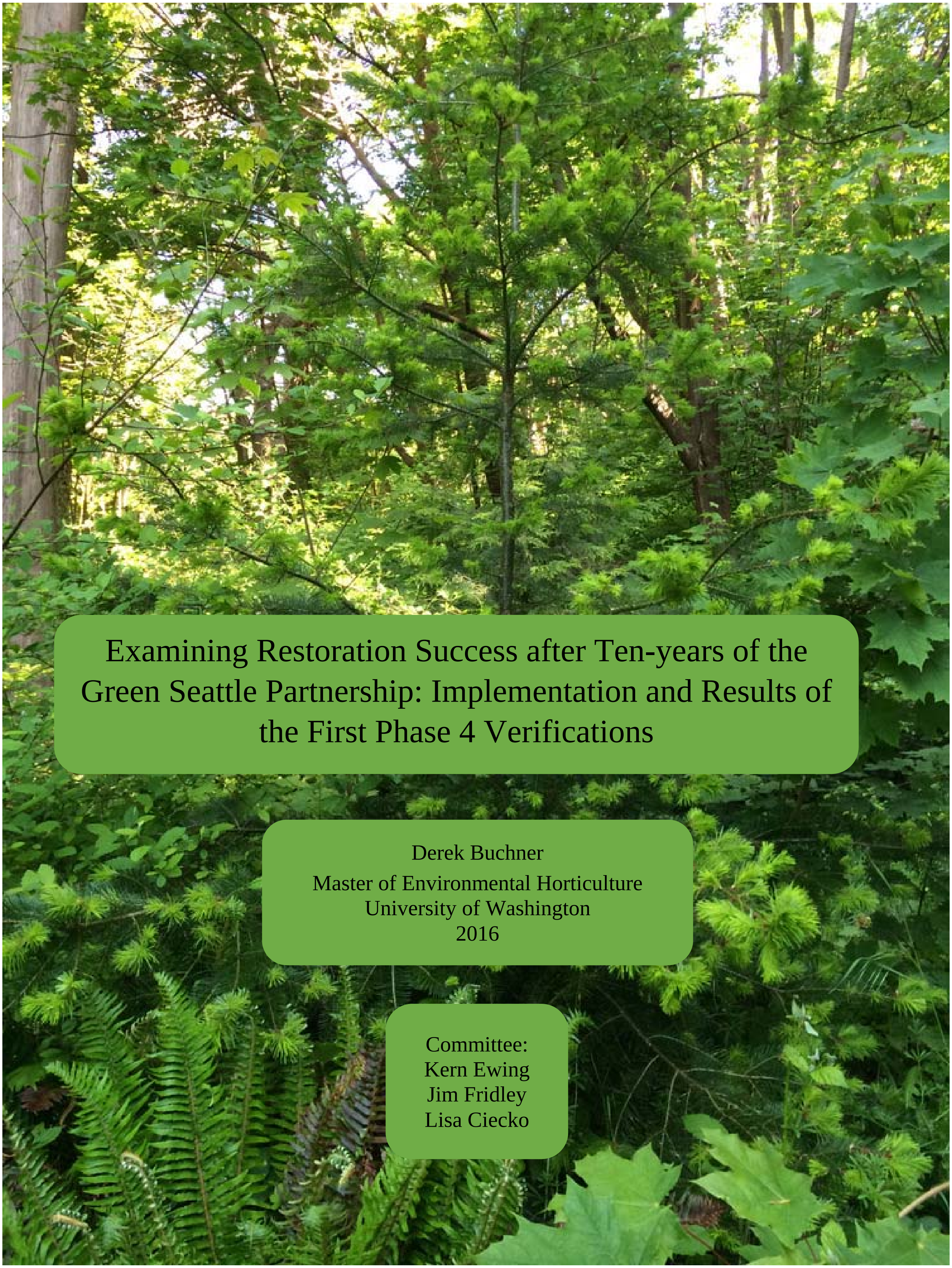


Examining Restoration Success after Ten-years of the Green Seattle Partnership: Implementation and Results of the First Phase 4 Verifications

Derek Buchner
Master of Environmental Horticulture
University of Washington
2016

Committee:
Kern Ewing
Jim Fridley
Lisa Ciecko

Contents

LIST OF FIGURES

LIST OF TABLES

FORWARD

Declining forests and an urge from Seattle's mayor in 2005 led to a twenty-year restoration goal of 2,500 acres (10.11 km^2) in urban forests. After five to seven years in active restoration, portions of the forest would be evaluated, and if considered "successful," they would transition from active restoration sites into a maintenance phase, called Phase 4. In 2015, half way through the twenty-year plan, a team of four people—myself, two plant ecologists from the City of Seattle Parks and Recreation Department, and a strategic advisor—began to assess the restoration sites for ecological success. We used data on diversity, vegetation structure, and ecological processes to help us determine success, as well as qualitative observations and gut-feelings. The restoration assessments in 2015 acted as a pilot study for the Phase 4 Verification process. This report will explain our process, report results, critique, and suggest improvements going forward.

BACKGROUND

Defining Restoration Success

Ecological restoration is a growing industry with over $9.5 billion spent annually in the United States (BenDor *et al.* 2015). The Society of Ecological Restoration defines ecological restoration as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER 2004). While there is a plethora of reasons for ecological restoration—from community building to habitat for rare species—one of the common reasons is sustainable ecological recovery of a natural area (Light 2002; SER 2004). Typically, ecological recovery is considered ecologically successful if 1) ecological conditions after restoration are comparable to conditions of reference sites (Ruiz-Jaen and Aide 2005) and 2) the site can continue its development without further assistance (SER 2004). However, in areas with continuous disturbance and invasion threat, like urban areas, sites will rarely continue to develop without further assistance (Grim *et al.* 2000; Koriak 2008).

Urban areas require more maintenance following restoration than lesser developed areas (Lonsdale 1999). The fragmentation of many urban natural-areas increases edge effects, which expose the natural areas to more invasion by exotic species (Honnay *et al.* 2002), including from invasive species common in adjacent residential yards (Raloff 2003, Alston and Richardson 2006). The urban environment causes elevated nutrient loads through fertilizer runoff, pollution, and hydrological changes (Kat *et al.* 2006)—all of which often further increase the risk of invasion (Davis *et al.* 2000). In addition, in urban areas, many biological processes are constrained, like "spontaneous recruitment of native species, which is impaired both by landscape fragmentation and by the lack of nearby habitat remnants" (Lindig-Cisneros and Zedler 2000). All of these conditions makes it logical to be more realistic in determining success of urban restoration sites, knowing that these sites will need to be continually maintained into the future. Ehrenfeld (2000) remarked that, "restoration ecology would be better served by recognizing that the diversity of conditions requiring restoration demands much flexibility in goal setting."

Determining "ecological success" ("success" going forward) is important for stakeholders of restoration projects. Funders want to know if their resources were well spent while resource managers, who oversee restoration sites, want to learn best practices and how to best adapt methods. Success is often determined through monitoring of a site. With the complexity of ecological systems, a manager can't measure all processes and biology to determine success, they must choose a few ecosystem attributes to measure that are hopefully representative of the entire site.

Ruiz-Jaen and Aide (2005) found that studies examining the success of restoration projects published in *Restoration Ecology* could be divided into three monitoring focus areas: diversity, vegetation structure, and ecological processes. Ruiz-Jaen and Aide (2005) reported that 97% of studies evaluated at least two of the three groups, but there was a wide range of sampling techniques within each group. For diversity recovery, they found studies examined plants, arthropods, birds, rodents, reptiles, and mammals. Plant cover, density, biomass, and height were the most prevalent measurements to determine success when looking at vegetation structure. For ecological processes, they found researchers most commonly measured biological interactions, nutrient pools, and the organic matter in soils.

Restoration sites change as vegetation grows, species assemble, and disturbances affect site conditions (Hobbs *et al.* 2007). Restoration sites are often given a target for final species assemblage, based on reference site data and site constraints. To determine if a site is reaching that target, managers consider the restoration trajectory of the site. The restoration trajectory is an estimation of how well the restoration site is transitioning into the stable target state (Hobbs *et al.* 2007). After restoration begins, "there is ample opportunity for inputs from succession to modify trajectories and plant composition" (Hobbs *et al.* 2007; Figure 1). Therefore, continued monitoring of trajectories is good practice for managers to ensure desired results.

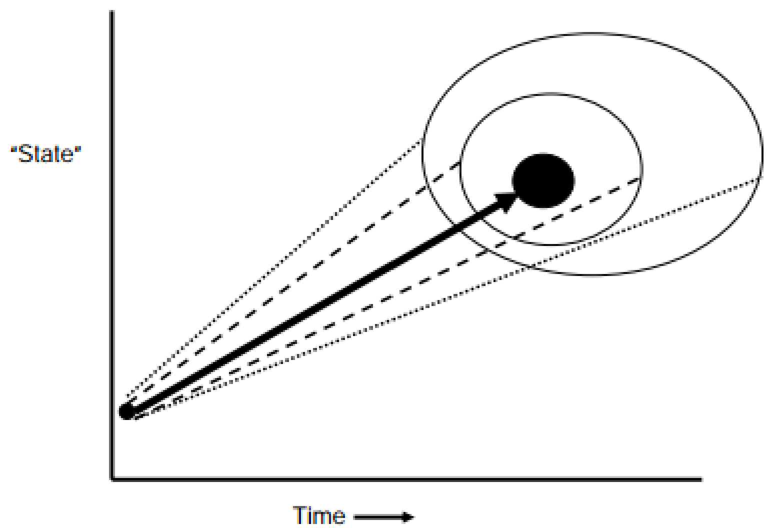


Figure 1. A diagram showing restoration trajectory from Hobbs *et al.* 2007: "Classical restoration trajectory (solid line) and increasingly wider targets (dashed and dotted lines) reflecting unpredictability or variability of endpoints and multiple potential outcomes for restoration. Options can expand or contract through the restoration process." The black circle is the target state.

Seattle's Forest History and the Formation of the Green Seattle Partnership

Seattle's forests drastically changed following the arrival of European-descended settlers in the 1850s (Larson 2005; GSP 2006). Using current-day Seattle as a base for lumber mills, the settlers logged the forests for the timber trade (Klingle 2007). Klingle wrote in *The Emerald City: an Environmental History of Seattle* that by the early 1900s, Seattle's "rainy, muddy, logged-over hills, smoking with fire of burning slash left over from the cutting" offered little to investors except cheap land. Eventually, in places where development didn't consume the land, a forest did return. But what returned was different—deciduous forests of *Acer macrophyllum* (big-leaf maple) and *Alnus rubra* (red alder) replaced the original coniferous forests. In many forested areas within Seattle, historically-native coniferous species like *Thuja plicata* (western redcedar) and *Tsuga heterophylla* (western hemlock) never returned (Larson 2005, GSP 2006).

By the 1990s—after 140 years of continued development, passive management, view clearing, and alien-species invasion—Seattle's forests were highly degraded and unhealthy (GSP 2006). Land managers declared that 75% of Seattle's forested parklands were composed of deciduous species like *Acer macrophyllum* and *Alnus rubra* (GSP 2006). Furthermore, most of the trees were reaching the end of their life-span and invasive plants had invaded natural areas reducing the opportunity for trees to replace themselves (GSP 2006). The "citizens and city government began to understand that the 'natural-areas-take-care-of-themselves' mindset was terribly wrong" (GSP 2006). One invader, *Hedera* spp. (English ivy) was particularly common and was having an enormous impact: it had infested the forests, climbed into the canopy, and was causing trees to topple in high winds (GSP 2006). Meanwhile, on the forest floor, dense mats of ivy vines were consuming the resources that seedlings needed to germinate, stopping tree species from regenerating. A senior urban forester for the City declared that if nothing was done to improve the health of the forest, Seattle would lose 70% of its forest canopy by 2025 (GSP 2006). The growing concern for Seattle's forests launched The Seattle Urban Nature Project (SUNP), which took inventory of the forests and natural areas in 1999 and 2000 (Ramsay 2004). Data from the survey showed that "invasive species were present in 94% of the urban natural areas and 20% of the city's forested areas were highly invaded by a suite of invasive species" (Ramsay 2004). Following the discouraging information learned from the SUNP, Seattle made a plan to restore the forest: the Green Seattle Partnership (GSP).

In 2004, Seattle Mayor Greg Nickles asked the Cascade Land Conservancy and the City of Seattle Parks and Recreation Department to form the Green Seattle Partnership. The GSP set a lofty goal: 2,500 acres (10.12 km^2) of forests to be restored in twenty years, making the GSP the largest urban restoration effort in the country. One of the primary goals of the GSP was to restore native forests: "to re-establish and maintain healthy forested parkland through Seattle" (GSP 2006). Work began in 2005, and since then, volunteers, city staff, and contractors have restored portions of Seattle's forested parklands in hopes of reaching this goal.

Benefits of Restoring Forests

There are many benefits of the GSPs efforts to restore later successional forests including improved ecosystem services (Table 1), as well as social and human benefits.

Restoration projects build community among participants. Research shows that the main reason people volunteer for restoration projects is the social component: to meet people and build community (Asah 2015). Restoration also engages community members with nature and helps them take ownership of their natural resources. Andrew Light, a professor of Philosophy and

Public Policy, argues that restoration is "as much about restoring the human-nature relationship as it is restoring natural processes" (Light 2002).

Table 1. The ecosystem services provided by increased forest coverage in urban areas.

Reduce Stormwater	Through rainwater storage and interception, stormwater will be reduced. While any natural area is better than concrete at storing rainwater, not all natural areas are the same at storing rainwater. Areas with vegetation are better than dirt because vegetation has bark and leaves that retain water (Fazio 2010). Much of the water intercepted is just slowed in its process of entering a waterway, but some of the water is retained in vegetation or evaporates. Trees intercept more water than a shrubs because of their larger size, larger leaf area, and thicker bark. By helping Seattle retain tree canopy in its natural areas, the Green Seattle Partnership is helping the City have less stormwater runoff (GSP 2006). Additionally, a greater composition of coniferous species will improve stormwater runoff because conifers don't lose their leaves in the winter, a factor in the intercepting potential of a tree (Deguchi *et al.* 2006).
Improve Air and Water Quality	Tree roots absorb water, including the minerals and contaminants associated with the water. While some pollutants are metabolized, others are trapped within the plant tissue—and stopped from entering the waterways (GSP 2006). Trees uptake gaseous pollutants through stomata and some gases are removed by the plant surface (Nowak *et al.* 2006). Trees also intercept airborne particles. Most are retained on the plant surface, but some are absorbed by the tree, offering an ecosystem service in removing airborne particle pollution (Nowak *et al.* 2006).
Reduce Erosion	Forests reduce erosion: the large tree roots stabilize the soil and a tree canopy slows the speed of rain. Slower rain means the rain has less energy, which leads to less soil being displaced by rain drop and eroding away (GSP 2006). Forests usually have plant litter on the forest floor, which acts as another layer of soil-erosion protection from water droplets (Pimentel and Kounang 1998). Less erosion means topsoil remains in the forests and doesn't enter waterways, which keep forests and waterways productive and healthy (Pimentel and Kounang 1998).

Increase Property Value	Being close to a forest matters to people. Evidence is given from the higher price they will pay for a house that is closer to a forest (Tyrvainen and Miettinen 2000; Sander *et al.* 2009). A study of property values in Finland by Tyrvainen and Miettinen (2000) found a 5.9% decrease in property value per kilometer of increased distance away from a forested area. Likewise, in Ramsey County, Minnesota, Sander *et al.* (2009) found increased home sales with close proximity to forests, trails, and parks. Additionally, people pay for a forest view: housing units that looked upon a forested area were 4.9% more expensive on average (Tyrvainen and Miettinen 2000). The City of Seattle estimated that residential properties next to greenbelts increase up to 15% in value—a benefit to property owners and the City because of more tax revenue (GSP 2006). By helping these Greenbelts remain forested, the GSP will maintain or improve property values within close proximity.

Definition of Park and Park-like Terms

It is important to define which greenspaces were assessed in Seattle and the greenspace terms that will be used in this report. We assessed property managed by Seattle's Park and Recreation (SPR). SPR manages only some of the forested greenspace within Seattle. Right of Ways are managed by the Seattle Department of Transportation, while other natural areas and greenbelts are owned by other public agencies or held privately.

Within Seattle's park system, the term "park" can include greenspaces of two types: developed park and natural area. Developed parks are greenspaces that "have formal landscapes and include active recreation for sports" (BMP Manual 2005). Examples of active recreation features in parks are ball-fields, playgrounds, grass fields, and turf fields. Developed parks might also be a formal garden (*e.g.* Kubota Japanese Garden) or a heavily landscaped area (*e.g.* Volunteer Park). Natural areas are "largely undeveloped, often thickly vegetated…and used for passive recreation," like walking and jogging (BMP Manual 2005). In contrast to developed parks, natural areas have minimal human disturbances and provide habitat for urban flora and fauna (BMP Manual 2005). Natural areas can be found within developed parks and specialty gardens, although oftentimes they are isolated (BMP Manual 2005). Throughout this report I will use the term natural area where it needs to be specified, but I will also use "park," and it is important to remember "parks" can have natural areas within them.

Zones, Target Systems, and Target Forest Types

To organize restoration effort, the City of Seattle partitioned its natural areas into management units called "zones." Zones were delineated using geographic, social, or ecological boundaries. Zones range in size from 0.002 acres to 23.7 acres, but most (68%) are between 0.1 and 2.0 acres. Each zone has a data associated with it, including the Target System, a "broad classification of the plant community" that guides the restoration projects (Reference Ecosystems 2016). Within the Target Systems, there are "Target Forest Types (TFTs)," or plant associations that are typically found within that ecological community. TFTs are a more detailed plant composition target for the zone (Table 2). TFTs are named based on their dominant canopy, shrub, and understory species. GSP uses seven Target Systems in Seattle parks and 23 Target Forest Types (see Appendix 1 for the complete list of Target Systems and Target Forest Types). The Target Systems and the Target Forest Type were determined using a combination of information from the 1999 surveys of Seattle (the SUNP), data captured in research plots in intact forests found around Washington State (through the Washington Natural Heritage Program and Chappell 2006), and historical plant surveys from the 1850s in Seattle (see Larson 2005). A zone has a designated TFT to guide planting efforts, but TFTs are flexible and can change as further knowledge of the site improves.

Table 2. The Target Systems and their associated Target Forest Types. The TFTs are named for the dominant species. The target species are listed by their four-letter botanical code. Dashes separate species in the same forest layer. Slashes separate the forest layers: canopy, shrub, understory. The number of acres present in Seattle natural areas is also listed (Reference Ecosystems 2016)

Target System	Target Forest Type
Bog and Fen	PICO/LEGR/SP
Conifer Broadleaf Evergreen Mixed	PSME-ARME/GASH
Conifer Broadleaf Evergreen Mixed	PSME-ARME/HODI/LOHI
Conifer Broadleaf Evergreen Mixed	PSME-ARME/VAOV
Dry-Mesic Conifer and Conifer Deciduous Mixed Forest	PSME/GASH/POMU
Dry-Mesic Conifer and Conifer Deciduous Mixed Forest	PSME-TSHE/GASH/POMU
Dry-Mesic Conifer and Conifer Deciduous Mixed Forest	PSME-TSHE/GASH-MANE
Mesic-Moist Conifer and Conifer Deciduous Mixed	ACMA-ALRU/POMU-TEGR
Mesic-Moist Conifer and Conifer Deciduous Mixed	PSME-TSHE/MANE-POMU
Mesic-Moist Conifer and Conifer Deciduous Mixed	THPL-TSHE/OPHO/POMU
Mesic-Moist Conifer and Conifer Deciduous Mixed	TSHE-PSME/POMU-DREX
Oak Woodland	QUGA-PSME/SYAL/POMU
Riparian Forest and Shrubland	ACMA-PSME/ACCI/POMU

Riparian Forest and Shrubland	ACMA-PSME/COCO/HYTE
Riparian Forest and Shrubland	ACMA-THPL/OECE
Riparian Forest and Shrubland	ALRU/RUSP/CAOB-LYAM
Riparian Forest and Shrubland	FRLA-POBA/RUSP
Riparian Forest and Shrubland	POBA/COSE
Riparian Forest and Shrubland	POBA/SYAL
Riparian Forest and Shrubland	POBA-ALRU/RUSP
Riparian Forest and Shrubland	TSHE-THPL-ACMA/ACCI/LYAM
Scrub Shrub Wetland	SA/SPDO-COSE-LOIN
Scrub Shrub Wetland	SASI/SPDO

The Restoration Phases and Tracking Activity

The Green Seattle Partnership uses a four-phase approach to track and guide restoration effort. Zones may have multiple restoration sites, each with a designated phase. Areas of zones undergoing restoration often move through the phases sequentially, although they can regress to previous phases if planting projects fail or exotic species invade. A zone may have multiple sites within it in different phases of restoration (GSP 2014).

Table 3. The phases of restoration in the GSP. This list was taken from the GSP 2014 Inventory Protocols (GSP 2014).

Phase 1: Initial invasive plant removal
Removing invasives through use of hand-pulling, coffee bags, mulch, compost piles, tree rings, herbicide, and tree-spike injections, or a previously planted site that had high plant mortality, but limited re-invasion.
Phase 2: Planting
Trees, shrubs, and forbs planted. May require spot weeding and/or planting.
Phase 3: Establishment weeding and watering (select if current ecological conditions are already present)
Restoration sites are weeded, mulched, and watered, as needed. Planting of native species occurs to fill gaps and replace unsuccessful plantings. Lasts 1-3 years to ensure proper establishment.
Phase 4: Long-term maintenance and monitoring (entire zone)
Long-term site stewardship for entire zone. Periodic monitoring to ensure desired restoration trajectory.

The phase of restoration is reported as part of the GSP CEDAR work log system (see GSP 2015) submitted by volunteer Forest Stewards, contracted professional crews, and SPR crews. Phase 4 is reached when a zone reaches long-term maintenance and monitoring. The goal is for zones to reach Phase 4 and stay in Phase 4. It's important to emphasize that Phase 4 does not mean human management is over. Because of the urban matrix, humans will need to maintain the Phase 4 zones within Seattle. However, in comparison to the previous three phases, Phase 4 should be less resource intensive.

Inventory

In addition to work log data, Seattle Parks and Recreation implements an inventory of active restoration sites to measure and track how zones are changing. The process involves walking through a zone during leaf-on season from May through October (GSP 2014). Surveyors also stop once per zone-acre to complete a regeneration plot, a 4.87 m (16 ft) radius circular plot in which all the trees are counted (GSP 2014). Inventory surveys examine regeneration, species richness, invasive species cover, canopy cover, amount of bare-ground, woody-debris, soil type, litter depth, and the number of homeless camps (Figure 15).

The inventory data assess many metrics that can be used to determine restoration success. In a study examining restoration trajectory in bottomland forests in the south-eastern United States, Berkowitz (2013) found that the variables that yielded the highest correlation to positive restoration trajectories were shrub-sapling density and ground vegetative cover, two metrics that were tracked in Seattle restoration projects through the inventory surveys.

Tree-iage

The Tree-iage model was developed as a way to rank the value of Seattle's forested parklands which helped define the scale of the problem in Seattle's natural areas and helped prioritize GSP restoration efforts. The first version of the Tree-iage model was a 3 x 3 matrix that assigned each GSP zone to one of three canopy composition values and one of three invasive threat levels. An updated version of Tree-iage, Tree-iage 3.0, was created to better represent tree regeneration by incorporating Inventory data (Figure 2). Tree-iage 3.0 includes the same invasive threat levels (<5%, 5-50%, >50%), but has different composition-value buckets, which were more focused towards future canopy than the original Tree-iage.

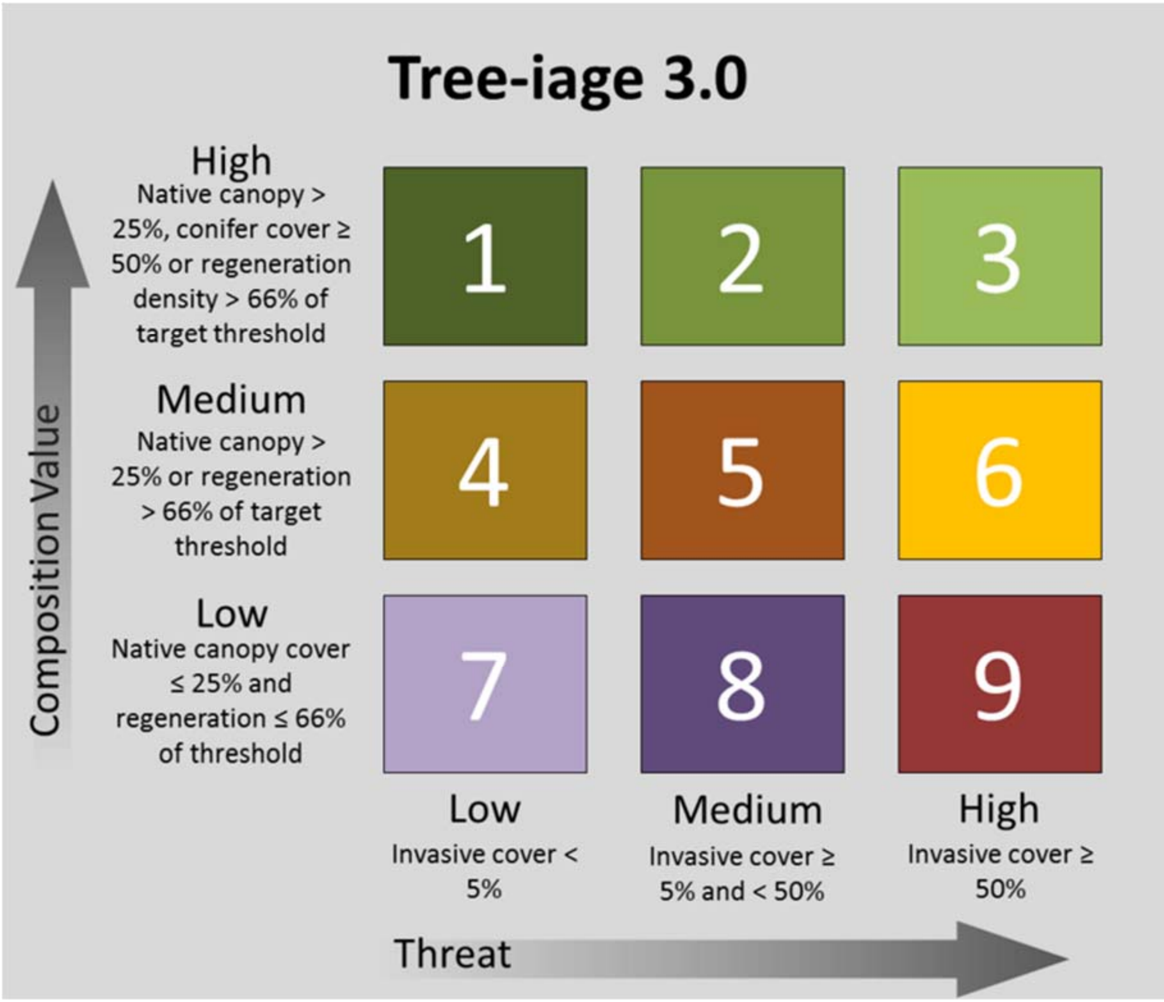


Figure 2. The Tree-iage 3.0 forest rating system. The tree-iage 3.0 is an updated version of the original. From Yadrick 2015a.

The Mid-Point at 2015: Ten Years of Restoration under the GSP

In 2015, the GSP was half-way through its twenty-year plan to restore Seattle's forests. There were 1,232 acres in some phase of restoration, almost exactly half of the total goal (Yadrick 2015b). The effort through ten years was enormous: 619,000 plants were planted and volunteers had contributed 781,000 hours (Yadrick 2015b). But no zones had moved officially into Phase 4: Long-term stewardship and maintenance. Phase 4 classification is important for ecological considerations, but it is also important for budgeting and funding. When a zone enters

Phase 4, it switches from a capital project to maintenance project. These are different money pools within the City of Seattle.

METHODS

From March through August 2015, I worked with three employees from the City of Seattle to develop the Phase 4 Verification. The process began by choosing candidates using the Inventory data. This was followed by a field visit to verify the Inventory data and to examine qualitative characteristics. A zone either passed, and became a Phase 4 zone, or failed and entered the list of candidates for future years (Figure 3).

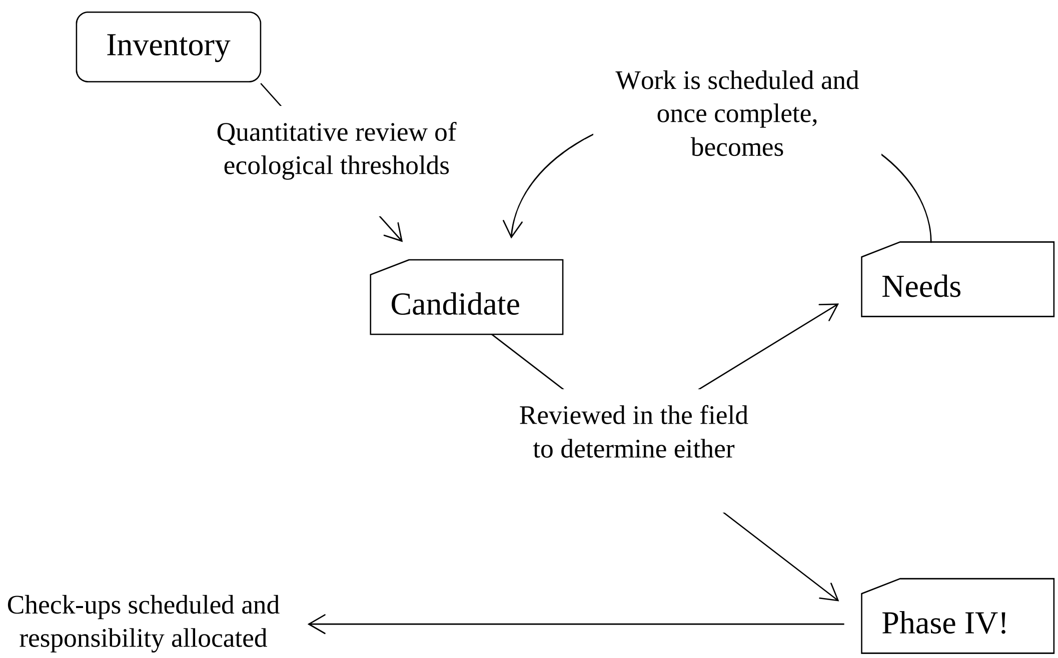


Figure 3. The flowchart for Phase 4 assessments. Credit: Oliver Bazinet from Seattle Parks and Recreation.

Phase 4 Candidacy

The first step of the Phase 4 process was selecting candidates. Candidates were selected from querying the most recent Inventory data for all of the 1,547 zones in Seattle. Zones that “passed” in six of the seven inventory categories listed below were considered candidates.

1) Native tree regeneration density (stems per acre)
2) Native tree regeneration richness (# species)
3) Native understory richness (# species)
4) Native understory cover (percent)
5) Invasive cover (percent)
6) Woody-invasive density (stems per acre)
7) Canopy composition: Tree-iage 3.0 score of 1, 2, or 3.

Passing meant the zone reached the threshold for the category. Thresholds were two-thirds of the target amount listed in the Target System for categories 1 through 4. For example, the understory richness target for Conifer-Broadleaf-Evergreen-Mixed Forest is ten species. To pass in this category, a zone must reach the threshold, which is seven species (two-thirds of ten equals 6.6 and we rounded up). Unlike the four native-species metrics, Categories 5 and 6 (invasive cover and the woody-invasive density) were the same for all Target Systems: 5% and 10 stems per acre (SPA) respectively. Category 7, the canopy composition, was also the same for all zones. The Target Systems are listed in Table 4.

We used two-thirds as our threshold for passing because GSP Plant Ecologists thought it was a number that appropriately took into account the fact that sites were still progressing towards their desired states, but haven’t necessarily achieved them yet. The goal in many restoration projects, including the GSP’s projects assessed in this report, is for sites to be progressing to an ecological system similar to the reference site. Box (a) in, a figure from Matthews and Spyreas (2010), diagrams this idea. Matthews and Spyreas (2010) simplified trajectories into four possibilities and urged practitioners to be aware of these possibilities.

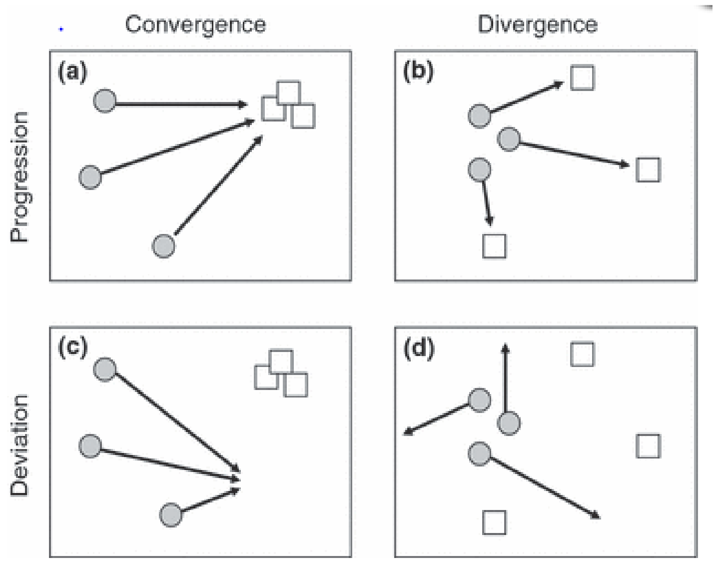


Figure 1. Given a set of restoration sites (grey circles) and reference targets (squares), four patterns are possible for temporal trajectories (arrows) in species composition: (a) convergence in species composition among restorations and progression towards the target composition, (b) divergence among restorations and progression towards a spectrum of potential targets, (c) convergence among restorations but deviation away from the intended reference targets, (d) divergence among restorations and deviation from intended targets.

Figure 4. Restoration trajectory diagram from Matthews and Spyreas (2010). This figure showed possible trajectories for wetland restoration.

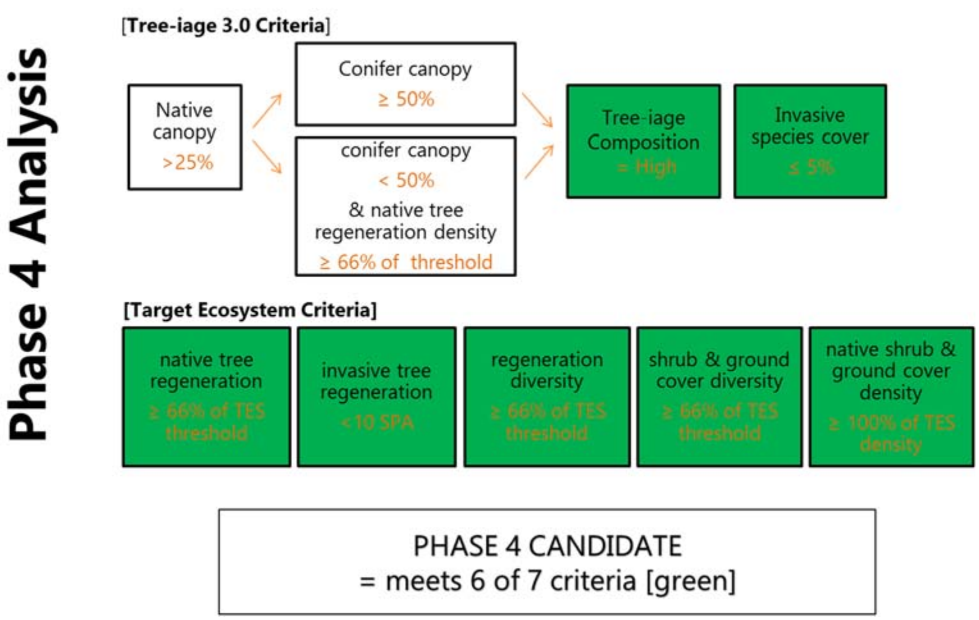


Figure 5. The Phase 4 candidate selection chart. Credit: Lisa Ciecko, Seattle Parks and Recreation.

Table 4. The Target Systems and their targets. Credit: City of Seattle Parks and Recreation.

Target System Name	Native tree regeneration density (stems per acre)	Native Tree Regeneration Richness (# species)	Understory Richness (# Species)	Native Understory Cover (percent)	Invasive Regeneration Maximum (stems per acre)
Conifer Broadleaf Evergreen Mixed Forest	125	3	10	110%	10
Dry-Mesic Conifer and Conifer Deciduous Forest	125	3	10	70%	10
Mesic-Moist Conifer and Conifer Deciduous Mixed Forest	200	4	14	50%	10
Oak Woodland	50	3	12	60%	10
Riparian Forest and Shrubland	125	2	14	150%	10
Scrub Shrub Wetland	25	2	11	120%	10
Bog & Fen	50	2	13	125%	10

Field Procedure

Phase 4 Verification field visits were completed from May 2015 through September 2015. We assessed 98 zones across 30 Seattle parks and natural Areas (Figure 6). Most of the field visits were attended by at least two Plant Ecologists from Seattle Parks as well as the Strategic Advisor and myself. After entering the zone, we would review the latest Inventory Assessment (Appendix 3, Figure 14) and the Activity Report (Appendix 3, Figure 14) to understand the amount of work accomplished, who lead the work, and how the site had been assessed previously. The second step was to walk and review site characteristics until we saw roughly 85% of the zone. Zone assessments usually took between ten and forty-five minutes, depending on the size of the zone. In larger zones, we found it helpful to separate into pairs or singles. We found separating improved our efficiency and also allowed us to interpret the landscape without each other's bias. After walking the zone, we would re-group and begin step three: completing the data sheet questions (Table 5). Because this was the first attempt at defining the Phase 4 Verification process, the datasheet was upgraded and modified throughout the field season. Table 5 is the latest version. As part of the third step, we discussed each question before reaching a consensus. We used an Android-based tablet to record data for the majority of the sites running Open Data Kit, an open-source software that worked offline. We started with paper data sheets, but we found the tablet to be more efficient, accurate, and legible.

Table 5. Data sheet questions used for Phase 4 assessment. A comma between answers means the ability to select more than one. A semi-colon or the word "or" means selection of only one of the answers was permitted.

	#	***Question***	***Possible Answers***
Inventory check	1	Does it meet tree regeneration density (SPA) threshold?	Yes or No
	2	Does it meet tree regeneration diversity?	Yes or No
	3	Does it meet understory cover?	Yes or No
	4	Does it meet understory richness?	Yes or No
	5	Does it have < 5% invasive cover?	Yes or No
	6	Does it have < 10 SPA woody invasive density?	Yes or No
	7	Is canopy composition High?	Yes or No
Ecological Characteristics	8	What is the weakest ecological characteristic?	Herbaceous invasive, woody invasive, low canopy cover, low future canopy cover, non-native canopy cover, aggressive natives, lacks ground cover, lacks shrubs, slope stability, social trails, encampments, other
	9	What is the 2nd weakest ecological characteristic?	*Same selection as question above*

	#	***Question***	***Possible Answers***
	10	Notes on weaknesses? Explain "Other"	*Write-in response*
	11	Is the site Phase 4?	Yes or No
	12	Confidence of above selection for Phase 4?	1; 2; 3
Work Prescriptions	13	Does the site need work?	Yes or No
	14	What work would you prescribe?	Remove woody invasive, remove herbaceous, social trail removal, plant trees, plant understory, erosion control, other
	15	What is the scope of the work?	Clump, sweep, large scale, spotty
	16	Is there Class A weed removal needed?	Yes or No
	17	Where does work need to be done?	N, NW, E, SE, S, SW, W, NW, center, all over
	18	Draw or take photo of work?	*Creates an image for the file*
	19	Who is work appropriate for?	Volunteer, professional
	20	What is priority for doing work at this site, compared to other sites?	1; 2; 3
Priority and Additional	21	Do any of these conditions exist?	Class A weed present, living woody invasive present, lack of regenerating conifers (desirable regen density failed), herbaceous, shade-tolerant invasives present
	22	Is there a Forest Steward?	Yes or No
	23	Additional Notes	*Write-in response*

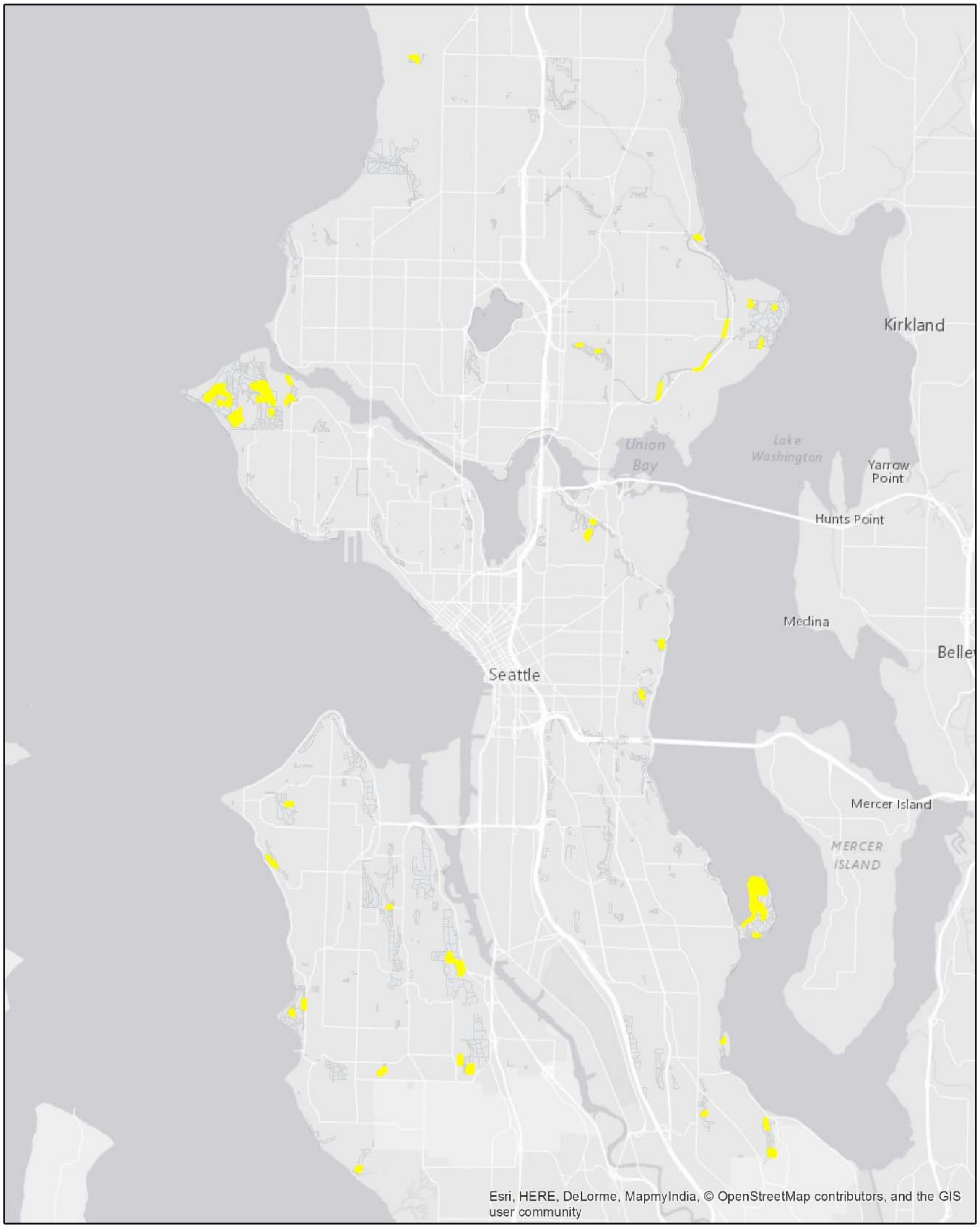


Figure 6. Map of the 79 zones that are analyzed in this report.

Explanations of the Verification Questions

Inventory Check

We used the information from the inventory check as a guideline when reaching consensus that the zone was Phase 4. Since our Phase 4 decision was subjective, zones could pass regardless of how many of the seven inventory-check criteria they passed. The word “meet” in the questions reflects passing the Target System category thresholds.

To count towards canopy composition, trees needed to be > 12.7 cm diameter (5 inch) at breast height. Trees smaller than 12.7 cm counted towards regeneration. For canopy composition, we included native trees and tolerated non-native species that are not considered invasive (*e.g*. California redwood *Sequoia sempervirens*). Invasive woody species that did not count are listed in Appendix 4. Including tolerable, non-natives is consistent with previous data collection methods of the GSP. Invasive trees counted towards invasive cover. Dead invasive trees did not count towards any metrics.

Ecological Characteristics

Social trails are un-official trails in natural areas. They typically stem-off of official trails, which are signed and maintained by Seattle Parks and Recreation. “Aggressive natives” are native plants that can outcompete other species and form a monoculture in places. This can deter natural tree regeneration and native plant diversity. An example of an aggressive native is *Rubus spectabilis* along certain drainages in Carkeek Park.

The confidence factor accounted for disagreement in deciding if the site was Phase 4. If it was clear consensus, then a score of “1” would be selected. If there was much discussion but ultimately the consensus swayed into Phase 4, then a score of “3” would be selected. A “2” was in-between these scenarios.

Work Prescriptions

Multiple work prescriptions could be entered. Following the completion of a work prescription, a new work prescription could be started. Examples of volunteer-appropriate are weeding, mulching, and planting in flat areas. Professional work would include herbicide application of woody-invasive species or work on steep slopes.

The work priority question attempted to capture whether the site would regress if nothing was done. It was based on how the site compared to other sites, the health of the forest, and the capacity of the Forest Stewards. It asked: How quickly should a crew/volunteer party get in here to do work? If the zone had a low invasive threat (*i.e.* small edge effects, few invasives currently present) and a good forest steward (well maintained, continuous volunteer events) it would be a low priority for revisiting, or a "3." If the site had a high invasive threat, and no forest steward, then that would be a "1" for priority.

Analysis Methods

Analysis was done to test if the zones that passed Phase 4 were significantly different than the zones that didn't pass in their number of passing inventory-check categories. I used Welch's two-sample t-test because the populations had different sample sizes. A p-value <0.05 would be considered significant.

I used a scatter plot with fitted regression line to test if the amount of passing inventory-checks correlated with Phase 4 status. This analysis was done in Microsoft Excel.

I used a logistic linear regression with multiple predictor variables to test which inventory data were most related to the binary criterion of a zone being Phase 4. The predictor variables were from the latest Inventory. I used Inventory data because more of these data were continuous, and all had a greater range than the inventory-check data. Invasive regeneration, understory cover, and regeneration density were the continuous data sets. Regeneration richness and understory richness were discrete data. Invasive threat and canopy composition were ordinal (1 - 3), based on the Tree-iage 3.0 buckets. A "3" for threat meant "low-threat" and a "3" for canopy meant "high" canopy. The logistic linear regression was done in R.

RESULTS

Candidacy

There were 109 candidates out of the 1547 zones in Seattle. Out of the seven inventory categories, fourteen zones met all the thresholds (13%) while 95 (87%) zones had one failure (Table 6).

Table 6. The number of candidates with zero fails vs. one fail. There were 109 total candidates.

Condition	# zones	%
Number of zones with 0 fails	14	13%
Number of zones with 1 fail	95	87%

If the zones failed in one category, the most common failures were in invasive species categories (63.6%) (Table 7). Thirty-seven failed (33.9%) in invasive species cover and 32 (29.4%) failed in invasive tree density. The categories with the least number of failures were native tree regeneration density (2 failures) and diversity (1 fail).

Table 7. The number of zones that failed by each category. Total was 110 zones that only failed one or zero categories.

Criteria	# Failed	Percent
Native tree regen. density	2	1.8%
Native tree regen. diversity	1	0.9%
Native understory cover	12	11.0%
Native understory richness	3	2.8%
Invasive species cover < 5%	37	33.9%
Invasive tree < 10 SPA	32	29.4%
Tree-iage 3.0 composition	8	7.3%

Phase 4 Assessments

Although we assessed 98 zones in thirty parks, data from 19 zones weren't transferred in time to be used in this report. See Appendix 3 for the list of these 79 zones (27 parks) and some of their assessment data.

Inventory Check

Almost all zones passed in tree regeneration diversity (97.4%) and understory richness (98.7%) (Table 8). The number of passing zones decreased for native tree regeneration density (67.9%) and invasive species cover (66.7%). Even fewer zones (52.6%) passed the invasive tree criteria of <10 SPA. The criteria that passed in the fewest zones was the canopy composition: only 28.2% of zones passed.

Table 8. Number of zones that met 2/3 of the following criteria for their Target Forest Type. Total zones was 79.

Inventory-check category	Yes	% Yes	No	% No
Native tree regen. density	53	67.9%	26	32.1%
Native tree regen. diversity	76	97.4%	3	2.6%
Native understory cover	65	83.3%	14	16.7%
Native understory richness	77	98.7%	2	1.3%
Invasive species cover < 5%	52	66.7%	27	33.3%
Invasive tree < 10 SPA	41	52.6%	38	47.4%
Tree-iage 3.0 canopy composition	22	28.2%	57	71.8%

Six zones passed all seven inventory-check categories (Table 9). All of these zones were considered Phase 4. Twenty-five zones passed six inventory categories and these were considered Phase 4. Fewer zones (23) passed in five categories, and only 70% of these moved into Phase 4. Thirteen zones passed in four categories and two (15%) were decided to be Phase 4. Seven zones passed in three categories, and one passed into Phase 4. Three zones passed two inventory categories and one zone passed no inventory categories. See Appendix 1 for a full table of results for each zone.

Table 9. Breakdown of how many zones passed multiple categories and whether those zones moved into Phase 4.

# of categories Passed	# zones	# zones also pass Phase 4	% pass Phase 4
Passed 7/7	6	6	100%
Passed 6/7	25	25	100%
Passed 5/7	23	16	70%
Passed 4/7	13	2	15%
Passed 3/7	7	1	14%
Passed 2/7	3	0	0%
Passed 1/7	0	0	NA
Passed 0/7	1	0	0%

Weakest Ecological Characteristics

The results for the weakest ecological characteristics were widely spread among the selections. Herbaceous invasive, woody invasive, and low future canopy cover were the most often reported weakest ecological characteristics (Table 10). The most common “other” category was edge effects, which was reported 12 times (Table 11). The rest of the “other” characteristics were erosion, root rot, soil rot, powerlines, and site lines.

Table 10. Results from Question 8 and 9: “what are the weakest and 2nd weakest ecological characteristics?”

Ecological Characteristic	weakest	2nd weakest	total
invasive spp. susceptibility	6	0	6
herbaceous invasive	12	17	29
woody invasive	18	13	31
low future canopy cover	14	6	20
canopy cover	2	3	5
non-native canopy	0	1	1
aggressive natives	0	2	2
lacks ground cover	5	4	9
lacks shrubs	6	2	8
slope stability	0	3	3
social trails	9	5	14
encampment	0	1	1
noxious weeds	1	0	1
other	6	18	24
SUM	**79**	**75**	**154**

Table 11. A breakdown of the “other” selection in Question 8 and 9: “what are the weakest and 2nd weakest ecological characteristics?”

"Other" explanations	Weakest	2nd weakest
edge effects	5	7
erosion	0	1
thinning	0	4
mountain beaver	0	2
root rot	0	1
soil rot	0	1
powerline	0	1
site lines	0	1
not specified	1	0
SUM	**6**	**18**

Did it Pass Phase 4?

In total, 50 of 79 (63.3%) zones were moved into Phase 4 (Table 12). We felt confident about this selection in about half of the zones. In only eight zones did we not feel confident and gave a "3" rating. On average, zones that weren't considered Phase 4 yet received a "1" confidence passed less Inventory-checks (Table 13). Zones that were considered Phase 4 and received a "1" confidence, passed more Inventory-checks on average.

Table 12. Results from "Is it Phase 4?" The number of zones that were moved into Phase 4 and the amount of zones receiving each Phase 4 confidence rating.

Phase 4				
	yes	no	sum	
# zones in Phase 4	50 (63.3%)	29 (36.7%)	79	
	1	2	3	sum
Confidence (# zones)	42 (53.8%)	28 (35.9%)	8 (10.3%)	78

Table 13. Confidence rating and the average # of passing inventory checks. "Confi" stands for confidence that the zone is or isn't considered Phase 4. "Avg. pass" is the average number of passing inventory checks. If a zone passed all inventory checks then it would have a score of 7. The zones # of passes were averaged depending on their confidence score and whether they passed Phase 4.

Confidence and avg. no. passing Inventory Checks					
Not Phase 4			Phase 4		
confi	avg. pass	n	confi	avg. pss	n
3	4.00	3	3	5.40	5
2	4.50	8	2	5.40	20
1	3.29	17	1	5.91	24

As a whole, zones that were considered Phase 4 passed more inventory-check categories than zones that were not considered Phase 4 (Welch's t-test, p = <0.001) (**Error! Reference ource not found.**). A boxplot helps shows this relationship (Figure 8). Zones that passed more inventory-check categories were also more likely to pass Phase 4 based on the fit of the regression line (R^2 = 0.886, Figure 7).

Table 14. Results from Welch Two Sample t-test for the number of passing inventory-checks and Phase 4 status.

t	df	p-value	Mean Phase 4	Mean Not Phase 4
-8.258	44.701	1.59 e^{-10}	5.66	3.71

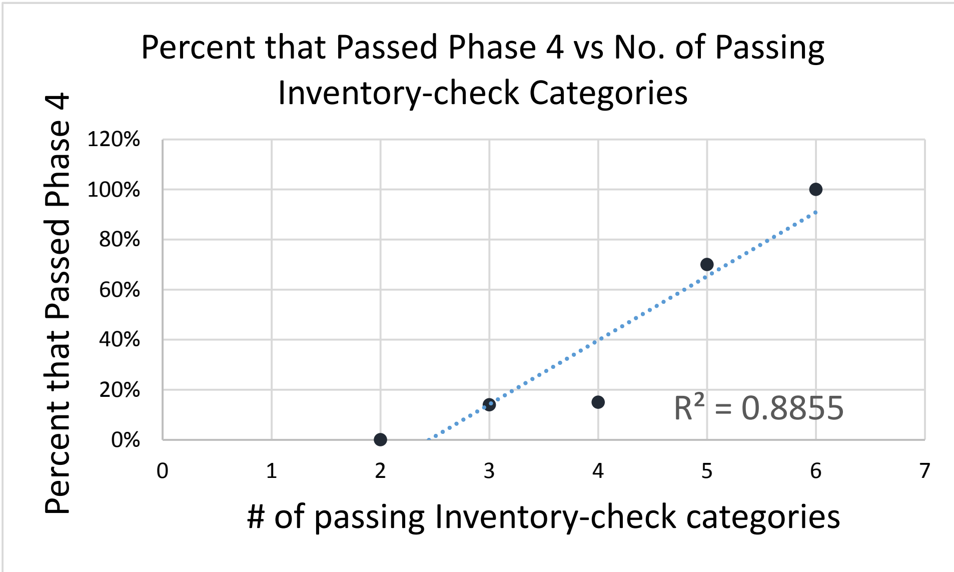


Figure 7. Scatter plot with regression line of the percent that passed Phase 4 vs number of passing inventory-check categories. Zones that passed zero inventory-check categories and seven inventory-check categories were eliminated for redundancy.

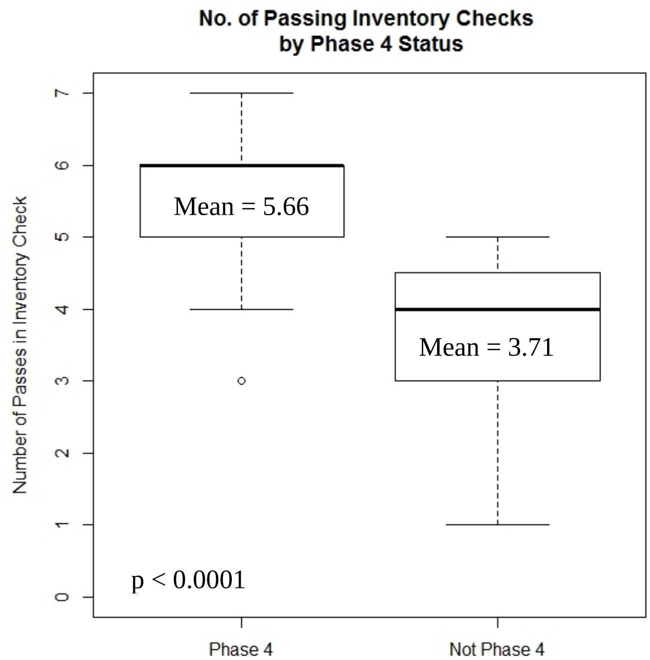


Figure 8. Boxplot of the number of passing inventory checks by Phase 4 status. The p-value is from a non-parametric t-test between the two selections. The bold line in the box plot represent median values. The top and bottom of the box are quartiles. The mean values were written-in, and are not indicated.

Work Prescriptions

Seventy-three zones (92.4%) received a work prescription (Table 15). The priority for the work prescriptions were usually rated a "2" (28 zones) or a "3" (27 zones).

Table 15 . The number of zones that "need work" and the priority results from the 79 zones.

Work Prescriptions					
	yes	**no**	**sum**		
Needs work?	73	6	79		
	1	**2**	**3**	**none selected**	**sum**
Priority for work	16	28	27	8	79

Special Conditions

Forty-two zones had woody invasive presence. Twenty-seven zones had herbaceous shade-tolerant invasives, and 21 zones lacked conifer regeneration. Only two zones had a Class A weed.

Table 16. The number of zones with each special condition.

Special Conditions	# Zones
Woody invasive presence	42
Herbaceous shade-tolerant invasive present	27
Lacks conifer regeneration	21
Class A weed present	2

Forest Steward

Fifty-one zones had a Forest Steward and twenty-seven zones did not have a Forest Steward.

Table 17. Number of zones with a Forest Steward.

Forest Steward?	
yes	no
57	21

Regression Analysis of Phase 4 Status and Inventory Data

After controlling for the all predictor variables, the logistic regression showed invasive cover and understory cover to be significantly related to Phase 4 status (Table 18). Conditional density plots more clearly show the relationship found between these variables and the criterion (Figure 9). According to the model, for every one unit increase in invasive cover (*e.g* moving from a "1" (>50% cover) to a "2" (5-50% cover), the odds of the zone passing Phase 4 increase by 3.2.

Table 18. Coefficients from the logistic regression. The covariate variable was Phase 4 status (binary) and the independent variables were the seven inventory categories from the latest Inventory. * = 0.05 significance. "Exp" stands for exponential, differing the estimate coefficient from the logged values.

Predictors	Estimate (log)	Estimate (exp)	Std. Error	z value	Pr(>|z|)
(Intercept)	-8.3077	0.0002	4.156	-1.999	0.046
canopy (1-3)	1.0014	2.7220	1.059	0.945	0.345
inv_cov (1-3)	1.1640	3.2026	0.477	2.439	0.0147*
inv_regen (SPA)	0.0020	1.0020	0.013	0.152	0.879
regen_dens (SPA)	0.0002	1.0002	0.001	0.177	0.859
regen_rich (# species)	0.1997	1.2211	0.167	1.198	0.231
und_rich (# species)	0.0009	1.0009	0.049	0.019	0.985
und_cover (%)	0.0179	1.0181	0.007	2.513	0.0120*

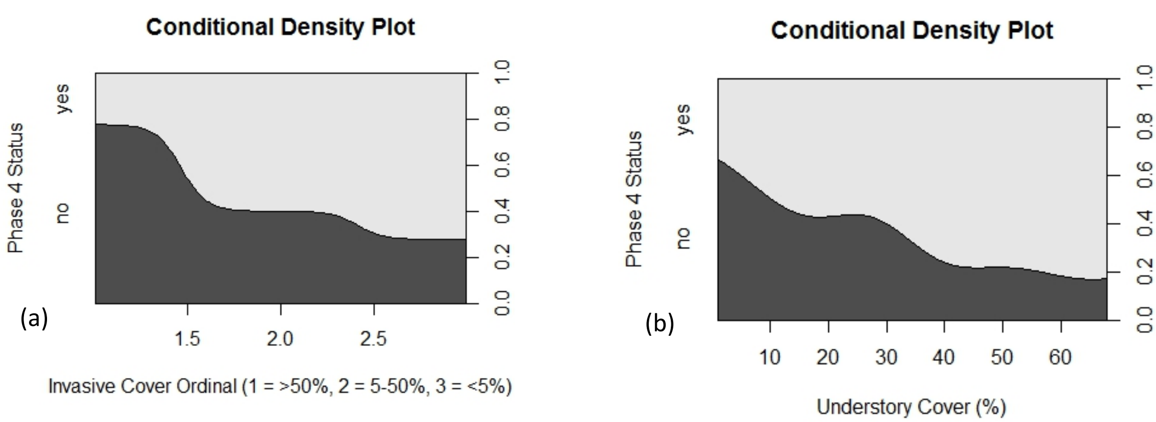


Figure 9. The conditional density plots for (a) invasive cover and (b) understory cover (%). The criterion variable was Phase 4 status either "yes" or "no". The invasive cover was ordinal with 1 = >50% invasive cover, 2 = 5-50% invasive cover, and 3 = < 5% invasive cover. The understory cover was continuous.

DISCUSSION OF RESULTS

Inventory Check

Purpose of question

The Inventory check was included for two reasons: firstly, to focus our attention to these important metrics for forest health; and secondly, to verify the values given by the last inventory assessment. We wanted to verify that the values were neither a data error (*i.e.* had been entered or recorded incorrectly) nor had changed significantly since the last assessment. In some instances, the last Inventory Assessment was performed five years prior to the Phase 4 Verification.

Discussion

Many of the results from the inventory-checks were similar to those from the inventory assessments. The results from invasive species cover were the closest: 33.9% of the candidates failed in the Inventory Assessment and 33.3% failed the inventory check (Figure 10).

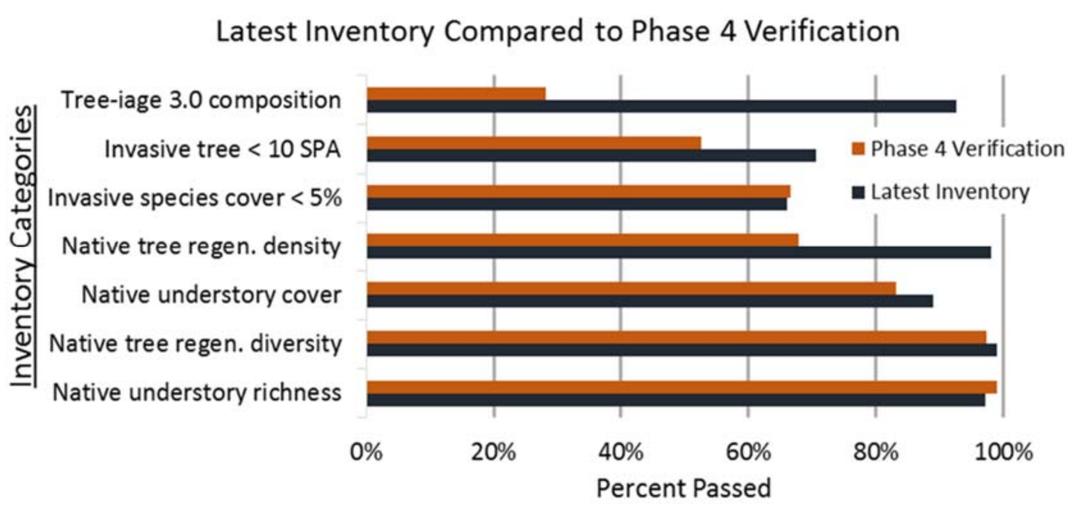


Figure 10. Comparison Inventory data and the Inventory-check data through their passing percentage for each category.

Native tree regeneration density and native understory richness were also close: both were within two percentage points. The likelihood of failure for the invasive tree category was greater for the Phase 4 Verification than the Inventory (47.4% compared to 29.4%). This could be because the Inventory monitoring were completed closer to a restoration event in which invasive species were removed or treated. It's possible that invasive species which can resprout from an herbicide-treated trunk, like English Holly *Ilex aquifolium* and Cherry Laurel *Prunus laurocerasus,* hadn't been counted in an inventory assessment but resprouted and then were counted in the Phase 4 assessment. It could also be a sign that the Phase 4 assessment over-estimated the density of invasive trees or that the inventory assessments underestimated this category. Another possibility is that, compared to the inventory assessments, which walk from one corner of a zone to another, the Phase 4 assessments cover more of the zone. This is especially a possibility in larger zones of >4 acres, when more areas are missed by walking corner to corner in the Inventory. Because of the increased coverage in some zones in the Phase 4 Verification, it's possible that the Phase 4 team saw patches of invasion that the inventory team missed. Even an isolated patch of five invasive trees could be the difference of a zone passing or failing since the threshold is ten stems per acre.

There were two categories that had a large difference between the two assessments: the native tree density and the canopy composition. The native tree density failed on 1.8% of the inventory assessments and failed on 32.1% of the Phase 4 assessments—this equates to 17 times more failures in Phase 4 assessments. The canopy composition value failed in 7.3% of the candidates, but the Phase 4 assessment had 71.8% of the zones fail. This difference in the canopy composition was likely because of some confusion with this category, especially initially, during the Phase 4 assessment.

For future years, a less subjective measure for measuring native tree regeneration might be helpful. The inventory check likely missed some regeneration because 1) small trees are sometimes hidden by vegetation or natural features and easy to miss when walking through a zone, and 2) I found extrapolating observed regeneration to the whole zone to be a difficult estimation. Instead of the inventory check, a more objective process for regeneration could be used. The idea was proposed by Rich Hallet, a research ecologist with the USDA Forest Service in New Hampshire, who accompanied us during three Phase 4 Verifications. I built upon his idea (Figure 11).

The native tree regeneration matrix (or one similar) could be used to assess the regeneration of zones. The matrix has four aspects that correlate with aspects of desired native regeneration: living regeneration, an appropriate level of tree plantings, natural regeneration, and conifer downed wood. Conifer downed-wood is important because it becomes nursery logs, especially important for western hemlock *Tsuga heterophylla* (Franklin and Dyrness 1973), which is the desired climax-species in Mesic-Moist Conifer and Conifer Deciduous Mixed Target Forest Types. To pass the native regeneration check, a zone would need to meet two of the four questions in the matrix. The score from the matrix could also be used for the quantitative Phase 4 question or for other calculations in the assessment process.

Plantable space is planted	Conifer downed wood
Natural regeneration	Living regeneration (planted or unplanted)

Figure 11. The native tree regeneration matrix. This matrix is proposed to replace the inventory check category for Phase 4 Verification. A zone would need at least two of the four characteristics to pass.

Ecological Characteristics

Purpose of question

We asked ourselves the worst and 2nd worst ecological characteristics to help us rank the issues with a site. Some characteristics can't be changed, like edge effects, but others can be changed, like low future canopy. The question added perspective to zones, helped form work prescriptions, and helped us ultimately decide whether the zone was Phase 4.

The main reason for the confidence factor was because we thought this information could be useful depending on how we decided to schedule re-evaluations. If a Phase 4 zone had a high-confidence, a "1", then a re-evaluation could wait longer than zones with a low confidence, because a high-confidence meant a zone was on a better trajectory and therefore less likely to regress.

Discussion

If “weakest” and “2nd weakest” are combined, then woody invasive and herbaceous invasive were the most common weakest characteristics. According to this sample—which one could argue is a representative sample of the “best” natural areas, with best meaning closest to pre-industrial ecological states—Seattle’s largest issue in their best natural areas in 2015 was invasive species. The next largest issues were low future canopy cover followed by social trails. A lack of plantings (lacks ground cover and/or lacks shrubs) was next, followed by edge effects.

Some characteristics were related and had cross-over with other characteristics. We added new selections part-way through the season without removing the past selections, like with canopy cover. For future assessments, “canopy cover” could be removed, since it is less specific than the other two: “low future canopy cover” and “non-native canopy.” Noxious weeds would benefit from being more specific since many invasives in Seattle’s natural areas are on the Class C noxious weed list *e.g.* Himalayan blackberry *Rubus discolor* and English ivy *Hedera* spp. A better selection is: “Class A or Class B weed presence.” A “Class C noxious weed” selection would be unnecessary since it overlaps with the herbaceous invasive and woody invasive.

The confidence factors correlated to the inventory-check data for the “1” ratings but not for the others. For the non-Phase 4 zones, the “1” confidence rated zones had an average number of inventory-check passes that was lower than the “2” and “3” rated zones. Likewise, the “1” rated zones that we considered Phase 4 had the highest average score. However, the “2” and “3” ratings for zones considered Phase 4 were the same. This shows that how we felt about a zone qualifying or not qualifying for Phase 4 correlated with the inventory-check data for the zones we felt strongest about. Our strong feelings of confidence (“1” ratings) for zones correlated with the subjective inventory-checks and that is reassurance that our opinions matched with objective data collection.

Our considerations for whether zones were Phase 4 also differed in their number of passing inventory-checks. We used the inventory checks as guidance, but we didn’t make our decisions solely on the inventory-checks. In part because the inventory checks were dichotomous data, and didn’t take into account factors like just barely passing or failing a category. In general, the Welch's t-test showed that the zones we considered Phase 4 were different than zones we didn't consider Phase 4, according to their objective, inventory-check categories.

Work Prescriptions

Purpose of question

The idea behind the work prescription was for them to go directly into the work plan for the next year. It was efficient to prescribe work as we were evaluating the zones.

Discussion

The "scope of work" question would benefit from modification for next season. We felt that the answer selection "clump," "spotty," and "sweep" were too similar. The selection also confounded effort with location: sweep gave an impression of quickness, while spotty gave an impression of concentrated effort. The difference between "sweep" and "large scale" we also found hard to distinguish. A more specific answer selection would be: "throughout," "in < 5 locations," and "single area."

Another possible question to aid in work prescriptions would be an estimation of the resources need to complete the work. A field for estimating human hours (or crew days) and materials required to perform the work could be helpful for writing work plans later. We often wrote these details in the notes, but if given their own field, the information would be more usable.

The Class A Weed removal question was included to have an easily searchable data-field for zones that have Class A weeds, which would make the zone a high priority for work and continued monitoring. Only two work prescriptions had a "yes" for Class A weed, but we felt the question was important enough to still include in every work prescription.

Priority and Additional

The question, "Do these conditions exist?" was included as a potential influencer into a quantitative-based decision for the Phase 4 decision. We didn't end up formulating a quantitative-based decision for 2015. This list could be improved if stakeholders wanted to use these measures as influencers into a quantitative-based Phase 4 decision.

The "Is there a Forest Steward?" question was created in part to help decide when to return to the site for re-evaluation. Eventually, sites would need to be re-evaluated that 1) had passed their last Phase 4 assessment; and 2) had not passed their last Phase 4 assessment. We thought that the presence of a Forest Steward, and their correlation with zone restoration activity, would influence this decision of re-evaluation. The re-evaluation system is still being developed, and forest steward presence could be included in this process.

FURTHER DISCUSSIONS

Adding an Objective Answer to the Phase 4 Question

The driver of the Phase 4 assessment was to decide whether sites qualified as Phase 4, and in 2015 this was a subjective decision. This seemed appropriate because the reason for the field assessment was for plant ecologists to examine the zone and give an opinion on it. If we didn't want to include the plant ecologists' opinion, then zones could be passed solely on data from Inventory Assessments. Additionally, the decision for the selection of phases 0-3 are subjective as well. Therefore, it was fitting that the Phase 4 decision was subjective. In future years, the subjective question should remain, but an objective decision could be added.

The objective decision would be a data-driven decision based on the answers to other questions during the assessment. I suggest a decision process that is formulated from the answers to the inventory-check questions. The inventory-check questions are quantitative and therefore are appropriate to incorporate into the objective decision.

To formulate an objective decision tree, I based the criteria on an examination into the inventory-check data from the 2015 assessments. For the zones that passed 7/7 and 6/7 inventory-check categories, they all were considered Phase 4. Therefore, any zone that passes at least 6/7 should be moved into Phase 4 objectively. Seven zones (30%) that passed 5/7 categories didn't move into Phase 4, and I examined this more closely (Table 19). Zones that passed four or less inventory criteria and passed Phase 4 were unusual, and therefore all zones that passed four or less inventory categories were removed from the objective decision tree. After examining the zones that passed 5/7 categories, four of the seven had special circumstances which could effectively eliminate them from the discussion.

Table 19. Reshowing of the zones that passed 5/7 inventory criteria, but failed Phase 4. Yellow shading means the zone passing was controversial.

Park Name	Zone	reg dens	regen rich	und cov	und rich	inv cov	inv reg	can opy	#No	Phase4?	confi
Carkeek	7b	Yes	Yes	Yes	yes	No	Yes	No	2	No	3
Discovery	capehart_area__3a	Yes	Yes	No	yes	Yes	Yes	No	2	No	1
Discovery	capehart_area__1a	Yes	Yes	No	yes	Yes	Yes	No	2	No	2
Discovery	capehart_area__3b	Yes	Yes	No	yes	Yes	Yes	No	2	No	1
Kiwanis	krw_9	No	Yes	Yes	yes	Yes	Yes	No	2	No	2
Me Kwa Mooks	spu_watershed_grant	Yes	Yes	Yes	yes	No	Yes	No	2	No	2
W. Duwamish Soundway	soundway_14	No	Yes	Yes	yes	Yes	Yes	No	2	No	2

Three zones encompassed the Capehart area of Discovery Park. The Capehart area was a 24-acre restoration project that removed fifty military buildings and restored native forest and prairie (Discovery Park 2016). The Capehart zones were recently planted (2010-2011) and started from a barren, degraded lot, save for a couple adult trees. With almost exclusively young trees and understory plantings, all three Capehart zones failed canopy composition and understory cover. At the time of assessment, we didn't have a protocol for deciding if a site could be Phase 4 with no canopy. We discussed the issue thoroughly in the field and decided that it was too soon to pass these zones into Phase 4. Upon reflection later, we leaned towards accepting these as Phase 4 zones in future years. If these zones would have been passed, then there were only four zones left that passed in 5/7 criteria, but didn't pass Phase 4.

One of the remaining four zones was Carkeek 7b. We found garlic mustard, a Class A noxious weed, in this zone. Carkeek 7b would have passed, if not for the garlic mustard. We made a quick decision in the field to not accept zones with a Class A weed. However, upon reflection after the field season, we considered that future zones with small patches of Class A weeds could be passed, but more thoroughly monitored and maintained. If we had decided this before our assessment of Carkeek 7b, then 7b would have passed. Therefore, under the new light, only 3 of 23 zones didn't pass Phase 4 that passed in 5/7 inventory criteria. With this high of a percentage of zones moving into Phase 4 that passed 5/7 inventory-checks, the objective decision tree should start there. If this change is plotted, then the data show a polynomial trend with a good fit to the regression line (R^2 = 0.924, Figure 12).

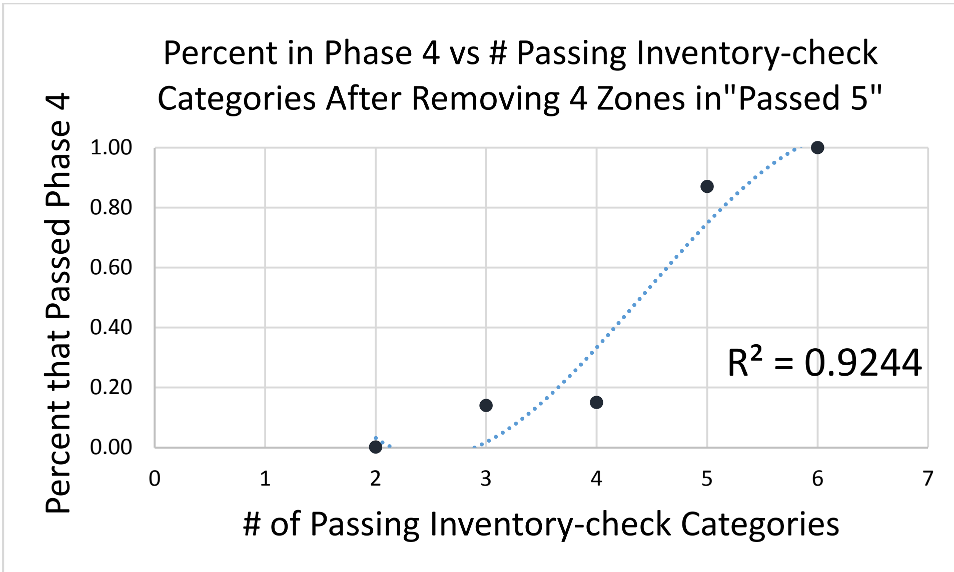


Figure 12. Scatter Plot and regression line for the percent that passed Phase 4 vs the number of passing inventory-check categories after removing four controversial zones from “passed 5.” A polynomial line with 3 orders had the best fit. Zones that passed 0, 1, or 7 inventory-check categories were omitted for redundancy.

A clear distinction between the three remaining zones is that none failed in both invasive cover and invasive tree regeneration. And after sorting through all 79 zones, the 18 zones that failed in both of these categories, only two (11%) passed into Phase 4—a low percentage. Therefore, another branch for the objective decision should include that the sites can’t fail in both invasive cover and invasive tree regeneration.

Another finding is that failing both native regeneration density and invasive cover correlated to not being moved into Phase 4. Ten zones failed both native regeneration density and invasive cover and only one was considered Phase 4. This makes sense because two of the main goals of GSP restoration projects are to reduce invasive species and improve future native canopy. If a restoration site is lacking in both of these categories, then it seems appropriate that it shouldn’t be considered restored, and moved into Phase 4. With such a low percentage, no zones that fail both native regeneration density and invasive cover should pass Phase 4 objectively. The decision process is shown via a flow chart in Figure 13.

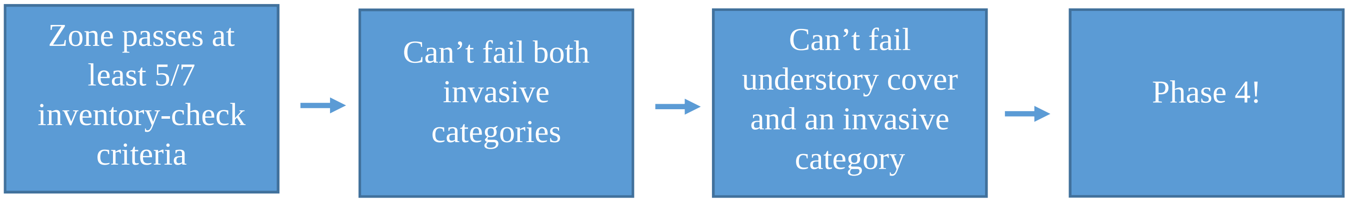


Figure 13. A proposed flow chart for the objective Phase 4 decision process.

Having both Phase 4 decisions would make for an interesting comparison: it’s possible that there could be disagreement between the data-generated decision and the assessment team’s decision, and that would be useful information. Why is there disagreement? Should we override the computer generated, and for what reasons? If quantitative and qualitative decisions are included, another important question going forward is how to weigh the plant ecologist’s opinion against the quantitative-driven decision. Future Phase 4 Verifications will gather more data on what inventory-checks correlate to Phase 4 status, and these data should be incorporated into the objective decision process to make it even more reliable as a method to help in Phase 4 Verifications.

Special-site Zones in Urban Areas

There were a few zones that we visited that had special characteristics that made us feel they might need to be assessed differently. These were zones with height restrictions, visibility restrictions, and/or had designated invasive species patches. If considered under the same stringencies as other zones, these sites were less likely to pass the thresholds to become candidates as well as less likely to pass during Phase 4 assessments.

Special-Site Overview

- Sight lines restrictions often occur when zones are below residential property. Neighbors want to preserve their view, and with the natural beauty and hilly topography of Seattle, there are frequently views to preserve.
- Powerlines are another height restricted zone because trees will be cut or heavily pruned that grow under powerlines. Only one zone we assessed in 2015 had obvious powerline issues: the Tom Palm Utah Ave zone in Discovery Park.

- Community gardens, also called P-Patches in Seattle, sometimes have zones surrounding them. To maximize sunlight and garden productivity, trees should be infrequent and small. We evaluated the "Native Plant Border" zone in Magnuson Park, which surrounded a community garden. The Native Plant Border zone was designated as Oak Woodland (*Quercus garryana - Pseudotsuga menziesii / Symphoricarpos albus / Polystichum munitum*). Because of the reduced SPA threshold of Oak Woodland, the Native Plant Border passed in all of its inventory checks. Had this zone had a forested Target System, then it likely would have failed in tree regeneration density: the latest inventory observed 50 SPA, below the 83 species threshold for the forested TFTs.
- Visibility restrictions occurred in zones that bordered the Burke-Gilman trail. Zones alongside the trail need to have high visibility so path users can see each other when paths merge. Visibility is also helpful at intersections.
- Designated blackberry patches on the Burke-Gilman trail also affected zone assessment. Because of the desire of Seattle's residents to pick blackberries from Himalayan blackberry bushes, some patches have become "designated blackberry patches," and protected. If they are included in the invasive cover, zones with these patches are more prone to failure in invasive species cover. A simple solution to fix this is to ignore these patches during Inventory Assessments and Phase 4 Assessments.

Solutions

I suggest two solutions to the issues above: 1) change the zone's TFT to a TFT with shorter or fewer trees, and less understory plantings, or 2) create special-site zones that have a unique candidacy and assessment process.

Solution One: Changing the TFT

Changing a zone's Target Forest Type would take-away from the ecological history of the site, but it would eliminate the need for a special-site assessment and candidacy. For the two Scrub Shrub Wetland TFTs, *Salix ssp. / Spiraea douglasii - Cornus sericea - Lonicera involucrate* and *Salix sitchensis / Spiraea douglasii*, the dominant trees are willows and the regeneration threshold is only 25 SPA. Oak woodland is another TFT with lower SPA and cover requirements. Oak Woodland has a tree regeneration density of 50 SPA and an understory cover of 60%. These lower targets would help zones pass into candidacy and also pass Phase 4 assessments.

Solution Two: Create special-site zones that have a unique candidacy and assessment process

Creating special-site zones would make it easy to adjust candidacy filters and Phase 4 assessments to be more lenient. To easily sort special-site zones, there could be a data column in the zone list indicating whether the zone is a special site.

Future Candidates

Choosing candidates for future years will be a different process than 2015 because we visited 98 of the 109 zones that passed the candidacy filters. The remaining eleven are top of the list to be evaluated, but future candidates would need to be found through a different manner. There are many possible solutions to this problem and some are outlined below.

1) Reduce inventory stringency. An easy solution would be to reduce the stringency of the passing criteria by reducing the amount of passing categories (*i.e.* to five of seven). This is where the logistic regression analysis is most useful. After the number of passing criteria is reduced to five, the results from the regression analysis could be used as a guide for prioritizing the candidates. The categories to prioritize would be the categories that had significant relatedness to Phase 4: invasive cover and understory cover. Since more invasive cover is correlated to not passing Phase 4, candidates with an invasive threat of "<5%" should be done first, followed by threat levels of "5-50%" and lastly, ">50%." Likewise, zones with high understory cover should be prioritized. By prioritizing zones that are more likely to pass, assessment time will be better utilized.

2) Find candidates through examining non-candidates. Another method to find candidates would be to examine why the zones that looked good (like other zones in Seward Park and Schmitz Preserve) didn't move through the candidacy filters in 2015. By examining exactly why those zones didn't move through the candidate query, we could figure out with thresholds to tweak in order to flag seemingly-good candidates through the candidacy system in future years.

3) Ask Forest Stewards. Forest stewards know their zones well. They could petition a zone for Phase 4 assessment. This would involve Forest Stewards more in the Phase 4 process, which would increase their interest and knowledge in Phase 4.

4) Assess neighboring zones. We noticed during our assessments that neighboring zones looked similar to the zone being assessed, yet it didn't flag through our query criteria. These are likely good candidates for future years. It could be fruitful to have a user-friendly system to mark Phase 4 candidates in the system whenever plant ecologists are in the field.

CONCLUSIONS

I hope this report can be of use for the City of Seattle, but also for other Green Cities in the region as they move forward in their programs and begin moving sites into Phase 4. The results from this report should be most useful to the City of Seattle, where the results can be interpreted and applied most confidently, since the matrix and many non-forest variables (*e.g*. contractors, managers, volunteers, culture) will remain somewhat consistent in the near future. I would caution the direct interpretation of the results and analysis by other regional municipalities because our data set was small, the team bias was large, and the matrix and non-forest variables would be different.

Having a team of multiple members helps reduce bias among team members, but it doesn't eliminate biases among different teams, and for this reason a team of four different surveyors could come to different conclusions on Phase 4 status. For example, we were inclined to consider woody-invasive removal as an easy fix, and favored moving zones into Phase 4 under the assumption that woody-invasive treatment would happen within a year. We knew which contractors would likely do this work and were familiar with their ability to perform the work. A different crew might feel differently about moving sites into Phase 4 that failed in woody-invasive density, and they might feel differently about the ability of their contractors. Additionally, we were comfortable with creating work prescriptions and assuming work would be done. Different managers might not be as comfortable with this assumption, and their decision to move less zones into Phase 4 would reflect this. The reliance on assumptions is one example of many issues that should be decided in advanced to improve consistency among Phase 4 teams. Whether different teams come to different conclusions on Phase 4 status is currently unknown, and to record this variability, it would be helpful to conduct a study comparing Phase 4 evaluations among different teams using the same sites. This seems like wishful thinking, as time-constraints made it hard for one team to do assessments, but a study like this could show variability of team dynamics and help with interpretations of data collected by Phase 4 Verifications.

Looking at the Phase 4 Verification through the lens of our field team, we can now model how other unvisited sites are most likely to respond to our Phase 4 Verifications based on their inventory data or their inventory-checks. At some point in the future, perhaps even after one more field season, a model might be of use to move zones into Phase 4. This brings up some tough management questions for SPR, mainly: Should a model be used in lieu of a field visit? A model that builds upon 2015 and incorporates at least two years of data, could be argued to be better than a team's judgement and therefore be a better way to move zones into Phase 4. Nay-sayers of using a model should think about whether relying on one team's judgement is better than relying on judgement built upon multiple sites over multiple years from multiple surveying teams. They should also think about the time requirements of needing at least two Plant Ecologists on site visits to eventually assess 2,500 acres in Seattle.

One area to use a model is in the Objective Phase 4 Decision. The Objective Phase 4 Decision was built upon the correlation between inventory-checks and Phase 4 status, and future Phase 4 decisions that don't align with expected results should raise flags and help managers remain consistent. Eventually, it could also allow for non-experts to complete inventory-checks and then have the objective-decision determine Phase 4 status. By employing non-experts to do inventory-checks, it would free-up time for the Plant Ecologists; but, it would still require resources like training and wages. Therefore, an interesting idea to draw from this report is the idea of eliminating the need for some Phase 4 Verifications by moving appropriate zones into Phase 4 based solely on their latest Inventory.

If a model based on Inventory data were to be used, like one similar to the logistical regression in this report, it seems the most logical zones to automatically make Phase 4 would be those that display the highest correlation to Phase 4 status. This correlation might be with a single predictor variable, like the ones in the logistic regression in this report, but it also could be with a combination of predictor variables, an area that I didn't explore in the regression model, but examined in the Objective Phase 4 Decision. Another consideration would be whether or not to group zones with similar site characteristics, like proportion of edge, forest age, and the amount of restoration activity. These are examples of characteristics that could make a model more site-specific and thus the application more reliable.

No matter the specifics of the future models, when relying on probability to assign Phase 4 status, error becomes important. It seems for the GSP, that the worse type of error is Type I, or moving a site into Phase 4 before it is ready. A site that is moved in too soon, and then consequently doesn’t receive necessary capital work, could be more likely to degrade to Phase 1 or 2. In comparison, a site that is actually Phase 4, but isn’t moved in by the model, an example of Type II error, could always wait another year with less consequence, as it would continue receiving any necessary capital work to sustain Phase 3.

Type I error would not only be frustrating for resource managers of Seattle Parks and Recreation, but it could also affect political will to include restoration projects as capital projects. Moving zones back into active restoration could have the same public perception as building a city bridge then closing it soon after it opens for repairs. While some error should be accepted because natural systems are extremely complex and the threats on urban forests are many, too much error of moving zones into Phase 4 could negatively affect the image of Phase 4. If sites were to move into Phase 4 via a model, it would seem prudent to begin conservatively, and move zones into Phase 4 that have a 95% probability of being considered Phase 4 based on previous Phase 4 Verifications. The chance of Type I error would thus be 5%, a commonly deemed acceptable level of Type I error.

A major downside of using a model to move zones into Phase 4 in the future would be the elimination of field time. An important benefit of the Phase 4 Verifications was the time spent in the forest, walking through different Parks in various states of health. Assessing ninety-eight zones in a single field season (which often included walking through neighboring zones for access), allowed for the comparison of restoration practices and their ecological response. Phase 4 Verifications allowed us to think deeply on how to best approach restoring and maintaining forest health. Through seeing and analyzing so many restoration sites, we constructed building-blocks to the conscious and subconscious development of restoration BMPs. Additionally, one could argue that field visits are necessary to assign work prescriptions anyways, and these can be combined with Phase 4 Verifications. Replacing field visits with a model would eliminate scheduled field time, a consequence that interacts with other management decisions, and thus should be considered in the decision to rely on models to move zones into Phase 4.

While seemingly powerful, I would caution Seattle Parks and Recreation from using a model for moving zones into Phase 4 for the near future for similar reasons that I caution interpretation of the results for other municipalities: the data set was small, team-bias was high, and inconsistencies arose as new issues presented themselves. By waiting, data collected under stricter guidelines could be incorporated into the model making the model more robust and accurate. Incorporating another season of data would also reduce biases from one field season and one team. More time would allow for the incorporation of data from zones that were not the best zones, like they were in 2015. Another benefit of waiting is allowing time for more sites to be inventoried under the new set of Inventory guidelines published in 2014 (GSP 2014). The new guidelines should improve accuracy by reducing inconsistencies in Inventory evaluation timing (*e.g.* some Inventory were completed in leaf-off months prior to 2014) and contractor crews.

Another reason to wait on using a model is because we don't know the accuracy of our Phase 4 decisions, the criterion of the regression model. Unfortunately, we won't know for several years if zones we moved into Phase 4 in 2015 were "ready" and will remain in Phase 4 after future monitoring. Any analysis on the judgement of our Phase 4 decision would also need to incorporate maintenance effort, but eventually these data could be incorporated into a model, making it better.

Finally, I hope that this report will add support to the idea of categorizing restoration projects as a capital projects for city governments. We showed that restoration sites can transition out of capital and into maintenance within 3-8 years. Future studies that examined more closely the time-line of this transition could prove helpful for continuing support of restoration within cities. One restoration project to highlight is the West Duwamish Greenbelt. The site began as highly degraded (a "9" on Tree-iage) and after many hours of volunteer work and numerous plantings, we deemed multiple zones ready for long-term maintenance. These restoration success stories are valuable information for funders and decision-makers. They could be used to encourage future support of capital restoration projects in the Puget Sound region, as well as in other cities throughout the United States.

ACKNOWLEDGMENTS

This report would not have been possible without the collaboration of Seattle Parks and Recreation. I especially would like to acknowledge the Phase 4 team: the two Plant Ecologists, Lisa Ciecko and Michael Yadrick, and the strategic advisor, Oliver Bazinet. I learned so much about restoration and forest assessments by participating in the Phase 4 Verification process with them. Lisa was also on my committee, and her GSP knowledge and editing were valuable components to this report. I would also like to thank my other committee members, Kern Ewing and Jim Fridley, for their advice and guidance through the process. I thank my parents for their support with the decision to enter graduate school and the continued support throughout the process. Finally, I thank my fiancé, Briana, for supporting me throughout the process of getting a masters and writing the final paper.

WORKS CITED

Alston, K. P., & Richardson, D. M. (2006). The roles of habitat features, disturbance, and distance from putative source populations in structuring alien plant invasions at the urban/wildland interface on the Cape Peninsula, South Africa. *Biological Conservation*, *132*(2), 183-198.

Asah, Stanley, Ph.D. "Motivations of Ecological Restoration." University of Washington, Seattle. 2 Dec. 2015. Lecture.

BenDor, T., Lester, T. W., Livengood, A., Davis, A., & Yonavjak, L. (2015). Estimating the size and impact of the ecological restoration economy. *PloS one*, 10(6).

Berkowitz, J. F. (2013). Development of restoration trajectory metrics in reforested bottomland hardwood forests applying a rapid assessment approach. *Ecological indicators*, *34*, 600-606.

BMP Manual (2005). “Chapter 5: Natural Areas.” City of Seattle Department of Parks and Recreation. Accessed online February 2016. http://www.seattle.gov/parks/projects/BMP/chapter5.pdf

Chappell, C.B. (2006). Upland Plant Associations of the Puget Trough Ecoregion, Washington. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA. Accessed online January 2016. http://www1.dnr.wa.gov/nhp/refdesk/communities/index.html

Davis, M. A., Grime, J. P., & Thompson, K. (2000). Fluctuating resources in plant communities: a general theory of invasibility. *Journal of Ecology*, *88*(3), 528-534.

Deguchi, A., Hattori, S., & Park, H. T. (2006). The influence of seasonal changes in canopy structure on interception loss: application of the revised Gash model. *Journal of Hydrology*, *318*(1), 80-102.

Discovery Park. (2016), Capehart Parks and Green Spaces Levy Project Information. Seattle Parks and Recreation website. Accessed online February 2016. http://www.seattle.gov/parks/projects/discovery/capehart/.

Ehrenfeld, J. G. (2000). Defining the limits of restoration: the need for realistic goals. *Restoration Ecology*, *8*(1), 2-9.

Fazio, J. R. (2010). How Trees Can Retain Stormwater Runoff. *Arbor Day Foundation. Tree City USA Bulletin*, (55).

Franklin, J. F., & Dyrness, C. T. (1973). Natural vegetation of Oregon and Washington. *USDA Forest Service General Technical Report, Pacific Northwest Forest and Range Experiment Station*, (PNW-8).

Green Seattle Partnership. 2006. Green Seattle Partnership 20-Year Strategic Plan. Edited by Eva Weaver. Seattle, WA. Accessed online December 2015. http://greenseattle.org/

Green Seattle Partnership. 2014. Inventory Protocols. Accessed online January 2016. http://greenseattle.org/wp-content/uploads/2015/08/Inventory-Protocols-2014-final.pdf

Green Seattle Partnership. 2015. Forest Steward CEDAR Guide. Accessed online March 2016. http://greenseattle.org/wp-content/uploads/2015/05/FS-CEDAR-User-GuideGSP.pdf

Honnay, O., Verheyen, K., & Hermy, M. (2002). Permeability of ancient forest edges for weedy plant species invasion. *Forest Ecology and Management*,*161*(1), 109-122.

Hobbs, R. J., Walker, L. R., & Walker, J. (2007). Integrating restoration and succession. *Linking restoration and ecological succession* (pp. 168-179). Springer New York.

Klingle, M. W. (2008). Lamar Series in Western History: Emerald City: an Environmental History of Seattle. Yale University Press.

Larson, R. J. (2005). The flora of Seattle in 1850: major species and landscapes prior to urban development. (Master’s thesis, University of Washington).

Lonsdale, W. M. (1999). Global patterns of plant invasions and the concept of invasibility. *Ecology*, *80*(5), 1522-1536.

Light, A. (2002). Restoring Ecological Citizenship. In Democracy and the Claims of Nature: Critical perspectives for a new century. Edited by Ben Minteer and Bob Taylor. New York: Rowman and Littlefield 2002.

Lindig-Cisneros, R., & Zedler, J. B. (2000). Restoring Urban Habitats: A comparison of three projects provides clues to better results. *Ecological Restoration*, *18*(3), 184-192.

Matthews, J. W., & Spyreas, G. (2010). Convergence and divergence in plant community trajectories as a framework for monitoring wetland restoration progress. *Journal of Applied Ecology*, 47(5), 1128-1136.

Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. *Urban forestry & urban greening*, *4*(3), 115-123.

Pimentel, D., & Kounang, N. (1998). Ecology of soil erosion in ecosystems. *Ecosystems*, *1*(5), 416-426.

Ramsay, M. (2004). A citywide survey of habitat on public land in Seattle a tool for urban restoration planning and ecological monitoring. 16th Int'l Society of Ecological Restoration Conference. Abstracts: 2004. Aug 24-26.

Raloff, J. (2003). Cultivating weeds: Is your yard a menace to parks and wild lands? *Science News*, *163*(15), 232-233.

"Reference Ecosystems." (2016). Green Seattle Partnership. Accessed online February 2016. http://greenseattle.org/information-for/forest-steward-resources/restoration-resources/reference-ecosystems/

Ruiz-Jaen, M. C., & Mitchell Aide, T. (2005). Restoration success: how is it being measured?. *Restoration Ecology*, *13*(3), 569-577.

Sander, H. A., & Polasky, S. (2009). The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota, USA. *Land Use Policy*, *26*(3), 837-845.

SER. (2004). Society for Ecological Restoration International Science & Policy Working Group. *The SER International Primer on Ecological Restoration*. Accessed online January 2016. http//www.ser.org

Tyrväinen, L., & Miettinen, A. (2000). Property prices and urban forest amenities. *Journal of environmental economics and management*, *39*(2), 205-223.

United States Census Bureau 2014. State and County Quick Facts: Seattle (city), Washington. Accessed online February 2016. http://quickfacts.census.gov/qfd/states/53/5363000.html

Yadrick, Michael. (2015a) "Seward Park: The Gem of the Park System." Green Seattle Partnership Blog: Entry June 30th, 2015. Accessed online January 2016. http://greenseattle.org/seward-park-the-gem-of-the-park-system/

Yadrick, Michael. (2015b) "Game Changers and Beyond." Presentation to Shareholders of the Green Seattle Partnership. Sept 29, 2015.

Appendix 1: Table of Phase 4 results

Table below is organized by the number of "no's" in the inventory check part of the assessment, then by Phase 4 passing, followed by park name. TFT stands for target forest type, which can cross-referenced to Appendix 1. For the weakest characteristics, st = social trails, ccf = future canopy cover, no_sh = no shrubs, w_i = woody invasive species, ot = other, lgc= lacks ground cover, cc – canopy cover, inv_sus = invasive susceptibility, agna = aggressive native, h_i = herbasive invasive, enc = encampment.

Park	zonename	TFT	reg dens	reg rich	und cov	und rich	inv cov	inv reg	cano py	#No	Phase 4	conf	Fst stwrd?	weak char 1	weak char 2
Lincoln	S Creek Forest Central	7	Yes	Yes	Yes	yes	Yes	Yes	Yes	0	Yes	1	Yes	st	ccf
Llandover Woods	Area 10	15	Yes	Yes	Yes	yes	Yes	Yes	Yes	0	Yes	1	Yes	ccf	no_sh
Madrona	Fir Grove	6	Yes	Yes	Yes	yes	Yes	Yes	Yes	0	Yes	2	Yes	st	w_i
Seward	MF5-N	7	Yes	Yes	Yes	yes	Yes	Yes	Yes	0	Yes	1	No	ccf	ot
Seward	MF3	7	Yes	Yes	Yes	yes	Yes	Yes	Yes	0	Yes	2	Yes	st	ot
Seward	MF10	8	Yes	Yes	Yes	yes	Yes	Yes	Yes	0	Yes	1	Yes	w_i	st
Schmitz Preserve Park	52nd Ave Trail	7	Yes	Yes	Yes	yes	Yes	No	Yes	1	Yes	1	No	inv sus	st
Beaver Pond NA	South 1B	8	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	1	Yes	h_i	slst
Colman	D3	7	Yes	Yes	Yes	yes	Yes	No	Yes	1	Yes	1	No	w_i	h_i
Discovery	West Parking Lot	6	Yes	Yes	Yes	yes	Yes	No	Yes	1	Yes	1	Yes	w_i	st
Kubota	West Kubota	8	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	2	Yes	ot	h_i
Lincoln	East of Ballfields	7	Yes	Yes	Yes	yes	Yes	No	Yes	1	Yes	1	Yes	st	ot
Llandover Woods Greenspace	Area 12	8	No	Yes	Yes	yes	Yes	Yes	Yes	1	Yes	1	Yes	ccf	h_i
Madrona	The Meadow	6	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	1	Yes	st	h_i
Matthews Beach	Matthews Beach Western Edge	5	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	2	Yes	lgc	ot
Ravenna	WNPS 2008 Site	15	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	2	Yes	h_i	w_i
W. Duwamish Riverview	Riverview 11-02 (REI Site)	6	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes		No	cc	enc
W. Duwamish Riverview	Riverview 21	6	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	3	No	inv sus	cc
W. Duwamish Riverview	Riverview 21-03	6	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	1	No	inv sus	agna
Roxhill	3 Peat Cell 3	25	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	1	Yes	h_i	st
Roxhill	11 Meadow	23	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	2	Yes	st	lgc
Roxhill	12 Aspen Sweep	7	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	1	Yes	st	ot
Roxhill	13 Upper Woodland	7	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	1	Yes	st	ot
Seward	MF5-S	7	No	Yes	Yes	yes	Yes	Yes	Yes	1	Yes	1	Yes	ccf	ot
Seward	LE5	2	Yes	Yes	Yes	yes	Yes	No	Yes	1	Yes	2	Yes	w_i	h_i
Seward	LE6	5	Yes	Yes	Yes	yes	Yes	No	Yes	1	Yes	1	Yes	w_i	h_i
Seward	MF5	8	Yes	Yes	Yes	yes	Yes	No	Yes	1	Yes	2	Yes	w_i	lgc
Magnuson	Promontory Point Central Ridge	5	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	2	Yes	lgc	h_i
Magnuson	Native Plant Border	10	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	1	Yes	ot	

Park	zonename	TFT	reg dens	reg rich	und cov	und rich	inv cov	inv reg	cano py	#No	Phase 4	conf	Fst stwrd?	weak char 1	weak char 2
West Duwamish GS: Soundway	Soundway 10	16	Yes	Yes	Yes	yes	Yes	Yes	No	1	Yes	2	Yes	no_sh	agna
Westcrest	Area 7	3	Yes	Yes	Yes	yes	No	Yes	Yes	1	Yes	3	No	h_i	ot
Carkeek	2A3	9	Yes	Yes	Yes	yes	Yes	No	No	2	Yes	1	Yes	ccf	
Carkeek	2B11	9	Yes	Yes	Yes	yes	No	Yes	No	2	Yes	2	Yes	no_sh	h_i
Discovery	Pearl Jam	8	No	Yes	Yes	yes	Yes	Yes	No	2	Yes	2	Yes	w_i	ccf
Discovery	Tom Palm Utah Ave	8	Yes	Yes	Yes	yes	Yes	No	No	2	Yes	1	Yes	w_i	ot
Kiwanis M. P.	KRE 6	8	No	Yes	Yes	yes	Yes	Yes	No	2	Yes	2	No	ccf	w_i
Kiwanis M. P.	KRE 7	8	No	Yes	Yes	yes	Yes	Yes	No	2	Yes	3	No	ccf	slst
Kiwanis M. P.	KRS a	10	Yes	Yes	Yes	yes	Yes	No	No	2	Yes	2	Yes	lgc	h_i
Lakeridge	DHC WNPS 2007	8	Yes	Yes	Yes	yes	Yes	No	No	2	Yes	1	No	h_i	w_i
Lakeridge	Lower Taylor Creek Ravine (North of Hairpin)	18	Yes	Yes	No	yes	No	Yes	Yes	2	Yes	1	Yes	h_i	lgc
Madrona	Frog Pond Ravine	15	No	Yes	Yes	yes	Yes	Yes	No	2	Yes	2	Yes	ccf	ot
Pritchard Island Beach	Pritchard SE Upland	8	Yes	Yes	Yes	yes	Yes	No	No	2	Yes	3	Yes	no_sh	w_i
W. Duwamish Riverview	Riverview 20-02 (Entry West)	7	Yes	Yes	Yes	yes	No	Yes	No	2	Yes	3	No	inv sus	cc
Roxhill	8 Maple Woods Phase I	16	Yes	Yes	No	yes	Yes	Yes	No	2	Yes	1	Yes	lgc	ot
Seward	MF6	3	No	Yes	Yes	yes	Yes	No	Yes	2	Yes	1	Yes	ccf	st
Seward	LE7	7	No	Yes	Yes	yes	Yes	No	Yes	2	Yes	2	Yes	st	w_i
Westcrest	Area 5	3	No	Yes	Yes	yes	Yes	No	Yes	2	Yes	2	No	w_i	ccf
Carkeek	7B	7	Yes	Yes	Yes	yes	No	Yes	No	2	No	3	Yes	nox_wd	ot
Discovery	Capehart Area-3A	8	Yes	Yes	No	yes	Yes	Yes	No	2	No	1	Yes	no_sh	ot
Discovery	Capehart Area-1A	8	Yes	Yes	No	yes	Yes	Yes	No	2	No	2	Yes	no_sh	ot
Discovery	Capehart Area-3B	8	Yes	Yes	No	yes	Yes	Yes	No	2	No	1	Yes	no_sh	lgc
Kiwanis M. P.	KRW 9	7	No	Yes	Yes	yes	Yes	Yes	No	2	No	2	No	ccf	ot
Me-Kwa-Mooks	SPU Watershed Grant	7	Yes	Yes	Yes	yes	No	Yes	No	2	No	2	No	inv sus	
West Duwamish GS: Soundway	Soundway 14	4	No	Yes	Yes	yes	Yes	Yes	No	2	No	2	Yes	ccf	h_i
Colman	B5_B9	5	No	Yes	Yes	yes	Yes	No	No	3	Yes	2	No	ccf	h_i
Lakeridge	Darrell's Slope	7	Yes	Yes	Yes	yes	No	No	No	3	Yes	2	Yes	ot	w_i
Burke-Gilman Trail	65th to 70th W	5	Yes	Yes	No	yes	No	Yes	No	3	No	1	Yes	h_i	ot
Burke-Gilman Trail	65th to 70th E	5	No	Yes	Yes	yes	No	Yes	No	3	No	1	Yes	h_i	w_i
Carkeek	2B2	16	Yes	Yes	Yes	yes	No	No	No	3	No	1	Yes	h_i	w_i
Discovery	Maduzia Invasive Tree Site - East	8	No	Yes	Yes	yes	Yes	No	No	3	No	3	Yes	ccf	no_sh
Discovery	Maduzia Invasive Tree Site - West	17	No	Yes	Yes	yes	Yes	No	No	3	No	2	Yes	w_i	ccf
Frink	WYCO Fund	3	Yes	Yes	Yes	yes	No	No	No	3	No	2	Yes	w_i	h_i
Interlaken	Forest Restoration Zone	7	Yes	Yes	Yes	yes	No	No	No	3	No	2	Yes	w_i	c_nonnat
Kiwanis M. P.	KRM 4	5	No	No	Yes	yes	Yes	No	Yes	3	No	2	No	ot	ccf

Park	zonename	TFT	reg dens	reg rich	und cov	und rich	inv cov	inv reg	cano py	#No	Phase 4	conf	Fst stwrd?	weak char 1	weak char 2
Seward	GO	10	Yes	Yes	Yes	yes	No	No	No	3	No	1	Yes	ot	h_i
Magnuson	Starflower Project	5	Yes	Yes	Yes	yes	No	No	No	3	No	1	Yes	w_i	w_i
Westcrest	8th Ave	3	Yes	Yes	Yes	yes	No	No	No	3	No	1	No	h_i	ccf
Kiwanis M. P.	KRM 5	6	No	Yes	Yes	yes	No	No	No	4	Yes	2	No	ot	h_i
Burke-Gilman Trail	Mgmt Unit 4 Central - Westside	10	Yes	Yes	No	yes	No	No	No	4	No	1	Yes	w_i	h_i
West Seattle Golf Course	Golf Course Woods South	17	No	Yes	Yes	yes	No	No	No	4	No	1	No	inv sus	cc
Interlaken	Redwood Grove	6	No	Yes	No	yes	No	No	Yes	4	No	1	Yes	lgc	ot
Kiwanis M. P.	KWC	5	No	Yes	Yes	yes	No	No	No	4	No	3	No	h_i	w_i
Ma-kwe-mooks	Pathfinder School Site	7	Yes	Yes	No	yes	No	No	No	4	No	1	No	cc	
Ravenna	EarthCorps Volunteer Site 2008	7	No	Yes	Yes	yes	No	No	No	4	No	1	Yes	w_i	ot
Burke-Gilman Trail	Wetlands to 60th	7	No	Yes	No	yes	No	No	No	5	No	1	Yes	ot	slst
Burke-Gilman Trail	Mgmt Unit 4 Central - Eastside	5	No	Yes	No	yes	No	No	No	5	No	1	Yes	w_i	h_i
Discovery	11_02	8	No	Yes	No	yes	No	No	No	5	No	1	Yes	w_i	h_i
Seola	Central Seola	2	No	No	No		No	No	No	6	No	1	Yes	h_i	w_i

Appendix 2: List of Target Systems, TFTs, acreages and # zones.

Target Systems	Target Forest Types (TFT)	TFT #	# of acres	# Zones
Bog and Fen	PICO/LEGR/SP shore pine / Labrador tea / sphagnum spp	25	6.2	5
Conifer Broadleaf Evergreen Mixed Forest	PSME-ARME/GASH Douglas-fir- Pacific madrone /salal	1	71.7	49
	PSME-ARME/HODI/LOHI Douglas-fir- Pacific madrone / oceanspray / honeysuckle	2	101.8	49
	PSME-ARME/VAOV Douglas-fir- Pacific madrone / evergreen huckleberry	3	34.2	18
Dry-Mesic Conifer and Conifer Deciduous Mixed Forest	PSME/GASH/POMU Douglas-fir / salal / sword fern	5	391.1	172
	PSME-TSHE/GASH/POMU Douglas-fir- western hemlock / salal / sword fern	7	570.3	324
	PSME-TSHE/GASH-MANE Douglas-fir- western hemlock / salal- dwarf Oregon grape	6	204.5	149
Mesic-Moist Conifer and	ACMA-ALRU/POMU-TEGR big leaf maple- red alder/ sword fern – fringecup	4	33.7	14

Target Systems	Target Forest Types (TFT)	TFT #	# of acres	# Zones
Conifer Deciduous Mixed Forest	PSME-TSHE/MANE-POMU Douglas-fir- western hemlock/ dwarf Oregon grape/ sword fern	8	647.7	372
	THPL-TSHE/OPHO/POMU western red cedar- western hemlock/ devils club/ sword fern	9	106.5	45
	TSHE-PSME/POMU-DREX western hemlock – Douglas-fir / sword fern – spreading woodfern	17	103.7	40
Oak Woodland	QUGA-PSME/SYAL/POMU Oregon white oak- Douglas-fir / common snowberry/ sword fern	10	24.9	22
Riparian Forest and Shrubland	ACMA-PSME/ACCI/POMU big leaf maple – Douglas-fir / vine maple / sword fern	13	15.2	19
	ACMA-PSME/COCO/HYTE big leaf maple – Douglas-fir / beaked hazelnut / Pacific waterleaf	14	30.5	23
	ACMA-THPL/OECE big leaf maple – western red cedar / Indian plum	15	122.0	79
	ALRU/RUSP/CAOB-LYAM red alder / salmonberry / slough sedge – skunk cabbage	16	136.6	72
	FRLA-POBA/RUSP Oregon ash – black cottonwood / salmonberry	19	6.3	5

Target Systems	Target Forest Types (TFT)	TFT #	# of acres	# Zones
Riparian Forest and Shrubland	POBA/COSE black cottonwood / red-twig dogwood	21	14.8	10
	POBA/SYAL black cottonwood / snowberry	22	13.8	10
	POBA-ALRU/RUSP black cottonwood – red alder / salmonberry	20	22.0	12
	TSHE-THPL-ACMA/ACCI/LYAM western hemlock – western red cedar – big leaf maple / vine maple / skunk cabbage	18	43.7	21
Scrub Shrub Wetland	SA/SPDO-COSE-LOIN willow / Douglas spirea – red-twig dogwood – black twinberry	23	24.2	19
	SASI/SPDO Sitka willow / Douglas spirea	24	27.8	16

Appendix 3: Field check-list for assessments

The Phase 4 Assessments

The Phase 4 Assessments comprised of two to four plant ecologists walking through a zone while assessing its ecological characteristics. We carried the following information and equipment with us:

<u>Informational Sheets</u>
1) Inventory data from the latest inventory assessment
2) Activity Summary
3) Map of the zone and surrounding area made in ArcGIS

<u>Equipment</u>
4) Android-based tablet with field case
5) Binoculars
6) Note pads
7) Bright vests
8) Smart Phones
9) Identification Guides *e.g*. Pojar and Mackinnon: *Plants of the Pacific Northwest*

Details on Information

The inventory data came from the values recorded in the most recent Inventory Assessment for a zone (Figure 14). The Activity Summary (Figure 14) showed restoration work on a temporal scale. Printed maps were useful to distinguish zone barriers, especially in zones where cellular service was weak.

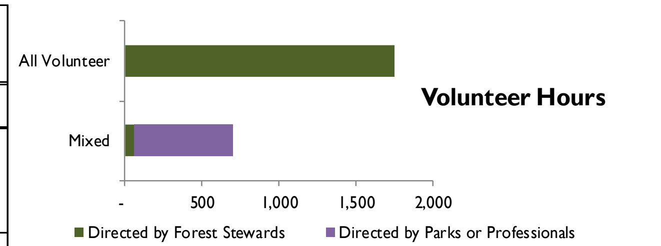
Details on Equipment

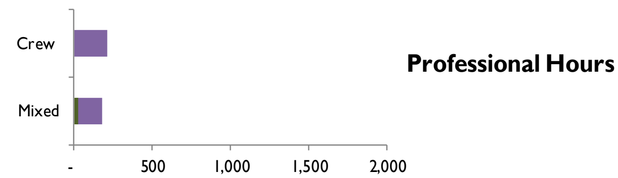
We used an Android-based tablet for data collection with a water and damage resistant case. We carried binoculars to aid in identifying plant species from a distance. Bright vests helped to locate each other in the forest. Smart phones with the ArcGIS app helped determine zone boundaries.

Interlaken: Redwood Grove Most Recent : 1/24/2015

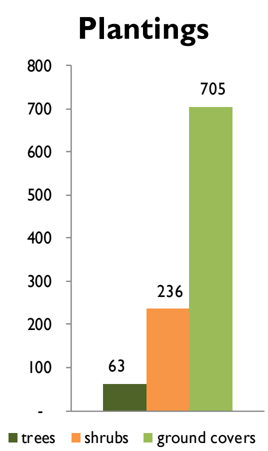
Reported Hours in the Field

Event Types	Volunteer Hours	Professional Hours
All Volunteer	1,752	
Mixed		
Led by Professionals	644	155
Led by Forest Stewards	56	22
Mixed Total	700	177
Crew		
Hired by Parks or Other Partners		213
Hired by Forest Stewards		-
Crew Total		213
Grand Total	**2,452**	**390**





Reported Tasks Accomplished



Phase 1

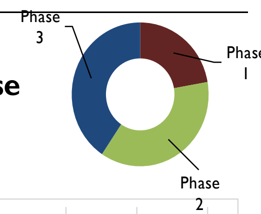
563 hours of phase 1 work
0.29 acres invasive species removed
- survival rings cut

Phase 2

942 hours of phase 2 work
63 trees planted
236 shrubs planted
705 ground covers planted
1,004 Total Plants

Phase 3

1,028 hours of phase 3 work
0 acres mulched
2 acres weeded
3,578 plants watered



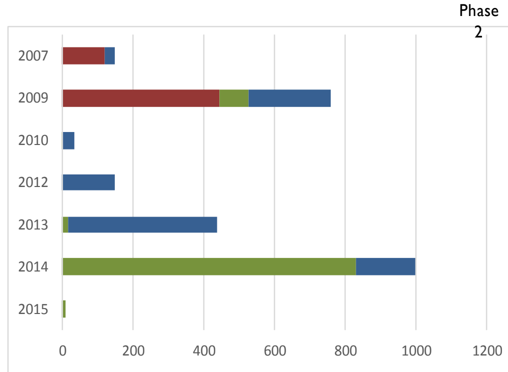


Figure 14. A sample activity report from Interlaken Park, Redwood Grove zone.

Puget Creek Natural Area

Zone **PP Steep Slope** Phase 4 Candidate ☑

Area (acres): 0.61 SUNP (1999-2000) Tree-iage: 9

Target Association (TFT): PSME/GASH/POMU

Target Ecosystem: Dry-Mesic Conifer and Conifer Deciduous Forest

Visit: 5/20/2010 VisitID: PP Steep Slope_0510

Most Recent: True Camps: Soil Texture: clay

Estimated Canopy Cover: >75% Litter Depth: .25"

Crew: EC Course Woody Debris: 0-5% Bare Ground: 0-20%

Notes:

Phase IV Performance

Tree-iage 3.0 Value: 1 Tree-iage Vertical (Eco) Value: 3	**Desireable Regeneration (SPA): 135** Target: 125 Threshold: 83 Meets Threshold: True	**Understory Richness (# species): 9** Target: 10 Threshold: 6.6 Meets Threshold: True
Invasive Regeneration (SPA): 20 Below Threshold (10 SPA): False	**Desireable Regen Richness (# species): 2** Target: 3 Threshold: 2 Meets Threshold: True	**Understory Cover (%): 137** Threshold (Target): 0.7 Meets Threshold: True

Number of Failed Thresholds: 1 Phase IV Candidate: True

Figure 15. A sample inventory zone report from Puget Creek Natural Area.

Appendix 4: Woody invasive species priority target list

GREEN CITY PARTNERSHIPS

Woody Invasive Species Priority Target List

Botanical name	Common Name
Acer platanoides	Norway Maple
Acer psuedoplatanus	Sycamore Maple
Aesculus hippocastanum	Horse Chestnut
Buddleia davidii	Butterflybush
Clematis vitalba	Traveler's Joy
Cotoneaster spp.	Cotoneaster
Crataegus monogyna	English Hawthorne
Ilex aquifolium	English Holly
Populus alba	Silver Poplar
Populus nigra	Black Polar (Lombardy)
Prunus domestica	domestic cherry
Prunus spinosa	Sloe
Prunus avium	Wild Cherry
Prunus cerasifera	Thundercloud plum
Prunus laurocerasus	Cherry Laurel, English Laurel
Prunus lusitanica	Portuguese Laurel
Pyracantha spp.	Firethorn
Robinia pseudoacacia	Black Locust
Sorbus acuparia	Mountain Ash
Tamarix ramosissima	Saltcedar
Ulex europaeus	Gorse
Ulmus parvifolia	Chinese Elm
Ulmus procera	English Elm
Ulmus pumila	Siberian Elm

updated spring 2015