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 ports young people who are disproportionately impacted by the criminal justice system in King County) to measure this phenomenon. Changes to a forest can be overlooked. They can also be exaggerated. Longitudinal data, collected year upon year, reveals the actual dynamics of the forest, sets the stage for understanding the mechanisms at play. Strategic response thus becomes possible. Our project establishes a base line data set on hemlock disease and mortality in Seward Park's forest.

Forest decline is reported elsewhere in the Pacific Northwest[1], and throughout he western United States[2]. Seward's forest presents an especially dramatic instance of this decline, perhaps due to its established and unusual maturity and complexity, and its exposure to urban stress. Prior work and the current study establish that now two late-succession species, sword ferns (*Polystichum munitum*) and western hemlock (*Tsuga heterophylla)* in 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 WSU and UW Drs. Marianne Elliott, Tim Billo and Joseph Hulbert. We assembled and curated data from field notes into a spreadsheet format, archived in several transformations: 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.

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[1] https://foresthealth.org/forest-health/

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

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 which 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* trail 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 1,2,3 (see below)

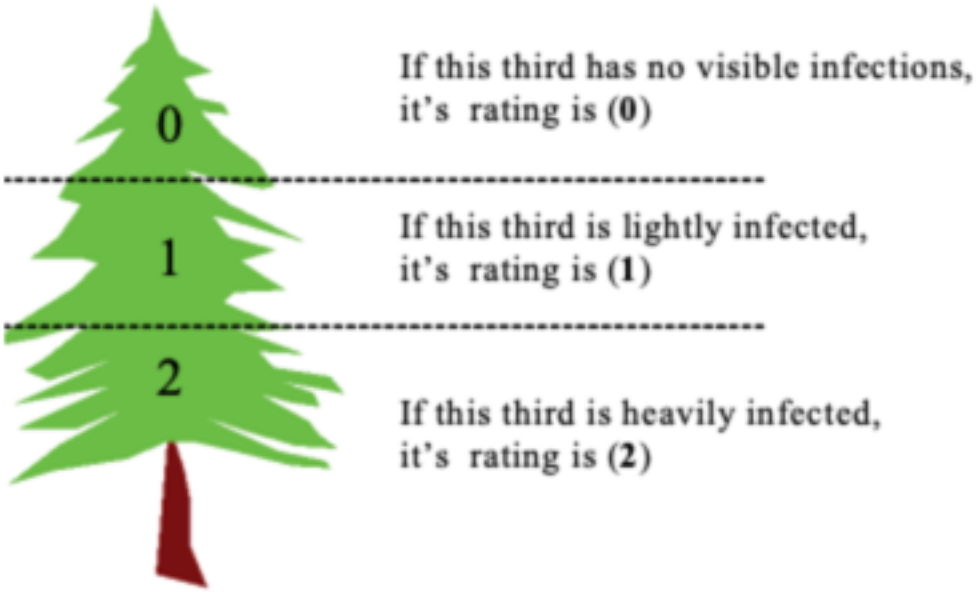
A Garmin Montana 680t hand-held GPS device gave us latitude and longitude within about 15 feet. Some coordinates were modified slightly during the transcription to the permanent digital record, so that locations were in register with OpenStreetMap coordinates used by our interactive map, to facilitate 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 used the DMR (Dwarf Mistletoe Rating) system[3], suggested by Marianne Elliott, to describe the health of each tree, as pictured 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 into thirds, are imprecise. Nonetheless, after the first few days in the field, all four of us easily reached consensus on each new tree we encountered. We suggest that these ratings are sufficiently reproducible by independent observers, rendering them adequate to our task.



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 dimension 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.

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

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 hemlocks with no branches in their lower third. Far more common are younger trees, less 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 do 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

Overall health estimated distribution: 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 close enough to the ground for us to inspect. 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.

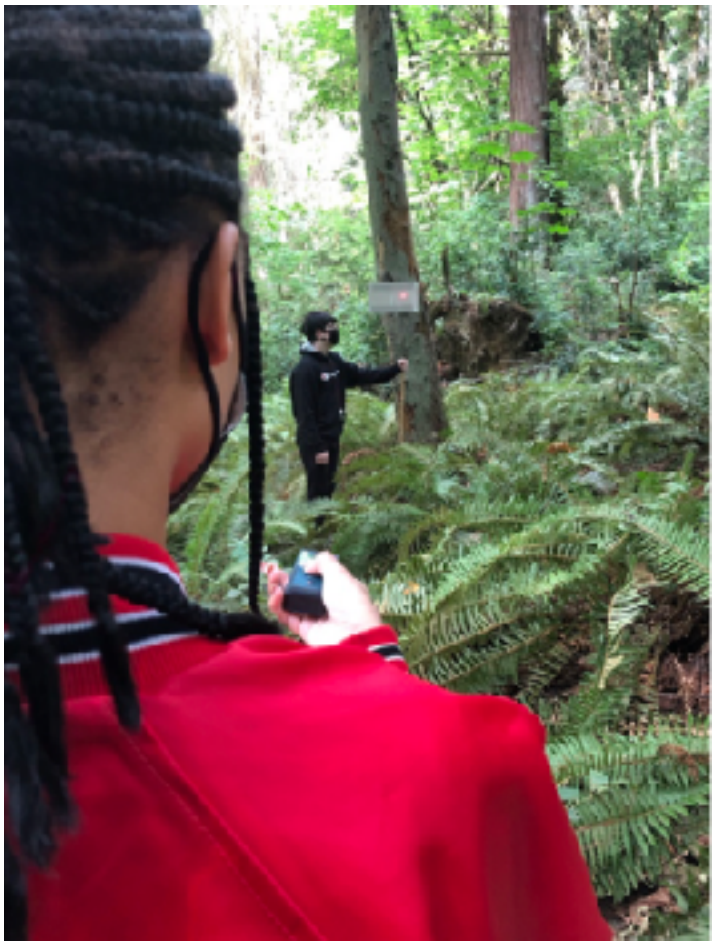
This proposed phenotype, and its possiblerelevance, is currently only a conjecture. Dr. Hulbert, perhaps acting an abundance of politeness, suggested that it may be worthy of further investigation. Videos from a sample size of 20 (10 healthy[4], 10 affected[5]) are available on youtube, elaborating on the contrast visible below in these photos:

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

[5] 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. They were indispensable., None had prior experience with field work, nor with forest assessment in particular. They were quick to learn, patient, observant, 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 our time together. The success of the project is a direct result of their competence with clinometer tree height estimation, laser range finding, consensus DRM assignments, and meticulous record keeping and data transcription.



Hope Allen (foreground) and Jayden Schnell-Dry establish a viewpoint baseline, the first step in obtaining tree height.

Nathiya Guerra records measurements made by Hope and Jayden