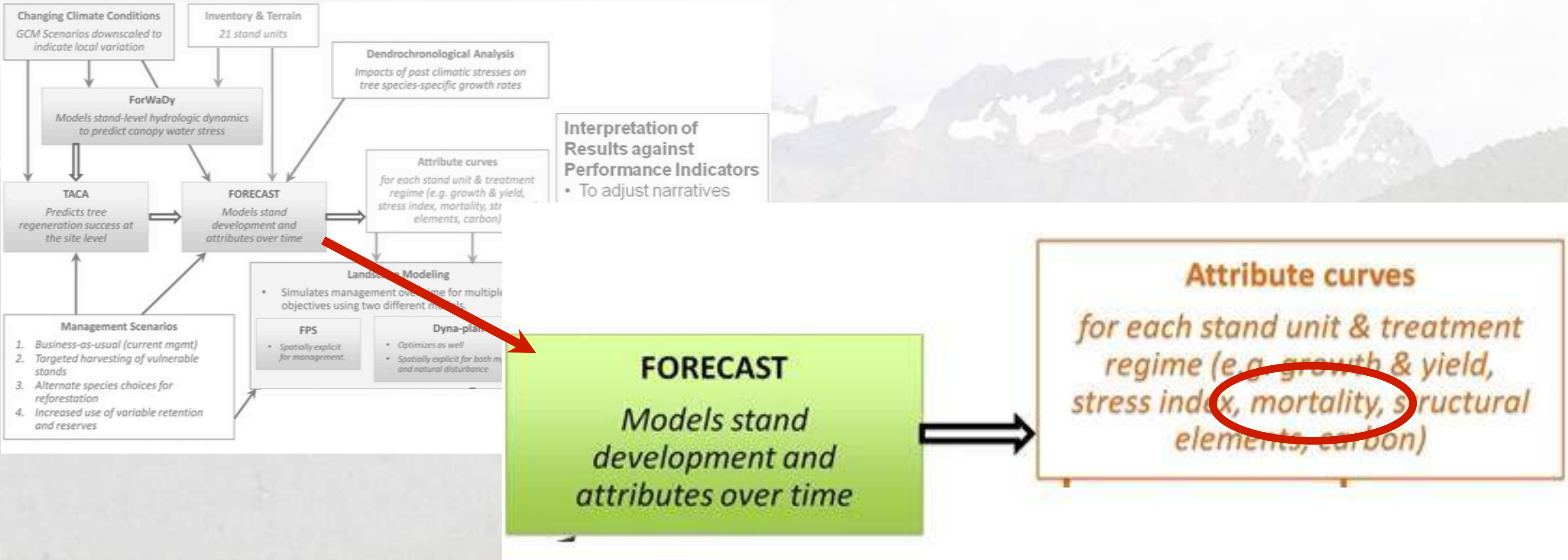
Overview of completed work:

# Modeling Suite and Mortality Considerations



Overview of completed work:

# Mortality from Insects and Disease

## Can't be ignored:

- More stress on trees – likely will get more impact from root disease and/or bark beetles.
- Climate variability over several years – influences budworm cycles
- Climatic extremes – may short circuit insect development

## Mortality from Insects and Disease:

# Explored CFS and MoF incidence data (75-2010)

- For:
  - Root disease in transition
  - Fd, Sx and Bl bark beetle.
  - Spruce and 2-yr cycle budworm.
  - Tussock moth in IDFxh.
- Also Considered:
  - Anecdotal observations
  - Biology and phenology of the insects and disease

E.g. Spruce Budworm

| Outbreak year | Attack code | Area | Attack code x area | Attack code | Area | Attack code x area | Attack code | Area | Attack code x area | Composite | % of area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 0.1 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0 | 0% |
| 1976 | 0.1 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .8 | 856.8 | 1% |
| 1977 | 0.1 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0 | 0% |
| 1978 | 0.1 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0 | 0% |
| 1979 | 0.1 | 448 | 44.8 | 0.2 | 142 | 28.4 | 0.3 | 1203 | 360.9 | 434.1 | 1% |
| 1980 | 0.1 | 3969 | 396.9 | 0.2 | 0 | 0 | 0.3 | 3320 | 996 | 1392.9 | 2% |
| 1981 | 0.1 | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 1982 | 0.1 | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 1983 | 0.1 | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 1984 | 0.1 | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 1985 | 0.1 | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 1986 | 0.1 | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 1987 | [illegible] | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 1988 | [illegible] | 9712 | 971.2 | 0.2 | 759 | 151.8 | 0.3 | 0 | 0 | 1123 | 2% |
| 1989 | [illegible] | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 1990 | [illegible] | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 199 | 0.1 | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 1992 | 0.1 | 17005 | 1700.5 | 0.2 | 16061 | 3212.2 | 0.3 | 0 | 0 | 4912.7 | 7% |
| 1993 | 0.1 | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 1994 | 0.1 | 3402 | 340.2 | 0.2 | 706 | 141.2 | 0.3 | 0 | 0 | 481.4 | 1% |
| 1995 | [illegible] | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 1996 | [illegible] | 0 | 0 | 0.2 | | 0 | 0.3 | | 0 | 0 | 0% |
| 1997 | [illegible] | 1951 | 195.1 | 0.2 | 2069 | 413.8 | 0.3 | 693 | 207.9 | 816.8 | 1% |
| 1998 | 0.1 | 17607 | 1760.7 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 1760.7 | 2% |
| 199 | 0.1 | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 2000 | 0.1 | 29874 | 2987.4 | 0.2 | 1826 | 365.2 | 0.3 | 0 | 0 | 3352.6 | 5% |
| 2001 | 0.1 | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 2002 | 0.1 | 16636 | 1663.6 | 0.2 | 272 | 54.4 | 0.3 | 0 | 0 | 1718 | 2% |
| 2003 | [illegible] | 1452 | 145.2 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 145.2 | 0% |
| 2004 | [illegible] | 13392 | 1339.2 | 0.2 | 788 | 157.6 | 0.3 | 0 | 0 | 1496.8 | 2% |
| 2005 | [illegible] | 0 | 0 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0% |
| 2006 | [illegible] | 6369 | 636.9 | 0.2 | 151 | 30.2 | 0.3 | 0 | 0 | 667.1 | 1% |
| 200 | 0.1 | 2164 | 216.4 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 216.4 | 0% |
| 2008 | 0.1 | 38356 | 3835.6 | 0.2 | 130 | 26 | 0.3 | 0 | 0 | 3861.6 | 5% |
| 2009 | 0.1 | 276 | 27.6 | 0.2 | 0 | 0 | 0.3 | 0 | 0 | 27.6 | 0% |
| 2010 | 0.1 | 6235 | 623.5 | 0.2 | 9 | 1.8 | 0.3 | 0 | 0 | 625.3 | 1% |

92

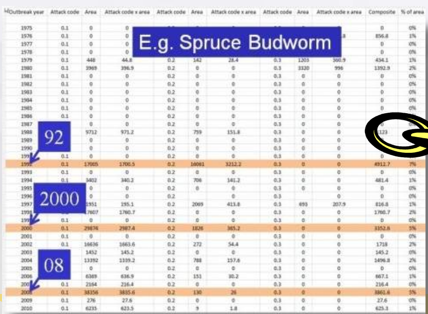
2000

08

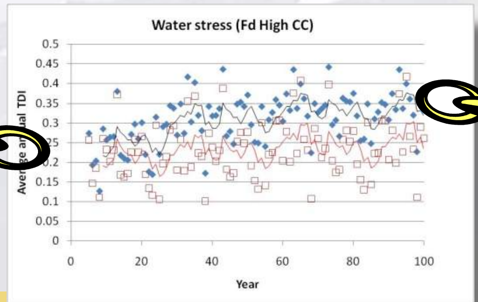
## Mortality from Insects and Disease:

# Determining Plausible Mortality Impacts

**Past Impact Data**




**Past Climate Data and Tree Stresses**




Literature

*Landscape Ecology* **14**: 105–120, 1999.



**Plant-pest interactions in time and space: A Douglas-fir bark beetle outbreak as a case study**

Jennifer Sarah Powers[1,*], Phillip Sollins[1], Mark E. Harmon[1] and Julia A. Jones[2]
[1]*Department of Forest Science, Oregon State University, 020 Forestry Sciences Laboratory, Corv... Oregon 97331–7501, USA;* [2]*Department of Geosciences, Oregon State University, Corvallis, Oregon 9733... 06, USA; (Corresponding author. Present address: Nicholas School of the Environment, Duke University, PO... 90328, Durham, NC 27708-0328, E-mail: powers@pinus.env.duke.edu.)*

...ceived 20 June 1997; Revised 20 January 1998; Accepted 24 January 1998

*Key ...ds:* bark beetle epidemic, Douglas-fir, hierarchy theory, multiple spatial and temporal scales

**Abstract**

A conceptual model of Douglas-fir bark beetle (*Dendroctonus pseudotsugae*) dynamics and associated host tree mortality across multiple spatial and temporal scales was developed, then used to guide a study of the association between the occurrence of beetle-killed trees and factors that might render trees more susceptible to attack. Long-term records of beetle kill showed that beetle epidemics were associated with windstorms and drought at statewide and local spatial scales. At the landscape scale, beetle kill was associated with (i) portions of the landscape that were potentially drier (southern aspects, lower elevations) and (ii) portions of the landscape that had more mature and old-growth conifer vegetation. The patches of beetle-killed trees were aggregated with respect to other patches at scales of approximately 1 and 4 km. At the scale of the individual tree, there was not a strong relationship between beetle kill and resistance to attack measured by tree growth rate prior to attack. Our results show that landscape-scale phenomena and temporal patterns were more strongly correlated with beetle-kill events than was recent growth history at the scale of individual trees. We suggest that the multi-scale approach we employed is useful for elucidating the relative roles of fine- versus coarse-scale constraints on ecological processes.

**Introduction**

From 1992–1993 the forests of the Western Cascades in Oregon experienced the largest Douglas-fir bark beetle (*Dendroctonus pseudotsugae*) epidemic in over 35 years. Efforts to mitigate economic losses due to the beetle have often overlooked potential coarse-scale constraints on beetle population dynamics and failed to consider patterns of bark-beetle induced tree mortality within the larger context of landscape and ecosystem processes and tree decline concepts (Castello et al. 1995). The magnitude and frequency of bark-beetle outbreaks reflect the population dynamics of the insects as well as the susceptibility of the host plants to attack. Specifically, beetle population density and associated tree mortality at a given point in time reflect the previous beetle generation's numbers and the availability of suitable breeding habitat (i.e., weakened trees). We propose that tree resistance to attack is influenced by a spectrum of environmental variables operating across a range of spatial and temporal scales. Thus we expect that both fine-scale and coarse-scale environmental phenomena influence beetle dynamics via differential effects on host resistance. The hypothesized role of environmental variables in predisposing trees to attack is similar to Manion's concept of the decline disease spiral, where a temporal sequence of abiotic and biotic stresses precede the death of individual trees (1981). Mueller-Dombois (1986) extends this concept to forest stands by hypothesizing that a sequence of climatic events such as droughts followed by rain storms cause the dieback of *Metrosideros polymorpha* stands in Hawaii and that the spatial patterns of mortality are influenced differentially by soil substrate and forest life stage. Our work draws upon both of these models by relating spatial and temporal

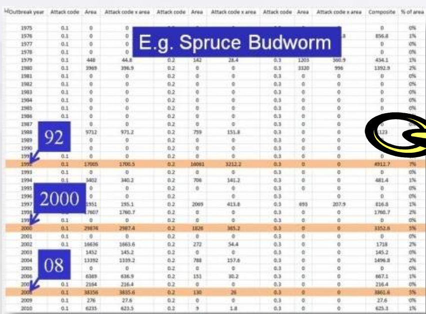
Expert Opinion

1. How does past impact line up with climatic and/or tree stress trends?

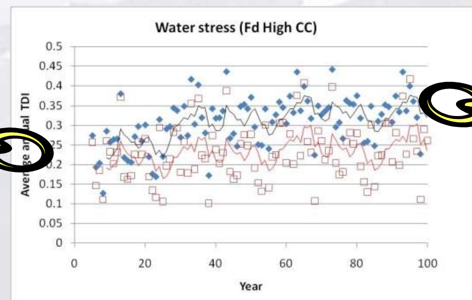
Mortality from Insects and Disease:

# Determining Plausible Mortality Impacts

Past Impact Data




Past Climate Data and Tree Stresses




**Literature**

Landscape Ecology 14: 105–120, 1999.
© 1999 Kluwer Academic Publishers. Printed in the Netherlands. 105

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[1]*Department of Forest Science, Oregon State University, 020 Forestry Sciences Laboratory, Corval Oregon 97331–7501, USA;* [2]*Department of Geosciences, Oregon State University, Corvallis, Oregon 9733 06, USA; (Corresponding author. Present address: Nicholas School of the Environment, Duke University, PO 90328, Durham, NC 27708-0328, E-mail: powers@pinus.env.duke.edu.)*

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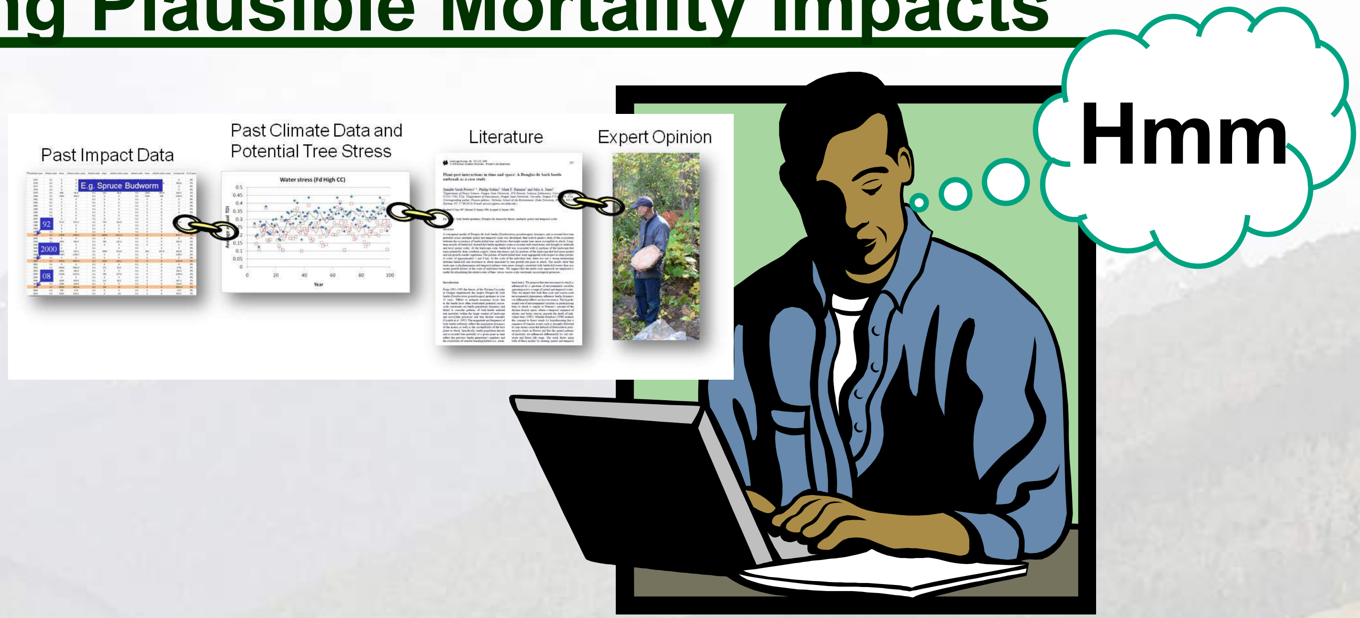
**Expert Opinion**

2. Consult the literature and experts for insights in triggers, timing, and linkages to host life cycles and stress?

## Mortality from Insects and Disease:

# Determining Plausible Mortality Impacts




3. Design initial modeling parameters
4. Modify according to modeling feasibility and limitations.