Institute for Sustainable Food Systems

Research Brief

From the Southwest BC Bioregion Food System Design Project

2016

photo credit: LoweStock (Thinkstock)

Wildlife Habitat and the Impact of Agriculture on Biodiversity in a Regionalized Food System

Anna Rallings[1]
Sean Smukler[2]
Kent Mullinix[1*]

[1]Institute for Sustainable Food Systems (Kwantlen Polytechnic University); Richmond, BC

[2] Faculty of Land and Food Systems (University of British Columbia); Vancouver, BC

*Corresponding author: Kent.Mullinix@kpu.ca

Abstract

A rich diversity of regional wildlife relies on habitats found on farmland. The quality of the habitat is dependent on the utility of the habitat for each species, the overall area it occupies as well as how it is connected to other habitats in the landscape. Although food crops provide suitable areas for some species, wildlife tend to rely more heavily on non-production areas, such as large forest stands, and established crops, such as pastures and perennial fruit crops. To assess the impact of agricultural practices on wildlife habitat, metrics were used to evaluate both the proportion of high value habitats (Wildlife Habitat Capacity, WHC) and connectivity of non-production habitats (Radius of Gyration, ROG). Currently, the SWBC bioregion has a low WHC rating of 37 and a landscape of highly disconnected habitats. Increases in either local food production or agricultural land use resulted in a decrease of habitat quality. Habitat enhancements, hedgerows and riparian buffers, were able to more than double habitat connectivity but only made small improvements to the overall WHC due to their relatively small size. On-farm habitat enhancements provide a low trade-off mitigation for some negative impacts of habitat loss, however, the SWBC bioregion would benefit from the conservation of high value non-production habitats.

Wildlife Habitat and Biodiversity

Adding habitat enhancements on agricultural land, such as riparian buffers and hedgerows, creates important space for wildflife to create homes, breed and find food.

Agricultural lands are home to a diversity of species that use a diversity of habitats. Although many species use crop fields for habitat, a large number of species require vegetated non-production areas, such as hedgerows or forest stands, for one or more of their life stages (Duelli & Obrist, 2003b). As agriculture is imposed and expands, the landscape tends to simplify and lose critical non-production habitats (Balmford et al., 2012; Vandermeer & Perfecto, 2007). Non-production perennial vegetation (NPPV), in the form of on-farm trees and shrubs, has been identified as critical permanent or connective habitat (Bentrup, 2008; Tscharntke et al., 2005). Wildlife on farmland use these habitats to move through the landscape, take refuge from predators, nest and feed (BC Ministry of Agriculture, 2010). The connection of a habitat patch to a network of habitats is an essential aspect of its quality (Duelli & Obrist, 2003a; Taylor et al., 1993). Without this connection, wildlife can become isolated in areas where they will not be able to survive (Hanski & Gilpin, 1991).

The SWBC bioregion is an area of substantial biodiversity, with many species living in or around protected farmlands (Millennium Ecosystem Assessment, 2005). Despite interest about landscape pattern effects on biodiversity (AXYS Environmental Consulting Ltd., 2006), there is little information on the impact of agricultural lands on the quantity and quality of habitat that support the bioregion's biodiversity. The objective of the Wildlife Habitat Capacity (WHC) and Connectivity indicators is to evaluate how what we grow and where we grow it affects the quality of habitats available and the connectivity of critical NPPV habitats.

Methods

The WHC index was developed by Javorek & Grant (2011) for the purposes of estimating the contribution of agricultural and non-production land covers to wildlife habitat in Canada. The authors evaluated the relationship of 320 Pacific Maritime and 377 Montane Cordillera species with 31 crops, non-production areas and other land uses (see Appendix I for complete list). The habitat value of each land cover was weighted according to its proportion of the SWBC bioregion agriculture landscape. These proportions were derived from the SWBC bioregion model outputs. The WHC value of each modelled scenario was calculated as the sum of the Species-Specific Habitat Availability (SSHA):

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

The SSHA factors breeding (b) and feeding (f) habitat use value (HUV) and the given land cover (LC) proportion in the SWBC bioregion. The results are interpreted per the following levels: 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.

Connectivity was measured directly from land cover maps for the SWBC bioregion. Radius of Gyration (ROG), a measure of the mean traversable distance through NPPV habitats, was used as a metric of habitat connectivity (Rallings, 2016). The metric was calculated in 45 2.25km2 subsamples of the SWBC bioregion land cover map (see Carbon Stocks indicator). ROG in each sample was measured using FRAGSTAT 4.2 (McGarigal & Ene, 2013) and compared to the maximum linear traversable distance of the subsampled area.

WHC and Connectivity were measured for SWBC bioregion land use scenarios, modeling changes in crop mix, the amount of agricultural land used, and imposition of on-farm habitat enhancements. Habitat enhancements included (1) 6m wide hedgerows along all roadsides and property boundaries and (2) 30m riparian buffers along all waterways and water body edges.

Results and Discussion

The SWBC bioregion baseline had a diversity of crop types, wetlands, on-farm NPPV, contiguous forests, and grasslands. In Pacific Maritime and Montane Cordillera zones, contiguous forest stands were the highest value habitats. Other desirable habitats included wetlands, pastures, berries and other non-production areas (such as hedgerows) (Javorek & Grant, 2011). Crops mimicking the historic forest and grassland habitats of the bioregion's species, such as pasture or perennial fruit crops, contribute to greater farmland WHC. The Baseline 2011 bioregion WHC rating was 37 (Low), primarily due to extensive cropping in addition to extensive pasture, small fruit production and semi-natural areas. The existing contiguous NPPV on the bioregion's farmland, of which 20% was in the form of small fragments and hedgerows, provided a mean connectivity of 133 meters (m), 6.3% of the maximum traversable distance of the subsamples. Without a change in the amount of NPPV or other high value habitats, a continuation of this Baseline 2011 crop mix per the Business-as-usual (BAU) scenario in 2050 would result in the same WHC and Connectivity. The habitat available within farmlands would remain Low and higher quality NPPV habitats would remain disconnected. However, these two indicators were affected in two 2050 scenarios in which there was an altered mix of crops produced, an altered amount of land used for agriculture, and implementation of on-farm habitat enhancements.

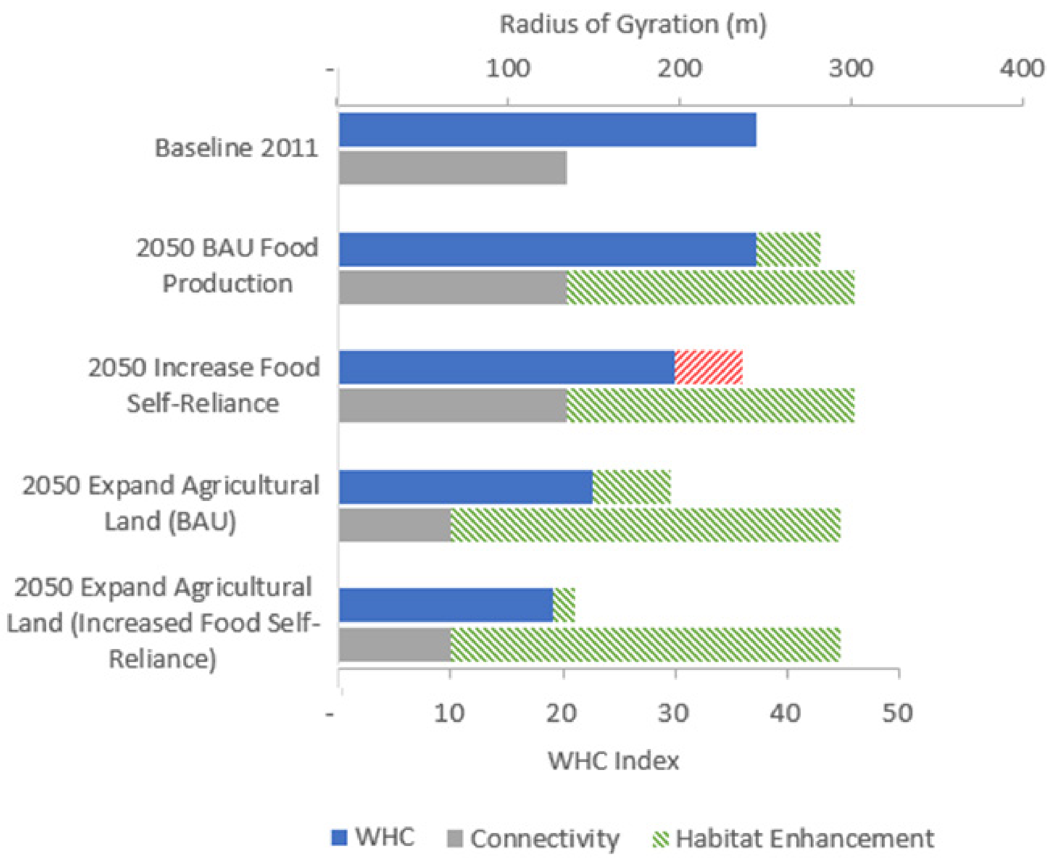

Figure 1 - WHC and Connectivity (Radius of Gyration) in Baseline 2011 and 2050 scenarios. The metric improvement due to Habitat Enhancements is shown in green stacked in addition to the initial result. Habitat Enhancements increased all metrics except in the case of "2050 Increased Food Self-Reliance" where the WHC fell by 6 (shown as red detraction from initial result).

A shift in crop production per the 2050 Increase Food Self-Reliance scenario had a small negative impact on WHC, reducing it to 36 (Low) as compared to the 2011 Baseline rating of 37 (Figure 1). The localized food system resulted in a somewhat less extensively farmed landscape. Although this shift in crop production resulted in a three-fold increase in annual vegetable production with a low habitat value, it also resulted in a six-fold increase in fallow land having a high habitat value. The reduction in perennial fruit crops between the 2011 Baseline and Increase Food Self-Reliance scenario also contributed to the low WHC rating. However, overall crop mixture did not have a large impact on the WHC rating largely because of retention of (Baseline 2011) NPPV.

The overall amount of non-production land was the critical factor in the bioregion's WHC rating and Connectivity. Scenarios which expanded agricultural land had the greatest negative impact on both measures of habitat quality. When agriculture was expanded to all farmable areas of the bioregion's ALR (2050 Expand Agricultural Land scenarios), 77.1% of NPPV and 75.4% of peatlands, swamps and wetlands were lost. Compared to the 2011 Baseline, increasing in farmed land per the 2050 Expand Agricultural Land- Business as Usual Cropping) resulted in a 37.8% decrease in WHC (23, Very Low). The 2050 Expand Agricultural Land -Increase Food Self-Reliance Crop Mix scenario resulted in a 48.6% decrease in WHC (19, Very Low) (Figure 1). For both scenarios loss of critical on-farm habitats also resulted in a substantial decrease (50.5%) in the ROG from a Baseline 2011 average of 133.5m to 66.0m (Figure 1). Connectivity was also substantially reduced in scenarios with agricultural land expansion. Habitat enhancements were evaluated for potential mitigation for these negative impacts. Imposition of hedgerows and riparian buffers had a substantial impact on Connectivity (ROG) but only a small impact on WHC values. When these on-farm NPPV management practices are implemented throughout the landscape, they improve the Connectivity of the existing network of NPPV. However, due to the relatively small land area they occupy, hedgerows and riparian buffers do not contribute greatly to the overall proportion of non-production land in the SWBC bioregion, and therefore do little to improve the low WHC value. When Baseline 2011 NPPV is retained (as in 2050 BAU Food Production and 2050 Increase Food Self-Reliance scenarios), the addition of habitat enhancements significantly increase ROG (Connectivity) from 133.5 m to 301.8 m, more than doubling the maximum traversable area from 6.2% to 14.2%. The impact of these practices was more dramatic when the existing habitat was converted to agricultural land (as in 2050 Expand Agricultural Land scenarios). In a landscape where agriculture was expanded to all farmable areas, the addition of habitat enhancements significantly increased ROG (Connectivity) by 344% to 293.5m. These habitat enhancements increased the connectivity of the landscape to similar levels for all scenarios, regardless of the status of other non-production areas. The results illustrate that on-farm habitat enhancements can be beneficial in all land use scenarios protecting habitat connectivity even when the landscape is otherwise simplified and that this is especially impactful if we are to expand agriculture production. However, these connecting habitats have greatest value when linking larger, high value habitat areas (Fischer & Lindenmayer, 2007), most of which were lost in the Expand Agriculture Land scenario.

Neither WHC nor Connectivity alone can provide a complete picture of habitat quality for bioregional biodiversity. The types of crops grown, the amount of NPPV and its configuration all have profound impacts on wildlife habitat. The conversion of SWBC's NPPV to agricultural production caused a dramatic decrease for both indicators regardless of the crops grown. The critical role of NPPV, including contiguous forest, wetlands and small patches of trees, in supporting biodiversity in the bioregion is evident and their loss in an expanded agriculture regime constitutes a significant trade-off. The strategic retention of NPPV will be critical to wildlife habitat quality throughout the SWBC bioregion. In an agricultural landscape with competing objectives, on-farm habitat enhancements were a potent management practice that could preserve and even improve habitat connectivity on farmland. Overall habitat quality will decrease as agricultural land expands, but the preservation of a habitat network could prevent the isolation of wildlife in the landscape and mitigate some adverse impacts on biodiversity from agriculture.

Appendix:

Research Brief definitions for WHC Index land cover types from Javorek & Grant (2011):

Agricultural Products:

- Berries: all fruit crops grown on perennial shrubs
- Cereals: all grain crops, including grain for livestock
- Corn: all corn crops
- Fruit Trees: all fruit crops grown on perennial trees and vines
- Improved pasture: all livestock pasture
- Other crops: potatoes
- Oilseed: crops used for oil production, including canola
- Pulses: all legume crops, including beans
- Tame pasture: managed vegetation adjacent to barns, greenhouses and other structures (multiplied by a factor of 0.1 to account for building footprint)
- Vegetables: all field crops excluding crops grown in greenhouses

Non-Production Lands:

- Wetlands (with and without margin): NPPV located on wetland areas
- Riparian Woodlands: Riparian Stands of NPPV within 30m of waterways and water bodies
- Shelterbelt Trees: Hedgerows within 6m of roadways and parcel boundaries
- Woodlands (interior): Large Stands > 9ha
- Woodlands (no interior): Small Elements < 9ha
- Peatland: NPPV located on organic soils
- Idle Land: all unaccounted for non-NPPV farmland
- Open Water: waterways and water bodies, including lakes and rivers

References

AXYS Environmental Consulting Ltd. (2006). Assessment of the regional biodiversity and development of a spatial framework for biodiversity in the Greater Vancouver region. Final Report. Metro Vancouver.

Balmford, A., Green, R., & Phalan, B. (2012). What conservationists need to know about farming. Proceedings. Biological Sciences / The Royal Society, 279(1739), 2714–24. http://doi.org/10.1098/rspb.2012.0515

BC Ministry of Agriculture. (2010). Stewardship Areas. In British Columbia Environmental Farm Plan Reference Guide (5th ed., pp. 1–19). Abbotsford, BC: BC Ministry of Agriculture. Bentrup, G. (2008). Conservation Buffers: Design Guidelines for Buffers, Corridors, and Greenways (General Technical Report SRS-109). Lincoln, NE.

Duelli, P., & Obrist, M. K. (2003a). Biodiversity indicators: the choice of values and measures. Agriculture, Ecosystems & Environment, 98(1–3), 87–98. http://doi.org/10.1016/S0167-8809(03)00072-0

Duelli, P., & Obrist, M. K. (2003b). Regional biodiversity in an agricultural landscape: the contribution of seminatural habitat islands. Basic and Applied Ecology, 4, 129–138.

Fischer, J., & Lindenmayer, D. B. (2007). Landscape modification and habitat fragmentation : a synthesis. Global Ecology and Biogeography, 16, 265–280. http://doi.org/10.1111/j.1466-8238.2006.00287.x

Hanski, I., & Gilpin, M. (1991). Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society, 42, 3–16.

Javorek, S. K., & Grant, M. C. (2011). Trends in wildlife habitat capacity on agricultural land in Canada, 1986-2006. In Canadian Biodiversity: Ecosystem Status and Trends 2010, Technical Thematic Report No. 14. Canadian (p. 46). Ottawa, Ontario: Canadian Councils of Resource Ministers.

McGarigal, K., & Ene, E. (2013). FRAGSTAT 4.2. Amherst, MA: University of Massachusetts. Retrieved from http://www.umass.edu/landeco/research/fragstats/fragstats.html

Millennium Ecosystem Assessment. (2005). Ecosystems and Human Well-being: Synthesis. Ecosystems (Vol. 5). Washington, DC: Island Press. http://doi.org/10.1196/annals.1439.003

Rallings, A. (2016). Evaluating potential impacts of hedgerow and riparian buffer management options on habitat and carbon stocks within the Agricultural Land Reserve of the Lower Fraser Valley, British Columbia. University of British Columbia.

Taylor, P. D., Fahrig, L., Henein, K., & Merriam, G. (1993). Connectivity is a vital element structure of landscape. Oikos, 68, 571–573.

Tscharntke, T., Klein, A. M., Kruess, A., Steffan-Dewenter, I., & Thies, C. (2005). Landscape perspectives on agricultural intensification and biodiversity- ecosystem service management. Ecology Letters, 8(8), 857–874. http://doi.org/10.1111/j.1461-0248.2005.00782.x

Vandermeer, J., & Perfecto, I. (2007). The agricultural matrix and a future paradigm for conservation. Conservation Biology : The Journal of the Society for Conservation Biology, 21(1), 274–7. http://doi.org/10.1111/j.1523-1739.2006.00582.x

About ISFS

The Institute for Sustainable Food Systems (ISFS) is an applied research and extension unit at Kwantlen Polytechnic University that investigates and supports regional food systems as key elements of sustainable communities. We focus predominantly on British Columbia but also extend our programming to other regions.

About the Southwest BC Bioregion Food System Design Project

The Southwest BC Bioregion Food System Design project was conceptualized at ISFS in 2012 and concluded in 2016. The project was conceived as a "research project within a research project," with the broad goals of developing a method to delineate the interconnected economic, food self-reliance, and environmental stewardship potentials of a bioregional food system and applying the method to the Southwest BC bioregion. To our knowledge, this project is the first of its kind. Project research briefs are one means used to present project findings. They are intended to report detailed, topic specific project methods and results. For other research briefs from the project, as well as the project report and summary, and peer-reviewed publications, please visit kpu.ca/isfs.

Major Financial Support Provided by

real estate foundation BRITISH COLUMBIA
Vancity
R. Howard Webster Foundation
Fondation R. Howard Webster
vancouver foundation