

# Remote Sensing Forest Inventory Modeling Database

Operational Lidar Inventory 2022  
Andrew Cooke (agcooke@uw.edu)

# About NRSIG

- Started in 2008
- Three research scientists, with backgrounds in forest engineering, forest management, silviculture, modeling, GIS, remote sensing
- Part of Precision Forestry Cooperative

**W NRSIG** Projects Staff Contact

**Healthy, Working Forests**  
We're leveraging investments in big data to determine what it will take to maintain healthy forests and communities in Eastern Washington.

**Open Source Forest Management**  
We're helping the United Nations develop an open source forest ecosystem tool to plan and track forest management alternatives over time.

**20 Years of Forest & Fish**  
We're part of a team helping to understand the impacts of the Forests & Fish law on small forest landowners 20 years after the passage of the Salmon Recovery Act.

**California Bioenergy Project**  
We're helping to generate recoverable energy that could be used to generate...

## Natural Resource Spatial Informatics Group

We are a research group within the *Precision Forestry Cooperative* at the *School of Environmental and Forest Sciences*. We provide technologies and expertise for analyzing forestry and agricultural issues, specializing in large spatial scales and big data. Our goal is to enable landscape, state, and regional scale analyses while simultaneously using the highest resolution data sets available. Our focus is on applied problems that integrate environmental, social, and economic objectives to consider the sustainability, acceptability, and productivity of management opportunities.

**SCHOOL OF ENVIRONMENTAL AND FOREST SCIENCES**  
UNIVERSITY of WASHINGTON  
College of the Environment

**PRECISION PFC Forestry Cooperative**

©2022 University of Washington | Terms | Privacy | Contact Us

<https://nrsig.org>

# About NRSIG

- Resource Assessment
  - Databases
  - Spatial Data
  - Large Areas
  - Remote Sensing (LIDAR, DAP)
  - Online data access through web mapping services, web apps, or APIs
  - Growth Modeling



# Washington Forest Inventory Project

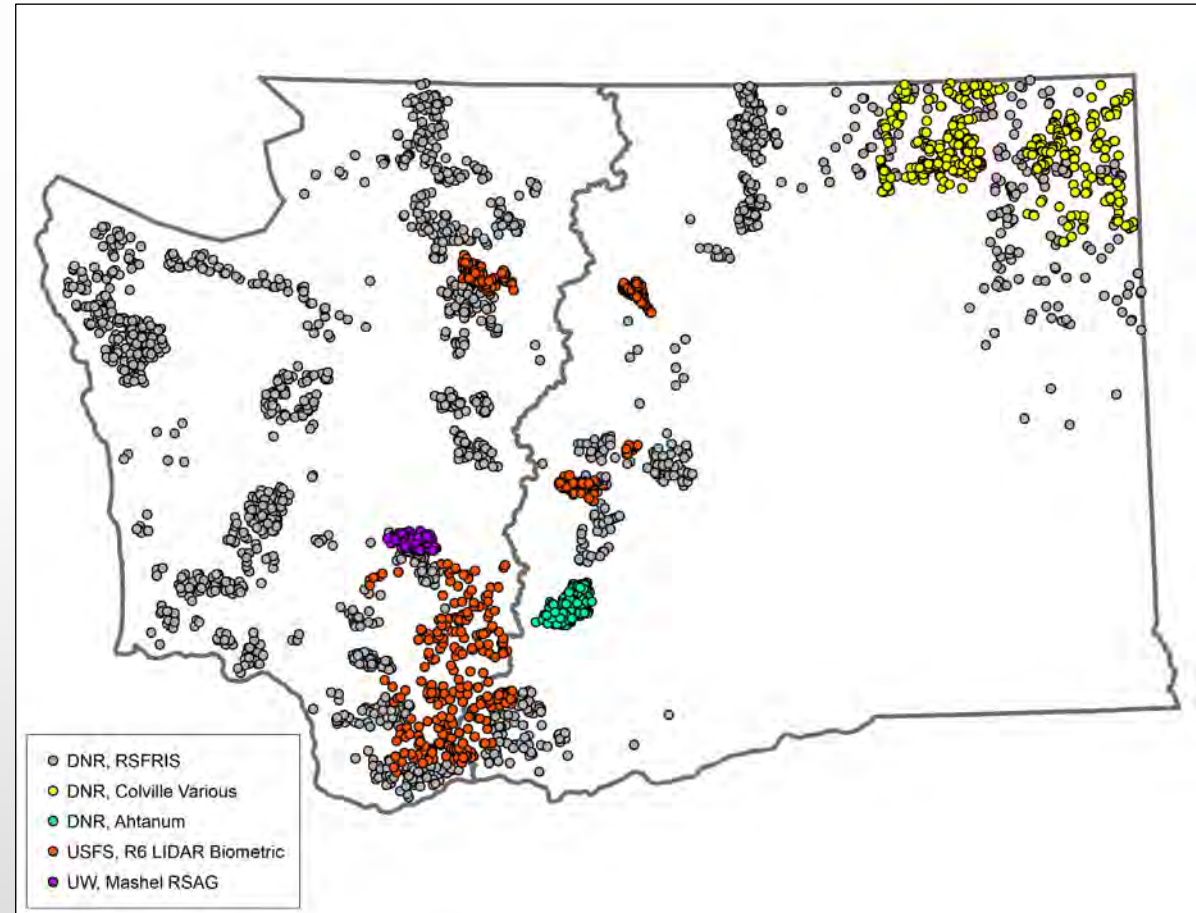
- Produce forest condition spatial datasets
- DNR used these datasets in developing a forest assessment and treatment framework for Eastern Washington
- Using Digital Aerial Photogrammetry (DAP)
- DAP data are collected every two years, making it possible to regularly produce forest condition datasets which can be used to monitor changing forest conditions and to monitor Forest Health Strategic Plan implementation and progress

The screenshot shows the Washington State Department of Natural Resources website. The header includes the state seal and the text "WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES HILARY S. FRANZ | COMMISSIONER OF PUBLIC LANDS". A search bar is located in the top right. The main navigation menu includes "PROGRAMS AND SERVICES", "ABOUT", "MANAGED LANDS", "EMPLOYMENT", and "COVID-19 INFO". The page content is titled "20-Year Forest Health Strategic Plan: Central and Eastern Washington". A sidebar on the left lists various programs and services. The main content area features a map titled "Forest Health Prioritization" showing forest health conditions in Central and Eastern Washington. The map uses a color scale from green (healthy) to red (poor). The sidebar on the right includes contact information for Jennifer Watkins and Will Rubin, as well as a "HEADLINES" section with several news items.

<https://www.dnr.wa.gov/ForestHealthPlan>

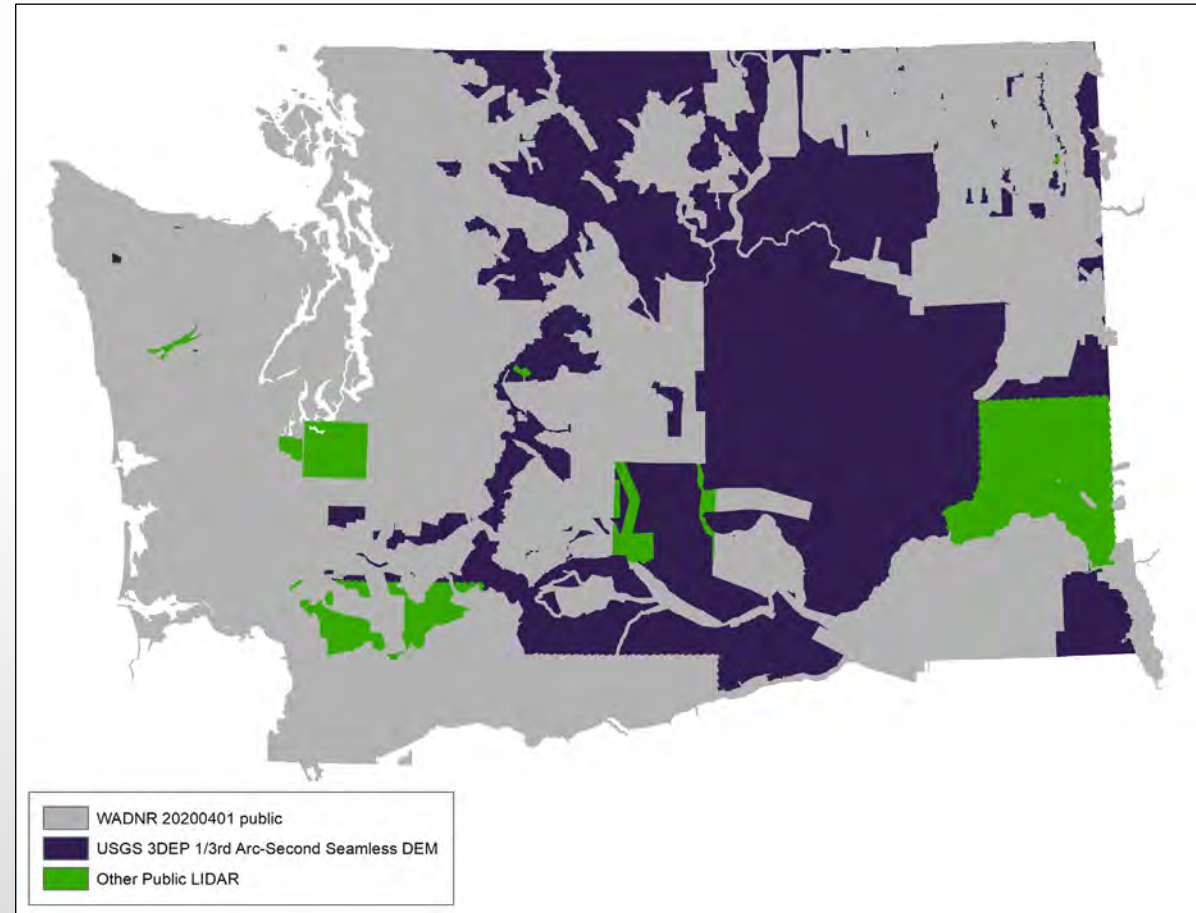
# Washington Forest Inventory Project

- ~2800 plots from DNR, USFS and UW
- 1/10<sup>th</sup> acre to ¼ acre
- DAP cloudmetrics
  - 2017 for all plots
  - 2015 and 2019 for some plots
- Climate, elevation, topographic, soils, location attributes



# Washington Forest Inventory Project

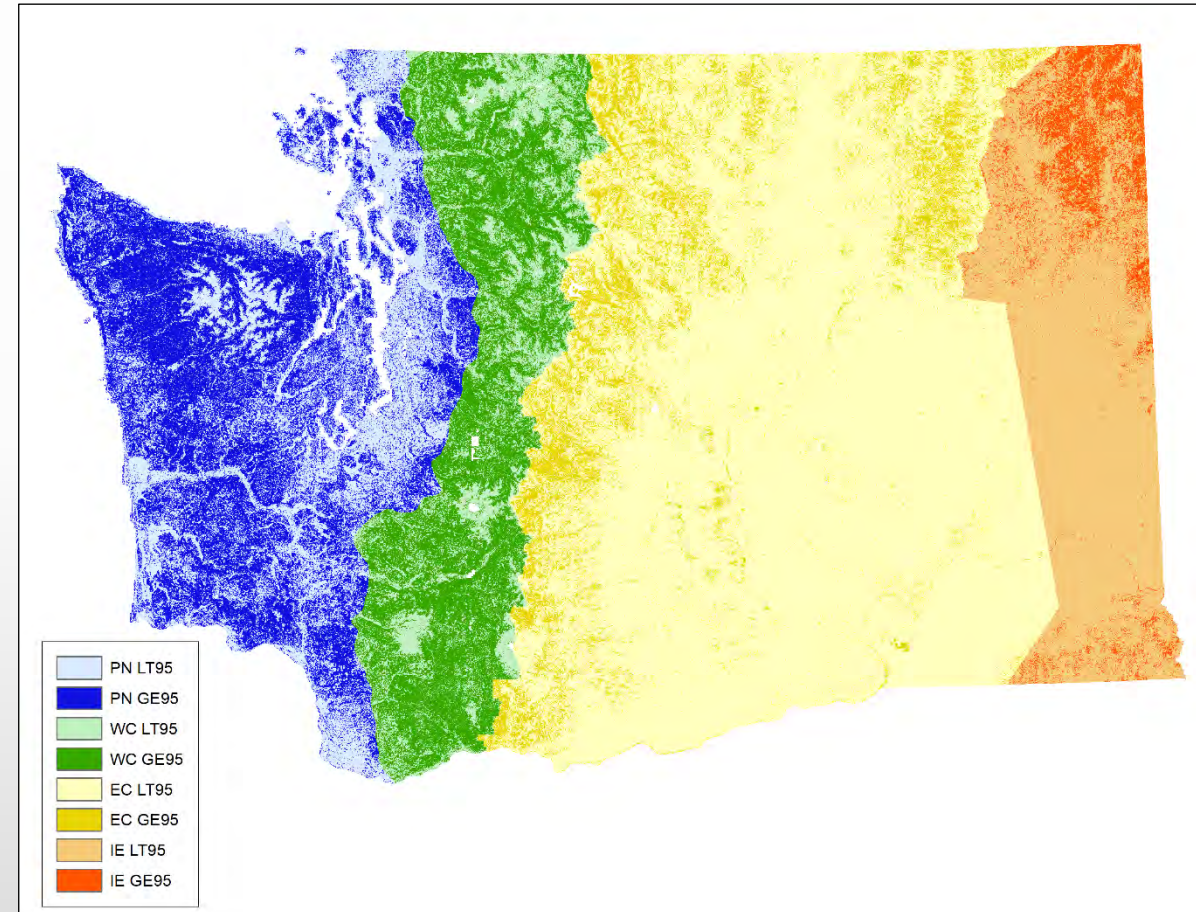
- Developed a statewide ground model from three sources
  - DNR raster
  - Additional public LIDAR
  - USGS 3DEP
- 15ft resolution



# Washington Forest Inventory Project

## Ten response variables

- all live and dead trees greater than 6" DBH
  - Basal area per acre
  - Stand density index
- all live trees greater than 6" DBH
  - Total cubic foot volume - National Volume Equation library
  - Board foot volume - Forest Vegetation Simulator
  - Total above ground biomass - Jenkins National Scale Biomass Estimators
- the largest 25<sup>th</sup> percentile trees over 6" DBH ordered by DBH
  - Lorey's height
- all live and dead trees greater than 6" DBH; the largest 25 percentile trees greater than 6" DBH ordered by DBH
  - Trees per acre
  - Quadratic mean diameter
- Forest Structure Class
  - Modeled QMD and Fusion canopy cover



# Washington Forest Inventory Project

## Model Results

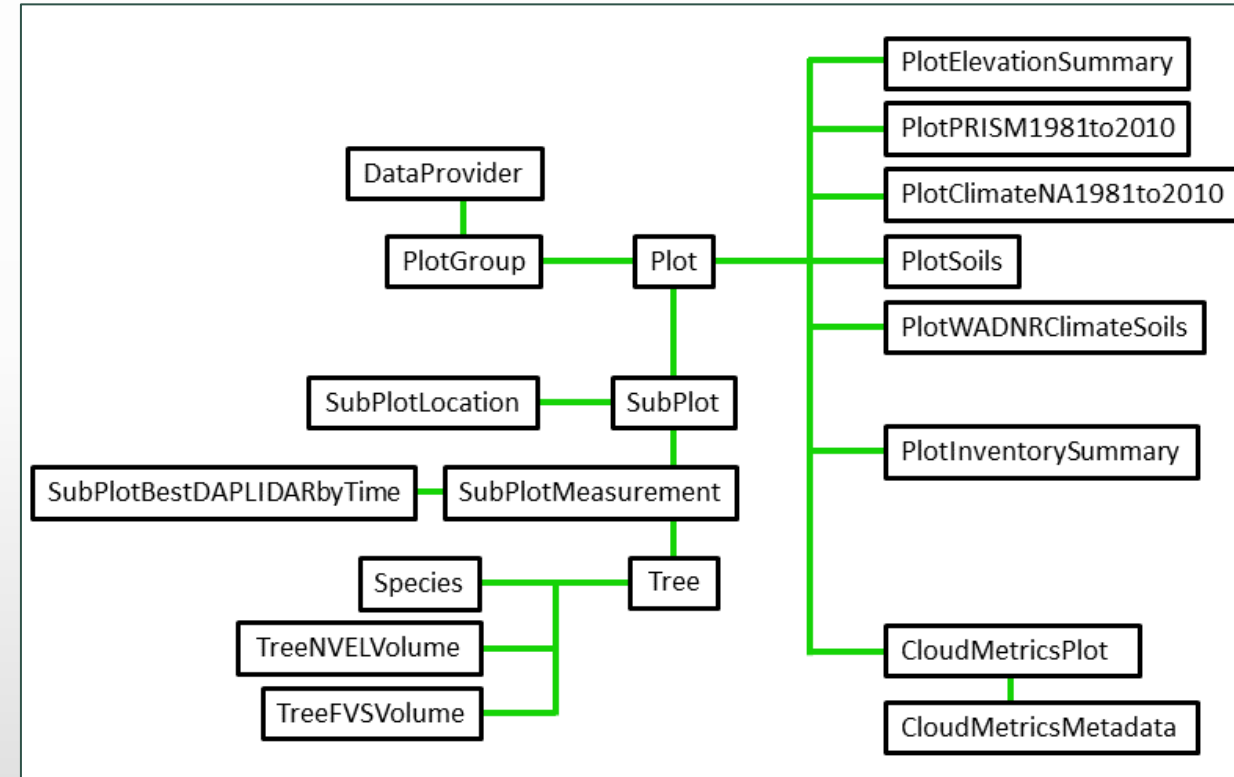
- Results are representative of what we think is possible with DAP and linear regression
- Added many additional variables but didn't see dramatic improvements in accuracy
- Other modeling approaches might be better

Model	Global Pseudo-R <sup>2</sup>	Global RMSE
Lorey's height	0.6514	83.05
QMD	0.5363	4.013
QMD (large trees)	0.6002	5.784
Basal area	0.6514	83.05
SDI	0.6546	115.1
Cubic Foot Volume	0.7319	2972
Board foot Volume	0.7016	18295
Total Aboveground Biomass	0.6875	52.72
Trees per acre	0.4768	84.79
Trees per acre (large trees)	0.4549	22.34



# Plot Database

- Forest Inventory from Remote Sensing
- Relational database on an enterprise database server
- Plots collected to develop remote sensing based forest inventory from LIDAR and DAP
- Plots located with survey-grade GPS systems
- Normalized field inventory from variable plot sizes, fieldwork protocols and specific attributes measured
- calculated DAP and LIDAR metrics
- additional physical and environmental variables for each plot's location



# Plot Database - Benefits

- Data
  - Ability to add new plots (data import tools/pipelines)
  - Re-measurement of existing plots (multiple field inventories for each plot)
  - Multiple DAP/LIDAR metrics per plot
  - Ability to add new attributes
- Security - ability to provide or restrict access to particular sets of plots
- Modeling
  - Selection of particular sets of plots for specific models, based on
    - plot location
    - plot size
    - the organization(s) that collected the data
    - the time differences between field measurement dates and remote sensing data acquisition
  - Selection of particular sets of plot attributes for specific models
  - Ability to model at large or small spatial scales (stands, forests, regions, states)
  - Ability to test varied modeling approaches

# Plot Database - Uses

- **Model Type** – compare machine learning, linear regression, and other model types
- **Change Detection** - spatial resolution and time differences required to detect changes in forest condition (growth and disturbance)
- **DAP vs LIDAR metrics** – changes in model accuracies
- **Time Lag** – the effects of time differences between field measurement and remote sensing data acquisition
- **Plot Size** – the effects on inventory estimates
- **Ground Model Resolution** – the effects on inventory estimates
- **Forest Type** – the effects on model accuracy and transferability

# Plot Database - Access

Modeling infrastructure on our server (use plots without knowing where they are)

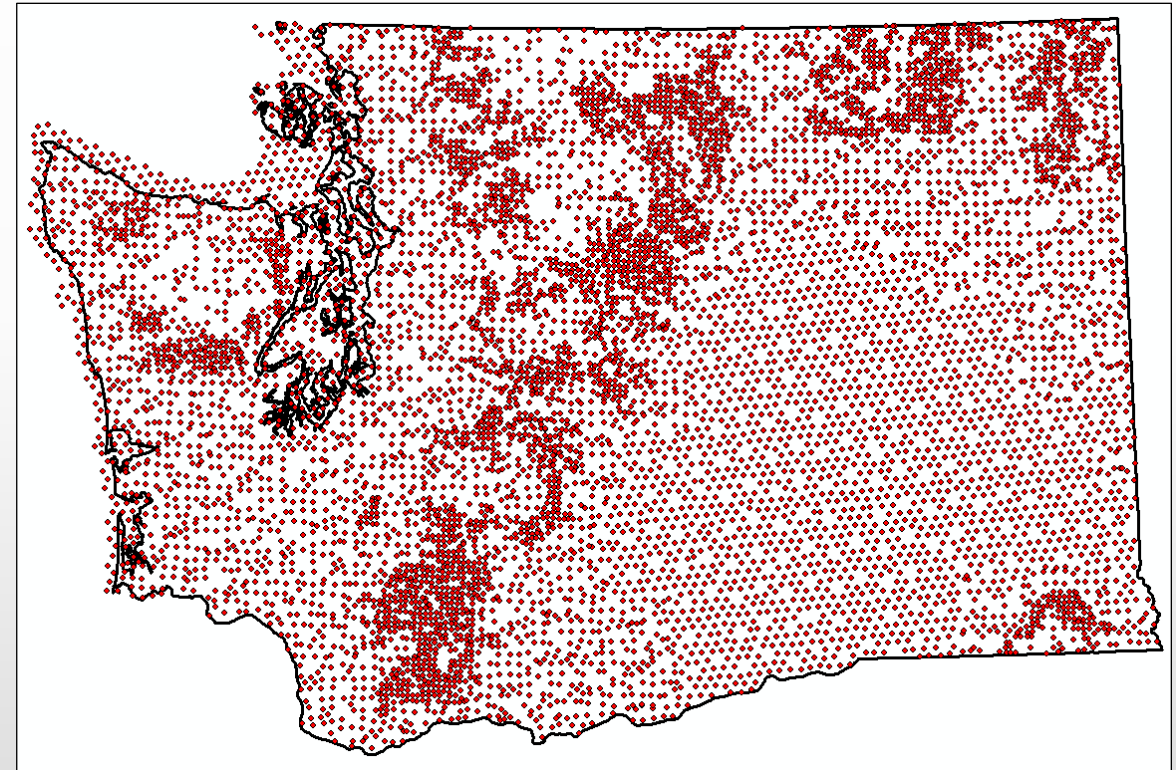
R-package – access data through an API (issues with FIA plots)

Microsoft Azure Machine Learning connected to our server

# Plot Database – Next Steps

## Added FIA Plots in Washington

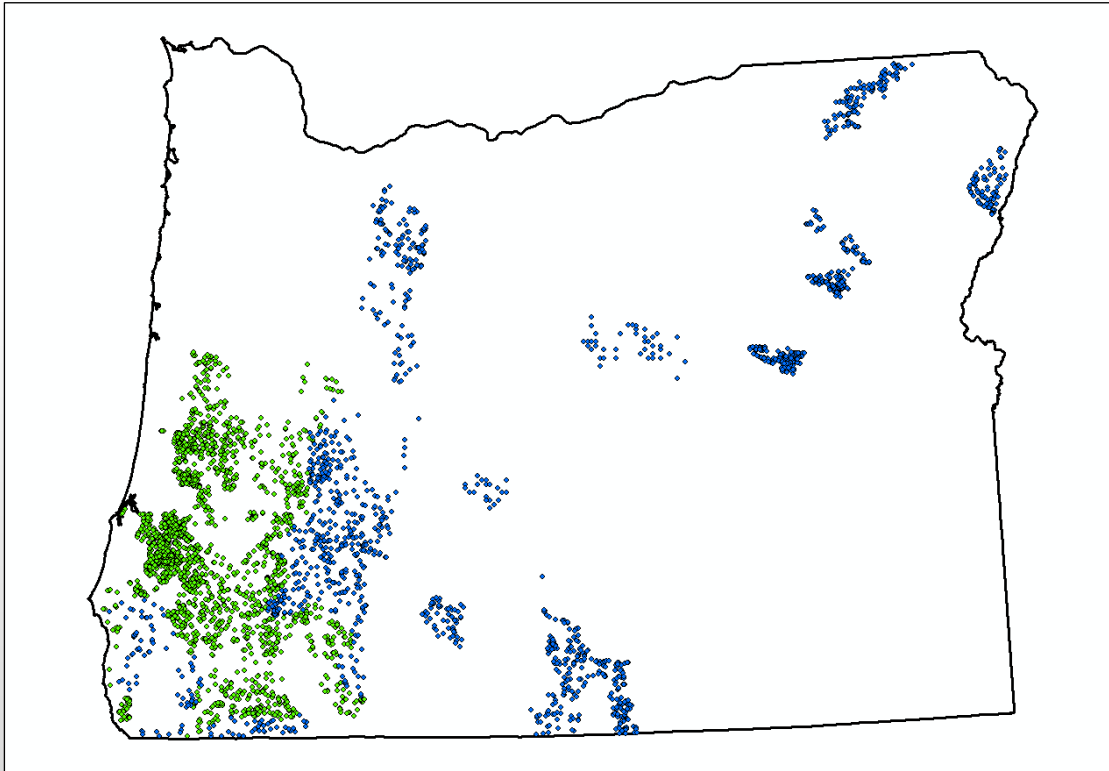
- Two sets
  - FIA plot
  - FIA subplots as individual plots
- Full database attributes
- DAP 2013 – 2020
- The fuzzed locations are in the database, but the true locations were used to process attributes



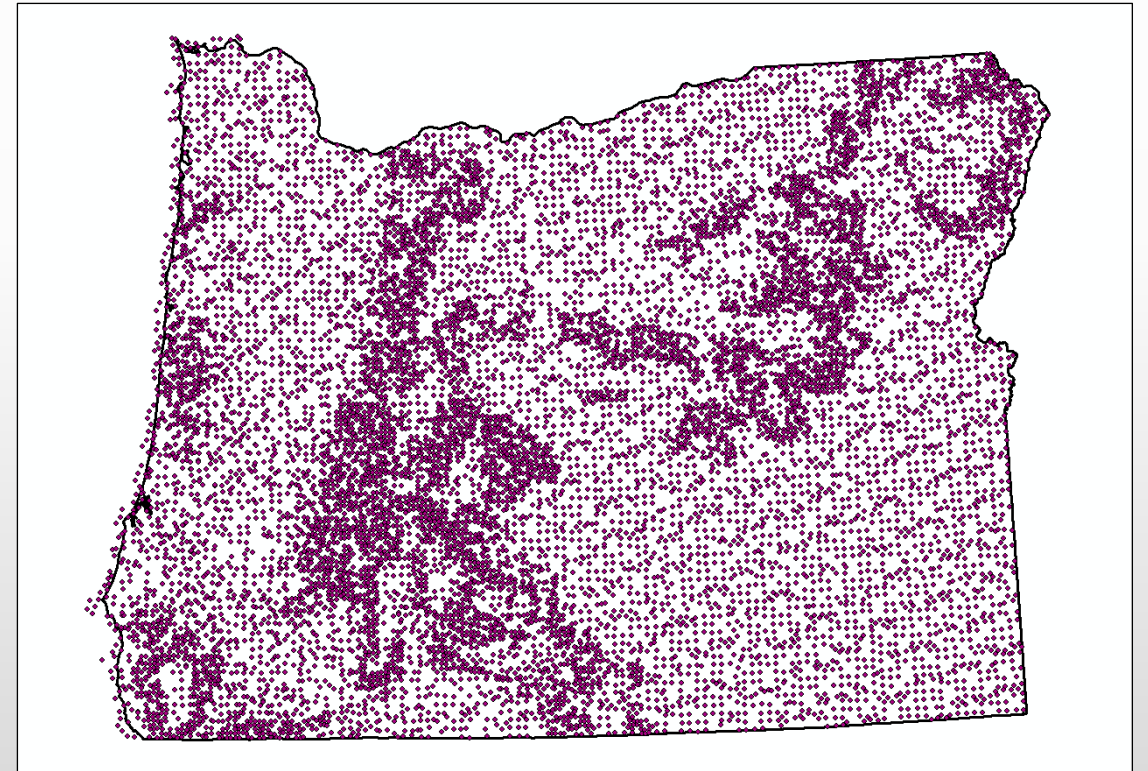
WA FIA (~8600)

# Plot Database – Next Steps

Add additional plots in Oregon



OR BLM (green ~2200), USFS R6 lidar plots (blue ~1700)



OR FIA, last 10 years (~12,400)

# Plot Database – Next Steps

- Make this database publically available online
  - Easy to use
  - Hopefully reduce redundancy
  - Share and test models made by other users
- RRF funding
- Support
  - Technical review (database design, use cases)
  - Partners with plot data they would like to include

# Thank You

## Questions?

Andrew Cooke ([agcooke@uw.edu](mailto:agcooke@uw.edu))