Continuing Project / Final Report

Incorporating bark beetle outbreak hazard into pine density management thresholds

Project Code CAFS 23.101

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Justification

Bark beetle Impacts:

Economic

- Timber losses affecting private landowners, government agencies
- Blue stain wood degrades wood quality
- Decline in property values
- Rural and First Nations communities disproportionately affected

Abiotic

- Carbon sequestration
- Nutrient cycling
- Land surface temperature
- Soil microbial dynamics and decomposition
- Forest pathogen interactions
- Air quality and aerosol formation
- Hydrology
- Fire and fuels

Biotic

- Introduction of fungal partners
- Changes in forest structure and composition
- Distribution and abundance of wildlife species
- Loss of habitat

Justification

Limitations of existing models and guides:

- Inaccessible variables (difficult or costly to obtain)
- Do not incorporate current or projected climatic data/data derived from multidecadal wet periods (1960's to 1990's)
- Fail to consider fine-scale changes to site/stand variables
- Regionally restrictive
- Sometimes contradict with one another

Hypotheses or Objectives

- To build a machine learning model that modifies existing maximum stand density index equations to include variables indicating hazard of pine beetle outbreaks in the northwestern United States under current and projected climate scenarios.

- Builds on SDImax work by Heiderman and Kimsey (2021, 2023)

Methods

Beetle Data- Sourced from USDA Forest Service Insect and Disease aerial surveys

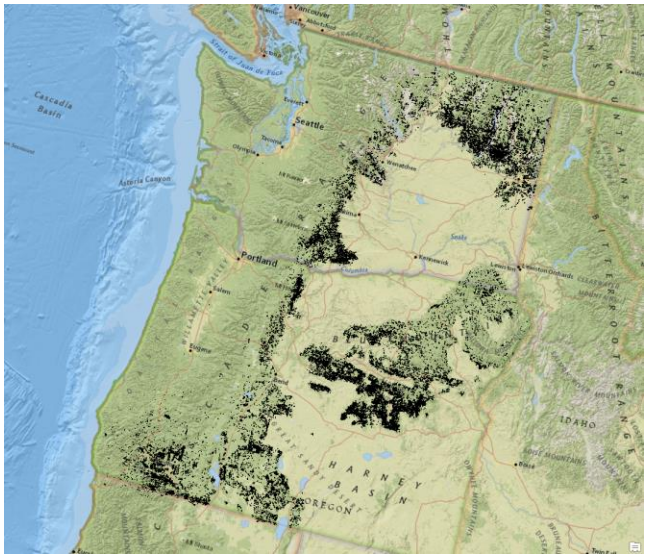
- Focuses on Pacific Northwest Region(R6) and Rocky Mountain Region (R1)

- Spatial data collected annually for outbreaks from 1997 to 2023

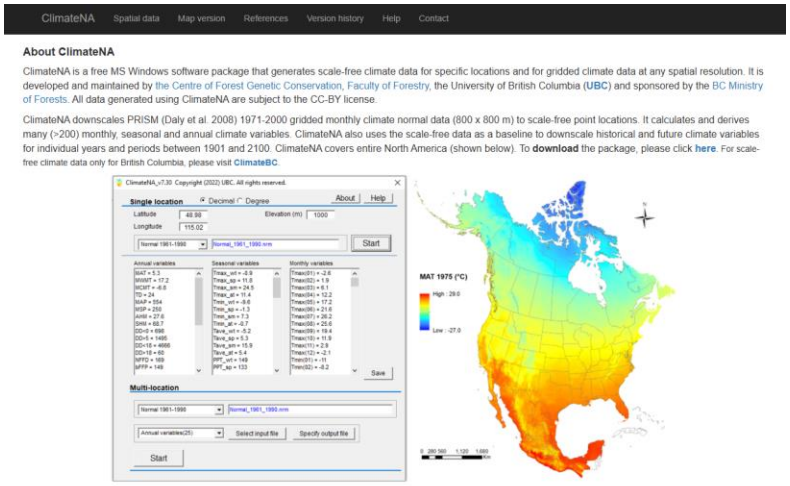
Attributes include:
- outbreak size
- survey year (outbreak year)
- severity TPA mortality/% BA mortality)
- Presence/absence of other insect/disease agents

Stand data- includes USDA Forest Service Forest Inventory and Analysis (FIA), Bureau of Land Management (BLM), and various private industry lands.

- SDI (Stand Density Index)
- SDImax
- Stand basal area (BA)
- Proportion of BA in host species



Methods



Climate data- Sourced from ClimateNA

- Precipitation and temperature normals (10-, 20-, and 30- year)
- Deviations from normals at various time scales (1, 5, and 5 years pre-outbreak)
- Standardized Precipitation Index (SPI) (Guttman 1999, McKee et al. 1993)
- Multidecadal Repeat-Dryness Exposure Index (MRDEI) (Egan et al. 2024)

Physiographic Data- multiple sources

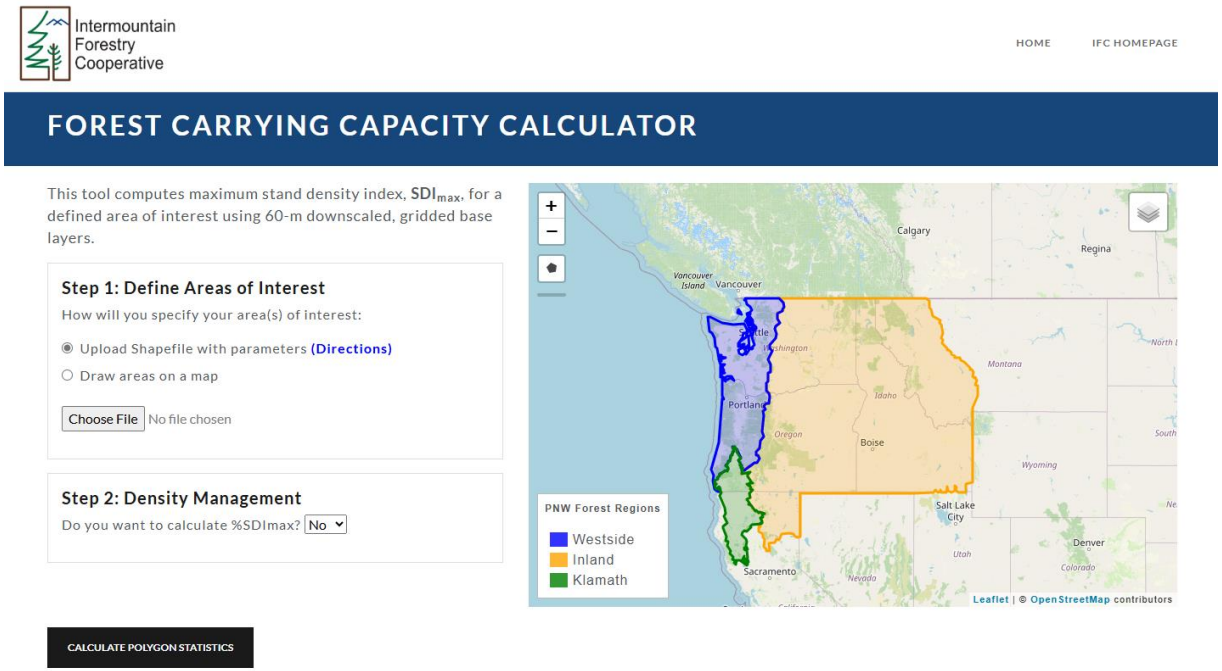
- Available water storage (in top 100 cm of soil)
- Depth to restrictive layer- depth at which soil properties limit root penetration
- Elevation and aspect
- Topographic Wetness Index- Terrian-driven variations in soil moisture
- Heatload- degree days between 10 and 40 degrees Celsius
- Solar Radiation- thermal load on soil surface

Progress 2024-25

As of June 2025:

- Chapter 1 complete (summary of existing research)
- Small grant secured for additional summer of research
- Stand, beetle and physiographic data collected

Deliverables



Web app

- Building upon SDImax model
- Site specific SDI thresholds for reducing likelihood of epidemic bark beetle outbreaks
- Not built for endemic (low severity) outbreaks

Company Benefits

- Potential time and cost savings by reducing large-scale mortality from pine beetle epidemics
    - Examples: time savings from new technique, cost savings from discovery of new protocol
- More resilient forest stands
- Density threshold modifiers for existing SDImax models that incorporate pine beetle epidemic risk factors.

Dave Powell, USDA Forest Service (retired), Bugwood.org

Future Plans

Anticipated Completion: **August 2026**

July-August 2025: Data collection, data processing

September - December 2025: Modeling current climate scenarios

January – February 2026: Modeling of future climate scenarios

March – April 2026: Completion of chapters 2-4 based on modeling results

May - August 2026: Incorporating beetle data into existing SDImax web interface

William M. Ciesla, Forest Health Management International, Bugwood.org

Summary

- Impacts of abiotic, biotic, and economic bark beetle epidemics are far reaching and impactful
- A need exists for a consistent, fine scale, multi-region bark beetle epidemic outbreak SDI model sensitive to stand, site and climatic (multidecadal dry cycle) variables
- We will build a machine learning model that modifies existing maximum stand density index equations to include variables indicating hazard of pine beetle outbreaks in the northwestern United States under current and projected climate scenarios
- Model will use aerial survey data, ClimateNA data, stand data from multiple federal and private sources, and physiographic data from multiple sources
- Model will build on SDImax work by Heiderman and Kimsey (2021, 2023)