# Adolescent Perceptions and Attitudes towards Invasive Species and Nature

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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Kyle Creelman

## Abstract

Invasive species are one of many important environmental issues facing Canadians today. A great deal of research has explored both the scientific and social aspects of invasive species. However, the cumulative research has not yet thoroughly explored people's thoughts and feelings about, or perceptions of, invasive species and the influence these may have on management of, or policy decisions regarding, invasive species.

This thesis research project was designed to assess the attitudes and perceptions that high school students have towards invasive species and to determine to what extent learning about invasive species alters their connection with nature. The study group was comprised of students from four Grade 11 Environmental Science classes from three high schools within the city of Guelph, Ontario. The students received regular classroom instruction from their teachers covering the course content, including invasive species. Students also made weekly visits to a local nature centre, providing them with hands-on learning experiences related to the course content.

Students responded to an 80-question survey that assessed their knowledge of local invasive species and attitudes towards them as well as students' connection to nature. Their connection to nature was assessed using a modified version of the Connectedness to Nature Scale (Mayer & Frantz, 2004). The surveys were administered by the classroom teachers in October, 2010, prior to the presentation of instructional material covering invasive species and then again in December, 2010 when the presentation of instructional material concerning invasive species was complete. The results showed that the students' knowledge of invasive species upon entering the course was quite low and each of the classes witnessed a significant increase in knowledge. The survey results did not reveal any change to the students' connection to nature; however, they did reveal three underlying themes in students' attitudes towards invasive species: a concern about invasive species as a threat or problem; feelings of acceptance towards invasive species; and feelings of anxiety about invasive species. These attitudes remained relatively unchanged after the course.

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# 1. **Introduction**

Although we have always learned about our physical environment in a variety of ways, such as exploring our surroundings, experimenting with what we find, and through knowledge passed down to younger generations, Environmental Education (EE), as a separate established educational discipline, is relatively young, first making its appearance in the early 1970's (Hungerford, 2010). Today, EE continues to evolve and find its place in Canada. The province of Ontario, for example, has recently begun establishing a framework for EE by producing a series of documents designed to ensure effective environmental education in its schools (Ontario Ministry of Education 2007a, b; 2009). Arising out of these policy and strategic efforts, many specific educational materials have already been created, with many more to come.

Lending urgency to these efforts from both educational policy makers and front line teachers is the understanding that values, attitudes and behaviours formed during adolescence will likely remain throughout adulthood (Alwin and McCammon, 2003; Smith, 1999). Also, as one recent U.S. study showed, there has been a decrease in the level of concern felt by adolescents towards environmental issues (Wray-Lake *et al*., 2009). Adolescent perceptions of the environment and related issues are crucial because today's adolescents will eventually become the leaders and policy makers that carry the responsibility for environmental stewardship and sustainability (Wray-Lake *et al*., 2009). Therefore, it is important that lessons and educational materials provide useful information while, at the same time, they engage students' attention. As an educator myself, I have witnessed firsthand the beneficial effects of materials with these dual characteristics in several subject areas, while as an environmental researcher I have become convinced they are especially important in EE.

Invasive species are one of the many important environmental issues facing Canadians today. Both provincial and federal authorities have recognized invasive species as serious threats. As a result, we have witnessed the creation of such formal plans of action as *An Invasive Alien Species Strategy for Canada*, which aims to prevent, detect and manage invasive species in Canada (Government of Canada, 2004). This is a clear indication that invasive species have become an important public policy issue in this country.

Despite the large costs associated with invasive species, and governments' recent focus on the issue, the general public tends to lack knowledge about the issue, and can name few, if any, invasive species (Boorse, 2004; Colton and Alpert, 1998; Gates *et al*., 2009; Lindgren, 2006). As a result, more attention has been placed on educating the public about invasive species in an attempt to raise awareness of the issue and to motivate behavioral change. For example, the term "invasive species" now appears in both the elementary and secondary school curriculums in Ontario. In addition, Conservation Authorities, and wildlife organizations, such as the Ontario Federation of Anglers and Hunters, produce informational brochures, fact sheets, and other educational materials that are made accessible to the public.

The language used to describe invasive species to the public has itself received some attention. While scientists who study invasive species, known as invasion biologists, debate how to define "invasive species" (e.g., Daehler, 2001; Colautti and MacIsaac, 2004; Colautti, 2005; Rejmanek *et al*., 2002), the messages used to communicate information about biological invasions to the public often focus on their harmfulness (Gobster, 2005). Media outlets provide updates on the latest plant, animal or microorganism species that spread to new regions with headlines advertising the threats they pose to native species or their characteristics that could be harmful to humans. Frequently, these media publications are paired with magnified, unnerving images of the invading species (Gobster, 2005), or images of the damage they can cause.

Larson (2010) suggests that since so many invasive species are already established and are here to stay (Soule, 1990), it is time scientists and the general public find a new way to relate to these problem species and warned that if we do not, we may find ourselves continuously frustrated in a world where invasive species are so commonly found. He suggests alternative metaphors which could replace the term "invasive" and aid in the development of a new narrative and new conceptualization of these problem species. Gobster (2005) and Larson (2010) have both expressed concern about the current narrative on invasive species and have wondered about the possible effects it may have on vulnerable audiences such as children.

How the general public, especially children, learn about nature and their surrounding environment can evoke a wide range of emotions, such as adoration, respect, hate, and fear (Bixler and Floyd, 1997). Today's generation of children are already facing what Louv (2006) referred to as a "nature deficit disorder." By not interacting with nature, children are missing out on opportunities to build valuable relationships with the natural world. Given this established "deficit," we cannot afford to further diminish the possibility of children connecting with nature by creating excessive fear about invasive species.

For the moment, the current narrative remains in place, and while there has been a great deal of literature concerning the biology, risk assessment, and spread of invasive species (Cadotte *et al*., 2006; Meloche and Murphy, 2006; Muirhead *et al*., 2006), other, mainly recent, research concerning the social aspects of invasive species (e.g. Aslan *et al*., 2009; Eagle *et al*., 2007; Larson, 2010) has not yet thoroughly explored people's thoughts, feelings or perceptions of invasive species nor the influence they may have on management and policy decisions regarding invasive species (Gobster, 2005). With an increased focus on educating the public about invasive species, it would be beneficial to have insight into people's perceptions about, and attitudes towards, invasive species, both before and after they learn about them. This information could be helpful in evaluating current educational materials and techniques concerning invasive species and could provide insight into any alterations or improvements that could be made to current educational practices.

This thesis analyzed the data on a group of Grade 11 students' knowledge of, and attitudes towards, invasive species. These students took part in an Ontario-based Environmental Science class that included both field and classroom instruction on the subject of invasive species. This research sought to address the following questions:

- "How much do adolescents know about invasive species and how does education affect their knowledge?"
- "What attitudes do adolescents have towards invasive species and how does education affect their attitudes?" and,
- "To what extent does learning about invasive species alter adolescents' connection with nature?"

# 2. Literature Review

## 2.1 Invasive Species and the Lack of Public Awareness

Species have always expanded or shifted their territories, both by accident – a flock of birds, for instance, blown by a hurricane to a new continent, carrying seeds in their bellies and parasites in their feathers – and (at least in the case of animals) by instinct – for instance, when food sources in existing territories become depleted. The phenomenon itself is entirely natural. Biological invasions have occurred slowly over long periods of time; there have also been major events in the earth's history that have made travel to new frontiers easier or have sped up the process. Tectonic activity, climate change, and asteroid impacts are all examples of how extreme circumstances have created opportunities for life forms to explore new frontiers (Brown and Sax, 2004).

Currently, the attention of both the popular media and invasion biologists is primarily focused on human-assisted biological invasions since these are now occurring at an unprecedented rate. Previous events were limited to neighbouring regions and involved only a fraction of the species that either region had to offer - whereas today, facilitated both directly and indirectly by human activity, every region on the planet is, potentially, simultaneously affected and the scale and rates at which modern invasions occur are significantly higher than ever before (Ricciardi, 2007). Species that are introduced to new regions are referred to by a variety of names, such as, alien, exotic, non-native, or non-indigenous. Some of these introduced species, once established in new regions, spread quickly and uncontrollably, and are capable of causing substantial ecological or economic damage. These problem species are thus referred to as invasive species. Invasive species have been identified as a significant threat to regional and global biodiversity (Clavero and Garcia-Berthou, 2005; IUCN, 2005; Lodge and Shrader-Frechette, 2003; Lowe *et al*., 2000; Mack *et al*., 2000; Novacek and Cleland, 2001). In Canada, Venter *et al*. (2006) assessed threats facing 488 at-risk species and determined that "introduced species" were a significant threat to 22% of the species in question, which ranked sixth out of the threats facing these species.

In addition to causing ecological disturbances, invasive species place a large financial burden on societies around the world – a large amount of money is spent in attempting to control existing invasive species or in trying to prevent their arrival. Pimentel *et al.* (2005) estimated that in the United States more than 50,000 invasive species cost the U.S. economy an estimated 12 billion dollars annually. In Canada, 11 nuisance invasive species impose a direct cost to the Canadian agriculture, forestry and fishery industries of approximately 187 million dollars annually and the indirect costs of 16 invasive species cost Canadians between 13.3 and 34.5 billion dollars annually (Colautti *et al*., 2006, p. 50).

Despite the apparent severity of the problem, the general public seems less knowledgeable and less concerned about invasive species than the governments in a number of jurisdictions and invasion biologists suggest they should be (Ehrlich, 2002; Lodge and Shrader-Frechette, 2003). For example, Colton and Alpert (1998) surveyed 206 visitors of the University of California Bodega Marine Laboratory regarding weeds and invasive plants and found that generally, the visitors did not perceive biological invasions to be a serious problem and that they were largely unaware of ecological and economic problems caused by invasive plants. Boorse (2004), in describing her use of invasive species as a case study to teach environmental ethics to students at Gordon College in Massachusetts, noted: "I have found my non-ecologist friends and many students to be completely unaware of the size and impact of the problem, unable to recognize NIS [non-indigenous invasive species] common in our area, and unfamiliar with the terms 'exotic' and 'invasive'" (p. 326). Furthermore, in a study of West Virginia woodland owners, Steele *et al*. (2006) surveyed 1,500 households concerning invasive plant species and found that only 34% of respondents had heard or read about invasive plant species found in their area.

A more recent study suggested that awareness of invasive species may be increasing. Daab and Flint (2010) surveyed 4,027 households in north central Colorado (a region where forests had been decimated by the native mountain pine beetle, *Dendroctonus ponderosae,* thus creating optimal conditions for invasive plants) to gauge public awareness and attitudes regarding invasive plant species. They found that the public in this area was very aware of invasive species with 88% of the respondents indicating that they had heard or read about

invasive plants. Although these respondents indicated that they were aware of invasive plants, far fewer were aware of specific invasive plants targeted by local management initiatives. The authors also stated that the high level of awareness demonstrated by the respondents might have been a result of the high-profile that natural resource issues have in the region, and that comparable results might not be found at a national level.

These findings are important because human actions play a large role in the dispersal of many invasive species. Global trade has created interconnected pathways around the world and behaviours associated with this allow species to spread faster than ever before (Brown and Sax, 2004). However, the actions of individuals are also capable of playing a large role in the dispersion process of invasive species. Individuals could unknowingly start an entirely new colonization simply by planting a pretty, exotic flower in their gardens, by bringing along their own fire wood when camping, by emptying their bait buckets after fishing, or by accidentally bringing home a foreign species from a vacation (Colton and Alpert, 1998; Poland and McCullough, 2006). Zebra mussels (*Dreissena polymorpha*), for example, may have originally arrived in North America via the ballast water of international marine vessels (Roberts, 1990), but they are also known to have been spread overland by recreational boaters to new aquatic areas (Johnson *et al*., 2001). Inspection regulations have been set in place and warnings distributed at both the industry and public levels concerning invasive species, yet new species continue to arrive.

There are several possible explanations for why the public does not view invasive species with more concern. Despite official efforts to educate the public and some indications that awareness is increasing, ignorance about invasive species could still be part of the problem. It is possible that there simply has not been enough time for a "trickle down" effect to reach the general public (Brewer, 2001). Boorse (2004) noted that the Office of Technology Assessment had only produced its first comprehensive report on invasive species in the US in the early 1990s and suggested that ten years would not have been enough time for the information to find its way into most school textbooks. Other reasons for public ignorance about invasive species may include the fact that the general public has a low

understanding of ecology (Boorse, 2004); or, that education does not focus on non-native species (Braun *et al*., 2010).

In Canada, the national action plan for invasive species was only published in 2004 (Government of Canada, 2004). The term "invasive species" first appeared in the Ontario Curriculum in 2007 under the Science and Technology strand of the elementary curriculum (Ontario Ministry of Education, 2007c), and in 2008 in the secondary curriculum (Ontario Ministry of Education, 2008a, b). Although the term "invasive species" may not have been included in previous versions of the curriculum, there was room for the concept to be included. For example, the previous version of the Grade 3 curriculum included an expectation that students would be able to describe ways in which humans can protect natural areas and native plant species (Ontario Ministry of Education, 1998). The previous Grade 11 Biology curriculum also included expectations where invasive species could be discussed (Ontario Ministry of Education, 2000). It included an expectation that students be able to explain how a change in a food chain could affect the entire food web and included the following examples: "explain how the killing of fish by the lamprey eel [*sic*] affects fishing communities; explain the effects of the introduction of zebra mussels into the Great Lakes (p.31)."

### 2.2 The Need for Education about Invasive Species

Given the generally low level of awareness the public has about invasive species, several studies have included the recommendation that a greater emphasis be placed on educating the public about invasive species (Alexander and Lee, 2010; Colton and Alpert, 1998; Moser *et al*., 2009; Poland and McCullough, 2006). Among the suggested reasons for low levels of public awareness about biological invasions listed by Colton and Alpert (1998) is the possibility that many people do not feel the impacts of biological invasions directly. They speculated that one of the few ways people learn about invasions is to be directly informed about them. Colton and Alpert (1998), Steele *et al*. (2006), and Daab and Flint (2010) all conducted surveys that revealed many of their participants were not familiar with

invasive species; all of these authors suggested that greater public education about biological invasions was needed.

There are several reasons for wanting to raise awareness about invasive species. In their assessment of the movement of the emerald ash borer (*Agrilus planipennis*) as a threat to North America's ash resource, Poland and McCullough (2006) mentioned the importance of outreach and education programs in preventing the continued spread of the species through the movement of ash products such as firewood. In this situation, quarantines may have been issued, but the public needed to be made aware of them. As a result, educational initiatives were implemented through major universities and government agencies. Poland and McCullough also argued that, in addition to preventing the artificial spread of invasive species, educating the public helps build support for containment and control efforts.

This statement was echoed by Moser *et al*. (2009), in a paper summarizing the impacts of non-native invasive species on US forests. Their highest policy and management recommendation regarding invasive species was to promote education and awareness of the issue. They discussed how, along with preventing the accidental spread of invasive species, public education is important for fostering the support of the drastic responses management efforts sometimes require. They added that without pivotal public support, control efforts, such as widespread tree removal, might not go forward.

Public education initiatives are not only helpful after an invasive species has established itself in an area. Along with suggestions for improving research about monitoring techniques for invasive species, Alexander and Lee (2010) mentioned the potential value of citizen science and a well-informed community. They described the benefit of providing public education before species have arrived by stating, "When community capacity to manage the natural environment is actively fostered, communities can jump-start the process of dealing with new pests while facilitating the scientific search for proven control technologies (p. 326)."

As calls for more public education have been made, there has been an increase in the creation of educational materials and initiatives promoting information about invasive species (Krasny and Lee, 2002). Outreach and education programs are vital for transferring

scientific knowledge created by the research community to the public and educational initiatives about invasive species have occurred at all levels. For example, in 2009, Ontario's Invading Species Awareness Program (ISAP), a partnership between the Ontario Ministry of Natural Resources and the Ontario Federation of Anglers and Hunters, launched a workshop for professionals in the resource and environment fields that focuses on invasive species identification, field equipment decontamination and reporting procedures (ISAP, 2010). ISAP also provides public service announcements; places staff at public events such as boat, garden, or sportsmen shows; runs an invasive species hotline; and distributes educational materials to schools and community organizations.

As the term "invasive species" begins to appear in education curriculums, there is evidence that invasive species are being taught at the most elementary stages. Two recent science teacher trade publications described how first and fifth grade students were able to play the role of citizen scientists by monitoring invasive species (Bennett, 2010; Spellman and Villano, 2011). These articles described lessons that are being used to teach science and ecology to students by studying invasive species. The authors of both articles noted that their students became engaged in the process, asked lots of questions, and were interested because the lessons involved their community and because they occurred outside, in nature.

Some invasion biologists have expressed concern about how invasive species are described to the public. The current narrative used to describe invasive species is filled with a militaristic vocabulary that revolves around death and destruction (Gobster, 2005; Larson, 2005). Frightening images of invasive species are not uncommon in the popular media, either. In the introduction to their paper on landowner perceptions of rapid response to the emerald ash borer, Mackenzie and Larson (2010) indicated that "although it is most effective to prevent the arrival of new and potentially invasive species, the dramatic attempts to eradicate species after they have arrived more often reach the media and capture the popular imagination (p.1)." In the summer of 2010, when giant hogweed (*Heracleum*

*mantegazzianum*) increasingly attracted the attention of reporters[1], there were numerous examples of such media coverage when images of conservation officers dressed in hazardous material body suits and gas masks were aired on newscasts in southwestern Ontario. With the increased focus on education about invasive species, there is cause for concern about whether these messages containing militaristic language are being used to educate children about invasive species, and if they are, how children are reacting to these messages.

### 2.3 Environmental Education about Invasive Species in Ontario

Like invasive species, the broader realm of environmental education has received an increasing amount of attention in recent decades. Environmental education as a discipline has evolved rapidly around the globe, including in the province of Ontario. Integrated environmental studies programs, where students remain with the same peers and teacher(s) for a semester and learn about several subjects at the same time (such as physical education, environmental science, geography and co-operative education), first emerged in Ontario during the 1970's and 1980's, yet these programs only became firmly established in the mid 1990's (Russel and Burton, 2000).

The situation is similar for mainstream environmental education subjects such as Environmental Science. According to Durst (2011), beginning in 1988, five environmental science courses could be offered in Ontario high schools if the school chose to offer them. Three of these were general level courses in Grades 10, 11, and 12 and two were advanced level courses in Grades 10 and 12. However, enrolment in these courses was very low and, as a result, the courses were discontinued. Consequently, environment/ecology education was placed under the realms of the Science curriculum and the Canadian and World Studies curriculum. For example, the Ontario Science curriculum included a science, technology, society and the environment focus in all of its courses in Grades 9 and 10. Furthermore, the

[1]A query using the Factiva database limited to the region of Canada for "giant hogweed" returned 106 news stories between May 1st, 2010 and September 30th, 2010 compared to 32 news stories between January 1st, 2000 and May 1st, 2010. In addition, the archives department at the Kitchener/Waterloo CTV station confirmed that their local news broadcast 4 stories about giant hogweed in July, 2010, whereas, since the early 2000's, they had aired only one story, in 2009.

compulsory Grade 9 Geography course included a major topic area on human-environment interactions.

In addition to changes directly involving environmental education, the Ontario education system as a whole has undergone mild reform in recent years. In 2007, the Ministry of Education implemented a cyclical review process and established an independent Curriculum Council to ensure the Ontario curriculum is able to adapt in a rapidly changing world (Ontario Ministry of Education, 2007b). The Curriculum Council's role is to review different topics of education on an ongoing basis to ensure that the curriculum remains correct, relevant and grade appropriate. The Curriculum Council appointed a working group chaired by former astronaut Dr. Roberta Bondar to provide expert advice to inform their deliberations. The working group provided the Council with a report including 32 recommendations, one of which was the creation of an optional Grade 11 course with an environmental focus (Ontario Ministry of Education, 2007b). The revised *Science, Grades 11-12* document (Ontario Ministry of Education, 2008b) includes two Environmental Science courses (one in the university and college preparation stream and one in the workplace preparation stream), which were piloted in 2008 (Durst, 2011). Beginning in 2009, high schools could choose to offer one or both of these courses. In addition to these new Grade 11 courses, all curriculums in all grades and subject areas were to be reviewed using the *Standards for Environmental Education* to ensure they include environmental education expectations and opportunities where appropriate (Ontario Ministry of Education, 2008c).

Each course in the Ontario Curriculum has both overall and specific expectations. These expectations have been defined by the Ontario Ministry of Education, while the teaching and assessment strategies used to address these expectations are left to the professional judgment of teachers (Ontario Ministry of Education, 2008b). Overall expectations are general descriptions of the knowledge and the skills that students are expected to demonstrate by the end of the course and specific expectations describe the knowledge and skills in greater detail. Examples are listed under some of the specific expectations as a means to illustrate the kind of knowledge or skills that the expectations

entail. The examples mentioned within the Ontario Curriculum documents are by no means a curriculum requirement.

Invasive species are first mentioned within a specific expectation in the sixth grade, under the Science and Technology strand (Ontario Ministry of Education, 2007c). The expectation is that, by the end of the course, students will be able to "explain how invasive species (e.g., zebra mussel, Asian longhorned beetle, purple loosestrife) reduce biodiversity in local environments (p.114)." Invasive species are also mentioned within a specific expectation in the Grade 11 Environmental Science class (Ontario Ministry of Education, 2008b). The expectation in the Grade 11 class is that, by the end of the class, students will be able to "explain how human activities (e.g., agriculture, travel, the purchase of exotic pets, importing and exporting, releasing domesticated fish into fresh water environments, the use of live bait) have led to the introduction of invasive species, and why it is important to measure and monitor the impact of invasive species on native species (p. 169)."

Most often, however, invasive species are referred to as examples within the expectations or within example questions. These examples are most often used to help illustrate human interactions with nature. The earliest that invasive species are referred to as an example is the Grade 4 Curriculum under the Science and Technology strand (Ontario Ministry of Education, 2007c). The expectation is that, by the end of the course, students will be able to "identify reasons for the depletion or extinction of a plant or animal species *(e.g., hunting, disease, invasive species, changes in or destruction of its habitat)*, evaluate the impacts on the rest of the natural community, and propose possible actions for preventing such depletions or extinctions from happening (p. 85)." Another illustration of invasive species being included as examples is found in a sample question within the Grade 11 Environmental Science course (Ontario Ministry of Education, 2008b). The specific expectation that, by the end of the class, students will be able to "propose possible solutions, on the basis of research, to a current practical environmental problem that is caused, directly or indirectly, by human activities (p. 168)," includes several example questions, such as, "What can be done to minimize the effect of an invasive species (e.g., purple loosestrife) on a native species (e.g., milkweed)? (p. 168)." While invasive species may not be a major topic

within the curriculum, the recent inclusion of the term within the curriculum is evidence that the topic is starting to attract more attention. This will likely result in students receiving more education about invasive species.

### 2.4 Today's Children Are Missing Out On Nature

According to Richard Louv (2006), today's generation of children is plagued by a "nature deficit disorder." This simply means that today's children have very little interaction with nature and, as a result, they are missing out on many of the beneficial aspects that exposure to nature can offer. Louv identified several barriers that are keeping children from nature and he also acknowledged that many of these barriers may have been created with the best of intentions. For example, a child's time is often very structured, with school, sports, music lessons, and a variety of other extra-curricular activities all taking place at designated times. Parents, who want their children to grow up as well-rounded adults, may be depriving their children of unstructured time, leaving little opportunity to explore nature (Louv, 2006). Other barriers include a preoccupation with electronic games, restrictions on natural play, and a lack of nature education in schools (Louv, 2006).

In addition, there is what Louv referred to as an increasing "generalized, unfocused fear" within society. People are fearful of the violence reported on the news, the bacteria found in public places, strangers, and the countless unknowns that could be lurking around the corner or in the shadows. As a result, parents want to keep their children close to home. A study looking at three generations of children from the 1970's to the 1990's found that the radius from their homes beyond which children were not allowed to stray had shrunk to a ninth of what it had been in the 1970's (Gaster, 1991). Furthermore, Valentine and McKendrick (1997) surveyed parents from roughly 400 households with children between eight and 11 years of age in northwest England, 70 of whom were selected to take part in interviews regarding their attitudes towards their local area, their concerns for their children, their children's play habits, and their children's travel to school. The study found that parental anxieties about children's safety and the perception that childhood itself has changed from being a time of innocence and exploration to one of surviving in an increasingly

dangerous world are the two most significant influences on children's access to independent play.

According to Bixler and Floyd (1997), the perception of a physical environment correlates with the perception of the activities associated with that environment. If children have a negative perception of nature, they will also have a negative perception of the activities that occur within nature. There are a wide range of experiences that children can have outdoors which might evoke a fear of nature, such as getting lost in the woods, or encountering bad weather, dangerous animals, or poisonous plants (Bixler and Floyd, 1997; Van den Berg and ter Heijne, 2005)

However, even without direct negative experiences with nature children may become fearful of it. One study found that children who have the least amount of experience with natural areas are those who are the most frightened of them (Bixler *et al*., 1994). This study suggested that the messages about nature that children receive from indirect sources such as their parents, teachers or the media are creating fearful perceptions (Bixler and Floyd, 1997). In addition, Sobel (1996) found suggestive evidence for concern about educating children about severe environmental problems facing the earth, such as deforestation in the rainforest, when they are incapable of acting to protect it. He asserted this doom and gloom approach to environmental education could result in what he refers to as "ecophobia," a fear of environmental tragedies and alienation from nature. Also, a number of recent horror films, such as *The Blair Witch Project* (1999) or *Red Riding Hood* (2011), depict nature and wooded areas as extremely frightening. In comparison to these, classic "scary movies" such as the 1930's *Wolfman*, where nature and wooded areas are also depicted as frightening, seem quite mild (Louv, 2006). For children who have little experience with nature, the fear evoked by these films could easily become associated with nature in general.

These fears and negative perceptions, even though they may be created at a young age, often play a role in future activity, education, and occupation choices (Bixler and Floyd, 1997). If children learn about invasive species using a narrative that portrays them as bad and dangerous, educators run the risk of creating or enhancing a fear of nature among children. For example, if we instill a fear of giant hogweed in children and they do not have

enough experience with nature to tell the difference between giant hogweed and the much more common look-alike wild carrot (*Daucus carota*, also commonly known as Queen Anne's lace), it seems possible that they will also experience fear every time they encounter wild carrot.

The use of "fear appeals" is a well-established tool that has long been used to influence people's perceptions and change their actions (O'Neill and Nicholson-Cole, 2009). Fear is often used in an attempt to foster public support for management initiatives and to inspire behavioural change (Gobster, 2005). But these fear appeals often carry with them unintended consequences, such as creating unnecessary worry among those who cannot help the situation (Hastings *et al*., 2004). For environmental issues like climate change or invasive species, children can be an extremely vulnerable audience. Invasive species are commonly found in regions across the country. Larson (2010) wondered what effect describing invasive species as something bad, when they are so commonly found, will have on children. He wondered whether they will perceive natural areas, or humans, negatively and whether they will feel guilt or responsibility for invasions beyond their control. Only time will provide the answers to the questions, but the concerns appear to be well founded.

### 2.5 Connection with Nature

Environmental education in recent decades has focused on increasing students' knowledge and awareness of environmental problems, instead of identifying and shaping their feelings towards nature. Mayer and Frantz (2008) argued this educational plan might be overlooking an opportunity to induce more environmentally friendly behaviour among students. While cognitive outcomes are important, we cannot ignore the possibility of fostering better relationships between humans and the natural world.

Whatever the reasons may be, the simple fact remains that children in our increasingly urbanized and consumerist societies are spending less time in nature (e.g. Clements, 2004; Kellert, 2005; Louv, 2006). Spending time in nature provides people with opportunities to develop deeper connections with the natural world (Hutson and

Montgomery, 2006), and with children having less access to nature, they have less opportunity to develop these connections.

Ecologists and environmentalists have reflected upon the human relationship with the natural world for years. The importance of feeling connected to nature is a theme that has been expressed by such influential environmental writers as Leopold (1949) and Orr (1994). Some have argued that since the most of mankind's past existence was spent in the natural world, that we have a primitive desire to feel connected to it (Dunlap *et al*., 2000; Schultz and Tabanico, 2007).

Mayer and Frantz have spent most of the last decade exploring people's relationship with the natural world (Frantz *et al*., 2005; Mayer and Frantz, 2004; Mayer and Frantz, 2008), a relationship they refer to as an individual's connection to nature. Schultz (2002) described an individual's connection to nature as "the extent to which an individual includes nature within his/her cognitive representation of self (p.67)." Mayer and Frantz have built their work on that of Leopold (1949), who believed that if people were to feel more connected to the natural world, they would treat it better. Their work, along with others, has provided evidence that feeling connected to nature is linked with environmentally friendly behaviour (Mayer and Frantz, 2004; Clayton, 2003; Gosling and Williams, 2010). They have even suggested that connection to nature can be a better predictor of environmental behaviour than knowledge of environmental problems (Mayer and Frantz, 2004). Individuals who are more connected to the natural world might possibly expand their sense of self to include other non-human living things, resulting in greater concern for the general biosphere (Gosling and Williams, 2010). Schultz (2002) also argued that the degree to which a person's cognitive self includes nature predicts the strength of his or her relationship with nature and indicates whether he or she will be more or less prone to environmentally friendly behaviour. Knowing that an individual's sense of connectedness to the natural world is linked to ecologically friendly behaviour, it is important to investigate the factors that might contribute to successfully motivating people towards completing environmentally friendly actions (Frantz *et al*., 2005).

## 2.6 Thesis Rationale and Questions

Educators and policy makers in environmental education are striving to improve environmental consciousness among students. There are an increasing number of programs and materials designed with the intent to produce such an end. Given the youthfulness of environmental education, researchers are still trying to determine what type of teaching programs and methods are most effective. In performing a meta-analysis on educational interventions that improve environmental behaviours, Zelezny (1999) noted that there was urgent need for high quality environmental education, particularly at the primary and high school levels, to advance "understanding of environmentalism and how it is related to maturation (p. 13)." We need to understand the attitudes and relationships that people have with nature and those things in it if we are ever going to be able to improve people's attitudes toward nature (Tikka *et al*., 2000).

Since much of the scientific language revolving around invasive species carries such high levels of negativity, and given the increased level of education about invasive species, it would be valuable to assess what students know and think about non-native and invasive species to see if, and how, they are reacting to these messages and whether their connection with nature is being changed. Adolescence is a significant period of cognitive advancement for an individual, but it is also marked by vulnerabilities to affective input (Crone, 2009).

Students may not even realize that most of the species that they experience daily are non-native (Foster and Sandberg, 2004; Larson, 2007; Knights, 2008). What students know and think about these species could play a role in how they feel about nature. Knights (2008) argued that interaction with a species plays a role in the conceptualization of whether that species is native. Since many of the invasive species in our society are well-established (Soule, 1990), and more are on the way (McIntosh *et al*., 2010), we can expect education initiatives on invasive species to continue. Educators need to understand students' attitudes and perceptions towards invasive species in order to create more effective educational materials that do not further alienate people from nature.

Using a group of students from four Grade 11 Environmental Science classes in the city of Guelph as a case study, this thesis examined the following questions: "How much do

adolescents know about invasive species and how does education affect their knowledge?" "What attitudes do adolescents have towards invasive species and how does education affect their attitudes?" and "To what extent does learning about invasive species alter adolescents' connection with nature?" Ultimately, this thesis will provide some of the research necessary to understand the development of adolescent attitudes to environmental learning material, as well as provide insight into how learning about a potentially negative environmental subject affects adolescents' connection with nature.

# 3. **Methodology**

## 3.1 Overview

A variety of methods could have been used to address the research questions posed by this study. Qualitative methods, such as interviews and focus groups, and quantitative methods, such as test scores and close ended surveys, are both viable methodologies to address the research questions. The two methodologies have important differences. Qualitative methodology takes a broad view of the world and the people and places within it. According to Creswell (2009), "qualitative research is a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem (p.4)." It produces multiple meanings and interpretations rather than implying one correct response (Winchester, 2005). On the other hand, quantitative research takes a more focused view of issues. According to Creswell (2009), it "is a means for testing objective theories by examining the relationship among variables (p.4)." Instruments are used to measure those variables that produce numerical data that can be analyzed using statistical processes (Creswell, 2009).

This study followed a pre-designed procedure to explore current education about invasive species in Wellington County, Ontario. I used survey methodology to collect a mixture of both qualitative and quantitative data. The use of close-ended questions provided statistical evidence, while the open-ended questions strengthened my interpretations by adding a qualitative perspective to them. I also interviewed the students' teachers, to add further depth and meaning to the survey results. These educators were the ones working directly with the students throughout the semester and witnessed firsthand their thoughts and reactions.

In addition, I followed a case study approach. According to Yin (1989), "a case study is an empirical inquiry that: investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used (p.23)." This research focused on a single case study that employed a survey questionnaire to assess how high school students from

Wellington County responded to learning about invasive species. The students completed the survey once, near the beginning of the course, before commencing lessons about invasive species, and then again, near the end of the course, after they had completed their lesson material on invasive species. Prior to the case study, a pilot study was conducted in order to evaluate the methods and procedures involved with the student surveys.

All study procedures and materials received full approval from the Office of Research Ethics at the University of Waterloo, the Wellington Catholic District School, and the Upper Grand District School Board. This included the survey proceedings and materials, including those utilized during the pilot study, as well as the interview proceedings and questions used when interviewing the educators.

### 3.2 Participants

The study was designed to consist of two groups, a study group and a control group. Bradshaw and Stratford (2005) describe typical case sampling as sampling that "illustrates or highlights what is considered 'typical', 'normal', or 'average' (p.72)." In this research both groups reflected typical Grade 11 Environmental Science students from Wellington County. The class is an elective and, according to educators with whom I discussed the course design prior to the study, typically contains a variety of students. Some students elect to take the class because they have an interest in Environmental Science while others take the class for different reasons, such as wishing to be in the class with their friends or because it fits conveniently into their schedule. Subsequent interviews with the teachers involved indicated this description matched the students participating in the case study.

Participants from the study group came from four Grade 11 Environmental Science classes within the Wellington Catholic District School Board (WCDSB). Two of the classes were in the same school and were taught by the same teacher; therefore, they were treated as one class. These classes were chosen because in addition to their regular classroom learning they would also be receiving instruction from staff at the Guelph Lake Nature Centre (one of five educational nature centres within the boundaries of the Grand River Conservation Authority). This provided a unique opportunity to access students who would receive

applied instruction, as well as classroom-based learning on the subject of invasive species. These students were to be granted an experience which is not made available to most students in the province.

The Grade 11 Environmental Science course offered in the WCDSB was designed in conjunction with the Grand River Conservation Authority. The intention is that students spend time in their classrooms, as well as on the grounds of the Guelph Lake Nature Centre. The students are meant to be introduced to the course in their classrooms for the first weeks of the semester, and then begin regular visits to the Nature Centre. During an average week, students receive instruction in their classrooms on Mondays and Tuesdays and visit the Nature Centre for instruction from Wednesday to Friday. The classroom teachers are responsible for education in the classroom and Nature Centre staff are responsible for education while on the Guelph Lake grounds. The format was designed to ensure that students spend approximately 60 % of their class time outdoors. Most of the students taking part in these courses tend already to be familiar with the Guelph Lake Nature Centre and its staff because students in the WCDSB typically visit the Nature Centre several times throughout their educational careers. The goal of the Grand River Conservation Foundation is to ensure that each student who resides within the boundaries of the Grand River watershed visits a nature centre at least three times between kindergarten and grade eight (Schneider, 2002). Each visit is intended to build upon knowledge gained from the last, and the visits allow students to develop relationships with both the Guelph Lake Nature Centre grounds and its staff.

Formal lessons at the Nature Centre generally involve students receiving instruction and demonstrations from staff for a variety of skill sets. After receiving instruction and viewing a demonstration, the students then practice the new skills on their own. Appropriate safety protocols are in place and there is both teacher and Nature Centre staff supervision; however, the students have a good deal of freedom.

Among the skill sets being taught in the Environmental Science course are identification techniques for various species, including native and invasive. The students might receive lectures on invasive species if they are discovered; however, there are also pre-

planned lessons where invasive species are discussed. Succession studies are one of the primary ways in which students are introduced to invasive species and there are several disturbed areas on the grounds which contain both native and invasive species. An example of a lesson activity for the students would be to calculate the percentage of non-native species in a specific area. Another specific lesson concerning invasive species focuses on the control of the invasive plant buckthorn (*Rhamnus cathartica*). Part of this lesson involves Nature Centre staff cutting down a buckthorn plant, and then asking the students why they might want to cut down a healthy living plant.

Students also learn about invasive species in their classrooms. The classroom teachers are responsible for designing the in-class portion of instruction; they might not elect to design lessons focusing specifically on invasive species, but the topic is often mentioned within other lessons. As a result, lessons and materials might differ from one class to another. Two examples of student activities prepared by some of the teachers are presented in Appendix C.

Effort was made to include a student control group which would also be learning about invasive species, but in a traditional classroom environment. The goal was to assess whether the survey results would vary based on the different learning environments. Unfortunately, the response rate was too low for a useful analysis. The returned survey packages contained a total of 15 complete copies of the pre-survey and the post-survey. Eight of those copies had to be matched based on identifiable penmanship and responses to demographic questions since the envelopes intended to keep individual students' surveys together had not been used. After further analysis, two matching pairs of surveys were eliminated due to a combination of incomplete sections and answers that demonstrated the students had not taken the exercise seriously. The remaining responses proved to be too few to properly complete the statistical tests used for analysis. As a result, there was no way to compare the two groups.

### 3.3 Pilot Study

Pilot studies are critical in evaluating the effectiveness of study methods or procedures (Hoggart, *et al*., 2002). They serve as a practice run and allow the researcher to evaluate the research instrument and make adjustments as necessary and also provide researchers with the opportunity to receive valuable feedback (McGuirk and O'Neil, 2005). Pilot studies should be run in precisely the same manner as the regular studies are intended to, and the participants should resemble those in the full study (Hoggart *et al*., 2002). Since most of the students participating in the pilot study were from a different course (Biology) and the others were from another stream, they did not perfectly resemble the students who would be participating in Guelph. There can also be problems related to demographic differences when the pilot group is selected from a different geographic location than the study group, and there was some potential for these problems to arise with this pilot.

This study was able to incorporate one pilot study to evaluate the methods and procedures used. The pilot study took place at a high school from the Upper Grand District School Board in Orangeville, Ontario. Orangeville is a considerably smaller community, and is located approximately 55 kilometres from Guelph. Two Grade 11 University stream Biology Classes and one Grade 11 Essential Stream Environmental Science class were available to participate in the pilot study.

The pilot study produced a total of fifty-four responses. It showed that the survey was generally satisfactory in that none of the students encountered much difficulty during the process and all students were able to complete it within 25 minutes.

A primary goal of the pilot study was to test the reliability of the Connection to Nature Scale (CNS) scale. While performing the alpha reliability test, 8 out of the 54 surveys were excluded due to incomplete data. Reliability of the CNS scale among the remaining 46 surveys was high ($\alpha = .845$), indicating that the scale held together well.

A factor analysis, often used to simplify data by identifying factors or themes, was conducted with the items used to assess the students' attitudes towards invasive species and produced a total of nine factors, which cumulatively accounted for 77 % of the variance. This was a relatively high number of factors, which likely meant that there were items within

the survey that were loading evenly on multiple factors (Harvey, 2010). Given time restraints, I decided against making changes to the survey before the study; the reliability of the CNS scale was high, and it appeared as though the students understood the questions and items within the survey (Harvey, 2010). The survey was therefore deemed satisfactory to complete the study.

### 3.4 Study Design and Treatments

The study used a pre- and post-survey design to investigate the knowledge and attitudes that adolescent students have towards invasive species. It also assessed the extent to which learning about invasive species alters a student's connection with nature. All teachers who agreed to have their class take part in the study were provided with a survey package. Each survey package contained a stack of large gold envelopes. The gold envelopes contained a copy of both the pre-survey and the post-survey. Attached to the pre-survey's front page was a green copy of a letter to the participating student (Appendix E), informing him or her about the survey and the research project. The gold envelopes also contained two white letter sized envelopes in which the students were to place their completed surveys.

The package also contained a series of supplemental materials (Appendix B) including information letters addressed to the teacher, principal, and science department head of the participating school, a list of instructions for the survey procedure, and a page labeled 'student questions' for the use of the classroom teacher to record any questions or events that might occur during the survey.

A questionnaire for the teachers designed to gather information about the lesson materials used to instruct the students about invasive species was also included. It included questions asking about which species were covered, as well as about the number of class hours spent covering the topic of invasive species. As a model, I used a questionnaire designed at the University of Zurich, Switzerland in 1995 (Lindemann-Matthies, 2002). I retained many of the Lindemann-Matthies questions, although some were modified to make them more appropriate for this study.

The final item in the survey package was a stack of brightly colored labels. The labels were part of a process suggested by Brown (2010) at the Department of Statistics and Actuarial Sciences at the University of Waterloo, which was designed to ensure the anonymity of the participating students. During the pre-survey, when the classroom teacher hands each student a large gold envelope, they would then hand the students a label as well. The students would write their name on the label and place it on the gold envelope. This would ensure that each student was given the same envelope at the time of the pre-survey and post-survey. Upon completion of the post-surveys the students, or teacher, could remove the label, ensuring the anonymity of the participant. This was important because of an agreement that had been arranged with the participating school boards that participation would remain anonymous.

### 3.5 The Instrument

The pre-survey and post-survey (Appendix A) were identical for both groups. The questionnaires consisted of six sections entitled Section A through Section F. Sections A through D were designed to assess the students' knowledge and awareness of invasive species. These sections were designed based on a review of government websites, outreach material from local conservation authorities, and high school textbooks. Sections E and F were designed to assess students' attitudes and perceptions towards invasive species, as well as their individual level of connection with nature. Students were instructed not to revisit previous sections of the survey once they were completed.

The surveys began with a short list of demographic and categorical questions. These questions asked the students to indicate their age, course stream (SVN3M/SVN3E.), gender, and whether they considered their upbringing to have been in primarily urban or rural locations.

Section A assessed the students' familiarity with the terms "native species" and "invasive species." Students were asked to label how familiar they were with these terms by circling a number on a five-point Likert scale with answers ranging from *not familiar* (1) to

*familiar* (5). Section A also asked students to provide an explanation for the term if they felt familiar with it.

On the following page, preceding Section B, was a paragraph which explained the terms native species, alien species, and invasive species. This paragraph was not visible to the students while they completed Section A. The purpose for this paragraph was to provide students with a brief reminder of the terms, or perhaps even an introduction to the terms if they were unfamiliar with them. This paragraph was necessary because the remainder of the survey focused a great deal on invasive species and it was important that students had a basic understanding of the terms so they could fully complete the survey. The paragraph was only included in the pre-survey. It was assumed that they would encounter the term at some point in their lessons between the pre-survey and the post-survey, and as a result this paragraph would no longer be needed.

Section B consisted of 13 True and False questions. For each item students were offered the following responses: *true*, *false* and *unsure*. The students were asked to circle one response per question. The unsure response offered students an active means of responding if they did not know the answer. I did not want the students to become overwhelmed if they did not know the answers to any of the questions. I feared this would discourage the students from attempting to complete the remainder of the survey. By offering the students the *unsure* option, they could select unsure for questions they did not know the answer to and still feel a sense of participation for those questions. It is also important to provide participants with choices that encompass all possible responses (Fowler, 2002).

Section C was designed to assess if the students were familiar enough with some invasive species to recognize images of them. It asked them to identify images of six relatively high profile invasive species. The species pictured in Section C were garlic mustard (*Allaria petiolata*), zebra mussels (*Dreissena polymorpha*), purple loosestrife (*Lythrum salicaria*), giant hogweed (*Heracleum mantegazzianum*), emerald ash borer (*Agrilus planipennis*), and sea lamprey (*Petromyzon marinus*).

Section D consisted of a 19 item species list. The students were asked if they believed the species listed to be native or invasive to Ontario. The students were offered three responses: *native*, *invasive*, or *unsure*. The list included the names of the species pictured in Section C. These names were included in case some students may have been aware of the name of the species but were not sure what it looked like. The list was composed of a mixture of invasive species and native species that could be found in the region of Guelph, Ontario, or nearby regions of Ontario.

Section E contained 42 Likert-scale items. These items were designed to assess the students' attitudes towards invasive species and their connection to nature. There are several approaches to measuring individuals' relationships with nature. One of the more familiar tools is the New Environmental Paradigm (NEP) scale, a 15 item scale that is designed to tap individuals' primitive beliefs about humanity's relationship with the natural world (Dunlap and Van Liere, 1978; Dunlap *et al*., 2000). However, the NEP does not assess an individual's experiential relationship with nature, but rather focuses on cognitive beliefs about humans as a collective and their combined relationship with nature (Mayer and Frantz, 2004).

Schultz created the inclusion of nature in the self (INS) scale (Schultz, 2001) and participated in creating a modified version of the Implicit Associations Test (IAT) (Greenwald *et al*., 1998), both of which were designed to assess individuals' relationships with nature. Unfortunately, the INS is a single item scale and it is not possible to assess single item scales for reliability (Schultz *et al*., 2004). The IAT also has disadvantages in that it requires a computer and low correlations are often found between IAT scores and behavioral measures (Mayer and Frantz, 2004).

For this study, I chose to use the Connection to Nature Scale (CNS) developed by Mayer and Frantz (2004) to interpret the students' relationships with nature. The CNS scale is designed to assess individuals' experiential sense of oneness with the natural world. Mayer and Frantz (2004) believed the scale had several potential applications, including use as a tool "to evaluate whether interventions aimed at increasing the contact of children or adults with nature actually increase their sense of feeling connected to nature (p.512)." The scale

includes 14 items to which participants respond on a 5 point Likert scale ranging from 1, representing strongly disagree, to 5, representing strongly agree. Items 4, 12, and 14 from the scale are reverse scored and the 14 items are then added together to create a total score, with a maximum possible score of 70 points and a minimum score of 14. This scale has demonstrated good internal reliability in past research ($\alpha = .84$ Frantz *et al*., 2005; $\alpha = .86$ Weinstein *et al*., 2009).

The CNS scale has received criticism. Perrin and Benassi (2009) argued that the CNS scale does reach a dimension of connectedness to nature, but does not reach an emotional connection. They have shown that the strong correlations found by Mayer and Frantz (2004) between participants' scores on the CNS scale and their environmentalism measure might have been better explained by "the self-referential nature of the CNS, the similarly positively toned wording of CNS scale items and environmentalism scale items, and the protocol used by Mayer and Frantz (2004) in their studies that included the CNS and environmentalism measures (p.439)." As a result, Perrin and Benassi (2009) produced recommendations for researchers who choose to use the CNS in the future. First, they suggested that researchers refrain from referring to the CNS as a measure of emotional connection to nature and instead focus on participants' beliefs about their relationship with nature. Secondly, they suggested researchers look to improve the language of the CNS by eliminating the word "feel" from the scale's items and replacing it with appropriate cognitive verbs. Thirdly, they suggested that future studies should be designed to take common method variance into consideration.

Taking the criticism of Perrin and Benassi (2009) into account, I still believe the CNS scale is well suited for this study. Based on Perrin and Benassi's criticism and advice of representatives from the Survey Research Center at the University of Waterloo, I made slight adjustments to the language of the CNS scale. Where feasible, I replaced the word "feel" with a more appropriate cognitive verb. For example, instead of the original item "I feel as though I belong to the Earth as equally as it belongs to me," the item read "I believe as though I belong to the Earth as equally as it belongs to me." I also adjusted the language to make it more appropriate for the participating students' age. For example, the item that

originally read “My personal welfare is independent of the welfare of the natural world” was changed to “My personal wellbeing is independent of the wellbeing of the natural world.” McSpurren (2010) advised that this wording would be more appropriate since the term ‘welfare’ might be associated with negative perceptions among high school students. There is a new version of the CNS scale intended for use with adolescents that has been fully validated; however, it has yet to be published, and was unavailable at the time the surveys were administered.

The remaining 28 items of Section E were designed to assess the students’ attitudes towards invasive species. Many of these items were modeled after items previously used in a variety of questionnaires designed to assess attitudes and perceptions of individuals towards a particular species, or a group of species. Some of these included dolphins (Barney *et al*., 2005), bats (Prokop *et al*., 2009), spiders (Prokop and Tunnicliffe, 2008), sharks (Thompson and Mintzes, 2002) and invertebrates (Kellert, 1993). Many of these questionnaires were based on the work of Dr. Stephen Kellert, from the Yale School of Forestry and Environmental Studies, one of the primary researchers in the field of attitudes toward nature and wildlife for the past several decades (Kellert, 1976; 1985; 1996; Kellert and Berry, 1980; Kellert and Westervelt, 1983). The remainder of the items were either created specifically for this study or modeled after a questionnaire drafted by Larson and Glass (2009).

Section F was an open-ended question asking the students how they felt about the state of nature. This section was designed to retrieve qualitative data regarding the students’ connection to nature, both before and after learning about invasive species. In the pre-survey, the question read “How do you feel about the state of nature?” On the post-survey, this question was changed to “After learning about invasive species, how do you feel about the state of nature?” Section F was not included in the original version of the surveys but was added after the pilot study in an attempt to retrieve a qualitative assessment of whether or not learning about invasive species would change the students’ perception of the state of nature.

### 3.6 Statistical Analysis

All survey data were originally entered in their entirety. Subsequently, after careful review of the surveys, I removed data for sections which a student had left blank or where responses were negligent. Examples of this neglect included: participants responding by creating a pattern (such as 1,2,3,4,5,4,3,2,1, etc.); participants making one large circle down a page as a means of showing their response for each individual question; or participants circling the same response through most of the survey. There were several instances where a student had inadvertently circled two different responses; these questions were treated as if they had been left blank.

Sections A through D of the surveys had been designed to assess the students' knowledge and awareness of invasive species. Each question was awarded a value of one point for each correct answer, providing a possible total knowledge score of 40. However, many of the students did not attempt to define the terms "invasive species" and "native species" in Section A. Also, many of those who did attempt to define these terms on the pre-survey did not attempt to define them on the post-survey causing some of these students' scores for Section A to decline. Due to the lower response rate to these two questions, and the multiple declining scores, I omitted them from the total knowledge score. The subsequent total knowledge score became 38.

I used paired *t* tests to compare the mean knowledge scores of the group as a whole on the pre- and post-surveys. This test was used because it allowed a direct comparison of individual students on the pre- and post-surveys; therefore, each student was compared against himself or herself. Students who had not completed both the pre-survey and the post-survey were not included in the comparison. I also used paired *t* tests for the comparison of knowledge scores for the individual Sections B, C, and D of the surveys. I then performed a one-way analysis of variance (ANOVA) to compare the change in students' total knowledge scores, as well as the scores for each knowledge section for the three participating classes of the study group.

The relationships between the students' change in knowledge and variables including the change in the CNS scale, the changes in individual items from the CNS scale and the

changes in each attitude statement were investigated using the Pearson correlation coefficient. Pearson's correlation coefficient was also used to examine the relationship between the students' change in the CNS scale and the changes in each attitude statement[2].

There were seven participants whose overall knowledge score declined. I examined these seven sets of surveys looking for any reason that could explain their decrease in overall knowledge score, such as a participant answering a section on the pre-survey and then neglecting that section on the post-survey or signs of the participants answering in a pattern during either survey. However, I found no discernible justification for the negative change in these 7 pairs of surveys, so they were included in the analysis.

Performing a factor analysis is a means of simplifying a data set by identifying themes, factors or dimensions which lie within the data. These themes or factors are realized by distinguishing sets of variables which have more in common with each other than other variables involved in the analysis (Meyers *et al*., 2006). Section E contained 28 items designed to assess the students' attitudes towards invasive species. The responses to these items for both the pre-survey and the post-survey were factor analyzed using the PASW Statistics 18 computer program. For both surveys the 28 items were subjected to a principal component analysis with varimax rotation. Due to the low sample size, missing data were replaced with the mean.

For the pre-survey, an initial analysis was run to obtain eigenvalues for each component in the data. The Kaiser-Meyer-Olkin measure (KMO) was used to verify sampling adequacy and Bartlett's test of sphericity was used to determine if the correlations between items were large enough for principal components analysis. Evaluating the scree plot is one of the best methods to determine the number of factors to retain in a factor solution, the cut off being where the slope of the line changes (Kline, 1994). However, the scree test is highly subjective (Meyers *et al*., 2006; Kline, 1994). Following a procedure described by Meyers *et al*. (2006), I examined a small range of factor solutions surrounding

[2] The correlations among the variables were interpreted at a significance level of $p = 0.05$. Some researchers argue for the adjustment of the $p$ value to account for multiple comparisons by performing a Bonferroni correction. It should be noted that after performing a Bonferroni correction, those correlations which were statistically significant at the $p = 0.05$ level were no longer significant.

the possible solutions indicated by the scree plot to aid in determining the number of components I would retain for the final analysis.

The factors were rotated to make the interpretation of the components easier and the varimax rotation strategy was selected since it was recommended by Field (2009) and is currently the preferred method of most researchers (Meyers *et al*., 2006). The elimination mark for a coefficient to achieve a level of practical worth varies amongst researchers. Kline (1994) suggested that anything above 0.6 is high, while anything above 0.3 is moderately high and anything below 0.3 can be ignored. Comrey and Lee (1992) classified coefficients greater than 0.7 as excellent, 0.63 as very good, 0.55 as good, 0.45 as fair, and 0.32 as a minimum. Tabachnick and Fidell (2001) echoed the sentiment that 0.32 should be seen as a bare minimum, and Stevens (2002) recommended the base level of 0.40. Based on the suggestion of Myers *et al*. (2006) that four or five items per factor should be the minimum number of items used to represent a factor; I selected an elimination mark of 0.44 that achieved a level of practical worth and presented enough items to represent the components revealed by the analysis.

### 3.7 Educator Interviews

Each of the classroom teachers and the lead resource interpreter from the Nature Centre were interviewed in person. The purpose of the interviews was to gain insight into the students' reactions to learning about invasive species, in addition to providing depth and meaning to the survey results. The interviews were semi-structured and contained a guiding script containing 17 questions that were organized into 4 topics (Appendix D). Following the suggestion of Dunn (2010), the questions were emailed to the educators in advance to allow the participants to contemplate the questions beforehand. The interviews were conducted at the schools and the Nature Centre. Each of the interviews ran slightly longer than 30 minutes and was digitally recorded. Both the hand-written notes and the voice recordings were transcribed for analysis. The responses were analyzed in a qualitative manner. They were not coded or reduced to specific words or categories; rather, themes were identified as they emerged. Some of the interview questions dealt with specific survey results and, during the

analysis, I made note of the responses concerning those results for discussion purposes. Similar procedures were taken when additional themes were discovered.

# 4. Results

## 4.1 Survey Results

The returned survey packages contained a total of 72 envelopes out of a possible 81, providing a response rate of 89 %. Class A returned 14 envelopes, class B returned 24 envelopes, and class C returned 34 envelopes. Unfortunately, not all the envelopes contained complete copies of the pre-survey and the post-survey. Some envelopes contained only one complete survey, and others contained surveys with responses clearly indicating the exercise had not been attempted in earnest. The selection of the unsure option presented to the students in Sections B and D varied by question. For Section B the unsure response rate ranged from 15.5% to 53.5% on the pre-survey and 6.3% to 31.3% on the post-survey; for Section D, the rate ranged from 18.3% to 71.8% on the pre-survey and 4.5% to 38.8% on the post-survey.

### 4.1.1 Knowledge

Of the students who attempted to define the terms "invasive species" and "native species", there were 10 who provided a correct definition of "invasive species" and 17 who provided a correct definition of "native species" during the pre-survey; 17 provided a correct definition of "invasive species" and 19 provided a correct definition of "native species" during the post-survey. There were a handful of students on both the pre- and post-surveys who defined invasive species as species that were not native to an area, but neglected to indicate that the species cause any harm. These definitions were not awarded a point. This section was excluded from the total knowledge score.

Students' familiarity with the terms invasive species and native species both increased after the learning experience (Table 1). The mean score for familiarity of the term "invasive species" increased by 0.95 ($p < 0.001$), and the mean score for the term "native species" increased by 0.44 ($p < 0.001$).

**Table 1. Two tailed *t* test comparison of students' familiarity with the terms "invasive species" and "native species" before and after instruction.**

| | | Pre-survey | | Post-survey | | |
|---|---|---|---|---|---|---|
| **Category** | **N** | **M** | **SD** | **M** | **SD** | **p value*** |
| Familiarity of the term "invasive species" | 63 | 2.92 | 1.20 | 3.87 | 0.81 | < 0.001 |
| Familiarity of the term "native species" | 63 | 3.40 | 1.09 | 3.84 | 0.95 | < 0.001 |

Overall, the students' knowledge scores increased for each individual section, as well as the total knowledge score (Table 2). The increases observed in each section, as well as the increase experienced by the total knowledge score, were significant. Average student scores for section B increased by 0.92 points ($p = 0.011$); for section C by 2.13 points ($p < 0.001$); and, for section D by 4.15 points ($p < 0.001$). The average total knowledge score increased by 7.20 points ($p < 0.001$).

**Table 2. Two tailed *t* test comparison of students' mean knowledge scores**

| | | Pre –survey | | Post - survey | | |
|---|---|---|---|---|---|---|
| Category | **N** | **M** | **SD** | **M** | **SD** | **p value*** |
| Section A | 68 | 0.40 | 0.65 | 0.53 | 0.78 | 0.151 |
| Section B | 63 | 6.86 | 2.58 | 7.78 | 2.22 | 0.011 |
| Section C | 67 | 0.61 | 0.82 | 2.75 | 1.76 | < 0.001 |
| Section D | 66 | 7.88 | 4.09 | 12.03 | 3.92 | < 0.001 |
| Total Knowledge Score | 66 | 15.05 | 5.58 | 22.24 | 6.31 | < 0.001 |

The results for the individual questions in Section B are presented in Table 3. There was a significant increase in the number of students who correctly answered that Canada has an action plan for invasive species. It is interesting to note that the percentage of students who correctly answered that most of the agricultural crops grown in Canada are not native to Canada, and the percentage of students who correctly answered that most alien species introduced to Canada do not become invasive, both declined.

**Table 3. Percentage of students who correctly answered true and false statements about invasive species before and after instruction.**

* Indicates change is significant at the 0.05 level (2-tailed). ** Indicates change is significant at the 0.01 level (2-tailed).

| Questions | Correct answers (%) pre-survey | Correct Answers (%) post-survey |
|---|---|---|
| Most agricultural crops grown in Canada are native to Canada. (**F**) | 38.6 | 24.6 |
| Invasive species are only a concern in some Canadian provinces. (**F**) | 70.4 | 76.6 |
| There are about 1500 invasive plant species found in Canada. (**F**) | 7.1 | 20.0* |
| Most alien species introduced to Canada become invasive species. (**F**) | 28.2 | 12.3* |
| Invasive species can create enormous economic losses. (**T**) | 77.1 | 84.4 |
| Invasive species can cause substantial ecological change. (**T**) | 73.5 | 86.2 |
| Canada has an action plan for invasive species. (**T**) | 23.9 | 54.7** |
| The Great Lakes are home to more than 150 alien species. (**T**) | 56.3 | 63.1 |
| Invasive species cost Canadian agriculture, fisheries and forestry billions of dollars a year. (**T**) | 48.6 | 57.8 |
| According to the World Conservation Union, invasive species are the second greatest threat to biodiversity. (**T**) | 50.7 | 61.5 |
| Some invasive species have impacts on human health. (**T**) | 73.9 | 82.8 |
| Many types of organisms, including plants, animals, and even bacteria, can become invasive species if they are introduced to Canada. (**T**) | 67.6 | 69.2 |
| People can contribute to the spread of invasive species when they introduce species into new areas. (**T**) | 76.1 | 84.6 |

The results for the individual questions in Section C are presented in Table 4. As was evident from the mean score for section C, most of the students were not able to identify the

pictures of the species. Before the learning experience none of the students was able to identify the picture of garlic mustard and very few students were able to identify purple loosestrife, giant hogweed, emerald ash borer or the sea lamprey. The most commonly recognized invasive species was the zebra mussel, with slightly under half of the students being able to recognize it. Correct answers for these identification questions rose significantly for each species. Zebra mussels remained the most recognizable, with nearly 80% of the students identifying its picture correctly after instruction.

**Table 4. Percentage of students who correctly identified pictures of six invasive species before and after instruction.**

** Indicates change is significant at the 0.01 level (2-tailed).

| Species | Correct answers (%) pre-survey | Correct answers (%) post-survey |
|---|---|---|
| 1) Garlic mustard (*Alliaria petiolata*) | 0 | 27.9** |
| 2) Zebra mussels (*Dreissena polymorpha*) | 43.7 | 79.4** |
| 3) Purple loosestrife (*Lythrum salicaria*) | 7.0 | 55.9** |
| 4) Giant hogweed (*Heracleum mantagazzianum*) | 2.8 | 33.8** |
| 5) Emerald ash borer (*Agrilus planipennis*) | 4.2 | 30.1** |
| 6) Sea lamprey (*Petromyzon marinus*) | 2.8 | 42.6** |

The results for the individual questions in Section D are presented in Table 5. There was a significant increase in the percentage of correct answers for eight out of the ten invasive species listed in Section D.

**Table 5. Percentage of students who correctly identified species as native or invasive before and after instruction**

* Indicates change is significant at the 0.05 level (2-tailed). ** Indicates change is significant at the 0.01 level (2-tailed).

| Species in question | Correct answers (%) pre-survey | Correct answers (%) post-survey |
|---|---|---|
| **Native species** | | |
| Walleye a.k.a pickerel (*Sander vitreus*) | 42.9 | 60.0* |
| Brook trout (*Salvelinus fontinalis*) | 59.2 | 54.4 |
| White trillium (*Trillium grandflorum*) | 44.9 | 67.6** |
| Sugar maple (*Acer saccharum*) | 63.8 | 75.76 |
| Largemouth bass (*Micropterus salmoides*) | 50.7 | 58.8 |
| Wild strawberry (*Fragaria vesca*) | 50.7 | 66.2 |
| Cattail (*Typha latifolia*) | 53.5 | 68.2 |
| Poison ivy (*Rhus radicans* L.) | 55.1 | 70.8 |
| Monarch butterfly (*Danaus plexippus*) | 57.1 | 70.6 |
| | | |
| **Invasive Species** | | |
| Garlic mustard (*Alliaria petiolata*) | 21.4 | 64.2** |
| Sea lamprey (*Petromyzon marinus*) | 37.9 | 67.2** |
| Zebra mussel (*Dreissena polymorpha*) | 58.0 | 86.6** |
| Periwinkle (plant) (*Vinca minor*) | 25.7 | 32.8 |
| Dog strangling vine (*Vincetoxicum nigrum*) | 30.0 | 46.3 |
| Emerald ash borer (*Agrilus planipennis*) | 18.3 | 72.1** |
| Round goby (*Neogobius melanostomus*) | 26.8 | 80.9** |
| Purple loosestrife (*Lythrum salicaria*) | 27.5 | 64.7** |
| Buckthorn (*Rhamnus cathartica*) | 21.4 | 37.3* |
| Giant hogweed (*Heracleum mantagazzianum*) | 27.5 | 63.2** |

The results of the ANOVA showed that, as expected, classes varied in their learning. The three classes were found to be significantly different in regards to their total knowledge change scores ($F_{(2,63)} = 5.38$, $p = 0.007$); their change in scores for section B ($F_{(2, 60)} = 3.71$, $p = 0.030$); and their change in scores for section C ($F_{(2, 64)} = 31.99$, $p < 0.001$).

### 4.1.2 Connection to Nature

The students indicated their connection to nature by responding to the items composing the modified version of the CNS scale. Their mean score on the scale did not change after instruction (Table 6).

**Table 6. Two tailed *t* test comparison of students connectedness to nature scores**

| | | Pre-survey | | Post-survey | | |
|---|---|---|---|---|---|---|
| **Category** | **N** | **M** | **SD** | **M** | **SD** | **p value*** |
| Connectedness to Nature Scale summed score (CNS) | 61 | 47.43 | 7.72 | 47.10 | 8.21 | 0.596 |

I also examined the relationship between the change in the students' knowledge and the change that occurred to the students' scores on the CNS scale. There was a small negative correlation found between the two variables (-0.051), but it was not statistically significant ($p = 0.696$).

In addition, I studied the correlation between the change in the students' knowledge and the change that occurred to individual items from the CNS scale. The change in the students' knowledge was found to have a small negative correlation with two CNS scale items. The smaller of the two correlations occurred between the change in the students' knowledge and the item from the CNS scale that read "When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature," ($r = -0.270$, $p < 0.05$). This statement is one of the three items which are reverse coded on the CNS scale; the negative correlation exists between the change in the students' knowledge and the original responses to the item. The second correlation occurred between the change in the students' knowledge and the item "Like a tree can be part of a forest, I believe I am embedded within the broader natural world," ($r = -0.329$, $p < 0.05$).

### 4.1.3 Attitudes

The initial analysis ran for the pre-survey revealed nine components with eigenvalues over Kaiser's criterion of 1 and together explained 74% of the variance. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO = .547. Bartlett's test of sphericity $\chi^2$ (df = 378) = 791.681, $p < 0.001$ indicated that correlations between items were sufficiently large for principal components analysis. The scree plot, figure 1, was slightly ambiguous and showed inflexions that would justify retaining both components 3 and 4. After evaluating two-factor through five-factor solutions I determined the three-factor solution was indeed the most logical of the four, and therefore determined the number of components I would retain for the final analysis. In combination these three components accounted for 42% of the variance. A minimum factor loading of 0.44 presented a minimum of 6 variables in each component for interpretation. Table 7 provides the factor loadings after rotation.

The items that cluster on the same components suggest that component 1 represents a concern towards invasive species as a threat or problem, component 2 represents an acceptance of invasive species, and component 3 represents feelings of anxiety towards invasive species. The names of the three components were chosen subjectively. The selection of the component names was driven by the nature of the most highly weighted items of each component. I evaluated the items that experienced higher loadings in their respective components and derived names that I felt represented the themes present among those higher loading items, as well as, the remaining items that loaded on the components.

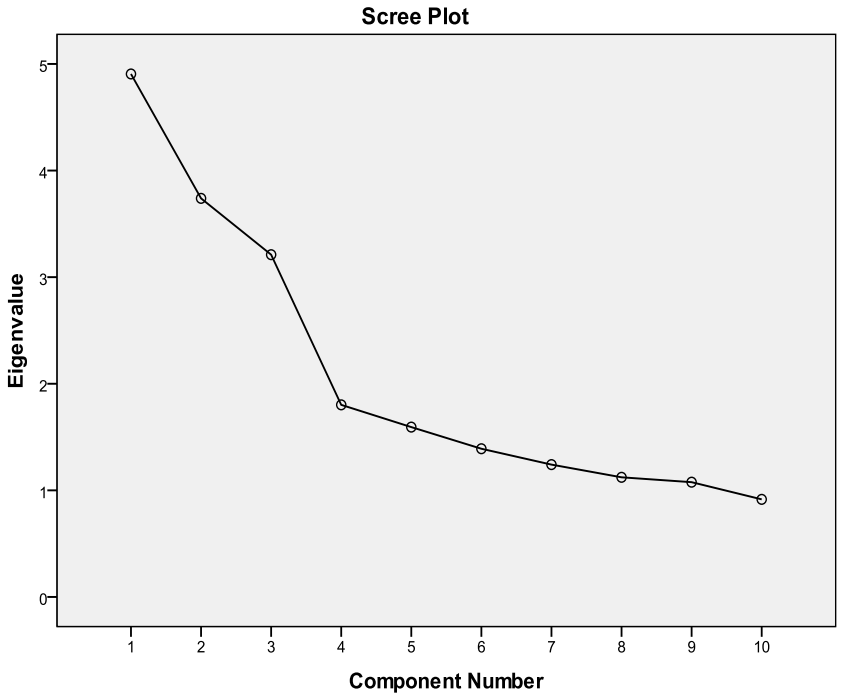


**Figure 1:** Scree plot of eigenvalues from the principal components analysis used to help determine the number of components from the pre-survey.

| **Table 7. Factor structure for the invasive species attitude items** | | | |
|---|---|---|---|
| *** Indicates items that were not included in the scales created for the components** | **Rotated factor loadings** | | |
| | | | |
| **Component 1**: concern about invasive species as a threat or problem | **1** | **2** | **3** |
| I believe invasive species have a negative impact on nature. | .700 | | |
| I am interested in learning more about invasive species found where I live. | .664 | | |
| I am worried that invasive species may cause the extinction of native species. | .661 | | |
| I believe that invasive species threaten species that I am familiar with and which I care about. | .646 | | |
| Invasive species should be controlled no matter how much money it might cost. | .642 | | |
| I believe invasive species are a tremendous problem for Canadians. | .577 | | |
| Whenever possible, I think we should remove invasive species to protect forest, agricultural and marine resources. | .534 | | |
| *I believe that humans are responsible for the problems caused by invasive species. | .511 | | |
| I do my best to ensure that my personal activities (pets, travel, etc.) do not contribute to the spread of invasive species. | .475 | | |
| I am personally familiar with the effects of one or more invasive species. | .455 | | |
| *The presence of invasive species decreases my enjoyment of nature. | .449 | | |
| | | | |
| **Component 2**: acceptance of invasive species | | | |
| I feel bad for the invasive species which are removed by conservation efforts. | | .783 | |
| I believe we should accept the presence of invasive species. | | .696 | |
| I believe that invasive species have as much right to exist as native species. | | .667 | |
| I believe that invasive species in my area have become part of who I am. | | .622 | |
| I like beautiful flowers and do not care whether they are native or not. | | .619 | |
| I believe that invasive species found where I live belong there. | | .588 | |
| *I am willing to commit my time and energy to removing invasive species from parks and natural areas. | | .549 | |
| I believe that invasive species provide variety in the natural world that we can enjoy. | | .516 | |
| | | | |
| **Component 3**: feelings of anxiety about invasive species | | | |
| I would be afraid to explore places that contain invasive species. | | | .760 |
| I believe that invasive species are an enemy and should be destroyed. | | | .695 |
| I would rather stay away from areas that contain invasive species. | | | .667 |
| I do not believe there is any hope that we can prevent the spread of invasive species. | | | .634 |
| Invasive species make me feel less connected to nature. | | | .579 |
| When I am around invasive species I get nervous. | | | .480 |

Similar procedures were used to assess the students' attitudes towards invasive species in the post-survey. The initial analysis ran for the post-survey revealed eight

components with eigenvalues over Kaiser's criterion of 1 and in combination explained 71% of the variance. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO = .664, and Bartlett's test of sphericity $\chi^2$ (df = 378) = 775.562, $p < 0.001$, indicated that correlations between items were sufficiently large for principal components analysis. The scree plot, fig. 2, was again slightly ambiguous, and once more showed inflexions that would justify retaining both components 3 and 4. After evaluating two-factor through five-factor solutions I determined the three factor solution was once more the more logical solution. The three factor solution for the post-survey accounted for 47% of the total variance.

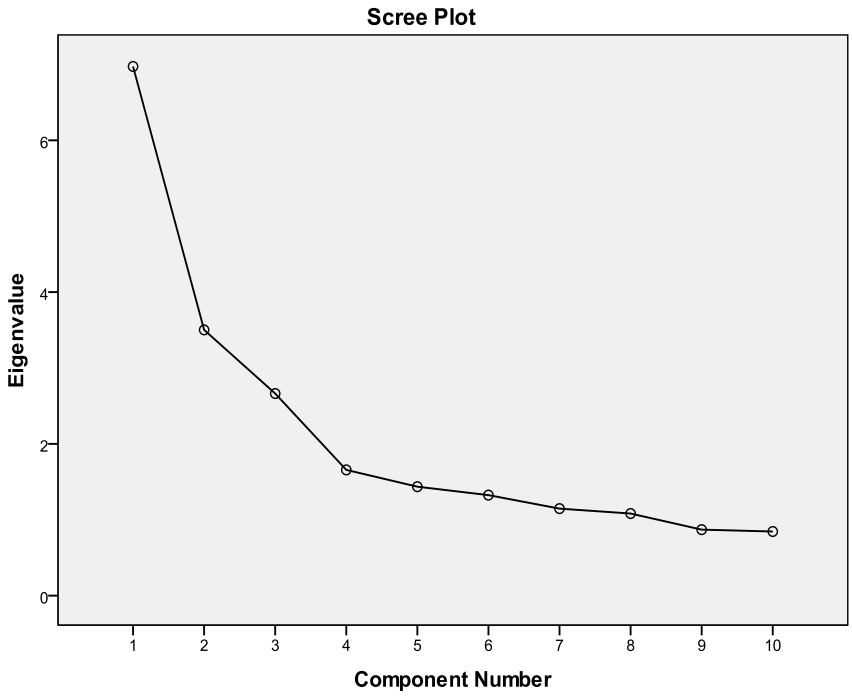


**Figure 2:** Scree plot of eigenvalues from the principal components analysis used to help determine the number of components from the post-survey.

**Table 8. Factor structure for the invasive species attitude items**

| *** Indicates items that were included in the scale created for the component** | **Rotated factor loadings** | | |
|---|---|---|---|
| | | | |
| **Component 1**: concern about invasive species as a threat or problem | **1** | **2** | **3** |
| I believe that invasive species threaten species that I am familiar with and which I care about. | .779 | | |
| Whenever possible, I think we should remove invasive species to protect forest, agricultural and marine resources. | .760 | | |
| I do my best to ensure that my personal activities (pets, travel, etc.) do not contribute to the spread of invasive species. | .738 | | |
| I am interested in learning more about invasive species found where I live. | .718 | | |
| I am worried that invasive species may cause the extinction of native species. | .715 | | |
| I am personally familiar with the effects of one or more invasive species. | .670 | | |
| I believe invasive species are a tremendous problem for Canadians. | .657 | | .468 |
| I believe invasive species have a negative impact on nature. | .606 | | |
| *I am willing to commit my time and energy to removing invasive species from parks and natural areas. | .538 | | |
| Invasive species should be controlled no matter how much money it might cost. | .521 | | |
| *I don't care about invasive species. | -.492 | | |
| | | | |
| **Component 2**: acceptance of invasive species | | | |
| I believe that invasive species provide variety in the natural world that we can enjoy. | | .800 | |
| I believe that invasive species have as much right to exist as native species. | | .730 | |
| I believe that invasive species in my area have become part of who I am. | | .717 | |
| *I do not mind the idea of seeing and touching invasive species. | | .620 | |
| I believe we should accept the presence of invasive species. | | .599 | |
| I feel bad for the invasive species which are removed by conservation efforts. | | .595 | |
| I believe that invasive species found where I live belong there. | | .549 | |
| I like beautiful flowers and do not care whether they are native or not. | | .519 | |
| | | | |
| **Component 3**: feelings of anxiety about invasive species | | | |
| I do not believe there is any hope that we can prevent the spread of invasive species. | | | .723 |
| Invasive species make me feel less connected to nature. | | | .687 |
| When I am around invasive species I get nervous. | | | .599 |
| I would rather stay away from areas that contain invasive species. | | | .591 |
| I would be afraid to explore places that contain invasive species. | | | .533 |
| I believe that invasive species are an enemy and should be destroyed. | | -.473 | .514 |

Table 8 presents the factor loadings after rotation. Once more, only those items possessing factor loadings of 0.44 or greater were interpreted. The items that cluster on the

same components suggest, as they did with the factor analysis results from the pre-survey, that component 1 represents a concern towards invasive species as a threat or problem, component 2 represents an acceptance of invasive species, and component 3 represents feelings of anxiety towards invasive species.

### 4.1.4 Factor Additive Scales

The results of the factor analysis performed with the pre-survey data and the post-survey data were similar. In the first component, 9 out of the 11 items remained the same, while 7 out of 8 items remained the same for the second component; the third component consisted of the same 6 items for each round of the factor analysis. The factor loadings of the individual items and the order in which they ranked on their respective components did fluctuate, but the themes suggested by the items remained the same.

I created an additive scale for each component using the items that had loaded on the component during both stages of factor analysis. The scales for the first two components held together well. The scale created for the first component, concern about invasive species as a threat or problem, produced alpha scores of 0.795 for the pre-survey and 0.884 for the post-survey, while the scale created for the second component, acceptance of invasive species, produced alpha scores of 0.801 for the pre-survey and 0.819 for the post-survey. The scale created for the third component, feelings of anxiety about invasive species, produced the lowest alpha scores, but still held together fairly well during both the pre-survey 0.738 and the post-survey 0.619. The mean scores of the scales remained relatively unchanged after the period of instruction (Table 9).

Additionally, the students' responses to the items comprising the scales were evaluated to determine what percentage of the students accumulated a score above half of the total score available for the scale. I interpreted these scores as an indication that these students identified with the themes suggested by the components from the factor analysis. The evaluation revealed that 77.9% of the students during the pre-survey and 75.8% during the post-survey were concerned about invasive species as a threat or problem; 47.1% of the students during the pre-survey and 46.8% during the post-survey were accepting of invasive

species; and, 19.1% of the students during the pre-survey and 14.5% during the post-survey were anxious about invasive species.

**Table 9. Two tailed *t* test comparison of attitude scales before and after instruction**

| | | Pre-survey | | Post-survey | | | |
|---|---|---|---|---|---|---|---|
| | **N** | **M** | **SD** | **M** | **SD** | **SE** | **P value*** |
| Scale for component 1: concern about invasive species as a threat or problem | 61 | 31.00 | 4.52 | 31.62 | 6.86 | .72 | 0.389 |
| Scale for component 2: acceptance of invasive species | 61 | 21.44 | 4.94 | 20.34 | 5.05 | .56 | 0.054 |
| Scale for component 3: feelings of anxiety about invasive species | 61 | 15.11 | 4.37 | 14.69 | 3.64 | .44 | 0.337 |

### 4.1.5 Change in Knowledge/Change in Attitudes

Correlations were also studied between the change in knowledge and the change that occurred with each attitude statement. The change in knowledge experienced a low negative correlation ($r = -0.290$, $p = < 0.05$) with the item "Invasive species should be controlled no matter how much money it might cost;" and a week positive correlation ($r = 0.286$, $p = < 0.05$) with the item "I believe that invasive species threaten species that I am familiar with and which I care about."

Correlations were also studied between the change that occurred in the CNS scale and the change that occurred in each of the 28 items regarding attitudes towards invasive species. Low correlations occurred between the student's change in the CNS scale and the following items: "I am interested in learning more about invasive species found where I live;" ($r = 0.335$, $p = < 0.01$) and "I believe that humans are responsible for the problems caused by invasive species" ($r = 0.283$, $p = < 0.05$).

### 4.1.6 Open-Ended Attitude Responses

The open-ended question (Section F) in the post-survey gave students an opportunity to express their opinions or feelings on the state of nature after having learned about invasive species. Some of their comments strongly resonated with the themes suggested by the components from the factor analysis. There were 53 viable responses to Section F; however, these responses varied greatly.

Examples of student responses that correspond with the first component (concern about invasive species as a threat or problem) include:

- "I believe that we need to take action and educate everyone about how to identify invasive species and prevent them from spreading in order to protect the lives of our native species;"
- "I believe, and did not know before, about the possible natural, ecological and economic loss potential that comes with invasive species. We must do something about invasive species;" and,
- "I feel that some parts [of nature] are in danger because of invasive species."

Among the examples of student answers that correspond with the second component (an acceptance of invasive species) are:

- "I feel that nature should not be threatened by invasive species because some invasive species have the right to be there as much as any other species;"
- "I feel fine. Over a certain amount of years other species will adapt to [the situation], and will learn how to deal with the invasive species;" and,
- "I believe that invasive species can be a problem but all sides of the situation must be calculated because sometimes they do more good than harm. Also, sometimes it is not worth a lot of time and money to remove them if they're not causing too much damage."

There were fewer student answers that correspond with the third component (feelings of anxiety about invasive species). The answer that most closely corresponds with the component is: "I still like nature but I will get a little nervous of invasive species being

around me." There were some answers that included terminology that could suggest anxiety, but the students went on to mention that they believe in nature's resiliency, with comments such as: "I worry about the effects of invasive species on natural ecosystems, but I believe in nature's amazing ability to adapt to change." This belief "in nature's amazing ability to adapt to change" appeared in other answers as well, and students providing these answers expressed less interest than some others in taking immediate actions to reduce problems caused by invasive species or to prevent their arrival.

There was great diversity among the students' responses, including those associated with the themes suggested by the components from the factor analysis. For example, the level of concern towards invasive species varied. There were eight students who felt that human action should be employed immediately to remove invasive species, while three indicated that human action could potentially make the problem worse and felt that no human action should be taken. There were also five students who identified human behaviours as the root cause of problems in the environment and included such statements as: "I think humans should be more careful;" and, "things will keep getting worse until we make some major changes to our lifestyle."

### 4.2 Interview Responses

The survey data analysis was mainly quantitative in nature, and focused on establishing a benchmark for the level of knowledge of, and attitudes towards, invasive species held by students in an Environmental Science program. It also provided a tool to help illustrate how these evolved during the course of the program. Conducting semi-structured interviews with the educators was a way to provide further depth and meaning to the survey results, as well as provide insight into the students' reactions to content on invasive species and the Environmental Science course in general. In addition, the interviews allowed educators the opportunity to comment on issues related to education about potentially negative environmental topics.

### 4.2.1 Learning Expectations

All of the educators predicted that most students would have little prior knowledge about invasive species. The following comment by the educator of class B was typical:

> I think they've heard of [invasive species], [but] I'd say [their knowledge is] relatively low. They may have heard of it, but … [they] don't really know a lot of species. And even if they've heard of some of the species, they probably wouldn't be able to identify them. They've probably heard of purple loosestrife, they've probably seen it, but I don't think they make the connection.

Each of the educators also predicted that, even among those students who were aware of invasive species, the level of that awareness would vary a great deal. As the educator of class A explained:

> …there might be a group of students who know very little, and then a group of students who know a little bit about it, and then there's a group of really keen students that eventually want to study, or go into … an Environmental Science related program … and they know a lot!

The educators were pleased to hear of the students' increase in knowledge scores. They also noted that the students are not expected to become experts on invasive species by the end of the course. Each of the educators also indicated that the subject is not one that receives a great deal of direct attention within the course material; instead, it is referred to in the context of other subjects (such as water quality, or terrestrial succession). The following comments from the educators of classes B and C regarding the importance of the subject of invasive species within the overall course were representative:

> I think we need to talk about it. It doesn't mean it's going to be the number one priority that we need to focus on … But, like I said, we'll come across invasive species throughout the semester and then that's when you would touch on them or talk about them.

> It's not huge for sure; we just mention it, like, when we look at terrestrial studies. They look at what species are native. So they have to know which ones are native and which ones are non-native. And then, just in doing that, which ones are invasive.

> So it sort of just kind of goes along with what we're talking about when we do our terrestrial study, but, it's not a major topic.

As these educators indicated, invasive species are not a topic that receives much direct attention within the course. However, they did mention that the subject is brought up frequently while discussing other topics and that it is an issue worthy of discussion. I asked the educator of class B what she hoped the students would take away from the experience of learning about invasive species in this course. She replied, "Well, I think just that they're aware of it, at least they know what an invasive species is and ways that invasive species spread. So, that at least they're not involved in spreading invasive species."

There is not a great deal of focus on invasive species within the curriculum expectations themselves, but since the course in this study was designed in partnership with the Grand River Conservation Authority, it is likely that more time was spent on the topic than there would have been otherwise. The lead nature interpreter indicated that the topic of invasive species held significant importance to the Conservation Authority. When asked how important the topic of invasive species was in the overall scheme of the course, he replied:

> …how important is it? - Very important. It fits into our restoration goals with the Grand River Conversation Authority. In a corporate way … we're involved in habitat restoration … and we don't want our natural areas … overrun by invasive species. We realize it's a huge issue, and do what we can to combat them.

As a result of the above concerns, invasive species are discussed frequently at the Nature Centre. Such discussions help to provide the students with a better picture of what it is like to work at the Grand River Conservation Authority or other Conservation Authorities within Ontario.

However, the main goal expressed by the educators was to provide the students with some general, and largely practical, knowledge about invasive species. For instance, they wanted the students to be aware of some of the locally found invasive species and of precautions the students could take to prevent spreading them. The educator of class A even

commented on how it was important to let the students know about these precautions because they were measures that various levels of government want the public to follow.

### 4.2.2 The Educators' Perspectives on the Students' Connection to Nature

The educators shared the opinion that this course was a great opportunity for some of the students to experience nature, especially those interacting with it for the first time. The educator of class B described some of the class activities and provided the following comment:

> They do spend a lot of time in the environment. We go camping for three days. For some students it's the first time they've ever been camping. I usually have a handful of students every year that have never been camping. So, it gives them an experience that they might not have with their family. And we don't have a car, so the bus drops us off and they have to hang all their food …they have to make sure that they don't have any food, or toothpaste, or whatever in their tent. So, it gives them an experience that they wouldn't [normally] get.

All of the educators indicated that, for the most part, those students who did not have much interaction with nature prior to the course really enjoyed the class and the outdoor experiences that went with it. They believed that the course offered a chance to affect the students' relationship with nature in a positive way. When asked what affects he hoped the course might have on students, the lead nature interpreter replied:

> …[learning to] push what they think their limits are, out farther … some kids have never camped before, some kids have never canoed, or been on a canoe trip … Treating it with more respect, it meaning nature. And [developing] a reverence, I hope, [I'd] even [go] that far, [a] curiosity and, just, comfort in it.

The educators all expressed a similar sense of hope that the course would leave a positive impact on the students and their relationship with nature. For the most part, the educators felt that the students truly enjoyed the class. The educator from class A mentioned, that after the semester finished, he had students approach him in the hallway and express how much they had enjoyed, and how much they missed, the course.

In addition to providing insight into the students' reactions to the amount of class time spent outdoors, the educators suggested a few possible reasons why the CNS scale did not experience any significant change and discussed whether providing instruction about invasive species could potentially alter the students' connection to nature.

Some of the educators indicated there were students in their classes who had a previously established appreciation for, and connection to, nature. These students were excited to be in the class and had chosen it because of the opportunity it provided for outdoor learning. For these students, this may have been their sole motivation for electing to take the course. The following comment by the educator of class C was typical: "a lot of the kids already have a connection to nature before they even come in [the class], so whether it's going to change or not…it might not change at all, right? Because they already have that [connection to nature]." She, as well as the others, felt that for those students who already spend a great deal of time outdoors, the experience of taking the course would not change their level of connection with nature.

Some educators also expressed uncertainty about whether or not the students were mature enough to experience a short-term change in their connection with nature, based solely on the knowledge learned in the course. The educator of class B, when asked whether the experience of the course could alter the students' connection to nature, replied: "I think they do appreciate the experience, but …they might not realize it right away. And we might not know the impact for a while." She believed that, for some of the students, the experience of the course may take time to cause a change in their individual levels of connection to nature. She also believed that some of the students may take the experience provided by the course for granted at the time and later come to a deeper understanding of their relationship with nature.

None of the educators felt that presenting students with knowledge about invasive species would be likely to alter their relationship with nature in a negative way. Some acknowledged it could be a slight possibility. In responding to the question of whether presenting invasive species in a negative light could alter a student's relationship with nature,

and if so, whether they had seen or heard any material that could so alter the relationship, the lead nature interpreter replied,

> Yeah … giant hogweed - "don't go outside because there's giant hogweed out there." Now we've got West Nile virus – "stay inside!" I mean, you've heard those ads. Those are disgusting. It's like you can't stir up [nature]…there's negative things [within it], [and] they're a threat. … it's so important [that]… you [don't] just dwell on them and say there's nothing the kids can do about it and that's it … you have to keep hope in there, right? One of them may be the ones to study it and come up with a solution....

He felt that the use of fear he had seen in advertisements was unnecessary. He felt that it was important for the students to know about potential dangers but that messages focusing on negative aspects should be coupled with positive messages. This was the only educator who indicated he had seen any form of public educational material that could be interpreted as scary or carried a message that might prevent students from wanting to go outside. The educator of class B recalled that, during the summer when dropping off their child at a daycare, there had been signs posted warning parents about the presence of giant hogweed in and around the grounds of the day care. She mentioned she found the information to be a little scary as a parent, but she did not feel the students found any of the species to be frightening. None of the other educators recalled seeing any educational materials that could possibly alter a student's relationship with nature in a negative way.

### 4.2.3 Lack of Interest

The educators indicated that not all of the students shared the same interest or enthusiasm levels in the course or in nature. Not every student was excited to take the course even though it was optional. Some of the educators indicated that some students selected the course because it fit their schedule, because their friends were in the course, or because they had been placed in the course by the school's guidance program.

Each of the educators also indicated that the weather (precipitation or cold temperatures) could have had a negative effect on the attitudes of the students in the class. The initial design of the study envisioned the post-surveys being completed only a few weeks

after the pre-surveys. I originally asked the classroom teachers to administer the post-surveys at their convenience upon the completion of instruction about invasive species; however, due to changes in the structure of the course, instruction about invasive species was not completed until December. The educators indicated that on cold or wet weather days, students who were not dressed appropriately had a difficult time focusing on the material, and some students simply did not come to class. So it could well have been the case that the delay into colder weather affected the level of interest of some students in the course and course material.

Another of the educators suggested that some of the students might not presently have a great deal of interest in nature due to competing interests related to their age. As the educator of class A noted:

> We have kids that are 15, 16, 17 years old, and [in] the big scale of things, what's important to their life? Is it nature or is it my iPhone, is it nature or is it my part-time job, is it nature or is it my game-boy, or whatever they're playing at home. So, it's a very small piece of what's important to them.

He indicated that such students may not pay particularly close attention to material presented in the course. As a result, these students may not benefit from the experiences the course offers in the same way as the other students. However, it should be noted that the educator was only referring to some of the students in his class who did not seem to care about the course, or nature, rather than the whole class.

### 4.2.4 The Educators' Perspectives on the Students' Attitudes

All of the educators indicated that none of the students would rank invasive species as a top priority in their lives; they also indicated that they had witnessed a moderate rise in interest about invasive species among some of the students. In particular, those students who had previously encountered invasive species outside of school, at their cottage or camping, seemed slightly more interested. Some of the educators also indicated that it was easier to get the students interested in the animal species rather than the plant species.

I also spoke with the educators about the students' attitudes towards invasive species and asked if they had seen or heard any of their students expressing feelings that could be associated with any of the three underlying themes suggested in the factor analysis. Their initial remarks were that it was rare for the students to express any sentiment at all towards invasive species. They did go on to indicate that when students referred to invasive species, they most commonly referred to them as a threat or a problem, but they did not recall any students expressing feelings of "acceptance" or "anxiety" about invasive species. These comments are somewhat at odds with some of the factor analysis findings, but it is perhaps worth noting that the educator interviews took place several months after the period of instruction and I had not asked the teachers to be mindful of their students' attitudes prior to the study. With the passage of time, it may have been difficult for them to accurately recall their students' attitudes during the period of instruction.

All of the educators also believed that, as was the case with their awareness of invasive species, there would be diversity amongst the students' attitudes about invasive species. Support for such an expectation was in fact found in the results of the additive scales created for the components suggested by the factor analysis (75-80% of the students being concerned about invasive species; 46-47% of the students experiencing feelings of acceptance about invasive species; and, 14-19% of the students being anxious about invasive species). In describing the potential diversity in attitudes amongst the students, the educator of class A exclaimed:

> You're going to have a group of kids that [say], "I'm here, I like going outside, oh there's invasive species here, no big deal." But you can have another group of kids who [say,] "yeah we should look at this" and another group of kids that [say], "oh man! That shouldn't be in there, you know what? If I catch it I'm going to kill it." So within your class there's diversity.

The educator from class A also felt that those students who are more knowledgeable about invasive species and have more experience with nature may be the students who take more of an interest in invasive species. He explained that other students may not have strong opinions about invasive species because they lack interest in the topic.

The educator of class C also indicated there was some diversity among her students' attitudes towards invasive species, and she echoed the thought that some of the students simply may not be concerned about invasive species. When asked if there might be any students who were worried about an invasive species taking over their natural area, she replied:

> I don't think they feel that [way]; I don't get that impression from them. I know they realize that … [But] it's probably not one of their number one concerns, right? "Ok, well this is buckthorn…well it's still here, it looks fine to me."

She said the students were mature enough to understand the concept of invasive species and the problems they are capable of causing. However, she still believed some students would simply not be concerned about invasive species.

I asked some of the educators in this study whether they believed students who do not care about invasive species may be less likely to follow the rules and regulations that govern such things as firewood restrictions or the planting of invasive species. The educators replied that, regardless of the answer to my question, at least those individuals would be informed about invasive species and aware of the possible consequences of disobeying the rules and regulations. The educator of class B also added that she believed most people, given the information, would make the right choice and follow the rules or restrictions.

## 4.3 The Broader Perspective

### 4.3.1 Positive Messages and a Sense of Empowerment

In addition to discussing the survey results and the students' attitudes about invasive species with the educators, I also asked for their comments on how they would approach teaching a potentially negative environmental topic such as invasive species, natural disasters, or climate change, and how they would present the information so that it still allows for a positive view of nature. All of the educators felt that informing students about negative environmental topics is necessary. They felt that even though some of the topics may seem overwhelming, the students still need to be made aware of the issues. The lead nature interpreter provided the following comment:

> I would say to a certain extent though…I mean we've got to be tough…what are we going to do? Do you give up on teaching about climate change because it's going to continue for the next fifty years no matter what we do? I mean we just do what we can to ameliorate [the situation]…

He stressed the importance of delivering information to the students even if the topic may be unsettling or seem overwhelming. However, each of the educators shared a belief that it is important to somehow include positive messages as well. The educators indicated that providing the students with a sense of hope is essential. The lead interpreter demonstrated this approach immediately following the above comment by going on to list several positive environmental messages. All of the educators provided their own positive messages at some point during the interview.

The educator of class C, while describing her approach to covering potentially negative environmental topics, provided the following comment:

> We're trying to teach them what's going on, but you don't want them to be always thinking about the negative part of what you're teaching them. I mean, they're there to learn about nature, and anything that is negative we may look at it from the perspective [of] "well how can we improve this" rather than being down about "this is terrible." What needs to be done? What can we do in the future?

The line of questioning at the end of her comment is evidence of an opinion shared by all the educators. They believed it was important that the students feel empowered after learning about a negative environmental topic. For example, they wanted to make sure the students were aware that their individual actions, including the small ones, could make a difference. When responding to the question of whether it is important to instill a sense of empowerment among the students, the lead interpreter replied:

> Yes, absolutely. Ownership of the solution, yeah, that's a big thing. It's important for them to be empowered … some of the kids get into this thinking they can make a difference … as professionals in the field [of] Education [or] resource management … … I think collectively as a group, [the Grand River Conservation Authority] feels good that they can work every day and make a difference.

The thrust of the interpreter's above comment was that he and other members of the Grand River Conservation Authority feel the course provides a good opportunity to instill a sense of empowerment in the students because the course gets the students outside in their local environment and allows them to take part in conservation activities.

### 4.3.2 The Influential Role of a Teacher

I asked the educators whether teachers have a responsibility to influence their students' attitudes towards invasive species - for example, should they encourage students to participate in the removal of invasive species on their own time? Some of the educators responded that it was important to provide the students with information and to allow the students to formulate their own opinions or attitudes. These educators felt this approach was of particular importance for a topic like invasive species, since they are just introducing the students to the topic. One of the educators indicated that after instruction students may search for more information on their own.

For a subject like invasive species, some of the educators indicated that a little bit of knowledge could be dangerous. A couple of the teachers worried about whether the students would be able to correctly identify invasive species on their own and wondered about the damage they could cause if they were not. As the educator of class C described:

> They may not be able to recognize them all the time; you're putting them in a situation where you're destroying something that they have to be sure they're supposed to be doing. Like if they're taking plants that are supposed to stay. Especially when you're in a provincial park where it says don't, or you're not allowed to do that.

She did not want to send students on a mission to remove a species that they could not properly identify and therefore did not feel comfortable suggesting that her students remove invasive species on their own time.

The educator of class A indicated why he felt it was important for the students to make their own decisions about their actions towards the environment: "it has to come from within … we can't tell you what to do. And, hopefully from seeing it, you can make some informed decisions as to what you should be doing with nature and so on." The point he was

emphasizing is that he believes the attitudes and choices that students achieve on their own would be stronger and longer lasting compared to opinions formed based on a teacher's suggestion.

I also asked the educators for their thoughts on their potential influence as a teacher on the students' relationship with nature. The educators indicated they felt there was a strong potential to influence the students' attitudes towards nature and the environment. Some indicated that simply bringing a positive attitude to the classroom can improve the students' attitudes towards nature. As the educator of class B stated:

> Whether you believe it or not, you're kind of their role model. So, your attitudes will definitely rub off on them. So, if you have a negative attitude towards the environment, or whether you have a positive [attitude] and try to convince them that there's solutions to these environmental problems, [that] we can recognize them and do something about it. So, I think your attitude definitely impacts them. And what you do as well. So if you say "don't use plastic water bottles", but then you show up every day with a plastic water bottle, then they notice.

She believes students are very perceptive and they are very aware of their teachers' actions. She indicated a teacher could have a positive influence on her students' relationship with nature simply by setting a good example. Students are very perceptive; they will watch teachers and notice things they do, both small and large.

The lead nature interpreter shared similar feelings on the influence a teacher's attitude could have on a student. When asked if an educator's actions could influence a student's relationship with nature he answered:

> Absolutely, right through high school … I wouldn't want to overstate it, but, there's a real mentoring role possible. Especially if the students are out of their comfort zone … if you show … your love of the whole thing and demonstrate it all the time it's … is it contagious? I don't know, but it could certainly influence how they feel about it.

His belief, that an educator can have a significant influence on their students' relationships with nature, was shared by all of the educators.

# 5. Discussion

## 5.1 Knowledge Analysis

### 5.1.1 Student Knowledge Before the Course

The results of the pre-survey revealed that overall the students had little knowledge about invasive species prior to taking the course. For example, their mean knowledge score for the pre-survey was only 15.05 out of 38 (39.6%), and aside from nearly half of the students correctly identifying zebra mussels, the scores for the remaining species that were pictured in the survey were very low, ranging from 0% - 7%. I interpreted the students' reluctance to define the terms "invasive species" and "native species" as further support of this analysis, while acknowledging it could also be due to other factors, such as lack of interest or motivation. This suggests that, at this stage of their education, the students had not been exposed to an extensive amount of material on invasive species.

The educators' expectations that the students would have little knowledge about invasive species, and that the level of awareness among students who were conscious of invasive species would vary, were supported by the survey findings. The pre-survey results revealed a small number of students who were able to identify more than one of the species pictured (10%). These students also scored higher than their peers in the remaining knowledge sections.

These results are consistent with the results of surveys performed by Colton and Alpert (1998) and Lindgren (2006). Each of these studies involved participants of various ages. Of the 206 participants surveyed by Colton and Alpert, both youth and adults showed very little awareness of invasive species. Lindgren (2006) surveyed 1470 anglers in Manitoba regarding aquatic invasive species. Among the anglers surveyed, those in the 0-20 age group provided the lowest awareness scores. The majority of the students in my study (54%) were not able to recognize any of the pictured species. However, as expected, among those students who did recognize a species, zebra mussels were the most frequently identified. The educators believed that the students in the study would likely have encountered zebra mussels at nearby lakes, cottages or on camping trips, or might have seen

park signs requesting patrons to take precautionary action to avoid introducing zebra mussels into a body of water.

Invasive species have been studied for decades, but it was the colonization of zebra mussels in North America in the late 1980's and the resultant media attention that really illuminated the problem for the public and policymakers (Marsden & Hauser, 2009). The study performed by Lindgren (2006) showed that 69% of those surveyed were aware of zebra mussels, even though zebra mussels are not found in the province. Lindgren's study also showed that while 69% of the respondents were aware of zebra mussels and 52% were aware of purple loosestrife, only 15% could name another aquatic invasive species, and many of the species named were not actually aquatic. These findings could be specific to the region, since zebra mussels had not yet arrived in Manitoba, and conservation efforts might have been focused on raising awareness in an attempt to prevent the arrival of this troublesome species.

I expected more students to identify giant hogweed after the media attention it received in Summer 2010. The pictures of giant hogweed used in the survey may have been part of the reason for the students' limited success. In hindsight, the pictures did not provide a fair representation of the size of the plant. There were a small number of students (pre-survey: 3, post-survey: 7) who identified the picture as wild carrot (also known as Queen Anne's lace), which is very similar in appearance, and based on the pictures, it would have been very difficult to distinguish the two plant species.

The scores for the six species in Section C were much higher in Section D, where the students were provided with the names of species and were asked to identify whether the species were native or invasive. This demonstrates that although some students may know the name of an invasive species, they may not actually know what the species looks like.

### 5.1.2 Learning Outcomes

The students acquired a considerable amount of knowledge about invasive species over the course, as evidenced by the increase to the mean knowledge scores. Their general knowledge of the topic increased, as well as their ability to recognize some of the high-

profile invasive species found locally. Increases in the mean scores for their level of familiarity with the terms "invasive species" and "native species" also indicated a greater knowledge of the topic. However, by no means did the students demonstrate what might be considered a high level of knowledge on the topic, as evidenced by the fact that even after instruction, their mean knowledge score had only risen from 15.05 to 22.24 out of 38. Based on the results of this study and other research findings, the educator of class C's remark that she did not want to send her students on a mission to remove invasive species seems well founded. A recent study of the Australian public's ability to distinguish between native and invasive frog species suggests that her concerns are warranted. Somaweera et al. (2010) tested the ability of 1328 participants to distinguish invasive cane toads (*Bufo marinus*) from native frogs at various life stages. They found error rates of 27-31% for eggs and tadpoles and 5-43% for sub-adult and adult frogs and suggested that any public collecting activities should be supervised by trained personnel. Given that the students in this study had difficulty identifying pictures of some high profile invasive species that could be found in their area, it is likely that similar, or greater, error rates would occur if students were expected to identify these species in the field with no expert assistance.

As expected, the students' knowledge scores varied among the three classes within the study group. As previously noted, the course itself was designed in conjunction with the Grand River Conservation Authority, with the Nature Centre staff playing a central role as educators in the program. Given that the Grand River Conservation Authority has a vested interest in promoting awareness of invasive species and preventing individuals from contributing to the spread of invasive species, there was almost inevitably going to be at least some focus on invasive species. However, even given this focus, a strong likelihood existed that the amount of attention devoted to this subject would vary. The educator of class B indicated that her background in environmental science and knowledge about invasive species made her comfortable in teaching such a topic. A teacher who was less knowledgeable about invasive species or who did not have a background in environmental science might be less comfortable discussing invasive species and might, therefore, spend less time on the subject. Perhaps the results of another study support this claim. In a study

assessing children's perceptions of the Brazilian Cerrado landscapes, Bizerril (2004) spent time talking to teachers and discovered that the less teachers know about the Cerrado, the less time they spent teaching about it, or they taught the subject poorly and moved on.

The classroom teachers in this study selected their own material to cover, as well as their own methods of instruction. For example, the educator indicated that the students in her class had completed a small research project on invasive species (Appendix C, Assignment A). The project involved the students presenting information about a chosen invasive species to their peers with a PowerPoint presentation. These presentations would most likely have exposed the students in this class to a larger number of species as well as more images of the species.

As with any evolving subject, new educational materials need to be created and it may take time to ensure materials are available that are relevant for all regions. As some of the educators in this study noted, it was more difficult to find educational materials about invasive species specific to Canada, as compared to the United States. However, the educators indicated that materials are now being distributed at science education conferences and that information produced by conservations authorities and wildlife organizations is available online, such as on the website invadingspecies.com, produced by the Ontario Federation of Anglers and Hunters.

Based on the results of this study, it appears that the goal of raising awareness about invasive species is being achieved. The students' surveys indicated that their familiarity with the term "invasive species" had increased and that their knowledge on the subject also improved significantly. Without a control group for comparison, it is not possible to say conclusively whether the students taking part in this unique course learned any more or less about invasive species than those students would have learned in a traditional classroom environment.

### 5.2 Connection to Nature

The mean summative score for the students' CNS scale experienced a low decline which was not significant. At least one previous study showed that immersing students in

nature increased their connectedness to nature (Weinstein *et al*., 2009). Based on this result, and the percentage of class time the students were spending outside, it would be expected that their score on this scale would increase. Some students experienced an increase in their summative CNS scale score, while others experienced a decrease. However, without a control group for comparative purposes, any attempt to determine whether the results experienced by the students in these courses would differ from results experienced by students in a traditional classroom environment would be inconclusive.

The students' increase in knowledge experienced low negative correlations with the items "When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature" ($r = -0.270$, $p < 0.05$), and "Like a tree can be part of a forest, I believe I am embedded within the broader natural world" ($r = -0.329$, $p < 0.05$). As the students went through the course, they not only learned about nature and invasive species, but also learned about ways to control both. Since they were learning about management techniques for land conservation, possibly students began to feel they had control over nature, which resulted in their feelings of being at the top of a hierarchy that exists in nature. Learning about ways to control nature may have also led the students to perceive it as something separate from themselves.

Even though the change in the students' mean CNS scale score was not statistically significant, based on the educators' responses, it does appear that there were opportunities to further develop a relationship with nature that some individual students might have taken advantage of. It was also reassuring to hear that only one of the educators was aware of informational material that, in his opinion, could have a negative impact on a student's relationship with nature and he consciously avoided using any of those materials in his instruction.

### 5.3 Attitudes

The attitude components revealed by the principal components analysis were particularly noteworthy. The Colton and Alpert (1998) study revealed that the youths they surveyed were concerned about the impact non-native species would have on native species.

This sentiment would be shared by the students in this study (approximately 75-78%) who identified with the theme found within the first component: concern about invasive species as a threat or problem. Also, given current concern about the effects on the public of using fearful language to describe invasive species it is not surprising that the principal component analysis revealed an attitude component that pointed to feelings of anxiety towards invasive species.

The attitude components varied little after the learning experience. There was a small but statistically insignificant increase in the scale created to represent the first component and small but statistically insignificant decreases in the scales created to represent the second and third components. Similar results were found in a study performed by Braun *et al*. (2010) in which 53 students completed an educational program on non-native species. Students completed a questionnaire which contained 11 questions designed to assess their attitude towards the value of non-native species. The students, who ranged in ages from 11 to 14, experienced an increase in knowledge, but, as with my study, their attitudes towards non-native species did not change as a result of their learning.

The change in the students' knowledge experienced a low negative correlation with the following attitude item: "Invasive species should be controlled no matter how much money it might cost" ($r = 0.335$, $p < 0.01$); and a low positive correlation with the item: "I believe that invasive species threaten species that I am familiar with and which I care about" ($r = 0.283$, $p < 0.05$). Prior to instruction, the students may not have realized the effort and cost that managing invasive species entails and, after learning about the challenges and costs associated with managing invasive species, the students may no longer have been sure if the cost associated with invasive species is warranted. In addition, it may be difficult to convince those students who do not perceive invasive species to be a major threat that a great deal of money should be spent on managing them, as opposed to health care or education. However, this potential explanation differs from the results of a recent study in the United States. McIntosh *et al*. (2010) surveyed 2,433 households in 2007, using a survey designed to elicit donations for delaying the introduction of aquatic invasive species (their premise was that, ultimately, introduction was inevitable). They found that the average household was

willing to make a one-time donation of $48 that accumulates to nearly 4 billion dollars for all American households - far above the $394 million the U.S. federal government allocated to the management and prevention of invasive species in 2006, suggesting that the current U.S. federal funds spent on managing invasive species are justified.

Furthermore, as the students learned more about invasive species, they learned about how invasive species can out-compete native species, possibly pushing them towards extirpation or extinction. It is therefore understandable that the students would increasingly perceive invasive species as a threat to native species after the learning experience.

The factor analysis results suggest there is an underlying theme of feelings of anxiety towards invasive species experienced by the adolescents in this study. However, these feelings probably only affected a minority of students since only 19.1% and 14.5 % of the students were associated with this theme during the pre- and post-surveys respectively. In addition, these feelings were generally not expressed by the students in written answers, and, as noted previously, the educators did not recall the students expressing any feelings that could be identified as anxious. The educators believed that even if some students did experience anxiety about invasive species, these feelings would not be severe enough to prevent them from exploring nature. The course was an elective, and, as the teachers mentioned, there were several students who opted to be in the course largely because of the opportunity to be outside. It is possible these students were more comfortable with nature and invasive species than other students who did not elect to take such a course and, as a result, were less likely to experience anxiety about invasive species.

The fact that the adolescents in this study did not express many feelings of anxiety about invasive species could in part be because of the educators involved in this study. In addition to often acting as the messengers conveying new information to students, the teachers may also be acting as a barrier against, or filter for, the language used to address the subject. The educators in this study expressed a desire to inform the students and to allow them to formulate their own opinions. Even though the lead nature interpreter, as an employee of the Grand River Conservation Authority whose objectives include the protection of natural areas and biodiversity, may have had an interest in fostering a concern about

invasive species, he also appeared, based on his overall interview, to have an overarching goal of making the students more comfortable in it. Although he referred to the management of invasive species as a battle once or twice during the interview, his language was not that of a general preparing new recruits in the war to protect native nature against invasive species. It therefore seems quite likely that the educators played a kind of prophylactic role, at least to some extent, in terms of the language about invasive species the students were exposed to. It is worth noting, however, that their efforts might not be enough. Teachers are just one of the sources of information to which students have access. Print, broadcast, and online media all carry stories about invasive species and are accessible to viewers of all ages. As Gobster (2005) pointed out, fear appeals are often included when informing the public about invasive species in an attempt to raise support for management efforts. O'Neil and Nicholson-Cole (2009) found that the use of fear appeals when informing the public about climate change produces unintended results such as desensitizing viewers, lessening their trust of the agencies providing the information, and contributing to feelings of denial and apathy. It is unknown whether these results would transfer to the subject of invasive species, but if it is indeed the case that the use or non-use of certain kinds of language can have a significant effect, then Larson's (2011) suggestion that scientists should perhaps choose their metaphors and language more carefully should not be ignored.

The educators' observations that the students were more interested in animal species than plant species, and that most of students did not seem to care a great deal about invasive species, did not come as a surprise. Previous studies have found animal species to be of greater interest to children and adolescents than plants (Bjerke *et al*., 1998; Lindemann-Matthies, 2002, 2005; Morgan, 1992). And as an educator myself, I have noticed that it is often difficult to get young students interested in almost any school subject material. However, as Wray-Lake *et al*. (2009) found, the level of concern among adolescents about environmental issues in particular has been declining for several decades. They assessed data from the *Monitoring the Future* study, a national study of high school seniors in the U.S. conducted annually since 1976 that gathers data on a wide range of topics, including environmental issues. Wray-Lake *et al*. assessed data from a sample size of roughly 100,000

from 1976 – 2005 and found that adolescents' environmental concern declined through the 1980's, 1990's and into the new millennium.

It was also reassuring to see that the educators in this study shared the belief that they could potentially have a significant influence on their students' relationship with nature and their attitudes towards the environment. The thoughts shared by these educators regarding their influential role are very encouraging, especially since teachers and school-related role models have been found to be highly influential on adolescents developing their understanding of the environment (Sivek, 2002).

# 6. **Conclusions**

This project was designed to assess the knowledge and attitudes that adolescents taking part in an Ontario Environmental Science program have about invasive species, and to try to determine if learning about invasive species altered their connection to nature. To address these questions I surveyed Grade 11 students from Guelph, Ontario, before and after they received instruction on invasive species during an Environmental Science class that was designed in partnership with the Grand River Conservation Authority. These students received both regular instruction from their classroom teachers and field instruction from staff at the Guelph Lake Nature Centre. Interviews performed with the classroom teachers and lead interpreter from the Nature Centre provided additional insight into the survey results, the students' reactions to instruction on invasive species, and the course in general.

The study was successful in assessing the students' knowledge and attitudes about invasive species. The students' knowledge of invasive species varied, but generally the students knew very little about invasive species at the beginning of the course. However, their knowledge increased significantly by the end of the course, indicating that the course was successful in raising the students' awareness about invasive species. The students' attitudes towards invasive species also varied. A factor analysis of the students' surveys revealed three underlying attitude components about invasive species: concern about invasive species as a threat or problem (75-78% of the students); acceptance of invasive species (46-47% of the students); and, feelings of anxiety about invasive species (14%-19% of the students). The students' attitudes towards invasive species remained relatively unchanged after instruction. The educators did indicate that some students referred to invasive species as a threat or problem; however, they did not recall the students expressing feelings that could be interpreted as acceptance of invasive species, or anxiety about invasive species. Generally, their perceptions of the students' attitudes towards invasive species were that most of the students did not care about invasive species either before or after learning about them.

The results of this study suggest that learning about invasive species did not alter the adolescents' connection to nature. Individual students did experience fluctuations in their

summative CNS scores, but the CNS scores did not reveal any changes in the students' connection to nature as a group. The interviews with the educators provided possible reasons for the scores remaining unchanged, including the fact that some students may already have had a previously established connection to nature.

Outdoor education is a unique and powerful education tool. The results of this study are proof that a course such as this can be successful in raising the students' awareness about environmental issues. The results of this study also provide evidence that a group of enthusiastic educators can provide instruction about a potentially negative or seemingly overwhelming environmental topic in a way that does not alter the students' connection to nature in a negative way.

This research focused on one region of Ontario, but I believe the results are also valid in a larger context. As previously indicated, several studies that assessed dispersion properties of invasive species included suggestions for an increase in public education and outreach initiatives to raise awareness about invasive species, motivate behavioural change, and foster public support for management initiatives. The results of this study suggest that while such education and outreach efforts might succeed in raising awareness about invasive species, they might not be successful in altering attitudes in a way that motivates behavioural change, or that fosters support for management initiatives. In this study, as the students' knowledge about invasive species increased, their attitudes about invasive species remained largely unchanged. These findings were echoed by several of the educators, who in their interviews observed that many of the students did not seem to care about invasive species before or after learning about them. These results could be of particular interest to future management planners, since the level of concern about invasive species among the general public could remain static despite a thorough education program.

These findings have also helped to create an understanding of the effect that learning about invasive species has on student perceptions of invasive species. This understanding will help teachers, conservationists, and naturalists create more effective educational materials on the subject of invasive species. The lessons learned from this project could quite likely be transferrable to other environmental educations subjects, as well.

The combination of surveys and educator interviews in this study worked well to address the research questions at hand. The survey itself, although designed for the research questions posed by this study, has potential practical use as well, given that at least one of the classroom teachers in this study has indicated that she plans to use the survey herself to assess the knowledge and attitudes of her future students and to monitor the results of different methods of instruction about invasive species.

### 6.1 Implications for Future Research and Education

Based on the findings from this study and my experience from working on this thesis research project over the last two years, I offer the following suggestions for future research and education policy regarding student attitudes towards environmental topics such as invasive species.

I do not think that the theme revealed by the third component, "feelings of anxiety about invasive species," should be ignored because the educators did not witness these feelings being expressed by the students, and few students provided a written response that identified possible feelings of anxiety. Educators should remain prudent when discussing potentially negative and overwhelming environmental topics. The dangers of creating adverse effects such as excessive fear about elements commonly found in the natural world should not be taken lightly. With students already facing a disconnect from nature, their relationships with nature should be encouraged and fostered. Providing youths with environmental education can be an extremely important part of this process and we cannot afford to accidentally increase students' fear of nature. Future research should continue to explore areas where increased fear or anxiety could be unintentionally produced.

The Connection to Nature Scale has proved itself to be highly reliable, both in previous studies and in this one. Although the scale did not reveal any changes in the students' connection to nature as a group, the results did reveal that changes were experienced by some individual students. Future researchers may benefit from coupling interviews with the use of the scale. These interviews could be performed with students who experience increases or decreases in their summative scales and the interviews could provide

insight into why certain students experience the changes that they do. Interviews could also provide students with the opportunity to describe their attitudes and perceptions in their own words, without being limited to the choices presented by a survey. Unfortunately, such interviews were not possible in the current study. In order to comply with the confidentiality policies of the particular school boards involved, this project was designed to retain the anonymity of participating students. As a result, I was not allowed to interact directly with students or allowed to know the identity of individual students, including those who experienced substantial changes.

Future research may also benefit from focusing on a younger age level. Students as early as the 6$^{th}$ grade in Ontario are expected to know about invasive species, and recent articles in trade publications directed towards practicing teachers provide evidence that invasive species are being discussed even earlier in other regions. Messages concerning the potential economic and environmental damages that invasive species are capable of causing may be interpreted differently at different age levels, and it would be beneficial to learn what these differences might be.

The results of this study suggest that simply educating people on the subject of invasive species may not be enough to change attitudes or behaviours that contribute to the spread of invasive species. Consequently, future research might explore a variety of educational programs and materials to see which are most successful at creating positive change in the attitudes of participants. Case studies where eradication efforts have been supported by the community, or in which community members have participated in eradication efforts, could also be explored to see what prompted those members of the community to support management efforts.

The findings from this study also point to the following suggestion for improvement to educational practices involving potentially negative environmental issues such as invasive species. As the educators in this study indicated, not all educators share the same level of knowledge about invasive species. It may be beneficial to provide training programs on invasive species to teachers, or at least make optional programs available for those teachers who are less knowledgeable on the subject.

The educators in this study also noted some key issues related to instruction about potentially negative environmental topics. The educators indicated the importance of providing instruction on all issues, including those that may seem overwhelming. However, they felt it was important to provide positive messages along with negative so that students are not left feeling hopeless. The educators also indicated that it was important to provide students with a sense of empowerment and ownership of solutions, and to let them know that their actions, including small ones, can make a difference. These are positive approaches that all educators could benefit from, and that could be used when dealing with any potentially overwhelming environmental subject.

If one of the goals of environmental education is to raise a more environmentally conscious generation, then we must make an effort to understand the learning process aimed at achieving this goal. We need to be aware of the attitudes that today's youth have towards the environment and to be mindful of the educational methods that influence those attitudes so that we avoid adverse effects. Since research suggests that environmental concern among young people is waning, those of us who consider ourselves to be environmental educators have our work cut out for us. The relationship between environmental knowledge and attitudes is complex; however, if we continue to make efforts to understand this relationship we will be able to adapt and improve our educational practices to produce future generations of environmentally conscious citizens.

## References


Alexander, J., & Lee, C. (2010). Lessons learned from a decade of sudden oak death in California: Evaluating local management. *Environmental Management, 46*(3), 315-328.

Alwin, D.F., & McCammon, R.J. (2003). Generations, cohorts, and social change. In J.T. Mortimer & M.J. Shanahan (Eds.), *Handbook of the life course* (pp. 23-49). New York, NY: Plenum.

Aslan, C.E., Hufford, M.B., Epanchin-Neill, R.S., Port, J.D., Sexton, J.P., & Waring, T.M. (2009). Practical challenges in private stewardship of rangeland ecosystems: Yellow starthistle control in Sierra Nevadan foothills. *Rangeland Ecology & Management, 62*(1), 28-37.

Barney, E.C., Mintzes, B.J., & Yen, C.F. (2005). Assessing knowledge, attitudes, and behavior toward charismatic megafauna: The case of dolphins. *Journal of Environmental Education, 36*(2), 41-55.

Bennett, K. (2010). Citizen scientists. *Science and Children, 48*(1), 50-53.

Bixler, R.D., & Floyd, M.F. (1997). Nature is scary, disgusting, and uncomfortable. *Environment and Behavior, 29*(4), 443-467.

Bixler, R.D., Floyd, M.F., & Hammitt, W.E. (1994). Observed fears and discomforts among urban students on school field trips to wildland areas. *Journal of Environmental Education, 26*(1), 24-33.

Bizerril, M.X.A. (2004). Children's perceptions of Brazilian Cerrado landscapes and biodiversity. *Journal of Environmental Education, 35*(4), 47-58.

Bjerke, T., Odegardstuen, T.S., & Kaltenborn, B.P. (1998). Attitudes toward animals among Norwegian children and adolescents: Species preferences. *Anthrozoos, 11*(4), 227-235.

Boorse, D. (2004). Teaching environmental ethics: Non-indigenous invasive species as a study of human relationships to nature. *Worldviews: Environment, Culture and Religion*, *8*(2-3), 323-335.

Bradshaw, M., & Stratford, E. (2005). Qualitative research design and rigor. In I. Hay (Ed.), *Qualitative research methods in human geography* (2nd ed.) (pp. 67-76). Melbourne, Victoria: Oxford University Press.

Braun, M., Buyer, R., & Randler, C. (2010). Cognitive and emotional evaluation of two educational outdoor programs dealing with non-native bird species. *International Journal of Environmental and Science Education*, *5*(2), 151-168.

Brewer, C.A. (2001). Cultivating conservation literacy: Trickle down is not enough. *Conservation Biology*, *15*(5), 1203-1205.

Brown, J.H., & Sax, D.F. (2004). An essay on some topics concerning invasive species. *Austral Ecology*, *29*(5), 530-536.

Brown, S. (2010). Personal communication, message to the author. Professor, Department of Statistics and Actuarial Science, University of Waterloo. September, 17.

Cadotte, M.W., Murray, B.R., & Lovett-Doust, J. (2006). Evolutionary and ecological influences of plant invader success in the flora of Ontario. *Ecoscience*, *13*(3), 388-395.

Clavero, M., & Garcia-Berthou, E. (2005). Invasive species are a leading cause of animal extinctions. *Trends in Ecology and Evolution*, *20*(3), 110.

Clayton, S. (2003). Environmental identity: A conceptual and an operational definition. In S. Clayton & S. Opotow (Eds.), *Identity and the natural environment* (pp. 1-24). Cambridge, MA: MIT Press.

Clements, R. (2004). An investigation of the status of outdoor play. *Contemporary Issues in Early Childhood*, *5*(1), 68-80.

Colautti, R.I. (2005). In search of an operational lexicon for biological invasions. In Inderjit (Ed.), *Invasive plants ecological and agricultural aspects* (pp. 1-15). Retrieved from http://www.springerlink.com/content/qv080u/#section=533515&page=1

Colautti R.I., Bailey S.A., van Overdijk C.D.A., Admunsen K., & MacIsaac H.J. (2006). Characterised and projected costs of nonindigenous species in Canada. *Biological Invasions, 8*(1), 45-49.

Colautti, R.I., & MacIsaac, H.J. (2004). A neutral terminology to define 'invasive' species. *Diversity and Distributions, 10*(2), 135-141.

Colton, T.F., & Alpert, P. (1998). Lack of public awareness of biological invasions by plants. *Natural Areas Journal, 18*(3), 262-266.

Comrey, A.L., & Lee, H.B. (1992). *A first course in factor analysis* (2nd ed.). Hillsdale, NJ: Erlbaum Associates, Inc.

Creswell, J.W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.) Thousand Oaks, CA: Sage.

Crone, E.A. (2009). Executive functions in adolescence: Inferences from brain and behavior. *Developmental Science Review, 12*(6), 825-830.

Daab, M.T., & Flint, C.G. (2010). Public reaction to invasive plant species in a disturbed Colorado landscape. *Invasive Plant Science and Management, 3*(4), 390-401.

Daehler, C.C. (2001). Two ways to be an invader, but one is more suitable for ecology. *Bulletin of the Ecological Society of America, 82*(1), 101-102.

Dunlap, R.E., & Van Liere, K.D. (1978). The "new environmental paradigm": A proposed measuring instrument and preliminary results. *Journal of Environmental Education, 9*(4), 10-19.

Dunlap, R.E., Van Liere, K.D., Mertig, A.G., & Jones, R.E. (2000). Measuring endorsement of the new ecological paradigm: A revised NEP scale. *Journal of Social Issues, 56*(3), 425-442.

Dunn, K. (2010). Interviewing. In I. Hay (Ed.), *Qualitative research methods in human geography* (3rded.) (pp. 101-138). Don Mills, ON: Oxford University Press.

Durst, S. (2011). Personal communication, message to the author. Director of Curriculum and Assessment Policy Branch at the Ontario Ministry of Education. March, 31.

Eagle, A.J., Eiswerth, M.E., Johnson, W.S., Schoenig, S.E., & Van Kooten, G.C. (2007). Costs and losses imposed on California ranchers by yellow starthistle. *Rangeland Ecology & Management*, *60*(4), 369-377.

Ehrlich, P.R. (2002). Human natures, nature conservation, and environmental ethics. *Bioscience 52*(1), 31-44.

Field, A.P. (2009). *Discovery statistics using SPSS: (And sex, drugs and rock 'n' roll*) (3rd ed.). Los Angeles, CA: Sage.

Foster, J., & Sandberg, L.A. (2004). Friends or foe? Invasive species and public green space in Toronto. *The Geographical Review*, *94*(2), 178-198.

Fowler, F.J. (2002). *Survey research methods* (3rd ed.). Thousand Oaks, CA: Sage.

Frantz, C., Mayer, F.S., Norton, C., & Rock, M. (2005). There is no "I" in nature: The influence of self-awareness on connectedness to nature. *Journal of Environmental Psychology*, *25*(4), 427-436.

Gaster, S. (1991). Urban children's access to their neighborhood – changes over 3 generations. *Environment and Behaviour*, *23*(1), 70-85.

Gates, K.K., Guy, C.S., & Zale, A.V. (2009). Angler awareness of aquatic nuisance species and potential transport mechanisms. *Fisheries Management and Ecology*, *16*(6), 448-456.

Gobster, P.H. (2005). Invasive species as ecological threat: Is restoration an alternative to fear-based resource management? *Ecological Restoration*, *23*(4), 261-270.

Gosling, E., & Williams, K.J.H. (2010). Connectedness to nature, place attachment and conservation behaviour: Testing connectedness theory among farmers. *Journal of Environmental Psychology*, *30*(3), 298-304.

Government of Canada, Environment Canada. (2004). *An invasive alien species strategy for Canada*. Retrieved from http://www.ec.gc.ca/Publications/26E24C67-2299-4E7A-8014-9FB6B80695C5/Final_IAS_Strategic_Plan_en.pdf

Greenwald, A.G., McGhee, D.E., & Schwartz, J.L.K. (1998). Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology*, *74*(6), 1464-1480.

Harvey, E. (2010). Personal Interview. Statistical Consultant, University of Waterloo. September, Waterloo, ON.

Hastings, G., Stead, M., & Webb, J. (2004). Fear appeals in social marketing: Strategic and ethical reasons for concern. *Psychology and Marketing*, *21*(11), 961-986.

Hoggart, K., Lees, L., & Davies, A. (2002). *Researching human geography*. New York, NY: Oxford University Press Inc.

Hungerford, H.R. (2010). Environmental education (EE) for the 21st Century: Where have we been? Where are we now? Where are we headed? *Journal of Environmental Education*, *41*(1), 1-6.

Hutson, G., & Montgomery, D. (2006). How do outdoor leaders feel connected to nature places? a Q-method inquiry. *Australian Journal of Outdoor Education, 10*(2), 29-39.

International Union of Concerned Naturalists. (2005). 100 of the world's worst invaders. In *Global invasive species database*. Gland, Switzerland: International Union for Conservation of Nature.

Invading Species Awareness Program. (2010). *Invading Species Awareness Program for Ontario Annual Report for 2009/10*. Retrieved, from http://www.invadingspecies.com/indexen.cfm

Johnson, E.J., Ricciardi, J.A., & Carlton, J.T., (2001). Overland dispersal of aquatic invasive species: A risk assessment of transient recreational boating. *Ecological Applications, 11*(6), 1789-1799.

Kellert, S.R. (1976). Perceptions of animals in American society. *Transactions of the North American Wildlife and Natural Resources Conference*, *41*, 533-546.

Kellert, S.R. (1985). Attitudes towards animals: Age related development among children. *Journal of Environmental Education*, *16*(3), 29-39.

Kellert, S.R. (1993). Values and perceptions of invertebrates. *Conservation Biology*, *7*(4), 845-855.

Kellert, S.R. (1996). *The value of life: Biological diversity and human society*. Washington, DC: Island Press.

Kellert, S.R. (2005). *Building for life: Designing and understanding the human-nature childhood development*. Washington, DC: Island Press.

Kellert, S.R., & Berry, J.K. (1980). *Knowledge, affection and basic attitudes toward animals in American society: Phase III.* Washington, DC: US Dept. of the Interior, Fish and Wildlife Service.

Kellert, S.R., & Westervelt, M.O. (1983). Children's attitudes, knowledge and behaviours toward animals. *Children's Environment Quarterly, 1*(3), 8-11.

Knights, P. (2008). Native species, human communities and cultural relationships. *Environmental Values*, *17*(3), 353-373.

Kline, P. (1994). *An easy guide to factor analysis.* New York, NY: Routledge.

Krasny, M.E., & Lee, S.K. (2002). Social learning as an approach to environmental education: Lessons from a program focusing on non-indigenous, invasive species. *Environmental Education Research, 8*(2), 101-119.

Larson, B.M.H. (2005). The war of the roses: Demilitarizing invasion biology. *Frontiers in Ecology and the Environment*, *3*(9), 495-500.

Larson, B.M.H. (2007). An alien approach to invasive species: Objectivity and society in invasion biology. *Biological Invasions*, *9*(8), 947-956.

Larson, B.M.H. (2010). Reweaving narratives about humans and invasive species. *Études Rurales*, *185*, 25-38.

Larson, B.M.H., & Glass, C. (2009). Personal communication, message to the author. August, 2010.

Leopold, A. (1949). *A sand county almanac: And sketches here and there*. London: Oxford University Press.

Lindemann-Matthies, P. (2002). The influence of an educational program on children's perception of biodiversity. *Journal of Environmental Education, 33*(2), 22-31.

Lindemann-Matthies, P. (2005). 'Loveable' mammals and 'lifeless' plants: How children's interest in common local organisms can be enhanced through observation of nature. *International Journal of Science Education, 27*(6), 655-677.

Lindgren, C.J. 2006. Angler awareness of aquatic invasive species in Manitoba. *Journal of Aquatic Plant Management, 44*(July), 103-108.

Lodge, D.M., & Shrader-Frechette, K. (2003). Non-indigenous species: Ecological explanation, environmental ethics, and public policy. *Conservation Biology, 17*(1), 31-37.

Louv, R. (2006). *Last child in the woods: Saving our children from a nature deficit disorder*. Chapel Hill, NC: Algonquin Books.

Lowe, S.J., Browne, M., & Boudjelas, S. (2000). *100 of the world's worst invasive alien species.* Auckland, New Zealand: IUCN/SSC Invasive Species Specialist Group (ISSG).

Mack, R.N., Simberloff, D., Lonsdale, M., Evans, H., Clout, M., & Bazzal, F.A. (2000). Biotic invasions: Causes, epidemiology, global consequences, and control. *Ecological Applications, 10*(3), 689-710.

Mackenzie, B.F., & Larson, B.M.H. (2010). Participation under time constraints: Landowner perceptions of rapid response to the emerald ash borer. *Society and Natural Resources, 23*(10), 1013-1022.

Marsden, J. E., & Hauser, M. 2009. Exotic species in Lake Champlain. *Journal of Great Lakes Research, 35*(2), 250-265.

Mayer, F.S., & Frantz, C.M. (2004). The connectedness to nature scale: A measure of individuals feeling in community with nature. *Journal of Environmental Psychology, 24*(4), 503-515.

Mayer, F.S., & Frantz, C.M. (2008). Framing the question of survival: Psychological insights and limitations. *Conservation Biology, 22*(4), 823-825.

McGuirk P.M., & O'Neill, P. (2005). Using questionnaires in qualitative human geography. In I. Hay (Ed.), *Qualitative research methods in human geography* (2nd ed.) (pp. 147-162). Melbourne, Victoria: Oxford University Press.

McIntosh, C.R., Shogren, J.F., & Finnoff, D.C. (2010). Invasive species and delaying the inevitable: Valuation evidence from a national survey. *Ecological Economics, 69*(3), 632-640.

McSpurren, K. (2010). Personal Interview. Senior Manager, Survey Research Centre, University of Waterloo. September, Waterloo, ON.

Meloche, C. & Murphy, S.D. (2006). Managing tree-of-heaven (*Ailanthus altissima*) in parks and protected areas: A case study of Rondeau Provincial Park (Ontario, Canada). *Environmental Management*, *37*(6), 764-772.

Meyers, L.S., Gamst, G., & Guarino, A.J. (2006). *Applied multivariate research: Design and interpretation*. Thousand Oaks, CA: Sage.

Morgan, J.M. (1992). A theoretical basis for evaluating wildlife-related education programs. *The American Biology Teacher, 54*(3), 153-157.

Moser, W.K., Barnard, E.L., Billings, R.F., Crocker, S.J., Dix, M.E., Gray, A.N., … McWilliams, W.H. (2009). Impacts of nonnative invasive species on US forests and recommendations for policy and management. *Journal of Forestry*, *107*(6), 320-327.

Muirhead, J., Leung, B., van Overdijk, C., Kelly D., Nandakumar, K., Marchant, K., & MacIsaac, H. (2006). Modeling local and long-distance dispersal of invasive emerald ash borer *Agrilus planipennis* (Coleoptera) in North America. *Diversity and Distributions*, *12*(1), 71-79.

Novacek, M.J. & Cleland, E.E. (2001). The current biodiversity extinction event: Scenarios for mitigation and recovery. *Proceedings of the National Academy of Sciences of the United States of America*, *98*(10), 5466-5470.

O'Neil, S., & Nicholson-Cole, S. (2009). "Fear won't do it": Promoting positive engagement with climate change through visual and iconic representations. *Science Communication*, *30*(3), 355-379.

Ontario Ministry of Education. (1998). The Ontario Curriculum Grades 1-8: Science and Technology. Retrieved from http://www.edu.gov.on.ca/eng/curriculum/elementary/scientec.html

Ontario Ministry of Education. (2000). The Ontario Curriculum Grades 11 and 12: Science. Retrieved from http://www.edu.gov.on.ca/eng/curriculum/secondary/science.html

Ontario Ministry of Education. (2007a). *Ready set green! Tips, techniques, and resources from Ontario educators*. Retrieved from http://www.edu.gov.on.ca/eng/document/policy/readySetGreen.pdf

Ontario Ministry of Education. (2007b). *Shaping our schools, shaping our future. Environmental education in Ontario schools*. Retrieved from http://www.edu.gov.on.ca/curriculumcouncil/shapingschools.pdf

Ontario Ministry of Education. (2007c). The Ontario Curriculum Grades 1-8: Science and Technology. Retrieved from http://www.edu.gov.on.ca/eng/curriculum/elementary/scientec.html.

Ontario Ministry of Education. (2008a). The Ontario Curriculum Grades 9 and 10 Revised: Science. Retrieved from http://www.edu.gov.on.ca/eng/curriculum/secondary/science.html

Ontario Ministry of Education. (2008b). The Ontario Curriculum Grades 11 and 12 Revised: Science. Retrieved from http://www.edu.gov.on.ca/eng/curriculum/secondary/science.html

Ontario Ministry of Education. (2008c). Standards for Environmental Education in the Curriculum. Retrieved April, 2010 from http://www.edu.gov.on.ca/eng/teachers/enviroed/standards.html

Ontario Ministry of Education. (2009a). *Acting today shaping tomorrow: A policy framework for environmental education in Ontario schools*. Retrieved from http://www.edu.gov.on.ca/curriculumcouncil/ShapeTomorrow.pdf

Orr, D.W. (1994). *Earth in mind: On education, environment, and the human prospect*. Washington DC: Island Press.

Perrin, J.L., & Benassi, V.A. (2009). The connectedness to nature scale: A measure of emotional connection to nature? *Journal of Environmental Psychology*, *29*(4), 434-440.

Pimentel, D., Zuniga, R., & Morrison, D. (2005). Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics*, *52*(3), 273-282.

Poland, T.M., & McCullough, D.G. (2006). Emerald ash borer: Invasion of the urban forest and the threat to North America's ash resource. *Journal of Forestry, 104*(3), 118-124.

Prokop, P., Fancovicova, J., & Kubiatko, M. (2009). Vampires are still alive: Slovakian students' attitudes toward bats. *Anthrozoos*, 22(1), 19-30.

Prokop, P., & Tunnicliffe, S.D. (2008). "Disgusting" animals: Primary school children's attitudes and myths of bats and spiders. *Eurasia Journal of Mathematics, Science & Technology Education, 4*(2), 87-97.

Rejmanek, M., Richardson, D.M., Barbour, M.G., Crawley, M.J., Hrusa, G.F., Moyle, P.B., … Williamson, M. (2002). Biological invasions: Politics and the discontinuity of ecological terminology. *Ecological Society of America*, *83*(2), 131-133.

Ricciardi, A. (2007). Are modern biological invasions an unprecedented form of global change? *Conservation Biology*, *21*(2), 329-336.

Roberts, L.W., Kampen, K., & Peter, T. (2009). *The methods coach: Learning through practice*. Don Mills, ON: Oxford University Press.

Roberts, R. (1990). Zebra mussel invasion threatens US waters. *Science*, *249*(4975), 1370-1372.

Russel, C.L., & Burton, J. (2000). A report on an Ontario secondary school integrated environmental studies program. *Canadian Journal of Environmental Education*, *5*, 287-304.

Schneider, D. (2002). River kids. *Grand Actions, 7*(5), 1-2.

Schultz, P.W. (2001). Assessing the structure of environmental concern: Concern for the self, other people, and the biosphere. *Journal of Environmental Psychology*, *21*(4), 327-339.

Schultz, P.W., (2002). Inclusion with nature: The psychology of human-nature relations. In P. Schmuck & W.P. Shultz (Eds.), *Psychology of sustainable development* (pp.61-78). Dordrecht: Kluwer Academic Publishers.

Schultz, P.W., Shriver, C., Tabanico, J., & Khazian, A. (2004). Implicit connections with nature. *Journal of Environmental Psychology*, *24*(1), 327-339.

Schultz, P.W. & Tabanico, J. (2007). Self, identity, and the natural environment: Exploring implicit connections with nature. *Journal of Applied Social Psychology*, *37*(6), 1219-1247.

Sivek, D.J., (2002). Environmental sensitivity among Wisconsin high school students. *Environmental Education Research*, *8*(2), 155-170.

Smith, E. (1999). The effects of investments in the social capital of youth on political and civic behavior in young adulthood: A longitudinal analysis. *Political Psychology*, *20*(3), 553-580.

Sobel, D. (1996). *Beyond ecophobia: Reclaiming the heart in nature education*. Great Barrington, MA: Orion Society.

Somaweera, R., Somaweera, N., Shine, R. (2010). Frogs under friendly fire: How accurately can the general public recognize invasive species? *Biological Conservation*, *143*(6), 1477-1484.

Soule, M.E. (1990). The onslaught of alien species, and other challenges in the coming decades. *Conservation Biology*, *4*(3), 233-239.

Steele, J., Chandran, R.S., Grafton, W.N., Huebner, C.D., & McGill, D.W. (2006). Awareness and management of invasive plants among West Virginia woodland owners. *Journal of Forestry*, *104*(5), 248-253.

Spellman, K.V., & Villano, C.P. (2011). Early primary invasion scientists. *Science and Children*, *48*(5), 27-31.

Stevens, J.P. (2002). *Applied multivariate statistics for the social sciences*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Tabachnick, B.G., & Fidell, L.S. (2001). *Using multivariate statistics*. Boston, MA: Allyn & Bacon.

Thompson, T.L., & Mintzes, J.J. (2002). Cognitive structure and the affective domain: On knowing and feeling in biology. *International Journal of Science Education*, *24*(6), 645-660.

Tikka, P.M., Kuitunen, M.T., & Tynys, S.M. (2000). Effects of educational background on students, attitudes, activity levels, and knowledge concerning the environment. *The Journal of Environmental Education, 31*(3), 12-19.

Valentine, G., & McKendrick, J. (1997). Children's outdoor play: Exploring parental concerns about children's safety and the changing nature of childhood. *Geoforum, 28*(2), 219-235.

Van den Berg, A.E., & ter Heijne, M. (2005). Fear versus fascination: An exploration of emotional responses to natural threats. *Journal of Environmental Psychology, 25*(3), 261-272.

Venter, O., Brodeur, N.N., Nemiroff, L., Belland, B., Dolinsek, I.J., & Grant, W.A. (2006). Threats to endangered species in Canada. *Biological Science, 56*(11), 903-910.

Weinstein, N., Przbylski, A.K., & Ryan, R.M. (2009). Can nature make us more caring? Effects of immersion in nature on intrinsic aspirations and generosity. *Personality and Social Psychology Bulletin, 35*(10), 1315-1329.

Winchester, H.P.M. (2005). Qualitative research and its place in human geography. In I. Hay (Ed.), *Qualitative research methods in human geography* (3rd ed.) (pp. 3-18). Don Mills, ON: Oxford University Press.

Wray-Lake, L., Flanagan, C., & Osgood, D. (2010). Examining trends in adolescent environmental attitudes, beliefs, and behaviors across three generations. *Environment and Behavior, 42*(1), 61-85.

Yin, R.K. (1989). *Case study research: Design and methods* (Rev. ed.). Newbury Park, California: Sage.

Zelezny, L.C. (1999). Educational interventions that improve environmental behaviors: A meta-analysis. *Journal of Environmental Education, 31*(1), 5-14.

# Appendix A: Surveys

**Invasive species Questionnaire**

**How old are you? _____(years)**

**Stream? SVN3M ____ SVN3E_____**

**What is your gender (circle one)? Male Female**

**Do you consider your upbringing to have been primarily urban or rural (circle one)? Urban Rural**

**Section A** Please indicate how familiar you are with each of the following terms by circling your answer. If you are familiar with a term, please try to define it.

1. **Invasive Species**

| Not Familiar | | Somewhat Familiar | | Familiar |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

_____

_____

2. **Native Species**

| Not Familiar | | Somewhat Familiar | | Familiar |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

_____

_____

In the remainder of the survey, we will adopt the following definitions. **Native species** have been found in a region for a long time. In contrast, **alien species (also known as exotic, non-native or non-indigenous species)** have been introduced by humans outside of their natural region. These introduced species become **invasive species** when they spread, threatening the environment, the economy, or society, including human health. Throughout the rest of the survey, we will focus on these invasive species, ones that have been introduced, tend to spread, and threaten the environment or human interests in some way.

With these definitions in mind, please answer the following questions.

**Section B** Please indicate whether you think the following statements are true or false by circling your answer. Choose one only.

| Statements | True | False | Unsure |
|---|---|---|---|
| 1) Most agricultural crops grown in Canada are native to Canada. | T | F | U |
| 2) Invasive species can create enormous economic losses. | T | F | U |
| 3) Invasive species can cause substantial ecological change. | T | F | U |
| 4) Invasive species are only a concern in some Canadian provinces. | T | F | U |
| 5) Canada has an action plan for invasive species. | T | F | U |
| 6) The Great Lakes are home to more than 150 alien species. | T | F | U |
| 7) Invasive species cost Canadian agriculture, fisheries and forestry billions of dollars a year. | T | F | U |
| 8) There are about 1500 invasive plant species found in Canada. | T | F | U |
| 9) According to the World Conservation Union, invasive species are the second greatest threat to biodiversity. | T | F | U |
| 10) Most alien species introduced to Canada become invasive species. | T | F | U |
| 11) Some invasive species have impacts on human health. | T | F | U |
| 12) Many types of organisms, including plants, animals, and even bacteria, can become invasive species if they are introduced to Canada. | T | F | U |
| 13) People can contribute to the spread of invasive species when they introduce species into new areas. | T | F | U |

**Section C:** Do you recognize the species shown below? If so, please write down their names.

1. Name_____ 

2. Name_____ 

3. Name_____ 

4. Name_____ 

5. Name_____ 

6. Name_____ 

**Section D** Please indicate whether the following species are native or invasive within Ontario. Choose one only.

| Species | Native | Invasive | Unsure/unfamiliar with this species |
|---|---|---|---|
| **1) Garlic Mustard** | N | I | U |
| **2) Walleye (a.k.a. Pickerel)** | N | I | U |
| **3) Brook Trout** | N | I | U |
| **4) White Trillium** | N | I | U |
| **5) Sea Lamprey** | N | I | U |
| **6) Zebra Mussel** | N | I | U |
| **7) Sugar Maple** | N | I | U |
| **8) Periwinkle (plant)** | N | I | U |
| **9) Dog Strangling Vine** | N | I | U |
| **10) Emerald Ash Borer** | N | I | U |
| **11) Round Goby** | N | I | U |
| **12) Purple Loosestrife** | N | I | U |
| **13) Largemouth Bass** | N | I | U |
| **14) Wild Strawberry** | N | I | U |
| **15) Cattail** | N | I | U |
| **16) Poison Ivy** | N | I | U |
| **17) Buckthorn** | N | I | U |
| **18) Giant Hogweed** | N | I | U |
| **19) Monarch Butterfly** | N | I | U |

**Section E** Please indicate how much you agree or disagree with the following statements by circling the appropriate number on the scale from strongly disagree to strongly agree. Choose one only.

| Statements | Strongly Disagree | Slightly Disagree | Neutral | Slightly agree | Strongly Agree |
|---|---|---|---|---|---|
| **1) I am worried that invasive species may cause the extinction of native species.** | 1 | 2 | 3 | 4 | 5 |
| **2) I am personally familiar with the effects of one or more invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **3) I often feel a sense of oneness with the natural world around me.** | 1 | 2 | 3 | 4 | 5 |
| **4) I believe invasive species have a negative impact on nature.** | 1 | 2 | 3 | 4 | 5 |
| **5) The presence of invasive species decreases my enjoyment of nature.** | 1 | 2 | 3 | 4 | 5 |
| **6) I think of the natural world as a community to which I belong.** | 1 | 2 | 3 | 4 | 5 |
| **7) I do my best to ensure that my personal activities (pets, travel, etc.) do not contribute to the spread of invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **8) I believe invasive species are a tremendous problem for Canadians.** | 1 | 2 | 3 | 4 | 5 |

| Statements | Strongly Disagree | Slightly Disagree | Neutral | Slightly agree | Strongly Agree |
|---|---|---|---|---|---|
| 9) I recognize and appreciate the intelligence of other living organisms. | 1 | 2 | 3 | 4 | 5 |
| 10) I believe that invasive species provide variety in the natural world that we can enjoy. | 1 | 2 | 3 | 4 | 5 |
| 11) I prefer parks and natural areas that have few invasive species. | 1 | 2 | 3 | 4 | 5 |
| 12) I often feel disconnected from nature. | 1 | 2 | 3 | 4 | 5 |
| 13) Invasive species should be controlled no matter how much money it might cost. | 1 | 2 | 3 | 4 | 5 |
| 14) I believe that invasive species threaten species that I am familiar with and which I care about. | 1 | 2 | 3 | 4 | 5 |
| 15) When I think of my life, I imagine myself to be part of a larger cyclical process of living. | 1 | 2 | 3 | 4 | 5 |
| 16) I do not mind the idea of seeing and touching invasive species. | 1 | 2 | 3 | 4 | 5 |
| 17) When I am around invasive species I get nervous. | 1 | 2 | 3 | 4 | 5 |
| 18) I often feel a connection with animals and plants. | 1 | 2 | 3 | 4 | 5 |
| 19) I like beautiful flowers and do not care whether they are native or not. | 1 | 2 | 3 | 4 | 5 |
| 20) Whenever possible, I think we should remove invasive species to protect forest, agricultural and marine resources. | 1 | 2 | 3 | 4 | 5 |

| Statements | Strongly Disagree | Slightly Disagree | Neutral | Slightly agree | Strongly Agree |
|---|---|---|---|---|---|
| 21) I believe that I belong to the Earth as equally as it belongs to me. | 1 | 2 | 3 | 4 | 5 |
| 22) I am willing to commit my time and energy to removing invasive species from parks and natural areas. | 1 | 2 | 3 | 4 | 5 |
| 23) I would rather stay away from areas that contain invasive species. | 1 | 2 | 3 | 4 | 5 |
| 24) I have a deep understanding of how my actions affect the natural world. | 1 | 2 | 3 | 4 | 5 |
| 25) I am interested in learning more about invasive species found where I live. | 1 | 2 | 3 | 4 | 5 |
| 26) I believe that invasive species in my area have become part of who I am. | 1 | 2 | 3 | 4 | 5 |
| 27) I often feel part of the web of life. | 1 | 2 | 3 | 4 | 5 |
| 28) I feel bad for the invasive species which are removed by conservation efforts. | 1 | 2 | 3 | 4 | 5 |
| 29) I believe that invasive species have as much right to exist as native species. | 1 | 2 | 3 | 4 | 5 |
| 30) I believe that all inhabitants of Earth, human, and nonhuman, share a common 'life force'. | 1 | 2 | 3 | 4 | 5 |

| Statements | Strongly Disagree | Slightly Disagree | Neutral | Slightly agree | Strongly Agree |
|---|---|---|---|---|---|
| **31) I believe that humans are responsible for the problems caused by invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **32) I would be afraid to explore places that contain invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **33) Like a tree can be part of a forest, I believe I am embedded within the broader natural world.** | 1 | 2 | 3 | 4 | 5 |
| **34) I believe that invasive species are an enemy and should be destroyed.** | 1 | 2 | 3 | 4 | 5 |
| **35) I don't care about invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **36) When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.** | 1 | 2 | 3 | 4 | 5 |
| **37) I believe that invasive species found where I live belong there.** | 1 | 2 | 3 | 4 | 5 |
| **38) Invasive species make me feel less connected to nature.** | 1 | 2 | 3 | 4 | 5 |
| **39) I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.** | 1 | 2 | 3 | 4 | 5 |
| **40) I do not believe there is any hope that we can prevent the spread of invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **41) I believe we should accept the presence of invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **42) My personal wellbeing is independent of the wellbeing of the natural world.** | 1 | 2 | 3 | 4 | 5 |

**Section F** Please provide a written answer for the following question.

1. How do you feel about the state of nature?

_____

_____

_____

## Invasive species Questionnaire

**How old are you? _____(years)**

**Stream? SVN3M ____ SVN3E_____**

**What is your gender (circle one)? Male Female**

**Do you consider your upbringing to have been primarily urban or rural (circle one)? Urban Rural**

**Section A** Please indicate how familiar you are with each of the following terms by circling your answer. If you are familiar with a term, please try to define it.

### 1. Invasive Species

| Not Familiar | | Somewhat Familiar | | Familiar |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

_____

_____

### 2. Native Species

| Not Familiar | | Somewhat Familiar | | Familiar |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

_____

_____

**Section B** Please indicate whether you think the following statements are true or false by circling your answer. Choose one only.

| Statements | True | False | Unsure |
|---|---|---|---|
| 1) Most agricultural crops grown in Canada are native to Canada. | T | F | U |
| 2) Invasive species can create enormous economic losses. | T | F | U |
| 3) Invasive species can cause substantial ecological change. | T | F | U |
| 4) Invasive species are only a concern in some Canadian provinces. | T | F | U |
| 5) Canada has an action plan for invasive species. | T | F | U |
| 6) The Great Lakes are home to more than 150 alien species. | T | F | U |
| 7) Invasive species cost Canadian agriculture, fisheries and forestry billions of dollars a year. | T | F | U |
| 8) There are about 1500 invasive plant species found in Canada. | T | F | U |
| 9) According to the World Conservation Union, invasive species are the second greatest threat to biodiversity. | T | F | U |
| 10) Most alien species introduced to Canada become invasive species. | T | F | U |
| 11) Some invasive species have impacts on human health. | T | F | U |
| 12) Many types of organisms, including plants, animals, and even bacteria, can become invasive species if they are introduced to Canada. | T | F | U |
| 13) People can contribute to the spread of invasive species when they introduce species into new areas. | T | F | U |

**Section C:** Do you recognize the species shown below? If so, please write down their names.

1. Name_____ 

2. Name_____ 

3. Name_____ 

4. Name_____ 

5. Name_____ 

6. Name_____ 

**Section D** Please indicate whether the following species are native or invasive within Ontario. Choose one only.

| Species | Native | Invasive | Unsure/unfamiliar with this species |
|---|---|---|---|
| **1) Garlic Mustard** | N | I | U |
| **2) Walleye (a.k.a. Pickerel)** | N | I | U |
| **3) Brook Trout** | N | I | U |
| **4) White Trillium** | N | I | U |
| **5) Sea Lamprey** | N | I | U |
| **6) Zebra Mussel** | N | I | U |
| **7) Sugar Maple** | N | I | U |
| **8) Periwinkle (plant)** | N | I | U |
| **9) Dog Strangling Vine** | N | I | U |
| **10) Emerald Ash Borer** | N | I | U |
| **11) Round Goby** | N | I | U |
| **12) Purple Loosestrife** | N | I | U |
| **13) Largemouth Bass** | N | I | U |
| **14) Wild Strawberry** | N | I | U |
| **15) Cattail** | N | I | U |
| **16) Poison Ivy** | N | I | U |
| **17) Buckthorn** | N | I | U |
| **18) Giant Hogweed** | N | I | U |
| **19) Monarch Butterfly** | N | I | U |

**Section E** Please indicate how much you agree or disagree with the following statements by circling the appropriate number on the scale from strongly disagree to strongly agree. Choose one only.

| Statements | Strongly Disagree | Slightly Disagree | Neutral | Slightly agree | Strongly Agree |
|---|---|---|---|---|---|
| **1) I am worried that invasive species may cause the extinction of native species.** | 1 | 2 | 3 | 4 | 5 |
| **2) I am personally familiar with the effects of one or more invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **3) I often feel a sense of oneness with the natural world around me.** | 1 | 2 | 3 | 4 | 5 |
| **4) I believe invasive species have a negative impact on nature.** | 1 | 2 | 3 | 4 | 5 |
| **5) The presence of invasive species decreases my enjoyment of nature.** | 1 | 2 | 3 | 4 | 5 |
| **6) I think of the natural world as a community to which I belong.** | 1 | 2 | 3 | 4 | 5 |
| **7) I do my best to ensure that my personal activities (pets, travel, etc.) do not contribute to the spread of invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **8) I believe invasive species are a tremendous problem for Canadians.** | 1 | 2 | 3 | 4 | 5 |

| Statements | Strongly Disagree | Slightly Disagree | Neutral | Slightly agree | Strongly Agree |
|---|---|---|---|---|---|
| 9) I recognize and appreciate the intelligence of other living organisms. | 1 | 2 | 3 | 4 | 5 |
| 10) I believe that invasive species provide variety in the natural world that we can enjoy. | 1 | 2 | 3 | 4 | 5 |
| 11) I prefer parks and natural areas that have few invasive species. | 1 | 2 | 3 | 4 | 5 |
| 12) I often feel disconnected from nature. | 1 | 2 | 3 | 4 | 5 |
| 13) Invasive species should be controlled no matter how much money it might cost. | 1 | 2 | 3 | 4 | 5 |
| 14) I believe that invasive species threaten species that I am familiar with and which I care about. | 1 | 2 | 3 | 4 | 5 |
| 15) When I think of my life, I imagine myself to be part of a larger cyclical process of living. | 1 | 2 | 3 | 4 | 5 |
| 16) I do not mind the idea of seeing and touching invasive species. | 1 | 2 | 3 | 4 | 5 |
| 17) When I am around invasive species I get nervous. | 1 | 2 | 3 | 4 | 5 |
| 18) I often feel a connection with animals and plants. | 1 | 2 | 3 | 4 | 5 |
| 19) I like beautiful flowers and do not care whether they are native or not. | 1 | 2 | 3 | 4 | 5 |
| 20) Whenever possible, I think we should remove invasive species to protect forest, agricultural and marine resources. | 1 | 2 | 3 | 4 | 5 |

| Statements | Strongly Disagree | Slightly Disagree | Neutral | Slightly agree | Strongly Agree |
|---|---|---|---|---|---|
| 21) I believe that I belong to the Earth as equally as it belongs to me. | 1 | 2 | 3 | 4 | 5 |
| 22) I am willing to commit my time and energy to removing invasive species from parks and natural areas. | 1 | 2 | 3 | 4 | 5 |
| 23) I would rather stay away from areas that contain invasive species. | 1 | 2 | 3 | 4 | 5 |
| 24) I have a deep understanding of how my actions affect the natural world. | 1 | 2 | 3 | 4 | 5 |
| 25) I am interested in learning more about invasive species found where I live. | 1 | 2 | 3 | 4 | 5 |
| 26) I believe that invasive species in my area have become part of who I am. | 1 | 2 | 3 | 4 | 5 |
| 27) I often feel part of the web of life. | 1 | 2 | 3 | 4 | 5 |
| 28) I feel bad for the invasive species which are removed by conservation efforts. | 1 | 2 | 3 | 4 | 5 |
| 29) I believe that invasive species have as much right to exist as native species. | 1 | 2 | 3 | 4 | 5 |
| 30) I believe that all inhabitants of Earth, human, and nonhuman, share a common 'life force'. | 1 | 2 | 3 | 4 | 5 |

| Statements | Strongly Disagree | Slightly Disagree | Neutral | Slightly agree | Strongly Agree |
|---|---|---|---|---|---|
| **31) I believe that humans are responsible for the problems caused by invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **32) I would be afraid to explore places that contain invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **33) Like a tree can be part of a forest, I believe I am embedded within the broader natural world.** | 1 | 2 | 3 | 4 | 5 |
| **34) I believe that invasive species are an enemy and should be destroyed.** | 1 | 2 | 3 | 4 | 5 |
| **35) I don't care about invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **36) When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.** | 1 | 2 | 3 | 4 | 5 |
| **37) I believe that invasive species found where I live belong there.** | 1 | 2 | 3 | 4 | 5 |
| **38) Invasive species make me feel less connected to nature.** | 1 | 2 | 3 | 4 | 5 |
| **39) I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.** | 1 | 2 | 3 | 4 | 5 |
| **40) I do not believe there is any hope that we can prevent the spread of invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **41) I believe we should accept the presence of invasive species.** | 1 | 2 | 3 | 4 | 5 |
| **42) My personal wellbeing is independent of the wellbeing of the natural world.** | 1 | 2 | 3 | 4 | 5 |

**Section F** Please provide a written answer for the following question.

1. After learning about the issue of invasive species, how do you feel about the state of nature?

_____

_____

_____

# Appendix B: Survey Facilitation Tools

The following documents were included in the survey packages that were delivered to the participating classes. These include: instructions for administering the survey, an optional questionnaire for teachers regarding their instruction of invasive species, and a page entitled student questions intended to be used by the classroom teachers to record any questions the students might have while completing the survey, as well as to record any event that might occur during the survey that the teacher might deem noteworthy, such as a fire drill or medical emergency.) For the purposes of anonymity, the information letters addressed to the principals, science department heads and classroom teachers have not been included in this appendix.

## Instructions for Administration of the Invasive Species Survey University of Waterloo

## Department of Environment and Resource Studies

Dear Classroom Teacher: Thank you for agreeing to participate in this research.

The following are a series of guidelines to help you administer the survey.

You have been provided with a box containing a number of large envelopes and a stack of post it notes. Each envelope contains the following:

- A copy of the pre-survey (white, with green student information letter sheet)
- A copy of the post-survey (white)
- Two letter size envelopes

The envelopes are intended to allow for an individual student's before and after surveys to be compared while maintaining anonymity.

Steps in Administering the Survey:

- Please distribute an envelope and a post-it note to each student. Please have the students write their name on the post-it note and stick the post-it note to the envelope. Then, please ask the students to remove the survey with the green information letter attached to it.
- Please take a minute to go over with the students the green information letter that is attached to the front page of the survey. This page explains to the

students the purpose for this research. Please advise the students that participation is voluntary and they are not expected to answer every question if they do not want to provide an answer. Also, students can choose to not complete the survey or not hand it in if they wish.

- Advise students that if they do not know how to answer a particular question, they can place a question mark on the left hand side of the question and move on to the next question.
- Inform the students the survey will not impact their course grade in any way and that you will not be reviewing the surveys or grading their answers.
- Please ask the students to complete the surveys individually and not discuss their answers with their peers.
- Before the students begin the survey, please briefly describe each section of the survey:
    - Section A: students circle a number to describe their familiarity with the term, and if they are familiar they should try to define the term. Ask them to please not change their answers after they have completed section A. Definitions for the terms are provided before section B in case they are unfamiliar with the terms or need a reminder. It is important that they just try to describe what they believe the terms mean before reading the definition.
    - Section B: a True/False section based on some statements regarding invasive species. Please remind students to not read the definitions at the top of the page.
    - Section C: an identification section. If students know the name of the species in the pictures they can write them down. For each number there are two different pictures of the same species. Please advise the students that it is ok if they do not know the names of any of the species in the pictures, especially when the pictures are in black and white.
    - Section D: a list of species where students indicate whether they believe a species to be native or invasive by circling a letter. If the students are not familiar with the species, or if they are unsure whether or not the species is native or invasive they can circle the letter U for Unsure.
    - Section E: a list of statements demonstrating attitudes towards invasive species and connectedness to nature. Students circle a number from 1 to 5 to show their level of agreement.
- Ask the students to begin the survey.

- When the students have completed the survey ask them to fold the survey and place it into one of the smaller envelopes and seal it.
- Ask the students to place the sealed envelope in the larger envelope, but not to seal the larger envelope.
- Please collect the envelopes and store them in the box until you feel the timing is appropriate for the post survey.
- For the post survey please re-distribute the envelopes to the appropriate students and have them complete the remaining copy of the questionnaire. When the students have completed the post-survey, have them place that copy in the remaining letter size envelope. Have them return the letter sized envelope to the larger envelope and remove the post-it from the larger envelope. Place the envelopes in the box which you can send to the office for a member of the research team to pick up.
- Please find the post-it labels taped to the inside of the box.
- My cell phone number is 226-788-0741, feel free to contact me if needed.
- Once again, thank you very much!

## Optional Questionnaire for Teachers

**Item I**: Age of the students from ____ to ____ **Item II**: Number of students: _____

**Item III**: Grade and Course Subject _____

**Item V**: Investigated invasive species

| Plant species: | Aquatic species: | Invertebrates: |
|---|---|---|
| _____ ( ) | _____ ( ) | _____ ( ) |
| _____ ( ) | _____ ( ) | _____ ( ) |
| _____ ( ) | _____ ( ) | _____ ( ) |
| _____ ( ) | _____ ( ) | _____ ( ) |

**Lesson Content**

**Item VI**: Total number of lessons that involved invasive species: _____

**Item VII**: Which lessons involving invasive species did you carry out with your students and how much time was spent on these lessons? Please judge how the children liked the individual lessons.

| Activity | Amount of time | Judgement | | |
|---|---|---|---|---|
| | | very good | satisfying | unsatisfying |
| ..... | ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... |

**Item VIII**: Please describe the main lessons which involved the subject of invasive species.

_____

_____

**Item IX**: Please describe any lessons which you have used to teach invasive species in the past and why you no longer use those methods.

_____

_____

**Item X**: Please describe any future changes you may wish to make to your lessons involving invasive species.

_____

**Item XI**: Were there any special experiences with the students

_____

_____

## Student Questions

Please use this sheet to make note of any questions the students ask while attempting to complete the survey. If/when a question is asked, please provide an answer if you wish, or you can simply make a note of where on the survey the student asked the question and ask the student to skip the question and move on to the next question. If you start to receive too many questions at once you may ask the students to place a question mark on the left hand side of the question, skip the question and move on to the next question.

# Appendix C: Invasive Species Student Assignments

## Class assignment A

## Course Culminating Activity, A Report on Invasive Species

New species are introduced into our environment on an ongoing basis. These species have the potential to change our environment and to make an impact on the way we live in Ontario.

You are a laboratory technician working for the Ministry of the Environment. A specific invading species is of concern to the ministry. As a laboratory technician, your role is to analyze the situation and write a report to the ministry. You will need to research background information on the species and the extent and effect of the invasion. Your report will include a recommendation for a course of action to deal with the invasion.

Your written report will need to be organized into sub-sections (as decided by you) and should include information on the following:

- a clear explanation of the actual or potential problem
- a scientific analysis of the actual or potential problem
- a prediction of the future impact of the problem on the environment and on other populations of species
- originally developed charts, table and/or graphs to support your findings
- a recommendation for a course of action
- a works cited listing all sources used

Please note:

- Initial proposal including a summary of the problem and a works cited with at least 5 reputable resources (including a minimum of 2 scientific journals) will be due on Monday, November 15, 2010.
- Final presentation/project is due on Monday, December 13, 2010.
- This project is worth 10% of your final mark!

To choose your invasive species, visit www.invadingspecies.com

Other websites to consider for your research:

The Ministry of the Environment Ontario

www.ene.gov.on.ca

The Ministry of Natural Resources Ontario

www.mnr.gov.on.ca

Assessment for Invasive Species Assignment

| Category | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| K & U | Demonstrates a limited understanding of how the invading species has adapted to the env. | Demonstrates some understanding of how the invading species has adapted to the env | Demonstrates a considerable understanding of how the invading species has adapted to the env | Demonstrates a high degree of understanding of how the invading species has adapted to the env |
| T& I | Analyzes the problem and predicts the future of the invading species with limited effectiveness | Analyzes the problem and predicts the future of the invading species with some effectiveness | Analyzes the problem and predicts the future of the invading species with considerable effectiveness | Analyzes the problem and predicts the future of the invading species with a high degree of effectiveness |
| Comm | Communicates ideas and information with limited clarity | Communicates ideas and information with some clarity | Communicates ideas and information with considerable clarity | Communicates ideas and information with a high degree of clarity |
| Application | Recommends and justifies a course of action of limited effectiveness | Recommends and justifies a course of action some effectiveness | Recommends and justifies a course of action considerable effectiveness | Recommends and justifies a course of action a high degree of effectiveness |

**Class Assignment B**

Name: _____

Invasive Species Proposal

Invasive Species: _____

Chosen Format for Project: _____

Summary of the Problem:

(include where the species comes from, where it is invading and how it is impacted the environment and other populations of species)

Research

List at least 5 different resources that have been used so far.

(2 of them must be from scientific journal articles)

# Appendix D: Semi Structured Interview Questions

**Curriculum Specific**

1. What are the course learning objectives (knowledge or skill sets)?
    a. How do you decide which smaller, specific topics you end up covering or that you use as an example? Current events? Local issues?
    b. How important is the singular topic of invasive species within the grand scheme of the class?
2. What materials do you use to teach the Environmental Science class? Is there a textbook for the class? Where would you seek educational materials on invasive species? What websites would you direct students to for their own research on invasive species?

**Curriculum General**

1. How do you put discussions about invasive species or other potentially negative environmental issues (natural disasters, climate change etc.) into a broader context that allows for a positive view of nature?
    a. Do you think that presenting invasive species in a negative light could alter a student's relationship with nature? Have you observed images, advertising, news reports, which could?
2. Is one of the goals of teaching environmental education to affect the way that students interact with nature? Do you think this course achieves that goal?
3. Do the knowledge and experiences gained from the Environmental Science class have the ability to alter the students' attitudes towards nature?

**Student Assessment (by teacher)**

1. What do you think the students know about invasive species before they enter the course?
2. Have you observed a specific age when students identify some species as invasive?
3. What do you think the students' attitudes are towards invasive species coming into the class?
4. The results from the attitude statements of the survey revealed three underlying themes. The first represented a concern towards invasive species as a threat or problem, the second represented an acceptance of invasive species, and the third represented feelings of anxiety towards invasive species. Have you observed your students expressing any of these feelings towards invasive species?

5. What sort of appreciation for/ or connection to nature do your students have?
6. According to the Guelph Lake Nature Centre staff, the course was designed so that the students would spend 60 % of their time outside. How do you think the students responded to that experience?
7. The results of the survey showed that the students' connection to nature did not really change (only a minuscule decline in the average of the scale used). Do you find this result surprising in any way?

**Teaching influence:**

1. Do you think anything about your classroom behaviour could influence students' relationship with nature?
2. What is a teacher's responsibility to influence the students' attitudes towards invasive species in one way or another? For example, should a teacher encourage students to remove invasive species on their own time, or ask them to be mindful of their actions to avoid contributing to the spread of invasive species?

# Appendix E: Student Information Letter

**University of Waterloo**
**Department of Environment and Resource Studies**

Dear Student:

As a Masters student in the Department of Environment and Resource Studies at the University of Waterloo, I am conducting research under the supervision of Dr. Brendon Larson on the effect of education about invasive plant, insect, and animal species on high school students' relationship with nature. This letter is an invitation to participate in this research study.

*Study Overview*

The issue of invasive species is a relatively new issue facing Canadians. Little is known about how the Canadian public relates to invasive species. The purpose of this study is to learn how educating high school students about invasive species affects their relationship with nature.

The research will be carried out in two parts. You will first be asked to complete a survey before you begin receiving instruction on invasive species. Then, after receiving instruction on topics involving invasive species you will be asked to complete another similar survey.

*Your Involvement*

The survey includes questions about your knowledge and awareness of invasive species, your attitudes towards invasive species, and your connection with nature.

Participation is entirely voluntary – you do not have to fill in the survey. If you choose to complete the survey, you do not have to answer every question and you can decide not to hand in your survey if you wish. At no time will you be asked to put your name on the survey. All information you provide will be considered confidential and the completed surveys will be kept in a secure location. Your decision to participate or not will have no impact on your course grade.

After the surveys have been analyzed, your teacher will receive a copy of the results and a summary of this research to share with you.

*Contact Information*

If you have any questions regarding this study please contact me at 226-788-0741or by email kdcreelm@uwaterloo.ca. You can also contact my supervisor Dr. Brendon Larson by telephone at 1-519-888-4567 ext. 38140 or by email at blarson@uwaterloo.ca

This study has been reviewed and received ethics clearance through the Office of Research Ethics at the University of Waterloo and the Wellington Catholic District School Board has given approval for this study to be conducted with your class. However, the final decision to participate is yours. If you have any comments or concerns resulting from you participation in this study, please contact Dr. Susan Sykes of this office at 1-519-888-4567 ext. 36005 or ssykes@uwaterloo.ca.

Thank you for your interest and assistance with this research.

Yours very truly,

Kyle Creelman
Masters Candidate
Environment and Resource Studies
University of Waterloo

## Appendix F: Modified CNS Scale Items

1. I often feel a sense of oneness with the natural world around me.
2. I think of the natural world as a community to which I belong.
3. I recognize and appreciate the intelligence of other living organisms.
4. *I often feel disconnected from nature.
5. When I think of my life, I imagine myself to be part of a larger cyclical process of living.
6. I often feel a connection with animals and plants
7. I believe that I belong to the Earth as equally as it belongs to me.
8. I have a deep understanding of how my actions affect the natural world.
9. I often feel part of the web of life
10. I believe that all inhabitants of Earth, human, and nonhuman, share a common 'life force'.
11. Like a tree can be part of a forest, I believe I am embedded within the broader natural world
12. *When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.
13. I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.
14. *My personal wellbeing is independent of the wellbeing of the natural world.

*Following the design of the CNS scale (Mayer and Frantz, 2004), I reversed the polarity of items 4, 12, and 14.