2015 Joint Meeting:
Western Forest Genetics Association
and
Northwest Seed Orchard Managers Association
University of Washington, Botanic Gardens
Seattle, WA
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Managed Relocation of Tree Genetic Resources Under Climate Change

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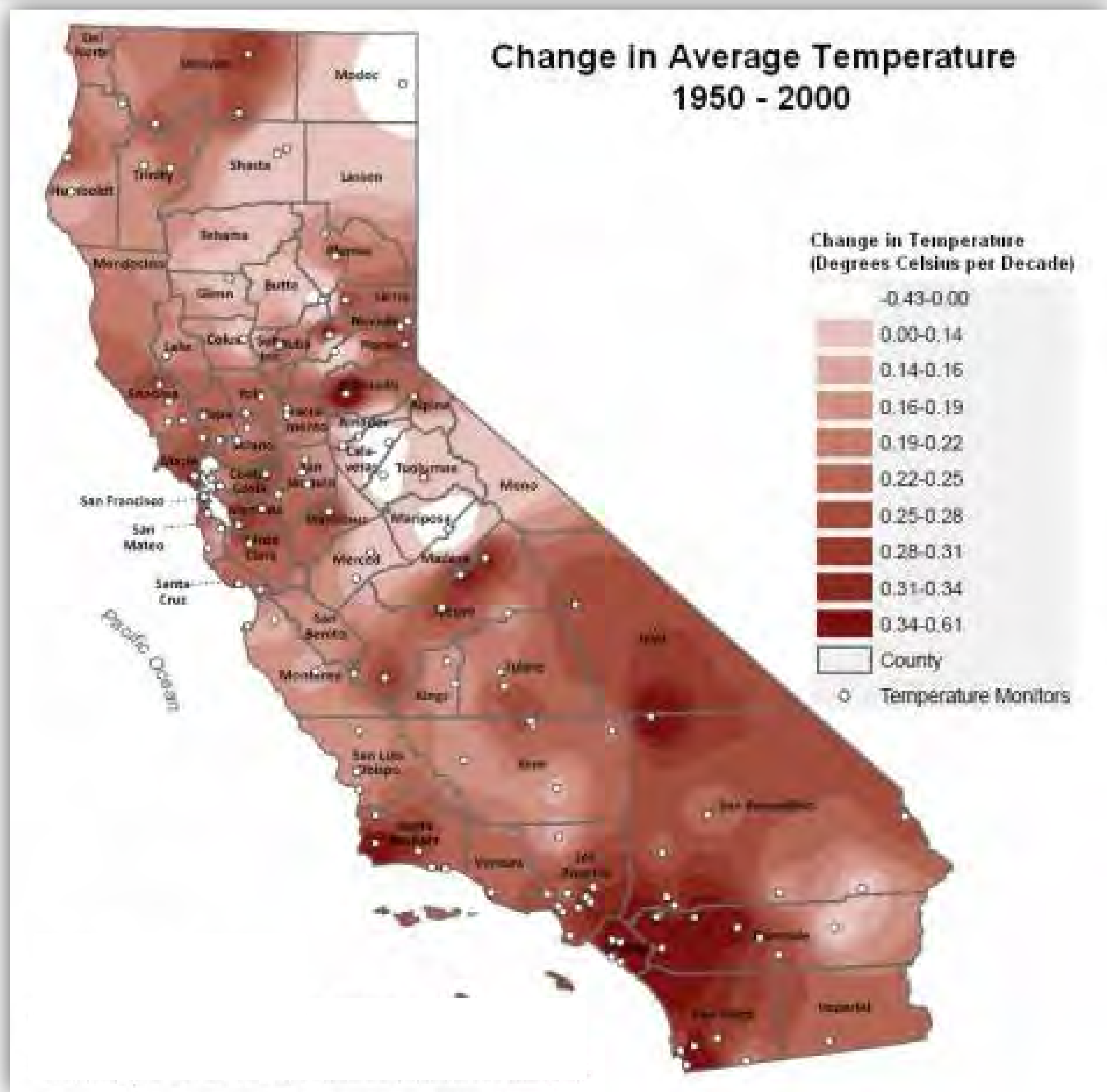
Forest Service
Pacific Southwest Region

Climate Change Considerations

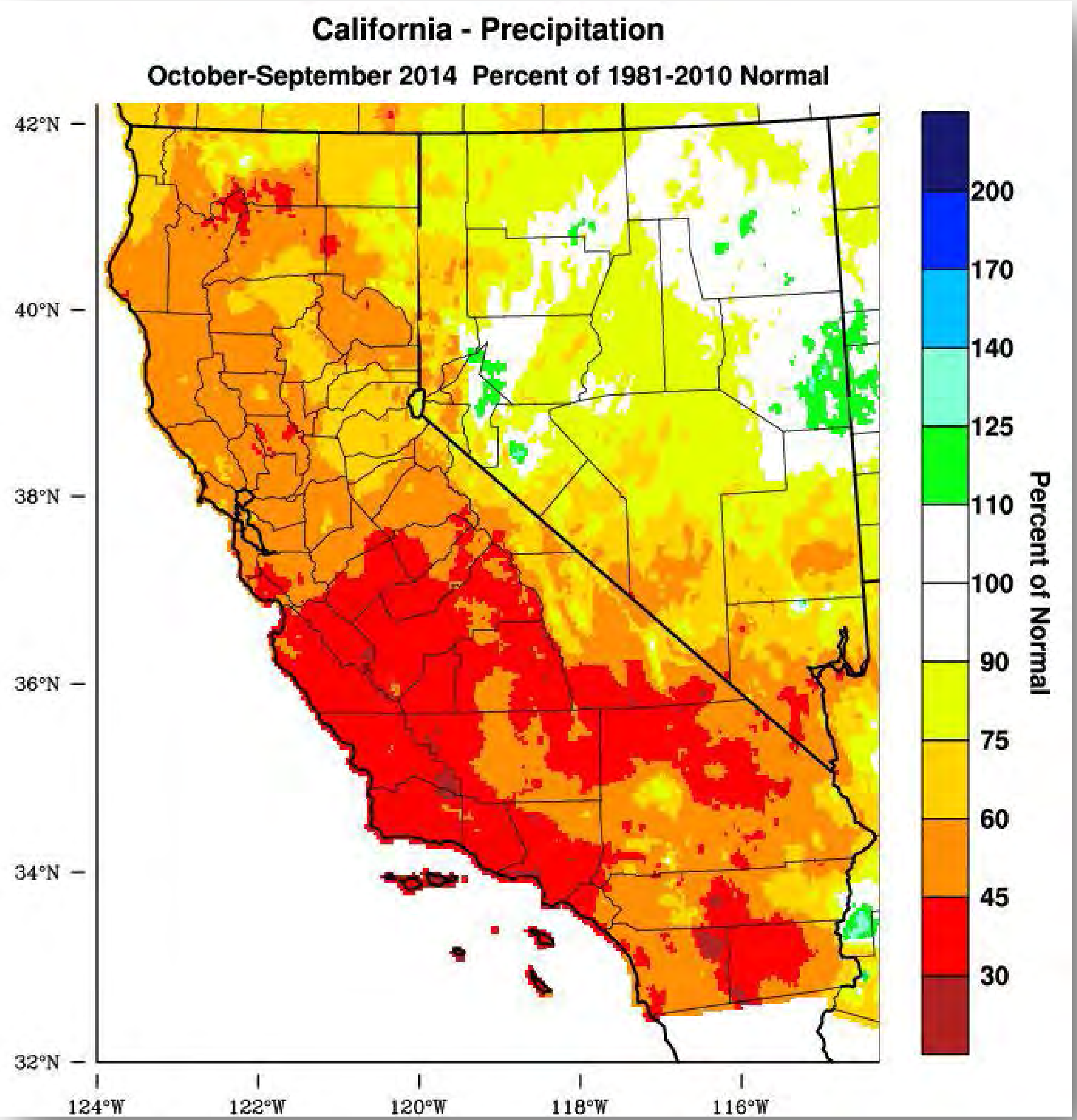
Recent Temperature Change in California



Source: LaDochy et al. (2007)

Climate Change Considerations

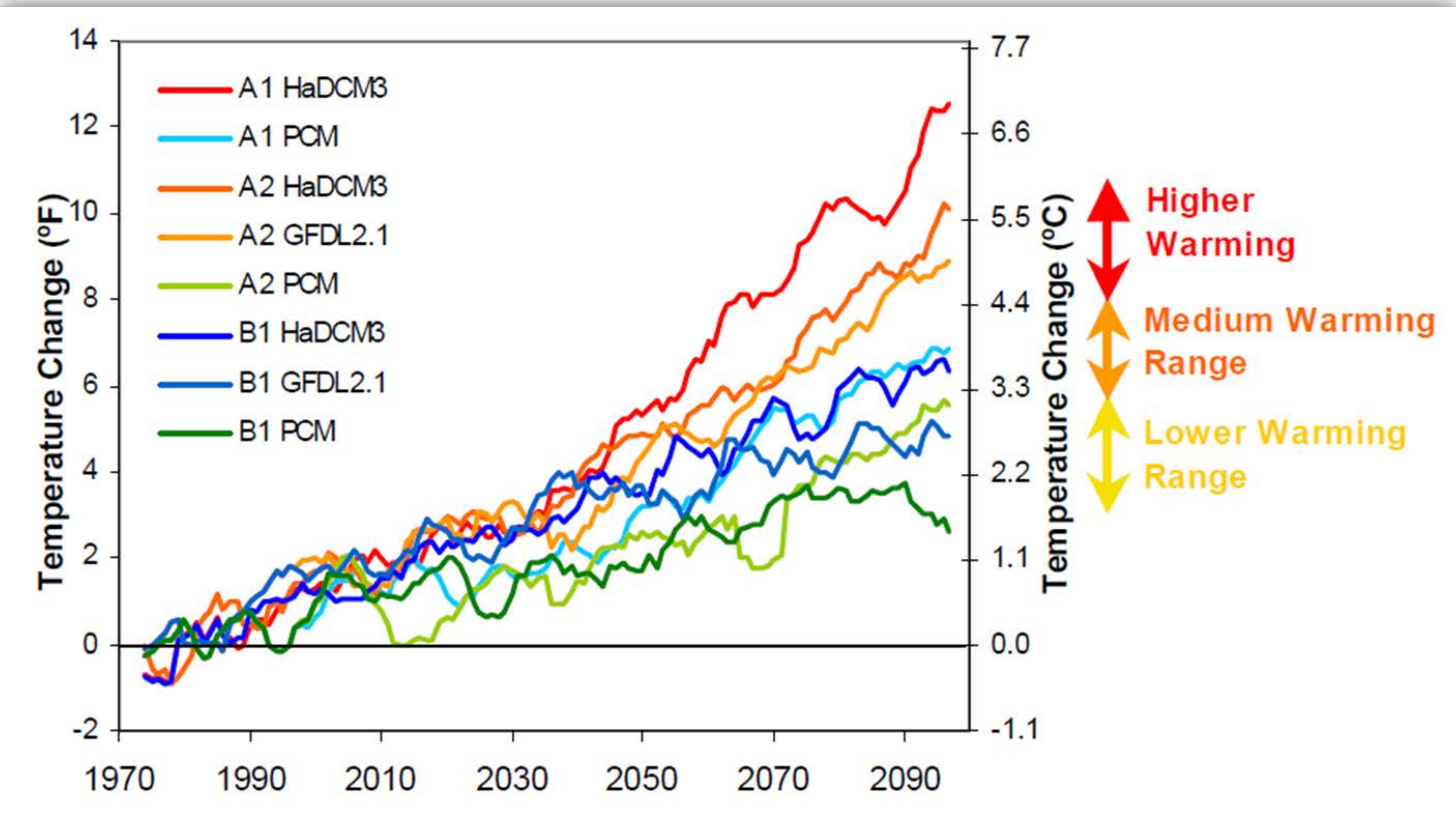
Recent Precipitation Change in California



Source: WRCC/UI Prism (2015)

Climate Change Considerations

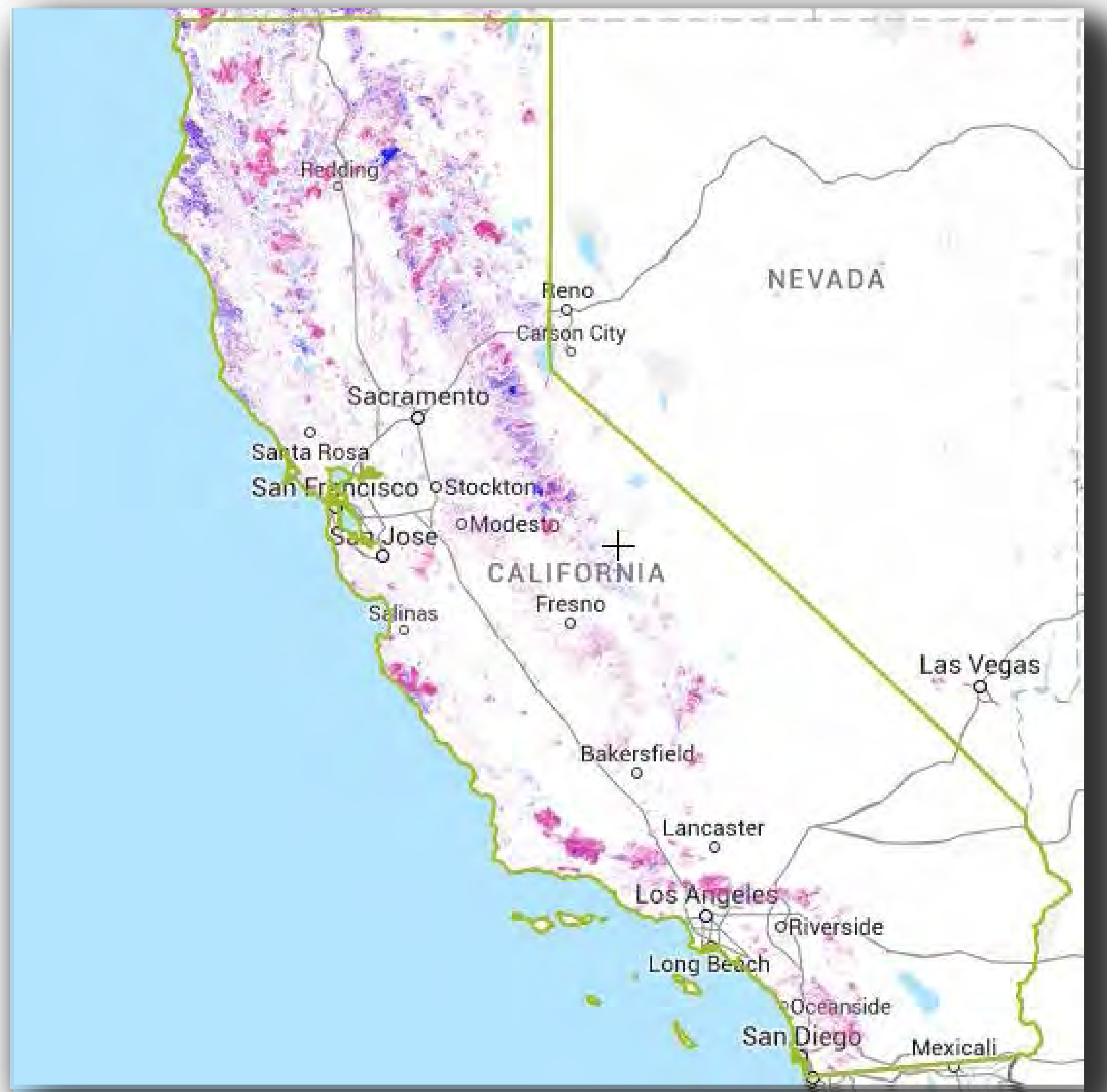
Projected Change in California Mean Annual Temperature



Source: Cayan et al. (2006)

Climate Change Considerations

Recent Tree Cover Loss in California



2001 Reference Year

Thru **2002**
Thru **2003**
Thru **2005**
Thru **2006**
Thru **2009**
Thru **2011**
Thru **2013**

Over <u>2.5 Million Acres</u> of forest cover (>30% Canopy) have been lost in 11 years.

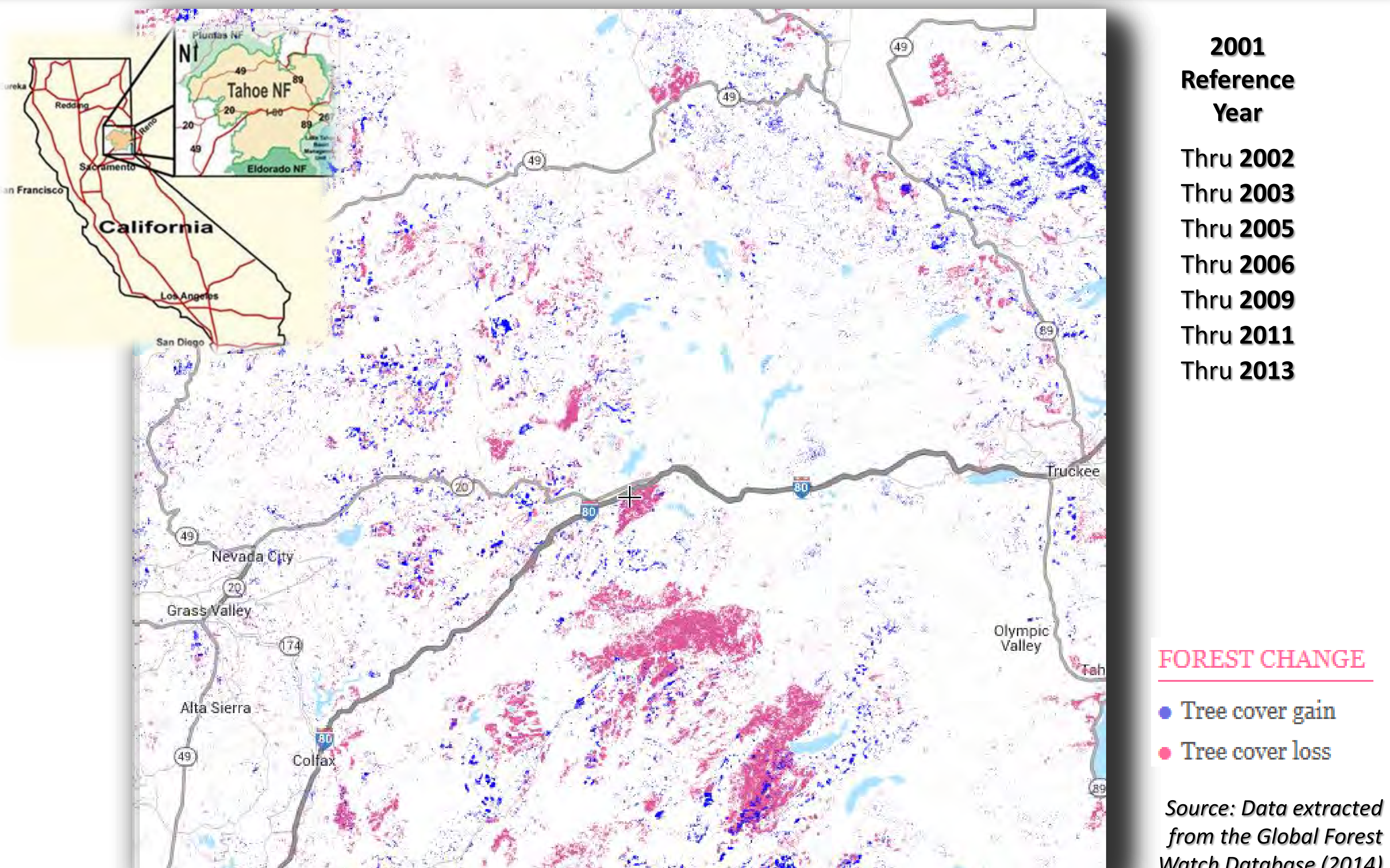
FOREST CHANGE

- Tree cover gain
- Tree cover loss

Source: Data extracted from the Global Forest Watch Database (2014)

Climate Change Considerations

Recent Tree Cover Loss in the Tahoe NF Area



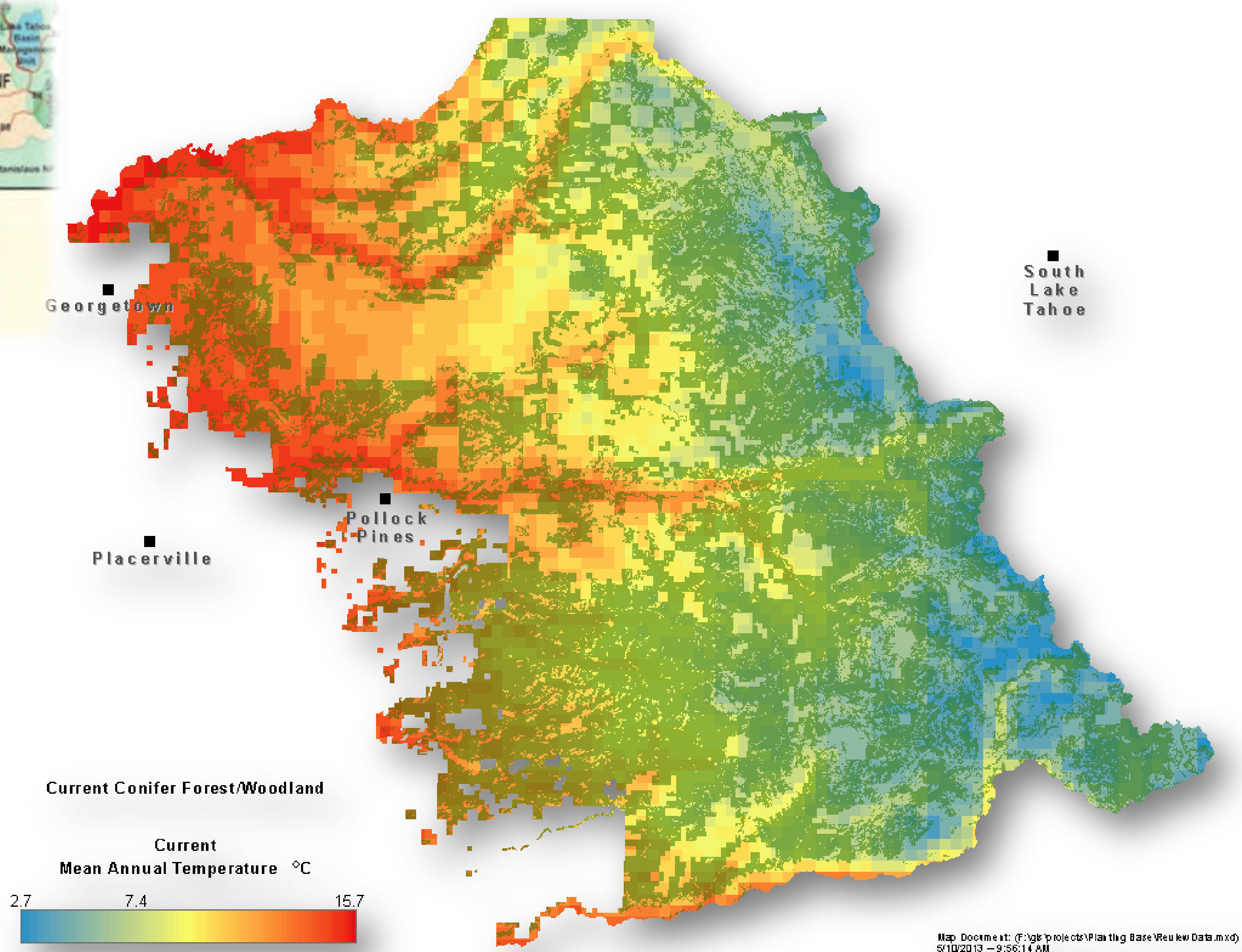
2001 Reference Year

Thru **2002**
Thru **2003**
Thru **2005**
Thru **2006**
Thru **2009**
Thru **2011**
Thru **2013**

Source: Data extracted from the Global Forest Watch Database (2014)

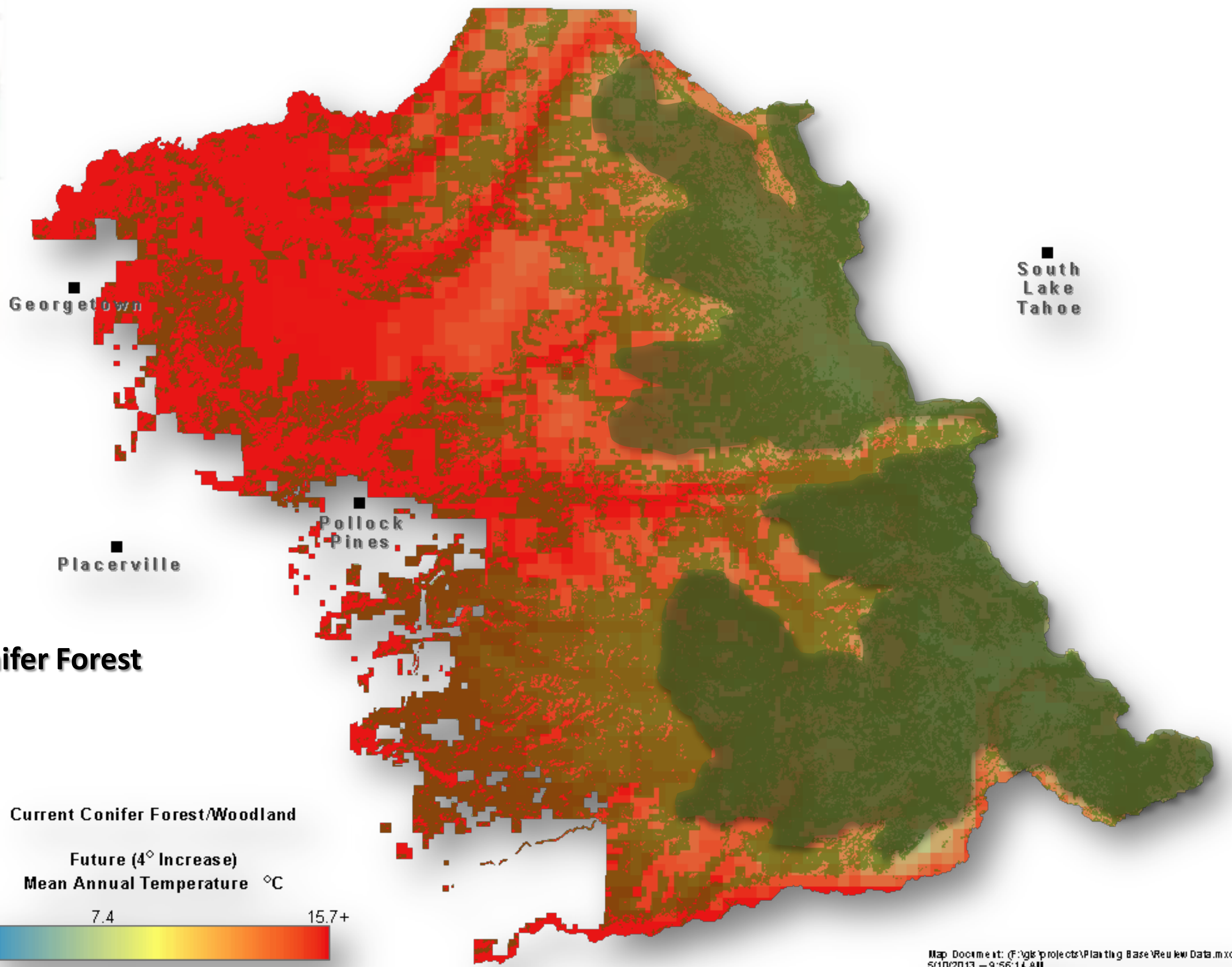
Climate Change and Forest Vegetation Shifts

Current Conifer Forest on Current MAT at the Eldorado NF



Climate Change and Forest Vegetation Shifts

Current Conifer Forest and Projected Year 2090 MAT



Current Conifer Forest

Year 2090 Estimated Conifer Forest

Current Conifer Forest/Woodland

Future (4° Increase)
Mean Annual Temperature °C

2.7 7.4 15.7+

Climate Model
B1 HaDCM3
Medium Warming

Climate Change and Forest Vegetation Shifts

Recent Vegetation Distribution Shifts with Climate Change

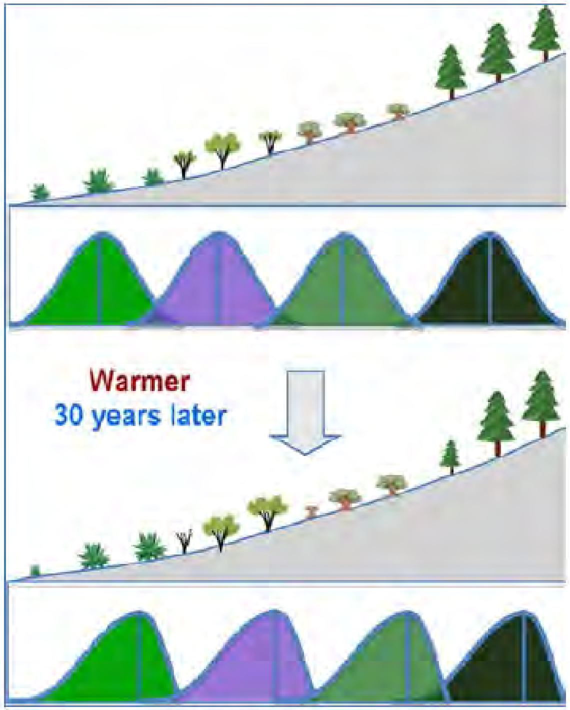
The distribution of vegetation across the north slope of Deep Canyon in the Santa Rosa Mountains has moved upward 213 feet in 30 years.

Change in mean elevation* of plant species in the Deep Canyon Transect

Common Name	Mean elevation, m: 1977	Mean elevation, m: 2006-2007	Change
White Fir	2,421	2,518	96
Jeffrey Pine	2,240	2,267	28
Canyon Live Oak	1,987	2,033	47
Sugar Bush	1,457	1,518	61
Desert Ceanothus	1,602	1,671	70
Muller's Scrub Oak	1,485	1,522	37
Creosote Bush	317	459	142
Burrobush	630	748	118
Brittlebush	574	674	100
Desert Agave	693	643	-50
Mean change in elevation (213 ft)			**65 m**
95% confidence interval (112 ft)			34 m

Change in cover-weighted mean elevation of ten most widely distributed species in the Deep Canyon Transect

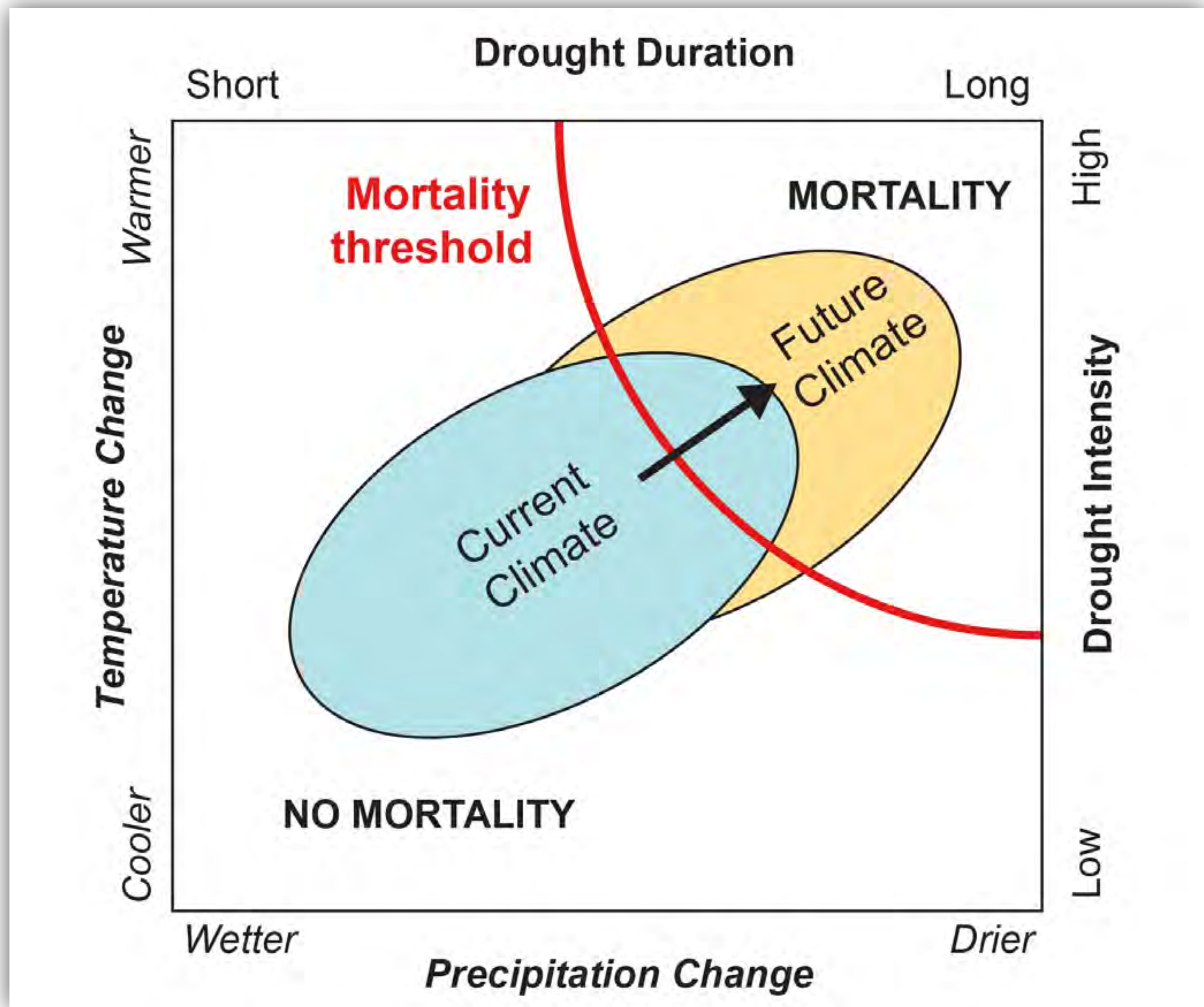
A conceptual diagram of vegetation distribution shifts



Source: Breshears et al. (2009)

Climate Change and Forest Vegetation Shifts

Forest Vulnerability to Changing Climate



Source: Allen et al. (2010)

Managed Relocation under Climate Change

Planting Base or Areas Suitable for Planting

PSW Region Forest Land in California

20.14 million acres of forest land in **18** National Forests in California.

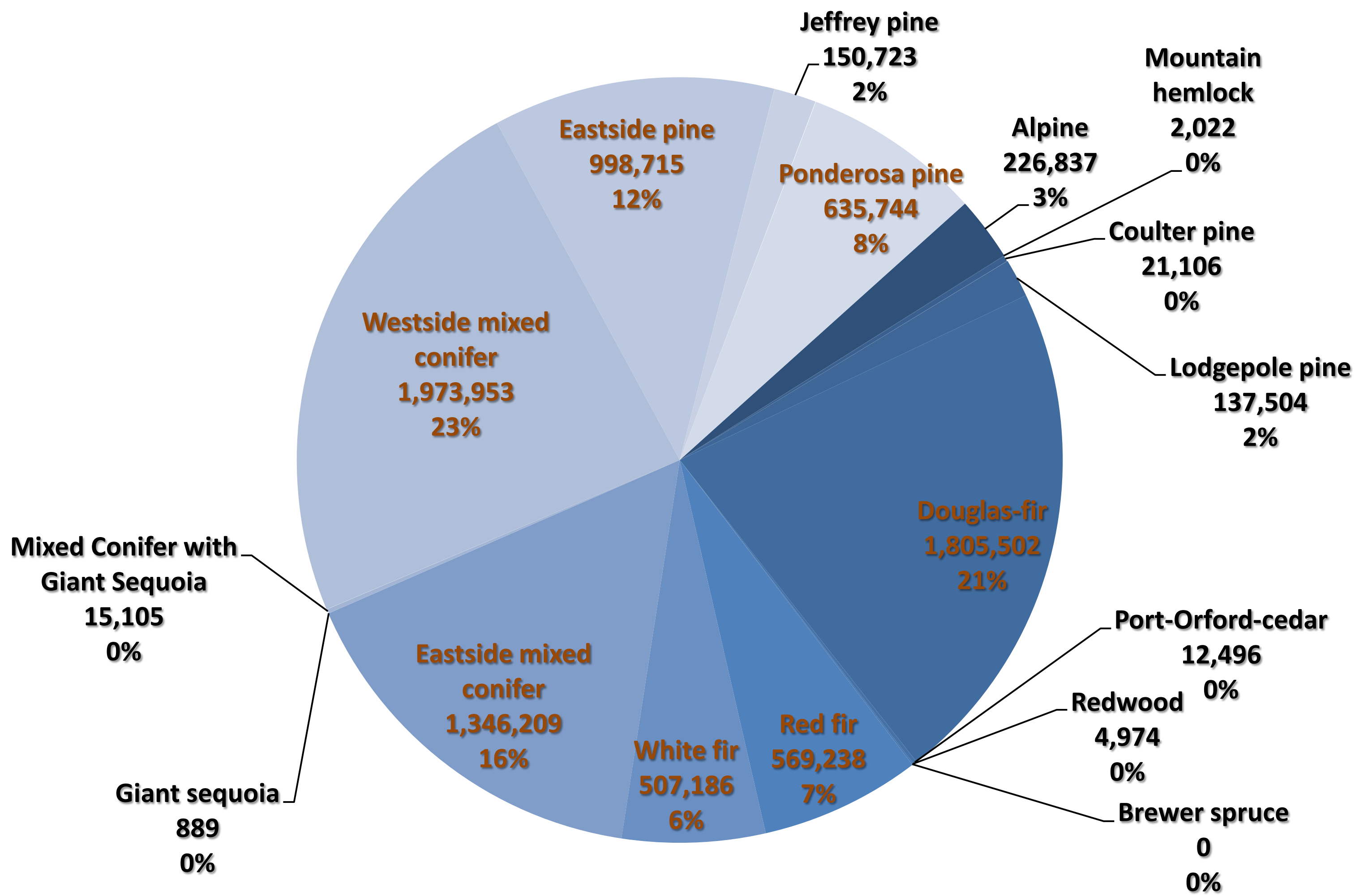
- **6,95** million acres of Non Forests and Shrubs
- **13.19** million acres of **Forest Land**:
  - 2.34 million acres of Hardwoods, Pynion, Junipers, Cypress
  - 10.85 million acres of Other Conifers

8.40 million acres as Planting Base or classified as Areas Suitable for Planting

Managed Relocation under Climate Change

Planting Base by Major Forest Types

PSW Region has 8.4 million acres of forest areas suitable for planting



Managed Relocation under Climate Change

Planting After Wildfires

Managed Relocation under Climate Change

Forest Vulnerability to a Changing Climate

- Environmental change may increase Forest Vulnerability by:
  - Reducing **fitness**;
  - Increasing **mortality**;
  - Decreasing **fecundity**.
- Population size may decline after the environmental change, leaving fewer individuals in subsequent generations to supply the genetic variation needed for adaptation to the new environment (Gomulkiewicz & Shaw 2013, Gonzalez & Bell 2013);
- If a population is compromised, Evolutionary Rescue is possible to the degree to which new stresses reduce the absolute fitness and:
  - The **initial population size**;
  - The amount of **genetic variation**;
  - The extent of **gene flow**.

Managed Relocation under Climate Change

Forest Vulnerability to Climate Change

Sawmill Campground – Angeles National Forest

Managed Relocation under Climate Change

Foundation Species Impact on Ecosystem Processes

- Forest trees are Foundation Species in many terrestrial ecosystems. They play key roles in structuring forested communities and provide habitat for other species (Ellison et al. 2005);
- Foundation tree species are declining throughout the world due to introductions/outbreaks of pests and pathogens, forest fires, etc;
- Loss of foundation tree species changes the local environment on which a variety of other species depend. This disrupts fundamental ecosystem processes, including:
  - **Rates of decomposition**;
  - **Nutrient fluxes**;
  - **Carbon sequestration**;
  - **Energy flow**;
  - **Dynamics of associated aquatic ecosystems**.

Managed Relocation under Climate Change

Foundation Species in Assisted Gene Flow

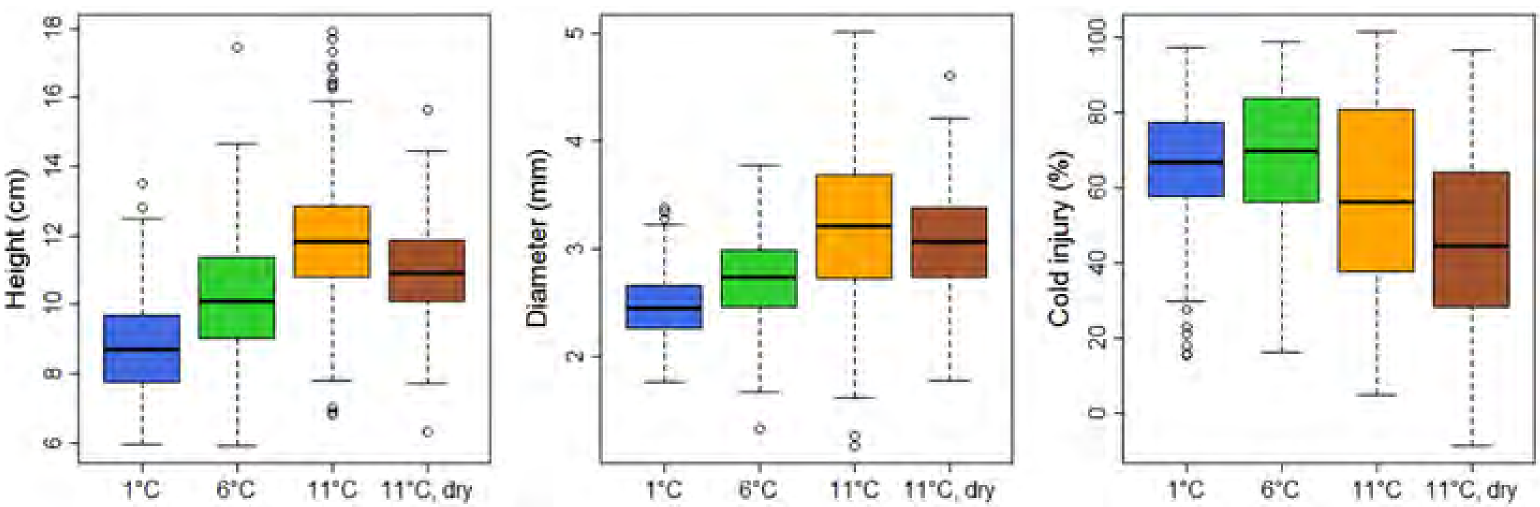
- Foundation species are prime candidates for <u>Managed Relocation</u> or <u>Assisted Gene Flow</u> owing to their central roles in ecosystem structure, function, and habitat;
- An <u>Increase in the Fitness</u> of Foundation Species may have positive impacts on other species in the community;
- Assisted Gene Flow for foundation species should attempt to increase the <u>frequency of climate-adapted alleles</u> to facilitate adaptation over generations;
- Assisted Gene Flow could increase diversity in leading edge populations and promote <u>positive adaptation</u> (Eckert et al. 2008);
- Forest productivity declines due to maladaptation of populations to new climates have been estimated to 10–35% (Wang et al. 2006);
- Assisted Gene Flow is being practiced in British Columbia.

Managed Relocation under Climate Change

Phenotypic Plasticity and Adaptation to Climate Change

- Phenotypic Plasticity can buffer the negative effects of climate change, and the evolution of plasticity can contribute to adaptive responses and population persistence (Chevin & Lande 2010);
- Increased phenotypic plasticity may allow populations to tolerate wider climatic fluctuations.

Some populations of lodgepole pine (*Pinus contorta*) show a wider climatic tolerance than others, and these populations also tend to be among the most productive for forestry (Wang et al. 2006).



Source: K. Liepe (2014)

Managed Relocation under Climate Change

Phenotypic Plasticity and Adaptation to Climate Change

White Mangrove

Phenotypic plasticity or genetic variation?

There are three mangrove species in Florida, the whites prefer the driest ground, so it's unusual to find this one growing out in the Atlantic ocean.

Source: P. Marcellini (2015)

Managed Relocation under Climate Change

Remarks on Vegetation Management

- Projected rates of climate change are faster than rates of response in natural systems;
- Management practices should be based on conserving genetic diversity in foundation species;

  Because different genotypes support different communities, greater biodiversity will be achieved by preserving the greatest genetic diversity in the foundation species (J.A. DeWoody, 2010).
- Land managers in the coastal ranges and low elevations of the Sierra Nevada and Cascade Range will face the least challenge;

  However, middle and higher elevations, conversion to better adapted climatypes would be appropriate.
- The need for comprehensive ecological restoration programs seems unequivocal.

Managed Relocation under Climate Change

Remarks on Vegetation Management

- Use genetic material from Tree Improvement programs when available;

  They have focused primarily on productivity improvements and sometimes included an insect pest and disease resistance component.

- Phenotypic Plasticity can often be explored with recommendations of Breeding Zones from Improvement programs;

  They frequently encompasses multiple Seed Zones and wider elevation ranges.

- Develop with geneticists a Managed Relocation plan, considering genetic resources available for Ecological Restoration projects.

  Seed Needs Assessment and Cone Collections Plans are currently available to help the NFs to prepare for future demands.

Planning Managed Relocation

Tree Planting Recommendation Unit

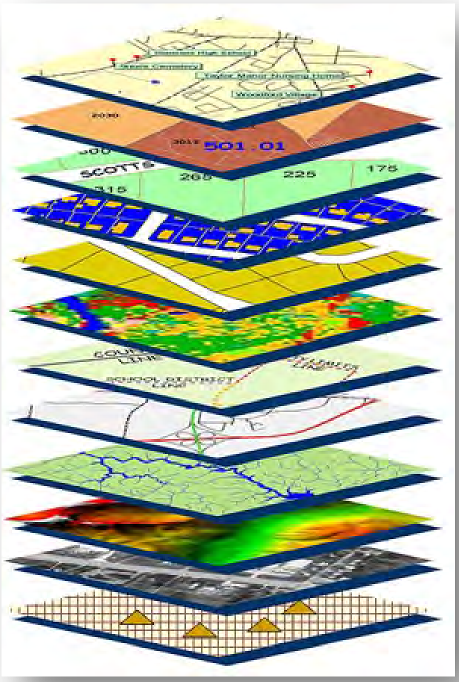
GIS Layers:

- NF Forest Management Units **MU**
  Ranger Districts and others
- NF Forest Planting Base **PB**
  - Land Suitability Classes
  - Slope
  - Distance from roads,
  - Spotted-owl habitats, etc.
- Elevation Bands **EB**
  Every 500 ft in elevation
- Slope Faces **SF**
  Based on Aspect
- Forest Vegetation Types **FV**
  Group of CalVeg Regional Forest Types
- Any other land classification relevant to Ecological Restoration

Needs to be available for planning and overlay with recent fires

Recommendation for (in Attribute Table):

- Species composition
- Planting density
- Preferred planting stock type
- Feasibility of chemical weed control
- Other relevant recommendations



Code	Regional Type
A	Alpine
T	Mountain hemlock
C	Coulter pine
L	Lodgepole pine
D	Douglas-fir
O	Port-Orford-cedar
S	Redwood
B	Brewer spruce
R	Red fir
W	White fir
F	Eastside mixed conifer
G	Giant sequoia
Y	Mixed Conifer with Giant Sequoia
M	Westside mixed conifer
E	Eastside pine
J	Jeffrey pine
P	Ponderosa pine

Planning Managed Relocation

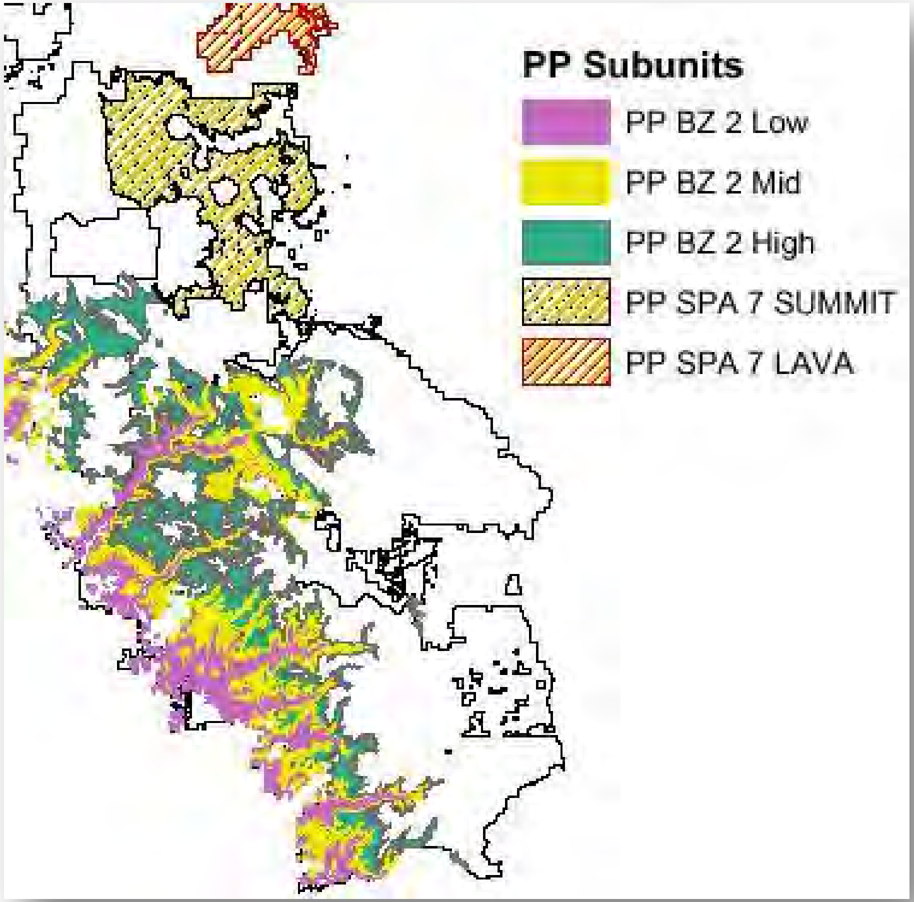
Genetic Resources for Tree Planting Recommendation Units

GIS Layers:

- Tree Planting Recommendation **PR**
  - Grouped by similar attribute values
- Seed Zones **SZ**
- Elevation Bands **EB**
- Breeding Zones **BZ**
  - Ponderosa Pine
  - Douglas-fir
  - Sugar Pine

Recommendation for: (in Attribute Table):

- Seed Zones
- Elevation Bands
- Breeding Zones
- Seed Orchards
- Disease Resistance
  - Blister Rust MGR for Sugar Pine



This is how we have seeds classified in the Seed Bank