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Ecosystem Services of Dairy Farms in the Eastern Fraser Valley
An Exploration of Two Case Studies

Prepared for ARDCorp, BCAC, IAF, Real Estate Foundation, Vancouver Foundation and the Government of Canada's Habitat Stewardship Program

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EXECUTIVE SUMMARY

Ecological Goods and Services are the aspects of ecosystems that provide benefits to humans. The concept helps us to recognize the benefits that humans receive from nature.

Farms that underpin communities in the eastern Fraser Valley have long grown and sold to market a variety of goods, from fruits and vegetables to grains, livestock and milk. Those farms have also produced and continue to support other benefits to people, ranging from soil conservation and flood protection to aesthetic appeal and salmon habitat. Historically, these non-market benefits have not been recognized by markets and decision-makers, resulting in the undervaluation of the natural areas that provide them.

This project sought to identify and communicate Ecological Goods and Services provided by dairy farms in the eastern Fraser Valley of British Columbia, and to understand how producers view their importance. We developed a pilot process to identify relevant ecosystem services produced on two dairy farms, and interviewed farmers regarding the importance of those services to their operation. Farmers identified the beneficiaries of those goods and services produced and ranked their relative value both on and off the farm. While doing so they described their own motivations for establishing, protecting and enhancing natural areas. We subsequently mapped land use, evaluated ecosystem services production from particular land uses, and developed communication documents to share the information with other farmers. Our results must be considered in the context of the small sample size and the pilot nature of the questionnaire used to rank ecosystem services.

Our research focused on two dairy farms in the eastern Fraser Valley. Each represents a different landscape context and landscape features and therefore produce different ecosystem services. Maarhuis Dairy, an organic dairy operation in Chilliwack, contains a watercourse with fish and endangered species and faces challenges with water management that are common in the farmland of the Fraser River floodplain. Holberg Farm, a conventional dairy operation in Agassiz, exists at the urban/agricultural interface and features wind breaks and public trails.

The most interesting result was the critical importance farmers placed on 'cultural services' – aesthetic appeal, recreation, inspiration, sense of place – to both the farmer and people around the farm. Farmers also highly valued soil development and retention, and water infiltration and attenuation. Habitat services were ranked of relatively low value on-farm but farmers perceived a much higher value off-farm. Some 'disservices' were also identified, especially saturated soils that hinder growth and machine access in the spring.

The survey / mapping process was also an effective communication tool. Naming, mapping and scoring ecosystem services on their own farms gave farmers a fresh perspective of their land base, and helped them focus on internally motivated incentives to maintain natural areas on their land. The findings of these case studies will be communicated to other farmers via pamphlets that include visual descriptions of relevant ecosystem goods and services on farm land in the Fraser Valley along with detailed maps that show different

types of land uses and the services they provide.

It should be noted that the concept of Ecosystem Goods and Services is not a single tool but rather a perspective and approach that permits the use of many different tools. Although the general concept is quite simple, it is tricky to work out the details clearly enough to discuss, map and score them in a consistent and logical way.

These case studies are intended as a tool for dialogue around the importance of healthy ecosystems and sustainable farm practices. We hope that the information obtained by this study, and the lessons learned, will help build the foundation of an incentive-based system to reward farmers who provide and invest in ecosystem services.

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1 Background

This paper is largely the result of three 'Agriculture-Environment' forums in 2013 and 2014 which brought together representatives from agricultural producer groups, non-profit organizations and government agencies with a goal of promoting stewardship on farmland in various parts of British Columbia (BC), Canada. Among other things, participants in these forums agreed that the concept of incentives for 'ecosystem goods and services' shows considerable promise as a non-regulatory approach to achieving that goal. Similar programs specifically targeting agriculture are being implemented in south-eastern BC and in the United States.

With that in mind, the BC Agriculture Council (BCAC), the umbrella group for agriculture producer groups in BC, has through its research and development arm (ARDCorp) funded a pilot study of ecosystem service providers and beneficiaries, at the individual farm level. The work was coordinated by the Fraser Valley Watersheds Coalition (FVWC), a non-profit fostering watershed health in the eastern Fraser Valley, forum participant and organizer of the third forum.

1.1 Introducing Ecosystem Goods and Services

The farms that underpin communities in the eastern Fraser Valley have long grown and sold to market a wide range of goods, from fruits and vegetables to grains, livestock and milk. Those farms have also produced, and continue to produce, a wide range of other benefits to people – so-called ecosystem services – ranging from soil conservation and flood protection to climate regulation and salmon habitat. Farmers are not paid for these 'non-market' services, resulting in the undervaluation of the natural areas that provide them. The FVWC believes it is helpful to identify the ecosystem services provided by farmland in order to develop a system of incentives for those services.

This pilot study seeks to explore tools and approaches associated with ecosystem goods and services as a foundation for further work on an incentive system. It does so by identifying, from the farmer's point-of-view, specific ecosystem services provided by and important to two dairy farms. Through a survey and interviews farmers identified both on and off-farm beneficiaries and described their own motivations for establishing, protecting and enhancing natural areas. The study findings will be communicated to farmers, specifically in pamphlets that include visual descriptions of relevant ecosystem goods and services on farm land in the Fraser Valley, along with detailed maps that show different types of land uses, and the services they provide.

1.2 Principles and Definitions

The terms and jargon used in the study of ecosystem goods and services are rapidly evolving. We based our work on language used in an international project called *The Economics of Ecosystems and Biodiversity* (TEEB) (Kumar 2010). It describes ecosystem services as "*the aspects of ecosystems that provide benefits to people*" (Turner, Georgio and Fisher 2008). That definition is used to show the relationships between key elements in the steps from living ecosystems to benefits received by people (Figure 1).

In essence, living ecosystems provide tangible 'goods' that are harvested and can be used or taken to market (like lumber and crops), as well as less tangible 'services' (like water filtration and

pollination of crops), that do not provide a harvestable product and provide no income to landowners. The common phrase 'ecosystem services' is short for 'ecosystem goods and services' and often refers to both. In this document, we use the terms 'ecosystem goods' and 'ecosystem services' to differentiate the two. We also use the term 'EGS' to differentiate the *concept* or ideas of ecosystem goods and services as a whole.

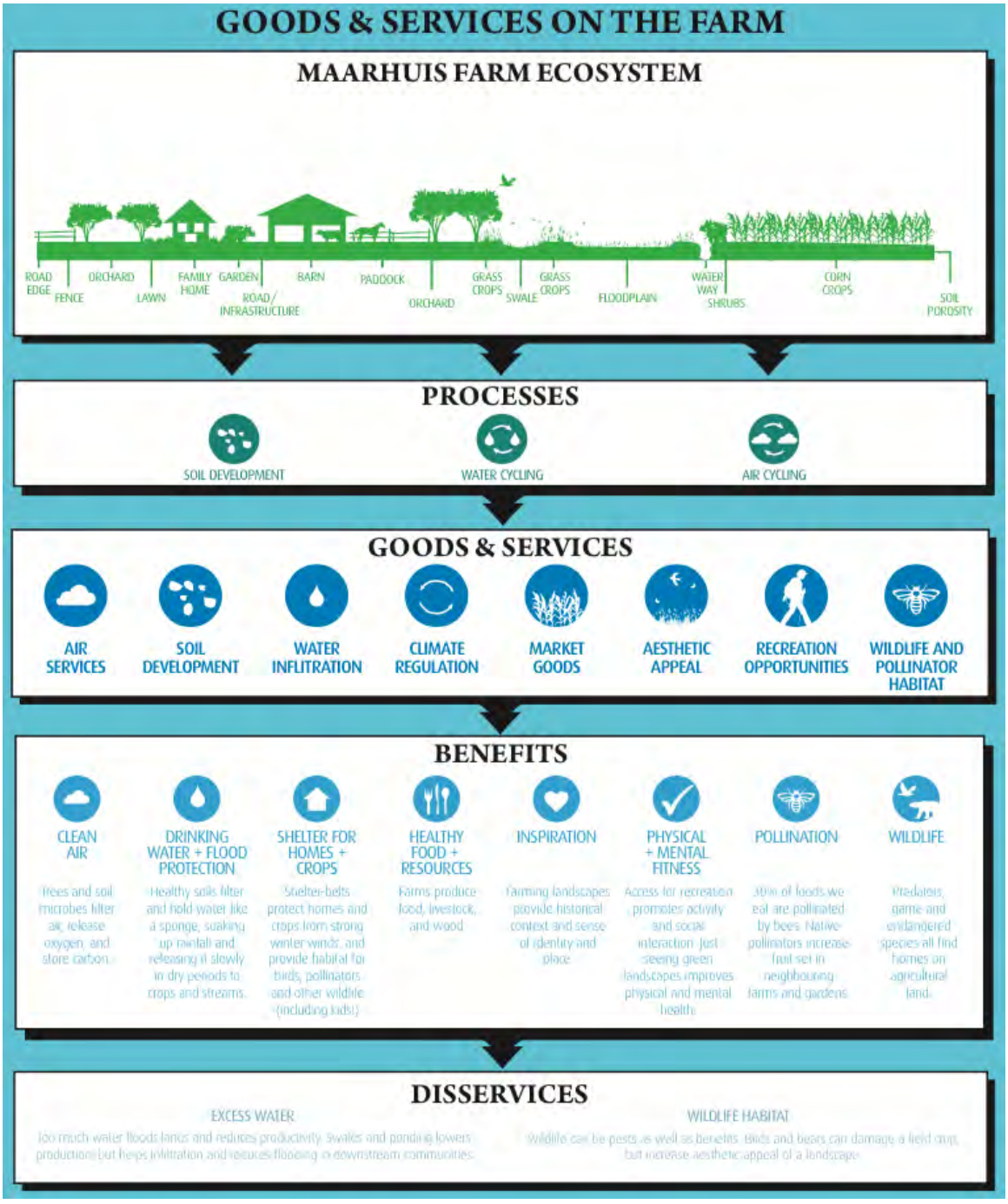

Figure 1. Examples of ecosystem goods, services, and benefits from agricultural ecosystems.

2 Scoping (narrowing the focus)

The two case studies are intended to identify ecosystem goods and services associated with agricultural land in the Fraser Valley, to investigate their 'value' and to consider their relevance at the *farm scale.* We also use the case studies as a tool for dialogue around the importance of healthy ecosystems and sustainable farm practices.

Imperative to the successful development of the case studies was input from producers, advisors and forum participants. This input made the case studies more relevant and compelling, through the use of real examples on real farms with real beneficiaries. It also helped us understand the language of agriculture and how farmers view and value natural areas on their farms. Especially useful to discussions at the farm scale were agricultural consultants focused on Environmental Farm Planning (EFP).

2.1 Prioritizing Dairy and Water

Initial scoping sought input from the Lower Mainland Working Group, a network of environment and agriculture representatives formed at Agriculture-Environment Forum III on Feb 20, 2014. For that purpose, the FVWC developed a ranking scheme and feedback form for participants to identify ecosystem service priorities in the Fraser Valley, and to identify information that needed to be gathered to implement the next steps. Oral and written responses helped to prioritize targets in:

- Agricultural industry (e.g. dairy, poultry, berry, etc.);
- Landscape features (e.g. riparian area, waterway, hedgerow, wetland, etc.); and
- Benefits (e.g. clean water, pollination, species-at-risk habitat).

We also requested feedback from several producers, including those who were not selected for a final case study, regarding the most important services to them.

This led us to focus on the dairy industry in the Fraser Valley, and on ecosystem services related to water, especially water quality, drainage and flood protection. Streams, wetlands and riparian areas were ranked as the most important landscapes, followed by hedgerows and windbreaks.

In identifying farms for specific case studies, it quickly became clear that there are substantial differences among dairy farms, depending on land use, presence of landscape features, owner perceptions and proximity to residential development. It also became clear that producers were largely driven by cultural benefits, including aesthetics, spiritual values and sense of place. This contrasted with our initial scoping survey, in which cultural importance had ranked lowest, tied with carbon sequestration.

In the end we chose two very different dairy farms in the eastern Fraser Valley. One is the Maarhuis Dairy in eastern Chilliwack, with high water tables, a watercourse, and the presence of endangered species. The other is Holberg Farm in central Agassiz, which represents a series of landscape features associated with windbreaks, recreation and cultural values.

2.2 Integration with Parallel Programs

There was broad agreement among all participants of Forum III that an Incentives for Ecosystem Services program aimed at the agricultural sector should be producer-led, and if possible

implemented as part of the existing Environmental Farm Planning (EFP) process. To that end we collaborated with two directly relevant projects: The Ecosystem Services Initiative (ESI) and a pilot Group Environmental Farm Plan (GFP), and have worked in parallel where possible.

The ESI program, coordinated by Dave Zehnder, is piloting an Incentives for Ecosystem Services initiative throughout BC, with the intention of merging with the EFP programs. One of our case study farms is also an ESI project farm. The first GFP in the Fraser Valley, meanwhile, is being developed by Darrell Zbeetnoff, and aimed at adding ecosystem services to the creation of an EFP.

Early in the project, we held a meeting with Mr. Zehnder, Mr. Zbeetnoff, and Bruce McTavish, and Hubert Timmenga. They walked us through the existing EFP process, the Group GFP and the ESI programs. Together, we also worked through a list of ecosystem services (based on TEEB) in order to identify relevant services provided by agricultural land in the Fraser Valley. The result was the first detailed list of ecosystem services, as well as a coordinated use of language and communications. In addition, we developed a farmer questionnaire similar to the EFP worksheets, with questions organized in sections that lead to informing best management practices.

2.3 Identifying Ecosystem Services and Benefits at the Farm Scale

We sought to identify specific ecosystem services provided by the whole farm, and the beneficiaries of those services. We became aware of subtle distinctions between goods and services themselves, and the resultant *benefits*, and have tried not to get bogged down by these distinctions. We used our list of relevant ecosystem services as a basis for conversations with producers. Then we identified the beneficiaries of the ecosystem services as either on-farm (to the farmer), off-farm (to the surrounding community) or both.

2.3.1 Identifying Relevant Ecosystem Goods and Services

Our initial list identified four main categories and 44 sub-categories of ecosystem goods and services used by the TEEB program (Kumar 2010, Wittmer and Gundimeda 2011). In our meeting with the agricultural consultants listed above and a pilot interview with the owners of Holberg Farm, we refined the initial list to 31 ecosystem services in 6 categories for the case studies (Table 1).

We ensured water-related services were well-represented on the list, as were soil services, to ensure our case studies describe a typical farm with challenges associated with water in the Fraser Valley. Initial discussions with producers indicated that cultural services were also very important to them. Because one purpose of the case studies was to identify ecosystem services with which to engage farmers, we increased the number of cultural services on our questionnaire. In doing so, we identified a list of cultural benefits received by people, including physical health, recreation, visual appeal and inspiration.

With the basic definitions provided in Table 1 we were able to identify and explain ecosystem services on farmland. Goods, water supply and cycling services, and soil services are intuitive to farmers and required little explanation. Habitat service evaluations were based on the knowledge of a local biologist specializing in agricultural ecosystems and species habitat needs. Cultural benefits were entirely based on the knowledge of the farmers, as they are the highest authority on their own benefits.

Table 1. Simplified list of EGS that served as the base of interviews with producers, with some changes based on participant feedback.

Services / Benefits	Description provided on last draft of checklist
Goods / Products	
Raw	Raw materials for use in food production on or off-farm
Market	Materials sold off-farm
Genetic	Genetic materials that benefit production or humans
Medicinal	Materials that have medicinal benefits on or off-farm
Ornamental	Materials for ornamental use on or off-farm
Hunting	Game for hunting
Water Services	
Groundwater	Groundwater to benefit crops, humans, livestock or wildlife
Deep Aquifer	Deep aquifers to benefit crops, humans, livestock or wildlife
Rain water	Rain water to benefit crops, humans, livestock or wildlife
Surface water	Surface water (streams or ditches) to benefit crops, humans, livestock or wildlife
Water attenuation	Rainwater capture before it hits the ground (eg. via shrub, tree canopy or rainwater collection), reducing erosive forces, flashiness and infiltration rate requirement
Water retention	Rainwater infiltration to reduce flooding, or retain water to attenuate impacts of flooding elsewhere
Water quality	High water quality influenced by providing or filtering potential pollutants (nutrients, metals, hydrocarbons, road dust etc)
Airshed Services	
Air quality	High air quality by either releasing or absorbing CO_2, methane, ammonia, particulate matter, etc. (iTree data)
Climate regulation	Micro-climate regulation by wind moderation, thermal cover, shading, or other
Soil Services	
Soil fertility	Nutrient and soil cycling processes
Soil retention	Soil retention
Soil development	Soil development in currently un-cultivated areas (fallow fields, wetlands)
Habitat Services	
Pollination	Pollinators or pollination activities
Biological control	Pest control services (wasp habitat +ve, pests -ve)
Wildlife habitat	Terrestrial or aquatic wildlife
Locally important species	Locally important species (salmon, trout)
SAR habitat	Endangered species (Salish sucker, Oregon spotted frog)
Cultural Benefits	
Aesthetic	Aesthetic enjoyment
Recreation	Recreation and/or tourism
Inspiration	Inspiration for art, culture and design
Spiritual experience	Connection with a higher being or with self
Sense of place	Connection to sense of place or place of cultural or social importance
Information	Education, research or knowledge, nature-based education
Health	Physical or mental health
Sense of Self	Feeling of identity / pride in self, family, community, industry, country

The benefits provided by air services were challenging to evaluate at the kitchen table, as filtration of air pollutants is somewhat abstract and we have no obvious cues to their effect. In addition, each of the farmers individually identified that they likely produce much more air pollution in normal farm operations than they absorb. We therefore used an online tool, iTree Canopy, to estimate the air quality services provided by each farm. The tool allows users to accurately estimate tree and other cover classes within the limits of an identified area by randomly laying points onto a orthophoto and asking users to classify the point (iTree Canopy Technical Notes). The tool then calculates physical values of air pollutants removed and their associated monetary value, derived from i-Tree Eco analyses in the United States in 2010 (Nowak et al. 2014). Values are calculated at the county-level in both rural and urban areas. We indicated farms were in rural areas in Whatcom County, Washington, given our near proximity to the Canada – US border.

2.3.2 Identifying Beneficiaries

We first identified six groups of potential beneficiaries, shown in Table 2. Note the pattern of multiple beneficiaries, and the benefits to people both on and off-farm, and how off-farm is further categorized based on proximity to the farm. Studies of payments for ecosystem services (PES) are often about the off-farm benefits, and how to get the various beneficiaries to pay landowners who provide them. For the purposes of this study, we have chosen to simplify the discussion by having just two broad categories, 'on-farm' and 'off-farm', shown in the center column. Examples of different benefits received by the different groups are shown in the right column.

Table 2. Beneficiaries of Ecosystem Goods and Services of eastern Fraser Valley farms

Beneficiaries of the services from farm land	Simplified Categories of Beneficiaries	Examples of Benefits Received
Farmers and their families, possibly employees	On-farm (farmers/producers / People on the farm	Income, flood protection, aesthetic appeal, sense of place, wildlife, game
People living nearby	Off-farm	Aesthetic appeal, recreational opportunities, salmon, game, wildlife, clean water
Neighbouring farmers	Off-farm	Flood protection, aesthetic appeal, windbreaks
People in the eastern lower Fraser Valley	Off-farm	Dairy products, beef, visual appeal, cleaner air, salmon, game, wildlife
People in the Lower Mainland	Off-farm	Dairy products, beef, visual appeal, cleaner air, salmon, game, wildlife
People living elsewhere in the province and the world	Out of scope	Carbon sequestration, salmon, migratory bird habitat (also apply to on- and off-farm categories)

Crops are the most commonly acknowledged services from agricultural ecosystems and the public is the main beneficiary: the crops provide them with food, and the farmers are compensated accordingly. Note that farmers also use ecosystem services from 'off-farm' (eg. neighbouring farms), in the productions of these crops, but for the sake of simplicity we did not identify and detail these.

Most studies strive to identify off-farm beneficiaries because they are a logical source of payments for ecosystem services. However it is clear that many of the benefits of ecosystem services accrue to

the landowner and others living on the farm. We focused heavily on the benefits to the farmers themselves, as the ultimate purpose of these case studies was to develop tools that help farmers recognize ecosystem services that they provide (and benefit from) on their own land.

3 Case Study Methods

3.1 Interviews

To develop the two case studies, interviewers held two meetings of several hours with each producer, walking the properties and using enlarged Google Map photos – one of the whole farm, a second of just houses and farm infrastructure – to identify farming infrastructure (barns, silos, roads, houses), farmed land uses (pasture, corn), human uses (family home, recreation zones), natural areas (trees, sloughs) and other places of interest or importance. The process encouraged storytelling, prompting more questions on histories and backgrounds behind specific parts of the farm. Interviewers also discussed with farmers the concept of ecosystem services and asked them to consider how ecosystem services, benefits and beneficiaries might apply to their own properties.

3.2 Land Uses – Agriculture, Human Use and Natural Areas

To map the case study farms, we identified and refined with the farmer a list of land-use types (Table 3), which we broadly categorized as Agricultural Use, Human Use and Natural Area.

Agricultural areas are specifically used and managed for the production of market goods. This includes barns, farm-related infrastructure, and all fields. Human areas are specifically managed for the shelter and pleasure of the family and other people. Natural Areas are better described as semi-natural areas that are planted, maintained or managed as natural places on the farm. Additional important areas that do not add to the total area of the site were added as overlays: Ponding indicates areas of field that collect surface water when soils are saturated; big old trees are single large trees on the landscape that have cultural importance; sacred places are sites that are recognized on the farm as being important for emotional or spiritual connections, often to loved ones who have passed.

Some parts of each farm fit into more than one category, but were categorized based on their 'highest and best' use. For example orchards and food gardens produce food, yet were planted for human recreation and sense of place rather than market goods. Roads we placed in the 'Human' category, as they contribute both to farming and to family use of the landscape. Shelter-belts and mixed forests planted for agricultural purposes were placed in the 'Natural Areas' category, as they do not contribute to the immediate production of market good and have the features (soil / vegetation) of natural areas.

We expect that additional land-use types will be identified for land uses not represented in this pilot sample.

Table 3. Land use categories and descriptions used in mapping.

Land Use Type	Description
Agriculture	
Barn	Housing for livestock.
Infrastructure	Equipment, feed and manure storage, milking parlour etc.
Cultivated	Cultivated fields, regularly tilled, planted and harvested with machinery
Pasture	Fields used for grazing with some mowing for hay. Irregularly tilled or re-seeded.
Under-utilized corner	Corners of cultivated fields not accessible to large machinery. Often grass or bare earth.
Human Use	
Home	House for family.
Orchard / Garden	Managed orchards and gardens, ornamental and food-production.
Public trail	Land managed for recreation, with public access, trails etc.
Recreation	Land managed for recreation, private access, incl lawns, trails, bike areas, etc.
Road	Paved or gravel surfaces for machinery and vehicles within property boundaries.
Natural Area	
Mixed Forest	Area with continuous tree canopy, planted or remnant.
Shelter-belt	Linear areas of planted shrubs and trees along roads, fencelines, and property boundaries, managed or wild.
Waterway	Area within the 'high water mark', often delineated from agricultural land by changes in vegetation and management.
Riparian grasses	Area alongside waterway dominated by non-cultivated grasses.
Riparian shrubs	Area alongside waterway dominated by shrubs.
Riparian mixed forest	Area alongside waterway dominated by trees.
Overlays	
Sacred Place	Place that holds high personal and/or cultural importance to the landowners, community or region.
Big Old Tree	Individual trees of significance on the landscape.
Ponding	Areas subject to regular flooding.

3.3 Identifying Ecosystem Services and Their Relative Value

Concurrent to the discussion on land uses, the interviewers and landowners identified what ecosystem services are provided by the farm. Valuing the food produced and sold by farms is straightforward, and not the intention of this exercise. We focused on ecosystem services not valued by the market, including clean water, clean air, soil conservation, pollination and pest control. Assigning monetary value is a long, expensive, inexact process beyond the scope of this study. Instead we chose to identify patterns and relative values in the provision of ecosystem services by various land use types.

Using the checklist of ecosystem services (Table 1), we developed a questionnaire that we gave to

three dairy producers (two case studies and a neighbour). The questionnaire asked two questions about each identified ecosystem service:

- How important is this ecosystem service to you and this farm?
- How important do you think this service is to people off farm (neighbours or people living farther away)?

In response they assigned a score to each the ecosystem services provided by each land use type, from +2 (highest) to -2 (lowest, 'disservice'), with 0 being neutral (no benefit). The third participant used a scale of one to 10, which we converted to our -2 to +2 scale. The three farmers were then asked to score, again on a scale of -2 to +2, the values of the different ecosystems to beneficiaries on-farm and off-farm.

Farmers also provided feedback on the questionnaire, and examples of the ecosystem services. The original questionnaire is provided in the appendix.

Note that the purpose of this process was *not* to develop a numerical rating system for the various ecosystem services but to identify the relative importance of categories to the farmer. A mathematical assessment of these numbers is not appropriate and was not conducted. To avoid misrepresentation, we provide written results in this document rather than numeric, but numeric results are provided in the appendix.

3.4 Mapping the Ecosystem Services

Although creating an initial paper map to use with producers was a useful data-gathering technique, we found that as data was further analyzed, we were able to refine the categories of services and beneficiaries, and create an electronic database indicating scores for each land use type around the farm. The land use 'polygons' (land use units) were digitized in a GIS database for visualization. Each polygon was assigned an individual identifier, and assessed against our list of ecosystem services, using the same scale as the farm-scale assessments (-2 to +2), to identify ecosystem services provided by that land unit, as well as the relative importance of that service to on-farm and off-farm beneficiaries.

Scoring for on-farm was done by Detmar Schwichtenberg for Holberg Farm, and by Monica Pearson for Maarhuis Farm, based on our knowledge of the farms, ecosystem services, and the benefits they provide learned in this project and in previous research activities.

Scores were combined across all polygons of a single type (eg. all cultivated fields combined in a single score), and summarized by polygon type, by ecosystem service, by beneficiary, and by farm to inform us of the relative importance of each polygon type. These scores were used to develop summary materials and visual aids. Note again that scoring was not intended as a mathematical system, and should not be used to calculate means etc across categories. To avoid misrepresentation, we translated these scores into visual ranks of High, Medium, Low, Negligible / Not Applicable, and Negative (+++,++,+,NA,-ve) for this document and the pamphlets. A summary of numeric results is provided in the appendix.

4 Case Studies: Ecosystem Services of Dairy Farms

4.1 Farm #1: Maarhuis Dairy – Floodplain Farming

The following paragraphs summarize information learned in interviews regarding Maarhuis Dairy's production of ecosystem goods and services. A summary of the ecosystem goods and services provided by particular land use types is provided in Table 4.

4.1.1 History and Background

Maarhuis Dairy was founded in 2009 by Calvin and Trudy Maarhuis, who live on the farm with their two children. The farm is a small organic dairy, milking 60 cows. The farm makes up 51.6 acres (20.8 Ha). Both grew up on farms, Calvin on a family dairy in Chilliwack, and Trudy on an orchard in Ontario. They chose to start up as an organic dairy for financial reasons – higher prices for organic milk made their small farm more financially viable as they were starting up – and have discovered that the financial benefits are buoyed by the personal satisfaction and self-sufficiency associated with reduced reliance on off-farm chemical and nutrient inputs.

Maarhuis Dairy is on Rosedale Prairie, with historically wet soils and challenging drainage conditions. Elk Creek bisects the farm and the fields experience regular ponding in the winter, which serves as waterfowl habitat or as a skating rink, depending on the temperature. This landscape is representative of many farms on the floodplains of the Lower Mainland that struggle to balance the joys of reliable water with the challenges of excess water and the desire to ensure clean and healthy waterways.

4.1.2 Land Use Mapping

Land use mapping on Maarhuis Dairy is shown in Figure 2.

Agricultural Use

Agricultural uses make up 92.3% of the land base on the Maarhuis Dairy, plus an additional 3.2% in roadways. As this is an organic farm, cows have daily access to fields. Cultivated fields are rotated through pasture, hay and corn production, with smaller fields near to the barn used exclusively as pasture. Barns and associated infrastructure make up 1.8% of the land-base and are the primary milk-production facilities, providing support to the farming operations.

Human Use

Areas associated with the family home, including play areas, gardens and orchards make up 1% of the land base. Orchards and gardens are particularly important features with cultural importance to the family. Areas close to the home are most heavily used areas for recreation, however the Maarhuis family also spends a lot of recreational time on the rest of the farm, walking the dogs and exploring the land.

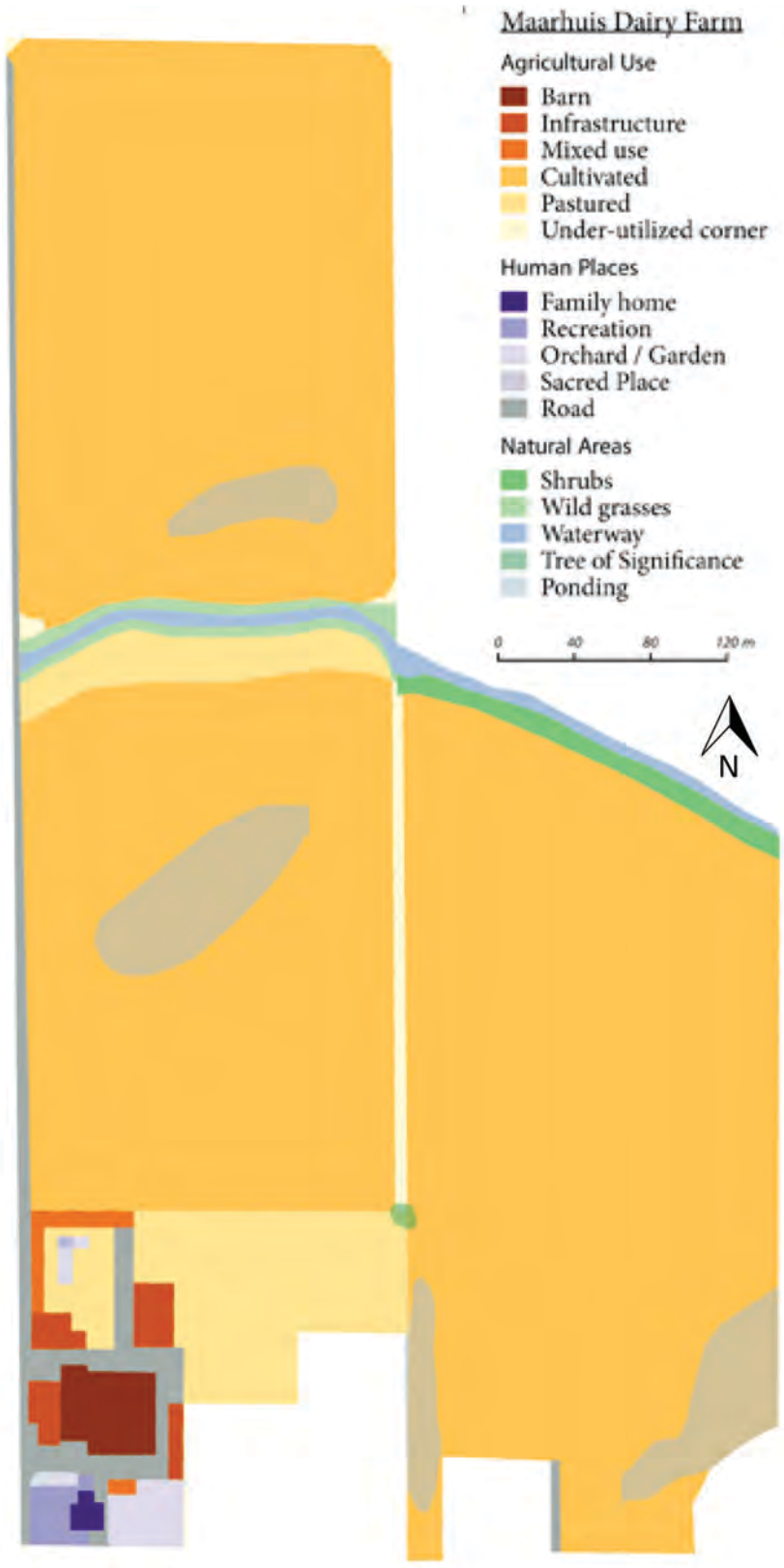

Figure 2. Land use map of Maarhuis Dairy, digitized based on interviews and information provided by landowners and orthophotos.

Natural Areas

Natural areas make up 3.2% of the property, mostly around a waterway that bisects the western field on the property and is bordered by grasses and shrubs. Planted shrubs in the east field alongside the waterway are in early stages of growth, but will eventually provide water filtration and soil retention services, along with shade and food for wildlife. Natural areas can be seen as 'untidy' but are valued for contributions to local pollinators and wildlife. They are also beautiful when in full leaf and flower. As the Maarhuis family has come to recognize the ecosystem benefits of riparian areas, so too has their appreciation of the visual appeal.

Overlays

Within a pastured orchard is the place where family pets have been buried. It is a place of quiet and contemplation, mainly for the children. It is placed in the single grove of trees present on the property when purchased by the family.

Regular ponding impacts 3.2 acres, almost 6% of the land on Maarhuis Dairy. This reduces productivity on the land, and delays machine access to several acres of farmland each spring.

4.1.3 Ecosystem Service Identification & Importance Valuation

The following paragraphs summarize information learned in interviews regarding Maarhuis Dairy's production of ecosystem goods and services. A summary of the ecosystem goods and services provided by particular land use types is provided in Table 4.

Goods

Forage crops produced by the land are the foundation of and financial driver of farming operations. Crops are primarily an intermediary product fed to cows that in turn produce milk, the farm's primary market good. The Maarhuis family also maintains chickens and a vegetable plot for family consumption and is developing an orchard. Additional goods that could be sold on the market are forage crops, livestock, chickens, vegetables and fruit. Game, specifically waterfowl, is hunted on the farm by the extended family. Cows also produce colostrum, which is considered a medicinal requirement for calves. Genetic materials from cows are managed, and male genetics are imported from off-farm to improve the herd.

Beneficiaries of ecosystem goods produced on the farm are both on-farm, in the form of self-grown food and financial remuneration, as well as off-farm, in the form of local, nutritious dairy products.

Soil Services

Soil services were ranked highest, by the farmer, among the ecological services produced on the farm. Soil management and development is critical to crop and grass production. Organic materials are applied to fields as manure to fertilize and rebuild soils.

The Maarhuis Dairy is on loamy soils with a sizeable clay component. The soils are heavier than some in the Fraser Valley, holding water, but still rich and productive. These fine soils are prone to erosion when exposed on sloping ground but vegetation, ponding topography and concave fields retain soil on the fields.

Beneficiaries of soil services on Maarhuis Dairy fall primarily on the farm, but also on the local

community and the region as food and future food production.

Water Services

A steady source of clean water is crucial to farming operations, as a typical dairy cow drinks 100 litres of water every day. The Maarhuis Dairy uses municipal water for the home and to water livestock, relying on a shallow aquifer in a different watershed. There is no financial incentive to irrigate fields, as the local water table is high.

Although recognized as an important resource, water can be more of a problem than a benefit. Heavy rains can harm crops, while normal rains dilute manure and create runoff from farmyard areas. Pooling can also damage access roads. In addition, the shallow water table means soils quickly saturate and regular ponding impacts 3.2 acres, almost 6% of the land on Maarhuis farm. This ponding provides an important ecosystem service for the community, by reducing flooding elsewhere, but at a cost to the farmer.

Impermeable surfaces speed the flow of rainwater off roofs and roads. This farm contains 2.9 acres of impermeable surface, or about 5% of the land-base, much lower than urban or semi-rural areas.

Beneficiaries of water services on Maarhuis Dairy include the farm, the local community, and the region. The local community is particularly benefited by farms in relation to flood regulation, and for the maintenance of clean water in the community's shallow aquifer.

Air Services

Trees make up 1% of the the farm's land-base. Annually these trees remove an estimated:

- 6.4 oz (181 g) of carbon monoxide
- 4.1 lbs (1.9 kg) of ozone
- 12.6 lbs (5.6 kg) of particulate matter
- 2.4 T (2.2 metric t) of carbon dioxide

Beneficiaries of air services on Maarhuis Dairy include the farm, the local community, and the region; however, emissions from the farm almost certainly exceed those removed.

Climate Regulation

The farm is affected by winds from the north-east in winter, but has no conspicuous climate-modifying features. The old orchard contains a small canopy of fruit trees with minimal micro-climate impacts on crops and buildings.

Beneficiaries of climate regulation on Maarhuis Dairy are primarily on-farm, with negligible impacts off-farm.

Wildlife Habitat

Endangered Oregon Spotted Frogs (*Rana pretiosa*) and Coho Salmon (*Oncorhynchus kisutch*) are present in Elk Creek and clean, chemical-free water from surrounding fields contribute to these socially important species. Orchards, gardens, mixed use areas, fields and under-utilized corners of fields provide habitat for pollinators and birds. Clover in fields and areas with lots of flowering plants are particularly important to pollinators, which affect fruit and vegetable production in their own and neighbouring gardens and fields.

Wildlife habitat can provide pest-control services (eg. wasps, swallows, dragonflies eat biting and destructive insects; owls control rats), but can also result in disservices. Rats eat crops and can spread disease; starlings and bears eat corn. Waterfowl rest in ponds, providing wildlife viewing and hunting opportunities, but eat seeds and young shoots. Beavers can block waterways and flood land during the growing season. Having endangered species on the farm has the potential to impact farming activities, if regulations require management changes.

Beneficiaries of wildlife habitat on the Maarhuis Dairy are both on-farm and off-farm. However, costs associated with the disservices associated with wildlife are borne by the farmer.

Cultural Services

Cultural services were identified as the most important service to the landowners, after crop production, and is the very reason they are taking part in this project. Each category in the 'cultural services' category was rated at the highest possible rating. Aesthetic enjoyment, recreation and inspiration were all very important, as was interacting with nature. The farm as a whole engendered a sense of identity and of place in the physical landscape and in community, as well as among peers in the dairy industry. It gives them a sense of connection, home, responsibility, self-sufficiency and pride.

It is important to the family to share these benefits with the community, and they regularly invite school groups, community groups, and researchers to access their farm for education and recreation. The ponding that is such a challenge for the farm brings joy when children use it as a skating rink in winter. They recognize and directly identify the benefits of both recreational exercise and less tangible benefits to mental and physical well-being.

Beneficiaries of cultural services are both on-farm and off-farm, with the strongest impact on the farmers themselves and their direct neighbours and community, but additional impacts to the region.

Table 4. Ecosystem Goods and services provided by land use types on Maarhuis Dairy in Chilliwack, BC. Relative importance of the service, to both farmer and society, are indicated as High, Medium, Low, or negligible / not applicable by symbols +++, ++, +, NA, or indicated as disservices by '–ve'. Relative financial values to farmer are indicated on as $$$, $$ or $. These values represent a summary of information gleaned from interviews, expert opinion, and are not representative of numeric values.

Maarhuis Farm	**Acres**	**%**	**Goods**	**Cultural Services**		**Ecosystem Services**						
Agricultural Use	51.6	92.3%	*Market Goods*	*Visual appeal*	*Recreation*	*Water Services*	*Air Services*	*Soil Services*	*Climate Regulation*	*Pollinator Habitat*	*Wildlife Habitat*	*Notes*
Barn	0.5	0.9%	$$$	NA	+	-ve	-ve	NA	NA	NA	NA	Critical to production of market goods, but disservice to air and water (methane production, impermeable surfaces)
Infrastructure	0.5	0.9%	$$$	NA	NA	-ve	NA	NA	NA	NA	NA	Supports production of market goods, dis-service to water (impermeable)
Mixed use	0.2	0.4%	NA	NA	NA	+	NA	NA	NA	+	NA	Mixed use areas in transitional use: semi-permeable surfaces, some low-lying vegetation
Cultivated	46.2	82.6%	$$$	++	NA	++	NA	+	NA	+	+	Critical to production of market goods, also contribute to water infiltration and soil conservation due to soil structure and level topography
Pastured	4.2	7.5%	$$$	+++	+	+++	+	+++	NA	++	+	Best water infiltration on productive land. Not tilled, no dust, no chemical applications. Mixed grasses and legumes produce high quality livestock feed, and habitat for wild pollinators
Under-utilized corner	0.5	0.9%	NA	++	NA	++	NA	+	NA	++	++	Right angle corners of fields are difficult to access with big machinery. Large ES potential, specifically opportunity for wildflowers (pollinators), shrubs and trees
Human Use	2.5	4.5%	*Market*	*Visual appeal*	*Recreation*	*Water infiltration*	*Air services*	*Soil retention*	*Climate regulation*	*Pollination*	*Wildlife*	*Notes*
Family home	0.1	0.2%	NA	+++	+++	NA	NA	NA	NA	NA	NA	Hearth of the farm. Aesthetic appeal associated with identity and pride
Public trail	0	0.0%	NA	NA	NA	NA	NA	NA	NA	NA	NA	None
Recreation	0.2	0.4%	NA	++	+++	+++	NA	++	NA	+	NA	Lawns, splash pool and play-space. Lawns have high infiltration capacity.
Orchard/ Garden	0.4	0.7%	$	+++	+++	+++	++	+++	+	+++	++	Orchard has important symbolic and aesthetic value to homeowner, associated with identity and connection to past
Road	1.8	3.2%	NA	NA	++	-ve	NA	NA	NA	NA	NA	Associated with all human activities. Usually impermeable surfaces

Natural Areas	1.8	3.2%	*Market*	*Visual appeal*	*Recreation*	*Water infiltration*	*Air services*	*Soil retention*	*Climate regulation*	*Pollination*	*Wildlife*	*Notes*
Mixed forest	0	0.0%	NA	NA	NA	NA	NA	NA	NA	NA	NA	None
Shelter-belt	0	0.0%	NA	NA	NA	NA	NA	NA	NA	NA	NA	None
Riparian shrubs	0.5	0.9%	NA	+	NA	++	+	++	+	++	++	Restoration planting in 2011, large potential for improvement
Riparian grasses	0.6	1.1%	NA	+	NA	++	+	+++	NA	+	+	
Waterway	0.7	1.3%	NA	+	++	+++	NA	–	NA	NA	+++	
Overlays *(do not count towards total)*			51.6	92.3%	*Recreation*	*Water infiltration*	*Air services*	*Soil retention*	*Climate regulation*	*Pollination*	*Wildlife*	*Notes*
Sacred place	0.5	0.9%		+++	+++							Overlain on orchard: Pet cemetery, quiet place
Ponding	0.5	0.9%	-ve	NA	++	+++	NA	+++	NA	+	++	Ponding reduces productivity but promotes infiltration and reduces flooding downstream. Ponding also provides recreation (skating, hunting) and wildlife habitat (swans, geese)
Big old tree	0.2	0.4%	NA	+++	+	+++	+++	+++	++		+++	Large maple on corner acts as corner marker at property line

4.2 Farm #2: Holberg Farm – In the Public Eye

Holberg Farm was founded in 1959 by Marianne and Gunther Schwichtenberg. The farm is now co-owned by their three children, Holger, Detmar and Kerstin. All three siblings live on the farm with their families, and participate in the functioning of the farm. Their children also do farm chores, field-work, milk cows, clean and learn the dairy business.

The farm is a mid-size dairy farm, milking 150 cows on 147 acres (59 hectares). Another 55 acres (22.2 hectares) are rented nearby but we have chosen to assess only land owned by Holberg Farm.

The farm is on high ground on well-drained fertile soils that holds moisture but rarely floods. There are no watercourses and no riparian areas but the farm is directly adjacent to the town of Agassiz, and shares 1.3 km of its perimeter with residential housing. Thirty homes have direct views on the farm, as does a senior's care home. This location offered an excellent opportunity to consider the Cultural Services associated with farms at the urban/agriculture interface, both to the producer and the community.

4.2.1 Land Use Mapping

Land use mapping on Holberg Farm is shown in Figure 3.

Agricultural Use

Agricultural uses make up 90.5% of the land base on Holberg Farm, plus an additional 1.7% in roadways. Cultivated fields are rotated on a 4-7 year basis between grass and corn silage. Pastures around the farm buildings are important to cow health and are used as a recovery area for cows that cannot be in the main herd. They are never tilled and are mowed on average twice a year.

'Under-utlilized corners' are corners of cultivated fields challenging to access with large machinery. Some corners have been transformed into mixed forests, shelter-belts or hardwood plantations. These small areas add up to almost 1% of the land-base, and have been identified as good opportunities to increase ecosystem services, particularly pollinator habitat.

Barns and associated infrastructure make up 1.5% of the land-base, providing support to the farming operations, and are the primary milk-production facilities.

Human Use

Areas associated with the family home, including play areas, and ornamental gardens make up 1% of the land base.

Holberg Farm is adjacent to the town of Agassiz and shares 1.3 km of property line with residential areas. These include 25 homes that border the farm, 5 across a street that borders the farm, a senior's care facility and three smaller farms. The farm has entered into agreements with the District to allow public trails on the north and south boundaries of the property, completing a loop through residential areas to the community fitness centre.

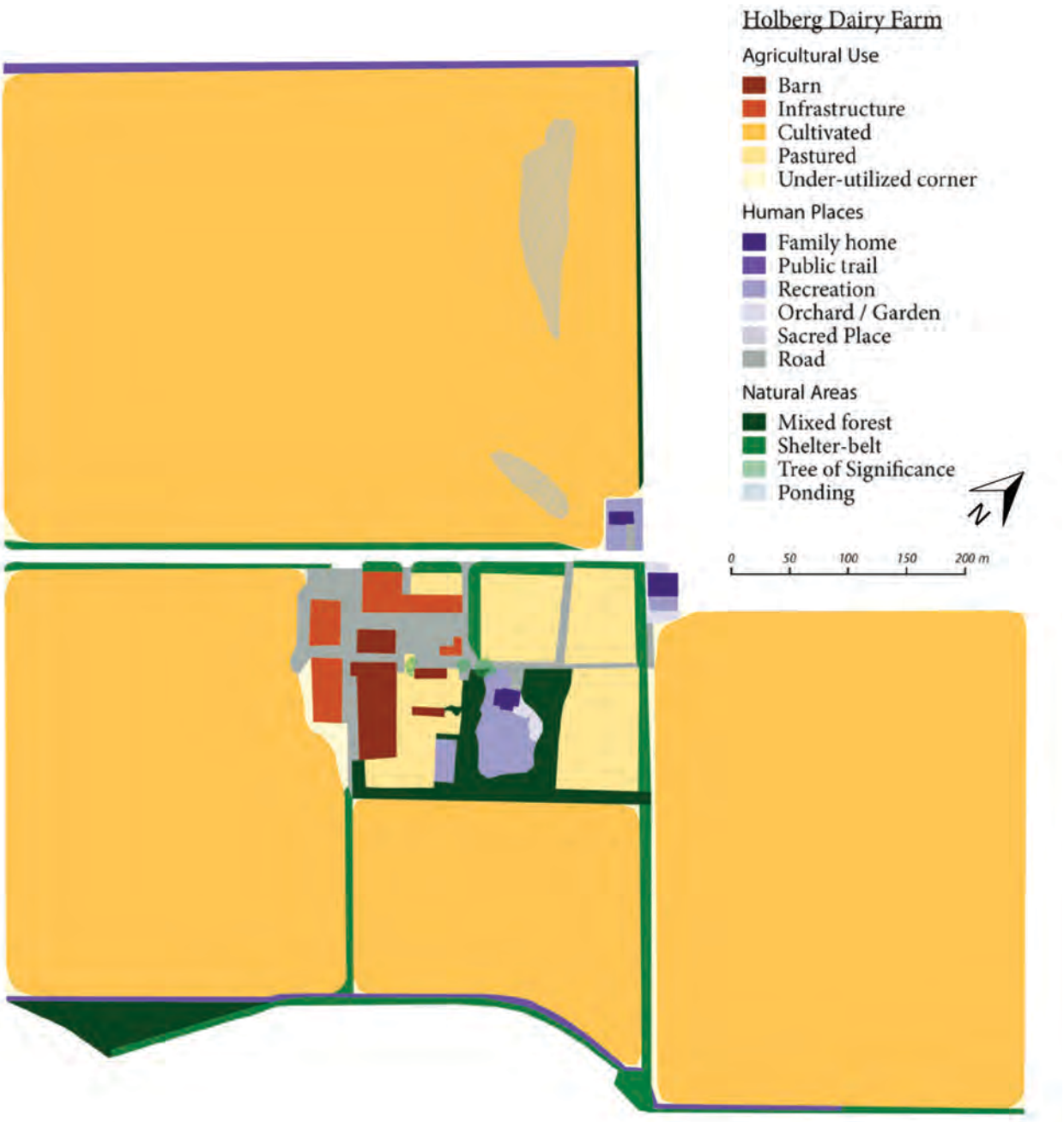

Figure 3. Land use map of Holberg Farm, based on interviews and information provided by landowners and orthophotos.

Natural Areas

Natural areas make up 5.3% of the land-base, mostly shelter-belts and mixed forests to protect fields and infrastructure from icy winter winds and, to a lesser degree, summer heat.

A mixed forest around the farmhouse was planted by original settlers as a wind-break (L-shaped, with the corner facing the prevailing winds), and has been maintained for that purpose, as well as

for aesthetic and recreation values. Tidy rows of trees were planted along property boundaries as wind-breaks and along the road for aesthetics. These shelter-belt trees are now pruned up – a significant effort – to allow machinery to work under and around them.

Hardwoods have been planted in a mixed forest (walnut, oak, chestnut and cherry) along property lines and one under-utilized corner as an investment for the future. The trees are pruned and maintained to ensure straight, clear lumber.

Overlays

In one especially under-utilized corner of the farm, a mixed forest was planted and a memorial stone and bench installed as a memorial to the family's mother and father, who founded the farm. This place was initially used only by the family, but is now a place of rest along the public trail.

4.2.2 Ecosystem Service Identification and Importance Valuation

The following paragraphs summarize information learned in interviews regarding Holberg Farm's production of ecosystem goods and services. A summary of the ecosystem goods and services provided by particular land use types is provided in Table 5.

Goods

Forage crops are the foundation of farming operations and used primarily as an intermediate product, fed to cows that in turn produce milk, the farm's main market good. Additional goods produced by the farm that could be sold on the market are forage crops, livestock, wood and cedar boughs. Cedar boughs can be cut and sold in the Christmas season, and are anticipated as a source of casual income for the children. Game are present on the farm but, given the proximity to residential areas, hunting is not allowed. As with the Maarhuis farm, cows produce colostrum for newborn calf health. Genetic materials from cows on-site are carefully managed, and male genetics are imported from off-farm to improve the herd.

Beneficiaries of ecosystem goods produced on the farm are both on-farm, in the form of self-grown food and financial remuneration, as well as off-farm, in the form of local, nutritious dairy products.

Soil Services

Soils are critical to the functioning of the farm and a lot of effort goes into soil management and maintenance of soil structure. The farm is situated on ideal soils, a silty clay loam, with enough sand content and height above the water table to ensure adequate drainage, but enough clay to hold moisture even into late summer and periods of drought. Level ground reduces potential of erosion from water, but bare soils can be carried away by winter winds, so cover crops are planted after the corn harvest. Cornfields are at the highest risk of soil compaction and erosion, as they are the most regularly disturbed and tilled soils.

Organic materials in the form of manure are applied to fields to fertilize and rebuild soils, and although they are historically undervalued, additional leaf-litter from shelter-belts is valued as organic material. New manure storage is being built to manage nutrients more efficiently, and reduce fertilizer use.

Beneficiaries of soil services on Holberg Farm fall primarily on the farm, as well as on the local community and the region as current and future food production (ie. food security).

Water Services

Holberg Farm uses a shallow well to provide water (10 metres deep) for humans and livestock. The soil holds moisture well and, so far, irrigation is considered too costly.

This farm is on high ground and does not face challenges posed by fields draining directly into waterways. However, heavy rains can harm crops and steady rains produce significant yard run-off that remains the farm's main management 'headache'. New manure storage capacity will address that problem.

During heavy, sustained rains, the soils saturate with water and ponds form in the cultivated fields but not on the pastures, which are on the highest ground around the main house. The infiltration capacity of the soils, and the ponds, hold vast quantities of water, reducing potential for flooding in downstream communities. Ponding rarely affects production on this farm as the fields quickly dry out in spring. Holberg farm contains 6.8 acres of impermeable surface, or 5% of the land-base.

Beneficiaries of water services on Holberg Farm include the farm, the local community, and the region. The local community in particular benefits from farms for their role in flood mitigation, and for the maintenance of clean water in the community's shallow aquifer.

Air Services

Based on iTree methods, treed areas, mostly shelter-belts and mixed forest, make up 7% of the farm's land-base. Annually these trees remove an estimated:

- 8 lbs (3.7 kg) of carbon monoxide
- 64 lbs (29 kg) of ozone
- 207 lbs (94 kg) of particulate matter
- 42.4 T (39.4 metric t) of carbon dioxide

Beneficiaries of air services on Holberg Farm include the farm, the local community, and the region; however, emissions from the farm almost certainly exceed those removed.

Climate Regulation

Most natural areas on the farm are shelterbelts and were planted to 'regulate microclimate' on the farm, in particular to protect crops and homes from the area's icy winter winds. The shelter-belts also reduce wind erosion on bare fields. Shade benefits animals, homes and infrastructure during summer heat, as well as along road-ways and trails used by the family and the public.

Beneficiaries of climate regulation on Holberg Farm are primarily on-farm, with some climate regulation benefiting users of the public trails and walking routes as well as near-neighbours (both farm and residential). As planted trees along residential areas grow, their climate regulation benefits on those areas will also increase.

Wildlife Habitat

Holberg Farm provides habitat to waterfowl, bears, coyotes, raptors, barn swallows and a wide variety of song-birds. Wildlife provide some pest control services: coyotes may provide rodent control, while birds and bats control flies and mosquitos. Raptors nest in the cottonwood trees in the mixed forest and hunt field mice.

Providing habitat to wildlife also creates challenges. Bears, coyotes, geese and ducks eat and trample crops, seeds and young grass. Yet successive generations have chosen to have the wildlife rather than chase it away. The exception is rodents, for which the farm employs a healthy roster of barn cats.

Beneficiaries of wildlife habitat on Holberg Farm are both on-farm and off-farm. However, costs associated with the disservices associated with wildlife are borne by the farmer.

Cultural Services

Cultural services were identified as the most important service to the landowners and the local community, after crop production. As Holberg Farm is directly adjacent to town, on the urban/agricultural interface, the landowners are distinctly aware of the benefits and challenges associated with this interaction.

Many local residents and the landowners use the public trails for running, dog-walking, cycling or horse riding, and social interactions that enhance the health of the whole community. Having the public present on farmland presents challenges, and the importance of the aesthetic values to neighbours becomes evident when pruning trees or making other changes to the landscape. Some neighbours and trail users have gotten quite upset but for the most part letters to the editor of the local newspaper express appreciation for the trails and tolerance for the intermittent smell, dust, and noise of dairy farming. Properties overlooking the farm are highly coveted, offering as they do an impeded view of surrounding mountains.

The farm as a whole provides the family with a strong sense of identity, pride and community. They keep the place beautiful for themselves, the community and the dairy industry. They invite the public onto their farm not only on the trails, but also through participation in tours, agriculture student placements and research.

For the family, large old Douglas Fir trees around the farmhouse represent the origin story of the farm. When the first Agassiz settler moved to the area, he was told by local First Nations that Douglas firs indicate high land that does not flood in the annual Fraser River freshet. Three of the trees still stand 150 years later, and the farm has never flooded.

The old mixed forests, shelter-belts, barns, roads and fields are important play areas for children, and foster a strong sense of well-being that contributes to mental and physical health.

Table 5. Ecosystem Goods and services provided by land use types on Holberg Farm in Agassiz, BC. Relative importance of the service, to both farmer and society, are indicated as High, Medium, Low, or negligible / not applicable by symbols +++, ++, +, NA, or indicated as disservices by '–ve'. Relative financial values to farmer are indicated on as $$$, $$ or $. These values represent a summary of information gleaned from interviews, expert opinion, and are not representative of numeric values.

Holberg Farm	Acres	%	Goods	Cultural Services		Ecosystem Services						
Agricultural Use	**131.0**	**90.5%**	*Market Goods*	*Visual appeal*	*Recreation*	*Water services*	*Air Services*	*Soil Services*	*Climate Regulation*	*Pollinator Habitat*	*Wildlife Habitat*	*Notes*
Barn	1	0.7%	$$$	NA	NA	-ve	-ve	NA	NA	NA	NA	Critical to production of market goods, but dis-service to air and water (methane production, impermeable)
Infrastructure	1.2	0.8%	$$$	NA	NA	-ve	NA	NA	NA	NA	NA	Supports production of market goods, dis-service to water (impermeable)
Mixed use	0	0.0%	NA	NA	NA	NA	NA	NA	NA	NA	NA	Identified as either infrastructure or road.
Cultivated	122.3	84.5%	$$$	++	NA	++	NA	+	NA	+	+	Contribute production of goods, but also infiltrating water and conserving soils due to soil structure and level topography.
Pastured	5.5	3.8%	$$$	+++	+	+++	+	+++	NA	++	+	Best water infiltration on farm. Soil structure maintained. Not tilled; no chemical applications. No dust. Mixed grasses and legumes produce high quality feed for livestock as well as for wild pollinators. Also used for cow health (recovery area).
Under-utilized corner	1	0.7%	NA	++	NA	++	NA	+	NA	++	++	Right angle corners of fields are difficult to access with big machinery. Large ES potential, specifically opportunity for wildflowers (pollinators), shrubs and trees.
Human Use	**6.0**	**4.1%**	*Market*	*Visual appeal*	*Recreation*	*Water services*	*Air services*	*Soil retention*	*Climate regulation*	*Pollinator Habitat*	*Wildlife*	*Notes*
Family home	0.3	0.2%	NA	+++	+++	-ve	NA	NA	NA	NA	NA	Historical significance of Old Agassiz Place. Heart of the Farm.
Public trail	1.8	1.2%	NA	+++	+++	+	NA	NA	NA	NA	NA	Inviting the public onto your farm imposes additional management constraints, but promotes good-will and community health.
Recreation	1.2	0.8%	NA	+++	+++	+++	NA	+++	NA	+	+	Personal recreation areas - bike trails, lawns, tree-houses benefit the health of residents and visitors.
Orchard/ Garden	0.2	0.1%	NA	+++	+++	+++	++	+++	+	+++	++	Most important for aesthetic reasons; also

												provide soil development, water infiltration, wide variety of flowers for native pollinators, and berries for birds.
Road	2.5	1.7%	NA	NA	++	-ve	NA	NA	NA	NA	NA	Important recreation place for kids: bikes, running, ball-hockey. Reduced infiltration of water.
Natural Areas	**7.7**	**5.3%**	*Market*	*Visual appeal*	*Recreation*	*Water services*	*Air Services*	*Soil Services*	*Climate Regulation*	*Pollinator Habitat*	*Wildlife Habitat*	*Notes*
Mixed forest	3.6	2.5%	$	+++	+++	+++	+++	+++	+++	+++	+++	Hardwoods planted as investment for the future. No financial value until cut. Mixed forest around house planted by original settlers as a wind-break. Maintained for aesthetic, recreational and wind-break values. (L-shape with corner facing wind).
Shelter-belt	4.1	2.8%	$	+++	+	+++	+++	+++	+++	+	++	This farm is 7% treed! Most were planted as shelter-belts to protect crops, delineate property lines, and for aesthetics. Now, shelter-belt trees are trimmed to allow machinery to work under and around them easily. All these trees also filter air.
Riparian shrubs	0	0.0%	NA	NA	NA	NA	NA	NA	NA	NA	NA	No waterways on farm connected to permanent watercourses.
Riparian grasses	0	0.0%	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Waterway	0	0.00%	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Overlays *(do not count towards total)*			*Market*	*Visual appeal*	*Recreation*	*Water services*	*Air Services*	*Soil Services*	*Climate Regulation*	*Pollinator Habitat*	*Wildlife Habitat*	*Notes*
Sacred place	0.1	0.1%	NA	+++	+++	NA	NA	NA	NA	NA	NA	Overlay on mixed forest; very high cultural values. Memorial marker.
Ponding	0.1	0.1%	-ve	NA	++	+++	NA	+++	NA	+	++	Ponding reduces productivity of area for crops. But, provides recreation value: Skating in the winter; wildlife value: Swans, waterfowl , and important soil retention and water infiltration services. Holding water on fields reduces flooding downstream as well as soil erosion.
Big Old Tree	1.8	1.2%	NA	+++	NA	+++	+++	+++	+++	+	++	Sense of place and history. First farmer chose this site because the 4 large Douglas Fir indicated high ground that would not flood.

4.3 Scoring the Value of Identified Ecosystem Goods and Services to Producers

A summary of the survey scores recorded from three producers is assembled in Table 6, and complete results are provided in the appendix. The averages of the totals by category, ranked in order of decreasing importance to the producers, show results in a broad overview. However, this across-category summation obscures a major point, which is that processes that benefit farmers, such as ground and rainwater, also cause flooding and drainage problems. Thus the combination of positive and negative scores makes the total score of the Water Services category lower. Although the Airshed and Habitat Service groups were collectively of lower importance, individual services within those groups were of the highest score of importance to one producer. The only significant disservice was that ecosystems were a source of pests to farms.

That cultural services, both individually and collectively, were almost as important as soil and water is probably the most notable result of this part of the project. Producers repeatedly connected these services to their farming way of life and their attachment to the land. They were very firm in their assignment of high importance to these services.

Off-farm scores confirm that producers are aware that many of the ecosystem services their farms provided benefit others, either close by or elsewhere in the Fraser Valley. They had different estimates of how much those people would benefit. Overall, they estimated that the benefits off-farm were somewhat lower than those that benefit producers themselves. However, they felt that ecosystem goods, airshed services and cultural services would be of particular importance to others. The disservice of pests was also identified as potentially relevant to people off-farm.

The different items within each category and the category totals show real differences in the importance assigned to different goods and services, and suggest where categories can be combined for simplicity, or should be expanded to examine the complexities of the service.

Table 6. Averages of Sums of Importance Scores for Ecosystem Goods and Services, from the perspective of the farmer.

Categories of Ecosystem Goods & Services	Average Importance On-farm	Average Importance Off-farm
Soil Services	1.8	1.3
Cultural Services	1.7	1.5
Goods	1.3	1.2
Water Services	0.9	0.7
Airshed Services	.8	1.0
Habitat Services	.4	.6

While there are a number of features of this first scoring approach that should be adjusted if repeated, the basic numerical patterns were confirmed during the interviews. Producers recognized a range of importance within the services they receive. The interviews confirmed data in the scoring table, showing that the goods and services that producers find of the greatest importance were:

- Crops produced from the land and used on-farm as feed,
- Soil processes critical to producing crops,
- Water for crops, and
- Cultural services

5 Major Observations and Conclusions

The major results of this project were maps showing land use, ecosystem services, and the relative importance of those services on two dairy farms in the eastern Fraser Valley. Along the way, much was learned about applying the concept of ecosystem goods and services (EGS) to agricultural land, and about landowner views, preferences and motivations. Of particular interest was the importance of cultural services – aesthetic appeal, recreation, inspiration, sense of place – to both the farmer (on-farm) and people around the farm (off-farm).

We also learned that EGS tools give producers a fresh perspective on their land, that some ecosystem services are actually disservices, that habitat provision ranks low among farmers but high off-farm, that identifying and ranking ecosystem services is a small step in a greater planning process, and that it is easy to downplay the impacts of ecosystem services of a single small site on the greater landscape. These lessons must be considered in the context of the small sample size, the pilot nature of the questionnaire used to rank ecosystem services, and the steep learning curve for both producers and researchers.

We must also note that the concept of EGS is not a single tool. It is rather a perspective and approach that requires and permits the use of many different tools. Although the general concept of ecosystem goods and services is quite simple, it is tricky to work out the details clearly enough to discuss, map and score them in a consistent and logical way. The steps of identifying services and benefits specifically enough for measurement is a continuing challenge discussed regularly in the literature (e.g. Boyd and Banzhaf 2007, Haines-Young and Potschin 2009).

Scoping was critical to this study, given the breadth and depth of potential investigations. It took several rounds of discussion, involving multiple meetings with experts, producers and researchers, to create a list of locally relevant ecosystem goods and services, to identify categories of beneficiaries, and to focus the study on services that originated on the farm and benefited producers. These steps were needed to frame mapping and evaluation activities for the case studies.

Identification and classification of ecosystem goods and services leads to further analyses and assessments (for overviews discussing multiple steps and tools see Ash et al 2010, DEFRA 2007, Kumar 2010, and Turner, Georgiou and Fisher 2008). We used a simple form of mapping, but there are many varieties of mapping approach (see Kareiva et al. 2011 and Fisher et al. 2011 for two different perspectives). We used one form of valuation, but there are many economic valuation tools applied to ecosystem services (see Haines-Young and Potschin 2009 and EPA 2007).

These ideas can deal with services at different scales, and for services with different geographical patterns: a comprehensive landscape-scale analysis of economic values of ecosystem services has previously been done for the Lower Mainland (Wilson 2010). We were able to identify the ecosystem resources available to two dairy farms in more detail than the producers had previously been aware. We could pinpoint, on the maps, different categories of land uses, and their associated ecosystem services. We noted that the mapping process could potentially be used with producers to identify areas for protection or restoration.

The main observations from our study of ecosystem services at the farm scale are identified and described in the following sections.

5.1 Mapping and Scoring Land Uses to Communicate EGS

Because maps can convey many different kinds of information and are powerful communication tools, there are many mapping approaches that can use concepts of EGS. However, mapping ecosystem goods and service categories is challenging. Ecosystem services are not perfectly correlated with the more easily mapped land uses and infrastructure categories. Further, many physical locations provide more than one ecosystem service so it is challenging to map services themselves in a precise and repeatable way.

Although producers know their lands well, naming, mapping and scoring ecosystem services on their own farms gave a fresh perspective. Researchers learned more about how dairy farms and related lands provide services and benefits. The idea that farmlands generate ecosystem goods and services was not revolutionary but the process did consolidate information for producers, helped us recognize the whole set of services from a given farm, and put them all into a relative perspective. The scoring activity reminds participants, and those who review the results, of the major feature of ecosystem services: they are the aspects of ecosystems *that benefit people*. These scores are about the details of how they are seen to benefit people. All of these services were seen as potentially providing some benefits to someone.

Participants were reminded of reasons to protect and enhance their land, and the maps helped them identify particular places on which to direct attention. In this way the survey and interview process helped farmers focus on internally motivated incentives to protect land. Producers became proficient enough with the EGS approach during the mapping and interview process that they were able to make summary comparisons by the end of it.

The summary graphics we have developed are intended to communicate these benefits to other farmers, and to help them recognize those benefits on their own farms. We propose that implementing an EGS-based element or questionnaire to the Environmental Farm Planning (EFP) process would raise awareness of the additional services that natural areas provide to both landowners and the community. We have some ideas around how to more efficiently map and identify ecosystem goods and services at the farm scale, and would like to continue to develop these tools.

5.2 Identifying the Relative Importance of EGS to Producers

Scoring surveys identified relative importance of different ecosystem services to producers through a relatively simple scan with a limited sample size, but it did reveal some interesting ideas. Interviews confirmed the general patterns revealed by scores and added some additional details.

Scoring or similar ranking approaches, particularly if done with more sophistication than this initial scan, are relatively easy to obtain and can give valuable insights. While monetary estimates do have a potential place in working with EGS, non-monetary approaches provide an overall comparison that is difficult to do with monetary measures, since many benefits are not easily 'monetized'. Indeed, several of the important cultural benefits do not have any agreed-upon monetary measures (Haines-Young and Potschin 2009). While more detailed scoring methods can be demanding, they are faster and cheaper to investigate than many monetary measures. We recommend that the non-monetary measures of values of services should be investigated in more detail as a relatively simple but powerful complement to other EGS tools.

5.3 Cultural Services are Strong Motivators

In our interviews we learned that cultural services – aesthetics, recreation, inspiration, education, physical and mental health – were motivating factors behind the installation of many natural features on the farm. Trees were planted by both participants for emotional and aesthetic reasons, sometimes borne of opportunism when trees became available. The aesthetic of straight rows of trees along a road or along the edge of a field is a strong source of pride. Gardens and shade trees provided recreation, respite, inspiration and opportunities for bird-watching.

Community appreciation of cultural services is evident to the farmers (we did not interview the general public). Letters to the local newspaper expressing gratitude for public trails promotes a strong sense of community and pride, as does the joy of seeing their neighbours walking, running and playing in the pleasant places created. On the other hand, pruning trees, cutting some down, or other routine farm maintenance activities have generated strong negative reactions from users of those trails (a cultural 'disservice').

In addition, wildlife such as bears or waterfowl can damage crops, causing more ecosystem disservices, though these may be largely offset by aesthetics and inspiration. For instance, watching a bear lope across a field gave pleasure, as did watching migrating flocks of geese, ducks and swans, which also provide hunting opportunities. Similarly, ponding may delay spring planting but this disservice might be offset by the delight of having children skate on ice caused by a December cold snap.

Also interesting is the comment, heard several times, that natural areas are undesirable because of their untidiness. The tidiness of a farm is an indicator of a good farmer, and a point of pride. Shrubby riparian areas and tall grasses can be messy and unsightly, and therefore undesirable.

Other studies of ecosystem services in the Fraser Valley did not show the strong benefit producers got from cultural services. Instead they looked at benefits to the public. Wilson's (2010) study of the lower mainland used land cover/ecosystem type categories. The only cultural category was recreation/tourism, which showed a total value to the public of farm-based recreation of $422/ha. Robbins, Olewiler and Robinson (2009) specifically looked at benefits from farmland, but they looked at broad 'public value', as measured by a survey of what people were willing to pay to preserve farmland (mean results: urban residents $69, suburban residents $63, and rural residents $83). The main reasons people offered (selecting three each from a list offered) were: local food (91%), green space (69%), wildlife habitat (51%), and nature (33%). Hence, our look at producers themselves and the farm level identified a different range of benefits and substantially different priorities.

5.4 EGS Incentives Specific to the Fraser Valley

The purpose of studying EGSs in the Fraser Valley is the potential creation of a Payment for Ecosystem Services (PES) program. These programs are generally supported by one of four major interests: watershed protection, habitat protection, carbon sequestration or protection of scenic amenities (Wunder 2008). They are one form of incentive that can support land management decisions, and are based on people some distance away who are willing to pay landowners to protect the sources of their benefits.

The less explicit intermediary step is that farmers should first seek to understand the concepts of

EGSs, so they know what the incentives are for. We focused on identifying EGSs that would improve farmers' specific understanding and knowledge of their own land, in order to better understand their motivations and management challenges. This, combined with our existing knowledge of the ecosystem services provided by natural areas on farmland, helped to identify the gaps in motivation that result in loss of broader ecosystem services. We did not directly investigate the impacts of services, provided by individual farms, on the common good, but we expect that the frameworks and steps that we began here could be compatible with EGS studies of off-farm beneficiaries.

Habitat Services

Habitat Services were scored low by producers, yet wildlife habitat, including for government-listed species, is among the important services that are most likely to attract the attention of people and organizations farther away. This is already recognized in agricultural programs that compensate farmers for wildlife impacts to their crops (eg. BC's Agriculture Wildlife Program). However, there is no compensation for important wildlife (eg. species-at-risk, salmon, game animals) that do not damage crops but may require alternative, and potentially more costly, land management practices. These Habitat Services might be linked to PES programs, where the high priorities of others can supplement the producers' own interests.

Water Services

Similarly, ecosystem services that provide farmers with water were highly valued (ie. rain-water, shallow groundwater used for irrigation and watering cattle). More distant or abstract services such as water attenuation, water infiltration and pollutant filtration associated with complex vegetation and ponding, were less important to the farm itself. Having a waterway through your property in the Fraser Valley is viewed as more of a hindrance than a benefit. Groundwater from rainfall and shallow aquifers is easily accessible and inexpensive, so surface water and its surrounding floodplain or riparian area can be seen as simply taking up valuable real-estate. Ponding in swales reduces productivity, and complex networks of ditches have been developed to carry water from fields as efficiently as possible. In the rainy floodplains of the Fraser Valley, surface water can be a liability.

However, water attenuation, infiltration and filtration are critical ecosystem services to the local and regional community because they help prevent floods and ensure clean water restores aquifers, well as for the habitat services discussed above.

Ponding and infiltration of rainwater in a single field may not appear important in the context of a larger landscape. However, the conversion of a single field from crop production to an impermeable surface would certainly impact downstream neighbours, and the transition of many fields would have a large impact on water-related services downstream. Draining these ponds is important to productivity for the individual farmer but increases flashiness of streams and reduces availability of groundwater and surface water in the dry season.

Many farmers in the Fraser Valley rely on shallow wells (< 10 m deep) for their homes and livestock; the city of Chilliwack relies on the Sumas-Vedder Aquifer for its drinking water, which in places is within 2 m of the surface. Aquifer recharge comes directly from agricultural lands that can impact water quality – it must be clean. The majority of BC farms have Nutrient Management Programs that indicate the necessity of managing such potential impacts.

These ecosystem services, which result in disservices or limited direct benefit to farmers yet provide important benefits to society are those that we propose be addressed by Incentives for Ecosystem Service programs in the Fraser Valley.

5.5 Limitations of this Study

The sample size is small and, while we spent much time working out the processes, they are still locally focused. Selecting and naming the mapping categories are important steps in a study, and ours were specific for two farms. Likewise, selecting and naming the EGS categories, both geographical and functional, are important steps and ours were specific for Fraser Valley farms. Adjustments would be needed for our steps to be used more broadly. The scoring process was overly simple and needs refinement to be used more widely.

This study focused on the on-farm services that benefit producers, but the other geographical patterns are relevant for other concerns. For example, the off-farm services could be the basis of regional planning efforts to protect the source locations of services that benefit other farms and nearby communities. The flows of benefits that go to people off-farm should be studied in more detail because they are worth bringing to the public attention, both locally or elsewhere in the Lower Mainland. Those who benefit should be made more aware of the source of the services that benefit them.

6 Suggestions for the Immediate Future

Knowing what services are present, where they are and having some measure of their importance are the results of the descriptive steps that we conducted in this study. Awareness of EGS information is an important result in its own right and we have made an effort to provide some of the information in graphic formats specifically created to enhance communication. Ultimately EGS is the foundation for information assembly and analysis approaches that make new information available. In this section, we provide recommendations for the next round of work with EGS in the eastern Fraser Valley, based on our initial results.

Seek Feedback

Our results will be presented at the next Agriculture – Environment Forum. We would like to discuss the results and the same 'what next' issues with other forum participants, who helped initiate this project. We would also like to consolidate their ideas and suggestions for future work.

Our purpose is to get farmers thinking at the farm-scale when discussing ecosystem goods and services, and to solicit feedback and ideas for streamlining and improving the assessment and valuation processes. The graphics developed should be tested with a wider audience, and feedback incorporated into the pamphlets before distribution to the farming community. We propose developing the 'stories' of these farms through the lens of ecosystem services for a wider audience in the format of an article that could be submitted to industry media.

Work with ESI and EFPs to Identify Trends and Mitigation Opportunities

This work is intended to fit with concurrent initiatives in the Environmental Farm Plan and with the Ecological Services Initiative. The language of EFPs deals with risk and mitigation, whereas the

language of ecosystem goods and services, as we have used it, deals with land use and production of services. We attempted to develop a survey that visually identified with the EFP workbooks, but it is not directly aligned. We propose working with an environmental farm planner to develop a survey / mapping process that fits naturally within the EFP manuals, and can incorporate improved production of ecosystem services as a best management practice. We expect that ecosystem service identification and mapping would lead to best management practices currently associated with the Biodiversity Guide.

To inform this work, we propose incorporating an additional layer on our two specific case studies to identify existing trends in ecosystem services produced (getting worse, staying the same, improving) and to specifically identify opportunities to increase their production at the farm-level.

Explicitly Address Species-At-Risk

Much of the impetus behind the three Agriculture-Environment Forums was concern over the management of federally and provincially legislated Species-At-Risk (SAR) in agricultural areas. Despite recognizing endangered species as abstractly important to the general public, direct discussions regarding species-at-risk may be off-putting to many producers. It is worth asking is whether incentives for ecosystem services should be tailored toward species-at-risk or whether the provision of ecosystem services should be aimed at a broader measure of overall ecosystem health, represented by a range of plant and animal species, perhaps with opportunities for additional 'bonuses' related to provision of SAR habitat.

Increase Sample Size and Contribute to the Literature on Ecosystem Goods and Services

We would like to refine the survey and mapping process, and apply it to a wider test group. Our ranking / scoring methods were basic, and we would like to develop a more sophisticated and robust survey to incorporate relative valuation from a larger sample of producers. Our mapping methods were detailed and time-consuming, but could be dramatically simplified using a random-point sampling method similar to that used in iTree, the ecosystem services tool used to evaluate the air purification services provided by the farms.

Our purpose was to use existing tools to assess ecosystem goods and services provided at the farm scale. However, we found available tools to be highly complex and incomplete. We discovered that our process, which attempted to transform academic language into a more usable form, was not well represented in the literature, and that some of our conclusions may in fact provide meaningful contributions to the application of ecosystem goods and services ideas on the ground.

There were tasks outside the boundaries of this study that could be addressed further. The main example is the geographic pattern of benefits—the sources and sinks—including benefits produced elsewhere but beneficial to the farm, as well as benefits produced by the farm but beneficial to people off-farm. The mapping process revealed some of this information but additional details should be explored, and there is much strength in GIS analysis tools that might be brought to bear.

More detailed investigations are possible, using the survey and ranking techniques, especially building on efforts to apply techniques to specific locations and with specific mapping methods (eg. Hein et al. 2006, Raymond et al. 2009). There are quite complex geographic patterns of ecosystem services, such as the non-linear ways in which they can be related (Qui and Turner 2013) or ways in which different services in the same location can be 'bundled' for management or policy (Raudsepp-

Hearne, Peterson and Bennett 2010). Further work with mapping approaches can move towards incorporating these more demanding details into analysis and support for decision-making.

Another future step, which builds on and consolidates local information, is to work with producers to create a sharable graphic model of key parts of the farm/ EGS system. Such a step – an initial element of adaptive ecosystem management (Meffe et al. 2002) – consolidates information and creates a model that can also be used to identify the types of information that have the highest benefit to cost ratio.

It is worth noting that a discussion of results and priorities with producers, a ranking activity, and the creation of a conceptual model, three things discussed just above, can all be done based upon one or two group workshop exercises.

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Appendix 1 – Prioritization Survey for Agriculture – Environment Survey

AGRICULTURE ENVIRONMENT FORUM III
DRAFT Potential Case Studies – Examples and Prioritization

The Fraser Valley Watersheds Coalition is working with BC Agriculture Council, ARDCorp, the Environmental Services Initiative and other Partners to develop an **"Incentives for Ecosystem Services" (IES)** program in the Fraser Valley. Within this process, we must **identify Ecosystem Goods and Services (EGS / EcoService) priorities in the Fraser Valley**, and **prioritize the information gathering** needed to implement next steps.

ECOSYSTEM SERVICE / FEATURE / PRODUCTION PRIORITIZATION

Please rank the options for those you consider to be of highest priority for review in the Fraser Valley.

Rank (10)	Benefit	Rank (5)	Landscape Feature	Rank (10)	Production Type
_____	Clean water	_____	Streams & Wetlands	_____	Dairy
_____	Drainage / Flood protection	_____	Hedgerows / Windbreaks	_____	Other livestock: Hogs, Sheep, Goats, Beef
_____	Pollination of crops	_____	Riparian Areas	_____	Poultry
_____	Species-at-Risk habitat	_____	Meadows	_____	Berries & Nuts
_____	Fish and wildlife habitat	_____	Fallow Fields	_____	Nursery & Sod
_____	Carbon sequestration	_____	Woodland	_____	Greenhouse
_____	Erosion prevention	Other:	_____	_____	Field Vegetables
_____	Clean air	Other:	_____	_____	Fruits
_____	Pest control			_____	Horse
_____	Cultural importance			_____	Grains
Other:	_____			Other:	_____

Your Comments: *What did we miss? Was this easy or challenging? Why did you select #1? Why the last?*

CASE STUDIES

We will be developing at least two case studies to help implement this work for the agricultural community. We need your feedback on which topics you think will be most useful. Below is a list of several possible topics, which we think would be practical and achievable, and space for you to add suggestions of your own.

Please rank the options (1 - 5) in the order of greatest to least interest to you.

Rank	Description
_____	**Landscape Feature Case Study** Select highest priority landscape feature for assessment. Identify costs and benefits of a protecting / enhancing particular landscape features that provide EcoServices with a focus on Fraser Valley needs. Identify costs and values of this feature on selected farms with recommendations for improvement. *Deliverable: Information document for Producers with specific examples.* **Notes:**

Rank	Description
_____	**EcoService Benefits Case Study** Select highest priority Benefit for assessment. Identify costs and benefits of protecting / enhancing a particular EcoService on a farm with a focus on Fraser Valley needs. Identify costs and values of this benefit on selected farms with recommendations for improvement. *Deliverable: Information document for Producers with specific examples.* **Notes:**
_____	**Farm-Type Benefits Case Study** Select highest priority production type for assessment. Identify costs and benefits of protecting / enhancing relevant EcoServices on a farm with a focus on Fraser Valley needs. Identify costs and values with recommendations for improvement. *Deliverable: Information document for Producers with specific examples.* **Notes:**
_____	**Implementation Case Study** Develop a short-list of existing examples of written agreements, standards, methods of setting and of making incentives, methods of monitoring, etc. Review examples with Producers / potential Funders for feedback on how well different mechanisms would work for them. We will then create a first draft incentives plan, which we will submit to our test community for feedback and improvements. *Deliverable: second revised draft. Implement pilot program?* **Notes:**
_____	**'Rapid Assessment' Process Development** Develop a 'Rapid Assessment' procedure to quickly assess major Landscape Features and EcoServices provided to and by individual farms. Combine ideas from existing 'rapid assessment' protocols for biodiversity, impact assessment and Environmental Farm Plans to develop a fast procedure to assess major features and EGS merits of a particular farm, and guide next steps for that given producer. *Deliverable: Draft fast assessment process with forms and written guidelines. Run sample farms through the process and provide results.* **Notes:**
_____	**Non-Monetary Value Identification** Use a comparative ranking approach to survey producers and other target audiences to identify important non-monetary values of EcoServices. Develop and conduct survey, in which the respondents consider and compare all possible values from services (including aesthetic, recreational, spiritual etc.) from an example agricultural system or specific farm, to improve understanding of producer and public perspectives pertaining to social license. *Deliverable: Ranked or weighted lists of agricultural EGS, from the different perspectives of several audience groups.* **Notes:**
_____	**Other / Your ideas and Comments:**

Appendix 2 -Ecological Goods and Services – Interview Guide and Scoring Form

Landowner Interview - Case Studies

Interviewee: _____ **Date:** _____

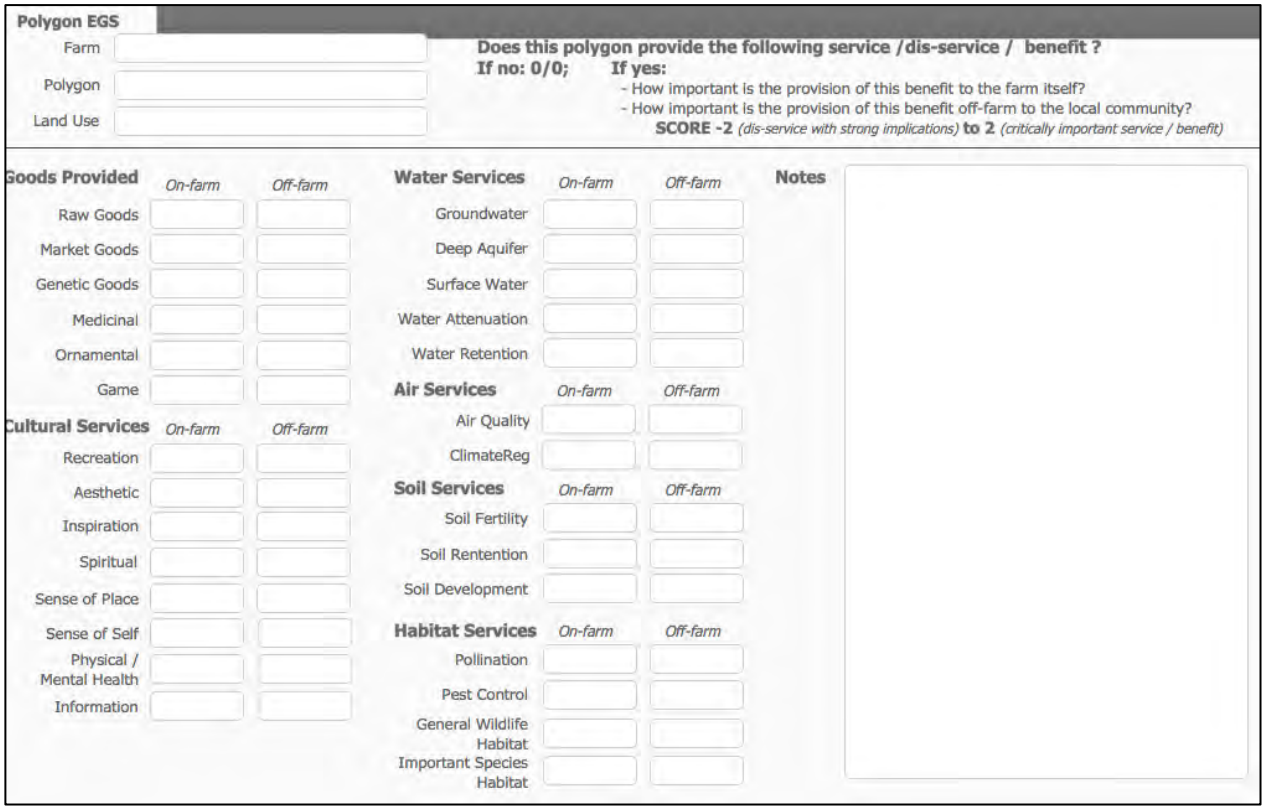
Farm: _____ **Interviewer:** _____

Benefits - Rank -2 to +2

Category	Name	Question: Does this FARM benefit from these services? Do they benefit people ON-FARM? OFF-FARM?	On-Farm	Off-Farm	Notes
Goods					
	Raw	Raw materials for use in food production on or off-farm?			
	Market	Materials sold off-farm?			
	Genetic	Genetic materials that benefit production or humans?			
	Medicinal	Materials that have medicinal benefits on or off-farm?			
	Ornamental	Materials for ornamental use on or off-farm?			
	Hunting	Game for hunting?			
Cultural Services					
	Aesthetic	Aesthetic enjoyment?			
	Recreation	Recreation and/or tourism?			
	Inspiration	Inspiration for art, culture and design?			
	Spiritual experience	Connection with a higher being or with self?			
	Sense of place	Connection to sense of place or place of cultural or social importance?			
	Information	Education, research or knowledge?			
	Health	Physical or mental health?			
	Pride	Personal / community pride			
Airshed Services					
	Air quality	High air quality by either releasing or absorbing CO2,methane, ammonia, particulate matter, etc.?			
	Climate regulation	Micro-climate regulation by wind moderation, thermal cover, shading, or other?			

Category	Name	Question: Does this FARM benefit from these services? Do they benefit people ON-FARM? OFF-FARM?	On-Farm	Off-Farm	Notes
Water Services					
	Groundwater	Groundwater to benefit crops, humans, livestock or wildlife?			
	Deep Aquifer	Deep aquifers to benefit crops, humans, livestock or wildlife?			
	Rain water	Rain water to benefit crops, humans, livestock or wildlife?			
	Surface water	Surface water (streams or ditches) to benefit crops, humans, livestock or wildlife?			
	Water attenuation	Rainwater capture before it hits the ground (eg. via shrub, tree canopy or rainwater collection), reducing erosive forces, flashiness and infiltration rate requirement?			
	Water retention	Rainwater infiltration to reduce flooding, or retain water to attenuate impacts of flooding elsewhere?			
	Water quality	High water quality influenced by providing or filtering potential pollutants (eg. nutrients, metals, hydrocarbons, road dust etc)?			
Soil Services					
	Soil fertility	Nutrient and soil cycling processes?			
	Soil retention	Soil retention?			
	Soil development	Soil development, including currently un-cultivated areas (eg. fallow fields, wetlands,)?			
Habitat Services					
	Pollination	Pollinators or pollination activities?			
	Biological control	Pest control services (eg. wasp habitat +ve, pests -ve)?			
	Wildlife habitat	Terrestrial or aquatic wildlife?			
	Locally important species	Locally important species (eg. coho salmon)?			
	SAR habitat	Endangered species (eg. Oregon spotted frog)?			

Appendix 3 – Ecological Goods and Services of Land Use Polygons – Scoring Form



Polygon EGS

Farm

Polygon

Land Use

Does this polygon provide the following service /dis-service / benefit ?
If no: 0/0; If yes:
- How important is the provision of this benefit to the farm itself?
- How important is the provision of this benefit off-farm to the local community?

SCORE -2 *(dis-service with strong implications)* **to 2** *(critically important service / benefit)*

Goods Provided	*On-farm*	*Off-farm*
Raw Goods		
Market Goods		
Genetic Goods		
Medicinal		
Ornamental		
Game		

Cultural Services	*On-farm*	*Off-farm*
Recreation		
Aesthetic		
Inspiration		
Spiritual		
Sense of Place		
Sense of Self		
Physical / Mental Health		
Information		

Water Services	*On-farm*	*Off-farm*
Groundwater		
Deep Aquifer		
Surface Water		
Water Attenuation		
Water Retention		

Air Services	*On-farm*	*Off-farm*
Air Quality		
ClimateReg		

Soil Services	*On-farm*	*Off-farm*
Soil Fertility		
Soil Rentention		
Soil Development		

Habitat Services	*On-farm*	*Off-farm*
Pollination		
Pest Control		
General Wildlife Habitat		
Important Species Habitat		

Notes

Appendix 4 – Raw Scores – Ecological Goods and Services Scoring

		Farm 1		Farm 2		Farm 2			
Category	**Name**	**On-farm**	**Off-farm**	**On-farm**	**Off-farm**	**On-Farm**	**Off-Farm**	**Average On farm**	**Average Off farm**
Airshed Services		**1.5**	**2**	**0**	**0**	**1**	**1**	**0.8**	**1.0**
	Air quality	1	2	0	0	1.5	1.5		
	Climate regulation	2	2	0	0	0.5	0.5		
Cultural Services		**1.8**	**2.0**	**2.0**	**1.3**	**1.4**	**1.3**	**1.7**	**1.5**
	Aesthetic	2	2	2	2	2	1.5		
	Recreation	2	2	2	1	1	1.5		
	Inspiration	2	2	2	0.5	1	0.5		
	Spiritual experience	1	2	2	1	1	1.5		
	Sense of place	2	2	2	1	1.5	1		
	Information	1	2	2	2	1.5	1.5		
	Health	2	2	2	1	1.5	1.5		
	PRIDE	2	2	2	2	1.5	1		
Goods		**1.4**	**1.4**	**1.7**	**1.7**	**0.8**	**0.4**	**1.3**	**1.2**
	Raw	2	2	2	2	2	0.5		
	Market	2	2	2	2	2	1.5		
	Genetic	2	2	2	2	0.5	0.5		
	Medicinal	2	2	2	2	0	0		
	Ornamental	0.5	0.5	1	1	0	0		
	Hunting	0	0	1	1	0.5	0		
Habitat Services		**0.5**	**0.2**	**0.3**	**0.2**	**0.5**	**1.4**	**0.4**	**0.6**
	Pollination	0.5	0.5	2	2	1.5	1		
	Biological control	1	1	-2	-2	1	1.5		
	Wildlife habitat	0	-0.5	0.5	0	0	1.5		
	Locally important species	1	0	0.5	0.5	0	1.5		
	SAR habitat	0	0	0.5	0.5	0	1.5		
Soil Services		**1.7**	**1.3**	**2.0**	**1.5**	**1.7**	**1.2**	**1.8**	**1.3**
	Soil fertility	2	2	2	2	2	1		
	Soil retention	2	2	2	2	1.5	1.5		
	Soil development	1	0	2	0.5	1.5	1		
Water Services		**0.6**	**0.0**	**1.2**	**1.3**	**0.9**	**0.8**	**0.9**	**0.7**
	Groundwater	2	0	2	1	2	1		
	Deep Aquifer	0	0	0	2	0	0		
	Rain water	0	0	2	2	2	0.5		
	Surface water	0	0	0.5		0.5	1		
	Water attenuation	0	0	0	0	0	0.5		
	Water retention	2	0	2	2	1	1.5		
	Water quality	0	0	2	2	0.5	1		

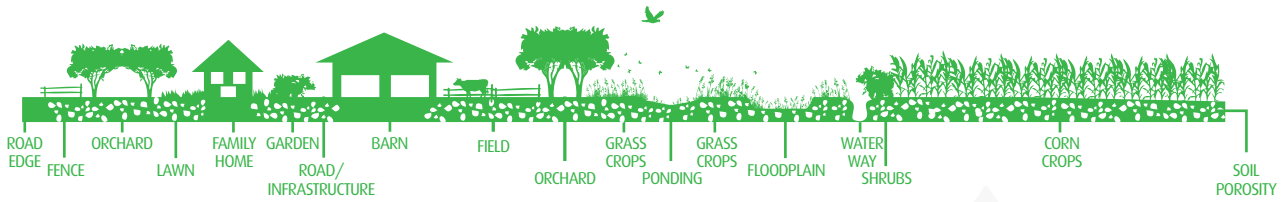
Appendix 5 – Average Scores – Land Use Polygons Ecosystem Goods and Services

Scoring of EGS on Farm Land Use Polygons - Average Scores

	Agricultural Use																				Human Use									Natural Area					
EGS \ Land Use Type	**Barn**		**Cultivated**		**Infrastructure**		**Mixed Use**		**Orchard**		**Pastured**		**Pond**		**Road**		**Shelter-belt**		**UUC**		**Family Home**		**Garden**		**Public trail**		**Recreation**			**Rip grass**		**Rip shrubs**		**Waterway**	
On-farm /Off-farm	*Off*	*On*	*Off*	*On*	*Off*	*On*	*Off*	*On*	*Off*	*On*	*Off*	*On*	*Off*	*On*	*Off*	*On*	*Off*	*On*	*Off*	*On*	*Off*	*On*	*Off*	*On*	*Off*	*On*	*Off*	*On*		*Off*	*On*	*Off*	*On*	*Off*	*On*
Air services	-0.2	-0.6	0.6	0.9	0.2	0.0	0.0	0.0	0.8	1.0	0.4	0.8	0.5	1.0	0.0	0.0	0.8	1.0	0.2	0.8	-0.1	0.2	0.6	0.6	0.0	0.0	0.0	0.4		0.3	2.0	0.3	2.0	0.0	0.0
Air Quality	-0.7	-1.0	0.2	0.9	0.1	0.0	0.0	0.0	0.3	0.0	0.3	0.8	0.0	1.0	0.0	0.0	0.9	0.9	0.1	0.8	-0.2	-0.3	0.5	0.5	0.0	0.0	0.0	0.5		0.0	2.0	0.0	2.0	0.0	0.0
Climate Regulation	0.3	-0.2	0.9	0.9	0.3	0.0	0.0	0.0	1.3	2.0	0.6	0.8	1.0	1.0	0.0	0.0	0.7	1.0	0.4	0.8	0.0	0.7	0.8	0.8	0.0	0.0	0.0	0.3		0.5	2.0	0.5	2.0	0.0	0.0
Cultural Services	0.7	1.2	1.0	1.1	0.0	0.3	0.0	0.0	0.3	1.0	0.3	0.9	0.1	0.8	0.0	0.0	1.4	1.5	0.0	0.6	0.6	1.3	0.1	1.4	2.0	2.0	0.1	0.8		0.0	1.5	0.0	1.5	0.0	1.1
Aesthetic	1.0	1.0	1.6	2.0	0.1	0.3	0.0	0.0	0.7	2.0	0.6	1.8	0.0	1.0	0.0	0.0	1.9	1.9	0.2	1.1	0.2	1.3	0.0	1.8	2.0	2.0	0.0	1.0		0.0	2.0	0.0	2.0	0.0	0.0
Health	0.5	1.5	1.4	1.2	0.1	0.2	0.0	0.0	0.3	0.0	0.4	0.7	0.0	1.0	0.0	0.0	1.8	1.9	0.0	0.8	0.3	1.3	0.0	1.5	2.0	2.0	0.0	1.0		0.0	2.0	0.0	2.0	0.0	0.0
Information	0.8	1.0	0.3	0.6	0.1	0.3	0.0	0.0	0.2	2.0	0.0	0.6	0.0	1.0	0.0	0.0	0.7	0.3	0.0	0.7	1.3	1.0	0.0	1.0	2.0	2.0	0.0	0.5		0.0	2.0	0.0	2.0	0.0	1.0
Inspiration	0.7	1.0	1.0	1.3	0.0	0.3	0.0	0.0	0.2	2.0	0.3	1.0	0.0	1.0	0.0	0.0	1.8	2.0	0.0	0.8	0.7	1.3	0.0	1.5	2.0	2.0	0.0	0.8		0.0	2.0	0.0	2.0	0.0	2.0
Place	1.3	1.2	1.1	1.0	0.0	0.2	0.0	0.0	0.2	-1.0	0.8	0.6	0.0	0.0	0.0	0.0	1.8	2.0	0.0	0.2	0.7	1.3	0.3	1.5	2.0	2.0	0.0	0.8		0.0	0.0	0.0	0.0	0.0	1.0
Recreation	0.0	1.2	0.6	0.6	0.0	0.4	0.0	0.0	0.0	-1.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.1	0.0	1.3	0.0	1.3	2.0	2.0	0.0	1.0		0.0	0.0	0.0	0.0	0.0	2.0
Self	1.0	1.3	1.0	1.2	0.0	0.3	0.0	0.0	1.0	2.0	0.4	1.1	0.5	1.0	0.0	0.0	1.8	2.0	0.0	0.5	1.0	1.3	0.5	1.3	2.0	2.0	0.5	0.8		0.0	2.0	0.0	2.0	0.0	1.0
Spiritual	0.5	1.2	1.0	1.2	0.0	0.3	0.0	0.0	0.0	2.0	0.3	0.9	0.5	1.0	0.0	0.0	1.8	2.0	0.0	0.5	0.7	1.3	0.0	1.3	2.0	2.0	0.0	0.8		0.0	2.0	0.0	2.0	0.0	2.0
Goods	0.2	0.5	0.3	0.9	0.0	0.3	0.2	0.1	0.5	1.3	0.2	0.5	0.3	0.8	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.8	0.1	0.6	0.0	0.0	0.1	0.7		0.8	1.3	0.8	1.3	0.3	1.0
Game	0.0	0.2	0.4	1.1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.1	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3		1.0	2.0	1.0	2.0	1.0	0.0
Genetic	0.5	0.8	0.1	0.8	0.0	0.2	0.0	0.0	0.0	1.0	0.0	0.3	0.5	0.5	0.0	0.0	0.0	0.2	0.0	0.3	0.3	1.3	0.0	0.4	0.0	0.0	0.0	0.0		1.0	2.0	1.0	2.0	1.0	2.0
Market	0.2	0.6	1.1	0.7	0.1	0.3	0.5	0.0	2.0	0.7	0.8	0.2	0.5	1.5	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.7	0.5	0.0	0.0	0.0	0.3	1.0		2.0	1.0	2.0	1.0	0.0	1.0
Medicinal	0.0	0.3	0.2	0.4	0.1	0.0	0.5	0.5	1.0	2.0	0.3	0.8	0.5	1.5	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.7	0.0	0.8	0.0	0.0	0.3	1.0		1.0	1.0	1.0	1.0	0.0	1.0
Ornamental	0.0	0.3	0.0	0.7	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.4	0.0	1.0	0.0	0.0	0.2	0.2	0.0	0.0	0.3	1.3	0.0	1.8	0.0	0.0	0.0	1.3		0.0	1.0	0.0	1.0	0.0	1.0
Raw	0.5	1.0	0.0	1.6	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.1	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.5	0.0	0.0	0.0	0.5		0.0	1.0	0.0	1.0	0.0	1.0
Habitat	0.0	0.3	0.2	0.4	-0.1	0.1	0.1	0.0	0.5	1.3	0.3	0.5	0.3	0.3	0.0	0.0	0.4	0.5	0.1	0.1	-0.2	0.4	0.6	0.7	0.0	0.0	0.2	0.6		0.3	1.0	0.3	1.0	0.5	1.0
Important Species	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	1.7	-0.1	0.4	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.3	0.0	0.0	0.0	0.8		1.0	1.0	1.0	1.0	0.0	1.0
Pest Control	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	1.0	0.5	0.0	0.5	0.0	0.0	0.0	0.7	0.9	0.2	0.1	0.0	0.0	0.5	0.5	0.0	0.0	0.3	0.5		0.0	1.0	0.0	1.0	2.0	1.0
Pollination	-0.3	0.3	0.3	0.4	-0.4	0.0	0.3	0.0	1.5	1.7	0.6	0.9	0.0	0.5	0.0	0.0	0.0	0.1	0.1	0.1	-0.3	0.7	1.3	1.8	0.0	0.0	0.3	0.8		0.0	1.0	0.0	1.0	0.0	1.0
Wildlife Habitat	0.2	0.5	0.5	0.6	-0.1	0.4	0.3	0.0	0.5	0.7	0.3	0.5	0.0	0.0	0.0	0.0	0.9	0.9	0.2	0.1	-0.3	0.2	0.8	0.3	0.0	0.0	0.3	0.5		0.0	1.0	0.0	1.0	0.0	1.0
Soil Services	-0.3	0.7	0.6	1.2	-0.3	0.1	0.2	0.0	0.8	1.4	0.5	1.2	0.8	0.8	-0.5	-0.2	0.3	1.3	0.4	0.4	-0.2	0.4	0.2	1.8	0.0	-0.7	0.3	0.7		1.3	1.0	1.3	1.0	1.3	1.0
Soil Development	-0.3	1.1	0.9	1.1	-0.4	0.2	0.3	0.0	1.0	1.7	0.5	1.4	1.5	1.0	-0.9	-0.3	0.0	1.0	0.4	0.1	-0.3	0.7	0.3	2.0	0.0	0.0	0.5	0.5		2.0	1.0	2.0	1.0	2.0	1.0
Soil Fertility	-0.3	0.8	0.9	1.4	-0.4	0.2	0.3	0.0	1.0	0.7	0.8	0.9	1.0	0.5	-0.7	-0.3	0.0	1.3	0.3	0.3	-0.3	0.0	0.3	1.5	0.0	-2.0	0.5	0.0		2.0	1.0	2.0	1.0	2.0	1.0
Soil Retention	-0.3	0.3	0.1	1.1	-0.1	0.0	0.0	0.0	0.5	2.0	0.3	1.4	0.0	1.0	0.0	0.0	0.8	1.7	0.4	0.8	0.0	0.7	0.0	2.0	0.0	0.0	0.0	1.5		0.0	1.0	0.0	1.0	0.0	1.0
Water Services	-0.1	-0.2	0.4	0.8	-0.4	-0.4	0.0	0.0	0.8	1.1	0.6	0.9	0.0	0.4	0.0	-0.1	0.7	1.1	0.6	0.4	-0.2	-0.1	0.2	1.0	0.0	0.0	0.1	0.7		0.8	1.0	0.8	1.0	0.6	1.0
Aquifer	-0.3	0.0	0.0	0.3	-0.1	0.0	0.0	0.0	0.5	0.7	0.1	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5		0.0	1.0	0.0	1.0	1.0	1.0
Attenuation	0.0	-0.3	0.4	0.9	-0.6	-0.6	0.0	0.0	1.0	2.0	1.0	1.5	0.0	0.8	0.0	0.0	1.8	1.8	0.7	0.7	0.0	0.0	0.3	1.8	0.0	0.0	0.0	1.0		0.0	1.0	0.0	1.0	1.0	1.0
Groundwater	0.7	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.5	0.7	0.4	1.3	0.0	0.3	0.0	-0.2	0.0	1.9	0.0	0.8	0.0	0.0	0.0	1.5	0.0	0.0	0.0	1.5		0.0	1.0	0.0	1.0	1.0	1.0
Surface	0.0	0.3	0.1	0.2	0.0	-0.1	0.0	0.0	0.0	1.3	0.0	0.4	0.0	0.0	-0.2	-0.2	0.1	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3		2.0	1.0	2.0	1.0	0.0	1.0
Water Retention	-0.7	-1.0	1.6	0.9	-1.1	-1.1	0.0	0.0	2.0	1.0	1.4	1.3	0.0	0.5	0.0	-0.1	1.8	1.8	1.3	0.7	-1.0	-0.7	0.8	1.5	0.0	0.0	0.0	0.0		2.0	1.0	2.0	1.0	0.0	1.0
Grand Total	0.2	0.5	0.6	0.9	-0.1	0.1	0.1	0.0	0.6	1.2	0.4	0.8	0.3	0.7	-0.1	0.0	0.7	0.9	0.2	0.4	0.1	0.6	0.2	1.0	0.6	0.5	0.1	0.7		0.5	1.3	0.5	1.3	0.4	1.0

GOODS & SERVICES ON THE FARM

MAARHUIS FARM ECOSYSTEM



PROCESSES

- SOIL DEVELOPMENT
- WATER CYCLING
- AIR CYCLING

GOODS & SERVICES

- AIR SERVICES
- SOIL DEVELOPMENT
- WATER INFILTRATION
- CLIMATE REGULATION
- MARKET GOODS
- AESTHETIC APPEAL
- RECREATION OPPORTUNITIES
- WILDLIFE AND POLLINATOR HABITAT

BENEFITS

CLEAN AIR
Trees and soil microbes filter air, release oxygen, and store carbon.

DRINKING WATER + FLOOD PROTECTION
Healthy soils filter and hold water like a sponge, soaking up rainfall and releasing it slowly in dry periods to crops and streams.

SHELTER FOR HOMES + CROPS
Shelter-belts protect homes and crops from strong winter winds, and provide habitat for birds, pollinators and other wildlife (including kids!)

HEALTHY FOOD + RESOURCES
Farms produce food, livestock, and wood. Local, nutritious food is the foundation of human health.

INSPIRATION
Farming landscapes provide historical context and sense of identity and place.

PHYSICAL + MENTAL FITNESS
Access for recreation promotes activity and social interaction. Just seeing green landscapes improves physical and mental health.

POLLINATION
30% of foods we eat are pollinated by bees. Native pollinators increase fruit-set in neighbouring farms and gardens.

WILDLIFE
Predators, game and endangered species all find homes on agricultural land.

DISSERVICES

EXCESS WATER
Too much water floods lands and reduces productivity. Swales and ponding lower production, but help to infiltrate water and reduce flooding downstream.

WILDLIFE HABITAT
Wildlife can be pests as well as benefits. Birds and bears can damage a field crop, but increase the aesthetic appeal of a landscape.

ECOSYSTEM GOODS & SERVICES ON
DAIRY FARMS IN THE FRASER VALLEY OF BC

MAARHUIS FARM
CASE STUDY

In addition to food, farmlands produce a range of 'ecosystem services' that benefit people and play a key role in community health.

More 'natural' areas are especially good at producing non-market services. These include everything from rainwater infiltration and soil development to recreation and visual appeal. Farmers bear the cost of managing natural areas without recognition or incentive to maintain, restore and invest in them.

This pamphlet examines land use on Holberg Farm and the ecosystem services it provides.

FRASER VALLEY WATERSHEDS COALITION
Healthy Watersheds, Healthy Communities

BCAC BC AGRICULTURE COUNCIL *Leading the way together*

BC AGRICULTURAL RESEARCH & DEVELOPMENT CORPORATION ardcorp

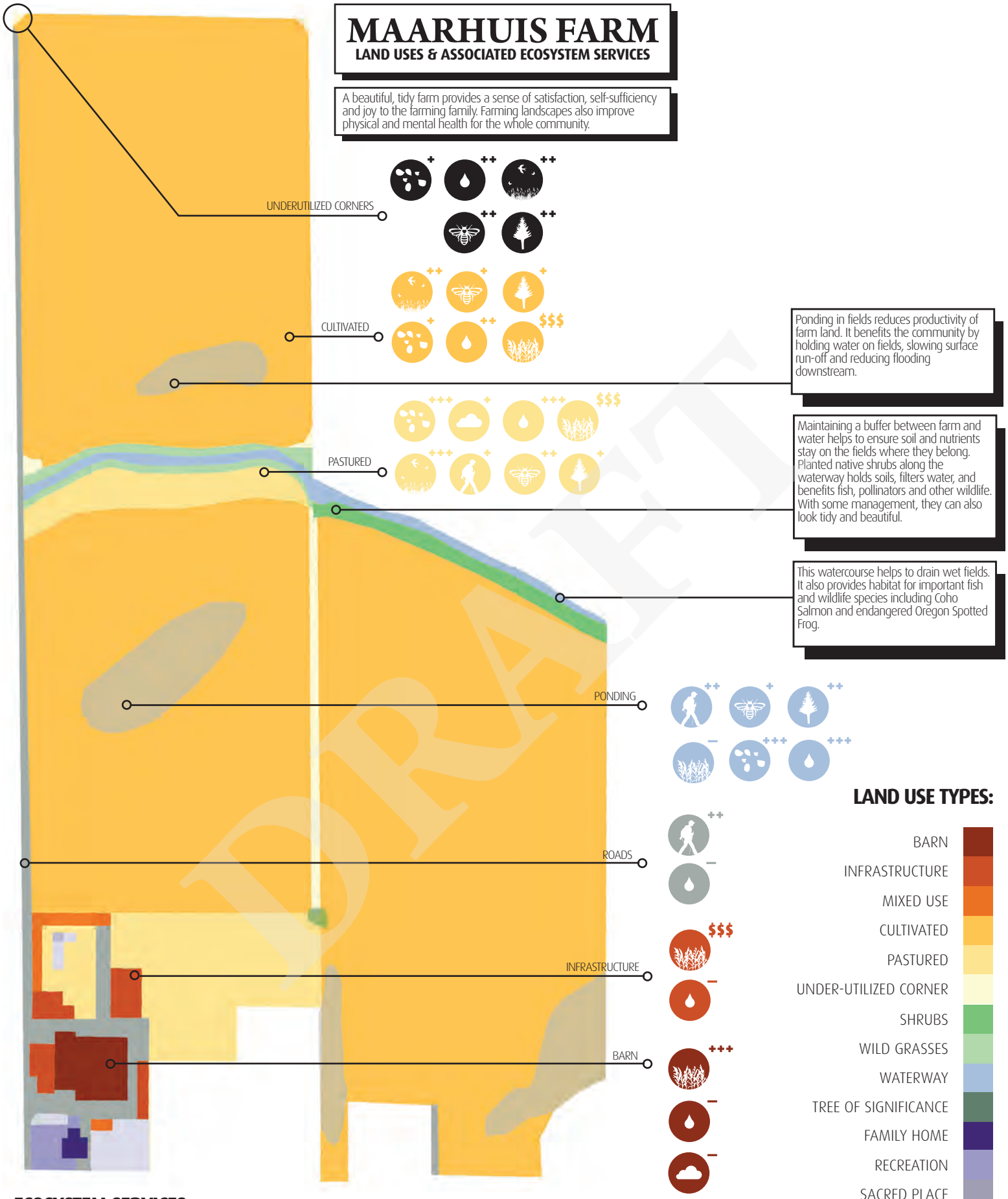
real estate foundation BRITISH COLUMBIA

Canada

MAARHUIS FARM

LAND USES & ASSOCIATED ECOSYSTEM SERVICES

A beautiful, tidy farm provides a sense of satisfaction, self-sufficiency and joy to the farming family. Farming landscapes also improve physical and mental health for the whole community.



Ponding in fields reduces productivity of farm land. It benefits the community by holding water on fields, slowing surface run-off and reducing flooding downstream.

Maintaining a buffer between farm and water helps to ensure soil and nutrients stay on the fields where they belong. Planted native shrubs along the waterway holds soils, filters water, and benefits fish, pollinators and other wildlife. With some management, they can also look tidy and beautiful.

This watercourse helps to drain wet fields. It also provides habitat for important fish and wildlife species including Coho Salmon and endangered Oregon Spotted Frog.

LAND USE TYPES:

- BARN
- INFRASTRUCTURE
- MIXED USE
- CULTIVATED
- PASTURED
- UNDER-UTILIZED CORNER
- SHRUBS
- WILD GRASSES
- WATERWAY
- TREE OF SIGNIFICANCE
- FAMILY HOME
- RECREATION
- SACRED PLACE
- ORCHARD/GARDEN
- ROAD

ECOSYSTEM SERVICES:

SOIL RETENTION | AIR SERVICES | WATER INFILTRATION | CLIMATE REGULATION | MARKET CROPS/GOODS | VISIBLE LANDSCAPES | RECREATION OPPORTUNITIES | POLLINATION | WILDLIFE HABITAT

0 40 80 120 m

GOODS & SERVICES ON THE FARM

HOLBERG FARM ECOSYSTEM

PROCESSES

- SOIL DEVELOPMENT
- WATER CYCLING
- AIR CYCLING

GOODS & SERVICES

- AIR SERVICES
- SOIL DEVELOPMENT
- WATER INFILTRATION
- CLIMATE REGULATION
- MARKET GOODS
- AESTHETIC APPEAL
- RECREATION OPPORTUNITIES
- WILDLIFE AND POLLINATOR HABITAT

BENEFITS

CLEAN AIR
Trees and soil microbes filter air, release oxygen, and store carbon.

DRINKING WATER + FLOOD PROTECTION
Healthy soils filter and hold water like a sponge, soaking up rainfall and releasing it slowly in dry periods to crops and streams.

SHELTER FOR HOMES + CROPS
Shelter-belts protect homes and crops from strong winter winds, and provide habitat for birds, pollinators and other wildlife (including kids!)

HEALTHY FOOD + RESOURCES
Farms produce food, livestock, and wood. Local, nutritious food is the foundation of human health.

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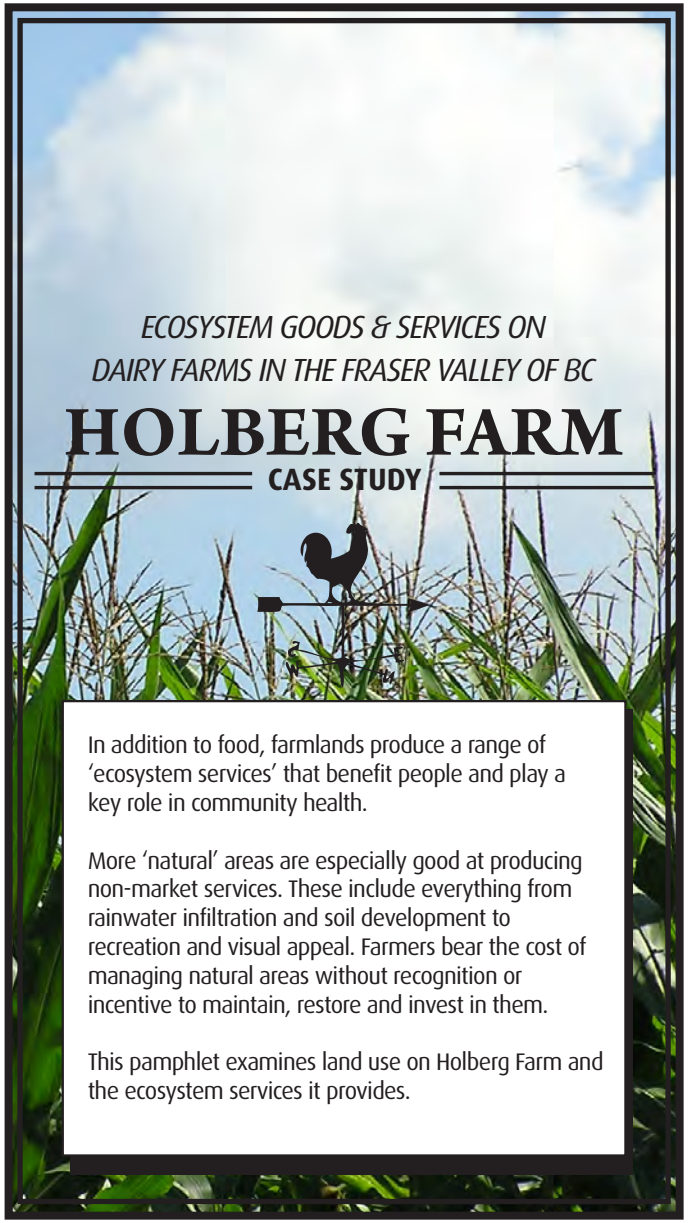

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FRASER VALLEY WATERSHEDS COALITION
BCAC BC AGRICULTURE COUNCIL Leading the way together
BC AGRICULTURAL RESEARCH & DEVELOPMENT CORPORATION ardcorp
real estate foundation BRITISH COLUMBIA
Canada

HOLBERG FARM

LAND USES & ASSOCIATED ECOSYSTEM SERVICES

Thirty residential homes border Holberg Farm. Local residents use the public trails for pleasure and exercise. The farm contributes to a sense of community identity and pride.

Ponding in fields reduces productivity of farm land. It benefits the community by holding water on fields, slowing surface run-off and reducing flooding downstream.

LAND USE TYPES:

- BARN
- INFRASTRUCTURE
- CULTIVATED
- PASTURED
- UNDER-UTILIZED CORNER
- ORCHARD/GARDEN
- BIG OLD TREE
- SHELTER-BELT
- MIXED FOREST
- PONDING
- ROAD
- FAMILY HOME
- PUBLIC TRAIL
- RECREATION

Shelter-belts and mixed forest make up **7%** of the farm's land-base. Annually, these trees remove an estimated:

- 8 lbs (3.7 kg) of Carbon Monoxide
- 64 lbs (29 kg) of Ozone
- 207 lbs of (94 kg) of Particulate Matter
- 42.4 T (39.4 metric T) of Carbon Dioxide

Source: www.itreetools.org/icanopy

ECOSYSTEM SERVICES:

MARKET GOODS | AESTHETIC APPEAL | RECREATION OPPORTUNITIES | AIR PURIFICATION | WATER INFILTRATION | CLIMATE REGULATION | SOIL RETENTION | POLLINATION | WILDLIFE HABITAT