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Understanding Individuals' Perceptions of Oak Wilt and Its Implications for Invasive Species Management

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UNDERSTANDING INDIVIDUALS' PERCEPTIONS OF OAK WILT AND ITS IMPLICATIONS FOR INVASIVE SPECIES MANAGEMENT

by

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Oak wilt, a thought-to-be exotic, invasive fungal disease preys upon oak tree species (*Quercus sp.*) and has begun to cause die-off in oak stands throughout the state of Michigan, with potential for increased cases and subsequent death. Despite efforts to treat the disease, there is no guaranteed treatment for already-infected oak trees. The best option is to control the infection and prevent its spread, by methods such as disconnection of root systems, removal of infected trees, and informed pruning. Given that humans play a role in oak wilt's artificial spread, it is imperative that the public understands their role in the management of oak wilt. This study's primary objective was to determine whether or not the general public within Grand Traverse County, Michigan, knows of oak wilt and whether or not they are willing to participate in behaviors that prevent its spread. The study involved a mixed-methods data collection approach, utilizing both Likert-type scale and open-ended questions, acquired through a door-to-door questionnaire. Statistical analyses were used to determine significance differences in understanding of oak wilt and willingness to participate in preventative measures among different demographic categories. Recommendations for state resource agencies and local environmental groups are given with regard to outreach and education efforts.

TABLE OF CONTENTS

Table of Contents—Continued

CHAPTER

Table of Contents—Continued

CHAPTER

APPENDICES

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Invasive species are increasingly becoming a problem within local habitats because of global, human interconnectivity and the decline in ecosystem stability caused by modern environmental problems. These invasive species generally are able outcompete their local, native counterparts because they lack a native predator, have the ability to reach maturity quickly, reproduce rapidly, and tolerate a wide range of environmental conditions. As such, invasives can cause changes at the population and community level and can even lead to the extinction of rarer species (Nuñez et al. 2010). Therefore, invasive species management is important in maintaining and conserving local ecosystems and their inhabitants.

Invasive species management is defined as the methods of controlling and eradicating invasive species within local ecosystems. These methods can range from governmental action, such as regulation of firewood transport to prevent the spread of invasives, to chemical treatments in an attempt to eliminate the species locally. The most successful way to inhibit these species' population growth is to detect the species early, impose measures that prevent their spread, and eradicate local occurrences. Despite measures put in place to prevent spreading, many invasives are able to establish themselves because the public is not aware of these species and subsequently does not adhere to the prescribed management practices. In many cases, individuals unaware of these species and their management plan unknowingly help with invasives' artificial spread (Vitousek et al. 1997).

Therefore, it is important that efforts that help prevent the spread of invasives be prioritized and adhered to by the public, otherwise these species will continue to invade local ecosystems and permanently establish themselves. Having the public follow prescribed measures will allow for the best chance of success from a management perspective. However, participation in preventative behaviors requires public knowledge of invasive species and an understanding of these species' threats to local landscapes. Without this understanding, people tend to not care or do not see an issue with going against management efforts (Garcia-Llorente 2011). Having an informed public can allow for greater adherence to preventative behaviors prescribed by environmental groups and governmental agencies.

Purpose

Grand Traverse County (GTC), Michigan has one of the highest occurrences of oak wilt in the state. Because an informed public is best for limiting the spread of invasive species, the purpose of this research was to determine whether or not GTC residents were aware of oak wilt and willing to participate in behaviors that prevent the disease's spread. A questionnaire was provided to the residents of GTC to determine if there were significant differences in understanding or willingness to participate in preventative behaviors among different demographic categories. Significant differences among demographic categories, or an outright lack of knowledge or willingness to participate among the surveyed population, could have implications for oak wilt management. For example, widespread ignorance of the disease could mean that the public is unknowingly participating in behaviors that are enhancing its spread. Significant differences among demographics could also indicate a necessity for increased outreach and education efforts by state agencies and local environmental groups with regard to more obscure invasive species. Furthermore, a population unwilling to participate or ignorant of oak wilt and its threats may provide the ideal conditions for oak wilt to continue to spread across the county and beyond, and potentially cause significant damage.

Hypothesis

It is possible that there are significant differences amongst demographics in Grand Traverse County, Michigan, when it comes to knowledge of oak wilt and willingness to engage in preventative behaviors. The hypotheses for this research are:

1. H_o: There exist no significant differences among demographic categories with regard to knowledge of oak wilt.

   H_a: There exist significant differences among at least one demographic category with regard to knowledge of oak wilt.

2. H_o: There exist no significant differences among demographic categories with regard to willingness to participate in preventative behaviors.

   H_a: There exist significant differences among at least one demographic category with regard to willingness to participate in preventative behaviors.

Demographic categories for these hypotheses include, education, income, gender, and residents' description of their home environment relative to tree presence. Significant differences could possibly indicate whether or not there are particular, underlying factors influencing the public involvement aspect of invasive species management, particularly with oak wilt. If certain groups are more knowledgeable or more willing to participate in preventative behaviors, then perhaps local environmental groups or state agencies can lead more targeted outreach campaigns regarding invasive species. For example, if individuals with a bachelor's degree or higher are more knowledgeable and willing to participate in preventative behaviors, then it is possible that universities are playing a role in educating the public regarding invasive species. It would then follow that agencies and environmental groups could lead more community events targeted towards those who have not received a higher education.

CHAPTER II

LITERATURE REVIEW

Michigan Forests

Michigan has the most forest among states in the Northeast and Midwest, and ranks 12th in the U.S. for total forest land area with approximately 20.3 million acres. That area is composed of 14.1 billion trees, with 73% hardwoods and 24% softwoods. The major forest types within Michigan are: white/red/jack pine, spruce/fir, oak/pine, oak/hickory, elm/ash/cottonwood, maple/beech/birch, and aspen/birch (Pugh et al., 2014). Despite this forest richness, it was not until recently that Michigan forests were managed sustainably. Dating back to European settlers, the entirety of lower Michigan was clearcut, with its forests cleared and burned for timber and other products (Dickmann and Leefers, 2003). This unsustainable forest management continued until the state and private landholders began adopting practices suggested by the Sustainable Forest Initiative. Similarly, the national forests within the state are now under the sustainable management of the National Forest Management Act and the National Environmental Protection Act (Pugh et al., 2014).

In spite of the fact that Michigan forests are now more sustainably managed, other threats continue to emerge for local, forest ecosystems. Invasive species introductions are on the rise. Most recently, emerald ash borer caused significant ash mortality with negative costs of 10.7 billion throughout the Midwest (Kovacs et al., 2010). Current invasive species in Michigan include organisms such as hemlock wooly adelgid and the forest tent caterpillar. A subset of these invasive species includes fungal pathogens, which are diseases that often cause host mortality because of a lack of coevolution (Loo, 2008). The most iconic example in the U.S. is the chestnut blight that significantly reduced the population of the American chestnut and originated from China. However, the main invasive fungal pathogens causing tree mortality in Michigan forests are thousand cankers disease, beech bark disease, and oak wilt (Michigan Department of Natural Resources, 2017).

Oak wilt

What is it?

Oak wilt, *Bretziella fagacearum,* formerly *Ceratocystis fagacearum*, is a thought-to-be exotic, invasive, fungal pathogen that affects oak trees' (*Quercus sp.*), vascular system. The disease produces reproductive structures and metabolic waste that clog the xylem of the infected tree. The blockage of the xylem vessels is what produces the characteristic wilt symptoms (Juzwick, 2000). Wilt begins at the top of the trees, but reveals itself differently amongst the different oak species groups, red, white, and live.

Red oaks have the tips of their uppermost leaves begin to discolor, before discoloration moves towards the midrib. Following infection, red oaks defoliate quickly and generally die within a year. White oaks show similar symptoms, but they develop slowly, such as an annual branch-to-branch spread. White oaks also resist the disease more and have been shown to evade death for several years, if not survive permanently depending on the species. White oaks' resistance to the disease can be explained by their ability to produce tyloses, structures that are produced within the tree to defend against foreign bodies (Wilson, 2005). Live oaks, however, have discoloration originate in their leaf veins, can have vascular discoloration in their infected sapwood, and often succumb to the disease quickly (Juzwik, 2000).

Following death of the tree, the disease produces fungal mats beneath the bark in red oak species. These mats produce spores that help spread the disease above ground. Timing of the mats is dependent on when the tree begins showing symptoms and succumbs to infection, geographic location, and environmental factors (Appel, 2001). Often, mats are found on red oaks that died the previous year, with mat production occurring in the spring or fall, and spore production lasting approximately 2-3 weeks. However, formation of fungal mats is dependent on temperature and moisture. Red oaks infected during high temperature and low moisture periods, such as from late spring through summer for much of its range, tend to not produce mats. (Wilson, 2005). These fungal mats are capable of producing pressure pads, which force open the bark and expose the mats' spores to insect vectors (Juzwik, 2000). Insect vectors are beetles that feed on the fungal mats and transmit the spores to nearby, susceptible trees. Fungal mats have not been found on white or live oak species (Wilson, 2005).

How does it spread?

Oak wilt spreads from tree to tree by two means: transmission of infectious spores by insect vectors, and underground via root grafting (Juzwik, 2000). Humans can artificially enhance the spread of oak wilt through transport of infected firewood, but insect vectors are still required to transmit the spores (Wilson, 2001). Nitidulid beetles are the main vectors for spore transmission throughout the Midwest and areas of Texas. These beetles are sap-feeding insects that are attracted to fungal mats and carry the mats' spores to trees with open wounds. For above-ground transmission to be successful, there must be a recently-injured oak nearby for the spore-carrying beetles to access (Juzwik and French, 1983). The most common nitidulid beetle for transmitting oak wilt spores is thought to be *Colopterus truncates* (Hayslett et al., 2008).

The second and most common mode of disease transmission is through root grafts. Root grafts are shared root networks between different trees. It is estimated that nearly 90% of all oak wilt infections within Minnesota are due to root grafting (Cook, 2001). This method of transmission is especially common among red oak species, with the disease being able to survive multiple years within the roots following tree death (Gleason and Mueller, 2005). Because of large, shared networks among oak trees, transmission via root grafts can produce groups of infected trees called infection centers (O'Brien et al., 2000). Infection centers pose the risk of expansion given the proximity of other oak trees. Because of the shared networks below ground, underground transmission of the disease usually expands these centers, whereas overland spread creates entirely new infection centers (Juzwik, 2000).

Where did it originate?

The disease was officially recognized in the United States in Wisconsin in 1942. However, it is likely that the disease was either introduced or began causing major problems earlier, given previous cases of widespread die off with similar symptoms. The first observations of the fungus came from the northern portions of the Mississippi River Valley, where it is believed to have spread to the Appalachians. It is theorized that the disease was killing oaks as early as the 1890s in the Upper Midwest (Juzwik et al., 2008). As of today, more than half of the contiguous United States has an oak wilt presence, with its range extending from New York to Texas (Wilson, 2005). Despite its expansion throughout the eastern US, it is still unclear whether the disease is a native or exotic pathogen.

Currently, there are three competing hypotheses for oak wilt's origin, with two proposing that it is native and the other supporting exoticness. The first of the native hypotheses makes the argument that the disease is a long-lived, underreported endemic that has maintained its geographical extent through time. It is supported by the fact that, even today, oak wilt does not spread rapidly except in special cases, its vectors are inefficient, and that white oaks are more resistant to the disease, indicating possible coevolution of a host/parasite relationship (Juzwick et al., 2008). Furthermore, recent epidemics and shifts in range, which would challenge the hypothesis, can possibly be explained by altered landscapes and ecosystems. As local ecosystem dynamics are changed, such as fire being suppressed in oak savannas, populations can become genetically homogeneous and easily infected (Johnson, 1993).

The second leading hypothesis for oak wilt's status as a native is that the disease recently evolved to become a distinct species. Theorized explanations for this evolution are speciation due to geographic barriers, mutations leading to a unique phenotype, or a hybridization event (Juzwick et al., 2008). All three avenues for speciation would promote genetic diversity (Juzwick et al., 2008). Furthermore, if the disease had recently evolved, a common ancestor would be easily identifiable, which is not the case, especially given the extensive knowledge of oak mycoflora (Harrington, 2008). Regardless of pathway, the major issue with this hypothesis is that it fails to explain the lack of genetic variability among oak wilt's vast population.

The nonnative hypothesis is that the disease was introduced to the United States from another country. It is supported by the fact that there is little genetic variation among oak wilt's U.S. population. Given that the disease is heterothallic, in that it has different sex structures and can reproduce via sexual reproduction, it would follow that the disease would have substantial genetic diversity (Hepting, 1952). However, that is not the case. Kurdyla et al. (1995) found little genetic variation, both mitochondrial and nuclear, among different oak wilt individuals sampled throughout its US range. Similarly, Harrington (2008) observed almost no genetic variability, both mitochondrial and nuclear, among different individuals sampled throughout the Midwest. Furthermore, white oaks' resistance to the disease, which would challenge the hypothesis, given coevolution of a host/parasite relationship, can possibly be explained by a coincidental adaptation to drought (Juzwick et al., 2008). It is theorized that the most likely region of origin is that of Mexico, Central America, and northern South America. This is because Europe and eastern Asia, areas of oak species presence, have had their oak mycoflora extensively studied, without a genetically or morphologically close species being found (Juzwick et al., 2008).

Oak Wilt Management

In response to the oak wilt threat, government agencies in partnership with local universities and environmental groups have created management plans in an effort to prevent the spread of the fungal pathogen. Depending on the management goal, multiple options are available to prevent the spread of the disease, including disconnection of root systems, removal of diseased material, chemical treatments, and basal girdling.

Root disconnection involves disrupting the infection below ground. Because oak wilt can spread from tree to tree via root grafts, it is important to disconnect tree root couplings. This disconnection can be accomplished by installing trenches or using plow lines (Koch et al., 2010). Plow lines or trenches are generally placed outside of infection centers to protect healthy trees, but secondary lines or trenches can be put in around the already-infected trees to increase efficacy of the barriers (Wilson and Lester, 2002).

Another method for managing the disease is sanitation, or removal of the infected material. Two management options exist for this method. The first includes removal of all infected oaks, with annual checkups to remove new infections. The second involves removing the infected oaks as well as all oaks within the infection center, or those that are able to be affected by underground root grafting (O'Brien et al., 2000). Given the ability of the disease to spread underground, the removal of all oaks within an infection center has proven to be the most effective at suppressing the spread of oak wilt between the two options (Young, 1949).

Using chemical treatments to manage oak wilt's spread is also an option. Chemical treatments can either be preventative or therapeutic. In terms of prevention, sought after outcomes might include prevention of infection, symptom development, or mortality, while therapeutic outcomes can include reduction of fungal mat production, or inhibition of disease progression or mortality (Koch et al., 2010). Given differences among oak species, specifically relative to white oak's increased resistance to the disease, different fungicide protocols should be taken for red, live, and white oaks.

Depending on desired outcomes and species of oak, fungicide treatments can have mixed results. The most common chemical is Propiconazole, a compound which inhibits oak wilt's growth (Wilson and Forse, 1997). In terms of preventative measures, the compound is ineffective at preventing infection in red and live oaks (Appel and Kurdyla, 1992). Limited research suggests that the chemical can help prevent infection within white oaks, as Eggers et al. (2005) witnessed only 4% of white oaks showing signs of infection, five years after fungicide application. However, it remains that the disease can still infect white oaks post-treatment (Eggers et al., 2005). Preventative treatments have been shown to have success in preventing/delaying symptom development in all oak groups. Appeal and Kurdlya (1992) witnessed significant reductions in leaf loss in the uppermost branches of live oaks and lower rates of mortality. White oaks are similar, with treatments almost always being effective at preventing symptom development (Eggers et al., 2005). Observations of red oaks indicate the chemical delays symptoms, but is not as effective relative to live and white oaks (Osterbauer and French, 1992; Eggers et al., 2005).

In terms of therapeutic measures, propiconazole is effective at slowing the progression of symptom development and mortality in white oaks. Live oaks have not been studied adequately enough to determine efficacy with regard to the chemical (Koch et al., 2010). However, the fungicide is ineffective with red oaks after trees' crowns begin to wilt (Ward et al., 2005). Despite variability in red oak species' responses to fungicide treatments, propiconazole injections are effective at reducing production of fungal mats. Osterbauer and French (1992) observed that all red oaks treated with the fungicide did not produce fungal mats, compared to untreated controls. Similarly, Johnson (2001) found that black oaks (part of the red oak section) treated with propiconazole did not produce fungal mats compared to untreated trees. While the chemical does not kill the fungus, it can limit overland spread via reduced fungal mat production.

Another method for managing oak wilt is basal girdling. This method involves removing the bark and cambium, or portions of the vascular tissue, of either symptomatic oaks or all oak trees within an infection center. The method can either involve cuts up to the sapwood or cuts deep within the sapwood, known as "deep girdling" (Gillespie et al., 1957). Girdling of oaks has been shown to reduce the incidence of fungal mat production in northern US forests as well as within the Edwards Plateau in Texas (Morris, 1955; Gillespie et al., 1957; Greene et al., 2008). Reducing the incidence of fungal mat production helps prevent overland spread.

While the aforementioned methods of control are generally significant investments in terms of time and/or money, simpler actions can be taken by the public to prevent the spread of the disease, such as informed pruning and cautious transport of firewood. As previously noted, fungal mats are formed underneath the bark of dying or dead red oak trees and produce infectious spores that require a nearby, injured oak in order to transmit the disease. The period during which these fungal mats are present is April to November. If humans prune oaks during these months, they are increasing the susceptibility of oak trees to the disease (Wilson, 2001). Therefore, having members of the public participate in informed pruning, or pruning December and March, reduces the chances of overland spread via infectious spores.

The transport of infected firewood by individuals can also increase the chances that the disease spreads above ground. Often, when a tree dies on someone's property, they cut it down and chop it up for firewood. However, if the tree was infected with oak wilt and is subsequently transported, with the fungal mats present, the individual is providing an avenue for the disease to disperse longer distances (Wilson, 2001). As an example, an area previously uninhabited by the disease could be colonized by spores from introduced, infected firewood. It has been found that in many cases, new populations of the disease surrounding residences are due to infected firewood (Wilson, 2001). Therefore, being cautious when transporting firewood can help prevent the overland spread of the disease.

Perception of Invasive Species

Introduction of species to non-native lands and their subsequent establishment has occurred throughout history, with many modern-day crops originating from other continents. However, as conservation biology and ecological principles came to the forefront of science in the late 20th century and the world became more interconnected, the negative consequences of non-native species began to be realized.

Opinions and perceptions of exotic, invasive species are largely driven by culture and type of organism (Nuñez and Simberloff, 2005). In California, more than 100 species of

Eucalyptus trees have been introduced to the natural landscape since the early 1800s. Despite its overwhelmingly negative effects on the ecosystem and native biota, a large majority of the public view it positively. As Nuñez and Simberloff (2005) mention, the introduced, non-native species have become a cultural icon, valued amongst the region's population and even harshly defended when efforts to eliminate them were suggested by local park authorities.

Invasive species appear to garner negative opinion by the public when they are visible in the public's eye and are understood to have a negative impact (Simberloff et al., 2013). At Fort Snelling State Park in Minnesota, an image-based questionnaire was provided to visitors, asking them which of the landscapes they preferred. These images showed varying levels of shrub and tree density and were indicative of possible emerald ash borer damage. The study yielded 307 responses and indicated that visitors had a negative opinion of the invasive pest as they preferred images with more dense vegetation (Arnberger et al., 2017). The contrary is seen when the species are less visible and unheard of, such as exotic earthworm species which have done considerable harm to subsoil ecosystems. Despite the damage done by these species, a large majority of the public remains unaware (Callaham et al., 2006).

Regardless of opinion, it would appear that the public remains ignorant of threats posed by invasive species. As Cerri et al. (2016) notes, hunters in Italy were unaware of the threats posed by the Eastern cottontail, a native to North America. The species poses threats to the native European hare because of its expanding distribution and ability to act as a vector for numerous diseases that can spread to the European hare. Despite this, it is viewed favorably as another source of food. Similarly, Vanderhoeven et al. (2011) found that even horticultural professionals lacked extensive acknowledge of invasive species and their threats to local ecosystems. While 58% of horticulturists were aware of the issue of invasive species, they lacked adequate knowledge of said species. These professionals were largely unaware of invasive species' ability to colonize areas rapidly and expand their distribution, as well as the general impact they have on ecosystems (Vanderhoeven et al., 2011).

CHAPTER III

METHODS

Study Area

Grand Traverse County (GTC) is located in the northwest portion of the lower peninsula of Michigan. The county contains the major city, Traverse City, and the Old Mission Peninsula. GTC is surrounded by Kalkaska, Bellaire, Wexford, Benzie, and Leelanau counties, as well as Lake Michigan to its north (Figure 1). According to the U.S. Census Bureau (2017), approximately 90,000 people reside in GTC, with a large portion of the county's population concentrated near Traverse City and its suburbs.

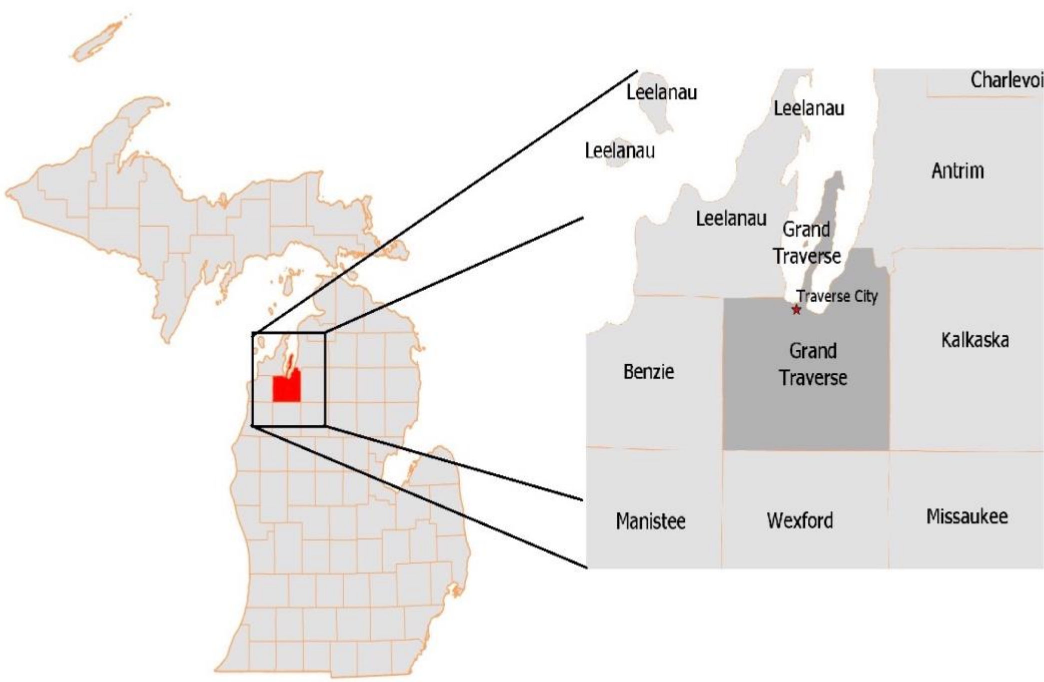

Figure 1. Grand Traverse County, Michigan

Of the 90,000 individuals residing in GTC, approximately 95% hold a high school degree, with more than 34% having a bachelor's degree or greater as their highest level of education. The county has a medium household income of $55,000, with 10% of the total population living in poverty (U.S. Census Bureau 2018). According to the data acquired from GTC's county office, and US Census Bureau (2018), there are approximately 44,000 primary residences in the county.

GTC was chosen as the site for conducting the questionnaire because of its high incidence of oak wilt relative to other counties in Michigan (Figure 2). It was assumed that a higher density of the disease in the county would lead to a population aware of the disease. `

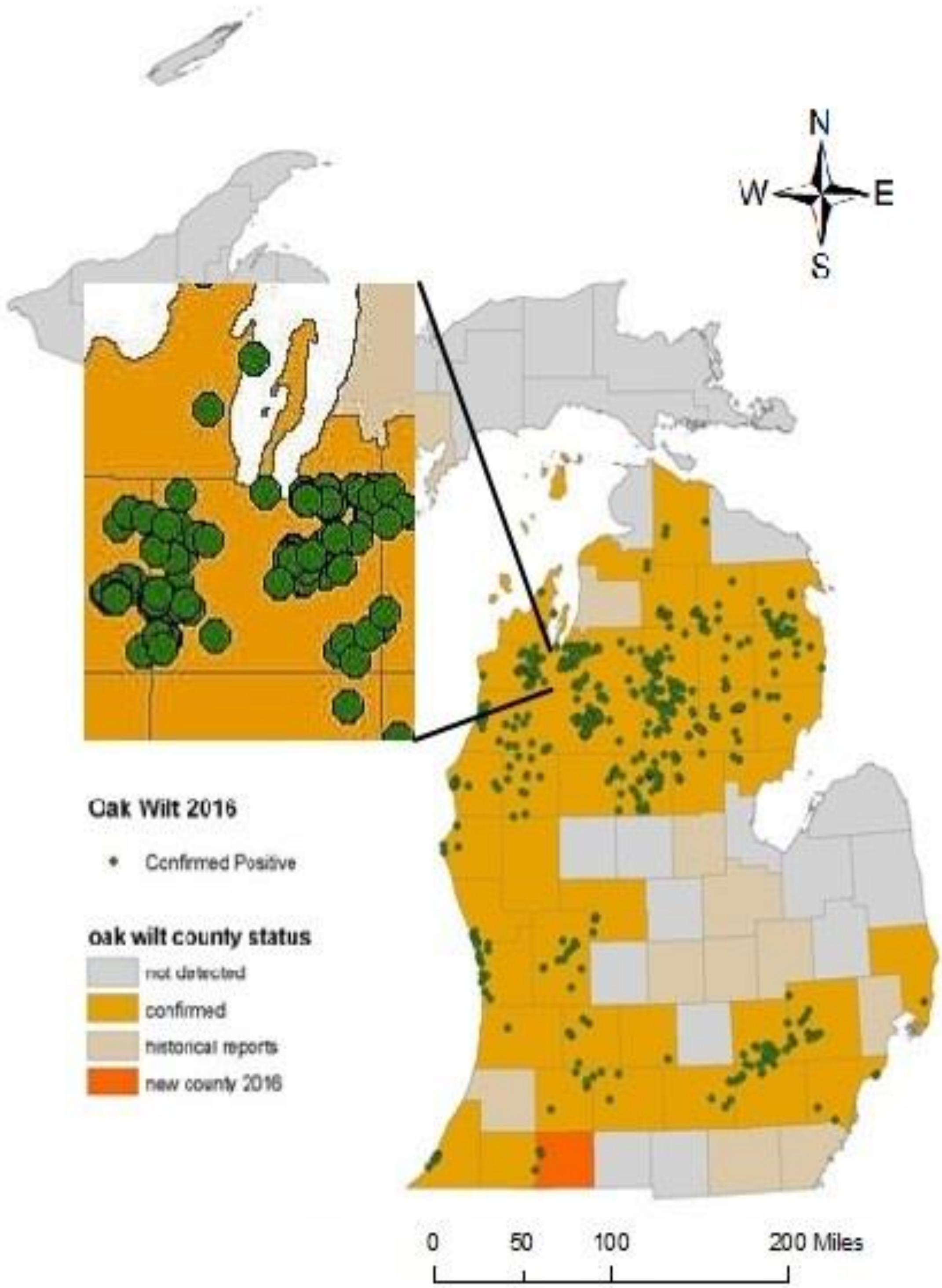

Figure 2. Map of oak wilt incidence in Michigan (Adapted from Michigan Department of Natural Resources, 2016).

Questionnaire Site Selection

Random locations throughout the county were chosen for the questionnaire using ArcGIS and a county parcel layer provided by Grand Traverse County (ArcMap Version 10.6.1, ESRI 2019). Beginning with the parcel layer, all non-residence parcels were removed. The removal of non-resident parcels was done by exporting the selected features from the select by attribute query “USEDSCRP” = “Residential.” Following creation of the new residential layer, parcels classified as “C-COMMERCIAL” were removed, in a similar select by attribute query and export, “PRIMEZONE” does not include the value(s) “C-COMMERCIAL,” to ensure that the output would be primary residences. After the derivation of primary residence parcels, a census layer composed of 2010 census tracts from the U.S. Census Bureau was added and subsequently trimmed to show only census tracts for GTC, using clip and dissolve tools. This new GTC census tract layer was used to split the parcels into separate tracts for randomization. Following the split operation, each tract’s total number of residences were summarized to determine their ratio relative to the entire county. This ratio was used to weight the number of questionnaires allocated to each tract out of the total 100 questionnaires.

To adequately represent the county with 100 questionnaires, randomization within census tracts was used in an attempt to gather responses with minimal spatial bias. This was done by using the unique code, FID, assigned to each parcel by ArcGIS. The list of parcels in each tract was broken down into a number of quantiles based upon the ratio number assigned to the tract. For example, if the tract was given seven questionnaires, based off of its ratio, the parcel listing would be broken into seven quantiles. From those seven quantiles, the FID was used to randomly select one residence within each of the seven value ranges, using a random number generator. Once residences were chosen, their locations were ascertained using ArcGIS and Google maps.

The goal was not to survey a specific house, but rather, choose random areas to get a questionnaire from, to prevent spatial autocorrelation.

Questionnaire

The questionnaire (Appendix A) used for this study was designed to determine whether or not residents in Grand Traverse County (GTC), MI, understood the threat of oak wilt and to determine their willingness to participate in behaviors that prevent the spread of the disease. To ensure confidentiality and anonymity of participants, names and addresses were not recorded. The study was also approved by Western Michigan University's Human Subjects Institutional Review Board (HSIRB; Appendix B).

The questionnaire began by asking participants where their home was located. There were six total options, with a variation for rural, suburban, and urban, that tried to ascertain whether or not trees were present nearby. Afterward, the questions began to focus on whether or not the individual knew of oak wilt, where they had heard of it, and their understanding of the disease. Personal experiences with the disease and knowledge of its damage were asked qualitatively. Following questions regarding their understanding, participants were asked to rank reasons for why they would be unwilling to participate in preventative behaviors from a list of four options, lack of convenience, cost, unaware of how to help, and no interest with 1 being most important and 4 being least important. This was followed by a list of preventative behaviors asking respondents how willing they were to participate, using a Likert-type scale where 1 = "Very Unlikely" and 5 ="Very Likely." The end of the questionnaire was composed of socio-demographic questions that asked participants their household income, highest level of education, occupation, and gender.

Data Collection

Questionnaires were collected by going door-to-door at random locations throughout GTC, and completing the survey face-to-face. The research was conducted the weekends of 7/28/18, 8/4/18, and 9/1/18, from 10 am to 6 pm on Saturday and Sunday. It was assumed that weekends during daylight hours would be the best time to acquire responses. Response rates varied by weekend, but generally were greatest in the mornings and evenings. If a homeowner was not home at the time that the researcher visited, another home nearby was used in its stead. The goal was not to get questionnaires from specific, random houses, but rather 100 responses from random locations throughout the county.

When the researcher made contact with participants, a statement was made to communicate the researcher's name, affiliation with Western Michigan University, and purpose of the study. Many respondents did not seem interested in participating and often asked for the researcher to leave their property. On a few occasions, conversations were had regarding the presence of oak wilt and invasive species within the county.

Participants were asked to fill out the survey after being given a clipboard and WMU Geography Department pen. Some residents asked for the questionnaire to be read orally and for the researcher to record responses. Towards the end of the study, given many individuals not reading the instructions, the researcher began asking the questions rather than offering the respondent the ability to personally fill out the survey. Following completion of the questionnaire, the researcher offered participants an informative brochure on oak wilt from the Michigan Department of Natural Resources if they were interested, which very few took.

Limitations

Data Acquisition

Using GTC's parcel layer with ArcGIS to randomize questionnaire locations throughout the county brought with it some issues. By using the split function to assign parcels to census tracts, some parcels were removed or double counted. This was because some parcels were along or between tract boundaries. While error from this was most likely minor, given that randomization was used to find general areas for questionnaire location, it could have influenced whether or not randomization was truly random. Similarly, the parcel layer acquired from GTC was given to the researcher in the spring of 2018, when methods and randomization were being designed. However, the parcel layer is generally updated annually in late spring, indicating there might have been changes in residential and commercial locations. The researcher did not receive the most recent update before beginning randomization.

Door-to-door questionnaires also posed issues, as a majority of people did not want to talk to the researcher, did not answer the door, or were not home. Given this issue, the researcher often had to move beyond the general, randomly selected locations to acquire a questionnaire. This produced cases where multiple questionnaires were acquired from areas near one another, possibly leading to spatial bias. This also most likely produced response bias, in that those that participated were individuals that tend to participate more in surveys.

The questionnaires themselves also posed problems, as many respondents did not answer questions correctly, despite instructions. Furthermore, many individuals classified the location of their residence differently than how the researcher intended. For example, an individual living in a suburban area with many trees near their home might have checked "rural, mostly forested," instead of "suburban, trees present frequently." This indicates that many individuals were either perceiving their surroundings differently than the researcher or were considering their surroundings from a broader perspective, such as their residence within the county, rather than their plot of land.

Data

All data from the questionnaire were not utilized or statistically analyzed. For example, qualitative questions were not analyzed for meaning given the lack of responses and overall misunderstanding of the questions. Furthermore, data from the question regarding why individuals would be unwilling to participate in preventative behaviors was not statistically analyzed for significant differences between demographic categories. This was due to the fact that a majority of respondents did not rank the four reasons, but instead checked one or multiple. Therefore, responses to this question were used solely for explaining why residents might be unwilling to participate in preventative behaviors. And finally, the demographic category of occupation was not analyzed because individuals in many cases either did not answer, answered multiple categories, or did not specify after checking "other."

Analysis

Responses to questionnaire questions were coded numerically and arranged within a spreadsheet. Analysis of the data was completed using SPSS Statistics (Version 25; IBM, 2019) provided by the Geography Department of Western Michigan University. Data were analyzed to determine if there was a majority of residents unaware of the disease or unwilling to participate in preventative behaviors, as well as if there were significant differences among demographic categories including, education, income, gender, and residents' description of their home environment relative to tree presence.

Determining whether or not there was an outright lack of knowledge among residents in GTC or an unwillingness to participate in preventative behaviors was done by using the descriptive statistics tool in SPSS. The percentage of the population that knew of the disease was compared to the percentage of the population that was unaware, to determine if a majority of individuals did not know of the disease. Also, the means of the responses to the Likert-type scale questions regarding willingness to participate in preventative behaviors were analyzed to determine if the average individual was unwilling to participate in behaviors that prevent the spread of oak wilt. If the average was below 3 (neutral), it was assumed that a majority of respondents were unwilling to participate in the particular behavior, whereas averages above three were assumed to mean the opposite. Following the determination of whether or not the public was largely unaware of the disease and/or were unwilling to participate in preventative behaviors, demographic categories were examined to determine significant differences.

Chi-squared tests were used to determine whether or not there were significant differences among demographic categories with regard to knowledge of oak wilt. In many cases, however, analysis could not be completed because the categories did not have an expected value of 5 or higher, which is one of the test's necessary assumptions. This was the case for education, income, and residents' description of their home environment relative to tree presence. To account for this issue, groups were combined in a meaningful manner to allow for analysis. For example, education groups were combined to become "bachelor's and above" and "associate's and below," instead of the individual categories of HS, technical, associate's, bachelor's, and graduate degree. Despite the effort to create categories that could be analyzed, residents' description of their home environment relative to tree presence still did not meet the requirement of an expected value of at least 5 for one of its groups, even when diluted down to "trees present" versus "trees absent." Therefore, it was unable to be determined whether or not there existed significant differences among the groups in the residents' description of their home environment category. This finding was in line with the limitations discussed regarding data acquisition. Many location categories were visited less than others and a number of individuals perceived their location differently than expected. This led to a number of categories being underrepresented.

Analysis of Variance tests (ANOVA) were used to determine whether or not there were significant differences among the demographic categories for the Likert-type scale data concerning individuals' willingness to participate in preventative behaviors. When applicable, Tukey's post hoc HSD test was used to determine which groups within demographic categories were significant from one another. However, it should be noted that all significant values acquired from ANOVA testing should be cautiously evaluated for meaning, because while the Likert-type scale data produced means that could be compared using ANOVA, Likert-type scale data itself is ordinal and not continuous. This presents issues given that a mean of 3.4, for example, is meaningless considering the categories near this value were 3 (neutral) or 4 (likely). Therefore, ANOVA testing was used to determine significant trends in the data, but not as a method for making firm conclusions regarding individuals' willingness to engage in preventative behaviors. This was especially the case given the previously mentioned limitations regarding data acquisition.

CHAPTER IV

RESULTS AND DISCUSSION

Questionnaire and Demographic Categories

One hundred questionnaires were collected from face-to-face interviews during the summer of 2018. Two others were collected, but discarded, because of insufficient information provided by the respondent. Participants were composed of 68% males, 31% females, with their median income near $75,000-99,000. This contrasts with the county's median income of $55,000, as reported by the U.S Census Bureau (2018). A majority of the surveyed population, 78%, had a bachelor's degree or higher, while the remainder had their highest degree between a high school diploma and associate's degree. All respondents completed at least high school. The high percentage of bachelor's degrees or higher within the surveyed population is different than the county's reported percentage of approximately 34% (U.S. Census Bureau, 2018). The discrepancies between the respondents' median income and highest level of education and the county's averages can be attributed to the data acquisition limitations previously mentioned. Therefore, certain income and education groups were surveyed more than others, resulting in a non-representative sample of the county's population. As for residents' description of their home environment relative to tree presence, a majority, 89%, perceived their home to be in an area with trees present ("rural, mostly forested," "suburban, trees present", or "urban, trees present").

General Public

Knowledge of Oak Wilt

Of the 100 respondents, 23% indicated that they knew of oak wilt, while 77% noted that they had not heard of the disease by name. While there were limitations in terms of data acquisition with regard to demographic groups, it would appear as though the majority of the public within GTC is unaware of the disease. This is not surprising, because as Callaham et al. (2006) explained, invasive species that are less visible and not mentioned in the general media, such as oak wilt, are largely unknown by the public.

Willingness to Participate

In terms of residents' overall willingness to participate in behaviors that prevent the spread of oak wilt, the majority of the means for the five behaviors hovered near neutral (3), except for "pruning" and "digging up infected roots" which had a value of 4.06 and 2.56 respectively (Table 1). Values closer to 5 indicate a respondent more willing to participate in preventative behaviors, while values closer to 1 indicate a respondent less willing. The relatively neutral values indicate that residents, for the most part, do not have a strong opinion, negative or positive, with regard to participating in preventative behaviors. The non-neutral means, however, can most likely be explained by two factors: cost and convenience. The value of 4.06 for pruning likely can be attributed to convenience and lack of cost, given that the preventative behavior is simply not pruning during certain months. It is not expensive and does not require significant effort. However, the lower value of 2.56 for digging up infected roots is likely due to cost and a lack of convenience, as digging up root networks and installing trenches is a significant undertaking, both in terms of labor and cost. These associations are further solidified based on the question that asked respondents what would make them unwilling to engage in preventative behaviors. A majority of respondents, 70%, reported that cost or a lack of convenience would prevent them from engaging in behaviors that prevented the spread of oak wilt. This is in line with the information in Table 1, as digging up infected trees, cutting down dying trees, and chemical treatments had the lowest means and are both expensive and labor intensive.

Table 1. Mean values for the entire surveyed population for each preventative behavior. (1 = very unlikely, 2 = unlikely, 3= neutral, 4 = likely, 5 = very likely)

Behavior	Mean Response
Pruning	4.06
Firewood	3.15
Cutting down dying trees	2.67
Digging up infected roots	2.56
Chemical	2.95

Education

Knowledge of Oak Wilt

Of the five education groups, respondents with a bachelor's or graduate degree had the first and second highest percentage, respectively, of "yes" responses with regard to knowledge of oak wilt (Table 2). However, the groups within the education category did not initially meet the requirements of chi square (X^2) testing given that that there were cells with expected values of less than five. Therefore, the groups were aggregated into "associate's and below" and "bachelor's and above." This was the only sensible grouping of data that allowed for expected values of at least five. Results from this grouping method were used to determine if a longer presence in higher education plays a role in knowledge of oak wilt.

Table 2. Percentages of responses with regard to knowledge of oak wilt for each education group.

Highest Degree	n	Yes (%)	No (%)
High school or less	5	0	100
Technical	14	7	93
Associate's	3	0	100
Bachelor's	64	29.7	70.3
Graduate	14	21.4	78.6

Following the breakdown of residents into the larger education groups previously mentioned, the chi square test produced a X^2 value of 5.424 and a p-value of 0.020, indicating a significant difference between the two groups. It is surprising that there are significant differences between these two groups, given that both associate's and bachelor's and above require general education courses, where non-environmental degree individuals are the most likely place to encounter invasive species information. However, this is explained by the fact that there were only three respondents who reported having an associate's degree as their highest form of education. This indicates that the significant difference in knowledge of oak wilt between the two larger groups was most likely because of the differences between the high school and technical degree respondents, and those with a bachelor's and above. Therefore, it would appear as though more education within GTC likely is correlated with a greater awareness of invasive species such as oak wilt.

Willingness to Participate

In terms of education groups, there were significant differences for all five of the preventative behaviors. Significant differences had p-values below the 0.05 alpha level between the education groups "technical" and "graduate" for all five of the behaviors, "technical" and "bachelor's" for three of the behaviors, and "high school" and "bachelor's"/"graduate" for one of the behaviors (Tables 3 and 4). This indicates that respondents in these categories were more likely to be willing to participate in preventative behaviors.

The significant differences present between the groups with higher education and those without is most likely due to two reasons. College-educated individuals are more likely to hear about invasive species, either through general education or environmentally focused courses, or campus environmental efforts. This education component gives individuals the chance to be more aware of invasive species, likely leading to participation in said species' management. Additionally, individuals with higher education, on average, get paid more, likely reducing the effects of cost as a factor for preventing participation in invasive species management.

Table 3. Education groups with significant p-values for the preventative behaviors, acquired from ANOVA and a Tukey's post hoc HSD test.

Education groups	p-value
Pruning	
High School vs. Bachelor's	<0.001
High School vs. Graduate	<0.001
Technical vs. Bachelor's	<0.001
Technical vs. Graduate	<0.001
Firewood	
Technical vs. Bachelor's	0.009
Technical vs. Graduate	<0.001
Cutting down dying trees	
Technical vs. Graduate	0.001
Digging up infected roots	
Technical vs. Graduate	0.008
Chemical	
Technical vs. Bachelor's	0.018
Technical vs. Graduate	0.001

Table 4. Means for education groups with regard to their willingness to participate in preventative behaviors.

Behavior	High School	Technical	Associate's	Bachelor's	Graduate
Pruning*	2.4	2.79	4.00	4.36	4.69
Firewood*	2.60	1.93	4.00	3.20	4.31
Cutting down dying trees*	2.00	1.71	3.33	2.66	4.00
Digging up infected roots*	2.20	1.64	3.33	2.52	3.69
Chemical*	2.40	1.86	3.67	3.02	4.00

*represents significance

Income

Knowledge of Oak Wilt

Of the seven income groups, the group "$100,000-124,999" had the highest percentage of yes responses (Table 5). However, the groups within the income category did not initially meet the requirements of chi square testing given that there were cells with expected values of less than 5. Therefore, groups were aggregated into household income of "below $100,000" and "$100,000 and above." Following grouping, the chi square test produced a X^2 value of 0.725 and a p-value of 0.394, indicating no significant differences in knowledge of oak wilt among income groups.

Table 5. Percentages of responses with regard to knowledge of oak wilt for each income group.

Income	n	Yes (%)	No (%)
$25,000-49,000	6	0	100
$50,000-74,999	25	31.6	68.4
$75,000-99,999	33	21.2	78.8
$100,000-124,999	12	50	50
$125,000-149,999	1	0	100
$150,000-199,999	17	17.6	82.4
>$200,000	2	0	100

Willingness to Participate

Significant differences exist between income groups for three preventative behaviors: “transportation of firewood”, “pruning”, and “digging up infected roots.” Post-hoc tests could not be run on the income groups given the lack of respondents within a few of the categories, but means were compared to determine which groups were more willing to participate in the five behaviors. Given the means for income groups, it appears as though higher income groups are more likely to participate than those in the lower income brackets (Table 4). However, it is interesting that cheaper behaviors such as “pruning” and “firewood” produced significant differences among income groups. It was expected that behaviors costing more, such as “cutting down dying trees” or “chemical” would produce these results, while cheaper behaviors would have less significant differences, if any at all. This can most likely be attributed to other factors preventing individuals from participating in preventative behaviors, such as lack of convenience, investment of time, and lack of resources.

Table 6. Mean values for income groups with regard to their willingness to participate in preventative behaviors.

Behavior	**$25,000-49,000**	**$50,000-74,999**	**$75,000-99,999**	**$100,000-124,999**	**$150,000-199,999**	**>$200,000**	**Did not report**
Pruning*	2.50	3.56	4.18	4.83	4.59	4.50	3.50
Firewood*	3.00	2.48	2.94	4.25	3.71	4.50	2.50
Cutting down dying trees	2.50	2.12	2.45	3.42	3.18	4.00	2.50
Digging up infected roots*	2.67	2.00	2.30	3.25	3.12	4.00	1.75
Chemical	2.83	2.40	3.00	3.50	3.24	3.50	2.50

*represents significance

Gender

Knowledge of Oak Wilt

For the gender category, males had a higher percentage of yes responses with regard to knowledge of oak wilt (Table 7). Chi square testing produced a X^2 value of 3.054 and a p-value of 0.081. The p-value was close to the threshold of 0.05, but remained insignificant in that it was still above the established alpha level. This proximity to significance indicates that gender may play a small role in knowledge of oak wilt. However, given these data, there are no significant differences in knowledge of oak wilt with regard to gender.

Table 7. Percentages of responses with regard to knowledge of oak wilt for each gender group.

Gender	Yes (%)	No (%)
Female (n=31)	12.9	87.1
Male (n=68)	27.9	62.1

Willingness to Participate

No significant differences exist between male and female respondents with regard to willingness to participate in preventative behaviors. Means for both males and females for all behaviors had a maximum mean difference of 0.51 (Table 5).

Table 8. Mean values for gender groups with regard to their willingness to participate in preventative behaviors. One response was excluded due to non-identification.

Behavior	Female	Male
Pruning	4.26	4.00
Firewood	3.52	3.01
Cutting down dying trees	2.84	2.64
Digging up infected roots	2.74	2.49
Chemical	3.13	2.93

Residents' Description of their Home Environment

Knowledge of Oak Wilt

Of the six home descriptions, "rural, mostly farmland" and "urban, trees present" had the first and second highest percentages, respectively, of "yes" responses with regard to knowledge of oak wilt (Table 9). However, the initial groups did not meet the requirements of chi square testing, nor did the aggregated groups of "trees present" versus "trees absent," preventing a determination of significant differences with regard to knowledge of oak wilt. Despite this issue, all of the groups except for "rural, mostly farmland" had a majority of its respondents unaware of the disease

Table 9. Percentages of responses with regard to knowledge of oak wilt for each group within the residents' description of their home environment category.

Description of Home Environment	Yes (%)	No (%)
Rural, mostly forested (n=15)	6.7	93.3
Rural, mostly farmland (n=5)	60	40
Suburban, trees present (n=52)	19.2	80.8
Suburban, trees absent (n=4)	0	100
Urban, trees present (n=22)	40.9	59.1
Urban, trees absent (n=2)	0	100

Willingness to Participate

Significant differences exist between home description groups for only one behavior, pruning. "Rural, mostly forested" was significantly different than "suburban, trees present" and "urban, trees present," with p-values of 0.008 and 0.009 respectively. In both cases, the "rural, mostly forested" had a lower mean (Table 10). The significant differences present solely between "rural, mostly forested" and "suburban, trees present" and "urban, trees present" can likely be explained by two factors. First, the categories with little to no tree presence had five or less respondents for each category. Based on the means of the "rural, farmland" group, it is possible that with a higher number of respondents, this group would have also been significantly different than others, given that ANOVA takes into account the number of entries for each factor. Second, "rural, forested" areas tend to have less interaction with state and local agencies, compared to individuals in the "rural, mostly farmland category." Farm owners generally come into contact with agencies such as soil and water conservation districts, where they learn of sustainable practices and other environmental issues such as invasive species. In that sense, "rural, mostly forested" areas possibly get less information regarding invasive species. These "rural, mostly forested" individuals might know of something killing their trees, but not have an explanation or a name for it.

Table 10. Means for home description groups with regard to their willingness to participate in preventative behaviors.

Behavior	Rural, forested	Rural, farmland	Suburban, trees present	Suburban, trees absent	Urban, trees present	Urban, trees absent
Pruning*	3.13	3.20	4.29	3.50	4.48	4.50
Firewood	2.53	2.20	3.23	2.75	3.62	4.50
Cutting down dying trees	2.13	1.60	2.67	2.75	3.29	3.50
Digging up infected roots	2.07	1.60	2.52	2.75	3.10	3.50
Chemical	2.47	2.00	2.96	3.00	3.48	4.00

*represents significance

Summary

After analysis and acknowledgement of the limitations of this research, it is relatively clear that questionnaire respondents, and potentially the general public, remain largely unaware of oak wilt. Furthermore, residents, for the most part, do not have a strong opinion regarding willingness to participate in behaviors that prevent the spread of the disease. On average, the public has a neutral view of these behaviors. However, significant differences exist between education and income groups, suggesting that those with higher education and larger household incomes are likely to be more aware of the disease and more willing to participate in preventative behaviors. While residents' description of their home environment relative to tree presence did have significant differences, it did not provide clear results as to whether or not tree presence may play a role in knowledge of the disease or individuals' willingness to participate in preventative behaviors. These results are significant because it means that access to higher education or larger wages can possibly invoke a more aware and involved public with regard to invasive species management. However, more research needs to be done to confirm and/or support these findings, given the aforementioned limitations of this research.

CHAPTER V

CONCLUSION

Data acquired from the questionnaire indicates that a majority of the respondents were unaware of oak wilt and did not hold a strong opinion regarding willingness to participate in behaviors that prevent the spread of the disease. Therefore, it may be that the population within Grand Traverse County (GTC), Michigan, is largely unaware of the disease and is unlikely to participate in behaviors that prevent the spread of the disease. This presents problems for invasive species management programs. An ignorant public can and will continue to spread the disease, either directly through actions such as transport of infected firewood, or indirectly, through complacent behavior, such as keeping infected and/or dead trees on their property.

It should be noted that while the majority of participants seemed unaware of the disease, the conclusion that GTC remains largely unaware of oak wilt should be stated with a number of caveats. First, while the majority of participants did not know of oak wilt by name, a few mentioned a disease killing trees. Furthermore, anecdotes from others not questioned mentioned something similar. It is very possible that these individuals know there is a problem affecting their oak trees, but do not fully know of the disease's existence or threat to the landscape. On a separate note, limitations with regard to data collection, such as possible spatial bias and collection from similar demographic groups, could have led to skewed results in which the majority of respondents were unaware.

Despite the majority of residents not knowing of the disease and not having particularly strong opinions, on average, of participating in preventative behaviors, there were significant differences among education and income groups. These differences can ideally help governmental agencies and local environmental groups in their outreach and education efforts. For example, given that lower income groups were less willing to participate in the behaviors, agencies or environmental groups could possibly provide aid or create programs to help these individuals with the more-costly behaviors. Furthermore, education events could be hosted at high schools and technical colleges to increase the understanding of invasive species and subsequently get residents to be more involved in invasive species management.

Given the limitations previously discussed with the questionnaire, it is necessary that future studies investigating the perception of invasive species address the issues encountered with this research. It is recommended that the questionnaire be limited to a single page, rather than front and back. In many instances participants were annoyed with the researcher for having to respond to so many questions. Furthermore, many of the questions confused participants, such as questions 6 and 7 (Appendix A). This could be addressed by doing a pilot study earlier on with a draft questionnaire, to determine whether or not individuals can understand what is being asked of them and whether or not they are willing to participate in the study. Additionally, more time should be spent collecting responses, and the surveying process should be conducted at different times throughout the week, as three weekends during GTC's peak recreation season did not lend itself to a high response rate. Finally, alternative methods of surveying the population should be enacted. Despite being courteous of residents' time, explaining the purpose of the research, and having a Western Michigan University shirt on to make it clear the state was not involved, residents were not interested in talking to the researcher. Therefore, it is recommended that future research find another avenue for collecting responses, such as approaching individuals in public, rather than a personal setting like their home.

Despite this study's limitations, it appears that the majority of GTC is unaware of oak wilt and education plays a role in awareness of the disease. However, it remains to be seen whether or not tree presence and/or abundance on residents' property contributes to knowledge of oak wilt or individuals' willingness to participate in preventative behaviors. Therefore, future research should address the possible effects of tree presence, disease presence, visible damage, and/or tree abundance within a resident's home environment on their awareness of invasive species, specifically those afflicting native tree species.

It is not known whether individuals within GTC were simply uninterested in sharing their time or if they were apathetic to something environmentally related. Regardless, their apathy leaves this researcher with two questions: Are people turned off by the idea of participating in menial actions related to the environment? Can researchers create an accurate depiction of the public's perception regarding invasive species, given such a lack of response noted in this research?

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APPENDIX A

Questionnaire

WESTERN MICHIGAN UNIVERSITY

Department of Geography
College of Arts and Sciences

CONSENT FORM

You are invited to participate in a Western Michigan University research project entitled "Understanding Individuals' Perceptions of Oak Wilt and its Implications for Invasive Species Management". The study is designed to analyze whether or not the public understands the threat of oak wilt and their role in its management. Information may help government and non-profit, environmental groups understand what residents know about oak wilt and its management. The study is being conducted by Dr. Lisa M. DeChano-Cook and Mr. Matthew W. Morrissey from the Department of Geography of Western Michigan University. The research is being carried out for part of the thesis requirements for Mr. Matthew W. Morrissey and will be completed in April 2019.

The attached questionnaire will ask you questions regarding your demographics, understanding of oak wilt, its management, and your willingness to participate in certain behaviors. There are no risks associated with completing this survey and you will be given a WMU geography department pen and oak wilt brochure for your time. Your participation will add to the knowledge base of public's perception of invasive species and their management.

Your responses will be completely anonymous, please do not put your name or address anywhere on this form. You may choose not to answer any question by leaving the question blank. If you do not want to participate in the survey, please tell the researcher and return the survey. Returning the completed survey indicates your consent for the use of the answers you supply. If you have any questions, you may contact Dr. Lisa M. DeChano-Cook at (269-387-3536 or lisa.dechano@wmich.edu), Mr. Matthew W. Morrissey at (703-473-4365 or matthew.w.morrissey@wmich.edu), the Human Subjects Institutional Review Board (269-387-8293) or the vice president for research (269-387-8298).

This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB) as indicated by the stamped date and signature of the board chair in the lower left corner. Subjects should not participate in this project if the stamped date is more than one year old.

Contact Information:

Dr. Lisa DeChano-Cook
1903 W. Michigan Ave. MS 5424
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Human Subjects Institutional Review Board
1903 W. Michigan Ave. MS 5456
Kalamazoo, MI 49008-5424
PH: 269-387-8293
E-mail: research-compliance@wmich.edu

Office of the Vice-President for Research
1903 W. Michigan Ave. MS 5456
Kalamazoo, MI 49008-5424
PH: 269-387-8293
E-mail: ovpr-info@wmich.edu

Survey Code: _____

Western Michigan University
H.S.I.R.B.
Approved for use for one year from this date:

MAR 19 2018

X
HSIRB Office

Wood Hall, Kalamazoo, MI 49008-5424
PHONE: (269) 387-3410 FAX: (269) 387-3442

Survey Code:_____

Understanding of Oak Wilt Questionnaire

1. Which of the following best describes your housing location:
   ___Rural, mostly forested
   ___Rural, mostly farmland
   ___Suburban, trees present frequently (sidewalks lined with them, local forests, etc)
   ___Suburban, trees mostly absent (a few here or there)
   ___Urban, trees present frequently (sidewalks lined with them, local forests, etc)
   ___Urban, trees mostly absent (a few here or there)

2. Have you heard of Oak Wilt? (*If no proceed to #7*)
   ___Yes ___No

3. Is there oak wilt in Grand Traverse County?
   ___Yes ___No

4. If yes, how did you learn of Oak Wilt?
   ___From your community ___Newspaper ___Online
   ___Personal experience ___Public event
   ___Fliers
   ___Other, please specify___________________________

5. Have you/family/friend experienced oak wilt personally? Briefly describe the situation where you/family member was personally impacted

6. To the best of your ability, briefly describe what oak wilt does to oak trees and the effect it can have on the landscape (backyard, greenspaces, local forests, etc)

7. Please rank the following reasons for why you'd be unwilling to participate in behaviors that prevent the spread of oak wilt (1 most important, 4 least important)
   ___Lack of convenience
   ___Cost of treatment
   ___Unaware of how to help
   ___No interest in oak wilt or its impacts

8. Regardless of whether you've heard of oak wilt, how likely are you willing to engage in the following behaviors that prevent the spread of oak wilt on a scale of 1 (very unlikely) to 5 (very likely)

Behavior	**Very Unlikely**	**Unlikely**	**Neutral**	**Likely**	**Very Likely**
Avoiding the pruning of trees during certain times of the year	1	2	3	4	5
Buying treated firewood when traveling to campsites, instead of bringing your own	1	2	3	4	5
Cutting down dying trees on your property and chipping/burning them on site	1	2	3	4	5
Digging up infected oak roots and disconnecting the root system	1	2	3	4	5
Using a chemical fungicide treatment on infected oaks	1	2	3	4	5

9. Gender:
_Male ___Female ___Other

10. What is your occupation?
___Education (teacher, educational admin., college professor, etc)
___Professional (doctor, engineer, CEO, lawyer, etc)
___General/Technical (construction, plumber, driver, chef, etc)
___DNR (Department of Natural Resources) or other state employee
___Self-employed
___Retired
___Homemaker
___Student
___Unemployed
___Other, please specify_____________________________

11. Highest education level:
___Less than high school ___High school or GED

___Technical/vocational degree

___Associate’s degree

___Bachelor’s degree

___Advanced degree beyond Bachelor’s

12. Approximate annual household income, before taxes?

___Less than $25,000

___$25,000 to $49,999

___$50,000 to $74,999

___$75,000 to $99,999

___$100,000 to $124,999

___$125,000 to $149,999

___$150,000 to $199,999

___Greater than $200,000

APPENDIX B

HSIRB Approval Letter

WESTERN MICHIGAN UNIVERSITY

Institutional Review Board
FWA00007042
IRB00000254

Date: March 19, 2018

To: Lisa DeChano-Cook, Principal Investigator
Matthew Morrissey, Student Investigator for thesis

From: Amy Naugle, Ph.D., Chair Amy Naugle

Re: HSIRB Project Number 18-03-13

This letter will serve as confirmation that your research project titled "Understanding Individuals' Perceptions of Oak Wilt and its Implications for Invasive Species Management" has been **approved** under the **exempt** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may **only** be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., ***you must request a post approval change to enroll subjects beyond the number stated in your application under "Number of subjects you want to complete the study***)." Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: **March 18, 2019**

Office of the Vice President for Research
Research Compliance Office
1903 W. Michigan Ave., Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276
WEBSITE: wmich.edu/research/compliance/hsirb

CAMPUS SITE: 251 W. Walwood Hall

APPENDIX C

Oak Wilt Brochure

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FOREST, MINERAL AND FIRE MANAGEMENT

OAK WILT

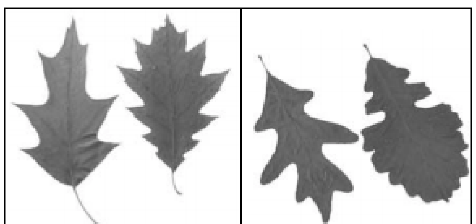
This information is provided by Michigan State University Extension and the Michigan Department of Natural Resources

Oak wilt is a disease that infects and kills ornamental and forest oak trees. In recent years, oak wilt has expanded dramatically and is found throughout Michigan.

It is easier to prevent oak wilt than to eliminate it once it becomes established. In Michigan, foresters, firewood cutters, landscapers, utility and road commission crews and others who work around trees need to be familiar with oak wilt and how to prevent it from spreading.

What is Oak Wilt?

Oak wilt is a tree disease caused by a fungus that plugs the water-conducting system of oak trees. To block the spread of the fungus, trees produce gums and resins which also plug the system, causing infected trees to die quickly.



Oak wilt is mainly a problem of red oak trees.

This group includes northern red oak, black oak and pin oak. Red oaks will die within a few weeks after becoming infected. White oaks are more resistant and the disease progresses more slowly.

How Does Oak Wilt Spread?

Diseased trees pass the fungus to adjacent healthy trees through root grafts. In addition, the fungus can be carried to new areas by sap-feeding beetles, which move spores from infected trees to freshly-wounded healthy trees.

Oak wilt, like gypsy moth and other exotic forest pests, can also be moved in firewood. Infected firewood can form spore-producing pads under the bark which attract sap-feeding beetles. Beetles feed on these pads and transfer oak wilt spores to healthy trees, sometimes several miles away. Healthy trees become infected when the spores enter through fresh wounds in the bark.

Preventing Oak Wilt

Wounding a red oak tree between April 15th and July 15th can lead to oak wilt. Wounding may be accidental (e.g. lawnmowers), intentional (e.g. pruning live branches) or weather-related (e.g. wind storms). While fresh sap is only attractive to sap-feeding insects for several hours after a wound occurs, the beetles are numerous and widespread during this period and the risk of oak wilt being transferred is high.

Fortunately, prevention is easy - do not injure or prune oak trees between mid-April and mid-July. Remember, once a tree becomes infected, the fungus will spread to nearby oak trees through interconnected (grafted) root systems. Root grafts between oak trees of the same species are very common and can occur between trees more than 50 feet apart.

Prevention is critical. It is much easier, cheaper and more effective to practice prevention then to try to stop the disease once it is established.

Controlling Oak Wilt

Controlling the spread of the oak wilt fungus between healthy and infected trees is simple in theory but difficult and expensive in practice. The key is to stop the movement of the fungus by severing root grafts between healthy and infected trees. Removing infected trees without severing root grafts first is not effective because the fungus stays alive in the root system and can still move into healthy trees. Removing an infected tree BEFORE the root grafts have been severed can actually speed the movement of the fungus into surrounding trees.

Vibratory plows (also called cable plows) or trenchers with five-foot blades or booms are the most effective way to break interconnected root systems. The placement of these barriers is extremely important. Barriers must be placed far enough out from infected trees to ensure that the disease has been isolated in the root systems within the barrier circle. This will include trees that may not yet be infected, but are close enough to infected trees to be grafted. Trees inside the barrier circle should be removed, cut and covered with a tarp for one year to prevent beetles from reaching the spore pads.

Fungicides containing the active ingredient propiconazole (e.g. Alamo®) may be effective, but they are expensive, must be applied by a licensed applicator using special equipment, and must be used before or shortly after infection takes place.

For more information, contact:

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IC 4166-C (05/07/2003)