Japanese Knotweed, an invasive species, has been found along the banks of the Delaware River in Easton, near the Scott and Riverside Parks. The existence of this species may have negative effects on the river’s ecosystem, such as killing native species by competing with them for resources. Therefore, the city of Easton decided to spray AquaNeat, an herbicide known to effectively eradicate knotweed, on the banks of the river in the summer of 2012. The citizens of Easton were unhappy with this decision and it resulted in a completely defoliated riparian buffer. Additionally, many concerned citizens were unsure of the effects of spraying the herbicide near a major source of drinking water. As a result, policy alternatives were researched.

Before policy alternatives were discussed, evaluative criteria had to be chosen in order to prevent bias. The criteria that were most appropriate include economic feasibility, effectiveness, efficiency, and social acceptability. They were weighed in order of importance so that when the policies were assessed the criteria that weighed more would have a bigger impact on the total score of each policy alternative. The rating was between one and four, with one being the worst in that criterion, and four being the best in that criterion.

Next, policy alternatives were researched. Three possible alternatives were discovered: mechanical control, chemical and cultural control, and biological control. The first potential method is manual labor. The city of Easton, in order to make the process efficient, could acquire voluntary laborers and teach them how to remove the Japanese knotweed by means of tools such as hoes and loppers. The second alternative was the use of glyphosate to remove the knotweed, and then the planting of glyphosate-resistant crops along the riverbank, such as corn and soybeans. If this method is used by the city, the crops could be sold to generate revenue which would help to pay the costs of the riverbank restoration. The third, and final, suggested policy was the use of goats to remove the Japanese knotweed. Goats are known for their non-selectivity with regards to their eating habits, so they would be able to ensure the complete eradication of the Japanese knotweed. This method would be extremely effective because goats eat and digest the seeds of the plants, preventing the Japanese knotweed to regrow.

When the policy of manual labor was assessed, it received a 3 in effectiveness, 4 in economic feasibility, 2 in social acceptability, and 4 in efficiency. This process was not ideal in effectiveness, because frequent visits would be required. The use of glyphosate and its resistant crops received a 2 in effectiveness, 2 in economic feasibility, 1 in social acceptability, and 2 in efficiency. This method received its lowest score in social acceptability because the crops may not be too aesthetically pleasing. The third alternative of biological control earned a 4 in effectiveness, 3 in economic feasibility, 2 in social acceptability, and 3 in efficiency. This method’s lowest score was social acceptability, because of potential noise and smells resulting from the goats.

The totals for mechanical, chemical and cultural, and biological control were 13, 7, and 12, respectively. Therefore, the recommendation was the use of manual labor.
I. General Overview

In the summer of 2012, the city of Easton defoliated the banks of the Delaware River along Riverside and Scott parks. The city sprayed pesticides twice to remove the vegetation. A certified applicator was contracted by the city to spray the herbicide AquaNeat along the riverbanks of the two parks (Lindsey, 2012). According to the product manufacturer’s website, “AquaNeat is an effective aquatic herbicide for use on emerged aquatic weeds and brush in aquatic and other non-crop areas. AquaNeat is a five pound glyphosate specially formulated for a wide variety of aquatic applications” (Nufarm, 2012). The city thought to use herbicides because removal of the vegetation by hand is labor-intensive and expensive. However, these chemicals can pollute the Delaware River and damage the riparian ecosystem. AquaNeat contains glyphosate, the same chemical used in the weed-killer Roundup, which the United States Environmental Protection Agency has classified as “moderately toxic;” AquaNeat contains a lower concentration glyphosate, earning it a rating of “slightly toxic” (Lindsey, 2012). According to the Environmental Protection Agency (2012), glyphosate does not harm humans when it is consumed in minimum dosages. However, this does not account for the uptake of glyphosate by the roots of plants eaten by non-human animals. A major flaw of the regulation of herbicides and pesticides is that the United States government primarily looks at ways that these chemicals affect humans, not other species with which we share the Earth. Many different species of animals and plants depend on the natural environment of the Delaware River for their survival and the use of pesticides on the riverbank jeopardizes the purity of these water and soil resources.
The Delaware River is one of the last major undammed rivers in the United States and its biological diversity and low levels of pollution make it an ecological cornerstone for the northeastern United States. The Upper Delaware River corridor contains diverse habitats that support abundant wildlife populations. There are over 50 species of mammals that live along the banks of the Delaware River, including black bears, bobcats, coyotes, wild turkeys, white-tailed deer, and river otters, which reside in the river (National Park Service, 2012). Any disruption to the water quality can affect the drinking water for these animals and the ability of the plants they eat to grow along the riverbank.

Additionally, the Delaware River is part of the Atlantic Flyway, an important migratory path for birds from the North Atlantic Coast through the Caribbean and to South America. This flyway is home to over 500 different species of birds, and at least 200 of those species can be found along the Upper Delaware River (National Park Service, 2012)(National Audobon Society, 2012). The Upper Delaware River Valley is an important habitat for the North American bald eagle, a species that was on the brink of extinction only several decades ago. The Delaware River ecosystem of clean water, food such as fish, and large deciduous and coniferous trees for nesting is crucial to the survival of the bald eagles. Over one hundred bald eagles migrate from Canada and New England to the warmer Upper Delaware River Valley during the harsh winter months each year (National Park Service, 2012). Although Easton is located in the central region of the Delaware River, this information is relevant because it demonstrates the dependence of wildlife on this geographical feature.

Many aquatic species also rely on the river as a habitat and are directly affected by pesticide contamination in the river. The Upper Delaware River contains some of the cleanest water in the eastern United States, which is why the river is home to a plethora of species of fish
including American shad, striped bass, smallmouth bass and walleye. As one of the “finest fishing rivers in the northeastern United States,” the Delaware River and its ability to support fish life should not be threatened (Pennsylvania Department of Conservation and Natural Resources, 2012). The Upper Delaware River is the only natural American shad river from Maine to West Virginia that is free of industrial pollution and man-made barriers, such as dams. This obstruction and pollution-free passage of water is necessary for the shad to be able to migrate to their spawning habitats each year. By spraying glyphosate on the Delaware River banks, the Easton city government will likely impose negative externalities for other communities located downstream from Easton along the banks of the Delaware River (National Park Service, 2012).

Not only fish, birds, and furry woodland creatures rely on the Delaware River for clean, life-sustaining water. Over five percent of the population of the United States uses the Delaware River as their primary source of water. The Delaware River provides the population of the northeastern United States with approximately two billion gallons of water daily (National Park Service, 2012). In addition to consumption, humans use the Delaware River as a place to recreate and enjoy the great outdoors. Pesticide contamination could make the water unsafe for recreation activities, such as boating and swimming.

Easton’s decision to remove the riparian buffer by means of chemicals negatively impacted the surrounding environment, and also failed to uphold its governmental obligations to the municipality’s citizens. The Declaration of the Rights in the Constitution of the Commonwealth of Pennsylvania states:

The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and aesthetic values of the environment. Pennsylvania’s public natural resources are the common property of all the people, including generations
yet to come. As trustee of these resources, the Commonwealth shall conserve and
maintain them for the benefit of all the people.

(Constitution of the Commonwealth of Pennsylvania, Art. I § 27, 1776)

The city of Easton’s use of toxic pesticides next to an important regional river clearly violates the
state’s legal obligation to provide its citizens with clean water and conserve and maintain natural
resources. The Easton Environmental Advisory Council is of the same opinion; it suggests that
Easton should prevent all potentially harmful actions taken near the Delaware River, in order to
maintain the water’s quality.

Because the city’s public water supply source is the Delaware River, and regional,
watershed-wide activities and decisions will impact the water quality of the
Delaware River, the city should support appropriate development upstream of the
city and, conversely, resist inappropriate development/land uses upstream which
may impair water quality.

(EAC Four Year Report)

While the AquaNeat cannot be completely eradicated from the ecosystem’s soil and
water supplies, the effects of the pesticides in the river are not necessarily immutable and the city
of Easton should begin to mitigate the harmful effects of chemical pollution as soon as possible.
There are several potential actions that can accomplish this feat, which will be outlined in the
Policy Alternatives section.

II. Nature and Extent of the Problem

The implementation of AquaNeat occurred on the banks of the Delaware River, which is
330 miles long and flows from New York through Pennsylvania. Many acknowledge the river’s
historical importance; George Washington crossed this river during the Revolutionary War.
However, the Delaware River currently has even more significance, because it provides drinking
water to approximately five percent of the current United States population (Rosenbaum). As
demonstrated by Figure 2, the Delaware River and its surrounding area also provide many
activities for people, such as fishing.
Before using an unnatural chemical along the river, it is necessary to thoroughly assess the possible effects that such an herbicide could have on its entirety. If glyphosate were to enter the town’s water supply, which is possible through the spraying of vegetation near the river, it would not be harmful. According to the EPA’s National Primary Drinking Water Regulations (2009), only those who drink water, which exceeds the maximum contaminant level (determined by the EPA to be the maximum level of contaminants at which no harmful health effects will occur) for extended periods of time may experience kidney or reproductive problems (p.2, 4).

AquaNeat was used at two separate locations: the Riverside and Scott parks. These areas are heavily used by Easton and the surrounding population. As described in Easton Patch, the

![Map of Delaware River area](image)

*Figure 1. Human activities along the Delaware River.*
former is “a busy place in warm weather.” For instance, it hosts well-attended musical and theatrical shows at its amphitheater. The eradication of vegetation along the river worsens the aesthetic qualities of the area. Prior to the defoliation, the park was a place of beauty, where Easton citizens could sit and enjoy the view of the river. Figure 1 portrays Easton’s appreciation of the riverside’s beauty during the 1920’s.

The use of the herbicide at these two popular sister parks directly affects those who spend time near the parks, either at town events, or just viewing the vegetation and wildlife. According to “Creating Sustainable Community Parks and Landscapes,” research at the Human Environment Research Laboratory at the University of Illinois Urbana-Champaign, vegetation has innumerable benefits on community life (p. 1). For instance, it has been found to lower crime rates, strengthen social ties, and improve health and education. As demonstrated by Figure 2, the

![Riverside Park, Easton, Pa.](image)

*Figure 2. Riverside Park around 1920 was so appealing that a painting of it was used on a popular postcard.*
Delaware River and its surrounding area provide many activities, such as fishing. The loss of vegetation caused by the use of AquaNeat could hinder the Easton community from achieving such benefits.

The absence of plant life also has great environmental consequences. It creates an area more prone to erosion, because the soil of the riverbank will be looser without roots to support a sturdy structure. This process was demonstrated during Hurricane Sandy, because the riverbank receded. Refer to Figure 3 to see the effects of Hurricane Sandy on the riverbank along Scott Park. Also, according to “Creating Sustainable Community Parks and Landscapes,” vegetation contributes to reduced flooding, air pollution filtration and air cooling (p.1).

Figure 3. Riverbank alongside Scott Park on Monday, the first day of Hurricane Sandy (Lindsey, 2012)
In addition to affecting the human population and the physical environment, this chemical could perhaps more seriously affect the various types of wildlife along and in the river. For instance, the so-called “Delaware River Striper Fish” is commonly sought by fishermen, and is present in the Easton area. Also, as previously mentioned, shad inhabits the river. Scott Park even hosts the annual Shad Tournament. There is a strong avicular presence as well; mallards, blue birds, great blue herring, and turkey vultures have been spotted along the river. The use of this herbicide could drastically affect the wildlife population along the Delaware River.

The elementary concept of the food chain is applicable to this issue, because it affects different animals. When one member of such a group is affected, it also results in a change for all other members. For instance, if the population of shad were to decrease due to the chemical imbalance of the river, it would affect its predators, including birds. Currently, there is an avid bird watching group: the Lehigh Valley Audubon Society. This organization lists the Delaware River as one of its “hot spots” in the northeastern region of the Lehigh Valley. Not only have birds lost their habitat among the bushes and trees, but they also may be affected if there is a change in the fish population. Therefore, it is crucial to consider both the direct and indirect results of AquaNeat use.

Although it seems that the city of Easton does not plan to continuously apply AquaNeat along the river, the issue of its use is still time-sensitive. For example, the fish inhabiting the river may develop differently over time, due to the different chemical make-up of the water. In addition, the lack of vegetation resulting from the AquaNeat use could cause certain wildlife inhabiting the foliage to migrate elsewhere. The planting of new plants along the river as soon as possible could prevent the permanent relocation of wildlife to another area. Erosion is an
extremely time-sensitive problem. The sooner vegetation is restored along the riverbank, the less erosion will occur.

III. Causes

Many Easton residents affected by the killing off of the invasive species along the Delaware River in downtown Easton, Pennsylvania asked the question of why the banks were sprayed down. One of the biggest concerns that led to the spraying down of the banks was the rapid growth of invasive species such as Japanese Knotweed. This weed is considered to be harmful because of its rapid growth, which can cause damage to flood defenses, roads, pavements, historical buildings, and drains (Sadik, 2012). The plant forms thick and very dense colonies that entirely crowd out and take over any other herbaceous species and is now considered one of the world’s worst invasive exotics (Lowe, Browne, de Poorter 2000). When asked about why the spraying occurred, Easton mayor Sal Panto Jr. stated “fishermen often called to complain to him about the growth along the bank” (Malone, 2012). Several complaints were submitted because of the lack of access to the river due to the overwhelming amounts of weeds and plants on the banks. Others also complained about the unsightly view of the weeds that covered the view of the river.

The herbicide that was used to kill off the vegetation along the banks uses the ingredient glyphosate, which has been linked to birth defects when imbibed in large doses. Although no harmful side effects from the use of the chemicals have risen thus far, the Concerned Citizens of Easton worry about the potential effects of this action on city’s wildlife. The strip of vegetation along the banks of the river, also known as a riparian buffer, is home to many different species of birds, rodents, and insects:

The trees, shrubs and plants, and grasses in the buffer provide a natural and gradual transition from terrestrial to aquatic environments. These areas are critical for
wildlife habitat, storing water during periods of high water flow, and protecting lakes and rivers from physical and chemical pollutants.

(Huron River Watershed Council, 2011)

The ecological health and stability of the riparian buffer in Easton is crucial for these animal species to maintain good health. Figure 4 demonstrates the Lehigh Valley Planning Commission’s portrayal of the riparian buffers near the Easton area. The LVPC defines riparian buffers as areas “where stream banks lack forest buffers (Lehigh Valley Planning Commission, 2011)”. Any threat to the vitality of these riparian buffers would be a threat to the animal species that reside there.

Figure 4. The parks in the Easton area, as well as the riparian buffers along the Delaware River, defined by the Lehigh Valley Planning Commission.
IV. Key Terms

AquaNeat

According to the company’s website, “AquaNeat is an effective aquatic herbicide for use on emerged aquatic weeds and brush in aquatic and other non-crop areas. AquaNeat is a five pound glyphosate specially formulated for a wide variety of aquatic applications” (AquaNeat 2012). AquaNeat is the herbicide that was used by the city of Easton to remove vegetation in Scott and Riverside Parks.

Biological Diversity

In a paper published by the Durrell Institute of Conservation and Ecology, biological diversity is defined as the “species, genetic, and ecosystem diversity in an area, sometimes including associated abiotic components such as landscape features, drainage systems, and climate” (Swingland, 2001, p. 377). High levels of biological diversity are important to the vitality of ecosystems through dynamic natural and man-made changes to the environment.

Biological Weed Control

Biological weed control is defined as the “use of other living organisms, such as insects, diseases, or livestock, for the management of certain weeds” (Pennsylvania State University, 2007, p. 10). This only works for certain plants that are edible for grazing animals and research is continuing on the successes of the approach to weed management.

Chemical Weed Control

Chemical weed control involves the use of herbicides to kill unwanted plants. There are many different methods of chemical weed control, some herbicides enter the plant through the root system and completely eradicate the plant while other herbicides only kill the part of the plant they come in contact with. Certain herbicides, such as Roundup, are selective in the plants
they kill in contrast to herbicides that will kill all types of vegetation (Pennsylvania State University, 2007, p. 11).

**Ecosystem**

The United States Army Corps of Engineers defines ecosystem as “An ecosystem is a biotic community together with its physical environment, considered as an integrated unit...An ecosystem may be characterized as a viable unit of community and interactive habitat. Ecosystems are hierarchical and can be viewed as nested sets of open systems in which physical, chemical and biological processes form interactive subsystems” (U.S. Army Corps of Engineers, 1999, p. 12).

**Glyphosate**

Glyphosate is a “broad-spectrum, non-selective systemic herbicide” that is moderately toxic to plants, slightly toxic to wild birds, and non-toxic to fish. The glyphosate compound is broken down by microbes and binds tightly to the soil, which results in insignificant leaching and run-off (Extension Toxicology Network 1995).

**Herbicide**

Herbicides are defined as “crop protecting chemicals used to kill weedy plants or interrupt normal plant growth” (Pennsylvania State University, 2007, p. 10). Herbicides’ strengths lie in their convenience, effectiveness, and cost-efficiency. The major drawback of using herbicides is that they can have deleterious effects on the health of the ecosystem and all of the species associated with it, including humans.

**Invasive Species**

Invasive species are plants that “reproduce rapidly, spread over large areas of the landscape, and have few, if any, natural controls, such as herbivores and diseases, to keep them
in check” (Pennsylvania State University, 2007, p. 6). Invasive species can be introduced into an ecosystem on purpose and by accident. In addition to humans planting invasive species, wildlife, wind, and water can transplant seeds from one environment to another. Some invasive species spread so rapidly that they displace most other plants, changing an ecosystem into a monoculture, which greatly reduces the natural biological diversity of an area. Invasive plants also impact nature in many other ways, including “growing and spreading rapidly over large areas, displacing native plants (including some very rare species), reducing food and shelter for native wildlife, eliminating host plants of native insects, and competing for native plant pollinators” (Pennsylvania State University, 2007, p. 7).

Japanese Knotweed

Japanese knotweed (*Polygonum cuspidatum*) was introduced to North America from Asia in the late 1800s for erosion control and its aesthetic value. The plant is an invasive species that crowds out other native species (United States Agricultural Library 1999).

Mechanical Weed Control

Mechanical weed control is a physical technique of either destroying the weeds or manipulating the environment so that it is less amenable for seed germination or weed growth. Some examples of mechanical weed control techniques include hand-pulling, hoeing, moving, plowing, disking, cultivating, mulching, and digging (Pennsylvania State University, 2007, p.10).

Native Species

Native species occur naturally in a particular ecosystem without humans introducing the species to the area (Pennsylvania State University, 2007, p. 6).
Riparian Buffer

A riparian buffer is the vegetated area next to a water resource. Riparian buffers protect water resources from runoff pollution and provide bank stabilization and aquatic and wildlife habitat. These areas also protect fragile aquatic ecosystems from potentially harmful human activity near the body of water (North Carolina State University).

Soil Erosion

Soil erosion is “the wearing away of the land surface by physical forces such as rainfall, flowing water, wind, ice, temperature change, gravity or other natural or anthropogenic agents that abrade, detach and remove soil or geological material from one point on the earth's surface to be deposited elsewhere” (Jones, 2007, p. 2). Soil erosion can occur from naturally occurring processes, such as rain and wind, but can also be catalyzed by human activities such as agricultural practices and development.

Sustainability

The United States Environmental Protection Agency defines sustainability as “the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations” (United States Environmental Protection Agency). Sustainability entails focusing on long-term impact of actions and creating lasting changes.

Nonpoint Source Water Pollution

According to the United States Environmental Protection Agency, nonpoint source water pollution results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. Sources of these pollutants can include sewage and industrial treatment plants, urban runoff, fertilizers, herbicides and pesticides (United States Environmental
Protection Agency 2012). Riparian buffers help to mitigate the amount of chemical runoff into
water sources.

V. Evaluative Criteria

The four criteria chosen to assess the policy alternatives are, in order of importance: economic feasibility, effectiveness, efficiency, and social acceptability. Economic feasibility is the most important criterion because, regardless of how well a policy scores for the other criterion, if the city is unable to fund the policy then it cannot be an option. If the policies are economically feasible, then the next most important criterion for evaluation of the policy alternatives is effectiveness. The policy alternative selected by the city should restore the riparian ecosystem to its healthy state prior to the removal of vegetation. Efficiency is the third most important criterion because the city of Easton has very few funds to invest in a new riverbank restoration project, so any capital that the city does spend should achieve maximum results for the least amount of money. Social acceptability is the fourth criterion. A group of citizens in Easton has become very involved in this issue so any future actions on the riverbanks by the city will be sure to receive plenty of publicity and will be assessed rigorously by the local group of environmental activists.

The four criteria will be measured on a scale of one to four in integer increments. Four will be the highest score a policy alternative can receive for fully meeting the requirements of a criterion. A score of one is the lowest and will be assigned to policies that do not meet an evaluative criterion. The criteria will be weighted based on their importance as listed earlier. Economic feasibility will have a weight of 1.0, effectiveness will be weighted 0.95, efficiency will be weighted 0.9, and social acceptability will be weighted 0.85.
Economic Feasibility

The city of Easton is facing major budget shortfalls because of an unfunded state mandate for municipal governments to provide healthcare and pension plans for part-time elected officials (J. Warren, personal communication, October 15, 2012). This leaves little money to spend on important ecological projects, such as restoring and maintaining the health of the Delaware River banks at Scott and Riverside Parks. It is important that the city of Easton has either the funds or borrowing capacity to finance the policy alternative selected. There are several possible ways the city can raise funds for riverbank restoration including implementation of park user fees, raising taxes, applying for grants or making budget cuts elsewhere. Additionally, if the policy alternative chosen is popular with environmentally conscientious citizens of Easton, individuals may be willing to donate funds for an upstanding environmental restoration project. This criterion may eliminate the ability of the city to choose from other highly effective or popular policy alternatives that are beyond their budget provisions.

Effectiveness

Effectiveness is defined as the “likelihood of achieving policy goals and objectives or demonstrated achievement of them” (Kraft & Furlong 185). The policy alternative selected by the city would ideally be the best possible solution to restore the riverbank ecosystem. Restoring the riverbank ecosystem would include revival of native vegetation, ensuring water quality and lack of contamination from herbicides, recreation of habitat for the animal species that resided along the riverbank, and reestablishment of an aesthetic landscape that pleases park patrons.

Efficiency

Efficiency is defined as “the achievement of program goals or benefits in relationship to the costs; the least cost for a given benefit or the largest benefit for a given cost” (Kraft &
Measuring the efficiency of a policy alternative will involve determining if the policy will need to be implemented more than one time. For example, if one policy allows an invasive species to grow back after a year, the policy will need to be re-implemented, multiplying the cost. An ideal policy alternative would not require the city to repeatedly revisit the issue and continuously devote time, money, and other resources to the issue. Because the city of Easton has very few funds it can allocate toward a new riverbank restoration project, any capital that is spent should achieve maximum results for the least amount of money. This will also bolster social acceptability among tax-payers for the chosen policy alternative because their tax dollars will be spent efficiently.

**Social Acceptability**

Social acceptability is defined as “the extent to which the public will accept and support a policy proposal” (Kraft & Furlong 185). We found that this criterion based on the public opinion of the policy was very important in dealing with the issue of the herbicide use on the banks of the Delaware River. Although the criterion is “difficult to determine even when public support can be measured” and it “depends on the saliency of the issues and the level of public awareness” (Kraft & Furlong 185), we find that it is indeed extremely salient to the current issue of the Easton banks. After the two riverbanks in Easton were sprayed with herbicide, the Coalition of Concerned Citizens was formed to investigate and address the city’s action (Lindsey 2012). The Coalition of Concerned Citizens has been using their Facebook page to regularly disseminate information about the city’s actions on the riverbanks and promote preservation of the natural environment (Coalition of Concerned Citizens 2012). It is certain that whichever policy alternative is chosen by the city will be publicized by this group and discussed among citizens. Furthermore, in an Easton City Council meeting on August 22, 2012, Councilmember Warner
said that the city and its Environmental Advisory Council would work together on this issue, signaling the city’s intention to gain social approval for any subsequent actions on the riverbanks (Council of the City of Easton, Pa. 2012).

VI. Policy Alternatives

The riparian buffers near the Scott and Riverside Parks are extremely influential in the river’s surrounding environment. Therefore, because invasive species have been found in the areas, it would be helpful if as many policies as possible were available for consideration. However, because of certain restricting factors, such as proximity to water, plausible policies are difficult to discover. One policy was to use AquaNeat, an herbicide containing the chemical glyphosate, on the unwanted plants, like Japanese knotweed. However, due to the protests of Easton citizens, and the fear that this action will negatively impact the environment, other policies are currently being studied.

The decision to use AquaNeat near the Scott and Riverside Parks was one that required serious consideration, due to the herbicide’s potential effects on the surrounding area. Dave Hopkins, Easton’s Public Works Director, decided to try using the herbicide, after many years of manually removing invasive species. “I’m not sure we even plan to do it again,” Hopkins said. “It was a shot at helping us maintain it.” (Lindsey, 2012) This action resulted in almost complete defoliation of the area, which can encourage erosion and have other negative impacts (Refer to Figure 1). However, the herbicide can be effective in removing knotweed. According to City Forester Randy Fey, “Large-scale removal of invasive species such as Japanese knotweed is almost impossible without herbicide because of its root system.” Fey also mentioned that herbicide has already been used in Hugh Moore Park in response to an invasive knotweed. Because of herbicides’ effectiveness, it is important to study alterations that could be made to
this policy, which would perhaps have less of an impact on the other vegetation. One such modification would be to continue the use of AquaNeat in this area, but to change the plant life. Although glyphosate is primarily used to eradicate unwanted plant life, vegetation such as maize has developed immunity to this chemical, which would allow its existence, regardless of the use of an herbicide. Therefore, one suggestion is to grow an immune plant, which would provide aesthetic satisfaction as well as a root system to prevent erosion. Another benefit to this modification is that most of the plants that have become immune to glyphosate are crops, and thus would potentially provide a source of income for Easton. Some glyphosate-resistant crops include corn, soybean, canola, cotton, sugar beet, and alfalfa (Duke, Powles 2010). The implementation of these crops in the riparian zone would be beneficial, because the city of Easton could continue to spray AquaNeat if the invasive species were to grow back, without the fear of killing the native plants.

To help prevent further spraying of herbicides to invasive species that grow along the banks of the Delaware River in Easton, one option is the use of manual labor to remove the plants. The removal of these plants is clearly an important priority because of the threat that they
pose on the surrounding ecosystems and wildlife. “According to a 1996 report by the Nature Conservancy, invasive species have contributed to the 42 percent population decline of threatened and endangered species in the U.S. Many also pose threats to agricultural areas, urban parks, yards, and roadsides” (Maryland Native Plant Society). By manually removing these invasive species that many consider to be hazardous to the infrastructure of the city and just an unsightly view, Easton can achieve the same goal of successfully removing these unwanted species of plants along the riverbanks without compromising the health of the areas affected by being sprayed with toxic herbicides.

With the Concerned Citizens of Easton group already working together for a cleaner and more “eco-friendly” way of sustaining the banks, it seems feasible to form clean up groups that can routinely go down to the banks of the river to dig up the unwanted species. In addition, the cost of manually removing the invasive species along the banks would remain low since professional landscape workers would not necessarily be needed for the job. Anyone who would want to volunteer to help out with the removal could do so if they desired. In order to begin

![Figure 6. Citizens work together to manually remove harmful invasive species.](image-url)
organizing the event for manually removing these plants, it could also be useful to set a list of
goals such as “help citizens see firsthand the impact of their efforts can have to improve habitat”
(Maryland Native Plant Society). By organizing a list of goals, it would be easier to determine
what exactly needs to be done in order to remove the plants. The Watershed Activities To
Encourage Restoration group defines the process of mechanical weed control as a series of steps:

- Pull seedlings and small or shallow-rooted plants when soil is moist. Dig out larger
  plants, including the root systems. Use a spading fork or weed wrench for trees or
  shrubs…To prevent spread of seeds of undesirable ornamental plants, cut off flowers
  and/or seeds or fruits before they ripen then bag them and send them to the landfill.
  (Maryland Native Plant Society, W.A.T.E.R)

- There are alternative policies to herbicide use, which would succeed in both maintaining
  control of the riverbank’s habitat and would not compromise the environment with unnatural
  chemicals. It is important that from now on Easton carry out the sustaining of the banks in a
  healthier way so that the natural resources are not compromised by any means, and by investing
  some manual labor, it will be easy to do so.

- Another alternative to be considered is the use of goats to eradicate the invasive species.
  Goats eat the undesired plants down to the ground, and then workers can pull up the roots or
  spray a more concentrated dosage of herbicide. One company, named Eco-Goats, claims that this
  method is extremely effective, and eco-friendly. “The seeds of invasive species are digested and
  expelled and can’t germinate,” says Brian Knox, founder of Eco-Goats (Gaines 2011). He puts
  up fencing and lets the goats loose, where they are able to completely defoliate a one-acre area
  within four to seven days. Benefits to using goats as a method for eradication include the
  effectiveness (the goats completely remove seeds, preventing any further development) and the
  ecologically friendly aspect. Another benefit to goats is their lack of noise, which would be more
accepted by the Easton community. Customers of Eco-Goats have given especially positive feedback:

This use of goats for targeted grazing serves as a role model for other parks and sends a strong conservation message to the community. Goats provide a unique opportunity to move toward economical, sustainable and ecological weed control and away from methods relying on the use of heavy equipment on herbicides. In this tight budget time, it is always helpful to find creative solutions and leverage partnerships. The goats are a welcome sight to help us out and also give area children a chance to come enjoy them along with the park.

(Leopold, J., County Executive of Anne Arundel, MD)

Refer to Figure 7 to see how goats are becoming a more common method for the removal of unwanted vegetation.

If Easton were to decide to use goats in order to eradicate the invasive species, they would first have to make sure that a company was available. Due to the rising success of goats as a method of invasive species removal, more companies have developed. For instance, some well-established businesses are Goat Trimmers, which is based in California, and Eco-Goats, which started in Maryland. In addition, the goats used are usually kept in the area by means of electric

\[ \text{Figure 7. Goats eat invasive species (English ivy and privy) at the University of Georgia.} \]
fences, but since this plant removal will occur along the riverbank, perhaps regular, temporary fencing would suffice. According to Don Miller, founder of Goat Trimmers, the process takes approximately two to three days, and is more effective at completely removing weeds seeds, eating “seeds that pesticides leave behind, keeping next year’s generation of weeds at bay. (Miller, D.)”

There are several methods to eradicate the Japanese knotweed that has begun to grow on the riparian buffers of the Delaware River. One method is to continue using chemical removal, or herbicides, and planting GR (glyphosate-resistant) crops. Another method is through mechanical control, or manually removing, the unwanted weeds. Biological control is another option, where goats would be placed on the riparian buffer and eat the invasive species, as well as its seeds. In the Policy Assessment section, these methods are reviewed and compared.

VII. Policy Alternative Assessment

To designate the best Policy Alternative for the improvement of the riparian buffers along the Delaware River in Easton, four evaluative criteria were chosen. The four criteria, which were previously mentioned, are effectiveness, economic feasibility, social acceptability, and efficiency. The three Policy Alternatives that were to be assessed include: the use of manual labor to remove the invasive species, the utilization of goats to consume the harmful invasive species, and the planting of a variety of glyphosate-resistant crops, such as corn and alfalfa, with the moderate use of glyphosate.

In order to properly assess the policy alternatives, an evaluation chart that compared the chosen evaluative criteria to the alternatives was used. A ranking ranging from one to four- one being the lowest desirable score and four being the highest. Each policy alternative was assigned to the criteria and assessed to the following values shown in Figure 8.
The first alternative assessed was the use of goats. This method has the goats eat the unwanted plants, which then can be rooted up easier and sprayed down. Effectiveness was assigned a 4 because the use of these goats would be a successful way to remove the plants. Effectiveness is the “Likelihood of achieving policy goals” (Kraft & Furlong 185) and based on research suggests that the goal would be reached with this method, especially since the goats completely stop the spread of new plants growing by removing and digesting the unwanted seeds. The next criterion used to evaluate the first alternative was Economic Feasibility. This alternative was assigned a 3 because the pricing for these animals would remain low and their presence could not only be just used for removing these plants but also for enjoyment such as a petting zoo for the children of Easton. This policy was assigned a 3 because the cost is within the resources of the city of Easton. The third criterion was Social Acceptability. A 2 was assigned for this alternative under social acceptability because this method of invasive plant removal is a rather unconventional method of which the citizens of Easton and the surrounding areas may not necessarily understand or approve. The entire public may not support this alternative for several

<table>
<thead>
<tr>
<th>Unweighted</th>
<th>Goats</th>
<th>Manual Labor</th>
<th>Corn + Glyphosate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Economic Feasibility</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Social Acceptability</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Efficiency</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>13</td>
<td>7</td>
</tr>
</tbody>
</table>

*Figure 8: Unweighted Policy Alternative Analysis Values*
reasons, including smell (Seattle City Light, 2007). The criterion was efficiency, which aims towards the lowest cost for a certain benefit of a policy. An appropriate assignment for this section is a 3, because there are many benefits to this alternative, especially for the price. Similar to the Economic Feasibility criterion, the goats are very useful several different things, so the cost of obtaining and maintaining these goats would be ideal.

The second alternative chosen to help improve the issue with the invasive plants was manual removal. This alternative was assigned a 3 with regards to effectiveness because although the manual removal of the plants would work in removing the plants that are already there, people would have to routinely return to remove the plants that grow back after being rooted up. This method is satisfactory, but would require a significant amount of time and work. For Economic Feasibility, this policy was rated a 4 because it is the cheapest of the three alternatives. This method only requires the use of volunteers and cheap instruments such as gardening gloves and trash bags. This method could easily be used without having to spend more than a total of thirty dollars. This alternative is definitely the most “wallet-friendly” choice for the removing of these plants. Thirdly, with regards to the social acceptance of this method, this alternative was assigned a 2. Although this method of using manual labor is a great method for the community to come together to help improve the city’s ecosystem and infrastructure, people will not necessarily be willing to pull weeds because of the hard labor that is required to do so. For Efficiency, the manual labor alternative was assigned a 4. This method is highly efficient because the benefits are high for the low cost of using manual labor in effort to help maintain the banks.

The third and final alternative suggested for the problem of the unhealthy river banks was the use of crops such as corn in addition to the use of moderate doses of glyphosate. This method
allows the growth of native plants and crops with the use of glyphosate to kill off the invasive species in the riparian buffers because the crops are resistant to the chemicals. The first evaluation of this method was assigned a 2. This alternative would not be the most effective of the three policy alternatives because of the high maintenance that is required for the crops to stay healthy along the banks of the river. This third method was rated a 2 for economic feasibility. It was rated this way because of the costliness of having to maintain and harvest crops-- the solution would be ideal for maintaining a healthy riparian buffer with native plants, but the cost would be so high that the city may not be able to provide this service. For the third criterion of social acceptability, this alternative was ranked a 1. This method was the least desirable with regards to this criterion because the public might not want crops growing along its riverbanks. Although this alternative would be helpful towards keeping the buffer healthy while keeping the invasive species away, the public might still not approve, because glyphosate would still be used to remove the harmful plants. Lastly, the crop alternative was ranked a 2 in efficiency. This policy alternative a 2 because although the city could benefit from selling crops, the cost and labor for maintaining the crops is much higher than the other two alternatives and it does not have the most benefits for the lowest cost.

After assigning the values to the alternatives a system of weighing the values based on the importance of the criteria was derived. The values were weighted by multiplying the ranking of each alternative by 1 for Effectiveness, which was found to be most important, followed by .95 for Economic Feasibility, .90 for Social Acceptability, and .85 for Efficiency. The calculated values are shown in Figure 9.

By looking at the weighted and unweighted values on both charts, it was clear that the most desirable alternative based off of the four chosen evaluative criteria was the use of manual
labor to remove the invasive species and to maintain the damaged riparian buffer along the banks of the river that flows next to downtown Easton.

**VIII. Recommendation**

The most ideal policy for the city of Easton to pursue is the use of manual labor to remove the knotweed. This policy would be highly effective in removing the invasive species and simpler than introducing goats as a mean to controlling vegetation, nor would it require the use of chemicals. This policy can be implemented year-round, which would allow the city to begin using manual labor as soon as the first sign of Japanese knotweed returns.

Implementation of this policy would not be burdensome on the administrative system of Easton’s government. The city would need to order loppers, hoes, and other tools. This investment will pay for itself over time and is much cheaper than contracting experts to apply herbicide. A significant strength of this alternative is that it can be very economically feasible and cost-efficient if the city is able to use volunteers’ labor to remove the Japanese knotweed. The Concerned Citizens of Easton could be a good potential source for volunteers because they have already shown a great amount of interest in restoring the ecological health of Riverside and

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<tr>
<td><strong>Effectiveness</strong></td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>Economic Feasibility</strong></td>
<td>2.85</td>
<td>3.8</td>
<td>1.9</td>
</tr>
<tr>
<td><strong>Social Acceptability</strong></td>
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<td>1.8</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td>2.55</td>
<td>3.4</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>11.2</td>
<td>12</td>
<td>6.5</td>
</tr>
</tbody>
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*Figure 9: Weighted Policy Analysis Alternatives*
Scott Parks. If the city is unable to successfully attract volunteer labor, it should pursue other means of securing free labor, such as contracting the work from prisons or parole programs. Additionally, the city could set up a system to provide individuals with traffic or parking fines with the option to do manual labor along the riverbank in lieu in paying the fine. Using free labor would mollify the burden of the city continuously having to revisit the weeds using manual labor, which was partially why the solution received an imperfect efficiency score. The city can lead a training session for volunteers to teach them how to properly remove the Japanese knotweed crowns, stems, and rhizomes so that the plants do not grow back. As volunteers work to remove the Japanese knotweed, it will grow back in lesser amounts and the need for manual labor will decrease. When the shores are cleared of the invasive species, other plants and animals will be able to reside on the banks of the shore without fighting for resources with the Japanese knotweed.

IX. Conclusion

The city of Easton decided to use herbicides to remove the Japanese knotweed over the summer, which upset many of the citizens. The city government has assumed responsibility for the use of the herbicides and is looking to use a more sustainable and natural method for invasive weed control in the future. The use of goats, glyphosate and selective crop planting, and manual labor to control Japanese knotweed are all meritorious options for the city to consider moving forward with the restoration of the riverbanks at Riverside and Scott parks. In the analysis of policy alternatives, manual labor proved to be the most ideal option for the city of Easton. As stated by Aldo Leopold, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold, 1966, p. 207). Manual removal succeeds at this challenge, because it does not threaten the ecosystem. Using
manual labor to remove the Japanese knotweed would be a cost-effective and environmentally harmless way to control invasive species and promote ecological health. In addition to being an important source of clean drinking water, many animal species rely on the riverbanks for a safe habitat, which is why this particular ecosystem needs protection and care from the government and citizens of Easton. Manual labor will help the city achieve the aesthetically pleasing look for the parks that the citizens desire while removing the invasive species to restore ecological balance.
References


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