An Alternative Agricultural Future for a Maitland Valley sub-watershed

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Abstract

It is well established that conventional agriculture imposes external costs on society and reduces the many benefits that agroecological systems produce, especially in highly cultivated watersheds where farm fields and larger landscape elements alike have been compromised and simplified. Conserving soil, water and biodiversity is essential to improve the ecosystem services that sustainable agroecosystems provide, including food, moderate and sufficient water flows, filtration of wastes and purification of surface and ground waters, and habitat for wildlife. Best management practices and landscape conservation objectives, when combined with support and financial incentives can reward farmers' provision of these multiple benefits. Organic farming integrates many 'best management practices' in a holistic approach to improving the farm environment by minimizing external inputs and fostering natural processes.

Future scenarios are a creative way to explore the impact of alternative land management approaches in a realistic manner to probe potential economic and ecological impacts over time and can be used to improve decision-making and perspective on the likely outcomes of distinct policy trajectories. This study took a future scenarios approach to exploring a sub-watershed level transition to organic agriculture in the Middle Maitland sub-watershed above Listowel, Ontario, combining geospatial, environmental, ecological, agricultural, economic and institutional factors and employing GIS and Enterprise Budgeting methods. The model permitted an assessment of some of the potential enhancements in the levels of ecosystem services provided by the farming area, combined with a model of annual net returns and a set of incentives designed to reward ecosystem services from farming over a ten-year period.

The organic scenario displayed the expected fluctuations in returns over the transition period, and beef farmers (both conventional and organic) and stockless farmers (organic) faced significant financial difficulty; overall, ten year returns saw organic receive higher net returns than conventional for 5 of 6 farm types. Program payments over ten years for the conventional and organic scenarios amounted to $1 million and $1.5 million respectively, however organic program total ten year costs to government and conservation foundations increased to $2.25 million when considering more aggressive support for beef and stockless farmers. Preliminary estimates from the model indicate significant expected improvements with the organic scenario above the conventional scenario for several ecosystem services, as well as higher satisfaction of landscape conservation targets established by authorities to achieve a ‘healthy watershed’ in the Maitland Valley. This work will set the stage for further alternative agriculture scenario modeling for the Maitland Valley in other research initiatives.

Foreword

The area of concentration for my plan of study emphasized my intrigue with the failures of ecosystems that are ostensibly managed to provide food, fuel and other benefits, and how they fall far short of delivering just and sustainable outputs. In the process, they deplete and degrade biodiversity, resilience, landscapes, livelihoods and communities. I sought to study these failures and some exciting solutions though coursework shaped around three broad components: the ecological basis of the benefits we receive from healthy ecosystems; the economic theory of managed systems, such as agroecosystems and forest systems, and the tensions in these theories surrounding our relationships with our environments; and the process of policy formation around environmental issues and managed systems in a Canadian context.

This MRP is an extension of these three components. Whereas my learning leading up to this MRP was largely based on literature reviews and coursework, the practical approaches and methods that I pursued – economic analysis, GIS applications, scenario modeling, and ecological restoration – became a way for me to integrate these components in a practical application. The exploration of an alternative agricultural future at a sub-watershed scale, in terms of ecological process and design, multiple benefits to communities, and financial implications for the residents and farmers, challenged me to apply what I have learned, and constitutes a more engaged process and more meaningful synthesis of my components than I initially believed I could find while in the coursework stage.

In my proposal for this research I set four objectives. The first was to study the framework of the Millennium Ecosystem Assessment approach and recent literature pertaining to ecosystem services and to the economic valuation of ecosystem services. While I have pursued valuation indirectly in this major paper, I did not tackle the in-depth review of the body of work produced by leading authors on economic and critical interpretations and critiques of valuation approaches. This aspect of my first objective gave way to greater focus on scenario modeling and ecological approaches to managed systems, which proved to be very challenging and more important to this study as it evolved. Aside from the constraints of time and resources, I also found that attaching a critical review of valuation literature to this study would prove ultimately incongruous.

The three remaining objectives, as described in my MRP proposal, have been fully addressed in this study.

List of Acronyms

ABMVSPR - Ausable Bayfield Maitland Valley Source Protection Planning Region

AAFC - Agriculture and Agri-Food Canada

AU - animal units

BMP - Best Management Practice

CAR - cost and revenue accounting

EPA - Environmental Protection Agency

ES - ecosystem services

EG&S – ecological goods and services

FES - Faculty of Environmental Studies, York University

GHG – greenhouse gas

GIS - Geographic Information System

ICASL - Interpolated Census of Agriculture to Soil Landscapes, Ecological Frameworks, and Drainage Areas of Canada

MA - Millennium Ecosystem Assessment

MMSL - Middle Maitland sub-watershed above Listowel

MRP - Major Research Paper

MVCA - Maitland Valley Conservation Authority

MWP TT - Maitland Valley Watershed Partnership – Terrestrial Team

OACC - Organic Agriculture Centre of Canada

OMAFRA - Ontario Ministry of Agriculture Food and Rural Affairs

OGO - Ontario Goes Organic

PES - Payments for Ecosystem Services

T4M/WRW – Trees for Mapleton / Wellington Rural Water Quality program

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Introduction

This research embraces the MES Major Research Paper spirit of openness to flexible and un-conventional formats and approaches to the major work in partial fulfillment of the degree. It synthesizes two of three components of my area of concentration for my individual curriculum in the MES program: ‘Environmental and Ecological Economics’ and ‘Ecological Models of Managed Systems’. The third component – ‘Environmental Policy Formation’ was not intended to be addressed directly in this MRP, but it underlies both the context and the motivation for this research.

The decision to review a major framework for the assessment of ecosystem services, and to apply it in a basic way to an Ontario agricultural context arose from my understanding of environmental policy formation. It stems from the observation that the ecosystem service (ES) approach, while only applied on a very small scale in Ontario as of yet, is gaining increasing currency in conservation and resource management policy discourses, from conservation non-governmental organizations (NGOs) to provincial and federal ministries. Several initiatives existing in or near the study area intersect with ecosystem service approaches and schemes for rewarding farmers for providing ecosystem services.

The study area context for this research is the Maitland Valley watershed. The watershed has undergone major land transformation since European settlement, with agriculture growing to occupy about 80 % of land uses, taking advantage of some of the best soils and growing conditions for agriculture in the country. With the adoption of a production-oriented approach to agriculture, production has increased, but many ecosystem services have been compromised as a result. The production-oriented approach typically includes reliance on external synthetic inputs and less use of historical cultural methods for managing soils and crops, increased row cropping, removal of most non-field vegetation to expand field areas, and extensive application of subsurface drainage infrastructure to facilitate to cultivation of a few crop types (COSEWIC, 2006).

Agriculture in general is currently facing many challenges:

> "*The intensification of agriculture in conventional production systems has resulted in major ecological, environmental and sociological, health and food safety problems in the recent decades. Low stability, climate change and global warming, decreasing biodiversity, accelerated soil erosion by wind and water, chemical fertilizers mainly nitrogen, phosphorous and pesticides in groundwater and on food, the pesticide "treadmill" caused by development of pest resistance to pesticides, routine use of antibiotics for animals leading to antibiotic-resistant strains of organisms, pesticide contamination of farm workers and agroecosystem health are some examples of those problems. Additionally, an over reliance on grain crop monocultures and loss of crop diversity in the aftermath of the 'green revolution' has resulted in a loss of well-balanced diets (Magdoff, 2007). On the other hand, the conventional approach of increasing dependence on off-farm inputs, including fertilizers, pesticides and energy for food, feed and fiber production, is of questionable sustainability resulting in environmental degradation. Therefore, development of alternative production systems that can preserve productivity and minimize the negative biological and environmental consequences and long-term sustainability problems associated with agricultural practices has a high priority in agriculture worldwide*" (page 78, Ghorbani et al., 2010.)

Organic agriculture responds to many of these challenges, and it is increasingly recognized for its environmental, economic, social and consumer benefits (MacRae et al., 2004).

The Middle Maitland sub-watershed above Listowel, Ontario (hereafter MMSL), which is the specific study area for this project, bears elevated concentrations of nutrients, sediments, pathogenic bacteria and metals in downstream surface water combined with losses of vegetative cover and an overall, hydrologically active landscape. Projections for climate change impacts in the area have watershed Conservation Authorities exploring how to engage land managers in efforts to promote the health of the watershed for all its residents, by promoting resilient agriculture and sustainable livelihoods, improving habitat, water flows, water quality, biodiversity, and ultimately resilient communities. Some of the Maitland Valley Conservation Authority's (MVCA) key findings about successful water quality and environmental improvement projects in the watershed were (Phil Beard, personal communication, 2008):

> *"Production and regulatory needs/requirements take precedence over projects that just benefit society"*
>
> *"Difficult to get interest in projects aimed at improving the health of the river if it is not used for production purposes"*
>
> *"Provide technical/financial support for landowners/municipalities to improve/protect water quality"*

These findings helped frame the broad research questions that I wish to explore, and address, rather than answer in this paper. The purpose of this study was to model land use and management changes in a transition to organic agriculture to explore two questions:

1) How can the set of ES mediated by farming in the Middle Maitland Valley above Listowel be improved so as to address existing environmental challenges, and move toward watershed health goals identified by the MVCA, in a way that respects current land uses and livelihoods, integrates organic methods and best management practices, and rewards farmers for the provision of ES while recognizing their role as stewards?

2) What will the farm economics of such changes to promote ecosystem services look like? More specifically, will these changes hurt farmers financially, or help them financially? Which ones

and to what degree? And can suitable and existing examples of policy and program supports be used to assist farmers in this transition?

Agricultural policies implemented today, whether to deal with the impact on ecosystems and their services, or to support farmers in financial difficulty, imply different future scenarios that are not readily apparent (Nassauer et al., 2005). Creating scenarios of medium to long-term changes in the landscape can assist decision-making by providing scientific information about plausible policy choices and their consequences (Alcamo and Bennett, 2005) and by suggesting policies that may achieve specific goals (Nassauer et al 2005).

The modeling is framed by three approaches in the sustainability literature: the ecosystem services approach as advanced by the Millennium Ecosystem Assessment; sustainable agriculture and specifically organic production systems; and the scenarios and alternative futures approach. Scenarios were developed to probe these two questions, using an iterative GIS modeling method that integrated agricultural, ecological, land use, environmental, economic and institutional dimensions. A conventional scenario, based largely on data characterizing the current land uses and agricultural practices in the MMSL, and an organic scenario that transforms the current MMSL into a mosaic of organic systems, were the core of the alternative futures modeling. These two broad scenarios are contrasted and assessed in a preliminary manner for their contributions to ecosystem services and for the financial implications faced by implementing farmers.

This paper has two sections. The first section consists of three chapters that review the relevant features of ecosystem services (Chapter 1), farm-based, landscape-based, and institutional means of enhancing ecosystem services (Chapter 2) and organic production systems and their implicit contribution to enhanced ecosystem services (Chapter 3).

The second section contains four chapters and addresses the scenario modeling carried out in this study. The study area (Chapter 4) and methods (Chapter 5) are followed by the results (Chapter 6) and discussion section (Chapter 7). Finally, a conclusion on the research in this paper and where and how it could be extended is elaborated.

Section 1: Ecosystem Services and Agriculture

1.0 Ecosystem Services

> *"The human species, while buffered against environmental immediacies by culture and technology, is ultimately fully dependent on the flow of ecosystem services"* (Alcamo and Bennet, 2003:1)

1.1 Ecosystems and Ecosystem Services

One way to view a farm or a landscape is as an ecosystem. From this perspective the farm or landscape is understood as a "…*complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit"* (Alcamo and Bennett, 2003:3). These 'functional units' can be seen at large scales, such as an ocean basin, or small scales, such as a pond; defining the boundaries of an ecosystem requires a pragmatic perspective. A well-defined ecosystem "*...has strong interactions among its components and weak interactions across its boundaries. A useful choice of ecosystem boundary is one where a number of discontinuities coincide, such as in the distribution of organisms, soil types, drainage basins, and depth in a water body*" (Alcamo and Bennett, 2003:8). Considering the structure of an ecosystem, there are individual organisms and their associations with other individual organisms, such as populations or communities. The age structure of these communities and their distribution in a particular area further characterize the structure of an ecosystem. Ecosystem function refers to the emergent properties that result from the interactions among the organisms and inorganic material in the area. These functions engender complexity and dynamism and make understanding and predicting ecosystem behaviour challenging (Daly and Farley, 2004).

The ecosystem lens is the basis of the "ecosystem approach", which the Convention on Biological Diversity (CBD) defines as: "…*a strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way*"

(Alcamo and Bennett, 2003:8). Humans and their diverse cultures are recognized as integral to many ecosystems. Implementing the ecosystem approach requires that the various effects of management changes on ecosystems be understood by decision-makers (Alcamo and Bennett, 2003). This approach arises from the understanding that humans depend on the functions of ecosystems for their existence and well-being; our well-being is dependent on how we manage or otherwise impact ecosystems.

Human well-being and ecosystem processes or functions are linked through the idea of 'ecosystem services', which the Millennium Ecosystem Assessment (MA)[1] defines as "…*the benefits people obtain from ecosystems*" (Alcamo and Bennett, 2003:3). Here 'ecosystems' include both natural and human-modified ecosystems (known as managed systems[2]) while 'services' encompasses both the goods, such as fuel or food, and the services proper, such as waste assimilation that ecosystems engender. Among the myriad processes or functions characterizing ecosystems, ecosystem services (ES) are those functions that are directly or indirectly beneficial to humans.

Tree roots, for example, are a source of oxygen in soils, creating pockets for water absorption. At the watershed level, forests moderate the extremes of drought and flooding by absorbing rainwater and releasing the water when it is dry (Daly and Farley, 2004) – an ES known as water regulation. In terms of drinking water, the quantity and quality provided by ecosystems such as forests are determined by forests' water provision and purification services

---

[1] The Millennium Ecosystem Assessment (MA) was convened to apply an ecosystem approach in a broad assessment of the benefits that humans derive from ecosystems, and to evaluate the capacity of various ecosystems to further supply these benefits given humans' large negative impact on the quantity and/or quality of many ecosystems

[2] Swinton et al. (2007:247) note that "…*agricultural land use lies somewhere in the middle of a human-impact continuum between unmanaged native ecosystems (e.g., wilderness) and human domination (e.g. built-up landscapes), and of course different kinds of agriculture vary in their relative positions on that continuum*."

(Alcamo and Bennett, 2003). Other ES that forests provide include carbon sequestration and biodiversity conservation (Pagiola et al., 2002).

The idea of ecosystems providing services directly beneficial to society was first articulated in the 1960s (King, 1996 - cited in Alcamo and Bennett, 2003) and since the late 1990s the idea has garnered increasing attention[3] resulting in a proliferation of studies in both academic and grey literatures (de Groot et al., 2001). How to appropriately classify these services remains a popular theme, and here again a pragmatic perspective is required. The overlap and interrelation among ES is a challenge for meaningfully disaggregating the complex functions of ecosystems and has given rise to several classification schemes for ES[4]:

> "*Note that ecosystem services and functions do not necessarily show a one-to-one correspondence. In some cases a single ecosystem service is the product of two or more ecosystem functions whereas in other cases a single ecosystem function contributes to two or more ecosystem services. It is also important to emphasize the interdependent nature of many ecosystem functions. For example, some of the net primary production in an ecosystem ends up as food, the consumption of which generates respiratory products necessary for primary production. Even though these functions and services are interdependent, in many cases they can be added because they represent 'joint products' of the ecosystem, which support human welfare.*" (Costanza et al. 1997: 253-254)

The classification scheme advanced by the MA is the scheme used in this study. The MA takes a functional approach, classifying ES into "*…provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease;*

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[3] Examples include theoretical work regarding the definition and classification of ecosystem services (see for example Costanza et al., 1997; Daily, 1997; deGroot et al, 2001); techniques of benefit transfer (see 2006 special issue of the International Journal of Ecological Economics devoted to benefit transfer), and the establishment of international databases of ecosystem valuation (such as EVRI, to which Canada, specifically Environment Canada, contributes, along with France and the USA, for example.)

[4] Caution should be taken when reducing complex systems to simpler notions, however, and Costanza (2008) has argued that removing levels of complexity and seeking a neat accounting-like framework, removing the interactions and feedbacks between and amongst ES and their interactions with societies, while satisfying the economist's desire for a neat calculus, is a potentially dangerous simplification of nature and our interactions with it when called upon to inform policy. For this reason, Costanza has argued that several classifications of ES, for different purposes, are needed.

supporting services such as soil formation and nutrient cycling; cultural services such as recreational, spiritual, religious and other nonmaterial benefits" (Alcamo and Bennett, 2003:3). These four categories are defined and exemplified in Figure 1.1.[5]

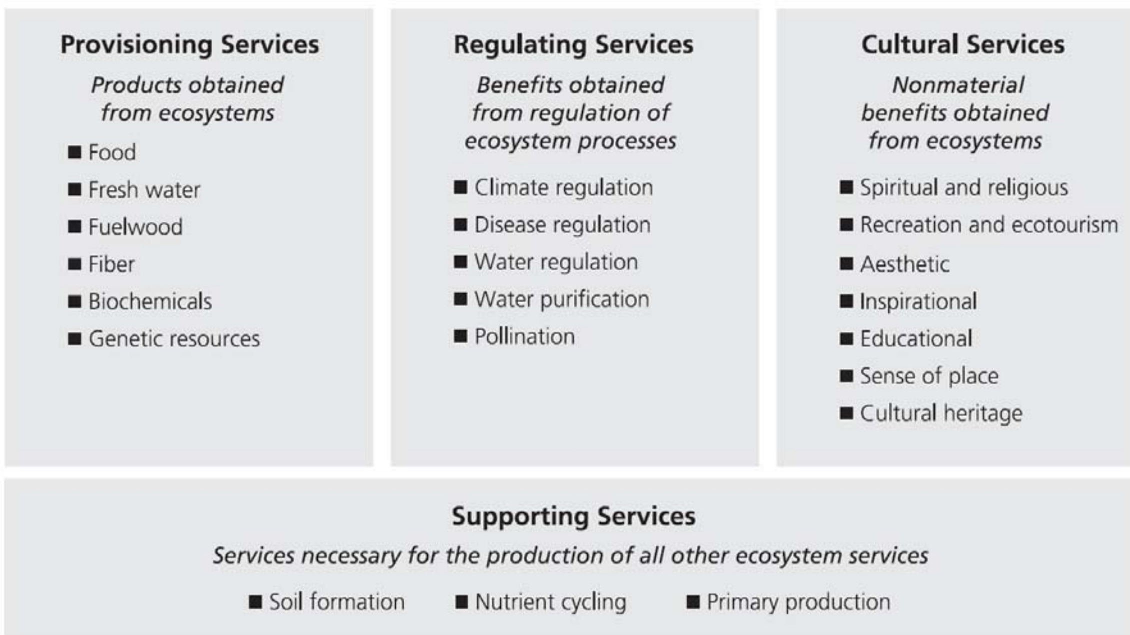

Figure 1.1: Ecosystem services as classified by the Millennium Ecosystem Assessment (reproduced from Alcamo and Bennett, 2003:57).

Applying the ES lens to farms, it's clear that farms engender provisioning services, such as food, fiber and fuel, but they also mediate, regulating, cultural and supporting services. Indeed, cultivated landscapes, or 'agroecosystems' can be thought of as both providing and receiving ES. Swinton et al., (2007) elaborate some of the services *to* agriculture in a U.S. context:

> *"Pollination services, which have only recently become threatened by honeybee colony collapse disorder, contribute to fruit, nut and vegetable production worth $75 billion in 2007 (USDA, 2007) – five times the cost of expected U.S. farm*

[5] The outline in Figure 1.1 is a partial listing of the phenomena classified as services by the MA, and it excludes erosion control and biological control of pests – both regulating services as defined by the MA –two of the ES considered more closely in this study.

> *subsidies. The soybean aphid, a pest new to the U.S. since 2000, is capable of lowering grain yields by over 25% when unchecked, but in many landscapes populations are kept low by coccinellid beetles that are naturally present when sufficient natural habitat is nearby (Costamagna and Landis, 2006). Wetlands and streams in agricultural watersheds can transform leached nitrate into a non-reactive form that keep it from harming downstream ecosystems (Whitmire and Hamilton, 2005). Wetland drainage and stream channelization in the Mississippi River basin have diminished this water quality regulating service, and as a result nitrate pollution contributes to hypoxia in the Gulf of Mexico, producing a significant economic impact on the coastal shrimp fisheries (NRC, 2000)…These sorts of services (and disservices, in the case of effects that are deemed undesirable) place agriculture in a web formed by linkages within and inherent to the agricultural landscape*" (247)

The web that Swinton et al. referred to notes the position of farms and farming activity in larger landscapes. The distinction between services to and services from agriculture can be blurred, depending on the scale of consideration. We will turn here to services *from* agriculture, as our focus is on the impact of farm design and activity on the level of ES, bearing in mind we are looking at some of the functional aspects of a larger web of activity.

1.2 *Selected Ecosystem Services associated with Agriculture*

An agricultural landscape is an ecosystem that is managed primarily for the provision of food, fiber and fuel. Owing to its broad spatial extent and its character as actively managed, agriculture holds the potential to diversify and enhance the set of ES that it mediates or engenders. Understanding of how agricultural ecosystems function is growing (Swinton et al., 2007) and so is our understanding of how managed systems can be manipulated to enhance ES that emerge from the interconnections of fields and surrounding landscapes (Landis et al., 2000, as cited in Swinton et al., 2007). Following these observations, a set of the prominent ES engendered by agriculture were chosen and arranged into three areas. The description of selected

ES that follows draws extensively on the review by Zhang et al. (2007), and falls into the classification scheme advanced by the MA (Alcamo and Bennett, 2003).

1.2.1 Water

The quantity and quality of water available for use by crops and society are affected by vegetative cover in upstream watersheds. Both forests and low lying cover (e.g. shrubs) influence the dynamics of water provision (a provisioning service) and water purification (a regulating service) (Goffman et al., 2004 as cited in Zhang et al., 2007). Forest cover in particular, stabilizes water flow seasonally, thereby moderating downstream water quantity and flow extremes during wetter and drier seasons (Guo et al., 2000, as cited in Zhang et al., 2007) and attenuating floods (Houlahan and Findlay, 2004, as cited in Zhang et al., 2007) (the services of water regulation). Riparian areas and vegetated buffers perform water purification services. Where land is cultivated, much of these services depend as well on the nature of the crop rotation and the cover crops used.

1.2.2 Soil

The location, quantity and quality of farming activity are, to a large degree, determined by soil structure and soil fertility. The burrowing activity of invertebrates enhances soil structure while the digestive activity and fragmentation of soil organic matter carried out by invertebrates contributes to soil fertility (Edwards, 2004, cited in Zhang et al., 2007). Microorganisms, such as fungi and bacteria, cycle nutrients in soils, fix atmospheric nitrogen (e.g., rhizobia) and render it available in soils for potential plant uptake (Vitousek et al., 2002, cited in Zhang et al., 2007). Moreover, microorganisms break down dead organic matter such as fallen leaves and contribute the secured nutrients to the soil medium (Paul and Clark, 1996, cited in Zhang et al., 2007). Bare soils expose nutrients and soil particles to erosion, which is countered by cover crops that retain soil (a regulating service), which maintain soil particle and nutrients in the soil medium, and vegetative hedgerows and buffers, which prevent runoff erosion at field edges. Each of these ES associated with soils[6] are threatened when soil is exposed for prolonged periods and where tillage and fertilization interrupt microbial functioning (Zhang et al., 2007).

1.2.3 Biological Control of Pests

Broad application of pesticides has often promoted the emergence of new pests or exacerbated problems with the targeted pests (Krisha et al., 2003, cited in Zhang et al., 2007). Biological control of pests (a regulating service) refers to the predation of crop pests by birds, spiders, and wasps, to name a few (Naylor and Ehrlich, 1997, cited in Zhang et al., 2007). It limits crop damage in the short run and ensures an agriculturally favourable, ecological balance amongst pests and predators in the long term, as biota harmful to crops are naturally suppressed and do not achieve pest threshold levels (Wilby and Thomas, 2002, cited in Zhang et al., 2007).

In addition to eliminating pesticide treatment, natural predators of pests flourish where there are a variety of food sources (e.g. seeds and sap) from diverse plants available to predators as well as the presence of suitable habitat (Wilkinson and Landis, 2005, cited in Zhang et al., 2007). Increasing landscape complexity is often determined by both increased variety of food and extent of suitable habitat (Thies and Tscharntke, 1999, cited in Zhang et al., 2007).

[6] For a discussion of the ES of Soil Biota, the reader is referred to Barrios (2007) “Soil biota, ecosystem services and land productivity” published in *Ecological Economics*, vol. 64, No. 2.

1.3 *Ecosystem Services and Human Well-Being*

The recognition of the dependence of human societies on ecosystems, the increasing impact of societies on these ecosystems, and the increasing degradation of those ecosystem services that enable human welfare, prompted the undertaking of the MA[7] in order to provide:

> "*…an integrated assessment of the consequences of ecosystem change for human well-being and the analyze options available to enhance the conservation of ecosystems and their contributions to meeting human needs*." (Chopra et al., 2005(3):27)

The MA discusses human well-being in terms of key components identified as: the basic material needs for a good life; freedom and choice; health; good social relations; and personal security. Access to ecosystem services is essential for well-being and the linkages between the main types of ES and the components of human well-being as discussed by the MA are schematized in Figure 1.2.

[7] This assessment involved the work of 1350 experts from 95 countries, including members from governments, non-governmental organizations (including UN agencies and International Conventions), indigenous groups, and the private sector.

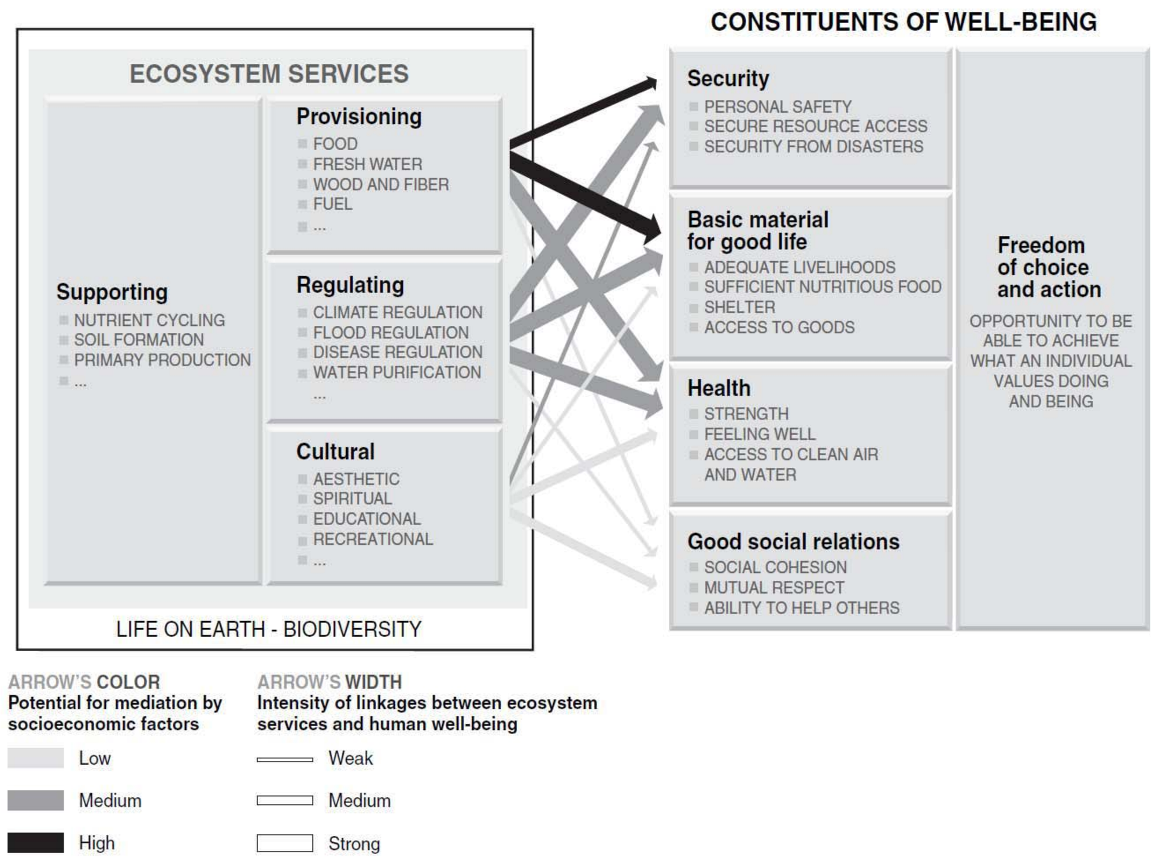

Figure 1.2: Ecosystem services' links with constituents of human well-being (Alcamo and Bennett, 2003).

The individual's experience of her own well-being, however, is context and situation-dependent reflecting numerous personal and social factors, such as age, gender, and culture. Furthermore, access to ES is greatly imbalanced between richer and poorer groups around the world. Institutions, charged with managing ES, are also sometimes captured by small groups of powerful actors. Generally speaking, human well-being:

> "*…can be enhanced through sustainable human interaction with ecosystems with the support of appropriate instruments, institutions, organizations, and technology. Creation of these through participation and transparency may contribute to people's freedoms and choices and to increased economic, social, and ecological security*" (page 71, Alcamo and Bennett, 2003)

The heart of the MA approach is the intimate connection between ES and human well- being. Applying this approach, however, requires a consideration of scales, drivers and decision makers, which will be discussed in turn.

1.3.1 Scale

An important consideration in the identification or institutional protection of ES is the scale at which the particular ES is most evident or more influential. Considering the provision of food from agriculture, farming and harvesting occurs at a local scale that varies on a weekly, if not daily, basis. Considering water regulation, and climatic regulation, the assessment moves to regional and seasonal scales, and global and decadal scales, respectively (Alcamo and Bennett, 2003).

1.3.2 Drivers

The MA framework highlights the role of "drivers", any factors that change an aspect of an ecosystem. Understanding these drivers is necessary for crafting interventions that can minimize negative effects and/or promote positive impacts. Drivers can be 'direct', which "*…unequivocally influence ecosystem processes and can therefore be identified and measured to differing degrees of accuracy*" (Alcamo and Bennet, 2003: 15-16). An 'indirect' driver "*operates more diffusely, often by altering one or more direct drivers, and its influence is established by understanding its effect on a direct driver*". These two types of drivers operate synergistically.

Drivers, in turn, can be affected by decision-making at different levels. The decision making process is complex and has many dimensions. The influence of decision-makers on drivers can be categorized as 'endogenous drivers', ones that decision-makers can influence e.g.

the amount of fertilizer applied by a farmer to her farm; or as ‘exogenous drivers’, that decision-makers do not control e.g. the price of fertilizer (Alcamo and Bennet, 2003: 15-16). The endogenous or exogenous nature of a driver depends on the organizational, spatial and temporal scale under consideration. A farmer can choose external inputs and the choice of technology on her farm, but cannot control fertilizer prices or technology development. A decision maker at a regional or national scale could potentially have much more influence over macroeconomic policy, prices, and technology development.

While the distinction between organizational levels may be fuzzy or hard to define, the following are key actors individuals and groups at the local level (such as a field or a forest stand) who directly alter some part of the ecosystem (e.g. farmers); public and private decision-makers at the municipal, provincial, and national levels; and public and private decision-makers at the international level, such as through international conventions and multilateral agreements (Alcamo and Bennet, 2003: 15-16).

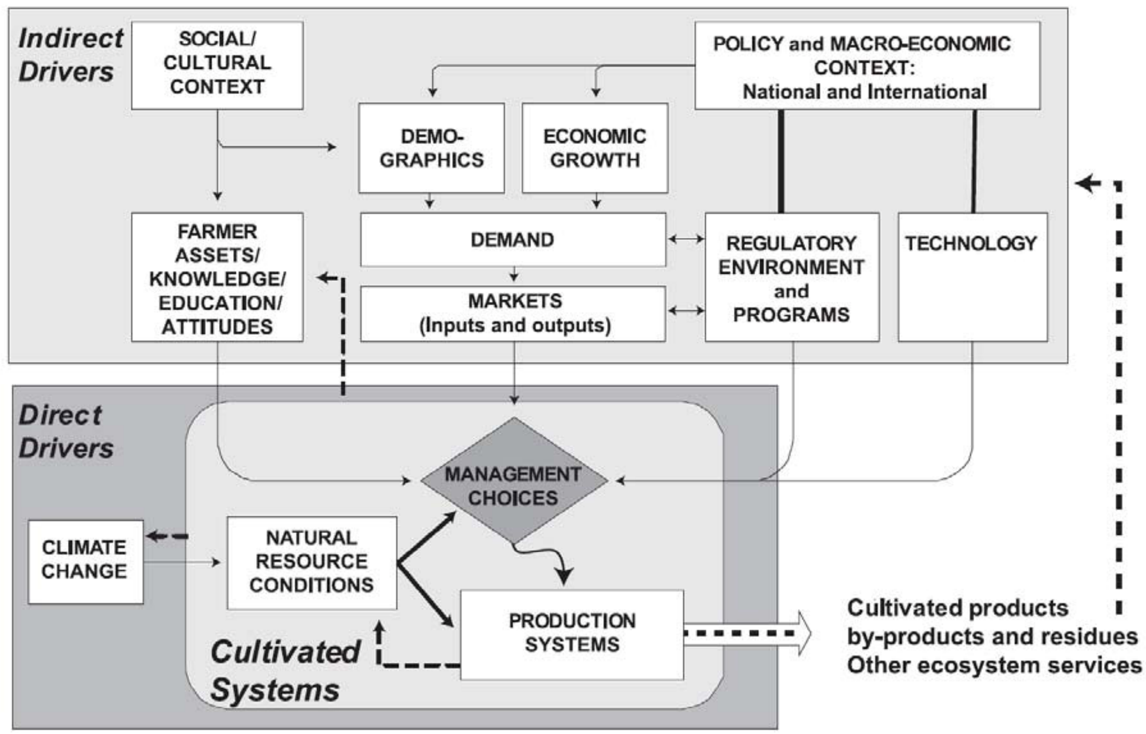

Figure 1.3: Interactions between drivers of cultivated systems (Chopra et al., 2005(3): 770).

To take a closer look at the drivers of change, focusing on agricultural systems and the central role of the manager (i.e. farmer) in this system, the capacity of farming systems to provide ES, whether the provision of food or the purification of surface water for local human consumption, is determined by the management choices concerning what and how to produce (Figure 1.3). Also evident in the schema is the large number of drivers, and their potential to impact management choices and ultimately impact food production and other ES (Chopra et al., 2005).

Chopra et al. (2005) note that:

> "*Within any given socioeconomic and environmental context, it is the sequence of choices made by these managers about what to produce and how to produce it that drives the long-term capacity of cultivated systems to deliver products and ecosystem services. These choices are driven by farmers' incentives to take*

particular courses of action and by their capacity to act on those incentives. Through a better understanding of the key drivers of change, decision-makers are better placed to target policy and investment interventions for improving the economic and environmental outcomes of cultivation" (Chopra et al., 2005(3): 770).[8]

1.3.3 Conceptual Framework of the Millennium Ecosystem Assessment

Gathering together the main categories of ES, the linkages between ES and human well-being, the direct and indirect drivers that influence these two, and the scales over which these phenomena arise, gives us the conceptual framework of the MA, as depicted in Figure 1.4.

[8] Some of the MVCA's key findings from their experience with water quality and conservation projects in the watershed indicate that from the local farmers' perspective: societal benefits are secondary considerations after production and regulatory requirements; recommended conservation practices that do not facilitate production are not attractive to farmers; protecting water quality should be facilitated by technical and financial supports for land owners (Phil Beard, personal communication, 2008)

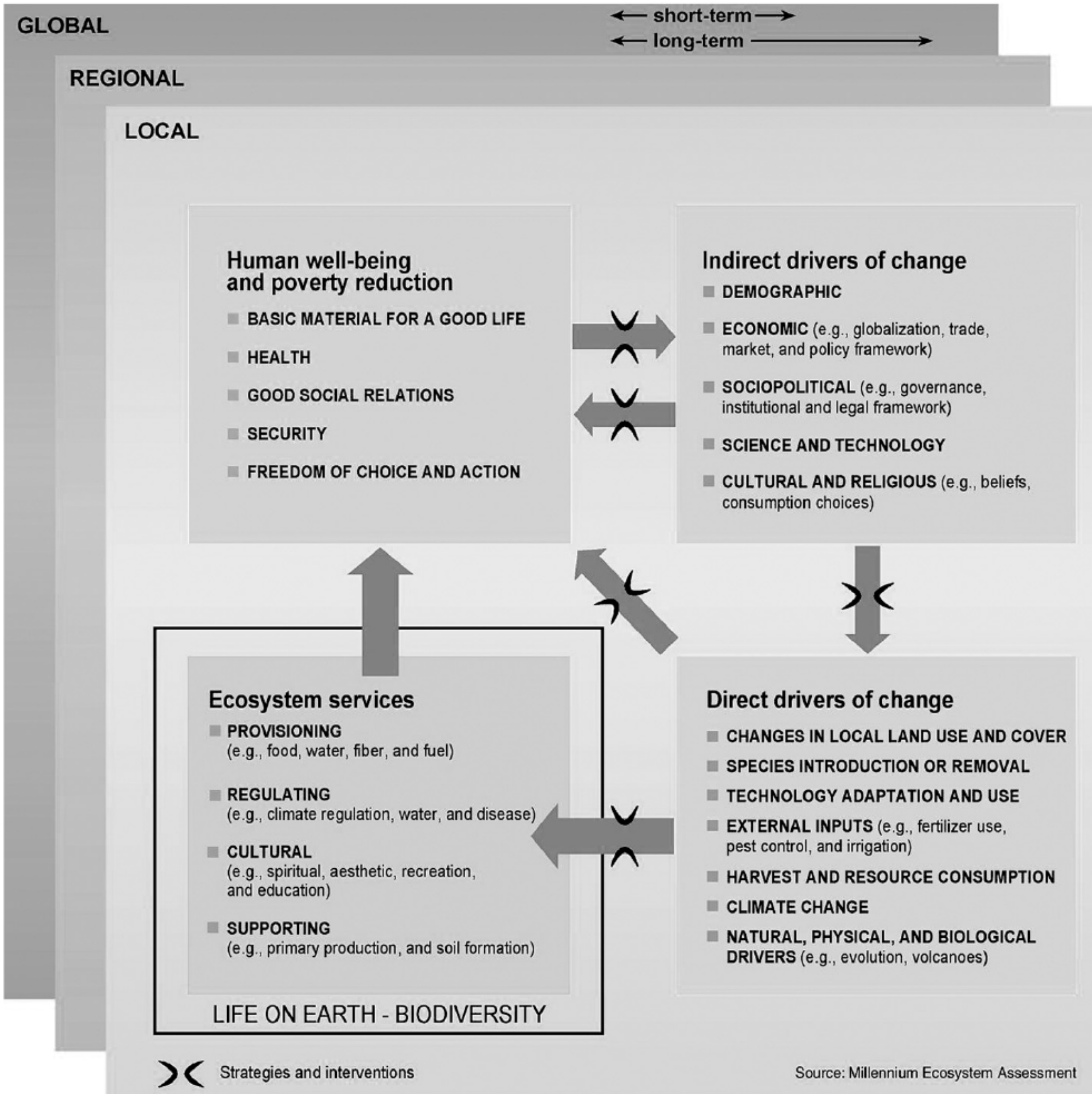

Figure 1.4: Conceptual framework of the MA, interrelating ecosystem services, human well-being, and indirect and direct drivers of change. Associated nodes for interventions and spatial and temporal scales are indicated (reproduced from Alcamo and Bennett, 2003).

The directional influence that ES, human well-being, and indirect and direct drivers have on each other are shown with thick arrows. Changes in indirect drivers, such as a change in technology or population, can result in changes to direct drivers, such as uptake of farming technology, or increased resource consumption due to population increase. These will impact ES and potentially impact human well-being positively or negatively. The interactions can occur on or over several temporal and spatial scales. Strategies and interventions (denoted with a black bowtie shape) can be implemented at most of these directional influences. This approach and the analytical framework associated with it inform the exploration of ES in this research paper.

2.0 Technical, Economic, and Institutional Dimensions of Enhancing Ecosystem Services

> "*Bryan Gilvesy used to grow tobacco on his 140-hectare ranch in southwestern Ontario, but now raises Texas Longhorns, endangered prairie grasses, wild birds, restored wetlands, and clean, cold creek water safe for wild fish. Some of his customers pay him a premium price for his drug free, free range, energy-conserving, politically 100-per-cent correct beef. And then he has other customers – or maybe stakeholders, or investors, or partners or well-wishers – who pay him to grow back the endangered tall grass prairie that provides habitat for birds hatching their young, to keep the creek that flows through his land clean and cool, to stabilize the fragile sandy soils that he says 'can turn into a beach in a heartbeat' by restoring 50 hectares of hardwood forest…*
>
> *On a haywagon ride around his farm, I check out the three hectares of tall grass prairie, which performs multiple functions. With roots that go five meters deep, the grass sucks down carbon from the air, which offsets global warming, stabilizes the sandy soil, lets rainfall percolate slowly so it doesn't flashflood into the creek, provides nesting grounds for birds, and even provides feeding grounds for patient Texas cattle. ALUS buys the prairie grass seed, and pays Gilvesy $400 a year to leave the field alone until mid-July, when the birds move on. The cattle are invited in for a feed, which Gilvesy says 'makes them fat and sassy', and ensures their beef is lean and well-priced. 'As I see it, society gets the use of my field for 10 months of the year, while I and my cattle only use it for two months,' he says, so it's fair that society pay its share of the overhead costs.*
>
> *'We're where the water for this area is born,' Gilvesy says, so he works hard to keep it clean and cool, the way the fish need it to be, and the way the townsfolk like to have the water coming into their filtration plant. A variety of organizations, including the town water utility, give him a fee for his extra troubles to keep the creek clear and cool. ALUS also donates 30 bird boxes to house 60 bluebirds that eat crazy-making flies off the back of the Longhorns, saving Gilvesy the cost of spraying pesticides on their backs, keeping their bodies and the nearby creek pesticide-free*" (Roberts, 2008, The No-Nonsense Guide to World Food:152-153).

The vivid anecdote from Roberts (2008) above speaks to many dimensions of a simple idea: farms and agricultural landscapes are not merely a substrate for the production of commodities – food, fuel and fiber – but rather they are places that produce multiple benefits for society. There is the network of beneficiaries who have come to understand multiple benefits from farms –

consumers, utilities, conservation groups and citizens. Also evident is the impact of financial and technical support on farmland management decisions – education about the important services arising from farm landscapes and financial incentives that can change the behaviour of land managers. These themes are considered in this chapter to develop a picture of how the flow of ecosystem services (ES) from agricultural watersheds can be enhanced.

2.1 *How can Ecosystem Services be enhanced?*

Options for sustaining or enhancing the levels of ES provided by farms include promoting education and awareness of ES, investing in conservation and restoration initiatives, creating markets for ES, including values for ES in decision-making, and channeling the distributed benefits of ES to local decision makers or land managers, such as farmers, who have an interest in maintaining those services. Effective strategies[9] combine several of these options and should address each of the links in the conceptual framework (see Figure 1.4) (MA, 2007:3). Among the links in this framework, the scales over which ES arise are a primary consideration for interventions to conserve ES. Taking the ES identified in the previous chapter we can consider actions that affect each of these ES at scales from the field, to the farm, the landscape, the region and the globe as shown in Table 2.1, and reproduced here from Zhang et al. (2007).

Considering the service of soil retention, cover crops are a primary strategy for mediating soil retention at the farm scale, but at the landscape scale, the primary structure is the vegetation around watercourses and field edges, which can halt the export of soil and nutrients from fields and non-field spaces over the landscape. At the regional scale, the degree of vegetation in the basin is the primary ecosystem structure that retains soils. Implications for appropriate

[9] The two farming systems to be modeled in this study touch on each of these options, although to different degrees, resulting in two different strategies for promoting the multiple ES from agricultural sub-watersheds.

management can be drawn from this example, as attempts to influence ES should be made at primary sites of their generation for that scale. Soil fertility and soil retention, for example, can be fostered by practices adopted by individual farmers, as the ES arises at the field level and benefits farmers directly. Biological control of pests, on the other hand, may be more effectively enhanced with landscape level intervention to enhance or restore the ES (Weibull et al., 2003, as cited in Zhang et al., 2007), such as could be achieved with regionally coordinated integrated pest management (IPM). Farmers' incentives for employing conservation methods will be discussed after describing particular methods improving ES provision from agriculture.

Table 2.1: Major Ecosystem Services (ES) and dis-services (EDS) to agriculture, the scales over which they typically are provided, and main guilds or communities whose activities typically supply them (reproduced from Zhang et al., 2007:257).

ES or EDS	Field [a]	Farm [b]	Landscape [c]	Region/globe [d]
Services				
Soil fertility and formation, nutrient cycling	Microbes; invertebrate communities; legumes	Vegetation cover		
Soil retention	Cover crops	Cover crops	Riparian vegetation; floodplain	Vegetation cover in watershed
Pollination	Ground-nesting bees	Bees; other pollinating animals	Insects; other pollinating animals	
Pest control	Predators and parasitoids (*e.g.*, spiders, wasps)	Predators and parasitoids (*e.g.*, spiders, wasps, birds, bats)		
Water provision and purification		Vegetation around drainages and ponds	Vegetation cover in watershed	Vegetation cover in watershed
Genetic diversity	Crop diversity for pest and disease resistance			Wild varieties
Climate regulation	Vegetation influencing microclimate (*e.g.* agroforestry)	Vegetation influencing microclimate	Vegetation influencing stability of local climate; amount of precipitation; temperature	Vegetation and soils for carbon sequestration and storage
Dis-services				
Pest damage	Insects; snails; birds; mammals; fungi; bacteria, viruses; weeds	Insects; snails; birds; mammals; fungi; bacteria, viruses; weeds	Insects; snails; birds; mammals; range weeds	
Competition for water from other ecosystems	Weeds	Vegetation cover near drainage ditches	Vegetation cover in watershed	Vegetation cover in watershed
Competition for pollination services	Flowering weeds	Flowering weeds	Flowering plants in watershed	

[a] Services provided from within agriculture fields themselves.
[b] Services provided from farm property, but not necessarily in active fields themselves.
[c] Services provided from landscape surrounding typical farms, not from farmer's property.
[d] Services provided from broader region or globe.

Management practices at the field and farm level that can conserve or enhance ES include provincially and federally recommended Best Management Practices (BMPs), while management interventions to conserve ES at the landscape level can be thought of as conservation or landscape goals. Holistic production systems, grounded in agroecology, such as certified organic production, integrate – and extend - recommended BMPs at the field and farm scales. These three approaches are combined and applied to the scenarios developed later in this study, and the interventions bear many points of overlap. BMPs are individual practices or sets of individual practices; organic production entails a set of integrated practices based on a holistic approach to the farm and its surroundings. Where BMPs may be recommended for all production systems to conserve soil, water and natural resources, organic practices are required for certification or are necessary in order to produce food consistently on organic farms.

Landscape goals may be achieved by BMPs, organic methods, or specific conservation and restoration activities. Taking the example of soil retention again, enhancing or sustaining the level of erosion control is best achieved with the proper use of cover crops at the field scale to keep soil held in place year round. Whereas cover crops are sub-optimally used in conventional systems (MacRae, 2010 - personal communication), they are very important to organic systems where they are included in crop rotations to promote soil fertility and to plan for crop nutritional needs (Delate et al., 2003). Cover crops are one practice recommended under the Nutrient Management BMPs and under Cropland Conservation Techniques BMPs (AAFA and OMAFRA, undated) and their use contributes to erosion control, water regulation and water purification and waste treatment. The unifying theme underlying BMPs, organic practices, and landscape goals is the protection and enhancement of specific ES, where ES includes provision (i.e. food) and regulating (e.g. erosion control services).

2.2 *Best management Practices (BMPs)*

AAFC and OMAFRA define a BMP as "…*a practical, affordable approach to conserving soil, water and other natural resources in rural areas*" which are decided by "…*a team of farmers, researchers, natural resource managers, extension staff and agribusiness professionals*" (AAFC and OMAFRA, undated: inside cover). The individual BMPs selected for this study to contrast conventional and organic systems are Nutrient Management, Livestock Management, Residue Management, treed windbreaks and vegetated buffers[10].

Nutrient contamination of waters occurs via point source pollution, such as from manure storage spills, or from residential and industrial effluent paths, and from more diffuse sources known as non-point source pollution. The latter phenomena are more relevant to this study as farm management practices and site characteristics typically influence the degree of nutrient delivery via non-point sources (ABMVSPR, 2007). Some of the practices that are recommended under the Nutrient Management BMPs include assessing the risks to water resources before applying nutrients such as synthetic fertilizer or manure[11] and employing cover crops when the risk of leaching is highest in order to use up residual nutrients.[12] Crop rotations are recommended to capture residual nutrients, while winter application of manure, especially on sloping land, is discouraged. Moreover, cultivating before applying liquid manure or liquid fertilizer is encouraged as it disrupts preferential surface flow paths and in-soil flow paths. Finally, farmers should monitor tile drainage systems carefully, especially if applying nutrients.

Among these recommended practices, some of the most effective for reducing nitrogen leaching include substituting perennials such as grasses or alfalfa for annual crops like corn and soybeans, and applying nitrogen fertilizer only when the crop needs it. Fields planted with perennial alfalfa lost less nitrate than fields growing soybeans and corn, on the order of 30 to 50 fold reductions at sites in Iowa and Minnesota (Randall et al., 1992; Randall and Mulla, 2001 – both cited in Howarth et al., 2007). Winter cover crops lost three fold less nitrate than fields

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[10] Another set of BMPs highly relevant to the MMSL (ABMVSPR, 2007) is Drainage Management BMPs (both surface drainage and artificial drainage); however they are not considered in this study.

[11] I.e. only apply nutrients at times when crops can absorb them, for example course textured soils don't absorb nutrients in the fall in Ontario (AAFC and OMAFRA, undated).

[12] This is also recommended on fields that are extensively tile-drained (AAFC and OMAFRA, undated).

without cover crops in a Maryland study (Staver and Brinsfield, 1998 – cited in Howarth et al, 2007). Fall application of fertilizer resulted in increased nitrogen leaching on the order of 30 to 40 % (Randall and Mulla, 2001 cited in Howarth et al., 2007).

Farmers in the upper mid-western U.S. apply on average 20 to 30 % more synthetic nitrogen fertilizer than is recommended owing to overly optimistic yield expectations, relatively low costs of fertilizers, underestimation of residual nitrogen, and as a strategy to ensure maximum yields (Boesch et al., Submitted; Howarth et al., 2002a; Howarth in press – all cited in Howarth et al., 2007). Researchers report that reduction of nitrogen fertilizer in these areas by 20 to 30 % would likely reduce nitrogen delivery downstream by significantly more than 20 to 30 % because applications are generally at or above the nitrogen absorption saturation point (Boesch et al., submitted; Howarth et al., 2002a; McIsaac et al., 2001 – all cited in Howarth et al., 2007).

Specific practices recommended under Livestock Management BMPs include erecting fences to keep livestock from watercourses, providing alternate watering facilities (e.g. powered by windmills), constructing livestock and machinery crossing (AAFC and OMAFRA, undated). Residue Management BMPs focus on reducing soil erosion, conserving soil structure and residual soil nutrients, and promoting water infiltration. This is achieved by leaving crop residues (old stalks, leaves and stems remaining after harvesting a crop) on the ground, aiming for at least 30% of the soil surface to be covered with residues (OMAFRA, 1997; AAFC and OMAFRA, undated). Tillage is a mechanical method of breaking and mixing the upper soil surface to reduce the size of soil aggregates to create a favourable seed bed for planting the next season's crop, but conventional tillage methods can excessively break down aggregates and compromise the soil structure, thereby promoting topsoil erosion (OMAFRA, 1997). Adopting less intensive tillage, such as conservation tillage, and tilling when conditions are favourable, can maintain some residues on the surface, conserving resources and promoting habitat for wildlife (AAFC and OMAFRA, undated).

Adding vegetated structures, such as buffers, or treed windbreaks to farmlands, are also recommended (OMAFRA, 1997; AAFC and OMAFRA, undated). Buffers or buffer strips consist of trees or grasses or shrubs, or a mixture of these in strips that line waterways such as drainage ditches and streams in order to filter sediment and nutrients from runoff. These strips can also serve as habitat for wildlife. The width of the buffer affects the services it provides, and the width should be decided after considering the quantity and type of pollutants, the slope of the land, soil types, local wildlife needs, sensitivity of the watercourse, ease of access and suitable vegetation (AAFC and OMAFRA, undated). Treed windbreaks are strips or rows of trees, typically ranging from one to five rows in width, planted along the edge of a field. Conifers and poplars are commonly used for windbreaks in Ontario (AAFC and OMAFRA, undated). In addition to reducing soil erosion from water and they can also boost production, by promoting a favourably warm and moist microclimate raising crop yields at the sub-field scale (Roulston, 2009; MacRae et al., 1989).

2.3 *Organic Practices*

The organic farming practices included in this study to assess ES enhancement are crop rotations (including green manures and cover crops), rotational grazing, elimination of synthetic inputs, and stocking rate adjustments. These will be discussed in Chapter 5.

2.4 *Landscape Goals*

In Landscape Ecology, the term 'landscape', like that of 'ecosystem' discussed in Chapter 1, is applied pragmatically, according to the scale of interest, and landscapes span a broad range of spatial and temporal scales. Defining the scales for a landscape depends on the organism of interest in the study:

> "…*the biology of the organism defining a landscape determines the spatial scale of the landscape; similarly, the function rate of the organism defines the temporal scale on which a landscape functions…For example, an earthworm landscape consists of only a few square meters and is characterized by process and changes rates measured in days or hours. In contrast, a forest landscape may measure several square kilometers and is characterized by process and changes rates measured in years*" (Perera et al., 2000:3-4)

There is no species, population or ecological guild dominating this study, nor is there a single ES of importance here. The populations and ES co-existing and occurring in the sub-watershed under study have obviously varying landscapes as defined by their specific biology. This study focuses on the joint human – natural system in the Maitland Valley and takes its boundaries as the sub-watershed above Listowel over the duration of years to decades.

Landscape ecology is based on the idea that the pattern of landscape elements or component ecosystems affect ecological processes. It studies the structural, functional and temporal relationships amongst landscape elements and distinct ecosystems, and it is increasingly used as an organizing paradigm for land management approaches (Ryszkowski, 2002). This approach underlies the inclusion of landscape goals in this model, as informed by the Iowa project's[13] inclusion of landscape effects such as landscape connectivity and landscape

[13] The Iowa project was funded by the Environmental Protection Agency of the U.S. and consisted of watershed and landscape level modeling of alternative agricultural futures.

grain resulting from particular policy agendas, and by conservation targets established for the Maitland Valley study area.

The Maitland Water Partnerships (MWP) Terrestrial Team set five targets for improving the overall health of the Maitland Valley watershed (MWP TT, 2010):

Target A: Reduce the absolute loss of natural areas by 50% by 2020

Target B: Prevent the net loss of forest interior by 2020

Target C: Increase the amount of natural connections on the landscape in the MVCA watershed from 87 sq. km to over 210 sq. km

i) Establish buffers ii) Enhance existing riparian buffers iii) Establish other connections and corridors

Target D: Increase woodlots in good condition from 45% to 60% by 2030

Target E: Increase the total amount of natural cover in the watershed from 18.9% to over 26%

Four landscape goals were chosen to include in the scenarios for this study. These are i) increased natural area coverage (woody and herbaceous); ii) increased connectivity between patches and corridors; iii) increased landscape complexity and/or diversity of habitat; iv) matching crops to soil and site conditions.

2.5 Supporting farmers for providing Ecosystem Services

Farmers' incentives for providing greater levels of ES are influenced by the particular scale over which ecosystem services (ES) and ecosystem dis-services (EDS) contribute to agriculture and society. At the field scale, farmers have a direct interest in conserving soil, maintaining soil fertility in their fields, and controlling pests. However, as the benefits (or harm) spread beyond the farm scale, an externality exists and the service arising from the farm resembles a public good (or bad). A farmer who establishes habitat for beneficial wildlife to encourage predation of pests cannot prevent neighbouring farmers from benefiting from her investments, even though those neighbours have not set aside areas for natural vegetation themselves. Neither is she remunerated for the costs she incurred to foster biological control of pests on her farm and nearby farms (Zhang et al., 2007:257).

Policy makers have several tools at hand to stimulate the production of ES by land managers.[14] These range from regulation, cross-compliance, moral suasion and voluntary approaches to more market-based approaches, such as taxes, subsidies and tradable permits and direct payments (Gagnon, 2005). The Clean Water Program and Rural Water Quality in Ontario are examples of one-time assistance to establish the ES and the federal Green Cover Canada program is an initiative providing farmers with a one-time direct payment for producing the desired ES. Manitoba's Riparian Tax Credit Program is an on-going remuneration for producing ES (Gagnon, 2005). On-going direct payments are seen as the most suitable for sustained provision of ES (Pagiola, 2008).

Payments for Environmental Services (PES) schemes are considered a market approach to internalize some of the costs and benefits of land use practices by remunerating farmers for ecosystem services from their lands, thus providing a motivation for them to practice sound management. Muradian (2010) defines PES schemes as:

> "*a transfer of resources between social actors, which aims to create incentives to align individual and/or collective land use decisions with the social interest in the management of natural resources*" (1205).

On the other side of this transaction are those who benefit from the services as well as those who pay for those services. While often seen as a market approach, Vatn (2010) points out

[14] These tools are often designed in a way that focuses on individual land managers (i.e. focus on the field and farm scales) but that falls short of fostering coordinated action amongst land managers (i.e. focus on the landscape scale) (Zhang et al., 2007)

that in practice such arrangements depend crucially on community or state actors stepping in to develop them: "…*PES are foremost a reconfiguration of the roles of public bodies and communities becoming core intermediaries or 'buyers'*" (1245).

Remunerating farmers based on outputs, i.e. according to specific changes in ES resulting from the farmers' individual actions, is rarely applied in PES schemes due to the difficulty establishing a clear link between a farmer's actions and the resulting level of ES. An output-based arrangement to reward farmers for water purification, for example, would pay farmers after demonstrating specific reductions in downstream nutrient delivery due to practices rendered on their farms. The difficulty measuring this and the expenses likely at a program level necessitate paying farmers instead on an input basis. The units of input could be hours spent clearing invasive species, or hectares of vegetation planted, and they are chosen as land management practices that are thought to give rise to the ES of concern (Pagiola, 2007).

Regarding the level of compensation for producers, a monetary value of the ES produced is seldom sought, although techniques exist to estimate these, however imperfectly. More commonly, a system of rates is established, often based on the value of foregone farm production. Other sources of consideration for setting rates include cost estimates for BMP adoption, soil productivity classes, the market value of the farmland, the taxation rate for the land, and the leasing rate for the land (Gagnon, 2005). Additionally, any program or agreement for remunerating farmers for producing ES must address several concerns, including program design and uptake, efficiency, compliance and monitoring ES outputs, among other considerations.

Rewarding farmers for the provision of ecosystem services from their land, and for enhancing the provision of these ecosystem services, has been very popular in the European Community (EC), where a transition to organic support program rewards farmers for the provision of ecosystem services. In 1992, the EC established its agri-environment program. The regulation motivating this program states its purpose as "*to reduce substantially [farmers'] use of fertilizers and/or plant protection products, or to keep to the reductions already made, or to introduce or continue with organic farming methods*" (MacRae and Jannasch, 2000:24). The program rewards farmers for providing environmental services (i.e. ecosystem services), while also reducing commodity price supports.[15]

The idea of paying farmers for the provision of ecosystem services has begun to take root in Canada. An alliance amongst farmers, conservationists, and other stakeholders has resulted in the Alternative Land Use Services (ALUS)[16] pilot projects that have started up in recent years, across Canada, including a few in Ontario. The ALUS projects are based on setting aside 'ecologically sensitive' agricultural land to provide environmental benefits to society (Tyrchniewicz and Tyrchniewicz, 2007). In Huron County, Ontario, the Huron County Payment for Ecological Goods and Services (PEGS) Pilot Project, initiated in 2007, and administered by the Maitland Valley Conservation Authority, among other partners, has contracted with 4 farmers to set aside floodplain acreage for a period of 5 years. Farmers are remunerated at $250

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[15] Many observers have noted, however, that there is room for improvement with the programs and with payment levels, and the effectiveness of payments to farmers to provide ES also depends on extension, training, research and market development. Such programs could improve results by allocating more resources to providing organic training and demonstration farm sites (MacRae and Jannasch, 2000). Also, there have been calls for greater focus on the whole-farm and landscape scales for organic subsidies in order to ensure maintenance of biodiversity at scales more likely to have a positive impact on wildlife populations (Bengtsson et al., 2005).

[16] ALUS is one of the payments to farmers for ecosystem services initiatives that Roberts (2008) mentioned in the passage quoted at the chapter outset.

per acre (Monk, 2008; Reid, 2008). Remuneration for ES has also become part of AAFC policy conversation (Royer and Gouin, 2007).

3.0 Organic Agriculture and Transition

3.1 *Organic agriculture*

Sustainable farming systems can be envisioned as situated along a spectrum related to their proximity to desirable goals, such as sustainability, optimal nourishment, and optimal social and individual development (Hill and MacRae, 1992). Sustainable agriculture, including the most developed forms of organic farming, is both a "philosophy and system of farming" rooted in the awareness of social and ecological realities and the values of empowerment and agency. Design and management methods emphasize harnessing natural processes (i.e. ecosystem functions) to maximize available resources, reduce waste, ensure farm economic viability, promote resilience of the agroecosystem, and to produce nutritious and healthy food. Sustainable farming approaches usually avoid synthetic fertilizers, growth hormones and pesticides, drawing on other techniques such as biological and cultural methods to enhance soil fertility and control pests, cover crops, green manures and animal manure, among other practices (MacRae et al., 1989; MacRae and Jannasch, 2000).

The Canadian organic standard established by the Canadian General Standards Board (2006, amended 2008 and 2009) codifies the management practices required to market a product as "organic" in Canada. The standard states:

> "*Organic production is a holistic system designed to optimize the productivity and fitness of diverse communities within the agroecosystem, including soil organisms, plants, livestock and people. The principal goal of organic production is to develop enterprises that are sustainable and harmonious with the environment*" (Canadian General Standards Board, 2006:iii).

The practices set out in the organic standard are use in this organic modelling scenario as a minimum approach to organic agriculture and more sustainable farming.

3.2 *Organic practices and transition*

As discussed above, organic farms must eliminate the use of synthetic fertilizers and pesticides, as well as growth hormones and progressively eliminate synthetic antibiotics. To adapt their farm to this situation, farmers must develop a focus on soil heath. Soil health is often judged by organic farmers by monitoring the amount of organic matter in their fields (Baldwin, undated) and the length of the rotation, the interaction with fertilization methods used on the fields, and the type of tillage method (which can sacrifice organic matter) all affect soil organic matter (Karlen et al., 1994, as cited in Baldwin, undated).

> "*Active soil organic matter refers to a diverse mix of living and dead organic materials near the soil surface that turn over or recycle every one to two years. Active organic matter serves as a biological pool of the major plant nutrients. The balance between the decay and renewal processes in this biological pool is very complex and sensitive. The populations of microorganisms that make up the biological pool are the driving forces in soil nutrient dynamics. Together they also play a key role in building a soil structure that both retains and freely exchanges nutrients and water – a soil where plant roots thrive*" (Baldwin, undated:3).

Biological activity in this pool refers to the nutrient cycling activity of microorganisms and the digestive and burrowing activities of invertebrates. This activity enhances soil structure and soil fertility (both supporting services, as discussed in Chapter 1) as organic matter from manure or vegetation is broken down and nutrients are rendered available for potential plant uptake.

Field additions such as treed windbreaks can boost biological activity at the beginning of the growing season by enabling soil to warm up earlier in the spring (Soltner, 1976, as cited in

MacRae et al., 1989). In addition to soil organic matter quality, organic decomposition by different soil biota is also key to managing soil health.

A principle method of organic farming is rotating crops on a sequence of several years with the purpose of fostering soil health and optimal crop yields while reducing the threat of crop diseases and pests. Rotations are a traditional cultural method and were followed in ancient China, Greece and Rome. As previously discussed, the traditional focus on complex crop rotations waned since the 1950s as farmers relied increasingly on synthetic inputs to control pests and fertilize crops. Crop rotations are still in use, indeed 80% of the U.S. corn crop is currently grown in short, two or three-year rotations with wheat and soybeans; however, pastures, green manures, and cover crops are seldom inlcuded in these rotations (Baldwin, undated).

Transitioning farmers must develop rotations of suitable length and with careful selection of the crops in the sequence. Maintaining and enhancing soil fertility is carefully undertaken in transition by drawing on several sources, such as animal manure, pasture rotations, green manure and catch crops. The timing of manure applications and the sequence of crops and green manures can be orchestrated to provide nutrients to particularly nutrient demanding crops, such as corn, which can be planted following nutrient contributing crops, such as legumes.

Many organic livestock operations reduce their herd size and/or increase their pasture base, and extend the amount of time herds spend on pasture upon converting to organic agriculture[17]. Along with the inclusion of pasture crops in organic rotations, livestock are often rotationally grazed. Grazing this way improves forage crops, heard health and reduces the costs of increasing livestock weight. This practice sees farmers direct the grazing of cows through a series of smaller

[17] Such changes are required by the Canadian Organic Standard although they are subject to the regional and the farm context.

sections of the larger field that have been temporarily fenced off. This area, known as a paddock, forces livestock to consume the variety of grasses and legumes and other vegetation within the paddock before moving onto the next temporary paddock. In sequence this rotates the herd through several paddocks, giving each section of the field time to replenish its forage cover. Herds are typically rotated to fresh grass in the next paddock every 1 to 3 days, taking care that cattle do not over graze the spot by eating newly re-grown grass roots that can inhibit subsequent growth and vigour of the resulting forage crop (Kyle, 2004, 2009).

In practice, organic farmers and researchers alike encourage those contemplating the conversion to develop a transition plan[18] that suits their particular farm's context (MacRae et al., 1989). A transition plan is also required by the national standard for each farmer proposing conversion and subsequent certification as organic (Canadian General Standards Board, 2006).

The organic farming practices included in this study to assess ES enhancement are crop rotations (including green manures and cover crops), rotational grazing, elimination of synthetic inputs, and stocking rate adjustments. Four organic crop rotation models suitable to the MMSL context were provided by the Organic Agriculture Centre of Canada (OACC).[19] The use of four rotations in the organic scenario permits a diversity of crop enterprise mixes and recognizes a diversity of site characteristics which are more suitable to particular types of crops and cultivation methods. These four rotations are discussed in Chapter 5: Methods.

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[18] MacRae et al. (1989) set guidelines for developing an action plan. The first step is to undertake a farm inventory to document the state of physical (e.g. soil organic matter and trace minerals), hydrological (e.g. availability of water and drainage character of soils), biological (e.g. crop histories, prominent pests and beneficial biota, forests etc.) human (available labour, management needs) and equipment resources (machinery and buildings) and assess need in each of these areas as sustainable agriculture aims to maximize internal resources while minimze reliance for external resources. Following this inventory, the plan should proceed to address the application of organic design and management practices on their particular farm.

[19] The rotation models were developed by the OACC in consultation with Rod MacRae.

3.3 *Benefits of Organic*

The benefits of organic agriculture are increasingly documented, including environmental, economic, social, health and consumer benefits.[20] Evidence is relatively strong that well-managed organic involves benefits to society in the form of reduced risks of biodiversity loss, reduction of pollution, an improved farm financial situation and improved energy efficiency linked with greenhouse gas (GHG) reductions. Further evidence suggests that organic practice can involve reductions in consumer anxiety about the food system; reductions in some food safety hazards; produce more nutritious food, enhance the welfare of farm animals, and stimulate rural employment and community vitality.[21]

Adoption of organic often promotes a change of values in farmers. According to MacRae et al. (1989) many farmers who convert to more sustainable farming identify more fully with their role as "…*guardians of human health, through the provision of essential nutrients to consumers, and of the health of the rural community and environment*" (pg. 5) and come to see their farms from a more "organismal" perspective, which "…*functions well when all its components are present and when essential biological processes are supported through the careful management of events in time and space*" (Koepf et al., 1976, as cited in MacRae et al., 1989: 4).

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[20] These benefits and the strength of the evidence supporting them are extensively reviewed by MacRae et al. (2006).
[21] MacRae (2007) Presentation given at York University, Faculty of Environmental Studies.

3.4 *Organic Agriculture and Enhanced Ecosystem Services: An example from New Zealand*

Bringing together the discussion of agricultural ES from Chapter 1: Ecosystem Services and the practices of organic farming described above, we can examine the impact that organic methods can have on the provision of ecosystem services by considering an emblematic study recently completed in New Zealand. Sandhu et al. (2008) completed field experiments on conventional and organic farms using a "bottom-up" approach to measure services and quantify their values instead of relying on benefit transfer. The study compared 14 organic fields and 15 conventional fields[22] for twelve agricultural ES, including soil formation, soil fertility, biological control of pests, water provision and purification, and climate regulation.

Regarding soil fertility and formation, the quantity of soil formed annually was estimated by assessing earthworm populations (earthworms are fundamental to the maintenance of soil structure and fertility) in the two production systems (organic and conventional). Values estimated for the ES of soil formation were an average of US$6 for organic versus US$5 for conventional. Regarding the ES of soil fertility, the amount of nitrogen available for crop uptake was assessed by field soil nutrient analysis for two production systems. This amount was then valued at the input price of urea, resulting in an estimate for the value of the ES from organic and conventional at US $40 and US $ 43[23], respectively.

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[22] What is not indicated in the study, however, is the management performance of the farms. The comparison between organic farms and conventional farms is most instructive when comparing well-managed systems, such as well-managed conventional with well-managed organic farms.

[23] The authors did not discuss why the organic farms' soil fertility was slightly less that for the conventional farms.

Biological control of pests was examined in fields by assessing predation of aphids and surrogate carrot rust fly eggs. The difference in predation for two production systems was valued using the avoided costs of pesticides giving the ES of biological control for organic and conventional of US $50 and US $40, respectively. Regarding water ES, field data on hydrology using the volume of infiltration on each field value the ES of hydrological flow for organic and conventional at US $107 and US $54, respectively.

Finally, several ES are enhanced with shelterbelts, such as soil retention by reduced field erosion, and biological control of pests by providing habitat and multiple food sources for beneficial biota, in addition to improving yields by promoting more favourable micro-climatic temperature and moisture conditions on fields. The increased yields due to windscreens were assessed based on the screen permeability and associated change in yield from standard for the screened field. The athors estimated the value of those services provided in organic systems were US $880 and in conventional systems at US $200, respectively (Sandhu et al., 2008).

The Sandhu et al. (2008) study estimated the total economic value (TEV) of ES provided by the two production systems ranged from US $1610 to US $19,420 per ha per year for organic and from US $1270 to US $ 14570 per ha per year for conventional, while the non-market values associated with the two ranged from US $460 to US $5240 per ha per year for organic and ranged from US $50 to US $1240 per ha per year.[24] The study found that organic provided significantly greater levels of ES than conventional for some ES and the authors conclude that: "*...conventional New Zealand arable farming practices can severely reduce the financial*

[24] The monetary values assigned to these ES are not prices, rather they are used to indicate relative magnitudes for the benefits of ES provided by the two farming systems.

contribution of some of these services in agriculture whereas organic agriculture practices enhance their economic value" (pg 834).

3.5 *Policy Support for Organic Transition*

Transition can be both an isolating and challenging undertaking (MacRae et al., 1989). To start with, transitioning farmers experience clear financial difficulties, which can be a source of anxiety to potential adopters. Revenues generally decline as yields are lower than conventional at first and farmers cannot receive organic premiums until they are certified. Net returns are impacted by a combination of effects: rotation adjustment (revenue generating crops like corn and soybeans may have to be substituted with less profitable crops that improve soil health); biological transition (poor soil health possibly including residues from pesticides requires time and active nurturing to raise soil biological activity and with it crop yields); learning (transition is a difficult process and the farmer must learn about her farm and the methods she is applying to increase yields and design suitable rotations); and a perennial effect (a combination of all other effects in a process) (Dabbert and Madden, 1986).

Transition is also hampered by difficulties associated with obtaining information on the process of transition and in finding mentors or models as few neighbouring farms have attempted transition. Personal anxieties are also serious impediments, as farmers report anxiety around, or difficulties with, thinking through the necessary changes to their farm – processes that are inconsistent with traditional management approaches on their farms. The farmer may lack confidence in her own abilities. The impression of peers should also not be discounted, as anxiety may surface about changing perception of the farmer by conventional farming neighbours, or about one's status in the community and amongst institutions such as banks.[25]

While much evidence confirms that organic farmers perform financially as well as or better than conventional farms over the medium term, the assumption that farmers adopting organic are primarily motivated by the promise of better net returns is incorrect. While economic factors are important, adopters are often motivated by values such as environmental protection, social justice, a healthy farm environment and the production of healthy food (MacRae et al., 1989). Similarly, the barriers to adopting organic farming by conventional farmers or new entrants to the sector, and the barriers to substantially increasing the scale of organic production on a provincial or national level, are numerous.

Despite these obstacles the organic sector continues to grow with retail sales growth estimated to be between 15 and 25% per year (Willer and Yussefi, 2006, as cited in MacRae et. al., 2009). In Ontario, organic farmers work about 1% of cropped acreage. More rapid and significant growth of Ontario's organic sector, including greater acreage in organic and greater processing and marketing capacity, however, is hampered by limited policy support for the sector thus far. European experiences with organic sector development have suggested that only supportive government intervention can rapidly increase the level of organic production in Ontario beyond what markets alone are only slowly achieving. Such intervention has been used with success by Canadian governments in the past for infant industry development, such as in the case of its active intervention in support of the development of the Ontario wine sector (MacRae et al., 2009).

[25] MacRae (2007) Presentation given at York University, Faculty of Environmental Studies.

Taking these lessons about adoption, institutional barriers, and successful institutional support for organic in several jurisdictions, researchers[26] have proposed in a couple of papers (MacRae et.al., 2006b; MacRae et al., 2009) a comprehensive proposal targeting the institutional and programming needs to achieve growth of the Ontario organic sector to the level of 10% of cropped acreage in the province over a fifteen year time period. Part of the plan's strategy is to provide farmers with payments for offsetting risk associated with transition during the years of transition (three consecutive years), based on average yield reductions for specific agricultural commodities (payments at 10% of gross revenue loss per commodity). A one-time payment (in the third year following certification) for avoided external costs of conventional agriculture in Canada, associated with potential damages wrought by pesticides and animal medications is also proposed. These direct payments are highlighted, as they will be included in the model organic scenario developed in Chapter 6.

The comprehensive proposal, while not elaborated upon further here, serves as an example of the policy context assumed in the organic scenario – active support for the transition to organic. Added to this, the organic scenario modeled in this study assumes carefully designed crop rotations and livestock populations suitable for the Maitland Valley, choice of crop and livestock operation by farmers largely determined by site characteristics, and commitment to landscape level goals such as increased vegetative cover and landscape connectivity, as well as buffered stream and riparian areas.

[26] The studies included researchers from universities, the Organic Agriculture Centre of Canada, and the World Wildlife Fund Canada.

Section 2: Exploring Alternative Agricultural Futures

4.0 Study Area

4.1 *Maitland Valley Watershed and the Middle Maitland sub-watershed above Listowel*

Located in southwestern Ontario, the Maitland Valley watershed includes the Maitland and Nine Mile rivers and several shorter streams along Lake Huron. The Maitland is divided into five sub-watersheds: South Maitland, North Maitland, Little Maitland, Lower Maitland and the Middle Maitland. The last of these, the Middle Maitland, is further divided in sub-watersheds and includes the study site for this research. This sub-watershed is located to the northeast of the town of Listowel, Ontario. The Maitland watershed covers 2572 sq. km, is home to a population of 60,000, and the river has five main tributaries. These are the Little Maitland, South Maitland and Middle Maitland tributaries, which flow to the main stem of the Maitland river, and the North Maitland and Lower Maitland Rivers, which are the two branches of the Maitland River that flow to meet Lake Huron in the west. The Maitland watershed, together with the Nine Mile River watershed, falls under the purview of the Maitland Valley Conservation Authority (MVCA) (see Appendix 3), which encompasses an area of 3266 sq. km (ABMVSPR, 2008).

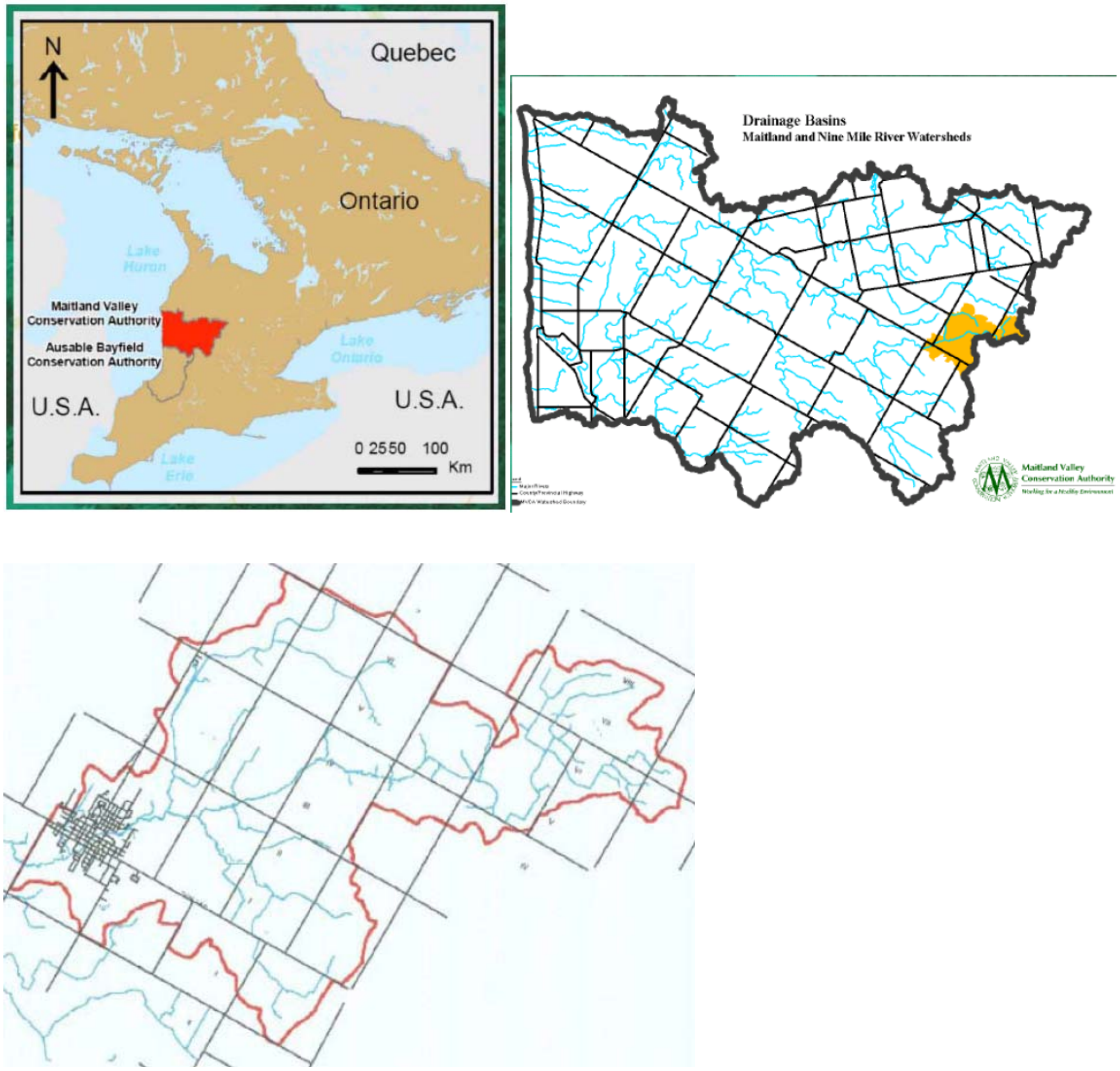

Figure 4.1: Location and jurisdiction of the Maitland Valley Conservation Authority (MVCA) in South Western Ontario (top left) (map reproduced from the MVCA, 2007); Middle Maitland and Nine Mile River Drainage Basins and associated streams with the Middle Maitland sub-watershed above Listowel highlighted in yellow (top right) (map reproduced from the MVCA, 2007); sub-watershed boundary shown in red, including the Middle Maitland River and associated streams, and also showing Listowel - identified by the concentrated road grid to the west (bottom) (map reproduced from the MVCA, 2007).

The Middle Maitland sub-watershed above Listowel (hereafter MMSL) refers to a 74 sq. km catchment area portion of the headwaters of the Middle Maitland River (see Figure 4.1). The MMSL straddles the counties of Perth and Wellington in Southern Ontario, and it is one among several sub-watersheds along the extent of the Middle Maitland River. The river itself is a tributary of the Maitland River – the largest river in the Maitland watershed. The town of Listowel was amalgamated in 1998 with the townships of Wallace and Elma into the municipality of North Perth, and in 2006 it had a population of 6303.

4.2 *Physical Environment*

Situated in the Western Saint Lawrence Lowland physiographic region, the MMSL and its environs are typified by drumlinized and undrumlinized till plains, with undulating topography (Singer et al., 2003; ABMVSPR, 2008). It predominantly straddles three rock formations, these are from west to east: the Bertie Formation; the Bass Island Formation; and the Salina Formation.[27] The elevation of the MMSL ranges from 350 meters above sea level in the west to about 450 meters above sea level in the east. A further gradient of the MMSL is the generally medium texture soils typifying the western portion and giving way to generally heavier texture soils in the eastern portion. These soils range from moderately drained in the western portion to slowly drained and at points poorly drained in the east (see maps 3.1, and 3.5, ABMVSPR Draft Assessment Report, 2008; The Soils of Perth County, 1952).

[27] These titles for these landforms may have been changed since the 1952 survey.

Figure 4.2: Aerial photograph of the Maitland Valley, Ontario, with the sub-watershed basin outline shown in blue.

Permeability of the soil and the topography of the land are the two factors determining drainage. Slowly permeable materials in level, depressional or even undulating areas, such as many field conditions in the MMSL, result in insufficient drainage for many row crops (Hoffman et al., 1963). Owing to this drainage character, much of the eastern region of the Maitland Valley has been extensively artificially drained, and it is estimated that over 75 % of agricultural land has been tile drained in the till plains area, which includes the MMSL (ABMVSWP, 2008).

Tile drains and associated outlets were installed in the 1970s facilitating a movement out of smaller farms focusing on hay, pasture and small grains (with corn planted on better fields), to larger farms focusing on corn and soybeans and substantial row cropping. Larger machinery required expanding and straightening fields and saw many hedges and fence lines removed (COSEWIC, 2006).[28]

Channels were also modified over time and the upper portions of the Middle Maitland and the South Maitland tributaries have undergone the most channel modification in the MVCA.

4.3 *Climate*

The climate of southern Ontario is described as temperate with mild winters, warm summers and consistent precipitation. Proximity to the Great Lakes, prevailing winds and topography determine local variation in climate, whereas the frequency and nature of weather systems that pass through the area determine annual variations in climate at the local level (Brown et al., 1968, as cited in Singer et al., 2003).The MMSL receives mean annual precipitation of between 900 and 1000 mm with mean annual snowfall at between 200 to 250 mm. Mean annual evapotranspiration for the MMSL is between 500 and 600 mm with mean annual runoff between 400 to 450 mm (Singer et al., 2003).

The MVCA notes several trends in the areas' weather over the past 40 years, including increased high intensity rainfall events of shorter duration, more events with 25mm or less

[28] Changes in seed varieties and favourable prices for crops in the 1980s brought even more row cropping as livestock operations moved to cattle feedlots. This had the effect of fewer cattle grazing near water, but resulted in a high production of liquid manure applied to crops that are tile drained leading to runoff and leaching of nutrients that can pollute water bodies (COSEWIC, 2006).

rainfall, and general increase in average annual precipitation of 27mm over the years 1951 to 1990 (MacRae, 2008).

4.4 *Hydrology, Water Quantity and Water Quality*

The flow of water through a basin is determined by elevation features, slope of the land, the permeability of soil, and the geology of land below the soil region. Areas of steep land gradient with less permeable land geology (e.g. till) and less permeabile soils (e.g. clay) promote the overland flow of water through the basin, as precipitation falls on the landscape and flows to rivers and streams (runoff). These basins are surface water systems with little infiltration of precipitation through the ground. For this reason, contaminates present on the landscape have potential to be transported to rivers in surface systems (ABMVSWP, 2008).

Landscapes with more permeable geology and soils permit the infiltration of water from precipitation into underground cavities called aquifers, which may be shallow or deep below ground. These basins are ground water systems, and when the landscape includes steep gradients and also highly variable topography, water that has infiltrated the ground at higher elevations may surface as springs downstream. This process results in better water quality, including moderated stream temperatures (cooler in the summer and warmer in the winter) and well as more stable stream flows. Drinking water in the MMSL is derived from groundwater wells, as is true for residents in most of the non -coast area of the Maitland Valley watershed (ABMVSWP, 2008).

The physical character of landscapes is modified by human activity and this affects the quantity and quality of water at usable points in the systems. In agricultural basins, land use and management often reduce vegetative cover, and expose soil, especially where row cropping is practiced. Exposed soils can be eroded by wind and runoff and transported as sediment to streams. Other contaminants include nutrients, such as phosphorous and nitrogen, that are produced in, added to and removed from farming systems. Livestock operations involve manure production, handling, and/or application to crops, and pathogens from manure or inadequately composted manure, such as bacteria, viruses and protozoa, can also contaminate waters (Martin, 2005, as cited in ABMVSPR, 2008:105).

The Middle Maitland is prone to occasional flooding, owing to increased speed of runoff in an area of little natural vegetation, clay soils, the steep gradient of headwaters topography, and the timing of precipitation (ABMVSPR, 2008). The proximity of upstream tributaries may also be a factor in the area's flood problems. The MMSL in particular is hydrologically active (Phil Beard, personal communication, 2008) and the town of Listowel constructed a conduit to mediate the flooding associated with extreme weather events, such as strong summer storms. While this has partly mediated the flooding, channel naturalization and riparian vegetation are recommended by the MVCA for the area, as a substantial flood risk remains (ABMVSWP, 2008).

Generally speaking, any landscape changes that shorten pathways for the flow of water, both in terms of the distance traveled and the time traveled, will increase the potential for contaminant delivery to local water bodies. Landscape changes, such as clearing natural vegetation to cultivate land with wide row crops, or installing artificial drainage, increase the potential for nutrient and sediment delivery by decreasing the time and surface area over which such contaminants could be diluted, filtered, stabilized, or bound (ABMVSWP, 2008). The likelihood that nutrients will be transported to surface or groundwater, as well as their concentration when delivered, increases with increasing production of or application of nutrients (ABMVSWP, 2008).

When farming extends to sensitive areas, operating on steep, poorly drained soils and on riparian areas, there is a significant increase in the likelihood of erosion and runoff transporting sediment and nutrients to streams and rivers. In the early 1980s, farmers were often unaware of the extent of these problems (Balint, 1984, as cited in ABMVSWP, 2008) but educational initiatives undertaken by Conservation Authorities in the region have raised farmer awareness of the problems of bacteria and nutrient contamination of waters. Presently, the Maitland is one of the highest manure producing areas in the country due to the high concentration of livestock (Beaulieu et al., 2001), and combined with extensive tile drainage systems, contaminant delivery remains a risk.

While data gaps are numerous for the Source Water Protection planning region[29], several observations are worth highlighting here. Recent monitoring in the ABMVSPR carried out at thirty stations over the years 2001 to 2005 suggests that concentrations of nitrates and fecal coliform are increasing while concentrations of phosphorous are decreasing. The surface water quality monitoring site in Listowel found *Eschericia coli* between 250 and 50 cfu/100 mL (ABMVSWP assessment report II map 2.5), exceeding the Provincial Recreation Objective of 100 cfu/100 mL (MOE, 2006). Total Phosphorous was found to be present between 0.07 and 0.15 mg/L (ABMVSWP, 2008), which exceeds the Interim Provincial Water Quality Objectives (the least demanding of these objectives is that of 0.03 mg/L, below which "*excessive plant growth in rivers and streams should be eliminated*" (MOE, 2006). Nitrate as Nitrogen

[29] There are significant data challenges when undertaking integrated environmental studies that cross several jurisdictions and the author experienced this throughout research process.

concentration was found to lie between 5.1 and 7.05 mg/L (ABMVSWP, 2008), which is below the Minimum Acceptable Concentration for the Ontario Drinking Water Standard of 10.0 mg/L (MOE, 2006).

4.5 *Potential Impacts of Climate Change and Implications for Agricultural Activity in the Area*

Expected changes to weather patterns in the Lake Huron region, of which the Maitland Valley is a part, include average temperature increases between 3 and 6 degrees Celsius over the next 50 years with dramatic fluctuations between years. Over this period, average annual precipitation is expected to decline by 4%. The current pattern of precipitation will change as up to 30 % more precipitation is expected in the spring and 30% less precipitation in the summer and winter, with much of the latter falling as rain due to expected average winter temperatures above 0 degrees Celsius (MacRae, 2008).

Intense rainfall events are also anticipated for the area, and the MVCA notes that this involves an increased potential for bank erosion in streams and ditches and soil erosion from fields, ultimately contributing higher sediment loads to local water bodies. Other implications of the expected changes to local climate and weather include drier summer and fall seasons and a wetter spring, presenting problems for soils with already low moisture. Crop damage from extreme weather events is likely to increase. Yields for major crops in the area are projected to decline due to reduced moisture in the growing season (for example, corn and soybean yields could decline by as much as 20% and 12%, respectively). Furthermore, extreme weather events and heat stress from drier, hotter conditions will mean increased stress on livestock and associated production declines (MacRae, 2008).

4.6 *Vegetation and Land Use*

The vegetation covering over 95% of the watershed prior to European settlement was climax

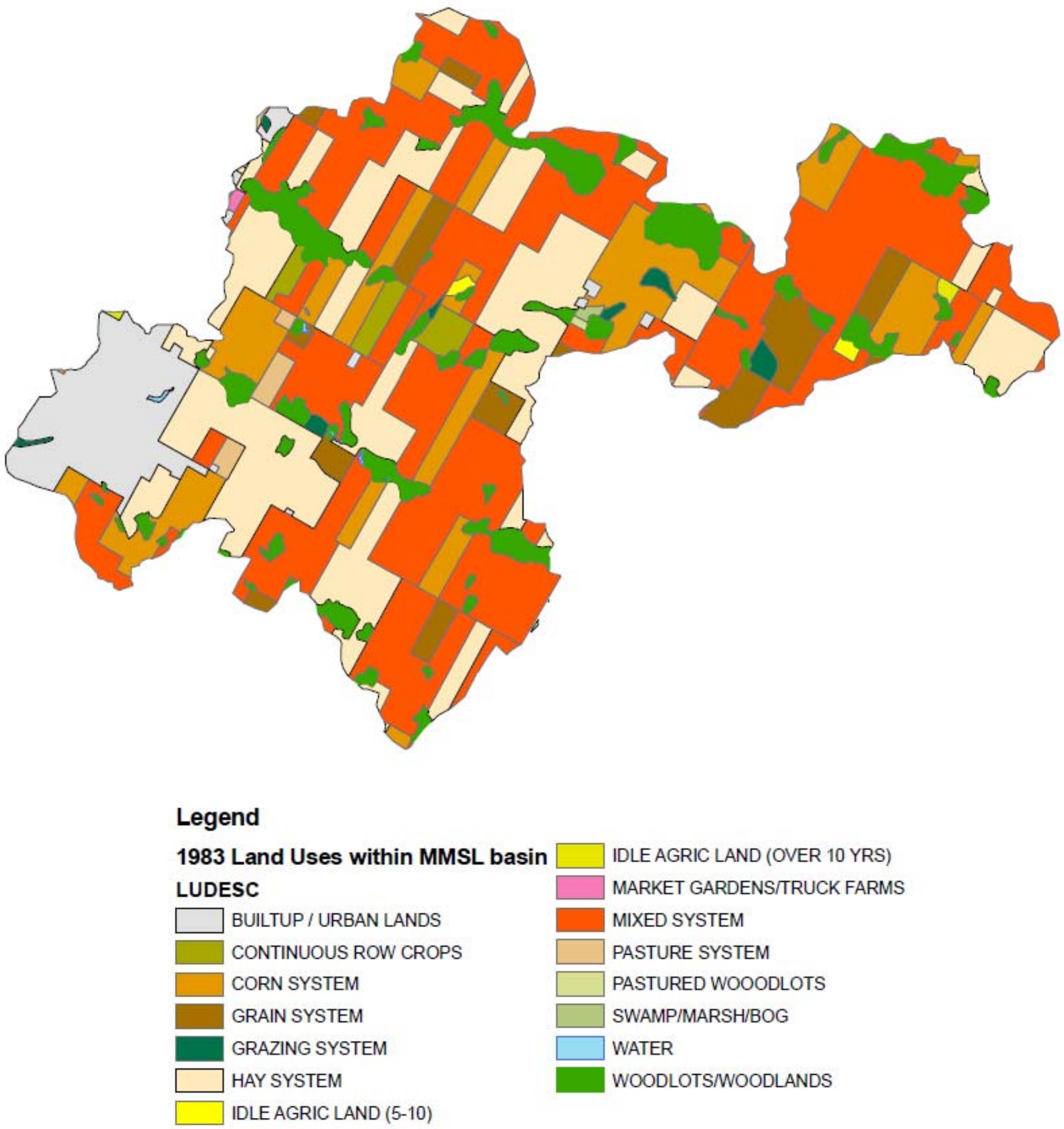

Figure 4.3: Major land uses recorded for the Middle Maitland Valley sub-watershed above Listowel, Ontario, in 1983. (Created from geospatial data file, Ontario Land Use Survey, 1983).

forest. Since settlement, forest cover has been reduced to its present level of 18.9% natural cover for the jurisdiction of the MVCA, with fragmented and scattered patches. More than half of the extant forests in the area are in poor condition (MWP TT v.8, 2009). The Land Use Survey of 1983 (see Figure 4.3) found that the MMSL had approximately 7% urban and built up land, about 10% in woodlands or woodlots and about 80% agricultural land, aside from water courses and wetlands. The agricultural lands of the MMSL were found to be 37% in a Mixed System, 22% in a Hay System, 12 % in a Corn System, 5% in a Grain System, 2% in Continuous Row Crops and smaller proportions in Pasture Systems and Grazing Systems (geospatial data file, Ontario Land Use Survey 1983).

5.0 Methods

5.1 *Interdisciplinary Project Team*

Because of the project team environment in which this MRP was developed it is important to distinguish between work undertaken by the author, and that undertaken by other project team members as part of the larger project[30], but which contributed to my project directly. For this reason, all of the research, literature review, modeling and writing in this MRP are the work of the author, except where specifically indicated and attributed to another project team member in footnotes throughout this Methods section. The project team members with whom I collaborated were Rod MacRae, Eric Gallant and Stephanie Schaffner (these last two were both graduate assistants).

As part of the project team, the author met and corresponded with contacts at the Maitland Valley Conservation Authority (MVCA) and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), both of which provided essential data for the project.

5.2 *Theoretical Background and Literature Review*

This MRP draws on three approaches to enhanced sustainability of managed systems: 1) the ecosystem services approach as established by the Millennium Ecosystem Assessment; 2) sustainable agriculture and specifically organic production systems; 3) the scenarios and alternative futures approach. These approaches are used to frame a modeling exercise that combines geographic information systems (GIS) and cost and revenue (CAR) farm enterprise

[30] The larger project is the Organic Science Cluster, based at FES, and commencing Fall 2010. The research focus for this project is to model agricultural sub-watersheds and transition to organic to assess adaptation to and mitigation of climate change.

budgeting to consider a sub-watershed level transition to organic agriculture. An explanation follows of how these approaches and techniques have been used.

5.2.1 Ecosystem Services Approach

Literature on Ecosystem Services (hereafter ES), and different classification systems and approaches was reviewed above. The Ecosystem Assessment approach to Ecosystem Services and Human Well-Being was chosen as an organizing framework to discuss ES and the transition to more sustainable agriculture in the MMSL as it is perhaps the most comprehensive and detailed framework available for integrating assessments of ES and policy. Building on the area context and its environmental problems, and the MA classification of agricultural ES, some key ES relevant to the MMSL context were selected, to serve as a focus throughout this MRP. The ES chosen correspond generally to three areas: Water, Soil, and Biodiversity (specifically biological control of pests). The brief review of ES literature, description of the MA framework and its application to the MMSL context including the choice of key ES selected for the study is summarized in Chapter 1: Ecosystem Services and Agriculture.

5.2.2 Policy and Economic Aspects of supporting Ecosystem Services

A brief review was carried out of the technical, economic, and institutional dimensions of some of the policy responses typically promoted or increasingly suggested for addressing deterioration and/or enhancement of the key ES areas identified in Chapter 3. This was combined with efforts to identify any current initiatives or proposed initiatives in the MMSL or neighbouring sub-watersheds for supporting Ecological Goods and Services (EG&S). This included a review of environmental and ecological economic literature on incentives for the provision of ES, case studies of payments for EG&S schemes, landscape agroecological literature and technical reports from provincial ministries on Best Management Practices (BMPs) for agriculture in Ontario. The results of this review are summarized in Chapter 2: Technical, Economic, and Institutional Dimensions of Enhancing Ecosystem Services.

5.2.3 Sustainable Agriculture and Organic Production Systems

A brief literature review was undertaken of sustainable agriculture and organic production systems including design and management considerations, ecological dimensions, and economic and policy considerations within the theory of organic transition. The Canadian Organic Standards (2006, 2008, and 2009) were reviewed as well as proposed government programs to increase organic production, processing and marketing in the Ontario context. Literature on policy supports for organic agriculture in other jurisdictions was also briefly reviewed. This is summarized in Chapter 3: Organic Agriculture and Transition.

5.2.4 Area Context

The chapter describing the area context for this study was informed by a visit with Phil Beard, General Manager of the MVCA, and by reviewing literature available pertaining to some of the more relevant physical, natural, cultural and institutional dimensions of the MMSL. These documents included Ontario Source Water Protection planning documents (produced by the Ausable Bayfield Maitland Valley Source Protection Region, or ‘ABMVSPR’), historical soil surveys for Ontario counties, hydrological surveys, geospatial data on land uses from 1983, assessment reports from the Maitland Water Partnerships Terrestrial Team, and briefing notes on the expected impacts of climate change to the region.

5.2.5. Scenarios and Alternative Futures

Alternative futures approaches were reviewed focusing on the recent work sponsored by the Environmental Protection Agency (EPA) in the U.S. regarding land use changes and sustainability at watershed levels. The Iowa watersheds interdisciplinary project resulted in several articles exploring realistic scenarios of change over twenty-five years for two primarily agricultural watersheds in Iowa, to probe policy implications and potential economic and environmental outcomes for the sub-watersheds (see Coiner et al., 2001; Nassauer and Corry, 2004; Nassauer et al., 2002; Rustigian et al., 2003; Santelmann et al., 2004; Santelmann et al., 2006; Vaché et al., 2002; White et al., 2003). These articles served to guide the modeling framework for this study, which is described below.

5.3 *Characterization of Baseline and Modeling Scenarios*

5.3.1 Data

Geospatial data on soils (digitized from the soil surveys of Wellington and Perth counties), Department of Fisheries and Oceans (DFO) information on streams, natural areas, wetlands, parcels, land uses (digitized from the 1983 Agricultural Land Use Systems classification), roads, sub-watershed boundary, and elevation were obtained from the MVCA[31] in addition to digital Aerial photos of the sub-watershed. Geospatial data of crop types on a field basis, including some observations of tillage, manure application, row width, stock height and direction of crops, were obtained from Ontario Ministry of Agriculture, Food and Rural Affairs.[32] Data were

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[31] Data was obtained from Phil Beard of the Maitland Valley Conservation Authority (MVCA).

[32] Data was obtained from Stewart Sweeney of the Environmental Management Branch, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA).

maintained in a database at the Faculty of Environmental Studies Geomatics Lab (the 'SpEAR Lab') and analyzed using ESRI ArcGIS 9.2 and Microsoft Excel and Access.

Owing to the common farming practice of occasionally changing a field's crops or dividing a previously homogenous field into multiple sections to accommodate different crops (known as "fields splits"), the database contained inconsistent boundaries over the years 2005 to 2009 (Stewart Sweeney, OMAFRA, Personal communication, 2009). To facilitate consistent modeling and analysis of the dataset, a single set of boundaries was required, and so 2006 was selected as the base year given that it had the highest number of field splits and the largest set of boundaries. The 2006 set was applied to each of the remaining years (2005, 2007, 2008, and 2009); joining or splitting boundaries was required based on the greatest number of boundaries.[33]

Once a consistent set of fields was defined, a subset of the dataset had to be defined to correspond with the hydrological boundary used by the MVCA to delineate the MMSL. All farm fields falling within the MMSL boundary were included as well as all farm fields straddling or touching the sub-watershed boundary to any degree. This set of farm fields was defined as that to be used in this project. This was done so that no fields would be split based on the hydrological boundary as it is assumed that field management is generally homogenous and not sensitive to hydrological mapping boundaries. The portions of the sub-watershed that were not farm fields were split (for the data layers i.e. digital maps) along the sub-watershed boundary, where they overlapped with the boundary. These non-field areas included driveways, ditches, natural areas, residential and urban areas.

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[33] This meticulous process of boundary checking, digitizing, annotating and changing field attributes, and verifying consistency across years was undertaken by Stephanie Schaffner as the GIS graduate assistant working on the project team.

Also, the datasets are incomplete observations in that within each of the five years, field observers could not determine all field crop types as their view was obstructed or the vegetation in the field was not identifiable while using the “windshield method”.[34]

Data on farm management units, their specific sizes and locations in the MMSL were not available from the Statistics Canada Census of Agriculture due to privacy concerns set out in the Statistics Act (1970-71-72), which suppresses sensitive data associated with small geographic or sub-census units. For this reason, total number of farms, farm sizes, livestock population numbers and the location of farms, all had to be estimated in an iterative manner and triangulated using both expert opinion (contacts at the MVCA) and data from Statistics Canada.

Farm data from the 2006 census was available in more aggregated forms for different purposes; in this case the North Perth census division contained most of the area of the MMSL. Also, the recent Interpolated Census of Agriculture to Soil Landscapes, Ecological Frameworks, and Drainage Areas of Canada, (hereafter the ICASL) which connects Census of Agriculture farm business and land use tables to non-census unit geographic areas, such as the Soil Landscapes geographic database, was relevant as the MMSL intersected three divisions of the Soil Landscapes database. An area proportion of the MMSL’s overlap with the ICASL provided very rough approximations of farm management units, livestock populations, total crop areas and environmental practices.

Average Animal Units (AU) were inferred from the “Distribution and Concentration of Canadian Livestock” report (Statistics Canada, 2001). The average number of AU for the area of

[34] In order to provide an aggregate picture for costs and returns of agriculture in the sub-watershed, fields that were not identified to crops were summed by area and given an area-weighted proportion of returns from all major crops observed in order to compare with the aggregate organic returns modeled for the MMSL.

Southern Ontario that includes the MMSL was combined with AU coefficients for Ontario to estimate total cows, calves and heifers for beef and dairy in the MMSL. Observed livestock pasture types and their prominence in the MMSL eliminated all livestock types except for dairy and beef for this study (horse and turkey operations were observed but in smaller numbers and they were excluded from the model for simplicity). The AU totals were apportioned to beef and dairy in a 33% and 66% share, respectively, as the MMSL was noted to be mostly in dairy operations (Phil Beard, MVCA, personal communication, 2008). From these figures, the number of dairy and beef farms were assumed by using the herd sizes given in the most recent dairy (2009) and beef cow-calf (2008) enterprise budgets published by OMAFRA and all beef livestock for the MMSL was assumed to be in cow-calf operations.

The total area of farm fields was found to be 6691.9 ha and the number of farms was estimated to be 100, as this number was close to both expert opinion (Phil Beard, personal communication, 2008) and the number suggested (95 farms) by the area proportion analysis of the ICASL. Average farm size then was assumed to be 67 ha, which is 165 acres and is close to the median farm size (between 130 and 179 acres) for the upper tier municipality of North Perth, which overlaps most of the MMSL.

5.3.2 Assigning Boundaries for 4 Representative Farms

Following the road grid, the MMSL data layers were divided into zones. Four sites were then chosen as farm management units[35]. These were chosen by visual inspection of the GIS field layers and satisfied the following imperatives: be located in different zones and be distributed across the sub-watershed overall; be comprised of adjacent fields and contained within a few

[35] It was not possible to identify real farm boundaries in the MMSL, due to confidentiality provisions.

land parcels rather than many parcels; be close to the average farm size assumed for the MMSL; contain several fields of a multiple of the number of years in the selected rotation model for the farm; contain predominantly the suitable soil types for a particular rotation model as described below. This selection process could have lead to selection of numerous other sites but the important step for this model was to establish four that met the above criteria, whatever combination of fields they involved. The farm units then included the fields designated to the model as well as the adjacent non-field spaces, including driveways, farmsteads, ditches, fence rows, and streams.

5.3.3 Designing Scenarios

Once the baseline situation of agricultural and land use practices in the MMSL was sufficiently characterized, two scenarios were elaborated. The first scenario was the Enhanced Conventional Scenario (or, the 'conventional scenario'), which was defined by the baseline data for farming, and land uses in the MMSL. It is essentially the Base Case, as it is commonly referred to in modeling literature, however, it includes some elements added to enhance expected environmental outcomes of the scenario, hence the descriptor 'enhanced'.

The second scenario was the Enhanced Organic Scenario and it was defined by the elimination of synthetic inputs, the application of cultural methods to promote soil health, improve yields and conserve resources, and the transition process by which farms move from conventional to organic certification, according to the Canadian organic standard.

The four sample farm sites were chosen to develop a farm level comparison for the scenarios. The same management and design changes applied to these four sample farms were applied to the entire MMSL, giving two sub-watershed level scenarios. The four farm sites of the

Enhanced Conventional used observed crops, field areas and rotations and the Enhanced Organic Scenario used the same field areas but with modeled crops and rotations, and modeled yield declines observed in organic transition, as described below.

5.3.4 Defining the Transition to Organic Scenario

Crop rotation data were organized to identify the major crop rotations and any anomalies or unusual crop or livestock operations in the dataset. Based on this review, four organic crop rotation models suitable to the MMSL context were provided by the Organic Agriculture Centre of Canada (OACC).[36] Analysis of suitable soils for each of the rotations was provided by expert opinion based on reviews of the soil types, drainage character, and elevations for the portions of the MMSL as described in the soil surveys for the former Perth and Wellington Counties.[37] Better soils for cropping were allocated to more intensive cropping operations, such as rotations 1 and 2. These four rotations with suitable soils are described in Box 5.1.

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[36] The review of observed crop rotations was undertaken by project lead Rod MacRae and the rotations models were developed by the OACC in consultation with Rod MacRae.

[37] The review of soils types, drainage character and elevations in order to assign generally suitable soil types was completed by project lead Rod MacRae.

Compared with conventional agriculture methods and short rotations, these rotation models are longer and more complex. They all include nutrient contributing legumes, and the mixed operations each have hay or pasture in their rotations. Pasture allows manure to be delivered to the fields as cattle graze, whereas manure collected in barns that house animals

Box 5.1: Four crop rotation models applied to give four different farm types for the modelling scenarios.

Rotation 1: Mixed operation of crops and livestock (beef or dairy):

A five year rotation of: corn-soy-spelt/undersown alfalfa/grass in the spring - alfalfa/grass - alfalfa/grass (then back to corn). Manure is applied before the corn. Suitable soils present in the MMSL: Huron clay loam; Huron silt loam; Harriston silt loam; Burford loam.

Rotation 2: Cash cropper with no livestock

A five year rotation of: spelt (with oil radish cover)-soy-oats undersown with clover / grass - hay - hay (and back to fall planted spelt). Suitable soils present in the MMSL: Huron clay loam; Huron silt loam; Perth clay loam; Perth silt loam; Listowel silt loam; Burford loam.

Rotation 3: Mixed Operation of cropping and Livestock (dairy)

A five year rotation with four years of alfalfa/grass followed by one year of either winter wheat, edible beans or oats/barley. Suitable soils present in the MMSL: Huron clay loam; Huron silt loam; Burford loam; Imperfectly drained soils where they are tile drained, such as Perth clay and silt loams and Listowel silt loam; Waterloo sandy loam.

Rotation 4: Pasture and Livestock (beef or dairy)

Permanent pasture. Conducive soils present in the MMSL: Brookston clay and silt loams; Parkhill loam; Donnybrook sandy loam; Waterloo sandy loam; Bottom lands; Muck if not used for natural areas.

when they are not in the fields, can be composted and applied strategically, for example in rotation 1 manure is applied before the corn. Grazing is rotational on these farms, further increasing the landscape complexity by fostering a shifting mosaic over pastured areas. Cover crops and green manures are also used, such as the oil radish cover applied to spelt in rotation 2. The spelt is harvested but the oil radish overwinters, and is plowed down in the spring, contributing nutrients that can be used by the soy crop that follows it. Finally, the four farm types are distributed to suitable soils in the MMSL (see Chapter 4: Methods), which sees rotations 3 and 4 assigned to poorer soils in the model. This is designed to ensure highly productive soils are the sites of more intensive cultivation, whereas less productive soils and/or poorer site conditions devoted to sustainably grazed pasture to reduce erosion pressure.

A decision matrix was structured based on the suitable soils for each rotation, the estimated total sub-watershed livestock population, and individual farm herd numbers in order to exhaust the allocation of farm fields in the MMSL to each of the four rotation models of the organic scenario (See Appendix 1 for table showing the assignment of rotation models to suitable soils).

5.3.5 Enterprise Budget Modeling

The enterprise budgeting approach as described in Coiner et al. (2001) was applied to model both an aggregate comparison and a comparison of four representative farms for both the conventional and the organic scenarios. Field areas for crop types were combined with sample enterprise budgets developed by OMAFRA in 2008 and 2009 for each crop type observed (conventional) or modeled (organic scenario).[38] Enterprise budgets were iterated for 10 years, repeating the five years of observed crop types in the baseline and repeating the five years of modeled rotations in the organic scenario. For the base case all default costs and prices of the sample budgets were accepted with the only modification being an adjusted (increased) yield in

[38] OMAFRA sample budgets available at http://www.omafra.gov.on.ca/english/busdev/bear2000/Budgets/budgettools.htm

year 8 to account for the expected effects of added treed windbreaks. Organic crop budgets developed by OMAFRA were used for organic crops and most of the default costs and prices were accepted, including the elimination of input costs for fertilizers and pesticides and including the adjusted (reduced) yields throughout the 10 years but adjusting (increasing) yields to account for windbreaks again in year 8. Prices for the 10 years of organic crops were of two types: conventional prices obtained in transition years 1 through 3; organic premium prices obtained in organic certified years 4 through 10. As there is no significant market for transitional (i.e. conventional) spelt in Ontario it was assumed that it could be sold at the significantly lower price for winter wheat (Rod MacRae, personal communication, 2010).

Livestock budgeting also relied on OMAFRA developed sample budgets and accepted the default costs and prices as well as the given herd size. Given that no organic livestock budgets were available from OMAFRA several modifications were made.[39] These included a reduction in herd sizes of 10% (and similar reductions in the numbers of calves retained and marketed accordingly), a reduction in animal weight of 10% (to account for the longer time generally required to reach marketable weights – Rod MacRae, personal communication, 2010), and a reduction in veterinary and medical costs due to prohibition of most conventional veterinary inputs. An increase in the days on pasture (in the case of beef operations) or in the pasture cost (in the case of dairy as the budget did not contain a line for days on pasture) was applied with a corresponding reduction in the winter feed cost or non pasture feed cost, and reductions in feed overall accounting for smaller herd sizes, as well as a reduction in the number of cull cows (from 5 to 4) and a 10% reduction in the value of culled animals sold. Finally, the value of animals sold for breeding was reduced by 10%. As in some cases the 2008 budget was

[39] These modifications were informed by discussions with Rod MacRae.

used where no 2009 budget was developed by OMAFRA, differences in prices for commodity inputs to livestock feed, such as the price of hay, had to be changed to make them consistent for both the crop and livestock portions of an operation across all budgets.

According to the practices recommended by the American Agricultural Economics Association's Commodity Costs and Returns Estimation Handbook (American Agricultural Economics Association's (AAEA) Economic Statistics and Information Resources Committee, 2001), all marketable commodities produced were assumed to be sold at market value and all marketable commodity intermediate inputs, such as hay, which could be grown on the same farm as the livestock operation and fed to the livestock, was assumed to be sold at market value. While the organic farms in this model are designed by rotation to be significantly self-sufficient, and therefore farms create their own intermediate inputs to production (i.e. crops and pasture grown on mixed operations are fed to the herd), the approach recommended by the AAEA was adopted in order to provide consistent accounting with measures of marketed value where possible.

Finally, this budgeting method was used to estimate the amounts and costs for pesticide and fertilizer inputs and application fees for the overall conventional scenario. The product costs and application fees were included in the sample budgets for the average Ontario farm by commodity, and totalling these across all farms gave an estimate of input savings for the MMSL.

5.3.6 Payments for Ecosystem Services and application of Best Management Practices.

The Chapter 2 review of Payments for Ecosystem Services (PES) initiatives (or initiatives inspired by PES theory) relevant to the MMSL context highlighted a set of Best Management

Practices (BMPs) and associated incentives to reward the provision of ES. Each of these were modeled for their spatial effect on changes to field areas and their financial effect for changes to areas cropped and contributions to expected returns from incentive payments.

Treed windbreaks were applied to both the conventional and the organic scenarios and modeled on the Trees for Mapleton and the Wellington Rural Water programs (Roulston, 2009), which provide trees and cover planting expenses to establish windbreaks to approximately 2% of cropped farmland, and provide an incentive payment of $107 per acre for seven years for each acre removed from cultivation and transformed into a treed windbreak. A conservative estimate of increased yields due to windbreaks around fields at a rate of 10% increase for each crop type was applied to both the conventional and organic scenarios starting in year 8 and sustained through year 10.

Riparian buffers of 20 m on each side were applied to all watercourses in the MMSL in both the conventional and organic scenarios. Riparian buffers are assumed to be of appropriate local vegetation, and are modeled on the ALUS (Alternative Land Use Services) proposal for Norfolk County Ontario (Gagnon, 2005), which proposed expected payments of $150 per acre for the "maintenance/enhancement or creation of margins with no agricultural use" (page 40). Where buffers overlapped with current fields, the reduction in cropped area due to the buffer impacted the crop budgets for that farm.

The Ontario Goes Organic proposal recommended transition risk offset payments for selected crop types including, corn, soybeans, spelt and oats, for each of the three years of organic transition. Also, a one-time environmental benefits payments of $22.50 per acre of converted field area was provided in year 6 to reward the provision of ES once organic benefits were established. Both of these incentives were included in the PES modeling, however, unlike the previous PES initiatives, these incentives only applied to the organic scenario as these policies support transition to organic (and the enhanced provision of ES expected from well run organic operations.)

5.3.7 Ten Year Timeline

The tables developed for each farm and for the aggregate analysis of both scenarios include crop rotations and run for 10 years each. Annual expected returns generated by the enterprise budget analysis are combined for each crop type and the livestock herd on the farm to provide farm level and aggregate sub-watershed level annual returns for 10 years. Net returns modeled for sample farms and for the aggregate sub-watershed level returns were calculated in year 1 dollars.

6.0 Results

This chapter presents the results, beginning with a comparison of the two scenarios according to the dominant crop types and their total field areas. This is followed by an assessment of the contributions to enhanced ecosystem services that each scenario provides from a sub-watershed perspective. Finally, the two scenarios are compared according to each one's annual expected returns, over the ten-year transition, from both representative farms and sub-watershed level perspectives.

6.1 *Distribution of Crop Types*

Table 6.1 shows the major crop types observed between 2005-2009 and gives the annual average area per crop type. Only 80 % of the field area was identified to crop type when data was collected, but dominant crops are evident, in particular, approximately 28 % of the MMSL field area is planted to corn annually, while another 16% for soybeans and 15% for alfalfa/hay. Wheat, especially winter wheat, was planted on about 12 % of field area. Several other cereals such as oats and barley, and mixtures, as well as white beans, were observed in smaller proportions. This distribution of crop areas was used for the Enhanced Conventional scenario.

Table 6.1: Distribution of observed crops and total field areas for the MMSL over the years 2005-2009. (Created from geospatial data file, OMAFRA, 2005-2009).

Observed Crop Type	Observed 5 year average (ha)	percent of total field area	percent of known crops by area
Corn	1858	27.77	34.56
Alfalfa &/or Hay	1012	15.12	18.82
Soybeans	1044	15.60	19.41
Pasture	211	3.16	3.93
Wheat	771	11.53	14.35
Cereals*	432	6.45	8.03
White beans	48	0.72	0.90
Subtotal known crops	5376	80.34	100.00
Unknown**	1282	19.15	
Total known and unknown crops	6658	99.49	
Total areas:	6692	100.00	
Discrepancy***	34		

*Includes field reporting categories: "oats", "oats/barley", "barley", "wheat barley", "wheat beans", "spring grain", "spring wheat", "mixed grain"

**Unknown corresponds to fields that could either not be observed by field data collectors due to obstruction, or could not be identified to crop type by field data collector

***Discrepancy is due to each year of dataset displaying somewhat different boundaries for fields and thus total field areas. 2006 was chosen as the base year and the 5 year average has a different area than the base year.

The Enhanced Organic scenario was driven by the four designated rotation types and soils in the MMSL that were deemed suitable or preferable for these rotations. The rotations emphasized increased pasture and alfalfa/hay fields alongside longer and more complex rotations involving more cover crops and much less row cropping. These specifications lead to the distribution of field area to the dominant crop types of alfalfa/hay at about 42 % annually and pasture at about 19 % annually on average (see Table 6.2). Corn was reduced from the conventional scenario down to about 6% in the organic scenario. Soybeans were somewhat reduced to about 12%, while cereals were more widespread with about 12% planted to spelt, about 6% planted to an oats and barley mixture, and about 6% planted to an oats and clover mixture.

Table 6.2: Distribution of modeled organic crops and total field areas for the MMSL over five years.

Modeled Organic Crop Type	Modeled 5 year average (ha)	percent of total field area
Corn	393	5.90
Alfalfa &/or Hay	2792	41.94
Soybeans	768	11.53
Pasture	1248	18.74
Oats and Barley*	314	4.72
Spelt	768	11.53
Oats with Clover	375	5.63
Subtotal	6657	100.00
	0	
Total area	6657	100.00

*While rotation 3 called for either winter wheat, white beans, or oats and barley in year 5, oats and barley was used exclusively for year 5 in this model, but crop area for the organic scenario shouls be thought of in terms of all of these three options for year 5 of rotation 3

6.2 *A Preliminary Assessment of Ecosystem Service Enhancement*

6.2.1 Enhanced Conventional Scenario

The enhanced conventional scenario is built on available data of current farming and land use practices in the MMSL. In instances where no data was available on current practices an assumption was made about the state of such practices in order to compare the conventional scenario with the fully specified enhanced organic scenario's practices (see Appendix 4 for the assessment table).

6.2.1.1 Buffers and Windbreaks

The enhanced conventional scenario owes its name to the addition of riparian buffers and treed windbreaks. The baseline MMSL has a portion of its watercourses lined with riparian vegetation comprising a total area of 220 ha. The additional buffers of 20 m on each side of all watercourses extends current coverage to the entire MMSL. The baseline extent of treed windbreaks is unknown but is likely low. The existence and objectives of the Trees for Mapleton Program (Roulston, 2009) were taken as sufficient indication that if such structures are present they are not very widespread. The enhanced conventional scenario sees every 100 acres of field area wrapped in rows of trees. The windbreaks and buffers both contribute to erosion control services, and the provision of fresh water, water regulation, water purification and waste treatment, and biological control of pests services are all potentially improved with well-established buffers.

6.2.1.2 Residue Management

Residue Management was also practiced in some instances in the MMSL. The most complete dataset for observed tillage practices available is for the year 2005, which recorded tillage types for just under 50% of total field area and found approximately 38%, 7%, and 3% of field area indicated conventional tillage, conservation tillage, and no-till, respectively.

6.2.1.3 Nutrient Management, Livestock Management and Rotational Grazing

The practices of nutrient management, livestock management, and rotational grazing could not be characterized for their extent of use in the baseline from the available data. It is assumed that they are practiced in some instances but not to a high degree. They are not considered to be practiced to a greater degree in the enhanced conventional scenario owing to the lack of incentives for adoption. However, with all watercourses buffered in this scenario, it can be assumed that livestock access to water courses is hampered, which could contribute to erosion control and water purification and waste treatment services.

6.2.1.4 Crop Rotations

Crop rotations were used in the baseline, and cover crops may also have been in use on some farms, but generally in conventional agriculture these practices are rarely practiced as they would need to be in order to be considered BMPs (or as similar to those methods are regularly practiced in organic systems.) Row cropping occupied at least 43% of all field area in the MMSL, with the remaining field area largely planted to various close growing crops or pasture. Close to a third of the field area was planted to corn annually, indicating predominantly short rotations of 1, 2 or 3 years combining corn (28%) and soy (16%), or, corn, soy, winter wheat (12%) and alfalfa (15%), which is consistent with conventional rotations dominant in the region (Nagy, 2003).

6.2.1.5 Landscape Goals

Owing to the implementation of riparian buffers and treed windbreaks, the enhanced conventional scenario satisfies three of the four landscapes goals. Increased natural area coverage contributes to the provision of fresh water, water regulating, erosion control, water purification and biological control of pest services. While forest and woodlots remain at 10% as in the baseline, windbreaks and increased buffers raise the natural area vegetation from the baseline of 16% to 21%. Increased connectivity amongst patches and corridors, which contributes to biological control of pests, also flows from the addition of buffers and windbreaks that added 5% of area in the form of corridors and connections, although the degree of connectivity was not assessed. Also contributing to biological control of pests is the goal of increased landscape complexity and a diversity of habitats, evidenced again by the addition of buffers and windbreaks and the attendant increases in quantity and variety of habitat and food source for wildlife. However, the contribution to biological control is ambiguous, as conventional farms control pests with chemical rather than biological means and therefore the direction of change for this ES is inconclusive.

6.2.2 Enhanced Organic Scenario

6.2.2.1 Buffers and Windbreaks

As with the conventional scenario, the organic scenario saw windbreaks and buffers implemented to the same specifications, and these contribute to the ecosystem services in the same way as discussed above.

6.2.2.2 Residue Management

Regarding residue management, the baseline would likely change from the 38% conventional tillage, 7% conservation tillage and 3% no-till profile to greater emphasis on conservation tillage, reduced conventional tillage (mostly for corn and soy crops) and 0% in no-till, as it is not usually successful in organic operations (Rod MacRae, personal communication, 2010)

6.2.2.3 Nutrient Management and Livestock Management

The sets of practices associated with nutrient management and livestock management, while not characterized for the baseline, are assumed to be highly practiced in the organic scenario. Nutrient management is arguably highly relevant to organic mixed production systems as it is necessary to maximize the fertilizing capacity of available manure by carefully choosing when and where manure is applied, e.g. prioritized to high nutrient demanding crops in the rotation. It is assumed therefore that nutrient management practices in the organic scenario contribute to enhanced provision of water purification and waste treatment services (although this picture is complicated by the extensive use of tile drainage in the MMSL).

Regarding livestock management, it was assumed that the organic scenario sees all livestock fenced out of watercourses, except at suitable crossings (all watercourses are already buffered in both conventional and organic scenarios) and alternate sources of water are procured (e.g. via windmill pumps), although an assessment of such resources and capital costs associated with their construction was not considered here. Such livestock management practices contribute to erosion control and water purification and waste treatment services.

6.2.2.4 Rotational Grazing

Rotational grazing could not be characterized for the baseline, but it is applied as the only method of grazing livestock in the organic scenario. The practice improves forage quality and herd health, and contributes to increased provision of erosion control and biological control of pests services.

6.2.2.5 Crop Rotations

The organic scenario included BMPs such as cover crops and crop rotations – both integral to organic production systems – but with improvements over the baseline and enhanced conventional. Row cropping is reduced from (at least) 43% in the baseline to approximately 17% of field area. Crop rotations are longer and more complex, with over half of the MMSL fields managed on 5-year rotations combining row crops, cereals, legumes, and grasses, while the remaining half is rotated between alfalfa grass and cereals, or in permanent pasture that is rotationally grazed. These practices indicate a greater contribution to water regulation, erosion control, water purification and waste treatment services, and enhanced biological control of pests.

6.2.2.2.6 Eliminating Pesticides and Reducing Stocking Rates

In addition to the BMPs applied in the organic scenario – which are integral to organic systems in addition to being prescribed as best management practices for all types of agriculture – two other practices not promoted as BMPs by OMAFRA are considered here. The first is a requirement for organic certification– the elimination of synthetic fertilizer and pesticides. The baseline applications of fertilizers are estimated to be about 350,000 kg of Nitrogen based fertilizer, about 92,000 kg of Phosphorous based fertilizer, and about 296,000 kg of Potassium based fertilizer. Also about 12,200 kg or L (active ingredient) of pesticides (e.g. herbicides, fungicides, and insecticides) is estimated to be applied annually in the MMSL. None of these are applied in the organic scenario – a practice that contributes to water purification and waste treatment services as well as to the biological control of pests.

The second practice is stocking rate reductions. Baseline Animal Units (AU) for total livestock (beef and dairy) in the MMSL were estimated to be 6600 AU, which was reduced to 5940 AU in the organic scenario. Organic generally emphasizes more days on pasture for herds and lower stocking rates on grazing areas, both of which are required to meet the Canadian Organic Standards[40]. To give some broad indications of changes in stocking rates between scenarios, the ratios of animal units to pasture decrease from 25 AU per ha of pasture in the

[40] There is no set formula to calculate stocking rate reductions, rather they are supposed to be decided in consultation with the local certification officer.

baseline to 4.8 AU per ha of pasture in the organic scenario. When both pasture and alfalfa/hay fields are considered, the ratios from the baseline and organic scenarios were 4.3 AU per ha of pasture or hay field and 1.5 AU per ha of pasture or hay field, respectively. The large difference in these ratios can be attributed to much lower presence of pasture and hay fields in the baseline versus organic scenarios. The Maitland Valley is one of the highest manure producing areas in the country, and while many factors influence nutrient delivery to waters, overall nutrient loadings would likely be reduced in this scenario.

6.2.2.7 Landscape Goals

Four landscape goals were applied to the organic scenario. Similar to the enhanced conventional scenario, the installed windbreaks and buffers contributed an increase of 5% in woody and herbaceous cover. Furthermore, fencerows and ditches were improved in the scenario, adding another 2% of vegetative cover for the MMSL. Finally, pasture comprised of suitable grasses, increased from (at least) 3% of MMSL field area in the baseline to 17% in the organic scenario. These changes together boost the overall natural area cover from 16% baseline (and 21% in the enhanced conventional) to 37% in the organic scenario. This boost contributes to multiple services, including the provision of fresh water, water regulation, erosion control, water purification and waste treatment, and biological control of pests services.

Connections between patches also increased in the organic scenario, owing again to the 7% increase in area of vegetative cover for windbreaks, buffers, and enhanced fencerows and ditches, and these changes also contribute to increased biological control of pests. Biological control of pests is further potentially improved by the increased landscape complexity and diversity of habitats. Longer and more complex crop rotations increase field vegetative diversity in time and space, while residue management, buffers, windbreaks, enhanced ditches and fencerows all contribute to increased quantity and variety of habitat and food sources for wildlife.

The fourth landscape goal applied to the organic scenario (but this one was not applied to the enhanced conventional scenario) was improved crop siting, which potentially contributes to erosion control, and water purification and waste treatment. Considering the baseline, the 1983 land use survey suggests that the Corn System (a land use classification for a parcel of land exhibiting a rotation comprised of between 30% and 90% corn and the second most intense cropping category after continuous corn) was located across several soil types and site conditions in the MMSL, including poorly drained sites such as those with Parkhill Loam and Brookston Loam soils. The organic scenario, with its specified rotations and matching with suitable soils, sees more intensive cropping practices situated on higher quality soils, such as those from the Huron, Perth and Listowel series, while pasture is situated on lower quality soils and sites.[41]

6.3 *Assessment of Annual Net Returns for Enhanced Conventional and Enhanced Organic Scenarios*

Four representative farms (see Figure 6.1) were assessed for their annual expected returns[42] over a ten-year time span. Annual crop returns are variable as crop rotations and different sized fields on the farm result in different total areas devoted to different crops, each of which has a specified yield and expected return. Livestock returns however are not variable in this way. Both the conventional farms' returns and the organic farms' returns change in year eight as yields for all

[41] See Appendix 1: Allocation of rotations based on soil type.

[42] See Appendix 2: Average expected returns matrix, for the returns calculated using both the OMAFRA enterprise budgets and the modified OMAFRA budgets. These returns for individual commodities were used to estimate total returns for individual farms and the sub-watershed level scenarios.

crops increase by 10%. The organic farms demonstrated more drastic variation in returns, owing to the effect of lower yields and conventional prices during the years of transition (years 1 to 3) and the effect of increased (organic) prices starting in year 4, for crop enterprises. Farms 1,3 and 4, which also raise livestock, exhibit the transition effect for livestock enterprises as well. During years 1 through 3, livestock are treated largely as conventional, while crop enterprises undergo transition. In year 4, with crop enterprises certified, livestock populations enter transition and in the following year (year 5) the livestock on the farm are certified. This accounts for the nature of year 4 returns, reflecting the effects of lower production of livestock and conventional prices. Both farms 1 and 4 were modeled to have either beef or dairy herds, but the aggregate picture described in the next section devotes most of the Rotation 1 farms to dairy and some to beef, while Rotation 4 farms are mostly beef farms and a few are dairy farms. Rotation 3 was a dairy operation.

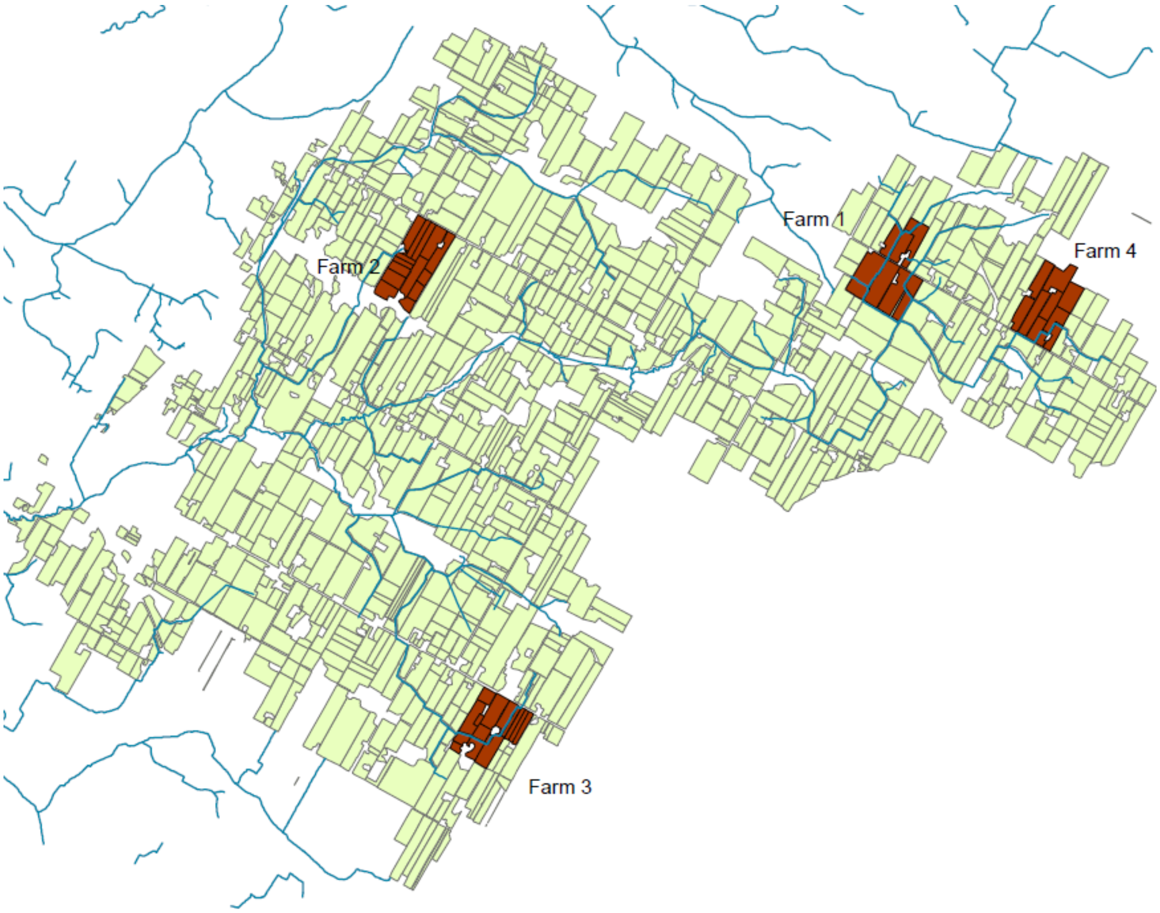

Figure 6.1 Map showing farm fields in the MMSL. The four farms i.e. four rotation models are identified in brown and stream locations are given in blue (Created from geospatial data file (MVCA, 2008; OMAFRA, 2009).

6.3.1 Crops

Annual returns for each farm of both scenarios are presented in Table 6.3. Crop enterprises received negative net returns in both Organic Farm 1 and Organic Farm 2. A large component of these losses is the inclusion of transitional spelt in rotation for which no likely market exists, and so it is sold into the conventional winter wheat market at a loss. For Organic Farm 1 the impact of negative crop returns on the farm's annual bottom line is exacerbated by negative returns from the beef enterprise for those few Farm 1's raising beef in addition to crops. The impact of negative crop returns is, fortunately, largely outweighed by the positive returns for dairy for the majority of Organic Farm 1's who are dairy farmers.

The stockless rotation, Organic Farm 2, faces negative returns for its crops, similar to Organic Farm 1. The severity of these losses is mitigated somewhat by ES payments, particularly the organic transition risk offset payments. Over the span of ten years, returns are profitable and starting in year 5 are quite similar to returns for Organic Farm 1 Beef operations. Organic Farm 2 also received higher returns over ten years garnering $234,662.41 compared with Conventional Farm 2's $196,090.76.

Crop and pasture enterprises on Organic Farms 3 and 4 brought positive expected net returns as they are modeled largely (rotation 3) and fully (rotation 4) on the alfalfa-timothy hay sample enterprise budget. Expected returns for alfalfa-timothy enterprises are affected by reduced organic yields and transitional organic prices (i.e. conventional prices), however they result in positive expected returns.

Table 6.3: Comparison of expected returns for both conventional and organic production on four representative farms over ten years.

Table 6.3: Comparison of expected returns for both conventional and organic production on four representative farms over ten years.

Conventional Farm 1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Total Crop Returns	17,016.06	31,728.62	18,351.03	22,701.47	26,931.58	17,016.06	31,728.62	25,666.15	29,141.09	35,249.26	255,529.93
Beef	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-82,976.70
Dairy	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	1,068,870.00
T4M/WRW	384.34	425.19	425.19	425.19	425.19	425.19	425.19				2,935.51
ALUS	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	28,632.00
Total EG&S Payments	3,247.54	3,288.39	3,288.39	3,288.39	3,288.39	3,288.39	3,288.39	2,863.20	2,863.20	2,863.20	31,567.51
Total Annual Returns R1 Beef	**11,965.94**	**26,719.34**	**13,341.75**	**17,692.19**	**21,922.31**	**12,006.79**	**26,719.34**	**20,231.68**	**23,706.62**	**29,814.79**	**204,120.74**
Total Annual Returns R1 Dairy	**127,150.61**	**141,904.01**	**128,526.42**	**127,150.61**	**137,106.98**	**127,191.46**	**141,904.01**	**135,416.35**	**138,891.29**	**144,999.46**	**1,350,241.19**
Organic Farm 1	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Totals**
Total Crop Returns	-1,802.85	-12,045.48	-2,984.85	27,807.36	33,088.79	36,826.61	36,411.02	41,692.08	35,783.56	41,984.81	236,761.06
Beef	-8,297.67	-8,297.67	-8,297.67	-18,314.78	-2,468.18	-2,468.18	-2,468.18	-2,468.18	-2,468.18	-2,468.18	-58,016.87
DAIRY	106,887.00	106,887.00	106,887.00	49,419.70	131,258.70	131,258.70	131,258.70	131,258.70	131,258.70	131,258.70	1,157,632.90
T4M/WRW	384.34	384.34	384.34	384.34	384.34	384.34	384.34				2,690.41
ALUS	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	2,863.20	28,632.00
OGO	1,306.29	1,636.29	1,251.67	0.00	0.00	3,916.18	0.00	0.00	0.00	0.00	8,110.43
Total EG&S Payments	4,553.84	4,883.83	4,499.21	3,247.54	3,247.54	7,163.72	3,247.54	2,863.20	2,863.20	2,863.20	39,432.84
Total Annual Returns R1 Beef	**-5,546.68**	**-15,459.32**	**-6,783.31**	**12,740.13**	**33,868.16**	**41,522.16**	**37,190.38**	**42,087.10**	**36,178.58**	**42,379.83**	**218,177.02**
Total Annual Returns R1 Dairy	**109,637.99**	**99,725.35**	**108,401.36**	**80,474.61**	**167,595.04**	**175,249.04**	**170,917.26**	**175,813.98**	**169,905.46**	**176,106.71**	**1,433,826.79**
Conventional Farm 2	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Total**
Total Crop Returns	16,108.52	17,951.23	17,091.46	15,852.99	20,195.80	16,108.52	17,951.23	24,916.65	19,870.26	27,229.32	193,275.97
T4M/WRW	374.55	374.55	374.55	374.55	374.55	374.55	374.55				2,621.83
ALUS	19.30	19.30	19.30	19.30	19.30	19.30	19.30	19.30	19.30	19.30	192.95
Total EG&S Payments	393.84	393.84	393.84	393.84	393.84	393.84	393.84	19.30	19.30	19.30	2,814.78
Total Annual Returns R2	**16,502.36**	**18,345.07**	**17,485.30**	**16,246.83**	**20,589.64**	**16,502.36**	**18,345.07**	**24,935.94**	**19,889.56**	**27,248.62**	**196,090.76**
Organic Farm 2	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Totals**
Total Crop Returns	-5,884.48	-2,536.79	-923.43	24,521.03	33,206.34	35,792.68	33,752.40	30,053.89	37,541.86	41,707.84	227,231.33
T4M/WRW	374.55	374.55	374.55	374.55	374.55	374.55	374.55				2,621.83
ALUS	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	192.00
OGO	1,387.06	1,151.24	884.83	0.00	0.00	3,816.36	0.00	0.00	0.00	0.00	7,239.49
Total EG&S Payments	1,780.81	1,544.98	1,278.58	393.75	393.75	4,210.11	393.75	19.20	19.20	19.20	10,053.32
Total Annual Returns R2	**-4,103.68**	**-991.80**	**355.15**	**24,914.78**	**33,600.08**	**40,002.79**	**34,146.15**	**30,073.09**	**37,561.06**	**41,727.04**	**237,284.65**

Table 6.3: Comparison of expected returns for both conventional and organic production on four representative farms over ten years.

Conventional Farm 3	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Total Crop Returns	9,219.54	12,857.02	15,837.72	12,704.36	12,934.74	10,359.84	12,857.02	21,349.98	18,432.10	16,816.52	143,368.84
Dairy	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	1,068,870.00
T4M/WRW	317.61	317.61	317.61	317.61	317.61	317.61	317.61				2,223.27
ALUS	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	16,158.00
Total EG&S Payments	1,933.41	1,933.41	1,933.41	1,933.41	1,933.41	1,933.41	1,933.41	1,615.80	1,615.80	1,615.80	18,381.27
Total Annual Returns R3	**118,039.95**	**121,677.43**	**124,658.13**	**121,524.77**	**121,755.15**	**119,180.25**	**121,677.43**	**129,852.78**	**126,934.90**	**125,319.32**	**1,230,620.11**

Organic Farm 3	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Totals
Total Crop Returns	4,487.44	4,487.40	4,478.28	14,309.45	14,368.04	14,335.42	14,335.42	19,379.25	19,348.71	19,431.84	128,961.27
DAIRY	106,887.00	106,887.00	106,887.00	49,419.70	131,258.70	131,258.70	131,258.70	131,258.70	131,258.70	131,258.70	1,157,632.90
T4M/WRW	317.61	317.62	317.62	317.62	317.62	317.62	317.62				2,223.30
ALUS	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	1,615.80	16,158.00
OGO	132.15	132.17	132.91	0.00	0.00	3,236.21	0.00	0.00	0.00	0.00	3,633.43
Total EG&S Payments	2,065.56	2,065.58	2,066.32	1,933.42	1,933.42	5,169.62	1,933.42	1,615.80	1,615.80	1,615.80	22,014.74
Total Annual Returns R3	**113,440.00**	**113,439.98**	**113,431.61**	**65,662.57**	**147,560.16**	**150,763.75**	**147,527.54**	**152,253.75**	**152,223.21**	**152,306.34**	**1,308,608.91**

Conventional Farm 4	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Total Crop Returns	17,328.85	16,870.34	13,561.45	25,845.27	16,415.46	17,328.85	16,870.34	20,207.08	30,098.19	22,825.95	197,351.78
Beef	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-8,297.67	-82,976.70
Dairy	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	106,887.00	1,068,870.00
T4M/WRW	356.87	356.87	356.87	356.87	356.87	356.87	356.87				2,498.11
ALUS	655.35	655.35	655.35	655.35	655.35	655.35	655.35	655.35	655.35	655.35	6,553.50
Total EG&S Payments	1,012.22	1,012.22	1,012.22	1,012.22	1,012.22	1,012.22	1,012.22	655.35	655.35	655.35	9,051.61
Total Annual Returns R3 Beef	**10,043.40**	**9,584.89**	**6,276.00**	**18,559.83**	**9,130.01**	**10,043.40**	**9,584.89**	**12,564.76**	**22,455.87**	**15,183.63**	**123,426.69**
Total Annual Returns R3 Dairy	**125,228.07**	**124,769.56**	**121,460.67**	**133,744.50**	**124,314.68**	**125,228.07**	**124,769.56**	**127,749.43**	**137,640.54**	**130,368.30**	**1,275,273.39**

Organic Farm 4	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Totals
Total Crop Returns (Modeled on Alfalfa/Hay enterprise budget)	6,863.97	6,863.97	6,863.97	16,996.50	16,996.50	16,996.50	16,996.50	23,043.34	23,043.34	23,043.34	157,707.94
Beef	-8,297.67	-8,297.67	-8,297.67	-18,314.78	-2,468.18	-2,468.18	-2,468.18	-2,468.18	-2,468.18	-2,468.18	-58,016.87
DAIRY	106,887.00	106,887.00	106,887.00	49,419.70	131,258.70	131,258.70	131,258.70	131,258.70	131,258.70	131,258.70	1,157,632.90
T4M/WRW	356.87	356.87	356.87	356.87	356.87	356.87	356.87				2,498.11
ALUS	655.35	655.35	655.35	655.35	655.35	655.35	655.35	655.35	655.35	655.35	6,553.50
OGO						3,916.18					3,916.18
Total EG&S Payments	1,012.22	1,012.22	1,012.22	1,012.22	1,012.22	4,928.40	1,012.22	655.35	655.35	655.35	12,967.79
Total Annual Returns R4 Beef	**-421.47**	**-421.47**	**-421.47**	**-306.05**	**15,540.55**	**19,456.73**	**15,540.55**	**21,230.51**	**21,230.51**	**21,230.51**	**112,658.86**
Total Annual Returns R4 Dairy	**114,763.20**	**114,763.20**	**114,763.20**	**67,428.43**	**149,267.43**	**153,183.61**	**149,267.43**	**154,957.39**	**154,957.39**	**154,957.39**	**1,328,308.63**

6.3.2 Beef

Beef enterprises were unprofitable in every year for both conventional and organic scenarios, and for both field cropping mixed operations (Farm 1) and pasture-based systems (Farm 4). The conventional scenario for Farms 1 and 4, however, managed to have positive returns overall, as returns from the crop enterprises on the farms cover the losses from the beef operations in each year. This is not the case for the organic scenarios on these farms, as transitioning fields result in negative returns in the field cropping operations, resulting in negative expected farm returns of several thousand dollars for Farm 1 and a few hundred dollars for farm 4 for the crop transition years.

This picture changes, however, over the ten-year timeline, as certified farms received higher expected returns, enabling farms to cover losses for their still unprofitable beef operations. Farm 1 returns from the ten-year timeline modeled show that organic beef operations, while facing large negative returns in years 1 to 3, are slightly more profitable overall, reaching \$217,884 compared with \$204,120.74 for conventional farms. For Farm 4 (beef) the conventional farm gains slightly more than the organic, at \$123,426 compared with \$112,658 over ten years. This was due to the conventional Farm 4's selling cash crops, whereas organic Farm 4's switched to pasture and earned much lower returns.

Aside from the above-mentioned case of conventional beef on farm 4 receiving a greater total return over ten years, organic beef farms receive higher returns over ten years than any of their conventional counterparts, with organic dairy on farm 1 (field cropping system) being the most profitable operation overall after ten years.

6.3.3 Dairy

Dairy operations were highly profitable in every year for both conventional and organic scenarios, and for field cropping mixed operations (Farm 1), hay farms (Farm 3), and pasture-based systems (Farm 4). While conventional dairy returns were static, organic returns dropped substantially to $49,419 during the livestock transition year, but then rose sharply to just over $130,000 annually thereafter, well above conventional dairy enterprises. Expected returns from dairy enterprises sustained positive returns for mixed operations when crop enterprises were transitioning and producing at a market loss. Turning to the ten-year overall returns, organic dairy operations receive higher returns than conventional operations in all cases. Conventional dairy on Farm 1 received $1,350,241 while organic dairy on the same farm received $1,433,534 over ten years. Conventional dairy on Farm 3 received $1,230,620 while organic dairy received $1,308,608 over ten years. Conventional dairy on Farm 4 received 1,275,273 while organic dairy on the Farm 4 received $1,328,308 over ten years.

6.3.4 Aggregate Returns and Program Payments

The total returns to production for all farms in the conventional scenario and for all farms in the organic scenario are listed in Table 6.4. Regarding program payments, the annual amounts would not appear to be unreasonably high. Two significant costs for program fees in the organic scenario would appear to be the one time environmental benefits payment under the Ontario Goes Organic program, which is paid in year 6 and is almost a third of total payments at $455,313.39, and the ALUS payment for buffers at $150 per ha, which amounts to half of the program payments at $730,200.00.

Table 6.4: Comparison of aggregate expected returns for both conventional and organic production over ten years in the MMSL.

Aggregate MMSL Conventional Base Case	year 1	year 2	year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	year 10	Totals
Total Crop Returns	1,737,003.94	1,848,484.89	1,794,610.03	1,889,619.47	1,887,451.46	1,737,194.38	1,848,484.89	1,794,610.03	1,889,619.47	1,887,451.46	18,314,530.01
Beef	-141,054.10	-141,054.10	-141,054.10	-141,054.10	-141,054.10	-141,054.10	-141,054.10	-141,054.10	-141,054.10	-141,054.10	-1,410,541.00
Dairy	5,878,785.00	5,878,785.00	5,878,785.00	5,878,785.00	5,878,785.00	5,878,785.00	5,878,785.00	5,878,785.00	5,878,785.00	5,878,785.00	58,787,850.00
Total Livestock Returns	5,737,730.90	5,737,730.90	5,737,730.90	5,737,730.90	5,737,730.90	5,737,730.90	5,737,730.90	5,737,730.90	5,737,730.90	5,737,730.90	57,377,309.00
T4M/WRW	34,321.28	34,321.28	34,321.28	34,321.28	34,321.28	34,321.28	34,321.28				240,248.94
ALUS	74,403.00	74,403.00	74,403.00	74,403.00	74,403.00	74,403.00	74,403.00	74,403.00	74,403.00	74,403.00	744,030.00
Total Annual MMSL EG&S Payments	108,724.28	108,724.28	108,724.28	108,724.28	108,724.28	108,724.28	108,724.28	74,403.00	74,403.00	74,403.00	984,278.94
Total Annual MMSL Returns	**7,583,459.11**	**7,694,940.07**	**7,641,065.21**	**7,736,074.65**	**7,733,906.63**	**7,583,649.55**	**7,694,940.07**	**7,606,743.93**	**7,701,753.37**	**7,699,585.36**	**76,676,117.95**

Aggregate MMSL Organic Scenario	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	
Total Crop Returns	6,500.33	6,500.33	6,500.33	2,233,189.66	2,233,189.66	2,233,189.66	2,233,189.66	2,886,112.61	2,886,112.61	2,886,112.61	17,610,597.45
Beef	-141,054.10	-141,054.10	-141,054.10	-311,354.15	-41,962.80	-41,962.80	-41,962.80	-41,962.80	-41,962.80	-41,962.80	-986,293.25
Dairy	5,878,785.00	5,878,785.00	5,878,785.00	2,718,083.50	7,219,228.50	7,219,228.50	7,219,228.50	7,219,228.50	7,219,228.50	7,219,228.50	63,669,809.50
Total Livestock Returns	5,737,730.90	5,737,730.90	5,737,730.90	2,406,729.35	7,177,265.70	7,177,265.70	7,177,265.70	7,177,265.70	7,177,265.70	7,177,265.70	62,683,516.25
T4M/WRW	34,166.12	34,166.12	34,166.12	34,166.12	34,166.12	34,166.12	34,166.12				239,162.87
ALUS	73,020.00	73,020.00	73,020.00	73,020.00	73,020.00	73,020.00	73,020.00	73,020.00	73,020.00	73,020.00	730,200.00
OGO	65,890.40	65,890.40	65,890.40	0.00	0.00	348,127.26	0.00	0.00	0.00	0.00	545,798.46
Total EG&S Payments	173,076.53	173,076.53	173,076.53	107,186.12	107,186.12	455,313.39	107,186.12	73,020.00	73,020.00	73,020.00	1,515,161.35
Total Annual Returns	**5,917,307.76**	**5,917,307.76**	**5,917,307.76**	**4,747,105.13**	**9,517,641.48**	**9,865,768.74**	**9,517,641.48**	**10,136,398.31**	**10,136,398.31**	**10,136,398.31**	**81,809,275.06**

Comparing production systems, aggregate returns for conventional are better for years 1 through 4 but starting in year 5 and continuing thereafter the organic farms received higher returns. The total returns over ten years (i.e. total farm income for ten years) also highlight this, with conventional receiving $76,676,117.95 while organic receives $81,809,275.06 – a difference of over $5 million. These returns include program payments. This amount is a few times the estimated total program payments in either scenario (conventional ten-year total program payments of $984,278.94 and organic ten-year total program payments of $1,515,161.35).

Much of this difference in ten-year total returns can be attributed to the organic scenario saving fertilizer and pesticide purchases and application costs of $1,497,625.67 annually, amounting to input savings of nearly $15 million over ten years (see Table 6.5).

Table 6.5: Reduction of fertilizer and pesticides calculated for the organic scenario.

Percent (%) of total MMSL BC used in Fertilizer Reduction Analysis:		**77.18**
Fertilizers	**Amount (kg)**	**Cost ($)/year**
N	354,103	421,382.75
P	92,105	77,368.23
K	296,284	361,466.67
Application costs:		149,440.93
Pesticides	**Amount (kg or l)**	**Cost ($)/year**
Herbicides, fungicides and insecticides	12,223	373,034.76
Chemical Application costs		114,932.33

6.3.5 Supporting Beef Farmers

The comparison of farms revealed that beef is unprofitable on its own; but that it is relatively more profitable under organic once the farm has been certified for both crops and livestock. Annual expected return is -$87.34 per beef cow for every year on the conventional farms and for years 1 to 3 on organic mixed operations in the model. Organic transition during year 4 sees the expected return per beef cow drop to -$215.47 before rising to -$29.04 in years 5 through 10. Total losses in net returns relative to conventional annual losses in year 4 are approximately -$170,000.00.

Transition risk offset payments were proposed in MacRae et al. (2009), however, unlike for crop enterprises, they were not included in this model. It is clear that dairy farmers do well in this model, and so support for dairy would seem unnecessary. It is also evident that supports for transitioning beef would be welcome. Applying the MacRae et al. (2006 and 2009) proposed beef support payment of $16.66 per animal to all beef animals (2610 comprised of 1350 beef cows and 1260 beef animals including calves, heifers, steers and bulls) would amount to total program payments of $43,482.60, which is well below year 4 losses for beef. If we assume it is desirable to support beef farmers so that during year 4 their returns, while negative, do not fall below losses anticipated with conventional beef, then a support payment of about $66.25 per beef animal would be required to cover the additional losses totaling $170,300.05 in year 4.[43] Total program costs would then increase by at least as much as the $170,300.05 compensated in year 4 (see Table 6.6).

[43] On a per cow level this payment would be approximately $128.00, accounting for reduced herd sizes in year 4, and the fact that cows represent about half of the total number of animals on the farm

The very low total returns for organic transitional crops (total $6,500.33 in each of years 1 to 3) compared with conventional returns during that time (close to $1.8 million in each of years 1 to 3) are also evident. As discussed previously the crop losses are due to crop enterprises on Farm 1's and Farm 2's and result in negative net returns for stockless farms (Farm 2's), with much of the loss attributable to transitional spelt.

Table 6.6: Revised program payments accounting for increased support for spelt and beef.

Aggregate MMSL Organic Scenario	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Modeled EG&S Payments	173,076.53	173,076.53	173,076.53	107,186.12	107,186.12	455,313.39	107,186.12	73,020.00	73,020.00	73,020.00	1,515,161.35
Revising Program Payments:											
Spelt support	190,193.03	190,193.03	190,193.03								570,579.10
Beef support				170,300.05							170,300.05
Revised Annual Total	**$363,269.56**	**$363,269.56**	**$363,269.56**	**$277,486.17**	**$107,186.12**	**$455,313.39**	**$107,186.12**	**$73,020.00**	**$73,020.00**	**$73,020.00**	**$2,256,040.50**

6.3.6 Supporting Spelt

Transition risk offset payments were used to support converting farmers for the three years of transition. As spelt accounts for a significant portion of losses during transition, raising this risk offset from the $15.12 payment per acre applied in the model (after MacRae et al., 2006 and 2009) could greatly improve stockless farmers' net returns. The transitional return for spelt was estimated to be -$169.19.[44] Raising the transition offset payment from 10%[45] of losses on the crop to 70% of losses would amount to a per acre payment of $118.43. The total area planted to spelt annually in the organic scenario is 1840.94 acres, and an additional $190,193.03 would be needed to bring the total to $218,022.52 annually to offset the losses of spelt thereby raising stockless farmers' net returns. Revised program payments for supporting spelt are presented in Table 6.6.

The three-year total paid out for spelt over the transition would equal $654,067.57, and it would raise stockless farms net incomes, taking Organic Farm 2 again as an example, from -$4103.68, -$991.80, and $355.15 for years 1 through 3 (see Organic Farm 2 in Table 6.3) to net returns of $71.05, $1706.32 and $2602.61 for the same years.

As spelt is included in rotations 1 and 2 (both farms 1 and 2) in nearly equal acreages overall, if a risk offset payment of this nature was applied to spelt at 70% of losses, close to half of the amount paid out would go farm 1, the majority of whom are dairy farmers and who have very profitable returns already in every year, according to the model. Also, it may not be

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[44] Calculated using the OMAFRA organic spelt budget, modified for the transition period and using the 5-year average conventional price for winter wheat.
[45] MacRae et al. (2006 and 2009) set offset payments at 10% of estimated crop losses during transition. As spelt was estimated to have a transitional average expected return of $169.19 per acre in this model, the $15.12 rate is slightly lower than 10% of losses.

desirable from a program perspective to greatly support only one crop type. Therefore supporting stockless farms in this scenario may be better achieved with other policies, which have not been explored here.

Revising program payment costs to account for supporting beef farmers and those planting spelt resulted in ten-year program costs of about $2.25 million for the organic scenario (see bottom of Table 6.6).

6.3.7 Yield and Price Assumptions

The net returns modeled for both conventional and organic scenarios hinge on yield and price assumptions. Prices cannot be predicted and the long term presence of significant price premiums for organic commodities will depend on many factors. Prices cannot be influenced by MMSL farmers in the current institutional framework, except of course by the impacts of increased supply relative to the current level of output. The capacity of marketing and processing to meet the needs of increased supply can also affect prices. However, changes in price were not explored here.

Yield, on the other hand, can be influenced by farmers to a certain degree. The model here spans a ten-year timeline, demonstrating some of the farm economic dynamics during transition, certification and beyond. As mentioned previously, yields on the organic crop budgets (and the modified livestock budgets) are static and are set at a proportion of conventional yields. Only the introduction of windbreaks, and the sudden impact on crop yields modeled in year 8, modify this picture. It is useful to compare the default sample annual organic crop yields used in this model, with more dynamic yields compiled in a review of organic studies and yield comparisons.

Table 6.7: Comparison of organic yields from OMAFRA enterprise budgets (2009) versus transitional yields summarized in MacRae et al. (2009).

	Organic Yields as percent (%) of conventional (OMAFRA Budgets)	Organic Transition Annual Yields as percent (%) of conventional from literature review (MacRae et al. 2009)			
Crop Type	All years	Year 1	Year 2	Year 3	5-10 years
Corn	68.61	70	80	85	90
Hay / Alfalfa	71.43	90	95	100	100
Pasture	71.43	100	100	100	100
Soybeans	78.95	70	80	85	90
Barley	78.57	70	80	90	95
Oats	79.49	80	90	95	100
	Organic Yields as percent (%) of conventional (Assumed 90 % based on literature for year 1)	Organic Transition Annual Yields as percent (%) of conventional from literature review (MacRae et al. 2009)			
Livestock Type	All years	Year 1	Year 2	Year 3	5-10 years
Beef	90	80	85	90	90
Dairy	90	80	85	90	90

Table 6.7 contrasts the yields used in the model with those from MacRae et al. (2009). Many of the crop yields were found to be higher than those suggested in the sample organic budgets from OMAFRA. In addition, yields increase over transition and many reach 100 % of conventional yields by year 5, which is sustained thereafter. Including these yields in the model developed here would have increased the total output from the organic scenario and also increased the total returns. As an example, the same amount of field acreage devoted to growing organic corn for grain resulted in total yield of corn at $911,532.71 versus $1,109,241.73 when using the MacRae et al. (2009) yields. Considering soybeans the difference in total yield is $568,848.94 for the model versus $601,617.59 using the MacRae et al. (2009) yields. Over ten

years, the yields would likely have favoured even higher net returns for organic agriculture in the aggregate.

More dynamic yields for livestock were also published in MacRae et al. (2009). Yield reduction for livestock was assumed to be 10% in this model as no organic budgets were available for Ontario. This figure is consistent with the long term yield of beef and dairy relative to conventional. Including the more dynamic yields in this model would have potentially reduced and/or increased net returns for organic livestock, depending on the enterprise.

7.0 Discussion

The modeling and integrative approach draws largely on the Iowa project and the many publications describing it. This model departs from the Iowa project in a few important ways. First, instead of an end point at year 2025 (representing a 25 year time span), this model elaborated a transition path year by year for a ten-year time span, in an effort to explore medium term changes and a plausible path through them to a closer endpoint. This permits the exploration of financial impacts at the farm level for current farmers. Second, the Iowa project assumed that the alternative scenarios arose each from distinctly favourable policy environments, without exploring policy tools that would be required in such milieux. This model constructs a potentially desirable organic scenario and includes considerations of incentives, certification requirements, and partial program costs along a transition path. It thus broaches the problem of collective action in the provision of ES that arise at different temporal and spatial scales.

Like the Iowa project, the model used a factor-income approach which:

> "*…involves quantifying the on-farm effects on income of different ES levels. The combined effects are used to produce a trade-off frontier that facilitates assessment of the cost-effectiveness of providing differing levels of off-farm ES. By measuring the profitability of different farming practices in relation to changes in levels of off farm ES that affect the farm (Coiner et al., 2001), one can elucidate the ES trade-offs and their relation to agricultural incomes without directly valuing the ES outcomes*" (Swinton et al., 2007:249).

In this case, the two sub-watershed level scenarios can be compared from total farm income over time and total program payments over time with the quantitative changes in land uses and management (where these could be quantified) and the qualitative assessment of contributions to enhanced ecosystem services (ES).

7.1 *Two Scenarios and a Preliminary Assessment of Ecosystem Services*

The enhanced conventional scenario is largely consistent with conventional agriculture in the region, as indicated by a review of crops planted for the years 2005-2009, literature (Nagy, 2003) and expert opinion (Phil Beard –personal communication, 2008; Rod MacRae – personal communication, 2009). The exception to the conventional scenario is the addition of windbreaks and increased riparian buffers to both scenarios. The enhanced conventional scenario (including the addition of buffers and windbreaks) was expected to contribute to improvements in several ES, as well as increasing livestock management practices and addressing the landscape goals of increased natural areas, increased connectivity, and greater landscape complexity. The ES potentially bolstered by these changes include some from each of the key areas of water, soils, and biological control of pests. However these changes are made within the context of continued application of external synthetic inputs, simple and short rotations, and several other potentially problematic practices.

Many of the BMPs could not be characterized for the MMSL at this point, but further investigation could establish quantitative estimates regarding the level of adoption of livestock management, nutrient management, and rotational grazing, long rotations and cover crops. Each of these BMPs was assumed to be practiced to low a degree, consistent with conventional agriculture in the region. Livestock management was enhanced in the model by the blanket application of buffers on all watercourses; however, it does not guarantee proper management. Nutrient management practices have been regulated in the past few years under the Nutrient

Management Act of Ontario (passed in 2002, brought into effect 2003) and practices, such as set backs from wells amongst others, have been required.

The enhanced organic scenario was designed with the principles and requirements of organic operations and so it is not a surprise to find that the organic system generates improvements, according to the literature, for the range of ES considered, as this was the intention. The design and management changes permitted preliminary assessment of ES improvements in a spatially explicit manner. This scenario incorporated the same windbreaks and buffers as the conventional scenario, and the associated contributions to ES are equally applicable. But the organic scenario goes much further toward delivering improvements to key ES by eliminating potentially problematic practices (either by certification requirement or by practical requirements), applying methods that conserve soil and water resources and promote natural pest control, and achieving landscape goals of increased natural areas, increased connectivity, greater landscape complexity and improved crop location.

Compared with the conventional scenario, the organic scenario has the same number or a greater number of practices contributing to the provision of each identified ES, and while such interventions are not merely additive, it does indicate a more comprehensive and robust strategy for enhancing ES.

The scenarios do not address the low and declining amount of healthy forests, and so do not address the MVCA Terrestrial Team’s objectives of preventing the net loss of forest interior by 2020 (target B) or increasing woodlots in good condition from 45% to 60% by 2030 (target D). However they do address target A (reduce the absolute loss of natural areas by 50% by 2020), target C (increase the amount of natural connections on the landscape in the MVCA watershed from 87 sq. km to over 210 sq. km by establishing or enhancing riparian buffers and other connections) and target E (increase the total amount of natural cover in the watershed from 18.9% to over 26%) (as discussed in Chapter 2).

The modeling results and their applicability to other contexts should be seen as a preliminary step towards more conclusive future modeling offering more robust decision support. The assessment of ecosystem services was based on general considerations of land uses and crop practices and lacks prediction and magnitudes. The levels of baseline ecosystem services – in biophysical flows – and the changes to them resulting from the adoption of either of the scenarios have not been explicitly established (nor were they attempted). With this in mind, the assessment offers some useful observations and potential applications.

Landscape components and land management practices were established for the baseline and the scenarios for many components of the assessment. These were mostly inputs, such as a certain width and overall areas of riparian buffers, the location and extent of pasture crops, or assumptions about management practices, such as livestock management. This can be contrasted with an output approach, such as measuring the baseline level and distribution of nitrate leaching and runoff and expected changes to these resulting from the design and management changes. The input approach is often used in PES schemes.

Expected improvements in the biophysical flows aspect of ecosystem services from such activities or inputs can be difficult and costly to monitor, and involve non-linear relationships over different temporal and spatial scales[46]. Some authors have pointed out that basing PES initiatives on commonly assumed simple relationships, such as the relationship between the

[46] The stock flow-model itself may be overly simplistic and unsuitable as an approach to the societal benefits from natural systems (Norgaard, 2010).

maintenance of upstream forests and its impact on downstream water quality and quantity, can be inappropriate as the level of ES may not arise as anticipated – and possibly compromise the long term sustainability of such initiatives (Aylward, et al., 2007).

But the approach is useful for setting broad landscape goals, such as those set by the MVCA to improve the health of the watershed. Cost-effective program design and economic impacts on farmers who adopt cropping practices or remove land from cultivation to establish buffers can be usefully explored with this approach.

7.2 *Farm Economic Considerations*

The improved financial picture for farmers post-certification is well established in the literature on organic conversion (MacRae et al., 2006) and the results of this model confirm this outcome. Dairy farms did well in the conventional scenario and significantly better in the organic scenario. Beef farmers had negative returns for their beef enterprises, but these were offset by crop enterprises in conventional farms, and even more so for the organic farms after crop and livestock enterprises were certified. Field crop farms and pasture-based system net returns follow these livestock patterns, depending on whether beef or dairy were raised. The beef results are not particularly surprising given the financial difficulties in the sector for several years. (Rod MacRae, personal communication, 2010).

A notable exception to the generally better financial performance of organic over conventional farm post certification and ten year total returns were the pasture-based beef farms, where the conventional beef farm 4 garnered higher total returns over ten years than the organic pasture-based farm modeled. This was due to Conventional Farm 4’s being able to sell cash crops, whereas Organic Farm 4's begin to cultivate pasture, which brings much lower returns as a crop.

The net returns associated with each enterprise in each scenario are sensitive to prices and yields used to calculate expected annual returns. Higher returns to organic are conditional on price premiums available in the medium term. On the other hand, yields used for organic crops in the OMAFRA-based model were lower than more dynamic yields that reflect transition effects reported in the literature.

The enterprise budgeting does not provide a picture of any existing financial support to farmers in Ontario, and some of the financial burden faced by farmers may be mitigated by existing programs and insurance. According to the budgeting in this model, program payments proved insufficient to deal with the acute challenges of beef farmers and stockless farmers. Modifying transition risk offset payments to address transitioning beef farms, and stockless farms, in particular spelt crops, can improve the attractiveness of adoption for these two sets of farmers.[47]

Program costs included assessments of the costs of payments for establishing buffers, windbreaks, internalizing some traditionally externalized environmental costs, and offsetting transition risk for adopters. Program administrative fees, costs associated with technical cooperation, program promotion, monitoring and evaluation of activities were not considered, but a review of literature on program design and costing could fill in these gaps.

[47] The high subsidization of beef herds and spelt crops relative to other crops and livestock raises distributional issues, and may also appear as a subsidy to production from an international trade perspective. On the other hand, such practices have been used in EU agricultural program payments for many years.

Program costs only associated with payments appear to be reasonable given the potential improvements of a range of ES important to production, recreation, human and watershed health, and improved farm finances. Program payments comprise the largest portion of government expenditures to the Canadian agriculture and agri-food system. These payments include transfers to producers and the sector through tax expenditures and social program payments, expenditures on extension and education. In 2008-2009, federal and provincial governments combined spent approximately $750 million for Ontario program payments alone (AAFC, 2009). Program costs in the model would appear to be modest at $100,000 to $150,000 per year compared with $750 million. As a rough comparison, the MMSL comprises about 0.18% of the cropped land in the province[48] (Statistics Canada, 2008), yet program payments for the model amounted to just 0.013 to 0.02% of total Ontario program payments in 2008-2009 (AAFC, 2009), for the conventional and organic scenarios, respectively. Even with the additional support for spelt and beef producers, the total annual program payments for the model, at 0.03% of Ontario program payments, is still an order of magnitude below current spending.

Whether such program payments are reasonable depends more generally on the framing of priorities and the public policies that are pursued. The MA communicated the inseparable link between human well-being and ecosystem services. Conservation Authorities in Ontario are increasingly emphasizing the important links between watershed health and quality of life for residents, now and into the future. Framed in this way program costs for improving watershed health would not seem unreasonable.

Promoting farm financial stability and viability can be achieved by supporting organic conversion, as organic farmers are less likely to suffer yield and revenue losses once certification

[48] This figure total Ontario cropland for 2006 does not include Christmas tree area.

is achieved, indicating potential savings for farm safety net program (MacRae et al., 2006). There is some evidence that payments to motivate adoption of organic and to reward farmers for the provision of ES, while not removing the need for farm safety nets, can be overall more cost effectivel than other payments made to support farmers who are conventional. This idea is also part of the EU position on supporting organic farmers and the resulting program efficiencies (Lampkin and Padel, 1994, as cited in MacRae et al., 2006).

8.0 Conclusions

This study reviewed the salient features of ecosystem services (ES) theory, important considerations of better farm management practices, and the theory of organic production and transition in order to inform, by way of practical and theoretical underpinning, an exploration of alternative agricultural futures for a Maitland Valley sub-watershed. The ecosystem services framework highlighted ecosystems services broadly classified under soil, water, and biodiversity conservation. The 74 sq. km Middle Maitland Valley sub-watershed above Listowel (MMSL) was the site studied for each of these areas of concern. Following this, and guided by interdisciplinary research into alternative futures modeling in Iowa watersheds, two agricultural scenarios were characterized for the MMSL and constructed with GIS, and cost and revenue farm enterprise budgeting methods.

The conventional scenario was largely specified by the baseline data, but it also included buffers and windbreaks added to fields and watercourses, with financial payments to farmers coming from existing initiatives. The organic scenario also assumed program payments were forthcoming, again to motivate farmers' implementation of buffers and windbreaks, but also to support the process of transition to organic agriculture. An assessment of the land use and farm management changes flowing from expected BMP usage levels or assumed adoption of organic practices, as well as landscape level conservation goals that largely emerged from field and farm level changes, permitted assessment in a preliminary fashion of the potential changes in levels of ecosystem services generated by two different future agricultural landscapes in the MMSL. While enhanced features such as buffers and windbreaks contributed to increased ES from both scenarios, the organic scenario, due to its incorporation of many sound management practices, contributed to potentially much greater increases in ES dealing with soil and water and with biodiversity (i.e. biological control of pests).

Following the ES assessment, the implications from adopted BMPs, organic practices and payments provided to farmers was explored by assessing farm net returns. Firstly, four representative farms with some different combinations of crops and livestock types for both the conventional and the organic scenario were compared via crop enterprise budgeting, to give estimated annual returns iterated over ten years. After this, aggregate returns for the two scenarios were assessed using the same budgeting method, including total costs for program payments. The payments were found to be insufficient to support beef farmers and cash croppers and adjustments to payment levels were assessed for their contribution to financial viability.

Total program payments from governments, conservation authorities, conservation and naturalist foundations, etc. totaled $1 million and $1.5 million over ten years for the conventional and organic scenarios, respectively. These are preliminary costs and only include direct financial payments. When more aggressive support was applied for beef producers and cash croppers for the organic scenario, total payments rose to $2.25 million over ten years. This latter amount is less than the difference between the ten-year total net returns for the scenarios (conventional about $76.6 million and organic at $81.8 million), suggesting a support program of this nature could be an efficient and beneficial use of government funds to the sector. Moreover, while enduring financial difficulties during the crop and livestock transitions, the organic scenario proved more profitable on a farm basis (five out of six farm-livestock combinations) and overall (aggregate net returns for ten years).

Reflections on the use of the Ecosystem Services Approach

Ecological systems are complex, involving emergent properties, drivers at different spatial and temporal scales, non-linear feedbacks, and biodiversity (genetic, species, population and ecosystem richness). The difficulties of demarcating ES and measuring baseline biophysical processes (choosing scales and indicators) and significant changes (assessing trends) in these processes on the one hand meets the difficulties of the use and management of these processes on the other hand. Processes that engender services beneficial to human welfare and their attendant challenges for institutional management involve political, economic and cultural dimensions as well as issues of uncertainty, justice, equity and sustainability. Alternative futures seem to be a fruitful way to explore possible changes.

The MA framework is not a critique of dominant power relations and their legitimizing institutions and narratives. It is silent on oppression and suggests no avenues for activism. The framework does focus on human well-being, and has taken efforts to identify where complex values of nature emerge from different cultural traditions and specific human-nature interfaces, and to draw on both scientific and indigenous knowledge. While the framework has been insightfully critiqued by MA contributors themselves[49], the framework renders the dependence

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[49] Norgaard (2010) notes that:

"*…the ecosystem service metaphor now blinds us to the complexity of natural systems, the ecological knowledge available to work with that complexity, and the amount of effort, or transactions costs, necessary to seriously and effectively engage with ecosystem management.*" (1220)

Norgaard further elaborates this critique of the Ecosystem Service approach as it is based on a "stock-flow" interpretation of natural systems e.g. a stock of natural capital, such as a forest, gives rise to a flow of ecosystem services, such as water regulation or carbon sequestration:

"*…the literatures representing our scientific understanding…*[of ecological systems, human behaviour, and social systems]*…do not fit neatly into the ecosystem service framework, or even provide information appropriate for any particular quadrant of the MA model…The major issue is that only some of the ways in which ecologists think, for example food webs or energetics models, can be interpreted as stock-flow models that fit the lower left quadrant...*[of the MA conceptual framework]*…Evolutionary and behavioral ecology, for example, provide insights* of societies on multiple ecosystems explicit and can potentially move the discussion of choices affecting ecosystem services that face decision makers to more appropriate grounds based on enhanced understanding of ecological systems and their complex functions. Such an approach considers the myriad of life forms that cycle matter and energy through the biosphere rendering human life possible and creatively develops scenarios that meet the requirements of human well-being. This process can suggest where coordinated action toward sustainable ends might be pursued.

Future Directions

This research extends the literature on organic transition to a sub-watershed scale in the Canadian context and also the literature on the provision of ES in Canada by integrating the MA ES classification, provincially endorsed agricultural BMPs, organic methods and theory in a preliminary, spatially explicit consideration of economic and environmental tradeoffs and complementarities.

While the model's scenarios permitted probing two overarching research questions, they also serve as a first approximation that can be extended and improved with more explicit and conclusive modeling approaches. Such modeling can assess potential changes in nutrient loadings (such as with a watershed based models like GIS based ArcSWAT) and changes in wildlife populations, for example, and thus provide a much clearer picture of the benefits a sub-watershed level transition to organic could achieve in this context. A good first step to build on

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into the nature and management of ecosystems, but these frameworks do not reduce to a stock-flow model. Indeed, to the extent that these other frameworks do provide insights, the insights are cautionary rather than complementary to the mechanistic prediction and control facilitated by stock-flow models" (1220).

The reader is referred to the MA model and its four quadrants as depicted in Chapter 1 Figure 1.4.

this model would be to undertake a sensitivity analysis of the farm budgeting, as time and resource constraints, unfortunately, did not permit including this important analysis.

The Ausable Bayfield Maitland Valley Source Water Protection Planning Region (BMVSPR, 2007, 2008, 2010) studies have identified resources and produced a conceptual water budget for the Maitland Valley, including publishing local parameterization for the watershed in their assessment reports, and their research has identified the MMSL as a modeling priority. The MVCA has developed erosion risk maps for the MMSL and these could be used for more specific targeting of sites for applying conservation measures in future scenario modeling. Targeting particular habitat for specific wildlife by integrating terrestrial and aquatic wildlife conservation priorities with native vegetation types that could be re-established on priority areas or non-field areas could also be pursued with modeling for habitat and wildlife as was undertaken in the Iowa project.

Farmer adoption of BMPs has received some study in southern Ontario (see Filson et al., 2009) and sub-watershed levels studies of BMP adoption, and environmental improvements due to adopting BMPs on farms in an integrated modeling framework are underway by AAFC, notably the WEBS (Watershed Evaluation of Best Management Practices) project (AAFC, 2008), although organic production has not been included in WEBS project. Farmer adoption could be usefully pursued again with more specific modeling within the framework developed in this research paper.

Adapting to climate change and increased variability will require major redesign of farming systems in the Maitland Valley, and even organic farmers will have to make careful alterations (MacRae, 2000). Environment Canada has recommended several adaptations to farms in order to protect prime agricultural land, conserve water and ensure river systems are healthy and resilient, including:

> "*…adoption of conservation tillage practices, rotations that include cover crops, conversion of agricultural land with low moisture retention capacity to other uses, planting of more wind breaks/shelter belts and hedgerows, agro forestry (inter planting trees and crops); increasing forest cover in headwater areas, river valleys, flood plains and stream corridors to help retain runoff and summer base flow, limiting irrigation from rivers and streams to protect base flow during the summer and fall periods*" (MacRae, 2000:2-3).

Organic farming can play a role in climate change mitigation and adaptation. Studies increasingly demonstrate that organic farming reduces both energy use and global warming potentials (GWP) compared with conventional farms when considered globally (i.e. all links in the energy chain). A meta-analysis by Gomiero et al. (2008) found that elimination of synthetic inputs and fewer energy-consumptive concentrated foods produced reduces energy consumed in both the production and transportation of these products leading to substantially lower energy consumption on organic farms, both in terms of yield (Gj/t) and for unit of land (Gj/ha). Organic farms are also better positioned to deal with expected future impacts due to climate change. Some U.S. studies have shown that longer rotations involving legumes conferred greater ability to withstand drought (Welsh, 1999 and Helmers et al., 1986 – cited in MacRae, 2000:3) due to the benefits of improved soil organic matter levels and enhanced soil tilth (MacRae et al., 2006).

Modeling of the energy and global warming potential of conventional versus organic systems on a sub-watershed level, and integrating models for nutrient delivery and farmer adoption has been identified as a gap in Canadian research by the Organic Science Cluster research project. The initial modeling and characterization undertaken in this MRP will feed into more in-depth and specific research and modeling of the MMSL by the Organic Science Cluster research project.

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Appendix 1: Allocation of rotations based on soil type.

Soil	Huron (loam and clay loam)	Harriston (silt loam)	Listowel (silt loam)	Perth (clay loam)	Brookston (loam and clay loam)	Parkhill (loam)	Donnybrook (sandy loam)	Bottom Lands	Muck	Stream Course	Total area assigned to Rotation	Approximate number of farms
Area of soil typeon fields in MMSL (ha)	826.96	1137.86	2957.47	486.95	161.13	740.84	68.98	266	10.63	35.08		
Percent of MMSL	12.36	17.00	44.19	7.28	2.41	11.07	1.03	3.97	0.16	0.52		
Potential rotations Rationale	R1,R2,R3	R1,R3	R2,*R3*	R2	R4	R4	R4,R5	R4,R5	R4,R5			
Targeted rotation Rationale	R1	R1	R2,*R3*	*R3*								
Area assigned to rotation:												
Rotation 1 Area of soil assigned to R1	826.96	1137.86									1964.82	29
Rotation 2* Area of soil assigned to R2			1873.48								1873.48	28
Rotation 3 Area of soil assigned to R3			1083.99	486.95							1570.94	24
Rotation 4** Area of soil assigned to R4					161.13	740.84	68.98	266	10.63	35.08	1247.58	19
Totals											6656.82	100
Rotation 5											b/c no SC here	

*Constrained by number of stockless farms and average farm size to 28*66.91 = 1873.48 ha

**Remaining 1282.66 ha of MMSL field areas assigned to remaining soil types. As some of these soil types may have issues when examined on a field basis, such as high slopes, not all of this need be assigned to Rotation 4, but could instead be assigned to Natural areas i.e. Rotation 5.

Appendix 2: Average expected returns matrix

Average expected net return by crop type, livestock type, and year of ten year time line, found using OMAFRA enterprise budgets and used to model farm returns for sample farms and aggregate returns

			year 1			year 2			year 3			year 4		
Observed Conventional Crops	**OMAFRA Budget**	**Yield unit**	**Expected yield**	**Expected price ($/unit)**	**Expected return per acre**	**yield**	**price**	**return**	**yield**	**price**	**return**	**yield**	**price**	**return**
"Winter Wheat"	HARD RED WINTER WHEAT		76	5.85	239.58	76	5.85	239.58	76	5.85	239.58	76	5.85	239.58
		bales/ac	50	2		50	2		50	2		50	2	
"Beans"	WHITE/BLACK BEANS	cwt/ac	18	34	274.7	18	34	274.7	18	34	274.7	18	34	274.7
"Corn"	GRAIN CORN-CONVENTIONAL	bu/ac	137	4.3	106.53	137	4.3	106.53	137	4.3	106.53	137	4.3	106.53
"Hay (alfalfa/grass)"	ALFALFA - TIMOTHY HAY	t/ac	3.5	110	59	3.5	110	59	3.5	110	59	3.5	110	59
"Pasture"	**as above**													
"Soybeans"	SOYBEANS-CONVENTIONAL		38	9.75	94.75	38	9.75	94.75	38	9.75	94.75	38	9.75	94.75
"Barley"	BARLEY	bu/ac	70	3.48	81.89	70	3.48	81.89	70	3.48	81.89	70	3.48	81.89
		bales/ac	50	2		50	2		50	2		50	2	
(Oats)	S.ONTARIO OATS	bu/ac	78	2.78	66.95	78	2.78	66.95	78	2.78	66.95	78	2.78	66.95
		bales/ac	50	2		50	2		50	2		50	2	
"Oats/Barley"	50% of OATS + 50% BARLEY				74.42			74.42			74.42			74.42
"Spring Cereal"	50% of OATS + 50% BARLEY				74.42			74.42			74.42			74.42
"Spring Grains"	50% of OATS + 50% BARLEY				74.42			74.42			74.42			74.42
Unidentified or uncommon					117			117			117			117
Organic Rotation Crops	**OMAFRA Budget**	**Yield unit**	**Expected yield**	**Expected price ($/unit)**	**Expected return per acre**	**yield**	**price**	**return**	**yield**	**price**	**return**	**yield**	**price**	**return**
Corn	GRAIN CORN-ORGANIC	bu/ac	94	4.3	-44.31	94	4.3	-44.31	94	4.3	-44.31	94	7.62	267.77
Soy	SOYBEANS-ORGANIC	bu/ac	30	9.75	-13.43	30	9.75	-13.43	30	9.75	-13.43	30	20.32	303.67
Spelt (underseed alfalfa/grass)	SPELT-ORGANIC	t/ac	1	159.8	-169.19	1	159.8	-169.19	1	159.8	-169.19	1	500	171.01
Spelt (with Oil Radish cover)	(as above)													
Hay	Modified Conv: ALFALFA - TIMOTHY HAY	t/ac	2.5	110	42	2.5	110	42	2.5	110	42	2.5	132	104
Alfalfa/Grass	as above													
Alfalfa	as above													
Pasture	**as above**													
Oats (undersown with clover/grass)	OATS-ORGANIC	bu/ac	62	2.78	-13.71	62	2.78	-13.71	62	2.78	-13.71	62	4.24	76.81
(Barley)	BARLEY-ORGANIC	bu/ac	55	3.48	-13	55	3.48	-13	55	3.48	-13	55	5.99	125.05
Oats/Barley	50% OATS + 50% BARLEY				-13.36			-13.36			-13.36			100.93
			year 1			**year 2**			**year 3**			**year 4**		
Conventional Assumed Livestock			**Herd size (cows only)**	**Expected return per cow**	**Expected return for herd**	**herd**	**return per cow**	**return for herd**	**herd**	**return per cow**	**return for herd**	**herd**	**return per cow**	**return for herd**
Beef	COWCALF		95	-87.34	-8297.67	95	-87.34	-8297.67	95	-87.34	-8297.67	95	-87.34	-8297.67
Dairy	DAIRY		79	1353	106887	79	1353	106887	79	1353	106887	79	1353	106887
Organic Modeled Livestock			**Herd size (cows only)**	**Expected return per cow**	**Expected return for herd**	**herd**	**return per cow**	**return for herd**	**herd**	**return per cow**	**return for herd**	**herd**	**return per cow**	**return for herd**
Beef	COWCALF		95	-87.34	-8297.67	95	-87.34	-8297.67	95	-87.34	-8297.67	85	-215.47	-18314.78
Dairy	DAIRY		79	1353	106887	79	1353	106887	79	1353	106887	71	696.05	49419.7

	year 5			year 6			year 7			year 8			year 9			year 10		
Observed Conventional Crops	yield	price	return	yield	price	return	yield	price	return	yield	price	return	yield	price	return	yield	price	return
"Winter Wheat"	76	5.85	239.58	76	5.85	239.58	76	5.85	239.58	84	5.85	294.13	84	5.85	294.13	84	5.85	294.13
	50	2		50	2		50	2		55	2		55	2		55	2	
"Beans"	18	34	274.7	18	34	274.7	18	34	274.7	19.8	34	334.67	19.8	34	334.67	19.8	34	334.67
"Corn"	137	4.3	106.53	137	4.3	106.53	137	4.3	106.53	150.7	4.3	155.78	150.7	4.3	155.78	150.7	4.3	155.78
"Hay (alfalfa/grass)"	3.5	110	59	3.5	110	59	3.5	110	59	3.85	110	102	3.85	110	102	3.85	110	102
"Pasture"																		
"Soybeans"	38	9.75	94.75	38	9.75	94.75	38	9.75	94.75	41.8	9.75	130.95	41.8	9.75	130.95	41.8	9.75	130.95
"Barley"	70	3.48	81.89	70	3.48	81.89	70	3.48	81.89	77	3.48	114.92	77	3.48	114.92	77	3.48	114.92
	50	2		50	2		50	2		55	2		55	2		55	2	
(Oats)	78	2.78	66.95	78	2.78	66.95	78	2.78	66.95	85.8	2.78	97.44	85.8	2.78	97.44	85.8	2.78	97.44
	50	2		50	2		50	2		55	2		55	2		55	2	
"Oats/Barley"			74.42			74.42			74.42			106.18			106.18			106.18
"Spring Cereal"			74.42			74.42			74.42			106.18			106.18			106.18
"Spring Grains"			74.42			74.42			74.42			106.18			106.18			106.18
Unidentified or uncommon			117			117			117			157			157			157
Organic Rotation Crops	yield	price	return	yield	price	return	yield	price	return	yield	price	return	yield	price	return	yield	price	return
Corn	94	7.62	267.77	94	7.62	267.77	94	7.62	267.77	103.4	7.6	332.82	103.4	7.6	332.82	103.4	7.6	332.82
Soy	30	20.32	303.67	30	20.32	303.67	30	20.32	303.67	33	20.32	363.96	33	20.32	363.96	33	20.32	363.96
Spelt (underseed alfalfa/grass)	1	500	171.01	1	500	171.01	1	500	171.01	1.1	500	220.30	1.1	500	220.30	1.1	500	220.30
Spelt (with Oil Radish cover)																		
Hay	2.5	132	104	2.5	132	104	2.5	132	104	2.75	132	141	2.75	132	141	2.75	132	141
Alfalfa/Grass																		
Alfalfa																		
Pasture																		
Oats (undersown with clover/grass)	62	4.24	76.81	62	4.24	76.81	62	4.24	76.81	68.2	4.24	102.42	68.2	4.24	102.42	68.2	4.24	102.42
(Barley)	55	5.99	125.05	55	5.99	125.05	55	5.99	125.05	60.5	5.99	157.15	60.5	5.99	157.15	60.5	5.99	157.15
Oats/Barley			100.93			100.93			100.93			129.79			129.79			129.79

	year 5			year 6			year 7			year 8			year 9			year 10		
Conventional Assumed Livestock	herd	return per cow	return for herd	herd	return per cow	return for herd	herd	return per cow	return for herd	herd	return per cow	return for herd	herd	return per cow	return for herd	herd	return per cow	return for herd
Beef	95	-87.34	-8297.67	95	-87.34	-8297.67	95	-87.34	-8297.67	95	-87.34	-8297.67	95	-87.34	-8297.67	95	-87.34	-8297.67
Dairy	79	1353	106887	79	1353	106887	79	1353	106887	79	1353	106887	79	1353	106887	79	1353	106887
Organic Modeled Livestock	herd	return per cow	return for herd	herd	return per cow	return for herd	herd	return per cow	return for herd	herd	return per cow	return for herd	herd	return per cow	return for herd	herd	return per cow	return for herd
Beef	85	-29.04	-2468.18	85	-29.04	-2468.18	85	-29.04	-2468.18	85	-29.04	-2468.18	85	-29.04	-2468.18	85	-29.04	-2468.18
Dairy	71	1848.71	131258.7	71	1848.71	131258.7	71	1848.71	131258.7	71	1848.71	131258.7	71	1848.71	131258.7	71	1848.71	131258.7

Appendix 3: Maitland Valley Conservation Authority

The Maitland Valley Conservation Authority (MVCA) evolved from its initial jurisdiction overseeing the Middle Maitland river in 1951, to oversee the entire Maitland watershed in 1961, and its jurisdiction was enlarged again in the early 1970s to include the Nine Mile River watershed. The role of the MVCA has similarly evolved and been enlarged from an earlier focus on flood control engineering and land acquisition, to include education in the 1980s, bolserting ecosystem health and functioning in the 1990s and restoration activities, water quality promotion and developing watershed partnerships in the 2000s ((ABMVSWP, Ch.1 page 3).

The MVCAs mandate is:

"*To establish and undertake a program that will promote and enhance the conservation, restoration, development and management of renewable natural resources associated with water, land and people (MVCA 1984)*" (Ch.1, page 3)

and its vision is to:

"Maintain essential natural processes and life-support systems, preserved biological diversity, and sustainable use of ecosystems (MVCA Conservation Strategy 1989)" (Ch.1, page 3)

The MVCA is engaged in several watershed stewardships services, including clean water diversion, cropland and streambank erosion control, manure storage and management, wellhead protection, fragile land retirement and reforestation projects (Pamphlet of watershed stewardship services of Ontario Conervation Authorites, Conservation Ontario, undated).

Appendix 4: Assessment table: Ecosystem Service improvements

	Provisioning		Regulating									
Component	**Food**	**Fresh Water**	**Water Regulation**	**Erosion Control**	**Water Purification and Waste Treatment**	**Biological Control of Pests**	**Inlcuded in Enhanced Conventional?**	**Included in Enhanced Organic?**	**Motivation for adopting component**	**Baseline Design and Management components**	**Estimated change from baseline with Enhanced Conventional**	**Estimated expected change from baseline with Enhanced Organic**
Best Management Practices (BMPs)												
BMP: Nutrient Management					*		?	Yes	**Necessary to maximize contribution of available manure**	Unable to determine	(same as baseline)	Expected much higher use of nutrient management techniques
BMP: Vegetated buffers		*	*	*	*	*	yes	yes	**Incentive Payment**	Riparian area along portions (how much?) of watercourses in MMSL constituting an area of 220 ha	Additional vegetated buffers of 20 m added on each side of all watercourses in MMSL	Additional vegetated buffers of 20 m added on each side of all watercourses in MMSL
BMP: Treed windbreaks				*			yes	yes	**Incentive Payment and expected yield increases**	Few present if at all	Treed windbreaks wrapping every 100 acreas of field in MMSL	Treed windbreaks wrapping every 100 acreas of field in MMSL
BMP: Cropland Conservation Technique - Residue Management (including Tillage)			*	*	*				**Adopted to promote soil organic matter and habitat?**	The most complete dataset for observed tillage pracitces in the OMAFRA dataset is for the year 2005, which recorded tillage types for just under 50% of total field area and found approximately 38%, 7% and 3% of field area indicated conventional tillate, conservation tillage, and no-till, respectively.	(same as baseline)	Expect a higher percentage in conservation tillage because of the higher levels of cover crops, with 0% in no till (it doesn't work so well in organic) and some conventional tillage in corn and soy, but at a much reduced level compared to conventional Also adds greater nutrient cycling, lower nutrient loading in streams, higher OM levels in soil
BMP: Livestock Management				*	*		no	yes	**<u>No formal incentive</u>: Assumed adopted owing to stewardship values consistent with managed, family farm organic and assumed educational and technical guidance from CA**	Unable to determine	(same as baseline)	Assume all livestock fenced out of watercourse except at suitable crossing; alternate source of water procured such as via windmill pumps
BMP: Rotational Grazing				*		*	?	yes	**<u>No formal incentive</u>: Adopted to improve forage crops, herd health, and reduce cost of animal weight gain**	Unable to determine	(same as baseline)	Assume all grazing is rotational

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Other Organic Methods												
Crop rotations including cover crops and green manures			*	*	*	*	**Yes**	**Yes**	**Integral method of organic production system**	Close to a third of field area planted to corn annually, indicating predominantly short rotations of 1, 2 or 3 years combining corn (28%) and soy (16%), or corn, soy winter wheat (12%) and alfalfa (15%). These represent 70% of MMSL field area, but only 80% of field area was identified to its crop type. Row cropping occupied approximately **at least** 39% of all field area*	(same as baseline)	Over half of MMSL field area operated on 5 year rotations combining row crops, cereals, legumes, and grasses. Remaining half Alfalfa grass, occasional cereals and permanent pasture with rotational grazing. Row cropping reduced to approximately 17% of MMSL field area
Elimination of Synthetic inputs (fertilizer, pesticides etc.)					*	*	**no**	**yes**	**Required to meet certification**	**Assumed consistent with OMAFRA sample crop budget inputs:**		
Fertilizers:												
N (kg)										354,103	354,103	-354,103
P (kg)										92,105	92,105	-92,105
K (kg)										296,284	296,284	-296,284
Pesticides:												0
Herbicides, fungicides and insecticides (kg or L)										12,223	12,223	-12,223
Stocking rate adjustments										Estimated baseline populations		
Total livestock Animal Units (AU) combining Beef and Dairy										6600	6600	5940
Ratio of total livestock population to pasture land										25 AU per ha pasture		4.8 AU per ha pasture
Ratio of total livestock population to pasture and hay/alfalfa fields										4.3 AU per ha of pasture or hay/alfalfa fields		1.5 AU per ha of pasture or hay/alfalfa fields
Beef Days on Pasture										Assumed OMAFRA livestock budget figure of 155 days	same as baseline	180 days
Dairy Days on Pasture										Unable to determine	same as baseline	Assumed to increase, as organic budgets altered to increase pasture costs in order to account for increased days
Landscape Goals												
Increased Natural Area coverage (Woody and Herbaceous) for MMSL overall		*	*	*	*	*	**yes**	**yes**				
Percent of MMSL area in following types of vegetation:												
Forest/Woodlots										**10**	**10**	**10**
Treed windbreaks										**n/a**	**2**	**2**
Riparian area plus vegetated buffers										**3**	**6**	**6**
Enhanced Fencerows and ditches										**n/a**	**n/a**	**2**
Extent of pasture										**3**	**3**	**17**
Total natural vegetation										**16**	**21**	**37**

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Increased Connectivity between patches and corridors						*	Yes	Yes		n/a	Added buffers and treed windbreaks, comprising 7% of MMSL.	Enhanced fencerow and ditches with native perennial vegetation or naturally seeded trees; no pesticide applied; occasional maintenace (these corridors comprise 2% of MMSL). Also added buffers and treed windbreaks, comprising 7% of MMSL.
Increased Landscape Complexity and a diversity of habitats						*	Yes	Yes		n/a	Buffers, windbreaks contribute to increased quantity and variety of habitat and food source for wildlife	Longer and more complex crop rotations increase field vegetation diversity in time and space; Residue management, buffers, windbreaks, enhanced ditches and fencrerows all contribute to increased quanity and variety of habitat and food sources for wildlife.
Optimal Crop Siting				*	*			Yes		1983 Land Use study suggests that Corn system (rotation comprising 30 to 90% Corn and second most intensive observed after continuous Corn) was located across all soil types and site in the MMSL, including poorly drained sites such as those with Parkhill Loam and Brookston Loam soils, whereas Org Scenario permitted siting more intensive cropping practices on higher quality soils, such as Huron, Perth and Listowel series and implementing pasture on poorer soils		