TRAIL-SIDE SURVEY OF *LIGUSTRUM LUCIDUM* AND *NANDINA DOMESTICA* THROUGHOUT PROSPECT PARK NATURAL AREA

by

Haley Tacker

HONORS THESIS

Submitted to Texas State University
in partial fulfillment
of the requirements for
graduation in the Honors College
August 2021

Thesis Supervisor:

Kimberly M. Meitzen

=

ABSTRACT

San Marcos Greenbelt Alliance (SMGA) and the City of San Marcos (COSM) actively manage a variety of greenspaces and trails throughout San Marcos, Texas. A crucial facet of the ecological management of protected places is exotic invasive species management. Exotic invasive species are non-native organisms that thrive in foreign environments, competing against native species for shelter, habitat, water, food and nutrient resources. Their lack of population controls in areas they have established enables them to occupy significant portions of natural landscapes. Overgrowth of invasive plants can compromise food webs and damage physical infrastructure, which may have dramatic detrimental effect on local natural resources, human health, and the economy. This project supports invasive removal efforts on behalf of SMGA and COSM by providing a GPS-based spatial inventory of *Ligustrum lucidum* and *Nandina domestica* via GIS and database of the descriptive statistics of the vegetation communities. A map was created showing the location of 3-meter invasive species plots in relation to trails, trail markers, and points of interest at Prospect Park in San Marcos, Texas. The database is an excel book with the survey information for 150 plots, and includes measurements for frequency, density, biomass, dominance value, and importance factor. These descriptive statistics were used to determine to best route for SMGA and COSM to begin removing/treating the two invasive species. I recommend a removal path prioritizing sections of the park near trail markers LL21, LL19, S3, and V5.

Key words: Invasive Species, Greenspace, Landscape Management

INTRODUCTION

For over 20 years, the local non-profit volunteer organization San Marcos Greenbelt Alliance (SMGA) and municipal entity City of San Marcos (COSM) have been removing exotic, invasive plant species from city-owned green spaces to mitigate the negative impacts of invasive overgrowth. According to the National Park Service, invasive species have proven to “disrupt ecological processes, threaten ecosystem integrity, degrade cultural resources, [exacerbate effects of habitat fragmentation], and potentially interfere with visitor experiences in parks” (NPS, 2021). Invasive vegetative overgrowth can even have far-reaching negative effects over the local environment, human health, and the economy (Ericson & Lusk, 2012). It is a long-standing goal of both SMGA and COSM to eradicate aggressive invasive species to the highest level logistically attainable in all protected City Park and Natural Areas such that native biodiversity is prioritized. Exotic, invasive woody plant species such as *Phyllostachys aurea* (Golden Bamboo), *Melia azedarach* (Chinaberry), *Triadica sebifera* (Chinese Tallow), are numerous others can be found throughout the central Texas region. Two species in particular, *Ligustrum lucidum* (Ligustrum) and *Nandina domestica* (Nandina), are unfortunately common invasive plants found throughout San Marcos, Texas and the rest of the region. Ligustrum and Nandina both generate significant quantities of fruit and seed, which enables them to easily germinate and establish large populations. Once established, these plants stress local ecology by outcompeting native vegetation for resources, decreasing available habitat and food resources for wildlife and pollinators, degrading soil health, and contributing to a general decrease in biodiversity. Further, each of these species' berries can be somewhat toxic, which can increase negative impacts on wildlife who consume the berries, flowers, and leaf matter.

In the wake of rapid urbanization, it is exceedingly crucial to preserve existing green spaces due to the larger-scale loss of natural terrain. Hays County was declared the fastest growing county in the nation for three consecutive years from 2013 to 2015. New, incoming construction and development projects will continually increase opportunities for non-native species to be introduced through landscaping practices, as both Ligustrum and Nandina (and several other invasive species) can be purchased from local plant retailers. As local trails and park systems become increasingly vulnerable to these growth pressures, it is absolutely essential to manage and mitigate the effects of invasive overgrowth in order to preserve biodiversity and maintain a biologically productive environment (Zillman, 2015). Invasive plant controls can be put into three categories: mechanical, chemical, and biological (Mattrick, n.d.). SMGA and COSM have used mechanical and chemical techniques often and effectively to remove exotic invasive species most popularly from Sessom Creek Natural Area.

PURPOSE

The purpose of this project is to support removal efforts of exotic, invasive vegetation from city-owned public park lands by creating a GPS-based spatial inventory of Ligustrum and Nandina distributions, plant sizes, and density, throughout Prospect Park in San Marcos, Texas. The two invasive species of concern have long been popular least favorites amongst local naturalists, academics, and environmental scientists.

Ligustrum lucidum is a dense-canopied, fast growing exotic and invasive evergreen tree that can grow upwards of 25 to 40 feet high (7.6 to 12.2 m) with a spread of 25-35 feet (7.6 to 10.6 m) (Gilman & Watson, 1993). It grows natively in China, Korea, and Japan, but has long been a common landscaping choice in the Americas due to its hardiness, glossy leaves, and fast growth. Ligustrum is a generalist species which can thrive under a variety of soil moistures and types, climates, and sunny to shady local insolation conditions. A mature Ligustrum tree is capable of annually producing between one and three million highly viable seeds. This tree also reproduces from resprouting stems and root-sprouts from its base – supporting further evidence of its especially aggressive growth habit. Ligustrum eventually forms impenetrable thickets of growth that reduce light availability for native species of grasses, shrubs, and smaller trees. Due to its evergreen nature and lack of deciduous dormancy, it may also outcompete native vegetation for water resources year-round. By suppressing native vegetation, understory habitat quality is degraded, thus consequentially disabling the space from supporting a variety of native fungi, insects, and animals.

Further, "the berries, leaves and perhaps other parts of Ligustrum are toxic" to both animals and humans (De Ruff, 2005). While this is a debated topic with some documented historical and currently researched medicinal uses for Ligustrum, there are several sources that claim this plant is dangerous to human health. For example, Ligustrum's popularity in Australia has prompted the Queensland government to warn citizens of the entire Ligustrum genus's effects on their Children's Hospital and Health Service webpage. The Queensland government even warns that one should seek medical assistance if more than 5 berries from the Ligustrum genus are consumed (Queensland, 2017). The North Carolina Extension gardening service also lists *Ligustrum lucidum* species specifically as being poisonous with ingestion symptoms including headache, nausea, abdominal pain, weakness, diarrhea, and/or low blood pressure (Ligustrum, n.d.). Because it appears that overgrowth of Ligustrum may pose undesirable ramifications for animal and human health, it is necessary to monitor its local populations. An ecologically significant native, endangered songbird species, *Setophaga chrysoparia*, the "Golden Cheeked Warbler", is an extremely important avian species to protect due to its endangered status. This bird, as well as many other, may be harmed by consuming the potentially toxic, overly abundant Ligustrum berries. The endangered status of this beloved migratory songbird contributed to the acquisition of Purgatory Park Natural Area and Prospect Park. So, it would support the original land acquisition intentions to provide suitable habitat and manage factors that threaten the endangered species which occupy these protected park lands.

The other invasive species in question is *Nandina domestica*, an invasive and exotic "medium evergreen shrub with cane-like growth", reaching anywhere from 18 inches to 8 feet (2.4 m) in height (*Nandina domestica*, n.d.). It is also a generalist species which thrives in a wide variety of environmental conditions and was intentionally introduced from its native eastern Asia for ornamental landscaping. Sometimes referred to as "heavenly bamboo", Nandina is a popular choice in local plant retailers because of its hardiness, vivid fall color, interesting leaf structure, and aesthetically pleasing bright red berries. Nandina creates similar issues as Ligustrum: prolific viable seed/berry production and a lack of biological controls inhibiting its ability to outcompete native vegetation for resources. There is also a discussion around the toxicity of Nandina berries, however most sources do acknowledge some level of toxicity- there appears no to be documented medical uses for this plant. Nandina seeds have proven to contain "cyanide and other alkaloids that produce highly toxic hydrogen cyanide (HCN), which is extremely poisonous to all animals" (Davis, 2017). The poison is typically only "extreme" if an excessive amount of berries are consumed by a smaller animal, but the American Society for the Prevention of Cruelty to Animals (ASPCA) does list *Nandina domestica* as a toxic plant for dogs, cats, and horses (ASPCA, n.d.). The North Carolina Extension gardening service advises that this plant is of low danger to humans, but may pose a threat for cats, grazing animals, and songbirds (nandina, n.d.).

In addition to protecting the health of wildlife and humans, another purpose of targeting these invasive species for removal is to enhance the recreational value of the natural spaces in which they are found. Ligustrum and Nandina can outcompete a plethora of beautiful native specimen which help create a sense of place and memorability for Central Texas. Native flowering trees such as *Sophora dermatophyllum* (Texas Mountain Laurel), *Prunus Mexicana* (Mexican Plum), and *Cercis canadensis* (Eastern Redbud) would provide a more enjoyable and special experience for park visitors than Ligustrum. Nandina shades out quite a bit of habitat that could have instead hosted various native wildflowers such as *Lupinus texensis* (Texas bluebonnet), *Ratibita columnifera* (Mexican hat), Indian Blankets (*Gaillardia pulchella*), and many more. Natural parks that host a wide variety of native vegetation generally provide more opportunities for observing and learning about nature. Monitoring invasive species to coordinate removal efforts can generate more unique and enjoyable, experiences for park visitors.

These findings will be of use for SMGA and COSM to coordinate the logistics of the removal process. SMGA and COSM will be able to measure removal success rates over time with reference to factors such as geographical species abundance, calculated baseline biomass, proximal species composition, environment type, etc. These findings may also influence the frequency of monitoring native vegetation recovery at sites formerly occupied by these exotic, invasive species. In the future, the project deliverables may be evaluated against current conditions to evaluate progress and determine appropriate next steps in management. This project will serve as a pilot for invasive removal missions in other parks maintained by SMGA and COSM. There is potential to inventory other species identified as being a greater threat to specific areas.

METHODS

While there were numerous other potential study areas, Prospect Park was chosen to collect invasive data from because of its size, history, and immediate proximity to residential neighborhoods. Prospect Park is the oldest section of a much larger Purgatory Creek Natural Area and was the original SMGA-protected greenspace established over two decades ago. According to SMGA, several “forward-thinking individuals worked with city council to create a parkland of about 9 acres”. Prospect Park has both relevant proximity to a residential neighborhood and is a perfect size for the given timeline such that the specified study area was thoroughly analyzed. Because the park is bordered by and is immediately adjacent to multiple average-seeming single-family homes, it is possible that invasive species in this area may be a direct result or nearby landscaping decisions. This neighborhood is essentially acting as a seed bank, seasonally dispersing new specimen throughout the neighboring natural area. Anecdotally, I have seen significant stands of Ligustrum and Nandina throughout Prospect Park while hiking for leisure and during an educational hike lead by a native horticultural researcher for my undergraduate environmental interpretation course.

My field assistant and I conducted our field work by executing a baseline vegetation survey throughout Prospect Park to locate Ligustrum and Nandina stands GPS locations and to measure plant sizes and relative invasive density, dominance values, and the same metrics of associated native species in association with the exotic plant stands. We carefully hiked all trails in the park, which are Limbo Loop, Virgil Trail, Sinon Trail and an ADA loop that connects Prospect Park to the larger Purgatory Creek Natural Area and recorded field conditions for every day of research (map in Figure 1).

=

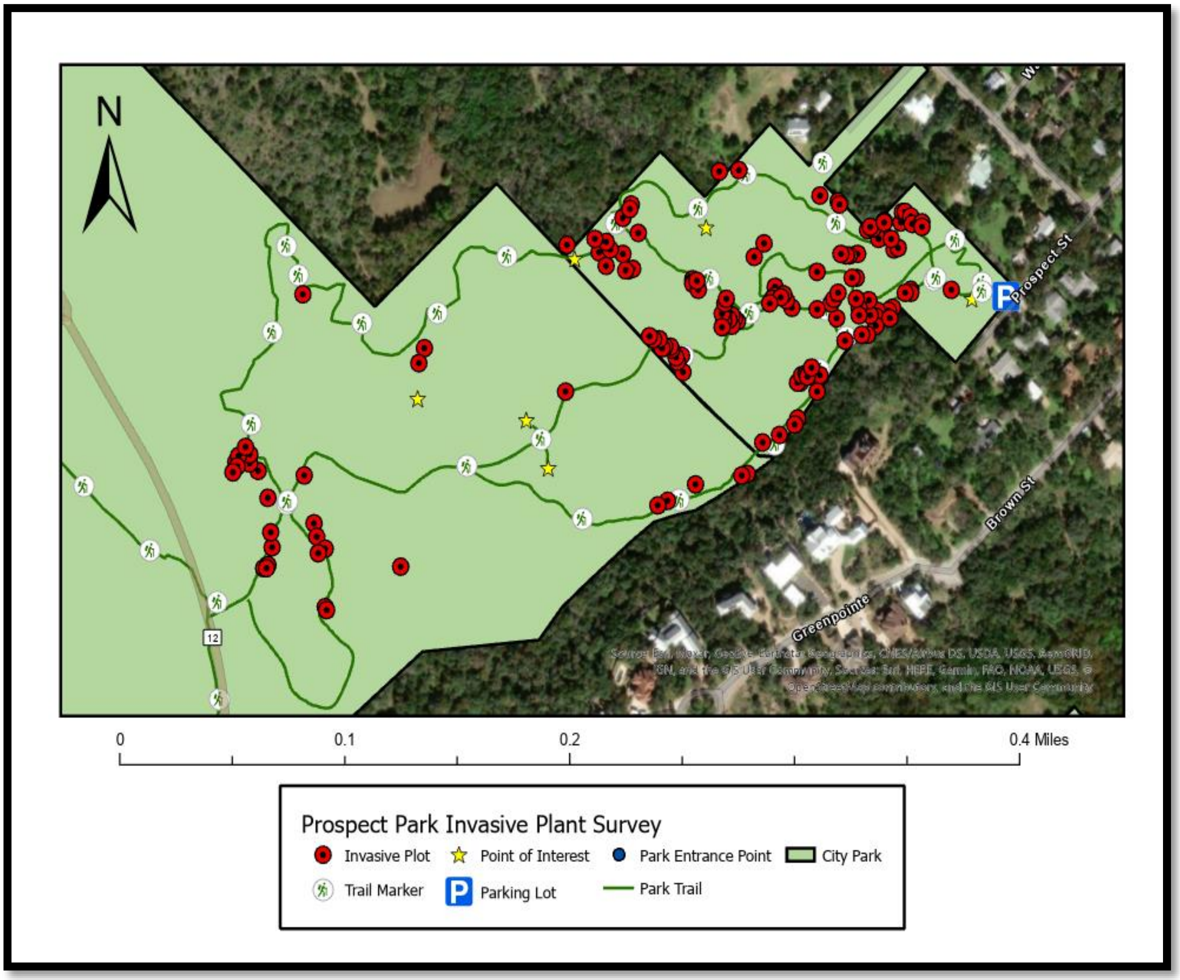

Figure 1- Prospect Park Invasive Plant Survey Map

We discriminately placed 3-meter circular plots to effectively capture the greatest abundance of invasive specimen such that we have the lowest number of plots. Upon locating a visible invasive specimen from walking the trails, we tied a biodegradable red tape around the plant in the middle of the plot to easy visualize the plot center. We then measured a 1.5-meter diameter with a rope to define the boundaries of our plot such that it was clear what plants should be catalogued in the survey and which were out of the plot perimeter. Using the Extrex30 GPS device, we electronically marked GPS coordinate waypoints closest to the center of each plot. We then conducted a woody species composition survey, recording the name and frequency of each plant (exotic and native) that had a diameter equal or greater than 1 cm at roughly 4.5 feet (1.4 m) high. This measurement is called Diameter at Breast Height (DBH), which is the measurement we used to record and calculate the biomass for all listed species in the survey.

All survey information was recorded in an excel workbook, with each plot being its own sheet with several calculated figures describing conditions in the plot. Each plot was analyzed to determine individual and total figures for total species frequency, and individual species density, relative species density, basal area sum, basal area sum per hectare area, relative dominance, and importance values. Frequency is the total number of all plants within the plot, so if a plot has a Ligustrum frequency of 2, then 2 total Ligustrum specimen were counted within that 3m plot. The density value calculates the hypothetical number of specimens that would be present if plot conditions were consistent over an entire hectare. Each density value was calculated by dividing the frequency value by the area of the plot converted to hectares, and is not actually dependent on the size of the specimen **(density= frequency/0.0007069)**. Relative species density can be described as a calculation for the density per species per plot out of a whole number 1. Relative density accounts for the density of each species within the 0.0007069-hectare area compared to each other as a greater part of the whole **(relative species density = species density/total density)**. Basal area sum describes the individual-species and plot-total amounts of basal area, or calculated biomass. Biomass figures were found by using DBH to calculate the area per species per plot in **meters ((basal area= (DBH/2)π^2))**. Basal area sum per hectare calculates the species-specific area and plot-total area as if plot conditions were again extended throughout an entire hectare **(basal area sum= basal area/0.0007069)**. Relative dominance describes the relationship between a species' basal area and the plot's total basal area **(relative dominance= basal area/basal area total)**. Importance values describe the significance of a species within the plot by comparing the species count and size to the rest of the plot's figures. This value (a fraction out of 1) can be compared across plots to determine a mitigation plan- the higher the importance value, the more present and threatening an invasive species is **((importance value= (relative species density + relative dominance)/2)**. These metrics will accompany the GIS data deliverables and are relevant because they can be used to describe findings and generate recommendations to SMGA and COSM.

RESULTS

The field data survey yielded 150 plots at Prospect Park, which is the equivalent of surveying 0.106 hectares or 450 square meters (Figure 1). Ligustrum was present in 147 of these plots- there were only 3 plots which hosted Nandina with no Ligustrum. Nandina was only present in 19 plots total, so 131 plots of Ligustrum were surveyed with no Nandina present. So, Ligustrum was present in 98% of the plots and Nandina was present in 12.6% of the plots. The highest plot frequency was 27 (plot 28 and plot 135), and both of these plots primarily consisted of small Nandina stalks. There were 13 plots with only 1 surveyed (invasive) woody plant per plot, which all tied for the lowest frequency of 1. Overall, there was an average plot frequency of 5 plants, regardless of their composition.

The average (mean) total basal area per 3m plot was 0.066 m², with a range of 0.000157 m² to 1.72 m² of plant matter present. The average basal area of Ligustrum in plots where it was positively identified was 0.02 m², with a range of a minimum 0.0000785 m² to maximum 0.33 m² (Figure 2).

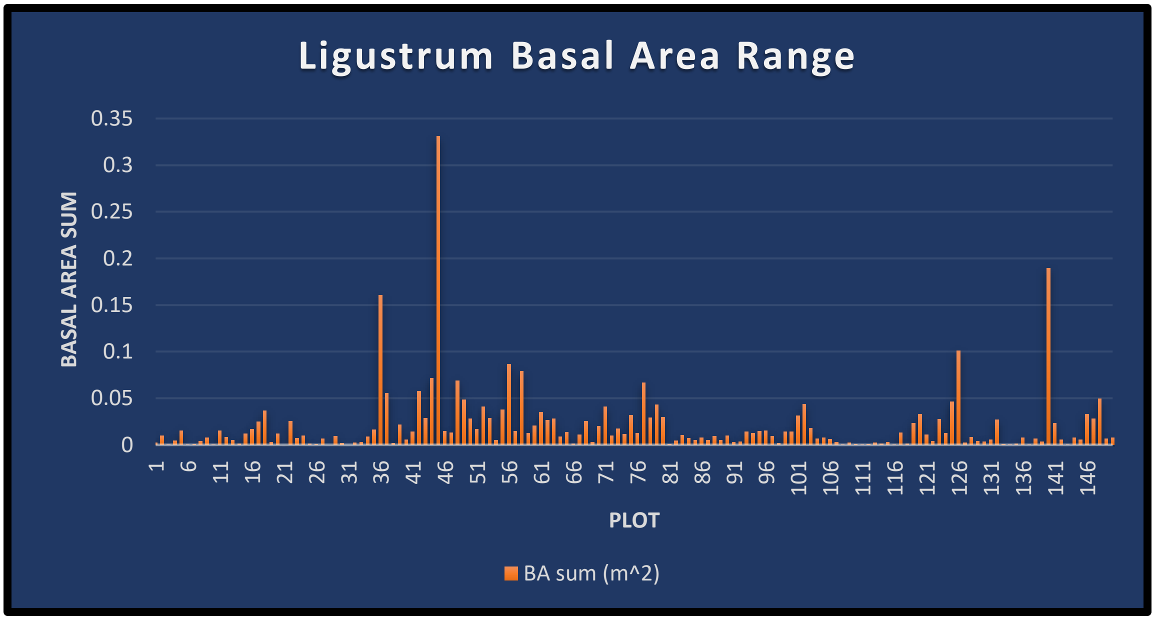

Figure 2- Ligustrum Basal Area Range (Min-Max)

Where Ligustrum is found, it has a trend of being the most prominent species within the plot. The average basal area of Nandina in plots where it was identified was 9.54572E-05 m², with a range of 9.8125E-06 m² to 0.0002355 m² of plant matter. This trend tells us that comparatively, Nandina is occupying significantly less space within the park and does not show a trend of dominating other woody plants to the extent of larger Ligustrum. Of all 9.899 m² of surveyed plant material, Ligustrum accounts for 2.988 m², which equates to 30.2% of all surveyed specimen. Nandina only represents 0.002% of all surveyed material, which supports the idea that Nandina is a much lesser issue in

Prospect park at the moment when compared to Ligustrum. These calculations have been visualized in figure 3.

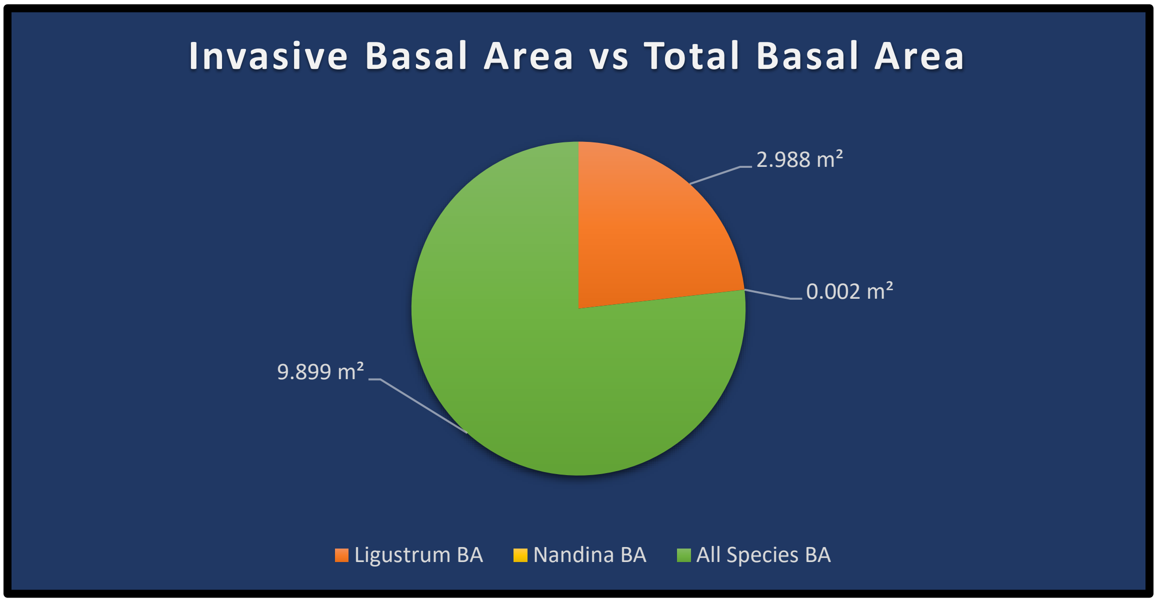

Figure 3- Invasive Basal Area Sum vs Total Basal Area Sum

The average Ligustrum importance value (in plots where it was identified) was 0.43, with a second highest value of 0.93 in plot 63 where Ligustrum was accompanied by one small Quercus spp. There were 24 plots with both Ligustrum's relative dominance and importance values equaling to 1, so this indicates that there are 24 plots which host Ligustrum with no other documented woody plant. Nandina's average importance value (in plots where it was positively identified) only comes out to be 0.24. There are 0 plots of only Nandina without the presence of native specimen. Figure 4 shows the relationship between Ligustrum and Nandina importance values by plot, which includes values of 0 when either species is not present per plot. The figure shows Nandina's maximum importance value of nearly 0.6, with a frequent minimum 0.

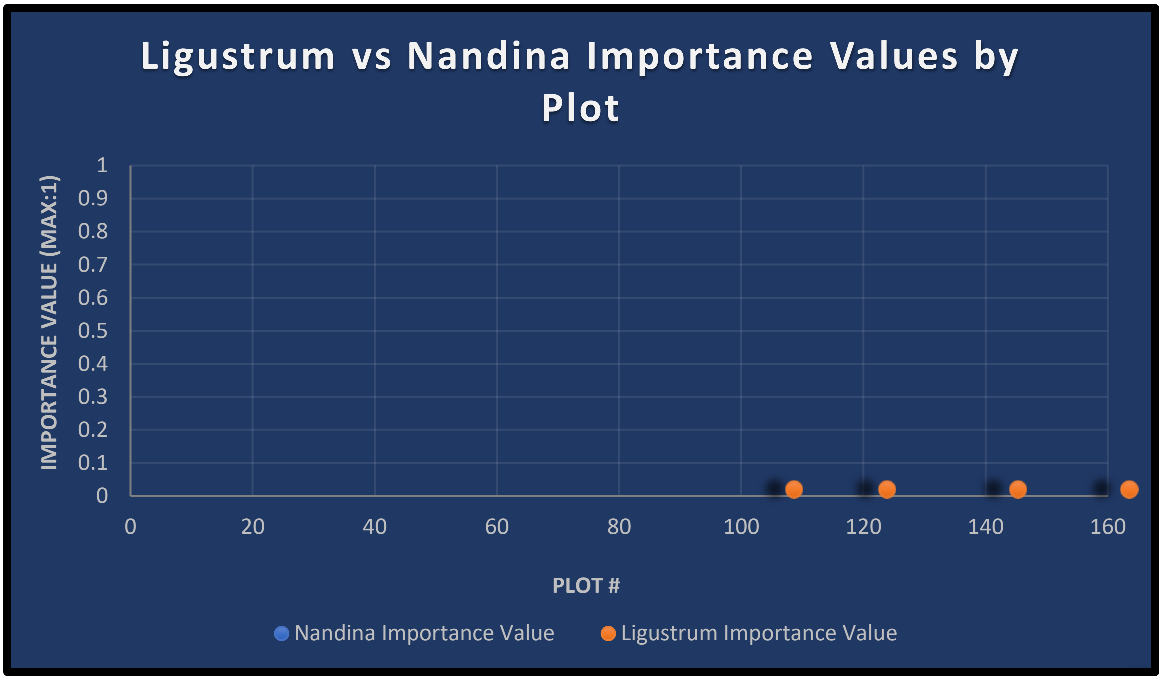

Figure 4- Ligustrum vs Nandina Importance Value per Plot

There were several instances during the field work that required expert decisions as to include specific areas of the park or not. There were a few Ligustrum specimen that were left out of the survey because they were behind private fences and/or on private residential property. The property lines get highly ambiguous on the northern edge on the park along Limbo Loop where houses appear to back up to Columbia Avenue and eventually Marlton Street. There are a few plots shown on Figure 1 that may not technically occur within park borders, so removal of these specimen would necessitate communication between SMGA/COSM and the property owners. All surveyed plots presented an accessible, Leave-No-Trace-friendly path to collect data through which we carefully traversed.

The majority of all plots were documented within the first 0.32 km (0.2 miles) of the path when entering from the parking lot on Prospect Street as indicated by Figure 1. The map shows a harsh border in the middle of the park that represents the boundary between Prospect Park and what is technically Lower Purgatory Creek, but I consider all parts of the map between the parking lot entrance and the Wonder World Drive to be part of Prospect Park. There are several significant stands of Ligustrum that are conveniently located near trail markers, which can be viewed when using the Prospect Park Invasive Plant Survey GIS project. There are notable clusters of plots that can be considered Ligustrum monocultures, one of which being near trail marker LL19. This cluster is comprised of 10 proximal plots that are within 0.1 miles from the park entrance. Some of these invasive specimens are immediately off the trail, leading to more that are up to several yards back. 8 of the 10 are located on the same side of the trail, with 2 more located on the other side- 1 of these plots is very close to a property border. There is another cluster of Ligustrum near the beginning of the ADA loop, which extends off Limbo Loop towards Wonder World Dr., this is the southernmost potion of the park. Both directions leading around the other side of this ADA loop have Ligustrum near their beginning (located near trail marker LL14). Between LL14 and LL13, there is another cluster of 9 plots which extend varying distances from the trail. LL6 and S1 trail markers are extremely close in proximity to one another, surrounded by 14 plots along Limbo Loop and Sinon Trail. This is the area where it was difficult to identify park borders and residential property lines. There is a significant Ligustrum monoculture located upon marker V6, where 11 plots comprise an invasive forest along Virgil Trail. Trail marker V5 is located between 2 clusters of plots to the east and west side where Sinon Trail and Virgil Trail meet. There is a multitude of plots along the internal Virgil trail that are less clustered but are located adjacent to the trail. There is an invasive plot cluster between markers V2 and LL3 within less than 0.16 km (0.1 miles) of the trail entrance, but several plots are further back on the property line away from the trail.

RECOMMENDATIONS

I recommend for SMGA and COSM to approach invasive removal by prioritizing Ligustrum stands that are close to each other and close to the trail entrance. Limbo Loop, Virgil Trail, and Sinon Trail all have easily accessible invasive plots within the first 0.16-3.2 km (0.1-0.2 miles) of the trail. The northeast portion of the park is where the majority of invasive specimen are located, and this area will continue to act as an invasive seed bank in the following seasons. Taking a left onto Limbo Loop when entering the park, trail marker LL21 begins a stretch of Ligustrum and Nandina plots which extends until slightly beyond marker LL19. There is another Ligustrum monoculture near marker LL19, which would likely be labor-intensive to treat, however the benefits of removing plant matter from this area would be high. After this section, turn around and make your way to LL20. Take a left to find trail marker S3 (Sinon Trail), where a smaller cluster of invasive plots can be found. Continuing down towards marker V5 (Virgil Trail), there are significant clusters of plots on the left and right side of the marker. There are 12 plots on the left (10 extremely close and 2 closer to Sinon Trail) and 8 plots on the right (also closer to Sinon Trail). This will also be another time and labor-intensive area. From here, exiting the park via Vigil Trail would take you by roughly 7 accessible plots on your way out.

CONCLUSION

Ligustrum and Nandina are invasive plant species that currently plague Prospect Park in San Marcos, Texas. This invasive inventory will aid SMGA and COSM in removing these specimens to the highest point logistically attainable. This GIS project can be used in the future to evaluate mitigation progress and guide the next steps towards recovering native vegetation in this area. This project may also serve as a pilot for other missions towards removing invasive plant material in other green spaces around San Marcos.

Citations

City of San Marcos. *Trail Markers, Park Trails, Points of Interest, City Parks, Parking Lots, Entrance Point*. (GIS shapefile). Referenced April 23, 2021

Davis, J. W. (2017, September 5). Nandina Berries Kill Birds. Retrieved from https://ar.audubon.org/news/nandina-berries-kill-birds

De Ruff, R. (2005, October). Retrieved from http://nathistoc.bio.uci.edu/Plants of Upper Newport Bay/ Oleaceae/Ligustrum lucidum.htm.

Ericson, J., Lusk, M., & Wildlife Service. (2012, November). U.S. Fish & Wildlife Service. Retrieved from https://www.fws.gov/invasives/faq.html.

Gilman, E. F., & Watson, D. G. (1993, November). Ligustrum lucidum. Retrieved from http://hort.ufl.edu/trees/LIGLUCA.pdf.

Gonzalez-Moreno, p. (2016, February 25). Retrieved from https://www.cabi.org/isc/datasheet/30751#84EB97E7-8725-489D-B0E1-17A7E42898F6.

Invasive species, national parks, and You (U.S. National PARK SERVICE). (n.d.). Retrieved April 18, 2021, from https://www.nps.gov/articles/invasive-species.htm#:~:text=Invasive%20species%E2%80%94nonnative%20organisms%20that,with%20visitor%20experiences%20in%20parks

Ligustrum lucidum. (n.d.). Retrieved April 18, 2021, from https://plants.ces.ncsu.edu/plants/ligustrum-lucidum/

Mattrick, C. (n.d.). Managing Invasive Plants- Methods of Control. Retrieved January 5, 2020, from https://extension.unh.edu/resources/files/Resource000988_Rep1135.pdf.

Nandina domestica. (n.d.). Retrieved January 5, 2020, from https://plants.ces.ncsu.edu/plants/nandina-domestica/.

Nandina domestica. (n.d.). Retrieved April 18, 2021, from https://plants.ces.ncsu.edu/plants/nandina-domestica/

ASPCA Nandina. (n.d.). Retrieved April 18, 2021, from https://www.aspca.org/pet-care/animal-poison-control/toxic-and-non-toxic-plants/nandina

Privet (Ligustrum): QUEENSLAND Poisons Information Centre. (2017, July 20). Retrieved April 18, 2021, from https://www.childrens.health.qld.gov.au/poisonous-plant-privet-ligustrum/

Zillman, C. (2015, May 21). Fastest Growing Cities In US: Census Releases New Data. Retrieved from https://time.com/3892311/fastest-growing-cities/.