Reintegrating Canadian Agriculture and Ecological Land Management

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

There are three distinct motivating factors behind this research: 1) ecosystems are threatened across Canada and require locations within which to establish or re-establish natural features to support native species; 2) agricultural livelihoods for small and medium farmers in Canada are insufficient; 3) there are increasing societal demands on farmers to ascribe to "environmentally friendly" agricultural practices. In Canada there is no comprehensive or integrated agricultural-environmental policy agenda that deals with these interrelated issues. This research explores the interaction of the issues within a cross-scalar framework that explores a relatively new concept, novel ecosystems, in order to provide a targeted approach to agri-environmental programming for the Canadian setting. Market forces and technological changes have driven Canadian agricultural policy and have shaped contemporary agriculture-ecological interactions on farmlands across Canada. The concept of novel ecosystems is expanded to focus on maintaining farm communities and protecting and rehabilitating rural ecosystems and ecosystem services as a response to the drivers of landscape decision-making. The outcome is a framework that integrates the literature pertaining to ecosystem management and transformation and sustainable transitions to guide the usage of novel ecosystems for agricultural programming. A case study in the Niagara Region that examined the program content of different relevant agri-environmental initiatives and engaged the local farming community revealed that landowners would be interested in programs that are based on the principle of maximum net gains (sensu Gibson et al. 2005). In this study, maximum net gains requires designing an agri-environmental program that ensures that, financially, farmers can continue farming while at the same time improving social, cultural, ecological and financial environment in which they are embedded. A pilot case example of the technical implementation of novel agro-ecosystem component using two irrigation ponds and and three species (*Scirpus atrovriens, Carex lacustris,* and *Sagittaria latifolia*) and as of 2011 repeated measures ANOVA indicated that singular plantings of *S. latifolia* at densities of as little as 1 ramet/50 cm^2 is an effective strategy in establishing a dominant plant community in semi-naturalized irrigation ponds. However, for restoration of irrigation ponds on agricultural lands devoid of facultative wetland species planting *S. atrovirens* at densities of 3 ramets/50 cm^2 is an effective strategy in establishing a dominant emergent vegetation community. A synthesis demonstrates how the findings interact in reality and forms the basis for a multi-scaled approach for an agroecological policy agenda. This is accomplished using research called Wild LifeLines™ by Fields et al. (2010) and a spatially explicit asset inventory to create an approach that triages agricultural landscapes and determines how to incorporate novel ecosytems into individual farms and particularly, outlines the significance of a cross-scalar approach for agri-environmentalism in Canada.

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Dedication

To Lin Robinson

"A conservationist is one who is humbly aware that with each stroke of the axe he is writing his signature on the face of the land."
— *Aldo Leopold,* A Sand County Almanac

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Prologue

This prologue represents both the beginning and end of my PhD process. It is the beginning because it functions as a way for me to introduce myself both as a researcher and as someone that approaches this research with a certain set of assumptions about agriculture and ecosystems in Canada. It marks the closure of my PhD end because it is also a written in response to my examiners' comments and questions on my thesis and the conversations surrounding the feedback and is therefore the final iteration of this thesis. The examiners have specifically asked me write this prologue in order to prepare readers for the beliefs and values I bring to this research and also to introduce the innovative multi-scalar approach with which I have chosen to explore agriculture in Canada and is the basis of my contribution to the literature.

I value both agriculture and ecology in Canada; growing up in the Niagara Region on and around tender fruit land that influence and are dependent on the Niagara Watershed has given me a certain set of perspectives about what issues contribute to what is often called "the family farm" problem and agroecological decline in Canada. The "family farm problem" is characterized by on-going rural decline, the lack of intergenerational transfer of lands and degradation of lands due to land consolidation and the loss of small to medium-sized farms to larger agribusiness. While this research could have focused on one aspect of the "family farm problem" I have also come to realize that the cause of the multi-faceted agricultural decline in Canada has been approached with a simplistic perspective for what is actually a very complicated problem. Namely, approaching agriculture with a narrow set of goals and objectives at the federal policy scale has encouraged a narrow set of objectives for production at the farm-scale, namely maximizing output. The truth of the matter is that farming in Canada is influenced by cross-scalar interactions in terms of how Canadian federal agricultural policy impacts regional conservation dynamics as a result of the choices made for land management on the farm-scale.

I have seen instances in my experience where agriculture and ecology function in tandem with one another with inspiring outcomes. I have also seen instances where the status quo of conventional agriculture is so deeply embedded a farmer cannot and will not admit there is another way of doing things. Policy pertaining to ecological land-use management decisions on farms must be cognizant of the multi-scaled interactions that shape decision-making. For example, Allison and Hobbs (2004, 2006) studied the Western Australian Wheat Belt, a region dominated by private land ownership and high agricultural production. They determined that land use decisions of farmers were collectively driven by macro-scale markets, technologies, and institutional forces which influenced regionally specific factors such as population decline, environmental pollution, and resource depletion. This is situation where a resilient but undesirable system is reinforced. The system there was maintained by highly connected institutions and policies that focused on facilitating commodity production and little else. The situation described in my thesis is similar to the one described by Allison and Hobbs; there are few mechanisms to leverage change in response to regional and social and ecological decline in order to disrupt the resilience of the existing system.

What is required is a set of criteria to alter the direction of agricultural policy so it covers the broad range of issues which it actually affects instead of narrowly focusing on one issue which has ultimately caused vast unintended consequences. Agricultural policy has been a driving force for the choices that are made at the farm-scale, arguably since the early 1900s. This research makes use of the concepts of general and specified resilience to discuss the difference between the impacts of narrow agricultural policy agenda and a broader more inclusive policy agenda. Specified resilience refers to the "resilience of some particular part of a system, related to a particular control variable, to one or more identified kinds of shocks" (Folke et al. 2010). Modern agricultural systems are examples of specified resilience; increasing fertilizers and machinery increases yields has ultimately increased the global agri-food system. General resilience, in contrast, is the "resilience of any and all parts of a system to all kinds of shocks, including novel ones" (Folke et al. 2010). General resilience can explicitly address past, present, and future conditions in terms of what actions should or should not be taken to ensure a functional agroecosystem which requires fostering biophysical functioning in agricultural landscapes.

This research methodology reflects my background which is both social and ecological and as a result this PhD is transdisciplinary and innovative. My greatest contribution to the literature is the development of a cross-scalar approach to agricultural land management by linking the federal policy-making scale to the regional conservation scale to the farm-scale in order to address this issue of specified versus general resilience that has been the status quo for agriculture in Canada. The thesis is structured using this cross-scalar approach and addresses broad-scale policy issues first before scaling down to pilot studies. Regional conservation objectives are discussed as a way to begin blending agricultural land-use with the preservation of our native ecological communities; this is a cross-scale linkage (the farm-scale to the regional landscape scale) that provides a good place for agri-environmental programs to be situated. Attempts have been made for regional conservation bodies to get farmers involved in conservation, but in my experience, landowners often feel that the conservation efforts work contra to their land management instead of with and within their land management dynamics. Throughout this research I will connect everything from broad, political-economic, agro-ecological trends down to the functioning of microbes in irrigation ponds.

I also expand the concept of novel ecosystems to incorporate deliberate creative undertakings that reintroduce ecological functioning at the farm-scale using assemblages of native species that contribute to the conservation of the regional ecological communities and systems. Generally, this new conceptualization of novel ecosystems provides an avenue for innovative experimentation that encourages purposeful diversification on agricultural landscapes reflecting a broad historic range of variability (i.e. native assemblages of species). Additionally it integrates the associated beneficial ecological functions that result from increased native species redundancy, selection of species well suited to deliver desired ecosystem services such as water purification, connectivity for native species at regional scales, habitat provision etc. This is one of the first "novel ecosystems" studies and as such it makes theoretical strides by linking community assembly concepts and methods with concepts from resilience theory and case-specified sustainability criteria. This is an important development for this concept, since contemporary research is still addressing novel ecosystems as an undesirable consequence of large-scale abiotic changes and biotic responses. In order to begin building the theoretical underpinnings of novel ecosystems I connect three bodies of literature that previously have not been integrated: transitions (the sociotechnical transition literature), ecological transformations and social innovation to develop this concept of novel ecosystems.

The focus here is the creation of resilient agroecological systems in Canada by redeveloping agricultural policy to encourage ecologically sustainable management. In this research I define transition as an alteration in the federal policy-making agenda that makes explicit the connections between agricultural land-use and the ecological setting. Transformation refers to the restructuring of ecological systems and enhancing their capacity to provide ecological functioning and farm-scale resilience of agroecological components. Innovation is the driving force of change that links the two scales (transformation and transition). It is the enhancement of the creativity of land management and funding schemes to encourage resilience at the farm-scale and sustainability in policies at the government scale. One main aspect is providing the incentives for actors to reconceptualise farm-management to cross-scalar socioecological change.

The core outcome is a description for how economic, ecological, cultural and political drivers interact and how the Canadian agricultural sector can (a) embrace policy and practice changes in order to plan responses to the range of future scenarios, and (b) implement ancillary yet integral facets of agricultural operations that will increase desirable agroecological resilience. The findings from these chapters therefore identify a new way forward for agri-environmental initiatives in Ontario, and even in Canada.

1 Novel Ecosystems: A New Concept for re-integrating Agriculture and Ecology

1.1 Introduction

The impetus for this research stems from the cumulative degradation of agricultural and ecological systems in Canada. Although these have been examined and treated in a somewhat parallel manner (Altieri, 1987; Vandermeer, 1995; Gliessman, 1998; Moonen and Barberi, 2008). However, to sustain agricultural livelihoods in Canada a new approach to agricultural programming is required that incorporates ecological functioning into the most basic tenets of the approach. Other models, e.g. market liberal and maximum sustained yields, are ineffectual for two interconnected reasons. If the market liberal approach came to dominate in Canada, most Canadian operators would be eliminated because they could not remain competitive without some form of subsidization. Many operators in central Canada (i.e. Ontario and Quebec) would be squeezed out because the market liberal model is mainly supported by large-scale operators in the mid-west who feel they are more competitive trading their commodities on the domestic and international market without government interference (Skogstad, 2009). Maximizing units of production would also be championed in the market liberal model, which would only exacerbate the existing ecological and environmental decline resultant from the productivist era.

Without a comprehensive approach to species establishment on and across farmscapes the larger goals pertaining to ecological conservation in Canada will suffer. Ecological systems are vulnerable to human development (of both the agricultural and residential kind) creating islands of ecosystems scattered across a mix of urban, ex-urban and agricultural landscapes. The remaining vestiges of useable land to provide ecosystem “stepping-stones” or corridors are relegated largely to agricultural lands. There are three salient and succinct issues that are motivating factors behind this thesis: 1) the biodiversity of ecosystems are threatened across Canada and require locations within which to establish or re-establish natural features to support species; 2) the average age of agricultural operators in Canada continues to rise with minimal recruitment of new operators; this signifies a reluctance to continue/ start farming in Canada because of unstable or insufficient livelihoods; 3) there are increasing societal demands on farmers to adopt “environmentally friendly” agricultural practices . This research explores the interaction of these three issues in order to provide a targeted approach to agri-environmental programming for the Canadian setting. To test this approach, a study in the Niagara Region was used (Chapters 4 and 5).

1.2 Novel Ecosystem Conceptual Framework

Deliberate and inadvertent introduction of species has resulted in novel ecosystems[1] via maintaining or surpassing abiotic and biotic thresholds. The rates of ecosystematic change are much faster in contemporary times because technologies provide the capacity to overcome biogeographical and biophysical barriers to species establishment (Hobbs et al. 2006). In the literature the terminology surrounding changes in ecosystem states can be daunting because several terms refer to similar phenomena with slightly varied nuances. For instance, in the literature various terms refer ecosystem state changes, including: stability domain shifts, alternative stable states, and multiple stable states. Additionally, research surrounding the action of "changing states" has also resulted in overlapping terminologies including: "flipping", "tipping points", "critical thresholds", "ecological filters", "catastrophic changes" etc. Thresholds in this literature refer the point at which, in a system, even small perturbations (in environmental conditions) can trigger large changes in system state variables (Suding et al. 2004). Realistically, it is difficult to determine whether a system is approaching a threshold and in some cases there is a lag time before it is obvious that a threshold has been surpassed. However, ecosystem configurations are the result of complex interactions between numerous abiotic and biotic factors that ultimately mediate community assembly (Hobbs and Norton, 2004) and when there are alterations to the biotic and abiotic factors community assembly is transformed. This idea of mediating community assembly is how I conceptualize thresholds in respect to novel ecosystems in this research.

Biotic thresholds in particular, are created by dispersal barriers (that cause new combinations of functional groups) which result from altered abiotic conditions (e.g. soil erosion, climate change, changed hydrologic conditions) (Hobbs et al. 2006). When abiotic and biotic thresholds are exceeded, the thresholds interact to transform ecosystems into *novel* ecosystems (sensu work by Hobbs, Higgs, Harris, Seastedt). Management approaches that aim at returning landscapes to historical trajectories are ignorant of the fact that many degraded systems have been altered so severely that a threshold(s) has been crossed irreversibly (Hobbs et al. 2006). Hobbs et al. (2009) argue that a novel ecosystem is one in which the species composition and/or function have been completely altered from the historic system. Removing the requirement to aim for achieving historic ecosystem trajectories increases the range of options available for management and increases our adaptive capacities (Fabricius et al. 2007) and could reduce financial resources and efforts to achieve valuable outcomes. This will require re-evaluating how we characterize valuable ecosystems (Higgs, 2003) and may require an evolution in the cultural norms surrounding nature, conservation and restoration (Hobbs et al. 2009).

1.3 Objectives of the Thesis

The thesis contributes to do what many have been unable or reluctant to do: Apply the theoretical frameworks of ecosystem resilience, transformative influences, and novel ecosystems to provide

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[1] When new compositions and abundances of species occur within a particular biome, combination, or specific location (Hobbs et al. 2009).

workable solutions that sustain agriculture and restore – in the functional sense – ecosystems. In particular, 'novel ecosystems' will be used beyond its current oeuvre of unintended species drift and widespread abiotic changes. In order to meet these objectives the thesis will examine how to include deliberate creative undertakings on altered landscapes that reflect societal, cultural, economic and ecological values. This will provide an avenue for innovative experimentation that encourages purposeful diversification on agricultural landscapes reflecting a broad historic range of variability (i.e. native assemblages of species) as well as the associated beneficial ecological functions that result from increased species redundancy, selection of species well suited to deliver desired ecosystem services such as water purification, connectivity for native species, and habitat provisions. Novel ecosystems, in concept and practice, can contribute to the sustainability of agricultural landscapes by reconnecting people with landscapes (landowners and the restored farmlands, see Chapter 3 for a suite of guiding principles) and ultimately improve the ecosystem services of those landscapes). This thesis has five main objectives as follows in order to accomplish this goal:

1.3.1 Examine the history of Canadian agricultural policy and decision-making to determine the extent of the influence that the agricultural policy setting has had on agricultural-ecological interactions.

In this research I will discuss both government and governance. Government refers to the actual institutional bodies that make agricultural policy most commonly either federal or provincial. Governance differs from government because it is not just the purview of the state through the organization of the government but "emerges from the interaction of many actors, including the private sector and not-for-profit organizations" (Lebel et al. 2006). In this research, governance refers to the decision-making processes that take place at the regional and farm-scales that are a result of the the function of or decisions made by the government. There is consensus in the literature that the Western world experienced two, arguably three, major phase shifts (see Wilson, 2001 for expanded discussion) in policy-making and consequentially, in agricultural operations. The three major phase shifts most of the modern agricultural world has experienced are protectionism, productivism and post-productivism. Some parts of Europe, the EU more specifically, have transitioned to/ towards multifunctionalism and agroecosystem thinking. The following table parses out the most relevant definitions (with relevant sources for these concepts) for Chapter 2.

TABLE 1-1. RELEVANT TERMS AND DEFINITIONS OF POLICY-MAKING ITERATIONS DISCUSSED IN RELATION TO THE WESTERN MODERNIZED AGRICULTURAL WORLD.

Term	Definition	Sources
Market liberalization	Refers to freeing global agricultural trade policy from government intervention (e.g. supply management programs and tariffs).	Skogstad (2009)
Ecosystem services	The resources, goods and processes supplied by natural systems (e.g. provisioning, regulating, cultural and supporting).	Millenium Ecosystem Assessment (2005)
Agroecological	Maximizing the beneficial interrelationship	King (2008); Murphy

resilience	between farming and the ecological system within which it is embedded to maintain the on-going production of ecosystem source, sink and performance capacities; insuring the productive capacities of agricultural operations through the protection and enhancement of ecological services on agricultural lands.	and McGrath (2011)
Protectionism	Government interventions that restrict or restrain international and intra-national trade, often done with the intent of protecting interests from competition.	Ward (1993)
Productivism	A commitment to maximizing output and productivity via an intensive, industrially driven and expansionist state-supported agriculture.	Lowe et al. (1993); Wilson (2001)
Post-productivism	Recognition that the production-logic is unsustainable; as a result, agriculture, agricultural operators and the environment are vulnerable and unresilient.	Potter (1998); Pond (2009)
Multifunctionalism	Agriculture can produce various non-commodity outputs in addition to food.	Wilson (2001); OECD (2000)
Agroecosystems	Agricultural systems that emphasize the interaction social, ecological and production aspects of operations.	Okey (1996); Waltner-Toews and Wall, (1997); Charron and Waltner-Toews (2008)
Policy	Under the jurisdiction of federal and provincial governments policy is the agenda that creates and regulates the agricultural programs e.g. *Growing Forward*.	Schmitz (2008)
Program	The "settings" of expenditure and regulatory policy instruments (e.g. adjustments to the level of benefits provided by a farm income support program) and the policy instruments (e.g. import quotas and tariffs).	Schmitz (2008)

The remainder of this dissertation approaches agricultural policy-making and operations from the perspective of the agroecosystem model. Agroecosystems are specialized (and to some degree) controlled ecosystems designed for the production of both food and other raw materials (Okey, 1996). The agroecosystem concept has made it easier to appreciate that there are natural capital and processes embedded in and enmeshed with the actual farms that provide a hidden underpinning for the ability of farms to exist and thrive. These would include the natural enemies of crop pests, pollinators, and the ability to maintain species diversity to ensure adaptive capacity and perhaps ecosystem processes like water, soil, and nutrient cycling. The applications of the term "agroecosystem" have been variable and as a result the definitions of what constitutes an "agroecosystem" are correspondingly varied. For instance, some researchers apply the term to include landscapes that are in possession of a farm management system (Okey, 1996) whereas agroecosystems could be considered to include all of the cross-scalar connections associated with a farming enterprise, including the fields and landscapes for production and more broadly incorporating the processing infrastructure and associated rural communities (Okey, 1996). The use of the term "agroecosystems" is a means of reconciling the dichotomization of agriculture from its natural environs and emphasizes the continuous exchange of energy and biomass across the visible delineations of farms and naturalistic or urban areas (e.g. water, carbon, nitrogen, phosphate, and potassium – the latter three often in the form of fertilizers).

The agroecosystem model is discussed in contrast to the industrialized agricultural systems that have persisted over the past 150 years that have been grounded in and maintained via regulations, subsidies, trade negotiations and policies often at the expense of ecological functioning, ecosystem resilience, and local innovations (King, 2008). Reviewing the history of market and technological forces that have driven Canadian agricultural policy demonstrates that on-going government intervention for the purposes of price-support and stabilization of Canadian agricultural operators has had resounding and extensive negative implications on the viability of Canadian agriculture. Attempts at increasing the competitiveness of Canadian agriculture (particularly in the post-Second World War globalization period) reinforced the separation of agriculture operations from ecological settings (Skogstad, 2009). Overall, government intervention for price-support, stabilization and competition has reinforced the breakdown of the agriculture-ecosystem relationship increasing the vulnerability of many farming practices by intensifying ecological as well as growing social problems (i.e. farm debt, falling commodity prices, farm foreclosures, and the loss of farm-community culture) (Okey, 1996).

In order to accomplish the research objective Chapter 2 is an examination of the historical shifts that have occurred in agriculture in industrial nations but looks particularly at the driving forces behind Canadian agricultural policy and operations. It also offers a set of criteria for agroecological policymaking as a response to the gaps identified during analysis.

1.3.2 Review the literature and concepts that are relevant to the novel ecosystem concept with particular attention paid to 'transformations' and 'transitions' in order to create a suite of guiding principles for agri-environmental decision-making (as a response to the evidence gathered from the first objective).

A rigidity trap occurs in a socio-ecological system when management is narrowly focused and power and profit are mutually reinforcing (Carpenter and Brock, 2008). Rigidity traps are characterized by highly-connected, self-reinforcing, inflexible institutions, and low potential for change (Gunderson and Holling, 2002 in Carpenter and Brock, 2008). An example of this phenomenon is demonstrated by the shifting reliance on large, input intensive, monocropping agribusinesses at the expense of small, diversified family-owned farms. Conversely, a poverty trap occurs when connectedness and the potential for change is not realized by community members (Carpenter and Brock, 2008). In these situations the materials (e.g. raw resources or intellect) may be available but the capacity to operationalize the resources is lacking. Although small farms may have some financial capital, agronomic intellect as well as available local markets, organizing civically-oriented agricultural ventures remains out of reach for family farms, causing on-going rural decline. The European agri-environmental transition (presented in

Chapter 2) demonstrates a shift from rigidity traps at the inter-national governmental level in order to enhance self-reliance of the agricultural community with mutual benefits for ecosystem health.

Resilient agroecosystems incorporate and generate the capacity for innovation and the generation of novelty and options (King, 2008) outside of the historic foci of technological and production advances alone. However, there are three commonly discussed iterations of resilience defined by a series of papers (Holling, 1973, 1987, 2010; Berkes and Folke, 1998; Gunderson and Holling, 2002; Gunderson and Pritchard, 2002; Folke, 2006; King, 2008). Specifically, these are: engineering resilience (predictable systems, assumes steady states are possible, concerned with efficiency); ecological resilience (assumes restructuring is possible but acknowledges that systems are unpredictable); and adaptive capacity resilience (management of unstable states or non-equilibrium systems). Adaptive capacity resilience incorporates what is termed an "adaptive cycle" by Holling (2001). A main purpose of the adaptive cycle heuristic is to illustrate the phases of system changes as it cycles through four potential domains: conservation, release, exploitation and reorganization. The adaptive cycle indicates stored capital (e.g. financial capital, ecological capital, social capital) is domain dependent and suppression of release events of the capital increases the storage to a critical point, which ultimately amplifies the eventual collapse (King, 2008). King (2008) argues that measuring resilience in this approach occurs by coupling social learning and evolution (adaptation and transformation). However, the management approach advocated by this position requires more understanding of the role that transformation plays (viz Folke et al. 2010) in current agricultural systems. Sustainable transitions (viz Smith et al. 2005) and transformative states provide a basis on which to redesign Canadian agricultural policy with a particular focus on agro-ecological interactions.

Most modern agroecosystems are "adaptable" because they are able to stabilize production via access to external resources (e.g. synthetic inputs). However, the high adaptability to external fluctuations and the access to external resources occur at a cost of dependency on forces that are outside the farmers' control and ultimately constrain the system. On the other hand, transformability is influenced by incentives to change, cross-scale awareness, experimentation, reserves and convertible assets (Walker et al. 2006 in van Apeldoorn et al. 2011). In this research two types of transformations are explored. First, "forced" transformations (sensu Folke et al. 2010) refer to the complete alteration of socio-ecological systems such that a completely system is created. Secondly, transformations also refer specifically to the deliberate changes in ecological communities and landscape features via the creation of novel ecosystems and the way they are implemented. A component of social innovation (sensu Biggs et al. 2010) that has previously not been examined in conjunction with agroecological management and policy is examined. The social innovation component of change in this research is called "transition". Transitions refer the alteration of the guiding agenda of policy-making; in this case I will talk specifically about the Canadian federal agricultural policy agenda. Modern agroecosystems are therefore, unlikely to transform in a desirable direction without active intervention. They possess eroded natural capital, a low diversity in crops, large scale subsidies, are influenced by the vested interests of the agri-foodchain (which reduce innovation, diversity and human organization). Canadian agricultural policy needs to take proactive steps in ensuring agroecological resilience by transitioning to multifunctional paradigms for agricultural programming. The following table parses out the most relevant definitions (with relevant sources for these concepts) for Chapter 3.

TABLE 1-2. RELEVANT TERMS AND DEFINITIONS DISCUSSED IN CHAPTER 3.

Term	Definition	Sources
Thresholds	After surpassing biotic and abiotic barriers in ecological systems a system changes *irreversibly* from one state to a new state (e.g. climate change projections which indicate that changes in abiotic conditions will influence the biological make-up of ecosystems)	Chapin and Starfield (1997); Suding et al. (2004)
Ecosystem management	Management of ecosystems with intra- and intergenerational conservation objectives including socioeconomic, political and cultural requirements.	Christensen (1996); Biggs et al. (2010)
Sustainable transitions	An iterative multi-level governance approach that is focused on the co-evolution of the social and the technical through mutual adaptations between/across macro, meso and micro scales and towards alternative sustainable system (the outcome is a fundamentally altered society or subsystem); concerned with mechanisms for change rather than outcomes.	Rotmans and Loorbach (2009)
Active transformations	The "deliberate initiation of a phased introduction of one or more new state variables (a new way of making a living) at lower scales, while maintaining the resilience of the system at higher scales as transformation change proceeds".	Folke et al. (2010)

In order to accomplish this research objective Chapter 3 is an initial discussion of the Novel Ecosystem approach including current definitions of novel ecosystems, principles of a Novel Ecosystem approach, particular problems this concept can address, continuing debates surrounding novel ecosystems (narrowly) and ecosystem management (generally). It examines the relevant literature and culminates with a set of guiding principles.

1.3.3 Explore the existing models of agri-environmentalism with direct/ potential applications in Ontario and redevelop program content where gaps are discovered.

According to Pond (2009) recent patterns of growth in the Toronto region have enhanced and reinforced the "negative externalities" of sprawl since the 1970s. Of particular concern were the lands suitable (in terms of soil, climate and water resources) for tender fruit farming (Gayler, 2004). By 2001, 11% of Ontario's best agricultural land had been converted to urban use (Pond, 2009). Sprawl-based planning fosters the loss of productive farmland. However, it is unlikely that the loss of agricultural land has played a significant role in the decision to pursue growth management in Ontario and yet, protection of farmland has become a major component of the resulting Greenbelt legislation. The Ministry of Public Infrastructure Renewal enacted the *Places to Grow Act* (PGA) in 2005 to manage planning outputs in a more strategic way. Under the PGA, the MPIR was required to prepare a Growth Plan for the Greater Golden Horseshoe area the (GGH Plan) in 2006.

Complementary to the PGA and the GGH Plan are the *Greenbelt Act* and Plan, also established in 2005. These approaches have their detractors – especially for ideological reasons – but there are some useful critiques (particularly Pond, 2009 and Deaton and Vyn, 2010). The concern here is that the impetus to implement intensive land use practices, greater use of off-farm inputs like fertilizers and pesticides, and technological investments, the trend in Ontario and much of the planet has been to use progressively less land to produce foodstuffs (Pond, 2009). The real issue is that this approach is not sustainable; particularly it is not an efficient use of non-renewable resources. A new approach to counteract the status quo approach to agricultural management takes into account the benefits proffered by ecological systems.

This chapter of the research, therefore, examines the interplay between "conservation" on and around farmlands in comparison to a program that would support active restoration. The focus on conserving natural ecosystems is only one part of what should be a multi-faceted strategy. Current agri-environmentalism programs both in Canada and in England[2] are evaluated to determine what the true objectives of agricultural programming are/ ought to be in the face of the unstable state of agriculture in Canada generally (see Chapter 2 for an expanded discussion of this topic), Ontario and the Niagara regions specifically. The research also investigates what the program content of current agri-environmental programs in Ontario actually targets and whether it is actually aligned with the present biophysical and livelihood concerns plaguing agricultural operators in Canada. The main programming gaps identified from this research determine that the agricultural models offered in Canada overlook the provision of ecosystem functioning.

In order to accomplish this research objective Chapter 4 examines the program content of different models of relevant (i.e. it is reasonable that they could be employed in Ontario) agri-environmental initiatives and overlapping models for agri-environmental policies. This paper is comprised of two parts. The first part of the paper is focused on analyzing agri-environmental initiatives. The second uses Q Methodology and engages the local farming community to provide feedback on the findings from Part 1 of this paper in terms of developing agri-environmental program content. The outcome is a suite of criteria based on the principle of maximum net gains (sensu Gibson et al. 2005). The following table parses out the most relevant definitions (with relevant sources for these concepts) for Chapter 4.

TABLE 1-3. RELEVANT TERMS AND DEFINITIONS DISCUSSED IN CHAPTER 4.

Term	Definition	Sources
Agri-environmentalism	Programs designed to encourage enrolment of farmers in order to protect and enhance the	Smithers and Furman (2003)

[2] Agri-environmental programs in England are examined because the efforts towards multifunctionalism in agriculture are perhaps the most innovative in the world and in terms of the iterations of agricultural programming, England has been tackling this issues for several decades longer than Canada (Lactaz-Lohman and Hodge, 2003).

	environment on their farmland.	
Ecological restoration	Definition: "an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability" (SER Science and Policy Working Group 2002); theory behind putting ecosystems and communities back together (reassembling them) because ecosystems are more than the sum of their parts (contrary to Gleason's "individualistic" concept in 1917)	Jordan (2000); Higgs (2003)
Maximum net gains	Maximum net gains offer a way to reconcile the differing conceptualizations of problems with sustainability goals. The rule stipulates that an acceptable trade-off "must seek mutually reinforcing, cumulative and lasting contributions; and must favour achievement of the most positive, feasible, overall result, while avoiding significant adverse effects".	Gibson et al. (2005)
Sustainability	The "capacity to create, test and maintain adaptive capability".	Holling (2001)

1.3.4 Determine what ecological theories are relevant as a foundation for assembling novel ecosystems on agricultural lands; examine how this plays out at the farm-scale.

Focusing on agroecological resilience means accepting a shift in objectives, i.e. maximizing the beneficial interrelationship between an ecological system and an embedded farming system to maintain the on-going production of ecosystem source, sink and performance capacities. Fostering these relationships requires including the natural enemies of crop pests, pollinators, and the ability to maintain species diversity to ensure adaptive capacity and ecosystem processes like water, soil, and nutrient cycling. Agroecological resilience can be defined as the insurance of the productive capacities of agricultural operations through the protection and enhancement of ecological services on agricultural lands in addition to the viability of farming operations, particularly smaller operators who have previously been ostracized by policies and programming (Bessant, 2007). This requires generating innovations in land management approaches to deal with the novel configurations of biophysical components resulting from environmental alterations that affect ecosystem service production.

When ecosystems have been transformed outside of a historic range of variability, the ecological processes upon which the society depends are also altered and can result in feedbacks between the social and ecological facets of the system (Suding et al. 2004). Re-assembling or maintaining ecosystems on agricultural lands is important because it provides important system functions to agricultural operations. Incorporating native species assemblages on production landscapes can make the entire regional landscape more resilient by increasing the heterogeneity of the landscape accounting with a particular focus on incorporating dominant species from functional groups that are not susceptible to agricultural pressures (Moonen and Barberi, 2008). Particularly, by maintaining communication (i.e. information transfer or material transfer such as community guilds) among levels, the interactions within levels can be altered without the entire system collapsing (Holling, 2001). Agricultural systems are dependent on the interaction of biophysical, socioeconomic, and human community health dimensions (Okey, 1996); therefore, the breakdown of agriculture-ecosystem relationship has damaged the capacity for agricultural landscapes to produce ecosystem services required by agricultural operations (Pretty, 2008). Transitions in agricultural policy-making approaches require the inclusion of all components of agroecosystems including ecological, socioeconomic, cultural and political aspects (Charron and Waltner-Toews, 2008). In order to accomplish this research objective Chapter 5 is a pilot case example of the technical implementation of a novel agro-ecosystem component using two irrigation ponds and examines the practical challenges of biophysical implementation. The paper uses a conceptualization of transformative resilience and basic resilience concepts (sensu Folke et al. 2010) to address the framing of novel ecosystems as beneficial functional components on agricultural landscapes. The following table parses out the most relevant definitions (with relevant sources for these concepts) for Chapter 5.

TABLE 1-4. RELEVANT TERMS AND DEFINITIONS DISCUSSED IN CHAPTER 5.

Term	Definition	Sources
Assembly rules	A variety of different approaches to finding rules that govern how ecological communities develop.	Weiher and Keddy (1995); Keddy (1999)
Ecosystem functioning	The processes e.g. energy flows and nutrient cycles (as opposed to structures) that are delivered and governed by the biota within an ecosystem.	Naeem (2006)
Habitat fragmentation	Discontinuities in ecological landscapes (e.g. in an organism's preferred habitat) which result in population fragmentation.	Altieri (1992); Suding and Gross (2006)

Additionally the paper discusses the benefits of acknowledging that landowners should decide what ecosystem services they are willing to support and generate using absent (but essential) native species in irrigation ponds (in terms of functional diversity from reference wetland ecosystems). This requires identifying what species assemblages are most effective for priority sequence colonization and other practical challenges that arise during restoration.

1.3.5 Create a workable solution for implementing this into the case study area.

New understandings of ecosystem management encourage investigating the novel (but potentially beneficial) linkages between cultural and natural heritage. The new constraints placed on both ecological and agricultural systems resulting from changing environmental conditions as well as obligations for the provision of public services require lessening the reliance on historic fidelity and historic range of variability in ecosystem management such that perceived "non-natural" systems (e.g. agricultural landscapes) can be incorporated into conservation and restoration strategies to meet public demands. Historic fidelity in respect to restoration refers to the extent to which restoration goals reflect the history of the place (Higgs, 2003). Historic range of variability refers to the reasonable long-term boundary of ecosystem change (Higgs, 2003).

The implementation of novel ecosystem initiatives on agricultural landscapes provides an avenue for fiscal transfer from governmental bodies to farmers by encouraging the creation of systems that respond directly to the conservation, natural and cultural heritage requirements of particular regions. Generally, novel ecosystems provide an avenue for innovative experimentation that encourages purposeful diversification on agricultural landscapes reflecting a broad historic range of variability (especially native assemblages of species) as well as the associated beneficial ecological function that results from increased species redundancy. This section of the research argues that strengthening the relationship between novel ecosystems and resilience can contribute to the sustainability of agricultural landscapes by fostering place-based relationships (between landowners and the restored farmlands) and ultimately improving the ecosystem services of those landscapes (Altieri, 1992; Fry, 2001). The Novel Agro-Ecosystems framework is proposed as a way to resolve the critical issues influencing agroecosystems as discussed above and instigate a transition to a multifunctional approach for agricultural policy in Ontario. The following table categorizes the crucial themes in terms of specific concerns illustrating the overlapping feedbacks between agricultural decline and current approaches to ecosystem management.

TABLE 1-5. MERGING OF CRUCIAL THEMES PERTAINING TO AGRICULTURAL DECLINE IN CANADA AND CASE STUDY AREA WITH ASSOCIATED PROGRAM OBJECTIVES

Themes	Specific Concerns	Sources	Novel Ecosystem Program Components
Transformation of the biophysical environment	Landscape/ habitat fragmentation	Suding and Gross (2006), Suding and Hobbs (2009)	Functional and response diversity
	Influx of invasive species, loss of functional groups	Moonen and Barberi (2008)	Regional native biodiversity and regional landscape connections
	Landscape constraints on conservation areas	Brussaard et al. (2007), Halpern and Floeter, (2008), Di Falco et al., (2010)	Natural and cultural heritage links (sense of place)
Feedbacks between ecological decline and the human environment	Internationalization of agricultural systems	Skogstad (2009)	Capacities for education and regional marketing (niche market labelling and local distinctiveness)
	Loss of ecosystem services (loss of biodiversity)	Altieri (1992); Elmqvist et al. (2003); Millennium Ecosystem Assessment (2005);Pretty (2008)	Ecosystem service delivery
Livelihood	Constraints on	Francis (2004);	Improved incentive

insufficiency	livelihood viability	Howitt et al., (2009)	structures (stimulus packages vs. entrenched aid structures)
	Farm consolidation	Pond (2009)	Civic agricultural infrastructure
Decline of intergenerational farming legacies	Rural depopulation	Lyson and Guptill (2004)	
Loss of viable agricultural land	Implications from urban sprawl and disjointed land-use planning history	Krueger (1978); Gayler (2004)	Fiscal transfers to maintain livelihood sufficiency outside of productivist status-quo; make farming viable

The concluding chapter, Chapter 6 provides an overview of the findings from each individual component of the research but the findings are synthesized to demonstrate how the findings interact. In addition, the final piece of the research is a demonstration of a recommended ecological triage approach for implementing the resolutions to these findings using research called Wild LifeLines ™ by Fields et al. (2010) and a spatially explicit asset inventory (sensu Harris) to create a the Novel Agro-ecosystem Agri-environmental Approach. The lesson outlined in the section is one that points to cross-scalar approaches to agricultural policy and particularly the programs that emerge from the policy at the federal scale. A set of criteria are outlined that will allow for critiquing new approaches which is concerned with maximum net gains (sensu Gibson et al. 2005) in agri-environmental policies and programs in Canada.

1.4 Rationale for a Novel Agro-Ecosystem Program

In order to address the social, political, cultural and economic challenges, a potential Novel Agro-Ecosystem Program as a response to current agri-industrial system failures is outlined and reviewed in terms of the capacity of program to address the gaps and inconsistencies listed above. In addition to the Novel Ecosystem Program design and review phase, a pilot case study investigated the biophysical, technical, economic and other social challenges (i.e. landowner participation) of implementing an ecosystem that is designed to support agroecosystem services and confront native species' population isolation issues facing the Niagara Region. Using the novel ecosystems concept as a framework, this dissertation will answer the following questions:

TABLE 1-6. OUTLINE OF THE RESEARCH QUESTIONS AND ASSOCIATED METHODS EMPLOYED

Research Question(s)	Title of Paper	Methods	Chapter
How should support for agriculture be altered to more effectively improve Canadian agricultural viability in both national and international settings? Have the shifts experienced in the policy-making setting reinforced the separation of agriculture and its environs as is likely? If so, how can this be resolved?	Changes in Canadian Agricultural Policy & Implications for - Agroecological Viability	Literature review, document analysis, and gap analysis	2

What bodies of literature can help shape changes at the policy-making and agricultural operation scales in Canadian agriculture? Can lessons from resilience be integrated with novel ecosystems to provide an intersection for transforming these contexts?	Transitions and Transformations: Developing the Theoretical Foundations for a Novel Agro-ecosystem Approach	Literature review, document analysis, creation of a suite of integrated criteria	3
What are the particular gaps apparent in program content that current agri-environmental models offered in Canada and other comparable industrialized agricultural settings (e.g. the European Union, and specifically the United Kingdom)?	Evaluating and Redeveloping Program Content for Agri-environmental Initiatives in Ontario	Literature review, document analysis and statement isolation, Q methodology	4
What are the challenges of trying to design/ implement the contents of an agri-environmental initiative in the Niagara Region?	Novel Ecosystem Design on Agricultural Lands: Assembling Functionally beneficial Native Wetland Species in two Irrigation Ponds in the Niagara Region	Baseline studies, combinatorial design planting, repeated measures ANOVA	5
What would a working solution to these challenges and gaps identified above look like?	Synthesis of the Findings: Framework for Novel Agroecosystem Implementation	Synthesis of criteria from suite of findings and interface design	6

1.4.1 Methodology

The approach taken for this research was a single subject exploratory case study (sensu Yin, 2003). The research touches on issues in Canadian agriculture at the broadest level only where generalizations about the topics of discussion are relevant. The main focus at the meso-scale is the issues of concern in Ontario, particularly because of the provincial land-use management changes (discussed above) pertaining to the Ontario Greenbelt. Finally, the particular locale for the case study is the Niagara region in the "Specialty Crop Area" because it is an area that has thoroughly confronted agri-environmentalism in terms of agricultural land protection measures. The lessons learned from this case study are meant to be applied, transferred and generalized more broadly to other areas confronted with managing the interaction between urban and suburban growth, natural heritage and cultural heritage and food production. The case studies methodology was an appropriate because the research focuses on the contextual conditions surrounding the object/subjects of interest because they are pertinent to the phenomenon (Yin, 2003). The entire case study is composed as a manuscript centred on four publishable learned journal-type manuscripts with a concluding chapter that integrates the overall purposes and research agenda into a conceptual whole[3].

This thesis provides evidence that novel ecosystems (as a concept) provide an opportunity to integrate ecological, cultural and socioeconomic objectives into an agricultural program. This approach is designed to deliver mutual gains to local farmers, conservation and protected areas and local rural communities and instigate a transition to a multifunctional paradigm for agricultural policy in Ontario. In order to answer these questions, this dissertation is constructed using four main chapters that address the integral facets of developing and incorporating a Novel Ecosystem Program into agri-environmental programming.

[3] This information is gathered from the Department of Environment and Resource Studies Doctoral Dissertation website http://www.environment.uwaterloo.ca/ers/grad/PhDinSocialandEcologicalSustainabiltityDissertation.htm

2 Changes in Canadian Agricultural Policy & Implications for Agroecological Viability

2.1 Introduction to the Issues

This chapter is an exploration how market and technological forces have driven agricultural policies in Canada. Of particular concern is how the resultant policy has shaped the interactions between agriculture and ecosystems. Especially, how should support for agriculture be altered to more effectively improve Canadian agricultural viability in both national and international settings? This chapter investigates the case for a shift in government policy in support of agriculture. It appears that current government policy respects and serves dominant market and technological forces – favouring concentration of agri-business in fewer and larger operations (Lyson and Guptill, 2004), encouraging adoption of more invasive technologies (e.g. genetic engineering), combining trade liberalization abroad with protectionism at home, and providing farm support mostly limited to disaster mitigation (Schmitz, 2008). The alternative, for broader sustainability purposes, would instead emphasize correction of the deficiencies of the market/technology approach, especially with respect to the social and biophysical externalities. Thus the alternative would be focused on maintaining farm communities, ensuring enough local production volume and diversity to preserve long term regional and national food security, protecting and rehabilitating rural ecosystems and ecosystem services.

In this chapter I make three main arguments. First, market and technological forces have been the main underlying drivers (that government policies have attempted to guide, encourage and in some ways mitigate) of agriculture in Canada. Second, these forces have significant social and ecological effects, some of which are highly adverse at least in the long term and are treated as externalities (effects that economic players have a vested interest in denying and/or imposing on someone else), and third, the resulting trajectory is not sustainable. The goal here is to identify the essential characteristics of the alternative package; part of it is the need to address ecological imperatives in ways that also support social and economic objectives.

2.2 Examination of the Market and Technological Forces that Drive Agriculture and Influence Agroecological Viability

The agricultural sector in Canada and abroad is shaped largely by market forces and evolving technologies. For operators to remain competitive, new more efficient technologies must be adopted in order to keep up with emerging low cost producers, the changing demands of the market and fluctuations in market prices. There have been ecological implications resulting from the Canadian agricultural sector trying to remain competitive in the face of decreasing profit margins and technological innovations that make products cheaper to produce and more readily available domestically and internationally (Jensen and Morand, 2011). These forces, changing market structures, global trade agreements and technological innovations are driving agricultural policy.

In order to adapt to these changing demands agriculture in Canada has experienced structural changes that in many instances have had negative consequences for the environment (Jensen and Morand, 2011). Some of the negative externalities associated with the evolution of agriculture in Canada listed by Jensen and Morand (2011) include:

- consolidation of land and greater specialization of commodities as well as increased intensity of production in order to capture economies of scale (e.g. 36% increase in the number of hogs between 1996 and 2006 and during those same years there was a 45% decrease in the number of farms reporting hogs)
- specialization has also had implications for the types of crops grown (e.g. decreases in the diversity of rotations of crops with more reliance on corn, soybeans, canola and peas)
- adoption of production methods aimed at enhancing competitiveness (more reliance on precision farming for example which also requires a greater reliance on new technologies); and,
- changes in the intensity of land use and management practices (e.g. increasing the use of synthetic inputs such as nitrogen fertilizer).

The market forces that shape agricultural policy are complex and stretch across international borders. Jensen and Morand (2011) argue that the global population increases have increased demands for the quantity and variety of food. Canada's small population, large land-base and access to water have allowed the Canadian agricultural sector to exploit opportunities for agricultural exports. The result in many instances has been for policymakers to encourage competitiveness through an evolving research agenda (i.e. moving from stabilization towards business risk management), marketing efforts and an attempt to insulate their domestic markets from competition abroad. For instance, supply management programs are stabilization programs that increase prices for supply managed commodities by controlling the quantity of a product entering a market; production is controlled through production quotas that raise and stabilize prices to producers (Schmitz, 2008). In the 1960s depressed economic conditions for the agricultural sector created an impetus for national supply management programs for dairy, poultry and eggs (e.g. chronic overproduction and low prices resulted in provincial chicken marketing boards to form a national associated known as the Canadian Broiler Council). The National Farm Marketing Act (NFMA) (passed in 1974) has allowed different agricultural sectors to set up marketing agencies. Supply management functions via import quotas and domestic production controls (including pricing that takes into consideration cost of production and allocations) (Schmitz, 2008). The program relies on custom tariffs that are regulated to manage the amount of foreign products entering Canadian markets.

2.3 Social and Ecological Consequences of the Market and Technological Forces Driving Agricultural Policymaking in Canada and Abroad

While the function of agriculture is still production of food or fibre, agricultural production oriented towards sustainability requires treating agriculture as an ecosystem (i.e.

"agroecosystems") (Altieri, 1992). Ultimately this requires investigating the influences that production activities have on the surrounding natural landscapes. In short, policy makers should not lose track of the importance of production and productivity of crops and yet they should not simply gear the entire agroecosystem to one goal lest long term sustainability suffer. This lesson is best illustrated by Jevon's Paradox and the Agricultural Treadmill.

2.3.1 Jevon's Paradox and The Agricultural Treadmill

Jevon's (1865) paradox, originally applied to coal production and use, argues that an increase in efficiency in using a resource in terms of improved output/input ratios ultimately will lead to an increased use of that resource as opposed to a reduction in usage (Giampietro, 2004). Jevon's paradox has been particularly salient in addressing industrial era agricultural trends. Giampietro (2004), for instance, argues that doubling the efficiency of food production per hectare over the last 50 years during the Green Revolution was meant to alleviate hunger but actually became one of the leading in population increases because it increased the number of people requiring food and the absolute number of malnourished. In effect, a promotion of efficiency at the microlevel (economic agents) tends to increase consumption at the macrolevel of a whole society (Herrings, 1999 in Giampietro, 2004).

Developments in agricultural efficiency, have, therefore, exhibited cyclical patterns of increasing mechanization and technological development that have created an impetus for farmers to purchase and use more new technology in their operations (Potter, 1998) in general conditions of economic growth. Farmers who do not adopt the new technologies risk being squeezed out because new technologies are typically designed to reduce costs per unit of production (if the scale of production is great enough). In 1958 Willard Cochrane, an agricultural economist (the Chief Economist in the US Department of Agriculture during the Kennedy administration) termed this pattern "the agricultural treadmill" in order to explain the processes of agrarian development. The agricultural treadmill functions via a cycle of stages of technology adoption characterized by early net windfall returns, production increases, commodity diffusion, price declines and eventually, an overall reduction in the financial benefits of the new technique (Ward, 1993). The few early adopters are commonly larger agricultural operations with the equity to invest in new technologies. These tend to benefit from the increased returns at the inception of the technological implementation (Potter, 1998). From a pure technology standpoint the agricultural treadmill has historically had positive connotations with the key indicator for success manifested in lower costs to consumers (Röling, 2009). It is viewed as the manifestation of successful and efficient technologies. However, this perspective fails to recognize that new technologies are capable of eliminating whole farm sectors in some regions. In reality, the diffusion of technology drives the price paid for commodities down and the farmers who adopt the technologies late do so when the prices paid for commodities have already declined (Röling, 2009).

Production-oriented agricultural development has tended to encourage simplification (diversity in farm characteristics was considered "backward"), technological development, and agricultural production based on mechanization (e.g. in the 1950s tractor numbers were rapidly growing) (Ward, 1993). Government policies have often encouraged development and adoption of new technologies that improve productivity (in the sense of lower costs per unit of production) but also favour larger scale agricultural operations (Skogstad, 2009). In other words the government subsidies (and other policy initiatives) have not introduced a new driver of agricultural change so much as they have acted to strengthen an existing driver. This has had consequences on the interaction of agriculture and ecosystems. Particularly, the simplification of agricultural landscapes (technology has tended to favour larger, simpler landscape configurations) and increased synthetic chemical inputs in terms of pesticide use and fertilization have become characteristic of modern agriculture. In the North American Midwest (i.e. the "prairie" provinces and states) agricultural landscapes are evidence of this approach where landscape simplification, crop intensification, and mechanization has created and exacerbated ecological degradation with far-reaching unintended consequences. For instance, DeVore (2002) examined southwest Minnesota where over-reliance on a two-crop (corn and soybean) system displaced a diverse system that also included wheat, oats, barley, rye, alfalfa and pasture. For DeVore (2002), part of the problem is the pace at which this occurred, i.e. a few decades; this means cultural disruption followed agroecological disruption. Wider still, this change reflects the landscape simplification, a leaking nutrient cycle and increased synthetic fertilizer inputs affecting the Mississippi collection basin. The ultimate impact is hypoxia that has dramatically reduced fishing catches (shrimping in particular) in the outlet of the Mississippi in the Gulf of Mexico (DeVore, 2002). The agricultural pollution of water systems is not unique to North America. Nitrate pollution of groundwater, for instance, has been a major concern for Europeans (especially in Germany and France) as evidenced by the emergence and takeover of the political agenda in the mid-1980s when public health implications became visible to the public (Potter, 1998).

By the 1980s the environmental and social consequences of the interactions between price-support policies and modernization had begun to emerge. As a result, new approaches were based on the assertion that processes that affect agriculture and the agro-food sector as a whole are broader than simply the pattern of adoption of new agricultural technologies; the era has been termed "post-productivist" by some (Ward, 1993). Wilson (2001) argues that a "post-productivist" mind-set is not so much a shift in policy-making, but the recognition that previous models of agricultural decision-making had created a series of social, cultural and environmental problems. In addition to the changing policy outlooks, greater social consciousness over food quality and the environment (including the costs of agricultural practices in terms of chemical pollutants, decreasing water quality, residues in food, habitat fragmentation and valued rural landscape features, in addition to animal welfare implications of intensive livestock practices) generated more impetus for a strengthened environmental regulatory arena (Ward, 1993).

However, it is questionable whether there is really any sign of these factors influencing Canadian government behaviour in agriculture support policy making at this juncture.

2.3.2 Managing trade distorting domestic agricultural policies in the international context

Many of the pressures to move away from state assistance models resulted from the Organization for Economic Co-operation and Development (OECD) and the World Trade Organization Agreement on Agriculture. The concept of decoupling emerged from a 1987 commitment by OECD member states to reform their agricultural policy to increase market orientation (Skogstad, 2009). Decoupling refers to separating farm income support from decisions pertaining to production i.e. supply management programs in Canada that limit foreign agricultural commodities from entering the Canadian market. The traditional state assistance model of payments (payments that support commodity prices, production or production factors, see Skogstad, 2009) is replaced by a model that no longer encourages farmers to increase production (i.e. payments are not based on the units of a commodity produced or a requirement to produce). The justification by OECD for decoupling agriculture from government support through new policies is that agriculture delivers other services to the public outside of the volume of commodity production such as the delivery of ecosystem services (provisioning, regulating and cultural services sensu MEA, 2005). Although the OECD has made this argument the organization has been predominantly driven by commitment to economic rationality through market discipline; the theory being that the delivery of greater wealth offers a better capacity to invest in the repair of ecological damage. Government intervention through agricultural policy is necessary because it plays a significant role in managing ecological systems and natural resources at domestic and international scales (Moon, 2011). The WTO is concerned with levelling the trade playing field by ensuring that nations are not unfairly advantaged by their domestic policies in terms of protection and taxation.

The call to begin removing safety net programs to manage trade distortion has challenged the dominant agricultural policy agenda that had been operating in Canada since the early 1920s. In 1922 the Crow's Nest freight rates[4] were reinstated by the Progressive Conservatives. Around the same time farmers began exercising their lobbying power by mobilizing their interests to manage their "competitive inferiority" via farmers parties (Skogstad, 2009). Farmers recognized that the federal government possessed legal authority over interprovincial and export marketing giving it more advantageous position for marketing and trade than the provinces or farmers on an individual basis (Skogstad, 2009). The Canadian Wheat Board was developed shortly thereafter (1919-21) as a temporary agency; but in 1943 it gained monopoly status as a "single-desk seller" in order to meet the grain requirements of allies during the Second World War (Skogstad, 2009). Until recently, the CWB had been western Canada's exclusive exporter of wheat and barley. It is a producer-marketing board that is backed by the federal government classified under the General Agreement on Tariffs and Trade as a "state trading enterprise" (STE). As from the

[4] The Crow's Nest Freight rate was a rail transportation subsidy imposed on the Canadian Pacific Railway by the Canadian government, benefiting farmers on the Canadian Prairies and manufacturers in central Canada.

single-desk seller status the CWB has two other components: price pooling and a "government guarantee of the initial payment to producers" (Rude, 2006). It is this last component of the CWB which made it vulnerable to the new regulations on export subsidies imposed by the WTO; the government cannot guarantee the borrowing of the CWB nor can it guarantee the initial payment. The federal government was also pressured to end the single-desk seller status of the CWB by producers who feel the market-liberal model would be more lucrative for their operations. Additional complaints surrounded the fact that Ontario grain farmers were able to sell their grain without the restrictions imposed on western grain farmers. In November of 2011 a vote in the House of Commons officially ended the CWB's monopoly. This event was significant in challenging the status quo agricultural policy agenda in Canada known as "agricultural protectionism" (Potter, 1998). There are four broad reasons that have made agricultural protectionism so prolific in the policy agenda in Canada and in most of the western developed world (Moon, 2011):

1. countries try to maintain what is considered a socially acceptable level of domestic agricultural production; preservation of the "culture of a place" and domestic food producing capacity as a kind of national insurance in an unsettled world;
2. because agricultural supply is generally fixed and prices are prone to sharp declines farmers bear the brunt of "asset fixity"
3. to promote and maintain the multifunctional roles of agriculture (e.g. production of commodities in conjunction with ecological, social and cultural benefits)
4. to respond to "rent-seeking" behaviours of influential interest groups concerned with agricultural politics (e.g. farm organizations, politicians, bureaucrats) (Moon, 2011).

The first three factors that shape agricultural protection are legitimate concerns about the livelihood of the farming community, notions of sovereignty and cultural identity as well as the environmental health of nation-states. The fourth factor, however, is what Moon (2011) calls "an illicit" component that has disproportionately shaped the political agendas on agriculture in developed countries and has resulted in the growth of farm production beyond economic reasoning—to the detriment of environmental and social systems.

The disintegration of the CWB is just one instance of a defeat of agricultural protection by the forces of trade liberalization. The "rent-seeking" behaviour that has emerged out of Canadian agricultural safety net programs has resulted in promoting productivity levels of agricultural systems to the point of overproduction which has had environmental, economic, social, and ecological consequences. Canadian producers are considered to be highly competitive in most commodities and have supported most measures to reduce trade distortion. The elimination of many government support programs for agriculture, such as the grain transportation subsidies, has meant that from 2001 to 2006, the Producer Support Estimate for Canada was about 25%, which was lower than in previous decades (Jensen and Morand, 2011). Other efforts have included decoupling farm income safety nets from specific commodity production.

2.3.3 Alternatives to safety-net policies: market liberalization and multifunctionalism

Although the big pressure has been for trade liberalization with minimization of both tariffs and non-tariff barriers to trade, the EU in particular, and to a lesser degree North America, have aligned themselves with multifunctionalism. Multifunctionalism allows for the persistent commitment to barriers in their domestic markets while continuing the general push for liberalization. In addition the historic propensity of governments of industrial nations has been to intervene with price-support policies so unstable producers could avoid losing their land and resources (Potter, 1998). The agendas of the Uruguay (1986-1994) and Doha (2001-2011) world trade negotiation rounds were shaped by concerns over managing the trade distortions that result from agriculture protectionism (Moon, 2011). The outcome of the rounds was the World Trade Organization's creation of the Agreement on Agriculture (AoA) which officially recognized that agriculture is "multifunctional" and accordingly recognized that the production of nonmarket goods and services is an important component of agriculture with varying degrees of connectivity to market commodities. As a result, the WTO created a system that categorizes agricultural policies and subsidies based on the degree to which they distort trade and whether they support the multifunctional roles of agriculture (Moon, 2011). The complete elimination of subsidies towards the goal of absolute trade liberalization is neither feasible nor desirable. Market liberalism as a governing philosophy came to the fore in the late 1970s (Coleman, 1998). The push for liberalism in trade was an entrenched ideology in the General Agreement on Tariffs and Trade (GATT) beginning as part of the Dillon Round (1960-1962). Coleman (1998) argues that market liberalism in agriculture came later and most of the pressure for changes in policy in terms of "fiscal restraint and international trade negotiations" was instigated domestically during the Uruguay Round. The market liberal vision for agriculture opposes the protectionistic notion of shielding the sector in order to improve productivity and efficiency. Instead, market allocation should take "precedence over state intervention: producers should draw their income from producing goods in light of expected supply and demand and selling them in competitive markets" (Coleman, 1998). Moon (2011) argues that government intervention is required to manage the implications from agricultural production on both domestic fronts in terms of ecological goods and services and international fronts, in terms of challenges associated with sustainability, food security and climate change. However, changing the Canadian domestic agricultural policy agenda to address the consequences of the production-logic of the last century is important and requires changing to a model of subsidization that is concerned chiefly with nonmarket amenity production. If applied everywhere, it would avoid distorting trade by directly funding the production of commodities and would provide producers a supplemental form of income that could be used in the case of market fluctuations, crop-loss, and other risks associated with farming.

2.3.4 The state of Canadian agricultural policy

Skogstad (2008) argues that Canadian agriculture has not yet experienced a fundamental change in agricultural policy approaches and therefore remains within a "state-assistance" (Skogstad, 2008) or "dependent" agriculture (Josling, 2002) policy paradigm. Safety net programs in Canada are designed to aid those farmers who produce and face significant financial risk;

therefore, the large and very large specialized farms are the main beneficiaries of safety net policies (Culver et al. 2001). According to Lyson and Guptill (2004) government subsidies have further dichotomized production operations because large commodity producers focused on efficiency and production outputs have been strengthened by government funding to the disadvantage of the small locally based operators. Alternative policies, therefore, need to be developed that target the unique needs of small and medium-sized farms. There is also pressure to extend agricultural support beyond the traditional safety net funding to provide income protection to producers against risks or costs associated with the relatively new consumer concerns for the environment, water and food safety (Culver et al. 2001). Since the 1970s, the average Canadian farm-size has been increasing as a result of specialization and amalgamation as farmers capture economies of size and scale; farm production is increasingly concentrated on large and very large farms (Culver et al. 2001). The on-going threats to Canadian farmers, particularly small operators, has stemmed from financial difficulties, intensified declines in farm numbers and the movement towards capital and energy intensive agriculture.

Walton (2003) argues that many of the issues associated with Canadian agriculture are the result of a "federal policy vacuum". By this Walton means that the federal government lacks a clear stance on just how important agriculture is to the Canadian economy. Additionally, she argues that Canadians are accustomed to some of the most inexpensive food in the world but the burden of this "cheap food policy" is, for the most part passed on to the producers, especially the smaller ones. According to Walton (2003) what is required is a way to expand the benefits and cut the risks for all players in order to allow the agricultural sector and Canadian society to take advantage of the benefits of production and consumption within a framework that supports safe food and healthy agro-ecological and agro-community interactions. However, agricultural conservation initiatives in Canada has tended to reflect federal policy-makers' preference for low agri-environmental standards (Monpetit, 2002). Canadian agricultural policy and policy making are especially complex because responsibility is divided between both the federal and provincial governments; this shared jurisdiction gives the provinces some power to create their own programs and regulations. The power that provincial governments possess has made federal policy-makers in Canada averse to command and control regulations (Monpetit, 2002). A major detriment to the success of agri-environmental programs in Canada is the limited use of financial incentives to increase program enrolment. In contrast to the US and Europe, Canada has rarely used financial incentives as a mechanism for agri-environmental initiatives (Monpetit, 2002). Instead, conservation that targets agricultural land in Canada has commonly been treated as a research problem; resolutions can be reached by gathering and applying scientific knowledge (Antsey, 1986 in Monpetit, 2002).

Farm income safety nets, however, are still a major facet of Canadian programs. In some cases they have shifted from commodity price stabilization to programs that stabilize the income of whole farm-units (Skogstad, 2009) – but this does not link financial support to long-term agroecosystem resilience. Structurally, agricultural policy has not changed because of the strength of the idea that governments are obliged to intervene in the agricultural market to serve public policy goals especially pertaining to higher and more stable farm incomes (Skogstad, 2008). This is in contrast to the market-liberal model or the multifunctional paradigm into which the EU has moved. Although market-liberal models have been promoted by politicians in Canada, they have not been adopted. Market-liberalism has not been an option in Canada that is economically or politically feasible according to Skogstad (2009). A majority of the producers in Canada persist in a cycle of financial insecurity so abandoning state transfers to raise and stabilize farm incomes is politically and economically perilous. Additionally, Skogstad argues that agriculture will always remain an exception to economic models because farmers will always face uncontrollable risks (e.g. pests, disease, climate, weather). A more realistic focus than the market-liberal model is to support farm incomes while also supporting the provision of biodiversity protection and other ecosystem goods (Skogstad, 2009). However, the commitment to this type of approach at the federal level in Canada is questionable with new reports of the intent to take on dairy supply management as a market liberalization initiative (see for instance the case of the Chobani Greek yogurt, an American company that was given a temporary permit to import yogurt to Canada outside the supply-management trade barriers). In the multifunctional shift experienced by the EU governments financial transfers are conditional based on the demonstration of agricultural practices that support safe food, biodiversity and environmental protection, and maintaining populated rural areas.

2.4 The Current Trajectory of Driving Forces and Policy Responses are not Sustainable

Overall, there have been damaging implications for the social, economic and cultural viability of rural communities in Canada. The favouring of fewer and larger producers has eroded the viability of the multi-product family farm, leading to rural depopulation and reducing long term regional food security as well as community well-being. These issues have been investigated in other studies, see for instance Krueger, 1978; Lapping and FitzSimons, 1982; Lyson and Guptil, 2004; Skogstad, 2009. The integral lesson, however, in terms of agricultural-ecological interactions to be learned from post WWII era agricultural history is this: technological change and market forces complemented by Canadian agricultural policy have directed agriculture in Canada into highly specialized and highly simplified (in terms of biological and spatial complexity of landscapes) farming systems that are inherently vulnerable to perturbations. Venema (2005) argues that the drought of the Great Depression is evidence of mal-adaptation in Canadian Prairie agriculture. The drought affected 7.3 million acres of farmland and caused a mass exodus away from farming communities that were suffering from the consequences of the drought. The response to this crisis was largely driven by institutional changes including the formation of Prairie Farm Rehabilitation Administration (PFRA) and the Canadian Wheat Board (CWB). However, comprehensive changes have not been made that indicate a more holistic, resilience-based approach to agriculture in this area, in fact there is significant evidence to the contrary. Bradshaw et al. (2004) demonstrated that since 1994 farms in the Canadian Prairies have become more specialized in crop production as opposed to more diverse; there is still a weak operating agenda at the policy-scale that demonstrates the understanding that maintaining healthy ecosystems leads to healthy agroecosystems and a more resilient milieu of farming. Additionally, a drought in 1988 resulted in agricultural export losses surpassing $4 billion CAD) and assistance payments (over $1.3 billion CAD to Manitoba alone); the Prairie Provinces saw net income losses of over 50 per cent in Manitoba and 78 per cent in Saskatchewan (Venema, 2005). Emergency payments (above and beyond regular assistance insurance programs) in 1991, a year of record high wheat production, exceeded $700 million (Sauchyn and Beaudoin, 1998 in Venema, 2005). What is revealed is the lack of resilience of the current system. Although the agricultural sector appears to be resilient because it is deeply entrenched (in terms of the structures of payment and operation) and has persisted for several decades, the current policymaking approach has encouraged reliance on pay-outs at the farmscale instead of redeveloping their policy agenda to foster resilience and sustainability such that operators would not be as reliant on relief payments to mitigate their losses. As a result at the federal and provincial scales, the government is destined to absorb the losses experienced by the operators.

Unlike American and European programs, conservation programs in Canada have never been utilized to support farm incomes (Monpetit, 2002). In fact, in most cases federal-policy makers excluded agricultural nutrients from the Canadian Environmental Protection Act (CEPA) revisions in 1999. The argument that followed this decision came from Environment Canada stating that their role was to research, operate and maintain environmental monitoring systems; rather than lawfully regulate agricultural pollution. Monpetit (2002) argues that aside from programs such as the National Program of Action for the Protection of the Marine Environment from Land-Based Activities, the Ecosystem Initiatives, and the Canadian Adaptation and Rural Development fund, the only other program, which actually looks at agricultural pollution is the Agri-Environmental Indicator Project. The capacity for a federal policy response to agri-environmentalism in terms of regulation is weakened by the jurisdiction that the provinces have over natural resources within the confines of provincial borders. Provinces often argue that they have Constitutional authority over these issues out of the fear that government intervention in resource-dependent sectors might prohibit certain provincial projects (e.g. resource extraction). Additionally, the provincial position may be closely related to the economic vulnerability of voting farmers, a large factor in why provincial environmental law tends not to apply heavily to agricultural operations and to be resisted heavily when it does. Federal agro-environmental regulation in Canada is difficult for these reasons. Arguably a more suitable approach would be to move away from regulation-based policies, which Lactaz-Lohmann and Hodge (2003) call first iteration agro-environmental approaches, towards a compensatory structure for agricultural improvements.

The agricultural practices employed are a reflection of the policy paradigm and is also reflected in the current research on farming practices, which still concentrates on reacting to environmental challenges mainly through coordinating practices with predictions regarding environmental changes. Moriondo et al. (2010) demonstrates that, research on agricultural management even in the face of large-scale irreversible environment changes still concentrates on narrow prescriptions like "crop-fitting", moving sowing dates or the use of longer cycle varieties, changing varieties, altering timing or location of cropping. These approaches taken towards sustaining agriculture indicate that a paradigmatic change has not occurred. Ward (1993) argues that structural constraints have shaped the perspectives possessed by farmers and as a result, have maintained the dominant approach wherein the "intensification of production through the application of science and technology has become a 'logic' of production at the farm level" and is characteristic of agricultural development in Canada.

2.5 Reasonable Alternative Approach for Multifunctional Programming in Canada

Canadian agricultural policy could benefit from the lessons learned by the European Union. The EU agricultural system and policies have become multifunctional (Skogstad, 2008). In practice, this allows governments to continue to support farm incomes. The main change has been a shift to a comprehensive policy that makes such support conditional on the demonstration of agricultural practices that support safe food, biodiversity and environmental protection, and maintaining populated rural areas.

Due to environmental and economic pressures in the 1980s the European Commission began to reshape and transition towards the implementation of an agri-environmental policy. The 1984 Halvergate Marshes case is one of the first documented approaches where farmers were paid a flat-rate (annual payment) under the proviso that they continue to farm at a low intensity. According to Latacz-Lohmann and Hodge (2003) it was a landmark agreement in European agri-environmental policy. A 1985 regulation (EC 797/85) permitted Member States to provide funding from their own resources for agri-environmental incentive schemes in environmentally sensitive areas (in Britain it was termed the Environmentally Sensitive Areas Scheme). The 1992 MacSharry Reforms (which accompanied the 1992 Agri-environmental regulation ECC 2087/92) altered the course of paid stewardship as a guiding principle in the European Union and transformed the Common Agricultural Policy (CAP). The regulation made it mandatory for all Member States to implement agri-environmental programs and elevated agri-environmental measures to the level (financially) of CAP's commodity programs by co-financing agri-environmental schemes between the member state and the EU. Although there have been difficulties in delivery of the program and initial issues related to provision of incentives, this has allowed for the improvement of incentive schemes that now constitute 'quasi-markets' for these public goods required and provided by agricultural landscapes (Latacz-Lohmann and Hodge, 2003).

In 2008 federal, provincial and territorial Ministers of Agriculture agreed to *Growing Forward,* an initiative which coordinates Federal/Provincial/Territorial agricultural policy until 2013. The main thrust of this new framework is risk management (Jensen and Morand, 2011). Although about $330 million more was invested in this framework than in the previous Agricultural Policy Framework the main component agri-environmentalism is the voluntary implementation of on-farm environmental risk assessments (Jensen and Morand, 2011). Additionally, the funding for this initiative is cost-shared between producers and a governing body which asks producers make a substantial investment.

Alternative policy approaches are, therefore, concerned with understanding the underlying causes of socio-ecological hardship, in this case, the interaction of price support and technological advancement, on agroecological processes. This allows for more complex and prescriptive approaches that avoid or mitigate further negative ecological impacts, encourage restorative activities and maintain productivity. Instead of reacting to undesirable changes in market structures, technological modifications or changes in demands, it is important to innovate and adapt while building and maintaining agro-ecological resilience. The following five aspects need to be included in an effective alternative for multifunctional programming in Canada.

2.5.1 Policy and cross-scalar resilience

Maintaining or strengthening the resilience of **desirable** systems or system components is one major aspect of a new approach to agricultural policymaking otherwise understood as general versus specific resilience (sensu Folke et al. 2010). The discussion above outlines what appears to be the evident resilience of conventional agricultural policies, associated institutions and habits of mind that entrench market and technology-led concentration at considerable cost to communities and ecosystems. However, it is important to note that those facets of the current policymaking context are evidence of the rigidity of the agricultural policy context in Canada and is not necessarily evidence of system resilience. A rigidity trap occurs in a socio-ecological system when management is narrowly focused and power and profit are mutually reinforcing (Carpenter and Brock, 2008). Based on Holling's adaptive cycle (see Holling, 2001) it is likely that the current Canadian agricultural system is locked-in the K phase or the conservation phase. While capital is accumulates in the foreloop and tends to conserve and stabilize and increase in the connectedness of relationships the capital can also become sequestered or locked-in and the system becomes more rigid but actually less resilient. Rigidity traps are characterized by highly-connected, self-reinforcing, inflexible institutions, and low potential for change but the potential for rapid and significant release (Gunderson and Holling, 2002 in Carpenter and Brock, 2008).

New policies that are grounded in resilience thinking can, in light of consolidation and globalization, both encourage local community development, and simultaneously tackle the need to navigate and adapt to those same market forces. Holling (2001) emphasized the notion of cross-scalar analysis and implementation within resilience building initiatives. Policies can indeed encourage more localism at the community scale and yet also grapple with the global scale markets. There are still strong tensions between these scales. Fostering resilience at smaller scales (e.g. the farm scale) can have implications for long term social, ecological and economic resilience at larger scale and is more manageable; just as destructive behaviour accumulates, positive contributions to resilience at small scales can accumulate as well (Folke et al. 2010). Socioeconomic viability, novelty, and innovation are good objectives to mediate between the conflicts between the current demands for sustainable avenues for food production in the face of rapidly and potentially drastically altered agroecosystems.

2.5.2 Ecosystem services

A new alternative agriculture policy should incorporate an agenda for landuse management that provides benefits to land owners with off-farm benefits as well. Commonly, in agri-environmentalism this is known as "paid stewardship" (Lactaz-Lohman and Hodge, 2003) and enhancing ecosystem functioning (Moonen and Barberi, 2010) in order to provide ecosystem services.

Agricultural production is directly linked to the services provided by ecological systems, e.g. the capacities to recycle water and nutrients, the ability to provide natural enemies of crop pests (Pretty, 2008). The ability for an agroecosystem to maintain or enhance the production of ecosystem services directly affects the economic viability of the agricultural operation (Altieri, 1992). Agricultural policymakers and operators who ignore the production services provided by native species assemblages are victim to higher production costs elsewhere, e.g. habitat fragmentation results in reduced capacity for pollination and an increase in pests (Altieri, 1992).

Enhancing the agricultural capacity to provide ecosystem services can improve ecosystem service delivery, e.g. the water filtration provided by wetland species, flood attenuation, water purification, nutrient cycling, habitat for pollinators, wind breaks. Policies that support ecosystem services can aid in mitigating the consequences resultant from the loss of functional groups and consequent response diversity because they reduce the ability of the system to self-organize after a disturbance and thereby disrupt the provision of ecosystem services (Deutsch et al. 2003). Enhancing the resilience of desirable ecosystems services can benefit social systems and have the potential to increase the productive capacity of the entire agroecosystem (Okey, 1996).

Prescribing agroecological solutions can be addressed by outlining the particular ecological services that are required for agricultural production based on the current land uses and practices. The following table provides an overview of the ecosystem services required/ threatened by current agricultural practices, which could be supported using agricultural programming with an on-going incentive structure. The table presents the three main types of ecological services of concern as reflected in the literature.

TABLE 2-1. EXAMPLES OF RELEVANT RESEARCH AND RECOMMENDED PRACTICES TO SUPPORT ECOSYSTEM SERVICES GENERALLY IN CANADIAN AGRICULTURE

Type	Ecosystem services	Authors	Findings	Recommended Practices

Agricultural Biodiversity	**Pollination**	Kremen et al., (2004)	Pollination services are significantly increased (spatially and temporally) with increased natural habitat size	Increasing natural habitats surrounding field crops will improve pollination services
		Vogler et al., (2009)	High temperatures and low wind-speed improve the capacity wind-dispersed corn pollination	Increased temperatures might support pollen dispersal but proximal land-use should be protective (incorporate variability of vegetation types) to improve pollen dispersal cycles
		Kwaiser & Hendrix (2008); Hendrix et al., (2010)	Bee communities in ruderal areas are significantly less diverse than in native tall grass prairies; ruderal areas can support small species of bees but not larger ones; bee diversity is significantly related to flowering forb diversity and is negatively affected by agricultural row crops	Increasing floral resources in habitats adjacent to field crops can increase species richness and size on agricultural lands
	Vegetation & Water recycling	Ryan et al., (2010)	Many agroecological systems are experiencing more extremes in climate variability and dry spells	Vegetated areas can be designed and implemented to enhance water recycling (water vapour recycling to the atmosphere) that will moderate water, wind and heat fluxes
	Pest Management & Pollination	Morandin et al., (2007); Simon et al., (2010) Zimmer et al., 2010	Integrating natural landscape mosaics (e.g. seasonal grazing and rest regimes) results in different native and perennial forb frequencies; intensive grazing without rest reduces native floristic diversity; increasing plant diversity within cultivated land areas aids in the control of pests by arthropods and birds	Native perennial forb frequency can be increased by incorporating periods of grazing and rest into management regimes; creating mosaics of land use is better for wild bees and pest management than homogeneous crop areas
Water Resources	**Water Quantity**	Rajala et al., (2009)	There are significant effects of water limitation and timing on the photosynthetic capacities of cereal grains	Synchronizing water and pollination improves photosynthesis and crop yield (measured in terms of grain filling)

		Gan (2000)	Prairie agriculture, for instance, is vulnerable to already observable increased temperatures and intensified dry spells	To manage water resources farmers can increase water storage through snow management, integrate existing water resource systems, promote water conservation measures
	Water Quality	Tiessen et al., (2010)	Conventional tillage methods can affect water quality through run-off events	Conservation tillage reduced the export of sediments in runoff water as well as reducing N during snowmelt
		Gordon et al., (2010)	Agriculture has substantially lowered water quality in the quest for increased production and yields	Water quality can be improved by addressing improving water management on farms and linking on-farm water to downstream impacts
Soil Conservation	**Conservation Tillage**	Lafond et al., (2006)	Soil degradation (as a result of wind and water erosion) can threaten food production, however, conservation tillage is an effective means for controlling this problem	A study spanning 12 years indicated that conservation tillage has demonstrated yield benefits over conventional tillage methods
	Soil Biodiversity	Fox and MacDonald (2003); Brussaard et al., (2007); Gianinazzi et al., (2010)	Soil biodiversity (i.e. microbes and mycorrhizae) confers protection against soil borne disease, decomposition of crop residue, detoxification of chemicals, nutrient and water use efficiency	Cropping system design and management should integrate principles of soil biodiversity such as: no-till to allow for mycorrhizae and microbial growth or inoculation of microbes or mycorrhizae
	Sequestering Carbon	Follett & Reed (2010)	Grazing lands can be managed to maximize the potential for soil organic carbon (SOC) sequestration	Rates of SOC sequestration are influenced by soil and management regimes employed; contribute to soil and water resources, air quality and human and wildlife habitat

2.5.3 Innovation and novelty

Modern agricultural systems have become reliant on synthetic inputs such as artificial fertilizers, concentrates, seeds and pesticides that are applied the land (Van Apeldoorn et al. 2011). The continuous disturbance by farm management prevents the system from developing a structure of internal recycling (i.e. diminishes the ecosystem delivery capacity of the system). Short-term coping responses are characteristic of unstable non-resilient socioecological systems.

The approach of 'novel ecosystems', is a particularly innovative and salient approach for integrating the above mentioned program components. Hobbs et al. (2009) argue that a novel ecosystem is one in which the species composition and/or function have been completely altered from the historic system. In brief, the relevance of the novel ecosystems approach is to assist in characterizing the suite of probable and desirable ecosystem states and functions and the various paths that lead to their development. For example, with agricultural systems, one can examine the very fact that most such systems are 'novel' (modified ecosystems for food production) and how newer ones will form under various scenarios of management incentives and biophysical interventions and anthropogenic climate change (Richardson et al., 2010). Strengthening the relationship between novel ecosystems and resilience can contribute to the sustainability of agricultural landscapes by fostering both place-based relationships (between landowners and the restored farmlands) and ultimately improve the ecosystem services of those landscapes (Altieri, 1992; Fry, 2001). What is required is an effective structure for funding this type of initiative—most probably in the form of incentives similar to the EU context.

2.5.4 Incentives

Agriculture and Agri-Food Canada's role is to provide research and information to operators and the agricultural sector in general while also reforming trade policy and fulfilling Canada's international agricultural commitments (Jensen and Morand, 2011). To provide producers with an incentive to meet environmental goals and standards, some countries have made eligibility for farm program support contingent on environmental compliance – a practice known as cross-compliance. As opposed to the approach taken in other countries where eligibility for incentives is contingent on cross-compliance, Canada's focus still consists of voluntary measures and modest incentives (Jensen and Morand, 2011).

Financial incentives are important for agricultural viability, 1) because the structure of subsidies has made landowners reliant on them. To encourage landowner engagement in agroecosystem health and farm-resilience approaches it is important to consider that the financial structure of agriculture in Canada historically has been significantly influenced by federal and provincial aid packages and has both created and maintained the entrenched cycles of recurrent crisis since the 1930s (Bessant, 2007). Therefore, financial stimulus incentives are often necessary to encourage participation in European style "agri-environmental schemes" (Wilson and Hart, 2001; Cao et al. 2009). 2) When farmers produce non-commodities with larger societal benefits, they should be paid for their efforts. This becomes a way of supporting farmers without dealing directly in commodity production and is therefore it is not "safety net oriented" where farmers are accustomed to only receiving payments when their yields are less than adequate. Agri-environmental support provides another avenue for generating revenue that is on-going and supported by the larger public perspective.

The literature offers little guidance on the design and funding of adequate incentive structures for ecosystem services on agricultural lands. As outlined above, some initiatives have been undertaken in Canada in this regard and additional examples can be obtained from the European agricultural context. The collection of papers on the European BioScene[5] project funded by the European Union 5th Framework Program provides the most recent and complete discussion pertaining to agroecological resilience by investigating the sustainability of alternative scenarios for improving biodiversity conservation on agricultural lands in Europe (see for instance Partidario et al. 2009).

2.5.5 Culture

The cultural aspect of agroecological systems requires linking conservation with economic viability in farming to protect and expand rural amenities, enrich rural opportunities, and maintain rural populations. An important focus for enriching local rural opportunities is related to championing local production and services called a 'value-added' approach by Francis (2004). Associated local production efforts include the processing of local resources into products that increase local employment and community investments (e.g. infrastructure), the branding and marketing of local products (e.g. agricultural or crafts) and services (e.g. hotels and restaurants), provision of start-up funding for small businesses in new 'niche' markets, and attraction of eco-tourism business to the area based on local landscapes and cultural heritage. All of these cultural aspects of rural communities should be incorporated into alternative policy approaches. In many cases rural community values are linked to the preservation of agroecosystems (Kaplan and Austin, 2004; Hochtl et al. 2007) and understanding values and representing them is central to development of locally-based model of landscape management (Glover et al. 2008). Place-based natural resource management, according to Cheng (2003) encourages diverse people to engage in a process of defining meanings and addressing landscape management issues that are bounded by a geographic place (e.g. watersheds, communities, forests, lakes).

Successful agro-environmental approaches are cognizant of the culture of agriculture (including sense of place) as well as the culture that surrounds agriculture e.g. tourism. According to Glover et al. (2008) people are connected to the landscapes in which they live. Agricultural landscapes are particularly emotionally charged because the landowner's identity and livelihood are both shaped by, and reliant upon, the landscapes in which they live (Atwell et al. 2009). In the process of landscape change, differing views emerge regarding what is valuable on the landscape and it is important to elicit these divergent views from the citizenry to understand what is important to them (Glover et al. 2008).

In rural landscapes in particular, protecting both natural and cultural resources may be supported by the local community. Hochtl et al. (2007) discovered that landscapes that are embedded in both culturally and ecologically significant landscapes require identification and support of the

[5] The project examined the implications of agricultural alterations and decline in respect to biodiversity conservation in the mountain regions in six European countries (France, Greece, Norway, Slovakia, Switzerland and the United Kingdom.)

synergies among politics, science, administrative agencies, local users and interest groups. Healey argues that because of the shared nature of spaces, place-based political communities can develop to address common concerns and define civic duties. This type of approach is important for rural landowners and rural communities to celebrate the uniqueness of place and the conservation values that are inherent in rural landscapes.

2.6 Conclusions

When reviewing agricultural policy history in Canada it becomes apparent that policy has served and been influenced by market and technological forces, which have shaped land-use management, determined what types of operations remain and encouraged landscape simplification and specialization. Largely the result has been the impoverishment of ecology by agriculture. The consequences of the division of agriculture from ecology are far-reaching; however, options exist for mutual reinforcement of positive aspects of agriculture via agri-environmental programming that is multifunctional in nature. Native ecosystems have been replaced in Canada as they have been dominated by humans over long periods of time; but agroecosystems are still reliant on ecological processes (Van Apeldoorn et al. 2011).

Overall, the absence of a true shift towards multifunctionalism in Canada has resulted in a weak agri-environmental agenda. There has been no perceptible shift in the state mindset towards agroecosystem-based decision-making. In a country that has relied on the government for direction via agricultural programs since the early 1900s (Skogstad, 2009) it is unlikely that a general shift in the mindset of agricultural operators will occur without a change in agenda at the federal level. The Canadian government needs to adopt a new approach to ensuring agricultural viability that is concerned with whole farm approaches to resilience to break out of the cycle of rigidity and poverty in which the agricultural setting currently resides. While a federal level shift may well be needed, it is unlikely to emerge prior to extensive demonstrated successes and demand from the farm level and successively larger scales which is explored in Chapter 3.

3 Transitions and Transformations: Developing the Conceptual Foundations for an Agro-ecosystem Approach to Land Management

3.1 Introduction

Agroecosystem approaches have the capacity to generate positive contributions at multiple scales. For instance, issues pertaining to the debate over localism and the viability of small communities (Altieri, 1992) can be linked to the larger issues of global trade and climate change. The trends in Canadian agriculture have been towards simplified landscape mosaics, increased off-farm production inputs, financial instability, a greater reliance on fossil fuels and machinery, and larger farms (due to land consolidation) (Giampietro et al. 1999). It has become increasingly unlikely that there will be any change in the trend towards consolidation as a response to the need to compete in a global market (Lyson and Guptill, 2004; Bessant 2007; Pretty, 2008; Thompson and Scoones, 2009). This means that creating programs, policies, and incentives that support production in the context of both larger farms and the greater ecosystems in which they are embedded is necessary.

The responses here to changes in social and environmental regimes have mostly relied on financial subsidies that are now being challenged by global trade agreements (Wilson and Hart, 2001; Carr et al. 2004; Bessant, 2007). This is partly a consequence of short-term outlooks; however, it is also due to the difficulty associated with gauging the influence of changing conditions that drive agriculture, which leads to uncertainty in the development of policies and programs that are appropriate. Generating policies that strengthen the relationship between policymakers and stakeholders also has the ability to generate positive contributions on privately owned landscapes that provide public amenities (i.e. services) are often overlooked in policymaking.

According to Van Apeldoorn et al. (2011), conventional agroecological management is controlled by socio-technical regimes rather than by the ecological context in which the agricultural operations are embedded. An important driving component of agroecological resilience is political and ideological coherence about what governance actions are necessary to implement multifunctional programming and particularly how *transformations* differ but are related to *transitions.*

The term "transformation" has two components, "Trans", which implies moving *beyond* something and "formation" which refers to the structure or arrangement of something. The term transformation thus, commonly refers to a physical change, or moving beyond, an arrangement, a structure, or an arrangement of structures. In this research, therefore, transformation occurs at the landscape scale because, as the described, the term refers generally to the practical or on-the-ground, physical changing/ addition/ alteration of physical structures. In this framework transformations refer specifically to the deliberate changes in ecological communities and landscape features via the creation of novel ecosystems and the way they are implemented. In contrast, transition as a noun, refers to a period of change, and/or the process of change. In this framework, transitions occur at the institutional scale for two reasons. First, because it is unlikely that a complete "transformation" of the political setting will occur, however, a process of change is possible in the focus of policy setting and the paradigms from which policy-making emerges. Secondly, because this research is concerned with the agricultural policy-setting context that has over time influenced the shape of agriculture. Van Apeldoorn et al. (2011) argues that in many modern agricultural systems the required transformations towards a multifunctionalism in agriculture should occur simultaneously at government level and the farm-scale governance level (refer to Chapter 1 for clarification).

The concern here is how effectively the literature surrounding novel ecosystems (more generally, transformations in ecosystem management) can interact with literature from sustainable transitions to create: 1) a set of principles to guide the creation/ management of novel ecosystems where appropriate, 2) a set of guidelines for creating/ managing novel ecosystems within agricultural landscapes within a new agri-environmental policy approach in Canada that recognizes the benefits these transformative states. The integration of these bodies of literature form the basis of set of criteria that recognizes the (in many cases) irreversible transformative aspects of environmental change termed "novel ecosystems". Building a conceptual framework for agri-environmentalism using novel ecosystems and sustainable transitions is a viable way to infuse agricultural policy reform with more explicit linkages to ecosystem functioning and services, *and* livelihood sufficiency for agricultural operators. The first part of this paper examines the theoretical constraints of sustainable transitions and the novel ecosystem concept. The second section is a synthesis of the concepts and examines how they can be combined to effectively contribute to agri-environmental programming that is founded on the novel ecosystem theory.

3.2 Sustainable Transitions and Governance

Social-ecological systems benefit from innovation and experimentation as a way of adapting to changing circumstances (Holling, 2001). The literature on Sustainable Transitions approaches have also been referred to as "transformations", "system innovation", "regime transformation", "industrial transformation", "technological transition", and "socio-economic paradigm shift" (Elzen and Wieczorerk, 2005). A system that is fundamental to the functioning of society that is altered is considered to have undergone a transition (Elzen and Wieczorek, 2005). A true transition is characterized by a coevolution in economic, cultural, technological, ecological and ecological facets of the system and subsystems (Rotmans and Loorbach, 2009).

Transition *management* is concerned with persistent complex problems. Complex problems are difficult to manage because they encompass a wide range of actors, are deeply embedded societal structures and have uncertain outcomes (Rotmans and Loorbach, 2009). Transition management developed out of complex (adaptive) system theories (sensu Rotmans and Loorbach, 2009) due to the overlapping focus between complex systems and state transitions in socioecological systems. Complex system theory examines the behaviour of complex systems throughout periods of equilibrium, order, and stability that are interrupted by periods of chaos and instability (Rotmans and Loorbach, 2009).

Complex adaptive systems are capable of coevolution, emergence and self-organization. Coevolution refers to the interdependencies between the complex system and its environment; the system "coevolves" with the environment. Emergence refers to the development of novel structures, patterns, properties, and processes during self-organization (Kay et al. 1999; Rotmans and Loorbach, 2009). Self-organization is the ability of a system to develop new system structures as a result of internal drivers (internal constitution) as opposed to external drivers/pressures on the system (Kay et al. 1999). The interrelationship of these components allows complex adaptive systems to continuously adapt to their environments during which the potential for variation and new opportunities is increased. Rotmans and Loorbach (2009) refer to this iterative development process during self-organization as "variation and selection". What this means is a system will continuously create variety (e.g. new components and relations—diversity) which is maintained by selection pressures (by preventing variation or pushing it in a particular direction). Within the context of the contemporary realm of environmental degradation and instability, managing complex adaptive systems means directing the process of state changes along sustainable trajectories.

Most transition literature has concentrated on socio-technological transitions, for instance the transition from the use of sailing boats to steamships. However, more recently, transitions are being examined in a holistic way to understand the dynamics behind social-ecological transitions with sustainability goals as the motivating factor. To make progress towards sustainable development objectives substantial changes of entrenched institutions are required which can be achieved through innovative transitions.

3.2.1 Selection pressures and agri-environmental policy design

Smith et al. (2005) argue that the contemporary policy challenge is to transition regimes to more sustainable configurations. A regime, in the transition literature refers to complex, nested phenomena that embody natural and artificial elements in conjunction with social, economic and cognitive attributes (Rip and Kemp, 1998 in Smith et al. 2005). The governance of regime alteration can be organized by addressing the form, intensity, articulation or direction of the selection pressures[6] that are pressuring the regime of interest (i.e. how resources are deployed or with-held). Regime changes may also address the quality and distribution of the capacity for coordinated responses and resource availability (in terms of finance, legitimacy or competence) to support these responses.

Common policy approaches seeking the promotion of sustainable configurations through modification of selection pressures include: environmental taxation, negotiated agreements and regulations. Other policy approaches that promote innovation (e.g. R & D, environmental

[6] The various pressures or demands that actors possessing agency use to maintain the incumbent regime, or conversely, actors desiring change can use to influence a shift in system states.

management systems, foresight and capital allowance grants) are more concerned with reconfiguring the adaptive capacities of regime members (Smith et al. 2005). Transition has great potential to tackle current problems in various domains of life because it is considered a policy objective. According to Elzen and Wieczorek (2005) there are two types of transition processes, radical and incremental. Commonly, transitions that occur are incremental. New technologies that are conceived and marketed to customers have little difficulty being established in regime domains because the technology is generally a variant of existing equipment. Therefore, the technology can be sold to customers will little instruction, training, and commonly, no large-scale disruptive changes in the supporting infrastructure. These technologies constitute a successive development strategy that is characterized by gradual technical changes with relatively little to no alteration of the technological trajectory. In contrast, radical transitions face obstacles to adoption because they require overhauls (or complete transformations) of production processes, regulations, preferences and fundamental infrastructure. In terms of agri-environmental/ sustainability objectives, the transitions that have prevailed are incremental innovations because they work within the constraints of the existing structure of governing bodies. Given these constraints, public authorities have a great responsibility to respond to the situation that has developed out of the agricultural policy protection history. Most agricultural operators are reliant upon the subsidies that are distributed from governmental organizations and as a result agri-environmental policy transitions need to work within the trajectory of compensatory mechanisms.

Public authorities play significant role in constraining or facilitating innovations via intentional or unintentional regulatory processes; protectionist policies have historically been the method of distribution used by Canada, the United States and the European Union. The agricultural policy framework that guided most industrialized countries in the post-Second World War period championed government intervention as essential for the viability of agricultural producers, consumers and society in general. State assistance was coupled with increasing competition in agriculture (Skogstad, 2009). Regulatory and expenditure capacities were deployed by governments across rich industrialized countries to intervene in agricultural markets rather than letting market forces stand alone to structure production (Skogstad, 2009). Governments gave producers collective marketing powers and they subsidized farm incomes all in the name of their protecting agricultural economies. Mass-production was championed during this period to feed the growing urban industrial workforce and ultimately resulted in *overproduction* in North America and the European community. Dealing with overproduction encouraged governing agencies to begin considered the consequences of this logic. Public authorities can support transitions by using the tools at their disposal (e.g. environmental standards pertaining to technologies and in terms of financial encouragement or discouragement of certain behaviours such as taxes or subsidies) (Elzen and Wieczorek, 2005). Governments therefore have the potential to play a duplicitous role: the prohibitive (or protectionist) and facilitative (or inventive). This can be accomplished by fostering knowledge transfer, encouraging collaborative relationships within the research and local communities and stimulating regulatory changes that alter the market for production.

Transition policy objectives need to modulate between the current regime dynamics and direct it toward desired endpoints (Elzen and Wieczorek, 2005). A successful modulated approach is the European Agri-environmental Policy (AEP) which is a multifunctional approach to agricultural policy. Multifunctionalism is described as the assertion that agriculture can produce various non-commodity outputs in addition to food (Wilson, 2001; OECD, 2001). Although there have been difficulties in terms of delivery of the program and initial issues related to provision of incentives, this has allowed for the improvement of incentive schemes that now constitute 'quasi-markets' for these public goods required and provided by agricultural landscapes (Latacz-Lohmann and Hodge, 2003). The modulated or phase-based approach to policy re-design allowed policymakers gradually implement facilitative approaches to ecologically sensible land management in order to deal with current and projected changes in the environment.

3.3 Ecosystem Management Theory and the Novel Ecosystem Concept

At the global scale, novelty is apparent in socioecological systems as disturbance regimes are changing with cascading consequences on vegetation dynamics; particular influences are apparent in respect to ecosystem functioning (Turner, 2010). New spatial patterns, novel trajectories of change, new disturbance regimes that will increase uncertainty and surprises are increasing (Turner, 2010) which ultimately affects the resilience of linked social and ecological systems. Several studies have examined the already perceptible cascading impacts from changing environmental conditions. For example, a study by Brandeis et al. (2009) in Puerto Rico and the U.S. Virgin Islands demonstrated that environmental factors have an overarching effect on forest species composition within specific climatic zones including climate, geologic, topographic conditions and broad geographic scales. Stralberg et al. (2009) further demonstrated that potential changes in climate will influence California terrestrial breeding bird populations; in particular, novel assemblages of bird communities are likely including transitions and alterations of patterns of species interactions. According to Christensen et al. (1996), in general, disturbances are important interruptions that affect ecosystem dynamics by providing opportunities to reset a successional trajectory. These disruptions can lead to mosaics and patterns of landscapes with ecosystems containing varying ages, habitat types and species; increased diversity. However, large scale environmental changes (e.g. climate change and the continued denuding of ecological landscapes by human actions) can influence the capacity for local landscapes to "reset" by decreasing biological diversity (Christensen et al. 1996) and reducing the production of ecosystem goods and services. Ecosystem goods and services sustain human production systems (e.g. the structures, functions and processes) and make it possible for societies to grow food, breathe clean air, and access water. The capacity for social-ecological systems to maintain or enhance the production of ecosystem services directly affects the economic viability of the societies dependent on those services (Aliteri, 1992).

3.3.1 Considerations for expanding the approaches to ecosystem management

In order to deal with the current and projected degrees of environmental change contemporary approaches to ecosystem management need to focus on the sustainability of ecosystem structures and processes that produce goods and services rather than the deliverables alone (Christensen et al. 1996). Landscape fragmentation (resulting from agricultural, urban and suburban expansion) reduces the size of habitats and diminishes the connectedness between habitats. The result of this fragmentation is increasing population isolation that also increases the risk of local extinction because decreased connectivity threatens the capacity of species migration between habitat patches (Christensen et al. 1996; Suding and Gross, 2006). Landscape dynamics are determined by the transport of propagules across landscapes that move into less modified areas (Hobbs et al. 2006) which can make protected areas vulnerable to species turnover. Accordingly, ecosystems need to be considered within a landscape context that incorporates mosaics of different land uses and ecosystems ranging from natural to intensively managed areas. Conservation of "natural" landscapes requires the incorporation of production (e.g. agricultural) landscapes into management strategies. Biodiversity and ecosystem functioning both have an *effect on* and are *affected by* surrounding landscapes and land management practices (Jacquemyn et al. 2003). Biodiversity provides resilience to production and conservation landscapes, and with proper management, could do so in a way that is mutually beneficial and reinforcing (Fischer et al. 2006). Policy approaches that consider adaptation as a strategy for managing ecosystems in the face of changing environmental conditions should be focused on ecosystem processes that sustain ecosystem service delivery (Vignola et al. 2009). Within this global context of changing environmental conditions it is imperative to develop and implement strategies to mitigate and correct (where possible) the implications of deleterious human-ecosystem interactions. This also requires the development of new approaches to ecosystem management that work within the confines of changing environmental conditions. Biggs et al. (2010) argue radical innovations (development and adoption of new combinations of processes for example) at the local scale can have cascading effects which lead to transformation at larger scales e.g. globally, and vice versa.

3.3.2 The state of the literature on novel ecosystems

Deliberate and inadvertent introduction of species from other regions has resulted in *novel ecosystems*[7] that are the result of the surpassing of biotic and abiotic thresholds. Chapin and Starfield (1997) first used term "novel ecosystem" to recognize the response of the boreal forest to current and anticipated climate change. In the literature the term "novel ecosystems" are used synonymously with *no-analog* ecosystems, and *emerging ecosystems*. Novel ecosystems are characterized by changes in biotic and/or abiotic thresholds. Biotic thresholds are created by dispersal barriers (that result in new combinations of functional groups) and abiotic thresholds, which result from altered abiotic conditions (e.g. soil erosion, climate change, changed hydrologic conditions) (Hobbs et al. 2006). These two types of thresholds interact to transform ecosystems into novel ecosystems.

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[7] When new compositions and abundances of species occur within a particular biome, combination, or specific location (Hobbs et al. 2009).

Fox (2007) reflects on recent work regarding no-analog ecosystems and reports that novel climate scenarios are considered to be a significant driver in the rate of ecosystem turnover and predicted novel compositions of species. Succinctly, changes in abiotic thresholds will determine biotic reorganization. Hobbs et al. (2009) point to a recent interest in literature surrounding the relevance of the idea of novel ecosystems. This is particularly attributed to new species combinations developing as a result of invasion by non-native species in conjunction with abiotic changes. For instance, Lindenmayer et al. (2008) examined the pathways by which novel ecosystems and found that the increasing occurrence of novel ecosystems will include both flora and (fauna) uncharacteristic of the site and region. Reaching a historical trajectory, therefore, may difficult or impossible in many restoration scenarios because many degraded systems have been altered so severely that a threshold(s) has been crossed (Hobbs et al. 2006). Hobbs (2009) argues that a novel ecosystem is one in which the species composition and/or function have been completely altered from the historic system. Therefore, removing the requirement to aim for achieving historic ecosystem trajectories increases the range of options available for management and could reduce financial resources and efforts to achieve valuable outcomes. This will require re-evaluating how we characterize 'valuable' ecosystems (Higgs, 2003) and may require an evolution in the cultural norms surrounding nature, conservation and restoration (Hobbs et al. 2009).

Attempting to restore degraded ecosystems to previous ecosystem states can be costly and often implausible (given the larger scale implications of environmental change on local or regional scales) so consideration of appropriate management goals and approaches is required (Hobbs et al. 2006). The unprecedented alterations of abiotic and biotic conditions have made relying on the use of historic ranges of variability ineffective within the realm of current and future projections of change in some systems. Historic range of variability refers to the reasonable long-term boundary of ecosystemic change (Higgs, 2003) and historic fidelity in respect to restoration refers to the extent to which restoration goals reflect the history of the place (Higgs, 2003). Historic ranges of variability in an operational context, is a useful approach if the record of historical conditions reflects the possible range of conditions for a given landscape in the future (Keane et al. 2009). Additionally, non-native species are often difficult to remove from ecosystems and in many instances have become integral parts of ecosystems (Hobbs et al. 2009) (by providing habitat ecosystem services in the place of absent native species). Discussions that consider novel ecosystems as unnatural systems (or indigenous versus introduced species) underline the dualisms of perspective that are characteristic of the ecosystem management literature. Attempting to discriminate between *what* species belong *where* are artefacts of social and cultural distinctions (Hobbs et al. 2009).

The contemporary discussions in the literature concerned with novel ecosystems focuses on four main themes:

1. *Abiotic and biotic thresholds*- a synergy exists between abiotic and biotic thresholds and as a result changes in abiotic conditions have the ability to impact biotic conditions and vice versa

2. *Historic trajectories*- because of changing abiotic and biotic regimes, it is difficult for ecosystem managers to use historic trajectories and reference conditions as management and monitoring objectives for current ecosystem states

3. *Ecosystem processes* (enhancement and preservation)- consideration of protecting and enhancing ecosystem processes will provide an iterative feedback between the goods and services required by human societies and the capacity of ecosystems to maintain production of those services by ensuring the sustenance of ecological processes

4. *Value conditions* (for ecosystem management)- social and cultural outlooks will influence the direction that management efforts take and therefore it is important to be cognizant of the fact that "natural", "wild" and "pristine" (as well as the antonyms of these states) are culturally iconic

The common denominator between these four themes is the concept of transformation. Successful ecosystem management within the confines of changing environmental conditions will require three kinds of transformations to successfully combat on-going declines: 1. Transformations of our cognitive acceptance of what is considered "natural" (this requires transitioning to outlooks beyond historic trajectories and historic fidelity); 2. Transformations of functional components of ecosystems (novel ecosystems can contribute to ecosystem processes *and* native species dispersal). The third transformation is a bridge between the first and second principles, 3. Decisions will have to made to determine if some novel ecosystems need to be understood outside the realm of past ecosystem management strategies because they represent a *transformative* ecological state (as opposed to alternate states (sensu Suding et al. 2004) and therefore, need to be interpreted and valued not in comparison to historic ideals, but as an completey transformed and therefore new system.

3.3.3 Transformations of ecosystem states

Chronic disturbances and large scale environmental change can constitute a complete transformation of ecosystem composition and states (as opposed to alternative states). Therefore, the quest for defining generalized rules about how biological communities are assembled from the regional pool of biodiversity and also what constrains community membership is made more difficult by the ongoing population fragmentation and is exacerbated by the introduction of exotic species (see Hobbs and Norton, 2004). Walker et al. (2004) define transformability as the "capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable". Ecosystem management of novel ecosystems are not operating in the realm of alternative states; Hobbs et al. (2006) argue that novel ecosystems represent the creation of an entirely new state. This is a result of the interaction of *both* biotic (dispersal barriers) and abiotic (result from severely changed abiotic conditions) factors. Human activities are the main drivers of altered ecosystem structures (e.g. forests and rangelands) and the transformation ecosystem processes (e.g. increased pest infestations, hot and extensive forest fires, changing vegetation ranges, increased invasion of plants) (Wilcox, 2010). According to Suding and Hobbs (2009) human impacts increases the complexity of management strategies. Crossing biophysical, economic and social thresholds can often result in irreversible changes regionally generated goods and services (Walker et al. 2009). The current conceptualizations of novel ecosystems in the literature are what could be considered "forced transformations".

3.3.4 Forced transformations—novel ecosystems version 1.0

Folke et al. (2010) argue that transformations at smaller scales are essential for novelty and innovation that can have cascading affects at other larger scales. The capacity to transform at smaller scales makes use of crises as windows of opportunity for novelty and innovation, and recombines sources of experience and knowledge to navigate social-ecological transitions. Sharp shifts in ecosystems that stand out of the blur of fluctuations around trends are called regime shifts and may have different causes (Folke et al. 2010) when they correspond to a shift between different stability domains they are referred to as critical transitions (Scheffer, 2009). Resilience offers many concepts, outlined above, for understanding the dynamism in social-ecological systems. However, the main limitation of the dynamical systems theory that forms the broader underlying resilience framework is that it does not easily account for the fact that the very nature of systems may change over time (Folke et al. 2010). As such, the concepts (response diversity, functional diversity and ecosystem services) are often constrained by models for ecosystem state shifts when in reality many systems have experienced ecosystem state transitions or transformations. Adaptability is a widely used concept in resilience that is based on the capacity of a social-ecological system to learn (including combining experience and knowledge i.e. social learning) adjust responses to changing external drivers and internal processes, and continue developing within the current stability domain or basin of attraction (Folke et al. 2010). One of the fundamental criteria for adaptability is the fact that the social-ecological system remains in the same basin of attraction. However, the rapid exchange and expansion of the range of species has in many instances, resulted in the construction of a new basin of attraction. In many instances, socially desirable adaptability strategies can increase the vulnerability of social-ecological systems and reinforce persistent undesirable states (i.e. poverty traps or rigidity traps). Folke et al. (2010) refer to these system alterations as "forced transformations" which are imposed transformations of a social-ecological system not introduced deliberately by the actors. In these cases, the social-ecological system needs to transform into a new stability landscape which has implications for deeply entrenched values and identities of the system constituents.

The approach of novel ecosystems is a particularly innovative and salient approach for integrating the above mentioned components. This offers a means to address the gap pertaining to large scale abiotic change and altered ecosystem states. Scholars that have entered the debate on novel ecosystems have focused on the core idea that novel landscapes contain new combinations of species that have resulted from human-ecosystem interactions and environmental change (Hobbs et al. 2006; Hobbs et al. 2009; 2010; Hobbs and Cramer 2008; Lindenmayer et al. 2008; Montoya and Raffaelli, 2010; Richardson et al. 2010). It is the deliberate and inadvertent introduction of species from other regions that have resulted in novel ecosystems unlikely to be returned to previous states. The current definition of novel ecosystems is premised on the surpassing of abiotic and biotic thresholds. For example, Chapin and Starfield (1997) investigated the range of possible future scenarios of responses of the advance of the artic treeline (changing biotic thresholds) to changes in temperature, precipitation and fire regime (changing abiotic thresholds). The authors found that there is a time lag in the forestation of the Alaskan tundra as a result of climatic warming with the probable eventual development of a novel ecosystem that is comprised of boreal grassland-steppe. Biotic thresholds are created by dispersal barriers that result in new combinations of functional groups and result from altered abiotic conditions, e.g. soil erosion, climate change, changed hydrologic conditions (Hobbs et al. 2006).

In brief, the relevance of the novel ecosystems approach is to assist in characterizing the suite of probable and desirable ecosystem states and functions and the various paths that lead to their development. For example, with agricultural systems, one can examine the very fact that most such systems are novel (modified ecosystems for food production) and how newer ones will form under various scenarios of management incentives and biophysical interventions and anthropogenic climate change (Richardson et al. 2010).

3.4 Section 2: Synthesis of the Novel Ecosystem Concept and Sustainable Transitions

The preceding discussion outlines the basis of linking ecosystem management, and sustainable transition management to lay the foundation with which to assess the delivery of agri-environmental objectives in settings that have been part of the protectionist policy context since around the 1930s. From this, a framework with relevant criteria has emerged which can provide a basis for both accepting and managing current and projected transformations in ecosystem states and capacities in conjunction with managing institutional transitions. Particularly applications of this framework relate to determining the objectives to be reinforced for agricultural programming (i.e. linked environmental and agricultural objectives or multifunctional programs) and how programs deliver compensation to agricultural operators.

3.4.1 Transformation-oriented management approach: principles of a novel ecosystem framework

Based on this assessment and synthesis from the relevant bodies of literature outlined above, the main principles of a guided transformation approach using novel ecosystems emerges outlined in Table 16-1 below.

TABLE 3-1. PRINCIPLES FOR SHAPING CHANGE IN AGROECOSYSTEMS

Farm-scale	Institutional-scale
Incorporating biophysical interactions and novelty through resilience.	Redesigning selection pressures.
Resilient systems have functional and response diversity.	Redistributing power to the farm-scale.
Ecosystem services depend on diversity in agriculture (and vice versa).	Avenues for stakeholder participation in agri-environmental initiatives.
Ecological functional groups should be used to promote resilience.	Understanding path-dependency at the farm-scale.
Ecosystem services and functional dominance the ecosystem scale.	Adapting to selection pressures.
Species tolerance, colonization sequence and nurse guilds.	Long-term outlook in policy-making.
Farmer identified ecosystem services.	
Cross-scalar resilience: applications for agriculture.	

3.5 Novel ecosystems framework: creativity and innovation in operations and decision-making

According to Allen and Holling (2010) greater attention should be paid to understanding the capacity of an ecological system to buffer shocks given rapid landscape and climate change. However, the trends in agricultural practices, and most other natural resource systems, have historically attempted to constrain the dynamism of social-ecological systems in order to maximize production. This has resulted in narrowly defined loci for innovations. Innovation has been particularly focused on technological innovation at the expense of agroecological innovations. Without innovation and novelty, however, systems may become overconnected and dynamically locked, and the capital (biophysical, financial, social and human) therein may be unavailable until a dramatic collapse forces reorganization. According to Allen and Holling (2010) novelty and innovation are required to create new structures and dynamics following system crashes. Commonly in ecological systems, novelty may be added to or introduced to a system during reorganization. Ecological phenomena such as invasion, extinction, nomadism, and migration in flora/fauna communities represent system innovations (Allen and Holling, 2010). In many cases this allows new compositions of species to successfully exploit environments.

3.5.1 Active transformations—novel ecosystems version 2.0

Many authors have demonstrated that "novel ecosystems" can strengthen connections between the theoretical underpinning of ecosystem management approaches and other established frameworks that focus on resolving the management complexities in socioecological systems. For example, Kueffer et al. (2010) concentrated on applications of ecological management techniques in novel ecosystems on the tropical island Mahe (Seychelles). The findings demonstrated that native species can be incorporated into exotic species-dominated landscapes to develop ecosystem function that incorporates the benefit of both native and exotic species processes.   These studies fall within the purview of the management options described by Hobbs et al. (2009); in any case, managers, landowners, and decision-makers should transition (and accept transitions) beyond narrowly defined classifications of "valued" ecosystems. Seastedt et al. (2008) argue that the logical approach to managing novel ecosystems is examine the potential for increasing genetic, species and functional diversity wherever possible to increase the viability of communities and ecosystems under certain climate regimes. Under severely altered environmental and/or biotic conditions (e.g. irreversible physiochemical changes) it is often unfeasible to return to/recreate environmental conditions (abiotic) and biotic components (e.g. species assemblages) characteristic of the historical trajectory (Richardson et al. 2010). Therefore, management goals should shift to constructing new systems or replicating systems that may be locally novel but have a regional importance. A study by Richardson et al. (2010) demonstrated that targeted novel ecosystem assemblages in ecosystem management efforts (especially restoration) can promote efficient site colonization and ex situ biodiversity conservation on landscapes that are particularly degraded (when compared to historic benchmarks). Seastedt et al. (2008) argues that when working with novel ecosystems managers should focus on tools and procedures to enhance the resilience of desirable (from a human valuation stand point) ecosystem qualities and facilitate transformations from undesirable ones.

Active transformation refers to the "deliberate initiation of a phased introduction of one or more new state variables (a new way of making a living) at lower scales, while maintaining the resilience of the system at higher scales as transformation change proceeds" (Folke et al. 2010). In reference to agroecosystems this requires assembling ecosystems at the local scale (i.e. farm or landscape scale) providing services that offer a wider stability domain (general resilience) at larger scales for agriculture and the general public. Explorations pertaining transformations help to broaden the social domain from investigating human action in relation to a certain natural resource, like fruit production, "to the challenge of multilevel collaborate societal responses to a broader set of feedbacks and thresholds in social-ecological systems" (Chapin et al. 2009 in Folke et al. 2010). Implications of transformation change includes shifts in perception and meaning, reconfiguration of social networks, patterns of social network configurations, patterns of interactions among actors including leadership and political and power relations, and associated organization and institutional arrangements (Folke et al. 2010).   Importantly, transformational changes at lower scales (either active or forced), in a sequential way, can lead to feedback effects at larger scales (i.e. regional), which is a learning process, and facilitate eventual regional scale transformational change (Folke et al. 2010).

Fowler and Rockstrom (2001) present a case where forced transformation under colonial powers in Africa reduced the resilience of agroecosystems by separating soil conservation from agricultural production. A greater emphasis was placed on technological innovations which overlooked the fact that in many semi-arid and regions prone to drought or erratic precipitation soil water is the major constraint limiting crop-production. In recent years a local movement towards conservation tillage has been successful in actively transforming the landscape, the institutional arrangements that structure agriculture as well as acceptance of soil conservation practices in many regions of Africa. Active transformation and general resilience is the foundation for the novel ecosystem program in concept and practice.

3.5.1.1 Shaping change at the Transformation Scale

Incorporating biophysical interactions and novelty through resilience. Folke et al. (2010) proposed two new definitions of resilience, *specified resilience* and *general resilience* which should not be thought of as in contrast to the other iterations, but should be understood as further clarification of the objectives of resilience approaches. “Specified resilience” refers to the “resilience of some particular part of a system, related to a particular control variable, to one or more identified kinds of shocks” (Folke et al. 2010). Folke et al. (2010) argues that increasing specified resilience can have unforeseen negative impacts on the system (particularly due to the interaction of interdependent scales) because in many instances it encourages narrowly defining a system based a few interaction components. Modern agricultural systems are examples of specified resilience; increasing fertilizers and machinery increases yields has ultimately increased the global agri-food system. General resilience, in contrast, is the “resilience of any and all parts of a system to all kinds of shocks, including novel ones” (Folke et al. 2010). General resilience can explicitly address past, present, and future conditions in terms of what actions should or should not be taken to ensure a functional agroecosystem which requires fostering biophysical functioning in agricultural landscapes.

Resilient systems have functional and response diversity. A resilient system requires functional diversity - many groups that contribute to redundancies in their potential or realized function (Holling 2001; Elmqvist et al. 2003; Allen et al. 2005; Berkes and Seixas 2005; Walker and Salt 2006). This allows a system to have response diversity – it can recover quickly from any shocks or loss of a functional group. Functional diversity and response diversity are linked concepts and also linked to the concept of ecological memory. Functional diversity refers to the variability of different functional groups that are present in a system upon which the system relies for renewal and reorganization (Walker and Salt, 2006). Berkes and Seixas (2005) argue that nurturing diversity maintains the composition of essential components in the system, such that the system can reorganize after a shock (maintaining structure so function can continue) (Walker and Salt, 2006). They also warn against both optimization and efficiency at the cost of response diversity. Although contemporary efforts towards optimization (e.g. maximum sustainable yields) often aims to reduce redundancy, the redundancy of functional groups helps ecosystems absorb disturbances by retaining structure and function (at various levels) (Walker and Salt, 2006). Moonen and Barberi (2008) argue that efforts to increase functional biodiversity particularly on agricultural lands require understanding on habitat diversity within a single agroecosystem (the farm-scale), and diversity at regional scales as well. The reason behind is this insurance against the presence of intensive production and low diversity agroecosystems. The benefits elicited from this approach include diversity at all other levels, buffering against large-scale pest invasions and increased multifunctionality in terms of economic activities (Moonen and Barberi, 2008). Response diversity, therefore, refers to the various actors (e.g. species) within a functional group that provides insurance to the system by reacting and responding differently to external pressures on a defined system (Elmqvist et al. 2003). Species are considered redundant if they can truly replace one another (i.e. perform the function of the other species if it is lost from the ecosystem) (Naeem, 2006). If one loses a functional group of decomposers, another such group is available to fill that niche. Holling (2001) goes furthest when he notes that the key is actually the transferance of functions across scales rather than just within scales. This cross-scalar nature is one reason why resilience is a useful approach.

Ecosystem services depend on diversity in agriculture. Another way of thinking about the importance of diversity is to link it with the ecosystem services provided by a diverse agroecosystem (Altieri 1992; Pretty 2008). If optimization of agricultural production and efficiency diminishes diversity and processes like nutrient cycling, then the agroecosystem becomes less resilient. Farming too much of the landscape means less refugia for predators of crop pests and pollinating insects, for example. Combining this with increased fragmentation results in limited habitat for these beneficial organisms and therefore may never return. Pest outbreaks can increase and pollinators needed for open cropped plants diminish.

More obvious impacts may include excessive tillage or fertilizer application that disrupts or overwhelms the nutrient and water cycles crucial to future farming production. Such services are not missed until they are gone – and then it is too late or very expensive to bring them back (Elmqvist et al. 2003). Push an agroecosystem too far and it cannot re-organize easily in response to an environmental or economic shock (Deutsch et al. 2003; Millennium Ecosystem Assessment 2005). Agriculture cannot forever rely upon expensive and non-renewable external inputs but must conserve and depend on regional ecosystem services (Paustasso et al. 2010; Turner, 2010).

Ecological functional groups should be used to promote resilience. Community assembly on agricultural lands is a result of the elimination of species that are not tolerant of the actual or past management frequency, intensity, and habitat isolation (Moonen and Barberi, 2008). Groups that can be distinguished within a community based on ecophysiological and life-history traits are the result of management intensity and frequency and habitat quality. Functional groups that should be encouraged or deliberately introduced on agricultural lands should be assembled based on species traits such as the capacity to host beneficial insects, improve water quality, and maintain soil moisture because these are the important functional groups in an agroecosystem context. The portioning of process, structure and function within and across scales provides resilience to complex systems (Allen and Holling, 2010). Species that exploit the same resource in similar ways are members of the same functional group but may have different cascading effects.

Ecosystem services and functional dominance at the ecosystem scale. Most plant communities are made of a numerically dominant species while the rest of the species remain relatively rare. Therefore, the removal of a dominant species is more likely to have a significant impact on ecosystem functioning than the removal of one of the rarer species. Establishing a species in a community that is capable of domination (in terms of total biomass) will also most likely significantly alter the ecosystem functioning and services provided by that community (Naeem, 2006). Additionally, Moonen and Barberi (2008) argue that many biodiversity introduction efforts on agricultural lands have failed to identify the important functional benefits of the species introduced. If the objective is to incorporate organisms or communities that have positive functional contributions to agroecological systems then taxonomic richness is less important that functional capcity. This is particularly relevant if no mechanistic relationships have been established between the numbers of species to be included in the biodiversity conservation efforts and the ecosystem functioning objectives (Moonen and Barberi, 2008). Naeem (2006) refers to this as taxonomic diversity as opposed to functional diversity. The provision of ecosystem services and functions is a consequence of the distribution of species among guilds or functional groups, and the fact that of these distributions many may be only weakly related to diversity as measured by number of species (Walker et al. 1999). The reason that a majority of species found in ecosystems occur in low abundances (with just a few making up the bulk of the biomass) is often because the minor species are "analogues" of the dominants in terms of the ecosystem functions they perform (Walker et al. 1999). Walker et al. (1999) argue that it is a small set of relatively abundant species that are functionally important by performing the bulk of photosynthesis, transpiration, nutrient uptake etc.

In ecological community assembly, the order of introduction of species is influential for individual species survival because abundant species may have the capacity to buffer shocks in order for minor species to become established. In this way functional dominance can become an important contributor to colonization sequence assuming a role as a facilitator or inhibitor (Temperton and Kirr, 2004).

Species tolerance, colonization sequence and nurse guilds. Connell and Slatyer (1977) formulated a theory regarding succession in natural systems. One of their major contributions was the concept of priority effects, that is, the identity and environmental effects of the first organisms in primary succession. According to authors, the first organisms in primary succession are extremely important (often undervalued) in shaping the community's further development. In this seminal work on priority effects, Connell and Slatyer discuss facilitation, tolerance and inhibition in respect to primary colonizers. These terms refer to the colonizers' relationship with other organisms, which could be positive (facilitative), negative (inhibitive) or neutral (tolerant) and arise out of basic competition theory. Murphy (2004, 2005) has built on some of these main principles discussed by Connell and Slayter (1977). In particular, Murphy (2005) found that using the inhibitive properties of native species (*Sanguria canadensis* L.) in a disturbed urban forest can help outcompete invasive species (*Alliaria petiolata* (Bieb.) Cavara & Grande). Additionally, in another study Murphy (2004) used the inhibitive relationship among various native forest species to outcompete invasive species and facilitate native regeneration.

Murphy demonstrated that certain orders of establishment are more effective for outcompeting invasive species and nursing later guilds of native species (demonstrating a positive facilitative relationship). Nurse plants are used in restoration to provide favourable microclimates for another plant species to establish; however, little critical attention has been paid to the value of nurse plants in the role of restored communities on degraded landscapes (Temperton and Kirr, 2004). Nurse plants are useful in scenarios where harsh abiotic conditions make it difficult for native species to survive after dispersal or emerge from a dormant seed bank. The establishment of nurse plants provides 'safe sites' where the harsh abiotic conditions are ameliorated so other native plants (either purposely planted or indirectly established) can regenerate (Murphy, 2004). Temperton and Kirr (2004) found that order of arrival affects the further development of community and that the timing of arrival of individuals is also important. They also found that the exact identity of the nurse plant may not play as a large of a role in establishment as they predicted, suggesting that finding a plant suited to the abiotic and biotic conditions of the site might be the most important factor.

Farmer identified ecosystem services. Broading the suite of priorities for novel ecosystems outside of natural resource and land managers to address farmers may be a challenge. Virtually every ecosystem in southern Ontario is a novel ecosystem in the sense that it is has been subject to more or less intentional disturbance that has disturbed the historical trajectory. What is desirable in terms of creating and managing novel ecosystems will drive what is desirable. For novel ecosystem efforts that target farmers the ecological priorities may be crucial but so are well-being considerations of the land-owner/operators.

Farmers are an important potential driver for change when considering conservation at regional scales by incorporating restoration at the farm scale. They are the most capable at determining what the ecological requirements of their landscapes constitute. For example, if the aim is to increase support to aphid predators and parasitoids, the agroecosystem functional group that should be encouraged consists of those plant and insect species known to host or attract them. Therefore, it would be the plant species that are found in the grassy field boundary that are important to establish to improve the 'management functional groups' of the boundary vegetation (Moonen and Barberi, 2008). Many examples of functional interactions are available in literature surrounding integrated pest management. Also, Altieri (1992) provides an overview of efforts pertaining to organic agriculture and biological control of pests in California. The main difference proposed here is the interaction between incentives at the policy level for functional biodiversity at the farm-scale. This includes not only biological control but other ecosystem services required at the farm-scale in concert with the conservation requirements at the regional levels.

Cross-scalar resilience: applications for agriculture. Moonen and Barberi (2008) warn that a requisite level of understanding of habitat diversity at regional, national and in some cases, trans-national (e.g. amongst the member states of the European Union) is pertinent to objectives that aim to influence aspects of diversity in the agroecosystem. Changing environmental and even socioeconomic conditions can influence diversity of agroecosystems within a given territory. Therefore, diversity can provide insurance in at least parts of a territory in case the favourable conditions change to unfavourable conditions at variable biophysical, political or socioeconomic scales (Moonen and Barberi, 2008). This is a context specific example of response diversity pertaining to agroecosystems and functional biodiversity. The impact of one individual organism introduced into an agricultural landscape has little impact on the agroecosystem processes. However, when many agricultural landscapes include important functional contributors there are many individuals present in a rather homogenous way on the territory (Moonen and Barberi, 2008).

The cross-scale agroecological functional diversity approach promoted by Moonen and Barberi (2008) complements the propositions made by Bengtsson et al. (2003) pertaining to the conservation of protected areas through actively fostering species diversity matrices on managed landscapes. Bengtsson et al. (2003) argue that the current management approach for reserves is in conflict with the landscapes in which these conservation areas are embedded. In principle, reserves are "protected" by assigning boundaries to ecosystems in possession of native species communities reflective of a historic range of variability. This approach, however, overlooks the fact that the static nature of reserve boundaries is vulnerable to the dynamic, and in many instances, rapidly changing environmental conditions that shape landscapes that surround these preserved areas. As a result, the protected areas become isolated from requisite genetic sources. Bengtsson et al. (2003) argue therefore, for the enhancement of ecological memory (i.e. species, interactions and structures) within "disturbed patches" to complement these currently static reserves.

A core problem is that the promotion of diversity is almost always at odds with efforts in agricultural systems which are managed to specialize, optimize and maximize efficiency and production. The presence of redundant groups, even if one is currently dominant, means there is within-group competition for resources which reduces overall production (Walker and Salt, 2006). Thus, one is tempted to reduce that diversity. But if environmental conditions change quickly, a lack of redundancy means a quick collapse or at least change to a less productive system. Although there is evidence that resource-conserving technologies are beneficial and are being adopted by some, the total number of farmers using them is limited worldwide (Pretty, 2008). The reason is that the adoption of resource-conserving environmental practices comes at a cost for farmers. Pretty (2008) argues that farmers cannot simply stop their agricultural practices (like cutting fertilizers and pesticides) and hope to maintain their outputs. The adoption of new agricultural practices requires a transition that is currently not supported by the policies that tend to promote specialized, non-adaptive systems that have minimal innovation capacity. Productivity trade-offs are a concern when environmental goods and services become as important as productivity in terms of policy objectives (Altieri, 1992; Pretty, 2008). The challenge is to seek sustainable intensification on landscapes that includes investing in the currently depleted natural resource components of agricultural lands (Pretty, 2008) which include the facilitation of both diverse agricultural practices as well as diversity of ecological facets of landscapes.

3.5.1.2 Shaping Change at the Transition Scale

Redesigning selection pressures. As discussed above, selection pressures in the transition literature refer to the the demands that actors possessing agency use to maintain the incumbent regime, or conversely, actors desiring change can use to influence a shift in system states. In the case of agri-environmental, selection pressures occur at the scale of the federal government in Canada as subsidies/ stabilization programs on the one hand, and environmental taxation, negotiated agreements and regulations on the other. The contemporary selection pressures that influences the farm-scale are the product of the legacy of government intervention in agriculture via protection-oriented policy-making (see for instance, Monpetit, 2002). A major detriment to the success of agro-environmental programs in Canada is the underestimation of the use of financial incentives to increase program enrollment. Therefore, developing Canadian programs with facilitative mechanisms like on-going compensatory incentives would redirect the selection pressures to support agroecosystem functioning.

Redistributing power to the farm-scale. The interaction between agency and power shapes the governance context within which societies define, reinforce or reinvent their political structures. Agency is described as the ability to take action and make a difference over a course of events (Giddens, 1984; Smith et al. 2005). In terms of transition, agency refers to the ability of actors to intervene and alter the balance of the possibility of new system directions and/or the capacity for adaptation to those pressures (which takes place in the social setting/regime via networks of actors and institutions and requires the exercise of political, economic and institutional power).

Power is the ability to get others to do something they might not otherwise have done (Dahl, 1957). Power both facilitates and circumscribes agency and can also constrain critical reflection on inequalities (Smith et al. 2005). As a result, power and agency can both facilitate and constrain dependency. Particularly in respect to resources in societal networks, individuals are dependent on other actors for resource allocation and therefore, resources become a source of strategic influence over the regime. Withholding or strategically deploying resources can increase the agency of certain regime constituents while impoverishing or restricting the agency of other groups. Smith et al. (2005) argue that incumbent regimes (influential corporations or majority governing bodies) represent one form of structured power with the ability to condition the identities, activities and inter-relationships of the actors in which the incumbent regime encompasses. The interest, expectations and motivating capacity of the enmeshed actors are profoundly influenced by the structures of the incumbent. This suggests that the regime that possesses agency can influence the direction of knowledge generation, governance capacities and development goals and therefore, positively or negatively direct regime actors towards or away from poverty or rigidity traps (Atwell et al. 2011) and facilitate or constrain constituents' ability to change system dynamics (Giddens, 1984).

The current resource deployment to agricultural operators from government funds is based either on supply or risk management (see Chapter 2 for elaboration). An alternative approach to resource deployment would be concerned with more sustainable approaches, that is, not just mitigating disaster but actually making a positive contribution (Gibson et al. 2005). Therefore, new strategies would give agency back to landowners by providing them incentives to develop socio-ecological sustainable landscapes from which they could derive financial gains. This can be accomplished by fostering knowledge transfer, encouraging collaborative relationships within the research and local communities and stimulating regulatory changes that alter the market for production (King, 2008).

Avenues for stakeholder participation in agri-environmental initiatives. Much of the research on agri-environmental programs is concerned with transitions to multifunctional agricultural landscapes. The research therefore, explores what fosters or constrains stakeholder participation in these programs, but few actually examine the epistemological grounding of the landowners in regards to program content (i.e. how they interpret the interaction of agriculture and ecology on their lands). Often policies are ignorant of fundamental differences in the perceptions of the researchers/ decision-makers and their constituents and result in non-equivalent perceptions of the same situation (Giampietro, 2004). This ultimately means that the way a program plays out on the ground is very different than how it was conceived of by decision-makers (Giampietro, 2004). The design of policy at the governmental level, therefore, needs to be cognizant not only of the objectives set out at the institutional level (e.g. more land set-aside in conservation reserves) but also needs to be cognizant of how those programs (and their content) is perceived by those that are targeted by these endeavours. Atwell et al. (2009) discovered that the adoption of conservation practices through multifunctional programming is contingent upon multiple factors. Landscape-scale adoption of perennial conservation practices, therefore, must be compatible with ecological, sociocultural, economic and political aspects of the farming regions at multiple times. The authors were concerned with how the potential for multifunctional landscape practices by rural stakeholders is constrained or fostered by social and ecological factors at multiple scales. The issues of concern in this research are focused on transitioning to multifunctional land-use paradigms in the US Midwest, and this study is one of the few (if not the only) that looks at how landowners conceive of ecological principles in their land-use management strategies. Chapter 4 explores this aspect of the "people as part of nature" aspect of the Novel Ecosystem framework via a case study that investigates the constraints to participation in agri-environmental programs based on program content in the Niagara region.

Understanding path-dependency at the farm-scale. Wilson (2008) also discusses the concept of path dependency as another conditional factor influencing agricultural transitions. In particular, the simultaneous occurrence of requirements for production as well as concerns over the environmental impacts of the production activities determines the multifunctional pathway of a farm and constrains the decision-making processes at the farm-scale. The starting position of a farm, which is the place at which an operator acquires the farm, the past operating practices and legacies of farming operations on that land, as well as the geographic location (i.e. particular region, community and/or land features) of the farm all interact to condition the path that the farmer-farm will traverse towards weak or strong multifunctionality. These conditions are sometimes referred to as “lock-in effects”. They can be internal- mentally conditioned and therefore self-reinforcing, or external- driven by the options available, for instance, in terms of social, economic and environmental capital and can severely influence the opportunities of individual farms (Wilson, 2008). In addition, apparent in historic documentation (see for instance the result of Bovine Spongiform Encephalopathy (BSE) outbreaks in the EU, or agricultural related hypoxia in Lake Erie), “transitional ruptures”, described as sudden breaks in transitional pathways, can also condition farm-level transitions. Policy-makers must be cognizant of these path-dependencies acting as selection pressures on the farm-scale and requires that at the policy-scale that makes implementing agri-environmentalism a viable option for farm-owners.

Adapting to the selection pressures. Current (and projected) environmental states are affected by ‘persistent problems’ resulting from entrenched societal structures that ignore the fundamental discrepancies between production and consumption patterns and the finite carrying capacity of the natural environment. Regime change is the function of two processes according to Smith et al. (2005): 1) Shifting selection pressures affecting the regime, and, 2) the coordination of resources available (both within and external to the regime) to adapt to the changing pressures. Governance, in the transition context, can be understood as either sustaining transition contexts or as a suite of interventions to alter contexts (Smith et al. 2005). Exercising governance in transition contexts refers to the incentives and barriers facing regime actors to generate pressure, allocate resources and collaborate in the process of system innovation. Skogstad (2008) argues that Canadian agriculture has not yet experienced a fundamental change in agricultural policy approaches and therefore remains within a “state-assistance” policy paradigm. A majority of the producers in Canada persist in a cycle of financially insecurity so abandoning state transfers to raise and stabilize farm incomes is politically and economically disastrous. Additionally, Skogstad argues the fact remains that agriculture will always remain an exception to economic models because farmers will always face uncontrollable risks (e.g. pests, disease, climate, weather). A realistic focus is to turn to new rationales that are concerned with state transfers to support farm incomes including the provision of biodiversity protection and other ecosystem goods (Skogstad 2009). Walton (2003) argues that a new way to balance conflicts between agriculture and the public in order to allow both groups to take advantages of the benefits of production and consumption within a framework that supports safe food and healthy agro-ecological interactions is required. The transition management approach to governing regime transformations recommends using purposeful creation and temporary protection of desirable niche alternatives that can help to spark regime changes- this requires encouraging agroecological innovation in the agricultural sector.

Long-term outlook in policy-making. van Apeldoorn et al. (2011) argues that high adaptability and fast recovery in modes of conventional farming become a trap of incremental adaptation;

short-term returns become a trade-off for other system configurations. Each small adaptation reinforces the dominant social and economic structures, further reinforcing the incremental adaptation process by economic forces and vested interests. This inertia thus generated by the land use history and biophysical processes might become so large that it precludes transformability of the system. This is a result of the embedded policy context shaping the viability of transition approaches. Canadian agricultural stabilization programs have been largely reactionary, fragmented and many have occurred as short-lived evolutions. Schmitz (2008) argues that this has made producers wary of new programs and policies because they cannot count on governments to leave rules of the programs in place for any length of time. Many previous programs have not fulfilled producers' expectation which also has made many operators leery of participating in new initiatives. Public authorities need to develop programs that demonstrate to their constituents that there is longitude in their policy purview and there is a commitment to agri-environmental programs.

3.6 Synthesis

The integral lesson to be learned from the agricultural history is this: the driving market and technological forces behind Canadian agricultural policy have directed agriculture in Canada into highly specialized and highly simplified (in terms of biological and spatial complexity of landscapes) farming systems that are inherently vulnerable to perturbations. Agricultural operators and the policy that drives their decision-making need a new approach to for working with and within changing environmental conditions. This paper investigates the origins of the concept of novel ecosystems in addition to the models of ecosystem change from the literature and identifies the justification for a paradigmatic change in the ecosystem management literature pertaining to transformative ecosystem states. Parallel to this discussion of accepted conceptualizations of ecosystem state changes is a discussion on managing transitions in institutional contexts. Ecosystem transformation and sustainable transitions can be integrated into a conceptual framework for a cross-scalar approach to agroecological management which includes new approaches to governmental decision-making. Based on the influence that the agricultural policy has had on decisions made at the farm-scale, it can be anticipated that there would also be a corollary transition in the governance of agricultural land-use at the farm-scale. It is at this intersection that agricultural policy in Canada and novel ecosystem management can interact through the theory of Sustainable Transitions to influence farm-scale deliberate ecosystem transformations to ensure the viability of Canadian agriculture.

4 Reviewing and Redeveloping Program Content for Agri-environmental Initiatives in Ontario

4.1 Introduction

For this research, currently employed agri-environmental programs in Ontario and Europe (England more specifically) were consulted reviewed and assessed in order to identify the potential gaps and benefits derived from the applications of these various alternatives. This research examines and builds specifically on the following body of research:

- Mackenzie (2008), examined the usefulness of the Alternative Land Use Services program in the Greenbelt region of Ontario,
- Holmes (1998) Smithers and Furman (2003) and Robinson (2006), all examine from various vantage points uptake of the Ontario Environmental Farm Plan,
- a Special Report in the *Journal of Applied Ecology* that synthesizes the findings from several studies that investigate the effectiveness of the content of the European Agri-environmental Schemes and
- the White Paper released in June 2011 by Britain's Secretary of State for Environment, Food and Rural Affairs titled *The Natural Choice: securing the value of nature.*

The purpose of this review is to define appropriate parameters for developing a program that focuses on incorporating native species assemblages on farmlands to further integrate ecosystem services and local conservation objectives in the Greenbelt in Ontario. The review of the literature and the case study are used to establish a set of case specified criteria for a pilot study (Chapter 5).

Most other reviews of the current agri-environmentalism models are interested in program participation and likely barriers to farmer involvement and have quite adequately identified the areas for improvement based on that agenda. The efficacy of agri-environmentalism, however, is dependent not only on participation but also on the objectives prescribed by program involvement. Based on a comparison of the findings of the aforementioned literature a suite of gaps and potential avenues for contributions to sustainability were identified for agri-environmental programming. As a result, unlike other critiques of agri-environmentalism in Ontario this paper is concerned with the content of agri-environmental programs in Ontario and examines how the content of agri-environmental programs can be developed to improve participation by farmers and contribute to ecosystem functioning on farms with regional conservation objectives.

An examination of relevant literature demonstrates that on-going incentives are effective in capturing participants in terms of enrollment (Smithers and Furman, 2003; Robinson, 2006), participant recruitment (Wilson and Hart, 2001) and strengthening the agricultural economy (MacKenzie, 2008) On-going incentives are particularly useful in terms of on-going sustainability livelihood and biophysical improvements (MacKenzie, 2008) and aids in the shift towards a multifunctional paradigm in agricultural programs. Research by Gerowitt et al. (2003) and Agriculture Quebec (PQ, 2005) determined that the best approach to aid in the provision of ecosystem goods and services is to encourage program enrolment by providing ongoing direct payments to farmers. Ongoing direct payments are the main vehicle for promoting multifunctionality and enhancing the value economic, social or environmental agricultural outputs and impacts (PQ, 2005). The interest here is in ecosystem service improvement/ habitat restoration on farmlands. Restoration efforts that enhance ecosystem functioning and services on farms across Canada have not been a significant part of agri-environmental initiatives (Robinson, 2006).

The case study focuses on the agricultural sector in the Niagara region. There are five major reasons for this case study selection: first, research undertaken by MacKenzie (2008) and Robinson (2006) provide research in this region on agri-environmentalism background in in the case study context. Second, the special status of the area in the Greenbelt plan (Protected countryside) makes this a critical area for agricultural production in Ontario and Canada. In addition, parts of the area are designated as a UNESCO Biosphere Reserve and therefore, this region is a good location to examine the interaction of "natural and cultural heritage" a concept that will be expanded on throughout this paper. Third, although the land has important agricultural and environmental features, Robinson (2006) provides evidence that landowners in the Niagara region are reluctant to participate in the available agri-environmental initiative (Ontario EFP). Fourth, the Niagara region has been working on agricultural viability programs, and is therefore a good location to propose innovations in incentive structures for farmers (research states that farmers are looking for other ways to obtain livelihood sufficiency). Finally, water quality and quantity are vital to survival of agroecosystems in Niagara, are the basis of other conservation programs and are now targeted by food safety initiatives in the area, providing a good intersection to explore options for new programs.

One question examined in this research is how best to reconcile the concepts of conservation and restoration and economic viability on farmlands. The development, design and delivery of a program that hinges on the interaction of conservation and agricultural operations is necessary to move towards multifunctional agricultural policies. In Canada, there is a particularly limited purview in agri-environmental programming for programs that focus on ecosystem functional requirements integrated with farm requirements. In England, for example, agri-environmental objectives recently changed from restoration, which implies adhering to the historic fidelity or trajectory of a system, to "natural improvement areas" which allows for a wider interpretation of conservation or natural improvements.

The research, therefore, examines the program contents of current agri-environmental programs in Ontario for what is actually targeted and whether they are aligned with the present biophysical and livelihood concerns plaguing agricultural operators in Canada. The main programming gaps identified from this research relate to ecosystem functioning; the agricultural models offered in

Canada overlook the provision of ecosystem functioning. The focus on conserving natural ecosystems is only one part of what should be a multi-faceted strategy. Especially in Canada, the cultural imperative to "preserve" landscapes overlooks the fact that many ecosystems have been altered and habitat fragmentation resulting from sprawl etc. requires incorporating ecosystem components on lands that are currently void of these habitat features (e.g. the Alterative Land Use Service (ALUS) program and the Ecosystem Stewardship Scheme in England). This will be discussed in relation to a new strategy called "Natural Improvement Areas" in England. Instead a new approach looks to Gibson et al. (2005) for the strategy of *maximum net gains* to ensure that programs are designed with all facets of agroecology in mind.

4.2 Overview of the Methodology

The methods for this research involved two stages. The first stage was an evaluation of how current agri-environmental policies address the critical issues in agriculture from relevant literature and information pertaining to the case specific area, and pared it down into major thematic groups. The second utilized Q Methods to evaluate the efficacy of this approach in addressing the outlined critical issues; and identify what is missing from the program, what aspects need improvement, and what particular challenges will be evident given the program goals.

4.3 Examining Existing Agri-environmental Programs

In Europe there has been a shift away from the sole focus on production maximization; this is particularly evident through the Common Agricultural Policy (CAP) reforms and even starker in particular countries, e.g. England (Robinson, 2006). According to Kleijn et al. (2010) over 45% of the European landscape is managed as farmland; consequently, many threatened species in Europe are strongly associated with farmland habitats and so the drivers of the decline in threatened species and species in general have been well documented and researched. In contrast, species in other parts of the world with more natural habitats (e.g. Canada) are only recently starting to receive a similar level of interest and attention; in Europe, therefore, conservation policy tools have been examined and reviewed for more than a decade in contrast to the Canadian policy setting (Kleijn et al. 2010).

In Canada, there have been limited and fragmented efforts to promote agricultural policy changes that are comparable with the 'post-productivist' CAP reforms (Robinson 2006). According to Hilts (1997) and Robinson (2006) in the mid-1990s in Canada a limited number of agri-environmental schemes with localized applications became apparent (e.g. The Island Nature Trust in Prince Edward Island, corporate conservation agreements in Nova Scotia, wildlife conservation agreements by landowners in three Prairie provinces, The Natural Heritage Stewardship Programme in Ontario etc.). However, there was no widespread development or adoption of agri-environmental programming that resembled the EU's Environmentally Sensitive Areas Scheme or England's Countryside Stewardship Scheme. In particular, England offers the best available examples of on-going monitoring of the resulting impacts of agri-environment schemes on landscapes with a particular focus on birds (Kleijn et al. 2010). The main thrust of these types of programs is a shift away from purely production-oriented agriculture towards agriculture that encourages (financially) farmers to "produce countryside" which is achieved by incorporating changes to operations and practices that focus on less intensive methods and, according to Robinson (2006), often include reversions to environmentally friendly traditional activities.

In Canada, few programs or mechanisms exist for providing compensation for the provision of ecosystem goods and services (MacKenzie, 2008). Instead, efforts are generally focused on providing direct, one-time payments to encourage farmers to implement agri-environmental management plans (e.g. Ontario EFP) and adopt environmentally beneficial practices in conjunction with the acquisition of facilities and infrastructures where appropriate. While these types of activities are important, these programs only incorporate habitat improvement as an eligible action within the program; it is overlooked by many landowners as superfluous to the management of their operation. As a result, habitat improvement projects, which may have many ancillary benefits for farms in terms of ecosystem services, tend to be ignored in program applications. In contrast, the EU agri-environmental schemes are multi-faceted and overall include a focus on either/and natural resources, biodiversity, or landscape aesthetics. The narrowly prescribed "habitat improvement" options need to be expanded, re-designated and re-categorized as a separate project to motivate farmers to improve ecosystem function on farms to emphasize the multiple, mutually reinforcing benefits for maximum net gains (*sensu* Gibson et al. 2005) from a multifunctional landscape and to offer an more comprehensive suite of options for agricultural land management.

McCallum (2002) reviewed agri-environmental programs in Ontario and found that most incentive programs have concentrated on conservation of soil and water resources, and have dealt largely with "best management practices". McCallum argues that there are three main kinds of programs in Canada none of which has a truly holistic outlook or a long term purview of agroecological viability. All three approaches have benefits but McCallum critiqued them as follows:

- Farmland protection that addresses the loss of farmland by limiting urban sprawl and other forms of development but does not address the viability of agriculture in areas where farmland is protected,
- Environmental stewardship that focuses on improvements in the biophysical environment but does not take a long-term, whole farm approach to stewardship, and does not necessarily create a stewardship mindset among farmers who participate. Funding is on ad hoc basis for discrete projects, and
- Providing farm support that focuses on viability through farming over the long-term transformation of farm enterprises. It has been criticized for supporting short-term solutions

(i.e. income stabilization) and does not link economic development with the protection of biophysical environment.

New orientations for agricultural programming, observes McCallum, must seek to include a wider scope of agri-environmental interactions including air quality, biodiversity, health issues and related environmental concerns. The structures and approaches for agri-environmentalism are outlined in Table 4.1. The objective here is to understand how programs operate and what is missing from existing programs in terms of the structure and deliverables in general, and the program content in particular. These programs have been evaluated by others in the literature which forms the basis of the identification of content short-comings in this research in order improve the participation in programs and begin to implement programs with measureable positive changes in agricultural-ecological interaction.

TABLE 4-1.COMPARISON OF THE MAIN APPROACHES TO AGRI-ENVIRONMENTALISM

Program	**Location & Time of Inception**	**Structure**	**Program Focus**
Ontario-Environmental Farm Plan	Ontario, pilot in 1992	Jointly funded by 'Growing Forward,' (which is supported by Agriculture and Agri-Food Canada) and the Ontario Ministry of Agriculture, Food and Rural Affairs.	Farm-level environmental appraisal, farm-specific environmental action plan
Environmental Stewardship Scheme (ESS)	England, 2005	Natural England delivers the ESS[8]	Safeguard parts of England for conservation value
Alternative Land Use Services	Ontario	Developed by farmers in collaboration with conservation organizations; implemented variously including by local stewardship councils	Promotes the provision of ecosystem goods and services by creating an incentive-based vehicle for encouraging resource stewardship by landowners
Ontario Greenbelt Plan	Ontario, 2005	Protectionist policy that delineates acceptable land-uses within the prescribed greenbelt area	Protection of prime agricultural lands as well as natural features

4.3.1 Alternative Land Use Services Program

Mackenzie (2008) addressed the issue of whether the Ontario Greenbelt legislation requires a supplemental program or option to ensure the viability of the farming economy and also to

[8] Natural England is an executive non-departmental public body that is responsible to the Secretary of State for Environment, Food and Rural Affairs.

incorporate ecological stewardship as it is one of the main tenants of the legislation. MacKenzie looked at the contributions that ALUS can make to supplement (complement) the current Greenbelt legislation towards ecological stewardship and agricultural viability. ALUS is based on the payment to farmers for environmental services that support public amenities. ALUS pays farmers for lost opportunity costs (i.e. land taken out of cropping). MacKenzie's study compares the potential contribution of the ALUS program with that of other reasonable alternatives currently available to promote farmland protection and farm stewardship. The primary findings from this research indicate that an ALUS program in the Greenbelt[9] would help to strengthen the Greenbelt's role in halting urban sprawl while preserving agricultural land and maintaining ecological goods and services. MacKenzie warns that for ALUS to make a stronger contribution packaging the program with a suite of existing programs that would be able to complement ALUS and address some of its weaknesses.

MacKenzie argues that ALUS is an alternative or supplement to these options for agricultural programming identified by McCallum (2002). MacKenzie suggests that because ALUS does not address farmland protection directly it would be best suited to areas where farmland protection policies in place. A new approach to policy programming would have the best chance in area where at the basic level, farmland loss is not an impending threat. However, MacKenzie also argues, for the application of ALUS as a complement to farmland policies that do not for the most part address the viability of the agricultural economy. An apparent gap in application are farms and regions that do not possess areas on farms that are considered "natural features" and are thereby overlooked by the majority of agri-environment programming in Canada to date. ALUS, for instance, requires farmers to set-aside what are deemed inefficient or marginal agricultural lands to rehabilitate. A separate initiative is required that targets restoring and enhancing the ecosystem functioning of agricultural lands that do not possess easily identified conservation areas (e.g. a pre-existing wetland or woodlot) or areas that can be used as set-aside. These lands are also capable of providing ecosystem services to the public and ecosystem functioning that is beneficial to the landowner and the agricultural operation. The ALUS model, unlike other agri-environmental programs, does have a link to economic development and agricultural viability and therefore, the structure of the program provides a good basis on which to expand the program focus or to create a separate initiative that focuses more particularly on the ecosystem functioning require to provide the desired ecosystem services. One of the main benefits of ALUS is its capacity to help to ameliorate the cost squeeze (inequitable distribution between the cost of production and prices received from farm produce) by paying farmers to produce other kinds of goods (e.g. clean water). Additionally, it appears not to be treated as a non-tariff barrier to trade.

4.3.2 The Ontario-Environmental Farm Plan (EFP)

[9] MacKenzie examines the potential of ALUS either as established as a stand-alone regional project or as a part of a provincial or national program.

The Environmental Farm Plan was one of the programs that emerged during the mid-1990s in Canada. Originally the EFP was localized to Ontario because it was the result of the release of "Our Farm Environmental Agenda" (OFEC, 1992) that was a produced a coalition of farm organizations and commodity groups in Ontario that was largely a statement of environmental attentiveness and intentions. According to Smithers and Furman (2003) the document inspired a grassroots vision for the interaction of farming and environmental quality that adamantly presented a strong position for farm-led planning and sustainability in agriculture. Arguably, the document sought to pre-empt any intrusive or heavy-handed position for government in farm-based environmental management (Smithers and Furman, 2003).

TABLE 4-2. MAIN SOURCES OF DISCUSSION ON THE ONTARIO EFP EXAMINED FOR GAPS IN PROGRAM OFFERINGS

Author(s)	Focus of Study	Methods
Holmes (1998)	Identifying factors that inhibit participation in the Ontario EFP	Personal interviews with participants, potential participants (25 in-depth interviews) and program administrators (16 in-depth interviews) in four regions (Grenville, Dundas, Ottawa-Carleton, and Lambton)
Smithers and Furman (2003)	Identifying the motivating factors for farmers to participate in the EFP	Questionnaire survey of known participants (400) in four county study areas (one of which is Niagara Region)
Robinson (2006)	The operation of the EFP drawing distinctions from its essential bottom-upapproach to farm-based management and the more 'top-down' model widely adopted in the EU.	Records on farmers taking part in the scheme from the OSCIA, survey of nearly 10000 participants (43% of the total) and randomly selected short informal interviews with 100 farmers in 8 different counties across Ontario • Counties with both high and low participation rates were visited to examine differences in farmers' attitudes (e.g. the very low rate of participation in Niagara compared with high rates of participation in some livestock producing areas)

In 1993 the pilot was initiated in seven selected counties and was officially launched with funding through Agriculture Canada's Green Plan Program. The design of the program was based on Wisconsin's Farm "A" System (Smithers and Furman, 2003).

Participation by farmers in the EFP is voluntary and involves a six-stage sequence from attendance at the introductory one-day workshop to the implementation of the Plan. Worksheets are designed to highlight environmental strengths on the farm, identify areas of environmental concern and set goals to improve environmental conditions according to own timetable (Robinson, 2006). The program allows farmers to self-evaluate the environmental performance of their own farm in terms of environmental risk. The workbooks contain detailed guides for 23 selected topics (and 260 individual questions) to aid in the self-evaluation. This is considered to be a both a strength and a potential weakness of the program design, because it places considerable onus upon individual interpretations of "environmental problems" (Robinson, 2006).

By mid-2000, some 17000 farmers signed on to participate in the EFP; however, questions still remain relating to the ultimate effectiveness of the program in delivering improved farm management in both short and longer term (Smithers and Furman, 2003). For instance, nearly 23.8% of province's farmers were enrolled in the program; 38% left the program after the workshops.

Holmes (1998; *et seq*) interviewed participants and non-participants in the program and identified several barriers to participation in the EFP. The principal issues constraining participation included the structure of the program; in particular, difficulty in scheduling time off the farm to attend the two required workshops also, the burden of the paperwork associated with the program was considered a significant barrier. Confidentiality and trust were also a concern for farmers with a particular emphasis on a strong distrust of government, concerns with divulging information, and a fear of litigation at a later date from information divulged during the peer review. Other issues that emerged as barriers to participation included a lack of urgency to participate, the burden of responsibilities and obligations post-action plan completion. Other issues included the difficulties associated with financing environmental projects outlined in plans, time and labour required to complete them. Additionally some respondents felt that the EFP has made farmers 'scapegoats' for environmental problems in the rural landscape and the EFP puts the government in a position to tell farmers how to run their operations. Other barriers included preferences by farmers for independent conservation action outside of the structure of the program, the fact that participation is redundant for farmers involved in other environmental initiatives, lack of awareness around environmental problems, and apathy on the part of some farmers a constraint to participation.

Robinson (2006) identifies the considerable sectorial and spatial variation in participation as a potential indicator of a flaw in the program design. Uptake (workshop attendance) is greatest in eastern Ontario with lower uptake in province's agricultural heartland in the southwest (Robinson, 2006). According to Robinson's study in 2006, highest participation per county as a proportion of possible adopters was found to be Granville (81.4%) in the east, Peterborough (75.8%) and Parry Sound (73.6%) in central Ontario and Dufferin in the south-west (85.3%). However, in the south-west of the province eight counties had an uptake of less than 30%, with York (19.1%), Niagara (13.8%), Brant (14.0%) and Oxford (14.6%). Farm type has had demonstrable influence over agri-environmental program participation in Europe (see for instance Morris and Young 1997 or Wilson and Hart, 2001). Robinson (2006) argues that farm type may also influence participation in the case of the Ontario EFP. For instance, the province's livestock producers are more common participants than crop and fruit and vegetable producers. According to Robinson's research, horticultural areas are associated with limited program uptake and out of those chief horticultural areas Niagara has the lowest rate of uptake. This is may prove significant because Niagara is the principal fruit and wine-producing county in Canada and is located in some of Canada's best class one agricultural land. The greater participation by livestock producers may suggest that it is the environmental challenges presented by this type of farming that have been most readily addressed within the EFP (Robinson, 2006).

Robinson also determined that participation may be increased where involvement does not require a significant alteration of farm management and practices. Participants with more complex management issues are less likely to participate than those with straightforward easily identified environmental problems with equally simple solutions (Smithers and Furman, 2003). Other questions over the longer term, related to the results of participation in the EFP in respect to the attitudinal changes in participants (Smithers and Furman, 2003). Similar to what Wilson and Hart (2001) discuss in respect to participation in Countryside Stewardship Scheme and Environmentally Sensitive Areas Scheme in England. One of the defining characteristics of the EFP is to develop "not only a farm plan, but a farm planner as well" (Smithers and Furman, 2003). Wilson and Hart (2001) question whether participation in certain schemes actually causes an attitudinal shift in participants from passive adopters (those that participate purely for the financial compensation) to active adopter (which refers to participants that become "conservation-oriented" thinkers after participating in the program). Wilson and Hart (2001) argue that an attitudinal change in participants is a significant driver for the success of agri-environmentalism and agricultural sustainability as a whole. Smithers and Furman (2003) argue that the interest in respect to attitudinal changes related to EFP participation is concerned with whether investment in an environmental farm program actually produces benefits that last beyond the existence of the duration of active participation in the program. Despite the positive feedback from participating farmers towards the EFP, as of July 2002 three-fifths of Ontario's farmers had not attended EFP workshops and three-quarters had not submitted an EFP for peer review (Robinson, 2006).

Robinson (2006) identified prime barriers to participation in the EFP as perceived costs of environmental actions and the farmers' personal priorities (e.g. whether environmental actions were deemed as relatively unimportant, see also Holmes, 1998). For instance, if a farmer views measures that are integral to the EFP as "extras" that are superfluous to their farming operations they may negate participation (Robinson, 2006).

Smithers and Furman (2003) argue that there are other issues to consider in terms of the effectiveness of the Ontario EFP outside of the issue of recruitment and participation. For instance, because of individual interpretations of environmental risk, the program tends to work against systematic assessments of farm environments and privileges particular views of these environments as opposed to other views from academics, government, environmentalists and wider community (Robinson, 2006). Other concerns pertain to the structure of the EFP and perhaps the design of the management activities. Because of the farm-specific focus of the EFP and the absence of "planning objectives other than those expressed by the farmer, the effectiveness in achieving specific conservation outcomes at a regional level or beyond is unclear" (Smithers and Furman, 2003). Additionally, the success of a self-evaluation approach depends on the availability and adequacy of the technical and financial support needed by farm participants.

Smithers and Furman (2003) also discovered that farmers are spatially selective in their evaluation of their operations (55% of respondents indicated that they did not apply the evaluation to their entire farming system); most farmers (78%) indicated that they confined their effort to those areas where problems where known (by them in advance); some farmers do not like to document each and every issue on their farm. The capacity for understanding ones' own farming system is an important determinant for what kinds of projects are undertaken in the EFP. As a result, the environmental issue receiving most frequent attention, and deemed most important by participants are related to water contamination and soil degradation (most respondents indicated a strong sense of the need to maintain the productivity of their soil resource); chemical storage and handling and manure management was also priority. In contrast, Smithers and Furman (2003) found that the priority for natural areas management was relatively low which is unfortunate because natural areas provide capacity to deal with many of the other highly prioritized issues that are eligible requirements (i.e. water contamination and soil degradation) but is under-communicated in the design of the program. Robinson (2006) found that data from OSCIA for 9991 worksheets completed by farmers between April 1993 and July 2002 indicate that soil management, water quality (particularly related to water wells) and storage of agricultural waste are priorities for environmental improvements under the EFP program. Additionally, data gathered from OSCIA reports on environmental programs indicate that in 2011 activities that pertain to livestock operations and arable producers still topped the EFP applications.

TABLE 4-3. 2011 TOP TEN ONTARIO EFP/ COFSP BENEFICIAL MANAGEMENT PRACTICES BASED ON PROJECTS APPROVED (INTERIM REPORT)

Beneficial Management Practice	Projects Approved	Federal Dollars Paid
Precision Agriculture	253	$915 314
Upland and Riparian Habitat Management	204	$734 400
Farmyard Runoff Control, Roofed Livestock Yard, Impermeable Base	202	$1 324 766
Well Water Management	200	$413 036
Improved Pest Management	181	$376 040
Product and Waste Management	170	$653 080
Energy Conservation Measures for Agricultural Uses	160	$436 521
Improved Cropping Systems	136	$530 709
Improved Manure Storage and Handling	128	$1 933 147
Resource Planning	121	$190 539

A relatively small number of respondents indicated that preservation of significant natural areas (including wildlife habitat) was a primary concern on their farm

However, Smithers and Furman (2003) found that over 90% of the respondents indicated that participation in the program increased their awareness of potential environmental issues relating to farming. Therefore, participation in the program should be accompanied by information output regarding natural ecosystem assemblages that can benefit farm and regional conservation objectives (not dissimilar to the Nature Improvement Areas approach paired with the Environmental Stewardship Scheme discussed below). Part of the issue regarding enrolling the farm in the program under the wildlife habitat requirement is that it limits the potential benefit to conservation objectives because the program fails to acknowledge the potential benefits that can be derived from natural area management and restoration on farmlands that include water quality improvement/ retention and improvements to soil structure and retention etc. which were identified as priorities for participation by the respondents. Farmers may overlook this component of the program because there is an undeniable absence of natural features on many farmlands, and therefore, the so termed "wildlife habitat" components address only to farmers who can readily identify the natural features existing on their lands. For example, the existence of a natural feature, like a wetland, on properties is positively associated with the farmers' degree of participation. The program design fails to acknowledge the fact that reintroducing "natural features" improves the interaction between regional conservation features *and* the farmer's operation. Farmers that did express concern with wildlife habitat were more likely to participate more fully in the program.

All of this points to a critical design flaw in the EFP program, at the very foundation of the EFP eligible actions, the program overlooks the subtle and yet vital interactions between native species assemblages which provide habitat that is important for species that interact with farms (e.g. wild pollinators, species that predate on pests, flora that can improve soil retention and water quality, Kleijn et al. 2010). Conversely, farmers whose properties include "natural features" are more inclined to enroll entire farms in agri-environmental programs; however, there are no options for farmers who currently lack "natural features" or "wildlife habitat". Therefore, the potential for increased holistic participation is restricted by the program design and, in addition, the potential benefits that stem from participation in the EFP are restricted by the management approaches promoted by the EFP eligible actions.

4.3.3 The Ontario Greenbelt Plan

According to the Canada Land Inventory only 11 per cent of Canada's land surface is useable for agricultural purposes and less than one per cent is Class One agricultural land. In Ontario, which possesses 56% of Canada's Class One land, (and 15.5% of Classes One to Three which are free of severe limitations for agriculture) agricultural landscapes have been threatened by the province's propensity for urban and suburban sprawl (Pond, 2009). By transitioning to intensive land use practices, greater use of off farm inputs like fertilizers and pesticides and technological investments the trend in Ontario (and arguably the majority of the Western agricultural world) has been to use progressively less land to produce foodstuffs (Pond, 2009). This has resulted in the release of human and physical resources to fuel growth in Ontario and has been forceful in driving agricultural policy trade-offs in the province.

Pond (2009) argues that the Greenbelt Plan is the first attempt in Canada of transitioning to a multifunctional paradigm for agriculture because it challenges the dominant orientation of the agricultural economy, which is focused on production in isolation from natural and cultural well-being. In 1990, however, during public hearings by an appointed Royal Commission studying the deficiencies of the existing Planning Act, local tender fruit farmers during public consultation isolated a main contention of land management in the Niagara Region. Farmers argued that saving agricultural land is destined to fail if greater efforts were not made to save the farmer first (Gayler, 2004). This still remains perhaps the most contentious issue in respect to protection of agricultural land even under the Greenbelt Act and Plan. Bunce and Maurer (2005) argue that securing the long-term sustainability of agriculture in the Greenbelt will require more in-depth and sophisticated strategies than mere land use regulation. Davidson (2007) also suggests that the singular focus of protecting agricultural land has not helped rural communities in the past and as a result what is required is a transition from merely restricting land use to fostering positive contributions to long-term sustainability of rural and agricultural communities (see also McCallum, 2002). One issue with the critique that the Greenbelt Plan at inception was not focused on measures to improving the viability of agriculture (K. MacPherson, personal communication, June 2011). The Greenbelt legislation was a means to halting the loss of productive agricultural lands and valued ecosystems. The Greenbelt therefore exists as a plan for managing urban sprawl with the ancillary benefit of protecting agriculture and the environment but is not an agri-environmental scheme. However, it does provide the groundwork (in terms of protection) for developing programming that decisively integrates agriculture and environmentalism in these previously designed areas.

4.3.3.1 The Ontario Greenbelt: natural and cultural heritage

The Greenbelt Act and Plan (2005) has a vision statement (1.2.1) that focuses on three interrelated objectives including: 1) “loss and fragmentation” of agricultural lands, 2) natural heritage and water resources, and 3) diversity of economic and social activities associated with the primary land uses (e.g. agriculture and tourism). The Greenbelt Plan pays particular attention to land use designation for agricultural purposes called the “Protected Countryside” (which covers 11 per cent) and to illustrate these distinctions four separate categories of land uses are outlined: specialty crop areas (there are two, one of which is the Niagara Peninsula Tender Fruit and Grape Area, the other is the Holland Marsh), prime agricultural areas (generalized agricultural zones which covers 57 per cent), rural land (which covers 17 per cent) and settlement areas (which covers 15 per cent). A main focus of the Geographic Specific Policies in the Protected Countryside is fostering a relationship between the “natural heritage and hydrologic features" and farm stewardship. The plan recognizes that "the Agricultural System is integral to the long-term sustainability of the Natural Heritage System within the Protected Countryside" (Greenbelt Plan, 2005, 3.1.1). The Ontario Greenbelt Legislation, therefore, is an attempt to manage feedbacks at the human-ecological interface and develop structure for local resource protection. The legislation is considered to be a "protectionist policy" (Pond, 2009) because it is organized around the principle of regulation (minimizing negative externalities from farming loss or landscape change). The Greenbelt legislation, although imbued with the spirit of enhancing ecosystem services does not possess a component of fiscal transfer for farmers for the positive externalities they are expected to protect and generate on their lands.

The Greenbelt Plan demonstrates the changing outlook on agricultural production by recognizing that agricultural lands offer some of the last remaining open spaces on which to foster and enhance non-market amenities in addition to the commercial production of food and fibre (Pond, 2009). The two major constraints identified by Pond (2009) are: 1) limitations on disposing of private property in the marketplace and, 2) the expectation that rural landowners are required to not only limit environmentally destructive behaviours (negative externalities) but actually make a positive contribution to environmental amenities (positive externalities) which they may feel are not legitimate demands on their business. Pond argues that Greenbelt Plan largely ignores the voice of the farm lobby, which is crucial to the success of any agri-environment program. The province has mostly overlooked the contentious issue of gaining the farm lobby support for providing public services on individually owned and operated landscapes in terms of fiscal transfer. The provincially-funded Friends of the Greenbelt Foundation has tried to address this with a cost-sharing "top-up" style program that works in conjunction with the Environmental Farm Plan under the Greenbelt Farm Stewardship Program (GFSP), which provides up to 75 per cent combined cost share to farmers implementing eligible beneficial management practices (BMP). Participants, however, are still restricted to the eligible actions outlined by the EFP.

4.3.4 Agri-environmentalism in Europe

Agri-environmental schemes (AES) in the EU have largely originated as reforms to policy with the aim of deriving environmentally desirable outcomes through voluntary participation by farmers (Robinson, 2006). In 1992 it became mandatory for EU member states to implement agri-environmental initiatives and in 1999 (as part of the CAP reform) AES were incorporated into the Rural Development Programmes (RDP) (Primdahl et al. 2010). AES are designed address an interrelated matrix of protection, maintenance and the enhancement of natural resources, biodiversity and landscape values (Primdahl et al. 2010). Payments are not directly linked to the achievement of outcomes but are allocated instead, based on principles of forgone income or the incurrence of increased costs resultant from increased agri-environmental obligations (Primdahl et al. 2010). Generally speaking, AES are structured using agreement obligations that dictate what farmers must do/ refrain from doing in order to remain enrolled in the program. The agreements are strongly customized because farmers select from a list of obligations; however the obligations may have differing effects on the practices pursued by farmers. Primdahl et al. (2010) observed that, for instance, an obligation that targets a grassland type may require three different actions by three different farmers. One farmer may be obliged to stop spraying pesticides, while another farmer who does not apply pesticides may be obliged to reduce fertilizer inputs while the third may be obliged to introduce extensive grazing. The programs are also geographically targeted, the structure of which is referred to as either "horizontal" (applied to all agricultural lands within the member state) or limited (applied only to designated areas). Also, targeting can either occur as part or whole farm approaches (Primdahl et al. 2010). Within member states/ regions agri-environment programs are established which can further be subdivided into various initiatives based on environmental objectives and obligations.

AES has been criticized as having unclear and imprecise standards for environmental objectives (Primdahl et al. 2010). Additionally, AES differ from typical protected area schemes because they are often applied to small patches of land, such as field boundaries, and are sometimes located in areas where the target species does not occur (Whittingham, 2007). In Whittingham's 2007 assessment of the effectiveness of the promoted content of AES he argues that the program may have more success in positively influencing biodiversity if larger areas were protected rather than supporting many small fragmented areas on farmlands. The argument stems from foraging and metapopulation theory, which predicts that the distance of suitable habitat from breeding individuals is likely to determine the patch use of (in this case) the enrolled land (Whittingham, 2007).

Whittingham's (2011) Special Report in the *Journal of Applied Ecology* synthesizes the findings from several studies that investigate the effectiveness of the content of the AES programs (i.e. does the program content actually have the intended effect of increasing biodiversity at farm, landscape, national and international scales in the EU). Whittingham (2011) is one of, or perhaps the only, true synthesis that examines the overall impact of the AES by compiling a wide variety of studies that examine the biodiversity conservation of plants, invertebrates, birds as well as other germane indicators of success that pertain to the principles of landscape ecology such as patch sizes, distance to foraging areas and the relationship of cropped versus noncropped habitats on biodiversity. Although program content is arguably the most important factor in the design of a program, the contents of programs are rarely evaluated for effectiveness even though they are expensive undertakings often funded at the governmental level (Whittingham, 2007). Arguably, when a program is funded at the governmental level it becomes a public good and is therefore of public concern and deserves scrutiny to determine if it is in fact delivering the program tenets. In Canada because agri-environmental programs are delivered across various federal and provincial jurisdictions, a synthesis, like the one undertaken by Whittingham is often cumbersome to compile and analyze to identify the most effective avenues for programming. As a result, the content of specific programs is rarely considered within or against a suite of other models to determine the efficacy of the program in place. The Special Report, therefore, is one of relatively few studies that that compiles evidence that focuses on the effectiveness of the content of agri-environmental programs wherein Whittingham discovered that recent work demonstrates that under a range of circumstance agri-environmental schemes like those employed in Europe can provide substantial benefits in terms of both biodiversity, ecosystem service delivery and economic viability of farming.

The findings in Whittingham (2011) provide a foundation for improving or furthering agri-environmental initiatives. In particular, the findings suggest that enrolling land in conservation or enhancement projects can improve ecosystem service delivery and provide biodiversity gains at various scales. This concept is the foundation for the new direction of integrated landscape conservation in England based on the White Paper produced in 2011 that lays the groundwork for Nature Improvement Areas, which is an expansion of the Environmental Stewardship Schemes developed in 2005.

4.3.4.1 Environmental Stewardship Schemes in England

England is a good example of the integration of ecosystems and agriculture as farmers can participate in different levels of the Environmental Stewardship Scheme and receive on-going incentives for their actions. These financial incentives are applied with both statutory and non-governmental agencies involved in policy delivery to farmers (Robinson, 2006).

The transition to widespread agri-environmentalism programs in England was smoothed by the efforts at the level of the European Union in addition to the fact that agriculture is packaged under the same department at the federal level titled the Department of Environment, Food and Rural Affairs. This is sometimes considered an unpopular merging whereby farmers or the farm lobby feel that agriculture is subsumed into environmental affairs; however, it does indicate a transition in the mindset in terms of governance when the environment and agriculture are designated as integrated areas of management. The Environmental Stewardship Scheme was launched in March 2005 to build on the Environmentally Sensitive Areas (ESA) Scheme and the Countryside Stewardship (CS) Scheme as well as the Organic Farming Scheme (OFS). It is open to farmers and land managers in England. It is an agri-environmental scheme managed under the England Rural Development Plan (ERDP) and has six main objectives: conservation of wildlife and biodiversity, maintenance and enhancement of landscape quality and character, protection of historic environments and natural resources, promotion of public access and understanding of the countryside, conservation of genetic resources, and provision of flood management. The scheme is built into three levels: Entry-Level Stewardship (ELS), Organic Entry-Level Stewardship (OFLS), and Higher-Level Stewardship.

TABLE 4-4. INFORMATION ON THE ENVIRONMENTAL STEWARDSHIP SCHEME IN ENGLAND SUMMARIZED FROM NATURAL ENGLAND 2012; ALSO INCLUDED IS THE STRUCTURE OF THE NIA

Program Level	**Management Scheme**	**Incentive Scheme**	**Program Objectives/ Eligible Actions**
Entry Level Stewardship	Whole farm; points based	Flat rate payment of approximately	Best management practices for water quality, soil maintenance, wildlife

(ELS)	enrollment	$49 CAD/ hectare every 6 months for eligible lands	habitat, protection of historical environment and maintaining and enhancing landscape character
Organic Entry Level Stewardship (OELS)	Largely the same as ELS but is open to farmers that manage at least part of holdings organically	Flat rate payment of approximately $97 CAD/ hectare once a year for eligible land	Actions include maintaining boundary features (e.g. stone wall, ditch and hedgerow management), protecting historic sites (e.g. taking archaeological sites out of arable production), management planning (e.g. soil, nutrient, crop protection and manure planning) maintaining buffer strips and protecting trees and woodlands
Higher Level Stewardship (HLS)	HLS aims to provide significant environmental benefits in priority areas and situations	Agreements are made for 10 year periods and payments are made every 6 months (the first payment for half of the annual management payment and the second half is paid upon the completion of a claim form)	The HLS management options are combined with the ELS and OELS management options into a single agreement that are specifically focused on local circumstances. Examples include maintenance of hedgerows; grassland, restoration and maintenance of lowland heath; wetlands e.g. maintaining ponds of high wildlife value and reed beds; and resource protection (e.g. prevent erosion and run-off). A main component of the HLS is working within the confines of regional conservation targets
Nature Improvement Areas	Conservation links "natural networks"	Delivered by the Department for Environment, Food, and Rural Affairs	Conservation at various scales (small to large) but focus the focus is on landscapes. Farming is seen as part of "natural landscape".

4.3.4.2 Nature Improvement Areas in England

The 2010 Lawton Report, *Making Space for Nature* found that nature in England is highly fragmented and unable to respond effectively to new pressures (e.g. climate and demographic change). In June 2011 Britain's Secretary of State for Environment, Food and Rural Affairs responded to that report and presented a White Paper to Parliament titled *The Natural Choice: securing the value of nature*. The emphasis of this report rests on a new approach in England is to promote an integrated view of the environment with a focus on "resilient ecological network" across England. A main point made by the paper focuses on broadening the meaning of "natural environment" to include not only the things commonly associated with naturalization (e.g. wildlife, rivers, streams, lakes, seas) but also urban green space, open countryside, and farmed land as well as all components integral to human survival (i.e. food, fuel, air and water) in conjunction with the ecosystem functioning that provides those services (e.g. the natural systems responsible for cycling water) (SSEFRA, 2011). The focus on both natural and cultural heritage has always been apparent in England because the systems considered "natural" are often artefacts of cultural modifications over many years (Higgs, 2003). This paper however, expands the integration of natural and cultural systems further. For one, the new biodiversity strategies are based on a system of re-incorporation of natural features/ species on managed lands. One major component of the new strategy is the creation of new "Nature Improvement Areas (NIAs)" to enhance and reconnect nature on a significant scale. The basis of this approach is to focus on both the goals (outcomes) of natural systems (i.e. services) but also places an emphasis on the functioning of ecosystems to maintain services. In particular the plan delineates restoring ecological networks with five components:

1. **Core areas** of high nature conservation value (contain rare or important habitats or ecosystem services)
2. **Corridors and 'stepping stones'** that will enable species to move between core areas which can be made up of a number of small sites acting as 'stepping stones' or a mosaic of habitats that allow species to move and support ecosystem functions
3. **Restoration areas**, where strategies are put in place to create high-value areas (the 'core areas' of the future) so that ecological functions and wildlife can be restored
4. **Buffer zones** that protect core areas, restoration areas and 'stepping stones' from adverse impacts in the wider environment, and,
5. **Sustainable use areas**, which are focused on the sustainable use of natural resources and appropriate economic activities. Together with the maintenance of ecosystem services they 'soften' the wider countryside, making it more permeable and less hostile to wildlife.

The "Natural Environment White Paper" published in 2011 commits the government to participate in partnerships that encourage ecological restoration on suitable lands. The NIA schemes will be delivered by the Department for Environment, Food and Rural Affairs. The program has officially received funding of £7.5 million, approximately $12 million CAD and will operate from 2012 to 2015. Only land management partnerships or consortiums are eligible for the grant money for this project; individuals and lone organizations are not (DEFRA, 2012). Twelve projects were chosen by an independent panel, each will get a fraction of the £7.5 million to implement their plan; the restored areas range from 40 ha to 1500 ha in size. The grant money is distributed based on criteria that is concerned with the sustainable of the project after the grant money is used (it is a one-time payment), the benefits to the community in terms of the capacity to integrate an enhancement the ecological system, whether the area is a habitat "priority", whether the area enhances existing natural areas (based on the five components listed above) etc. (DEFRA, 2012).

4.3.5 Summary

The disparity between farming and conservation on Ontario agricultural landscapes is difficult to overcome for many landowners. This gap between managed lands and conservation on managed lands perhaps points to an opportunity for recalibrating the way agricultural policy is designed for Ontario landscapes, in this case, in the Niagara region. In particular it may suggest that pure conservation efforts tend to alienate many landowners from participating in these types of endeavours. For instance, Atwell et al. (2009) discovered when researching the rate of adoption of innovations in transitional government policies in the US Corn Belt, that interviewees perceived the practicing of conservation as advantageous in some ways for agricultural operations; however, they also reported that these types of programs are only minimally compatible with their current farming strategies in terms of profitability, practices, and technologies, which restricts the program uptake. Additionally, these respondents felt that the conservation programs offered by the government were less reliable and more complex than maintaining their current commodity production, which points to what many farmers feel is an inconsistency and turnover in farm policies (Atwell et al. 2009).

Program type, therefore, is also a determinant in uptake of agri-environmental policies and deals particularly with what the content of the program is concerned. According to Rogers (2003) conservation usually requires “preventive innovations” but do not present an immediate profitability and are proffered in order to alleviate further/future problems. Glover et al. (2008) would refer to this as the “use” versus “preservation” conflict. According to William Jordan (2000) conservation is considered a “non-act” whereas restorative efforts are an applied socioecological practice that is also imbued with transformative power. Restoration is valuable because it provides a context for negotiating the relationships between humans and the restoration of function. Additionally, farmers who are unsure of the importance of conservation because it is more of a “preventative innovation” may be more inclined to implement the functional components of ecosystems (via “restoration” i.e. a “hands-on” approach) that provide services while also building linked human and ecological communities where rural landowners can define the limits of acceptable change of landscapes (Jordan, 2000).

Mackenzie (2008) highlights this distinction in agri-environmental programming in Ontario and argues that there is a difference between a program that supports services delivered (i.e. ecosystem services) versus actions taken (i.e. the eligible actions targeted by the EFP which may actually result in “non-acts”). Therefore, ALUS is a fundamentally different program from the EFP; however, the insights gathered from MacKenzie’s work indicate that a program designed to bridge the services versus actions orientation of the two programs could provide a nexus point wherein the creation of ecosystem services could be supported and enhanced. That is, applicants could participate in the EFP under an eligible action where they would receive the $1500 payment to initiate the design and planting of the ecosystem and then could perhaps transfer into ALUS and receive payment for annual delivery of service. There is an opportunity for a new program to act as a complement to the EFP and ALUS rather than an alternative.

The Nature Improvement Area model outlined in the 2011 paper has particular salience in addressing the main gaps in programming currently offered in Canada. One main reason this model is appropriate is because it has a focus on ecosystem functioning in the ecological networks. Farms could therefore, be targeted for the corridor and ‘stepping stone’ areas for restoration potential because the focus is less about the historic fidelity of the ecosystems supported and more about assembling systems so ecosystem function is present at farm-level, and species diversity is present at the landscape level.

The focus of the remainder of this paper is to sort through the overlaps among regulation and protection in agriculture, and environmental protection in Ontario to reach a nexus where it is easy and desirable for farmers to enroll in programs that emphasize the interactions between the natural features of their landscape and their operations

4.4 Case Study Context: The Regional Municipality of Niagara

The Niagara Region has significant settlement areas (e.g. Niagara-on-the-Lake established in 1781) and historic sites (e.g. Fort George, Navy Hall, Butler's Barracks, Queenston Heights) as well as advantageous positioning for transport (e.g. Lake Ontario, Lake Erie and the Welland Canal), infrastructure (e.g. the Sir Adam Beck Hydro Generating Station), climate and soils (Gayler, 1994). Agriculture is an economically critical component of industry in the Great Lakes Basin, in Canada (1991-1992); 22 percent of all agricultural revenue was produced from the five million hectares of agricultural land in Ontario (Charron and Waltner-Toews, 2008). In respect to the importance of this area for farming, the Niagara fruit belt is one of three tender fruit producing areas in Canada that can support large-scale commercial production (Gayler, 2004). This area extends about 25 miles along the southern shore of Lake Ontario (between Grimsby and the Niagara River) and extends a mere seven miles inland from the lakeshore and overlaps in some areas with the Niagara Escarpment Biosphere Reserve (Gayler, 2004). Lake Ontario and the peninsular shape reduces the extreme temperatures felt elsewhere and as a result makes tender fruit farming, and (in the recent past) non-native *Vinifera* grape farming complementary to the area (Hill, 2002). The exceptional soil in addition to these amiable climatic conditions have given the area local distinction within Canada for growing tender fruits which include: peaches, pears, plums and prunes, apricots, sweet and sour cherries (Krueger, 1978).

The agricultural sector in the Niagara region contributes in a significant way to the economy as well as general quality of life of the area (Planscape, 2006). In 2003 the "Regional Agricultural Economic Impact Study" reported that in 2001 $1.8 billion was generated by agriculture and Niagara ranked first in the Province in terms of agricultural productivity (average gross farm receipts of $2195.00 per acre) (Planscape, 2006). A review of the 2006 agricultural census demonstrated that high productivity in Niagara continued with an average per acre gross farm receipt of $2899.00 (still the highest in the province) (Planscape, 2010). Protection of the agricultural land base is of critical importance in this region as a result. The Greenbelt Plan and legislation is the Provincial reaction to agricultural land losses wherein tender fruit lands are given special distinction.

Robinson (2006) argued that it is important to research the areas that currently have low participation rates in the EFP i.e. Niagara. Niagara is an important farming region in Ontario and Canada and has received particular distinction as a mecca of natural and cultural value. In this area it is particularly important that agri-environmental programs deliver a proactive approach to improving interactions of natural and cultural heritage if agriculture is to remain viable.

4.4.1 Rationale for case study location: Ontario Greenbelt focus

The Greenbelt Plan area is suitable for a case study for several reasons. First, as mentioned above, the Greenbelt Plan is an innovative approach to managing urban, suburban and exurban sprawl, all of which have threatened the Niagara Tender Fruit Region in particular, for several decades now (Gayler, 1994). The Plan is primarily a protectionist-type program that manages sprawl by curbing the growth areas and allocating special designations, as outlined above. Second, although this approach is evidently an important step for transitions to a more sustainable future it also creates some challenges for landowners within the confinement of the Greenbelt boundary. By curbing growth in this region the province has indicated a willingness to protect culturally, hydrologically and ecologically valuable landscapes. As the province states in the Plan, both cultural heritage (agriculture) and natural heritage (water and ecosystems) are worthy of protection but the consequences of restricting the capacity for farmers to manage, in terms of agro-ecological interactions, their lands as they require has been overlooked. The Greenbelt has taken the first step towards a multifunctional paradigm by imposing the regulatory facets of the agri-environmental program similar to the first stage adopted by the EU during the progression from a productivist to multifunctional paradigm. However, the incorporation of an incentive structure for the provision of public goods on private lands would ameliorate the current issues with the Greenbelt Plan and allow for the progression of the state dependency model to the agri-environmental programming now characteristic of the EU.

4.5 Q Methodology

Wilson (2008) argues that most of the data that are collected on agricultural activities and agricultural change is still gathered using R-methods meaning minimal amounts of data are collected pertaining to the less tangible qualitative on-farm multifunctionality indicators such as *mental* changes and social perceptions of ecological changes. Perceptions of program efficacy and content are considered non-tangible indicators that help to understand opinions regarding multifunctionality, the ‘depth’ of diversification activities, or the viability and sustainability of rural communities (Wilson, 2008). According to Wilson and Buller (2001) studies that are concerned with interactions of human agency and institutional structures allows for a better understanding of the indicators of transitions towards multifunctional paradigms in agricultural communities. The focus on measurable entities to be expressed in data leads to the neglect of more complex indicators where immediate quantitative data may not be available (e.g. changes to nature and extent of wildlife habitats and changing environmental management practices and attitudes of farmers). Wilson and Buller (2001) and Lowe et al. (1999) criticise this exclusive quantitative focus that receives wide support most probably because of the OECD indicator framework. Lowe et al. (1999) argue that this type of framework perpetuates a policy outlook that is fundamental to policy problems because it abstracts farming from its social and environmental context.

In addition, Atwell et al. (2011) argues that quantitative cause and effect models are often incapable of predicting environmental outcomes because they do not incorporate the perspectives of social actors who intervene and alter a system's trajectory (see also Gunderson and Holling, 2002; Peterson et al. 2004; Folke, 2006). When researching the potential contribution ALUS could make as a complement to the Ontario Greenbelt MacKenzie (2008) discovered that interviewees, particularly the farming community, were concerned with using social criteria (i.e. income) as a determinant for program eligibility. This discovery suggests that social criteria (or variables) are perceived as an abstraction of the main issues that concern the agricultural community. Interviewees felt that programs should be linked to the services targeted as opposed to categorizing the farm community by what are typical "R-method" classifications. As a result, the methods employed for this portion of the research also avoid restricting participation to typical R-method tools like categorizing participants based on income class, gender or age. Instead, the methods are concerned with the perceptions related to the content of agri-environmental programs irrespective of the variables associated with respondents.

In Q Methodology respondents are tasked with organizing their perspectives around the related topic in order to avoid devolving into R-method variables (Reber et al. 2000). This is achieved by ranking a series of self-referential opinion statements, in this case, statements that have been distilled out of literature and documents pertaining to agri-environmentalism in Ontario and other relevant agricultural land management literature in the Niagara Region. The objective of this type of methodology "is to unmask deeply held opinions in such a manner that people who respond to the sort in specific ways can be identified, grouped into factors or types, and described according to similarities and differences in attitudes, motives and desires as represented by their individual Q sort" (Reber et al. 2000). Q Methodology is well-suited to this particular research because it avoids a redundancy of efforts by gathering findings from surveys, interviews and critical literature reviews and assembles the important findings and commentary into what is called a "statement concourse" which is made up of statements that are then sorted by the respondent (Brown, 1993). This approach has been found to be particularly beneficial in cases where the researcher is interested in increasing understanding of the preferences and opinions of the public, in this case, potential program participants and administrators. For instance Popovich and Popovich (1994) found Q methodology useful in strategic public relations and planning. Proponents of the methodology argue that it may be more useful in its "ability to reveal broadly held individual attitudes than can be topic-specific response rating surveys" (Reber et al. 2000). According to Brown (1993) there are three main points that demonstrate suitable applications of Q Methodology in addition to its merits as a qualitative tool, Brown argues that:

> (1) The Q sample is comprised solely of things which people have said, and it is therefore indigenous to their understandings and forms of life. (2) The Q sorting operation is wholly subjective in the sense that it represents "my point of view": issues of validity consequently fade since there is no external criterion by which to appraise a person's own perspective. (3) As a corollary, the factors which

> subsequently emerge -- factors, that is, in the factor-analytic sense -- must represent functional categories of the subjectivities at issue, i.e., categories of "operant subjectivity."

The factors are the areas of contention or significance that emerge during analysis of the suite of Q sorts submitted by respondents. According to Brown, Q methodology is a valuable tool because it has an inherently indeterminant aspect of subjectivity built into the methodology design. Brown argues that this is a result of the fact that prior to the study inception researchers are neither aware of how many factors the responses may produce nor what structure they will reveal. The emergent factors will provide important insight into what the respondents (the recruited participants from the farm community) feel is relevant in the design of program content that pertains to ecological functioning on farmed landscapes. Additionally, Q Methodology is particularly useful in single case studies (Brown 1993) because the factors in a single case can expose the complementarity or distinctions between factors based on the viewpoints of the respondents and provides a comprehensive approach to subjectivity on a given topic.

In addition, Brown (1993) points to a number of studies that demonstrate the capacity that Q methodology has for deconstruction, social construction, identity theory, and discourse analysis. For instance, Q has been effective in applications to a wide variety of substantive matters Kitzinger's (1986, 1987) studies on lesbianism are illustrative. Stainton Rogers and Stainton Rogers (1989, 1990) have used Q to deconstruct the child abuse controversy and alcoholism. McKeown (1990) has discussed Q in terms of textual interpretation more generally, and Dryzek (1990) has tied Q to discourse analysis. Other illustrative examples would include Cottle et al.'s (1989) and Senn's (1991) studies of pornography, Gopoian and Brown (1989) on political campaign strategy, Peritore's (1990) series of studies on religion and politics in Brazil, and Steuernagel and Poole's (1989) examination of an aspect of a particular theory of justice. Other more recent examples of the applications of Q methodology have included studies focused on contentious discourse on sustainability (Wolsink and Breukers, 2010), applications in human geography (Eden et al. 2005), land management (Burns and Cheng, 2007) and the politics of restoration ecology (Woolley and McGinnes, 2000). These applications have demonstrable overlapping rationale useful to the contentious issues pertaining to land use regulation, ecological sustainability and agricultural viability in the Niagara Region tender fruit area as subsumed by the Greenbelt Plan area.

The history of Q Methodology is linked to the career of its inventor, William Stephenson (1902-1989) and connections have been made between the values of Q in eliciting narratives about people’s perspectives (e.g. Sharpless, 1986 explored the connection between oral history and Q). Unlike other types of methodologies, the categories are not overlaid onto the data; they emerge from it (Brown, 1993). McKeown and Thomas (1988) provide clear guidelines for executing the Q Methodology and argue that it generally occurs in five stages. First, the researcher develops the concourse. Second, a subset of statements called a “Q sample,” is drawn from the larger concourse, which is eventually presented to participants in the form of a Q sort. Third, the researcher ensures that (if categories exist for the statements prior to the sort) that each category contains an equal number of statements. Importantly, "meanings are not to be found solely in the categorical cogitations of the observer, but in the reflections of the individual as he or she sorts the statements in the context of a singular situation" (Brown, 1993). The categorizations are a way of ensuring that the entirety of the topic is covered by the researcher. The fourth stage is the Q sort. The Q sample (the statement concourse) is administered to participants (subjects, respondents) in the form of Q sort, which has most commonly been administered in form of a pack of randomly numbered cards (one statement to a card). Generally, the respondents are provided with a scale and a suggested distribution and are instructed to rank the statements along a continuum from "most agree" at one end to "most disagree" (Brown, 1993). Once the respondent has completed a cursory reading of the statements they sort them according to the instructions. The fifth stage is an interview with a brief list of questions that explores the respondent's position on the statements.

In this study the Q sorts were executed using Q Assessor a relatively new computer program for online Q sorts. Online Q sorts are a new approach to Q Methodology and although there is some contention in respect to the efficacy of this approach, there are indicators that online Q sorts viewed as favourable by respondents. For instance, Singer (1994) argues, that in addition to appearing less intrusive to respondents, collecting data via computer-based Q sorts may actually be enjoyable for the sorter. The conventional Q sort advocated by Stephenson (the table-top card sorting method) is not dissimilar in terms of "play theory[10]" from the online sorting (a result of the fact that computers are commonly utilized for game purposes or during leisure time) (Singer, 1994).

4.5.1 Document analysis and statement isolation

The documents that were gathered for analysis were meant to cover a range of interests/concerns related to the Niagara Region case study area. This forms the first stage of the Q Methodology, wherein pertinent statements are distilled out of semi-structured interviews or (in this case) documents and relevant literature (McKeown and Thomas, 1988). Extracting the statement concourse for primary and secondary sources is a validated method for providing a comprehensive discourse on relevant subject matter (Brown, 1993). When the concourse subject incorporates a broad array of documents, literature, public media dialogues, opinions, previous research and responses to regulatory bodies by organizations, it is analysis of the existing statements is an appropriate way of defining the concourse space. The documents that were included in the analysis fell into three thematic categories: 1) Criticisms and concerns pertaining to the Ontario Greenbelt, 1) Strategies by the Regional Municipality of Niagara pertaining to a) agricultural viability (including irrigation studies, farm economic viability, value-added activities, a review of the Provincial Policy Statement from 2005 and proposed regional policy plan amendments related to agricultural value-added activities policies); and b) input from the

[10] Stephenson argued that the conventional Q sort technique encouraged "pure play" that fostered browsing, wandering, and the emergence of new or unusual ideas (see Singer, 1994 for expanded discussion).

community on the future of the region (including a resident survey, and a summary of community workshops) and 3) Concerns about the natural heritage features of Southern Ontario in general (and the Niagara region in particular). Additional statements were extracted from the literature review on agri-environmental programs from the first section of this paper. Other documents included regional media coverage of issues (newspaper articles) and a letter from the Ontario Federation of Agriculture to the Ministry of Municipal Affairs and Housing on "Criteria for assessing municipal requests to expand the Greenbelt", studies commissioned by the region, a study by Nasir et al. (2010) on participation in the NPCA's WQIP, committee recommendations to the Regional Council and academic papers on these topics.

An initial list of 182 statements was pared down to 36 statements relevant to questions of program content. Q Methodology experts suggest that it is important to reduce the statements to fewer than 100 because it becomes too cumbersome for the participants during sorting (McKeown and Thomas, 1988). The document analyses of local farming concerns revealed that agricultural viability, ecosystem functioning and landscape-level restoration are important components that need to be addressed by agri-environmental programming in order to address agricultural sustainability concerns. The Q-sort statements, therefore, were condensed to focus particularly on these issues. The following table provides the list of statements presented to the respondents, covering the major program content issues extracted from the issues identified.

TABLE 4-5. EXTRACTED STATEMENTS PROVIDED TO THE RESPONDENTS FOR SORTING

1. Natural heritage features are inadequately protected and enhancement projects are limited.
2. Habitat enhancement/restoration projects are sufficient.
3. Water improvement projects are important to the farming in this community.
4. Farmers have a more specific and enhanced role in stewardship due to recent changes in land-use legislation.
5. Pest control can be enhanced through maintenance of natural features on farms.
6. Riparian buffers can filter field run-off.
7. Riparian buffers of certain sizes can filter field run-off.
8. Riparian buffer sizes must be designed according to specific needs of a site in order to filter field run-off.
9. Water quality can be improved using native species plantings.
10. Ecological restoration – in the form of natural habitat improvement – is not a priority on farms.
11. Fostering habitat diversity on marginal land on farms is important to farming operations.
12. There is a need to increase the ecological restoration efforts on agricultural landscapes including managing farm inputs and outputs using native species assemblages.
13. Native species generally are an important part of farmlands.
14. Certain types of native species (e.g. beneficial insects, mutualistic fungi and bacteria) are important parts of farmlands.
15. If information on the beneficial functional aspects of native species was provided to farmers they would be more likely to participate in restoration programs (e.g. information on the benefits of important combinations of native species and

associated benefits of those groups).

16. Water quality issues could be cross-listed with other programs (e.g. food safety and traceability) to reduce the regulatory (‘red tape’) burdens on farmers.
17. Local farms are important locales for restoration projects with regional goals.
18. Farmers would plant native species in particular combinations and densities if provided the correct information on how to proceed.
19. Farmers would like to participate (evenly marginally) in monitoring the restoration projects taking place on their properties.
20. Marginal lands on farms can be useful to farmers (e.g. wild pollinators, pest control, erosion control etc.)
21. How “managed lands” interacts with “natural lands” on farms influences the health of the farm.
22. Wildlife habitat is important to farmers in Niagara.
23. Natural features play an important role in how farmers’ perceive their land in the Niagara region.
24. Allocation of funds for conservation efforts should place more emphasis on the landowner’s agricultural requirements.
25. The amount of rented farmland in Niagara is growing and influences farmer participation in multi-year agricultural-environmental programs.
26. Single-desk marketing boards are key to farming viability.
27. Single-desk marketing boards are key to maintaining viability of smaller family owned and operated.
28. Land stewardship has an important and inherent role in farming.
29. There is adequate support and encouragement from the government for farmers to adopt environmentally-oriented farming practices.
30. Farmers must capitalize on available incentive/ funds in order to remain a viable operation.
31. On-going financial incentives (e.g. monthly, bi-annual, or annual payments) for participation in environmental programs are effective for supplementing farming incomes.
32. Ecosystem services are important to farming.
33. There are important benefits from natural pest control.
34. Biodiversity is important in the functioning of farms.
35. Agriculture and related industries are (should remain) significant part of economic base and should be fostered by hospitable incentive structures.
36. More information on funding options for innovations pertaining to farm diversification strategies is necessary.

TABLE 4-6. INTERVIEW QUESTIONS THAT FOLLOWED THE Q SORT

1. What if anything, do you think is missing from the agri-environmental programs that are currently available for farmers in Ontario?
2. What do you think are the important ecological services agricultural landscapes provide?
3. Do you think that current policy/ funding structures adequately support the protection or enhancement of the provision of ecological services on farms?
4. What do you think is the most important role of environmental programs that target farmers?
5. How important do you think the role of stewardship is for farmers today?
6. Do you think restoring altered landscapes is important? Do you think it should be

funded?

4.5.2 Participant recruitment for Q Sorts

Participant recruitment focused on local farmers. "Local" in this research refers to those agricultural operators within the Greenbelt who are also tender fruit and grape farmers in the Niagara region. Atwell et al. (2009) suggest that using nonprobability sampling techniques allow researchers to delve in deeper into a smaller number of cases relevant to the study questions. The authors argue that the restrictions from quantitative studies are moot because the aims and methods differ from studies where the researcher attempts to generalize to a broad population and therefore, a representative sample is drawn from a large number of cases. In this study purposive sampling was used (Neuman, 2003; Handwerker, 2005) to choose the initial participants for the Q sort. The represented a diversity of local perspectives within the following overlapping groups, farm operators, rural opinion leaders, local conservation personnel. The intention behind this facet of the research was not to recruit a large sample size as is required by R-method surveys. Q methodology is based on the understanding that increasing sample size does not increase the validity of the study (McKeown and Thomas, 1988). Rather, a grouping from the farm community and associated administrators were recruited to ensure during the factor analysis from the Q sort that the relevant spectrum of factors emerged from the sorting exercise. Although researchers may have a priori hypotheses for Q sorting factors, the important aspect of the participation is that the relevant voices (in this case, the farm community) covers the array of issues possessed by that community. Therefore, increasing sample size does not improve the study once the various issues have emerged during the factorial analysis (McKeown and Thomas, 1988). For this study recruitment focused on local farmers that either have participated in projects (e.g. Ontario EFP, local initiatives or any combination therein), are at the forefront of innovation in their operations (social, ecological, technological, or any combination therein) as well as individuals who hold a position of importance in the farming community (e.g. on the board of local cooperatives or tender fruit of grape marketing boards) because it is theorized, that these individuals would be most likely to give careful consideration to the content offered by potential programs. Thirteen individuals were recruited for the study five agreed to participate. Three are farm operators and three are considered to be administrators[11] with relevant experience or insight into this topic.

4.6 Results

Q-methodology uses factor analysis to parse out the factors from the Q sorts. Factor analysis examines a correlation matrix and determines how many basically different Q sorts exist within the study (McKeown and Thomas, 1988). Factor analysis is useful for parsing out the Q sorts that are highly correlated with one another, also known as possessing "family resemblance" according to McKeown and Thomas (1988). The purpose behind the analysis is to extract the Q

[11] One farmer is also an administrator in a local food cooperative and can be classified as both a landowner and administrator.

sorts that are correlated with members of one family or one "emergent theme" but not do not resemble the members of other families (i.e. factors). The actual number of factors that emerge during analysis is dependent on how the respondents rank the statements (i.e. the factor loadings). As this study used Q-Assessor for data collection purposes, Q-Assessor was also used for data analysis. The data management and analysis option offered by Q-Assessor is one of the major benefits of this program. Processing the data collected from Q sorts has always been a major limiting step for Q methodology (Q-Assessor, 2010). This program was chosen for data analysis because it uses a modern version (Ruby) of the Q specific command-line tool (PQMethod) which handles the peculiarities of Q data where standard statistical packages are not as capable (Q-Assessor, 2010).

TABLE 4-7. ORIGINAL UNROTATED AND ROTATED FACTORS

	Original unrotated factors						
	Respondents	**A**	**B**	**C**	**D**	**E**	**h²**
	1	0.56218*	-0.15388	0.15259	-0.05914	-0.20747	0.4095
	2	0.14317	-0.02856	-0.00262	0.75969*	-0.02275	0.5989
	3	0.37517	0.24505	0.76644*	-0.01424	0.45996	1
	4	0.56218*	0.3672	0.00017	0.21287	0.20769	0.5392
	5	-0.01041	0.71025*	-0.15188	-0.21352	0.03886	0.5748
	Eigenvalues	0.7934	0.7238	0.6338	0.6717	0.2997	3.1224
	% Total Variance	15.868	14.476	12.676	13.434	5.994	62.448
	*Significant by Fuerntratt Criterion.						
	Rotated Factors						
	Respondents	**A**	**B**	**C**	**D**	**E**	**h²**
	1	0.62255*	-0.08837	0.10213	0.02048	0.05759	0.4095
	2	0.0214	-0.11805	0.01063	0.76159*	0.06661	0.5989
Sorts	**3**	0.15317	0.0636	0.98178*	0.01461	0.09153	1
	4	0.28072	0.34335	0.29241	0.30379	0.406	0.5393
	5	-0.11973	0.73264*	0.043	-0.13172	0.06661	0.5747
	Eigenvalues	0.5047	0.6804	1.0617	0.6903	0.1853	3.1224
	% Total Variance	10.094	13.608	21.234	13.806	3.706	62.448
	*Significant by Fuerntratt Criterion.						

In Q-Assessor the centroid method (sensu Brown, 1993) is used to generate the unrotated factors. The centroid factors are the extracted categories of correlations around which Q sorters align themselves during sorting (McKeown and Thomas, 1988). The loadings "express the extent to which each Q sort is associated with each factor (factor loadings in excess of 0.50 (plus or minus) can be considered significant" (McKeown and Thomas, 1988). After the unrotated data was extracted, varimax rotation[12] was used because manual rotation is difficult when data sets are fuzzy, thereby reducing the accuracy of the rotations (Q Assessor, 2010). The factors that emerge during analysis are qualitative categories of thought. According to McKeown and Thomas (1988), in general, including additional respondents does not have a perceptible influence on the factor scores because the real purpose of this type of study is to examine the emergent factors (types of perspectives) in existence in the general population and is not concerned with the proportions of individuals that hold those views.

Prior to the varimax (orthogonal) rotation respondents 1 and 4 both clustered around Factor A. Post-rotation however, respondent 4 fell below the threshold of significance and is no longer aligned with any particular emergent factor. According to Rummel (1967) this is often the case with simple structure rotations because they minimize the number of variables (i.e. respondents) loading highly on a factor. When using a simple structure rotation, each factor is rotated until it defines a distinct cluster of interrelated variables; through this rotation the factor interpretation shifts from unrotated factors delineating the most comprehensive data patterns to factors delineating the distinct groups of interrelated data (Rummel, 1967). The purpose of the rotation is to define a small number of distinct clusters of interrelated phenomena and changes the "unrotated factor patterns from being general to the largest number of variables to patterns involving separate groups of variables". The main assumption behind this type of analysis is that if phenomena can be described effectively using simpler factors (i.e. patterns) than the principle of parsimony states that we should shift from general factors involving *all* the variables to group factors involving different sets of variables (Rummel, 1967). In this case, this analysis examines the strength of the correlations between the ranked statements by the respondents to determine commonalities regarding principles behind agri-environmental program content.

4.6.1 Emergent Factors

Using factor analysis four main issue clusters emerged from the Q sorts as factors or patterns. A fifth factor, Factor E also emerged but is largely insignificant and was removed from the analysis because it contained neutral responses from the participants, i.e. the Factor E loadings were clustered around "0" on the rating scale and therefore do not pertain to the issues that elicited the vehement responses (agreement or lack of agreement). According to Rummel (1967) this is characteristic of rotated factor analysis where the emergent factors become less significant in terms of loading from A, B, C onward.

4.6.2 Factor A: Multi-scale interactions

Factor A is most closely aligned with the perspectives of two respondents. The first is a member of the regional conservation authority the second (who was aligned with this factor prior to the rotation) is a local landowner (farmer) who has participated in both regional conservation

[12] Varimax rotations search for a linear combination (a rotation) of the original factors such that the variance of the respondents' loadings is maximized. After a rotation each original variable is associated with one or a few factors (Rummel, 1967).

initiatives as well as a provincial agri-environmental program (i.e. the Ontario EFP). The distinguishing statements for this factor pertain to multi-scale interactions in terms of policy (e.g. cross-listing regulations) and land-use decisions (e.g. restoration on private lands that are directed by regional conservation agendas). The conservation administrator ranked this statement "Local farms are important locales for restoration projects with regional goals" as (4) and ranked the other distinguishing statement "Water quality issues could be cross-listed with other programs (e.g. food safety and traceability) to reduce regulatory ('red tape') burdens on farmers" as (-4). The conservation authority has a distinct agenda in restoration and conservation projects on agricultural lands in the region with different objectives than agricultural operators and this choice of ranking may indicate that changes in policy that are perceived as infringing on those undertakings are not supported.

4.6.3 Factor B: Farm viability (economic and ecological)

Factor B is most closely aligned with the perspectives held by a local farmer who could be considered an innovative thinker in local community. The distinguishing statements in this category pertain mostly to farm viability in terms of economic viability as well as ecological viability. The statement "Native species generally are an important part of farmlands" was ranked (-3) by this individual. The statements that pertain to economic viability, "Single-desk marketing boards are key to farming viability", "Single-desk marketing boards are key to maintaining viability of smaller family owned and operated farms" and "Farmers must capitalize on available incentive/ funds in order to remain a viable operation" were ranked (4, 3, and 5) respectively by this individual. The economic aspect of agricultural viability was most characteristic of this individual's sort. It is interesting to note that this individual also ranked this statement "Allocation of funds for conservation efforts should place more emphasis on the landowner's agricultural requirements" as (3), and this statement "On-going financial incentives (e.g. monthly, bi-annual, or annual payments) for participation in environmental programs are effective for supplementing farming incomes" as (4). This suggests that this landowner may be willing to participate in an agri-environmental program if it was structured and marketed as an on-going program with ecological benefits for the farmscape.

4.6.4 Factor C: Ecosystem services and restoration on farmlands

Factor C was most closely aligned with an administrator who has experience in agri-environmental program research and the distinguishing statements are concerned with ecological restoration and ecosystem services on farmlands. This factor is considered the most significant in terms of eigenvalue. In addition to the Fuerntratt Criterion displayed above, when determining whether or not a factor is significant, it is a common practice to employ the eigenvalue criterion (sensu McKeowen and Thomas, 1988). This principle states that a factor's significance is demonstrated when a factor's eigenvalue is greater than 1.00. According to this principle, Factor C, with an eigenvalue of 1.0617 is significant. There was largely a consensus on these statements indicating that ecological restoration is considered by landowners and that ecosystem services are considered at least moderately important to farming.

4.6.5 Factor D: Natural landscape features and landowner decision-making

Factor D is most closely aligned with the perspective of the local farmer/ involved member in agricultural organizations for food distribution. This emergent theme is related to natural features influencing landowner decision-making and vice versa. The individual that most defined this category ranked the distinguishing statements very high in terms of agreement. The statements, "Are water improvement projects important to the farming in this community?" and "Natural features play an important role in how farmers' perceive their land in the Niagara region" were ranked +4 and +5 respectively. Although this respondent felt strongly about the issues within this factor, there was little consensus among the other respondents.

TABLE 4-8. DISTINGUISHING STATEMENTS FOR FACTORS A THROUGH D

Factor A	**Distinguishing Statements For Factor A (Significant at < 0.05)**
Multi-scale interactions	Water quality issues could be cross-listed with other programs (e.g. food safety and traceability) to reduce the regulatory ('red tape') burdens on farmers.
	Local farms are important locales for restoration projects with regional goals.
Factor B	**Distinguishing Statements For Factor B (Significant at < 0.05)**
Farm viability (economics and ecology)	Native species generally are an important part of farmlands.
	Single-desk marketing boards are key to farming viability.
	Single-desk marketing boards are key to maintaining viability of smaller family owned and operated.
	Farmers must capitalize on available incentive/ funds in order to remain a viable operation.
Factor C	**Distinguishing Statements For Factor C (Significant at < 0.05)**
Ecosystem services and restoration on farmlands	Ecological restoration – in the form of natural habitat improvement – is not a priority on farms.
	Ecosystem services are important to farming.
Factor D	**Distinguishing Statements For Factor D (Significant at < 0.05)**
Natural landscape features and landowner decision-making	Are water improvement projects important to the farming in this community?
	Natural features play an important role in how farmers' perceive their land in the Niagara region.

The following table provides the distinguishing statements for each factor and compares each factor Z-score (standard score) and ranking across the categories.

TABLE 4-9. DISTINGUISHING STATEMENTS FOR FACTORS (SIGNIFICANT AT P < 0.05)

	Factors									
	A		B		C		D		E	
	Z-Score	Rank	Z-Score	Rank	Z-Score	Rank	Z-Score	Rank	Z-Score	Rank
Factor A										
Water quality issues could be cross-listed with other programs (e.g. food safety and traceability) to reduce the regulatory ('red tape') burdens on farmers.	-1.633	-4	0.408	1	0	0	0.817	2	0	0
Local farms are important locales for restoration projects with regional goals.	1.633	4	-1.633	-4	0	0	-0.408	-1	0	-1
Factor B										
Native species generally are an important part of farmlands.	0.817	2	-1.225	-3	0.817	2	1.633	4	0	-1
Single-desk marketing boards are key to farming viability.	-0.408	-1	1.633	4	-1.225	-3	-1.225	-3	0	1
Single-desk marketing boards are key to maintaining viability of smaller family owned and operated.	-0.408	-1	1.225	3	-1.225	-3	-0.408	-1	0	2
Farmers must capitalize on available	-1.225	-3	2.041	5	0.408	1	0	0	0	2

incentive/ funds in order to remain a viable operation.										
Factor C										
Ecological restoration – in the form of natural habitat improvement – is not a priority on farms.	-0.408	-1	-0.408	-1	-2.041	-5	0.817	2	0	-2
Ecosystem services are important to farming.	0.408	1	0	0	2.041	5	-0.817	-2	0	3
Factor D										
Are water improvement projects important to the farming in this community?	0	0	0	0	-0.817	-2	1.633	4	0	-4
Natural features play an important role in how farmers' perceive their land in the Niagara region.	0	0	-1.225	-3	-0.408	-1	2.041	5	0	1

4.6.6 Consensus statements: areas to start re-developing program content

The purpose of this study is to extract areas of program content on which a more inviting agri-environmental program can be established. While examining the rankings two distinct areas of consensus emerged which are significant factors for program re-development: perceptions of ecological restoration on farmlands and incentives for agroecological viability.

4.6.6.1 Perceptions of ecological restoration on farmlands

"Are habitat enhancement/ restoration projects sufficient?" The rankings from the respondents were (-4,-1,-2,-4,-1). This suggests that there is a consensus among the respondents that habitat enhancement and restoration projects are perceived as insufficient in the Niagara region area. In addition the statement "Ecological restoration—in the form of natural habitat improvement—is not a priority on farms" was ranked (-1,-1,-5, 2,-2). This suggests that the respondents felt that ecological restoration and natural habitat improvement is at least somewhat of a priority for farm operators. Interestingly enough however, the statement "There is a need to increase the ecological restoration efforts on agricultural landscapes including managing farm inputs and outputs using native species assemblages" was ranked (1, -2, 1, -5, 1) by the respondents. This suggests that the respondents do not feel that ecological restoration in the form of management of farm inputs and outputs should be increased on agricultural lands.

In response to the question "What if anything, do you think is missing from the agri-environmental programs that are currently available for farmers in Ontario?" one local farmer responded that "Agri-environmental programs are band aids at best as long as the the whole agri-business structure favors industrial farming, monoculture, and globalization." This same respondent answered "What do you think is the most important role of environmental programs that target farmers?" with the response "Enabling farmers to improve environmental impact of their farming operation."

4.6.6.2 Incentives for agroecological viability

Another area of agreement pertains to incentives for farmers. The statement "Farmers must capitalize on available incentive/ funds in order to remain a viable operation" was ranked (-3, 5, 1, 0, 2) by respondents. In addition, there was consensus among respondents that incentives are important part of agri-environmental programs as well as farm viability. The statement "Agriculture and related industries are (should remain) a significant part of economic base and should be fostered by hospitable incentive structures" was ranked (0, 3, 3, 1, 4) by respondents. Respondents also agreed that incentives are an important tool in the recruitment of farmers. The rankings also suggested that most respondents were receptive to the idea of offering farmers an on-going incentive as way to encourage farmers to participate in production of ecological services (this structure is reminiscent of the European model as discussed above). For instance, the statement "On-going financial incentives (e.g. monthly, bi-annual, or annual payments) for participation in environmental programs are effective for supplementing farming incomes" was ranked (0, 4, 4,-2, 3) respectively with the three landowners/ farmers rating this statement (4, 4, and 3). In the interview questions that succeeded the Q sort, respondents were asked "do you think that current policy/ funding structures adequately support the protection or enhancement of the provision of ecological services on farmlands?" One respondent, a local farmer, provided insight into this issue by saying:

> "basically, here is what you need to do: 1. provide great *[sic]* incentive through funding for farmers to support farmers, than, everything else will fall into place… 2. if you want the protection of ecological services on farms, provide 100% funding and continual funding on a yearly basis to maintain these zones at NO net cost to the farmer. Infact *[sic]*, it should be a net profit."

In response to this question: "Do you think restoring altered landscapes is important? Do you think it should be funded?" the same respondent went on to say "i think anything that anyone tells me to do, that doesnt *[sic]* own my land should be funded. the rest of the world pays their farmers greatly for these programs."

4.6.7 Summary of the findings: developing a new direction

Getting to the heart of what an effective agri-environmental program would centre on and what it would offer is an important task in order to improve program uptake. The statements on ecological restoration and agroecological incentives offer insight into what is required by landowners and the extended farming community but some responses appear contradictory. Other statements perhaps offer insight into parsing out these conflicts and further defining program content. It does not appear that any of the respondents feel that farmers would evade participation in a properly designed and funded agricultural program; on the contrary it appears that improving the structure of the program would greatly increase the participation in these endeavours.

"What if anything, do you think is missing from the agri-environmental programs that are currently available for farmers in Ontario?" Two of the administrators included in this study answered this question with the following responses:

> More available funding and political will. The Environmental Farm Plan funding provided through the OSCIA is always over subscribed to the point where farmers need to line up early in the morning just to hopefully get some funding on the first day the funding is available. Funds available municipally and regionally are also over subscribed. There is a will and desire to make changes from the farm side, the only clog in the system comes from the availability of funds and the will of government (fed provincial and local) to prioritize these funds for a better farming community and cleaner environment.

The second response offered insight into the failures of current agri-environmental program offerings. The respondent suggests that current programs are insufficient in respect to aiding in agricultural livelihood protection.

> One missing piece is that there is no widespread program to support farmers for their role in providing environmental services on an ongoing basis. Existing programs, such as the environmental farm plan, provide funding for environmental enhancement projects on farms, but these programs do not directly support and contribute to the livelihood of farmers, or compensate them for the public service they are providing – on an ongoing basis.

In addition, one of the farmers responded to this question with a more vehement opposition to current agri-environmental structures suggesting that the current approach to policies are just insufficient, but that they actually work to the detriment of farmers in Canada.

> The fact that this is OUR land, and we have invested in purchasing it and maintaining it for several years, decades and centuries. in other words, the agri-environmental programs do not address the fact that without farmers YOU GO HUNGRY. You make us try to compete on a global scale with other countries whos *[sic]* input costs are a fraction of ours and use pesticides Canada banned decades ago.

4.6.7.1 Incorporating the rule of Maximum Net Gains

Based on the Q sorts and the insight gained from these interview responses, the crux of the issue is that farmers are willing, in some cases, even eager, to participate in agri-environmental programs; in particular, they would participate in them if the programs were centred on ecological services with adequate compensatory structures for landowners. The issue of demanding public goods from private lands is something that needs to be addressed in order to gain support from landowners that are concerned with government interference. In particular, farmers may feel that providing ecological services on private land is another way that farmers are delivering a crops to the market. Farmers appear to dislike the idea of government intervention for the purposes of ecological services production but it is less controversial if farmers are not only compensated for it, but if it becomes a form of paid commodity in itself (recall this statement from above "if you want the protection of ecological services on farms, provide 100% funding and continual funding on a yearly basis to maintain these zones at NO net cost to the farmer.") This statement suggests that offering a program that makes producing ecological services a competitive market in the same way that units of production have been championed over time in the productivist agricultural paradigm could more adequately reflect the desires of the farming community than the current program options. To follow up on this point, as stated above, one respondent (a local farmer) argued, in respect to current approaches of agri-environmental programs, that they are "band-aid" solutions "as long as the whole agri-business structure favors industrial farming, monoculture, and globalization." Offering a fiscal transfer that supplements their incomes in addition to the production of commodities based on the degree or level of contribution of ecological services they provide is an interesting concept which requires a transition from the current productivist stabilization status quo in agricultural policy in Canada (Skogstad, 2009).

In addition, the responses suggest that farmers are reluctant to participate in programs if they feel that it places limitations or restrictions on their right to operate, so the program should also offer tangible benefits in addition to financial incentives so the program does not appear to be only concerned with the public good. There appears to be both a fear of government intervention but also an inherent appeal for the government to re-develop the way it interacts with farmers financially and in terms of policies that influence the lives of farmers (e.g. there are bans on pesticides but not enough help for farmers to compete in the international market against cheap food produced using those same banned substances). This apparent contradiction could be best resolved using the concept of *maximum net gains* discussed by Gibson et al. (2005) as an important trade-off rule in sustainability assessments. This rule recognizes that projects and policies often have detrimental effects on social-ecological systems and that what is perceived as beneficial at one scale of the system can be perceived differently at another scale. Giampietro (2004) argues that our problem descriptions and models for policymaking are often not dynamic enough to actually address the entirety of problems in social-ecological systems. As a result policies often only address certain aspects of the system (treating a symptom as opposed to the cause of the problem). The rule of maximum net gains offers a way to reconcile the differing conceptualizations of problems with sustainability goals. The rule stipulates that an acceptable trade-off "must seek mutually reinforcing, cumulative and lasting contributions; and must favour achievement of the most positive, feasible result, while avoiding significant adverse effects" (Gibson et al. 2005).

Offering feasible options to increase the competitiveness and/or viability of farmers might be encouraged by Canadian farmers thus improving livelihood sufficiency. Livelihood sufficiency therefore, needs to be reconciled with *socio-ecological system integrity* which Gibson et al. (2005, pg. 95) describes as building "human-ecological relations to establish and maintain the long-term integrity of socio-biophysical systems and protect the irreplaceable life support functions upon which human as well as ecological well-being depends". Concerns of socio-ecological system integrity were reflected in the Q sorts by respondents. The statement "How 'managed lands' interacts with 'natural lands' on farms influences the health of the farm" was ranked (2, -1, 3, 3, 0) by respondents. There is some consensus on this statement, importantly; there was no vehement disagreement about the interaction of farmlands and natural lands. This provides a good, almost neutral issue, on which to begin to address the issue of maximum net gains in agri-environmental programs in Ontario. In addition, two other statements offered some consensus among respondents. "There are important benefits from natural pest control" was ranked (2, 2, 0, 2, 3) and "Land stewardship has an important and inherent role in farming" was ranked (2, 2, 4, 0, 2). The intersection of these three statements relates to concept of "maximum net gains" as proposed by Gibson et al. (2005). In this study, maximum net gains requires designing an agri-environmental program that ensures that, financially, farmers can continue farming while at the same time improving their interaction with the environment in which they are embedded. Achieving maximum net gains in agri-environmental programming requires offering farmers competitive or at least sufficient on-going incentives to provide public goods and services.

Additionally, based on the burden of the rule of maximum net gains, it is important to offer a program that allows farmers to design the ecological services that they will deliver based on a "mutually reinforcing" with "cumulative and lasting contributions" to ecological functioning and agricultural sustainability, that is, farmers choose to enroll in the program by determining what ecological functions are required by their operations, and then participate in providing ecological services. This would allow farmers to avoid "set-aside" programs that concern many of agricultural operators because it requires them to remove land from production and would encourage farmers who are less likely to participate in programs that are based on set-aside particularly if their land does not contain natural landscape features. One respondent argued that "in a capitalistic society… things that are wanted, desired and demanded also receive monetary compensation. The more you want, desire, demand ecological protection the more you should pay the lucky farmer with these features on THEIR property." The content of a new program should focus on encouraging farmers to participate based on what their land offers the public (ecological services) and what the land can offer them (ecological functioning). The argument pertains to ecological protection of natural features on private property, as of right now there is no option for farmers do not possess what would be classified as "natural features" worthy of protection.

4.7 Design Characteristics for New Agri-environmental Programming

This section of the research is the third contributing source for criteria or design characteristics for useful agri-environmental programs and will be integrated with the literature review and information gathered from the Q methodology. The outcome is a set of design criteria that incorporate the findings from the first two sections of the chapter.

4.7.1 Institutional Transitions

The European Agri-environmental Policy (refer to Chapter 2) or AES provides a useful template from which a Canadian perspective can be developed. In this study, Factor B emerged as a theme that reflects a desire from the local farming community to derive an agri-environmental program that is similar to structures employed in the European context. Agricultural viability would be linked to on-going incentives for ecosystem service provisions. The literature provides many examples of required ecosystem services in addition to the provision of public goods from agricultural lands. However, exact configurations of landscape and habitat mosaics will be context dependent. A unifying approach that incorporates indicators, ecosystem objectives and monitoring of agri-ecological health and resilience, land owner perspectives, land use requirements, and transitions to incentives for livelihood viability is the most adaptive and effective way to deal with impending large-scale abiotic changes that will have cascading impacts on agriculture in Ontario.

4.7.2 Generating Regional and Localized Ecosystem Services

Additional considerations for a new agroecosystem approach pertain to recognizing the interaction between individual land parcels and regional conservation strategies. Factor A emerged as a theme that pertains to multi-scale interactions in this study. This includes multi-scale interactions in terms of policy as well as the multi-scale dynamics reflected in ecosystems. Giampietro (2004) argues that designing effective policies in social-ecological systems requires being cognizant of the possibility of differences of opinions on the efficacy of the policy at various scales; there is often a local level of improvement and a larger scale definition of improvement. This study addresses the impacts of agricultural policymaking that narrowly focused on production outputs at the expense of ecological and social well-being in conjunction with the state assistance paradigm for agricultural policymaking. For instance, the Environmental Farm Plan was designed to address concerns over environmental degradation resulting from agricultural operations. However, the program is designed to address specific facets of agricultural operations (e.g. water quality) and does not take a multifunctional approach to addressing the interactions of managed and natural systems. According to Giampietro (2004) what appears as solutions on one hierarchical level can overlook the root of problems at the local scale, which often makes the policies ineffective and inefficient.

One of the multi-scale issues that agri-environmental programs should begin to consider pertains to meta-population theory. Suding and Gross (2006) discuss the differences in the various scales of consideration relevant during restoration initiatives. They divide the scales of restoration into fast processes (which happen at smaller scales) and slow processes (which occur at larger scales over-longer periods of time). These designations are useful because they aid in theoretical projections about the scale of interest for a restoration project and about the rate of change the system of interest may be experiencing. Accordingly, Suding and Gross (2006) argue that fast processes interact with slower processes through the relationships among various hierarchical scales. In particular, one of the main drivers of ecosystem change which happens over a longer time scale is the disintegration of metapopulations (a slow scale degradation that we ultimately will be affected by on smaller scales). This is the result of the accumulation of individual degraded landscapes (e.g. conversion of land for development or agriculture) which weakens the dynamics that link the landscape and population scales.

Suding and Gross (2006) argue that metapopulations can exist at either a high density (connected state) or a low-density (fragmented state). If a population becomes extinct at one site, recolonization is dependent on the combined size of, and the distance between the surrounding populations as well as the behaviour and vagility of the species (Suding and Gross, 2006). Therefore, a feedback exists between regional metapopulation size and the probability that a single population can sustain itself. If a population is not re-established it jeopardizes the future potential (probability) of a population recolonizing another site, which will cause the regional population to decline rapidly (Suding and Gross, 2006). One suggestion to ameliorate these effects and strengthen the resilience (connection between populations) is to incorporate analogue systems (i.e. novel ecosystems) into landscape level restoration planning. The analogues are not meant to replicate natural systems but to serve as propagule sources to connect populations and increase the response diversity of the entirety of the populations (Suding and Gross, 2006).

Whittingham's (2011) which synthesizes the findings from several studies that investigate the effectiveness of the content of the AES programs (i.e. does the program content actually have the intended effect of increasing biodiversity at farm, landscape, national and international scales in the EU) demonstrated that patch size does influence biodiversity to some degree; however, smaller habitat fragments laced throughout the landscape may also play an important role in biodiversity conservation by increasing the connectivity of the larger protected areas. Whittingham assembled thirteen papers into a Special Report that provides the basis for these claims. In particular, Whittingham discovered that applying management approaches that promote biodiversity conservation to small fragmented pieces of land can have population level effects on farmland birds, invertebrates as well as plants.

Perkins (2011) demonstrated that typical AES - those applied on small fragmented pieces of land- can have substantial population level effects when practical guidance is provided for farmers and when behaviour is modified by advice under the principles of adaptive management.

This means developing appropriate program content with effective communication of materials and objectives in conjunction with farmers changing tactics as the situation changes. Additionally, at the smaller, within-farm scale, noncropped habitat is an important indicator for faunal abundance. For instance, Fuentes-Montemayor et al. (2011) showed a significant positive relationship between noncropped habitat and the abundance of moths whereas Whittingham et al. 2009 and Hanspach et al. (2011) had similar findings for bird abundances.

Additionally, another study by Dallimer et al. 2010 demonstrated that the amount of AES enrolled land in proximity may influence bird abundance such that the extent of noncropped habitat (and AES) both within and between farms is likely to be an important determinant of the effect of AES management on biodiversity (Whittingham, 2011). According to Whittingham, beyond the "within farm scale" other studies uncovered trends at the landscape level that demonstrate that biodiversity is influenced by the extent of land enrolled in AES in the surrounding 10 km by 10 km expanse. For instance, Gabriel et al. (2010) found evidence that birds and a range of invertebrates (e.g. arthopods, bees and butterflies), which are often used as biodiversity indicators, are influenced by the extent of AES within the landscape.

Kleijn et al. (2010) propose two hypotheses of the interaction of conservation and agricultural lands influence on biodiversity. The first termed "land use-moderated conservation effectiveness hypothesis" focuses on within-field processes and suggests that extensively managed "low-input" farmland generally contains more spatial heterogeneity due to low rates of disturbance (i.e. less disturbances in terms of cutting, spraying, fertilizer applications etc.) than intensively managed agricultural fields. As a result, many species occupy the available niches and habitats and are more likely to colonize and reproduce in these areas due to the lengthened time-span between agricultural disturbances. This makes it more likely that viable populations can be sustained in these areas. The second hypothesis termed "landscape-moderated conservation effectiveness hypothesis" suggests that "population persistence of farmland species depends on the continuous colonization and extinction processes in both crop and non-crop habitats." Additionally, "complex landscapes consist of a mosaic of different habitats in which population colonization and extinction rates of many different species are balanced, thus supporting high overall biodiversity" (Kleijn et al. 2010). As a result, extinction becomes the dominant process in intensively managed agricultural landscapes. Importantly, these theories are not competing directly with one another; rather, most species are influenced by factors at both the field and landscape level (Kleijn et al. 2010). Initiatives that are concerned with biodiversity conservation that deliver ecosystem services require consideration of the interaction of the farm/ field scale set within considerations of regional biodiversity dynamics.

4.7.3 Generating ecosystem functions to deliver ecosystem services

Agricultural systems rely upon the delivery of ecosystem services; Factor C was most concerned with the influence of ecosystem services on agricultural lands. Preliminary research by Power (2010) suggests that the value of these services is enormous and yet extremely underappreciated. Depending on the management approaches and particular operating practices, agriculture can be the source of abundant disservices (e.g. loss of wildlife habitat, nutrient run off, sedimentation of water ways, emissions, pollution from pesticides) (Power, 2010). Reidsma and Ewert (2008) argue that it is imperative that agricultural operations adapt to large scale environmental changes in order to retain the capacity to provide services in terms of food and ecological processes; evidence demonstrates that diversification in agricultural operations reduces the vulnerability of farms to environmental variability. In additional agri-environmental programs that foster structurally complex landscapes can enhance local diversity in agroecosystems, which can compensate for local-high intensity management (Tscharntke et al. 2005).

One of the barriers to the implementation of new ecosystem features on landscapes relates to miscommunication of program objectives and eligible actions on farms. Eligible actions in programs like the Ontario Environmental Farm Plan relegate restoration to "habitat improvement" which tends to limit the participation by farmers and attract only the most conservation-oriented of applicants (Smithers and Furman, 2003; Robinson, 2006). Program content could communicate the importance of integrating ecosystem features into farmlands by promoting the ecosystem functions and services derived from these systems as opposed to alienating farmers that may be less inclined to incorporate a natural feature under the impression that it is "nature for nature's sake". ALUS provides incentives to applicants for *conserving* natural features, which is important for those lands with pre-existing ecosystems, but provides no avenue for farmers that are currently without natural landscape features. Additionally, programs (i.e. ALUS in Canada) that focus on ecosystem services are a "goal-oriented" approach to agri-environmentalism. Although there is nothing wrong with protecting ecosystem services, ALUS is not designed to create systems by supporting farmers that (re)instate the components that *provide* those services (e.g. a functional ecosystem may not resemble a historic ecosystem in its entirety but may possess enough structural components to offer the function and services characteristic of the historic system). In most models of ecosystem service supported programs, farmers that are targeted are those with lands already "valuable" in terms of conservation (i.e. ALUS, Environmentally Sensitive Areas, the Countryside Stewardship Scheme in the EU and the Conservation Reserve Program promoted by the USDA). Ecosystem functioning is what provides ecosystem services that are desirable for farm operations and public amenities. Currently no Canadian agri-environmental program is effective (in terms of content) for targeting farmers that desire ecosystem services and providing them the tools via program content to create ecosystems that function to provide services.

This issue relates to two concepts examined by Kleijn et al. (2010); the difference between intrinsic biodiversity and ecosystem function biodiversity. Conservation initiatives with what Kleijn et al. call "intrinsic biodiversity objectives" are concerned with "the conservation of all possible species that could be sustained by a site" or is concerned with particular rare species as an example. Functional aspects of biodiversity "generally target the services biodiversity provides, such as crop pollination or pest control". Initiatives focused on intrinsic biodiversity are best suited to areas that are at the minimum moderately extensively managed and still possess high levels of biodiversity; it is more likely that rare or threatened species would survive in these less altered areas. Functional biodiversity initiatives are better suited to more intensively farmed areas because the ecosystem services derived from these projects will help to off-set the impacts from agriculture particularly in areas where ecosystem services are reduced due to farming practices. Kleijn et al. (2010) argues that clarification of the objectives of agri-environmentalism that is concerned with ecosystem services makes program applications more effective and offers the potential for maximum and mutual net gains for landowners and the wider public.

4.8 Conclusions

The interaction of federal agricultural policymaking (dating back to the post Second World War period) and provincial approaches to land management has had negative implications that have played out in farm communities across the country (Skogstad, 2009) and is visible at the regional and farm scale in the Niagara region. A history of incrementalism in agricultural stabilization programs has resulted in financial instability of small to medium sized operators (Skogstad 2009). This is coupled with disorganised land use planning and devolution and decentralization of planning responsibilities at the provincial level, which has encouraged farmers to rely on sale of holdings for financial reparations. The situation is critical at the regional level in Niagara where agriculture is considered an economic driver as well as cultural identity that is founded on prime agricultural lands. The protectionist approaches to land management for the sake of natural and cultural heritage (and sprawl control) has largely ignored the history of the interaction between state assistance (federal mandates) and reliance on freeholdship (since the shift away from provincial centralized planning in the 1970s in Ontario). This interaction has generated a situation that requires decisive government intervention to remedy the entrenched reliance the sale of land to equalize financial deficits for farmers. It is also important to recognize that this has only been an option for farmers in the peri-urban areas. No such advantage has been enjoyed by farmers in fully rural Ontario. Ultimately this requires bridging the gap between anti-sprawl, natural heritage and cultural heritage imperatives advocated under the new centralized provincial planning interventions. One way to achieve this bridging is to transition towards a multifunctional paradigm for agri-environmental initiatives. Tscharntke et al. (2005) define agri-environment schemes as “incentives for farmers to benefit the environment” however; eligibility for such a program will have to deal with challenges of equitably; such that schemes would benefit rural as well as peri-urban farmers.

This chapter, has therefore, examined the gaps and/or benefits derived from current models of agri-environmentalism in Canada and the European Union (England specifically). The major impetus behind this research agenda is defining appropriate parameters for developing an agri-environmental program that focuses on incorporating native species assemblages on farmlands in order to improve farm functional requirements with the ancillary goal of uniting those requirements with regional conservation objectives (i.e. ascribing to the rule of maximum net gains). In particular, this research examined literature on the content of agri-environmental programs in Ontario and how the content (focus) of programs can be developed to improve participation and the benefits derived from these initiatives (both to farmers and the environment). The agri-environmental models offered to farmers in Canada overlook ecosystem functioning, which should be a major concern for agricultural operators and policymakers alike. A new more effective program particularly suited to Ontario and central Canada (see Skogstad, 2009) should be based on the concept of maximum net gains. The main focus of an effective program would focus on working with farm requirements in terms of ecosystem functioning in terms of functions required by farm type and operations and would account for the "spatial selectiveness" discovered by Smithers and Furman (2003) in the Ontario EFP where farmers are concerned with enrolling facets of the farm that are considered tricky because they fear reprimand due to shaky agricultural practices. A new program would focus more explicitly on those areas and would encourage farmers to enroll the difficult areas of the farm into the program in order to make improvements based on fostering ecosystem functioning (e.g. an irrigation pond that acts also as a collection basin for field run-off could be restored to filter run-off and recycle clean water back onto the fields). Offering on-going incentives was championed by the respondents in the case study in the Niagara region. This type of program would also help to manage the concerns of "natural" and "cultural" heritage that is a main tenet of the Ontario Greenbelt plan. Natural heritage would be improved through incorporating species selections that improve agroecosystem functioning but can also incorporate regional species conservation objectives reminiscent of the Nature Improvement Area model espoused by Great Britain. A regional plan could be developed that would use both farm requirements for ecosystem function as well as corresponding regional requirements to determine where the farm is located in terms of 1) Core areas (high nature conservation value that contain rare or important habitats or ecosystem services), 2) Corridors and 'stepping stones' that will enable species to move between core areas, 3) Restoration areas, where strategies are put in place to create high-value areas (the 'core areas' of the future) so that ecological functions and wildlife can be restored, 4) Buffer zones that protect core areas, restoration areas and 'stepping stones' from adverse impacts in the wider environment, and, 5) Sustainable use areas, these locations are focused on the sustainable use of natural resources and appropriate economic activities.

According to Kleijn et al. (2010) it is important to consider the reasons behind the impetus for biodiversity conservation efforts that incorporate managed lands. Conservation initiatives that are concerned with rare species or high diversity levels should be implemented in different landscapes or areas and using different approaches than initiatives aiming to increase biodiversity because of the services it delivers. This program amendment would focus on native species assemblages with particularly desirable functional attributes for farm operations that also subscribe to regional conservation objectives (e.g. wetland species) and provide the capacity to fill a local ecosystem niche (e.g. improve water quality for irrigation, increases local wetland species, and increases water quality in regional watershed). The particular necessary components isolated from the analysis of local commentary on land management strategies demonstrate a capacity for these areas of concern as points for redevelopment to respond to both regional and national concerns regarding agriculture. The objective is to deliver maximum net gains in the service of the landowners, local and regional ecosystems, as well as the public. Other economic benefits for farmers, other than funding for provision of public ecosystem services, may also encourage consideration of possibilities for additional gains – perhaps pollinators, farm scale hydrology, harvestable crops in buffers and agri-ecological tourism.

5 Assembling Functionally Beneficial Native Wetland Species in two Irrigation Ponds in the Niagara Region

5.1 Introduction

This chapter is a pilot study that investigates native species assembly at the farm-scale. The concern here is trying to increase the amount of restoration efforts that occur on managed lands (i.e. agricultural lands) while also improving the success and effectiveness (i.e. survival and competitiveness of native species) of these types of endeavours. Projects that are undertaken on conservation easements, protected areas, and particularly private lands require techniques that can be employed successfully with minimal efforts by landowners. Additionally, there are always budgetary restrictions particularly with programs that offer incentives to landowners in the form of public funding. These types of programs are also subject to scrutiny in order to ensure that public funds are not being squandered (Whittingham 2011) which makes demonstrating the success of these restoration efforts paramount. Although the scale of focus is zones that have potential for the introduction of functional habitats the objective is to link the individual efforts on farms to regional conservation agendas. The pilot study should be examined with the understood within the context of landscape dynamics of a farming region that are influenced by decisions and policies made the federal and provincial scales. What is currently required is a strategy that provides farmers information on what approach to take on managed lands when the objective is improving ecosystem functioning for the landowner and providing ecosystem services at regional scales that also includes information on appropriate communities, densities and inter and intraspecific competition. Exploiting this relationship between the farm-scale and the regional-scale offers an opportunity to link privately owned land via ecological services (functional plant groupings) to regional conservation diversity goals (see Jackson, 2002).

Agroecosystems require resilience[13] –the ability to maintain fundamental function and structure even with profound socioeconomic or biophysical shocks. Production of food and fibre remains the main focus but this can only continue if governments, producers, and citizens understand that ecosystem services on agricultural lands are essential to the long-term survival of agricultural production in the face of environmental and financial stresses. The focus of this chapter is to begin creating a strategy that responds to the pervasive farm management logic that aim at maintaining production under short-term episodic shocks towards policies and landscape management based on transformation in the face of long-term stress (Smith and Stirling, 2009). Resilience approaches have historically focused on self-organizing human and natural systems that are structured by a set of relatively few dominant processes whose alteration is evident when the resilience of a system has been exceeded and which appears qualitatively altered (Allen et al. 2005). When resilience approaches, however, fail to discriminate between *shock* and *stress,*

[13] Resilience thinking is a theoretical framework for understanding what drives social-ecological systems based on resilience concepts (Folke et al. 2010).

approaches towards social-ecological management tend to obscure the consequences of adapting to (responding to) shocks (Walker et al. 2006) instead of transforming the social and ecological components of the system to maintain requisite levels of functionality (Smith and Stirling, 2009).

Agricultural systems that emphasize both community and ecological resilience can be referred to as resilient agri-ecological systems (King, 2008). The extended emphasis counteracts the dichotomization of conventional contextualization of agriculture and includes all components (or perspectives *sensu* Charron and Waltner-Toews, 2008) such as ecological, socioeconomic, cultural and political aspects. The mode of conventional industrialized agricultural systems that have persisted over the past 150 years has been grounded in and maintained via regulations, subsidies, trade negotiations, policies etc. often at the expense of ecological functioning and ecosystem resilience (King, 2008). Instead the agroecological resilience approach constructed in this study focuses on maximizing the beneficial interrelationship between farming and the ecological system within which it is embedded to maintain the on-going production of ecosystem source, sink and performance. Agroecological resilience therefore, can be defined as the insurance of the productive capacities of agricultural operations through the protection and enhancement of biologically diverse ecosystem functions and consequently, ecological services on agricultural lands.

Social-ecological systems are characterized by sets of discontinuous distribution of structures and frequencies of pulse disturbances that mark the transition between scales. A self-organizing social-ecological system (sensu Kay et al. 1999) that is resilient will maintain the patterns of function within and across scales despite the turnover of specific elements characteristic to the system. Bengtsson et al. (2003) discuss the concept of the conservation of native genetic material and demonstrate the importance of restoring or preserving landscapes outside of reserves or protected areas. Re-assembling or maintaining ecosystems on agricultural lands is important because it provides ecological memory (in terms of seed sources etc.) to the protected landscapes. These production landscapes can make the entire regional landscape more resilient by accounting for longer-term stresses via the assembly of dominant species in functional groups that respond variously to characteristic agricultural stresses (Moonen and Barberi, 2008). Particularly, by maintaining communication (i.e. information transfer or material transfer such as community guilds) among levels, the interactions within levels can be altered without the entire system losing its integrity (Holling, 2001). To reach a goal of increased agroecological resilience and biodiversity, biodiversity management should be directed at increased diversity within or between the functional groups which regulate the main agroecosystem processes of an agricultural operation (Moonen and Barberi, 2008). This study redefines novel ecosystems in terms of active transformations (Folke et al. 2010) in order to provide a basis for establishing required functional linkages associated with particular ecological services. The focus of an actively transformed novel ecosystem can be based on the functional group requirements (and tolerant species) that can generate ecosystem services for individual farms with associated benefits for regional conservation and habitat requirements.

In a study that examined 58 wetlands in South-eastern Ontario Houlahan et al. (2006) determined that wetlands are influenced by adjacent land uses. Perhaps the most important conclusion from this research pertains to managing wetlands in isolation. According to their findings, neighbouring wetlands and neighbouring land use are both influential on the species composition of wetlands. The study determined that a key component in the maintenance of diverse wetland communities is related to the protection of propagule sources up to 250 meters away from the wetland (in terms of buffering capacity of anthropogenic disturbances and invasive species, e.g. forests) and that vectors of dispersal are requisite for the provision of seed sources.

5.1.1 Managing Habitat Fragmentation

One of the main drivers of ecosystem change is the disintegration of metapopulations (a slow scale degradation that ultimately affects smaller scales). This is the result of the accumulation of individual degraded landscapes (e.g. conversion of land for development or agriculture) which weakens the dynamics that link the landscape and population scales. Suding and Gross (2006) argue that metapopulations can exist at either a high density (connected state) or a low-density (fragmented state). For instance, Jacquemyn et al. (2003) discovered that nonisolated ecosystem patches contained significantly more species than isolated patches because the distance to existing habitat remnants is a driver of species richness. This may be an artefact of the interplay of extinction and colonization rates as a consequence of limited dispersal sites. If a population becomes extinct at one site, recolonization is dependent on the combined size of, and the distance between the surrounding populations (Suding and Gross, 2006). Therefore, a feedback exists between regional metapopulation size and the probability that a single population can sustain itself. If a population is not re-established it jeopardizes the future potential (probability) of a population recolonizing another site which will cause the regional population to decline rapidly (Suding and Gross, 2006). The study by Jacquemyn et al. (2003) corroborates this theory. Given that species similarity over a landscape decreases with increasing interpatch distance, species diversity of recently restored patches is interdependent on surrounding “old” patches (remnant habitats) establishing more habitat patches distributed across a landscape will result in a greater quantities of species colonizing newly restored patches (Jacquemyn et al. 2003).

The facilitation of non-native species is another consequence of native species decline resulting from habitat fragmentation (Peters et al. 2006) because many non-native (invasive) species possess competitive traits (e.g. hyper-abundant annual seed set of *Alliaria petiolata,* sensu Murphy, 2005) that allow them to outcompete native species (Tanentzap et al. 2009). Habitat fragmentation is also commonly associated with changing patch sizes and shapes. Decreases in species richness are commonly associated with the decrease in patch size due to disturbance related edge creation (Lovejoy et al. 1986; Bierregaard et al. 1992; Fagan et al. 1999). External pressure on an ecosystem’s boundary can alter the actual shape of the habitat remnant which can make the system more vulnerable to disturbances (e.g. increases the permeability of the boundary to propagule pressures and has the capacity to restrict native species recruitment, increase invasive species composition) (Fagan et al. 1999).

The impacts of disturbances along the edge of an ecosystem can often lead to "modifications" in the interior (Malcolm, 1994). Edge effects can very easily impact species by increasing the abundance of some species while decreasing the abundance of other species (Malcolm, 1994). If the marginal areas of agricultural lands are modified by, for instance, expanded cultivation or land abandonment, new areas will become exposed to the adjacent area that is disturbed and cleared with the edge impacts permeating the habitat (Collinge 1996; Chen et al. 1992; Lovejoy et al. 1986). This can lead to a whole host of changes to the interior area such as changes in temperature, light, moisture and wind (Collinge, 1996). Matlack (1993) found edge effects altered humidity and litter moisture up to 50 metres into the interior of the forest. These types of changes can affect the herbaceous communities in proximity (Collinge, 1996). Disturbances associated with edge creation can also influence ecological mechanisms, functions and processes at a variety of scales (Fagan et al. 1999).

Houlahan et al. (2006) discovered that forest cover was positively correlated with species richness for native species, obligate and facultative forest species and perennial species. Additionally, forest cover has a negative effect on exotic species. This suggests that forest cover around wetlands can serve as a barrier to invasive species. There was also evidence from this study that wetland plant species richness decreases with increased eutrophication (which is corroborated by other studies including Moore et al. 1989; Guesewell and Kloetzli, 1998 and Alvarez-Cobelas et al. 2001). Road density (because of the barrier to seed dispersal by animals or alter-wind patterns as well as increased sediment quantity or altered hydrology) has a negative impact on native wetland species and facilitates colonization by invasive species in wetlands (Houlahan et al. 2006). In cases where organisms are not mobile, landscape structure and configuration do not play an important role in the life cycle of the individuals, but they can affect their population dynamics through gene flow (Moonen and Barberi, 2008).

One way to ameliorate these effects and strengthen the resilience (connection between populations) is to incorporate analogue systems (i.e. novel ecosystems) into landscape level restoration planning. The analogues are not meant to replicate natural systems but to serve as propagule sources to connect populations and increase the response diversity of the entirety of the populations (Suding and Gross, 2006) and generate ecological services.

5.2 Case Specific Information

The document analysis from Chapter 4 revealed that at both regional and local scales access to water and watershed health are a concern relating to agricultural viability in the Great Lakes Basin, the Niagara Region area and on individual farm landscapes. Agriculture is an economically critical component of industry in the Great Lakes Basin (see Chapter 4 for detailed exploration of agricultural revenue of the Niagara region. However, intensification of agricultural activity in the Great Lakes Basin has resulted in decreased water quality for households, recreational activities and irrigation and has also decreased the biodiversity of flora and fauna (Charron and Waltner-Toews, 2008). The Niagara fruit belt is one of three tender fruit producing areas in Canada that can support large-scale commercial production (Gayler, 2004). This area extends about 25 miles along the southern shore of Lake Ontario (between Grimsby and the Niagara River) and extends a mere seven miles inland from the lakeshore and overlaps in some areas with the Niagara Escarpment Biosphere Reserve (Gayler, 2004). Lake Ontario and the peninsular shape reduces the extreme temperatures felt elsewhere and as a result makes tender fruit farming, and (in the recent past) non-native Vinifera grape farming complementary to the area (Hill, 2002). The exceptional soil in addition to these amiable climatic conditions have given the area local distinction within Canada for growing tender fruits which include: peaches, pears, plums and prunes, apricots, sweet and sour cherries (Krueger, 1978).

Farmers need both proximity and access to water during the growing season to irrigate fruit in an effort to maintain fruit size especially when the weather is the warmest. Many farmers, therefore, are located in various riverine systems in the Niagara region either directly pumping water from the streams onto the fruit, or collecting water in ponds in the spring or pumping water from streams during high flow to ameliorate water scarcity during the growing season. Ontario farmers primarily use surface water for overhead irrigation (Poirier, 2009). Surface water contains more pathogens and contaminants than ground water because ground water irrigation is filtered by soil particles before reaching the water table (OMAFRA, 2009). Additionally, overhead irrigation is more risky in terms of exposing the fruit to contaminants and pathogens because the alternative, trickle irrigation, applies the water source to the base of the plants and not directly on the edible surface of the crop (OMAFRA, 2009). Irrigable water is directly linked to the watersheds that surround these ponds via groundwater, extraction from rivers and run-off that re-enters watersheds and subwatersheds (Albanis et al. 1995; Schulz and Peall, 2001; Carriger and Rand, 2008).

Assembling native wetland species is effective for breaking down associated farming contaminants (Adamus et al. 2001) outcompeting invasive species (De Steven and Sharitz, 2007) and providing habitat for displaced wetland wildlife (Mann et al. 2009). However, farmers may not feel confident in implementing measures to manage water quality (E. Schmitz, pers. communication, 2009) even though water quality is an important factor in fruit production. Irrigation ponds are often colonized by invasive species that are not as effective at dealing with associated farming contaminants (De Steven and Sharitz, 2007). At the same time, irrigation ponds are important for the cultural value of agricultural landscapes (Lannas and Turpie, 2009). Communication with the tender fruit farming community suggested that a lack of knowledge on macrophytic restoration in wetlands limits the landowners' ability to properly maintain their ponds with stewardship as the ancillary goal of possessing the ponds (E. Schmitz, pers. communication, 2009).

In North America, agriculture and urban development has reduced the gross area of wetlands. Due to the gravitation in Ontario to the southern regions for industry and suitability for agriculture the loss of wetlands is apparent (Donnan, 2008). The estimated loss of wetlands in the Muskoka region, for instance, is close to twenty percent and is closer to one hundred percent in urban and agricultural areas (Daigle and Havinga, 2004) which comprise a large part of the Niagara Region. To some degree the loss of wetlands in the region has been mitigated by the creation of farm ponds which now represent a major wetland habitat type in many farming regions (Knutson et al. 2004).

According to Devine and Furlong (2007) compared to urban sprawl or industry, agriculture is the greatest consumer of lands globally. However, Schulz and Peall (2001) found that constructed wetlands are an effective means to manage agricultural pesticide run off. Properly vegetated and maintained agricultural ponds can ameliorate water quality issues while also increasing biological diversity and providing habitat for displaced species (Brix, 1999; Kantawanichkul et al. 1999; Schulz and Peall, 2001). Agricultural pollutants combine to cause a suite of contaminants with more complex effects on our water systems. Proper restoration, however, would address both the water quality issues associated with agricultural sprays and also providing habitat for native species of flora and fauna. At the same time it would address some of the goals posed by members of the tender fruit community regarding stewardship.

Because farm ponds are a reality on many farms in the Niagara region they also provide an opportunity to enrich the diversity of the landscapes and restoration provides a suite of tools to manage these landscape features with potential ecological and cultural benefits. For example, farm ponds can act as surrogates to natural wetland environments and provide critical habitat and resources for wildlife (Campbell et al. 2009). Farm ponds also provide ecological services as collection basins that limit the movement of sediments and nutrients across the landscape thereby reducing sedimentation and eutrophication in streams and rivers located downstream (Knutson et al. 2004 in Campbell et al. 2009). Ecosystem goods and services are an important consideration for the sustainability of agricultural landscapes (Pretty, 2008). To this end, farm ponds provide an opportunity to create synthetic analogues to natural wetlands. This can be accomplished by enhancing the ecosystem services provide wetlands provide to social systems especially those as explicitly linked with the local hydrology like fruit farming. Some of the services include disturbance regulation, flood attenuation, functional biological diversity and habitat, food production, and importantly in this case, water supply and treatment (Pretty, 2008). Wetlands also provide extremely important services at the watershed scale as well. For instance, wetlands can improve water quality, by treating the water before it moves downstream (Spieles and Horn, 2009). Natural wetlands often support rich biodiversity and play a major role in the landscape by providing habitat for a large number of organisms (Campbell et al. 2009).

5.3 Assembly Rules and Wetland Restoration

The Society for Ecological Restoration defines restoration as "an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability" (SER International Science & Policy Working Group, 2004). In the simplest terms, restoration ecology is the theory behind putting ecosystems and communities back together (reassembling them) however, ecosystems are more than the sum of their parts (contrary to Gleason's "individualistic" concept in 1917) and therefore, how you put the system back together is also important the study of which is termed "Assembly Rules" in community and restoration ecology.

Most scholars interested in assembly rules allude to the work done by Keddy, Weiher and others as foundational work for connecting assembly rules and restoration ecology. Keddy (1999) takes a community ecology approach, when looking at the responses of a given community (particularly wetland guilds) to changing environmental conditions. Assembly is the ultimate test for community ecology and pushes restoration past haphazard assemblages of species with a focus on merely enriching taxonomic diversity in individual case studies. Keddy (1999) urges researchers to increase understanding to make predictions about environmental factors and responses of species to various abiotic conditions which help to identify which species will be able to establish (which he does using the method of 'screening').

Resilient agroecosystems require enhancing the relationship between communities and ecosystems and especially, the fundamental relationship between biodiversity and ecosystem functioning (May, 1973; Pimm, 1984; Naeem, 2006). Restoration that is based on biodiversity and ecosystem functioning focuses on maximizing response diversity and ecosystem processes and functions, particularly, understanding what species compositions are effective for cycling material throughout ecosystems between organic and inorganic forms.

By understanding the responses of communities of interest to shocks and stresses (both natural pulse shocks and also chronic human instigated perturbations) restoration projects could use the knowledge gained from defined assembly rules about certain species to increase response diversity (in particular species redundancy and biological insurance as defined by Naeem, 2006) (Keddy, 1999). Approaches to agricultural management require a resilience focus in order to manage the on-going and dynamic nature of human interference impacting natural systems. For instance, the application of pesticides and fertilizers on agricultural lands in particular, is changing continuously resulting in new combinations of chemical components in greater volumes with the continued advances made to increase agricultural yields (Mann et al. 2009). Defining some basic assembly rules for ecosystems would allow managers to improve restoration procedures (Keddy, 1999) and be more flexible (adaptable) in management approaches as opposed to becoming more rigidly attached to out-dated ecological knowledge and the inappropriate management strategies that result from these knowledge sources.

5.3.1 Emergent vegetation

Robust emergent wetland vegetation is an important yet absent functional community in most irrigation ponds. According to Galatoswitsch and van der Valk (1996) other community guilds i.e. submersed aquatics colonize restored wetlands more readily and rapidly than other community guilds such as robust emergents. The reason behind this disparity in colonization potential is a result of the different dispersal mechanisms characteristic of the guilds. For instance, waterfowl and wetland wildlife through ingestion and expulsion of the seeds distribute submersed aquatics. However, many emergent species reproduce more frequently by clonal reproduction thereby limiting the dispersal of this guild to other appropriate habitats (Galatoswitsch and van der Valk, 1996). Also, the reduction of wetland habitats throughout the region according to metapopulation and island biogeography theory will also reduce the potential for species colonization from one wetland habitat to another which is a consequence of population isolation, discussed above. As similar habitats become more isolated from one another, as is the case with the destruction of wetland habitat in Ontario (especially in the southern region over the past two centuries refer to Gayler, 2004) species richness will be negatively affected (Suding and Gross, 2006). Jacquemyn et al. (2003) found that total species richness was higher for non-isolated islands than for isolated island patches. The closer that restored habitats are to other intact habitats and populations the more opportunity there will be for dispersal, colonization, establishment and persistence of native species. Restoration efforts of emergent species in wetlands will be more successful if emergent species are actively planted as opposed to waiting for the species to colonize the site naturally (Galatoswitsch and van der Valk, 1996).

5.3.2 Enhancing ecosystem function in irrigation ponds

Assembling a functionally beneficial robust emergent community provides an important basis for the restoration experimentation in this study for three main reasons. First, emergent species provide sites for microbes to attach to which increases the nutrient and contaminant breakdown in the water body and also directly uptake nutrients in through their roots, therefore emergent vegetation will increase ecosystem functioning to the benefit of the landowners. Wetland vegetation in the water column obstructs flows and facilitates sedimentation (Bastian and Hammer, 1993). Macrophytes (vascular plants) are sensitive to wetland hydrology and are good for delineating wetland boundaries (see Cronk and Fennessey, 2001). Vegetation is effective for purification functions (Bastian and Hammer, 1993). The principle function of vegetation in the wetland system is to create additional surface areas to foster the growth of microbial populations (Gottschall et al. 2007); wetland vegetation has valuable "thin-film" reaction surfaces for microbial attachment which allows the plants to thrive in hydrophytic soils (Bastian and Hammer, 1993).

Microbes are bacteria, fungi (mycorrhizae and hyphomycetes), protozoans, yeasts and viruses which alter contaminant substances to obtain the necessary nutrients or energy to carry out their life cycles. In some cases microbes predate on pathogens (Bastian and Hammer, 1993; Adamus et al. 2001). Microbes are useful in wetlands because they can remove inorganic nutrients, heavy metals, dissolved organic carbon, particulate matter and suspended solids (Mickle, 1993; Adamus et al. 2001).

Second, rhizomatic vegetation in particular, provides areas for sedimentation, seed collection and seed germination sites while also leaking oxygen from their rhizomes that stimulates aerobic decomposition of organic matter and the growth of nitrifying bacteria (Brix, 1999). Oxygen leakage from rhizomes serves to oxidize and detoxify potentially harmful reducing substances in the rhizosphere (Brix, 1999). In wetlands, the principal contaminants from field runoff include suspended solids, nitrate, phosphorus and mixed agricultural chemicals (Kadlec and Wallace, 2009). Wetlands are useful for the treatment of non-point source (NPS) pollution because they have ability to deal with pulses of pesticides from fields in modern agriculture (Rodgers and Dunn, 1992 in Kadlec and Wallace, 2009). Accordingly, treatment wetlands are favourable in rural settings because of relatively low efforts and costs for maintenance (in most cases they can be constructed from local materials).

Third, clonally reproducing vegetation is capable of rapid establishment and can function as a nurse crop for other more sensitive species (De Steven and Sharitz, 2007) which will ultimately increase species redundancy and functional biodiversity. De Steven and Sharitz (2007) found that planting two grass species in a recently restored depressional wetland can improve native vegetation cover. By planting species that reproduce clonally, the wetland increased in native coverage, directly from the planted species and also provided safe sites (Temperton and Kirr, 2004) for other native plants to establish.

5.4 Methods

5.4.1 Study sites

Two sites were chosen in the Niagara region both on privately owned farmland located in the "prime agricultural areas" as designated by the Ontario Greenbelt Plan (2005). The first site was located on a tender fruit farm that has been in cultivation for at least fifty years in Virgil Ontario (http://goo.gl/LO2LG). The other site was also on a tender fruit farm located in Winger Ontario (http://goo.gl/iCKMA), adjacent on one side to a field crop farm (in 2009 the field was used for corn, soy beans in 2010, and corn in 2011) and also adjacent to a bush lot used for deer hunting. The irrigation pond in Virgil (Pond A) was dug in 1980 by a previous owner and is spring fed. The pond in Winger (Pond B) was dug in 2007 using subsidies from the Ontario Environmental Farm Plan application by expanding an existing pond on the property. Both ponds are currently owned by the same family. The ponds were chosen based on three criteria: 1) the willingness of the landowners to participate in restorative activities to improve ecological services on their properties[14]; 2) the difference in age structure (30 years versus 3 years at the inception of the

[14] There was a particular interest in re-vegetation of the newly excavated pond because the landowners felt they had little guidance from the Ontario EFP guidelines and during 2010 the landowners were required to participate in the Ontario Food Safety and Traceability Program in order to sell their produce to Vineland Growers. Part of the OFSTP includes water quality testing.

study); 3) Pond A, although older, is not naturally a depression-wetland area whereas Pond B is an enlargement of a smaller pre-existing pond thereby providing different initial vegetation compositions. A third site, a provincially significant wetland, the Four Mile Creek Wetland was used as a local reference site to examine the vegetation composition in comparison to the two study sites.

5.4.2 Baseline studies in 2010

In 2010 baseline studies were undertaken at each of the sites to characterize the sites in comparison to the reference site. In order to gather this general baseline information, water quality data was collected at three separate occasions during the growing season from Pond A, Pond B and the reference site to examine the characteristics of the water quality during the major chemical application times during the agricultural season (May 5th, June 1st, and August 21st). In field measurements included water height on the bank (important for planting locales) (Kadlec and Wallace, 2009), water temperature, pH, and conductivity. Grab samples were taken using the protocols established by the Department of Environmental Protection for the State of Maine[15]. The grab samples were analyzed for: turbidity, chlorides, nitrates, and total suspended solids.

Additionally, during the June 1st collection, biomonitoring using the collection of benthos macroinvertebrates also occurred using an adaptation of the protocols used by the Maine Department of Environmental Protection (DEP) which are specifically focused on sampling aquatic macroinvertebrates in freshwater wetlands. Based on the protocols used by the Maine DEP (and the assemblages of wetland literature referenced in Adamus et al. 2001) macroinvertebrate sampling occurred in June for two reasons. First, the invertebrate taxa will have developed so they are identifiable. Second, the wetlands are less likely to dry down at this point and therefore the taxa should be present as compared to later in the season. According to the Maine DEP to select appropriate locations it is important to take into consideration the preferred habitat of macroinvertebrates. Therefore sampling was focused on areas with emergent vegetation, macrophyte beds consisting of floating and/or submerged plants as well as any other representative areas with appropriate emergent and aquatic bed vegetation. Also, the water depth in areas that were sampled was less than one meter in depth. Three replicate samples were collected in areas of emergent or aquatic bed vegetation or in other representative habitat areas (replicate samples will be collected in undisturbed locations).

The collected samples were preserved in 95% ethyl alcohol for later sorting and taxonomic analysis in the laboratory. The method of sampling to used was ‘multi-habitat sampling’ because it can be used as a screening tool for assessing aquatic invertebrates. Using a 600 micron D-frame net, the inundated microhabitats at each site were sampled by forcing the net in the wetland substrate and rapidly sweeping upward to the water’s surface. All of the material collected in the net was transferred into a sieve bucket (600 micron) inspecting the net to remove

[15] When establishing the sampling protocols for the field and laboratory components of the wetland analysis many sources were consulted, however, the EPA for the State of Maine offers one of the most comprehensive and well-researched (based on findings in Eaton and Lenat, 1991; Turner amd Trexler, 1997) manuals for sampling and analysis.

any clinging organisms. All material collected at a given site had a corresponding depth reading and a designation of the type of vegetation habitat where it was found. Any vegetation, woody debris and stones was removed from the sample (which a cursory inspection of the debris in order to remove all clinging invertebrates).

On May 17th six soil samples were collected (two at each site) to examine the nitrate and inorganic phosphates at near shore locations. The samples are not meant to provide a definitive characterization of the areas but provided a basic understanding of the soil nutrient levels immediately before the water bodies which allowed for a comparison of nutrient levels in the water bodies in comparison to these soil sample locations. The results were insignificant in terms of nutrient levels; the highest phosphate levels were at the reference wetland site which may be an artefact of its location at the mouth of the Four Mile Creek Estuary (a highly concentrated farming area), suggesting it may act as a collection basin for agricultural run-off emptying into Lake Ontario.

The last baseline measurement technique employed in the initial field season was a Wetland Macrophyte Index (WMI). This method is preferable for sampling the vegetation species richness as compared to the formerly used grid method or transect method (Croft and Chow-Fraser, 2009) The grid method (which requires sampling the wetland area like a grid) is time consuming and difficult once you reach the aquatic portions of the wetland (Croft and Chow-Fraser, 2009). The transect method tends to underestimate the species richness of the submersed aquatic vegetation which is important for fish (Seilheimer and Chow-Fraser 2007; Croft and Chow-Fraser, 2009) and benthic macroinvertebrates (Croft and Chow-Fraser, 2009). In a study by Croft et al. (2009) that compared the effectiveness of these two methods for sampling coastal wetlands, the WMI using a stratified method (ST) modified by Croft and Chow-Fraser (2007) was the most effective for monitoring wetland quality in relationship to water-quality impairments.

Using the ST approach the researcher divided the wetland into different zones based on the vegetation type (i.e. upland; floating, emergent stand; and floating, submergent). Croft and Chow-Fraser (2007) found this method to be successful by establishing quadrats in each zone and sampling a new quadrat until no new species were revealed (Croft and Chow-Fraser, 2009). This continued until all major habitat types were sampled and upon the establishment of a new quadrat no new species were revealed during sampling (this is approximately, 10 to 15 quadrats) (Croft and Chow-Fraser, 2009). This technique is appropriate in that it has been tested to reveal more rare taxa when calculating the Wetland Macrophyte Index (WMI) (Croft and Chow-Fraser, 2009), the second part of the monitoring protocol for this study. The WMI is a biotic index that was designed to assess the habitat quality (particularly in coastal wetlands) that is relative to degree of water quality impairment based on human development along the shoreline of the coasts and also in the watersheds (Croft and Chow-Fraser, 2009). Although this index was created with fish habitat in mind the assumption behind the index is that fish habitat is indicated by macrophytic assemblages which is ultimately the same goal as this study, where improved water quality is by-product of macrophytic assemblages in wetlands affected by human activities. A study by Croft et al. (2007) successfully used this index in the Jordan Harbour (which is also located in the Lake Ontario watershed) and which similarly receives run-off from tender-fruit farming activities including vineyards and orchards.

The sampling of vegetation took place on June 1st (reference site), June 2nd (Pond B) and June 4th (Pond A). Required equipment will included canoes for surveying in deeper sections (0.25-2m) and by chest waders for shallower areas and the wet meadow (Croft and Chow-Fraser, 2009) and 0.5 by 0.5m quadrat to survey macrophyte presence-absence data at each sampling point. The boundary of the wetland was determined before sampling began so as to ensure that the same area was equally covered with each monitoring instalment. All macrophytes were identified to species and specimens of plants that could not be identified in the field were collected, dried and pressed when necessary, and examined in the lab (Croft and Chow-Fraser, 2009).

For the Stratified (ST) method the researcher organizes the quadrats into the various vegetation zones and habitat features of the sites (Croft and Chow-Fraser, 2009). According to Croft et al. (2009) the zones include: shrubs/meadow, shoreline herbaceous, robust emergent, narrow-leaved shoreline emergent, shallow emergent, rooted basal rosettes, free floating, rooted and unrooted submergent, and canopy.

5.4.3 Summary of baseline findings which shaped the experimental design

The water quality analysis did not reveal any particularly significant changes in water chemistry over the duration of the season. The water quality tests performed were all well within the Provincial standards for recreation, aesthetics and fish and wildlife (see Canadian Council of Ministers of the Environment, 2007) for the duration of the season. The water height on the banks provided useful observational data to direct the locations for proper planting for effective establishment (Fraser and Kindscher, 2001).

The findings revealed by the WMI were consistent with the research by Galatoswitsch and van der Valk (1996). The irrigation pond in Virgil (Pond A) is devoid of robust emergent wetland species in comparison to the reference site and Pond B which possesses some characteristic wetland species, particularly in the end that was the original pond. Whereas other community guilds like submersed aquatics were present at all three sites because, according the Galatoswitsch and van der Valk (1996) submersed wetland species colonize restored wetlands more readily and rapidly. The reason behind this disparity in colonization potential is a result of the different dispersal mechanisms characteristic of the guilds. For instance, submersed aquatics are distributed by waterfowl and wetland wildlife through ingestion and expulsion of the seeds. However, many emergent species reproduce more frequently by clonal reproduction thereby limiting the dispersal of this guild to other appropriate habitats (Galatoswitsch and van der Valk, 1996).

5.4.4 Experimental design

In order to investigate the possibility of introducing robust emergent wetland species into irrigation ponds to improve ecosystem functioning and biodiversity simultaneously a combinatorial experiment was initiated using three robust emergent wetland species. Robust emergent vegetation refers to "the emergent band of dense vegetation occurring at the shoreline and extends into shallow water up to 0.3 m" (Croft and Chow-Fraser, 2009). Plugs were used (as opposed to direct seeding) wetland vegetation direct seeding survival is limited due to the light, heat and water requirements (Hoag, 2000). The plant plugs were purchased from St Williams Nursery & Ecology Centre: Pterophylla Native Plants and Seeds, Long Point Ontario and transported to both sites in the Niagara Region on the same day (September 22nd 2010). Plant plugs were planted within the plots on September 26th 2010. Monitoring of the plant species was continued biweekly until the end of November 2010. The timing of the plantings was based on the normative seasonal decline in herbicide application on the farms (Hoag, 2000). This was also the time in the growing season when water levels are the lowest in the ponds which will help to protect the plantings because young plants have not yet developed the aerenchymous material necessary for them to survive in anaerobic soils (or standing water) (Hoag, 2000). The planted vegetation was tagged for measurement. Additionally, a vegetation inventory within the plots occurred four times throughout the 2011 season to measure species abundance, richness, diversity and presence of invasive species in the plots (Adamus et al. 2001). A study by De Steven and Sharitz (2007) demonstrated that upland vegetation plantings should focus on a matrix of two to three dominant rhizomatic native species to outcompete invasive species and facilitate other native species (De Steven and Sharitz, 2007). Planted plots in that study using this method, achieved greater total vegetative cover after two and four years. Observations from the initial field season examination of the construction design plans of the ponds at the sites indicate that the ponds most closely resemble tea-cup wetlands and therefore, the restoration efforts focused on preparing the banks and planting the banks. The objective of these efforts is to first increase the buffering capabilities of the pond edges as well as providing more surface area for seed collection, ultimately fostering more growth in the water column over time.

Combinatorial experiments involve selecting an ecosystem and a pool of species from this ecosystem, establishing monocultures and polycultures and investigating the rates of establishment and the influence that the various combinations of species have on environmental processes (Naeem, 2006). The influence that the various combinations of species have on environmental processes would require a lengthy examination period, far beyond the possible constraints of the research period. Therefore, the analysis is restricted to examining the interaction of the species, the rates of establishment for individual species, the interaction of different species' rates of establishment on each other, on other naturally occurring species and the differences that emerge between the two study sites.

5.4.5 Vegetation selection and planting design

Emergent wetland plants offer a range of treatment capacities in wetlands. The following list of treatment mechanisms offered by emergent wetland vegetation is taken from Kadlec and Wallace (2009) including:

- Increased sedimentation by reducing wind-induced mixing and re-suspension
- Additional surface area in the water column (increases biofilm and soluble pollutant uptake)
- Increased surface area for particle interception
- Shape from the plant canopy over the water column to reduce algae growth
- Included flocculation of colloidal particles into larger, settleable particles

The above listed mechanisms are mostly structural in nature which implies that one of the most important factor species selection is the potential for establishing a functional plant canopy (Kadlec and Wallace, 2009). Additionally, a diverse mixture of plant species is more capable of accommodating changes in water quality and movement (Kadlec and Wallace, 2009). A wide variety of plant species make suitable potential candidates for planting in wetlands, and several suggestions are available in the literature on treatment wetlands but other important considerations pertain to hydropattern, climate and cultural choices.

The species that were chosen for planting were *Scirpus atrovirens, Carex lacustris, Sagittaria latifolia.* Several species were ruled out based on the initial WMI observations. For consistency sake one of the reasons these species were chosen was because they were absent from the species inventory at both study locations which reduced possible contamination from local seed sources or the rhizomatic spread of the species within the ponds (Griffith and Forseth, 2003) with the potential for considerable vegetative coverage (De Steven and Sharitz, 2007). Other additional considerations included access to planting materials (including the capacity for the nursery to germinate certain species) and precedence from screening tests (Weiher and Keddy, 1995; Keddy, 1999; and information assembled by Kadlec and Wallace, 2009). The three species were chosen because they reproduce clonally, two of them (*Carex lacustris* and *Scirpus atrovirens*) are important contributors to above ground biomass with considerable above ground canopy growth. *Sagittaria latifolia* can also reach heights of 80cm providing it a competitive edge for light requirements (Newmaster et al. 1997). *Sagittaria latifolia* also meets a requirement by the land owners to incorporate aesthetically pleasing species (the species is known for its attractive white flowers throughout a considerable blooming season). All three species are tolerant of variable soil type with the capacity to adapt to degraded wetland habitats (Newmaster, 1997).

A combinatorial planting design was used to test the effects that the three treatments had on growth, regeneration, abundance of planted species as well as species diversity and abundance and community composition (wetland species guilds, natives versus non-native) at the two different ponds including potential variability of species competition and establishment between the two different age structures (see Grace and Wetzel, 1998 and DeBerry and Perry, 2004).

The combinatorial approach was chosen because the experiment's purpose was to test the capacity for establishment of the three species (*Scirpus atrovirens, Carex lacustris, Sagittaria latifolia)* in terms of intraspecific competition (monocultures of each species), interspecific competition (the polyculture plots included one plug of each species) as well as the influence that the monocultures and polycultures have on other naturally occurring species in the robust emergent wetland vegetation zone.

The pattern of planting was based on regular (as opposed to random) distribution. The reason behind the purposive sampling design is because the objective was to position the emergent species in the most suitable exposure gradient and water depth gradients (Shipley et al. 1989) around the edge of each pond. Additionally, it provided a thorough coverage of the emergent wetland zone (sensu the WMI in Croft and Chow-Fraser, 2009). In total 156 plots of $50cm^2$ plots were established (seventy-eight at each study location). Sixty of the plots received one of three combinatorial planting treatments; eighteen plots at each site were left alone and used as a control. On August 23rd, 2010 a plot-based vegetation inventory was taken prior to hand-weeding during site preparation for planting to outline the characteristic community members (Fischer and Kindscher, 2001). The treatment plots were not weeded and received no plants. The planting design used was based on four treatments and the pattern is consistent around the perimeter of each pond. The planting density for each $50cm^2$ plot is three plugs per plot.

The five planting treatments created each site are as follows:

1) Mixed Plot Treatment – includes one plant each of *Sagittaria latifolia, Scirpus atrovirens* and *Carex lacustris.*

2) Monoculture: *Sagittaria latifolia* – Each plot contained three plant plugs of *S. latifolia* (plugs were planted approximately 5 cm from one another).

3) Monoculture: *Scirpus atrovirens* – Each plot contained three plant plugs of *S. atrovirens* (plugs were planted approximately 5 cm from one another).

4) Monoculture: *Carex lacustris* – Each plot contained three plant plugs of *C. lacustris* (plugs were planted approximately 5 cm from one another).

5) Treatment Monitor – No plant plugs were planted in these plots

This planting pattern is repeated twelve times at each site location, resulting in a total of 15 replicates of each treatment at each site. In total 180 plugs were planted at each site, 60 of each species.

5.4.6 Variables measured

Two types of sampling took place during the growing season of 2011. A monthly vegetation inventory was conducted in May, June, July and August to gather information on plant abundance and diversity. During these inventories the maximum height of the canopy with the associated species was recorded, in addition to the percent cover of plants, water, rocks, detritus, bryophytes, and soil for each plot (including the control plots). The second set of measurements that were executed every two weeks beginning when the planted species were first visible (June 13th) are classified as survival and establishment measurements. The assemblage of measurements used in this study is based on by Murphy (2005) which is a study that offers a broad suite of competition-oriented plant measurements in addition to work by Shipley et al. (1989). Aside from offering a clear, concise and manageable set of measurements for research purposes, it also one of a limited number of papers that examines competition of wetland plants using plant growth as the basis for regeneration and establishment without disturbing the plant community (others often require removing the plant for measurements in the laboratory). Because the goal of the study is to provide a prescriptive set of guidelines for farmers in establishing a functional novel community, in situ measurements are obligatory to properly address the objectives of the study.

The variables measured included presence and absence of the planted species, diameter of the stem at the base of the plant (three measurements were taken and averaged), diameter of the entire canopy (taken in two measurements as North to South and East to West), maximum plant height, leaf length (three measurements taken and averaged) and leaf width (taken as three measurements and averaged), the total number of leaves per plot (this includes the mother plant and the clones that establish from that original plant), and the total number of ramets per mother plant (i.e. the number of clones that occur). For the plants that survived the first winter, these measurements were taken seven times during the growing season in 2011 at two week intervals.

5.5 Statistical analysis

The purpose of the analysis was to examine the interaction of time and treatments, which was why repeated measures design was suitable for statistical analysis. A repeated measure, or within-subject design, studies the same subjects over time to assess the influence of change temporally. Repeated measures design reduces the variance of estimates of treatment-effects which allows for statistical inferences to be made using fewer subjects (Minke, 1997). The primary benefit of a repeated measures design is statistical power relative to sample size (Minke, 1997).

Because the data from this study was normally distributed (following the Shapiro-Wilks test for normality), it has multiple response variables *and* it violates the rule of compound symmetry and sphericity (sensu O'Brien and Kaiser, 1985 and von Ende, 1993) the Repeated Measures MANOVA test was used to analyze the data. Six treatments were considered during the analysis: Treatment One: *Sagittaria latifolia* in the mixed plot, Treatment Two: *Scirpus atrovirens* in the mixed plot, Treatment Three: *Carex lacustris* in the mixed plot, Treatment Four: *Sagittaria latifolia* monoculture planting, Treatment Five: *Scirpus atrovirens* monoculture planting, and Treatment Six: *Carex lacustris* monoculture planting.

Relevant to the MANOVAR model, the measures were repeated over time on a per-plot basis, and interactions were expected to occur on an individual basis. However, the response variables were expected to be non-independent as well. For all the repeated measures, there was one within-subjects factor (time, measured in weeks; measurements were taken every two weeks from June until September). Seven sets of measurements were collected and recorded. There were six between-subjects factors for the survivorship analysis (six different treatments) and five between-subjects factors for the vegetation inventory analysis (five different treatments).

Multivariate and univariate F values are representative of the degree of difference in the dependent variable created by the independent variable; in this study the F value refers to the influence that treatment and/or time have on the response variables (e.g. plant height, number of ramets, stem diameter). In a multivariate analysis F is based on the sum of squares calculation (used in ANOVA) and it also accounts for the covariance of the variables.

The Pillai's Trace Test was used to assess the statistical significance between the groups of independent variables. Pillai's Trace is considered to be the most reliable of the multivariate measures (as compared to Wilk's lambda, Hotelling-Lawley trace and Roy's largest root) and offers the greatest protection against Type I errors with small sample sizes. This is particularly salient for this study because a smaller sample size is appropriate for repeated measures analysis because measurements are recurring. Pillai's trace calculates the amount of variance in the dependent variable which is accounted for by the greatest separation of the independent variables. Additionally, it tests the equality of mean vectors of multivariate normal distributions with a common unknown covariance matrix, independence between two sets of multivariate normal variables, and equality of covariance matrices of two multivariate normal distributions with unknown mean vectors (SYSTAT 12, 2008). Data are reported using F, p, and Pillai's trace because Pillai's trace is the actual test for significant differences of the repeated factor of time (and time X treatment) within subjects (Murphy 2005).

5.6 Results

5.6.1 Survivorship analysis

5.6.1.1 Pond A: Virgil, Ontario

The means for all of the survival traits measured the means Treatment Five, the monoculture of *Scripus atrovirens* differed significantly as compared to the other treatments. The second most successful treatment consistently for each measured trait was Treatment Two, which refers to the *Scirpus atrovirens* in the mixed plot. For Mean Leaf Surface Area, Treatment One, *Sagittaria latifolia* in the mixed plot was not different than Treatment Two (*Scirpus atrovirens* in the mixed plot).

TABLE 5-1. MANOVAR TESTING RESPONSES OF SURVIVAL FOR POND A

Variable	Treatment	Time	Time * Treatment

	F	P	Pillai	F	P	Pillai	F	P
Stem Diameter	21.11	***	0.91	85.61	***	0.22	16.78	***
Max Plant Height	10.89	***	0.95	89.89	***	0.25	18.99	***
Spread	54.32	***	0.78	61.45	***	0.20	15.21	***
Mean Leaf Surface Area	59.87	***	0.86	76.08	***	0.34	31.87	***
# of Leaves	64.51	***	0.81	71.33	***	0.27	22.94	***
# of Ramets	35.41	***	0.58	62.04	***	0.39	34.16	***

5.6.1.2 Pond B: Winger Ontario

Of the means for each of the survival traits measured, Treatment One, *S. latifolia* in a mixed plot, differed significantly than of the other treatments including the monoculture planting of *S. latifolia*; although *S. latifolia* as a monoculture was second to *Sagittaria latifolia* in the mixed plot. *Carex lacustris* had a zero percent survival rate after winter at this pond.

TABLE 5-2. MANOVAR TESTING RESPONSES FOR SURVIVAL FOR POND B

Variable	Treatment		Time			Time * Treatment		
	F	P	Pillai	F	P	Pillai	F	P
Stem Diameter	41.18	***	0.87	79.01	***	0.21	16.11	***
Max Plant Height	45.67	***	0.84	75.22	***	0.19	14.27	***
Spread	57.61	***	0.80	72.74	***	0.23	18.33	***
Mean Leaf Surface Area	71.14	***	0.89	83.14	***	0.45	40.13	***
# of Leaves	68.79	***	0.83	73.57	***	0.17	13.50	***
# of Ramets	39.12	***	0.48	44.38	***	0.25	21.22	***
# of Bolts	66.77	***	0.44	40.85	***	0.16	12.41	***
Mean Flower Height	71.32	***	0.61	57.81	***	0.18	13.86	***
Mean # of Flowers	54.98	***	0.64	59.26	***	0.22	16.49	***

5.6.1.3 Pond A compared to Pond B

Flowering only occurred at Pond B for one species; *Sagittaria latifolia.* The measurements taken for the flowers included number of bolts, mean flower height, and mean number of flowers. For the traits pertaining to flowering, the means of Treatment One, *S. latifolia* in a mixed plot, differed significantly than all of the other treatments. Since *S. latifolia* was the only species that flowered, Treatment Four (the monoculture of *S. latifolia*) was second in trait means.

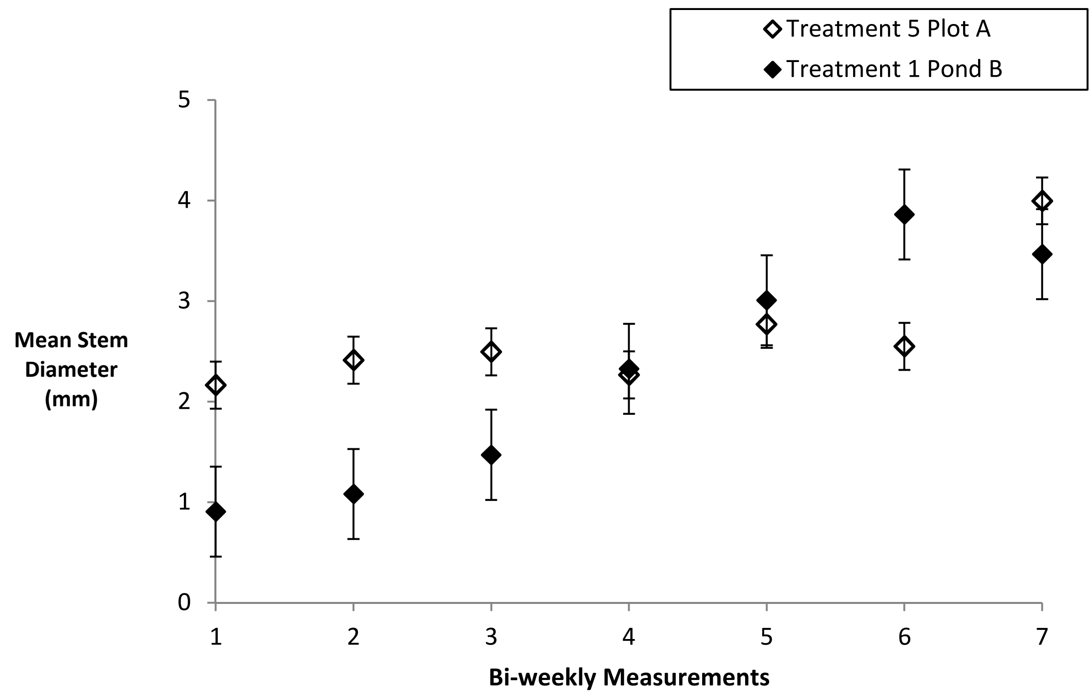

FIGURE 5-1. MEAN STEM DIAMETER FOR THE SIGNIFICANT TREATMENTS FROM BOTH SITES FROM JUNE TO SEPTEMBER 2011. DATA ARE REPORTED AS THE MEANS AND STANDARD ERRORS ACROSS ALL BI-WEEKLY MEASUREMENTS. ABSENT PLANTS, RECORDED AS ZEROES IN THE DATA SET, WERE EXCLUDED FROM GRAPHING; N= 7 FOR TREATMENT 5 FROM POND A AND N=8 FOR TREATMENT 1 FROM POND B.

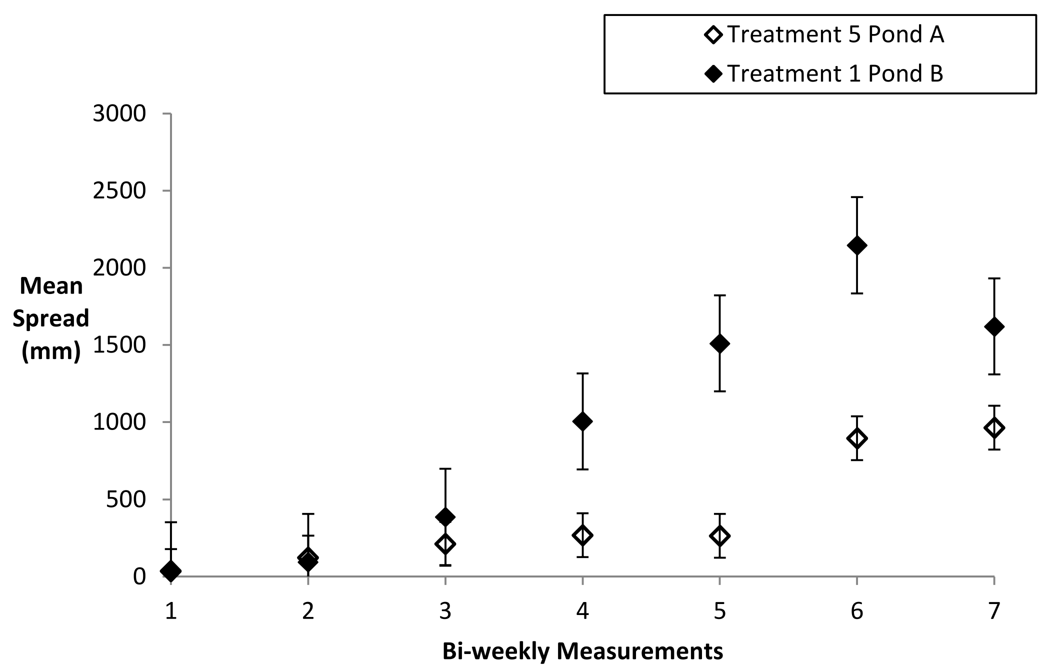

FIGURE 5-2. MEAN PLANT SPREAD FOR THE SIGNIFICANT TREATMENTS FROM BOTH SITES FROM JUNE TO SEPTEMBER 2011. DATA ARE REPORTED AS THE MEANS AND STANDARD ERRORS ACROSS ALL BI-WEEKLY MEASUREMENTS.

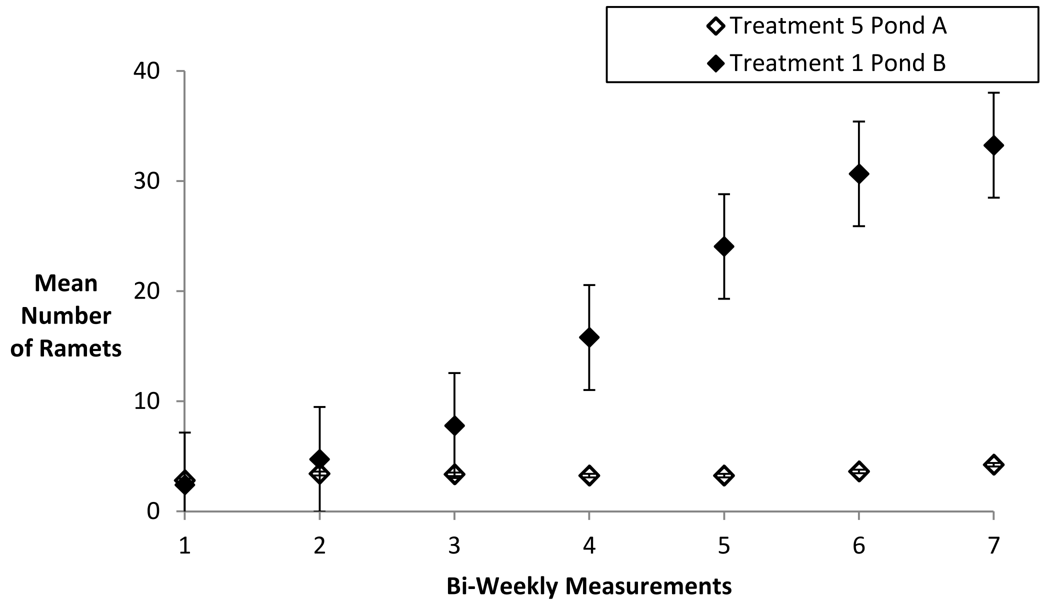

FIGURE 5-3. MEAN NUMBER OF RAMETS FOR THE SIGNIFICANT TREATMENTS FROM BOTH SITES FROM JUNE TO SEPTEMBER 2011. DATA ARE REPORTED AS THE MEANS AND STANDARD ERRORS ACROSS ALL BI-WEEKLY MEASUREMENTS.

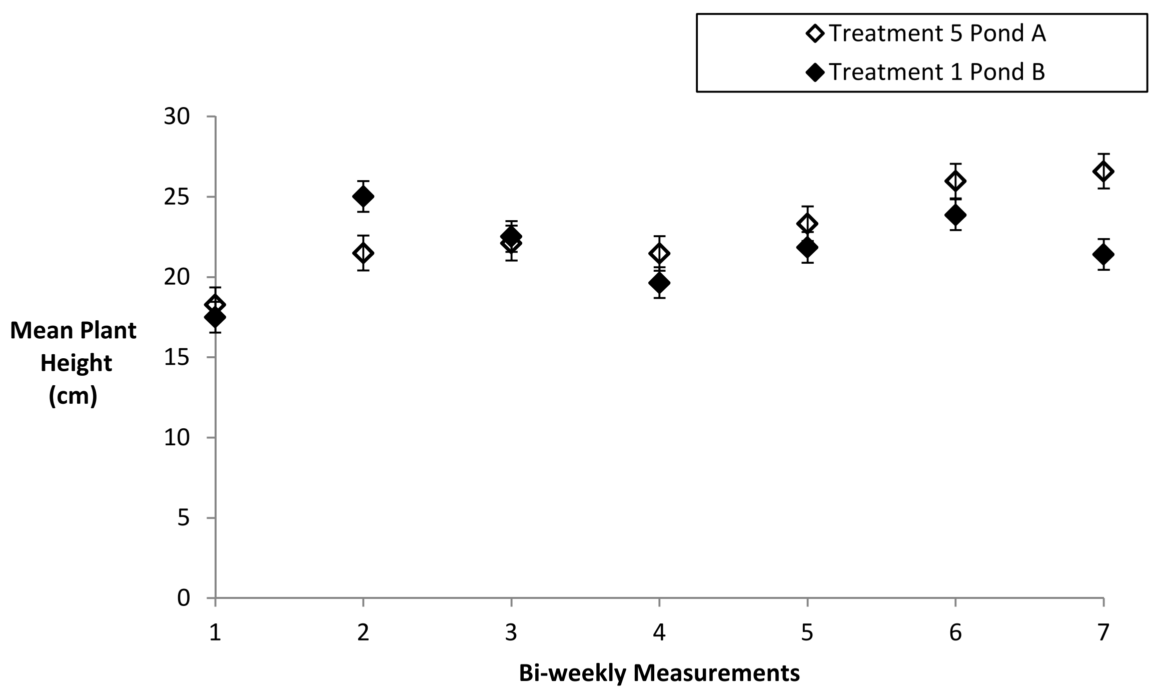

FIGURE 5-4. MEAN PLANT HEIGHT FOR THE SIGNIFICANT TREATMENTS FROM BOTH SITES FROM JUNE TO SEPTEMBER 2011. DATA ARE REPORTED AS THE MEANS AND STANDARD ERRORS ACROSS ALL BI-WEEKLY MEASUREMENTS. ABSENT PLANTS, RECORDED AS ZEROES IN THE DATA SET, WERE EXCLUDED FROM GRAPHING; N= 7 FOR TREATMENT 5 FROM POND A AND N=8 FOR TREATMENT 1 FROM POND B.

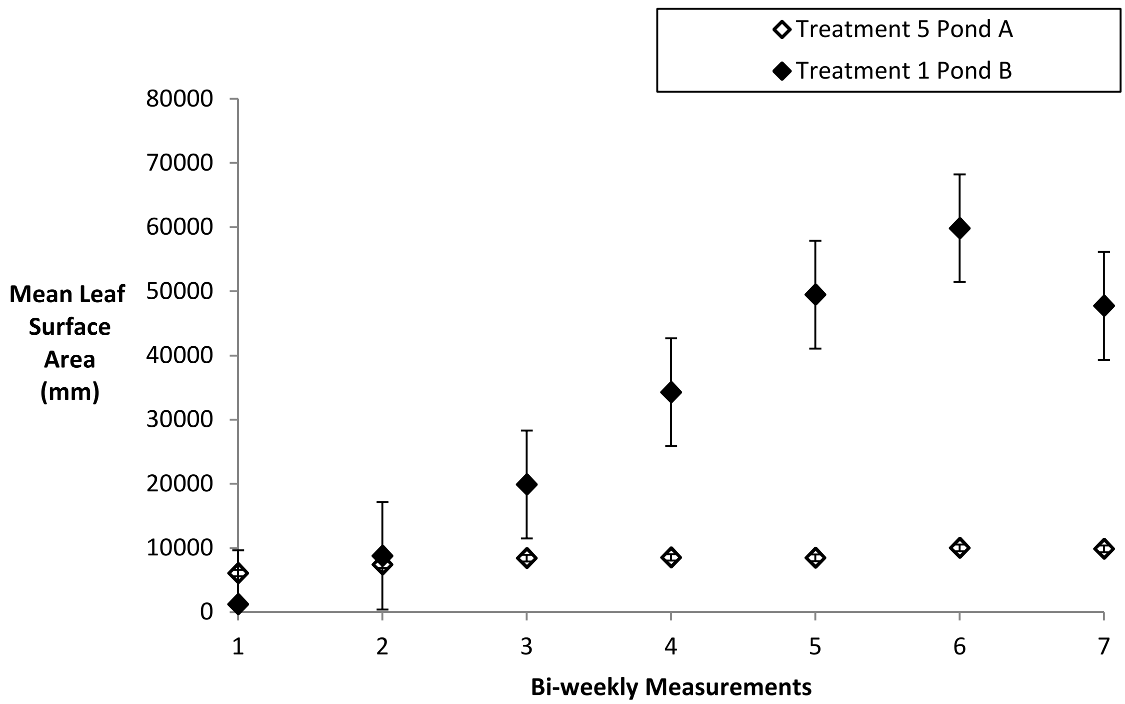

FIGURE 5-5. MEAN LEAF SURFACE AREA FOR THE SIGNIFICANT TREATMENTS FROM BOTH SITES FROM JUNE TO SEPTEMBER 2011. DATA ARE REPORTED AS THE MEANS AND STANDARD ERRORS ACROSS ALL BI-WEEKLY MEASUREMENTS. ABSENT PLANTS, RECORDED AS ZEROES IN THE DATA SET, WERE EXCLUDED FROM GRAPHING; N= 7 FOR TREATMENT 5 FROM POND A AND N=8 FOR TREATMENT 1 FROM POND B.

5.6.2 Vegetation inventory

The vegetation inventory data was analysed using five specific treatments. Treatment One: is a mixed plot (one plant each of *S. latifolia, S. atrovirens* and *C.* lacustris); Treatment Two: *S. latifolia* monoculture; Treatment Three: *S. atrovirens* monoculture; Treatment Four: *C. lacustris* monoculture; and last, Treatment Five: a control (no plants were planted). The analysis was concerned with examining whether or not time and/or treatment influences the seven particular response variables. The response variables are: total number of species, number of native species, number of exotic species, canopy height, percent cover of the treatment, percent cover of native species and percent cover of non-native species.

5.6.2.1 Pond A

The analyses revealed that Treatment One (the mixed plot treatment) was consistently the most influential treatment for all seven response variables over time for Pond A. Treatment Three was the next most influential treatment on the response variables over time. This is consistent with the survivorship analyses where Treatment Three was the most influential Treatment for survivorship.

TABLE 5-3. TESTS FOR VEGETATION INVENTORY DATA FOR POND A

Variable	Treatment		Time			Time * Treatment		
	F	P	Pillai	F	P	Pillai	F	P
Total # species	14.23	***	0.84	72.13	***	0.19	13.15	***
# of native species	11.16	***	0.72	56.19	***	0.16	11.20	***
# of exotic species	16.77	***	0.85	74.98	***	0.18	12.56	***
canopy height	10.24	***	0.89	79.46	***	0.25	20.23	***
% cover treatment	12.66	***	0.74	59.08	***	0.20	13.86	***
% cover native	10.33	***	0.43	33.75	***	0.15	10.54	***
% cover exotic	11.57	***	0.48	38.69	***	0.14	10.01	***
% cover remainder	6.12	*	0.39	31.18	***	0.17	11.94	***

5.6.2.2 Pond B

The analyses revealed that Treatment One (the mixed plot treatment) was consistently the most influential treatment for all seven response variables over time for Pond B. Treatment Two was the next most influential treatment on the response variables over time. This is consistent with the survivorship analyses where *S. latifolia* was most successful in the mixed plot planting. Treatment Two was the second most influential treatment on the seven response variables. This is also consistent with the survivorship findings where *S. latifolia* in a monoculture was the second most influential treatment for survivorship in Pond B.

TABLE 5-4. TESTS FOR VEGETATION INVENTORY DATA FOR POND B

Variable	Treatment		Time			Time * Treatment		
	F	P	Pillai	F	P	Pillai	F	P
Total # species	16.48	***	0.86	77.27	***	0.22	14.88	***
# of native species	12.96	***	0.79	63.54	***	0.23	15.31	***
# of exotic species	15.22	***	0.81	67.21	***	0.26	22.24	***
canopy height	10.80	***	0.82	70.44	***	0.28	23.07	***
% cover treatment	11.56	***	0.77	60.37	***	0.31	24.93	***
% cover native	11.79	***	0.49	39.96	***	0.30	23.47	***
% cover exotic	12.54	***	0.51	42.41	***	0.37	26.85	***
% cover remainder	7.71	**	0.36	28.67	***	0.14	10.13	***

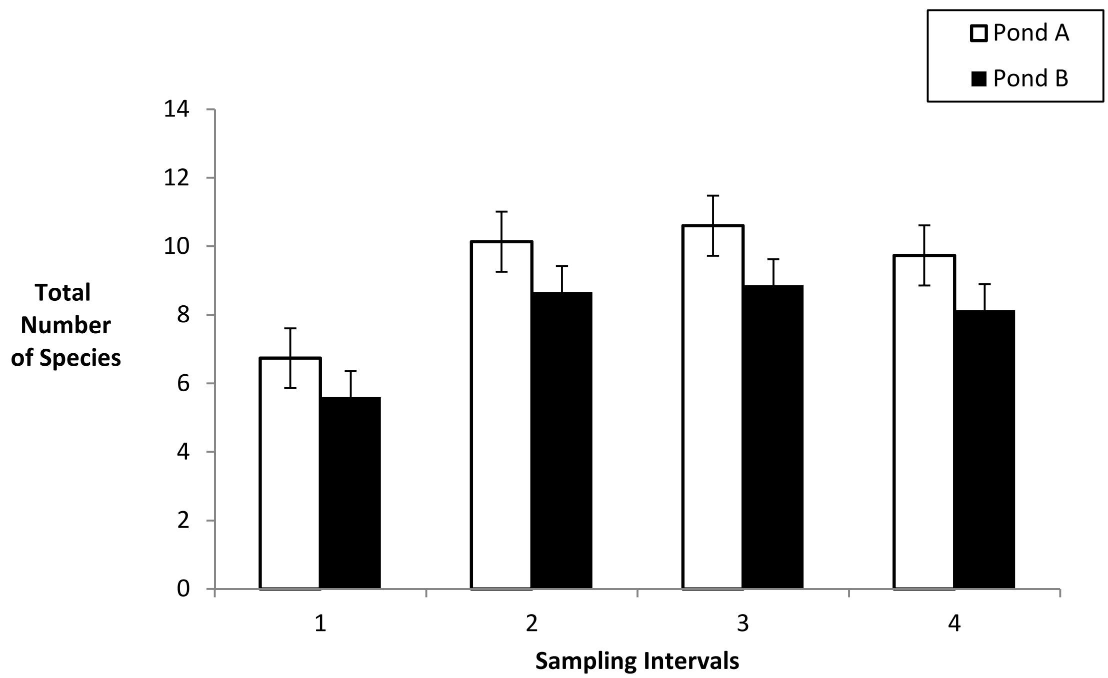

FIGURE 5-6. TOTAL NUMBER OF SPECIES FOR THE SIGNIFICANT TREATMENTS (TREATMENT 1) FROM BOTH SITES FROM JUNE TO SEPTEMBER 2011. DATA ARE REPORTED AS THE MEANS AND STANDARD ERRORS ACROSS ALL THE FOUR GROWING SEASON VEGETATION INVENTORIES.

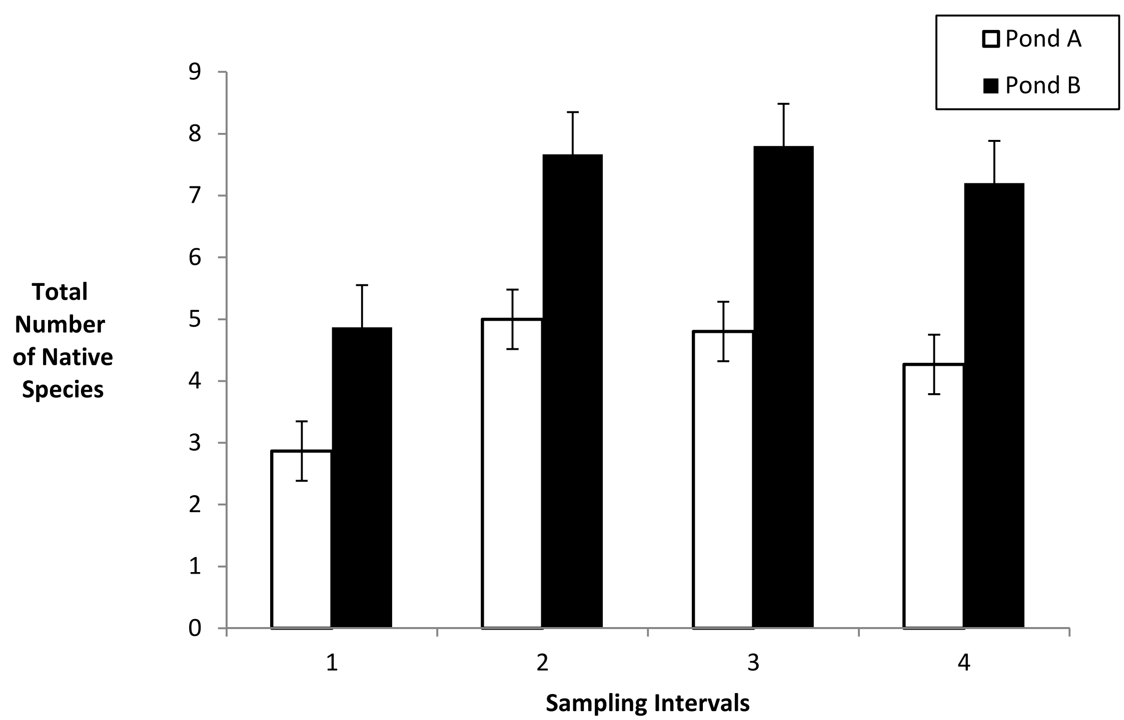

FIGURE 5-7. TOTAL NUMBER OF NATIVE SPECIES FOR THE SIGNIFICANT TREATMENTS (TREATMENT 1) FROM BOTH SITES FROM JUNE TO SEPTEMBER 2011. DATA ARE REPORTED AS THE MEANS AND STANDARD ERRORS ACROSS ALL THE FOUR GROWING SEASON VEGETATION INVENTORIES.

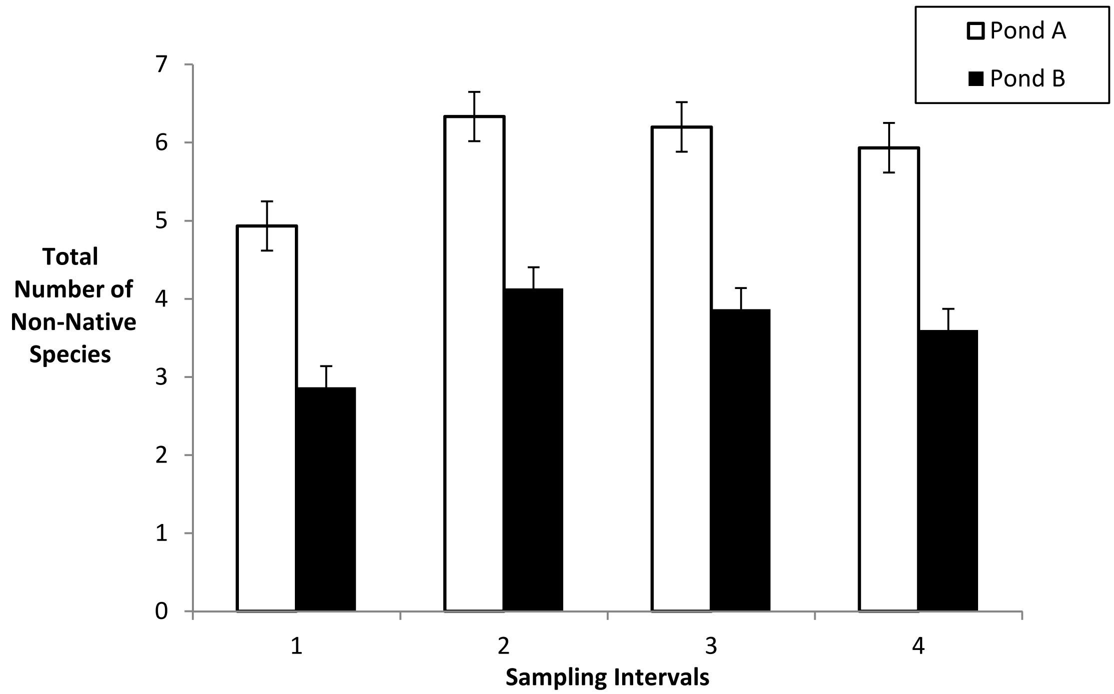

FIGURE 5-8. TOTAL NUMBER OF NON-NATIVE SPECIES FOR THE SIGNIFICANT TREATMENTS (TREATMENT 1) FROM BOTH SITES FROM JUNE TO SEPTEMBER 2011. DATA ARE REPORTED AS THE MEANS AND STANDARD ERRORS ACROSS ALL THE FOUR GROWING SEASON VEGETATION INVENTORIES.

5.7 Discussion

The concern here is beginning to determine approaches for reintroducing and reassemble native ecological functional communities on farmland that, cumulatively, can contribute to the conservation of native ecosystems at regional scales. Based on this research, which is interested in the survival and establishment of native robust emergent species in irrigation ponds two community assembly criteria emerged. For ecological restoration on agricultural lands, the results suggest that singular plantings of *S. latifolia* at densities of as little as 1 ramet/50 cm^2 is a good strategy in establishing a dominant plant community in semi-naturalized irrigation ponds. The findings suggest that *S. latifolia* is better suited to competing with existing agricultural weeds and wetland species (interspecific competition) rather than intraspecific competition. *S. latifolia* is a native North American wetland species that can be found inland, in coastal freshwater marshes, in the margins of both lakes and ponds, and along rivers and streams (U.S. Army Engineer Waterways Experiment Station 1978 in Marburger, 1993). Additionally, Marburger provides a list (compiled from early studies on the species) of other plants associated with *S. latifolia* which includes: *Peltandra virginica* (arrow arum), *Pontederia cordata* (pickerel weed), *Caltha palustris* (marsh marigold), *Typha* spp. (cattails), *Alisma plantago-aquatica* (water plantain), *Leersia oryzoides* (rice cutgrass), *Scirpus validus* (soft-stem bulrush), *Sparganium eurycarpum* (giant burred), and *Carex* spp. (sedges).

S. latifolia provides important benefits to organisms dependent on wetlands for food including waterfowl, muskrats, porcupines and habitat including usage as cover for fish (e.g. channel catfish, white bass, shiners and) and provides both food and habitat to macroinvertebrates (e.g. chironomid, mayfly, and water beetle see Rosebloom et al. 1989 in Marburger 1993).

S. latifolia can be either monoecious or dioecious, however, the dioecious populations of this species occur more frequently in the Northeast and Midwest whereas the monoecious condition is more prevalent in the southern reaches of the species's range e.g. in the southern United States (a map by Wooten, 1971, offers a geographical distribution of *S. latifolia* in the continental United States). The assumption made is that the species planting during for this research (based on work by Wooten, 1971 and Marburger, 1993) were dioecious plants. This is confirmed by the fact that the dioecious condition of *S. latifolia* flower continuously throughout the summer (as observed at Site B). Plants produce one or two inflorescences from July to September (Kaul, 1985 in Marburger, 1993) but monoecious inflorescences produce fifteen to twenty-three flowers on average (two-thirds of the flowers on the same inflorescence are male) (Delesalle and Muenchow, 1992 in Marburger, 1993). On dioecious plants female inflorescences produce on average eleven to sixteen flowers whereas male inflorescences produce on average thirteen to twenty-five flowers. Dioecious forms are limited in terms of sexual reproduction because outcrossing is required whereas the monoecious forms can self-pollinate and cross-pollinate to reproduce (Wooten, 1971 in Marburger, 1993). As a result dioecious forms may rely more heavily on clonal reproduction for regeneration than monoecious forms (Marburger, 1993).

For ecological restoration of irrigation ponds on agricultural lands devoid of facultative wetland species planting *S. atrovirens* in monocultures at densities of 3 ramets/50 cm^2 is a good strategy in establishing a dominant emergent vegetation community presumably capable of managing field run-off (see Kadlec and Wallace, 2008). Intraspecific competition is not as of much an issue for *S. atrovirens'* survival and dominance; rather interspecific competition is improved with at least three plants/50 cm^2. This study was concerned primarily with how plant species interact with different species and how monocultures of the same species interact. Other measurements of competition were not tested directly, although in literature on wetland species (Keddy, 1999 for example) has examined how competition for resources influences species establishment. The most important resource for wetland species is access to water; limited access to water is particularly influential at various points throughout the growing season (Galatoswitsch and Van der Valk, 1996). Clinton et al. (2010) discovered that the hydrology of a restoration site is capable of limiting sedge recovery. Ultimately, a more complicated competition experiment would be useful in examining the complexities of different resources and also would build on these findings to examine the most effective densities of *S. atrovirens* in particular.

At both sites the survivorship of *C. lacustris* was limited. Budelsky and Galatowitsch (2000) observed that seedling survival of *Carex lacustris* Willd. was highly dependent on water levels during the first growing season (precipitation was extremely low during the growing of 2011 which required the landowners to irrigate regularly. Percent cover from the vegetation surveys indicate that by June some plots at both sites were entirely dry and by July all of them were devoid of contact with water). Pond A was particularly dry because the pond was used for irrigation from July 15 to September 10. This may help to explain why the only flowers observed during this study was *S. latifolia* at Pond B. Clark and Clay (1985) and Kaul (1985) found that low water levels or dry conditions may reduce flower production in *S. latifolia* which may explain why the plants from Pond B flowered while the plants in Pond A began to die out during the point in the season when precipitation became scarce and irrigation was increased in frequency and duration.

C. lacustris was chosen as a potentially suitable competitor in these sites because it is a sedge with spreading rhizomes and it is considered to possess an aggressive growth habit termed "guerrilla" (Yetka and Galatowitsch, 1999). Under suitable conditions *C. lacustris* can exploit open spaces quickly. Based on findings by Yetka and Galatoswitsch (1999) the success of sedge revegetation using rhizome propagules and plugs in restored or created wetlands is likely to vary depending on the species, time of year of planting and water levels during the initial season of establishment.

Although plugs were used for planting, this research may confirm findings from Yetka and Galatoswitsch (1999) in their finding that rhizome planting is most successful if executed in the spring. According to the authors, *C. lacustris* populations form new rhizomes and initiate new shoots in the fall, making them susceptible to transplant failure during this season. Plugs already possess above ground growth. This is important for *C. lacustris* because above ground shoot presence is important for rhizome survival (Yetka and Galatoswitsch, 1999). Additionally plugs do not suffer the stress of rhizome cutting (the soil on the plugs should remain intact during planting) because they have already established roots at the time of transplanting. A third consideration in time of year for planting was that fall planting is effective for the other two species, therefore, for consistency sake, planting of all three species was to occur at the same time (since the research was concerned with directly comparing survival and growth rates of the three species). Since plugs were considered to be more advanced than rhizome cuttings (sensu Yetka and Galatoswitsch, 1999) it was hypothesized that this may outweigh the disadvantages of fall planting for *C. lacustris* (as opposed establishing rhizome cuttings). Additionally the decision to plant later in the season was also based on conversations with the landowner regarding at what point in the season they would most likely have the time execute a planting. However, the above ground growth in combination with the normally competitive growth habit of *C. lacustris* may not have been enough to offset the consequences of the reduction of survival that results from inadequate underground reserve storage (which is accumulated over the growing season) Yetka and Galatoswitsch (1999).

My study has also determined that mixed plots of facultative wetland species, in this study, *S. atrovirens, S. latifolia,* and *C. lacustris* is an effective way to influence the native and exotic species community composition of agricultural irrigation ponds. This is somewhat of a contradictory finding when reviewed in relation to the survivorship findings. Land managers must clearly identify their particular goal for restoration to determine the most appropriate type of planting to execute. *S. atrovirens* in a monoculture differs significantly in its capability to establish and dominate the planted plots adjacent to weedy agricultural fields. Therefore, a monoculture planting of this species may be preferable for some land managers if the goal is to create a dominate community capable of managing agricultural pollutants. If the goal is to establish a more biodiverse and "natural" ecosystem in the irrigation pond, planting a mixed plot would help to influence the community by increasing the total number of species colonizing each plot.

5.7.1 Plant Apparency

The vegetation survey indicated many more agricultural weeds in the plots in Pond A. It may be more difficult for native introduced plants to establish into the communities of highly resistant agricultural weeds. For the duration of the vegetation inventory, Pond B supported thirteen facultative wetlands species whereas Pond A supported only four before planting.

TABLE 5-5. TOP 10 MOST COMMONLY OCCURRING SPECIES IN VEGETATION COMMUNITIES, SEPTEMBER 2010

Pond A	Pond B
Medicago lupulina L.(Black medick) *Poa canadensis* (Canada bluegrass) *Taraxacum officinale* (Common dandelion) *Plantago major* (Common plantain) *Vicia cracca* (Cow vetch) *Lysimachia nummularia* (Moneywort) *Dactylis glomerata* L.(Orchard grass) *Daucus carota* (Queen Anne's Lace) *Trifolium pratense* (Red clover) *Mentha arvensis* L. (Wild mint)	*Medicago lupulina L.* (Black medick) *Carex intumenscens* (Bladder sedge) *Juncus Canadensis* J. Gay (Canada rush) *Equisetum arvense* (Common horsetail) *Bidens frondosa* (Devil's beggar tick) *Juncus tenuis* (Path rush) *Daucus carota* (Queen Anne's Lace) *Trifolium pratense* (Red clover) *Festuca rubra* (Red fescue) *Eleocharis palustris* (Spike rush)

One obstacle often confronted by restoration ecologists working on managed and degraded landscapes is dealing with herbivory of introduced native plant materials that may be selected for predation over existing members of the community. In many instances, the introduced material offers the most palatable and nutritious plant selection to herbivores (Diaz et al. 2007). This is a result of the habitat fragmentation and patch isolation that has become characteristic of rural and suburban landscapes. This can have important consequences on the quality and composition of remaining habitat fragments. According to Vandermeer and Lin (2008) reductions in the rate of migration of prey or forage among isolated habitats increases the likelihood of extinction events of native species that can ultimately lead to ecosystemic collapse. Accordingly, predation pressures on native plantings are often increased when they occur within landscapes comprised mainly of agricultural weed species.

The age of the pond and history may also have influenced the predation dynamics at these sites. Pond A was only 20 years old at the time of the planting and is located in an area that is largely rural and suburban; the remaining vestiges of wetlands from which species migration might occur are minimal in number and isolated (Daigle and Havinga, 1996). As a result, Pond B which is located in a low-lying area and in possession of more facultative wetlands species was merely expanded in 2007; it is also adjacent to a slough and is presumed to be a "natural wetland" or is at least located in a region where species migration is more likely because wetlands and vernal pools are more prevalent.

After the initial planting took place at the close of August 2010 an interesting and significant discovery was made during the pre-winter survival monitoring. Fifty and a half percent of the plants at Pond A had removed completely (the plug was pulled from the soil in-tact) or were browsed by white-tailed deer. Ninety-three percent of the total plants of *Sagittaria latifolia* had been browsed and were missing or were grazed to the ground by deer. The tubers that are formed during clonal reproduction are produced in the latter part of the season and allows the species to avoid freezing, drought, burning, and excessive herbivory of above ground tissue because of the reserves (specifically starch) stored underground. According to Yeo (1966) as many as forty tubers may be produced by a single plant (in Marburger, 1993). Most of the literature on herbivory of *S. latifolia* talks about muskrats, waterfowl and beavers (Marburger, 1993). Muskrats are known to forage for and predate on tubers in the fall (Marburger, 1993) which can completely decimate *S. latifolia* beds (Rosebloom et al. 1989 in Marburger, 1993). However at these sites deer were observed and tracks and deer scat were observed around the plants at both sites during the pre-wintering monitoring.

Thirty-eight percent of *Scirpus atrovirens* were also browsed or removed. *Carex lacustris* was browsed the least during the pre-winter survival monitoring as only ten percent of the plants were predated upon.

The results from the pre-winter monitoring for plant survival may be a practical example of what is known as "plant apparency" in the literature. This is similar to the concept of host-plant resistance (HPR) which describes a range of evolutionary adaptations possessed by plants that influence their capacity for survival and reproduction by minimizing their attractiveness to herbivores. Examples of this include allelochemicals like repellants or toxins that discourage herbivory. Conversely plant apparency refers to situations where herbivory is influenced by the presence or absence of particular host community members which may explain the predation selection of the planted species.

Chew and Courtney (1991) were interested in whether the variation in hosts (i.e. plant species predated upon by herbivores) is the dominant parameter determining host associations in a large assemblage of pierid butterflies feeding on plants. Although the research is concerned with butterfly species, their study offers possible insights into the phenomenon observed during the pre-winter monitoring. The authors were concerned with temporal variation (in terms of seasons and years) in plant availability and discovered that the diet of the herbivores is increased when the availability of food type is less predictable and consequently narrows to monophagy when food is abundant and numerically stable from year to year. The pre-wintering monitoring took place during October and November 2010 when the herbaceous understory of forests are in decline due to senescence in the Northern hemisphere. Additionally, grazing animals prefer communities with low proportions of senescent leaves and absence of woody biomass (Dubey et al. 2011). Planting, therefore, coincided with seasonal decline of food sources and at the same time added a new food type to the host community. This implies that planting species that are absent from the ponds offered an unpredictable source of food for herbivory thereby expanding the breadth of the diet for the deer perhaps increasing the predation on the planted species. Because obligate and facultative wetland and riparian species were largely absent from Pond A the predation pressure on the planted species may have been increased. For instance, Opperman and Merelender (2000) found that deer herbivory significantly influences the capacity for regeneration and recovery of riparian species during restoration by reducing vigour, reproductive output of mature plants and increased mortality of seedlings. In terms of a desirable food source for deer, therefore some riparian and wetland community species may be selected for predation over the agricultural weeds that are dominant on many farmlands. These impacts can be reduced by using enclosures around project sites. By eliminating deer from riparian restoration areas by using enclosures the restoration sites responded with vigorous regeneration (Opperman and Merelender, 2000).

5.7.2 Designing the initiative

The information gathered here (and in the previous chapters) provides the baseline for a program that focuses on incorporating novel ecosystems into farm operations/landscapes with linkages to regional conservation objectives. Although this study was not focused on the spatial linkages between these two scales explicitly (i.e. the methodology was concerned with species assemblages at the ecosystem scale), there is an implied recognition that improving the delivery of ecosystem services (in terms of processes i.e. like water quality improvement as well as the structural aspects, i.e. improving the connectedness of native species currently in decline) at the farm-scale can foster if a regional approach began to orchestrate the species selection for individual farms, for insance, targeting species in decline.

Lovell and Johnston (2009) offer an approach to designing multifunctional landscapes such that they offer pubic amenities (environmental, social and economic functions) while at the same time considering the interests of the landowners. The authors provide a list of steps in order design of multifunctional landscapes in this approach including 1) defining the project site and landscape context, 2) analyzing landscape structure and function, 3) master planning using an ecosystem approach, 4) designing sites to highlight ecological functions and 5) monitoring ecological functions. One of the main tenants of this approach is concerned with connecting these “multifunctional” sites to their surroundings.

5.8 Conclusions

This research examined how to establish functionally dominant robust emergent communities in irrigation ponds. Functional dominance was central to the research because species coverage and reproduction was lacking in the water column of the ponds. When incorporating restoration efforts into farmlands with the objective of building ecosystem services it is necessary to consider the potential challenges (e.g. pollutants, deer herbivory) one could face. For land managers and landowners alike the potential barriers to survival and establishment of new species and communities are a very real concern. Other considerations pertain to understanding the potential functional benefits of the prospective candidates for re-introduction prior to planting. The findings suggest that the pre-existing vegetative community, the density of the planted species, and the capacity for clonal reproduction influences community establishment and dominance. The species chosen for the research have the ability to reproduce clonally which offers significant spread and coverage within the first growing season.

Due to the potential constraints of competing with the pre-existing community (interspecific) and within species (intraspecific) this research demonstrates that landowners/ land managers looking to improve water quality and habitat in irrigation ponds need to investigate the species exist in/around the community (e.g. presence of obligate and facultative wetland species), need to think about the age of the pond and think about other challenges (e.g. habitat fragmentation, species dispersal/ isolation, deer densities and existing community membership) to maximize the success of plant survival and dominance. This research demonstrates that establishing dominant community of robust emergent macrophytes in irrigation ponds is possible if one is cognizant of the age of the pond and existing vegetative community.

6 Synthesis of the Findings: Framework for Agroecosystem Pilot Program and Implementation

6.1 Introduction

In this chapter I summarize and reflect upon the research conducted for this study, discuss the management implications and recommendations that result from the study, identify directions and approaches for future research, and place the contributions of this research into academic and applied contexts. This thesis is concerned with resilience at the most essential level; resilience of ecosystems and native species and also the resilience of farms and farmers. Highly connected institutions and policies that focused on facilitating commodity production and little else maintained the system. In order to deal with these concerns this thesis has a cross-scalar agenda that attempts to provide a thorough examination of the various aspects of agroecological resilience relevant in Canada and also within a particular case study. Research pertaining to ecological land-use management decisions on farms must be cognizant of the multi-scaled interactions that shape decision-making. The pilot work that took place is a small part in the larger suite of needed changes and reflects an effort to begin examine how one actually engages in a cross-scalar agrienvironmental program. As a result the global and national dynamics lead into an examination of the programs the are facilitate the delivery of the policy agenda, how it plays out at the farm-scale in terms of landowners perspectives on program content and also the biophysical challenges one would face with implementing a new agrienvironmental agenda that is based on the criteria that emerged from the pilot.

Chapters 2 through 5 investigated the history of agricultural policy in Canada, the body of literature that could aid in paradigmatic change, and used pilot studies to examine the gaps and potential areas of improvements in current agri-environmental program models and also the practical challenges facing the installation of agri-environmental land management projects. The overarching goal is to uncover how these pieces fit together to drive an agri-environmental agenda forward; i.e. how can my research lead to an improved and more desirable state- a welcome resilience.

6.2 Synthesis of the Findings

The key points follow from the evidence and thinking that is presented through the study but to sharpen these, the significant components are synthesized here.

1. The consequence of the history of protectionism and productivism in Canadian agricultural policy history has generally been harmful to the economic development trajectories of Canadian farms as well as the viability of most agroecosystems. Most Canadian farmers are reliant on fiscal transfers ensured via subsidies or stabilization programs (Skogstad, 2009). This entrenched situation makes it unlikely that Canada will transition to a market-liberal or competitive market model any time in the near future and yet a change in the policy that directs Canadian agriculture is necessary (Skogstad, 2009).

Instead, it is more reasonable for Canadian agricultural policy to embrace and support a multifunctional model of agriculture where fiscal transfers are based not only on commodity production but also the production of other goods and services (e.g. ecosystem goods and services) characteristic of the European Union AES programs and the UK Countryside Stewardship, ESS and Nature Improve Area programs.

2. The current model in Ontario, the Environmental Farm Plan has merit because it is available to all Ontario farmers. However, many gaps in the program deliverables have been identified. The voluntary nature of the program, the capacity for farmers to select specific parts of their farms to enroll, the set-up of the program, and the lack of emphasis of agro-ecological functioning make the efficacy of this program limited to specific farmers and farms. The ecosystem service focus of Alternative Land Use Services is an interesting angle on which to build a new program that is concerned with agroecosystem functioning. ALUS is primarily concerned with land that can be enrolled as "set-aside" and requires landowners to possess natural features within their landscapes. The Nature Improvement Area concept espoused by the UK is an interesting concept for developing a spatially explicit method for incorporating native species into managed landscapes. Using the model of the Nature Improvement Areas with the focus on ecosystem functioning in the ecological networks farms could be targeted for the corridor and 'stepping stone' areas for restoration potential that is based on assembling systems that provide ecosystem function at the farm-level, and species diversity at the landscape level.
3. The goal for a new approach to agri-environmentalism in Ontario is to define the appropriate parameters for incorporating native species assemblages on farms to improve farm functional requirements using the principle of *maximum net gains.* As mentioned in Chapter 4 the central aim is to begin building cross-scalar resilience in agroecological landscapes as well as the broader landscape settings of regions, provinces and nations. Therefore, this research looks to link regional conservation goals to farm-scale ecological functioning and the way to do this is to incorporate native species assemblages. The case study involving landowners in the Niagara region demonstrates linking ecosystem functioning to *agro*-ecosystem functioning is a good integrating point to create a pilot agri-environmental program. One main concern for landowners stems from apprehensions about livelihood insufficiencies; the multifunctional approach to fiscal transfers for ecosystem services where participants receive on-going incentives was supported by the respondents in this study.
4. Canadian agricultural policy history has influenced land-use management, the types of agricultural operations that remain viable, and has created homogeneous landscapes largely devoid of ecological communities capable of delivering ecosystem services within the farm landscape and to the greater regional landscape. Agricultural policy in Canada needs a new agenda to ensure agricultural viability that is concerned with the whole farm

approach to resilience which presents a new approach for agri-environmentalism particularly well-suited to Ontario[16].

5. Developing a theory that incorporates landscape change and transformation as well as and novelty in terms of government policies and species assemblages, is a new theoretical grounding to guide change in Canadian agriculture. The concept of novel ecosystems is relatively new but has the ability to improve the understanding of landscapes and land-use management. Agroecological resilience is concerned with using ecosystem functioning as the motivating factor that links restoration objectives (e.g. ecosystem services) and farm operations. Conceptualizing agricultural systems as novel ecosystems that are reliant on ecosystem functioning moves past the concept of *specified resilience* which is concerned with the resilience of specific parts of the system (Folke et al. 2010). Specified resilience has been championed at the federal policy-making scale in Canadian agriculture and consequently became the management focus at the farm-scale. Increasing specified resilience can have unforeseen negative impacts on the system (particularly due to the interaction of interdependent scales) because in many instances it encourages a narrowly defined system that is based a few interaction components (Folke et al. 2010). *General resilience* on the other hand is concerned with the resilience of the entirety of the system to all kinds of disturbances (Folke et al. 2010). General resilience can explicitly address past, present, and future conditions in terms of what actions should or should not be taken to ensure a functional agroecosystem.
6. The concept of active transformation in addition to general resilience makes up the foundation for the novel ecosystem program in concept and practice. Because of the history of government intervention in Canadian agriculture, shifting to a paradigm that is based on general resilience that is concerned with multifunctional aspects of agroecosystems will occur on two scales; the institutional scale (i.e. transitions) and the agroecosystem scale (i.e. transformations). This research used “shaping changes” as the main principle for agroecological and institutional transformations. The focus of the outlined criteria is to incorporate and encourage novelty at the transformation and transition levels.
7. Transforming agricultural systems to functioning agroecosystems will require mimicking ecosystem functioning and will require the introduction of native species back into farmlands. Atwell et al. (2010) found that initiatives focusing on perennials have the potential to span differences between conservation and agricultural interests by blurring the distinction between working lands and protected lands in the US Corn Belt. The maintenance of ecosystem services and societal goods is now dependent on responsive policies that mediate the drivers and outcomes of land use at broad landscape scales; because arable agricultural landscapes are often privately owned and operated, landscape-

[16] Although many of the Canadian provinces and territories are reliant on stabilization programs and subsidies, there are varying degrees and different reasons behind the reliance on fiscal transfers. This study speaks generally about the agricultural history of Canadian agricultural policy but only deals specifically with the Ontario case which is composed of a variety of types of farming including livestock, chicken and egg producers, horticulture, grain etc.

scale change is the product of an amalgamation of decisions by individual actors, which are in turn influenced by local social norms and networks and macro-level markets, technologies, and policies.

8. Incorporating native species into agricultural systems has specific objectives that need to be identified prior to the start of a project. First, one must identify and analyze the goals behind increasing biodiversity. Initiatives focused on intrinsic biodiversity or taxonomic richness are best suited to areas that are at the minimum are only moderately managed and still possess high levels of biodiversity; it is more likely that rare or threatened species would survive in these less altered areas (Kleijn et al. 2010). Functional biodiversity initiatives are better suited to more intensively farmed areas because the ecosystem services derived from these projects will help to off-set the impacts from agriculture particularly in areas where ecosystem services are reduced due to farming practices. If the objective is to incorporate organisms or communities that have positive functional contributions to agroecological systems then some biodiversity conservation efforts are superfluous to the functional attributes that pertain to agroecological functioning. If there are no mechanistic relationships established between the numbers of species to be included in the biodiversity conservation efforts and the objectives (in terms of ecosystem services) then mere taxonomic richness is not as important as functional dominance (Moonen and Barberi, 2008). Understanding the main method of reproduction employed by the introduced species is also important. In this study robust emergent species that reproduce clonally were used because it was hypothesized that they would be able to compete with the existing vegetative community composed primarily of agricultural weeds within the first growing season. Additionally it is important to investigate what species exist in and around the ecological community because it can influence the re-introduction efforts. Kleijn et al. (2010) argues that clarification of the objectives of agri-environmentalism that is concerned with ecosystem services makes program applications more effective and offers the potential for maximum and mutual net gains for landowners and the wider public.

6.3 Cross-scalar Agroecosystem Thinking

The research contributes to the literature because it takes a cross-scalar approach to examining the resilience issues relate to agriculture and Canada. In response I have designed a new conceptual basis for linking federal policy to regional conservation of native species to the enhancement of ecological function at the farm-scale.

6.3.1 Future Research and Pilot Program

Based on these findings this research contributes a tripartite decision-making scheme that was developed based on spatially explicit land management decisions using research from the Wild LifeLines™ paper by Fields et al. (2010) and the concept of spatially explicit toolkit for ecosystem service enhancement being developed in England by Harris et al. This decision-making scheme would allow a governing agency to implement the Novel Agroecosystem approach based on the concept of "triage". Triage as a medical term is a process or system used to sort injured people into groups based on their need for or the likelihood of them benefiting from immediate medical treatment (Merriam-Webster, 2012). One particular component of triage is the allocation of resources e.g. medical attention or in this case, situating ecological restoration, such that the effectiveness of those resources is maximized. Other connotations associated with the term include the urgency of care and priority deployment of resources to achieve success. The culmination of this research is the theoretical and practical groundings to create an agri-environmental initiative that is based on principles of conservation, restoration and agroecological functioning that would allow governing agencies to assess potential participants (farmers) land-use improvement goals in terms of improving ecological functioning on their land by using information collected in maps of local farm boundaries *and* ecological features. In other words, the landscape would be mapped in terms of ecological health (sensu the Natural Improvement Areas whitepaper) and projects would be executed based on the principle of triage by determining, based on the existing landscape features and native species inventories (or lack thereof), which novel ecosystems should be implemented in what specific areas.

6.3.2 The Tripartite Model of Decision-making for Novel Agroecosystem Functioning

The Wild LifeLines ™ paper by Fields et al. (2010) depicts the potential migration pathways in the United States between the Mexican and Canadian borders. The modeling program uses maps of Natural Landscapes that is built by layering land cover types, distance to roads, traffic volume, and housing density. This is a novel approach to determining the so-called "path of least resistance" for wildlife and makes predictions on the likely routes for movement that will be taken. The purpose is to identify the least fragmented connections that remain between natural areas (Fields et al. 2010). Although this initiative is concerned with the continental migratory and movement routes of wildlife, the modeling approach could provide valuable for other initiatives. One of the main objectives of this program is to help organize regional conservation efforts because the information provided by the maps would aid in making decisions about protecting extant landscape connectivity. Wild LifeLines™ could provide useful for identifying areas for conservation and restoration.

The spatially explicit asset inventory being developed in England for land-use planning looks at mapping ecosystem services. The goal is to create an asset inventory that is accessible in a mapped form in order to improve governance and decision-making during planning. The objectives for the purposes of agri-environmentalism vary slightly. Instead of mapping ecosystem services for land-use development purposes, existing natural features would be mapped (sensu Wild LifeLines ™) and with the delineation of the restoration components in mind (sensu Nature Improvement Areas see Chapter 4).

Using the technology from this modeling program and the concept of a spatially explicit asset inventory regions could be mapped based on both the built areas (e.g. by land use) as well as by ecosystem (habitat and community). At the micro-scale the species from specific habitats could be layered on (based on vegetation inventory data). This would allow organizations to access the habitat fragments to determine what species are abundant/ absent and would help to guide the content (what species to incorporate) and context (locations based on connectivity to habitat fragments or degrees of isolation to create new patches) of restoration projects.

One way to make this accessible to conservation organizations, authorities offering agri-environmental incentives as well as landowners that would participate in agri-environmental programs is to create an interface that would possess the mapped information. Additionally, overlaying maps of farmlands would allow potential participants (and the organization directing the program) to determine where the farm is in relation to the five landscape components listed above. The following figure demonstrates how this modeling approach could be useful for synthesizing regional conservation objectives with ecosystem functional requirements advantageous for farm operations.

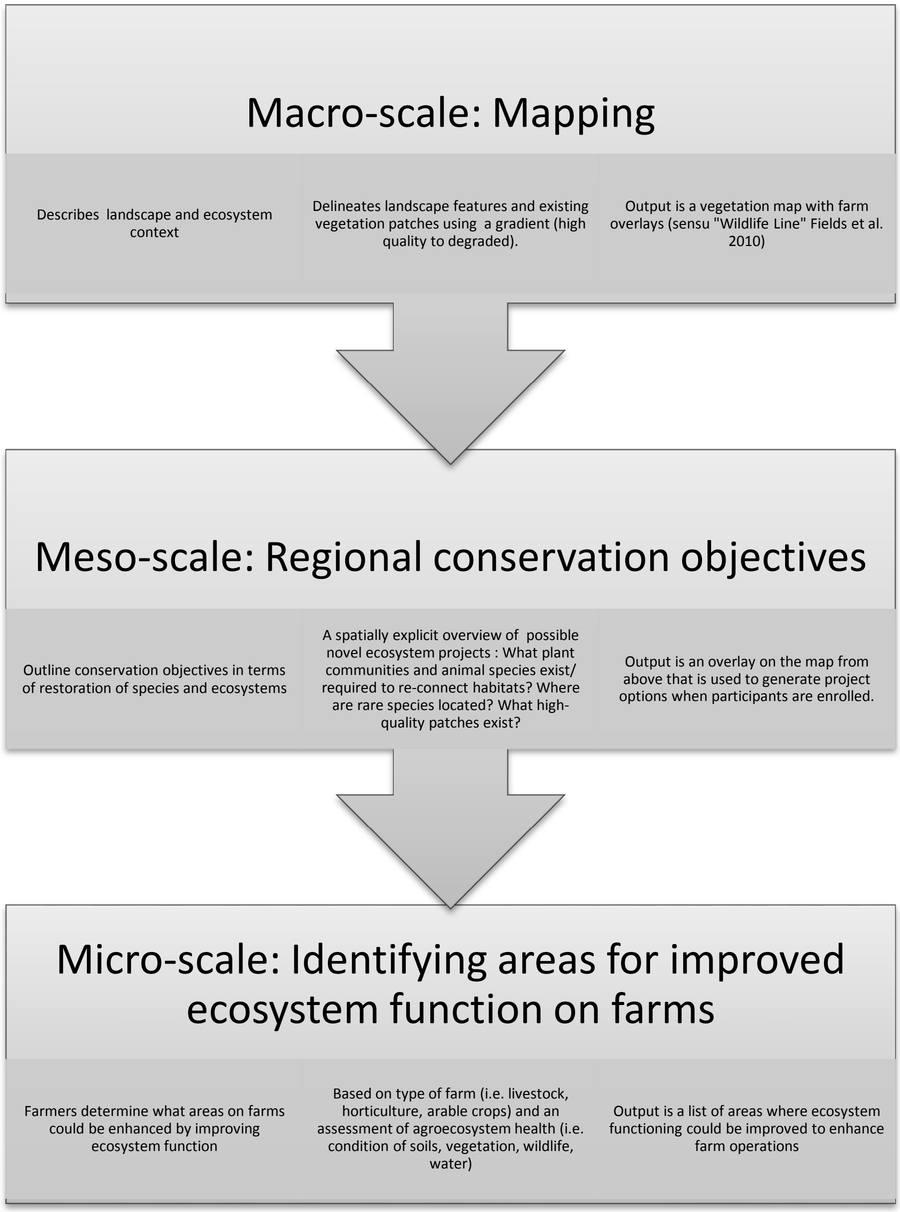

FIGURE 6-1. EXPLANATION (WITH EXAMPLES) OF THE TRIPARTITE DECISION-MAKING FRAMEWORK/INTERFACE FOR THE NOVEL AGROECOSYSTEMS.

Based on the information provided in the macro-scale map the regional conservation objectives are identified by the controlling authority. An online interface would be the most accessible and the most efficient way to communicate this information. When a farmer visits the interface, they examine the map which contains the ecosystem information inputted with the data points on existing vegetation and the target areas for habitat connectivity and finds their farm on the map and clicks on it and begins answering questions about their type of farm, farm operations etc. The farmer interacts with both the macro-scale information and the meso-scale objectives which ultimately guide the potential projects they can receive payment for at the micro-scale (on the farm). Based on the regional requirements identified on the map (i.e. water quality improvement areas, restoring species in decline, creating habitat corridors etc.) and the functional requirements identified by the farmer, a list of potential projects is generated (see below). The projects are triaged based on the information gathered and presented at the mapping stage.

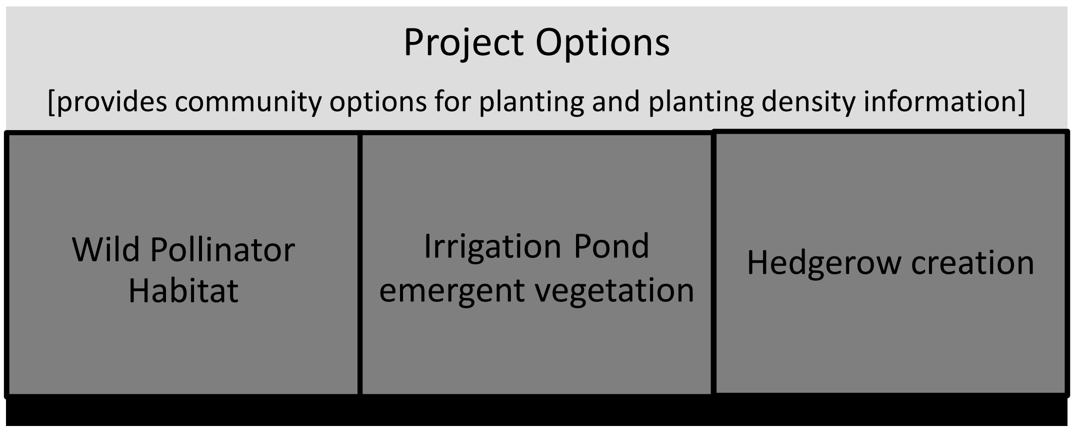

FIGURE 6-2. EXAMPLE OF THE OUTPUT OF PROJECT OPTIONS THAT A PARTICIPANT WOULD ENCOUNTER USING THE SPATIALLY EXPLICIT ASSET INVENTORY INTERFACE FOR THE NOVEL AGROECOSYSTEMS.

From these options, the landowner selects which project they are interested in incorporating into their landscape. At this point, information is provided on the communities they will plant, planting requirements, densities for successful competition/ dominance, and survival (e.g. information gathered from studies like the one undertaken in Chapter 5).

This research investigates the best and newest ideas with the premise that they can be applied for/by farmers, researchers, commodity experts, purchasers, and policymakers to ensure that Canadian agriculture will thrive despite changes that can be anticipated with some certainty and those that will inevitably surprises. This is possible – as long as one builds redundancy and resilience to an agricultural system and the socioecological system in which it is embedded. The capacity for socioecological systems to maintain or enhance the production of ecosystem services directly affects the economic viability of the societies dependent on those services (Altieri, 1992). In order to moderate the damaging effects influencing ecological service delivery, ecosystem managers and decision-makers must concentrate on enhancing biodiversity (ecosystem processes) through policy initiatives to assure that ecosystem services can be delivered to human societies.

6.4 Case-specified Sustainability Criteria

In addition to the cross-scalar approach to the research and decision-making the outcome of this research is a suite of case-specified sustainability criteria. The objective is to use the findings from this research to critique and scrutinize the development and design of future agri-environmental programs that emerge. Pretty (2008) defines five main components of capital that combine to make agriculture sustainable. The following table is partitioned into the five components of capital and is based on the integration of desirable gains that emerged from the review of the literature from the chapters, the Q factor analysis and the findings from the pilot studies. The five areas of capital can be used as a suite of case specified criteria to scrutinize new design characteristics of agri-environmental pilot programs to determine how effectively programs will address the burden of *maximum net gains* outlined in Chapter 4.

TABLE 6-1. THE SUITE OF CASE SPECIFIED CRITERIA FOR DESIGN CHARACTERISTICS OF AGRI-ENVIRONMENTAL PILOT PROGRAMS DERIVED FROM THE PRINCIPLES OF MAXIMUM NET GAINS (SENSU GIBSON ET AL. 2005).

Social: Fostering mutually beneficial collective action
Social learning in and around the agricultural community Scaling up of sense of place, sense of community, sense of duty to regional conservation Knowledge sharing in an amongst the agricultural community Mutually beneficial collective action Being cognizant of the collection of norms, attitudes, values Normalization of a new set of rules Structuring of groups and organizations
Financial: Enhancing the viability of agricultural livelihoods
Equitable distribution of opportunities and access to programs Economic viability and livelihood sufficiency Financial systems that gather savings and distribute payments (e.g. pensions, remittances, grants, incentives and subsidies)
Physical: Providing the required human-made material resources
Access to sustainable research and technologies Access to resources for running efficient sustainable operations e.g. buildings, houses, market infrastructure, irrigation structure, communication, tractors, energy and transport system
Natural: Enhancing ecological functioning (the processes of ecosystem services) at the farm-scale
Nutrient cycling Water supply and regulation Biodiversity Efficiencies in energy and material use Natural pest control (Integrated Pest Management) Wild pollinators Minimize the use of non-renewable inputs Production of raw materials Climate regulation Wildlife habitats Storm and flood protection Carbon sequestration Recreation and leisure
Human: Enhancing the capacity of individuals

Concern for the intergenerational transfer of farms Explore the context and rural identity and "sense of place" Investigate issues pertaining to stewardship identity Enhance the awareness of local distinctiveness Learn how to and then provide better access to public services Foster leadership and organizational skills

Based on this one can begin to identify a set of recommendations for actors that are involved in agricultural and ecological management in Canada.

6.5 Recommendations

Various recommendations emerged from this study, ranging in scope from specific actions and approaches that could be taken by practitioners and agencies responsible for policy and land use decisions, to methodological recommendations for future researchers. These recommendations apply to a variety of audiences, including but not limited to provincial and regional government agencies, rural communities and farm organizations, local conservation authorities, landowners, and researchers. It is hoped that the thesis results and recommendations will be of some interest and benefit, especially to Canadian rural landowners and communities interested in pursuing different avenues for farm viability in terms of social, cultural, ecological and economic aspects. There are three general areas in terms of recommendations discussed here, to guide program development and land management in respect to alternatives to agricultural policy approaches currently employed in Canada. Broadly speaking, the recommendations are presented to agricultural policymakers in Canada (particularly in respect to federal and provincial governing bodies), the research community, and also landowners, in terms of agricultural operators and land managers, in terms of relevant agencies that would be involved in delivering agri-environmental initiatives.

6.5.1 Policymakers

Canadian policymakers need to examine the benefits derived from programs that encourage agroecological resilience. This requires more thoroughly examining the relationships between ecological functioning, social well-being and economic viability in the Canadian context. Then one can ask: what are the elements of local cultural and livelihood practices that interact and help to maintain and encourage ecological functioning on agricultural landscapes as part of a resilient agroecological system? Based on those relationships, funds should be earmarked for multifunctional programming with an agenda that begins to move away from a purely state assistance model. Additionally, policymakers need to begin working on an agenda that is multifunctional in nature. This requires creating a new agri-environmental mandate which should be built on a new research approach; the research agenda set at the federal level needs be cognizant of the perhaps less tangible and immediate gains from a research agenda concerned with the multifunctional aspects of agricultural landscapes but which will provide gains and resilience to the sector over the longer term. Policymaking, as discussed in Chapter 2, influences the management decisions made at the farmscale in Canada. Therefore, a new policy agenda should promote multifunctionalism and stewardship and then should fund it adequately to support farm economic viability in a different vein than has been the norm. One approach to doing this would be to amend the structure of the EFP to incorporate more initiatives that encourage the enhancement of ecological functioning and which would make particular linkages to regional conservation efforts and make better use of regional conservation authorities. The payment scheme for the EFP, the one-time pay-out approach, should also be restructured to offer an on-going incentive structure. It would be suitable to also make explicit linkages to regional or municipal conservation authority efforts, some of which are already linking their local problems to the EFP for funding support (e.g. the Niagara Peninsula Conservation Authority and the Water Quality Improvement Program).

6.5.2 Research community

The agricultural and ecological research communities should build on the conceptual framework of novel ecosystem to begin building a body of literature and thus the theory of novel ecosystems with a particular focus on how it can be implemented on agricultural landscapes. This will require delving further into the literature that is discussed in this study in terms of ecological management, transformation and sustainable transitions to examine how agriculture and ecological functioning can be reconnected to the benefit of both. Additional research on the political economy of Canadian agriculture would also aid in the delivery of new incentive structures. Lessons can be learned from ALUS, the Ontario EFP and also the EU ESA funding structures. Innovations in agriculture are not just technological; further research should look at how innovations of land-use management can drive agricultural transitions and transformations.

6.5.3 Landowners and land managers

Agricultural operators need to place a larger emphasis on ecological functioning in their landscapes. In particular, identifying what functions actually drive their agricultural operations would help to identify what ecosystem services are provided as ancillary benefits of their land-use. It would also help to identify the intersection between ecological functioning, for which they could be funded under a new agri-environmental initative, and ecosystem service delivery. Additionally, landowners need to begin demanding that more effective and comprehensive multifunctional options are offered by Canadian policymakers.

6.6 Future Research

A number of themes and suggested directions for further research emerged from this study, some specific to the location and situation in the case study, and others related to the topical areas of research. The next stage of research should investigate how to implement the novel ecosystem program. More than likely, a program like this would be best suited to commence as a pilot project, similar to how ALUS began, and could be coordinated with/ by local conservation agencies.

6.6.1 Recommendations for future research

- Begin examining how best to coordinate the mapping of ecosystems and farms and how to map ecological change

- Create a pilot interface for how best to present the mapped information to project participants
- Initiate a pilot project using maps and the interface in the Niagara region where the case study occurred
- Collect data on native species in pilot location using vegetation inventories
- Map land-uses in terms of agricultural productions
- In depth research on how ecological assembly rules is useful for guiding novel ecosystem implementation
- Examine the agricultural economy of Canada and determine where the funding for a comprehensive agri-environmental approach would come from
- Explore the costs of implementing these types of projects (what would it take to finance something like this?)
- Explore further the ways in which local livelihoods, ecology and culture can form the foundations of agroecological approach to land use and habitat planning and management

6.7 The Last Word

Although this research has dealt primarily with building the mutual resilience of agriculture and ecosystems in Canada it is undeniable that the people that live within those landscapes shape Canadian agriculture. I set out on my research journey concerned with reinvigorating the ecological-life of agricultural landscapes with particular research questions and goals in mind. However, as is the case with scientific discovery as I traversed my research path, the path kept widening and widening into larger fields and vistas. My objectives during the course of this research have never changed—I wanted to understand the state of Canadian agro-ecological relationships and to create an implementable solution to address the gaps I exposed—along the way I discovered, however, that the relationship between agriculture and ecosystems influences, and is influenced by many other processes and relationships. The blending of these relationships has ultimately shaped the trajectory of agroecological health and viability as well as the health and viability of those who rely on agricultural landscapes for their livelihoods.

I think it is difficult at this juncture to provide a conclusive end for the story that this research sought to tell; in fact, I believe in many ways, I have only uncovered the beginning of an important story for Canadian agriculture that has yet to be told in any meaningful or comprehensive way. Canadian agro-ecological health is at a crossroads due to large-scale environmental change, globalized markets and livelihood insufficiency for the masses of small to medium-sized operators a new approach for agri-environmentalism in Canadian agriculture offers a way forward to deal with these issues. I hope that this research provides a set of recommendations that form the basis of on-going academic inquiry into an important sector that has significant ecologically, socially, economically and culturally iconic connotations for Canada.

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