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INVADING MINNESOTA:
A MIDDLE SCHOOL INVASIVE SPECIES CURRICULUM

by

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A capstone submitted in partial fulfillment of the requirements for the degree
of Master of Arts in Education: Natural Science and Environmental Education.

Hamline University

Saint Paul, Minnesota

May 2018

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"Treat the earth well: it was not given to you by your parents, it was loaned to you by your children. We do not inherit the Earth from our Ancestors, we borrow it from our Children."

-American Indian Proverb

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CHAPTER ONE

INTRODUCTION

For as long as I can remember, I loved being in nature. I had the privilege of growing up in a rural area surrounded by farm fields and a forest of sugar maples oozing with sweet sap, and acorn-filled oak trees. I spent summers biting open goldenrod galls to expose the larva inside and building forts with my cousins. I am so fond of those memories and am lucky to be able to return to that place from time to time. When I do go back, some things have stayed the same, but they do not look as familiar as they once did. The oak trees are still standing proud, there are still maples and goldenrod galls, that fort is barely standing, yet still there. I am struck by how much has changed. The structure of the forest is still there, it has not been leveled for new development, and the trees have not been logged for their wood. But, what is impossible to miss is the presence of a species that I do not recall from my childhood. The forest of my memories has been taken over by invasive European or common buckthorn. Everything is still green and beautiful, but on closer inspection, that dense, green foliage is from the thickets of buckthorn. That green foliage not only invades my precious forest, but most of the state of Minnesota.

Invasive species pose great threats to personal property, the economy and above all to the diverse native organisms that inhabit this planet (Invasive Species, 2011). For those reasons, invasive species have become a passion of mine and therefore the topic of this capstone written for Hamline University's Natural Science and Environmental Education program. I am a science teacher. I teach life and earth science to middle school students. Prior to writing the curriculum for this capstone, I taught students an overview

of invasive species, one being buckthorn. By the end of the unit, most students had a distaste for buckthorn equal to my own. Through this capstone research, I will develop a curricular unit that focuses on invasive species and what can be done to prevent their spread while also promoting environmental literacy. I will be focusing on the following research question: How might a curricular unit about invasive species be designed to enhance the environmental literacy of middle school students?

Rationale

According to Oregon State University's Environmental Literacy Program, environmental literacy is defined as, "An individual's understanding, skills and motivation to make responsible decisions that considers his or her relationships to natural systems, communities and future generations." (2014). I believe it is important to foster a relationship between children and the natural world. A respect for nature and all things wild is not acquired at birth, but is built and bridged by our experiences and attitudes. Not all students have had the opportunity to play and interact with nature, so do not recognize its value. It is important that our society places a greater non-monetary value on the natural world, or I fear that the upcoming generations will have a very different definition for nature and what is wild. Understanding and appreciating the natural world is an important goal of education (What is Environmental Literacy?, 2015). As an educator I believe it is my duty to help foster an understanding, appreciation and connection to the natural world.

Why is environmental literacy so important? What difference does it make to middle school students? The Environmental Literacy Council states, "While we cannot predict all the issues the next generation will confront, we can be certain that among them will be

issues related to the environment.” (What is Environmental Literacy?, 2015). Our students, which will one day be the leaders of our society, will be faced with many environmental challenges. The challenges they will be faced with will affect quality of life and health, clean water, and renewable resources. These challenges are overarching and interconnected, much like nature itself. It is impossible to address the challenges that face our world without considering the consequences to the plants, animals, soil, water, and air quality. To truly empower the next generation to be environmentally literate, we must expose them to these challenges now. Children of all ages possess the skills to address these challenges head-on and to make a positive impact for generations to come.

The Story Behind the Question

Growing Up. I attribute my love for nature to my upbringing. Not only did I grow up in a rural area with wild and open spaces, but I also had great mentors who instilled in me the importance of caring for the earth. My dad loves nature too, he would rather spend time outside than contained between four walls with the television on. Since I can remember, along with my siblings, my dad and I would go walking in the woods, fish on every clear summer day, spend the day working in the garden, or stay out until it was dark enough to catch fireflies. Nature has always been something that has caught my curiosity. I did not go too far without my “bug box” or an old plastic jar to contain my fascinating finds. My mom was always astounded by what I brought home and was brave enough to help me capture just about anything. These experiences have fostered in me a deep love and respect for the natural world.

Evolution of Teaching. It has been a life-long goal of mine to teach, and my love for the outdoors inspired me to major in science. I have been teaching science for the last 11

years and love it. I have always enjoyed working with kids and feel privileged to have the opportunity to teach them. When I first started teaching I focused more on the curriculum and less on the experiences and emotions the topics sparked in my students. After a decade of teaching, I now realize that my job is less about making sure students learn the facts and more about providing experiences that pique curiosity, provide the opportunity to make connections to the real world, and are fun. I still hope to engage students in science and to get them excited about the concepts we are learning, but I also want them to understand topics in a larger context. I want them to understand that their choices can have positive or negative impacts on the world around them.

Goal of Education. My ultimate goal as an educator is to ignite the desire to learn in all students. Not only in the classroom, but in all aspects of their lives. The classroom should be a place to teach students valuable skills that students can apply to whatever challenges they may face. Another goal of mine is to encourage students to reach their full potential, so they can become informed citizens and truly understand the impact of their decisions. I believe it is my responsibility to set a positive example and create a foundation that students can build upon. There is a quote I often refer to in order to remind myself of the example I want to provide for my students. Richard Louv said in his book, *Last Child in the Woods*, “Parents, educators, other adults, institutions-the culture itself-may say one thing to children about nature’s gifts, but so many of our actions and messages-especially the ones we cannot hear ourselves deliver-are different.” (pg. 14). I want to be cognizant of the messages and attitudes I display for my students. I believe one way to be an effective teacher is to model what I hope to see in the future. One of my hopes for the next generation is to have a group of environmentally literate

young people who have the strength to preserve. The challenges that face our world will take strength, courage, motivation and creativity to overcome.

Conclusion

The purpose of this chapter was to introduce the topic of my research, provide a context to why it is important, and share insight into my chosen topic. The purpose of my research is to answer the following question: How might a curricular unit about invasive species be designed to enhance the environmental literacy of middle school students? The next generations will be faced with many environmental challenges. They will have the responsibility of coming up with solutions to these challenges. Decisions that make positive impacts on the environment will be imperative for the generations of all species to come. The reason this topic is so important to me is because I had the opportunity to experience nature as a young person and had mentors that instilled in me a strong sense of environmental literacy. I want to help foster environmental literacy in the generations to come.

Chapter two will present a review of literature related to the research question: How might a curricular unit about invasive species be designed to enhance the environmental literacy of middle school students? The topics included in chapter two will be the earth as an interconnected system, what are invasive species, specifically why European Buckthorn is a problem in Minnesota and ways to improve student environmental literacy. Chapter three will outline the methods used to develop a curriculum about invasive species, and includes the framework used to organize the lessons in chapter four. Chapter four will show the results of my research. This chapter will be the curricular unit influenced by the research in chapter two to help improve environmental literacy among

middle school students. The final chapter of the capstone will be a conclusion of what I have learned while researching and developing this unit.

CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter will start with a review of the biosphere and how intimately connected ecosystems are. After that, chapter two will provide an overview of invasive species. Topics will include: arrival, success, impact to ecosystems, and eradication or controlling the spread of invasive species. Invasive species will be revisited with an in-depth look into the history of European Buckthorn, how it reproduces, how it impacts native ecosystems, and how it can be controlled. The final topic explored in chapter two will be environmental literacy. Environmental literacy includes: the definition of, how it is developed, and techniques for enhancing environmental literacy through education.

The Earth System

Earth is a complex system of interactions that, in some cases, are only beginning to be understood. It is important to consider the earth as a whole, if we look at something too narrowly, it is hard to understand how interconnected the entire system is. A change in one part of the system will likely result in a change in one or more other parts (Williams, 2012). Generally speaking, the earth has two primary components, the biosphere and the geosphere. The biosphere includes those things living on this planet and the things needed to support their lives (Agundo, 2017). The geosphere includes the non-living factors such as the lithosphere (solid rock), atmosphere (protective gases) and the hydrosphere (water existing as a solid, liquid and gas) (Williams, 2012). While the main focus of this research may seem to be about the biosphere, it is imperative to understand that without the geosphere earth would not have its diverse biosphere. Rachel Carson

was a pioneer of environmental literacy and in her book, *Silent Spring*, she wrote, “[...] to a large extent, the physical form and the habits of the earth’s vegetation and its animal life have been molded by the environment.” (pg. 5). Ecology is in essence the study of how the biosphere and geosphere interact with and shape one another. Yet, these relationships are just beginning to be understood (Gates, Thompson, and Thompson, 2016). As we draw our focus in, the next section of research will outline the biomes of Minnesota and how they support the beautiful balance of living diversity found here.

Biomes. The biosphere is divided into major communities influenced by the predominant vegetation in a particular environment. The mix of species and physical environments vary based on the temperature and precipitation of the region (Gates et al., 2016). The state of Minnesota is dominated by four ecological biomes. Figure 1 is a map from the Minnesota Department of Natural Resources that shows the four biomes of Minnesota. The first is the coniferous forest biome. This biome is considered to be cool



Figure 1: Minnesota’s Biomes

and moist. It is dominated by cone-bearing evergreen trees. Another biome of Minnesota is the tallgrass aspen parkland. This biome is dominated by tall grass prairies with aspen and bur oak trees mixed in. The climate is harsh in this biome, the winds are strong and the precipitation is slight. The third biome that dominates the state is the deciduous

forest. This biome is home to trees that lose their leaves seasonally such as, oaks, maples, cottonwoods and aspens. Warm air masses keep this area warm and sunny in the summer and provide a long growing season. The winter brings less moisture and sunlight, so the trees shed their leaves (Minnesota Department of Natural Resources, n.d.). The final biome that is found in Minnesota is prairie grassland. This area was once dominated by native prairie, but now is home to much of Minnesota's fertile farmland (Sagor, 2007). Generally temperatures are higher and precipitation is lower in the prairie biome relative to the others found in Minnesota (Minnesota Department of Natural Resources, n.d.). Minnesota's biomes are dominated by the type of vegetation growing there which is reliant on the climate of the area. Narrowing our focus a bit more, biomes are characterized by the ecosystems within them. The next section of research will delve into the interconnectedness of the biosphere and geosphere known as an ecosystem.

Ecosystems. Ecosystems are an organized view of nature. According to Encyclopedia Britannica an ecosystem is defined as, "the complex of living organisms, their physical environment and all their interrelationships in a particular unit of space." ("Ecosystem," 2017). Sir Arthur George Tansley was a British ecologist who coined the term "ecosystem" in 1935. He said (as cited in Agundo, 2017) ecosystems were in "constant interchange" among the biotic and abiotic parts. While the term ecosystem was not used until 1935, surely people were studying the interactions taking place in nature before that time. In *Silent Spring*, Rachel Carson stated, "the history of life on earth has been a history of interaction between living things and their surroundings." (pg. 5). Whether being studied or not, living things and their nonliving environments are inseparable and have been constantly interacting upon one another since earth harbored

life (Gates et al., 2016). The link between the living and nonliving constituents in an ecosystem has to do with how energy and nutrients flow through the ecosystem (“Ecosystem,” 2017).

The living portion of the ecosystem can be classified into three broad groups. Each classification is based on how the organisms of that group acquire energy and nutrients. The first group, producers are able to use the energy from the sun to produce their own food through a process called photosynthesis. Producers are generally made up of green plants (“Ecosystem,” 2017). Not only do these organisms produce the food that is vital for their survival, they also produce the food that is needed for all other organisms to survive too. The next group is known as the consumers. These organisms must eat or consume other organisms to obtain the energy they need to carry out life’s functions. This group includes animals, like humans. These organisms may eat producers, other consumers or both. The final way an organism can obtain nutrients and energy is by breaking down the remains of other biota. These organisms are nature’s recyclers, they return the nutrients and energy of once living things back to the soil (Gates et al., 2016). Once the nutrients are returned to the soil, they can be used by producers. This is part of a bigger cyclical process known as a food chain or web. Food chains and webs show feeding relationships and energy transfers within an ecosystem (“Ecosystem,” 2017). Aldo Leopold noted in *A Sand County Almanac* that, “The pyramid is a tangle of chains so complex as to seem disorderly, yet the stability of the system proves it to be a highly organized structure. Its functioning depends on the co-operation and competition of its diverse parts.” (p. 215). This highly organized level of balance carefully crafted by nature will be explored next.

Ecological Balance. In looking at the tender balance of an ecosystem, Rachel Carson states:

It took hundreds of millions of years to produce the life that now inhabits the earth-eons of time in which that developing and evolving and diversifying life reached a state of adjustment and balance with its surroundings. Given time-time not in years but in millennia-life adjusts, and a balance has been reached. (p. 6)

Ecological balance ensures the stability of the ecosystem and its inhabitants. Ecological balance provides benefits to all species and makes sure no particular group is overused or exploited (Thompson, 2015).

In order to maintain the balance of an ecosystem, the feeding relationships within a food web must be upheld. The cyclical passing of energy from the abiotic factors to biotic factors and back again is crucial in maintaining the diversity and balance of an ecosystem (Agundo, 2017). This flow of energy that has been brought about by the complex feeding relationships of a food web has been shaped and reshaped overtime by evolution (Gates et al., 2016). Evolution plays an important role in ecological balance. Evolution happens when pressures of a changing environment cause slow changes that can result in the changing of a species or the formation of a new species (Szyniszewska, 2007). Changes in a species or the creation of a new species often affect the ecosystem. Ecological balance is a harmonious relationship between the changes in an ecosystem and the time allowed for organisms and the environment to make adjustments to those changes (Stuart, 1997). Given enough time, ecosystems can make necessary adjustments to maintain balance. Ecological balance may be threatened by the rapid changes caused by humans. Rachel Carson stated in *Silent Spring*, “The rapidity of

change and the speed with which new situations are created follow the impetuous and heedless pace of man rather than the deliberate pace of nature.” (p. 7). As humans, we oftentimes think of ourselves as something other than organisms that are deeply connected to the natural world. As a result of this, humans have impacted the balance of the environment in many ways.

Human Impact. It would not be fair to say that all human-nature interactions are negative. The positive impacts humans can have on the environment will be explored later in this chapter. The pace at which humans have changed the environment has been alarming to its ecosystems. Humans have undone the built-in checks and balances that have taken the biosphere millennia to put in place (Carson, 2002). Humans alter the earth in many direct and indirect ways, thus it seems we are in constant competition with the earth system that sustains us (Williams, 2012). Outlined next will be some of the many ways human beings can alter the environment.

The human race causes many changes to the environment at an exceedingly fast pace. One way humans have impacted nature is through the creation of synthetic products such as herbicides and pesticides (Agundo, 2017). These products intentionally limit biodiversity of organisms we deem “pests,” but they can also unintentionally limit the success of other plant and animal species. These chemicals do not stay confined, they penetrate the soil, pollute the water and lead to disruption at every level of the food chain. Another way human activity causes changes in an ecosystem is through habitat exploitation, conversion, and destruction. As the human population continues to increase, people will continue to be in competition with organisms in nature for available resources. Those resources include food, shelter, water, and space. The more space

humans take up, the less is available for all of the other diverse organisms of this planet. Additionally, humans impact ecosystems by introducing new species, which can lead to the simplification of the diversity of a particular ecosystem (Stuart, 1997). The topic of introduced or invasive species will be discussed at length later in this chapter. Humans share this planet with a multitude of other species and resources. We must consider the consequences of our actions and respond with vigor to reverse the negative ways we have impacted this place we call home. Conserving this planet and all things precious on it should be a major concern to all humans. The task we are charged with is big, but there are leaders among us that are trying to tackle some of these issues.

Environmental Stewardship. Aldo Leopold noted in *A Sand County Almanac* that, “each species, including ourselves, is a link in many chains.” (p. 215). Those chains bring about balance within an ecosystem. Humans can cause imbalance within an ecosystem, but if we recognize the negativity of our ways, we can work to conserve and restore the delicate balance nature has developed over earth’s existence. The responsible use and protection of the environment is the basis of environmental stewardship. A person who practices these qualities is an environmental steward. Al Gore challenges each of us in his book *Earth in the Balance*:

When considering a problem as large as the degradation of the global environment, it is easy to feel overwhelmed, utterly hopeless to effect any change whatsoever. But we must resist that response because this crisis will be resolved only if individuals take some responsibility of it. (p. 366)

As with an ecosystem small changes can cause big impacts, which can be positive or negative. Some of the things done on this planet may be irreversible, but that does not

mean environmental stewards should give up. Some places and organisms may never return to their original form, but we can stop them from getting worse. Perhaps the biggest impact can come from educating people about the consequences of their actions. If people had a better understanding about how they were influencing the environment, that may shift their way of thinking (“The World’s Biomes,” 2007). If people viewed the earth as something more than a commodity, they may learn to love and respect it. Overall, this will take internal change within us all, but it will also take the collective efforts of this generation and the ones yet to come to preserve things natural, wild and free (Leopold, 1949). Specific ways to enhance environmental stewardship and develop environmental literacy will be discussed later in chapter two.

Summary. The earth is a vast system of interconnected ecosystems. The living and nonliving constituents of an ecosystem are dependent on each other. This dependence is delicate and took eons to perfect. The earth is a place of wonder with the ability to adapt and preserve balance if given the time to do so. Humans have disrupted that balance, but it is time for a shift in thinking. Now is the time for change, to undo the damage done, or preserve the natural parts of our world. Al Gore summarized this idea in his book *Earth in the Balance*:

The ecological perspective begins with a view of the whole, an understanding of how the various parts of nature interact in patterns that tend towards balance and persist over time. But his perspective cannot treat the earth as something separate from human civilization: we are part of the whole too, and looking at it ultimately means looking at ourselves. (p. 2)

Invasive Species

Inadvertently or intentionally, humans have been moving organisms from their native ecosystems to new ones for generations. An organism that has been introduced to a new place is called exotic, alien or simply an introduced species (McGinley, 2011). Many of these introduced species do not thrive, due to improper climate and a lack of food sources. Some introduced species survive, but their populations are maintained by natural means of competition, predation, and pests. Yet others, survive but require the intervention of humans to continue their success. Most of these types of organisms are food crops, or crops that bring economic value to the new region. The final group of introduced species that are able to survive, thrive and compete with the species native to the introduced ecosystem (Hill, n.d.). These species are called invasive and it is estimated that one in every 1,000 introduced species actually becomes invasive (Muth, 2014).

Invasive Species Defined. According to the United States Department of Agriculture an invasive species is “non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.”. In order to be invasive a species must adapt to the new environment, multiply quickly, and cause harm (“Invasive Species,” 2011) Invasive species can be any type of organism such as, plants, animals, pathogens or microbes (U.S. Department of Agriculture, 2016). Invasive species pose great threats to this planet’s biomes and ecological balance. These species pose an enormous threat to native biodiversity, even more so than pollution, harvest and disease combined (McGinley, 2011). We know

these species bring about grave consequences, but how did they get here? The arrival of introduced invasive species will be discussed next.

Arrival. Species can be introduced to a new location by one of two ways. The first, yet less common way, is through natural means of range extension. This introduction is slower and gives the native ecosystem more time to adapt. The second method of introduction is through human activity (McGinley, 2011). The practice of transporting organisms from their native land to new ecosystems has been going on for thousands of years (Hill, n.d.). Aldo Leopold kept record of his observations in his book *A Sand County Almanac*, he noted that, “1879 saw the first planting of carp in Wisconsin, and also the first arrival of quack-grass as a stowaway from Europe.” (p. 14). Both of these organisms are ferocious invaders that are still impacting ecosystems today with little being done to limit their success.

Our actions have helped the spread of invasive species, which outcompete our native species (Muth, 2014). As stated before, some organisms are introduced intentionally, while others are introduced accidentally. Allyson Muth of Penn State estimates that:

The horticulture industry is responsible for 60% of the plant species that have become invasive in the U.S. [...]. Conservation practices, trying to prevent erosion, feed wildlife, etc. are responsible for 30% of invasive plant introductions [...].

Accidental introductions account for 10% of invasive plants. (Muth, 2017).

While the introduction of species to new places has been happening for millennia, our rapid means of transportation has increased the rate of these introductions (Meinesz, 2003). This is one of many consequences of globalization (Hill, n.d.). Once these organisms arrive in their new ecosystem, the means of arrival becomes less important as

how to limit their spread and success. So, what makes an invasive species different from all the other species introduced to new regions? The success of invasive species will be explored next.

Invasive Success. If only one in 1,000 introduced species is considered invasive, what factors contribute to the success of those few? Rachel Carson stated in *Silent Spring* that in the new location the invasive species is, “out of reach of the restraining hand of the natural enemies that kept down its numbers,” (p. 11). The natural enemies Carson reference include predators, parasites, pathogens, and competitors (Agundo, 2017). These organisms had predators and competition in their native ecosystems, but when introduced to a new one, those natural checks and balances were left behind (Wisconsin Department of Natural Resources, 2012). The relationship between predator and prey often results from a long history of coevolution in the native landscape. As one organism gains an advantage, the other must adapt or face extinction. This constant battle for new defense mechanisms and manners of outwitting each other helps to keep balance within the ecosystem. Without such balance, some members become too successful, which leads to the dominance of certain species (Hill, n.d.). The lack of predators and competitors in the new ecosystem is just one of the many reasons invaders are successful.

Many invaders are considered persistent, relentless and tenacious (Bald, 2016). These traits are attributed to invasive species because of the variety of ways they find success. Many invasive species are considered highly adaptable and respond to changing environments more quickly than their native counterparts. Specifically invasive plants have been observed to adapt to changing climates. Some plants are able to leaf out

earlier in the spring and keep their leaves longer into the fall, others are able to modify their flowering schedule to maximize the growing season. These adaptations can put the invasive species at an advantage compared to those that are not able to change as quickly or at all (Nijhuis, 2013). In addition to adapting to their new environment, many species considered invasive have high reproductive ability. They are able to produce more offspring and in the case of plants have an efficient way of dispersing the seeds of the next generation (Muth, 2014). Another interesting factor for success is that some invasive organisms may alter the environment making it more favorable for themselves. This is called ecological facilitation (Hill, n.d.). An example of this is plant allelopathy. Allelopathy is the hypothesis that some plants exude biochemical agents to alter the environment in ways that are toxic to native plants and other organisms (Muth, 2014). While the diversity of invasive species is great, so are their means of success. No matter the method of success, by definition, invasive species cause harm to the environment and economy.

Invasive Impacts. Species are introduced to new locations without anticipating the significant consequences to the environment or economy. The impact of invasive species on the environment is great. Second only to habitat destruction, the introduction of new species threatens the biodiversity of a native ecosystem. Invasive species can alter the existing relationships in an ecosystem by causing disease, acting as predators, outcompeting native organisms and altering habitat (McGinley, 2011). Invasive species can be vectors for disease that the immune systems of the native species have never been exposed to (Hill, n.d.). As stated before, the relationship between predators and prey does not happen due to happenstance, but due to a long coevolution in a particular

ecosystem. When a new predator is suddenly introduced, the prey species may be defenseless. This can drive down the population of the native prey and may lead to extinction (McGinley, 2011). Another way invasives impact biodiversity is through competition. Invasive species can crowd out native organisms by multiplying and taking over, overfeeding on food sources pivotal for native species survival and destroying habitat (“Invasive Species,” 2011). It is estimated that 42% of species on the federal Threatened or Endangered Species List make the list primarily because of invasive species (Wisconsin Department of Natural Resources, 2012). Invasive species threaten the balance of ecosystems in many ways, but they also pose threats to the human economy.

The impacts on the ecosystem by invasive species cannot be measured by monetary value, but the impacts they pose to the economy can. As of 2011, it was estimated that the U.S. economy alone spent \$137 billion dollars a year to negate the impacts of introduced species. This cost was due to property damage and impacts on industries such as agriculture, forestry and fisheries (McGinley, 2011). Much of the efforts used to negate the impacts of invasive species were spent on also trying to regain the balance of ecosystems that are important to the economy. These efforts include how to control the spread of invasive species and ultimately how to eradicate them from their non-native ecosystems. These topics will be discussed next.

Invasive Eradication and Control. The ecosystem is diverse, as is the variety of invaders within it. Therefore, each case is unique and needs to be treated that way (Meinesz, 2003). The best method of defense is preventing the arrival of invasive species in the first place (McGinley, 2011). Because even scientists do not always know how a

species will adapt to a new environment, it is best to limit the introduction of new species (“Invasive Species,” 2011). One of best tactics of preventing the arrival is anticipating the pathways of arrival (“Pathways of Entry,” n.d.). Historically, introduced species have arrived through ship ballast water, wooden packing materials and horticulture plants. By monitoring known pathways of arrival, the number of introduced species can be limited.

Once established, invasive species can be difficult, if not impossible, to eradicate and control. One way to control the success of invaders is through the monitoring and observing of populations. It is easier to control and possibly eradicate a species when numbers are low. If the population surges, so does the spread and the effort it takes to control that species. Early, persistent intervention, can keep populations at acceptable levels (McGinley, 2011). Another way to control invasive species populations is through education. Just as humans have unintentionally introduced invasive species in the first place, we also spread them without knowing. Government agencies are working to educate the public about the dangers of transporting wildlife to new areas (“Invasive Species,” 2011). Governments have passed many laws and regulations to limit the spread of invasives (Hill, n.d.). If people are not aware that they are part of the problem, they cannot be part of the solution. There have been many initiatives to educate people of the ways they spread invasive species. These initiatives include removing aquatic plants and animals from watercraft before moving from one body of water to another, and buying local firewood rather than transporting firewood to prevent the transfer of invasive species into an uninfected area (Wisconsin Department of Natural Resources, 2012).

If prevention and eradication are not possible, there are a variety of other ways humans can try to control the spread of invasives. Some of these interventions have some success, but some can compound the problem. The following methods of control are grouped into the categories of mechanical control, chemical control, and biological control. The first method of control, mechanical, means to physically remove the invader by machinery or human efforts (McGinley, 2011). This could be removing invasive aquatic weeds, pulling buckthorn seedlings or encouraging the harvest of organisms such as carp through fishing. (Hill, n.d.). It is important to note that mechanical control is not a one and done type of method. To be successful the mechanical controller needs to be more persistent than the invader (Bald, 2016). The second method is chemical control. This method uses chemicals such as herbicides and pesticides to limit the populations of invaders (“Invasive Species,” 2011). This method must be deployed with caution because it can have unintended consequences. Some chemicals can harm non-invasive species as well as the intended invasive species. Chemical control is costly and may only last for a short period of time due to organisms developing a resistance to certain chemicals (McGinley, 2011). The final method of control is biological, which should be done with caution. Biological methods include infecting invasives with diseases and introducing other organisms to limit the success of the invader, such as a natural predator (“Invasive Species,” 2011). This method can be effective, but also has its limits. One unintended consequence is that the biological control agent attacks nontarget species in addition to the target species. Another is that by introducing another organism into a non-native environment, it may become invasive itself (McGinley, 2011). Anytime humans change the environment it should be done

with caution, because the consequences of our actions are hard to anticipate and even harder to reverse.

Summary. Invasive species are those that are not native to a particular area and cause great economic and environmental harm to the areas they are introduced (“Invasive Species,” 2011). As Rachel Carson warned, “these invasions both naturally occurring and those dependent on human assistance are likely to continue indefinitely.” (p. 11). Because this is a problem that is likely to persist, we must be equally relentless and tenacious in our efforts to prevent, control and eradicate these organisms as they are at their quest for survival (Bald, 2016).

European Buckthorn (*Rhamus cathartica*)

European or common buckthorn (buckthorn) is considered an invasive species in the United States. This section of research will give an overview of buckthorn characteristics, a history of buckthorn in the U.S., specifically in Minnesota, the methods of reproduction, impacts to the ecosystem, and ways to control buckthorn.

Common or European buckthorn is a small tree or shrub native to western Asia and Europe (Whitfeld, Reich, Lodge, Roth, and Buschena, n.d.). Its multiple upright stems can grow 10-25 feet tall. Buckthorn is a highly adaptable plant that can thrive in dry to moist areas in both full sun or full shade. It has dark green oval leaves that emerge early in the spring and stay green through November. Buckthorn produces small, yellow-green flowers in May (Minnesota Department of Natural Resources, 2017). Buckthorn plants are dioecious, meaning there are male and female flowers on separate plants (Michigan Department of Resources, 2012). If pollinated, the female flowers turn into round berry-like fruit. The berries ripen from green to a dark purple-black color with 3-4 seeds in

each (Minnesota Department of Natural Resources, 2017). Female plants are more abundant than male plants and produce a large number of fruit (Michigan Department of Resources, 2012). The reproductive success of buckthorn is just one of the reasons it is considered an invasive species in the United States.

History. European buckthorn has a long history in North America and was brought here in the late 18th century (Whitfeld et al., n.d.). It was brought from Europe as a hedging material and was also used for medicinal purposes (Minnesota Department of Natural Resources, 2017). The dried berries and bark have been used medicinally to treat constipation (Alderson, 2016). Since the introduction of buckthorn, it quickly spread across the northern regions of North American (Whitfeld et al., n.d.). It became a nuisance plant and the nursery industry stopped selling European buckthorn in the 1930s (Jeannette, 2000). It was not until 1937 that it was first recorded in Minnesota (Whitfeld et al., n.d.). Shortly after its recorded arrival it was found to be very invasive and found across much of Minnesota (Jeanette, 2000). Figure 2 is a 2018 map of the United States that shows the population density of European Buckthorn by county (EDDMapS, 2018). Especially striking is the abundance of buckthorn in Minnesota. Not only is it present in nearly every county, but the population density is astounding. Buckthorn has invaded each of the four biomes of Minnesota and has had drastic impacts on those ecosystems. Common or European buckthorn and glossy buckthorn are two different species considered invasive in Minnesota. The Minnesota Department of Agriculture lists both types of buckthorn as noxious weeds. This means that, “the sale, transport, or movement of these plants is prohibited statewide.” (Minnesota Department of Natural Resources, 2017).

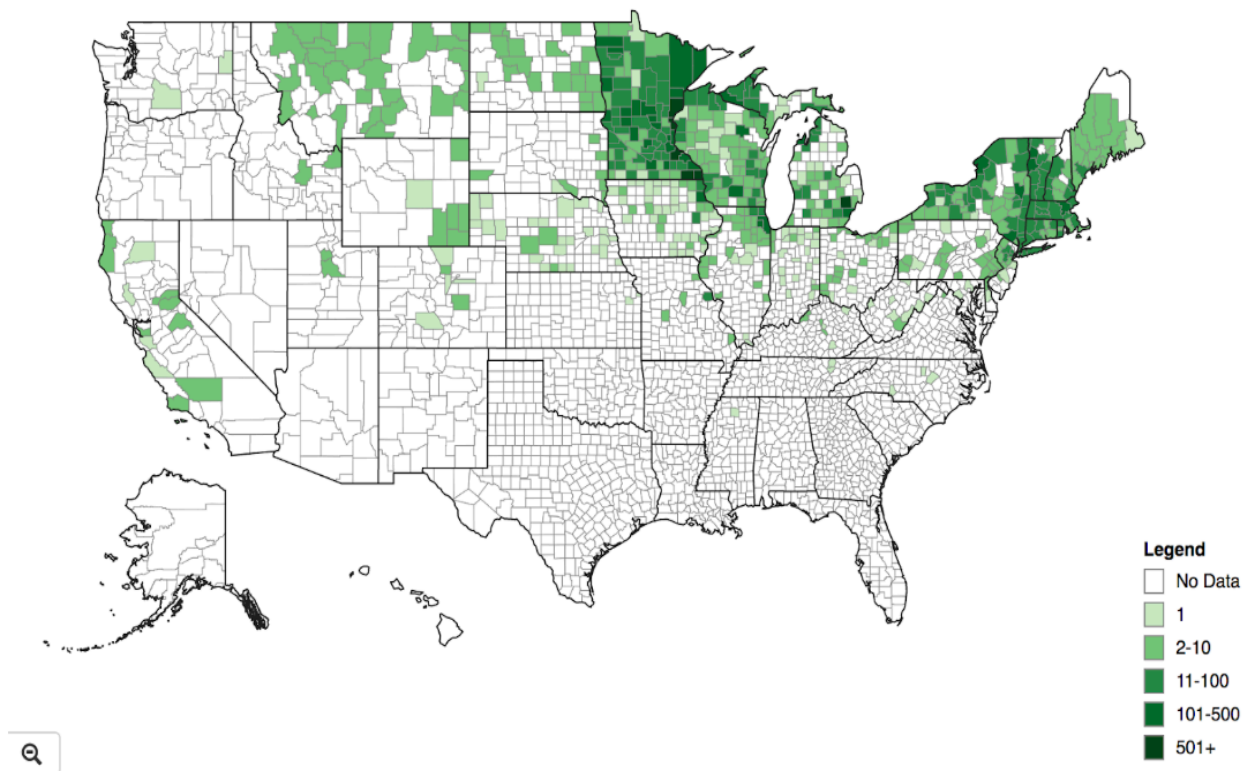


Figure 2: 2018 U.S. European Buckthorn Population Density by County

Reproductive Success. Buckthorn reproduces primarily through the dispersal of seeds. The seeds have low mortality rates and high rates of germination (Whitfeld, et al., n.d.). Buckthorn can also regenerate from cut roots and stump sprouts (Michigan Department of Resources, 2012). The wildly invasive success of buckthorn can be attributed to the spread of seeds from birds, mice, and other animals that eat the berries and drop them in previously uninvaded areas (Alderson, 2006). Buckthorn seeds are not very nutritious and cause a severe laxative effect on the organisms that eat them. Therefore, these organisms eat a large volume of berries and disperse a large number of seeds (“Buckthorn: How can a shrub be so harmful?” n.d.). In addition to animal dispersal, many berries fall to the ground beneath the parent tree which creates a dense

thicket of seedlings (Michigan Department of Resources, 2012). These factors increase the rate of reproduction and in turn, increase the rate of buckthorn invasion.

Impacts. European buckthorn impacts ecosystems primarily by out-competing native plants for nutrients, light, and moisture (Minnesota Department of Natural Resources, 2017). One way buckthorn does this is by growing quickly. Buckthorn leaves are very efficient at doing photosynthesis due to the high levels of nitrogen within them. The ability to grow fast as well as emerging early in the spring and persisting late into the fall, extends buckthorn's growing season, allowing it to aggressively invade native forests. In doing so it increases shade which reduces native seedling growth and survival (Alderson, 2006). Buckthorn is also known to crowd native plants and shrubs to create dense thickets (Minnesota Department of Natural Resources, 2017). These thickets have been observed to be much denser in introduced ecosystems compared to its native ecosystems in Europe and Asia (Alderson, 2006).

In addition to being a fierce competitor, buckthorn also deploys other tactics to ensure its success. Buckthorn has few predators in its introduced ecosystem. Observations of spots or small holes are rarely seen on the leaves ("Buckthorn: How can a shrub be so harmful?" n.d.). This could be because buckthorn is an example of a plant with allelopathic properties. Buckthorn is believed to produce a compound called emodin that deters herbivores from feeding on the leaves and also limits the growth of neighboring plants (Whitfeld, et al., n.d.). This gives buckthorn an additional competitive edge against native plants. This change to soil chemistry has also been linked to the increase of invasive earthworm populations (Seitz, 2017). Non-native earthworms seem to prefer to feed on fallen buckthorn leaves. This increases the decomposition of leaf litter, which

allows more buckthorn seeds to germinate and decreases the number of native species. More earthworms invading and eating the leaf litter leads to a decrease in native leaf litter invertebrates and soil decomposers. Together, earthworms and buckthorn are reducing the overall diversity of organisms in invaded ecosystems (Whitfeld, et al., n.d.).

As stated before, it is impossible to comprehend all of the ways an invasive species impacts an ecosystem. Buckthorn is negatively impacting organisms it is not in direct competition with by providing habitat and harboring overwintering pests such as the soybean aphid and alfalfa mosaic virus. (Michigan Department of Resources, 2012). These are both agricultural pests that stunt plant growth and lead to crop loss (Alderson, 2006). Buckthorn primarily impacts terrestrial ecosystems, but can contribute to the degradation of aquatic ecosystems as well (Seitz, 2017). The lack of leaf litter and native plant roots to help keep soil in place has led to increased erosion in dense stands of buckthorn (Minnesota Department of Natural Resources, 2017). When it rains, there is nothing to keep the soil in place and it washes out forming deep ravines and gullies. This precious topsoil is washed into bodies of water where it causes sediment and organic material to accumulate (Seitz, 2017). Buckthorn is highly adaptable and has huge impacts on the native ecosystems. Buckthorn threatens the future of all ecosystems, wetlands, prairies, forests, and other natural habitats (Minnesota Department of Natural Resources, 2017). Without natural predators and competitors buckthorn populations are growing out of control. The native ecosystems provide no match to the threats buckthorn poses, therefore humans need to take action to control the spread of buckthorn and preserve the biodiversity of our ecosystems.

Control. As with any invasive species, the best way to control the spread of buckthorn is to prevent its arrival in the first place. Humans can prevent the invasion of buckthorn by enhancing the diversity of native species. This leaves less space for invaders to take hold in the ecosystem. Another way humans can prevent the spread of buckthorn is to minimize disturbances to the environment. This can be done by harvesting timber in winter and staying on trails to reduce trampling of native species (Whitfeld, et al., n.d.). Once buckthorn has invaded an area, limiting its spread is important, but it is nearly impossible to completely eradicate.

Buckthorn can be controlled mechanically, chemically, or by using a combination of both. Small trees less than $\frac{3}{8}$ of an inch in diameter can be pulled and will not re-sprout. If the number of small trees is too great to hand pull, spraying the leaves with a herbicide can be effective. It is important to use a herbicide that kills the intended target with little impact on the native species nearby. Larger trees are best controlled by cutting the stem at the soil level. The stump must then be treated with a herbicide or covered by a tin can or thick plastic bag to prevent re-sprouting. Prescribed burning can offer control in grasslands and prairies, but needs to be repeated every two to three years. No matter the method of control, follow up is critical. Buckthorn is persistent and the seeds can lay dormant in the soil for up to five years (Minnesota Department of Natural Resources, 2017).

Summary. European buckthorn is one of two invasive varieties found in Minnesota. It has been identified extensively in the state and in high populations. It has a high capacity for reproduction and is capable of competing with members of many different ecosystems. For these reasons, it is important to prevent the spread and try to

control buckthorn. Controlling buckthorn is a monumental effort and takes the action of many individuals to make a difference.

Environmental Literacy

Literacy was first used to describe the degree to which one was able to read and write. Merriam-Webster also defines literacy as, “having knowledge or competence.” (“Literate,” 2018). A basic definition of environmental or ecological literacy, therefore means to have knowledge of the environment and ecosystems. This definition does not begin to scratch the surface of what ecological literacy is. Environmental educators argue that science may be the basis for literacy, but literacy is more than science (Minnesota State Office of Environmental Assistance, 2002). Science may provide the foundation of knowledge, but to be truly environmentally literate, it requires an awareness of the environment beyond the naming of the animals and plants. One must also foster an understanding of the relationships between these organisms and recognize the impacts humans have on them as well (Locke, Russo, and Montoya, 2013). According to Roland W. Scholz in the book *Environmental Literacy in Science and Society*, “a fully developed environmental awareness requires adequately anticipating environmental change and feedback resulting from human behaviors.” (p. 16). The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines ecological literacy as, “A basic functional education for all people, which provides them with the elementary knowledge, skills, and motives to cope with environmental needs and contribute to sustainable development.” (Moseley, 2000). Ecoliteracy requires not just knowledge, but a deep understanding and need for action to reach sustainability between our needs and the needs of the environment

Measuring Environmental Literacy. Just as reading literacy is not binary: the literate and illiterate, neither is environmental literacy. Environmental literacy is a continuum from being illiterate to possessing an advanced understanding of the topic and the skills needed to take action (Roth, 1992). The Campaign for Environmental Literacy, outlined the steps an individual takes to become environmentally literate and created a visual called the Environmental Literacy Ladder. The ladder is shown in Figure 3

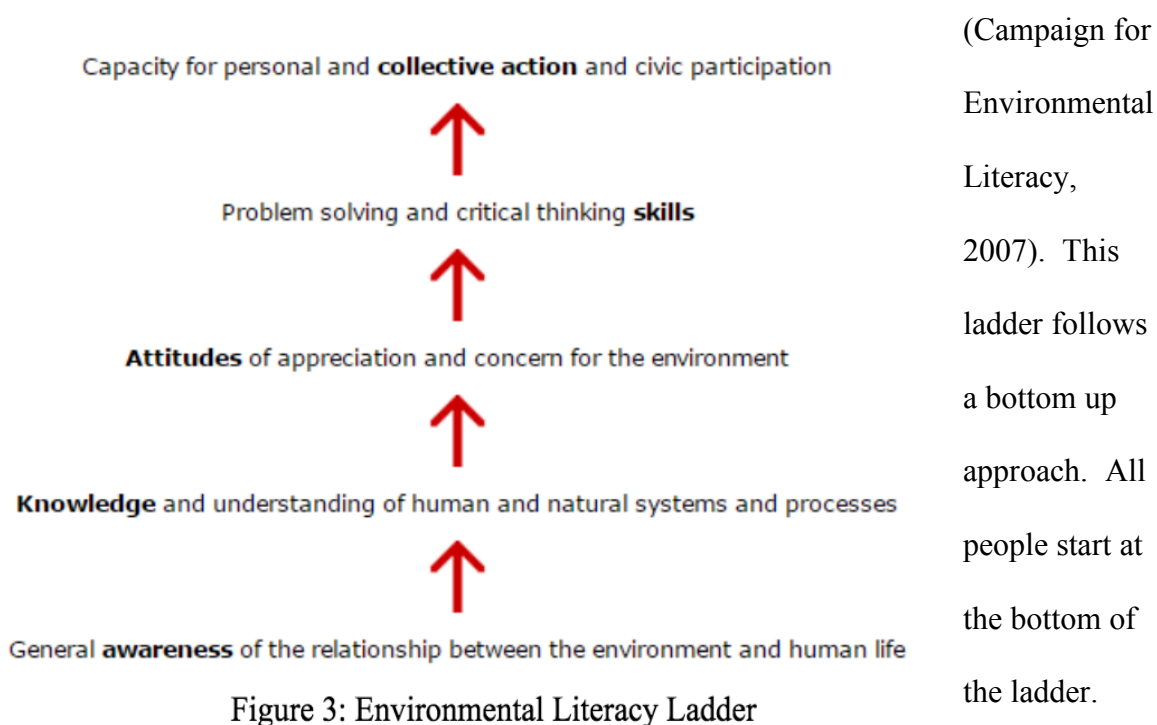


Figure 3: Environmental Literacy Ladder

Even if very little, all people have a general awareness of their relationship to the environment. As that awareness deepens, it evolves into knowledge and the ability to comprehend the relationship between the natural world and themselves. As that knowledge progresses, it may foster positive attitudes about the environment. Feelings of concern and appreciation promote a need to help make this place better for all who live here. People start thinking critically about the environment and try to come up with solutions to environmental problems. The top of the Environmental Literacy Ladder is

action. Action is the goal of environmental literacy (Campaign for Environmental Literacy, 2007). Those at the top of the ladder treat environmental literacy as a way of life. They practice a lifestyle that meets their needs and the needs of future generations while also taking into account the consequences of their actions on the environment (Goleman, Bennet, and Barlow, 2013). This ability to make choices for the good of all is dependent on where an individual is on the environmental literacy continuum.

Rational. The need for ecologically literate people is great. Across the globe all people regardless of their consciousness or intent, impact the environment (Roth, 1992). Yet, according to a 2004 Children's Environmental Literacy Foundation (CELf) report, "Only 32% of Americans have a basic understanding of environmental topics and issues." (Manser, n.d.). In order to elicit the mobility and action of these people, they must first have that elementary understanding of the environment UNESCO cited in their definition for ecological literacy. Charles Roth agrees and says, "The more people there are with even an elementary environmental literacy the better will be the quality of the environment; the greater the number of people with even greater degrees of environmental literacy the better still." (Roth, 1992). Ultimately we need citizens to realize that the fate of their own well-being is tied to the fate of the well-being of all the communities that inhabit the earth (Reynolds, Brondizio, and Robinson, 2010). One way to build greater degrees of environmental awareness and literacy is through education.

Strategies for Teaching Environmental Literacy. Albert Einstein once said, "The problems we have created in the world today will not be solved by the same level of thinking that created them." With that said, the current generation and the generations of the future will be solving problems presented to them by the generation before. The

challenges they will be faced with are unknown and so are the solutions. These generations must possess critical thinking and creative problem solving skills in order to tackle these problems. Therefore it is the responsibility of all educators to nurture environmental literacy in the next generation. Those educators include, “family, community, media, religious organizations, schools, interest groups, and the workplace.” (Roth, 1992). The goal of environmental education is that, “all students will embrace the value of nature for reasons beyond human self-interest.” (Reynolds, et al., 2010). Educators of all disciplines can help foster environmental literacy. Environmental discussions can help students connect what they are learning with real problems that affect their lives (Environmental Literacy Council and the National Science Teachers Association, 2007). The focus of this research is to answer the question: How might a curricular unit about invasive species be designed to enhance the environmental literacy of middle school students? With this focus in mind, the next sections of research will outline proven methods for increasing environmental literacy.

Varied Teaching Methods. As with any curriculum, one key to success is providing the learners with a variety of learning experiences. This rings true with environmental literacy as well. Students learn best when teaching strategies are diverse. Such strategies include hands-on experiences, discussions, exploration, time for reflection, writing prompts, opportunities to ask questions, inquiry based projects, and collaborating with peers (Sly, 2015). In addition to diverse teaching strategies, students benefit from a variety of learning environments as well. Student learning can take place in a traditional classroom, an outdoor classroom, in a park or even a small stand of trees near the school (California Department of Education, 2015). Especially important to environmental

literacy is learning outside of the classroom in nature. Learning in an outdoor environment has been proven to improve environmental literacy (Stevenson, 2013). Natural areas provide the opportunity for students to make connections to what is being taught in the classroom and real-life problems the environment is facing. Some environmental content is abstract, especially to those that do not have a connection to nature. Natural environments provide memorable, sense-stimulating experiences that foster a better connection with and understanding of nature (Reynolds, et al., 2010). Research shows that, “time outdoors fosters pro-environmental attitudes and higher levels of environmental sensitivity which over time leads to more environmentally friendly behavior. Not only can taking students outside foster environmental literacy, but it can enhance social, mental and physical health as well (Stevenson, 2013). The success of environmental literacy is contingent on students making connections to the environment. Therefore, by varying teaching strategies and learning environments, educators can increase the likelihood of engaging students and fostering that connection.

Place-Based Learning. Place-based learning is different from simply taking students outside. It is engaging students in their own environment-their own sense of place (Sly, 2015). The words of Aldo Leopold (as cited in Reynolds, et al., 2010) hold true, “How do we nurture a land ethic in people who have less and less contact with land? How do we inspire people to take care of their home place-if they feel no sense of place? (p. 74). If the goal is to encourage sustainable action, people must feel an intimacy with the land (Reynolds, et al., 2010). So, how does an educator foster this connection with nature and one’s place? According to the book, *Teaching Environmental Literacy*, fostering a sense of wonder can awaken a sense of place and vice versa (p. 93). The book defines wonder

as an “intense sensory and emotional engagement with nature” (p. 89). Educators can provide opportunities for students to explore and discover their sense of place by observing with all of their senses and then connect those experiences to memories from their childhood. “People will often defend places they know and love, but first they must become attached, they must *become native* to the places they already inhabit.” (Reynolds, et al., 2010). A sense of place “captures students’ imaginations and advances environmental stewardship and civic engagement” (Sly, 2015). A sense of place can help students realize their place in the larger context of the biosphere and therefore, feel a deep emotional attachment and a responsibility to heed the call to act on behalf of the environment (Reynolds, et al., 2010).

Service Learning. Effective environmental literacy strategies connect environmental issues to student’s lives. A strong sense of place can foster a strong willingness to take action. One way students can take action is through service learning. Service learning can be done in a variety of ways, but one thing that is true of all service learning is that the recipient and the provider both benefit from the experience. There are two types of service learning: direct-service learning and project-based service learning. The first, direct-service learning, involves students providing volunteer services at a site. Examples of this could include building loon nesting platforms or building wood duck boxes to provide habitat for birds that are in need. The second service learning opportunity is project-based. This type does not involve students visiting a site, but creating a product that serves the needs of a community (Reynolds, et al., 2010). Examples of this could be researching and creating an educational brochure about the hazards of transporting eurasian watermilfoil on a boat trailer or creating a public

service announcement to educate people about invasive species. In reality, most service learning is a combination of both types. Either way, the environment benefits as does the producer of service. This is a situation that is good for all involved and can enhance a student's connection to the environment while promoting environmental literacy.

Summary. Environmental literacy is complex and is developed over a person's lifetime. It is dependent on the experiences one has and the connection they feel with nature. Environmental literacy is a continuum that starts with awareness and results in taking action on behalf of the environment. Education is a powerful tool in fostering environmental awareness. Richard Peters has a powerful call to action for us all (as cited in Roth, 1992) :

We must begin, now, to educate a generation of "quality environment" conscious people who will, in the routine of their everyday lives, continually and logically balance the interests and needs of nature and human populations whenever decisions regarding Earth's usage are to be made. (p. 11)

Conclusion

Chapter two provided a review of literature surrounding the topics of earth systems, invasive species, buckthorn, and environmental literacy. All of these are essential in answering this question: How might a curricular unit about invasive species be designed to enhance the environmental literacy of middle school students? This question is the foundation of my research and was introduced in chapter one. Chapter three will outline the methods used in creating a curricular unit about invasive species. The format used will be a lesson design plan from Grant Wiggins and Jay McTighe, authors of the book *Understanding by Design*.

CHAPTER THREE

METHODS

Introduction

Invasive species have been wreaking havoc on Minnesota's ecosystems. Chapter one provided an introduction of the importance of invasive species education, especially for the next generation of naturalists and environmental stewards of Minnesota. Chapter two reviewed literature providing a history of invasive species and how they have influenced native ecosystems. This chapter will outline the methods used in developing a curricular unit about invasive species. Each prompt of the lesson plan design process will be defined. In the end, this capstone will provide a proposed curriculum to educate middle school students about the impacts of invasive species while promoting environmental literacy.

Unit Considerations

Educators are designers. According to Grant Wiggins and Jay McTighe, authors of the book *Understanding by Design*, "An essential act of our profession [education] is the crafting of curriculum and learning experiences to meet specified purposes." (p. 13). Educators develop curriculum for many purposes, such as meeting the state mandated content standards. Educators also develop curriculum to encourage students to think critically and develop meaningful skills.

The first step in developing curriculum is identifying what students must know and be able to demonstrate. In other words, what is the goal of the curriculum? The next step is determining how students will show what they have learned. What evidence will they provide? How will the teacher know if the student has achieved the goals established in

the first step of designing curriculum? The final step is creating instructional practices and lesson plans to provide experiences that will deliver on the intention of the curriculum (Wiggins & McTighe, 2005, p. 17-18).

Enduring Understandings

The driving force for creating curriculum are the big ideas that the learners should understand by the end of the unit. Big ideas are concepts that provide a link between facts and skills (Wiggins & McTighe, 2005, p. 5). One way to engage learners is by providing an opportunity for students to connect with the information in a way that adds value and can be applied to everyday situations. This elicits a purpose to understand something fully rather than just memorizing and recalling information (Wiggins & McTighe, 2005, p. 4). In addition to students seeing the value of what is being taught, it is important to know that understanding is not just a mental act, but requires students to do something such as apply a skill effectively (Wiggins & McTighe, 2005, p. 6-7).

Part of fully understanding is to identify potential student misunderstandings. Each learner brings a diverse background to the classroom, therefore may infer or experience a lesson differently than intended or than other students within the class. As curriculum designers, it is important to remember that what is obvious to the designer is not always obvious to the learner (Wiggins & McTighe, 2005, p. 75). As a teacher, it is easier to treat a misunderstanding as a mistake that needs to be fixed rather than a valuable opportunity to reevaluate and adjust the clarity of the teaching method (Wiggins & McTighe, 2005, p. 51).

Essential Questions

Essential questions are designed to foster the understanding of a topic, promote deeper thinking, and to engage the learner. Essential questions cannot be simply answered, but should require students to transfer ideas from one situation to another (Wiggins & McTighe, 2005, p. 106-107). When considering the essential questions of a unit, it is important to reflect on the enduring understandings, the diversity of the audience and the generation of additional questions the essential question may pose (Wiggins & McTighe, 2005, p. 110).

Standard Addressed

Standards refer to the content that is intended to be understood. Wiggins and McTighe refer to those writing curriculum as designers, and they state, “As in all design professions, standards inform and shape our work.” (p. 13). Curriculum is driven by standards, which are “...blueprints for learning that is [are] derived from desired results” (p. 5). Many states have created standards that are the blueprints for what students are expected to learn in each of their classes. Minnesota state standards do not just expect students to recall information, but to truly understand the big ideas. These big ideas become the targets that drive the curriculum design.

Learning Targets

Learning targets are the intended outcome of a lesson. They should be clear and the learner should understand what they are required to learn and the skills they must execute. Learning targets are specific to the enduring understandings and provide evidence of the learning taking place (Wiggins & McTighe, 2005, p. 14). According to

Wiggins and McTighe, “The best curricula are written from the point of view of the desired learnings, not merely what will be covered.” (p. 6). Often times educators write learning targets that are content focused, but effective learning targets will be results focused (Wiggins & McTighe, 2005, p. 14).

Assessments To Be Employed

Assessment can happen in a variety of ways, but no matter the method, the intent of assessing is always the same. Assessments are used to evaluate the extent to which the learner is understanding the learning targets and big ideas (Wiggins & McTighe, 2005, p. 6). Assessments are another driving force for teachers. If students are mastering the standards, it may be an opportunity to provide more rigor. If students are developing skills, but not yet mastering the standards, it provides the opportunity to check-in on progress and adjust the curriculum if necessary. Those that design and employ assessments use them to determine whether or not students have met the goals (Wiggins & McTighe, 2005, p. 13).

Assessments can be broken into many categories. Two of those categories are formative and summative. Formative assessments are ongoing check-ins used to collect data as a student is learning. These are used to guide curriculum based on the results. Summative assessments are generally given at the end of a learning sequence and are used to determine how much a student understands and has retained (Dixson & Worrell, 2016, p. 153). Grant Wiggins and Jay McTighe note that to assess understanding, a traditional fact-focus test will not do. Assessments of understanding required evidence of the learning that has taken place (Wiggins & McTighe, 2005 p.7).

Lesson Description

It is important for lessons to follow a logical sequence that allows learners to make meaningful connections to the content (Wiggins & McTighe, 2005 p. 8). Each lesson must connect to the learning targets and enduring understandings of the unit. In order to engage students, a variety of learning experiences must also be presented. When designing lessons, it is critical to consider how diverse the intended audience is. Each student is unique and learns differently than their peers. No matter how the lesson is taught, teachers must remember that each child has had different experiences and therefore learns differently (Adcock, 2014, p. 50-52).

Procedures

Procedures are an outline of how the learning will unfold. As stated before, lessons should follow a logical sequence. With additional information, that sequence becomes the procedures. In the procedures section of the lesson design plan, the curriculum designer will provide a series of action steps for the lesson. Procedures include an explanation of what will take place and the estimated time to complete the tasks.

Instructional Strategies

Instructional strategies are methods teachers use to reach the goals set forth by the learning targets. According to the Advancement Via Individual Determination (AVID) website, instructional strategies provide the, “opportunity to implement well-constructed learning activities that promote collaborative interaction”. AVID also encourages teachers to use a variety of instructional strategies from WICOR. WICOR is an acronym for Writing, Inquiry, Collaboration, Organization and Reading (AVID.org, n.d.).

Resources Used

This section of the lesson design plan lists the materials that will be used in the lesson. Those materials may include: books, videos, websites, handouts or lab equipment.

Addressing the Ascending Levels of Difficulty

“Designers in education must be mindful of their audiences”, warns Wiggins and McTighe (p. 13). Student interest, reading, speaking and maturity levels, class size and prior learning should be taken into account when designing lesson plans (Wiggins & McTighe, 2005, p. 14). The classroom is full of diverse learners, therefore the lesson plans should also be diverse to engage all individuals.

Evidence of Effectiveness

In order to be effective teachers, we must constantly be assessing the quality of our lessons. Did the lesson flow as intended? What worked well? What didn't work well? Did the learners understand the intended outcomes? How could this lesson be changed to better reach the learning targets and the intended audience? Wiggins and McTighe assume “all purposeful and effective teachers follow a cycle of plan-revise-teach-assess-reflect-adjust many times” (p. 8).

Questions Posed

This portion of the lesson plan design plan is a place to list the questions the educator will ask to engage the learner. Questions should hook and hold the attention of the audience (Wiggins & McTighe, 2005, p. 109). A mix of different types of questions can be used at different points throughout the lesson. Wiggins and McTighe outline many

different types of questions in their book, *Understanding by Design*. One of those types are entry questions, these are questions that are used to open a lesson and evoke thoughtfulness (p. 342). Another type are leading questions. Leading questions are used to check for understanding or to assess knowledge (p. 345). Additional questions may be open-ended questions, those questions that do not have a simple right or wrong answer (p. 346).

Conclusion

This chapter provided a description of each of the lesson design plan prompts. I will be using this format in chapter four. Chapter four will include several lessons from a unit with a focus on Minnesota's invasive species. In this unit, students will realize what an invasive species is and how they can become environmental stewards to hinder the spread of them throughout Minnesota. The final chapter will include a summary of what I have learned as I developed this curriculum.

CHAPTER FOUR

RESULTS

Introduction

The goal of this research is to develop a middle school curricular unit that introduces students to the effects invasive species have on Minnesota's ecosystems while promoting environmental literacy skills. The title of the curriculum created is *Invading Minnesota: A Middle School Invasive Species Curriculum*. The question used to guide the development of this curriculum is: How might a curricular unit about invasive species be designed to enhance the environmental literacy of middle school students?

Chapter one gave an introduction to this question and justification for its importance. As stated in chapter one, the students of today will be faced with many challenges over their lifetimes and surely some of them will be related to the environment (What is Environmental Literacy?, 2015). Chapter two reviewed literature that provides a foundation to this research question. In order to understand the consequences of invasive species one must first have a solid understanding of the systems that interact to create an amazingly interconnected planet. Once that is understood, the history and impacts of invasive species on an ecosystem can be realized. An in-depth look at European Buckthorn was also provided. The curricular unit described in this chapter will use buckthorn as an example of an invasive species. The final section of chapter two explored environmental literacy and components that make curricula a successful tool for fostering the environmental literacy of middle school students. Chapter three creates the framework for building the curricular unit. Grant Wiggins and Jay McTighe, authors of

the book, *Understanding by Design*, designed the lesson design process used to create the curricular unit described in chapter four.

Understanding by Design Lesson Plan Framework

As noted, the format used to design this curricular unit was developed by *Understanding by Design* authors Grant Wiggins and Jay McTighe. Wiggins and McTighe suggest starting at the end when developing a lesson plan or unit. An educator must first identify what they want the student to learn or be able to do at the conclusion of the lesson or series of lessons. The goal of this research is to provide students with an opportunity to enhance their environmental literacy skills while learning about Minnesota's invasive species, such as buckthorn. The goals of the unit are better known as the enduring understandings. Enduring understandings are the big picture ideas that all students should be able to demonstrate by the end of the unit. These big ideas should provide a connection between learning the content and mastering skills (Wiggins & McTighe, 2005).

The lesson design plan framework also includes essential questions. These are questions posed to the students that are thought provoking, yet do not always have a simple answer. The next part of the framework is the standards to be addressed. The standards addressed for this curricular unit are from the Minnesota Department of Education K-12 academic science standards. Next, are the learning targets. These are the skills students should be able to do at the completion of the lesson or lessons. These are the intended outcome of a lesson. Assessments to be employed are next. This curricular unit uses a combination of formative and summative assessments to assess the learning of individual students.

The next steps are lesson descriptions and then procedures in the lesson design plan framework is the lesson description then the procedures. These two sections flow nicely together. First, the lesson description, provides the reader with an overview of the learning that will take place and the tasks students will be completing. The lesson description is followed by a detailed procedure section. This section provides detailed instructions in a step-by-step, chronological order.

After the procedure section are the instructional strategies. Instructional strategies are the teaching methods that will be used throughout the lesson. Examples of instructional strategies include: direct instruction, inquiry, hands-on learning, and many more. The invasive species curricular unit developed by this research employs many instructional strategies to provide a variety of experiences and opportunities for students to learn.

Finally, the lesson design plan framework concludes with resources that will be used in the lesson. These resources include links to videos that will be played in class, handouts for students, and supplies needed to complete the activities. Each section of the lesson design framework was thoughtfully analyzed with the goal of the curriculum in mind.

Background Information

Audience. This section of chapter four will provide a background about the intended audience, setting, and sequence for this series of lessons. In the case of this curriculum: *Invasive Species: A Middle School Invasive Species Curriculum*, the intended audience is seventh grade middle school students, who are studying life science. Seventh graders are generally 12 to 13 years old. These particular seventh graders attend school in a suburban Minnesota district.

Setting. This section will provide insight into why some activities were developed and a disclaimer about timeframe. Class periods are fairly short at this school, only 43 minutes per day, therefore the timeframe to complete the lessons may change depending on the length of class time. The school is extremely fortunate to have a large stand of trees behind the football field. In the fall, students explore the forest while adopting and observing a tree of their own. This same forest will be visited throughout the course of the proposed unit, but the focus of the visits will be different. The focus this time will be on buckthorn.

Sequence. This unit is designed to follow in sequence after a much larger ecology unit. Students will have already learned about the interconnectedness of the ecosystem and studied how energy flows through an ecosystem. The best time of the year to study this unit is in late fall or early spring because buckthorn will be one of a few plants to still have green leaves (Alderson, 2006).

Invading Minnesota: A Middle School Invasive Species Curriculum

This curricular unit is the culmination of what was learned through research while always keeping this question in mind: How might a curricular unit about invasive species be designed to enhance the environmental literacy of middle school students? The goal of this unit is to introduce middle school students to the concept of invasive species, but also to provide them with the opportunity to take action. Environmental literacy is a continuum that starts with knowledge and progresses toward action (Campaign for Environmental Literacy, 2007). This unit provides the knowledge, yet provides learning experiences that promote action as well. Each series of lessons in this unit was thoughtfully developed while always keeping the intended outcome in mind. The

lessons in this unit are placed in the appendix (Appendix A) and are intended to be a sampling of ways to teach students about invasive species, while also enhancing students' environmental literacy. Also included in Appendix A are sample student handouts, teacher resources, and a grading rubric. All are included chronologically to enhance the flow of the curriculum.

Conclusion

Chapter four displays the results of the research done in an effort to teach students about invasive species, while also fostering environmental literacy skills. This chapter provided a summary of the lesson design plan framework outlined by Grant Wiggins and Jay McTighe. It also included background about the intended audience, setting, and sequence of the curriculum. Finally, this chapter directs the reader to Appendix A where the lessons for this unit can be found in addition to supplemental resources. The final chapter of this capstone, chapter five, will include a summary of what was learned throughout the process of writing and researching, it will revisit the literature review found in chapter two, and will discuss future research projects.

CHAPTER 5

CONCLUSION

Introduction

The researching and writing of this capstone has been a process that has taught me about education, the environment, and myself. Chapter one started with a reflection of my childhood and provided the context to why I am interested in teaching young adults about invasive species and fostering environmental literacy. Chapter two provided the literary background needed to create a curriculum that teaches students about the interconnectedness of all living things as well as ways to engage students in environmentally literate behaviors. Chapter three provided the framework that served as a method for writing this curricular unit. Chapter four provided background information that was pertinent to the students I teach and introduced that curricular unit designed as part of this research. The final chapter, five, will provide a reflection about this process, another look at the literature review, possible implications and limitations of the curriculum and potential future research topics.

Personal Learning

Education and nature have both long been passions of mine. I have been fortunate enough to have grown up surrounded by people that appreciate the earth and have passed that appreciation on to me. Now as an educator, I would like to pay-it-forward. It is now time for me to provide experiences for my students to feel a connection to and an appreciation for the natural world. This is a personal goal of mine, but there are others that believe in the importance of educating children about earth systems and our connection to them as well. Michael Bald, author of the article, *Stewardship=Presence*

states, “Understanding and appreciating the natural world, and our place in it, is an important goal of K-12 education.” (Bald, 2016). With that goal in mind, I set off to explore this question: How might a curricular unit about invasive species be designed to enhance the environmental literacy of middle school students? Through researching and developing a curriculum rooted in this question, I learned about about myself personally and professionally.

This process started a long time ago for me. I finished most of my graduate coursework in 2010, but never landed on a research question I felt a strong connection with, so I strayed away from the process. Even after recommitting to the capstone, I had a difficult time deciding on what I wanted to research. I began working with a question about gender differences in environmental awareness, but that idea never gained traction. I then had a great opportunity for professional development around science notebooking. I began researching that topic, but quickly lost interest. It was not until I reflected on the things I am passionate about that I decided to explore the topics of invasive species and environmental literacy. Once I began this process, things started to flow together naturally and I knew I had finally decided on a topic that personally and professionally was worth the immense effort.

This process has allowed me to reflect both personally and professionally. The topic I chose ties my personal and professional goals. In my personal life, I strive to make decisions and take actions with the environment in mind. These are attitudes I hope one day my own children will uphold. Personally this is important, but professionally I have the great opportunity to educate the next generation about environmental concerns. As the environmental literacy ladder illustrated in chapter two, the foundation to becoming

more environmentally aware is knowledge and understanding (Campaign for Environmental Literacy, 2007). As an educator, my job is not just to pass on knowledge to my students, but to help them develop a deeper understanding and hone the skills it takes to make a change. Developing this curriculum has taught me a variety of strategies I can use in my classroom to foster environmental literacy in my students.

Future Research

The research I conducted has given me the opportunity to reflect on my passions. The topic of invasive species has always been a concern of mine. If I pursued other research topics, they would most likely be tied to this concept as well. I would also like to further my knowledge of service learning. I believe this is a powerful tool for people of all ages to take action on issues they feel strongly about. A project related to service learning could include the benefits, successful examples, and methods of incorporating service learning in middle school classrooms.

Literature Review Revisited

Chapter two was organized from a big-picture look at ecosystems down to the personal connections humans need to feel to develop environmental literacy skills. The first section of research was titled Earth Systems and provided insight into how the environment is organized. The earth is divided into two spheres, the biosphere and the geosphere (Agundo, 2017). The intersection of these two spheres is at the heart of ecology. Understanding how each one is dependent on the other provides the context for the delicate balance that is our planet. Ultimately, the goal of this section was to realize

that a change in one part of the system will likely results in a change in one or more other parts (Williams, 2012). One such change is invasive species.

Invasive species was the topic of the second section of research. This section focused on the arrival of invasive species, the impacts they can have on the ecosystem and methods of controlling these organisms. Invasive species are those brought to a new ecosystem, one that lacks the natural checks and balances to keep the population in control. Without these checks and balances, these species threaten the biodiversity of their new ecosystem (McGinley, 2011). Many of these species have been introduced to new locations by humans and as globalization increases so does the possibility of future species becoming invasive (Meinesz, 2003).

Invasive species are wildly successful because they are highly adaptable species that can quickly respond to changes in the environment (Nijhuis, 2013). The biggest threat invasive species pose is to the biodiversity of the introduced ecosystem. When introduced to a new ecosystem these species out-compete native species for food, shelter, space, and water resources. They destroy the habitat for other organisms and have the potential to be vectors for disease. In addition to harming the environment, invasive species also damage property and negatively impact the industries of agriculture, forestry, and fisheries. These economic impacts add up to approximately 137 billion dollars in the U.S. alone each year (McGinley, 2011).

Invasive species can be controlled or eradicated, but each case is unique and therefore must be treated that way (Meinesz, 2003). The first line of defense against invasive species is not allowing them to become invasive in the first place. Keeping organisms in their native ecosystems is a best practice that should be followed. Once populations are

established in a new ecosystem there are three methods to control them. The first is mechanical, which involves physically removing the species from the environment. Chemical control is the next method, which involves spraying or treating species with chemicals such as herbicides and pesticides. The final method is biological control which involves introducing a predator or a parasite to keep populations of invasive species in check (McGinley, 2011). With each of these methods, care should be taken to not further the problem while trying to solve it.

The literature review continued with a look at European Buckthorn, which is an invasive species in the United States. Buckthorn is a shrubby tree that is native to Europe and Asia. It was introduced in the United States in the late 18th century as a popular landscape hedge. It quickly took hold to its new surrounding and spread throughout most of the country. The first record of buckthorn in Minnesota was in 1937 (Whitfeld, Reich, Lodge, Roth, and Buschena, n.d.). This species of shrub is especially competitive and very successful. It is known to create dense thickets that crowd out native trees. It has few predators, as most wildlife will not eat its foliage (“Buckthorn: How can a shrub be so harmful?” n.d.). In addition to having few predators, buckthorn has found an ally in the invasive earthworm. Together these two species threaten the biodiversity of our forests and cause harm to our waterways (Whitfeld, Reich, Lodge, Roth, and Buschena, n.d.). Buckthorn can be controlled by pulling small seedlings or cutting and treating large stumps with an herbicide. No matter the method of control, persistence is key. Controlling buckthorn is not done in a single effort, but takes follow-up maintenance to ensure it does not reinvade (Minnesota Department of Natural Resources, 2017).

The final section of the literature review focused on environmental literacy. According to Oregon State University's Environmental Literacy Program, environmental literacy is defined as, "An individual's understanding, skills and motivation to make responsible decisions that considers his or her relationships to natural systems, communities and future generations." (2014). The goal of the curriculum developed in this capstone is to enhance the environmental literacy of middle school students. This can be done in a variety of ways. The first way is by providing a variety of learning experiences such as: direct instruction, inquiry, collaboration, and so on (Sly, 2015). Another successful method is outdoor education. Natural environments provide experiences that enliven the senses and create memorable learning experiences (Reynolds, Brondizio, and Robinson, 2010). In addition to outdoor education, creating a sense of place is important to enhancing environmental literacy. Place-based learning is not just an outdoor experience, but a deep connection to where one is from and how one is connected to that place (Sly, 2015) Research shows that people are more willing to defend spaces to which they have become attached and love. The final method of teaching environmental literacy that was discussed in chapter two was service learning. Service learning provides benefits for the learner as well as the environment. Service learning can be direct or project-based. No matter the type, the learner is taking action on an issue they feel connected to (Reynolds et al., 2010). The goal of these teaching strategies is to enhance the awareness students have of the environment and encourage them to take action to make a change.

Possible Implications and Limitations

My hope is that this curriculum provides a foundation in environmental literacy that will one day result in action taken by the students that experience it. This would result in implications for the next generation and the environment. One possible implication is that there would be action taken to eradicate and control invasive species. Another could be an awareness brought to environmental issues. This curriculum could be limited if students do not develop a connection to the environment and therefore do not care about taking action for change. It is possible that the intended outcome of this research is not reached. It is also possible that students do not see invasive species as a problem that needs attention. Ultimately, the goal of this curriculum is not to push my agenda, but to elicit a response in the skills and actions taken by students to pursue goals to make a change.

Conclusion

Chapter five provided the opportunity to reflect on the entire capstone process. It started with an assessment of my personal and professional learning. It included the struggle I had with picking a topic, to the point of putting the writing of this capstone off for many years. A summary of the literature review provided some highlight from my research. The final section included the possible implications and limitations of the curriculum that was developed. Ultimately, this has been a positive experience that has resulted in a curriculum I am proud of.

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Appendix A: Invading Minnesota: A Middle School Invasive Species Curriculum

Lesson One-What is an Invasive Species?
Understanding by Design Lesson Plan Format

| | |
|--|---|
| <p>Unit Considerations Enduring Understandings:</p> <ul style="list-style-type: none"> • Invasive species are species introduced into non-native ecosystems. • Invasive species cause harm to their new ecosystem. • Humans have helped invasive species spread. • European buckthorn is a problem in Minnesota. | <p>Unit Considerations Essential Questions:</p> <ul style="list-style-type: none"> • What makes an organism invasive? • What impacts do invasive species have on ecosystems? • How do populations and communities interact and change? • How can humans impact ecosystems and Earth's resources. |
| <p>Standards Addressed: Minnesota Academic Standards Science 6-8 Standard 6.1.3.1. Designed and natural systems exist in the world. These systems consist of components that act within the system and interact with other systems. Standard 7.4.2.1. Natural systems include a variety of organisms that interact with one another in several ways. Standard 7.4.4.1. Human activity can change living organisms and ecosystems. Standard 8.3.4.1. In order to maintain and improve their existence humans interact with and influence Earth systems.</p> | |
| <p>Learning Targets: Students will be able to...</p> <ul style="list-style-type: none"> • Identify characteristics of an invasive species. • Describe examples of invasive species and how they change the ecosystems. • Identify methods invasive species have used to inhabit new ecosystems. • Differentiate between true and false facts about buckthorn. • Identify buckthorn in a forest. | <p>Assessments To Be Employed: Formative Assessment- students will be asked to write a two minute quick-write at the conclusion of this lesson. The quick-write will answer this question: what is an invasive species?</p> |
| <p>Lesson Description: This lesson is designed to take two 43 minute class periods. In the first class period, students will find out what invasive species are and why they are a problem. They will be provided with many examples of invasive species and their impacts on the ecosystem. The second class period will focus on European Buckthorn specifically. Students will conduct a fact scavenger hunt to learn some characteristics of buckthorn. After that, students will go to the school forest to positively identify buckthorn from the facts that they learned in the scavenger hunt.</p> | |
| <p>Procedures: Day 1: Introduction to invasive species.</p> | |

1. Show students the 4:45 TED-Ed video titled, “The Threat of Invasive Species”. As students watch the video they will fill in as much information as they can on the student handout “What is an Invasive Species? Concept Map”. Once the video is over, ask students to share what they have learned. Have a discussion about each of the quadrants of the concept map. Encourage students to add detail to their maps as the class discusses.
2. To learn about other examples of invasive species, students will play a matching game on the NOVA website. As students correctly match the invasive species with how they have impacted their new ecosystem, they will add detail to their concept maps. Once all students are finished, discuss what students have learned from the game or what they thought was interesting.
3. The final task is to provide students two minutes to summarize their learning in the form of a quick write. In a quick write students must write for the entire two minutes while answering the question “what is an invasive species?”

Day 2: What is Buckthorn?

1. To introduce the lesson today, ask students if they have ever heard of buckthorn? Have they ever seen buckthorn? After a quick discussion inform them that Minnesota has been invaded by European Buckthorn, which is an invasive species.
2. To learn more about buckthorn, students will conduct a fact scavenger hunt. Prior to students arriving place buckthorn fact cards around the room from the teacher resource “European Buckthorn Scavenger Hunt Facts”. Once students are given the student handout “European Buckthorn Scavenger Hunt Fact Sheet”, tell students they will travel around the room reading each of the facts about buckthorn. As they read the facts they will identify whether or not the statements on the student handout are true or false. If the statement is false, students must rewrite the fact to make it true.
3. The final part of this lesson is to take students outside to identify buckthorn in the school forest. Students should use what they have learned in the scavenger hunt to positively identify European Buckthorn.

| | |
|---|---|
| <p>Instructional Strategies:</p> <ul style="list-style-type: none"> • Direct instruction • Writing • Inquiry • Collaboration • Organization • Critical thinking • Hands-on learning | <p>Resources Used:</p> <ul style="list-style-type: none"> • Student Handout-What is an Invasive Species? Concept Map • TED-ED Video: “The Threat of Invasive Species” https://ed.ted.com/lessons/the-threat-of-invasive-species-jennifer-klos • NOVA Invasive Species Matching Game http://www.pbs.org/wgbh/nova/nature/invasive-species-game.html • Student Handout- European Buckthorn Scavenger Hunt Fact Sheet • Teacher Resource- European Buckthorn Scavenger Hunt Facts • Electronic device to access the internet (Ex. tablet, computer or cell phone). |
|---|---|

Student Handout-What is an Invasive Species? Concept Map

Name: _____ Hr: ____

| | |
|--|--|
| General Characteristics of Invasive Species | Invasive Species Methods of Arrival |
| Problems Caused Invasive Species | Invasive Species Examples |
| 2 Minute Quick Write: _____ _____ _____ _____ _____ | |

Student Handout-European Buckthorn Scavenger Hunt Fact Sheet

Name: _____ Hr: _____

Directions: As you travel around the room looking at buckthorn facts, identify whether the statements below are true or false. If the statement is false, rewrite it to make it true.

| True | Buckthorn Facts | False |
|------|--|-------|
| | Buckthorn was first brought here from Australia as a popular landscape plant. | |
| | Buckthorn has small, pink flowers produced in May. | |
| | Buckthorn leaves out early in the spring and keeps its leaves late into the fall. | |
| | Buckthorn lives in dry to moist areas such as woodlands, savannas, abandoned fields, and roadsides. | |
| | Buckthorn will only grow in shade. | |
| | Buckthorn outcompetes native plants for nutrients, light, and moisture. | |
| | Buckthorn produces round, berry-like fruit that is red in color when ripe. | |
| | Buckthorn has sharp thorns or spines at tip of the twig. | |
| | Each buckthorn berry has 3-4 seeds that can survive for 3-4 years in the soil. | |
| | Buckthorn produces habitat for native wildlife. | |
| | Buckthorn does not have “natural controls,” such as insects or disease that can limit its growth. | |
| | Buckthorn has dark green, oval leaves with finely toothed edges. Each leaf has 3–5 pairs of curved leaf veins. | |

All facts were taken from The Minnesota Department of Natural Resources Website.

Teacher Resource-European Buckthorn Scavenger Hunt Facts

Directions: Prior to the lesson, enlarge these fact cards and hang them around the room.

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| <p>Buckthorn leaves out early in the spring and keeps its leaves late into the fall.</p> | <p>Buckthorn outcompetes native plants for nutrients, light, and moisture.</p> | <p>Buckthorn was first brought here from Europe as a popular landscape plant.</p> |
| <p>Buckthorn will grow in both full sun and in shade</p> | <p>Buckthorn lives in dry to moist areas such as woodlands, savannas, abandoned fields, and roadsides.</p> | <p>Buckthorn has small, yellow-green flowers produced in May</p> |
| <p>Buckthorn has sharp thorns or spines at tip of the twig.</p> | <p>Buckthorn produces round, berry-like fruit that is black in color when ripe.</p> | <p>Each buckthorn berry has 3-4 seeds that can survive for 3-4 years in the soil.</p> |
| <p>Buckthorn destroys habitat for native wildlife.</p> | <p>Buckthorn does not have “natural controls,” such as insects or disease that can limit its growth.</p> | <p>Buckthorn has dark green, oval leaves with finely toothed edges. Each leaf has 3–5 pairs of curved leaf veins.</p> |

Lesson Two-Buckthorn Invades
Understanding by Design Lesson Plan Format

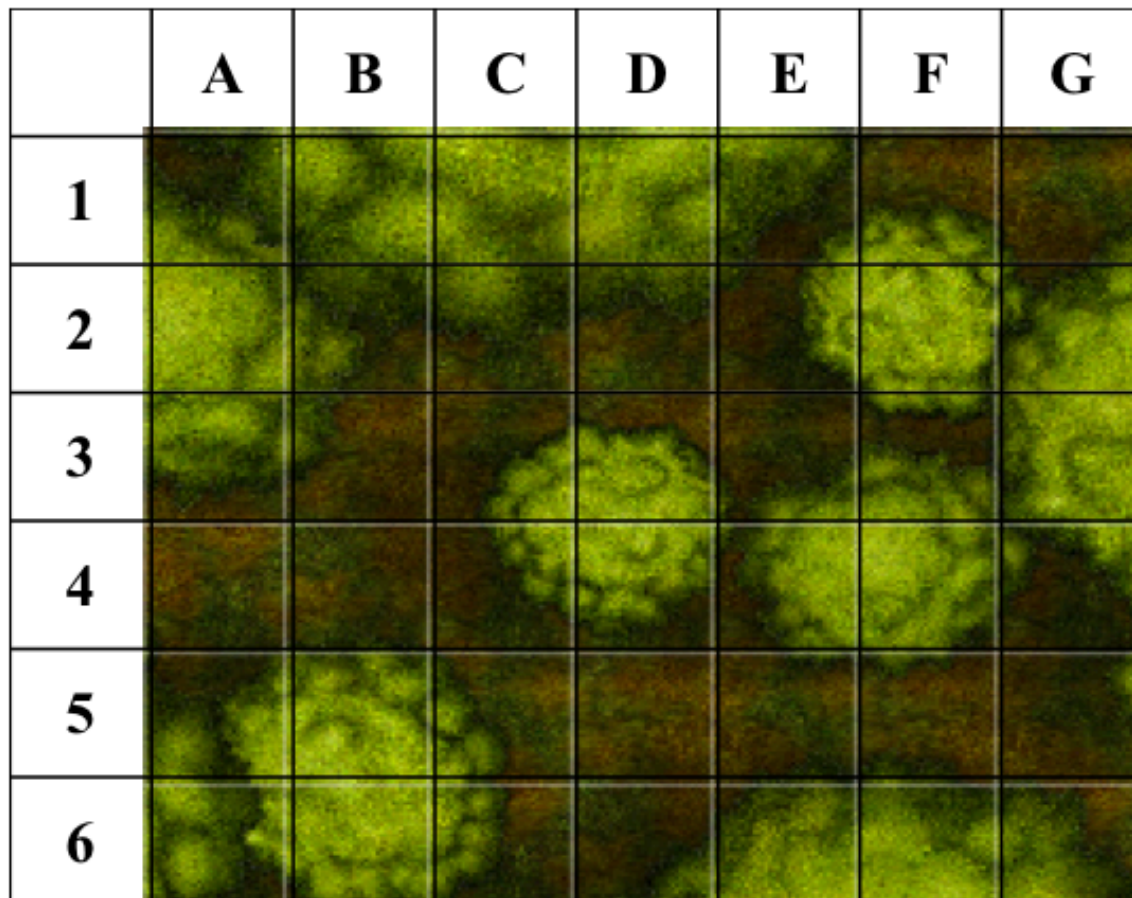
| | |
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| <p>Unit Considerations</p> <p>Enduring Understandings:</p> <ul style="list-style-type: none"> • European buckthorn is a problem in Minnesota. • Humans can help or hinder the spread of buckthorn. | <p>Unit Considerations</p> <p>Essential Questions:</p> <ul style="list-style-type: none"> • What makes buckthorn so successful in Minnesota? • How big of a problem is buckthorn in Minnesota’s forests? • How have humans helped buckthorn spread? • How can humans help control the spread of buckthorn? |
| <p>Standards Addressed: Minnesota Academic Standards Science 6-8</p> <p>Standard 6.1.3.1. Designed and natural systems exist in the world. These systems consist of components that act within the system and interact with other systems.</p> <p>Standard 7.4.2.1. Natural systems include a variety of organisms that interact with one another in several ways.</p> <p>Standard 7.4.4.1. Human activity can change living organisms and ecosystems.</p> <p>Standard 8.3.4.1. In order to maintain and improve their existence humans interact with and influence Earth systems.</p> | |
| <p>Learning Targets: Students will be able to...</p> <ul style="list-style-type: none"> • Identify how buckthorn invades native ecosystems. • Positively identify buckthorn in a forest. • Estimate the population of buckthorn in the school forest. | <p>Assessments To Be Employed:</p> <p>Formative Assessment- students will be assessed formatively throughout this lesson. As they complete the student handouts they will be asked to participate in activities and reflect on what they have learned.</p> |
| <p>Lesson Description:</p> <p>This lesson is designed to take two 43 minute class periods. During the first class period students will develop a connection to the forest through a fictional game exploring how buckthorn spreads in native forest ecosystems. Students will start with a native population of trees and monitor that population as buckthorn invades the forest. The second class period involves students visiting the school forest and estimating the buckthorn population. It is important students can identify buckthorn to get accurate results.</p> | |
| <p>Procedures:</p> <p>Day 1: How does buckthorn spread?</p> <ol style="list-style-type: none"> 1. Pass out the student handout “How Does European Buckthorn Spread?” Students will draw 20 circles anywhere they want on the map with a marker. Each circle must be entirely in a square. The circles represent native trees in a fictional Minnesota forest. As the teacher reads the events that take place in this forest from the teacher resource “How Does European Buckthorn Spread?”, students must place an X in each box buckthorn invades. If that box has a native tree (a circle) students must place an X over the tree. That tree is unable to compete with buckthorn for available resources and does not survive. | |

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| <p>2. After the completion of the activity students will reflect on and answer the after activity questions. Discuss how students felt after participating in this activity.</p> <p>Day 2: What is the population of buckthorn in the school forest?</p> <ol style="list-style-type: none"> 1. Give each student the handout “Buckthorn Population Study”. Read the problem statement together and give students time to write a hypothesis. Students already visited the school forest in lesson one, so they know buckthorn is present in the forest. Even if students have to guess, they should write down a hypothesis. 2. Students will now collect data. The directions are best given inside so students understand what to do before getting to the school forest. Divide the class into eight groups and assign each group a place to start. Because population studies need to be randomized, students will roll a dice to see how many meters they will need to go into the forest to get to their first sample. Students roll the dice and take that many steps into the forest. Once to the sample site, they lay four meter sticks out in a square to make a one square meter sample plot. Students count the number of buckthorn that are growing inside of the meter square and record it on their handout. Students then roll the dice again and repeat the steps for sample two. Instruct students on where to meet once they have gathered their data. 3. As students return to the meeting space, they will share their data with the other groups. Once all the data has been compiled students will calculate the mean number of buckthorn per square meter of the school forest. 4. After the mean number of buckthorn is calculated, students will multiply that number by the total area of the forest to find the estimated buckthorn population for the school forest. One way for students to calculate the area is by using an aerial map of the forest. Some websites such as Bing Maps, will calculate the area for you if you outline the boundaries of your forest. 5. The final step is to answer the after activity questions on the student handout. Be sure to allow students to discuss their answers, thoughts and feelings with their peers at the conclusion of this activity. | |
| <p>Instructional Strategies:</p> <ul style="list-style-type: none"> • Direct instruction • Inquiry • Collaboration • Critical thinking • Hands-on learning • Data analysis | <p>Resources Used:</p> <ul style="list-style-type: none"> • Student Handout-How Does European Buckthorn Spread? • Markers • Teacher Resource-How Does European Buckthorn Spread? • Student Handout-Buckthorn Population Study • Map of your school’s forest to calculate area • Calculator • Four meter sticks per group to make a square meter plot • One dice per group |

Student Handout-How Does European Buckthorn Spread?

Name: _____ Hr: _____

Directions: Draw 20 circles anywhere you want on the map with a marker. Each circle must be entirely in a square. The circles represent native trees in a fictional Minnesota forest. As your teacher reads about this forest, you must place an X in each box buckthorn invades. If that box has a native tree (a circle) you must place an X over the tree. That tree is unable to compete with buckthorn for available resources and does not survive.



Forest image taken from: <http://www.undercoveryeti.com/blog/2013/02/11/the-cliffside-camp/>

After activity questions:

1. What was your starting population of native trees? _____
2. What was your ending population of native trees? _____
3. Describe how you felt as you participated in this activity. _____

4. What do you predict will happen to the native trees if nothing is done to stop the spread of buckthorn? _____

Teacher Resource-How Does European Buckthorn Spread?

Directions: Once students have randomly placed their native tree circles, read the following scenarios. As buckthorn invades this fictional Minnesota forest, students must place an X in each box buckthorn invades. If that box has a native tree (a circle) students must place an X over the tree. That tree is unable to compete with buckthorn for available resources and does not survive.

| Events | Outcome |
|--------|---|
| Call 1 | In late winter, a flock of robins fly through the forest eating berries. They perch on a tree in E3 and drop the remains of their lunch including buckthorn seeds. These seeds sprout. |
| Call 2 | Small buckthorn bushes emerge in early spring and steal the water needed for trees in B2 and F5. |
| Call 3 | A maple tree in D6 does not survive the winter. This allows dormant buckthorn seeds to sprout. |
| Call 4 | Later in the spring, leaves emerge on a tall buckthorn and shade out a native oak tree seedling in C4. |
| Call 5 | In early summer a white-tailed deer visits the forest with her two young fawns. They love to nibble on the tender leaves of the native trees in B5. The deer do not like the taste of the buckthorn leaves and avoid them. The lack of leaves makes it harder for the native trees to compete with buckthorn. |
| Call 6 | A group of people take a hike in the woods. They do not take care to stay on the trail and trample small cottonwood trees in F2 and G2. This allows buckthorn to spread from nearby. |
| Call 7 | Humans pull small buckthorn shrubs, leaving more resources for native trees. Add a tree circle to any box you would like that does not have an X. |
| Call 8 | Invasive earthworms eat all of the fallen leaves from last fall. As they do, they expose bare soil that allows a buckthorn tree to grow in A3. |

Student Handout-Buckthorn Population Study

Name: _____ Hr: _____

Problem Statement: How many buckthorn plants are in the school forest?

Hypothesis: Make a prediction to answer the question in the problem statement.

Procedure

Part 1: Collecting Data

Count the individual buckthorn plants per square meter for two separate sample plots.

Sample 1: _____ buckthorn/square meter Sample 2: _____ buckthorn/square meter

Part 2: Compiling Class Data

Collect data from all groups and find the mean (average).

| Groups | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|----------|---|---|---|---|---|---|---|---|
| Sample 1 | | | | | | | | |
| Sample 2 | | | | | | | | |

Total buckthorn plants/total number of samples = mean number of buckthorn per square meter.

The mean number of buckthorn plants in the school forest is _____ / square meter.

Part 3: Estimated Population of Buckthorn

The total area of the school forest is _____ / square meters.

Total area of the forest x class mean = estimated buckthorn population

The estimated population of buckthorn in the school forest is _____.

After Activity Questions

1. Based on your results and observations, what is your conclusion - is there a "buckthorn problem" in the school Forest? _____ Give specific evidence to support your answer: _____

2. Based on your observations and knowledge of invasive species, what can you infer about the buckthorn population for next year? _____

Lesson Three-It's Not Only Buckthorn
Understanding by Design Lesson Plan Format

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| <p>Unit Considerations</p> <p>Enduring Understandings:</p> <ul style="list-style-type: none"> • Minnesota has been invaded by many invasive species, not just buckthorn. • Humans can help or hinder the spread of invasive species. | <p>Unit Considerations</p> <p>Essential Questions:</p> <ul style="list-style-type: none"> • What other types of invasive species have invaded Minnesota? • How can students take action to prevent the spread of invasive species? |
| <p>Standards Addressed: Minnesota Academic Standards Science 6-8</p> <p>Standard 6.1.3.1. Designed and natural systems exist in the world. These systems consist of components that act within the system and interact with other systems.</p> <p>Standard 7.4.2.1. Natural systems include a variety of organisms that interact with one another in several ways.</p> <p>Standard 7.4.4.1. Human activity can change living organisms and ecosystems.</p> <p>Standard 8.3.4.1. In order to maintain and improve their existence humans interact with and influence Earth systems.</p> | |
| <p>Learning Targets: Students will be able to...</p> <ul style="list-style-type: none"> • Identify multiple species that have invaded Minnesota. • Collect information about a chosen invasive species. • Create a public service announcement to educate Minnesotans about an invasive species. | <p>Assessments To Be Employed:</p> <p>Formative Assessment- students will be formatively assessed based on the detail and accuracy of their invasive species research sheet.</p> <p>Summative Assessment- students will be summatively assessed on the public service announcement they will be creating from their research. A rubric is included for assessment.</p> |
| <p>Lesson Description:</p> <p>This lesson may take 4-6 days to complete. To start this lesson, students will explore the Minnesota Department of Natural Resources website to learn more about and identify an invasive species other than buckthorn to research. Once identified, students will be given time to complete the research sheet about their chosen invasive species. After the research is completed, students will turn the research into a public service announcement (PSA) educating their peers and other Minnesotans about the characteristics, habitat, arrival methods, impacts to local ecosystems and methods used to control their invasive species. The PSAs will be recorded and watched in class and placed on the teacher's website to inform parents and guardians as well.</p> | |
| <p>Procedures:</p> <p>Day 1: Invasive Species Research</p> <ol style="list-style-type: none"> 1. The first day of the lesson will serve as an introduction to the days to come. Start by showing students an example public service announcement (PSA) for buckthorn. This sample video is titled "Buckthorn Removal Instructional Video" and was created by the city of Edina, Minnesota. 2. Next, students will be picking their own invasive species to research and create a PSA about to inform other Minnesota's about that particular species. Split the class into groups of 3-4 students. Each group will research a different invasive | |

species. Direct students to the Minnesota Department of Natural Resources webpage and allow them to explore and learn about the different invaders of Minnesota. As a group, students will need to select one invasive species to research and create a PSA about.

3. After student groups have selected their invasive species give them the student handout titled, "Invasive Species Research Sheet". Students will complete the research using the internet and other print sources provided. Each group will finish their research at varying times and can move to the next step at their own pace.

Days 2-5: Invasive Species Public Service Announcement Creation

1. As groups finish their research they will begin creating their PSA. Students will be given the rubric titled, "Invasive Species Public Service Announcement (PSA) Rubric" before they begin to brainstorm, plan and record their PSA. They should use this as a guide to what should be included in their PSA and how they will earn the points for this summative assessment.
2. Once the PSA is recorded, students can use the remainder of the time to edit or add final details to their video. The final version of the video needs to be shared with the teacher prior to class starting on day 6.

Day 6: Invasive Species Public Service Announcement Viewing Party

1. Today will be a viewing party to honor the work of the students. Students have already shared their PSA videos with the teacher. The teacher will play the videos for the class. As the PSA videos are being played, the teacher will score the videos using the "Invasive Species Public Service Announcement (PSA) Rubric".
2. At the completion of class links will be added to the teacher's website and sent to parents and guardians to view from home.

Instructional Strategies:

- Writing
- Reading
- Inquiry
- Collaboration
- Critical thinking
- Problem Solving

Resources Used:

- Edina TV Video: "Buckthorn Removal Instructional Video"
https://www.youtube.com/watch?v=RV4WJMIR_u4
- Minnesota Department of Natural Resources Invasive Species webpage
<https://www.dnr.state.mn.us/invasives/index.html>
- Electronic device to access the internet and record the PSA (Ex. tablet, computer or cell phone).
- Books or other resources checked out from the school or local library.
- Student Handout-Invasive Species Research Sheet
- Student Handout-Invasive Species Public Service Announcement (PSA) Rubric
- Props or pictures provided by students to enhance their PSA.

Student Handout-Invasive Species Research Sheet

Name: _____ Hr: _____
Group Members: _____
Invasive Species: _____

Directions: Use the internet and provided library resources to fill in information about your selected invasive species.

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|--|---|
| <p>General Characteristics What does this species look like? How can it be identified?</p> | <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> |
| <p>Habitat What does this species need for survival? Where does it get food, shelter water and space?</p> | <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> |
| <p>Methods of Arrival How did this species arrive in Minnesota? How does it spread in its non-native ecosystem?</p> | <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> |

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| <p>Impacts to Local Ecosystems What problems does it cause in its non-native ecosystem. How does it impact native organisms?</p> | <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> |
| <p>Control How can the spread of this invasive species be slowed or stopped? What can humans do to help control or eradicate this species?</p> | <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> |
| <p>Other Interesting Information</p> | <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> |
| <p>Sources List all sources that provided</p> | <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> |

Student Handout-Invasive Species Public Service Announcement (PSA) Rubric

Name: _____ Hr: _____

Group Members: _____

Invasive Species: _____

Task: Once your invasive species research is complete, you will be turning that research into a Public Service Announcement (PSA) to teach fellow Minnesotans about a particular invasive species. You will work in groups of 3-4 to brainstorm, plan and record your PSA. Every group member must have a role. Use pictures and props to enhance your video. Your PSA will be graded using the rubric below.

| Invasive Species PSA Rubric | | | | |
|--|---|---|--|--------------------------|
| Criterion | 3 | 2 | 1 | Score |
| General Characteristics | Characteristics were detailed, observers could easily identify organism. | Characteristics were present, observer could identify organism. | Characteristics lacked detail, observer would have a hard time identifying organism. | /3 |
| Habitat | Habitat is well described and includes food, shelter, water and space. | Habitat is described and includes food, shelter, water and space. | Habitat lacks detail or does not include food, shelter, water and space. | /3 |
| Methods of Arrival | Examples of arrival and spread were accurate, thorough and well detailed. | Accurate examples were present, but could use more detail. | Examples of arrival were not accurate or could use more detail. | /3 |
| Impacts to Local Ecosystems | Impacts are clear, detailed and results are well explained. | Impacts are clear and detailed or results are well explained, but not both. | Impacts are unclear, need more detail and results are not explained. | /3 |
| Control | Examples of control were accurate, thorough and well detailed. | Accurate arrival examples of control were present, but could use more detail. | Examples of control were not accurate or could use more detail. | /3 |
| Pictures and Props | Pictures and props were used and enhanced the PSA. | Pictures or props were used and enhanced the PSA. | Pictures and/or props were used, but didn't enhance the PSA. | /3 |
| Creativity, organization and effort | PSA is organized, shows extra creativity and effort. | PSA is organized, shows creativity and effort | PSA needs more organization, creativity and/or effort | /3 |
| Total | | | | _____ / 21 points |