Urban Environmental Stewardship in Practice: using the Green Seattle Partnership to examine relationships between ecosystem health, site conditions, and restoration efforts

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ABSTRACT

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Ecological restoration of urban natural areas can enhance ecological function and ecosystem services within cities and has become a common focus of civic environmental stewardship. This study examines the effectiveness of civic environmental stewardship in urban restoration ecology by examining preliminary data from the Green Seattle Partnership (GSP), a collaborative forest management program in Seattle. Particularly, it asks how invasive cover, native or non-invasive cover, and species richness have changed and responded to restoration efforts and how restoration can fit into and contribute to self-reinforcing functions of ecological systems.. For ecological data, 424 management units were surveyed both before and during restoration activities and compared against work logs that recorded restoration activity. The results indicate a relationship between restoration activities and invasive species cover in the sampled management areas. However, non-invasive vegetative cover and species richness have not yet been as responsive to intervention. While there is evidence that the reduction in invasive species will contribute toward self-reinforcing function, the results also point to a continued need for management and intervention to achieve and sustain restoration goals.

KEY WORDS

Urban Ecology, Restoration Ecology, Urban Forestry, Invasive Species, Native Species, Civic Environmental Stewardship, Parks & Recreation

TABLE OF CONTENTS

Figures

Tables

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1. INTRODUCTION

A. URBAN ECOSYSTEMS – STRESS, SERVICE & THE NEED FOR STEWARDSHIP

Human colonization and development alters the endemic/pristine condition of landscapes in dramatic ways. Development may suppress natural predators; reduce and fragment habitats; foster invasion by aggressive exotic species; alter hydrology; and change environmental conditions (Goddard, Dougill, and Benton 2010; Kowarik 2011; Mckinney 2002; Miller 2012). Urban development introduces greater complexity and heterogeneity of landscapes, often within relatively small areas. Dense urban development also has its environmental benefits. In comparison to more spatially disparate suburban or exurban development, it is favored because it reduces the amount of area over which these environmental impacts pervade. There are also good arguments and evidence that the complexity of urban development creates novel ecosystems that taken as a whole contain greater biodiversity than rural or wild land areas. Taken individually and compared with a pristine condition, however, the patches of natural areas in cities that are either passed over for development or deliberately conserved are almost perpetually stressed and exposed to a wide range of disturbances.

Meanwhile, the growth of cities makes the social and economic benefits derived from ecosystem function ever more important. Commonly referred to as "ecosystem services," such benefits serve human communities in many ways, including air filtration, reduced noise, micro-climate regulation, and provision of recreational and cultural values (Bolund and Hunhammar 1999; Wolf 2012). Access to greenbelts, parks, and even street trees have been shown to be correlated with human benefits such as increased longevity (Takano, Nakamura, and Watanabe 2002), stress reduction (Ulrich et al. 1991), encouraging physical activity (Payne et al. 1998), and commercial activity (Tzoulas et al. 2007; Wolf 2005). Urban ecosystems also provide services that reduce the overall impact of urban development on surrounding areas. These ecosystem services include storm water filtration, reduced run-off, and sewage treatment (Bolund and Hunhammar 1999).

Urban ecosystems are thus increasingly referred to as "green infrastructure" (Kattel, Elkadi, and Meikle 2013) which can increase the livability of cities (Houk 2011). Ecosystem function and services can be provided by a wide variety of natural elements in cities that range from street trees, community gardens, roadside planting strips, parks, and greenbelts. Constructed landscapes can also provide services, including green roofs, green walls, and rain gardens. Like the roads, bridges, and power lines that make up more traditional facilities of a city's infrastructure, these natural and constructed landscapes also require management and human intervention to be maintained and sustained (Clark et al. 1997). This need is exacerbated as heavy use by urban populations may lead to degradation over time. Urban ecosystem stewardship thus arises from a tension between stresses often imposed on natural features within cities and the extensive service that communities sometimes tacitly but often explicitly demand from them.

Many different agents can be involved in urban ecosystem stewardship. While public agencies are common actors, especially on public land, many non-profits, volunteer groups, and private companies or contractors are often involved. For human-designed and constructed ecosystem elements within cities, the responsibility for stewardship and management are often considered as part of the design and construction process. In remnant natural areas, however, public and private land owners can sometimes lack the resources, knowledge or foresight to take stewardship actions. Environmental stewardship in these areas can thus take more complex forms as combinations of public, private, non-profit and volunteer groups work either independently or in concert to steward these areas. This is a case study of such a multi-stakeholder ecological restoration and stewardship effort currently under way in natural areas on public land in Seattle, Washington.

B. RESEARCH QUESTIONS

The goal of this study is to understand the ecological impact that restoration activity and environmental stewardship can have on urban natural areas. More specifically, questions for this study include:

1. Can ecological structure change in response to restoration intervention and stewardship?
    - Can we distinguish between different types of interventions?
    - What site characteristics appear to be drivers of ecological conditions?
2. To what degree can stewardship activity support ecologically self-reinforcing function?

These questions can be summarized as: is restoration working, and, from an ecological perspective, will its progress be resilient or (more) sustainable going forward? This study thus fits into a body of work to better understand the ecological and social dimensions of urban environmental stewardship (Wolf et al. 2011) by examining a case in which both management interventions as well as ecological conditions have been monitored. It also serves as an opportunity to add to an expanding research literature on positive feedbacks as a component of restoration ecology (Suding 2011) within an urban context. In addition, it is an examination of what is becoming an ever-richer collection of data surrounding the Green Seattle Partnership program.

2. BACKGROUND

A. SELF-SUSTAINABILITY VS MAINTENANCE IN URBAN RESTORATION ECOLOGY

The Society of Ecological Restoration makes a distinction between ecological restoration and ecosystem management. While the former's purpose is "assisting or initiating recovery, ecosystem management is intended to guarantee the continued well-being of the restored ecosystem thereafter" (SER, 2004). This distinction is important because it highlights two important assumptions about the practice of ecological restoration.

The first is an implicit yet important assumption made by restoration practitioners that an upfront investment in altering the structure of an area in restoration will lead to improvement in function, reducing ecosystem management needs over time. The concept of alternative states is a more explicit expression of this idea that an ecosystem may shift through a number of possible stable states as it reaches certain thresholds through disturbance, management intervention, species introduction, or stressors (Beisner, Haydon, and Cuddington 2003; Clewell and Aronson 2007; Hobbs and Suding 2009; Hobbs 2007; Lewontin 1969; Suding, Gross, and Houseman 2004). There are many mechanisms that could lead to these virtuous (or destructive) cycles and non-linear relationships in restoration ecology (see Suding, Gross and Houseman [2004] or Beisner, Haydon and Cuddington [2003] for an extended description). An relevant example is the finding by Wood (2011) in the Puget Sound region that greater levels of conifer cover is associated with lower invasive vegetation presence, implying that at a certain level, conifer canopy closure provides its own form of invasive control.

This study uses ecological and program data collected from the Green Seattle Partnership, a restoration and environmental stewardship program in Seattle, WA, to examine the extent to which these relationships hold true – that is, to what degree the effects of restoration may be self-reinforcing in urban natural areas. This question is important from a program development and fiscal support perspective due to the high monetary cost of restoration (Guinon 1989; Zentner, Glaspy, and Schenk 2003) and that especially in public agencies costs are considered in two categories: construction costs (or capital development costs), and operation and maintenance costs (Robbins and Daniels 2012; Zentner et al. 2003). As mentioned above, one strong argument for restoration programs is a reduced cost of maintenance for an ecosystem that provides more ecosystem services going forward.

The second assumption about the distinction between restoration and maintenance work is that some degree of ongoing maintenance will be necessary for restoration sites. Despite the positive feedbacks mentioned above and although ecosystem self-sustainability is often a stated goal of restoration (Clewell and Aronson 2007; Wood 2011), it is more commonly recognized that, especially within urban systems, some restored areas will never reach complete self-sufficiency (Kowarik 2011) and that "restoration represents an indefinitely long-term commitment of land and resource"(SER, 2004). The necessity of continued monitoring, maintenance, and intervention in the ecosystem is due to two factors, according to Clewell and Aronson (2007): 1) the pervasiveness of human-mediated environmental impacts, and 2) that many desired ecosystem types were products of historic cultural management. Thus, the goal of natural area restoration in an urban setting is often not to achieve an independent self-sustaining ecosystem, but rather to enhance the area's desirable structure and function to a specified level so as to minimize the sustained costs of management and further enhancement.

B. CIVIC ENVIRONMENTAL STEWARDSHIP

If internal self-sufficiency is an unrealistic goal for desirable urban ecosystem elements, ecosystem sustainability, and thus ecosystems themselves can take on a broader meaning that includes the role of environmental stewardship. The urban forest sustainability model proposed by Clark et. al. (1997) advocates such a comprehensive management approach for public lands and urban forest resources. The model emphasizes that urban forest sustainability entails three elements: 1) the integrity of the forest (or ecological resource itself), 2) management capacity, and 3) community support. The interdisciplinary study of these interactions has been labeled "civic ecology" by Krasny and Tidball (2012). Within this framework, environmental stewardship is posited as the social response to ecological degradation and internal to the ecosystem itself.

In addition to actions by private land owners and land management agencies, *civic* environmental stewardship in particular has become a focus of research across the cities of the United States (Fisher, Campbell, and Svendsen 2012; Krasny and Tidball 2012; Romolini, Brinkley, and Wolf 2012; Romolini 2013), including places within the Puget Sound region (Sheppard 2014; Wolf et al. 2011). Civic environmental stewardship is defined by Romolini et al. (2012), as "physical activities on behalf of the environment, conducted by volunteers, on public or private lands." This definition can encompass a wide range of activities from street tree planting to volunteering regularly at a park (Romolini et al. 2012). Specific research has been done on stewardship organization characteristics and networks (Fisher et al. 2012; Romolini 2013), motivations of volunteer stewardship participants (Asah and Blahna 2013; Brinkley 2011), and monitoring practices (Sheppard 2014). Despite this attention, however, little is known about the ecological outcomes of citizen stewardship actions on the environment (Sheppard 2014; Suding 2011).

C. STUDY AREA: SEATTLE AND THE GREEN SEATTLE PARTNERSHIP - LANDSCAPES & STEWARDSHIP

Seattle is located in the *Tsuga heterophylla* lowland forest zone in the Puget Trough (Franklin and Dyrness 1988). This zone occurs between sea level and 2100 ft (the highest point in Seattle is 520 ft.), and is characterized by mild temperatures, relatively dry summers, and 35-100 inches of precipitation a year. Larson (2005) describes pre-Euro-American Seattle as ecologically diverse in both forest and non-forest landscape types. Large swaths of forests historically dominated by conifers *Tsuga heterophylla* (Western hemlock), *Thuja plicata* (Western red cedar) and *Pseudostuga menziesii* (Douglas fir) in upland areas were felled in the early 1900s (City of Seattle 2012). Likewise, the complex lowland shoreline, bog, riverine and ravine ecosystems dominated by deciduous and deciduous conifer mixed forest and shrubland (Larson 2005) were highly valued for their rich soils and relatively level surfaces. As such, they were converted to agricultural uses in many areas. Remaining natural areas have been fragmented by urban development and are now primarily forests where hardwoods such as *Alnus rubra* (red alder), and *Acer macrophyllum* (big leaf maple) have regenerated and dominate (Collins and Montgomery 2002; Davis 1973). By the late 20th Century, the local seed source that would have led to a natural succession of conifer dominance was greatly diminished. A habitat survey of Seattle's public lands conducted by the Seattle Urban Nature Project in 1999 – 2000 found that many remaining natural areas were replete with introduced species that threaten continued ecosystem succession (Ramsay, Salisbury, and Surbey 2004).

Many local volunteer groups recognized the issues of invasive species and halted succession in natural areas during the previous decade and began organizing and participating in (in some cases unsanctioned) restoration work. To address both the ecological concerns of the forest and provide a framework under which these volunteers could be sanctioned, the Green Seattle Partnership

(GSP) was initiated in 2004 with a goal to restore 2,500 acres of natural (non-landscaped) parcels managed by Seattle Parks & Recreation (SPR) by 2025 (Green Seattle Partnership 2006). These public lands now encompass about 2,750 diverse acres, and comprise about 5% of Seattle's land area. While many of the GSP work sites are established parks with trail systems, the properties portfolio also includes greenbelts, green space buffers that line bike trails, and ravines that are too steep or too close to streams for development (Figure 1). More information on the diversity of this landscape can be found in Ramsay et al., 2004.

This diversity of landscape types also extends to stakeholder participation. As with many emerging environmental stewardship and restoration programs across the U.S., the GSP is an example of polycentric governance approach, involving non-profits, volunteer stewards, and public agencies (Andersson and Ostrom 2008; Romolini 2013). SPR and other partners provide training, tools, and expertise to local non-profits and community stewardship groups that carry out restoration work. SPR plant ecologists also assign work to an in-house natural areas crew, contract externally for a substantial portion of the restoration work, and oversee both contractor and volunteer implemented monitoring programs. Non-profit and community partners recruit volunteers and seek grant funding to support restoration work, thus leveraging the city's expenditures using volunteer hours and external financial resources. The largest contribution of outside funds was a $3 million campaign by Forterra, a founding partner, in 2004, with much of the funding coming from the U.S. Forest Service (Green Seattle Partnership 2006). More detailed information on the history and structure of the Green Seattle Partnership can be found in Appendix A - Green Seattle Partnership General Information.

Of the range of activities that may be included in civic environmental stewardship, restoration has been found to be a common focus (Fisher et al. 2012; Romolini 2013; Sheppard 2014) . The GSP offers an exceptional opportunity to examine the site-level restoration outcomes due to urban civic environmental stewardship activity. Furthermore, involving a network of public, private, non-profit, and volunteer partners, the GSP is a collaborative partnership that is a model organization for representing the emerging diversity and functions associated with civic environmental stewardship (Ernstson, Sörlin, and Elmqvist 2009; Moskovits et al. 2002; Romolini 2013).

FIGURE 1: Examples of GSP-managed Zones

This area of northeast Seattle demonstrates the diversity of GSP zones (highlighted in red) and their surroundings. Visible in the lower right is a strip that lines a popular multi-use trail, surrounded by commercial and residential development. The large group of zones in the middle-left form a park that is predominately natural area surrounded by residential development. The small areas visible toward the top of the image are of a small strip of natural area within a landscaped park.

3. METHODS

Ecological, intervention, and site characteristic data was collected through a selection of GSP management units ("zones") with a goal of creating a multivariate model that approximates how both intervention and initial site characteristics contribute to restoration success. The sections below describe indicators of success, the independent variables, as well as model specification.

A. DEFINING AND MEASURING RESTORATION SUCCESS

As the field of restoration ecology has developed over the years, so too has the understanding of restoration objectives. The Society for Ecological Restoration Science & Policy Working Group (SER 2004) defines ecological restoration as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed." This broad definition allows a wide variety of interpretation as far as creating specific restoration goals. For many practitioners and ecologists, the replication of structure and function of an historical or undisturbed reference system define criteria for success (Clewell & Aronson, 2007; SER, 2004). However, in many cases, especially in urban settings such as Seattle where endogenous stressors and alterations in disturbance regimes are outside the manager's control, these goals may be unrealistic or unachievable (Hobbs 2007; Standish, Hobbs, and Miller 2012). For this reason, Westphal et. al (2010) choose to use the term "renaturing" as opposed to "restoration" to acknowledge the difficulty of comparing urban natural areas to pre-development or rural reference ecosystems.

Due to the variation in restoration scenarios and expectations, using a standard set of outcome metrics to apply to all restoration results can be challenging. Ruiz-Jean and Aide (2005) identify three categories of metrics for restoration success: (1) diversity (species or structure), (2) vegetation structure; and (3) ecological processes. Cairns (2000) and others have argued that ecosystem structural and functional elements associated with ecosystem services should be a primary measure of success when evaluating restoration projects. However, processes such as mycorrhizae recovery or nutrient cycling are often more time intensive and expensive to measure (Ruiz-Jaen and Aide 2005), and protocols for measuring the full range of biophysical ecosystem services in many cases do not exist (Krasny et al. 2014). Instead, attempts to estimate ecosystem services such as the i-Tree software or online National Tree Benefit Calculator use vegetation structure as a proxy for the services provided by that vegetation. This study, similarly, is limited to metrics of diversity and vegetation structure, though again with the assumption that these structural characteristics correspond to ecological function. These vegetation structure and diversity metrics and are listed in Table 1. They are not meant to nor can they provide a complete indication of restoration success, but they meet the following four criteria:

i. their observability given the data that had and is being collected by the GSP;
ii. their correspondence to assumed increasing values of ecosystem function, services and resilience as outlined

iii. Table **1**;

iv. their applicability over the range of different possible zones within the study area; and

v. their inclusion as metrics by which the Green Seattle Partnership measures success.

Table 1: Selected Metrics of Ecological Restoration Outcomes

Metric	Functional Definition	Significance
Native and other non-invasive species richness - "Species Richness"	Total number of species observed within a zone not classified by state or local agencies as invasive	Species complexity is tied to ecosystem function (Bradshaw 1987); biodiversity can enhance experience of nature (Miller 2005); native vegetation species can benefit native bird populations (Sears and Anderson 1991) ; on a number of restoration sites, biodiversity has correlated to greater delivery of ecosystem services (Rey Benayas et al. 2009).
Total estimated native and other non-invasive species cover "Native Cover"	Sum of percent coverage within a zone of species not classified by state or local agencies as invasive	Greater vegetative coverage is correlated with a suite of ecosystem services, including reduced temperatures, flooding, storm-water run-off, erosion, and polluted air (Dwyer et al. 1992); non-invasive coverage provides less opportunity for sun-loving invasive species to take hold (Wood 2011).
Total invasive species cover "Invasive Cover"	Sum of percent cover for species within a zone classified by state or local agencies as invasive	Exotic species can threaten native plant species and lead to species homogenization (McKinney 2006); invasive exotic species may arrest succession (Clewell and Aronson 2007).

B. DATA COLLECTION & VARIABLES

i. Ecological Data Collection & Site Selection

The units of observation for this study are a sample of GSP management units, referred to as "zones." As can be seen in Figure 1, zones are diverse in nature and could be a portion of a park, a trail buffer, or greenbelt. Zone boundaries were developed by EarthCorps Science, a partner organization, based on a three-fold process. First, for those public properties for which the City of Seattle had previously prepared a vegetation management plan (VMP) and included delineated areas of distinct habitats, zone delineation followed those established boundaries. Second, if the property did not have a VMP, zone boundaries were drawn based on the habitat delineations made by the Seattle Urban Nature Project (SUNP) in 1999-2000 (more information below). Finally, topographic and recognizable features such as trails or streams were used to separate zones so that they could be more easily observed in the field. Over time, zones have also been added as new areas are brought under GSP stewardship.

For each zone included in the study, ecological data were collected at two points in time. Baseline data collection took place in 1999-2000 as part of the SUNP habitat assessment. For that project, all public land throughout the city of Seattle was delineated into polygons of contiguous habitat types based on orthophotos and field truthing (Ramsay et al. 2004). Site visits were conducted in which binned percent cover and canopy position were estimated for each plant species within a habitat polygon. These estimates were entered into an Access relational database for use with an ArcGIS geodatabase (Ramsay et al. 2004). More information on the methods for the SUNP habitat assessment can be found in Ramsay et al. 2004.

After the GSP zones had been established, follow-up ecological data were collected during 2009-2013 in GSP's inventory program. Contracted trained vegetation surveyors followed the longest possible straight line through zones and estimated for the entire zone percent cover of each plant species encountered along this line. Canopy cover (tree species > 5 inches DBH) was recorded separately from understory cover. Inventory data was collected for zones in which SPR knew restoration work had taken place or was taking place. EarthCorps Science conducted the inventory from 2009- 2011, and Puget Sound GIS, a city contractor, conducted the inventory from 2011-2013.

While less rigorous than methods used in traditional ecology, the assessment methods employed by SUNP habitat survey and in the GSP inventory program are becoming more common for urban and exurban land management agencies throughout the Puget Sound. See Ceicko et al., 2014 for more information on how a similar technique has been applied on King County lands. Key disadvantages of such techniques in comparison to permanent or random plot sampling are that they are based on estimations rather than more direct field measurements, and that they assume a certain homogeneity within management units. Boundaries of actual habitat types may be more dynamic than zone or other management unit boundaries, and habitat types may also vary within management units. The advantage of these techniques for land managers and landscape-level analyses, however, is that they provide condition estimations for each management unit or area in an expedient way, thus allowing for assessments of much greater total area and direct comparisons between zones or management units at a lower cost than traditional ecological field sampling techniques.

Zones were selected for inclusion in this study based on the availability of both SUNP inventory data. Because the original SUNP polygon boundaries did not always match the zone boundaries, they were overlaid on each other within ArcGIS. Where at least 66% of a was covered by a single SUNP polygon, the data for that SUNP polygon was used to zone's baseline data. Where no individual SUNP polygon overlapped a zone by at least 66%, zone was not included in the study. Currently, GSP is responsible for managing 1,547 zones encompasses about 2,753 acres throughout the city. 424 zones, encompassing 772 acres total zones by number, 28% by area) fit the criteria of both SUNP and Inventory data and included in the study. A map of these zones can be seen in Figure 2: All zones managed by the Green Seattle Partnership (City **of Seattle)**

ii. Those highlighted in green were included within the study; insufficient data precluded use of those highlighted in purple.Vegetation Variables:

Vegetation variables were calculated from both the SUNP and Inventory surveys by categorizing the recorded plant species and aggregating individual percentage coverage for each zone. Each percentage value can therefore be greater than 100%, indicating multiple layers of vegetation; ground covers or forbs beneath shrubs and trees, for example. For the Inventory, vegetation estimates from the survey were created for the specific zone. For the SUNP, values are based on polygons that covered at least 66% of each zone. Many of the species found in both the

SUNP habitat assessment and Inventory program are neither native, nor considered invasive. Due to the beneficial ecosystem function that can be provided by such species (Schlaepfer, Sax, and Olden 2011), and that they are not targeted for removal by SPR, they were grouped with native species as beneficial in the analysis – hence the label "non-invasive" as opposed to "native."

- **Invasive Cover (Baseline & Follow-up) –** Aggregate percentage cover of all species in a zone categorized as invasive by SPR, the baseline serves as an independent variable to understand invasive species impact on native or non-invasive species structure and diversity, the follow-up value is a dependent variable.
- **Non-Invasive Canopy (Baseline)** – An aggregate percentage cover for all species in a zone not categorized as invasive by SPR and categorized as canopy (> 15 ft) in the SUNP survey, used as an independent variable to differentiate the effect that specifically overstory cover may have on outcome dependent variables.
- **Non-Invasive Understory (Baseline)** – Aggregate percentage cover for all species in a zone not categorized as invasive by SPR and not categorized as canopy (>15 ft) in the SUNP survey, used as an independent variable to differentiate the effect of specifically understory cover on the dependent variables.
- **Non-Invasive Cover (Follow-up and Baseline)** – aggregate percentage cover for all species in a zone not categorized as invasive by SPR, follow-up used as a dependent variable, and baseline used as an independent variable where the model specification was enhanced compared to using separate canopy and understory values.
- **Non-Invasive Species Richness (Baseline and Follow-up)** – the total number of species found on the zone not categorized as invasive by SPR, follow-up used as a dependent variable and baseline used as an independent variable to understand the effect of species richness on other dependent variables.

Because baseline data was estimated in bins, the midpoints of these bins were used to quantify SUNP vegetation estimates. All of the species recorded in SUNP and Inventory were classified as either invasive or non-invasive based on their status on Washington State, King County, SPR, and EarthCorps Science watch lists (A species list including status can be found in Appendix C). Desirable and invasive species cover were not combined into a single variable because an important component of the research question is to examine how baseline site conditions - including the presence of invasive species and non-invasive species – may affect the other restoration outcomes.

iii. Stewardship Intervention Data Collection

The intervention data for this study comes from self-reported worklogs in the GSP. GSP events are organized by either program staff, contractors, or volunteer Forest Stewards. Forest Stewards are specially trained volunteers who take responsibility for restoration and stewardship of particular natural areas, including further volunteer recruitment. They are often, though not exclusively, members of "friends-of" groups. Participants in a work event may be either locally recruited volunteers, volunteers brought in from an outside organization, professional restoration practitioners, or some combination of all of these groups.

Since 2007, the organizer of each event has been instructed to fill out a work log that includes the number of volunteer and professional hours spent on the event, the zones worked on for the event, as well as estimated quantities of work completed for each of the zones worked on during the event. From 2007 to 2010, these records were collected via paper forms that were reviewed by staff at EarthCorps, a partner organization, and then entered into an Access database. In 2011, the GSP developed an online electronic data entry system called CEDAR that enabled work event organizers to enter work logs directly into the database. Data entries could then be reviewed and approved by GSP staff. Work log submission is required from staff and contractors, so compliance in these groups are considered quite high. Reporting compliance is probably high for volunteer Forest Stewards who organize work parties at parks that they've "adopted," but at this time it is unknown exactly how many work events go unreported.

iv. Stewardship Intervention Variables:

Work logs for each zone were collected between 2007 (the beginning of electronic work log records) until the date of a zone's Inventory evaluation (2009-2013). Where indicated, quantities are normalized by the acreage of the zone to create quantities per acre.

- **Professional hours per acre** – Total reported professional hours recorded for zone per acre, used as an independent variable to represent both effort of intervention and differentiate from volunteer effort. Professionals include a wide range of paid workers in the field that include private contractor staff, non-profit volunteer organizers, SPR crews and plant ecologists, and conservation corps-type workers to name a few.
- **Volunteer hours per acre** – Total reported volunteer hours for zone per acre, used as an independent variable to represent both effort of intervention and differentiate from professional hours.
- **Total hours per acre –** Total reported hours from both professionals and volunteers for zone per acre, used as an independent variable where its inclusion led to better model specification compared to differentiating between volunteer and professional hours.
- **Total plants per acre** – Total reported number of plants of all types (trees, shrubs, groundcovers, from bare root, live stake, plug, or potted) installed per zone per acre, used as an independent variable to see impact of planting activity on a zone.
- **Mulch per acre** – Total reported square feet of mulch spread for zone per acre, used as an independent variable to see impact of mulch application, a common practice, on restoration outcomes.

- **Project months** – Total number of 30-day intervals between first reported work log and inventory data collection, used as an independent variable to approximate the importance of project length on restoration outcomes.
- **Work months –** Total number of the 30-day intervals in which work was reported, used as an independent variable to approximate the effect of sustained effort, as opposed to concentrated time spent on a zone.
- **Herbicide** – A dichotomous variable indicating whether or not herbicide use was reported on the zone, used as an independent variable to see the effect of herbicide application as opposed to alternative methods of invasive removal on restoration success.

A total of 2,843 work logs were included in the analysis and the total number of entries for specific zones numbered 3,149. In the original work log format, volunteer and professional hour totals were recorded for the particular event as opposed to being divided between the zones worked on, an estimation technique was used to divide hours between zones based on the work reported in each zone. More information on this estimation technique can be found in Appendix B.

It is likely that not all of the work performed on the sampled zones could be represented in the study. There are three main reasons for possible omission. The first is the issue of reporting compliance mentioned above; not all volunteer Forest Stewards consistently submit work logs. The next is the absence of records before 2007. While work was certainly performed in some sample zones before then, the current (or even most recent previous) work log recording system was not in place at that time. While this absence of data is unfortunate, most of the work for the GSP has been conducted between 2007 and 2014, and so it is of minor concern. The final reason for absence of intervention data is that before 2010, the reporting system did not require all work logs to be linked to a zone. As a result, about 34% of work logs, while associated with a park, cannot be assigned to a particular zone within the park. Fortunately, these work logs appear to be randomly distributed between parks.

v. Site Condition Data Collection & Variables

A number of other site condition variables were used to understand and control for potential landscape effects on the ecological outcomes. Geographic Information Systems (GIS) datasets from the City of Seattle's Department of Planning and Development (DPD) were used to identify designated wetland and riparian areas. A 2008 LIDAR dataset of the City of Seattle (having 4 sq. ft. resolution) was also used within ArcGIS to create a raster slope layer, and in turn, a dichotomous raster layer indicating whether the area represented by any pixel has greater than a 40% (21.80°) grade – the angle at which slides become an important consideration and the angle above which volunteers are [officially] not allowed to work. To capture possible edge effects, zone boundaries were merged within ArcGIS to create polygons of contiguous natural areas. The boundary lines of the resulting polygons were converted to a line feature and were buffered by 10 meters to create a natural areas edge layer. These techniques were used to generate the following variables:

- **Acres –** Size of a zone, in acres, used as an independent variable to understand the effects zone size and natural area contiguity on vegetation outcomes.
- **Slope percentage –** Percentage of a zone with a slope > 40% based on a LIDAR 2ft resolution Digital Elevation Model, used as an independent variable.
- **Wetland percentage –** Percentage of a zone designated as a wetland according to Seattle Department of Planning and Development, used as an independent variable.
- **Riparian percentage –** Percentage of a zone designated as part of a riparian area according to Seattle Department of Planning and Development, used as an independent variable.

- **Edge buffer percentage –** Percentage of a zone within 10m of a designated natural area boundary - higher values indicate that more of the zone is edge as opposed to interior of natural areas, used as an independent variable to view an edge effects on dependent variables.
- **Total months –** Number of 30-day intervals that have passed between the baseline (SUNP) and inventory surveys, used as in independent variable to estimate the effect and general trend over time.

C. REGRESSION METHODS

Ecological, intervention and site condition variables were constructed as described above and entered into Stata software to create a number of Ordinary Least Squares (OLS) regression models for which the dependent variables were the ecological outcomes of interest from the Inventory measurements. Two model specifications were created for each of the outcome variables: one in which the inventory measure of the outcome variable of interest was the dependent variable, and the SUNP value for that variable was included as a control variable (the level model), and another in which the change in the variable of interest from SUNP to Inventory was the dependent variable (change model). The level model can be thought of as predicting the outcome state or level of the outcome variable while the change model can be thought of as predicting the change that took place between the SUNP and Inventory measurements. Each type of model has its advantages. The level models are better able to control for the starting value of the dependent variable, which may be important in cases such as this one where the other independent variables may be correlated to it, and thus may be more appropriate for understanding the effects of the ecological and site independent variables of interest. The change models on the other hand, tend to be more beneficial in which differences in initial condition may lead to different treatment, a situation which also applies in this case. The change models may therefore reveal more about the effects of intervention. For more details on the difference between these two strategies, see Allison (1990).

In order to reduce model heteroscedasticity and correlation in error terms, a subset of the ladder of powers (Tukey 1977) was tested using skewedness and kurtosis tests described by Agostino, Belanger, and Agostino (1990), with the adjustment made by Royston (1991). This method tests multiple transformations of the variables of interest and provides a measure of fit with the normal distribution. Those transformations with the highest Chi-squared statistic (indicating a better fit) were selected for use in the regressions. Models for each dependent variable were tested first with the full set of independent variables. Those independent variables that increased adjusted R-squared values one of the two models for each dependent variable were retained.

4. RESULTS

Vegetation data was examined to observe differences in the most common species' distribution between baseline and inventory sampling. Species percentage cover and count were then aggregated to create the variables to serve as indicators of restoration success based on their invasive or native (or non-invasive) status to see the distribution of change across the system. Finally, all variables were used in the regression models described above to approximate the impact of stewardship intervention on restoration success.

A. GENERAL TRENDS

i. Vegetation Trends

Figure 3 and Figure 4 show the estimated vegetation cover and presence aggregated for the 20 most reported trees and understory species from both the SUNP (1999-2000) and inventory data (2009-2013). Among the tree species, big leaf maple (*A. macrophyllum*), red alder (*A. rubra)*, Douglas fir *(P. menziesii)*, and Western red cedar (*T. plicata)* maintain similar high constancy and variable estimated cover values from one period to the next. Likewise, in the understory, sword fern (*P. munitum)*, beaked hazelnut, (*C. cornuta)*, and Indian plum (*o. cerasiformis)* remain prevalent. The clearest change from the baseline to the follow-up in both tree and understory species is that many of the most prevalent invasive species from the SUNP survey have decreased in estimated presence for the inventory surveys. A visible exception to this trend is Himalayan blackberry (*R. armeniacus*) which, although remains present on 77.4% of zones, but has decreased in average estimated cover from 25.1% to 7.9%. English ivy (*H. helix)* likewise maintains a presence in many of the sample areas but has decreased in average estimated cover from 32% to 11.4%. Invasive tree species have decreased dramatically in presence and moderately in estimated percent cover – particularly English holly (*I. aquifolium*) and cherry laurel (*P. laurocerasus*). It is likely that the more explicit designation of species from the SUNP survey to Inventory explains the appearance of wild cherry (*P. avium*), Norway maple (*A. platanoides*), and English hawthorn (*C. monogyna*), which could have been mistaken for native species or grouped with similar species in the SUNP survey. Another visible change in the understory categories is that the prevalence of each non-invasive species seems to have increased, though their average estimated percentage cover shows less change. This may also be the result of a more sensitive data collection in the Inventory than the SUNP survey.

On aggregate, the distribution of total estimated non-invasive species cover remained similar from SUNP to Inventory (Figure 5a). The distribution of total estimated invasive cover declined considerably, however (Figure 5b), and a slight improvement can be seen in species richness (Figure 5c), though without controlling for zone area, it is hard to confirm change in richness. A paired t-test for each outcome variable was statistically significant to .01 percent, indicating differences in mean values for each outcome variable between the two time periods.

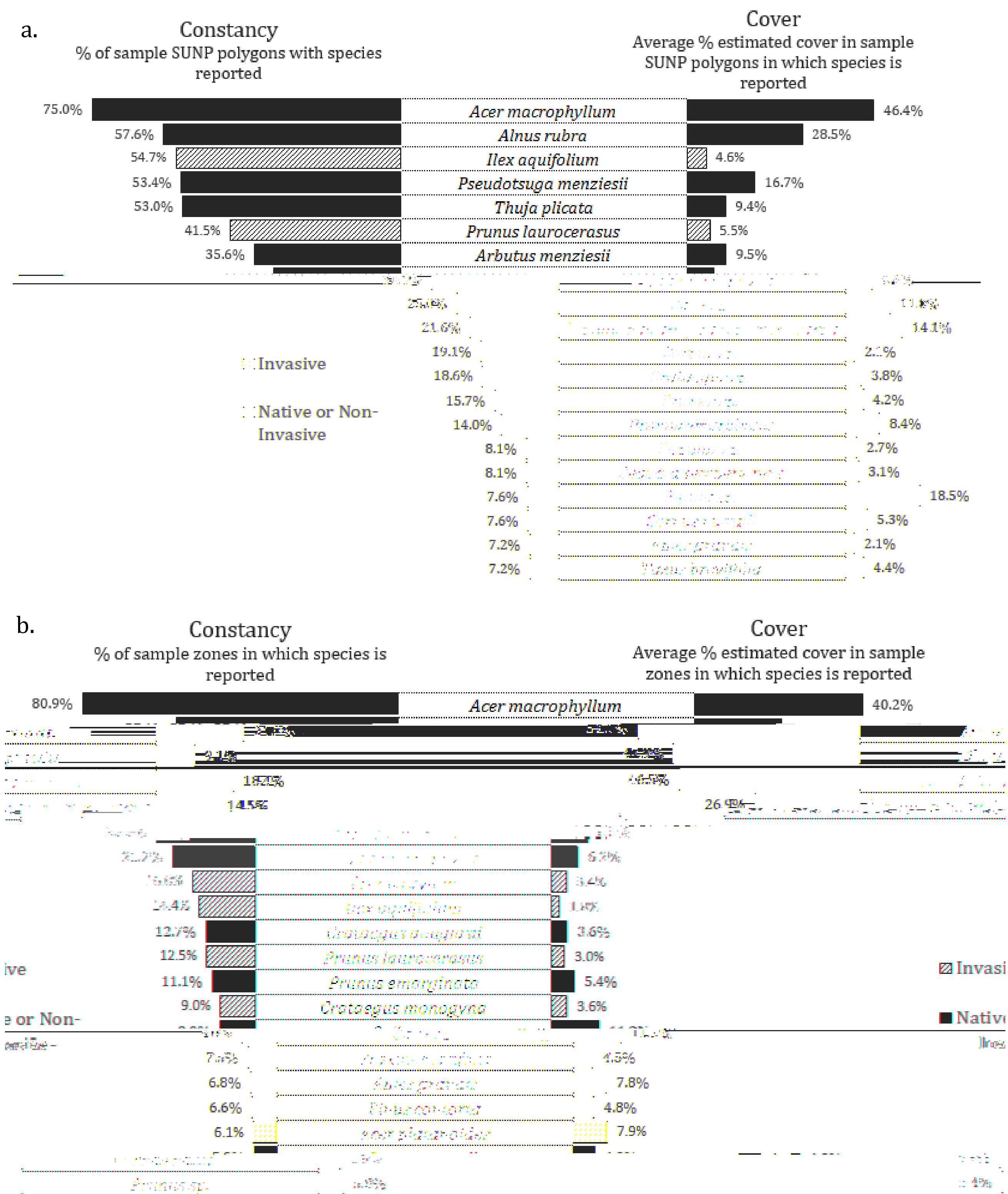

FIGURE 2: Tree Cover and Constancy

The percentage estimated constancy and cover of the 20 most reported tree species in (a) the 236 SUNP polygons from the 1999-2000 survey included in the study sample; and (b) the 424 GSP zones inventoried from 2009 – 2013.

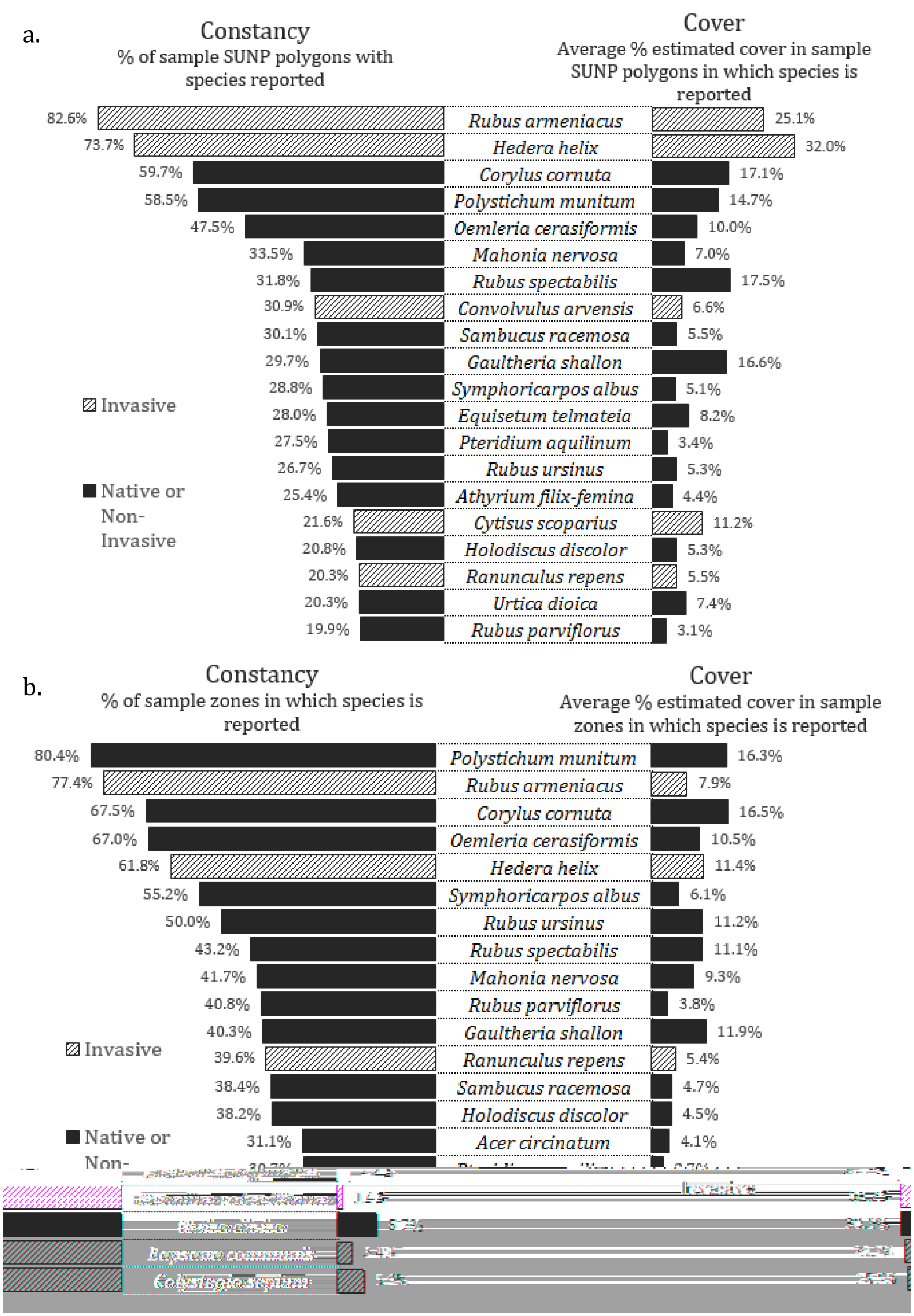

FIGURE 3: Understory Cover and Constancy

The percentage estimated constancy and cover of the 20 most reported understory species in (a) the 236 SUNP polygons from the 1999-2000 survey included in the study sample; and (b) the 424 GSP zones inventoried from 2009 – 2013.

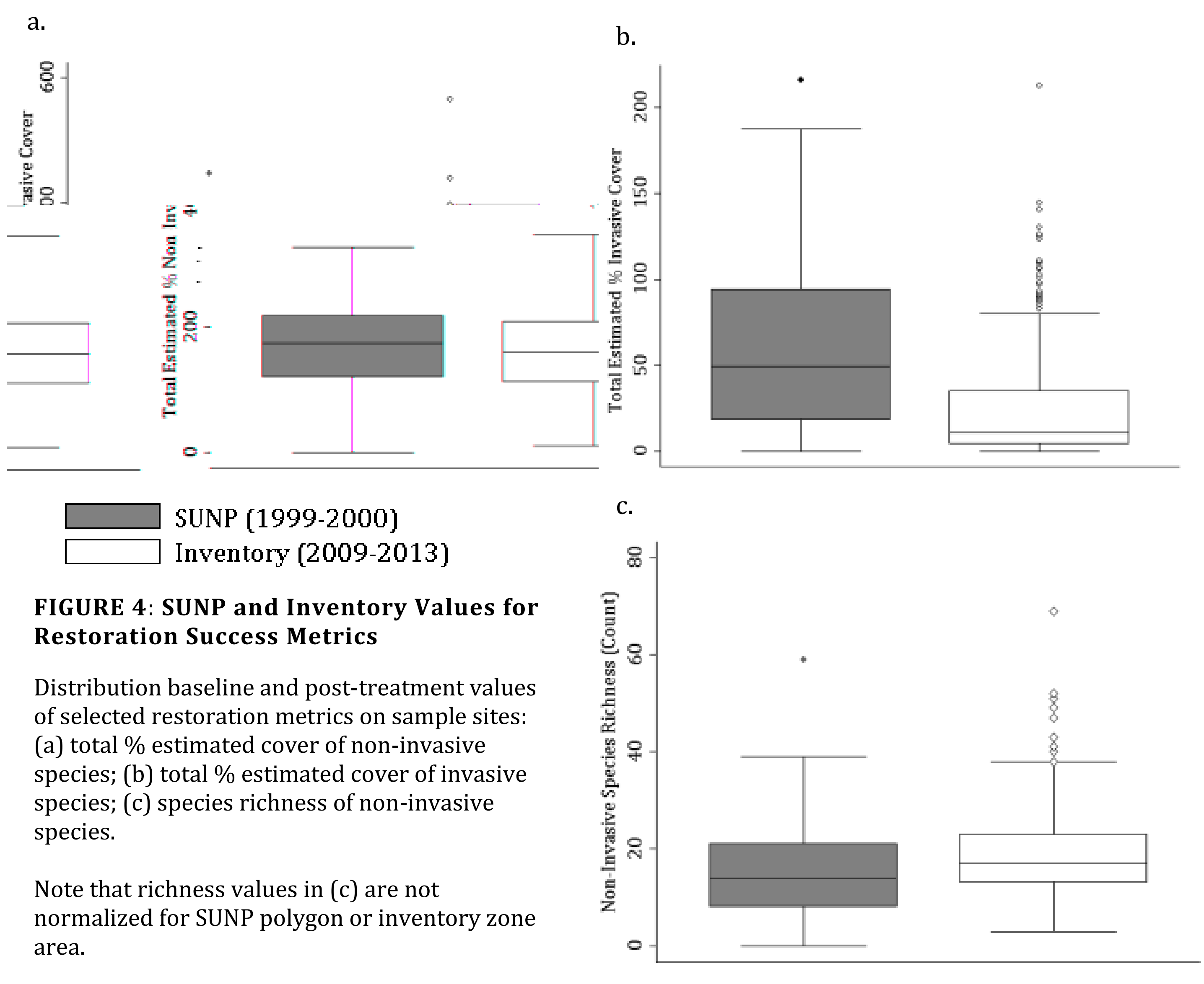

FIGURE 4: SUNP and Inventory Values for Restoration Success Metrics

Distribution baseline and post-treatment values of selected restoration metrics on sample sites: (a) total % estimated cover of non-invasive species; (b) total % estimated cover of invasive species; (c) species richness of non-invasive species.

Note that richness values in (c) are not normalized for SUNP polygon or inventory zone area.

ii. Work Distribution

Within the 424 sample zones, 301 (70%) have reported work between 2007 and the date of inventory measurement. The lack of any reported work in 121 zones (30% of the sample) was mentioned to SPR staff who reviewed department records and confirmed that work, had, in fact taken place in these areas, pointing to either a lack of reporting for those areas or that work logs were among those that were miscoded. For those zones with reported work, both professional and volunteer total hours-per-acre (HPA) per zone, the primary measure for intervention, for that time period appears to follow a log-normal distribution (Figure 6), a common distribution for time-activity data (McCurdy and Graham 2003). For the 237 zones (55% of sample) that reported volunteer work, the mean volunteer HPA was 451 and the median was 156. For the 256 zones (60% of sample) in which professional hours were reported the mean was 185 and median was 78. 192 zones (45% of sample and 64% of the zones in which work was reported) had both volunteer and professional hours reported.

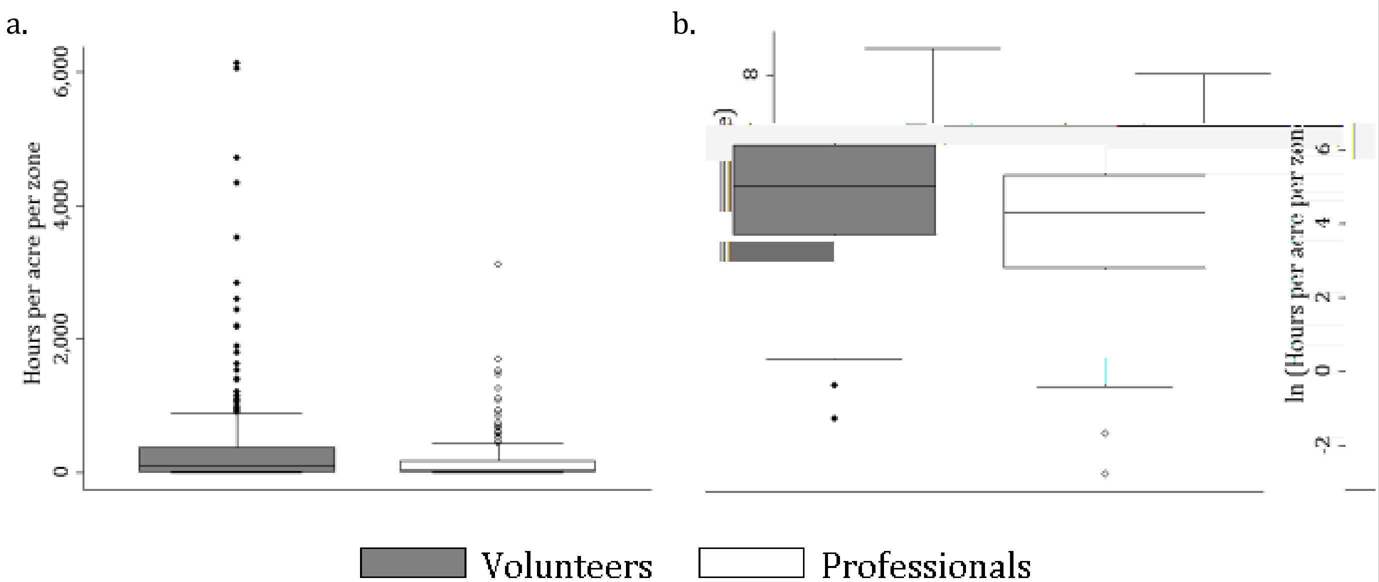

FIGURE 5: Distribution of Reported Hours per Acre (HPA)

The distribution of (a) absolute and (b) natural log of reported hours per acre across the 301 sample zones in which work was reported.

B. REGRESSION RESULTS

i. Non-Invasive Cover Models Results

The results for the two native and non-invasive cover models are shown in Table 2. Intervention variables showed very small coefficients and little statistical significance with the exception of herbicide, whose application seems to be correlated with an increase of 21-24 percentage points of the expected value of non-invasive cover. The lack of significance in the other variables, however, indicate that recorded intervention has not yet led to a measured increase in non-invasive vegetation cover. This is consistent with the lack of change in non-invasive species cover overall (Figure 5). From a data standpoint, this could be due to the fact that inventory surveys were often conducted in the midst or soon after restoration planting which would not allow for establishment or growth of new plants. In some cases, inventory took place during winter months, which might have biased results away from deciduous non-invasive species. Alternatively, it could be a sign that the disturbance associated with restoration may, in the short term, cancel out the increase in non-invasive vegetative cover (due to soils disturbance, for instance).

Not surprisingly, baseline invasive cover was found to be detrimental to native and non-invasive cover, even when controlled for baseline native and non-invasive cover. Each additional percentage point of invasive cover in the past is associated with a .24 -.34 decrease in expected non-invasive total percentage cover in the Inventory. More dramatically, time appears to be working against desirable cover, even when baseline invasive cover and desirable cover are controlled for, consistent with the narrative of a slowly maturing and declining native canopy across the system. Of the abiotic factors, one percentage point of a zone within 10 meters of a natural area edge predicts an expected .25 percentage points lower total cover of non-invasive species, though this relationship seemed to have existed in the SUNP survey as well, and thus shows no statistical significance in the change model.

TABLE 2: Regression Results for Non-Invasive Species Cover
Results of ordinary least squares (OLS) regression for non-invasive species level and change using study variables and maximizing adjusted R-squared value.

		Level Model Dependent variable = Total estimated cover of non-invasive species	Change Model Dependent variable = Δ total estimated cover of native and non-invasive species
	Constant	347.2114*** (26.3589)	272.9169*** (33.355)
Intervention Variables	Volunteer Hours Per Acre	0.0051 (0.0047)	0.0110* (0.0060)
	Plants Installed Per Acre	-0.0057 (0.0050)	-0.0089 (0.0064)
	Yards of Mulch Installed Per Acre	-0.0004 (0.0002)	-0.0001 (0.0003)
	Herbicide (Boolean)	23.8647*** (8.2581)	21.9212** (10.5655)
	Project Months	0.2558 (0.2104)	0.4881* (0.2661)
Abiotic Environmental Conditions	Total Months	-1.4380*** (0.1733)	-1.3853*** (0.214)
	Zone Size (acres)	3.301** (1.378)	-2.3591 (1.7061)
	Percentage Slope	0.2082* (0.1244)	0.0415 (0.1544)
	Percentage Riparian	0.1212 (0.1057	0.1006 (0.1353)
	Percentage Edge (≤ 10m)	-0.2487** (0.0998)	-0.195 (0.126)
Ecological Baseline	Invasive Cover	-0.3491*** (0.0699)	-0.2412*** (0.0821)
	Non-Invasive Canopy	0.2634*** (0.0878)	
	Non-Invasive Understory	0.1419** (0.0585)	
	Non-Invasive Species Richness	0.2970 (0.4398)	-4.6358*** (0.3929)
	R-squared:	0.377	0.326
	Adjusted R-squared:	0.356	0.307
	No. observations:	424	424

Standard errors are reported in parentheses. *, **, *** indicates significance at the 90%, 95%, and 99% level, respectively.

ii. Invasive Cover Models Results

In the ladder of powers analysis of invasive cover, the square root of invasive cover was found to have the lowest Chi-squared value and was used as the dependent variable for the level model. This result, consistent with Figure 5b, indicates that while many sample zones had low levels of estimated invasive species cover, for many areas above the median value or some other threshold, those values increase dramatically. A number of intervention variables correlate significantly to reduced invasive cover in both models, particularly professional HPA and project months. It is possible this is a result of professionals being brought in to remove the most invaded sites and having higher reporting compliance rates. Coefficients still remain low, however, as the maximum recorded professional HPA (3,114) would only be associated with a 65 percentage point decrease in (or 3.7 reduction in the square root of) expected invasive cover. The high coefficient value for project months, however, points to effects of intervention which may not be captured in (or recorded) in the other intervention variables. Negative constant values are also a sign that intervention factors have gone unreported unless invasive species have declined on their own. The fact that herbicide again shows up as significant, but only in the change model could be an indication that it was effective but only applied in areas with a greater initial invasive cover.

Controlling for other factors, though, both models show invasive species increases over time, more evidence for missing data within the intervention realm. Zone size seems to be associated with higher values and increases in estimated invasive presence, even when controlling for baseline levels, a sign of possible measurement bias towards larger total estimated cover values in larger zones. The edge effect also seems to favor invasive species. Baseline non-invasive cover as both canopy and understory are associated with reduced invasive species presence, though only understory contributed to adjusted R-squared when controlling for initial invasive cover, implying an association between initial non-invasive canopy levels and initial invasive cover. Species richness does not appear to provide much resilience to invasive species in this time frame or spatial scale.

TABLE 3: Regression Results for Invasive Species Cover

Results of ordinary least squares (OLS) regression for invasive species level and change using study variables and maximizing adjusted R-squared value.

		Level Model Dependent Variable = $\sqrt{\textbf{Total estimated cover of invasive species}}$	Change Model Dependent Variable = Δ total estimated cover of invasive species
	Constant	-3.3314** (1.1850)	-66.293*** (20.315)
Intervention Variables	Professional Hours Per Acre	-0.0011** (0.0005)	-0.021** (0.009)
	Volunteer Hours Per Acre	-0.0002 (0.0002)	-0.007* (0.003)
	Plants Installed Per Acre	-0.0007*** (0.0002)	-0.007* (0.004)
	Herbicide	-0.0536 (0.3614)	-18.300*** (6.162)
	Project Months	-0.0260*** (0.0092)	-0.253 (0.159)
Abiotic Environmental Conditions	Total Months	0.0400*** (0.0076)	0.390*** (0.132)
	Zone Size (acres)	0.1428** (0.0600)	2.981*** (1.028)
	Percentage Slope	0.0052 (0.0056)	0.016 (0.097)
	Percentage Wetland	0.0072 (0.0056)	-0.076 (0.097)
	Percentage Riparian	-0.0067 (0.0047)	-0.225 (0.075)
	Percentage Edge (≤ 10m)	0.0163*** (0.0043)	-0.037 (0.074)
Ecological Baseline	$\sqrt{\text{Invasive Cover}}$	0.2694*** (0.0414)	
	Non-Invasive Canopy	0.0008 (0.0038)	-0.251*** (0.063)
	Non-Invasive Understory	-0.0093*** (0025)	-0.078* (0.042)
	Non-Invasive Species Richness	0.0107 (0.0190)	0.144 (0.327)
	R-squared:	0.276	0.274
	Adjusted R-squared:	0.249	0.249
	No. observations:	424	424

Standard errors are reported in parentheses. *, **, *** indicates significance at the 90%, 95%, and 99% level, respectively.

iii. Non-Invasive Species Richness Results

Like invasive species cover, the square root of non-invasive species richness cover provided the highest Chi-squared value in the ladder analysis (Table 4). Of the direct intervention variables, only plants installed and total HPA (combined professional and volunteer) had a statistically significant association, though their low coefficients makes them almost negligible. Project months and active work months, however, seem to be associated positively with species richness. The statistical significance of these intervention time variables as opposed to hours per acre could indicate the importance of consistent intervention in increasing species richness, or alternatively it could also be a sign that there was a lot of unreported work, which may have had an impact.

Based on the statistically significant negative coefficient for total months, it appears that species richness is in decline overall. Other unexpected statistically significant results in the change model were that baseline canopy and understory cover were negatively correlated with growth in species richness. The fact that this relationship was reversed in the level model, however, points to collinearity and regression to the mean.

iv. Regression Limitations

Certain limitations should be noted for each of the models discussed above, a couple of limitations should be noted. The first is that there is that there is still substantial noise in the data. Even the model with the highest adjusted R-squared (non-invasive cover) only explains between 35-37% of the variation within the outcome predictors. The species richness models only explain about 18-30% of the variation. In addition, many of the variables included – particularly the intervention variables and vegetation variables, are collinear. Distinguishing between variables that tend to track each other closely is dependent upon a level of precision that is not yet possible with these data sources.

TABLE 4: Regression Results for Species Richness

Results of ordinary least squares (OLS) regression for non - invasive species richness and change in richness using study variables and maximizing adjusted R-squared value.

		Level Model Dependent Variable = $\sqrt{\textbf{non − invasive species richness}}$	Change Model Dependent Variable = Δ non-invasive species richness
	Constant	5.3426*** (0.4181)	27.990*** (4.685)
Intervention Variables	Total Hours Per Acre	-0.0001 (0.0001)	-0.002** (0.001)
	Plants Installed Per Acre	0.0002** (0.0001)	0.003*** (0.001)
	Project Months	0.0110*** (.0037)	0.054 (0.042)
	Active Work Months	0.0264** (0.0109)	0.082 (0.123)
Abiotic Environmental Conditions	Total Months	-0.0117*** (0.0028)	-0.093*** (0.031)
	Zone Size (acres)	0.0733*** (0.0210)	0.929*** (0.247)
	Percentage Slope	-0.0002 (0.0020)	0.035 (0.022)
	Percentage Riparian	0.0023 (0.0017)	0.002 (0.019)
Ecological Baseline	Baseline Invasive Cover	-0.0027** (0.0011)	-0.019 (0.012)
	Baseline Non-Invasive Canopy	-0.0003 (0.0009)	-0.111*** (0.012)
	Baseline Non-Invasive Understory	0.0023** (0.0009)	-0.051*** (0.009)
	$\sqrt{\text{Baseline Non − Invasive Species Richness}}$	0.0202 (0.0532)	
	R-squared:	0.200	0.285
	Adjusted R-squared:	0.176	0.266
	No. observations:	424	424

Standard errors are reported in parentheses. *, **, *** indicates significance at the 90%, 95%, and 99% level, respectively.

5. DISCUSSION

A. OUTCOMES & FEEDBACK

The most visible ecological progress to date for the GSP appears in the removal of invasive species, where the median change in estimated cover was a 26.4 percentage point reduction in estimated cover and the mean was a 33.7 percentage point reduction. The regression models also show a significant relationship between the intervention variables, particularly professional time dedicated per acre, in producing a decline in estimated invasive cover.

Reported levels of planting, mulching, and watering indicate stewardship efforts dedicated to the objective of increasing non-invasive (in most cases, native) cover and richness. The data indicates only modest success toward these outcomes. There are several possible explanations for this. There may be discrepancies in data collection. It is possible that surveys were either taken either too soon after projects (or even before planting took place) to detect a significant increase in estimated cover and richness. It also appears that, in some instances, measurements were taken in late fall or early winter when many herbaceous species as well as native deciduous trees and shrubs may have shed their foliage and thus may not have been accurately counted. It is also possible that there hasn't been much success in increasing desirable cover or richness in the field. The restoration process may include disturbance such as soil compaction. It is also probable that species mis-identification and removal by volunteers or practitioners may contribute to these results.

The regression model results do show promise for future restoration successes, however. The most pervasive trend across each of the regression models was the negative relationship between invasive species cover and non-invasive species cover across the two time periods. This provides strong evidence that lower levels of invasive species cover may lead to, or at least not interfere with, higher levels of non-invasive species cover and richness in the future for areas with the same baseline values. Thus, success in invasive removal is likely to contribute to success in non-invasive growth and diversity. Conversely, it appears that non-invasive cover increases the resilience of a zone to invasion. Together, these results provide strong evidence that, with some degree of stewardship effort, desirable conditions can be somewhat self-reinforcing.

If the GSP is successful in increasing non-invasive cover and richness, it is unlikely that these more desirable conditions can be entirely self-sustaining without the intervention of stewardship, as many of the drivers of ecological degradation will not be eliminated. Natural areas will still be fragmented, thus having a limited supply of non-invasive seed sources, and continuing to be susceptible to invasive species pressure from surrounding areas. This can be seen in the significant negative edge effects in both invasive and non-invasive cover models. A further investigation comparing these outcomes based on matrix land use would likely yield interesting results.

One way of illustrating the relationships found in the results is by using the framework of alternative states and positive feedbacks provided by Suding et al. (2004). Barriers to restoring degraded systems result from feedbacks, which in this case would include limited native seed sources and invasion by exotic species. By this logic, restoration success in terms of non-invasive species cover and richness can only be achieved once these feedback elements have been eliminated, as in Figure 7. Through the introduction and maintenance of propagules and the control of invasive species, environmental stewardship can provide some of the internal controls and feedback mechanisms fostered historically by more complete and contiguous canopy and understory. It remains to be seen, however, the extent to which any of the study zones can be restored to historical or reference conditions.

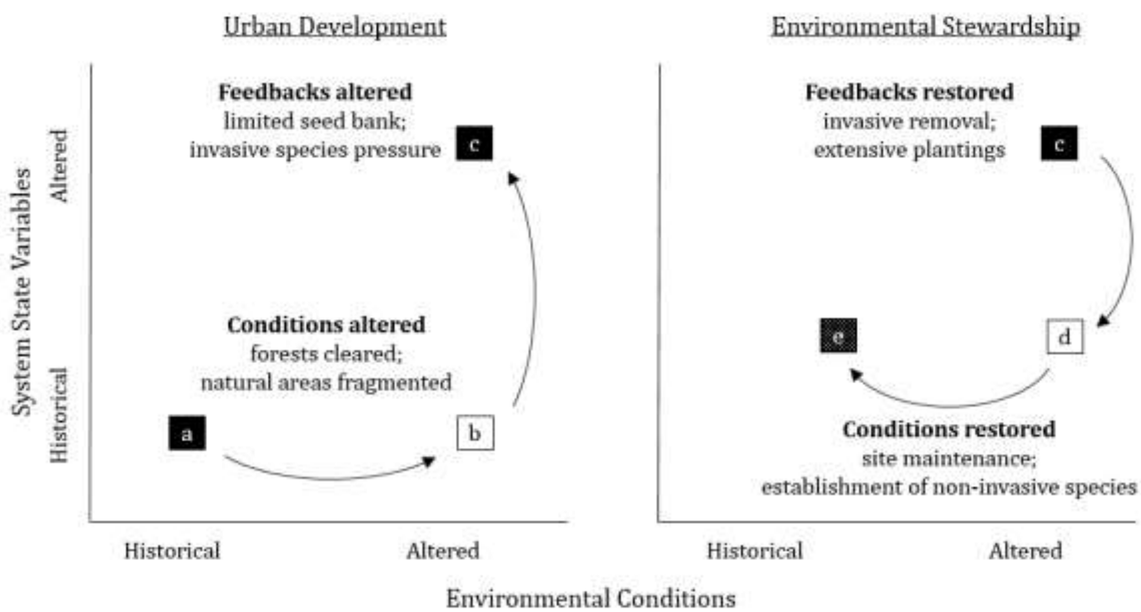

FIGURE 6: Alteration and Restoration of Environmental Conditions and Feedback Mechanisms

This figure uses the framework from Suding et al. (2004) to map environmental stewardship of GSP zones. Urban development includes the clearing of land and fragmentation of natural areas (a to b) which provides an opportunity for feedback mechanisms and internal controls such as limited propagules and invasive species pressure to prevent natural restoration to historical or desirable conditions (b to c). There is strong evidence that the GSP has addressed these biotic feedbacks and controls (c to d) on many zones, which, with continued effort, may allow for the restoration of near-historical or desirable conditions (e).

Stable states are represented by points with black letters whereas white letters are in a state of change. Since certain conditions such as fragmentation and invasive species exposure can never be eliminated in an urban setting, the desired end (e) is neither in the same place as (a) nor fully filled. This assumes that continued stewardship is part of the restored area's internal controls.

B. STUDY LIMITATIONS

There are a number of limitations in the data which should be reviewed in a discussion of the results and consideration of future use in studies. The first stems from the work logs, which is primarily due to some inconsistent reporting. As is made clear by the results, there are likely many events, especially those organized by volunteers, which do not make it into the work logs. For future studies using this data, a survey of these volunteers to get an estimate of compliance rates may allow for adjustments that would better reflect work performed. In addition, all work logs before 2007 and many between 2007 and 2010 could not be included because they were not linked to a particular zone. An improved reporting system initiated in 2011 will address this issue over time for future studies, but for this study and any others using pre-2011 data, this absence should be noted. In both instances, absence of work log data could serve to diminish the statistical significance of intervention coefficients, but where significant, could also overstate their value. Furthermore, the aggregation of volunteer and professional hours does not allow the model to account for variations within these groups. Some volunteer hours are certainly more valuable in terms of ecological outcomes than others, for example, and the same is likely true for professional hours.

Another limitation within the data is the use of new, and relatively untested more qualitative methods of ecological data collection. The coarse conditions estimation techniques, such as those employed by the SUNP and inventory protocols, while relatively inexpensive and useful for management, are yet still untested in terms of reliability and consistency. For both management and the purposes of future studies, some evaluation of assessments reliability, and a comparison with plot sampling techniques for evaluation of ecological attributes is recommended. The qualitative methods may not be as appropriate for certain attributes, such as species richness, in comparison to species cover or presence, for example.

There are also some quality considerations for the ecological data. Despite efforts to divide zones based on habitat qualities and according to the original SUNP habitat divisions, the inventory is still not a perfect match to the baseline data and imposes (or assumes) homogeneity within zones while they may actually have diverse associations and landscape types. As future inventory data is collected within the same zone boundaries, comparisons with the SUNP will become less necessary and the question of zone mismatch will become less of an issue. The problem of assumed homogeneity will remain, however, though it also applies to techniques that involve extrapolation from more precise plot sampling. Furthermore, as mentioned above, some of the this data was collected outside of what is generally considered the field season in the Pacific Northwest, and that may have biased results against deciduous or herbaceous species.

Aside from data considerations, it is important to note that the study's metrics of success are relatively coarse and limited, due to both the limitations of the data as well as their broad application across many different ecosystem types. On a site level, measures of success are far more nuanced than the three metrics chosen for this study, which, while intended to provide a proxy for ecosystem function and services, are not direct measures of these functions and services.

6. CONCLUSIONS

Preliminary results indicate that GSP restoration efforts are having an ecological impact, primarily in terms of reducing invasive cover, but not yet indicating increased non-invasive species cover or richness. Additional follow-up measurement of restoration zones may be necessary to see these changes. Intervention factors that seem most important to restoration success are the parcel's time in restoration as well as the application of herbicide, though collinearity makes factor distinction difficult. Reported professional hours and volunteer hours (to a lesser extent) were statistically significant but do not seem to be the best predictor of restoration outcomes. More consistent and reliable reporting would help with these issues – or a method of estimating and correcting for unreported work.

While the results imply a greater impact from professional effort than that of volunteers, there are a number of reasons to pause before reallocating restoration resources in this direction. One is that while the return on volunteer hours may be less than professional hours, the cost of that hour in terms of resources is likely far less for volunteers. Furthermore, because volunteers were less likely to report hours than contractors, their impact may also have been understated in the results. Perhaps more importantly, volunteer participation can be beneficial in its own right by both providing cultural ecosystem services to those participating in the activity and by maintaining a core of community support for the resources that make professional work possible.

Of the site factors reviewed, size of natural areas and their contiguity with others seems to be the most important abiotic predictor of the ecological conditions included in the study. Program managers may find that larger, more contiguous areas such as greenbelts are the relatively low hanging fruit, requiring less effort to maintain than more exposed areas such as trail buffers. More comprehensive landscape and matrix considerations would also be a recommended consideration in future research efforts.

The results also indicate that changes brought about by environmental stewardship can be self-reinforcing to a limited degree. It is very likely that continued stewardship in some form will be necessary to maintain desired ecological qualities. If we assume that environmental stewardship and management by public agencies can fill part of the gap in controls and feedback mechanisms imposed by urban development, this indicates a need for further studies to investigate the social sustainability of such practices. Measurements for independent variables that more directly track ecosystem function as opposed to structure may also be warranted in future investigations.

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APPENDICES

APPENDIX A - GREEN SEATTLE PARTNERSHIP GENERAL INFORMATION

The sections below provide some background on the Green Seattle Partnership that is intended to serve as a concise reference in understanding the accompanying data. More information on the Green Seattle Partnership can be found at http://www.greenseattle.org.

i. Program History

Before the Green Seattle Partnership

Community volunteers and stewardship groups began doing restoration work in Seattle Parks in the early 1990s when Seattle Parks and Recreation (Parks) had no official guidelines on volunteer restoration work. Initially, when volunteers (authorized or not) would begin doing restoration work in a park, Parks would create a Vegetation Management Plan (VMP) for that park which would serve as a guide for these volunteers.

In 1999-2000, Seattle Urban Nature Project (SUNP), a local non-profit, performed a habitat survey of the entire city, which further demonstrated the need for a city-wide restoration effort to renew the native canopy within forested park land.

GSP Genesis

The City of Seattle and Forterra were able to leverage the findings of the SUNP data to initiate the Green Seattle Partnership (GSP) program in 2004. This public-private partnership provides resources and technical support to local non-profits and community groups with the goal of restoring 2,500 acres (now closer to 2,750 acres) of forested Seattle park land. GSP is primarily funded and run by Seattle Parks and Recreation (Parks), though $3 million was raised by Forterra (primarily from the USFS) to help jumpstart the program, and Seattle Public Utilities have contributed between $100 - $250 thousand annually to the program.

ii. Field Work – Labor

Field work in the GSP is carried out by a combination of different groups, descriptions of which are detailed below.

Forest Stewards

One of the unique aspects of the GSP is that it trains willing volunteers to become "Forest Stewards." These volunteers complete a training and registration process. They each agree to organize at least 2 work parties per year, and many host far more. Parks provide them with support in the form of tools, plants, materials, and some time from the Parks Natural Areas Crew (NAC) to work on a section of park that they adopt. Forterra staff provide much of the day-to-day support for Forest Stewards. Some Forest Stewards are individuals from the neighborhood while others are part of more formal "Friends of" groups or other community associations. Forest Stewards contribute a great deal of time to restoration work, organize a large share of the total field work events, and recruit and involve many other volunteers from their community. Many are very resourceful about both recruiting volunteers and creating partnerships with local associations, community service organizations, and schools.

Professionally Led Work Parties

Volunteers are also involved in the GSP through participation in work parties organized by professionals. Local non-profit volunteer management and restoration oriented organizations such as EarthCorps and Nature Consortium are able to recruit large numbers of volunteers through mailing lists, advertisements, partnerships with local service organizations, and private businesses that are interested in participating in days of service and the like. Parks contracts with these non-profits s to recruit, provide a brief training to, and organize these volunteers for restoration work parties. These work parties on average tend to be larger than the Forest Steward work parties. Occasionally, the NAC or other Parks or Forterra staff will also lead volunteers in the field.

Professional Crews

A great deal of labor is also conducted directly by professional crews. These are either private contractors, the NAC, or Conservation Corps-style labor from organizations like Seattle Conservation Corps, Washington Conservation Corps or EarthCorps. The NAC also participates in a number of volunteer support activities that include delivery of tools and materials such as mulch before work parties, and removal of waste after work parties.

Who Works Where

In a given restoration area, any number of these labor options may be employed, though professional crews are largely reserved for areas in which there is not enough community support for a Forest Steward, the slope is deemed too steep for volunteers (for either safety, erosion, or access reasons), or the work involves an activity that is inappropriate for volunteers (herbicide application, use of power tools, or irrigation system installation, for example).

Reporting GSP Work

All Forest Stewards, contractors, and the NAC are directed to record all work done for the GSP in work logs, collected by an online system called CEDAR, for which they have logins. CEDAR is maintained by Forterra and was instituted in January of 2011. From 2007 - 2010, work logs were filled out on paper and sent to EarthCorps. Much of the information collected from both systems was the same, though structured a bit differently.

iii. Field Work – Location

The primary management units for the GSP are called “zones.” They range in size from about .002 acres to 23 acres, though most are within .01 - 2 acres. They are delineated roughly by habitat type but intuitive boundaries such as trails, roads, and streams often serve as boundaries as well. Zones have been added from time to time, but for the most part their boundaries remain static.

APPENDIX B: DESCRIPTION OF WORK LOG HOUR ALLOCATION METHOD FOR SELECTED WORK LOGS

Within the 2007-2010 and CEDAR work log databases, work log hours were reported by event, rather than attributing them to specific zones worked on during an event. In the example table below for example, 8 volunteer hours were spent on Event 1 at Carkeek Park. However, these 8 volunteer hours were distributed between Zone A and Zone B, where they removed 30 and 40 square feet of invasive plants and planted 3 and 8 potted plants, respectively.

Event	Park	Volunteer Hours	Zone	Invasive Removal	Potted Plants
1	Carkeek	8	A	30 ft	3
1	Carkeek	8	B	40 ft	8

In order to estimate total number of hours spent on each zone, the following steps were taken:

1. All single-zone work events in which only one task was reported for all GSP worklogs from 2007 - May 2013 were identified.
2. For each task, these single-zone, single-activity work logs were used to calculate a median number of hours per activity.
3. These median rate values were used to generate an *expected time* for each task in all of the study work logs (see example table below, which uses the same quantities as that above.
4. The total expected time for each zone was divided by the total expected time for the entire event to create an estimated time ratio for the zone within the event. This number was then multiplied by the actual number of reported hours for the event to estimate the time spent on each zone.

Zone	Reported Inv. Rem.	Median Inv. Rem. Rate	Exp. time for Inv. Rem.	Estimated Inv. Rem. Time	Reported Pot. Plants	Median Pot Plnt Rate	Expected time for Pot Plnt.	Est. Zone Ratio
A	30 ft.	.1 hr/ft	3 hr	3.42 hr	3	.25 hr/ft	.75 hr	4.17/10.74
B	40 ft.	.1 hr/ft	4 hr	4.57 hr	8	.25 hr/ft	2 hr	6.57/10.74

Estimated time for Zone A would be 8 * (4.17/10.74) = 3.11 hours

Estimated time for Zone B would be 8* (6.57/10.74) = 4.89 hours

All calculations were performed in Microsoft Excel.

APPENDIX C: SPECIES LIST & CLASSIFICATIONS

Latin Name	Common Name	Life Form	Native	Invasive List				Study Classification
				King Co.	WA State	SPR	ECS	
Abies amabalis	silver fir	tree	Yes					Non-Invasive
Abies grandis	grand fir	tree	Yes					Non-Invasive
Abies sp.	fir	tree	No					Non-Invasive
Abies procera	noble fir	tree	Yes					Non-Invasive
Acer campestre	field maple	tree	No	X				Invasive
Acer circinatum	vine maple	shrub	Yes					Non-Invasive
Acer sp.	maple	tree	No					Non-Invasive
Acer glabrum	Rocky Mountain maple	shrub	Yes					Non-Invasive
Acer macrophyllum	bigleaf maple	tree	Yes					Non-Invasive
Achillea millefolium	yarrow	herb	Yes					Non-Invasive
Acer palmatum	Japanese maple	tree	No					Non-Invasive
Acer platanoides	Norway maple	tree	No	X	X	X		Invasive
Acer pseudoplatanus	sycamore maple	tree	No	X				Invasive
Actaea rubra	baneberry	herb	Yes					Non-Invasive
Acer rubrum	red maple	tree	No					Non-Invasive
Acer saccharinum	Silver maple	tree	No					Non-Invasive
Achlys triphylla	vanilla leaf	herb	Yes					Non-Invasive
Adiantum aleuticum	maidenhair fern	herb	Yes					Non-Invasive
Adenocaulon bicolor	pathfinder	herb	Yes					Non-Invasive
Aesculus hippocastanum	horse chestnut	tree	No	X				Invasive
Aegopodium podagraria var. variegatum	snow-on-the-mountain	herb	No					Non-Invasive
Agrostis capillaris	creeping bentgrass	graminoid	No					Non-Invasive
Agrostis exarata	spike bent grass	graminoid	Yes					Non-Invasive
Agrostis sp.	bentgrass	graminoid	No					Non-Invasive
Agrostis stolonifera	creeping bentgrass	herb	No					Non-Invasive
Aira caryophyllea	silver European hairgrass	graminoid	No					Non-Invasive
Ajuga reptans	bugleweed	herb	No					Non-Invasive
Ailanthus altissima	tree of heaven	tree	No	X				Invasive
Allium cernuum	nodding onion	herb	Yes					Non-Invasive
Alliaria petiolata	Garlic mustard	herb	No	Class A	Class A			Invasive
Alisma plantago-aquatica	water plantain	herb	No			X		Invasive
Alopecurus pratensis	meadow-foxtail	graminoid	No					Non-Invasive
Alnus rubra	red alder	tree	Yes					Non-Invasive
Amelanchier alnifolia	serviceberry	shrub	Yes					Non-Invasive
Angelica genuflexa	kneeling Angelica	herb	Yes					Non-Invasive
Anaphalis margaritacea	pearly everlasting	herb	Yes					Non-Invasive
Antennaria microphylla	little-leaf pussytoes	herb	Yes					Non-Invasive
Anthoxanthum odoratum	sweet vernalgrass	graminoid	No					Non-Invasive
Andromeda polifolia	bog rosemary	shrub	Yes					Non-Invasive
Aquilegia formosa	western columbine	herb	Yes					Non-Invasive
Aquilegia sp.	columbine	herb	X					Non-Invasive
Argentina anserina	silverweed	herb	Yes					Non-Invasive
Arctostaphylos columbiana	hairy manzanita	shrub	Yes					Non-Invasive
Arctium sp.	burdock	herb	X			X		Invasive
Aruncus dioicus	goatsbeard	herb	Yes					Non-Invasive
Arrhenatherum elatius	tall oatgrass	graminoid	No					Non-Invasive

Latin Name	Common Name	Life Form	Native	Invasive List				Study Classification
				King Co.	WA State	SPR	ECS	
Arum italicum	Italian Arum	shrub	No					Non-Invasive
Arbutus menziesii	Pacific madrone	tree	Yes					Non-Invasive
Arctium minus	lesser burdock	herb	No					Non-Invasive
Artemisia suksdorfii	coastal wormwood	herb	Yes					Non-Invasive
Arbutus unedo	strawberry tree	shrub	No					Non-Invasive
Arctostaphylos uva-ursi	bearberry, kinnickinnick	shrub	Yes					Non-Invasive
Asarum caudatum	wild ginger	herb	Yes					Non-Invasive
Athyrium filix-femina	ladyfern	herb	Yes					Non-Invasive
Aucuba japonica	Japanese laurel	shrub	No					Non-Invasive
Bambusa sp.	bamboo	shrub	No			X		Invasive
Berula erecta	cutleaf waterparsnip	herb	Yes					Non-Invasive
Betula glandulosa	swamp birch	shrub	Yes					Non-Invasive
Betula papyrifera	paperbark birch	tree	Yes					Non-Invasive
Betula pendula	European white birch	tree	No	X				Invasive
Bellis perennis	English daisy	herb	No			X		Invasive
Berberis sp.	barberry	shrub	No					Non-Invasive
Berberis thunbergii	Japanese barberry	shrub	No					Non-Invasive
Betula sp.	birch	tree	No					Non-Invasive
Bidens frondosa	leafy beggar-ticks	herb	Yes					Non-Invasive
Blechnum spicant	deerfern	herb	Yes					Non-Invasive
Bolboschoenus maritimus	salt-marsh bulrush	graminoid	Yes					Non-Invasive
Borago officinalis	borage	herb	No					Non-Invasive
Brassica sp.	mustard	herb	No					Non-Invasive
Bromus racemosus	bald brome	graminoid	No					Non-Invasive
Bromus sp.	brome	graminoid	No					Non-Invasive
Bromus diandrus ssp. rigidus	ripgut brome	graminoid	No					Non-Invasive
Bromus sitchensis	Alaska brome	graminoid	Yes					Non-Invasive
Bromus tectorum	cheatgrass	graminoid	No					Non-Invasive
Bromus vulgaris	Columbia brome	graminoid	Yes					Non-Invasive
Buddleja davidii	butterflybush	shrub	No	Non-designated	Class C			Invasive
Buxus sempervirens	common box	shrub	No					Non-Invasive
Carpinus betulus	European hornbeam	tree	No					Non-Invasive
Calamagrostis canadensis	Canada reedgrass, blue joint	graminoid	Yes					Non-Invasive
Cajanus cajan	Pigeonpea	graminoid	No					Non-Invasive
Carex deweyana	Dewey sedge	graminoid	Yes					Non-Invasive
Castanea dentata	American chestnut	tree	No					Non-Invasive
Calocedrus decurrens	incense cedar	tree	No					Non-Invasive
Cardamine hirsuta	hairy bittercress	herb	No					Non-Invasive
Camellia japonica	camellia	shrub	No					Non-Invasive
Camellia sp.	camellia	shrub	No					Non-Invasive
Castilleja miniata	scarlet Indian paintbrush	herb	Yes					Non-Invasive
Carex obnupta	slough sedge	graminoid	Yes					Non-Invasive
Carex pachystachia	chamisso sedge	graminoid	Yes					Non-Invasive
Campanula persicifolia	peach-leaf bellflower	herb	No					Non-Invasive
Camassia quamash	common camas	herb	Yes					Non-Invasive
Cardaria sp.	hoary cress	herb	NO					Non-Invasive
Carex sp.	sedge	graminoid	Yes					Non-Invasive
Calystegia sepium	hedge false bindweed	herb	No	Concern			X	Invasive
Carex stipata	sawbeak sedge	graminoid	Yes					Non-Invasive

Latin Name	Common Name	Life Form	Native	Invasive List				Study Classification
				King Co.	WA State	SPR	ECS	
Castanea sp.	chestnut	tree	No					Non-Invasive
Cedrus atlantica	atlas cedar	tree	No					Non-Invasive
Cedrus deodara	Deodar cedar	tree	No					Non-Invasive
Ceratophyllum demersum	coontail	herb	Yes					Non-Invasive
Cedrus sp.	cedar	tree	No					Non-Invasive
Centaurium erythraea	Centaurium	herb	No					Non-Invasive
Cercidiphyllum japonicum	katsura tree	tree	No					Non-Invasive
Cercis occidentalis	California redbud	shrub	No					Non-Invasive
Ceanothus velutinus	snowbrush	shrub	Yes					Non-Invasive
Chamaecyparis sp.	cedar	tree	No					Non-Invasive
Chamerion angustifolium ssp. angustifolium	fireweed	herb	Yes					Non-Invasive
Chamaecyparis lawsoniana	Port Orford cedar	tree	No					Non-Invasive
Chamaecyparis nootkatensis	Alaska yellow cedar	tree	Yes					Non-Invasive
Chamaecyparis obtusa	Hinoki falsecypress	tree	No					Non-Invasive
Chamaecyparis pisifera var. 'Squarrosa'	moss falsecypress	tree	No					Non-Invasive
Chaenomeles speciosa	flowering quince	shrub	No					Non-Invasive
Circaea alpina	enchanter's nightshade	herb	Yes					Non-Invasive
Cirsium arvense	Canada thistle	herb	No	Non-designated	Class C	X		Invasive
Cichorium intybus	chicory	herb	No					Non-Invasive
Cinna latifolia	drooping woodreed	graminoid	Yes					Non-Invasive
Cirsium sp.	thistle	herb	X					Non-Invasive
Cirsium vulgare	bull thistle	herb	No	Non-designated	Class C	X		Invasive
Clethra alnifolia	coastal sweetpepperbush	shrub	No					Non-Invasive
Clarkia amoena	farewell to spring	herb	Yes					Non-Invasive
Clematis sp.	clematis	herb	No	*	*			Invasive
Claytonia perfoliata	miner's lettuce	herb	Yes					Non-Invasive
Claytonia sibirica var. sibirica	Siberian miner's lettuce	herb	Yes					Non-Invasive
Clematis vitalba	evergreen clematis	herb	No	Non-designated	Class C	X		Invasive
Convolvulus arvensis	field bindweed	herb	No	Non-designated	Class C	X		Invasive
Corylus avellana	European hazelnut	shrub	No					Non-Invasive
Cotoneaster bullatus	hollyberry cotoneaster	shrub	No	X				Invasive
Corylus cornuta	beaked hazelnut	shrub	Yes					Non-Invasive
Cotula coronopifolia	brass buttons	herb	No					Non-Invasive
Cotoneaster divaricatus	spreading cotoneaster	shrub	No	X				Invasive
Cotoneaster franchetii	franchet cotoneaster	shrub	No	X				Invasive
Conium maculatum	poison hemlock	herb	No	Non-designated	Class C	X		Invasive
Cornus nuttalli	Pacific dogwood	tree	Yes					Non-Invasive
Convolvulus sp.	bindweed	herb	No	X				Invasive
Comarum palustre	marsh cinquefoil	herb	Yes					Non-Invasive
Cornus sp.	dogwood	shrub	X					Non-Invasive
Cornus sp.	dogwood	tree	No					Non-Invasive
Corylus sp.	hazelnut	shrub	X					Non-Invasive
Corydalis scouleri	Pacific fumitory	herb	Yes					Non-Invasive
Cornus sericea	red-osier dogwood	shrub	Yes					Non-Invasive
Cortaderia selloana	pampas grass	herb	No					Non-Invasive
Cornus sericea 'Kelseyi'	redtwig dogwood 'Kelseyi'	shrub	No					Non-Invasive
Cotoneaster simonsii	Simons cotoneaster	shrub	No	X				Invasive
Cotoneaster sp.	cotoneaster	shrub	No	X				Invasive

Latin Name	Common Name	Life Form	Native	Invasive List				Study Classification
				King Co.	WA State	SPR	ECS	
Cornus unalaschkensis	bunchberry	herb	Yes					Non-Invasive
Crataegus sp.	horticultural hawthorne species	tree	No					Non-Invasive
Crataegus douglasii	Pacific hawthorn	tree	Yes					Non-Invasive
Cryptomeria japonica	Japanese cedar	tree	No					Non-Invasive
Crataegus monogyna	oneseed hawthorn	tree	No	X		X	X	Invasive
Crocosmia sp.	crocosmia	herb	X					Non-Invasive
Cucurbita sp.	garden squash	herb	No					Non-Invasive
× Cupressocyparis leylandii	Leyland cypress	tree	No					Non-Invasive
Cyclamen sp.	cyclamen	herb	No					Non-Invasive
Cynosurus cristatus	crested dogstail grass	graminoid	No					Non-Invasive
Cytisus scoparius	scotch broom	shrub	No	Non-designated	Class B	X		Invasive
Daucus carota	Queen Anne's lace	herb	No	Non-designated	Class B	X		Invasive
Dasiphora fruticosa	shrubby cinquefoil	shrub	Yes					Non-Invasive
Dactylis glomerata	orchardgrass	graminoid	No					Non-Invasive
Daphne laureola	Spurge Laural	shrub	No	Non-designated	Class B	X	X	Invasive
Daphne sp.	daphne	shrub	X					Non-Invasive
Deschampsia cespitosa	tufted hairgrass	graminoid	Yes					Non-Invasive
Deschampsia elongata	slender hairgrass	graminoid	Yes					Non-Invasive
Dicentra formosa	western bleedingheart	herb	Yes					Non-Invasive
Dipsacus fullonum	teasel	herb	No			X		Invasive
Digitalis sp.	foxglove	herb	No					Non-Invasive
Disporum hookeri	Hooker's fairybells	herb	Yes					Non-Invasive
Digitalis purpurea	foxglove	herb	No					Non-Invasive
Digitaria sanguinalis	hairy crabgrass	graminoid	No					Non-Invasive
Distichlis spicata	inland saltgrass	graminoid	Yes					Non-Invasive
Dryopteris expansa	wood fern	herb	Yes					Non-Invasive
Duchesnea indica	mock strawberry	herb	No					Non-Invasive
Echinochloa crus-galli	barnyard-grass	graminoid	No					Non-Invasive
Elaeagnus sp.	elaeagnus	shrub	X					Non-Invasive
Elodea canadensis	Canadian waterweed	herb	Yes					Non-Invasive
Eleocharis sp.	spike rush	graminoid	X					Non-Invasive
Elymus glaucus	blue wildrye	graminoid	Yes					Non-Invasive
Elymus mollis	dunegrass	graminoid	Yes					Non-Invasive
Eleocharis palustris	spike rush	herb	Yes					Non-Invasive
Elymus repens	quackgrass	graminoid	No					Non-Invasive
Empetrum nigrum	black crowberry	shrub	Yes					Non-Invasive
Epilobium ciliatum	fringed willowherb	herb	Yes					Non-Invasive
Epilobium sp.	willowherb	herb	X					Non-Invasive
Epilobium minutum	Chaparral Willow	shrub	No					Non-Invasive
Epilobium watsonii	willowherb	herb	Yes					Non-Invasive
Equisetum arvense	scouring rush	herb	Yes					Non-Invasive
Equisetum hyemale	horsetail rush	herb	Yes					Non-Invasive
Equisetum telmateia	giant horsetail rush	herb	Yes					Non-Invasive
Equisetum sp.	horsetail	herb	X					Non-Invasive
Erica sp.	heath	shrub	X					Non-Invasive
Eriophyllum lanatum	woolly sunflower	herb	Yes					Non-Invasive
Erythronium oregonum	while fawn-lily	herb	Yes					Non-Invasive
Eschscholzia californica	California poppy	herb	No					Non-Invasive
Eucalyptus sp.	eucalyptus	tree	No					Non-Invasive

Latin Name	Common Name	Life Form	Native	Invasive List				Study Classification
				King Co.	WA State	SPR	ECS	
Euonymus europaeus	European spindle tree	shrub	No					Non-Invasive
Euonymus fortunei	winter creeper	shrub	No					Non-Invasive
Euthamia occidentalis	Western goldenrod	herb	Yes					Non-Invasive
Fagus sp.	beech	tree	No					Non-Invasive
Fagus sylvatica	European beech	tree	No					Non-Invasive
Festuca idahoensis ssp. roemeri	Idaho Fescue	graminoid	Yes					Non-Invasive
Festuca rubra	red fescue	herb	No					Non-Invasive
Festuca sp.	fescue	graminoid	X					Non-Invasive
Ficus sp.	fig	shrub	No					Non-Invasive
Forsythia sp.	forsythia	shrub	No					Non-Invasive
Foeniculum vulgare	fennel	herb	No					Non-Invasive
Fragaria sp.	strawberry	herb	No					Non-Invasive
Fraxinus sp.	ash	tree	No					Non-Invasive
Fragaria chiloensis	beach strawberry	herb	Yes					Non-Invasive
Fraxinus latifolia	Oregon ash	tree	Yes					Non-Invasive
Fraxinus pennsylvanica	green ash	tree	No					Non-Invasive
Frangula purshiana	cascara	tree	Yes					Non-Invasive
Fragaria vesca	woodland strawberry	herb	Yes					Non-Invasive
Fragaria virginiana	virginia strawberry	herb	Yes					Non-Invasive
Galium aparine	stickywilly	herb	Yes					Non-Invasive
Garrya elliptica	silktassel	shrub	No					Non-Invasive
Galium sp.	bedstraw	herb	Yes					Non-Invasive
Gaultheria shallon	salal	shrub	Yes					Non-Invasive
Galium trifidum	threepetal bedstraw	herb	Yes					Non-Invasive
Geranium dissectum	Cutleaf geranium	herb	No					Non-Invasive
Geum macrophyllum	bigleaved avens	herb	Yes					Non-Invasive
Geranium molle	dove-foot geranium	herb	No					Non-Invasive
Geranium sp.	geranium	herb	No					Non-Invasive
Geranium robertianum	herb Robert	herb	No	Non-designated	Class B	X		Invasive
Geum urbanum	herb bennet	herb	No					Non-Invasive
Glechoma sp.	glechoma	herb	No					Non-Invasive
Glyceria elata	tall mannagrass	graminoid	Yes					Non-Invasive
Glechoma hederacea	ground ivy	herb	Yes					Non-Invasive
Glyceria striata	tall mannagrass	graminoid	Yes					Non-Invasive
Glyceria sp.	mana grass	graminoid	Yes					Non-Invasive
	grass	graminoid	No					Non-Invasive
Grindelia integrifolia	Pacific gumweed	herb	Yes					Non-Invasive
Helenium autumnale	common sneezeweed	herb	Yes					Non-Invasive
Hebe sp.	hebe	shrub	No					Non-Invasive
Hedera helix	English ivy	herb	No	Non-designated	Class C	X		Invasive
Helleborus sp.	hellebore	herb	No					Non-Invasive
Heracleum maximum	cow parsley	herb	Yes					Non-Invasive
Hesperis matronalis	dames rocket	herb	No					Non-Invasive
Heracleum mantegazzianum	giant hogweed	herb	No	Class A				Invasive
Hemerocallis sp.	daylilly	herb	No					Non-Invasive
Heuchera micrantha	small-flowered alumroot	herb	Yes					Non-Invasive
Hieracium albiflorum	White-flowered hawkweed	herb	Yes					Non-Invasive
Hordeum brachyantherum	meadow barley	graminoid	Yes					Non-Invasive
Holodiscus discolor	oceanspray	shrub	Yes					Non-Invasive

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				King Co.	WA State	SPR	ECS	
Holcus lanatus	velvetgrass	graminoid	No	X				Invasive
Hosta sp.	plantain lily	herb	No					Non-Invasive
Hydrangea sp.	hydrangea	shrub	No					Non-Invasive
Hyacinthoides hispanica	Spanish bluebell	herb	No	X			X	Invasive
Hypericum perforatum	St. John's wort	herb	No	Non-designated	Class C	X		Invasive
Hypericum sp.	St. Johnswort	herb	No					Non-Invasive
Hypochaeris radicata	hairy cat's-ear	herb	No	Non-designated	Class B	X		Invasive
Hydrocotyle ranunculoides	floating marsh-pennywort	herb	Yes					Non-Invasive
Hydrophyllum tenuipes	Pacific waterleaf	herb	Yes					Non-Invasive
Ilex aquifolium	English holly	tree	No	Concern		X		Invasive
Ilex crenata	Japanese holly	shrub	No					Non-Invasive
Ilex sp.	Holly	tree	No					Non-Invasive
Impatiens capensis	jewelweed	herb	No	X				Invasive
Impatiens glandulifera	Policeman's helmet	herb	No	x				Invasive
Iris douglasiana	Douglas iris	herb	No					Non-Invasive
Iris sp.	iris	herb	X					Non-Invasive
Iris pseudacorus	yellow flag iris	herb	No	Non-designated	Class C			Invasive
Iris tenax	Oregon iris	herb	Yes					Non-Invasive
Juncus acminatus	tapertip rush	graminoid	Yes					Non-Invasive
Juncus balticus	Baltic Rush	graminoid	No					Non-Invasive
Juniperus communis	common juniper	tree	Yes					Non-Invasive
Juncus effusus	soft rush	graminoid	Yes					Non-Invasive
Juncus ensifolius	daggerleaf rush	graminoid	Yes					Non-Invasive
Juncus filiformis	thread rush	graminoid	Yes					Non-Invasive
Juglans sp.	walnut	tree	No					Non-Invasive
Juncus sp.	rush	graminoid	X					Non-Invasive
Juglans nigra	black walnut	tree	No					Non-Invasive
Juniperus sp.	juniper	shrub	X					Non-Invasive
Juniperus sp.	juniper	tree	No					Non-Invasive
Juglans regia	English walnut	tree	No					Non-Invasive
Juncus tenuis	slender rush	graminoid	Yes					Non-Invasive
Kalmia microphylla	Western swamp laurel	shrub	Yes					Non-Invasive
Kerria japonica	Japanese rose	shrub	No					Non-Invasive
Kniphofia uvaria	torch lily	herb	No					Non-Invasive
Laburnum anagyroides	golden chain tree	tree	No				X	Invasive
Laburnum sp.	golden chain tree	tree	No	X				Invasive
Lapsana communis	nipplewort	herb	No				X	Invasive
Lamiastrum galeobdolon	yellow archangel	herb	No	X				Invasive
Lathyrus japonicus	beach pea	herb	Yes					Non-Invasive
Lathyrus latifolius	everlasting pea	herb	No					Non-Invasive
Lamium sp.	deadnettle	herb	X					Non-Invasive
Lathyrus nevadensis	Sierra pea	herb	Yes					Non-Invasive
Larix occidentalis	western larch	tree	Yes					Non-Invasive
Lathyrus polyphyllus	leafy pea	herb	Yes					Non-Invasive
Lamium purpureum	dead-nettle	herb	No			X	X	Invasive
Larix sp.	larch	tree	No					Non-Invasive
Lactuca serriola	prickly lettuce	herb	No					Non-Invasive
Lavandula sp.	lavender	herb	No					Non-Invasive
	lawn	graminoid	X					Non-Invasive

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				King Co.	WA State	SPR	ECS	
Ledum groenlandicum	Labrador tea	shrub	Yes					Non-Invasive
Lepidium latifolium	perennial pepperweed	herb	No	Class B				Invasive
Lemna minor	duckweed	herb	Yes					Non-Invasive
Leymus mollis	dune grass	graminoid	Yes					Non-Invasive
Leucanthemum vulgare	oxeye daisy	herb	No					Non-Invasive
Linaria dalmatica	Dalmatian toadflax	herb	No	Class B	Class B			Invasive
Ligustrum sp.	privet hedge	shrub	No					Non-Invasive
Liriodendron sp.	tuliptree	tree	No					Non-Invasive
Ligustrum sinense	Chinese privet	shrub	No	X				Invasive
Liquidambar styraciflua	American sweetgum	tree	No					Non-Invasive
Liriodendron tulipifera	tuliptree	tree	No					Non-Invasive
Lonicera ciliosa	orange honeysuckle	herb	Yes					Non-Invasive
Lotus corniculatus	bird's-foot trefoil	herb	No					Non-Invasive
Lonicera hispidula	hairy honeysuckle	herb	Yes					Non-Invasive
Lonicera involucrata	twinberry	shrub	Yes					Non-Invasive
Lolium sp.	ryegrass	herb	No					Non-Invasive
Lonicera nitida	box honeysuckle	shrub	No					Non-Invasive
Lonicera sp.	honeysuckle	shrub	No					Non-Invasive
Lolium perenne	perennial ryegrass	graminoid	No					Non-Invasive
Lotus unifoliolatus	American bird's-foot trefoil	herb	Yes					Non-Invasive
Lunaria annua	annual honesty	herb	No	X			X	Invasive
Lupinus arcticus	arctic lupine	herb	Yes					Non-Invasive
Lupinus bicolor	two -color lupine	herb	Yes					Non-Invasive
Lupinus latifolius	broadleaf lupine	herb	Yes					Non-Invasive
Luzula multiflora	common woodrush	herb	Yes					Non-Invasive
Luzula parviflora	small-flowered woodrush	graminoid	Yes					Non-Invasive
Lupinus sp.	lupine	herb	Yes					Non-Invasive
Lupinus polyphyllus	bigleaf lupine	herb	Yes					Non-Invasive
Luzula sp.	woodrush	graminoid	X					Non-Invasive
Lysichiton americanus	skunk cabbage	herb	Yes					Non-Invasive
Lycopus americanus	cut-leaved bugleweed	herb	Yes					Non-Invasive
Lychnis coronaria	rose campion	herb	No					Non-Invasive
Lycopus sp.	water-horehound	herb	Yes					Non-Invasive
Lythrum salicaria	purple loosestrife	herb	No	Class B	Class B	X		Invasive
Lycopus uniflorus	Northern water horehound	herb	Yes					Non-Invasive
Mahonia aquifolium	tall Oregon grape	shrub	Yes					Non-Invasive
Maianthemum dilatatum	false lily-of-the-valley	herb	Yes					Non-Invasive
Malus domestica	domestic apple	tree	No					Non-Invasive
Malus fusca	western crabapple	shrub	Yes					Non-Invasive
Magnolia grandiflora	southern magnolia	tree	No					Non-Invasive
Maianthemum sp.	solomon's seal	herb	Yes					Non-Invasive
Malus sp.	horticultural apple species	tree	No					Non-Invasive
Madia	tarweed	herb	X					Non-Invasive
Mahonia nervosa	low Oregon grape	shrub	Yes					Non-Invasive
Maianthemum racemosum	false Solomon's seal	herb	Yes					Non-Invasive
Mahonia repens	creeping barberry	shrub	Yes					Non-Invasive
Maianthemum stellatum	Star-flowered false solomon's seal	herb	Yes					Non-Invasive
Melilotus albus	white sweet clover	herb	No					Non-Invasive
Mentha arvensis	field mint	herb	Yes					Non-Invasive

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				King Co.	WA State	SPR	ECS	
Metasequoia glyptostroboides	dawn redwood	tree	No					Non-Invasive
Medicago lupulina	hop clover	herb	No					Non-Invasive
Melissa officinalis	lemon balm	herb	No					Non-Invasive
Melica spectabilis	purple oniongrass	herb	Yes					Non-Invasive
Melica subulata	Alaska oniongrass	graminoid	Yes					Non-Invasive
Mimulus guttatus	seep monkey-flower	herb	Yes					Non-Invasive
Morus alba	White mulberry	graminoid	No					Non-Invasive
Morella californica	pacific wax myrtle	shrub	Yes					Non-Invasive
Myosotis discolor	changing forget-me-not	herb	No					Non-Invasive
Myrica gale	sweet myrtle	shrub	Yes					Non-Invasive
Mycelis muralis	wall-lettuce	herb	No					Non-Invasive
Myosotis sp.	forget-me-not	herb	No					Non-Invasive
Myosotis scorpiodes	water forget-me-not	herb	No					Non-Invasive
Myriophyllum spicatum	milfoil	herb	No	Non-designated	Class B	X		Invasive
Myosotis sylvatica	garden forget me not	herb	No					Non-Invasive
Najas guadalupensis	Guadalupe water-nymph	herb	Yes					Non-Invasive
Narcissus sp.	daffodil	herb	No					Non-Invasive
Nothochelone nemorosa	woodland beardtongue	herb	Yes					Non-Invasive
Nuphar sp.	yellow water lily	herb	X					Non-Invasive
Nuphar lutea ssp. polysepala	yellow pond-lily	herb	Yes					Non-Invasive
Nymphaea sp.	waterlily	herb	X					Non-Invasive
Nymphaea odorata	fragrant waterlily	herb	No	Non-designated	Class C	X		Invasive
Oemleria cerasiformis	indian plum	shrub	Yes					Non-Invasive
Oenanthe sarmentosa	water parsley	herb	Yes					Non-Invasive
Olsynium douglasii	purple-eyed grass	herb	Yes					Non-Invasive
Oplopanax horridus	devil's club	herb	Yes					Non-Invasive
Ornithogalum umbellatum	star-of-Bethlehem	herb	No					Non-Invasive
Osmorhiza berteroi	sweet cicely	herb	Yes					Non-Invasive
Osmanthus sp.	devilwood	shrub	No					Non-Invasive
Osmorhiza purpurea	sweet cicely	herb	Yes					Non-Invasive
Oxalis oregana	redwood sorrel	herb	Yes					Non-Invasive
Panicum capillare	Old Witch grass	graminoid	No					Non-Invasive
Pachistima myrsinites	Oregon boxwood, Oregon boxleaf	shrub	Yes					Non-Invasive
Papaver sp.	poppies	herb	No					Non-Invasive
Petasites frigidus v. palmatus	coltsfoot	herb	Yes					Non-Invasive
Penstemon rupicola	rock penstemon	herb	Yes					Non-Invasive
Penstemon serrulatus	coast penstemon	herb	Yes					Non-Invasive
Phalaris arundinacea	reed canarygrass	graminoid	No	Non-designated	Class C	X		Invasive
Physocarpus capitatus	Pacific ninebark	shrub	Yes					Non-Invasive
Phragmites australis	common reed	graminoid	No	X				Invasive
Philadelphus sp.	ornamental mock orange	shrub	No					Non-Invasive
Philadelphus lewisii	mockorange	shrub	Yes					Non-Invasive
Photinia sp.	chokeberry	shrub	No					Non-Invasive
Phleum pratense	timothygrass	graminoid	No					Non-Invasive
Picea Abies	Norway spruce	tree	No					Non-Invasive
Picea sp.	spruce	tree	No					Non-Invasive
Pinus contorta	shore pine	tree	Yes					Non-Invasive
Picea engelmannii	Engelmann's spruce	tree	Yes					Non-Invasive
Pieris japonica	Japanese pieris	shrub	No					Non-Invasive

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				King Co.	WA State	SPR	ECS	
Picea mariana	black spruce	tree	No					Non-Invasive
Pinus monticola	western white pine	tree	Yes					Non-Invasive
Pinus mugo	mugo pine	tree	No					Non-Invasive
Pinus nigra	Austrian pine	tree	No					Non-Invasive
Pinus sp.	pine	tree	No					Non-Invasive
Pinus ponderosa	ponderosa pine	tree	Yes					Non-Invasive
Picea pungens	blue spruce	tree	No					Non-Invasive
Pinus sabiniana	digger pine, gray pine	tree	No					Non-Invasive
Picea sitchensis	Sitka spruce	tree	Yes					Non-Invasive
Pinus sylvestrus	scotch pine	tree	No					Non-Invasive
Pinus tabuliformis	Chinese Pine	tree	No					Non-Invasive
Pinus thunbergii	Japanese black pine	tree	No					Non-Invasive
Platanus × acerifolia	London planetree	tree	No					Non-Invasive
Plantago sp.	plantain	herb	X					Non-Invasive
Plantago lanceolata	lance-leaved plantain	herb	No			X		Invasive
Plantago major	broad-leaved plantain	herb	No			X		Invasive
Plantago maritima	salt marsh plantain	herb	Yes					Non-Invasive
Poa sp.	bluegrass	graminoid	X					Non-Invasive
Populus alba	white poplar	tree	No			X		Invasive
Poa annua	annual bluegrass	graminoid	No					Non-Invasive
Populus balsamifera ssp. trichocarpa	black cottonwood	tree	Yes					Non-Invasive
Polygonum ×bohemicum	Bohemian knotweed	herb	No	x				Invasive
Polygonum convolvulus	black bindweed	herb	No					Non-Invasive
Polygonum cuspidatum	Japanese knotweed	herb	No	Concern	Class B	X		Invasive
Populus deltoides	eastern cottonwood	tree	No					Non-Invasive
Polypodium glycyrrhiza	licorice fern	herb	Yes					Non-Invasive
Potentilla gracilis	slender cinquefoil	herb	Yes					Non-Invasive
Polygonum hydropiperoides	mild waterpepper	herb	Yes					Non-Invasive
Polygonum lapathifolium	smartweed	herb	No			X		Invasive
Polygonum sp.	knotweed	herb	No	*	*			Invasive
Polystichum munitum	sword fern	herb	Yes					Non-Invasive
Populus nigra	black poplar	tree	No					Non-Invasive
Polygonum persicaria	spotted ladysthumb	herb	No					Non-Invasive
Poa pratensis	Kentucky bluegrass	graminoid	No					Non-Invasive
Potamogeton pusillus ssp. tenuissimus	Berchtold's pondweed	herb	Yes					Non-Invasive
Populus sp.	horticultural poplar varieties	tree	No					Non-Invasive
Potamogeton richardsonii	Richardson's pondweed	herb	Yes					Non-Invasive
Polygonum sachalinense	giant knotweed	herb	No	Concern	Class B	X		Invasive
Populus tremuloides	aspen	tree	Yes					Non-Invasive
Prunus avium	sweet cherry	tree	No	X				Invasive
Prunus cerasifera	cherry plum	tree	No					Non-Invasive
Prunus emarginata	bitter cherry	tree	Yes					Non-Invasive
Primula sp.	primrose	herb	No					Non-Invasive
Prunus laurocerasus	cherry laurel	tree	No	Concern		X		Invasive
Prunus lusitanica	Portugal laurel	tree	No	X				Invasive
Prunus x pugetensis	hybrid bitter cherry	tree	No					Non-Invasive
Prunus sp.	horticultural cherry species	tree	No					Non-Invasive
Prunella vulgaris	common self heal	herb	Yes					Non-Invasive
Pseudotsuga menziesii	Douglas fir	tree	Yes					Non-Invasive

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				King Co.	WA State	SPR	ECS	
Pseudognaphalium stramineum	cotton-batting plant	herb	Yes					Non-Invasive
Pteridium aquilinum	bracken fern	herb	Yes					Non-Invasive
Pyracantha sp.	firethorn	shrub	No					Non-Invasive
Pyrus sp.	ornamental pear	tree	No					Non-Invasive
Quercus dentata	Daimyo Oak	tree	No					Non-Invasive
Quercus sp.	oak	tree	No					Non-Invasive
Quercus garryana	Garry oak	tree	Yes					Non-Invasive
Quercus kellogii	black oak	tree	No					Non-Invasive
Quercus palustris	pin oak	tree	No					Non-Invasive
Quercus robur	English oak	tree	No					Non-Invasive
Quercus rubra	red oak	tree	No					Non-Invasive
Ranunculus acris	meadow buttercup	herb	No	X				Invasive
Ranunculus repens	creeping buttercup	herb	No	X		X	X	Invasive
Ranunculus uncinatus	woodland buttercup	herb	Yes					Non-Invasive
Rhus glabra	smooth sumac	shrub	Yes					Non-Invasive
Rhododendron macrophyllum	western rhododendron	shrub	Yes					Non-Invasive
Rhododendron sp.	horticultural rhododendron varieties	shrub	No					Non-Invasive
Rhus typhina	staghorn sumac	shrub	No					Non-Invasive
Ribes sp.	currant	shrub	X					Non-Invasive
Ribes bracteosum	stink currant	shrub	Yes					Non-Invasive
Ribes divaricatum	wild gooseberry	shrub	Yes					Non-Invasive
Ribes lacustre	swamp gooseberry	shrub	Yes					Non-Invasive
Ribes sanguineum	red-flowering currant	shrub	Yes					Non-Invasive
Ribes viscosissimum	sticky currant	shrub	Yes					Non-Invasive
Rosa gymnocarpa	baldhip rose	shrub	Yes					Non-Invasive
Rosa multiflora	Japanese rambler rose	shrub	No					Non-Invasive
Rorippa nasturtium-aquaticum	water cress	herb	No					Non-Invasive
Rosa nutkana	Nootka rose	shrub	Yes					Non-Invasive
Rosa pisocarpa	clustered wildrose	shrub	Yes					Non-Invasive
Robinia pseudoacacia	black locust	tree	No	x				Invasive
Rosa rugosa	beach rose	shrub	No					Non-Invasive
Rosa sp.	rose	shrub	No					Non-Invasive
Rosa woodsii	wood's rose	shrub	Yes					Non-Invasive
Rumex acetosella	sheep sorel	herb	No					Non-Invasive
Rumex aquaticus	Western Dock	graminoid	No					Non-Invasive
Rubus armeniacus	Himalayan blackberry	shrub	No	Concern		X		Invasive
Rubus sp.	raspberry	shrub	No					Non-Invasive
Rumex crispus	curly dock	herb	No					Non-Invasive
Rudbeckia hirta	Black Eyed Susan	graminoid	No					Non-Invasive
Rubus laciniatus	evergreen blackberry	shrub	No	Concern		X		Invasive
Rubus leucodermis	blackcap	shrub	Yes					Non-Invasive
Rumex sp.	dock	herb	X					Non-Invasive
Rumex obtusifolius	bitter dock	herb	No					Non-Invasive
Rubus parviflorus	thimbleberry	shrub	Yes					Non-Invasive
Rubus spectabilis	salmonberry	shrub	Yes					Non-Invasive
Rubus ursinus	creeping blackberry	shrub	Yes					Non-Invasive
Sassafras albidum	common sassafras	tree	No					Non-Invasive
Sambucus cerulea	blue elderberry	shrub	Yes					Non-Invasive

Latin Name	Common Name	Life Form	Native	Invasive List				Study Classification
				King Co.	WA State	SPR	ECS	
Salicornia depressa	Virginia glasswort	herb	No					Non-Invasive
Salix hookeriana	Hooker's willow	shrub	Yes					Non-Invasive
Salix hookeriana	Hooker's willow	tree	Yes					Non-Invasive
Sagittaria latifolia	wapato	herb	Yes					Non-Invasive
Salix sp.	willow	tree	No					Non-Invasive
Salix lucida ssp. lasiandra	Pacific willow	shrub	Yes					Non-Invasive
Salix lucida ssp. lasiandra	Pacific willow	tree	Yes					Non-Invasive
Salix purpurea 'Nana'	Alaska blue willow	shrub	No					Non-Invasive
Sambucus racemosa	red elderberry	shrub	Yes					Non-Invasive
Salix scouleriana	Scouler's willow	shrub	Yes					Non-Invasive
Salix scouleriana	Scouler's willow	tree	Yes					Non-Invasive
Salix sitchensis	Sitka willow	shrub	Yes					Non-Invasive
Schoenoplectus acutus var. acutus	hard-stemmed bulrush	graminoid	Yes					Non-Invasive
Scirpus cyperinus	woolgrass	graminoid	Yes					Non-Invasive
Scilla sp.	wood hyacinth	herb	No					Non-Invasive
Scilla sp.	scilla	herb	No					Non-Invasive
Scirpus sp.	bulrush	graminoid	X					Non-Invasive
Scirpus microcarpus	small-seeded bulrush	graminoid	Yes					Non-Invasive
Schedonorus phoenix	tall fescue	graminoid	No					Non-Invasive
Schoenoplectus tabernaemontani	soft-stemmed bulrush	graminoid	Yes					Non-Invasive
Senecio cineraria	dusty miller	herb	No					Non-Invasive
Sedum sp.	sedum	herb	X					Non-Invasive
Sequoiadendron giganteum	giant sequoia	tree	No					Non-Invasive
Senecio jacobaea	tansy ragwort	herb	No	Class B	Class B		x	Invasive
Senecio sp.	groundsel	herb	No					Non-Invasive
Sequoia sempervirens	coast redwood	tree	No					Non-Invasive
Sisyrinchium californicum	golden-eyed grass	herb	Yes					Non-Invasive
Sidalcea hendersonii	Henderson's checker-mallow	herb	Yes					Non-Invasive
Sisyrinchium idahoense	Idaho blue-eyed grass	herb	Yes					Non-Invasive
Sisyrinchium idahoense	Idaho blue-eyed grass	herb	Yes					Non-Invasive
Sonchus arvensis	perennial sowthistle	herb	No	Class B				Invasive
Sorbus aucuparia	European mountain ash	tree	No	X				Invasive
Solidago canadensis	Canada goldenrod	herb	Yes					Non-Invasive
Solanum dulcamara	deadly nightshade	herb	No	Concern		X	X	Invasive
Solidago sp.	goldenrod	herb	X					Non-Invasive
Sonchus sp.	sowthistle	herb	No					Non-Invasive
Sonchus oleraceus	annual sowthistle	herb	No					Non-Invasive
Sorbus sp.	mountain ash	tree	No					Non-Invasive
Sorbus sitchensis	Sitka mountain ash	tree	Yes					Non-Invasive
Spartina alterniflora	smooth cord grass	graminoid	No	Class B	Class B			Invasive
Spiraea betulifolia	birch-leaved spirea	shrub	Yes					Non-Invasive
Spiraea douglasii	hardhack	shrub	Yes					Non-Invasive
Sparganium eurycarpum	broad-fruited bur-reed	herb	Yes					Non-Invasive
Spiraea sp.	spirea	shrub	X					Non-Invasive
Spiraea japonica	Japanese spirea	shrub	No					Non-Invasive
Stachys sp.	hedgenettle	herb	X					Non-Invasive
Stachys chamissonis var. cooleyae	Cooley's hedge-nettle	herb	Yes					Non-Invasive
Stellaria crispa	curled starwort	herb	Yes					Non-Invasive

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Stellaria media	chickweed	herb	No					Non-Invasive
Stipa occidentalis	Western needlgrass	graminoid	Yes					Non-Invasive
Symphoricarpos albus	snowberry	shrub	Yes					Non-Invasive
Symphoricarpos hesperius	creeping snowberry	shrub	Yes					Non-Invasive
Symphoricarpos mollis	creeping snowberry	shrub	Yes					Non-Invasive
ymphotrichum sp.	aster	herb	Yes					Non-Invasive
Symphytum officinale	garden comfrey	herb	No					Non-Invasive
Syringa sp.	lilac	shrub	No					Non-Invasive
Syringia sp.	lilac	shrub	No					Non-Invasive
Symphyotrichum subspicatum var. subspicatum	Douglas aster	herb	Yes					Non-Invasive
Taxus brevifolia	western yew	tree	Yes					Non-Invasive
Taxodium distichum	bald cypress	tree	No					Non-Invasive
Taraxacum officinale	dandelion	herb	No					Non-Invasive
Tanacetum vulgare	common tansy	herb	No	Non-designated	Class C			Invasive
Taxus sp.	yew	tree	No					Non-Invasive
Tellima grandiflora	fringecup	herb	Yes					Non-Invasive
Thuja occidentalis	American arborvitae	tree	No					Non-Invasive
Thalictrum occidentale	western meadow-rue	herb	Yes					Non-Invasive
Thuja plicata	western red cedar	tree	Yes					Non-Invasive
Tilia cordata	littleleaf linden	tree	No					Non-Invasive
Tilia sp.	linden	tree	No					Non-Invasive
Tiarella trifoliata	foamflower	herb	Yes					Non-Invasive
Toxicodendron diversilobum	poison oak	shrub	Yes					Non-Invasive
Tolmiea menziesii	piggy-back plant	herb	Yes					Non-Invasive
Trientalis borealis ssp. latifolia	starflower	herb	Yes					Non-Invasive
Trifolium sp.	clover	herb	X					Non-Invasive
Triticum sp.	wheat	graminoid	No					Non-Invasive
Triglochin maritima	seaside arrowgrass	graminoid	Yes					Non-Invasive
Trillium ovatum	trillium	herb	Yes					Non-Invasive
Trifolium pratense	red clover	herb	No					Non-Invasive
Trifolium repens	white Dutch clover	herb	No					Non-Invasive
Tsuga heterophylla	western hemlock	tree	Yes					Non-Invasive
Tsuga mertensiana	mountain hemlock	tree	Yes					Non-Invasive
Tulipa sp.	tulip	herb	No					Non-Invasive
Typha latifolia	cattail	graminoid	Yes					Non-Invasive
Ulmus americana	American elm	tree	No					Non-Invasive
Ulex europaeus	gorse	shrub	No	Class B	Class B	X		Invasive
Ulmus sp.	elm	tree	No					Non-Invasive
Ulmus procera	English elm	tree	No	X				Invasive
Umbellularia californica	California bay	tree	No					Non-Invasive
Unknown tree sp.	Unknown tree sp.	tree	No					Non-Invasive
Urtica dioica	stinging nettle	herb	Yes					Non-Invasive
Vancouveria hexandra	inside-out flower	herb	Yes					Non-Invasive
Vaccinium ovatum	evergreen huckleberry	shrub	Yes					Non-Invasive
Vaccinium parvifolium	red huckleberry	shrub	Yes					Non-Invasive
Veronica americana	American brooklime	herb	Yes					Non-Invasive
Veronica americana	American brooklime	herb	Yes					Non-Invasive

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Veronica officinalis	common gypsyweed	herb	No					Non-Invasive
Veronica sp.	speedwell	herb	No					Non-Invasive
Veronica serpyllifolia	thymeleaf speedwell	herb	No					Non-Invasive
Verbascum thapsus	mullein	herb	No			X		Invasive
Vicia americana	American vetch	herb	Yes					Non-Invasive
Viburnum bodnantense	dawn viburnum	shrub	No					Non-Invasive
Viburnum sp.	viburnum	shrub	No					Non-Invasive
Viola canadensis	Canadian violet	herb	Yes					Non-Invasive
Vicia sp.	vetch	herb	No					Non-Invasive
Vicia cracca	bird vetch	herb	No					Non-Invasive
Viburnum edule	high-bush cranberry	shrub	Yes					Non-Invasive
Vicia gigantea	giant vetch	herb	Yes					Non-Invasive
Viola glabella	pioneer violet	herb	Yes					Non-Invasive
Vicia hirsuta	hairy vetch	herb	No					Non-Invasive
Vinca major	bigleaf periwinkle	herb	No					Non-Invasive
Vinca minor	periwinkle	herb	No					Non-Invasive
Vinca sp.	periwinkle	herb	No				X	Invasive
Viola sp.	violet	herb	Yes					Non-Invasive
Viburnum opulus	American cranberrybush	shrub	Yes					Non-Invasive
Viola orbiculata	round-leaved yellow violet	herb	Yes					Non-Invasive
Vicia sativa	garden vetch	herb	No					Non-Invasive
Viola sempervirens	evergreen violet	herb	Yes					Non-Invasive
Viburnum tinus	laurustinus	shrub	No					Non-Invasive
Vitis sp.	grape	herb	No					Non-Invasive
Xerophyllum tenax	beargrass	herb	Yes					Non-Invasive
Zelkova serrata	Japanese zelkova	tree	No					Non-Invasive