

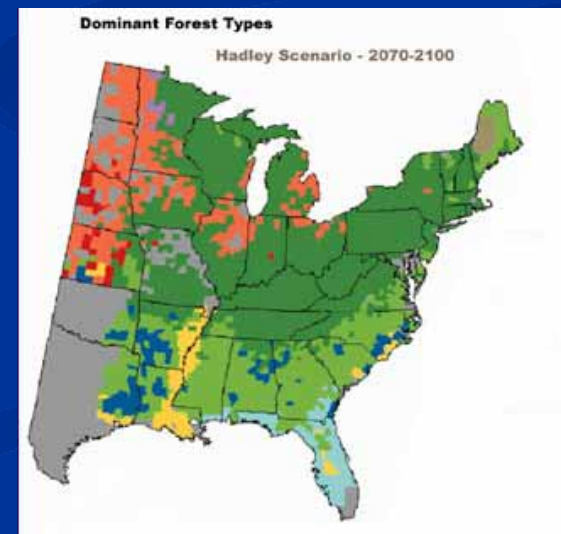
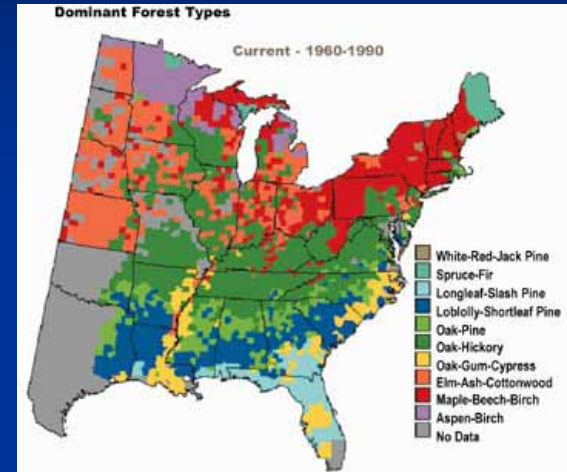
# Towards a field-based understanding of climate change-induced shifts in tree species ranges



**Teresa Chuang, UC Berkeley**

# Large shifts in species ranges are expected to occur in response to climate change resulting from anthropogenic emissions of greenhouse gases

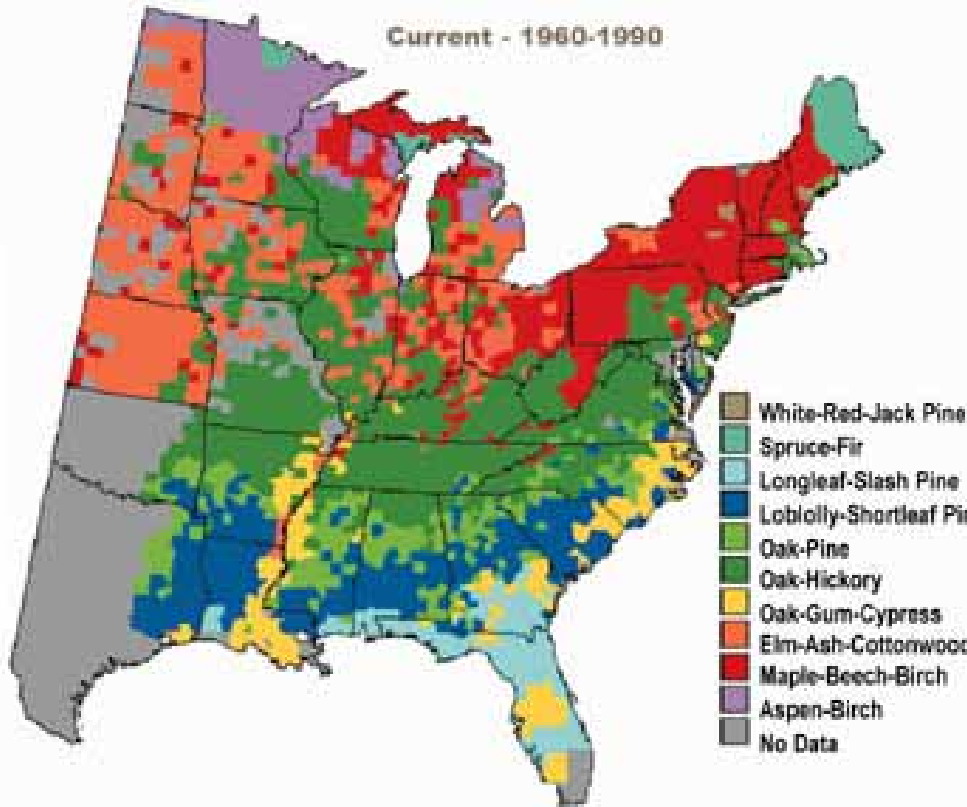
- Why should we care?
  - Implications for conservation biology
  - Implications for ecosystem structure and functioning
  - Direct implications for human social and economic systems



# Current bioclimate models use a climate envelope approach to relate species distributions to climate

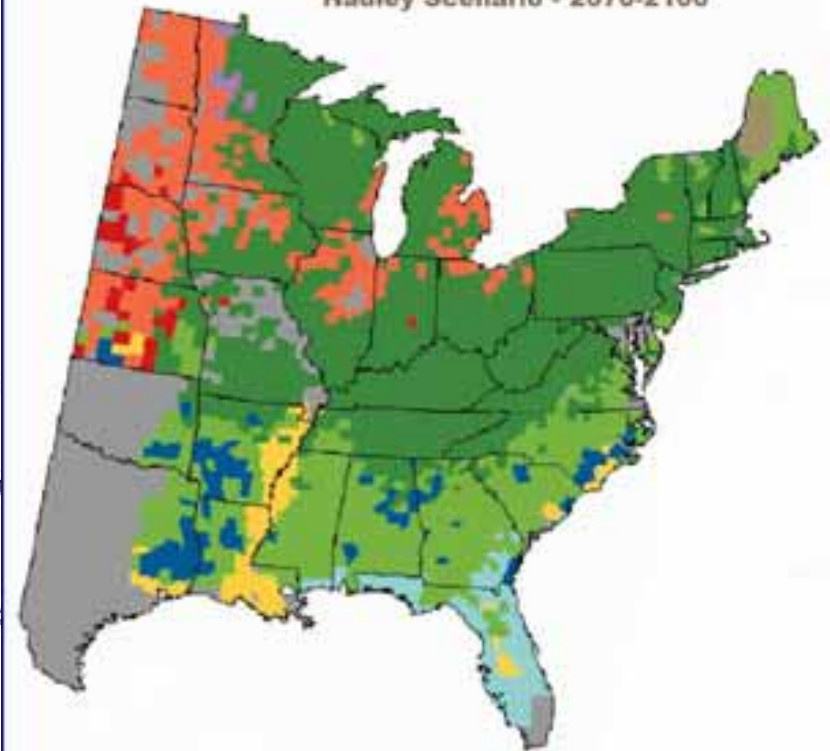
Dominant Forest Types

Current - 1960-1990



Dominant Forest Types

Hadley Scenario - 2070-2100



## **The predictions of bioclimate models have been supported by two main lines of evidence:**

- Evidence of range shifts and phenological changes in response to current climate change
- Strong evidence from the fossil record that past episodes of climate change were also accompanied by large-scale shifts in species distributions

Both support the relatively rapid range shifts predicted by these models.

**However, we know that current biological distributions are not a perfect representation of biotic interactions and climatic tolerances.**

- Current species distributions are a result of three filters:
  - Historical (what arrives)

**However, we know that current biological distributions are not a perfect representation of biotic interactions and climatic tolerances.**

- Current species distributions are a result of three filters:
  - Historical (what arrives)
  - Abiotic (what can survive)

**However, we know that current biological distributions are not a perfect representation of biotic interactions and climatic tolerances.**

- Current species distributions are a result of three filters:
  - Historical (what arrives)
  - Abiotic (what can survive)
  - Biotic (what else arrives and can survive)

**However, we know that current biological distributions are not a perfect representation of biotic interactions and climatic tolerances.**

- Current species distributions are a result of three filters:
  - Historical (what arrives)
  - Abiotic (what can survive)
  - Biotic (what else arrives and can survive)
- As a result, many sites are “won by forfeit”

**However, we know that current biological distributions are not a perfect representation of biotic interactions and climatic tolerances.**

- Current species distributions are a result of three filters:
  - Historical (what arrives)
  - Abiotic (what can survive)
  - Biotic (what else arrives and can survive)
- As a result, many sites are “won by forfeit”
- This is particularly true in plants

# What does this mean for climate change-induced species shifts?

- “Native” plants may continue to occupy an area even if they are competitively inferior to “colonizing” plants, so long as:
  - Seeds of native plants are more available than seeds of colonizing plants

# What does this mean for climate change-induced species shifts?

- “Native” plants may continue to occupy an area even if they are competitively inferior to “colonizing” plants, so long as:
  - Seeds of native plants are more available than seeds of colonizing plants
  - There is overlap in the two niches (particularly the recruitment niche)

# What does this mean for climate change-induced species shifts?

- “Native” plants may continue to occupy an area even if they are competitively inferior to “colonizing” plants, so long as:
  - Seeds of native plants are more available than seeds of colonizing plants
  - There is overlap in the two niches (particularly the recruitment niche)
  - Conditions for the germination, establishment, and growth of native plants continue to exist

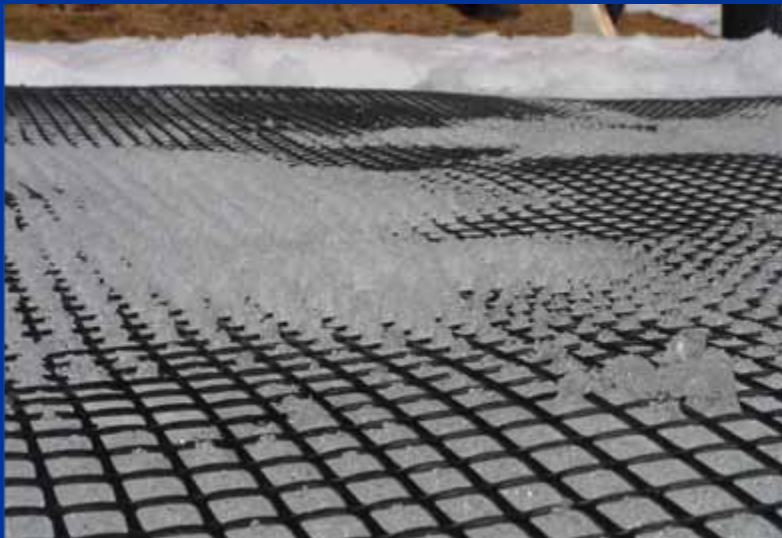
# What does this mean for climate change-induced species shifts?

- “Native” plants may continue to occupy an area even if they are competitively inferior to “colonizing” plants, so long as:
  - Seeds of native plants are more available than seeds of colonizing plants
  - There is overlap in the two niches (particularly the recruitment niche)
  - Conditions for the germination, establishment, and growth of native plants continue to exist

**If these conditions are met, range shifts in this system are likely to be relatively slow.**



**My research seeks to tie together a knowledge of seed dispersal and seedling demography with an understanding of the effects of predicted advancement in snowmelt date to evaluate predictions of uphill shifts in tree species ranges in the E. Sierra Nevada.**



# Research takes place along an elevational gradient in the John Muir Wilderness near Mammoth Lakes, CA.



- Gradient runs from 7400' to 9200'
- 5 study sites along gradient accessible only by trail
- Species composition changes from 100% Jeffrey pine at lower elevations to 100% Sierra juniper and W. white pine at higher elevations
- With increasing elevation, temperature decreases, and precipitation increases
- Area experiences a strongly Mediterranean climate with effectively no summer precipitation

# Q1: Can Jeffrey pine successfully germinate and grow outside of its current geographic range under existing climatic conditions?

- Confirmed that Jeffrey pine seedlings and saplings are not found above the current range of JP adults



# Q1: Can Jeffrey pine successfully germinate and grow outside of its current geographic range under existing climatic conditions?

- Confirmed that Jeffrey pine seedlings and saplings are not found above the current range of JP adults
- Planted seeds and transplanted seedlings within and outside (above) the current range



## Q2: What are the patterns of seed rain within and outside the current distributional limits of Jeffrey pine?

- Seed trap sites in 3 of the 5 study areas



## Q2: What are the patterns of seed rain within and outside the current distributional limits of Jeffrey pine?

- Seed trap sites in 3 of the 5 study areas
- Each 60m x 60m seed trap site contains 20 seed traps to quantify wind dispersal (secondary animal dispersal known to be important but very local)



## Q2: What are the patterns of seed rain within and outside the current distributional limits of Jeffrey pine?

- Seed trap sites in 3 of the 5 study areas
- Each 60m x 60m seed trap site contains 20 seed traps to quantify wind dispersal (secondary animal dispersal known to be important but very local)
- Know location and DBH of all adult trees



## Q2: What are the patterns of seed rain within and outside the current distributional limits of Jeffrey pine?

- Seed trap sites in 3 of the 5 study areas
- Each 60m x 60m seed trap site contains 20 seed traps to quantify wind dispersal (secondary animal dispersal known to be important but very local)
- Know location and DBH of all adult trees
- Inverse modeling methods to determine dispersal kernel



# What about rare long-distance seed dispersal?

- Extremely rare but significant long-distance seed dispersal has often been used to explain rapid shifts in species ranges in the past

# What about rare long-distance seed dispersal?

- Extremely rare but significant long-distance seed dispersal has often been used to explain rapid shifts in species ranges in the past
- However, recent molecular work suggests that low-density refugia not picked up by the fossil pollen record may have existed

# What about rare long-distance seed dispersal?

- Extremely rare but significant long-distance seed dispersal has often been used to explain rapid shifts in species ranges in the past
- However, recent molecular work suggests that low-density refugia not picked up by the fossil pollen record may have existed
- Combining seed dispersal data with a demographic analysis of adult trees also suggests that rare long distance dispersal cannot “push” the system unless recruitment and regeneration success is high

### Q3: What are the natural demographics of this species, and where is the bottleneck?

- Recorded size, age, and species of all trees and saplings in seed trap sites and seedling plots



### Q3: What are the natural demographics of this species, and where is the bottleneck?

- Recorded size, age, and species of all trees and saplings in seed trap sites and seedling plots
- Continued monitoring of seed traps



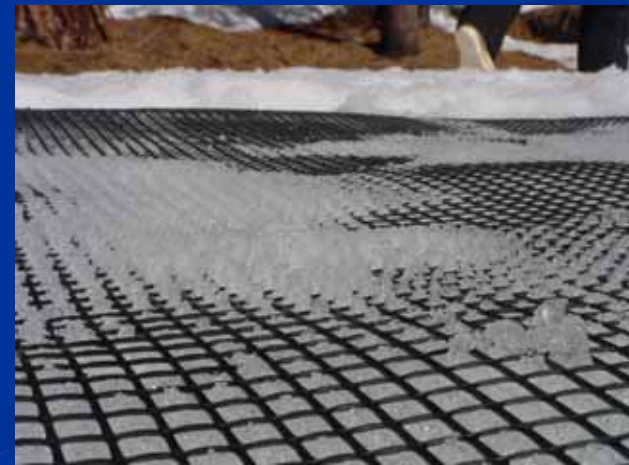
### Q3: What are the natural demographics of this species, and where is the bottleneck?

- Recorded size, age, and species of all trees and saplings in seed trap sites and seedling plots
- Continued monitoring of seed traps
- Observed natural seedling dynamics along transects within and outside seed trap sites



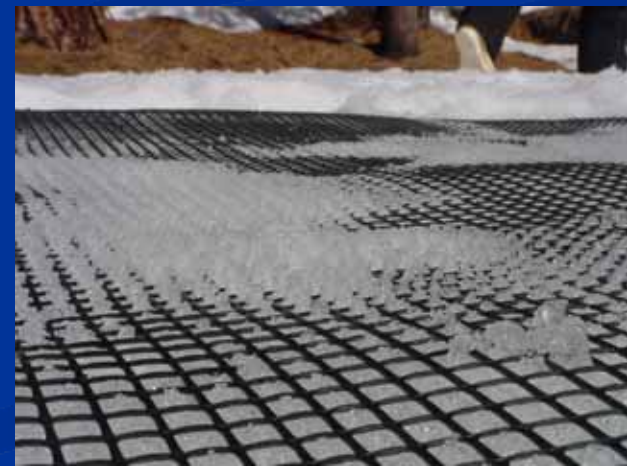
# Q4: Do climate manipulations that mimic future climatic conditions affect seedling germination and establishment rates?

- SWE loss quantified with snow cores



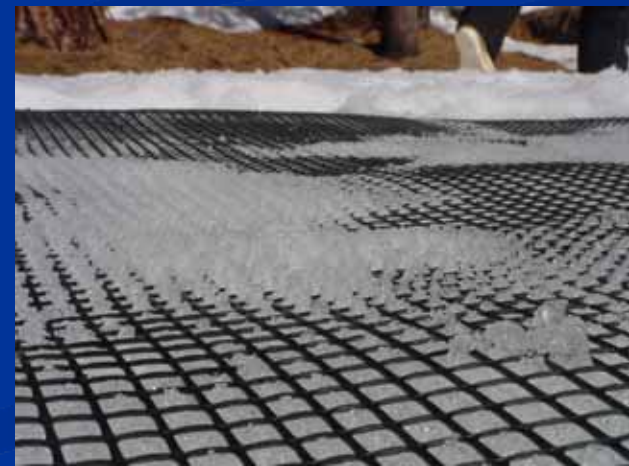
# Q4: Do climate manipulations that mimic future climatic conditions affect seedling germination and establishment rates?

- SWE loss quantified with snow cores
- In level areas, results in lower soil moisture levels and an effective increase in growing season length



# Q4: Do climate manipulations that mimic future climatic conditions affect seedling germination and establishment rates?

- SWE loss quantified with snow cores
- In level areas, results in lower soil moisture levels and an effective increase in growing season length
- In 2007, I altered snowpack over half the study plots outside the current range to observe the effects on seedling dynamics



## Take-home messages from research

- Seeds caught in seed traps reflect composition of overstory trees in the site, with no evidence of long-distance dispersal.
- Seedlings of the lower elevation species can successfully germinate and establish above its current range, but only following wet winters.
- Climate manipulations that simulate predicted advancements in snowmelt date do not increase germination and establishment success of the lower elevation species either within or above the current range.
- There is an extraordinarily small probability that any given seed will become an overstory tree.
- Climate manipulations do not increase this probability for lower elevation species.

## Many thanks to:

- John Harte, John Battles, Roger Byrne
- The Harte lab
- The Valentine Eastern Sierra Reserve
- Dai Shizuka, Miranda Redmond, Alex Yu, Gillian Fairchild, Michelle Ben-David, Daria Mazey, Christine Yin, Joel Figueroa, Danielle Svehla, Cristina Castanha, and Holly Alpert for field and lab assistance

Funding provided by: NSF Graduate Research Fellowship Program, UC Berkeley Graduate Division Fellowship, American Alpine Club Research Grant, Mildred E. Mathias Graduate Student Research Grant, Valentine Eastern Sierra Reserve Graduate Student Research Grant, Lewis and Clark Fund for Exploration and Field Research, UC Berkeley's Sponsored Projects for Undergraduate Research, and UC Berkeley's Undergraduate Research Apprentice Program.