Evaluation of the Well-KEPT English Ivy Best Management Practices

By

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Introduction

Environmental organizations and programs can be restricted in their restoration projects due to the inexperience in their workforce. Organizations that are focused on volunteer work or youth corps programs can be constrained in the methods of restoration, tools, and time of year they can implement their projects. Since there are unavoidable limitations, this Masters of Environmental Horticulture project focused on analyzing the restoration projects implemented with the Bellevue Well-KEPT program (a summer youth corps) during the summer 2018. This analysis will attempt to determine the success of the restoration as well as whether there are particular criteria that should be favored when selecting projects for laypersons. For example, should project managers favor site conditions such as soil compaction, and/or if there are particular constraints, such as drought, what conditions should be favored under those constraints.

Questions:

- Are there specific techniques that contribute better than others during this time of the year?
- Should restoration practitioners favor *Hedera hibernica* removal from the ground or trees due to ease removal and overall control?

Well-KEPT Program

The Bellevue Well-KEPT (Kids Environmental Project Training) program is a two-month youth program that trains twenty high school students ages 13-18 in environmental stewardship such as restoration and trail construction. The City of Bellevue employs the high schoolers during the school district's summer vacation and provides all of the projects, which are located on Bellevue City Properties (City of Bellevue 2017). During July and August of 2018, the crew observed in this project performed five invasive plant removal projects. Due to the crew's inexperience, they were limited to performing manual invasive plant removal techniques with limited tools (See appendix C). The target species for each of the projects was *Hedera hibernica* (English ivy).

According to several environmental restoration organizations in the Pacific Northwest, removal of *Hedera Hibernica* should occur during the fall, winter and spring months for best control. During these seasons the ground and roots are moist, making them easier to remove without breaking. This can also reduce the amount of post-treatment regrowth (KCND 2014, Soll 2005). Therefore, timing for the Well-KEPT projects was unideal. However, each of the projects had a set of unique challenges and best management practices (BMPs).

There were two manual BMPs the Well-KEPT crews used to control the English ivy. These BMPs were survival rings (the removal of ivy from trees and the surrounding ground) and, below-ground vegetation management (removal of roots) (Soll 2005).

The primary goal for each of the projects was to assist in the overall restoration of the city properties, but the projects were not necessarily selected based on the probability of success. Safety when working with youth is the most critical priority, and therefore the projects ultimately were determined based on the safety of the participants, need for work and appropriate work. Need for work simply refers to if there is work to be done, and appropriateness refers to if a project is suited meets the overall objectives for the program. The overarching objective is to provide meaningful experience to the participants while performing environmentally based work.

English Ivy

The *Hedera* or ivy genus is native to Eurasia, including the Caucasus mountains, Norway, Iran, and North Africa (USFS 2010). *Hedera hibernica*[1] (English ivy) was brought to the United States by European colonists in the early 1700s as an easy groundcover and evergreen. It continues to be cultivated and planted in ornamental landscapes (Invasive.org 2010). Sixteen species are classified under the genus *Hedera* in its native range (Ackerfield & Wen 2003). However, there could be over 400 cultivars in the United States (American Ivy Society 2017).

English ivy is a perennial evergreen vine that can either trail on the ground or climb structures and trees (King County 2019). According to the United States Forest Service (USFS), ivy has two distinct growth phases: 1) when juvenile plants remain vegetative and 2) when mature plants flower and produce seed (USFS 2010). Plants can remain in a juvenile state until they have sufficient sunlight to produce flowers and seeds, which usually occurs when the plant begins to climb structures (USFS 2010). The leaves are alternate, entire, waxy and glabrous dark green with light green veins. Juvenile leaves typically have three to five lobes, and mature leaves will have no lobes and are obdeltoid (Soll 2005). Vines attach to structures with small root-like formations that excrete adherent to help them fasten to trees and buildings (OSU 2008). Juvenile plants sprout from nodes, forming lateral vines, and can form thick mats from six to eight inches in depth. Climbing vines can reach diameters between four to twelve inches and up to ninety feet tall, but can climb higher depending on the height of the structure. Ivy can reproduce vegetatively from roots or by seed (USFS 2010,

[1] *Hedera hibernica* and *hedera helix* have been used to distinguish English ivy and therefore for the remainder of the report, the common name (English ivy) will be used to avoid confusion.

King County 2019). The seeds can be eaten by birds such as starlings and sparrows and then spread by bird droppings. Ivy seeds do not form persistent seed banks (Metcalfe 2005).

Ivy can grow in a range of soil types ranging from saturated to dry, but favors slightly moist soils (Metcalfe 2005). It can tolerate temperatures as low as -23 degrees F and has a pH range of 5.2 to 7.8 (USFS 2010). The USFS (2010) also states that Ivy has a high fire tolerance and is drought tolerant, meaning that it can withstand periods of low moisture and dry soil (USFS 2010). During the juvenile state, ivy is shade tolerant and can stand full sun once it reaches maturity (Metcalfe 2005, USDA 2019, USFS 2010). Because of its ability to tolerate a wide range of environmental conditions, ivy has become weedy and invasive across the United States (USFS 2010, USDA 2019).

The United States Department of Agriculture (USDA) classifies an invasive species under Executive Order 13112 as a plant or animal that is "non-native to the ecosystem under consideration, whose introduction causes or is likely to cause economic or environmental harm to human health" (USDA 1999). When unmanaged, English ivy can become an aggressive invasive species, escaping into parks, natural areas, and open spaces that are not regularly managed (Invasive.org 2010). Since its introduction, ivy has spread across the United States from the North East to the South, into the Midwest and West Coast and reaching North into Canada (USDA 2019). On a national level, the USDA defines English ivy as a class "B" weed, meaning that it can be weedy or invasive depending on the severity of infestation (USDA 1999). The USFS acknowledges that English ivy has become particularly pervasive in the Pacific Northwest, as its mild climate with moderate wet winters and dry summers create favorable growing conditions. Washington State Noxious Weeds Control Board classifies English ivy as a Class C noxious weed, meaning it is already widely spread in the state of Washington and is of particular interest to the agricultural industry. Under this state classification, the state permits counties to enforce control if it is beneficial to that county (WSNWCB 2018).

The damage that English ivy can cause to native Pacific Northwest ecosystems can include massive die-off of overstory trees and reduction of plant and wildlife biodiversity (OSU 2008, KING 2019, Green City Partnerships, 2010). According to King County Noxious Weeds, English ivy that dominates native understory reduces seedling growth from native trees and shrubs, significantly reducing understory plant populations. When ivy grows up trees, reaching their canopies, it can create a "wind sail" effect that can cause blowdowns. The bark of native trees is also more susceptible to insect and disease, damaging the health of the tree and reducing the overall life of the tree (King County 2019). *See Appendix A, Figure 1.*

English Ivy Control

The environmental restoration industry uses a wide range of control techniques for English ivy, including chemical, mechanical, and manual control methods (King County 2019, WSNWCB, 2018, OSU 2008). These methods employ a variety of tools, machines, or chemicals--all of which can be effective in controlling English ivy. Mechanical methods use machines, such as using a mower to regularly to exhaust the plant's energy stores (OSU 2008). Controlling English ivy via manual control may require installing a physical barrier such as mulch to prevent regrowth, which can take several years. Manual control can also include removing roots, vines, flowers, and seeds that can be reached either by hand pulling or using tools such as shovels, tillers, loppers, and pruners. Mechanical and manual methods are popular in the Puget Sound region, however chemical control has become more commonly used (Soll 2005). For example, a study conducted by the City of Portland showed strong control of English ivy using a combination of chemicals applied during the spring when new leaves are forming (City of Portland 2019).

Ivy Removal by Non-professionals

Despite the growing popularity of chemical control in the Puget Sound area, nonprofessional ecological restoration (such as volunteers or youth corps), organizations typically avoid using both chemical and mechanical method in favor of manual removal methods with a select toolset. The tools to which nonprofessionals are typically limited include shovels, hand tillers, and pruners, which limit or reduce the risk of injury (City of Portland 2019). There are several types of manual control techniques nonprofessionals utilize with the approved toolset that can be effective in controlling English ivy. For example, tree survival rings (See image 1) (also referred to as survival rings or life rings) involve removing the ivy vines from chest height to the ground and then removing the ivy roots three to five feet from the base of the tree. The additional ground removal delays the roots from regrowing on the trees. This technique may be used when follow-up treatments will not be immediate, however English ivy can regrow up tree trunks (up to six feet per year) if there is no follow up treatments (Green Seattle Partnership 2017).

Above-ground vegetation management may include removing vines from trees and other structures, to kill vines in tree canopies or at the top of other structures, but will not kill the roots left in the ground. Ivy removed from tree trunks at chest height, may prolongs the life of the tree, but will not reduce the amount of infestation. Ground ivy removal involves removing all vines and roots from the ground and from native vegetation (See image 2)(City of Portland 2019, Soll 2005, King County 2019, WSNWCB, 2018, OSU 2008). In some cases, a combination of these techniques may be used together to complete projects.

Ivy Disposal

After removal, ivy can be left onsite to compost, or it can be taken off site to a local waste station or composting facility. For composting onsite, English ivy must be piled and separated from the ground. This can be done either by placing the ivy piles on cardboard or using woody debris to make a platform to raise piles of ivy off of the ground (OSU 2010).

Removal Timing

The time of year can affect the success of manual removal of English ivy. Several restoration organizations and municipalities in the Pacific Northwest note that they have had better control of English ivy via manual control when removal takes place during the fall, winter, and spring seasons. King County Noxious Weeds Control Board, Seattle Parks and Recreation and Portland Parks and Recreation suggest that wet season removal will not only have better results but will also be easier for practitioners and non-professionals to perform the removal activities. (Green Seattle Partnership 2017, King County 2019, Portland 2019). A study conducted in three Seattle Parks to understand the effects of English ivy on native plant communities noted that winter removal in Discovery Park showed successful manual root extractions that had taken place over five winters (Dlugosch 2005). In contrast, during the summer months or times of drought, the ground can become dry, and hard and the roots can become dehydrated making them brittle (Young, Simmons and Hamblin-Katnik 2012), which can make removing the roots without breaking them difficult. Thus, though there are few studies comparing the success of English ivy removal across seasons, removal during wet seasons is common practice and has shown to not only be successful, but also easier for practitioners and nonprofessionals to perform manual removal.

In summary, English ivy is a hardy species that can grow in a multitude of environments and has become a pervasive, invasive species in Pacific Northwest. If left unmanaged, it is predicted that English ivy could have profound effects on the Pacific Northwest's native ecosystems (See Appendix 1, Figure 1) (OSU 2008, Green City Partnerships, 2010, KCNWB 2014, King County, 2019). However, ecological restoration has been known to reverse the effects that English ivy can have on native ecosystems (See Appendix 1, Figure 2) (Green City Partnership 2010). Therefore, controlling this invasive species has become a part of many local municipality's strategic land management plans, including the city of Bellevue, City of Seattle, City of Everett, and several more (Green Everett Partnership 2004, Green Seattle Partnership 2017, City of Bellevue(a) 2017).

Ecological Restoration by Well-KEPT

Determining Stages of Infestation

The following section outlines how levels of infestation are defined. The guidelines for determining the stages of infestation were observed from the Green City Partnership, who uses a model called a "Tree-iage" to determine the current state of forests in their cities (Green City Partnership 2010). This model was adapted for the Well-KEPT projects and defines the stages as follows:

- Mild Infestation - English ivy has infested less than 20% of the total property, has not grown more than chest high on trees, and/or mats are less than six inches in depth on the ground. The average diameter of vines is less than .5 inches.
- Moderate - English ivy has infested 20-50% of the total property, has reached up to halfway up the tree trunks or more and/or has formed mats six inches deep or more on the ground. The average diameter of vines is .5 to 2 inches.
- Severe Infestation - English ivy has infested more the 50% of the total property, has reached the tree canopies and/or has formed mats greater than six inches on the ground. The average diameter of vines is greater than 2 inches.

Well-KEPT Ivy Removal Approach

The Well-KEPT youth corps are limited to manual removal with necessary hand tools, which still allows for several control methods to be used on Well-KEPT projects. The following list describes each of the control methods used on Well-KEPT projects.

- **Ground Removal -** Ground removal refers to removing the English ivy roots and vines above and below the ground (OSU 2008, City of Portland 2019). It is important to note that the technique used is often determined by how difficult the roots and vines are to remove. The ground removal techniques are as follows:
    - "Burrito Rolling" - Refers to rolling ivy to remove the roots and vines into a log, or like a burrito. The log is then severed once it reaches the desired size and could be composted onsite or removed from the site (City of Portland)**.** This technique is usually used when there are large areas of ivy.
    - "Pull and Cut" - Done from a kneeling position, this technique is done by pulling an ivy vine in any direction as far as one can reach and then cutting, repeating until the area is clear. One must make sure to "ball up" the ivy vines as they are

cut and pile them for later disposal (Soll 2005). This technique can be used in many situations where the ivy is growing amongst native vegetation. It is generally less efficient than burrito rolling.

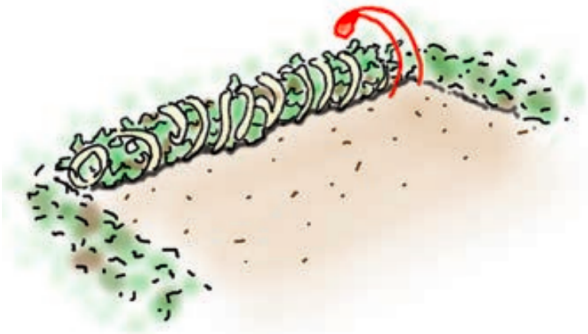


Image 1: English ivy "burrito roll"

Image courtesy of Green Seattle Forest Steward Guide

Image 2: Ivy "pull and cut" technique.

Image courtesy of Green Seattle Forest Steward Guide

- **Survival Rings (also known as "life rings") -** This method requires removing the English ivy from tree trunks by cutting the vines at chest height and then pulling them off and away from the tree at the desired diameter (usually between three and five feet), leaving a ring of bare ground around the base of the tree. This practice can be used alone or in conjunction with ground removal, a decision usually determined by land managers based on the severity of infestation and the time and/or funding allotted for the project (OSU 2008, City of Portland 2019). Practices used for survival rings are:

    - Roll Back - After cutting the ivy from the tree trunk, the vines are rolled tightly away from the trunk at the desired diameter and left in place, leaving the ground around the base of the tree bare (Rick Ballie 2018).

    - Severing - Cutting the ivy from the tree trunk and rolling it away at the desired diameter, severing the roots from the ground and surrounding vines. The roots are then taken away to be composted onsite or hauled offsite (Rick Ballie).

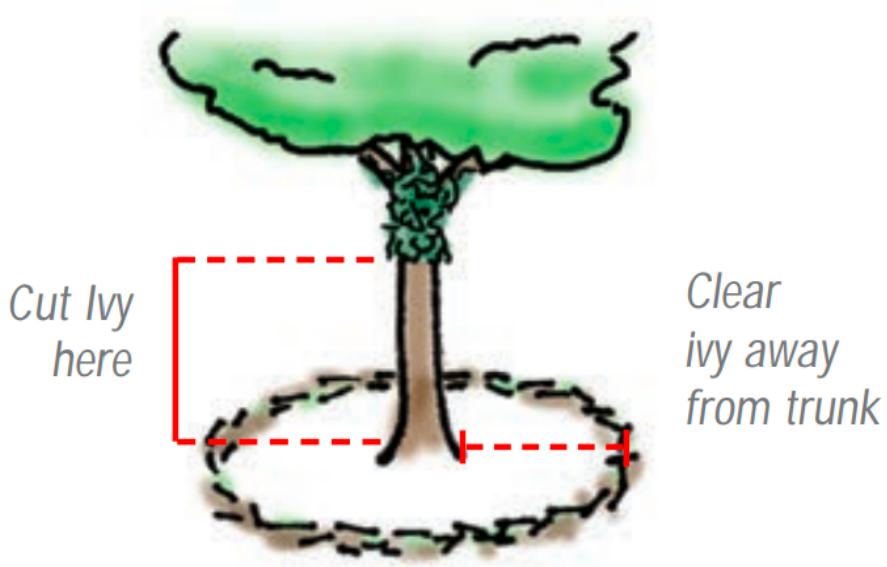


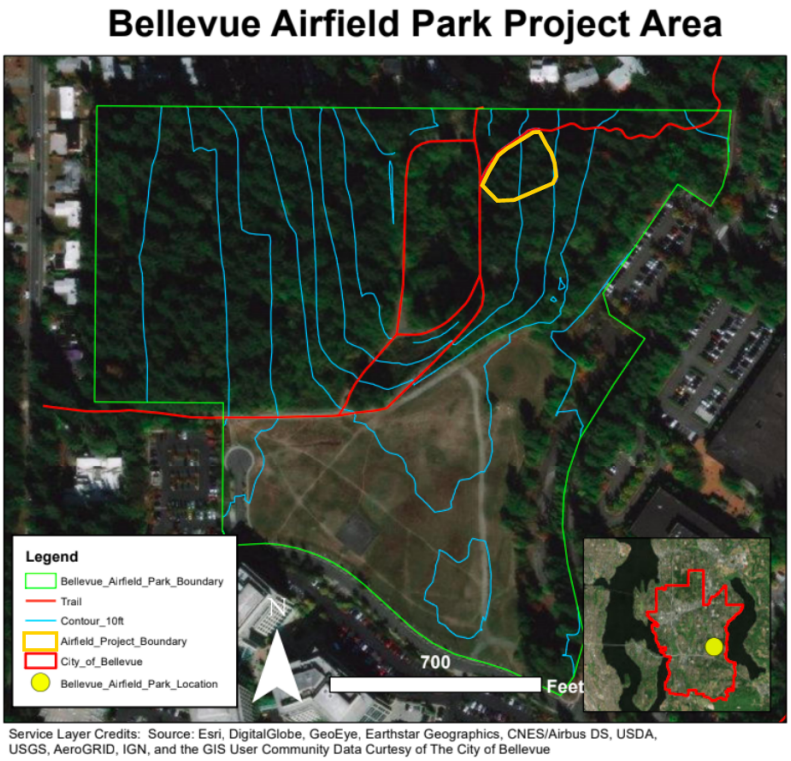
Image 3: English ivy "survival ring"

2018 Well-KEPT Ivy Removal Projects

Bellevue Airfield Park

Bellevue Airfield Park was acquired by the City of Bellevue in 2012 and is 27.55 acres total. The park is located in the Eastgate neighborhood of Bellevue and has a connecting corridor to the nearby Robinswood park (City of Bellevue(b) 2017). At this time the park is still under development for active and passive recreational use. The master plan for the park dictates that there will be two artificial turf ballfields installed, as well as picnic areas and 10.71 acres of wooded areas. The vegetative makeup of the park is a typical deciduous-conifer upland forest, with a dominant makeup of mature *Pseudotsuga menziesii* (Marcotte 2018). The city lead for the project area disclosed that there is known root rot in the *P. menziesii* and therefore several hazard trees had been removed from the project area. The dominant understory was *Berberis nervosa* and *Gaultheria shallon* with English ivy growing sparsely amongst the native ground cover. Since the purchase of the park, there have been efforts to restore what will be the wooded areas. According to the project lead, a combination

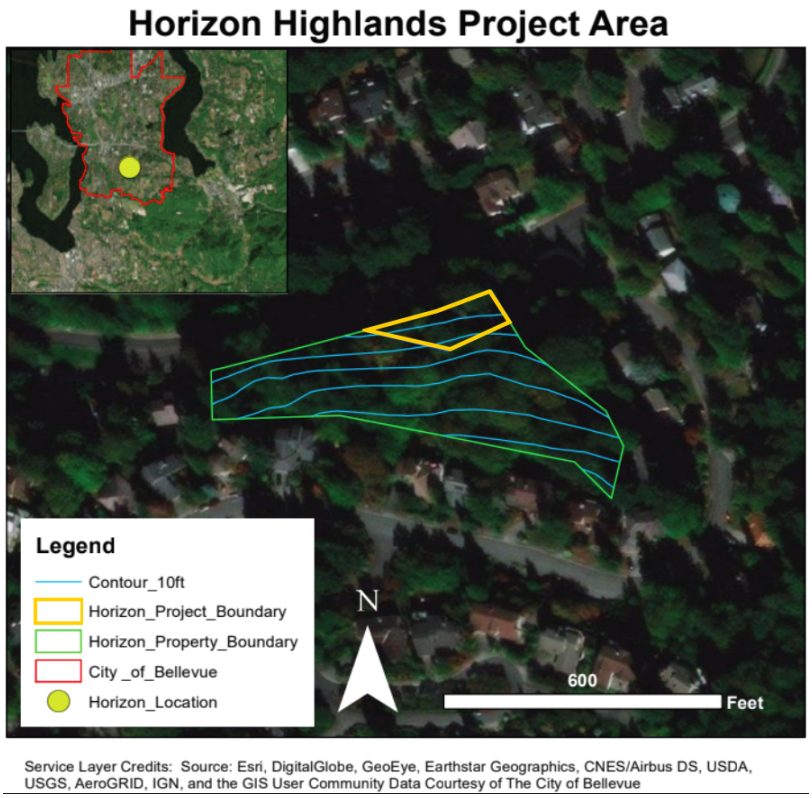
of mechanical, chemical, and manual control techniques have previously been used on the English ivy project area. The Well-KEPT program has been a part of maintaining the restoration project area for the past two years (Anderson 2018). There have been plantings of native conifers, shrubs, and ground covers in the project area. It is unknown how the infestation started in this park. However, it is suspected that the infestation could have been from the surrounding private residences. The 2018 Well-KEPT project area is located in the Northeast corner of the park's property (See map 1).



(MAP 1: BELLEVUE AIRFIELD PARK PROJECT AREA)

Horizon Highlands Open Space

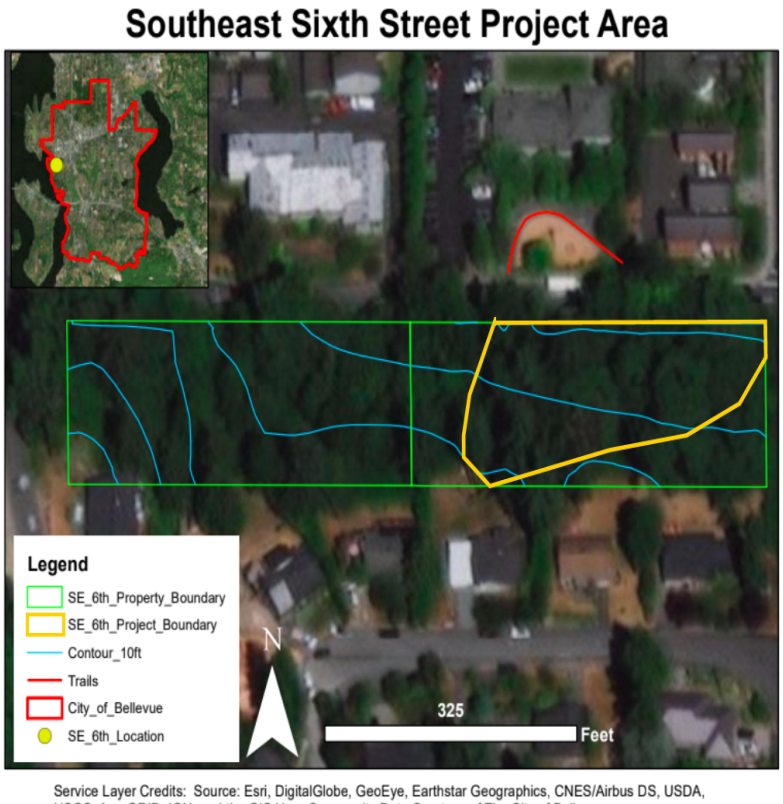
Horizon Highlands is one of the City of Bellevue's open spaces, meaning that it has no established trails and serves as an "open" or green space that is undeveloped. The open space is roughly 2.95 acres and is situated in the Westwood Highlands neighborhood (City of Bellevue 2016). Horizon Highlands open space has two parcels that are bisected by neighborhood roads and private homeowners, making North and South parcels. The 2018 youth corps project focused on the northern parcel of land and therefore for the remainder of this report, all descriptions and project details will focus on the northern parcel. The vegetative makeup is a typical deciduous-conifer upland forest with a dominant tree canopy of *Acer macrophyllum* (Marcotte 2018). There a dominant understory comprised of *Berberis nervosa* and *Oemleria cerasiformis* and an established English ivy ground cover. English ivy was manually controlled in 2017 along the northern sidewalk border. It is likely that the infestation is sourced from the surrounding private properties (Anderson 2018). The 2018 youth Corps project focused on the North West Corner of the Northern Horizon Highlands properties (See map 2).



(Map 2: Horizon Highlands Open Space Project Area)

South East Sixth Street Open Space

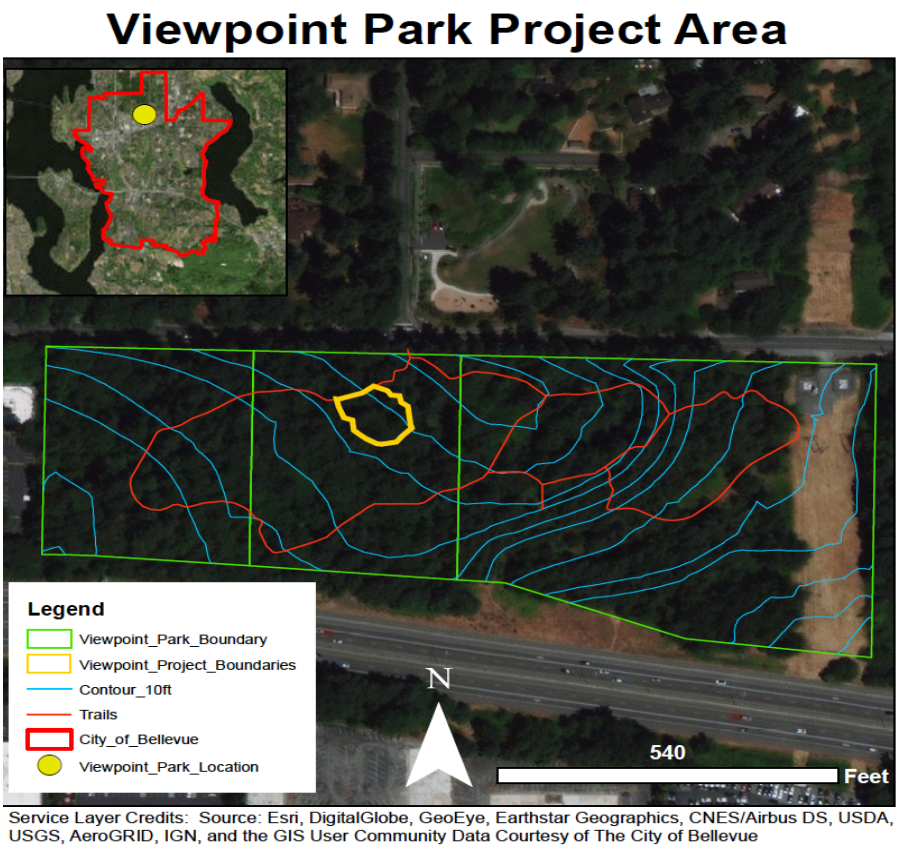
The South East Sixth Street property is another of the City of Bellevue's open spaces. The 1.7-acre property is located in the West Bellevue neighborhood. The open space is divided in two east and west parcels (City of Bellevue, 2016). The vegetative makeup throughout the entire area of the open space is a typical deciduous-conifer upland forest, with a dominant makeup of mature *Acer macrophyllum* **(**Marcotte 2018). The dominant native shrub cover is a mix of *Acer circinatum* and *Corylus cornuta.* English ivy dominated the ground cover in the east parcel and roughly half of the west parcel. At this time there have been no known previous ecological restoration activities before the Well-KEPT project in 2018, and there are no known follow-up treatments (Ballie 2018). It is unknown how the infestation started for this property. However, given the surrounding matrix of private residences, it is likely that the infestation could have spread from private property. The 2018 Well-KEPT crew worked in the east parcel, implementing ivy survival trees to the standard specification, and only removed ivy from the trunks in the west parcel due to time constraints. Therefore, the project in consideration is the work done in the east parcel (See map 3).



(Map 3: Southeast Sixth Street Project Area)

Viewpoint Park

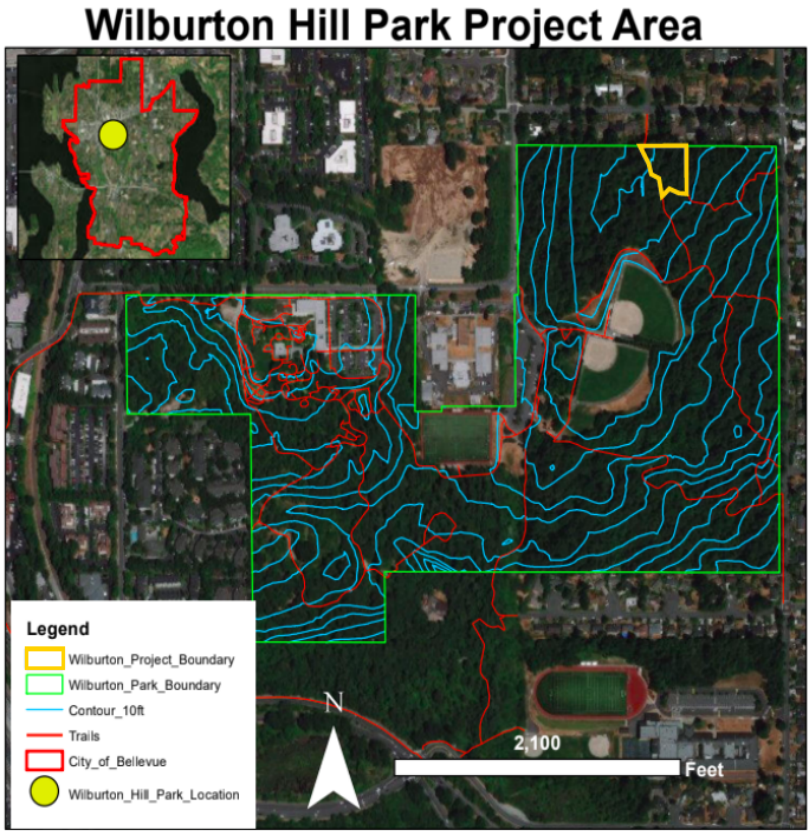
Viewpoint Park is located off of state road 520 and acts as a buffer between the neighborhood and the highway. The 13.5-acre park features half a mile of loop trails and a viewpoint bench (City of Bellevue(c) 2017). The dominant vegetative makeup of the park is a typical deciduous-conifer upland forest with a dominant tree canopy of *Acer macrophyllum* and *Pseudotsuga menziesii,* with some mature *Tsuga heterophylla* (Marcotte 2018). The dominant native understory is comprised of *Gaultheria shallon* and the dominant ground cover is English ivy. Rick Ballie, the Forest Management Program Supervisor for the City of Bellevue, disclosed that the infestation is likely sourced from the SR 520 corridor, and that the long-term goal is to eradicate English ivy from the park (Timeline TBD) (Ballie 2018). In June of 2018, volunteers removed vines from the tree trunks to the base of the trees. The 2018 youth corp's target restoration area for Viewpoint Park was located in the left loop trail (See map 4).



(Map 4: Viewpoint Park Project Area)

Wilburton Hill Park

At 105.49 acres, Wilburton Hill Park is Bellevue's largest upland park. It is located in the Wilburton neighborhood and has many recreational highlights for residents to enjoy (City of Bellevue(d) 2017). The vegetative makeup of the park is a typical deciduous-conifer upland forest, with a dominant tree canopy of *Acer macrophyllum,* and *Pseudotsuga menziesii* (Marcotte 2018). The dominant understory species in the project area is comprised of *Oemleria cerasiformis* and *Corylus cornuta* and a dominant ground cover of English ivy. It is likely that the infestation came from the surrounding private residences. However, some areas of the park could have been infested by bird droppings (Baillie 2018). The youth corp's project of 2018 was located in the Northwest corner of the park bordering the northernmost park boundary (See map 5).



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Data Courtesy of The City of Bellevue

(Map 5: Wilburton Hill Park Project Area)

Site assessments

The following table outlines the condition of the restoration projects at the time of project implementation. All of the projects were implemented during the summer of 2018. There had been no significant rainfall in the weeks leading up to the Well-KEPT restoration projects. The surrounding matrix for all sites were residential neighborhoods.

The site assessment procedures for all project included recording the percent cover of ivy by use of two meter by two meter quadrats and data collection from the City of Bellevue ArcGis public data. The soil and root conditions, were onsite observations made by the author.

Property	Project Date	Survey Dates	Topography	Soil Conditions	Ivy root condition	Ivy diameter	% Ivy cover	Tree infestations
Bellevue Airfield Park	8/22/2018	8/22/2018	NE to SW	Dry/ Compact	Dry/Brittle	<1"	13.75%	None
Horizon Highlands Open Space	8/6-7/2018	7/6/2018	N to S	Dry	Dry/ Brittle	<1"	36.92%	<5 ft on tree trunks
South East Sixth Street Open Space	7/23-24/2018 7/30-31/2018	7/23/2018	N to S	Dry/highly compact	Dry/Brittle	Up to 6"	36.33%	Canopy infestations with recent blowdowns
Viewpoint Park	8/14-17/2018	8/14/2018	NE to NW	Dry with ~8 in duff layer	Dry/brittle	<1"	92.38%	None
Wilburton Hill Park	8/2-3/2018 8/15-16/2018	8/2/2018	NE to NW	Dry/compact	Dry/brittle	<1"	85.00%	>10 ft, little or no canopy infestations

(Table 1: Site Assessments by project)

Project goals and best management comparisons

The goal for each project was to target and control English ivy. The best management practices used were different for each property. Determining the goal and best management practice for each property was based on safety and need for work on the property, not based on the success of restoration. There were no project criteria set by the City of Bellevue for project completion. All projects were presented as need for work (e.g., there was no planned amount work for any project). The amount of time spent and the areas completed are the actual amounts completed. The following table illustrates the primary activity, bmp methods, differences between projects during and prior to control.

Ground Removal

Property	Activity & Goal	*Stage of Infestation	*Actual Size in (sqft)	*Person Hours	Previous Control	Notes
Bellevue Airfield Park	Remove ivy from existing and planted vegetation	Mild	10,000	54	Yes: manual, mechanical, and chemical	Plants installed 2016-2017. Continued management and control of English ivy in process.
Horizon Highlands Open Space	Remove ivy from native plants and surrounding area	Moderate	3,000	54	Yes: manual	No continued control plan at this time.
Viewpoint Park	Remove ivy from native plants and surrounding area	Severe	10,200	250	Yes: volunteer work on native trees. Removal only to the base of trunks.	Long term plan to control of English ivy in the process.

Tree Removal

Property	Activity & Goal	*Stage of Infestation	*Number of Survival Rings	*Person Hours	Previous Control	Notes
SE 6th St Open Space	Remove ivy from native trees	Severe	72	240	No	No long term control plan at this time.
Wilburton Hill Park	Remove ivy from native trees	Severe	128	300	No	No previous control. Long term control plan of English ivy in place

*Project difficulty, size and person hours were calculated for this MEH project and are the actual hours and sizes completed at each project.

(Table 2: Project Goals and Best management practices by project)

Methods

The five English ivy removal projects conducted by the Well-KEPT Program youth corps in 2018 were monitored before, during, and after the ivy removal activities were conducted.

Determining stages of infestation

The following section outlines how levels of infestation are defined. The guidelines for determining the stages of infestation were observed from the Green City Partnership, who uses a model called a "Tree-iage" to determine the current state of forests in their cities (Green City Partnership 2010). This model was adapted for the Well-KEPT projects and defines the stages as follows:

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Severe Infestation - English ivy has infested more the 50% of the total property, has reached the tree canopies and/or has formed mats greater than six inches on the ground. The average diameter of vines is greater than 2 inches.

Regrowth survey methods

The regrowth survey was conducted in November of 2018. The purpose of the regrowth survey was to determine if there was significant regrowth of English ivy in the project areas after removal by recording the density of English ivy re-sprouts (See table 5). The objective for every project was to remove English ivy from native vegetation (sometimes including the space between native plants) so that every survey plot observed native trees and shrubs.

Transect lines were used to survey each of the project areas. A compass was used to determine the angle of the transect lines. Survey plots of one square meter were taken at a set linear foot and at a set distance on either side of the transect line (See Appendix B). Transect lines and survey plots were determined by the size of the project area. A minimum of 10 survey points was taken for each project area. For trees larger than one square meter, a random compass degree generator was used to place the quadrat around the base of the trees to eliminate bias. Survival rings include a three to five-foot diameter of ground removal in addition to chest height removal. Therefore the quadrats were placed within the ground removal areas.

Work productivity Determination

The level of difficulty was determined by supervisor observations and removal rate. The supervisor observations were specifically if crew members struggled to remove the roots from native vegetation or the ground without breaking. The crew rates were determined by dividing the area of work completed or survival rings completed, by person hour to get the rate of treatment per square feet per person-hour or tree per person-hour. Then the observations made by the supervisor (the author of this MEH project) were compared with the rate of removal to determine the level of difficulty which was then divided into three categories, easy, moderate and difficult. Airfield park is the only project that has a contradicting rate and difficulty level. This is because this project had a low percent cover but the crew members struggle to remove the roots without breaking them.

Results

Removal technique comparison

The following table outlines the differences between each project area as to methods used and at what phase of restoration the projects were in at the time of the Well-KEPT projects. "Initial removal" refers to any property that had no previous restoration or where the infestation has returned to an initial removal state. "maintenance" refers to any property that had previous infestation control prior to the 2018 Well-KEPT restoration.

Ground Removal				
Site Name	**Actual project area (sqft)**	**Method**	**Disposal if Applicable**	**Initial Removal or Maintenance**
Bellevue Airfield Park	10,000	Pull and Cut	3 onsite compost piles on *LWD	Maintenance
Horizon Highlands Open Space	3,000	Burrito rolls	~20 onsite compost piles on *LWD	Initial
Viewpoint Park	10,200	Burrito rolls	24 onsite compost piles on* *LWD	Initial
Tree Removal				
Site Name	**Number of Survival Rings**	**Method**	**Disposal if Applicable**	**Initial Removal or Maintenance**
SE 6th Street Open Space	72	Roll Back	N/A	Initial
Wilburton Hill Park	129	Roll Back	N/A	Initial

*LWD= Large Woody Debris

(Table 3: Removal Technique Comparison by project)

Youth Crew Productivity

The following table outlines the crew productivity by manual removal technique. There was no planned amount of work therefore, all of the numbers reflected in this table represent the actual amount of work completed in the actual time.

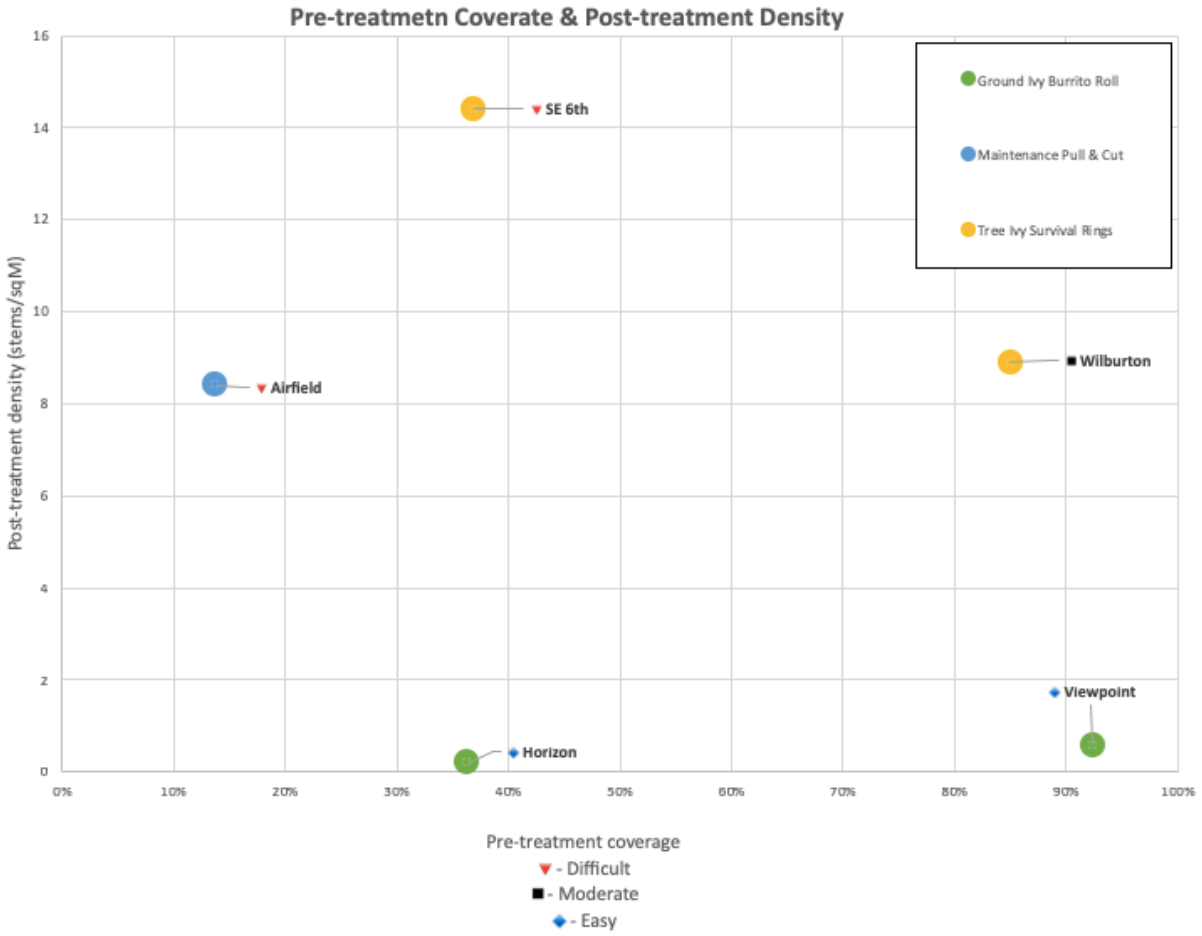
Ground Removal						
	Stage of Infestation	**Area (sqft)**	**Person Hours**	**Removal Rate (sqft/*PH)**	****Adjusted Removal Rate (sqft/*PH)**	**Level of Difficulty**
Bellevue Airfield Park	Mild	10,000	54	185	25.5	Difficult
Horizon Highlands Open Space	Moderate	3,000	54	56	20.5	Easy
Viewpoint Park	Severe	10,200	250	41	37.7	Easy
Tree Removal						
	Stage of Infestation	**Number of Trees**	**Person Hours**	**Removal rate PH/tree**	**Removal rate Trees/PH**	**Level of Difficulty**
SE 6th St Open Space	Severe	72	240	3.33	0.3	Difficult
Wilburton Hill Park	Severe	128	300	2.33	0.43	Moderate

*PH= Person Hour **Adjusted Rate = % pretreatment coverage X area

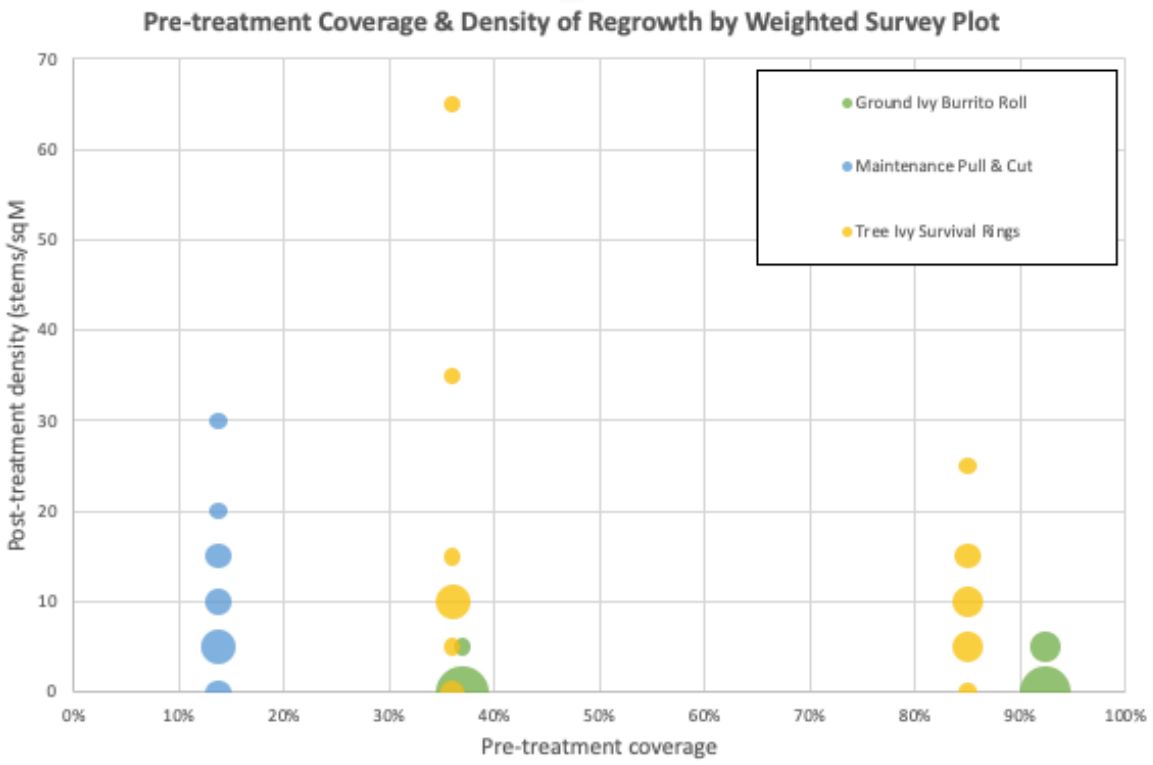
(Table 4: Crew rates by project)

English ivy regrowth

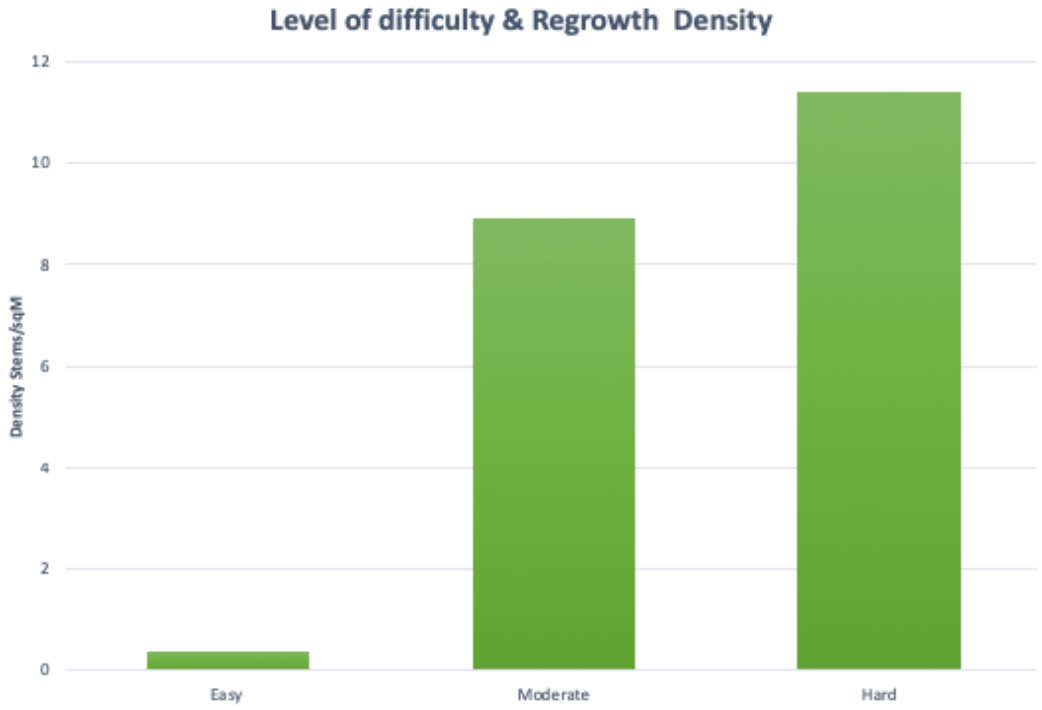
The following graphs show various comparison between site variables, pre-treatment cover and regrowth densities.



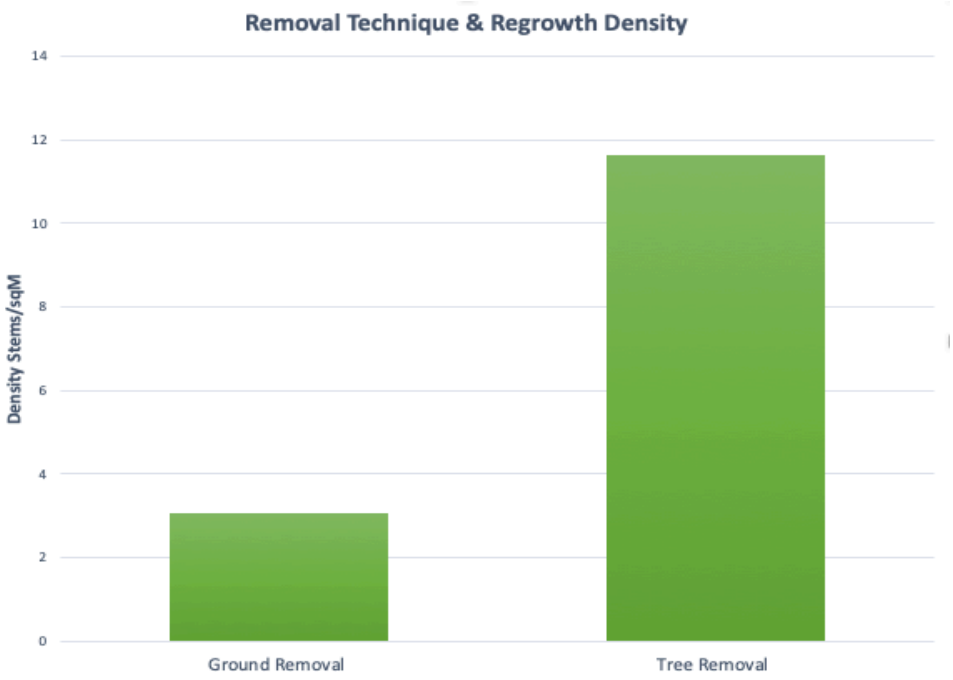
(Graph 1: Pre-treatment and regrowth comparison)



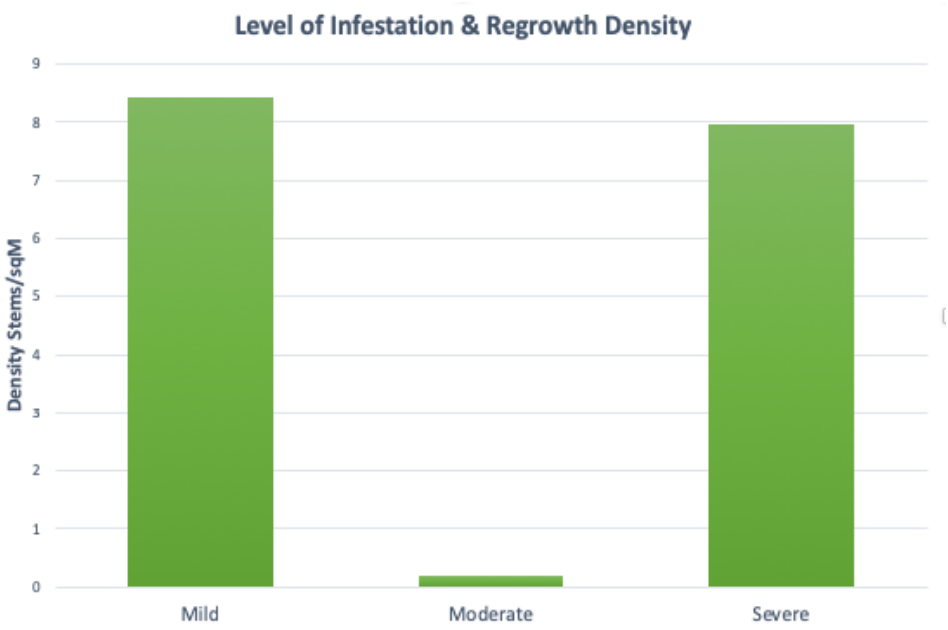
(Graph 2: Pre-treatment coverage and regrowth by weighted survey plot: The points represent a survey plot and the size of the point represents the frequency in which the number of stems per plot occurred. For example, if a project survey had a high frequency of 0 stems/sqM then the point indicated on the graph is larger, and if a project survey had a low frequency of 0 stems/sqM then the point will be smaller)



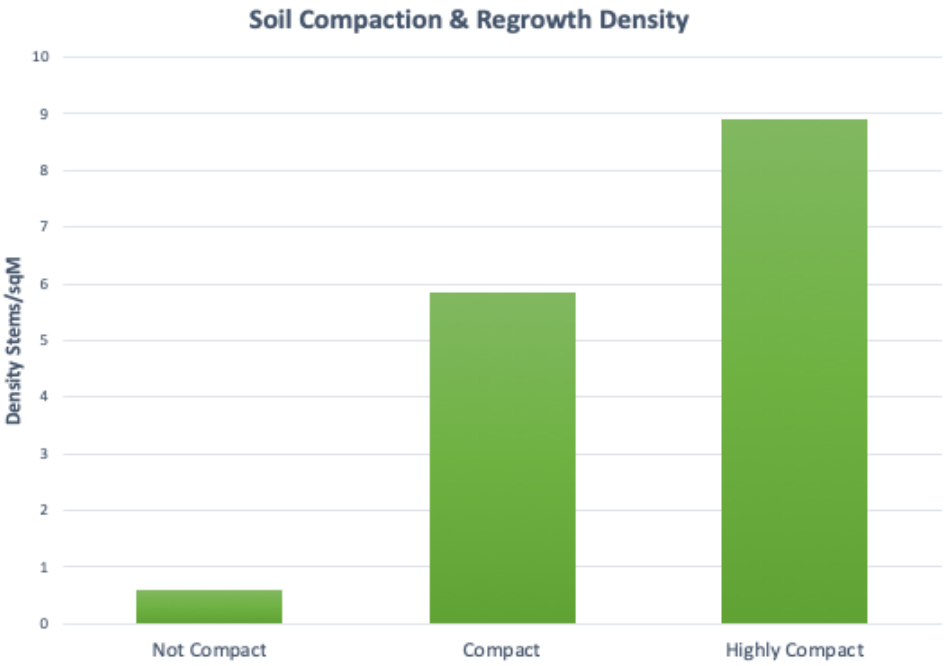
(Graph 3: Average regrowth by difficulty level)



(Graph 4: Regrowth density by removal technique)



(Graph 5: Average regrowth by level of infestation)



(Graph 6: Average regrowth and soil compaction)

Before and after comparisons

Image 4: Airfield Before Ivy Maintenance

Image 5: Airfield After Ivy Maintenance`

Image 6: Horizon Highlands Before Ivy Removal

Image 7: Horizon Highlands After Ivy Removal

Image 8: SE 6th St. Before Ivy Ring

Image 9: SE 6th St. After Ivy Ring

Image 10: Viewpoint Before Ivy Removal

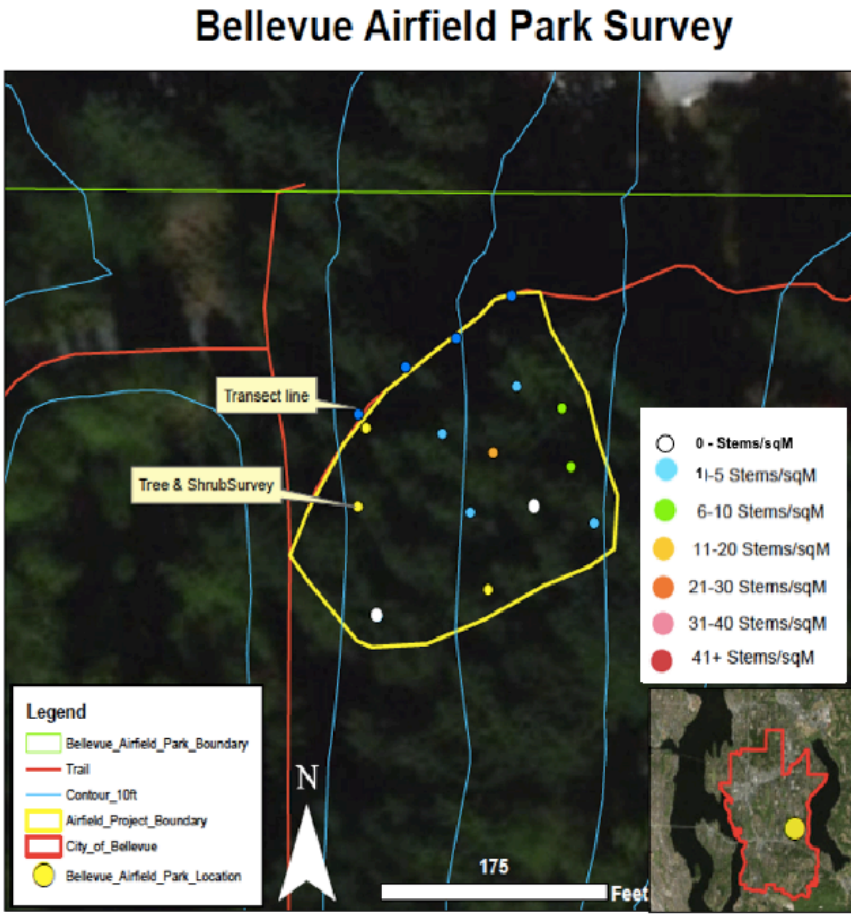
Image 11: Viewpoint After Ivy Removal

Image 12: Wilburton Before Ivy Ring

Image 13: Wilburton After Ivy Ring

Bellevue Airfield Park

During the follow-up survey, the Airfield park project had the second highest average regrowth, at 11.2 stems per square meter The Airfield Park project had a project goal to implement maintenance on trees and shrubs. There were no trees larger than the meter-by meter-quadrat used in the survey. Therefore, the trees and shrubs were not delineated in the survey. There were in total twelve survey points taken in the project area. Overall there was an even distribution of densities throughout the site. There was a range of 0-30 stems per square meter (See map 6).

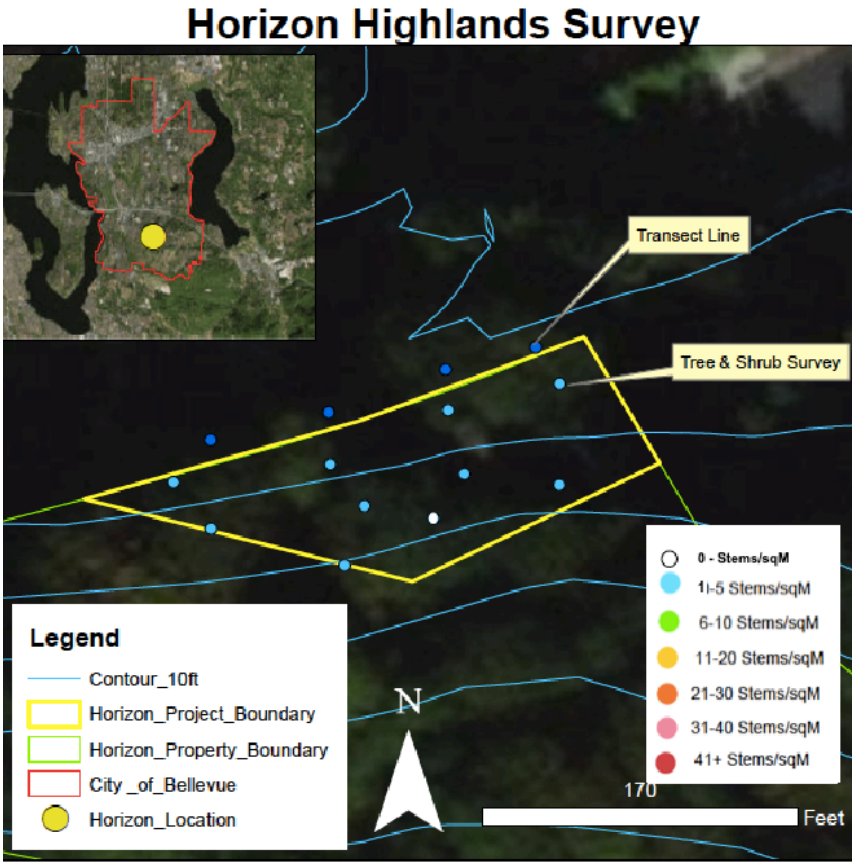


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Data Curtesy of The City of Bellevue

Map 6: Bellevue Airfield Park Regrowth Survey

Horizon Highlands Open Space

During the follow-up survey, the Horizon Highlands project area had the second lowest average regrowth at 0.16 stems per meter. There was a significantly thick layer of partly decomposed duff along the sidewalk where leaves had been blown off the sidewalk into the project area (See Image 17). Plots taken close to the sidewalk had significantly less ground vegetation under the duff, which could have assisted in suppressing any regrowth for that area. However, there was no survey plot that had more than 5 stems per square meter.

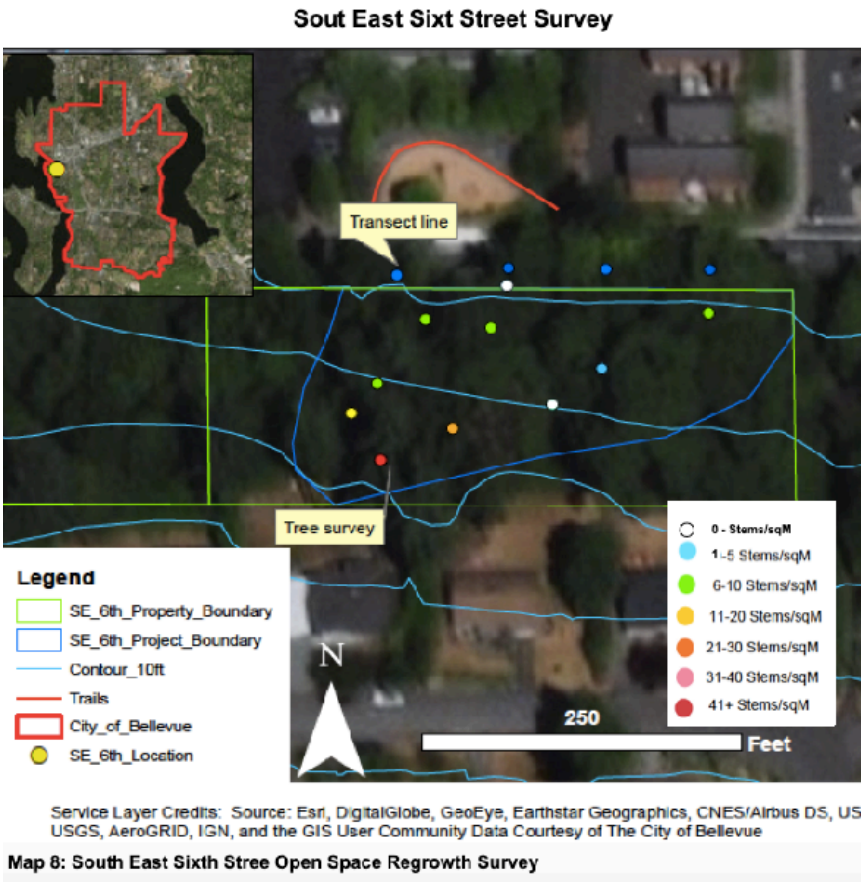


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Data Courtesy of The City of Bellevue

Map 7: Horizon Highlands Open Space Regrowth Survey

South East Sixth Street Open Space

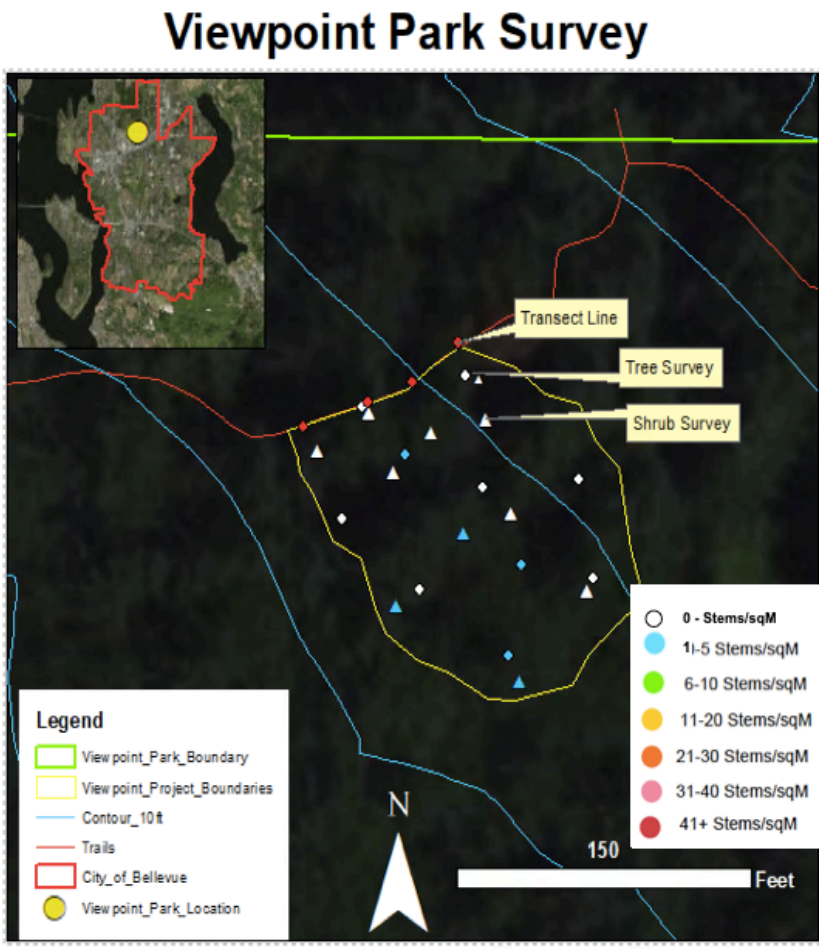
During the follow-up survey, the South East Sixth Street Open Space project had the highest average regrowth at 11.6 stems per square meter (See image 18). In total ten survey points were taken in the project area. The west end of the project area showed a higher number of stems per square meters. This area also had larger diameter vines compared to the east side of the project. There was a range of 0- 65 stems per square meter (See map 5).



Map 8: South East Sixth Stree Open Space Regrowth Survey

Viewpoint Park

During the regrowth survey, Viewpoint Park had the lowest average regrowth at 0.78 stems per meter for trees, and 0.9 stems per meter for shrubs that were surveyed (See image 19). There were 10 trees surveyed and 13 shrubs surveyed in the project area. There was a range of 0- 4 stems per square meter (see map 9).

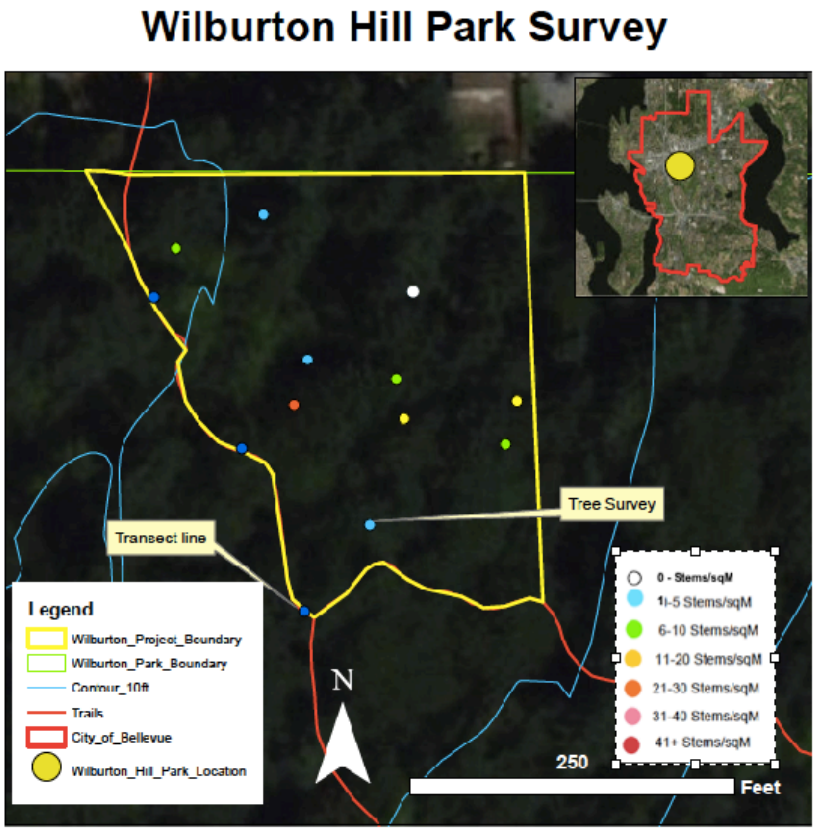


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Data Courtesy of The City of Bellevue

Map 9: Bellevue Airfield Park Regrowth Survey

Wilburton Hill Park

During the regrowth survey, Wilburton Hill Park had an average regrowth of 8.4 stems per square meter (See appendix b image 20). There were 10 survey plots taken in total. The goal for the Wilburton Hill Park project was to implement survival rings on trees in the project area, therefore only trees were surveyed. There was an even spread of densities across the project area, with a range of 0 to 22 stems per square meter (See map 10)



Map 10: Wilburton Park Regrowth Survey

Discussion

Soil Condition:

There was not enough variation in the data produced in this study to make meaningful correlations between the success of restoration and soil conditions (See graph 6). The South East Sixth Street Open Space project had highly compacted soils and had the highest regrowth. Whereas the Viewpoint Park project had a thick duff layer which the roots were loosely attached, showed the lowest average regrowth. Soil compaction was observed with how difficult it was for the crew members to extract roots without breaking. Further data will need to be collected to compare soil compaction and density of regrowth confidently.

Stage of Infestation:

There was not enough variation data produced in this study to make meaningful correlations between the success of restoration and the stage of infestation (See graph 5). However, the root and vine size could have played a role in the higher regrowth densities at South East Sixth Street Open Space. Large vines (>2") were difficult for the crew members to remove from native plants and the ground without the proper tools. More data collected over a more extended period would provide better results for an understanding stage of infestation and regrowth.

Technique:

The data collected in this study showed that ground removal had less density of regrowth than tree removal (See graph 4). Bellevue Airfield Park had a high regrowth density and was the only park that utilized the "pull and cut" technique as a form of ground removal. As with other site conditions, this could have played a role in how difficult it was for the crew members to remove the roots and vines thoroughly. In contrast, Horizon Highlands Open Space and Viewpoint Park were able to utilize the "burrito roll" technique and were associated with lower regrowth densities. While utilizing the "burrito roll" technique, the roots and vines were strategically removed in large rolls, making root removal more thorough. More data collected over a more extended period would provide better results for understanding the technique and regrowth.

Drought Conditions:

There was not a significant amount of data collected in this study to make correlations between drought conditions and the success of the restoration. A duplicate study during other seasons might provide a meaningful comparison between seasons. However, some research showed that restoration during drought conditions could have a positive impact, though it is not the "best" time to control English ivy. All of the projects showed signs of drought. The ivy roots were dry and brittle, causing them to be easily broken (Young, Simmons and Hamblin-Katnik, 2012). However, all projects showed signs of decreased English ivy densities in the treated areas. Therefore removal during drought conditions could have a positive impact (See graph 1 &2).

Level of Difficulty:

The level of difficulty is likely the most meaningful correlation between site conditions as well as regrowth densities (See graph 3). If a project was particularly difficult, then higher regrowth densities were seen. For example, South East 6th Street's soil compaction and vine diameter made it difficult for the crew members to perform the task and therefore showed higher regrowth density. For Wilburton Hill Park, the project was neither difficult nor easy for the crew members to perform the task, and therefore the regrowth density was comparatively average.

Continued Work

The Bellevue Well-KEPT program has been an annual program for nearly 30 years and will continue to be offered every summer for the foreseeable future. Further study and data collection at future Well-KEPT restoration projects could provide valuable information that would contribute to the creation of meaningful experiences for the participants as well as successful restoration for the City of Bellevue. Furthermore, monitoring past Well KEPT English ivy restoration projects could be incorporated into the educational curriculum. Incorporating monitoring would not only satisfy the educational goals of the program but could provide continued data collection for further study. This program offers a unique opportunity to continue a long term study and continuation of this Masters of Environmental Horticulture final project.

Summary

In summary of the original research questions, there was not enough data available in this study to make meaningful correlations between the success of restoration, site conditions, time of year or drought conditions. The does data suggest, that when working with youth, ground ivy removal is more effective at reducing the density of English ivy than implementing survival rings. Also, sight conditions might have affected how easy or difficult it was for the Well-KEPT crew to remove vines from the ground and tree trunks. Current Pacific Northwest practices suggest that summer is not the most effective time of year to remove English ivy by manual control (KCND 2014, Soll 2005). However, the data collected in this MEH project may suggest that if an organization is limited to summer English ivy manual removal, ground removal may be more effective.

The purpose of this Masters of Environmental Horticulture project was not to determine if the work implemented this summer was "good" or "bad" work but rather to determine if project managers should favor certain site conditions paired with the existing criteria (such as the need for work and safety). Out of the five projects, The Horizon Highlands Open Space and Viewpoint Park projects had the best outcomes during the implementation and the regrowth survey, and both projects were relatively easy for the crew to implement. The South East Sixth Street project required extra tools and was quite challenging to implement the survival rings; however, it will still likely have an overall positive impact on the property. The Airfield Park project goals were suitable for the Well-KEPT crew. If there were more time on the Airfield Park Project, there could have been more time spent on removing the roots and vine thoroughly.

In conclusion, removing any amount of ivy could have a positive impact, regardless of season, especially if there are long term plans for further removal. If agencies that work with youth are constrained to removal during summer, favoring the ground removal technique may result in less ivy regrowth after removal.

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Appendix A

Effects of Ivy and Restoration

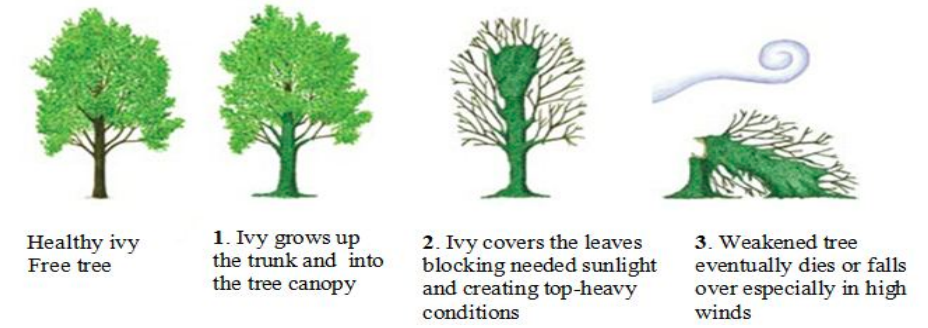

Image 14: When English Ivy is allowed to grow into tree canopies, it can weaken the structure of the tree and create a "wind sail" affect, causing blow downs during windy conditions.

Image Courtesy of Green City Partnership

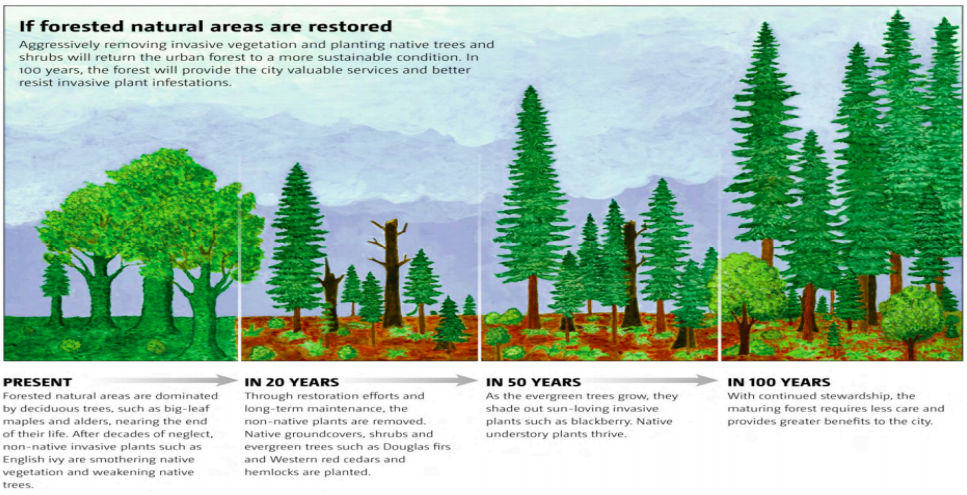

Image 15: Forest Restoration Image courtesy of Green City Partnership

Appendix B

Example of Survey Plots

Image 16: Example of survey at Bellevue Airfield Park (*Gaultheria shallon*)

Image 17: Example of survey at Horizon Highlands (*Rubus ursinus*)

Image 18: Example of survey at SE Sixth St. Open Space (*Acer macrophyllum*)

Image 19: Example of survey at Viewpoint Park (*Pseudotsuga menziesii*)

Image 20: Example of survey at Wilburton Hill Park (*Alnus rubra*)

Appendix C

Tools

Property Name	Tools
Airfield Park	Hand Claws Hand Pruners (Clippers)
Horizon Highlands Open Space	Hand Claws Hand Pruners (Clippers) Hand Saws
ViewPoint Park	Hand Claws Hand Pruners (Clippers)
South East Sixth Street	Hand Claws Hand Pruners (Clippers) Hand Saws Pulaskis Pick mattock
Wilburton Hill Park	Hand Claws Hand Pruners (Clippers) Hand Saws