Novel Diseases in Rocky Mountain Forests

Links to Climate

Jim Worrall

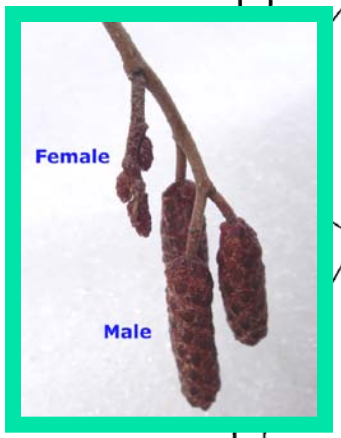
Forest Health Management
Rocky Mountain Region
US Forest Service

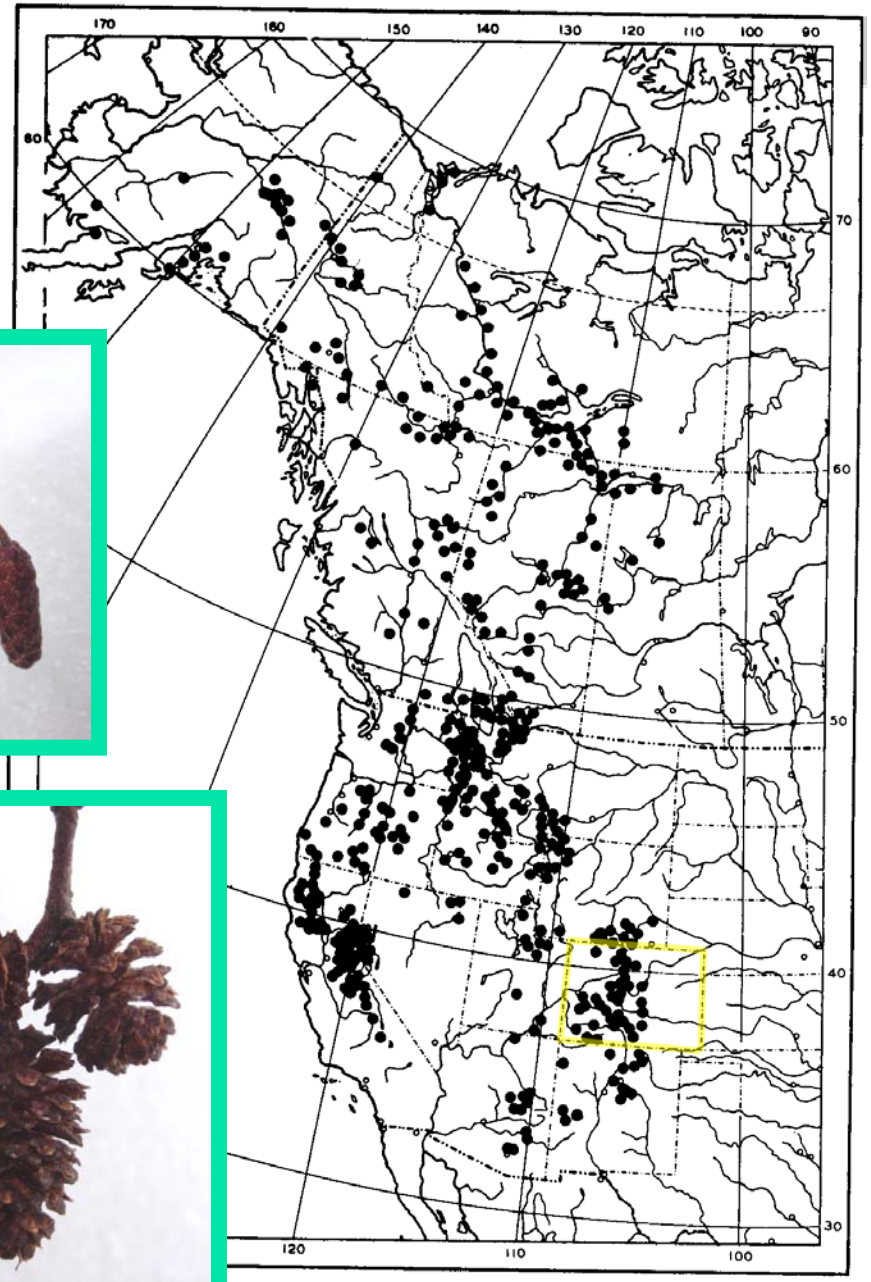
Thinleaf alder

An epidemic of Cytospora canker

Alnus incana ssp. *tenuifolia*

- Thinleaf alder
- Family Betulaceae
- Large shrub or tree to ~10 (15) m
- Sprouting → small clumps/clones
- From Arctic Ocean to Mexico border
- Strictly riparian in Southern Rockies





Condition of all stems

- Survey of northern New Mexico, Colorado, and southern Wyoming

Stem condition class	% of 6,503* standing stems
Live, no dieback	34%
Live, with dieback	29%
Dead	37%

* 68 transects, 859 genets

Funded by
USFS Forest Health Monitoring,
Evaluation Monitoring

Genet Condition Index

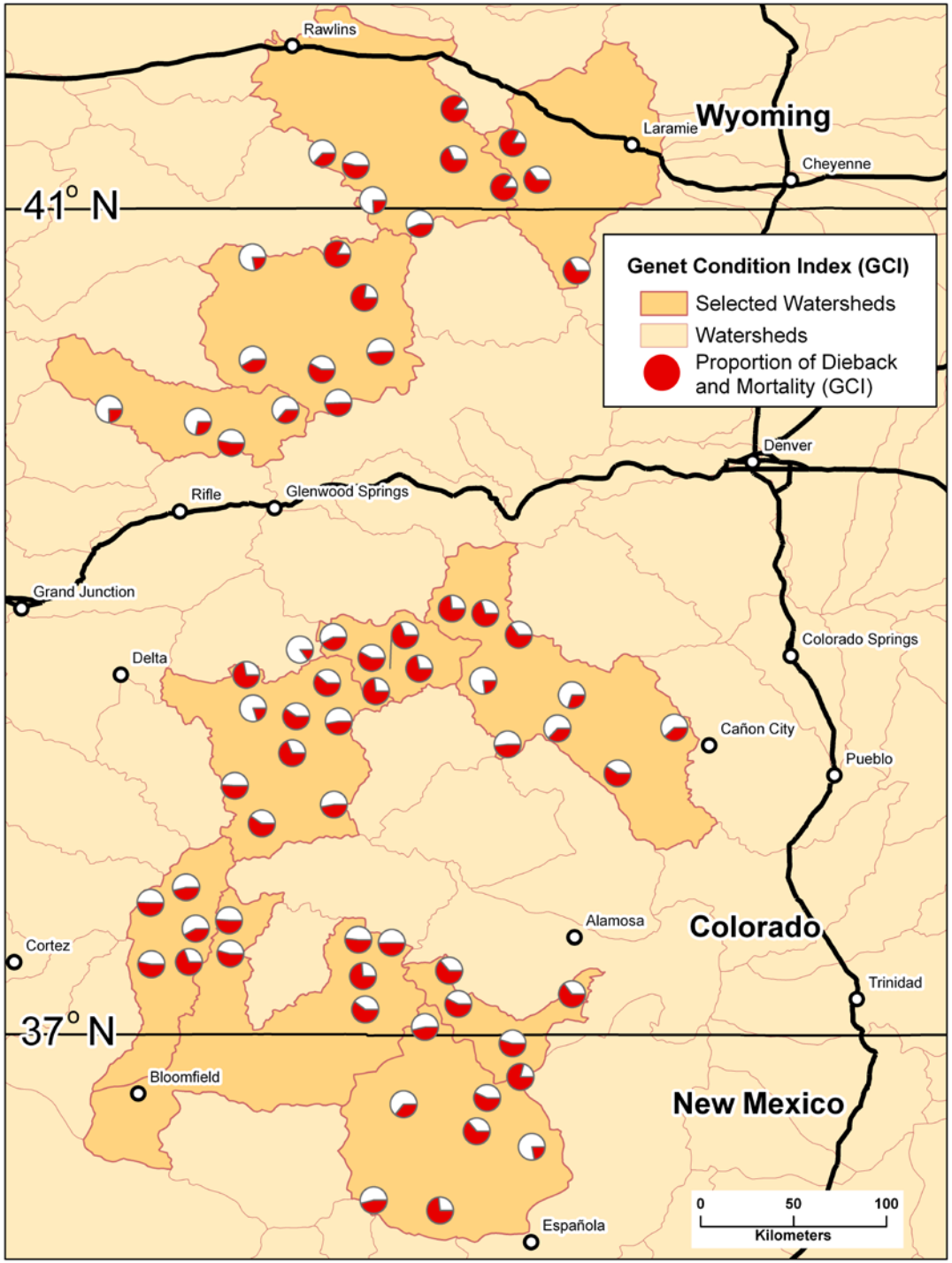
$$GCI = \left(\frac{d + (0.5 \bullet s)}{d + s + h} \right) \bullet 100$$

where:

d = number of dead stems

s = number of stems with dieback

h = number of healthy stems



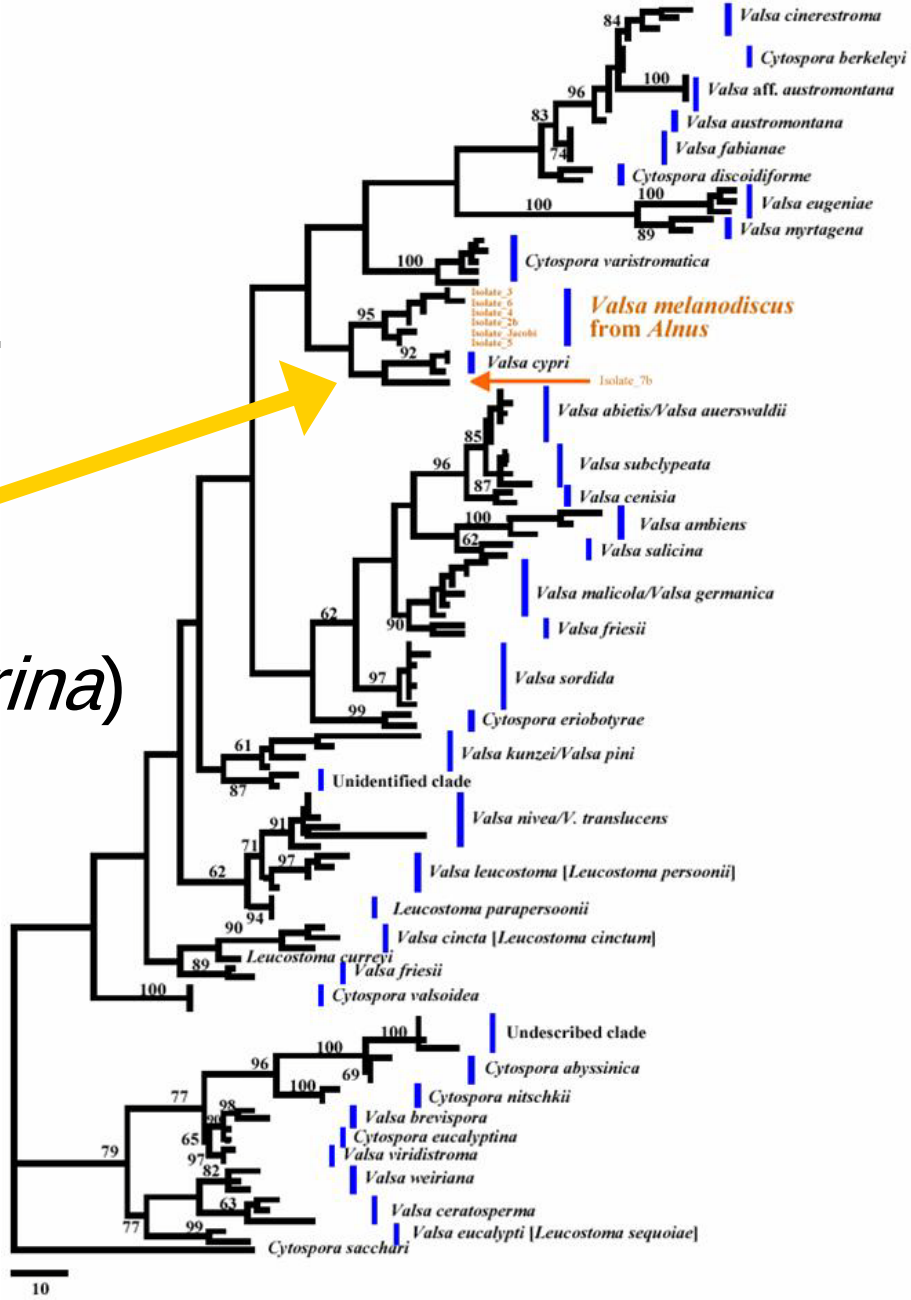
Cytospora canker of alder

- Long narrow stem cankers
- Abundant fruiting
- Stop before root collar
- Also occurs as
  - shoot blight
  - branch cankers

Pathogen

Valsa melanodiscus

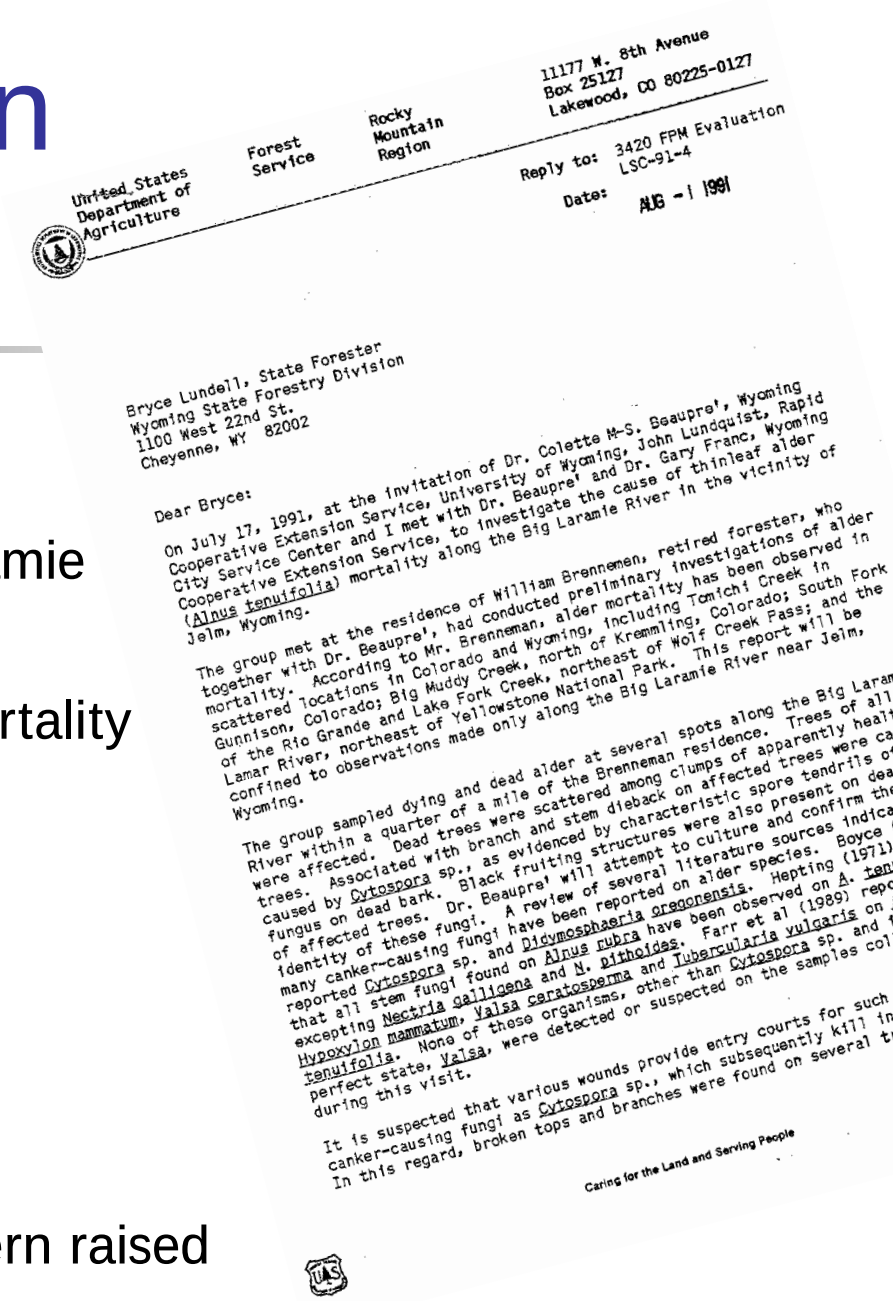
(anamorph *Cytospora umbrina*)



Gerry Adams, based on ITS1-5.8S-ITS2 ribosomal DNA

Epidemic began before 1991

- 1991 Wyoming requested visit
- Unusual alder mortality along Big Laramie River
- A Wyoming forester had also seen mortality
  - Along Tomichi Creek near Gunnnison, CO
  - North of Kremmling, CO
  - South Fork of Rio Grande, CO
  - Lamar River, northeast of Yellowstone NP
- Attributed to Cytospora canker
- Another report noted it in 1996, concern raised in 2001, 2002



United States Department of Agriculture
Forest Service
Rocky Mountain Region
11177 W. 8th Avenue
Box 25127
Lakewood, CO 80225-0127

Reply to: 3420 FPM Evaluation
LSC-91-4

Date: AUG - 1 1991

Bryce Lundell, State Forester
Wyoming State Forestry Division
1100 West 22nd St.
Cheyenne, WY 82002

Dear Bryce:

On July 17, 1991, at the invitation of Dr. Colette M-S. Beaupre', Wyoming Cooperative Extension Service, University of Wyoming, John Lundquist, Rapid City Service Center and I met with Dr. Beaupre' and Dr. Gary Franc, Wyoming Cooperative Extension Service, to investigate the cause of thinleaf alder (Alnus tenuifolia) mortality along the Big Laramie River in the vicinity of Jelm, Wyoming.

The group met at the residence of William Brennemen, retired forester, who together with Dr. Beaupre', had conducted preliminary investigations of alder mortality. According to Mr. Brenneman, alder mortality has been observed in scattered locations in Colorado and Wyoming, including Tomichi Creek in Gunnison, Colorado; Big Muddy Creek, north of Kremmling, Colorado; South Fork of the Rio Grande and Lake Fork Creek, northeast of Wolf Creek Pass; and the Lamar River, northeast of Yellowstone National Park. This report will be confined to observations made only along the Big Laramie River near Jelm, Wyoming.

The group sampled dying and dead alder at several spots along the Big Laram River within a quarter of a mile of the Brenneman residence. Trees of all were affected. Dead trees were scattered among clumps of apparently healt trees. Associated with branch and stem dieback on affected trees were ca caused by Cytospora sp., as evidenced by characteristic spore tendrils o fungus on dead bark. Black fruiting structures were also present on dea of affected trees. Dr. Beaupre' will attempt to culture and confirm the identity of these fungi. A review of several literature sources indica many canker-causing fungi have been reported on alder species. Boyce reported Cytospora sp. and Didymosphaeria oregonensis. Hepting (1971) that all stem fungi found on Alnus rubra have been observed on A. ten excepting Nectria galligena and N. pithoides. Farr et al (1989) repo Hypoxylon mammatum, Valsa ceratosperma and Tubercularia vulgaris on tenuifolia. None of these organisms, other than Cytospora sp. and perfect state, Valsa, were detected or suspected on the samples col during this visit.

It is suspected that various wounds provide entry courts for such canker-causing fungi as Cytospora sp., which subsequently kill in In this regard, broken tops and branches were found on several t

Caring for the Land and Serving People

Why?

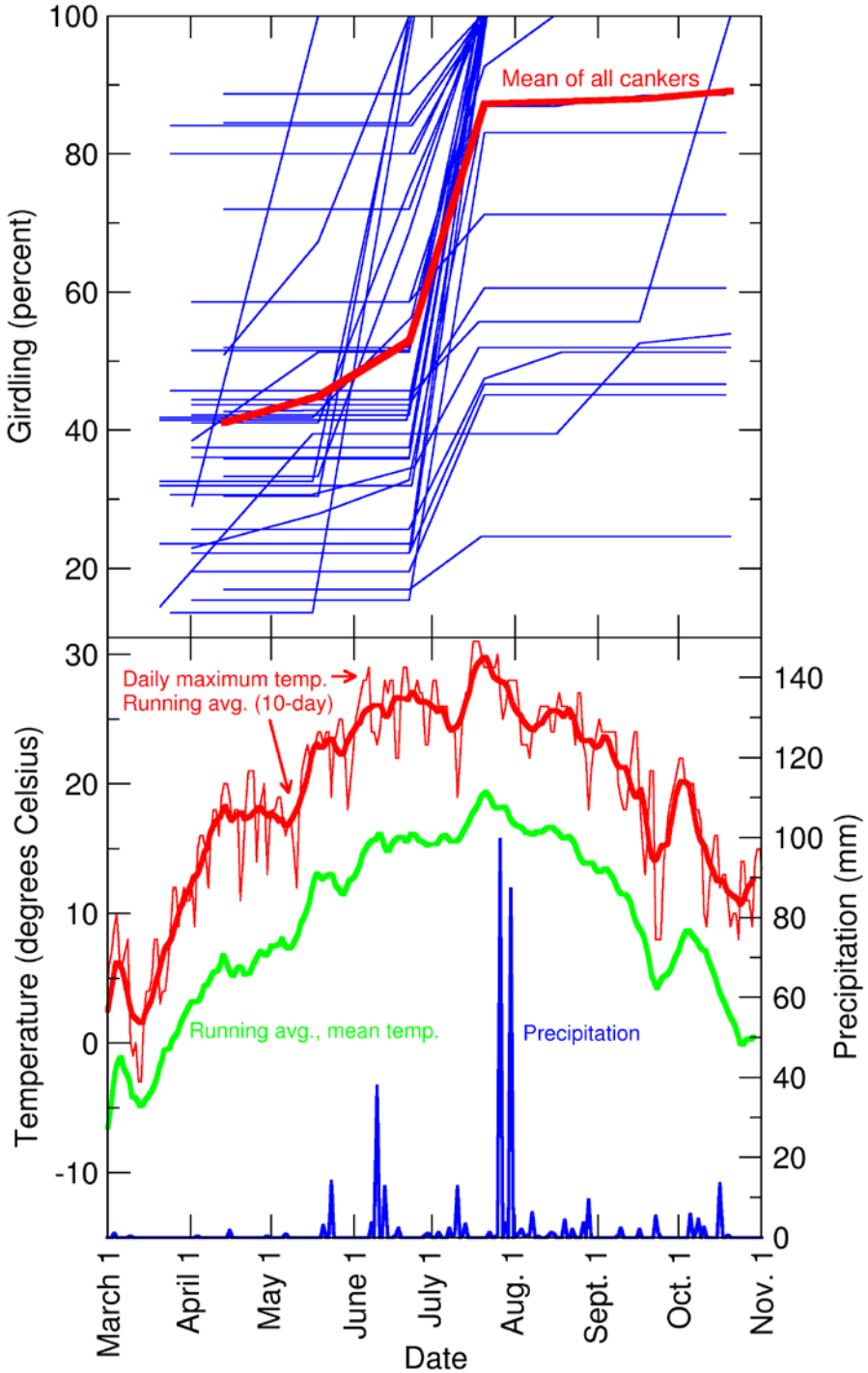
- Cytospora canker certainly the proximal cause of the mortality, but:
  - Such diseases usually kill stressed trees
  - Why would a presumably native pathogen cause such a long-term and severe epidemic?

Measuring canker growth

- Marked about 75 cankers
- Monitored and remeasured for various periods
- Objective:
  - Determine expansion rate
  - Determine season of expansion

Canker growth

Weather



- Most cankers grew and killed host within one year of marking
- Canker growth rates highly variable
  - Up to 50 cm/month in one direction
- Most growth occurs during midsummer at hottest time of year

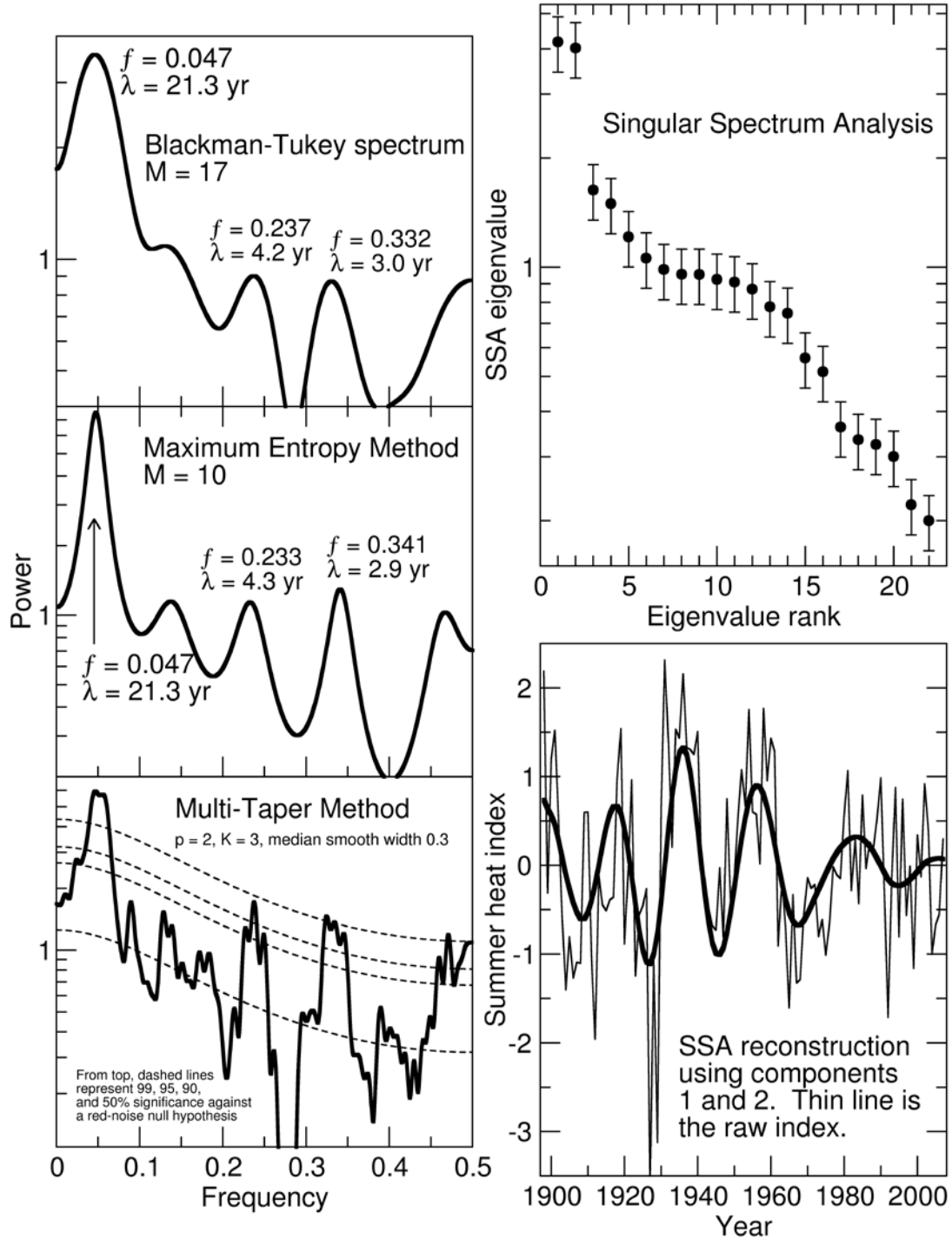
Climate?

- Initially, studies suggested that temperatures in CO did not increase significantly over past century *
- We therefore looked for evidence for long-term cyclic variation
  - Warm phases may shift balance in favor of pathogen

* Baldwin CK. 2003. **Historical climate analysis.** In: Wagner FH, editor. **Rocky Mountain/Great Basin regional climate-change assessment.** Report for the U.S. Global Change Research Program. Logan, UT: Utah State University. p 58-72.

* Kittel, TGF et al. 2002. **Climates of the Rocky Mountains: historical and future patterns.** Pp. 59-82 in: JS Barnes, ed, Rocky Mountain Futures: An Ecological Perspective. Island Press, Covelo CA.

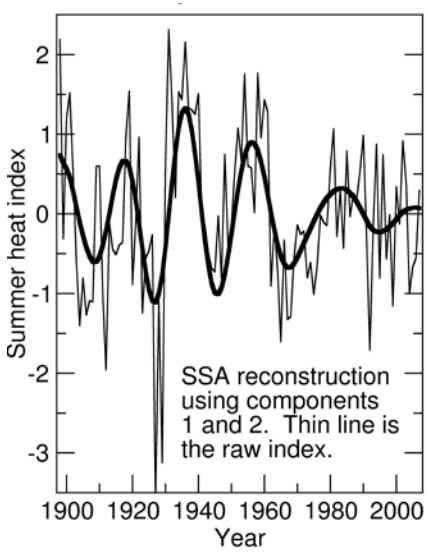
Spectral analyses of summer heat index in Gunnison



- Dominant, significant cycle with period 21 yr
- Amplitude decreasing

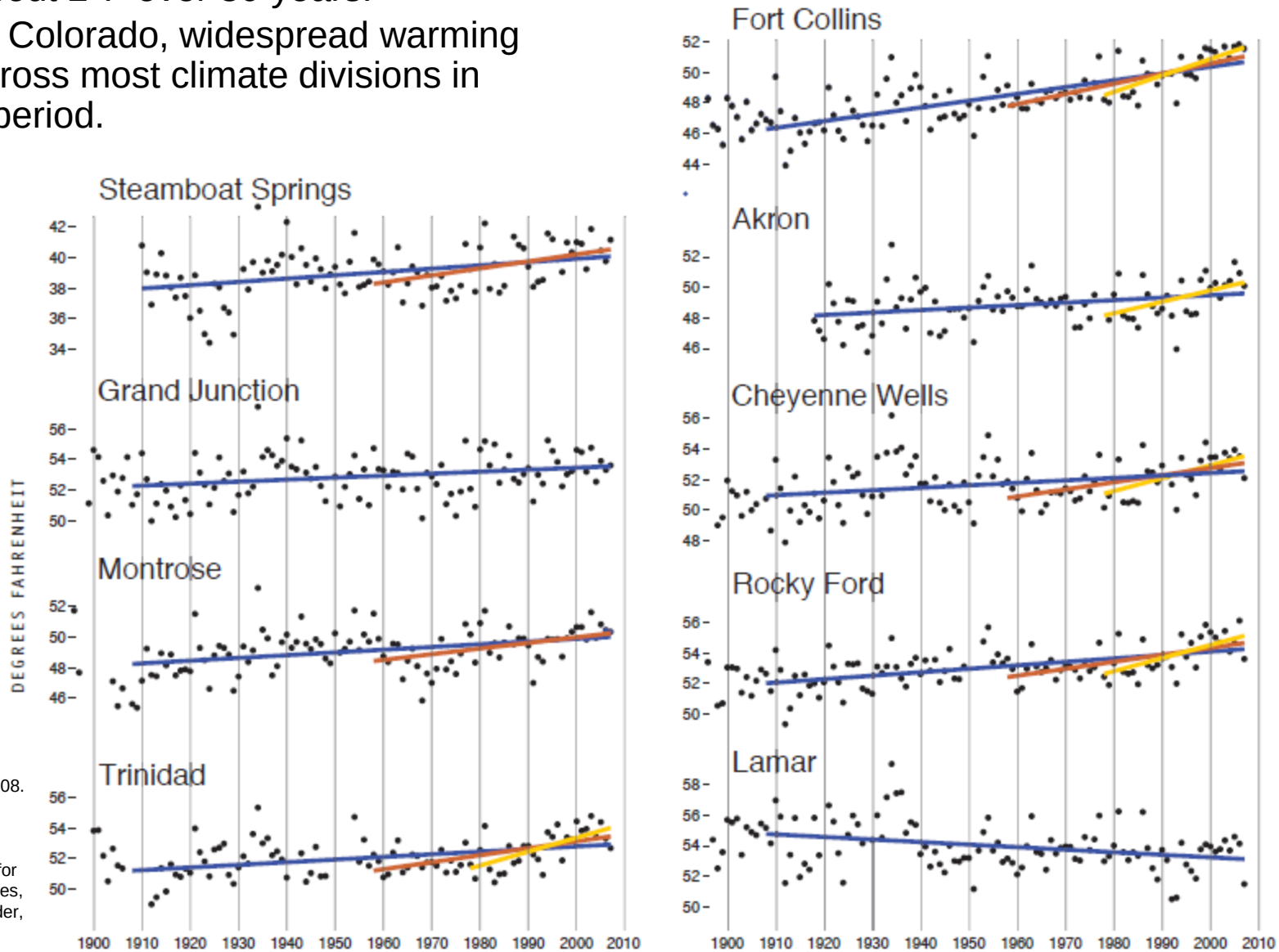
Temperature cycles → epidemic cycles?

- So oscillating summer temperatures may explain periodic epidemics
  - Epidemics during positive phases, recovery during negative phases?
  - No long, cool "recovery" period since 1976
- But more recent climatological analyses of Colorado also show increasing trend . . .



Increases in annual mean temperatures

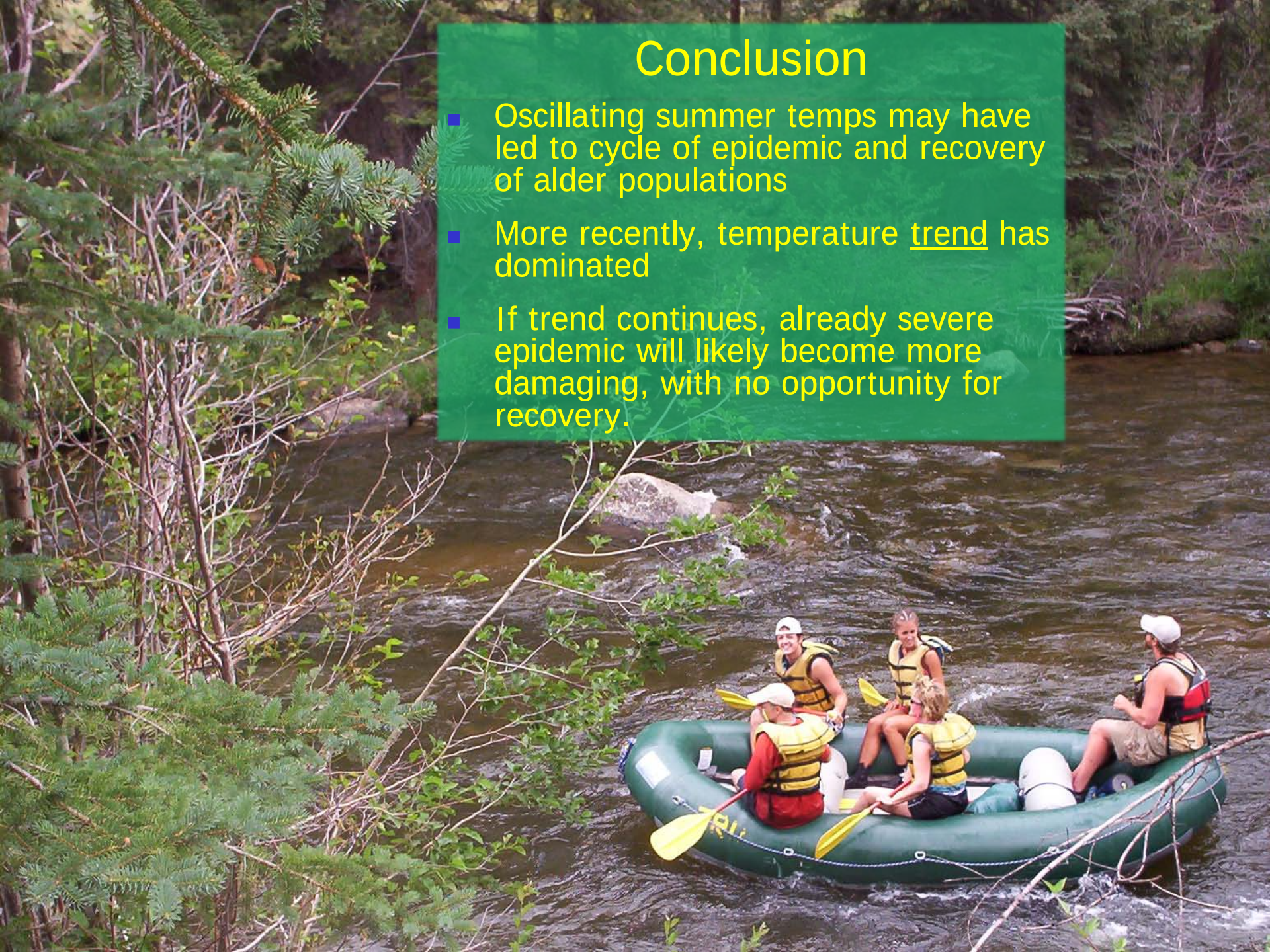
- In Colorado, statewide temperatures have increased about 2 F over 30 years.
- In regions of Colorado, widespread warming is evident across most climate divisions in the 30-year period.



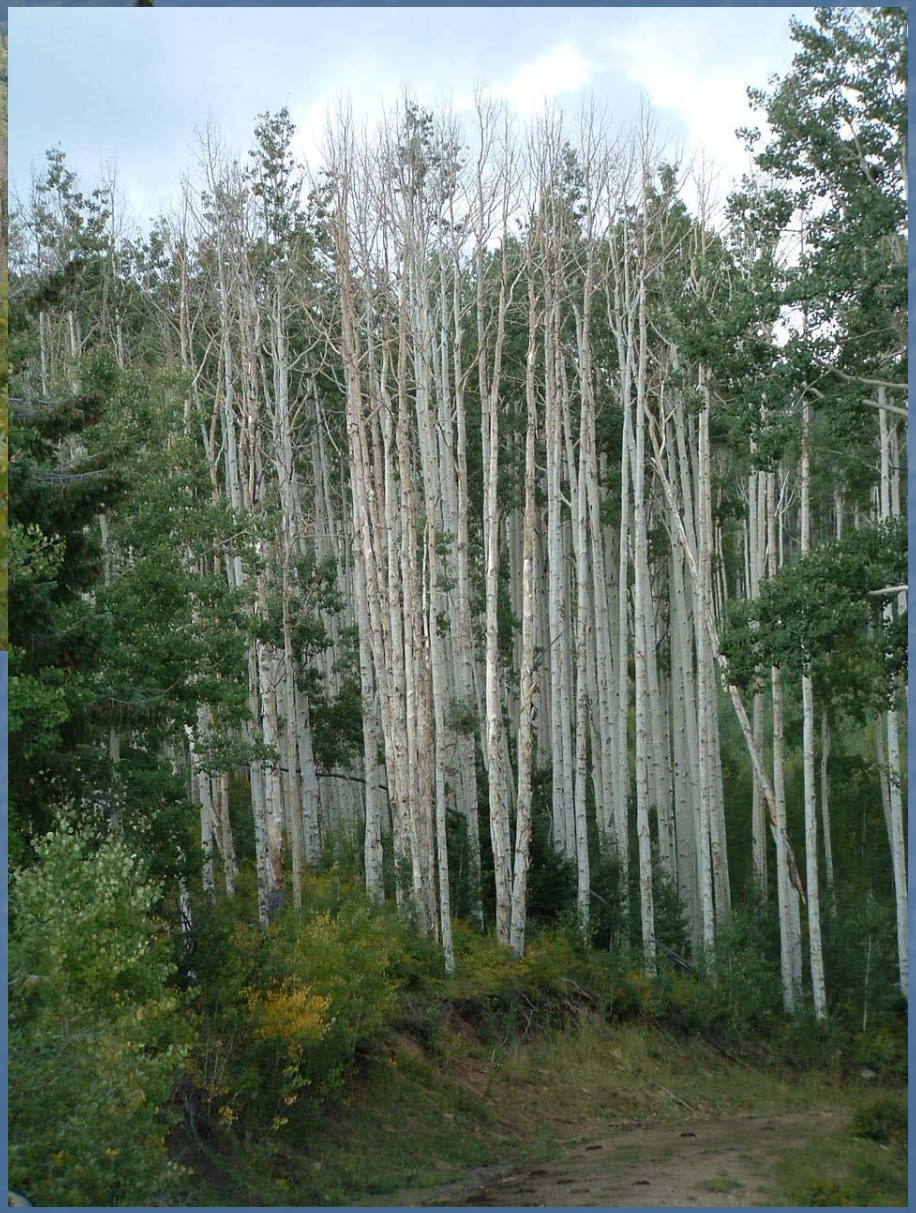
Ray AJ, Barsugli JJ, Averty KB. 2008. Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation. Cooperative Institute for Research in Environmental Sciences, Western Water Assessment, Boulder, Colorado. 52 pp.

Conclusion

- Oscillating summer temps may have led to cycle of epidemic and recovery of alder populations
- More recently, temperature trend has dominated
- If trend continues, already severe epidemic will likely become more damaging, with no opportunity for recovery.



Sudden Aspen Decline



Mancos-Dolores District,
San Juan NF
2006

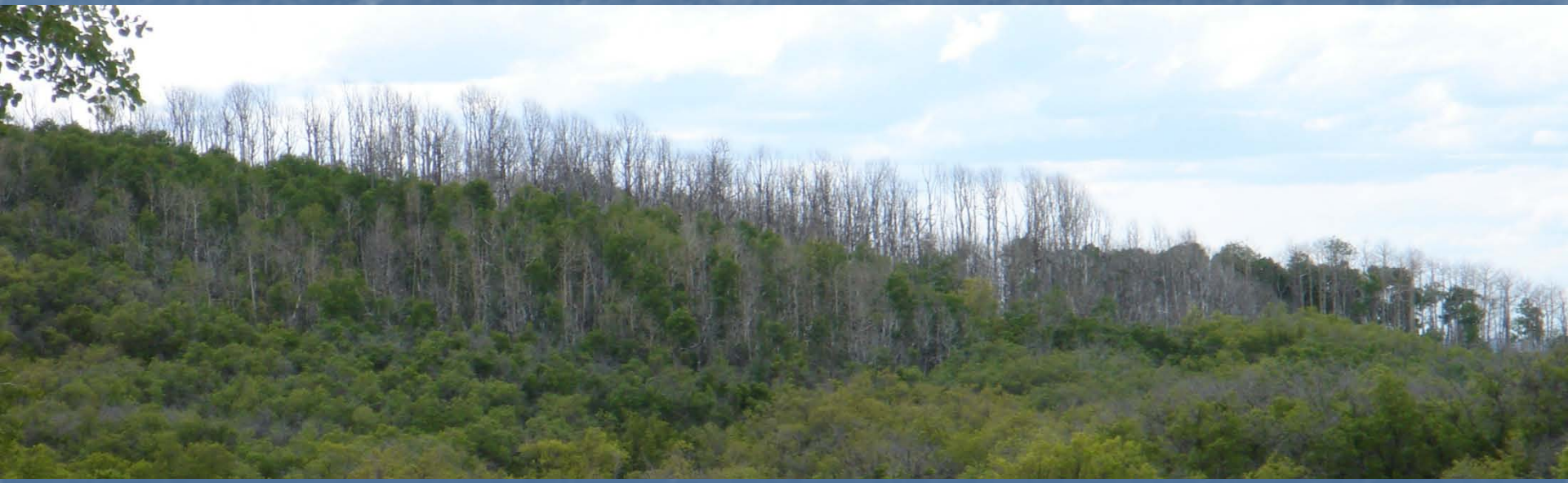
Photos by Phil Kemp

Near Gunnison
2006

Photos by Dave Kinateder

Leroux Creek watershed,
near Grand Mesa NF
30 July 2008

Photo by Angel Watkins



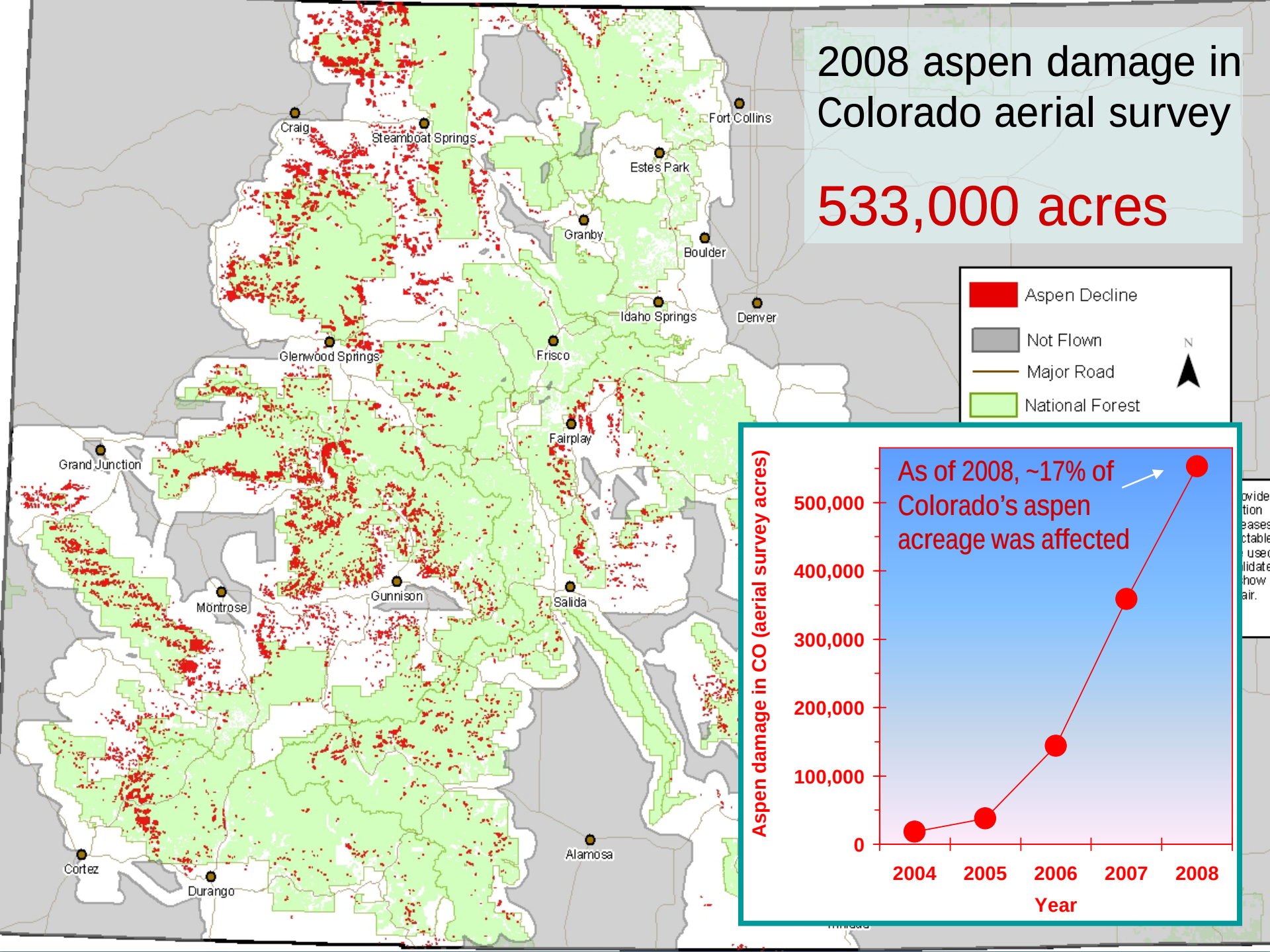
San Juan NF, Mancos-Dolores District

June 19 2009

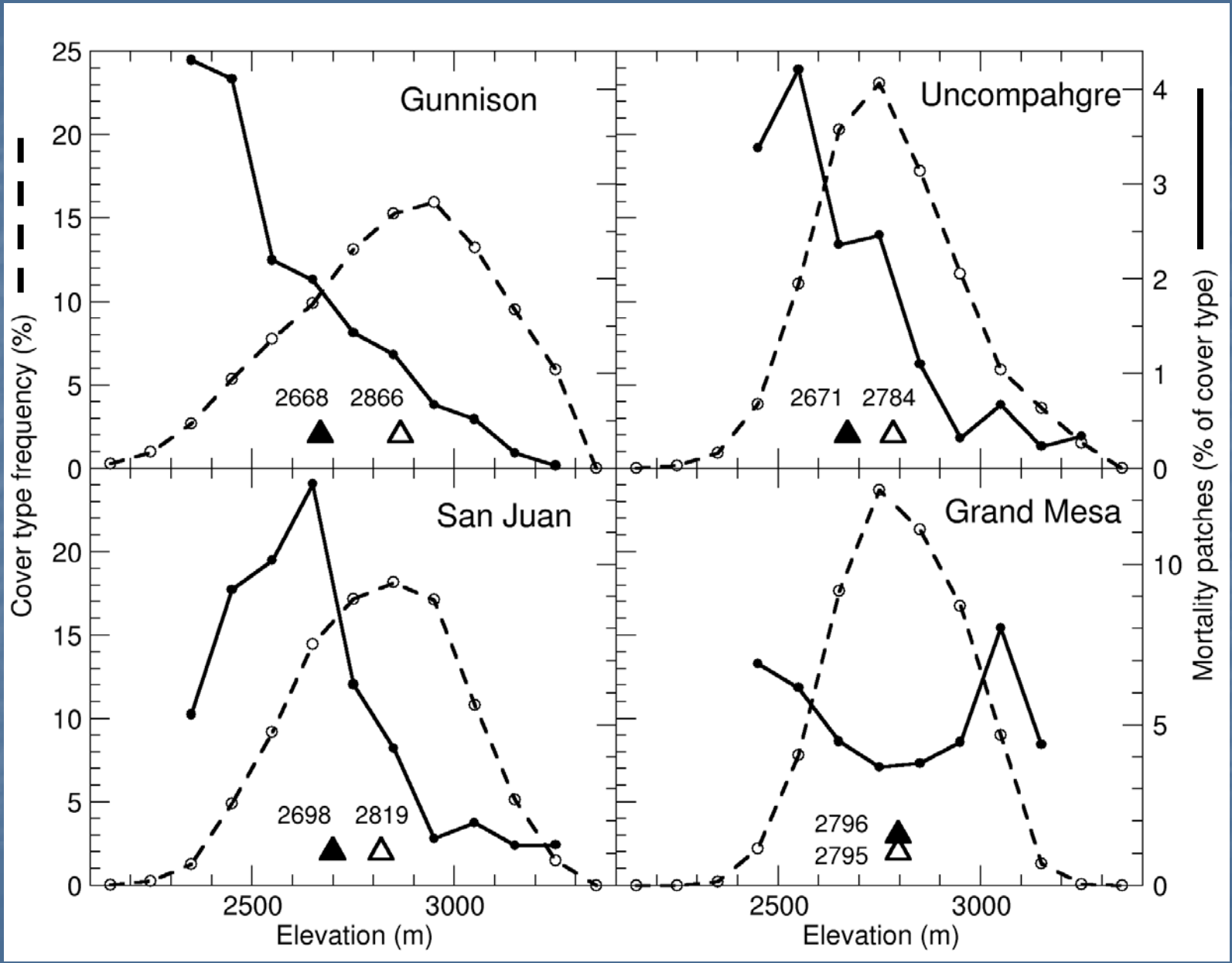
Terror Creek, north of Paonia
Gunnison National Forest
25 July 2007

2008 aspen damage in Colorado aerial survey

533,000 acres



GIS/DEM analysis based on 2006 aerial survey and aspen cover type layers from R2veg



Around the basalt cap of the Grand Mesa is a “landslide bench”

Figure 9. Landslide bench (outlined). Looking across Mesa Lakes to the west. (Yeend, 1969)

- Coarse tumble of basalt fragments
- Droughty soils likely
- Coincides with anomalous peak of aspen mortality

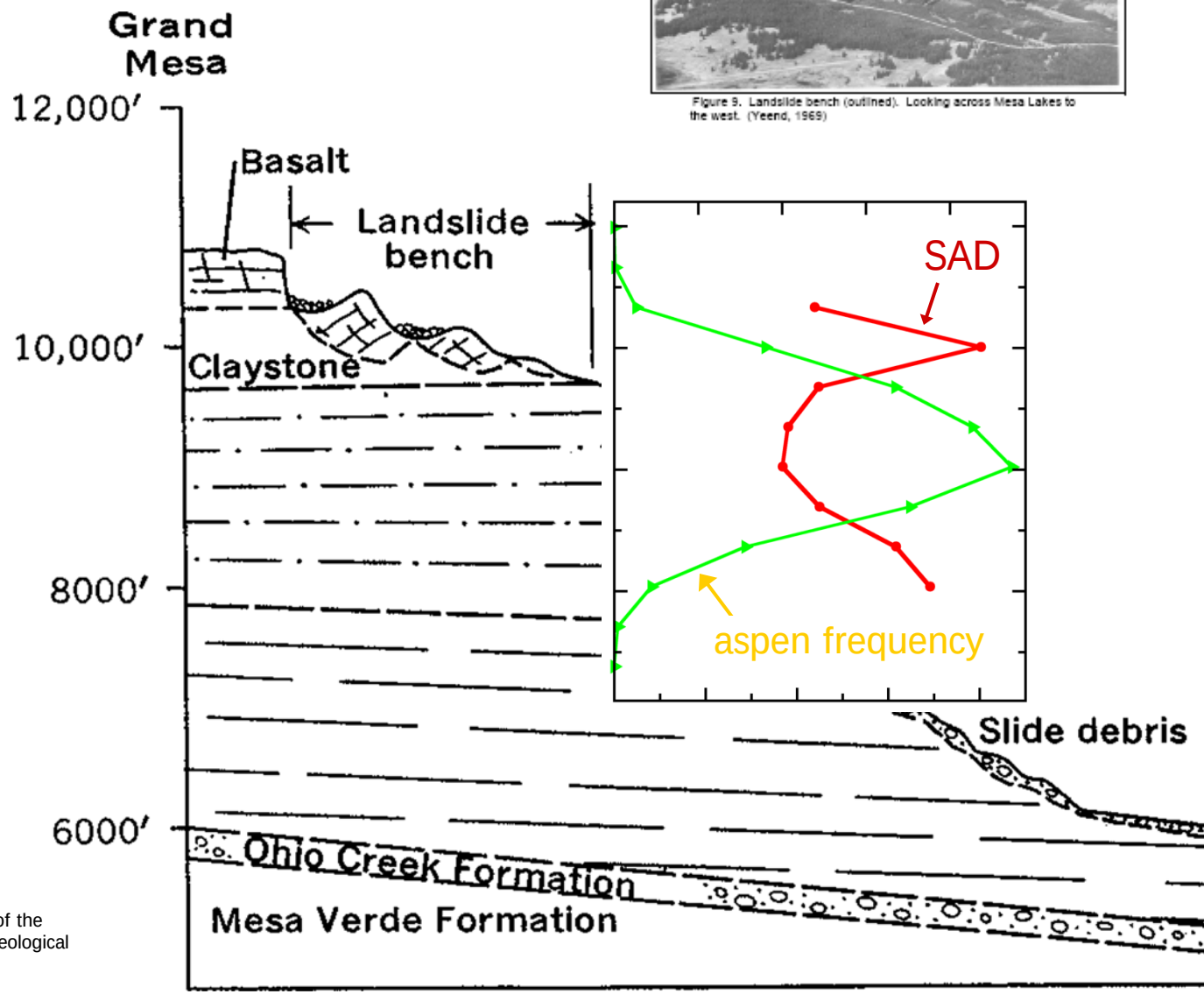
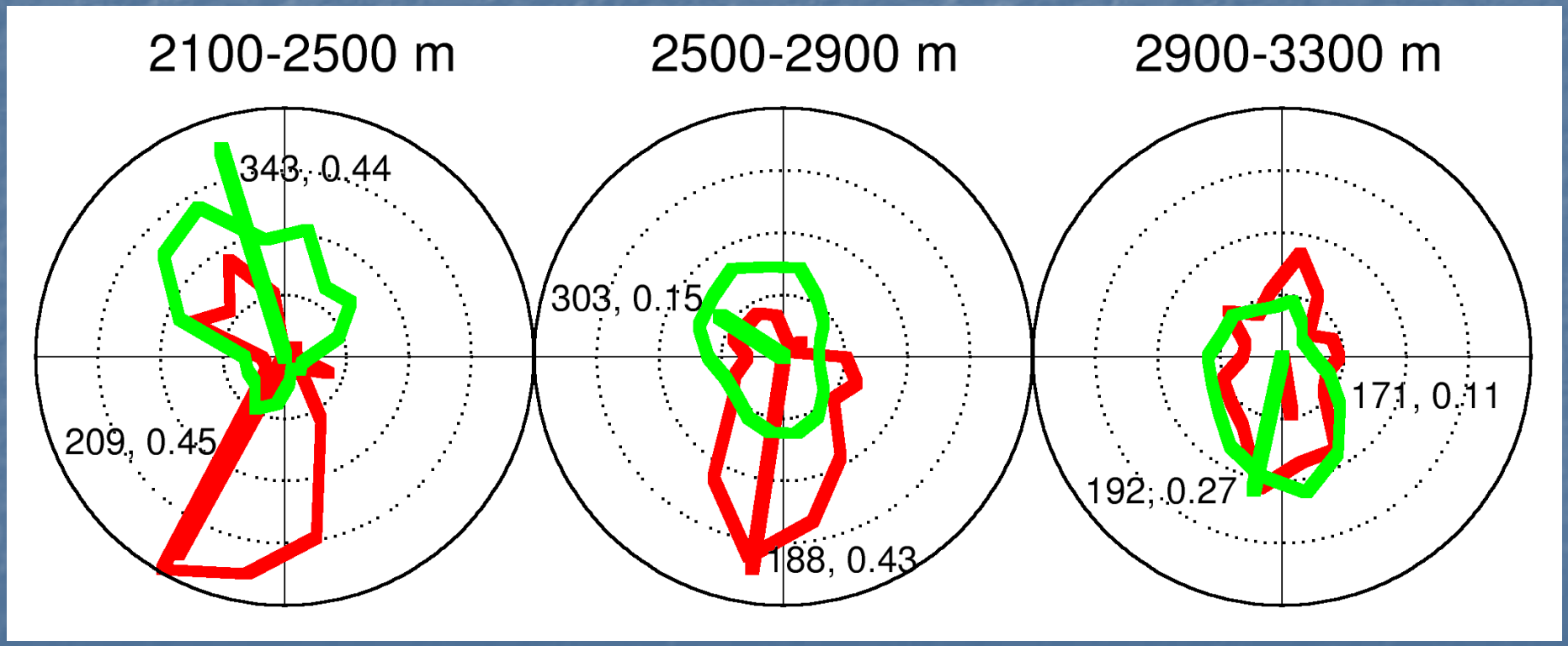


Diagram: Yeend, WE. 1969. Quaternary Geology of the Grand and Battlement Mesas Area, Colorado, U.S. Geological Survey Professional Paper 617. 50 pp..

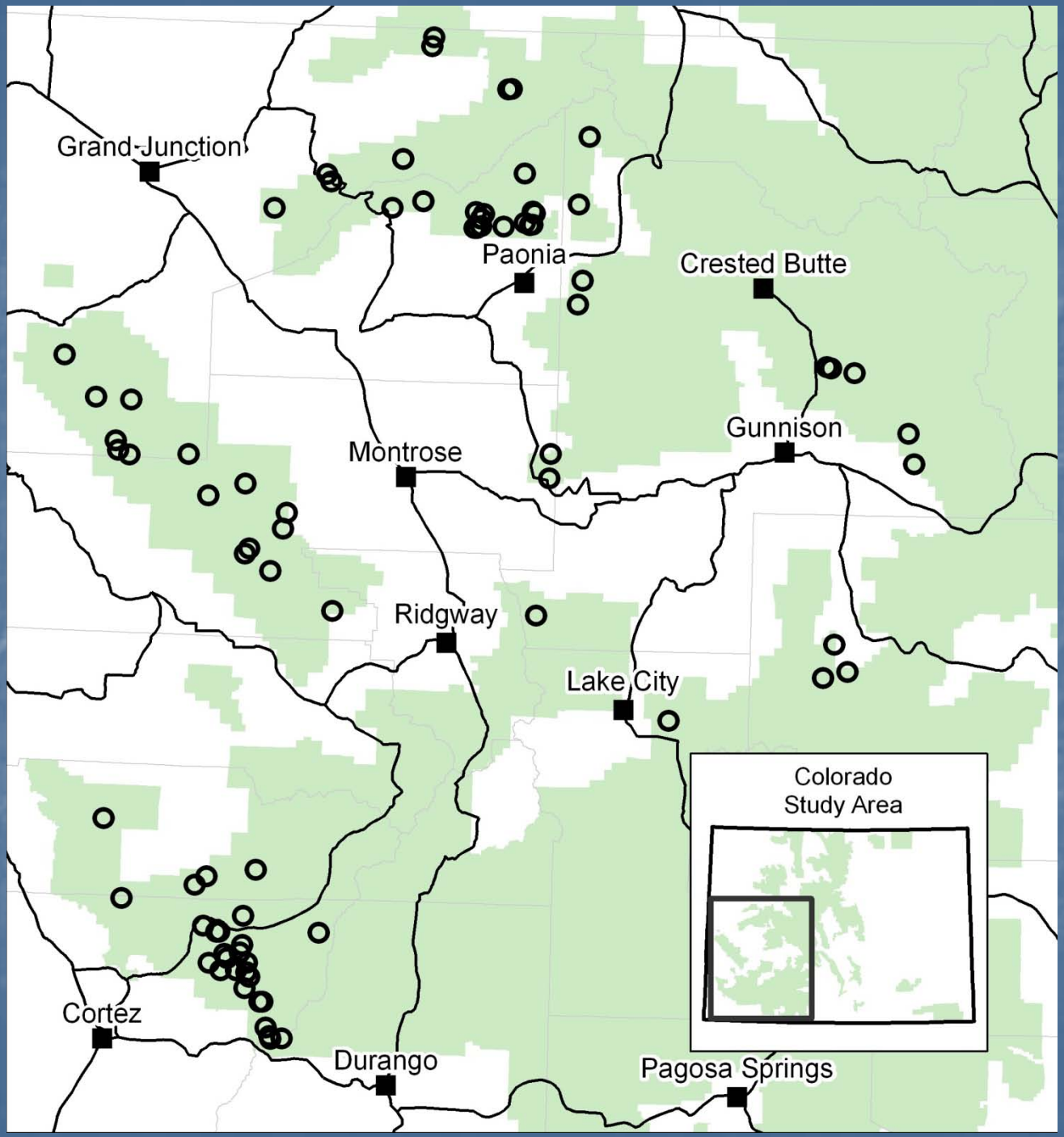
Aspect in 3 elevation classes
Grand Mesa NF

Polygon indicates relative frequency of aspects in 20-degree classes

Line indicates slope-weighted mean aspect and r



Green is healthy, red is dead. Based on 2006 aerial survey.

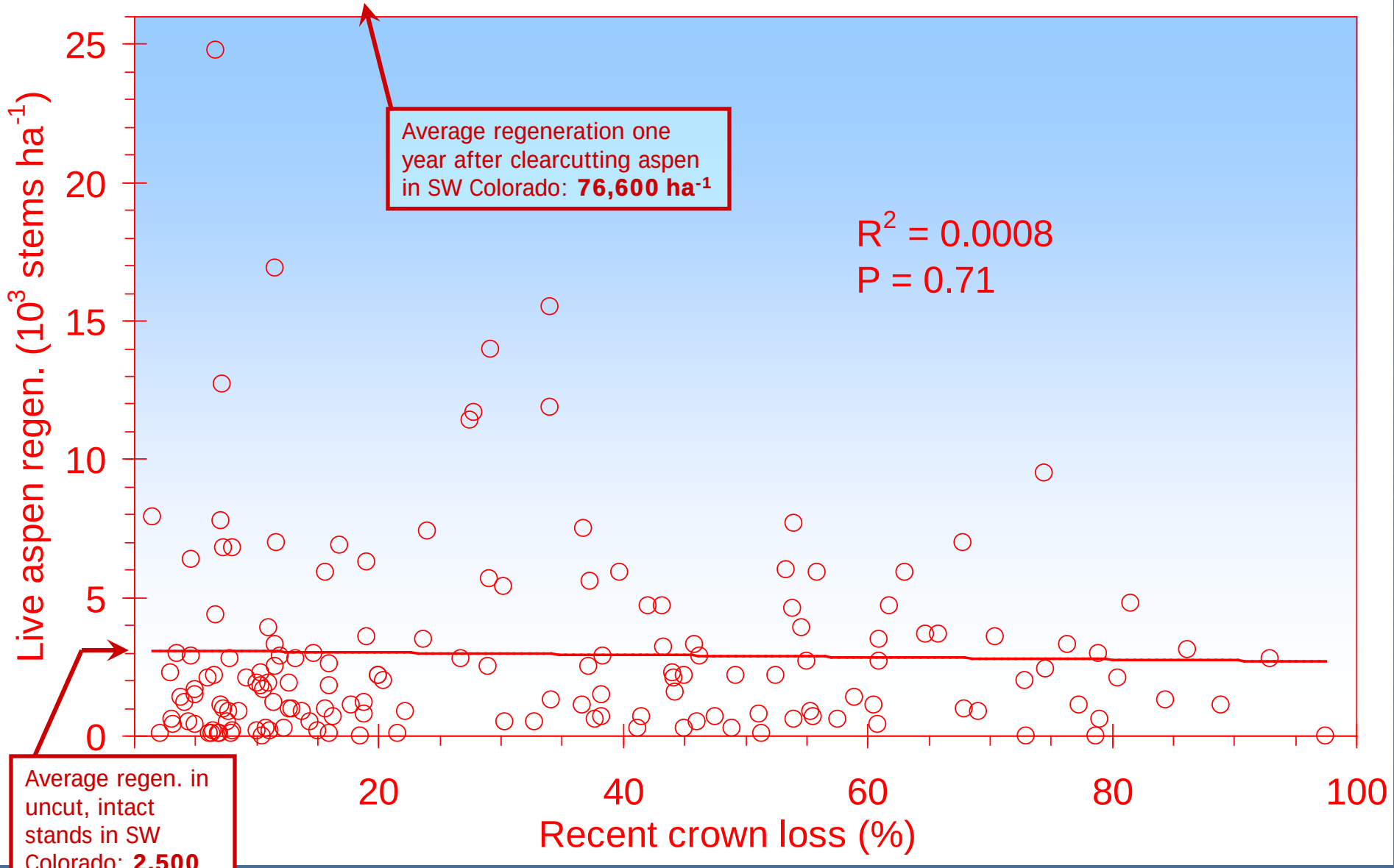


2007/2008 Survey of SW Colorado

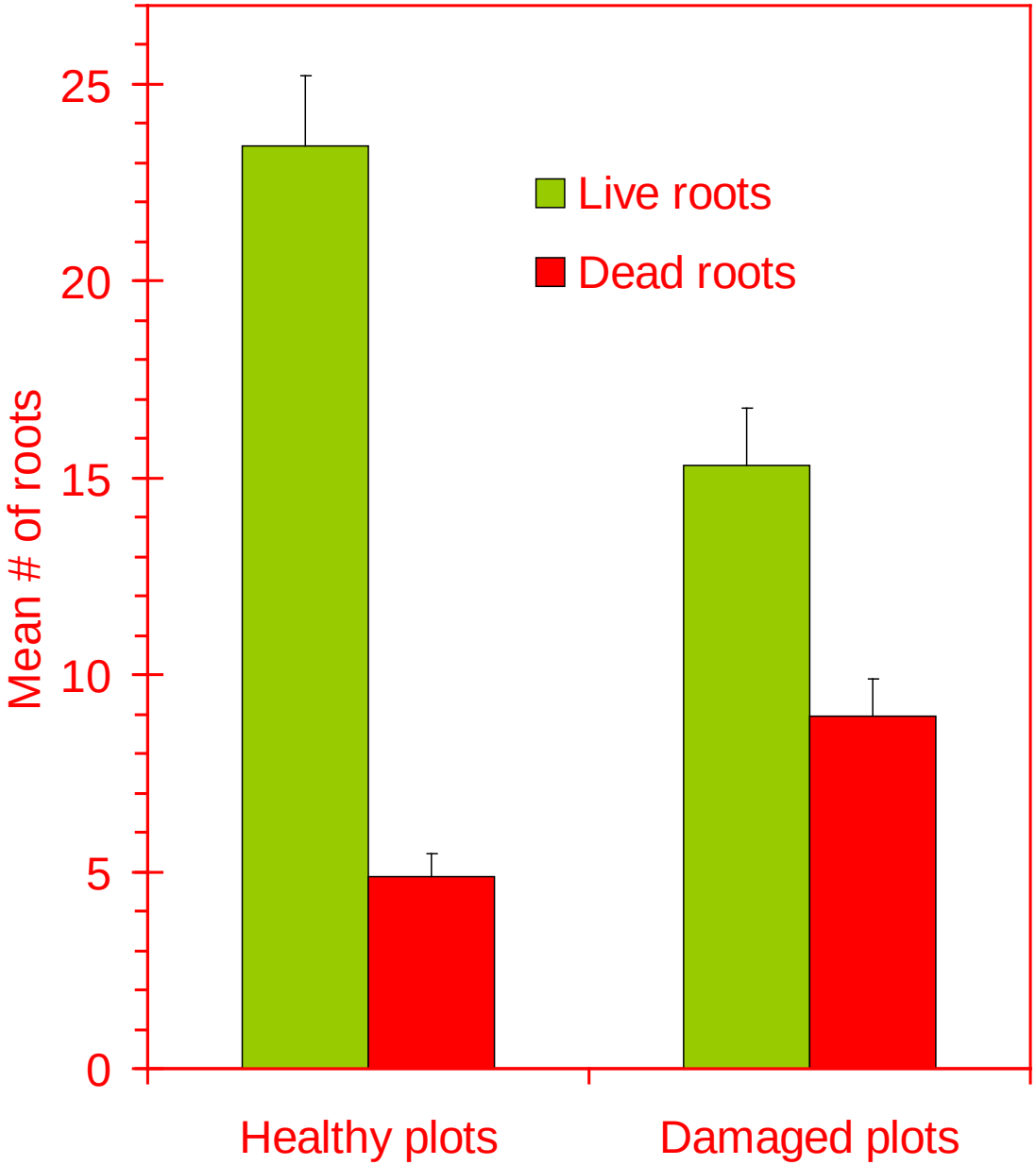
- 162 plots, pairing "healthy" and damaged
- Trees
  - Stand parameters
  - Recent crown loss
  - Increment cores (age, growth changes)
  - Biotic agents
- Quantify live and dead roots
- Regeneration
- Soil pit
- Vegetation

Funded by
USFS Forest Health Monitoring, Evaluation Monitoring

Regeneration low, no increase with mortality

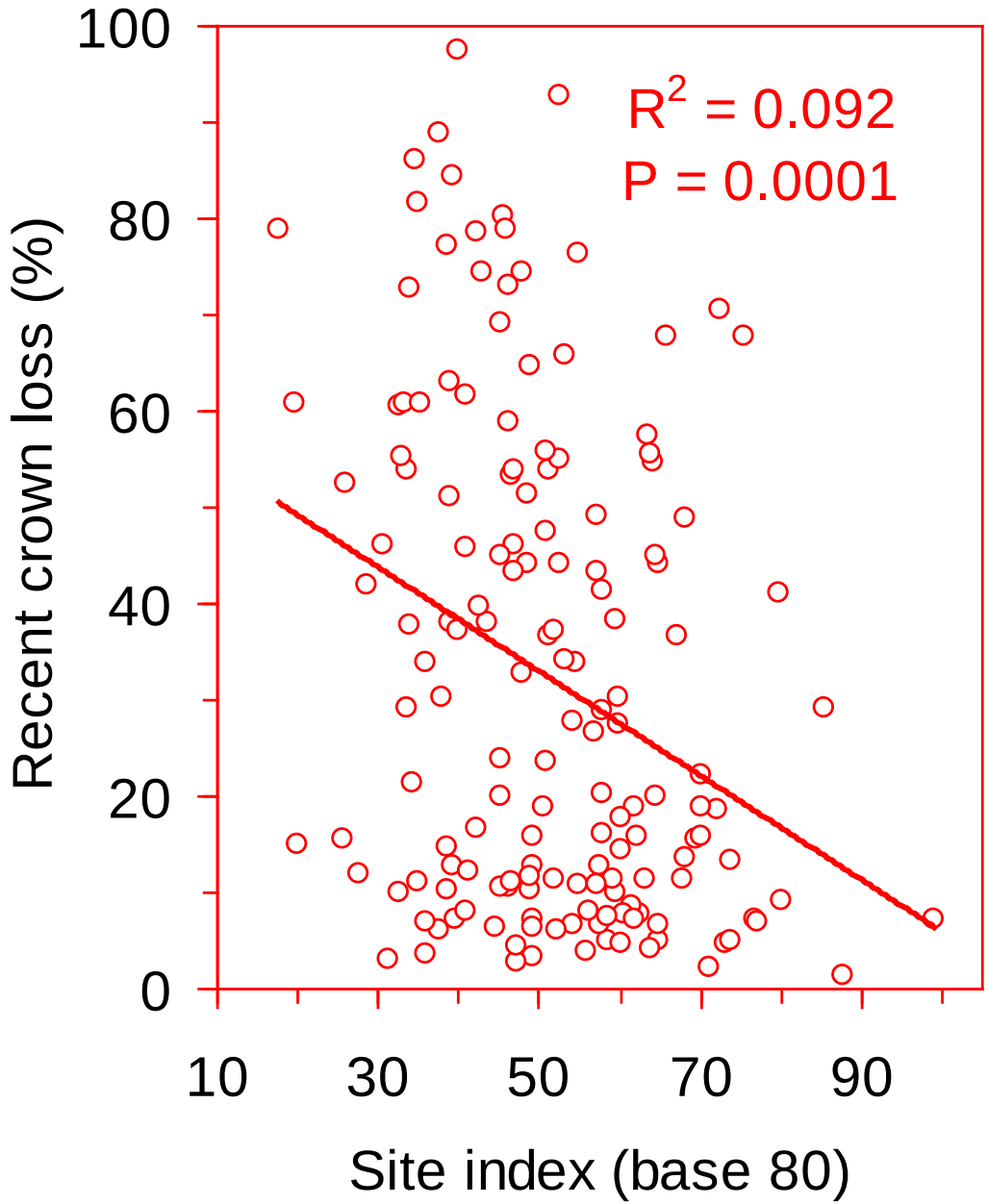


Average regen. in uncut, intact stands in SW Colorado: **2,500 ha^{-1}** (Crouch 1983)



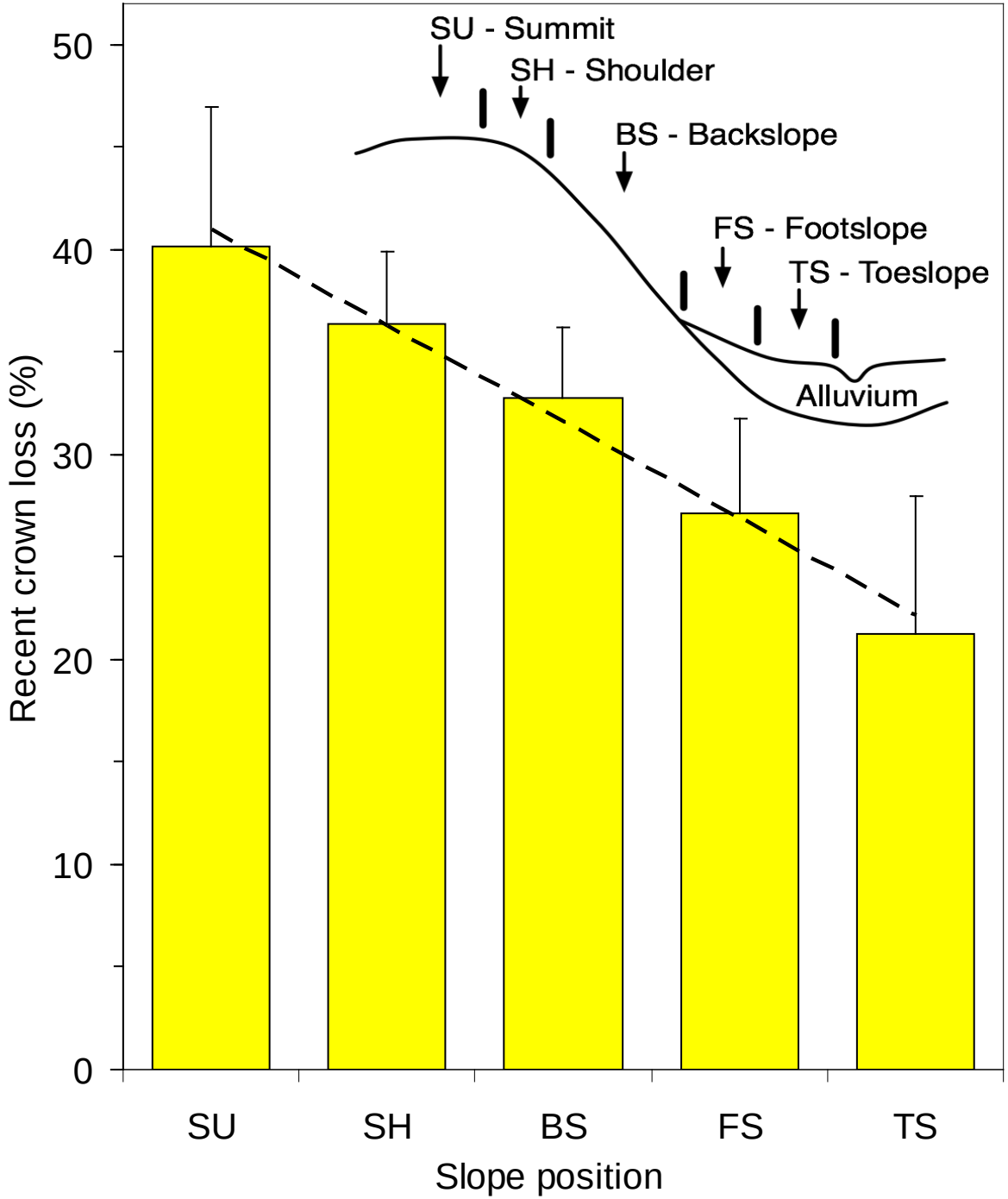
Roots are dying in many SAD stands

Both live and dead roots differ significantly between healthy and damaged plots



Lower site index → more SAD

Regression highly significant, but site index only explains about 9% of variation in crown loss



Higher slope positions → more SAD

One analysis shows summits have significantly higher crown loss than toeslopes, otherwise not significant

Climate – the "smoking gun"

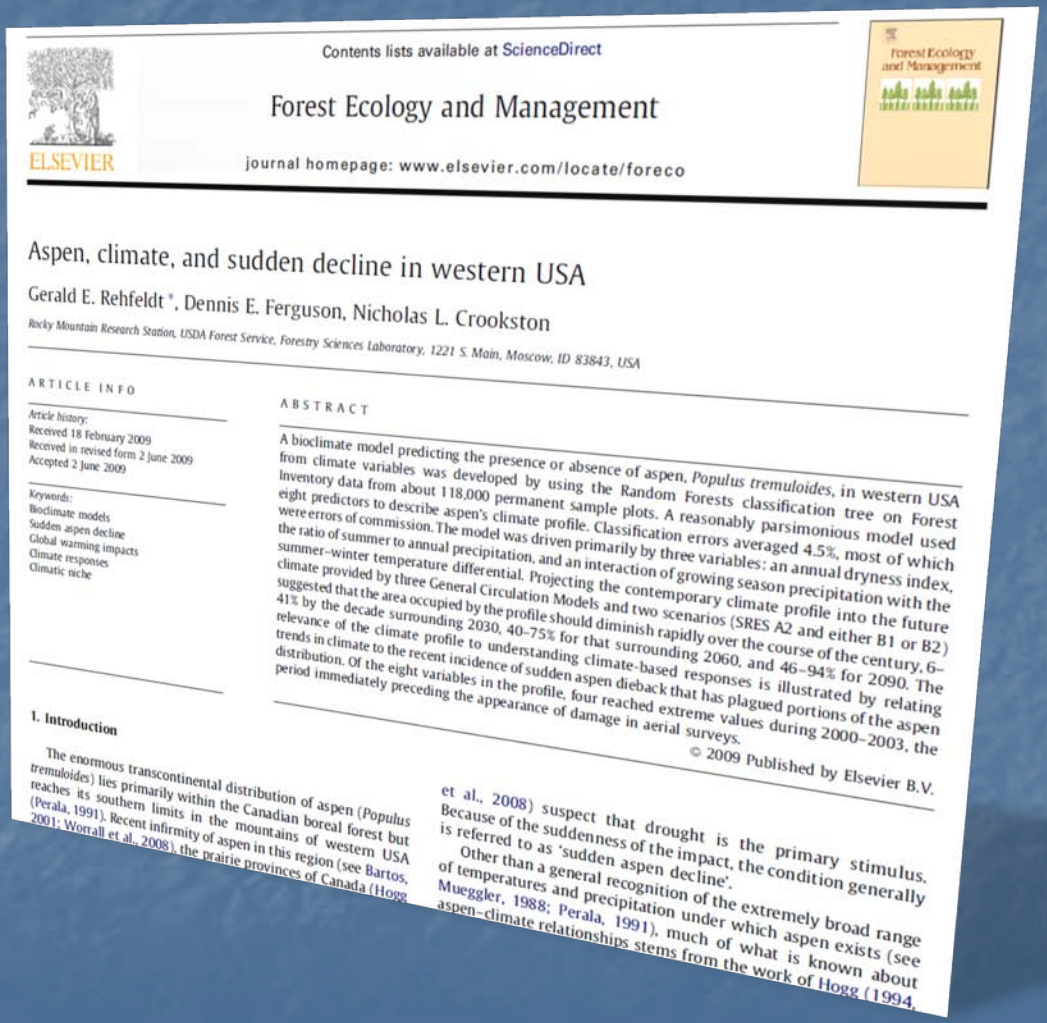
- Climate moisture index (CMI)
  - Precipitation ÷ evapotranspiration
- 2002 hydrologic year CMI vs 2008 aspen status

- Results
  - CMIs all negative (moisture deficit)
  - Damaged aspen consistently had lower CMI than healthy
  - Worst was San Juan, where SAD first appeared

Climate Moisture Index of Aspen		
	Healthy	Damaged
Grand Mesa	-14.2	-16.2
Gunnison	-29.7	-31.8
Uncompahgre	-33.1	-39.1
San Juan	-36.4	-44.6

Climate – the “smoking cannon”

- 2002 had the most extremely unfavorable climate based on indices of climate favorability for aspen
- Sites with SAD are at the fringe of aspen’s climate niche
- Lower elevation suitable for aspen expected to rise 250 m by 2030; 750 m by 2090
- Based on climate change models, 58% of sites with SAD will be outside aspen’s climate profile by 2030; 76% by 2060



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Aspen, climate, and sudden decline in western USA

Gerald E. Rehfeldt *, Dennis E. Ferguson, Nicholas L. Crookston

Rocky Mountain Research Station, USDA Forest Service, Forestry Sciences Laboratory, 1221 S. Main, Moscow, ID 83843, USA

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ABSTRACT

A bioclimate model predicting the presence or absence of aspen, *Populus tremuloides*, in western USA from climate variables was developed by using the Random Forests classification tree on Forest Inventory data from about 118,000 permanent sample plots. A reasonably parsimonious model used eight predictors to describe aspen's climate profile. Classification errors averaged 4.5%, most of which were errors of commission. The model was driven primarily by three variables: an annual dryness index, the ratio of summer to annual precipitation, and an interaction of growing season precipitation with the summer–winter temperature differential. Projecting the contemporary climate profile into the future climate provided by three General Circulation Models and two scenarios (SRES A2 and either B1 or B2) suggested that the area occupied by the profile should diminish rapidly over the course of the century, 6–41% by the decade surrounding 2030, 40–75% for that surrounding 2060, and 46–94% for 2090. The relevance of the climate profile to understanding climate-based responses is illustrated by relating trends in climate to the recent incidence of sudden aspen dieback that has plagued portions of the aspen distribution. Of the eight variables in the profile, four reached extreme values during 2000–2003, the period immediately preceding the appearance of damage in aerial surveys.

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1. Introduction

The enormous transcontinental distribution of aspen (*Populus tremuloides*) lies primarily within the Canadian boreal forest but reaches its southern limits in the mountains of western USA (Perala, 1991). Recent infirmity of aspen in this region (see Bartos, 2001; Worrall et al., 2008) the prairie provinces of Canada (Hogg et al., 2008) suspect that drought is the primary stimulus. Because of the suddenness of the impact, the condition generally is referred to as 'sudden aspen decline'.

Other than a general recognition of the extremely broad range of temperatures and precipitation under which aspen exists (see Mueggler, 1988; Perala, 1991), much of what is known about aspen–climate relationships stems from the work of Hogg (1994,

Summary

1. Predisposing factors: warm, dry site and stand conditions
   - Low elevations
   - South/west slopes
   - Upper slope positions
   - Low site index
   - Dry vegetation types
2. In CO first noticed in 2004, two years after “global-change-type drought” *
3. Climate moisture index for 2002
   - Consistently greater H_2O deficit in damaged than in healthy areas
   - Deficit most severe where SAD appeared first.
4. Rehfeldt *et al.* – SAD consistent with and following pattern predicted for early climate change effects

* Breshears, *et al.* 2005. Regional vegetation die-off in response to global-change-type drought. Proc. National Academy Sciences USA 102, 15144-15148.

“The trees got hit hard by the drought,

they put out the stress vibe,

and here comes every little cootie in the world.”

— Gail Bertram, Mancos resident,
Rocky Mountain News
Sept. 11 2006

Mortality agents

- NOT involved: typical killers of mature, vigorous aspen
  - sooty-bark canker, mottled white root rot
- Group of typically 2° agents in various combinations
  - Cytospora canker
  - poplar borer
  - bronze poplar borer
  - aspen bark beetles

Trypophloeus populi