An Evaluation of the Reintroduction of Atlantic Salmon to Lake Ontario and its Tributaries

by

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Author's Declaration

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

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Abstract

As the field of restoration continues to develop, it is important that initiatives are evaluated for their effectiveness and to explore the motivations and justifications behind the projects' designs. Current restoration ecology seeks to orient projects toward the future instead of rooting them in the past. By focusing on ecosystem function rather than specific species composition, the needs of the current ecosystem are better able to be addressed. The dynamic and complex nature of ecosystems means restoration ecologists must have a firm understanding of current conditions and design several trajectories for restoration projects.

Not all current restoration projects adhere to this more recent framework, and many fall short of achieving goals set by international organizations, such as the Society for Ecological Restoration. The Atlantic Salmon Reintroduction Program for Lake Ontario began in 2006 with the goal of establishing a self sustaining Atlantic salmon population in Lake Ontario. Over 30 organizations have joined together to implement this program which involves fish production, habitat restoration, monitoring and assessment as well as education and outreach. Though some success has been achieved through habitat projects and observation of some returning adults, the future of the project is still being evaluated.

By reviewing relevant literature and conducting interviews with key partners, the program was evaluated for its adherence to restoration principles and the following areas were used to evaluate its success. These broad themes included: (1) the biological interactions of these fish with their surroundings; (2) the history of the ecosystem; (3) the influence of humans on the restoration process; (4) the value laden aspect of the

process; and (5) the extent of a "systems" approach. The justification for this program appears to be based more on culture, aesthetic and economic value than sound ecological science but, as all respondents agreed, the ability of Lake Ontario to support a healthy, self-sustaining population of Atlantic salmon would be a good indicator of overall ecosystem health at least in terms of water quality and quantity. Despite this potential achievement, reintroducing a single extirpated species while focusing solely on its habitat and survival, fails to address the multitude of concerns within the Lake Ontario watershed. Consequently this reintroduction limits the potential for restoration of the Lake and is far less efficient and effective than had other opportunities been pursued.

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1 Introduction

As human development continually impacts the environment, it is no longer enough to simply protect and conserve the ecosystems and species around us. We realize that we must start to recreate these wild areas and that we must manage them in a way that improves overall ecosystem health[1] and one way to do so is through ecological restoration. Restoration has potential to reunite humans with nature, as we realize our interconnectedness with the environment around us. People, in the face of the offences we have been responsible for, feel the need to atone and absolve ourselves through a renewed communion with nature (Jordan, 2003). Restoration can serve as a conversation with nature, where we can start to repair the human-nature relationship (Higgs, 2003). Moving beyond metaphors, we can delve into the theories that inform how we choose to restore specific landscapes and begin to take the practical steps required for restoration.

Ecological restoration has two threads, theory and practice, that are sometimes contradictory, yet by bridging this gap we can increase our understanding of ecological systems, as well as our understanding of the relationship between humans and nature (Eden, 2006). Ecosystem restoration is a relatively young discipline with roots in landscape architecture, conservation, reclamation, mitigation and of course, ecology

[1] There are several assumptions made when discussing ecosystem health as a normative concept including that biological diversity and ecological complexity are desirable and that biotic diversity has intrinsic value (Soule, 1985). Definitions of "health" are highly contested, but for the purposes of discussion on restoration, these assumptions will be used. The value based aspects and subjectivity of the word health are acknowledged and no judgment is passed as to the extent or value of naturalness or human intervention within a particular system (Lackey, 2001).

(Egan and Howell, 2001). The field of ecology has developed a strong and diverse body of theory addressing nearly every aspect of ecological interactions (Palmer *et al.*, 2006). Ecological restoration can test ecological theory by allowing theorists and practitioners to monitor the restored ecosystem and evaluate the new ecological processes. Halle (2007, p. 358) believes that in order to bridge the gap between theory and application the practice of restoration should be "translated into vocabulary and thinking of basic ecology". By linking natural succession and what is known about ecosystem processes with the application of ecological restoration, we are in a better position to successfully restore degraded ecosystems.

According to Higgs (2003), restoration initiatives should be based on ecological integrity and historical fidelity, yet, as these terms are neither easily defined nor easily described, making the decision as to how restore an ecosystem is difficult. Broadly, for a system to have ecological integrity, it must be restored based on what is known about ecological theory. Historic fidelity may be achieved by restoring a system based on what is known about that system's past. Each situation is unique to the ecosystem being restored and the stakeholders involved. Furthermore, because many scientists choose to emphasize claims of objectivity, they have often left restoration up to the more practically and politically minded (Young, 2001). Reconciling all of these differences requires a holistic and participatory approach where the various stakeholders are able to voice their considerations and work toward establishing a restoration plan that adheres to shared values and is beneficial to the ecosystem in question.

Restoration projects inevitably bring together various sets of frameworks and ethics and designing specific actions for restoration is often contentious. Actions that pertain to manipulation of the ecosystem include the removal of exotics, recovery of

native species, and provision for natural processes and disturbances (Soule, 1999). It is unclear exactly how these are to be carried out, and to what extent. The simplest restorations may only involve the removal of a disturbance or perturbation so that the system may recover all on its own. Much more often than this, ecological restoration involves multiple stakeholders and multiple perturbations, as the degradation of the system has been occurring over an extended time period. Each restoration initiative is unique and uniquely complex, some have been successful, some controversial, and some have failed to achieve their goals.

Several attempts to intentionally introduce species have been made throughout the world. Reintroductions attempts have occurred for at least a century, though they vary in terms of success (Keiman, 1989; Armstrong and Seddon, 2008). The reintroduction of wolves (*Canis lupus*) to Yellowstone Park is among the most famous initiatives. After "2 decades, 120 meetings, 160 000 comments and $12 million for scientific analysis", the wolves were released into parts of their historic range in 1995 (Wilson, 1997, p. 454). As of 2009, over 1700 wolves were thriving, even though the initiative was not fully supported by all members of the public (USFWS, 2010). As another example, the restoration of several species of butterflies was found to depend on their habitat requirements, the availability of resources to manage that habitat, and utilization of a formal scientific approach (Pullin, 1996). Finally, six attempts to reintroduce wallabies (*Marsupialia macropodoidea*) in Australia resulted in failure as non-native terrestrial predators were not taken into account (Short, 1992). As no clear strategy has been developed for reintroduction, management practices and subsequent results are varied.

In Canada, several strategic documents at the Federal and Provincial level discuss restoration of ecosystems and set principles to be followed. Recently, Parks Canada (2008) developed "Principles and Guidelines for Ecological Restoration", a collaborative effort that details management strategies for the restoration of parks and protected areas. Canada's Biodiversity Strategy (1995) states that we should "rehabilitate and restore degraded ecosystems and promote the recovery of threatened species through the development and implementation of plans or other management strategies", while the Fish Communities Objectives of the Great Lake Fisheries Commission (1999) seek to "reflect the current and most complete scientific understanding of the Lake Ontario ecosystem, and must be responsive to social, economic, and cultural needs". These broad principles inform local restoration and have led to efforts to establish self sustaining native and naturalized species to support diverse and long term fish communities. An example of these efforts is the Atlantic Salmon Reintroduction Program (ASRP) headed by Ontario Federation of Anglers and Hunters (OFAH) and the Ministry of Natural Resources (MNR).

Prior to European colonization Atlantic salmon were abundant in Lake Ontario, but were extirpated in the late 1800's due to overfishing and habitat degradation (Parrish *et al.*, 1998). After years of research examining spawning, competition and juvenile survival (Stanfield and Jones, 2003; Scott *et al.*, 2003, 2005; Stewert and Schaner, 2002), sufficient data were collected to develop a full scale restoration effort of Atlantic salmon population. A multi-partner project has been developed by the MNR, OFAH and several organizations to "Bring Back the Salmon", which is the slogan adopted by the campaign. This ASRP is currently being carried out in three tributaries of Lake Ontario: Cobourg Brook, Duffin's Creek, and Credit River. The program

involves producing hatchery fish, stocking, habitat restoration, research and assessment and education and outreach.

Though the program's contributors will determine the success of the program by the establishment of a self sustaining Atlantic salmon population in Lake Ontario, this program can serve as a case study with which to evaluate the restoration process, the interpretation of theory and how the practice is being carried out by environmental mangers. The desire to re-establish this extirpated species is admirable, though the extent to which it follows established restoration criteria and practice is arguable. Soule and Terborgh (1999, p.813) state that small, localized restorations are still important but they should not be "planned and implemented in isolation with unstated goals, little monitoring and no consideration of regional priorities"; otherwise they run the risk of creating one of a kind 'ecological museum pieces' with little functional role in conservation. The ASRP, with its 30+ organizations and millions of dollars invested is fully committed to restoring this particular species, yet they should be sure that their mandate and methods adhere to the most holistic restoration processes in order to bring the most benefit to the ecosystem.

Recently, restoration ecologists have argued that restoration should be oriented toward the future (Choi, 2007; Choi *et al.*, 2008; Temperton, 2007). The inherent complexity and dynamic nature of ecosystems make it impossible to fully recreate a historic system. Several frameworks are proposed for designing a restoration project. For example, Choi (2007) proposes the following: 1) manage sustainable ecosystems for the future; 2) set multiple goals to allow for surprise; 3) focus on function, not specific historic species; and 4) acknowledge that restoration is incredibly value laden and takes place within a social and economic framework. This framework is an example of the

most current restoration guidelines, and by examining the ASRP within the context of these guidelines, a more suitable way to improve conditions in Lake Ontario may be able to be established. .

This thesis will analyze the ASRP and the decisions made by its key players in their effort to restore Atlantic salmon to Lake Ontario. OFAH, MNR and several other organizations have come together to reintroduce this species to the lake through fish production, habitat restoration, research and assessment and education. By examining the program components and goals through documents, websites and interviews with program participants, I will evaluate the ASRP for its adherence to the latest restoration theory.

2 Literature Review

2.1 A brief overview of restoration

The word "restoration" may make one think of making something new again through repairs and redesign, and in ecological terms, restoration is often interpreted the same way. There is much to suggest that humans have proven to be a destructive force in nature. Whether it is through burning for agricultural purposes or removal of resources for our use, there are countless ways that we drastically affect the environment in which we live. There are reports of early civilizations practicing conservation and protecting the environment from which they get their resources, but there is also evidence of great destruction from modern industrial civilization. In the 19th century, several visionaries including John Muir and Theodore Roosevelt moved to protect and conserve large swaths of landscape and this "conservation mindset" infiltrated popular culture. At the turn of the next century, a well documented move occurred from solely protecting these incredible vistas to protecting more biologically rich but far less spectacular ecosystems (Soule and Terbough, 1999). Toward the end of the century, another movement pushed to move past simple conservation and preservation to instead restore, enhance and redevelop ecosystems that had been degraded (Gross, 2008).

When an ecosystem has been degraded through physical or chemical destruction, restoration is often thought to be a remedy. To which point in time it is to be "restored" and if there is even the possibility of going back in time remains to be determined. For example, the Society for Ecological Restoration defines ecological restoration as "the process of assisting the recovery of an ecosystem that has been degraded, damaged or

destroyed" (SER, 2004). Not less than a decade ago, this definition was instead "the process of repairing damage caused by humans to the diversity and dynamics of indigenous ecosystems" (Jackson *et al.*, 1995). The subtle differences are important, noting that both "humans" and the indigenous nature of an ecosystem have been removed from the current definition. Perhaps the Society is less apt to assign blame, and feels that environmental areas should be restored regardless of the cause of their degradation. The indigenous nature of landscapes is also called into question, as concepts of "pristine" and "native" are not as definitive as they once were (Denevan, 1992). As we continue to debate what restoration is and how it should be conducted, this definition will continue to be amended.

Several pathways have been identified as means of repairing an ecosystem. Restoration ecologists can choose to focus on ecosystem function, which includes biomass, nutrient regimes and system interactions, or ecosystem structure, which includes species composition and complexity (Bradshaw, 1996). Inevitably, as a system is degraded, both attributes decline. It is important to decide which of these is most important to pursue, as that dictates which trajectory to take as a means of ecosystem recovery. Restoration ecologists can choose: rehabilitation (some movement along the trajectory toward the original ecosystem); replacement (achievement of some other (healthy) state); and restoration (fully achieving the original ecosystem state) (Figure 1). Though restoration is usually seen as the main objective, it is often more practical to focus on rehabilitation or replacement (Bradshaw, 1996).

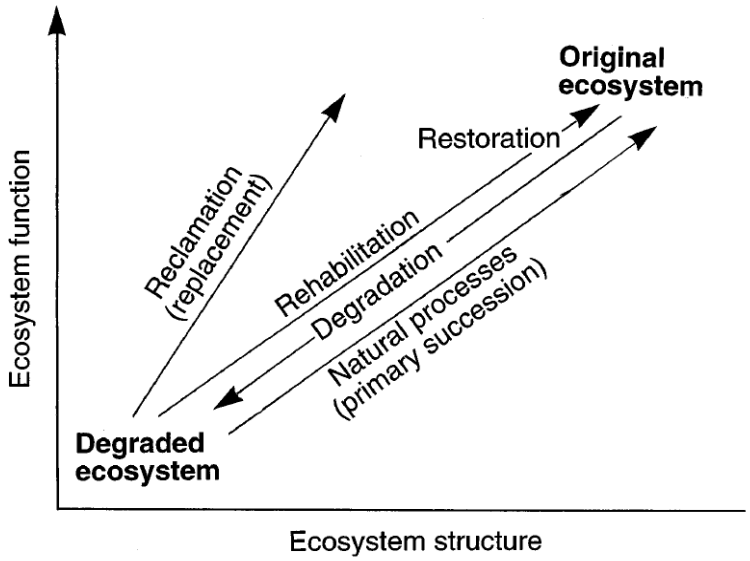

Figure 2-1: relation between ecosystem structure and ecosystem function illustrating the three pathways that may be taken to reverse ecosystem degradation (see text). Adapted from Bradshaw (1996).

It is difficult to argue with a desire to repair an ecosystem. Increasingly, some humans seek to look after the natural world around us. This may be to slow the depletion of resources we need to survive, or perhaps to compensate for the actions taken by previous generations. Contention may arise when practitioners attempt to identify goals and values as well as determine what means are acceptable to achieve these desired goals. Restoration ecologists and the people who practice ecological restoration continually evaluate the process and their motivations and justifications for undertaking such initiatives.

2.1.1 Reconciliation of restoration theory and practice

Part of studying ecology is learning what drives communities of organisms to transition from one state to another and developing theories about these processes. An understanding of ecology can help to inform practical restoration and the results of restoration projects can test ecological theories (Temperton, 2007). Yet, with the field of restoration being as young as it is, there can be a large disconnect between the theory and the practice. Initiatives can be undertaken in the name of restoration without adhering to any established principles that seek to future orient, set multiple trajectories, or focus on ecosystem function (eg, Choi (2007) and Hobbs (2007)). The multitude of practitioners means that many projects are attempted and completed haphazardly with no real thought for the ecosystem as a whole. What is required, and what is being continually developed, is a set of guiding principles that are rooted in the theory, and also take into account the politics, science, and society surrounding each project. As these guidelines are developed, it is imperative that the people undertaking so-called restoration projects use them and not attempt simply to act for their own interests. Many, including Temperton (2007), Choi (2008) and Higgs (2005) have called for the increased inclusion of socioeconomic and political aspects in the process and for restoration to be firmly planted in the transdisciplinary arena, where the boundaries of several disciplines are crossed, creating a holistic approach. As restoration projects inevitably bring together various sets of frameworks and ethics, so too should these projects bring together multiple disciplines and experts from diverse fields. This transdisciplinary approach would be much more holistic and participatory and would be beneficial for considering options, identifying tradeoffs and weighing long term effects.

Restoration projects can initiate natural processes and ecosystem recovery but they can also provide opportunities for the public to develop a better relationship with their surrounding environment (Gross, 2008). Restoration initiatives, if well planned, can give the public something to latch on to, to believe in, and to take part in. However, some restoration ecologists conclude that the public may be lacking competency to judge projects effectively and therefore the public is often underutilized in this process (Eden, 2006). Ecological restoration must acknowledge societal expectations and increase public participation to increase likelihood of success (Hobbs, 2004). It is vital that we recognize that people dictate initial restorative actions, and not biotic or abiotic processes (Burke and Mitchell, 2007). This does not mean we can ignore ecosystem processes, but we must acknowledge that we are working on these projects for ourselves, and not "on behalf of nature".

2.1.2 The problem of "historic" systems

With all the degradation that humans have caused, it is likely that we would desire to reverse this trend and one way to do so is through restoration. An old standard for restoration is to achieve some "predisturbance structure" or to "reset the ecological clock" (Cairns, 1991). This goal of essentially going back in time is difficult, if not impossible. Not only is it very difficult to determine what a predisturbance ecosystem looked like, but our knowledge of how to restore all parts of a system is limited.

Though historic information is important and can even help convince people to modify their behavior, there are still major problems with basing restoration on historic systems (Steedman, 1996). Ecosystems are in constant flux, so the systems surrounding the landscape to be restored have likely changed dramatically since the time of

predisturbance. Wild nature devoid of human influence has ceased to exist, which means baseline data regarding these sites are difficult to obtain (Rees, 2000). Simple recreation of isolated and fragmented naturalized patches is not likely to restore ecosystem function and any attempt to recreate a historic environment is unlikely to persist into the future (Choi, 2008). Despite much advance, the scientific community's understanding of complex ecosystem processes is still limited. In an effort to remain objective, science has often left restoration up to the more practically and politically minded who have a much more arbitrary approach (Young, 2001). If restoration is too focused on specific sites or species and lacks ecological understanding, it can do more harm than good (Kershner, 1997). Unrealistic goals are another major limitation for restoring systems to these historical benchmarks, as sometimes the damage is irreparable. Restoration becomes more of an art than a science without exact methods and standards, and the cost of synthesizing ecological, social and political goals can be prohibitive when attempting to reconcile various frameworks (Michener, 1997, Choi, 2007).

So why would any practitioner seek to do the impossible? Throop (2000) gives two major reasons. First, restoring an ecosystem based on its historic characteristics may be "the least risky way of returning a system to health". If the system was at one point deemed healthful, then to strive to emulate that structure is perhaps not the worst we can do. Second, there is a tendency for humans to "put things back the way we found them", a lesson many learn in childhood. The majority of humans' manipulations of ecosystems have severely degraded the surrounding environment. Is it not prudent, if not required, that we intervene to set things right? The feasibility of achieving a goal of a predisturbance structure may be highly improbable, but nonetheless practitioners will

pursue this goal knowing full well they will fall short, simply in hope that they will at least somewhat improve conditions.

2.1.3 Restoration: a value-laden process

Restoration ecologists must acknowledge the value-laden aspects of restoration. It is difficult to ascertain what makes a particular ecosystem more desirable than another. Which goals are set for each restoration project depend upon the values of the people or institutions driving the restoration effort. Projects can focus on bettering the aesthetic of a landscape, but more often focus on improving ecosystem function by stopping physical and chemical degradation, rehabilitating diminishing species and removing unwanted, detrimental species. Arguments have developed when choosing one species over another or choosing to protect a species at the cost of human desires. Recently, for example, Californians have taken issue with protection of Delta smelt habitat, as this has lead to reduced water available for urban and agricultural uses (Bennett, 2005). Debates also revolve around more philosophical issues. If a predisturbance state is desired, can that be achieved by continual human intervention, or does this only add to the disturbance? These kinds of questions remain contentious as we strive to define key aspects and interactions of ecosystems (Throop, 2000). As a "truly transdisciplinary field" the practice of restoration should involve as many disciplines and participants as possible, though reconciling so many values exacerbates an already difficult process (Young, 2001).

Though there may be unclear ideas of how a system may have been and on the preconceptions individuals or groups have about what is important for an ecosystem, some principles are generally agreed upon. These include the removal of exotics,

recovery of native species, and provision for natural processes and disturbances (Soule and Terborgh, 1999). How best to achieve these principles is still debatable. Not only are definitions of "exotic", "native" and "natural" unclear, but the value of carrying out these principles is equally contentious. Perhaps not all of these actions are required during restoration and the extent to which they have to be completed varies.

Native, or indigenous species, are generally considered those species which have existed within a certain region for a long period of time, or in the case of North America, since before European colonization. Exotic species, also referred to as alien or non-indigenous species, are generally agreed to be species that have entered an ecosystem in the more recent past, usually through a human vector, either intentionally or unintentionally (Cohen and Carlton, 1998; Williams and Meffe, 2005). This description does not describe the effect these species have on the ecosystem. Sometimes, exotics become "invasive" species, ones which proliferate through an ecosystem and may negatively impact indigenous species. Rejmanek *et al.* (2002) feel that negative labeling of invasive species vilifies beneficial non-native species. "Naturalized" exotics have integrated themselves into the new ecosystem and successfully reproduce, yet their detrimental effects are either no longer apparent, or non-existent. Davis and Thompson (2000) argue that in time, all invasive species can become native. Species that have been in an environment for an extended period of time and are fully integrated into the system may no longer be considered threats, and would likely not be removed as part of the restoration process. There is not one definition that is unanimously agreed upon and several aspects are contested, which can lead to divergent interpretations and a confusion of concepts and theory (Colautti and MacIsaac, 2004).

Just as ecosystems are inherently complex, so is the process and reasoning behind trying to restore them. Though restoration can be subjective and the motivation, justification and means of restorative action vary for each situation, restoration is capable of repairing function, improving diversity, remediating and mending the human-nature relationship (Allison, 2007; Palamar, 2008). It is also possible that restoration, even with the most benevolent intentions, can cause harm to a system we do not fully understand. When ideas for restoration are put into practice we can examine the process most fully. McDonald *et al.* (2008) remark that the sentiment of restoration and our desire to make our environment better one widely accepted, but large-scale restoration projects are often considered unfeasible. According to Hobbs (2007) restoration ecologists must acknowledge the dynamic nature of ecosystems, diagnose damage, and set realistic goals, all while incorporating social and philosophical aspects. These suggestions are not being observed by many practitioners of so-called restoration initiatives around the world, including the ASRP in Lake Ontario.

2.1.4 A new way forward?

Restoration is no longer about achieving a prior static state, but instead moving toward a healthy future that acknowledges the dynamic nature of ecosystems. It is also critical in ecosystem restoration that *function* is maintained and/or created within the ecosystem, as ultimately this is more important than species composition (Armstrong and Seddon, 2008). Non-indigenous species may be able to provide adequate or even increased function of an ecosystem, meaning native species should not be a requirement for a healthy ecosystem. Gozlan (2008) discusses the positive impacts of freshwater fish introductions. He notes that some benefits of introductions include economics,

predator control, food sources and increased biodiversity. Ewel *et al*, (1999) agree that there are benefits, but acknowledges the limitations of introductions and concludes there is still much room for further study.

There are many aspects of current restoration strategies that are debatable and warrant examination, yet this does not mean the practice should be abandoned. Instead, managers should ensure they adhere to the most current applicable restoration guidelines and theories. Any process should begin with thorough identification of the degraded state including species composition, trophic interactions and ecosystem functions (Halle, 2007), not so that restoration ecologists can return the system to a previous state, but so that they can garner a better understanding of the current system. Davis and Thompson (2000) argue that even the word "restoration" should be retired as it no longer adequately describes ecosystem management. They feel that goals for restoration are too subjective, a static approach to dynamic ecosystems is inapplicable and the attempt to replace losses is impractical.

Woolley and McGinnis (2000, p.339) note that "restoration takes on varied forms because human beings do not always share the same views, perceptions, and beliefs about the meaning of nature." They discuss competing discourses of restoration ranging from those who find it a necessary component of conservation, those who can justify it only in certain cases and those who do not find it an acceptable management strategy for nature in any case. Initiatives can be used to find a balance among conservationists despite the contention surrounding what actions are deemed appropriate.

Though not everyone will agree on the motivation behind restoration projects, projects are (and should) be used to find a better balance between humans and nature and to achieve a more sustainable way of living. To do this, Hobbs (2007) proposes that

in order to set goals, people attempting restoration should: enhance translation of understanding of ecosystem dynamics into conceptual and practical restoration frameworks; future orient; and have a synthetic approach to ecological and social aspects of issues. Restoration practitioners should have full understanding of the ecosystem; they should accept the dynamic nature of ecosystems and plan for surprise. Population increase, industry, new species, and climate change can drastically affect the ecosystem in question. Answers to these questions are not easily answered by science, politics or public participation alone. Hobbs' suggestions are in line with several of the most current guidelines described in this chapter which all seek to orient restoration initiatives toward the future, plan for the unexpected, identify ecological and social frameworks as part of the restoration process, and acknowledge the complexity of ecosystem. The extent to which the ASRP adheres to these guidelines will be discussed within this thesis. As Crifasi (2005, p. 636) notes, if we "do not periodically devote energy to discussions about issues of nature, naturalness, perception, and value, our role diminishes as we base our actions on dogma rather than insight."

2.2 The case study: Lake Ontario

Lake Ontario is, and always has been, a vital resource to the people living near its shores, not only as a source of water and for transportation, but also for fisheries. However, lakes and tributaries can be drastically altered over the course of decades by nutrient regime changes, physical changes and the appearance of exotics (Chapin III *et al.*, 1997). At times during the last century, Lake Ontario was considered a wasteland for industrial and municipal uses, but more recently it has been cleaned up considerably

and is now highly valued as a unique aquatic resource (Taylor and Ferreri, 1999). Since records have been taken, researchers and lake users have seen tremendous changes within the watershed.

In particular, the current fish assemblage in Lake Ontario is relatively recent, as many of the species have entered the Great Lakes from neighbouring watersheds or were put there in the last 150 years by humans (Coon, 1999). Prior to intensive European colonization, Lake Ontario was dominated by large species such as sturgeon (*Acipenser fulvescens*), whitefish (*Coregonus spp*.), burbot (*Lota lota*), Atlantic salmon, and Lake trout (*Salvelinus namaycush*) that were the heart of the commercial fishery (Kerr and LeTendre, 1989). The most noticeable changes to fish assemblages in Lake Ontario are the elimination of historic large predators, reduced abundance and extirpation of native fishes, and the introduction of several non-native species (Figure 2).

Since European colonization, many species have been subject to large declines, including the extirpation of Atlantic salmon beginning in the 1830s and 40s due mainly to overfishing, environmental degradation and physical obstruction of the rivers (Smith, 1995). Other species have declined in part due to new species that were introduced to the ecosystem. Unintentional introductions include zebra mussels (*Dreissena polymorpha*) and round goby (*Neogobius melanostomus*), both of which have caused a significant amount of damage (Mills *et al.*, 1993; Charlebois *et al.*, 2001). Intentional introductions include sport fish, mainly Rainbow trout (*Oncorhynchus mykiss*) and other salmonids from the West coast of Canada.

Table 2-1: Major fish assemblage changes in Lake Ontario. The dominant species in nearshore and offshore environments historically and presently are listed. Non native species preceded by an asterisk. Stocked species indicated by underlining. (Stewert *et al.*, 1999; Bowlby *et al.*, 2003; Hoyle *et al.*, 2003; Lantry *et al.*, 2003; Mills *et al.*, 2005; Kerr, 2006; OMNR 2009)

		nearshore	offshore	
historic	Prey fishes	*Notropis atherinoides* *Notropis hudsonius* *Perca flavescens*	*Coregonus artedi* Deepwater *Coregonus spp.* *Coregonus clupeaformis*	*Myoxocephalus thompsoni* *Cottus cognatus* *Coregonus hoyi*
	Large predators	*Sander vitreus* *Esox lucius* *Acipenser fulvescens* *Anguilla rostrata*	*Salvelinus namaycush* *Lota lota*	*Salmo salar*
modern	Prey fishes	*Perca flavescens* **Cyprinus carpio* **Neogobius melanostomus*	**Osmerus mordax* *Cottus cognatus* *Coregonus clupeaformis*	**Alosa pseudoharengus* *Gasterosteus aculeatus*
	Large predators	*Sander vitreus* *Micropterus dolomieu* *Micropterus salmoides* *Esox lucius*	*Salvelinus namaycush* **Petromyzon marinus*	**Oncorhynchus tshawytscha* **Oncorhynchus kisutch* **Oncorhynchus mykiss* **Salmo trutta*

2.2.1 The history of stocking efforts in Lake Ontario

Intentional sport fish introductions have been carried out by the Provincial government and other wildlife organizations. With nine provincial hatcheries and many other hatcheries acting on their behalf through the Community Fish and Wildlife Program, the MNR has a yearly output of over 8 million fish. Half of these fish are used for species rehabilitation and half to augment fishing opportunities. Angling in Ontario is important to the province's identity, as it offers an experience to outdoor enthusiasts, cottagers and families, thus numerous management programs and initiatives ensure that this opportunity will persist for all who want to engage in fishing Ontario waters.

The first documented attempt at fish culture for Lake Ontario was in 1865, when Samuel Wilmot tried to rear Atlantic salmon, which eventually led to the construction of a permanent hatchery and full scale production (Kerr, 2006). Atlantic salmon stocking failed to be successful at reversing the decline in stocks, despite continued attempts throughout the 1900s. Fry (newly hatched fish) were stocked regularly, but none have managed to establish self sustaining populations, unlike other salmonid species.

Rainbow trout were first stocked in the late 1800s and now MNR recognizes naturalized populations within Lake Ontario. The Ontario government began full scale stocking programs in the 1920s and as of 1990 was stocking over 1 million Rainbow trout annually (Kerr, 2006). Rainbow trout have had negative impacts on the ecosystem, as they have replaced native Brook trout in some areas and continue to proliferate throughout tributaries, requiring barriers to limit their distribution. Despite this, they remain a hugely popular fish and are continually stocked to provide artificial fisheries and diversify angling opportunities (Kerr and Grant, 2000).

Chinook salmon was first stocked in the late 1800s as well, and upon the discovery of an adult specimen upriver from Lake Ontario in 1876, it was proven that this anadromous[2] species can survive without access to the sea (MacCrimmon, 1977). In the 1930s there was a large push to establish this top predator throughout Lake Ontario by stocking fry in every available tributary, yet it was unsuccessful (Kerr, 2006). In the 1970s, after the collapse of Lake Ontario fisheries due to sea lamprey and alewife invasion, the Chinook salmon was again stocked throughout the Lake in an attempt to restore predator/prey balance and it successfully provided top predator control (Kerr, 2006). Currently, over half a million Chinook salmon are stocked into Lake Ontario each year, and about 50% of Chinook salmon caught are of wild, non- hatchery, origin (Bowlby *et al.*, 2005).

Coho salmon have had a similar stocking history to Chinook salmon, with several attempts at establishing a population taken throughout the last two centuries, but they have failed to establish a self-sustaining population. Coho salmon are a valued sport fish, but budget constraints meant the stocking program was discontinued in 1991. Several years later local angling groups requested they be stocked again and the MNR complied. Coho salmon are only actively managed in the Western Lake Ontario basin, and though they provide a viable fishery, they are dependent on hatcheries (Kerr, 2006).

For decades now, the Federal and Provincial governments have been enacting policies to support the fisheries of Lake Ontario by reintroducing species that existed in this system prior to European colonization. These policies are found in everything from biodiversity strategies to fish community objectives. Though many acknowledge that

[2] Anadromous refers to fish species that spawn in fresh water but spend their adult life in a marine environment.

too little is known about these systems to take definitive action, there are several initiatives that have been started in recent years that include persistent, yet judicial stocking of many fish species. Early fish culture and stocking efforts were based on the assumption that, since hatching rates could be dramatically improved under artificial conditions, stocking would enhance native populations. Stocking was widely viewed as a panacea for all fisheries' problems and is still regarded as a measureable way of establishing desired fish populations (Chambers 1971).

The MNR has stated that managing for viable trout and salmon fisheries is incompatible with managing for native fishes and that there is a fundamental dilemma in creating policies that reflect both the scientific assessment of ecological trends and what stakeholders want (Stewart *et al.*, 1999). Thus, despite concerns about exotic species in Lake Ontario, non-native trout and salmon are still being maintained to provide for good quality fishing opportunities. Policies regarding exotic and naturalized Pacific salmon and trout species appear not to be in line with desired mandates, but instead these species are encouraged for the fisheries they provide. An attempt to rectify this discrepancy may be the reason for the push for Atlantic salmon reintroductions. Despite Atlantic salmon being extirpated from Lake Ontario for over 100 years, fisheries managers consider the Atlantic salmon to be a native species and thus believe that its successful reintroduction will not only provide fishing opportunities, but will also be in line with biodiversity and restoration policies for Lake Ontario.

2.2.2 Atlantic salmon in Lake Ontario

The 19th and 20th centuries brought many changes to Atlantic salmon populations and stocking efforts (Table 2-2). During the 1800s, Atlantic salmon were abundant in Lake Ontario and were a very important resource to native people and early European settlers. Stories, journals and pictures describe the abundance of Lake Ontario Atlantic salmon prior to European settlement. The personal diary of Lady Simcoe, the wife of the first Lieutenant Governor of Upper Canada (1791-96), explains how bountiful the Atlantic salmon were in Lake Ontario, as these fish used to be caught and sold by the barrel (Simcoe and Robertson, 1911). Overfishing and habitat degradation (e.g., mills physically blocking areas for spawning), caused Atlantic salmon populations to decline rapidly and were extirpated from Lake Ontario in the late 1800s (Parrish *et al.*, 1998). Individuals and government agencies tried re-stocking them to replace the lost population, but failed repeatedly throughout the 1900's due to poor habitat conditions and predation (Kerr, 2006).

The MNR in Ontario began a small scale effort in 1987 to research stocking methods, genetic strains and habitat viability in several Lake Ontario tributaries and continued this research with subsequent stocking initiatives (Daniels, 2003). The first effort hoped to establish a self-sustaining population in at least one tributary on the Canadian side of Lake Ontario, and to provide a sport fishery based on stocking and a naturally reproducing population. This push resulted in lower returns than expected, but MNR decided to invest even more and began a concerted, large scale, formal Recovery Strategy in 1995 that stocked 150-200 thousand fry per year over 8 years. Promising results from this project convinced several researchers involved to push for a full scale recovery of the Atlantic salmon, and thus the current ASRP or "Bring Back the

Table 2-2: Timeline of Atlantic salmon populations and stocking efforts in Lake Ontario (Daniels, 2003; Kerr, 2006)

Time Period	**Major Player**	**Effort/Result**
Prior to European colonization		Abundant salmon
1800-1850		Large decline in populations from habitat degradation and over fishing
1866	Samuel Wilmot	First stocking initiative/ultimately unsuccessful
1890		Atlantic salmon extirpated
1940's	Department of Lands and Forests (now MNR)	Five year program. Unsuccessful establishment due to predation and high stream temperatures
Through 1964	Various	Sporadic, unsuccessful stocking attempts
Mid 1980's	New York State Department of Environment Conservation	Modest program establishes small recreational fishery on the American side of Lake Ontario, but not self sustaining population
1987	MNR	Small scale research efforts results in low returns
1995	MNR	Large scale, formal Recovery Strategy to research factors important to establishing self sustaining population
2006	MNR, OFAH and others	Launch of Atlantic Salmon Reintroduction Program for Lake Ontario

Salmon" campaign was born.

The ASRP has been envisioned by various governing bodies for over a century, but not until very recently were the data, funding, and will amassed to be able to see a program of this magnitude through. Data collected from the formal Recovery Strategy in the mid-1990s included survival rates of eggs and juveniles, rearing success, and habitat selection and adult behaviour. Survival rates were found to be adequate, though results showed heavy competition between Pacific salmonids and Atlantic salmon. Nonetheless, managers concluded that a large scale effort could be successful in establishing a self sustaining population (Stanfield and Jones, 2003; Johnson and Wedge, 1999; Daniels, 2003). In 2005, Trout Unlimited Canada made a presentation to the OFAH advocating for a concerted reintroduction effort (Smitka and Imhof, 2005). Though the desire and drive was present, neither organization could fund such a venture alone. OFAH, along with MNR, found funding though the Liquor Control Board of Ontario's (LCBO) Natural Heritage Fund in conjunction with Banrock Station Wines, an Australian winery committed to multiple reintroduction projects worldwide (Banrock, 2006). The LCBO funds several conservation projects in Ontario and they have teamed up with Banrock to promote the program. LCBO patrons are able to contribute to the program through their purchase of Banrock wines. Further funding came from the Canada-Ontario Agreement Respecting the Great Lakes Basin (Environment Canada, 2007), and as the program commenced, more organizations and companies were brought together as contributors to increase the funding. The OFAH, MNR, Trout Unlimited Canada, and many others have donated funds and services in kind to the program (OFAH, 2006). The ASRP now has over thirty organizations as partners, supporters or friends and has been stocking fry (newly hatched), fingerlings

(approximately 6 months old) and yearlings (at least one year old) into three tributaries of Lake Ontario since 2006 (Table 2-3) (OFAH, 2008). The explicit goal of the program, with all of its member organizations is to achieve a self sustaining population of Atlantic salmon in Lake Ontario and its tributaries in 10-15 years.

The ASRP's website clearly describes the four broad components of the program (see www.bringbackthesalmon.com). The first, fish production, includes strain and stock evaluation to determine best possible genetic broodstock as well as a plan to explore alternate ways to increase fry and yearling production. The second, habitat restoration, includes water quality protection and the identification of critical habitat and any limiting factors for Atlantic salmon development. Critical habitat, that which is vital to spawning and development, includes physical and biological environments and fish community interactions. Because so much land in the watershed is privately owned, a stewardship program has been developed to engage local landowners. Habitat projects include tree planting, bank stabilization, debris management, wetland protection, cattle fencing and dam mitigation. The third, monitoring and assessment, allows flexibility in the design of the program. This part of the program will continue to evaluate survival and reproductive success of various life stages as part of the feedback necessary for appropriate management. The fourth, outreach and education, includes a classroom hatchery where young students have an opportunity to raise Atlantic salmon and release them into the river. Students also learn the history of Atlantic salmon and of the biodiversity of Lake Ontario. An opportunity to "adopt an Atlantic" allows the public to make a monetary donation that helps to support broodstock. Anglers are also being taught to identify Atlantic salmon and report sightings.

Table 2-3: Organizations involved in the ASRP as listed on the “Bring Back the Salmon” website (www.bringbackthesalmon.ca).

Sponsors:
Banrock Station Wines
LCBO Natural Heritage Fund
Ontario Federation of Anglers & Hunters

Partners:
Canadian Sportfishing Industry Association
Fishing Forever Foundation
Friends of the Greenbelt Foundation
Ontario Ministry of Natural Resources
Sir Sandford Fleming College

Contributing Partners:
Belfountain Hatchery
Conservation Halton
Credit Valley Conservation (CVC)
Ganaraska Region Conservation Authority
Let's Talk Science
Metro East Anglers
Ontario Streams
South-Central Ontario Big Game Association
Toronto and Region Conservation Authority
Trout Unlimited Canada - Greg Clark Chapter
Trout Unlimited Canada - Ted Knott Chapter

Supporters:
Canadian Wildlife Federation
Ontario Wildlife Foundation
Trees Ontario Foundation
WFN: World Fishing Network

Contributing Supporters:
Green Side Up Environmental Services
Human Resources and Social Development Canada
Islington Sportsman's Club
Ontario Federation of Anglers and Hunters - Zone G
Ontario Federation of Anglers and Hunters - Zone H
Ontario Federation of Anglers and Hunters - Zone J
Ontario Trillium Foundation
Quinte Wildlife Conservation Dinner

Friends of the Program:
Atlantic Salmon Federation
Belfountain Inn
Cobourg Creek Golf Course
J. J. Stewart Motors
Scotty Plastics Ltd.
Terra Cotta Inn

There is no doubt that those deeply involved in the ASRP believe in its ability to restore this species to Lake Ontario, as evident in the main goal of the program. The practice of restoration may be imperfect as many facets are still to be determined through further examination and research. Whether the decision to route time and funds to the reintroduction of Atlantic salmon to Lake Ontario was the best decision for this ecosystem is debatable. This thesis aims not to quantify the benefit or detriment Lake Ontario has incurred as a result of this program. Rather, the thesis will give insight into the interpretation of biodiversity mandates, environmental management practices and how the goals and values of the ASRP conform to the restoration process. The ASRP is an example of how a project can be initiated in the name of restoration yet fail to address many of the required elements necessary for a well planned restoration project that has the potential to be successful. An examination of the program, through interviews and current literature will help to clarify how this project fits into, and at times disregards, current restoration theory and practice.

3 Research Methodology

3.1 Overview

The purpose of this study is to evaluate the restoration initiative to reintroduce extirpated Atlantic salmon to Lake Ontario and its tributaries. A literature review and interviews with program partners were used to assess the overall feasibility of the restoration program and to determine how well it adheres to current restoration guidelines. Information regarding the ASRP was obtained through a qualitative research design characterized by in-depth, open ended personal interviews. A qualitative research methodology such as this is especially appropriate when exploring complex, dynamic phenomena like the ASRP (Marshall and Rossman 1998). An inductive research approach was adopted to preserve the detail and richness of study participants' perspectives while allowing for unanticipated responses (Davenport *et al.*, 2007). An inductive research design is characterized by gathering information and asking open ended questions so as to analyze the data looking for broad themes and patterns in the hopes of posing generalizations (Cresswell, 2008). These generalizations were used to develop themes in which to discuss the adherence of the ASRP to current restoration guidelines. This research focuses on a single case study, the reintroduction of Atlantic salmon to Lake Ontario tributaries, but the findings may help to illuminate restoration projects elsewhere.

3.2 Interviews

3.2.1 Participants

In an exploratory study such as this, it is common to focus on a particular subset of individuals directly involved in the particular item being studied (Berg 2004). In this case they were representatives of major partners in the program, as indicated by the program website (www.bringbackthesalmon.com). An attempt was made to contact partner organizations and sponsors via email during winter 2009. Sponsors and partners were chosen for interviews because of their increased commitment to, and status of these organizations within, the ASRP suggested they had participated in the decision making processes. The original program partners are listed as OFAH, MNR, the Canadian Sportfishing Industry Association, Trout Unlimited Canada, Sir Sandford Fleming College, and Trees Ontario (OFAH, 2006). As Trout Unlimited Canada (TUC) presented the original project and the ASRP is founded by the OFAH in conjunction with MNR, with Conservation Authorities overseeing a lot of the groundwork, representatives from these four organizations were also interviewed. Several other sponsors were contacted to verify contributions to the program, but did not respond. Where individual names could be obtained from ASRP documents, emails were sent directly to these individuals. If the individual was not able to be identified, emails were sent to the appropriate department or branch of each organization with a request to forward the email to the representative that would be able to best answer questions regarding the ASRP.

These emails contained an introductory letter that detailed the information to be discussed in a future interview and were written according to the guidelines set forth by

the Office of Research Ethics at the University of Waterloo. Seven partner organizations were not contacted in this initial email, as isolating the contact information and contribution to the ASRP was extremely difficult. These organizations were to be contacted once information could be garnered from snowball sampling in the first round of interviews, though no respondents indicated these organizations as decision makers for the ASRP. As major funders, LCBO and Banrock Station Winery were also contacted, but a brief discussion determined they had little to do with the choice of project, simply acting as donors rather than decision makers, so interviews were not necessary. After concluding the interviews, all participants volunteered other potential study participants who were also involved in the ASRP. One individual was recommended by two of the interview participants, and thus was contacted as well. Each of the suggested individuals had already been contacted for an interview, suggesting that all the key informants had been identified. In total, 8 interviews were conducted with individuals from OFAH, MNR, TUC and conservation authorities.

Participants were chosen based on their involvement in the program and their ability to answer questions that pertained to the ASRP and restoration initiatives in general. The sample of key informants was intended to provide a rich description of how ecological restoration is understood by managers (Miles and Huberman 1994). Though participants were asked to respond as representatives from their organization, personal thoughts and biases were a factor in their responses. Not all listed partners were interviewed, and individuals from branches of organizations not directly involved in the ASRP but who had worked on previous studies and initiatives that informed ASRP were also not part of this study. These individuals may have been able to provide a historic perspective of reintroductions in Lake Ontario and give insight as to why the

Atlantic salmon have been touted as so beneficial to the Lake. Anglers and communities that are affected by the ASRP were not consulted either, despite their potential influence on fisheries management decisions. Their knowledge of restoration theory and policy decisions was considered limited, and the public was not specifically involved in the design of the ASRP. Interestingly, many of the people interviewed were also anglers, which may have affected their responses and their involvement in the program.

3.2.2 Interview content

According to Babbie (2008), qualitative interviews include a general plan of inquiry, including topics to be covered, but not a set of questions that have to be asked in a particular order or using particular words. The interviews in this study contained twenty questions organized into four general topics: information about the respondent's organization, the Lake Ontario ecosystem, restoration practice, and restoration theory (see Appendix 1 for the list of questions). Interviews were approximately an hour in length and questions were used as a rough guide for the interview. All questions received an answer, albeit in no particular order. Respondents were not provided with interview questions prior to the interview, though general areas of discussion were indicated in the introductory email. Respondents were given the option of choosing the time of the interview so as to best fit their schedule thereby ensuring as relaxed an atmosphere as possible.

Five interviews were conducted in person and three were over the phone. Either method was given to the participants to accommodate their schedules and preference, though the researcher was willing to travel to meet them where necessary. Shuy (2001) discusses telephone versus in-person interviews and though both have their own

advantages and disadvantages, it was determined for this study that using both could be appropriate. In-person interviews offer a contextual naturalness which aids in more accurate responses and are said to provide slightly better quality data than over the phone. The researcher allowed the respondent to speak for as long as they wanted about whichever issues they felt were most important so the respondent could feel as comfortable as possible when answering questions. This also made the interview more of a conversation and less of a series of questions and answers. Lavrakas (1993) notes that complex issues are better dealt with in-person, as lengthy phone conversations can be tiresome. This could not be avoided in the phone interviews, as the complexity of the interview required approximately an hour to answer. Respondents were informed of this in advance and all were willing to remain on the phone until all questions had been answered. Phone interviews, on average, were no shorter in length than in person interviews.

Interviews were recorded with a digital voice recorder, and in the case of phone interviews, a speaker phone was also used. All questions and procedure received full clearance from the University of Waterloo Office of Research Ethics. Interviews were transcribed for qualitative analysis, so that specific answers to questions could be identified within the conversation. Quotes presented in the following chapter were modified for clarity only, and no meaning was changed. Responses were not coded or reduced to specific words or categories, rather responses to each question were used to illustrate the opinions of organizational representatives. As there were only a small number of key informants, a formal quantitative analysis was not appropriate. Instead, responses presented in the following chapter are used only as an illustration of the feelings and attitudes that organizational representatives of the ASRP have toward

restoration and the reintroduction program itself. This kind of analysis comes at a cost to specificity and reliability, but was more appropriate given the flexible structure of interviews with respondents free to share their own perspectives.

4 Results and Discussion

4.1 Issues with the ASRP

Some of the broader practical and philosophical issues with restoration were introduced in the literature review, and these issues were examined in the context of the ASRP. This evaluation can test our understanding of restoration and how its theory is interpreted and brought into practice. Those involved in the ASRP are ultimately concerned with the success of the project - would the salmon begin to naturally reproduce in the waters and become a viable species? Yet a closer inspection reveals specific issues related to (1) the biological interactions of these fish with their surroundings; (2) the history of the ecosystem; (3) the influence of humans on the restoration process; (4) the value laden aspect of the process; and (5) the lack of a "systems" approach. The ASRP is an ambitious, multifaceted endeavor that offers restoration ecologists an opportunity to explore their field and better their practices. By examining the program using these themes, the ASRP's adherence to general restoration guidelines can be determined.

4.1.1 Biological interactions of introduced salmon and the current ecosystem

The first question to answer is whether the establishment of Atlantic salmon in the current Lake Ontario watershed is feasible. It is important to ground this restoration practice in ecological theory and to address both its natural and human dimensions (Halle, 2007). Practitioners must thoroughly understand the ecology of a site before attempting to manipulate it and must focus on the biology of all aquatic species as well as those that exist at the terrestrial edge of all water bodies.

Species interactions are especially important both among the same species (intraspecific) and between different species (interspecific) and these interactions should be evaluated in terms of food web dynamics, which take into account resource use at various stages of development, as well as nutrient availability and competition for resources. MNR and external researchers in this reintroduction program have purposely focused on interspecific competition, as top predators with very similar niches compete for habitat and food (Stanfield and Jones, 2003 ; Scott *et al.*, 2003, Daniels, 2003). Two theories for interspecific competition include the "competitive exclusion principle," which states that two species with identical resource requirements will eventually lead to the exclusion of one species (Pianka, 1981) and "interactive segregation," which asserts that two species in sympatry will reduce competitive interactions by segregating into habitats they are most suited to exploit (Nilsson, 1967). These theories may help to predict the species interactions between naturalized, exotic and reintroduced salmonids in Lake Ontario.

Anglers and fisheries managers desire that Lake Ontario offer good recreational fishing, and this is currently provided by exotics, naturalized and reintroduced species. What should be examined are the specific interactions that occur between these species as they are forced to live sympatrically in Lake Ontario waters. Several studies, as discussed by Johnson and Wedge (1999), have concluded that where suitable accessible stream habitat for Atlantic salmon occurs, it is likely that it is being used by other exotic and naturalized salmonids. Interspecific competition was found between Rainbow trout (steelhead) and Atlantic salmon juveniles, with trout displaying increased aggressiveness and dominating the salmon, though Atlantic salmon may outcompete in riffle habitats (Gibson 1981). Scott *et al.* (2003) examined interaction between Chinook

salmon and Atlantic salmon in a Lake Ontario tributary and found that the presence of Chinook salmon caused an increase in Atlantic salmon male agonistic behaviour and depressed survival of Atlantic salmon males and females. This was likely due to increased activity of Atlantic salmon. Greater energy expenditure put these salmon at a disadvantage when competing with Pacific salmons. This study also showed the presence of Chinook salmon caused a delay in Atlantic salmon spawning, exacerbating the effect of increased mortality.

Despite small successes, such as reduced competition in larger tributaries and in limited winter habitat, it has been reported that Atlantic salmon likely do better without any competition from Rainbow trout or Pacific salmons (Stanfield and Jones, 1993). Interestingly, most studies of competitive interaction have not involved hatchery-reared salmon, and may not be able to predict how the hatchery stock of reintroduced salmon will perform in these circumstances (Johnson and Wedge, 1999). Also, few studies have predicted what impacts reintroduced Atlantic salmon will have on existing salmonid populations, as opposed to the effects existing salmonids will have on newly introduced Atlantic salmon (Johnson and Wedge, 1999).

Interview participants were asked about the interactions between the Atlantic salmon and other salmonids already in the rivers, as well as the perceived fate of the Pacific salmonids if Atlantic salmon reintroduction is successful. The MNR and other organizations intervene to make sure certain species remain in particular areas of rivers in order to maximize the health and numbers of each species. However, full scale reintroduction would likely mean that Atlantic salmon have access to their full biological range in every tributary, where competition is inevitable. Interview responses indicated that the current partitioning of rivers prevents newly introduced Atlantic salmon from

having to directly compete with other salmonids. This leads to artificial fisheries, meaning there are large sport fish in the rivers and anglers can catch these fish, but they only exist in these numbers because they are not likely to spawn, develop and compete as they would if they were not stocked. This partitioning gives Atlantic salmon a better chance of survival, as it reduces their competition. Though there may be some areas where species would not naturally interact, dams and human intervention will prevent any other interactions that might occur. As stated by one respondent:

> I don't think that [Atlantic salmon] have the same temperature regime as some other species, so there may be some areas where they do deviate and they don't have competition in the lake. The way the Credit [River] is managed, the Atlantic [salmons] get lifted over the dam at Streestville, and they don't have to worry about Chinook [salmon] anymore after that. [Atlantic salmon are also] allowed further upstream than Rainbow [trout].

Another respondent did not believe that river partitioning would be effective, but was hopeful that Atlantic salmon could successfully compete, though likely only particularly high quality habitats, even if these areas are not easily identified. For example, a respondent stated:

> At this stage in the restoration they're trying to stock Atlantic salmon in areas that you can partition other species away from. As far as the long term, realistically if we want Atlantic salmon to succeed they have to be able to compete with these other species. There is no way we could effectively partition Atlantic

> salmon away from these other species on every tributary. Some literature shows that in areas with highest ecological integrity, there is enough habitat heterogeneity that you can have these species occurring together with minimal competition. So do we just ensure that we just protect the highest quality habitats where possible to a point where we can have everybody living together in some sort of stable state – whatever that may be?

Another concern addressed by a respondent involved what would happen to native fish upstream if Atlantic salmon were allowed to proliferate throughout the tributaries and Lake. The respondent believed the focus should be in protecting the native species that still exist within certain upstream areas of the rivers.

> I suspect that Atlantic salmon will never be sufficiently prolific to threaten Pacific salmon, but I could be wrong. If they are so successful, no one would miss the Pacific [salmon] if we could get Atlantic [salmon] in the same quantities. I think Atlantic [salmon] are a superior fish from an angling point of view. I'm much more concerned that if in order to get Atlantic [salmon] up the river, you end up opening it to Rainbow [trout], and I know that the Rainbow [trout] will thrive and be very successful and they will destroy the fishing in the Credit [river] up to that point.

Compounding issues related to species competition is also the concern about thiamine deficiency in Atlantic salmon from a diet composed mainly of introduced alewife and smelt. Both of these non-native prey fish contain thiaminase, an enzyme

that breaks down the B vitamin, thiamine, in salmonids resulting in neurological, developmental and reproductive problems as well as Early Mortality Syndrome (EMS) (Fisher *et al.* 1996, Brown *et al.*, 2005). EMS affects recovering Lake trout populations as well, and is a complicated issue that still needs to be resolved, even after decades of reintroductions (Honeyfield *et al.*, 2009). So long as the majority of prey species for Lake Ontario predators contain thiaminase, salmonid development in the Lake will be hindered.

The fate of the Atlantic salmon, Pacific salmonids and indeed the entire fish assemblage of Lake Ontario is still very much undetermined and those involved in the ASRP do not have clear answers for future management strategies. While recent research and established literature are not promising for the establishment of Atlantic salmon, proponents of the ASRP were willing to take a chance at fulfilling the mandate to restore historic species to Lake Ontario. Overall, some respondents appeared skeptical of the feasibility of the program and the measures being taken to establish an Atlantic salmon population. Several biological issues with establishing Atlantic salmon in Lake Ontario have yet to be fully resolved, though there are many other issues surrounding this restoration initiative that need to be addressed as well.

4.1.2 Historical systems: focusing on the past

The extensive amount of change that has occurred within the Lake Ontario watershed reminds us that we are not starting, and cannot start, "from scratch" (Halle, 2007). Burke and Mitchell (2007) agree that too little research has explored the ways that restoration impacts upon or adds to the extant ecological processes operating within a proposed restoration site. These systems, however degraded, changed or even

improved, need to be analyzed based on their current conditions, with the species and functions that are already there. This is not to say that history is not important. In fact, it can help convince people to modify behavior and limit destruction of habitats and resources (Steedman, 1996). History also plays an important role in teaching us how ecosystems have changed and adapted over the years. For example, the study of paleolimnology seeks to uncover the historical environments of freshwater and identify major events of climate change and human impact, and can even help to answer questions about current environmental conditions (Paterson *et al.*, 2004). These kinds of records help us to determine historical perspective as we try to restore a landscape.

History can be subjective, and is able to be interpreted numerous ways, making our knowledge of the past incomplete. Many attempting to carry out restoration projects often avoid engaging with cultural choices as they try to restore ecosystems to pre-European conditions, while dismissing the profound impacts that Natives had (Denevan, 1992). Some suggest that species reintroduction only "makes sense if the time between extirpation and reintroduction is short enough that neither ecosystem nor species has evolved that much", which is clearly open to interpretation (Rubenstein *et al.*, 2006, p. 236). Concepts of history and the information gleaned from historical studies have the potential to be misconstrued, especially by those not specifically in that field. This makes it imprudent to try and achieve a former state when attempting to improve ecosystem function and integrity. Egan and Howell (2001, p. 1) believed that "a fundamental aspect of ecosystem restoration is learning how to rediscover the past and bring it forward into the present". This kind of thinking roots restoration projects too much in the past and does not provide successful restoration trajectories. By focusing

on the specific history of Lake Ontario in an attempt to recreate what once was, the potential for improvement of the watershed though restoration is limited.

Knowledge of the past Lake Ontario ecosystem is essential for managing it into the future. Solid baseline data allows restoration ecologists to see what they are starting with and allows them to make informed decisions about the course of action. The end goal of recreating a system that once existed is problematic for the many reasons discussed in chapter 2. Yet, instead of using baseline data to aid in understanding the history of the system and illustrate where Lake Ontario has come from, this program is using the baseline data as a map for how to recreate what once was. Crifasi (2005, p. 627) states that "baselines create arbitrary boundaries across otherwise continuous human action on landscapes", acknowledging the profound impact humans have had, and continue to have, on ecosystems.

Interviewees were asked about the purpose of restoration, and though some differentiated between restoring physical landscapes and species reintroductions, the overall consensus appeared to be in line with an attempt to return the current ecosystem to a former healthy state versus a restoration plan that focuses on the future.

The objective of the program was unanimously agreed to be establishing a self sufficient population of Atlantic salmon to Lake Ontario. Despite having been extirpated from Lake Ontario for over 100 years, fisheries managers consider the Atlantic salmon to be a native species and thus believe that its successful reintroduction will not only provide fishing opportunities, but will also be in line with biodiversity and restoration strategies they have for Lake Ontario. Almost all respondents felt that Atlantic salmon were native to Lake Ontario, though one respondent did not believe this

was the case. The respondent indicated that the system had changed too much to be viable for the original strain (non-existent) of Atlantic salmon:

> I believe that Atlantic salmon used to be native to Lake Ontario, but that the ones being introduced now are in no way native, but I'm not sure that makes a bit of difference. If we were to somehow get back those exact fish and put them into the river now, they would die pretty quickly.

Atlantic salmon were native and abundant centuries ago, but that (non-existent) strain of fish would no longer be able to survive in the Lake as it is today. Instead, the Atlantic salmon being introduced are being taken from other systems, which in no way makes them native to Lake Ontario.

Finally, respondents were asked about the importance of Atlantic salmon being in Lake Ontario. Responses indicated either ecological importance in rebuilding a healthy ecosystem, or nostalgic importance that can draw attention to the Lake and its tributaries in hopes of garnering support for building and maintaining a healthy ecosystem in other ways.

> If the Atlantic salmon were to be restored as they historically were, it will have a phenomenal impact. I think the potential upside in terms of elevating the profile of the river will be just tremendous…If millions of dollars have been spent restoring Atlantic salmon to the river then when somebody comes along and

> [wants to develop or negatively impact the river] we now have leverage [to make them use the best technology and practices available].

This respondent believes that if the reintroduction is successful, then the investment will have paid off and proponents of the rivers and Lake will be in a better position to advocate for each of the rivers. Conversely, another respondent felt that the addition of Atlantic salmon would play an ecological role in controlling prey populations, though the respondent acknowledged that Pacific salmonids would likely remain the most dominant predators in the system. This respondent also mentioned the symbolic nature of the Atlantic salmon representing the ecosystem.

> [Atlantic salmon] will be another top predator in the ecosystem. Unless there are changes in the way Lake Ontario is managed they probably won't be the most dominant top predator, but they will be in the ecosystem. They will play a role controlling the alewives and smelt because in the past, the reason that Pacific salmons were introduced was because of the overabundance of alewive and smelt [and lack of predation]. I think they'll fit themselves in, and we still have to see how they do because we aren't quite sure of their historic prey base, we have ideas from what they do on the East coast and we can guess based on what was here…but how just they fit we can't really predict until we have enough of them here… I [also] think their value will be as a symbol for that ecosystem.

These responses illustrate different approaches to the reintroduction. The ASRP can serve as publicity for the Lake, allowing funding to be rooted to protection and

conservation, or the Atlantic salmon are regarded as a solution for restoring the Lake, as a recreation of the former ecosystem.

4.1.3 Human influence: people as a part of the ecosystem

Of all components in an ecosystem, humans have the most influence, and though this can be a positive influence, within most ecosystems humans are considered the most destructive force. Though this makes us unlike any other part of the system, it does not make us separate from it. In order to gain understanding and appreciation for the ecosystem and to help warrant proper protection of it, humans must be viewed as an integral part of the ecosystem in which they exist. Restoration ecologists are required to engage with the environment and the people in order for the restoration to be deemed successful (Allison, 2007). This may mean humans are being "restored" as well. By involving surrounding communities as much as possible and increasing their understanding of their environment, the human-nature relationship can be improved. By ignoring how we live and even *that* we live in this ecosystem, all restoration efforts are being undermined.

The reintroduction of Atlantic salmon to Lake Ontario will impact recreational angling, a popular pastime for many in Southern Ontario that creates significant revenue for the province (Stewert and Schaner, 2002). In order to maintain this fishery, the Ontario government and affiliated groups stock millions of fish, and as indicated in a previous chapter, many of these are Pacific salmonids and are considered non-native to the Lake Ontario ecosystem. No document explicitly states that Pacific salmonids stocking will cease if Atlantic salmon reintroduction is successful, despite the stated goals of various organizations that encourage the reintroductions of so-called native

species. When asked about the impact of Atlantic salmon almost all respondents indicated that the political pressure of anglers would prevent the termination of Pacific salmonid stocking. For example:

> The biggest pressure is actually going to be from the anglers. They are not going to want to see their spring Rainbow [trout] disappear or their charter boat operations disappear. That's going to be a tough call at the end of the day…if we reduce or eliminate stocking of those fish.

Much of the million dollar recreational fishing industry relies on these stocked fish. Charter boat operations focus on Pacific salmonids in the open water of Lake Ontario and fishing derbies, daily rentals of boats and the purchase of fishing gear contribute to this highly profitable industry. Without these stocked salmonids, not only would fewer people be partaking in this pastime, but there would be loss of employment in this sector. Another respondent indicated that the cessation of stocking would not be a good move politically, as anglers expect good fishing opportunities which are easily maintained with adequate stocking.

> If a successful Atlantic salmon fishery means that we now withdraw from stocking Chinook [salmon] and Coho [salmon], this will be the next political and ecological dilemma. Anglers won't give those up. Anglers expect to catch numbers [of fish] most of the time, and the only way to do that is to artificially create that, and they have no problem with that – just stock more.

Another respondent agreed that the public, and perhaps more specifically the anglers, will have a say in how these stocking procedures are managed. The respondent noted that, perhaps, if the ASRP is successful, the stakeholders will be more accepting of angling for these fish as well, and will not mind if fewer Pacific salmonids are stocked.

> Largely the fate of Chinook [salmon] and Rainbow [trout] will be in the hands of people. They are largely sustained by stocking, there is natural reproduction, that could sustain them, but they are still being stocked. So down the road there could be that conversation amongst the stakeholders… [F]uture fish community objectives [could look at], if we have Atlantic salmon back, do we want to change the species mix and that will be a big discussion that goes back to science versus stakeholders.

Though the program is seeing some returns of adult Atlantic salmon to the tributaries (as evidence that they are surviving in the watershed), the fish are being stocked as fry, fingerlings, and yearlings, which many feel does not adequately represent the challenges that the species will have once stocking has ceased and they are left to spawn, hatch and develop on their own. These "artificial" progeny are why some refer to fish stocking as a "halfway technology", meaning that hatcheries address the symptoms, but not the cause of fish decline and they cannot be considered a long-term solution. If a recovery plan is designed to rely solely on hatcheries, it will likely fail (Meffe, 1995). The ASRP is planned as a 10-15 year program, indicating it will not supplement Atlantic salmon populations through hatcheries forever. Every interviewee agreed that continual stocking is not ideal, though each of them addressed their personal reasons for allowing

stocking of fish species in varying circumstances. These range from completely artificial pond stocking to a short-term mechanism for restoring fish populations that have been degraded or extirpated and for providing a recreational fishery. There is a large focus on angling, because of its importance as a pastime, for the exposure Lake Ontario can receive as a result of this campaign, and for the revenue that recreational fishing generates. Responses to questions about stocking show there is a clear desire to end hatchery-supported fish communities, but they also acknowledge the difficulty, and perhaps reluctance, of eliminating the process.

This respondent felt stocking had no place in systems that were not fully enclosed. Though this may represent a more terse opinion, whereas many fisheries management strategies include some stocking, the respondent averred that stocked populations would be unsustainable.

> I think any sport fishery that constantly requires stocking is not sustainable and therefore in the long run is destroying the habitat and the resource. If you're going to stock animals, you should stock them in ponds and fish them out of the pond. If you're talking about stocking as a mechanism for restoring a self-sustaining population, I think that's a great idea – but if you're talking about a put and take, [whether for anglers or predators], I don't think that's sensible in the long run.

Another believed there is a time and a place for stocking, though cautioned about repercussions in the future. The respondent alluded to the original decision to stock Pacific salmonids in Lake Ontario, noting that these populations are not sustained

without consistent stocking and any future population of Atlantic salmon may need to be sustained the same way.

> If we can't have a natural system, [I understand] stocking, but the line needs to be drawn somewhere. If the Atlantic salmon program doesn't work in terms of being self sustaining, do we continue to try to stock it and I think if that happens, we've just worsened an existing problem in the sense that we've given something to somebody that they now like, but we can't sustain it, just like the Chinook [salmon] and [Rainbow trout].

Though concerns exist, one respondent noted that the stocking of Pacific salmonids resulted in some physical restoration of Lake Ontario and its tributaries as well as heightened public support for the resource. If stocked fish, despite being of non native origins, were so beneficial to the Lake, this respondent did not feel they should be regarded so negatively.

> There are concerns, [though not everyone] shares them, because Chinook [salmon] do provide a big socioeconomic impact and a lot of the work restoring the streams really began when these other sport fish were realized as something that we could have. The native species were gone, this is working, people were interested and began to do the stream work, and this led to Atlantic salmon. So [Pacific salmonids] aren't really the villains they are portrayed to be. They were there when nothing else was, and in Ontario it's probably 100 million dollars a year on that open water

fishery and even more in the States. That's providing jobs [and] providing resources to MNR to do work on Lake Ontario.

Several respondents brought up their concerns about how persistent stocking is severely detrimental to the ecosystem. By creating these artificial fisheries, the overall health of the ecosystem is disregarded in favor of maintaining sufficient numbers of fish for angling purposes. Even a severely degraded river system may be able to support salmon and trout runs if these fish are continually placed in the river at various life stages. Anglers may not fully realize the true state of the river if they can continually fish for full size adult salmon and trout. Despite this, respondents felt Lake Ontario would always be stocking with fish. For example:

Well the concern to me is…the ability of the environment to maintain those large runs…[Anglers are happy to take big fish out of a river that's not necessarily healthy] and that isn't going to go away. [You can argue from] the theoretical vantage point [that this shouldn't be the case], but from a practical or a real world situation, you'll never see a policy statement where it says…theoretically this is what need to do but in reality this is what we are going to do.

Stocking is such an integral part of fisheries management strategies, that even though it may not be the best course of action for the ecosystem, recreational angling is too important to the province to jeopardize runs of large predators. Respondents acknowledged the degraded state of the rivers, but admitted stocking was likely always going to be a part of management strategies.

There are millions more people and their industries surrounding Lake Ontario than there were prior to European colonization. Goals for restoring Lake Ontario must be realistic and include changing environmental conditions as people are not going to go away. Proper education can help to achieve better land and resource use, but restoration attempts should not be made as if humans are not influencing the ecosystem daily. Crifasi (2005 p. 629) cautions that "ignoring the human role neglects the human agency as an ecosystem process", and that if we recognize our role within the ecosystem, we are capable of a "more honest articulation of resource management goals". Any restoration effort must acknowledge all the ways in which humans are integrated into the watershed system if we can hope to set appropriate and realistic restoration trajectories.

The ASRP is explicitly committed to involving students, anglers, and communities in fish rearing and habitat restoration. Though the ASRP has an explicit commitment to involve people in the restoration process, it does not appear to recognize how the surrounding human communities and management decisions are continually affecting the ecosystem that is to be restored as its focus remains on raising a population of a single species. Just as we cannot travel back in time and restore a system to exactly what it used to contain and how it used to function, we cannot ignore that the current system is inundated with humans and that their actions over the past hundred years shaped the current conditions of that system. If we want to improve this system we must acknowledge the influence that the human component has had and continues to have.

4.1.4 Reconciling values

Ultimately, restoration is about choice. Allison (2007, p. 602) believes that "the future of all habitats will depend on human choice, whether our choice is to preserve, restore or continue to develop habitat". How this future unfolds will depend on the values of the individuals and groups who are making these decisions. As stated earlier, the ASRP is built on partnerships among organizations, and though most are directly involved with some aspect of Lake Ontario, they do not all share the same mandate. This can make for conflicting interests. All partners stated that the goal of the program was to establish an Atlantic salmon population in Lake Ontario. Not all partners agreed on why this decision would be beneficial for the Lake or how the process should be carried out. Reconciling the values of various stakeholders or program partners can be an insurmountable task, as each group will bring its own mandate and procedural criteria.

How and when each of the partners became involved varied, and though all believed that this program has the potential to achieve great things for Lake Ontario, there were varying levels of confidence in the success of the program. The program has been developing for many years, but is finally being carried out because there is enough evidence collected and funding established to warrant a large scale trial. So much effort had gone into planning the ASRP, that all that was left was to find enough funding to make it happen. Once the program began, many organizations were willing to take part and become partners. One interviewee indicated that any attention given to the river could provide support for projects beyond the ASRP.

> The story that came to us was that there was an opportunity to put enough money into stocking the river to get enough fish in there to see if they would actually start returning to the river and there was also enough money to do some stream rehabilitation where it was appropriate in order to make that happen and it was a part of a multi-river project so the Credit [river] was not just the one place it was happening. So we said anything that brings positive attention to the river and that provides some money for cold clear water is something that we cannot not support.

Likewise, another interviewee felt the project would support habitat work already occurring along the river. Many had the opinion that the ASRP was going to happen regardless, and that perhaps the program could lend support to their own respective work. Though all responses indicate a real desire to better the Lake Ontario ecosystem, each group involved believes they can further their own cause for the watershed using the ASRP as a vehicle to engage other partners and community groups. Ultimately, it appears the ASRP was chosen because of a nostalgic desire to bring back an extirpated species and because so many resources had been committed to the project for so many years. When asked about the motivation behind the ASRP, one respondent stated the following, noting how accessible the program was, as well as the desire to fix what happened.

> It was chosen because it was there and it was [ready to go]. It has a straight up history appeal, [Atlantic salmon] had great importance to the province…There is a "we broke it, we bought it" consideration. Our ancestors did this, and we don't

> want to attach blame [but] now is a chance to make good. There is also a symbolic perspective of being able to bring this species, a sensitive cold water species back and do something good for the watershed.

Other respondents conceded that the ASRP went ahead because it had been planned for so long, but that the reason for reintroducing this particular species was for recreational purposes, not for improving habitat quality. For example:

> MNR has been experimenting (with research projects) for the last 20 years to gauge whether the tributaries are suitable for reintroducing Atlantic salmon and whether they'd have suitable juvenile Atlantic salmon survival, growth rates and spawning areas. Through that mechanism they determined that the ecological health of our tributaries is suitable for reintroducing Atlantic salmon. Being considered a recreationally important species in other parts of Canada (they felt) it would be viable to pursue this project further.

As for the partners who were engaged after the decision was made to commence the ASRP, none were willing to argue that attention, time and money spent on Lake Ontario tributaries could be detrimental. Though all interviewees believe the end goal of a self sustaining Atlantic salmon population is noble, they also believed it may be better suited as a means to bring attention to the river and allow some of the physical restoration work they are already working on to go ahead even faster. Instead of focusing on just this single fish species and its potential to be a quality sport fish for anglers, several respondents felt that projects involving habitat restoration for a variety

of species would be more prudent. Perhaps skeptical of the process indicated by the ASRP, they believe their own values and potential achievements from their own work would be more beneficial to the ecosystem as a whole.

4.1.5 Complexity

Some question whether a community can return to a predisturbance state by repairing itself or whether historic events might instead lead to alternative stable states for a community (Young, 2001). Years of research have established that ecosystems are complex, nonlinear, and open and that their current conditions are shaped by the past (Anand and Desrochers, 2004). Ecosystems do not achieve "stable states", but rather are dynamic entities where several thresholds exist that, once crossed, means the ecosystem will develop in an entirely new direction. Systems theory suggests that ecosystems are inherently complex and thus our traditional managerial approaches, which are often governed by simple rules, will not suffice when dealing with such a system (Kay and Schneider, 1994). Managers who attempt to carry out restoration are better served if they abandon the idea of "balance" in nature and focus instead on the complex interactions of the entire system. The focus cannot be on only the aquatic organisms, but the people as well, to include society and economy in discussions and decision making. Fisheries management decisions should utilize an ecosystem approach to merge citizens, science and economics in order to provide more complete and holistic solutions to what can be very complex problems. It is easy to take an ecosystem apart, to analyze each individual component, and think that each significant attribute has been identified, but when the attempt is made to put the ecosystem back

together the cumulative effects of these components are revealed and we can start to grasp the complexity of these systems (Dobson *et al.*, 1997).

Restoring Lake Ontario is not as simple as the addition of one particular species, or the replacement of others. Much physical restoration and human behavioural modifications must be undertaken to improve the overall watershed. The physical restoration that the ASRP is conducting includes removal of online ponds and dams and improvements to Atlantic salmon habitat. Though beneficial to the tributaries, these specific actions will most immediately aid in fish passage for introduced Atlantic salmon. The main focus of the ASRP remains establishing an Atlantic salmon population.

Recent literature states that ecological restoration must focus on function, not species recomposition. Halle (2007) believes it is "necessary to identify the system in depth, because what is left with respect to species composition, trophic interactions, and ecosystem functions are the basis from which any transitional process to a more desirable state has to develop". Armstrong and Seddon (2008, p.23) caution that "the primary goal of translocations should be to restore ecosystem function rather than species composition." They suggest that justification for reintroducing species should be to restore the functional role of extinct species rather than recover the species themselves.

Interviewees were asked to comment on the importance of focusing restoration projects on ecosystem function as opposed to composition. The goal of the ASRP is to reintroduce Atlantic salmon as a heritage species, but it is uncertain if this is to benefit the function of Lake Ontario, or to provide an additional sport fish to Lake Ontario. From the interview responses, it is evident that this concept of function over

composition is *theoretically* embraced, but many felt that current management strategies make developing and maintaining ecosystem function come second. The main focus of the ASRP is the Atlantic salmon, thus the process of restoration revolves around creation of habitat suitable for this species. Affiliate partners expressed their concern with this kind of localized rehabilitation, and continually strive to foster a more holistic approach that recognizes the complexities of the entire system. As one respondent stated:

> Ecosystem function is something we are focusing on. Some of the partners are still focusing on projects that are Atlantic salmon specific, putting a lot of time and effort into in-stream structures to benefit a certain life stage of Atlantic salmon over a really short length of stream. We generally don't do this; we don't feel it's the best bang for your buck on habitat projects. For us, through a lot of our management planning a lot of lip service is paid to an ecosystem approach and not putting a lot of resources into certain species and looking at fish communities as our restoration target, but in reality this may not be occurring as much as we'd like it to be. It's something we're really trying to push in an approach for restoration, ensuring that the restoration enhances the natural fish assemblages and other aquatic communities as well as trying to promote the evolutionary histories of the species within each tributary. With the physical habitat we try to put less emphasis on creating or maintaining certain habitat types within a fixed location, but trying to recreate the processes that maintain those habitats, and trying to push that management paradigm to our partners.

Much of the difficulty of restoration projects is maintaining focus on ecosystem function and acknowledging the dynamic nature of these systems as opposed to focusing on structure or specific individual species. The ASRP claims to be dealing with this obstacle though their monitoring and assessment component by obtaining research and employing adaptive management. Ascough (2008, p. 218) describes adaptive management as a management style that "incorporates initial uncertainty, treats decisions as hypotheses to be tested, and demands that managers learn from the consequences of their decisions and alter their decisions (or implement new decisions) accordingly". A respondent describes the ASRP adaptive management as follows:

> When we talk about a body of water like Lake Ontario and all that's around it, it's hard to figure out what the ecosystem is like now, much less try to predict what it will become, so we're moving toward adaptive management for the lake and watershed, but by the time you collect the data and enough of a trend, everything could've changed on you, so we have to work on these bigger frameworks so we have goals and objectives and strategies to work with what we know at the time but we have to be prepared to change things as things get changed on us.

These management issues are most apparent in how Lake Ontario fisheries are regulated. As stated earlier, the MNR believes that managing for viable trout and salmon fisheries is incompatible with managing for native fishes. Dealing with this discrepancy puts maintaining recreation fisheries and upholding strategies that mandate for native fish communities in opposition. Perhaps the ASRP has the ability to

provide both, and is thus desired as a restoration initiative for Lake Ontario. If the majority of managers and ecologists consider Atlantic salmon to be a native species, and anglers consider them good sport fish, then they may be able to fulfill both mandates.

Respondents were asked about the "fundamental dilemma" faced by fisheries managers and whether stakeholder desires and ecological trends were becoming more or less aligned. Respondents were also asked to comment on how they felt this situation affected management decisions and strategies.

One respondent simply confirmed MNR's official stance, stating that:

> If we try to manage this for a natural system, that's in conflict with a [desired] Rainbow trout and Chinook salmon fishery.

Another respondent offered a more realistic approach. If we continue to adhere to the belief that historical systems should prevail, we will fall short. Instead, we should accept the changed ecosystem even if we consider these "new species" somewhat artificial:

> There is what we call "native" and there's what we want when it comes to a salmon or trout fishery, but maybe the reality is somewhere in between, in the sense that we might not be able to have what we historically had, because the watershed just isn't there to do that anymore. What is sustainable might be a little bit artificial.

Other respondents focused on the stakeholder issue, acknowledging that it is good to include many perspectives and personal values. For example:

> What needs to be recognized is that the stakeholders are going to play a role in any restoration that does happen so the theory may not always translate into any practical implementation. So there needs to be an understanding that stakeholders often have a role and are often the ones placing the value on the resources and that we have to balance all of that out and it's not going to be easy, but choosing either extreme isn't going to work at all. From a scientific point of view I don't know how anyone is thinking of getting rid of alewife or smelt, and from Chinook [salmon] angler point of view, they have to realize that other people have values for the ecosystem as well.

Consensus is difficult to reach, and choosing one side over another is neither a productive nor effective method. As discussed previously, the issue when attempting to make any decision is determining what values, and therefore consequent actions, will best serve the entire system.

Another respondent chose to focus on predator-prey relationships, suggesting that a desire for Chinook and Coho salmons may mean less stocking, as too many would result in a decline of alewife, their food source:

> Chinook [salmon] and Coho [salmon] are much more dependent on alewife than introduced Brown or Rainbow [trout]. So it depends what direction the public steers us in what they want to see out of their fishery. If they still want Chinook

> [salmon] and Coho [salmon] then we'll have to cut back on stocking to ensure that we don't push the alewife past the point of sustainability. We have to get a gauge on the amount of natural recruitment of Chinook [salmon] and Coho [salmon] and what role they play in the big scheme of things – this might let us scale back on stocking. We could actively manage barriers to make sure they're not in the best spawning areas, but this might not be realistic or feasible.

Though less stocking is agreed to be beneficial for a system, the alternative fish species presented were still non-native Brown and Rainbow trout.

All of these respondents seem to suggest that managers are reluctant to take a stance either way, and though consensus is not always achievable, choosing the middle ground is not always productive. Management decisions appear to be governed less by an adaptive process, and more by what leads to the greatest revenue. Solutions to this problem are not definitive, but the variety of answers to this set of questions does offer insight into how complexity may be resolved when stakeholders and decision makers work through issues together, and how complexity can be entirely dismissed if individuals pursue their own goals. By admitting that removing all non-native fish from the system is a scientific improbability, but agreeing that continual stocking of fish is not sustainable, whether they are so-called native or non native, the best answer may indeed be "somewhere in between." The diversity of these responses, the various concerns that respondents identified and their inability to produce a solution, alludes to how complex ecosystem restoration truly is.

It is crucial to note that the purpose of the ASRP is not to restore Lake Ontario in its entirety, but rather to contribute to this restoration by reintroducing a species that once existed in the Lake. The justification for this appears to be based more on culture, aesthetic and personal value than sound ecological science but, as all interviewees agreed, the ability of Lake Ontario to support a healthy, self-sustaining population of Atlantic salmon would be a good indicator of overall ecosystem health at least in terms of water quality and quantity.

5 Conclusions

It is imperative that governments and other organizations embrace current theories and guidelines for restoration, as well as analyze the motives and justification for taking these initiatives. Taking care of our environment, protecting it, and indeed helping to heal it, should never be considered a negative action, though it is not enough to take aim at one specific aspect rather than to evaluate the ecosystem and our actions within a larger context. A narrow focus on bringing back Atlantic salmon will not adequately restore Lake Ontario. A future-oriented plan is informed by history, but does not seek to create the past. Flexible goals allow for multiple trajectories making success and failure less about whether a particular state is achieved, and more about the process. Though reconciling values is difficult, key considerations about the health of future of ecosystems can be agreed upon and the relationship between humans and nature can be repaired.

The ASRP may have a noble goal, and its ultimate success is desired by all those involved, though adequate restoration guidelines have not been followed. Through interviews and a review of relevant research, the reintroduction program is shown to be rooted in outdated mandates that fail to address the current state of the ecosystem and its inherent complexity. This single species reintroduction is perhaps too focused on recreating one aspect of an ancient ecosystem. Biological issues, historical premise, human influence, competing values and the complex nature of the ecosystem are identified as areas in which the ASRP is limited.

Though this project revealed the information required for the ASRP to move forward, there are still unanswered questions regarding biological interactions of introduced Atlantic salmon with the Lake Ontario ecosystem. Competition between Atlantic salmon and Pacific salmonids already in the system impacts survival of Atlantic salmon (Stanfield and Jones, 1993). Research appears to be limited to the survival of Atlantic salmon, and not the impacts Atlantic salmon will have on the existing ecosystem. There are no immediate plans to eliminate the stocking of Pacific salmonids, but the cessation of that stocking would mean an overhaul of current policy and likely a political debate. The fisheries in Lake Ontario are largely artificial, and though this is widely agreed to be detrimental to the overall health of a system, the reintroduction of Atlantic salmon only compounds the issue, it does not alleviate it.

This reintroduction program is being presented as returning an important heritage species to the system it once existed within. This kind of restoration is based on the premise that what once existed is what should still be. The Lake Ontario system has evolved for over 100 years without the presence of Atlantic salmon. Though much habitat work is being conducted to make the tributaries conducive to this new species, the entire food web has been altered from when this species once thrived. The attempt to recreate the past is unlikely to restore ecosystem function or to improve overall health (Choi *et al.*, 2008). So long as restoration initiatives are based on historic recompositions and rooted in nostalgia, our ability to better our environment will be hindered by focusing solely on fragmented naturalistic patches instead of the currently existing ecosystem in its entirety.

The complex nature of ecosystems and the sheer size of Lake Ontario means that there are numerous stakeholders involved in the process. The underlying plan for

reintroducing Atlantic salmon was conceived decades ago, though only more recently was the plan turned into a specific program. The ASRP focuses on creating an Atlantic salmon fishery in Lake Ontario, and though habitats throughout the tributaries are being repaired, they are habitats that will generally benefit the survival of the Atlantic salmon. Some interview respondents felt this to be detrimental to the overall health of the tributaries and Lake, but conceded that any efforts focusing on the Lake could give these bodies of water valuable public and political exposure. Each organization has its own mandate for bettering Lake Ontario, and though Atlantic salmon reintroduction may not be a priority on everyone's list, they are willing to use the excitement and resources generated by the program to launch their own initiatives of habitat restoration, conservation efforts and education programs.

The ASRP has not yet been fully realized. The dynamic nature of ecosystems and their inherent complexity needs to be taken into account when designing large-scale restoration initiatives such as this. Though the ASRP claims to be about more than just the reintroduction of Atlantic salmon, the focus is simply adding this species to the current ecosystem, a system that is largely made up of other introduced and continually stocked species. Restoration should not be about removing so called non-native species and replacing them with native species. Instead, restoration should examine the ecosystem and identify existing species and their interactions. Partners of the ASRP noted that anglers have heavy political influence, and that maintaining quality fisheries is an important consideration in policy making. This program is focused on the fishery, even if that may mean compromising the health of the Lake, or more importantly losing opportunities to better the ecosystem in other ways.

Restoration, in both theory and practice, is moving toward a paradigm that sets future goals and allows for multiple trajectories and surprise along the way. By working from an older paradigm and adhering to historic time periods, managers confine themselves and their projects to isolated parts of an ecosystem in an attempt to recreate particular aspects of that ecosystem while disregarding the immense changes that have taken place within the system and its surroundings. Reintroducing an extirpated species as a means of restoration can fail to address the biological feasibility of such a task and the drastic changes that have occurred since extirpation. Communities, individuals and our current lifestyles will affect the success of the program and all of those involved must fully acknowledge the complexity of the ecosystem if they hope to better this system. As Hobbs (2007 p. 356) cautions, "[this] mix of scientific uncertainty, value-laden decisions, and unrealistic expectations could lead to costly and demoralizing failures, loss of confidence that restoration can deliver useful outcomes, and a redirection of funds to other initiatives, while leaving important ecosystem degradation untreated". If these issues are fully realized, coordinators and participants of the ASRP may be inclined to choose another method for restoring Lake Ontario and bringing it into the future, despite the long term, historic commitment to this initiative.

The purpose of this study was to evaluate how the ASRP adheres to current restoration themes and guidelines. Clearly the ASRP, as it currently exists, is not influenced by the latest trends in restoration theory. By focusing on a single, historic, sport fish the ASRP is neither future-oriented nor focused on the functionality of the entire ecosystem. Though some adaptive management is occurring, the goals and the trajectory of the program are unwavering. Program participants have failed to recognize the bigger picture of ecosystem health in choosing Atlantic salmon as a means of

restoring Lake Ontario. Instead of enabling discussion on how Lake Ontario could best function and attain better overall health and functioning, and then devising a plan that utilizes criteria such as those laid out by Hobbs (2007) and Choi (2007), the proponents first chose Atlantic salmon as a singular goal. By facilitating discussion of stakeholder values and considering the functionality of the ecosystem as a whole, restoration efforts could have been made much more effective for bringing Lake Ontario into a healthier future.

6 A New Way Forward

The first question anyone approaching Lake Ontario for conservation or management issues might ask is "What is desirable for this ecosystem?" Meaning, what should the Lake and its tributaries look like, and how should they function? Interview respondents answered these questions and described the barriers they felt limited the ability to achieve these goals. Ranging from requiring so-called native species, to wanting sustainable fisheries, to simply a desire for clean water, the responses touch on the many aspects required to increase the health of Lake Ontario. Some examples of responses given when describing their ideal Lake Ontario are as follows:

> [It would have] water quality, water quantity, all the species, everything from insect life to fish species….one which is based on native species, no non-native species, in a dynamic balance…

> It would be an ecosystem that is primarily composed of native species, or if those aren't present then surrogate species that fill the same ecological niche but carry out the appropriate ecological functions. A system that has connectivity between both Lake Ontario and the headwaters as well as connections to the terrestrial landscape. Minimal agricultural or urban development. An ecosystem that has all the different trophic niches filled.

> It would be one where we have sustainable resources in the Lake. We have healthy fisheries and healthy water for fish and all species and for people and one that is ideally functioning without human intervention.

> The perception of healthy is the historical community [but] we can't go back to that…so to me if we have one that is functioning well in terms of productivity, species diversity, good representation, multiple trophic levels, communities that are resilient enough that they are fairly resistant to more invasion, we'll be pretty well off.

Though these responses differ with respect to their focus for ecosystem health, each respondent has acknowledged the need for improvements to Lake Ontario and a desire to see changes to the ecosystem in the future. Before making decisions for specific action, stakeholders should ensure that they have common goals, meaning that at least that they can agree on a common future.

Stepping back from species reintroduction and the ASRP, stakeholders are able to describe the system they hope to achieve. It's quickly apparent that a single species reintroduction is not an obvious answer to obtaining an ecosystem marked by such things as diversity, productivity, high water quality and quantity, and resilience. In 2008, the Great Lakes Regional Research and Information Network contracted the Human Dimensions Research Unit (HRDU) at Cornell University to hold conferences with diverse stakeholders from Canada and the United States (Lauber and Brown, 2008). Questions under the categories of water, stressors, fisheries, people, information and analysis and decision making and management were identified through a lengthy and thorough process. These questions established research and information needs for Lake Ontario. Though this study does not immediately provide solutions to the problems facing Lake Ontario, it does illustrate the possibility and effectiveness of

stakeholder discussion, prioritization and, eventually, consensus for improving the overall health and functionality of Lake Ontario.

There are, of course, very real limitations to being able to achieve any of these kinds of goals. In this study of the ASRP, each respondent was asked to indicate which barriers they felt were preventing their "ideal Lake Ontario". All responses indicated the barrier involved contending with increased population pressures and the need to increase political will. For example:

> [There are] too many people. Major limitations are contradictory regulations and the complete absence of funds and will to apply the regulations that exist.

> The simplest barrier is the human demographic…that's a huge impact. To have a healthy ecosystem that's what we're up against and it's about finding a balance between the two of them and determining what our impacts are on the watershed.

> There are things we can do that would help us along, [but] I think they would require more political will then we are going to see.

Clearly population numbers are not going to decrease in future, but that does not mean the pressures placed on the ecosystem cannot be mitigated. The second barrier, lack of political will, involves governments that are unwilling to make the often difficult decisions for policy changes. Though if changes are not made, an increase in the overall health of Lake Ontario is unlikely to occur. The lack of regulatory enforcement is a key

component that remains unaddressed. For any initiative involving Lake Ontario to be successful, not only must all stakeholders and the public be involved and able to voice their opinions, but governments must produce adequate policy, and equally importantly, they must also provide the means to uphold those regulations.

With our increasing knowledge of Lake Ontario, its foodwebs, species interactions, and range of human impacts, we are in a position to design policies and regulations and actually support them. The interest is clearly there, perhaps we should focus on the political will required to move Lake Ontario management and conservation into the future. This is every stakeholder's responsibility. The HDRU conferences described an ideal management as one with "an iterative process, a human ecosystem approach, adaptive management with social learning and a precautionary approach to deal with uncertainty (Lauber and Brown, 2008, p. 33)." This approach follows the criteria set by Hobbs (2007), Choi (2007) and others for setting ecological restoration goals. Focus should be on collecting required data for information needs, but we must nonetheless remain critical of our management approaches.

The public, the 6 million people who reside around Lake Ontario within the province, need to be thoroughly educated, but they also need to be given credit that they can make appropriate behaviour changes that will be better for Lake Ontario. As environmental consciousness becomes more prevalent throughout society and with younger generations, it should reason that society can move to value and to defend Lake Ontario if given proper information, education and good examples to follow.

Lake Ontario is a precious resource. It is part of a larger Great Lake system that contains a sizeable proportion of the world's freshwater. Currently it is being heavily impacted by humans. There are countless specific areas to focus attention including,

but of course not limited to, invasive species prevention and extraction, stricter industry regulations, and riparian habitat preservation and repair. However, any of these campaigns and initiatives, including the ASRP, must acknowledge the social frameworks in which they are being set, be oriented toward the future, and allow for unknown events to occur. We must also recognize the existence of the competing values of individuals and groups that will inevitably, and indeed should be, part of the process.

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Appendix

Interview questions

Background

Could you give a brief overview of what your organization does and your specific role within the organization?

The Lake/Ecosystem

How would you describe a healthy Lake Ontario ecosystem?

What are the barriers to achieving this?

The Practice of Restoration

What was (and is) the objective of Atlantic salmon restoration?

Assuming resources are limited, before the decision to reintroduce Atlantic salmon to Lake Ontario was reached, were any other methods to improve the lake considered?

Which stakeholders were consulted to make the decision to reintroduce Atlantic salmon to Lake Ontario? How were they consulted (timeframe/venue etc)

At what point did your organization enter the process and begin a dialogue?

Why do you think the "Bring back the salmon" campaign was chosen, what was it that gave it widespread appeal?

What is your role within the Restoration Program? What contributions has your organization made?

In your opinion, what are the major achievements of the restoration program and what do you expect in future?

Restoration Theory

In your opinion what is the purpose of restoration?

There is some recent literature that states ecological restoration must focus on ecosystem function, **not** species recomposition. How do you feel about this statement?

Does the current restoration mandate for Lake Ontario adhere to this vision?

> Choi (2007): "Future oriented restoration should focus on ecosystem functions rather than recomposition of species or the cosmetics of landscape surface, our paradigm of ecological restoration needs to be redefined with functional rehabilitations for the future, not nostalgic recompositions"
> Halle (2007): "It is precarious and misleading to rely on casual and aesthetical features alone; rather it is necessary to identify the system in depth, because what is left with respect to species composition, trophic interactions, and ecosystem functions are the basis from which any transition process to a more desirable state has to develop"

> Armstrong and Seddon (2008): "It can be argued that the primary goal of translocations should be to restore ecosystem function rather than species composition. Although the

> IUCN reintroduction guidelines make provision for introducing species to new areas to satisfy species recovery goals, a better justification might be to restore the functional roles of extinct species"

Though many other documents mention this, I am going to give a quote from the 1999 GLFC Fish Communities Objectives which states that: "managing for abundant alewives and viable trout and salmon fisheries is incompatible with managing for native fishes. An incongruity between the fishery that stakeholders want and what a scientific assessment of ecological trends in Lake Ontario indicates is possible presents a fundamental dilemma"

Please comment.
Do you think these are becoming more or less aligned?
How does this factor into management decisions and strategies?

Do you believe that Atlantic Salmon are native to Lake Ontario? Are they or will they be important to the ecosystem? How?

Concerns

Are the genetic origins of the introduced fish of great concern?

Some studies (Meffe, 1995) have stated we should be more concerned about conserving genetic diversity as genetic structures "reflect evolutionary histories of fish and ecological requirements of populations" and other studies indicate that "genetics are of less concern in the case of extirpated species; strain evaluation will be a high priority"

There is evidence of interspecific competition between Atlantic salmon and Pacific salmonids such as Chinook salmon and Rainbow Trout.

Johnson and Wedge (1999): Offer a collection of research where Atlantic salmons are shown to be competition with other salmonids and would likely d better with the exclusion of other populations

Scott et al (2005): Chinooks were found to court spawning Atlantic females

What do you perceive the fate of Pacific salmonids already in the Lake Ontario system to be?

Is there any concern about persistent stocking of sport fish?

Do you believe this may fail to address the need for protection and establishment of liveable habitats?

Please define the following terms as applied to various species: native; non native; naturalized; exotic; invasive