An Assessment of Mechanical Removal Methods of Privet (*Ligustrum japonicum & Ligustrum sinense*) at Wild Basin Wilderness Preserve

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Abstract

Invasive plant species have characteristics that allow them to invade, proliferate, and outcompete native species, which gives them the propensity to damage natural ecosystems, sometimes resulting in novel ecosystems. To maintain and restore native biodiversity in these damaged systems, it is important to identify successful methods for invasive plant species removal that is both effective and appropriate for the target ecosystem. Riparian ecosystems are vulnerable to some known removal methods such as application of chemical herbicide, which could cause further damage to the ecosystem due to its proximity to a water source. Our study site was at Wild Basin Wilderness Preserve (WBWP) and, as it is a part of the Balcones Canyonlands Preserve (BCP), it has many riparian corridors. *Ligustrum japonicum* (Japanese Privet), and *Ligustrum sinense* (Chinese Privet) are two invasive plant species coexisting and disrupting the natural riparian ecosystem at WBWP. The objective of this research project was to identify an effective mechanical removal method, with the capability of being implemented on a large scale by the volunteers and staff at WBWP, and the greater BCP. A plot experiment was conducted at WBWP to assess which removal method was the most effective at inhibiting the re-growth of the two *Ligustrum* species. Of the three mechanical removal methods that were tested, results showed that hand-pulling and subsequent over-sowing with the native grass, Inland Sea Oat (*Chasmanthium latifolium*), was the most successful at inhibiting re-growth of *L. japonicum* and *L. sinense*.

Introduction

Founded in 1947 in Austin Texas, the Wild Basin Wilderness Preserve (WBWP) is a 227-acre preserve focused on serving the community while providing a center for students from St. Edward's University to perform creative research. As a part of the Balcones Canyonlands Preserve system (BCP), Wild Basin is dedicated to preserving the natural ecosystems found in the surrounding areas (Wild Basin Research Center, 2016). Invasive species are a growing threat to the naturally occurring ecosystems in Wild Basin, as well as much of the country, and can degrade the biodiversity and productivity of the surrounding ecosystem (Mullin et al. 2000). Invasive species often have characteristics that allow them to invade, proliferate, and outcompete native plants. The result is a new, or novel, ecosystem that may cause differences to occur among that ecosystem's previous productivity and functionality (Hobbs et al. 2006). Successful management of particularly detrimental invasive species is required when those invasives significantly harm the structure and productivity of the biotic and abiotic components.

The riparian ecosystem within WBWP is particularly vulnerable to invasive plant encroachment. This area's sensitivity is attributed to the fact that it is frequently disturbed due to flooding periods, which opens up the understory for new establishment of plant species (Hanula et al. 2009). These flooding episodes increase the probability of invasive species establishment and further succession. Riparian zones are of great ecological significance because the vegetation along these areas controls the flow of water, nutrients, and sediments into streams, and stream corridors enable species

movement (Hanula et al. 2009). Therefore, the riparian ecosystem contributes to and helps control the ecosystem services and functioning within Wild Basin.

We addressed two invasive plant species that are persistent along the riparian zones at WBWP: *Ligustrum japonicum* (Japanese Privet) and *Ligustrum sinense* (Chinese Privet). The presence of invasive *Ligustrum* species is concerning because these woody plants disrupt the natural ecosystem and create interspecific competition for native species; both create a competition for resources including sunlight and nitrogen resources.

Additionally, these two invasive species possess many traits that allow them to outcompete the native plant population. Due to their high shade tolerance, they can quickly occupy and establish themselves as the dominant species in a well-developed forest understory (Hanula et al. 2009; Miller 1998; Schierenbeck 2004; Vaughn 2013). Invaded areas that contain one, or both, of these species are correlated with less-diverse understory layers, indicating they decrease overall species abundance and richness, which can negatively impact forest regeneration (Hanula et al. 2009; Miller 1998; Webster et al. 2006). Other traits contributing to their success include, but are not limited to, higher resource efficiency, ability to form pure stands and competitively exclude other species, high reproductive output, ability to reproduce vegetatively, animal dispersed seeds, and the ability to form a seed bank (Webster et al. 2006). Previous studies have also noted that these species lack adequate control from natural herbivorous predators and may even possess chemical defenses against such predators (Maddox et al. 2010; Miller 1998). By invading riparian areas at WBWP, *Ligustrum spp*. are excluding native understory species and decreasing hardwood

regeneration and species diversity (Harrington and Miller 2005; Miller 1998). Further invasion of these exotics into the WBWP boundary will continue to decrease the flora and fauna diversity, if left unmanaged. This will result in the diminishment of the ecological value of the land and Wild Basin's primary mission of preserving the natural ecosystem.

L. japonicum and *L. sinense* are coexisting and disrupting the natural ecosystem at the WBWP. The sites in question that contain these two species are located along the riparian forest of Bee Creek, which runs through the southern part of WBWP. Little is known about large-scale management plans in a riparian forest, especially for these *Ligustrum spp.* when they are coexisting with one another. Our project served first to identify the most successful method(s) for removal for *Ligustrum spp.* through a four-week plot experiment in the field at WBWP. Then, results from the plot experiment were used to create a holistic and adaptive management plan to be used by staff and volunteers at WBWP for years to come.

Of the three mechanical removal methods that were assessed, we hypothesized that the best method of removal would be a combination of hand-pulling and spreading of a cedar-based mulch. Cedar contains allelochemicals, phytochemicals that inhibit growth of neighboring plants, in both the wood as well as the leaves (Rathinasabapathi et al. 2005). When used as a mulch, the allelochemicals found in cedar have been proven to inhibit seed germination and prevent growth of weeds such as *Desmodium tortuosum* (Rathinasabapathi et al. 2005).

Methods

Study Site

This study took place at WBWP, part of the BCP, between July and December of 2016. Within the preserve, the experiment was conducted in the riparian zones along Bee Creek. There were four replications of the experiment: each area contained four, 4 m^2 plots (three treatment and one control), for 16 plots in total. Plots, all within one meter of the creek, were located based on the presence of the invasive species *L. japonicum. L. sinense* was included for the first two areas but was left out in areas three and four because it was not present. Figure 1 depicts the four replication areas that were located across the southern portion of Wild Basin. All plots were located within riparian habitat along Bee Creek.

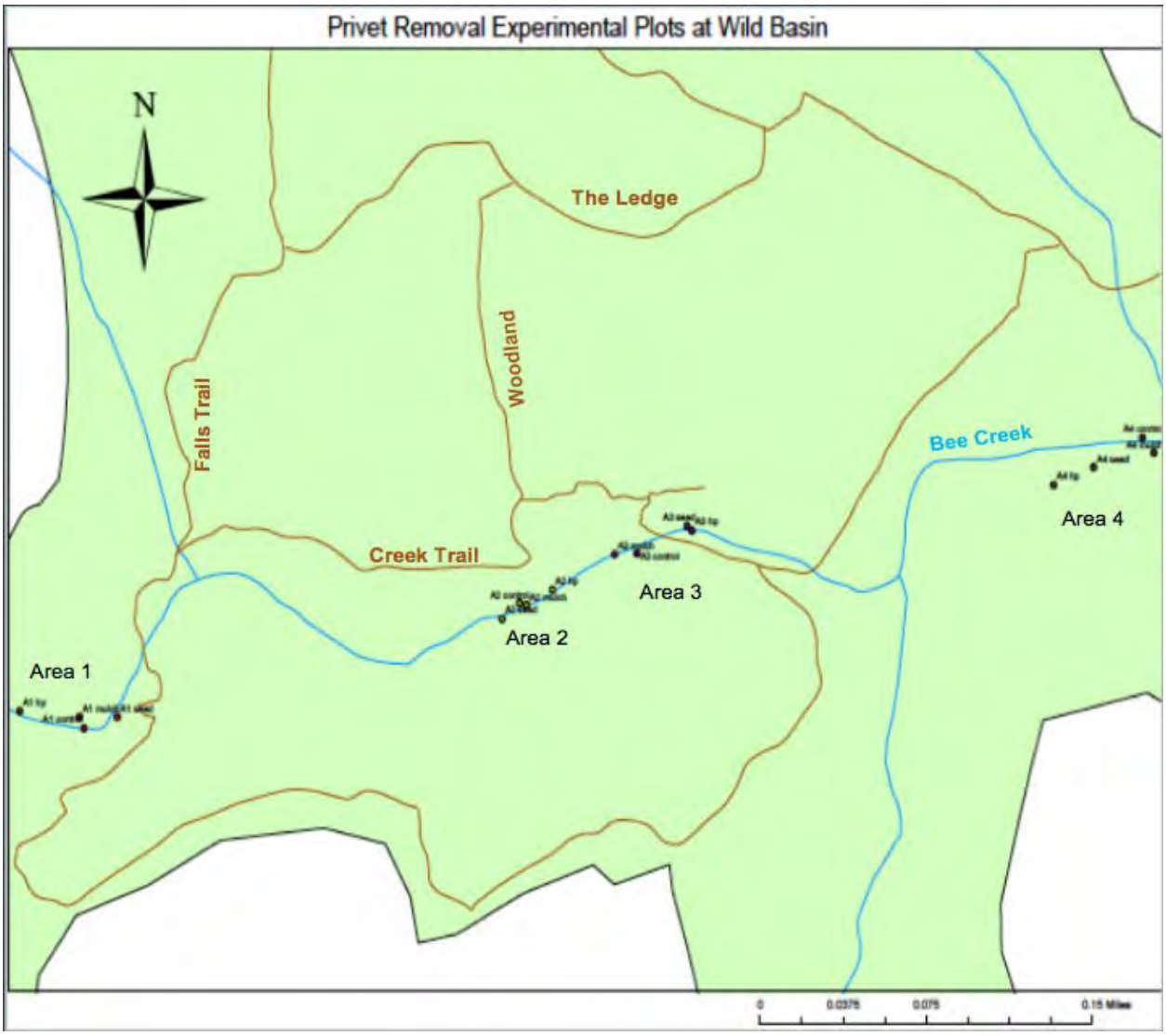


Figure 1: Map of WBWP and the location of the study sites along Bee Creek

Treatments: Experimental Methods of Removal

For the purpose of clarity, we will first define our methods of removal for the invasive plant material. We used a hand-pulling method for small stems that allowed, removing aboveground and belowground invasive plant biomass. A Weed Wrench was used to remove the larger-stemmed invasive species, again thoroughly removing both aboveground and belowground plant biomass. In each case, the uprooted soil was replaced to minimize disturbance. For the remainder of this proposal, the term “hand-pulling” is meant to entail all forms of plant material removal that we implemented during our field work, including hand-pulling and Weed Wrenching.

For each replication of the experiment, the area and plots were identified and marked using a Garmin Oregon 600 GPS unit. The 2m x 2m plots were constructed using meter tape and identifiable flags to mark their boundaries.

Once the plots were identified, a pre-treatment assessment was conducted. First, each plot was assigned a treatment randomly: control, hand-pull, over-sow, or mulch. Then a species richness assessment, along with a stem density census, was conducted for every plant species within the plot. This was done as part of a Before-After-Control-Impact, or BACI, experimental design. The pre-treatment assessments would be used to determine if the impact of removal of the invasive species affected the native plant community in any way.

Hand-pulling

The hand-pulling treatment consisted of pulling the *Ligustrum spp.* from the base of the plant: the aim was to extract all of the aboveground and belowground, or root,

material. This method was used across the three treatment plots in each area. The removed biomass of *Ligustrum spp.* was placed in labeled bags to be measured, dried and weighed, as another comparison of pre and post-treatment.

Over-sowing

The second method used was a combination of hand-pulling and subsequent over-sowing with a native grass, Inland Sea Oat (*Chasmanthium latifolium*) (Dahl & Woodward, 1977). After all *Ligustrum spp.* individuals were hand-pulled from the plot, shovels and spades were used to break up the soil. Enough Inland Sea Oat seeds were sprinkled across to cover the entire plot and were buried with a shallow layer of the soil found in or around the experimental plot. Then, using the water from Bee Creek, the over-sowing plot was watered to help facilitate seedling growth. Not only is Inland Sea Oat native to the area, it is especially prevalent within riparian zones at WBWP and the seed source that was used for over-sowing the experimental plot had been collected from WBWP and the surrounding Barton Creek Greenbelt area in Austin. Simmons (2005) suggests that success of an invasive species may be due to the absence of a native species due to seed limitation or due to a superior competitor. This method introduces a native species into the plot as well as reduces competition of the invasive species by loss of photosynthetic material.

Mulch

The final treatment was a combination of hand-pulling and the application of a cedar-based mulch. Once *Ligustrum spp*. was removed from the plot, a layer of mulch,

roughly 2” in depth, was applied. The cedar-based mulch has two purposes; first, the addition of a carbon source will stimulate microbial activity, which will create competition for nitrogen resources (Concilio & Loik, 2013). Second, a cedar-based mulch contains allelochemical components which will prevent re-growth of invasive plant species as well as prevent seed germination (Rathinasabapathi et al. 2005). Furthermore, cedar, or *Ashe juniper*, is already native to WBWP and Central Texas.

Analysis

After the treatments were applied, each plot was monitored at least once a week for four consecutive weeks following the application of the treatment. During the monitoring process, qualitative observations were made for each plot and all re-growth of the *Ligustrum spp*. was removed to be dried and weighed in order to calculate the percent re-growth post-treatment. The re-growth obtained across the four subsequent weeks of monitoring was summed to compare pre-treatment stem density per m^2 with post-treatment stem density per m^2 by treatment type. Using the statistical software R, a two-way ANOVA was run using the stem density data to assess significant differences among treatment types. Post-hoc Tukey HSD tests were conducted to determine significant differences between the specific treatments in order to conclude which was most effective based on differences between pre and post-treatment stem density.

Results

Stem Density

Although all treatments did have a significant effect in the removal of *Ligustrum spp.* ($p = 0.007$), the results suggested the application of a treatment, in addition to hand-pulling, was more successful in inhibiting long-term *Ligustrum spp.* re-growth than hand-pulling alone. When considering the pre and post-treatment stem density of each removal method, the most effective treatment in inhibiting re-growth was the over-sowing treatment ($p < 0.0001$), in comparison to the mulch ($p < 0.001$) or hand-pull ($p < 0.001$) treatments (Fig. 2). The control plots were not significantly different from one another when comparing pre-treatment versus post-treatment ($p = 0.99$), which suggested no other factors were affecting stem density of the *Ligustrum spp.* other than the removal methods that were applied.

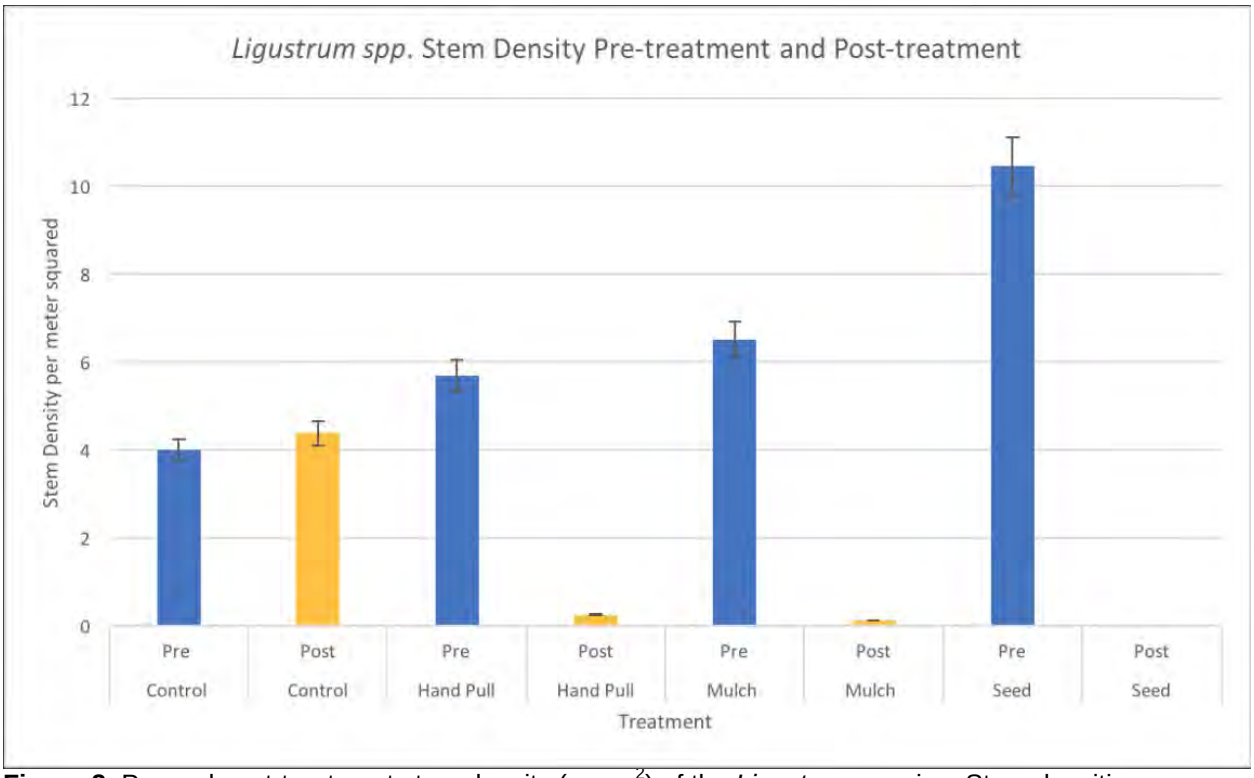


Figure 2: Pre and post-treatment stem density (per m^2) of the *Ligustrum* species. Stem densities were averaged across the four plot replications. Re-growth of *Ligustrum* was most significantly affected by the over-sowing removal method ($p < 0.0001$), with 100% reduction of *Ligustrum spp.* stem-density within the oversowing experimental plots.

Biomass and Species Biodiversity

Biomass, which was also collected during the study was inconclusive due to the inconsistency of size number of *Ligustrum spp*. in each plot across the four study sites. The biodiversity assessments did not show any significant difference between the plots and did not change over the course of the study from the pre and post assessments. This may be due to the short duration of the study, which occurred during one season.

Discussion

Invasive species are a growing problem in the United States, and problematic *Ligustrum spp*. populations are especially prevalent in the southeastern region. *Ligustrum spp*. have the propensity to disrupt natural ecosystems, and create a problem for land managers, by outcompeting native plants and creating an unwanted homogenous community. Declining native plant diversity will lead to a decrease in global biodiversity, which can degrade overall ecosystem functioning (Groom et al. 2006). For these reasons, effective management of invasive plants like *Ligustrum* is needed to maintain healthy, viable ecosystems that are capable of supporting various species and carrying out vital ecosystem functions that contribute to the Earth's environmental cycles.

The plot experiment at WBWP has shown that mechanical methods can be successful at removing *Ligustrum spp*. and preventing regrowth. These results provide important management alternatives for land managers that rely on herbicides to control invasive *Ligustrum* populations, as these herbicides contain harmful chemicals that destroy both native and invasive species populations and have cascading effects on the

abiotic elements of the ecosystem (DiTomaso 2000; Rinella et al. 2009). Herbicide use has become a popular method of *Ligustrum spp*. removal; however, most contain chemicals that greatly damage the surrounding ecosystem, which is especially problematic in riparian habitats which are located near natural water sources. This is a costly method that requires certification of the user as well as several applications before it is successful. The use of mechanical methods compared to herbicide is more feasible and it can be easily implemented by volunteers. The feasibility, and environmental cost, are important factors to take into consideration when deciding on the most effective management solutions. WBWP, which primarily relies on volunteer workers to help with land management activities, will greatly benefit from these successful mechanical removal methods to eradicate the *Ligustrum spp.* from the preserve. Table 1 shows the advantages and disadvantages of each mechanical removal method to help land managers determine the best method for their restoration project.

Feasibility of Removal Methods

	Hand-pulling	Mulch	Oversowing
Advantages	• Minimal equipment required • Inexpensive; requires only labor • Nothing added to plant community structure	• More effective than just hand-pulling • Inhibits regrowth of invasive plant species through allelochemicals	• More effective than just hand-pulling • Inhibits regrowth of invasive plant species via competition • Nothing exotic is added • Enhances native plant community
Disadvantages	• No additional safeguards against regrowth • Requires multiple hand-pulling events	• Can be costly • Transportation of mulch • Unknown how native plant species community is affected • Requires re-application if disturbed	• Finding a suitable native competitor • Potential to alter plant community structure

Table 1: Advantages and disadvantages of each mechanical removal method.

Removal and management for invasive species is costly and time consuming. To prevent further invasions of harmful plant and other species, education and public awareness on the implications of species invasions are essential. *Ligustrum spp*., as well as other invasive plant species, can be bought from many nurseries across the United States and planted by homeowners who don't know the harmful extent of their actions. Although Benjamin Franklin was referring to fire with his quote "an ounce of prevention is worth a pound of cure", it is applicable to the dilemma of invasive species. Education and public awareness may result in the end of invasive species trade, and save land managers time and money in the eradication of *Ligustrum spp*. and other harmful invasive species before it's too late.

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