# Susceptibility of forests to insect attack: responses to climate and management

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**Questions:**

1) **How do we know when natural mortality will start?**

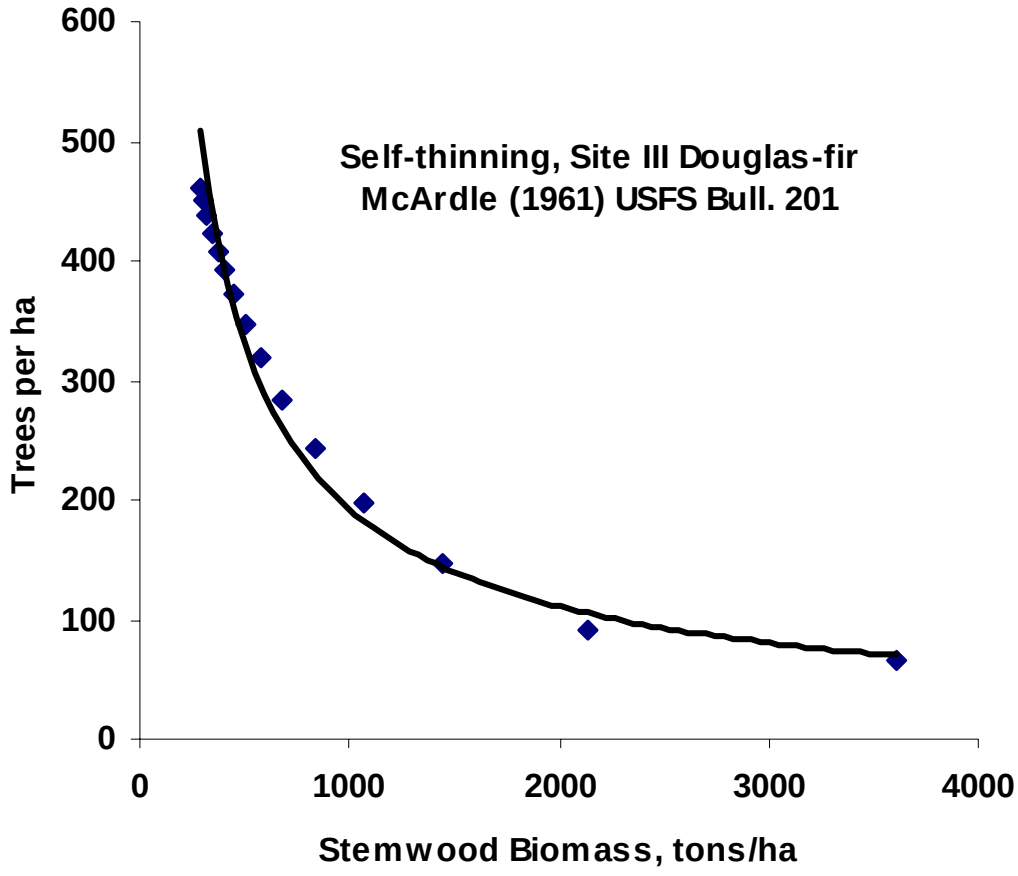
2) **Why do some trees die while others live?**

3) **How might we reduce the annual rate of tree mortality under a changing climate**?

# Answer to Question 1:

# Natural mortality is a predictable function of site productivity

# “As trees grow in size, fewer survive”

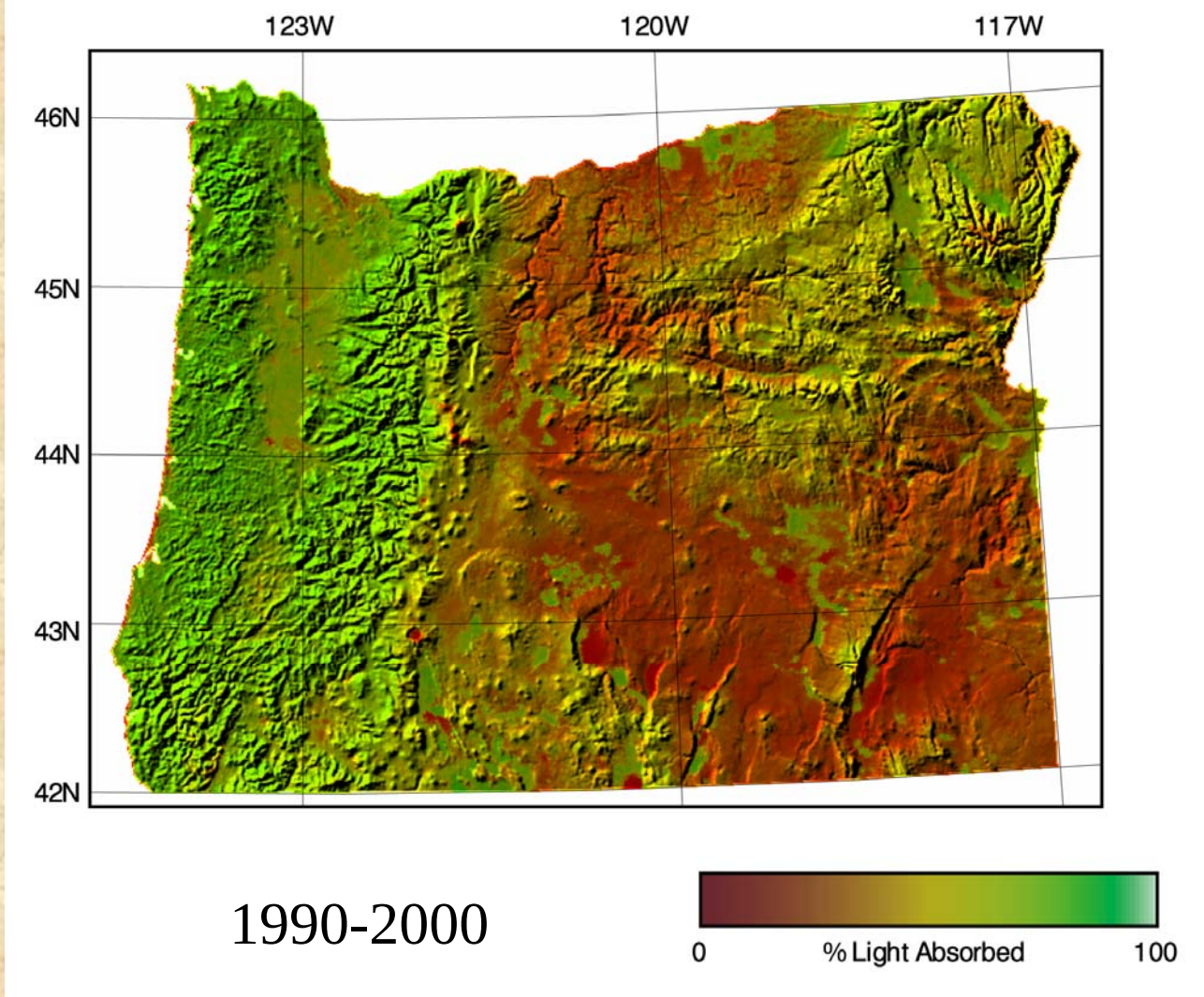


# Self-thinning begins in Coast Range Douglas-fir when the canopy closes, equivalent to when 99% of the light is absorbed by leaves

# Self-thinning begins in lodgepole pine at canopy closure when 95% of the light is absorbed by leaves

# Canopy closure in ponderosa pine occurs when 70% of the light is absorbed by leaves

# Satellite-estimate of max. light absorbed by all vegetation in Oregon




**Waring et al. (2002) Ecology 83:2964-2970**

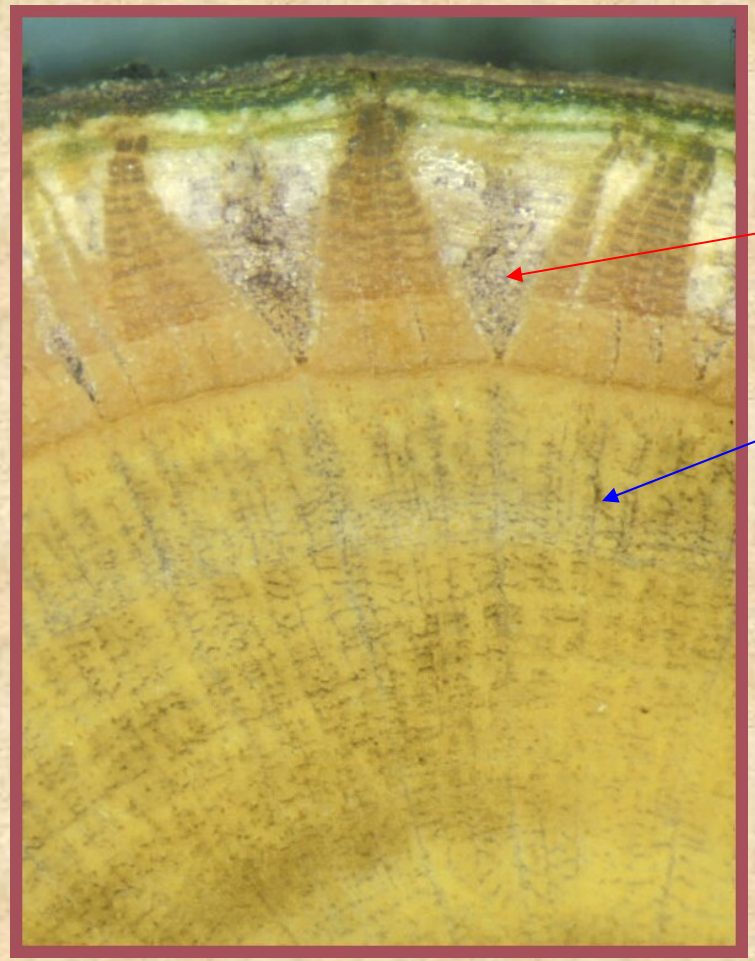
# Question 2
# Why do some trees die (red arrow) while others live?

**1980** **1985**

Photo by Boyd Wickman, USFS

**Answer:**
**Resistant trees draw on stored resources or reallocate resources not available to unhealthy trees.**

# Healthy trees store starch, which stains black with potassium iodine in the cross-section of a pine stem



Starch in phloem

Starch in sapwood

# 1st defense against bark beetles is for a tree to induce the flow of resin

# 2nd level of defense is to produce fresh resin to wall-off blue-stain fungi introduced by bark beetles

**Tree killed by fungus**

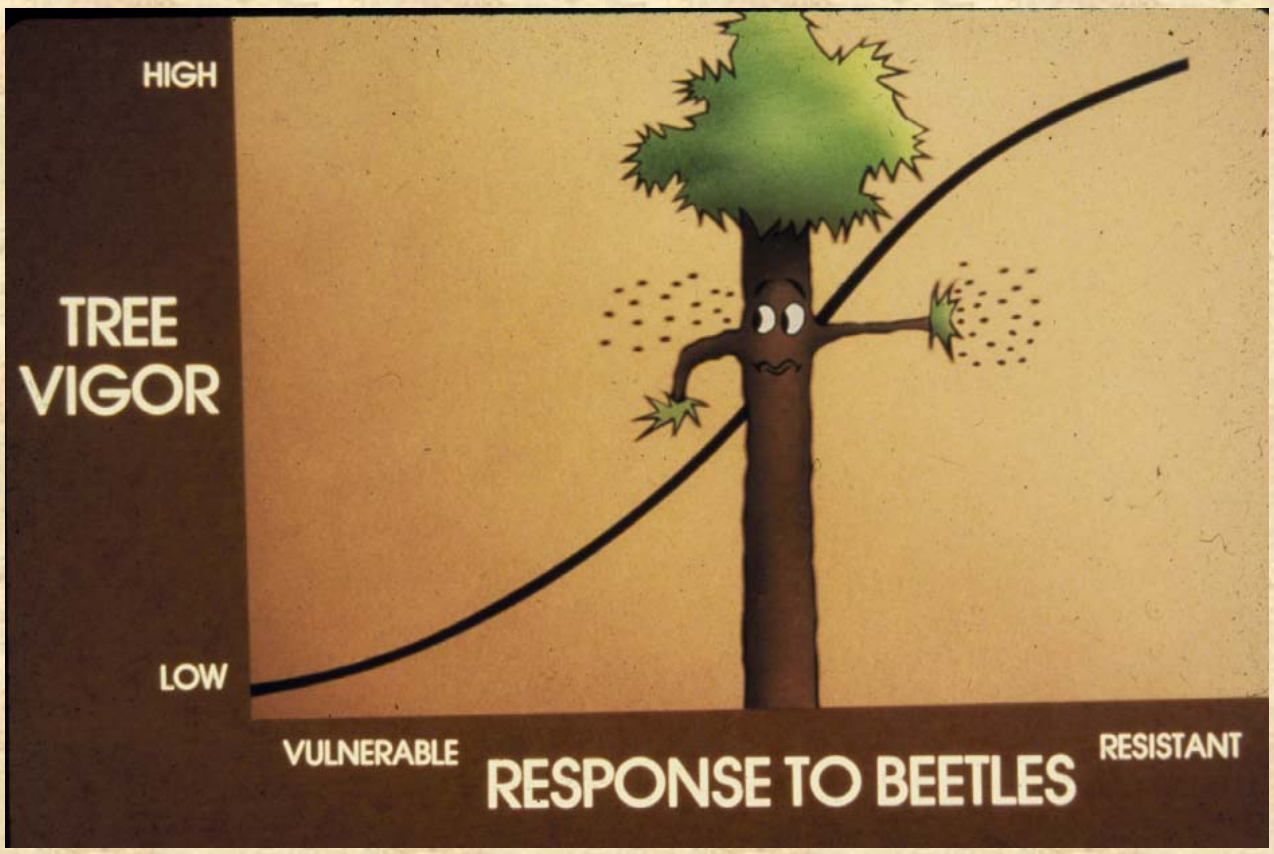
**Tree survives attack**

# Premise: if we improve a tree's environment, its resistance should increase, and vice-versa

Waring & Pitman (1985) Ecology 66:889-897.

# Heavy thinning with trees equally spaced increases supply & reduces demand for resources (light, nutrients, water)

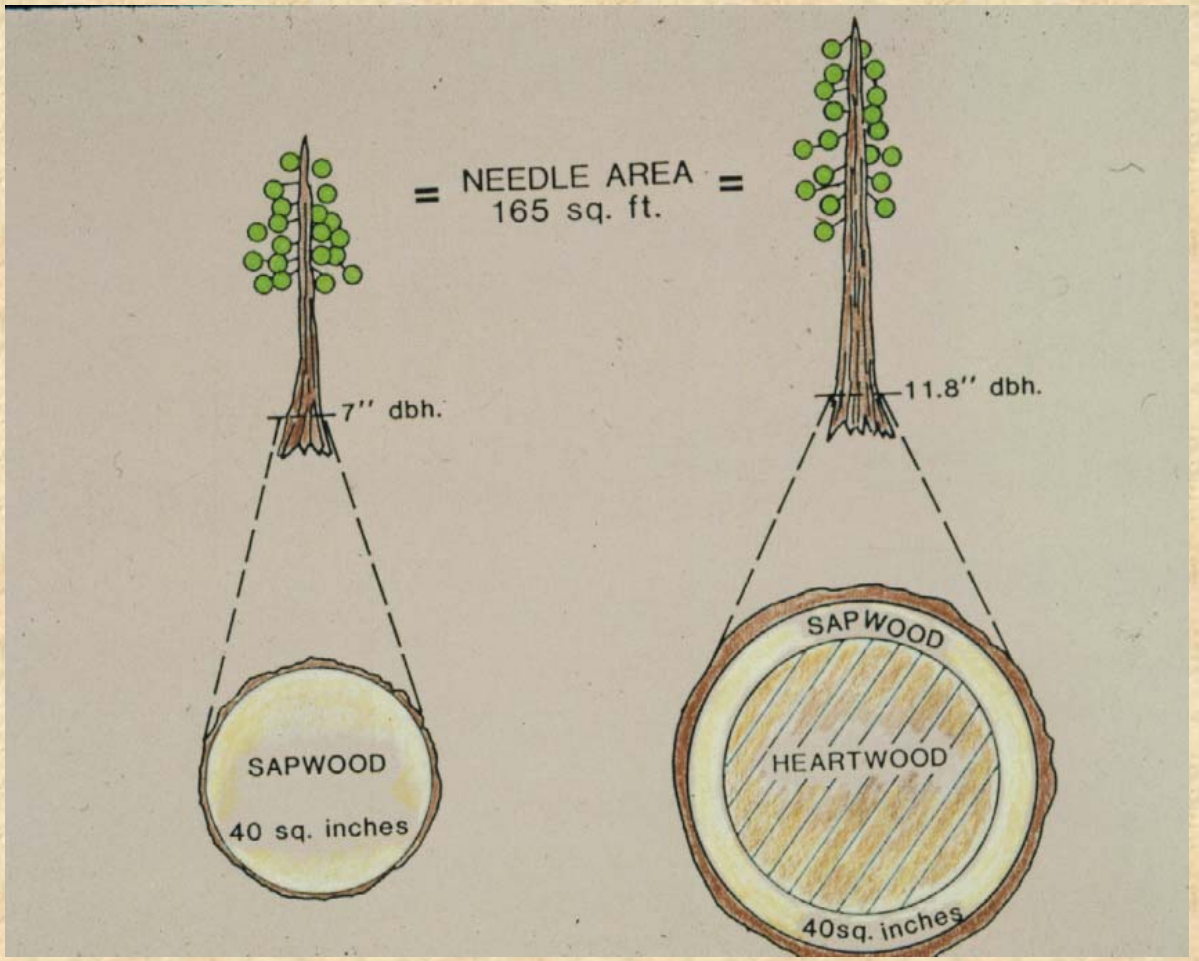
# How do we judge if a tree gains or losses resistance?




**Answer:**

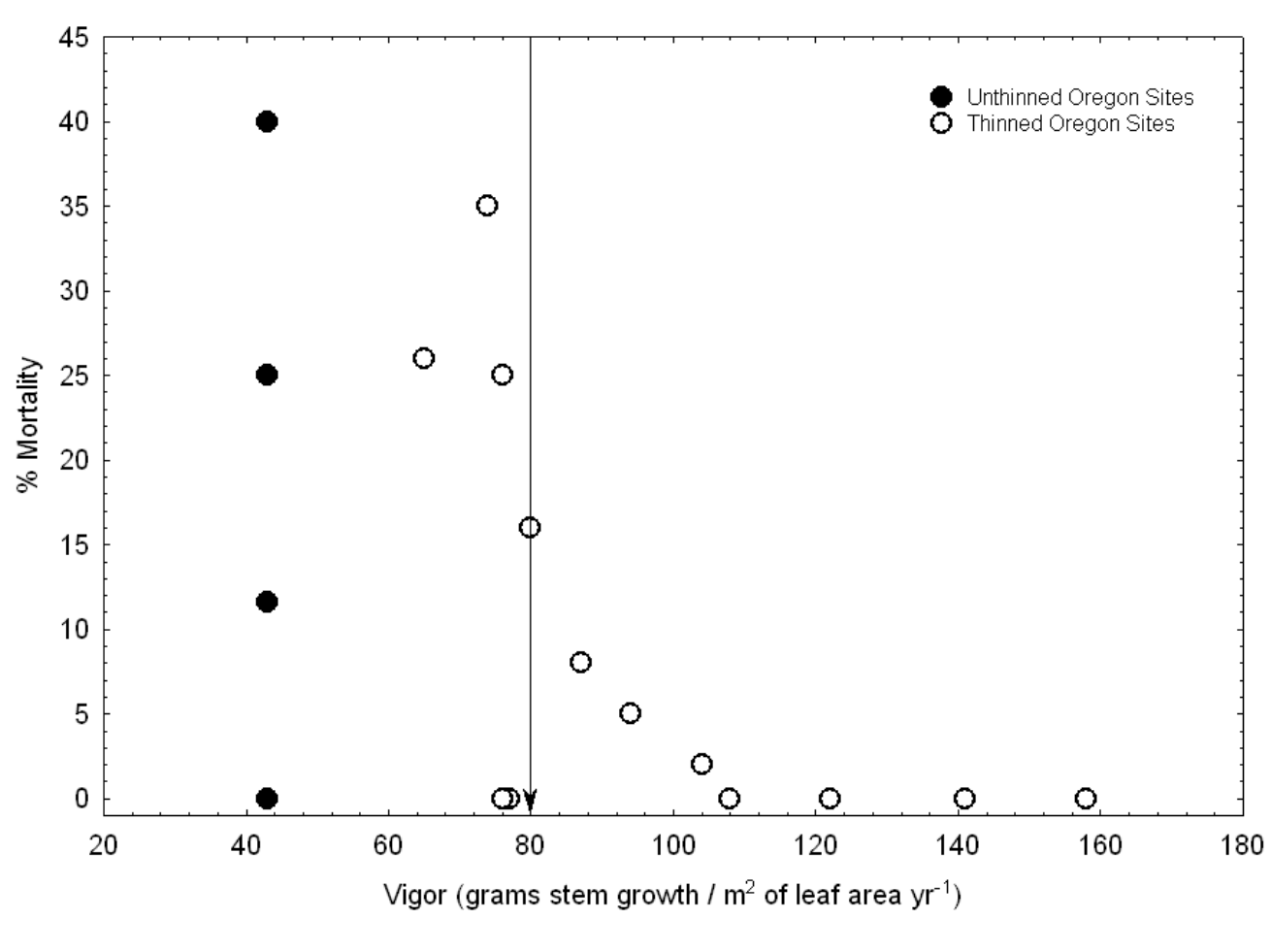
**We compare the efficiency that leaves convert $CO_2$ to wood**

# Estimate a tree's leaf area from a correlation with its sapwood area



# Measure current growth as a fraction of total sapwood area

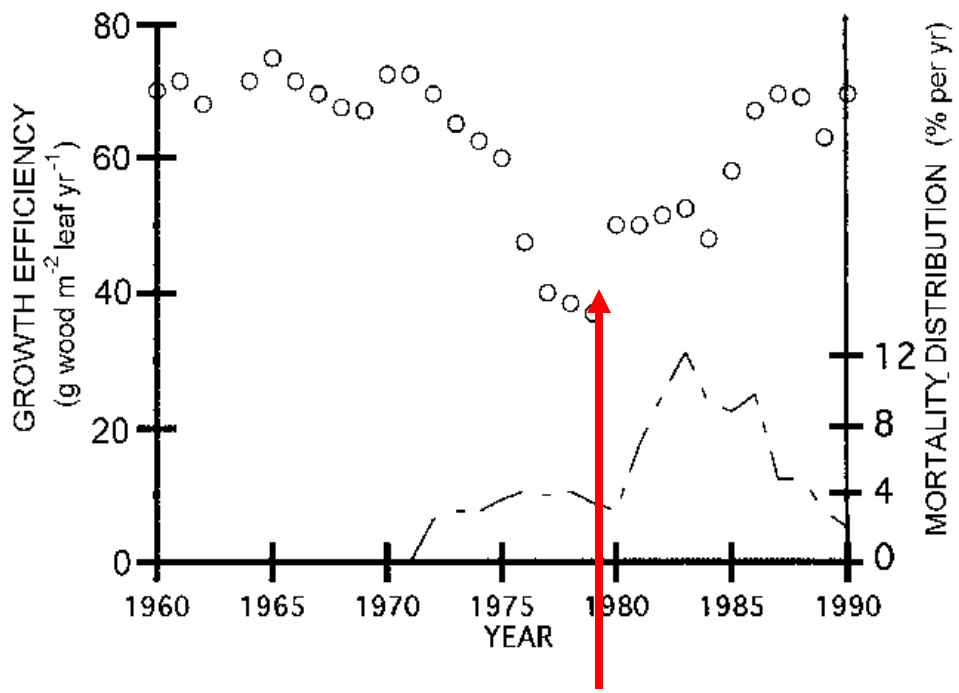
# As the ratio of tree growth to leaf area increases, a threshold is reached, above which most trees are resistant to attack from bark beetles




[safe threshold equivalent to yearly growth of 5% of sapwood area]

Coops et al. (2009) Remote Sensing.of Env.12: 1058-1066.

# Periodic outbreaks of spruce budworm defoliate stands of balsam fir in eastern Canada. The death of some trees improves the vigor of those that survive




outbreak peaks

**Coyea & Margolis (1994) Can. J. For.Res. 24:2208-2221**

**Question 3.**

**How might we reduce the annual rate of tree mortality under the present or a less favorable climate?**

**Answer:**

**Improve the environment for selected trees**

# Prescribe fire to kill younger trees

# Thin to increase tree vigor and reduce size of outbreak

# Permit a stand replacement fire

# Slow natural succession by reducing understory

# Recognize climate change
# Higher temperatures make pinyõn pine more susceptible to drought than juniper

Craig D. Allen, U.S. Geological Survey

These photos show the massive die-off of pinyon pines that occurred during the recent drought. Pinyons, normally evergreen, have reddish-brown foliage in October 2002 (above).

**http://ag.arizona.edu/pubs/general/resrpt2005/article14_2005.pdf**

**Canopy leaf area will be reduced in drought-prone areas, while the riparian zone may remain unaffected**


**3-yr drought in San Diego County, California near Julian**
**Photo by California Department of Forestry and Fire Protection**

# Recommendations

- Consider managing to favor some species or size classes over others
- Shorten rotation to accommodate climate change
- Recognize role of natural events (fire, wind, insects, climate change)
- Leave some areas unmanaged to compare with those managed