2024 Forest Health Assessment

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Prepared by:

Dylan Mendenhall and Angelica Amesquita

Haven Ecology and Research LLC

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Acknowledgements

This report is intended to guide the ongoing stewardship of a small part of the traditional and ancestral territory of the Duwamish Tribe, who have managed the natural resources of this land since the beginning. Additionally, much of the work that was done writing the plan was completed in the traditional and ancestral territory of the Suquamish Tribe.

We gratefully acknowledge Dr. Matthew Distler for sharing his insights and expertise in plant ecology and data interpretation.

Executive Summary

Background

The 2024 Forest Health Assessment (FHA) was conducted in the City of Mercer Island to 1) establish a new baseline for evaluating the management needs of the open spaces, 2) determine how biodiversity and structure have changed over time, and 3) measure progress towards the habitat restoration targets outlined in the Climate Action Plan (CAP).

The approach used for the 2024 FHA is closely aligned with the previous assessment conducted in 2014. Two complementary surveys were done in parallel, one using 446 small-sized plots (25 m^2) for surveying the understory plant community, and one using 146 large-sized plots (400 m^2) for inventorying the overstory trees. Most of the data collected in 2014 can be compared to data collected in 2024. Additional data was collected during the current assessment to establish baseline conditions for other ecosystem attributes and processes, such as the abundance of snags, downed wood, or changes in tree species composition over time.

Overstory Trees

Forest structure was evaluated using several different metrics, including basal area (BA), trees per acre (TPA), quadratic mean diameter (QMD) and Curtis relative density (RD). Mean basal area was 191.6 ft^2/ac and was almost evenly divided between deciduous and conifer trees. Mean stem density was 100.4 trees per acre, with conifer trees representing about 1/3 of all stems and deciduous trees representing nearly 2/3 of the stems. Conifer trees make up a relatively large proportion of basal area, despite having fewer stems, because their diameters tend to be larger (mean QMD: 23.1 inches) compared with deciduous trees (mean QMD: 16.7 inches). Approximately 1% of the overstory trees are broadleaf evergreen.

The overstory is largely composed of native tree species, which represent over 99% of total basal area and over 97% of total stems. Recent analysis estimated tree canopy in parks and open spaces to be 67% (Plan-It Geo, LLC, 2018). Together, these data suggest that a key target in the CAP for 2030 has already been met (10% of open space in “monitoring and maintenance”, with at least 60% native tree cover).

Big leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), and Douglas fir (*Pseudotsuga menziesii*) are the most abundant tree species in terms of stem density. Big leaf maple (*Acer macrophyllum*) and Douglas fir (*Pseudotsuga menziesii*) are also the two most abundant tree species in terms of basal area. Western red cedar (*Thuja plicata*) is the third most abundant tree based on its share of total basal area, exceeding that of red alder. Madrona (*Arbutus menziesii*) is the only native broadleaf evergreen species in the overstory and has decreased in stem density by approximately 40% over the past decade.

It is not possible to compare trends in the abundance of other native tree species between 2014 and 2024 because of differences in methodology. However, the overall density of overstory trees is trending upwards, which suggests that the current rate of tree regeneration for conifer trees and deciduous trees is exceeding their rate of mortality.

Approximately 27% of the open spaces are moderately overstocked, with RD values ranging between 50 and 80. Overstocked stands are expected to have slower growth, greater drought stress, and lower resilience to pests and disease. Approximately 3% of the open spaces are extremely overstocked, with

RD values exceeding 80. These stands of trees are at risk of severe and potentially irreversible decline if management actions are not soon taken to reduce tree competition. Wildfire risk is also elevated in overstocked stands.

Snag density was relatively low, with a mean of 13.2 snags per acre. Coarse woody debris (downed wood) had a mean volume of approximately 1,500 cubic feet per acre. Both snag density and coarse woody debris volume were spatially heterogenous, with many areas depleted. Snags were missing in approximately 40% of the inventory plots. The low abundance of coarse woody debris likely contributes to lower tree regeneration, especially for conifer trees species that require it as a substrate.

Tree Regeneration

Native tree regeneration was moderately high, with a mean density of 182.4 stems per acre. Native tree regeneration was dominated by three species: big leaf maple (*Acer macrophyllum*), Oregon ash (*Fraxinus latifolia*) and western red cedar (*Thuja plicata*). Of these, big leaf maple and Oregon ash regeneration appears to be largely driven by self-propagation (i.e. natural regeneration). Most western red cedar regeneration appears to be the result of intentional tree planting. Except for big leaf maple, all other drought-tolerant native tree species have low regeneration.

Non-native tree regeneration was dominated by invasive species, with a mean density of 160.9 stems per acre. English holly (*Ilex aquifolium*) remains the most abundant invasive tree species on Mercer Island and represented approximately 2/3 of all non-native saplings and seedlings. Non-native tree regeneration may have decreased by as much as 84% over the past decade, likely due to management actions focused on treating and removing invasive trees. However, differences in tree regeneration between 2014 and 2024 should be interpreted with caution due to potential differences in methodology.

Understory

Native plants had a mean cover-abundance of 75.9%, which has remained relatively unchanged over the past decade. Non-native plants have increased from a mean of 30.6% to 42.1% cover since 2014, mostly due to increases in the abundance of two invasive species: English ivy (*Hedera helix*) and Himalayan blackberry (*Rubus bifrons*). Approximately 28% of the open space areas surveyed have non-native cover below 5%, which means that another key target in the CAP for 2030 has already been met.

Although native cover-abundance remains steady, changes in species composition have resulted in a net decrease in the biodiversity of native plant communities over the past decade, mostly due to decreases in species richness. Most of the native species that are in decline are herbaceous species which may be more vulnerable to increasing drought stress associated with climate change.

Management Recommendations

Management recommendations focus on six interrelated topics: 1) strategic planning, 2) capacity building, 3) invasive species, 4) stand structure, 5) stand composition, and 6) climate change adaptation. Stand-improvement thinning is recommended for areas that are overstocked, in part to increase resilience to drought conditions, pests and plant pathogens. Overall tree composition should be modified by prioritizing the regeneration of drought-tolerant native and near-native species.

Invasive understory species appear to be increasing in abundance at a rate that exceeds the resources that are currently available to control them. Invasive species management should be deprioritized in areas dominated by invasive species until areas that are more intact have been restored.

A focused climate change vulnerability assessment is recommended to support updates to the open space vegetation management plan, in part by identifying natural areas that are vulnerable to climate change and areas of potential refugia. A climate change vulnerability assessment can also be used to identify reference ecosystems with historical climates that are similar to the future climate that is projected for Mercer Island.

Introduction

Background

The City of Mercer Island manages approximately 300 acres of open space, representing a wide range of habitat types, including shoreline, upland forest, scrub-shrub, wetlands, and riparian forest. There is a need to periodically monitor these ecosystems to provide data that can be used to update management plans, prioritize resources, and inform adaptive management practices. The current Open Space Vegetation Management Plan was developed in part through the analysis of data collected during a forest health assessment in 2014, with the intention of there being additional assessments every 10 years to update the plan. This report summarizes findings from the 2024 Forest Health Assessment (FHA) and provides a new baseline to compare with future assessments.

Previous resource assessments were reviewed to better understand the policy context, history, and knowledge gaps related to the management of Mercer Island's open spaces, including:

- 2008 Pioneer Park Forest Management Plan (Mercer Island Open Space Conservancy Trust and City of Mercer Island Parks and Recreation Department, 2009)
- 2014 Open Space Vegetation Management Plan study (Distler et al., 2015)
- 2018 Urban Tree Canopy Assessment (Plan-It Geo, LLC, 2018)

Additionally, the recently adopted Climate Action Plan (City of Mercer Island, 2023) was reviewed to identify target metrics related to the management of the City's open spaces. The Climate Action Plan (CAP) includes two strategies related to "Natural Systems" that are relevant:

1. Increase urban tree canopy and green space
    - 2030 target: Retention of healthy, mature canopy in parks, rights-of-way, and open space areas continues to be prioritized
    - 2050 target: All new City plantings are climate-adapted species
2. Foster healthy & resilient natural systems
    - 2030 target: 10% of public open space transitions from active restoration to a monitoring and maintenance phase of management.
    - 2050 target: 50% percent of public open space transitions from active restoration to a monitoring and maintenance phase of management

The "monitoring and maintenance" phase of management is further defined as open space areas having less than 5% invasive plant cover, greater than 60% native tree cover, and "a diversity of plant species, tree ages, and forest structure".

Based on a review of these policies and resource assessments, project objectives were developed to guide the design and implementation of the monitoring protocol for the 2024 FHA. During the summer and early autumn of 2024, staff at Haven Ecology and Research LLC used this protocol to survey 446 understory plots and 146 overstory plots using a spatially representative sampling grid that covered 24 parks and open spaces. This report summarizes the methods of the 2024 FHA, key findings from the analysis, and management recommendations related to habitat restoration and forest stewardship.

Objectives

This project was guided by the following objectives:

1. Establish new baseline metrics for the diversity, structure and composition of the open space ecosystems that can be used to inform habitat restoration and other management activities
2. Provide data that can be used to support implementation of the Climate Action Plan
3. Design the monitoring protocol in a way that allows for analysis of change over time

Approach

For the 2024 FHA, the overall intent was to build on the previous assessment by expanding the amount of data being collected while also collecting the data in a way that would enable comparisons of change over time, as well as comparisons with other ecosystem monitoring programs in the region.

To determine the ideal sample size, a power analysis was conducted using reference data from the 2014 assessment. Based on this analysis, we concluded that the previous sample size used in 2014 would be adequate for most hypothesis testing, if desired. Without the need for additional plots, the same grid-sampling approach was chosen and effort was taken to establish plots as closely as possible to where they were surveyed in 2014. However, given that these were not monumented as permanent monitoring plots, they should not be treated as paired samples for statistical analysis. A small number of new plots were established in open spaces that were not surveyed in 2014.

Potential differences between the 2014 and 2024 assessment methodologies are discussed further in the **Methods** chapter. Special data preparation steps were used to improve the alignment of the two data sets prior to comparing change over time. This data preparation did not affect the results of the analysis reported elsewhere in the report.

How to Read This Report

This report includes three core chapters focused on the analysis of the monitoring data:

- **Overstory Trees**
- **Tree Regeneration**
- **Understory Plants**

Each of these three core chapters has a sub-section focused on how diversity and structure have changed over time, comparing data from the 2014 assessment with the current study. The chapters can be read independently and in any order.

The **Methods** chapter summarizes the monitoring protocol used for collecting data in the field, but additional details on methodology are included in a separate monitoring protocol document, a README file associated with the R scripts, and metadata. The Methods chapter also includes recommendations for future assessments to consider when developing monitoring protocols or analyzing data.

The **Management Recommendations** chapter describes recommendations based on an evaluation of the current conditions, interpretation of the policy context, and our professional judgement.

Terminology

Much of the analysis in this report focuses on differences in the diversity, abundance and structure of the plant community by distinguishing between native species and non-native species. For the purposes of this assessment, native species are defined as those whose ranges included areas west of the Cascade Crest, in the Puget Sound basin, prior to Euro-American contact (circa 1850). Non-native species are those that have been introduced to the region since then.

The terms “non-native” and “invasive” are often used interchangeably in this report. Following the precautionary principle, non-native species that are actively reproducing without intentional cultivation are generally assumed to be invasive, either because of their demonstrated impacts to ecosystem health in the broader region or based on the assumption that species with self-sustaining populations are in the lag-phase of invasion. Domesticated varieties (e.g. domesticated apple trees) and other horticultural plants that do not have self-sustaining populations contribute to a negligible proportion of the plant communities discussed in this report.

Some species that are technically non-native have ranges further south on the Pacific Coast – for example, California bay laurel (*Umbellularia californica*). These “near-native” species were included in the non-native species category for this analysis because of how low in abundance they currently are. However, future assessments could include near-native species as de facto native species for the purposes of evaluating forest health, especially as the climate envelopes of these species shift northward due to climate change.

Methods

For the 2024 Forest Health Assessment, two complementary resource surveys were conducted: an overstory survey with larger plots and an understory survey with smaller plots. A total of 146 overstory plots and 446 understory plots were surveyed between June and October. The methodology was intended to closely align with the 2014 forest assessment, in part to allow for comparisons of change over time. The methods of the two surveys used in 2024 are summarized below. Key differences in how vegetation was surveyed in 2014 and 2024 are also described. Additional information on how edge cases were interpreted is available in the full protocol (*FHA_Protocol_FINAL_2024-05-22_full_description.pdf*).

Table 1: Parks and open spaces included in the 2024 FHA.

Park	**Facility ID**	**Area Surveyed (acres)**	**Overstory Plots**	**Understory Plots**
Cayhill Open Space	PA-CH	1.08	1	1
Clarke Beach Park	PA-CB	6.96	4	11
Clise Park	PA-CP	1.55	1	2
Ellis Pond	PA-EP	4.13	2	4
Engstrom Open Space	PA-EN	8.51	3	14
Gallagher Hill Open Space	PA-GH	11.34	6	15
Groveland Beach Park	PA-GB	1.63	1	2
Hollerbach Park	PA-HP	5.23	3	10
Homestead Park	PA-HF	3.53	2	4
Island Crest Park	PA-IC	30.39	13	49
Luther Burbank Park	PA-LB	20.06	10	29
Mercerdale Hillside Park	PA-MD-HP	18.14	9	24
Mercerdale Park	PA-MD	6.26	3	7
North Mercerdale Hillside	PA-MD-HPN	6.20	3	9
Parkwood Ridge Open Space	PA-PR	3.80	3	5
Pioneer Park NE	PA-PP	38.56	22	59
Pioneer Park NW	PA-PP	36.56	18	61
Pioneer Park SE	PA-PP	37.67	18	62
SE 47th St Open Space	PA-47	1.37	1	3
SE 50th Pl Open Space	PA-50	1.78	1	5
SE 53rd Pl Open Space	PA-53	25.08	11	38
Secret Park	PA-SC	0.73	1	2
Upper Luther Burbank Park	PA-ULB	18.07	9	28
Wildwood Park	PA-WW	1.69	1	2
Total		290.32	146	446

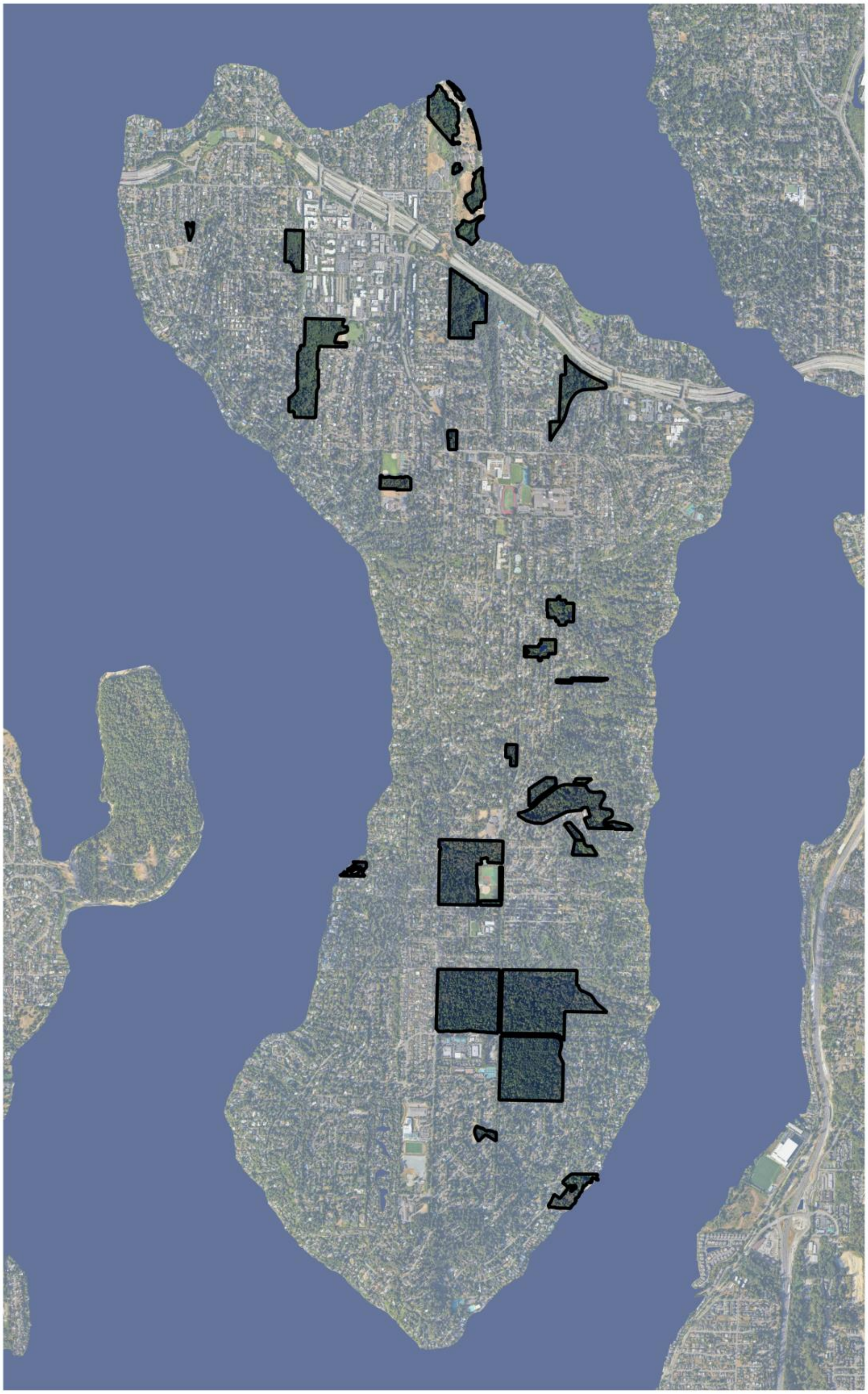

Figure 1: Map highlighting the parks and open spaces included in the 2024 FHA

Overstory Survey

Location and Plot Design

A nested plot design was used for the overstory survey, with a 10 m X 40 m macroplot used for inventorying saplings and mature trees, and a smaller 10 m X 10 m microplot used for estimating understory cover and seedling density. The microplot was located at the beginning of the macroplot, with one of its sides centered on the origin point where the latitude/longitude coordinates were recorded. Coarse woody debris was sampled along a 40 m transect running along the centerline of the macroplot, starting at the origin point.

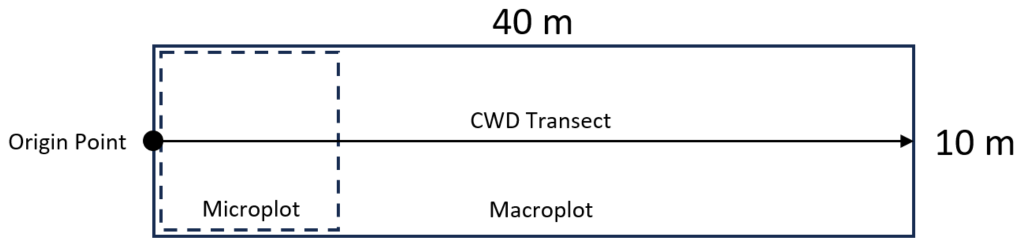

Figure 2: Schematic of overstory plot

Plots were located as close as possible to the idealized locations of the plots that were surveyed in 2014. The orientation of the plots (N, E, S, W) were also aligned with the 2014 plots. For plots installed in locations without an analog from 2014, the orientation of the plot was chosen at random.

Macroplot

For all mature trees (DBH ≥ 5”), the following information was recorded:

- Species
- Diameter (DBH)
- Presence of invasive vines (yes, no)
- Ivy height class (no ivy, 0 to 3 ft, 3 to 15 ft, > 15 ft)

Saplings (DBH ≥ 1” and < 5”) were tallied by species based on the number of stems at the location along the bole where DBH would normally be measured (typically 4.5 ft above the ground). For each tree or sapling with a forked stem, the total number of stems beyond the first stem were tallied so that stem density could later be adjusted to match the 2014 methodology, which likely counted multi-stemmed trees as individuals.

For snags, the minimum height was 5 feet and the minimum diameter was 5 inches.

A photo was taken at the plot origin for the purpose of illustrating the overall stand structure of the macroplot. The line-of-sight of the photo was aligned with the transect by default. However, if vegetation or terrain features obstructed this line-of-sight, professional judgement was used to realign the photo in another direction to better illustrate the overall diversity and structure of the stand. The plot photos were not created with the intent of them being used in the future to relocate the plots.

The following site characteristics were recorded as they relate to the overall conditions and topography of the entire macroplot:

- Presence of stream (yes, no)
- Presence of trail (yes, no)
- Slope (%)
- Aspect (degrees)

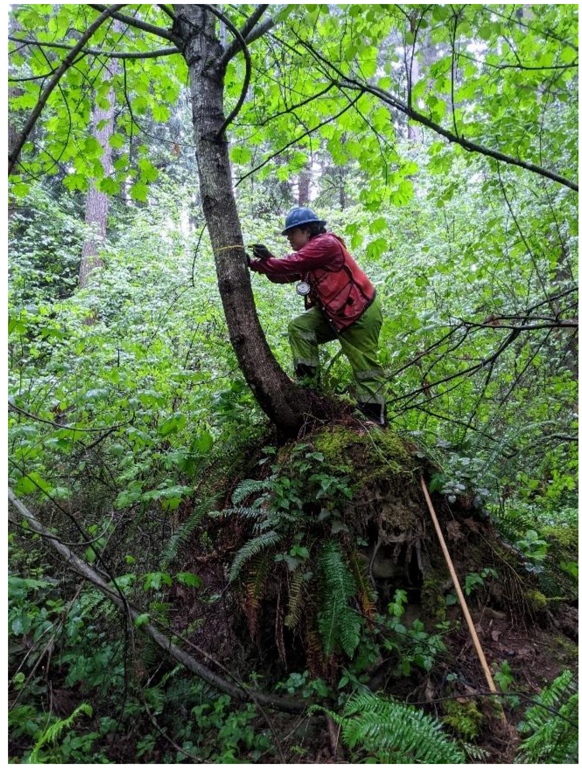

Figure 3: Measuring DBH on a perched big leaf maple tree, 4.5 ft above the root flare

Microplot

Cover-abundance was recorded for all other understory species (shrub, graminoid, forb, fern, etc). For each tree species with seedlings (DBH < 1”) present in the microplot, the total number of stems was also tallied. Because it is often difficult to differentiate between side branches and forked stems in this size-class, forks were not tracked for tree seedlings.

CWD Transect

Coarse woody debris was surveyed using the line-intersect method (Marshall et al., 2003, 2000; Van Wagner, 1968).

- For each piece of CWD that intersected the transect, diameter was recorded at the location where its central axis intersected the transect.
- The minimum diameter for coarse woody debris to be inventoried was 5 inches.
- Decay class (1 - 5) was recorded based on the concurrence of the criteria outlined in **Table 2**.

Table 2: Criteria for CWD decay class, adapted from Maser et al. (1979) and British Columbia (2009).

Characteristic	Decay Class				
	1	2	3	4	5
Branches (< 1")	Intact	Absent	Absent	Absent	Absent
Bark	Intact	Mostly intact	Mostly loose or absent	Absent	Absent
Shape	Round	Round	Round	Round to elliptical	Elliptical
Structural integrity	Sapwood hard	Sapwood hard	Sapwood soft	Heartwood soft; unable to support weight	Heartwood soft; unable to maintain shape
Integration into soil	Elevated on support points	Elevated on support points	Sagging or in full contact with soil	Full contact with soil	Partially integrated into soil

Understory Survey

The understory survey consisted of 5 m X 5 m square plots, with the origin point representing the southwest corner of the plot. Plots were located as close as possible to the idealized locations of the plots that were surveyed in 2014.

For each understory species and tree seedling (DBH < 1”), the following was recorded:

- Species
- Cover-abundance (%) estimated to the nearest integer or entered as 0.5% for species with cover less than 1%

The following site characteristics were recorded at each plot:

- Presence of stream (yes, no)
- Presence of trail (yes, no)
- Bare mineral soil (none, 1 - 20%, 20 - 40%, 40 - 60%, 60 - 80%, 80 - 100%)
    - Soil was not considered bare in areas where any amount of organic matter (i.e. duff, wood chips, etc) had accumulated
    - Concrete paths were interpreted as representing bare mineral soil
- Soil stability – presence of unstable soil conditions (none, erosion, slumping, slides)
- Soil moisture (dry, moist, saturated, standing water)
    - Moving water (i.e. streams) was not interpreted as representing standing water
- O-horizon depth – average of 10 random points, each rounded to the nearest whole centimeter, as measured from the surface of the organic horizon to the surface of the mineral soil

Differences Between 2014 and 2024

Although both the 2014 and 2024 overstory surveys used nested plot designs, the cover-abundance of tree seedlings and understory species was not recorded in the 10 m X 10 m microplots in 2014. Only the density of tree seedlings was recorded in the 2014 microplots.

There are differences in how the concept of “growth form” was interpreted for vine maple (*Acer circinatum*) and pacific hawthorn (*Crataegus douglasii*). In 2024, vine maple was interpreted as a shrub and was only recorded using cover-abundance (%) in the 5 m X 5 m understory plots and in the 10 m X 10 m microplots of the overstory survey. In contrast, vine maple was interpreted as a tree in 2014 and was likely tallied in the overstory survey as a native deciduous tree (DBH ≥ 5”) or as a native deciduous tree sapling (DBH ≥ 1” and < 5”) where present. The cover-abundance of vine maple would likely have only been recorded in the 2014 understory survey where seedlings (DBH < 1”) were present. The opposite growth form interpretation applies to pacific hawthorn, which was inventoried as a tree in the 2024 overstory survey, but was recorded as a shrub in the 2014 understory survey.

Figure 4: In the 2014 overstory survey, multi-stemmed trees such as this big leaf maple tree were likely tallied as individual trees. In the 2024 FHA, this tree would likely have been inventoried as 5 or 6 stems, depending on where DBH was measured.

In the 2014 FHA, native tree species were tallied by canopy type (conifer, deciduous, broadleaf evergreen), meaning that their specific taxonomy was not recorded in the overstory survey. This makes it impossible to compare changes in the abundance of native tree species between 2014 and 2024, except in terms of overall canopy type. Additionally, the 2014 overstory survey appears to have counted each multi-stemmed tree as an individual stem. In contrast, the 2024 overstory survey inventoried multi-stemmed trees as multiple stems if they forked below the 4.5 ft height along the bole where DBH was measured.

Although efforts were made to locate plots as closely as possible to their idealized locations, some understory and overstory plots in 2024 were located in places without analogs from 2014, generally because a given park or management unit had been omitted entirely in the 2014 assessment. At times, the target plot locations were relocated to avoid hazards (e.g. ground-nesting wasps). In these cases, plots were surveyed at alternative locations nearby to preserve the overall plot density intended for that park.

There are differences in how cover-abundance was estimated for the least abundant species. In 2024, 0.5% was used as the minimum cover-abundance value for any understory species with under 1% cover. However, cover-abundance appears to have been recorded at values as low as 0.01% in the 2014 understory survey. This difference in methodology is expected to result in the average cover-abundance of rare species being overestimated in 2024, relative to the 2014 FHA. However, the frequency of occurrence of any given species should not be affected by this difference in methodology.

There are likely differences in how the taxonomy of some species were interpreted in 2014 and 2024. For example, *Geum urbanum* is entirely absent from the understory data in 2014, but was highly abundant in 2024. Although it is possible that *Geum urbanum* was in fact absent from the natural areas in 2014, it is more likely that it was misidentified as the native species *Geum macrophyllum*. A review of the data suggests there may be conflicts involving the following taxa, either in terms potential misidentification or differences in the taxonomic level (i.e. genus vs species) that they were identified to:

- *Agrostis* spp
- *Bromus* spp
- *Cotoneaster* spp
- *Eleocharis obtuse*
- *Eleocharis palustris*
- *Equisetum* spp
- *Eleocharis* spp
- *Fragaria* spp
- *Galium* spp
- *Geum macrophyllum*
- *Geum urbanum*
- *Glyceria* spp
- *Juncus effusus* (multiple subspecies)
- *Lathyrus* spp
- *Lotus* spp
- *Polygonum hydropiperoides*
- *Persicaria* spp
- *Pyracantha* spp
- *Quercus robur*
- *Rosa pisocarpa*
- *Stellaria* spp
- *Viburnum lantana*
- *Viburnum opulus* (multiple subspecies / varieties)

Analysis

Diversity and Structure Metrics

Analysis of overstory data focused on stand structure and species composition. The following structure metrics were calculated for each plot based on all trees with DBH greater than or equal to 5 inches: basal area (BA), trees per acre (TPA), quadratic mean diameter (QMD), Reineke's stand density index (SDI) and Curtis relative density (RD). Basal area is reported in ft^2/ac, while QMD and DBH are reported in inches. BA, TPA and QMD were also summarized by species origin (native vs non-native) and by canopy type (broadleaved evergreen, conifer and deciduous). Overstory species abundances were summarized by BA and TPA for each individual native and non-native tree species.

Coarse woody debris volume was calculated for each decay class (1-5) and is reported in ft^3/ac. Snag density is reported in stems per acre.

For regenerating trees (DBH < 5”), stem density was summarized for both native and non-native species. Tree regeneration was also summarized by seedling size-class (DBH < 1”) and sapling size-class (1” ≤ DBH < 5”), as well as for each regenerating tree species to compare species abundances. Tree regeneration is reported in stems per acre.

Analysis of the understory data involved calculating cover-abundance (%), as the sole structural metric, as well as three metrics for alpha diversity: species richness, Pielou’s species evenness, and the Shannon diversity index. These metrics were calculated both for the entire plant community (all species), and were also summarized by species origin (native vs non-native).

All structure and diversity metrics were summarized per park as well as citywide.

The outputs of the analysis (table data) were stored in MS Excel files (.xlsx). Spatial data with plot locations were stored as shapefiles.

Documentation

All analysis was conducted using the R programming language (R Core Team, 2023): version 4.3.1 (2023-06-16 ucrt) -- "Beagle Scouts", and run using R Studio: 2023.09.0 Build 463 "Desert Sunflower" Release (b51c81cc, 2023-09-25). Additional documentation is available in separate metadata and a README file.

Change Over Time

Comparisons of tree density between 2014 and 2024 account for differences in how multi-stemmed trees were evaluated by adjusting the 2024 data based on the number of forked stems. For example, a big leaf maple tree (*Acer macrophyllum*) measured in the 2024 FHA as having six stems at the 4.5 ft bole height would be adjusted to only represent a single tree prior to comparing with the 2014 data.

Potential conflicts in taxonomy are difficult to resolve when comparing data between 2014 and 2024. In some cases, species were consolidated into a single genus to allow for more accurate comparisons. For example, all *Agrostis* species were consolidated into the same genus prior to making comparisons of change over time. Likewise, all *Fragaria* species were consolidated into the same genus prior to making those comparisons. These data preparation steps are documented in separate tables used for mapping the original species codes to revised codes.

Some cover-abundance data were dropped entirely prior to making comparisons of change over time. Trees and shrubs with growth forms that were interpreted differently in the two studies (e.g. vine maple) were removed from both datasets prior to making comparisons.

Recommendations for Future Assessments

Future assessments can build on the lessons learned from the 2024 FHA:

- If a similar inventory approach is used, with a separate understory survey independent from the overstory survey, include estimates of seedling density in the methodology for the understory survey, not just in the microplots of the overstory survey. Native seedling density is typically very low and quick to tally up by species.
- Consider excluding areas from the survey that were converted from open space into developed park facilities (e.g. the bike track in Island Crest Park).
- Plant communities are patchy and spatially heterogenous. If using elongated fixed-area tree inventory plots (i.e. "belt transects" or other rectangular plots similar to the 10 m X 40 m plots used in the 2024 FHA), consider using 4 subplots spaced evenly along the length of the macroplot for collecting understory data instead of a single microplot at the beginning of the macroplot, as was done in 2024. Alternatively, if using a single microplot in an elongated macroplot, assume that any data collected in the microplot may not be representative of the entire macroplot. Nested plots at the center of either circular fixed area plots or variable radius plots are less likely to face this issue.
- Consider measuring total height and live crown height so that other structure metrics can be calculated, such as the live crown ratio or timber volume.
- Carefully review the monitoring protocol for 2024, particularly how edge cases were handled for inventorying seedlings and saplings (e.g. stump sprouts, ephemeral seedlings, etc).
- In 2024, near-native species contributed to a negligible component of the overall abundance and diversity of trees and understory plants. As species ranges shift and assisted migration becomes more commonly practiced, consider adapting future analysis by binning native and near-native species in the same category when calculating diversity and structure metrics. For example, the following near-native species could be considered de facto native species for the purpose of evaluating forest health:
    - Silk tassel bush (*Garrya elliptica*)
    - Pacific wax myrtle (*Myrica californica*)
    - Coastal redwood (*Sequoia sempervirens*)
    - California nutmeg (*Torreya californica*)
    - California bay laurel (*Umbellularia californica*)

Overstory Trees

Stand Structure

The structure of the forested stands on Mercer Island has high spatial heterogeneity. Basal area was as low as 11.9 ft^2/ac in some areas, but was also found to be as high as 588.7 ft^2/ac, particularly in areas where quadratic mean diameter (QMD) was over 25 inches and stem density was over 100 trees per acre (TPA). Mean basal area was 191.6 ft^2/ac, with nearly even contributions from conifer trees (105.8 ft^2/ac) and deciduous trees (84.3 ft^2/ac). Broadleaf evergreen trees (1.4 ft^2/ac) account for less than 1% of total basal area, and are almost exclusively represented by madrona (*Arbutus menziesii*).

Nearly two thirds of all stems are deciduous trees (62.9 TPA), and another third are conifer trees (36.1 TPA). Despite being fewer in number, conifer trees make up over half of the total basal area because their diameters tend to be considerably higher (QMD = 23.1) compared to the deciduous trees (QMD = 16.7). Approximately 1% of all overstory trees are broadleaf evergreen (1.3 TPA).

Curtis relative density (RD) values in the inventory plots ranged from 4.4 to 107.8. Because the current management objectives do not prioritize timber production, areas with low relative density (RD < 15) are not necessarily understocked. These areas with low tree density typically occur in forested wetlands, scrub-shrub habitat and upland areas with large canopy gaps or open canopies.

Table 3: Overstory structure metrics for the entire island

		BA	TPA	QMD	SDI	RD
Mean	Conifer	105.8	36.1	23.1	---	---
	Deciduous	84.3	62.9	16.7	---	---
	Broadleaf Evergreen	1.4	1.3	14.2	---	---
	All Species	191.6	100.4	19.5	265.7	42.7
Minimum		11.9	20.2	7.0	24.6	4.4
Maximum		588.7	263.1	41.0	701.2	107.8

BA = basal area, TPA = trees per acre, QMD = quadratic mean diameter, SDI = stand density index, RD = relative density

Approximately 27% of the open spaces are moderately overstocked, with RD values exceeding 50 but under 80. Competition between trees in these areas is expected to be high, resulting in slower growth, reduced vigor, and an overall decline in resilience to biotic and abiotic stress. Without stand-improvement thinning, tree mortality will likely increase in these stands over time, especially as summer drought stress increases due to climate change. Riparian areas are likely more resilient to increasing drought conditions, but competition for light and soil nutrients may remain high in overstocked stands. Crown closure in these areas can also suppress tree regeneration and the growth of understory plants.

Approximately 3% of the plots were located in areas that were extremely overstocked, with RD values exceeding 80. These areas were mostly found in Pioneer Park, although isolated areas with RD values over 80 can be found in other parks as well, such as Island Crest Park, Mercerdale Hillside Park, and Wildwood Park. Tree density in these areas can be so high that even the dominant trees have small, weak crowns and active self-thinning. Trees in these extremely overstocked areas may respond poorly to thinning treatments if too many trees are removed at the same time.

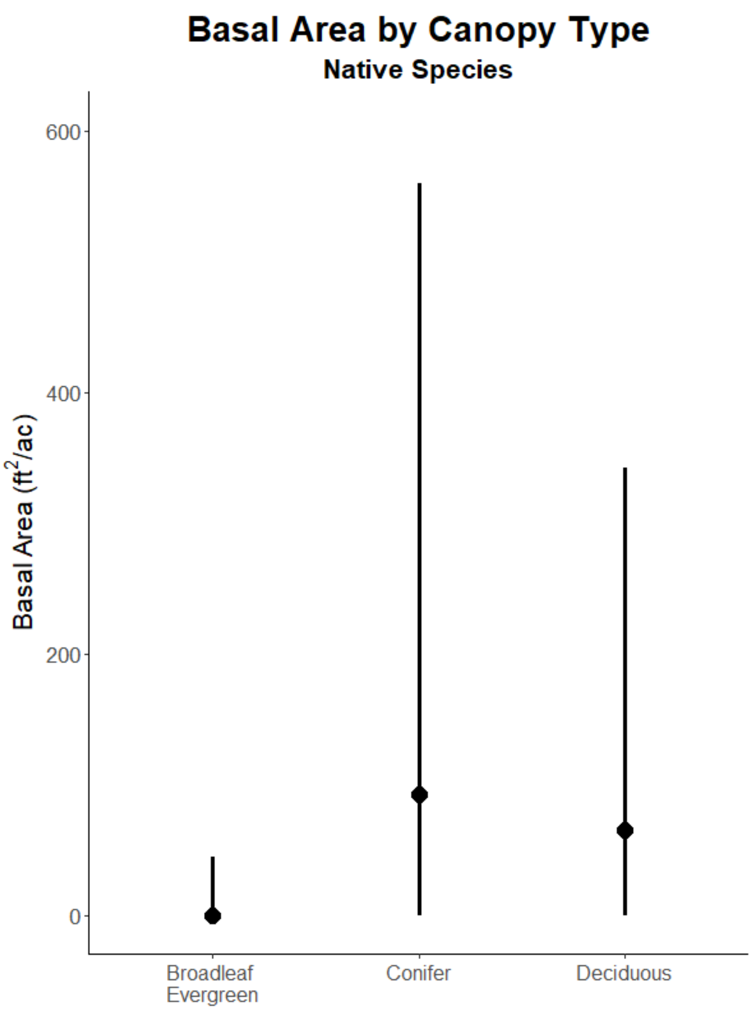

Figure 5: Basal area by canopy type. Points represent mean values; lines represent minimum and maximum values.

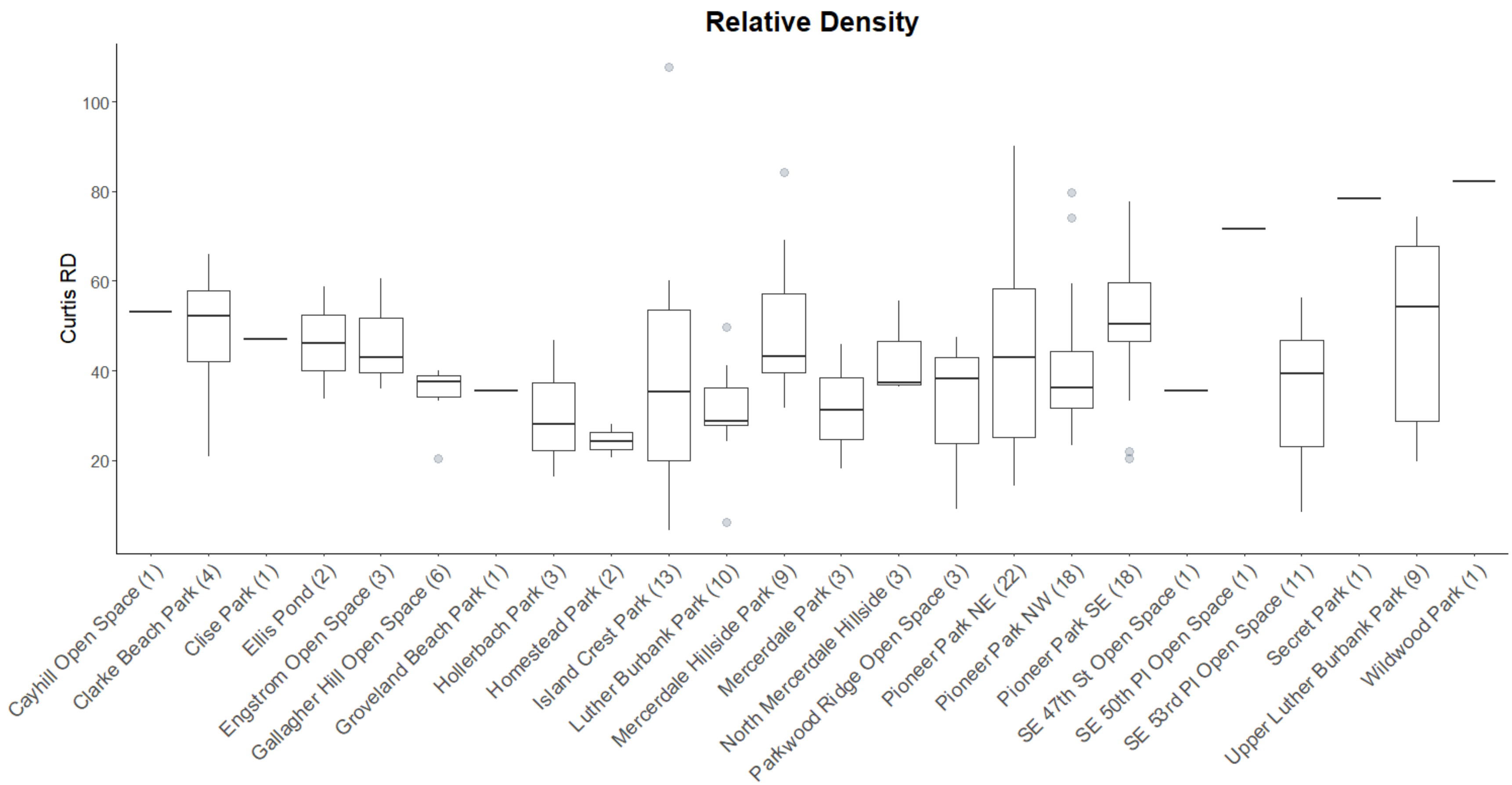

Figure 6: Relative density of all inventoried parks and natural areas. Bold horizontal lines represent medians; boxes represent the interquartile range (ITR); vertical lines represent minimum and maximum values up to 1.5 x ITR; points represent outliers. Parks with only a single inventory plot are displayed with a horizontal line representing the individual value at that plot. Total number of plots per park is included in parenthesis after the park name, e.g. "Pioneer Park NE (22)".

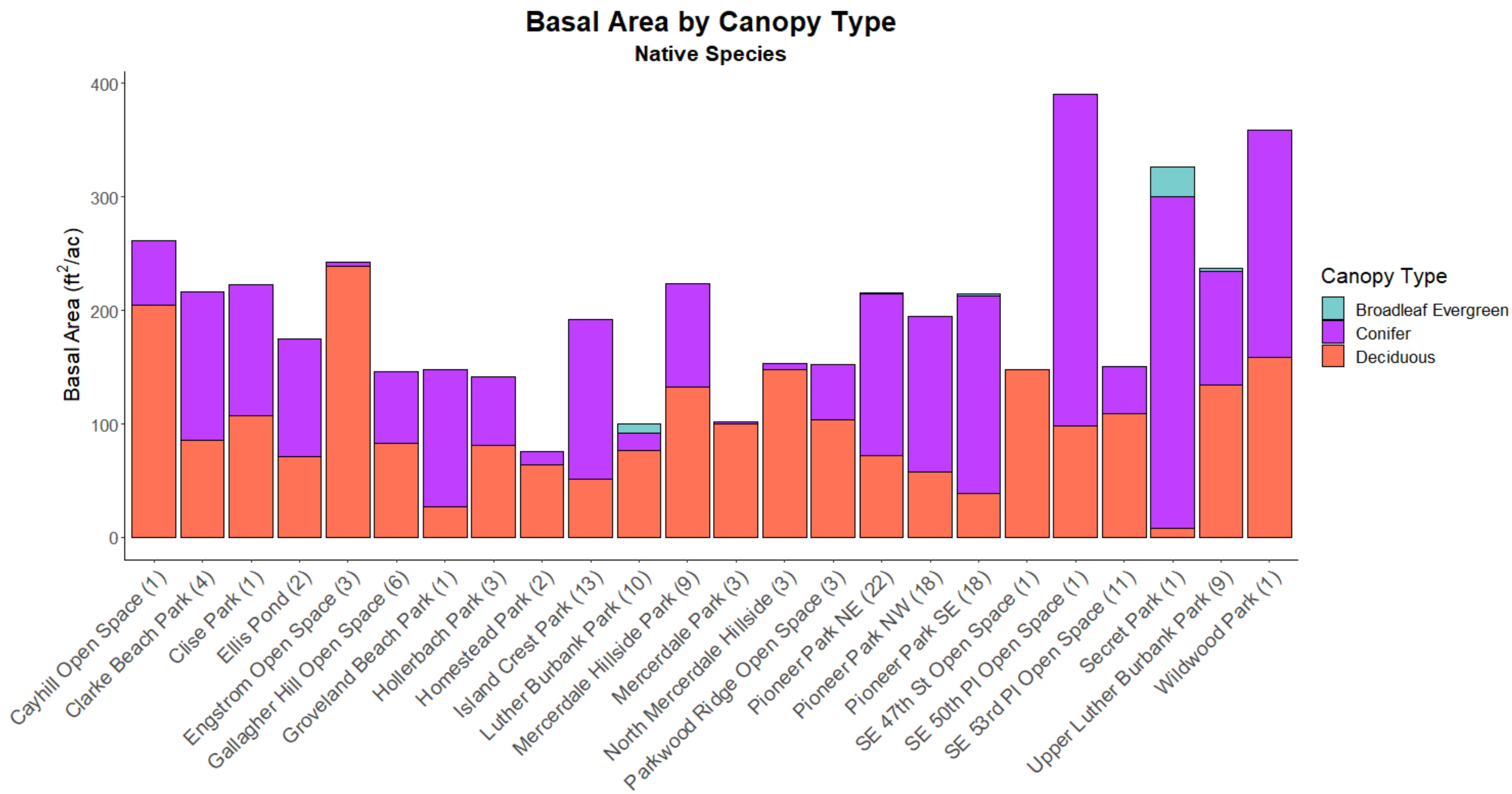

Figure 7: Basal area summarized by park and canopy type (broadleaf evergreen, conifer, deciduous). All values represent means. Total number of plots per park is included in parenthesis after the park name, e.g. "Pioneer Park NE (22)".

Snags and Coarse Woody Debris

Snag density is relatively low on Mercer Island, with a mean density of 13.2 snags per acre. Although snags were present in the majority of the inventory plots, and could be found at densities as high as 70.8 snags per acre, standing dead wood was completely absent in 40% of the plots.

Table 4: Snag density

	Snag Density (stems/ac)
Mean	13.2
Min	0.0
Max	70.8

Coarse woody debris (CWD) volumes are also spatially heterogenous. Approximately 28% of the inventory plots had CWD volumes exceeding 2,000 ft^3/ac – with the volume of CWD at a plot in Island Crest Park exceeding 7,000 ft^3/ac. However, CWD volumes were under 500 ft^3/ac in 39% of the inventory plots, and CWD was completely absent in 12% of the plots. Coarse woody debris volume tended to be higher in stands with large diameter conifer trees and/or forested wetlands, such as Island Crest Park (mean: 1,947.8 ft^3/ac), Pioneer Park NW (mean: 2,369.5 ft^3/ac), and Upper Luther Burbank Park (mean: 1,554.5 ft^3/ac). CWD volumes were often low in parks dominated by relatively young deciduous trees, such as Luther Burbank Park (mean: 155.3 ft^3/ac) or Homestead Park (mean: 247.8 ft^3/ac).

At the time of the survey, CWD was predominantly distributed between decay classes 2 and 4, indicating moderate to moderately-advanced decomposition. Decay class 1, which represents recently fallen trees with fine branches still attached, accounted for 1.5% of total volume. Likewise, highly decomposed wood (decay class 5) accounted for only 9.9% of total CWD volume.

Table 5: Coarse woody debris volume by decay classes 1 - 5.

	CWD Volume (ft^3/ac)					
	1	**2**	**3**	**4**	**5**	**Total**
Mean	23	534	310	508	152	1,526
Min	0	0	0	0	0	0
Max	1,509	5,098	4,650	6,175	2,221	7,089

Table 6: Coarse woody debris (CWD) volume and snag density summarized by park. CWD volumes are summarized by decay classes 1 – 5 as well as total volume. All values represent means.

Park	**CWD Volume (ft^3/ac)**						**Snags (stems / ac)**
	1	**2**	**3**	**4**	**5**	**Total**	
Cayhill Open Space	0.0	177.5	0.0	472.2	0.0	649.7	0.0
Clarke Beach Park	0.0	394.6	0.0	69.9	31.0	495.4	17.7
Clise Park	0.0	203.8	0.0	1096.6	0.0	1300.3	0.0
Ellis Pond	0.0	423.0	369.3	204.8	0.0	997.1	15.2
Engstrom Open Space	0.0	367.9	0.0	314.6	345.5	1028.0	0.0
Gallagher Hill Open Space	0.0	609.2	285.4	1320.5	101.0	2316.1	3.4
Groveland Beach Park	0.0	147.4	1048.3	0.0	0.0	1195.7	0.0
Hollerbach Park	155.3	1833.7	0.0	0.0	0.0	1989.0	3.4
Homestead Park	0.0	172.1	0.0	0.0	75.8	247.8	20.2
Island Crest Park	26.5	718.2	247.4	763.4	192.2	1947.8	8.6
Luther Burbank Park	10.2	48.5	96.5	0.0	0.0	155.3	15.2
Mercerdale Hillside Park	0.0	172.0	247.2	328.7	23.4	771.2	6.8
Mercerdale Park	0.0	168.6	311.4	503.6	101.0	1084.5	10.1
North Mercerdale Hillside	0.0	284.5	0.0	0.0	0.0	284.5	20.2
Parkwood Ridge Open Space	0.0	810.4	2204.3	689.3	272.0	3975.9	13.5
Pioneer Park NE	18.9	862.8	56.1	649.1	197.5	1784.4	14.7
Pioneer Park NW	10.6	639.2	232.3	1096.9	390.6	2369.5	16.3
Pioneer Park SE	103.7	727.2	499.1	169.9	255.4	1755.3	21.9
SE 47th St Open Space	0.0	956.6	739.2	76.9	0.0	1772.7	20.2
SE 50th Pl Open Space	0.0	451.5	639.8	0.0	0.0	1091.3	20.2
SE 53rd Pl Open Space	0.0	212.5	270.9	443.4	30.7	957.6	15.6
Secret Park	0.0	307.6	0.0	859.8	0.0	1167.4	30.4
Upper Luther Burbank Park	0.0	161.7	988.0	394.1	10.6	1554.5	4.5
Wildwood Park	0.0	102.4	123.9	71.1	0.0	297.3	10.1

Diversity and Composition

The forested areas on Mercer Island are generally dominated by three native tree species: big leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), and Douglas fir (*Pseudotsuga menziesii*). Big leaf maple is the most abundant species in terms of stem density (BA = 64.2, TPA = 39.5), while Douglas fir is the most abundant species in terms of basal area (BA = 72.8, TPA = 18.7). Although less abundant, western red cedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) are often locally co-dominant, especially in riparian corridors or areas with a relatively high water table where the trees are less exposed to drought stress. Grand fir (*Abies grandis*), Garry oak (*Quercus garryana*), shore pine (*Pinus contorta*), ponderosa pine (*Pinus ponderosa*) and bitter cherry (*Prunus emarginata*) were not observed as overstory trees (DBH ≥ 5”) in any of the inventory plots. Additionally, only a single western white pine tree (*Pinus monticola*) was observed in the overstory survey, at an inventory plot in Clarke Beach Park.

Table 7: Structure metrics for native overstory trees (DBH ≥ 5”). Unknown willow trees were generally assumed to be native species. All values represent means.

Common Name	Scientific Name	BA	TPA
Douglas fir	*Pseudotsuga menziesii*	72.8	18.7
bigleaf maple	*Acer macrophyllum*	64.2	39.5
western red cedar	*Thuja plicata*	21.8	9.6
red alder	*Alnus rubra*	12.6	11.9
western hemlock	*Tsuga heterophylla*	10.7	6.9
Oregon ash	*Fraxinus latifolia*	3.1	5.1
black cottonwood	*Populus trichocarpa*	2.3	0.5
madrona	*Arbutus menziesii*	1.4	1.3
Pacific willow	*Salix lasiandra*	0.6	1.3
Scouler's willow	*Salix scouleriana*	0.5	1.0
Sitka spruce	*Picea sitchensis*	0.3	0.6
cascara	*Frangula purshiana*	0.3	0.9
western white pine	*Pinus monticola*	0.1	0.1
Pacific dogwood	*Cornus nuttalli*	0.1	0.3
willow	*Salix* sp.	0.1	0.4
Pacific hawthorn	*Crataegus douglasii*	0.1	0.3
Pacific crabapple	*Malus fusca*	< 0.1	0.1
Total		190.9	98.3

BA = basal area, TPA = trees per acre

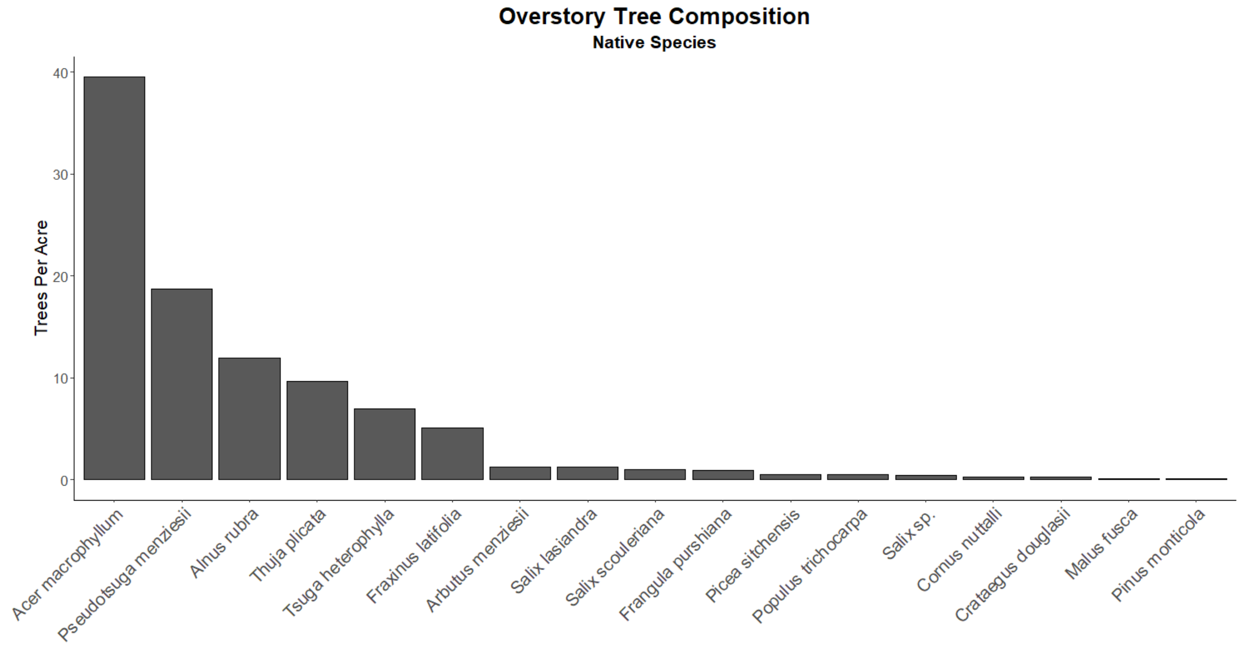

Figure 8: Composition of native overstory trees based on stem density (TPA)

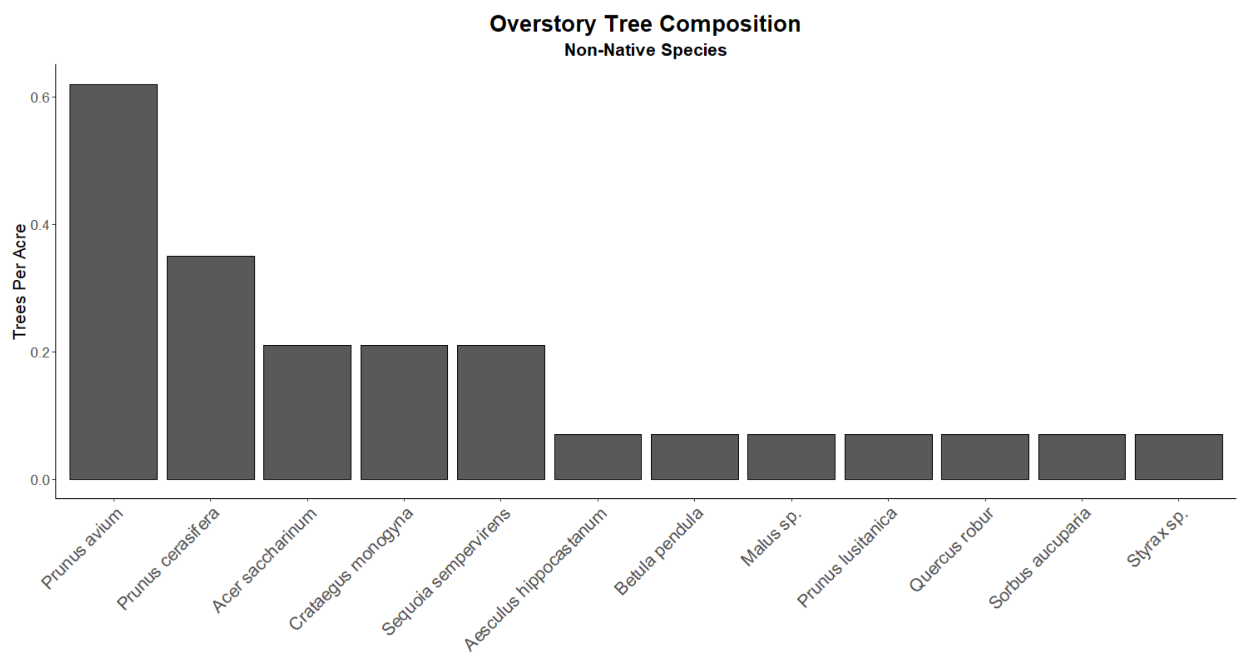

Figure 9: Composition of non-native overstory trees based on stem density (TPA)

In total, native trees represent 99.7% of overstory basal area and 97.9% of all overstory stems. During the 2018 Urban Tree Canopy Assessment, total tree canopy in parks and open spaces was estimated to be 67%. However, this analysis included areas of developed parkland with relatively low tree canopy cover, such as sports fields and other park facilities (Plan-It Geo, LLC, 2018). Canopy cover in the undeveloped open spaces included in the current study is generally higher. Together, these data suggest that native tree canopy cover already exceeds a key target in the Climate Action Plan (10% of open space in "monitoring and maintenance" phase of restoration by 2030, with more than 60% native tree cover).

Non-native species contribute to a relatively small proportion of the overstory, representing 0.3% of total basal area and 2.1% of all stems. Some of these non-native trees include near-native species that are unlikely to be invasive, such as coastal redwood (*Sequoia sempervirens*). Invasive tree species are more abundant in the seedling and sapling size-classes, discussed in the **Tree Regeneration** chapter.

Of the non-native tree species in the overstory size-class, bird cherry (*Prunus avium*) and thundercloud plum (*Prunus cerasifera*) are the most abundant (Figure 9), both in terms of basal area and stem density. English holly (*Ilex aquifolium*) was not observed in the overstory size-class.

Table 8: Structure metrics for non-native overstory trees (DBH ≥ 5"). All values represent means.

Common Name	Scientific Name	BA	TPA
bird cherry	*Prunus avium*	0.28	0.62
thundercloud plum	*Prunus cerasifera*	0.08	0.35
coastal redwood	*Sequoia sempervirens*	0.07	0.21
European white birch	*Betula pendula*	0.06	0.07
English hawthorn	*Crataegus monogyna*	0.05	0.21
silver maple	*Acer saccharinum*	0.04	0.21
horse chestnut	*Aesculus hippocastanum*	0.03	0.07
horticultural apple species	*Malus* sp.	0.02	0.07
Portuguese laurel	*Prunus lusitanica*	0.01	0.07
English oak	*Quercus robur*	0.01	0.07
European mountain ash	*Sorbus aucuparia*	0.01	0.07
snowbell tree	*Styrax* sp.	0.01	0.07
Total		0.67	2.08

BA = basal area, TPA = trees per acre

Change Over Time

Data Preparation

In the 2014 assessment, native trees were tallied by canopy type (i.e. conifer, deciduous, broadleaf evergreen). Taxonomic identity was not recorded. Additionally, multi-stemmed trees were likely counted as single individuals. In contrast, during the 2024 FHA, multi-stemmed trees were counted as multiple stems if they forked below the point where DBH was measured (generally, 4.5 ft bole height). To align the two data sets for comparing change over time, the 2024 inventory data was adjusted by subtracting each forked stem beyond the first stem of each tree. The density of native trees was then summarized by canopy type. Non-native trees were recorded to species during the 2014 assessment, allowing for species-specific comparisons of change over time.

As a result of these data preparation steps, the structure metrics described in this sub-section may differ from those described elsewhere in the report.

Structure and Composition

Changes in the net density of overstory trees can be driven by multiple processes. Stem density in this size-class increases when trees in the sapling size-class increase enough in diameter to meet the criteria for an overstory tree (DBH ≥ 5”). Stem density decreases when trees die and become snags or downed wood. Density metrics can also differ between years as a result of systematic error – for example, if the in/out trees were assessed using different approaches during the two assessments.

Native tree density is trending up for deciduous and conifer trees, but trending down for broadleaf evergreen trees. Because madrona (*Arbutus menziesii*) was the only native broadleaf evergreen species inventoried in the overstory tree size-class, during both the 2014 and 2024 assessments, the data suggests that this species is rapidly declining, with stem density decreasing by approximately 40%. Native conifer trees have increased from a mean TPA of 33.1 to 35.6 (absolute difference: +2.5 TPA, relative difference: +7.6%). The mean TPA of deciduous trees has increased from 49.9 to 52.9 (absolute difference: +3.0 TPA, relative difference: +6.0%).

Table 9: Changes in the stem density of native overstory trees (DBH ≥ 5”). All values represent means.

	Trees Per Acre (Native Species)			
	Conifer	Deciduous	Broadleaf Evergreen	Total
2014	33.1	49.9	2.0	85.0
2024	35.6	52.9	1.2	89.8
Absolute Difference	+2.5	+3.0	-0.8	+4.8
Relative Difference (%)	+7.6	+6.0	-40.0	+5.6

Because tree diameters were not measured in 2014, it is not possible to interpret how potential shifts in the DBH size-class distribution may have affected these trends. For example, it is unclear how the number of large diameter trees may have changed. However, the overall increase in stem density is best explained by the growth and regeneration of sapling-sized trees outpacing the rate of tree mortality.

In 2014, there were 7 non-native tree species inventoried in the overstory size-class. In contrast, there was a total of 11 non-native species in the overstory size-class in 2024, not including near-native coastal redwood (*Sequoia sempervirens*). English holly (*Ilex aquifolium*) was recorded in the overstory size-class in 2014 but stems over 5 inches in diameter were not observed in 2024.

In 2024, there were 5 new non-native trees species inventoried in the overstory size-class:

- Horse chestnut (*Aesculus hippocastanum*)
- European white birch (*Betula pendula*)
- English oak (*Quercus robur*)
- European mountain ash (*Sorbus aucuparia*)
- Snowbell tree (*Styrax* sp.)

Of these, *Aesculus hippocastanum* appears to be the most aggressive species, readily reproducing in partial shade and closed-canopy conditions. *Quercus robur* may be emerging from the lag phase of invasion – it was often found regenerating in partial shade and closed-canopy conditions, but saplings and mature trees remain uncommon. European mountain ash (*Sorbus aucuparia*) is less of a management concern now that it is partially controlled by the European mountain ash sawfly (*Pristiphora geniculate*), a non-native pest that can completely defoliate *Sorbus aucuparia* trees. The European white birch and *Styrax* trees were likely planted intentionally at the locations where they were found and do not show signs of having self-sustaining populations.

The overall density of non-native overstory trees has nearly doubled since 2014, increasing from a mean of 1.13 to 2.01 TPA. Most non-native tree species have increased in stem density – only English holly has appreciably decreased in the overstory size-class. The two non-native tree species that have increased the most are bird cherry (*Prunus avium*) and thundercloud plum (*Prunus cerasifera*). Since 2014, bird cherry overstory trees have increased in density 1.9x, while thundercloud plum trees have increased in density 3.9x (Figure 10). Taken together, these findings suggest that the control of invasive tree species has primarily focused on the removal of *Ilex aquifolium*.

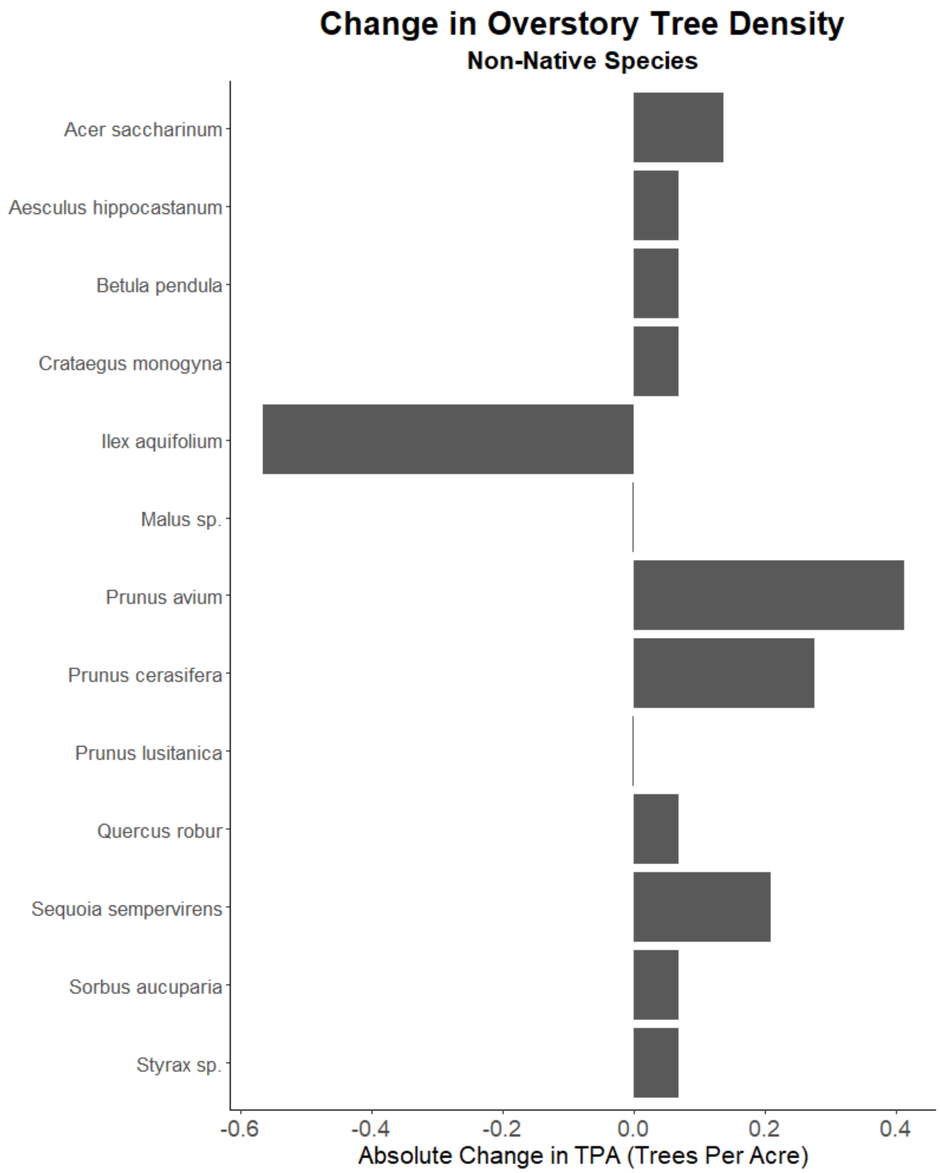

Figure 10: Change in the density of non-native overstory trees (DBH ≥ 5”) between 2014 and 2024. All values represent means.

Tree Regeneration

The analysis of tree regeneration discussed in this chapter is based on data from the overstory plots (n = 146). Regenerating trees consist of two size-classes: seedlings (DBH < 1”), and saplings (1” ≤ DBH < 5”). Saplings were inventoried in the 10 m X 40 m macroplots, while seedlings were inventoried in the nested microplots (10 m X 10 m).

Density

The density of regenerating trees is highly variable, with total native stem density ranging from 0 to 1,608.6 stems per acre (mean: 182.4, median: 111.3), and total non-native stem density ranging from 0 to 2,387.7 stems per acre (mean: 160.9, median: 40.5). Notably, mean seedling density of non-native species is relatively high (mean: 145.2 stems per acre) compared to the sapling size-class (mean: 15.7 stems per acre), likely due to extensive work to treat and remove invasive trees in the sapling size-class.

Table 10: Tree regeneration metrics for the entire island

		Stems Per Acre	
		Native Species	Non-Native Species
Mean	Seedlings	102.8	145.2
	Saplings	79.6	15.7
	All Stems	182.4	160.9
Minimum		0.0	0.0
Median		111.3	40.5
Maximum		1,608.6	2,387.7

Most plots had at least one native tree regenerating in the understory. However, native seedlings were present in 62% of the plots, while native saplings were present in 94% of plots. This pattern suggests that tree regeneration is both spatially and temporally variable. Tree planting efforts have resulted in discrete cohorts of regenerating trees that have reached the sapling size-class in many areas, without sustained natural regeneration to produce new seedlings.

Non-native trees were regenerating in 63% of all plots. Non-native seedlings were present in 51% of the plots, while non-native saplings were present in only 30% of plots. This pattern is opposite to the way that native seedlings and saplings are spatially distributed, and suggests that invasive tree species continue to have high propagule pressure on Mercer Island.

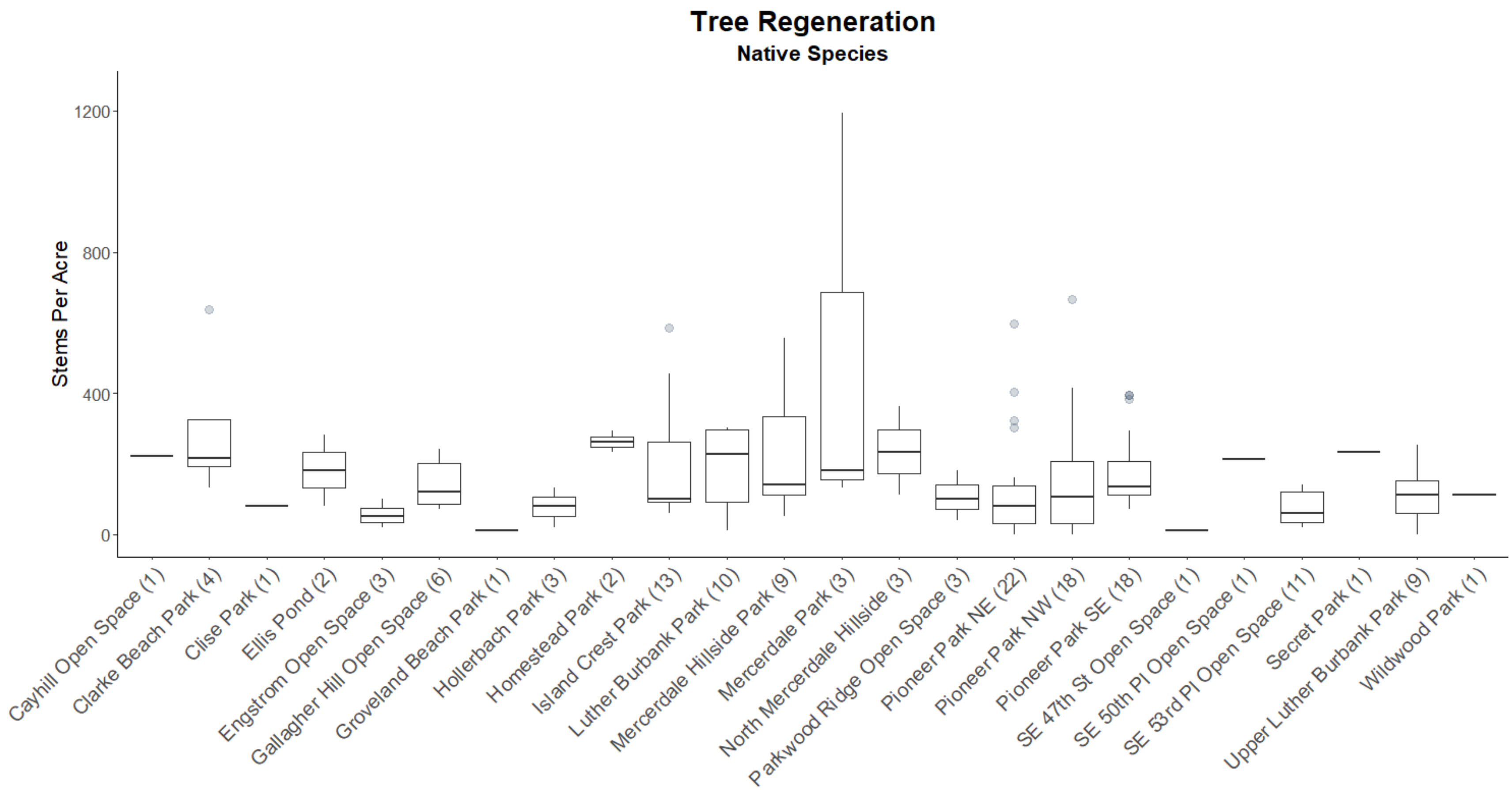

Figure 11: Native tree regeneration density for all inventoried parks and natural areas. Bold horizontal lines represent medians; boxes represent the interquartile range (ITR); vertical lines represent minimum and maximum values up to 1.5 x ITR; points represent outliers. Parks with only a single inventory plot are displayed with a horizontal line representing the individual value at that plot. Total number of plots per park is included in parenthesis after the park name, e.g. "Pioneer Park NE (22)".

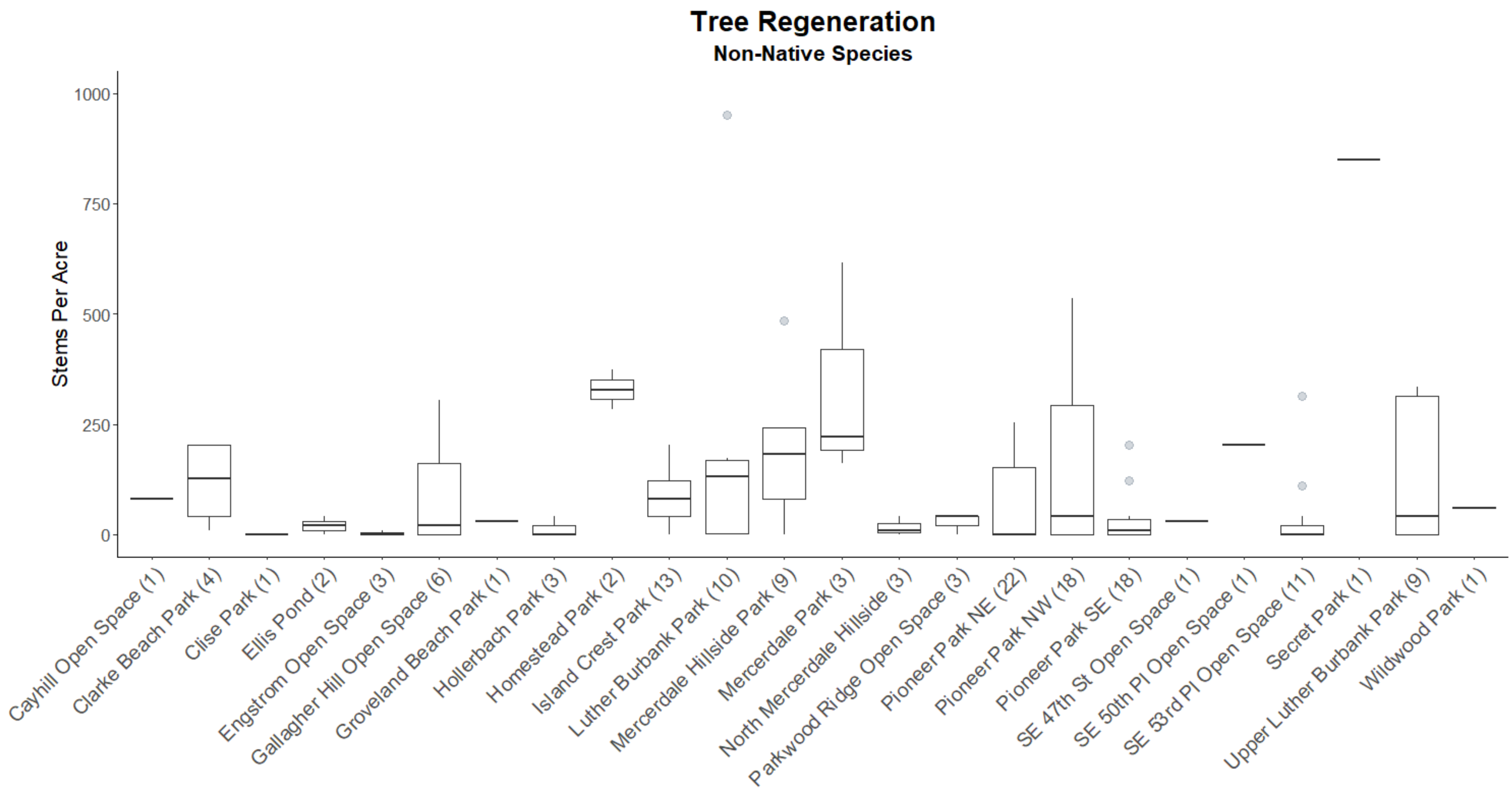

Figure 12: Non-native tree regeneration density for all inventoried parks and natural areas. Bold horizontal lines represent medians; boxes represent the interquartile range (ITR); vertical lines represent minimum and maximum values up to 1.5 x ITR; points represent outliers. Parks with only a single inventory plot are displayed with a horizontal line representing the individual value at that plot. Total number of plots per park is included in parenthesis after the park name, e.g. "Pioneer Park NE (22)".

Composition

Native Species

The three most abundant native tree species regenerating in the understory were:

- Big leaf maple (*Acer macrophyllum,* mean: 62.4 stems per acre)
- Western red cedar (*Thuja plicata,* mean: 50.1 stems per acre)
- Oregon ash (*Fraxinus latifolia,* mean: 36.4 stems per acre)

For all other native species, regenerating trees were under 10 stems per acre each.

Most big leaf maple seedlings and saplings appear to be the result of natural regeneration. Oregon ash also appears to readily propagate on its own. However, anecdotal observations suggest that most of the western red cedar regeneration is likely the result of intentional tree planting and not the result of natural regeneration. Although the 2024 FHA was not designed with the intention of quantifying natural and artificial regeneration, all native conifer species appeared to have low natural regeneration, likely the result of multiple factors, including competition with understory plants (both non-native and native species), closed canopy conditions, and low volumes of coarse woody debris. Coarse woody debris is a critical substrate that many native shade-tolerant conifers require to regenerate in the understory. Sun-loving tree species generally require open canopy conditions and/or bare mineral soil to propagate.

After excluding big leaf maple, all other native species that are relatively drought-tolerant collectively represented under 5 stems per acre, inclusive of the following species:

- Grand fir (*Abies grandis*)
- Madrona (*Arbutus menziesii*)
- Sitka spruce (*Picea sitchensis*)
- Shore pine (*Pinus contorta*)
- Western white pine (*Pinus monticola*)
- Ponderosa pine (*Pinus ponderosa*)
- Douglas fir (*Pseudotsuga menziesii*)

Garry oak (*Quercus garryana*) was not observed in the seedling or sapling size-classes in any of the natural areas surveyed. Additionally, most of the Pacific dogwood (*Cornus nuttallii*) saplings appeared to be in poor health, likely due to a combination of excessive shade in closed-canopy conditions and infection by the fungal pathogen, *Discula destructive*, which causes dogwood anthracnose.

Although regenerating cedar trees were typically found in good health, it was not uncommon to see foliar die-back or mortality in this species, likely the result of drought stress.

Figure 13: Big leaf maple regenerating in Pioneer Park NW

Non-Native Species

Among non-native tree species, English holly (*Ilex aquifolium*) had the highest regeneration density, with a mean of 100.4 stems per acre. The next most abundant species were:

- bird cherry (*Prunus avium*) at 17.4 stems per acre
- cherry laurel (*Prunus laurocerasus*) at 13.0 stems per acre
- English hawthorn (*Crataegus monogyna*) at 11.3 stems per acre

All other non-native tree species had fewer than 10 stems per acre each. Thundercloud plum (*Prunus cerasifera*) was higher in abundance in the sapling size-class (mean: 1.7 stems per acre) than all other invasive species except for English holly and English hawthorn. However, English oak (*Quercus robur*) had higher densities in the seedling size-class (mean: 5.0 stems per acre).

Two near-native species were also observed in the seedling and sapling size-classes: California bay laurel (*Umbellularia californica*) and coastal redwood (*Sequoia sempervirens*). Both species have native ranges on the Pacific Coast, in Oregon and California.

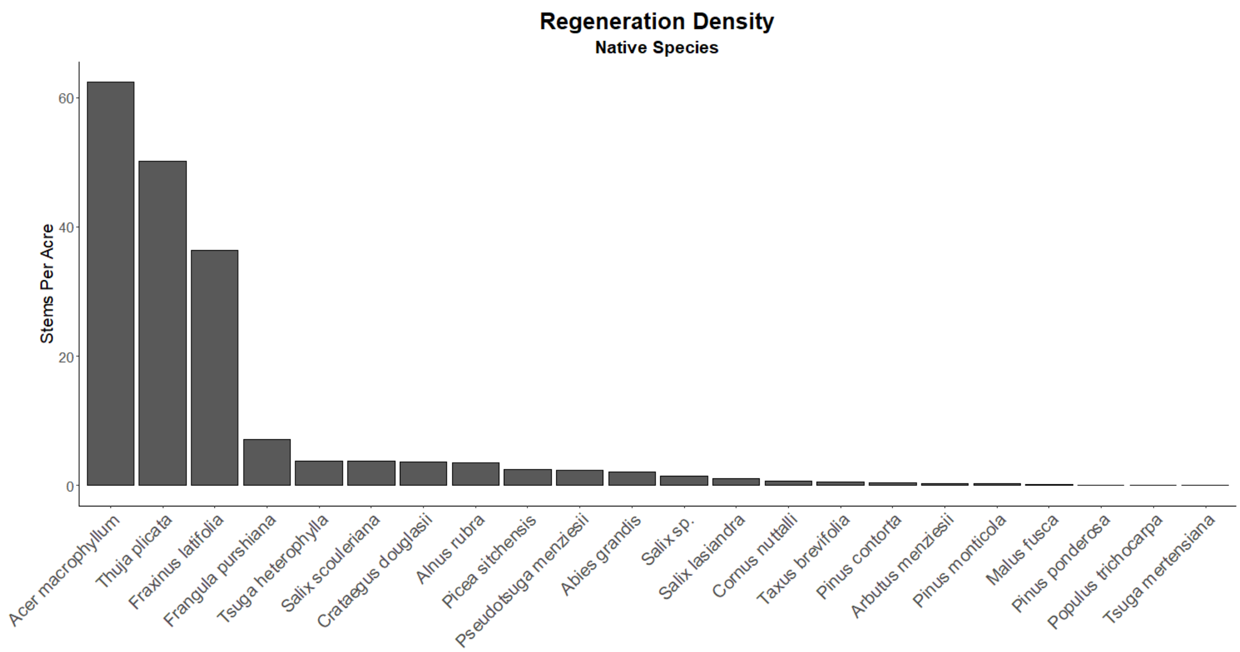

Figure 14: Species abundances of all native regenerating trees (DBH < 5”), inclusive of both seedling and sapling size-classes. All values represent means.

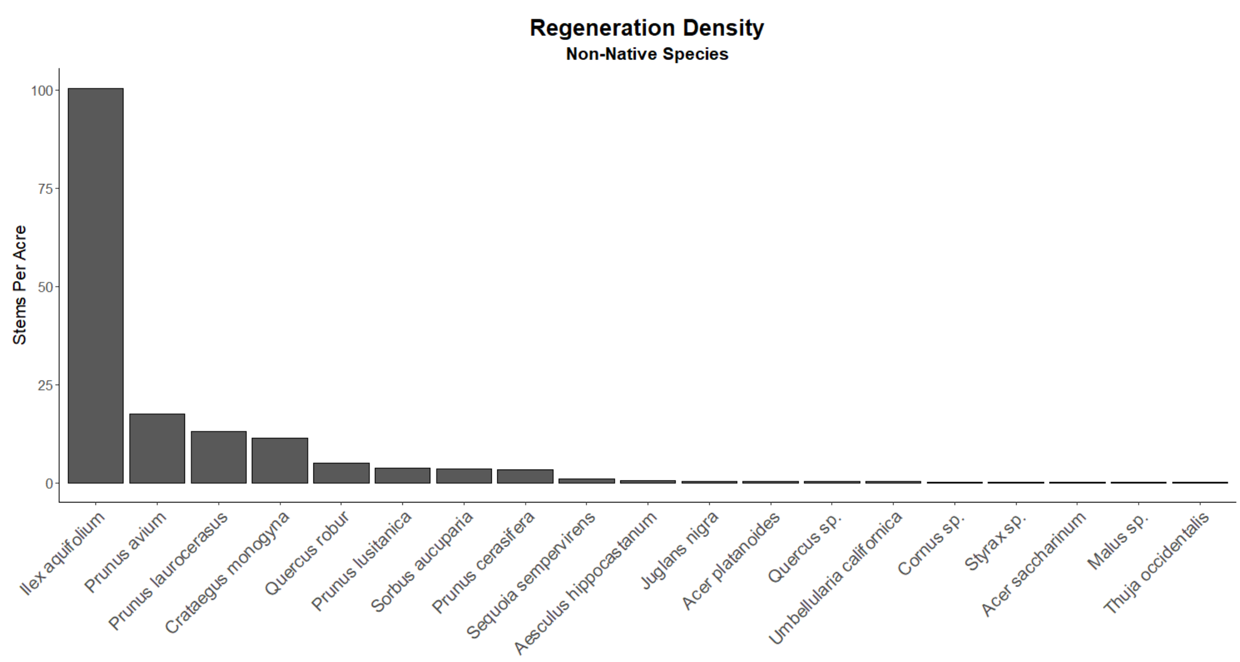

Figure 15: Species abundances of all non-native regenerating trees (DBH < 5”), inclusive of both seedling and sapling size-classes. All values represent means.

Change Over Time

Data Preparation

The stem density of saplings was adjusted in the 2024 data by subtracting extra forks from multi-stemmed saplings. Forked stems were not tracked for seedlings and so no adjustments were made for that size-class. Because Douglas hawthorn (*Crataegus douglasii*) was inventoried as a shrub in 2014 but as a tree in 2024, this species was removed from the data prior to comparing change over time. Vine maple (*Acer circinatum*) was inventoried as a tree in 2014 but as a shrub in 2024. However, because the specific taxonomy of native tree species was not recorded in 2014, it was not possible to remove vine maple from the tree inventory data. However, vine maple is relatively uncommon.

As a result of these data preparation steps, the structure metrics described in this sub-section may differ from those described elsewhere in the report.

All comparisons of tree regeneration between 2014 and 2024 should be treated with caution because of potential differences in how seedlings and saplings were counted in the two assessments. Stump sprouts, basal sprouts, harp branches and ephemeral seedlings can all contribute to skewed estimates of stem density. There are different ways to interpret these edge cases and it is unclear how they were handled in the 2014 assessment.

Native Species

The overall density of native saplings shows no appreciable trend between 2014 and 2024, with the mean density increasing from 63.7 to 64.8 stems per acre. The only native broadleaf evergreen tree species inventoried in 2014 and 2024 was madrona (*Arbutus menziesii*), which was present in the sapling size-class in 2014, but was absent in 2024. Conifer sapling density has nearly doubled over the past decade, with the mean density increasing from 16.3 to 32.8 stems per acre. Anecdotal observations suggest that this increase is primarily due to tree planting efforts and not from natural regeneration.

Table 11: Changes in the stem density of native saplings (1” ≤ DBH < 5”). All values represent means.

	Stems Per Acre (Native Species)			
	Conifer	Deciduous	Broadleaf Evergreen	Total
2014	16.3	46.8	0.6	63.7
2024	32.8	32.0	0.0	64.8
Absolute Difference	+16.5	-14.8	-0.6	+1.1
Relative Difference (%)	+101.2	-31.6	-100.0	+1.7

The data suggest that there may have been a net decrease in the density of native deciduous saplings. This may be due to a combination of processes, such as fewer seedling-sized deciduous trees growing large enough to become saplings (DBH ≥ 1”), mortality, or saplings growing large enough to enter the overstory size-class (DBH ≥ 5”). In other words, the rate that native deciduous trees enter the sapling size-class may be lower than the rate that they are exiting, but not necessarily due to mortality.

Superficially, the data may suggest that the density of native seedlings has decreased over the past decade. However, this trend should be regarded with skepticism because of potential differences in how seedlings were interpreted in 2014 and 2024. The protocol used in the 2024 assessment describes detailed approaches for the handling edge cases such as basal sprouts and stump sprouts, with the general intention of counting individual plants only once. It is possible that the 2014 inventory protocol counted seedlings that would not have been counted in 2024. Edge cases are especially relevant to deciduous tree species, which (predictably) appear to be lower in density in 2024 (Table 11, Table 12).

Edge cases are less likely to influence the way that conifer seedlings were inventoried. The mean density of conifer seedlings has nearly doubled since 2014, increasing from 15.3 to 28.0 stems per acre.

Only a single madrona seedling was inventoried in 2024. None were inventoried in 2014.

Table 12: Changes in the stem density of native seedlings (DBH < 1”). All values represent means.

	Stems Per Acre (Native Species)			
	Conifer	Deciduous	Broadleaf Evergreen	Total
2014	15.3	210.5	0.0	225.8
2024	28.0	74.0	0.3	102.3
Absolute Difference	+12.7	-136.5	+0.3	-123.5
Relative Difference (%)	+83.0	-64.8	NA	-54.7

Non-Native Species

The mean density of all non-native regenerating trees has decreased from 971.1 to 159.2 stems per acre over the past decade, largely driven by a decrease in the seedling size-class. The mean density of non-native saplings (1” ≤ DBH < 5”) remains relatively unchanged, decreasing from 14.6 to 14.0 stems per acre (**Table 13**). Although the net change sapling density is relatively small, there has been a dramatic shift in the species composition of this size-class. The three non-native tree species with the greatest decreases in sapling density are English holly (*Ilex aquifolium*), bird cherry (*Prunus avium*), and cherry laurel (*Prunus laurocerasus*) – together representing a decrease of -2.4 stems per acre. Increases in non-native sapling density were driven by English hawthorn (*Crataegus monogyna*, +0.6 stems per acre) and thundercloud plum (*Prunus cerasifera*, +0.5 stems per acre).

Table 13: Changes in the stem density of non-native seedlings and saplings. All values represent means.

	Stems Per Acre		
	Seedlings	Saplings	Total
2014	956.5	14.6	971.1
2024	145.2	14.0	159.2
Absolute Difference	-811.3	-0.6	-811.9
Relative Difference (%)	-84.8	-4.1	-83.6

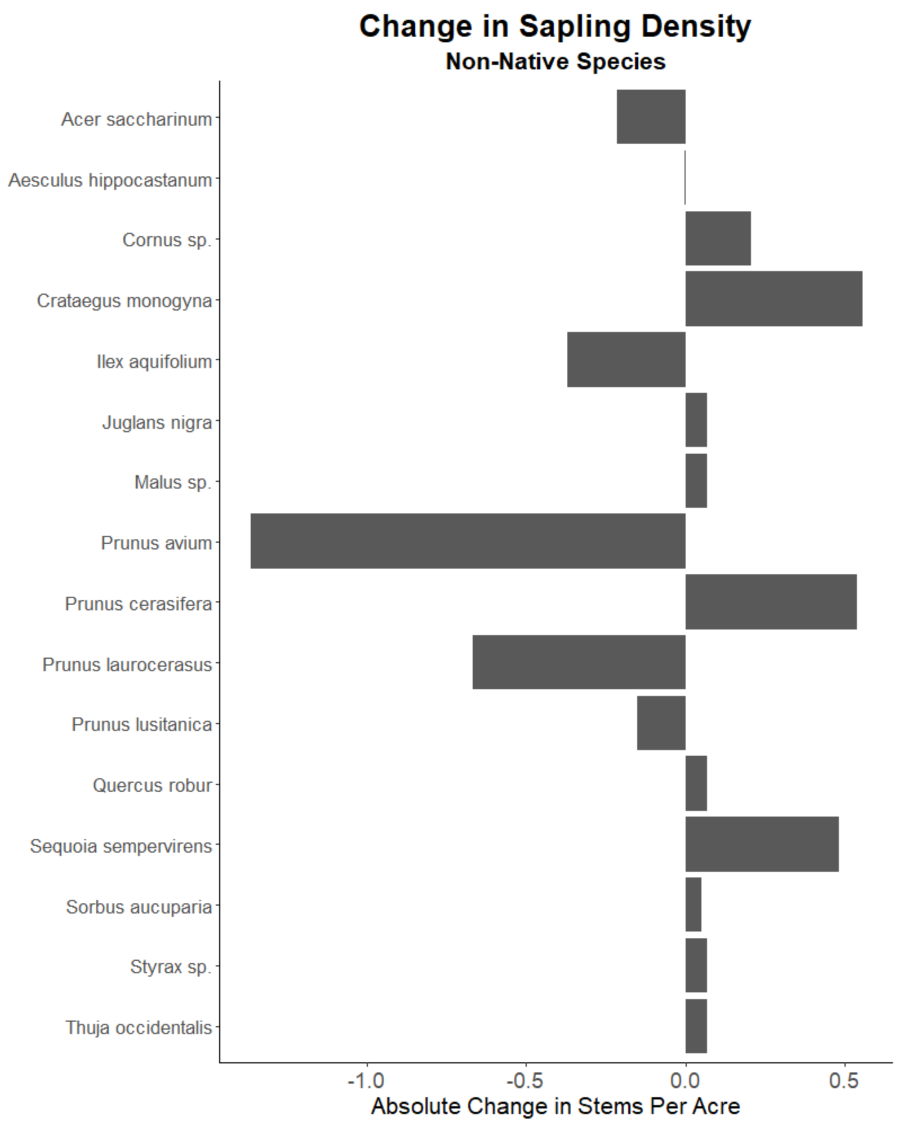

Figure 16: Change in the density of non-native saplings (1” ≤ DBH < 5”) between 2014 and 2024. All values represent means.

The data suggest that non-native seedling density has decreased by 85% over the past decade. However, as with native seedlings, this decrease may be influenced by potential differences in how seedlings were counted in the 2014 and 2024 assessments. For example, if clusters of sprouts from the same holly stump were counted as multiple seedlings in 2014, that would inflate the overall seedling density and exaggerate the decrease in mean density over time. However, this decrease in non-native seedling density is also likely driven by management actions that have removed or treated invasive species, especially *Ilex aquifolium* (absolute difference: -614.7 stems per acre), *Crataegus monogyna* (absolute difference: -74.9 stems per acre), and *Prunus laurocerasus* (absolute difference: -101.6 stems per acre).

Two invasive species had notable increases in seedling abundance, each increasing by approximately 5 seedlings per acre: bird cherry (*Prunus avium*) and English oak (*Quercus robur*).

Two near-native species were inventoried in the seedling size-class: coastal redwood (*Sequoia sempervirens*) and California bay laurel (*Umbellularia californica*), each at 3 stems per acre.

Table 14: Change in the density of non-native seedlings (DBH < 1") between 2014 and 2024. All values represent means.

Scientific Name	**Seedling Density (Stems Per Acre)**		
	2014	2024	Abs Diff
Acer palmatum	1.7	---	**-1.7**
Acer platanoides	---	0.3	0.3
Aesculus hippocastanum	---	0.6	0.6
Crataegus monogyna	81.5	6.7	**-74.9**
Ilex aquifolium	710.9	96.2	**-614.7**
Juglans nigra	---	0.3	0.3
Malus sp.	0.3	---	**-0.3**
Prunus avium	10.8	16.4	5.6
Prunus cerasifera	5.7	1.7	**-4.0**
Prunus laurocerasus	113.2	11.6	**-101.6**
Prunus lusitanica	10.5	3.3	**-7.1**
Quercus sp.	---	0.3	0.3
Quercus robur	---	5.0	5.0
Sequoia sempervirens	---	0.3	0.3
Sorbus aucuparia	22.1	2.5	**-19.6**
Umbellularia californica	---	0.3	0.3

Abs Diff = absolute difference

Understory Plants

Structure

The mean cover-abundance of native understory species was 75.9%, and ranged from 0% to 230%. Approximately 31% of the plots had native cover greater than or equal to 100%. Only 4.3% of the plots had native cover less than 5%. Native plant cover was greater than non-native cover in approximately two thirds of the plots.

The mean cover-abundance of non-native species was 42.8%. However, non-native species were often much more abundant at finer spatial scales, particularly in areas where invasive species outcompeted the native plant community. The cover-abundance of non-native species ranged from 0% to 202%, with non-native cover greater than or equal to 100% in approximately 13% of the understory plots. Non-native cover was less than 5% in approximately 28% of the plots, meaning that a key target in the Climate Action Plan (CAP) has already been met (10% of open space in "monitoring and maintenance" phase of restoration by 2030, with non-native cover below 5%).

Approximately 35% of the plots had a moderate abundance of non-native plants, with cover between 5 and 50%. Based on this analysis, it would be possible to meet the CAP target for 2050 (50% of open space in "monitoring and maintenance") by focusing weed removal exclusively in areas with under 50% non-native cover.

Maps showing the local cover-abundance of non-native plants for parks with survey areas larger than 10 acres are available in **Appendix B: Maps – Non-Native Cover-Abundances**.

Table 15: Contingency table showing the distribution of areas with low (< 5%), moderate (5 - 50%), high (50 - 100%), and very high (≥ 100%) cover-abundance, comparing native and non-native understory species. All values represent percentages.

		Native Species Cover				
		Low (< 5%)	**Moderate** (5 - 50%)	**High** (50 - 100%)	**Very High** (≥ 100%)	Total
Non-Native Species Cover	**Low** (< 5%)	0.9	5.8	8.5	13.2	28.4
	Moderate (5 - 50%)	1.1	9.0	12.1	12.3	34.5
	High (50 - 100%)	0.9	9.4	9.2	4.5	24.0
	Very High (≥ 100%)	1.3	7.4	3.4	0.9	13.0
	Total	4.2	31.6	33.2	30.9	100

Table 16: Understory structure metrics summarized by park. All values represent means.

Park	Cover-Abundance (%)	
	Native Species	Non-Native Species
Cayhill Open Space	27.0	101.0
Clarke Beach Park	33.8	67.5
Clise Park	91.0	24.3
Ellis Pond	122.5	5.5
Engstrom Open Space	76.6	37.9
Gallagher Hill Open Space	20.7	90.9
Groveland Beach Park	7.0	10.0
Hollerbach Park	82.1	77.3
Homestead Park	46.6	133.4
Island Crest Park	77.4	30.2
Luther Burbank Park	46.4	51.7
Mercerdale Hillside Park	71.0	76.8
Mercerdale Park	97.4	43.6
North Mercerdale Hillside	68.4	54.6
Parkwood Ridge Open Space	103.5	1.4
Pioneer Park NE	90.9	16.7
Pioneer Park NW	93.7	37.1
Pioneer Park SE	75.1	40.8
SE 47th St Open Space	51.2	101.7
SE 50th Pl Open Space	40.2	93.4
SE 53rd Pl Open Space	81.6	46.0
Secret Park	96.3	18.0
Upper Luther Burbank Park	79.6	30.4
Wildwood Park	52.3	65.3

Diversity

The alpha diversity of the understory plant community varies considerably depending on the habitat type (e.g. wetland, scrub-shrub, upland forest) and the abundance of invasive species. Biodiversity tends to be higher in areas with diverse environmental conditions, such as soil moisture gradients in wetland and riparian areas, or gradients in shade at the edges of canopy gaps. In the understory plots (25 m^2), the mean Shannon diversity index was 1.27 but was as high as 2.35 at a plot in a riparian corridor in SE 53rd Pl Open Space. Most understory plots with a Shannon diversity index greater than 2.0 were located in wetlands or riparian corridors.

Pielou species evenness ranged from 0 (the lowest possible value) to 0.99, which is close to the highest possible value for this diversity metric (1.0). Approximately 13% of the plots had a Pielou evenness under 0.4, indicating that the plant community was dominated by a small minority of the total species. These areas with low species evenness are typically dominated by invasive plants such as English ivy (*Hedera helix*), Himalayan blackberry (*Rubus bifrons*), reed canary grass (*Phalaris arundinacea*) or creeping buttercup (*Ranunculus repens*). Some areas with low species evenness are dominated by native species, especially rhizomatous shrubs, ferns, or other relatively large perennial species, such as:

- Red-twig dogwood (*Cornus sericea*)
- Beaked hazelnut (*Corylus cornuta*)
- Dwarf Oregon grape (*Mahonia nervosa*)
- Osoberry (*Oemleria cerasiformis*)
- Sword fern (*Polystichum munitum*)
- Nootka rose (*Rosa nutkana*)
- Salmonberry (*Rubus spectabilis*)
- Red elderberry (*Sambucus racemosa*)

Table 17: Understory diversity metrics for the entire island, based on data from 25 m^2 plots. Minimum values exclude two plots with less than 1% total cover-abundance in Island Crest Park.

	Shannon Diversity	**Pielou Evenness**	**Species Richness**		
			All Species	Native Species	Non-Native Species
Mean	1.27	0.56	10.1	6.9	3.2
Min	0.12	0.09	2	0	0
Max	2.34	0.99	23	16	11

A total of 85 native understory species were identified. A total of 63 non-native taxa were also identified, including 49 identified to species and 14 identified to genus. Taxa that were not identified to species were generally assumed to be non-native, with the exception of *Equisetum* and *Salix*.

Species richness ranged from 0 to 23 species per plot. The mean number of native understory species was 6.9 and the mean number of non-native species was 3.2. The only plot with zero plant species was located in an area in the NE corner of Island Crest Park that was converted into a bike track. Most plots had at least one non-native species present – non-native understory species were absent from only 2.6% of plots. Approximately 38% of the plots had 4 or more non-native species. Native species were absent from less than 1% of the understory plots, and 89% of the plots had 4 or more native species.

Even in areas that were severely invaded, native plant species were often found intermixed with the invasive species. For example, in the 13% of plots with non-native cover greater than or equal to 100%, the mean number of native species was 5.1. Native species were completely absent from only one of these severely invaded plots.

Native species richness was negatively correlated with the total cover-abundance of non-native species, likely because some native species that had been present on site were outcompeted by the invasive species (Figure 17). In contrast, native species richness was positively correlated with the total cover-abundance of native plants.

Maps showing the species richness of native plants for parks with survey areas larger than 10 acres are available in **Appendix A: Maps – Native Species Richness**.

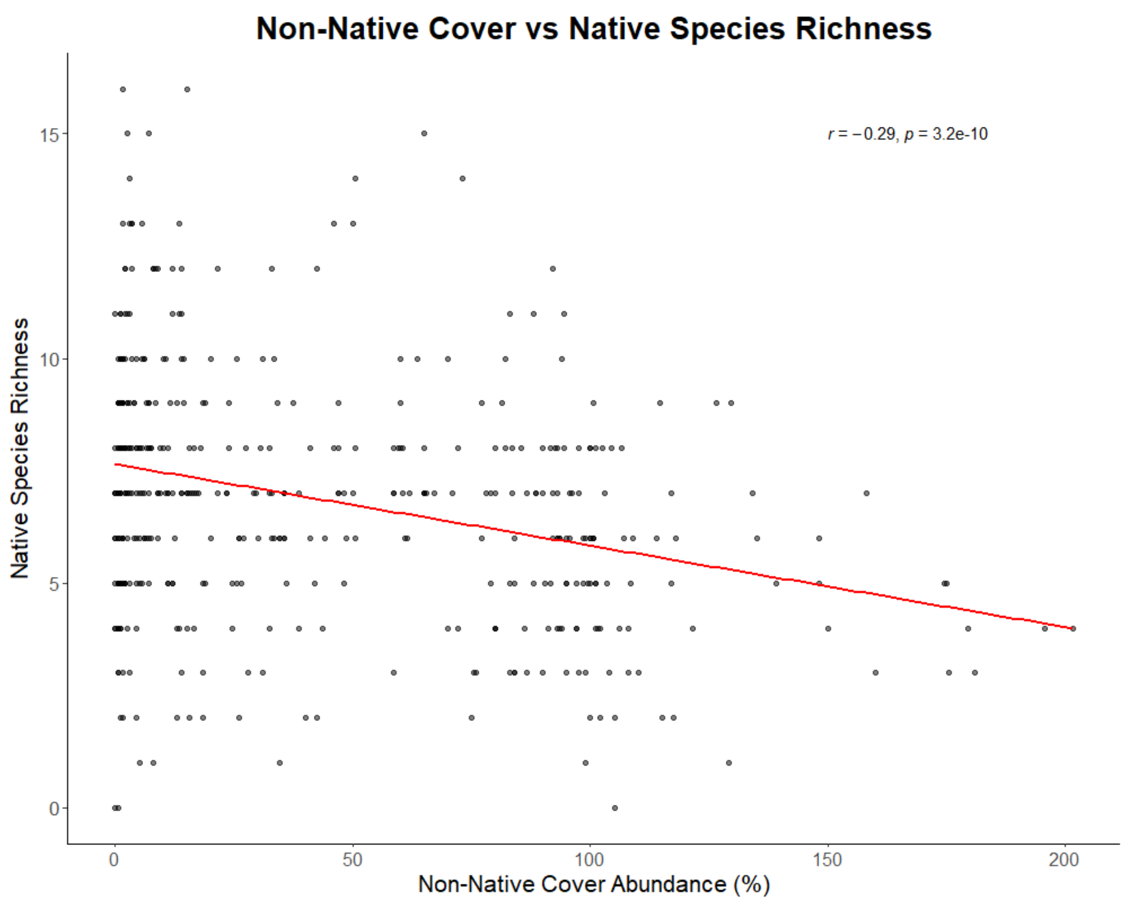

Figure 17: Correlation between non-native cover-abundance and native species richness.

Table 18: Understory diversity metrics summarized by park. All values represent means.

Park	**Shannon Diversity**	**Pielou Evenness**	**Species Richness**		
			All Species	Native Species	Non-Native Species
Cayhill Open Space	0.89	0.43	8.0	4.0	4.0
Clarke Beach Park	1.48	0.58	12.6	6.6	6.0
Clise Park	0.74	0.33	7.5	5.0	2.5
Ellis Pond	1.58	0.68	12.3	8.8	3.5
Engstrom Open Space	1.17	0.53	9.2	6.9	2.4
Gallagher Hill Open Space	0.96	0.45	9.1	5.1	4.0
Groveland Beach Park	1.90	0.92	8.0	2.0	6.0
Hollerbach Park	1.16	0.55	9.1	5.6	3.5
Homestead Park	1.18	0.56	9.3	5.0	4.3
Island Crest Park	1.22	0.55	9.3	6.6	2.7
Luther Burbank Park	1.13	0.55	8.2	4.4	3.8
Mercerdale Hillside Park	1.32	0.57	10.5	6.2	4.4
Mercerdale Park	1.42	0.53	14.6	8.0	6.6
North Mercerdale Hillside	1.30	0.57	10.1	6.3	3.8
Parkwood Ridge Open Space	1.03	0.46	10.0	7.8	2.2
Pioneer Park NE	1.37	0.58	11.2	8.7	2.5
Pioneer Park NW	1.40	0.60	10.7	7.8	2.9
Pioneer Park SE	1.35	0.58	10.4	7.7	2.7
SE 47th St Open Space	0.91	0.46	7.7	5.3	2.3
SE 50th Pl Open Space	1.31	0.51	13.0	7.8	5.2
SE 53rd Pl Open Space	1.08	0.50	9.2	5.9	3.3
Secret Park	1.72	0.64	14.5	6.5	8.0
Upper Luther Burbank Park	1.24	0.58	8.8	6.0	2.8
Wildwood Park	1.19	0.56	8.5	5.0	3.5

Figure 18: Upland vegetation in a mixed conifer deciduous stand in Pioneer Park SE.

Figure 19: Wetland vegetation in an area of Luther Burbank Park maintained by a beaver dam.

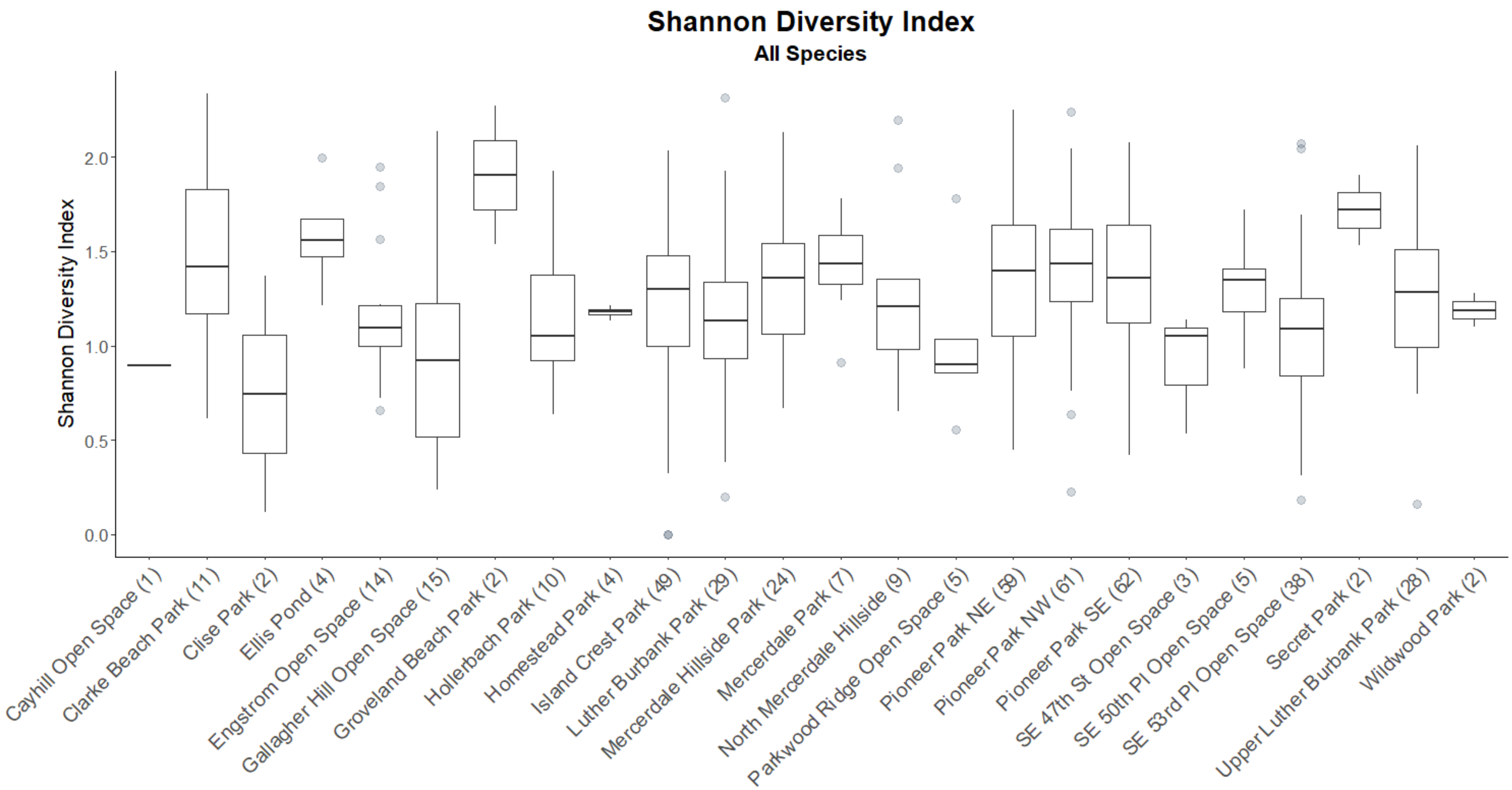

Figure 20: Shannon diversity index of the entire understory plant community for all inventoried parks and natural areas. Bold horizontal lines represent medians; boxes represent the interquartile range (ITR); vertical lines represent minimum and maximum values up to 1.5 x ITR; points represent outliers. Parks with only a single inventory plot are displayed with a horizontal line representing the individual value at that plot. Total number of plots per park is included in parenthesis after the park name, e.g. "Pioneer Park SE (62)".

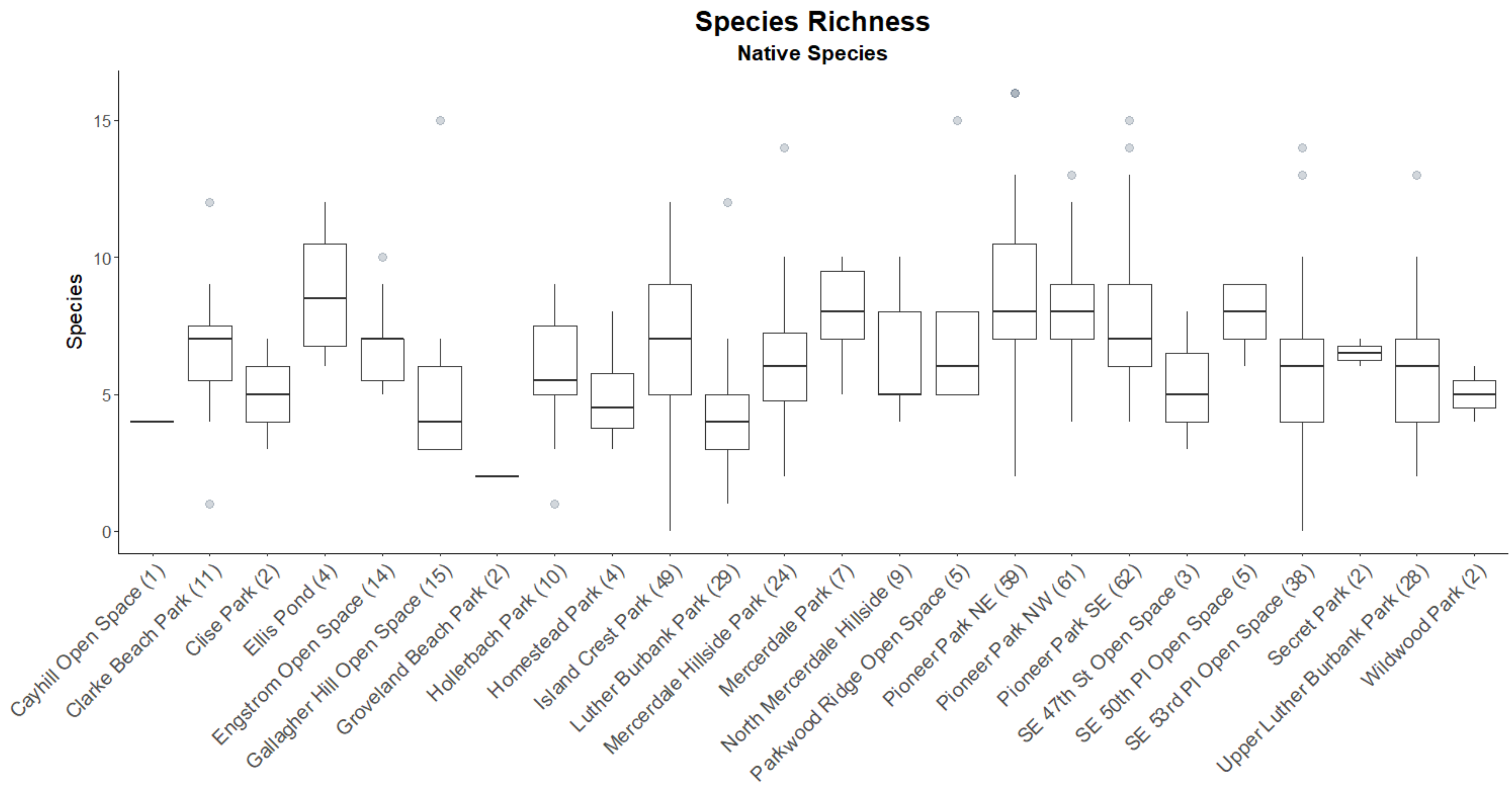

Figure 21: Species richness of native understory species for all inventoried parks and natural areas. Bold horizontal lines represent medians; boxes represent the interquartile range (ITR); vertical lines represent minimum and maximum values up to 1.5 x ITR; points represent outliers. Parks with only a single inventory plot are displayed with a horizontal line representing the individual value at that plot. Total number of plots per park is included in parenthesis after the park name, e.g. "Pioneer Park SE (62)".

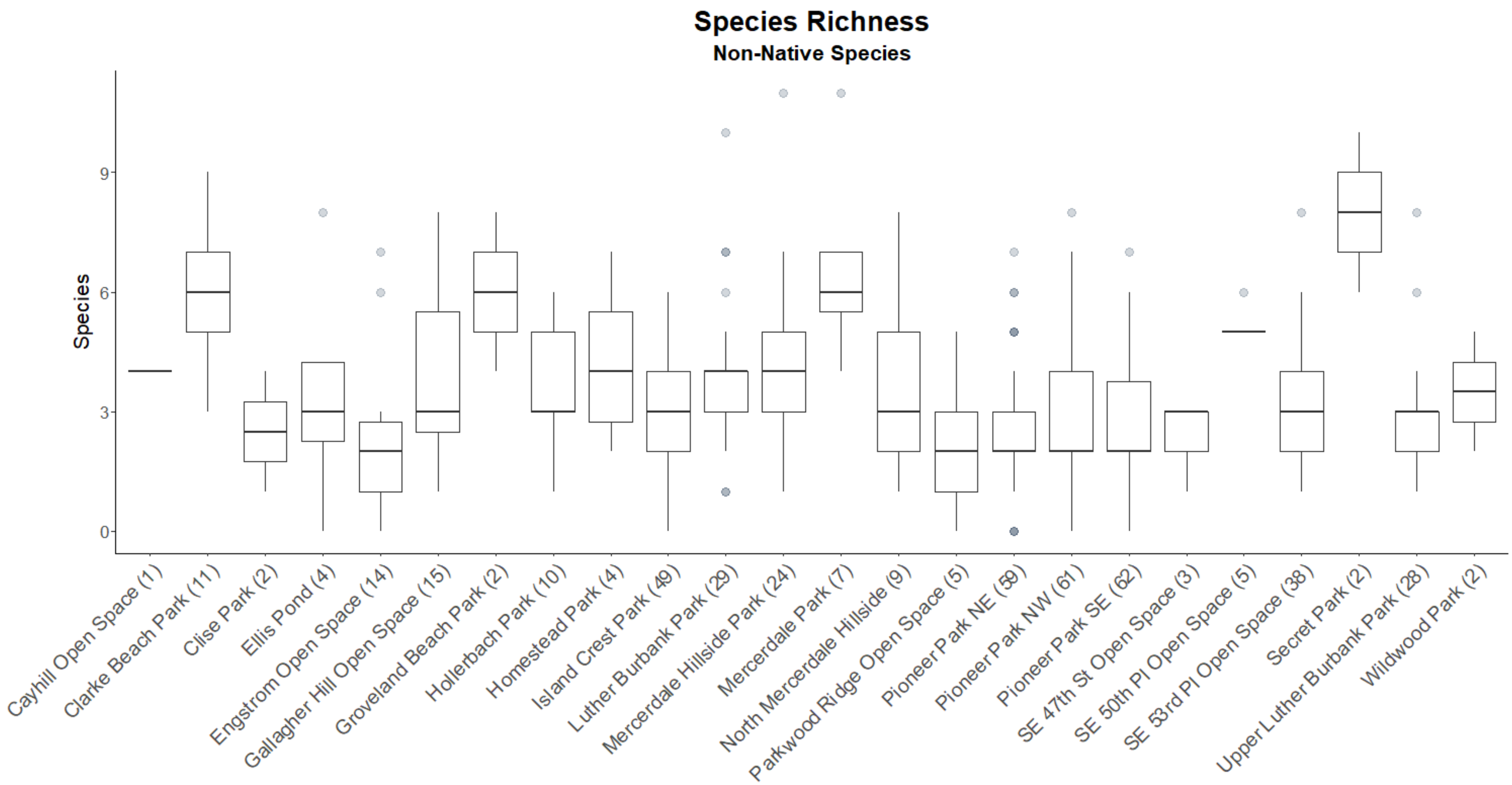

Figure 22: Species richness of non-native understory species for all inventoried parks and natural areas. Bold horizontal lines represent medians; boxes represent the interquartile range (ITR); vertical lines represent minimum and maximum values up to 1.5 x ITR; points represent outliers. Parks with only a single inventory plot are displayed with a horizontal line representing the individual value at that plot. Total number of plots per park is included in parenthesis after the park name, e.g. "Pioneer Park SE (62)".

Species Composition

Native Species

Because of the wide range of species associations present on the island, understory species composition is spatially heterogenous, especially for native plant communities that are adapted to specific environmental tolerances, such as shade or soil moisture.

In upland areas, sword fern (*Polystichum munitum*) is often dominant or co-dominant (cover: 20.3%, frequency: 84.3%) and often co-occurs with beaked hazelnut (*Corylus cornuta*, cover: 14.4%, frequency: 34.1%). Other common understory species in upland forests (cover > 1%) include salal (*Gaultheria shallon*), oceanspray (*Holodiscus discolor*), dwarf Oregon grape (*Mahonia nervosa*), osoberry (*Oemleria cerasiformis*), bracken fern (*Pteridium aquilinum*), trailing blackberry (*Rubus ursinus*) and red elderberry (*Sambucus racemosa*). Although relatively low in mean cover-abundance (< 1%), both red huckleberry (*Vaccinium parvifolium*) and trillium (*Trillium ovatum*) occur quite often across the landscape, with both species having a frequency of occurrence over 12%. In forests with mesic site conditions, nettle (*Urtica dioica*) is often present but rarely dominant (cover: 1.2%, frequency: 28.7%).

Many native species are restricted to riparian corridors and wetlands due to their low drought-tolerance, but can be locally abundant despite having a low mean cover-abundance island-wide (< 1%). These species include lady fern (*Athyrium filix-femina*), red-twig dogwood (*Cornus sericea*), common horsetail (Equisetum arvense), swamp lantern (*Lysichiton americanus*), devil's club (*Oplopanax horridus*), salmonberry (*Rubus spectabilis*) and piggyback plant (*Tolmiea menziesii*).

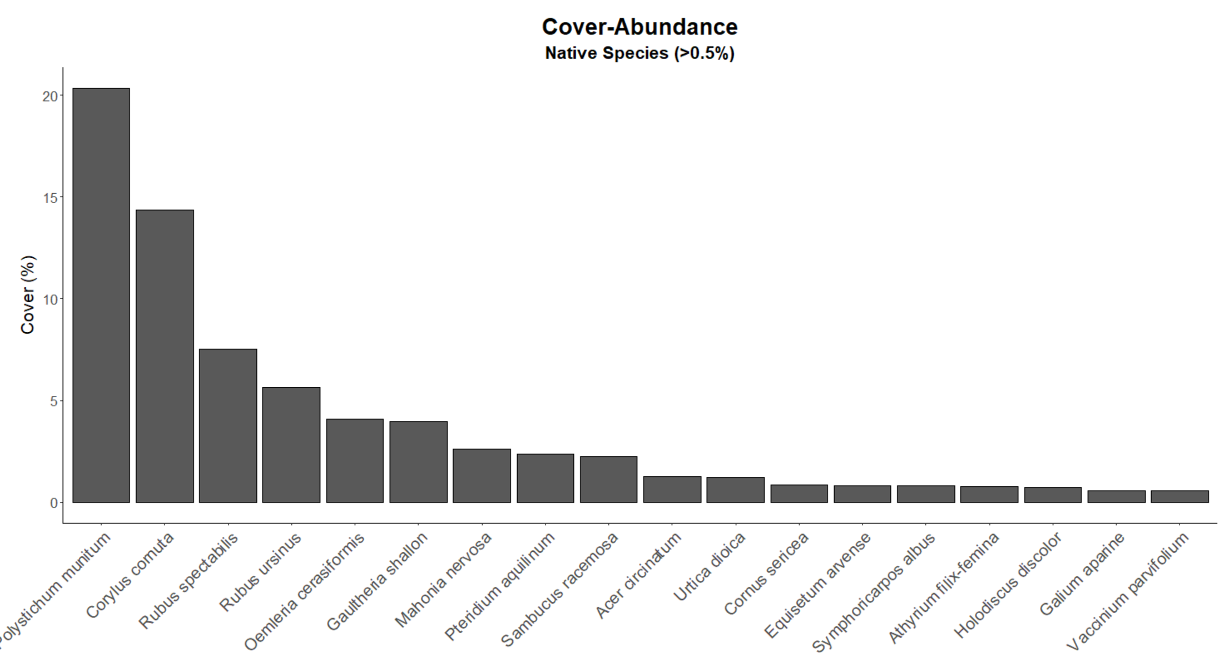

Figure 23: Cover-abundances for native understory species, limited to species with mean cover greater than 0.5%. See the Appendix for a complete list of native species.

Some taxa that are likely native species were difficult to identify given the traits that were present at the time of observation:

- In forests and wetlands with saturated soil conditions, an *Equisetum* species was often locally abundant but not always identifiable to species. Its traits were most similar to giant horsetail (*Equisetum telmateia*). When the traits of these horsetails were intermediate between giant horsetail and common horsetail (*Equisetum arvense*), they were recorded as *Equisetum* sp.
- In Mercerdale Hillside Park, a bipinnate *Polystichum* species was observed outside of the understory plots that is likely *P. braunii*, *P. andersonii*, or *P. californicum* (Figure 24). *P. californicum* is threatened in Washington (WANHP). Only a single individual was observed.
- Some willow trees, assumed to be native species, were only identified to genus due to the lack of flowers or other distinguishing traits.
- One *Lathyrus* plant was observed with traits resembling *L. vestitus*, which is common in California but endangered in Washington (WANHP). It remains unlikely that such a rare species would be present on Mercer Island – this specimen is most likely *Lathyrus nevadensis* or *Lathyrus polyphyllus*, which are both more common on the island.
- A *Rhododendon* species was observed in Mercerdale Hillside park that is likely *Rhododendron macrophyllum*. However, follow-up observations of the flowers may be necessary to confirm that it is not a non-native *Rhododendron* species.

A full list of observed native species is available in **Appendix E: Tables – Understory Species Abundance**.

Figure 24: Unidentified Polystichum species in Mercerdale Hillside Park

Table 19: Native understory species, limited to species with mean cover-abundance greater than 0.25%. Taxa ordered by cover-abundance (%). Cover values represent means. See the Appendix for a complete list of native species.

Common Name	Scientific Name	Cover (%)	Freq (%)
sword fern	*Polystichum munitum*	20.34	84.3
beaked hazelnut	*Corylus cornuta*	14.35	34.1
salmonberry	*Rubus spectabilis*	7.51	29.2
trailing blackberry	*Rubus ursinus*	5.64	64.1
osoberry	*Oemleria cerasiformis*	4.09	46.0
salal	*Gaultheria shallon*	3.96	27.1
low Oregon grape	*Mahonia nervosa*	2.61	36.8
bracken fern	*Pteridium aquilinum*	2.35	32.3
red elderberry	*Sambucus racemosa*	2.26	25.3
vine maple	*Acer circinatum*	1.27	7.6
nettle	*Urtica dioica*	1.23	28.7
red-osier dogwood	*Cornus sericea*	0.87	3.6
common horsetail	*Equisetum arvense*	0.82	9.6
snowberry	*Symphoricarpos albus*	0.81	7.0
lady fern	*Athyrium filix-femina*	0.76	15.3
oceanspray	*Holodiscus discolor*	0.74	5.2
bedstraw	*Galium aparine*	0.58	28.7
red huckleberry	*Vaccinium parvifolium*	0.58	12.6
Nootka rose	*Rosa nutkana*	0.46	2.5
wood fern	*Dryopteris expansa*	0.35	15.7
piggy-back plant	*Tolmiea menziesii*	0.33	5.8
tall Oregon grape	*Mahonia aquifolium*	0.30	2.7
devil's club	*Oplopanax horridus*	0.30	2.5

Cover = mean cover-abundance, Freq = frequency of occurrence

Non-Native Species

English ivy (*Hedera helix*) is generally the most dominant non-native species in shaded upland areas (cover: 27.14%, frequency: 75.9%). Himalayan blackberry (*Rubus bifrons*), being less shade tolerant, is generally more dominant in forest edges, scrub-shrub and canopy gaps (cover: 10.12%, frequency: 52.2%). The two species often co-occur, which can result in dense, multi-layered understory conditions with a low diversity of native species. In upland forests, herb Robert (*Geranium robertianum*), herb bennet (*Geum urbanum*), field bindweed (*Convolvulus arvensis*), nipplewort (*Lapsana communis*), and wall lettuce (*Mycelis muralis*) are the next most abundant non-native understory species, either in terms of mean cover-abundance or their frequency of occurrence (Table 20).

In riparian corridors, moist forests and wetlands, other invasive species can be locally abundant, including: spotted ladysthumb (*Persicaria maculosa*), reed canary grass (*Phalaris arundinacea*), creeping buttercup (*Ranunculus repens*), and bittersweet nightshade (*Solanum dulcamara*). Itadori knotweed (*Fallopia japonica*) and other invasive knotweeds were not observed in the understory plots (nor in the microplots of the overstory survey). However, they were sometimes anecdotally observed along forest edges and in stream corridors outside of the plots, including in areas of right-of-way adjacent to the parks and open spaces.

A full list of non-native species is available in **Appendix E: Tables – Understory Species Abundance**.

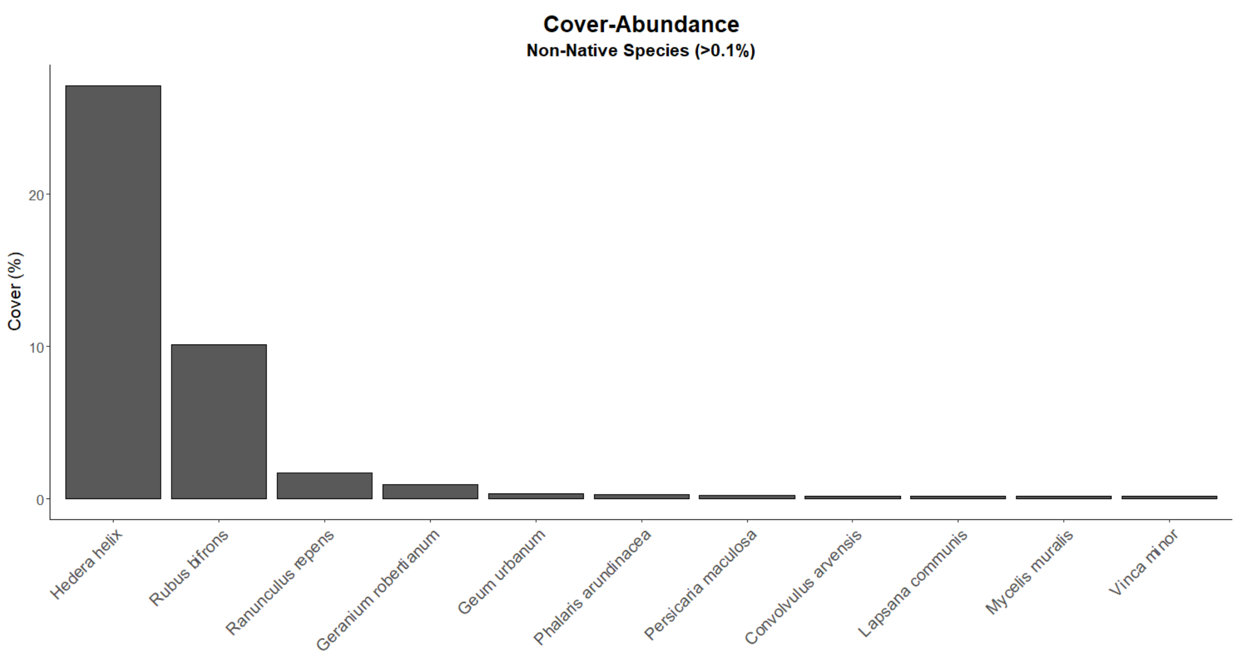

Figure 25: Cover-abundances for non-native understory species, limited to species with mean cover greater than 0.1%. See the Appendix for a complete list of non-native species.

Table 20: Non-native understory species, limited to species with mean cover-abundance greater than 0.01% or frequency greater than 0.5%. Taxa ordered by cover-abundance (%). Cover values represent means. See the Appendix for a complete list of non-native species.

Common Name	**Scientific Name**	**Cover (%)**	**Freq (%)**
English ivy	*Hedera helix*	27.14	74.9
Himalayan blackberry	*Rubus bifrons*	10.12	52.2
creeping buttercup	*Ranunculus repens*	1.73	9.0
herb Robert	*Geranium robertianum*	0.95	41.3
herb bennet	*Geum urbanum*	0.34	8.1
reed canary grass	*Phalaris arundinacea*	0.27	2.0
spotted ladysthumb	*Persicaria maculosa*	0.24	0.5
field bindweed	*Convolvulus arvensis*	0.18	4.7
wall-lettuce	*Mycelis muralis*	0.16	25.3
nipplewort	*Lapsana communis*	0.16	18.6
vinca	*Vinca minor*	0.16	0.5
hairy bittercress	*Cardamine hirsuta*	0.08	8.5
bittersweet nightshade	*Solanum dulcamara*	0.08	3.6
cotoneaster	*Cotoneaster* sp.	0.04	0.5
dandelion	*Taraxacum officinale*	0.02	3.4
spurge laurel	*Daphne laureola*	0.02	2.2
chickweed	*Stellaria media*	0.02	2.0
bullate cotoneaster	*Cotoneaster rehderi*	0.02	0.5
tutsan	*Hypericum androsaemum*	0.01	1.4
annual bluegrass	*Poa annua*	0.01	0.9
bitter dock	*Rumex obtusifolius*	0.01	0.9
thymeleaf speedwell	*Veronica serpyllifolia*	0.01	0.9
creeping bentgrass	*Agrostis stolonifera*	0.01	0.7

Cover = mean cover-abundance, Freq = frequency of occurrence

Change Over Time

Data Preparation

Prior to comparing differences in the understory plant community between 2014 and 2024, data were prepared to better align the two methodologies. Taxonomy was harmonized by aggregating taxa when the species-level taxonomy was judged to have a high likelihood of conflict between the 2014 and 2024 assessments. For example, in the 2024 assessment, *Juncus effusus* was identified to subspecies, some of which are non-native. However, *Juncus effusus* was only identified to species in the 2014 assessment, so these taxa were consolidated into the genus *Juncus* and assumed to be non-native prior to analyzing change over time. Similar consolidation was applied to other taxa that are likely to have conflicting identification, such as *Lathyrus* spp or *Agrostis* spp.

Additionally, some understory species were filtered out of the 2014 data if they were inventoried as trees in the overstory survey in 2024. This data preparation step primarily affects invasive tree species. For example, English holly (*Ilex aquifolium*) was included in the cover-abundance estimates in 2014, but only surveyed as a tree in 2024, so it was removed prior to comparing changes in structure or diversity. As a result of these data preparation steps, the diversity and cover-abundance metrics described in this sub-section may differ from those described elsewhere in the report.

Additional documentation is available in separate tables showing how the original species codes were mapped to new species codes for the purpose of aggregating and filtering taxa.

Structure

The total cover-abundance of all understory plants increased from a mean of 102.8% to 115.5% between 2014 and 2024, primarily due to an increase in the cover of non-native plants, which increased from 30.6% to 42.1% (absolute difference: +11.5%). Native plant cover has not appreciably changed over the past decade, with mean cover increasing from 72.2% to 73.4% (absolute difference: +1.7%).

The percentage of plots with non-native cover below 5% has not appreciably changed over the past decade, increasing from 28.5% to 29.0% of plots (absolute difference: +0.5%). However, the percentage of plots with non-native cover equal to or greater than 90% cover has increased from 9.2% to 22.2% of plots (absolute difference: +13%).

Table 21: Changes in understory structure between 2014 and 2024

	Cover-Abundance (%)		
	Native	Non-Native	All Species
2014	72.2	30.6	102.8
2024	73.4	42.1	115.5
Absolute Difference	+1.2	+11.5	+12.7
Relative Difference (%)	+1.7	+37.8	+12.4

Diversity

Overall understory diversity has decreased over the past decade, with the Shannon diversity index decreasing from 1.41 to 1.21 (absolute difference: -0.2). This change was largely driven by a decline in overall species richness (11.7 to 9.0 mean number of species per plot), as the Pielou species evenness between 2014 and 2024 was not appreciably different (0.58 vs 0.56). The mean species richness of native plants decreased from 8.1 to 6.3 species per plot, while non-native plant diversity decreased from a mean of 3.6 to 2.8 species per plot. Differences in species richness cannot be explained by potential differences in how cover-abundance was estimated between 2014 and 2024.

Table 22: Changes in understory diversity between 2014 and 2024

	Shannon Index	**Pielou Evenness**	**Species Richness**	
			Native	Non-Native
2014	1.41	0.58	8.1	3.6
2024	1.21	0.56	6.3	2.8
Absolute Difference	- 0.20	- 0.02	- 1.8	- 0.8
Relative Difference (%)	- 14.18	- 3.44	- 22.3	- 23.3

Composition

Most of the native species that have increased in cover or frequency are perennial shrubs that are relatively drought-tolerant and have relatively long lifespans. For example, beaked hazelnut (*Corylus cornuta*) has increased in cover-abundance from 11.91% in 2014 to 14.38% in 2024, which is an absolute difference of +2.47% and a relative difference of +20.74%. The frequency of beaked hazelnut has also increased, from 32.2% of plots to 34.2% of plots (absolute difference: +2.0%, relative difference: +6.2%), meaning that it is found in more locations than before, regardless of its local cover-abundance.

Some native species have increased in mean cover-abundance while decreasing in frequency, meaning that they have become more dominant locally but are present in fewer locations. For example, sword fern (*Polystichum munitum*) has increased in mean cover-abundance from 19.42% to 20.39% between 2014 and 2024 (absolute difference: +0.97%, relative difference: +4.99%). Yet, sword fern has also decreased in frequency, from 89.0% to 84.5%. Changes in the cover and frequency of sword fern may in part be driven by the apparent blight affecting the species regionally, resulting in sudden mortality events that have rapidly diminished local populations, including on Mercer Island.

Most native species that have decreased in both cover and frequency happen to be herbaceous plants, including vanilla leaf (*Achlys triphylla*), Siberian miner's lettuce (*Claytonia sibirica*), foam flower (*Tiarella trifoliata*), star flower (*Trientalis borealis*), and trillium (*Trillium ovatum*). Of the native species that have decreased in abundance, the following three species have decreased in frequency by over 15% (absolute difference): wood fern (*Dryopteris expansa*), red elderberry (*Sambucus racemosa*), and nettle (*Urtica dioica*). In the case of red elderberry, it was observed in over 50% of the plots in 2014 but only 25% of the plots in 2024. Wood fern (*Dryopteris expansa*) was also observed in half as many plots in 2024 as it was in 2014.

It is unclear what factors are driving these declines. It is plausible that some of these changes in species composition are the result of normal ecological succession, as dominant species modify site conditions (e.g. overstory trees creating closed canopy conditions), and the species that are more competitive in those conditions slowly increasing in cover-abundance. It is also possible that herbaceous species have been exposed to greater herbivory by black-tailed deer, invasive rabbits, or other herbivores. Lastly, as the climate has become warmer and drought conditions in the summer have become more severe, it might be expected that some herbaceous species would be less tolerant of these drier conditions compared with shrubs or other species with deeper root systems.

A curated list of native species that have changed in cover or frequency is available in **Table 23**.

Figure 26: Photo of a symptomatic sword fern in Upper Luther Burbank Park

Most non-native species have decreased in both cover-abundance and frequency of occurrence. Two invasive species have had notable increases in their mean cover between 2014 and 2024. English ivy (*Hedera helix*) has increased in cover from 17.11% to 27.20% (absolute difference: +10.09%, relative difference: + 86.44%), despite its frequency of occurrence decreasing from 86.4% to 75.1%. This suggests that while habitat restoration activities have locally extirpated ivy in at least 9% of the open spaces, the species has increased in overall abundance in places where it may have already been present but not yet managed. Similarly, Himalayan blackberry (*Rubus bifrons*) has increased in cover-abundance from 7.29% in 2014 to 10.15% in 2024 (absolute difference: +2.86%, relative difference: +39.23%), despite a concurrent decrease in its frequency from 54.0% of plots to 52.4% of plots. Daphne laurel (*Daphne laureola*) is one of the few invasive species that has increased both in cover-abundance and frequency, with its frequency of occurrence nearly doubling since 2014. Herb robert (*Geranium robertianum*) has decreased in frequency more than any other invasive species, decreasing from 64.8% of plots in 2014 to 41.4% of plots in 2024 – an absolute difference of -23.5% and a relative difference of -36.2%.

Geum urbanum would appear in the data to have dramatically increased in abundance between 2014 and 2024. However, it is likely that *Geum urbanum* was in fact present on Mercer Island during the previous survey in 2014, potentially being misidentified as native species *Geum macrophyllum*.

A curated list of non-native species that have changed in cover or frequency is available in **Table 24**. Full lists with all changes in understory species composition are available in **Appendix F: Tables – Changes in Understory Species Composition Between 2014 and 2024**.

Table 23: Changes in the native plant community – curated table highlighting species that have increased or decreased in their mean cover-abundance or frequency of occurrence between 2014 and 2024, ordered by absolute difference in frequency. Cover values below 0.01% are represented by "---". Cover values represent means.

	Common Name	Scientific Name	Growth Form	Cover (%)			Frequency (%)		
				2014	2024	Abs Diff	2014	2024	Abs Diff
Increasing Abundance	red-twig dogwood	*Cornus sericea*	S	0.22	0.87	0.65	1.2	3.6	2.5
	Nootka rose	*Rosa nutkana*	S	0.01	0.47	0.46	0.2	2.5	2.2
	Lathyrus sp.	*Lathyrus* sp.	H	---	0.01	0.01	0.5	2.7	2.2
	beaked hazelnut	*Corylus cornuta*	S	11.91	14.38	2.47	32.2	34.2	2.0
	oceanspray	*Holodiscus discolor*	S	0.37	0.74	0.37	3.2	5.2	2.0
	serviceberry	*Amelanchier alnifolia*	S	---	0.02	0.02	0.5	1.8	1.3
	thimbleberry	*Rubus parviflorus*	S	0.10	0.11	0.01	3.0	4.0	1.1
	snowberry	*Symphoricarpos albus*	S	0.79	0.81	0.02	6.0	7.0	1.0
	tall Oregon grape	*Mahonia aquifolium*	S	0.08	0.30	0.22	2.1	2.7	0.6
	bedstraw	*Galium aparine*	H	0.26	0.58	0.32	28.3	28.8	0.5
	trailing blackberry	*Rubus ursinus*	S	3.96	5.66	1.70	64.1	64.3	0.1
Mixed Changes	Pacific ninebark	*Physocarpus capitatus*	S	0.03	0.14	0.11	0.9	0.5	**-0.5**
	salmonberry	*Rubus spectabilis*	S	6.14	7.53	1.39	30.6	29.2	**-1.4**
	osoberry	*Oemleria cerasiformis*	S	2.85	4.10	1.25	47.6	46.1	**-1.5**
	sword fern	*Polystichum munitum*	H	19.42	20.39	0.97	89.0	84.5	**-4.5**

	Common Name	Scientific Name	Growth Form	Cover (%) 2014	Cover (%) 2024	Cover (%) Abs Diff	Frequency (%) 2014	Frequency (%) 2024	Frequency (%) Abs Diff
Decreasing Abundance	devil's club	*Oplopanax horridus*	H	0.64	0.30	**-0.34**	3.9	2.5	**-1.4**
	starflower	*Trientalis borealis*	H	---	---	**< 0.01**	2.1	0.5	**-1.6**
	blackcap	*Rubus leucodermis*	S	0.06	0.05	**-0.01**	4.1	2.3	**-1.9**
	foamflower	*Tiarella trifoliata*	H	0.05	0.02	**-0.03**	3.5	1.4	**-2.1**
	bracken fern	*Pteridium aquilinum*	H	2.57	2.36	**-0.21**	34.7	32.4	**-2.4**
	vanilla leaf	*Achlys triphylla*	H	0.33	0.19	**-0.14**	8.5	5.6	**-2.9**
	red huckleberry	*Vaccinium parvifolium*	S	0.63	0.58	**-0.05**	16.3	12.6	**-3.7**
	lady fern	*Athyrium filix-femina*	H	1.15	0.76	**-0.39**	19.8	15.3	**-4.5**
	fringed willowherb	*Epilobium ciliatum*	H	0.02	0.03	**0.01**	9.0	3.6	**-5.4**
	salal	*Gaultheria shallon*	S	4.06	3.97	**-0.09**	32.9	27.2	**-5.7**
	enchanter's nightshade	*Circaea alpina*	H	0.08	0.05	**-0.03**	11.7	5.6	**-6.1**
	low Oregon grape	*Mahonia nervosa*	S	2.69	2.62	**-0.07**	45.5	36.9	**-8.7**
	Dewey's sedge	*Carex leptopoda*	H	0.08	0.04	**-0.04**	13.8	4.9	**-8.9**
	trillium	*Trillium ovatum*	H	0.16	0.08	**-0.08**	21.6	12.4	**-9.3**
	Siberian miner's lettuce	*Claytonia sibirica*	H	0.11	0.05	**-0.06**	15.9	5.8	**-10.0**
	nettle	*Urtica dioica*	H	3.42	1.24	**-2.18**	46.7	28.8	**-17.9**
	wood fern	*Dryopteris expansa*	H	1.34	0.35	**-0.99**	33.8	15.7	**-18.1**
	red elderberry	*Sambucus racemosa*	S	5.55	2.26	**-3.29**	53.1	25.4	**-27.7**

Growth Forms: S = shrub, H = herbaceous; Abs Diff = absolute difference

Table 24: Changes in the non-native plant community – curated table highlighting species that have increased or decreased in their mean cover-abundance or frequency of occurrence between 2014 and 2024, ordered by absolute difference in cover. Cover values below 0.01% are represented by "---". Cover values represent means.

	Common Name	**Scientific Name**	**Growth Form**	**Cover (%)**			**Frequency (%)**		
				2014	2024	Abs Diff	2014	2024	Abs Diff
Increasing Abundance	English ivy	*Hedera helix*	V	17.11	27.20	10.09	86.4	75.1	**-11.4**
	Himalayan blackberry	*Rubus bifrons*	S	7.29	10.15	2.86	54.0	52.4	**-1.7**
	creeping buttercup	*Ranunculus repens*	H	0.88	1.73	0.85	9.7	9.0	**-0.7**
	spurge laurel	*Daphne laureola*	S	---	0.02	0.02	1.2	2.3	1.1
Decreasing Abundance	hairy bittercress	*Cardamine hirsuta*	H	0.10	0.08	**-0.02**	16.3	8.5	**-7.8**
	nipplewort	*Lapsana communis*	H	0.20	0.16	**-0.04**	22.8	18.7	**-4.1**
	bittersweet nightshade	*Solanum dulcamara*	V	0.16	0.08	**-0.08**	4.4	3.6	**-0.8**
	reed canarygrass	*Phalaris arundinacea*	G	0.59	0.27	**-0.32**	2.5	2.0	**-0.5**
	wall-lettuce	*Mycelis muralis*	H	0.49	0.16	**-0.33**	44.1	25.4	**-18.8**
	field bindweed	*Convolvulus arvensis*	V	0.77	0.18	**-0.59**	6.9	4.7	**-2.2**
	herb Robert	*Geranium robertianum*	H	2.05	0.96	**-1.09**	64.8	41.4	**-23.5**

Growth Forms: S = shrub, H = herbaceous, G = graminoid, V = vine; Abs Diff = absolute difference

Management Recommendations

Strategic Planning

Strategic planning can involve redefining mission and visions statements, establishing new goals or objectives, and selecting key performance metrics that are useful for tracking progress towards meeting those goals and objectives. The 2024 FHA provides an opportunity to revise the open space vegetation management plan based on new data on the existing conditions and insights into how the parks and natural areas have changed over the past decade.

The following recommendations focus on the development of potential metrics for tracking changes in biodiversity and ecosystem structure:

1. Reevaluate management objectives and key performance metrics based on what is achievable given existing conditions, personal experience, and available resources (staff, community volunteers, funding, skillsets, etc). More specifically, the “monitoring and maintenance” targets in the CAP could be better defined – the current criteria specifies “a diversity of plant species, tree ages, and forest structure”.
2. When developing target metrics for diversity or structure, consider reference ecosystems for different habitat types (e.g. scrub-shrub, forested wetland, upland forest, shoreline, etc).
3. Understory diversity – target metrics for alpha diversity should be area-based to account for the diversity-area relationship (e.g. species richness per 25 m^2)
4. Consider developing targets for the following:
    - Snag density
    - Coarse woody debris
    - Overstory tree density
    - Overstory tree composition (canopy type and/or species)
    - Native tree regeneration density
    - Tree canopy (cover, rumple index, gap-size distribution, etc)

Capacity Building

Organizational capacity includes personnel (staff, volunteers), resources (funding, tools, infrastructure, time), and less tangible assets such as skillsets, institutional knowledge, partnerships, and community engagement. Consider the following recommendations for skill training and supply-chain management:

1. Train staff, volunteers, and/or contractors on the Bradley approach to invasive species management.
2. Train staff, volunteers, and/or contractors on identification of more obscure invasive species, especially those that may be misidentified as native species (and vice versa).
3. Consider establishing multi-year contracts with native plant nurseries to increase their capacity for special orders, especially to obtain near-native species or non-local genotypes (i.e. “assisted migration”). Involve plant nurseries in the early stages of planning habitat restoration projects like any other collaborator.

Invasive Species

Invasive species are one of the greatest threats to preserving the biodiversity and ecosystem functions of the parks and open spaces on Mercer Island. Data from the 2024 FHA suggest that invasive species are increasing in abundance at a pace that may exceed the resources currently available to control them. Consider the following recommendations for adaptive management and resource prioritization:

1. Prioritize the control of invasive species in areas where resources can be used most efficiently to achieve management goals. Consider the following criteria for areas to prioritize:
    - Low cover-abundance of invasive shrubs / forbs / vines (< 20% cover)
    - Areas with relatively shallow slopes (< 30%)
2. For ivy rings, prioritize areas where ivy is less developed on the tree trunks (i.e. low ivy-height index – see data). Avoid areas where ivy is highly developed (Figure 27).
3. Continue the current practice of conducting follow-up weeding each year for 2 - 3 years after initial weed removal.
4. In areas where the abundance of invasive species already meets target metrics (e.g. < 5% cover), conduct maintenance weeding every 5 years. Assume that propagule pressure will remain high in the foreseeable future.
5. When controlling invasive species in areas where invasive cover is spatially heterogenous, consider using cover-thresholds to guide work and avoid resources being exhausted on areas that are inefficient to control. For example, a potential guideline could specify avoiding the removal of invasive plants from patches where local cover is greater than 50% in any given area greater than a 12 ft X 12 ft area. In this example, patches smaller than a 12 ft X 12 ft area would always be removed, but larger areas dominated by invasive species would be ignored, at least during initial weed removal phases. This approach can be integrated with the Bradley method.

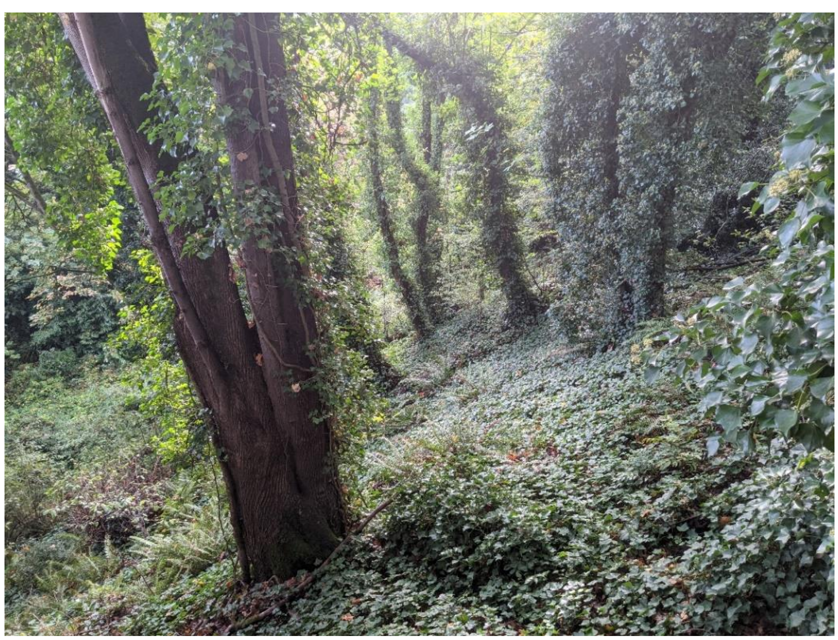

Figure 27: Areas dominated by invasive species should be deprioritized until areas with more intact native plant communities are meeting targets for non-native cover (< 5%).

Stand Structure

Some forested stands on Mercer Island are overstocked and require thinning to reduce competition. The alternative, continued passive management, will result in the inevitable decline in the health and vigor of these stands as competition between the dominant trees continues to increase. Additionally, coarse woody debris volume, snag density and native tree regeneration are relatively low in many areas. Stand-improvement thinning can be used to both reduce tree competition and increase the density of snags and coarse woody debris. Thinning treatments can also be designed to release shade-tolerant tree species regenerating in the understory, or to create canopy gaps suitable for sun-loving species.

1. Revisit locations identified in the inventory data as being potentially overstocked. Use rapid assessments to delineate areas that require thinning. Recommended criteria for areas to prioritize for thinning: RD values over 70, and/or live crown ratios under 20 for dominant or co-dominant trees. Parks that should be prioritized for potential thinning include:
    - Island Crest Park
    - Mercerdale Hillside Park
    - Pioneer Park
    - SE 50th Pl Open Space
    - Upper Luther Burbank Park
    - Wildwood Park
2. Conduct stand-improvement thinning treatments in overstocked stands, upland areas that lack climate change refugia, and riparian corridors with low amounts of coarse woody debris in the stream channels. Consider using both an upper diameter limit (to retain the largest and oldest trees) as well as a lower diameter limit (to retain regenerating trees).
3. Thinning treatments should generally be conducted after invasive species cover-abundance has been reduced to under 5% – avoid conducting thinning treatments where it could release invasive species that are currently being suppressed by shade.
4. Increase overall tree regeneration. Avoid planting trees at densities that would result in overstocked stands in the near future, especially if thinning treatments are unlikely to be feasible. Consider installing trees at densities between 80 and 120 stems per acre, prioritizing areas where native conifer regeneration and/or overstory tree density is relatively low:
    - Conifer tree regeneration under 100 stems per acre
    - Curtis RD < 35
5. Use a phased approach when conducting thinning treatments in areas that are extremely overstocked (RD values over 85 or live crown ratios under 10% among dominant and co-dominant trees). Partial cuts over multiple years may reduce the chance of thinning shock.
6. Consider the following target metrics for managing stand structure:
    - Mean snag density: 20 stems per acre
    - Mean coarse woody debris volume: 2,000 ft^3/ac
    - Mean conifer tree regeneration: 100 stems per acre
    - Overstory tree density
        - Mean: RD 35
        - Maximum: RD 55

Stand Composition

The tree canopy on Mercer Island is currently dominated by native species that are relatively drought tolerant: big leaf maple (*Acer macrophyllum*) and Douglas fir (*Pseudotsuga menziesii*). However, western red cedar (*Thuja plicata*) is overrepresented in the seedling and sapling size-classes, especially considering that this species is less tolerant of drought conditions, which are projected to increase in severity due to ongoing climate change.

Another concern is that stands dominated by one or two tree species may be less resilient to pests and pathogens, which are often host-specific. For example, big leaf maple is susceptible to defoliation by winter moth (*Operophtera brumata*), a non-native pest that is active in the region. Douglas fir is susceptible to a wide range of root and buttress rots, including laminated root rot (*Coniferiporia weirii*, syn. *Phellinus weirii*) and armillaria root rot (*Armillaria spp*).

Stand composition can be augmented through the following recommendations:

1. Increase overall biodiversity by installing a greater variety of tree species that are tolerant of local site conditions. Consider increasing the abundance of native tree species that may be in decline or are relatively underrepresented:
    - Grand fir (*Abies grandis*)
    - Madrona (*Arbutus menziesii*)
    - Pacific dogwood (*Cornus nuttallii*)
    - Pacific hawthorn (*Crataegus douglasii*)
    - Cascara (*Frangula purshiana*)
    - Pacific crabapple (*Malus fusca*)
    - White pine (*Pinus monticola*)
    - Bitter cherry (*Prunus emarginata*)
2. Increase the regeneration of native conifer species and broadleaf evergreen species in areas where deciduous trees represent over 50% of basal area or overstory stem density. Conifer trees and broadleaf evergreen trees tend to have higher drought tolerances, although some native and near-native deciduous species do have moderately high drought tolerance (Table 25).
3. In the absence of stand-improvement thinning, it may be difficult to increase the regeneration of drought-tolerant tree species, many of which are intolerant of the deep shade. Grand fir (*Abies grandis*) is moderately shade tolerant and drought tolerant, while California nutmeg (*Torreya californica*) is a near-native conifer species that is extremely shade tolerant and drought tolerant. Some broadleaf evergreen species are also moderately shade tolerant, including madrona (*Arbutus menziesii*) and California bay laurel (*Umbellularia californica*).
4. Avoid felling/treating native species that may resemble invasive species. Consider marking either native leave-trees or the targeted invasive trees with boundary paint prior to implementing management actions in any given area. Consider the following species:
    - Vine maple (*Acer circinatum*) versus Norway maple (*Acer platanoides*)
    - Big leaf maple (*Acer macrophyllum*) versus Norway maple (*Acer platanoides*)
    - Pacific crabapple (*Malus fusca*) versus thundercloud plum (*Prunus cerasifera*)
    - Bitter cherry (*Prunus emarginata*) versus thundercloud plum (*Prunus cerasifera*) or bird cherry (*Prunus avium*)
    - Garry oak (*Quercus garryana*) versus English oak (*Quercus robur*)

Table 25: Native and near-native tree species with moderate to high drought tolerance

Common Name	Scientific Name	Canopy Type	Origin
Grand fir	*Abies grandis*	conifer	native
Douglas maple	*Acer glabrum*	deciduous	native
big leaf maple	*Acer macrophyllum*	deciduous	native
madrona	*Arbutus menziesii*	broadleaved evergreen	native
Pacific dogwood	*Cornus nuttallii*	deciduous	native
cascara	*Frangula purshiana*	deciduous	native
Oregon ash	*Fraxinus latifolia*	deciduous	native
seaside juniper	*Juniperus maritima*	conifer	native
Pacific wax myrtle	*Myrica californica*	broadleaved evergreen	near-native
Sitka spruce	*Picea sitchensis*	conifer	native
shore pine	*Pinus contorta*	conifer	native
western white pine	*Pinus monticola*	conifer	native
ponderosa pine	*Pinus ponderosa*	conifer	native
Douglas fir	*Pseudotsuga menziesii*	conifer	native
Garry oak	*Quercus garryana*	deciduous	native
smooth sumac	*Rhus glabra*	deciduous	near-native
Scouler's willow	*Salix scouleriana*	deciduous	native
California nutmeg	*Torreya californica*	conifer	near-native
California bay laurel	*Umbellularia californica*	broadleaved evergreen	near-native

Climate Change Adaptation

Climate change adaptation strategies are intended to address potential vulnerabilities in an ecosystem to changing environmental conditions, such as higher winter and summer temperatures, more severe summer drought conditions, newly introduced pests and pathogens, or sea-level rise. The following recommendations focus on options for modifying the structure and community composition of the plant community to increase its adaptive capacity and increase its robustness to projected climate change. Site conditions can also be modified to mitigate potential drought stress.

Figure 28: Example of a cedar tree in decline on Mercer Island, likely due to severe drought stress

1. Conduct a climate change vulnerability assessment focused on the natural resources of the parks and open spaces to identify areas of potential refugia and areas that are more vulnerable to increasing drought conditions. A climate change vulnerability assessment can also be used to identify reference sites with historical climates that are similar to the projected climate of Mercer Island.
2. Recommended criteria for refugia include:
    - **Community composition**: understory plant community currently dominated by wetland associated species (OBL or FACW) as indicators of the soil moisture regime
    - **Topography**: aspect at least 90 degrees off SW
    - **Hydrology**: areas in proximity to wetlands, streams or other water resources
3. Increase coarse woody debris in upland areas, especially in parks and open spaces where climate refugia are absent or where CWD volume is especially low. Coarse woody debris is a critical substrate that many conifer trees require to regenerate in the understory. Additionally coarse woody debris can mitigate some of the impacts of drought stress.
4. Augment community composition by prioritizing the installation of sensitive species in areas of refugia (e.g. *Thuja plicata*, *Alnus rubra*), and by increasing the overall abundance of drought-tolerant species in all other areas (e.g. *Acer macrophyllum*, *Pinus ponderosa*).
5. Prioritize silvicultural thinning treatments in upland areas that lack climate change refugia. Reducing tree competition indirectly reduces drought stress during the dry season.
6. Apply a climate-adjusted provenancing approach for sourcing plant species and genotypes from areas with historical climates that are similar to the projected climate of Mercer Island (i.e. “assisted migration” or “assisted gene flow”). Consider the use of near-native plant species whose ranges already include the Pacific Coast (e.g. *Torreya californica*, *Umbellularia californica*)

and/or near-native plants known to co-occur with the tree species that are dominant on Mercer Island (*Acer macrophyllum, Pseudotsuga menziesii, Thuja plicata*).

7. Consult with a hydrology specialist about alternatives for removing culverts and daylighting streams. Many parks have stormwater systems that partially or fully enclose streams in pipes that divert the water downhill, preventing that water from infiltrating the soil in the upland areas. Culverts also increase water velocity, resulting in flashier hydrology during winter storms, potentially increasing soil erosion at the outlets of the pipes.
    - Remove pipes entirely to daylight streams in natural areas.
    - Install riprap to armor channels at the outlets of pipes to disperse water and reduce soil erosion.
    - Densely plant native species with rhizomes and/or fibrous root systems along stream channels to reduce soil erosion and stabilize banks.
    - Increase coarse woody debris in stream channels to reduce water velocity. This option is especially viable in areas where silvicultural thinning treatments are desirable due to overstocked stands.
    - Parks with streams that are known to be partially or fully enclosed in pipes include:
        - Gallagher Park
        - Mercerdale Hillside Park
        - SE 47th St Open Space
        - SE 50th St Open Space
        - Upper Luther Burbank Park

Miscellaneous

1. Follow-up botany surveys should reconcile ambiguous taxa, especially those that were only identified to genus in the 2024 FHA, or those taxa that may be species with conservation status. Consider seeking follow-up support from the Burke Museum Herbarium and/or the DNR Natural Heritage Program to identify the following taxa:
    - *Lathyrus* sp, including *L. vestitus*, endangered in Washington (WANHP)
    - *Polystichum* sp, including *P. californicum*, threatened in Washington (WANHP)
2. Consider further analysis of the 2024 FHA data:
    a. Summarize understory structure by strata (i.e. groundcover, small shrubs, large shrubs) or growth form (forbs, shrubs, vines, trees) and reevaluate change in composition between 2014 and 2024.
    b. Preliminary analysis suggests that herbaceous species that are sensitive to drought may have declined in abundance. Analyze changes in understory species composition by growth form or wetland indicator status (OBL, FACW, etc).
    c. Compare intact native plant communities with the composition of native plant species in areas dominated by ivy, blackberry or other invasive species. Determine which native species are persisting in these areas dominated by invasive species and which species are most sensitive.
    d. Use cluster analysis to develop plant associations specific to Mercer Island that can be used as references communities for habitat restoration.

Glossary

Term or Abbreviation	Description
Alpha Diversity	Local biodiversity – can be measured using a variety of metrics, including species richness, Pielou species evenness, and the Shannon diversity index. Alpha diversity is separate from beta diversity, which refers to differences in species composition between habitats or locations.
BA	Basal Area – the cross-sectional area of a tree or stand of trees, generally measured in square feet per acre.
Cover	A metric representing the abundance of plants or trees at a site, usually measured as the total geographic area covered by leaves or tree canopy, generally measured as a percentage of the total area (e.g. 25% cover).
CWD	Coarse Woody Debris – downed wood, stumps or logs, generally over a standard diameter (e.g. 5 inches); CWD can be measured in units of volume, mass or number of pieces. Volume is generally measured in cubic feet per acre.
DBH	Diameter at Breast Height – diameter of a tree at a standard height above the ground (e.g. 4.5 ft); also known as Diameter at Standard Height (DSH).
LCR	Live Crown Ratio – the ratio between the vertical section of a tree with live branches and the total height of the tree.
QMD	Quadratic Mean Diameter – a metric representing the typical diameter of a stand of trees, similar in concept to an average diameter, generally measured in inches.
RD	Relative Density – a metric representing the density of trees in a forested stand. Higher RD values represent higher tree densities and greater competition between those trees. RD generally refers to Curtis Relative Density.
SDI	Stand Density Index – a metric representing the density of trees in a forested stand. Higher SDI values represent higher tree densities and greater competition between those trees. SDI generally refers to Reineke's Stand Density Index.
Snag	A dead tree stem, also known as standing dead wood.
Stand	A group of trees sharing similar site conditions, species composition and management history.
TPA	Trees Per Acre – a metric representing the density of tree stems in a given area.

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Appendix A: Maps – Native Species Richness

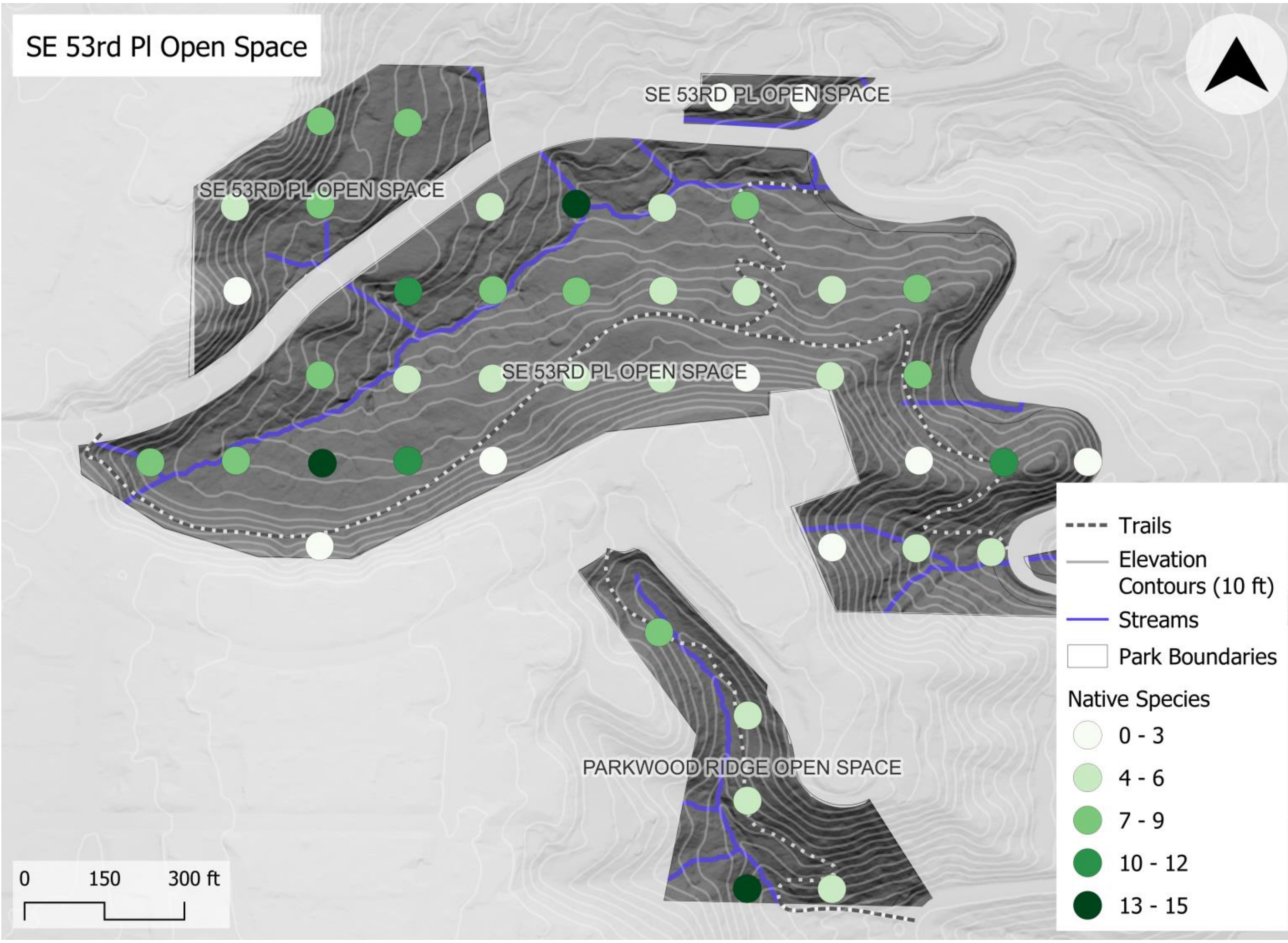

Figure 29: Map of native species richness in the SE 53rd Pl Open Space

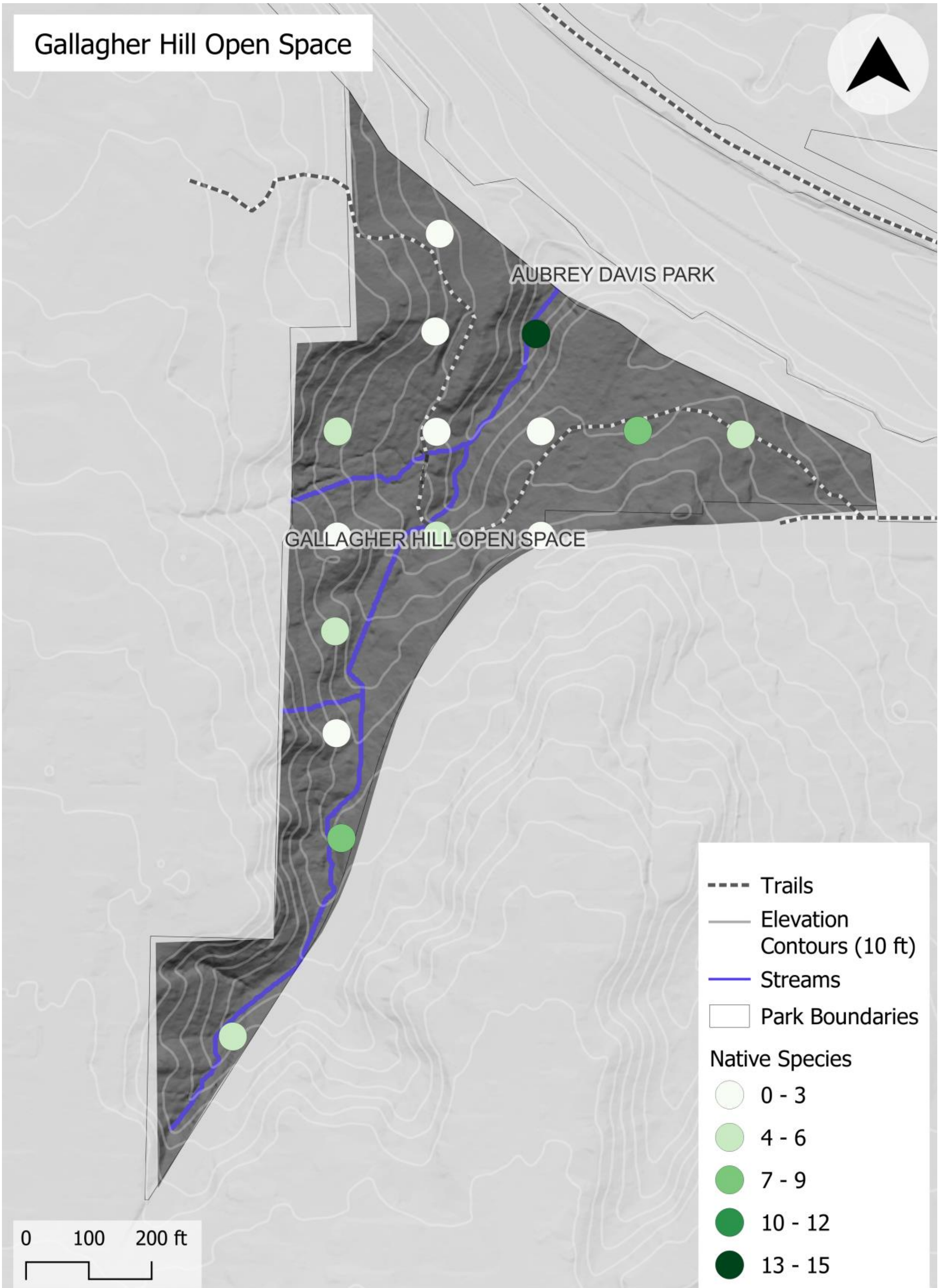

Figure 30: Map of native species richness in the Gallagher Hill Open Space

Figure 31: Map of native species richness in Island Crest Park

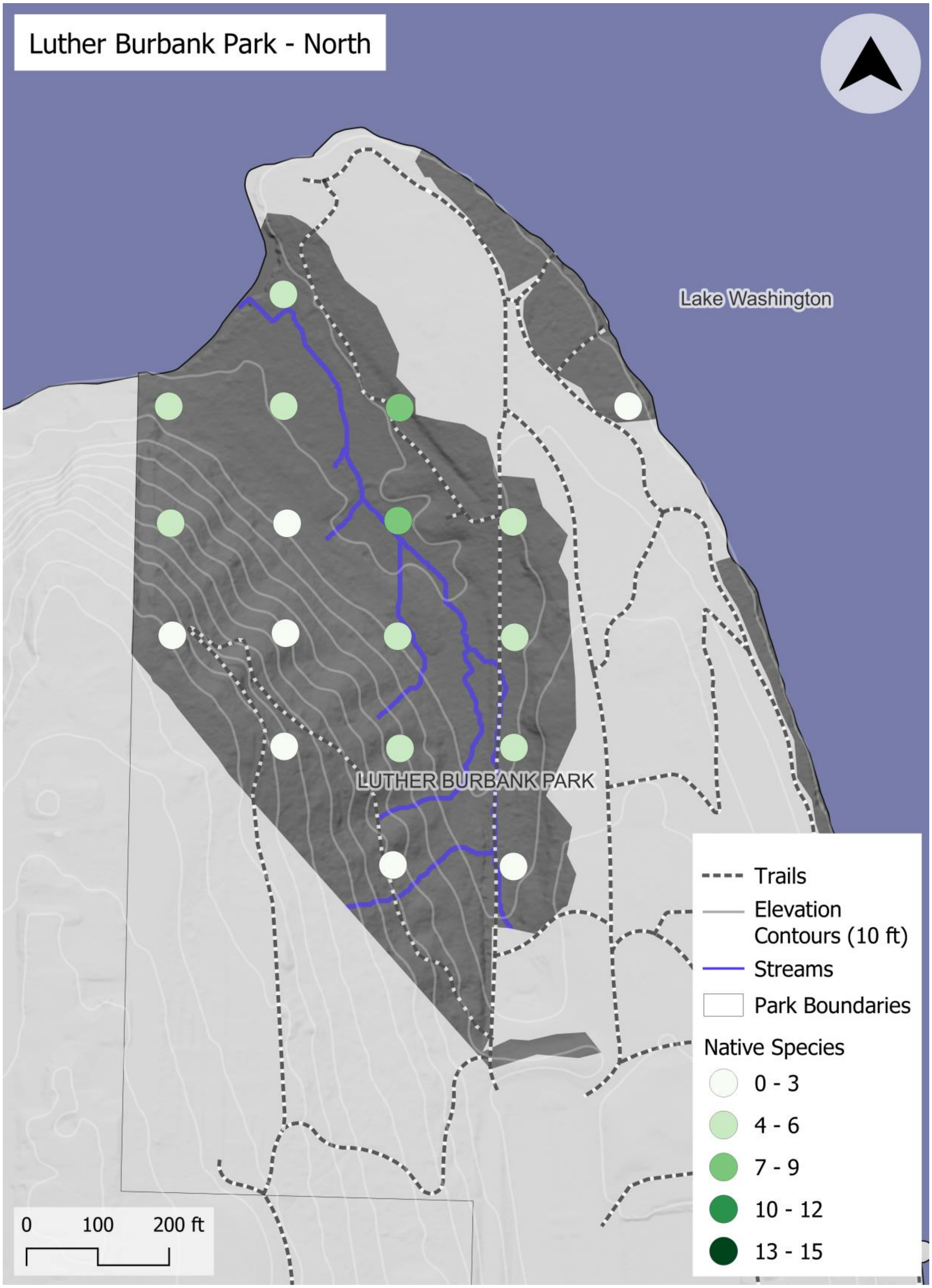

Figure 32: Map of native species richness in the north portion of Luther Burbank Park

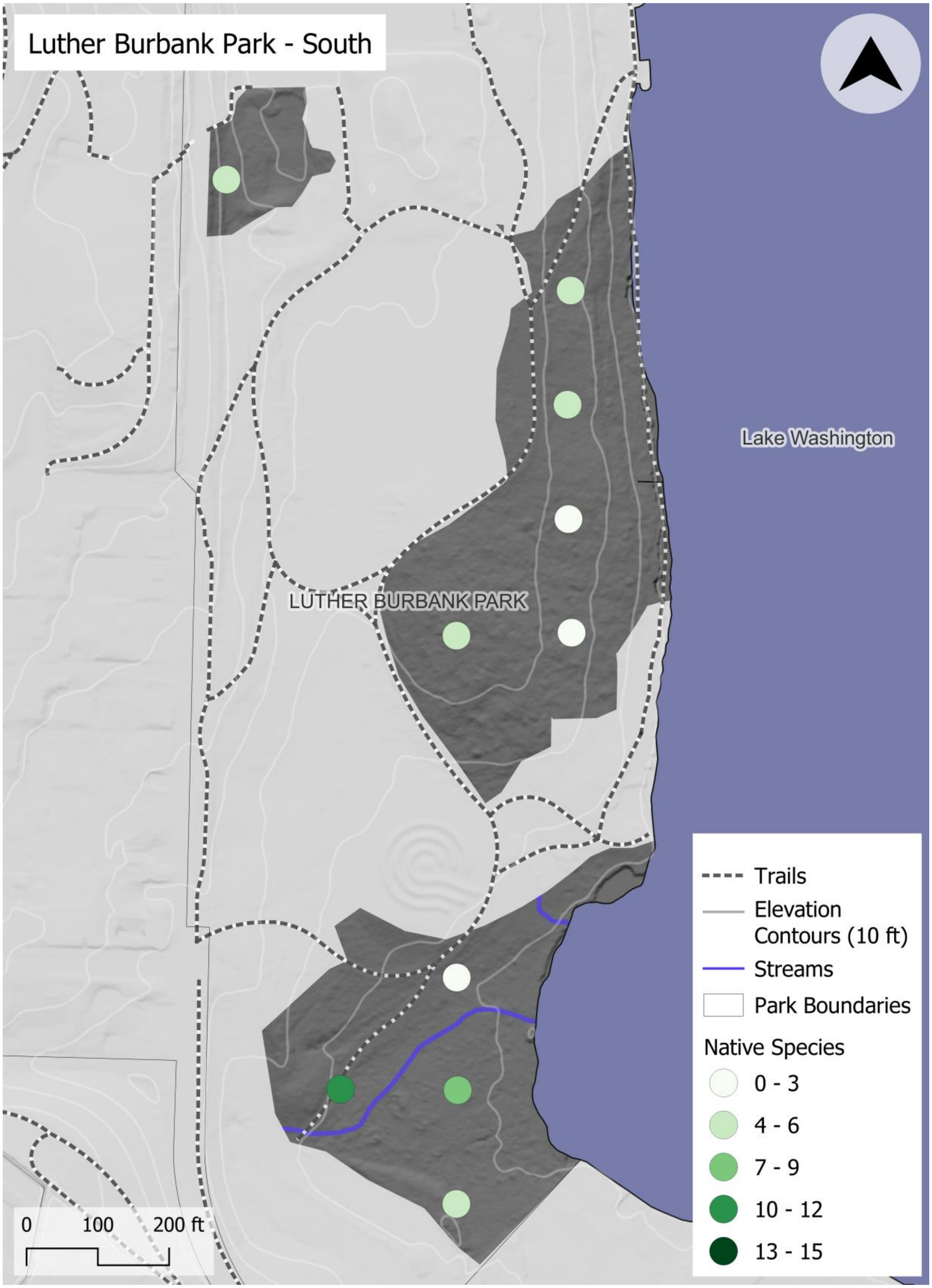

Figure 33: Map of native species richness in the south portion of Luther Burbank Park

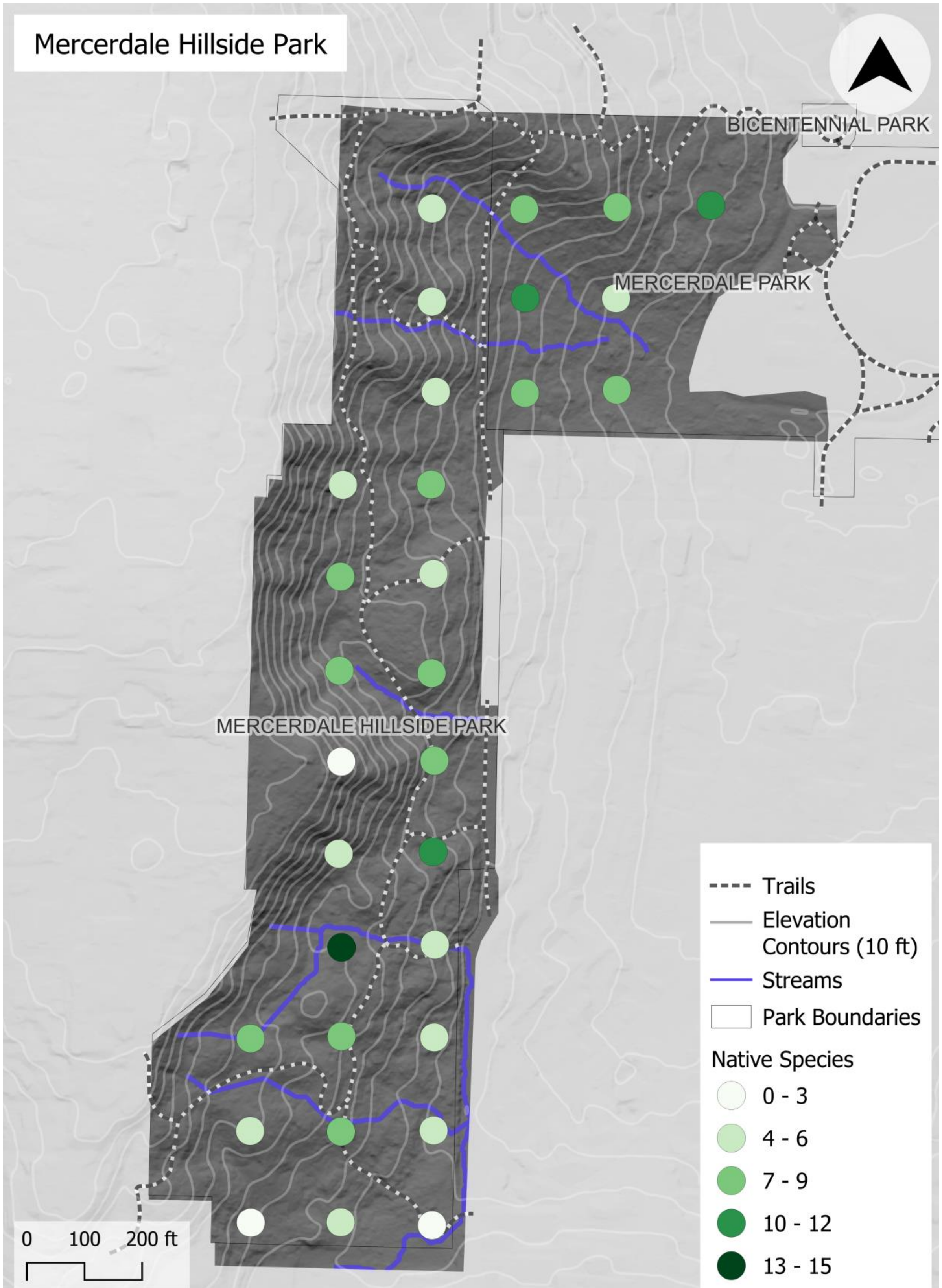

Figure 34: Map of native species richness in Mercerdale Hillside Park

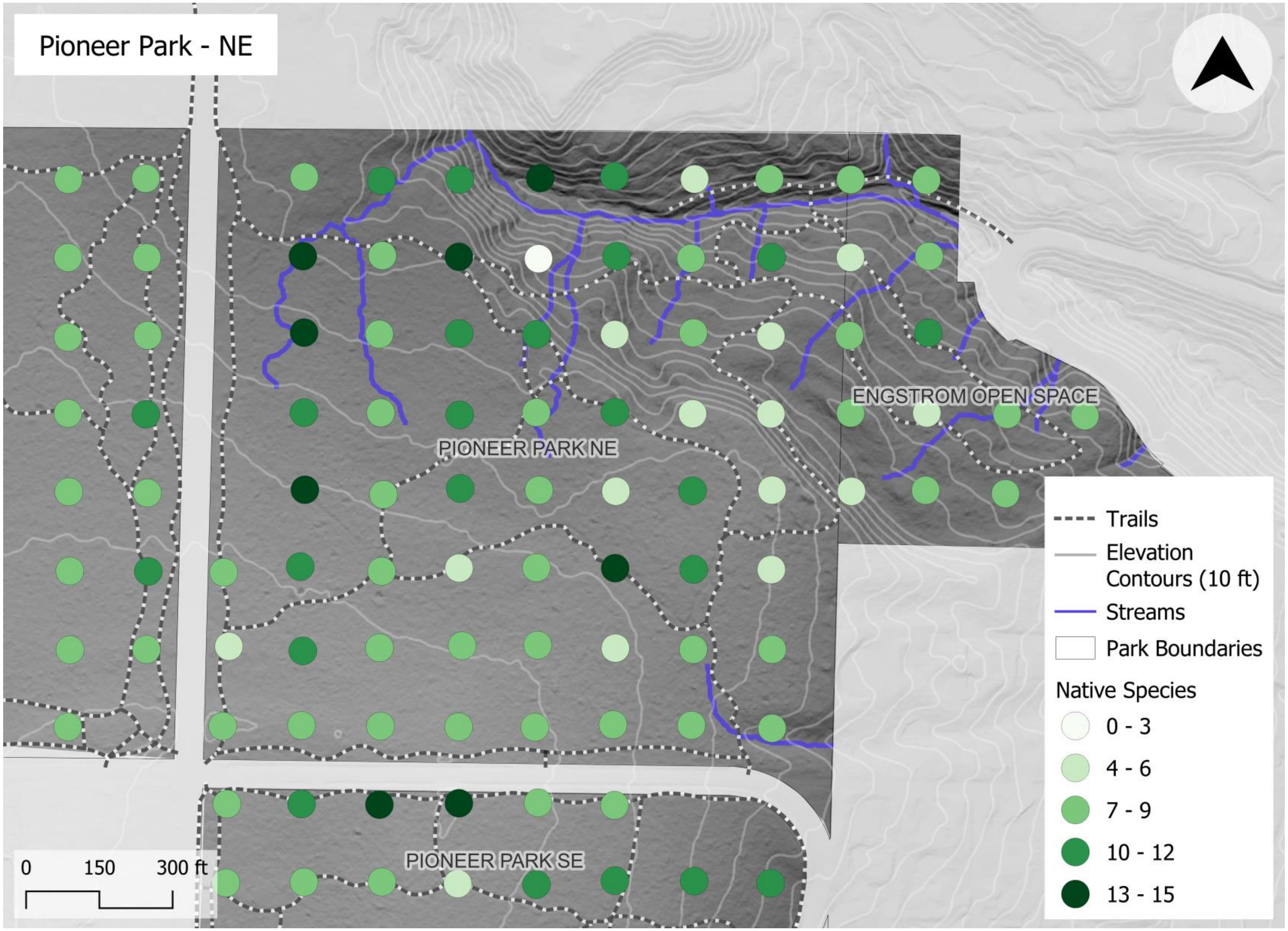

Figure 35: Map of native species richness in the NE quadrant of Pioneer Park

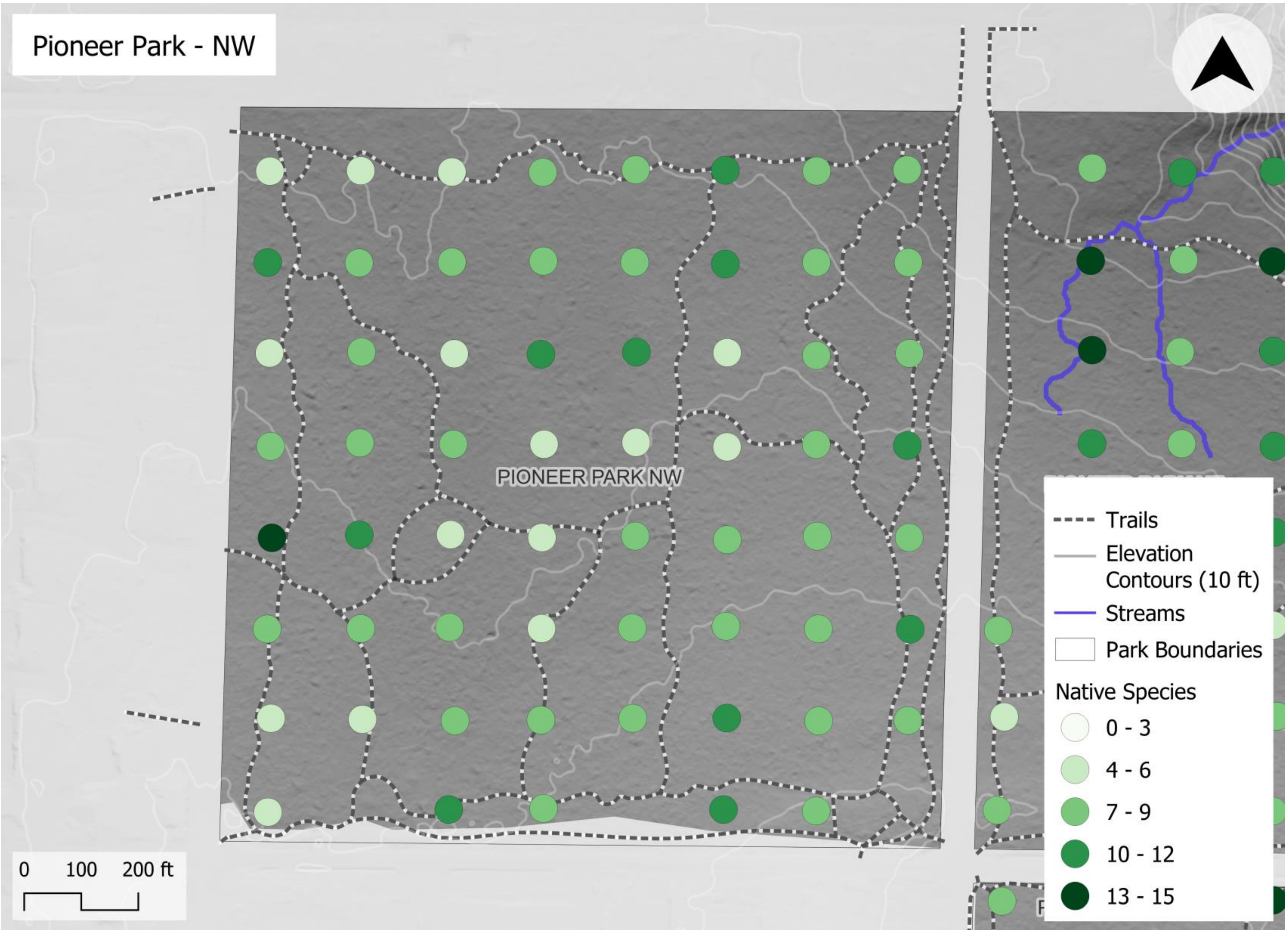

Figure 36: Map of native species richness in the NW quadrant of Pioneer Park

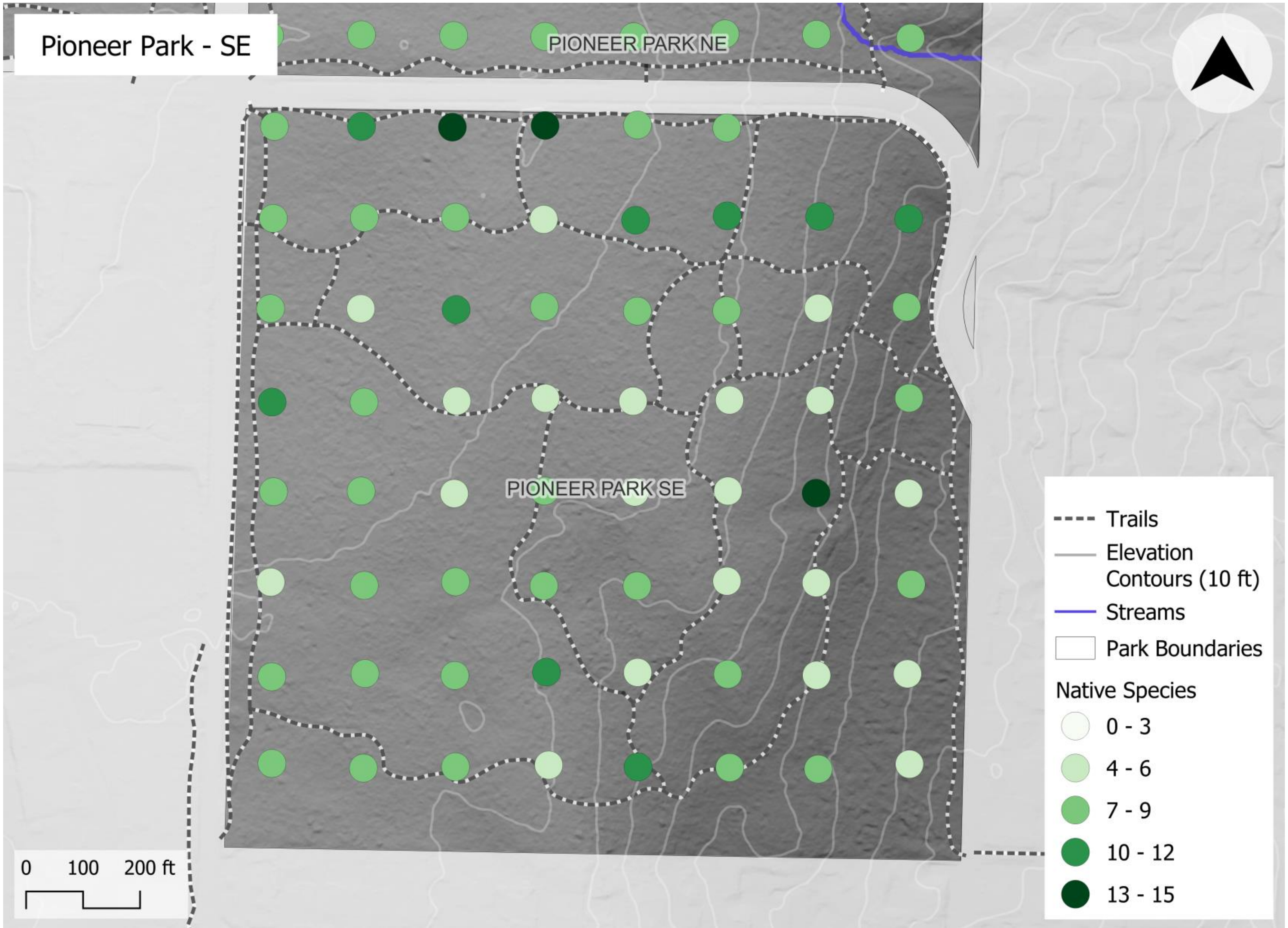

Figure 37: Map of native species richness in the SE quadrant of Pioneer Park

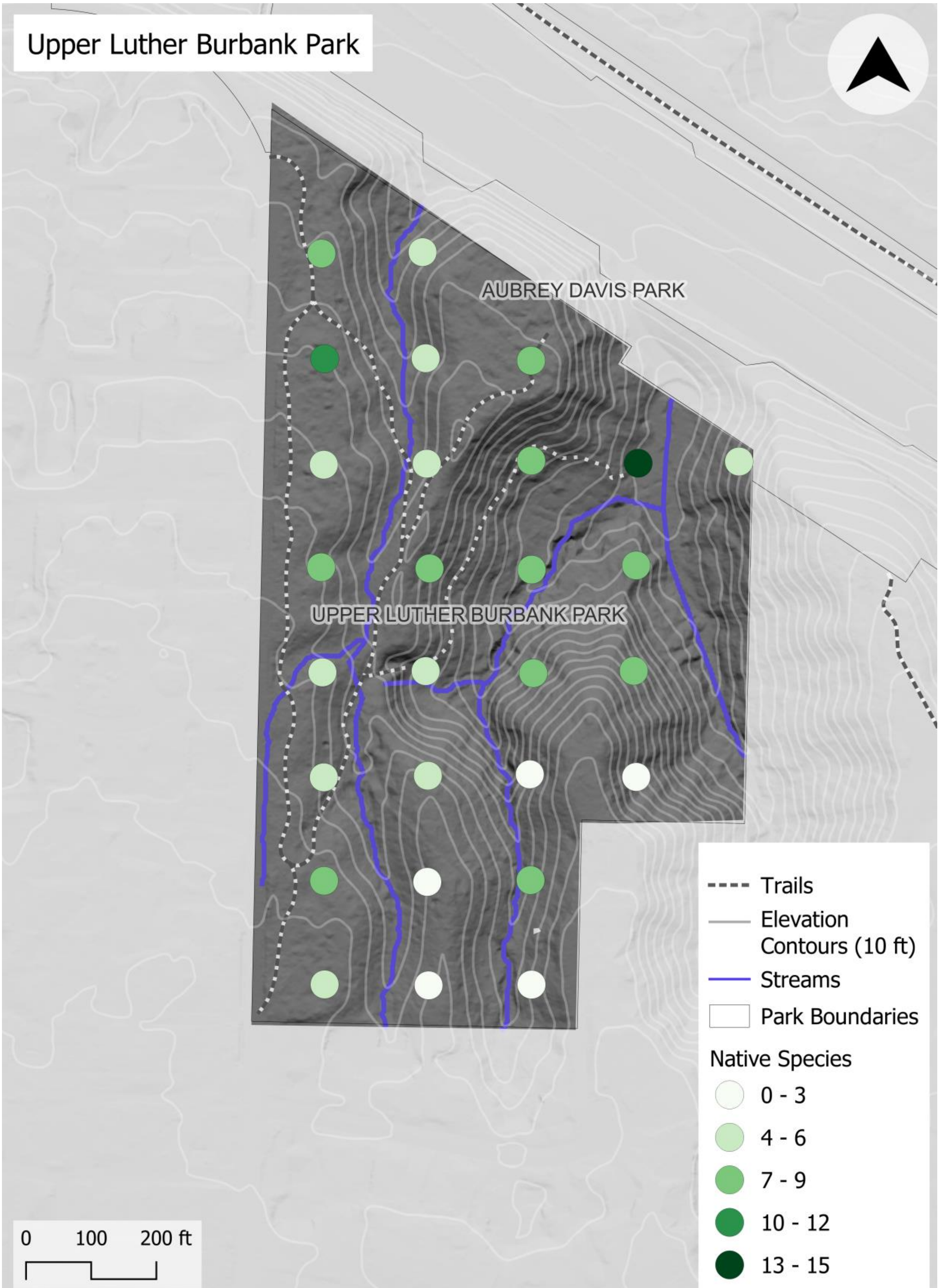

Figure 38: Map of native species richness in Upper Luther Burbank Park

Appendix B: Maps – Non-Native Cover-Abundances

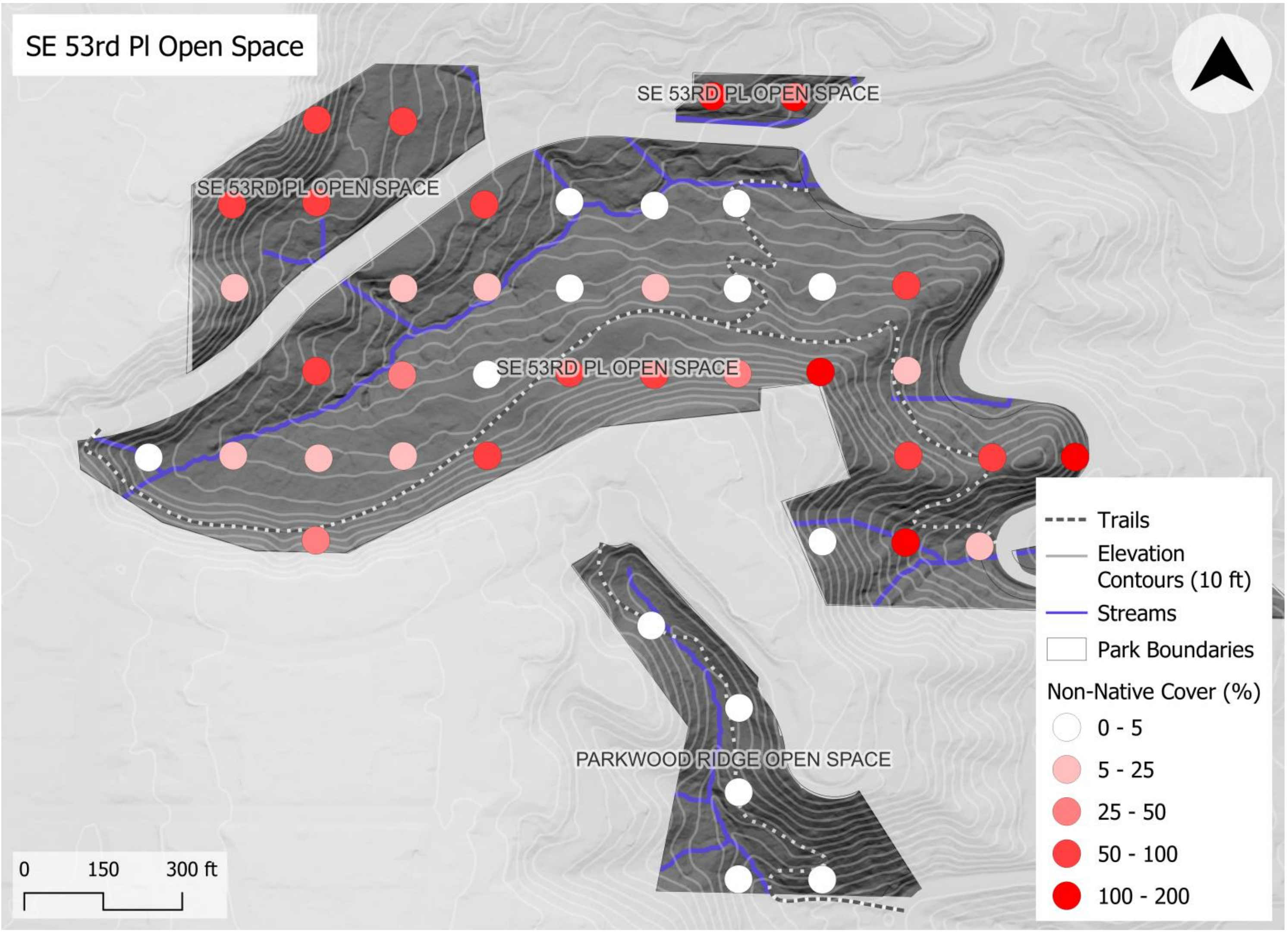

Figure 39: Map of non-native cover-abundance (%) in the SE 53rd Pl Open Space

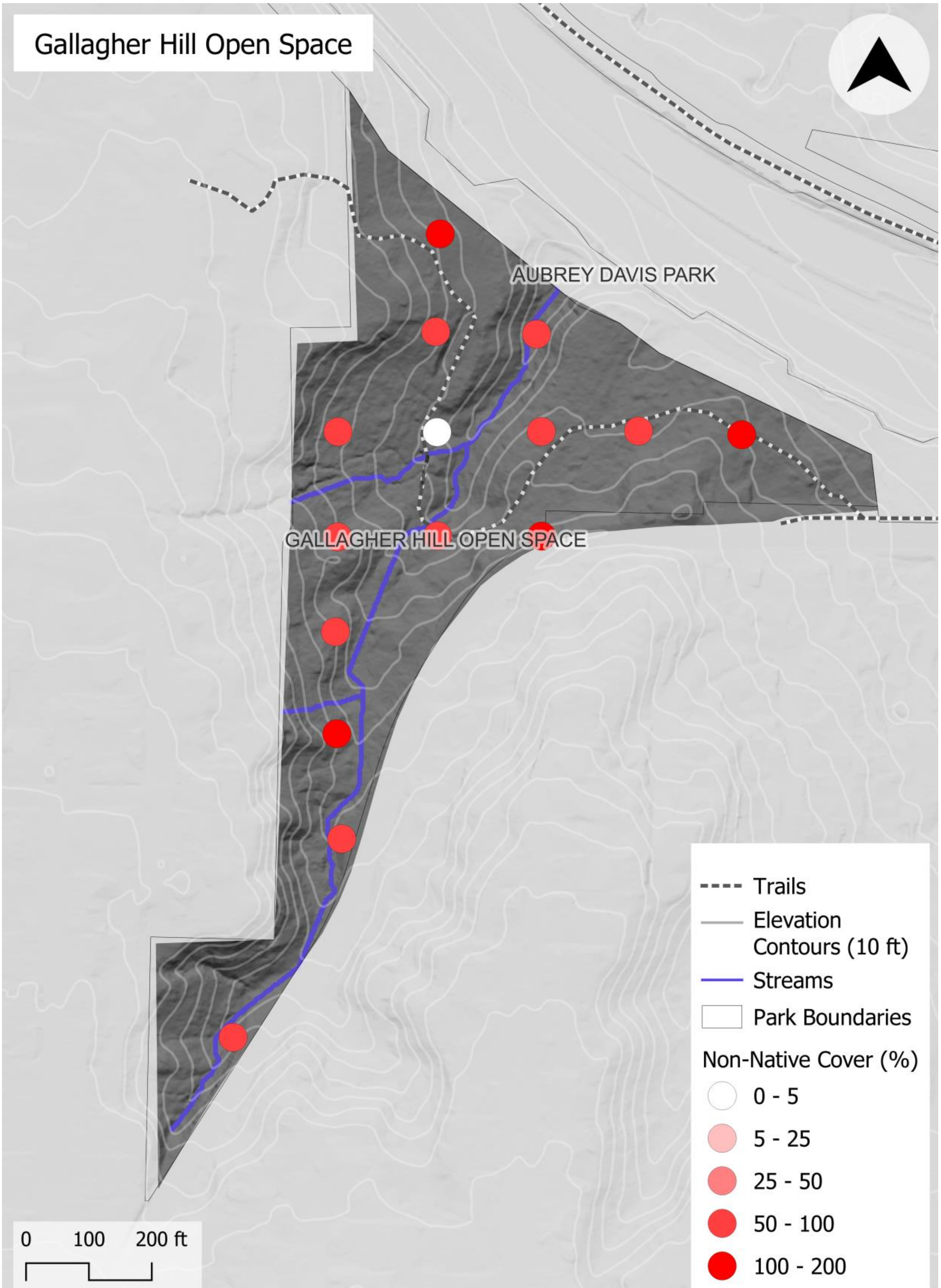

Figure 40: Map of non-native cover-abundance (%) in the Gallagher Hill Open Space

Figure 41: Map of non-native cover-abundance (%) in Island Crest Park

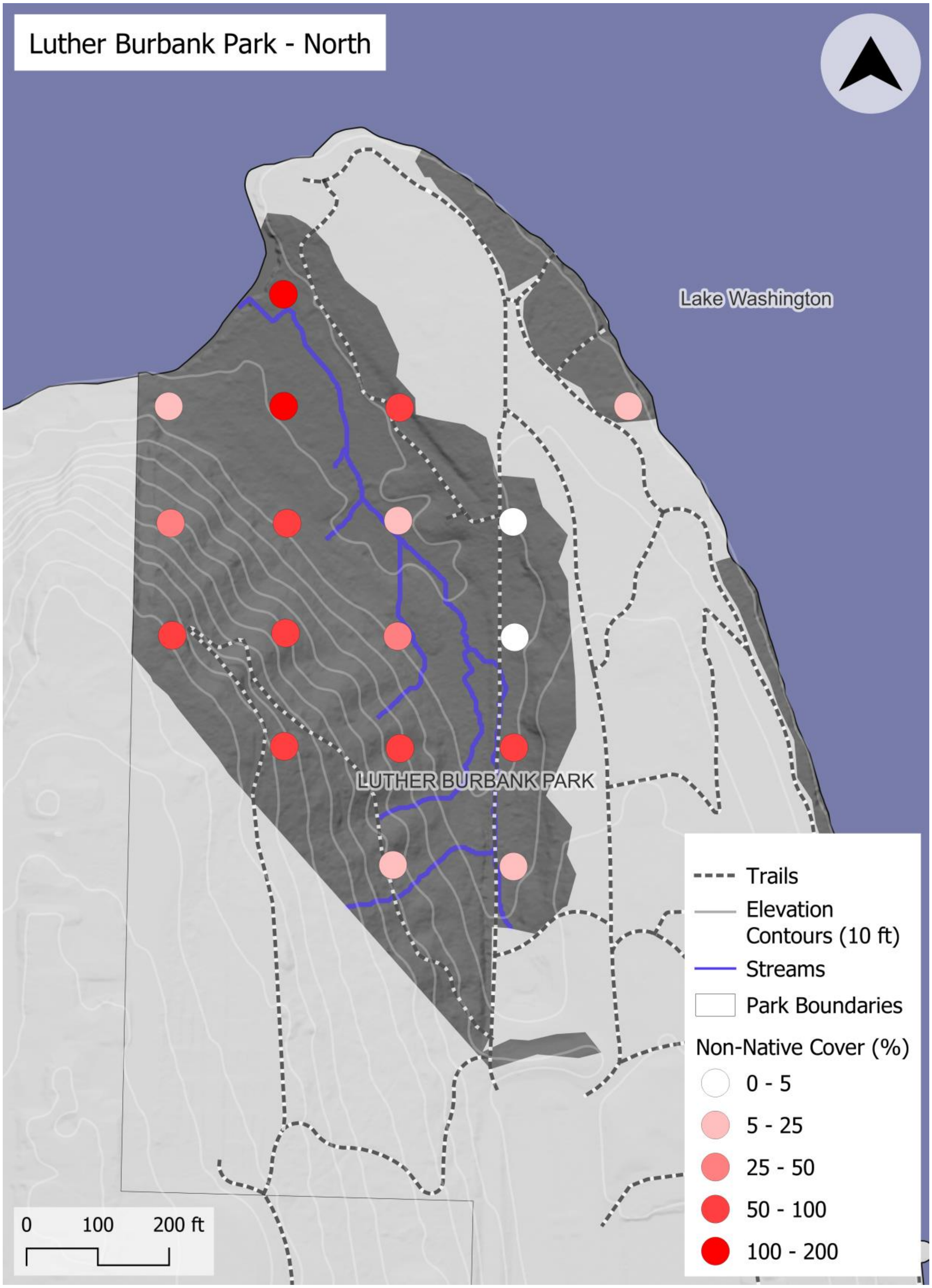

Figure 42: Map of non-native cover-abundance (%) in the north portion of Luther Burbank Park

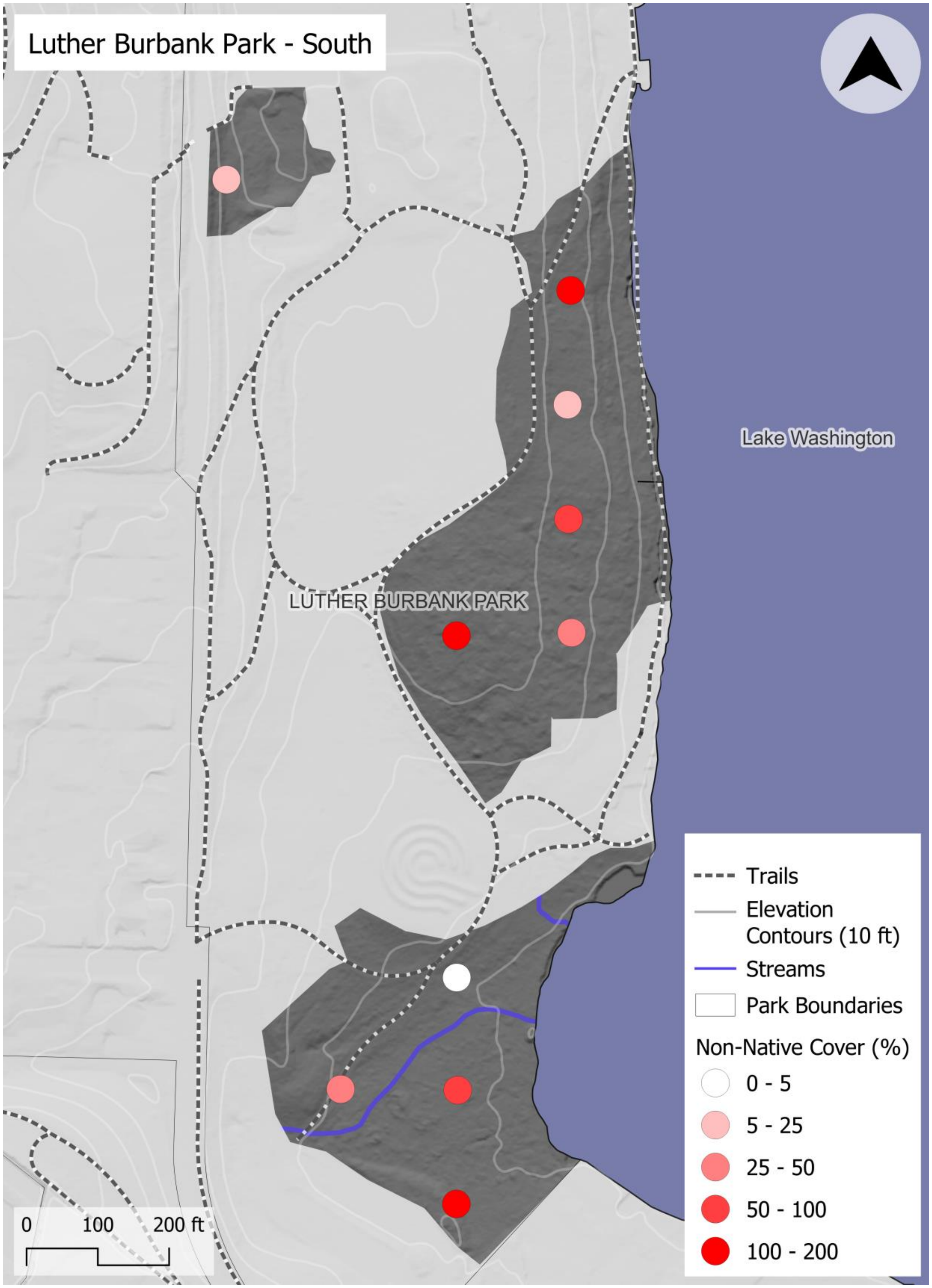

Figure 43: Map of non-native cover-abundance (%) in the south portion of Luther Burbank Park

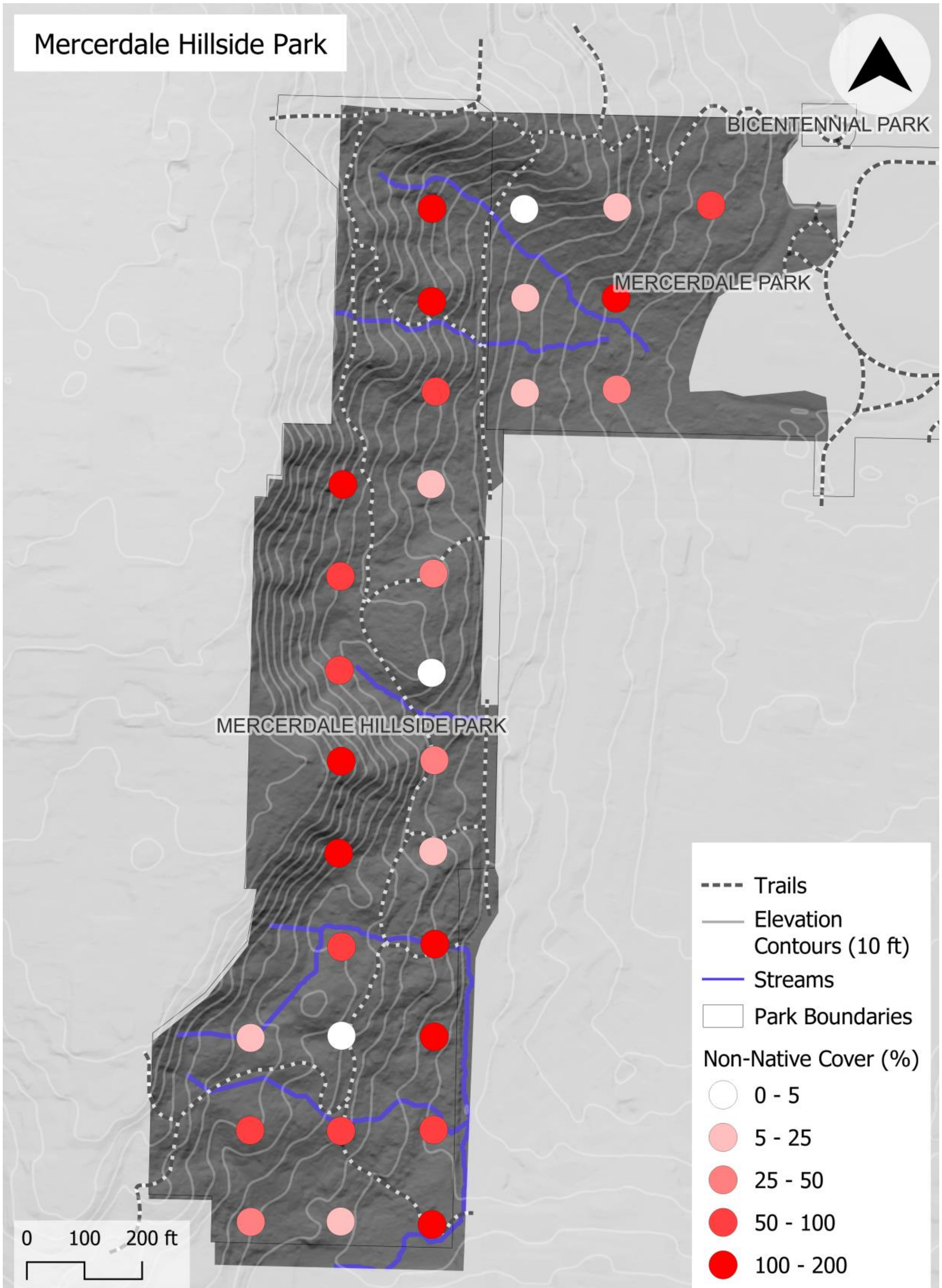

Figure 44: Map of non-native cover-abundance (%) in Mercerdale Hillside Park

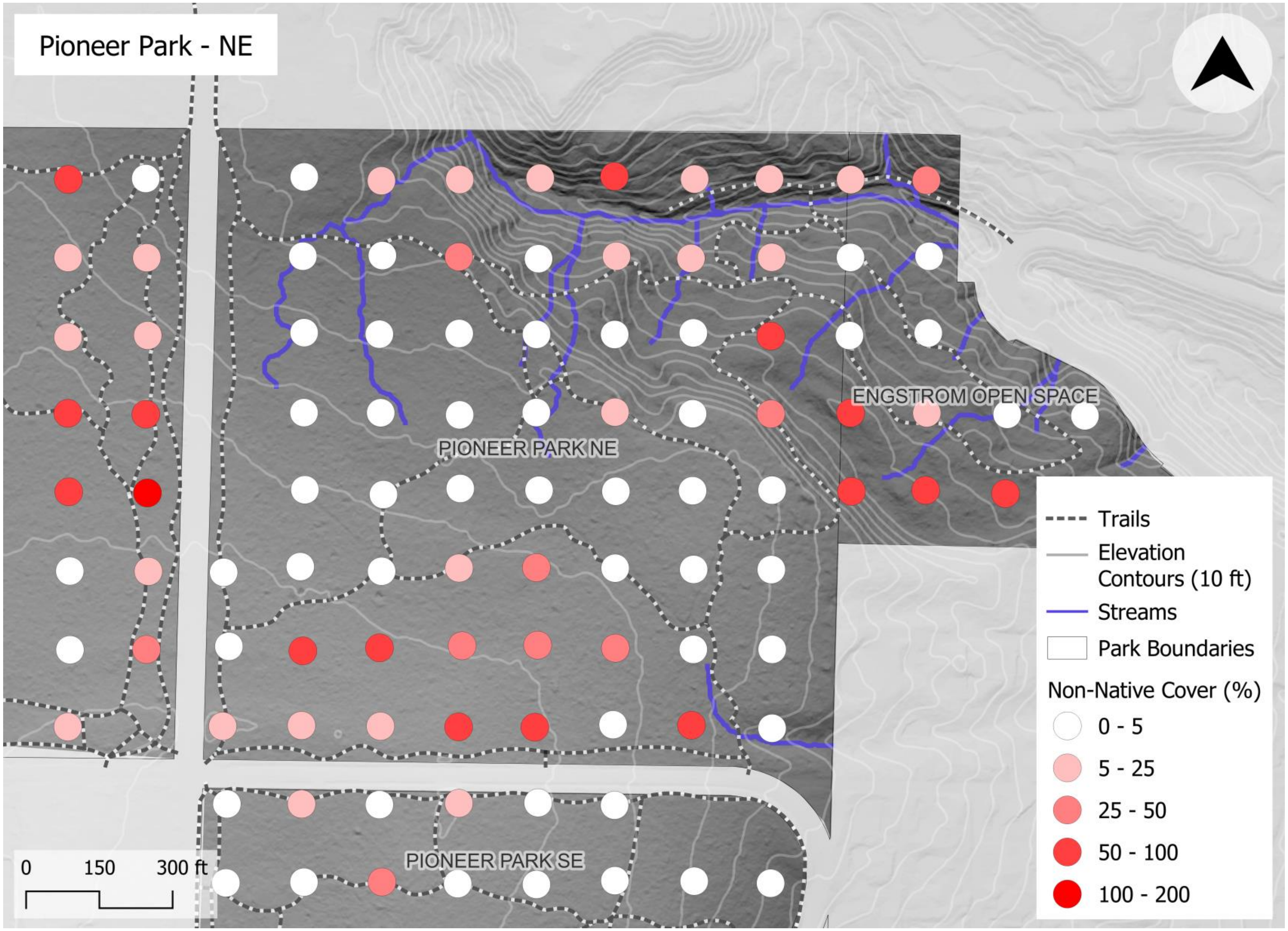

Figure 45: Map of non-native cover-abundance (%) in the NE quadrant of Pioneer Park

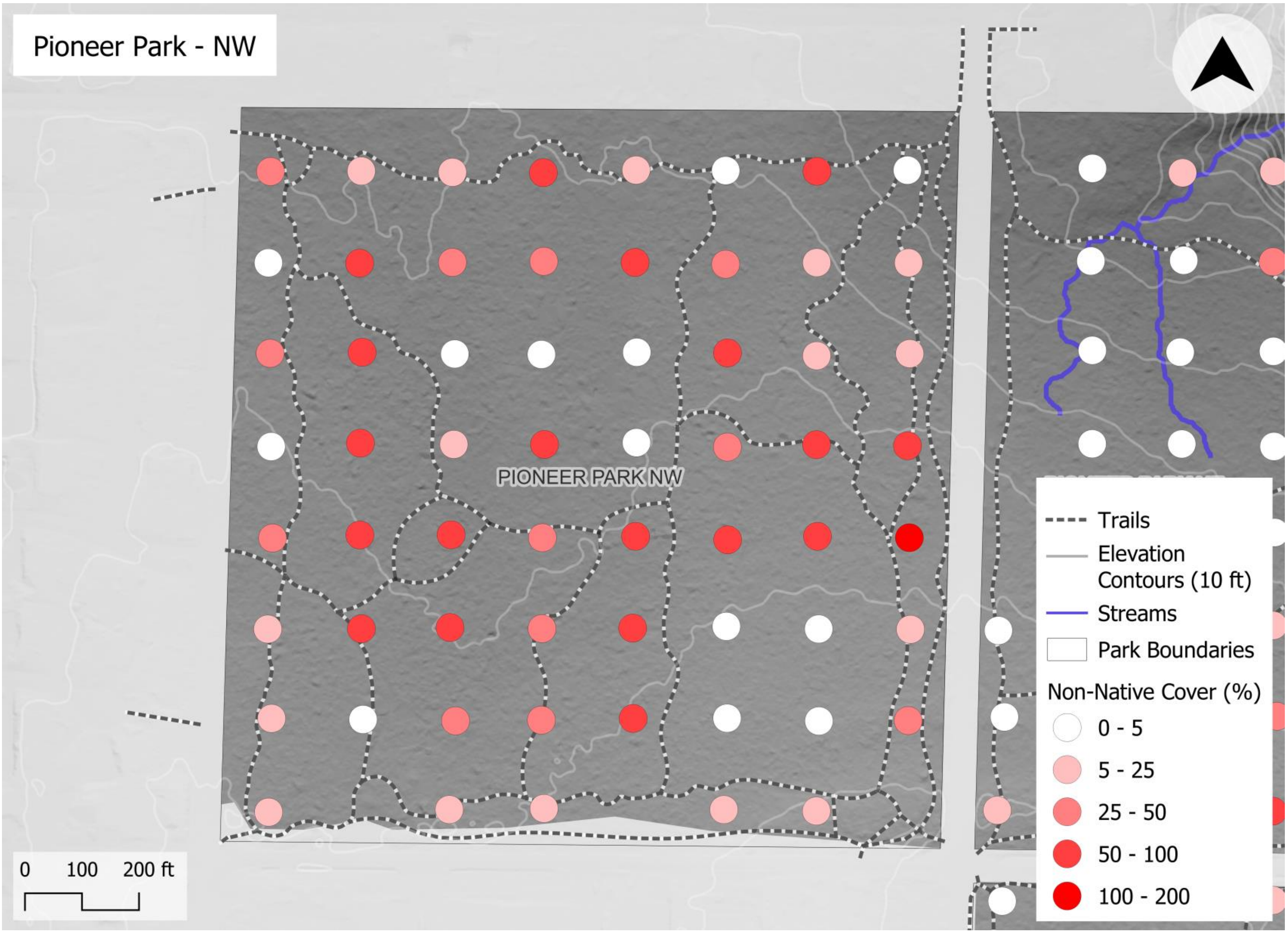

Figure 46: Map of non-native cover-abundance (%) in the NW quadrant of Pioneer Park

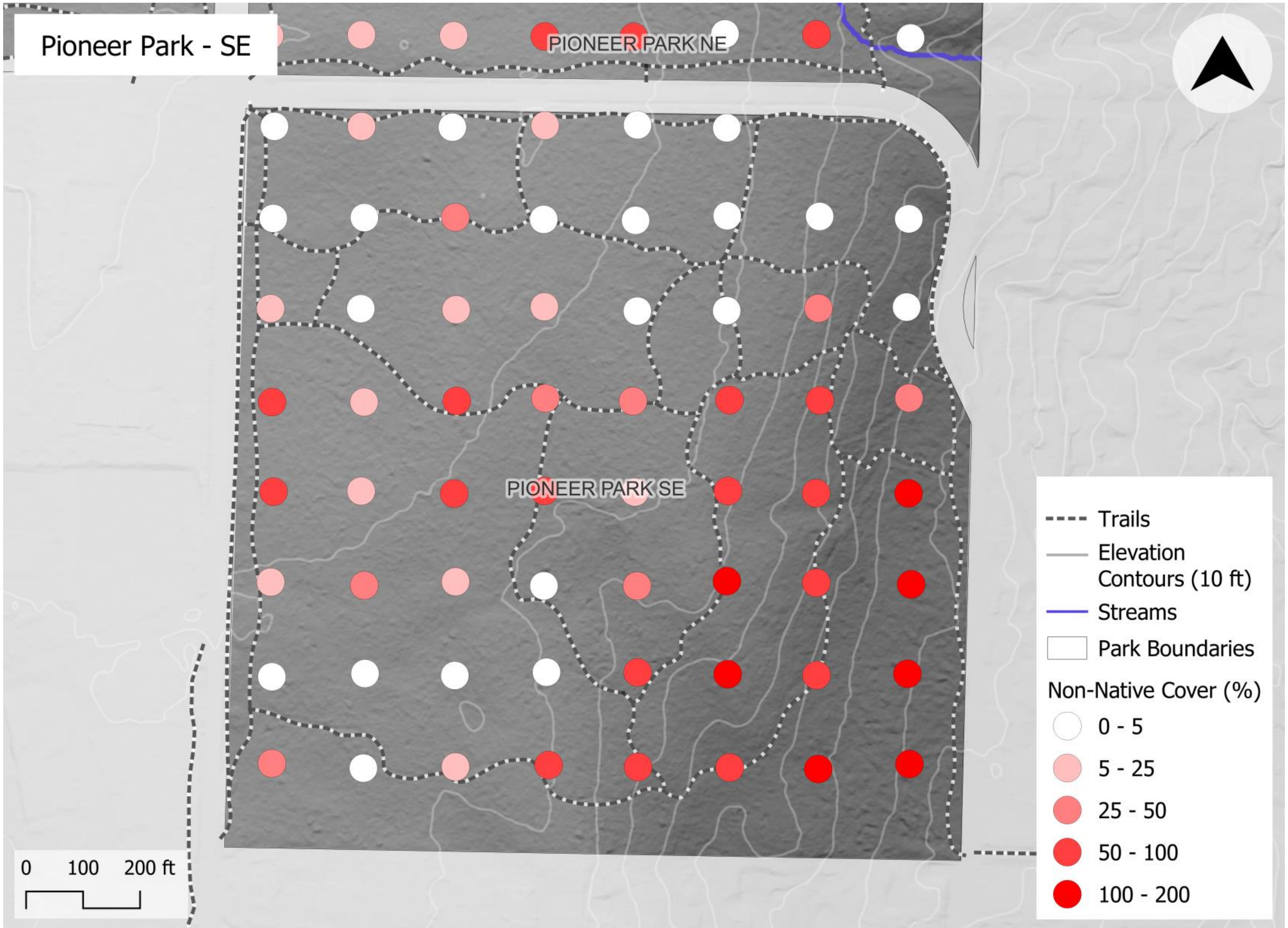

Figure 47: Map of non-native cover-abundance (%) in the SE quadrant of Pioneer Park

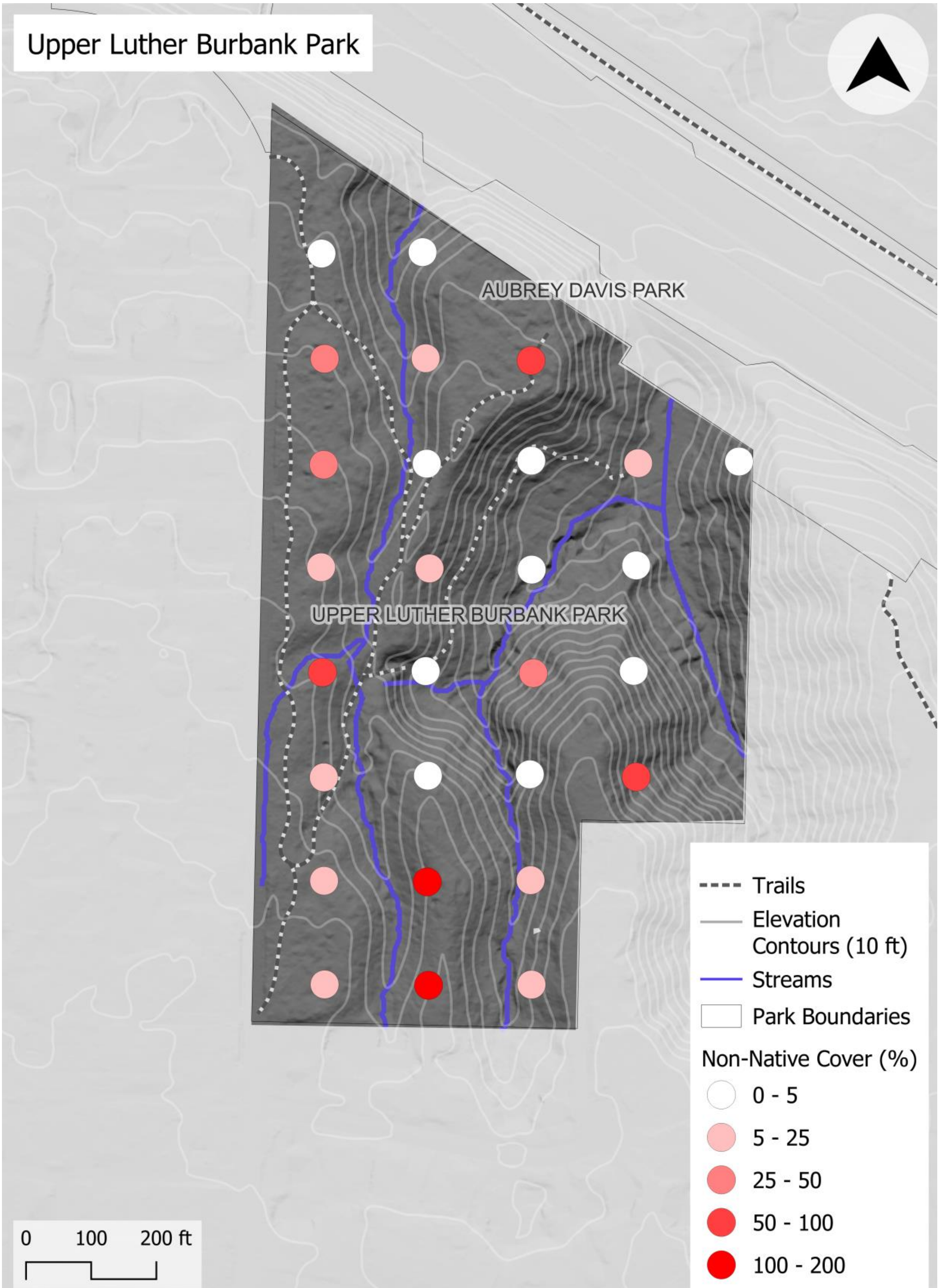

Figure 48: Map of non-native cover-abundance (%) in Upper Luther Burbank Park

Appendix C: Tables – Overstory Structure and Composition

Table 26: Basal area (ft^2/ac) of mature native tree species (DBH ≥ 5”) summarized by park. Species codes are used as abbreviations of scientific names: Acer macrophyllum (ACMA), Alnus rubra (ALRU), Arbutus menziesii (ARME), Fraxinus latifolia (FRLA), Pinus monticola (PIMO), Picea sitchensis (PISI), Populus trichocarpa (POTR), Pseudotsuga menziesii (PSME), Salix spp (SALIX), Thuja plicata (THPL) and Tsuga heterophylla (TSHE). The basal areas of all willow species were aggregated together and assumed to represent native species. Basal area values below 0.1 ft^2/ac are represented by “---". All values represent means.

Park	ACMA	ALRU	ARME	FRLA	PIMO	PISI	POTR	PSME	SALIX	THPL	TSHE	All Native Species
Cayhill Open Space	204.1	---	---	---	---	---	---	57.2	---	---	---	261.3
Clarke Beach Park	70.8	14.9	---	0.4	4.2	1.9	---	56.3	---	67.5	---	216.0
Clise Park	107.3	---	---	---	---	---	---	114.9	---	---	---	222.3
Ellis Pond	6.1	59.8	---	---	---	---	---	28.6	5.3	74.7	---	174.5
Engstrom Open Space	229.7	8.7	---	---	---	---	---	---	---	2.1	2.3	242.7
Gallagher Hill Open Space	81.0	1.9	---	---	---	---	---	33.3	---	22.0	8.1	146.4
Groveland Beach Park	24.2	---	---	---	---	---	---	95.1	---	25.9	---	148.0
Hollerbach Park	71.7	---	---	---	---	---	9.2	---	---	1.5	58.7	141.1
Homestead Park	35.2	7.6	---	---	---	---	---	9.7	21.3	1.6	---	75.4
Island Crest Park	44.9	6.4	---	---	---	---	---	93.9	0.2	39.7	6.8	191.8
Luther Burbank Park	15.8	30.9	8.7	19.5	---	3.9	0.2	10.8	7.7	0.6	---	100.4
Mercerdale Hillside Park	117.1	10.1	---	---	---	---	4.3	52.4	1.1	14.2	24.6	223.5

Park	ACMA	ALRU	ARME	FRLA	PIMO	PISI	POTR	PSME	SALIX	THPL	TSHE	All Native Species
Mercerdale Park	13.6	8.7	---	75.5	---	---	---	---	1.8	1.8	---	102.0
North Mercerdale Hillside	131.3	11.8	---	---	---	---	---	---	4.5	5.5	---	153.2
Parkwood Ridge Open Space	101.6	1.9	---	---	---	---	---	42.5	---	1.7	4.4	152.1
Pioneer Park NE	66.2	4.7	0.7	---	---	0.1	---	108.2	0.5	23.9	10.2	215.1
Pioneer Park NW	33.4	23.7	0.6	---	---	---	---	72.4	---	50.1	14.2	194.8
Pioneer Park SE	35.9	1.5	2.0	0.8	---	---	---	156.5	---	6.1	11.1	214.8
SE 47th St Open Space	148.0	---	---	---	---	---	---	---	---	---	---	148.0
SE 50th Pl Open Space	98.4	---	---	---	---	---	---	260.7	---	---	31.3	390.4
SE 53rd Pl Open Space	56.3	34.4	---	---	---	---	18.1	5.1	---	19.7	16.6	150.1
Secret Park	---	---	25.7	8.5	---	---	---	291.8	---	---	---	326.0
Upper Luther Burbank Park	131.1	3.0	2.8	---	---	---	---	78.4	---	17.9	4.0	237.2
Wildwood Park	---	91.0	---	---	---	---	67.2	118.6	---	1.7	80.1	358.7

Table 27: Stand metrics summarized for the entire island.

Structure Metric	Data Subset	Mean	SD	Median	Min	Max
BA	All Species	191.6	100.7	174.7	11.9	588.7
	Native Species	190.9	100.5	173.5	11.9	588.7
	Non-Native Species	0.7	3.1	0.0	0.0	31.4
	Conifer Species	105.8	102.1	92.8	0.0	559.8
	Deciduous Species	84.3	67.4	65.5	0.0	342.5
	Broadleaf Evergreen Species	1.4	6.2	0.0	0.0	44.4
QMD	All Species	19.5	6.5	19.3	7.0	41.0
	Native Species	19.7	6.5	19.3	7.0	41.0
	Non-Native Species	7.0	1.9	6.6	5.1	11.0
	Conifer Species	23.1	10.4	22.5	5.7	51.5
	Deciduous Species	16.7	7.4	15.3	5.7	50.3
	Broadleaf Evergreen Species	14.2	4.4	14.5	5.3	21.2
TPA	All Species	100.4	48.8	91.1	20.2	263.1
	Native Species	98.3	47.5	91.1	20.2	252.9
	Non-Native Species	2.1	8.2	0.0	0.0	80.9
	Conifer Species	36.1	31.9	30.4	0.0	141.6
	Deciduous Species	62.9	50.6	50.6	0.0	263.1
	Broadleaf Evergreen Species	1.3	6.5	0.0	0.0	60.7
SDI		265.7	121.9	251.9	24.6	701.2
RD		42.7	18.9	40.3	4.4	107.8

BA = basal area, QMD = quadratic mean diameter, TPA = trees per acre, SDI = stand density index, RD = relative density, SD = standard deviation

Appendix D: Tables – Regenerating Tree Species Abundances

Table 28: Native species abundances for seedlings and saplings. All values represent means.

Common Name	**Scientific Name**	**Tree Regeneration (stems/ac)**		
		Seedlings	Saplings	Total
grand fir	*Abies grandis*	1.39	0.76	2.15
bigleaf maple	*Acer macrophyllum*	35.20	27.16	62.37
red alder	*Alnus rubra*	1.11	2.36	3.46
madrona	*Arbutus menziesii*	0.28	0.00	0.28
Pacific dogwood	*Cornus nuttalli*	0.28	0.35	0.62
Pacific hawthorn	*Crataegus douglasii*	0.55	3.05	3.60
cascara	*Frangula purshiana*	2.77	4.30	7.07
Oregon ash	*Fraxinus latifolia*	33.54	2.84	36.38
western crabapple	*Malus fusca*	0.00	0.14	0.14
Sitka spruce	*Picea sitchensis*	0.83	1.59	2.43
shore pine	*Pinus contorta*	0.28	0.14	0.42
western white pine	*Pinus monticola*	0.28	0.00	0.28
ponderosa pine	*Pinus ponderosa*	0.00	0.07	0.07
black cottonwood	*Populus trichocarpa*	0.00	0.07	0.07
Douglas fir	*Pseudotsuga menziesii*	1.11	1.25	2.36
Pacific willow	*Salix lasiandra*	0.28	0.76	1.04
Scouler's willow	*Salix scouleriana*	0.83	2.91	3.74
willow	*Salix sp.*	0.00	1.46	1.46
western yew	*Taxus brevifolia*	0.28	0.28	0.55
western red cedar	*Thuja plicata*	21.07	29.03	50.10
western hemlock	*Tsuga heterophylla*	2.77	0.97	3.74
mountain hemlock	*Tsuga mertensiana*	0.00	0.07	0.07
Total		102.84	79.55	182.39

Table 29: Non-native species abundances for seedlings and saplings. All values represent means.

Common Name	**Scientific Name**	**Tree Regeneration (stems/ac)**		
		Seedlings	Saplings	Total
Norway maple	*Acer platanoides*	0.28	0.00	0.28
silver maple	*Acer saccharinum*	0.00	0.07	0.07
horse chestnut	*Aesculus hippocastanum*	0.55	0.07	0.62
dogwood	*Cornus* sp.	0.00	0.21	0.21
English hawthorn	*Crataegus monogyna*	6.65	4.64	11.30
English holly	*Ilex aquifolium*	96.18	4.23	100.41
black walnut	*Juglans nigra*	0.28	0.07	0.35
horticultural apple species	*Malus* sp.	0.00	0.07	0.07
bird cherry	*Prunus avium*	16.35	1.04	17.39
thundercloud plum	*Prunus cerasifera*	1.66	1.66	3.33
cherry laurel	*Prunus laurocerasus*	11.64	1.39	13.03
Portuguese laurel	*Prunus lusitanica*	3.33	0.35	3.67
English oak	*Quercus robur*	4.99	0.07	5.06
oak	*Quercus* sp.	0.28	0.00	0.28
coast redwood	*Sequoia sempervirens*	0.28	0.69	0.97
European mountain ash	*Sorbus aucuparia*	2.49	0.90	3.40
snowbell tree	*Styrax* sp.	0.00	0.14	0.14
American arborvitae	*Thuja occidentalis*	0.00	0.07	0.07
California bay	*Umbellularia californica*	0.28	0.00	0.28
Total		145.24	15.66	160.90

Appendix E: Tables – Understory Species Abundances

Table 30: Native plant species abundances. Cover values below 0.01% are represented by "---". All cover values represent means.

Common Name	Scientific Name	Cover (%)	Freq (%)
vine maple	*Acer circinatum*	1.27	7.6
vanilla leaf	*Achlys triphylla*	0.19	5.6
maidenhair fern	*Adiantum aleuticum*	0.02	0.7
northern water plantain	*Alisma triviale*	---	0.2
serviceberry	*Amelanchier alnifolia*	0.02	1.8
lady fern	*Athyrium filix-femina*	0.76	15.3
Alaska brome	*Bromus sitchensis*	---	0.5
Columbia brome	*Bromus vulgaris*	0.01	1.1
Henderson's sedge	*Carex hendersonii*	---	0.2
Dewey's sedge	*Carex leptopoda*	0.04	4.9
slough sedge	*Carex obnupta*	---	0.2
enchanter's nightshade	*Circaea alpina*	0.05	5.6
Siberian miner's lettuce	*Claytonia sibirica*	0.05	5.8
red-twig dogwood	*Cornus sericea*	0.87	3.6
beaked hazelnut	*Corylus cornuta*	14.35	34.1
fragile fern	*Cystopteris fragilis*	---	0.2
Pacific bleedingheart	*Dicentra formosa*	0.03	0.9
wood fern	*Dryopteris expansa*	0.35	15.7
blunt spike rush	*Eleocharis obtusa*	---	0.2
fringed willowherb	*Epilobium ciliatum*	0.03	3.6
common horsetail	*Equisetum arvense*	0.82	9.6
horsetail rush	*Equisetum hyemale*	0.02	0.7

Common Name	Scientific Name	Cover (%)	Freq (%)
horsetail	*Equisetum* sp.	0.23	3.1
woodland strawberry	*Fragaria vesca*	---	0.5
bedstraw	*Galium aparine*	0.58	28.7
fragrant bedstraw	*Galium triflorum*	0.01	0.9
salal	*Gaultheria shallon*	3.96	27.1
large-leaved avens	*Geum macrophyllum*	0.04	7.4
tall mannagrass	*Glyceria striata*	0.01	0.9
oceanspray	*Holodiscus discolor*	0.74	5.2
floating marsh-pennywort	*Hydrocotyle ranunculoides*	---	0.2
Pacific waterleaf	*Hydrophyllum tenuipes*	0.02	0.5
Pacific rush	*Juncus effusus ssp. pacificus*	0.01	0.2
Sierra pea	*Lathyrus nevadensis*	---	0.2
leafy pea	*Lathyrus polyphyllus*	0.01	2.2
duckweed	*Lemna minor*	---	0.2
orange honeysuckle	*Lonicera ciliosa*	0.15	1.8
hairy honeysuckle	*Lonicera hispidula*	0.03	0.9
twinberry	*Lonicera involucrata*	0.02	0.9
marsh primrose-willow	*Ludwigia palustris*	0.05	0.5
small-flowered woodrush	*Luzula parviflora*	---	0.2
swamp lantern	*Lysichiton americanus*	0.02	0.7
tall Oregon grape	*Mahonia aquifolium*	0.30	2.7
low Oregon grape	*Mahonia nervosa*	2.61	36.8
western crabapple	*Malus fusca*	---	0.2
small-flowered nemophila	*Nemophila parviflora*	0.04	5.6

Common Name	Scientific Name	Cover (%)	Freq (%)
osoberry	*Oemleria cerasiformis*	4.09	46.0
water parsley	*Oenanthe sarmentosa*	0.05	0.7
devil's club	*Oplopanax horridus*	0.30	2.5
sweet cicely	*Osmorhiza berteroi*	0.05	7.9
redwood sorrel	*Oxalis oregana*	---	0.2
water smartweed	*Persicaria amphibia*	---	0.2
mock orange	*Philadelphus lewisii*	0.04	0.7
Pacific ninebark	*Physocarpus capitatus*	0.14	0.5
licorice fern	*Polypodium glycyrrhiza*	0.02	3.4
sword fern	*Polystichum munitum*	20.34	84.3
common self heal	*Prunella vulgaris*	---	0.9
bracken fern	*Pteridium aquilinum*	2.35	32.3
blister buttercup	*Ranunculus sceleratus*	---	0.2
western rhododendron	*Rhododendron macrophyllum*	0.09	0.5
red-flowering currant	*Ribes sanguineum*	0.01	0.2
baldhip rose	*Rosa gymnocarpa*	0.04	1.6
Nootka rose	*Rosa nutkana*	0.46	2.5
blackcap	*Rubus leucodermis*	0.05	2.2
thimbleberry	*Rubus parviflorus*	0.11	4.0
salmonberry	*Rubus spectabilis*	7.51	29.2
trailing blackberry	*Rubus ursinus*	5.64	64.1
Pacific willow	*Salix lasiandra*	0.01	0.2
Sitka willow	*Salix sitchensis*	0.01	0.2
red elderberry	*Sambucus racemosa*	2.26	25.3

Common Name	Scientific Name	Cover (%)	Freq (%)
soft-stemmed bulrush	*Schoenoplectus tabernaemontani*	---	0.2
woolgrass	*Scirpus cyperinus*	---	0.2
small-seeded bulrush	*Scirpus microcarpus*	---	0.2
Douglas spirea	*Spiraea douglasii*	0.04	0.7
Cooley's hedge-nettle	*Stachys cooleyae*	---	0.9
deerfern	*Struthiopteris spicant*	0.01	0.7
snowberry	*Symphoricarpos albus*	0.81	7.0
fringecup	*Tellima grandiflora*	0.10	5.8
foamflower	*Tiarella trifoliata*	0.02	1.4
piggy-back plant	*Tolmiea menziesii*	0.33	5.8
starflower	*Trientalis borealis ssp. latifolia*	---	0.5
trillium	*Trillium ovatum*	0.08	12.3
nettle	*Urtica dioica*	1.23	28.7
evergreen huckleberry	*Vaccinium ovatum*	0.01	0.5
red huckleberry	*Vaccinium parvifolium*	0.58	12.6
American brooklime	*Veronica americana*	0.03	1.4

Cover = mean cover-abundance, Freq = frequency of occurrence

Table 31: Non-native plant species abundances. Taxa only identify to genus were assumed to be non-native. Cover values below 0.01% are represented by "---". All cover values represent means.

Common Name	Scientific Name	Cover (%)	Freq (%)
creeping bentgrass	*Agrostis stolonifera*	0.01	0.7
meadow-foxtail	*Alopecurus pratensis*	---	0.2
parsley-piert	*Aphanes* sp.	---	0.2
lesser burdock	*Arctium minus*	---	0.2
English daisy	*Bellis perennis*	0.01	0.5
brome	*Bromus* sp.	---	0.2
hairy bittercress	*Cardamine hirsuta*	0.08	8.5
sedge	*Carex* sp.	---	0.7
field thistle	*Cirsium arvense*	---	0.5
evergreen clematis	*Clematis vitalba*	---	0.5
field bindweed	*Convolvulus arvensis*	0.18	4.7
European hazelnut	*Corylus avellana*	0.10	0.2
franchet cotoneaster	*Cotoneaster franchetii*	---	0.2
bullate cotoneaster	*Cotoneaster rehderi*	0.02	0.5
cotoneaster	*Cotoneaster* sp.	0.04	0.5
crocosmia	*Crocosmia* sp.	---	0.2
orchardgrass	*Dactylis glomerata*	0.01	0.5
spurge laurel	*Daphne laureola*	0.02	2.2
foxglove	*Digitalis purpurea*	---	0.2
broadleaf helleborine	*Epipactis helleborine*	---	0.2
fescue	*Festuca* sp.	0.01	0.2
herb Robert	*Geranium robertianum*	0.95	41.3
geranium	*Geranium* sp.	---	0.2

Common Name	Scientific Name	Cover (%)	Freq (%)
herb bennet	*Geum urbanum*	0.34	8.1
English ivy	*Hedera helix*	27.14	74.9
dames rocket	*Hesperis matronalis*	---	0.2
tutsan	*Hypericum androsaemum*	0.01	1.4
jewelweed	*Impatiens capensis*	---	0.2
yellow flag iris	*Iris pseudacorus*	---	0.2
iris	*Iris* sp.	---	0.2
soft rush	*Juncus effusus*	---	0.2
soft rush	*Juncus effusus ssp. effusus*	0.01	0.2
eastern soft rush	*Juncus effusus ssp. solutus*	0.01	0.2
nipplewort	*Lapsana communis*	0.16	18.6
everlasting pea	*Lathyrus latifolius*	---	0.2
large bird's-foot trefoil	*Lotus uliginosus*	0.01	0.5
money plant	*Lunaria annua*	0.01	0.5
wall-lettuce	*Mycelis muralis*	0.16	25.3
milfoil sp	*Myriophyllum* sp.	---	0.2
Japanese pachysandra	*Pachysandra terminalis*	---	0.2
spotted ladysthumb	*Persicaria maculosa*	0.24	0.5
reed canary grass	*Phalaris arundinacea*	0.27	2.0
annual bluegrass	*Poa annua*	0.01	0.9
scarlet firethorn	*Pyracantha coccinea*	---	0.2
firethorn	*Pyracantha* sp.	---	0.2
creeping buttercup	*Ranunculus repens*	1.73	9.0
currant	*Ribes* sp.	---	0.2

Common Name	Scientific Name	Cover (%)	Freq (%)
Himalayan blackberry	*Rubus bifrons*	10.12	52.2
evergreen blackberry	*Rubus laciniatus*	---	0.2
bitter dock	*Rumex obtusifolius*	0.01	0.9
bulrush	*Scirpus* sp.	---	0.2
bittersweet nightshade	*Solanum dulcamara*	0.08	3.6
chickweed	*Stellaria media*	0.02	2.0
dandelion	*Taraxacum officinale*	0.02	3.4
clover	*Trifolium* sp.	---	0.5
thymeleaf speedwell	*Veronica serpyllifolia*	0.01	0.9
speedwell	*Veronica* sp.	---	0.2
wayfaringtree	*Viburnum lantana*	0.02	0.2
European cranberry bush	*Viburnum opulus var. opulus*	0.01	0.2
viburnum	*Viburnum* sp.	---	0.2
vinca	*Vinca major*	---	0.2
vinca	*Vinca minor*	0.16	0.5
violet	*Viola* sp.	---	0.2

Cover = mean cover-abundance, Freq = frequency of occurrence

Appendix F: Tables – Changes in Understory Species Composition Between 2014 and 2024

Table 32: Changes in the composition of the native plant community. As a result of data preparation steps that aggregated some taxa prior to comparing change over time, values in this table may differ from values reported elsewhere in the report. Unknown species (i.e. taxa aggregated at the genus level, or aggregated at the species level if there were multiple subspecies), were assumed to be non-native for the purpose of this analysis and were not included in this table. Cover values below 0.001% and frequency values below 0.1% are represented by "---". All cover values represent means.

Scientific Name	Cover-Abundance (%)			Frequency (%)		
	2014	2024	Abs Diff	2014	2024	Abs Diff
Achlys triphylla	0.332	0.191	-0.141	8.5	5.6	-2.9
Adiantum aleuticum	0.008	0.017	0.009	1.1	0.7	-0.5
Alisma triviale	0.001	0.001	0.000	0.5	0.2	-0.2
Amelanchier alnifolia	0.003	0.021	0.018	0.5	1.8	1.3
Asarum caudatum	0.002	---	-0.002	0.2	---	-0.2
Athyrium filix-femina	1.148	0.764	-0.384	19.8	15.3	-4.5
Bidens frondosa	---	---	0.000	0.2	---	-0.2
Carex hendersonii	0.009	0.001	-0.008	0.2	0.2	0.0
Carex leptopoda	0.077	0.037	-0.040	13.8	4.9	-8.8
Carex obnupta	0.002	0.001	-0.001	0.2	0.2	0.0
Chamerion angustifolium	0.003	---	-0.003	0.5	---	-0.5
Circaea alpina	0.077	0.054	-0.023	11.7	5.6	-6.1
Claytonia sibirica	0.114	0.051	-0.063	15.9	5.8	-10.0
Cornus sericea	0.216	0.869	0.653	1.1	3.6	2.4
Corylus cornuta	11.912	14.379	2.467	32.2	34.2	2.0
Cystopteris fragilis	---	0.001	0.001	---	0.2	0.2
Dicentra formosa	0.002	0.031	0.029	0.7	0.9	0.2
Dryopteris expansa	1.338	0.349	-0.989	33.8	15.7	-18.1

Scientific Name	Cover-Abundance (%)			Frequency (%)		
	2014	2024	Abs Diff	2014	2024	Abs Diff
Eleocharis obtusa	---	0.001	0.001	---	0.2	0.2
Eleocharis palustris	0.009	---	-0.009	0.2	---	-0.2
Epilobium ciliatum	0.021	0.027	0.006	9.0	3.6	-5.4
Equisetum arvense	0.069	0.824	0.755	0.5	9.7	9.2
Equisetum hyemale	0.076	0.018	-0.058	0.5	0.7	0.2
Equisetum telmateia	1.147	0.226	-0.921	13.6	3.1	-10.4
Galium aparine	0.257	0.581	0.324	28.3	28.8	0.5
Galium triflorum	0.019	0.008	-0.011	4.8	0.9	-3.9
Gaultheria shallon	4.062	3.971	-0.091	32.9	27.2	-5.7
Geum macrophyllum	0.150	0.044	-0.106	14.0	7.4	-6.6
Glyceria striata	0.023	0.012	-0.011	0.7	0.9	0.2
Holodiscus discolor	0.368	0.742	0.374	3.2	5.2	2.0
Hydrocotyle ranunculoides	---	0.001	0.001	---	0.2	0.2
Hydrophyllum tenuipes	0.001	0.017	0.016	0.2	0.4	0.2
Lathyrus sp.	---	0.013	0.013	0.5	2.7	2.2
Leersia oryzoides	0.001	---	-0.001	0.2	---	-0.2
Lemna minor	---	0.001	0.001	---	0.2	0.2
Lonicera ciliosa	0.059	0.149	0.090	4.6	1.8	-2.8
Lonicera hispidula	0.039	0.026	-0.013	0.9	0.9	0.0
Lonicera involucrata	0.026	0.025	-0.001	0.7	0.9	0.2
Ludwigia palustris	0.018	0.049	0.031	0.2	0.4	0.2
Luzula parviflora	0.003	0.001	-0.002	1.1	0.2	-0.9
Lysichiton americanus	0.066	0.024	-0.042	1.6	0.7	-0.9

Scientific Name	Cover-Abundance (%)			Frequency (%)		
	2014	2024	Abs Diff	2014	2024	Abs Diff
Mahonia aquifolium	0.082	0.297	0.215	2.1	2.7	0.6
Mahonia nervosa	2.694	2.616	-0.078	45.5	36.9	-8.7
Malus fusca	0.005	0.001	-0.004	0.5	0.2	-0.2
Mitella caulescens	0.002	---	-0.002	0.2	---	-0.2
Nemophila parviflora	0.049	0.036	-0.013	6.0	5.6	-0.4
Oemleria cerasiformis	2.852	4.100	1.248	47.6	46.1	-1.5
Oenanthe sarmentosa	0.010	0.047	0.037	0.7	0.7	0.0
Oplopanax horridus	0.638	0.297	-0.341	3.9	2.5	-1.4
Osmorhiza berteroi	0.066	0.046	-0.020	15.2	7.9	-7.3
Oxalis oregana	---	0.004	0.004	---	0.2	0.2
Persicaria amphibia	---	0.001	0.001	---	0.2	0.2
Philadelphus lewisii	0.003	0.039	0.036	0.5	0.7	0.2
Physocarpus capitatus	0.035	0.137	0.102	0.9	0.4	-0.5
Polypodium glycyrrhiza	0.027	0.022	-0.005	7.4	3.4	-4.0
Polystichum munitum	19.422	20.388	0.966	89.0	84.5	-4.5
Prunella vulgaris	---	0.004	0.004	0.5	0.9	0.4
Pteridium aquilinum	2.567	2.355	-0.212	34.7	32.4	-2.4
Ranunculus sceleratus	---	0.001	0.001	---	0.2	0.2
Rhododendron macrophyllum	0.004	0.091	0.087	0.5	0.4	0.0
Ribes lacustre	0.019	---	-0.019	1.1	---	-1.1
Ribes sanguineum	0.004	0.011	0.007	0.5	0.2	-0.2
Rosa gymnocarpa	0.133	0.036	-0.097	2.3	1.6	-0.7
Rosa nutkana	0.014	0.465	0.451	0.2	2.5	2.2

Scientific Name	Cover-Abundance (%)			Frequency (%)		
	2014	2024	Abs Diff	2014	2024	Abs Diff
Rosa pisocarpa	0.160	---	-0.160	1.4	---	-1.4
Rubus leucodermis	0.058	0.049	-0.009	4.1	2.2	-1.9
Rubus parviflorus	0.103	0.110	0.007	3.0	4.0	1.1
Rubus spectabilis	6.141	7.528	1.387	30.6	29.2	-1.4
Rubus ursinus	3.956	5.655	1.699	64.1	64.3	0.1
Salix lasiandra	0.011	0.013	0.002	0.5	0.2	-0.2
Salix scouleriana	0.007	---	-0.007	0.7	---	-0.7
Salix sp.	---	0.007	0.007	---	0.2	0.2
Sambucus racemosa	5.552	2.263	-3.289	53.1	25.4	-27.7
Schoenoplectus tabernaemontani	0.046	0.001	-0.045	0.2	0.2	0.0
Scirpus cyperinus	---	0.004	0.004	---	0.2	0.2
Scirpus microcarpus	0.028	0.004	-0.024	1.1	0.2	-0.9
Spiraea douglasii	0.043	0.043	0.000	0.9	0.7	-0.2
Stachys cooleyae	0.019	0.004	-0.015	1.4	0.9	-0.5
Stellaria crispa	0.067	---	-0.067	12.2	---	-12.2
Streptopus amplexifolius	0.001	---	-0.001	0.2	---	-0.2
Struthiopteris spicant	0.011	0.008	-0.003	0.5	0.7	0.2
Symphoricarpos albus	0.786	0.812	0.026	6.0	7.0	1.0
Tellima grandiflora	0.111	0.100	-0.011	6.4	5.8	-0.6
Tiarella trifoliata	0.045	0.018	-0.027	3.4	1.3	-2.1
Tolmiea menziesii	0.421	0.334	-0.087	6.7	5.8	-0.8
Trientalis borealis ssp. *latifolia*	0.003	0.002	-0.001	2.1	0.4	-1.6
Trillium ovatum	0.164	0.078	-0.086	21.6	12.4	-9.2

Scientific Name	Cover-Abundance (%)			Frequency (%)		
	2014	2024	Abs Diff	2014	2024	Abs Diff
Typha latifolia	0.115	---	-0.115	0.2	---	-0.2
Urtica dioica	3.421	1.237	-2.184	46.7	28.8	-17.9
Vaccinium ovatum	---	0.013	0.013	---	0.4	0.4
Vaccinium parvifolium	0.626	0.583	-0.043	16.3	12.6	-3.7
Veronica americana	0.002	0.028	0.026	1.1	1.3	0.2
Vicia americana	0.007	---	-0.007	3.2	---	-3.2

Abs Diff = absolute difference

Table 33: Changes in the composition of the non-native plant community. As a result of data preparation steps that aggregated some taxa prior to comparing change over time, values in this table may differ from values reported elsewhere in the report. Unknown species (i.e. taxa aggregated at the genus level, or aggregated at the species if there were multiple subspecies), were assumed to be non-native for the purpose of this analysis and included in this table. Many genera in this table that are not identified to species likely contain some native species. Cover values below 0.001% and frequency values below 0.1% are represented by "---". All cover values represent means.

Scientific Name	**Cover-Abundance (%)**			**Frequency (%)**		
	2014	2024	Abs Diff	2014	2024	Abs Diff
Agrostis sp.	0.337	0.007	-0.330	3.9	0.7	-3.2
Alopecurus pratensis	---	0.001	0.001	---	0.2	0.2
Aphanes sp.	---	0.001	0.001	---	0.2	0.2
Arctium minus	---	0.001	0.001	---	0.2	0.2
Aucuba japonica	0.005	---	-0.005	0.2	---	-0.2
Bellis perennis	---	0.006	0.006	---	0.4	0.4
Bromus sp.	0.028	0.009	-0.019	12.2	1.6	-10.6
Cardamine hirsuta	0.099	0.078	-0.021	16.3	8.5	-7.8
Carex sp.	---	0.003	0.003	---	0.7	0.7
Cirsium arvense	0.011	0.002	-0.009	0.5	0.4	0.0
Cirsium vulgare	0.001	---	-0.001	0.2	---	-0.2
Clematis vitalba	0.039	0.002	-0.037	0.2	0.4	0.2
Convolvulus arvensis	0.771	0.179	-0.592	6.9	4.7	-2.2
Corylus avellana	---	0.099	0.099	---	0.2	0.2
Cotoneaster sp.	0.018	0.053	0.035	1.6	0.9	-0.7
Crocosmia sp.	---	0.001	0.001	---	0.2	0.2
Cyclamen sp.	---	---	0.000	0.2	---	-0.2
Dactylis glomerata	---	0.006	0.006	---	0.4	0.4
Daphne laureola	0.003	0.017	0.014	1.1	2.2	1.1

Scientific Name	Cover-Abundance (%)			Frequency (%)		
	2014	2024	Abs Diff	2014	2024	Abs Diff
Digitalis purpurea	0.002	0.001	-0.001	0.5	0.2	-0.2
Duchesnea indica	0.005	---	-0.005	0.2	---	-0.2
Elymus repens	0.083	---	-0.083	1.1	---	-1.1
Epipactis helleborine	---	0.001	0.001	---	0.2	0.2
Festuca sp.	---	0.009	0.009	---	0.2	0.2
Fragaria sp.	0.002	0.002	0.000	1.1	0.4	-0.7
Geranium robertianum	2.050	0.956	-1.094	64.8	41.3	-23.5
Geranium sp.	---	0.001	0.001	---	0.2	0.2
Geum urbanum	---	0.337	0.337	---	8.1	8.1
Hedera helix	17.106	27.201	10.095	86.4	75.1	-11.4
Hesperis matronalis	---	0.001	0.001	---	0.2	0.2
Holcus lanatus	0.005	---	-0.005	0.5	---	-0.5
Hypericum androsaemum	0.001	0.008	0.007	0.5	1.3	0.9
Hypericum perforatum	---	---	0.000	0.2	---	-0.2
Hypochaeris radicata	0.005	---	-0.005	0.2	---	-0.2
Impatiens capensis	---	0.004	0.004	---	0.2	0.2
Iris pseudacorus	0.069	0.001	-0.068	0.2	0.2	0.0
Iris sp.	---	0.001	0.001	---	0.2	0.2
Juncus sp.	0.075	0.038	-0.037	1.4	1.3	0.0
Lapsana communis	0.200	0.160	-0.040	22.8	18.7	-4.1
Ligustrum sp.	0.023	---	-0.023	0.2	---	-0.2
Lotus sp.	0.004	0.011	0.007	0.7	0.4	-0.2
Lunaria annua	0.002	0.010	0.008	0.2	0.4	0.2

Scientific Name	Cover-Abundance (%)			Frequency (%)		
	2014	2024	Abs Diff	2014	2024	Abs Diff
Mycelis muralis	0.485	0.163	-0.322	44.1	25.4	-18.7
Myriophyllum sp.	---	0.001	0.001	---	0.2	0.2
Pachysandra terminalis	---	0.001	0.001	---	0.2	0.2
Persicaria maculosa	0.036	0.240	0.204	0.7	0.4	-0.2
Phalaris arundinacea	0.594	0.267	-0.327	2.5	2.0	-0.5
Plantago major	0.015	---	-0.015	1.6	---	-1.6
Poa annua	0.042	0.010	-0.032	0.7	0.9	0.2
Poa trivialis	0.010	---	-0.010	2.1	---	-2.1
Pyracantha sp.	0.028	0.006	-0.022	0.2	0.4	0.2
Ranunculus repens	0.875	1.735	0.860	9.7	9.0	-0.7
Ribes sp.	---	0.004	0.004	---	0.2	0.2
Rubus bifrons	7.294	10.146	2.852	54.0	52.4	-1.7
Rubus laciniatus	0.003	0.004	0.001	0.5	0.2	-0.2
Rumex crispus	0.003	---	-0.003	0.5	---	-0.5
Rumex obtusifolius	0.008	0.006	-0.002	1.4	0.9	-0.5
Scirpus sp.	---	0.002	0.002	---	0.2	0.2
Solanum dulcamara	0.159	0.081	-0.078	4.4	3.6	-0.8
Sonchus asper	0.002	---	-0.002	0.9	---	-0.9
Sonchus oleraceus	---	---	0.000	0.2	---	-0.2
Stellaria media	0.005	0.017	0.012	1.4	2.0	0.6
Tanacetum parthenium	---	---	0.000	0.2	---	-0.2
Taraxacum officinale	0.012	0.022	0.010	5.1	3.4	-1.7
Trifolium sp.	0.001	0.002	0.001	0.5	0.4	0.0

Scientific Name	Cover-Abundance (%)			Frequency (%)		
	2014	2024	Abs Diff	2014	2024	Abs Diff
Veronica serpyllifolia	0.047	0.008	-0.039	1.8	0.9	-0.9
Veronica sp.	---	0.001	0.001	---	0.2	0.2
Viburnum lantana	0.002	0.022	0.020	0.5	0.2	-0.2
Viburnum opulus var. *opulus*	---	0.007	0.007	0.2	0.2	0.0
Viburnum sp.	---	0.001	0.001	---	0.2	0.2
Vicia hirsuta	0.002	---	-0.002	0.2	---	-0.2
Vicia sativa	---	---	0.000	0.2	---	-0.2
Vinca major	0.002	0.004	0.002	0.2	0.2	0.0
Vinca minor	0.002	0.157	0.155	1.4	0.4	-0.9
Viola sp.	---	0.001	0.001	---	0.2	0.2

Abs Diff = absolute difference