The Invasive Plant Species of Stanley Park:

Leveraging Citizen Science to Investigate the Distribution of Invasive Plants

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Executive Summary

Invasive plant species (non-native plants that are introduced to ecosystems outside their natural range) can cause a disproportionate amount of damage to native species. These species are characterized by their fast growth and rapid dispersal and can therefore thrive in new environments by outcompeting native species for resources. Globally, invasive species are recognized as the second greatest cause of biodiversity decline. The negative impacts of invasive plants can extend far beyond single species, by effecting the soil chemistry, hydrology, and even the resilience of ecosystems to disturbances. Managing these impacts can become quite expensive, accruing billions in costs in North America alone. The introduction (both deliberate and accidental) and subsequent spread of invasive species is therefore cause for concern across many municipalities, provincial parks, conservation management areas, and federally managed wildlife reserves.

The cumulative pressures of climate change and urbanization exacerbate the effect of invasive species, making Stanley Park especially vulnerable to the proliferation of invasive plants. To mitigate these effects, the Stanley Park Ecology Society (SPES) employs a series of short-term and long-term strategies to manage the spread of invasive species in the park. One such strategy is the mapping of the composition and distribution of invasive plants throughout the Park. These efforts are actualized by volunteers, who are trained in species identification and the use of mapping technologies to map the occurrence of various invasive plants throughout the Park.

In this project, SPES's citizen science database is used to generate a series of maps outlining the distribution of various invasive species throughout the Park. GIS tools and techniques were then employed to delineate areas of high species densities, and then used to pinpoint areas throughout the Park in need of active worksites. Approval of such worksites are paramount for the Stanley Park Ecology Society to continue the management and removal of invasive plants throughout the Park.

Introduction

Invasive species are plants, animals, and other organisms that are introduced to ecosystems outside of their natural range and cause negative impacts on native biota and the ecosystems they inhabit. These species are characterized by their rapid dispersal, fast growth, and can therefore thrive in new environments by outcompeting native organisms. The negative impacts of invasive plants can extend far beyond single species, by effecting the soil chemistry, hydrology, and even the resilience of ecosystems to disturbances. Additionally, invasive species can create a myriad of ecosystem disservices that effect humans. This can often occur by acting as vectors for infectious diseases (Eritja et al., 2005), replacing native species which provide valuable ecosystem services (Daru et al., 2021), and exacerbating the effects of disturbances that could negatively affect urban areas. The damage caused by invasive species can be severe and is globally recognized as the second greatest cause of biodiversity declines after habitat loss (Wilson 1992, Ballie et al. 2004, Bellard et al 2016). In North America alone, invasive species cost 10 billion USD per year since 2010, and over $1.26 trillion cumulatively over the last 60 years (Crystal-Ornales et al. 2021).

Therefore, the spread of invasive species, both deliberate and accidental, is cause for concern to natural resource managers and environmental stewards. Invasive plants are overwhelmingly the most common type of invasive species in British Columbia and make up around 86.8% of all invasive species (Environmental Reporting BC, 2015), and cost the agricultural industry approximately 50 million in crop productivity per year. A recent study found that the Georgia depression (an Ecoprovince which includes the lower mainland) had the most species at risk threatened by invasive species in all British Columbia (Tamburello & Litt, 2021). A changing climate, and an expected doubling of urban populations by 2050 (Johnson & Munshi-South, 2017) further increases the vulnerability of ecosystems. Stanley Park, Vancouver's oldest and largest park, lies at the forefront of all these pressures. With over 97 species of invasive plants documented throughout the entire Park, the threat to biodiversity and ecosystem functioning is steadily increasing. Stanley Park employs both short term and long-term strategies to manage these invasive species, however effective management relies on a working knowledge of the composition and distribution of invasive plants within the Park.

Background on Invasive Plant Species

Although most non-native species are benign, the invasive species minority are defined by the disproportional amount of damage they can cause to native species and their ecosystems. These Invasive plant species can be introduced into an area via a series of modes. Historically, most were introduced for their aesthetics in ornamental gardens, with their seeds, fruits, and other plant-matter spread naturally via wind, wildlife, and waterways. Globalization, and the increased volume and frequency of human movement has facilitated the spread of invasives across the world (Meyerson & Mooney, 2007). Urban areas are not only central entry points for many invasive species due to the higher level of movement and disturbance, and relatively low levels of competition (Cadotte et al., 2017), they also enable the spread of invasive species into neighboring landscapes (Marco et al., 2009; von der Lippe & Kowarik, 2008).

Many Invasive plant species exhibit key traits which allow them to proliferate. Invasive plants are commonly generalists, meaning they have a broad environmental tolerance which allows them to grow and reproduce under a wide range of biotic and abiotic conditions. Specifically, they often exhibit the ability to alter their growth form to adapt to current conditions (known as "phenotypic plasticity"). Furthermore, these species can often grow quickly and disperse widely by producing propagules (any part of the plant that can detach to form a new individual) early on in their development. Additionally, certain invasive plant species are allelopathic, meaning they can fundamentally change the soil chemistry and inhibit native plants from taking up nutrients. Taken together, these traits often allow the invasive plant to effectively outcompete native species for resources (nutrients, light, space, water, etc.). The effects of invasive plants can further indirectly threaten native wildlife by reducing the abundance/diversity of plant species that they rely on for food and shelter. The invasion of ecosystems can also act to homogenize communities of flora and fauna by replacing unique endemic species with a collection of common non-native invasive species (Daru et al., 2021; McKinney & La Sorte, 2007). This loss of biodiversity can have profound negative effects not only on the array of ecosystem services provided by the native communities, but can substantially reduce the resilience of ecosystems to disturbances (Linders et al., 2019; Shochat et al., 2010).

Climate change is not only one of the key drivers of biodiversity loss but is now known to further escalate the spread of invasive species. Rising temperatures, sporadic precipitation, and increased frequency of extreme weather events all have measurable impacts on species distributions and their reproductive behaviors. The majority of a plant's reproductive events (ie budding, flowing, dormancy, etc.) are triggered primarily by temperature (Menzel et al., 2006). Atypical seasonal temperature fluctuations trigger reproduction at the wrong time of the year, disrupting the way species interact and therefore the ecosystem as a whole (Colautti et al., 2017).

This disruption restricts the ability of specialist native plants to thrive, and favours generalist plant species such as invasives (Mainka & Howard, 2010). Furthermore, climate change has led to an increase in the frequency and duration of extreme weather events. These extreme events clear large areas, allowing invasive species to disperse and establish the area relatively quickly. This can often lead to a feedback loop, whereby the newly established invasive species further reduce the resilience of the ecosystem to disturbance. For example, invasive species such as Scotch Broom and Gorse have oily branches which increase the intensity/duration of wildfires. A similar effect is brough on by English Ivy, which can grow vertically and weaken the ability of trees to withstand strong winds. Fires and storms create perfect conditions for invasive plants to establish in the newly open patches.

Stanley Park and Invasive Plant Management

Stanley Park is the oldest and largest park in Metro Vancouver. Surrounded by the Burrard inlet and English Bay, the approximately 400-hectare coastal temperate rainforest is recognized as one of the greatest urban parks in Canada. The Park itself is the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səl̓ílwətaʔɬ (Tsleil-Waututh) Nations, and the former site of Whoi Whoi (X̱wáy̓x̱way), one of the largest First Nations villages in the Lower Mainland. The land was acquired by the City of Vancouver (the 'City') in 1886 which sparked a series of evictions that continued into the 20th century. Today Stanley Park is one Metro Vancouver's biggest tourist destinations, attracting approximately eight million visitors every year. Pressures from urbanization, combined with a changing climate, make Stanley Park especially vulnerable to invasive species. Furthermore, a series of windstorms in 2006/07 led to a substantial amount of blowdown in the Park. These newly disturbed sites were ideal areas for invasive plant species to spread and establish new patches.

Invasive plants exhibit distinct phases of invasion which reflect the dynamic spatiotemporal process by which populations spread. Briefly, this begins with a (1) Pre-introduction phase occurring before any individual of a species is observed, (2) an Introduction/Establishment phase during which species occur as isolated and sparse populations, (3) an Expansion phase during which populations expand rapidly, and (4) the post-expansion phase characterized by the widespread abundance of a species across the landscape. Park management clusters species in the park into three distinct groups to reflect their relative level of priority.

The first grouping is of Established species, which include Himalayan blackberry, English ivy and English holly. These species are abundant and widely spread throughout the Park. Therefore, the goals of management are no longer to completely eradicate these species, but rather reduce their negative impact by minimizing the size of patches. The second grouping is the Expanding

species, such as Japanese Knotweed, Reed Canary Grass, Yellow Lamium. These species are expanding rapidly throughout the Park, making eradication increasingly difficult. Effective management often involves digging up groups of individuals, however it should be noted that some species are considered noxious (eg: Knotweed species) and can only be removed by the Vancouver Park Board or contractors with a commercial pesticide spraying license. Furthermore, this group includes many noteworthy aquatic invasive plants such as Purple Loosestrife, Yellow Flag Iris, and Fragrant Water Lilly. Aquatic invasive plants are of special concern, as their propagules can travel through small streams to and from important wetlands such as Beaver Lake and Lost Lagoon. These species can quickly propagate and outcompete native species, producing dense stands which are typically not used by native wetland species for cover, food, or nesting. The rapid spread of these species can have severe negative effects similar to Harmful Algal Blooms, by covering the surface of lakes and decreasing oxygen levels and increasing temperatures. The final group is the Emergent species, which include species such Burdock, Scotch Broom, Gorse, Spurge Laurel, and Giant Hogweed. These species have a limited distribution and are therefore considered "new" invaders to the Park with a high level of priority.

Methods

The principal objective of this project was to collate all geospatial data on the past and present occurrences of invasive plant species to produce a series of maps. The maps would aid SPES both technically in their volunteer program as well as more broadly by providing context on the current composition and distribution of invasive species throughout the park.

First, spatial data on the occurrence of a wide range of invasive species was collated. These data have been collected in mass since 2017 through SPES's stewardship mapping program and encompass both single occurrences of individuals (points), as well as patches of multiple individuals of a single species (polygon) taken along the various trails of Stanley Park. The data was organized into three distinct groups of species (Established species, Expanding species, and Emergent species) as outlined by the Stanley Park Ecology Society Invasive Species Management Plan (most recently updated in June of 2022).

Second, the organized spatial data was used to produce a simple map detailing the occurrence and distribution of all grouped invasive plants in the park (Figure 1).

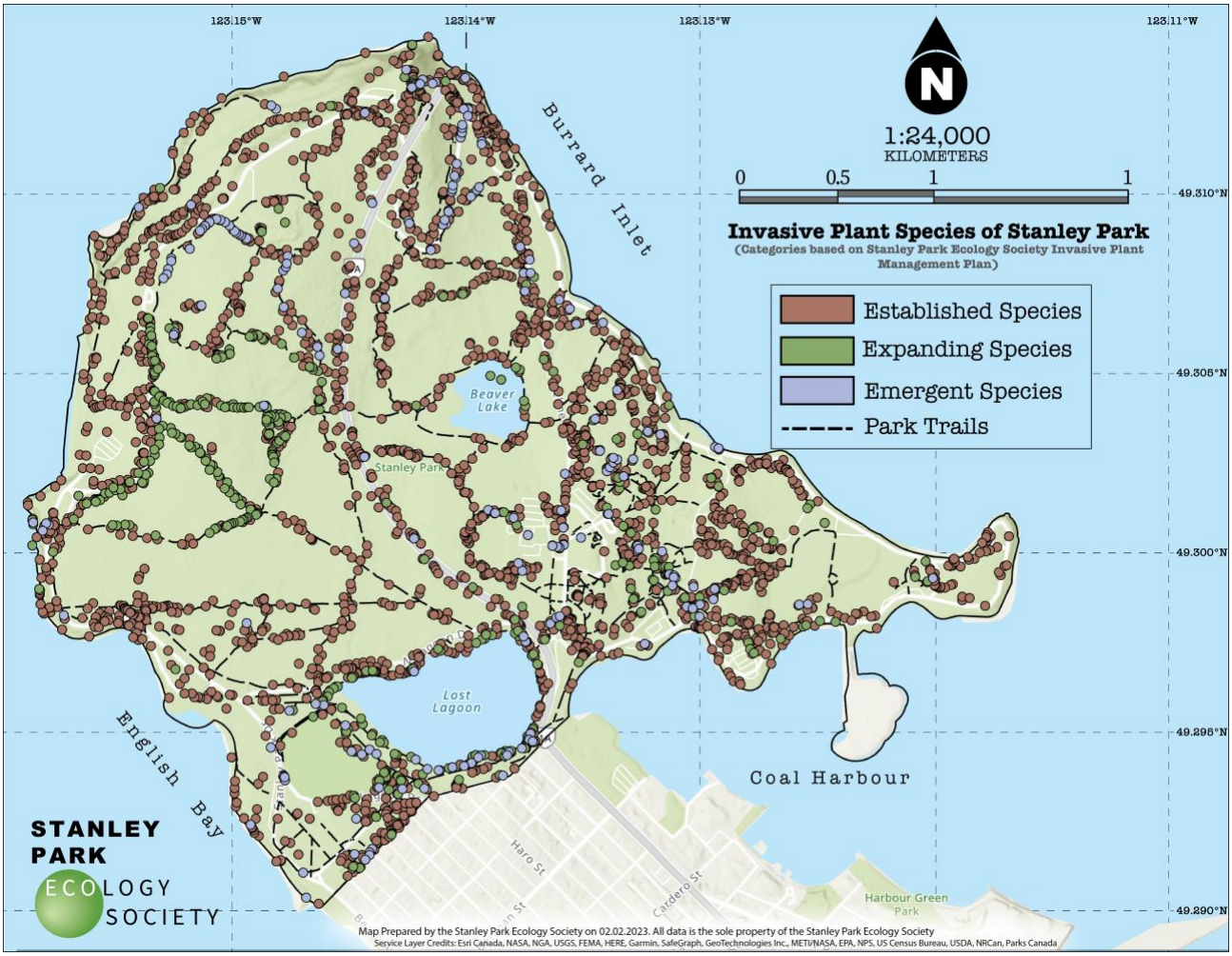

Figure 1. Invasive plant species distributions throughout Stanley Park. Invasive plants are segregated into three groups in accordance with the Invasive Plant Management Plan created by SPES in 2014. For a full list of species included in each category, please see the Appendix C in the SPES Invasive Species Management Plan (2014).

Additionally, understanding the relationship between the distribution of invasive species and SPES worksites used for invasive plant management was of high value. Therefore, GIS techniques were used to create density maps of invasive plants, and then further overlayed with geospatial polygons of current/proposed worksites. This process identified worksites that are of high priority, as well as worksites that need to be authorized by the Vancouver Park Board (Figures 3-5).

As previously mentioned, the spatial data used to generate these maps was taken by volunteers who were restricted to the park trails. Therefore, additional data off the trails was necessary to further understand the distribution of invasive plants in the Park. A technical map was then

created to visualize high density areas in more detail, and aid in selecting new sites for off-trail mapping (Figure 2). In response, weekly sessions were run whereby volunteers were trained to use mapping software to collect data in designated areas of the Park on their handheld mobile devices.

Findings

All three groups of invasive plants can be found spread throughout the Park, with patches of high density commonly towards the eastern portion. Emergent species can be split into two main sub-populations in the northern and southern portions of the Park. The northern sub-population appears to be denser near Rawlings trail and Avison trail, with the southern sub-population appearing in high density near Lost Lagoon and to the east of Pipeline Road. The distribution of Expanding species is relatively similar, however there are only few occurrences in the north. Expanding species are highly concentrated in the west on Rawlings trail between Lake trail and Tatlow walk. Established species are highly abundant and can be found almost anywhere throughout the Park. Notably, English Ivy was found in every area that was mapped.

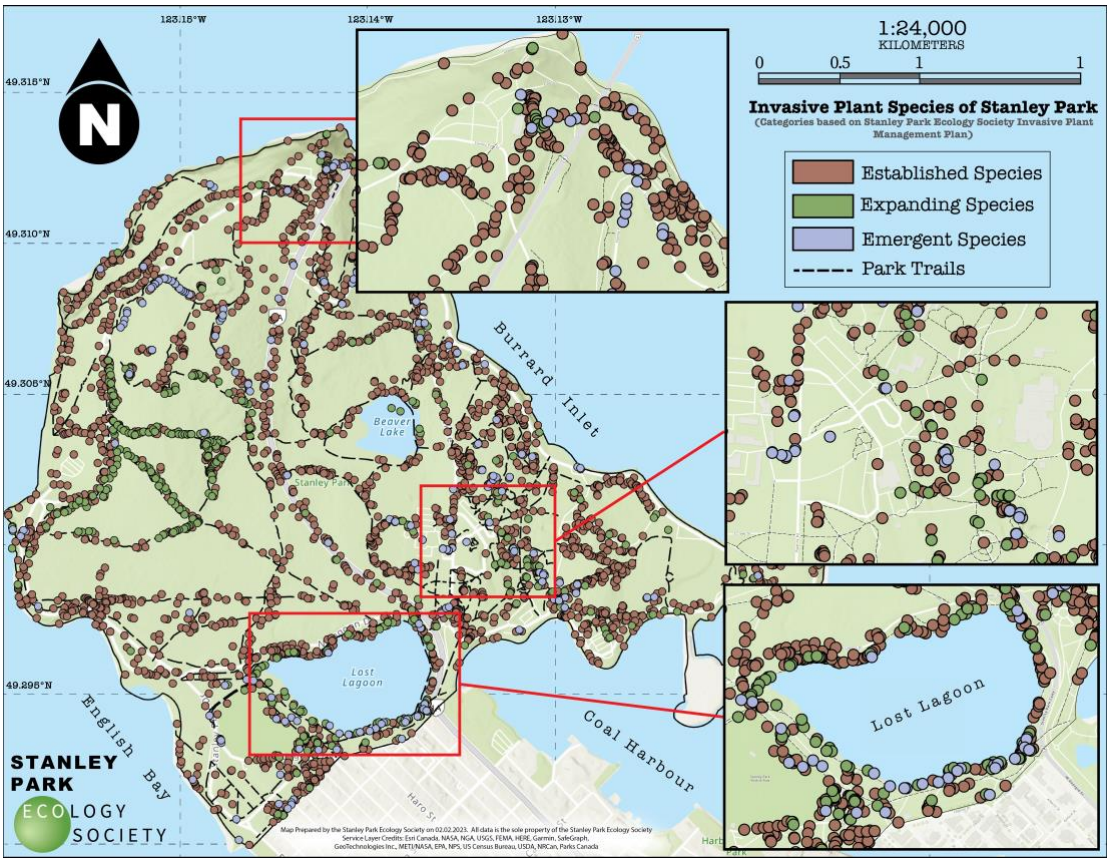

Figure 2. Map of invasive plant species distributions throughout Stanley Park. Data collection is ongoing and is led by the Stanley Park Ecology Society (SPES) and their extensive group of volunteers since 2017. Invasive plants are segregated into three groups in accordance with the Invasive Plant Management Plan created by SPES in 2014. The map details three key areas of high invasive plant concentrations throughout the park.

More Worksites are Required in Areas with the Highest Densities of Invasive Plants

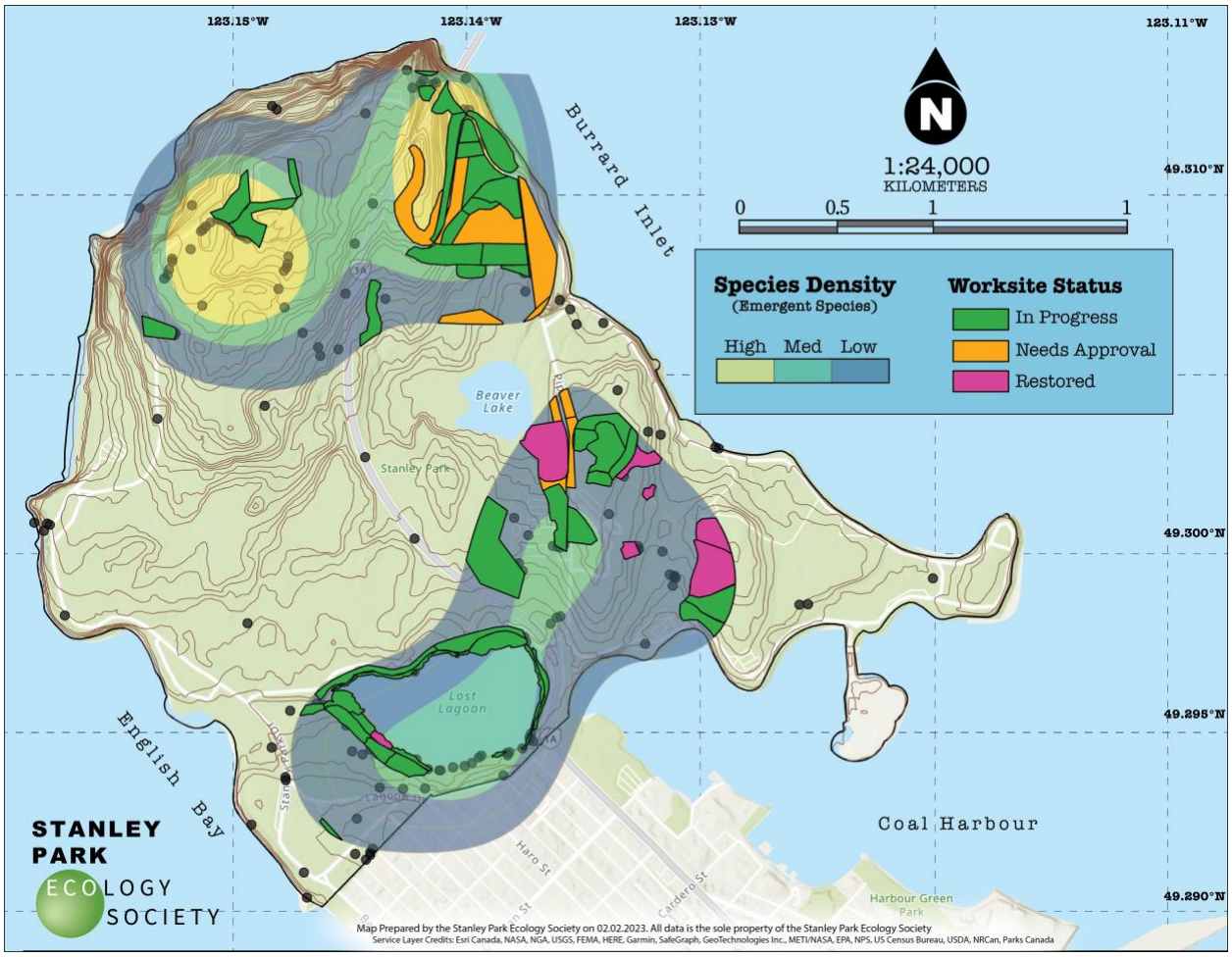

Figure 3. Map of Emergent species densities throughout Stanley Park and the worksites found within areas of high density. For a full list of Emergent Species, please see the Appendix C in the SPES Invasive Species Management Plan (2014).

Unfortunately, not all areas of high invasive plant densities are actively managed with approved worksites. Emergent species are of high concern, as these species are relatively new invaders with limited distributions across the Park. However, there is a clear lack of approved worksites in areas of high emergent species densities, especially in the north of the Park (Figure 3).

Additionally, Established species such as Himalayan Blackberry could benefit from more worksites in the southeastern portion of the Park (Figure 4). However, it should be noted that a lack of approved sites may be the result of conflict and overlap with archaeologically sensitive areas.

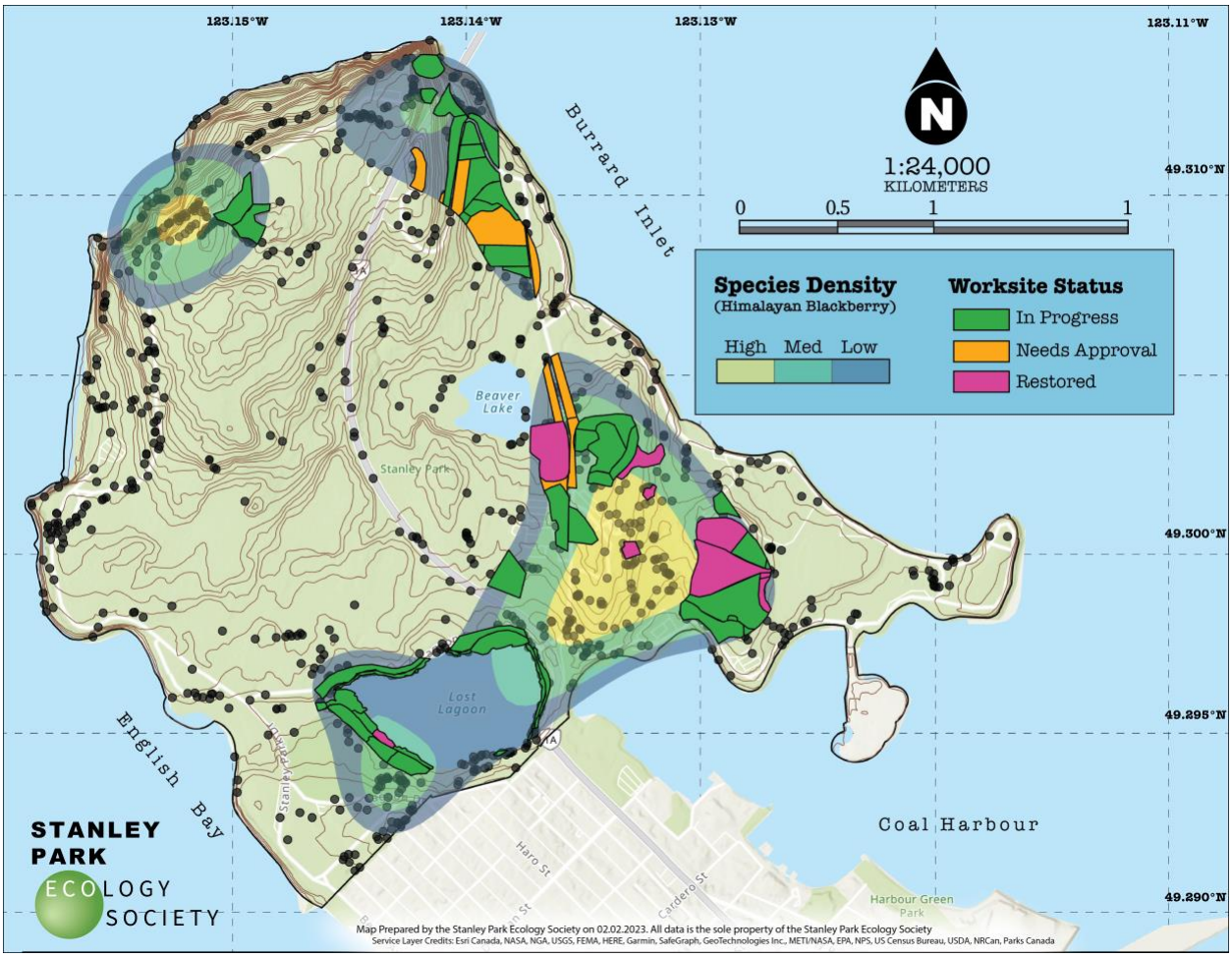

Figure 4. Map of Himalayan Blackberry densities throughout Stanley Park and the worksites found within areas of high density.

Continued Mapping is imperative for Future Management of Invasive Plants in the Park

Mapping invasive plant distributions is an invaluable management tool that can be used to monitor the spread of invasive plants, and plan for areas to conduct field operations. In the case of established species that cannot be removed from the Park, continued mapping of their distribution would allow Park staff to identify areas where two large patches could potentially merge. Clearing two small patches can be done with less volunteers and in a timelier manner compared to one large patch. Continued mapping would further allow the detection of newly emerging species before they spread and establish throughout the Park. In the future, annual maps of emergent species could even be used to pinpoint regions where new invasive plants tend to enter the park from. These areas could then be targeted for more frequent management

to prevent the spread of new invasive plants. Certain species are hard to identify during the winter without their flowers. Therefore, continued mapping throughout the entire year would provide a wealth of data on the occurrence of these hard to identify species, and aid in understanding their seasonal distributions.

The current data is not suitable for visualizing changes in species distributions over time

Contrasting the temporal observance data against abiotic factors to determine any links between climate and species distribution/composition was deemed not possible. Previous volunteer data was collected in 2017, 2018, and 2019, with a goal of mapping species along all the trails in the Park. Each volunteer mapping session was therefore conducted in areas where previous mapping had not taken place. Any analysis on the spread of invasive plant species across the three years would therefore misleadingly show the distribution of invasive plant species as spreading southward along the trails. However, visualizing the change in species composition and distribution both seasonally and annually is possible with continued mapping of invasive plants throughout the Park.

Summary

Invasive plant species (non-native plants that are introduced to ecosystems outside their natural range) can cause a disproportional amount of damage to native species, ecosystems, and economies. The introduction (both deliberate and accidental) and subsequent spread of invasive species is cause for concern across many municipal, and provincial parks. Stanley Park (Vancouver's oldest and largest park) is particularly vulnerable to invasive species due to a changing climate and increasing pressures from urbanization. In this project, we used historical records of plant occurrences to map the past and present distributions of invasive plants within Stanley Park. These maps were used to identify areas of high invasive species concentration and determine new areas where continued mapping is required. Overall, we found high concentrations of invasive species in the southeastern portion of the park (near many of the park facilities), as well as in the northern portion of the park. Specifically, we found a clear lack of approved worksites in areas with high concentrations of new invader species. Furthermore, we found Established species such as English Ivy were found in every mapped area throughout the park. We therefore recommend the continued mapping of invasive plants, across all seasons, to further aid in identifying areas of high concern.

References

Cadotte, M., Yasui, S., Livingstone, S., & MacIvor, J. (2017). Are urban systems beneficial, detrimental, or indifferent for biological invasion? *Biological Invasions*. http://dx.doi.org/10.1007/s10530-017-1586-y

Colautti, R. I., Ågren, J., & Anderson, J. T. (2017). Phenological shifts of native and invasive species under climate change: Insights from the Boechera–Lythrum model. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *372*(1712), 20160032. https://doi.org/10.1098/rstb.2016.0032

Daru, B. H., Davies, T. J., Willis, C. G., Meineke, E. K., Ronk, A., Zobel, M., Pärtel, M., Antonelli, A., & Davis, C. C. (2021). Widespread homogenization of plant communities in the Anthropocene. *Nature Communications*, *12*(1), Article 1. https://doi.org/10.1038/s41467-021-27186-8

Environmental Reporting BC. (2015). *Status of Invasive Species in B.C. State of Environmental Reporting, Ministry of Environment, British Columbia, Canada* [Government]. Province of British Columbia. https://www.env.gov.bc.ca/soe/indicators/plants-and-animals/invasive-species.html

Eritja, R., Escosa, R., Lucientes, J., Marquès, E., Roiz, D., & Ruiz, S. (2005). Worldwide invasion of vector mosquitoes: Present European distribution and challenges for Spain. *Biological Invasions*, *7*(1), 87–97. https://doi.org/10.1007/s10530-004-9637-6

Johnson, M. T. J., & Munshi-South, J. (2017). Evolution of life in urban environments. *Science (New York, N.Y.)*, *358*(6363), eaam8327. https://doi.org/10.1126/science.aam8327

Linders, T. E. W., Schaffner, U., Eschen, R., Abebe, A., Choge, S. K., Nigatu, L., Mbaabu, P. R., Shiferaw, H., & Allan, E. (2019). Direct and indirect effects of invasive species: Biodiversity loss is a major mechanism by which an invasive tree affects ecosystem functioning. *Journal of Ecology*, *107*(6), 2660–2672. https://doi.org/10.1111/1365-2745.13268

Mainka, S. A., & Howard, G. W. (2010). Climate change and invasive species: Double jeopardy. *Integrative Zoology*, *5*(2), 102–111. https://doi.org/10.1111/j.1749-4877.2010.00193.x

Marco, A., Lavergne, S., Dutoit, T., & Bertaudiere-Montes, V. (2009). From the backyard to the backcountry: How ecological and biological traits explain the escape of garden plants into Mediterranean old fields. *Biological Invasions*, *12*(4), 761.

McKinney, M. L., & La Sorte, F. A. (2007). Invasiveness and Homogenization: Synergism of Wide Dispersal and High Local Abundance. *Global Ecology and Biogeography*, *16*(3), 394–400.

Menzel, A., Sparks, T. H., Estrella, N., Koch, E., Aasa, A., Ahas, R., Alm-Kübler, K., Bissolli, P., Braslavská, O., Briede, A., Chmielewski, F. M., Crepinsek, Z., Curnel, Y., Dahl, Å., Defila, C., Donnelly, A., Filella, Y., Jatczak, K., Måge, F., … Zust, A. (2006). European phenological response to climate change matches the warming pattern. *Global Change Biology*, *12*(10), 1969–1976. https://doi.org/10.1111/j.1365-2486.2006.01193.x

Meyerson, L. A., & Mooney, H. A. (2007). Invasive alien species in an era of globalization. *Frontiers in Ecology and the Environment*, *5*(4), 199–208. https://doi.org/10.1890/1540-9295(2007)5[199:IASIAE]2.0.CO;2

Shochat, E., Lerman, S. B., Anderies, J. M., Warren, P. S., Faeth, S. H., & Nilon, C. H. (2010). Invasion, Competition, and Biodiversity Loss in Urban Ecosystems. *BioScience*, *60*(3), 199–208. https://doi.org/10.1525/bio.2010.60.3.6

Tamburello, N., & Litt, A. (2021). *A Systematic Assessment of Invasive Species Impacts to Species at Risk in BC*. Invasive Species Council of BC (ISCBC).

von der Lippe, M., & Kowarik, I. (2008). Do cities export biodiversity? Traffic as dispersal vector across urban–rural gradients. *Diversity and Distributions*, *14*(1), 18–25. https://doi.org/10.1111/j.1472-4642.2007.00401.x

Appendix A: Additional Map

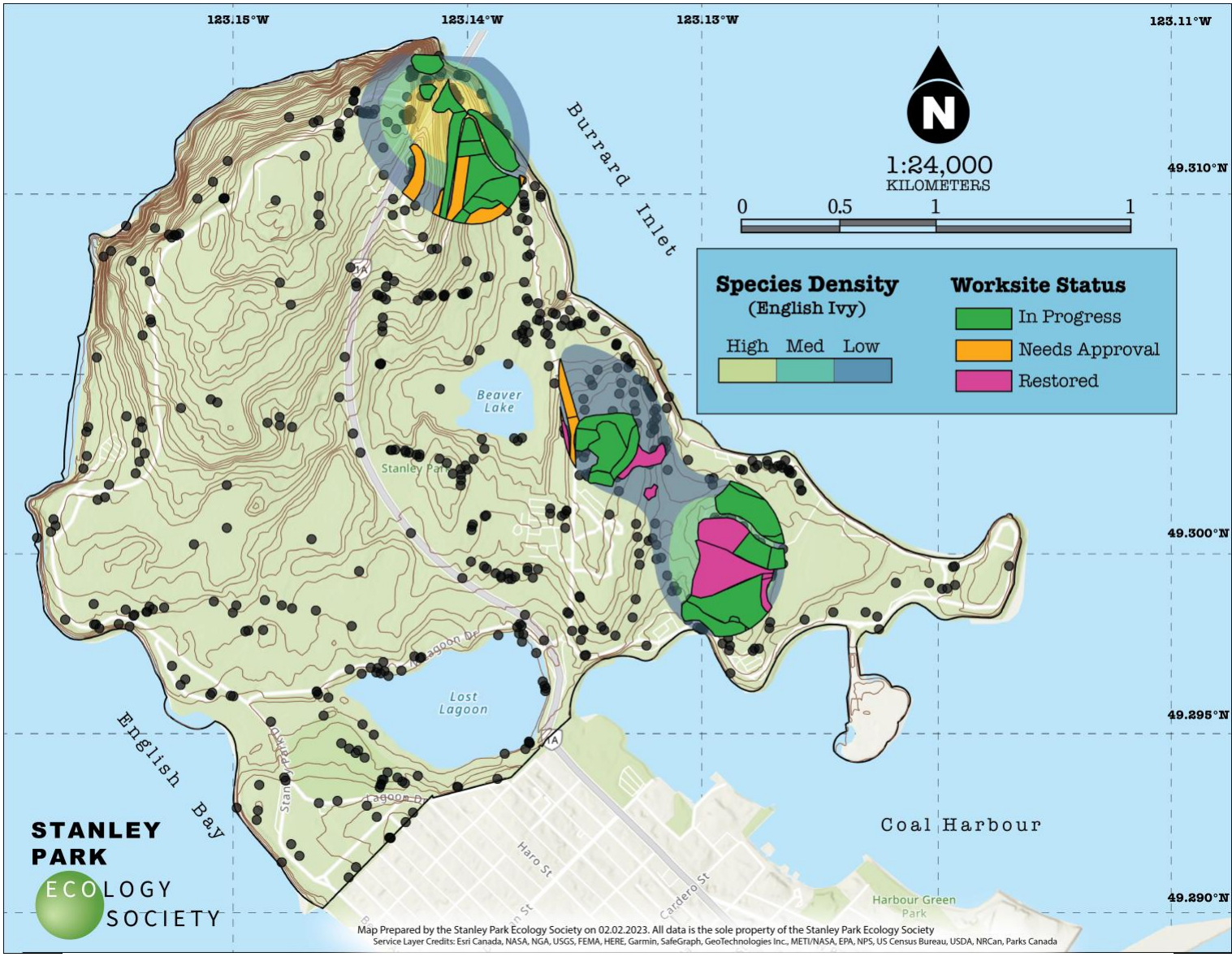

Figure 5. Map of English Ivy densities throughout Stanley Park and the worksites found within areas of high density.