

# 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 SDI<sub>max</sub> work by Heiderman and Kimsey (2021, 2023)



# Methods

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

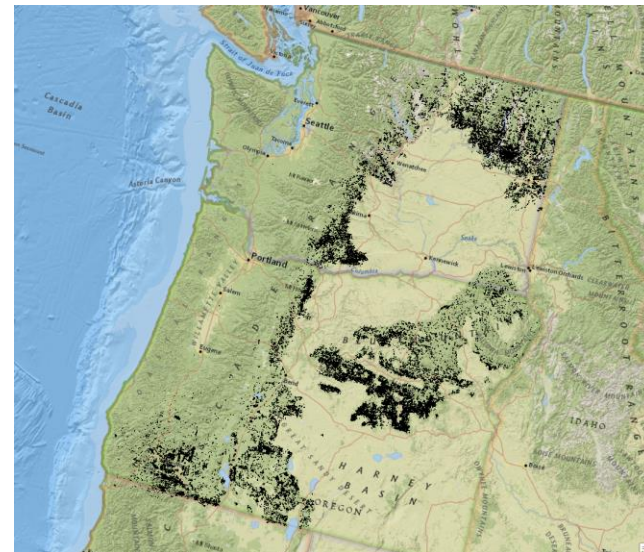
- Focuses on Pacific Northwest Region(R6) and Rocky Mountain Region (R1)
- Spatial data collected annually for outbreaks from 1997 to 2023

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)
- SDI<sub>max</sub>
- Stand basal area (BA)
- Proportion of BA in host species

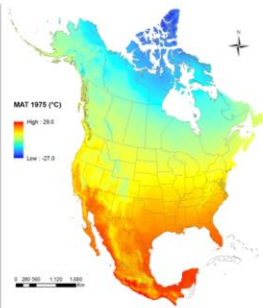
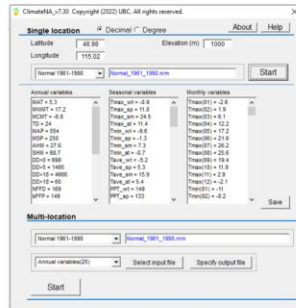




### About ClimateNA

ClimateNA is a free MS Windows software package that generates scale-free climate data for specific locations and for gridded climate data at any spatial resolution. It is developed and maintained by the [Centre of Forest Genetic Conservation](#), Faculty of Forestry, the University of British Columbia (UBC) and sponsored by the BC Ministry of Forests. All data generated using ClimateNA are subject to the CC-BY license.

ClimateNA downscales PRISM (Daly et al. 2008) 1971-2000 gridded monthly climate normal data (800 x 800 m) to scale-free point locations. It calculates and derives many (>200) monthly, seasonal and annual climate variables. ClimateNA also uses the scale-free data as a baseline to downscale historical and future climate variables for individual years and periods between 1901 and 2100. ClimateNA covers entire North America (shown below). To [download](#) the package, please click [here](#). For scale-free climate data only for British Columbia, please visit [ClimateBC](#).



# Methods

## 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

## 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)



# 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



## FOREST CARRYING CAPACITY CALCULATOR

This tool computes maximum stand density index,  $SDI_{max}$ , for a defined area of interest using 60-m downscaled, gridded base layers.

### Step 1: Define Areas of Interest

How will you specify your area(s) of interest:

☒ Upload Shapefile with parameters ([Directions](#))

☐ Draw areas on a map

No file chosen

### Step 2: Density Management

Do you want to calculate % $SDI_{max}$ ?



## Web app

- Building upon  $SDI_{max}$  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 SDI<sub>max</sub> work by Heiderman and Kimsey (2021, 2023)

