerfallow and annual crops (Oilseeds, Pulses, Soybeans, Cereals, Corn, Tame Hay, Other Crops, Vegetables, and Winter Cereals).

[7] Cropland includes all agricultural land except for All Other Land, Unimproved Pasture, Improved Pasture, and Summerfallow.

Unimproved Pasture for both breeding and feeding habitat. When other land cover types are present to provide for a single habitat requirement, 48% (282) of species could then utilize Unimproved Pasture. This demonstrates that the value of certain cover types can fluctuate based on the presence of complimentary habitats that fulfill partial life history requirements. Therefore, the maintenance of heterogeneous agricultural landscapes can often benefit wildlife.

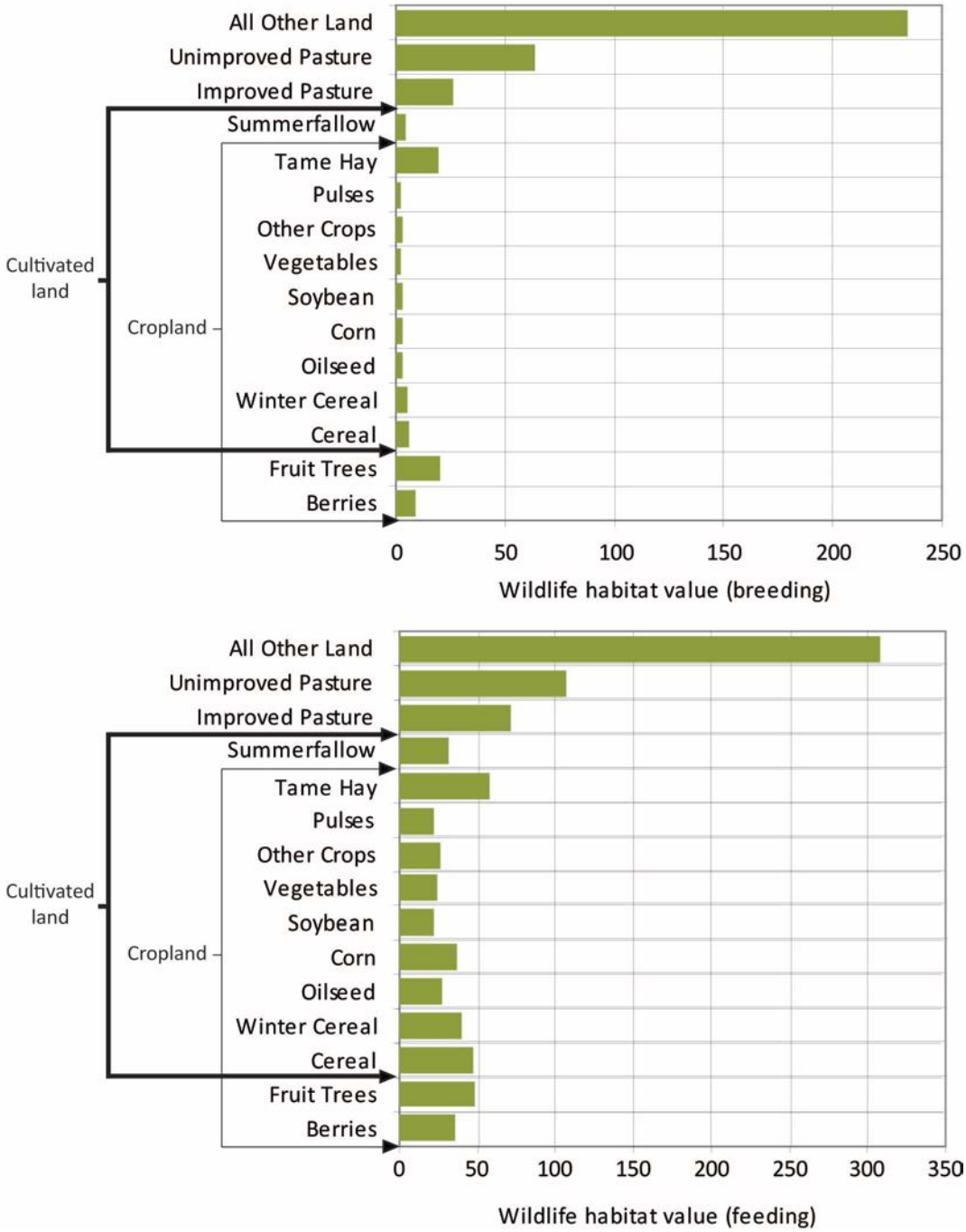


Figure 1. Comparative value of cover types used by wildlife for breeding (top) and feeding (bottom) on agricultural land in Canada.
The scale on the x-axis is the sum of the habitat values.

INTERPRETATION BY ECOZONE+

Atlantic Maritime Ecozone+

Agricultural landscapes

The agricultural landscape[8] comprised close to 10% of the Atlantic Maritime Ecozone+ in 2006 and was characterized by generally small scale farming that included, beef, hog, and poultry production, dairy operations, and the growing of vegetables, fruits, and berries. With the exception of a few areas of higher production located in the Prince Edward Island, Annapolis Minas Lowlands, Saint John River Valley, and the Appalachians ecoregions, agriculture made up a relatively small component of the broader landscape (Figure 2) and consisted of a diversity of cover types that included a considerable amount of natural and semi-natural land.

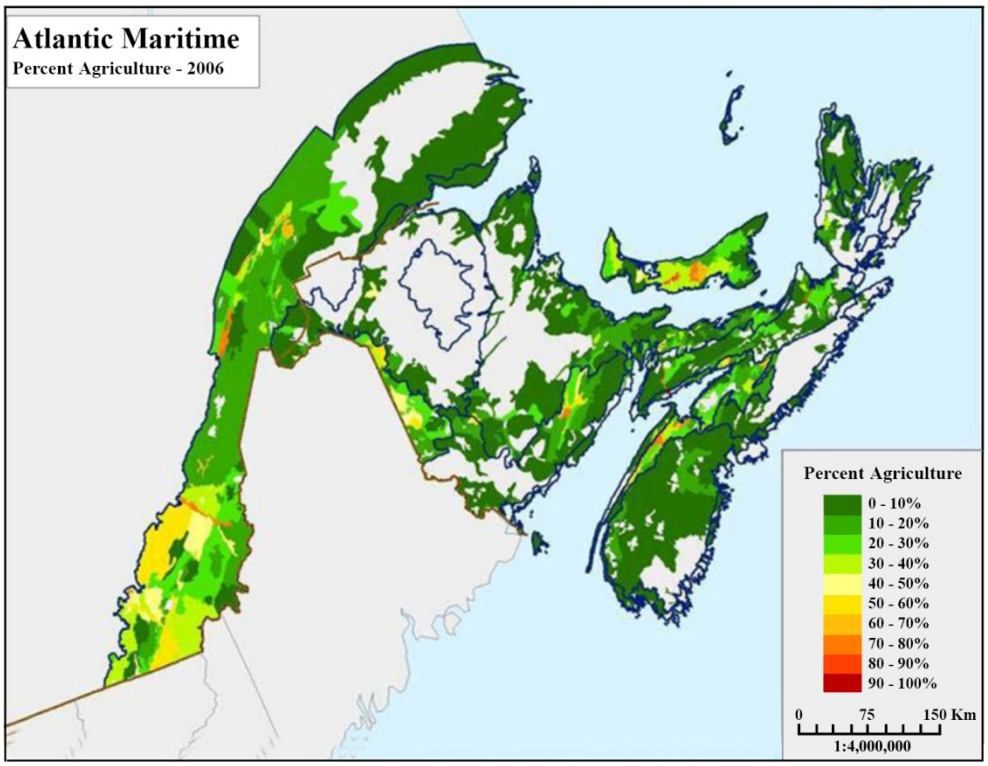
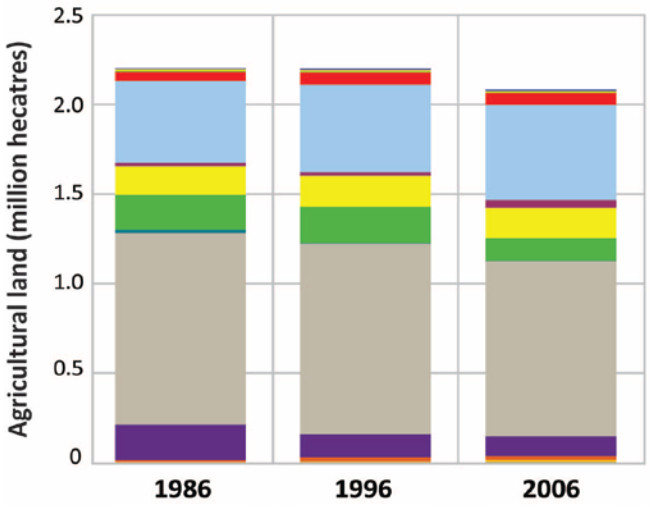


Figure 2. The percentage of agricultural land within the SLC polygons of the Atlantic Maritime Ecozone+, 2006.

From 1986 to 2006, the total agricultural landscape shrank by about 6% (2.20 to 2.08 million hectares). Figure 3 shows the total agricultural area and the amount of land per cover type in

[8] The agricultural landscape (or agricultural land), as discussed throughout this report, includes the "All Other Land" category from the Census of Agriculture, which is made up of areas such as wetlands, riparian zones, shelterbelts, woodlands, idle land/old fields, and anthropogenic areas (farm buildings, green houses, and lanes).

1986, 1996, and 2006. All Other Land was the dominant land cover type in the Atlantic Maritime Ecozone+ making up close to half of the total agricultural landscape in all 3 years. Over twenty years, the share of All Other Land declined from approximately 49 to 47% of the agricultural landscape. Tame Hay was the second most abundant cover type expanding its share from 21 to 26%. Both Improved Pasture (9 to 5%) and Unimproved Pasture (9 to 6%) declined. The share of Other Crops expanded from 2 to 3% mainly due to increased potato production in Prince Edward Island and the Saint John River Valley.



	Percentage of agricultural land		
Cover type	1986	1996	2006
Winter Cereals	0.3	0.3	0.4
Vegetables	0.4	0.4	0.3
Fruit Trees	0.3	0.2	0.2
Other Crops	2.3	3.2	3.2
Tame Hay	20.7	22.2	25.6
Corn	0.8	0.9	2.1
Cereals	7.4	7.8	8.0
Unimproved Pasture	8.8	9.3	6.1
Summerfallow	0.8	0.1	0.1
All Other Land	48.6	48.3	47.0
Improved Pasture	8.9	5.9	5.2
Berries	0.5	1.1	1.0
Soybeans	0.1	0.2	0.7
Pulses	0.0	0.0	0.0
Oilseeds	0.0	0.0	0.1

Figure 3. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Atlantic Maritime Ecozone+ for 1986, 1996, and 2006.

Potential wildlife use of agricultural land

A total of 292 species (215 birds; 52 mammals; 9 reptiles; 16 amphibians) potentially used agricultural land in the Atlantic Maritime Ecozone+. The considerable natural and semi-natural land component of the agricultural landscape supported many species and was the primary reason for the generally high habitat capacity within the ecozone+. All Other Land was clearly the most important land cover for wildlife as 88% (257) of species associated with agricultural land could use it to fulfill all the breeding and feeding habitat requirements. In sharp contrast, only 17% (50) of species can fulfill both breeding and feeding requirements on cultivated land.[9] However, when natural land was present, 27% (79) of species are able to use cultivated land for at least a single habitat requirement (either breeding or feeding).

Wildlife habitat capacity

In 2006, average wildlife habitat capacity on agricultural land in the Atlantic Maritime Ecozone+ was rated as high (88.7 ± 18.7) despite a significant decline since 1986 (93.2 ± 16.1) (ANOVA, $F = 14.2$, Tukey HSD $p<0.05$) (Figure 4). The spatial distribution of habitat capacity values for

[9] Cultivated land includes Summerfallow and annual crops (Oilseeds, Pulses, Soybeans, Cereals, Corn, Tame Hay, Other Crops, Vegetables, and Winter Cereals).

1986 and 2006 are shown in Figure 5 and Figure 6. Over 20 years, habitat capacity decreased on 43% of agricultural land in this ecozone+, increased on 28%, and was constant on 29% (Figure 7).

Declining habitat capacity trends were associated with a number of ecoregions reporting more intensive agricultural activity. In the Prince Edward Island Ecoregion, habitat capacity fell from 57.6 ± 10.9 (moderate) in 1986 to 48.3 ± 7.9 (low) in 2006 to rank as the lowest in the ecozone+. Other ecoregions that had significant habitat capacity decline were the Saint John River Valley (85.9 ± 13.9 to 73.9 ± 22.0) and Appalachians (84.4 ± 12.7 to 77.0 ± 17.2) (ANOVA, Tukey HSD $p<0.05$). Among ecoregions with more intensive agriculture production, only the Annapolis Minas Lowlands had constant habitat capacity (85.5 ± 14.0 to 85.6 ± 13.7).

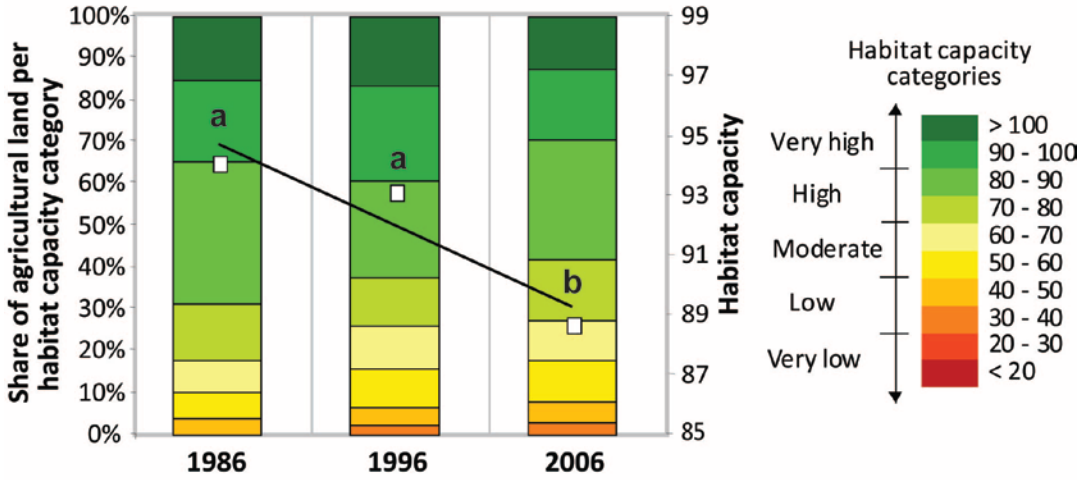


Figure 4. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Atlantic Maritime Ecozone+ in 1986, 1996, and 2006 (points and line, right axis). Years with different letters differed significantly (ANOVA: F = 14.2, Tukey HSD p<0.05).

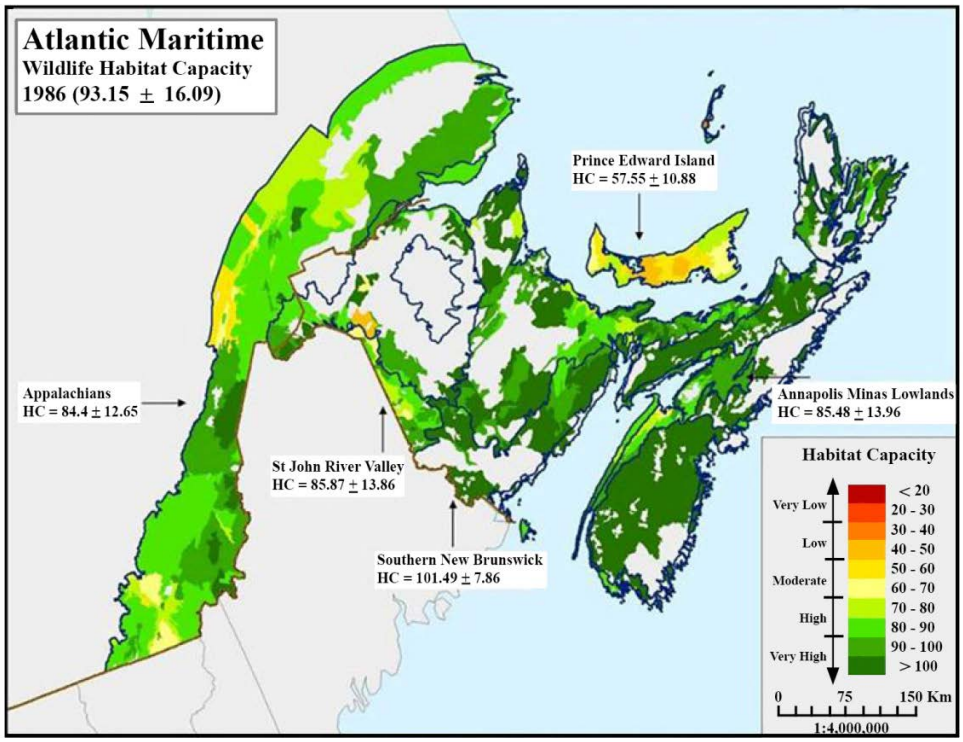


Figure 5. Wildlife habitat capacity on agricultural land in the Atlantic Maritime Ecozone[+], 1986. HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

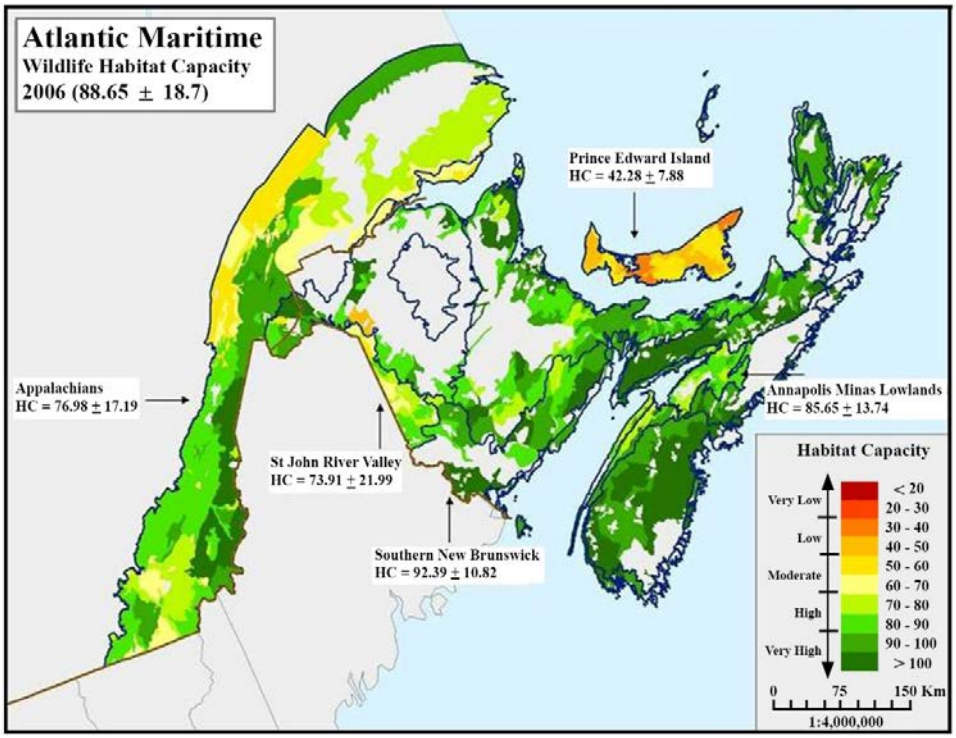


Figure 6. Wildlife habitat capacity on agricultural land in the Atlantic Maritime Ecozone[+], 2006. HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

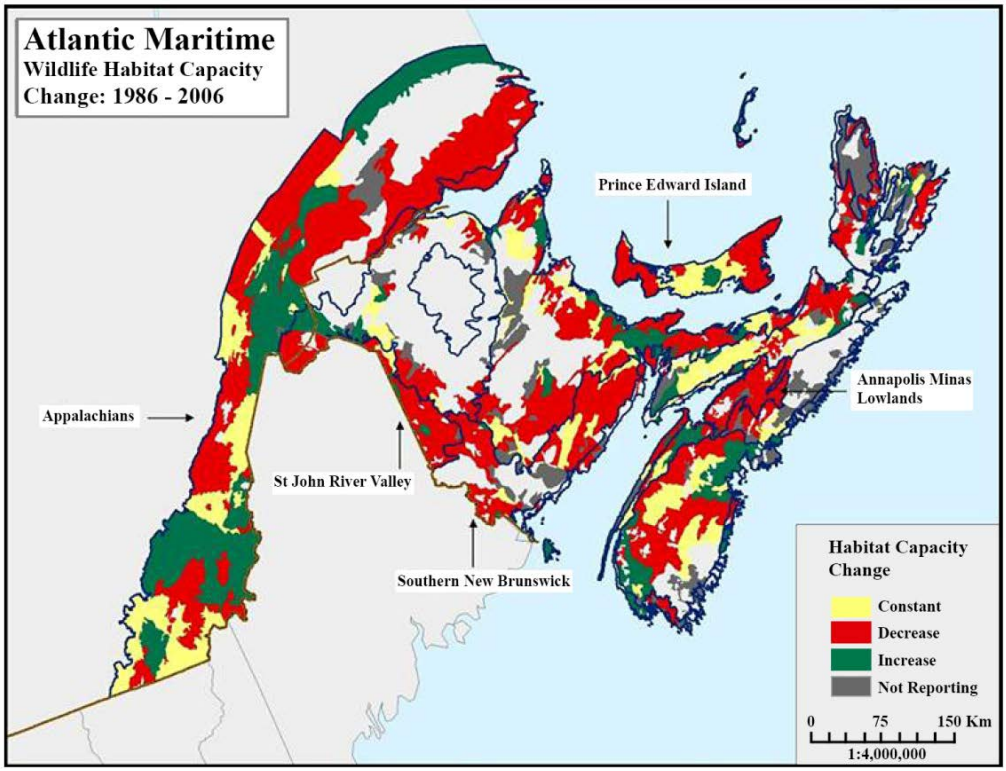


Figure 7. Change in wildlife habitat capacity on agricultural land in the Atlantic Maritime Ecozone[+] between 1986 and 2006.
ANOVA, Tukey HSD p<0.05. All SLC polygons with >5% agricultural land were included in the analysis.

Interpretation

The relatively light agricultural footprint along with the presence of abundant, high value habitat on agricultural land presented considerable wildlife habitat options, both on and adjacent to, agricultural land in much of the ecozone[+]. As such, the influence of agriculture on habitat is much less here than in the major Canadian agricultural ecozones[+]. Still, agriculture's occupation of the Atlantic Maritime's most productive sites, especially river valleys, means that wildlife habitat availability is affected in these areas. Although the total area of agricultural land shrank by about 6%, the share of Cropland[10] expanded from 33 to 42% and All Other Land was reduced from 49 to 47%.

The significant decline in habitat capacity between 1996 and 2006 resulted from a general expansion of the comparatively low habitat value Cropland component of the agricultural landscape (33 to 42%). As a result, there was a shift in the share of agricultural land with comparatively higher wildlife value land covers (All Other Land: 49 to 47%, Unimproved Pasture: 9 to 6%, Improved Pasture: 9 to 5%) to those with lesser values (Tame Hay: 21 to 26%,

[10] Cropland includes all agricultural land except for All Other Land, Unimproved Pasture, Improved Pasture, and Summerfallow.

Other Crops (potatoes): 2 to 3%, Corn: 1 to 2%). Despite this decline, average wildlife habitat capacity in the Atlantic Maritime remained high.

The ecoregions with higher agricultural production, with the exception of Annapolis Minas Lowlands, all reported declines in habitat capacity. Habitat capacity decline in the Appalachians was primarily due to the loss of Unimproved Pasture (10 to 6%) and Improved Pasture (10 to 5%) as the share of Cropland increased from 32 to 41%. In the Saint John River Valley and Prince Edward Island ecoregions, expanding potato production (14 to 19% and 10 to 16% respectively) and associated rotational crops, along with concurrent losses of All Other Land (46 to 41% and 28 to 22%, respectively) were the main drivers of wildlife habitat capacity decline. In both of these ecoregions the share of Cropland expanded (Saint John River Valley: 41 to 51%; Prince Edward Island: 56 to 68%). With the exception of Prince Edward Island, wildlife habitat capacity in ecoregions with higher agricultural production still ranked high as natural and semi-natural continued to make up approximately half of total land cover. In Prince Edward Island, All Other Land made up a considerably smaller proportion of the agricultural landscape, declining from 28 to 22%. The net changes in land cover in the Prince Edward Island Ecoregion reduced habitat capacity from moderate (57.6 ± 10.9) in 1986 to low (48.3 ± 7.9) in 2006.

Mixedwood Plains Ecozone^{+}

Agricultural landscapes

The agricultural landscape[11] in the Mixedwood Plains Ecozone^{+} is characterized by corn, soybeans, grains, hay and fruit production, and dairy operations. The agricultural landscape expanded between 1986 and 2006 from approximately 6.0 to 6.5 million hectares to comprise around 60% (Figure 8) of the ecozone^{+}.

Figure 9 shows the total agricultural land area and the amount of land per cover type in 1986, 1996, and 2006. Over this period the share of Cropland[12] expanded from 61 to 70% of the agricultural landscape representing an intensification of agriculture based primarily on the substantial increase in Soybean production (7 to 16%). The share of the other major crops in the Mixedwood Plains (Corn) was stable comprising around 19% of total agricultural land. Unimproved Pasture (10 to 6%), Improved Pasture (8 to 5%), and All Other land (19.9 to 19.6%) declined while Tame Hay (12 to 19%) increased.

[11] The agricultural landscape (or agricultural land), as discussed throughout this report, includes the "All Other Land" category from the Census of Agriculture, which is made up of areas such as wetlands, riparian zones, shelterbelts, woodlands, idle land/old fields, and anthropogenic areas (farm buildings, green houses, and lanes).

[12] Cropland includes all agricultural land except for All Other Land, Unimproved Pasture, Improved Pasture, and Summerfallow.

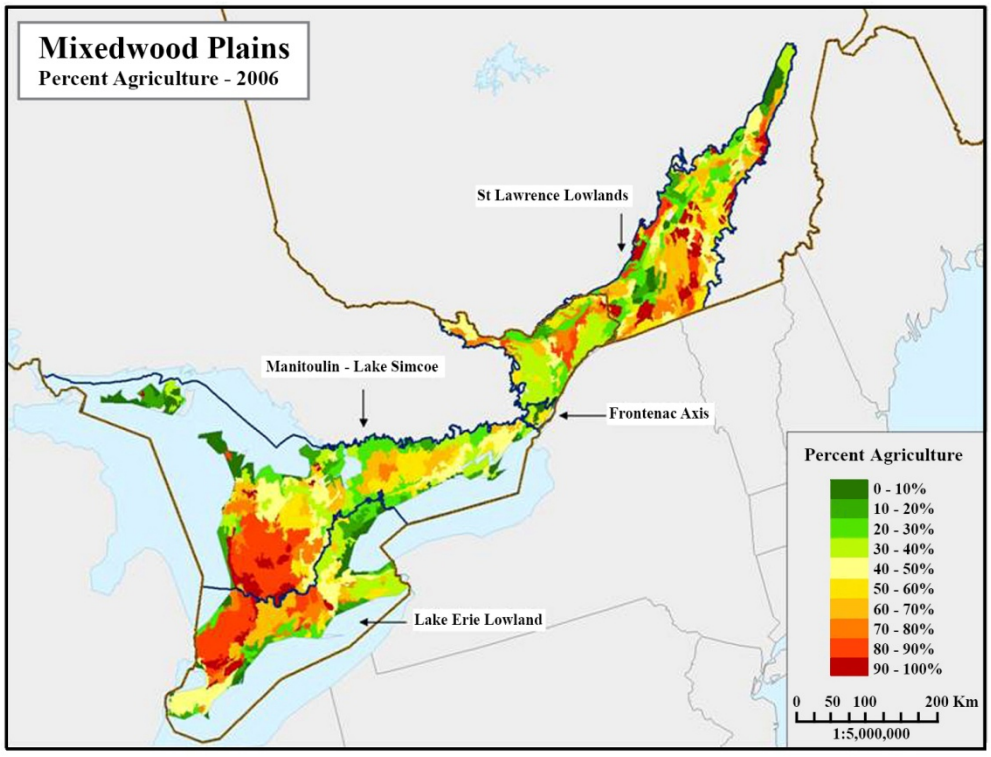
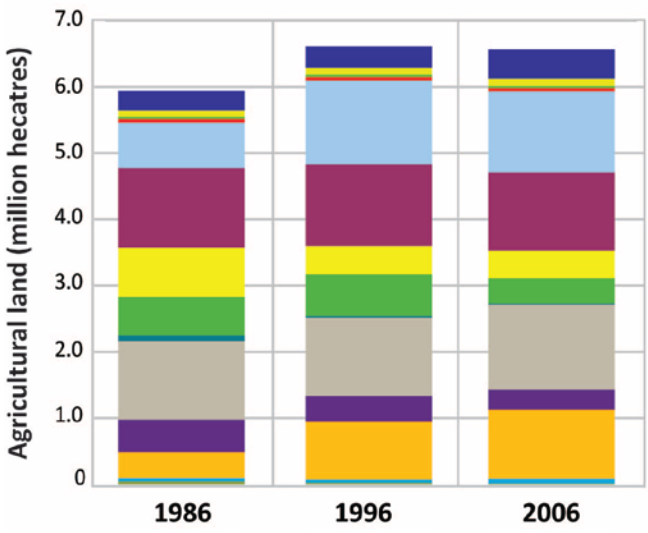


Figure 8. The percentage of agricultural land within the SLC polygons of the Mixedwood Plains Ecozone[+], 2006.



Cover type	Percentage of agricultural land 1986	1996	2006
Winter Cereals	4.9	4.9	6.8
Vegetables	1.6	1.5	1.6
Fruit Trees	0.6	0.5	0.4
Other Crops	0.9	0.9	0.8
Tame Hay	11.5	19.1	18.7
Corn	20.2	18.7	18.0
Cereals	12.6	6.5	6.3
Unimproved Pasture	9.8	9.5	5.8
Summerfallow	1.5	0.4	0.2
All Other Land	19.9	17.9	19.6
Improved Pasture	8.2	5.9	4.6
Berries	0.1	0.1	0.1
Soybeans	6.5	13.2	15.8
Pulses	1.0	0.7	1.1
Oilseeds	0.7	0.3	0.2

Figure 9. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Mixedwood Plains Ecozone[+] for 1986, 1996, and 2006.

Potential wildlife use of agricultural lands

A total of 355 wildlife species (252 birds; 58 mammals; 24 reptiles; 21 amphibians) used agricultural land in the Mixedwood Plains Ecozone[+]. Of these, 86% (305) of species could fulfill their breeding and feeding habitat requirements within the cover types represented in the All Other Land category. In contrast, only 15% (53) of species had both these requirements met on Cropland alone. Twenty-six percent of species (91) could use Cropland habitat for a single habitat requirement (either breeding or feeding) given that sufficient alternative land cover was present to meet the other habitat requirement. Similarly, 19% (66) of species used Unimproved Pasture for both breeding and feeding, while 33% (118) utilized this cover type for a single requirement.

Wildlife habitat capacity

Average wildlife habitat capacity on agricultural land declined significantly from 1986 to 2006 (52.5 ± 17.7 to 50.0 ± 14.6) (ANOVA, F = 3.19, p = 0.041) (Figure 10). The spatial distribution of habitat capacity values for these years are shown in Figure 11 and Figure 12 respectively. Over this period, habitat capacity decreased on 36% of agricultural land, increased on 20%, and was constant on 45% (Figure 13).

Habitat capacity on agricultural land declined in all ecoregions within the Mixedwood Plains. The Lake Erie Lowlands had the lowest habitat capacity (38.2 ± 14.1to 37.8 ± 10.3) among ecoregions followed by Manitoulin-Lake Simcoe (52.3 ± 12.2 to 47.3 ± 8.3), Frontenac Axis (64.9 ± 4.2 to 50.7 ± 0.7 and St Lawrence Lowlands (56.9 ± 17.1 to 56.7 ± 15.5).

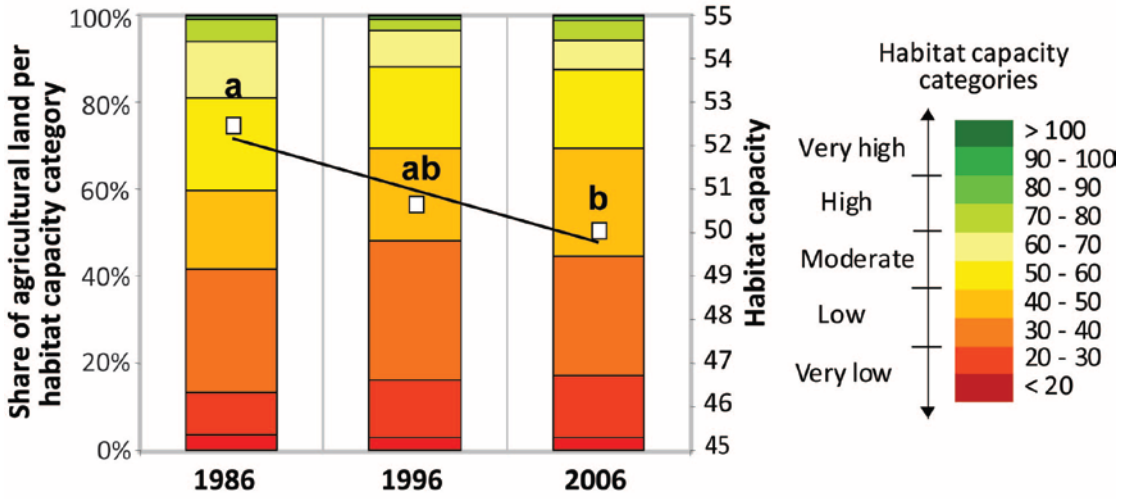


Figure 10. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Mixedwood Plains Ecozone[+] in 1986, 1996, and 2006 (points and line, right axis).
Years with different letters differed significantly (ANOVA: F = 3.19, Tukey HSD p<0.05).

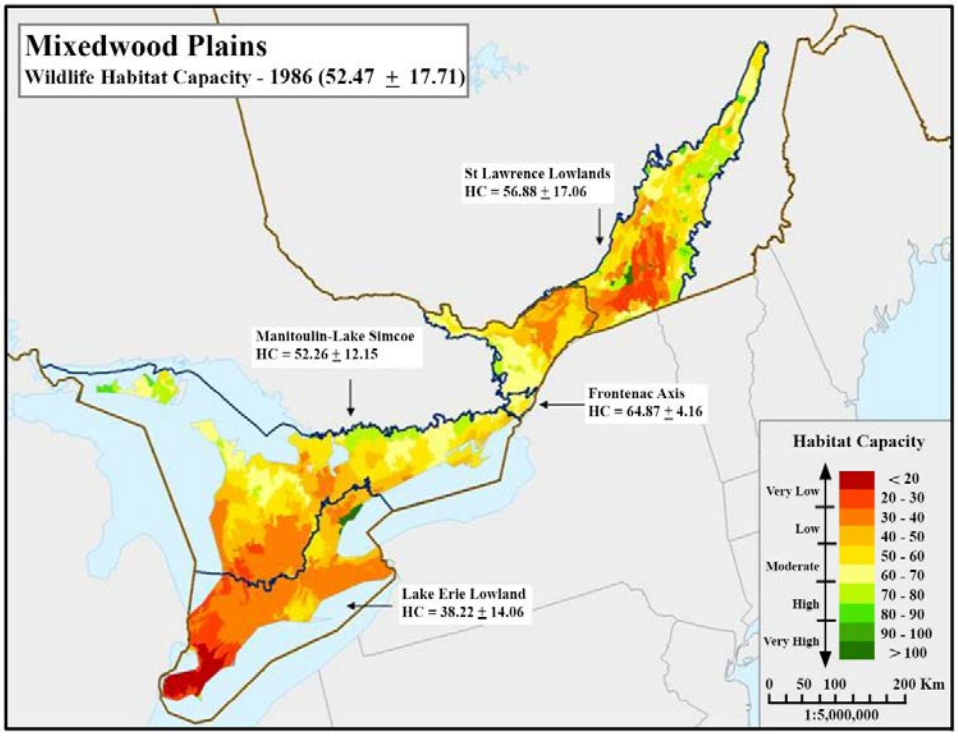


Figure 11. Wildlife habitat capacity on agricultural land in the Mixedwood Plains Ecozone[+], 1986. HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

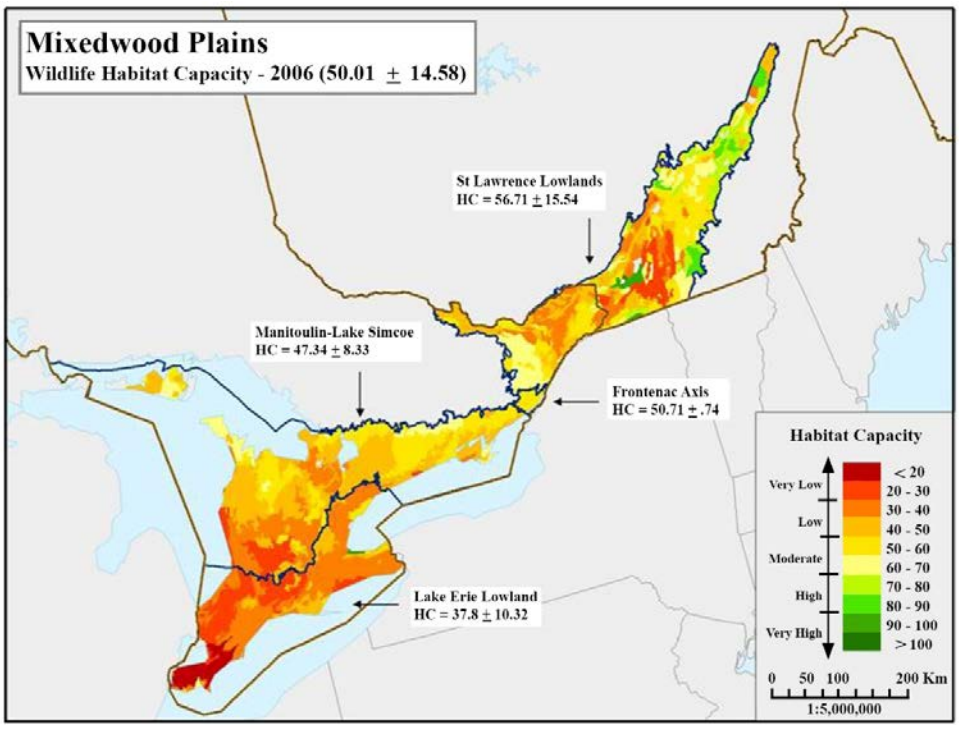


Figure 12. Wildlife habitat capacity on agricultural land in the Mixedwood Plains Ecozone[+], 2006. HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

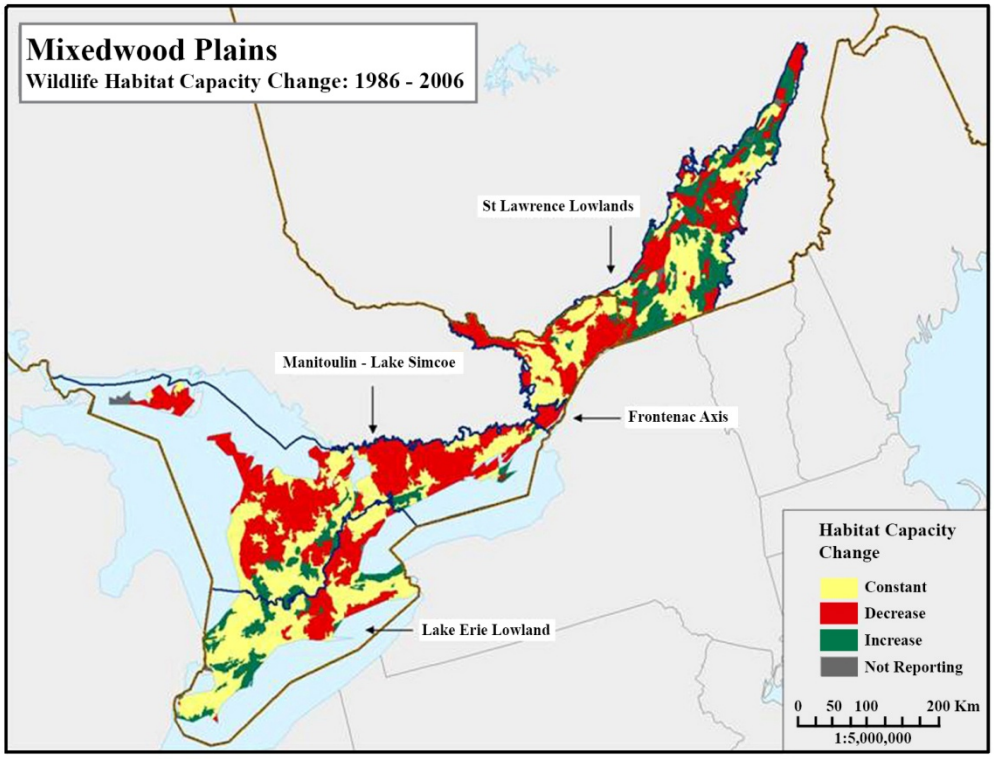


Figure 13. Change in wildlife habitat capacity on agricultural land in the Mixedwood Plains Ecozone⁺ between 1986 and 2006.
ANOVA, Tukey HSD p<0.05. All SLC polygons with >5% agricultural land were included in the analysis.

Interpretation

The current status of habitat capacity (low) in the Mixedwood Plains Ecozone⁺ is attributable to Cropland comprising close to 70% of the agricultural landscape – much of which is under intensive agricultural production, leaving only limited natural and semi-natural land cover to provide suitable habitat needed by the majority of species to fulfill breeding and feeding requirements.

The intensification of agriculture was the primary cause of the significant habitat capacity decline that occurred between 1986 and 2006 as the share of total agricultural land with Soybean more than doubled from 7 to 16%. When combined with Corn, which actually declined slightly over this period (20 to 18%), the expansion of Soybean represented an expanded portion of agricultural land with cover types of little value as wildlife habitat (27 to 34%). The expansion of intensive agricultural production reduced the share of comparatively more valuable wildlife habitat such as All Other Land (19.9 to 19.6%), Unimproved Pasture (10 to 6%), and Improved Pasture (8 to 5%) and was the primary driver of habitat capacity decline in the ecozone⁺. The majority of Unimproved Pasture decline occurred between 1996 and 2006 and given its relatively small share of total agricultural land to start with represented additional pressure on grassland dependant species. The expansion of Tame Hay (12 to 19%) had variable impact on habitat capacity depending on what cover type was converted. Land converted from Cereals to

Tame Hay would benefit wildlife whereas any conversion of All Other Land, Unimproved Pasture, or Improved Pasture to Tame Hay reduced habitat capacity of agricultural land.

The major variability in the status of habitat capacity among ecoregions in the Mixedwood Plains in 2006 primarily resulted from the amount and type of Cropland along with the relative share of natural/semi-natural land. The Lake Erie Lowland reported the lowest habitat capacity (low: 37.8 ± 10.3) as Cropland comprised over 82% of the agricultural landscape (Corn/Soybean close to 50%) with only 13% All Other Land and 2% Unimproved Pasture. Higher habitat capacity in the Frontenac Axis (50.7 ± 0.7) and Manitoulin-Lake Simcoe (47.3 ± 8.3) and Saint Lawrence Lowlands (56.7 ± 15.5) was due to comparatively lower share of Cropland (52, 66 and 66% respectively) and greater All Other Land (21, 18 and 26%, respectively). The higher All Other Land component in the Saint Lawrence Lowlands was the main reason for this ecoregion reporting the highest habitat capacity on agricultural land in the Mixedwood Plains Ecozone[+]. There were, however, other agricultural land use differences among these ecoregions, that impacted wildlife habitat capacity. Intensive Corn/Soybean production was considerably higher in Saint Lawrence Lowlands (32%) and Manitoulin-Lake Simcoe (30%) as compared to the Frontenac Axis which had less than 1% Soybean and 17% Corn. The Frontenac Axis had considerably more Unimproved Pasture (20%); the second most important cover type for wildlife, than did the Saint Lawrence Lowlands (5%) and Manitoulin-Lake Simcoe (9%).

Habitat capacity on agricultural land declined in all ecoregions within the Mixedwood Plains between 1986 and 2006. As for the ecozone[+] as a whole, the main driver of habitat capacity decline in the Lake Erie Lowland, Manitoulin-Lake Simcoe, and Saint Lawrence Lowlands ecoregions was the intensification of agriculture with the Saint Lawrence Lowlands and Manitoulin-Lake Simcoe also experiencing loss of Unimproved Pasture (10 to 5% and 14 to 9% respectively). Unimproved Pasture declined only by 1% in the Lake Erie Lowland (3 to 2 %), however this reduction of an already small, yet important cover type certainly impacted the value of agricultural land as wildlife habitat. Habitat capacity decline in the Frontenac Axis did not result from intensification of farming but rather the loss of All Other land (28 to 21%) and Improved Pasture (13 to 7%) along with a slight decline in Unimproved Pasture (22 to 20%).

Boreal Shield Ecozone+

Agricultural landscapes

Agriculture in the Boreal Shield Ecozone+ is limited to a few areas where soil quality and microclimate are suitable. From 1986 to 2006, approximately 193,000 hectares were removed from the agricultural landscape[13] leaving just over 1.3 million hectares of agricultural land which made up less than 1% of the ecozone+ (Figure 14). Figure 15 shows total agricultural land area and the amount of land per each cover type for 1986, 1996, and 2006. All Other Land was the dominant cover type but declined from 40 to 30% of total agricultural land area. Unimproved Pasture and Improved Pasture declined (17 to 15% and 9 to 8%, respectively) while Tame Hay increased its share from 20 to 29%. Overall the share of agricultural land comprised of Cropland[14] expanded by around 15%.

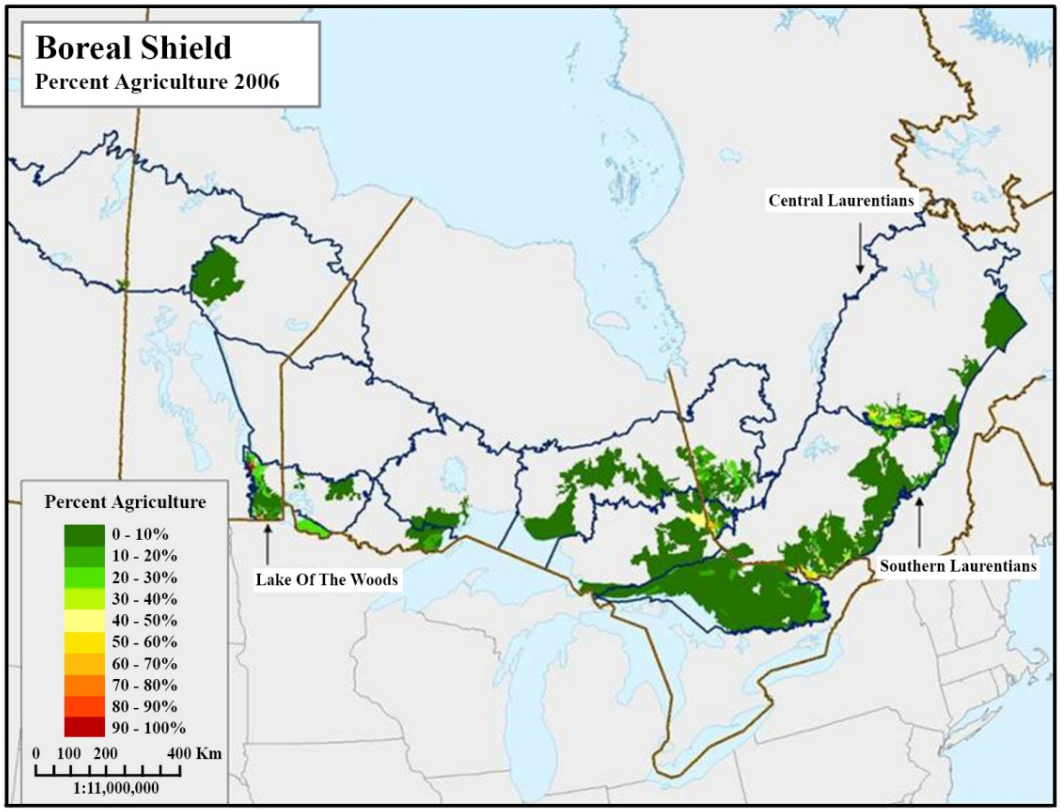
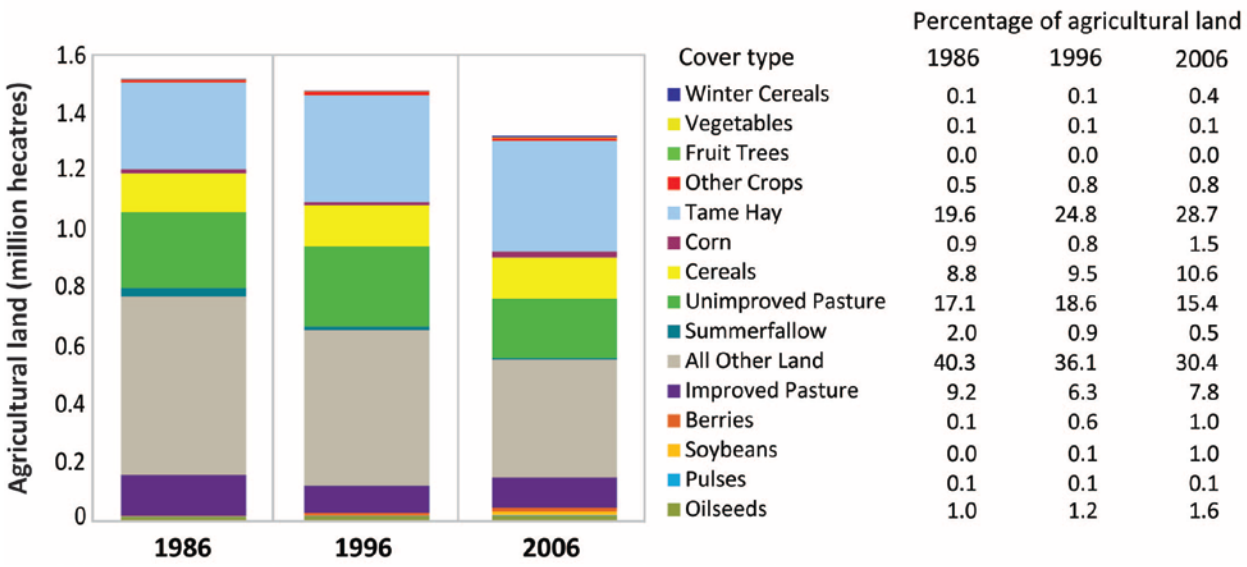


Figure 14. The percentage of agricultural land within the SLC polygons of the Boreal Shield Ecozone+, 2006.

[13] The agricultural landscape (or agricultural land), as discussed throughout this report, includes the "All Other Land" category from the Census of Agriculture, which is made up of areas such as wetlands, riparian zones, shelterbelts, woodlands, idle land/old fields, and anthropogenic areas (farm buildings, green houses, and lanes).

[14] Cropland includes all agricultural land except for All Other Land, Unimproved Pasture, Improved Pasture, and Summerfallow.



Cover type	Percentage of agricultural land 1986	1996	2006
Winter Cereals	0.1	0.1	0.4
Vegetables	0.1	0.1	0.1
Fruit Trees	0.0	0.0	0.0
Other Crops	0.5	0.8	0.8
Tame Hay	19.6	24.8	28.7
Corn	0.9	0.8	1.5
Cereals	8.8	9.5	10.6
Unimproved Pasture	17.1	18.6	15.4
Summerfallow	2.0	0.9	0.5
All Other Land	40.3	36.1	30.4
Improved Pasture	9.2	6.3	7.8
Berries	0.1	0.6	1.0
Soybeans	0.0	0.1	1.0
Pulses	0.1	0.1	0.1
Oilseeds	1.0	1.2	1.6

Figure 15. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Boreal Shield Ecozone⁺ for 1986, 1996, and 2006.

Potential wildlife use of agricultural land

A total of 349 species (249 birds; 60 mammals; 21 reptiles; 19 amphibians) used agricultural land in the Boreal Shield Ecozone⁺. All Other Land with its diverse natural and semi-natural land cover was the most important land cover as it provided both breeding and feeding habitat for 85% (298) of species associated with agricultural land. Unimproved Pasture provided both breeding and feeding habitat for 17% (59) of species and at least a single habitat requirement for 32% (112). Only 13% (46) of species could fulfill both breeding and feeding habitat needs entirely on Cropland while 26% (89) could utilize these cover types for a single habitat requirement.

Wildlife habitat capacity

Wildlife habitat capacity on agricultural land in the Boreal Shield Ecozone⁺ declined significantly between 1986 and 2006 from 79.7 ± 13.4 to 63.8 ± 14.4 to rank as moderate (ANOVA, $F = 88.6$, $p = 0.0001$) (Figure 16). Figure 17 and Figure 18 show the spatial distribution of habitat capacity values for 1986 and 2006. Over this period, habitat capacity decreased on 71% of farmland, increased on 6%, and was constant on 23% (Figure 19).

Among the ecoregions with higher agriculture production, the Central Laurentians had the largest decline in habitat capacity (78.0 ± 15.4 to 59.4 ± 11.5) followed by the Southern Laurentians (83.4 ± 12.1 to 73.8 ± 14.8) and Lake of the Woods (58.0 ± 13.9 to 51.3 ± 9.8).

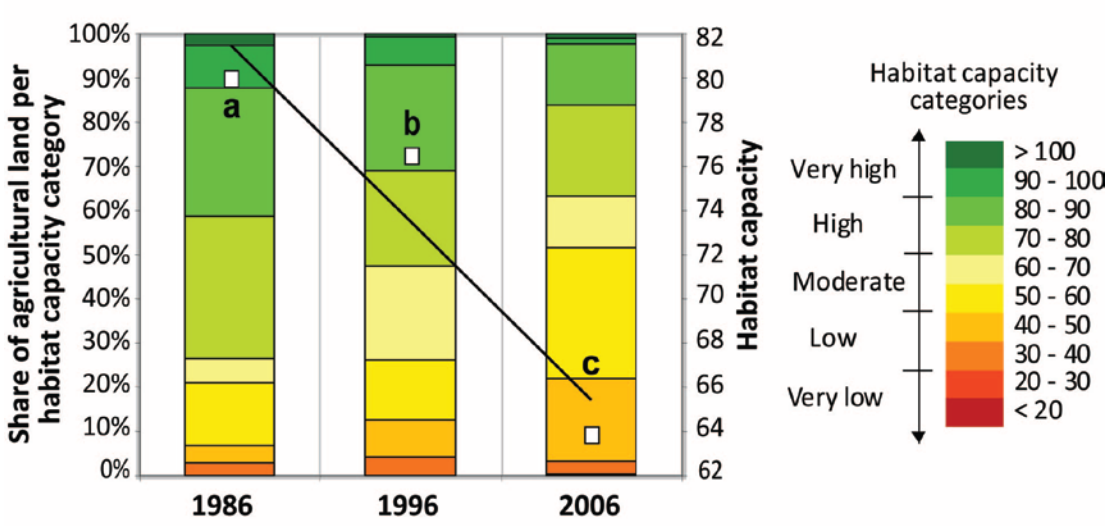


Figure 16. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Boreal Shield Ecozone[+] in 1986, 1996, and 2006 (points and line, right axis).
Years with different letters differed significantly (ANOVA: F = 88.6, Tukey HSD p<0.05).

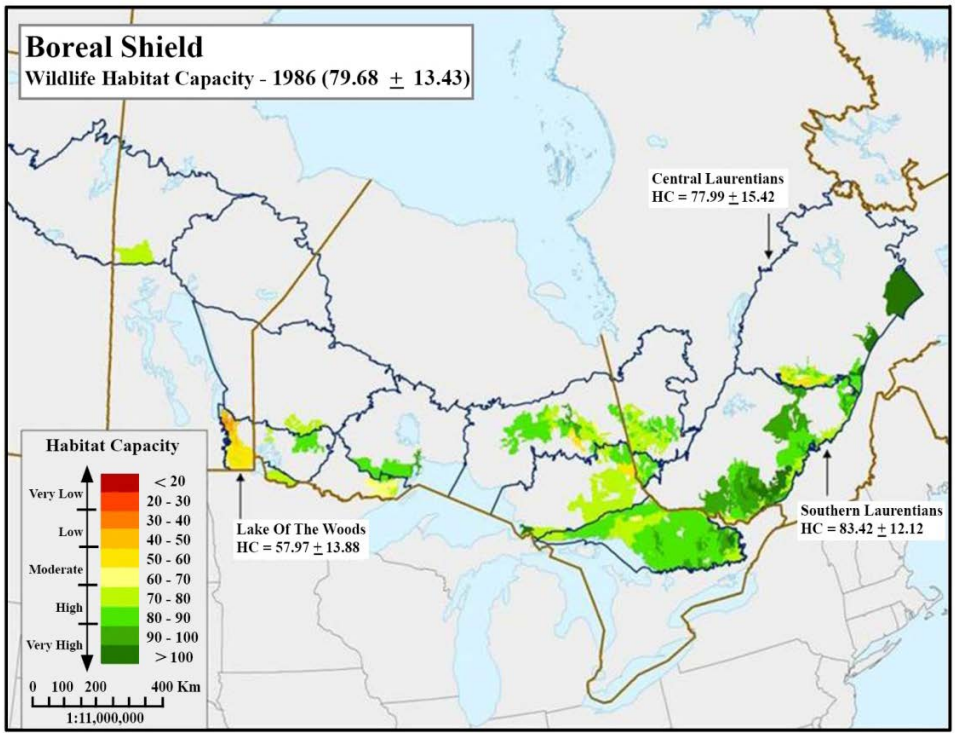


Figure 17. Wildlife habitat capacity on agricultural land in the Boreal Shield Ecozone[+], 1986.
HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

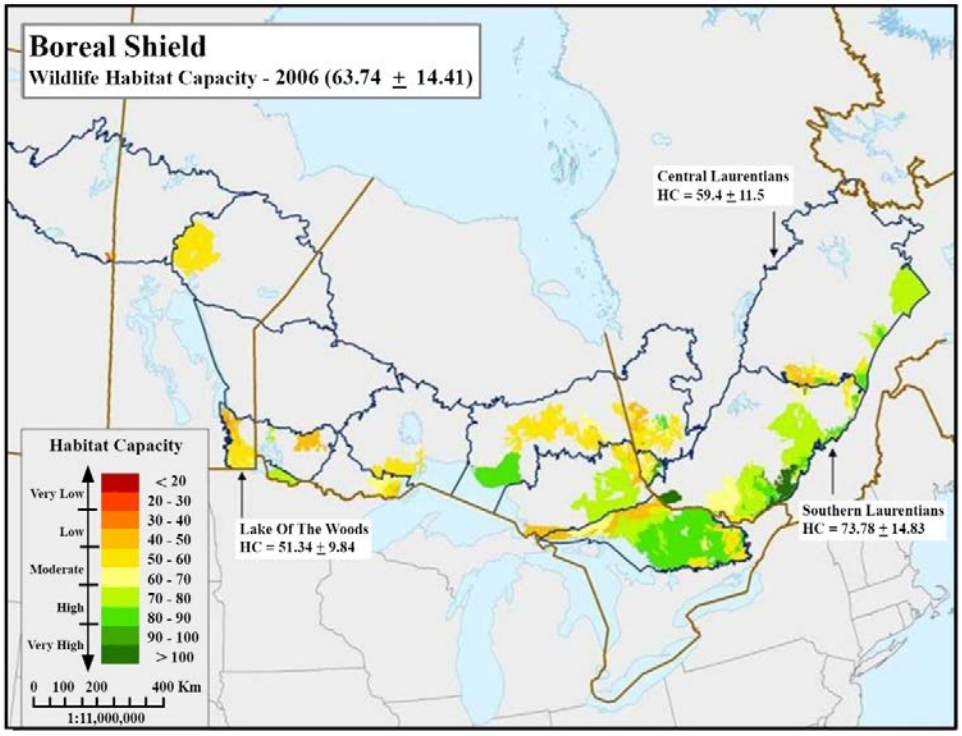


Figure 18. Wildlife habitat capacity on agricultural land in the Boreal Shield Ecozone[+], 2006.
HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

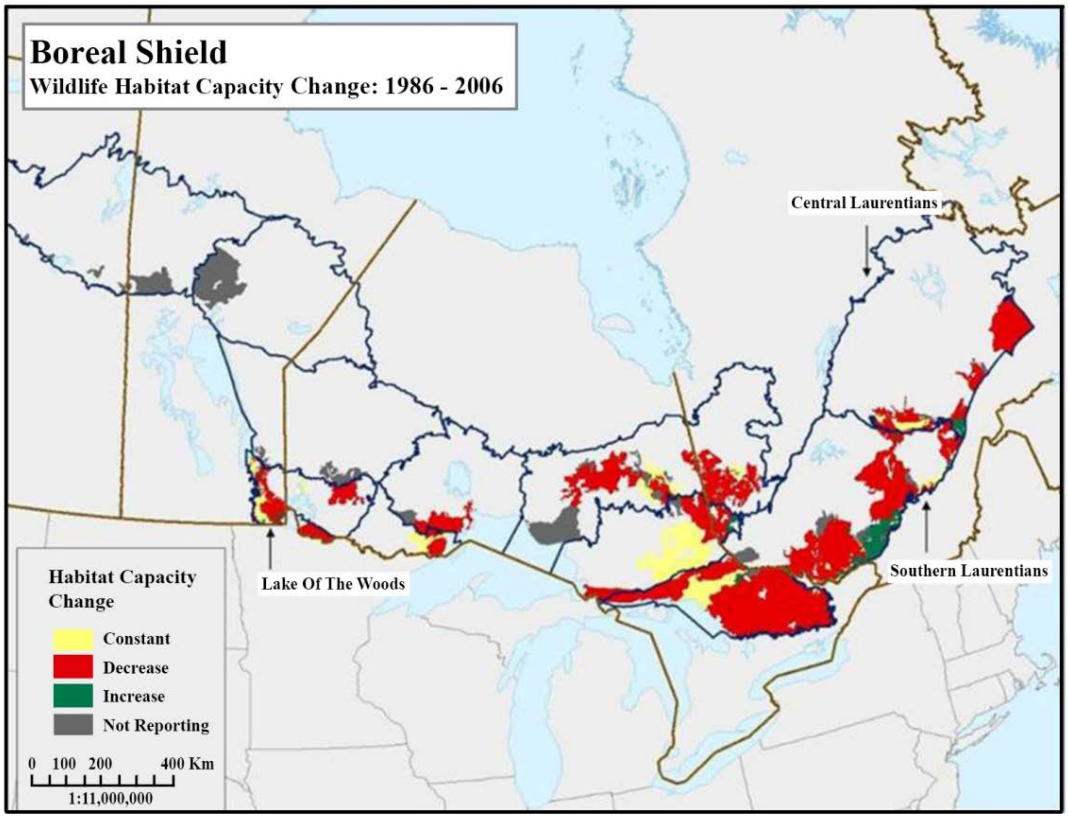


Figure 19. Change in wildlife habitat capacity on agricultural land in the Boreal Shield Ecozone⁺ between 1986 and 2006.
ANOVA, Turkey HSD p<0.05. All SLC polygons with >5% agricultural land were included in the analysis.

Interpretation

Agricultural land in the Boreal Shield Ecozone⁺ is a small component of the broader landscape making up less than 1% of total land area. Where agricultural land occurs, it is well dispersed among forested areas and has a high All Other Land component associated with it. As such, the impact of agricultural land on wildlife at the ecozone⁺ scale is low as considerable habitat options are available on and adjacent to agricultural land.

Within the agricultural landscape, declining habitat capacity was linked to a reduction in the share of All Other Land (40 to 30%). As the agricultural footprint shrank in the Boreal Shield, Cropland expanded its share of total agricultural land from 31 to 46%. This was primarily due to a 9% increase in Tame Hay. The combination of these factors reduced wildlife habitat capacity on agricultural land from high to moderate.

Among the ecoregions with higher agricultural production, the Lake of the Woods consistently recorded the lowest habitat capacity primarily due to its relatively small and declining share of All Other Land (23 to 17%). In comparison, the share of All Other Land in the Central and Southern Laurentians, although also reporting declines, was higher (37 to 26% and 46 to 39%, respectively) offering greater habitat options for wildlife on agricultural land. The importance of All Other Land was evident as habitat capacity levels tracked availability of this cover type.

Boreal Plains Ecozone+

Agricultural landscapes

The agricultural landscape[15] in the Boreal Plains Ecozone+ expanded from 1986 to 2006 (13.0 to 13.5 million hectares) to comprise around 21% of the ecozone+ (Figure 20). Figure 21 shows the total area for agricultural land and the amount of land per each cover type in 1986, 1996, and 2006. Unimproved Pasture was the dominant land cover but declined from 27 to 24% of total agricultural land over 20 years. The amount of Cereals was generally stable between 1986 and 1996 comprising around 26% of agricultural land then declined to 19% by 2006. Tame Hay (6 to 16%), Improved Pasture (8 to 12%), and Oilseeds (10 to 11%) gained a greater share while Summerfallow (9 to 3%) and All Other Land (14 to 13%) decreased.

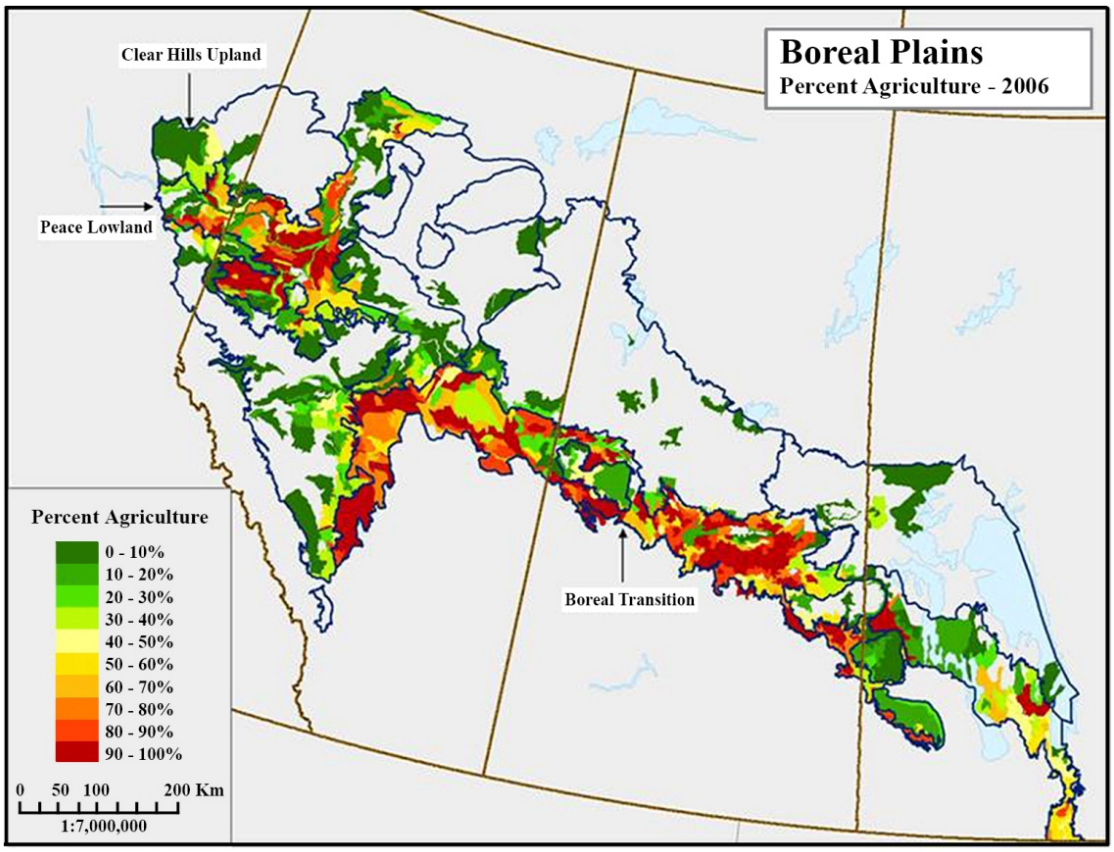
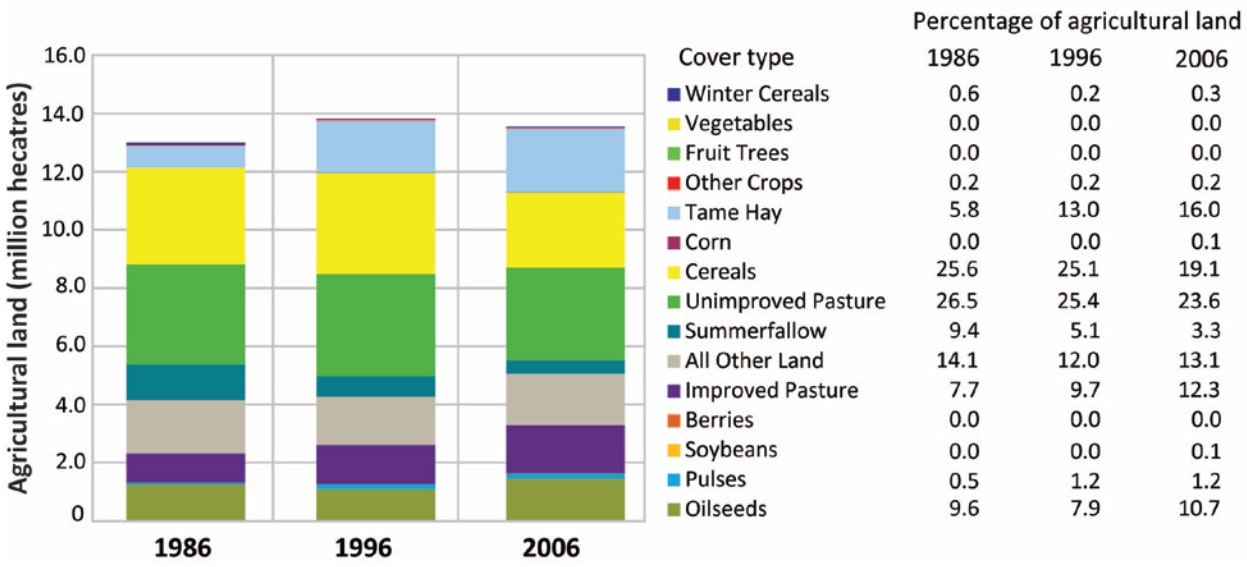


Figure 20. The percentage of agricultural land within the SLC polygons of the Boreal Plains Ecozone+, 2006.

[15] The agricultural landscape (or agricultural land), as discussed throughout this report, includes the "All Other Land" category from the Census of Agriculture, which is made up of areas such as wetlands, riparian zones, shelterbelts, woodlands, idle land/old fields, and anthropogenic areas (farm buildings, green houses, and lanes).



Cover type	Percentage of agricultural land 1986	1996	2006
Winter Cereals	0.6	0.2	0.3
Vegetables	0.0	0.0	0.0
Fruit Trees	0.0	0.0	0.0
Other Crops	0.2	0.2	0.2
Tame Hay	5.8	13.0	16.0
Corn	0.0	0.0	0.1
Cereals	25.6	25.1	19.1
Unimproved Pasture	26.5	25.4	23.6
Summerfallow	9.4	5.1	3.3
All Other Land	14.1	12.0	13.1
Improved Pasture	7.7	9.7	12.3
Berries	0.0	0.0	0.0
Soybeans	0.0	0.0	0.1
Pulses	0.5	1.2	1.2
Oilseeds	9.6	7.9	10.7

Figure 21. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Boreal Plains Ecozone⁺ for 1986, 1996, and 2006.

Approximately 75% of agricultural land in the Boreal Plains was found in the Boreal Transition and Peace Lowlands ecoregions. The share of both Cereals and Unimproved Pasture declined over 20 years (23 to 20% and 29 to 22%, respectively) but they remained the dominant land covers. Summerfallow decreased from 10 to 4% of total agricultural land area while the share of Tame Hay (6 to 15%) and Improved Pasture (9 to 13%) increased. All Other Land declined by less than 1% to make up just under 12% of the agricultural land. Overall, the share of cultivated land[16] was stable throughout this period at around 55%. In the Peace Lowlands (21% of agriculture in the ecozone⁺), the share of Unimproved Pasture was stable at around 20% while the share of Cereals declined from 28 to 18%. The share of Summerfallow declined (13 to 4%) while Tame Hay (5 to 17%) and Improved Pasture (6 to 11%) gained a greater share of total agricultural land. All Other Land declined from 17 to just over 13%.

Potential wildlife use of agricultural lands

A total of 313 species (235 birds, 63 mammals, 6 reptiles, 9 amphibians) potentially used agricultural land in the Boreal Plains Ecozone⁺. All Other Land was the most important land cover type for wildlife as it accommodated both breeding and feeding requirements for 89% (280) of species. Unimproved Pasture was the next most valuable wildlife habitat as it fulfilled both breeding and feeding requirements for 20% (62) of species. When other appropriate land cover provided for breeding habitat, 41% (127) of species were able to use Unimproved Pasture for feeding. Both breeding and feeding requirements for only 4% (11) of species were met entirely on Cropland. However, when other breeding habitat was present, 29% (90) were then able to use Cropland as feeding habitat.

[16] Cultivated land includes Summerfallow and annual crops (Oilseeds, Pulses, Soybeans, Cereals, Corn, Tame Hay, Other Crops, Vegetables, and Winter Cereals).

Wildlife habitat capacity

Average wildlife habitat capacity on agricultural land decreased significantly from 1986 (49.8 ± 12.2) to 2006 (47.8 ± 11.7) when it ranked as low (ANOVA: F = 3.95, p = 0.014) (Figure 22). The spatial distribution of habitat capacity values in 1986 and 2006 are shown in Figure 23 and Figure 24. The overall declining trend resulted from significant decreases in habitat capacity on 13% of agricultural land, increases on 9%, and no change on 78% (ANOVA, Tukey HSD $p<0.05$) (Figure 25). Wildlife habitat capacity was stable in the Boreal Transition Ecoregion (43.4 ± 9.9 to 43.1 ± 9.1) but declined significantly in the Peace Lowlands Ecoregion (51.4 ± 10.5 to 46.3 ± 7.6) (ANOVA, Tukey HSD $p<0.05$).

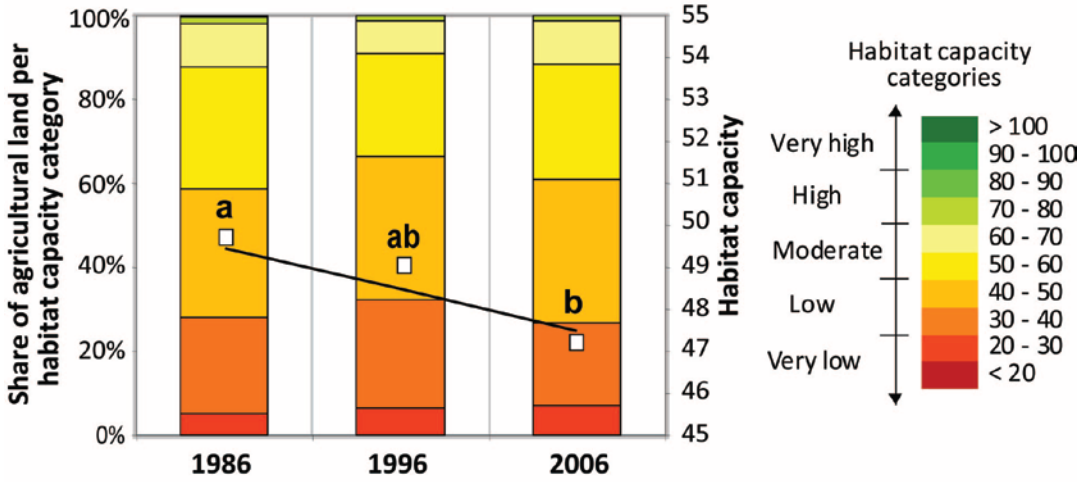


Figure 22. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Boreal Plains Ecozone[+] in 1986, 1996, and 2006 (points and line, right axis).
Years with different letters differed significantly (ANOVA: F = 4.25, Tukey HSD p<0.05).

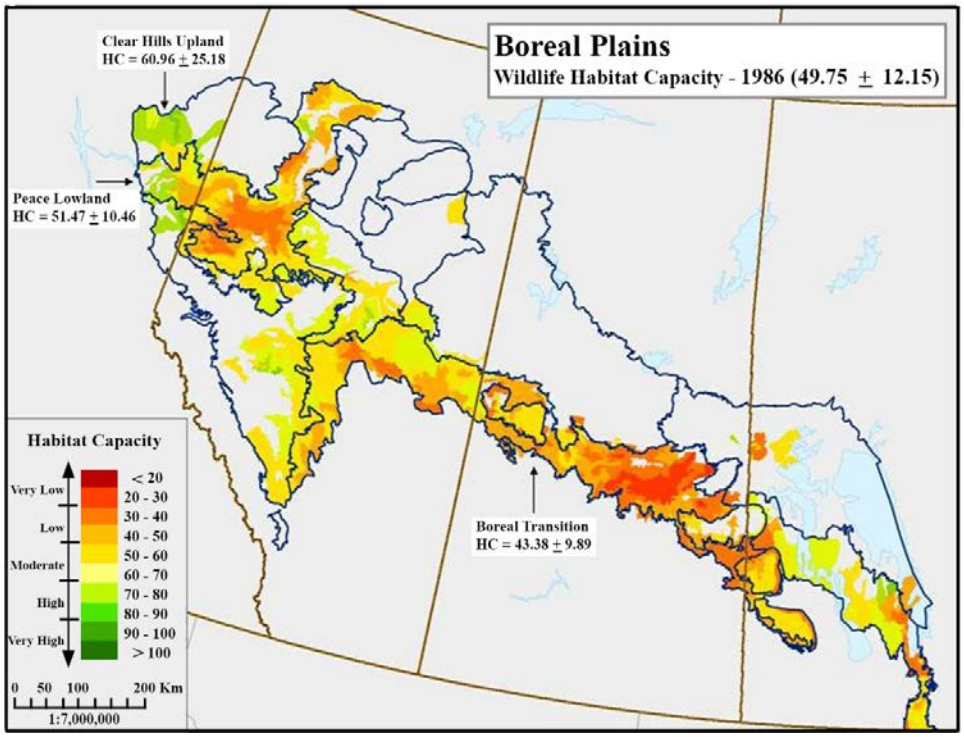


Figure 23. Wildlife habitat capacity on agricultural land in the Boreal Plains Ecozone[+], 1986.
HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

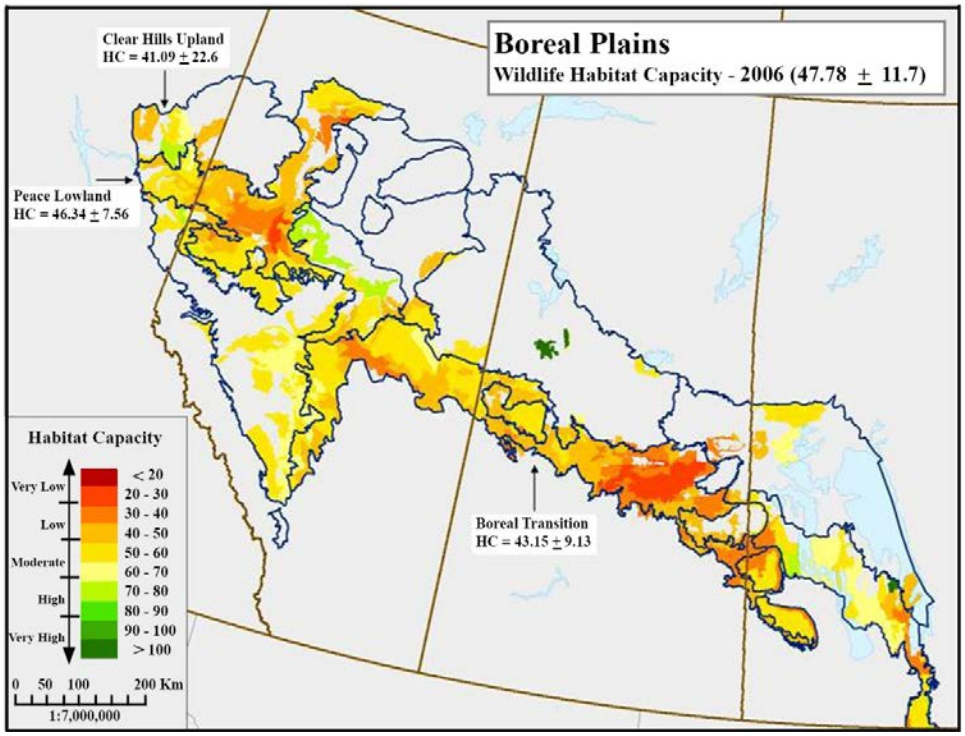


Figure 24. Wildlife habitat capacity on agricultural land in the Boreal Plains Ecozone[+], 2006.
HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

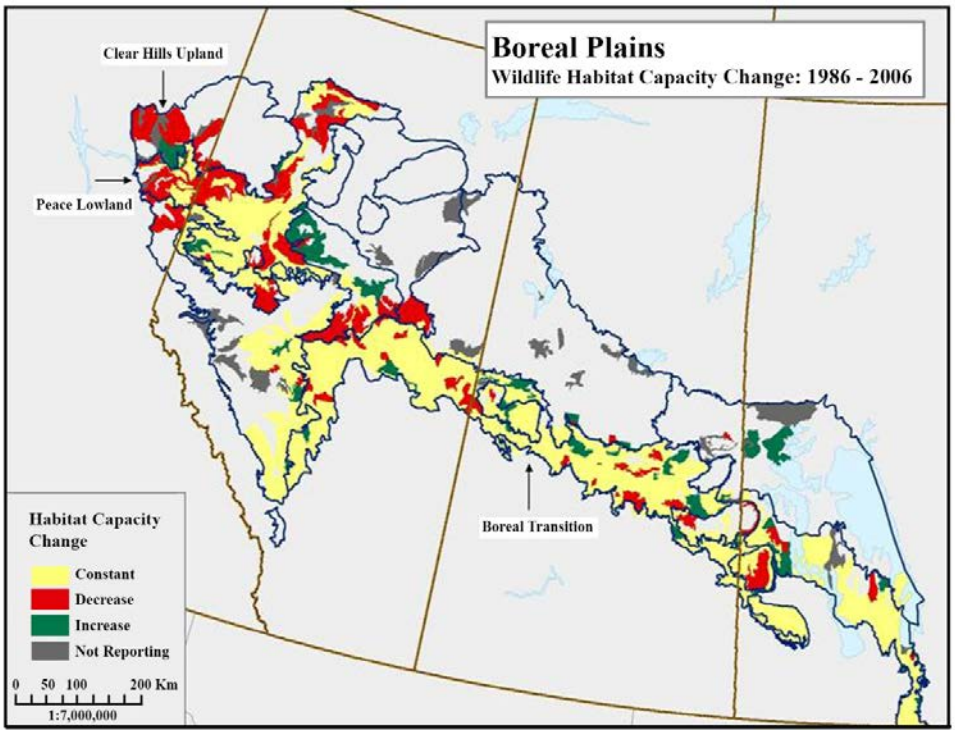


Figure 25. Change in wildlife habitat capacity on agricultural land in the Boreal Plains Ecozone⁺ between 1986 and 2006.
ANOVA, Tukey HSD p<0.05. All SLC polygons with >5% agricultural land were included in the analysis.

Interpretation

The low habitat capacity in the Boreal Plains resulted from a relatively small percentage of All Other Land (13%) combined with cultivated land that comprised over 51% of total agricultural land. The primary shifts in land cover that caused wildlife habitat capacity decline were: (1) a reduction in the share of Unimproved Pasture (3%); and (2) the loss of All Other Land (1%). Over this period, decreases in Summerfallow and Cereals while Tame Hay increased signified an improvement to the cultivated portion of agricultural land. Given that few species can fulfill habitat needs on Cropland cover types alone, these beneficial changes have little true value to wildlife without sufficient natural and semi-natural land that is required to support the life history requirements of most species.

The Boreal Transition had the lowest habitat capacity (43.2 ± 9.1) among ecoregions within the Boreal Plains Ecozone⁺. Over twenty years, the overall habitat capacity in the Boreal Transition Ecoregion declined by less than 1%. In the Peace Lowlands Ecoregion, wildlife habitat capacity declined significantly from 51.5 ± 10.5 to 46.3 ± 7.6 (ANOVA, Tukey HSD $p<0.05$). This was mainly due to a considerable decline in the share of All Other Land (17 to 13%). The Clear Hills Ecoregion comprised less than 2% of agricultural land in the Boreal Plains. Here, a reduction in the share of All Other Land (28 to 21%) was the primary reason for the significant drop in habitat capacity (61.0 ± 25.2 to 41.1 ± 22.6) (ANOVA, Tukey HSD $p<0.05$). Despite this decline, habitat capacity in the Clear Hills remained highest among ecoregions in the Boreal Plains Ecozone⁺.

Prairies Ecozone+

Agricultural landscapes

The majority of agricultural land in Canada was found in the agriculturally dominated Prairies Ecozone+. Agricultural landscapes[17] comprised close to 93% of the Prairies Ecozone+ in 2006 (Figure 26) and consisted of considerable wheat, cereal, oilseed, and pulse crop production with extensive range and pasture land. The agricultural landscape expanded by approximately 1.3 million hectares between 1986 and 1996 (40 to 41 million hectares) then remained generally stable through to 2006. Figure 27 shows total agricultural land area and the amount of land per each cover type for 1986, 1996, and 2006. Cereals were the dominant cover type in each year despite a decline that occurred between 1996 and 2006 (37 to 29%). Unimproved Pasture was the second most abundant cover type. Over 20 years, the share of Unimproved Pasture declined from 25.4 to 24.5% of agricultural land. The percentage of All Other Land was stable around 5%. Oilseed (6 to 11%), Tame Hay (2 to 8%), and Improved Pasture (4 to 8%) gained an increased share while Summerfallow (18 to 7%) decreased.

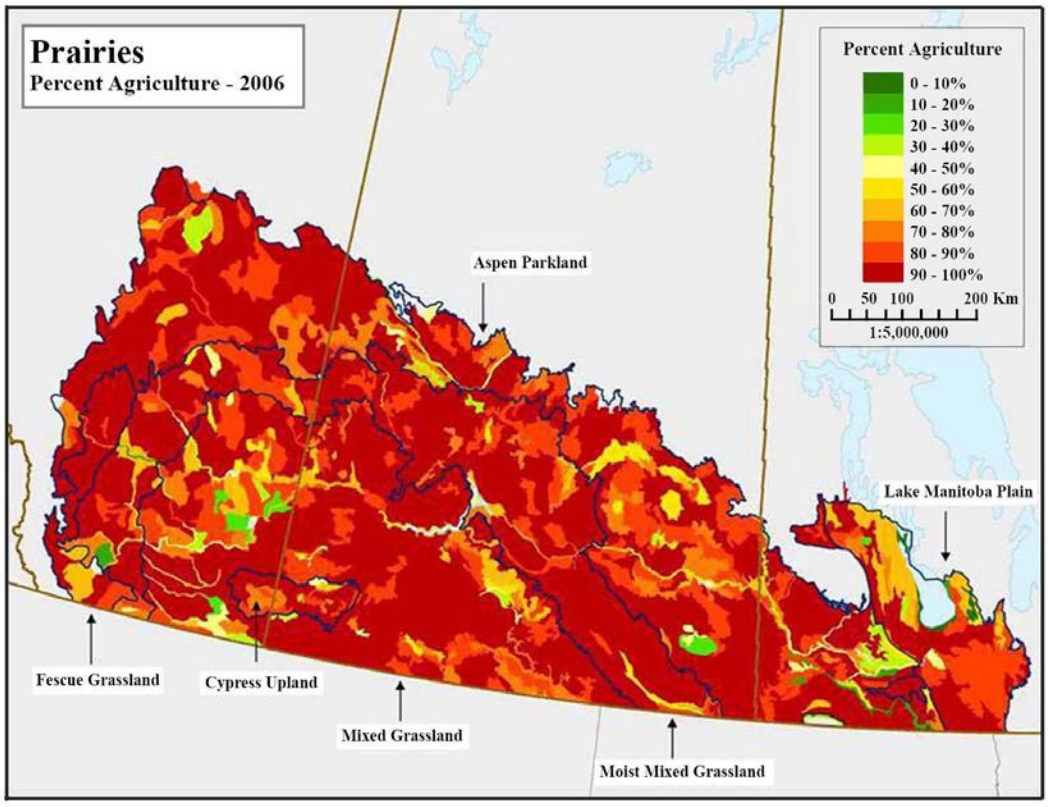
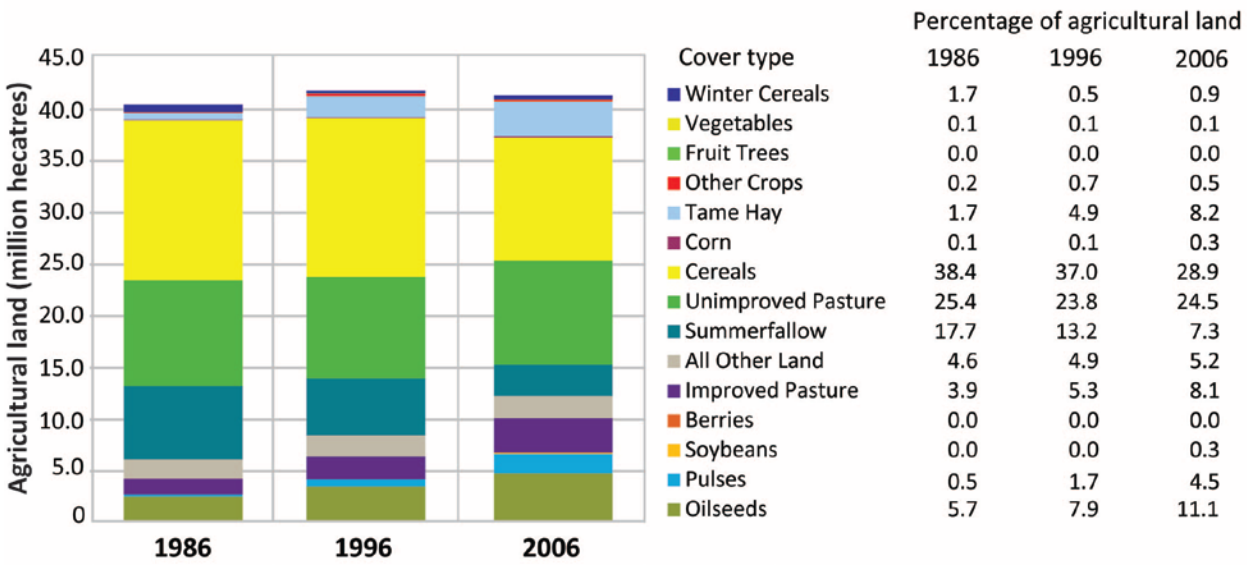


Figure 26. The percentage of agricultural land within the SLC polygons of the Prairies Ecozone+, 2006.

[17] The agricultural landscape (or agricultural land), as discussed throughout this report, includes the "All Other Land" category from the Census of Agriculture, which is made up of areas such as wetlands, riparian zones, shelterbelts, woodlands, idle land/old fields, and anthropogenic areas (farm buildings, green houses, and lanes).



Cover type	Percentage of agricultural land 1986	1996	2006
Winter Cereals	1.7	0.5	0.9
Vegetables	0.1	0.1	0.1
Fruit Trees	0.0	0.0	0.0
Other Crops	0.2	0.7	0.5
Tame Hay	1.7	4.9	8.2
Corn	0.1	0.1	0.3
Cereals	38.4	37.0	28.9
Unimproved Pasture	25.4	23.8	24.5
Summerfallow	17.7	13.2	7.3
All Other Land	4.6	4.9	5.2
Improved Pasture	3.9	5.3	8.1
Berries	0.0	0.0	0.0
Soybeans	0.0	0.0	0.3
Pulses	0.5	1.7	4.5
Oilseeds	5.7	7.9	11.1

Figure 27. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Prairies Ecozone⁺ for 1986, 1996, and 2006.

Potential wildlife use of agricultural land

A total of 340 species (245 birds; 71 mammals; 13 reptiles; 11 amphibians) were associated with agricultural land in the Prairies Ecozone⁺. Land cover represented under the All Other Land category (natural and semi-natural land including wetlands, riparian vegetation, and wooded areas) was extremely important wildlife habitat as 78% (264) of species could use such habitats for both their breeding and feeding requirements. Unimproved Pasture was also valuable wildlife habitat as 30% (103) of species used it for both breeding and feeding while 53% (180) could use it for a single life history requirement. In contrast, only 4% (14) of species were able to utilize Cropland[18] for both these habitat requirements. However, when other suitable habitat was present to provide for partial life history requirements, 32% (110) of species were able to use Cropland.

Wildlife habitat capacity

In 2006, the average wildlife habitat capacity on agricultural land for the Prairies Ecozone⁺ was low (43.4 ± 11.5). Despite slight shifts in the relative percentage among habitat capacity categories over 20 years there was no significant change at the ecozone⁺ level (ANOVA, $F = 0.48$, $p = 0.62$) (Figure 28). The spatial distribution of habitat capacity values in 1986 and 2006 are shown in Figure 29 and Figure 30, respectively. Over this period, habitat capacity was constant on 92% of agricultural land, increased on 5%, and decreased on 3% (ANOVA, Tukey HSD $p<0.05$) (Figure 31).

[18] Cropland includes all agricultural land except for All Other Land, Unimproved Pasture, Improved Pasture, and Summerfallow.

There was considerable wildlife habitat capacity variability among ecoregions within the Prairies Ecozone[+]. The Moist Mixed Grassland had the lowest habitat capacity (low: 38.0 ± 9.5) while the Cypress Upland reported the highest value (moderate: 61.5 ± 9.8).

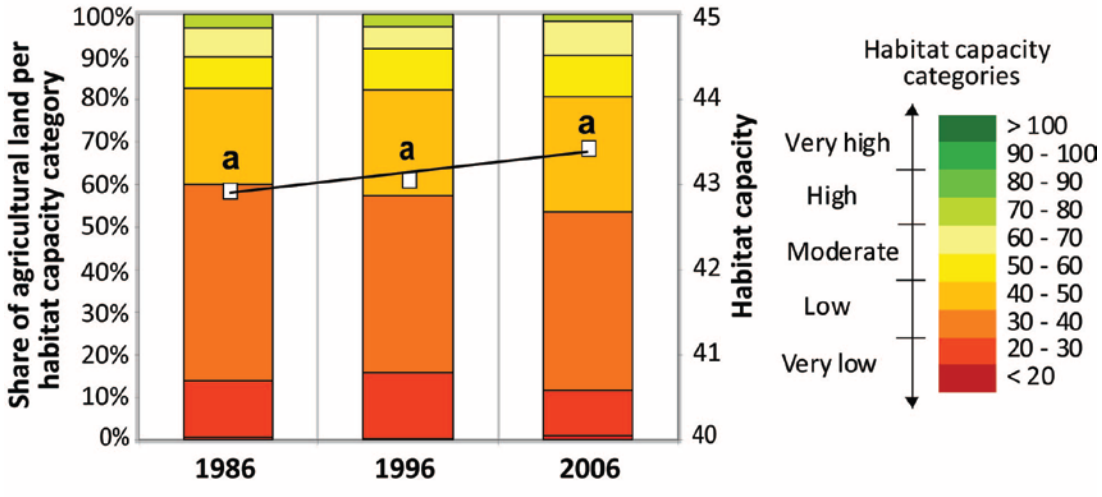


Figure 28. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Prairies Ecozone[+] in 1986, 1996, and 2006 (points and line, right axis). No significant difference occurred between years (ANOVA: F = 0.43, Tukey HSD p<0.05).

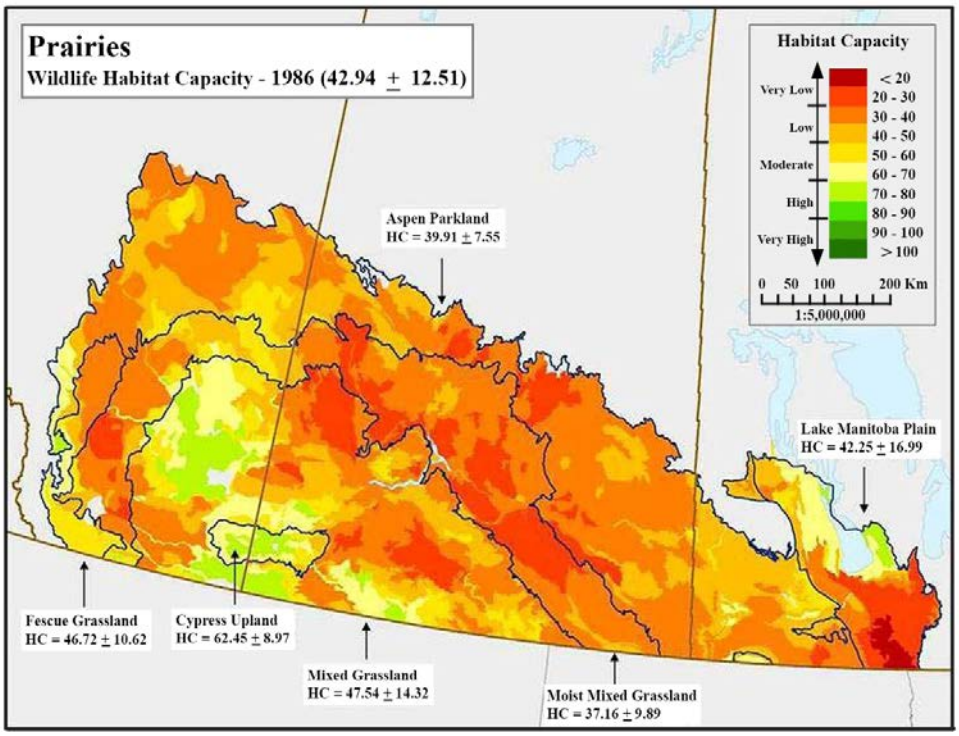


Figure 29. Wildlife habitat capacity on agricultural land in the Prairies Ecozone[+], 1986.
HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

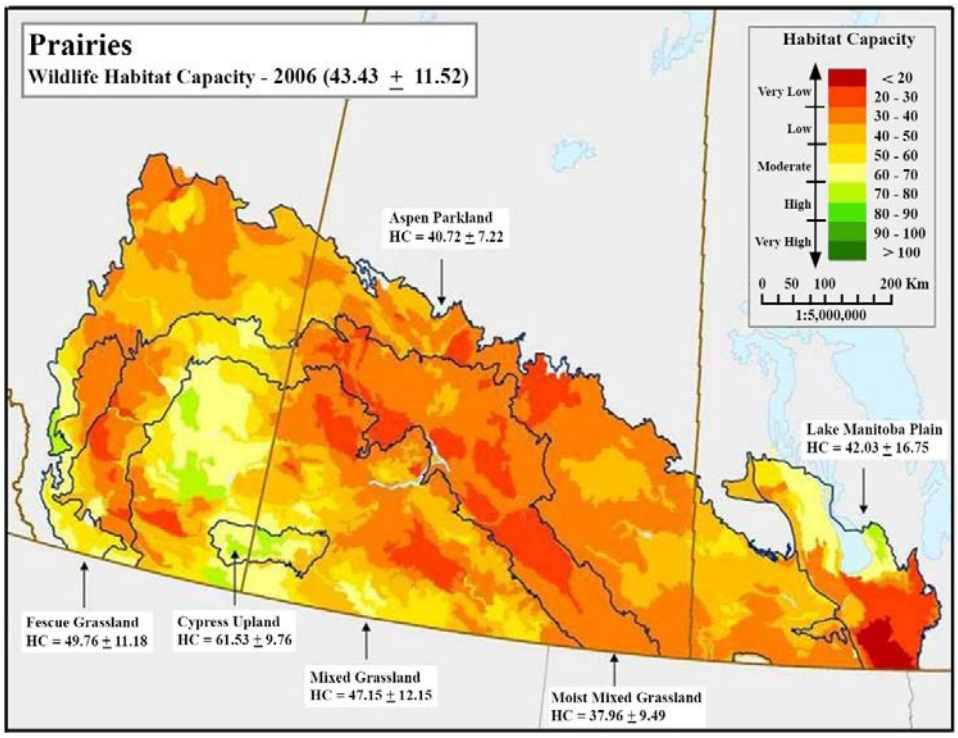


Figure 30. Wildlife habitat capacity on agricultural land in the Prairies Ecozone[+], 2006.
HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

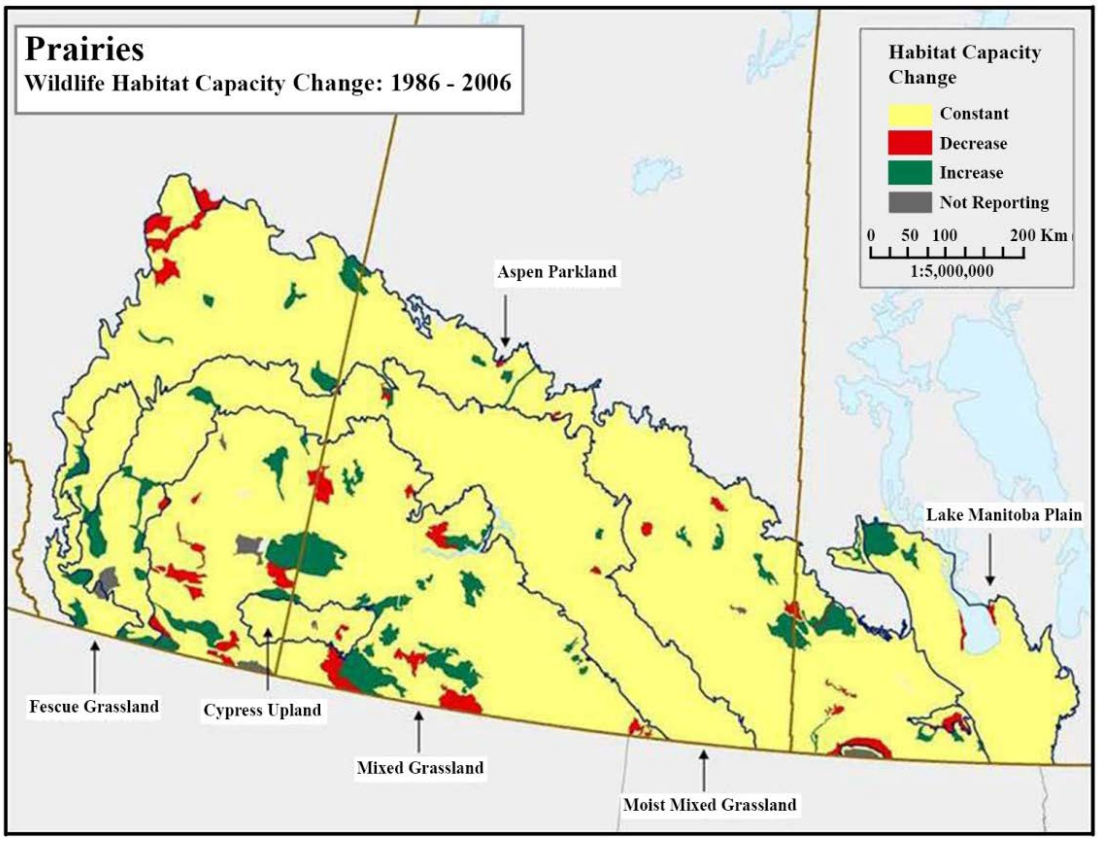


Figure 31. Change in wildlife habitat capacity on agricultural land in the Prairies Ecozone⁺ between 1986 and 2006.
ANOVA, Tukey HSD p<0.05. All SLC polygons with >5% agricultural land were included in the analysis.

Interpretation

Agriculture is the dominant land use in the Prairies Ecozone⁺, comprising close to 93% of total land. As such, the population viability and persistence of many species within the ecozone⁺ depends on the availability of suitable habitat on agricultural land. Between 1986 and 2006, the share of cultivated land[19] declined from 66 to 62% of total agricultural land based largely on the reduction of Summerfallow. However, cultivated land still represented a considerable portion of the agricultural landscape that offered comparatively little in the way of wildlife habitat as the vast majority of species required natural or semi-natural land cover to fulfill breeding and/or feeding requirements. Therefore, cover types such as Unimproved Pasture and All Other Land, which together accounted for less than 30% of agricultural land, played a crucial role in determining the viability of wildlife populations in this ecozone⁺. The relatively small percentage of these important cover types, which included only 5% All Other Land, was the primary reason for the overall low habitat capacity in the Prairies. At the ecozone⁺ level, Unimproved Pasture declined by just under 1%. The loss was generally the result of "squaring

[19] Cultivated land includes Summerfallow and annual crops (Oilseeds, Pulses, Soybeans, Cereals, Corn, Tame Hay, Other Crops, Vegetables, and Winter Cereals).

the field" although large blocks of native grassland habitat were occasionally removed (Watmough and Schmoll, 2007). The share of All Other Land was constant as cumulative losses were not detected at such a broad spatial scale. Watmough and Scholl (2007) estimated a 5% decline in natural wetland area between 1985 and 1996 with the average size of lost wetland basins equaling 0.2 hectares. The loss of such important habitats, although relatively small, represents a considerable degradation of the landscape as wildlife habitat.

The Moist Mixed Grassland had the lowest habitat capacity which resulted from a relatively small share of Unimproved Pasture (19%) and All Other Land (4%). Close to 65% of agricultural land in the ecoregion was cultivated and offered little in the way of wildlife habitat. Although the Aspen Parkland and Lake Manitoba Plain registered similar percentages of Unimproved Pasture and cultivated land, habitat capacity was slightly higher as All Other Land attained it greatest share of agricultural land (8%) in these ecoregions. Despite low All Other Land in the Mixed Grassland and Fescue Grassland, habitat capacity was higher than the previously mentioned ecoregions due to a higher share of Unimproved Pasture which in part contributed to a 12% lower share of cultivated land. The Cypress Upland had the highest wildlife habitat capacity (moderate) primarily due to its extensive Unimproved Pastures which comprised close to 62% of agricultural land in the ecoregion. All Other Land, however, made up less than 3% of total agricultural land limiting habitat options for many species.

Montane Cordillera Ecozone[+]

Agricultural landscapes

The agricultural landscape[20] expanded from approximately 1.0 million hectares in 1986 to 1.4 million hectares in 2006 to comprise just over 3% of the Montane Cordillera Ecozone[+] (Figure 32). Figure 33 shows the total agricultural land area and the amount of land per cover type for 1986, 1996, and 2006. The share of the dominant cover type, Unimproved Pasture, increased from 56 to 64% of total agricultural land. Tame Hay expanded from 9 to 13%. All Other land experienced the largest decline among cover types as its share fell from 21 to 11% over this 20 year period.

[20] The agricultural landscape (or agricultural land), as discussed throughout this report, includes the "All Other Land" category from the Census of Agriculture, which is made up of areas such as wetlands, riparian zones, shelterbelts, woodlands, idle land/old fields, and anthropogenic areas (farm buildings, green houses, and lanes).

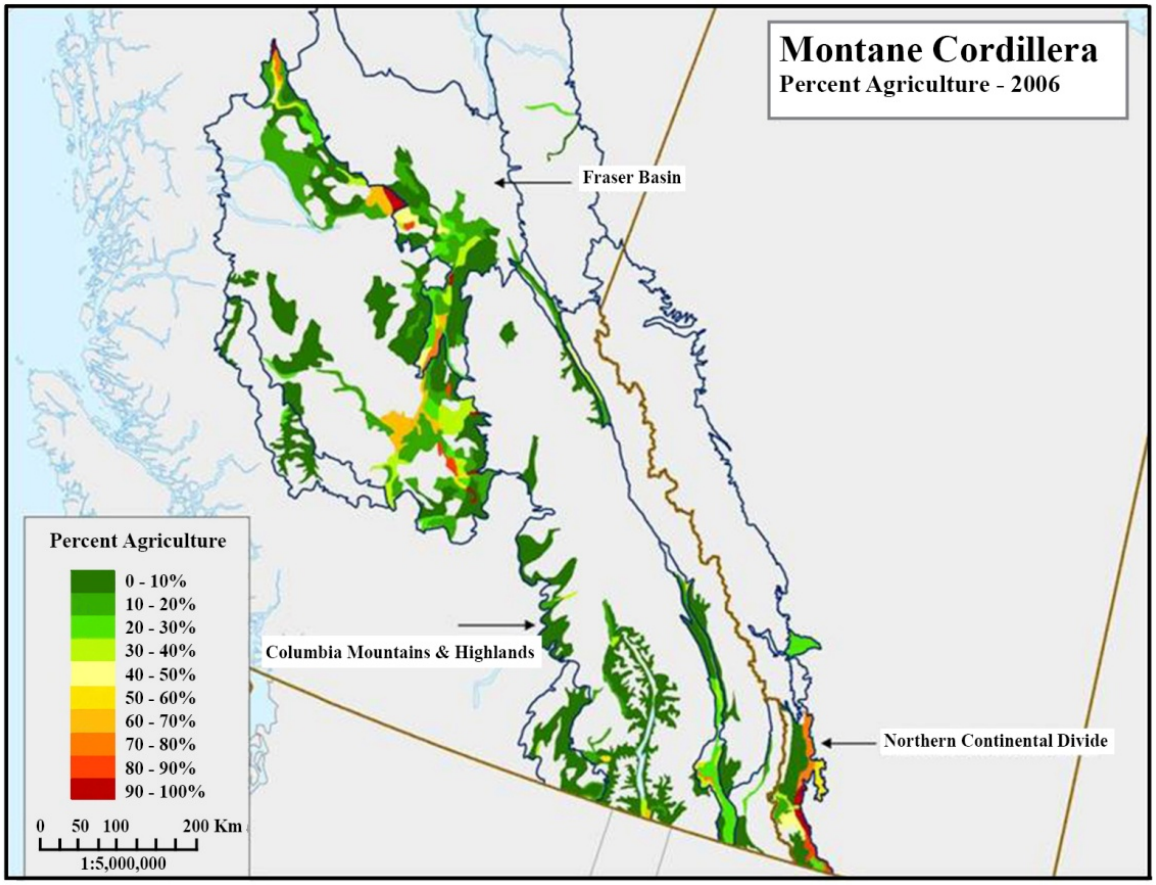
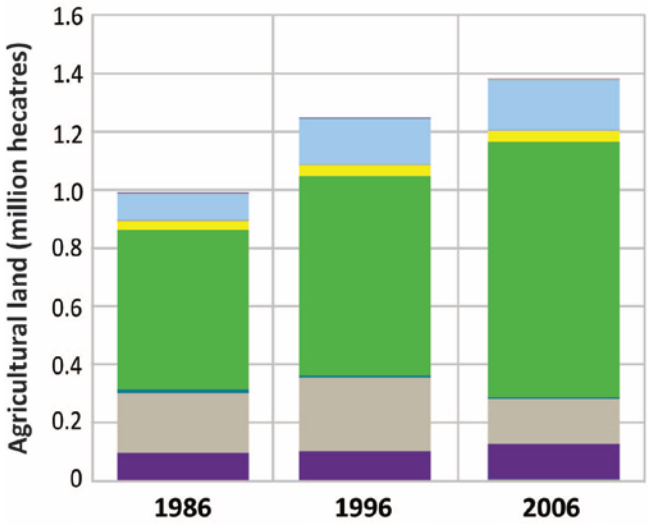


Figure 32. The percentage of agricultural land within the SLC polygons of the Montane Cordillera Ecozone[+], 2006.



Cover type	Percentage of agricultural land 1986	1996	2006
Winter Cereals	0.4	0.2	0.1
Vegetables	0.0	0.0	0.0
Fruit Trees	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0
Tame Hay	9.2	12.7	12.7
Corn	0.2	0.1	0.1
Cereals	3.1	3.1	2.7
Unimproved Pasture	55.5	54.9	63.6
Summerfallow	1.2	0.7	0.4
All Other Land	20.8	20.3	11.2
Improved Pasture	9.4	7.9	8.9
Berries	0.0	0.0	0.0
Soybeans	0.0	0.0	0.0
Pulses	0.0	0.0	0.1
Oilseeds	0.2	0.1	0.2

Figure 33. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Montane Cordillera Ecozone[+] for 1986, 1996, and 2006.

Potential wildlife use of agricultural land

A total of 351 species (254 birds; 78 mammals; 9 reptiles; 10 amphibians) used agricultural land in the Montane Cordillera Ecozone[+]. All Other Land accommodated breeding and feeding requirements for close to 90% (312) of species associated with agricultural land. Unimproved Pasture was the second most important agricultural cover type for wildlife as it supported the breeding and feeding needs of 89 species. In the presence of other complimentary habitat (primarily All Other Land) that provided partial habitat requirements, Unimproved Pasture could be used by 43% (152) of species for at least a single habitat use. Cropland[21] cover types fulfilled both breeding and feeding life history requirements for close to 12% (42) of species and partial habitat requirements for 30% (91).

Wildlife habitat capacity

There was a significant decline between each reporting year signifying a negative wildlife habitat capacity trend on agricultural land in the Montane Cordillera (ANOVA, $F = 85.2$, $p = 0.001$) (Figure 34). From 1986 to 2006, average habitat capacity decreased from 71.0 ± 10.4 (high) to 58.6 ± 9.2 (moderate). The spatial distribution of habitat capacity values in 1986 and 2006 are shown in Figure 35 and Figure 36, respectively. Over this period habitat capacity decreased on 48% of agricultural land, increased on 5%, and was constant on 47% (Figure 37). Among ecoregions with higher agricultural land use, the Fraser Basin (about 16% of agricultural land in the Montane Cordillera) experienced the largest habitat capacity decline (70.3 ± 7.4 to 56.2 ± 5.4). Habitat capacity also declined significantly in the Columbia Mountains and Highlands (75.5 ± 13.4 to 64.7 ± 15.4) (ANOVA, Tukey HSD $p<0.05$) but was stable in the Northern Continental Divide (58.0 ± 6.1 to 57.0 ± 4.5).

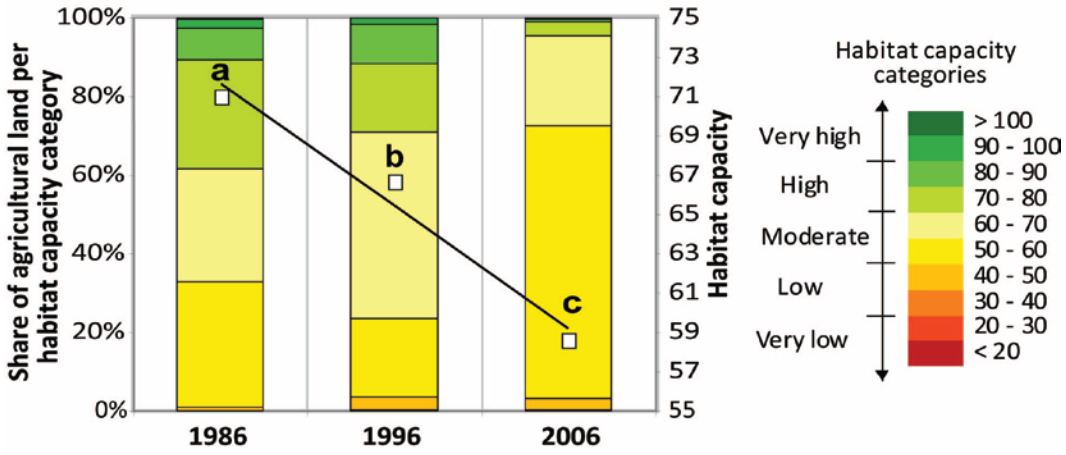


Figure 34. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Montane Cordillera Ecozone[+] in 1986, 1996, and 2006 (points and line, right axis).
Years with different letters differed significantly (ANOVA: $F = 85.2$, Tukey HSD $p<0.05$).

[21] Cropland includes all agricultural land except for All Other Land, Unimproved Pasture, Improved Pasture, and Summerfallow.

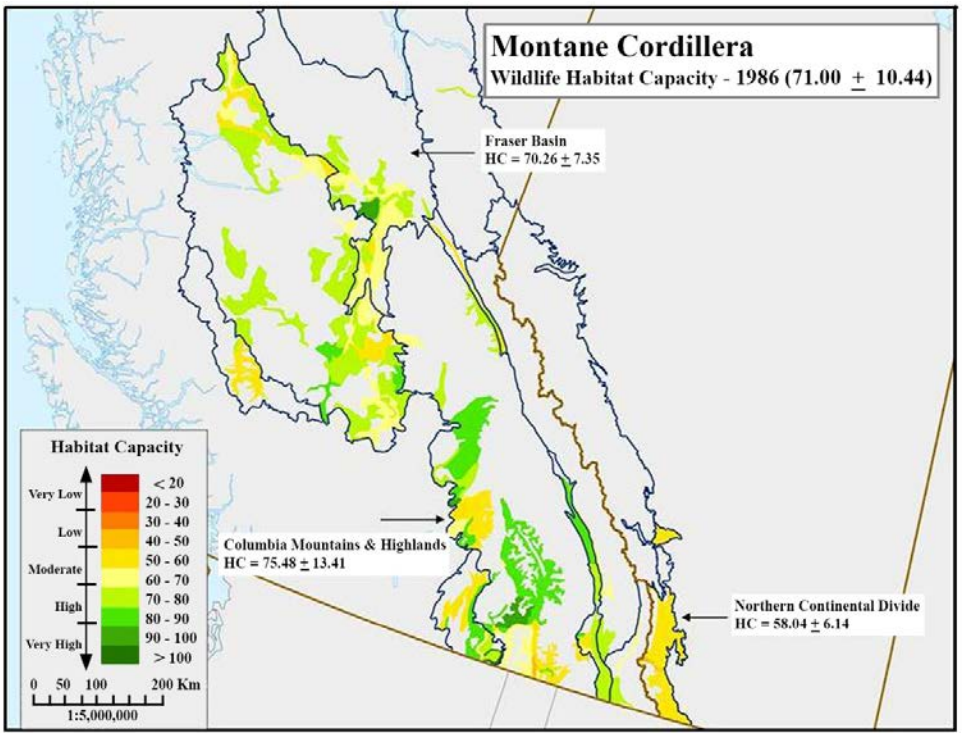


Figure 35. Wildlife habitat capacity on agricultural land in the Montane Cordillera Ecozone[+], 1986. HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

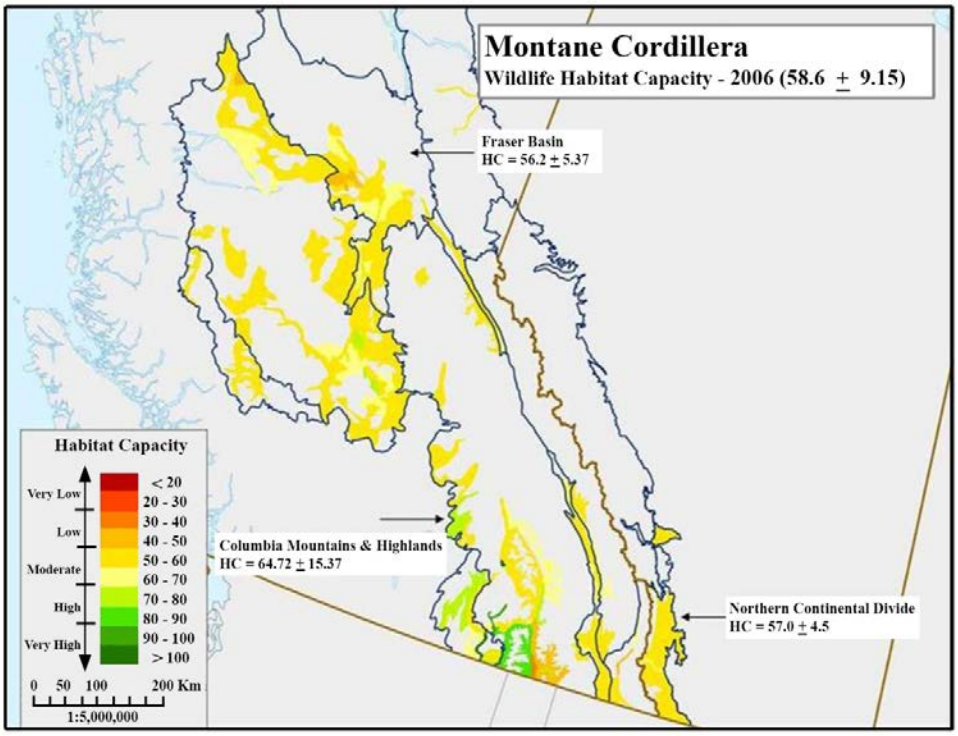


Figure 36. Wildlife habitat capacity on agricultural land in the Montane Cordillera Ecozone[+], 2006. HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

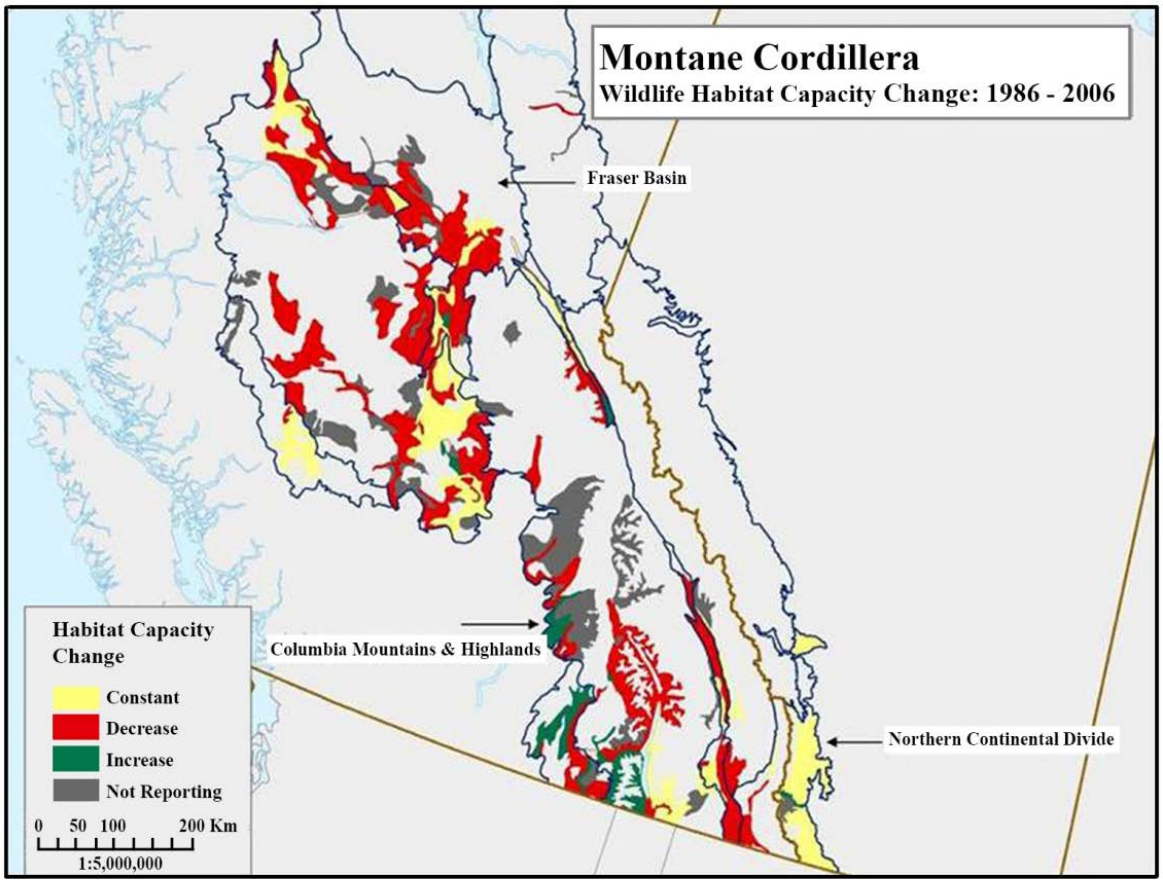


Figure 37. Change in wildlife habitat capacity on agricultural land in the Montane Cordillera Ecozone⁺ between 1986 and 2006.
ANOVA, Tukey HSD p<0.05. All SLC polygons with >5% agricultural land were included in the analysis.

Interpretation

In the broad sense, agriculture had limited impact on wildlife in the Montane Cordillera as it occupied only about 3% of the ecozone⁺. However, given that agriculture generally occurred along river valleys and adjacent slopes in a more mountainous landscape, it occupied a specific, more restricted ecotype in which its activities altered the availability of natural habitats.

Provincial policies that favored agricultural land contributed to the 28% increase of agricultural land in the Montane Cordillera (Grant, 2007). The vast majority of agricultural growth resulted from an approximately 40% expansion of the dominant cover type – Unimproved Pasture. Deforestation on agricultural land contributed to declines in habitat capacity as woodland was replaced with land cover of lesser value for wildlife. The overall moderate habitat capacity in 2006 was related to Unimproved Pasture being the dominant cover type comprising close to 65% of agricultural land in the ecozone⁺ providing both the breeding and feeding habitat requirements for over 25% of species. Sixteen percent of total agricultural land was comparatively poor-value Cropland, up slightly from 1986 where it made up close to 13%. This was due to an increase in the amount of Tame Hay.

Consistent with the ecozone+ overall, significant habitat capacity declines in the Fraser Basin and Columbia Mountains and Highlands were due to declines in the share of All Other Land (28 to 15% and 28 to 16%, respectively). In both these ecoregions, cover types comparatively less favorable to wildlife than All Other Land increased their share of the agricultural land. Unimproved Pasture increased by about 8% while Tame Hay increased 11 and 6% in the Columbia Mountains and Highlands and Fraser Basin, respectively. In the Northern Continental Divide habitat capacity was stable over this 20 year period as the relative share of cover types saw only slight changes. The habitat capacity rating for the Northern Continental Divide (moderate) resulted from the lowest share of All Other Land (6%) among ecoregions as Unimproved Pasture made up over 72% of agricultural land.

Western Interior Basin Ecozone+

Agricultural landscapes

At lower elevations of the Western Interior Basin, grazing, forage production, and orchards were common while woodland grazing was associated with middle elevations. Over twenty years (1986 to 2006), the agricultural landscape[22] in the Western Interior Basin expanded from 482,000 to 570,000 hectares to make up approximately 10% of the ecozone+ (Figure 38). Figure 39 shows the total agricultural land area and the amount of land per each agricultural cover type in 1986, 1996, and 2006. Unimproved Pasture was the dominant land cover in the ecozone+ increasing its share from 64 to 67% of total agricultural land over 20 years. The share of Tame Hay expanded (4 to 11%) while declines were associated with Improved Pasture (9 to 5%) and All Other Land (18 to 12%). Overall, the share of Cropland[23] expanded by 6% to make up 15% of agricultural land.

[22] The agricultural landscape (or agricultural land), as discussed throughout this report, includes the "All Other Land" category from the Census of Agriculture, which is made up of areas such as wetlands, riparian zones, shelterbelts, woodlands, idle land/old fields, and anthropogenic areas (farm buildings, green houses, and lanes).

[23] Cropland includes all agricultural land except for All Other Land, Unimproved Pasture, Improved Pasture, and Summerfallow.

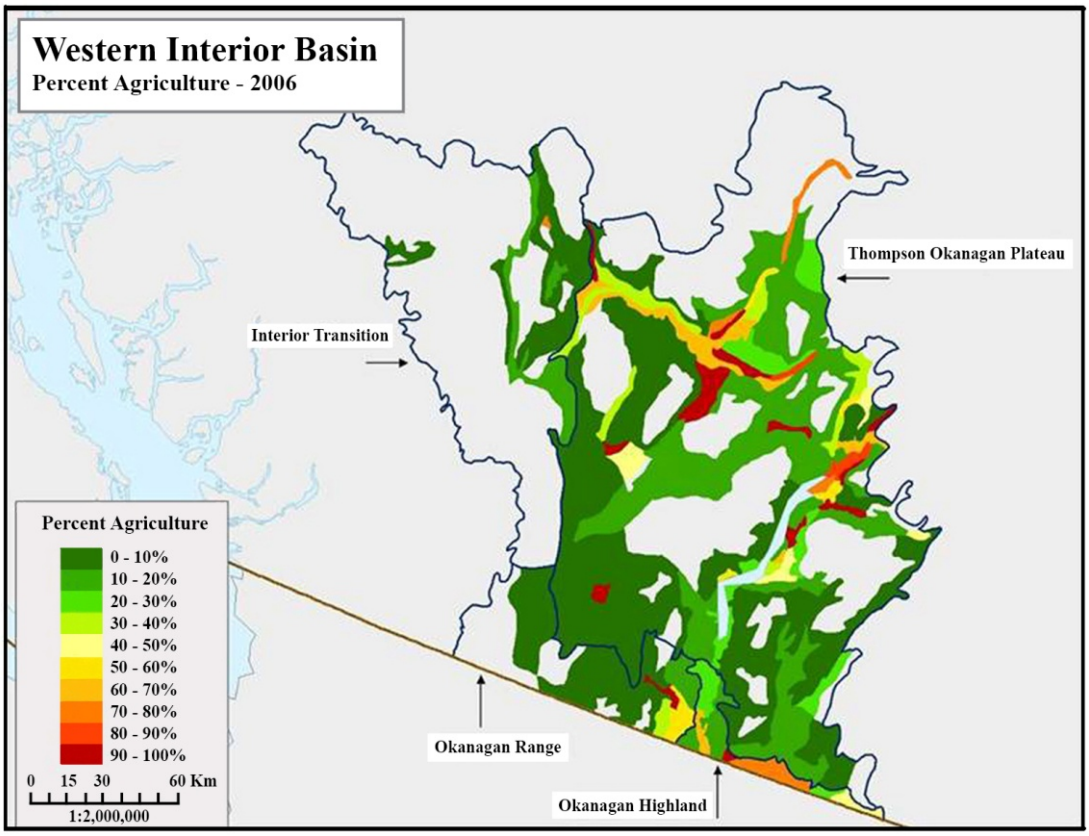
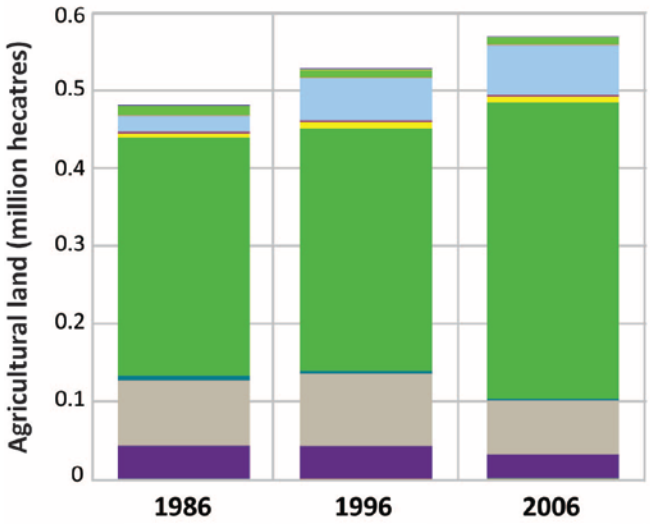


Figure 38. The percentage of agricultural land within the SLC polygons of the Western Interior Basin Ecozone[+], 2006.



Cover type	Percentage of agricultural land 1986	1996	2006
Winter Cereals	0.3	0.2	0.1
Vegetables	0.2	0.2	0.1
Fruit Trees	2.4	1.8	1.6
Other Crops	0.1	0.1	0.1
Tame Hay	4.3	10.3	11.3
Corn	0.5	0.3	0.4
Cereals	1.1	1.6	1.3
Unimproved Pasture	63.5	59.1	66.9
Summerfallow	1.2	0.6	0.4
All Other Land	17.5	17.7	12.1
Improved Pasture	8.7	8.0	5.4
Berries	0.0	0.0	0.0
Soybeans	0.0	0.0	0.0
Pulses	0.0	0.0	0.1
Oilseeds	0.1	0.0	0.1

Figure 39. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Western Interior Basin Ecozone[+] for 1986, 1996, and 2006.

The majority of agriculture (81%) in the Western Interior Basin Ecozone+ occurred in the Thompson-Okanagan Plateau Ecoregion over the 20 years. The dominant land cover; Unimproved Pasture gained a greater share of agricultural land (63 to 66%) as did Tame Hay (5 to 12%). Declines were associated with All Other Land (18 to 13%) and Improved Pasture (5 to 2%). The Cropland portion of the agricultural landscape expanded from 9 to 15% of the ecoregion.

Potential wildlife use of agricultural land

A total of 323 terrestrial vertebrates (232 birds; 72 mammals; 10 reptiles; 9 amphibians) were associated with agricultural land in the Western Interior Basin Ecozone+. All Other Land was the most species rich habitat as it was used by 85% (276) of species for both breeding and feeding habitat. The dominant agricultural land cover (Unimproved Pasture) fulfilled both breeding and feeding requirements of 25% (80) of species while providing a single habitat requirement (either breeding or feeding) for 44% (142). Only 12% (37) of species were able to use Cropland for both breeding and feeding habitat while 25% (82) were able to obtain a single habitat requirement.

Wildlife habitat capacity

Average wildlife habitat capacity on agricultural land in the Western Interior Basin Ecozone+ showed a significant declining trend among reporting years (ANOVA; $F = 22.1$, $p<0.05$) dropping from 70.4 ± 10.9 in 1986 to 61.3 ± 7.3 in 2006 (Figure 40). Figure 41 and Figure 42 show the spatial distribution of habitat capacity values for 1986 and 2006. Over this time period, habitat capacity decreased significantly on 35% of agricultural land, increased on 7%, and was constant on 58% (ANOVA, Tukey HSD $p<0.05$) (Figure 43).

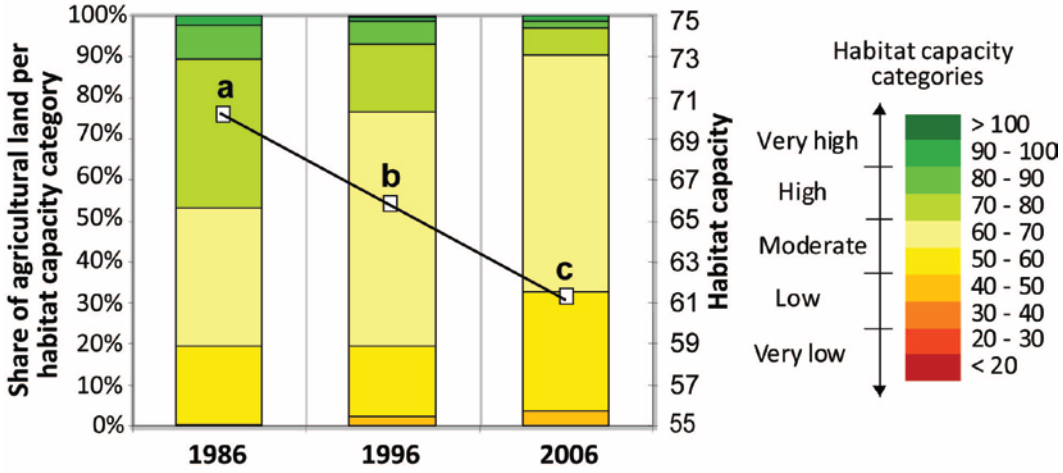


Figure 40. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Western Interior Basin Ecozone+ in 1986, 1996, and 2006 (points and line, right axis).
Years with different letters differed significantly (ANOVA: $F = 22.1$, Tukey HSD $p<0.05$).

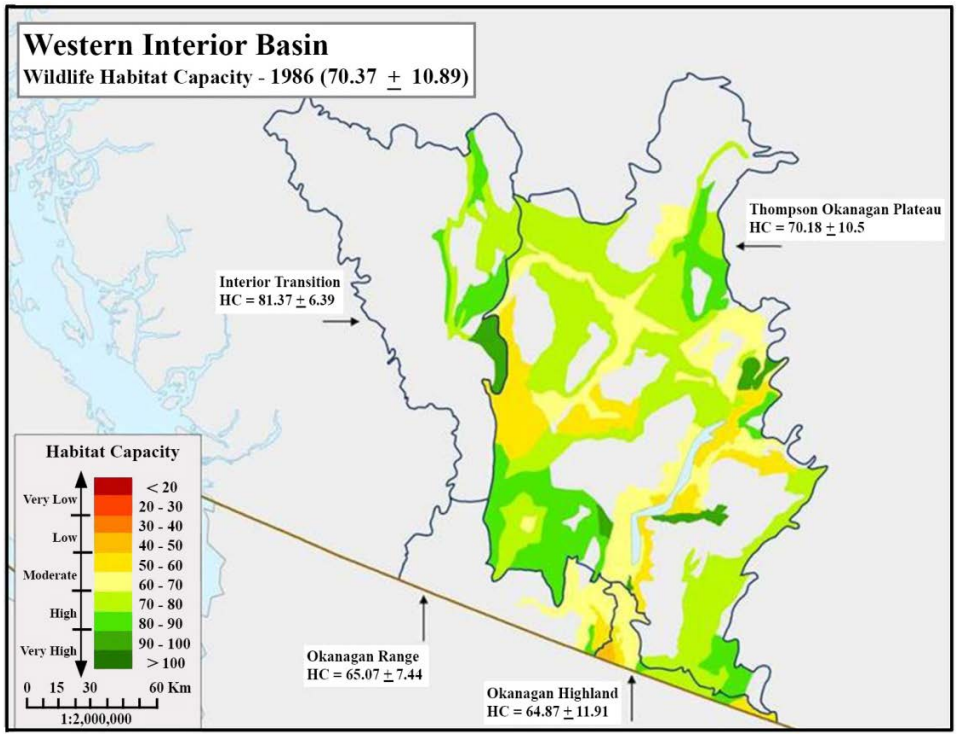


Figure 41. Wildlife habitat capacity on agricultural land in the Western Interior Basin Ecozone[+], 1986. HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

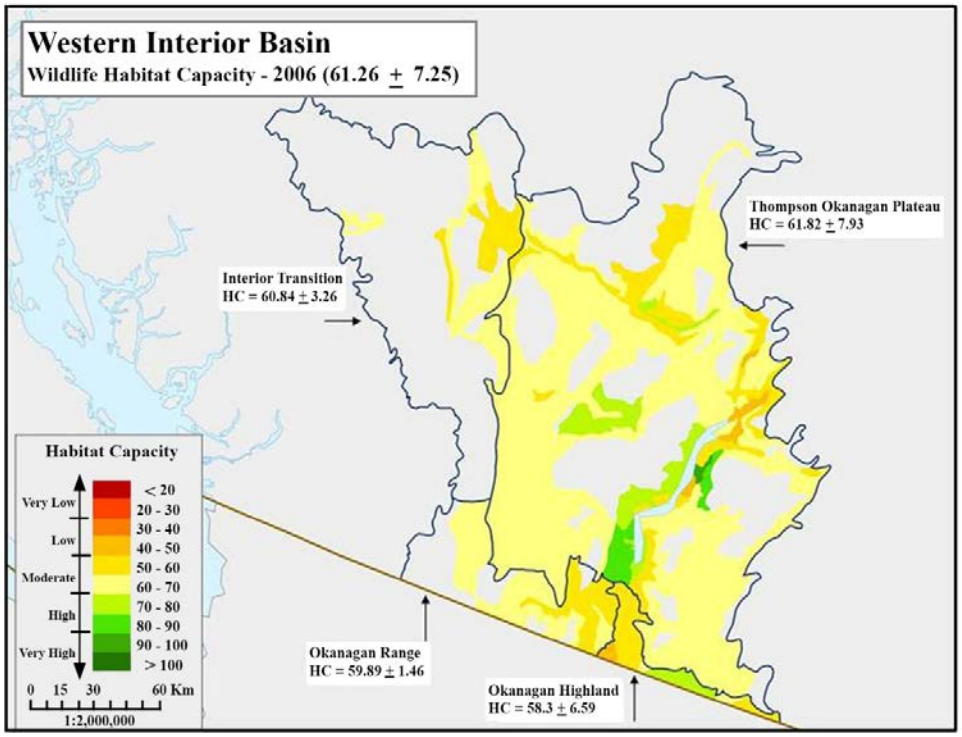


Figure 42. Wildlife habitat capacity on agricultural land in the Western Interior Basin Ecozone[+], 2006. HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

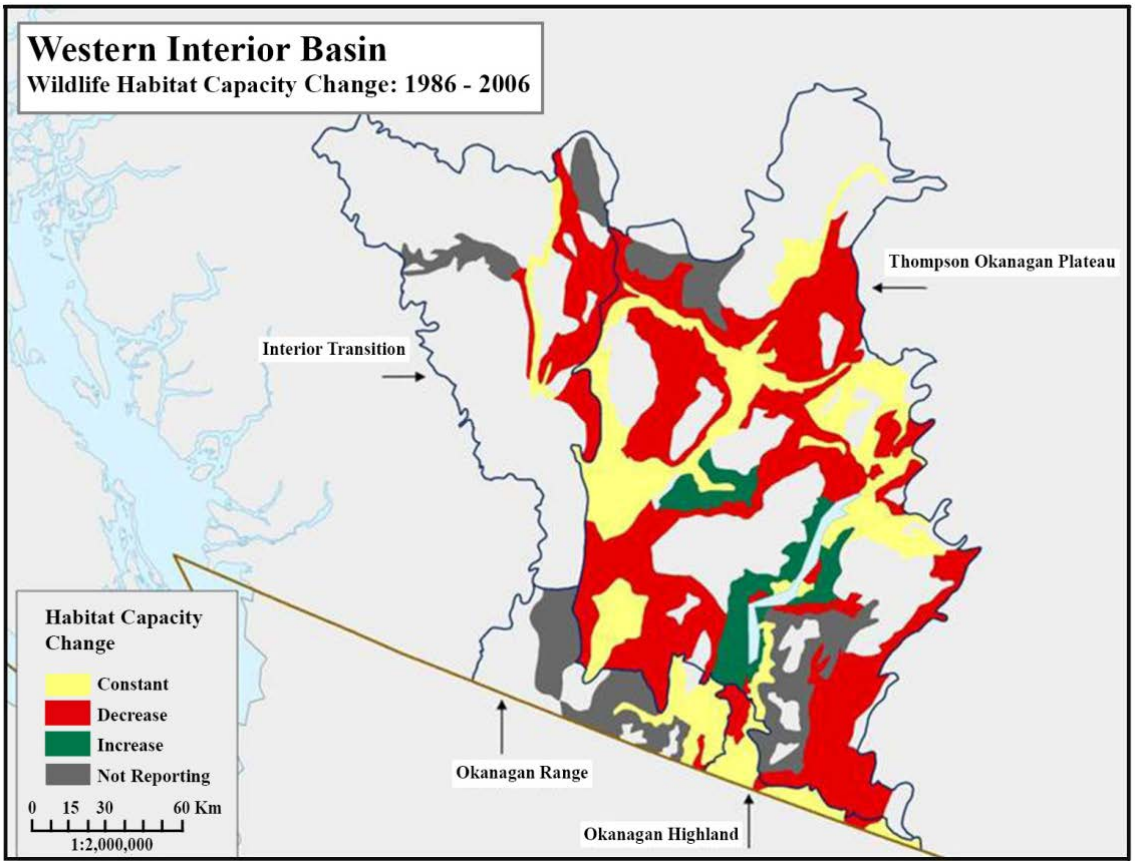


Figure 43. Change in wildlife habitat capacity on agricultural land in the Western Interior Basin Ecozone⁺ between 1986 and 2006.
ANOVA, Tukey HSD p<0.05. All SLC polygons with >5% agricultural land were included in the analysis.

Interpretation

Agricultural land in the Western Interior Basin Ecozone⁺ is dominated by Unimproved Pasture which is of considerable value as wildlife habitat, ranking second only to All Other Land. Declining wildlife habitat capacity was primarily related to almost 6% loss of All Other Land reducing its share to just over 12% of agricultural land. In addition, the share of Improved Pasture dropped from 9 to 5% of agricultural land. These combined losses represented a shift of agricultural land from comparatively higher to lower quality wildlife habitat, as the share of Cropland expanded from 9 to 15%. The expansion of Cropland was mainly due to an increase in the share of Tame Hay from 4 to 11%.

Pacific Maritime Ecozone+

Agricultural landscapes

The agricultural landscape[24] decreased in size by approximately 12% between 1986 and 2006 to make up just over 1% of the Pacific Maritime Ecozone+ (Figure 44). Figure 45 shows total agricultural land area and the amount of land per each cover type in 1986, 1996, and 2006. Unimproved Pasture was the dominant land cover increasing its share of total agricultural land from 32 to 38% over twenty years. The proportion of Cropland[25] expanded from 27 to 38%, as the share of Tame Hay (18 to 22%) and other crops (10 to 16%) increased. The share of All Other Land declined from 26 to 16% of agricultural land. The majority of agricultural land was found in the Lower Mainland (40%) and Eastern Vancouver Island (26%) ecoregions. In the Lower Mainland, the share of Unimproved Pasture and Improved Pasture was constant at around 20 and 27% of agricultural land, respectively. All Other Land decreased (19 to 10%) while the share of Cropland increased (48 to 57%). On Eastern Vancouver Island, the share of Cropland also increased (19 to 29%) but comprised a far smaller component of agricultural land compared to the Lower Mainland. Within the Eastern Vancouver Island, the share of Unimproved Pasture dropped slightly from 38 to 37%, but remained as the most abundant cover type. Tame Hay expanded from 15 to 25% of agricultural land, while Improved Pasture and All Other Land declined (from 17 to 7% and from 25 to 21%, respectively).

[24] The agricultural landscape (or agricultural land), as discussed throughout this report, includes the "All Other Land" category from the Census of Agriculture, which is made up of areas such as wetlands, riparian zones, shelterbelts, woodlands, idle land/old fields, and anthropogenic areas (farm buildings, green houses, and lanes).

[25] Cropland includes all agricultural land except for All Other Land, Unimproved Pasture, Improved Pasture, and Summerfallow.

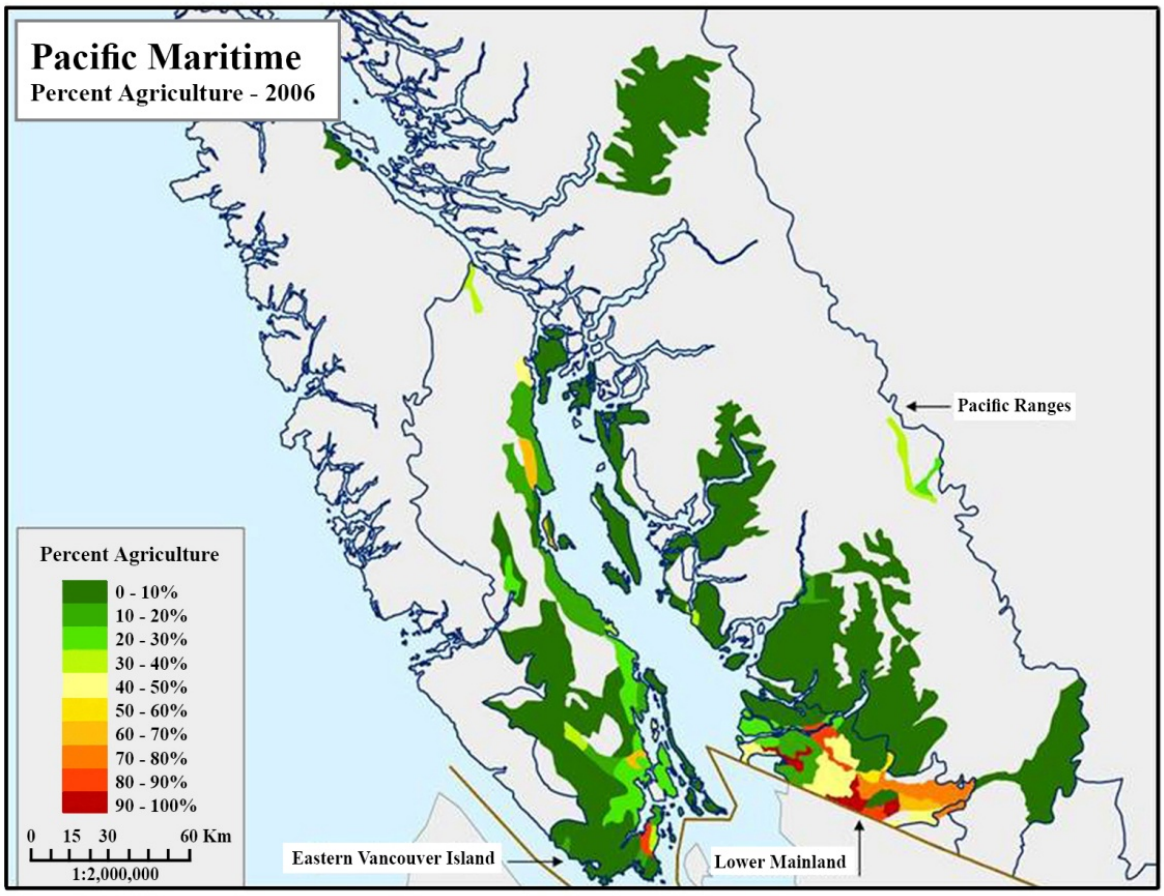
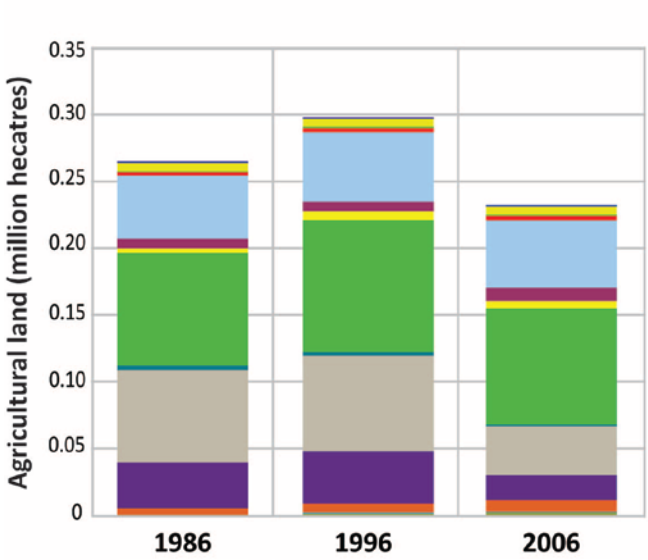


Figure 44. The percentage of agricultural land within the SLC polygons of the Pacific Maritime Ecozone⁺, 2006.



Cover type	Percentage of agricultural land 1986	1996	2006
Winter Cereals	0.4	0.4	0.4
Vegetables	2.4	2.0	2.5
Fruit Trees	0.2	0.4	0.5
Other Crops	0.9	1.0	1.4
Tame Hay	17.8	17.5	21.8
Corn	2.8	2.5	4.3
Cereals	1.2	2.1	2.5
Unimproved Pasture	31.9	33.1	37.5
Summerfallow	1.3	1.0	0.5
All Other Land	26.1	24.1	15.9
Improved Pasture	12.9	13.2	8.0
Berries	1.9	2.2	3.7
Soybeans	0.0	0.0	0.0
Pulses	0.0	0.2	0.2
Oilseeds	0.0	0.4	0.9

Figure 45. Total agricultural land area, the amount of land per cover type (chart), and the relative percentage of each cover type (table) for the Pacific Maritime Ecozone⁺ for 1986, 1996, and 2006.

Potential wildlife use of agricultural land

A total of 319 species of terrestrial vertebrates (221 birds; 76 mammals; 8 reptiles; 14 amphibians) used agricultural land in the Pacific Maritime Ecozone⁺. All Other Land was the most important land cover providing both breeding and feeding habitat requirements for 81% (258) of species. Unimproved Pasture provided both breeding and feeding habitat for 21% (66) of species and a single habitat requirement for 36% (114). Cropland fulfilled the entire habitat requirements of only 12% (37) of species while providing either breeding or feeding habitat for 25% (81).

Wildlife habitat capacity

Although still within the moderate category, average wildlife habitat capacity on agricultural land in the Pacific Maritime Ecozone⁺ declined significantly between 1986 and 2006 (64.4 ± 19.2 to 52.6 ± 15.4) (ANOVA, $F = 14.0$, $p<0.05$) (Figure 46). Figure 47 and Figure 48 show the spatial distribution of habitat capacity values for 1986 and 2006. Over this period, habitat capacity significantly decreased on 68% of agricultural land, increased on 6%, and was constant on 26% (ANOVA: Tukey HSD, $p<0.05$) (Figure 49). Habitat capacity declined from 56.9 ± 23.9 to 43.2 ± 15.0 in the Lower Mainland and from 59.5 ± 13.3 to 51.9 ± 10.7 on Eastern Vancouver Island.

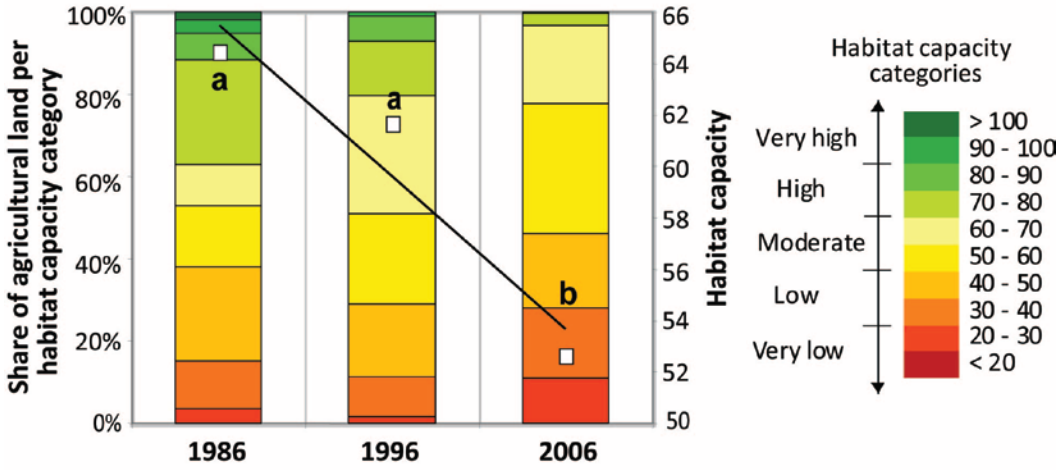


Figure 46. The share of agricultural land in each habitat capacity category (bars, left axis) and the average habitat capacity for the Pacific Maritime Ecozone⁺ in 1986, 1996, and 2006 (points and line, right axis).
Years with different letters differed significantly (ANOVA: $F = 14.0$, Tukey HSD $p<0.05$).

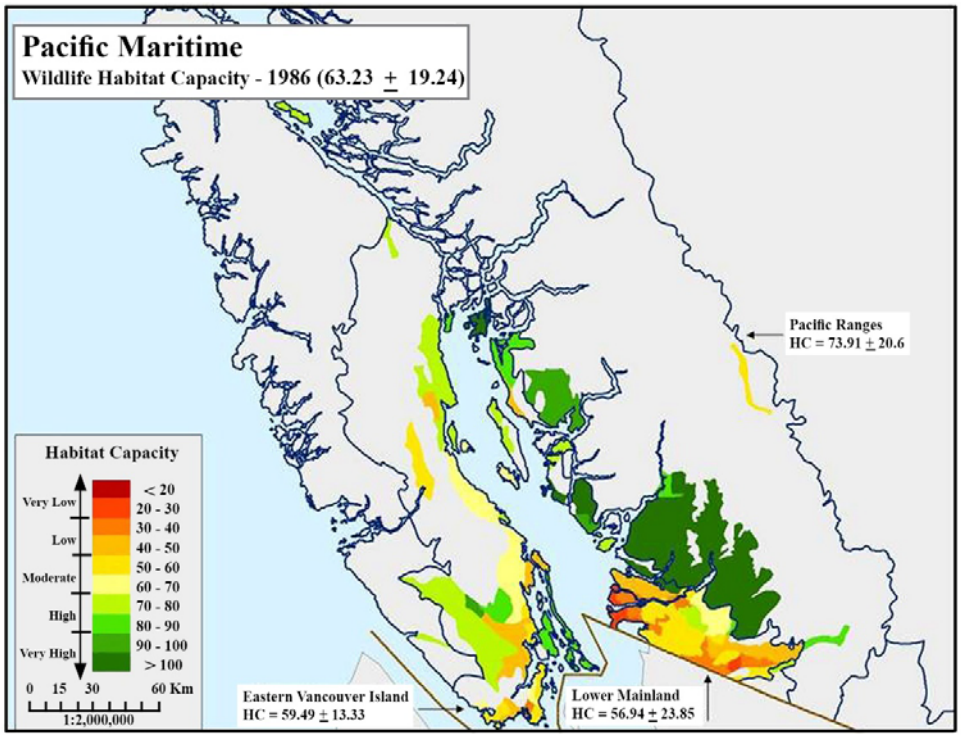


Figure 47. Wildlife habitat capacity on agricultural land in the Pacific Maritime Ecozone[+], 1986. HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

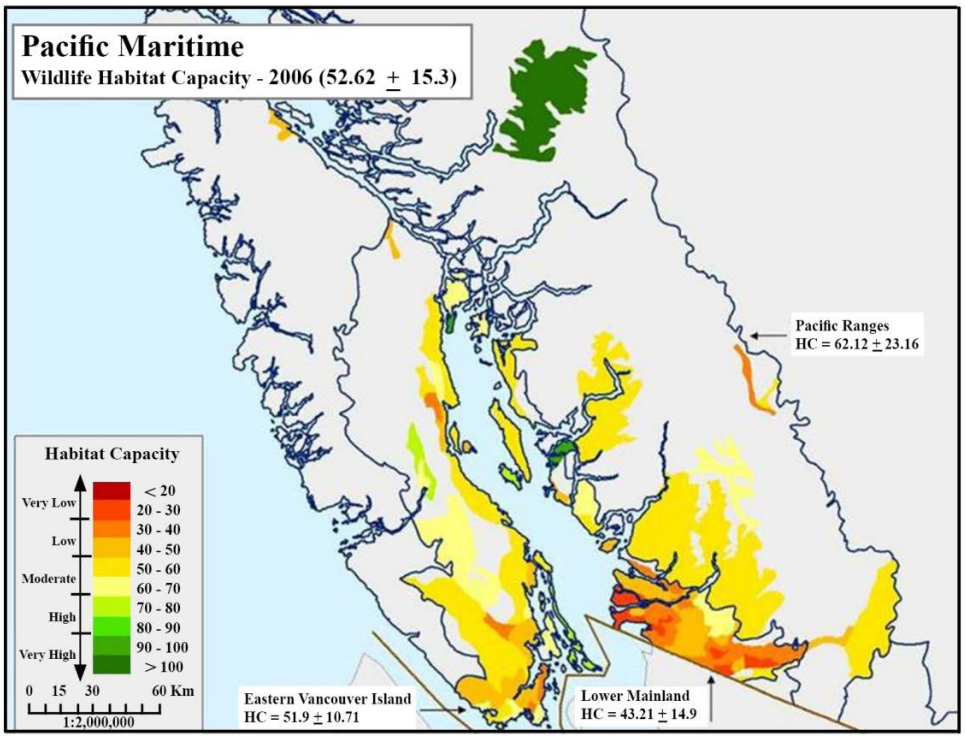


Figure 48. Wildlife habitat capacity on agricultural land in the Pacific Maritime Ecozone[+], 2006. HC means average Habitat Capacity for the ecoregion. All SLC polygons with >5% agricultural land were included in the analysis.

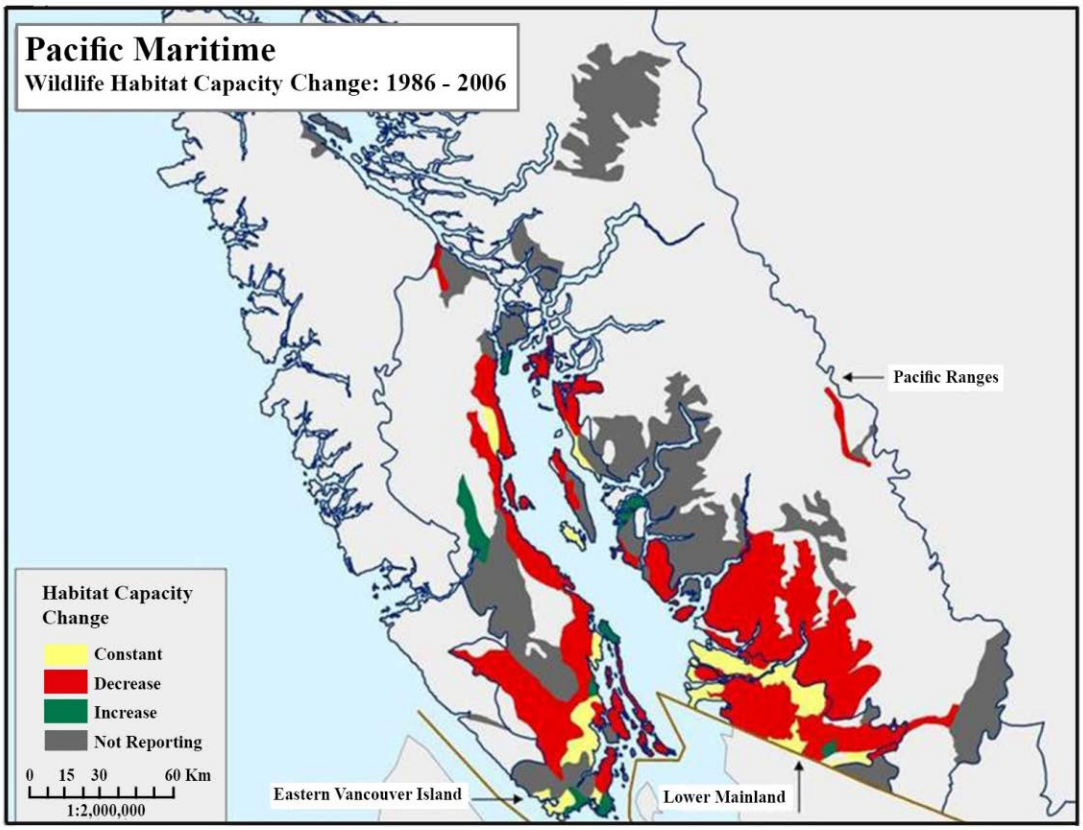


Figure 49. Change in wildlife habitat capacity on agricultural land in the Pacific Maritime Ecozone⁺ between 1986 and 2006.
ANOVA, Tukey HSD p<0.05. All SLC polygons with >5% agricultural land were included in the analysis.

Interpretation

The loss of All Other Land was the primary cause of significant habitat capacity decline on agricultural land in the Pacific Maritime Ecozone⁺. At the ecozone⁺ level, the share of All Other Land declined by close to 10%, representing a loss of the most valuable natural/ semi-natural habitat, while Cropland expanded. This trend was most evident in the Lower Mainland Ecoregion where a 9% loss reduced All Other Land to under 10% while Cropland gained 9% to comprise just under 60%. Habitat capacity declines on Eastern Vancouver Island were also linked to declines in All Other Land (-4%) and Improved Pasture (-10%), and corresponding increases in the amount of Cropland (10%) to comprise just under 30% of agricultural land. The higher habitat capacity in this ecoregion compared to the Lower Mainland was due to an overall higher All Other Land content (21 compared to 10%) and a smaller share of Cropland (29 compared to 57%). Unlike much of the ecozone⁺, the agricultural footprint expanded in the Pacific Ranges Ecoregion, primarily through the addition of Unimproved Pasture. In 2006, Unimproved Pasture (59%) accounted for the majority of agricultural land in the ecoregion while Cropland comprised only 20%. Although declines in the share of All Other Land (38 to 13%) reduced habitat capacity from 73.9 ± 20.6 to 62.1 ± 23.2, it still ranked as highest in the Pacific Maritime. This is because the second most valuable agricultural land cover for wildlife (Unimproved Pasture) comprised close to 60% of total agricultural land.

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