Spotlight

ECOLOGICAL GOODS AND SERVICES

Advancing Canadian Agriculture by Supporting Ecological Goods and Services

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A discussion paper developed and presented by the Arrell Food Institute at the University of Guelph

ARRELL FOOD INSTITUTE
AT THE UNIVERSITY of GUELPH

CONTENTS

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EXECUTIVE SUMMARY

Ecological Goods and Services (EG&S) are benefits that humans receive from their ecosystems, and are essential for healthy, functioning, and sustainable agricultural landscapes. The provision of EG&S is often seen as counter to agricultural productivity; however, they provide major benefits to agricultural landscapes. Natural areas provide trillions of dollars in EG&S globally through carbon sequestration, water purification, reduced soil erosion, and foraging and habitat provision for insects and wildlife, as well as cultural services that support spiritual, mental, and physical well-being, recreation, and other community benefits. EG&S are mainly achieved through farm management (e.g. cover cropping) and the establishment or maintenance of natural habitats (forest, native prairie, wetlands) and semi-natural habitats (buffer strips, woodlots, man-made water features, hedgerows).

There are several program, policy, and market-based solutions within Canada that have attempted to address this issue. Here we present examples of solutions that protect existing-, restore degraded-, and establish new EG&S within existing agricultural landscapes, largely based on monetary incentive structures that provide direct (e.g. payment) or indirect (e.g. tax break) compensation. While these examples provide a starting point, better valuations and measurements are needed that consider the multiple EG&S benefits gained from maintaining a natural or semi-natural area or letting areas of cultivated land naturalize, as well as the time scale required to see benefits. These structures generally also fail to recognize intrinsic and cultural values of existing landscape features and lack strategies for the long-term adoption of ecological practices, such as improving peer-to-peer learning between farmers, involving farmers in agricultural research and policy development, and acknowledging the economic and policy obstacles that farmers face in adopting innovative environmentally based management on their lands.

There are opportunities to develop better incentive structures, and indirectly incentivize ecological practices through improved value-chain support, harmonization with internationally recognized sustainability standards, and improved understanding by farmers, administrators, and the broad public of how land tenure impacts the provision of EG&S.

This discussion paper shares information with policy advisors related to the mechanisms and opportunities to increase Ecological Goods and Services in Canadian agricultural landscapes and develop collaborative research.

WHAT YOU WILL LEARN

- Limitations restricting widespread adoption of programs delivering Ecological Goods and Services in agriculture.
- Challenges to policy and program development for promoting Ecological Goods and Services.
- Solutions to increasing Ecological Goods and Services through policy, markets and behavioural shifts.
- Future research collaborations and key opportunities for policy advisors.

Definitions

For purposes of clarity, the following definitions are used for this paper:

Agricultural Landscape
Coupled human and natural ecosystems to produce food under different levels of management intensity, from relatively unmanaged to intensively modified. A mosaic of farm fields that produce food, fibre and fuel, semi-natural and natural habitats, and human infrastructure (i.e. roads, ditches, buildings, etc.) along a continuum of highly simplified to ecologically complex.[5,13]

Carbon Sequestration
Carbon sequestration is the process of capture and long-term storage of atmospheric carbon dioxide (CO_2). Sequestration is possible through a range of processes, including those occurring naturally in plants (e.g. photosynthesis) and soils. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change.[3]

Ecosystem Process
The physical, chemical, and biological actions that link organisms to the environment. This includes ecosystem processes such as decomposition, nutrient cycling, and fluxes of nutrients and energy.

Ecological Goods & Services
Benefits that humans obtain from ecosystems and their processes. These can include provisioning services such as food production, regulating services against floods and disease control (additional service); cultural services such as spiritual, recreational, mental wellbeing and cultural benefits (intrinsic value); and supporting services such as nutrient cycling that maintain the conditions for life on Earth (ecosystem processes).[1,12]

Externalities
A consequence of an agricultural activity that affects others without being reflected in the cost of the product.[62]

Positive: Establishment of windbreaks; can reduce erosion and capture carbon.
Negative: Water pollution from fertilizer runoff; consumer does not pay for the clean-up of excess nutrient loading.

Groundwater Recharge
Groundwater recharge is a hydrologic process where water moves downward from surface water to groundwater. Recharge is the primary method in which water enters an aquifer. Recharge occurs through both natural (the water cycle) and anthropogenic processes (i.e., artificial groundwater recharge), where rainwater and or reclaimed water is routed to the subsurface.[2]

Nutrient Retention
Ability of soil to retain nutrients (particularly Nitrogen and Phosphorus) required for plant growth. Nutrients added to farmland, such as by application of fertilizers, need to be retained in the soil to be taken up by crops. Nutrient run off into surrounding soils and waterways can be highly problematic.[4]

Spatial Scale
Extent of an area over which a phenomenon or process occurs. For example, nutrient loading in streams is a much smaller scale than the algal blooms in Lake Erie. Spatial scale refers to an area.[13]

Stewardship
Implementing or supporting practices that protect or improve the quality of resources such as water, air, soils, pollinators, wildlife, and crop and livestock diversity.[63]

Sustainability
Implementing systems that meet current economic, environmental, and social needs of the present without compromising the ability of future generations to meet their own needs.[11]
The avoidance of depleting natural resources to maintain ecological balance.

Temporal Scale
Extent of time (past or future) over which a phenomenon or process occurs. For example, how much nutrients are in a river before a riparian buffer area vs after. Temporal scale refers to a time frame.[23]

INTRODUCTION

This discussion paper provides an overview of the role of **Ecological Goods and Services (EG&S)** in Canadian **agricultural landscapes**. EG&S are products of healthy, functioning ecosystems and provide many benefits to people. Goods and services produced within agricultural landscapes can either be valued by markets (e.g. grains, vegetables, livestock, etc.) or be considered outside of conventional market systems (e.g. pollination services, biodiversity, clean air, societal benefits).[1] The latter are often referred to as Ecological Goods and Services to indicate the ecosystem benefits that can come from well managed agricultural landscapes. These important services, such as groundwater recharge[2], carbon sequestration[3], nutrient retention[4], and provision of wildlife habitat, while valued by society at a theoretical, or inherent level, are not bought and sold within conventional market systems.[5] While traditional market systems place an emphasis on economic value of EG&S, ignoring the substantial environmental and cultural values fails to recognize their essential contribution. Thus, these important ecosystem functions are often undervalued by current market structures, which places a potentially unfair burden on farmers who provide these services to society. In addition, supporting Ecological Goods and Services is often thought to limit productivity, but often has the opposite effect. As such, the management of EG&S is an important investment in economic, environmental and social **sustainability**.[1] This poses the question: how do we create sustainable solutions that incorporate Ecological Goods and Services to enhance Canadian agriculture?

> Ecological Goods and Services: Ecosystems provide food and clean water, manage disease, regulate climate, and can provide spiritual fulfillment.[1]

Assigning a monetary value to EG&S can highlight their importance and create incentives for their effective management. The David Suzuki Foundation and The Economics of Ecosystems and Biodiversity Institute (hosted by the United Nations) have valued EG&S across Canada and internationally[6,7], and both found that natural areas can provide trillions of dollars per year from EG&S.[6,7] These value estimations are determined in several ways, including assessing economic damages, the willingness of individuals to pay for EG&S, and the willingness to accept compensation for losses.[7] Nature often provides a multitude of EG&S for free, such as clean water, carbon storage, food provisioning, and nutrient cycling.

Understanding the value of EG&S could assist the introduction of monetary incentives to preserve EG&S in agricultural landscapes and increase appreciation of these natural areas by helping us to understand how much they are worth.

Agriculture is both a provider and beneficiary of EG&S. Ecological Goods and Services are naturally occurring in agricultural landscapes and can be enhanced through the effective management of soil, cover cropping, and the protection of riparian systems, streams, wetlands, woodlots, and grasslands (see Figure 1). Proactive and preventative programs to support the provision of EG&S lead to better outcomes compared to reactionary programs that serve to stop environmental degradation. Approximately 60% of all land ecosystems are degrading at an increasing rate. Once these systems reach a critical point of degradation, restoration will become extremely difficult or even impossible.[1]

Significant land-use change, such as changing from one production system to another (e.g. tree cover, wetland, or native grassland converted to conventional agriculture), can have a negative effect on the landscape and consequently the provision of EG&S. For example, the first metre of soil contains a significant amount of carbon.[8] As a result, greenhouse gas emissions are increased when land is converted from forests to agriculture because 42% of soil organic carbon is lost in the process.[9,10] Maintaining established tree or permanent perennial plant cover prevents additional carbon releases to the atmosphere, as well as providing an abundance of other EG&S to the agricultural landscape such as wildlife habitat, nutrient retention, water and air purification, and social and cultural wellbeing through nature recreation (see Figure 1).

Ecological Goods and Services are an essential aspect of healthy, functioning, and sustainable agricultural landscapes. This paper provides examples of existing EG&S policies and programs, as well as market-based solutions that have been adopted in Canada. Broadly, we outline solutions that protect existing-, restore degraded-, and establish new EG&S within existing agricultural landscapes. These examples highlight and inform emerging policy opportunities, future considerations, and directions for providing EG&S.

FIGURE 1

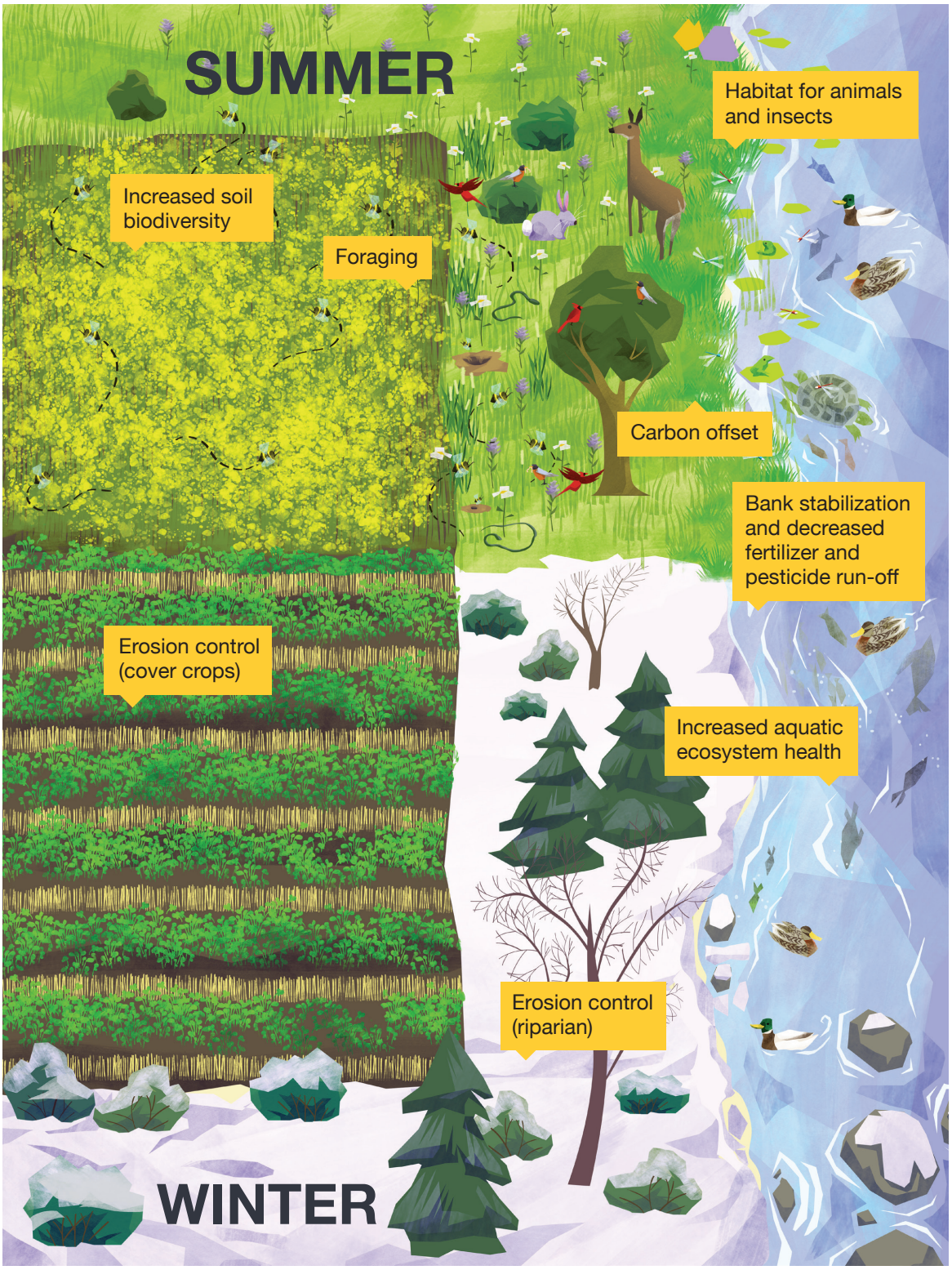

Figure 1 depicts an agricultural landscape with a riparian buffer strip — an area of grasses, shrubs, and trees that provides a barrier between agricultural activities and the watercourse.[14] This landscape provides multiple EG&S within fields and riparian areas which are listed below.

Legend

Increased soil biodiversity
Soil biodiversity is added through crop rotation, cover cropping and reduced tillage.[15] Riparian buffer areas offer greater soil microbiome diversity through several different plant interactions.[16,17]

Pollinator foraging
Pollinator foraging is increased (through provision of more diverse and abundant flowers as sources of nectar and pollen) in areas of trees and perennial grasslands next to agricultural activities.[18]

Animal habitat
Riparian buffer areas and field margins provide habitat for a variety of animals e.g. birds nesting in trees, plants as food sources for predatory insects & arachnids and nesting opportunities for insect pollinators.[18–21]

Carbon offset
Riparian buffer areas can reduce the amount of atmospheric carbon dioxide by sequestering carbon in the soil and vegetation.[22,23]

Bank stabilization and decreased fertilizer and pesticide run-off
Riparian buffer areas stabilize stream banks through the strong root development of grasses and shrubs[15,24] and also work as a catchment for excess fertilizer and pesticide that may runoff into waterways. The fertilizer and pesticides are taken in by the roots of trees, shrubs and grasses.[14]

Erosion control (cover crops)
Cover crops stabilize the soil and reduce wind erosion outside the cropping period – particularly important in winter.

Erosion control (riparian)
Riparian buffer areas can reduce soil erosion by stabilizing the soil with improved root structure and reducing the strength of wind moving across the landscape.[15,21,23]

Increased aquatic ecosystem health
Riparian buffer areas can reduce the amount of soil, fertilizer and pesticide runoff, which increases water quality, and balances pH.[14,25,26] Trees in riparian areas provide shade, lowering stream temperature and increase habitability for aquatic animals.[21,24–26] All are factors in ecosystem health and biodiversity.

INCREASING ECOLOGICAL GOODS AND SERVICES IN CANADIAN AGRICULTURE

Policy and Program Options

EG&S associated with agricultural landscapes, such as groundwater recharge, carbon sequestration, and provision of wildlife habitat, while valued innately by society, are not bought and sold in conventional market systems. The current market is set up to sell tangible items only, such as crops for food, fibre, or fuel, meaning services such as climate control and natural hazard mitigation are not easily valued in the market.[27] The absence of a market for environmental services represents a 'market failure',[28] prioritizing land conversion and revenue generation over conservation.[27] Ironically, as we delay creating and implementing a system to value EG&S, the value of these services increases due to growing scarcity of land suitable for providing EG&S and increased costs to supplementing natural processes (e.g., farmers paying to rent managed honeybees to pollinate crops when there are insufficient wild pollinators present in the landscape to do this job for free[29]). However, this is only true to a critical point after which the entire system is so degraded (e.g., oxygen-deprived dead-zones, drought) that intervention may become ineffective. For example, as fertilizer run-off increases, so does the cost of cleaning up waterways that it has infiltrated. As the cost for clean-up increases, the value of planted areas of vegetation beside waterways (riparian strips) that can prevent runoff also increases. This increase in value continues until the point when the water course is so degraded that natural processes are irrecoverable (at which point the value of riparian strip becomes zero).

Despite this dilemma of a 'market failure', multiple organizations (including the Food and Agriculture Organization (FAO) and the Organization for Economic Co-operation and Development (OECD)) have estimated values for EG&S associated with farming.[28,30] More importantly, systems have been implemented to create direct (e.g., payment for maintaining landscape features) or indirect (e.g.,tax credits) mechanisms so that value can be extracted from the marketplace. For example, Bill 28, ***Alternate Land Use and Services Program for Agricultural Land Act*** passed second reading in the Legislative Assembly of Ontario in 2018. This bill proposes a voluntary program so that agricultural land-owners can receive incentives for production of EG&S through setting aside land or establishing new EG&S projects, although full details are not available at the time of writing.[31] EG&S provision can also be achieved by targeting and promoting on-farm practices such as cover cropping (see case study).[32-34] Cover crops offer several EG&S, such as soil erosion control, increased microbial biodiversity, and

increased soil health and fertility. The following are other examples of policy and program-based solutions that have been implemented across Canada.

Environmental Farm Plans

Across Canada, all provinces and one territory offer Environmental Farm Plan (EFP) programs to enhance awareness and education of environmental conditions and Best Management Practices (BMPs) on the farm. Although EFPs are delivered differently across the country, there are often opportunities for farmers to apply for cost-shared funding programs to implement projects that improve on-farm environmental management practices. These practices will often result in enhancing EG&S. For example, Ontario's Canadian Agricultural Partnership Funding Program includes project funding to support the development of riparian buffer strips to prevent nutrient and soil loss into nearby waterways. The activities supported by this program include establishing permanent plant cover on field margins and purchasing and planting non-invasive trees, shrubs, wildflowers, and grasses to stabilize riparian areas. Through such cost-sharing programs, individual farmers can access financial support to implement projects that reduce environmental risk on the farm, as well as gain valuable learning tools.

There is additional potential for EFPs to stimulate economic activity in international markets as well as reduce insurance costs for farmers. With increased environmental concern, international markets are requiring more stringent environmental regulations for the production of their imports. Harmonization with internationally recognized standards, such as the International Organization for Standardization (ISO) sustainability standards would allow provincial EFPs to be recognized globally, thereby accessing novel markets. While EFPs are not currently ISO Certified, an ISO Certification of provincial EFPs could result in additional benefits such as insurance companies offering lower insurance rates for farmers.[35]

Conservation Land Tax Incentive Program

The Ontario Ministry of Natural Resources and Forestry (MNRF) administers the Conservation Land Tax Incentive Program (CLTIP) that encourages private land stewardship of provincially important natural heritage features.[36] Under this program, a portion of the land-owner's property may be eligible for 100% property tax exemption. Eligibility must be demonstrated through one of four features present on the property: provincially significant wetlands; provincially significant areas of natural and scientific interest; habitats of regulated endangered species; and designated 'natural area' within the Niagara Escarpment Plan. Regular farming practices may take place if the natural features are underground (such as an aquifer, geological formations, or habitat for endangered species) or in marginal land, while other features may constrain farming activities. When participating, landowners agree to protect the feature and allow MNRF staff to inspect the site when necessary. Recent research shows that CLTIP participants were as likely to engage in conservation behaviours as landowners who are not in the program,[33] clearly demonstrating that participation in incentive programs is not strictly financially motivated.

STRATEGIES FOR ESTABLISHING ECOSYSTEM SERVICES

CASE STUDY 1: COVER CROPS FOR SOIL HEALTH

Soil erosion costs Canada $3.1B per year.[32] Cover crops are grown to support ecosystem health, rather than for harvestable products.[33]

What are the benefits?
Cover crops are planted for enrichment and protection of soil. They provide:

- Reduced soil erosion over winter
- Reduced soil erosion from water runoff
- Additional income from cover crops
- Increased soil health & fertility

Numerous organizations in Ontario have championed the use of cover crops, including the Ontario Ministry of Agriculture, Food and Rural Affairs' New Horizons program.[34] **As a result, the number of farmers using cover crops** has more than doubled in Ontario from 12% in 2011 to 25% in 2016.

Cover crops can be used for forage and biofuel, though they may no longer be considered cover crops.

CASE STUDY 2: AGROFORESTRY

Agroforestry outperforms conventional agricultural systems for marketable and non-marketable ecosystem services.

What is it?
Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland.

How does it help?
This intentional combination of agriculture and forestry has varied benefits such as:

- Reduced pollution
- Reduced nutrient loss
- Reduced soil loss
- Increased carbon capture
- Increased wildlife habitat
- Economic gains

Bonus: Trees can provide supplementary income from fruit, nuts, or lumber.

ALUS is the longest running paid EG&S system in Canada

ALUS is a farmer-driven, fee-for-service approach that offers farmers annual payments for the provisioning and enhancement of Ecological Goods & Services. ALUS invests in farmers and ranchers who are producing clean air, clean water, wildlife habitat and other ecological goods & services in communities across Canada. It currently operates in 6 provinces.

Some examples of funded projects:

- Expanded riparian buffer zones that provide critical wildlife habitat and improve water quality.
- New, enhanced or restored wetlands that improve water quality and can protect communities against spring flooding and offset the impact of droughts.
- Pollinator hedgerows that provide habitat for native bees which in turn pollinate our agricultural crops.

Between 2008 and 2021, ALUS has enrolled over 32,100 project acres and distributed over $12.3 million to over 1100 farmers and ranchers across Canada.

Ontario Managed Forest Tax Incentive Program

Through the Managed Forest Tax Incentive Program, land owners who get their property classified as 'managed forest' pay 25% of the municipal tax rate set for residential properties.[38] Ontario, for example, already implements a farm-land tax class, where agricultural land-owners pay a maximum of 25% of the municipal property tax for registered land. However, forest land that exists in agricultural landscapes falls under the full residential tax-class rate unless registered with the MNRF as 'managed forest'. Farm properties with a minimum of 4 hectares of managed forest may be eligible. The program requires land owners to submit 5-year progress reports, and updated forest management plans every 10 years. Recent research indicates that the MFTIP program increases the likelihood that landowners will be successful in removing invasive species and planting native species.[37] Retaining managed forests in agricultural land also provides habitat for wildlife, sequesters carbon, and reduces soil, fertilizer, and pesticide runoff.

Market-Based Solutions

The following section provides an overview of market-based solutions that exist to compensate farmers for the provision of EG&S within the Canadian context.

ALUS Canada

ALUS (Alternative Land Use Services) Canada is a national charitable organization that funds projects to enhance EG&S provided by farmers and ranchers that benefit all Canadians. Projects include wetland restoration, reforestation, windbreak planting, installation of riparian buffers, management of drainage systems, and pollinator habitat creation, among others.[39] Most projects focus on marginally productive and/or environmentally sensitive agricultural lands. In addition to funding project costs, ALUS provides per-acre annual payments to farmers maintaining ALUS projects on their land. As a community-delivered program, each ALUS community establishes a Partnership Advisory Committee to direct funding in its area. Approximately half of each Partnership Advisory Committee is made up of farmers.

ALUS works as a mediator to deliver funding from a wide spectrum of sources. These include private donors such as the Weston Family Foundation, federal programs like the Great Lakes Protection Initiative, provincial programs like the Ontario Species at Risk Stewardship Fund, municipal governments, and corporate Canada through the New Acre Project.[39]

Market-based requirements

In order to sell to certain markets, environmental considerations can be made a prerequisite to sale. The Potato Sustainability Initiative was created as a response to concerns by the food industry of pesticide use on potatoes

used for frozen products.[40] As a result, growers of processing potatoes (which, in Canada, are largely concentrated in Alberta and New Brunswick) are required to meet environmental management standards around pesticide use and impact to surrounding landscape in order to supply their goods to major businesses such as McDonald's.[40] Similar models could be applied by existing membership and standards organizations. The Dairy Farmers of Canada (DFC) have already begun this process through their ProAction initiative, which is mandatory for all milk producers in Canada.[41] This program promotes environmental sustainability and is moving towards mandating that all participants develop an EFP. Taken a step further, DFC could require certain best management practices to be included in EFPs, thereby creating a high level environmental standard consistently across the sector. Similar models could be adopted for certifications that exist in wine-growing regions.[42] Certification or enrollment in membership programs can provide benefits such as additional advertising, or increased sales prices.[42,43] Wine growing regions also benefit greatly from tourism in part due to the aesthetics of "ideal" rural and agricultural landscapes.[42,44] However, wine certifications, such as the Vintner's Quality Assurance (VQA) certification, rarely include environmental considerations.[42] Integrating environmental considerations into existing certification structures can have impacts on regional and local scales, as well as align growers to the same sustainability standards.

Conservation Easements

Conservation easements (CE) offer a market-based solution for preserving ecologically significant land. CE's are defined as instruments by which a landowner grants the rights of their land to another party.[45] CE's are written agreements between a landowner and a qualified organization (generally an organization whose core activities include land conservation) identified on the land title. In Canada, eligible CE holders and governance vary from province-to-province. Once donated, it is protected permanently by the recipient organization.

The Ecological Gifts program is an example of a tax-break policy resulting from CE's. The program is administered through Environment Canada. Through this program, private land owners can donate their ecologically significant land by way of conservation easements. Landowners receive a charitable receipt for the fair market value of their donation among other financial benefits*.

Alberta Carbon Offset Program

The Alberta Ministry of Agriculture and Forestry facilitates a carbon offset program, where farmers can sell carbon credits after they adopt an agricultural practice that improves carbon sequestration.[46] Farmers are required to register with aggregation companies, which in turn, sell large bundles of farm offsets to large company purchasers. This gives farmers an opportunity to earn extra income, while reducing their carbon footprint.

* Other advantages include: no tax on capital gains for gifts, no limit on the total value eligible for deduction/credit in any one year and a ten-year period to apply the receipt to income.

EG&S: CHALLENGES IN CANADIAN AGRICULTURE

Gaining Value-Chain Support

The challenge for agriculture and EG&S is that producers benefit only from selling their agricultural commodities, while EG&S, such as pollinator services or wildlife habitat, are more difficult to quantify. The question is, what role could the government play in addressing this gap?

Currently, there is variation between individual provinces' and territories' Environmental Farm Plans. This variability, as well as differing priorities between provinces and in federal policy, contributes to confusion on how to most effectively implement BMPs as well as a lack of understanding of their long-term effectiveness. The Canadian Agri-Food Sustainability Initiative (CASI) is a national initiative to unify sustainability tools and practices while creating a transparent system of accountability for environmental farming practices. This creates assurances throughout the value-chain that sustainability standards are being maintained across the country. For example, producers use an online portal to report on topics such as wetlands and other marginal lands, nutrient management practices, and riparian buffer strip management. Providing transparency through the value-chain allows policy and decision makers to better understand the efficacy of BMPs and work towards developing projects and programs that use and enhance existing EG&S practices.

It is also important to ensure that, as a vital part of the value-chain, consumer perceptions around incentive programs for farmers are positive. Ultimately, an ideal EG&S program is implemented so that consumers recognize the direct beneficial ecological impacts that farming has on the landscape. Such considerations may affect purchasing decisions at the consumer level with effects seen throughout the value-chain.

Market Response Time for Ecological Goods and Services

A key challenge in valuing EG&S is the time lag between implementing a management practice and successfully measuring the resulting EG&S within a feasible time-frame, as it may take multiple seasons for EG&S to be realized. Additionally, the value of the EG&S may change over time. For example, in the Alberta carbon offset program aggregators can hold offsets, and re-sell when the market value goes up. Farmers, however, must register and sell their offsets in that given year — meaning farmers do not see the benefit of the increased value over time.[46] Activities like increasing the capacity for carbon capture have a lag time between implementation and measurable response, and this will also vary with farm size and commodity type. Research has shown that to implement conservation behaviours at the farm level, practices must be economically profitable and result in productivity gains (or, at the very least, do not result in decreased productivity).[47] Measurable productivity gains also depend on farm size. Additionally, there is a lag between research and application at the farm-level. Information dissemination is an opportunity to not only increase the prevalence of practices resulting in the provision of EG&S, but also to communicate the market value of EG&S in agriculture.

> Taking low producing areas out of production would mean that these areas could return to a naturalized state, such as native grasslands or woodlots. Once restored these areas would start to provide more EG&S through habitat creation, increased carbon sequestration, and water purification.[51]

The lag time between implementation of measures to support the provision of EG&S in landscapes and a measurable response will differ depending on the desired outcome. For example, the response of native pollinators in newly established native grasslands will have a quicker measurable response than carbon sequestration. These are inherently different and need to be accounted for when assessing ‘success’. The time scale shift depending on the EG&S will require patience to measure and report on. Importantly, the time it takes to see and measure EG&S can take longer than typical political cycles, meaning tools to allow time to measure outcomes must be incorporated into incentive programs and policy development.

Incentives for Ecological Goods & Services Are Not Always Needed

Incentives are not always needed to maintain lands and practices that provide EG&S. For example, EG&S associated with native grassland can provide services for humans such as food and other raw materials. Plants, animals, and microorganisms provide regulating services such as pollination, prevention of soil erosion and water purification, as well as cultural services, like recreation and a sense of place.[48,49] In some cases the intrinsic value of nature or the added benefit of reducing management intensity is enough motivation to preserve the area, and the associated positive environmental externalities. Nature is not monetized but rather the intrinsic economic and cultural values are recognized. In some cases, monetary incentives for EG&S can cause a loss of intrinsic value. For example, if existing land features are incentivized, farmers may be less inclined to keep those features once the incentive is removed.[50] However, long-term monetary incentives for natural features can be unrealistic and thus intrinsic value should be promoted through education and awareness.

A study from the University of Guelph suggests that using precision agriculture tools can save farmers money by taking low producing areas out of production.[51] Low producing areas requiring greater inputs and producing lower yields make certain parcels of land less profitable. Precision agriculture was used to map areas of high and low productivity over time, which was then linked with economic data on commodity yields compared to the costs of investing in alternative management for EG&S.[51] Taking low profitability areas out of production would return areas to a semi-natural state, such as restored native grasslands or woodlots. Once restored, these areas provide more EG&S through created habitat, increased carbon sequestration, and water purification.[51] By converting marginally productive agricultural land to natural areas that support EG&S, the land owner may derive higher profits from the land in the long term.

Agroforestry is an example of agriculture and EG&S working together. Agroforestry offers the cultivation of crops grown between rows of trees and is further discussed in case study 2.[20,26,52,53]

Other Means of Facilitating Adoption of EG&S Practices

When it comes to the adoption of environmental practice, monetary incentives are not always enough to change behaviour. Incentive programs across the world have seen low enrolment rates in environmental agriculture programs, with research suggesting a link between social factors and the likelihood of enrolling in such programs.[54,55]

Research on landowners in southwestern Ontario found that the likelihood of enrolling in a voluntary land enhancement program was strongly motivated by access to information on how the decline in natural areas would directly affect landowners.[50] When learning about ecological on-farm practices, farmers across Manitoba and Ontario ranked learning from other farmers and neighbours (peer-to-peer) as the most important learning source, followed by independent learning from the internet and print publications. Learning from government programs was ranked much lower than these options by farmers.[56] Integrating farmers into research and policy has shown potential to engage farmers, change the intention and motivation of farmers towards sustainable practices, and bring together diverse learning communities.[56,57] Therefore, there is an opportunity for innovative agricultural and environmental solutions through education, the support of peer-to-peer learning, and encouraging research and practitioner collaboration.

However, other economic factors may still impede action. For example, farmers with diversified incomes that do not rely entirely on farming are more likely to set aside land for conservation.[50] In some circumstances this could mean that assisting farmers to diversify their income (e.g., through tourism or hosting community events) might encourage them to adopt ecological practices. However, such an approach would likely be less feasible or viable for larger-scale farm operations, and could be construed by farmers as an attempt to try and stop them from farming. Overall, this could make suggestions to diversify income streams detrimental if they alienate farmers that might otherwise have engaged with initiatives to support the provision of EG&S. Quick fixes may not support long-term change, and any program or plan should consider benefits as part of a long-term strategy. Longer-term changes to societal beliefs and values sets will likely require substantial inputs of time and resources.[57]

Land Tenure

Farmland in Canada can be owned, rented, or shared[58] and each have their own constraints when it comes to the provision of EG&S. While farmers are generally good stewards of the land, the notion of land tenure poses three main challenges for EG&S:[59]

1. Lease agreements can limit the ability for renters to implement certain practices that result in EG&S.[60]

2. Farmers who farm their own land are more likely to be good stewards because they are more likely to see return on their investment.[60] Unless renters are constrained by terms in their lease agreements, they do not have the same incentives to invest in the BMPs resulting in provision of EG&S as landowners do.

Hectares of farmland in Canada

Owned: 40,319,298 ha
Rented: 16,218,269 ha
Shared: 1,832,424 ha

3. Landowners who are leasing their land may not be incentivized to require practices supportive of EG&S from their tenants.[60]

Of course, the implementation of practices supporting the production of EG&S depends on several other factors including the rental agreement and relationship between owners and renters. Overall, there is evidence to suggest that provision of EG&S may be reduced when land is rented rather than owned[60] and that values of ecosystem services are better predicted by who owns the land (i.e. private, public, or government ownership) than by assigned protected area status.[59] However, work is still needed to fully understand the links between values, land tenure systems, and provision of EG&S.

Long-term Goals and Strategies

The cultural, intrinsic, and aesthetic value of the environment plays an important role in agricultural EG&S, but monetizing this value is difficult. More research is needed to identify economic value of a variety of EG&Ss across Canada.[59] Current evidence suggests that motivation to preserve the intrinsic values of the environment correlates with wider participation and lasting commitments to implementing BMPs that result in the provision of EG&S.[61] The main economic barriers are identifying what is important to society versus what is feasible to protect for the purpose of supporting EG&S, how can payments be provided, and can one strategy work across several spaces (i.e., provision of land in Wellington County versus Okanagan Valley). The literature suggests that place-based market structures are more achievable due to temporal and spatial scale.[1]

Farmers and decision-makers often have different backgrounds, and so communication and collaboration may be more difficult because of differing understanding of local agricultural practices and norms. Directly involving farmers — the implementers of BMPs, EG&S strategies, and regulations — will help to improve uptake and adoption. This suggests that researchers need to adopt an integrated knowledge translation (IKT) model. IKT involves farmers and decision-makers from the onset and throughout the investigation, development, and recommendation processes. IKT has been shown to both enhance the relevance and utility of project outcomes and recommendations and to increase the likelihood of end-user adoption. IKT partnerships involve collaboration and information sharing to define research questions, enhance research design and data collection, strengthen interpretations and policy recommendations and establish plans to improve the integration and uptake of recommendations.

CASE STUDY 2

CREATING VALUE AT THE LANDSCAPE LEVEL FOR HABITAT CONSERVATION

About the program:
Since 2014, hay producers who register their fields with the Credit Valley Conservation Authority as Bird-Friendly Certified agree to delay cutting until July 15.

Grassland birds like the Bobolink and Eastern Meadowlark are threatened by habitat loss due to changes in land use and cover type. These birds prefer to breed and nest in native grasslands.

More animals grazing per acre results in decreased vegetation height. Hay crops are also cut earlier, which coincides with the nesting period for these birds.

The Results

41 Program participants	15 Farmers and **19** properties	388 Acres certified as bird-friendly
267 Bobolink sightings	41 Eastern Meadowlark sightings	22 Pairs of nesting grassland birds

CONCLUSIONS AND FUTURE WORK

Agriculture and Agri-Food Canada (AAFC) recommends that initiatives to support environmental services should be **locally-based, adapted to local conditions, and draw onlocal expertise** and access to local resources. The AAFC recommendation fits well with the objectives of this report.[12]

Ecological Goods and Services are products of healthy, functioning ecosystems. Implementation of practices resulting in the provision of EG&S help create sustainable and resilient agricultural landscapes. Many farmers already champion environmental stewardship practices, whether it be by improving soil health through cover cropping or conserving native bird populations in open pasture fields. Although some farmers are proactively supporting the provision of EG&S on their land, there should be recognition and support from policy advisors, academia and industry leaders to provide research and incentive-based programming, as well as adequate education for farmers on the large-scale, long-term and direct benefits of these practices.

Current market structures undervalue the economic contribution of EG&S and fail to recognize their intrinsic and cultural benefits. Measuring and assigning monetary values to EG&S by introducing relevant market structures is a way to increase their uptake and increase recognition of their importance. For example, environmental farm plans are used to help farmers stay informed about best management practices that not only increase their productivity but also preserve the environment. This could be a steppingstone for a monetized EG&S framework, and collaboration between industry, academics and policy leaders would be necessary to develop market structures that are supportive.

However, introducing an all-encompassing financial incentive system across Canada would not be appropriate for provision of EG&S. Climatic and crop conditions vary from coast to coast to coast. For example, the groundwater recharge capabilities of farmland in a near-urban area may provide significantly more value compared to the same function provided in a sparsely populated rural area. Landscape design for the provision of EG&S is complex, and requires ecologists to engage with other disciplines, stakeholders and policy makers.

Additionally, incentives can be provided through indirect means such as sustainability certification, which can positively influence value chains by providing greater oversight and guidance across different agricultural and environmental management systems. This solution also provides direct benefits to farmers through access to new international markets and indirect benefits like reduced insurance costs.

Additionally, we should strive to create innovative policy solutions that are not only based on the economic value of providing EG&S, but also facilitate collaboration between policymakers, farmers, and researchers. Collaborative projects between researchers and non-governmental organizations (NGOs) like ALUS could improve provision of EG&S in marginal agricultural lands. Policy should also integrate effective learning strategies that promote intrinsic valuations of EG&S to promote long-term adoption of sustainable practices. Further, food systems will benefit from transparency to consumers about the EG&S provided by agricultural landscapes. Academia, government, NGOs, and farmers should work together to make this a reality for the Canadian agricultural sector.

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Workshop Summary

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Workshop Participants

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REFERENCES

[1] Roy D, Venema HD, McCandless M (2011) Ecological Goods and Services: a review of best practice in policy and programing. Report prepared by The International Institute of Sustainable Development for Manitoba Water Stewardship. pp. 85. https://www.iisd.org/system/files/publications/egs_policy_programing.pdf

[2] Peters NE, Böhlke JK, Brooks PD, Burt TP, Gooseff MN, Hamilton DP, Mulholland PJ, Roulet NT, Turner JV (2011) 2.11 — Hydrology and Biogeochemistry Linkages. *Treatise on Water Science*, Ed. P. Wilderer, Elsevier. pp. 271–304. doi:10.1016/j.baae.2016.07.005

[3] Sedjo R, Sohngen B (2012) Carbon sequestration in forests and soils. *Annual Review of Resource Economics* 4: 127–153. doi:10.1146/annurev-resource-083110-115941

[4] Hedlund K (2012) Agriculture and ecosystem services: soils and retention of nutrients. Policy Brief from SoilService Project. http://www.reading.ac.uk/caer/documents/pb_nutrient.pdf

[5] Landis DA (2017) Designing agricultural landscapes for biodiversity-based ecosystem services. *Journal of Basic and Applied Ecology* 18: 1–12. doi:10.1016/j.baae.2016.07.005

[6] The Economics of Ecosystems and Biodiversity (TEEB) (2018) Measuring what matters in agriculture and food systems: a synthesis of the results and recommendations of TEEB for Agriculture and Food's Scientific and Economic Foundations Report. Report prepared by UN Environment. pp. 73. http://teebweb.org/our-work/agrifood/reports/measuring-what-matters-synthesis/

[7] Wilson S (2013) Nature on the edge: Natural capital and Ontario's growing golden horseshoe. Report prepared for the David Suzuki Foundation. pp. 33. https://davidsuzuki.org/wp-content/uploads/2018/02/nature-edge-natural-capital-ontario-golden-horseshoe.pdf

[8] Lemus RW, Lal R (2005) Bioenergy crops and carbon sequestration. *Critical Reviews in Plant Sciences* 24: 1–21. doi:10.1080/07352680590910393

[9] Guo LB, Gifford RM (2002) Soil carbon stocks and land use change: a meta analysis. *Global Change Biology* 8: 345-360. doi:10.1046/j.1354-1013.2002.00486.x

[10] de Vries W, Kros J, Kroeze C, Seitzinger SP (2013) Assessing planetary boundaries related to food security and adverse environmental impacts. *Current Opinion in Environmental Sustainability* 5: 392–402. doi:10.1016/j.cosust.2013.07.004

[11] United Nations (2018) Sustainable Development Goals. https://sustainabledevelopment.un.org

[12] Agriculture and Agri-food Canada (AAFC) (2011) Ecological goods and services: policy considerations for Canadian agriculture. pp. 69. http://publications.gc.ca/collections/collection_2013/aac-aafc/A22-576-2013-eng.pdf

[13] Marshall EJP (2004) Agricultural landscapes: field margin habitats and their interaction with crop production. *Journal of Crop Improvement* 12: 365–404. doi:10.1300/J411v12n01_05

[14] Stutter MI, Chardon WJ, Kronvang B (2012) Riparian buffer strips as a multifunctional management tool in agricultural landscapes: introduction. *Journal of Environmental Quality* 41: 297-303. doi:10.2134/jeq2011.0439

[15] Power AG (2010) Ecosystem services and agriculture: tradeoffs and synergies. *Philosophical Transactions of the Royal Society B* 365: 2959–2971. doi:10.1098/rstb.2010.0143

[16] Vasileiadis S, Puglisi E, Arena M, Cappa F, van Veen JA, Cocconcelli PS, Trevisan M (2013) Soil microbial diversity patterns of a lowland spring environment. *FEMS Microbiology Ecology* 86: 172–184. doi:10.1111/1574-6941.12150

[17] McCracken DI, Cole LJ, Harrison W, Robertson D (2012) Improving the farmland biodiversity value of riparian buffer strips: conflicts and compromises. *Journal of Environmental Quality* 41: 355–363 doi:10.2134/jeq2010.0532

[18] Cole LJ, Brocklehurst S, Robertson D, Harrison W, McCracken DI (2015) Riparian buffer strips: their role in the conservation of insect pollinators in intensive grassland systems. *Agriculture, Ecosystems and Environment* 211: 207–220. doi:10.1016/j.agee.2015.06.012

[19] Yang W, Liu W, Liu Y, Corry RC, Kreutzwiser RD (2014) Cost-effective targeting of riparian buffers to achieve water quality and wildlife habitat benefits. *International Journal of River Basin Management* 12: 43–55. doi:10.1080/15715124.2014.880710

[20] Gibbs S, Koblents H, Coleman B, Gordon A, Thevathasan N, Williams P (2016) Avian diversity in a temperate tree-based intercroppingsystem from inception to now. *Agroforestry Systems* 90: 905–916. doi:10.1007/s10457-016-9901-7

[21] Jose S (2009) Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry Systems* 76: 1–10. doi:10.1007/s10457-009-9229-7

[22] Coleman B, Bruce K, Chang Q, Frey L, Guo S, Tarannum MS, Bazrgar A, Sidders D, Keddy T, Gordon A, *et al.* (2018) Quantifying C stocks in high-yield, short-rotation woody crop production systems for forest and bioenergy values and CO2 emission reduction. *The Forestry Chronicle* 94: 260–268. doi:10.5558/tfc2018-039

[23] Dade MC, Mitchell MGE, McAlpine CA, Rhodes JR (2018) Assessing ecosystem service trade-offs and synergies: the need for a more mechanistic approach. *Ambio* 48: 1116–1128. doi:10.1007/s13280-018-1127-7

[24] Lee P, Smyth C, Boutin S (2004) Quantitative review of riparian buffer width guidelines from Canada and the United States. *Journal of Environmental Management* 70: 165-180. doi:10.1016/j.jenvman.2003.11.009

[25] Newbold JD, Herbert S, Sweeney BW, Kiry P, Alberts SJ (2010) Water quality functions of a 15-year-old riparian forest buffer system. *Journal of the American Water Resources Association* 46: 299–310. doi:10.1111/j.1752-1688.2010.00421.x

[26] Thevathasan NV, Coleman B, Zabek L, Ward T, Gordon AM (2018) Agroforestry in Canada and its role in farming systems. Temperate Agroforestry Systems, Eds. Gordon AM, Newman SM, Coleman BRW. CABI, pp. 7–49.

[27] Dronamraju KR (2002) The Economics of Biodiversity. *Biological Wealth and Other Essays* 126–145. doi:10.1142/9789812706546_0029

[28] Lipper L, Neves B (2011) Payments for environmental services: what role in sustainable agricultural development? ESA Working Paper No. 11–20: http://www.fao.org/3/a-an456e.pdf

[29] IPBES (2016) The assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production. SG Potts, VL Imperatriz-Fonseca and HT Ngo (Eds). Bonn, Germany, Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services: 552 pp. https://www.ipbes.net/sites/default/files/downloads/pdf/individual_chapters_pollination_20170305.pdf

[30] Smith R (2004) A Capital-based Sustainability Accounting Framework for Canada. Measuring Sustainable Development: Integrated Economic, Environmental and Social Frameworks, OECD Publishing, Paris. pp. 111–128. https://doi.org/10.1787/9789264020139-10-en

[31] Barrett T (2018) Bill 28: An Act respecting a voluntary program for the alternative use of agriculture land and the production of ecosystem services on that land. Legislative Assembly of Ontario: https://www.ola.org/sites/default/files/node-files/bill/document/pdf/2018/2018-08/b028_e.pdf

[32] Arnason R (2019) Soil erosion costs farmers $3.1 billion a year in yield loss: scientist. The Western Producer: https://www.producer.com/news/soil-erosion-costs-farmers-3-1-billion-a-year-in-yield-loss-scientist/

[33] Ogilvie CM, Deen W, Martin RC (2019) Service crop management to maximize crop water supply and improve agroecosystem resilience: a review. *Journal of Soil and Water Conservation* 74: 389–404. doi:10.2489/jswc.74.4.389

[34] Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) (2019) *New Horizons: Ontario's Agricultural Soil Health and Conservation Strategy*: http://www.omafra.gov.on.ca/english/landuse/soil-strategy.htm

[35] Schmidt C, Sweetland J, Mussell A (2013) Potential role of the Ontario Environmental Farm Plan in responding to sustainability demands of the Agri-food supply chain. George Morris Centre. pp. 72. https://www.canadianfga.ca/wp-content/uploads/2013/12/OSCIA-EFP-FINAL-Report-June-25-13-1.pdf

[36] Ontario Ministry of Natural Resources and Forestry (2019) Conservation Land Tax Incentive Program Ministry of Natural Resources and Forestry: https://www.ontario.ca/page/conservation-land-tax-incentive-program

[37] Drescher M, Epstein GB, Warriner GK, Rooney RC (2019) An investigation of the effects of conservation incentive programs on management of invasive species by private landowners. *Conservation Science and Practice* 1: e56. doi:10.1111/csp2.56

[38] Ontario Ministry of Natural Resources and Forestry (2020) Managed Forest Tax Incentive Program: https://www.ontario.ca/page/managed-forest-tax-incentive-program

[39] Kolinjivadi V, Mendez AZ, Dupras J (2019) Putting nature 'to work' through Payments for Ecosystem Services (PES): tensions between autonomy, voluntary action and the political economy of agri-environmentalpractice. *Land Use Policy* 81: 324-336. doi:10.1016/j.landusepol.2018.11.012

[40] Swaffield SR, Corry RC, Opdam P, McWilliam W, Primdahl J (2019) Connecting business with the agricultural landscape: business strategies for sustainable rural development. *Business Strategy and the Environment* 28: 1357–1369. doi:10.1002/bse.2320

[41] Dairy Farmers of Canada (2020) The ProAction Initiative — Environmental Module: https://www.dairyfarmers.ca/proaction#environment

[42] Oles T (2016) Wine trails as organizational pathway toward landscape coherence: the case of the Finger Lakes region, New York, USA. *Geografisk Tidsskrift — Danish Journal of Geography* 116: 24–32. doi:10.1080/00167223.2015.1111767

[43] Ugochukwu AI, Hobbs JE, Bruneau JF (2017) Determinants of wineries' decisions to seek VQA certification in the Canadian wine industry. *Journal of Wine Economics* 12: 16–36. doi:10.1017/jwe.2016.28

[44] Holmes MR (2017) Integrated rural wine tourism: an integrated approach. *Journal of Wine Research* 28: 216–238. doi:10.1080/09571264.2017.1336081

[45] Good K, Michalsky S (2008) Summary of Canadian experience with conservation easements and their potential application to agri-environmental policy. Agriculture and Agri-food Canada. pp. 46. http://publications.gc.ca/collections/collection_2011/agr/A125-17-2011-eng.pdf

[46] Government of Alberta (2019) Agricultural carbon offsets: https://www.alberta.ca/agricultural-carbon-offsets-overview.aspx

[47] Cary JW, Wilkinson RL (1997) Perceived profitability and farmers' conservation behaviour. *Journal of Agricultural Economics* 48: 13–21. doi:10.1111/j.1477-9552.1997.tb01127.x

[48] Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naaem S, O'Neill RV, Paruelo J, *et al*. (1997) The value of the world's ecosystem services and natural capital. *Nature* 387: 253–260. doi:10.1038/387253a0

[49] Mace GM, Norris K, Fitter AH (2012) Biodiversity and ecosystem services: a multilayered relationship. *Trends in Ecology & Evolution* 27: 19–26. doi:10.1016/j.tree.2011.08.006

[50] Nebel F, Brick J, Lantz VA, Trenholm R (2017) Which factors contribute to environmental behaviour of landowners in southwestern Ontario, Canada? *Environmental Management* 60: 454–463. doi:10.1007/s00267-017-0849-9

[51] Capmourteres V, Adams J, Berg A, Fraser E, Swanton C, Anand M (2018) Precision conservation meets precision agriculture: a case study from southern Ontario. *Agricultural Systems* 167: 176–185. doi:10.1016/j.agsy.2018.09.011

[52] Matthews S, Pease SM, Gordon AM, Williams PA (1993) Landowner perceptions and the adoption of agroforestry practices in Southern Ontario, Canada. *Agroforestry Systems* 21: 159–168. doi:10.1007/BF00705227

[53] Kay S, Graves A, Palma JHN, Moreno G, Roces-Díaz JV, Aviron S, Chouvardes D, Crous-Duran J, Ferreiro-Domínguez N, García de Jalón S, *et al*. (2019) Agroforestry is paying off — Economic evaluation of ecosystem services in European landscapes with and without agroforestry systems. *Ecosystem Services* 36: 100896. doi:10.1016/j.ecoser.2019.100896

[54] Le Coent P, Préget R, Thoyer S (2018) Do farmers follow the herd? The influence of social norms in the participation to agri-environmental schemes. Working paper prepared by the Center for Environmental Economics, Montpellier. pp. 29. halshs-01936004: https://halshs.archives-ouvertes.fr/halshs-01936004/document

[55] Mills J, Gaskell P, Ingram J, Dwyer J, Reed M, Short C (2017) Engaging farmers in environmental management through a better understanding of behaviour. *Agricultural and Human Values* 34: 283–299. doi:10.1007/s10460-016-9705-4

[56] LaForge JML, McLachlan SM (2018) Learning communities and new farmer knowledge in Canada. *Geoforum* 96: 256–267. doi:10.1016/j.geoforum.2018.07.022

[57] Noguera-Méndez P, Molera L, Semitiel-García M (2016) The role of social learning in fostering farmers' pro-environmental values and intentions. *Journal of Rural Studies* 46: 81–92. doi:10.1016/j.jrurstud.2016.06.003

[58] Statistics Canada (2019) Tenure of land owned, leased, rented, crop-shared, used through other arrangements or used by others. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210040701

[59] Hausner VH, Brown G, Lægreid E (2015) Effects of land tenure and protected areas on ecosystem services and land use preferences in Norway. *Land Use Policy* 49: 446–461. doi:10.1016/j.landusepol.2015.08.018

[60] Deaton BJ, Lawley C, Nadella K (2018) Renters, landlords, and farmland stewardship. *Agricultural Economics* 49: 521–531. doi:10.1111/agec.12433

[61] Smithers J, Furman M (2003) Environmental farm planning in Ontario: exploring participation and the endurance of change. *Land Use Policy* 20: 343–356. doi:10.1016/S0264-8377(03)00055-3

[62] Engel S, Pagiola S, Wunder S (2008) Designing payments for environmental services in theory and practice: an overview of the issues. *Ecological Economics* 65: 663–674. doi:10.1016/j.ecolecon.2008.03.011

[63] McIntyre J (2010) Measuring agricultural stewardship: risks and rewards. *Journal of Agriculture, Food Systems and Community Development* 1: 19–22. doi:10.5304/jafscd.2010.011.005

[64] Agriculture Sustainability Institute (2019) Sustainable Agriculture Research and Education Program. https://asi.ucdavis.edu/programs/ucsarep/about/what-is-sustainable-agriculture

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