Public Outreach on Japanese Knotweed in Washington Township, Michigan

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Introduction

Invasive species are a threat to the natural functioning of ecosystems. To prevent their negative effects, which can include property damage, inhibition of ecosystem services, and loss of biodiversity, invasive species require effective management. Implementing management plans becomes feasible when invasive species management receives community support and involvement. Community support is essential to beginning invasive species management because support from many people can lead to more pathways for change to occur. A community is a patchwork of individual stakeholders, with each stakeholder having the ability to encourage or halt the spread of an invasive species. People can be empowered to encourage their local officials to take action on invasive species, whether it be to initiate management or to create policies that prevent further invasion. Community members can support the removal of invasive species on their own property and can plant native species instead of nonnative flora. People who do not own property can act as public monitors by identifying and reporting new appearances of invasive species. These efforts build a foundation on which a comprehensive invasive species management program can form. The only requirement is that residents of a community must be motivated to make these preliminary steps. One strong motivation is knowledge about the issues of invasive species. Thus, for a community that is unaware of invasive species, public outreach is a necessary step towards invasive species management.

According to Oele, Wagner, Mikulyuk, Seeley-Schreck, and Hauxwell (2015), aquatic invasive species cause 6.6 billion dollars' worth of damage per year in the United States. One such species is the ornamental forb Japanese knotweed. Japanese knotweed is a perennial shrub belonging to the buckwheat family. This species was first planted for decoration and erosion control. Currently, Japanese knotweed is considered to be one of the most aggressive invasive

species in North America (Aguilera, Alpert, Dukes, & Harrington, 2009). Current research on Japanese knotweed has focused on the life history of the plant as well as finding a successful eradication method. Consequently, Japanese knotweed requires more attention from communities. Common with invasive species, Japanese knotweed is an anthropogenic issue that people know very little about. Japanese knotweed is well known in the scientific community but is faintly known about in the general public (Eiswerth, Yen, & Van Kooten, 2011). Oftentimes, people are aware of the concept of invasive species, but do not know of any in their community. Even when Japanese knotweed knowledge is present in a community, Japanese knotweed can be easily overlooked by the untrained eye. Additional education on plant identification skills are needed to differentiate Japanese knotweed from native plants. Furthermore, people tend to have little knowledge about the harm that Japanese knotweed causes the environment and the community (Eiswerth et al., 2011). Without knowledge regarding the negative impacts of Japanese knotweed, the urgency of management goes unrecognized and Japanese knotweed is allowed to further expand its range. Due to the possibility of Japanese knotweed invading public and private lands, public education on the species is critical for the health of ecosystems.

The community of Washington Township, Michigan is at risk for Japanese knotweed invasion. Washington Township is a suburban community located in southeast Michigan, with a population of 27,878 people (U.S. Census Bureau QuickFacts: Washington township, Macomb County, Michigan, n.d.). 23.0% of the population in Washington Township was under the age of 18 years and 17.3% of the population was over 65 years old. The remaining 59.7% of the population was between the ages of 19 and 64 years old. 51.1% of the population the population consisted of women. According the Michigan Invasive Species Information Network, sightings of Japanese knotweed have already been reported in the township (Michigan State University,

2017). Washington Township actively participates in managing invasive species that plague the community, such as phragmites. They are a member of the Lake St. Clair Cooperative Invasive Species Management Area, which is a partnership of communities that addresses invasive species across ecological boundaries (Newlin, 2017). Most of Washington Township's management efforts are implemented by the judgement of township employees, rather than from pressure from the community. Since the community is already managing present invasive species, there is a need to prevent further invasions such as Japanese knotweed. Support from the community is an untapped reserve for action that should be used to ensure the management of Japanese knotweed. In order to acquire this support, residents of Washington Township must be informed on Japanese knotweed. This study focuses on drafting an outreach program for Japanese knotweed with a focus on the residents of Washington Township, Michigan.

According to the United States Census Bureau, the population of Washington Township in 2017 was 27,878 people. The gender of the population consisted of a slight majority of women, who were 51.1% of the population. The largest proportion of the population (59.7%) was between the ages of 19 and 64 years old. 23.0% of the population was under the age of 18 years and 17.3% of the population was over 65 years old. Washington Township has a low proportion of people who obtained higher education. Of the residents who were at or above the age of 25 years, 92.7% had a high school degree and 34.4% had a bachelor's degree or higher. Washington Township was largely a middle-class community, with a median household income of $87,264 and. 6.1% of the population living in poverty (U.S. Census Bureau QuickFacts: Washington township, Macomb County, Michigan, n.d.).

Establishing Outreach Methods Based on Level of Education

Cole, Keller, and Garbach (2016) divide communities into two groups that are essential for management support. These groups include people with prior invasive species knowledge and people without previous knowledge. People lacking Japanese knotweed knowledge need to be educated so that they can begin proper management practices. Education also needs to reach people with prior Japanese knotweed knowledge in order to motivate them to participate in stricter management behaviors (Cole et al., 2016). Therefore, education about Japanese knotweed must reach every resident in the community in order to attain the maximum amount of participation and results. In this study, the hypothesis of whether an individual has invasive species knowledge will be positively correlated with education level, as indicated by Fischer and Van der Wal (2007). To educate both groups of people in Washington Township, multiple forms of outreach are needed. Contacting to the public can occur through face-to-face communication. According to the National Endowment for Democracy (n.d.), face-to-face communication allows for more personal conversations by allowing the audience to ask questions. On the other hand, it can be time consuming and difficult to widely distribute the information. Print media, such as posters, flyers, and brochures, is another form of effective outreach. Printed materials are beneficial since they can be stored for future reference. However, they are more difficult to distribute to a large population of people (National Endowment for Democracy, n.d.). Quick distribution of information can be accomplished with social media although social media restricts your audience to those who use that application. Audiovisual media is capable of reaching wider audiences but can be costly to produce and distribute (National Endowment for Democracy, n.d.). Washington Township employees have previously suggested using informational brochures and television segments. Informational brochures were to be included in every water bill and informational segments were to be broadcasted on the local television station. The

outreach strategy of sending brochures and broadcasting television segments is suggested in this essay.

Studies have indicated that those who are highly educated have stronger support for managing invasive species and keeping nature in balance. In a study by Fischer and Van der Wal (2007), urban residents tended to prefer ‘‘wild’’ and ‘‘unmanaged’’ land. Fischer and Van der Wal (2007) also recorded that urbanized areas had a higher amount of people who had knowledge on local invasive species. The high amount of knowledge urban residents had on local invasive species was attributed to their access to television (Fischer & Van der Wal, 2007). Since people living in urban areas are more likely to be separated from the natural environment, informational television provided a way for urban residents to experience and learn about nature (as cited by Fischer & Van der Wal, 2007). Fischer and Van der Wal (2007) continue by explaining that urban residents are more likely to be highly educated. In actuality, education level is believed to be the underlying factor that makes television effective at informing these people. This is due to informational media being more influential to the highly educated (Fischer & Van der Wal, 2007). Additionally, people with higher degrees are more skilled at choosing trustable media sources to learn from. According to a study by the Media Press Insight, people with a higher education tend to focus on the accuracy, completeness, and transparency of media. Sources and data within media were noted as highly important to 76 percent of college graduates in comparison to 65 percent of people with a high school degree or lower (A new understanding: What makes people trust and rely on news, 2016). Television has thus been reported as a reliable way to effectively communicate knowledge to individuals with higher degrees.

In Washington Township, 34.4% of residents who are over 25 years old have a bachelor’s degree or higher. Following the results of Fischer and Van der Wal’s study, targeting over one-

third of the population could be accomplished through informational television segments. Washington Township has a local television station called W-Bruce-Romeo-Washington (WBRW) that broadcasts local information for residents. Based off of Fischer and Van der Wal's study, residents with a higher education will know to trust the Japanese knotweed information provided by WBRW. Since WBRW already broadcasts Washington Township information, broadcasting a segment on Japanese knotweed should easy to accomplish.

Written outreach methods have been shown to be useful for reaching less educated populations. Young and Witter (1994) studied the relationship between the reading level of brochures and the effectiveness informing the public on the invasive gypsy moth. People who received informational brochures and those who did not took a questionnaire on biological and management content regarding the gypsy moth. Knowledge of the gypsy moth was significantly higher for people who read the brochures in comparison to those who did not receive the brochures (Young & Witter, 1994). As an additional component to the study, the distributed brochures varied by length and reading level. Young and Witter (1994) found that length and reading level had no significant effect in the knowledge obtained by brochure recipients. Brochure recipients answered the biological and management questions with similar accuracy. Recipients of each type of brochure displayed a similar increase in gypsy moth knowledge in comparison to those who did not receive a brochure (Young & Witter, 1994). These findings indicate that informational brochures can be made easy to read for those who have a lower education without losing the significance of the information.

In Washington Township, 65.6% of residents have earned less than a bachelor's degree. Outreach targeting this majority of the population needs to be easy to comprehend yet still retain its effectiveness. Sending easy to read brochures is a practical way to achieve reaching residents

with lower education attainment. Since people with lower educations lack the skills to discern trustable sources, the content provided must come from a reliable source (Bremner and Park, 2007). The Washington Township employees' idea to send brochures with water bills will resolve this issue. Sending the brochures with water bills will make people aware that the information is coming from the township. Having the pamphlets sent out by a reputable source like the local government will give the brochures more credibility. Additionally, people will be less likely to assume that the brochures are unsolicited advertisement which will draw more attention to them (Young & Witter, 1994).

Outreach Content: Connecting with Uneducated Residents

Outreach content plays a large role in motivating residents to take action against Japanese knotweed by explaining why management is needed. The content included in outreach communications can promote people to make educated choices on managing Japanese knotweed. It can do this by providing knowledge that can be directly applied to making informed decisions. For instance, a study by Eiswerth et al. (2011) showed that when people were informed about the harm aquatic invasive species cause to water-based recreation, they were more likely to take preventative actions. Information must target the proper audience and elicit a change in the reader's behavior. According to Cole et al. (2016), content targeting residents with no prior knowledge is beneficial for improving a community's total preventative behaviors. The transition of not participating to managing Japanese knotweed is significant enough to see positive results in the community. In order to identify the residents that are uninformed, Bremner and Park (2007) compared management support to various demographics. Gender and

age were identified as the most influential for opinions on invasive species management, with males and older people showing support for management.

According to Bremner and Park (2007), men expressed strong support for invasive species management programs. Men tended to agree that all invasive species should be controlled and eradicated whenever possible. Men explained that conservation and protecting rare species justified invasive species management. Women tended to disapprove of managing invasive species due to the assumed cruelty of having to kill the species (Bremner and Park, 2007). Gender strongly influences opinions towards invasive species management. In Washington Township, the population is 51.1% women. This prompts the possibility that over half of the population will potentially not support Japanese knotweed management. To target this majority of the population, outreach should emphasize the hardships imposed on native species due to the invasion of Japanese knotweed. Residents need to realize that the true cruelty is to allow Japanese knotweed to kill native flora and fauna. A sense of responsibility to fix anthropogenic mistakes should be constructed to replace sympathy for Japanese knotweed. To encourage the desired attitude towards Japanese knotweed, its adverse environmental impacts should be discussed.

Age is another factor that influences opinions towards invasive species management. According to Bremner and Park (2007), older people between the age of 45 to 54 were more likely to support invasive species management. People in this age group justified eradiation with financial savings and protection of native species. The percentage of the Washington Township population between the ages of 45 and 54 years old is unknown based on the information provided by the United States Census Bureau. The United States Census Bureau states that 59.7% of the population is between 19 and 64 years old. This also means that the percentage of

the population lacking invasive species knowledge is unknown. Outreach content must target the unknown percentage of people who are in the younger and oldest sections of the population. According to Olden and Tamayo (2014), the negative impacts of Japanese knotweed either fall into two categories: financial burdens and environmental damage. Since environmental impacts will already be covered in the outreach program, the next option is to discuss the financial detriments of Japanese knotweed. The age group between 45 and 54 years old mentioned that financial savings caused them to support management. Since savings was not mentioned by the other age groups, they may be lacking this knowledge. By describing the economic costs of Japanese knotweed, outreach has the potential to grab their attention and lead to their support for management (Olden & Tamayo, 2014).

Japanese Knotweed Outreach Information

Public outreach concerning Japanese knotweed has several goals. These goals are to draw attention to Japanese knotweed, make individuals learn about the species, and motivate them to take action against the invasive species. When educating the public on Japanese knotweed, major topics must be included so that people realize the importance of management practices. As detailed in the following section, outreach should include biological information, ecological and financial costs, and management options. With the major topics being identified, the next task is to acquire specific content to include in outreach. The following provides specific information to use in Japanese knotweed outreach programs.

Description of Japanese knotweed

The morphology of Japanese knotweed should be included in public outreach for the purpose of introducing the species to residents. Furthermore, descriptions can be used to help promote resident involvement. Forms of productive outreach include an identification guide and a description of the invasive species because they motivate the audience to identify species in their community. Identification guides can help people begin the process of management by determining if Japanese knotweed is on their property. According to Larsen et al. (2011), making people more invested in Japanese knotweed management can make them feel like it is their own project. Self-identification of Japanese knotweed has the potential to motivate people to control Japanese knotweed on their property. By engaging residents in management from the start, participants tend to develop a feeling of responsibility for the ecosystem and the management project. As cited by Larsen et al. (2011), feelings of personal responsibility could further lead to that individual becoming an advocate for managing Japanese knotweed. The following provides recommended biological information to use in outreach to get residents associated with Japanese knotweed.

Japanese knotweed is an herbaceous perennial plant (Skinner et al., 2012). According to Weston et al. (2005), Japanese knotweed have upright stems that can reach up to five meters in height. Stems are hollow and have a reddish color. The leaves of Japanese knotweed can be triangular to heart shaped. Flowers are a cream color and form panicles in July to August (Weston et al., 2005). Japanese knotweed has rhizomes that can grow two meters deep and up to twenty meters in length (as cited by Aguilera et al., 2009). The rhizomes have a distinctive orange interior (as cited by Oele et al., 2015).

Japanese knotweed reproduces primarily by clonal propagation of their rhizomes (as cited by Boyd, White, & Larsen, 2017). Rhizomes grow outward from existing stands and produce

new shoots (as cited by Boyd et al., 2017). Fragments of rhizomes and stems can produce new knotweed individuals. As cited by Aguilera et al. (2009), stem fragments the size of a node are capable of producing a new plant. Fragments can be spread by running water and people. Japanese knotweed is capable of producing viable seeds in the United States. Seeds are buoyant have high germination rates (as cited by Aguilera et al., 2009).

Japanese knotweed (*Fallopia japonica*) is in the Polygonaceae family, which is native to Japan, Taiwan, and northern China (as cited by Weston, Barney & DiTommaso, 2005). Other common names for Japanese knotweed include false bamboo, fleeceflower, and elephant ears (as cited by Clements, Larsen, & Grenz, 2016). Japanese knotweed was first brought to the United States in the 1870's as an ornamental plant (as cited by Skinner, Grinten, & Gover, 2012). It has now spread from the northeast to the Midwest, southwest, and Pacific northwest of the United States (Groeneveld et al., 2014). Japanese knotweed is classified as a noxious weed and is identified on the United States' National Exotic Pest Plants list (as cited by Oele et al., 2015). Japanese knotweed has no significant predators in its introduced range (as cited by Groeneveld, Belzile, and Lavoie, 2014).

Japanese knotweed commonly invades sites where light availability is high, such as in riparian zones and open woodlands. Highly disturbed areas are susceptible to Japanese knotweed invasions, including roadsides, railroad right of ways, and abandoned agricultural land (Skinner et al., 2012). Japanese knotweed is capable of growing in soils with a wide pH range, high concentrations of salt, and high concentrations of heavy metals (Gillies, Clements, & Grenz, 2016). Japanese knotweed prefers moist soils but is capable of growing in dry soils.

Environmental Impacts

Japanese knotweed outreach also needs to include an explanation on why Japanese knotweed is a concern. Bremner and Park (2007) explain that such information is needed so that people do not sympathize with the species that needs to be eradicated. The negative impacts of Japanese knotweed will give people a sense of why they should care about Japanese knotweed. As previously mentioned, ecological costs need to be discussed with the people of Washington Township to grab their attention. A significant portion of the damage caused by Japanese knotweed occurs to the ecosystem. For instance, direct effects of Japanese knotweed include a loss of habitat for invertebrates. A loss of invertebrates then restricts their predator's food source, which magnifies the problem to many species in the food web. Thus, ecological impacts are important to discuss. Suggested environmental impacts to include in outreach programs are detailed below.

Japanese knotweed invasions change the structure of plant communities (as cited by Clements et al., 2016). Japanese knotweed produces monocultures, which reduces species diversity. Dense colonies of Japanese knotweed choke out native vegetation (as cited by Skinner et al., 2012). According to Gillies et al. (2016), Japanese knotweed stands contain 50% less plant species richness than in uninvaded sites. Japanese knotweed grows quickly and early in the season (Clements et al., 2016). This growth advantage allows Japanese knotweed to reduce the amount of sunlight that reaches native vegetation, which decreases native plant survival (as cited by Oele et al., 2015).

Japanese knotweed stands change the nutrient cycling of an ecosystem. Areas that contain Japanese knotweed have greater aboveground biomass, which results in greater amounts of standing nitrogen in comparison to uninvaded areas. According to Aguilera et al. (2009), areas with Japanese knotweed have up to five times as much aboveground biomass than areas

that contain native species. Due to the large amount of aboveground biomass of Japanese knotweed, standing nitrogen and carbon is higher in Japanese knotweed stands than in areas without the plant. The nutrients then become unavailable for native plants to use (as cited by Aguilera et al., 2009). Leaf litter of Japanese knotweed is 25-85% higher in lignin to nitrogen ratios than in areas containing native canopy species (Aguilera et al., 2009). High lignin to nitrogen ratios slows down the rate of leaf decomposition. Slow leaf decomposition reduces the amount of nitrogen returned to the soil for native plants to use. To add to the problem, Japanese knotweed is successful in environments that are low in nitrogen, which makes Japanese knotweeds more successful in their habitat (Aguilera et al., 2009). According to Groeneveld et al. (2014), soils containing Japanese knotweed have increased concentrations of copper, manganese, phosphorus, potassium, and zinc. The extensive root system of Japanese knotweed is able to access soil minerals that other plants are unable to reach (as cited by Groeneveld et al., 2014).

Japanese knotweed is capable of altering terrestrial food webs. The low-quality leaf litter created by Japanese knotweed causes litter consuming invertebrates to decline in species diversity and abundance. In a study by Gerber et al. (2008), invertebrate abundance decreased by 40% in Japanese knotweed stands. The loss of invertebrates in Japanese knotweed stands can affect higher trophic levels. Green frogs (*Rana clamitans*) have been observed to have reduced foraging success in areas invaded by Japanese knotweed. According to Maerz, Blossey, and Nuzzo (2005), their prey consists of herbivorous invertebrates that cannot survive using Japanese knotweed as a resource. The reduction of invertebrate prey results in declines of the green frog population (Maerz et al. 2005).

Japanese knotweed in riparian habitats can change the trophic structure in low order streams by altering the composition of allochthonous leaf litter. Japanese knotweed leaves that fall into streams are of low quality due to the high amounts of lignin the leaves contain. As a result, more shredders specialized in low-quality leaf litter are present in the stream (Lecerf et al., 2007). Streams near Japanese knotweed stands have shown selection for fungal species best adapted to grow on Japanese knotweed leaves (Lecerf et al., 2007). Furthermore, primary production is hindered in streams due to the ample shade casted by Japanese knotweed.

Japanese knotweed exhibits allelopathy. According to Gillies et al., (2016), the allelopathy of Japanese knotweed effects growth and gemination of forbs. Japanese knotweed has phenolics that have antimicrobial and fungicidal properties (Gillies et al., 2016). It is possible that the phenolics are targeting the mycorrhizae of native plants (Murrell et al., 2010). Invasive allelopathy can be particularly detrimental to native plants since the plants did not coevolve together (as cited by Murrell et al., 2010). As a result, native plants do not have mechanisms for living with the allelopathic chemicals.

Another concern of Japanese knotweed is its hybrid, Bohemian knotweed. Bohemian knotweed is a cross between Japanese knotweed and giant knotweed. Bohemian knotweed is found in North America and can be difficult to differentiate from Japanese knotweed. As cited by Clements et al. (2016), Bohemian knotweed is the most aggressive knotweed. It has a higher chance of evolving resistance to chemical or biological controls due to its ability to reproduce by seed (as cited by Clements et al., 2016). The seeds of Bohemian knotweed can be wind dispersed and can travel over water (as cited by Groeneveld et. al, 2014). Bohemian knotweed can backcross with Japanese knotweed and giant knotweed (as cited by Clements et al, 2016).

Financial Impacts

The explanation of the concerns of Japanese knotweed can be expanded upon by including financial costs. The financial costs of Japanese knotweed are another tool for expressing to the public why Japanese knotweed is an issue. Financial costs directly impact people, so they can act as a strong motivator for managing the species (Olden & Tamayo, 2014). As discussed earlier, these financial costs have the capabilities to grab their attention of the people of Washington Township. Financial impacts are an effective way to get people on board with management, since these impacts immediately effect residents (Bremner and Park, 2007). The following provides recommended financial information to include in Japanese knotweed outreach.

Although Japanese knotweed was originally grown as an ornamental plant, its presence lowers the aesthetic of a home. Scenic views around the house and of the house itself are obstructed by Japanese knotweed. The loss in aesthetic leads to the decline of property values, which hurts the resale of the property. In addition to a loss in property value, Japanese knotweed can lead to property damage. The rhizomes of Japanese knotweed are strong enough to tear up walkways, driveways, and foundations. Gardens and other designed landscapes can be disrupted by the emergence of Japanese knotweed. Fixing the disturbance of landscapes is costly and time consuming. According to "The Problem with Invasive Plants" (2016), Japanese knotweed can hurt agriculture by losing yields of crops and livestock, which reduces the export potential of a farm. When Japanese knotweed grows on fields, it crowds out crops. With less productive land to grow crops on, crop yields will decrease. Additionally, Japanese knotweed will overtake grazing land used by livestock. Japanese knotweed is not a preferred food source for livestock, so livestock will not feed on Japanese knotweed. Farmers are then left with land that is unable to

support livestock. Due to the financial burden that Japanese knotweed adds to raising crops and livestock, the price of agricultural products will increase for consumers ("The Problem with Invasive Plants," 2016).

Management Methods

The treatment options available for Japanese knotweed should be included in outreach. Residents should know what their choices are in eliminating Japanese knotweed and be able to choose a method that best fits their situation. Specifically, people need to be presented with the drawbacks associated with each of the treatment methods. Every management method has disadvantages and people should be aware of them as they attempt to create a management plan. Knowledge of each method's disadvantages would allow people to choose what is right for their landscape, budget, end goals, and the amount of effort they are willing to put into management. Discussing proper eradication methods is also important because mishandling Japanese knotweed, such as leaving remnants of stems in the environment, is very crucial to avoid. With a stem as small as a node being able to produce a new plant, management can quickly turn into an amplification of the problem. Makeshift attempts to eradicate Japanese knotweed need to be avoided and proper methods must be followed to achieve successful eradication. Specific information on Japanese knotweed eradication is provided below.

Some mechanical methods exist for controlling Japanese knotweed. These methods include using tarps to stunt young shoot growth (as cited by Boyd et al., 2017) and repeatedly cutting the stems to expend energy stored in the rhizomes (as cited by Oele et al., 2015**)**. All stems cut from the plant must be disposed of properly so that the shoots do not disperse (as cited

by Oele et al., 2015**)**. Proper disposal consists of burning the shoots. Physical methods are expensive, labor intensive, and are not the most effective at eradicating Japanese knotweed.

The most effective herbicides for Japanese knotweed are aminopyralid, glyphosate, and imazapyr (Clements et al., 2016; Boyd et al., 2017). After the herbicide is sprayed onto the aboveground biomass, the herbicide is translocated to the rhizomes (as cited by Skinner et al., 2012). Herbicide must be applied when rhizomes are an active sink for nutrients, which is from June until autumn senescence (Jones et al., 2018). According to Boyd et al. (2017), combinations of aminopyralid and imazapyr can be useful for managing Japanese knotweed. Early aminopyralid application suppresses knotweed growth, which makes applying imazapyr later in the season more convenient. Other herbicides used are 2,4-D, dicamba, picloram, clopyralid, and triclopyr (as cited by Boyd et al., 2017). Herbicide treatments can also be paired with mechanical control to increase the ease of applying herbicide. One disadvantage of using herbicides is that they are not species specific, so herbicides will damage surrounding vegetation (as cited by Oele et al., 2015**)**. Furthermore, Japanese knotweed has the potential to develop genetic resistance to herbicides (Clements et al., 2016). Genetic resistance is especially a concern for Bohemian knotweed since it reproduces by seed.

Glyphosate can be less effective than imazapyr (as cited by Clements et al., 2016). However, glyphosate may be preferable since it can be applied near bodies of water and persists in the soil for shorter periods of time. It is important to note that glyphosate still persists in the soil. In a study by Ghafoor, Jarvis, Thierfelder, and Stenström (2011), glyphosate had a half-life of 14 to 116 days. Research by Bento et al. (2016) indicated that glyphosate persisted 30 times longer under cold and dry conditions. Degradation of glyphosate increases with rises in pH, temperature, soil moisture, and laccase activity (Ghafoor et al., 2011; Bento et al., 2016).

Increases in these variables create ideal living conditions for microorganisms that degrade glyphosate. Decreases in soil organic carbon (SOC) and the soils Freundlich sorption coefficient cause an increase in glyphosate degradation. Low SOC and sorption coefficients decrease the amount of glyphosate that can bind to soil particles (Ghafoor et al., 2011). Microorganisms are then able to access and degrade the glyphosate. Another main concern with glyphosate is that it can encourage the regrowth of Japanese knotweed by hormesis. According to Cedergreen, Hansen, and Arentoft (2016), plants can use glyphosate as a source of phosphorous, which aids in plant growth.

Once Japanese knotweed is sufficiently reduced, the land needs to be replanted with native species to prevent reinfestation. Planting native species is also important so that other invasive species do not replace Japanese knotweed (Clements et al., 2016). In a study by Oele et al. (2015), two native species mixtures successfully competed with suppressed Japanese knotweed. The mixtures were a 27-species riparian buffer mixture and a mixture of Virginia wildrye (*Elymus virginicus*) and prairie cordgrass (*Spartina pectinata*). The success of both mixtures is due to their species diversity. Oele et al. (2015) elaborates that a successful species mixture consists of a colonizing species used to quickly cover the landscape and a slow growing species used to compete with Japanese knotweed. Species diversity also maximizes the mixtures success in different soils and climates and reduces resource availability for Japanese knotweed (Oele et al., 2015).

Effects of Public Outreach: Successful Management Stories and Positive Public Opinions on Outreach Methods

Outreach programs have been successful in educating the public about invasive species. This was demonstrated with *Caulerpa taxifolia* in Southern California. *C. taxifolia* invasions began in the Mediterranean Sea. Since the invasion was unexpected, no information was known or provided on the species. As cited by Larson et al. (2011), management was not undertaken immediately, which caused *C. taxifolia* to invade six countries. The invasion in the Mediterranean Sea was used as a lesson for southern California. Information was shared with residents on the potential threat of *C. taxifolia*. When *C. taxifolia* invaded southern California, it was identified by two informed citizens. Immediate action was taken from federal, state, and local stakeholders and *C. taxifolia* was successfully eradicated. With support of the public, aggressive treatment and long-term monitoring was funded both by public and private sources. Management teams were assembled quickly due to the immediate involvement of the public. Public advocacy also motivated legislators to ban *C. taxifolia* and create regulations to help prevent their proliferation (as cited by Larson et al., 2011).

Minnesota participated in the *Stop Aquatic Hitchhikers!* campaign, which informed recreational boaters on how to prevent the spread of aquatic invasive species. The *Stop Aquatic Hitchhikers!* campaign worked to involve communities in educational efforts. Outreach included training watercraft inspection volunteers and educational newsletters (Larson et al., 2011). These educational methods have been shown to improve the knowledge of boaters as well as prevent the introduction of aquatic invasive species. For example, a study conducted in Minnesota, Wisconsin, and Ohio indicated that boaters in Minnesota were more informed on invasive species. As cited by Larson et al. (2011), 70% of boaters in Minnesota claimed to use practices that prevent the spread of invasive species. In comparison, 39% of Wisconsin boaters and 33% of Ohio boaters claimed to use preventative practices. The substantial amount of

outreach provided in Minnesota was correlated to Minnesota having the most informed boaters. High participation in safe practices was attributed to having multiple methods of public outreach (as cited by Larson et al., 2011). The aquatic invasive species education campaign in Minnesota continued for another six years. After six more years of education, 90% of boaters reported participating in preventing the spread of aquatic invasive species (as cited by Larson et al., 2011). The 20% increase in boaters using preventative practices indicates that invasive species education can change the actions of the public.

A specific aquatic invasive species that Minnesota targeted in their outreach program was zebra mussels. By 2009, 37 water bodies in Minnesota had zebra mussels in comparison to 120 water bodies in Wisconsin and 233 in Michigan (as cited by Larson et al., 2011). The low amount of lakes invaded with zebra mussels is believed to be due to the comprehensive content and aggressive approach of Minnesota's outreach efforts (as cited by Larson et al., 2011).

A study by Cole et al. (2016), identified media as the best source of information for invasive species. Such media outlets included newsletters, brochures, television, and the internet. Similarly, Seekamp, Mayer, Charlebois, and Hitzroth (2016) found that organism-in-trade hobbyists preferred pamphlets for outreach. Organism-in-trade hobbyists considered pamphlets to be the most effective way to inform others on invasive species. Organism-in-trade hobbyists also deemed television to be an effective way to educate the public. On a one to five scale, with five being extremely effective, television campaign advertisements were rated an average of 3.2 (Seekamp et al., 2016). In comparison, the favored method of pamphlets was rated a 3.7. Television advertisements are comparable to the highest rated method of outreach, which implies that television is an effective way to communicate to the public. The preference

of pamphlets and informational television segments by people who are regularly involved in handling organisms indicates that these methods will be highly effective.

Euphorbia esula, or leafy spurge, invaded the Northern Plains of the United States in the 19th century (Larson et al., 2011). Through integrative pest management, the range of leafy spurge was minimized during the 21st century. Before integrative pest management was employed, educational information and a cost-benefit analysis of management options was given to ranchers and public land managers. According to Larsen et al. (2011), successful leafy spurge management was due to high public investment in creating the appropriate control methods. It is notable to mention that substantial public investment was present since the ranching industry was highly susceptible to leafy spurge (as cited by Larson et al., 2011). In comparison, management of the leafy spurge invasion in Canada was less successful. Canadians formed an outreach program that was inconsistent, short term, and poorly coordinated (as cited by Larson et al., 2011). These mistakes lead to an unsuccessful attempt to minimize the range of leafy spurge. Poor outreach was not completely to blame in this situation. Biological controls were not as successful in the geographical region of Canada. Although geography created a management setback, poor outreach made leafy spurge unmanaged in Canada.

Expected Outcomes

With this outreach program implemented, the residents of Washington Township can expect to see improvements in different aspects of their community. Immediate results consist of increases Japanese knotweed awareness. Education has been shown to cause a 20% increase in community knowledge of invasive species (as cited by Larson et al., 2011). It is reasonable to expect a similar increase in Japanese knotweed knowledge in Washington Township. Education

of residents will cause new Japanese knotweed appearances to be quickly identified. New growth will be reported to the township so that it can be treated immediately. Early treatment will have a higher probability of successful eradication. Proper education will lead to an overwhelming amount of public support for the township to increase management efforts. Management efforts include strengthening the policies that prevent the spread of Japanese knotweed, such as ornamental plant trade regulations. With preventative policies in place, new appearances of Japanese knotweed will become a rare occurrence. On a larger scale, the spread of Japanese knotweed will halt, and the area covered by Japanese knotweed could even minimize.

The benefits of Japanese knotweed elimination are numerous and include higher home values and increased crop yields. Homes will become more aesthetically pleasing with the removal of the dense vegetation created by Japanese knotweed. As a result, homes will increase in value. Farmers seeking to remove Japanese knotweed are likely to have greater crop yields as a result of management. The land that was once consumed by Japanese knotweed can be used to grow crops or raise livestock. Greater agricultural yields and profits will result from higher productivity. On unmanaged land, ecological systems will be restored. Native species will return to the area and biodiversity will increase. The ecosystem services people rely on will resume, such as water purification and nutrient cycling. The restoration of ecosystem services will lead to improvements in recreational activities that were once inhibited by poor ecosystem functioning.

Conclusion

Optimal public outreach methods can be identified for a community. Face-to-face communication, printed materials, social media, audiovisual media or a combination of tactics can be used to reach out to reach out to residents. Supported by the studies of Seekamp et al. (2016) and Cole et al. (2016), brochures and television segments are an optimal method to effectively educate the residents of Washington Township on Japanese knotweed. A large proportion of the population will receive outreach information when both methods are used. By focusing outreach on background information, financial and ecological impacts, and management methods for Japanese knotweed, residents of Washington Township will have adequate information to make educated decisions concerning Japanese knotweed. Outreach success has been shown in the case of *C. taxifolia*, zebra mussels, and leafy spurge. Organism-in-trade hobbyists have expressed their preference for television and brochure outreach, while residents of various communities have shown that these methods increase invasive species knowledge.

Although the outreach program discussed was made with the community of Washington Township in mind, the outreach suggestions can be applied to other communities. Communities similar to Washington Township could adopt the same program outlined in this study. Outreach methods for Japanese knotweed need to be as diverse as the communities targeted, so differing communities can modify this outreach method to fit their specific needs. Alternatively, the program formed in this study could be used for different invasive species. This would consist of changing the information in the brochures and television segment.

The destruction that Japanese knotweed and other invasive species cause makes management of these species a critical task. Since public support encourages communities to begin management, public knowledge on invasive species is imperative. With public outreach

having such a significant influence, it is arguably one of the most important steps in the management process. Invasive species outreach holds the key to upholding ecosystem integrity for a sustainable future.

References

Aguilera, A. G., Alpert, P., Dukes, J. S., & Harrington, R. (2009). Impacts of the invasive plant Fallopia japonica (Houtt.) on plant communities and ecosystem processes. *Biological Invasions, 12*(5), 1243-1252. doi:10.1007/s10530-009-9543-z

Bento, C. P., Yang, X., Gort, G., Xue, S., Dam, R. V., Zomer, P., . . . Geissen, V. (2016). Persistence of glyphosate and aminomethylphosphonic acid in loess soil under different combinations of temperature, soil moisture and light/darkness. *Science of The Total Environment, 572*, 301-311. doi:10.1016/j.scitotenv.2016.07.215

Boyd, N. S., White, S. N., & Larsen, T. (2017). Sequential aminopyralid and imazapyr applications for Japanese knotweed (Fallopia japonica) Management. *Invasive Plant Science and Management, 10*(03), 277-283. doi:10.1017/inp.2017.31

Bremner, A., & Park, K. (2007). Public attitudes to the management of invasive non-native species in Scotland. *Biological Conservation, 139*(3-4), 306-314. doi:10.1016/j.biocon.2007.07.005

Cedergreen, N., Hansen, N. K., & Arentoft, B. W. (2016). The influence of nitrogen and phosphorous status on glyphosate hormesis in Lemna minor and Hordeum vulgare. *European Journal of Agronomy, 73*, 107-117. doi:10.1016/j.eja.2015.11.003

Clements, D. R., Larsen, T., & Grenz, J. (2016). Knotweed management strategies in North America with the advent of widespread hybrid Bohemian knotweed, regional differences, and the potential for biocontrol via the psyllid Aphalara itadori Shinji. *Invasive Plant Science and Management, 9*(01), 60-70. doi:10.1614/ipsm-d-15-00047.1

Cole, E., Keller, R. P., & Garbach, K. (2016). Assessing the success of invasive species prevention efforts at changing the behaviors of recreational boaters. *Journal of Environmental Management,184*, 210-218. doi:10.1016/j.jenvman.2016.09.083

Eiswerth, M. E., Yen, S. T., & Van Kooten, G. C. (2011). Factors determining awareness and knowledge of aquatic invasive species. *Ecological Economics, 70*(9), 1672-1679. doi:10.1016/j.ecolecon.2011.04.012

Fischer, A., & Van der Wal, R. (2007). Invasive plant suppresses charismatic seabird – the construction of attitudes towards biodiversity management options. *Biological Conservation, 135*(2), 256-267. doi:10.1016/j.biocon.2006.10.026

Gerber, E., Krebs, C., Murrell, C., Moretti, M., Rocklin, R., & Schaffner, U. (2008). Exotic invasive knotweeds (Fallopia spp.) negatively affect native plant and invertebrate assemblages in European riparian habitats. *Biological Conservation, 141*(3), 646-654. doi:10.1016/j.biocon.2007.12.009

Ghafoor, A., Jarvis, N., Thierfelder, T., & Stenström, J. (2011). Measurements and modeling of pesticide persistence in soil at the catchment scale. *Science of The Total Environment, 409*(10), 1900-1908. doi:10.1016/j.scitotenv.2011.01.049

Gillies, S., Clements, D. R., & Grenz, J. (2016). Knotweed (Fallopia spp.) invasion of North America utilizes hybridization, epigenetics, seed dispersal (unexpectedly), and an arsenal of physiological tactics. *Invasive Plant Science and Management, 9*(01), 71-80. doi:10.1614/ipsm-d-15-00039.1

Grevstad, F., Shaw, R., Bourchier, R., Sanguankeo, P., Cortat, G., & Reardon, R. C. (2013). Efficacy and host specificity compared between two populations of the psyllid Aphalara

itadori, candidates for biological control of invasive knotweeds in North America. *Biological Control, 65*(1), 53-62. doi:10.1016/j.biocontrol.2013.01.001

Groeneveld, E., Belzile, F., & Lavoie, C. (2014). Sexual reproduction of Japanese knotweed (Fallopia japonica s.l.) at its northern distribution limit: New evidence of the effect of climate warming on an invasive species. *American Journal of Botany, 101*(3), 459-466. doi:10.3732/ajb.1300386

Jones, D., Bruce, G., Fowler, M. S., Law-Cooper, R., Graham, I., Abel, A., . . . Eastwood, D. (2018). Optimizing physiochemical control of invasive Japanese knotweed. *Biological Invasions, 20*(8), 2091-2105. doi:10.1007/s10530-018-1684-5

Larson, D. L., Phillips-Mao, L., Quiram, G., Sharpe, L., Stark, R., Sugita, S., & Weiler, A. (2011). A framework for sustainable invasive species management: Environmental, social, and economic objectives. *Journal of Environmental Management, 92*(1), 14-22. doi:10.1016/j.jenvman.2010.08.025

Lecerf, A., Patfield, D., Boiché, A., Riipinen, M. P., Chauvet, E., & Dobson, M. (2007). Stream ecosystems respond to riparian invasion by Japanese knotweed (Fallopia japonica). *Canadian Journal of Fisheries and Aquatic Sciences, 64*(9), 1273-1283. doi:10.1139/f07-092

Maerz, J. C., Blossey, B., & Nuzzo, V. (2005). Green frogs show reduced foraging success in habitats invaded by Japanese knotweed. *Biodiversity and Conservation, 14*(12), 2901-2911. doi:10.1007/s10531-004-0223-0

Michigan State University. (2017). Michigan Invasive Species Information Network (Version 2.2.5.0) [Mobile application software]. Retrieved from https://www.play.google.com/

Murrell, C., Gerber, E., Krebs, C., Parepa, M., Schaffner, U., & Bossdorf, O. (2010). Invasive knotweed affects native plants through allelopathy. *American Journal of Botany, 98*(1), 38-43. doi:10.3732/ajb.1000135

National Endowment for Democracy. (n.d.). *Outreach and external communication: A field guide for the West Africa Election Observers Network* [PDF file]. Retrieved from https://www.ndi.org/sites/default/files/Outreach%20and%20Communication_WAEON_EN.pdf

A new understanding: What makes people trust and rely on news. (2016). Retrieved from https://www.americanpressinstitute.org/publications/reports/survey-research/trust-news/single-page/#trust-differences-by-age-class-race-and-gender

Newlin, D. (2017). *Invasive plants in southeast Michigan: an* introduction [Powerpoint Slides].

Oele, D. L., Wagner, K. I., Mikulyuk, A., Seeley-Schreck, C., & Hauxwell, J. A. (2015). Effecting compliance with invasive species regulations through outreach and education of live plant retailers. *Biological Invasions, 17*(9), 2707-2716. doi:10.1007/s10530-015-0907-2

Olden, J. D., & Tamayo, M. (2014). Incentivizing the Public to Support Invasive Species Management: Eurasian Milfoil Reduces Lakefront Property Values. *PLoS ONE, 9*(10). doi:10.1371/journal.pone.0110458

The Problem with Invasive Plants. (2016, February 17). Retrieved from https://www.portlandoregon.gov /bes/article/330681

Richards, C. L., Schrey, A. W., & Pigliucci, M. (2012). Invasion of diverse habitats by few Japanese knotweed genotypes is correlated with epigenetic differentiation. *Ecology Letters, 15*(9), 1016-1025. doi:10.1111/j.1461-0248.2012.01824.x

Seekamp, E., Mayer, J. E., Charlebois, P., & Hitzroth, G. (2016). Effects of Outreach on the Prevention of Aquatic Invasive Species Spread among Organism-in-Trade Hobbyists. *Environmental Management, 58*(5), 797-809. doi:10.1007/s00267-016-0748-5

Skinner, R. H., Grinten, M. V., & Gover, A. E. (2012). Planting native species to control site reinfestation by Japanese knotweed (Fallopia japonica). *Ecological Restoration, 30*(3), 192-199. doi:10.3368/er.30.3.192

U.S. Census Bureau QuickFacts: Washington township, Macomb County, Michigan. (n.d.). Retrieved from https://www.census.gov/quickfacts/fact/table/washingtontownshipmacombcountymichigan/RHI325217#RHI325217

Vanwallendael, A., Hamann, E., & Franks, S. J. (2018). Evidence for plasticity, but not local adaptation, in invasive Japanese knotweed (Reynoutria japonica) in North America. *Evolutionary Ecology, 32*(4), 395-410. doi:10.1007/s10682-018-9942-7

Wang, Y., Wu, K., & Ding, J. (2010). Host specificity of Euops chinesis, a potential biological control agent of Fallopia japonica, an invasive plant in Europe and North America. *BioControl*, *55*(4), 551-559. doi:10.1007/s10526-010-9279-9

Weston, L. A., Barney, J. N., & Ditommaso, A. (2005). A review of the biology and ecology of three invasive perennials in New York state: Japanese knotweed (Polygonum cuspidatum), mugwort (Artemisia vulgaris) and pale swallow-wort (Vincetoxicum rossicum). *Plant and Soil,277*(1), 53-69. doi:10.1007/s11104-005-3102-x

Young, C. F., & Witter, J. A. (1994). Developing Effective Brochures for Increasing Knowledge of Environmental Problems: The Case of the Gypsy Moth. *The Journal of Environmental Education, 25*(3), 27-34. doi:10.1080/00958964.1994.9941955