Final Report: Seward Old-growth Hemlock Survey & Youth Training Department of Neighborhoods Project O21019
Friends of Seward Park
CHOOSE 180

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Introduction

Western Hemlock trees in Seward Park's 100 acre old-growth forest appear to be diseased and dying in unusual numbers. The Friends of Seward Park teamed up with CHOOSE 180 (which supports young people in King County disproportionately impacted by the criminal justice system) to gather preliminary data on this phenomenon.

Changes in a forest can be overlooked. They can be exaggerated. Longitudinal data, collected year upon year by an explicit protocol is the remedy. Such data reveals the actual dynamics of the forest, setting the stage for discerning the mechanisms at play, and providing a basis for possible strategic responses[1]. This is the motivation for the project reported here, in which we establish a base line data set on hemlock disease and mortality in Seward Park's forest.

Forest decline is reported elsewhere in the Pacific Northwest[2], and throughout the western United States[3]. Seward's early old-growth forest[4] presents an especially dramatic instance of this decline, perhaps due to the rare juxtaposition of old-growth and a variety of urban stress factors.

The current study, along with prior work on sword ferns, establishes that now two late-succession species show multi-year sign of dramatic decline. The ongoing loss of large numbers of these two climax signature species bodes ill for the future of this forest.

Executive Summary

Three paid interns (DON grant O21019) and one volunteer supervisor surveyed 116 western hemlocks, working four afternoons a week for six weeks in July and early August of 2021. We developed measurement and sampling protocols in consultation with Drs. Marianne Elliott, Tim

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1 Lutz, James A. "The evolution of long-term data for forestry: large temperate research plots in an era of global change." *Northwest Science* 89.3 (2015): 255-269.

2 https://foresthealth.org/forest-health/

3 Stanke, Hunter, et al. "Over half of western United States' most abundant tree species in decline." *Nature Communications* 12.1 (2021): 1-11.

4 Freund, James A., Jerry F. Franklin, and James A. Lutz. "Structure of early old-growth Douglas-fir forests in the Pacific Northwest." *Forest Ecology and Management* 335 (2015): 11-25.

Billo and Joseph Hulbert (WSU and UW). We curated data from field notes into a spreadsheet format which are now archived in several version: an interactive map and data table, an excel spreadsheet, an iNaturalist project. 24% of the trees are fully dead, 7% appear to be in good health, 69% are in various stages of decline. The decline and die-off is noticeably more severe in the north-central, formerly hemlock-dense survey area, and mildest towards the south, suggesting a possible north-south progression of the phenomenon. This distribution may be seen in the map on the next page.

Overview

Figure 1: Summary map
black: dead **grey**: in decline **green**: relatively healthy

Interactive version available at https://paulshannon.shinyapps.io/hemlockMap/
Interactive data table: https://paulshannon.shinyapps.io/hemlockDataTable/

Methods: region sampling

We measured 116 hemlocks in three disjoint sections of Seward's forest. These regions are arrayed on the peninsula on (approximately) a north-south axis.

- central: 58 trees
- southern: 17
- northern: 41

We began with the 4.6 acre (1.8 hectare) central section, an area bounded the *sqebeqsed* and Windfall trails. We applied the assessment protocol (see below) to every hemlock in this section, navigating cautiously off-trail throughout this sometimes difficult terrain.

We used a different approach with the southern section, surveying only those hemlocks found within 60 feet of the *sqebeqsed*, Woodpecker and Andrews Bay trails. An unknown number of hemlocks in the center of this region were not included.

The northern section employed this same 60-feet-from-trail protocol, but due to the geometry of this hemlock-rich section we were able to assess every hemlock.

Methods: per-tree assessment protocol

Seven measurements were made of each tree:

1. latitude
2. longitude
3. DBH
4. height
5. DMR scale 1,2,3 (see below)

A Garmin Montana 680t hand-held GPS device gave us latitude and longitude within about 15 feet. Some coordinates were modified slightly during the transcription to the permanent digital record, so that locations were in register with OpenStreetMap coordinates used by our interactive map, to facilitate future relocation of the measured trees.

DBH was measured by hand-held tape as inches of circumference (CBH), and subsequently divided by *pi*.

Tree height in feet was estimated for each tree using a low power laser range finder (Bosch GLM 30) paired with a home-made target covered with reflective tape, and a SUUNTO clinometer, on loan from the University of Washington. For each tree, the interns established a viewpoint baseline, read off the angle to the top of the tree, and corrected for the viewpoint-to-tree base vertical distance. Crowded canopies and forest mid-stories sometimes made it hard to find the top of a tree. In these cases, an estimated treetop angle was used.

We adapted aspects of the DMR (Dwarf Mistletoe Rating) system[5], as suggested by Marianne Elliott, to describe the health of each tree; see diagram below. Our proxy for infection was an informal estimate of the robustness and extent of needles on each third of the tree. In our scheme, DMR1 is the bottom third of the tree, DMR2 is the middle third, and DMR3 the top. Each section received a number on a scale of 0 (healthy: abundant healthy looking needles) to 2 (entirely bare branches). These ratings, and indeed the informal division of each tree's trunk

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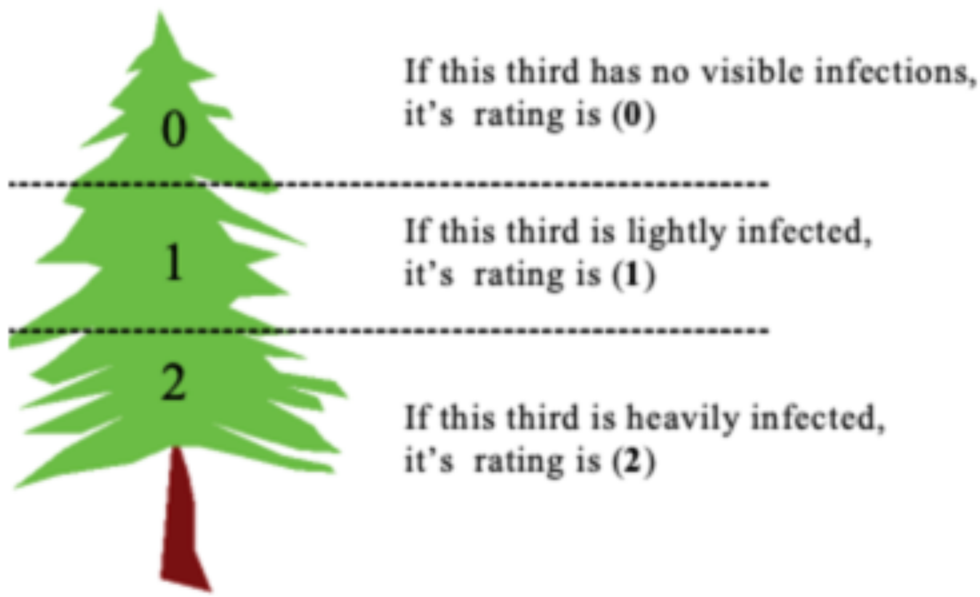
[5] https://forestpathology.org/parasitic-plants/dwarf-mistletoe/ecology/

into thirds, are imprecise. Nonetheless, after the first few days in the field, all four of us easily reached consensus on each tree that we encountered, suggesting that these informal ratings can be easily reproduced by independent observers.



Phenotypes and Categorization

We adopted a simple algorithm to transform field estimates of DMR1-3 into a color scheme (green, grey, black as seen on the map), and a corresponding single numerical measure of tree health. In our survey, and *without exception*, we found that Seward hemlock decline appears first in the bottom third of the tree and then progresses upwards. Without longitudinal data we cannot be sure, but it appears that progression towards tree death is universal once needles are dropped from the lower and middle sections of the tree.

Many forest tree species self-prune lower branches as they grow. It is not clear to us if this applies to the western hemlock. We observed a few large, mature and healthy hemlocks with no branches in their lower third. Far more common are younger trees, smaller than 12" DBH, with dead branches in the lower third. Many of these show progression of needle loss into their middle third. In an attempt to illuminate this question, we collected two additional measures in the 58 central section trees: height to first dead branch, and height to first healthy branch.

Informal visits to other forests (Schmitz Preserve in West Seattle, and lower elevations of the Mt.Baker-Snoqualmie National Forest) suggest that healthy hemlocks, even in a dense forest, often retain needle-bearing lower branches.

However, with this question unanswered, we categorize Seward's hemlocks in two ways: loosely (DMR1 dead branches are normal) and strictly (DMR1 dead branches indicate decline). Only 8 hemlocks had healthy needle-bearing branches in bottom, middle and top sections. But if one omits bottom section reports, then 31 trees can be described as fully healthy.

DMR distributions:

	DMR 1	DMR2	DMR3
0 (healthy):	10	21	57
1 (intermediate):	25	42	30
2 (diseased):	81	53	29

Estimated overall health: sum of DMR1, DMR2, DMR3 for each tree, bare lower tree treated as healthy (the “loose” categorization):

healthy (0-2):	31	27%
intermediate (3-5):	57	49%
dead (6):	28	24%

On the assumption that healthy hemlocks always have robust needles in their lower third (the “strict” categorization):

healthy (0):	8	7%
intermediate (1-5):	80	69%
dead (6):	28	24%

Microscopy

By mid-July, after surveying about 20 hemlocks, we encountered our first small tree with partially affected lower branches which were close enough to the ground for us to inspect up close. Using a hand-held video-enabled microscope, we captured images of a possible disease-in-process phenotype, observations we tentatively confirmed on subsequent trees, and on two visits to Schmitz Preserve in West Seattle. In brief: the previous season’s small stems, in an affected branch, have an apparently unusual concentration of black substance adhering to them.

This proposed phenotype, and its relevance, are currently only a conjecture. Dr. Hulbert suggested that it is worthy of further investigation - along with several other possibilities, see “Next Steps” section below. Videos from a sample size of 20 (10 healthy[6], 10 affected[7]) are available on youtube. These elaborate on the contrast visible below in these two photos:

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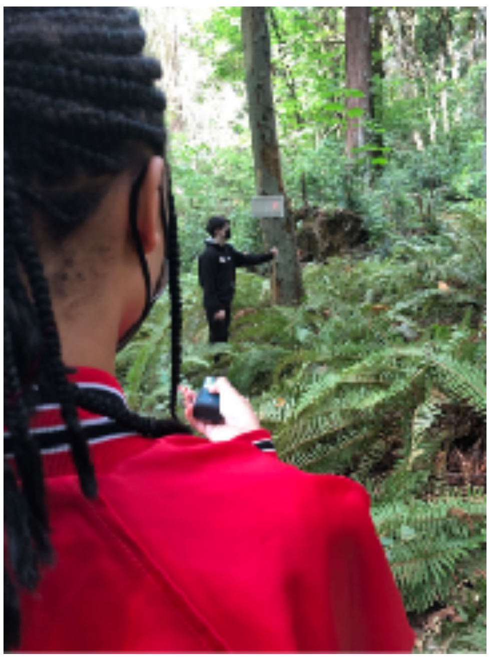
[6] https://www.youtube.com/playlist?list=PLWNzMz4QSB0vTOI78ufPiWlaEtzqELRWE

[7] https://www.youtube.com/playlist?list=PLWNzMz4QSB0vsX24wuE2_TGcuWmu2cHpF

The Interns

Three fourteen year-old students staffed this project: Hope Allen, Nathiya Guerra, and Jayden Schnell-Dry. Though none had prior experience with field work nor with forest assessment, they quickly became indispensable. They were quick to learn. They were patient and disciplined. Within a few days of our start, they achieved such competence that I unquestionably relied upon them - their skill and their judgement - throughout the project. They demonstrated competence and consistency with clinometer, laser range finding, consensus DRM assignments, and meticulous record keeping and data transcription.



Hope Allen (foreground) and Jayden Schnell-Dry measure baseline

Nathiya Guerra records measurements

Possible Causes of Seward's Hemlock Decline, Possible Responses

After consulting with UW professor (emeritus) Robert Edmonds, and WSU plant pathologist Joseph Hulbert, we propose the following:

1. Background and "hotspot" hemlock mortality has been seen in Seward's forest for at least 20 years.

2. Since approximately 2015, however, the PNW and Seward in particular have seen accelerated decline.

3. Hemlock decline first appears as needle loss in the lower branches, and proceeds over time up the affected tree. Drought effects in PNW trees typically progress from the top to the bottom of the tree.

4. Needle loss in lower canopy is consistent with known foliar infection by Phytophthora and rhizoctonia web blight.

5. Another possibility is that the hemlocks manage drought or other effects by sacrificing lower, less productive branches.

6. Past analyses by Dr. Edmonds found that fungal diseases (Annosus, Armilliaria, Laminated Root Rot) can kill hemlocks, and have been seen to do so at Seward. The current degree of decline and die-off appears to dramatically exceed past rates.

7. No direct link to climate change has been found, but recent longer, hotter summers likely add to tree stress and compound possible biotic factors to increase mortality.

8. Wooly adelgids, responsible for the nearly complete loss of the Eastern and Carolina Hemlock, are present in small numbers on Western Hemlocks at Seward, but are not thought to be harmful.

9. The “black residue” phenotype should be further explored.

10. Dr. Edmonds predicts that over the next several decades *all* conifers at Seward will die. Doug firs have “jug butt” infections, cedars are seeing unusual mortality, the hemlocks are in rapid decline. Unless remedies are found Edmonds predicts that Seward’s forest will, within decades, have only deciduous trees and exhibit markedly reduced complexity.

Conclusion

For seven years, and initially with a focus on the sword fern die-off, the Friends of Seward Park have attempted to track and understand community decline in the early old growth forest at Seward Park. A few small grants ($8k in 2019; $4.5k this year for intern salaries in this project) have been helpful. Seattle Parks has also run a few research projects. None of these have efforts have established cause; no remedies are yet known.

Climate change, though perhaps still central to Seattle Parks analysis, appears to us to be only peripherally involved. Some preliminary evidence of biotic causation has emerged for the sword ferns. Fungal diseases are well known in hemlocks, and their virulence may be compounded by other newly destructive biotic, climate and other environmental factors.

It may be that most - or all - of the hemlocks will die. That loss, along with the bare ground left by sword fern die-off, open gaps in the forest ecosystem. These gaps may combine to trigger more ecosystem failures. Better understanding of the dynamics of these changes is urgently needed.

Citizen science, shoestring budgets, and a few projects from Seattle Parks are not adequate to this task. We need sustained, competitively awarded, grant-funded, peer-reviewed research.

Citizen science and Parks participation are important. We hope that they will be part of the larger effort we would like to see. . But because they are, by themselves, inadequate, the Friends of Seward Park, with advice from the Seattle Parks Foundation, and advised by Dr. Edmonds, is now engaged in fund raising to support more substantive, more sustained research. Collaboration with Seattle Parks is welcome.

Credit and Thanks

- Seattle Department of Neighborhoods: Karen Selander: for funding and advice.
- CHOOSE 180 staff: Sean Goode, Natasha Moore, Tascha Johnson, Chris Harris, Cortez Charles, Lamaria Pope : for making the entire project possible
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- Joey Manson, Audubon: for welcoming our group many times into the Audubon Center to do lab work.
- Marianne Elliott and Tim Billo: for devising the sampling protocol, and the loan of field equipment.
- Joey Hulbert: for advice throughout, and for giving the interns a magnificent introduction to lab methods.
- Michael Yadrick, Seattle Parks: for reviewing the research plan, and offering helpful suggestions.
- Hope, Nathiya and Jayden: for great good work and collegiality.
- Their parents and families: for six weeks of intern drop-off and pickup, despite the rigors of South Seattle traffic.
- Dr. Bob Edmonds: for visiting our sites, identifying fungi, teaching us about tree diseases.