The Sound of Science: Acoustic Monitoring and Occupancy Modeling of Songbirds in the Olympic Experimental State Forest

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Background

Intensely managed forests can truncate habitat window, decrease area, or fragment home ranges for birds and other species

In the Olympic Experimental State Forest, DNR aims to integrate ecological health and timber production, requiring understanding species response to forest management techniques

Passive acoustic monitoring is an efficient method to observe soundscape DNR placed recording devices in the OESF across 4 forest stages to collect acoustic data

Figure 1. Acoustic recording unit affixed to a tree

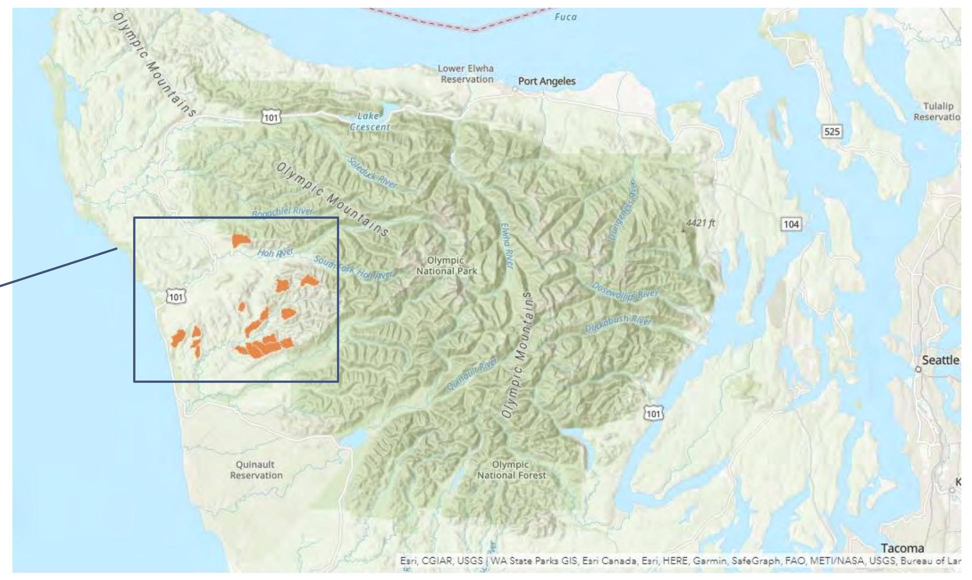

Figure 2. Study area. Survey regions in orange. Olympic Experimental State Forest

Do Pacific-slope Flycatcher and Orange-crowned Warbler occupy forest stage areas in the OESF according to known habitat associations?

Internship & Methods

Process surveys by viewing spectrograms and listening to audio in Audacity software. Validate and annotate target species vocalizations, aircraft, and rain events

Model occupancy of Pacific-slope Flycatcher & Orange-crowned Warbler using variables of occupancy: strata, time period, and detection probability: aircraft, rain, Julian day

Literature review investigating habitat associations for Pacific-slope Flycatcher and Orange-crowned Warbler

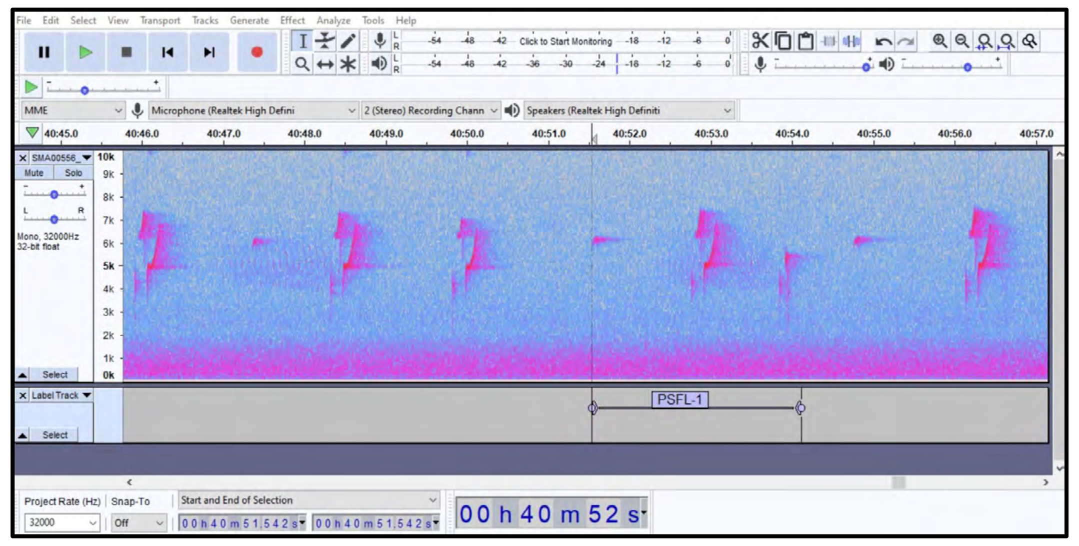

Figure 3. Spectrogram view of survey in Audacity showing 3-syllable song of Pacific-slope Flycatcher

When monitoring presence or absence, species may go undetected despite being present. **Occupancy models** help account for imperfect detection

Data from **86 stations** and **4 repeat** surveys per station

Results

Figure 4. Pacific-slope Flycatcher

Known habitat association: mature forest: mixed conifer & deciduous canopy, large snags, riparian areas

Naïve occupancy 70%
Model occ estimate 71%
Detection probability 65%

Strata strong predictor of occ.
Rain had slight negative effect on detection probability
Aircraft & Julian day had slight positive effect on detection probability

Figure 5. Bar graph illustrating PSFL detection (presence) at each forest stage

Table 1. Top 5 best-fit models for Pacific-slope Flycatcher

Model	ΔAIC	*AICw*	*K*
Ψ(STRATA,PERIOD), *P*(Aircraft,Rain,JulianDay)	0.00	.9983	9
Ψ(.), *P*(Aircraft,Rain,JulianDay)	12.83	.0016	5
Ψ(STRATA), *P*(Rain)	22.02	0	6
Ψ(.), *P*(Rain)	27.24	0	3
Ψ(.), *P*(Aircraft,Rain)	27.93	0	4

Figure 6. Orange-crowned Warbler

Known habitat association: early-seral forest with abundant deciduous shrub layer

Naïve occupancy 10%
Model occ estimate 11%
Detection probability 53%

Strata strong predictor of occ.
Aircraft slight positive effect on detection probability
Julian day and rain had slight negative effect

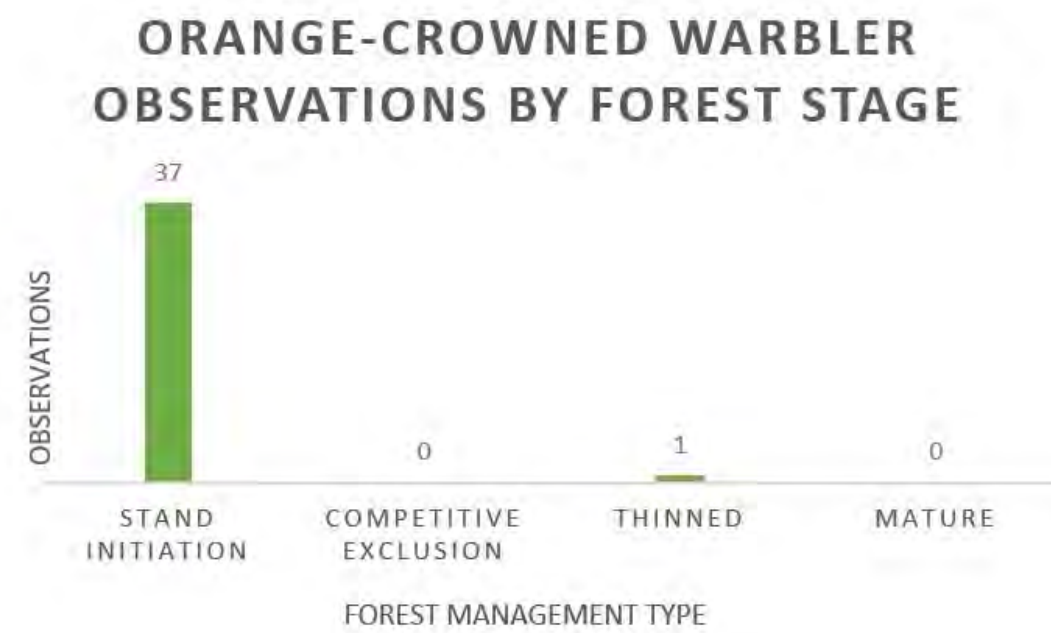

Figure 7. Bar graph illustrating OCWA detection (presence) at each forest stage

Table 2. Top 5 best-fit models for Orange-crowned Warbler

Model	ΔAIC	*AICw*	*K*
Ψ(STRATA), *P*(.)	0.00	.3642	5
Ψ(STRATA), *P*(Aircraft)	1.4	.1809	6
Ψ(STRATA,PERIOD), *P*(.)	1.62	.162	6
Ψ(STRATA), *P*(Rain)	1.82	.1466	6
Ψ(STRATA), *P*(JulianDay)	2.0	.134	6

Takeaways

Forest stage is important variable in predicting site occupancy

Rain and aircraft events had some effect on detection probability

Use of forest management areas by these two species consistent with expected habitat associations

Pacific-slope Flycatcher observations were higher than Orange-crowned Warbler

Figure 8. Early seral near forest edge, OESF

Figure 9. Recently thinned area, OESF

Significance

Acoustic monitoring is effective method for observing songbirds in the OESF

Future occupancy modeling may investigate species use at finer site-level scales

With many songbird populations declining, forest management is an opportunity to enhance and protect ecosystem health and wildlife habitat

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Songbirds as Indicator Species on the Olympic Peninsula

Alternative Selection Criteria and Considerations

Developed by Levi A. Casto in association with the University of Washington Program on the Environment
and under the mentorship of Dr. Teodora Minkova and Lauren Kuehne

Listening to songbirds to assess their habitats

- Songbird species are used by researchers to indicate habitat quality and function
- Indicator species selection can be ambiguous or limited in scope
- Passive Acoustic Monitoring (PAM) is a cost-effective and data-prolific wildlife monitoring tool

The Pileated Woodpecker, a common indicator species with a major challenge
(Photo Courtesy of Cornell Ornithology Lab)

Research Objectives

- Identify the most relevant criteria for indicator species selection in anticipation of climate change
- Develop considerations for indicator species selection when using PAM
- Compare indicator species currently in use by DNR against new criteria and considerations

Internship

- Interned with Dr. Minkova and Lauren Kuehne's research team, manually validating PAM surveys for indicator songbird occupancy
- Validated 43 surveys for presence of ten selected indicator species

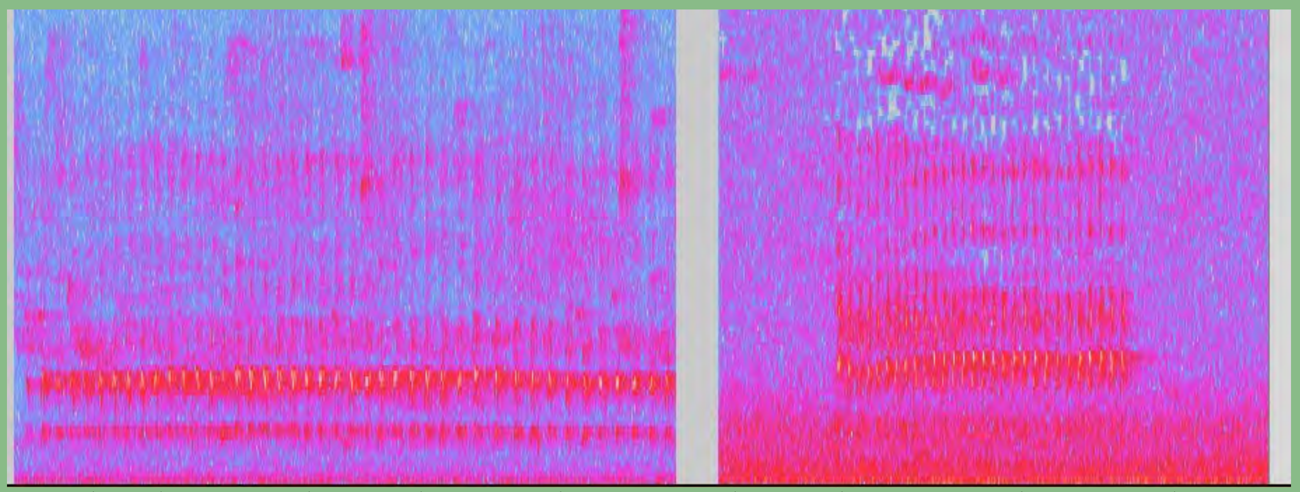
Methods

- Literature review topics:
  - Current selection criteria for indicator species
  - Anticipated effects of climate change on bird populations of the Olympic Peninsula
  - PAM research and application for songbird detection
- Evaluation of DNR indicator species and data with consideration of new criteria and considerations

A photo of myself beside logging equipment in DNR-managed forests near our study area

Preliminary Findings

- Criteria for climate change:
  - Vulnerability to competitive displacement
  - Range and migration shift
  - Effects of extreme weather events
- Criteria for PAM use:
  - Unique vocalization and timing
  - Sound-alike limitation



Side-by-side Pileated Woodpecker and Northern Flicker vocalizations in a spectrogram

Applications/Further Research

- Current and future DNR Indicators
  - Challenging Species
    - Bewick's Wren
    - Pileated Woodpecker
    - Orange-crowned Warbler
  - Alternative species options
    - White-Crowned Sparrow
    - Swainson's Thrush
    - Golden-Crowned Kinglet
- Need for more research of PAM use for indicator songbirds

Stream invertebrate assemblage composition in relation to environmental variables: Progress report on the T3 study in the OESF

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Background

Macroinvertebrates are essential to stream ecosystems and form a critical **trophic link** connecting autochthonous **primary producers and detritus to stream vertebrates**, including **salmonids** (Brenkman et al. 2011). Headwater macroinvertebrate assemblages appear to be **heavily influenced by environmental filtering**, as headwater streams are typically more isolated than mainstem rivers and have diverse physical habitats (Brown et al. 2018).

Overarching Research Questions

- What factors and processes structure perennial headwater macroinvertebrate assemblages in temperate rainforests?
- What are the relative roles of dispersion and environmental heterogeneity in structuring macroinvertebrate assemblages?

Top: *Hexatoma* (Limoniid Crane Fly)
Bottom: Tipulidae (Large Crane Fly)

Hesperoperla pacifica (Golden Stonefly)

Drift invertebrates were sampled with a drift net placed in the stream for 30 minutes.

Benthic invertebrates were collected with a Hess sampler.

Sample elutriation and preservation – separating the invertebrates from sediments to be preserved in ethanol.

Methods

Fieldwork

- Sites sampled: **31 sites** over **16 watersheds**: one adjacent to riparian treatments and one downstream at the pour point (lowest watershed point) on each stream
- Sampling occurred in late summer 2020 (Aug. – mid-Oct.) and followed National Ecological Network protocols*
- **148** quantitative benthic invertebrates samples were taken with a **Hess** sampler
- **39** quantitative samples of **drift** invertebrates were taken with a drift net, set up in the main current for 30 minutes
- **103 periphyton** chlorophyll samples (from rock scrubs) and **60 seston** chlorophyll samples (from grab samples) were collected

Lab & Data Analysis (on-going)

- Invertebrates are being identified to lowest possible taxonomic unit
- Chlorophyll a concentration in filtered seston and periphyton samples were determined via fluorometry
- Multivariate statistical analysis will be done via non-metric multidimensional scaling

Implications

- Parsing out the relative roles of the **environment** and **dispersal** in structuring macroinvertebrate assemblage composition will inform on the ongoing debate in ecology of the **mechanisms of metacommunity structure**.
- Identifying which **environmental factors** are most closely associated with macroinvertebrate assemblage composition will enable natural resource managers to **prioritize** specific aspects of habitat quality for **conservation**.
- This work is an essential part of **pre-treatment monitoring** of the **T3 project** and the subsequent testing of project-wide hypotheses about the effects of such forest management treatments.

References

Brenkman, S.J., Duda, J.J., Torgersen, C.E., Welty, E., Pess, G.R., Peters, R., & McHenry, M.L. (2011). A riverscape perspective of Pacific salmonids and aquatic habitats prior to large-scale dam removal in the Elwha River, Washington, USA. Fisheries Management and Ecology, 19(1), 36-53.

Brown, B. L., Wahl, C., & Swan, C. M. (2018). Experimentally disentangling the influence of dispersal and habitat filtering on benthic invertebrate community structure. Freshwater Biology, 63(1), 48–61.

* https://www.neonscience.org/data-collection/protocols-standardized-methods

Acknowledgements

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Using LiDAR to Identify Red Alders

in the Sappho Long-Term Ecosystem Productivity Experiment

By Ally Kruper

Project Objectives:

Step 1: Line up LiDAR data with existing field data on tree species locations from LTEP

IN PROGRESS

Step 2: Use LiDAR point returns from above step to create a training dataset

IN PROGRESS

Step 3: Use the training dataset to create a model that can identify red alders

NOT YET

Background: LTEP Experiment

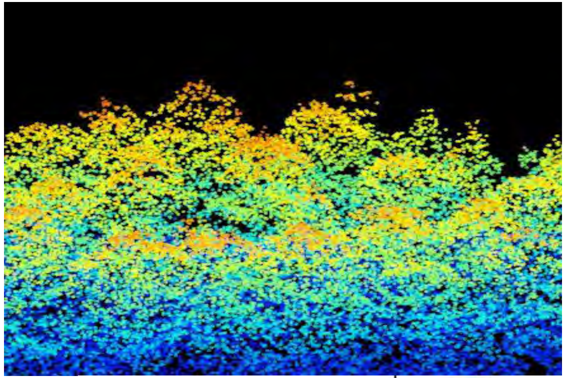
- Long-Term Ecosystem Productivity Experiment
- Located in the OESF near Sappho, WA
- Established 1995

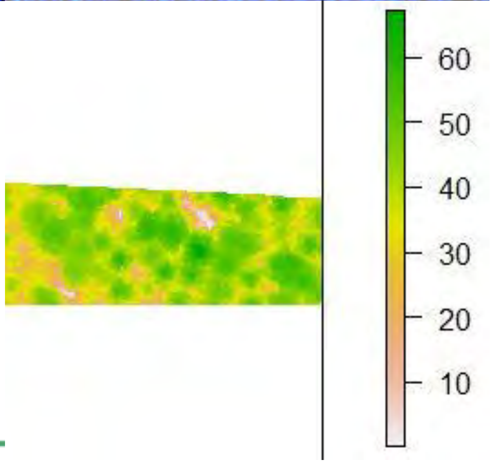
Background: LTEP Experiment

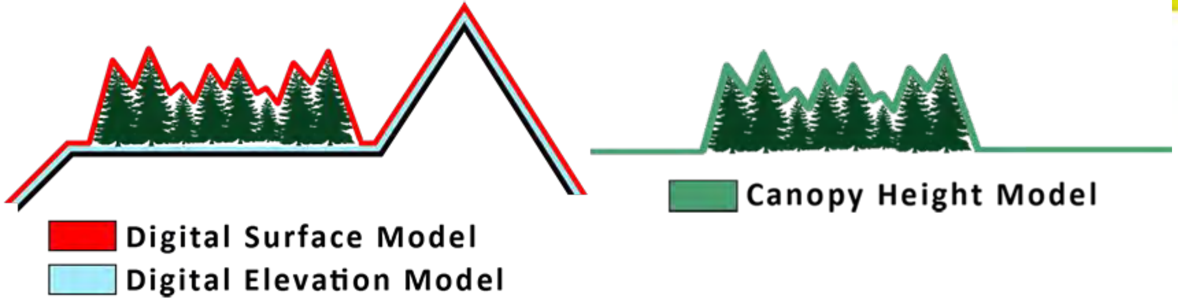
- Goal: study the impact of management practices on long-term ecosystem productivity
  - Mimics different stages of development
  - Manipulated variables:
    - Thinning
    - Trees replanted
    - Downed wood left behind
- Summer, 2020
  - Collected azimuth and distance
    - Created stem maps

Background: LiDAR Data

> Light Detection and Ranging
> 2015 LiDAR
  – From the DNR LiDAR Portal
> Used point clouds to create canopy height models (CHM)

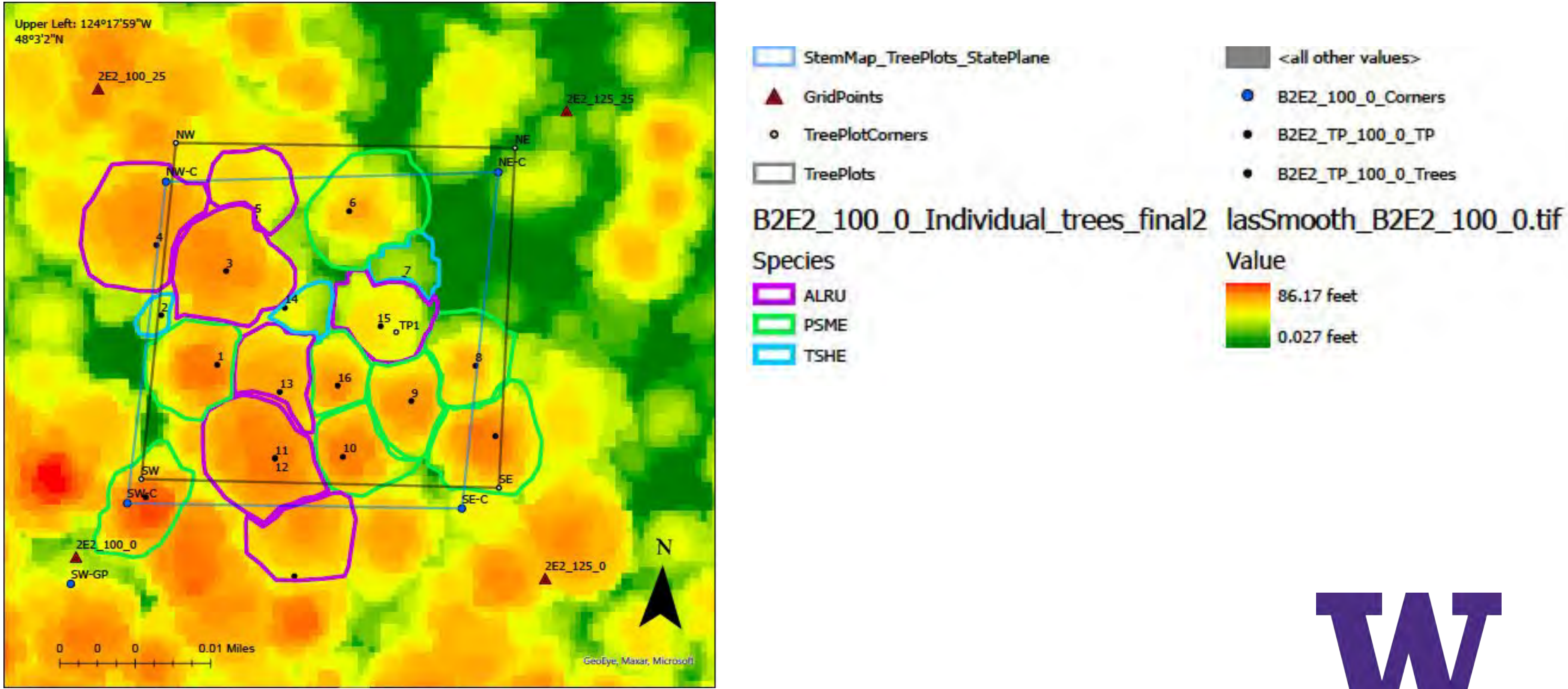






http://gsp.humboldt.edu/OLM/Courses/GSP_216_Online/lesson7-1/applications.html

Methods: Combine Field Stem Maps with LiDAR



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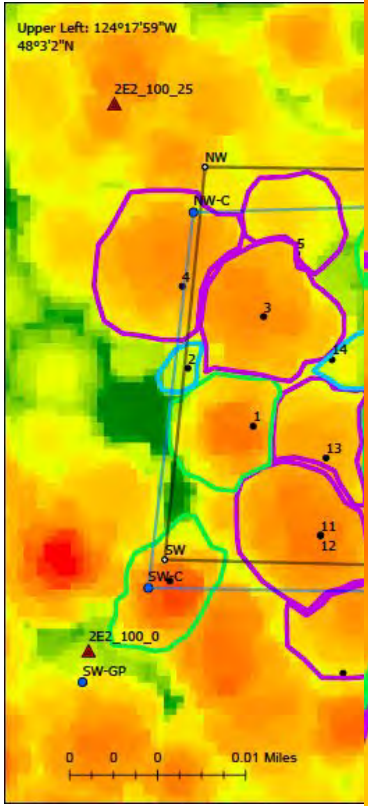

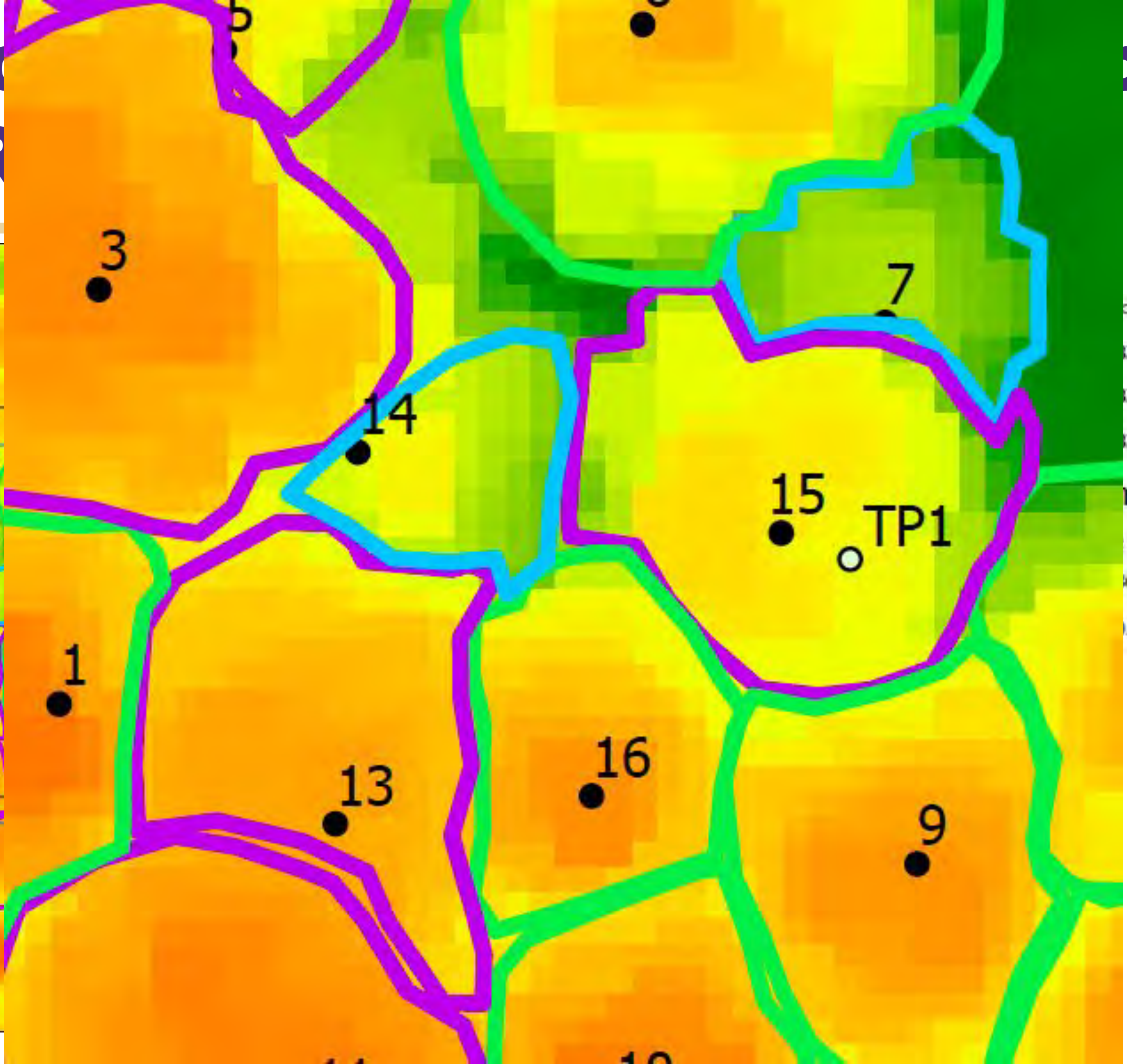

Results

Preliminary results show a significant difference between red alder and other species using several LiDAR metrics

Thank you!!

Keven Bennett, Courtney Bobsin, Bernard Borman, Sarah Crumrine, Robert J. McGaughey

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Ethnoforestry and Adaptive Management: Exploring new pathways to manage Olympic Peninsula forests to enhance ecosystem wellbeing

Courtney Bobsin and Bernard Bormann, Olympic Natural Resources Center

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What is ethnoforestry?

Ethnoforestry is using knowledge and input from local people in the forest management process. Oftentimes, the livelihoods and wellbeing of local communities are tied to public lands management, but they rarely get a direct say in how these lands are managed. Through the process of ethnoforestry, we are working with local people to understand how lands management can better meet their needs.

Ethnoforestry on the Olympic Peninsula

On the Olympic Peninsula, the first two decades following a timber harvest results in a pulse of available nutrients and an increase in sunlight reaching the forest floor. Typical management prescriptions include planting conifer seedlings and eliminating any potential understory competition. A goal of this approach is to accelerate conifer growth and limit the early seral stage. As a contrast, we propose actively managing for understory species that enhance ecosystem wellbeing, examples being promoting beargrass for tribal basket weaving or promoting plants that provide nutritional forage for elk herds, while also actively managing to produce timber on approximately 50-year rotations.

This approach uses a new model to achieve ecosystem wellbeing that highlights the need to give equal weight to both community and environment wellbeing, underscoring that people are inherently part of our ecosystems (Figure 1).

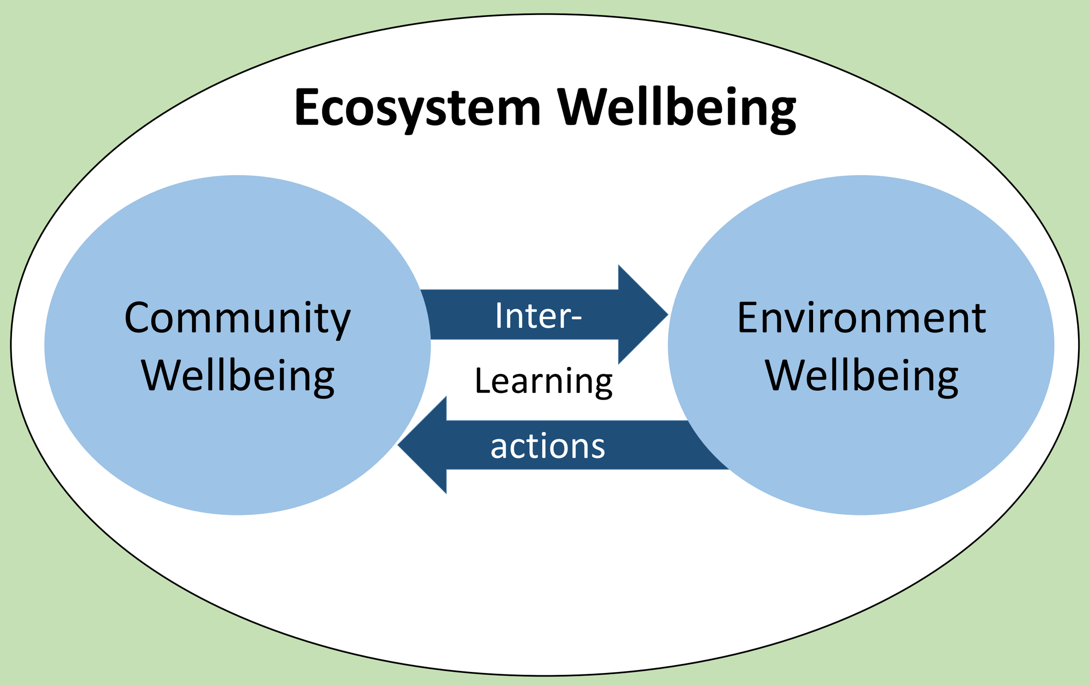

Figure 1: Ecosystem wellbeing model that highlights the importance of and the interaction between community and environment wellbeing.

Field Study

We have established an ethnoforestry field study located on state land managed by Department of Natural Resources (DNR). Using a factorial design, we have created nine unique treatments and 3 blocks (replicates), resulting in 27 experimental units, each 1/10 acre in size, located throughout this 100-acre unit.

Research Questions

Examples of research questions addressed through this study include:

- Does understory growth and regeneration influence survival rates of timber species over time?
- Does herbivory of installed plants influence their survival and to what extent?
- What is the difference in net present value between the ethnoforestry treatments and DNR's usual lands management approach (controls)?

Treatments

This study explores both understory/silviculture and wildlife treatments (Figure 3).

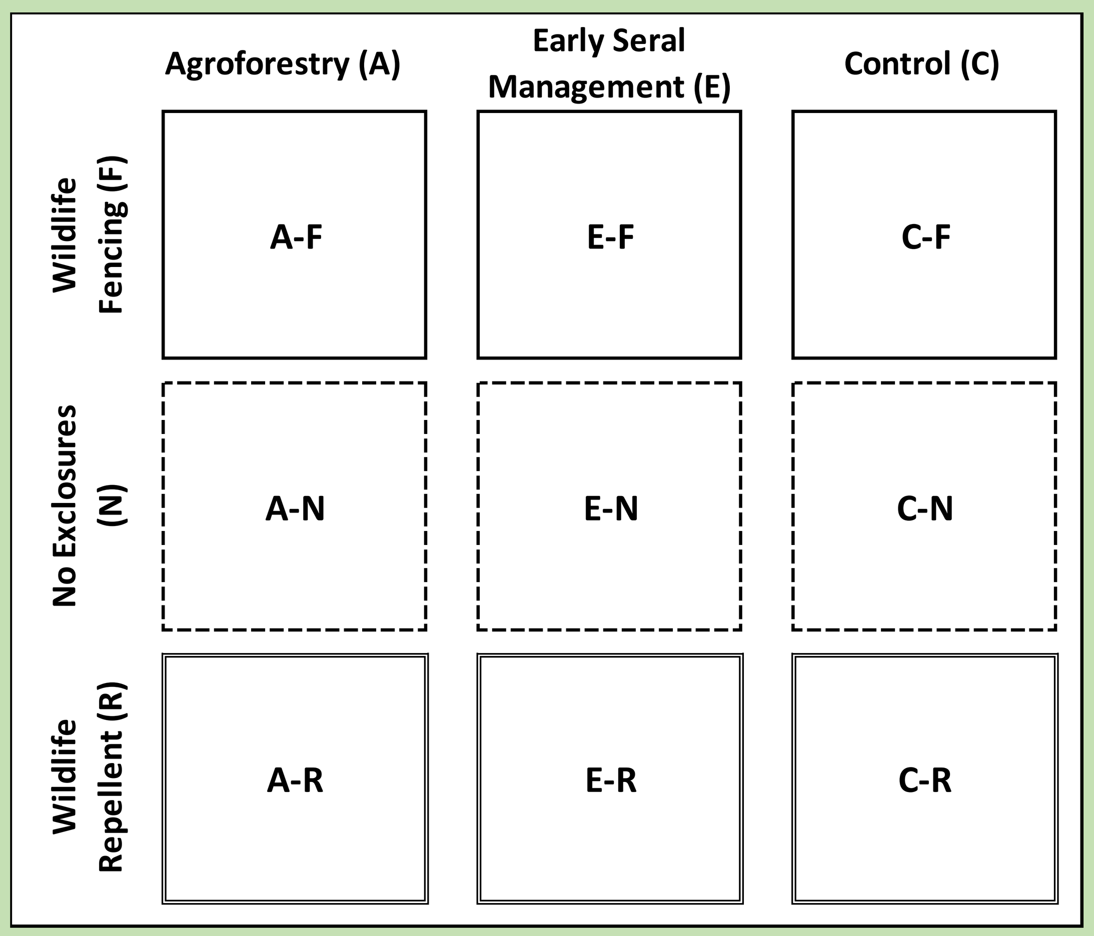

Figure 3: Factorial design of treatments in field study

Treatment Details

Agroforestry: understory plants installed every 1/2m in rows with 1m gaps between rows. Douglas-fir seedlings planted at a density of 180 trees per acre (TPA).

Early Seral Management: understory plants installed every 2m in rows with 1m gaps between rows. Douglas-fir installed at 180 TPA and red alder at 50 TPA.

Control: Replicating typical DNR prescription at 360 TPA of Douglas-fir with no understory plants added.

Planting

Understory species will be planted in the agroforestry and the early seral management treatments, while timber seedlings (Douglas-fir and red alder) will be planted in all treatments but vary in density and species composition.

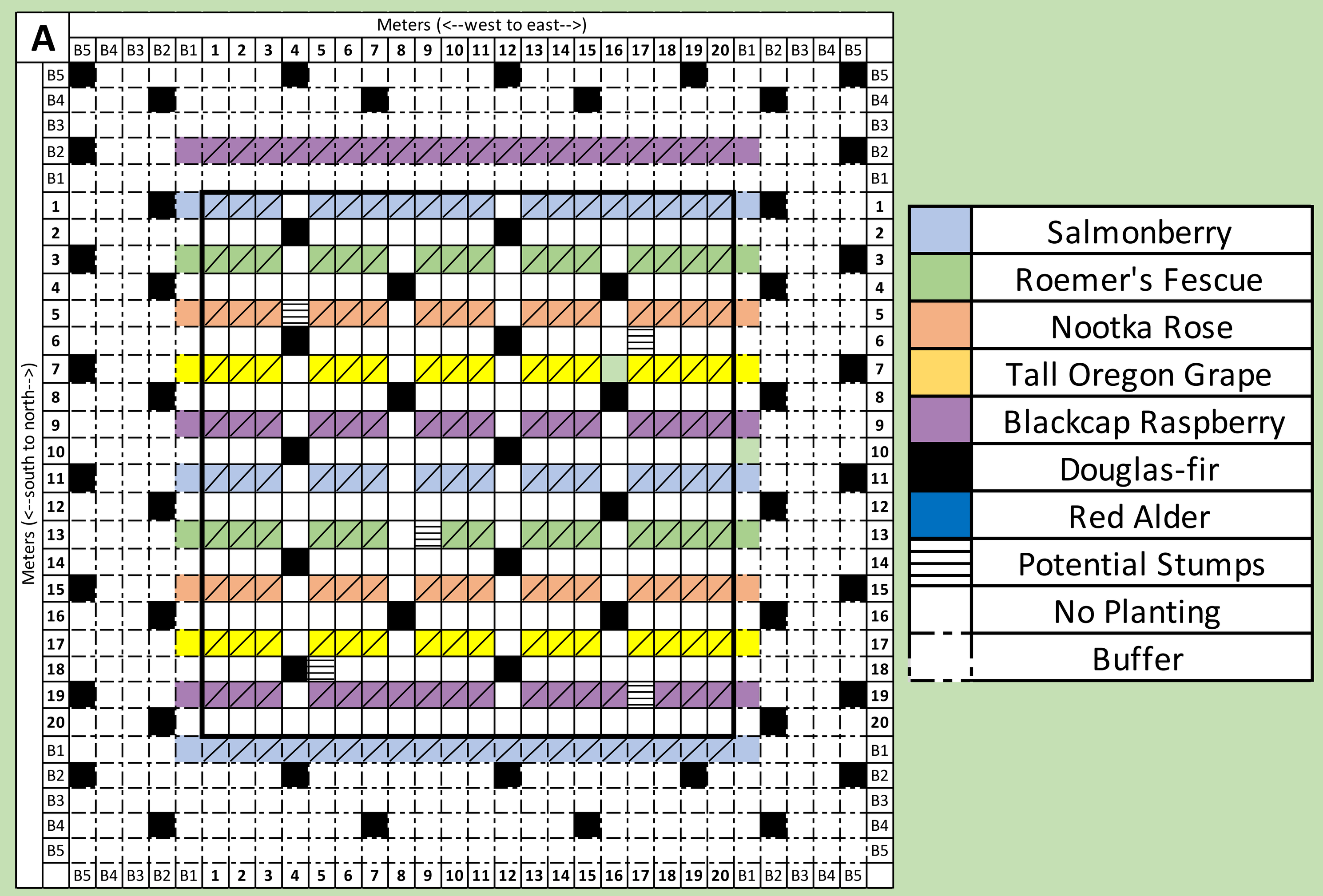

Figure 4: An example of the agroforestry treatment layout with understory plants installed in rows and Douglas-fir seedlings planted in alternating rows

Next Steps

This winter and spring, crews finished installing the 8-ft elk fencing and planted over five thousand plants. Monitoring will begin in Summer 2021, with quarterly measurements taken for the first year.