THE IMPACT OF CHINESE PRIVET (*Ligustrum sinense*) ON THE SURVIVAL AND RE-ESTABLISHMENT OF NATIVE PLANTS AT THE DALLAS FLOODWAY EXTENSION

Jennifer M. Barnett, B.S.

Thesis Prepared for the Degree of:

MASTER OF SCIENCE

UNIVERSITY OF NORTH TEXAS

August 2016

APPROVED:

Paul Hudak, Major Professor and Chair of the Department of Geography
Reid Ferring, Committee Member
Gary Dick, Committee Member
David Holdeman, Dean of the College of Arts and Sciences
Victor Prybutok, Vice Provost of the Toulouse Graduate School

Barnett, Jennifer M. *The Impact of Chinese Privet (*Ligustrum sinense*) on the Survival and Re-Establishment of Native Plants at the Dallas Floodway Extension*. Master of Science (Applied Geography), August 2016, 75 pp., 11 tables, 7 figures, references, 100 titles.

Invasive woody shrubs are a problem when they displace native species and threaten habitats, especially those that harbor rare or endangered species. They not only compete with native plants, but also alter habitat and food that many organisms depend upon. Invasive plants undergo a release from their specialist predators in the nonnative range, providing them advantages over native species. Because modes and pathways of how invasive species spread are not fully understood, predicting spread and implementing restoration ecological controls remain inexact. Due to the lack of comparative studies on woody shrubs, especially invasive privets, we understand very little about conditions affecting their invasiveness. A study was conducted near Dallas, Texas to determine if privet has allelopathic properties that influences growth of native plants. Soil nutrients and other analyses were made and compared between field plots supporting privet, plots in which privet has been removed, and plots where privet has not been observed. In some field plots, natives were planted under the three previously mentioned conditions, and their survival and condition were monitored to evaluate effects of privet on their establishment and growth. It was found that Chinese privet did hinder seed germination in red mulberry, soapberry and beautyberry and root formation in beautyberry cuttings. The soil in the sites were found to be normal for bottomland forests that endured two flooding events within one year.

ACKNOWLEDGEMENTS

I would first like to thank my thesis advisor Dr. Paul Hudak whose office was always open whenever I ran into a trouble spot or had a question about my research or writing. He consistently allowed this paper to be my own work, but steered me in the right direction whenever he thought I needed it.

Besides my advisor, I would like to thank Prof. Reid Ferring for his insightful comments and encouragement during my research and writing. Thank you to Dr. Gary Dick for assisting me with setting up my research and collaborating with me when things did not go as planned. You were an invaluable asset.

I would also like to give my most sincere appreciation to Cullen Lightsey for helping me set up my field study. Your assistance was instrumental in the success of my experiment.

Finally, I must express my very profound gratitude to my mom, in-laws and to the love of my life, Branden Barnett, for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you. This thesis is dedicated to Dale Nabors.

TABLE OF CONTENTS

Page

ACKNOWLEDGMENTS……….…………………………………………...…………..……iii

LIST OF TABLES……………………………….………………………………………..v

LIST OF FIGURES…………………………………………..…………………………..vi

CHAPTER 1 INTRODUCTION AND BACKGROUND……….……………………………….1

Characteristics of Chinese Privet and Its Effects on the Landscape: A Literature Review…...3
The Effects of Chinese Privet on Plant Communities………..……………………………..…4
Chinese Privet Effects on Animal and Insect Communities…………………………………...7
Chinese Privet Impacts on Soil Nutrients……………………………………………….....….9
Flooding in Bottomland Forest………………………………………………………….12

CHAPTER 2 Effects of Chinese Privet Allelopathic Properties on Native Species……………15

Study Area…………………..…………………………...……………………………..16
Methods…………….….……………………………………………………………..……18
Results...………………………………………………...…………………………23
Discussion.………………..……………………………………..………………………28

CHAPTER 3 CONCLUSION………………………………..…………………………..…39

Limitations.………………..……………..………………..…………..……………………..40
Further Research……………………………………………...……………………………42
Implications for Management……………………..……………………………………..43

REFERENCES……….…………………………………………………………………….68

LIST OF TABLES

Page

1. List of bee species found in Hanula and Horn (2011) 2006 and 2007 study…………44

2. Initial soil moisture readings for the twenty-four field plots……..…………………..…47

3. Summary of plant species found in the Dallas Floodway Extension forested area......47

4. Soil nutrients data……………………..……………………………………………….48

5. Effects of Chinese privet extract on seed germination………………………………..50

6. Chi Square test for Independence of seed germination……………………………….51

7. Cuttings experiment data……………...……………………………………………….51

8. Chi square test for Independence for cuttings experiment…………………………….52

9. Plant survival in field experiment data………………………………………………..52

10. Air temperature of field sites …………………………………………………………..58

11. Amount of precipitation in field sites…………………………………………………..58

LIST OF FIGURES

Page

1. Map showing location of forested area……………………………………………….59

2. Image depicting location of the four sites…………………………….……….…59

3. Illustration of planting pattern……………………………..………………………….60

4. Constrained Correspondence Analysis on soil nutrients…………………….….……60

5. Graph of soil nutrients data…………………………………………………………62

6. Image of litter under Chinese privet shrub…………..………………………………66

7. Images of early successional plant species in infested plots………………..………..67

CHAPTER 1

INTRODUCTION AND BACKGROUND

Invasive plants are a problem when they displace native species and threaten sensitive habitats that possibly harbor rare or endangered species. They not only compete with native plants but also can destroy habitat, food and protection many organisms depend on (Rodewald 2011). Invasive plants undergo a release from their specialist predators in the nonnative range allowing them advantages over native species. As a result, they are able to reproduce with fewer limits and eradication is particularly challenging especially in forested areas. Colonization is usually small, consisting of one or two plants which are easily concealed in the array of plants found in forested areas. Even with monitoring, the initial colonization is difficult to detect due to the terrain and the amount of area that needs to be covered. Modes and pathways of how invasive species spread are not fully understood making prediction impossible and controls tough to implement.

One of the most difficult and hardest to detect invasive species is Chinese privet (*Ligustrum sinense.*). It was brought to the United States in the 1800s from Southeast Asia as an ornamental bush and escaped captivity with the help of birds and mammals. Although considered invasive, Chinese privet may be important to northern bobwhite in the winter when other food sources are scarce. Deer also browse Chinese privet and can make up 40% of a white tail deer's diet (Munger G. T., 2003). The seeds travel long distances in the digestive tract of birds and other mammals making the invasion hard to trace, allowing Chinese privet to move into open niches in a habitat. It has dispersed from Massachusetts down to Florida and over to Texas with very few limitations. Once established, Chinese privet creates a monoculture (Chinese privet-only understory) by forcing out native plants in once open forest canopy near disturbed areas. It suppresses native plant seedling growth by shading out and out competing the native plants causing a decline in the native plant population (Greene & Blossey, 2012).

The majority of research on Chinese privet has examined dispersal, management and growth. A very few papers have hinted at Chinese privet releasing allelochemicals and its possible soil legacies as part of its competitive advantages over native species. Chinese privet has also been shown to increase decomposition rates by increasing the amount of nitrogen fixation in the forest litter. Other studies of co-occurring invasive woody shrubs have demonstrated that Chinese privet does impact soil composition, but how it impacts the soil has not been identified (Kuebbing et al., 2014). Some investigators have suggested that Chinese privet may leave legacy or long-term effects in soil that need to be addressed during land management (Kuebbing et al., 2014). Research into allelopathy, negative soil feedback and alterations to mycorrhizal communities as possible explanations for native plant diversity decreases in invasion areas should be addressed (Greene & Blossey, 2012). Allelopathic properties of Chinese privet have been tested using radish and tomato seed, but its effects on native plant species have not been determined (Willard and Hardig 2013; Pokswinski 2008).

Biological attributes of invasive species interacting with the landscape can result in particular patterns of invasion such as nutrient, light and disturbance requirements that can aid managers in decisions on how to monitor or control invasions (Minor & Gardner, 2011). Due to the lack of comparative studies on shrubs, especially Chinese privet, we understand very little of the attributes that determine their invasiveness. My experiment was to determine if Chinese privet has an effect on germination and growth of a selected set of native vegetation and if the presence of Chinese privet altered soil nutrients on the Trinity River Trail in South Dallas Texas. First, I looked at the effects a Chinese privet invasion has on soil nutrients by conducting soil quality tests looking at the nitrogen, phosphorus, potassium and pH levels in the soil before the Chinese privet was removed and after its removal. Secondly, I removed the Chinese privet from an area and planted native plants to determine if there were any lasting effects from the Chinese privet invasion on native plants. The third experiment was a bioassay to determine what part of the Chinese privet plant might contain allelopathic chemicals that could affect germination or growth of selected native species.

Characteristics of Chinese Privet and Its Effects on the Landscape: A Literature Review

Chinese privet was introduced to the United States in the 1800s as an ornamental, evergreen woody shrub due to the size of the plant and its use in cut-flower arrangements and hedges (Natural Resources Conservation Services, 2003). There are 12 known species of privet found the United States, three of which are still sold in nurseries today. Chinese privet has been reported in Virginia down to Florida and west to Kentucky, Missouri, Oklahoma and Texas. It has also been reported in Massachusetts, Puerto Rico and Oregon (Munger 2003). Chinese privet can be identified by the simple, opposite positioned leaves and white flowers in dense panicles. The fruits are closed fruit containing one to four seeds and can last from July to March (Maddox el al., 2010). They turn a blue-black during the winter months and are used as a food source for deer, other mammals and birds when their primary food sources are scarce (Maddox et al., 2010).

The most common way of managing Chinese privet is to mechanically remove the plant. This can be achieved by hand pulling seedlings or hand falling mature plants (Munger, 2003). When hand pulling, it is important to remove all of the root system or sprouting will occur from the remaining roots. Hand falling the plant as close to the ground as possible is not enough; an herbicide must be used as well to reduce sprouting from the remaining stem and root system. Both of these methods can reduce seed production and with regular monitoring can eradicate Chinese privet.

The Effects of Chinese Privet on Plant Communities

The ability of native species to have effective seed germination is key in the continuance of native species. The ability of Chinese privet to effectively slow or stop germination can hinder native plant diversity and eventually produce a monoculture of Chinese privet (Hart & Holmes, 2013). Without the production of new seedlings forests will become shrub habitat in just a few generations. Riparian areas are particularly vulnerable to invasion by alien plants due to frequent disturbances from flooding that favor high species richness (Hood & Naiman, 2000; Hulme & Bremner, 2006; Planty-Tabacchi et al., 1996; Pysek & Prach, 1993). These areas are important due to the ability to control water flow, nutrients, and sediments into streams and stream corridors enabling species movement (Hood & Naiman, 2000). Chinese privet is the one of the primary causes of native species diversity and abundance decline in infested riparian areas and the increasing amounts of infestation results in declining abundance of trees (Merriam & Feil, 2002; Hanula et al, 2009; Greene & Blossey, 2012). Five years after the removal of Chinese privet in the Oconee River watershed in northeastern Georgia, Hanula et al. (2009) found 1% reinfestation of privet seedlings in the herbaceous layer of removal plots and the reinfestation had gone up to 3% in hand fell plots and 7% in mulched plots. None of the Chinese privet found was large enough to be considered a shrub and the few remaining were missed in the initial treatment. This suggests control following one removal can last at least five years (Hudson et al., 2014). The restoration of plant communities to pre-invasion condition is probably not feasible

(Richardson et al., 2007), but recovery of a native vegetation community is possible. Native plant recovery and secondary succession in the cleared plots increased by 10% in mulched plots and 20% in hand fell plots in the 2009 survey from originally measured in 2007 (Hanula et al., 2009). Woody saplings cover increased in the five years after, including species such as box elder (*Acer negundo*), sweet gum (*Liquidambar styraciflua*), and green ash (*Fraxinus pennsylvanica*) (Richardson, et al., 2007). An abundance of species with pioneer traits, like early successional colonization, is the key to recovery and early resistance to reinvasion (Hughes et al., 2012).

Most research on invasive species look at plant diversity in invaded and uninvaded areas, before and after removal of the invasive plant, but fail to look at other biotic and abiotic factors that may play a role in the decline of native species in that habitat (Greene & Blossey, 2012). Some of the other factors include but are not limited to light reduction, competition, and allelopathy. Allelopathy (allelopathic/allelochemicals) is the beneficial or harmful effects of one plant on another plant, from the release of biochemicals from plant parts by leaching, root exudation, volatilization, residue decomposition, and other processes in both natural and agricultural systems (Ferguson et al., 2003). The most common effects of allelopathy are reduced seed germination and seedling growth. Allelochemicals can be found in flowers, leaves, leaf litter and mulch, stems, bark, roots, soil and soil leachates that can vary over a growing season. It can also remain in the soil affecting neighboring plants and successional plants.

Allelopathy

Allelopathy and competition effects are greater in forest communities due to the amount of biomass and root layers each species contains (Pellissier et al., 2002). The lowering of seed germination can have negative impacts on recruitment for native species. Seedlings are vulnerable to various abiotic and biotic factors once they use the limited resources within the seed. They then must exploit external resources in competition with other plants causing high mortality rates. Stable populations are maintained if one reproductive individual is replaced by one successfully recruited offspring (Eriksson & Ehrlen, 2008). Any restriction of the successful recruitment of offspring into the natural history of a species has the potential to alter community dynamics by changing composition and abundance of plant communities (Canham, 1990; Fulton, 1991). These limitations may operate at different spatial and temporal scales (Leak & Graber, 1976).

There have been few studies researching the possibility of Chinese privet containing allelopathic properties. Grove and Clarkson (2005) observed a limited number of species growing under Chinese privet canopies and conducted a preliminary experiment using leaf leachate and radish seeds. The seeds were germinated in sealed dishes, half with distilled water and the other with the leachate. Germinating seeds were counted after four days and 90% of the control had germinated where only 80% of the treated seeds germinated. Mean root lengths for the treated seed were also lower than the control.

Pokswinski (2008) used 1%, 2%, 3%, 4% and 5% concentrations of leaf and root extracts in his bioassay. He used four treatments: 1:1 of leaf/root mix, just leaves, just roots and control consisting of plain water. He used sand potting medium and fifty tomato seeds per dish. The seeds were then placed in a south facing window for 13 days. Radicle length was measured and a ratio of mean control values to mean treatment values were calculated to determine allelopathic potential. It was determined that leaves and roots inhibited germination and growth in tomato seeds and seedlings. He goes on to state that major germination hindrance did not take place except in treatments of 5% concentration or greater.

Chinese Privet Effects on Animal and Insect Communities

Invasive species are a major environmental threat to both native habitats and the species that inhabit the area. Wilcox and Beck (2007) studied how density of privet affects the abundance and species richness of songbirds. It was found that abundance and species richness of songbirds were not significantly affected by the density of privet. During the winter, a greater number of birds were in the higher-density plots as compared to lower density and both abundance and species richness were passively correlated with actual privet density.

One group of insects that is effected by the presence of Chinese privet are bees. Chinese privet is widely used by European honeybees (*Apis mellifera* L.) and various studies have recorded varying results for other bees (Butz et al., 1995). Tepedino et al. (2008) found that invasive species were visited twice as much as native species, that the bees were primarily generalists, and that over time invasive plants will increase the carrying capacity of the ecosystem for generalist pollinators. Bartomeus et al. (2008) theorized invasive plants act as pollinator super generalists, though they warned it could alter the structure of the plant-pollinator network. Others have noted the presence of invasive plants can affect the reproductive success of native plant species (Grabas & Laverty, 1999; Brown & Mitchell, 2001; Brown et al., 2002; Ghazoul, 2004; Aizen et al., 2008; McKinney & Goodell, 2010; Munoz & Cavieres, 2008; Traveset & Richardson, 2006; Vanparys et al., 2008). Hanula and Horn (2011) found that removing Chinese privet resulted in large increases in bee abundance and diversity. Some of the most common species captured were *Augochlora pura* (blue-green sweat bee), *Augochlorella aurata* (blue-green sweat bee), *Ceratina calcarata* (small carpenter bee), *Lasioglossum (Dialictus) bruneri* (dark sweat bee) and *Andrena violae* (mining bee) (Table 1). The results from their study demonstrated that mature, closed canopy riparian forests have diverse and abundant native bee communities that are almost completely excluded when the understory is infested with Chinese privet. They noted shrub removal alone and fire treatments alone had no effect on pollinator communities. The combination of the two treatments resulted in some over story tree mortality and a reduction in live tree basal area. This reduction of basal area was correlated with an increased herbaceous plant cover and increasing pollinators (Hanula 2011).

Beetles (*Coleoptera*) are also affected by Chinese privet. Ulyshen et al. (2007) sampled beetles at 0.5 and ≥15 m above the forest floor in the Oconee National Forest's Scull Shoals experimental forest in Oglethorpe County, Georgia. Their study showed richness was similar between the two heights and diversity was significantly higher near the ground. Ulyshen et al. (2010) did a follow up study in the same area where they removed the Chinese privet found in the previous study. They mechanically removed privet, leaving a layer of mulch; hand removed privet, leaving cut piles; and removed none in the forested area. Beetles were then trapped using flight intercept traps set at 0.5, 5 and 15 m above the ground. It was found that removing Chinese privet, particularly by machine, increased the richness and diversity of beetles near the ground but not in the forest canopy. In the 2010 study, Ulyshen et al. found significantly fewer beetle species near the ground in control plots than at 5 or 15 m above the ground. Removing the Chinese privet increased beetle richness near the ground, resulting in similar vertical distribution patterns to those observed in forested areas devoid of Chinese privet (Ulyshen et al., 2010).

Butterflies are considered a flagship taxon for invertebrate conservation and the plight of the butterfly is of concern to entomologists and others (New et al., 1995). Factors effecting butterfly decline are human activities such as pesticide use, urbanization, intensive forestry, agriculture, and introduction of exotic species (New, 1997; Wagner & VanDriesche, 2010). Of exotic species, invasive insects, diseases and plants are becoming recognized as serious threats.

Hanula and Horn (2011) used mechanical, hand fall and no removal of Chinese privet as three treatments in a study conducted in the Oconee River watershed in northeast Georgia. Butterflies were sampled using pan traps filled with 70% alcohol. It was found that the removal of Chinese privet had significant impacts on butterfly abundance and community composition. Two years after the removal, butterfly communities were more diverse, abundant and distinctly different than untreated control plots. The mechanical removal method had 70% herbaceous cover and the hand fall method had 40%. The elimination of invasive shrub layers benefited butterflies and other flower visiting insects

Chinese Privet Impacts on Soil Nutrients

Invasive plant species have been shown to alter timing and quality of nutrient availability in forested ecosystems due to changes in the litter chemistry produced and the timing of senescence (Ehrenfeld, 2003). Studies on nitrogen cycling and the effects of nitrogen on growth and mineral composition of Chinese privet have shown that it is effective at using nitrogen (Kuebbing et al., 2014; Mitchell et al., 2011; Stratton et al., 2001). Nutrient availability patterns can be altered by increased concentrations of nitrogen causing rapid mineralization of the nitrogen, and depending on environmental conditions, decay can be stimulated, slowed or remain the same (Mitchell et al., 2011). Mitchell et al (2011) used nylon litterbags with 6 mm openings in the top and 1 mm openings in the bottom containing 20 g of air dry leaf litter. The litter consisted of sweetgum, hickory, red maple, elm, yellow poplar, hophornbeam, oak species, sycamore, black walnut, black cherry and Chinese privet concentrations ranging from 0 to 17.1%. It was determined that Chinese privet increased decomposition rates and the more Chinese privet present in the litter bag, the higher the decomposition rate increased. Chinese privet has a very low lignin to nitrogen ratio and low carbon to nitrogen ratios making it easily decomposed. The low carbon to nitrogen ratio stimulates nitrogen mineralization rather than immobilization increasing the rates of carbon and nitrogen cycling in nitrogen-restricted systems. With the increase in litter decomposition, there can be change in the carbon sequestration of riparian forests though it is unknown how. Net primary production (NPP) increases with the increased presence of Chinese privet. Even at low occupancy, Chinese privet changes the forest floor dynamics (Mitchell et al., 2011). It was found that when Chinese privet comprises 30% of the litter fall in an area, there is an increase carbon turnover rate by a factor of 2.6. There is a decrease in carbon storage due to the increased decomposition with an increased input from Chinese privet. Mitchell et al. (2011) also showed that Chinese privet enhances nitrogen availability and nitrogen microbial immobilization, stimulating plant growth and decomposition rates. With a rise in nitrogen microbial immobilization, there is an escalation in nitrogen retention and increased sink activity. The occurrence of Chinese privet modifies both nitrogen and carbon cycling (Mitchell et al., 2011). The preceding investigators studied effects of Chinese privet on soil, but none have studied its long-term effects on the tessera (ecosystem component) after removal of the privet.

The importance of soil quality and potential changes caused by invasive species such as Chinese privet cannot be overstated. Soil quality affects the soil's ability to function as a living organism to sustain plants, animals and humans. Good soil quality regulates water, sustains plant and animal life, filters and buffers pollutants, cycles nutrients and provides stability and support for plant roots. There are numerous ways to assess soil quality. Some of the more common assessments are measuring soil organic matter to determine how well the soil retains nutrients, how fertile the soil is, the structure of the soil, and how fast the soil erodes. Conducting physical measurements on the soil measures the bulk density of the soil, infiltration rates of water entering the soil, the soil structure and macropores, the horizon depths, and how much water it will retain. Conducting chemical testing on the soil measures the conductivity of the soil, how much reactive carbon and nitrate are present, pH, amount of extractable potassium and carbon, plus the thresholds of biological and chemical, plant and microbial activity and available nutrients and nitrogen in addition to potassium loss potential. The pH of the soil determines how acidic or basic the soil is. The optimal pH for growth of plants is between 5.0 and 8.5. If the soil is too acidic, then it can become toxic reducing the soil microbes' activity. If the soil is too alkaline, basic, then the soil may have deficient micro-nutrient availability (LaMotte Company, 2011). The biological aspects of the soil can be observed to define the amount of earthworms, carbon and nitrogen microbial biomass, particulate organic matter, nitrogen that is potentially mineralizable, enzymes, respiration and total organic carbon present.

Nitrogen is essential for amino acids, nucleic acids, enzymes and many vitamins used in almost all biochemical processes that sustain plant life. It is a component of chlorophyll in plants and encourages the use of phosphorus, potassium and other nutrients in the soil. An overabundance of nitrogen can cause delayed maturity, weakened stem and excessive foliage growth with very little reproduction. Nitrates are the most readily absorbed nutrient by plants, it aids in tissue development and disease resistance. Nitrites are a middle step when producing nitrates allowing for just a little to remain in the soil, though, excess nitrites are toxic to plants (LaMotte Company, 2011). Phosphorus assists in healthy growth and cell activity. It encourages root development by increasing the rate of maturity of the plant. It also aids the plant in the resistance of disease with no negative effects if there is excess in the soil (LaMotte Company, 2011). Potassium is required to stabilize the plants pH at 7 to 8 to assist in optimal enzyme reactions and it also facilitates the activation of enzymes for plant growth. It regulates the opening and closing of stomata for respiration and produces a gradient in the roots for the uptake of water. Potassium is a key component in photosynthesis, activating enzymes that regulate the rate of the process. It supports transportation of sugars, water and nutrients through the plant and is also a major part of protein and starch synthesis (Better Crops 1998).

Flooding on Bottomland Forest

One of the issues with land restoration and the establishment of native species in bottomland forest is their ability to withstand flooding. Important variables affecting the ability of native species to withstand flooding are size and age of the species, timing and length of the flood and oxygen content of the flood waters (Kozlowski & Pallardy, 1997). Flooding occurring during the growing season, where root and shoot growth are predominant, can be more damaging than when the plants are dormant due to the restriction of oxygen to the roots. Also, if the flood waters cease to flow the oxygen availability to the plants is greatly reduced (Kozlowski & Pallardy, 1997). The concept of flood tolerance is difficult to define and is currently expressed using terms like “moderately tolerant” or “somewhat tolerant” (Allen et al., 2004).

There are two categories that express the plant’s tolerance to submergence. The first is Low Oxygen Quiescence Syndrome (LOQS) which is characterized by the plant’s deceleration of nonessential metabolism and lack of shoot extension to promote survival during flooding. The second category is Low Oxygen Escape Syndrome (LOES), where the plant promotes rapid shoot growth that allows some plant material to break the water’s surface to assist with gas diffusion (Iwanaga et al., 2015). The mechanism used by woody species is LOQS due to their slow growth patterns. Another challenge for species that endure flooding is rapid exposure to air once the waters recede. Free oxygen radicals can cause severe membrane damage and cell death due to the period of anoxia (Colmer & Pedersen, 2008). Flooding can also cause aerobic organisms to be replaced with anaerobic organisms causing denitrification and reduction of other minerals.

It has been determined that short term flooding (0-60 days) does cause a reduction of plant biomass in Chinese privet, but has no long term effects on the survival (Brown et al., 2000). Long term flooding (60+ days) has not been evaluated. The study by Brown and Pezeshki (2000) showed that a degradation in soil conditions during flooding promotes stomatal closure and decreases photosynthesis. Chinese privet showed morphological and anatomical changes such as leaf epinasty, leaf abscission, aerenchyma tissue, lenticel and adventitious root formations indicating the capability of Chinese privet to counter oxygen deficiency. A reduction in biomass and survival was recorded in some treatments but was not enough to warrant using flooding as a possible control for Chinese privet.

Summary

In summary, Chinese privet is a prolific seed producer able to adapt to various environments and conditions. Understanding its effects on the environments it invades is key to better land management practices and controlling the spread of Chinese privet. How it effects the soil, and how native plants respond to the removal of Chinese privet has important implications on how managers respond to infestations. When dense thickets of privet form they out compete native plants for resources and effectively produce monocultures of Chinese privet (Hart & Holmes, 2013). By removing the privet and preventing it from forming dense thickets, managers can assist the continuance of native species in the area. Another benefit to removing Chinese privet is its beneficial effect on the abundance of native pollinators compared to areas with Chinese privet present (Hudson et al., 2013). Studies have been done on different methods of removing Chinese privet. Some use fire, others cut and paint herbicides on the stubs, and others have looked at flooding to control invasion (Hanula et al., 2009; Munger, 2003; Brown et al., 2000).

The rest of this paper is organized as follows. Chapter 2 examines the possibility of lingering allelochemicals affecting native plant species once Chinese privet is removed, and which parts of Chinese privet plants (roots, leaves, stems, etc.) are more likely to affect seed germination and root formation. Data was collected and analyzed from field experiments conducted along the Trinity River Trails adjacent to the Audubon center in South Dallas, Texas to determine the potential effects of allelochemicals and the success of the reestablishment of native species. Chapter 3 is the conclusion based on the results of the analysis, limitations of the study and suggestions for further research and implications for land management.

CHAPTER 2

EFFECTS OF CHINESE PRIVET ALLELOPATHIC PROPERTIES ON ESTABLISHING NATIVE SPECIES

Invasive species are a threat to biodiversity of forests worldwide (Hudson et al., 2013). Examples of direct effects include out-competing native species for resources such as light, nutrients, space and water. They can also have indirect effects such as secreting chemicals that inhibit the establishment of native species and floral visits from pollinators, limiting propagation and biodiversity (Hudson et al., 2013). Understanding the indirect and direct effects Chinese privet has on the environment can contribute to better land management. For example, narrowing down the most effective method of removal to ensure minimal disturbance to native species in the area will allow the natives to rebound from the invasion. Understanding the legacy effects of the invasive once it is removed can determine when the appropriate time to plant native species for maximum survival is.

The purpose of this chapter is to examine the possible legacy effects of Chinese privet allelochemicals on native plant species once the Chinese privet is removed from a restoration area. To determine if the allelochemical affects native species after removal one must first remove the invasive and plant native species in its place. Further experiments were conducted to determine the effects of the different parts of Chinese privet on germination of seeds and production of roots from cuttings of those same native species. If the allelochemical is having an effect on the seed germination and root formation, but not on the native plants planted where the privet was removed, it can be expected the Chinese privet may contain allelochemical properties without any long-term effects for restoration plantings.

Study Area

Trinity River Trails is a 7 km, 4 m wide concrete, walk/bike/jog trail that connects Dallas County's Joppa Preserve/Lemmon Lake to the Trinity River Audubon Center (Fig. 1). It is home to many different animal and plant species. It is a popular spot for birding, fishing, and enjoying the outdoors. The field experiment took place in the forested area adjacent to the Trinity River Audubon Center.

The location for the field sites is a half-mile stretch adjacent to the concrete trail that runs through the forest adjacent to the Trinity River Audubon Center (Fig. 2). Dominant species in this area are sugarberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), and cedar elm (*Ulmus crassifolia*). Other species recorded in the study area are listed in Table 3 (Schad et al., 2013).

The Dallas/Ft Worth area received 10-18 cm of snow which lasted for multiple days in February 2015 and intense thunderstorms and flash flooding started at the end of April. Subsequently, multiple storms producing flash flooding occurred causing Lake Ray Roberts and Lewisville Lakes to rise above conservation pool levels. Typical rainfall for the months of March through May are 29 cm and in 2015 North Texas received 64 cm of rain for those three months, making it the second wettest spring on record (FWD Webmaster, 2016). The Dallas area received a total of 1.59 m of precipitation in 2015, equaling 176-200% more than the normal precipitation. November 2015 received 25 cm of rainfall, 263% above the normal 69 mm. November 26th and 27 received the highest total of 16 cm ever recorded between September 23 and April 24. This was the Dallas-Fort Worth area's wettest year on record. The two above mentioned lakes also received 151-175% more than their normal precipitation causing them to overflow and flood the Trinity River and its surrounding areas (FWD Webmaster, 2016).

Water levels for Lake Ray Roberts in January 2015 were -2 m below conservation pool. By June of 2015, the water level was 2 m above conservation level and as of January 2016 it was still above conservation pool level. Lake Lewisville was also below conservation level in January 2015, by -2 m, but by June it had increased to 2 m above the conservation pool, and it remained above conservation pool as of January 2016 (Water Data for Texas). The Trinity River connects both of these lakes and flows adjacent to my sites downstream of these lakes. Due to the lakes becoming filled to above conservation pool and releases being made to control high water levels in both reservoirs, the Trinity River flooded, leaving its banks and flooding my sites for an extended period of time. At its peak it reached 12 m above its normal level according to the Office of Emergency Management.

The seed germination and cuttings experiments were both conducted in growth chambers at the U.S. Army Corps of Engineers Lewisville Aquatic Ecosystem Research Facility in Lewisville, Texas. The facility is an experimental facility that supports research on biology, ecology and management of aquatic plants. It provides an intermediate-scale research environment to combine small-scale laboratory studies with large-scale field tests. The growth chambers are light and temperature controlled and are used for seed germination, seedling development, tuber/turion sprouting and algae production. They are also used in studying physiological processes such as photosynthesis and respiration (Lewisville Aquatic Ecosystem Research Facility (LAERF), 2012).

Methods

Field Study Site Characteristics

In the forested area, four sites with six plots each were chosen, three of the six plots were infested with Chinese privet and three were not. Initially, the sites were chosen by density of the Chinese privet and the presence of mature privet bushes with stems five centimeters in diameter or greater within the study area. To ensure homogeneity within the sampling sites, soil moisture, and topography were analyzed, making data collected comparable between sites. An Extech MO750 digital soil moisture meter was used to determine the moisture content of the soil. The probe was placed in the soil and the moisture content recorded. This was done within each of the infested and non-infested plots to determine if soil moisture was consistent throughout the four study sites. The average soil moisture reading was 35.62% (Table 2). Soil samples were taken from each site to determine if any changes within the soil occurred after the privet was removed. Samples were taken before the removal of the privet, February 17, 2015 and then on October 19, 2015 and March 3, 2016. These measurements were used to determine the sites with the closest characteristics to minimize variability within the study area. If the sites were not the same there could be variations in how well the native plants perform after they were planted within the Chinese privet infested and managed areas.

Field Study

A field experiment was conducted to compare survival and growth of selected native species between areas where Chinese privet had been removed and areas where infestations had not occurred. Three mature privet bushes were selected within 76 m from each other in four separate plots. Three non-infested sites or controls were chosen within 76 m from each other in the same vicinity of the infested sites. The privet bushes were removed using the hand fall method and each stump was painted with a 1:1 glyphosate: water mixture to treat the remaining stump (Hanula et al., 2009).

Each of the plots was planted with eight species of native plants from the nursery at the Lewisville Aquatic Research Facility in February 2015. These species included, soapberry (*Sapindus saponaria*), red mulberry (*Morus rubra*), persimmon (*Diospyros virginiana*), elderberry (*Sambucus sp.*), beautyberry (*Callicarpa americana*), coralberry (*Symphoricarpos orbiculatus*), mustang grape (*Vitis mustangensis*) and heartleaf peppervine (*Ampelopsis cordata*), all native to the area. All plants were grown in 4x8 in. pots and were planted with backfill from the holes dug with no added irrigation. Elderberry and heartleaf peppervine were two years old and the remaining plants were under a year old. Four locations 61 cm from the center and four locations 1 m from the center of the plot were mapped out using Figure 3's pattern to ensure plants could be located during data collection. Each species and planting location were given a number and a random number generator was used to determine the location each species was planted in within the plot. All species were planted in the rain drip of the removed Chinese privet or with in a similar circumference from the center in the non-infested plots. This ensured the plants would be affected by the allelochemicals if present in the infested plots.

Native Plant Survival and Condition

The survival and condition of each of the native plants were recorded when planted in February 2015, again in October 2015 and in March 2016 to monitor the health and survival of each plant. This assessment assisted in determining if the native plants were being affected by environmental changes due to previous occurrence of the Chinese privet.

The height and circumference of the trunk of each plant were taken during the initial planting and again during each of the two assessments to determine how much the plants grew during the study. Height was measured using a standard 25 ft. tape measure and the circumference was assessed using a standard Vernier caliper. These measurements assisted in tracking the growth of the plants over the course of the study.

S*oil Evaluations*

Soil nutrients were monitored to compare for differences between Chinese privet-infested areas and non-infested areas, and to determine if changes occurred following privet removal. Soil samples were taken from within each of the twenty-four plots at the same times the plants within the plots were evaluated. Samples were analyzed for nutrient content using a Model STH Series combination soil outfit from the LaMotte Company. The nutrients monitored were nitrites, nitrates, phosphorus, and potassium. Soil pH was also measured.

The pH of samples taken from each of the plots was determined by mixing dry sample with demineralized water and shaking until the soils was dispersed. Five drops of Soil Flocculating Reagent were added and the sample was shaken again. The sample was then allowed to settle and the clear solution was placed on two depression plates where two drops of a duplex indicator was added. The resulting color was compared against the duplex color chart to determine the type of narrow range indicator to use. Two drops of the narrow range indicator were added to the second depression and the resulting color was compared against the appropriate narrow range indicator chart to determine the precise soil pH.

Before the remainder of the soil test could be conducted, a soil extract had to be produced. This was accomplished by filling a tube with a Universal Extracting Solution. Next, the 0.5 gram (g) spoon was used to add 4 g of the soil sample and agitated for one minute. The sample was then filtered and the filtrate was used for the remaining soil tests.

Nitrates were measured by placing 1 mL of the extract on a depression plate and adding ten drops of Nitrate Reagent #1. Nitrate Reagent #2 was added using the 0.5 g spoon and the sample was stirred using a stirring rod. The sample was allowed to set for five minutes and the resulting color was compared to the Nitrate Nitrogen Color Chart and recorded in pounds per acre nitrate nitrogen. The amount of nitrite in the soil was determined by adding five drops of the soil extract to a depression plate. Then one drop of Nitrite Nitrogen Reagent #1 and one drop of Nitrite Nitrogen Reagent #2 were added. The sample was stirred using a stirring rod, and three drops of Nitrite Nitrogen Reagent #3 was added then stirred again. The sample sat for one minute then compared to the Nitrite Nitrogen Color Chart and recorded as parts per million (ppm) nitrite nitrogen.

To test for phosphorus, the soil extract was placed in a “Phosphorus B” tube and six drops of Phosphorus Reagent #2 was added then shaken to mix. Once mixed, the Phosphorus Test Tablet was added and the sample was shaken till the tablet dissolved. The sample color was immediately compared to the Phosphorus Color Chart and the results were recorded as pounds per acre available phosphorus.

Potassium was measured by filling a Potash “A” tube to the lower line with the soil extract. A Potassium Reagent B tablet were added then shaken till dissolved. Potassium Reagent C was introduced and the tube was swirled to mix. An empty Potash “B” tube was placed on the Potassium Reading Plate (a rectangle piece of white plexiglass with a solid black line down the middle) and the sample was transferred to the Potash ”B” tube until the black line was no longer visible. The amount was recorded as pounds per acre available potassium.

Seed Germination Study

Seeds from each of the field-tested native plants (beautyberry, coralberry, soapberry, red mulberry, persimmon, and mustang grape) typically propagated by seed germination were used during the germination study. The seeds were placed in petri dishes on paper towels and moistened with a 1% privet extract. Four extracts and one control were used; stem, leaf, berry, root and distilled water. Each of the four parts (10 g) were soaked in distilled water (1000 mL) for three days to produce the 1% extracts used. Four repetitions of each extract was used and each petri dish received a specific number of seeds based upon availability of seeds for each species. In each petri dish, eight beautyberry seeds, nine soapberry seeds, and eleven red mulberry, persimmon and mustang grape seeds were used. To improve germination, the persimmon, mustang grape, soapberry, and red mulberry seeds were cold stratified for 45-60 days as defined by Jill Nokes (1986). Cold stratification is the process of exposing seeds to a period of moist cold to simulate natural winter conditions that some seeds require before germination. Beautyberry were the only seeds not requiring cold stratification. Upon completion of the cold stratification the seeds were then placed in a growth chamber at 25˚C and checked twice a week for three months or until no subsequent germination occurred. During the checks the seeds that germinated were counted, removed and planted in containers using bag potting soil.

Cuttings Study

Cuttings from the plants that are not typically propagated by seed germination (elderberry, coralberry, and heartleaf peppervine) as well as mustang grape and heartleaf peppervine (can be propagated by either method) were used to assess the different 1% privet extracts on root growth. Four replications of one stem per test tube were wrapped in cotton to allow for stem swelling and suspended in one of the five treatments. The cuttings were monitored for five weeks and data was recorded for root growth (Table 7).

Statistical Analyses

A one-way parametric ANOVA with a Constrained Correspondence Analysis was used to analyze the pH and soil nutrients taken from within the twenty-four plots (twelve with privet and twelve without). Samples from the subplots of each site were analyzed for statistical significance with an α of .1 to interpret the results.

A Pearson's chi-squared test with Yates' continuity correction analysis was utilized to determine statistical significance of the seed germination/root growth within the bioassay. The chi-square was used to determine if there was a difference with in the observed distribution is due to chance and if the observed distribution fits the expected distribution. The number of germinating seeds and cuttings with root growth were analyzed to determine the statistical significance. Procedures for the statistical analyses followed Cronk (2012).

No statistical analysis was done on the plant data collected from the field sites due to the low number of surviving plants in the study. Due to the extended periods of flooding beginning two months after planting conclusions cannot be accurately drawn using statistics. Using tables and visual charts, the recorded field data and observations will be discussed instead.

Results

The results are divided into four sections. First is the field study where the privet was removed and native species were planted within the privets rain shadow. Second, is the soil samples taken from each of the plots within the four sites. The third is the bioassay where the effects of four different privet extracts were analyzed to determine if Chinese privet affects seed germination in five of the eight native species planted. The last section is the cuttings, where the effects of Chinese privet's ability to affect root production in cuttings were analyzed.

Field Study

The field study showed very little about the effects of Chinese privet on the native species planted. Soon after planting the eight species (heartleaf peppervine, coralberry, beautyberry, elderberry, persimmon, red mulberry, soapberry and mustang grape) there was a flood event that inundated all four sites with water from the Trinity River for approximately 60 days. Due to the flooding of the Trinity River and its adjacent river bottoms, my sites included, I was not able to conduct the spring assessment of the field plants. The two months of flooding caused some of my species to die while others flourished. The first data collection occurred in October 2015 with 33 of the total 192 plants survived. The 33 survivors consisted of 20 heartleaf pepper vine, seven soapberry, five red mulberry, and one persimmon. Out of the 33 that survived the spring flood event only seven were alive after the heavy winter rains for the March 2016 data collection. These consisted of five red mulberry, 1 soapberry and 1 heartleaf peppervine. One of the red mulberries and one of the soapberries counted in the March data collection were not present in the October collection. They appear to have been damaged by feral hogs. These included heartleaf peppervine, soapberry, and red mulberry (Table 9). The flooding provided an opportunity to observe the effects of flooding on the Chinese privet in the general area, which by visual estimates had declined by at least 40%, presumably due to long-term inundation.

Soil Samples

The constrained correspondence analyses for the four sites are found in Figure 4 and graphs of data are found in Figure 5. Raw data of the soil nutrients can be found in Table 4.

These nutrients are key components in a healthy ecosystem. By looking at these nutrients within the infested areas and in areas without Chinese privet, differences in soil quality were detected.

Plots within the four sites maintained a pH ranging from 7.2 to 8.4 during the course of the study. Forest areas tend to have pH ranges from slightly acidic to slightly alkaline (6.1-7.8) (Seiler & Groninger, 2009). Two of the plots, March 2a.1 and March 4.1 did not continue with this trend. March 2a.1 had a pH of 8.6 (strongly alkaline) and March 4.1 had a pH of 6.0 (moderately acidic).

Nitrates had a wide range of 10-100 lbs. per acre among the 24 plots, with all varying among the infested and non-infested plots. The nitrite levels ranged from 0-20 lbs. per acre. Where the majority of the plots had levels of 10 lbs. per acre or less, three of the plots (February 3a.2, 4.1, and 4a.3) had levels of 20 lbs. per acre or more.

Potassium levels in the plots ranged from 50-280 lbs. per acre. The levels were randomly distributed throughout the plots during the course of the study. Site 1 plot 1a.1, 1.2 and 1.3 had high levels of potassium in February and gradually decreased over the course of the next two data collections. Plot 1a.2 decreased from February to October and had increased by March. Plot 1a.3 started low in February and increased over time. Plot 1.1 had low potassium in February, increased in October and then decreased again in March. Site 2 had high amounts of potassium in the system, ranging from 50 to 140 lbs. per acre. The non-infested sites had concentrations of 100 lbs. per acre or greater and did not fluctuate much where the infested site showed some variability. Plots 2.1 and 2.2 both increased in potassium over the time while 2.3 increased from February to October and decreased in March. Site 3 plots 3.1, 3a.1, 3a.2 and 3a.3 diminished from February to October and started increasing from October to March. Plots 3.2 gradually decreased over from February to March and plot 3.2 stayed the same from February to October and decreased from October to March. Site 4 plots 4.1 and 4a.2 remained constant during the study and plot 4.3 remained constant from February to October and decreased from October to March. Plot 4.2 decreased from February to October and improved from October to March. Plot 4a.3 decreased from February to October and increased from October to March. Plot 4a.1 had an increase from February to October and it remained the same from October to March.

Phosphorus ranged from 10 to 100 lbs. per acre over the course of the study. In site 1, plots 1a.2 and 1a.3 remained constant over the course of the study. Plots 1a.1 and 1.1 increased from February to October and decreased from October to the March data collection. Plots 1.2 and 1.3 remained the same from February and October and decreased in March. Site 2, plot 2.3 remained constant throughout the study, while plots 2.1, 2.1, 2a.1, 2a.2 and 2a.3 all remained constant from February to October then decreased in March. Site 3, plot 3.2 remained constant throughout the study, while 3.1 and 3.3 decreased from February to October and remained constant through March. Plots 3a.1, 3a.2 and 3a.3 decreased over the course of the study. Site 4, plot 4a.1 remained constant throughout the study and plots 4.1 and 4.2 decreased over the course of the study. Plot 4.3 increased from February to October and then decreased again from October to March. Plots 4a.2 and 4a.3 decreased from February to October and remained constant through March.

Seed Germination

Descriptive statistics for seed germination during the bioassay are provided in Tables 5 and 6. The null hypothesis was that privet extract will hinder the germination of native plant seed.

None of the mustang grape seeds in the extracts or control germinated and were not analyzed.

The red mulberry seeds had one significant X^2 value from the seeds in the leaf extract ($X^2_{(1, N=91)}$ =3.3869, p=.06572). The soapberry seeds had two significant results, one from the leaf extract ($X^2_{(1, N=71)}$ =14.173, p=0.0001667) and the berry extract ($X^2_{(1, N=70)}$ =13.393, p=.002526). The beautyberry seeds had the most significant p-values. Both the leaf and berry extracts had X^2 values of 6.0128 with p-values of 0.0142. The root extract had an X^2 value of 4.4695 with a p-value of 0.0345. None of the remaining treatments showed significant results.

Cuttings

The cuttings that were used in this experiment were of elderberry, mustang grape, coralberry, heartleaf peppervine and beautyberry. One would expect to see lower root production from the cuttings if the extract was affecting them and high root production from the control. Raw data and statistical analyses for the production of roots from cuttings exposed to Chinese privet extract can be found on Tables 7 and 8.

None of the mustang grape cuttings in the extracts or control formed roots.

Elderberry has a successful strike (plant cutting or cloning) rate of nearly 100% (Milliken, n.d.). Elderberry strike success in the experiment was 50% in the root extract and leaf extract. Strike success was 75% successful in the berry extract and 100% successful in the stem extract and control. Coralberry is easy to propagate using cuttings (Beyl & Trigiano, 2011). Coralberry control, leaf extract and berry extract only had 25% strike success. No root growth was present in the stem extract or root extract. Heartleaf peppervine is relatively easy to propagate using cuttings. The heartleaf peppervine in the experiment had 25% strike success in the control, root extract and berry extract. In the leaf extract and stem extract, striking was 50% and 75%, respectively. Beautyberry has a 70% striking rate from soft stem cuttings. Beautyberry in the experiment had 100% success in the control with only 50% in the stem extract, root extract and berry extracts. Beautyberry in the leaf extract had no striking success. The only significant result was from the beautyberry in the leaf treatment ($X^2_{(1, N=8)}$ =4.5, p=.03389). All other treatments produced no significant results.

Discussion

Chinese privet shows some species/propagule type-dependent allelopathic effects. However, this does not appear to be great enough to prevent root germination or root production, only lowering the rate. The discussion of the results is divided into three sections. The first section discusses the effects of the removal of Chinese privet on the establishment of native plant species. The second section discusses the influence of soil nutrients and pH in the study area. Nutrients tested were nitrates, nitrites, potassium and phosphorus, all key elements in the establishment of plant assemblages. The pH of the soil was also analyzed to determine the acidity of the soil. The third will look at the ability of allelochemicals in Chinese privet to affect seed germination and rooting of plant cuttings on native species. These three experiments showed that Chinese privet may not have a significant impact on the establishment of native species once it is removed.

Influence of the Removal of Chinese privet

It has been shown that when privet is removed there is an increase in herb and tree seedlings in the next growing season (Merriam & Feil, 2002). By removing the Chinese privet, the native species are given a chance to re-colonize the area. If privet is not removed, it can become so dense the forested area may succeed to shrub land that excludes many native species (Merriam & Feil, 2002; Collier et al., 2002).

Flood tolerance of the species being planted is important when planting in a bottomland forest. Of the eight species chosen to be planted adjacent to the Trinity River only two were completely flood tolerant. These being the persimmon and elderberry. The red mulberry, soapberry and heartleaf peppervine are only moderately flood tolerant and the coralberry, beautyberry and mustang grape are not flood tolerant (Coder, 1994; Martin & Mott, 1997; Robinson C. , 2006; Natural Resources Conservation Service, 2008). The field sites were planted in February of 2015 and the first data was recorded in October.

Heartleaf peppervine had an 83% success rate in October but dropped to 4% in March. Of the 83% that survived in October, 45% established in infested plots and 41% in the non-infested, suggesting that establishment was comparatively the same for infested and non-infested areas once the Chinese privet was removed. The 4% success in March was in an infested plot. Soapberry had a 29% establishment rate in October and 4% in March. The infested plots comprised 12% of the 29% establishment rate. The Red Mulberry had an overall establishment rate of 21%. The infested plots made up 12% of successful establishment and the non-infested was 8% successful. The establishment rate remained the same for March. Persimmon had a 4% survival rate in October but had no success in March. Overall, the success of re-establishment of native species in infested plots was similar or better than those in the non-infested plots. This suggests that re-establishment of natives immediately after Chinese privet is removed is can be achieved.

The flood was one of the factors that affected the survival of the eight species planted. Few species can survive complete submersion and even less can survive for more than one month submersed. Not only are they deprived of light, oxygen, and carbon dioxide, they can be pushed over, buried in sediment or uprooted. The flood started in the beginning of the growing season which is more harmful to seedlings than during the growing season, due to the plants trying to develop new roots and shoots (Flooding and Its Effects on Trees). When trees are submerged in water for long periods of time it can have an adverse effect on growth. Of the eight species planted, six (persimmon, red mulberry, soapberry, coralberry, beautyberry and mustang grape) were under one-year-old and the heartleaf peppervine and elderberry were two years old. The four species that survived to the October were listed as tolerant or moderately tolerant of flooding. The only species that was tolerant that did not survive was elderberry. Physical damage appeared to be the cause of elderberry not surviving. All 24 elderberry plants were either covered by debris or gone all together. The age of the elderberry made the plant more ridged and easier to break under the pressure of the current and being hit by debris. Coralberry, beautyberry and mustang grape were all intolerant of flooding. Flood intolerance coupled with being under one year of age (small plants) can explain the death of all three species. None were large enough to break the surface of the water during the flood exposing them to low oxygen levels, and little light.

Of the 33 plants to survive the flood, only seven survived at the March data collection. These species were five red mulberries, one heartleaf peppervine and one soapberry. Between the October and March data collection hog presence significantly increased in the area and hogs damaged 90% of the plots within the study. Feral hogs are non-native, highly adaptable animals that cause significant ecological and economic damage in Texas. Feral hogs root up pastures and rangelands, consume native vegetation, and effect water quality. They use riparian areas as travel corridors and the presence of water and diverse plant communities concentrate feral hog activity to these areas, consuming seeds, roots, and other plant parts, reducing plant recruitment in the area. Seed consumption plus the addition of an invasive plant species that reduces seed germination, such as Chinese privet, can be very damaging to native plant communities. Hogs turn over the soil when rooting for seeds and hog defecation and urination increasing nitrogen levels (Timmons et al., 2012). Feral hogs reduce the number of large-seeded tree species, destroys vegetative ground cover and litter layers used by invertebrates and small vertebrates for cover and microclimatic conditions necessary for seedling establishment. They also encourage invasive plant invasion by disturbing the soil and alter invertebrate and microbe communities that are the foundation for stream ecosystem food chains (Timmons et al., 2012). They use the bare understory of the Chinese privet as corridors to travel and for nesting or farrowing. Chinese privet makes good cover for the hogs due to the density of the understory and how unobstructed the ground is. Having dese understory invasive species could promote the presence of feral hogs.

During the March data collection, species such as dewberry (*Rubus trivialis*), bedstraw (*Galium sp.*), and wild onion (*Allium ascalonicum*) where among the species that were recolonizing the infested sites where the Chinese privet was removed (Fig. 7). Chinese privet once removed does not seem to have any negative impacts on natural recruitment of native species in the environment. Dewberry, wild onion and bedstraw are all early successional plants, meaning they have the ability to colonize quickly after disturbance. They are characterized by high productivity and provide habitat for many disturbance-adapted wildlife species. They reproduce sees that can be widely dispersed by water, wind or animals and are disturbance adapted (Smith, 2007). Dewberry is a semi-evergreen vine that has one to three small flower clusters on lateral branches. The flowers are white five-petaled and occur in the early to mid-spring, and leaves remain dark green from late winter to early spring (Arnold, 2004). Dewberry makes up 10-25% of the diet of large and small mammals and terrestrial birds. It is also occasionally used as cover for small mammals and terrestrial birds (Miller, 1999). Wild onion is a bulbous herb that has a distinct oinion oder. It has slender grass-like leaves and reaches about 0.61 m tall when flowering in late summer. The leaves are narrow, and long with parallel edges arising from a small underground bulb. The flowers can vary in color, from white to pink,and appear at the top ofa leafless stem. The flowers become bulbets that drop off the plant and propagate. The wild onion is not typically used as a food source or cover for animal species (Wild Onion (Allium spp.), n.d.). Bedstraw is an annual weed with oblong to egg shaped cotyledons with slightly notched tips. They are smooth and range from ½ to 1 inch long. Mature bedstraw has square stems up to 1.83 m long and form dense, tangeled mats. The leaves are worled and small with downward-curved prickles. These prickles aide in the disperdal of the species. Flowers are greenish-white borne on short branches originating in the leaf axils on the upper parts of the plant (Lanini, 2010). Although allelopathy cannot be ruled out, it appears more likely that overshading was the primary factor inhibiting growth of recovering plants prior to the Chinese privet removal.

Soil Quality Before and After Chinese Privet is Removed

Chinese privet forms dense stands within the understory of bottomland forested areas and excludes native plant species drastically altering habitat and critical wetland functions (Brown & Pezeshki, 2000; Harrington & Miller, 2005; Merriam R. W., 2003). Rates of decomposition of forest litter is greatly increased by the presence of Chinese privet. Mitchell, et al., (2011) found in their study of Chinese privet's effects on nutrient cycling that both nitrogen availability and nitrogen microbial immobilization are enhanced with higher percentages of privet. Increases in nitrogen can stimulate plant growth and may contribute to more rapid decomposition rates. Higher nitrogen immobilization enhances sink activity which increases nitrogen retention. Due to the increase in nitrogen retention, the presence of Chinese privet significantly alters both the carbon and nitrogen cycling within riparian forests (Mitchell et al., 2011). Higher immobilization rates keep the nitrogen from being available for plant use. Due to the high amounts of nitrogen and lower amounts of carbon, the microorganisms in the soil require more nitrogen from the soil to decompose the carbon in organic materials, thus immobilizing the nitrogen. With this immobilization one would expect to see low amounts of nitrates in the soil. Nitrification, when restricted, causes nitrogen to be lost forming N_2 (nitrogen gas) and N_2O (nitrous oxide). It has been shown that nitrites are decomposed slowly or not at all in alkaline soils (Robinson R. H., 1923; Fraps & Sterges, 1939; Tyler & Broadbent, 1960). Substantial gaseous loss of nitrogen may occur though chemical decomposition of nitrites is based upon the fact that nitrites are the only intermediate that has been detected in studies of nitrification in soils (Nelson, 1967).

Initially, only 4 of the 12 infested plots that had high amounts of nitrites in the soil. Four of the non-infested sites also exhibited high amounts of nitrites. None of the plots showed high concentrations of nitrites in October. The random dispersal of high nitrites in the infested and non-infested plots indicates the Chinese privet was not having an effect on the soil in the area. There were the same number of non-infested sites with high nitrite levels indicating the soils dynamics are variable throughout, but not due to the presence of Chinese privet. The soil in the non-infested plots was being affected in the same way as the infested plots are.

Chinese privet is an evergreen and older leaves are replaced by newer ones regularly, due to this there is a large amount of leaf litter under the shrubs (Fig. 6). Chinese privet leaves are thought to be the main source of allelochemicals in the plant (Pokswinski, 2008). The allelochemicals in the leaves, leaf litter and those still on the plant could influence the native species ability to uptake nutrients. If the privet was having a significant effect on the immobilization of nitrogen in the environment, then one would expect a greater number of infested plots with high nitrite concentrations.

Causes of the low amounts of nitrification in the sites may be due to low soil temperatures when the samples were taken, pH and soil moisture (Table 10). Due to colder temperature nitrification is slowed down and almost completely ceases below 40˚F. This can explain the higher amounts of nitrites in the soil. In February the temperatures were not high enough for complete nitrification to occur in the system. September and March both had temperatures high enough to facilitate nitrification. It is estimated that nitrification becomes restricted when water moisture is greater than 60%. All had high enough precipitation to enable nitrification (Table 11). With the favorable conditions in October and March the nitrification rates were higher than in February were the temperatures were too low for nitrification.

Out of the 24 plots, 7 had high concentrations of nitrates, 6 of which were infested plots. Out of the six infested plots four of the concentrations were from samples collected in October. One was collected in February and the other in March. The only non-infested plot with high nitrates was in October. Flooding promotes mobilization of certain elements such as nitrogen, phosphorus, magnesium, iron, boron, copper, and zinc by altering pH in the soil (Bottomland Hardwoods Web-Based Forest Management Guide, 2009). These alterations can promote nitrification and increase the concentration of nitrates in the soil. With the flooding, the nitrogen in the soil would have been mobilized allowing for nitrification to occur, explaining the higher concentrations of nitrates in the soil in October.

February had one infested plot with high pH, October had three plots and March had five. The only plot with high pH in February was an infested plot. In October all three were infested plots and March had two infested and three non-infested plots with high pH. The pH for optimal nitrification to occur is 6.5 to 8.8. All of the plots within the study had pH within the optimal pH range for nitrification to occur throughout the course of the study. Soil acidity is important to plant nutrients due to its influence on soil organisms such as bacteria and actinomycetes and plant nutrients such as nitrogen, calcium, magnesium, phosphorus, potassium, sulfur, iron, zinc, manganese, copper, cobalt, molybdenum and boron. Soil pH can be altered by flooding, wildfires, acid deposition, and fertilizers (Seiler & Groninger, 2009). Nitrification can be either increased or decreased depending on the pH of the soil. At a pH near neutral (7) nitrification is rapid and when the pH decreases to <6 the nitrification slows (McKenzie, 2003). Phosphorus reacts quickly with calcium and magnesium in soils with pH greater than 7.5 forming less soluble compounds. In acidic soils phosphorus reacts with aluminum and iron to also produce less soluble compounds. Potassium is lost when the soil becomes more acidic (McKenzie, 2003). The pH remained comparatively the same for all the plots during the course of the study indicating the pH of the soil did not have negative effects on the nitrification of the soil.

Chinese privet's high ability to cause microbial immobilization of nitrogen in the environment suggests the carbon to nitrogen ratio would be above 24:1 to facilitate microbial growth that can't process nitrogen until the excess carbon is broken down. The microorganisms convert the inorganic nitrogen to organic nitrogen to increase microbial growth. Flooding alters how long litter is exposed to the environment, changing litter quality and increasing nitrogen in leaf litter during early phases of decomposition (Swift et al., 1979; Webster & Benfield, 1986). From the soil tests there are no long term effects on soil quality once Chinese privet is removed from the environment. Within bottomland forests soil dynamics change frequently and the broad range of the results from the soil samples demonstrate this. In my study, the removal of Chinese privet had no discernable effect on the composition of the soils in the field sites.

The Effects of Chinese Privet Extracts on Seed Germination and Cuttings

The ability of native species to have successful recruitment is important to maintaining hardwood bottomland forest. Chinese privet has the capability to inhibit seed germination in native species altering future generations of plant species. Without recruitment, bottomland forests will become dense thickets of Chinese privet once the mature native species die.

The persimmon seed were the only seeds to produce no significant results in the bioassay. The four extracts and the control had comparatively the same results. This suggests the allelochemicals in the Chinese privet do not hinder the germination of persimmon seeds. However, the concentration of the extract may not have been high enough to produce a result. Pokswinski (2008) noted from his bioassay with tomato seeds that results were significant with concentrations of 5% or higher of Chinese privet extract. In my bioassay, the concentration of Chinese privet was 1%. It remains uncertain if higher concentrations would affect persimmon seed germination.

Red mulberry, soapberry and beautyberry seeds showed significant results when exposed to the leaf extract. The average germination rates for red mulberry are 15% to 50% (Alexander, Jr., 2008). The germination rate of the red mulberry my study's control was 22%, within the normal range of germination for the species. Germination rates of the red mulberry in the leaf extract was 7%. Acid treated soapberry seeds have an average germination rate between 70% and 88% and the study control had a germination rate of 83% (Alexander, Jr., 2008). In the leaf extract, the germination rate was 36%. Beautyberry with no acid scarification treatment average germination rates are 9% (Contreras & Ruter, 2009). The beautyberry control in the bioassay had a germination rate of 40%, higher than the reported. The leaf extract had a germination rate of 10%. It has been suggested the allelochemicals within the Chinese privet are within the leaves of the shrub (Pokswinski, 2008). If this is the case, then germination of the species appears to have been affected by the allelochemical in the extract. Red mulberry, soapberry, and beautyberry all had germination rates of 15%, 47% and 30%, respectively. These were lower than the controls, showing the allelochemicals in the extracts had a negative effect on the germination of these species.

The five species used in the cuttings experiment were mustang grape, elderberry, coralberry, heartleaf peppervine and beautyberry. The mustang grape did not form any roots but did form large white nodes at the base of the stem which could be a precursor to root formation.

Effects of extracts on other species appeared to be species and/or extract-source dependent. The coralberry and heartleaf peppervine both had very low germination rates in the control, making it difficult to determine the effects the allelochemicals extracted from the Chinese privet. However, the poor striking success of these two species could be attributed to the wrong type of cutting being used. Instead of softwood cuttings, it may have been more successful if semi-hardwood or hardwood cuttings were used. The leaves that were left on the cuttings may not have produced enough energy within the cutting to allow for root formation. If the plant doesn't have enough energy for the formation of roots, then the plant will rot. This may have been the case for the coralberry (and some beautyberry) cuttings. The ones that did not produce roots demonstrated new growth on the stem and the beautyberry flowered. The bark peeled from the coralberry stem and the stems rotted in the tube. The formation of flowers on the beautyberry took up energy that could have been used for root production (Welch-Keesey & Lerner, 2009).

The extracts did have a negative effect on the root production of two species, elderberry and beautyberry. The elderberry showed a decrease in striking success in the leaf, root and berry extracts when compared to the control. The beautyberry had decreases in striking in all four of the extracts. Although, to confirm the presence of allelopathy, an allelochemical has to be identified and proven to be released by the aggressor species. Not only must it be found in the plant itself, it also needs to be found in the soil around the plant naturally in the community in high enough concentrations to alter the growth and germination of other species (Willis, 1985). Allelopathy is difficult to discern due to the many confounding effects of competition (Blum et al., 1999). The rapid breakdown of Chinese privet leaves and their ability to increase breakdown of other litter suggests possible allelochemicals retained within the leaves degrades quickly in the soil not leaving high enough concentrations for allelopathy inhibition to occur (Pokswinski, 2008).

In summary, Chinese privet allelopathic properties appeared to lower seed germination in red mulberry, soapberry and beautyberry in the leaf extract, berry extract and root extract. In the cuttings experiment elderberry and beautyberry had suppressed root growth in the leaf extract, stem extract, root extract and berry extract. Overall, the soil quality changed throughout the study as expected for a bottomland forest that was affected by a flood, with no changes attributable removal of Chinese privet. Soil dynamics changed from high concentrations of nitrites to higher concentrations of nitrates, phosphorus and potassium. This change could have been caused by the flood, or temperature affecting the rate of nitrate production. It was suggested that Chinese privet may affect the re-establishment of native vegetation once removed. This was not the case in during the field experiment. The flood and feral hog activity during the field experiment had negative effects on the field study though the natural establishment of species in the infested plots suggest Chinese privet allelochemicals did not negatively affect species recruitment in my study.

CHAPTER 3

SUMMARY AND CONCLUSION

The purpose of this study was to determine whether allelochemicals produced by Chinese privet effected the re-establishment of native species in North Texas. Soil quality was examined before and after the removal of Chinese privet shrubs to determine the effects on nutrients cycling in the area. A bioassay and cut stem experiment was also conducted to determine the effects of four Chinese privet parts (stem, root, leaf and berry) had on the seed germination and root production of native species. The third experiment was a field experiment where Chinese privet was removed and eight native species (elderberry, soapberry, coralberry, beautyberry, heartleaf peppervine, red mulberry, persimmon and mustang grape) were planted within the rain drip of the Chinese privet.

Chapter 2 outlined the effects of Chinese privet on native species re-establishment. Soil quality was expected to have high amounts of immobilized nitrogen due to privets high nitrogen concentrations. Seed germination in the bioassay and root production in the cutting experiment were expected to be hindered by the 1% extracts used. If Chinese privet had a negative effect on the establishment of native species once removed a low survival rate would be expected for native species planted.

The results showed that soil nutrients were normal for a bottomland forest with a major flood event. Experimentally, seed germination was hindered for red mulberry, soapberry and beautyberry when exposed to Chinese privet leachates. Beautyberry was the only species with suppressed striking in the cutting experiment when exposed to leachates. During the field experiment a major flood event occurred and feral hog damage made analyzing the effects of the allelochemicals on the native species impossible. Field observations did note the presence of other natives recolonizing plots with removed privet. Overall, Chinese privet did hinder some of the species in the seed germination and cut stem experiments but the concentrations were not high enough in the field study to hinder the establishment of native species, or establishment of field tested species was otherwise impacted (flooding; hog damage).

Limitations

Due to the flood and hog damage, analysis of allelopathic effects in field plantings could not be determined. The flood may have diluted the allelopathic effects, if the concentrations were high enough before the flood, to where they no longer impacted native species transplants. Feral hog presence increased after the flood and they consumed some plants while uprooting others, destroying the plots. The Chinese privet infestation had created a habitat for the feral hogs to move during high human presence and concealed farrowing nests.

Seeds in the bioassay may not have all been viable. Some may have been too old or too young. The stratification/scarification may not have been long enough or may have been too long for the species requiring stratification/scarification. If the seed coat is not weakened enough to allow the seed to imbibe water, the seed will not germinate (Evans and Blazichn.d.). If the seed is acid scarified too long the seed may be damaged and the seed will not germinate. There is a lot of variability in the literature on the length of time to scarify and stratify seeds. However, because seeds of each species were treated similarly, and treatments replicated four times, differences in germination rates were most likely due to exposure to Chinese privet extracts, not variability among seeds.

Soft or new growth cuttings were used in the cut stem experiment. The cuttings did not receive misting for the leaves to stay moist and the humidity could have dropped below 90% in the growth chamber, affecting the ability of some of the tested species to form roots. If the leaves dried out photosynthesis would have been reduced and energy production would have been hindered. Without energy produced by photosynthesis the plants would have used what little energy they had on survival and not on root formation. For instance, some of the beautyberry flowered during the experiment though the flowers bloomed and within a day or two died they used resources the cuttings could have used for root production.

A field kit was used to analyze the soil samples giving coarse readings of soil nutrients. Though readings from the La Mott Soil Kit is comparable to analytical laboratory testing there could have been discrepancies in the depth the sample was taken. The amount of sediment deposits from the flood altered the depth of the soil. Even though the samples were all taken at the same depth, the sediment may have altered the layer the sample was taken from. Another limitation to field kits are the approximate/ categorical values assigned to nutrient levels such as low, medium or high. The La Mott Soil Test Kit is one of the most accurate testing kit available (Faber et al., 2007).

The sample sizes for the bioassay, cuttings experiment and field study are all under 30 samples. Though the sample sizes are small, we are still available to make general assumptions based on the data and patterns presented in the analysis. Due to the small sample size a 95% confidence interval was used with an $\alpha = 0.1$. The confidence level for an interval determines the probability that the confidence interval produced will contain the true confidence parameter value.

Further Research

Chinese privet is a problem for most of the southern United States and with increases in temperatures may spread to northern states as well. This spread and its ability to alter ecosystems by excluding native species will greatly impact our forested areas. This study demonstrated that Chinese privet does have allelochemicals that can effect seed germination though the allelochemical may not be present in high enough concentrations to hinder native plant establishment from transplants. The allelochemical in Chinese privet needs to be identified and how much Chinese privet excretes needs to be determined. The amount that reaches the soil needs to analyzed and how long it stays in the soil needs to be examined as well.

An examination on how much northern bobwhite quail depend on Chinese privet for cover and food sources needs to be better examined in Texas. Land use practices have been altered to help support bobwhite quail in Texas in the attempt to assist the populations' persistence. Bobwhites prefer mixtures of grassland, cropland, brushy areas and woodlands making Chinese privet infested areas good for escape cover, loafing, and winter protection. Bobwhite quail survival is reduced with the lack of heavy cover, the removal of Chinese privet in areas where bobwhite quail nest may cause the population to become extirpated in the area (Bobwhite Quail Management, n.d.). One potential solution to this problem is to ensure that native vegetation is restored in areas where Chinese privet is removed.

How Chinese privet affects the presence of other invasive species such as feral hogs can give insight into how both invasive species facilitate each other's presence. Chinese privet offers cover and food while the feral hogs assist in the spread of privet by disturbing the area and eating the privet fruits. By controlling Chinese privet, controlling feral hog presence in established ranges may be more manageable. Feral hogs survive, adapt and populations increase despite attempts at population controls, by controlling invasive cover and food sources may be a way to control hog populations.

Biological controls for Chinese privet is an area that needs more research into the effects the controls will have on the native species in the area. Selecting an agent that attacks the flowers or seeds of the plant effectively suppressing the reproduction of the plant could assist in keeping the shrub from being spread by birds and mammals. Because other controls are uneconomical and can be environmentally disruptive, finding a biocontrol agent may be a solution to the thick, hard to manage infestations (Cuda & Zeller, 2006).

The effects of long term management on forested areas need to be examined to determine if the management of Chinese privet alters the native species communities in the area. Constant manipulation and chemical controls can build up, changing the dynamics of the ecosystem. Knowing how management can effect an ecosystem is important in maintaining the ecosystem.

Implications of Management

Knowing if Chinese privet has long term effects on the establishment of native species once removed is important in land management. Being able to immediately plant once the Chinese privet has been removed is important to keep other invasive plant species from filling the newly opened niches in the environment, as well as to provide habitat lost due to management activities. This analysis should assist land managers and restoration practitioners in planning proactive management strategies and control treatments. In particular, managing large scale infestations to prevent other invasive species, such as feral hogs, from exploiting the thick canopy under the Chinese privet and further hindering native plant species from successful recruitment.

Table 1: Complete list of species found in the 2006 and 2007 sampling of bee species from the Hanula and Horn (2011) paper.

Family	***Genus***	***Species***	**2006**	**2007**
Andrenidae	*Andrena*	*H2113*	3	0
		H2116	3	0
		H2127	5	1
		H2225	0	2
		arabis	1	0
		confederata	0	4
		crataegi	0	2
		cressonii	4	16
		forbesii	4	0
		hippotes	1	1
		ilicis	3	6
		imitatrix	10	130
		mendica	1	2
		miserabilis	1	2
		morrisonella	1	2
		nasonii	2	30
		nida	0	5
		obscuripennis	0	1
		perplexa	5	62
		personata	9	198
		rubi	5	33
		salictaria	1	0
		sayi	0	3
		simplex	0	1
		spiraeana	2	1
		violae	107	227
	Panurginus	*polytrichus*	0	11
		potentillae	3	4
Apidae	*Anthophora*	*abrupta*	1	4
	Melissodes	*agilis*	0	1
		bimaculata	17	63
		comptoides	3	16
		denticulata	30	29
		dentiventris	3	41
		druriella	1	0
	Melitoma	*taurea*	6	7
	Nomada	*H2101*	3	0

		H2211	0	1
		H2233A	0	1
		autumnalis	1	0
		cressonii	12	10
		dentariae	0	1
		denticulata	2	15
		depressa	10	9
		illinoensis	3	3
		imbricata	7	15
		integerrima	0	1
		lepida	2	2
		luteola	1	22
		media	4	0
		ovata	2	2
		parva	1	20
		perplexa	1	2
		pygmaea	1	14
		sayi	0	11
		sulpurata	1	0
	Ptilothrix	*bombiformus*	3	6
	Eucera	*atriventris*	7	11
		dubitata	5	32
	Apis	*mellifera*	35	5
	Bombus	*bimaculatus*	10	13
		griseocollis	4	0
		impatiens	23	32
		pensylvanicus	0	1
		vagans	15	2
		citrinus	3	7
	Ceratina	*calcarata*	382	653
		dupla	10	39
		strenua	0	3
	Xylocopa	*virginica*	2	20
Colletidae	*Colletes*	*inaequalis*	0	10
	Hylaeus	*H2266*	0	1
		fedorica	0	7
		illinoisensis	11	12
		modestus	4	16
		sparsus	2	21
		mesillae	0	3

Halictidae	*Augochlora*	*pura*	580	952
	Augochlorella	*aurata*	727	954
	Augochloropsis	*metallica*	1	1
	Dieunomia	*heteropoda*	0	1
	Halictus	*confusus*	0	1
		lagatus	6	7
		parallelus	0	1
		rubicundus	4	0
	Lasioglossum	*JG-04*	3	1
		apophense	38	40
		atlanticum	61	118
		bruneri	123	225
		callidum	1	0
		coeruleum	5	9
		cressonii	1	2
		fuscipenne	0	5
		illinoense	0	1
		imitatum	29	22
		lustrans	0	2
		macoupinense	49	84
		oblongum	26	45
		puteulanum	0	2
		sopinci	0	6
		subviridatum	1	2
		tegulare	5	14
		versatum	13	19
		zophops	2	0
	Sphecodes	*carolinus*	2	6
		illinoensis	0	1
Megachilidae	*Heriades*	*JH2230*	0	2
	Hoplitis	*producta*	4	2
		simplex	2	8
	Megachile	*campanulae*	2	2
		frigida	2	5
		petulans	2	0
	Osmia	*atriventris*	2	9
		collinsiae	0	4
		conjuncta	0	2
		georgica	9	32
		lignaria	4	23

		michiganensis	1	11
		proxima	0	5
		pumila	5	17
		sandhouseae	1	12
	Paranthidium	*jugatorium*	0	2

Table2: Initial soil moisture readings from the infested and non-infested field experiment plots.

Site	Plot	% Soil Moisture
1	1a.1	22.30
1	1a.2	21.30
1	1a.3	23.20
2	2a.1	28.50
2	2a.2	31.00
2	2a.3	31.00
3	3a.1	31.00
3	3a.2	45.90
3	3a.3	46.10
4	4a.1	48.10
4	4a.2	49.50
4	4a.3	49.50

Table 3: Summary of plant species found in Dallas Floodway Extension forested area adjacent to the Trinity River Audubon Center south of Loop 12 and between I45 and US 175.

Pecan (*Carya illinoinensis*)	Eastern Cottonwood (*Populus deltoides*)
Oak (*Quercus sp.*)	Coralberry (*Symphoricarpos orbiculatus*)
Red Mulberry (*Morus rubra*)	Chinese Privet (*Ligustrum sinense* Lour.)
Mexican Plum (*Prunus mexicana*)	Roughleaf Dogwood (*Cornus drummondii*)
Deciduous Holly (*IIex decidua*)	Green Brier (*Smilax bona-nox)*
Gum Bumelia (*Sideroxylon lanuginosum)*	Poison Ivy (*Toxicodendron radicans)*
Peppervine (*Nekemias arborea*)	Japanese Honeysuckle (*Lonicera japonica*)
Eastern Redbud (*Cercis Canadensis*)	American Beautyberry (*Callicarpa americana*)

Table 4: Raw data of the soil nutrients found in each of the six plots in the four sites adjacent to the Trinity River Audubon Center. Nitrates (lbs. /acre), Nitrites (ppm), pH, Phosphorus (lbs. /acre) and Potassium (lbs. /acre) measurements before and after the removal of Chinese privet. Sites without Chinese privet are labeled with an 'a' in the name.

Site Sample	pH	Nitrate (lbs/acre)	Nitrite (lbs/acre)	Potassium (lbs/acre)	Phosphorus (lbs/acre)
Feb1.1	8.2	60	10	120	10
Feb1.2	8.2	100	2	200	75
Feb1.3	8.0	10	2	280	75
Oct1.1	7.8	100	2	180	75
Oct1.2	8.0	40	2	180	75
Oct1.3	7.6	40	2	160	75
Mar1.1	8.2	40	2	150	50
Mar1.2	8.4	40	2	150	75
Mar1.3	8.2	10	2	120	75

Site Sample	pH	Nitrate (lbs/acre)	Nitrite (lbs/acre)	Potassium (lbs/acre)	Phosphorus (lbs/acre)
Feb1a.1	8.2	10	0	160	25
Feb1a.2	8.2	10	1	130	75
Feb1a.3	8.2	10	1	75	75
Oct1a.1	7.2	60	1	140	75
Oct1a.2	8.0	40	1	90	75
Oct1a.3	7.8	40	1	100	75
Mar1a.1	8.4	40	1	130	25
Mar1a.2	8.2	20	1	140	25
Mar1a.3	8.2	20	1	120	50

Site Sample	pH	Nitrate (lbs/acre)	Nitrite (lbs/acre)	Potassium (lbs/acre)	Phosphorus (lbs/acre)
Feb2.1	8.2	10	0	50	75
Feb2.2	8.2	10	1	90	75
Feb2.3	8.2	10	0	90	75
Oct2.1	7.4	40	1	120	75
Oct2.2	7.6	60	1	100	75
Oct2.3	7.6	40	5	140	75
Mar2.1	8.4	40	1	125	50
Mar2.2	8.2	60	1	140	50
Mar2.3	8.2	40	1	120	75

Site Sample	pH	Nitrate (lbs/acre)	Nitrite (lbs/acre)	Potassium (lbs/acre)	Phosphorus (lbs/acre)
Feb2a.1	8.2	10	1	120	75
Feb2a.2	8.2	20	1	140	75
Feb2a.3	8.2	10	1	130	75
Oct2a.1	7.6	40	1	100	75
Oct2a.2	8.0	40	1	120	75

Oct2a.3	7.4	100	1	115	75
Mar2a.1	8.6	40	1	130	25
Mar2a.2	8.2	40	1	140	25
Mar2a.3	8.2	40	1	100	25

Site Sample	pH	Nitrate (lbs/acre)	Nitrite (lbs/acre)	Potassium (lbs/acre)	Phosphorus (lbs/acre)
Feb3.1	8.2	10	0	220	100
Feb3.2	8.2	10	5	180	75
Feb3.3	8.0	10	5	160	100
Oct3.1	7.6	40	1	115	75
Oct3.2	8.0	40	1	160	75
Oct3.3	8.2	60	1	160	75
Mar3.1	8.0	40	1	120	75
Mar3.2	8.2	60	1	150	75
Mar3.3	8.2	20	1	120	75

Site Sample	pH	Nitrate (lbs/acre)	Nitrite (lbs/acre)	Potassium (lbs/acre)	Phosphorus (lbs/acre)
Feb3a.1	8.2	10	5	175	100
Feb3a.2	8.2	10	10	140	100
Feb3a.3	8.2	20	5	220	100
Oct3a.1	7.6	100	1	100	75
Oct3a.2	7.6	60	1	120	75
Oct3a.3	7.4	100	1	90	75
Mar3a.1	8.4	20	1	115	25
Mar3a.2	8.2	100	5	160	25
Mar3a.3	8.0	10	1	160	10

Site Sample	pH	Nitrate (lbs/acre)	Nitrite (lbs/acre)	Potassium (lbs/acre)	Phosphorus (lbs/acre)
Feb4.1	8.2	10	10	120	100
Feb4.2	8.2	10	5	180	75
Feb4.3	8.0	10	5	160	25
Oct4.1	8.0	100	1	120	75
Oct4.2	7.8	60	1	140	50
Oct4.3	7.8	100	1	160	50
Mar4.1	6.0	40	1	120	50
Mar4.2	8.2	20	1	160	25
Mar4.3	8.4	20	1	140	25

Site Sample	pH	Nitrate (lbs/acre)	Nitrite (lbs/acre)	Potassium (lbs/acre)	Phosphorus (lbs/acre)
Feb4a.1	8.2	10	5	160	25
Feb4a.2	8.0	10	5	160	75
Feb4a.3	8.0	10	10	160	75
Oct4a.1	8.2	60	1	180	25

Oct4a.2	8.4	60	1	160	25
Oct4a.3	8.4	100	1	100	25
Mar4a.1	8.2	20	1	180	25
Mar4a.2	7.8	60	1	160	25
Mar4a.3	8.2	20	1	90	25

Table 5: The effects of Chinese privet extracts on seed germination. Each table represents the total number of seeds that germinated from each of the repetitions. All four extracts (root, stem, leaf and berry) were a 1% concentration.

	Treatment (germinated/total)				
Repetition	**Root**	**Leaf**	**Stem**	**Berry**	**Control**
A	3/11	4/11	2/11	4/11	5/11
B	2/11	1/11	2/11	3/11	3/11
C	2/11	1/11	2/11	1/11	5/11
D	0/11	3/11	1/11	2/11	3/11

A) Persimmon

	Treatment (germinated/total)				
Repetition	**Root**	**Leaf**	**Stem**	**Berry**	**Control**
A	1/12	1/12	1/12	2/11	4/12
B	1/12	1/12	1/12	2/11	1/11
C	4/11	0/11	0/11	1/11	1/11
D	2/12	1/11	2/11	2/11	4/11

B) Red Mulberry

	Treatment (germinated/total)				
Repetition	**Root**	**Leaf**	**Stem**	**Berry**	**Control**
A	0/11	0/11	0/11	0/11	0/11
B	0/11	0/11	0/11	0/11	0/11
C	0/11	0/11	0/11	0/11	0/11
D	0/11	0/11	0/11	0/11	0/11

C) Mustang Grape

	Treatment (germinated/total)				
Repetition	**Root**	**Leaf**	**Stem**	**Berry**	**Control**
A	8/9	2/9	6/9	7/9	8/9
B	7/9	0/9	4/9	0/9	7/9
C	1/9	3/9	5/9	1/9	8/9
D	9/0	8/9	7/8	5/8	6/8

D) Soapberry

	Treatment (germinated/total)				
Repetition	**Root**	**Leaf**	**Stem**	**Berry**	**Control**
A	1/8	2/8	5/8	0/8	4/8
B	1/8	0/8	0/8	0/8	3/8
C	1/8	0/8	0/8	2/8	2/7
D	1/7	1/7	3/7	1/7	3/7

E) Beautyberry

Table 6: Chi Square Test for Independence comparing seed germination in Chinese privet extracts to the control. Values in bold indicate a significant relationship (α = .1).

	Persimmon	Red Mulberry	Soapberry	Beautyberry
Root	$X^2_{(1,N=88)}=2.2516$ p=0.1335	$X^2_{(1,N=92)}=0.13376$ p=0.7146	$X^2_{(1,N=71)}=1.094$ p=0.297	**$X^2_{(1,N=61)}=4.4695$ p=.0345**
Leaf	$X^2_{(1,N=88)}=0.94181$ p=0.3318	**$X^2_{(1,N=91)}=3.3869$ p=.0657**	**$X^2_{(1,N=71)}=14.173$ p=.0001667**	**$X^2_{(1,N=61)}=6.0128$ p=.0142**
Stem	$X^2_{(1,N=88)}=2.2516$ p=0.1335	$X^2_{(1,N=91)}=2.2425$ p=0.1343	$X^2_{(1,N=70)}=2.6006$ p=.1068	$X^2_{(1,N=61)}=.82407$ p=.364
Berry	$X^2_{(1,N=88)}=0.51562$ p=0.4727	$X^2_{(1,N=89)}=0.23798$ p=0.6257	**$X^2_{(1,N=70)}=13.393$ p=.0002526**	**$X^2_{(1,N=61)}=6.0128$ p=.0142**

Table 7: Raw data of the cut stem experiment. Yes, indicates the stem did produce roots and no indicates no root production.

	Treatment				
Repetition	Root	Leaf	Stem	Berry	Control
A	No	No	No	Yes	Yes
B	Yes	No	Yes	No	Yes
C	No	No	No	No	Yes
D	Yes	No	Yes	Yes	Yes

A) Beautyberry

	Treatment				
Repetition	Root	Leaf	Stem	Berry	Control
A	Yes	No	Yes	No	No
B	No	Yes	Yes	Yes	No
C	No	Yes	No	No	No
D	No	No	Yes	No	Yes

B) Heartleaf Peppervine

	Treatment				
Repetition	Root	Leaf	Stem	Berry	Control
A	No	No	No	No	Yes
B	No	Yes	No	Yes	No
C	No	No	No	No	No

D	No	No	No	No	No

C) Coralberry

	Treatment				
Repetition	Root	Leaf	Stem	Berry	Control
A	No	No	No	No	No
B	No	No	No	No	No
C	No	No	No	No	No
D	No	No	No	No	No

D) Mustang Grape

	Treatment				
Repetition	Root	Leaf	Stem	Berry	Control
A	Yes	Yes	Yes	Yes	Yes
B	No	Yes	Yes	No	Yes
C	Yes	No	Yes	Yes	Yes
D	No	No	Yes	Yes	Yes

E) Elderberry

Table 8: Chi square Test for Independence comparing root production from cuttings in extracts vs the control. Values in bold indicate a significant relationship (α = .1).

	Elderberry	Coralberry	Heartleaf Peppervine	Beautyberry
Root	$X^2_{(1,N=8)}=.66667$ p=0.4142	$X^2_{(1,N=8)}=0$ p=.9999	$X^2_{(1,N=8)}=0$ p=.9999	$X^2_{(1,N=8)}=.66667$ p=0.4142
Leaf	$X^2_{(1,N=8)}=.66667$ p=0.4142	$X^2_{(1,N=8)}=0$ p=.9999	$X^2_{(1,N=8)}=0$ p=.9999	**$X^2_{(1,N=8)}=4.5$ p=0.03389**
Stem	$X^2_{(1,N=8)}=NaN$ p=NA	$X^2_{(1,N=8)}=0$ p=.9999	$X^2_{(1,N=8)}=0.5$ p=0.4795	$X^2_{(1,N=8)}=.66667$ p=0.4142
Berry	$X^2_{(1,N=8)}=0$ p=.9999	$X^2_{(1,N=8)}=0.5$ p=0.4795	$X^2_{(1,N=8)}=0$ p=.9999	$X^2_{(1,N=8)}=.66667$ p=0.4142

Table 9: Raw data of survival of species planted in the field experiment. The yellow highlight indicates the species that survived to the October 2015 data collection and the green highlight are those that persisted to the March 2016 data collection.

			Initial Planting		10/15/2015		3/3/2016	
Site	**Position**	**Plant**	**Height (cm)**	**Diameter (mm)**	**Height (cm)**	**Diameter (mm)**	**Height (cm)**	**Diameter (mm)**
1.1	3	Persimmon	0.03	1.50	0.00	0.00	0.00	0.00
	5	Red Mulberry	0.00	1.60	0.00	0.00	0.00	0.00
	7	Soapberry	0.02	1.50	0.00	0.00	0.00	0.00
	1	Coralberry	0.03	1.50	0.00	0.00	0.00	0.00
	2	Beautyberry	0.03	1.60	0.00	0.00	0.00	0.00
	6	Elderberry	0.00	1.60	0.00	0.00	0.00	0.00

	4	Mustang Grape	0.00	1.40	0.00	0.00	0.00	0.00
	8	Heart Leaf Peppervine	0.16	1.80	0.10	1.80	0.00	0.00
1.2	3	Persimmon	0.00	1.50	0.00	1.50	0.00	0.00
	7	Red Mulberry	0.03	1.60	0.03	1.70	0.03	1.70
	8	Soapberry	0.00	1.40	0.00	1.40	0.00	0.00
	2	Coralberry	0.04	1.50	0.00	0.00	0.00	0.00
	6	Beautyberry	0.00	1.50	0.00	0.00	0.00	0.00
	5	Elderberry	0.03	1.80	0.00	0.00	0.00	0.00
	4	Mustang Grape	0.03	1.40	0.00	0.00	0.00	0.00
	1	Heart Leaf Peppervine	0.10	1.80	0.13	1.80	0.12	1.80
1.3	4	Persimmon	0.03	1.50	0.00	0.00	0.00	0.00
	3	Red Mulberry	0.03	1.60	0.00	0.00	0.00	0.00
	1	Soapberry	0.00	1.50	0.00	0.00	0.00	0.00
	2	Coralberry	0.03	1.60	0.00	0.00	0.00	0.00
	6	Beautyberry	0.03	1.60	0.00	0.00	0.00	0.00
	8	Elderberry	0.00	1.80	0.00	0.00	0.00	0.00
	5	Mustang Grape	0.00	1.40	0.00	0.00	0.00	0.00
	7	Heart Leaf Peppervine	0.04	1.90	0.03	1.70	0.00	0.00
1a.1	6	Persimmon	0.03	1.70	0.00	0.00	0.00	0.00
	7	Red Mulberry	0.00	1.50	0.00	0.00	0.00	0.00
	4	Soapberry	0.00	1.70	0.00	0.00	0.00	0.00
	8	Coralberry	0.07	1.50	0.00	0.00	0.00	0.00
	1	Beautyberry	0.03	1.60	0.00	0.00	0.00	0.00
	3	Elderberry	0.00	1.50	0.00	0.00	0.00	0.00
	2	Mustang Grape	0.00	1.50	0.00	0.00	0.00	0.00
	5	Heart Leaf Peppervine	0.03	1.80	0.03	1.60	0.00	0.00
1a.2	7	Persimmon	0.00	1.80	0.00	0.00	0.00	0.00
	5	Red Mulberry	0.00	1.40	0.00	0.00	0.00	0.00
	6	Soapberry	0.03	1.50	0.00	0.00	0.00	0.00
	3	Coralberry	0.03	1.60	0.00	0.00	0.00	0.00
	8	Beautyberry	0.03	1.40	0.00	0.00	0.00	0.00
	4	Elderberry	0.00	2.10	0.00	0.00	0.00	0.00
	1	Mustang Grape	0.03	1.50	0.00	0.00	0.00	0.00

	2	Heart Leaf Peppervine	0.10	1.90	0.07	1.70	0.00	0.00
1a.3	6	Persimmon	0.03	1.50	0.00	0.00	0.00	0.00
	2	Red Mulberry	0.00	1.40	0.00	0.00	0.00	0.00
	3	Soapberry	0.00	1.60	0.03	1.60	0.00	0.00
	1	Coralberry	0.03	1.40	0.00	0.00	0.00	0.00
	4	Beautyberry	0.03	1.60	0.00	0.00	0.00	0.00
	8	Elderberry	0.00	1.60	0.00	0.00	0.00	0.00
	7	Mustang Grape	0.00	1.40	0.00	0.00	0.00	0.00
	8	Heart Leaf Peppervine	0.13	2.00	0.16	1.70	0.00	0.00
2.1	2	Persimmon	0.03	1.60	0.00	0.00	0.00	0.00
	1	Red Mulberry	0.04	1.60	0.00	0.00	0.00	0.00
	5	Soapberry	0.00	1.40	0.00	0.00	0.00	0.00
	8	Coralberry	0.07	1.70	0.00	0.00	0.00	0.00
	7	Beautyberry	0.03	1.60	0.00	0.00	0.00	0.00
	6	Elderberry	0.03	1.80	0.00	0.00	0.00	0.00
	4	Mustang Grape	0.03	1.60	0.00	0.00	0.00	0.00
	3	Heart Leaf Peppervine	0.10	1.80	0.13	1.80	0.00	0.00
2.2	3	Persimmon	0.05	1.60	0.00	0.00	0.00	0.00
	7	Red Mulberry	0.04	1.50	0.00	0.00	0.00	0.00
	2	Soapberry	0.03	1.60	0.00	0.00	0.00	0.00
	1	Coralberry	0.03	1.60	0.00	0.00	0.00	0.00
	4	Beautyberry	0.00	1.50	0.00	0.00	0.00	0.00
	6	Elderberry	0.00	1.90	0.00	0.00	0.00	0.00
	5	Mustang Grape	0.03	1.60	0.00	0.00	0.00	0.00
	8	Heart Leaf Peppervine	0.07	1.70	0.07	1.80	0.00	0.00
2.3	6	Persimmon	0.03	1.50	0.00	0.00	0.00	0.00
	2	Red Mulberry	0.03	1.60	0.00	0.00	0.00	0.00
	7	Soapberry	0.03	1.70	0.00	0.00	0.00	0.00
	4	Coralberry	0.03	1.40	0.00	0.00	0.00	0.00
	5	Beautyberry	0.03	1.70	0.00	0.00	0.00	0.00
	3	Elderberry	0.00	1.70	0.00	0.00	0.00	0.00
	8	Mustang Grape	0.03	1.50	0.00	0.00	0.00	0.00
	1	Heart Leaf Peppervine	0.10	1.80	0.03	2.10	0.00	0.00

2a.1	6	Persimmon	0.00	1.50	0.00	0.00	0.00	0.00
	2	Red Mulberry	0.04	1.70	0.00	0.00	0.00	0.00
	5	Soapberry	0.00	0.00	0.00	0.00	0.00	0.00
	4	Coralberry	0.03	1.60	0.00	0.00	0.00	0.00
	3	Beautyberry	0.03	1.60	0.00	0.00	0.00	0.00
	7	Elderberry	0.00	1.90	0.00	0.00	0.00	0.00
	1	Mustang Grape	0.03	1.50	0.00	0.00	0.00	0.00
	8	Heart Leaf Peppervine	0.07	1.80	0.07	1.80	0.00	0.00
2a.2	6	Persimmon	0.03	1.50	0.00	0.00	0.00	0.00
	3	Red Mulberry	0.04	1.70	0.00	0.00	0.00	0.00
	1	Soapberry	0.03	1.70	0.03	1.80	0.00	0.00
	7	Coralberry	0.00	1.70	0.00	0.00	0.00	0.00
	2	Beautyberry	0.00	1.40	0.00	0.00	0.00	0.00
	8	Elderberry	0.00	1.70	0.00	0.00	0.00	0.00
	5	Mustang Grape	0.00	1.40	0.00	0.00	0.00	0.00
	4	Heart Leaf Peppervine	0.03	1.90	0.07	1.80	0.00	0.00
2a.3	6	Persimmon	0.03	1.70	0.00	0.00	0.00	0.00
	2	Red Mulberry	0.06	1.50	0.00	0.00	0.00	0.00
	8	Soapberry	0.03	1.60	0.00	0.00	0.00	0.00
	5	Coralberry	0.04	1.40	0.00	0.00	0.00	0.00
	7	Beautyberry	0.03	1.60	0.00	0.00	0.00	0.00
	4	Elderberry	0.00	1.80	0.00	0.00	0.00	0.00
	3	Mustang Grape	0.00	1.40	0.00	0.00	0.00	0.00
	1	Heart Leaf Peppervine	0.07	1.80	0.00	0.00	0.00	0.00
3.1	4	Persimmon	0.03	1.50	0.00	0.00	0.00	0.00
	5	Red Mulberry	0.04	1.60	0.03	1.50	0.05	1.70
	6	Soapberry	0.00	1.40	0.00	0.00	0.00	0.00
	7	Coralberry	0.03	1.60	0.00	0.00	0.00	0.00
	8	Beautyberry	0.03	1.50	0.00	0.00	0.00	0.00
	1	Elderberry	0.03	1.70	0.00	0.00	0.00	0.00
	2	Mustang Grape	0.03	1.40	0.00	0.00	0.00	0.00
	3	Heart Leaf Peppervine	0.04	1.70	0.04	1.70	0.00	0.00
3.2	6	Persimmon	0.03	1.50	0.00	0.00	0.00	0.00

	1	Red Mulberry	0.03	1.50	0.00	0.00	0.00	0.00
	7	Soapberry	0.00	1.40	0.00	0.00	0.00	0.00
	2	Coralberry	0.07	1.40	0.00	0.00	0.00	0.00
	3	Beautyberry	0.03	1.50	0.00	0.00	0.00	0.00
	4	Elderberry	0.00	1.70	0.00	0.00	0.00	0.00
	8	Mustang Grape	0.04	1.50	0.00	0.00	0.00	0.00
	5	Heart Leaf Peppervine	0.07	1.70	0.07	1.70	0.00	0.00
3.3	1	Persimmon	0.04	1.60	0.00	0.00	0.00	0.00
	2	Red Mulberry	0.04	1.60	0.07	0.00	0.07	1.70
	8	Soapberry	0.03	1.70	0.00	0.00	0.00	0.00
	7	Coralberry	0.03	1.70	0.00	0.00	0.00	0.00
	6	Beautyberry	0.03	1.40	0.00	0.00	0.00	0.00
	5	Elderberry	0.03	1.60	0.00	0.00	0.00	0.00
	4	Mustang Grape	0.00	1.40	0.00	0.00	0.00	0.00
	3	Heart Leaf Peppervine	0.03	1.60	0.14	1.90	0.00	0.00
3a.1	4	Persimmon	0.03	1.70	0.00	0.00	0.00	0.00
	2	Red Mulberry	0.03	1.50	0.03	0.00	0.03	2.00
	5	Soapberry	0.00	1.40	0.00	0.00	0.00	0.00
	7	Coralberry	0.03	1.50	0.00	0.00	0.00	0.00
	3	Beautyberry	0.03	1.50	0.00	0.00	0.00	0.00
	6	Elderberry	0.03	1.90	0.00	0.00	0.00	0.00
	8	Mustang Grape	0.00	1.40	0.00	0.00	0.00	0.00
	1	Heart Leaf Peppervine	0.10	1.80	0.10	1.90	0.00	0.00
3a.2	3	Persimmon	0.03	1.60	0.00	0.00	0.00	0.00
	1	Red Mulberry	0.04	1.50	0.00	0.00	0.00	0.00
	5	Soapberry	0.03	1.50	0.00	0.00	0.00	0.00
	8	Coralberry	0.00	1.40	0.00	0.00	0.00	0.00
	7	Beautyberry	0.03	1.50	0.00	0.00	0.00	0.00
	6	Elderberry	0.00	1.50	0.00	0.00	0.00	0.00
	2	Mustang Grape	0.04	1.50	0.00	0.00	0.00	0.00
	4	Heart Leaf Peppervine	0.00	1.80	0.00	0.00	0.00	0.00
3a.3	3	Persimmon	0.00	1.50	0.00	0.00	0.00	0.00
	1	Red Mulberry	0.03	1.50	0.00	0.00	0.00	0.00

	8	Soapberry	0.00	1.40	0.00	0.00	0.00	0.00
	5	Coralberry	0.05	1.60	0.00	0.00	0.00	0.00
	7	Beautyberry	0.03	1.40	0.00	0.00	0.00	0.00
	6	Elderberry	0.00	1.60	0.00	0.00	0.00	0.00
	4	Mustang Grape	0.03	1.40	0.00	0.00	0.00	0.00
	2	Heart Leaf Peppervine	0.04	1.60	0.07	1.80	0.00	0.00
4.1	5	Persimmon	0.04	1.60	0.00	0.00	0.00	0.00
	1	Red Mulberry	0.00	1.40	0.00	0.00	0.00	0.00
	6	Soapberry	0.00	1.70	0.00	1.60	0.00	0.00
	7	Coralberry	0.04	1.70	0.00	0.00	0.00	0.00
	2	Beautyberry	0.03	1.50	0.00	0.00	0.00	0.00
	4	Elderberry	0.00	1.70	0.00	0.00	0.00	0.00
	8	Mustang Grape	0.03	1.40	0.00	0.00	0.00	0.00
	3	Heart Leaf Peppervine	0.04	2.00	0.07	1.80	0.00	0.00
4.2	5	Persimmon	0.03	1.60	0.00	0.00	0.00	0.00
	1	Red Mulberry	0.03	1.50	0.00	0.00	0.00	0.00
	6	Soapberry	0.00	1.50	0.00	1.80	0.00	0.00
	7	Coralberry	0.04	1.50	0.00	0.00	0.00	0.00
	2	Beautyberry	0.03	1.60	0.00	0.00	0.00	0.00
	4	Elderberry	0.00	1.50	0.00	0.00	0.00	0.00
	8	Mustang Grape	0.03	1.50	0.00	0.00	0.00	0.00
	3	Heart Leaf Peppervine	0.03	1.90	0.07	1.60	0.00	0.00
4.3	5	Persimmon	0.03	1.60	0.00	0.00	0.00	0.00
	7	Red Mulberry	0.03	1.40	0.00	0.00	0.00	0.00
	2	Soapberry	0.03	1.50	0.00	0.00	0.00	0.00
	8	Coralberry	0.03	1.50	0.00	0.00	0.00	0.00
	1	Beautyberry	0.03	1.50	0.00	0.00	0.00	0.00
	4	Elderberry	0.00	1.90	0.00	0.00	0.00	0.00
	3	Mustang Grape	0.03	1.40	0.00	0.00	0.00	0.00
	6	Heart Leaf Peppervine	0.00	0.00	0.00	0.00	0.00	0.00
4a.1	4	Persimmon	0.03	1.60	0.00	0.00	0.00	0.00
	6	Red Mulberry	0.03	1.40	0.00	0.00	0.00	0.00
	3	Soapberry	0.03	1.40	0.03	1.30	0.00	0.00
	5	Coralberry	0.03	1.60	0.00	0.00	0.00	0.00

	7	Beautyberry	0.03	1.50	0.00	0.00	0.00	0.00
	2	Elderberry	0.03	2.50	0.00	0.00	0.00	0.00
	1	Mustang Grape	0.03	1.50	0.00	0.00	0.00	0.00
	8	Heart Leaf Peppervine	0.10	1.80	0.00	0.00	0.00	0.00
4a.2	2	Persimmon	0.00	1.50	0.00	0.00	0.00	0.00
	7	Red Mulberry	0.04	1.30	0.00	0.00	0.03	1.70
	3	Soapberry	0.03	1.90	0.00	0.00	0.00	0.70
	8	Coralberry	0.03	1.40	0.00	0.00	0.00	0.00
	4	Beautyberry	0.03	1.50	0.00	0.00	0.00	0.00
	6	Elderberry	0.00	1.80	0.00	0.00	0.00	0.00
	5	Mustang Grape	0.03	1.40	0.00	0.00	0.00	0.00
	1	Heart Leaf Peppervine	0.10	1.90	0.07	2.00	0.00	0.00
4a.3	6	Persimmon	0.04	1.60	0.00	0.00	0.00	0.00
	4	Red Mulberry	0.00	1.50	0.00	0.00	0.00	0.00
	7	Soapberry	0.03	1.50	0.00	0.00	0.00	0.00
	2	Coralberry	0.03	1.50	0.00	0.00	0.00	0.00
	8	Beautyberry	0.03	1.50	0.00	0.00	0.00	0.00
	1	Elderberry	0.03	1.60	0.00	0.00	0.00	0.00
	3	Mustang Grape	0.03	1.60	0.00	0.00	0.00	0.00
	5	Heart Leaf Peppervine	0.07	1.70	0.10	1.70	0.00	0.00

Table 10: Air temperatures of field sites during data and soil collection.

Date	Temperature (˚F)
February	40
October	51
March	51

Table 11: Amount of precipitation field site received the month before and the month of data collection.

Date	Precipitation (cm)
January/February	170
September/October	30
February/March	12

Figure 1: Map showing the location of the forested area adjacent to the Trinity River Audubon Center in South Dallas. The forested area is South of loop 12, east of I45 and west of US 175. Yellow box is the location of the four sites within the forested area.

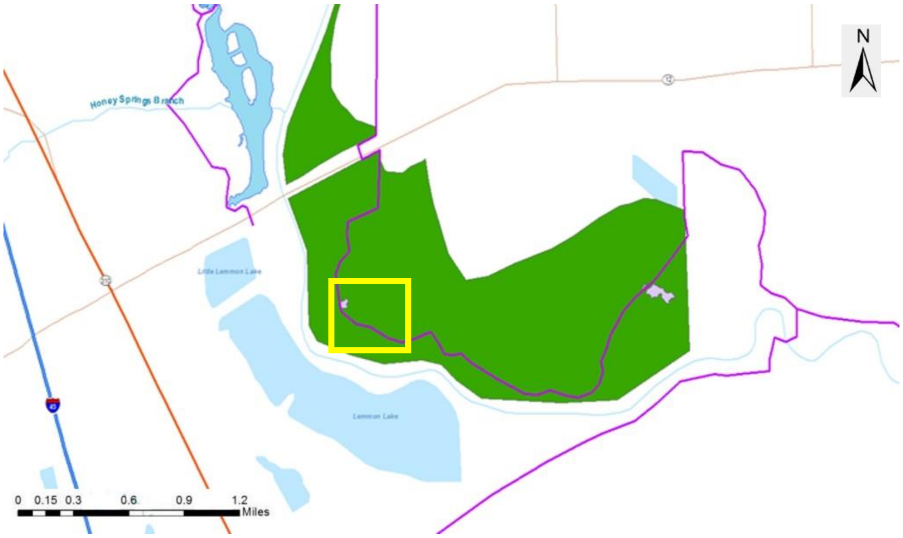


Figure 2: Location of the four sites adjacent to the Trinity River Trails Audubon Center.

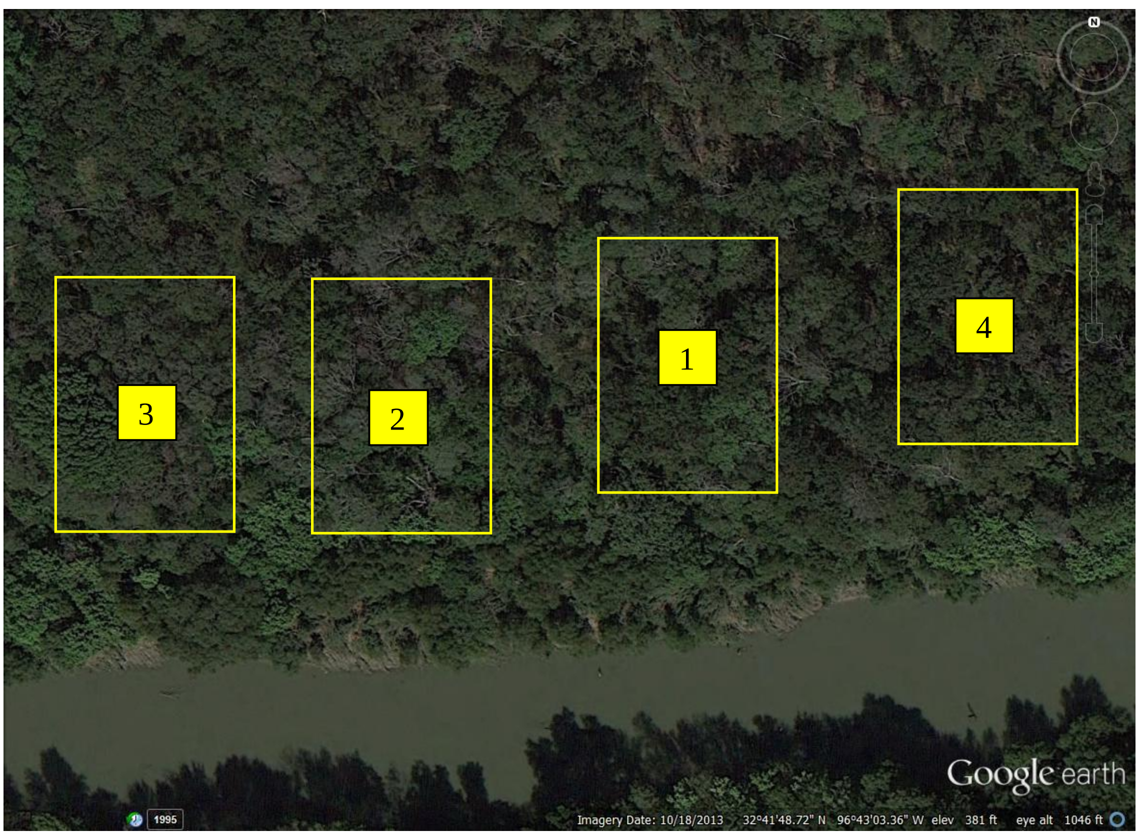


Figure 3: Illustration of the pattern the native species were planted in. Each plant was given a number and a random number generator was used to determine the location the individual species would be placed in the pattern.

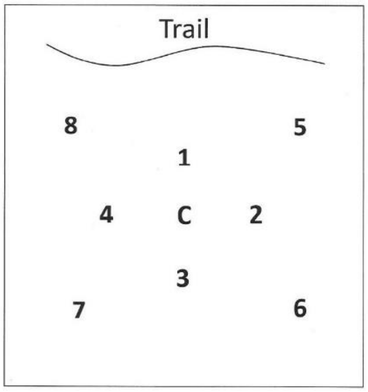
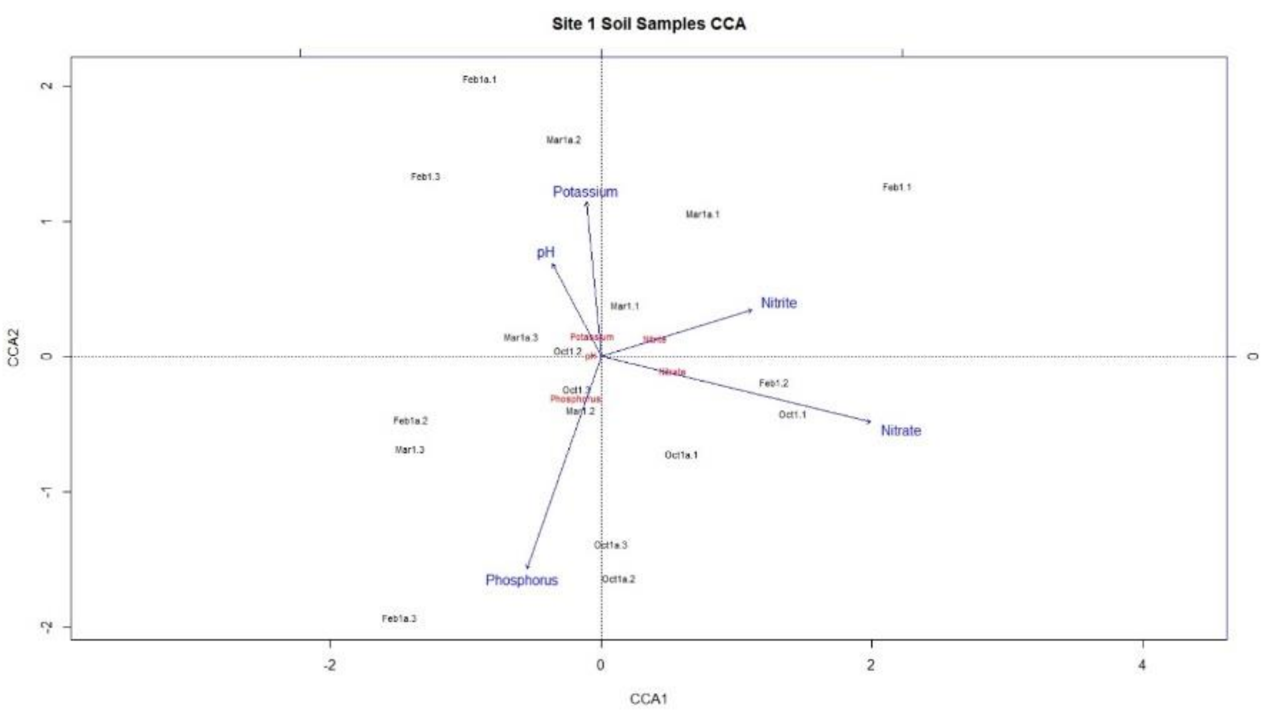
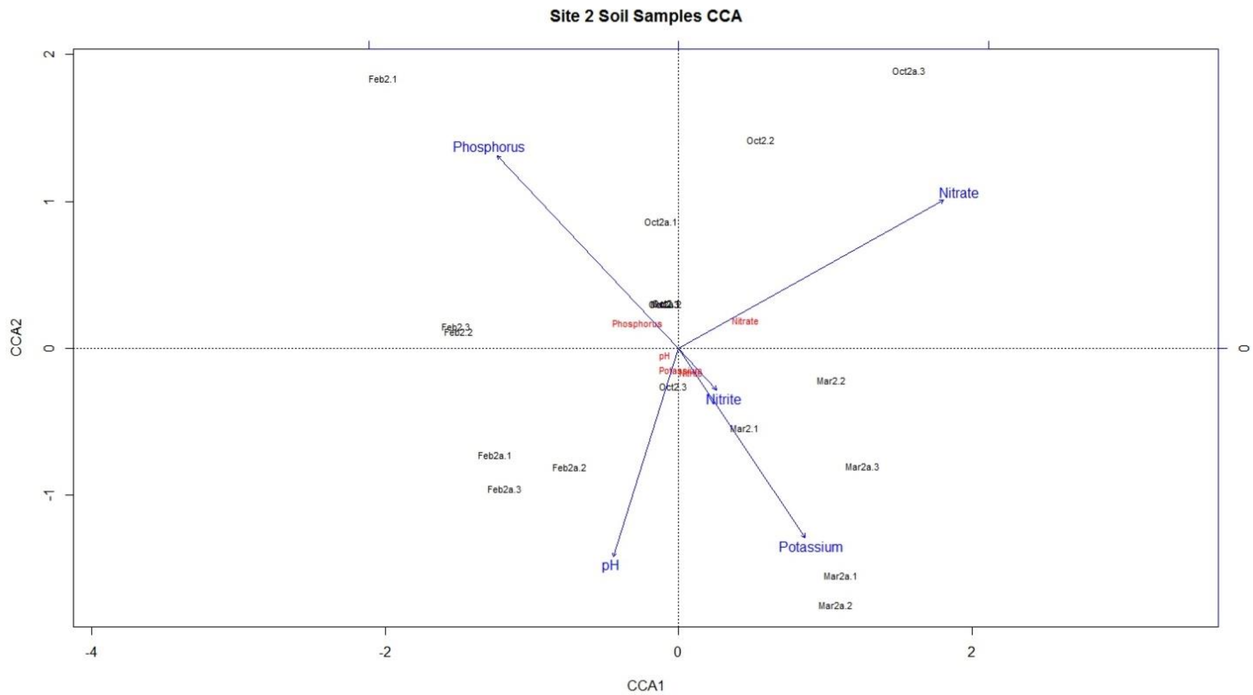


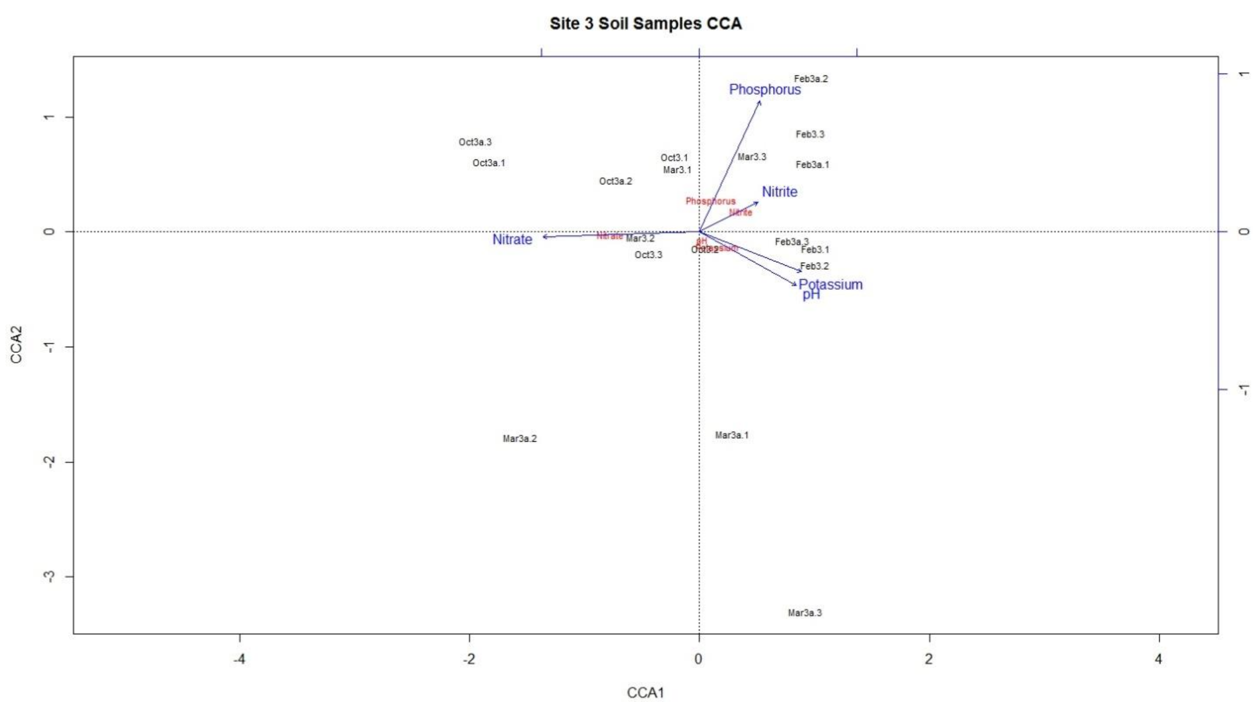
Figure 4: Constrained Correspondence Analysis on soil the amounts of pH, N, P, and K found in the four field sites. The solid arrows represent the factor that is having the greatest impact on the plot. The privet infested sites are labeled without letters and the un-infested sites have the letter 'a' in their label to delineate plot types.



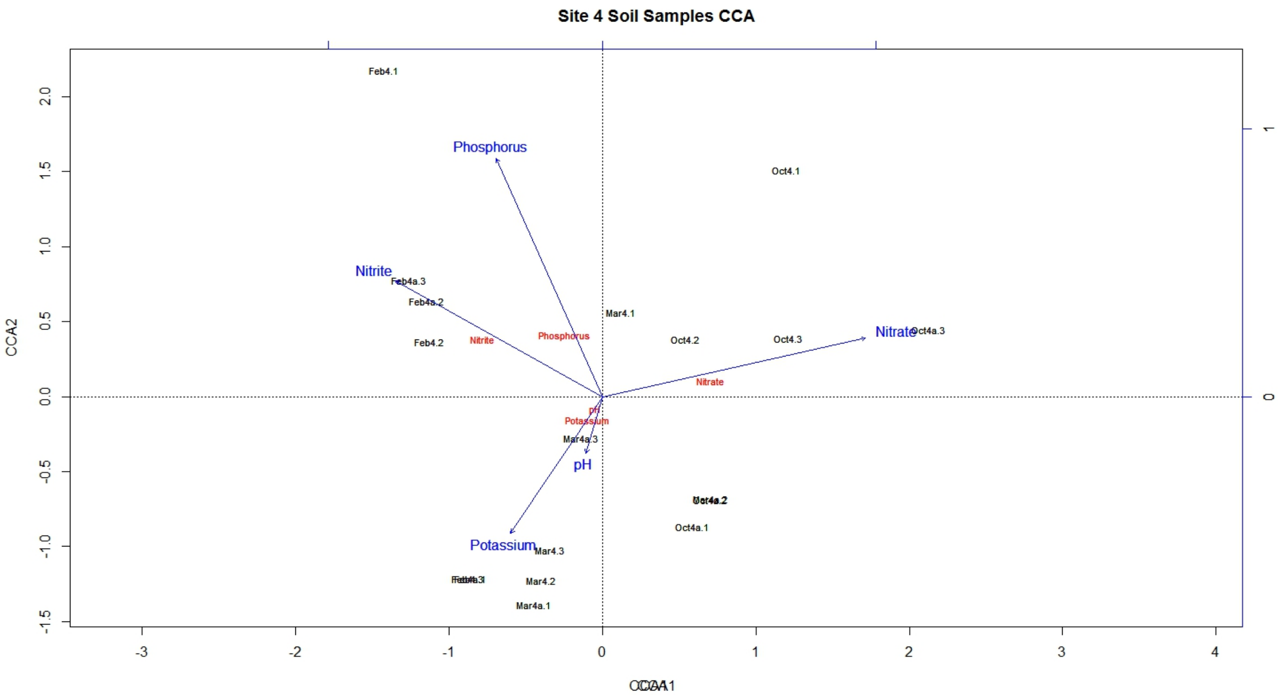
A) Site 1 infested and non-infested plots



B) Site 2 infested and non-infested plots

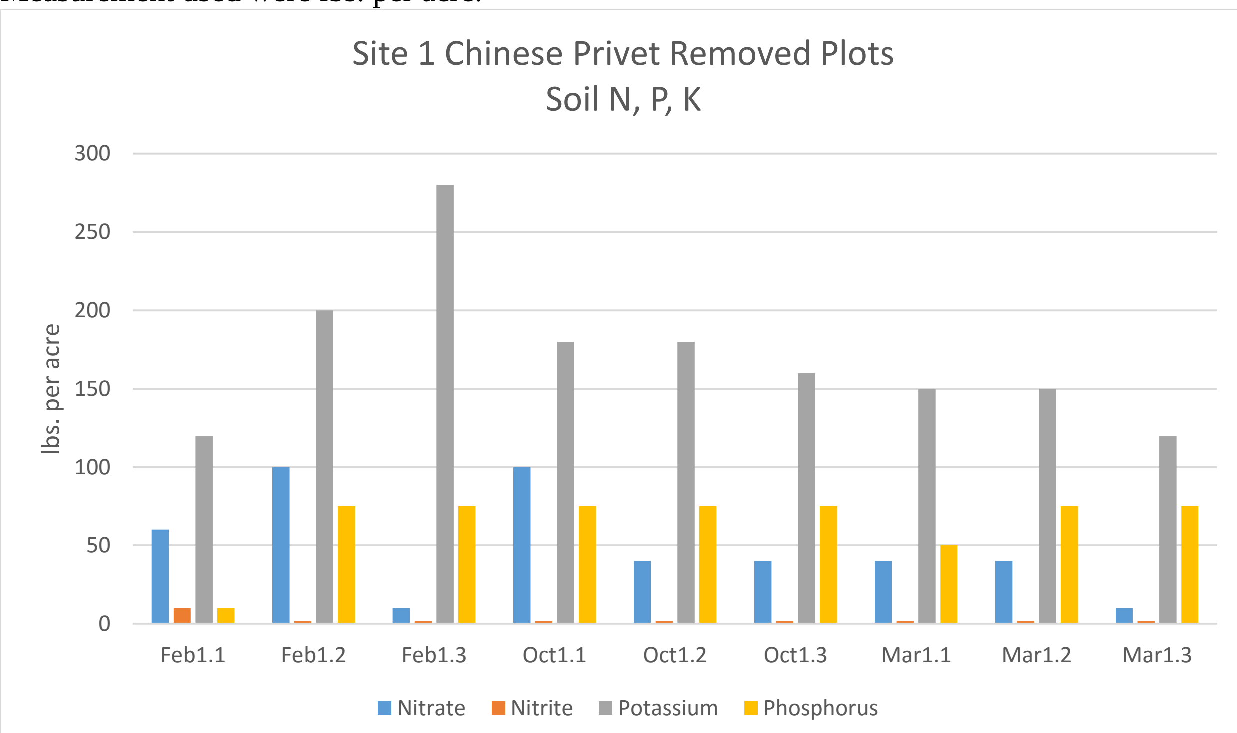


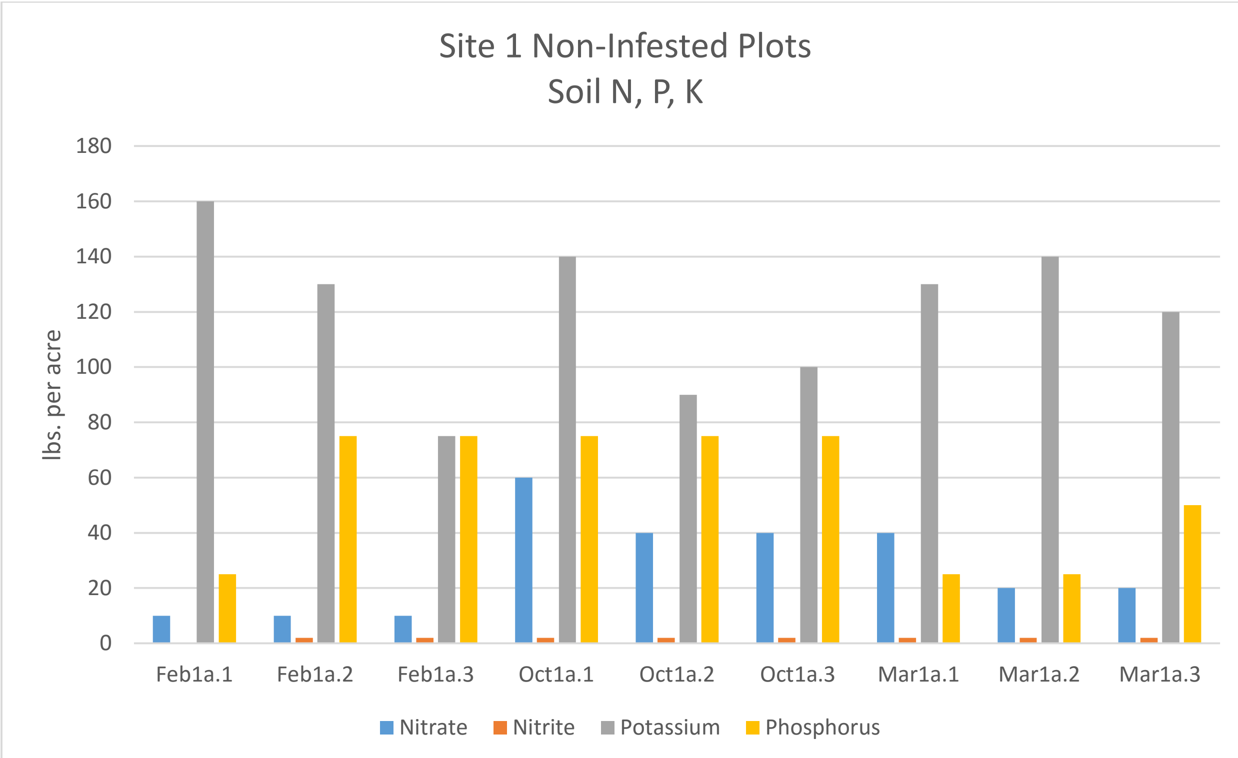
C) Site 3 infested and non-infested plots

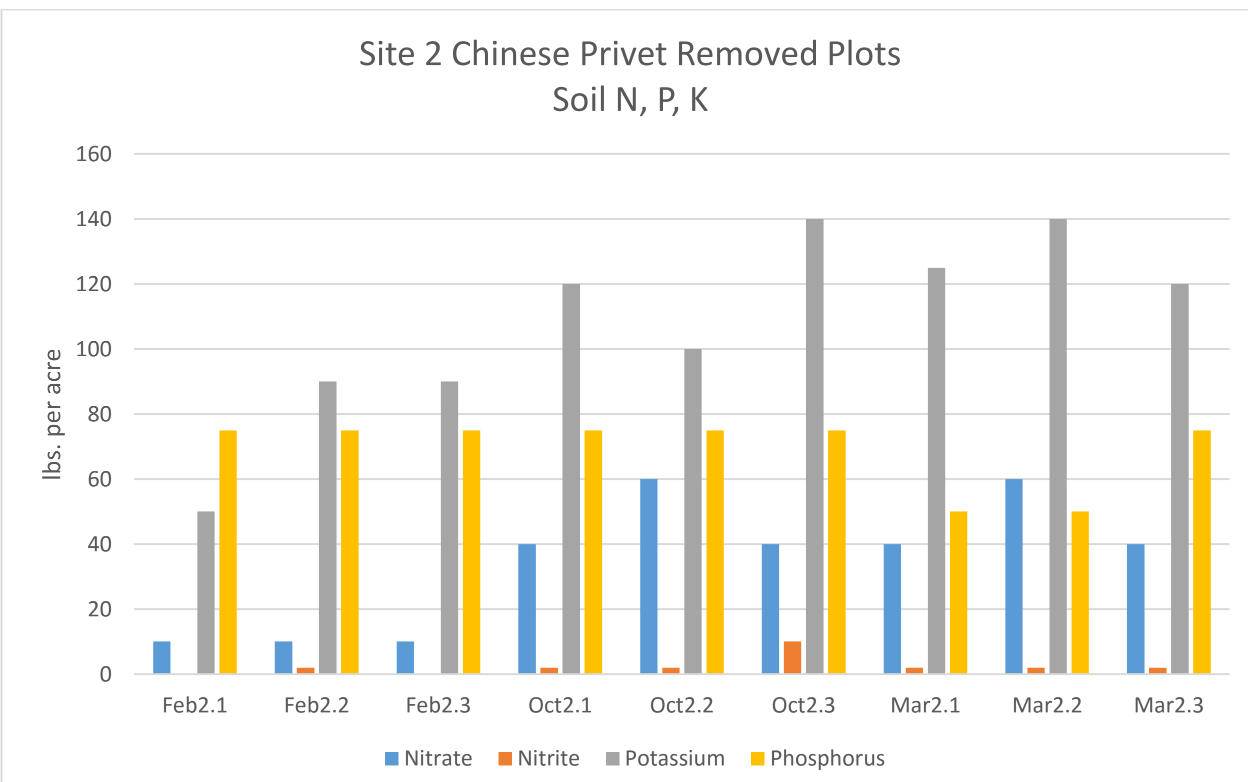


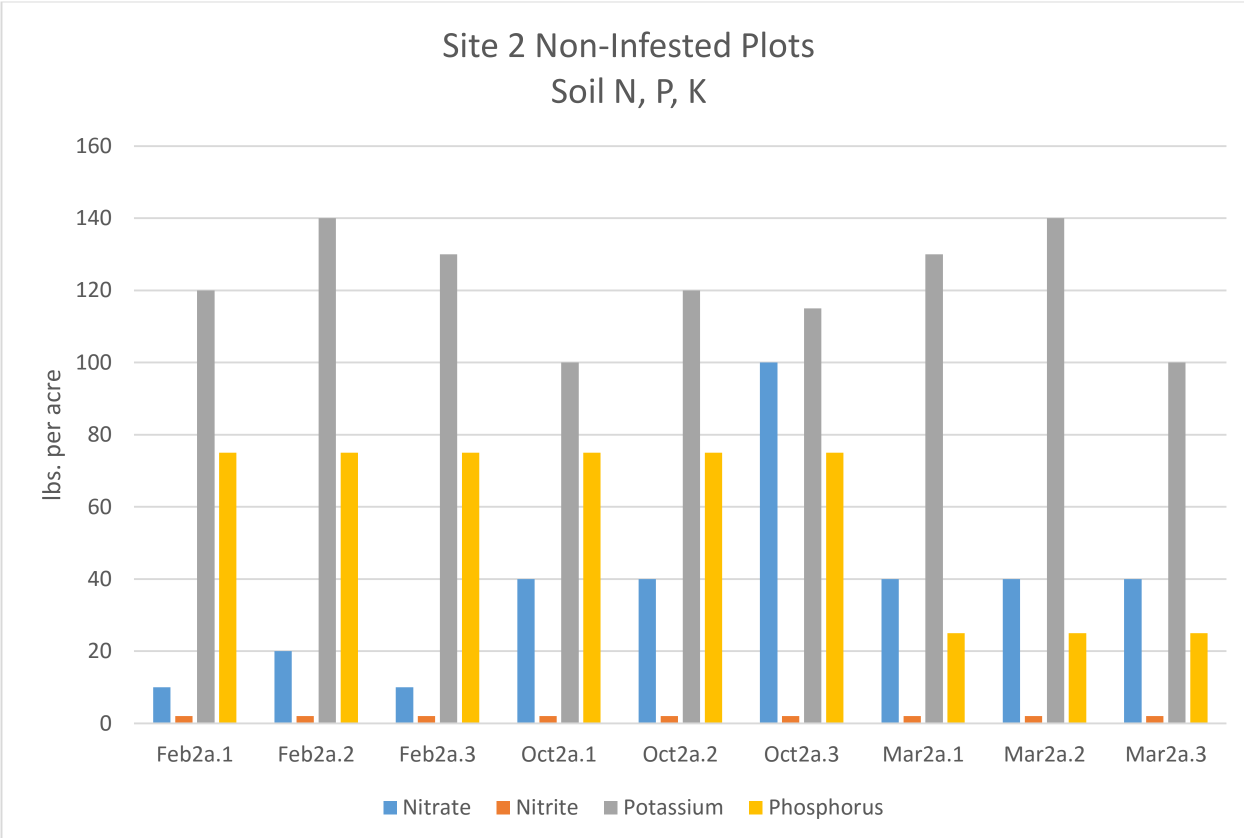
D) Site 4 infested and non-infested plots

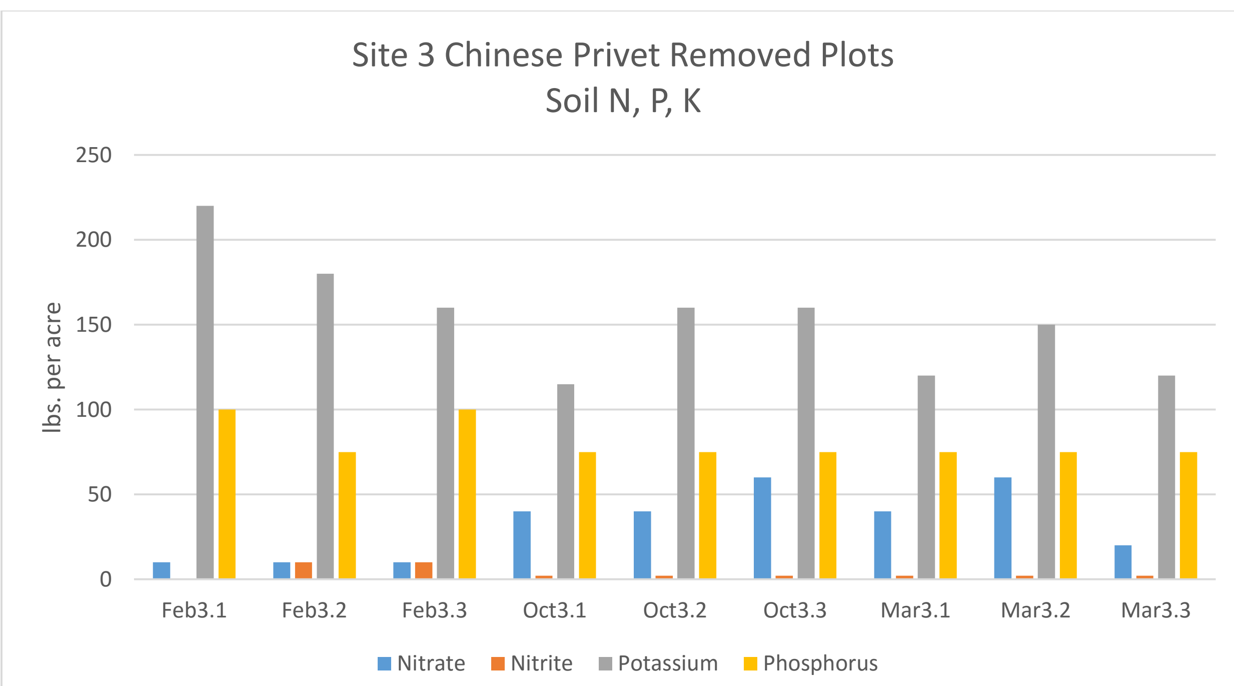
Figure 5: Graphs of the soil N, P, K amounts by site infested and non-infested plots. Measurement used were lbs. per acre.

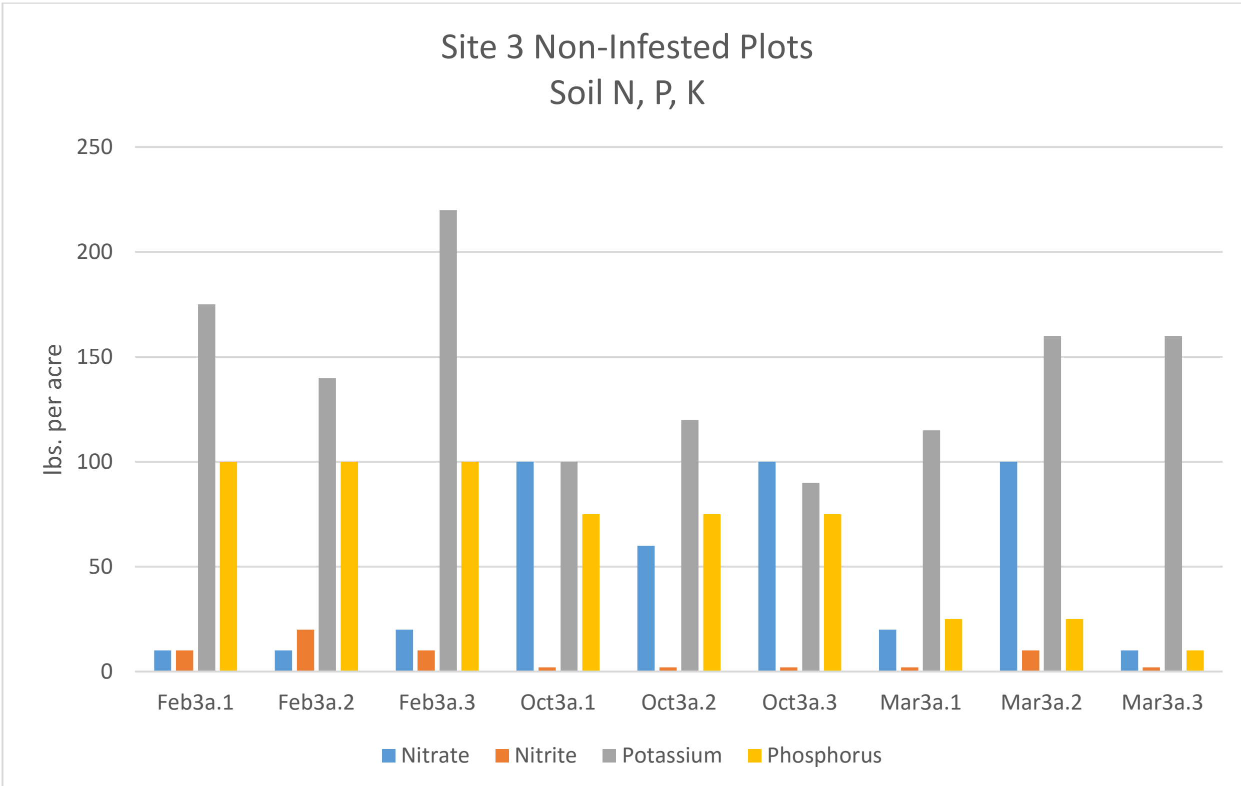


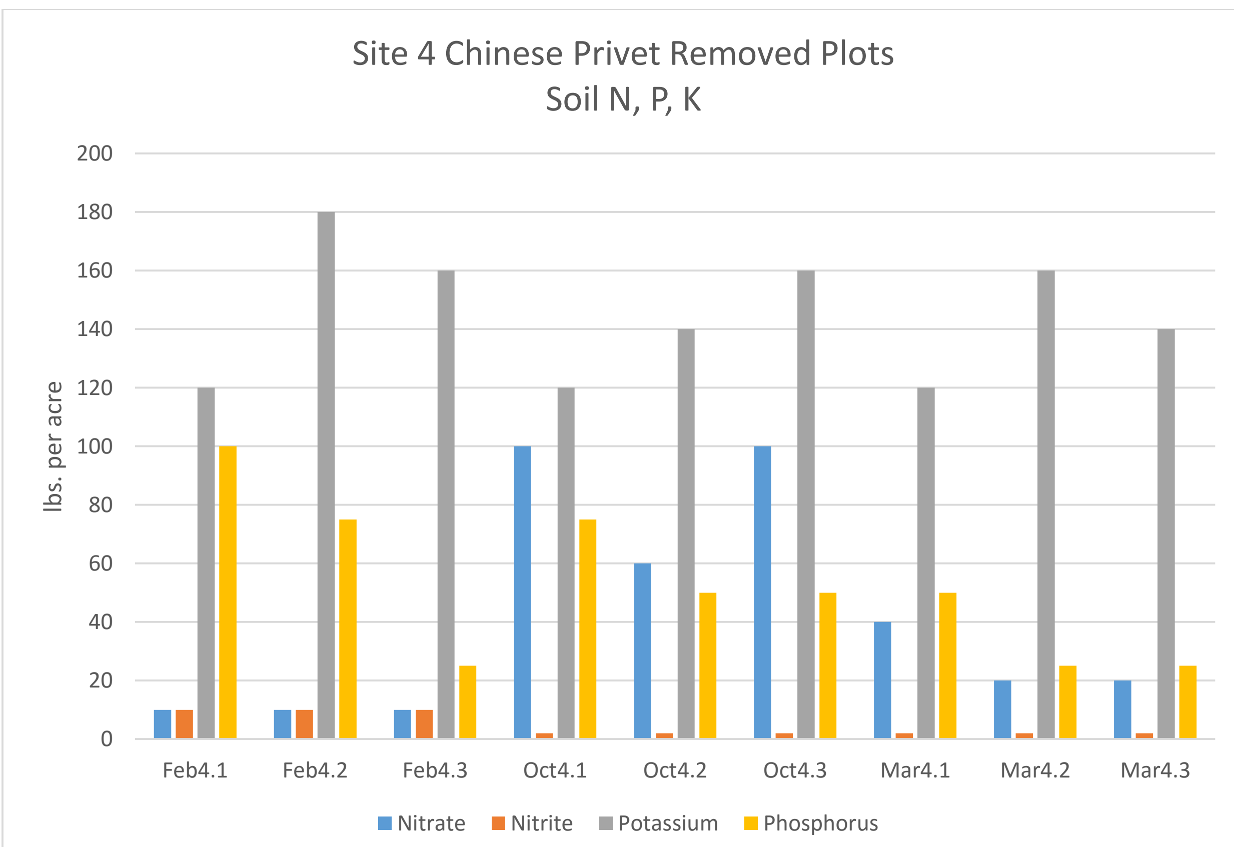

Site 1 Non-Infested Plots
Soil N, P, K
lbs. per acre
180
160
140
120
100
80
60
40
20
0
Feb1a.1
Feb1a.2
Feb1a.3
Oct1a.1
Oct1a.2
Oct1a.3
Mar1a.1
Mar1a.2
Mar1a.3
Nitrate
Nitrite
Potassium
Phosphorus


Site 2 Chinese Privet Removed Plots
Soil N, P, K
lbs. per acre
160
140
120
100
80
60
40
20
0
Feb2.1
Feb2.2
Feb2.3
Oct2.1
Oct2.2
Oct2.3
Mar2.1
Mar2.2
Mar2.3
Nitrate
Nitrite
Potassium
Phosphorus


Site 2 Non-Infested Plots
Soil N, P, K
lbs. per acre
160
140
120
100
80
60
40
20
0
Feb2a.1
Feb2a.2
Feb2a.3
Oct2a.1
Oct2a.2
Oct2a.3
Mar2a.1
Mar2a.2
Mar2a.3
Nitrate
Nitrite
Potassium
Phosphorus


Site 3 Chinese Privet Removed Plots
Soil N, P, K
lbs. per acre
250
200
150
100
50
0
Feb3.1
Feb3.2
Feb3.3
Oct3.1
Oct3.2
Oct3.3
Mar3.1
Mar3.2
Mar3.3
Nitrate
Nitrite
Potassium
Phosphorus


Site 3 Non-Infested Plots
Soil N, P, K
lbs. per acre
250
200
150
100
50
0
Feb3a.1
Feb3a.2
Feb3a.3
Oct3a.1
Oct3a.2
Oct3a.3
Mar3a.1
Mar3a.2
Mar3a.3
Nitrate
Nitrite
Potassium
Phosphorus


Site 4 Chinese Privet Removed Plots
Soil N, P, K
lbs. per acre
200
180
160
140
120
100
80
60
40
20
0
Feb4.1
Feb4.2
Feb4.3
Oct4.1
Oct4.2
Oct4.3
Mar4.1
Mar4.2
Mar4.3
Nitrate
Nitrite
Potassium
Phosphorus

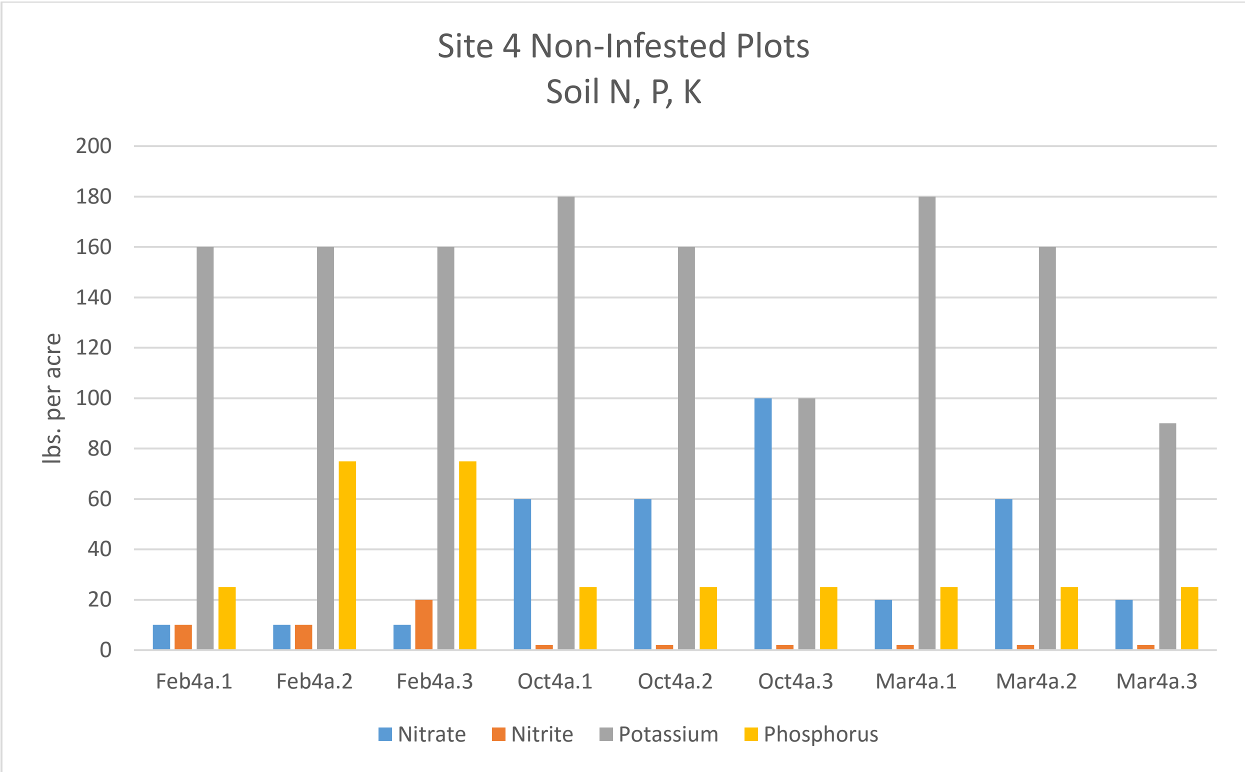


Figure 6: Picture of the amount of litter found under Chinese privet shrubs.

Figure 7: Photographs of the establishment of native plant species in an infested plot. Establishment of early successional plants indicate the removal of Chinese privet will not leave

lasting effects on the establishment of native species.

A) Dewberry (*Rubus trivialis*)

B) Bedstraw (*Galium sp.*) and wild onion (*Allium ascalonicum*)

REFERENCES

Aizen, M. A., Morales, C. L., & Morales, J. M. (2008). Invasive Mutualists Erode Native Pollination Webs. *PLoS Biology 6*, 396-403.

Alexander, Jr., G. E. (2008). *Red Mulberry (Morus rubra L.)*. Retrieved 2016, from http://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/lapmcbr7910.pdf

Allen, J., Keeland, B., Stanturf, J., Clewell, A., & Kennedy, H. (2004). A Guide to Bottomland Hardwood Restoration. *US Goeological Survey, Biological REsources Division Information and Technology Report USGS/BRD/ITR-2000-0011*, 132. Asheville: US DEpartment of Agriculture, Forest Service, Southern Research Station.

Arnold, M. A. (2004). *Rubus trivialis*. Retrieved from Texas A&M Horticulture: http://aggie-horticulture.tamu.edu/syllabi/608/Lists/second%20ed/Rubustrivialis.pdf

Bartomeus, I., Vila, M., & Santamaria, L. (2008). Contrasting Effects of Invasive Plant-Pollinator Networks. *Oecologia 155*, 761-770.

Better Crops. (1998). *Functions of Potassium in Plants.* Retrieved from International Plant Nutrition Institute: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB4QFjAA&url=http%3A%2F%2Fwww.ipni.net%2Fppiweb%2Fbcrops.nsf%2F%24webindex%2F84CBB51751971AB3852568F000673A10%2F%24file%2F98-3p04.pdf&ei=sPN1VPSFK8WqNv3tgRA&usg=AFQjCNEXF3mQveGp3dEXiiUzP0

Beyl, C. A., & Trigiano, R. N. (2011). *Plant Propagation Concepts and Laboratory Excercises.* CRC Press .

Blum, U., Shafer, S. R., & Lehman, M. E. (1999). Evidence for Inhibitory Allelopathic Interactions involving Phenolic Acids in Field Soils: Concepts vs. an Experimental Model. *Critical Reviews in Plant Sciences 18*, 673-693.

Bobwhite Quail Management. (n.d.). Retrieved from Texas Parks and Wildlife: http://tpwd.texas.gov/landwater/land/habitats/high_plains/upland_game/bobwhite.phtml

Bottomland Hardwoods Web-Based Forest Management Guide. (2009, January 28). Retrieved 2016, from USDA Forest Service: http://www.nrs.fs.fed.us/fmg/nfmg/bl_hardwood/eco/site/soils.html

Brown, B. J., & Mitchell, R. J. (2001). Competition for Pollination: Effects of Pollen of an Invasive Plant on Seed Set of a Native Congener. *Oecologia 129*, 43-49.

Brown, B. J., Mitchell, R. J., & Graham, S. A. (2002). Competition for Pollination Between an Invasive Species (Purple Loosestrife). *Ecology 83*, 2328-2336.

Brown, C. E., & Pezeshki, S. R. (2000, September). A STUDY ON WATERLOGGING AS A POTENTIAL TOOL TO CONTROL LIGUSTRUM SINENSE POPULATIONS IN WESTERN TENNESSEE. *Wetlands*, pp. 429-437.

Butz Huryn, V. M., & Moller, H. (1995). An Assessment of the Contribution of Honey Bees (Apis mellifer) to Weed Reproduction in New Zealand Protected Areas. *New Zealand Journal of Ecology 19*, 111-122.

Canham, C. D. (1990). Suprpression and Release During Canopy Recruitment in Fagus grandifolia. *Bulletin of the Torrey Botanical Club 117*, 1-7.

Coder, K. D. (1994, July). *Flood Damage to Trees*. Retrieved 2016, from NC Forest Service: ncforest.gov/managing_your_forest/pdf/flooddamagetotrees1994pdf

Collier, M. H., Vankat, J. L., & Hughes, M. R. (2002). Diminished Plant Richness and Abundance below Locinera Maackii an Invasive Shrub. *The American Midland Naturalist Vol 147, No.1*, 60-71.

Colmer, T., & Pedersen, O. (2008). Oxygen Dynamics in Submerged Rice (Oryza sativa). *New Phytol*, 326-334. Retrieved from http://dx.doi.org/10.1111/j.1469-8137.2007.02364.x

Contreras, R. N., & Ruter, J. M. (2009). Sulfuric Acid Scarification of Callicarpa americana L. (Lamiaceae) Seeds Improves Germination. *Native Plants Journal 10*, 283-286.

Cronk, B. C. (2012). *How to Use SPSS.* Glendale, CA: Pyrczak Publishing.

Cuda, J. P., & Zeller, M. C. (2006). *Chinese privet, Ligustrum sinense, Prospects for Classical Biological Control in the Southeastern United States*. Retrieved from University of Florida Integrated Pest Management: http://ipm.ifas.ufl.edu/environmental/Chinese_privet.shtml

Ehrenfeld, J. G. (2003). Effects od Exotic Plant Invasions on Soil Nutrient Cyclying Processes. *Ecosystems 6*, pp. 503-523.

Eriksson, O., & Ehrlen, J. (2008). *Seedling Ecology and Evolution.* Cambridge: Cambridge University Press.

Evans, E., & Blazich, F. A. (n.d.). *Overcoming Seed Dormancy: Trees and Shrubs.* North Carolina Coopertive Extension Service.

Faber, B. A., Downer, A. J., Holstege, D., & Mochizuki, M. J. (2007). Accuracy Varies for Commercially Available Soil Test Kits Analyzing Nitrate–Nitrogen, Phosphorus, Potassium, and pH. *HortTechnology 17*, 358-362.

Ferguson, J. J., Rathinasabapathi, B., & Chase, C. A. (2003, July). Allelopathy: How Plants Suppress Other Plants. *University of Florida IFAS Extension*.

Flooding and Its Effects on Trees. (n.d.). Retrieved 2016, from NortheasternArea State and Private Forestry: https://www.na.fs.fed.us/spfo/pubs/n_resource/flood/toler.htm

Fraps, G. S., & Sterges, A. J. (1939). Possible Losses of Nitrogen From Acid Soils Through the Decomposition of Nitrites. *Soil Science 48*, 175-181.

Fulton, M. R. (1991). Adult Recruitment as a Funcion of Juvenile GRowth Rate in Size-Structure Plant Populations. *Oikos 65*, 102-105.

FWD Webmaster. (2016, January 14). *2015 North and Central Texas Weather Event Review*. Retrieved January 25, 2016, from National Weather Service Weather Forecast Office: www.srh.noaa.gov/fwd/?n=2015wxreview

Ghazoul, J. (2004). Alien Abduction: Distruptionof a Native Plant-Pollinator Interaction by Invasive Species. *Biotropica 36*, 156-164.

Grabas, G. P., & Laverty, T. M. (1999). The Effects of Purple Loose-strife (Lytrum salicaria L,;Lythraceae) on the Pollination and Reproductive Successof Sympathric Co-Flowering Wetland Plants. *Ecoscience 6*, 230-242.

Grand Parkway (SH99) Segment C, From US 59 to SH288,FOrt Bend and Brazoria Counties, Texas: Environmental Impact Statement, Volume 1. (2000). US Department of Transportation Federal Highway Administration .

Greene, B., & Blossey, B. (2012). Lost in the Weeds: Ligustrum sinense Reduces Native Plant Growth and Survival. *Biological Invasion 14 (1)*, 139-150.

Grove, E., & Clarkson, B. (2005). *An Ecological Study of Chinese Privet (Ligustrum sinense Lour.) in the Waikato Region.* Waikato Regional Council.

Hanula, J. L., & Horn, S. (2011). Removing an Exotic Shrub From Riparian Forests Increases Butterfly Adundance and Diversity. *Forest Ecology and Management 262*, 674-680.

Hanula, J. L., & Horn, S. (2011). Removing an Invasive Shrub (Chinese Privet) Increases Native Bee Diversity and Abundance in Riparian Forests of the Southeastern United States. *Insect Conservation and Diversity 4*, 275-283.

Hanula, J. L., Horn, S., & Taylor, J. W. (2009). Chinese Privet (Ligustrum sinense) Removal and its effect on Native Plant Communities of Riparian Forests. *Invasive Plant Science and Management*, 292-300.

Harrington, T. B., & Miller, J. H. (2005). Effects of Application Rate, TIming and Formulation of Glyphosate and Tryclopyr on Control of Chinese Privet (Ligustrum senense) . *Weed Technology 19*, 47-54.

Hart, J. L., & Holmes, B. N. (2013). Relationships between Ligustrum sinense Invasion, Biodiversity, and Development in a Mixed Bottomland Forest. *Invasive Plant Science and Management*, 6:175-186.

Hood, W. G., & Naiman, R. J. (2000). Vulnerability of Riparian Zones to Invasion by Exotic Woody Plants. *Plant Ecology 148*, 105-114.

Hudson, J. R., Hanula, J. L., & Horn, S. (2013). Removing Chinese Privet From Riparian Forests Still Benefits Pollinators. *Biological Conservation*, 355-362.

Hudson, J. R., Hanula, J. L., & Horn, S. (2014). Impacts of Removing Chinese Privet From Riparian Forests on Plant Communities and Tree Growth Five Years Later. *Forest Ecology and Management 324*, 101-108.

Hughes, R. F., Uowolo, A. L., & Togia, T. P. (2012). Recovery of Native Forest After Removal on an Invasive Tree, Falcataria moluccana, in American Samoa. *Biological Invasions*, 1393-1413.

Hulme, P. E., & Bremner, E. T. (2006). Assessing the Impact of Impatiens gladulifera on Riparian Habitats: Partitioning Diversity Components Following Species Removal. *Journal of Applied Ecology 43*, 43-50.

Iwanaga, F., Tanaka, K., Nakazato, I., & Yamamoto, F. (2015). Effects of Submergence on Growth and Survival of Saplings of Three Wetland Trees Differing in Adaptive Mechanisms For Flood Tolerance. *Forest Systems, 24*(1), 9. Retrieved from http://dx.doi.org/10.5424/fs/2015241-03010

Kozlowski, T., & Pallardy, S. (1997). *Growth Control in Woody Plants.* New York: Academic Press.

Kuebbing, S. E., Classen, A. T., & Simberloff, D. (2014). Two Co-Occuring Invasive Woody Shrubs Alter Soil Properties and Promote Subdominate Invasive Species. *Journal of Applied Ecology 51 (1)*, 124-133.

LaMotte Company. (2011). Combination Soil Outfit Instruction Manual.

Lanini, W. T., & Hanson, B. (2010, November). *Catchweed Bedstraw*. Retrieved from University of California Agriculture & Natural Resources: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn74154.html

Leak, W. B., & Graber, R. E. (1976). Seedling Input, Death and Growth in Uneven-Aged Northern Hardwoods. *Canadian Hournal of Forest Research 6*, 368-374.

Lewisville Aquatic Ecosystem Research Facility (LAERF). (2012). Retrieved from US Army Corps of Engineers: http://www.erdc.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/9254/Article/476784/lewisville-aquatic-ecosystem-research-facility-laerf.aspx

Maddox, V., Byrd Jr., J., & Serviss, B. (2010). Identification and Control of Invasive Privets (Ligustrum spp.) in the Middle Southern United States. *Invasive Plant Science and Management 3 (4)*, 482-488.

Martin, C. O., & Mott, S. P. (1997). *Ecosystems Management and Restoration Research Program American Beautyberry (Callicarpa americana).* US Army Corp of Engineers Wildlife REsources Management Manual.

McKenzie, R. H. (2003). *Soil pH and Plant Nutrients.* Retrieved from Alberta Agriculture and Forestry: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex6607

McKinney, A. M., & Goodell, K. (2010). Shading by INvasive Shrub Reduces Seed Production and Pollinator Services in a Native Herb. *Biological Invasions 12*, 2751-2763.

Merriam, R. W. (2003). The Abundance, Destruction and Edge Associations of Six Non-indigenous, Harmful Plants Across North Carolina. *Journal of the Torrey Botanical Society 130*, 283-291.

Merriam, R. W., & Feil, E. (2002). The Potential Impact of an Introduced Shrub on Native Plant Diversity and Forest Regeneration. *Biological Invasions 4*, 364-373.

Miller, J. H., & Miller, K. V. (1999). Rubis trivialis. *Forest Plants of the Southeast and Their Wildlife Uses*. Southern Weed Science Society. Retrieved from USDA NAtural Resources Conservation Service: http://plants.usda.gov/core/profile?symbol=RUTR

Milliken, W. (n.d.). *Sambucus nigra (elder)*. Retrieved from Kew Rotal Botanical Gardens: http://www.kew.org/science-conservation/plants-fungi/sambucus-nigra-elder

Minor, E. S., & Gardner, R. H. (2011). Landscape Connectivity and Seed Dispersal Chrarcteristics inform the best managment Strategy for Exotic Plants. *Ecological Applications, 21*(3), 739-749.

Mitchell, J. D., Lockaby, B. G., & Brantley, E. F. (2011). Influence of Chinese Prive (Ligustrum sinense) on Decomposition and Nutrient Availablility in Riparian Forests. *Invasive Plant Science and Management*, 437-447.

Munger, G. T. (2003). *Forest Services.* Retrieved from U.S. Department of Arigiculture: http://www.fs.fed.us/database/feis/

Munger, G. T. (2003). *Ligustrum spp. In: Fire Effects Information System, [Online]*. Retrieved from U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory : http://www.fs.fed.us/database/feis/ [2014, November 7]

Munoz, A. A., & Cavieres, L. A. (2008). The Presence of a Showy Invasive Plant Disrupts Pollinator Service and Reproductive Out-Put in Native Alpine Species Only at High Densities. *Journal of Ecology 96*, 459-467.

Natural Resources Conservation Service. (2008, January). Retrieved 2016, from US Department of Agriculture: nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/azpmstn7363.pdf

Natural Resources Conservation Services. (2003, February 03). Retrieved from United States Department of Agriculture: https://plants.usda.gov/core/profile?symbol=LISI

Nelson, D. W. (1967). Chemical Transformations of NItrite in Soils. *Paper 3172*. Retrospective Theses and Dissertation.

New, T. R. (1997). *Butterfly Conservation.* Oxford, England: Oxford University Press.

New, T. r., Pyle, R. M., Thomas, J. A., & Hammond, P. C. (1995). Butterfly Conservation Management. *Annual REview of Entomology 40*, 57-83.

Nokes, J. (1986). *How to Grow Native Plants of Texas and the Southwest.* Houston: Gulf Publishing Co.

Pellissier, F., Gallet, C., & Souto, X. C. (2002). Allelopatic Interactions in Forest Ecosystems. In M. J. Reigosa, P. Nuria, A. M. Sanchez-Moreiras, & L. Gonzales, *Allelopathy: From Molecules to Ecosystems* (pp. 257-269). Enfield, New Hampshire: Science Publishers.

Planty-Tabacchi, A. M., Tabacci, J. N., Deferrari, C., & Decamps, H. (1996). Invasibility of Species-Rich Communities in Riparian Zones. *Conservasion Biology 10*, 598-607.

Pokswinski, S. M. (2008, August 9). Invasive Characteristics of Chinese Privet (Ligustrum sinense Lour.) in a Bay Swamp in the Fall Line Hills of East-Central Alabama. Auburn.

Pysek, P., & Prach, P. (1993). Plant INvasions and the Role of Riparian Habitats: A Comparision of Four Species Alien to Central Europe. *Journal of Biogeography 20*, 412-420.

Richardson, D. M., Holmes, P. M., Esler, K. J., Galatowitsch, S. M., Stromberg, J. C., Kirkman, S. P., . . . Hobbs, R. J. (2007). Riparian Vegetation: Degradation, Alien Plant Invasions, and Restoration Propects. *Diversity and Distributions 13*, 126-139.

Robinson, C. (2006, February). *Trees and Shrubs for Difficult Sites.* Retrieved 2016, from Kansas State University Forestry: www.kansasforests.org

Robinson, R. H. (1923). Action of Sodium Nitritein Soil. *Journal of Agricultural Research 26*, 1-7.

Runkle, E. S. (2006, August). *Successfully Propagating Cuttings Takes Planning.* Retrieved 2016, from GMPro: http://flor.hrt.msu.edu/assets/Uploads/Sucessfullypropagatingcuttingstakesplanning.pdf

Schad, A. N., Dick, G. O., & Dodd, L. L. (2013). *Dallas Floodway Extension: An Adaptive Management Approach for Establishing Flood-TolerantNative Trees, Shrubs and Vines.* Status Report.

Seiler, J. R., & Groninger, J. W. (2009). *Forest Biology.* Viginia Tech.

Smith, E. T. (2007, January). Early Successional Habitat. *Fish and Wildlife Habitat Management Leaflet, 41*. Retrieved from http://www.americaslongleaf.org/media/11802/early-successional-habitat.pdf

Stratton, M., Good, G., & Barker, A. (2001). The Effects of Nitrogen Source and Concentration on the Growth and Mineral Composition of Privet. *Journal of Plant Nutrition 24 (11)*, 1745.

Swift, M. J., Heal, O. W., & Anderson, J. M. (1979). *Decomposition in Terrestiral Ecosystems.* Berkeley: University of California Press.

Tepedino, V. J., Bradley, B. A., & Griswold, T. L. (2008). Night Flowers of INvasive Plants Increase Native Bee Carrying Capacity? Intimations From Capitol Reef NAtional PArk. *Natural Areas Journal 28*, 44-50.

Timmons, J. B., Alldredge, B., Rogers, W. E., & Cathey, J. C. (2012, January). *Feral Hogs Negatively Affect Native Plant Communities.* Retrieved 2016, from Texas A&M University: http://www.invasivespecies.wa.gov/documents/squealonpigs/FeralHogsNegativelyAffectNativePlantCommunities.pdf

Traveset, A., & Richardson, D. M. (2006). Biological Invasions as Disruptors of Plant Reproductive Mutualisms. *Trends in Ecology and Evolution 21*, 208-216.

Tyler, K. B., & Broadbent, F. E. (1960). Nitrites Transformations in Californina Soils. *Science Society of American Proceeding 24*, 279-282.

Ulyshen, M. D., & Hanula, J. L. (2007). A Comparison of the Beetle (Coleoptera) Fauna Captured at Two Heights Above the Ground in a North American Temperate Deciduous Forest. *American Midland Naturalist 158*, 260-278.

Ulyshen, M. D., Horn, S., & Hanula, J. L. (2010). Response of Beetles (Coleoptera)at Three Heights to the Experimental Removal of an Invasive Shrub, Chinese Privet (Ligustrum sinense), From Floodplain Forests. *Biological Invasions 12*, 1573-1579.

Vanparys, V., Meerts, P., & Jacquemart, A. L. (2008). Plant-Pollinator Interactions: Comparison Between an Invasive and a Native Congeneric Species. *Acta Oecologia*, 361-369.

Wagner, D. L., & VanDriesche, R. G. (2010). Threats Posed to Rare or Endangered Insects by Invasion of Nonnative Species. *Annual REview of Entomology 55*, 547-568.

Water Data for Texas. (n.d.). Retrieved January 25, 2016, from Texas Water Developemnt Board: www.waterdatafortexas.org/reserviors/idividual/lewisville

Webster, J. R., & Benfield, E. F. (1986). Vascular Plant Breakdown in Freshwater Ecosystems. *Annual REviewof Ecology and Systematics 17*, 567-594.

Welch-Keesey, M., & Lerner, B. R. (2009, August 11). *HO-37 New Plants From Cuttings.* Retrieved 2016, from Purdue University Consumer Horticulture: https://hort.purdue.edu/ext/HO-37web.html

Whiting, D., Wilson, C., & Reeder, J. (2014). *CMG GardenNotes.* Retrieved from Colorado State University: http://www.ext.colostate.edu/mg/gardennotes/214.html#triangle

Wilcox, J., & Beck, C. W. (2007). Effects of Ligustrum sinense Lour. (Chinese Privet) on Abundance and Diversity of Songbirds and Native Plants in a Southeastern NAture Preserve. *Southeastern Naturalist 6*, 535-550.

Wild Onion (Allium spp.). (n.d.). Retrieved from Veterinary Medicine Library: http://www.library.illinois.edu/vex/toxic/wonion/wonion.htm#references

Willard, A., & Hardig, M. (2013). *Potential Allelopathic Effects of Invasive Species Ligustrum sinense Lour. (Chinese Privet) and Triadica sebifera (L.) Small (Chinese Tallow Tree) on the Germination of Raphanus sativus L. (Radish) Seeds.* Retrieved from University of Montevallo: www.legacy.montevallo.edu

Willis, R. J. (1985). The HIstorical Basis of the Cencept of Allelopathy. *Journal of Historical Biology 18*, 71-102.