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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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**Urban Environmental Stewardship in Practice:  
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conditions, and restoration efforts**

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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

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

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# 1. INTRODUCTION

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

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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

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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

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### A. SELF-SUSTAINABILITY VS MAINTENANCE IN URBAN RESTORATION ECOLOGY

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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

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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

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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 *Pseudotsuga 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 20<sup>th</sup> 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).

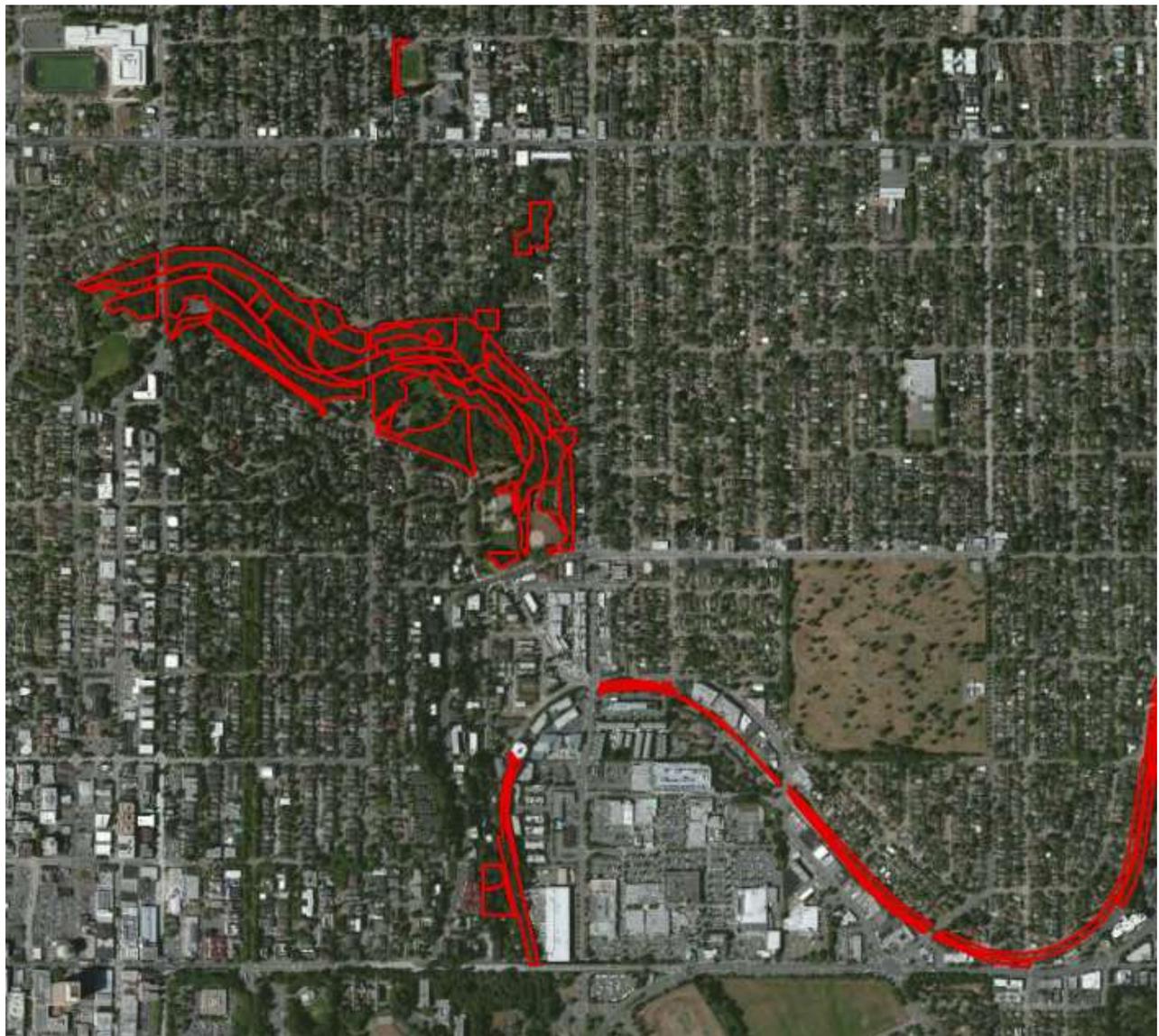
Many local volunteer groups recognized the issues of invasive species and halted succession in natural areas during the previous decade and began organizing and participating in (in some cases unsanctioned) restoration work. To address both the ecological concerns of the forest and provide a framework 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

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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

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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 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

<b>Metric</b>	<b>Functional Definition</b>	<b>Significance</b>
<b>Native and other non-invasive species richness - “Species Richness”</b>	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).
<b>Total estimated native and other non-invasive species cover “Native Cover”</b>	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).
<b>Total invasive species cover “Invasive Cover”</b>	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 zone was covered by a single SUNP polygon, the data for that SUNP polygon was used to determine the zone's baseline data. Where no individual SUNP polygon overlapped a zone by at least 66%, the zone was not included in the study. Currently, GSP is responsible for managing 1,547 zones encompassing 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 were 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

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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

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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

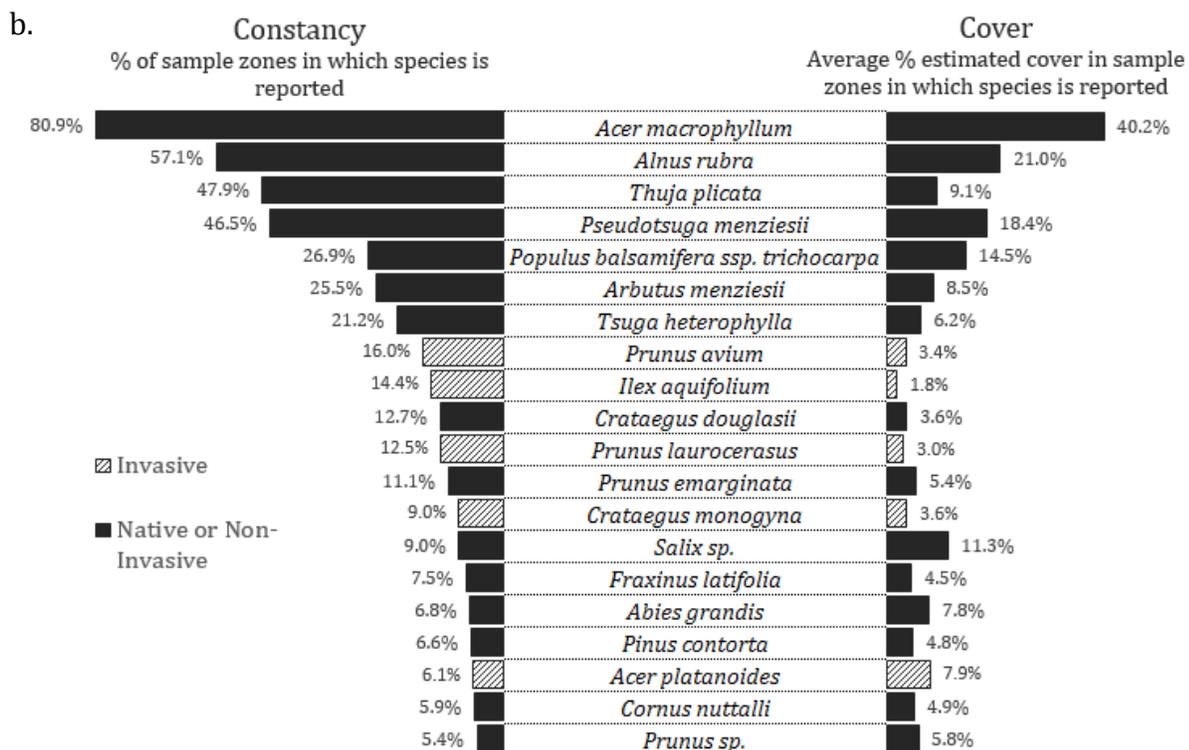
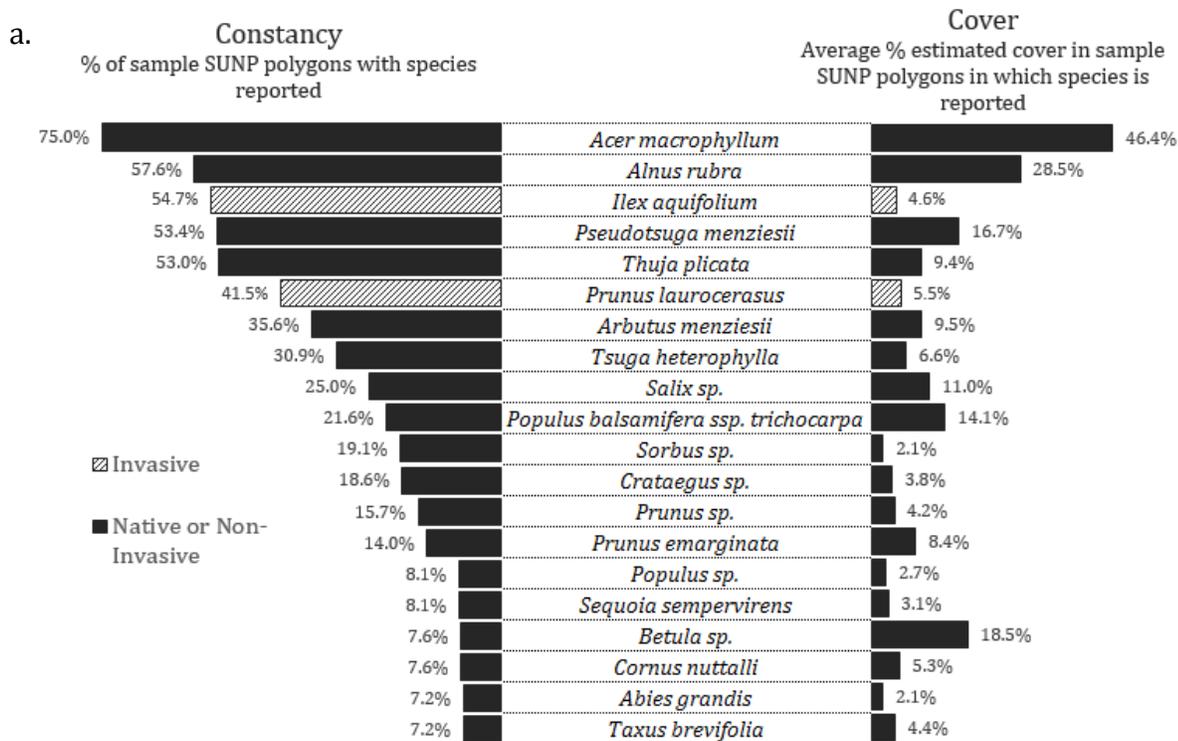
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#### i. Vegetation Trends

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

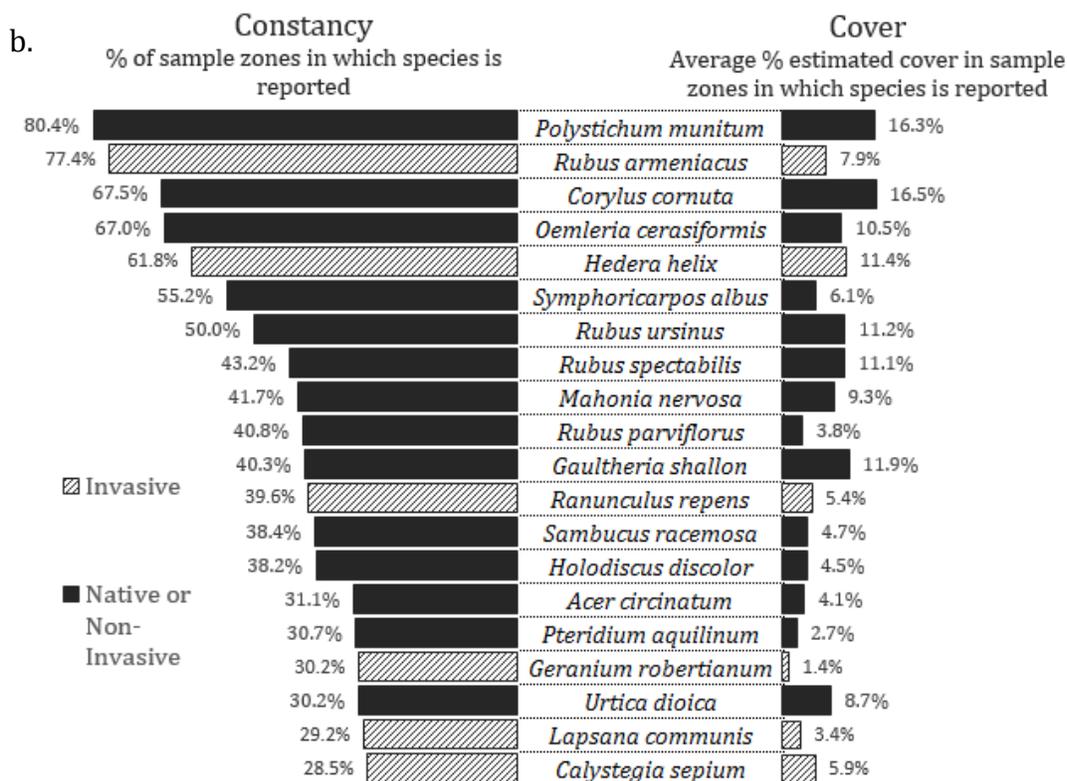
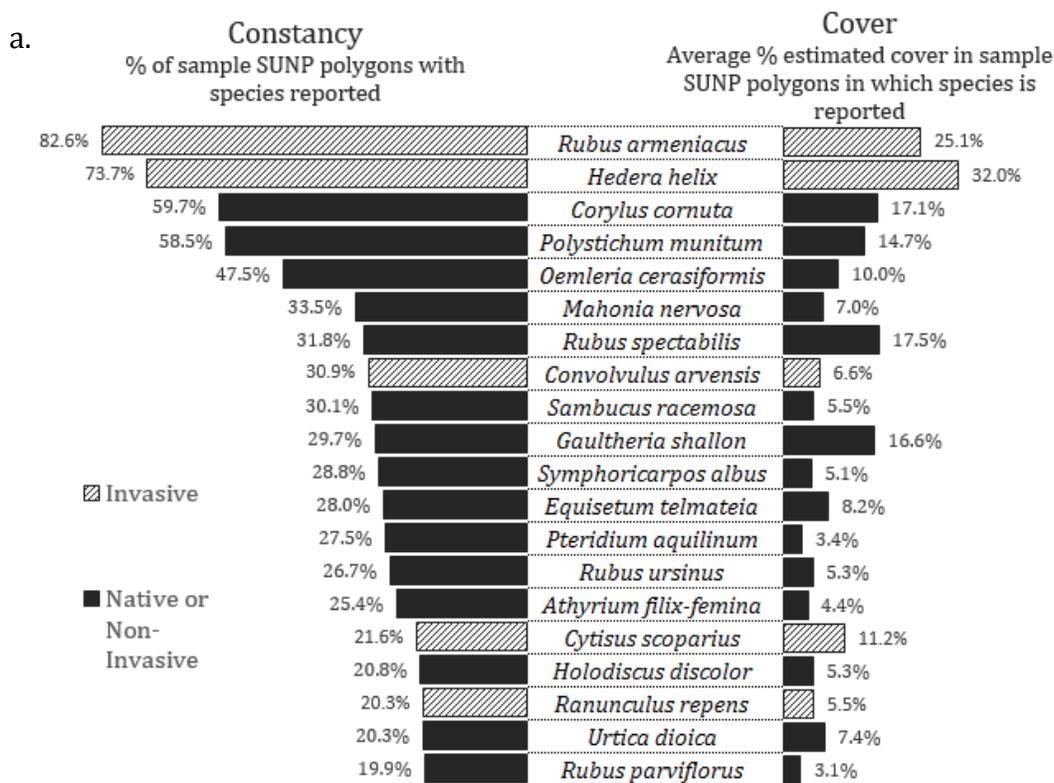
percent cover – particularly English holly (*I. aquifolium*) and cherry laurel (*P. laurocerasus*). It is likely that the more explicit designation of species from the SUNP survey to Inventory explains the appearance of wild cherry (*P. avium*), Norway maple (*A. platanoides*), and English hawthorn (*C. 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.



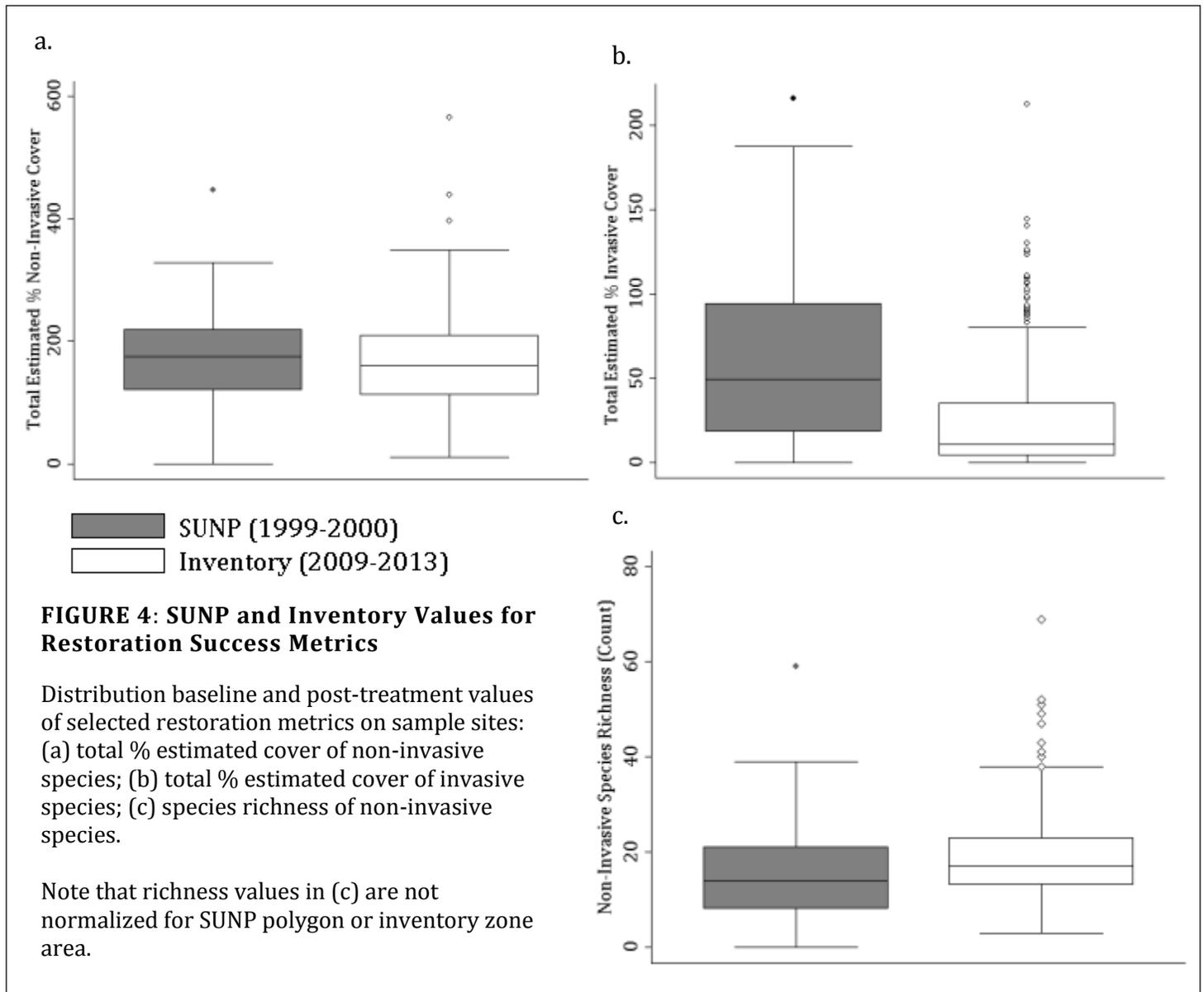
**FIGURE 2: Tree Cover and Constancy**

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**

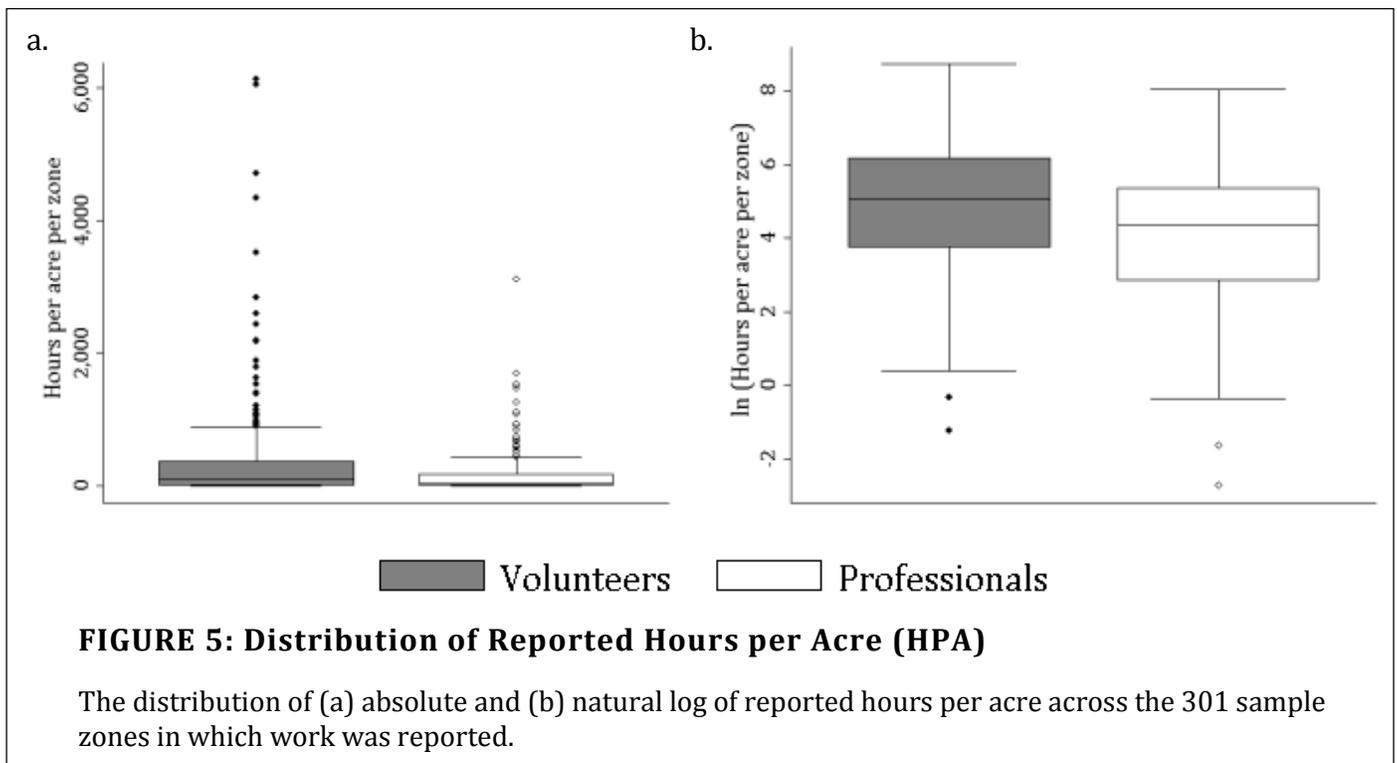
The percentage estimated constancy and cover of the 20 most reported understory species in (a) the 236 SUNP polygons from the 1999-2000 survey included in the study sample; and (b) the 424 GSP zones inventoried from 2009 – 2013.



## 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.



## B. REGRESSION RESULTS

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### 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.

	<u>Level Model</u> Dependent variable = Total estimated cover of non- invasive species	<u>Change Model</u> Dependent variable = $\Delta$ 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 ( $\leq$ 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.

	<u>Level Model</u> Dependent Variable = $\sqrt{\text{Total estimated cover of invasive species}}$	<u>Change Model</u> Dependent Variable = $\Delta \text{ total estimated cover of invasive species}$
Constant	-3.3314** (1.1850)	-66.293*** (20.315)
Intervention Variables	Professional Hours Per Acre	-0.0011** (0.0005)
	Volunteer Hours Per Acre	-0.0002 (0.0002)
	Plants Installed Per Acre	-0.0007*** (0.0002)
	Herbicide	-0.0536 (0.3614)
	Project Months	-0.0260*** (0.0092)
Abiotic Environmental Conditions	Total Months	0.0400*** (0.0076)
	Zone Size (acres)	0.1428** (0.0600)
	Percentage Slope	0.0052 (0.0056)
	Percentage Wetland	0.0072 (0.0056)
	Percentage Riparian	-0.0067 (0.0047)
	Percentage Edge ( $\leq 10\text{m}$ )	0.0163*** (0.0043)
Ecological Baseline	$\sqrt{\text{Invasive Cover}}$	0.2694*** (0.0414)
	Non-Invasive Canopy	0.0008 (0.0038)
	Non-Invasive Understory	-0.0093*** (0.0025)
	Non-Invasive Species Richness	0.0107 (0.0190)
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 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.

		<u>Level Model</u> Dependent Variable = $\sqrt{\text{non - invasive species richness}}$	<u>Change Model</u> Dependent Variable = $\Delta \text{ non-invasive species richness}$
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

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### A. OUTCOMES & FEEDBACK

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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.

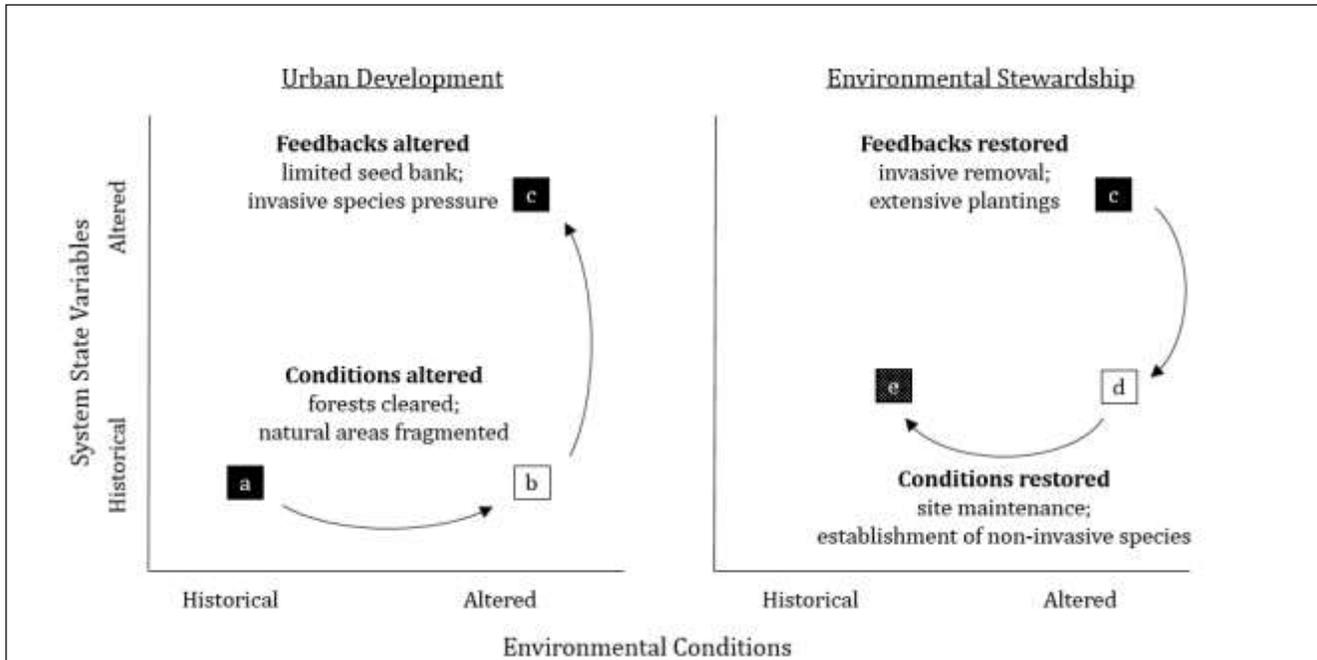
Reported levels of planting, mulching, and watering indicate stewardship efforts dedicated to the objective of increasing non-invasive (in most cases, native) cover and richness. The data indicates only modest success toward these outcomes. There are several possible explanations for this. There may 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

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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

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### APPENDIX A - GREEN SEATTLE PARTNERSHIP GENERAL INFORMATION

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

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

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

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

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

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

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

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

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

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

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

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

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