A Resilience Assessment of a Small-Scale Agroecosystem:

Case Study of Mount Wolfe Forest Farm in Caledon, Ontario

By:
Kathleen Moore
20474859

An undergraduate thesis presented to the
University of Waterloo
For the degree of
Bachelor of Environmental Studies in
School of Environment, Resources, and Sustainability

April 6, 2017
ERS 411
Professor Daniel McCarthy

Abstract

This research involved conducting a resilience assessment on a small-scale agroecosystem using Mount Wolfe Forest Farm as a case study and using the Resilience Assessment Workbook by Resilience Alliance as a framework. The purpose of this research is to assess the resiliency of local sustainable food systems and how land use policies can be used to benefit conservation but also support a working landscape as a complex social-ecological system such as a small-scale farm.

As climate change becomes a greater threat and industrial agriculture has created an environmental crisis, there is a need to shift towards a model of agriculture that is based on diversity, ecological integrity, and limited chemical inputs. This type of agriculture is also known as "agroecological" practices that can exhibit resiliency and sustainability. Mount Wolfe Forest Farm is an example of a small-scale agroecosystem that has adopted these practices. Mount Wolfe Forest Farm (MWFF) is located in Caledon, Ontario situated on the Oak Ridges Moraine which has been protected by the Oak Ridges Moraine Conservation Act (2001) and the Greenbelt Act (2005) as an environmentally sensitive geological landform. A resilience assessment was conducted on the farm to assess how a working landscape can make use of the policy protected land by combining livelihood and conservation.

This resilience assessment included using a literature review and interviews with key informants to answer questions related to "resilience of what, to what and with what?" The literature review consisted of exploring concepts of resilience thinking, adaptive capacity, conducting a policy analysis and historical profile of the system, and background research of conservation efforts and small-scale agriculture in southern Ontario. Participants of the interviews included members of the farm, CSA members, and a municipal employee at the Town of Caledon. Results of "resilience of what?" defined MWFF as a social-ecological system its main issues, and key components. "Resilience to what?" addressed the main threats, disturbances, and uncertainty regarding MWFF as well as multiple states and thresholds, cross-scalar interactions, adaptive governance and social networks of the system. Finally, "Resilience with what?" identified the assets of the system that make it resilient.

The results of this research conclude the main threats to MWFF are economic viability, long-term viability of the local food system, weather and climate disturbances, and the stringent provincial policies. In addition, the main assets for resilience of the system include ecological practices, a supportive network, relationship building and availability/accessibility. Recommendations for MWFF to enhance its resiliency include advocating for a strong support network of stakeholders, encourage rigid policies to become more flexible towards sustainable agriculture, build an integrated resilience plan, and use social innovation as a tool for resilience. Recommendations for the Resilience Assessment Workbook by Resilience Alliance include making it more usable for small-scale systems, create a section on resilient assets of a system, and give examples of characteristics of a resilient system.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

Industrial agriculture stemmed from the Green Revolution as an effort to increase food security by intensifying and mechanizing crop production (FAO, 2011). However, this industrialized food system has created serious global consequences, including the depletion of non-renewable resources, soil degradation, greater gender and income disparity and loss of crop and seed diversity (FAO, 2011; IPES-Food, 2016; Oxfam, 2014). It is clear that conventional industrial practices of agriculture lead to negative outcomes and vulnerabilities towards people, resources, and the natural environment. Therefore, there has been an increasing need to shift towards a model of agriculture that is based on diversifying farms and landscapes by optimizing biodiversity and species interactions and limiting chemical inputs, otherwise known as "diversified agroecological systems" (IPES-Food, 2016). This research project aims to assess the resiliency of local sustainable food systems such as agroecological practices rather than the conventional industrial practices of farming. In addition, how land use policies involving conservation can be used to benefit a sustainable working landscape as a complex social-ecological system such as a small-scale farm.

Much of southern Ontario's agriculture is conventional and many farmers produce cash crops and own large amounts of land for producing one rotation crop (Miller, 2013). Ontario's farmland is being threatened by urban sprawl, aging farmers, and new farmers not being able to access land (Miller, 2013). In order to create sustainable future of farming some farms have adopted "alternative agriculture" or agroecological practices that is characterized by food sustainability and food sovereignty (Warner, 2007). Small-scale agroecological farming practices strive to produce food without sacrificing the health of humans, animals, or ecosystems (Wezel et al., 2009) while also creating a local food system rather than a conventional globalized one.

Resiliency applied to agriculture includes a farm's dependence on its own resources instead of external outputs, promoting a short supply chain, and its ability to absorb disturbances (Borron, 2006). Farms that practice enhancing biodiversity on the farm and surrounding ecosystems can strengthen the resiliency of both the farm and the environment (Borron, 2006).

Resiliency refers to the amount of change or disturbance a system can experience without shifting into an alternate state and remain within the same regime, essentially it is a system's ability to bounce back after a major disturbance (Walker & Salt, 2006). Resiliency is associated to complex systems thinking in social ecological systems. The key to sustainability within resilience involves enhancing social-ecological systems and interconnected and not in isolating key components of a system (Walker & Salt, 2012). Using resilience as a method of planning and managing systems for changes that are human induced is more important than ever since humans are now changing the environment faster than ever. Traditional command-and-control approaches to managing systems that do not consider the connectedness of the environment and its resources can make a system vulnerable to disturbances that can be detrimental to a system (RA, 2010). The Resilience Assessment Workbook by Resilience Alliance is used as a framework for assessing and potentially enhancing the resilience of a system, such as a small-scale agroecosystem. In practice, resilience is often applied to specific issues or aspects within a system which is known as specific resilience but resilience can also be applied to a broad range of issues or disturbances known as general resilience (Folke, Carpenter, Walker, Scheffer, Chapin, & Rockström, 2010); however, the resilience assessment has most often applied to a broad or larger system rather than a community based system such as MWFF. The Resilience Assessment Workbook by Resilience Alliance uses a series of questions and activities that are applicable to build a conceptual model of any social-ecological system and attempts to identify

any thresholds, disturbances, or states that could threaten the system (RA, 2010). A resilience approach assumes uncertain and complex natural resource systems and the Resilience Assessment framework aims to assist in developing and implementing management goals without compromising the resilience and integrity of the system (RA, 2010).

The Greater Golden Horseshoe (GGH) area is in Southern Ontario ranging from Lake Ontario, Lake Erie, and up to Georgian Bay (MMA, 2013). The GGH is one of the most densely populated and fastest growing regions in North America (MMA, 2013). As a result of this rapidly growing region, the GGH will experience many benefits including diversified and expanding communities, and increased cultural diversity and recreation; however poorly managed growth can have negative consequences including deteriorating ecosystem services such as air quality, agriculture landscapes, and natural resources. As an attempt to properly manage growth within the area the Places to Grow Act (2005) was created which also builds on the Ontario Greenbelt Plan (2005). The Ontario Greenbelt is a unique land mass located in Southern Ontario that includes lands within The Niagara Escarpment to the Oak Ridges Moraine as part of protected land for current and future generations. The Oak Ridges Moraine is especially environmentally sensitive and geological landform that covers 190,000 acres and is under the Oak Ridges Moraine Conservation Act (2001) that protects the whole area and provides land use and resource management for all land and water (MMAH, 2001). As the Golden Horseshoe Area continues to grow, more pressure will be put on the natural resources and ecosystem services that occur in the area. It is important to foster the use of the natural lands but also protect it which is where resiliency of social-ecological systems can be applied to this area and specifically the Oak Ridges Moraine agricultural lands. The Oak Ridges Moraine, the

Town of Caledon, and the GGH as a whole faces pressures of growth and urbanization, and land use changes that threaten the ability of the system to absorb disturbance and threats.

Using a case study methodology, a resilience assessment of Mount Wolfe Forest Farm (MWFF) in Caledon, Ontario will be conducted. MWFF is situated on the Oak Ridges Moraine which is part of Ontario's Greenbelt and has been protected by the Oak Ridges Moraine Protection Plan as an environmentally sensitive geological landform. This study was conducted because Mount Wolfe Forest Farm is a unique small-scale community supported agriculture (CSA) based farm that also happens to be on policy protected land. A resilience assessment is beneficial for the farm to understand their social-ecological system and what might threaten or enhance their resiliency in the future in order to adjust planning and management practices. However, it is also beneficial for other systems to be able to replicate a system similar to MWFF's in other places on the protected landscape of the Oak Ridges Moraine or the Niagara Escarpment in order to increase small-scale agriculture operations and overall resiliency of agriculture in an ever-growing southern Ontario. In the long term, this resilience assessment can be used to replicate MWFF's agroecological practices on farms throughout the Oak Ridges Moraine and Ontario Greenbelt to make the liability of the land an asset by combining livelihood and conservation. The main research question of this project is what factors threaten or enhance the resiliency of Mount Wolfe Forest Farm as a sustainable working landscape to create revenue and pass on to future generations while also under policy protected land due to the Oak Ridges Moraine Conservation Plan?

The goal of this research is to assess and potentially enhance the resiliency of MWFF to generate revenue and to pass the land down to future generations while also adhering to the

policies of the protected land, and its abilities to adapt to social and ecological changes. The key objectives for achieving this goal are as follows:

1. Conduct a resilience assessment of Mount Wolfe Forest Farm (MWFF)
2. Complete background research and a literature review including a historical profile to apply to the Resilience Assessment Workbook
3. Complete interviews with key informants including farm members, CSA members, and a municipal employee from the Town of Caledon
4. Develop recommendations for enhancing resiliency of MWFF in order to reach their long-term goals
5. Develop ways to improve the current Resilience Assessment Framework
6. Create a case study in relation to resilience of a small-scale agroecosystem within protected land as a complex social-ecological system

This study is divided into introduction, methodology, literature review, results, recommendations, and conclusions. The introduction section includes a broad overview of the issue and resiliency, the goals of this study, and the research question and rationale. The methodology section describes the methods that were used for including MWFF as a case study, the literature review, using the Resilience Assessment Workbook, and methods of collecting primary research through interviews and focus groups. The literature review gives background information in order to help define the system including concepts of systems and resilience thinking, adaptive capacity, a policy analysis of the area, a short historical profile of the area, and conservation efforts and small-scale agriculture in southern Ontario. The results section of this report is split into three sections that relate directly to the resilience assessment; the three sections are: “resilience of what?”, “resilience to what?”, and “resilience with what?” by using the resilience assessment to answer these questions along with interviews and literature review. This report concludes with recommendations to enhance resilience for MWFF and

recommendations for Resilience Alliance on the resilience assessment as it applies to small-scale system, and finally, conclusions.

2.0 Literature Review

Industrialized food systems in the 21st century have been one of the greatest achievements by human civilization by providing increased crop productivity, processing, and distributing capacities to allow many parts of the world varied and affordable diets (IPES-Food, 2016). Unfortunately, industrialized agriculture is also one of the greatest threats to our modern world contributing to significant land degradation, loss of biodiversity, and ongoing food insecurity due to monocultures and reliance on chemical inputs (IPES-Food, 2016). An alternative agricultural practice to industrial agriculture is the concept of "agroecology" which is an emerging approach in sustainable food systems. Agroecology encourages communities of plants and animals to interact with their physical and chemical environments in addition to producing knowledge and practices that aim to make agriculture more sustainable (Oxfam, 2014). Agroecology can be used for redesigning agricultural systems in a way that maximizes biodiversity as part of holistic approaches in order to build long-term fertility, healthy agro-ecosystems and secure livelihoods (IPES-Food, 2016). Successful agroecology uses concepts from resilience thinking and adaptive capacity such as enhancing the resilience of social-ecological systems through acknowledging the complex dynamics in nature and not isolating certain components from each other (Walker & Salt, 2012). Therefore, a case study on the resiliency of Mount Wolfe Forest Farm was conducted; a policy analysis, historical profile, and review of conservation efforts and small-scale agriculture practices in southern Ontario will also be researched in order to gain a better understanding of the farm and surrounding areas as a tool for assessing the resiliency of the system.

2.1 Systems and Resilience Thinking

Complex systems thinking is a concept that draws on other concepts emerging from new science such as catastrophe theory, chaos and complexity theory, non-equilibrium thermodynamics and self-organization (Kay, Regier, Boyle & Francis, 1999). Systems thinking recognizes that any type of phenomena are interconnected and causality is complex, therefore, change does not confine itself to one structure or category of a complex system (Stockholm Resilience Centre, 2016). Complex systems can only be understood through assessing the relations of their components that form patterns over time (Kay, Lister, & Walter-Toews, 2008). Therefore, systems thinking can be used as a way to understand the problems of sustainability as they involve social-ecological systems and environmental problems that relate to resilience thinking (Kay et al., 2008).

Resilience is a concept of sustainability that is defined as "a measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973). The concept of resilience also recognizes the interdependence between people and nature as a linked dynamic system and the interactions that occur in both social and ecological disciplines at various scales (Walker, Abel, O'Connell, Grigg, 2016). Three characteristics of social-ecological resilience include the amount of change a system can undergo while maintaining functions/structures, degree of self-organization, and adaptive capacity (Milestad, 2003). Resiliency of farm systems are of particular interest because food systems are an integral part of our lives and are increasingly threatened by industrial practices. In addition, it is important to assess the capability of small-scale agroecological farms to be resilient and social-ecological systems that are able to meet the food needs of the world without compromising the environment. Managing a system component-

by-component can work well over short timeframes but it will inevitably lead to long term problems; managing resilience comes down to assessing the short-term profit losses from enhancing resilience with the long-term benefits of a resilient system (Walker & Salt, 2006). Therefore, the Resilience Assessment Workbook is used in this study in order to assess the resilience of MWFF as a system in ways that it can build its resiliency but also in ways where it is already resilient and how this system's socio-ecological components can be replicated to other farming systems.

The Resilience Assessment Workbook by Resilience Alliance was designed for practitioners and draws on insights from research of complex adaptive systems to provide users with an alternative way practicing natural resource management (RA, 2010). The Resilience Assessment Workbook has been revised from the original version 1.0 (2007) to 2.0 (2010). The Resilience Assessment Workbook was created by Resilience Alliance, established in 1999, which is an international multidisciplinary research organization that aims to advance the understanding and practical application of resilience (Resilience Alliance). The concept of resilience was originally introduced by Holling (1973) to help understand the capacity of ecosystems to persist in their original state and return to a state of equilibrium upon disturbances; this also resulted in the book "Panarchy" (2002) (Folke et al., 2010). However, resilience has often been criticized as being too abstract to apply in practice, therefore in 2006 "Resilience Thinking" by Brian Walker and David Salt was published as an attempt to remove the jargon from the concept and how it can add value to the way we manage systems around us (Walker & Salt, 2006). Subsequently, in 2012 the two published "Resilience Practice" as a sequel in order to apply the thinking and put it into practice and the idea that anyone can apply it to systems including business leaders, policy makers, farmer, conservationists etc. (Walker & Salt, 2012). Therefore, the Resilience Assessment

Workbook is a product that came out of decades of theoretical research and case study comparisons by members of the Resilience Alliance and other researchers as efforts to better understand practical applications of resilience thinking for social-ecological systems (RA, 2010). The workbook strives to challenge the conventional ways of attempting to control natural resources for maximum yield and short-term economic gain by promoting a resilience approach that assumes complex dynamics and interconnectedness of all social and ecological components and aims to produce long-term sustainability to the environment and people (RA, 2010).

Although the Resilience Assessment Workbook was designed to be a practical application system of resilience, it is not a perfect framework and has its flaws. Liu (2011) stated that the Workbook does not provide any guidance on identifying assets of a system that make it resilient and can build its resilience, and therefore suggested adding a "resilience with what?" section of the workbook. In addition, the Workbook lacks guidance on identifying what purpose resilience should serve and does not explicitly state normative qualities a resilient system should exhibit (Liu, 2011). Nadasdy (2007) argues that resilience thinking and adaptive management does not recognize that social-ecological systems are embedded in institutions of capitalist production and removes the social-ecological systems from culture and politics, which is unrealistic. In addition, it is important to remember that resilience is not always desirable. Nadasdy states that many scholars contributing to literature on resilience have now replaced "the balance of nature" with "resilience" as the ecological ideal to which to assess social-ecological systems (Nadasdy, 2007). It is important to be aware that resilience is not always desirable, and a crucial political issue of the resilience assessment is who gets to decide what is the "desired" of the social-ecological system is (Nadasdy, 2007).

2.2 Adaptive Capacity

Resilience determines how vulnerable a system is to unexpected disturbances which is achieved by adaptive capacity (Holling, 2001). Social-ecological systems are always changing which can happen at multiple scales of time and space moving through four phases of rapid growth, conservation, release, and reorganization; usually but not always in the sequence (Walker & Salt, 2006). Holling (2001) describes the three properties that shape the adaptive cycle as: the potential or current "wealth" of a system, the controllability of a system by how it is interconnected with its components, and the resilience of the system by its vulnerability to disturbances. The adaptive cycle is controlled by these four "ecosystem functions" and how a system flows through each of them and how a system naturally changes over time (Figure 1). The ecosystem functions include slow accumulation and transformation of resources (exploitation and conservation) to shorter periods of resources release and reorganization (Holling, 2001). The drivers of the adaptive capacity of a system can include accumulation of ecological, social, economic, and cultural capital (Holling, 2001).

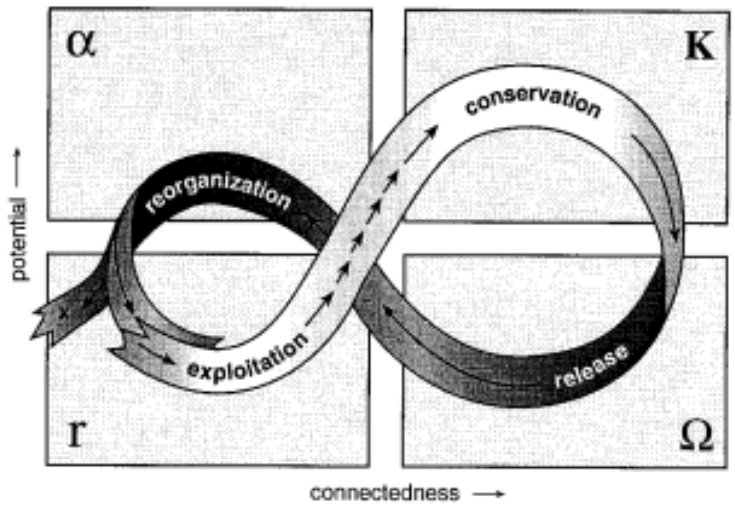


Figure 1. A representation of the four ecosystem functions and how they flow from one phase to the other in adaptive capacity (Holling, 2001).

However, the adaptive cycle can occur at multiple scales above and below the focal scale, which is known as "panarchy" (Walker, Holling, Carpenter & Kinzig, 2004). The functioning of panarchy and the communication and relationships between them determines the sustainability of a system (Holling, 2001). Adaptive capacity and panarchy explain the meaning of sustainable development in which sustainability refers to the adaptability of the system and development refers to simultaneously creating opportunities through social innovation (Holling, 2001). By understanding how a system can change internally using the adaptive cycle and panarchy, systems' vulnerability and capacity can be assessed as it responds to movement throughout the four ecosystem functions which can inform type and timing of management interventions (RA, 2010).

Adaptive capacity to manage and understand resilience is important especially in farming because there can be many drivers that influence disturbances and uncertainties and if they are managed properly, can be used as opportunities for the future. Farming systems are not only economically productive but also have important political, social, cultural, and environmental dynamics which is why they can be considered socio-ecological systems that can use adaptive capacity (Dixon, Stringer, & Challinor, 2014).

2.3 Policy Analysis

Mount Wolfe Forest Farm is located in Caledon, Ontario and situated on the Oak Ridges Moraine (ORM) that has been protected by the Ontario Ministry of Municipal Affairs and Housing under the Oak Ridges Moraine Conservation Act (2001) and Greenbelt Plan (2005). As a result of the legislation that Mount Wolfe falls under, it makes the farm unique however it is also seen as a dilemma since growth of the farm is restricted by the following plans.

2.3.1 Greenbelt Plan

The Greenbelt Plan was established under The Greenbelt Act (2005) and includes and builds upon the environmental protection covered by the Niagara Escarpment Plan (NEP) and the Oak Ridges Moraine Conservation Plan (ORMCP) (Ministry of Municipal Affairs and Housing, 2016). The Greenbelt is an area of land that stretches from the Oak Ridges Moraine and across the Niagara escarpment and protects 1.8 million acres of agriculture land and environmentally sensitive areas in the area of the Greater Golden Horseshoe (MMAH, 2005). The Greenbelt Plan is used together with the Greater Golden Horseshoe Growth Plan in order to establish a land-use planning framework that is able to support the growing economy but also conserve the unique and valuable ecosystems (MMA, 2013). The Greenbelt Plan's goals are to protect against the loss and fragmentation of agricultural land as well as to give permanent protection to natural heritage and water resource systems (MMAH, 2016). The proposed Greenbelt Plan (2016) has also incorporated a Protected Countryside section that is intended to enhance the extent to which agriculturally and environmentally significant lands are protected that are not necessarily protected by the NEP and ORMCP (MMAH, 2016). The Greenbelt Plan ensures conformity by municipalities modifying their Official Plans to ensure they conform to the provincial legislation (Liu, 2011).

2.3.2 Oak Ridges Moraine Conservation Plan

The Oak Ridges Moraine Conservation Plan (ORMCP) was created after the establishment of the Oak Ridges Moraine Conservation Act (2001) as a settlement to provide land use and resource management planning direction to ministries, municipalities, and landowners on how to protect the moraine's ecological and hydrological features and functions (MMAH, 2001). The conservation plan provides land use and resource management direction for all 190,000 hectares

of land and water within the moraine (MMAH, 2001). Therefore, MWFF is restricted in land use developments due to the ORMCP which only allows limited development to continue on the Moraine. The ORMCP's four land use designations include; natural core areas (38%), natural linkage areas (24%), countryside areas (30%), and settlement areas (8%). (Oak Ridges Moraine Foundation). Within natural core areas, natural linkage areas and countryside areas there are high restrictions on development, and only very few new infrastructure developments are permitted within these land use designations (MMAH, 2005). Development within these areas is only approved if it will not adversely affect the ecological integrity of the area and must meet very stringent standards and regulations of the conservation plan (MMAH, 2005). Overall, any planning or zoning decisions within the municipality must comply with and be approved by the legislation.

2.4 Historical Profile

Within the focal system of interest, there is a hierarchy of systems that function at multiple time and scales (RA, 2010). The Resilience Assessment workbook recommends analyzing sets of systems at different time scales and also at different space scales in order to understand the focal system better. Therefore, a brief historical profile was conducted not only of Mount Wolfe Forest Farm but also of the Oak Ridges Moraine and Town of Caledon.

2.4.1 The Development of the Oak Ridges Moraine

The Oak Ridges Moraine was formed by multiple advances and retreats of glaciers and is approximately 190,000 hectares in size, 160 km in length, and between 3 and 24 km wide (Whitelaw & Eagles, 2007). As the glaciers began to retreat and melt, torrential flood channels developed beneath the melting ice carrying sediments that were deposited forming the initial moraine (Oak Ridges Moraine Land Trust). 9,000 years ago, after the glaciers had retreated from southern Ontario, the Oak Ridges Moraine remained over 300 metres above Lake Ontario (Oak

Ridges Moraine Land Trust). The Oak Ridges Moraine in the Caledon area is characterized by clay soils over till which are fertile and prime for agricultural purposes (Town of Caledon, 2009).

2.4.2 Oak Ridges Moraine Pre-Contact Era

It is believed that the earliest human settlement of the Oak Ridges Moraine was by the Paleo-Indians from 9000-7000 BC who were primarily a hunter-gatherer society inhabiting the area after the last glacial retreat (Town of Caledon, 2009). From 1000 BC to AD 1650 larger more permanent villages were established along with innovation of new weapons, growing of crops, and trade and travel routes between tribes (Town of Caledon, 2009). On Mount Wolfe, one Iroquoian village has been discovered in the north-east corner of former Albion Township thought to date back to the 15th century (Town of Caledon, 2009). Caledon is on the traditional territory of the Mississaugas of the New Credit First Nation which is part of the Ojibway (Anishinaabe) Nation that started at Long Point along Lake Eerie and eastward to Lake Ontario, northward up the Rouge River and along the dividing ridge between Lake Ontario and Lake Simcoe (Mississauga of the New Credit First Nation, 2014). Most of the First Nations that inhabited the land that is now southern Ontario, practiced farming for their main source of carbohydrates and fibres using an integrated poly-crop system of corn, kidney beans, and squash (Fridman, 2014). This technique of farming not only created substantial nutrient basics, but effectively fortified the soil, creating healthy ecological infrastructure for crops to grow (Fridman, 2014).

2.4.3 Oak Ridges Moraine European Settlement Era

European settlement of the Oak Ridges Moraine began in 1783 after the United States became independent and the British Government sought homes for Loyalists (Howard, Eyles, Smart, Boyce, Gerber, Salvatori & Doughty, 1995). Large-scale European migration occurred

after the war in 1812-1814 (Howard et al., 1995). The British Crown purchased over 85,000 acres from the Mississaugas of the New Credit First Nation between 1805-1818 that included parts of the ORM and Caledon and was referred to as the "Mississauga Tract" (Town of Caledon, 2009). Settlement on the ORM was the first line of military defense because of the physical landscape, and the soils were recognized for their agricultural potential (Howard et al., 1995). Therefore, the moraine was widely deforested in order for make way for agriculture during settlement in the 1800s, which led to extensive erosion on the regions sandy soils (Whitelaw & Eagles, 2007). The converting of the land had devastating effects on wildlife habitats and the Indigenous populations and the exposed soil became frozen in the winter leading to reduced recharge of the groundwater aquifers (Howard et al., 1995). The population on the ORM peaked in 1861 and then began to decline afterwards due to failure of agricultural success and the development of City of Toronto (Howard et al., 1995). In the 1930s and 1940s much of the moraine was reforested due to conservation efforts of the Ontario government (Whitelaw & Eagles, 2007). Threats to the Oak Ridges Moraine from urban development started in the 1980s which lasted 15 years and resulted in the Oak Ridges Moraine Conservation Act and Plan, respectively. The Ontario Parliament was pushed to pass the act largely due to advocacy of citizens, environmental groups, media, and conservation principles (Whitelaw & Eagles, 2007).

2.4.4 Establishment of the Town of Caledon in 1974

The Town of Caledon was established on January 1, 1974 by combining the former County of Peel townships of Albion, Caledon, the northern half of Chinguacousy, and the Villages of Bolton, and Caledon East (Town of Caledon). Caledon forms the northern municipality of the Region of Peel from the former County of Peel that was created in 1805. The two major river systems, The Credit River and Humber River, and many tributaries serve the

basis on which the socio-economic components of the Town of Caledon has evolved (Town of Caledon, 2016). Due to Caledon's unique geographic features, environmental protection, conservation and management of its resources are a vital role for not only the town but the Region of Peel and the Greater Toronto Area for many ecosystem services (Town of Caledon, 2016).

2.4.5 Mount Wolfe Forest Farm 1966-Present

The land that is now Mount Wolfe Forest Farm was bought in 1966 by the Crandall family as a conventional farm field. Since 1967, the Crandall family has planted tens of thousands of trees and created trails to restore the landscape to its more natural state after a century of continuous agriculture use (MWFF Slideshow). The land has been transformed from a barren and erosion-prone traditional agriculture landscape to a vast area of mature woodlots with pockets of perennial grasses and wildflowers (MWFF Slideshow). However, the second generation of Crandall's were faced with the financial burden of 70-acres of maintenance on the land with no revenue generated by it. This is how the idea of Mount Wolfe Forest Farm was created rather than selling the land for it to be cleared once again for industrial agriculture practices. The idea of creating a livelihood on the land without compromising the ecological integrity of the successional landscape was the basis of the farm. The land ethic of Mount Wolfe Forest Farm is imbedded in conservation and ecological approaches that enhance the ecological integrity of the soil fertility, biodiversity and animal health (MWFF). The farm offers a year-round CSA (community supported agriculture) program for up to 100 families producing a variety of vegetables, herbs and free-range meat chickens in addition to a variety of foods produced by other local farms including fruit, honey, maple syrup, eggs, flour and much more (MWFF Slideshow). After the first year of production, Mount Wolfe Forest Farm has 25 CSA

members, and in 2017 (second year of production) it is expected to grow to 50 CSA members with an end goal of 100 CSA members in total (FM3, personal communication, January 31, 2017). Farm Member (FM) 3 stated that:

> *We have gotten to know the [CSA] members and we have open days where they can come and explore our 10 km of trails. Our mission is also to get people to know what farming is about and to get their hands in the soil, and children to have a connectedness to pull a carrot out of the ground and walk the forests.*

2.4.6 Caledon and the ORM in the 21st Century

Today, the moraine acts as a water recharge and discharge system to provide clean drinking water to more than 250,000 people in addition to having an abundance of native plant and animal species (Oak Ridges Moraine Foundation). Rapid urbanization has caused major concerns regarding land-use change including aquifer recharge, aggregate extraction, and sewage and well-water systems (Howard et al., 1995). Land-use planning on the Oak Ridges Moraine was largely influenced by the environmental movement groups and the concept of conservation biology that enabled the government to move towards more stringent land-use planning policies (Whitelaw & Eagles, 2007). The Oak Ridges Moraine is now part of Ontario's Greenbelt which is an area that contains nearly two million acres of farmland, communities, forests, wetlands and watersheds in the Golden Horseshoe area; it is the most strongly protected greenbelt in the world (MMA, 2013). The greenbelt extends 325 km from the eastern end of the Oak Ridges Moraine to the Niagara river and contains 800,000 acres of protected land by the Niagara Escarpment Plan and the Oak Ridges Moraine Conservation Plan (MMA, 2013). The Oak Ridges Moraine is the first natural-heritage system that includes designation of long, wide conservation corridors on

private lands based on conservation biology to be regulated by land-use legislation (Whitelaw & Eagles, 2007).

The Town of Caledon has evolved from a predominately rural-based economy to being increasingly influenced by the activities and demands from surrounding urbanized areas, most notably, Toronto. The Town faces immense pressures of development and population growth from the ever-expanding Greater Toronto Area, however, due to its important natural and heritage areas it is also required to be a steward for the land. Caledon's extensively protected natural areas are a vital role in the Region of Peel and Greater Toronto Area for climate change mitigation as a carbon sink, and to moderate the extreme consequences of rainfall and temperature (Town of Caledon, 2016).

2.5 Conservation Efforts in Southern Ontario

There are a total of 36 conservation authorities in Ontario, 31 of which are operating in southern Ontario (Conservation Ontario, 2013). Boundaries of conservation authorities (CAs) are based on watersheds (Ivey et al., 2001). Conservation authorities are mandated by the Conservation Authorities Act (1946) in order to ensure the conservation, restoration, and responsible management of Ontario's natural terrestrial and aquatic habitats (Conservation Ontario, 2013). The creation of conservation authorities in Ontario was sparked by social and environmental concerns including finding jobs for veterans of the armed forces once they returned from WWII and the fear that environmental degradation would eventually affect economic growth (Mitchell & Shrubsole, 1992). Conservation authorities were a form of relationship between the municipal and provincial governments; some of the early projects included flood protection, low flow augmentation, and reforestation (Mitchell & Shrubsole, 1992). The Conservation Authorities Act grants CAs the power to purchase land and to regulate

the use of land that they own and to enter agreements with other agencies to manage their lands; however, it does not allow a legal basis for them to regulate the land use, management practices, or contaminant sources (Ivey et al., 2001).

The portion of the Oak Ridges Moraine that is in the Town of Caledon is part of both the Credit Valley Conservation Authority and the Toronto Region Conservation Authority (TRCA, 2016). Mount Wolfe Forest Farm is situated on the Oak Ridges Moraine and is within the regulated area of the TRCA and the TRCA managed Albion Hills Conservation Area is just southwest of the farm (Appendix C). Industrial agriculture can be a concern for conservation authorities especially since the impact of intensive agriculture can have negative effects on quality and quantity of groundwater (Ivey et al., 2001). Therefore, conservation authorities can hinder the practices of conventional agriculture. Agroecological and small-scale farming practices can be complimentary to a conservation authority's goals by working with the land to create a sustainable livelihood. The TRCA currently owns and manages approximately 400 acres of land zoned as agricultural land and has made farming a greater priority with its recent Sustainable Near-Urban Agriculture Policy which encourages local sustainable food systems by producing local food for the Toronto Region (TRCA, 2016). The TRCA has recognized the importance of local food and has recently leased approximately 135 acres to four community farms which are: McVean Farm, Albion Hills Community Farm, Black Creek Community Farm, and The Living City Farm. All of these farming projects aim to provide local food, sense of community, economic opportunities, and learning opportunities in addition to reduced environmental impacts (TRCA, 2016). Many CAs tend to see farmers as a threat to the land, however TRCA is recognizing the importance and need for small-scale sustainable food production to feed cities. A Town of Caledon employee (CE) stated, "provincial policies and

conservation authorities need to rethink if farmers are really the threat to the natural environment or are they the stewards to the natural environment" (CE, personal communication, March 2, 2017).

2.6 Small-Scale Agriculture in Southern Ontario

Concerns surrounding human and environmental health linked to the vulnerability of the industrial food system have sparked numerous alternative food initiatives across the world and more specifically, in Ontario (Knezevic, Landman, Blay-Palmer & Nelson, 2013). Ontario has made efforts to create innovative ways to foster the development of local sustainable food systems such as creating food hubs, and local food networks which both consist of community or region-based food projects (Knezevic et al., 2013). There is no single definition of a local food system, however, most definitions focus on distance such as 100km, within a single province, or the time of distance a food travels (e.g. food travels less than five hours from point of production to point of consumption) (Edge, 2013). Provincial definitions of local food now emphasize the definition of anything produced in the province of Ontario and 50km beyond that (CE, personal communication, March 2, 2017; Edge, 2013). However, definitions of local food can be embedded within values and beliefs about the manner in which the food is produced and sold that make it sustainable and possibly small-scale (Edge, 2013). The local sustainable food system is often associated with small-scale farms which are usually defined by their practices of agricultural production methods, labour practices, and animal welfare rather than the size of the farm (Edge, 2013).

The Golden Horseshoe area specifically, has a rich and diverse range of farmlands that have been faced with considerable farmland pressures but have been somewhat mitigated by Ontario's Greenbelt and ORMCP legislation (Ohberg & Wakefield, 2013). The GGH is a mixed

farm region consisting of grain and oilseed, beef and dairy operations that are dominant but there are also many farms growing vegetables, fruit, and poultry. Most regions within the GGH have created initiatives with intentions to promote local sustainable food systems such as community stakeholder coalitions in order to create collaboration; these initiatives all have intentions of creating opportunities to sell local produce locally (Ohberg & Wakefield, 2013).

One popular local food initiative is a CSA (community supported agriculture) program as a way to sell produce to consumers in a variety of regions and sourcing additional produce from growers in the same region to supplement their own growth (Ohberg & Wakefield, 2013). A CSA is a form of a direct marketing channel (in addition to farmers' markets, pick-your-own operations) where consumers purchase food from a producer before it is grown and therefore, sharing the risk and rewards of harvest and providing farmers with a source of financial security (Edge, 2013). The main revenue generated on Mount Wolfe Forest Farm is from their CSA program. CSAs and other local food initiatives aim to shrink the physical supply-chain and socio-cultural distance between producers and consumers that facilitates communication and awareness of environmental and social costs (Christy, Landman, Nowatschin & Blay-Palmer, 2013). Mount Wolfe Forest Farm also practices agroecological farming methods by using limited chemical inputs, planting tens of thousands of trees on the property, and using an intercropping system rather than monocrop which makes the farm significantly more sustainable than a conventional monocrop farm (MWFF).

The most prevalent challenge in small-scale agriculture productions and local food initiatives is financial sustainability and self-sufficiency (Ohberg & Wakefield, 2013) which makes it hard to compete with conventional agriculture that are much larger and in some cases, more established. Another concern with local food production is that consumers may not be able

to or willing to pay the cost of production and distribution within the localized food system, limiting target consumer bases and ability for farmers to generate a sustainable livelihood (Ohberg & Wakefield, 2013). Overall, although there are some challenges, small-scale agriculture that practice agroecological processes are important in building overall farm resilience and to see long-term benefits from the enhanced resiliency in the future.

2.7 Conceptual Framework

This literature review outlined the policy that is associated with the land, a historical profile of the area, conservation efforts in southern Ontario, and small- scale agriculture in southern Ontario. These topics all help to define the components that make up the system in which the farm is embedded and to answer the questions of "resilience of what, to what and with what?" Outlining resilience thinking and adaptive capacity within agroecological farming techniques demonstrates how these practices of farming can be beneficial for building resilience in the system. The Resilience Assessment Workbook is used as a conceptual framework to identify factors that can threaten or enhance the resiliency of an agroecosystem such as MWFF. The policy analysis was conducted in order to assess how policies such as the ORMCP and Greenbelt Plan can enable and inhibit the small-scale enterprise. It was assessed that although the plans protect farms from development, they can be stringent and inflexible towards small-scale sustainable farms that have much less of an impact than traditional agriculture. The historical profile of MWFF, Town of Caledon, and ORM is important to understand how the system and scales above it have moved through transitions and thresholds to aid in answering the question of "resilience to what?" Background information on conservation efforts and small-scale agriculture in southern Ontario is beneficial to define the system and what can threaten or enhance its resiliency. The Resilience Assessment Workbook has been often used for larger scale systems,

however in the case of MWFF it will be adapted to defining the system with the question "resilience of what?" Identifying the main threats and disturbances of the system and main thresholds, transitions, cross-scalar interactions, adaptive governance, and social networks with the question of "resilience to what?" Finally, ending with assets of the system's resilience and desirable characteristics within the local food system with the question of "resilience with what?"

3.0 Methodology

To assess the resiliency of local sustainable food systems, a case study approach was used in order to conduct a resilience assessment on a particular system and to apply this framework to a real small-scale farm. The Resilience Assessment Workbook (2.0) was used as a framework that was applied to develop a model of the MWFF system that includes resources, stakeholders, and institutions that assess factors that threaten or enhance its resilience. In order to conduct a resilience assessment, background research was performed from a literature review, government documents and also using participatory research including key informant interviews. Interviews included members of MWFF, the CSA members and community members, and an employee from the Caledon municipal government. Key topics in the interviews included defining a local sustainable food system and how it can be threatened, desirable traits in the system, historical land use changes or significant events in the system and area and more. Participatory action research (PAR) was used for this study as another methodological approach which is defined as participants and researchers working together on a study to develop an action of change for the better (Kindon, Pain & Kesby, 2007). The researcher worked closely with the members of MWFF on all aspects of this research project. PAR is beginning to become a leading paradigm

within social and environmental sciences as social-ecological systems are recognized as being interdisciplinary and diverse and given greater recognition (Kindon, Pain & Kesby, 2007).

3.1 Case Study Method: Mount Wolfe Forest Farm

A case study is defined as "an intensive study of a single unit with an aim to generalize across a larger set of units" (Gerring, 2004). Case studies are useful in the case of descriptive inferences, in-depth exploratory research and exploring and explaining phenomena within a real-life context (Gerring, 2004; Yin, 2003). In addition, a resilience assessment requires an issue-based socio-economic system to be able to assess its resiliency. Therefore, Mount Wolfe Forest Farm was chosen to be a case study for this assessment for its small-scale agroecological practices, and also its unique location on policy protected land.

Mount Wolfe Forest Farm is a family owned small-scale farm that runs a year-round Community Supported Agriculture (CSA) program located in Caledon, Ontario on the Oak Ridges Moraine. The farm offers a full share membership that includes fresh vegetables and herbs all year long in addition to a separate chicken share membership that provides free-range meat (MWFF). Since the family farm was bought in 1966, extensive reforestation and conservation efforts have been made in order to restore the depleted farmland to improve biodiversity, soil health and ecological integrity by using ecological approaches to farming (MWFF). The farm promotes community engagement by offering the CSA program and also a workshare program that offers all the benefits of the full share program at a reduced price in exchange for general farm labour, maintenance, or organizational work. MWFF also has a strong network of stakeholders by partnering with a network of local producers and farmers to provide a large range of local foods for the CSA program.

A unique characteristic of MWFF is that it is situated on the Oak Ridges Moraine, and therefore has been protected by the Oak Ridges Moraine Conservation Plan (ORMCP). Due to the land use restrictions and the ecological approaches of agriculture that MWFF practices as a small-scale farm, it makes this particular farm a unique system and of interest to do a resilience assessment on. Resilience was assessed on MWFF's ability to generate revenue and pass the land on to future generations by operating as a sustainable working landscape under policy protected land. Resilience "to", resilience "from", and resilience "with" was all assessed. By conducting the resilience assessment of this case study farm, the resiliency results can be used to improve the practices of the farm and to also replicate these practices on other farms on the Oak Ridges Moraine and other protected (and unprotected) landscapes.

3.2 Methods of Literature Review

A literature review was used as qualitative research in order to gather background information on the farm, the Oak Ridges Moraine, Caledon and surrounding areas. The purpose of a literature review is to "objectively report knowledge on a topic" (Baker, 2016). A literature review provides a summary of the knowledge available on the topic and provides clarity and understanding for the reader (Baker, 2016). This research is qualitative in nature, meaning it is non-numerical in interpretations of observations. Peer reviewed literature, government publications, conservation documents and information from non-governmental organizations was used to broaden the understanding of MWFF and surrounding areas as a system. The Resilience Assessment Framework requires the researcher to define the social-ecological system and main issues within that system (RA, 2010). By conducting background research, a better understanding of the system components was acquired to proceed with the Resilience Assessment.

3.3 Methods of Using Resilience Assessment Framework

The Resilience Assessment Workbook encourages using an issue-based approach to help focus and direct the assessment to each section of the workbook by describing a key concept with corresponding activities or questions that apply resiliency to the focal system (RA, 2010). "Resilience of what?" and "resilience to what?" are two sections in the workbook which will be included in this paper. "Resilience of what?" focuses on defining the system and the components of the social-ecological system and the main issues within the system. "Resilience to what?" focuses on disturbances, threats, and uncertainty to the system; in addition, for the purpose of this paper sections of the workbook on system states, thresholds and transitions, cross-scalar interactions, adaptive governance, and social networks will be included in the "resilience to what?" section. In addition, in a study done by Liu (2011), a section called "resilience with what?" was added, which is not included in the workbook that investigates the assets of a system that can enhance its resiliency; a "resilience with what?" section will be included in this paper. As stated previously, there are critiques of using the Resilience Assessment Workbook, however it is used in this study as a framework as a way to define the agroecosystem as a whole, address the threats and disturbances to the system, and to assess the general resilience of the system in order for future research to continue at MWFF and for MWFF to reach its long-term goals.

3.4 Methods of Primary Research

The use of interviews with key informants is used to help in completing the resilience assessment for Mount Wolfe Forest Farm. Interviews were used to expand on background information and the literature review to assist in the completion of the resilience assessment. A total of 10 interviews were conducted with members of the farm, the farm's CSA (community supported agriculture) members, and an employee of Town of Caledon municipal government. It

was intended to conduct an interview with the Toronto Region Conservation Authority as well as some of the producers to MWFF, however due to time constraints no interviews were unable to be arranged.

Interview questions are documented in the Appendix A (General Key Informant Interview Questions) and Appendix B (Farm Specific Interview Questions). Interviews were conducted in a semi-structured manner to allow participants to have flexibility in their answers. Semi-structured interviews use a standardized set of questions to ensure the correct material is covered, however, information is collected in a way that is conversational (Harell & Bradley, 2009). Semi-structured interviews are ideally used when the researcher wants to understand thoroughly the answers delivered and the topic at hand (Harell & Bradley, 2009). All of the interviewees were either directly connected to MWFF or the Oak Ridges Moraine and Caledon. Interview questions mainly focused on the local food system and MWFF specifically and the threats, disturbances, and desirable traits within that system. Specific questions on the history of Caledon's food system and land use was also asked in order to back up the literature review section of this resilience assessment.

The interviews for this research project were approved by The University Waterloo Department of Research Ethics under application ORE#21952. All participants in this study gave their consent to have the interview either transcribed or audio-recorded and to have anonymous quotations included in this paper. Interviewees were recruited via email or phone. All interviewees remained anonymous and any quotes provided in this paper are anonymous. The identities of the key informants are represented as acronyms throughout the paper which are shown in Table 1.

Table 1. Anonymous key informant interviewee identifiers.

Acronym	Profession/Identifier
FM (1-5)	Farm Member
CSA (1-4)	CSA member/ Community member
CE (1)	Town of Caledon municipal employee

4.0 Results: Resilience of What?

The Resilience Assessment Workbook begins with asking the question of "resilience of what?" This question prompts the researcher to define the focal system and the socio-ecological boundaries of the system, both spatial and temporal, that will be assessed (RA, 2010). In addition, this question requires one or a few related issues to be identified in the assessment as well as identifying the key components of the socio-ecological system that are related to the main issue. Key components of the system can include both the biophysical properties and social properties (social, cultural, political) (RA, 2010). This section aims to answer the question of "resilience of what?" by identifying Mount Wolfe Forest Farm as a social-ecological system and defining the focal system boundaries, the main issues as identifyed by the members of the farm and the components that make up the system.

4.1 MWFF System Defined

The focal system of Mount Wolfe Forest Farm is defined by the spatial boundaries of 70 acres located in Caledon Ontario and the temporal boundaries of 1966-2017, or three generations of the Crandall family who own the farm (MWFF). The focal system of MWFF is based on the perspective of a sustainable working landscape and its ability to generate revenue and pass down to future generations. Mount Wolfe Forest Farm is a small-scale agroecological system that uses

sustainable producing practices that enhance its resiliency, however it also faces many challenges to its socio-ecological components that can threaten its resiliency.

4.2 Main Issues

A resilience assessment is framed around one central or a few related issues in order to provide focus to a system (RA, 2010). The main issue regarding Mount Wolfe Forest Farm as defined by the members and owners of the farm, community members, and the municipal government is its ability to become economically viable as a sustainable working landscape to pass on to future generations. Some related issues as expressed by key informants include:

1. Stringent provincial policies from the Greenbelt Plan and Oak Ridges Moraine Conservation Plan on land that is already being used sustainably
2. Competition with industrial agriculture and "big-box" grocery stores
3. Maintaining quality and values of sustainability and interest with the population
4. Success of the farm can be weather dependent

4.3 Key Components of the Social Ecological System

There are many components that make up the social-ecological system of Mount Wolfe Forest Farm. The biophysical components of the system include weather, diversity, variety and ecological integrity. The viability of the farm is somewhat weather dependant because if the seasons start changing more rapidly and the summers and winters become warmer it can influence the farm negatively. The main natural resource use of the farm is planting, tending, harvesting, processing, and producing year-round vegetables by using a diverse intercropping system. In addition, chickens are used to fertilize the crops and as pest control and later processed to use in the farm's "chicken-share." The community supported agriculture members and farm members benefit from the natural resource use as food produced sustainably, without

chemical inputs. MWFF uses agroecological practices on the farm including no chemical inputs, intercropping diverse produce, in addition to planting 100,000 trees on the property when it was bought in 1966 (FM 1, personal communication, January 31, 2017). Ecological approaches to agriculture enhance soil fertility, biodiversity, and animal and human health (FAO, 2011). In addition, MWFF has Cold Creek running through the property which is a tributary of the Humber River and is fed by groundwater sources making it a coldwater stream that supports rainbow and brown trout and sensitive minnow and darter species (Town of Caledon, 2009). Therefore, activities on the farm can affect the health of Cold Creek, which is an incentive for MWFF to continue using ecological practices of farming, aiming to become "an oasis for humanity and humility for what happens when you let the land be" (FM 2, personal communication, January 31, 2017). Local sustainable food systems aim to shorten the supply chain of producing, processing, and selling to the customer straight from the producer (Edge, 2013) as well as practice community engagement with the members and citizens of the Town of Caledon.

Local food systems have a small but significant economic impact and can have financial benefits throughout the supply chain (Edge, 2013); however, one of the greatest challenges for a small-scale farm is becoming economically viable. The main economic components of the farm are the CSA members that have bought into the share program. In the first year of production (2016) MWFF acquired 25 CSA members and are expected to double that to 50 for 2017; with a goal of eventually reaching 100 CSA members. The weekly cost of the MWFF food-share is $43 a week (MWFF). MWFF also has 15 local producers from less than 100km around the farm that produce maple syrup, eggs, jams, soups, flour, bread and more to supplement the amount of

products within the CSA (FM 1, personal communication, January 31, 2017). Farm member (FM) 1 stated that,

> *We [at MWFF] have 15 local people that produce local products like maple syrup, soup in a jar, eggs and bread and when we buy from them it's really good for their bottom line, and it's really good for us and our share people so they get to have local products to and support the economy of the region. That to me is the main raison-d'etre of MWFF in my opinion.*

The political components of the farm are the provincial policies such as the Greenbelt Plan and the Oak Ridges Moraine Conservation Plan that can inhibit but also enable the farm's success. The conservation plan can protect local sustainable food systems, especially in Caledon, from impeding development of the Greater Toronto Area (MMAH, 2001). However, the current stringent policy framework can inhibit the success of a small-scale agroecosystem similar to MWFF. Farm Member (FM) 4 expressed that there "should be fewer regulatory processes for small-scale farms which isn't even a consideration within [the policies] that sustainability is already embedded into our practices and don't need to be double regulated." A Town of Caledon Employee (CE) expressed that much of the provincial policies have imposed a very tight control on the area and "the control is too rigid and doesn't make a lot of sense and there needs to be some flexibility for creative ideas such has what is happening with MWFF."

The social components of the farm are the support networks that can be formed with other local food systems such as the producers that produce for MWFF. Many of the CSA members connect with the farm, and it can be a way to get people out of the city and see where their food is being grown, and become a part of the process of growing their own local food. In addition, the workshare program is a way to get the CSA members involved with the harvesting process and to take part in growing their own food and exploring the landscape (MWFF). The

local producers to MWFF help to build a stronger social network in order to gain interest of the public and create a collaborative support network, remove competitiveness to build relationships, and an overall stronger local food system (FM 4, personal communication, January 31, 2017).

5.0 Results: Resilience to What?

This section aims to answer the question of resilience to what by assessing the threats, disturbances and uncertainties to the system of MWFF. Within the Resilience Assessment Workbook, multiple states, thresholds, cross-scalar interactions, governance, and stakeholder networks are also assessed which will be addressed in this section.

5.1 Threats, Disturbances and Uncertainty

Economic viability is one of the biggest threats to the MWFF system. Since this agroecosystem is small-scale it is faced with many challenges in order to make it an economic model and compete with other much larger industrial practices of farming. Local food initiatives like the CSA program are competing with big box grocery stores that are not local or sustainable. Farm Member (FM) 5 stated that:

> *Pressure on people to spend as little money on food as possible to leave enough to spend in our consumer culture or on expensive education/housing/utilities undermine the efforts of producers who grow and make high quality food and goods to sell them at their actual value.*

In addition, the long-term viability of the local food system is an uncertainty to MWFF. Maintaining the interest of people is important part of the system in order to maintain economic viability. MWFF must be able to keep growing in the number of CSA members to 100 in order to prove that it is a viable economic venture (FM 4, personal communication, January 31, 2017). Today, there is a trend towards local and holistic foods and maintaining this interest in local

sustainable food systems is vital to the viability of the farm (Edge, 2013). The lack of actors within a supporting network of local food initiatives also makes the system vulnerable since the system of local food is still at a young stage, and it only takes one bad producer to taint the market (FM 4, personal communication, January 31, 2017).

Weather and climate are always a factor in any agricultural practice. Weather can be a disturbance, especially if the seasons become off-balance, it can affect the quality and quantity of crop yields. An unpredictable climate catastrophe could be devastating for a small-scale agroecosystem like MWFF. In addition, changing climate conditions within seasons can hinder the ability of a farm to grow and harvest.

Development is not necessarily an issue in the case of MWFF because of the conservation plans that protect the land from the encroaching development of the Greater Toronto Area. The land has been zoned agricultural, and therefore is protected from any development; however, the land across the farm was recently zoned residential and a subdivision of 13 houses is set to be built (FM 2, personal communication, January 31, 2017). Within other small-scale agroecosystems that are not on policy protected land, development can be one of the biggest threats especially in the Greater Toronto Area; in 2001, urban land occupied 3% of all dependable agricultural land, and 7.5% of the best agricultural land in Canada (Edge, 2013). Development on surrounding and adjacent lands can have a negative effect to the MWFF system as residential development and gravel quarries extractions lead to increased traffic, leading to scaling up of transportation infrastructure and creating more air pollution (FM 5, personal communication, January 31, 2017). The use of agricultural chemicals in adjacent farm fields can have an indirect negative impact on the ecological integrity of MWFF that can cause soil acidity, salinity, sodality and toxic substances (FAO, 2011).

5.2 Multiple States, Thresholds, and Transitions

The historical states of the system were outlined in the historical profile within the literature review; from being first inhabited by First Nations Iroquois and Mississaugas of the New Credit to European Settlers who deforested the land for mass agriculture. When the land was bought in 1966 it was a conventional farm field, however the Crandall family reforested it by planting thousands of trees and creating a productive but sustainable land using agroecological practices. These historical states of the system can be applied within the adaptive cycle (Figure 1). European settlement led to displacement of the Indigenous population and the exploitation of the Oak Ridges Moraine resources for timber and agriculture (exploitation phase). The population peaked in 1861 and land became so degraded people started to move away from it and into Toronto (conservation phase). However, advocacy from environmental groups, citizens, and media led to conservation efforts to the area which resulted in the ORMCP and Greenbelt Plan. Industrial agriculture became widespread on the farm, and before the farm was owned by the Crandall's it was a conventional farming system vulnerable to normal disturbance patterns (release phase). Since the farm has been owned by the Crandall's, it has been reforested and biodiversity introduced back into the system to create a working landscape that is complementary to the land's natural attributes (reorganization phase). Although, the population of Caledon is once again rising from encroaching pressures of the GTA. The Resilience Assessment Workbook suggests using a "rule of hand" where any system can be described using 3-5 key variables that characterize and determine its current state (RA, 2010). The key variables of the current system state include, agroecological practices, CSA members, producers and the size of the operation. The unique characteristic about MWFF is that it since it has only had one

year of production, the system is in constant progress, and needs to be open for change to make it a viable venture.

However, the system also has multiple future states that need to be addressed. Many systems can be in more than one stable state, which are known as "alternate states" that may have occurred in the past or could occur in the future (RA, 2010). The alternative future states that could occur for MWFF may include the need to upscale the farm to obtain economic viability and sacrifice some ecological practices. Another alternative state could be from a zoning change from the provincial policy; The ORMCP is subject to zoning changes and municipality could rezone the land in Caledon to residential, commercial, or industrial in the future. This could result in major development around the farm affecting its long-term viability as a sustainable working landscape.

Factors that could push the system into these alternative states and beyond a threshold include the economic market and encroaching population of the Greater Toronto Area. The economic market and consumer interest significantly influences farmer's activity and how that activity contributes positively or negatively to sustainability because at the end of the day "it is the market that prevails" (CE, personal communication, March 5, 2017). Consumer interests play a large role in the success of a small-scale agroecosystem as the population must continue support and be interested in local food for it to be economically viable. In addition, the population of Caledon is forecasted to grow from 74,534 in 2016 to potentially 87,000 by 2021 and 108,000 by 2031 due to the growing population of the Greater Toronto Area (Town of Caledon, 2016). These factors could both be of significant concern as they would push the farm into an undesirable trajectory and potentially an alternative stable state that is not necessarily

desired. Both of these factors would lead to an abrupt system trajectory change, however the factors would require a gradual transition that would not happen abruptly without any warning.

Based on the current state of the system and its desired trajectory of progress and opportunity for positive change, the long-term goals for the system of MWFF were identified by the farm members in the interviews that were conducted which are presented in Figure 2. The long-term goals are based on the current state of the system size, practices, and growing number of CSA members and producers within the local food network. These long-term goals are contingent on maintaining and enhancing the resiliency of the system in order to ensure the system does not fall into an undesirable state or cross a threshold of concern. Actions for maintain and enhancing resiliency to reach these long-term goals are outlined in section 7.0 Recommendations for MWFF.

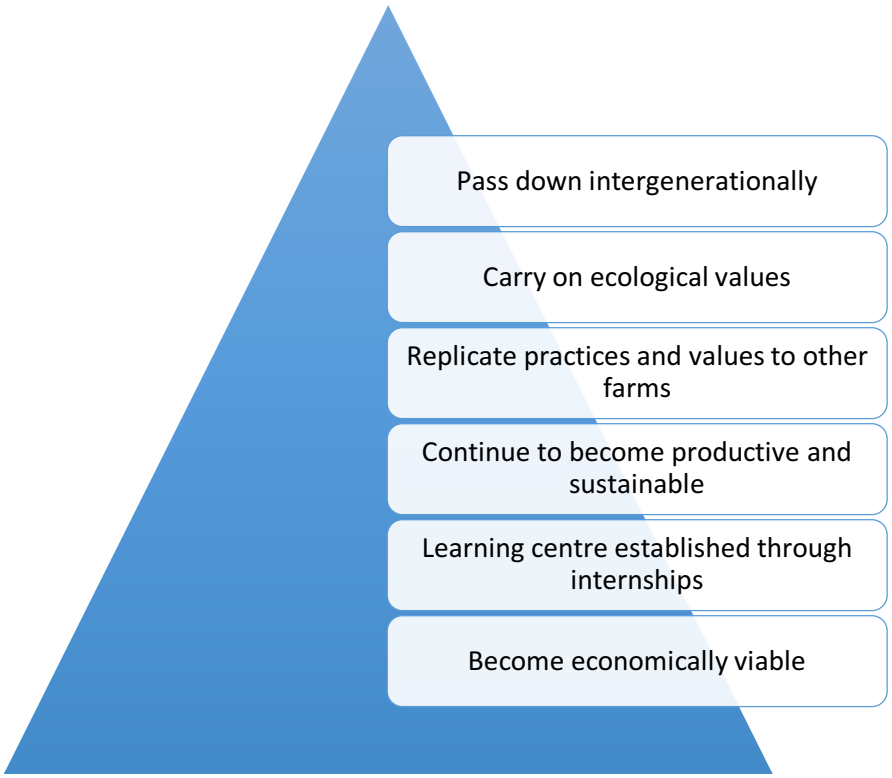


Figure 2. Long-term goals for MWFF as identified by key informant interviews with farm members from bottom to top being the ultimate goal of the farm.

5.3 Cross Scalar Interactions

The focal system of conducting a resilience assessment on MWFF has scales above and below it that influence and interact with it. Cross-scalar interactions above and below the focal system were identified and assessed as shown in Figure 3. Industrial agriculture within southern Ontario has been a popular practice of agriculture ever since the Green Revolution because of its high productivity, processing, and distributing capacities as an effort to feed a growing population (IPES-Food, 2016). In addition to this, Ontario's Greenbelt has some of the most fertile lands for agriculture use in Canada (CE, personal communication, March 2, 2017; Town of Caledon, 2009). Due to encroaching development on the Greater Golden Horseshoe Area, and specifically the Oak Ridges Moraine, the provincial government implemented the Oak Ridges Moraine Conservation Plan to provide land use and resource management planning direction to conserve the moraine's ecological and hydrological features and valuable productive agricultural land (MMAH, 2001). Small-scale agriculture within the Town of Caledon is on the rise, and is a way to create a sustainable working landscape while also conserving biodiversity to be complementary to conservation efforts within the Oak Ridges Moraine. The focal system of this study is a resilience assessment of a small-scale agroecosystem as a way to demonstrate the sustainability and viability of these agriculture practices. A scale below the focal system is assessing the resiliency of each component that makes up a small-scale agroecosystem and the factors that influence it. There are some system vulnerabilities at the focal system due to the scales that influence it such as the support network between the small-scale agroecosystems that has not yet been established, and stringent policies within the ORMCP that can limit the innovation and growth of the farm and its network.

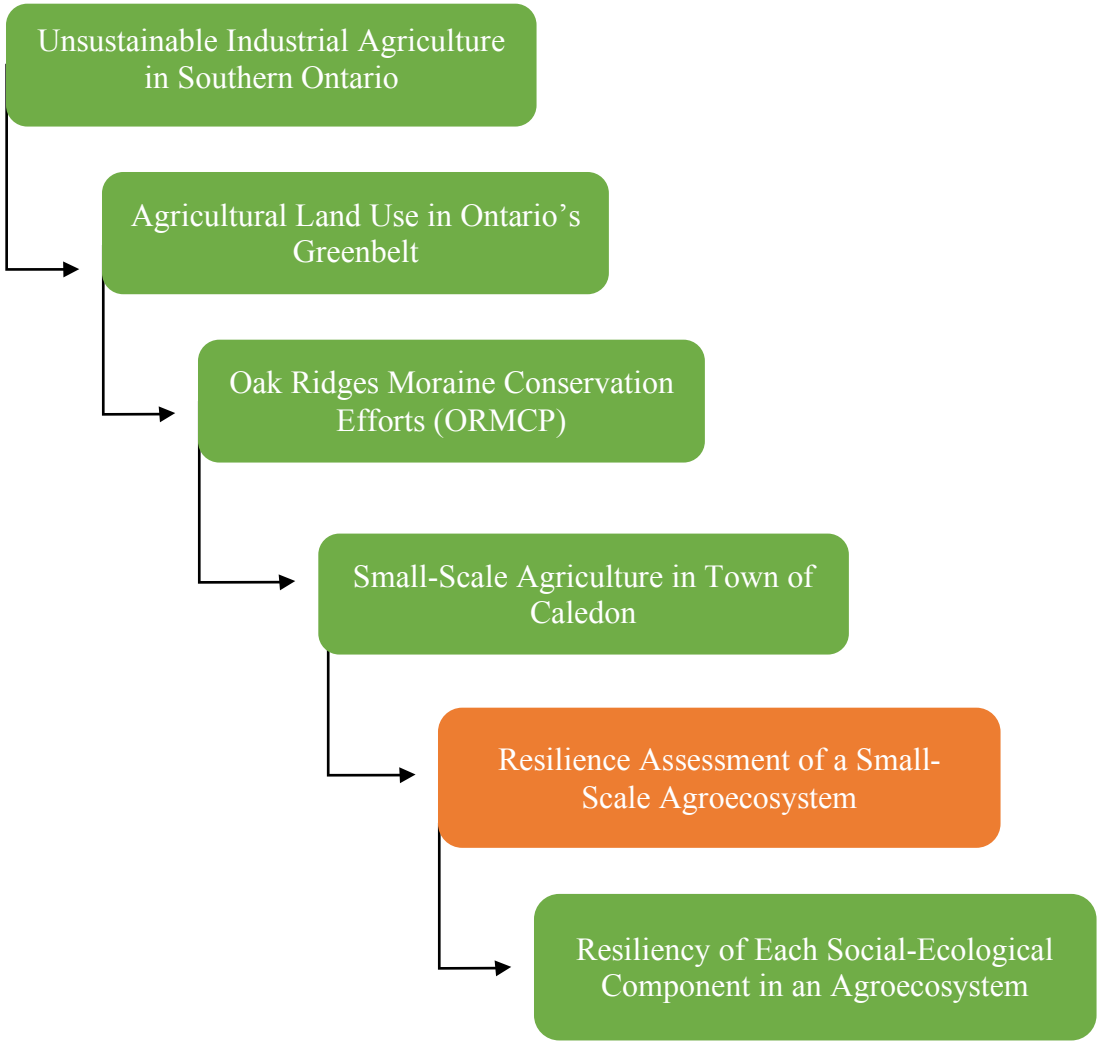


Figure 3. Scales above and below (green) the focal system (orange) of a Resilience Assessment of a small-scale agroecosystem (MWFF).

5.4 Adaptive Governance and Social Networks

Adaptive governance is a form of governance that emphasized by the ability to adapt to changing relationships between society and ecosystems in order to sustain ecosystem services. Adaptive governance can enhance resiliency by encourage flexibility, inclusiveness, diversity, and innovation (RA, 2010). As stated previously, policy plays a large role in the activities of farming that fall under the Greenbelt Plan and Oak Ridges Moraine Conservation Plan. These provincial policies dictate much of the decisions made within the focal system and at higher

scales of land use management planning. There were mixed opinions among the key informants on the ability of the conservations plans to enhance or inhibit small-scale agroecosystems. Most interviewees recognized that the policies can both be restrictive and positive towards a small-scale agroecosystem. Farm Member (FM) 3 stated that "the policies have in fact caused us some limitations within the farm, we have to get permission to do what we want to do on the land, like putting up a greenhouse, so it can be extremely inhibitive." Farm Member (FM) 4 expressed that small-scale farming systems aren't a consideration within the policy network and "we [MWFF] have to make more inroads in getting the government to see agriculture through different lenses, one is large scale industrial, which still needs more than ever environmental restrictions, and the other is small-scale" where sustainability is already embedded in them. A Town of Caledon Employee also recognized that the policies are one-sided and said, "there are a lot of conflicts between natural heritage conservation and viable agriculture." However, many of the interviewees also recognized the importance of the ORMCP in prohibiting the land from development to secure enough land for agriculture locally. Two of the community members stated that the plans were beneficial because it reduces the high-density development in the area; and two of the community members did not comment based on lack of knowledge on the topic. Therefore, based on these results, it is clear there needs to be more flexibility within the policies to distinguish between industrial agriculture and small-scale practices that are already exhibiting sustainable activities.

The main social network within the system includes the Crandall family, CSA members, and producers to the farm. There are 15 producers that supply MWFF with food such as free range eggs, baked goods, flour, dried beans and legumes, fruits, soups, maple syrup, honey, and preserves (MWFF). All the producers are within 100km of the farm from towns such as

Rockwood, Erin, Caledon, Milton, Brampton and more. A few of the producers include Nature's Nurturing, Spirit Tree Cidery, Pfennings Farms, Albion Orchards and more. By partnering with these producers, MWFF is building relationships with other small-scale farms to build a stronger local food system. Farm Member 4 stated, "the next step is that we have to work together, and recognize ourselves as a network, which is not yet happening, whether or not we use a food hub it would be really wonderful if we could be a little more self-organizing." Collaboration between small-scale farmers can be beneficial to allow for staggering crop plantings, and purchase agricultural inputs as a group; a successful model of collaboration among farms is engaging in a food hub (Edge, 2013). In addition, the Town of Caledon is a stakeholder within the system and it is important for MWFF to build a relationship with the municipality by proving economic viability and being self-reliant in order to have their support in the social network.

6.0 Results: Resilience with What?

This section will focus on assets of the system for resilience and characteristics of the system that make it resilient. Liu (2011) identified that the Resilience Assessment Workbook does not include a section for assets of a system that demonstrate resilience and suggested including a "resilience with what?" section in order to address this.

Interviewees were all asked to describe the characteristics that they thought to be valuable or desirable in the local food system. Based on the results, several categories were identified as being desirable characteristics in a local sustainable food system; these include ecological practices, supportive network, relationship building, respect, availability and accessibility, freshness, variety, and a short supply chain (Figure 4).

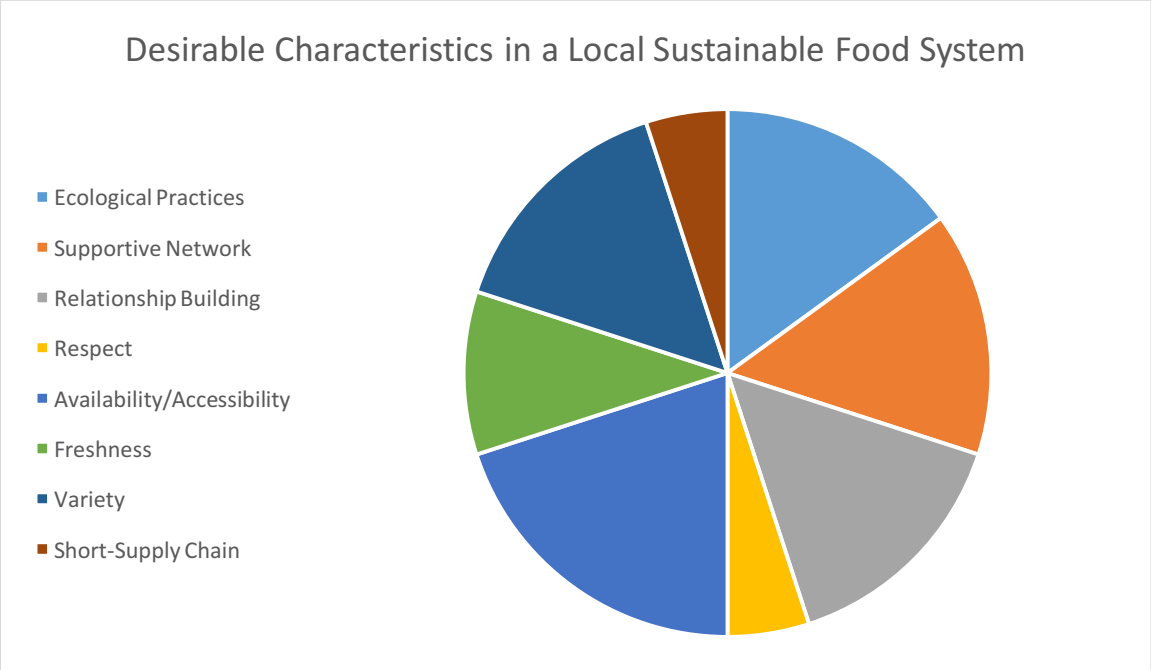


Figure 4. A pie chart of each key informants top 2-3 desirable characteristics in a local sustainable food system.

Ecological practices were seen as a valuable characteristic of the local food system. Interviewees appreciated the agroecological approach to farming that MWFF uses and that the farm has a foundational value system of respect for one another and respect for the land and animals. Farm member (FM) 4 stated that "I think it would very cool if we could be embedded in the modern world but also looking at different infrastructures that have a small ecological footprint to do our business successfully." Ecological practices on farms is a way to redesign agricultural systems in a way that fosters resilience by embracing biodiversity, ecosystem services, long-term fertility and securing livelihoods (IPES-Food, 2016). Farm Member (FM) 5 expressed "I have a vision that we could one day perpetuate and be an integral part of the robust and complex ecosystems instead of burdensome to them."

Relationship building and interactions with like-minded people was considered another desirable characteristic in the local food system. CSA Member (CSA) 3 stated that "I appreciate the fact that I can meet the farmer and know where my food is coming from… I can come here

and see how things are grown from a seed to actually consuming the food." In addition, all of the members of the farm appreciated being able to meet their neighbors and community members, but also build relationships with them through the scheduled "open farm days" that the farm hosted in 2016.

Availability and accessibility was considered one of the most desirable characteristics that was identified by the interviewees in the local food system. Farm Member (FM) 2 pointed out that "all the food we produced was done on about 5 acres of land and was planted for 100 people." Having an engaged and informed population is important, since people must be aware of the benefits of small–scale agriculture, and the proximity and availability that they are able to be involved in. A report from the Conference Board of Canada on local food systems states that consumers are most likely to purchase local food because they want to support their local economy and believe that local food is fresher than non-local, however price, availability, and convenience are the main reasons that prevent consumers from purchasing local food (Edge, 2013). It is important to remember that local food is usually more expensive than non-local/non-organic and many people of lower wage classes may not be able to afford it, which is a problem in its own and needs to be addressed.

A supportive network between local small-scale farms from a collaborative working relationship was also identified as an asset for resilience. By working with 15 producers, MWFF is building a stronger supportive network in hopes to have strong ties with many local food producers in the Caledon area. Farm Member (FM) 4 emphasized that removing competition and being able to become a formal network with all of the small-scale farms in the area to eventually share seeds, produce and supporting each other overall would be very beneficial for the food system.

Respect, freshness, and variety of local food were all identified by interviewees as being desirable characteristics as well. Farm Member 2 (FM) stated that "being able to see the food from seed packets in March and seedling trays in April, planting out in May, harvesting in June-October and producing food for so many people, it is quite remarkable." However, Canadian agriculture is limited by growing seasons and people must be willing to make behavioural changes in order to become used to eating food that is in season.

The short supply chain of small scale agriculture in the local food system rather than imported foods from "big-box" grocery stores was also seen as an asset for resilience in the local food system. Direct sales and short supply chains bridge the distance between consumers and producers by eliminating the middle-men (Edge, 2013). All of the community members interviewed appreciated being able to see where their food is coming from and know that it is of good quality.

7.0 Recommendations for Mount Wolfe Forest Farm

This resilience assessment of Mount Wolfe Forest Farm is meant to be a broad overview of the system, its history, system dynamics and threats and disturbances that could affect it in the future. This study is helpful for the members at MWFF to understand the key components of the farm, the cross scalar interactions in which they are embedded and how to move forward into the future. The farm would eventually like to become an educational hub and build a partnership with the University of Waterloo; this research will hopefully be the start of more research projects to take place on the topic of the farm and resiliency of small-scale agroecosystems on the Oak Ridges Moraine.

Based on this resilience assessment, recommendations are made for MWFF to enhance its resiliency and reach its long-term goals. It is recommended that MWFF should continue to

advocate for a strong support network between all other local small-scale farms to eradicate competition and encourage sharing and support with one another to ensure long-term viability of the local food system. Establishing a Food Hub could be a way to build the support network, diminish competition, and help find new markets and better product prices (Edge, 2013). Walker and Salt (2012) state that some attributes of a resilient system include promoting trust, well-developed social networks and effective leadership. Therefore, it is also important to continue to build relationships with CSA members, citizens of Caledon, and municipal workers at the Town of Caledon to ensure a strong network of stakeholders that all support the economic viability of the farm and the interest of local food systems. Also, MWFF should continue to become a spokesperson for small-scale farms to have a stronger voice in policy and work towards making the rigid provincial ORMCP more flexible on sustainable farming to ensure successful adaptive governance that enhances resiliency. Walker & Salt (2012) define adaptive governance as "changes in anticipation of or in response to new circumstances, problems, or opportunities and embraces experimentation in laws, rules, regulations, policies, plans, and investments." Therefore, as long as the ORMCP remains strict in its policies by looking at agriculture through only one lens, rather than multiple lenses including agroecological practices, it is not an adaptive governance system and is putting the sustainable food system at risk.

In addition, building an integrated resilience plan that fosters social innovation and ensures economic viability could be beneficial for MWFF. Traditional economic models tend to ignore costs and benefits from environmental and social services or classify them as externalities; therefore, small-scale farms are seen as less economically efficient than larger farms as they are less likely to be able to compete in conventional wholesale markets (Perez, Brown, & Miles, 2015). The Center for Agroecology and Sustainable Food Systems at the University of California

has created a template for creating an integrated and resilient food plan that includes creating a marketing plan and analysis, financial analysis, and a farming and post-harvest plan to create a resilient farm that is protected by uncertainty by managing for liability and risk (Perez et al., 2015). This report suggests strategies for ensuring economic viability that include direct marketing not only with a CSA program but also through farmer's markets, direct sales to restaurants, food hubs, and adding services such as "U-pick" operations and agricultural tourism to diversify income (Perez et al., 2015). Considering more forms of direct marketing could help ensure economic viability for MWFF and enhance resiliency.

The farm could also consider using social innovation as a tool in the future to enhance its resiliency. The Resilience Assessment Workbook encourages subsidizing innovations that foster economic novelty, cultural diversity and ecological integrity (RA, 2010). Social innovation is defined as any initiative that challenges and contributes to changing the broader system in which it is introduced such as changing consumer's behaviours towards the sustainable food system (Westley & Laban, 2015). The Social Innovation Lab Guide by the Waterloo Institute for Social Innovation and Resilience is a process of developing, testing, and instigating innovation strategies that address complex problems and identify opportunities for transforming a system (Westley & Laban, 2015). This could be used as a tool by MWFF to address the challenges of the local food system and build resilience among it as well as incorporating innovation on the farm such as introducing a farm internship to increase farm education or upscaling direct marketing strategies.

8.0 Recommendations for Resilience Assessment Framework

The Resilience Assessment Workbook tends to be applied to larger scale systems since the examples that are included in the workbook are the Grand Canyon, Hurricane Katrina in New

Orleans, Southern Madagascar forest conservation and more that are also large in scale (RA, 2010). In addition, the "publications" section on the Resilience Alliance website also focus mostly on large scale systems and the agriculture related publications include tropical forest croplands, climate-smart agriculture in Africa, dryland salinity in south-western Australia and many more very large systems. However, there are very little to no examples of a resilience assessment done on a small-scale agroecosystem. The Resilience Assessment Workbook could improve methods on how to apply this workbook to a small-scale system easier, and give more of a range of system scales as examples. The Resilience Assessment Workbook could give better guidance to apply the workbook concepts such as system states, thresholds, transitions and cross scale interactions to a smaller scale system since it is mostly tailored to larger systems.

In addition, the Resilience Assessment Workbook focuses mostly on the exploitation of a resource in a system, and does not consider where a system is already resilient. Liu (2011) master's thesis suggested incorporating the "resilience with what?" section as a way to address this, which was also suggested in this study. This study is unique because it focused on a sustainable small-scale agroecosystem and how it is already resilient to compare to industrial agriculture; also, it can be used as a tool to replicate this practice of agriculture to other parts of the Oak Ridges Moraine and move away from unsustainable conventional agriculture. The workbook should outline what a resilient system should look like, or what are characteristics of a resilient system that the user can identify and can aim for within their own system. Some of these characteristics of a resilient agroecosystem were outlined in the "resilience with what?" section of this study. In addition, "Resilience Practice" by Walker and Salt (2012) identify nine attributes of a resilient world some of which include diversity, modularity, social capital, innovation, and ecosystem services.

9.0 Conclusions

This resilience assessment of a small-scale agroecosystem using a case study of Mount Wolfe Forest Farm in Caledon is a broad exploratory study on the resiliency of the farm as a working landscape on policy protected land. This research is meant to help define the system of MWFF, the threats and disturbances that could affect it, and how to move forward with it as a viable economic venture into the future. In addition, by using MWFF as a case study this resilience assessment can be used as a management practice for other farms to adopt in order to replicate ecological approaches like MWFF's in other parts of the Oak Ridges Moraine, and Ontario's Greenbelt to increase resiliency. Another outcome from this research project is a critique on the current resilience assessment framework as it applies to smaller scales systems such as MWFF and how it can not only assess resilience but also how it can assess and increase social innovation.

One limitation of this study is the time-constraint since this is an undergraduate thesis there was only 8 months to complete the study. Therefore, if there was more time the resilience assessment could be analyzed more thoroughly and applied to MWFF to a greater extent. In addition, only 10 interviews could be conducted and interviews were not able to be conducted with the Toronto Region Conservation Authority, and only one interview was conducted with Town of Caledon. It would have been beneficial to interview the conservation authority, more municipal government employees, and some of the producers to MWFF in order to define the system fully and apply it to the resilience assessment.

Overall, the goal for this research was to assess and potentially enhance the resiliency of MWFF to be able to generate revenue and pass down to future generations while also adhering to the policies of the protected land. The small-scale agroecosystem was identified as a complex

social-ecological system and the Resilience Assessment Workbook by Resilience Alliance was applied to it. A literature review was conducted that included a policy analysis, a historical profile of the system and related scales, and background information on conservation efforts and small-scale agriculture in southern Ontario. In addition, the questions of "resilience of what?" "resilience to what?" and "resilience with what?" were answered for MWFF. "Resilience of what?" defined MWFF as a social-ecological system, its main issues, and key components. "Resilience to what?" addressed the main threats, disturbances, and uncertainty regarding MWFF as well as multiple states and thresholds, cross-scalar interactions, adaptive governance and social networks of the system. Finally, "resilience with what?" identified the assets of the system that make it resilient.

Recommendations that are made for Mount Wolfe Forest Farm to enhance resiliency and reach its long-term goals include advocating for a strong support network of stakeholders, becoming a spokesperson for small-scale agriculture to encourage rigid policies become more flexible and exhibit adaptive governance. Also, to build an integrated resilience plan to ensure economic viability and use social innovation as a tool for resilience. Recommendations that are made to the Resilience Assessment Workbook include making the workbook more available and user-friendly for smaller-scale systems, to create a section of assets of the system that are resilient as identified by Liu (2011), and to give examples of resilient characteristics within a system.

Future research directions that could follow this resilience assessment of MWFF include researching how to replicate their practices elsewhere on the ORM and GGH area, create an integrated resilience plan to ensure economic viability, and utilize social innovation as a resilience tool. It could be beneficial to research The Center for Agroecology and Sustainable

Food Systems at the University of California's resilience plan and how it could be applied to MWFF and the local sustainable food system. In addition, it would also be relevant to investigate the Social Innovation Lab Guide by the Waterloo Institute for Social Innovation and Resilience and how this could be beneficial for MWFF and its resiliency. This study is hopefully one of the first of many research studies done on the farm. As the farm and University of Waterloo continue to work together in striving for sustainability and resilience not only on MWFF but also the local food system to create widespread practices of agriculture that succeed in productivity and ecological integrity.

References

Baker, J.D. (2016). The Purpose, Process, and Methods of Writing a Literature Review. *AORN Journal, 103*(3). 265-269.

Borron, S. (2006) *Building Resilience for an Unpredictable Future: How Organic Agriculture Can Help Farmers Adapt to Climate Change*. Food and Agriculture Organization of the United Nations, Sustainable Development Department. Retrieved from http://www.fao.org/3/a-ah617e.pdf

Christy, E., Landman, K., Nowatschin, E., & Blay-Palmer, A. (2013). *Local Food Systems in North America A Review of Literature.* Prepared for Ontario Ministry of Agriculture and Food. Retrieved from http://nourishingontario.ca/wp-content/uploads/2013/07/NA-FoodHub-LitReview-2013.pdf

Conservation Ontario. (2013). "Conservation Authorities of Ontario." Retrieved from http://conservationontario.ca/about-us/conservation-authorities

Dixon, J. L., Stringer, L. C., & Challinor, A. J. (2014). Farming system evolution and adaptive capacity: Insights for adaptation support. *Resources, 3*(1), 182-214.

Edge, J. (2013). *Cultivating Opportunities: Canada's Growing Appetite for Local Food*. The Conference Board of Canada. Retrieved from http://www.actualitealimentaire.com/wp-content/uploads/2013/08/14-021_localfood_cfic_rpt.pdf

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology and Society,15*(4).

Food and Agriculture Organization of the United Nations (FAO). (2011). *Save and Grow: A policy makers guide to the intensification of smallholder crop production*. Retrieved from http://www.fao.org/docrep/014/i2215e/i2215e.pdf

Fridman, J. (2014). *Settlement, Foodlands, and Sustainable Habitation: The Historical Development of Agricultural Policy and Urban Planning in Southern Ontario*. (Master's thesis). Retrieved from http://nourishingontario.ca/wp-content/uploads/2012/10/Fridman_Joel_D_201406_MA_thesis.pdf

Gerring, J. (2004). What is a case study and what is it good for? *American political science review, 98*(02), 341-354.

Harrell, M. C., & Bradley, M. A. (2009). *Data collection methods. Semi-structured interviews and focus groups*. Santa Monica: California: Rand National Defense Research Institute.

Holling, C.S. (1973). "Resilience and stability of ecological systems," in *Annual Review of Ecology and Systematics*, Vol. 4 :1-23.

Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystems, 4*(5), 390-405.

Howard, K. W., Eyles, N., Smart, P. J., Boyce, J. I., Gerber, R. E., Salvatori, S. L., & Doughty, M. (1995). The Oak Ridges Moraine of southern Ontario: a ground-water resource at risk. *Geoscience Canada, 22*(3).

International Panel of Experts on Sustainable Food Systems (IPES-Food). (2016). *From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems* (Report No. 2). International Panel of Experts on Sustainable Food Systems. Retrieved November 7, 2016 from: http://www.ipes-food.org/images/Reports/UniformityToDiversity_FullReport.pdf

Ivey, J. L., De Loë, R. C., & Kreutzwiser, R. D. (2002). Groundwater management by watershed agencies: an evaluation of the capacity of Ontario's conservation authorities. Journal of *Environmental Management, 64*(3), 311-331.

Kay, J., Lister, N., & Waltner-Toews, D. (2008). *An introduction to systems thinking. The Ecosystem Approach: Complexity, Uncertainty, and Managing for Sustainability*. New York, New York: Columbia University Press.

Kay, J. J., Regier, H. A., Boyle, M., & Francis, G. (1999). An ecosystem approach for sustainability: addressing the challenge of complexity. *Futures, 31*(7), 721-742.

Kindon, S., Pain, R., Kesby, M. (2007). *Participatory Action Research Approaches and Methods: connecting people, participation, and place*. New York, New York: Routledge. 1-9.

Knezevic, I., Landman, K., Blay-Palmer, A. and Nelson, E. (Eds.). (2013). *Models and Best Practices for Building Sustainable Food Systems in Ontario and Beyond*. Guelph, ON: Ontario Ministry of Agriculture, Food and Rural Affairs.

Liu, W.T.E. (2011). *An Application of the Resilience Assessment Workbook on the Town of Caledon, Ontario, Canada: Resilience of What? Resilience to What? Resilience with What?* (Master's thesis). Retrieved from UWSpace. http://hdl.handle.net/10012/6198

Milestad, R. (2003). *Building farm resilience: Prospects and challenges for organic farming.* Swedish University of Agricultural Science. (Doctor's dissertation). ISSN 1401-6249, ISBN 91-576-6410-2

Miller, S. (2013). *Places to Farm: Alternative practices and policies for Ontario's changing agricultural landscape.* Metcalf Foundation. Retrieved from http://metcalffoundation.com/wp-content/uploads/2013/07/PlacestoFarm.pdf

Ministry of Municipal Affairs (MMA). (2013). "Growth Plan for the Greater Golden Horseshoe, 2006: Office consolidation, 2013". Retrieved from https://www.placestogrow.ca/index.php?option=com_content&task=view&id=359&Itemid=12

Ministry of Municipal Affairs and Housing (MMAH). "Greenbelt Protection" Retrieved November 8, 2016 from http://www.mah.gov.on.ca/Page187.aspx

Ministry of Municipal Affairs and Housing (MMAH). (2001). "Oak Ridges Moraine Conservation Plan" Retrieved November 8, 2016 from: http://www.mah.gov.on.ca/AssetFactory.aspx?did=11177

Mississaugas of the New Credit First Nation: Traditional Territory. (2014). Retrieved from http://www.newcreditfirstnation2015.com/wp-content/uploads/MNCFN-Traditional-Map.pdf

Mitchell, B., Shrubsole, D. A. (1992). *Ontario Conservation Authorities: Myth and Reality. Waterloo, Ontario*: Department of Geography, University of Waterloo.

Mount Wolfe Forest Farm: *How we got here*. [PowerPoint Slides].

Mount Wolfe Forest Farm (MWFF). "About Us." Retrieved October 31, 2016 from: http://mountwolfefarm.ca/

Nadasdy, P. (2007). Adaptive Co-Management and the Gospel of Resilience. In: D. Armitage, F. Berkes and N. Doubleday (Eds.) *Adaptive Co-Management: Collaboration, Learning, and Multilevel Governance*. Vancouver: University of British Columbia Press. 208-227.

Oak Ridges Moraine Foundation. "Land Use Designations". Retrieved November 7, 2016 from: http://www.moraineforlife.org/living/legislation.php

Oak Ridges Moraine Land Trust. "Formation." Retrieved from http://www.oakridgesmoraine.org/formation.html

Ohberg, L., Wakefield, S. (2013). *Chapter 3- Golden Horseshoe*. In: Knezevic, I., Landman, K., Blay-Palmer, A. and Nelson, E. (Eds.) (2013). *Models and Best Practices for Building Sustainable Food Systems in Ontario and Beyond*. Guelph, ON: Ontario Ministry of Agriculture, Food and Rural Affairs.

Oxfam. (2014). *Scaling-up agroecological approaches: what, why and how?* Retrieved November 2, 2016 from: http://ag-transition.org/wp-content/uploads/2014/01/201401-Scaling-up-agroecology-what-why-and-how-OxfamSol-FINAL.pdf

Perez, J., Brown, M., Miles, A. (2015). *Teaching Direct Marketing & Small Farm Viability: Resources for Instructors.* (2nd ed.). University of California: Santa Cruz: The Center for Agroecology and Sustainable Food Systems.

Resilience Alliance. “About.” Retrieved from http://www.resalliance.org/about

Resilience Alliance. “Background.” Retrieved from http://www.resalliance.org/background

Resilience Alliance (RA). (2010). *Assessing resilience in social-ecological systems: workbook for practitioners.* (version 2.0). Retrieved from http://www.resalliance.org/files/ResilienceAssessmentV2_2.pdf

Stockholm Environment Institute and Stockholm Resilience Centre (2016). *Arctic Resilience Report.* Retrieved March 29, 2017 from http://www.stockholmresilience.org/research/research-streames/complex-adaptive-systems/arctic-resilience-report-2016.html

Toronto Region Conservation Authority (TRCA). (2016). “Urban Agriculture.” Retrieved from https://trca.ca/conservation/urban-agriculture/

Toronto Region Conservation Authority (TRCA). “Regulated Area Search.” Retrieved from https://trca.ca/planning-permits/regulated-area-search-2/

Town of Caledon. “Local History.” Retrieved from https://www.caledon.ca/en/live/caledonhistory.asp

Town of Caledon. (2009). *South Albion-Bolton Community Plan, Employment Lands Study, and North Hill Supermarket.* Cultural Heritage Landscapes Assessment and Built Heritage Resources Assessment. Retrieved from http://www.caledon.ca/en/townhall/resources/sab_p2_cultural_resources_report.pdf

Town of Caledon. (2016). *Town of Caledon Official Plan*. Retrieved from https://www.caledon.ca/en/townhall/resources/Official_Plan_Master_Copy_-_complete.pdf

Walker, B., Abel, N., O’Connell, D., and Grigg, N. (2016). *A Resilience Approach to Conservation And Development:* Working Paper Version 1.5. CSIRO, Australia. Retrieved November 1, 2016 from: http://www.resalliance.org/files/files/A_resilience_approach_to_conservation_and_development_V1_5_-_ePublish_version.pdf

Walker, B., Holling, C. S., Carpenter, S., & Kinzig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. *Ecology and society, 9*(2).

Walker, B. & Salt, D. (2006). *Resilience Thinking*. Washington, DC: Island Press.

Walker, B. & Salt, D. (2012). *Resilience Practice*. Washington, DC: Island Press.

Warner, K. (2007). *Agroecology in action: Extending alternative agriculture through social networks*. MIT Press.

Westley, F., Laban, S., Rose, C., McGowan, K., Robinson, S, Tjornbo, O., Tovey, M. (2015). *Social Innovation Lab Guide*. Waterloo Institute for Social Innovation and Resilience. Retrieved from https://uwaterloo.ca/waterloo-institute-for-social-innovation-and-resilience/sites/ca.waterloo-institute-for-social-innovation-and-resilience/files/uploads/files/10_silabguide_final.pdf

Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., & David, C. (2009). Agroecology as a science, a movement and a practice. A review. *Agronomy for sustainable development*, *29*(4), 503-515.

Whitelaw, G.S., Eagles, F.J. (2007). Planning for Long, Wide Conservation Corridors on Private Lands in the Oak Ridges Moraine, Ontario, Canada. *Conservation Biology, 21*(3). 675-683.

Yin, R.K. (2003). *Case Study Research Design and Methods.* (3rd ed.). California: Sage Publications.

Appendix A: General Key Informant Interview Questions

Interview Questions:

1. How would you define a local sustainable food system? And what factors can threaten or disturb it?
2. What characteristics do you consider to be valuable or desirable in a local food system?
3. What role does policy play in a local food system?
4. Do you think conservation plans such as Ontario's Greenbelt or the Oak Ridges Moraine Conservation Plan inhibit or enable the success of small-scale agriculture practices?
5. How do you think the food system (or land use) has evolved over time in the Caledon area?
6. How do you think the land-use has changed over time in the Caledon area, specifically the Oak Ridges Moraine?
7. Have there been any significant events in the past that you know of that have disturbed the landscape?
8. Do you have any other sources (documents) that I should enquire, or people I should talk to?

Appendix B: Farm Specific Interview Questions

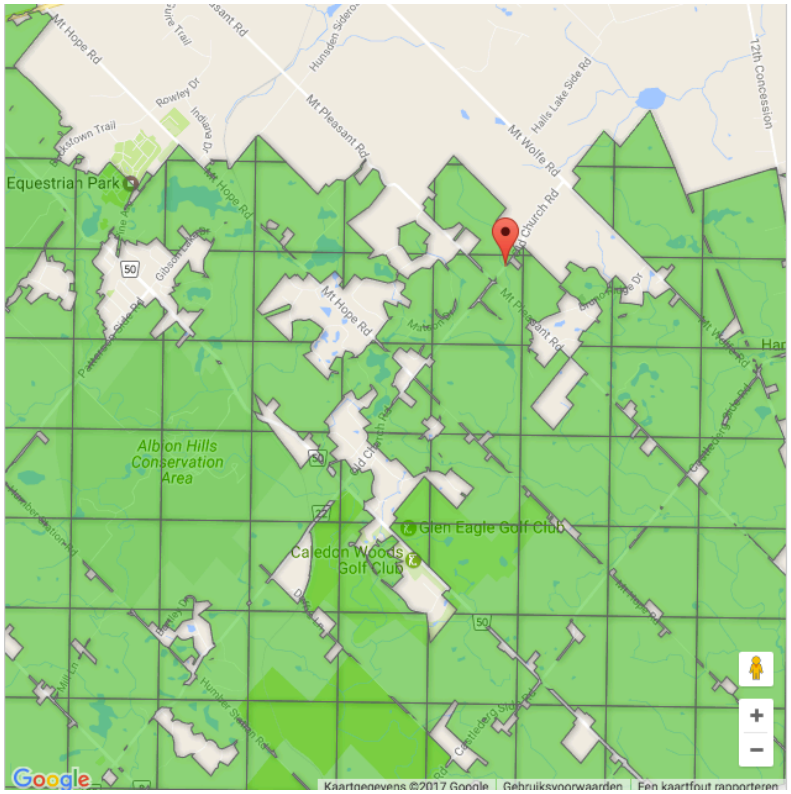
Questions: General Resilience of the Regional Local Food System

1. How would you define a local sustainable food system? And what factors can threaten or disturb it?
2. What characteristics do you consider to be valuable or desirable in a local food system?
3. Do you think policies such as Ontario's Greenbelt or the Oak Ridges Moraine Conservation Plan inhibit or enable the success of small-scale agriculture practices?
4. How do you think the land-use and the local food system has evolved and changed over time in the Caledon area? (Any significant changes in the landscape or disturbances)?

Questions: Specific Resilience of Mount Wolfe Forest Farm as a System

1. What is the long term goal/ desired state of the system (farm)?
2. What is necessary in order to meet the long term goal/ desired system state? (What characteristics)
3. Is the system currently in a "desired" state? Is it on trajectory to one that less "desirable"?
4. What is the historical timeline of the farm? (the story of the farm)
5. What are the drivers of the system (farm)? Things that influence the system (farm) from the outside?
6. What are potential future disturbances that could affect the system? What potential disturbances pose the greatest threat to the resilience of the system?
7. Do you have any other sources (documents) that I should enquire, or people I should talk to?

Appendix C: Map of MWFF and TRCA Regulated Area



A map representing the regulated area of the TRCA and the red pin representing the location of MWFF (TRCA, Regulated Area Search).