Spring 2015

An Ethical Analysis of Lethal Control Practices for Invasive Species Management

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AN ETHICAL ANALYSIS OF LETHAL CONTROL PRACTICES FOR INVASIVE SPECIES MANAGEMENT

by

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AN UNDERGRADUATE THESIS

Presented to the Faculty of
The Environmental Studies Program at the University of Nebraska-Lincoln
In Partial Fulfillment of Requirements
For the Degree of Bachelor of Science

Major: Environmental Studies
With the Emphasis of: Natural Resources

Under the Supervision of Doctoral Candidate Allison Fritz

Lincoln, Nebraska

May 2015

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University of Nebraska, 2015

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Non-native species are invading foreign ecosystems at a rate that has never been seen before, and they cause significant damage to these ecosystems. In order to preserve species diversity, these invasive organisms are often eradicated. Typically, conservation biologists run a cost-benefit analysis to determine what action they should take. In this project, I identify the need to also conduct ethical analyses. I chose three scenarios in which invasive species are eradicated: yellow crazy ants on Christmas Island, barred owls in the Pacific Northwest, and leafy spurge in the central United States. Each of these scenarios was analyzed using two ethical theories: utilitarianism and biophilia.

Ultimately, whether or not it is permissible to eradicate invasive species depends on the specific details of the situation. In most cases, it is permissible to use lethal control measures when it is the most cost-efficient option, or the fastest way to prevent future suffering. Additionally, lethal control is permissible when it is necessary to do so in order to preserve the biodiversity found within the ecosystem.

Introduction:

Philosophy and science frequently meet at an intersection dubbed "ethical analysis." Ethics are generally thought of as practical, shared principles in various interactions, though it is a word often used interchangeably with morals. These analyses are an integral—and often invisible—part of applied science, conducted at an individual level any time a person takes an action that favors one stakeholder over another. Science is by no means exempt from philosophical considerations; value judgments lie at the center of things we would consider to be only pragmatic concerns. What we decide to study, the reports we seek to publish, the resources we conserve, what we experiment upon, and the methods used to go about this process all involve choices and have consequences associated with them. These consequences may include, but are not limited to, the way government money will be spent, the extent to which the environment will be manipulated, and the specific perspective cast upon a particular issue. Furthermore, any of these consequences can affect the well-being of both people and non-human organisms, and this is a moral concern.

Inherent in the very study and practice of conservation biology are value judgments and ethical decisions; the name itself uses a term that implies normativity—the way things ought to be. Conservation biologists determine which things ought to be conserved and saved based upon value judgments, then study and dictate the correct ways to ensure something is conserved. While not all normativity is moral, conservation is because it is based on value judgments that lead to actions that will impact the moral community. It does not matter whether these value judgments are implicit or explicit—when they are made, a person is doing ethics through their actions that are ultimately driven by their values and beliefs. It is worthwhile to thoroughly

examine how these value judgments are being made so that we can ensure people consistently arrive at the proper conclusion and act in a morally sound manner.

Ethical analyses—that is, examining a situation in a way that accounts for the community that will be impacted— are especially important when people aim to maintain an ecosystem's health through culling an invasive species. An invasive species is often defined as a non-native or exotic organism that has caused or has the potential to cause damage to the local ecosystem, economy, or human health. The prevalence of invasive species has exploded with human globalization and people's ability to travel to any location on the planet. Invasive species tend to outcompete native organisms, and have the potential to cause massive damage to the ecosystem. If left unchecked, these invaders can compromise the ecosystem's ability to provide the services necessary for the continued existence of both people and non-human organisms (Simberloff 2002).

Within the realm of conservation biology, the eradication of invasive species remains a controversial issue among both the public and scientists. Scientists themselves tend to regard invasive species eradication as a bad idea for three primary reasons: this method is often regarded as unlikely to succeed, it may be costly (especially over large areas), and eradication may impose considerable collateral damage (Simberloff 2002). Incidentally, all of these concerns have ethical considerations. Even with these considerations, we still see many instances where eradication is presented as the only solution to a problem with invasive species.

To examine the morality of the actions taken in the name of conservation biology, particularly in the cases where the lethal control of non-human organisms is involved, I will apply two primary ethical theories: utilitarianism and the virtue ethics theory of biophilia. These two theories were chosen because they most closely resemble the intrinsic value judgments that

occur in both conservation and preservation ethics. Conservation ethics aim to ensure that the earth's natural resources are still available for human use, a value that closely resembles modern utilitarianism, which aims to maximize the amount of good for the greatest amount of beings. On the other hand, preservation ethics most closely resemble the virtue theory, biophilia. Biophilia aims to maintain ecosystem health regardless of how much use it would be for people.

The three situations I have identified for analysis primarily involve the lethal control of invasive species. Situation one occurs on Christmas Island where the invasive crazy ant has dramatically altered the natural ecosystem. The next case involves the invasive barred owl overtaking the habitat of spotted owls in the Pacific Northwest. The third situation is controlling leafy spurge on rangeland and prairie habitats.

Theory:

Utilitarianism

Consequentialism is "the view that normative properties depend only on consequences" (Sinnott-Armstrong 2011). More explicitly, consequentialism typically holds that whether or not an act is morally right depends only the consequences of that act. Utilitarianism is a specific type of consequentialism that claims "an act is morally right if and only if that act maximizes the good—typically defined as well-being, pleasure, or happiness—for the greatest number" (Sinnott-Armstrong 2011). The action we ought to take is the one that will yield the greatest amount of good after considering the negative consequences that will also arise from doing that act. Utilitarianism is often conceptualized as a way of thinking that seeks to maximize the greatest amount of good or utility for the greatest number of humans. However, utilitarianism

was not originally designed with a central concern that people must be the benefactors of the good obtained by an action.

Jeremy Bentham first described the school of thought that became known as utilitarianism in 1781. In this first description of utilitarianism, the central focus was on hedonic pleasure and pain. Bentham claimed that pleasure and pain are the only things that should determine what we ought to do and what we shall do. Moreover, he believed we should take actions with consequences that will maximize pleasure and minimize pain. The method by which pleasure and pain are weighed became known as "hedonic calculus." In its original form, a hedonic calculus made no rational distinction between the types of creatures that can experience these sensations—more specifically, it did not matter if an organism was human or not. The only criteria that truly mattered was whether or not an organism has the capacity to feel pain (Bentham 1781).

The modern concept of utilitarianism often leaves out the considerations of non-human organisms all-together. This form of the theory takes it roots from one of Bentham's students, John Stuart Mill. Mill's description of utilitarianism focused considerably more on the utility of man, though Mill had originally intended to keep hedonic calculus of non-human organisms as part of the route to determining the action that will promote the most good (Mill 1863). However, with the increased focus on human considerations, scholars inevitably misinterpreted Mill's theory to focus entirely upon anthropocentric pains and pleasures—this is the reason that most people tend to regard utilitarianism as an ethical theory that deals only with human utility.

For the purposes of this analysis, I will be applying utilitarianism as it was originally intended—to include non-human organisms in the calculation. I intend to use the hedonic calculus when it applies, and welfare interests when the calculus may not apply, e.g., cases in

which the invasive species charted for eradication is an organism we know cannot feel pain. Generally speaking, an organism can have two types of interests: preference interests and welfare interests. Preference interests indicate that one "has an interest in something, in the sense of wanting, desiring, preferring, or caring about that thing" (Baxter 2004). For example, an organism that is experiencing pain will prefer to not be in pain. One has a welfare interest in something when "it is in one's interest that one have that thing, that is it has a positive effect on one's good, welfare, or well-being" (Baxter 2004). For example, a tree cannot have a conscious preference interest in not being chopped down, but it is obvious that it is in the best interest of the tree to not get chopped down—in this respect, it has a welfare interest. In general, preference interests will be weighed more heavily than welfare interests.

Utilitarianism does not exist without flaws, and it faces a variety of objections. One issue with this ethical theory is that it ignores the means by which an end is met; related to this concern, it also ignores an agent's motive (Bentham 1781). Perhaps the most critical objection to utilitarianism lies within its focus on the consequences of an action. While we can foresee some of the consequences of an action, we cannot possibly foresee everything; we don't know if we are doing the right action until after it has been done. This concern is especially prevalent when we are working with ecosystems—people often don't have a complete understanding of how the system works, and identifying the trouble species can be very difficult in some cases.

Biophilia

In 1984, E.O. Wilson first coined the term biophilia. He described biophilia as an emotion—a person's "innate tendency to focus on life and life-like processes" (Clowney 2013). Wilson believes humans are biologically wired to feel biophilia, though it can be fostered

through learning and practice (Wilson 2007). Whether or not biophilia is innate is not an important consideration for my analysis. What is important is how this emotion can help or hinder our ability to make decisions within conservation efforts.

David Clowney introduces biophilia as an environmental virtue, and one that "has its status as a virtue by its contribution to human flourishing (eudemonia), while having care for live nature as its target, and care about live nature as its affective content" (Clowney 2013). Clowney describes a biophilic person as someone who will "honor, appreciate, learn about and seek to protect non-human life" (Clowney 2013). More importantly, biophilia should motivate people to examine—through science—the most effective ways to take care of non-human life. This disposition means that biophilia should motivate people to study ecology and other life sciences.

There is an important difference between the justification and content of this virtue, and the two are not in conflict with one another. The care of non-human nature is the focus of the virtue because ultimately, without caring for and about earth's ecosystems, humans cannot flourish—we rely on ecosystems to provide us with vital ecosystem services. This environmental virtue cannot have human flourishing as its focus, because it would result in bad actions that only promote human interests. If the virtue focused only on human flourishing, people would be justified in destroying ecosystems to obtain short-term benefits, which would only promote equally short-term flourishing for people.

Virtue ethics takes its roots from Aristotle, who believed that emotions are inherently tied to the motivation to action—emotions guide us to the things we believe are important. He also thought that emotions played an important role in guiding us toward morality, and as such believed emotion should be fostered as an intermediate condition between two states: one involving excess, and the other deficiency (Kruat 2014). This intermediate became known as the

golden mean. Additionally, Aristotle believed that virtues were no different from technical skills: a skilled worker knows how to avoid both excess and deficiency and maintain an intermediate condition. A famous example of the golden mean is courage. Courage is an emotion that exists between two extremes (vices): cowardice and rashness. Without enough confidence, one is cowardly and so overwhelmed with fear that one cannot act when it is necessary. On the other hand, if one is too confident and does not feel enough fear, one will be prone to make rash and foolish decisions. However, when one's emotions exist in this middle condition, one will not be so cowardly that one cannot act, nor will one be so rash that one takes unnecessary risks while acting (Kruat 2014).

In this manner, emotions became an integral part of virtue ethics; we must practice controlling our emotions, and we must also have the practical wisdom to know how to properly act upon our emotions (Kruat 2014). To properly foster biophilia, a modern community must rely on its own set of practical wisdom: the current scientific knowledge about ecology, biodiversity loss, and human environmental impact (Clowney 2013).

Wilson's conceptualization of biophilia as an emotion is also subject to the golden mean: one should foster enough biophilia to care about the presence and well-being of non-human organisms, but not so much that action will not be taken at all if it requires the death of a non-human organism. When one does not foster enough biophilia—an amount below the Golden Mean, one will simply not care at all for non-human life, and will be content with whatever happens to it—including its continued destruction from human activity and invasive species. On the other hand, when one experiences too much biophilia—an amount above the Golden Mean, one's love of non-human life may be so strong that one is paralyzed when faced with the possibility that a population of non-human organisms must be culled for the health of an

ecosystem. With the correct amount of biophilia—the golden mean—one will care for non-human and strive to protect it, and will accept that there will be situations in which a population of non-human organisms must be culled to maintain the health of the larger community.

Above all else, biophilia aims to protect the environment—in particular, it seeks to protect biodiversity. Biodiversity matters for what it means for the ecosystem as a whole; to protect biodiversity only for biodiversity's sake would be another example of harboring excess biophilia. Fortunately, biodiversity is often used as an indicator of ecosystem health. One description of a healthy ecosystem is a system that is "stable and sustainable, maintaining its organization and autonomy over times and its resilience to stress" (Rapport et all 1998). Some common assessments of ecosystem health are vigor, organization, and resilience – all of which already incorporate biodiversity to some degree. The activity, metabolism, or primary productivity within an ecosystem comprise an ecosystem's vigor. Organization is assessed as the number of interactions between the organisms in an ecosystem, as well as the diversity of organisms found within an ecosystem. Resilience is a system's capacity to function and maintain structure in the presence of stress. The point at which resilience is exceeded is known as an ecosystem's tipping point – the point beyond which the system has changed into an alternate, unfamiliar state (Rapport et al 1998). Many different studies have shown that biodiversity is extremely important to an ecosystem's resilience.

However, biodiversity is not the only metric we can use to assess the health of an ecosystem, and in some cases, using only this measure can lead us to the wrong action, e.g., situations in which an invasive species is increasing biodiversity even though it is drastically altering the ecosystem. A biophilic person who is using practical wisdom will be able to identify cases when biodiversity is not the proper metric. In situations such as these, a different measure

of ecosystem health should be used. Additional measures include an ecosystem's ability to provide essential ecosystem services, which can decrease when an ecosystem is out of balance.

Given that biophilia itself aims to protect biodiversity, some people might think that it then logically follows that we ought to kill the entirety of humanity who is responsible for the overwhelming majority of the current mass extinction. However, this solution does not hold, and it is not what biophilia calls for. Biophilia is justified as a virtue through its contribution to human flourishing, and it is quite obvious that in death, a person cannot thrive.

Scenarios:

***Anoplolepis gracilipes:* The yellow crazy ant on Christmas Island**

Problem overview:

Yellow crazy ants, *Anoplolepis gracilipes* are listed among the most troublesome of all known invasive species. Their impacts have been felt on virtually every tropical island on the planet. However, no place is burdened more heavily by the impacts of this invasive species than Christmas Island, an island located in the northeastern Indian Ocean.

The island supports a forest characterized by tall trees and the absence of underbrush; the forest floor's litter is managed by the system's keystone species, the red land crab, *Gecarcoidea natalis.* A keystone species is defined as a native species whose absence results in a massive alteration of the local ecosystem. These crabs play a key role in regulating seedling recruitment, the composition of seedlings, the density of litter invertebrates, and litter breakdown (O'Dowd et al. 2003). With the loss of seedling regulation, there is an increase in the biodiversity of the forest, although the composition of the plant life becomes predominantly invasive species (O'Dowd et al. 2003).

These invasive ants pose a significant problem on Christmas Island because they kill the red land crabs, whose role is vital to maintaining the ecosystem's functionality. Estimates suggest that these invaders have killed 10-15 million red crabs, as much as one-third of its total population (O'Dowd et al. 2003). Crazy ants are found in supercolonies, which allows them to gain the numerical dominance necessary to completely overhaul the entire forest ecosystem on the island (Abbott 2005). A 2002 estimate stated that approximately 28% of the rainforest on the island was occupied by the yellow crazy ant (Abbott 2005).

The options for control are to take no action, work for total eradication using pesticides, or to use aerial baiting to decrease the ant population to a point that it is not high enough to cause harm to the red crabs and the ecosystem. All of these options have been proposed by the park service on the island, and I will examine the method that is currently in use—aerial baiting.

Utilitarian Perspective:

The utilitarian analysis of the situation focused strictly upon the consequences that come from both the ants' presence on the island in addition to the techniques that will be used to remove them. One of the primary consequences of the ants living on the island is the removal of a keystone species, the red crabs. As stated previously, these crabs play a crucial role in managing the forest floor's litter. Without these crabs, the entire forest ecosystem changes into one that favors invasive species and displaces native species.

The crazy ant kills red crabs primarily through the use of formic acid, which is sprayed into the mouths of the crabs, and causes death within forty-eight hours—a significant period of suffering (O'Dowd et al. 2003). Historically, there has been some contention in the literature regarding the status of crustaceans and the ability to feel pain. However, emerging literature has

cast new light upon the situation, and several studies have gathered evidence that suggests that crustaceans can feel pain (Elwood et al. 2009). Through the way that crazy ants impact the ecosystem, by extension, they also impact the people who live on the island and the industries that rely on the pristine status of the ecosystem, such as the ecotourism industry.

In addition to the consequences associated with the ants' presence itself, a utilitarian will also be concerned with the suffering and pleasure that could come from the management practices used to eradicate this invasive species. Current management practices involve placing poisonous bait in areas that have high crazy ant activity. Boland et al. (2011) studied one such eradication campaign in which low concentration (0.01g/kg) fipronil (an insecticide) bait was deposited from a helicopter onto target supercolonies, which can cover several meters (O'Dowd et al 2003). The campaign was an overwhelming success; within a week of baiting, ant densities declined by an average 79.3%. The densities had decreased by 98.4% by the end of four weeks (Boland et al. 2011).

The method was not only successful, but it also had very few impacts on non-target species. In Christmas Island National Park, only supercolonies of crazy ants are subject to management practices. With the high ant densities, the toxic bait doesn't remain on the ground where it could be taken up by other species. Additionally, before the bait was deployed, the park rangers set traps to prevent the native nomadic robber crab from entering a supercolony and consuming the insecticide. These measures prevented virtually all unwanted damage to non-target species. Furthermore, because the concentration of fipronil was so low (ten times less than the concentration that had been used before this particular campaign), there was no residual concentration found in the soil even two years after the bait had been used.

An additional concern is the cost of the eradication campaign. The estimates for the type of control described above are between $7,000-$12,000 per treatment of numerous colonies (Vanderwoude et al. 2006). Utilitarians consider the other uses this money could have gone towards—in this case—the other conservation efforts or scientific endeavors that could have been funded in place of the eradication effort. Because of the way crazy ant populations are managed—that is, they are only treated with the bait when they reach a high density of ants, described as 1000s of ants per m^2, it is a reasonable cost to bear, especially when considering the overwhelmingly positive consequences of removing the invasive ants(O'Dowd et al 2003).

Biophilic Perspective:

When evaluating the culling of crazy ants through biophilia, we must consider the metric to use—it is clear that biodiversity is not the best metric to use. Without the presence of red crabs that control the litter on the forest floor, the seeds of invasive plants are free to take root, and these invaders harm the ecosystem. A better metric to use could be the resilience of the ecosystem (Rapport et al 1998). By using this metric, it becomes very clear that the presence of crazy ants has a negative impact on the ecosystem—without the keystone crab species, the ecosystem changes in a positive feedback loop. It will take time for the ecosystem to recover from the changes, whereas with the presence of keystone species, the ecosystem can recover from the invasion of plant species—which likely would not be able to sprout altogether.

The impact of the crazy ant are felt in the canopy of the forest as well. Many ant species enjoy mutualistic relationships with scale insects that generate honeydew. Due to the large masses of crazy ants on the island, the population of scale insects also explodes, resulting in the

overproduction of honeydew and resultant growth of sooty molds on the leaves of trees—which serve to decrease photosynthesis, and cause dieback.

When the crazy ants are eradicated from infested areas of the island, the ecosystem reverts back to its original state. The red crabs return to the forest floor and regulate the litter, preventing the growth of invasive plant species and maintaining the sparing underbrush that should be present in the healthy ecosystem.

Both utilitarianism and biophilia favor culling the crazy ants with low-level insecticides applied via aerial baiting, though they do so for slightly different reasons. The utilitarian calculus favors their removal due to the negative changes to the ecosystem that result from the ants' presence, in addition to the suffering endured by numerous red land crabs. Additionally, the proposed removal methods themselves carry positive consequences such as reverting the ecosystem back to its original state for a relatively low cost, and doing so with very few negative impacts such as harming non-target species. While there is the negative consequence associated with denying the welfare interests of the ants, the suffering of the ecosystem as a whole and the individuals within it outweighs any suffering endured by the ants.

A biophilic person will also favor culling the ants. It is clear that this invasive species drastically changes the ecosystem in a way that compromises its integrity and resilience through the removal of members of the keystone species. This creates a situation which allows numerous invasive plants to take root. While the ants do increase the biodiversity of the system, it is not a positive increase, as it decreases the stability of the ecosystem.

Strix occidentalis **vs.** ***Strix varia:*** **Spotted owls vs. barred owls**

Problem Overview:

The spotted owl's range extends from British Columbia through the Cascade Mountains and coastal regions in Washington, Oregon, and California. This species has been listed as threatened under the Endangered Species Act since 1990. Annual surveys continue to indicate that the spotted owl population is in decline in most of eleven study areas. The population as a whole declines at a rate of 2.9 percent per year. There are two primary factors that threaten the owls' survival: habitat loss to timber harvest and fire, and competition from barred owls (USFWS 2013).

The barred owl is a species of owl that is not native in the western United States. Due to land change in the buffering zone that had separated the two owl species, the barred owl was able to encroach upon the spotted owls' territory. Barred owls are larger, more aggressive, and more adaptable. They compete with spotted owls for resources such as nesting sites and food, and often outcompete the native species. Because the population of spotted owls is already so vulnerable, this additional threat has increased the rate of spotted owl decline (USFWS 2013).

The Oregon Fisheries and Wildlife Services has conducted an environmental impact statement that listed several different ways the barred owls could be removed, including non-lethal and lethal methods. These options include capture and permanent captivity, while the lethal methods include killing the barred owls on site with a shotgun.

Further complicating the issue is that the barred owls are protected under the Migratory Bird Treaty Act of 1918. In order to manage the population of this invasive species, the Fisheries and Wildlife Service must obtain a permit to capture or kill the barred owl.

Utilitarian Perspective:

For utilitarians, the most important moral consideration when examining management practices is the suffering of both species of owls. The Oregon Fisheries and Wildlife Services supported lethal removal procedures over non-lethal methods. A utilitarian views death as morally neutral; what matters is the suffering that comes with death. The organization justifies its decision by saying lethal methods are "considered the best way to minimize the potential for trauma, pain, and suffering because it is most likely to result in instantaneous death" (USFWS 2013). Every effort is made to use lethal practices that are safe, humane, and efficient to reduce the risk of unnecessary injury to barred owls and other species (USFWS 2013). This suffering must be weighed against the suffering endured by the spotted owls when they are displaced from their territory. It seems that the suffering of spotted owls is greater than that of the barred owl, because displacement from their territory is likely to result in a long period of suffering which may include starvation.

From this comparison, it seems that the suffering of the spotted owl will outweigh the suffering of the barred owl. In the current management regime, while barred owls are killed, it is done in a way that ensures the animals do not suffer. Whereas, when spotted owls are pushed out of their territory, these animals have to deal with a death may come as a result of starvation. In this way, it seems that culling the barred owls is the right thing to do in order to avoid a large amount of suffering.

A utilitarian is also very concerned with the cost of the management solution. The proposed removal of barred owls carry a cost between $400,000-$12 million per campaign, depending upon which specific method is used (lethal control or non-lethal capture) (USFWS 2013). It will take numerous removal procedures to reduce the number of barred owls to the

point that the spotted owl can adequately recover, which indicates a long term commitment of a considerably large amount of money.

A utilitarian generally thinks about the monetary cost of an action through a particular lens in the case of funding for scientific endeavors, by asking the question: of all the diversity of projects that need funding, why should all of that money go to this particular endeavor? When added all together, this one project will require an enormous amount of money which could be used to fund numerous other conservation efforts. For example, instead of conserving just one species—the spotted owl—that funding could be spent to conserve many different species. The funding could also be given to medical research, which would benefit a large number of people. The sheer cost does not justify removing the barred owls, because there are so few benefits gained from preserving the spotted owls.

Biophilic perspective:

When looking at the situation from the perspective of biophilia, it is important to look at how the barred owls' presence impacts the ecosystem as a whole. It seems that there are very few impacts to the environment as a result of the barred owl invasion. The barred owl and spotted owl occupy the same niche within the ecosystem of the northwestern forest. In fact, the two species are so similar in niche and relation that they can hybridize and produce fertile offspring (Haig et al 2004).

Spotted owls and barred owls occupy the same niche; the noticeable difference between the two species is the aggressive nature of the larger barred owl. It is not likely that the barred owl will carry adverse consequences to the ecosystem or other species that reside within its habitat. The barred owl only impacts the spotted owl. Because biophilia does not aim to

maximize biodiversity, it is not justified to remove the barred owl. The barred owl is not a threat to the integrity of the ecosystem.

Although, it may be the case that because this owl is larger than its native counterpart, it will consume more prey. However, the nature of predator-prey relationships will dictate that the barred owl never consumes so many that it risks dismantling the ecosystem. The dynamics of a predator-prey relationship is such that the predator's population is always controlled by the prey's population. When there are more prey animals available, the predator's population will also increase. However, should the prey's population fall, the predator's population will crash to reflect the circumstances of food availability (Ricklefs and Relyea 2015).

From the analysis above, humans are not justified in removing barred owls to save the spotted owl, primarily due to the enormous cost of the efforts that could be spent elsewhere on other types of research. Additionally, there are few consequences associated with the presence of the barred owl—its impacts are felt only by the spotted owl. The barred owl is not a threat to the ecosystem's functionality, as it displaces the spotted owl and occupies that niche in the ecosystem.

However, it is worth noting that utilitarianism may reach a different conclusion. A utilitarian may perceive the human happiness that arises from the existence of spotted owls (its existence value) as a utility that outweighs the monetary cost of managing the population of barred owls. This discrepancy demonstrates a problem within the theory of consequentialism: it is incredibly difficult to determine weigh different classes of consequences against one another. In this particular case, those two classes are human happiness against the monetary cost of removing the barred owl. It is an interesting problem that arises, as utilitarianism and biophilia only reach different conclusions when we consider a more human element in the calculus.

***Euphorbia esula*: Leafy Spurge**

Problem Overview:

Leafy spurge is an invasive (noxious) weed found primarily throughout the Midwestern and Western United States. The plant is native to parts of Europe and Asia; its exact route to the United States remains unknown. This plant poses a significant problem in prairie ecosystems, where it shades out native species and produces a chemical that prevents other plants from growing near it. Additionally, this invasive species is a serious problem for people who are using rangeland to graze animals; leafy spurge produces a toxic substance that acts an irritant, emetic, and purgative when consumed by livestock (Lym and Kirby 1987).

Leafy spurge presents significant economic impacts that stem from its impact on the forage availability for cattle. Estimates blame this invasive plant for as much as $120 million in lost cattle production in Montana, North Dakota, South Dakota, and Wyoming. An additional estimate places a $10 million annual loss in nonagricultural industries such as recreation and watersheds in this four-state area (Hansen, et al. 1997).

This plant's presence also imposes negative consequences on the ecosystem. Infestations significantly reduce the abundance of native prairie plants, which in turn has a negative impact on wildlife populations whose habitats are changed by this invader. In addition, the plant produces a toxic substance that harms certain herbivores that consume it (Hansen, et al. 1997).

Leafy spurge is a persistent weed, and difficult to fully remove from an infected area. The driving force behind removing leafy spurge is to increase cattle production and to maintain the status of the native plant population. There are two primary control methods available for this invader: the use of herbicides or biological control agents. A utilitarian will be primarily

concerned with the use of herbicides, the use of which can carry many tangible consequences. Most herbicide options will control up to 70% of unwanted leafy spurge. Depending upon the size of the infestation, herbicide application can be very cost effective, with the options ranging from $30-$40 per hectare, though it takes multiple annual applications to reach and maintain the desired level of control. However, herbicides will impact non-target species that come into contact with it (Lym 1998).

Utilitarianian Perspective:

A utilitarian is concerned with the consequences that arise from the presence of leafy spurge, the majority of which are negative. The plant produces a toxin that harms livestock, which causes them to suffer the unpleasant experiences associated with its ingestion—vomiting and irritation. Additionally, that toxin prevents other plants from growing, ensuring a monoculture of leafy spurge, which is unpalatable to livestock.

The impacts of this noxious weed on livestock has serious implications for human wellbeing. If the invasive plant is found in a rancher's pasture, it can cause them to lose a considerable amount of money—either through reduced cattle production, or more directly through the costs associated with managing it. Ranchers partake in a profession that does not grant them very much disposable income, and so any reduction in profit or additional inputs to their grazing system may have a large impact on the quality of life for the rancher themselves as well as anyone who is dependent upon that income.

Both utilitarianism and biophilia are concerned with the consequences that will arise from biological control. There are innumerable causes wherein a non-native organism was introduced to control an invasive species, but instead wreaked havoc on the ecosystem or preferred to target

a different species altogether. Insects are the primary type of biological control agent available for leafy spurge. The insects themselves are considered an invasive species, and must be closely monitored and studied to ensure that they will only target leafy spurge.

According to the study by Lym, a population of flea beetles has had the greatest success with biological control, because its larvae feed on the root system of leafy spurge. The adults can be easily captured and transported to another location to establish a new population. However, the study has also found that five years after the initial flea beetle release, there has not been an increase in the production of the native grass species. An additional issue with this form of control is that is only effective in conjunction with another type, such as herbicide use (Lym 1998).

Biophilic Perspective:

A biophilic analysis is concerned with the way that leafy spurge decreases biodiversity in a rangeland or prairie setting. In ecosystems like these, biodiversity is a key indicator of the health of the system, as the more plant species that are present in the area can support more types of organisms. Leafy spurge decreases the biodiversity of these systems through its use of toxins to prevent other plants from growing near it. In turn, it can form a monoculture within a pasture and reduce the available forage and habitat for the organisms that depend upon it. In order to protect the integrity of the system, it is necessary to remove leafy spurge from the area. In this way, removal is justified.

In this case, both methods of analysis reach the same conclusion: that people are justified in the removal of leafy spurge, so long as the control methods used do not cause more harm than good for the ecosystem as a whole. The economic loss attributed to leafy spurge in addition to

the hardships experienced by ranchers when this noxious weed invades their fields justifies the removal of this weed. Additionally, the plant's ability to outcompete native species and monopolize a field reduces the productivity, resilience, and biodiversity of the ecosystem and ought to be removed. Plants introduce a unique problem into ethical analyses, in that the suffering of the species being removed is not a consideration. Careful analysis is then needed to ensure that removing the plant will indeed be good for all parties involved, both human and not.

Summary and Conclusion

Conservation biologists who aim to manage invasive species should take measures to ensure that the actions they take are morally permissible, especially when they propose killing a large number of organisms they have deemed unwanted within an ecosystem. The primary goal of this research was to identify the circumstances under which it is permissible for people to use lethal control measures to eliminate invasive species from an ecosystem. Two ethical theories, utilitarianism and biophilia were used to analyze three cases in which invasive species are eradicated in order to determine if the action is indeed justified.

The answer I gathered from this series of analyses is that the permissibility of eradication regimes depends upon the specific details of the situation. Utilitarianism showed that it is permissible to use lethal control measures when the positive consequences of doing so outweigh the negative consequences. The use of this theory is helpful in making decisions about the action to take because it is easy to see what ought to be done in order to maximize the pleasure and happiness of all the creatures in the moral community whilst minimizing their suffering. However, in some cases it is difficult to weigh consequences against one another, as was the case

in the barred owl situation. It is hard to determine what action to take when it may increase human happiness, but at an enormous cost.

With biophilia, it is permissible to eradicate invasive species when the members of that species pose a significant threat to the ecosystem. In the analyses, a significant threat was presented as a dramatic change in the ecosystem that compromises its ability to function properly—as was the case in the crazy ant. Additionally, in the case of leafy spurge, when an invasive species decreases the biodiversity of an ecosystem, it is permissible to eradicate it.

Using these two ethical theories has shown that even when people have different reasons for taking a certain action or value different things, we can still reach the same conclusion—it is not necessary to fully adopt either one exclusively, because our reasons can come from different places. Occasionally, these two theories will reach different conclusions, as was mentioned in the analysis of the barred and spotted owls. Typically, the disagreement is caused by considering a more anthropocentric element such as economic reasons, or specifically on the basis of suffering.

Ethical analyses are a useful tool to use in addition to the more traditional use of cost-benefit analyses for conservation biologists. Especially when conservation biologists are trying to determine the fate of members of an invasive species, it is important to take a step back to analyze the situation from an ethical standpoint. It can help ensure that all of the values and perspectives have been taken into consideration, and it may help to eliminate sources of bias. Additionally, examining the situation from an ethical perspective can provide additional justification for the actions that are taken.

In future research, different ethical theories should be used. I chose two theories out of a large variety, and it would be interesting so analyze these same situations with different ethical theories, to see how the answers change given the relevant considerations. Additionally, different

scenarios should be analyzed—the scenarios I chose for this research had fairly clear answers, and it would be better to analyze scenarios that are more complicated because they have more ethical considerations to take into account.

A more pluralistic approach should be taken in order to conduct these ethical analyses. I treated utilitarianism and biophilia as though their ethical considerations were exclusive, however there is a lot more overlap than I showed in this paper. Additionally, there is value to analyzing situations using many different ethical theories, because people generally approach ethics pluralistically and do not adhere to only one specific theory.

References:

Abbot, K. L. 2005. "Supercolonies of the invasive yellow crazy ant, *Anoplolepis gracilipes*, on an oceanic island: Forager activity patterns, density and biomass." Insect Sociaux. 52: 266-273. DOI 10.1007/s00040-005-0800-6

Baxter, Brian. 2004. "Theory of Ecological Justice." Routledge.

Bentham, Jeremy. 1781. "An Introduction to the Principles of Morals and Legislation."

Boland, C. R. J., et al. 2011. "Heli-baiting using low concentration fipronil to control invasive yellow crazy ant supercolonies on Christmas Island, Indian Ocean." Island Invasives: Eradication and Management. 152-156.

Clowney, David. 2013. "Biophilia as an Environmental Virtue." Journal of Agricultural and Environmental Ethics. 26: 999-1014.

Elwood, Robert, Stuart Barr, and Lynsey Patterson. 2009. "Pain and Stress in Crustaceans?" Applied Animal Behavior Science. 118: 128-136.

Haig, Susan et al. 2004. "Genetic Identification of Spotted Owls, Barred Owls, and Their Hybrids: Legal Implications of Hybrid Identity." Conservation Biology. 18: 1347-1357.

Hansen, Richard, et al. 1997. "Distribution of Biological Control Agents of Leafy Spurge (*Euphorbia esula L.*) in the United States: 1988-1996." Biological Control. 10: 129-142.

Kraut, Richard. 2014. "Aristotle's Ethics." Stanford Encyclopedia of Philosophy.

Lym, Rodney and Kirby, Donald. 1987. "Cattle Foraging Behavior in Leafy Spurge (*Euphorbia esula)*-Infested Rangeland." Weed Technology. 4: 314-318.

Lym, Rodney. 1998. "The Biology and Integrated Management of Leafy Spurge (*Euphorbia esula*) on North Dakota Rangeland. Weed Technology. 12: 367-373.

Mill, John Stuart. 1863. "Utilitarianism."

O'Dowd, Dennis J., Peter T. Green, and P.S. Lake. "Status, Impact, and Recommendations for Research and Management of Exotic Invasive Ants in Christmas Island National Park."

O'Dowd, Dennis J., Peter T. Green and P.S. Lake. 2003. "Invasional 'Meltdown' on an Oceanic Island." Ecology Letters. 6: 812-817. DOI: 10.1046/j.1461-248.2003.00512.

Publishers. New Brunswick, New Jersey, USA. Pgs 249-259.

Rapport, D.J., R. Costanza, and A.J. McMichael. 1998. "Assessing Ecosystem Health." Trends in Ecology & Evolution. 13: 397-402. DOI: 10.1016/S0169-5347(98)01449-9

Reiners, William and Jeffrey Lockwood. 2010. "Philosophical Foundations for the Practices of Ecology." Cambridge University Press. New York, New York. Print.

Ricklefs, Rober and Rick Relyea. 2015. "The Economy of Nature." W. H. Freeman. Print.

Shogren, Elizabeth. 2014. "To Save Threatened Owl, Another Species is Shot." NPR. Web.

Simberloff, 2002. "Today Tiritiri Matangi, tomorrow the world! Are we aiming too low in invasives control?" Turning the Tide: The Eradication of Invasive Species. 4-12.

Sinnott-Armstrong. 2011. "Consequentialism." Stanford Encyclopedia of Philosophy. Web.

USFWS Oregon Fish and Wildlife Office. July 2013. "Barred Owl: Frequently Asked Questions."

Vanderwoude, et al. 2006. "Assessment of Yellow Crazy Ants (Anoplolepis gracilipes) on Nuulua Island, Aleipata, Samoa with recommendations for population control."

Wilson, Edward O. 2007. *Evolutionary Perspectives on Environmental Problems.* Transaction