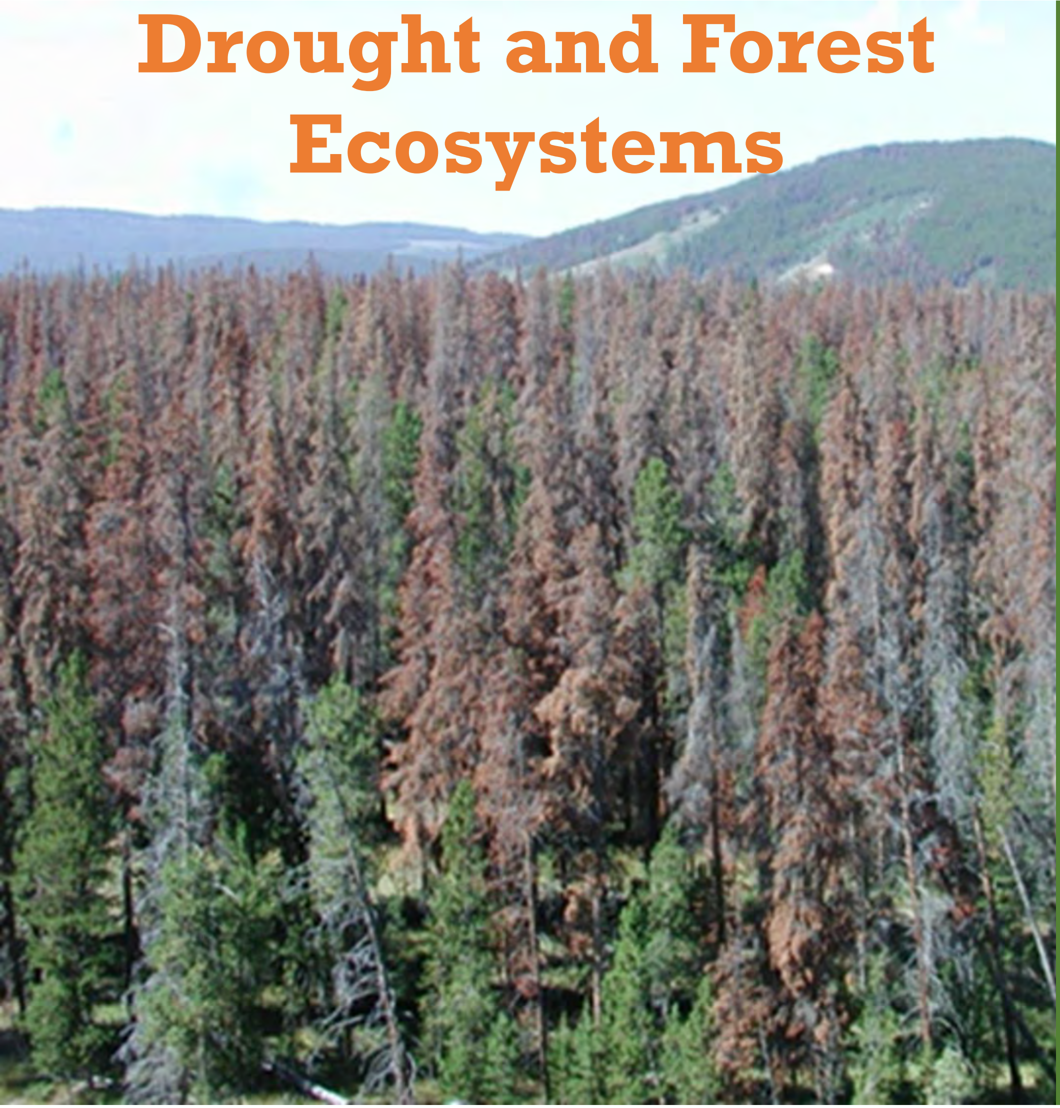
Drought and Forest Ecosystems



AUDIO CONNECTION

1. Phone: mute your computer speakers and call 1-877-369-5243; access code: 0116421#
OR
2. Audio through the computer: Make sure your computer speakers are on and listen with speakers or headphones.

Note: Phone audio will allow you to both listen and speak up with questions. If you listen through the computer, you will not be able to speak up with questions, but will be able to type questions into the Q&A pod which will be answered by the appropriate speaker.

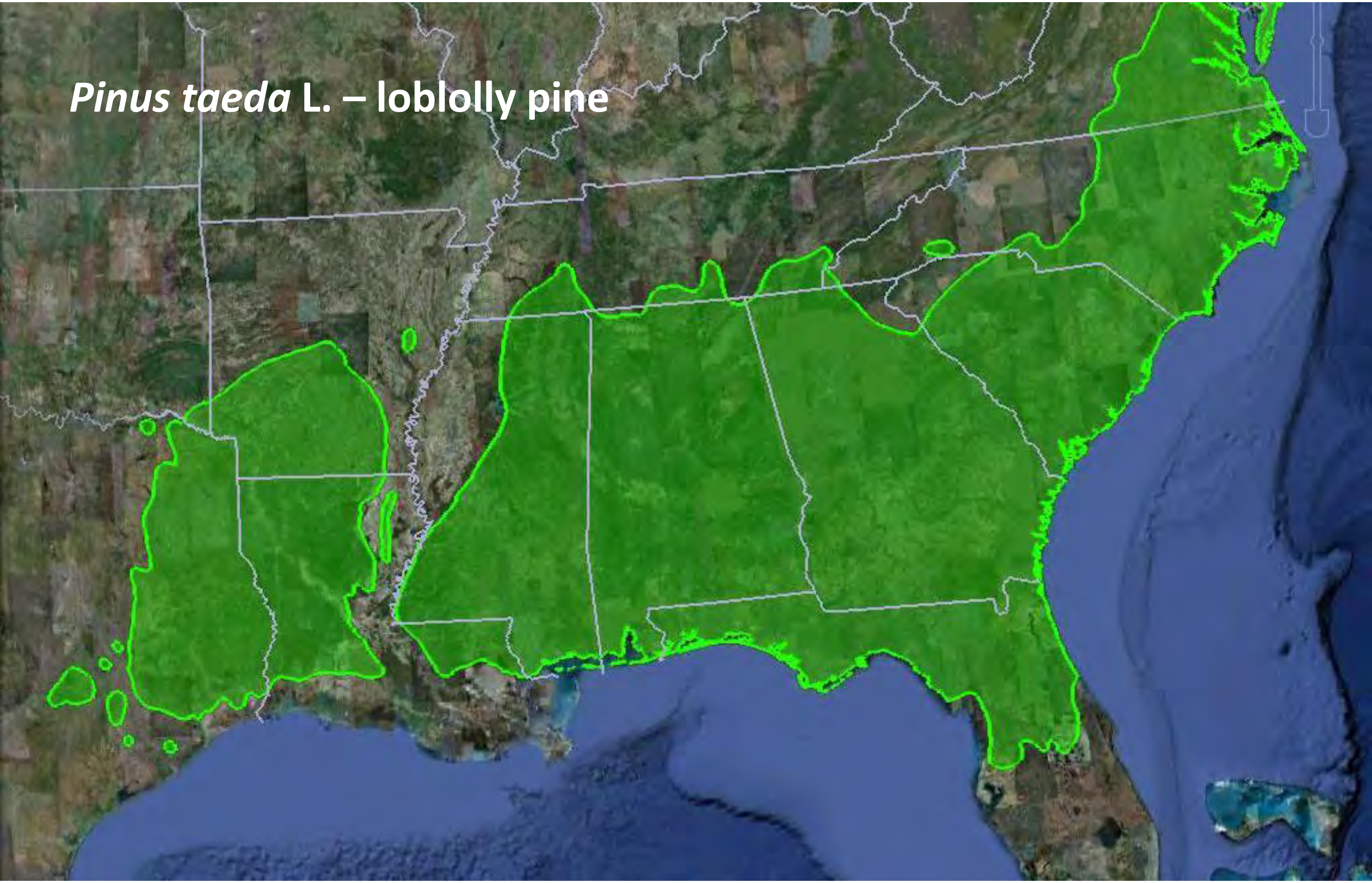
Throughfall reduction and nutrient availability effects on carbon balance in loblolly pine plantations in the southeastern United States

R. Bracho, J. Vogel, E. Jokela, A. J. Cucinella, A. Noormets, E. Ward, M. A. Laviner, C. González-Benecke, S. Bartkowiak, L. Samuelson, D. Markewitz, A.O. Maggard, R.E. Will, C. Meek, T. Fox, J. Seiler, B. Strahm, K. McElligott, T. A. Martin *et al.*

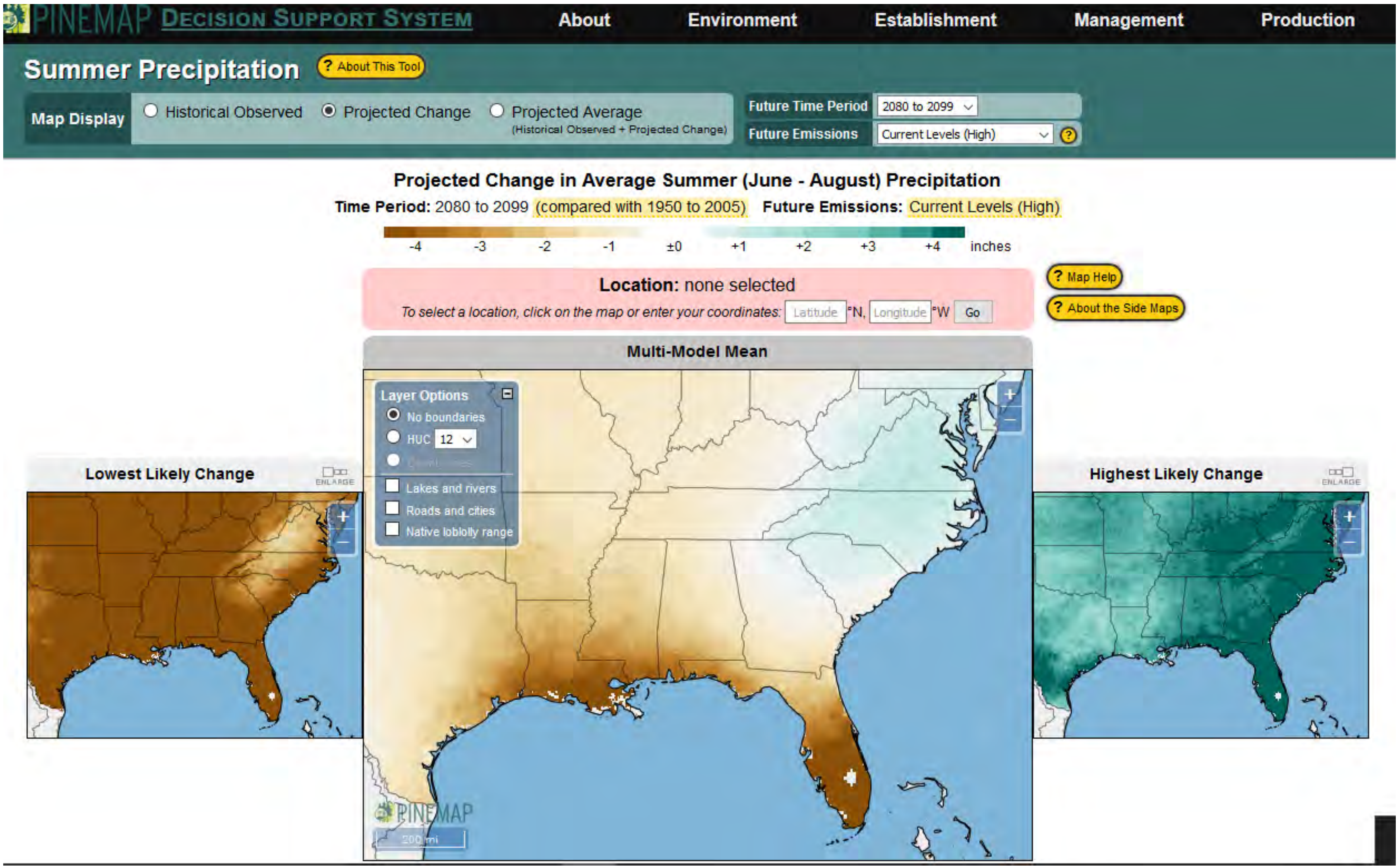
University of Florida
North Carolina State University
Virginia Polytechnic Institute and State university
Oregon State University
Auburn University
University of Georgia
Oklahoma State University

PINEMAP, The Pine Integrated Network: Education, Mitigation, and Adaptation project was funded by the USDA – NIFA Award #2011-68002-30185.

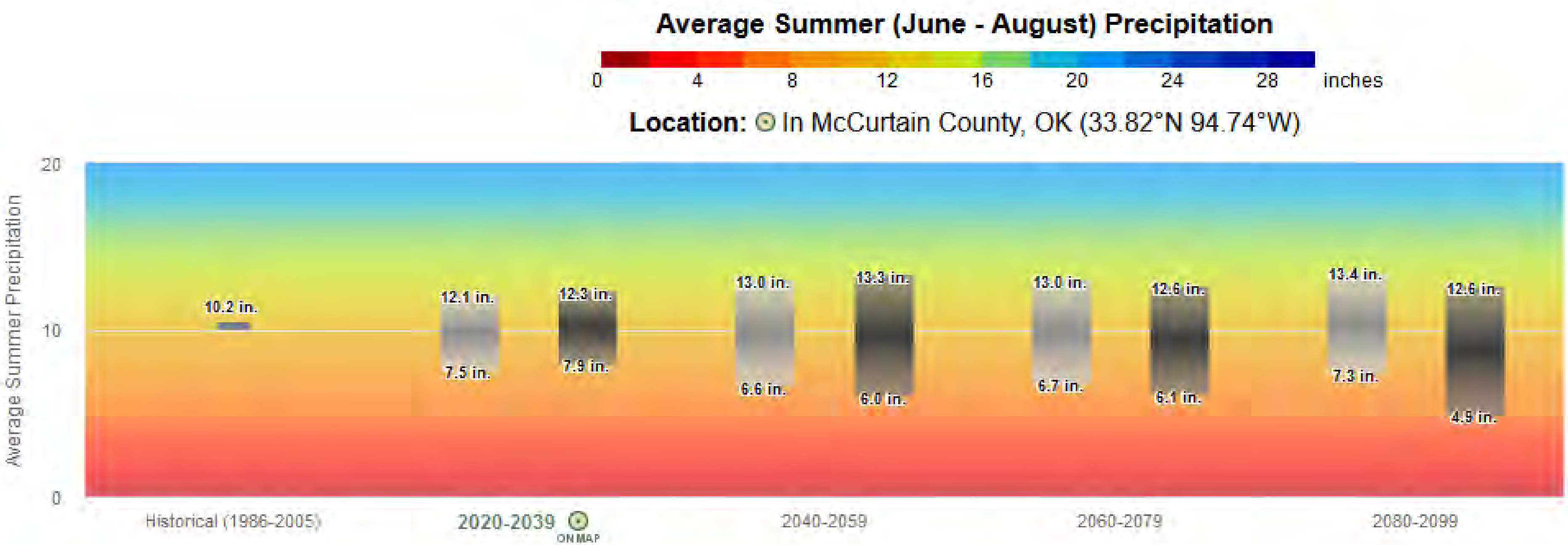
Pinus taeda L. – loblolly pine

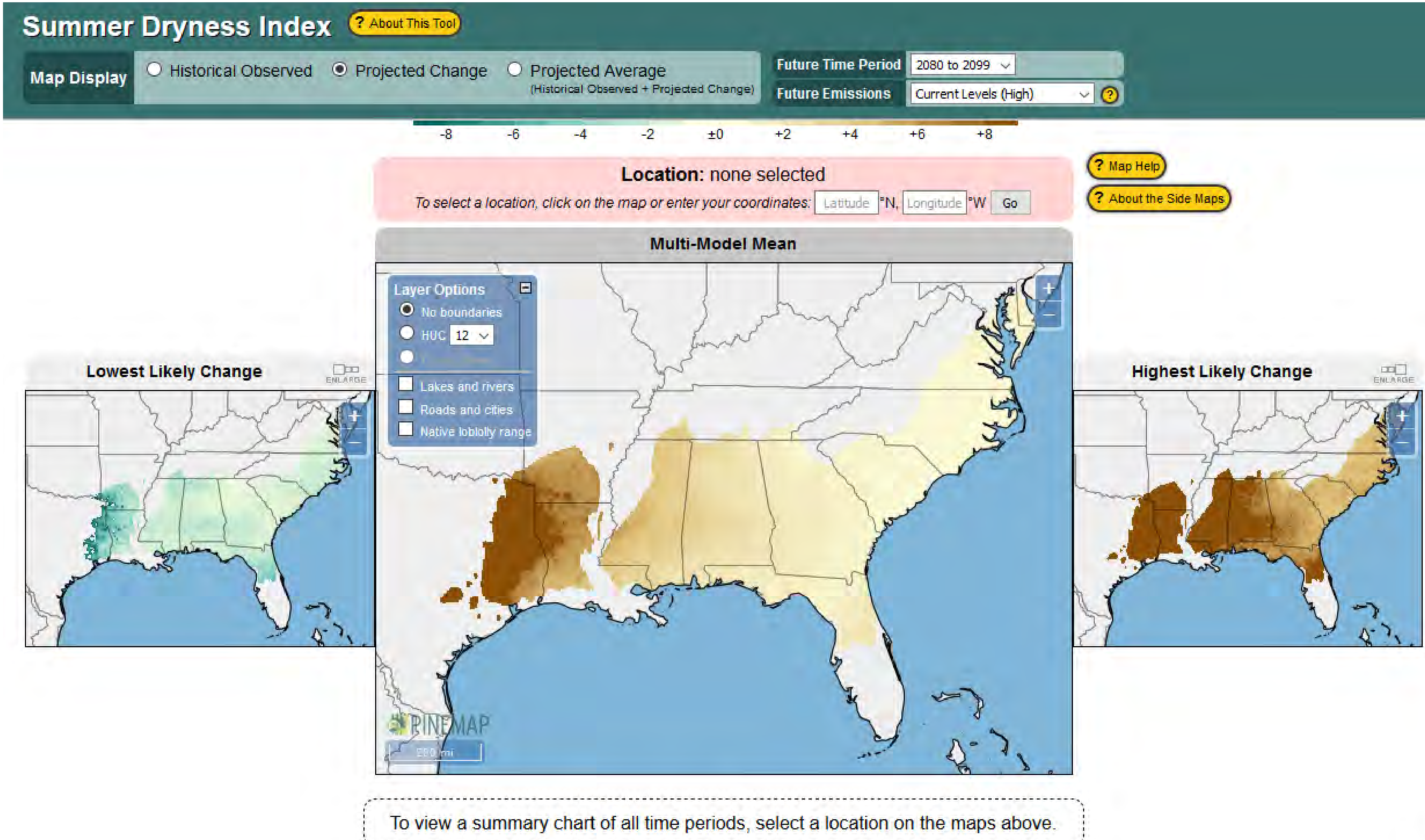


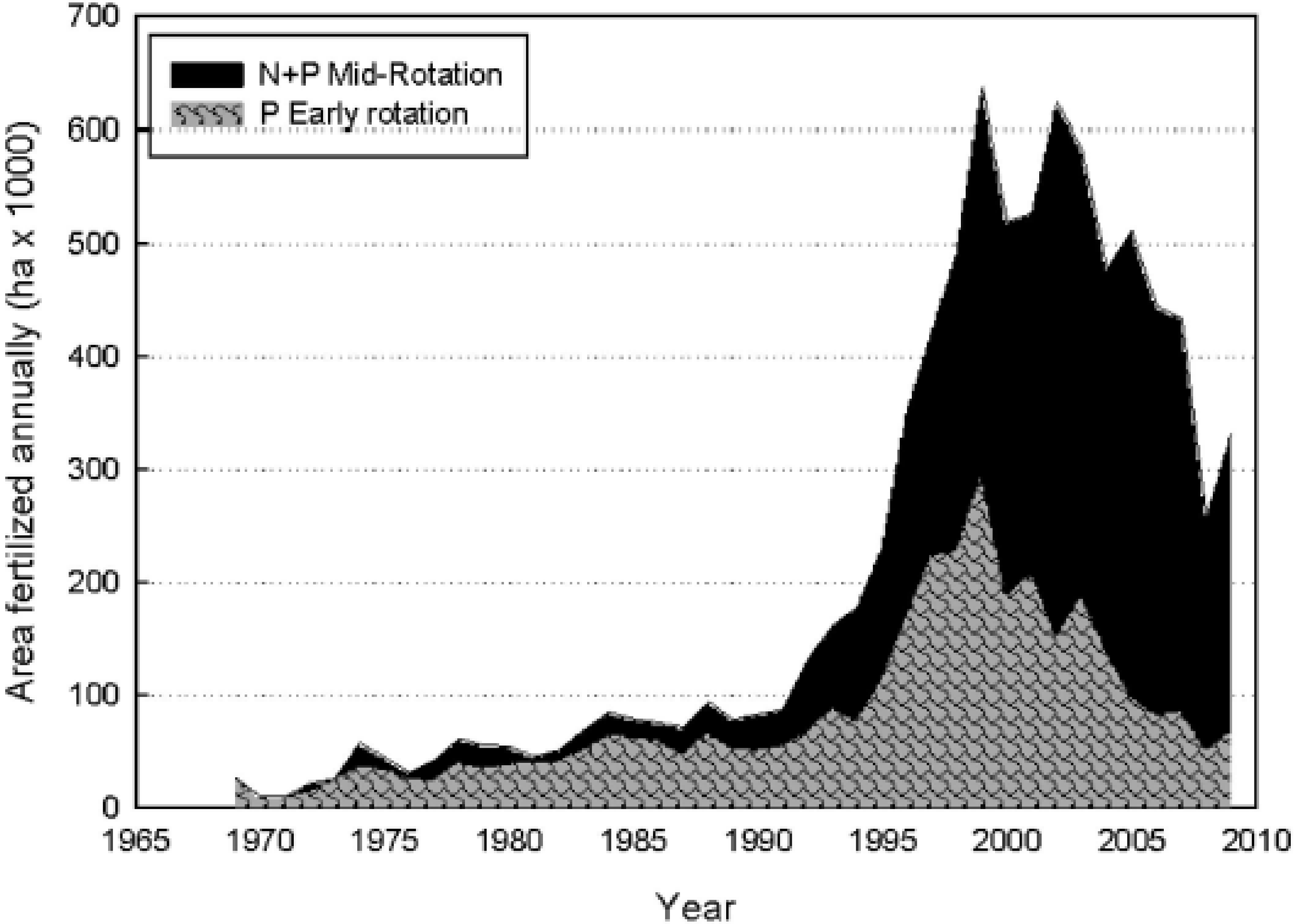
20 CMIP5 models predict a range of precipitation outcomes at EOC



http://pinemapdss.org


Average Summer (June - August) Precipitation
0
4
8
12
16
20
24
28
inches
Location: In McCurtain County, OK (33.82°N 94.74°W)
Average Summer Precipitation
20
10
0
10.2 in.
12.1 in.
7.5 in.
12.3 in.
7.9 in.
13.0 in.
6.6 in.
13.3 in.
6.0 in.
13.0 in.
6.7 in.
12.6 in.
6.1 in.
13.4 in.
7.3 in.
12.6 in.
4.9 in.
Historical (1986-2005)
2020-2039
ON MAP
2040-2059
2060-2079
2080-2099


Summer Dryness Index
? About This Tool
Map Display
Historical Observed
Projected Change
Projected Average
(Historical Observed + Projected Change)
Future Time Period
2080 to 2099
Future Emissions
Current Levels (High)
-8
-6
-4
-2
±0
+2
+4
+6
+8
? Map Help
? About the Side Maps
Location: none selected
To select a location, click on the map or enter your coordinates:
Latitude
°N,
Longitude
°W
Go
Multi-Model Mean
Layer Options
No boundaries
HUC
12
Lakes and rivers
Roads and cities
Native loblolly range
Lowest Likely Change
ENLARGE
Highest Likely Change
ENLARGE
PINEMAP
To view a summary chart of all time periods, select a location on the maps above.



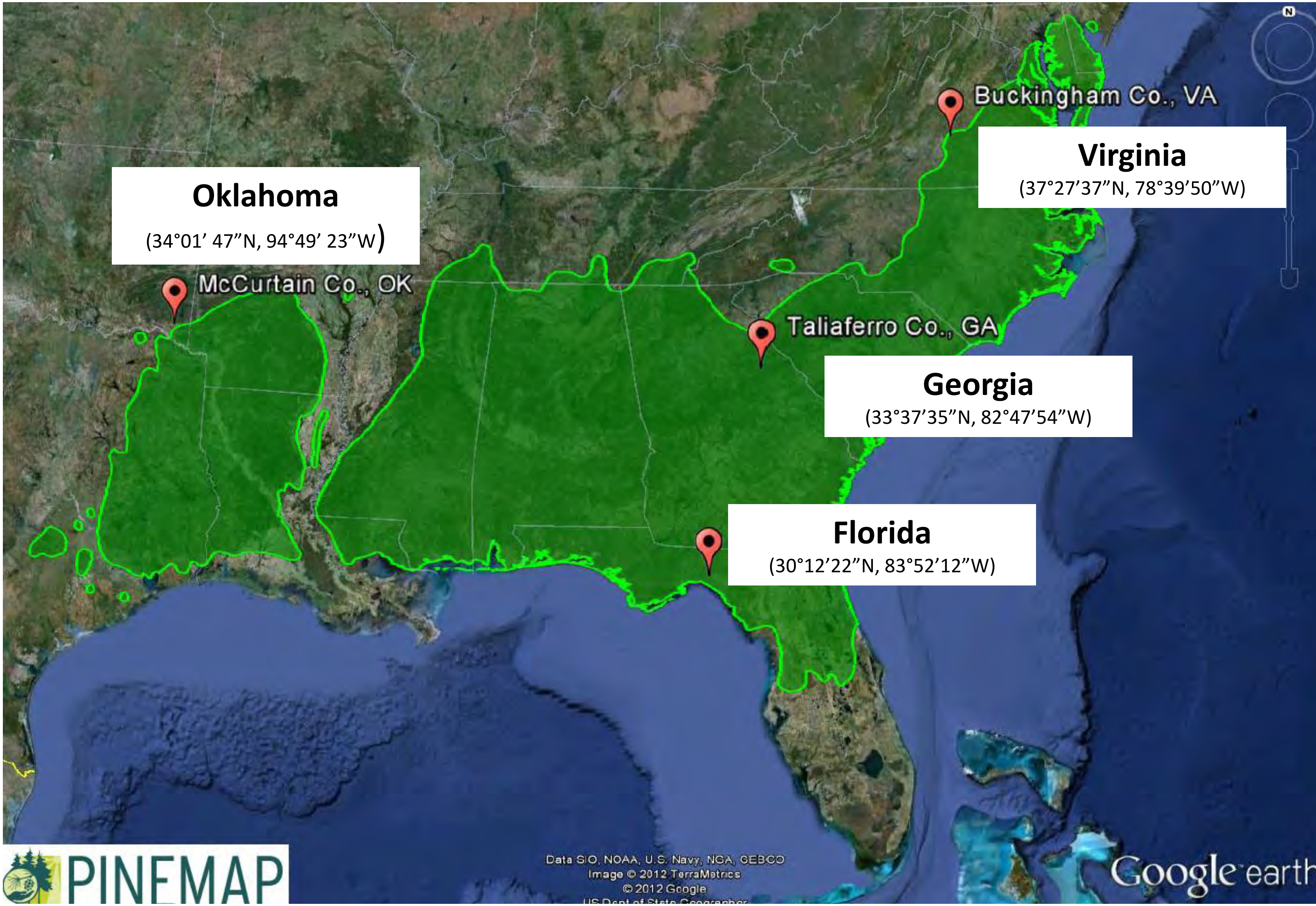
Albaugh et al, 2012

How does altered water availability affect NEP and its components?

Does nutrient availability interact with water availability?

How do responses vary across the natural range of *Pinus taeda*?

PINEMAP Tier III "Throughfall Exclusion x Fertilization" network



PINEMAP

Locations, climate information & soil drainage classes.

Site	Annual precipitation (mm)	Annual Temp (°C)	Drainage class
Florida	1450	19.4	Somewhat poorly drained
Georgia	1220	16.1	Well drained
Oklahoma	1300	16.6	Well drained
Virginia	1120	13.6	Well drained

Will et al 2015

Stand density, tree height, diameter breast height (dbh), stand basal area (BA), by treatment initiation.

Site	Year Est	Stand density 2011 (Trees/ha)	Mean Height (m)	Mean dbh 2011 (cm)	Mean BA 2011 (m^2/ha)
Florida	2004	1720	10.48	12.52	22.42
Georgia	2006	1384	6.34	8.84	8.79
Oklahoma	2008	1611	2.85	3.55	1.80
Virginia	2003	788	8.8	14.45	13.20

N=16

Adapted from Will et al., 2015

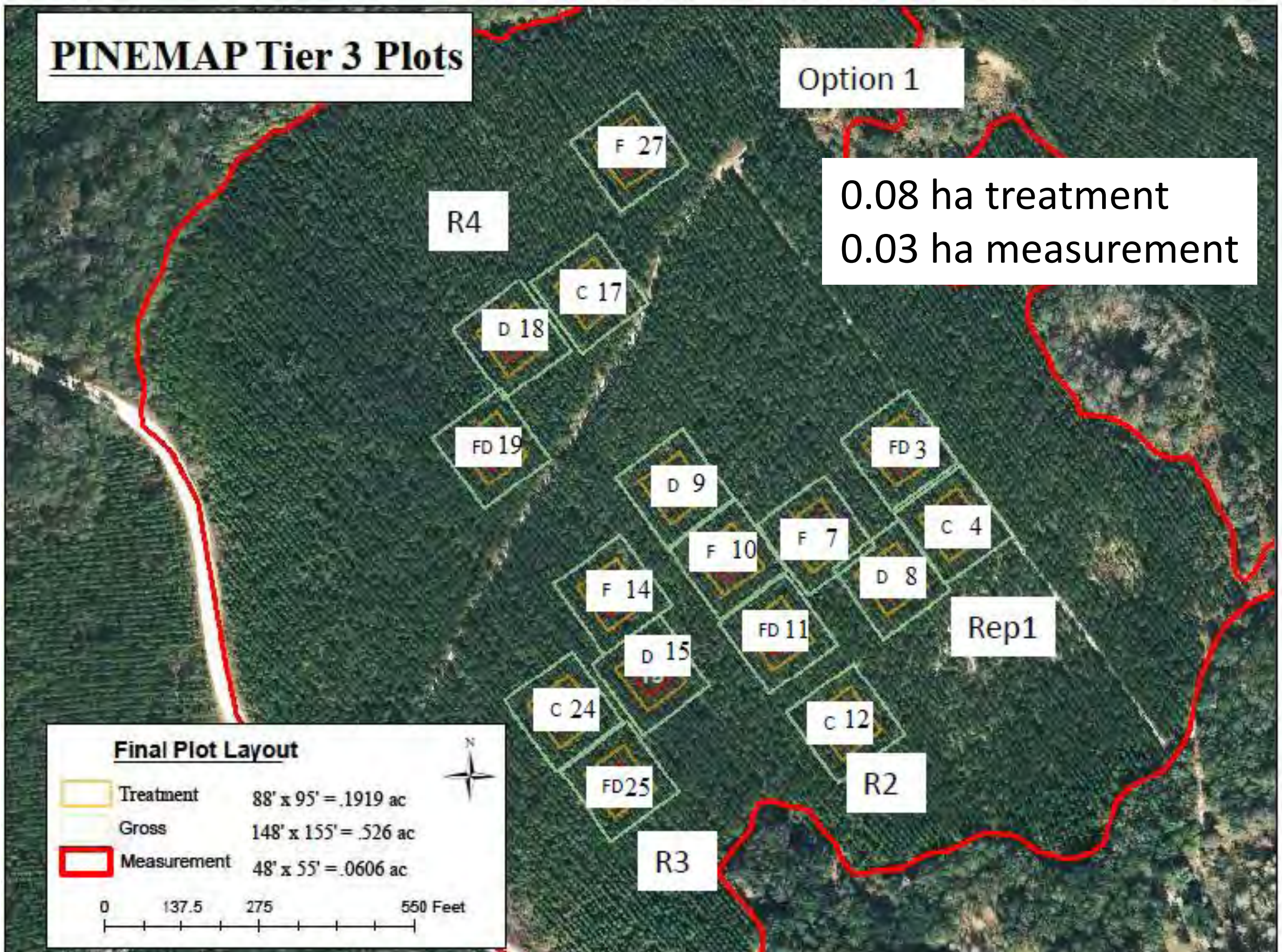
At each site:

4 Replications 2 X 2

Control (**C**), throughfall reduction (**D**),

Fertilizer (**F**), Fertilizer + throughfall reduction (**F*D**)

Genetically diverse, seed orchard mixes



Throughfall reduction (D):

Spring-summer 2012
Covered 30% of the area

Fertilizer: → Applied by hand
March – April 2012.

- N & P (Operational applications).
- Elemental potassium (K).
- Micronutrients.


McCurtain County, OK
Google earth
Imagery Date: 11/13/2012
1995
34°01'50.26" N 94°49'22.79" W elev 488 ft
Eye alt 3065 ft

Carbon Fluxes

Net primary Productivity (**NPP**)
from inventory, litterfall, root increment

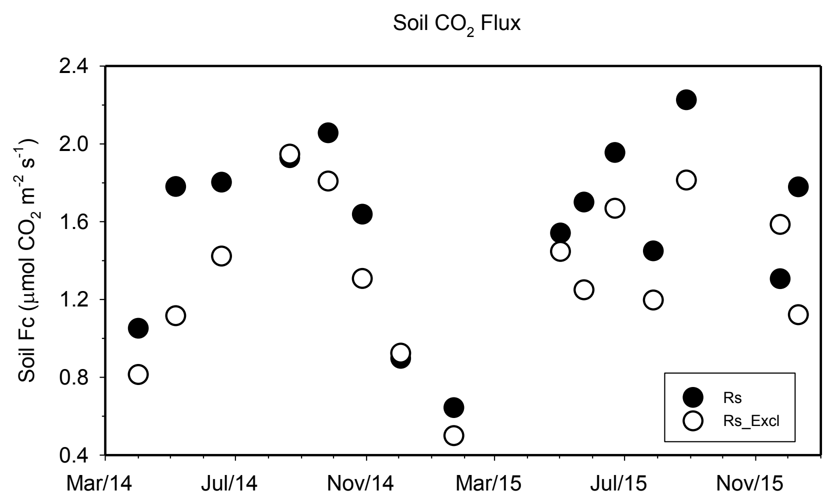
Soil respiration (**R_S**) & Heterotrophic respiration (**R_H**)

Net ecosystem productivity (**NEP**)

Soil respiration (R_S & R_H):

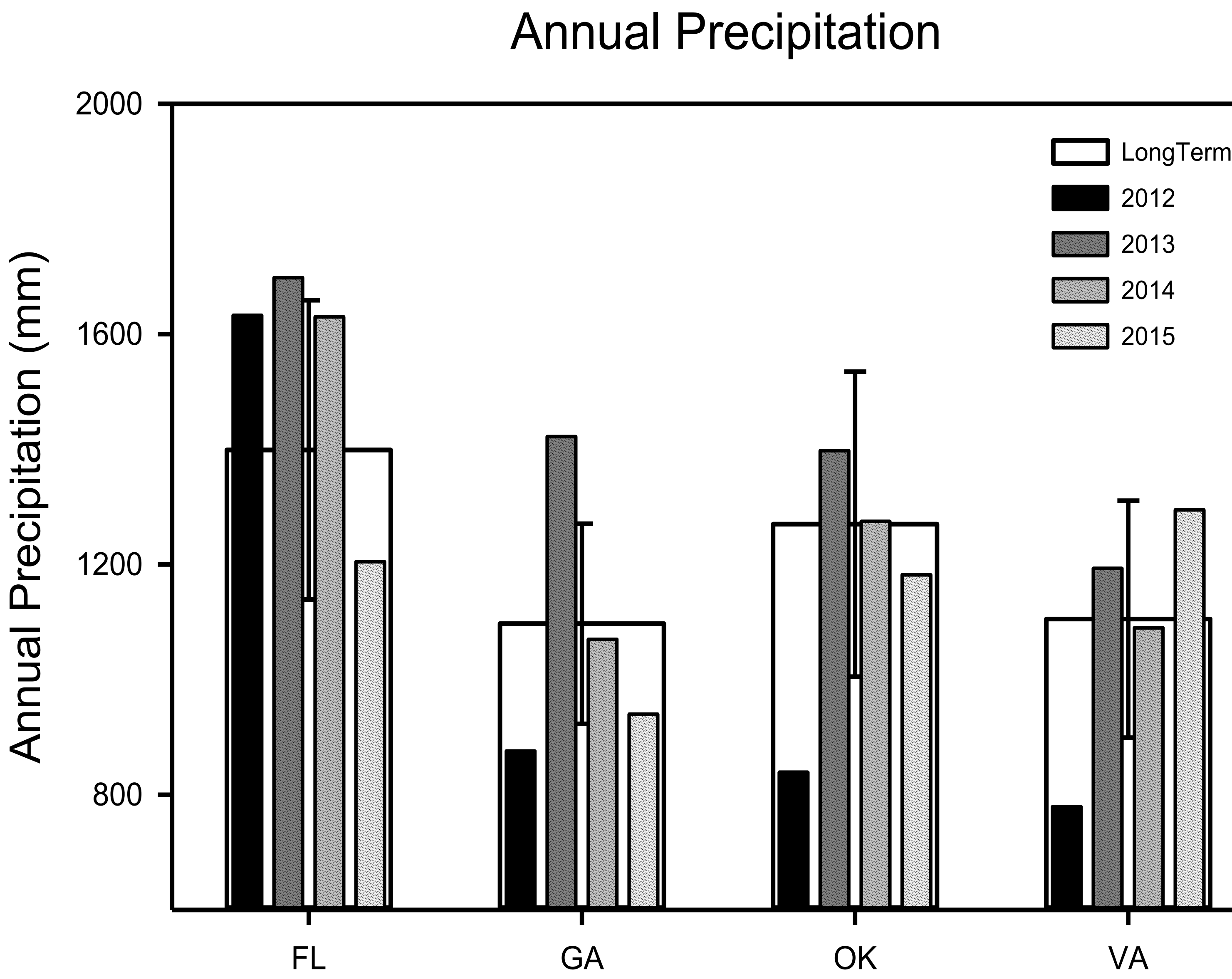
R_S: Measured at different times along with soil temp (T_S) and soil moisture.
R_S = f(Ts) → daily and annual R_S estimated.

R_H: Root severing collars. Paired R_S and R_H → after 40-80 days of installation.
Ratio (R_H:R_S)

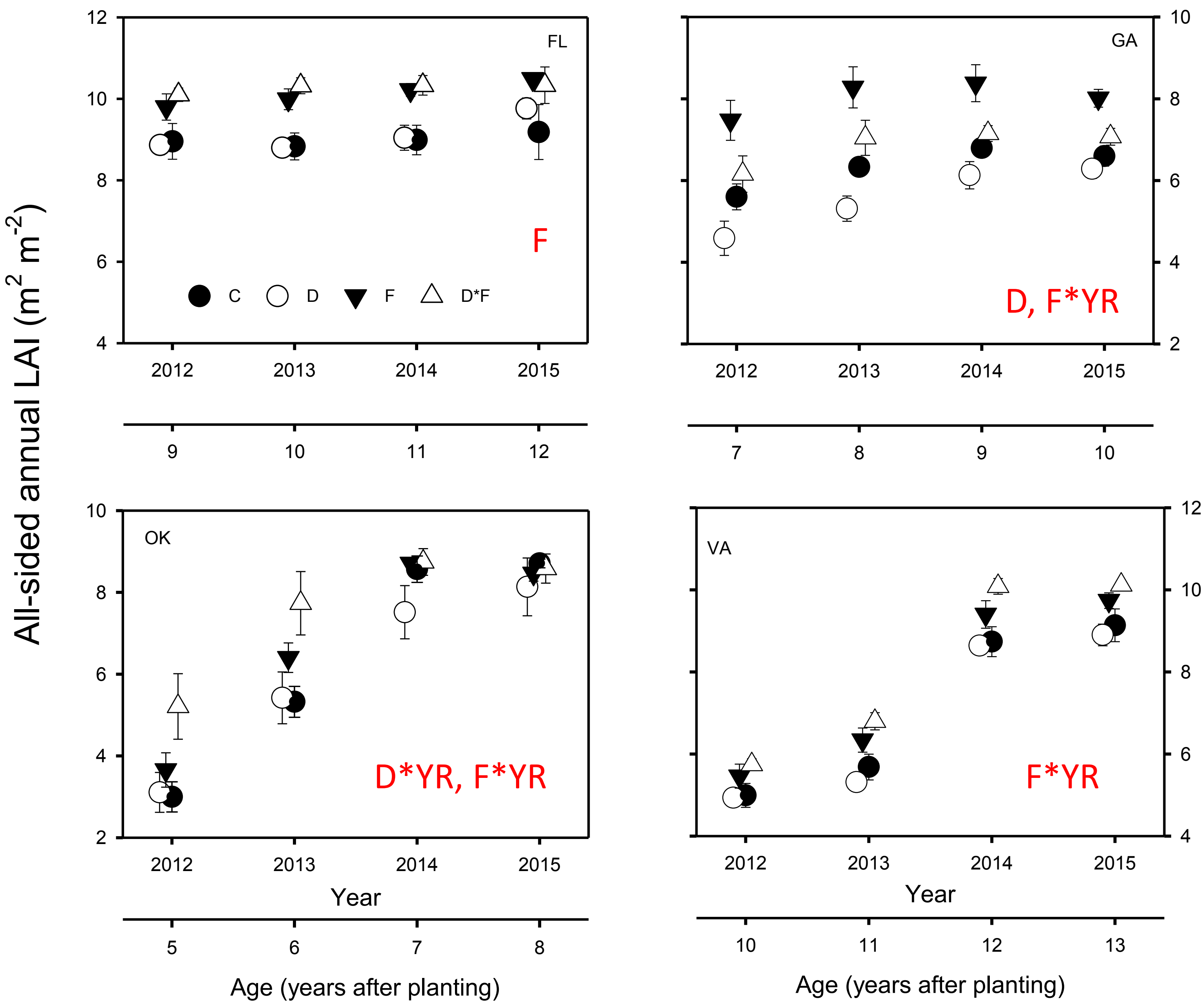


NEP = NPP - R_H

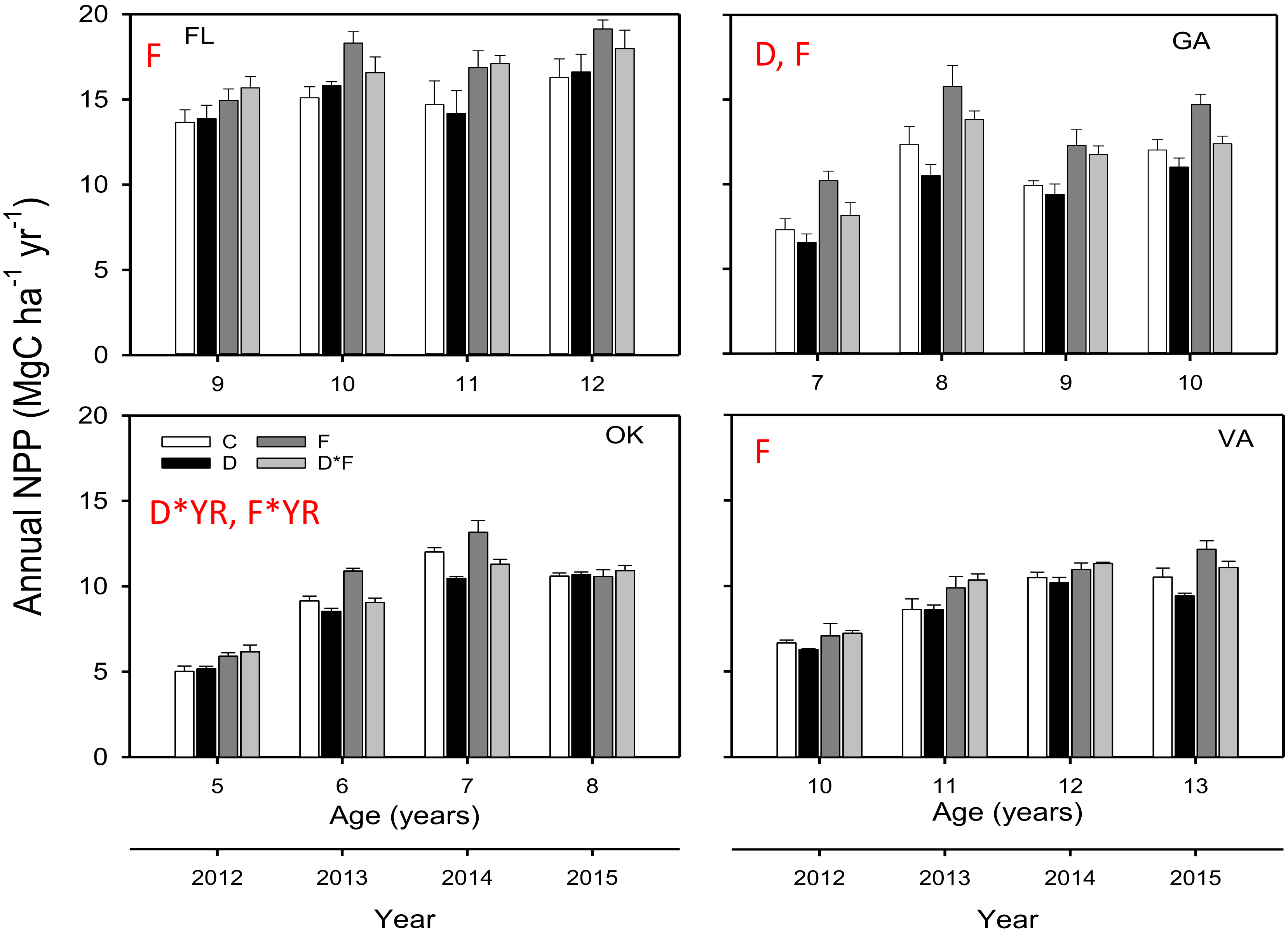
Results

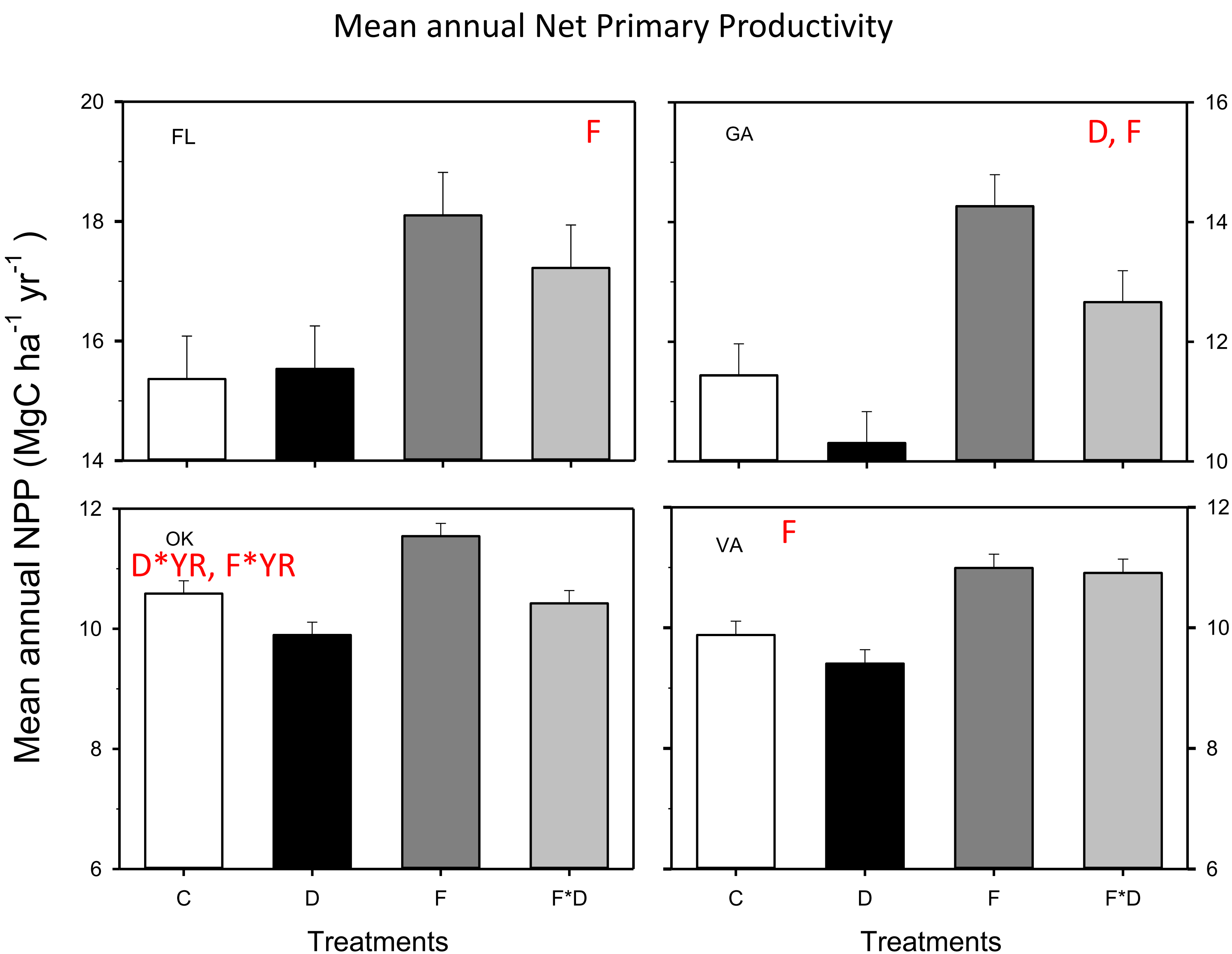

Annual Precipitation
Annual Precipitation (mm)
2000
1600
1200
800
LongTerm
2012
2013
2014
2015
FL
GA
OK
VA

All sided Leaf Area Index



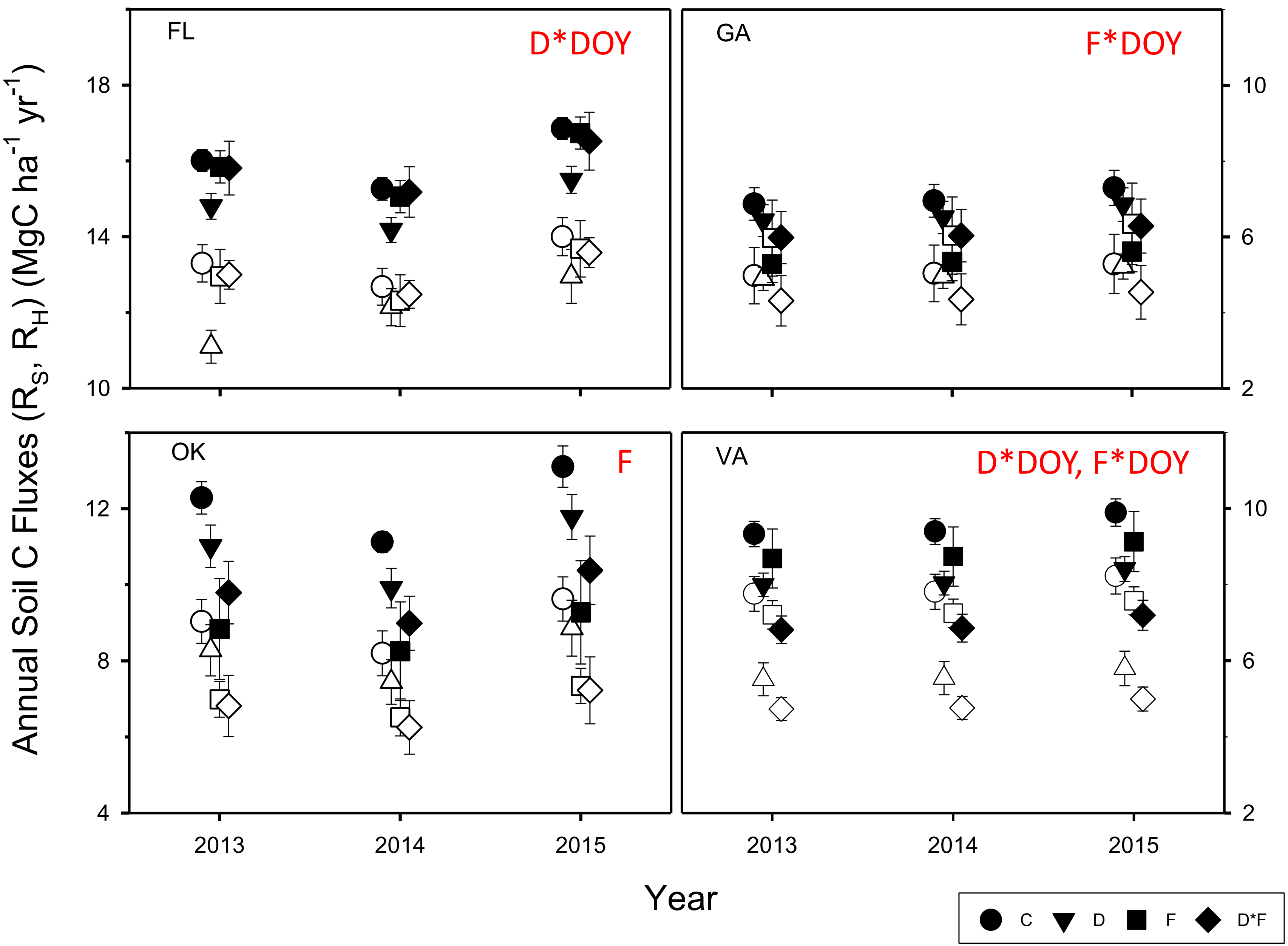
Net Primary Productivity (NPP)

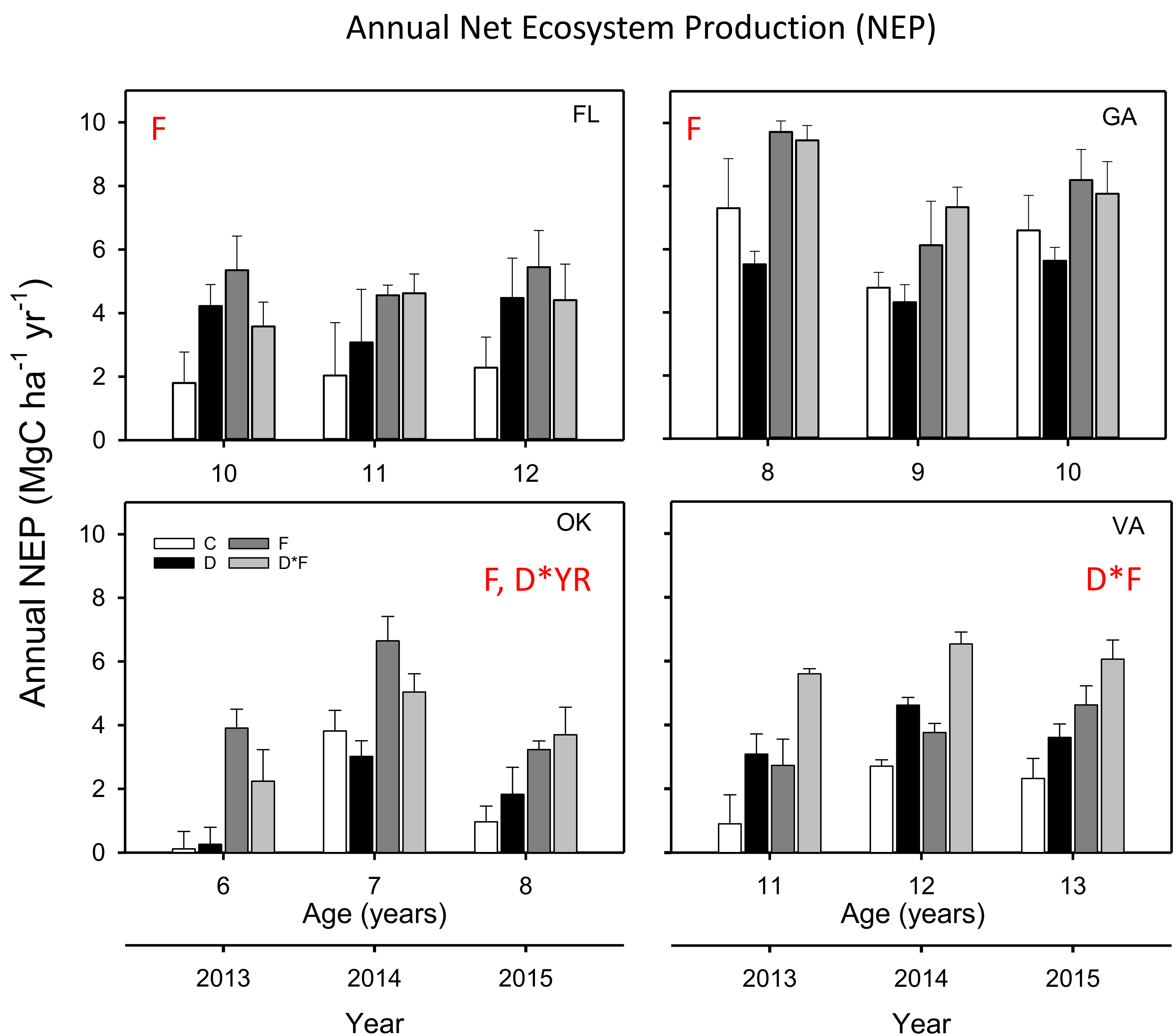




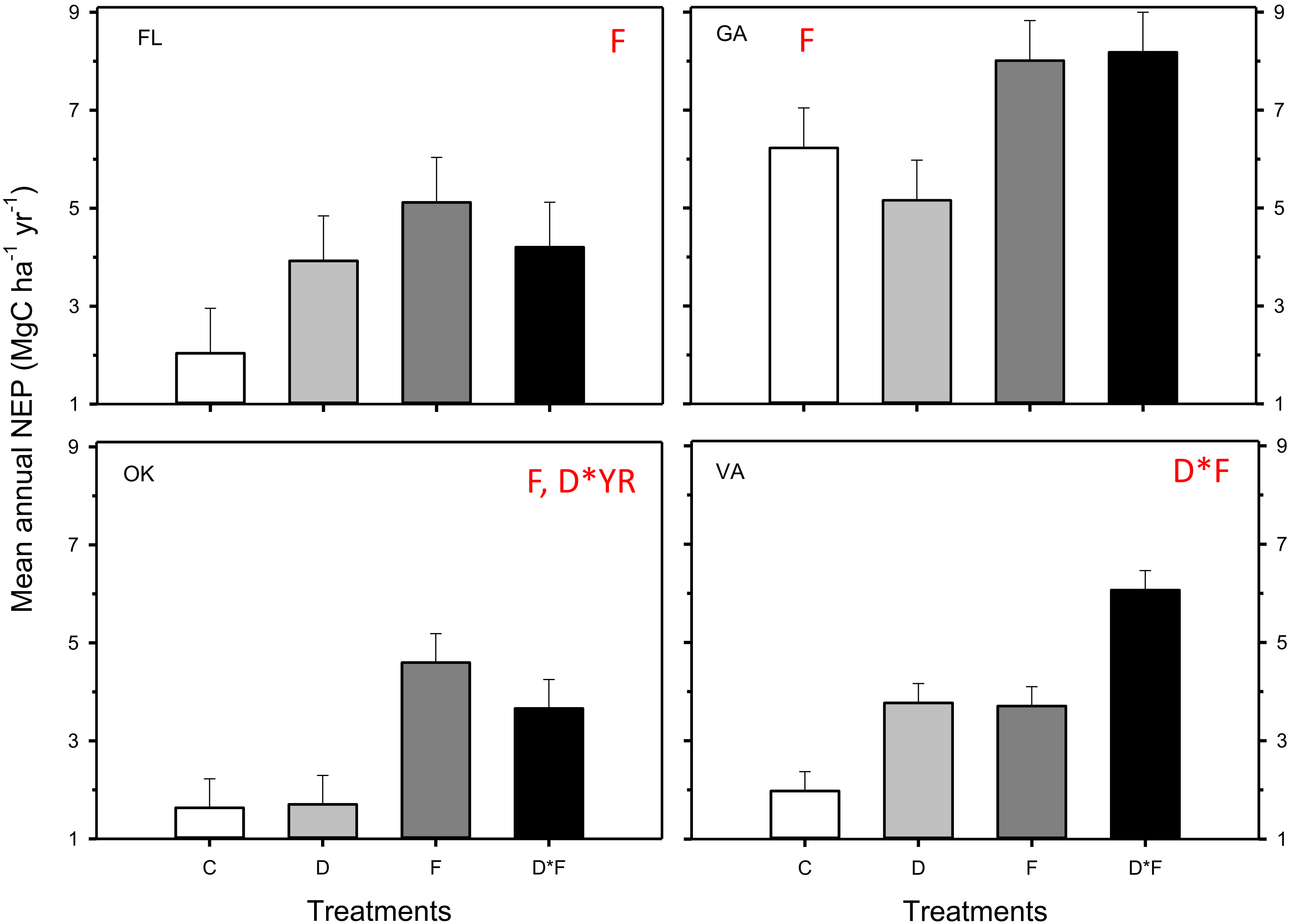
Mean annual Net Primary Productivity
Mean annual NPP (MgC ha-1 yr-1)
FL
F
GA
D, F
OK
D*YR, F*YR
VA
F
20
18
16
14
16
14
12
10
12
10
8
6
12
10
8
6
C
D
F
F*D
C
D
F
F*D
Treatments
Treatments

Annual Soil Respiration (R_S & R_H)




Annual Net Ecosystem Production (NEP)
Annual NEP (MgC ha-1 yr-1)
FL
F
GA
F
OK
F, D*YR
VA
D*F
C
D
F
D*F
0
2
4
6
8
10
10
11
12
8
9
10
6
7
8
11
12
13
Age (years)
Age (years)
2013
2014
2015
2013
2014
2015
Year
Year

Mean annual Net Ecosystem Production (NEP)



10,000 ft view

- Most consistent effects across sites were positive effects of F on productivity and NEP
- Only strong effects of D were at GA
- Only D*F was at VA, where NEP was elevated due to positive effects of F on NPP and decreased Rh due to D
- Caveats: role of subsurface water transport?; timing of precip not altered; role of disturbance; insert your favorite here ______

Further detail and context

- **Tier III overview:** Will *et al*., 2015. A range-wide experiment to investigate nutrient and soil moisture interactions in loblolly pine plantations. *Forests 6 (6):2014-2028.*
- **OK:** Maggard *et al*., 2017. Fertilization can compensate for decreased water availability by increasing the efficiency of stem volume production per unit of leaf area for loblolly pine (*Pinus taeda*) stands. Can.J.For.Res. 47 (4):445-457.
- **OK, 100% exclusion**: Maggard *et al.*, 2016. Response of mid-rotation loblolly pine (*Pinus taeda L.*) physiology and productivity to sustained, moderate drought on the western edge of the range. Forests 7:203
- **FL:** Wightman *et al*., 2016. Loblolly pine productivity and water relations in response to throughfall reduction and fertilizer application on a poorly drained site in northern Florida. *Forests 7:214.*
- **GA:** Samuelson *et al.*, 2014. Two-year throughfall and fertilization effects on leaf physiology and growth of loblolly pine in the Georgia Piedmont. *Forest Ecology and Management 330:29-37.*
- **VA:** Ward *et al*., 2015. Fertilization intensifies drought stress: Water use and stomatal conductance of *Pinus taeda* in a midrotation fertilization and throughfall reduction experiment. Forest Ecology and Management 355:72-82.

Questions & Answers

- **By phone:** **Dial #2 to enter the queue.**
- **On your computer:** **Type your question into the Q & A pod on the left side of your screen.**

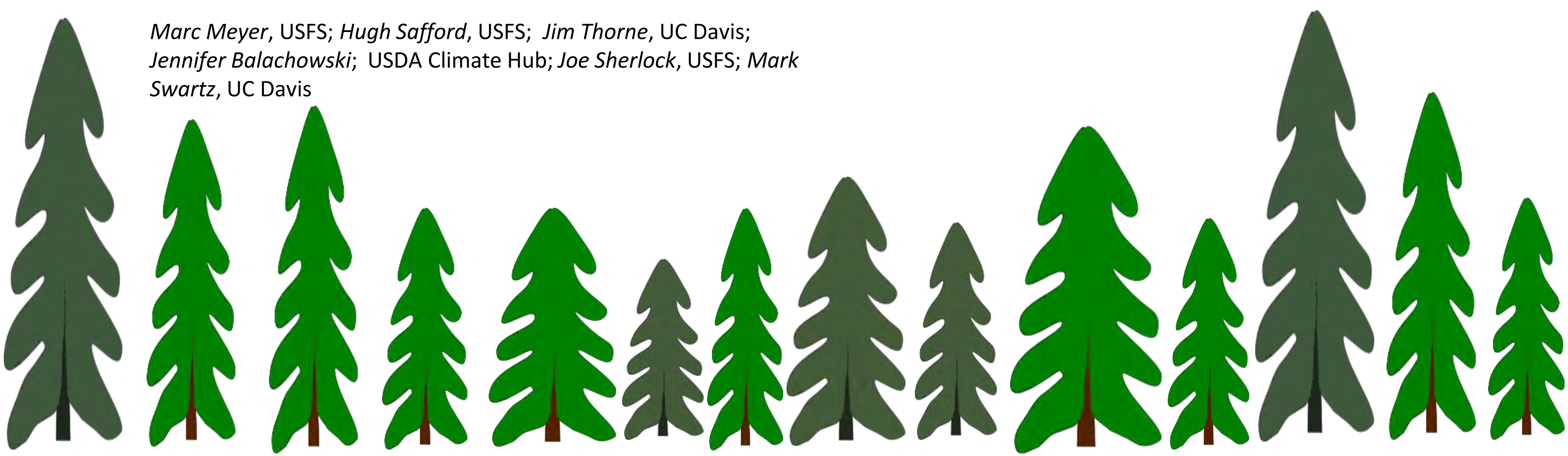
California Forests are Changing: Drought and Tree Mortality in the Sierra Nevada

Steven Ostoja

Director, USDA California Climate Hub, Agricultural Research Service, John Muir Institute of the Environment, University of California Davis

Acknowledgements

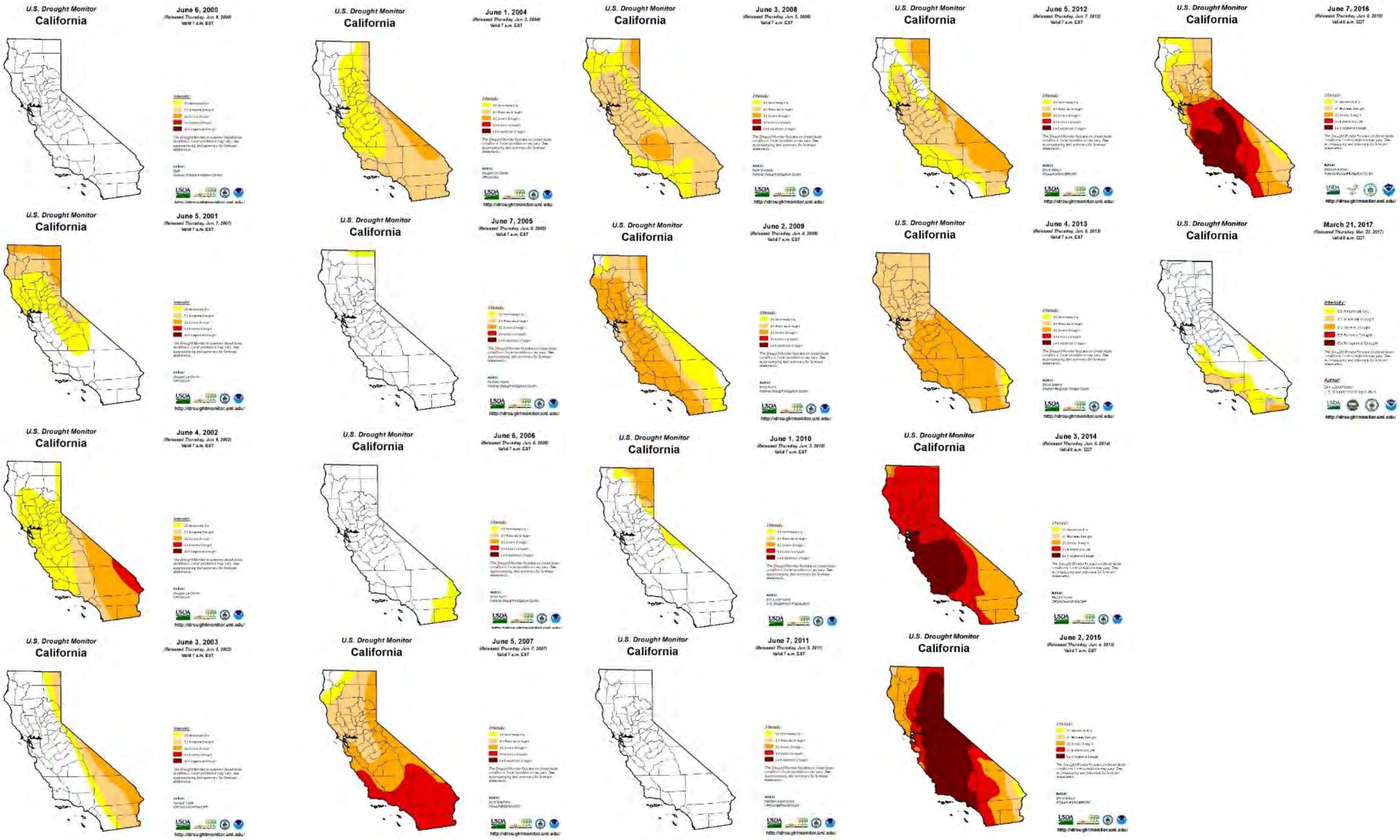
Marc Meyer, USFS; *Hugh Safford*, USFS; *Jim Thorne*, UC Davis; *Jennifer Balachowski*; USDA Climate Hub; *Joe Sherlock*, USFS; *Mark Swartz*, UC Davis



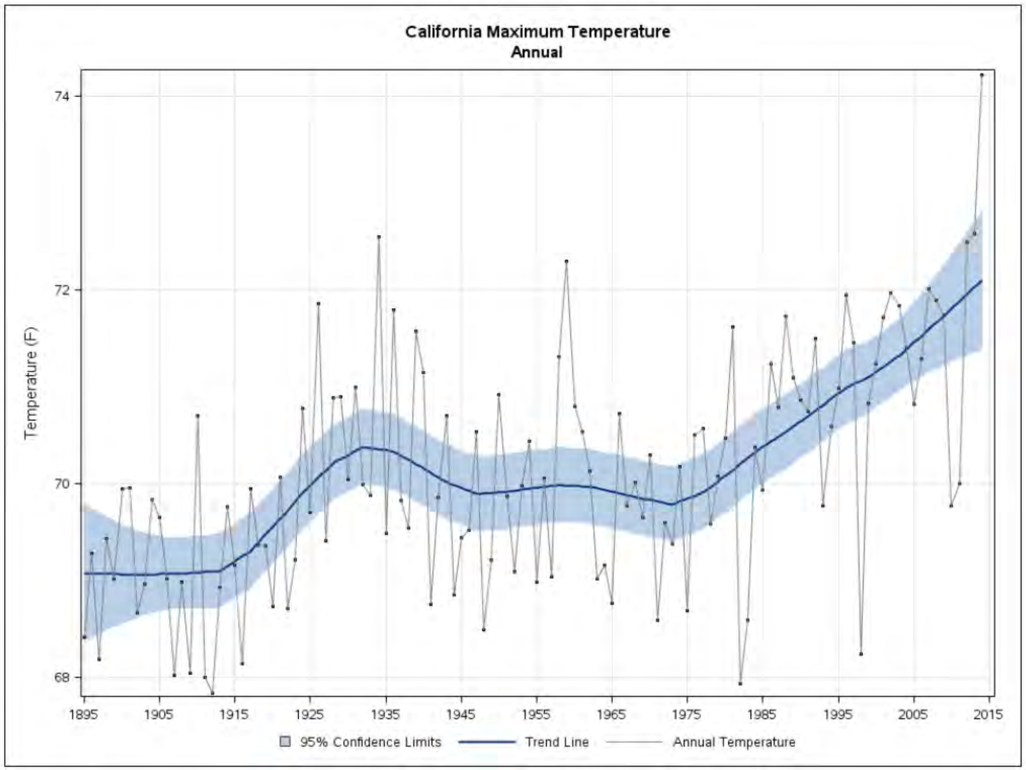
Talk Outline

- California's hot drought
- The ghost of forest management
- Thinking toward the future
- Prioritizing restoration
- Seed collection and reforestation

United States Department of Agriculture
California Climate Hub


U.S. Drought Monitor
California
June 6, 2000
U.S. Drought Monitor
California
June 5, 2001
U.S. Drought Monitor
California
June 4, 2002
U.S. Drought Monitor
California
June 3, 2003
U.S. Drought Monitor
California
June 1, 2004
U.S. Drought Monitor
California
June 7, 2005
U.S. Drought Monitor
California
June 6, 2006
U.S. Drought Monitor
California
June 5, 2007
U.S. Drought Monitor
California
June 3, 2008
U.S. Drought Monitor
California
June 2, 2009
U.S. Drought Monitor
California
June 1, 2010
U.S. Drought Monitor
California
June 7, 2011
U.S. Drought Monitor
California
June 5, 2012
U.S. Drought Monitor
California
June 4, 2013
U.S. Drought Monitor
California
June 3, 2014
U.S. Drought Monitor
California
June 2, 2015
U.S. Drought Monitor
California
June 7, 2016
U.S. Drought Monitor
California
March 21, 2017
http://droughtmonitor.unl.edu/

Hot Droughts



CLIMATE SCIENCE

The challenge of hot drought

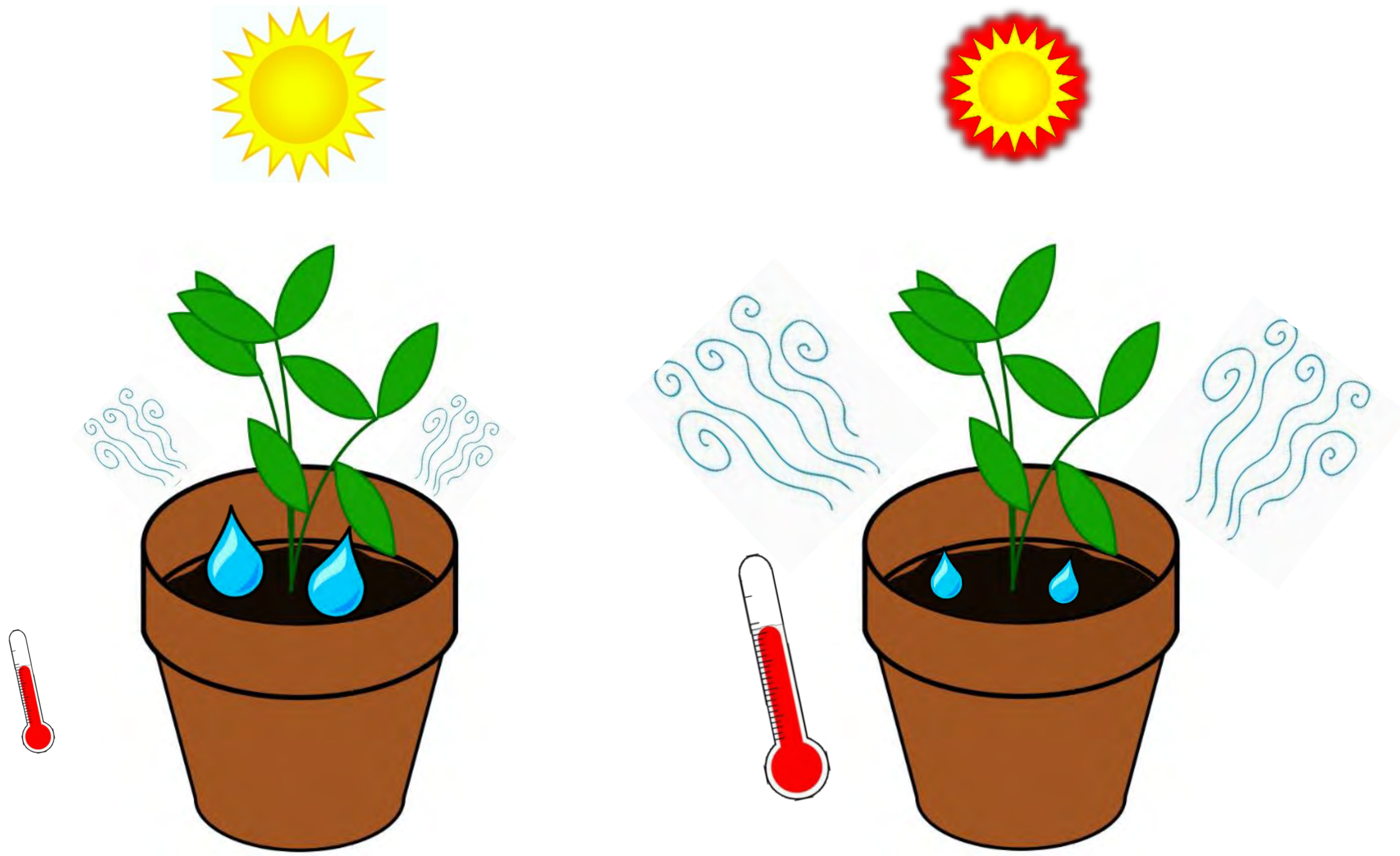
An analysis of North American drought variability over the past millennium shows that it is not unusual for widespread drought to persist for years, prompting fresh thinking about our ability to deal with such climate conditions.

JONATHAN T. OVERPECK

Drought is heating up around the warming world. Particularly hot drought has cost more than US$40 billion and claimed 218 human lives since 2010 in the United States alone[1]. These hot and dry covered more than half of the continental United States in 2012[4]. This drought affected several regions of North America (Fig. 1), earning it the distinction of being a pan-continental drought rather than the more common regional drought[3]. Cook *et al.* tap a continental array of 1,000-year drought

explanation and yet it i
persistent anomalies o
ture can combine with
vegetation and soil to d
they happened today —
of our institutional capa
aridity. For example, an
highlighted a 50-year d
normal year of precipita
of both the Colorado Ri
during Roman times. It
such a drought would
would surely prove a m
to regional water resou
any drought of the past

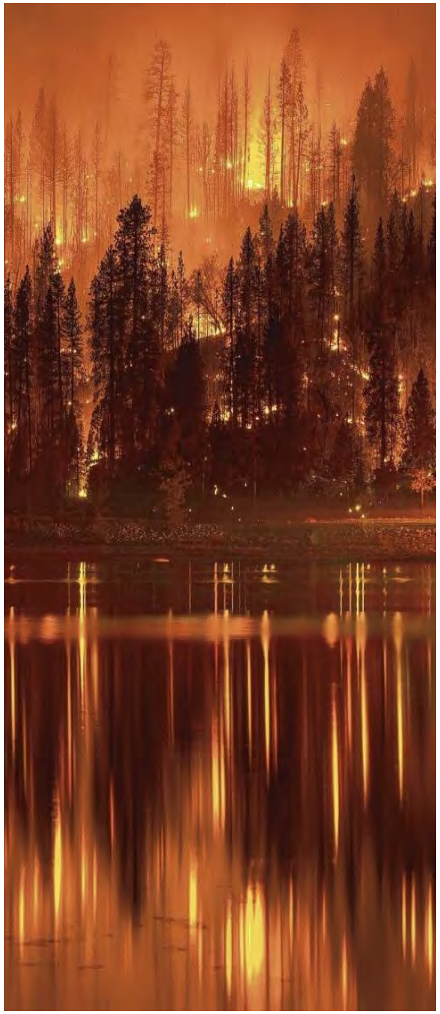
Tree-ring records a
source of palaeoclimat
climate records from la
formations also help to
varied over timescales
understood from the sh



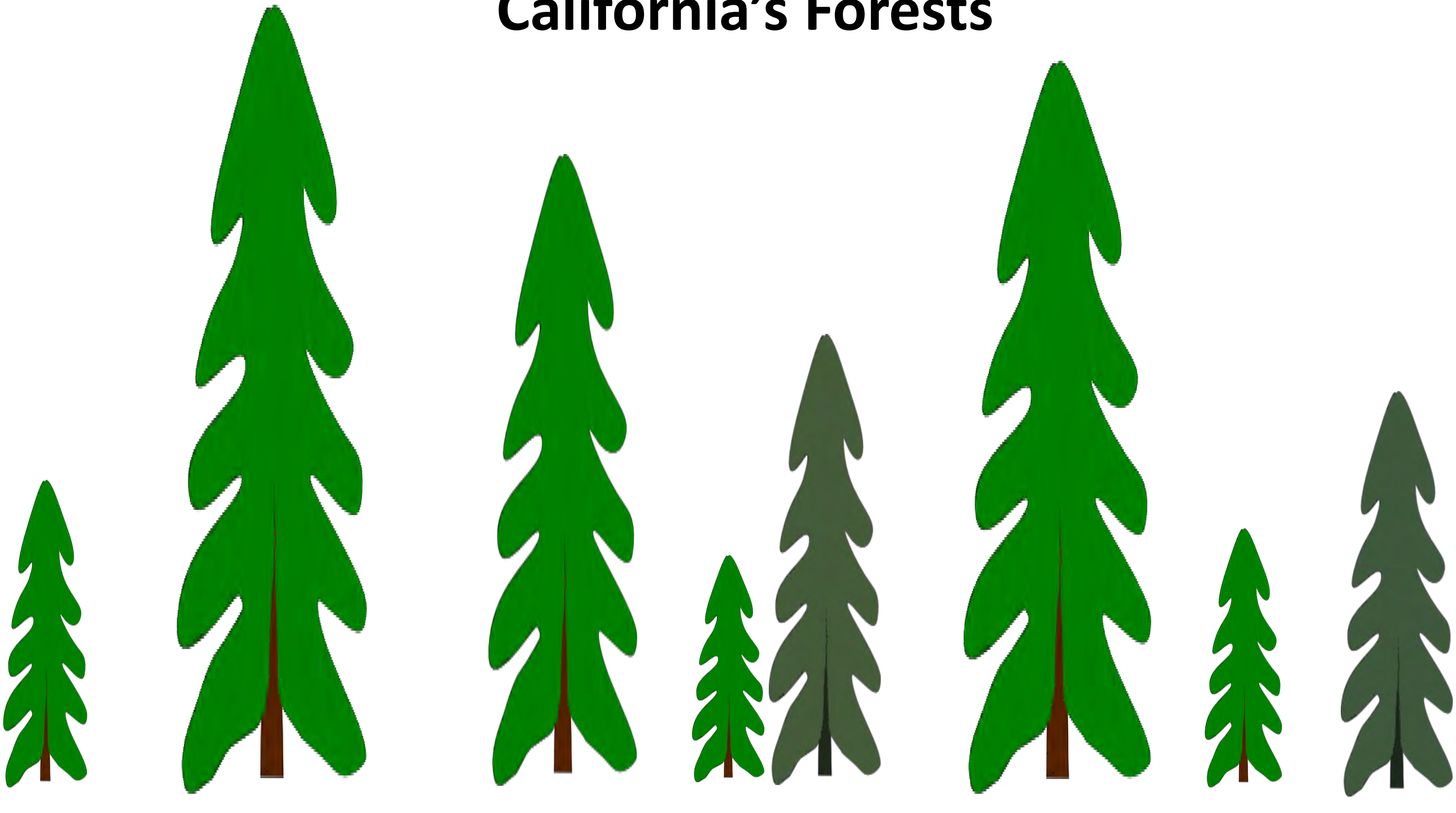
Expected Climate Trends

- Temperatures will increase
- Precipitation change uncertain
- Snowpack will decline
- More extreme wet and dry years
- Larger, more severe fires

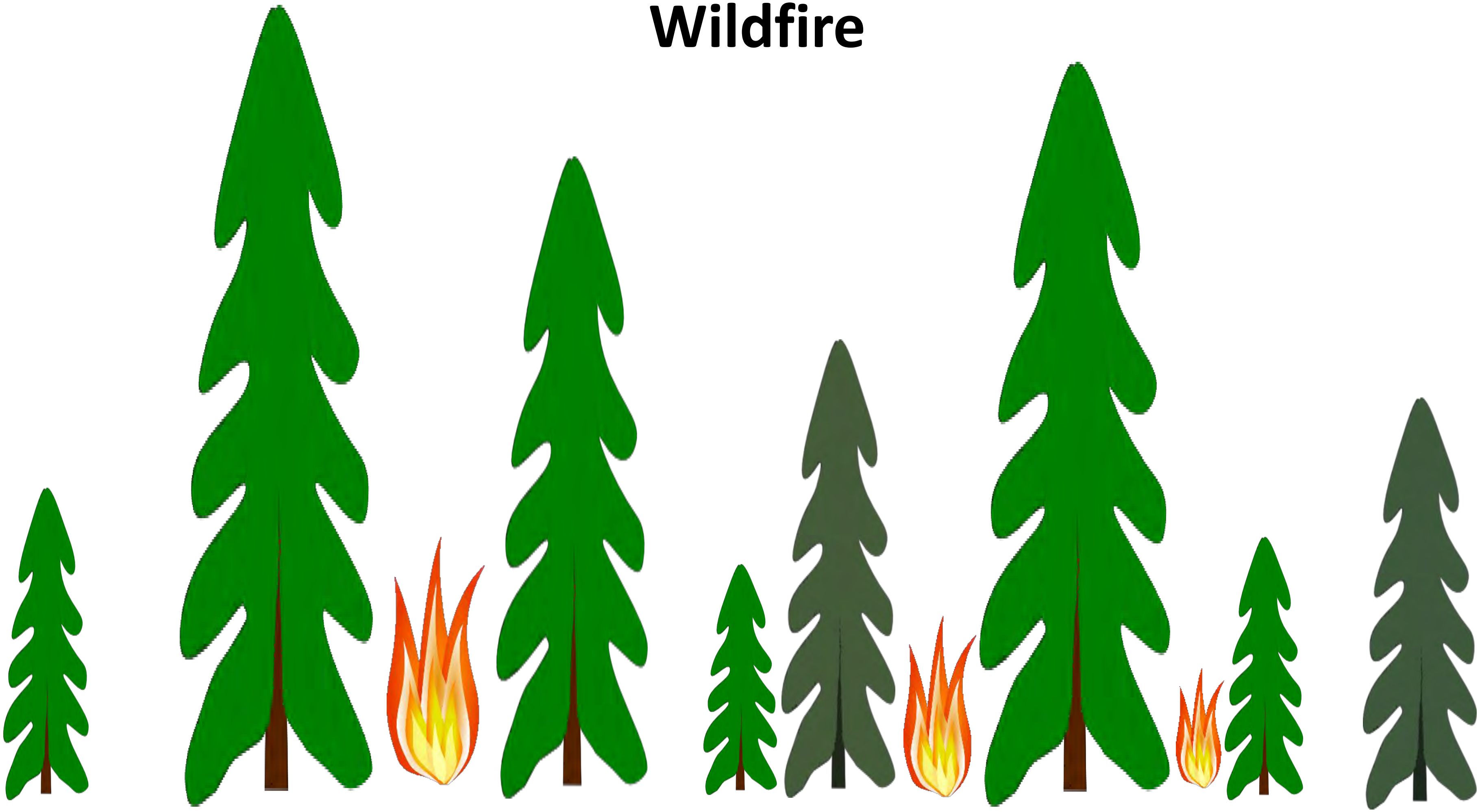
United States Department of Agriculture
California Climate Hub



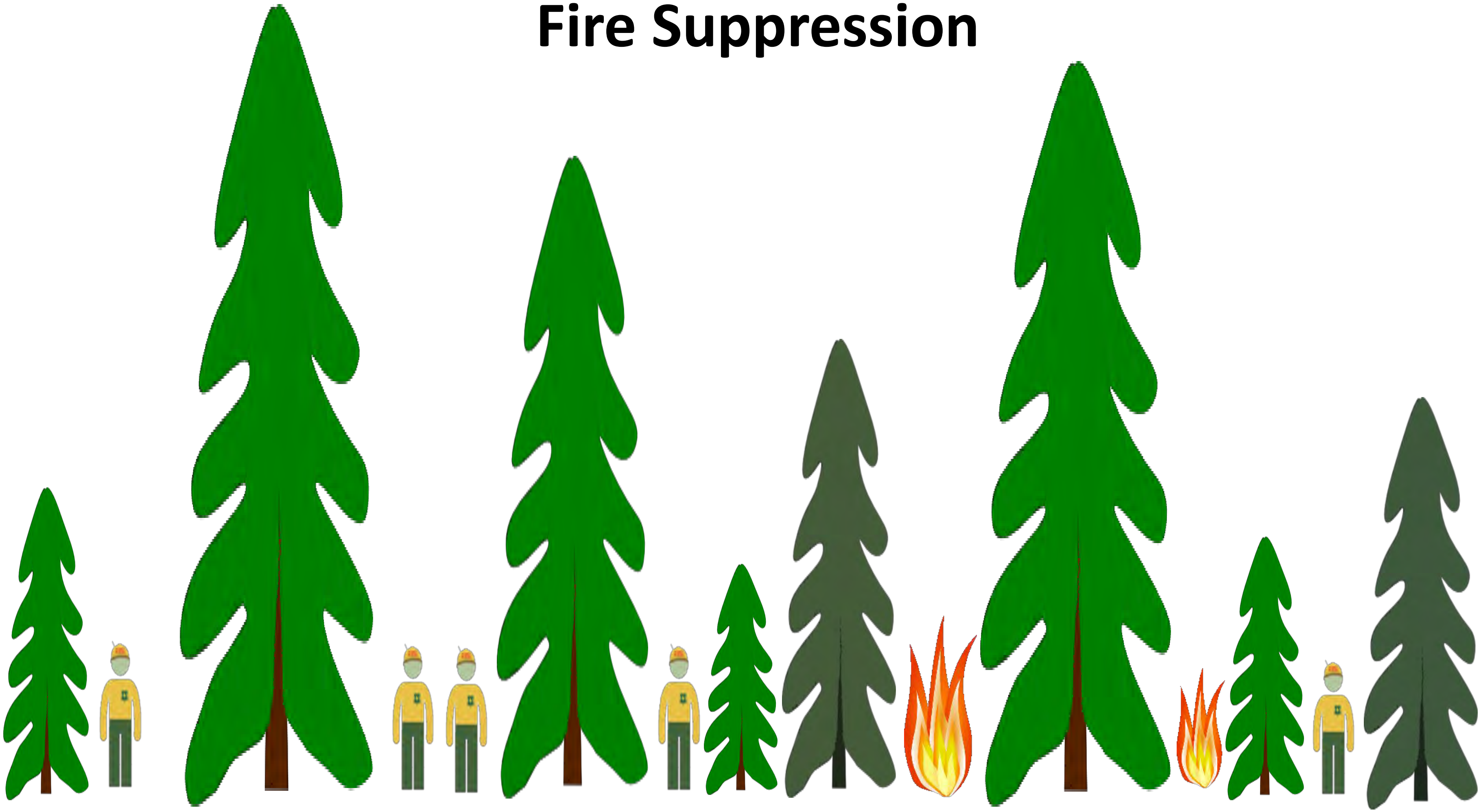
California's Forests



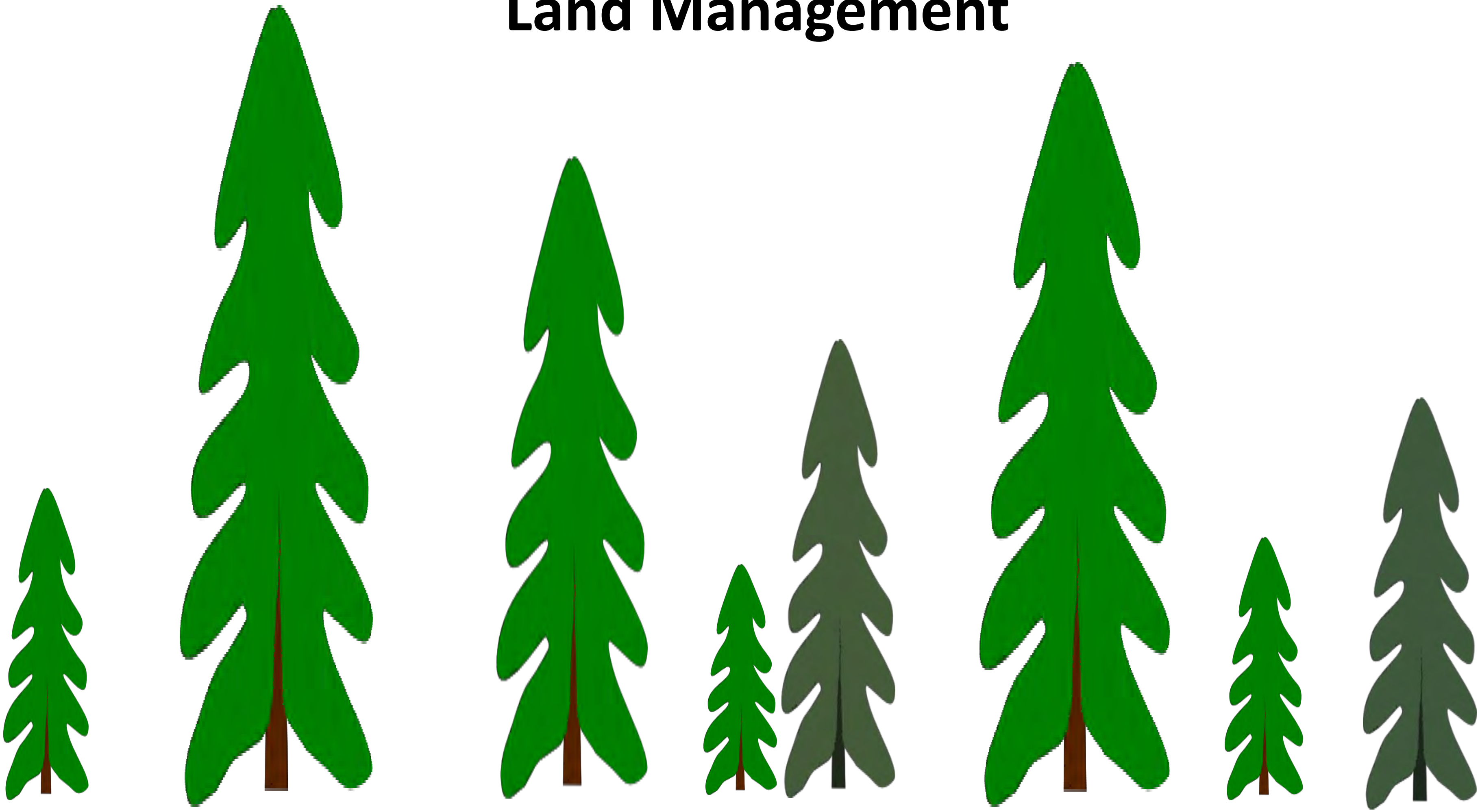
Wildfire



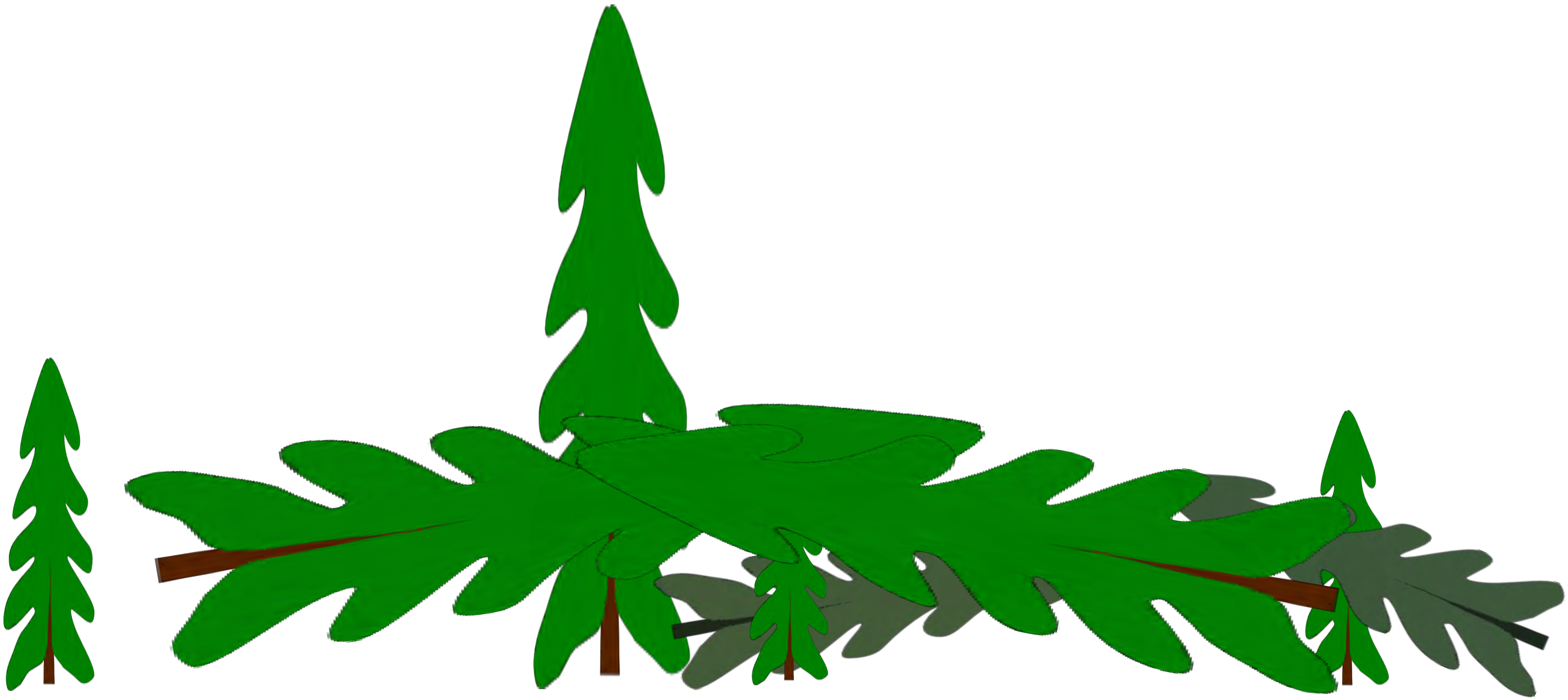
Fire Suppression



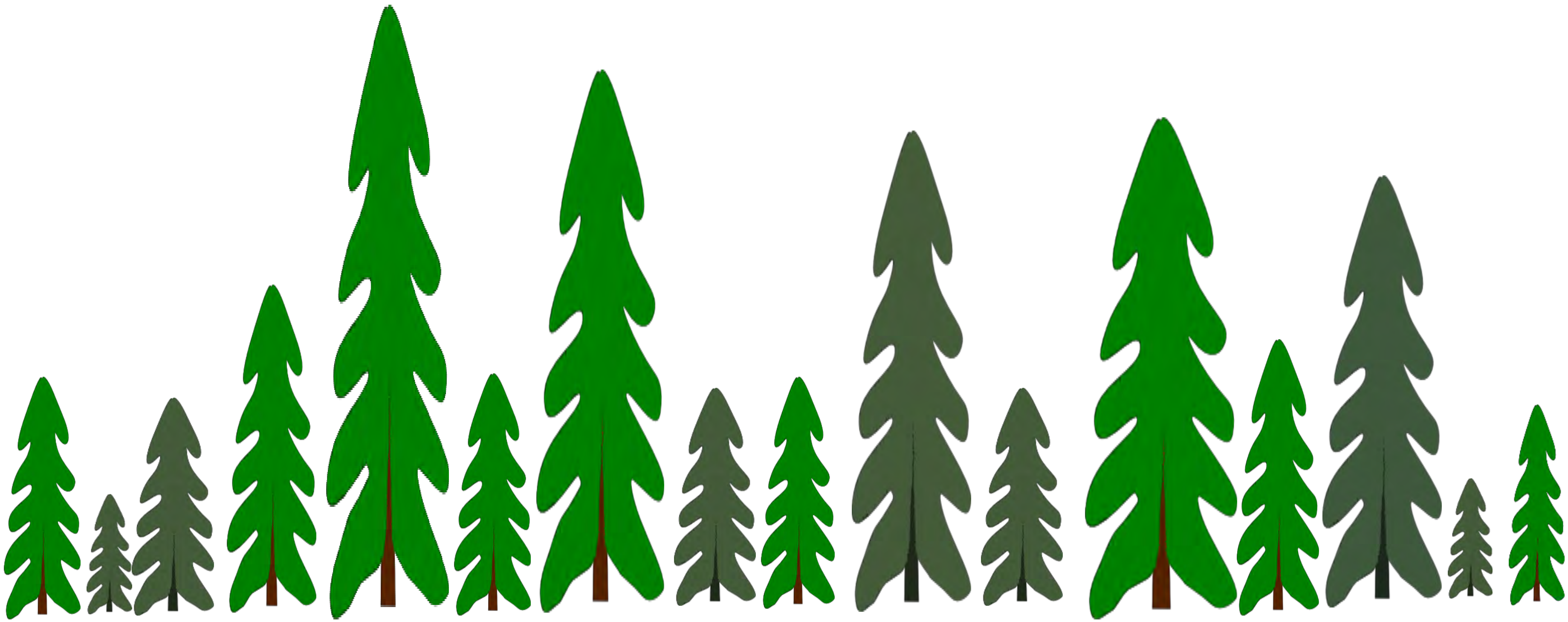
Land Management



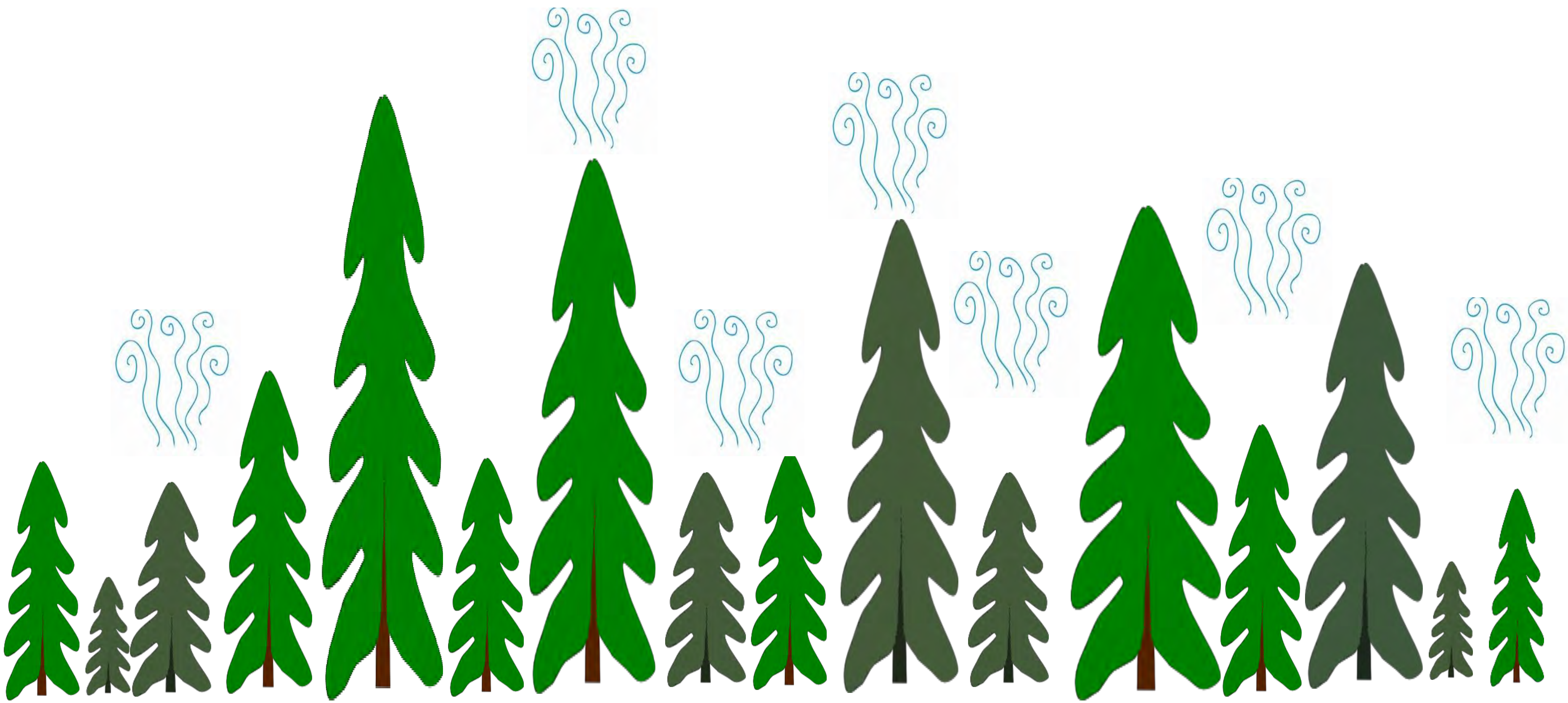
Timber Harvest



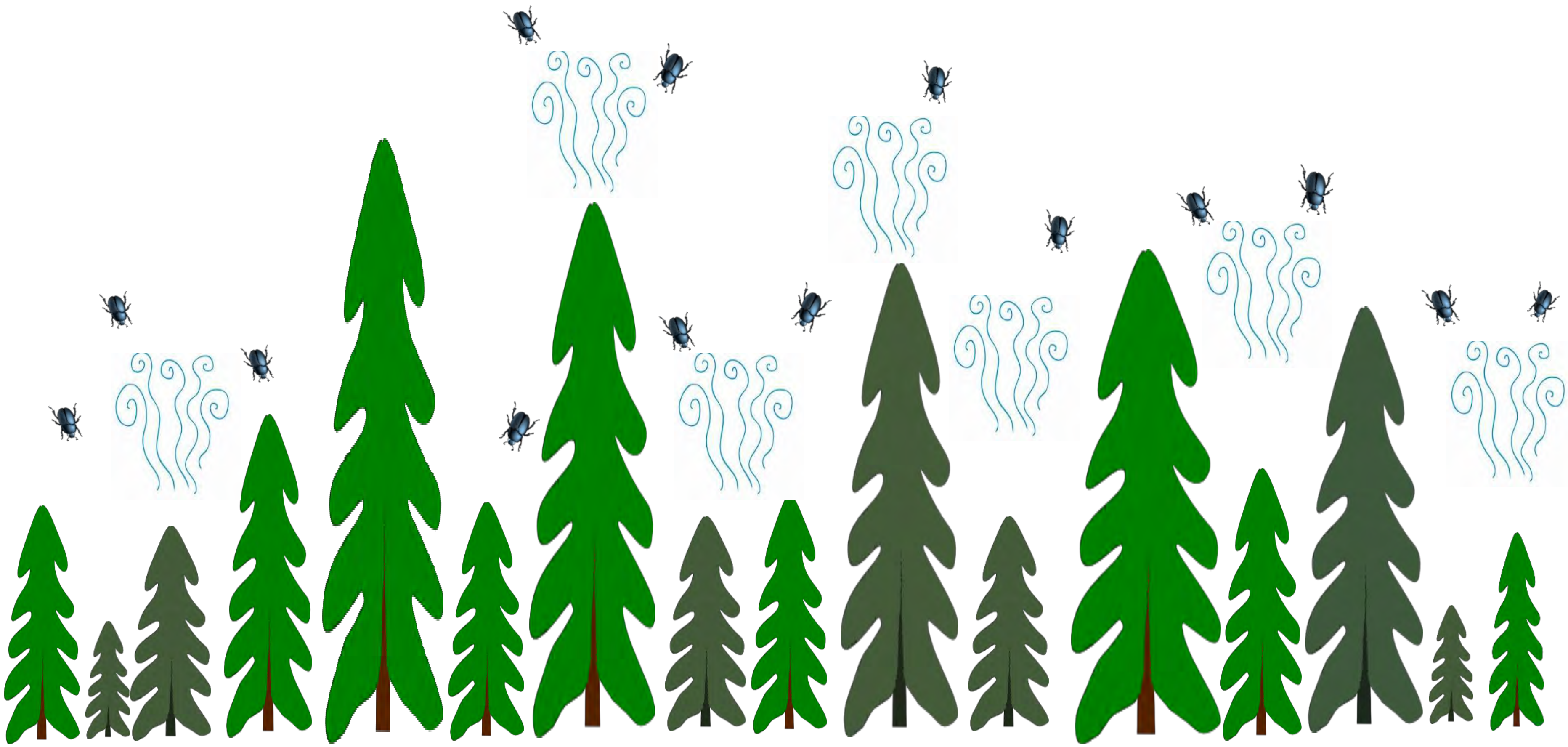
Densification



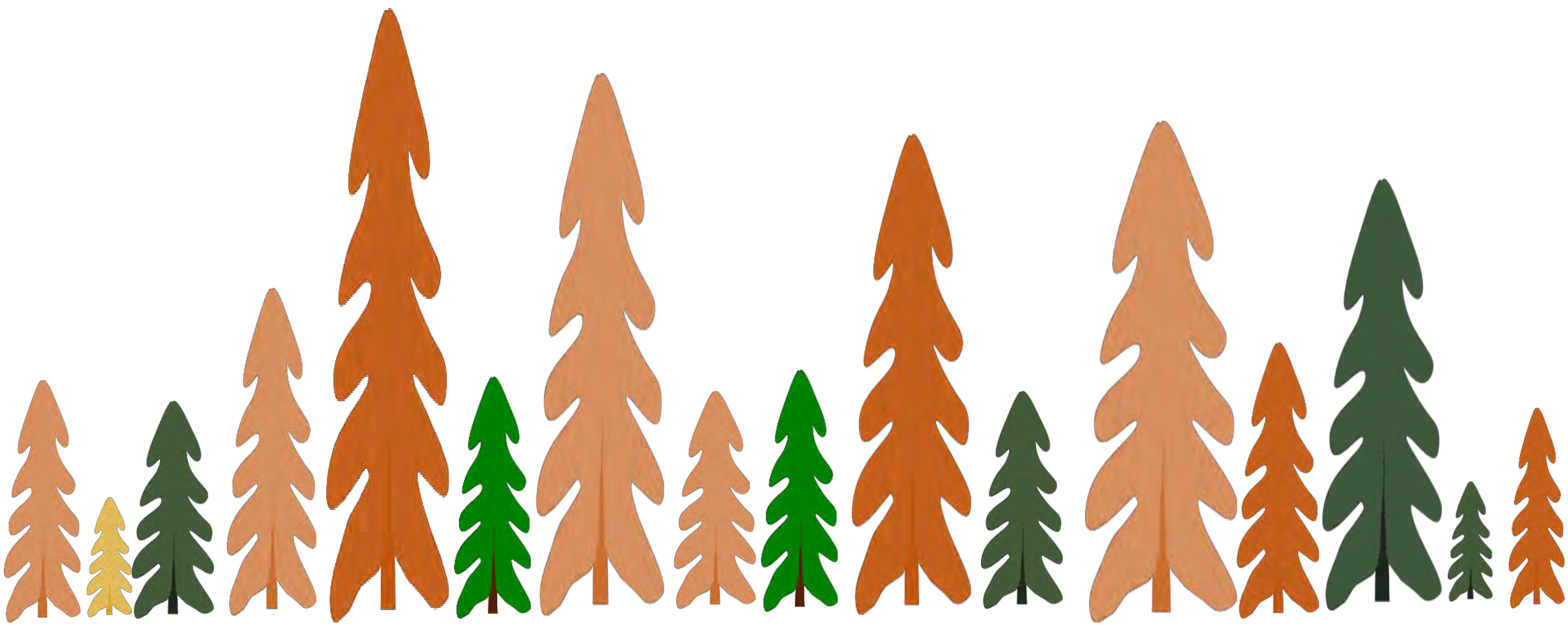
Climate Change, Warming, Drought… Water Stressed Trees

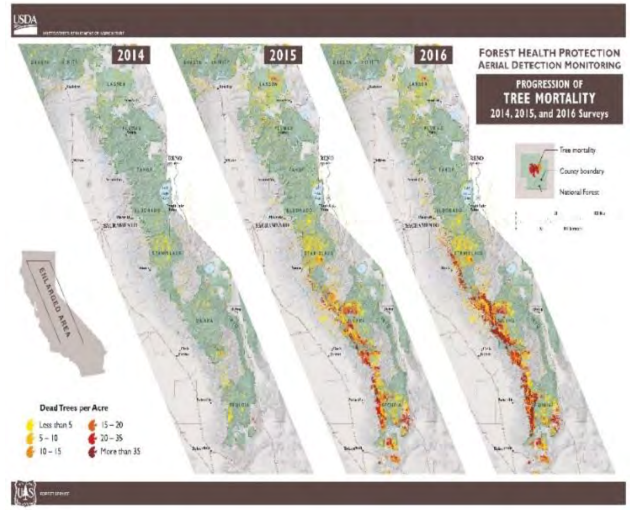


Beetle Response



>100 Million Dead Trees and Counting

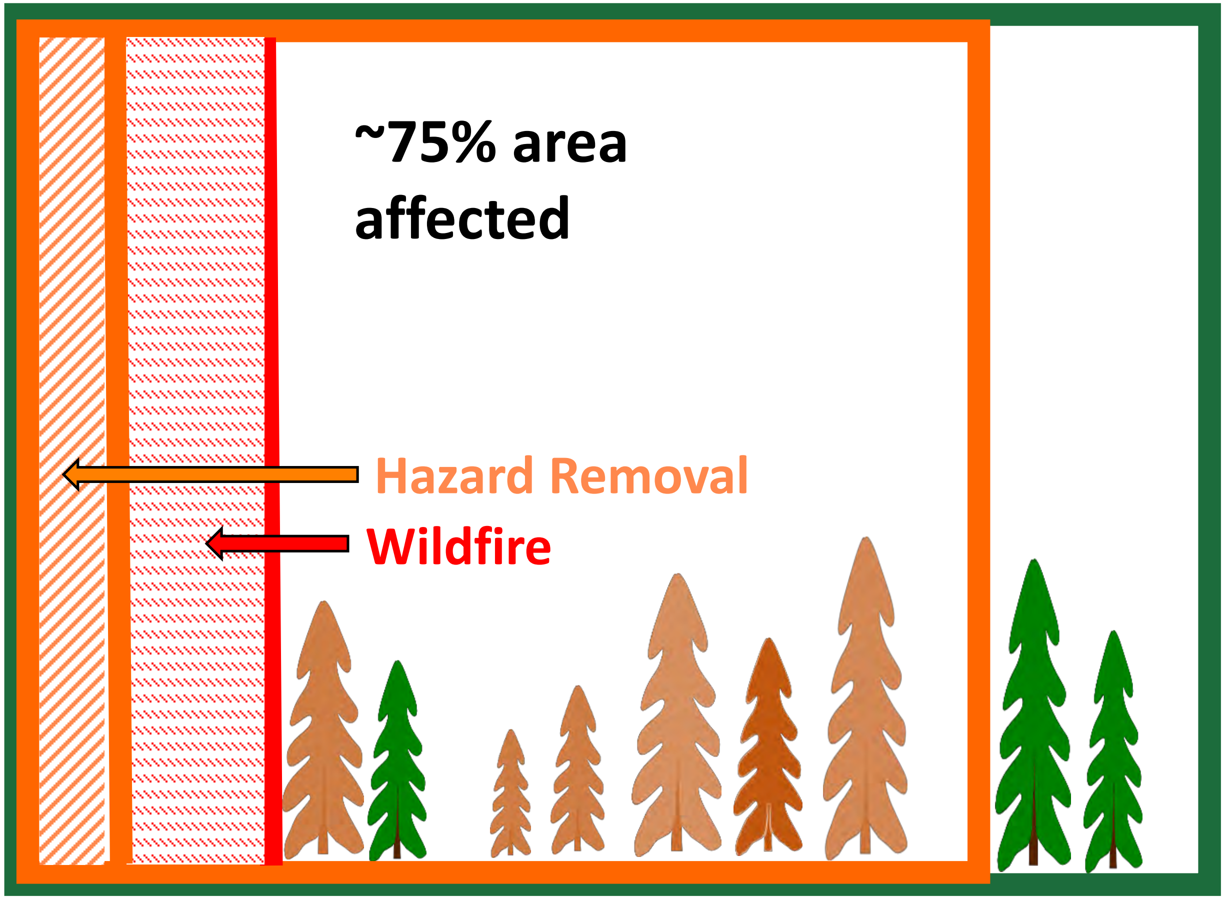




Forest	Est. Acres
Eldorado	105,000
LTBMU	17,000+
Sequoia	535,000
Sierra	554,000
Stanislaus	270,000
Tahoe	110,000
Total	1,591,000

USDA United States Department of Agriculture
California Climate Hub

National Forest Unit



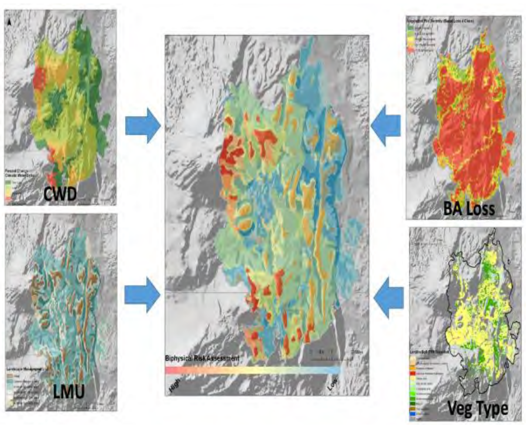

?
Restoration Treatments?
Seed Collection and Reforestation?

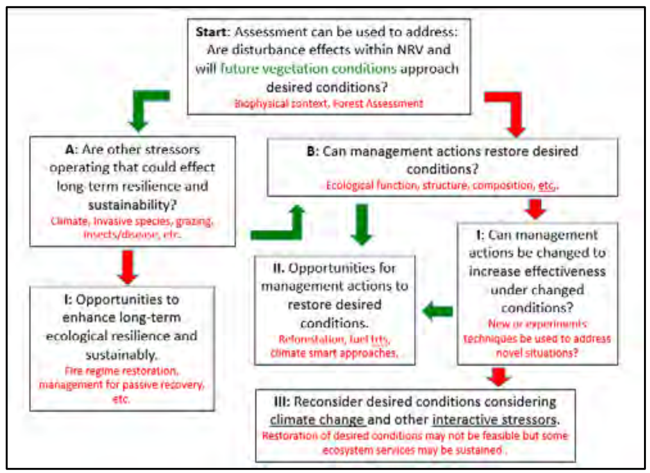
Restoration Process

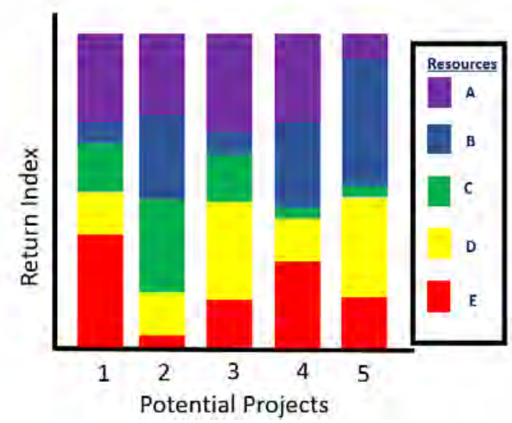
1. Relevant Landscape Context
2. Restoring Critical Ecological Processes
3. Supports Native Biodiversity
4. Sustains Ecosystem Services & Values
5. Incorporates Climate Change Adaptation

Landscape Assessment

Prioritization

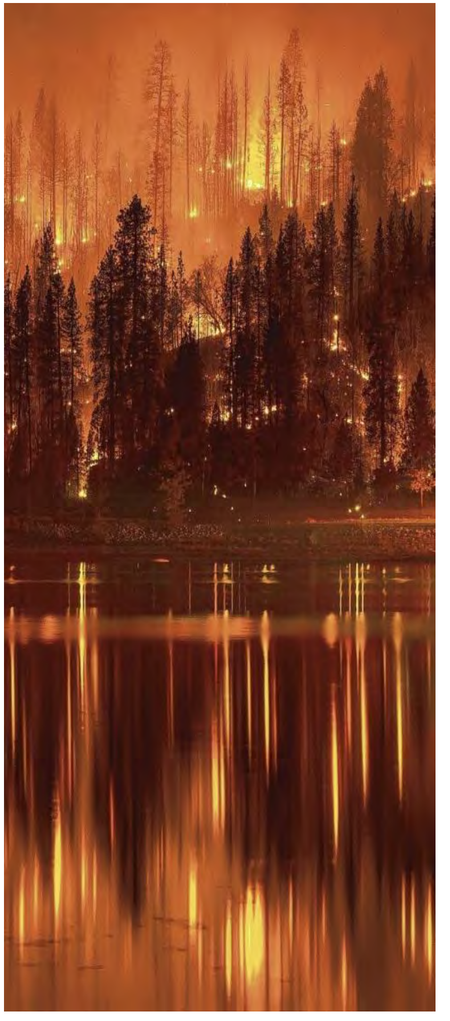






Seed Collection and Reforestation

1. Prioritizing seed collection
2. Reforestation – where, how and what?



United States Department of Agriculture
California Climate Hub

Seed Collection and Reforestation

1. Prioritizing seed collection
2. Reforestation – where, how and what?

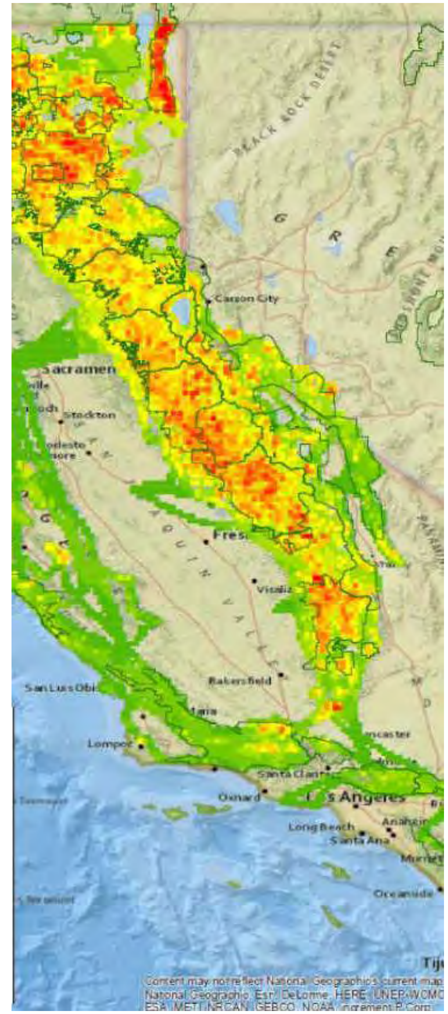


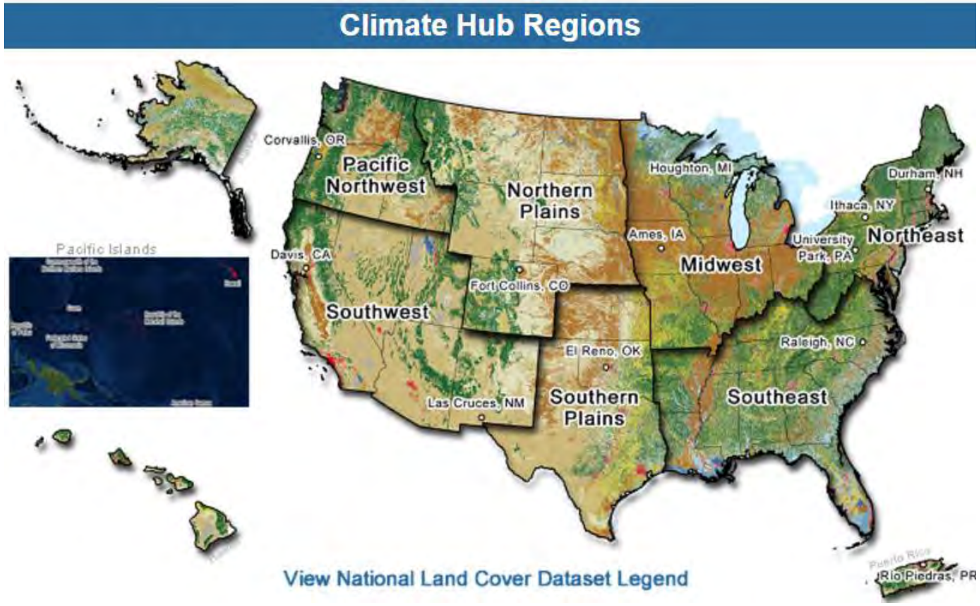
Photo Credit: USDA USFS

Thank you –
Contact Your Regional Climate Hub

Steven Ostoja, PhD
Director, USDA California Climate Hub
Agricultural Research Service
John Muir Institute of the Environment
University of California at Davis

530.752.3092
smostoja@ucdavis.edu

http://www.climatehubs.oce.usda.gov/california



United States Department of Agriculture
California Climate Hub

Questions & Answers

- **By phone:** **Dial #2 to enter the queue.**
- **On your computer:** **Type your question into the Q & A pod on the left side of your screen.**

Drought, Insects, and Forest Carbon in Western Forests

Jeff Hicke
Department of Geography
University of Idaho

...and many coauthors

Funding: USDA FMEC, USGS Western Mountain Initiative

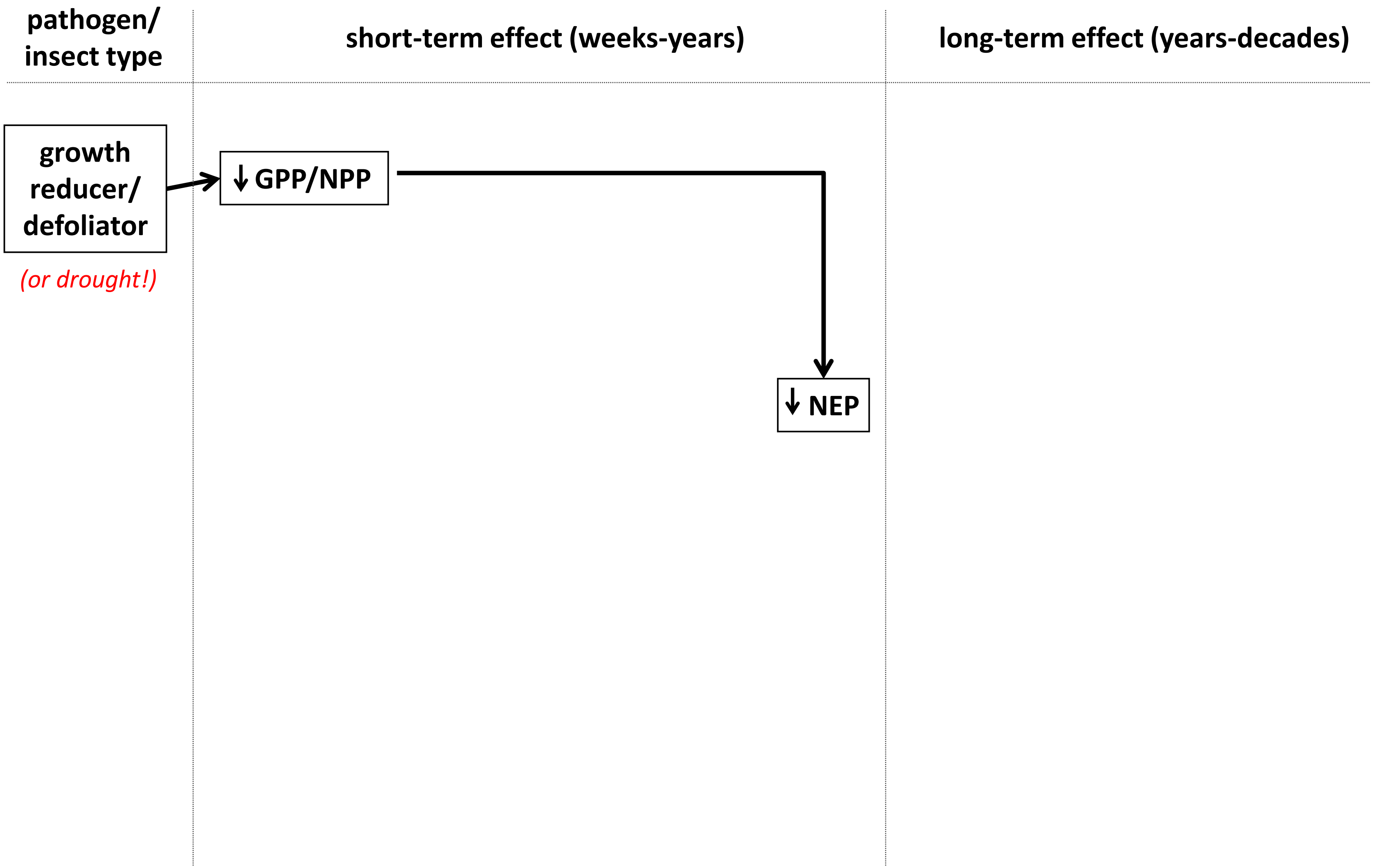
Photo Jeff Hicke

Carbon cycle terms

- Stocks

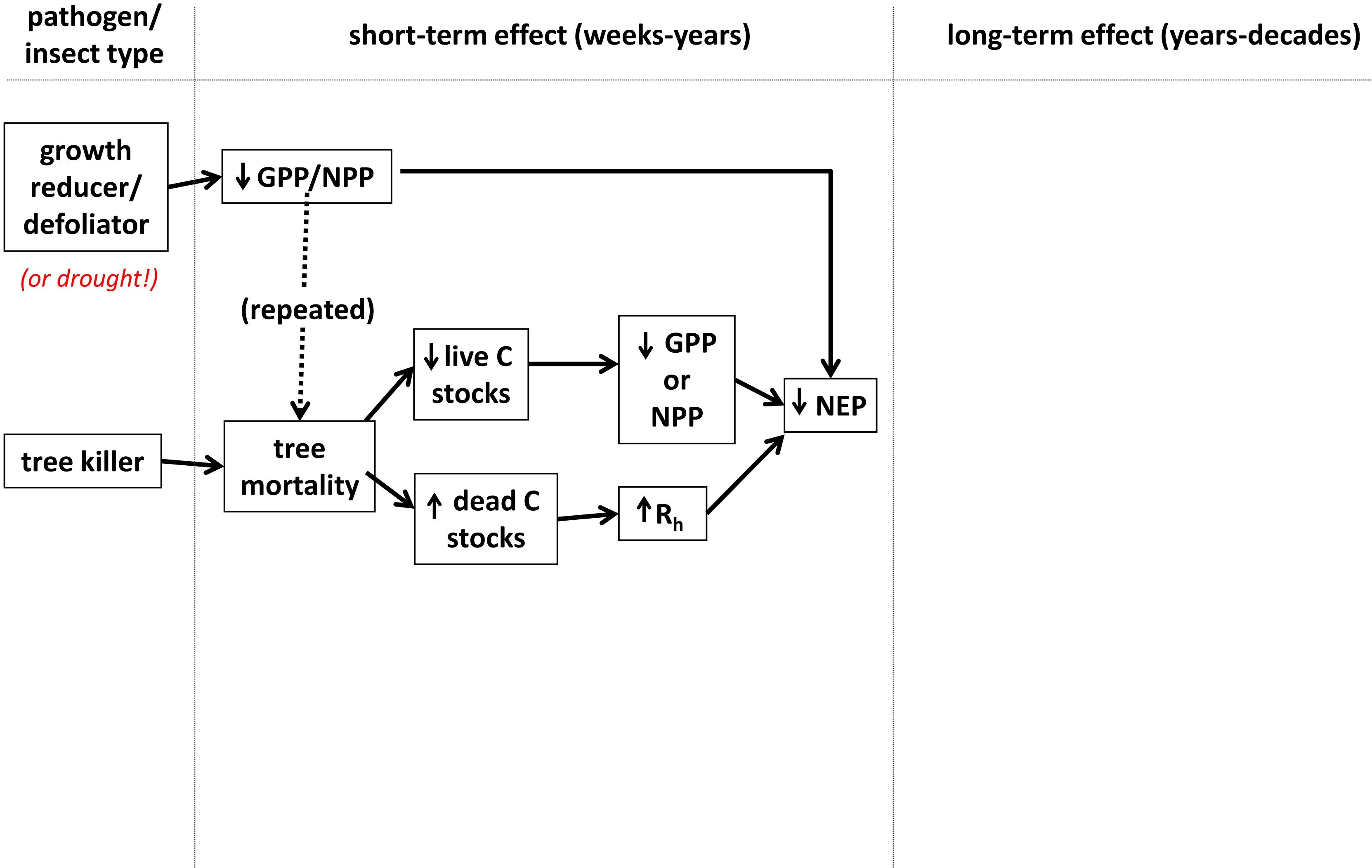
- Fluxes
  - gross primary productivity (GPP)
  - net primary productivity (NPP)
  - heterotrophic respiration (Rh)
  - net ecosystem productivity (NEP)

Conceptual model: effects on C stocks, fluxes



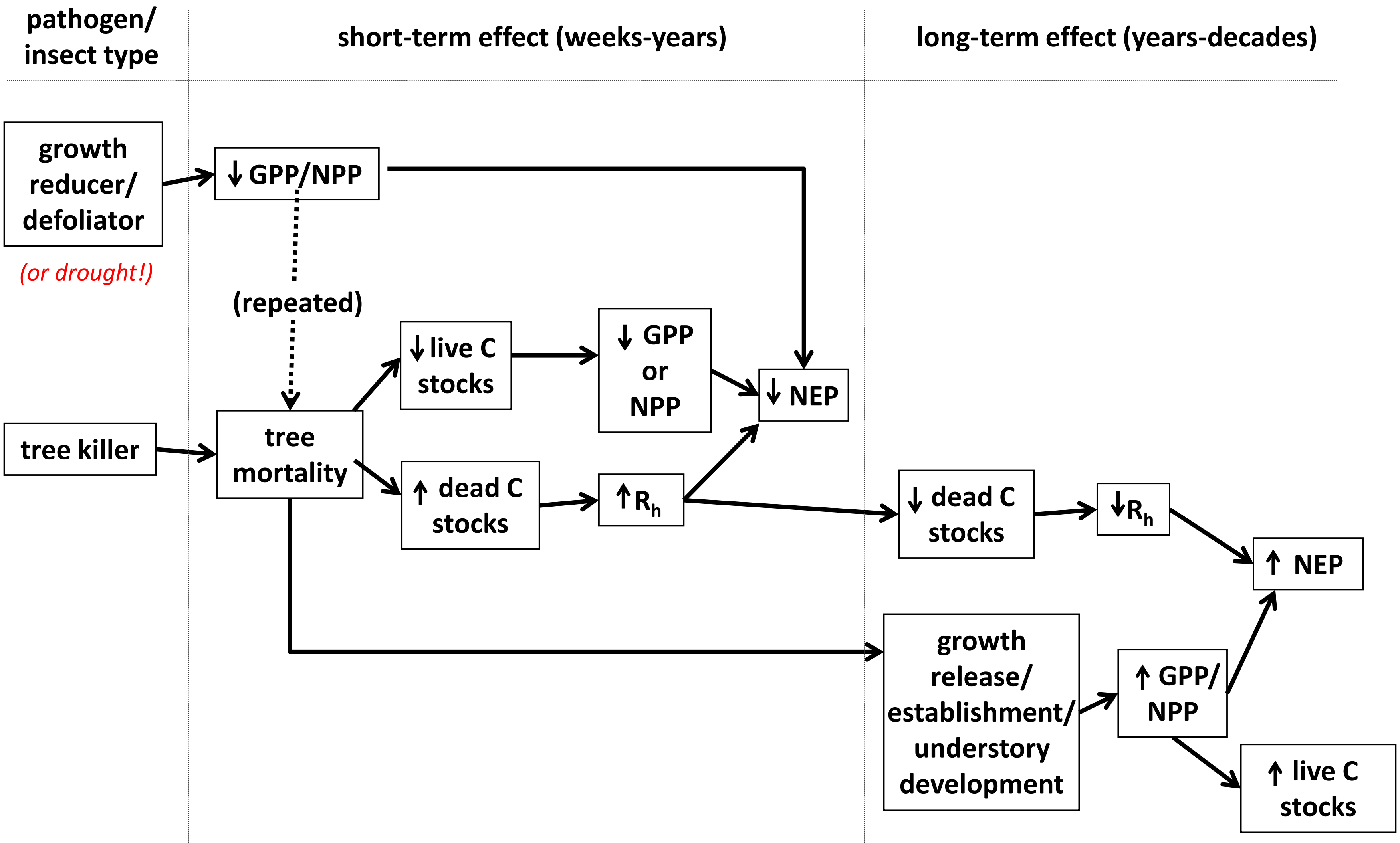
Hicke et al., Global Change Biology, 2011

Conceptual model: effects on C stocks, fluxes



Hicke et al., Global Change Biology, 2011

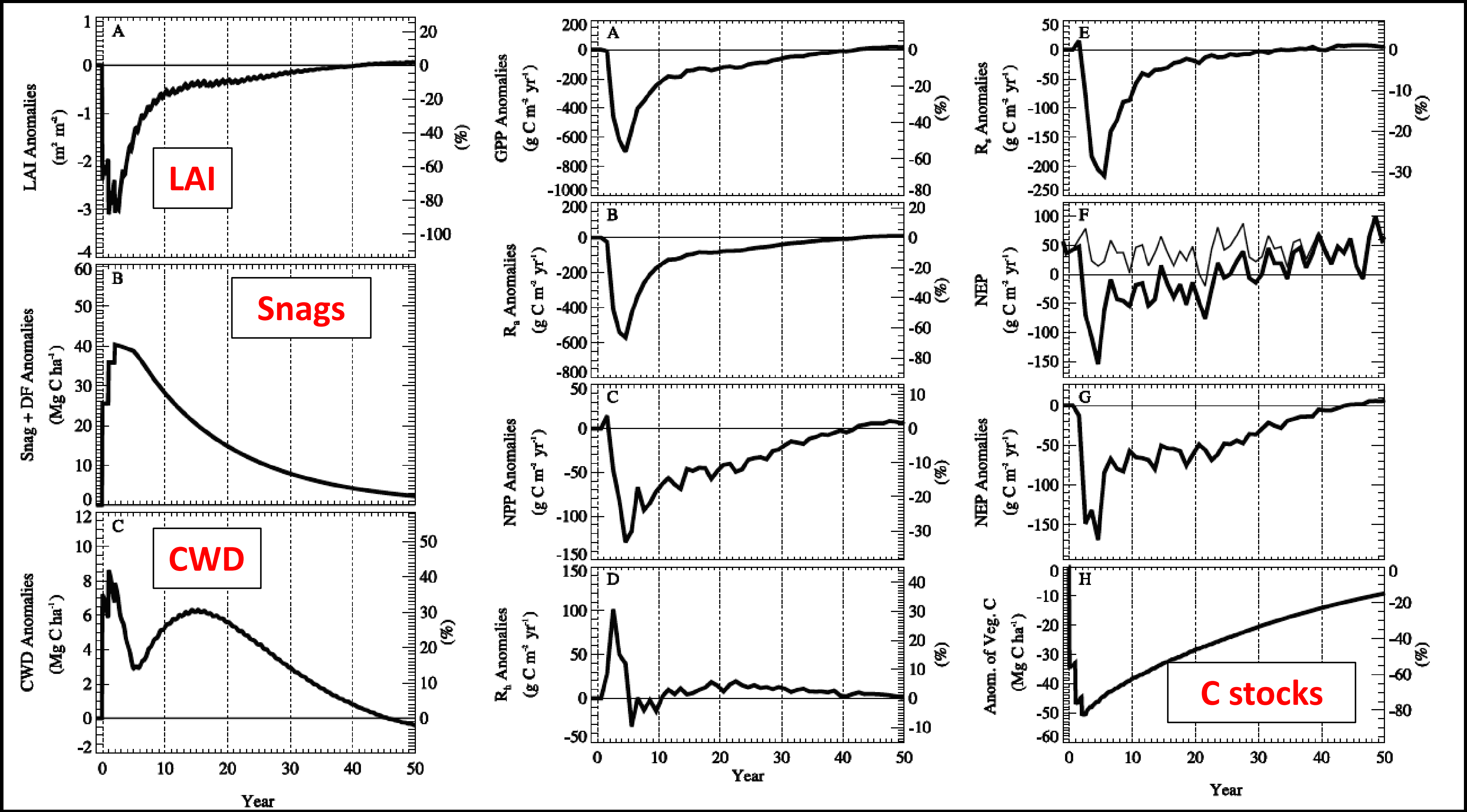
Conceptual model: effects on C stocks, fluxes



Hicke et al., Global Change Biology, 2011

Simulated C dynamics following severe beetle outbreak

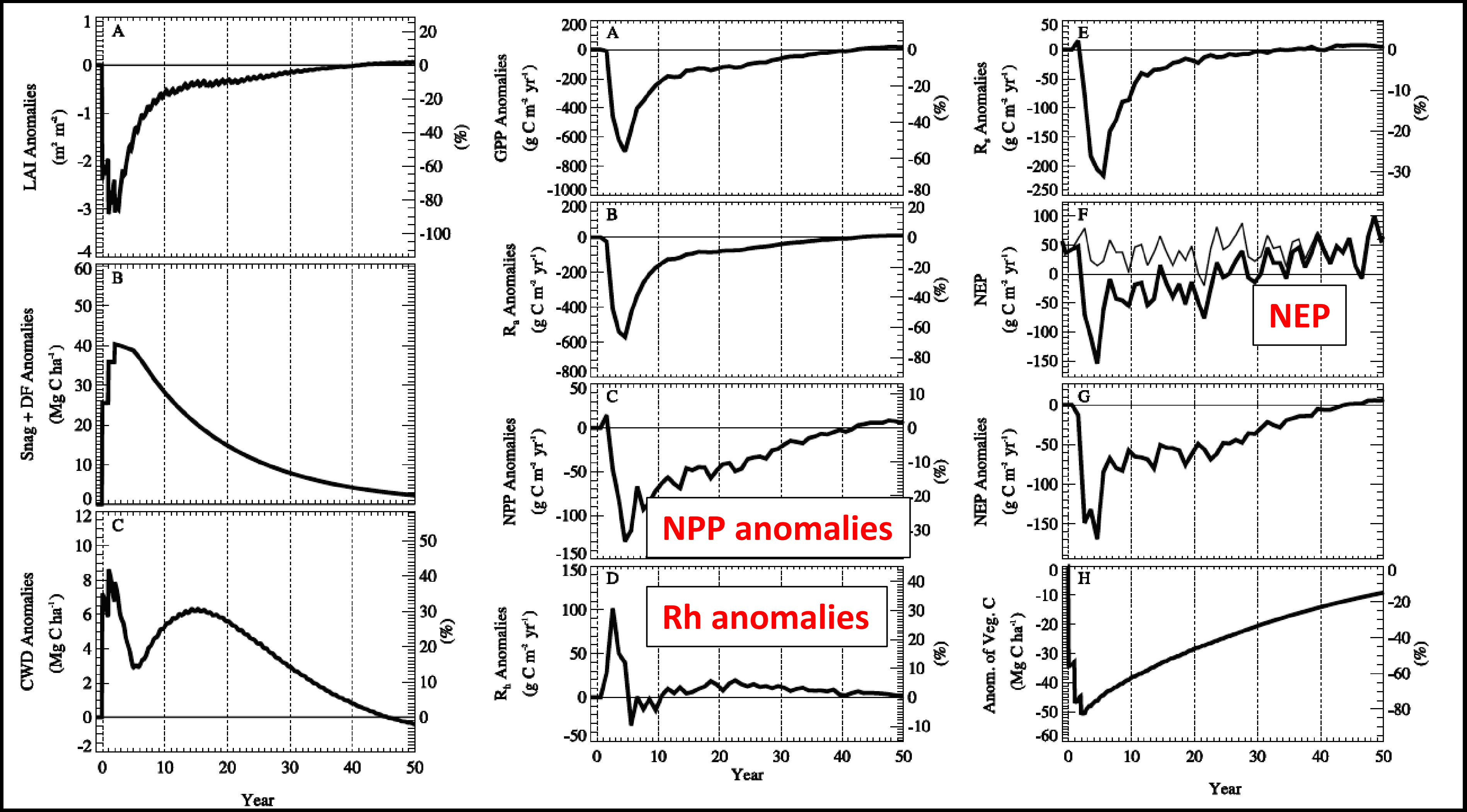
Anomalies of carbon stocks



Edburg et al., JGR, 2011

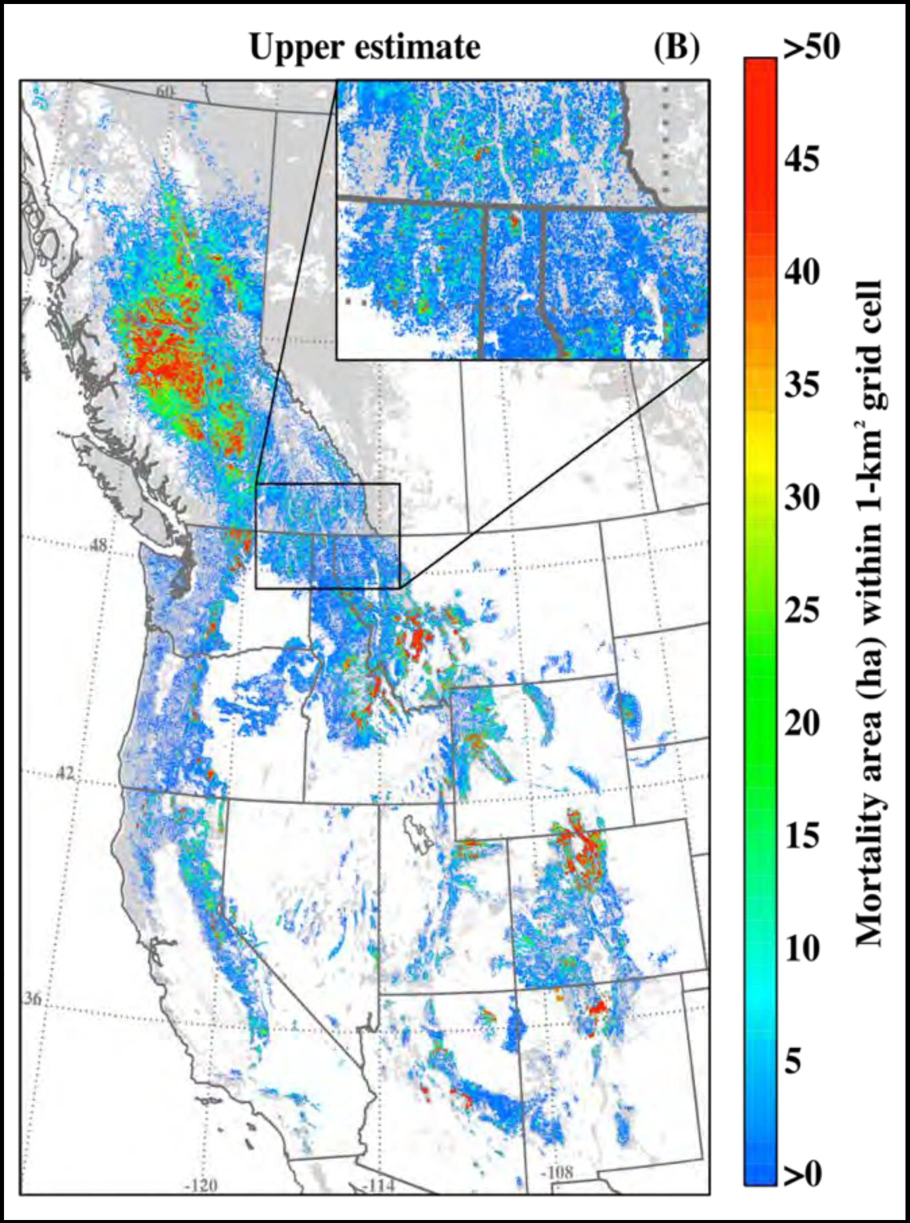
Simulated C dynamics following severe beetle outbreak

Carbon fluxes

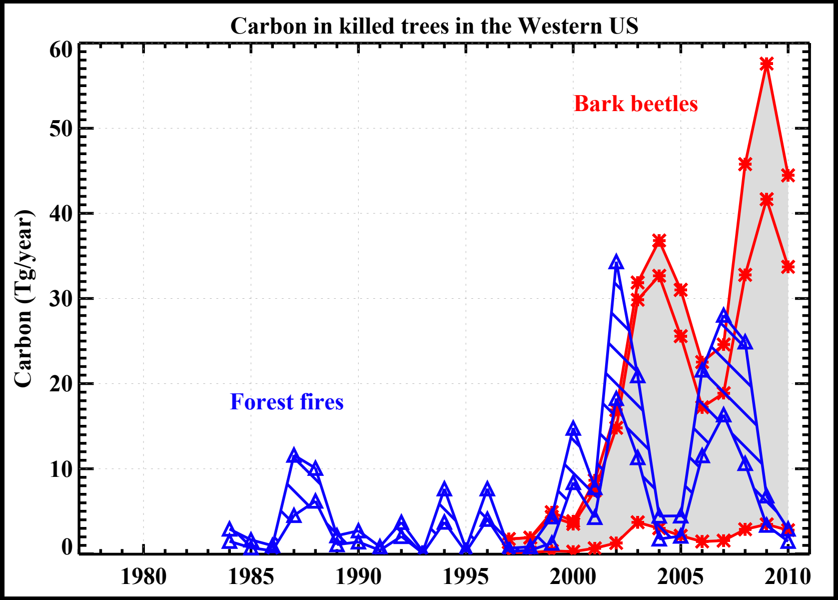


Edburg et al., JGR, 2011

Example: Carbon stocks in the Western US



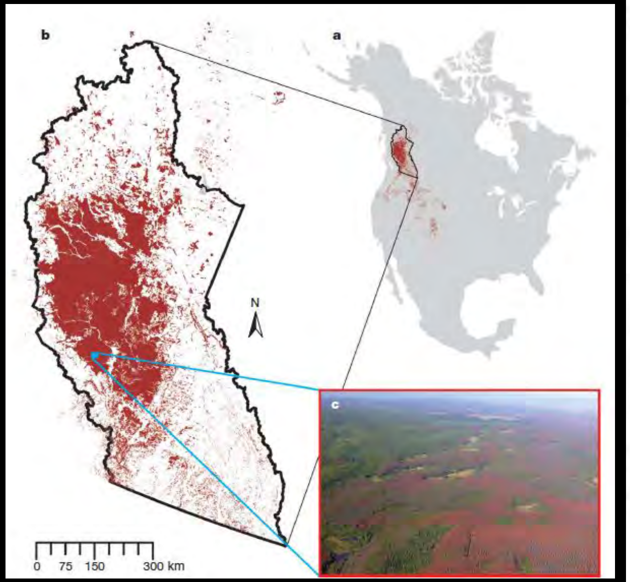
Meddens et al., Eco. App., 2012

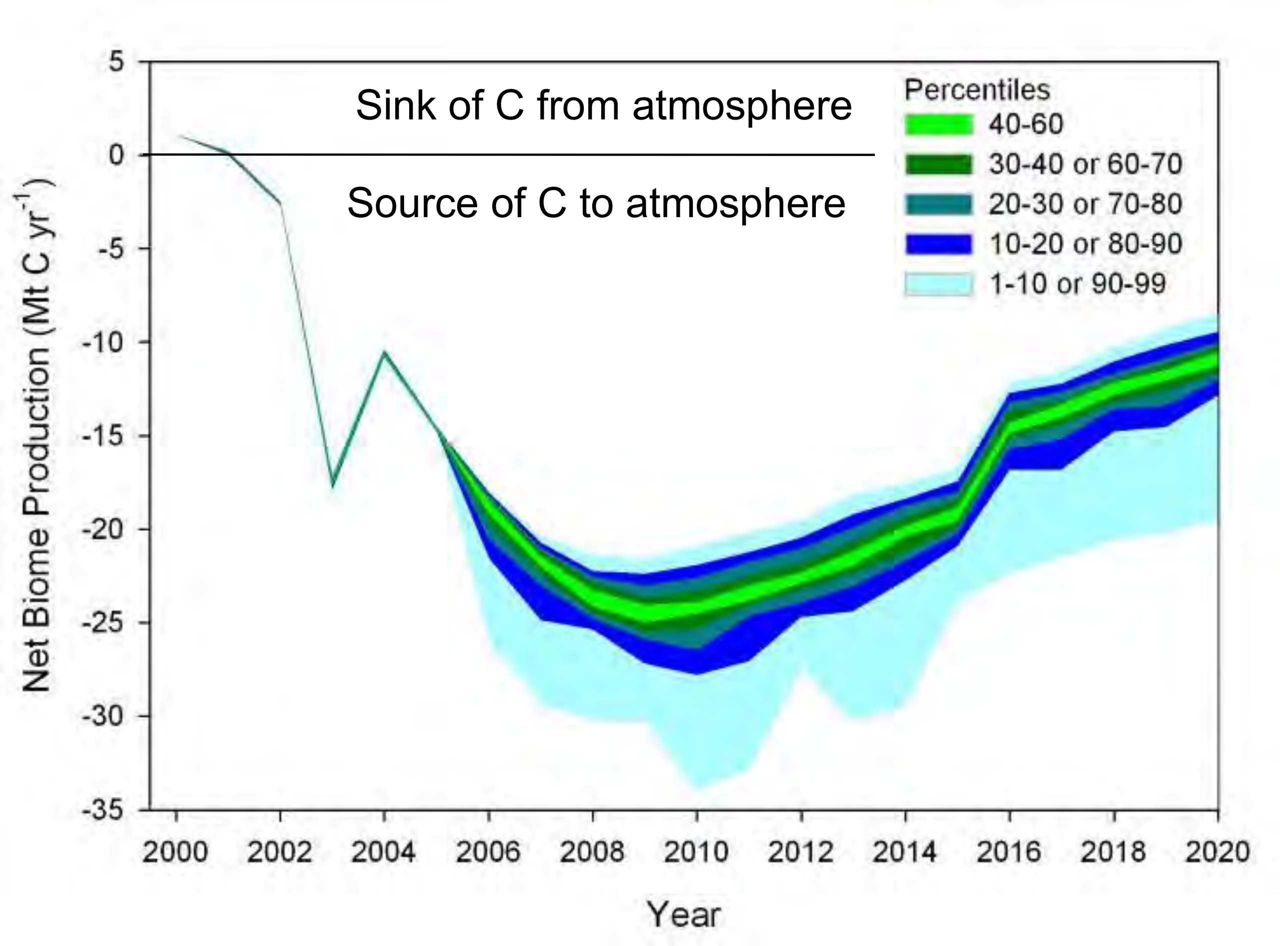


Hicke et al., ERL, 2013

Cumulative amounts
beetles: 289 Tg C (5% of total)
fire: 285 Tg C
Sum = harvest

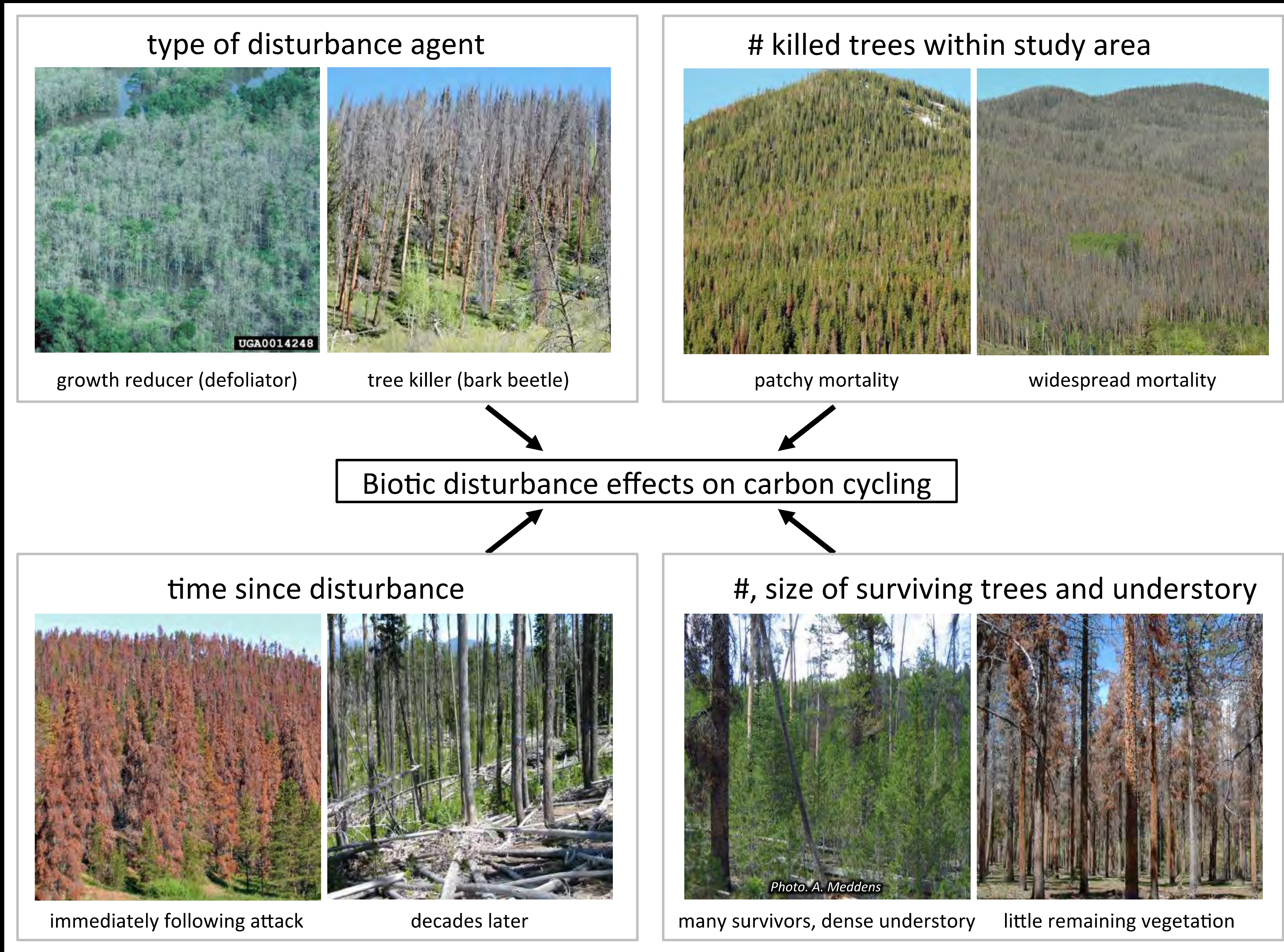
Example: Carbon fluxes in British Columbia





Kurz et al., Nature, 2008

Effects of biotic disturbances on C cycling depend on:



Photos from bugwood.org, A. Meddens, J. Hicke

Hicke et al., Global Change Biology, 2012

Type of disturbance agent

Growth reducers *(or drought!)*

William M. Ciesla, Forest Health Management International

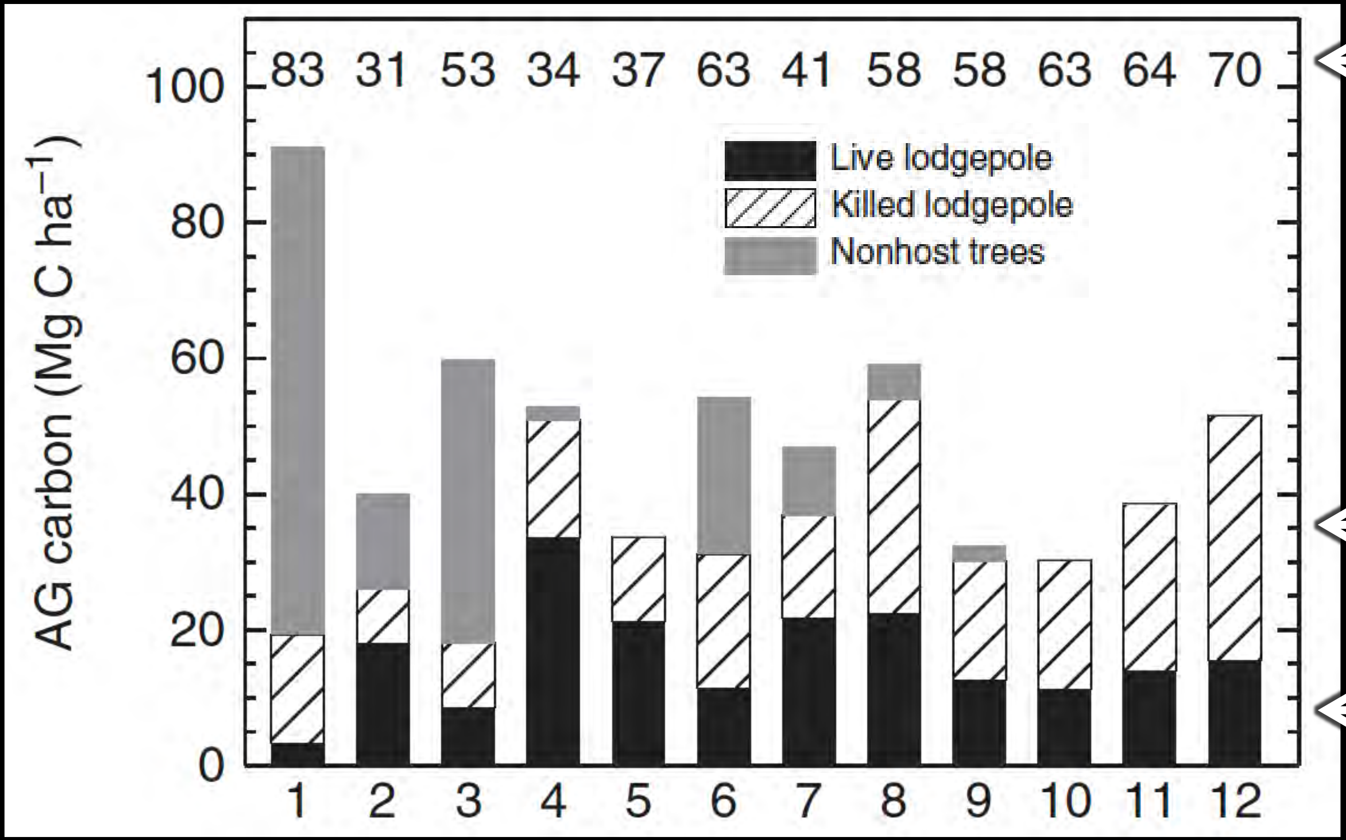
USDA Forest Service - Ogden Archive, USDA Forest Service, Bugwood.org

Tree killers

bugwood.org

Number of killed trees within study area

Observations of carbon in beetle-killed trees



%C in killed lodgepole

C in killed lodgepole

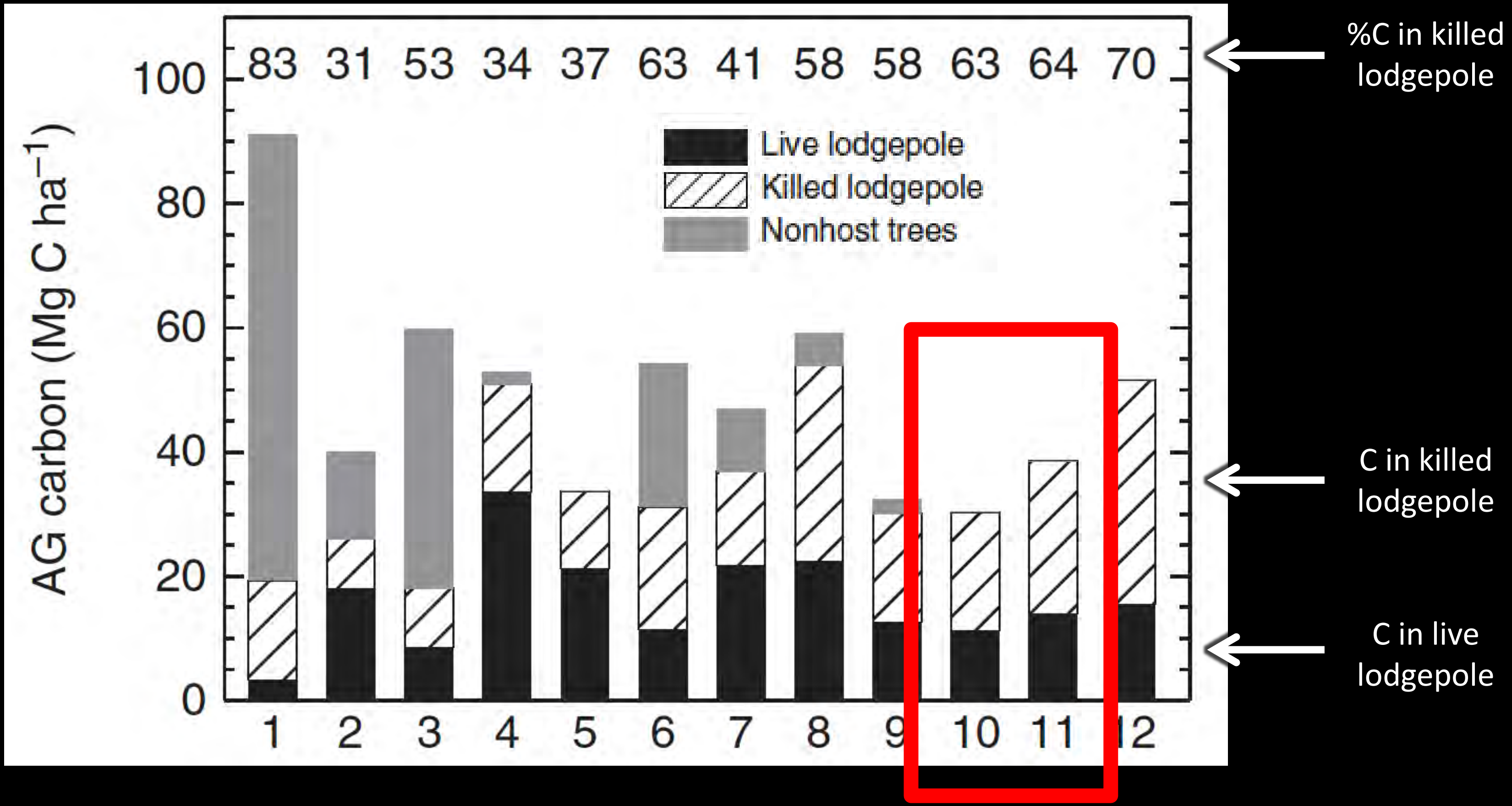
C in live lodgepole

Plot number

Pfeifer et al., Global Change Biology, 2011

Number of killed trees within study area

Observations of carbon in beetle-killed trees



Plot number

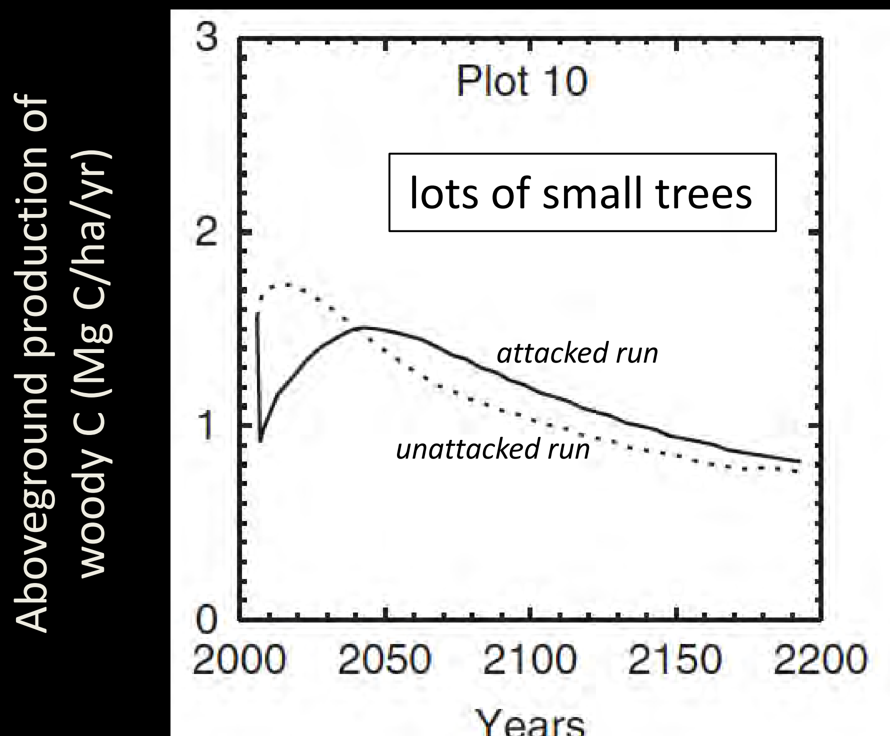
Pfeifer et al., Global Change Biology, 2011

Recovery rate depends on size, # of surviving trees

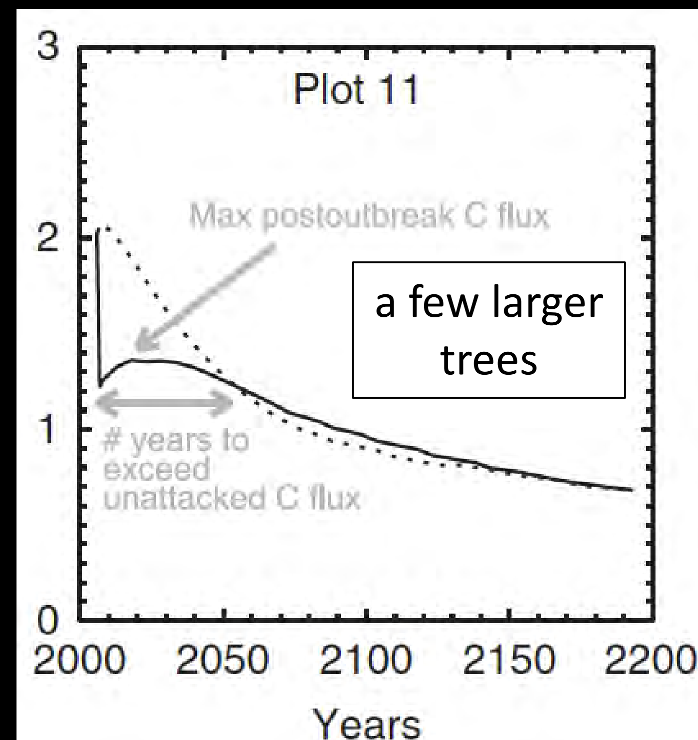
Two plots attacked by mountain pine beetle

- similar predisturbance conditions and mortality
- modeling with Forest Vegetation Simulator

larger postdisturbance ANPP increase

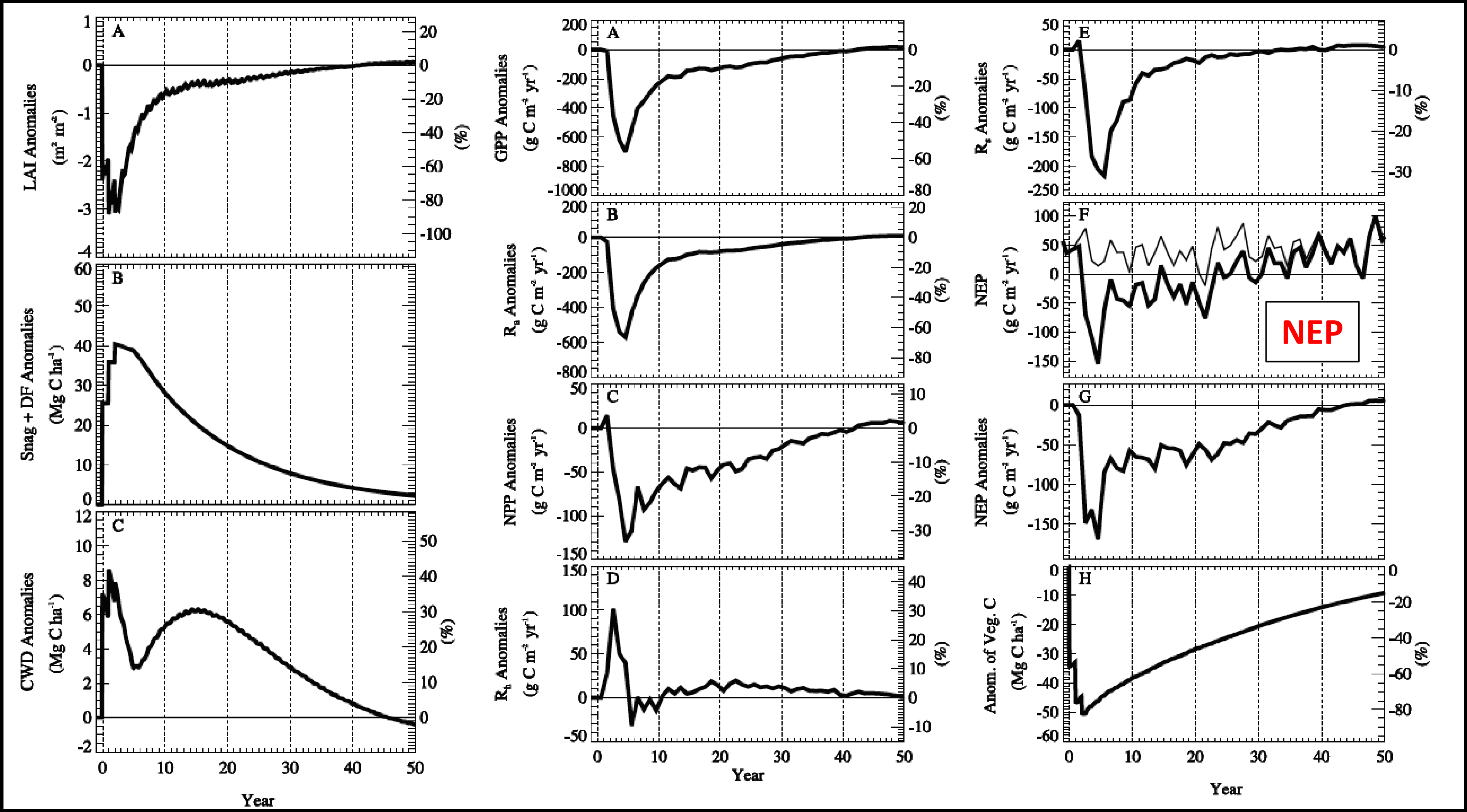


smaller postdisturbance ANPP increase



Pfeifer et al. 2011

Time since disturbance



Edburg et al., JGR, 2011

Summary

- Drought and insects/diseases can cause major changes to carbon stocks and fluxes
- Tree mortality from drought and insects in western NA has been important
- Magnitude, sign of effect depends on outbreak type, severity, residual forest, timing

Questions & Answers

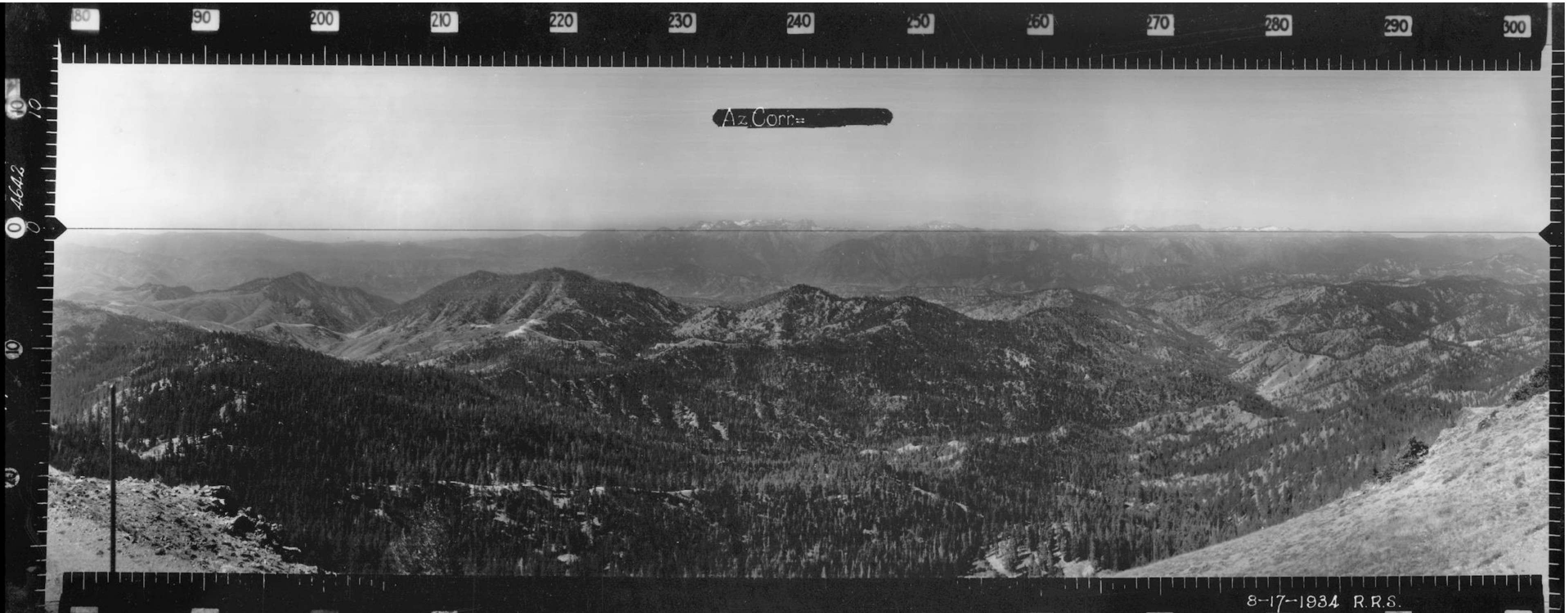
- **By phone:** **Dial #2 to enter the queue.**
- **On your computer:** **Type your question into the Q & A pod on the left side of your screen.**

Managing for Resilience in Eastside Forests

Dr. Richy J. Harrod

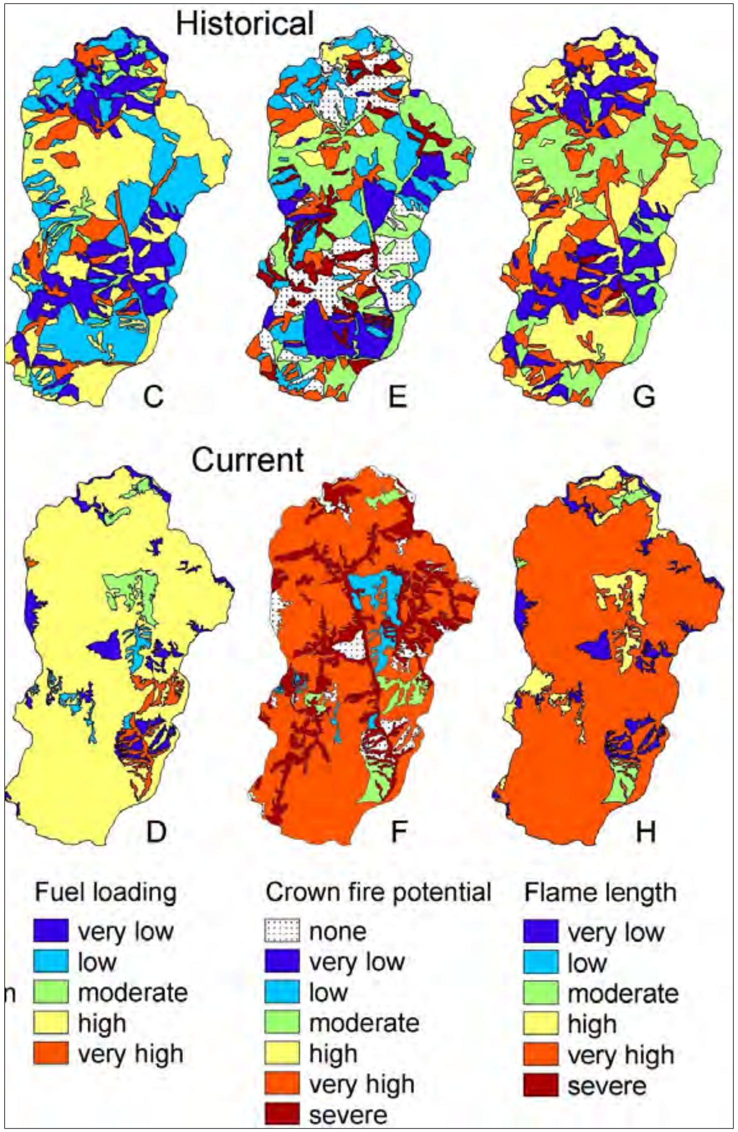
Presentation Outline

- Briefly describe the need for fuel treatments
- Describe the management objectives for eastside forests
- Provide some restoration principles
- Present some examples of fuel treatments in different forest types


Az Corr=
8-17-1934 R.R.S.

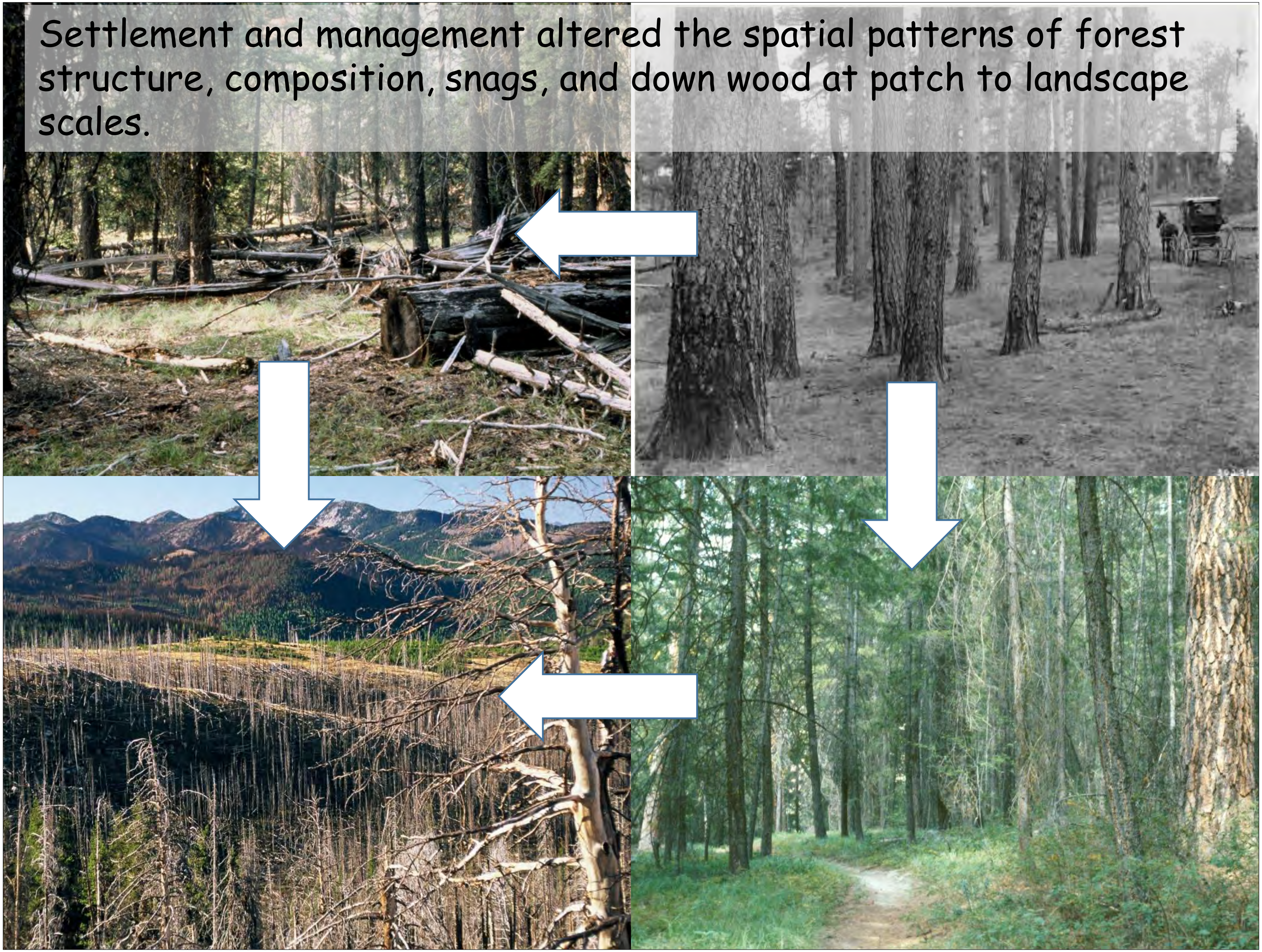

Changes in Fire and Fuels

Figure shows changes over the past century in fire and fuels in an example watershed. Landscapes were patchy with respect to vegetation and fuels which resulted in a mosaic of fire effects (top images). Today, landscape are homogeneous and have the potential for very large and destructive wildfires (bottom images).



Hessburg et al. 1999

Settlement and management altered the spatial patterns of forest structure, composition, snags, and down wood at patch to landscape scales.



Fire and Fuel Changes Lead to Key Changes to Ecosystem

- Uncharacteristically severe fires
- Wildlife and fish habitat loss
- Hydrological problems, particularly roads
- Insect infestations and disease epidemics.




Goals of Restoration Treatments

- Change how fire behaves within stands and across landscapes
- Create stands and landscapes that are resilient to fire
- Mitigate fire hazard in the wildland/urban interface
- Important to integrate resource objectives, not about reducing fuels everywhere.

Management Objectives in Fire Frequent Forest Types

- Reduce surface fuels
- Increase height to live crown
- Decrease crown density
- Retain fire tolerant structures

Management Objectives in Fire Infrequent Forest Types

- Restore the spatial distribution of forest structure patches
- Utilize topography as a template for burn mosaics

Fuel Management Objectives

- Treatment sequence
  - Harvest, pile, pile burn, underburn
  - Thin, pile, underburn
  - Underburn
- Can use FCCS to determine sequence

Dry Forest Example

Reduce Surface Fuels

- In dry forest types, average of 3-5 tons/acre within stands
- Loading should be discontinuous, variability is desired.

Reduce Ladder Fuels

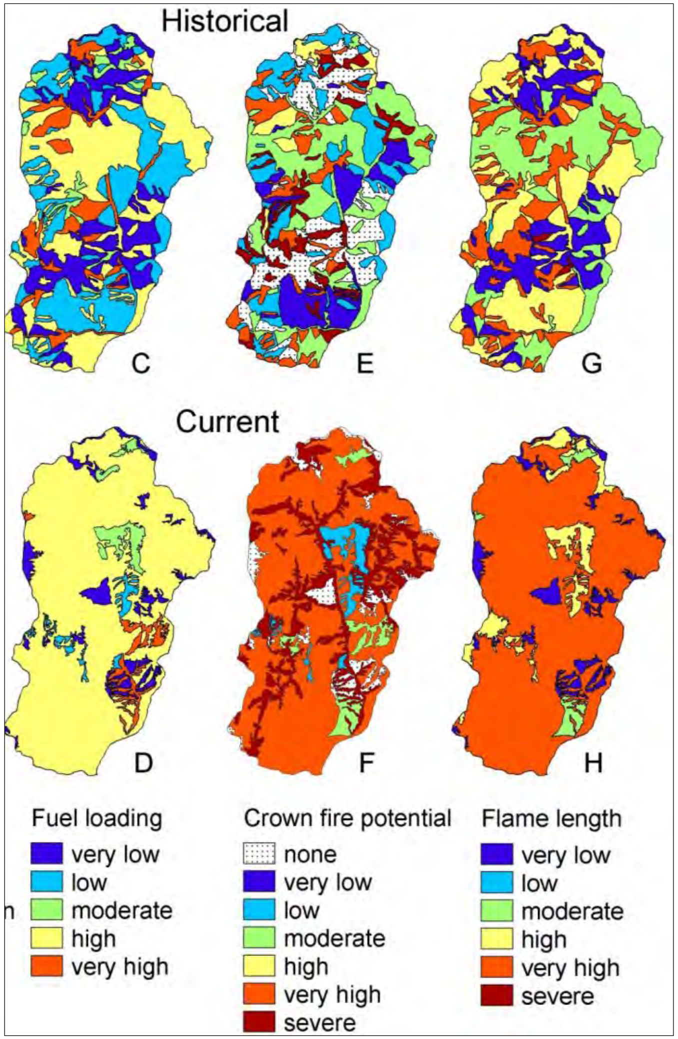
- Decrease potential for torching
    - Eliminate branches on large trees
    - Reduce understory density
- Variability throughout stand is desirable

Decrease Crown Density

- Reduce potential for crown fire
  - Harvest or thinning
  - Torching through prescribed fire
- Variability is desirable
- Retain large fire resistant trees!

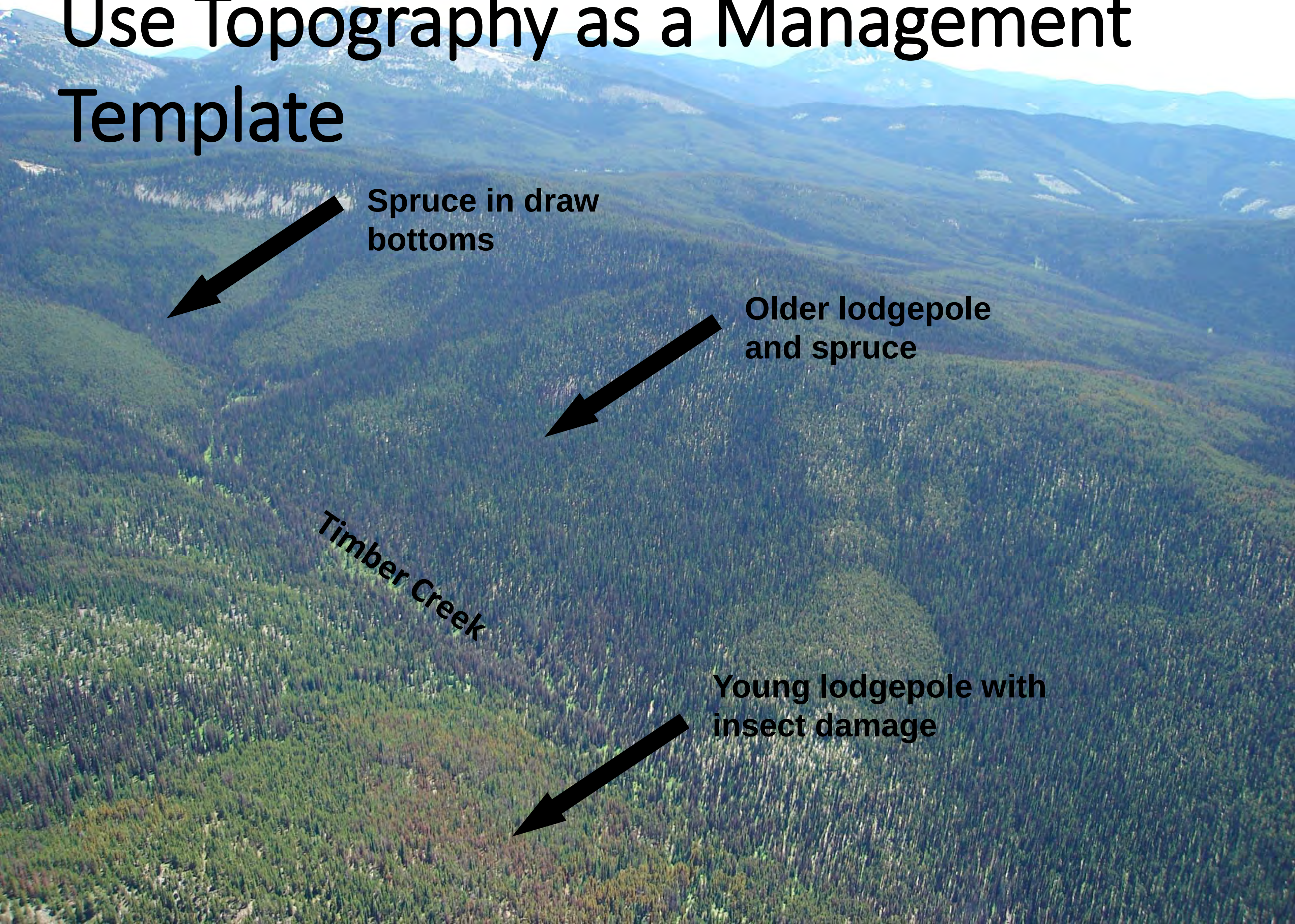
Moist Forest Example

Restore Patch Dynamics



Current Fires Patterns

Use Topography as a Management Template




Bethel Ridge
NF-320

Snowshoe hares (Plate 2.3) are the primary prey of lynx through

Manage Wildlife Habitats

Hares utilize dense young lodgepole pine forest for cover and forage in the winter.

Plate 2.3. Across the range of lynx, snowshoe hares are the pri
from white in winter to brown in summer.

Lynx can hunt for hares in young forest patches especially when old forest is nearby.

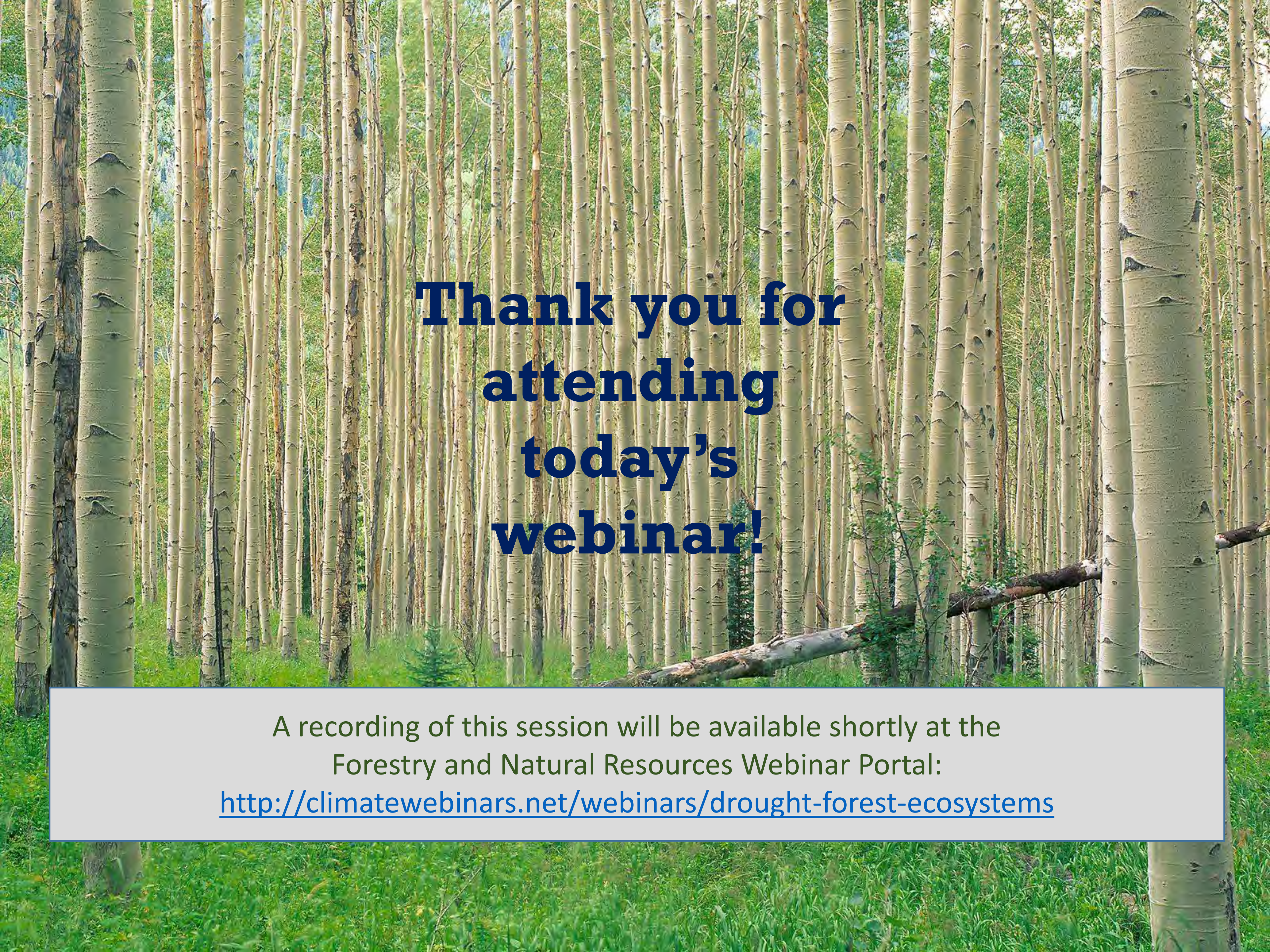
It is thought that the summer diet of lynx may include a greater c
greater seasonal availability of prey (Quinn and Parker 1987, Koe
summer diet of lynx has not been quantified in the southern port
mation is available.

Summary

- Treatments need to be strategically placed on the landscape
- Stand level treatments should focus on principles of fuel management, especially in dry forests
- Treatments need to consider the importance of spatial patterns, fire tolerant structures, and species composition
- Important to integrate resource objectives, not about reducing fuels everywhere

Questions & Answers

- **By phone:** Dial #2 to enter the queue.
- **On your computer:** Type your question into the Q & A pod on the left side of your screen.



Thank you for attending today's webinar!

A recording of this session will be available shortly at the Forestry and Natural Resources Webinar Portal:
http://climatewebinars.net/webinars/drought-forest-ecosystems