INTEGRATING ECOSYSTEM SERVICES AND BIODIVERSITY IN LANDSCAPE MANAGEMENT FOR MULTIFUNCTIONAL AGROECOSYSTEMS: A CASE STUDY IN THE OKANAGAN VALLEY, BRITISH COLUMBIA

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Abstract

Agricultural land represents a significant proportion of global land use; consequently, agricultural activities can have a profound effect on the surrounding landscape, including the ecosystems and habitat relied upon by species within. Managing for ecosystem services (ES) and biodiversity in agroecosystems can provide benefits that offset the environmental impacts of agriculture, including improved soil health and water quality, natural pest control, and climate change mitigation. The goal of this research project is to investigate how integrating ES and biodiversity in agroecosystems can serve to support sustainable multifunctional landscapes, focusing on the Okanagan Valley, Canada, a multifunctional landscape facing challenges of population growth, land use/land cover change, and climate change. Research questions were informed by the principles of agroecology, and designed to explore how integrating ES and biodiversity into agricultural practices and policies might serve to address regional challenges. To investigate the contribution of agricultural land to ES provisioning, a methodology was developed for mapping ES on agricultural parcels in the study area. The parcels were ranked from high to low ES provisioning to show the relative contribution of agricultural parcels to the greater landscape. The results show that parcels in the study area generally provide a moderate level of ES, and including maps of this nature in community plans and stewardship programs can serve to inform land use planning and policies for agricultural land in the Okanagan. The second research question investigates the mechanisms that could be used to assist agricultural producers in maintaining ES provisioning and biodiversity on their properties by conducting interviews of agricultural landowners in the study area. The interview results produced themes that highlight the need for more education, outreach, and assistance for farmers, showing that there is opportunity to enhance programs and services to support farmers in implementing practices that support biodiversity and ES provisioning. Ultimately, the results of this research are meant to provide some methods and validation for supporting and adopting agricultural land management strategies that consider the ecological value of the land by integrating ES, biodiversity, and agroecological practices into land use planning and policy designed to support multifunctional land use.

Lay Summary

Agriculture affects the surrounding landscape, and can result in harmful impacts when managed without environmental awareness. This research project contributes to investigating opportunities for enhancing environmental awareness in agricultural activities for the Okanagan Valley, Canada. Research questions were designed to explore how integrating environmentally-friendly practices in agriculture might help reduce negative impacts to the surrounding landscape. There were two research objectives. First, agricultural properties in the study area were mapped using software to show their contribution to promoting environmental health in the landscape. The results show that agricultural land is moderately beneficial, and could benefit from some more enhanced environmental practices. Second, farmers were interviewed to determine how they could meet environmental goals on their property. The results showed that farmers could benefit from more education, outreach, and assistance. Integrating environmentally-friendly practices in agriculture can improve the overall impact of agriculture on the surrounding landscape.

Preface

This research project was undertaken with the supervision of Dr. Lael Parrott and members of the supervisory committee, Dr. John Janmaat and Dr. Adam Ford. Identification and design of the research program was developed by Dr. Parrott and Theresa Loewen, BSc and MSc Candidate, with approval from Dr. Janmaat and Dr. Ford. Research, fieldwork, interviews, mapping, analysis and writing was conducted by Theresa Loewen. Approval for conducting interviews was provided by the UBC Behavioural Research Ethics Board, Certificate Number H17-02341**.**

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Dedication

I would like to dedicate this thesis to my grandmother, Anita Funk, and my mother, Sylvia Loewen, for their unfailing support and belief in my success throughout my academic journey.

Chapter 1: Introduction

Agricultural land represents a significant proportion of global land use, with 38% (5.1 billion ha) of Earth's ice-free land used for agricultural crops and pastures, and an estimated 2.7 billion ha of land available with the potential for agricultural expansion, making agriculture the largest land use on the planet (FAO, 2003; Foley et al., 2011). Consequently, agricultural activities have a profound impact on the surrounding landscape, including the natural environment and species within. Agriculture affects the landscape at multiple scales, for example, individual fields and farms influence local scale soil communities, water sources, micro-climates, and nutrient cycling, while collectively, the agricultural industry affects the environment at regional and global scales, including water quality and resources, carbon sequestration, and biodiversity (Lovell et al., 2010; Landis, 2017).

Environmental impacts can also result from agricultural expansion into areas with natural ecosystems, causing disturbance or destruction of forests, habitats, soils, and biodiversity (Foley et al., 2011; Power, 2010; Tilman et al., 2001). Despite the negative effects of land conversion for agriculture, the demand for agricultural food production is high and continues to grow, as the human population is expected to reach 9.7 billion by 2050, with a 50% rise in demand for food coupled with an increasing scarcity of arable land and a projected 10^9 hectares of natural ecosystem conversion to agriculture (FAO, 2019; Garbach et al., 2017; Pretty, 2008; Tilman et al., 2001). This trend of increasing agricultural demand will undoubtedly have cascading landscape-scale impacts on regional biodiversity and ecosystem services provisioning. Biodiversity (*biological diversity*) includes all forms of life in ecosystems, which are the "individuals, species and populations in a spatially defined area" (Likens, 1992). Ecosystem services are, simply put, the benefits that humans receive from ecosystems (MEA, 2005). These benefits include services such as food, fresh water, timber, water regulation, climate regulation, carbon sequestration, pollination, recreation, aesthetics, cultural heritage, and habitat. Maintaining both ecosystem services provisioning and biodiversity are key components of sustainable agricultural systems, which are becoming increasingly more important as global and regional demands for agriculture rise.

Historically, increased agricultural demand has been met with more efficient technologies and practices, agricultural land expansion, the use of agrochemicals, large scale monocultures, and dependence on external inputs, allowing agricultural production to triple between 1960 and 2012 (FAO, 2019; Wratten et al., 2014; Altieri, 1999). These innovations have resulted in the intensification, commercialization, and industrialization of agricultural activities with the explicit goal to increase yield (Francis & Wezel, 2015; Wratten et al., 2014). Intensified agriculture includes the use of fertilizers, pesticides, irrigation, mechanization and monocultures that increase production, but raise concerns regarding long-term sustainability, food security, environmental degradation, and loss of ecosystem services and biodiversity (Landis, 2017; FAO, 2019; Foley et al., 2011; Francis & Wezel, 2015; Wratten et al., 2014; Altieri, 1999; Tilman et al., 2001). Furthermore, intensified agriculture results in high input costs, dependency on fossil fuels, and production of greenhouse gas emissions (Wratten et al., 2014). As such, agriculture is contributing to climate change, while in turn climate change will pose further challenges for agriculture resulting from rising sea levels, variability in rainfall, increased temperatures, natural disasters, and loss of species (FAO, 2019; Loreau et al., 2001). Climate change may also have unpredictable effects on agriculture, in particular the dynamic between certain crops, pests, pathogens, and weeds, resulting in more challenges for agricultural land managers (FAO, 2019; Myers et al., 2017).

Now more than ever, agriculture and agrifood systems face significant, multi-scale challenges including increased demand for production, land use/land cover change, climate change, resource availability, population growth, and increased external costs. There is a global recognition of the need for change, to adopt new models that reduce the negative externalities associated with agriculture while allowing for food security, sovereignty and sustainability in the face of the global climate and population projections of 2050 (Garbach et al., 2017). To this end, there is a concerted effort realized by the development and research conducted by international organizations such as the Food and Agriculture Organization of the United Nations (FAO), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Intergovernmental Panel on Climate

Change (IPCC), the Millennium Ecosystem Assessment (MEA), and The Economics of Ecosystems and Biodiversity (TEEB), who have invested in researching these challenges and identifying solutions. Collectively, there is a mandate for sustainable, viable, and actionable best management practices and policies that consider the synergies and trade-offs between agricultural yield and ecosystem services as they fit into the context of projected, global-scale change (Garbach et al., 2017; Geertsema et al., 2016; Myers et al., 2017; Power, 2010; Tilman et al., 2001). Thus, implementation of sustainable agricultural paradigms and policies poses a key challenge to land managers who are faced with the difficult task of implementing on-the-ground practices that must consider both global and regional implications.

This research project contributes to the investigation of opportunities to integrate ecosystem services and biodiversity into agroecosystems in the Okanagan Valley, BC, Canada. The Okanagan Valley is a multifunctional landscape characterized by a mosaic of diverse land uses, including urban, commercial, and industrial areas, transportation corridors, intensive and extensive agriculture, recreation, and natural habitats. Agriculture is the single most extensive land use on privately owned land in the Okanagan, and faces many challenges including: population growth, as the Central Okanagan Regional District is one of the fastest growing regions in the province of BC, increasing at a rate of approximately 2% per year since 2012 (Province of BC Statistics, 2016); land use/land cover change, with expanding urban areas and demand for agricultural land exclusions from the Agricultural Land Reserve (ALR), resulting from growing development pressure and the high cost of land in the Okanagan (BC Ministry of Agriculture, 2014[2]); and climate change, with local climate change projections for the Okanagan predicting a mean annual temperature (MAT) increase of 2.0 - 2.4 °C and decline in mean summer precipitation (MSP) of 10 mm (-9%) by 2050 (BC Agriculture & Climate Change Regional Adaptation Strategies, 2016; Spittlehouse, 2008).

In an effort to address these challenges, this research project was designed to investigate how ecosystem services and biodiversity could be integrated into land management practices, programs, planning, and policies on agricultural land, and was guided by the following research questions:

1. How can the contribution of agricultural properties to ecosystem services provisioning be quantified at the landscape scale?
2. What mechanisms can be used to assist agricultural producers in maintaining ecosystem services provisioning and biodiversity on agricultural land?

The research design includes a mixed methods approach of spatial analysis and landowner interviews for a case study region. A mixed methods approach was chosen because both qualitative and quantitative data are inherent in sample populations, and are complementary approaches for making inferences about sample set data. Qualitative research is important because it generates descriptive data that can provide a level of depth or insight into a research question that quantitative research alone cannot provide. Quantitative research is important because it allows conclusions to be drawn from qualitative data by translating the data from words or images into numbers.

For this research project, spatial analysis was chosen as a method to quantify the contribution of agricultural properties to ecosystem services provisioning, as it provides both a visual and numerical solution derived from data. Agricultural landowner interviews were chosen as a complementary method to provide in-depth descriptive qualitative data to supplement the visual and numerical data from spatial analysis. Ultimately, when used together, both methods provide valuable data and a balanced, holistic approach to investigating the research questions for the study area.

A case study region was chosen as the study area because it provides a more focused method of exploring the research questions that is feasible in terms of available data and accessibility of landowners, with the possibility of replicating the methodology for other areas, as well as the opportunity to adjust the approach for different scales, from individual land parcels to neighbourhoods, local communities, regional communities, and the greater landscape. The Okanagan Valley was selected for the case study because it is a fast-growing, diverse, multifunctional, and multi-governed landscape with a rich history of agriculture, which provides an excellent example of the complexity and challenges of land management for agroecosystems, with the opportunity to

explore innovative ideas and generate unique solutions.

1.1 Literature Review

The following sections discuss the various components of sustainable agroecosystems and the benefits of integrating agroecological principles into policy and practice for holistic landscape management designed to support multifunctional land use.

1.1.1 Biodiversity and Ecosystem Services in Agroecosystems

Biodiversity is a key component for the functioning of healthy ecosystems, particularly agroecosystems (*agricultural ecosystems*), and is necessary for productive sustainable agriculture and ecosystem services (ES) provisioning (Kazemi et al., 2018; Landis, 2017; Pimentel et al., 1992). For example, biodiversity has direct and indirect functions in agroecosystems, as it can result in increased food production, natural pest control, carbon sequestration, and reduced soil erosion, as well as serve as an indicator of farming practices (Altieri, 1999; Kazemi et al., 2018). However, global biodiversity losses have been observed at an unprecedented rate due to agricultural intensification, which has been largely responsible for the conversion of complex natural ecosystems into simplified managed ecosystems (Landis, 2017; Matson et al., 1997; Tilman et al., 2001; Tscharntke et al., 2005). For example, habitat destruction, monocultures, and pesticide use negatively affect organisms such as soil microbes, pollinators, and natural predators of pests, reducing the ability of ecosystems to function and maintain their natural processes (FAO, 2019; Kazemi et al., 2018). Agricultural intensification at the local and landscape scale have compounding and cumulative effects that contribute to global biodiversity losses (Tscharntke et al., 2005). Examples of local scale intensified farming practices include shorter crop rotation cycles, decreased crop diversity, maximum tillage, high-yield monocultures, amalgamation of smaller fields into one crop, and increased inputs of fertilizers and pesticides, while landscape scale intensified farming practices include conversion of grassland and other habitats to arable crops, destruction of edge habitats leading to reduced resistance to invasive

species, landscape homogeneity, lowering of water tables, and fragmentation of natural habitat (Tscharntke et al., 2005). Both local and landscape scale intensified farming practices can reduce biodiversity and affect ecosystem health, functioning, and yield, resulting in species population declines and disruption of biological pest control, pollination, and invasive species resistance (Tscharntke et al., 2005; Altieri, 1999).

On the other hand, agricultural land can also contribute to global biodiversity and ES provisioning when compared to the built landscape, particularly when it is managed sustainably (Pimental et al., 1992; Tscharntke et al., 2005). Sustainable agriculture can be defined as practices that integrate biodiversity and ecology into food production to mitigate environmental problems, such as minimizing waste, supporting the functioning of healthy ecosystems, encouraging collaboration through knowledge sharing and partnerships, and supporting the economic viability of agricultural operations (Altieri, 1999; Pretty, 2008). The principles of sustainable agriculture are intended to reduce the negative impacts of intensified agriculture by restoring functional biodiversity, maximizing the use of renewable inputs, minimizing waste production, and using human capital and renewable resources over external, non-renewable inputs (Altieri, 1999; Pretty, 2008). Sustainable agricultural practices aim to support natural systems without reducing productivity, by using people and technologies that do not cause undue harm to the environment. However, lowered yields do not necessarily mean lowered profit, as a reduction in productivity can be offset by lower input expenses and by the production of fewer, higher quality products that farmers are able to market and sell for higher profits. A study by LaCanne and Lundgren (2018) found that grain fields managed by regenerative agricultural practices yielded 29% lower production but 78% higher profits over traditional corn production systems, and that higher profits were positively correlated with the soil particulate organic matter rather than yield.

According to Pretty (2008), there are four key principles that define sustainable agriculture: 1) integrating biological and ecological processes into food production; 2) minimizing the use of non-renewable inputs that cause harm to the environment; 3) using knowledge and skills of farmers

(human capital); 4) solving agricultural and natural resource problems by using the integrated capacity of people working together collaboratively. The goal of sustainable agriculture is to ensure the continued provisioning of food and the functioning of healthy ecosystems over time, so that humans can rely on the benefits of both essential systems in the future. According to Kazemi et al. (2018), "biodiversity is one of the basic principles of sustainable agriculture, food security and health and it is one of the most important elements to manage systems toward a sustainable agroecosystem."

Similarly, the concept of regenerative agriculture focuses on "enhancing and restoring resilient systems supported by functional ecosystem processes and healthy, organic soils capable of producing a full suite of ecosystem services, among them soil carbon sequestration and improved soil water retention" (Gosnell et al., 2019). Regenerative agriculture began as an approach for more sustainable agricultural production systems using resources found on-farm in place of expensive inputs such as energy, fertilizers and pesticides (Francis et al., 1986).

Agroecosystem managers can employ sustainable and regenerative practices to plan for biodiversity by using beneficial management practices focused on ecosystem-based approaches designed to increase crop diversity (cash crops, forage, cover crops, and livestock) and improve overall agrifood system sustainability (Duru et al., 2015; FAO, 2011; Kazemi et al., 2018). To this end, Fischer et al. (2006) propose ten strategies for maintaining biodiversity, ecosystem function, and resilience on agricultural land (Table 1).

Table 1. Landscape management strategies for maintaining biodiversity, proposed by Fischer et al. (2006).

	Pattern-oriented management strategies	**Process-oriented management strategies**
Strategies		
1 - 2	Maintain and create large, structurally complex patches of native vegetation	Maintain key species interactions and functional diversity
3 - 4	Maintain structural complexity throughout the landscape	Apply appropriate disturbance regimes
5 - 6	Create buffers around sensitive areas	Control aggressive, over-abundant, and invasive species
7 - 8	Maintain or create corridors and stepping stones	Minimize threatening ecosystem-specific processes
9 - 10	Maintain landscape heterogeneity and capture environmental gradients	Maintain species of particular concern

Overall, the strategies proposed by Fischer et al. (2006) have common themes, including maintaining landscape heterogeneity, complexity, and integrity of native plants and ecosystems, as

well as integrating buffers and corridors into landscape designs. Specifically for agricultural land, buffers are especially important to reduce effects of agrochemical spraying and invasive species on the surrounding landscape. As agricultural land is commonly used as intensively managed monocultures, heterogeneity and natural patterns in landscape designs are necessary to provide a high level of biodiversity (Fischer et al., 2006). Furthermore, agriculturally managed land alters ecological community composition, which can change species interactions; therefore conserving keystone species and maintaining species diversity within functional groups is important for maintaining ecosystem functioning (Fischer et al., 2006). By integrating biodiversity and ES into agricultural policies and practices, it is possible to shift from intensified agriculture to more sustainable agriculture through strategic landscape designs, or redesigns, aimed to support the conservation of biodiversity and ES at the local and landscape scale (Landis, 2017). Successful agroecosystem landscape designs address energy flows, nutrient cycling, and system resilience, while incorporating social, cultural, and economic values through a participatory, collaborative approach by engaging stakeholders, NGO's, educators and policy makers at multiple levels of governance (Landis, 2017; Prager, 2015; Pretty, 2008). Landis (2017) argues that future landscapes will need to be designed specifically for biodiversity and ES in order to meet sustainable methods of production, and Pretty (2008) adds that redesigning agricultural systems at the landscape scale can result in ecologically managed agroecosystems.

Landscapes with a high degree of natural biodiversity promote healthy ecosystems, which provide valuable services to the surrounding landscape and human inhabitants (Altieri, 1999). Biodiversity allows for ES provisioning in agricultural systems such as nutrient cycling, microclimates, pest control, water regulation and pollution detoxification, while the loss of biodiversity due to landscape simplification can result in reduced ES provisioning as well as associated economic and environmental costs (Altieri, 1999). The concept of ES first emerged in the 1980s, as a collaboration between ecologists and economists in an effort to bridge the gap between humans and nature by integrating the value of nature's services in decision making (Ehrlich &

Ehrlich, 1981; Boval et al., 2017). Since then, there has been substantial research dedicated to investigating the value of ES, most notably the publication by Costanza et al. (1997), who were the first to place a monetary value on non-market ES provisioning to society at a global average of $33 trillion US dollars per year. Several years later, the United Nation published the Millennium Ecosystem Assessment (MEA, 2005), grouping ES into four categories: provisioning services (products obtained from ecosystems), regulating services (benefits obtained from regulation of ecosystem processes), cultural services (non-material benefits obtained from ecosystems), and supporting services (services necessary for the production of all other ecosystem services). Of these categories, provisioning services, such as food and fiber production, are intensively managed for on agricultural lands, while supporting and regulating services such as soil formation and pollination are relied heavily upon for agricultural production (Zhang et al., 2007). This results in an unbalanced relationship of ES managed for on agricultural land. Agriculture makes an important contribution to the landscape by delivering ES such as food, timber, habitat, drought and flood regulation, agritourism, and landscape aesthetics. In turn, ES provide benefits to agriculture such as pollination, biological pest control, nutrient cycling, climate regulation, soil formation, erosion control, soil structure and fertility, water purification and regulation, and genetic resources (Heal & Small, 2002; MEA, 2005; Ricou et al., 2014; Hannon & Sisk, 2009; Martin & Dewenter, 2015; Tzilivakisa et al., 2016; Power, 2010).

Agriculture also provides and receives ecosystem dis-services (EDS) to and from the surrounding landscape. EDS reduce the quality and quantity of ES provisioning. Examples of EDS to agriculture include pest damage and competition for water resources and pollination, while EDS from agriculture include habitat loss, nutrient runoff, pollution, greenhouse gas emissions, and unintentional pesticide poisoning of non-target species (Zhang et al., 2007; Power, 2010). EDS are problematic for two reasons: first, they come with significant costs associated with ecosystem remediation, rehabilitation, and replacement, of which society is more often held responsible for than the agricultural sector; and second, they occur over multiple scales, from pesticides and nutrient

runoff impacting local community water quality, to greenhouse gas emissions contributing to global warming (Power, 2010). Consequently, Power (2010) suggests that linking EDS to agricultural activities can incorporate negative externalities into the costs of production, holding both society and agriculture responsible as producers and consumers, ultimately lessening the negative impacts of EDS on the environment and promoting more sustainable agricultural practices.

Although agriculture typically manages for provisioning ES such as food and fiber, ES can occur together in bundles, or sets of services that appear together repeatedly in the same spatial context, as many ES provided by the landscape are often interrelated (Raudsepp-Hearne et al., 2010; Reyers et al., 2009; Turner et al., 2014). In application, policies intended to promote or maintain a particular ES will consequently enhance the entire ecosystem and flows of ES thereof; for example a healthy watershed managed to maintain water filtration and flood control may also provide wildlife habitat even though that may not be a management priority (Heal & Small, 2002). On the other hand, competing interests can result in tradeoffs between different ES. A study by Raudsepp-Hearne et al. (2010) found that tradeoffs frequently occur between provisioning and almost all regulating and cultural ES at the landscape scale, and that ES-bundle analysis can be useful for determining desirable or undesirable sets of ES that occur in areas of the landscape as a result of ecosystem management practices. However, Renard et al. (2015) caution against defining ES bundles in discrete time frames, as they found that multiple ES provisioning varied through time, shifting between scenarios of tradeoff, no relationship, or synergy, over a 35-year period for a multifunctional landscape in Canada. Managing landscapes for multiple ES is indeed challenging, but necessary to support healthy ecosystems as well as sustain agricultural production and food security for the future.

According to Duru et al. (2015), land use management in agricultural systems determines the spatiotemporal distribution and state of ES and biodiversity, therefore, managing agroecosystems requires an understanding of the flow of ES and EDS to and from agriculture that occurs on multiple spatial and temporal scales, such as individual fields, farms, landscapes, and regions over time. For example, climate regulation is an ES provided to agriculture that is supplied at the field and farm

scale by vegetation and local microclimates, while at the landscape scale vegetation influences local climate, amount of precipitation, and temperature, and at the regional and global scale vegetation and soils provide carbon sequestration and storage (Zhang et al., 2007). This issue of scale can influence farmers' decision making and management strategies. For example, ES at the field and farm scale directly impact the farmer, thus they have a vested interest in maintaining ES such as soil fertility and retention, pollination, and pest control, while ES at larger scales such as landscape aesthetics, habitat, and climate regulation have indirect impacts that are often costly for individual farmers to maintain alone, and are also common public services that benefit not only individual farmers, but the surrounding community (Zhang et al., 2007; Power, 2010). The flow of ES and EDS on agricultural land and the scale on which they occur over time should be taken into consideration in agricultural management strategies, land use planning, and policies, as on-farm practices can have consequential effects resulting in negative externalities to the local community and greater society (Pretty, 2008; Heal & Small, 2002).

Furthermore, recommended management practices for agroecosystems need to address tradeoffs between managing for maximum production (one ES) versus multiple ES to society (MEA, 2005; Smith & Sullivan, 2014). ES and EDS flows on intensively managed agricultural lands are focused primarily on maximizing provisioning services, while supporting and regulating services are relied heavily upon, thus any evaluation of tradeoffs should consider spatial scale, temporal scale and reversibility of ES and EDS (Power, 2010; MEA, 2005; Rodriguez et al., 2006). Management strategies and policies often prioritize local or immediate ES and commodities as a tradeoff for ES that are more distant spatially and temporally, creating potential problems and uncertainties for future management (Power, 2010). Zhang et al. (2007) assert that tradeoffs between ES and agricultural production should be optimized to maximize social benefits in public policy. However, managing for ES is inherently complex, as agricultural activities controlled by farmers and land managers (ES producers) influence the delivery of those services to the public (ES consumers) who have little control over their production, yet receive the majority of the benefits from ES provisioning to society

(Power, 2010). This brings into question the issue of compensating farmers for ES provisioning of common ES to society. Power (2010) summarizes several approaches for incorporating non-market ES values and ecological incentives into public policy, including government and private sector programs and initiatives that provide direct payments for ES, agri-environment payment schemes for farmers designed to financially incentivize environmentally friendly agricultural practices, and cap and trade initiatives with global markets for pollution and carbon.

Ultimately, agricultural policies and incentives should be developed to include growing knowledge about ecological production, function and valuation, while being easy to implement, adaptable, and responsive to changes in economic and ecological market conditions (Power, 2010). Smith and Sullivan (2014) propose that investigating farmers' perceptions of ES can help develop models of payment schemes for ES, determine which ES management practices would most likely be employed by farmers, and ascertain farmers' values of ES based on their motivations, knowledge and interests. Agricultural policies and programs designed to include ES will ultimately be put into practice at the farm-scale by those that directly manage the land, thus their development should involve extensive consultation with farmers, landowners, land managers, and stakeholders in order to be successful in uptake. Incorporating ecological values into agricultural systems by integrating biodiversity and ES into policies, programs and practices supports healthy, resilient ecosystems, while allowing for sustainable agricultural production and multi-use landscape management.

1.1.2 Landscape Connectivity and Multifunctionality

Agricultural landscapes can support high biodiversity, as well as maintain resilience to recover from disturbances when maintained as a mosaic of connected, heterogeneous habitats (Altieri, 1999; Bengtsson et al., 2003). Landscape heterogeneity refers to the variability of patterns and patches in the landscape at multiple spatial scales, and has been linked to increased biodiversity on agricultural land (Benton et al., 2003), while landscape connectivity relates the spatial components of ecosystems and landscapes (Duru et al., 2015). A complex landscape matrix connects habitat patches,

contributing to the overall connectivity of the landscape for ecological processes (Fischer et al., 2006). On the other hand, simplified landscapes in intensified agricultural systems and agricultural expansion into natural areas can result in habitat fragmentation causing loss of species, biodiversity, and ES provisioning (Tscharnktke et al., 2005; Robinson & Sutherland, 2002; Tilman et al., 2002; Benton et al., 2003; Vaca et al., 2018). Thus, managing landscapes for habitat connectivity and resource continuity promotes ES provisioning and biodiversity enhancement by increasing the heterogeneous complexity of natural areas and the composition and configuration of production cover types on agricultural land (Schellhorn et al., 2015; Fahrig et al., 2011). For example, studies have shown that the biology of arthropods, which make up 90% of all species, is directly and indirectly affected by spatial patterns in agricultural landscapes, such that large and homogeneous monocultures that fragment the landscape can lower the viability of populations, while diverse, mosaic patterns of trees, fences, hedges and wetlands in farmyards can create multiple habitats that lead to population benefits (Altieri, 1994; Altieri, 1999; Pimentel et al., 1992).

Increasing the diversity of vegetation on large-scale monocultures by planting field margins and hedgerows can enhance connectivity by serving as biological corridors between habitat patches and ecological processes (Altieri, 1999; Fischer et al., 2006). Connecting large patches of native vegetation is important for supporting species habitat and maintaining high natural biodiversity, particularly on agricultural land. Connectivity can be achieved through corridors (long vegetated strips that link distant patches of native vegetation) and stepping stones (small vegetated patches scattered over larger areas of the landscape) (Forman, 1995). Enhancing landscape connectivity by linking habitats helps promote species dispersion and can contribute to ecosystem resilience after disturbance events by promoting migration and propagation of species from distant habitats (Duru et al., 2015), thereby enhancing overall biodiversity. Recently, the concept of biological corridors has emerged as an approach to mitigate habitat fragmentation on agricultural land by influencing the configuration of agricultural matrices for land use distributions over spatial and temporal scales (Vaca et al., 2019). Biological (or ecological) corridors are areas that allow for, or are defined by, wildlife

movement through landscapes, thereby connecting habitat patches, reducing fragmentation and barriers to movement, and increasing overall landscape connectivity (Vaca et al., 2019). As such, corridors are naturally areas of conservation priority that aim to protect biodiversity, sensitive ecosystems, and species at risk.

In multifunctional landscapes, connectivity is important to maintain, as there are often many competing interests for land use that can result in landscape discontinuity and fragmentation if land use is not well-planned or maintained. According to Holting et al. (2019), multifunctionality is "the capacity of a landscape or ecosystem to provide multiple socio-economic and ecological benefits to society… characterized by a high diversity and abundance of different functions and services within the same spatial unit." Therefore, multifunctional landscapes have the capacity to provide high biodiversity and ecological resilience when ecosystems are connected and integrated within areas of mixed land use. Agriculture is just one component of multifunctional landscapes, including urban, commercial, and industrial areas, transportation corridors, recreation, and natural habitats. Adopting a multifunctional landscape management approach allows for "stacking" or combining multiple functions of the greater landscape, such as public services and cultural functions provided by farms, to enhance the overall contribution of agroecosystems to landscape scale provisioning (Lovell et al., 2010). Thus, management and policies for agricultural land should consider the role of agriculture within a multi-use landscape and the effects of activities both to and from agricultural land and the surrounding areas.

Furthermore, agriculture itself is considered multifunctional when it provides multiple ES in addition to food and fibre (Huang et al., 2015). According to Boval et al. (2017), multifunctional agriculture (MFA) should be prioritized, as MFA and ES are key components of sustainable agricultural systems and policies, and should be integrated to improve their application for operational use (Huang et al., 2015). Lovell et al. (2010) propose that landscape multifunctionality is a beneficial approach to integrate in farm designs for several reasons: first, its emphasis on regional, whole-farm spatial scales; second, its inclusion of cultural functions provided by farms; third, its

framework for successful design evaluation; and fourth, its flexibility in application, particularly for unconventional agricultural systems.

Maintaining multiple functions of agriculture and ecosystems on the same land naturally presents challenges, and conservationists often debate about the best approach for landscape management (Huang et al., 2015; Dudley et al., 2017). Two conceptual strategies have emerged in the literature as contrasting approaches aimed to resolve multifunctional land use conflicts as well as reduce trade-offs between food production and biodiversity: land sharing (LSH) and land sparing (LSP) (Karner et al., 2019). LSH is a wildlife-friendly approach to farming and land use management that involves integrating the values of agricultural production and environmental conservation with less intensified, environmentally-friendly agricultural practices, and a focus on the provision of multiple services from a single land parcel (Karner et al., 2019; Huang et al., 2015; Dudley et al., 2017). By contrast, LSP involves managing for single services from multiple, distinct land use parcels by setting aside land for nature conservation that is separate from agricultural land, while prioritizing production on agricultural land, in order maximize each type of land to its highest potential: to permanently preserve species-rich areas or marginal agricultural land strictly for environmental conservation, and to intensively farm concentrated areas of fertile agricultural land to reduce conservation pressures (Karner et al., 2019; Huang et al., 2015; Dudley et al., 2017). LSP focuses on preserving the areas of land that are optimal habitat for individual species and are often incompatible with intensive agricultural production, while LSH considers human use associated with beneficial management practices that support ecosystem services and biodiversity (Gonzalez de Molina & Casado, 2017). Both approaches have validity for multifunctional landscape management, and can be seen as different solutions to the same problem (Fischer et al., 2008; Kazemi et al., 2018). A study by Barral et al. (2015) concluded that LSH and LSP strategies for agroecosystems are case-dependent, particularly for areas of ecological restoration. Therefore, multifunctional land use planning and policy should consider both LSH and LSP approaches to conservation on a case by case basis by

taking into consideration the existing diversity of land use, the suitability and capability of the land, the demands for land use, and the desired state for future land use.

1.1.3 Agroecology

Several actionable management approaches for achieving sustainable goals on agricultural land have been defined in the literature, all of which focus largely on the intensification of systems to increase yield while minimizing negative effects on the environment and mitigating the impacts of climate change. Sustainable Intensification (SI) is the broadest concept, and recommends beneficial management practices for inputs, outputs, environmental services, and natural resources to increase production while reducing environmental impacts (Wezel et al., 2015). Similarly, Ecological Intensification (EI) aims to do the same by "integrating the management of ecosystem services delivered by biodiversity into crop production systems" (Bommarco et al., 2013). Additionally, Agroecological Intensification (AEI) integrates ecological principles and biodiversity management into farming systems by using a whole system approach to sustaining or enhancing ecosystem services, as well as emphasizing social and cultural practices based on intensifying and sharing knowledge of farmers and local land experts (Boval et al., 2017; Wezel et al., 2015).

It has been noted that there is considerable overlap in the definitions and applications of these various management approaches, and as a result the terms are used almost interchangeably (Wezel et al., 2015). According to Gonzalez de Molina and Casado (2017), "'sustainable intensification' and 'ecological intensification' are contradictions in terms, since they have no thermodynamic foundation… but in a specific place and over a limited period of time [intensification] could be sustainable if the intensification occurs under agroecological criteria."

For this reason, agroecology (*agricultural ecology*) has been selected as the preferred approach to guide this research project, as it encompasses all of the qualities of sustainable agriculture, biodiversity, and ES in one practical concept. Unlike other approaches, agroecology provides a framework for applied, actionable, on-farm practices guided by ecological principles and

sociocultural factors designed to sustain and increase production while reducing the impacts of intensified agriculture (Wratten et al., 2014). Agroecology is both a conceptual and applied approach for integrating agricultural and ecosystem-based landscape management strategies. Agroecology encompasses the values of sustainable agriculture, biodiversity, and ES by integrating the knowledge systems of farmers, landowners, industry professionals, the Indigenous community, and the scientific community as a means of intensifying knowledge to define agroecological principles and beneficial management practices (Altieri et al., 2017). According to Gliessman (2014), "agroecology is a science, a productive practice, and part of a social movement that is at the forefront of transforming food systems to sustainability."

The term agroecology first appeared in the literature dating as far back as 1928, in two publications by Klages (1928) and Bensin (1928), emerging from concerns about the long-term sustainability of resources and food production (Francis & Wezel, 2015). Since then, agroecology has gained increasing popularity, and research has more recently been spearheaded by Altieri (1983) and Gliessman (1990; 2014). Many definitions of agroecology have evolved over time, though the most thorough definition is described by Méndez et al. (2017) below:

> "Agroecology [is] an approach that seeks to integrate ecological science with other academic disciplines (e.g., agronomy, sociology, history, etc.) and knowledge systems (e.g., local, indigenous, etc.) to guide research and actions towards the sustainable transformation of our current agrifood system. This definition embodies a transdisciplinary-oriented agroecology, integrating different knowledge systems in a search for solutions to the challenges posed by current agrifood system issues. It also supports the notion that agroecology is an approach that expresses itself as a science, a practice, and a social movement, and that it is most effective when these three dimensions converge. The agroecological principle of integrating farmer/local and scientific knowledge represents one of the core intersections of science and practice in agroecology."

For the purposes of this research project, the concise definition offered by Francis et al. (2003) has

been chosen to define agroecology and its applications as the following: "Agroecology [is] the integrative study of the ecology of the entire food system, encompassing ecological, economic and social dimensions."

In practice, agroecology focuses on reducing dependence on external inputs, challenging the monoculture system by promoting biodiversity, and achieving sustainability by maintaining yield through renewable resources (Altieri et al., 2017). A wide variety of actionable agroecological practices have been defined in the literature, which are listed in Table 2 below.

Table 2. Agroecological (AE) practices (adapted from Wezel et al., 2014, with additional data from Garbach et al., 2017; Garibaldi et al., 2017; Kovacs-Hostyanszki et al., 2017; Pretty, 2008; Francis and Wezel, 2015).

Type of Practice	AE Practices	Scale of Application	Implications
Crop Choice, Distribution, Succession			
	Cultivar Diversity	Practice	Efficiency Increase/Substitution Practice
	Crop Rotations	System	Redesign
	Intercropping (Mixed or Relay)	Practice, System	Redesign
	Agroforestry	System	Redesign
	Aquaculture	System	Redesign
	Permaculture	System	Redesign
	Polycultures	System	Redesign
	Cover Crops	System	Redesign
	Mixed Livestock/Crop	System	Redesign
	Holistic Grazing Management	System	Redesign
	Spatial Heterogeneity	System	Redesign
	Fallow Fields	System	Redesign
Pollination			
	Insectary Flower Strips	Practice	Efficiency Increase/Substitution Practice
	Edge Plantings, Buffers	Practice	Efficiency Increase/Substitution Practice
Fertilization			
	Split	Practice, System	Efficiency Increase/Substitution Practice
	Biofertilizer	Practice	Efficiency Increase/Substitution Practice
	Organic	Practice, System	Efficiency Increase/Substitution Practice
	Integrated Nutrient Management	Practice, System	Efficiency Increase/Substitution Practice
	Compost, Manure	Practice, System	Efficiency Increase/Substitution Practice
Irrigation			
	Drip	Practice	Efficiency Increase/Substitution Practice
	Precision	Practice	Efficiency Increase/Substitution Practice
	Water Harvesting	Practice	Efficiency Increase/Substitution Practice
Pest Control, Weed and Disease Management			
	Natural Pesticides	Practice	Efficiency Increase/Substitution Practice
	Biological Pest Control	System	Efficiency Increase/Substitution Practice
	Allelopathic Plants	Practice, System	Redesign
	Integrated Pest Management	System	Efficiency Increase/Substitution Practice
	Hedgerows	Practice	Efficiency Increase/Substitution Practice
	Native Grasses Between Rows	Practice	Efficiency Increase/Substitution Practice
	Riparian Buffers	Practice	Efficiency Increase/Substitution Practice
	Hand Weeding	Practice	Efficiency Increase/Substitution Practice
Tillage			
	None	Practice, System	Redesign
	Reduced/Conservation/Direct Seeding	Practice, System	Redesign
	Mulch	Practice, System	Redesign
Labour			
	Human Capital	Practice, System	Redesign
Landscape Integration			
	Semi-natural (field or farm)	Practice, System	Redesign
	Riparian/Wetland Restoration or Creation	System	Redesign
	Ecosystem Patches (woodland, wetland)	Practice, System	Redesign
	Landscape Management	Multi-Stakeholder	Redesign

Stewardship and incentive programs designed to support farmers could recommend integrating agroecological practices, such as those listed in Table 2, into their recommendations as a means to promote sustainable agriculture. Table 2 highlights a range of agroecological practices that are accessible to a producers based on the desired scale of application and implication (by practice, system, and redesign).

Currently, knowledge gaps in the field of agroecology include actionable knowledge, political agroecology (multi-governance), practical action plans and guidelines for farmers, multifunctionality of agroecological systems, communicating knowledge and translating it into policies and practices, integrating information to inform sustainable approaches to systems and landscape management, and quantifying the value and costs of maintaining ES (Altieri et al., 2017; Garbach et al., 2017; Gonzalez de Molina & Casado, 2017; Kovacs-Hostyanszki et al., 2017; Bellamy & Ioris, 2017; Wezel et al., 2015). This research project aims to address several of these knowledge gaps, including actionable knowledge, practical action plans and guidelines for farmers, and translating knowledge into policies and practices, through the use of a mixed methods approach of spatial analysis and landowner interviews for a case study region.

Chapter 2: Background and Context

The following chapter covers the background and context for the research project and describes the study area.

Agricultural land in British Columbia, Canada currently occupies 25,902 km^2, accounting for 2.7% of the province's total area, of which the Okanagan Valley represents 2,017 km^2 (7.8%) (Statistics Canada, 2016). A wide variety of commodities are produced in the Okanagan, including tree fruits, grapes, field and greenhouse vegetables, forage, grains and oilseeds, berries, mushrooms, nursery plants, and livestock. The Okanagan is a north-south trending valley ranging in length of just over 200 km with an area of approximately 20,000 km^2 including the regional districts of North Okanagan, Central Okanagan and Okanagan-Similkameen (Statistics Canada, 2016). The glacial history of the Okanagan has produced landforms and deposits that are well-suited for agriculture, including valley terraces, alluvial fans, unconsolidated till, and lacustrine deposits with fertile soils of mixed gravel, sand, sandy loam and silt (Krueger & Maguire, 1985; Wittneben, 1986; Koroscil, 2008). The Okanagan Basin Watershed contains a variety of water bodies including wetlands, creeks, and lakes, the largest of which is Okanagan Lake with an area of 348 km^2, spanning 135 km of the 200 km long valley. Due to its size and proximity to farmland, Okanagan Lake provides a moderating effect on climate for crops in the region. Collectively, the Okanagan's glacial landforms, arable soils, and micro-climates allow crops to thrive in the region, making conventional agriculture an important contributor to local livelihoods dating back to the early European settlements of the 1860s (Koroscil, 2008).

As a multifunctional landscape and one of the most biodiverse regions in Canada, the Okanagan possesses a high degree of complexity in its natural ecosystems, sociocultural history, and governance structure. High biodiversity can be found throughout the region's six biogeoclimatic

zones[1] (BEC zones) containing sensitive ecosystems such as wetlands, riparian, old forests, grasslands, broadleaf woodlands, coniferous woodlands, and sparsely vegetated (Iverson et al., 2008; MacKillop et al., 2016). These ecosystems provide valuable habitat to over 150 red and blue-listed animal and plant species at risk (SAR) in the Okanagan such as the American Badger (*Taxidea taxus*), Townsend's Big-eared Bat (*Corynorhinus townsendii*), Lewis's Woodpecker (*Melanerpes lewis*), Yellow-breasted Chat (*Icteria virens*), Flammulated Owl (*Otus flammeolus*), Great Blue Heron (*Ardea herodias*), Western Rattlesnake (*Crotalus oreganus*), Great Basin Gopher Snake (*Pituophis catenifer deserticola*), Big Horn Sheep (*Ovis Canadensis*), Kokanee Salmon (*Oncorhynchus nerka*), and Western Painted Turtle (*Chrysemys picta bellii*) (BC Conservation Data Centre, 2019).

The Okanagan's sociocultural complexity comes from a rich history of First Nations traditions as well as large-scale immigration from Europe, mainly British, Irish and Scottish aristocrats who purchased, settled and cultivated large areas of land for agriculture from the 1860s to 1900s. During this time, approximately 1 million European immigrants settled in Western Canada and the Prairies, expanding the economy in business, administration, mining, forestry and agriculture (Koroscil, 2008). Since the late 1800s, agriculture in the Okanagan has changed significantly, from large scale ranches operated by European settlers, to smaller parcels of treefruits and vineyards operated by a mix of local and foreign workers.

Administratively, the Okanagan traverses sixteen municipalities and three regional districts, with a variety of land ownership classifications (e.g. privately owned, First Nations, crown land). Adding to the administrative complexity, the Agricultural Land Commission (ALC) was initiated by the provincial government in the 1970s in an effort to preserve agricultural land for farming purposes. The ALC regulates allowable activities on land in the Agricultural Land Reserve (ALR), which is a provincial level land use zoning regulation. Land that is within the ALR has a limited number of

[1] Interior Cedar – Hemlock (moist cool), Interior Douglas-fir (moist warm & very dry hot), Montane Spruce (dry mild & very dry cool), Ponderosa Pine (very dry hot), Bunch Grass (very dry hot), Engelmann Spruce – Subapline Fir (dry cold)

allowable uses beyond agriculture. Agricultural Land Reserves (ALRs) were created based on land capability classifications of soil type, climate and topography to establish a rating system of seven classes, with Class 1 representing land of the highest agricultural value and Class 7 of little to no agricultural value. In 1974, agricultural land capability maps were completed for the Okanagan Valley (Krueger & Maguire, 1985). Collectively, agricultural land in the Okanagan is governed at multiple administrative scales (municipal, regional, provincial, and federal), which creates complexity for implementation of policies and regulations for landscape management. In the Okanagan, 180,020 ha or 8.6% of the total land area is in the ALR, with the highest proportion in the Central Okanagan Regional District with 9.3% of total land area, and over 70% of privately owned land in the ALR, making agriculture the largest land use by private landowners in the region (Statistics Canada, 2017).

Agricultural land in the Okanagan is concentrated in low elevation areas where many of the species at risk and sensitive ecosystems are found. However, relative to urban development, agricultural land makes an important contribution to ES provisioning to the landscape, and is potentially more amenable to wildlife for habitat and movement between patches of habitat than the built environment. These contributions of agricultural land to society, in addition to food production, are often overlooked.

Land use and land cover (LULC) change has been recognized as a significant factor affecting ecosystems, biodiversity, and associated ES (Reyers et al., 2009; Kazemi et al., 2018; Metzger et al., 2006; MEA, 2005; Pascual & Perrings, 2007). Previous mapping and analysis of agricultural land using the Agricultural Land Use Inventory (ALUI) dataset (BC Ministry of Agriculture, 2014[1]) for the Central Okanagan has shown that 1,386 agricultural parcels have changed land cover classification between 2006 and 2014, for example, naturally vegetated land to cultivated land, and of those, 1,014 cultivated parcels changed crop type, for example, treefruits to vineyards, or other uses such as residential or commercial purposes (Loewen, 2018). Furthermore, 4,529 acres of agricultural land in the Okanagan were removed from the ALR between 1974 and 1982 (Krueger & Maguire, 1985). Table 3 shows a comparison of ALR land exclusion and population growth by regional

district.

Table 3. The decrease of acreage in the ALR between 1974 and 1982 and population changes between 1971 and 1981 for the North, Central and South (Okanagan-Similkameen) regional districts of the Okanagan. Adapted from Krueger & Maguire (1985).

Regional District	Change in ALR Acreage 1974-1982	Population 1971	Population 1981	Population % Change
North Okanagan	-1,494	34,000	54,400	+ 60%
Central Okanagan	-1,792	50,200	85,000	+ 70%
Okanagan-Similkameen	-1,245	42,800	57,200	+ 34%
Total Okanagan	**-4,529**	**127,000**	**196,000**	**+ 55%**

These data show the largest change in the Central Okanagan where the highest amount of ALR land was excluded and the highest population growth occurred, demonstrating that land excluded from the ALR was most likely converted for urban development, as the rate of conversion of farmland to urban areas was higher between 1976 and 1981 than it was between 1966 and 1976 (Krueger & Maguire, 1985). Therefore, if ecological processes and function are to be maintained in the region, the value of ES on agricultural land should be considered in regional planning and policy as LULC in the Okanagan continues to change with population growth and urban expansion.

This research project contributes to investigating the potential contribution of agricultural land to sustaining native biodiversity, species at risk, and ES provisioning within a larger mosaic of anthropogenic and natural land cover types in the Okanagan.

2.1 Study Area

A Wildlife / Ecological Corridor (the Corridor, Figure 1) spanning an area from Okanagan Mountain Provincial Park to Kalamalka Lake Provincial Park has been identified in previous research as high priority for conservation initiatives involving species at risk and sensitive ecosystems in the Okanagan Valley (Parrott et al., 2019). Presently, the Corridor exists as the last remaining contiguous route for wildlife movement through the Central Okanagan on the east side of Okanagan Lake, but increasing pressures from a growing population, urban development expansion, and LULC change threaten habitat and landscape connectivity.

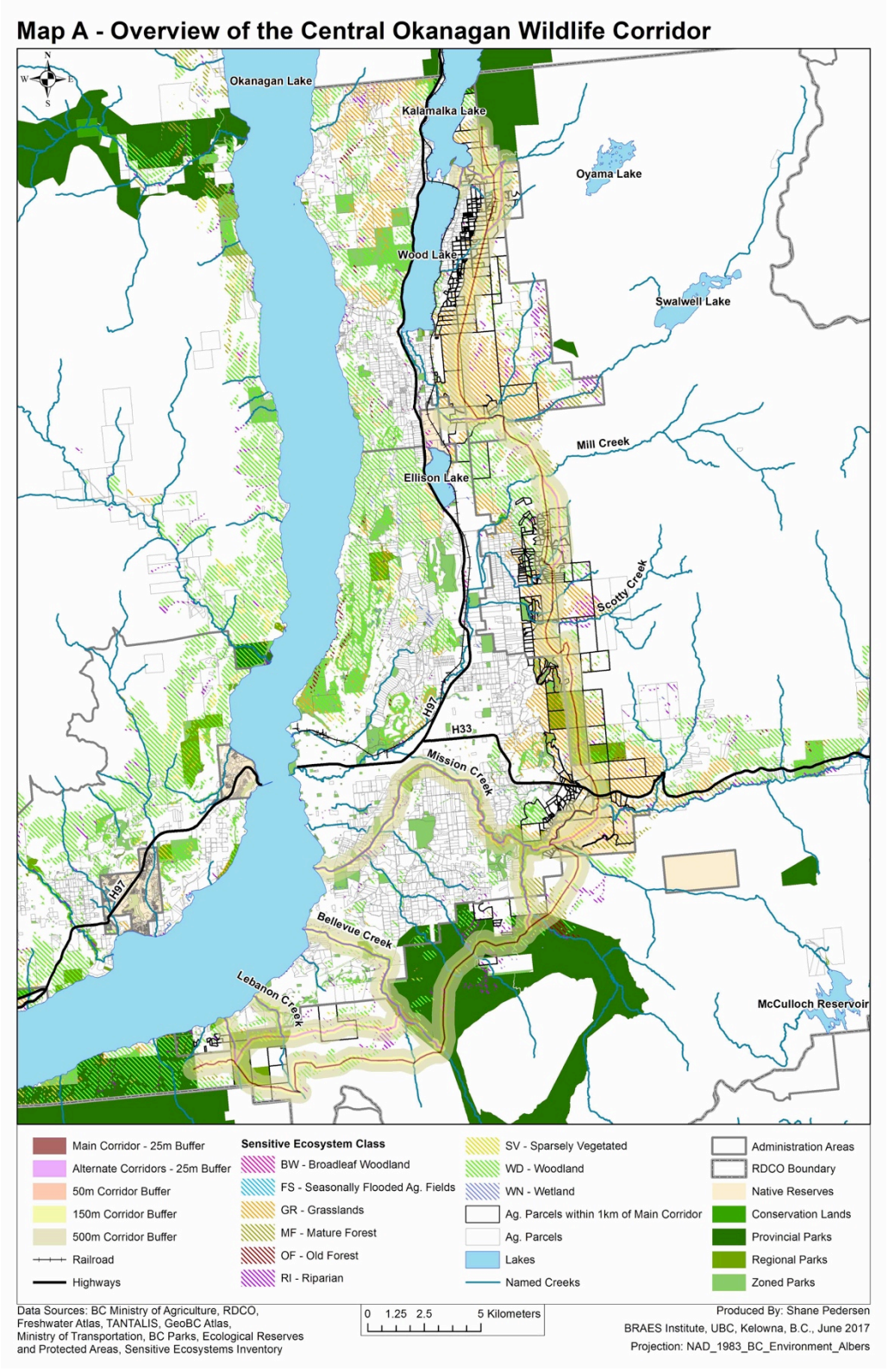

Figure 1. Map A provides an overview of the Wildlife / Ecological Corridor for the Central Okanagan. Produced by © Shane Pedersen (2017).

The main path of the Corridor is 64.4 km long and spans an area of 7,638 ha through the districts of the Central Okanagan and Lake Country, ranging mainly in the low elevation areas from Okanagan Mountain Provincial Park to Kalamalka Lake Provincial Park, with a buffer region of 1 km (500 m on either side). Land use along the Corridor includes privately owned land (46%), parks (26%), crown land (24%), and First Nations land (4%), as shown below in Figure 2.

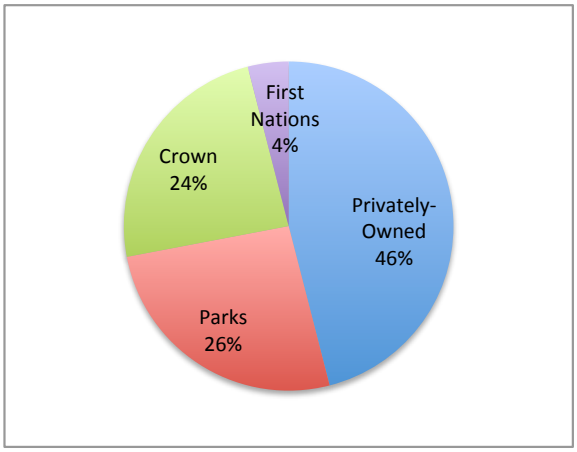

Figure 2. Land use classes of the Okanagan Mountain to Kalamalka Lake Ecological Corridor. (Data Source: Government of BC, 2018).

Of the privately owned land, 73% is designated in the Agricultural Land Reserve (ALR), making agriculture the largest land use by private landowners with property along the Corridor. For this reason, the agricultural parcels that fall within the Corridor boundaries have been prioritized for the study area of this project.

Previous mapping (Figure 1, Pedersen, 2017) has shown that the proposed path of the Corridor passes through a total of 210 agricultural land use parcels that range in size from 0.3 ha to 952.3 ha, based on data from the Agricultural Land Use Inventory (ALUI) dataset (BC Ministry of Agriculture, 2014[1]). Of the 210 agricultural parcels that intersect the Corridor, 137 of them (65%) have either complete or partial ALR designation. The ALUI for the Central Okanagan classifies 93% of all agricultural land cover in the Corridor as "Natural Terrestrial Vegetation" (NTV), as shown in Table 4 below.

Table 4. Land cover classes for agricultural land in the Okanagan Mountain to Kalamalka Lake Ecological Corridor from the Agricultural Land Use Inventory (ALUI) dataset (BC Ministry of Agriculture, 2014[1]).

Land Cover Class	Area (ha)	Proportion (%)
NTV – Natural Vegetated Land	3755.1	92.8
ATVC – Lands Under Cultivation for Harvest or Pasture	93.4	2.3
OUT – Not Surveyed	66.2	1.6
ATBB – Built Lands (Permanent or Semi-Permanent)	52.3	1.3
ATBN – Human Created Bare Areas	35.1	0.9
ATVM – Vegetated Lands Seeded or Planted for Landscape	31.2	0.8
AWW – Artificial Waterbodies	7.6	0.2
NWW – Non-Vegetated Waterbodies, Snow, Ice	4.4	0.1
NWV – Natural Vegetated Wetlands	0.2	0
Total	**4045.5**	**100**

A large percentage of these parcels are classified by the Province of BC as sensitive ecosystems (3,937 ha, or 52% of the total area), the most predominant of which is grasslands (55%), as shown in Figure 3 below.

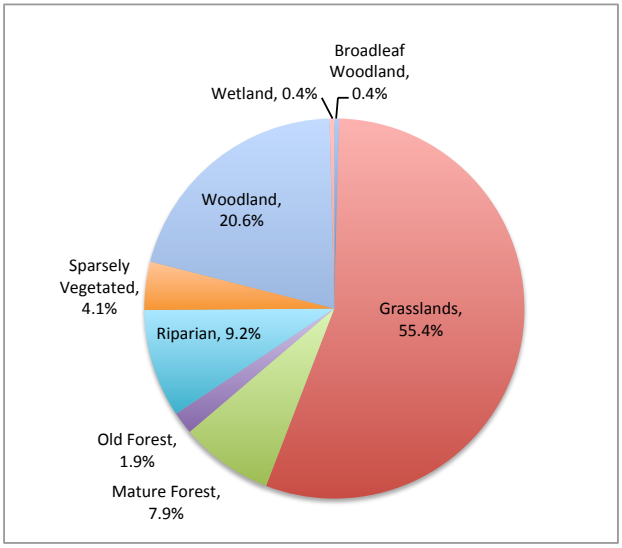

Figure 3. Sensitive ecosystems of the Okanagan Mountain to Kalamalka Lake Ecological Corridor. (Data Source: Government of BC, 2018).

Open grassland ecosystems within the Corridor provide habitat for numerous species at risk in the Central Okanagan, including the red-listed American Badger (*Taxidea taxus*), and blue-listed Great Basin Gopher Snake (*Pituophis catenifer deserticola*), Big Horn Sheep (*Ovis Canadensis*), and Western Rattlesnake (*Crotalus oreganus*) (BC Conservation Data Centre, 2019). Grasslands also provide important soil conservation and water regulation ecosystem services and contribute to the

aesthetic quality of the landscape (a cultural ecosystem service). Figure 4 below shows an example of a grassland ecosystem in the study area.

Figure 4. Open grassland ecosystem on Beaver Lake Road in the district of Lake Country, BC. Photo credit: Theresa Loewen.

Chapter 3: Mapping the Contribution of Agricultural Land to Ecosystem Services Provisioning

The following chapter reviews the mapping methodology, results and conclusions for mapping ecosystem services on agricultural land in the study area.

In order to investigate Research Question 1, quantifying the contribution of agricultural land to ES provisioning, mapping at the parcel scale was established as a way to visualize the contribution of agricultural parcels within the greater landscape, as well as provide support for integrating ES values into land management practices, planning, and policy for the Okanagan. Managing land for ES requires an understanding of the scales at which ES are provided, thus ES mapping provides a spatial approach to document ES flows in the landscape, which allows for visualization of ES supply and demand, particularly on agricultural land that is often located far from ES providers and consumers (Zhang et al., 2007). Parcel scale mapping ES on agricultural land allows for spatial analysis of the flow of services from one parcel to the next as a means to quantify the contribution of ES provisioning provided by and to agricultural land (Zhang et al., 2007).

Mapping ES presents many challenges involving the difficulty of directly measuring ES and the subsequent lack of data (Eigenbrod et al., 2010[1]). A simple approach is to derive information on ES directly from LULC or habitat maps (Burkhard et al., 2009, Vihervaara et al., 2010, Haines-Young, 2009). Such approaches are appropriate for large areas where the dominant service relates directly to land use (e.g., crop and timber production) (Cihlar & Jansen, 2001), or where data availability or expertise is limited and the focus is on the assumed presence of ES rather than on quantification of the supply. Therefore, using LULC data for mapping *indicators,* or proxies of ES, on agricultural land can serve to be an appropriate approximation of ES in lieu of direct data. Mapping indicators at the parcel scale allows for visualization of each parcel's collective contribution to ES provisioning to the landscape. ES mapping has been widely used as a tool to visualize ES on the landscape, and there are a variety of mapping methodologies. Martinez-Harms and Balvanera (2012) identify three main, broad-brush approaches for mapping the value of ES: 1) Benefit Transfer (using monetary valuation); 2) Community Valuation (using social values); 3) Social-ecological Valuation

(using ES supply). The methods used in this project align most closely with the third approach, and is consistent with similar research for mapping ES indicators in case study areas (Darvill and Lindo, 2015; Eigenbrod et al., 2010[2]; Reyers et al., 2009). In this case, LULC classes are used as proxy indicators for the presence or absence of ES provisioning by landscape, rather than directly quantifying the ES supply (Maes et al., 2012). This methodology consists of both a field-based, parcel-level inventory of LULC on agricultural properties, as well as a desktop methodology using the ALUI dataset and provincially available data to map ES indicators on the parcels of interest.

The objectives for conducting the field survey and mapping ES indicators for this research project are to:

1. Inventory the ES provided by agricultural land in the study area and their potential contribution to conservation of species at risk and sensitive ecosystems;
2. Enhance the Agricultural Land Use Inventory (ALUI) dataset (BC Ministry of Agriculture, 2014[1]) by providing another layer of data for ES;
3. Create a methodology for mapping ES on agricultural land in the study area.

3.1 Mapping Methodology

A parcel-level inventory of ES relevant to agricultural land was conducted in August 2018 to ground-truth the 210 agricultural land use parcels in the study area. The purpose of the field survey was to complete an inventory of LULC indicators that could potentially be used as proxies for mapping ES. Prior to going into the field, a desktop survey of existing data was conducted, and a map of the study area was created in ArcGIS 10.6.1 including the 210 agricultural land use parcels that intersect the Corridor study area as defined by the Agricultural Land Use Inventory (ALUI) dataset (BC Ministry of Agriculture, 2014[1]). The map was georeferenced and exported for use in Avenza, a mobile map application that allows the use of downloadable maps for offline field use. Avenza was used to direct the field survey by determining the real-time location relative to the parcel boundaries shown on the map. The field survey was conducted by driving through the study area where

landowner parcels were accessible by public roads, and surveying each parcel from the roadside (Figure 5).

Figure 5. An agricultural land use parcel of field vegetables with wood post and wire mesh fencing in the study area as surveyed from the roadside. Photo credit: Theresa Loewen.

Inventory data were collected by taking hand-written notes, as well as photographs at various locations. The type of data collected included information on fencing (whether it existed, and what type), approximate proportion and density of natural vegetation, an assessment of natural vs. disturbed area (developed, landscaped, built on), type of agriculture, the presence of ditches, vegetative field margins or hedgerows, and agritourism (assessed by presence of signage for agritourism businesses). These data were entered into a database (Microsoft Excel spreadsheet) and imported into ArcGIS.

The results of the field survey demonstrated that field inventory and ground-truthing alone

does not provide consistent or reliable enough information to make inferences, as many parcels were not accessible by road at all, visible from only one vantage point, or obscured by vegetation or structures. However, the agritourism and fencing data collected from the field survey were determined to be beneficial, as the presence and type of fencing can help provide information about the level of landscape connectivity, ease of wildlife movement, habitat fragmentation and potential disturbance to sensitive ecosystems in the study area. Therefore, these data served to augment the ALUI dataset and was mapped for the study area, while the other data collected was not mapped, and best serves as a validation for desktop mapping data.

Given the limitations of the field survey method, a desktop survey methodology was developed using existing, regionally-relevant open source datasets as well as the province's ALUI dataset (BC Ministry of Agriculture, 2014[1]). The ALUI dataset is a series of polygons representing the boundaries of agricultural land cover parcels, systematically surveyed using defined methodologies developed by the BC Ministry of Agriculture's GIS unit. Variables surveyed include private agricultural parcel boundaries, LULC classes, type of commodities farmed, and irrigation systems, for example. It is maintained by the BC Ministry of Agriculture, and is available for use through data-sharing agreements. The purpose of developing this methodology using the ALUI was to produce a straightforward, easily replicable method for mapping ES that could be adapted for other areas of the province, or for specific parcels, using the ALUI and publicly available data as a means to operationalize ES mapping for other institutes.

Due to the challenges involved with directly measuring ES and the lack of data available for the case study area, indicators for ES were used for mapping. In this case, six ES with LULC indicators were chosen for mapping based on the availability of data in the study area and the relevance of the data for selected indicators (Table 5). The indicators are defined primarily by data from the ALUI as described in the AgFocus Field Guide (BC Ministry of Agriculture, 2015).

Table 5. Ecosystem service indicators selected for mapping in the study area.

Ecosystem Service Category	Ecosystem Service	Indicators	References
Cultural	Agritourism	Signage, direct sales (farm gate, market, store), u-pick, petting zoo, corn maze, guest house, equine rental, tours, camping	Turner, 2014, Chan et al. 2006, Boyd and Banzhaf 2007, Maes et al. 2012, Crossman et al. 2013, Qiu and Turner 2013, Raudsepp-Hearne et al. 2010, Carpenter et al. 2015, Reyers et al., 2009
Provisioning	Food & Timber	Presence of agriculture (cultivated or range) or woodlot	Egoh et al. 2012, Maes et al. 2012, Queiroz et al. 2015, Chan et al. 2006, Reyers et al., 2009
Regulating	Climate Regulation	Vegetated vs. bare land, adjacency to forests and woodlands	Anderson-Teixeira et al., 2012, Kremen 2005, Chan et al. 2006, Zhang et al. 2007, Raudsepp-Hearne et al. 2010, Lavorel et al. 2011, Maes et al. 2012, Crossman et al. 2013, Gamfeldt et al. 2013, Mitchell et al. 2013, Qiu and Turner 2013, Reyers et al., 2009
	Drought & Flood Regulation	Topography, slope, aspect, vegetation (type and density), soil drainage classification, soil depositional environment, presence or absense of ditches, swales	Tzilivakisa et al. 2016, Heal & Small 2002, Chan et al. 2006, Keesstra et al., 2018, Orr et al., 2008
	Water Purification	Presence of water bodies including streams, rivers, wetlands, riparian areas	Maes et al., 2012, Heal & Small 2002, Houlahan and Findlay 2004, Chan et al. 2006, Qiu and Turner 2013, Reyers et al., 2009
Supporting	Habitat	Sensitive Ecosystems	Heal & Small 2002, Martin & Dewenter 2015

Mapping was conducted using ESRI ArcGIS 10.6.1 by importing the data for each ES Map listed below in Table 6.

Table 6. Ecosystem service indicators selected for mapping in the study area.

Map	Ecosystem Service	Data Source	ALUI Data Layers	Data References
1	Agritourism	Agricultural Land Use Inventory (ALUI), field survey data	Land Use - Agriculture - Value Added (A920, A930)	Ministry of Agriculture (2014); Loewen (2018)
2	Food & Timber	ALUI, Province of BC (Range & Woodlot Tenures)	Land Cover - Primary (ATVC)	Ministry of Agriculture (2014); Government of BC (2018)
3	Climate Regulation	ALUI, Vegetation Resource Inventory (VRI)	Land Cover - Primary (NTV, NWV)	Ministry of Agriculture (2014); Government of BC (2018)
4	Drought & Flood Regulation	ALUI, Vegetation Resource Inventory (VRI), Soils	Land Use - Primary (W000, W100, W200)	Ministry of Agriculture (2014); Government of BC (2018)
5	Water Purification	ALUI, RDCO (Streams), RDCO/Ecoscape (Unofficial Okanagan Wetlands)	Land Cover - Primary (NWV, NWW)	Ministry of Agriculture (2014); Regional District of Central Okanagan (2007; 2018)
6	Habitat	Sensitive Ecosystem Inventory (SEI)	N/A	Government of BC (2018)

Polygons that intersected the study area were isolated for mapping. In the ALUI, a single legal parcel may be subdivided into several land cover parcels to capture the different agricultural land covers on a property (for example, a hay field and an apple orchard on the same property would be defined as two distinct land cover parcels). For the purposes of this report, the term “parcel” is used to describe a polygon in the ALUI dataset representing a single land cover parcel. Each parcel

has a unique identifier (BC Lot Link number) that was used to join the parcels with the tables containing ALUI attributes. Contained within the tables are ALUI codes that describe the parcels in the context of different LULC categories, such as land use (primary), land use agriculture (value added), and land cover (primary) (BC Ministry of Agriculture, 2015). Within each LULC category are lists of features that are used to classify parcels within the ALUI. Ultimately the LULC categories and associated features were used to determine the indicators used to define each ES. A description of each ES indicator map can be found in section 3.1.1.

3.1.1 Maps 1 – 6 (Appendices A - F): Indicator Descriptions

Map 1 (Agritourism): Agritourism is a type of rural or farm tourism that connects people with food production and allows farmers additional sources of income (Turner, 2014). According to the ALUI, agritourism includes on-farm attractions such as direct sales, farm tours, and markets. Agritourism can provide social, environmental, and economic benefits that humans receive from the environment through the act of farming (Turner, 2014). The indicators used for mapping agritourism for Map 1 include signage or advertisement referring to direct sales (a permanent retail store, seasonal fruit stand, u-pick operation, food/beverage service, farm gate sales), corn mazes, petting zoos, seasonal events, guest houses, campsites, tours, guest ranches, and equine rentals, as defined by the data available in the ALUI dataset (BC Ministry of Agriculture, 2014[1]) as well as data collected from the field survey (Loewen, 2018).

Map 2 (Food and Timber): Food and timber are defined by lands under cultivation, for harvest (tree fruits, grapes, ground crops, berries, hay, forage) or pasture, including winter cover and fallow farmland, as defined by the ALUI (BC Ministry of Agriculture, 2014[1]), as well as lands with Range and/or Woodlot Tenures as defined by the Government of BC (2018).

Map 3 (Climate Regulation): Climate regulation is represented by vegetated surfaces, which have a lower albedo than dry bare ground such as sand and gravels, allowing them to absorb more solar radiation, and then use that energy for evapotranspiration; thus vegetation regulates climate

through the use of solar energy that would otherwise be absorbed by bare ground and emitted back as radiant heat (Anderson-Teixeira et al., 2012). Climate regulation is defined here as the percentage of land with greater than 10% of natural vegetative cover dominated by naturally occurring species, which may be influenced by human actions but are not maintained (e.g. irrigated), excluding areas such as golf courses, landscaped gardens, and lawns which may provide climate regulation but require intervention in order to do so. This map includes data from the ALUI (BC Ministry of Agriculture, 2014[1]), as well as the Vegetative Resource Inventory (VRI) (Government of BC, 2018).

Map 4 (Drought and Flood Regulation): Drought and flood regulation presented the most challenges for mapping based on the many factors that influence these dynamics. For example, landscape topography, slope, aspect, presence of ditches, vegetation (type and density), and soil classification, as well as the interactions between these features, all influence drought and flood regulation. Based on available data and the objective of developing an accessible mapping methodology, soil drainage class and presence of vegetation were used to represent drought and flood regulation, with data from the ALUI (BC Ministry of Agriculture, 2014[1]), the Vegetative Resource Inventory (VRI) and Soils data from the Government of BC (2018). Within the context of this project it was not possible to map the interaction between soil drainage class and vegetation presence.

Map 5 (Water Purification): Water purification can be represented by the removal of nitrogen from rivers and lakes resulting in improved down-stream water quality, as measured by total nitrogen fluxes in river basins and watersheds (Maes et al., 2012). Mapping the network of water bodies such as streams, rivers, wetlands, and lakes represents the "blue infrastructure" or natural capital that provides the nitrogen-removal service (Maes et al., 2012). Therefore, indicators for water purification are simply represented by areas with watercourses such as streams and rivers, as well as wetland and riparian ecosystems, with data from the Regional District of the Central Okanagan (2018) and ALUI (BC Ministry of Agriculture, 2014[1]).

Map 6 (Habitat): Habitat is represented by sensitive ecosystems in the study area, such as grasslands, woodlands, riparian areas, mature forests, sparsely vegetated land, old forests, wetlands,

and broadleaf woodlands. These ecosystems are areas that contain native plants and provide habitat for wildlife and species at risk. It is important to note that other areas of the landscape may also be used as habitat, such as vegetated areas from the Vegetative Resource Inventory (VRI), however including that data oversaturated the map, double counted areas of the same vegetation as the sensitive ecosystems, and when used alone oversimplified habitat, therefore for this ES indicator, habitat was defined only by areas with sensitive ecosystems using data from the Sensitive Ecosystem Inventory (SEI) (Government of BC, 2018).

3.1.2 Maps 7 – 9 (Appendices G - I): Descriptions

Further to mapping ES, the data collected on parcel fencing from the field survey conducted in August 2018 was mapped in the context of landscape connectivity for wildlife movement to produce an Ecological Connectivity map (Map 7, Appendix G) for the study area. The fencing data collected includes the presence and type of fencing observed for parcels that were accessible by public road. For parcels that were not accessible, no fencing data is available. All data collected was entered into an Excel spreadsheet containing parcel ID numbers (BC Lot Link numbers), presence or absence of fencing, and type of fencing. The type of fencing was then ranked for degree of hindrance to wildlife movement into categories of low, moderate or high hindrance. For example, fencing composed of wood posts or wood with barbed wire at a low height was considered to be a low degree of hindrance to wildlife, due to ability of wildlife to move under or over fencing (Figure 6).

Figure 6. An example of wood and barbed wire fencing, considered a low hindrance to wildlife movement. Photo credit: Theresa Loewen.

Short chain link, or wood and mesh, fencing was considered a moderate degree of hindrance due to the lack of open spaces for wildlife to move underneath fencing. Finally, tall chain link and or 9 foot deer fencing was considered to be a high degree of hindrance to movement for a wide range of wildlife (Figure 7).

Figure 7. An example of tall, metal mesh / chain link fencing considered a high hindrance to wildlife movement. Photo credit: Theresa Loewen.

The fencing data was then imported into ArcGIS and joined with the ALUI dataset by matching the parcel ID (BC Lot Link numbers). Data for ALR land and parks was also included, as it was assumed that agricultural land, parks and protected areas provided more opportunities for wildlife to move through the landscape compared to other areas along the Corridor such as golf courses, businesses and residential communities. ALUI data for protected areas (codes K100 – K300) would have been included, but there was no data present for protected areas in the study area, therefore that layer was removed.

For Map 8, ES Bundles at the Parcel Scale (Appendix H), a focus area of the Corridor was mapped to show the parcel-scale delivery of ES bundles provided to the landscape. ES from Maps 1 – 6 were bundled into four categories (Cultural, Provisioning, Regulating, Supporting) as shown in Table 5 to show the contribution of ES provisioning at the parcel scale. This map is an example of documentation that could be provided to a landowner as part of their participation in an incentive

program, providing them with a visual example of the ES their property provides.

Finally, the 210 agricultural parcels in the study area were ranked based on a scale of low, moderate, and high ES provisioning, with an equal-weighting structure for the number of ES present on each parcel. For example, a parcel that has 1 – 2 ES was classified as low provisioning, 3 – 4 ES as moderate, and 5 – 6 ES as high. This methodology was chosen as the simplest way to value all ES equally without placing a higher value on one ES over another. The results were mapped for the entire study area and shown in Map 9, ES Ranking for Priority Areas (Appendix I). The purpose of this map was to provide a practical way to quantify the value of ES provisioning for each parcel in the study area, in order to highlight areas that could be targeted for strategic landowner stewardship incentive programs. This methodology helps identify parcels of low ES provisioning that could have higher priority for enhancing biodiversity and ES as part of stewardship programs, while parcels with high ES provisioning could have higher priority for protection and conservation efforts. Regions with several high ES provisioning parcels could be highlighted as areas of ES bundling and serve as examples for community-wide conservation initiatives or the establishment of conservation neighborhoods.

3.2 Mapping Results

The results of Maps 1 – 6 (Appendices A - F) are outlined below in Table 7.

Table 7. Results for ES Maps in the Okanagan Mountain to Kalamalka Lake Ecological Corridor.

Map	Ecosystem Service	Number of Parcels	Area (ha)	Percentage of Total Parcels (210)	Percentage of Total Area (6,608 ha)
1	Agritourism	12	145	5.7%	2.2%
2	Food and Timber	63	1,809	30.0%	27.4%
3	Climate Regulation	210	6,608	100.0%	100.0%
4	Drought and Flood Regulation	210	6,608	100.0%	100.0%
5	Water Purification	90	5,364	42.9%	81.2%
6	Habitat	191	6,546	91.0%	99.1%

Based on the data, Maps 1 – 6 show Agritourism as the least frequent ES in the study area (2.2% of the total area of all agricultural parcels in the Corridor), followed by Food and Timber

(27.4%), Water Purification (81.2%), Habitat (99.1%), Climate Regulation (100%) and Drought and Flood Regulation (100%). Note that the total area of 6,608 ha represents the total area of all 210 agricultural land use parcels in the ALUI, not the total area of the Corridor (7,638 ha).

Map 1 (Agritourism) shows parcels providing Agritourism are mainly concentrated in the northern part of the study area in the District of Lake Country, representing 2.2% of the total parcel area. This is consistent with data collected from landowner interviews, which identified Lake Country as a locally-recognized community farming region, thus it may provide more agritourism opportunities such as direct sales from markets, small hobby farms, u-pick, farm-gate sales, guest houses/ranches, petting zoos and equine rentals. However, at only 2.2% of the parcel area, this shows that agritourism is not well-represented overall. This is likely due to a lack of data for the study area, determined by comparing the results of the field survey with data in the Agritourism category of the ALUI dataset. Therefore, these mapping results cannot be taken as representative of the study area, and augmentation of data in the ALUI is recommended for future mapping of Agritourism.

Map 2 (Food and Timber) shows that there is a variety of cultivated land, range land and woodlot tenures in the study area, representing 27.4% of the parcel area. However, only 63 out of 210 (30%) agricultural land use parcels are providing food and timber, while the remaining 147 parcels (70%) comprise other land uses such as natural areas (i.e. ALUI classes for natural terrestrial vegetation (NTV) and others), bare or built areas, and anthropogenic managed areas (BC Ministry of Agriculture, 2015). Interestingly, 137 (65%) agricultural parcels that intersect the Corridor have either complete or partial ALR designation, which shows that even though a parcel is in the ALR, that does not mean it is contributing to agricultural production, as there is roughly a 30% difference between the parcels providing food and timber, and the parcels that are in the ALR.

Map 3 (Climate Regulation) shows that all parcels in the Corridor study area (100%) contribute to climate regulation, either by classification in the ALUI dataset as NVW (natural vegetated wetlands) or NTV (natural terrestrial vegetation), or through the Vegetation Resources Inventory (VRI) classes for Herbs and Grasses, Shrubs, or Trees. This is due to the fact that all

parcels in the study area have some form of vegetation, as the NTV class of ALUI is defined by parcels with >10% natural terrestrial vegetation. Further analyses could investigate the proportion of parcels covered by natural vegetation, as well as the type of vegetation, but for the purposes of this project only the presence of vegetation was mapped, therefore all parcels are seen as contributing to the climate regulation ES by having some form of vegetative cover.

Map 4 (Drought and Flood Regulation) shows the soil drainage classes for the Corridor, and while 100% of the parcels are shown as contributing, there are some parcels that contribute more than others based on the type of soil drainage class. In general, the majority of the Corridor is classed as Rapidly Drained and Well Drained soils, with only a small amount of Moderately Well Drained and Imperfectly Drained, indicating that parcels in the study area function well for flood regulation but may be more susceptible to drought. In order to show this distinction on the map, soil classes would need to be ranked, which would have involved more rigorous mapping methodologies. Furthermore, the presence of vegetation is mapped from the Vegetation Resource Inventory (VRI), and covers the majority of the study area, however, vegetation type and density were not mapped, though they are factors known to influence drought and flood regulation. This was in part due to the fact that data for vegetation density is not available and also because vegetation type was already mapped for Climate Regulation, with 100% coverage of the study area. More sophisticated mapping methodologies could consider the contribution of different types of vegetation and the proportion of parcel coverage in addition to the interaction with soil drainage in order to better represent drought and flood regulation.

Map 5 (Water Purification) shows that 90 parcels (81% of total area) have watercourses, riparian and wetland areas. The proportion of area contributing to water purification is smaller in actuality, as there are two large areas in the northern part of the Corridor with entire parcels showing as contributing. This is due to their classification in the ALUI as wetlands and water, which applies that class to the whole parcel even if only a portion is covered. Furthermore, the contribution of agricultural land to nitrogen loading in watercourses was not taken into account, as data was not available. Future mapping could look at the relationship between agricultural land and watercourses

with measurements of nitrogen concentrations in watercourses with close proximity to agriculture compared to downstream measurements.

Map 6 (Habitat) shows 191 parcels (99%) contributing, with the majority classed as Grasslands, which is consistent with the ALUI data showing that the Corridor is 93% natural terrestrial vegetation (NTV). The data used for this map is from the Sensitive Ecosystem Inventory (SEI), therefore shows only the sensitive ecosystems, but when taken together with the vegetation mapped for Climate Regulation, all parcels in the Corridor could be seen as providing some type of habitat for wildlife.

Map 7 (Connectivity) shows parcels that have fencing data outlined in a black border, and areas that are most prohibitive for wildlife movement by level of hindrance (low, moderate or high). The areas of high hindrance (red) occur in the north part of the Corridor on properties near Wood Lake where there are more intensive cherry orchards with 9-foot deer fencing, and in the south near golf courses. The areas without data are either not fenced, or data was not collected due to inaccessibly of the parcel by public road. The majority of parcels surveyed are either low (green) or moderate (yellow) levels of hindrance to wildlife movement.

Map 8 (ES Bundles at the Parcel Scale) shows a focus area for bundled ES by category (Cultural, Provisioning, Regulating, Supporting). Mapping at this scale provides the ability to view individual properties in detail to see the number of ES each parcel provides, as well as how an individual parcel fits within the larger landscape. This map is an example of one that could be given to a landowner for stewardship program participation or advising, providing them with a visual example of the ES their property provides.

Map 9 (Ecosystem Services Ranking for Priority Areas) shows the ranking of parcels for ES provisioning of low (red), moderate (orange), and high (yellow) based on the number of ES present on each parcel. For example, if a parcel provides agritourism, food production, and a climate regulation, it would be classified as moderate ES provisioning (3 ES present). For the study area, there are no parcels with 0 ES, 6 parcels (3%) with low provisioning (1 – 2 ES present), 174 parcels

(83%) with moderate provisioning (3 – 4 ES), and 30 parcels (14%) with high provisioning (5 – 6 ES). Therefore the majority (83%) of parcels are ranked as moderate ES provisioning, which could be used to support initiatives to conserve or enhance ES in the study area. These results provides insight on ES provisioning across the landscape within the study area, which could be used to guide targeted or prioritized landowner stewardship incentive programs, conservation efforts, and community planning.

3.3 Mapping Discussion

Mapping ES for this research project aimed to address Research Question 1: "How can the contribution of agricultural properties to ecosystem services provisioning be quantified at the landscape scale?" By conducting a field survey and developing a desktop mapping methodology, the data collected and the maps produced provide a methods-based, quantitative, spatial solution to the research question.

The results show that agricultural land in the study area does provide an important contribution to ES provisioning for the landscape, with parcels providing anywhere from 2 – 100% coverage of mapped ES in the study area. Mapping ES indicators at the parcel scale provides the quantitative data for spatial analysis as well as a visual depiction of how agricultural parcels are collectively contributing to ES provisioning to the landscape. This supports the case that agricultural land is worth investing the resources to conserve, maintain and enhance for both food production and ecological value. These results ultimately provide support for including ES in land use planning and policy as the Okanagan landscape continues to change and grow.

Using LULC indicators as proxies for ES provides a foundation for mapping ES that is feasible and available to a wide variety of users, and is appropriate for visualizing broad-scale trends in ES. However, limitations of this methodology arise from the inherent approximation of ES in the absence of direct measurements, affecting the quality of data and restricting the scale to which data can be mapped and the ability to extrapolate (Eigenbrod et al., 2010[1]). Using the indicator method

over-simplifies ES mapping, limiting the extent to which ES can be truly quantified. The importance of mapping ES indicators lies in the ability to provide a starting point for visualizing ES on the landscape, and the value of the maps should been taken as such.

Further limitations arise from the bundling of ES (Map 8), in which the ES categories (Cultural, Provisioning, Regulating, Supporting) are not wholly represented by the full spectrum of ES that each category has the potential to provide. In particular, the Cultural ES category could include additional ES, such as recreation, landscape aesthetics, and heritage, all of which are particularly significant in the Okanagan, especially in relation to agricultural land, yet the mapping does not reflect this due to lack of data for the study area. The ES categories are also not equally represented, for example, Agritourism is the only Cultural ES included, Food and Timber is the only Provisioning ES included, and Habitat is the only Supporting ES included, while the Regulating category is proportionately over-represented by Climate, Water, Drought and Flood Regulation ES. In actuality, there are more ES in every category, and the data in the ALUI has the potential to offer more opportunities to represent additional ES, such as Pollination, Recreation, and Heritage. However, the data in the ALUI and other publicly available datasets did not sufficiently qualify these ES to the extent that they could be mapped with the same degree of detail as the others, therefore, they were not included in the analysis.

Limitations of the field survey method include incomplete data, as some parcels were not accessible by public road at all, visible from only one vantage point, or obscured by vegetation or structures. The fencing data collected by field survey for Map 7 only includes parcels that were visible from at least one vantage point, thus, it was difficult to assess whether a property was fully fenced or partially fenced in certain areas. Furthermore, parcels that were not accessible by public roads were not mapped, limiting the extent to which fencing can be used as an indicator of connectivity. In addition, factors contributing to landscape connectivity beyond fencing, such as landscape fragmentation from residential communities, developments such as golf courses, and natural topographic barriers, were not taken into consideration in Map 7, in addition to the fact that

the Corridor itself provides a level of inherent connectivity. Therefore, Map 7 shows connectivity barriers at a very fine, parcel scale, and cannot be taken as a true measure of landscape connectivity for the study area. More detailed methods to collect fencing data could include using aerial photographs to assess the presence or absence of fencing, obtaining permission to access private roads and enter landowner properties, or collecting fencing data as part of landowner interviews of the entire study area.

Overall, the results of the field survey and ES mapping provide some first steps forward for visualizing ES on agricultural land in the Okanagan, and serve to highlight areas of conservation priority, stewardship potential, and opportunities for targeted incentive program delivery. The mapping results are meant to be taken together with the results from landowner interviews (Chapter 4) to provide a complete overview of the study area that guides recommendations for land use planning and policy in the Okanagan.

Chapter 4: Mechanisms for Assisting Producers in Maintaining Ecosystem Services and Biodiversity on Agricultural Land

The following chapter reviews the methodology, results and conclusions for landowner interviews in the study area.

The purpose of conducting landowner interviews was to investigate Research Question 2: "What mechanisms can be used to assist agricultural producers in maintaining ecosystem services provisioning and biodiversity on agricultural land?" Interviews were designed to collect data on agricultural landowners' perspectives, knowledge and opinions regarding land use, environmental issues, wildlife movement, stewardship practices, connectivity, ecosystem services, and willingness to participate in stewardship incentive programs.

Objectives for conducting landowner interviews are to:

1. Explore how increasing awareness of ES on agricultural land can serve to strengthen farming, maintain high agricultural productivity, and support viable agricultural operations;
2. Investigate how existing regionally-relevant agricultural stewardship models and incentive programs could be employed or adapted to achieve biodiversity conservation objectives in the study area;
3. Provide land use planning and policy recommendations for how to protect and enhance agricultural land in the Ecological Corridor and buffer area for conservation priorities.

4.1 Interview Methodology

Prior to the interviews, a desktop survey of municipal, provincial and federal government and non-government resources and programs was conducted to provide an overview of existing stewardship programs and incentives available to landowners (Appendix J). Programs were assessed for relevance to the project objectives of how land management strategies and incentive programs on agricultural land in the Okanagan can serve to:

1. Protect the sensitive ecosystems and species at risk;

2. Prevent further land use/land cover (LULC) change;
3. Sustain the natural terrestrial vegetation (NTV);
4. Achieve biodiversity conservation objectives;
5. Maintain landscape connectivity;
6. Address ES benefits and trade-offs of agricultural stewardship;

This analysis determined that the BC Ministry of Agriculture's Environmental Farm Plan (EFP) program was most relevant to the study area, as it has similar objectives for ecosystem services and biodiversity, is well-known in the community compared to other programs, and already has a strong participation base. For this reason, the EFP program was chosen as an example for program recommendations, enhancement opportunities, and discussion with landowners as part of the interview questions.

The design of the interview questions was informed by a combination of conceptual approaches in the literature: qualitative methods common to environment related research (e.g. Cox, 2015), participatory action research (e.g. Méndez et al., 2017) and agroecological research (e.g. Altieri et al., 2017, Landis, 2017 and Méndez et al., 2017), which views the participants as the experts, with the aim to collect knowledge from a range of experts and integrate the findings to inform decision making and planning. Questions were designed in a meaningful and relevant manner to the intended interview participants, and phrased in a way to avoid polarizing questions (questions resulting in yes/no answers) when possible in order to solicit more detailed answers from participants.

The interview questions were organized into the following topics:

1. Participant History & Background
2. Participant Attitudes & Norms
3. Participant Knowledge & Past Behaviour
4. Participant Actions & Future Behaviour

These topics were influenced by the Theory of Planned Behaviour model (Ajzen, 1991) which describes how participants' attitudes, subjective norms, and perceived behavioural controls

affect each other and influence participants' intentions, and ultimately, their behaviours. A copy of the Interview Guide with a list of the questions posed to the participants is included in Appendix K.

Two case study communities in the Okanagan (The District of Lake Country and the Regional District of the Central Okanagan) were identified through previous research (Pedersen, 2017; Parrott et al., 2019) as being of high priority for conservation initiatives in the study area of the Corridor. Purposive sampling (Cox, 2015) was used to select participants from these areas, which includes 210 agricultural land use parcels. Criteria for selection included:

(a) owning an agricultural property or land parcel in or near the study area; *and/or*

(b) holding a Range Land or Woodlot Tenure in the study area

Private landowner contact information is protected by the Freedom of Information and Protection Act (FOIPA) and therefore was not available. However, mapping of the study area provided the location of the parcels without landowner names or addresses. Therefore, generic flyers containing information about the project as well as the request to participate in the study via interview were hand-delivered to those parcels with road-side mailboxes, or posted on community mailboxes in the neighbourhood. A copy of the flyer is attached (Appendix L).

Summary of Recruitment:

1. Recruitment was done by public posting of flyers at community mailboxes and direct contact when possible (e.g., in rural areas where road-side mailboxes are present). Flyers distributed instructed participants to contact Theresa Loewen by phone or email.
2. Prospective participants were screened over the phone by confirming agricultural land ownership or land tenure.
3. The interview sites were determined based on participants' preference, either the participant's home or in a public or community venue depending on what was convenient to the participant.
4. A letter of consent was provided to participants once they had set an interview appointment.

The goal was to randomly select 10 - 20 interviewees from a list of respondents, however only 9 landowners responded to the flyer and of those, only 7 were able to successfully book interview appointments. Reasons for the unsuccessful respondents were attributed to participants' time constraints. For this reason, all 7 respondents were interviewed.

Summary of Interview Procedures:

1. The field investigator, Theresa Loewen, arranged a meeting date and time with participants upon initial contact, at a location that was convenient for them (e.g. their home, a public meeting space, or community facility, as decided by the participant).
2. Upon arriving for the meeting, an overview of the project as well as the purpose of the Interviews was explained to participants.
3. The interviews lasted approximately 1 - 1.5 hours
4. Interviews were recorded, with the participants' consent, on a personal recording device, and subsequently uploaded by computer for storage on the university's secure Workspace platform.
5. At the end of the interviews, participants were debriefed by reiterating the research study goals, reminded that their information will be kept private and confidential, and asked if they had any questions or concerns. Contact information for the field investigator was provided to them. An overview of interview participant demographics is listed below in Table 8.

Table 8. Participant information collected from Part 2 of the Interview Guide (Appendix K).

Participant Number	Age	Agricultural Education	Education	Education Institute	History in Farming?	Parcel Size	Farm Status	Lease	Commodities	Years Farmed	Years on Parcel	Years in Okanagan	Birth Place	Other Residences
1	63	No	Bachelors in Economics	Saskatchewan	Yes (grain farm)	10 acres	No	No	Hobby farm (vegetable garden, plums, pears)	1	5	5	Vancouver	Saskatchewan, Manitoba, Ontario, United States, Japan, France, Saudi Arabia, Korea
2	64	No	PhD in hydrogeology	Kazakhstan	No	< 10 acres	Yes	No	Hobby farm (apples, peaches, pears, plums)	5	5	5	Kazakhstan	
3	29	No	BSc in Biology	University of Victoria	No	< 10 acres	No	No	Garlic, flowers, broiler chickens, market garden	7	7	29	Kelowna	
4	83	No	Bachelors in History	United States	No	10 acres	No	No	Apples, peaches, apricots	20+	18	18	United States	Kootenays, Vancouver
5	64	Some	Some college	Olds Ag. College	Yes (ranch)	> 10 acres	Yes	Yes	Cattle	28	59	59	United States	
6	54	No	Some college	Okanagan College	Yes (treefruits)	> 10 acres	Yes	No	Apples, peaches, nectarines	29	29	54	Kelowna	
7	80	No	Trade school (auto mechanic)	Germany	No	> 10 acres	Yes	No	Apples, peaches, cherries, vegetables, blueberries, blackberries	39	39	41	Germany	Vancouver

The interview recordings were transcribed by hand and then coded using NVivo to determine emergent themes. NVivo is a software program that allows users to upload interview transcriptions and analyze data using the query function to determine trends such as frequently used words, word associations, and word groupings. From the results, NVivo produces graphics such as word trees and other visualization tools. These queries and tools help summarize and condense interview data that can often be dense and lengthy, distilling the data into common trends and themes. For example, if participants frequently used the word "environment," which was also associated with their use of "climate change," NVivo would pair those words together as a grouping, showing an association that could indicate an emergent theme depending on relative frequency (per interview, and across all participants). In this case, NVivo was used to summarize and condense interview data using queries and visualization tools, and the themes and associations produced were streamlined into categories relevant to the interview questions, the results of which are shown in Sections 4.2 and 4.3, Tables 13 and 14.

4.2 Interview Results

The interview results are summarized in the Interview Summary document (Appendix M). Table 9 (below) shows an overview of questions posed to participants in Section 1 of the Interview Guide.

Table 9. Interview questions from Section 1: Participant Attitudes & Norms (Interview Guide, Appendix K).

	Section 1: Participant Attitudes & Norms
1	What do you like about living and working in the Okanagan?
2	What do you like about your property?
3	What do you find to be the most rewarding part of working in agriculture?
4	What does it mean to you to be a good environmental steward?
5	Do you think landowners should be stewards?
6	What are some barriers or challenges of being a good steward?
7	Do you think stewardship is an individual responsibility, or should communities collectively contribute to land stewardship?
8	What are your neighbors doing to be landowner stewards?
9	What are your environmental concerns about your property? (For example, have you had issues with flooding, drought, erosion, soil loss, pests, or invasive species in the past? Any other issues?)
10	Have these issues become more serious in recent years?
11	Are there any environmental issues on your property that you think will get worse in the future?
12	What have your heard from your neighbors about their properties?

In general, what participants appreciate the most about living and working in the Okanagan

can be distilled down to the ecosystem services that the landscape offers (landscape aesthetics, food production, fresh water, climate, recreation, good quality soils, and culture). Most participants had similar responses that included the natural beauty of the land and connection with nature, access to lakes and mountains, the rural/semi-rural farming community, and physical qualities of the land to provide food. One participant noted:

> *"First and foremost is the climate. Second, is having access close by the lake and mountains, for skiing and snowshoeing. It's a very diverse environment and I enjoy that. But more broadly, access to BC and Vancouver. The airport was very important to us, because it gives us access to the world quickly and easily."*

All participants seemed to genuinely enjoy working in agriculture, especially if farming was a second job for them. When asked what they find most rewarding about working in agriculture, participants responded with the following comments:

1. Love and joy of growing food
2. Ability to provide food for people who need it
3. Connection to food, people and nature
4. Providing education to children on food production
5. Production - seeing the results of labour
6. Pride in growing a good quality product
7. Autonomy (you can choose to grow whatever you want)
8. Simplicity and peace of growing, takes you a step back in time

When asked about environmental stewardship, all participants had a general understanding of good stewardship practices, including limiting disturbance (especially to soils), organic farming practices, taking care/reducing damage to the land, maintaining native species and vegetative land cover, managing invasive species, keeping the land clean, fire prevention, and awareness of sensitive species and habitat areas.

Regarding the barriers or challenges of being a good steward, the majority of participants had

similar comments, including:

1. Time
2. Effort
3. Motivation
4. Economics
5. Environmental (water, pruning)
6. Rules and regulations, broad-brush policies
7. Strict industry production standards
8. Producing quality vs. quantity
9. Unsure what the optimum future is for this land from a conservation or ecological point of view
10. Keeping land use consistent (with new owners, succession)

One participant commented:

> *"It takes time and effort. You have to have the motivation because certainly I don't feel that the authorities provide any motivation or external reason for doing that, it has to come from within. So it's a trade off, with competing interests."*

Participants felt that there should be more emphasis placed on community stewardship, that communities and individuals should collectively contribute to shared stewardship objectives and that farming community cultures should be preserved. One example given was the rural farming culture in Lake Country that some participants felt was threatened by increasing population density and urban development. Environmental concerns that participants had included:

1. Invasive species (knapweed, bindweed, twitch grass, Murdock's thistle)
2. Erosion/soil loss
3. Pests (pine beetle, tussock moth, spruce budworm, coddling moth, spotted-wing drosophila)
4. Drought

5. Flooding

Of these, participants noted that erosion and drought, invasive species (knapweed in particular), and pests (pine beetle and spotted-wing drosophila) have become more of a problem in recent years. Furthermore, climate change, urban development and increased disturbance were mentioned as factors that may result in more serious problems in future years. Table 10 (below) shows an overview of questions posed to participants in Section 2 of the Interview Guide.

Table 10. Interview questions from Section 2: Participant Knowledge & Past Behaviour (Interview Guide, Appendix K)

	Section 2: Participant Knowledge & Past Behaviour
1	What types of wildlife do you see on your property?
2	Have you noticed that thes the type or occurrence of wildlife species has changed over the time that you've owned this property?
3	Have any types of wildlife been a problem to you?
4	Why has wildlife been a problem?
5	In what ways does your property help or hinder wildlife movement?
6	What does the term "ecosystem" mean to you?
7	What types of ecosystems are present on your property?
8	What actions have you taken to maintain or alter ecosystems on your property?
9	What does the term "ecosystem services" mean to you?
10	What ecosystem services does your property provide?
11	What actions have you taken to enhance or reduce ecosystem services on your property?

Participants seemed to be well aware of the types of wildlife present in their area and were able to provide an extensive list of the types of wildlife observed:

1. Ungulates (mule deer, white tail deer, moose, elk)
2. Bears (black bears)
3. Birds (wrens, chickadees, sparrows, quail, pheasants, catbirds)
4. Birds of prey (owls, bald eagles, hawks, raptors, American kestrels)
5. Small mammals (gophers, marmots, moles, groundhogs, weasels, squirrels, chipmunks, skunks, raccoons, foxes)
6. Large mammals (coyotes, wolves, cougars, lynx)
7. Reptiles & amphibians (bull snakes, garter snakes, Spadefoot toad)

Of these, it was noted that elk were relatively new to the area, observed after the 2003 Okanagan Mountain Park fire. Other changes include increased deer, bear and small mammal populations, and a difference in the type of bird populations (disappearance of meadow lark, swallows, and bluebirds,

and increase of eagles and pheasants).

One participant speculated on cause of the increased deer population in their area:

> *"My father subdivided land up here in the late 1980s and did a 10 acre lot subdivision. One of the main concerns at the time was that this was mule deer winter range and it would have an effect on the mule deer population. And it has had quite an effect, we probably have 4 times the amount of mule deer here than we had before that, because there's more water, gardens, and lawns. It's really interesting because this was a huge concern at the time, that if we subdivided that land we'd chase the deer away, and from what I've seen it's worked the exact opposite."*

For the most part, participants did not see wildlife as a major problem due to most properties having at least some fencing, although deer, bear, small mammals, and coyotes were occasionally noted as problematic for causing damage to gardens, trees and livestock and digging holes in crop fields.

In order to gauge participants' present knowledge of ecosystem services and landscape connectivity, participants were asked what the terms meant to them and how their properties contributed. Participants seemed to have a general knowledge of ecosystems, and identified grassland, woodland, wetland, old growth, rock bluff, riparian, semi-arid, deciduous and coniferous ecosystems on their properties.

When asked what actions they've taken to maintain or alter ecosystems on their properties, their responses included the following:

Maintaining Actions:

1. Reseeding native grasses
2. Invasive weed control
3. Planting trees
4. Not spraying pesticides

Altering Actions:

5. Mowing natural grass
6. Farming
7. Fire prevention (removing dead trees, limbing trees)
8. Logging

Participants were less knowledgeable about ecosystem services, as none of the participants were able to provide a clear definition. However, after hearing the definition, participants were able to identify the following ecosystem services that their properties provide:

1. Pollination
2. Landscape Aesthetics
3. Water Filtration
4. Food & Timber Production
5. Climate Regulation
6. Carbon Sequestration
7. Cultural Value
8. Habitat
9. Fresh Water and Air
10. Drought and Flood Regulation
11. Soil Production

When asked what actions they have taken to enhance or reduce ecosystem services on their properties, participants had similar answers to the same question about maintaining and altering ecosystems, with the following additional actions:

1. Plant drought resistant native plants and grasses in areas prone to dryness and erosion
2. Plant several wild flower gardens, have seen a huge increase in the number of bees
3. Collect native plant seeds - has allowed different grasses to grow, and an observed increase in bird species and insects
4. Leave some areas natural

5. Plant native trees
6. Restore existing seasonal watercourses

In general, the concept of ecosystem services seemed to make good sense to participants, as they were able to talk in more detail about the services their properties provide as well as discuss the more intangible services that the landscape provides, as described by one participant:

> *"I have trouble thinking of services as discrete benefits to human beings. An active or viable ecosystem as a whole provides benefit to humans just by being there and being accessible, but the benefits are much less specific like fresh air, clean water, and carbon sequestration. I think it's more the emotional and physical benefits that we notice"*

Table 11 shows an overview of questions posed to participants in Section 3 of the Interview Guide, and an overview of the interview questions that resulted in yes/no answers are shown in Table 12.

Table 11. Interview questions from Section 3: Participant Actions & Future Behaviour (Interview Guide, Appendix K)

	Section 3: Participant Actions & Future Behaviour
1	Would you be willing to make changes to your property to keep landscape connections and natural habitats a part of your land?
2	What would deter you from making changes?
3	Have you heard of government incentive programs, like the Environmental Farm Plan?
4	Would you be interested in learning more about how you could improve connectivity and ecosystem services on your property?
5	Would you support local government in identifying connectivity corridors in documents like Official Community Plans, so that they are considered and protected in future development?
6	How effective do you think government incentive programs are?
7	Have you ever participated in an incentive program, or know someone that has?
8	Would you be open to having an Environmental Advisor come to do a personalized, on-farm assessment?
9	Would you consider participating in an incentive program?
10	What kind of support would you find valuable if you were to participate in an incentive program?
11	What challenges would prevent you from participating in an incentive program in the event that you wanted to?

Table 12. Participant answers to Yes/No interview questions from the Interview Guide (Appendix K). (Note: ES = Ecosystem Services, EFPs = Environmental Farm Plans, OCPs = Official Community Plans).

	Question 22	**Question 23**	**Question 25**	**Question 26**	**Question 27**	**Question 28**	**Question 30**	**Question 31**
	Believe in Connectivity Benefits	**Willing to Make Changes to Property**	**Prior Knowledge of EFPs**	**Open to Learning about ES**	**Would Consider an EFP**	**Support Corridors in OCPs**	**Prior Incentive Program Participation**	**Open to EFP Advisor Farm Assessment**
Yes	71%	57%	50%	86%	29%	67%	43%	86%
No		29%	50%	14%	42%	16%	57%	14%
Unsure	29%				29%			
Depends on other factors		14%				17%		

Overall, the majority of participants were in support of landscape connectivity (71% in favour) and including corridors in Official Community Plans (OCPs) (67%), willing to learn more about ecosystem services (86%), and open to having an Environmental Farm Plan advisor perform an

on-farm assessment (86%).

Some comments from participants regarding landscape connectivity include:

"I think it's a great idea, I think it very much should and needs to include agriculture. Because my neighbours who are not in the Corridor are more sensitive to it than the people who are just below us in the agriculture zone, they're there to make money, their land makes money. Our land gives us enjoyment, there's a difference. I think though it has to be something that's tied to the title of the property. You can't just agree to do it, get paid, and the next guy comes and lets it go. It needs to be insured maintenance."

"Yes, it should be a community program. If the government gives money to me for improvement, they should check, there should be follow up on the recommendations. If people don't follow through, there should be no money."

"Sure, but I suspect that if it's under the Ministry of Agriculture it's only available to certified farms. We're on agricultural land, we do sell products from the orchard but we don't have official farm status and that might be an issue, we don't sell enough. If I made a real effort I could probably make the minimum amount, and if I was 40 I would do it, but at my age it's not cost effective in terms of the time it would take. We need a son that wanted to do it, and our son doesn't want to."

With respect to including corridors in Official Community Plans, participants noted the following:

"I think that's really important and is something that hasn't happened yet in a lot of areas. I think it's super cool and interesting to plan for those areas with respect to future development. Hopefully they make it into a park or protected ecological area. Our neighbours have problems with people trespassing and recreating, which they don't like, so it would be nice to have those areas protected."

"I want to see what has happened over the last 50 or 60 years, and after that make a decision

if it's good or bad. Maybe we have more information on a government website, but I haven't found it. There should be more information sharing. We should understand what the limit is for this area of the natural growing population. If we keep building houses, what happens next? It's a lot of pressure on natural areas. An ecological corridor should be part of this study. How much population should we have in this area, what is the limit? A half million, 2 million, 5 million? Or just 100 thousand? How much is enough?"

Participants were less willing to make changes to their properties to support wildlife connectivity and natural habitats (57% in favour) or consider participating in an Environmental Farm Plan (EFP) (29%). Some reasons for the lack of support include:

1. Belief that they are already good stewards
2. Belief that their property is sufficiently natural / connected
3. Lack of rationale for making changes
4. Fear of losing property rights
5. Lack of information about the best use for the land
6. Unrealistic or inconvenient recommendations
7. Financial concerns
8. Belief that other issues are of more importance

When asked if they would be willing to make changes to their property, participants commented:

"I guess if someone could show me a good reason for it, but I don't see looking down the road how this side of the valley is really going to change. I think it will become more dense, so it will probably be subdivided and broken down into smaller parcels. Right now the minimum parcel size is 10 acres, which I don't know is the best use of the land. It has very little agricultural value. By owning land and living up here are you responsible to provide visuals for the people that live in the subdivision?"

"It would be nice if there was a better recognition that there are people that are motivated

and are more sensitive to these concerns, and that do value nature more than bureaucrats may think. The top half of the property that we're not using, we would fence it off or implement a "no disturb" area on it, sure."

When asked if they would consider participation in an EFP, participants stated:

"I don't know, it's a good idea but I don't think it works. Why should I do something, for what point? This is connected to education. I should understand completely - if I improve this, what are the natural benefits, what are the results? Lots of people do something, and what is if for? It's all part of education."

"Because it is marginal agricultural land, there was talk about carbon credits and carbon sequestration on private land, if the trees are here and the consensus is to leave the trees in order for future generations to make a living and keep this the way it is, there needs to be some sort of assistance because you can't keep it the way it is especially in the Okanagan with land prices and taxes, it's not sustainable."

In general, about half of participants believed that incentive programs are effective, while the other half disagreed, were undecided, or did not have experience with incentive programs. Qualities of effective incentive programs included:

1. Education and Training
2. Cost-sharing, Subsidies or Tax Deductions
3. Long-term Monitoring
4. Flexible Program Guidelines
5. Lack of Complex Regulations
6. Easy Application Process
7. Voluntary Participation

When asked if participants would be open to having an Environmental Advisor come to do a personalized, on-farm assessment, one participant commented:

"Yes if it was made available to me. I had an environmental evaluation done as part of the development permit requirement for my property, which I didn't know when I bought the land that there were environmentally sensitive parts to it. I found the guy really good. He knew the trees and he had some really good suggestions. So I found that was very useful. To the extent that someone is advising me, yes. But if that would lead to creating requirements for me, I would be less interested. Because it's just an unknown effort. I think the voluntary component of the program is critical. In particular for the take up for people."

The results for the final questions regarding the support participants would find valuable for incentive programs, as well as the perceived challenges of participation in incentive programs are displayed in Table 13 below.

Table 13. Participants' suggestions of desired support and perceived challenges for participation in incentive programs.

	Participation Support for Incentive Programs	Participation Challenges for Incentive Programs
1	Free Education & Training	Lack of rationale and understanding for programs and stewardship recommendations (need to be explained and convincing)
2	Free Advice & Consulting	Lack of Time
3	Financial/Cost-sharing	Finances
4	Recognition (Signage, Certification)	Lack of economic options available on ALR land
5	Online Information Services	Not enough publicly-accessible information sources
6	Knowledge Sharing (between old and young farmers, governments, industry organizations, non-profits)	Knowledge gaps, lack of education
7	Programs that connect older farmers with younger farmers who want experience (labour sharing)	Age (feel too old to take on extra projects, or too old to farm, need help with labour)
8	Extra financial assistance for Small-Scale farmers	Farming is no longer a viable livlihood (farming is a second job)
9	Support neighbourhood farming culture/communities	Lack of compensation for stewardship
10	Community cost-sharing projects that support farming	Lack of community support/payments for ecosystem services provisioning
11	Promote Agritourism	ALR restrictions, no solutions for retirement
12	Free Organic certification	Complex guidelines
13	Access to historical land use information & maps	Unsure of what the "best" use of the land is
14	Access to digitized historic aerial photographs	Costs related to obtaining information
15	Long-term monitoring of programs	Lack of follow-up or accountability for program recommendations
16	Succession planning for agricultural parcels	Land prices too high for children to take over family farms
17	Education for students and teachers in elementary schools	Young generation's lack of interest to farm
18	Farm equipment sharing program	Regulation inconsistency (appears biased)
19	Fewer restrictions, flexible guidelines, simple and easy to follow	Lack of coordination/power struggle between different levels of government
20	Voluntary Participation	Too much regulation, red tape, barriers to participation

Some comments from participants regarding incentive programs include:

"I really don't like being dictated to how I grow my fruit. A recommendation would at least be better. I've grown both ways, I've leased orchards that are high density and I know what works for me. If you plant high density orchards, it doesn't necessarily mean it's going to be a better apple. If I'm a good grower I can grow on older trees. It's the grower that dictates

the final product."

"Advice would be very helpful, to have a better understanding of where I should be putting my time and effort, prioritizing for the biggest impact. It would be nice to have some sort of recognition that different landowners are part of a program, a sign on your driveway or something. Then there's moral sway for those that don't have it, and some recognition for those that do. If you have 10 acres no one ever sees it, so road side signage is good."

"There should be less studies, and more education, to teach people about ecosystems and stewardship. Also, for producers that are small scale, they shouldn't have to pay to be in the farmer's market. To become certified organic is very expensive, and if you care about ecological values, make it free for producers. That's why when you go to the store organic food is more expensive. If the government wants to care about this stuff it should be free. Make the corridor an organic area where it's free to become organic so everyone will know that area is organic food."

4.3 Interview Discussion

Conducting interviews allowed for the investigation of the mechanisms that could be used to assist agricultural landowners in maintaining ecosystem services (ES) provisioning and biodiversity on agricultural properties (Research Question #2).

Analysis of the data using NVivo software produced themes (Table 14) that can be used to augment and inform new or existing stewardship incentive programs, policies, practices and services to support landowners.

Table 14. Themes derived from data collected from landowner interviews through NVivo analysis.

Interview Themes			
Participant Values:	**Participant Concerns:**	**Participant Motivations:**	**Participant Solutions:**
Natural environment	Succession/future land use	Food quality/organic certification	Voluntary, flexible, free support programs and certifications
Local amenities	Urban development/loss of farming culture	Belonging to a farming community	Community support/conservation neighbourhoods
Healthy ecosystems	Climate change (flooding/drought/erosion)	Learning about ecosystem services (ES)	Knowledge sharing, free resources and information access
Growing food	Age/health	Ensuring future local food security	Succession planning, land trust programs, farm leases
Giving back to the community	Lack of time	Being a conscientious neighbour	Connections with programs to assist with tasks/farm labour
Biodiversity	Finances	Recognition, certification	Payments for ES and certification programs
Productivity	Invasive species & pests	Learning about optimal land uses and practices	Free education, training, advice, outreach, extension
Landscape connectivity	Strict property & production regulations	Stewardship/taking care of the land	Convincing stewardship recommendations

These themes serve to highlight information gaps and support mechanisms that could be incorporated into existing incentive programs and services for landowners. The values, concerns, motivations, and needs can be interpreted by reading linearly across the table, or by matching across rows. For example, if a landowner values healthy ecosystems, is concerned about climate change, and motivated to learn about ES, then a potential solution could be providing them with knowledge sharing opportunities, free resources and access to information to support them. Alternatively, if a landowner has the same values and concerns and is motivated by learning about optimal land use practices, a solution could be providing them with free education, training, advice, outreach and extension services. Any of the values, concerns, motivations, and solutions in Table 14 can be paired together to provide the best support for landowners. For example, for a landowner that values productivity, growing food, and the natural environment, is concerned about their age and health, lack of time, and finances, and motivated to produce quality food, farm organically, and contribute to food security, some solutions could include free education and extension services, succession planning support, and connecting them with existing programs, such as Young Agrarians, to match landowners with new/young farmers to help with farm labour, or the BC Ministry of Agriculture's Environmental Farm Plan (EFP) with guidance and funding for Beneficial Management Practices (BMP's). Ultimately, providing landowners with the solutions that address their needs can serve to increase

program participation and success, increase participants' knowledge and awareness, and result in a stronger, more cohesive farming community.

Limitations of the data collected from landowner interviews include the small sample size (7 interviews), which limits the ability to make broad generalizations about landowners in the study area. The demographics were also skewed toward older, educated participants, which may not be representative of the larger population. The recruitment method of posting flyers in the community was ineffective for attracting large numbers of respondents, therefore other methods such as promotion of the study through partner organizations, direct mail outs, or emails are recommended where landowner contact information is available. In addition, landowners that responded to the interview flyers may have done so because they are already interested in environmental stewardship compared to those that did not respond, or they may have participated because they were concerned about protecting their individual property rights. Those influences may have affected the interview results such that challenges, such as finances or lack of information, may be stronger among those that didn't participate. Therefore, the views expressed by participants cannot be taken as representative of the general population of landowners in the area. Furthermore, the majority of respondents were concentrated mainly in the northern reach of the study area, from Ellison Lake to Kalamalka Lake, therefore landowners located near each other may have more similar views than those in other areas. Lastly, the commodity types produced by landowners interviewed are not representative of all producers in the Okanagan, as large-scale commercial treefruit operations, vineyards, and timber producers were not interviewed and may have dissimilar views that are influenced by differences in farm practices. However, the data collected from conducting just a small number of landowner interviews provided a wealth of valuable information. Conducting more interviews over a broader area with a greater diversity of farm types is recommended for future studies, and would provide more data with the ability to make broader generalizations about the population of landowners in the Okanagan. Alternatively, mailed or emailed surveys in place of interviews would also enable data collection at a greater scale for a broader scope of data.

Ultimately, the results from the landowner interviews contributed to achieving the project objectives of: determining how incentive programs could be employed or adapted to achieve biodiversity conservation objectives in the study area; how increasing awareness of ES on agricultural land for landowners in the Okanagan can serve to strengthen farming, maintain high agricultural productivity, and support viable agricultural operations; and finally, providing land use planning and policy recommendations for how to protect and enhance agricultural land in the Corridor and the greater Okanagan for conservation priorities.

Chapter 5: Conclusion

This research project set out to explore the potential contribution of agricultural land to sustaining native biodiversity, species at risk, and ecosystem services (ES) provisioning within a larger mosaic of anthropogenic and natural land cover types in the Okanagan. In particular, the contribution of agricultural land parcels to ES provisioning and ecological connectivity in the Okanagan. By mapping ES on agricultural land and conducting landowner interviews, this thesis investigated the following research questions:

1. How can the contribution of agricultural properties to ecosystem services provisioning be quantified at the landscape scale?
2. What mechanisms can be used to assist agricultural producers in maintaining ecosystem services provisioning and biodiversity on agricultural land?

Mapping ES indicators shows that agricultural properties do indeed contribute to ES provisioning for the landscape, and are home to many sensitive ecosystems and associated species. ES mapping provides a way to visually quantify this contribution by showing the number of ES provided by agricultural land in the study area when compared to built and developed areas of the Corridor that are less amenable for wildlife. Furthermore, the maps show that the Corridor has value in its entirety as a continuous landscape of connected habitat for wildlife movement in areas that are used for agriculture and rural living. This mapping supports the argument that agricultural land has value beyond food production, and is critical to protect and enhance for ES provisioning, as well as for its contribution to the greater landscape for maintaining natural areas, connectivity, and wildlife habitat.

The landowner interviews provide insight into the knowledge, concerns and needs of farmers and agricultural landowners that can be used to inform stewardship incentive programs and sustainable agriculture practices and policies. The interview results provide some proposed solutions for the mechanisms that can be used to assist producers in maintaining ES and biodiversity on agricultural land, which are: education, community programs, compensation for ES provisioning,

extension services and expert advice, and free, accessible voluntary stewardship programs. By knowing what farmers need and want, these suggestions can be passed on to organizations and policy makers for land use planning and programs on agricultural land.

To this end, the following recommendations have been developed from the results of this research project, including the field survey, ES mapping, and landowner interviews conducted for the study area.

1. Enhance and update the ALUI dataset to include ES and to provide more comprehensive ES mapping opportunities for the Okanagan. The ALUI is currently the only dataset available in the province with agricultural land use information on privately owned land. Thus, it is worth maintaining, updating and augmenting for future use. The following ES in particular require more data for mapping using the ALUI dataset: Agritourism, Heritage and Culture, Habitat, Recreation, and Pollination. In addition, the dataset would benefit from further augmentation to include organic producers and ecological connectivity, in particular, fencing data.
2. Include ES as part of the BC Ministry of Agriculture's Environmental Farm Plan (EFP). This research has identified the EFP as a stewardship incentive program that could be augmented to include ES as part of the framework along with the existing Biodiversity Plan by including ES mapping for agricultural properties. By promoting those components of the program through outreach to landowners, education, workshops and media, landowners would be provided with a foundation for learning more about ES.
3. Use ES mapping to identify conservation priority areas for targeted strategic landowner stewardship initiatives and incentive programs. Areas such as the Central Okanagan Ecological Corridor have been identified by multiple levels of government as being of importance for ecological connectivity and should be prioritized for conservation initiatives. Using mapping such as the ES Priority Areas for Conservation (Map 9, Appendix I), a parcel with low ES provisioning could be targeted for prioritized program funding, while parcels with high ES provisioning could have a higher value for conservation and protection from

development.

4. Provide education, training, advice and consulting services to landowners for ES, biodiversity, and stewardship of agricultural land. The request for free education and training was a recurring theme that was mentioned multiple times by interview participants. A variety of formats were noted as helpful: Workshops, extension, training and advice from qualified professionals or experienced producers, government or industry association information sheets that could be handed out to producers or available on websites.
5. Encourage knowledge and information sharing amongst the farming community. Interview participants felt that information was not made accessible enough, was difficult to find, costly, or insufficient. Recommendations include providing free, online resources that are easy to find and user friendly, including mapping, referrals to a wide range of stewardship programs, and opportunities for networking, especially for new farmers. In particular, landowners mentioned wanting knowledge of historic land uses, including what types of natural vegetation and ecosystems were there before the land was cultivated and developed, in order to know how the landscape was shaped and how it should be managed.
6. Promote community farming cultures. Interview participants expressed an appreciation for living in rural or semi rural areas where a distinct farming community presence existed. Concerns were expressed about increasing urban development and reduction of actively farmed land resulting in a loss of the community farming culture. Some ways to support community farming cultures include: Posting signage or promotional materials for Agritourism areas, providing free signage for participants of the Environmental Farm Plan, developing community stewardship neighbourhoods, community recognition and marketing for local farmers, encouraging the community to buy locally produced commodities and products.
7. Develop payment schemes for compensating farmers for ES provisioning. Landowners appreciated the value of ES and were in support of maintaining ES on their land, however

they felt that they should be compensated for providing ES to the community, especially when provisioning infringed on their business. Proposed methods suggested included tax deductions (property tax or farm income tax) and subsidies funded by regional and provincial governments.

8. Support farm succession planning. Many landowners expressed concern about the future use of their properties, as their children were either not interested or could not afford to continue farming their land. Furthermore, they were concerned that if they participated in a program such as the Environmental Farm Plan, there would be no long-term monitoring to ensure the continued stewardship in their lifetime, and beyond. Recommendations include having a degree of accountability for long-term stewardship that is monitored and maintained on a regular basis (e.g. every 5 years the EFP is reviewed and either extended, extended with further recommendations, or terminated if stewardship has not been maintained), and that is attached to the parcel to pass from one owner to the next.

Ultimately, these recommendations are meant to highlight opportunities for more comprehensive ES mapping, to identify conservation priority areas and areas of enhancement priority for strategic, targeted landowner stewardship incentive programs, to increase landowner awareness of ES, and to assist agricultural producers in maintaining ES provisioning and biodiversity on their properties. Future research in this field could include conducting more landowner interviews or surveys over a greater area for more robust data, investigating or creating new data sources for ES mapping, mapping more or novel ES indicators, investigating landowner's willingness to pay for ES, and exploring the dynamic between urban expansion, and landscape connectivity and wildlife conflicts.

As agricultural land in the Okanagan continue to face challenges related to population growth, LULC change, and climate change, it is becoming increasingly more important to employ land management strategies that consider the ecological value of the land by promoting sustainable agricultural practices and integrating the benefits of agroecological principles into policy and practice

for holistic landscape management designed to support multifunctional land use. For example, the strategies proposed by Fischer et al. (2006), including maintaining landscape heterogeneity, complexity and integrity of native plants and ecosystems, as well as integrating buffers and corridors into landscape designs, can be included in policies and land use planning using local examples such as the Central Okanagan Ecological Corridor as well as programs such as the BC Ministry of Agriculture's Environmental Farm Plan (EFP).

In addition to the research questions, this project also endeavored to address several agroecological knowledge gaps, including actionable knowledge, practical action plans and guidelines for farmers, and translating knowledge into policies and practices. By developing an accessible desktop methodology for mapping ES and providing recommendations from landowner interviews, this knowledge can be translated into action plans, policies, and practices for increasing ES awareness and stewardship on agricultural land. These results can be used to fill knowledge gaps by sharing guidelines, tools, and resources within farming communities, industry organizations, and multiple levels of government to inform farm practices, community land use plans, and policies. Governments can also rely on the framework of agroecology to provide knowledge, programs and services to agricultural landowners that are relevant, practical, actionable, and guided by ecological principles designed to sustain and increase production while reducing the impacts of intensified agriculture.

Agroecology can be seen as the way forward for managing agroecosystems, by integrating the knowledge systems of farmers, landowners, industry professionals, the Indigenous community, and the scientific community to define agroecological principles and management practices, used to guide research and actions towards the sustainable transformation of the entire agrifood system, encompassing ecological, economic and social dimensions (Altieri et al., 2017; Méndez et al., 2017; Francis et al., 2003). As the global population rises and climate change threatens uncertainty, the need for sustainable agrifood systems is undeniable, but solutions are available by taking action on every scale, from individual landowners implementing sustainable farming practices, to community farming

cultures and agritourism, to local governments protecting farmland and ecological corridors in their bylaws, to provincial and federal governments including the principles of sustainability in land use policies and agricultural legislation. Collectively, we can ensure the continued production of food and the functioning of healthy ecosystems into the future by integrating ecosystem services and biodiversity in landscape management for multifunctional agroecosystems.

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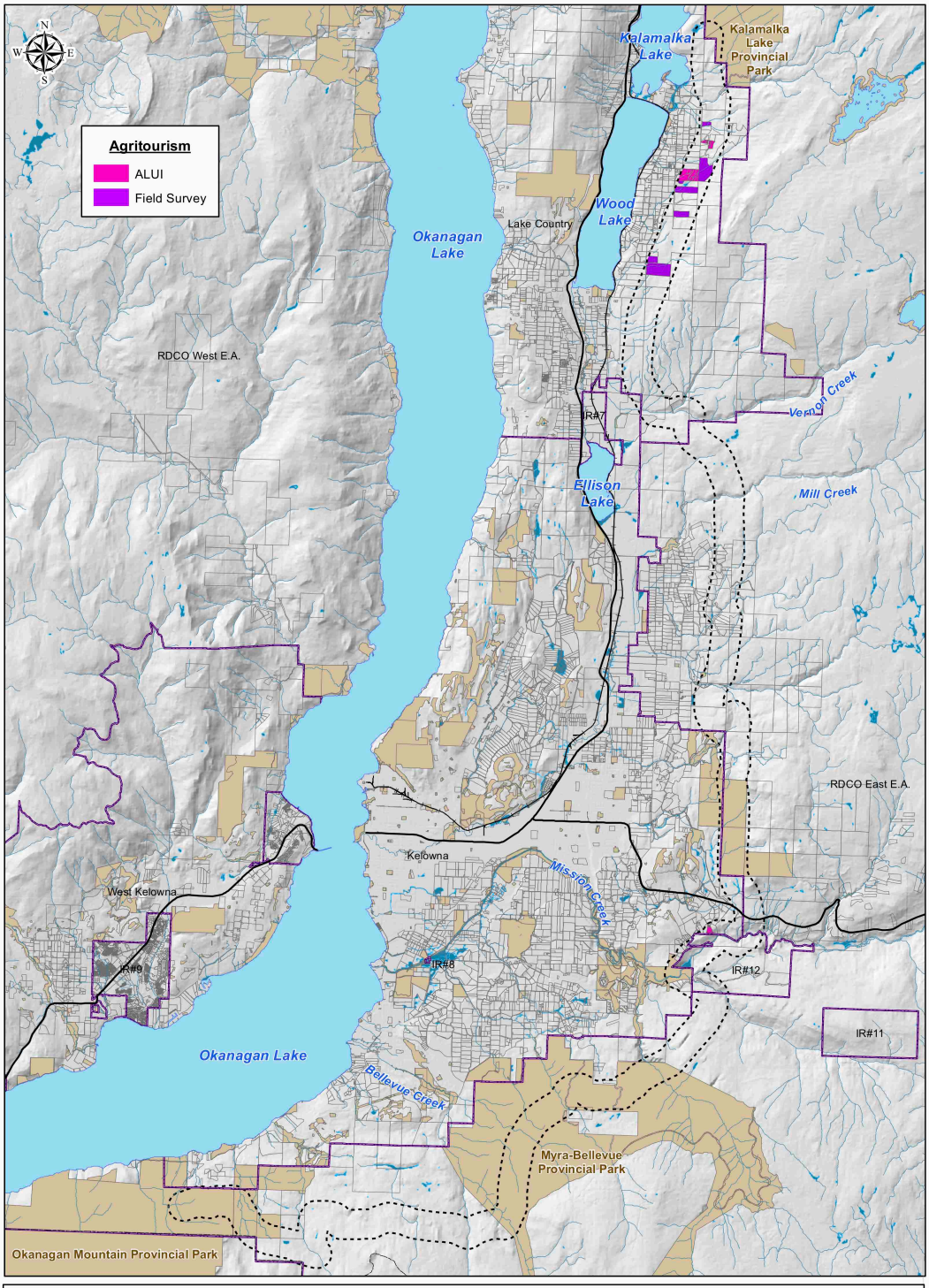
Appendices

Appendix A: Map 1 (Agritourism)

Map 1: Ecosystem Services for the Okanagan Mountain to Kalamalka Lake Ecological Corridor



Data Sources: Ministry of Agriculture, RDCO, City of Kelowna, City of West Kelowna, District of Lake Country, District of Peachland, Freshwater Atlas, Ministry of Transportation, Ministry of Environment, Sensitive Ecosystems Inventory, FLNRO, FLNRORD

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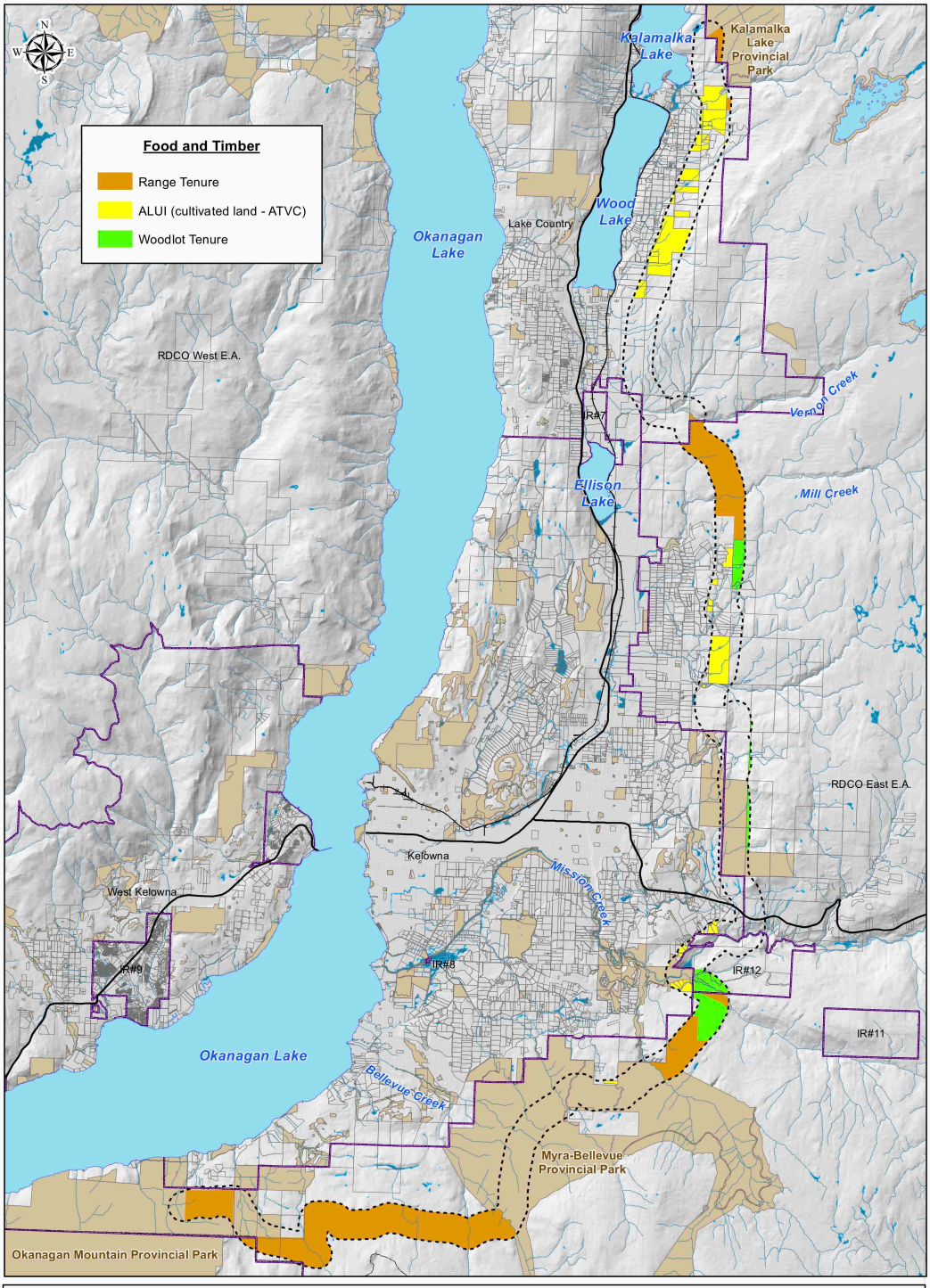
Projection: NAD 1983 UTM Zone 11

Appendix B: Map 2 (Food and Timber)

Map 2: Ecosystem Services for the Okanagan Mountain to Kalamalka Lake Ecological Corridor



Data Sources: Ministry of Agriculture, RDCO, City of Kelowna, City of West Kelowna, District of Lake Country, District of Peachland, Freshwater Atlas, Ministry of Transportation, Ministry of Environment, Sensitive Ecosystems Inventory, FLNRO, FLNRORD

0 5 Kilometers

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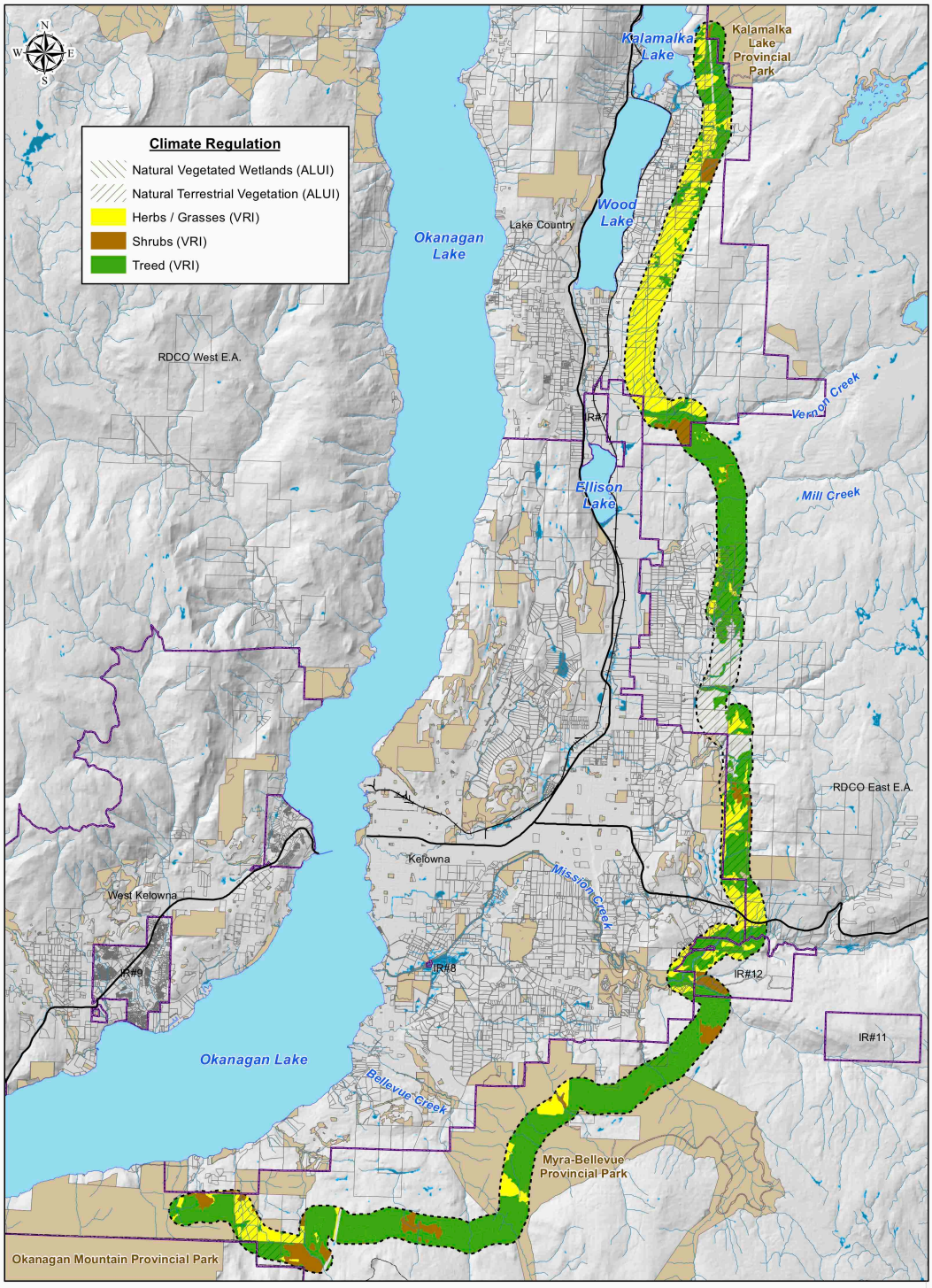
Appendix C: Map 3 (Climate Regulation)

Map 3: Ecosystem Services for the Okanagan Mountain to Kalamalka Lake Ecological Corridor



Data Sources: Ministry of Agriculture, RDCO, City of Kelowna, City of West Kelowna, District of Lake Country, District of Peachland, Freshwater Atlas, Ministry of Transportation, Ministry of Environment, Sensitive Ecosystems Inventory, FLNRO, FLNRORD

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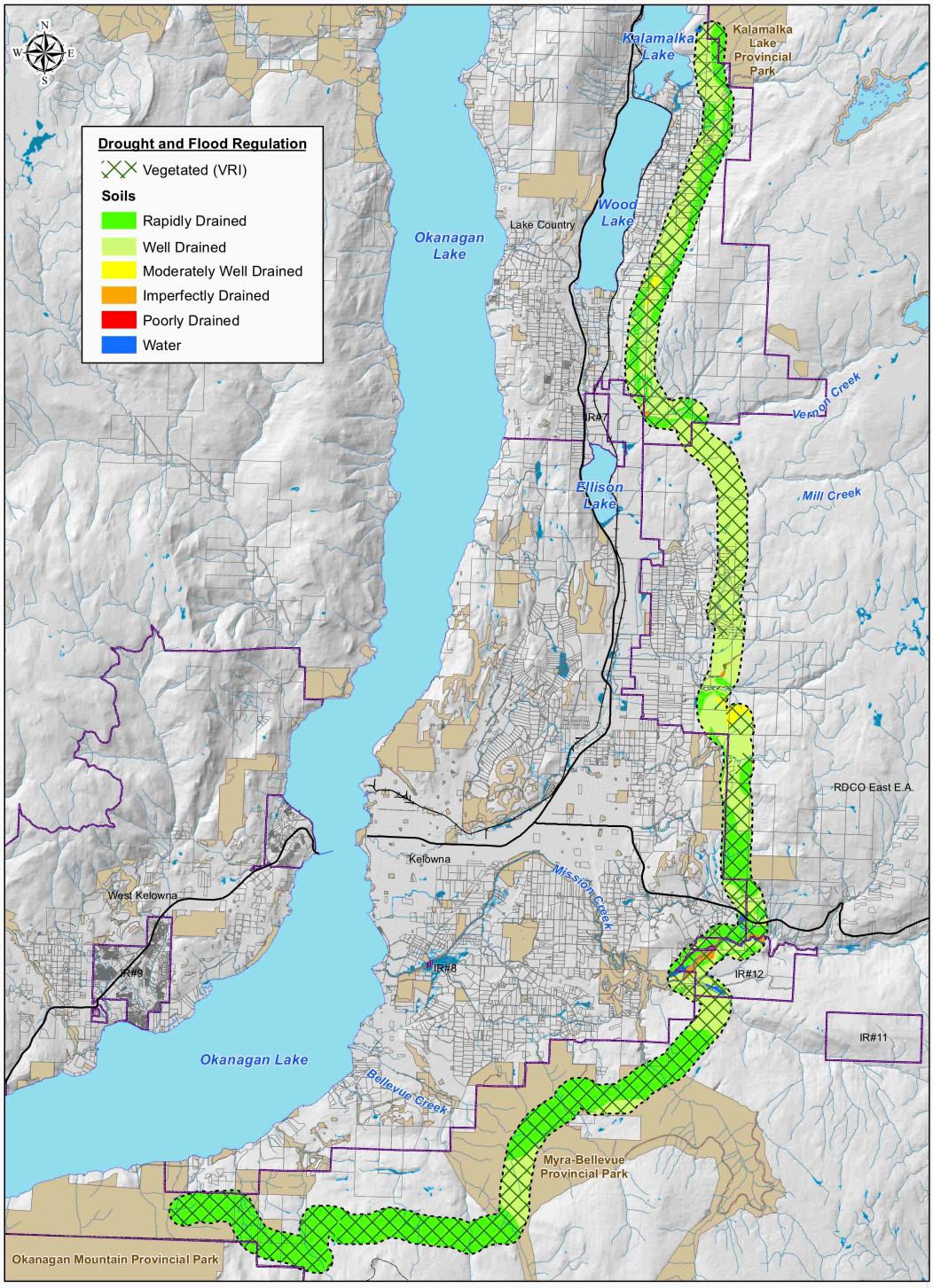
Appendix D: Map 4 (Drought and Flood Regulation)

Map 4: Ecosystem Services for the Okanagan Mountain to Kalamalka Lake Ecological Corridor



Data Sources: Ministry of Agriculture, RDCO, City of Kelowna, City of West Kelowna, District of Lake Country, District of Peachland, Freshwater Atlas, Ministry of Transportation, Ministry of Environment, Sensitive Ecosystems Inventory, FLNRO, FLNRORD

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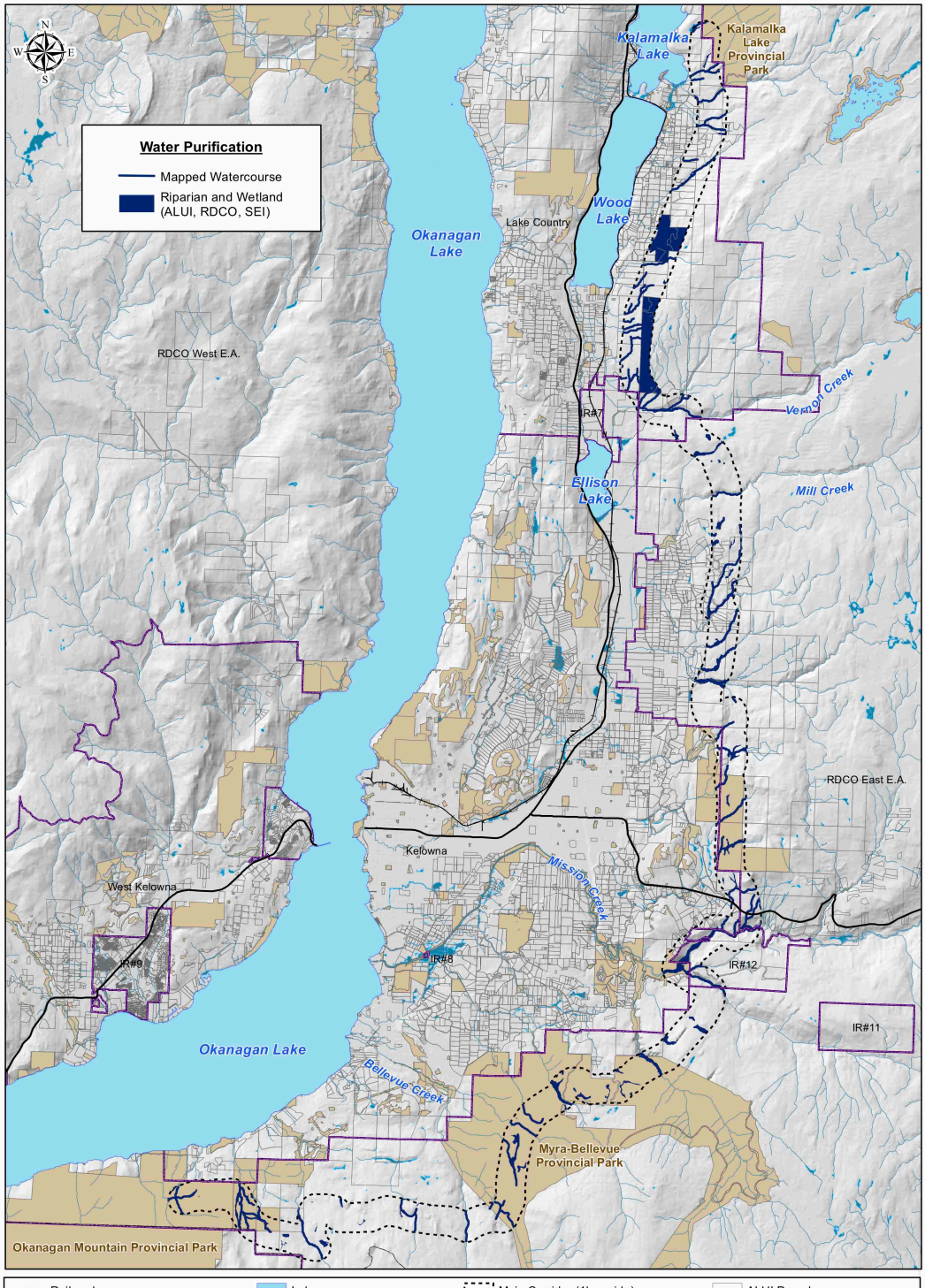
Appendix E: Map 5 (Water Purification)

Map 5: Ecosystem Services for the Okanagan Mountain to Kalamalka Lake Ecological Corridor



Data Sources: Ministry of Agriculture, RDCO, City of Kelowna, City of West Kelowna, District of Lake Country, District of Peachland, Freshwater Atlas, Ministry of Transportation, Ministry of Environment, Sensitive Ecosystems Inventory, FLNRO, FLNRORD

0 5 Kilometers

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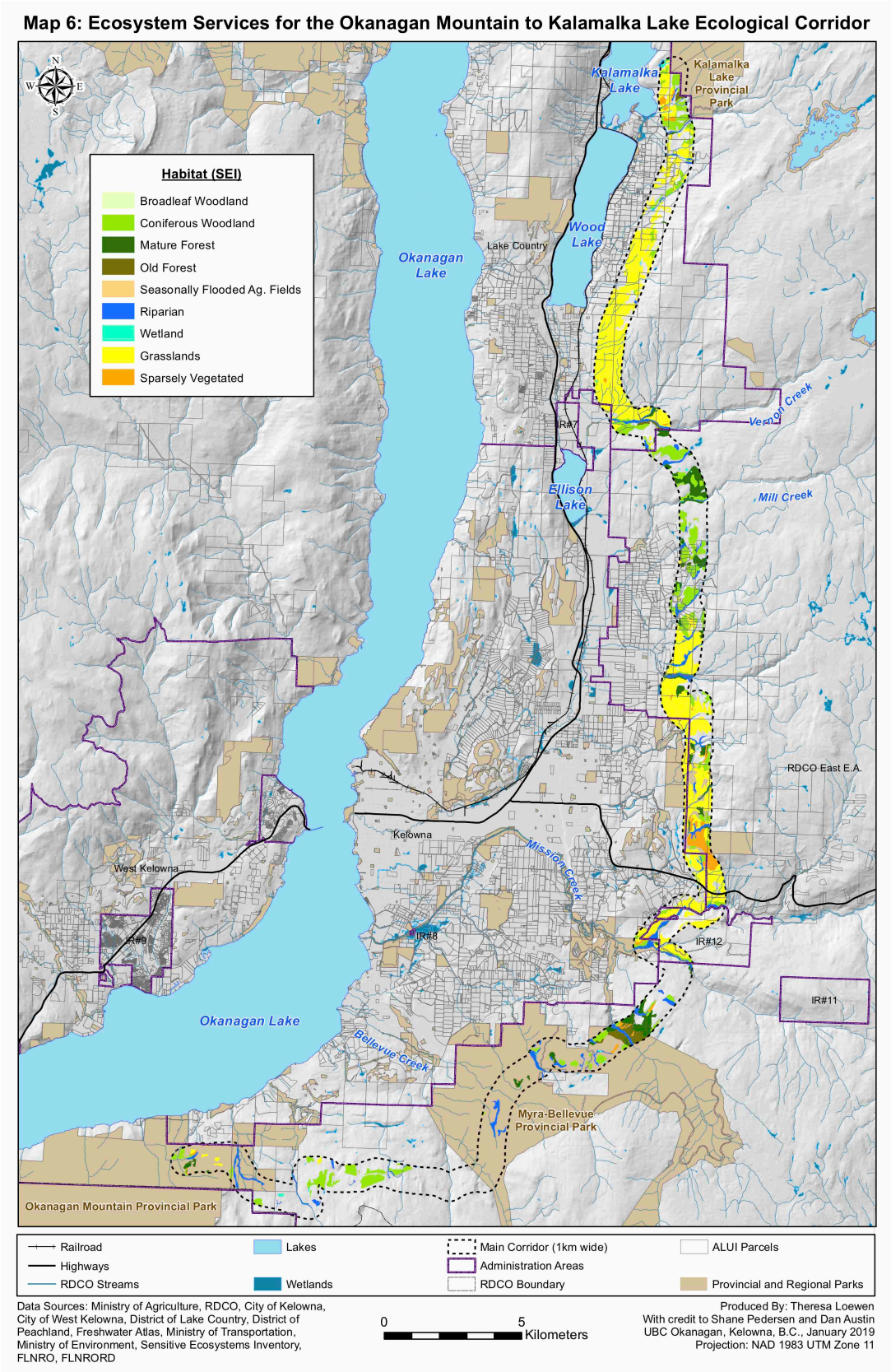
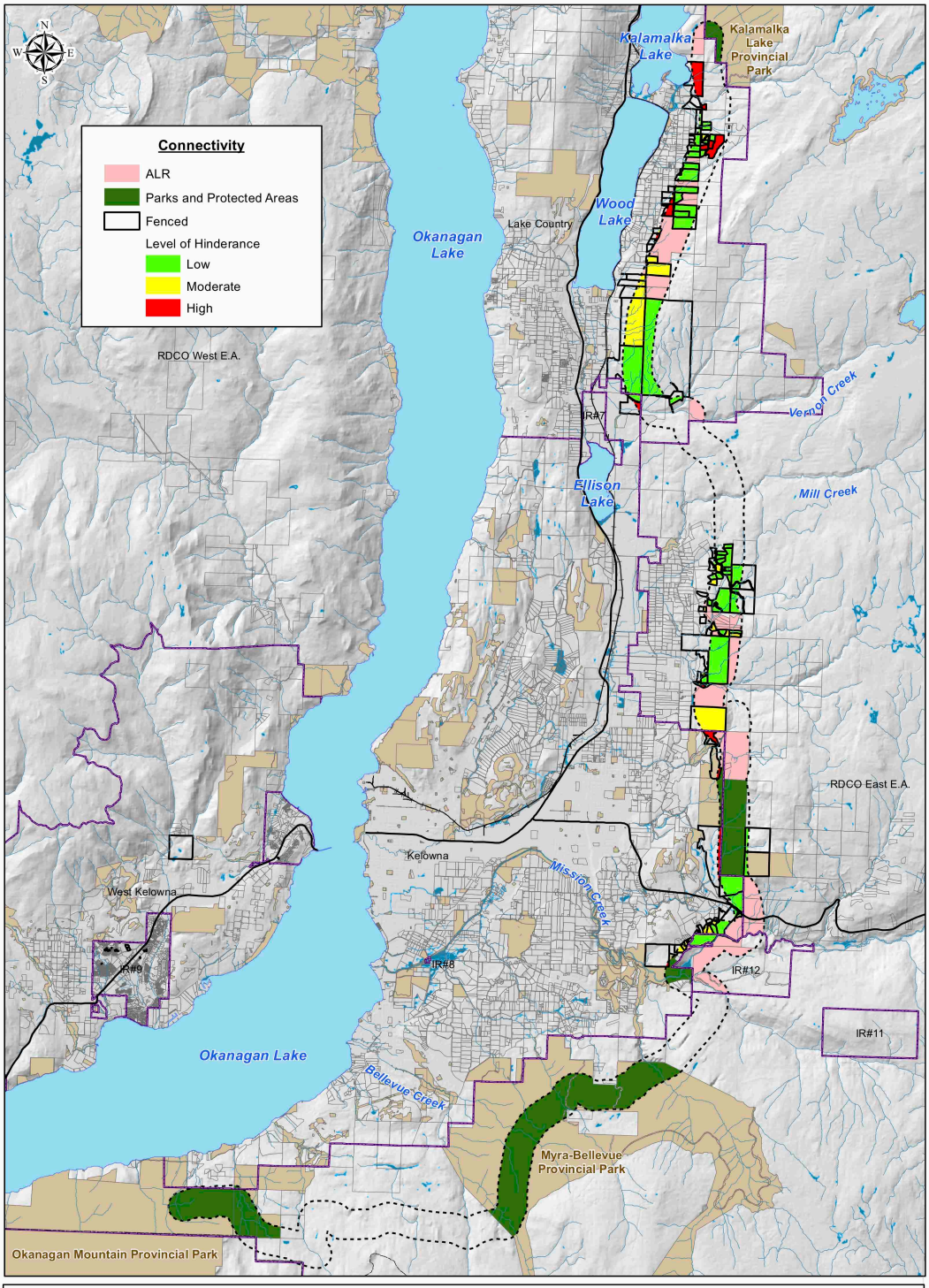
Projection: NAD 1983 UTM Zone 11

Appendix F: Map 6 (Habitat)



Appendix G: Map 7 (Connectivity)

Map 7: Connectivity for the Okanagan Mountain to Kalamalka Lake Ecological Corridor



Data Sources: Ministry of Agriculture, RDCO, City of Kelowna, City of West Kelowna, District of Lake Country, District of Peachland, Freshwater Atlas, Ministry of Transportation, Ministry of Environment, Sensitive Ecosystems Inventory, FLNRO, FLNRORD

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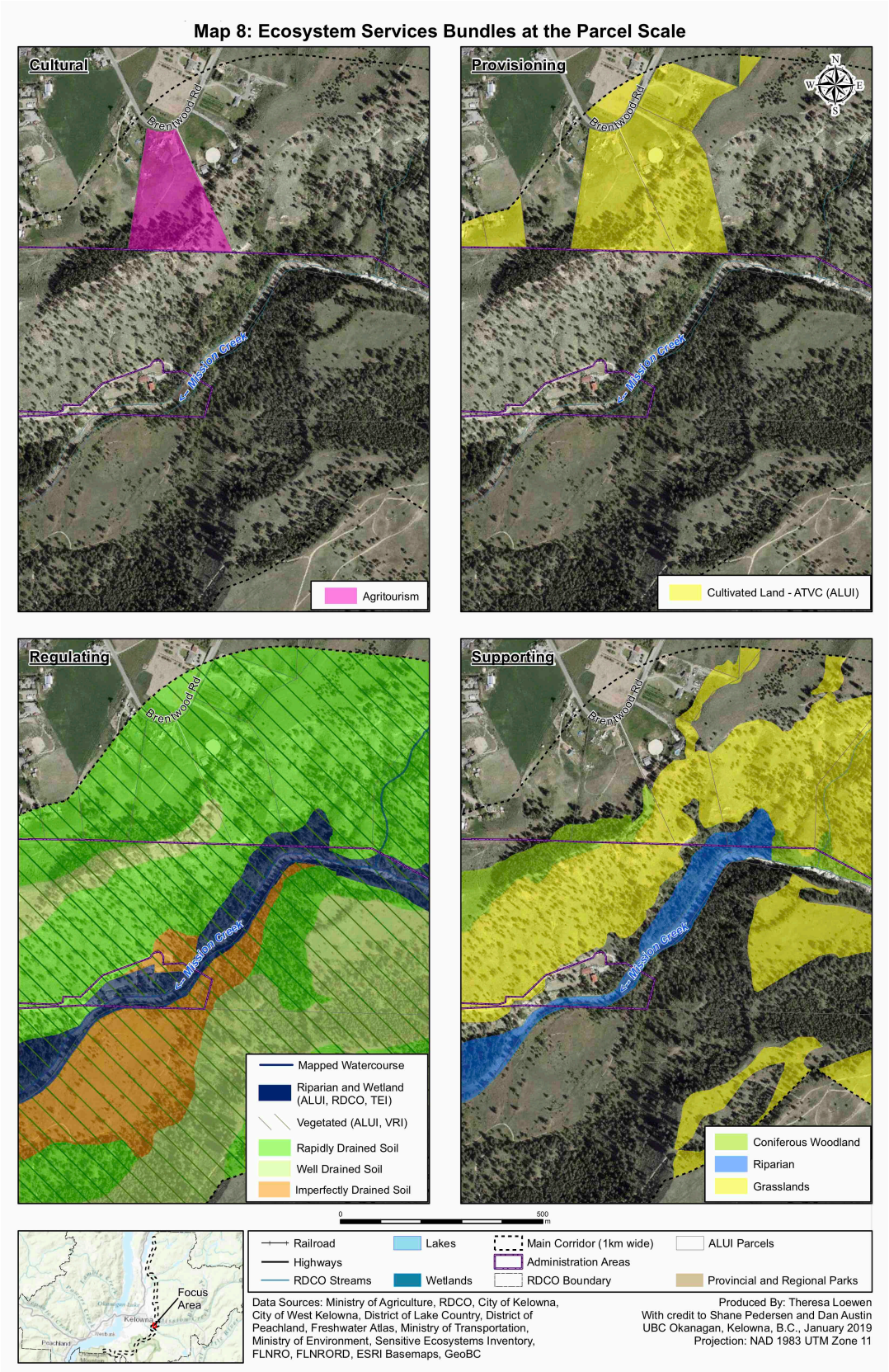
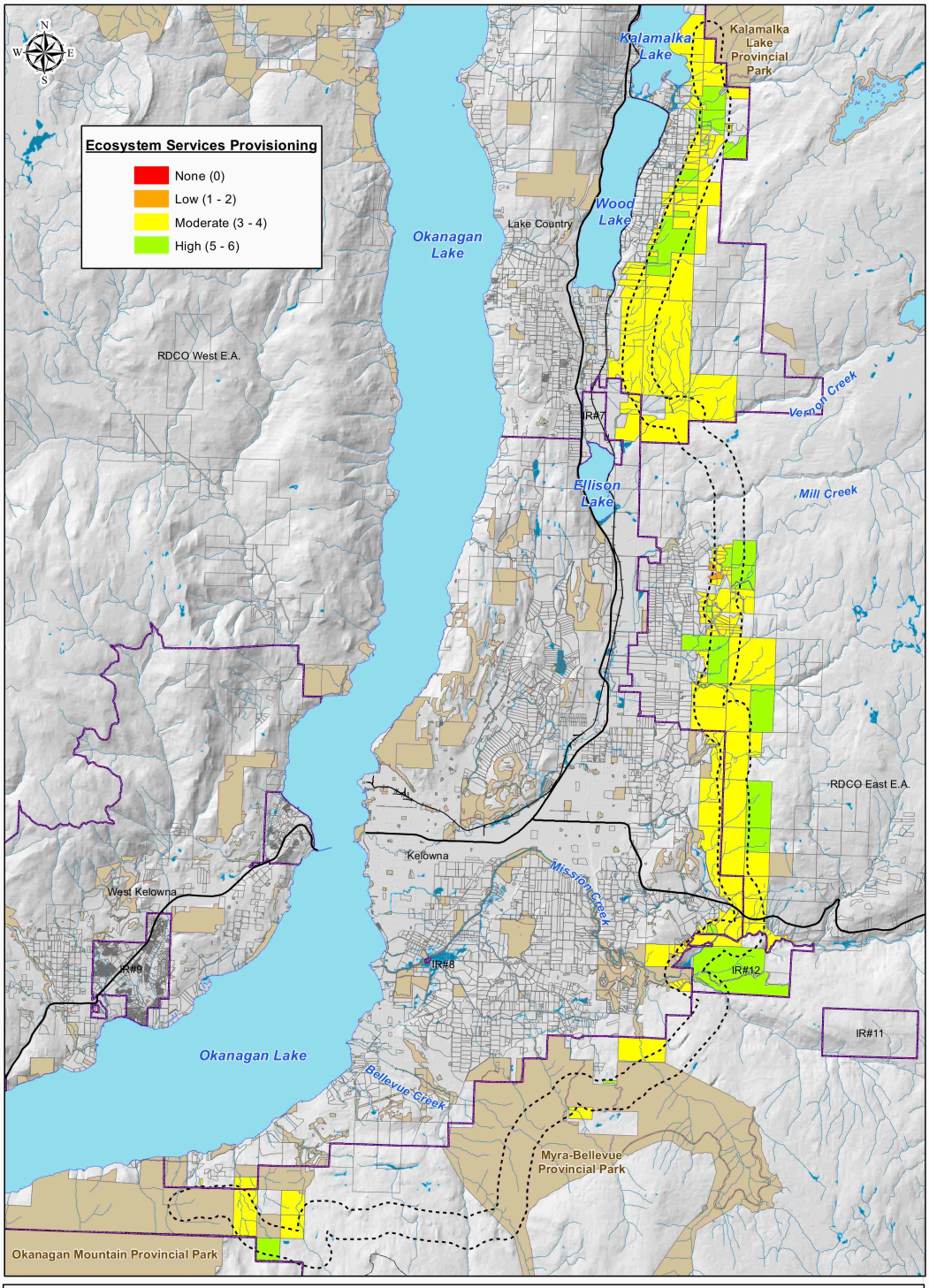
Appendix H: Map 8 (ES Bundles at the Parcel Scale)



Appendix I: Map 9 (ES Ranking for Priority Areas)

Map 9: Ecosystem Services Ranking for Priority Areas



Data Sources: Ministry of Agriculture, RDCO, City of Kelowna, City of West Kelowna, District of Lake Country, District of Peachland, Freshwater Atlas, Ministry of Transportation, Ministry of Environment, Sensitive Ecosystems Inventory, FLNRO, FLNRORD

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Appendix J: Inventory of Incentive Programs

Inventory of Existing Stewardship Programs

Inventory, analysis and summary of existing stewardship models and incentive programs in that could be employed or adapted to achieve biodiversity conservation objectives in the pilot study area

Objectives of Biodiversity Conservation:

1. Sustain the natural terrestrial vegetation (NTV) of the current landscape
2. Protect the sensitive ecosystems (ex. Grasslands) and species at risk on the agricultural parcels
3. Prevent land cover change
4. Maintain connectivity of the corridor that the agricultural parcels are located on
5. Land sparing and land sharing approaches to conservation
6. Land use planning and policy for regional climate change projections

Programs	Overview	Incentives	Advantages/Limitations	Sources
Agriculture Area Plan (AAP) *Administered by: Ministry of Agriculture & City of Kelowna*	- An Agricultural Area Plan focuses on a community's farm area to discover practical solutions to issues and identify opportunities to strengthen farming and ultimately to contribute to agriculture and the community's long-term sustainability. - The planning process is led by the municipality or regional district. An agricultural planning steering committee normally guides the process, & the steering committee should be inclusive of members of the farm community	- None, would need to be incentivized	- A whole community approach to sustainability of the landscape, as opposed to individual landowners - Issues and opportunities are identified to guide the emerging plan policies. The plan's policies are intentionally "action oriented" providing practical solutions to the local issues that are identified. A clear plan for implementation is included. Organizations that are best positioned to implement solutions are identified	https://www.kelowna.ca/our-community/planning-projects/current-planning-initiatives/agriculture-plan https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/strengthening-farming/agricultural-area-plans
Agriculture Environment and Wildlife Fund (AEWF) *Administered by: Investment Agriculture Foundation (IAF)*	- The AEWF was established by the Investment Agriculture Foundation of British Columbia (IAF) under the Agri-Food Futures Fund (AFFF) with support from the BC Ministry of Agriculture and Agriculture and Agri Food Canada. The purpose of the AEWF was to provide funding for environmentally oriented projects that assist farmers and ranchers of BC in addressing environmental issues, enhancing environmental sustainability and	An allocation of $2.5 million committed by IAF. Applications for funding from the AEWF were accepted and adjudicated in 2009, 2010 and 2011. Of 110 proposals reviewed, 69 were approved and ultimately completed, receiving $1,646,930 in funding from the program	Pros: - Good structure of the report they produced, could use for composing the AAP and action plan Cons: - Funding ended in 2011	http://iafbc.ca

Programs	Overview	Incentives	Advantages/Limitations	Sources
	reducing the impacts of wildlife on agriculture.			
Agriculture Environment Initiatives (AEI) *Administered by: ARDCorp*	- Provides funding assistance for projects aimed at improving environmental sustainability in agriculture. Topics addressed may for example be related to soil, air or water quality, water conservation, pesticide reduction biodiversity. - Wildlife impact mitigation projects may involve innovative ways of reducing wildlife impacts in an environmentally responsible way.	- Project funding	Pros: - Projects aimed at improving environmental sustainability in agriculture - Could support corridor design using their Wildlife impact mitigation projects Cons: - Government agencies, universities and colleges may be participants in a proposal but are not eligible to apply - Generally projects will be submitted by farm associations or by organizations with support from the agricultural community. Priority is given to projects that include evaluation, demonstration or development of new approaches to agri-food environment issues	https://ardcorp.ca
Alberta Biodiversity Monitoring Institute (ABMI)	The ABMI monitors and reports on the state of Alberta's biodiversity. In the course of monitoring terrestrial and wetland ecosystems across the province over the past twelve years, the ABMI has assembled a massive biodiversity database, developed reliable measurement protocols, and found innovative ways to summarize complex ecological information. This dataset has enormous value to environmental managers and land-use decision makers and, to demonstrate the use of biodiversity data, the ABMI has an active research and development program. By applying this capacity to specific management challenges, the ABMI has extended its relevance far beyond its original vision and added value to the ABMI's core business of measure and reporting on the state of	- Funding for projects in Alberta - Projects include: • Biodiversity Management and Climate Change Adaptation • Ecosystem Services Assessment • Ecological Recovery Monitoring • Rare Plants & Rare Animals Monitoring in the Lower Athabasca		http://www.abmi.ca/home/what-we-do/overview.html?scroll=true

Programs	Overview	Incentives	Advantages/Limitations	Sources
	biodiversity in Alberta			
Alberta Fish & Game Association Landowner Recognition Program	The Alberta Fish and Game Association realizes the importance of retaining wildlife habitat on private land. It has two landowner recognition habitat programs to assist local fish and game clubs throughout the province in recognizing landowners for retaining habitat. The programs, entitled "Habitat Steward" and "Heritage Farmstead", were developed to recognize landowners who have a lifelong interest in preserving wildlife habitat and who also carry out responsible land management practices on their land. The Habitat Chairperson or competent member of the local fish and game club is required to complete the application forms for these programs and submit them to the provincial Habitat Development Coordinator. Applications approved through the "Habitat Steward" program will receive an 18" x 24" yard sign, along with a wall plaque. The landowner's name will appear on the sign and plaque. Approved applications for the "Heritage Farmstead" program will also receive an 18" x 24" yard sign to be installed at the abandoned farmstead site. The current landowners name, as well as the pioneering families name will appear on the yard sign.	- There is no financial compensation offered to the landowner for being involved in these programs.		http://www.afga.org/landowner-recognition.html
Alberta Innovates Bio Solutions	"Farmers and government are trying to understand opportunities to support ecosystems in agricultural landscapes," says Dr. Marian Weber, who leads Alberta Innovates Technology Futures' Environmental Planning and	- Funding for projects in Alberta - Good framework to use for our project		For more information about this project, visit www.BioLINK.albertainnovates.ca and search for project number "BIO-14-013."

Programs	Overview	Incentives	Advantages/Limitations	Sources
	Economics Program. But it isn't clear which beneficial management practices (BMPs) are most cost-effective when it comes to mitigating environmental impacts. A new research project supported in part by Alberta Innovates Bio Solutions is developing a suite of tools to help industry and government assess which BMPs work the best. "We are developing tools to quantify the costs and benefits of carbon, water quality, and biodiversity management practices," says Weber. Other funders are the Alberta Livestock and Meat Agency and Alberta Innovates Technology Futures.			
Biodiversity Management Plan (BMPs) *Administered by: Ministry of Agriculture and ARDCorp*	- A Biodiversity Plan is an assessment for farmers and ranchers who wish to increase their understanding of biodiversity and what it means to their operations. Managing for biodiversity ensures that agricultural lands can continue to receive the benefits provided by natural systems - Biodiversity plans based on 8 principles of biodiversity (go native, semi-natural is valuable, location, connections, achieve new heights, healthy ecosystems, variety, avoid non-native species) - 4-step process for BMP (assessing opportunities, planning, monitoring, implementation)	- None directly (except from EFP), would need to be incentivized	Pros: - Works with the EFP program to address the biodiversity conservation component of environmental stewardship Cons: - There is no funding for farmers, so would need to add incentives	https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/environmental-farm-planning/agri_bmp_report_final.pdf https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/programs/environmental-programs/beneficial-management-practices
BC's Climate Leadership Plan 2016 *Administered by: The Province of BC*	- Document of 21 actions that targets key areas we can act on now. The Climate Leadership Plan will be updated over the course of the following year as work on the Pan-Canadian Framework on climate action progresses. - The strategic actions included in the document represent the first steps the B.C. government is taking	$1.9 billion has been dedicated to keeping British Columbia on the path to a lower carbon economy	- Outlines practices for climate change adaptation, including agriculture	https://climate.gov.bc.ca

Programs	Overview	Incentives	Advantages/Limitations	Sources
	to update our climate action plan to work towards our 2050 goal.			
Environment and Climate Change Canada 2016-17 Report on Plans and Priorities *Administered by: The Government of Canada*	- This program aims to prevent biodiversity loss while enabling sustainable use by: protecting and recovering species at risk and their critical habitat; conserving and protecting healthy populations of migratory birds; and monitoring, conserving and restoring significant habitats by establishing and maintaining a network of protected areas, and developing and implementing stewardship programs. It also supports coordinated and coherent national assessment, research, planning and action to protect biodiversity, including viable, self-sustaining populations of species, healthy and diverse ecosystems, and genetic resources. - The program forms strategic partnerships for integrated management of Canada's natural capital, including stewardship and the sustainable management of landscapes - Strategic Outcome 1: Canada's natural environment is conserved and restored for present and future generations	- 2017–18 Planned Spending $133,903,800 - 2018–19 Planned Spending $120,985,239	- The Protected Areas program also promotes public awareness and understanding of wildlife and nature conservation and of Environment and Climate Change Canada's role in conservation efforts. - The program directs research and conducts wildlife and habitat monitoring in its protected areas. Program work also includes landscape conservation assessment and planning, which plays a key role in consolidating species population, observation and habitat data to inform planning and decision-making for priority habitat protection and conservation, using regulatory (SAR critical habitat protection) and non-regulatory (stewardship funding) tools. This also includes monitoring and reporting on habitat conservation activities with the aim of tracking gains made towards Canada's Biodiversity 2020 and Federal Sustainable Development Strategy goals. - The program operates as part of a broader network of protected areas, including those managed by other federal departments (Parks Canada and Fisheries and Oceans Canada) and provincial and territorial agencies, along with conservation properties owned and/or managed by non-governmental organizations.	https://www.canada.ca/en/environment-climate-change/corporate/archive/departmental-plans/report-priorities-2016-2017.html
Environmental Farm Plan (EFP) / Beneficial Management Practices Program *Administered by:*	- A qualified planning advisor works with qualified farmers or ranchers to complete a confidential Environmental Farm Plan Assessment that outlines recommended actions to help improve operation - Key Objectives: -- Improve the sustainability of B.C.'s agricultural industry	- Project funding to increase agricultural sustainability and contribute to a cleaner, healthier environment may be available through the Beneficial Management Practices Program - No-charge, confidential	- Promotes sustainability and disaster response - Action oriented, practical hands-on approach	https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/programs/environmental-programs/environmental-farm-plan

Programs	Overview	Incentives	Advantages/Limitations	Sources
Ministry of Environment	-- Recognize producer efforts to manage land sustainably -- Enhance marketing opportunities for B.C. farmers -- Improve relationships with environmental agencies -- Improve the response to environmental incidents	on-farm environmental assessment - Project funding up to 100% (max $70 000 per farm operation)		
Farm Adaptation Innovator Program (FAIP) *Administered by: Climate Action Initiative*	- Seeks to build adaptive capacity and encourage the adoption of effective farm practices to help mitigate impacts related to climate change by supporting projects that: -- Promote innovation in farm practices, approaches and technologies that support climate change adaptation -- Demonstrate farm practices that reduce weather related production risks, and identify new production opportunities -- Develop informational and knowledge sharing resources and support increased organization capacity to support adaptation	- 9 proposals were approved and all of the program's $1.75 million in Growing Forward funding has been committed. - Funding will be distributed over a four-year period (2014-2017)	- Provides direct financial assistance to projects including applied research, pilots and demonstrations - Will increase the capacity of B.C. farmers to adapt to climate change and weather related production risks and impacts - Regional climate change strategies have been developed collaboratively with agricultural producers, agricultural organizations, local governments, and provincial agencies using funding from Growing Forward 2	https://www.bcagclimateaction.ca/farm-level/adaptation-innovator-program/
Farmland Advantage Program *Partners include: Ardcorp Balance Ecological British Columbia - Provincial Govt. BC Agriculture Council Canada - Federal Govt. Columbia Basin Trust Investment Agriculture Foundation of*	- Farmland Advantage is a research and development project that works with farmers to conserve and enhance critical, natural values in British Columbia, Canada. We assist hard-working farmers who look after their land, so the land can continue to work hard for us. - Farmland Advantage is a five-year research and development project, working towards establishing a long-term program. Farmland Advantage consists of a full complement of partners and agencies working together to develop a solid, replicable program model capable of being administered independently and sustainably.	- Focused on 3 targeted BC regions - the Lower Mainland, Okanagan, and Kootenays. Over 60 farmers have been contracted to conserve or enhance riparian areas and the results are being monitored and analyzed. The project is currently engaging long-term funders and working with multiple levels of government and administration to develop future program parameters and success. Farmland Advantage is placing considerable focus on developing relationships with	- Farmland Advantage works with farmers to enhance the natural values on their land. These natural values are often referred to as 'ecosystem services'; services of a natural environment that benefits humans. They are values that are not traded in the markets but have great value to us all. They can include areas like wetlands that filter and purify water, and forests that clean the air and provide habitat for healthy wildlife populations. - The project helps farmers identify the natural values which can be protected and enhanced, and develops recommendations and plans to preserve them. These plans can include actions such as water or stream setbacks, strategic fencing, reforestation, or rangeland enhancement. Farmers then carry out	http://www.farmlandadvantage.com/about

Programs	Overview	Incentives	Advantages/Limitations	Sources
BC Local Conservation Fund / RDEK Fraser Valley Watersheds Coalition Langley Sustainable Agriculture Foundation Township of Langley Vancouver Foundation Real Estate Foundation Windermere District Farmers' Institute		farmers, agencies and funders throughout the province.	the recommendations, and Farmland Advantage helps to provide compensation based on successful implementation.	
FRISP (Farmland Riparian Interface Stewardship Program) *Administered by: BC Cattlemen's Association*	- Designed to assist agricultural producers in their efforts to protect and enhance water quality, riparian vegetation, and fish habitat	- Funding for the FRISP program is provided from a cross section of stakeholders, industry, government and private funders. BCCA continues to advocate for more project funding on a regular basis	- Promotes environmental stewardship and sustainability for the ranching community - Restores and enhances farmland - Promotes cooperative planning of riparian / fish habitat restoration and farming activities between landowners, resource management agencies, and community groups	http://www.cattlemen.bc.ca/frisp.htm
Habitat Stewardship Program (HSP) for Species at Risk *Administered by: The Government of Canada*	The overall goals of the HSP are to "contribute to the recovery of endangered, threatened, and other species at risk, and to prevent other species from becoming a conservation concern, by engaging Canadians from all walks of life in conservation actions to benefit wildlife."	The HSP allocates approximately $12.2 million a year to projects that both conserve and protect species at risk and their habitats and to those that prevent other species from becoming a conservation concern. Hundreds of stewardship projects are underway across Canada, many of them funded by the HSP.	- The HSP Prevention Stream focuses on projects addressing other species, beyond those listed on SARA to prevent them from becoming a conservation concern.	https://www.canada.ca/en/environment-climate-change/services/environmental-funding/programs/habitat-stewardship-species-at-risk.html

Programs	Overview	Incentives	Advantages/Limitations	Sources
Natural Areas Conservation Program (NACP) *Administered by: Environment Canada & Nature Conservancy of Canada*	The Natural Areas Conservation Program is an important on-the-ground initiative that takes real action to preserve our environment. It is expected to result in the long-term protection of up to more than 200,000 hectares of ecologically sensitive land across Canada. The Program helps non-profit, non-government organizations secure ecologically sensitive lands to ensure the protection of our diverse ecosystems, wildlife and habitat - Using a science-based process, the Nature Conservancy of Canada and its partners work to acquire ecologically sensitive lands through donation, purchase or stewardship agreements with private landowners.	- Since 2007, $277.5M has been invested in the NACP by Environment and Climate Change Canada - This investment has been matched with more than $500M in contributions of donated land and funding from provincial governments, the private sector and Canadians at large	- Under the Program, priority is given to lands that are nationally or provincially significant, that protect habitat for species at risk and migratory birds, or that enhance connectivity or corridors between existing protected areas such as National Wildlife Areas, National Parks and Migratory Bird Sanctuaries - More than 418,000 hectares (1 million acres) has been conserved since the onset of the program. The NACP is on track to conserve $1B worth of ecologically significant land by 2020. - In the most recent phase of the program, from September 2014 to March 2016, more than 25,000 hectares (62,000 acres) of habitat was protected.	http://www.natureconservancy.ca/en/what-we-do/conservation-program/
Official Community Plan (OCP) *Administered by: RDCO*	An Official Community Plan (OCP) is a bylaw of policies that reflect the goals and objectives of the community. They are developed with considerable public input and describe what a community would like to see in terms of land use and servicing. - Also have a Regional Growth Strategy to plan for population growth and climate change	- None	The OCP recognizes SAR and Environmentally Sensitive Areas (ESA) are specific locations that have been identified as being sensitive to development. Official Community Plans (OCP) designate these areas from potential detrimental effects of development and for the protection of life and property from natural hazards. All new development and infrastructure should occur with minimal impact or disturbance to the ESA. The protection of these ESA's may require leave areas by dedication or registration of a conservation covenant or no-building in the leave area.	https://www.kelowna.ca/our-community/planning-projects/long-range-planning/official-community-plan
Range Management Plan (RMP) *Administered by: Ministry of Forests, Lands, and Natural*	Best Management Practices on Crown Range in Community Watersheds explains FLNRO's approach and considerations in managing livestock grazing on Crown range in Community Watersheds. This BMP document builds on information from our Rangeland	- None (requirement of tenure holders)	- Lots of resources for management of healthy range ecosystems, grasslands (ex. Seeding guide, BMP, ER) - Sustainable management is achieved through ecological monitoring activities, controlling the establishment and spread of invasive plant species, advocating sustainable	https://www.for.gov.bc.ca/hra/index.htm

Programs	Overview	Incentives	Advantages/Limitations	Sources
Resources	Health series of publications and on the collaborative work of Range program staff, range tenures holders, water purveyors, Water Stewardship staff, and Interior Health staff in the Okanagan-Shuswap Forest District.		range management practices, developing policy and legislation, assisting in the restoration of degraded rangeland and providing extension services to staff, clients and partners.	
Recreational Fisheries Conservation Partnerships Program (RFCPP) *Administered by: Fisheries and Oceans Canada*	- Recreational Fisheries Conservation Partnerships Program was established in June 2013 to support multi-partner projects at the local level aimed at restoring recreational fisheries habitat in order to enhance the sustainability and productivity of Canada's recreational fisheries. - The program's objective is to restore, rebuild and rehabilitate recreational fisheries habitat.	- Funding from federal govt	- Stream, Lake and Floodplain Habitat Restoration - Bioengineering and planting of native species to reinforce or stabilize stream banks and/or stabilize instream sand and gravel bars - Riparian planting using native species. - Livestock exclusion fencing in conjunction with riparian planting and suitable buffer strips	http://www.dfo-mpo.gc.ca/pnw-ppe/rfcpp-ppcpr/index-eng.html
Salmon Safe BC	- Pacific Salmon Foundation (PSF) and Fraser Basin Council joined forces in 2010 to launch Salmon-Safe BC with pioneering growers. To date, more than 40 farms and vineyards across British Columbia have achieved Salmon-Safe certification. - Salmon-Safe is an eco-certification program that encourages farmers to use agricultural practices that protect Pacific salmon habitat and water quality. Farms are evaluated by independent, professional certifiers. - Salmon-Safe certification demonstrates leadership and commitment to the health of BC's watersheds.	- None	- Certification is also available to BC municipalities and regional districts, developers and other landowners in both the private and public sector. The certification can apply to such places as parks and natural areas, college or university campuses, business sites and residential developments in urban, suburban and rural settings. - Supports healthy aquatic ecosystems and provides guidelines for eco-friendly agricultural practices	https://www.salmonsafe.org/bc
Species At Risk Partnerships on Agricultural Land (SARPAL) *Administered*	- The BC Cattlemen's Association has received funding from Environment Canada to deliver a pilot program that will enable cattle producers to implement Best Management Practices (BMP's) and projects that will protect habitat	- The pilot program has funding to operate until March 31, 2019	- Funding can be used for materials, planning, and project costs. Currently, we are seeking landowners who have suitable projects that can be completed by March 31st of each fiscal year. The program has funding until March 31, 2019.	http://www.cattlemen.bc.ca/sarpal.htm https://www.ontariosoilcrop.org/oscia-programs/sarpal/

Programs	Overview	Incentives	Advantages/Limitations	Sources
by: *BC Cattlemen's Association & Ontario Soil and Crop Improvement Association*	for the Yellow Breasted Chat and the Lewis's Woodpecker.		Possible project examples: Riparian fencing – fencing to restrict cattle access to the riparian corridor. Riparian restoration & replanting – replanting of wild rose or willow shrubs in the riparian zone. Protection of wildlife trees– installation of livestock rubbing posts to prevent pushing over of known nesting trees. Other – projects that benefit the species or conserve habitat would also be considered	
South Okanagan-Similkameen Stewardship Program (SOS Stewardship Program)	The SOS Stewardship Program works to protect and enhance species at risk, plant communities, and habitats in the South Okanagan-Similkameen, an area that is one of the four most endangered ecosystems in Canada	- None	Pros: - The SOS Stewardship Program helps people: find information on native plants and wildlife, prepare conservation plans, habitat assessments, and management plans, provide information on potential wildlife interactions, complete habitat restoration projects, protect habitat through the use of stewardship agreements and conservation covenants Cons: - The South Okanagan-Similkameen is outside the pilot area regional district	http://stewardshipcentrebc.ca/case-studies/south-okanagan-similkameen-sos-stewardship-program/
Sustainable Winegrowing BC (SWBC) *Administered by:* *BC Wine Grape Council*	- SWBC is currently a voluntary, self-assessment program. Third party assessment and certification will eventually be offered to reinforce the credibility of the program and ensure it is setting high and verifiable standards for sustainability. Options for the structure and timing of the certification program are being studied and will be brought forward to industry members for their input in the near future	- None	- Best practices guide available for sustainable grape growing practices	http://bcwgc.org/sustainable-winegrowing-british-columbia

Appendix K: Interview Guide

Agricultural Landowner Interview Guide

Part One: Introduction

Thank you for agreeing to participate in this interview. My name is Theresa Loewen, I am currently pursuing my Master's degree in Environmental Science at the University of British Columbia. My research focuses on investigating the connection between ecosystems on agricultural land in the Okanagan. Your participation with this interview today helps me understand the landscape from your perspective. The information you give me will be used as data in my research project, and helps to provide feedback to local governments as they work on incorporating connectivity into future planning and policy.

Part Two: Background Information, Participant History

I would like to start by asking you some background questions about your experience on your property:

1. Do you have farm status on your property?
    a. If no, why do you choose to live on agricultural land? (Then skip to Q2)
    b. If yes, do you farm the land yourself or lease it?
    c. How long have you been farming?
    d. How long have you farmed this particular parcel of land?
    e. What type of commodities do you produce?
2. What is the size of your parcel of land?

3. How long have you lived in the Okanagan?
4. Was farming a part of your childhood or family history?
5. What is your level of education?
    a. Where did you go to school?
    b. Did you have any formal education in agriculture before you started farming?
6. What year were you born in?

Part Three: Participant Attitudes & Norms

7. What do you like about living and working in the Okanagan?
    a. Follow up: What do you like about your property?
    b. Probing question: Why do you think you like those things?
8. What do you find to be the most rewarding part of working in agriculture?
    a. Probing Question: Why did you choose to work in agriculture?
9. What does it mean to you to be a good environmental steward?
    a. Follow up: Do you think landowners should be stewards?
    b. Follow up: What are some barriers or challenges of being a good steward?
    c. Follow up: Do you think stewardship is an individual responsibility, or should communities collectively contribute to land stewardship?
    d. Follow up: What are your neighbors doing to be landowner stewards?
10. What are your environmental concerns about your property?
    a. Probing question: For example, have you had issues with flooding, drought, erosion, soil loss, pests, or invasive species in the past? Any other issues?
    b. Follow up: Have these issues become more serious in recent years?
    c. Follow up: Are there any environmental issues on your property that you think will get worse in the future?
    d. Follow up: Do you think your neighbors have the same environmental concerns?
    e. Probing question: What have your heard from your neighbors about their properties?

Part Four: Participant Knowledge & Past Behaviour

11. What types of wildlife do you see on your property?
    a. Follow up: Have you noticed that the type or occurrence of wildlife has changed over the time that you've owned this property?
    b. Follow up: Have any types of wildlife been a problem to you?
    c. Probing question: Why has wildlife been a problem?
    d. Follow up: In what ways does your property help or hinder wildlife movement?
12. What does the term "ecosystem" mean to you?
    a. Follow up: (If they don't know what ecosystems are) Ecosystems are areas made up of living things that interact with the environment, such as grasslands, woodlands, and riparian areas which provide habitat to wildlife as well as benefits to humans.
    b. Probing question: What types of ecosystems are present on your property? For example, do you have native grasses, a stream or wetland on your property? (Show the Ecosystem infosheets)
    c. Follow up: What actions have you taken to maintain or alter ecosystems on your property?
13. What does the term "ecosystem services" mean to you?
    a. Probing question: What ecosystem services does your property provide?
    b. Follow up: (If they have no idea)… Ecosystem services are the benefits that humans receive from ecosystems[1]. For example, a woodland ecosystem would provide timber, habitat, fresh air, etc. Other ecosystem services include food, fresh water, pollination, drought & flood regulation, landscape aesthetics, cultural value, and much more.

[1] Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. *Island Press*.

c. Follow up: What actions have you taken to enhance or reduce ecosystem services on your property?

14. What do you think are the benefits of having a naturally connected landscape?
    d. Follow up: (If they have no idea)… Show them the "Ecosystem Connectivity" infosheet
    e. Follow up: What actions have you taken to increase or reduce landscape connections on your property?

Part Five: Participant Actions & Future Behaviour

15. Would you be willing to make changes to your property to keep landscape connections and natural habitats a part of your land?
    a. Probing question: (If Yes) What kind of changes?
    b. Probing question: (If No) What would deter you from making changes?
16. Have you heard of government incentive programs, like the Environmental Farm Plan?
    a. Probing question: (If a non-farm property) Would you be interested in learning more about how you could improve connectivity and ecosystem services on your property?
    b. Probing question: (If they have not heard of programs, provide info about EFP's first)… Would you consider participating in an Environmental Farm Plan?
    c. Follow up: Would you support local government in identifying connectivity corridors in documents like Official Community Plans, so that they are considered and protected in future development?
17. How effective do you think government incentive programs are?
    a. Probing question: Have you ever participated in an incentive program, or know someone that has?
    b. Follow up: Would you be open to having an Environmental Advisor come to do a personalized, on-farm assessment?
18. Would you consider participating in an incentive program?

a. Probing question: What kind of support would you find valuable if you were to participate in an incentive program?

b. Follow up: What challenges would prevent you from participating in an incentive program in the event that you wanted to?

Part Six: Conclusion

19. Do you have any questions for me, or any other comments you would like to make?

Appendix L: Interview Flyer

THE UNIVERSITY OF BRITISH COLUMBIA

Fall/Winter 2018

REQUEST TO PARTICIPATE: UBC STUDY

Your property as part of an ecological corridor

What are the benefits of participating?

1. A chance to be heard - as a landowner, we want to hear about your opinions on land management and your experiences as a landowner in the Okanagan
2. Your feedback will help inform future policies and programs that will help meet environmental objectives and support the agricultural community

Who can you contact to participate in this study?

If you would like to participate, please contact:

Theresa Loewen, Co-Investigator:

theresa.loewen@alumni.ubc.ca
250.870.0714

Or mail: Dr. Lael Parrott, Principal Investigator

The University of British Columbia, Okanagan

Dept of Earth, Environmental & Geographic Sciences

SCI 377 - 3333 University Way

Kelowna, BC, V1V 1V7

Why are we doing this study?

This study, the "***Central Okanagan Ecological Corridor***," aims to explore the opportunities and challenges of protecting and enhancing landscape connections between ecosystems on agricultural land. We want to hear from you, the landowner, to learn about your experience as a property owner in the Okanagan, and to hear your perspectives and opinions about land stewardship. We hope that our results will help inform future policies and programs that will help meet environmental objectives and support the Okanagan's valuable agricultural industry.

How is the study done?

We have chosen a study area in the Central Okanagan and Lake Country Regional District because it is a natural interface between wildlife movement and agricultural activities. By distributing these letters in your area, we are hoping to recruit participants for our study. We will be interviewing willing participants to ask questions about landscape values, knowledge, and opinions on the effectiveness of stewardship incentive programs.

If you choose to help us, we will contact you prior to your interview, and arrange with you a convenient time and place to meet. Your responses are valuable to us, and will be kept confidential.

Please express your interest by: December 31, 2018

Appendix M: Interview Summary

Summary of Interview Responses

Section 1: Participant Attitudes & Norms

1. Why do you choose to live on agricultural land? What do you like about living and working in the Okanagan? What do you like about your property?

- The property space, larger parcels of undeveloped land
- Rural/semi-rural living
- Close to city and amenities (airport)
- Connection with nature
- The quiet, solitude
- Weather/climate (long growing season)
- Beauty (lakes, environment, natural space, view)
- Recreation (access to lakes and mountains, skiing and snowshoeing)
- Farming community, ability to grow food
- Ability to be your own boss
- The people (happy, friendly people)
- Physical properties (good soils, arable, aspect/exposure/slope of land, elevation)
- Availability of water, irrigation
- Diversity (in the ability to shape the land, build a house of good size, grow a wide variety with the longer growing season)

2. What do you find to be the most rewarding part of working in agriculture?

- Love and joy of growing food
- Ability to provide food for people who need it (food banks)
- Simplicity and peace of growing, takes you a step back in time

- Connection to food and people
- Educating children on food production
- A way of life
- Connection to nature
- Production - seeing the results of labour
- Pride in growing a good quality product
- Autonomy (you can choose to grow whatever you want)

3. What does it mean to you to be a good environmental steward?

- To not damage or effect the land any more than you need to for your own distinct purposes
- To be mindful
- To maintain the soil
- Fencing to keep animals out of things
- Organic farming procedures/no pesticides (certified or not)
- Keep as many trees as possible
- Maintain the aesthetics
- Fire prevention
- Taking care of the land
- Understanding environmentally sensitive areas (landowners and government)
- Chemical vegetation management
- Invasive weed control
- Awareness of the environment and sensitive plants
- Education in schools for children about agriculture and the environment
- Leaving the land in the original condition
- To keep the land clean

- Help wildlife (make nest boxes for birds, have a bird feeder)
- Plant native grasses and flowers

4. What are some barriers or challenges of being a good steward?

- Time
- Effort
- Motivation
- Government constraints, rules and regulations
- Broad-brush policies that say this is what is right for everybody
- Strict/rigid industry production standards (fruit color/size)
- Economics
- Environmental (moisture and water, pruning)
- Producing quality vs. quantity
- To know what is an optimum future for this land from a conservation or ecological point of view
- Lack of knowledge of what the land looked like hundreds of years ago
- To keep land use consistent (with new owners, succession)

5. Do you think stewardship is an individual responsibility, or should communities collectively contribute to land stewardship?

- Need to reconcile value differences (nature vs. infrastructure)
- Inconsistency with local government
- Inconsistency between different scales of government
- Need an overall system of management and community stewardship objectives with individual owners doing what they can

- Property succession planning
- Need an inventory of all the species that are on the land, and protective measures
- Education is needed (so people understand the connection between how food is produced and where it comes from)
- Create/preserve culture of farming community, make it part of growth

6. What are your neighbours doing to be landowner stewards?

- Pesticide spraying
- Habitat destruction
- Invasive weeds
- Replanting trees
- Keeping the land clean
- Over-grazing the land
- Animal abuse (goats and sheep left on bare, muddy land that's been severely overgrazed that's there's nothing left anymore, some people in the neighbourhood called the district and animal control, but were told because it's agricultural land the person could do what they wanted. If there are concerns about wildlife, there should also be concerns about domestic animals, "paying" life. But what really upset my neighbor, because he's the one that really lead the charge in raising it with the different agencies, and the answer he got was no, that's just agriculture. We wouldn't treat our dog like that, so why would we treat others like that? They're unhappy animals but they get fed. We all dislike it, it's a blemish on the landscape)

7. What are your environmental concerns about your property?

- Invasive species (knapweed, bindweed, twitch grass, Murdock's thistle)
- Off-road vehicle use

- Erosion/soil loss
- Pests (pine beetle, tussock moth, spruce budworm, coddling moth, spotted-wing drosophila)
- Drought
- Flooding

8. Have these issues become more serious in recent years?

- Erosion
- Drought
- Pine beetle
- Invasive plants
- Spotted wing drosophila

9. Are there any environmental issues on your property that you think will get worse in the future?

- Climate change
- Pine beetle
- Off-road vehicle use/disturbance
- Invasive weeds
- Further development
- Drought

10. What have your heard from your neighbours about their properties?

- There's quite a few wetland draws on this hillside that are where no one is disturbing them, so people must what their value is, they've been on this land a long time. Their animals are able to use it, and it's filtering and doing it's own thing, so hopefully it stays that way.

- For the last 10 years, there's been a house built in the neighbourhood every 2 years or so, there's only one (lot) left now. And whenever the area gets disturbed this one weed comes up. I don't know what it is, but it's about 6 feet high, big leaves, and the big top part is all seeds. We had it up and down our driveway and we pulled it all out, and last year there was hardly any, so it's manageable.
- They probably have concerns about my spraying, because I'm not organic so there's still some pesticides, so they get that drift. The whole area used to be orchard, now I'm the only one that still does.
- What I'm noticing now though is there's a number of Agritourism places in the area so you get many more people coming around, walking their dogs, so that's what I pay attention to. It's definitely changed my approach. Now I spray really early in the morning, or late at night.
- They've mentioned spotted wing drosophila, and we've shared bait for cherry fruit flies.
- My neighbor says there's a lot of stink bugs, I've seen a ton of those everywhere.

Section 2: Participant Knowledge & Past Behaviour

11. What types of wildlife do you see on your property?

- Ungulates (mule deer, white tail deer, moose, elk)
- Bears (black bears)
- Birds (wrens, chickadees, sparrows, quail, pheasants, catbirds)
- Birds of prey (owls, bald eagles, hawks, raptors, American kestrels)
- Small mammals (gophers, marmots, moles, groundhogs, weasels, squirrels, chipmunks, skunks, raccoons, foxes)
- Large mammals (coyotes, wolves, cougars, lynx)
- Reptiles & amphibians (bull snakes, garter snakes, Spadefoot toad)

12. Have you noticed that thes the type or occurrence of wildlife species has changed over the time that you've owned this property?

- Elk (new to the area)
- Deer (population increased)
- Birds (more diversity, different species)
- Groundhogs and ground squirrels (new to area)
- Eagles (population increased)
- Pheasants (have come back recently)
- Bears (increased occurrence)

13. Have any types of wildlife been a problem to you?

- Gophers
- Coyotes
- Raccoons
- Weasels
- Deer (mule deer)
- Bears
- Groundhogs, ground squirrels

14. Why has wildlife been a problem?

- Digging holes
- Eating chickens
- Damage to garden and trees
- Damage roots of trees
- Danger for falling/tripping over holes

- Cost money
- Eating fruit

15. In what ways does your property help or hinder wildlife movement?

- Fully fenced with deer fencing
- Fully fenced but not prohibitive fencing
- Deer-fence around the house, everything else is open
- Not completely fenced
- No deer fencing

16. What does the term “ecosystem” mean to you?

- A naturally functioning landscape
- Flora and fauna
- The whole environment
- Everyone as part and in harmony with the ecosystem
- The interaction of all the living animals with the living environment
- Some kind of naturally occurring assemblage of vegetation, geologic features, hydrologic features and fauna, everything from birds to toads
- Unsure

17. What types of ecosystems are present on your property?

- Grasslands
- Woodlands
- Wetlands
- Deciduous trees

- Desert/cactus
- Old growth
- Rock bluff ecosystem
- Riparian
- Ponderosa pine savannah

18. What actions have you taken to maintain or alter ecosystems on your property?

- Mowing the natural grass
- Farming it has changed the land
- Fire prevention (removing dead trees, limbing trees)
- Reseeding native grasses
- Invasive weed control
- Maintain the grass
- Select logging has reduced the canopy
- Stopped spraying
- Collect native plant seeds
- Planted trees
- Put up bird boxes

19. What does the term “ecosystem services” mean to you?

- Water filtration through a wetland, bees pollinating
- Haven’t heard the term before
- Unsure
- Should be as close to natural as possible

20. What ecosystem services does your property provide?

- Pollination
- Landscape aesthetics
- Water filtration
- Food & timber production
- Air and climate regulation
- Carbon sequestration
- Cultural value
- Habitat
- Fresh water and air
- Drought and flood regulation
- Soils (good, arable soil)
- Slope/aspect of land provides microclimate, avoids the frost pocket, protection from frost damage
- Emotional and physical benefits

21. What actions have you taken to enhance or reduce ecosystem services on your property?

- Plant drought resistant native plants and grasses
- Mow grasses
- Grow food, so have changed the soils
- Planted several wild flower gardens
- Stopped spraying
- Collect native plant seeds
- Leave some areas natural
- Planted maple trees, removed cottonwood trees

- Restoring existing seasonal watercourses

Section 3: Participant Actions & Future Behaviour

22. Do you think are the benefits of having a naturally connected landscape?

- Yes. The deer have a daily migration route so it's important for them and other wildlife to be able to travel
- Yes, for wildlife to travel
- I don't know, I think what we have seen over the years with growth and development I don't know that it makes that much difference. Wildlife seem to be very diverse, with stuff going on at Tower Ranch golf course had elk on it last year, I know on the airport they get deer and bear, so the idea of having everything connected maybe isn't as important as we think it is because of the adaptability. So I think that's maybe a perception people have without realizing how diverse animals are.
- Yes, of course it's great, more natural stuff. But do not include in landscape the golf courses. Because golf course destroyed all natural stuff. There should be some regulation. They destroyed all stuff around, no insects or birds.
- For sure. I'd be curious to know once they started fencing things off, how that affected wildlife movement and counts, it created corridors for them that funnelled them down the roads.
- It would depend on the species. Some animals its much more important to than others. Birds can fly over things, but they still would benefit from having a much larger area than just a pocket.
- Yes, I don't like the landscape all fragmented, but that's what they've done here by Scotty Creek Rd, there's all houses and the golf course. The people up top had a natural looking

landscape but then they wanted to build and wanted it flat, so they blasted the hillside put lots and lots of soil in there to level it out. I don't know if that is allowed or not. For 2 years we've had trucks going up there dumping dirt.

23. Would you be willing to make changes to your property to keep landscape connections and natural habitats a part of your land?

- Yes I would. If I had a huge cherry farm with huge fences I might say no, but in our case we don't so I would say yes
- Yeah, I would like it to be incentivized
- No, we already have corridors and connections through riparian areas, so without seeing the changes the answer would be no. Because that would be more regulation, encumbrance to management, and I don't feel we have an issue
- I guess if someone could show me a good reason for it, but I don't see looking down the road how this side of the valley is really going to change. I think it will become more dense, so it will probably be subdivided and broken down into smaller parcels. Right now the minimum parcel size is 10 acres, which I don't know is the best use of the land. It has very little agricultural value. By owning land and living up here are you responsible to provide visuals for the people that live in the subdivision? Are you being penalized? So some of those things I have a hard time with. To look at land in BC and figure out what's the best use for the land when it's very minimal agricultural land with a growing population, are you better to say this land should be 5 acre lots? There are areas of land that are more agriculturally suited.
- Yes, I agree with this stuff. And of course if there was a big reserve area, if some students in a study would collect the seeds and after that go to the farmer and say this example of seeds we give to you. Not sell, if sell then forget about it. Just a little bit, try it and after that it will

be spread over the area. If you say it's good. I know a lot but I cannot know all the grasses around, but I would be happy if I saw more grasses around and flowers and insects.

- For sure, I'm not sure exactly what. Anything that wouldn't negatively affect my business or cost too much.
- No, I think it's pretty natural. The upper part of our property is totally natural, we've never done anything to it. When we moved here the land was not useable, it was a gulley filled with all sand, we had a grater and earthmover that had to come in and make it all level. Otherwise we couldn't plant anything here. We didn't bring any soil in, we just used what we had and moved it around. I would potentially be open to watercourse restoration.

24. What would deter you from making changes?

- If it was super inconvenient or unrealistic
- If it was an easy thing to implement and not a huge life changing or costly thing then yes
- Anything that's going to bankrupt me
- If it was inconvenient for the time but had a long term benefit that would be fine
- Economics, there is a certain threshold

25. Have you heard of government incentive programs, like the Environmental Farm Plan?

- Yes (50%)
- No (50%)

26. Would you be interested in learning more about how you could improve connectivity and ecosystem services on your property?

- Yes (86%)
- No (14%)

27. Would you consider participating in an Environmental Farm Plan?

- Yes (29%)
- No (42%)
- Unsure (29%)

28. Would you support local government in identifying connectivity corridors in documents like Official Community Plans, so that they are considered and protected in future development?

- Yes, I think that's really important and is something that hasn't happened yet in a lot of areas. I think it's super cool and interesting to plan for those areas with respect to future development. Hopefully they make it into a park or protected ecological area
- I don't think that's a priority. That's a priority for wildlife corridors. I don't think that's the biggest issue we have. I think if we were to pursue that they wouldn't pursue other things that were more important.
- It would depend on the wording, because of erosion of property rights. Everything I've seen over the last 60 years is about what you can do on your own property and a lot of it doesn't impact others, so I have a bit of a problem with subsidies and government. So much of it depends on how it's put together.
- Yeah of course, but for the extent of what I need and what we should do, I should have access to all maps. I want to see what has happened over the last 50 or 60 years, and after that make decision if it's good or bad. Maybe we have more information on government website, but I haven't found it. There should be more information sharing. We should understand what is the limit for this area of the natural growing population. If we keep building houses, what happens next? It's a lot of pressure on natural areas. Ecological corridor should be part of this

study. How much population should we have in this area, within this limit? A half million, 2 million, 5 million? Or just 100 thousand, how much is enough?

- Yes, for sure
- Sure, to explore exactly how we can promote environmental benefits here

29. How effective do you think government incentive programs are?

- Very effective, the one I participated in helped so much and I know others that did it and they are farming as their main income now
- Yes, they're effective, I studied economics
- There's some good government programs and some not so good ones. Quotas on the dairy industry are good, where we are protecting the dairy industry, subsidizing the dairy industry should it stand on its own. Crop insurance - you kind of have to have those things to be able to have agriculture. There are provincial programs between the BC Cattlemen's Association and department of agriculture for fencing on highway corridors, so I think some of the programs are good. I think it's site-specific. But you can't broad brush it and say that they're all good because there are some that aren't so good, and a lot of them are based on public opinion. Should we subsidize a dairy farmer by having quotas where you can only have cows if they government says you can, and where we pay more for a gallon of milk than others that don't have quotas? In the US they have "set-aside" lands where they pay you not to farm, they pay you so many dollars an acre just to leave the land alone and it's been going on for 50 years
- No, program itself cannot be effective. Only if you have money and control on how it works probably it will be. But really it's about education.
- They are effective, I planted my whole peach orchard from the Replant Program. But I've had an issue with the Replant Program, because they'll give you a certain amount per tree, but

they put restrictions on the density of trees planted. So if you don't fit into that cookie cutter mold you don't qualify. What I see happening is that people apply, get the money, get them inspected, and then pull out every second tree. So the program gets people to cheat, which is wrong.

- I haven't had a huge amount of experience with them, a couple in the Kootenays. I think they can be they're often surrounded by so many restrictions, limits and red tape that they're not very attractive to the average landowner. Government's job is to write complicated regulations to dot all the i's and cross all the t's and I think it's difficult to administer any plan without that, but on the other side from the point of view of someone who's applying, it turns a lot of people off.
- I had an environmental evaluation done as part of the development permit requirement for my property, which I didn't know when I bought the land that there were environmentally sensitive parts to it. I found the guy really good. He knew the trees and he had some really good suggestions. So I found that was very useful. To the extent that someone is advising me, yes. But if that would lead to creating requirements for me, I would be less interested. Because it's just an unknown effort. I think the voluntary component of the program is critical. In particular for the take up for people.

30. Have you ever participated in an incentive program, or know someone that has?

- Yes (43%)
- No (57%)

31. Would you be open to having an Environmental Advisor come to do a personalized, on-farm assessment?

- Yes (86%)

- Unsure (14%)

32. What kind of support would you find valuable if you were to participate in an incentive program?

- Training (free)
- Financial support/cost-sharing
- Advice (free) - advice about what is most valuable and where you can best spend your money when you have a certain amount of money to spend, which of several options should you choose to have the most impact on the environment?
- Consulting services (free) - it would be very helpful to have a better understanding of where I should be putting my time and effort, prioritizing for the biggest impact, and for help with difficult or persistent issues
- Recognition (Signage) - then there's moral sway for those that don't have it, and some recognition for those that do. If you have 10 acres no one ever sees it, so road side signage is good
- Support and information services (for ecosystem restoration, environmental advising)
- Online services
- Knowledge-sharing (more explanation as to what is expected of ecological corridors, things like that. The more informed people are, the better the program is. And also to know what you're buying into)
- Education (to teach people about ecosystems and stewardship)
- Elementary school education/training for teachers to teach children (teachers should spend 1 week or a couple days to teach students how to farm. Schools have big pieces of land, for football or whatever, but not for agriculture. So there should be agricultural land for students, special land to study different stuff, to grow vegetables and fruit, take care of animals, for

vineyards and other stuff. Children usually are more willing to try different things. If they finish the course of this education, they should get credits for biology or zoology)

- Have ecological or agricultural education centers (like science centers, but for agroecology)
- Support/promotion of the program that connects farmers with people willing to work or young famers (if I'm a farmer and I need some help on my farm they come and work for free, they come and get work and boarding, then they get to know the area, this is great for young people. But it should be more promoted so young people understand, for education)
- Free entry for producers into Farmer's Markets
- Any type of support or financial assistance directly geared toward small-scale farms
- Financial assistance for small-scale producers who want to participate in programs (organic certification, etc)
- Free/lower cost to become certified organic (if you care about ecological values, make it free for producers)
- Agritourism (support neighbourhoods/communities to create a culture that supports agriculture, make the corridor an organic area where it's free to become organic so everyone will know that area is organic food)
- Information to be freely available
- Historic information about the land (what was there before we developed it (200 years before), what ecosystems were there, what were the native plants and animals, where were the old waterways)
- Free access to digitized historic aerial photographs, to see how the land looked in the past. It would be good to have maps of how the land has changed over time and then you will understand what's happened and what way we should go. This all should be free and easy to access for everybody
- Programs should be free, and maintained (with control and follow up)

- Education in the school systems (education for teachers and students)
- Help with equipment (funding directed specifically to small scale farmers, because we don't have the money to buy new equipment, develop some kind of equipment sharing program or neighbour rental program)
- Less strict industry standards for apple production (there are so many specific features like size, color, variety, orchard density that farmers have to abide by, what happened to just growing a good quality apple. I would rather grow less apples of higher quality and make more money that way than have a high production. I really don't like being dictated to how I grow my fruit. It's the grower that dictates the final product)
- Anything that supports farming as a primary source of income, a viable way to make a living (older farmers are discouraging their children/grand children against being a farmer because it's hard work and doesn't support a family)
- Community cost-sharing programs (I remember when they first started putting deer fencing around here, there was a big push that they should put up a community fence, that all the growers should chip in to put it up, and keep all the deer up there in one place. But farmers never really ban together. I was more than wiling to give my contribution, because it's a pain having those fences separated. It was put forth at a BCFGA meeting (late 80s, early 90s) but it got hammered and axed, all it took was one dissenter. But if the government or city was to help subsidize it, like 30% or something, then I think it would have helped because there's a lot of expense with fencing)

33. What challenges would prevent you from participating in an incentive program in the event that you wanted to?

- Time
- Farming is a second job

- Finances
- Age (feel too old to take on something that would create a lot of work)
- Requirements
- Lack of rationale (any recommendations need to be explained so that anyone can understand, advisors should have common sense, a broader perspective, be able to tell the story, and provide reasoning or make a case that's convincing)
- Regulation
- Unsure what is the "best" use for land (seen good agricultural land go into subdivisions, and very marginal agricultural land be preserved so you wonder what the agenda is with the ALR)
- Lack of compensation (when you live here your whole life and you have property and you work - that's your retirement plan because you work for yourself, and to sell that property and have someone say well no, that should be a park or an ecological corridor, you can't sell that or subdivide it. I think that's been the problem with the ALR. If they gave you a price that's fair for your land to protect it, or if someone said Ok, don't cut any trees down and that tree is worth "x" amount of dollars and we're going to give you "x" amount of dollars to leave the tree there then it works I guess. I'm not big on subsidies, but on the other hand, if I can't do something on my property because someone else wants to appreciate the aesthetics then they should have to pay for it)
- Lack of coordination/power struggle between different levels of government
- Restriction (there should be more economic options available on ALR land. I don't want to see the whole valley turned into subdivisions, but there's no reason I shouldn't be able to sell off half an acre to my son, because he can't afford 20 acres, but he can afford half. There should be a little tweaking to the program)
- Red tape