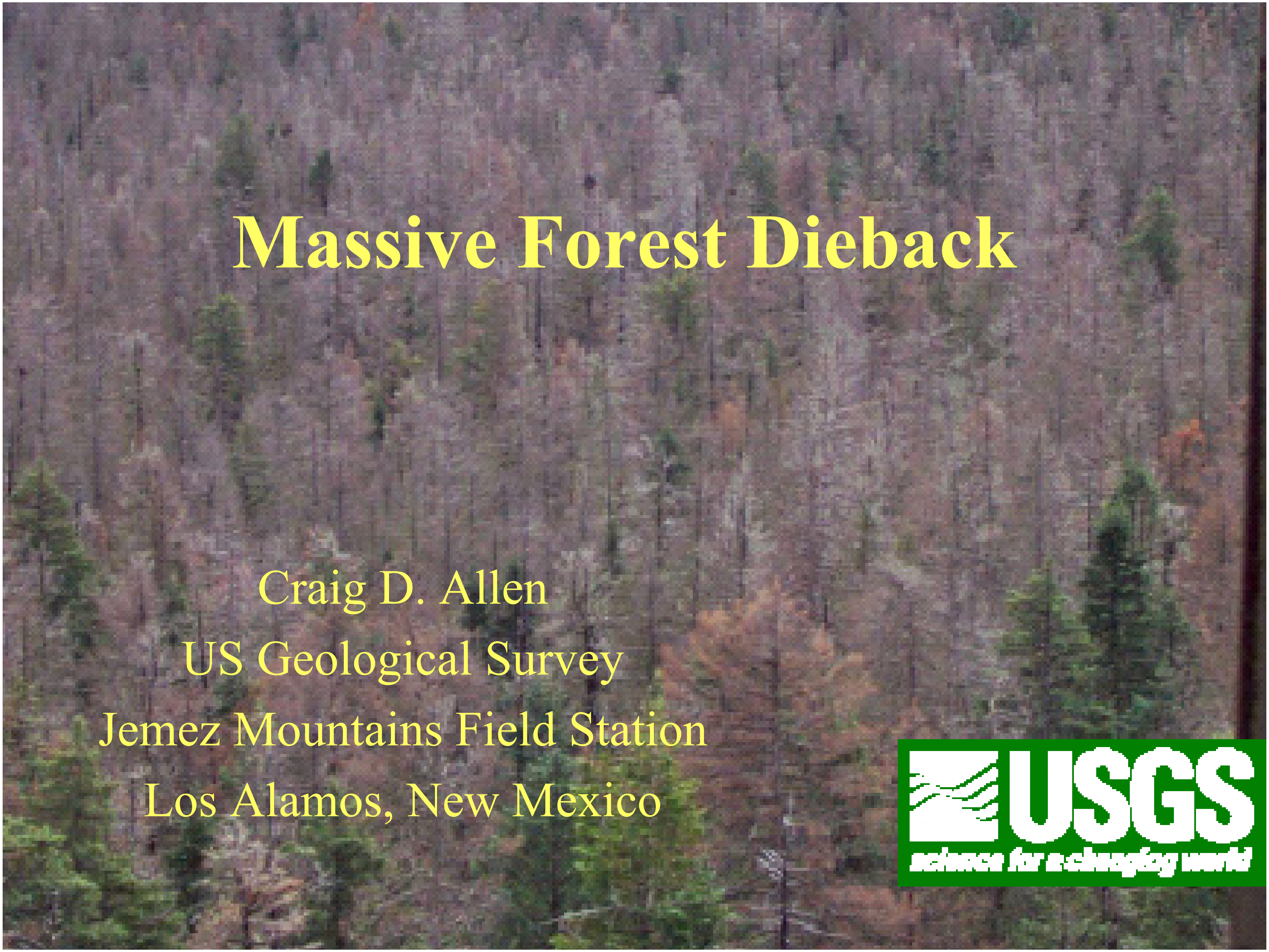

Massive Forest Dieback
Craig D. Allen
US Geological Survey
Jemez Mountains Field Station
Los Alamos, New Mexico
USGS
science for a changing world

“Massive Forest Dieback” (MFD) is defined here as tree mortality that is:

1) **Extensive – landscape to regional in scale.**
2) **Rapid – occurs in months to years (subdecadal).**
3) **Related to environmental stress (especially climate), including biotic feedbacks like insect and disease outbreaks.**

This talk will:

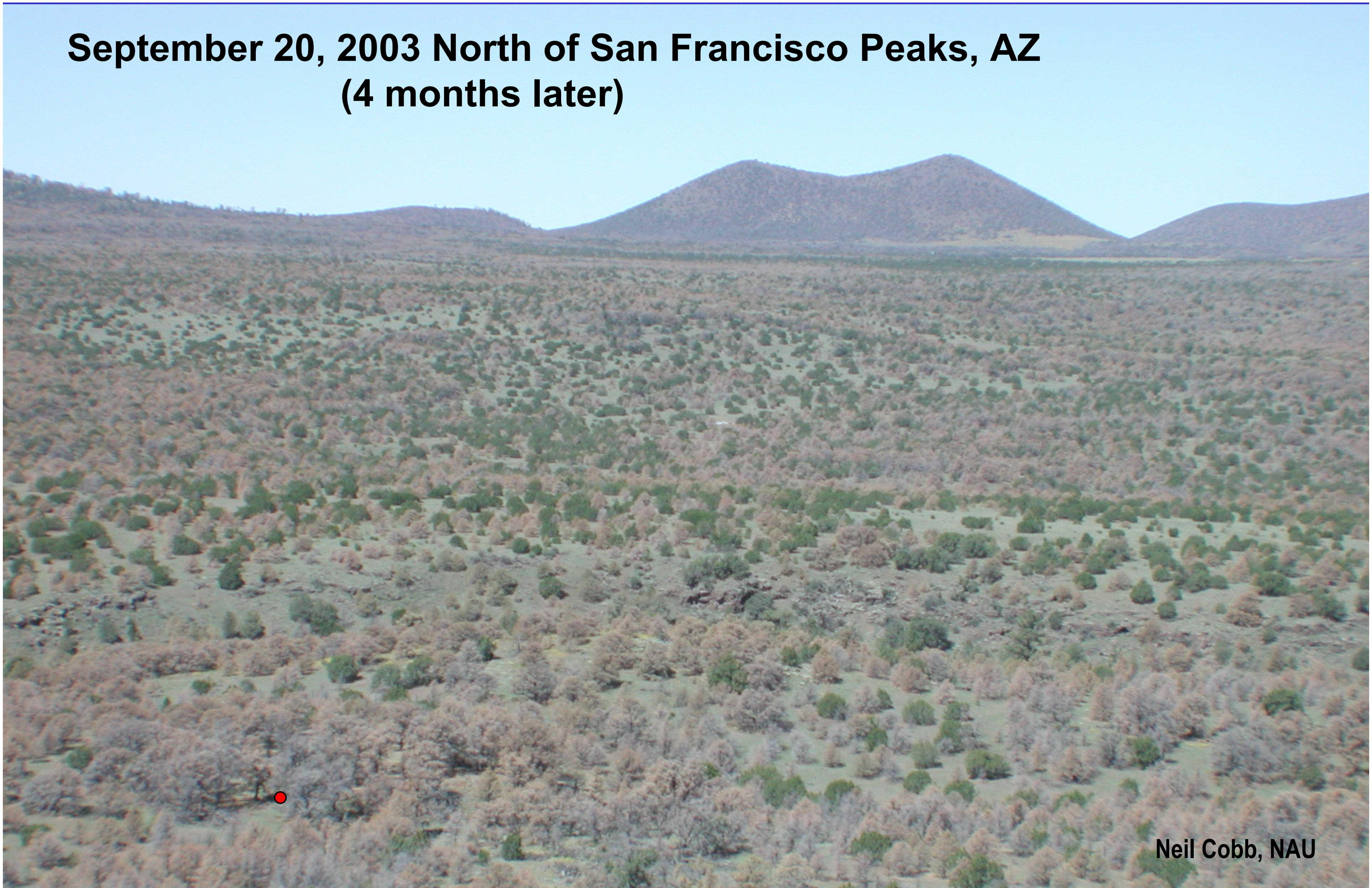
1) **Illustrate past and ongoing examples of MFD.**

2) **Review uncertainties and knowledge gaps in the causes of MFD.**

3) **Consider risk of increases in MFD with projected global climate changes.**

Trees are long-lived dominants, once established they have lots of inertia, tend to tolerate environmental stress and persist.

So forests are often thought of as slow-changing, gradually adjusting to new climate conditions through competition and establishment.



But, once thresholds of environmental stress are exceeded, rapid changes can occur through *massive forest dieback*.

Causes of Massive Forest Dieback include:

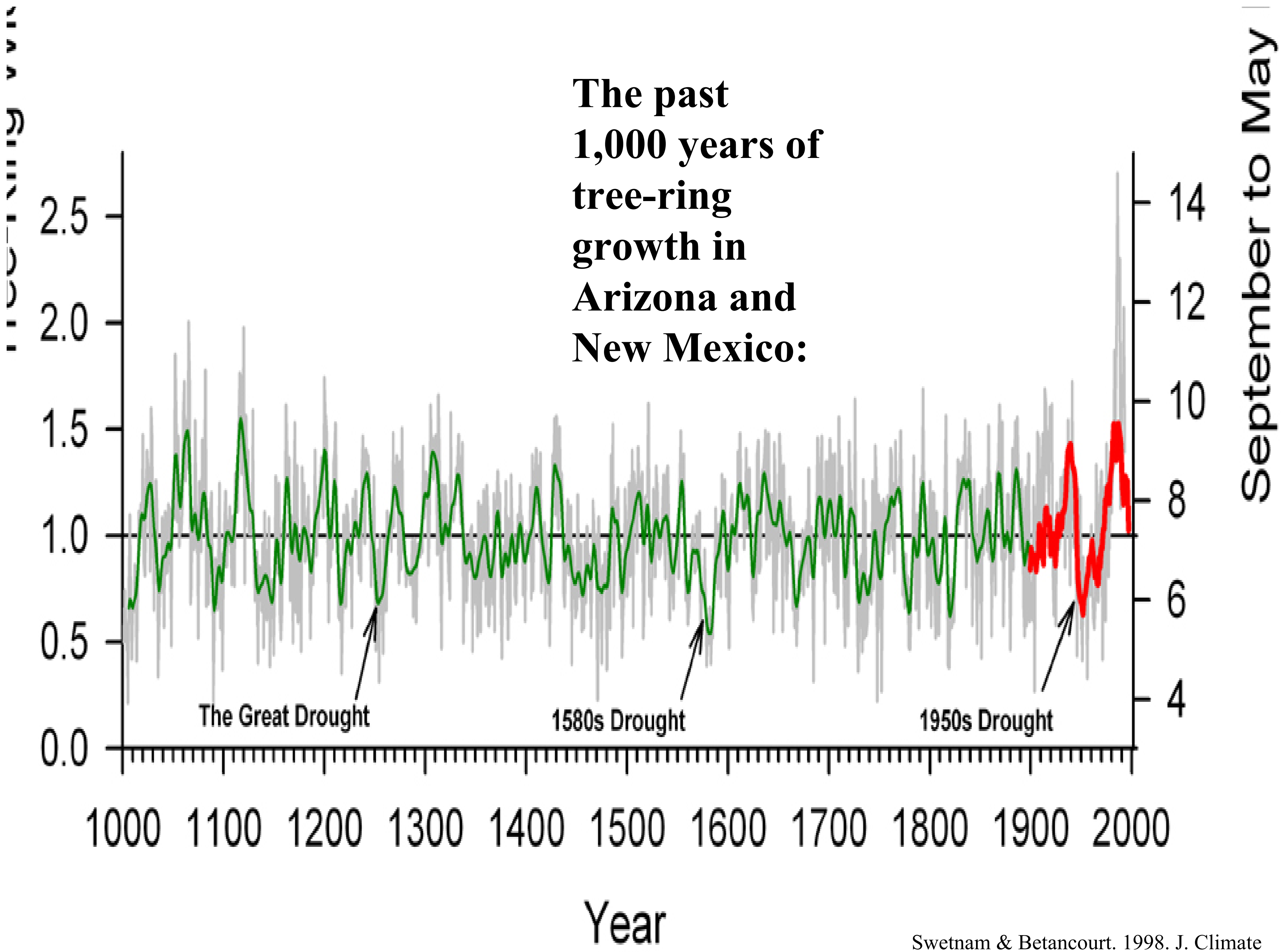
1) ***Direct*** **tree mortality through** ***extreme*** **climate events (especially drought, but also extreme heat or cold).**

2) **Decreased tree vigor through** ***cumulative effects of chronic environmental stress*****, like moderate intensity but long-term drought or air pollution.**

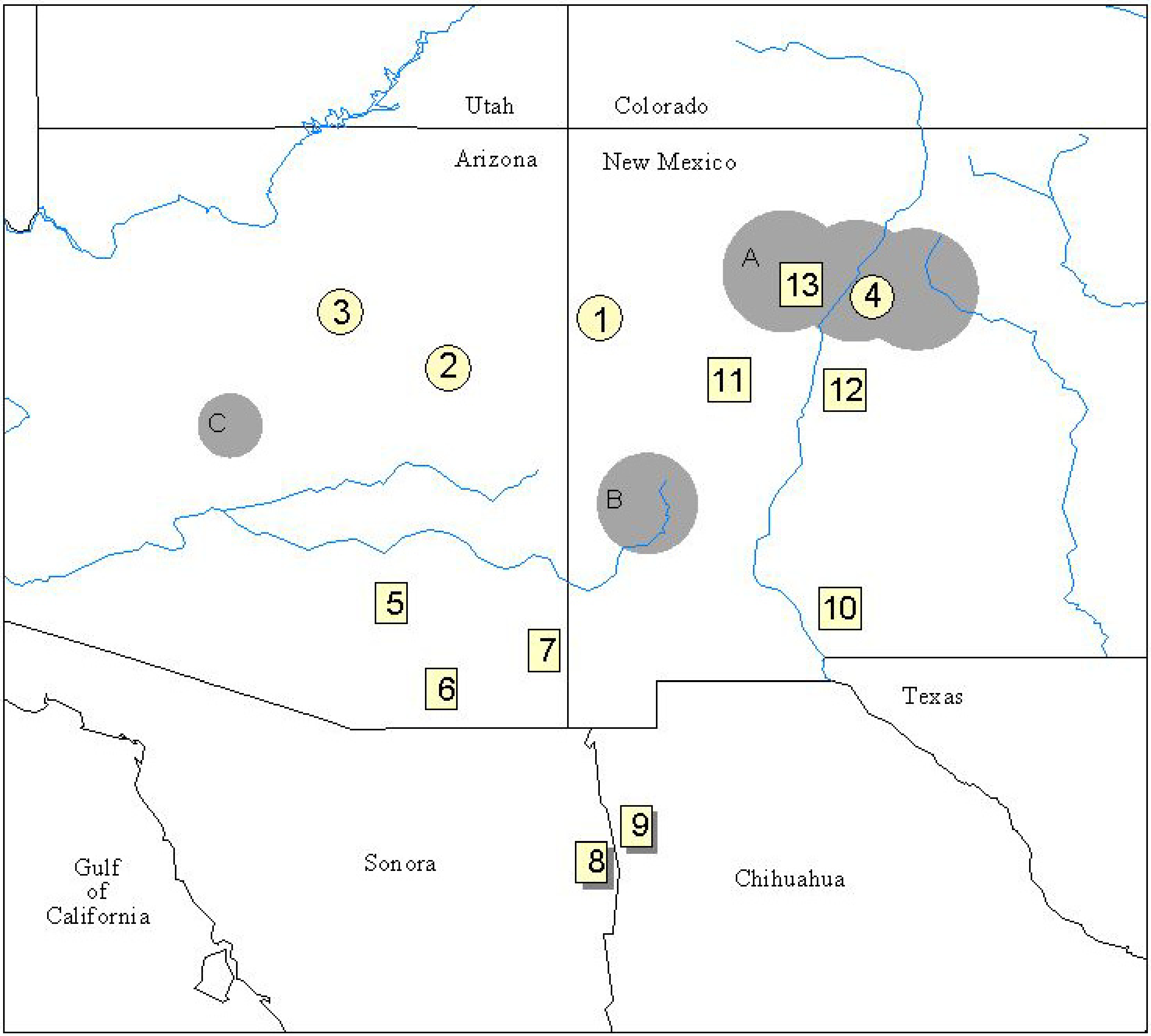
3) ***Climate-amplified feedbacks with other mortality agents*****, such as insect or disease outbreaks in climate-stressed forests. It's often hard to disentangle the role of insects from direct climate stress, as insects selectively attack weakened trees, and insect outbreaks have their own complex ecological dynamics associated with climate, host species, and predators.**

Fire-caused forest mortality not addressed here.

The past 1,000 years of tree-ring growth in Arizona and New Mexico:



Swetnam & Betancourt. 1998. J. Climate

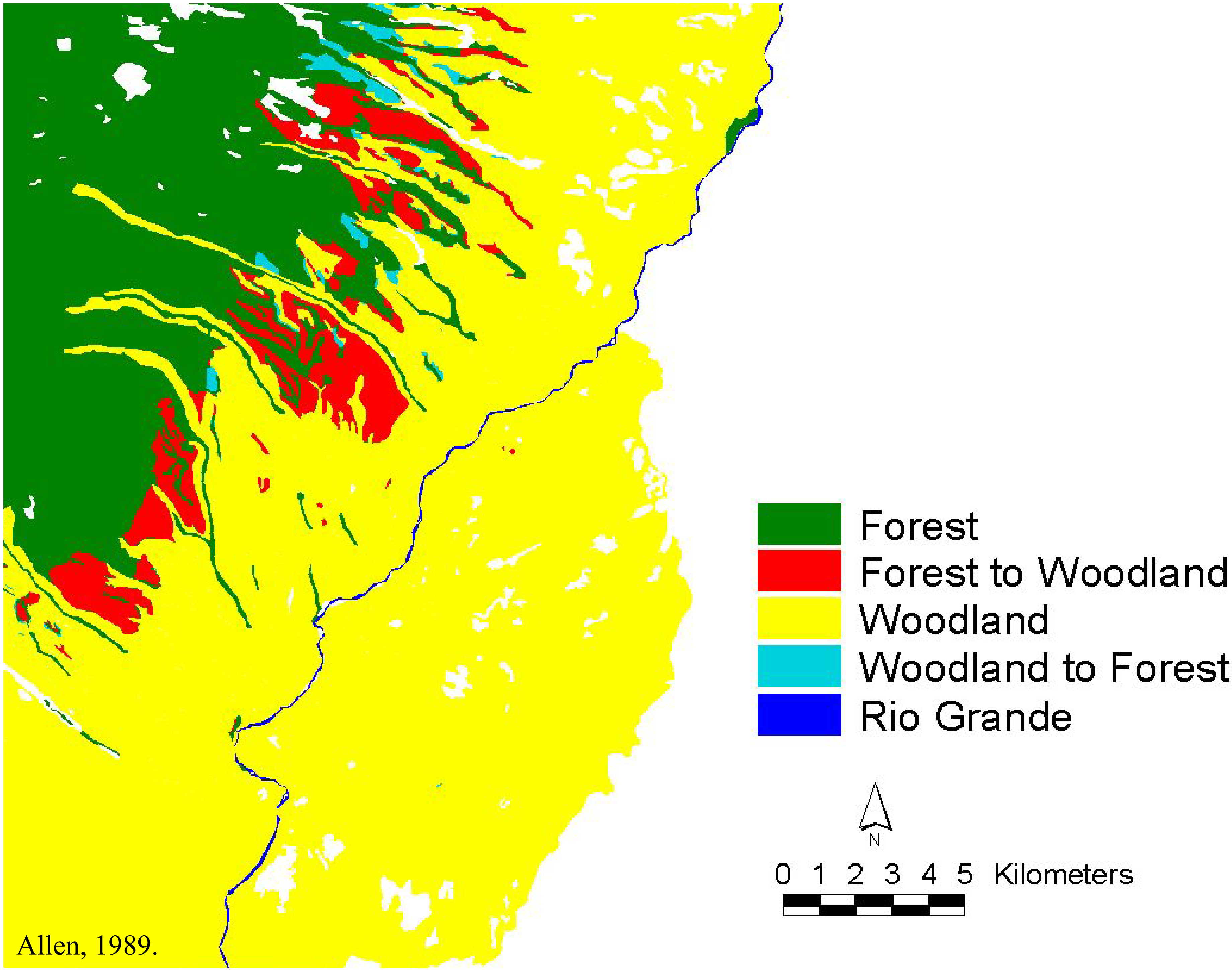


Sites with documentary evidence of substantial forest mortality during the 1950s drought.

Allen and Breshears, in press

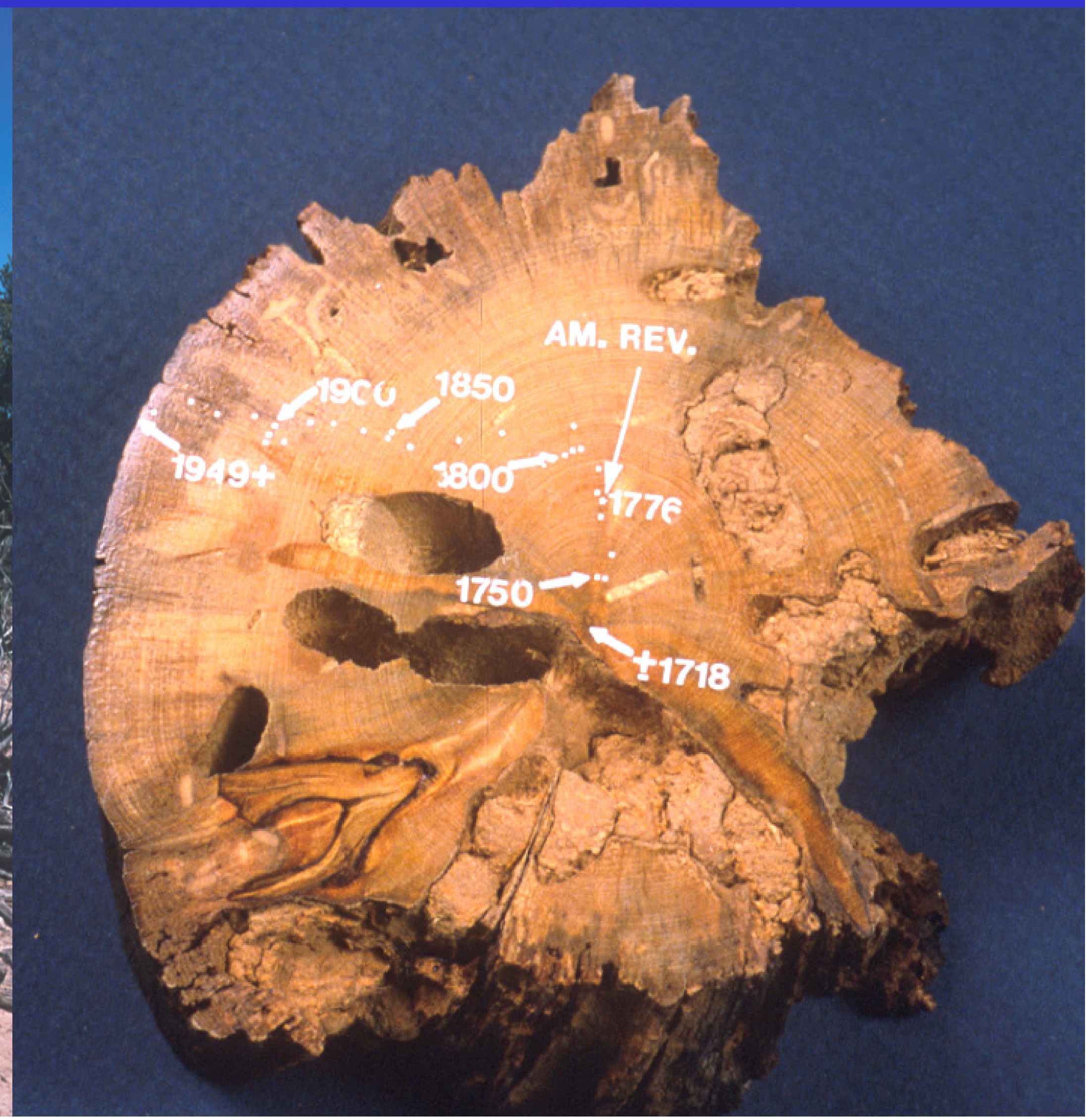
SEVERE DROUGHT DURING THE 1950S CAUSED THE LOWER FRINGES OF THE PONDEROSA PINE ZONE TO DIE BACK IN THE JEMEZ MTS.

THIS ECOTONE SHIFT OF AS MUCH AS 2 KM IN LESS THAN 5 YEARS LEFT STANDS DOMINATED BY PINYON-JUNIPER WOODLAND.

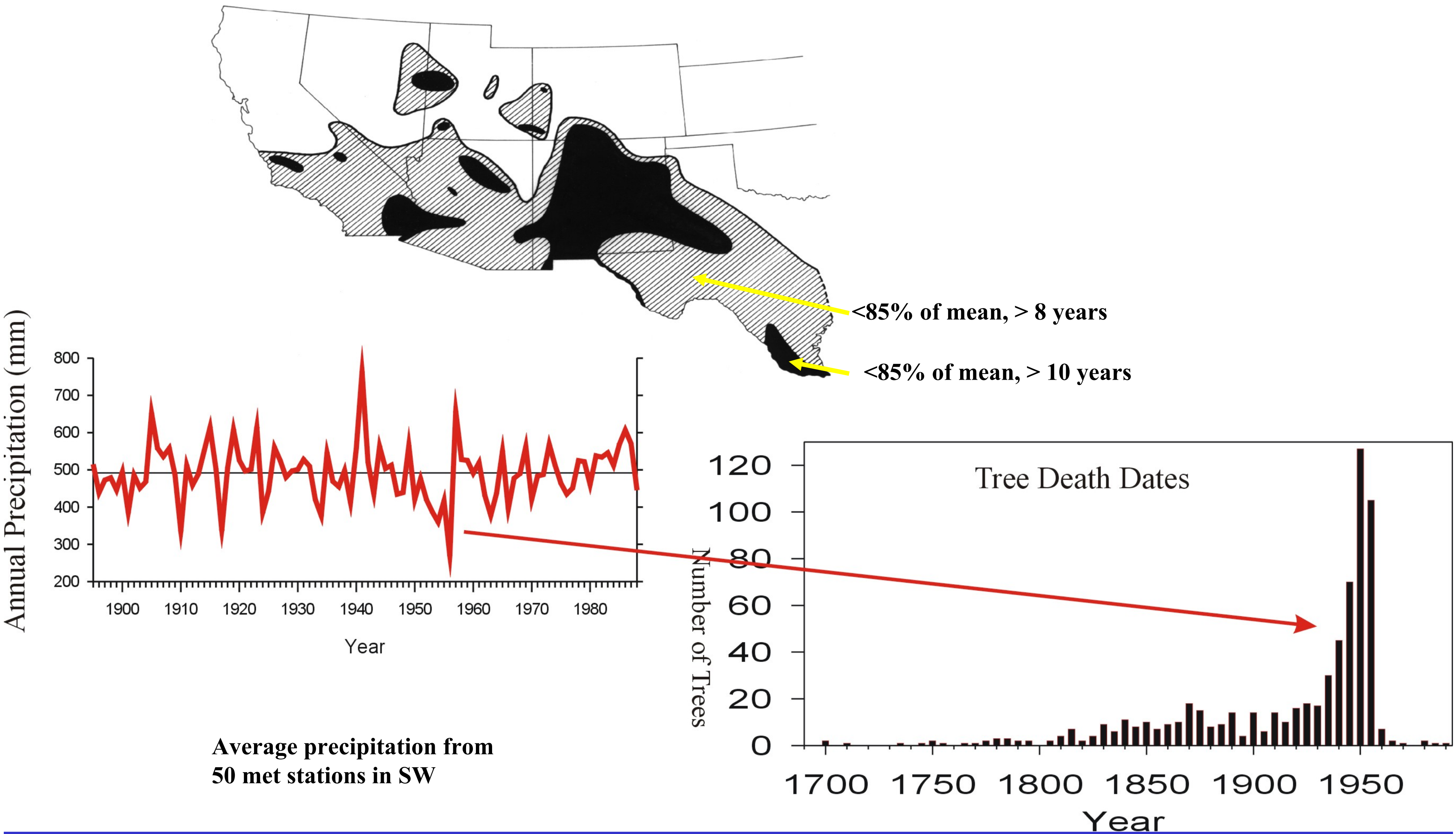

Forest
Forest to Woodland
Woodland
Woodland to Forest
Rio Grande
N
0 1 2 3 4 5 Kilometers
Allen, 1989.

Recent studies on *Pinus edulis* mortality and natality have included extensive sampling of all live and dead pinyon in multiple plots in 5 different mountain ranges in the Southwest.

Source: Tom Swetnam.



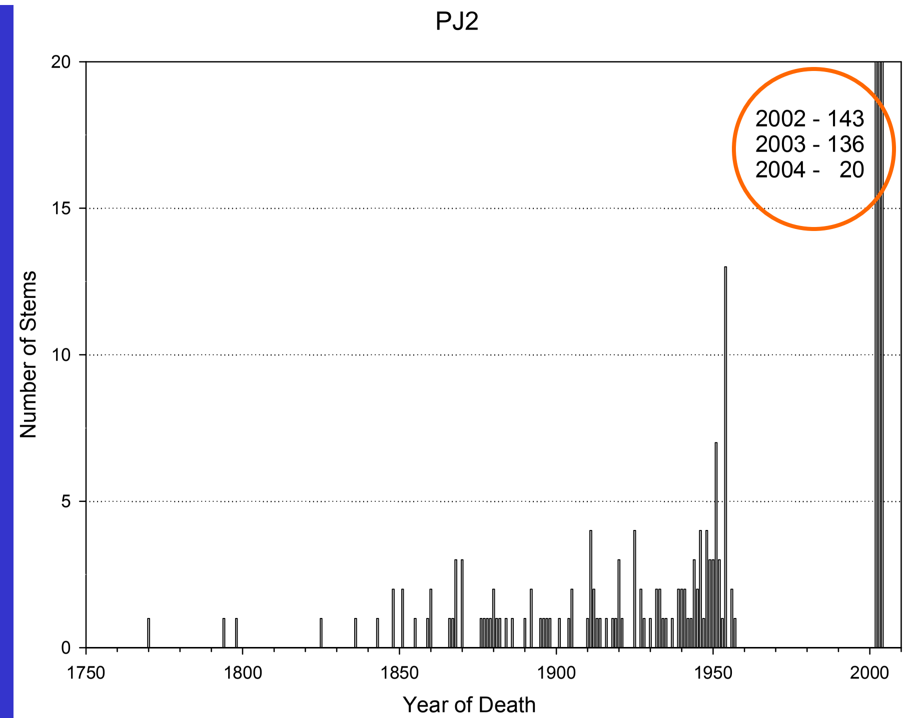
1950s Drought and Pinyon Pine Dieoff



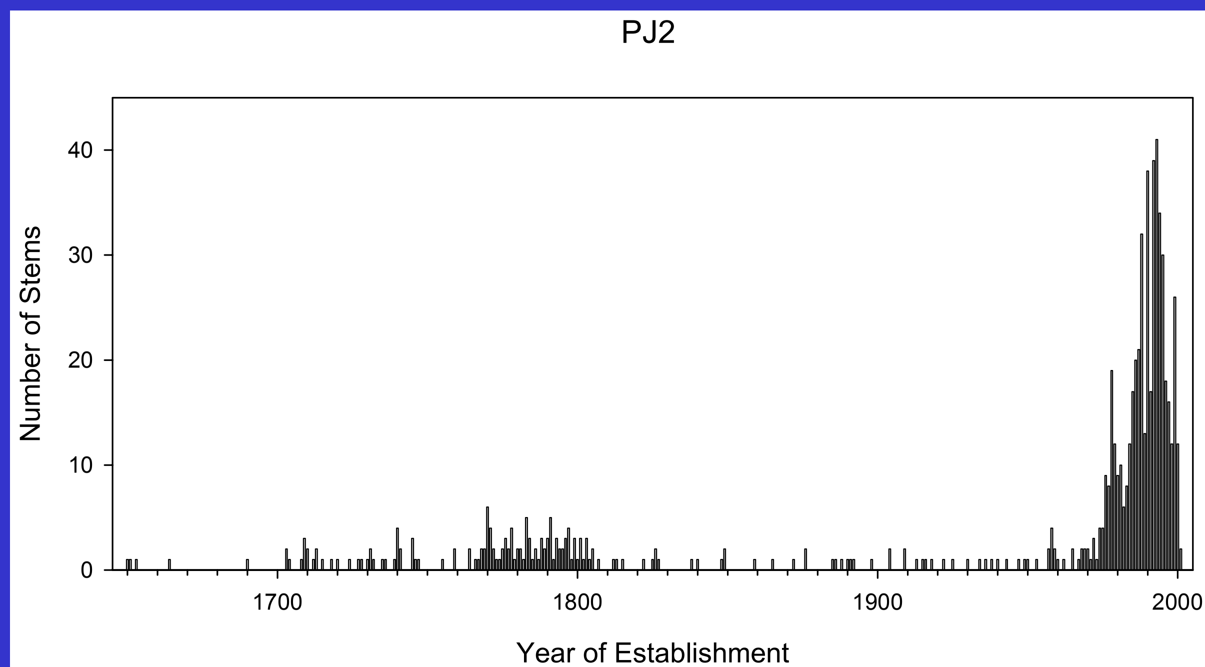
Swetnam & Betancourt. 1998. J. Climate

Data for all Pinyon on a 100 X 50 m plot

Pulses of *mortality*

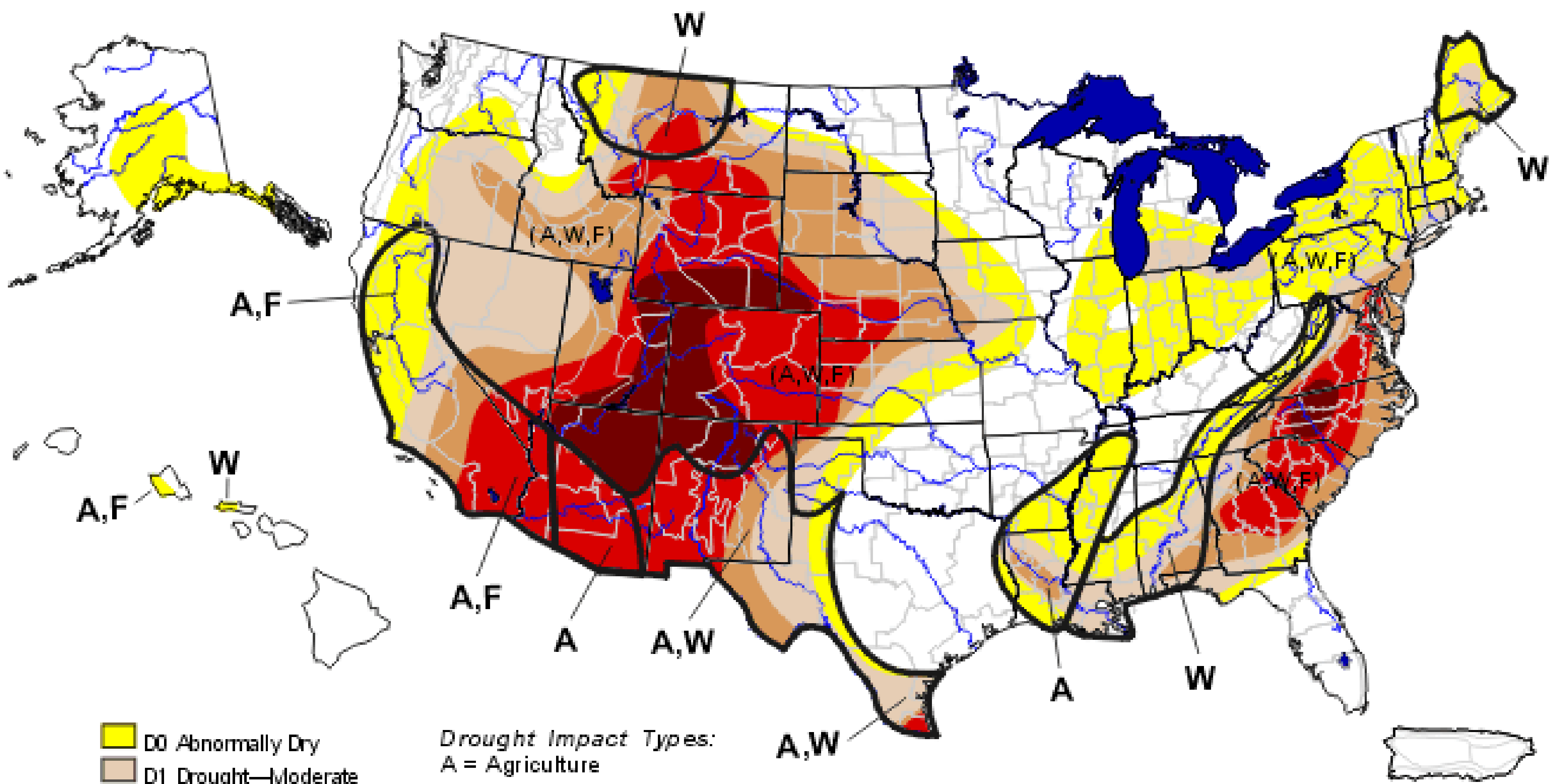


And interspersed pulses of *natality*



U.S. Drought Monitor

July 23, 2002
Valid 8 a.m. EDT



D0 Abnormally Dry
D1 Drought—Moderate
D2 Drought—Severe
D3 Drought—Extreme
D4 Drought—Exceptional

Drought Impact Types:
A = Agriculture
W = Water (Hydrological)
F = Fire danger (Wildfires)
Delineates dominant impacts
(No type = All 3 impacts)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

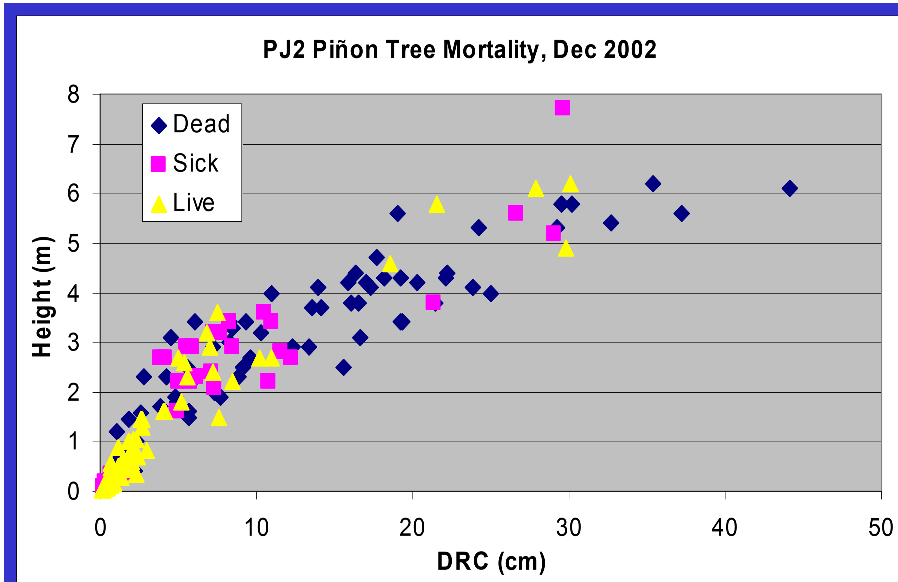
http://drought.unl.edu/dm

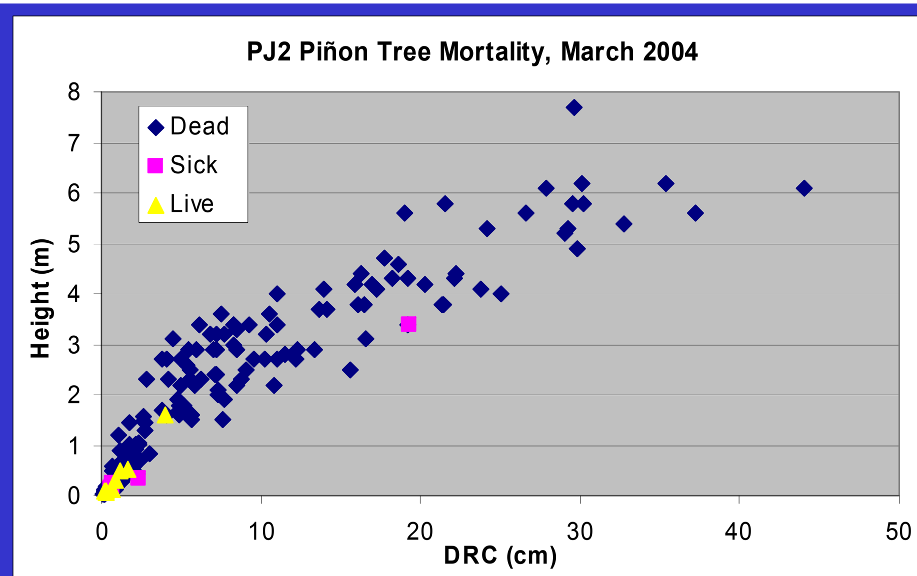
Released Thursday, July 25, 2002

Author: *Brad Rippey, USDA*

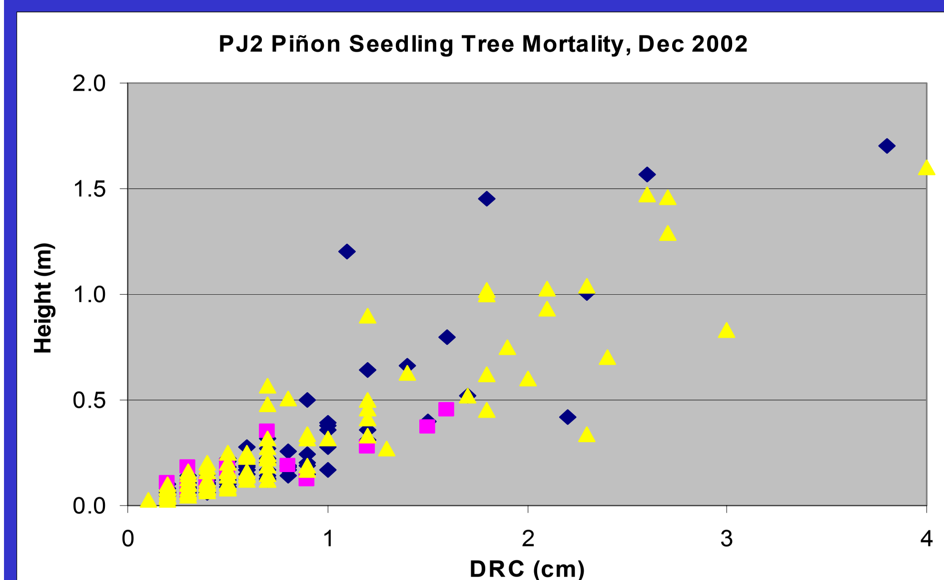
Pinyon (*Pinus edulis*), began dying *en masse* in summer 2002 from drought and an associated *Ips* bark beetle outbreak.

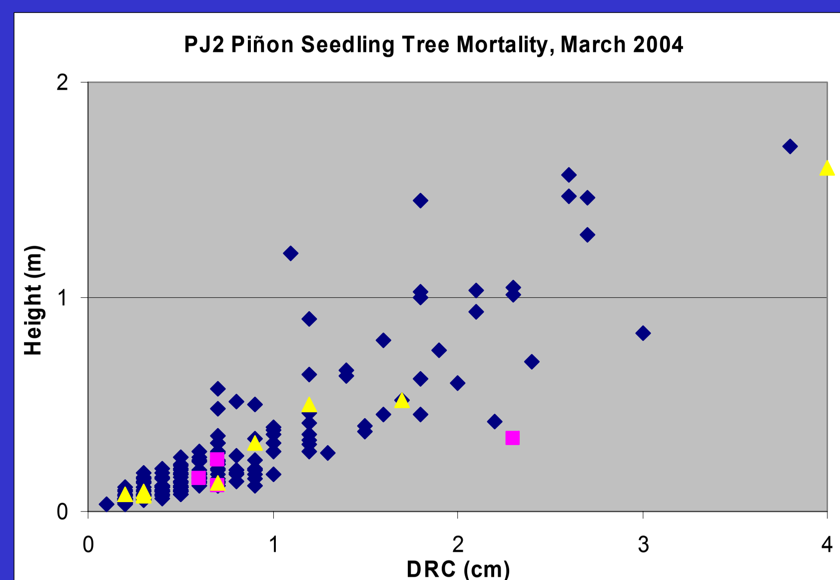
Jemez Mts. near Los Alamos, October 2002

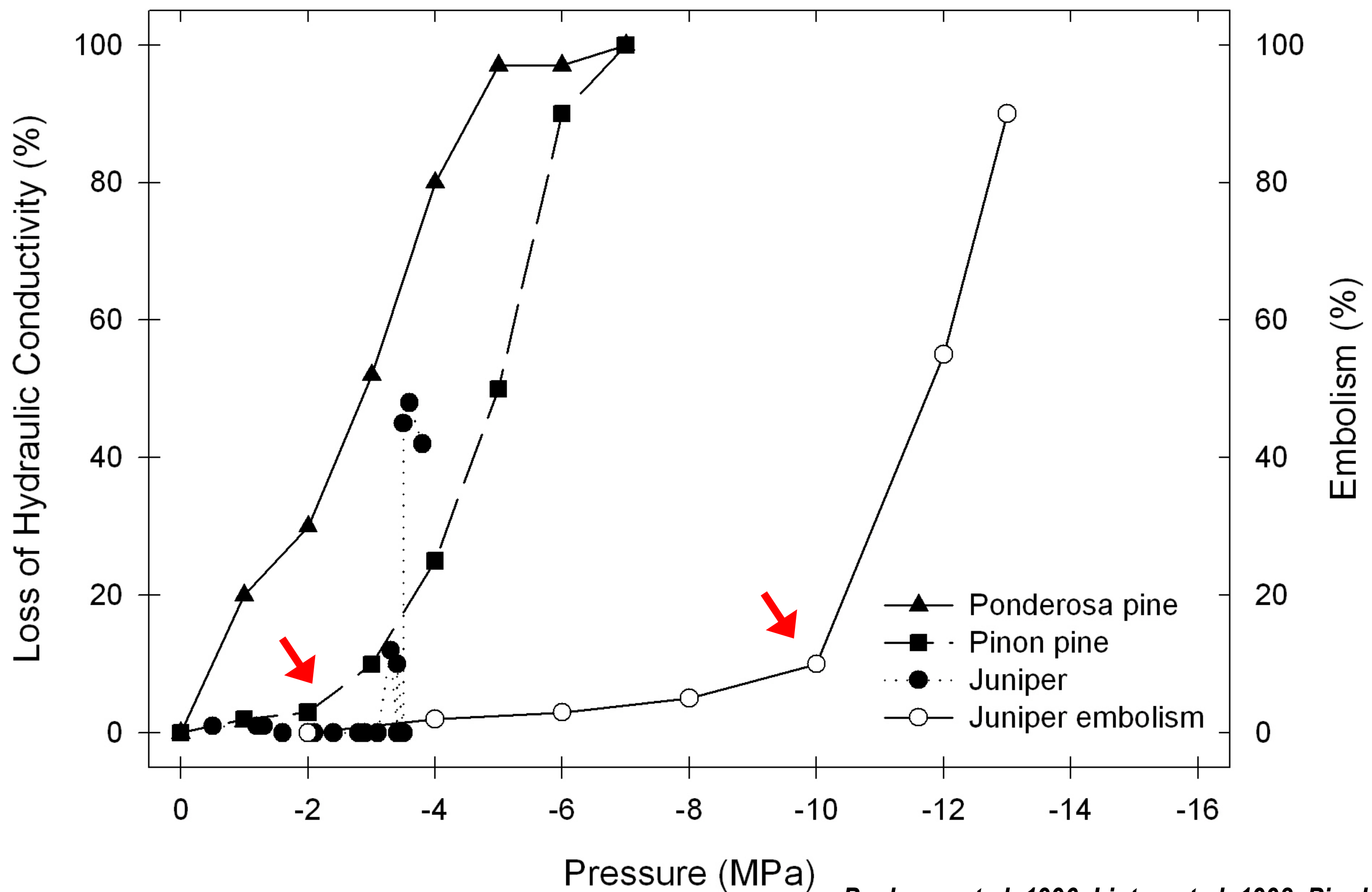




Bigger (older) trees tend to die first, with major demographic effects on residual stands. The current pinyon dieback is >> than the 1950s, taking 95+ % of all non-seedling size classes, and most seedlings.







Pockman et al. 1996, Linton et al. 1998, Pinol and Sala 2000

Extreme drought events (various combinations of magnitude, duration, and seasonal timing) can cause cavitation of the water column within stem conducting tissues due to water stress, leading to embolism and failure of hydraulic conductance, and thus tree death.

<u>These nonlinear, physiological thresholds of tree drought tolerance are species-specific, and mostly undetermined.</u>

Note failure of water conductance in pinyon at ~3 MPa, vs. juniper at > 10 MPa.

Generalized Drought Response Surfaces

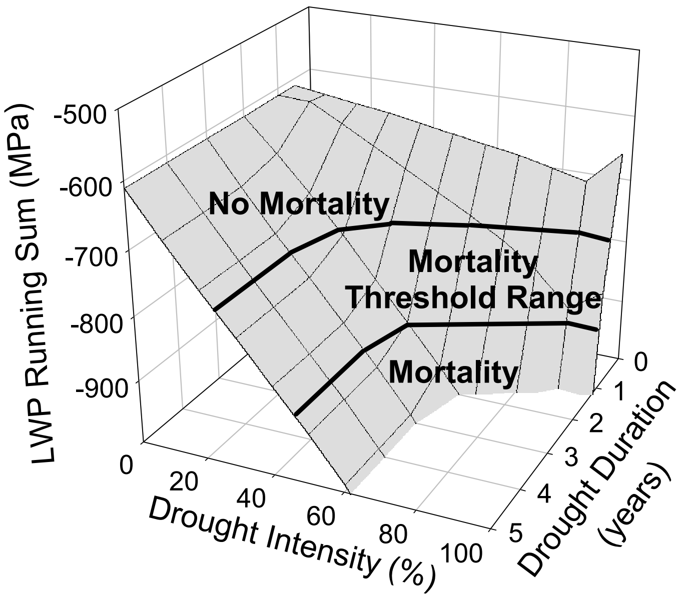
THE THRESHOLDS OF TREE TOLERANCE FOR DROUGHT INTENSITY AND DURATION ARE POORLY KNOWN.

WE'RE USING FOREST-BGC IN AN EFFORT TO MODEL THOSE LIMITS FOR THE OBSERVED PONDEROSA PINE MORTALITY IN THE 1950s DROUGHT.

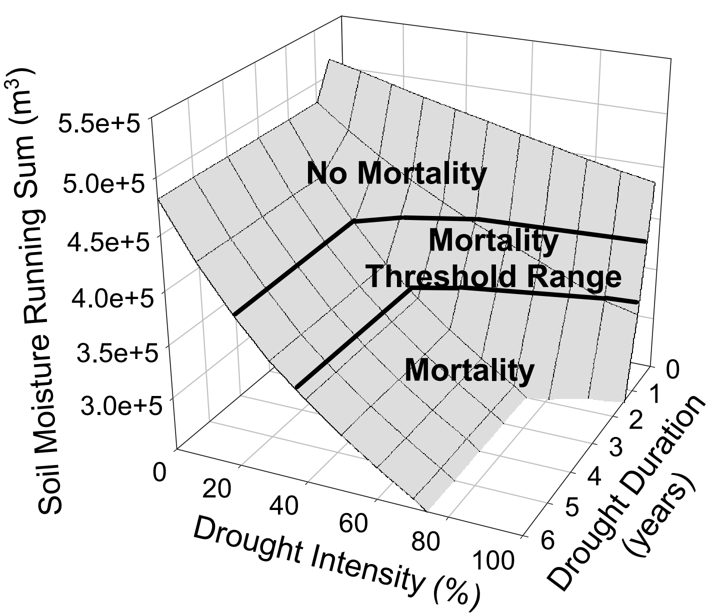
MUCH MORE SPECIES-SPECIFIC WORK OF THIS SORT IS NEEDED.

D.D. Breshears and C.D. Allen, in preparation

A. Leaf Water Potential

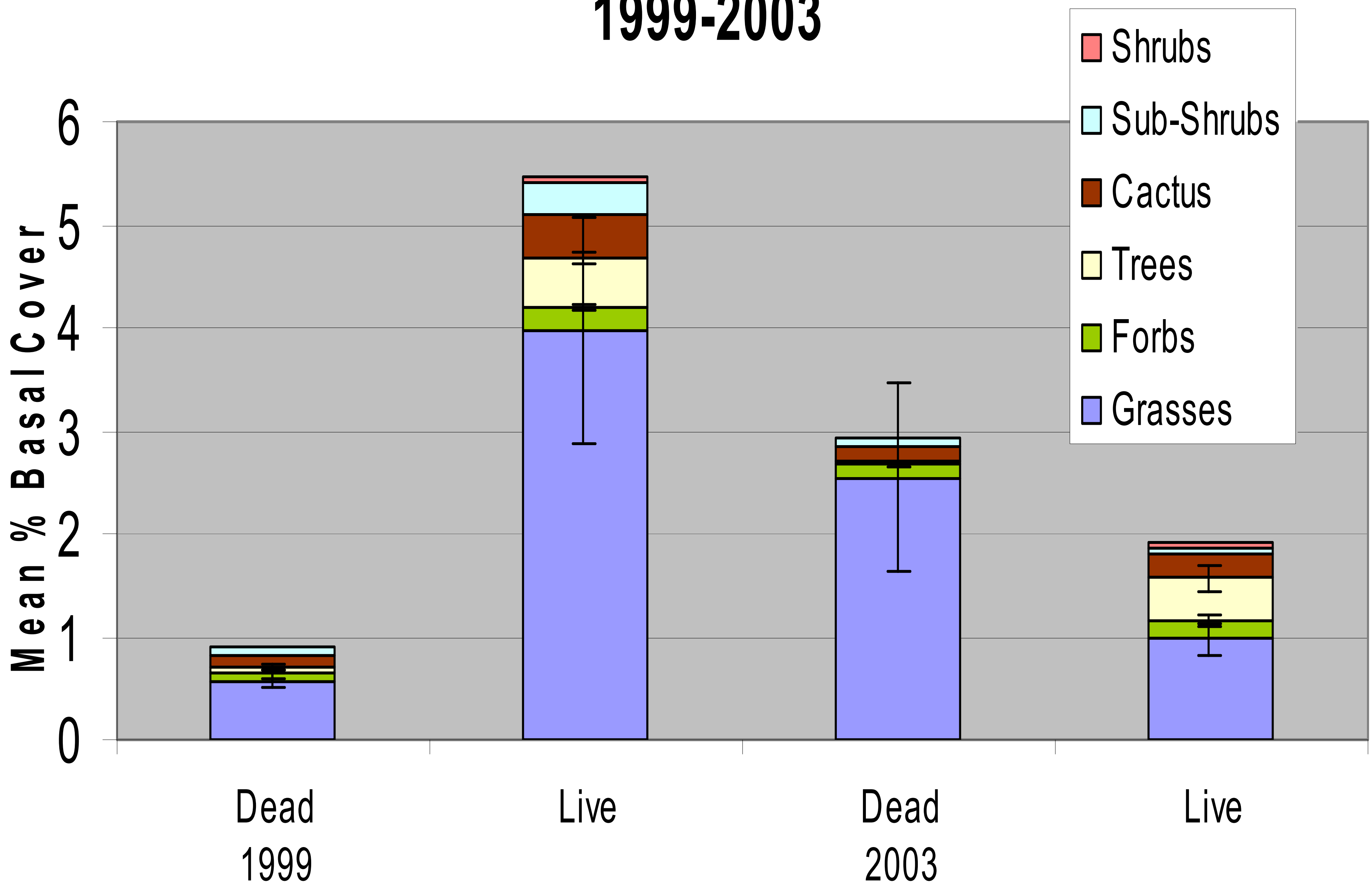


B. Soil Moisture



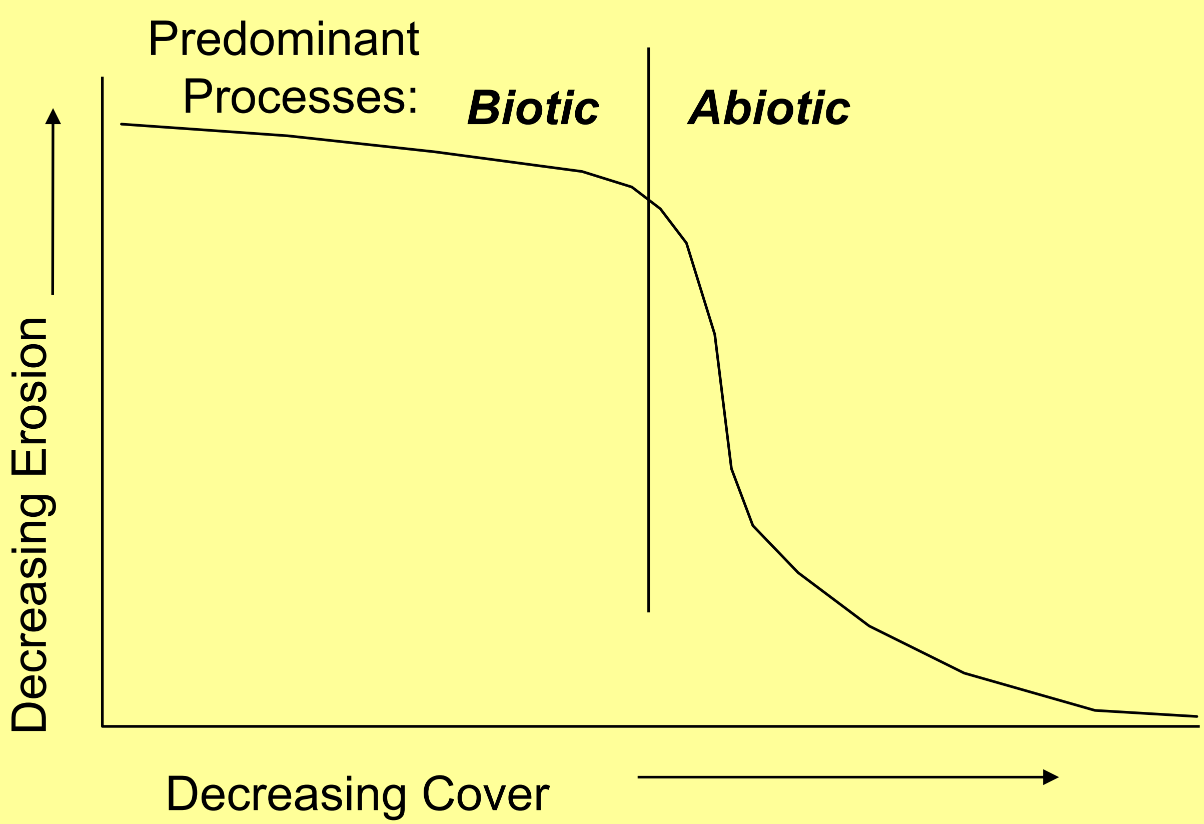
3 KM OF VEG TRANSECTS IN PJ WOODLANDS, BASELINE IN 1990.

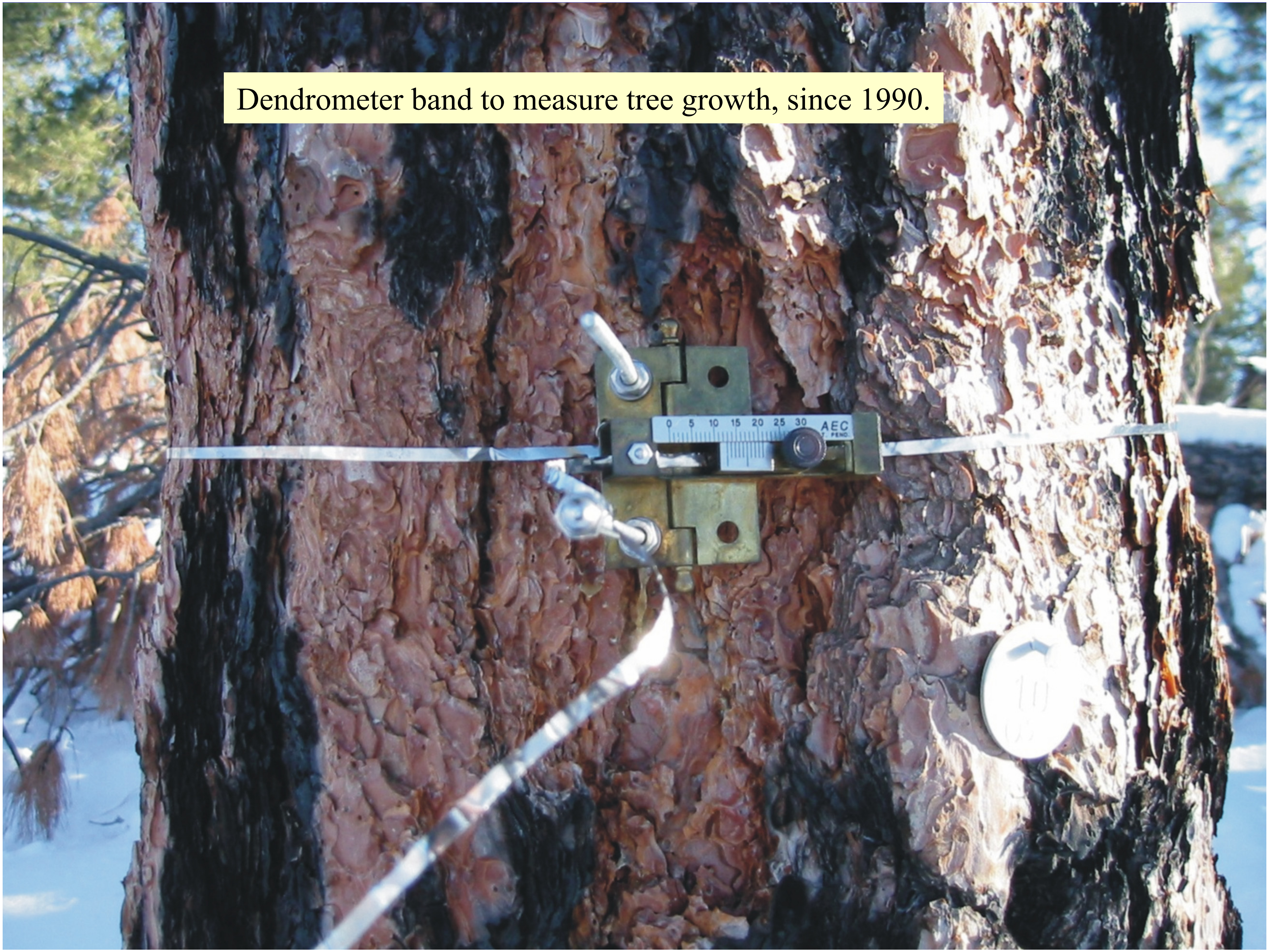
Mortality by Lifeform on PJ Transects 1999-2003



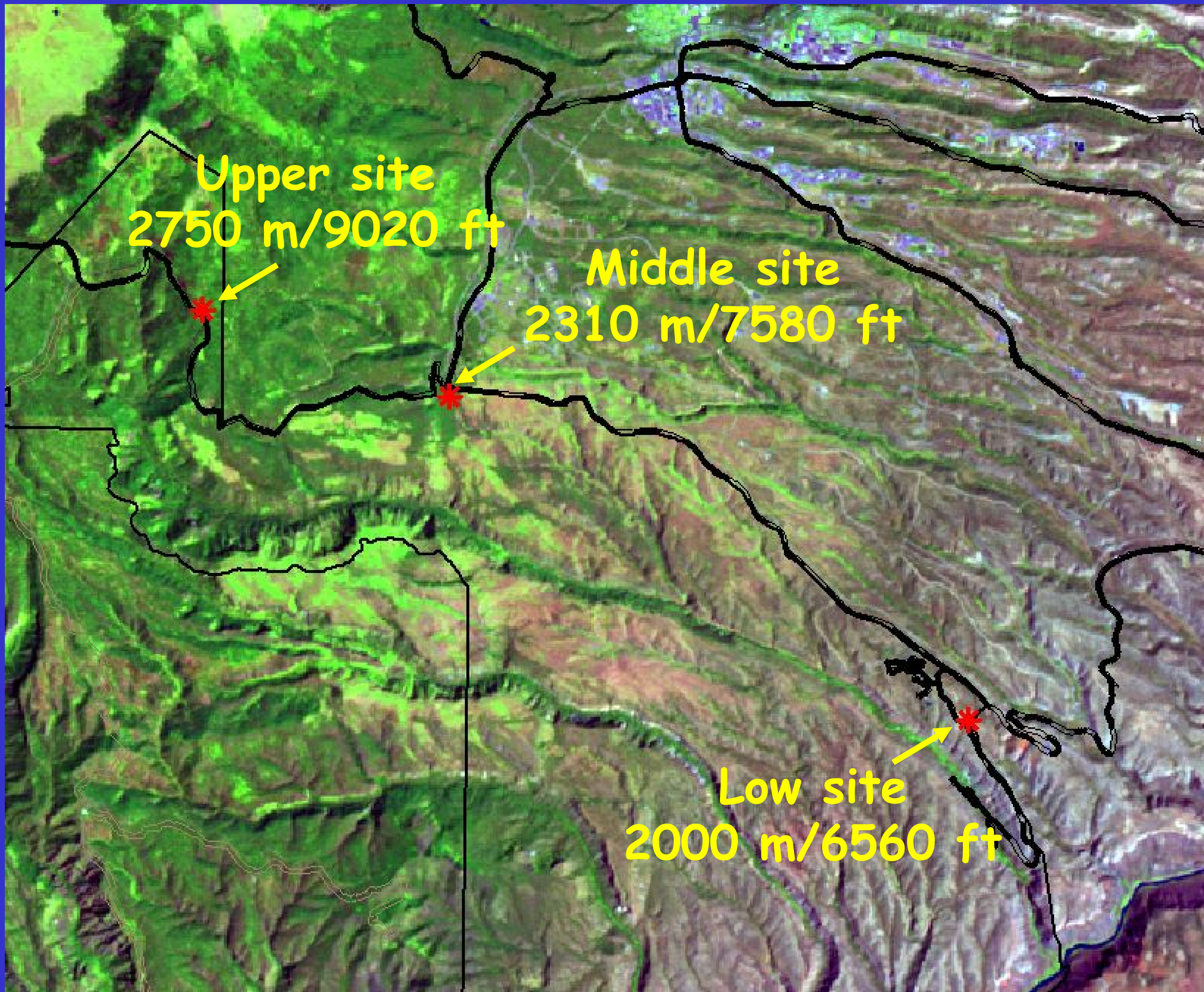
REDUCED SURFACE COVER LEADS TO HIGHER RUNOFF AND EROSION RATES, DESERTIFICATION, AND LOSS OF SOIL CARBON POOLS.

Soil Erosion Behavior

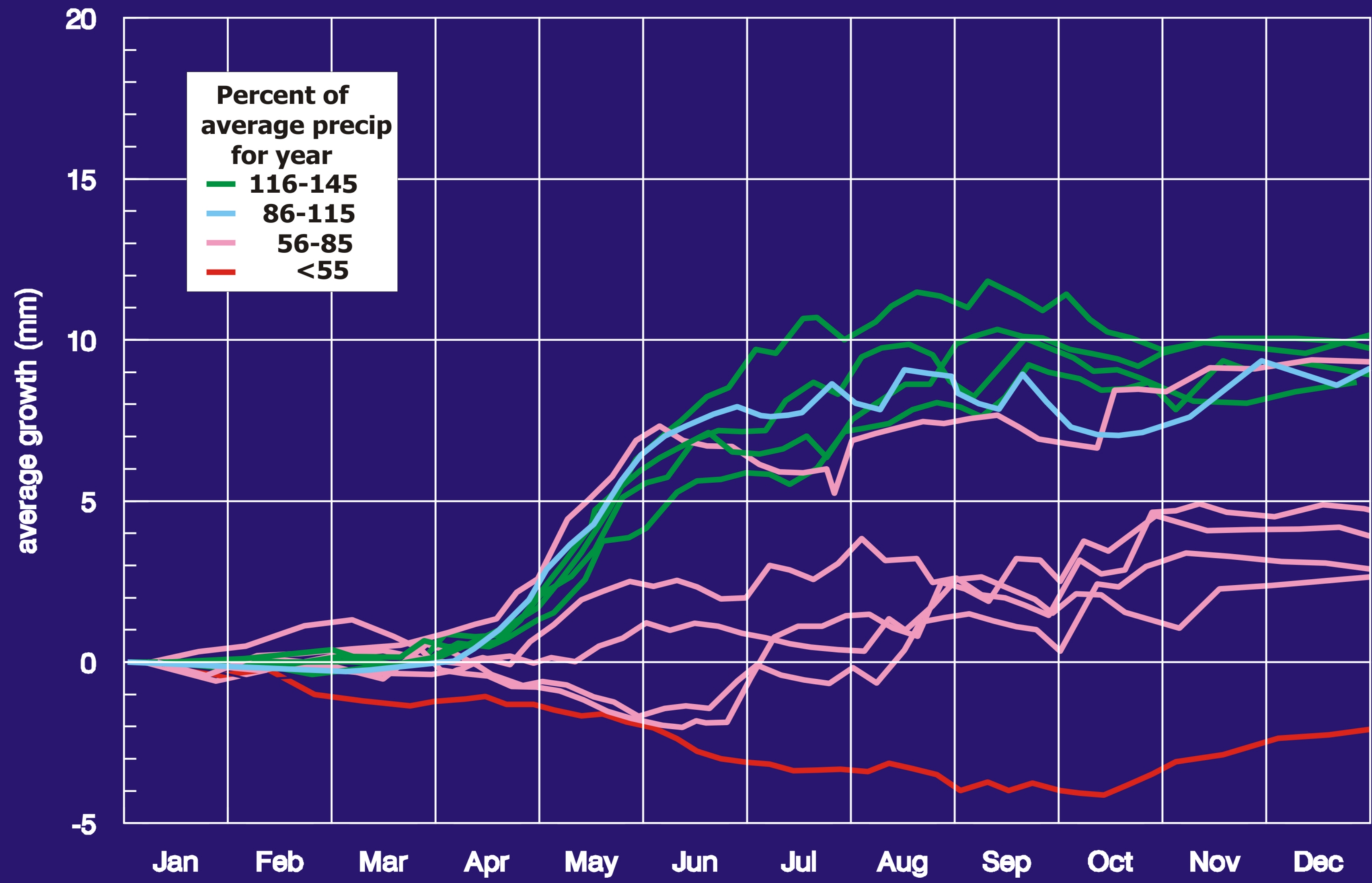




Dendrometer band to measure tree growth, since 1990.


Upper site
2750 m/9020 ft
Middle site
2310 m/7580 ft
Low site
2000 m/6560 ft

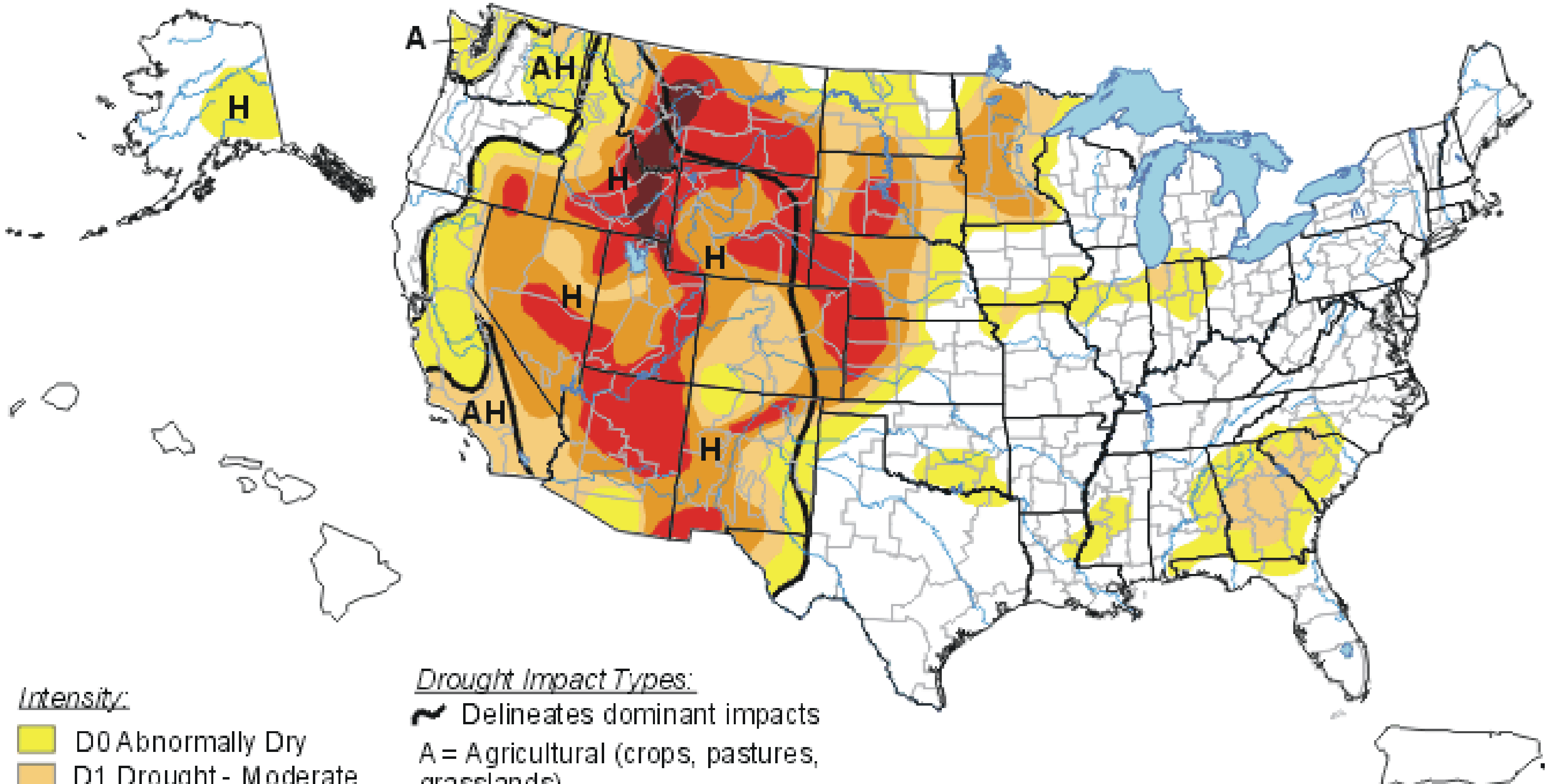
Low Site
1992-2003



C.D. Allen and K. Beeley, unpublished data

U.S. *Drought Monitor*

May 11, 2004
Valid 8 a.m. EDT



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

Drought Impact Types:

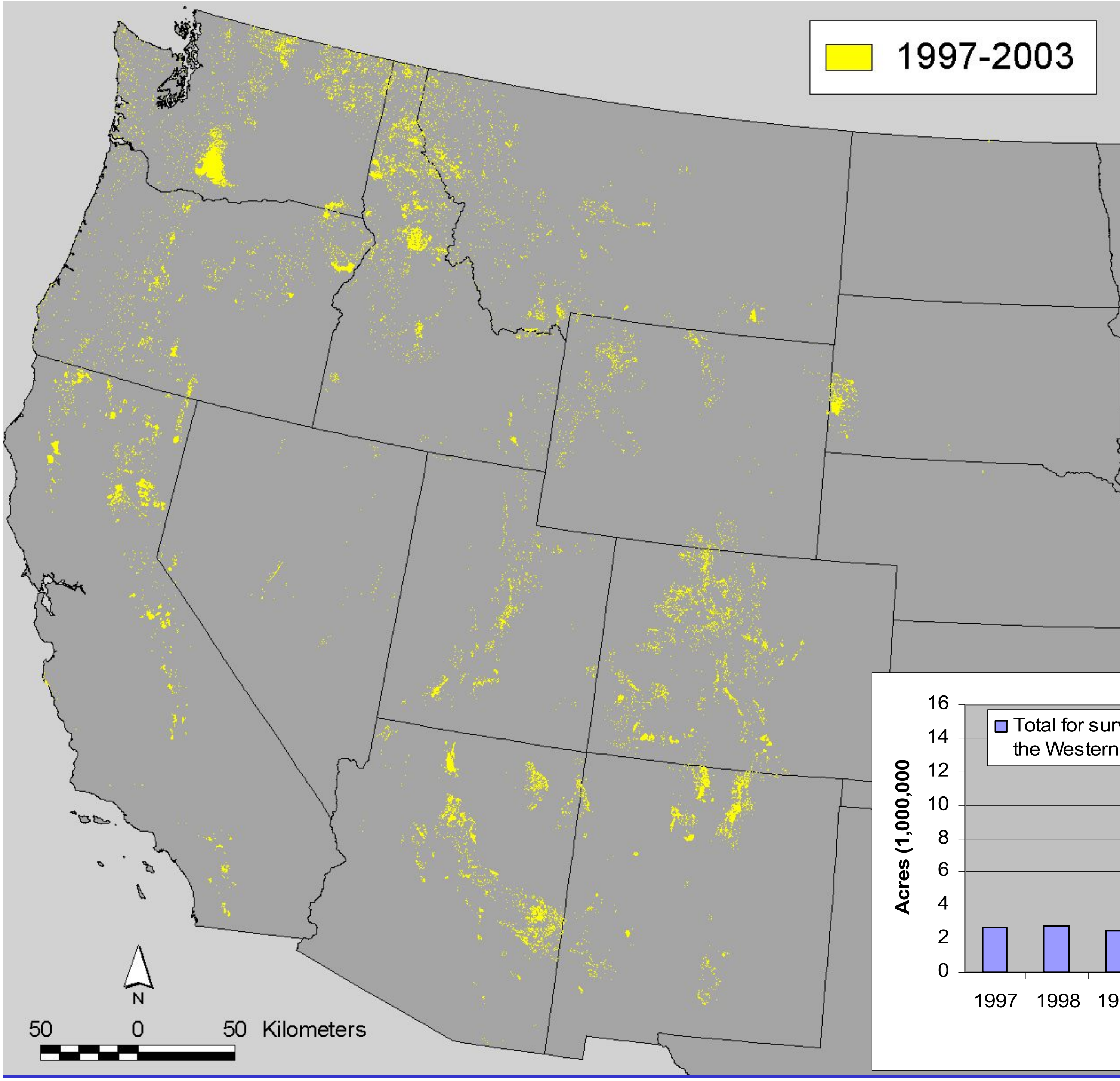
~ Delineates dominant impacts

A = Agricultural (crops, pastures, grasslands)
H = Hydrological (water)
A,H = Agricultural and Hydrological
(No type = Both impacts)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

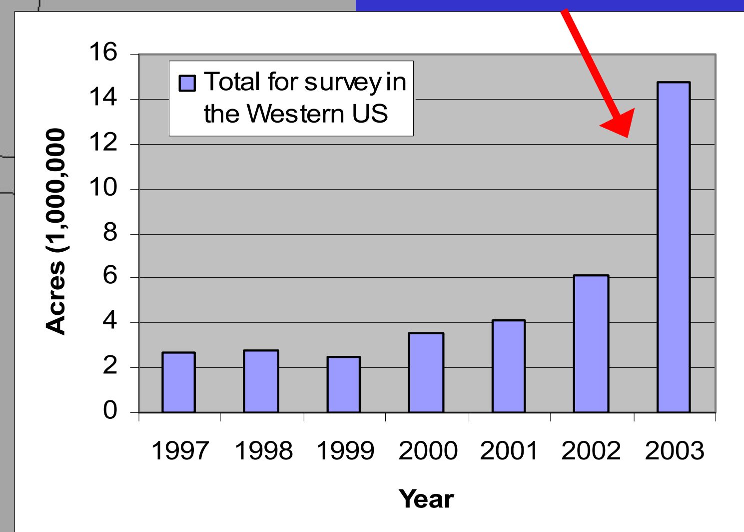
http://drought.unl.edu/dm

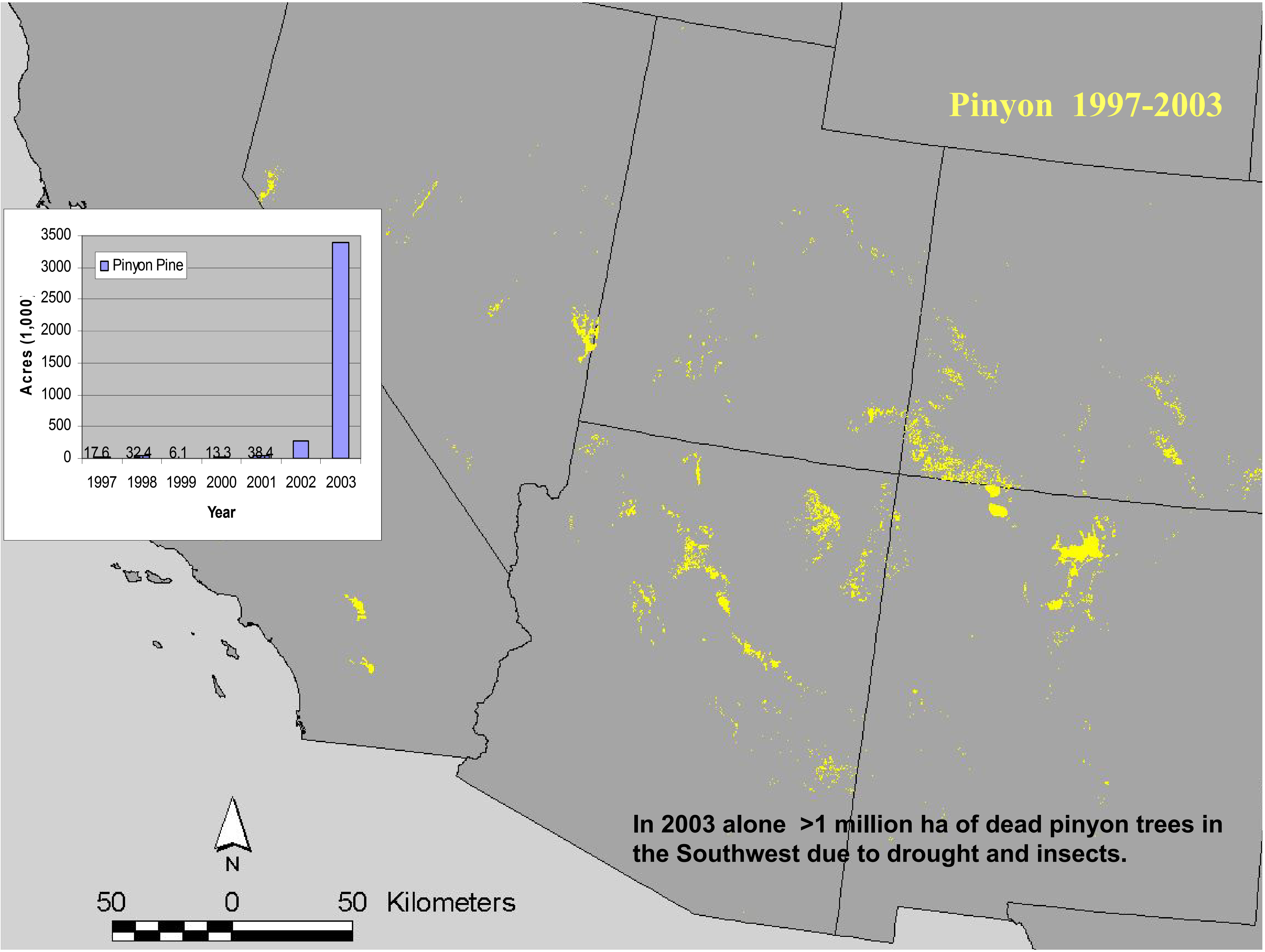
Released *Thursday, May 13, 2004*
Author: David Miskus, JAWF/CPC/NOAA

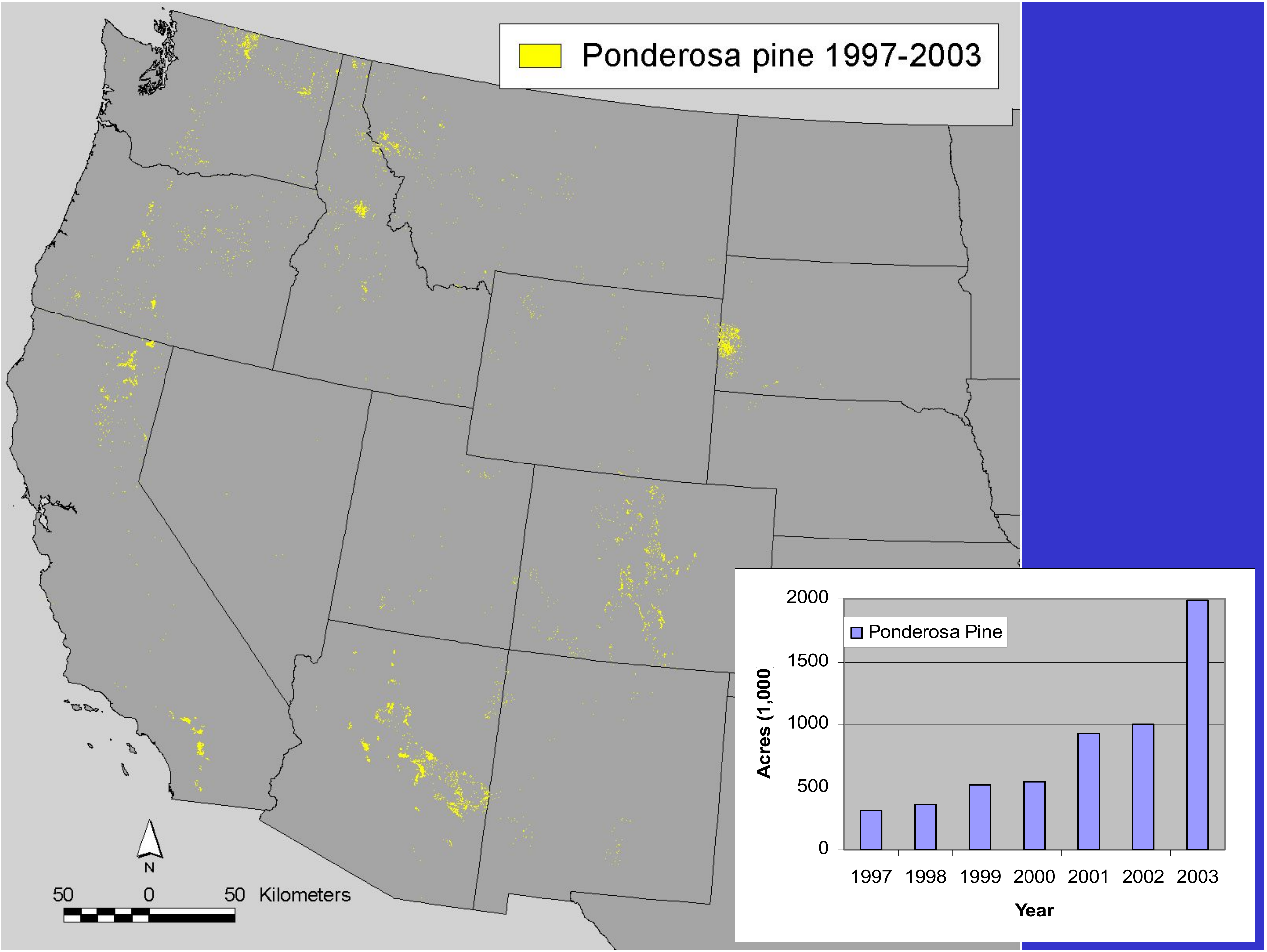


USFS surveys for insect and disease, cumulative map of affected areas for 1997-2003, highlights forest dieback in Western mountains.

Note trend.

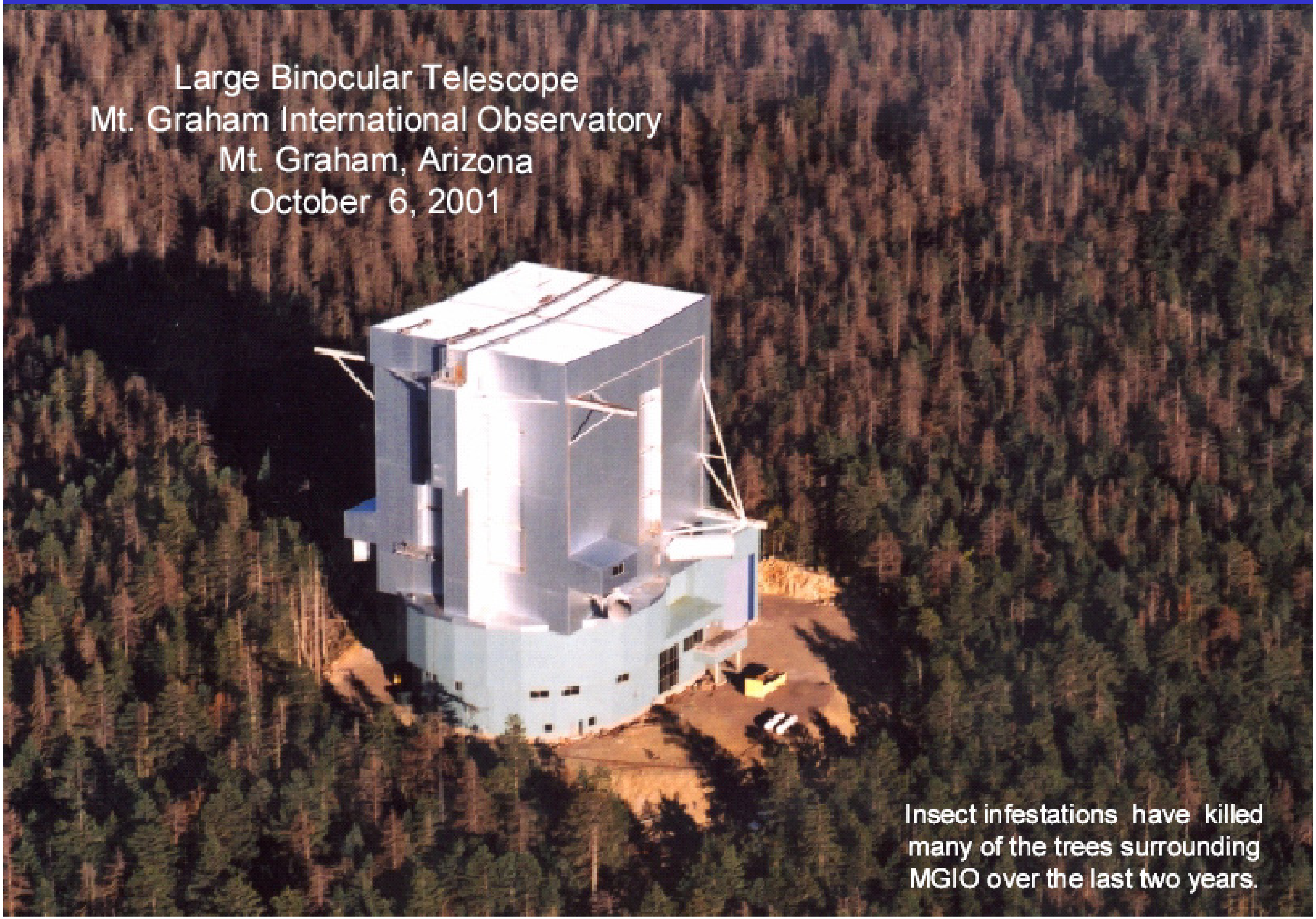


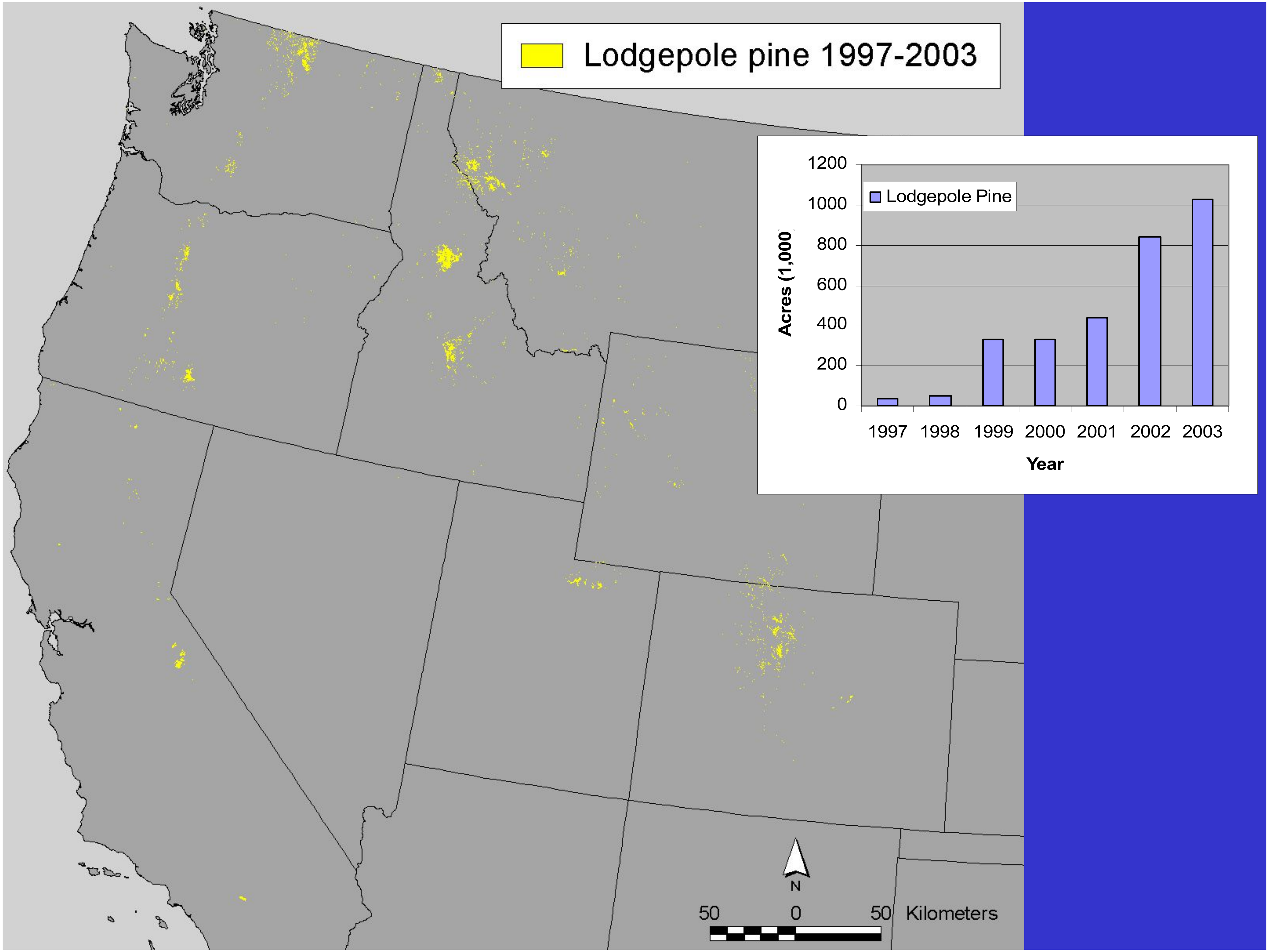

Pinyon 1997-2003
Acres (1,000)
3500
3000
2500
2000
1500
1000
500
0
Pinyon Pine
17.6
32.4
6.1
13.3
38.4
1997
1998
1999
2000
2001
2002
2003
Year
N
50
0
50
Kilometers
In 2003 alone >1 million ha of dead pinyon trees in the Southwest due to drought and insects.



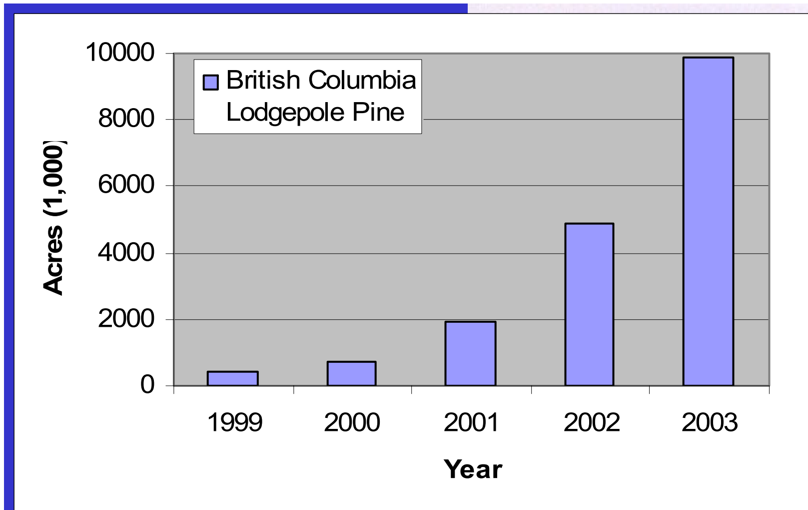
Ponderosa pine 1997-2003
N
50 0 50 Kilometers
Ponderosa Pine
Acres (1,000)
2000
1500
1000
500
0
1997 1998 1999 2000 2001 2002 2003
Year

Ponderosa pine dieback, Crown King, AZ August 2002 -- Joel McMillan


Large Binocular Telescope
Mt. Graham International Observatory
Mt. Graham, Arizona
October 6, 2001
Insect infestations have killed
many of the trees surrounding
MGIO over the last two years.



Lodgepole pine 1997-2003
Lodgepole Pine
Acres (1,000)
1200
1000
800
600
400
200
0
1997
1998
1999
2000
2001
2002
2003
Year
N
50
0
50
Kilometers



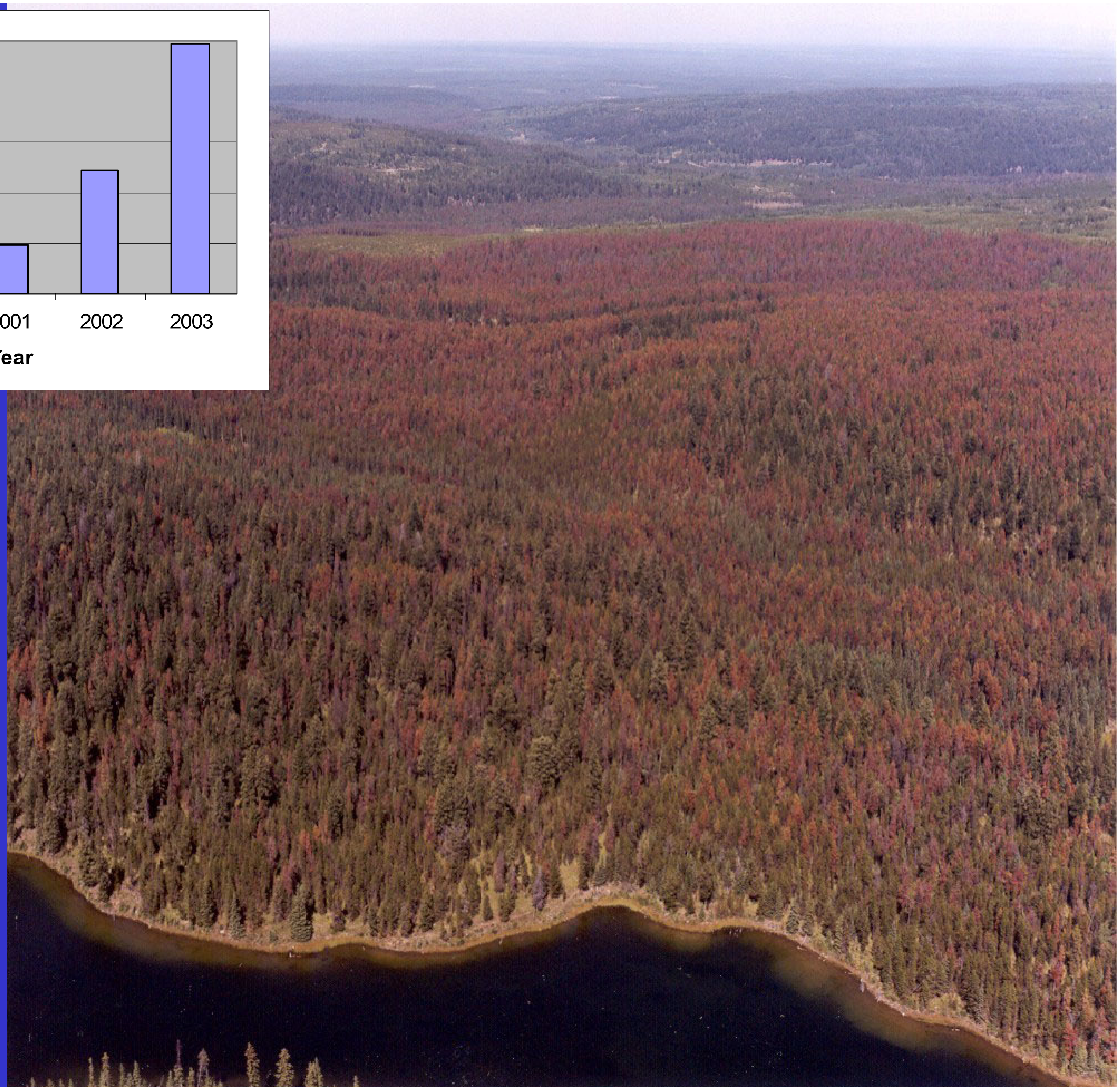
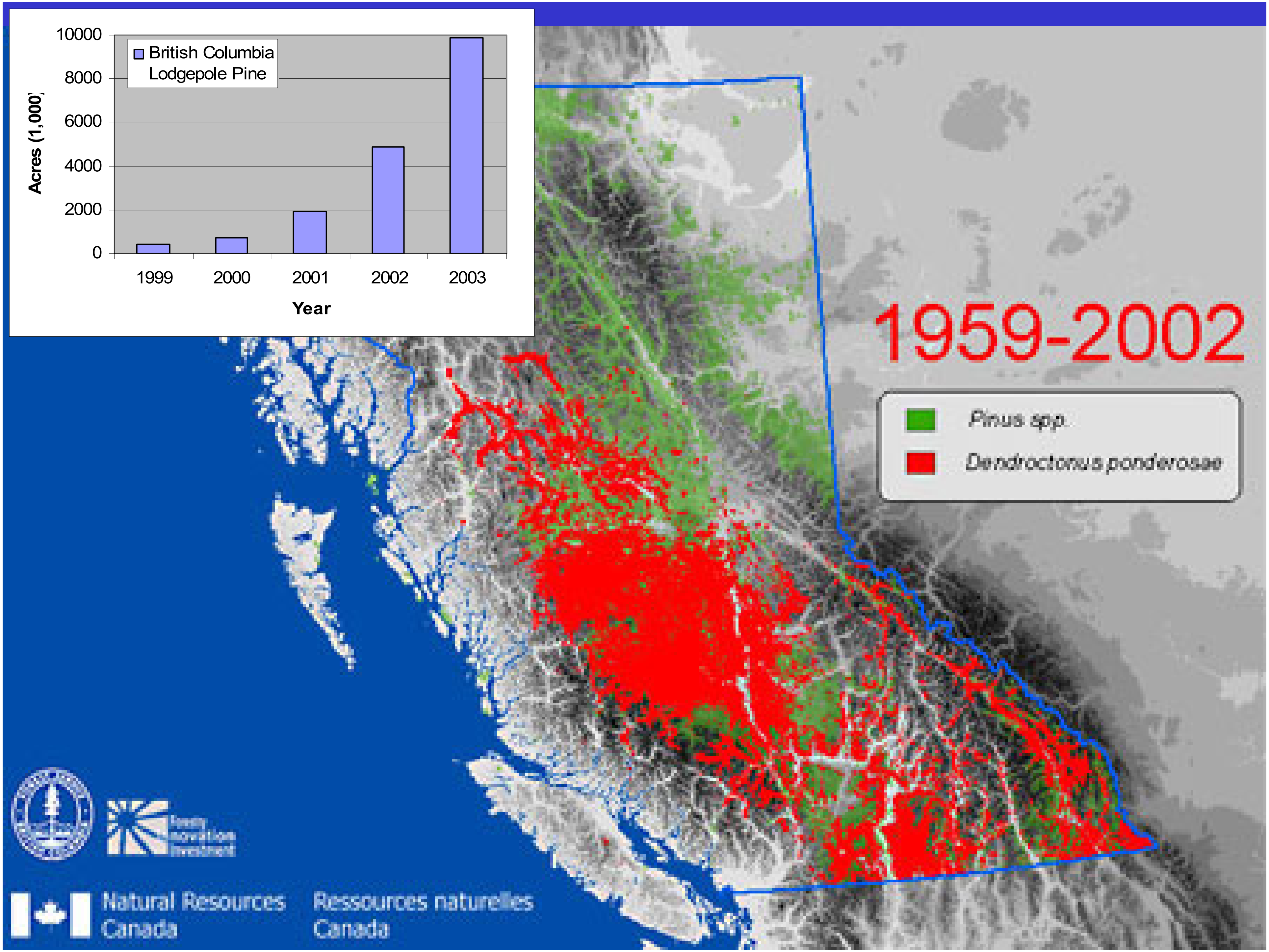
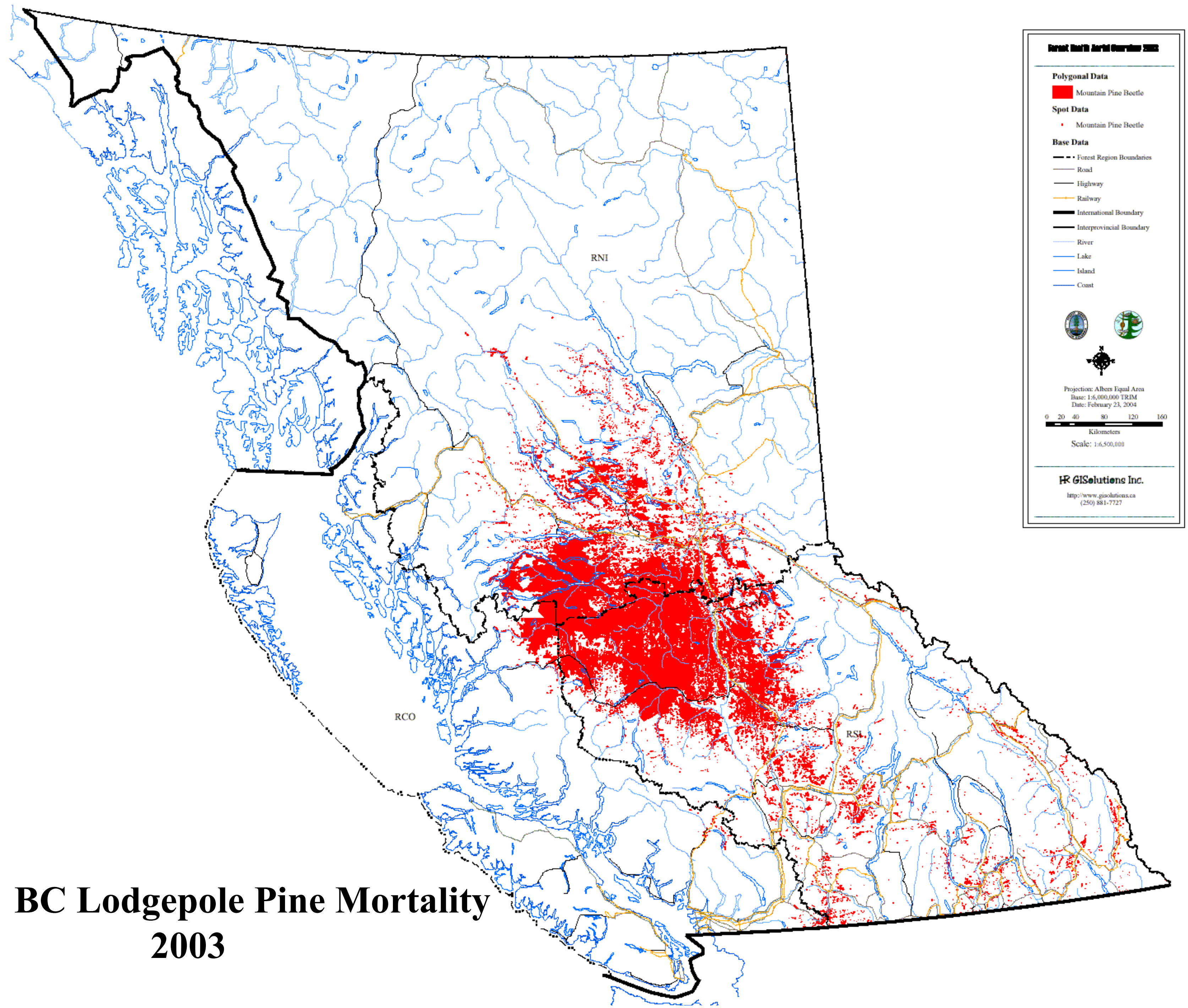


Photo: Allan Carrol, CFS


10000
8000
6000
4000
2000
0
Acres (1,000)
British Columbia Lodgepole Pine
1999
2000
2001
2002
2003
Year
1959-2002
Pinus spp.
Dendroctonus ponderosae
Natural Resources Canada
Ressources naturelles Canada



BC Lodgepole Pine Mortality
2003

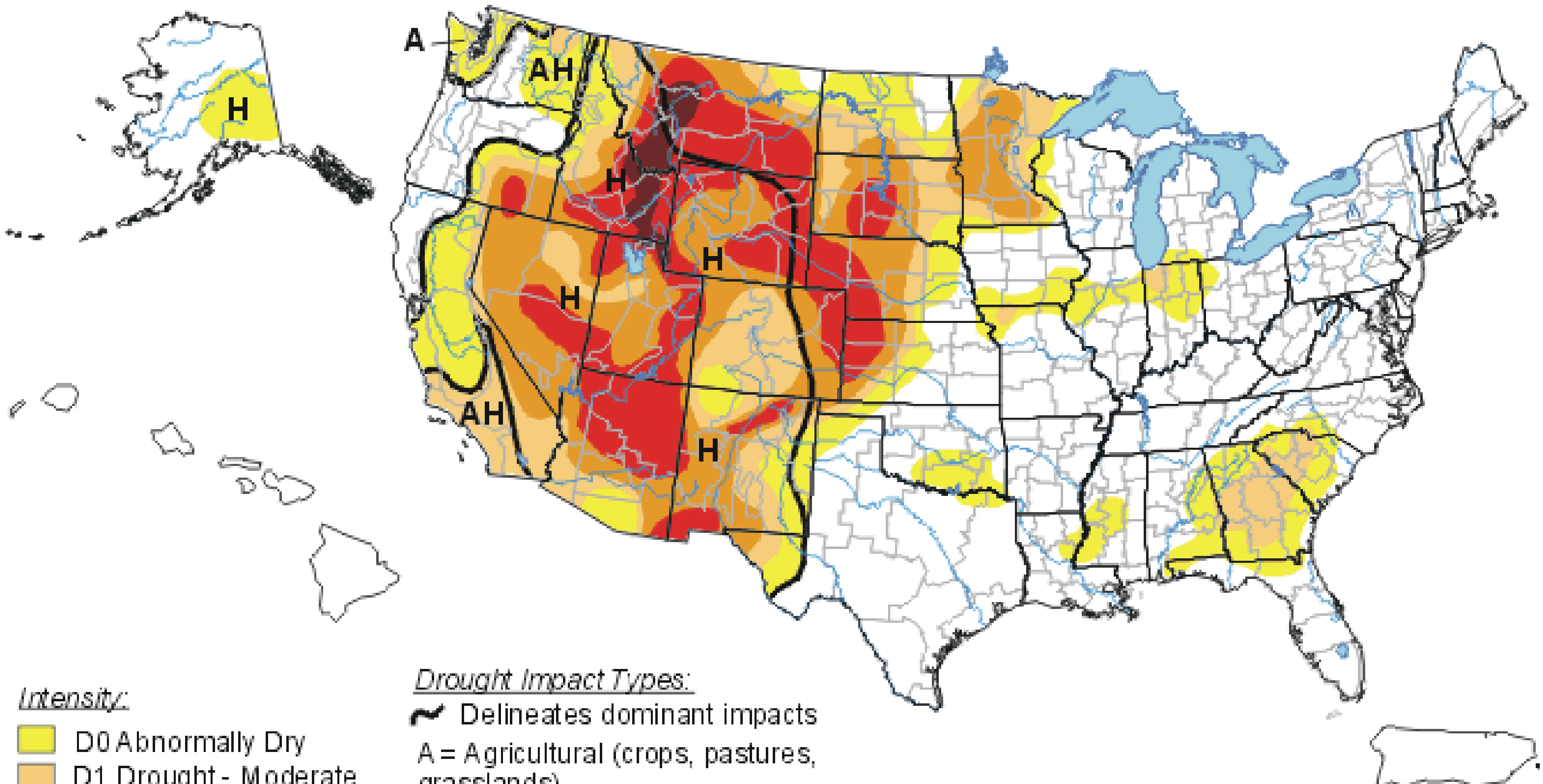
Common to all of these examples:

1) **Fire suppression and/or wet climate periods have fostered high tree densities in various Western forests, increasing vulnerability to subsequent drought stress and bark beetle outbreaks.**

2) **Drought and warmer temperatures have stressed trees across regional scales, and triggered rapid increases in bark beetle populations, resulting in massive forest dieback and associated insect outbreak dynamics.**

U.S. *Drought* Monitor

May 11, 2004
Valid 8 a.m. EDT



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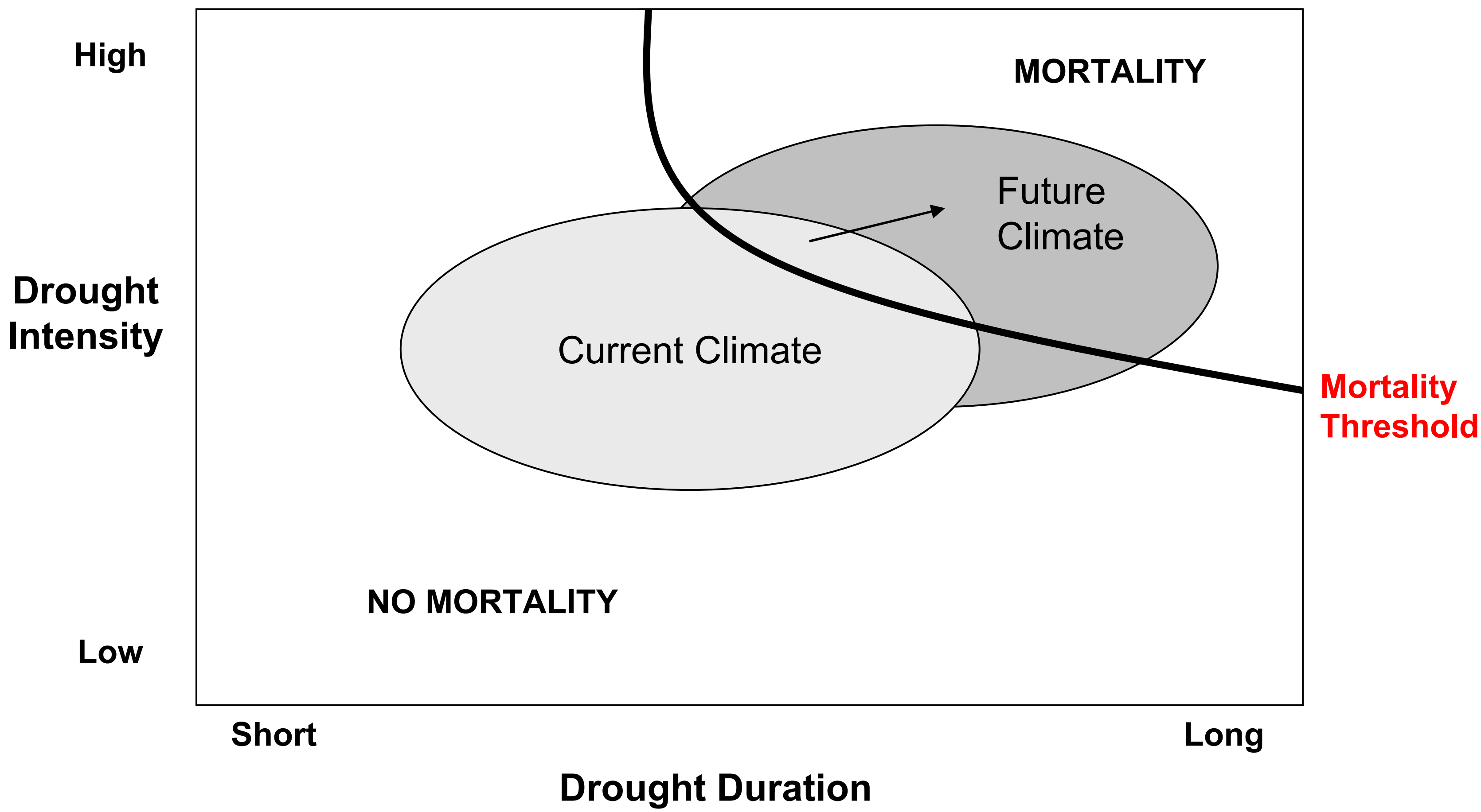
http://drought.unl.edu/dm

USDA — National Drought Mitigation Center — NOAA

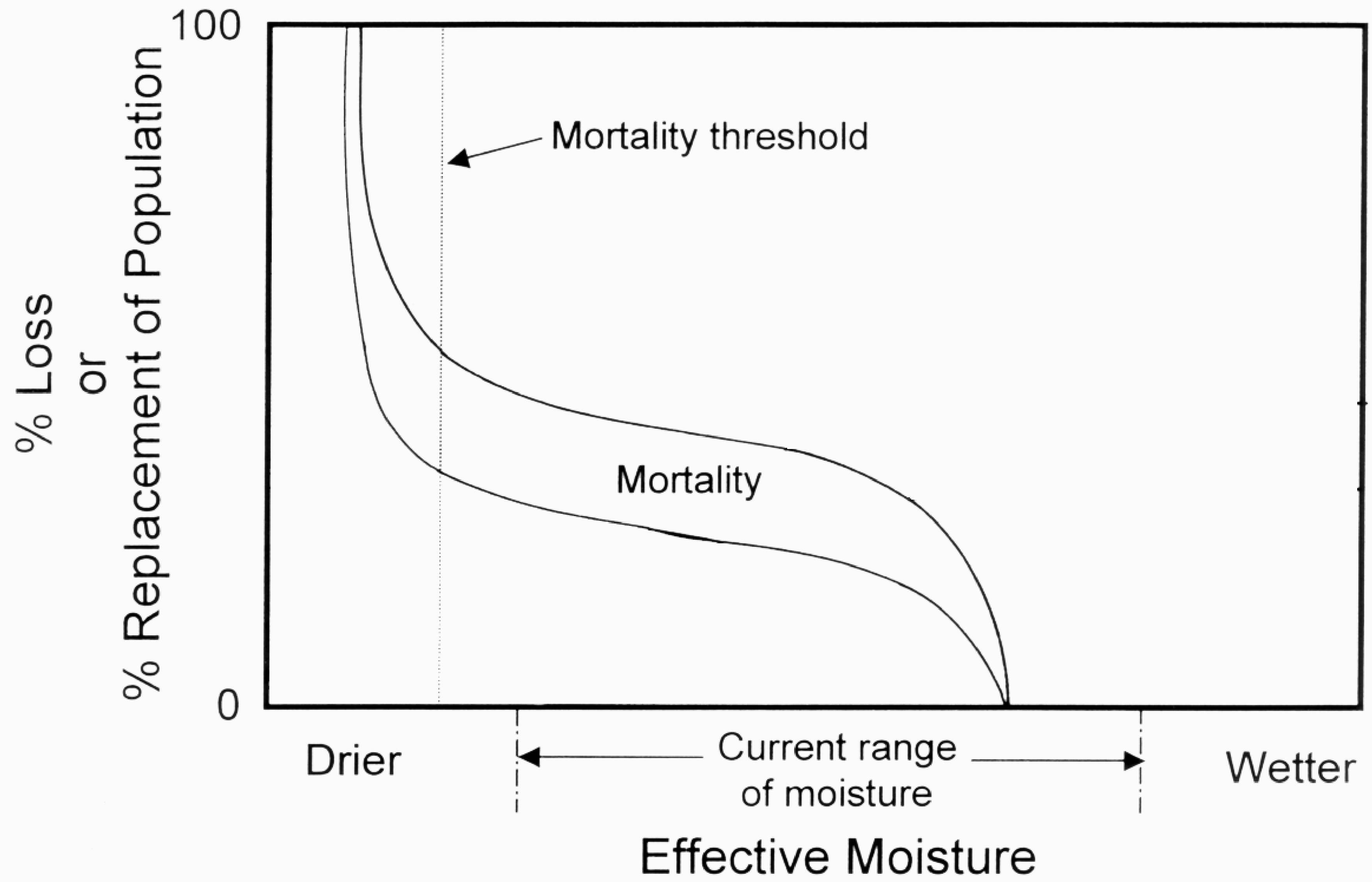
Released Thursday, May 13, 2004

Author: David Miskus, JAWF/CPC/NOAA

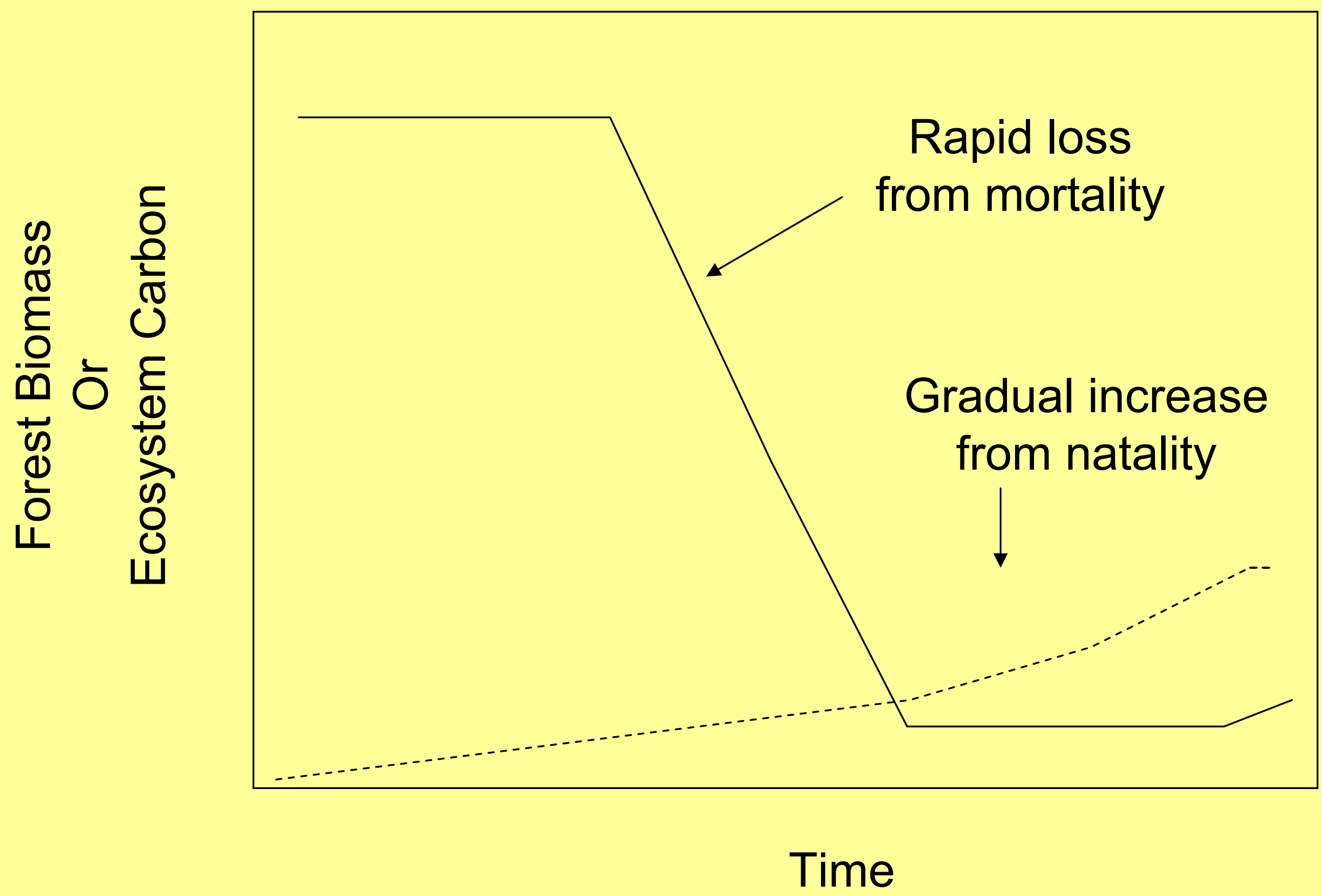


Allen and Breshears, in press

Predicted increases in extreme drought events associated with global climate change suggests heightened risks of amplifying Massive Forest Dieback.



Generalized curve for species-specific thresholds of drought-induced mortality. Increases in extreme drought events could cause mortality thresholds to be exceeded.



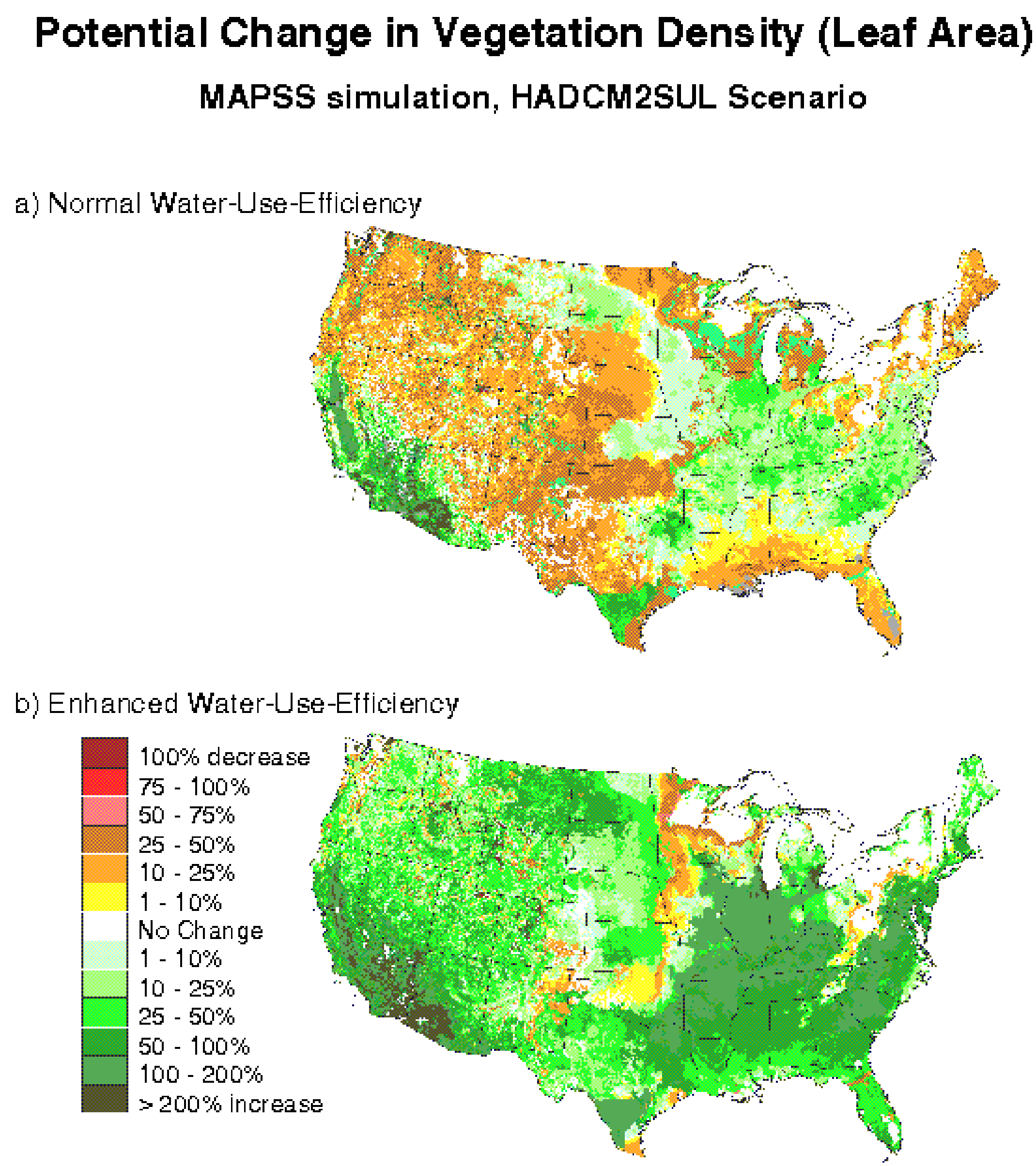
Massive forest dieback has the potential to alter regional and perhaps global carbon fluxes through widespread pulses of rapid disturbance-induced losses in terrestrial carbon pools. Note that mortality losses of long-accumulated carbon from large (older) trees can outstrip growth sequestration through natality (small, young trees).

Modeling efforts continue to be hampered by a general lack of information about about tree mortality.

Key mechanistic thresholds of individualistic tree species responses to stress are lost in empirical formulations of most simulation models.

"A mechanistic treatment of tree mortality in gap models is probably not possible at this time because most causal mechanisms are either unknown, complex, or difficult to measure. A comprehensive field database is needed to design, parameterize, and validate gap model mortality algorithms."

(Reynolds, Bugmann, and Pitelka, 2001, *Climate Change* 51:541-557)



Source: Ron Neilson.

Key Uncertainty: How does forest dieback affect crown fire risk?

Jemez Mts., October 2002

Once needles drop (6-12 months for pinyon, Douglas-fir), crown fire risk is greatly reduced, although surface fire risk may increase. **Jemez Mts., October 2002**

CROWN FIRES
BURN PRIMARILY
CANOPY NEEDLES,

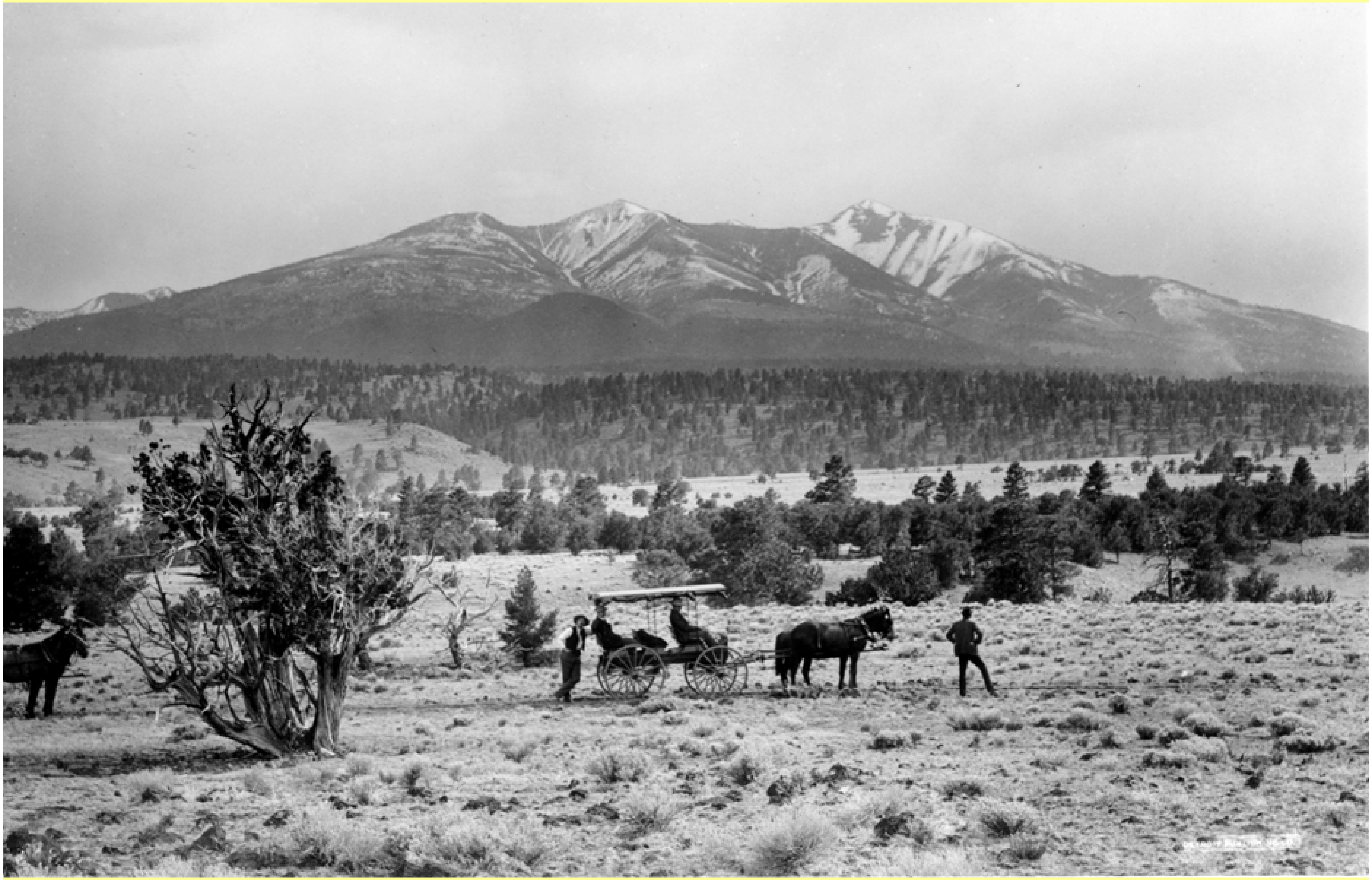
LEAVING
SCORCHED
TRUNKS AND
BRANCHES
UNCONSUMED.

DIEBACK IS NATURALLY THINNING MANY WESTERN FORESTS, RAPIDLY RESETTING STAND STRUCTURES.

MODERATE LEVELS OF DIEBACK IN OVER-DENSE MIXED CONIFER AND PONDEROSA PINE FORESTS MIGHT PROVE TO BE A BLESSING, ESPECIALLY ON HARD-TO-ACCESS STEEP SLOPES, BY DIRECTLY REDUCING LADDER AND CANOPY FUEL LOADS AND THUS RISK OF EXTREME FIRE ACTIVITY DURING THE CURRENT PERIOD OF EXTENDED REGIONAL DROUGHT.

THESE MORE OPEN STANDS ARE ALSO EASIER TO REINTRODUCE PRESCRIBED FIRE SAFELY, TO FURTHER REDUCE FUEL LOADS AND RESTORE FOREST HEALTH.

1892 San Francisco Peaks, near Flagstaff, AZ



Neil Cobb, NAU

2001

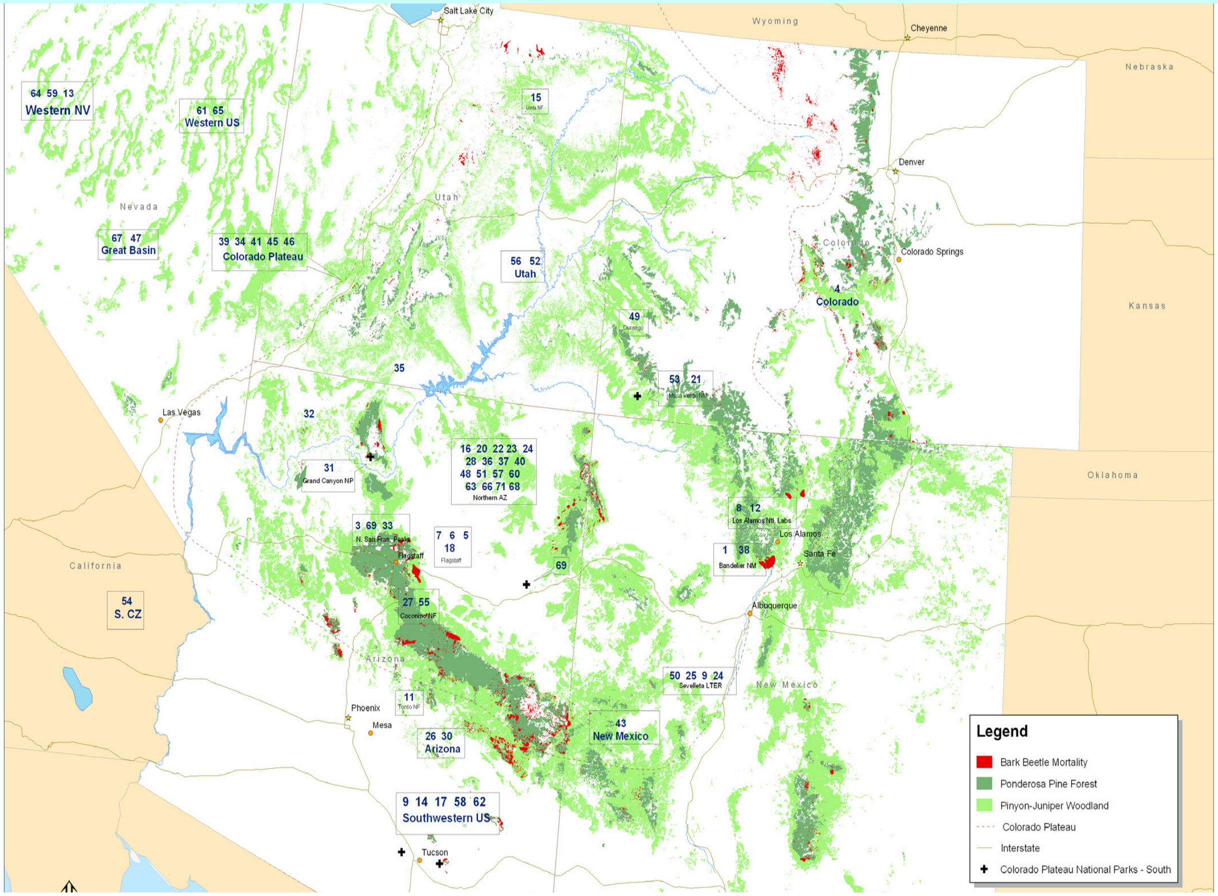
Neil Cobb, NAU

2003

DIEBACK CAN RESET TO MORE NATURAL CONDITIONS

Neil Cobb, NAU

Drought Impacts on Regional Ecosystems Network



DIREnet Collaborators

4	MAP ID	STUDY LOCATION	LAST	FIRST	EMAIL	AFFILIATION	STUDY HABITAT	STUDY INTEREST
5	1	Bandelier NM	Allen	Craig	craig_allen@usgs.gov	USGS-Jemez Mountain Field Station	P-J, Ponderosa	Population & Landscape Ecology
6	2		Allen-Reid	Debra	dallenreid@fs.fed.us	USDA FHM	P-J, Ponderosa	Drought Ecology
7	3	N. of San Francisco Peaks	Anderson	Jesse	jja8@dana.ucc.nau.edu	Northern Arizona University	P-J	Drought Ecology
8	4	Colorado	Anderson	Scott	scott.anderson@nau.edu	Northern Arizona University	Ponderosa	Paleoecology of Bark Beetles
9	5	Flagstaff	Anhold	John	janhold@fs.fed.us	USDA FHM	Ponderosa, P-J	Bark Beetles
10	6	Flagstaff	Bailey	John	john.duff.bailey@nau.edu	Northern Arizona University	Ponderosa, P-J	Forest Health-Silviculture
11	7	Flagstaff	Balda	Russ	russell.balda@nau.edu	Northern Arizona University	P-J	Pinyon Jay
12	8	Los Alamos Natl. Lab	Balice	Randy	balice@lanl.gov	Los Alamos National Laboratory	P-J, Ponderosa	Drought Ecology
13	9	Southwestern USA-Sevilleta	Betancourt	Julio	jlbetanc@usgs.gov	USGS-Desert Laboratory	P-J	Climate-Pack Rat Middens
14	10		Bradbury	Dave	dbradbury@lanl.gov	Los Alamos National Laboratory	Ponderosa, P-J	Drought Ecology
15	11	Tonto National Forest	Brasher	Wayne	wbrasher@fs.fed.us	Tonto National Forest	P-J, Ponderosa	Drought Ecology
16	12	Los Alamos Natl. Lab	Breshears	Dave	daveb@lanl.gov	Los Alamos National Laboratory	Ponderosa, P-J	Drought Ecology
17	13	Western Nevada	Chambers	Jeanne	jchambers@fs.fed.us	FS-Rocky Mtn. Research Station	P-J	PJ Ecology / PJ Recruitment
18	14	Southwestern USA	Chavez	Pat	pchavez@usgs.gov	USGS	P-J	Remote Sensing
19	15	Uinta National Forest	Church	Chris	cchurch@fs.fed.us	Uinta National Forest	P-J, Ponderosa	Drought Ecology
20	16	Northern Arizona	Cobb	Neil	neil.cobb@nau.edu	Northern Arizona University	P-J	Drought Ecology
21	17	Southwestern USA	Cole	Kenneth	kenneth.cole@nau.edu	USGS-Colorado Plateau Field Station	P-J	Paleo in Grand Canyon
22	18	Flagstaff	DeGomez	Tom	degomez@ag.arizona.edu	USDA Renewable Natural Resources Extension	Ponderosa, P-J	Bark Beetles
23	19		Doerry	Eck	eck.doerry@nau.edu	Northern Arizona University	Ponderosa, P-J	Develops Web Communities
24	20	Northern Arizona	Fitzgibbon	Bobbe	bfitzgibbon@fs.fed.us	FS - NAU, Coconino N.F., Region 3	Ponderosa, P-J	Insect Pest Outbreaks
25	21	Mesa Verde NP	Floyd-Hanna	Lisa	lfloyd-hanna@prescott.edu	Prescott College	P-J	PJ Ecology
26	22	Northern Arizona	Fule	Pete	pete.fule@nau.edu	Northern Arizona University	Ponderosa	Fire Ecology-Dendro Ecology
27	23	Northern Arizona	Gaylord	Monica	mlg36@dana.ucc.nau.edu	Northern Arizona University	Ponderosa	Physiological Ecology
28	24	Northern Arizona / Sevilleta	Gehring	Catherine	catherine.gehring@nau.edu	Northern Arizona University	P-J, Ponderosa	Mycorrhizal
29	25	Sevilleta	Gosz	Jim	jgosz@sevilleta.unm.edu	University of New Mexico	P-J, Ponderosa	Drought Ecology
30	26	Arizona	Gottfried	Jerry	ggottfried@fs.fed.us	FS-RMRS, Asd-Research, Toliver, 4156-SW Forest Health	P-J, Ponderosa	PJ Ecology
31	27	Coconino National Forest	Green	Heather	hgreen@fs.fed.us	FS-Region 3, Coconino National Forest, Supervisor's Office	Ponderosa, P-J	Drought Ecology
32	28	Northern Arizona	Hampton	Haydee	haydee.hampton@nau.edu	Northern Arizona University	Ponderosa, P-J	Remote Sensing / GIS
33	29		Hansen	Leslie	hansen@lanl.gov	Los Alamos National Laboratory	Ponderosa, P-J	Fire Ecology
34	30	Arizona	Hart	Steve	steve.hart@nau.edu	Northern Arizona University	Ponderosa, P-J	Soil
35	31	Grand Canyon NP	Hiebert	Ron	ron.hiebert@nau.edu	National Park Service	P-J, Ponderosa	Ecology of Invasives
36	32	Mt. Trumble	Huffman	David	david.huffman@nau.edu	Northern Arizona University	P-J, Ponderosa	Pipo / PJ
37	33	N. of San Francisco Peaks	Hungate	Bruce	bruce.hungate@nau.edu	Northern Arizona University	P-J, Ponderosa	Ecosystem Ecology
38	34	Colorado Plateau	Jackson	Lynn	lynn_jackson@blm.gov	Bureau of Land Mgmt.	P-J	Management
39	35	Grand Staircase-Escalante NM	Kalkhan	Mohammed	mohammed@nrel.colostate.edu	Colorado State University	P-J, Ponderosa	Remote Sensing / GIS
40	36	Northern Arizona	Koch	George	george.koch@nau.edu	Northern Arizona University	P-J, Ponderosa	Ecosystem Ecology
41	37	Northern Arizona	Kolb	Tom	tom.kolb@nau.edu	Northern Arizona University	Ponderosa, P-J	Physiological Ecology
42	38	Bandelier NM	Kuenzi	Amanda	amandakuenzi@nps.gov	NPS	Ponderosa, P-J	Drought Ecology
43	39	Colorado Plateau	Martinez	AJ	a.j._martinez@blm.gov	Bureau of Land Mgmt.	P-J	Management
44	40	Northern Arizona	McMillin	Joel	jmcmillin@fs.fed.us	USDA FHM-Region 3, Coconino National Forest	Ponderosa, P-J	Bark beetle
45	41	Colorado Plateau	Mitton	Jeff	mitton@colorado.edu	University of Colorado	P-J, Ponderosa	Genetics
46	43	New Mexico Heritage Prgm.	Muldavin	Esteban	muldavin@sevilleta.unm.edu	University of New Mexico	P-J, Ponderosa	PJ Veg Distribution
47	44		Natori	Taomi	tnatori@dinecollege.edu	Dine College	P-J, Ponderosa	Ecology, Natural History
48	45	Colorado Plateau	Negron	Jose	jnegron@fs.fed.us	FS-RMRS, Asd-Research, Saveland, 4451-Alpine/Forest Ecosystems	P-J, Ponderosa	Bark Beetle Distribtion Modeling
49	46	Colorado Plateau	Noble	Bill	bnoble@fs.fed.us	Kaibab National Forest	P-J, Ponderosa	Drought Ecology
50	47	Great Basin-Reno	Nowak	Bob	nowak@scs.unr.edu	University of Nevada, Reno	P-J	PJ Ecology
51	48	Northern Arizona	Ogle	Kiona	ko5@acpub.duke.edu	Duke University	P-J	PJ Population Modeling
52	49	Durango-Ft. Lewis	Ortega	Catherine	ortega_c@ fortlewis.edu	Fort Lewis College	P-J	PJ Population Ecology
53	50	Sevilleta	Pennington	Deana	dpennington@lternet.edu	Sevilleta LTER	P-J, Ponderosa	Remote Sensing / GIS
54	51	Northern Arizona	Prather	John	john.prather@nau.edu	Northern Arizona University	Ponderosa, P-J	Avian Ecology / Spatial Modeling
55	52	Utah	Ramsey	Doug	dougr@cnr.usu.edu	Utah State University	P-J, Ponderosa	Remote Sensing / GIS
56	53	Mesa Verde NP	Romme	Bill	romme@cnr.colostate.edu	Colorado State University	P-J, Ponderosa	Fire Ecology-PJ Woodlands
57	54	Southern California	Rotenberry	John	rote@citrus.ucr.edu	University of California, Riverside	P-J, Ponderosa	Avian Ecology
58	55	Coconino National Forest	Sandusky	Sheila	ssandusky@fs.fed.us	Coconino National Forest	P-J, Ponderosa	Management
59	56	Utah	Schupp	Geno	schupp@cc.usu.edu	Utah State University	P-J	PJ-Population Dynamics - PJ Recruitment
60	57	Northern Arizona	Smith	Doc	doc.smith@nau.edu	Northern Arizona University	Ponderosa	Restoration Ecology
61	58	Southwestern USA	Swetnam	Tom	tswetnam@ltrr.arizona.edu	University of Arizona	Ponderosa, P-J	Dendro Ecology / Climate
62	59	Western Nevada	Tausch	Robin	rtausch@fs.fed.us	FS-Rocky Mtn. Research Station, Reno, NV	P-J	PJ Woodlands-PJ Ecology
63	60	Northern Arizona	Theimer	Tad	tad.theimer@nau.edu	Northern Arizona University	P-J	Mammal Ecology
64	61	Western USA	Thier	Ralph	rthier@fs.fed.us	FS-Region 4, Regional Office	Ponderosa, P-J	Bark Beetle Ecology
65	62	Southwestern USA	Thomas	Kathryn	kathryn.thomas@nau.edu	USGS-Colorado Plateau Field Station	P-J, Ponderosa	Global Climate Change / Vegetation Distribution
66	63	Northern Arizona	Trotter	Talbot	rtt3@dana.ucc.nau.edu	Northern Arizona University	P-J	PJ Woodlands
67	64	Western Nevada	Vander Wall	Stephen	sv@unr.nevada.edu	University of Nevada, Reno	P-J	Mammal Foraging Seed Ecology
68	65	Western USA	vanMantgem	Phillip	pvanmantgem@usgs.gov	USGS	P-J, Ponderosa	Population Modeling
69	66	Northern Arizona	Wagner	Mike	mike.wagner@nau.edu	Northern Arizona University	Ponderosa	Centennial Forest
70	67	Great Basin-Reno	West	Neil	new369@cc.usu.edu	Utah State University	P-J	PJ Ecology
71	68	Northern Arizona	Whipple	Amy	amy.whipple@nau.edu	Northern Arizona University	P-J	PJ Ecology
72	69	Sunset Crater NM / N. San Fran Peaks	Whitham	Thomas	thomas.whitham@nau.edu	Northern Arizona University	P-J	PJ Ecology
73	70		Wright	Debbie	dwright@gf.state.az.us	AZ Game and Fish	P-J, Ponderosa	Drought Ecology
74	71	Northern Arizona	Xu	Yaguang	yaguang.xu@nau.edu	Northern Arizona University	Ponderosa, P-J	Remote Sensing
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Drought Impacts on Regional Ecosystems Network

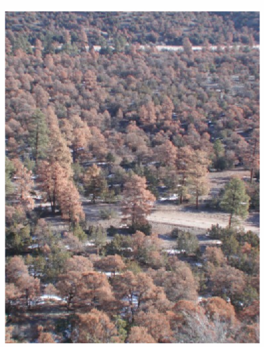
Google: DIRENET

Coordinating Drought Studies on Southwest Ecosystems

Background Information
- Climate
- Ponderosa Pine
- Pinyon-Juniper
- Sagebrush

DIRENET Information
- DIREnet Home
- DIREnet Associates (SERF)
- 2003 Drought Summit
- 2003 Drought Symposiun

Drought Research
- ForestERA
- Los Alamos
- Mesa Verde
- San Francisco Peaks
- MPCER



The **Drought Impacts on Regional Ecosystems Network (DIREnet)** is an association of researchers and land managers interested in documenting impacts on major ecosystems of the western United States resulting from drought related processes. The research network is currently focused on Ponderosa Pine Forests and Pinyon-Juniper Woodlands in the Southwest. A severe regional drought has gripped the Southwest in recent years, and is rapidly and dramatically altering forest, woodland and shrubland ecosystems. The drought has become a catalyst in bringing researchers and land managers together to assess the impacts of the drought.

DIREnet will promote research needed to address specific questions that could not be addressed otherwise. For example, how does tree mortality change over regional environmental gradients and to what degree does climate variability explain ecosystem dynamics? DIREnet will implement two mechanisms to foster collaborations of researchers from academia and land management agencies: **Southwest Ecological Research Forum (SERF)**, will be a sophisticated online information archive and community forum which will serve as a globally accessible clearinghouse and provide an effective forum for discussion and communication. **Cross-Pollination in Research and Education.** The organization of conferences and workshops will foster new research, and complement SERF activities by establishing new collaborations and strengthening existing relationships. In combination, these efforts will greatly aid understanding of how major ecosystems function and respond to climatic perturbations.

Drought in Southwest Southwestern arid and semi-arid ecosystems may be particularly sensitive to climate changes (Risser 1995, Swetnam & Betancourt 1998). The primary production of these ecosystems is limited by water, making the consequences of changes in temperature and precipitation more extreme. Also, human populations have increased up to 40% in the Southwest during the last decade (US Census Bureau, Census 2000) exacerbating drought impacts due to increased risk of fires. We are focusing our network coordination activities on research carried out in the Southwest.

Latest Updates

Letter to EPA & DOI
Bill Romme (Colorado State University) is leading an effort to inform policy makers about the ecological and economic implications of land management decisions in dealing with dead trees in Pinyon-Juniper woodlands. **full story...**

Responses to Letter
The above letter was printed in the Santa Fe New Mexican recently. Read current responses from the public **here**.

Apache-Sitgreaves NF
The latest map of tree mortality in one of the southwest's hardest hit areas. **Mortality Maps**

Summary:

- **Tree death is an important ecological process, but we don't know very much about it.**

- **MFD is often driven by stress from extreme climate events, rather than equilibrial mean climate conditions.**

- **MFD occurs naturally in many forest types. However, there are indications that emerging patterns of dieback in some montane areas are being amplified by global climate change, and predictions of more extreme climate events suggest risk of increases in associated forest dieback episodes.**

- **We cannot accurately predict the effects of climate change on montane forest ecosystems without better field data and model incorporation of species-specific thresholds of stress-induced tree mortality, and the dynamics of amplifying disturbances like insect outbreaks and fire.**

- **CIRMOUNT could help address these knowledge gaps by fostering regional networks for long-term monitoring and research on: 1) plot-based demographies of multiple tree species across landscape and regional gradients to get data on pulses of mortality and natality; 2) tree growth using straightforward dendrometer band methods; 3) feedbacks between forest dieback, other disturbances, and overall ecosystem patterns and processes; and 4) effectiveness of mitigation strategies (e.g., thinning, prescribed burning).**