Hot Science Cool Talks

UT Environmental Science Institute

# 72

# *Creative Conservation in a Changing Climate*

**Dr. Camille Parmesan**

**April 22, 2011**

# Creative Conservation in a Changing Climate


## Camille Parmesan

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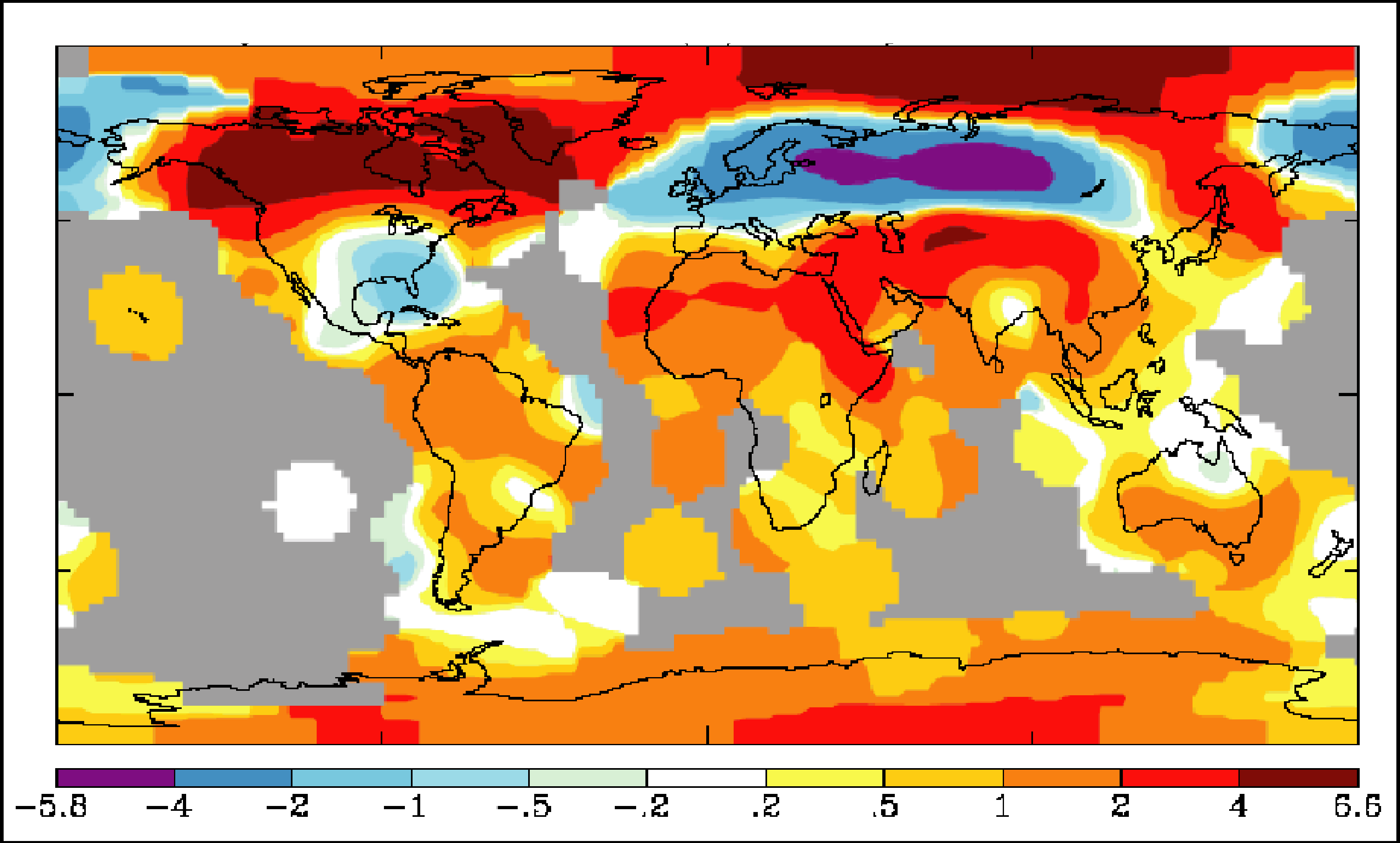
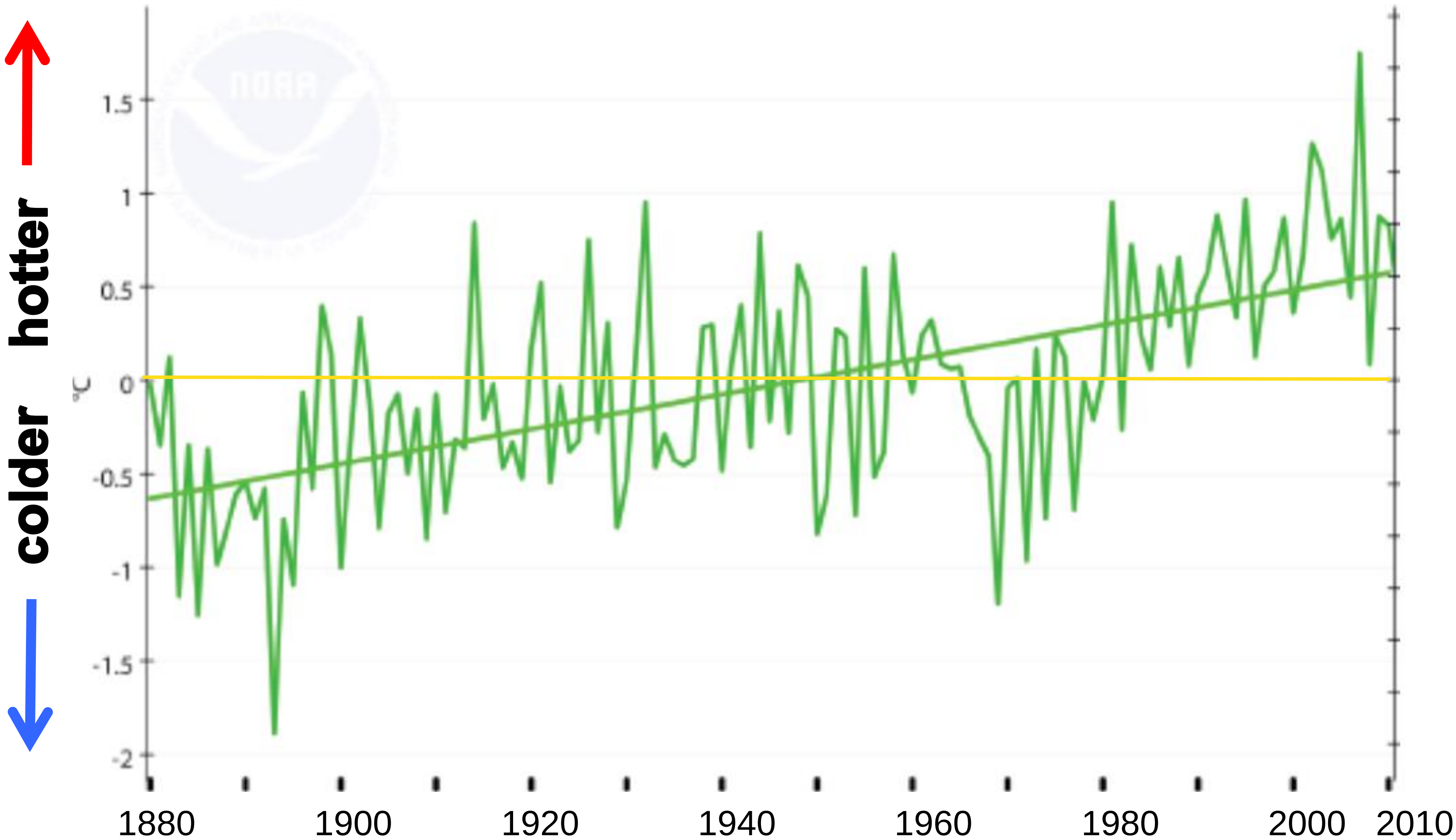
April 22, 2011

# Jan. 2010; departures from regional average temperatures (1951-1980)




National Climatic Data Center / National Oceanic and Atmospheric Administration 2009

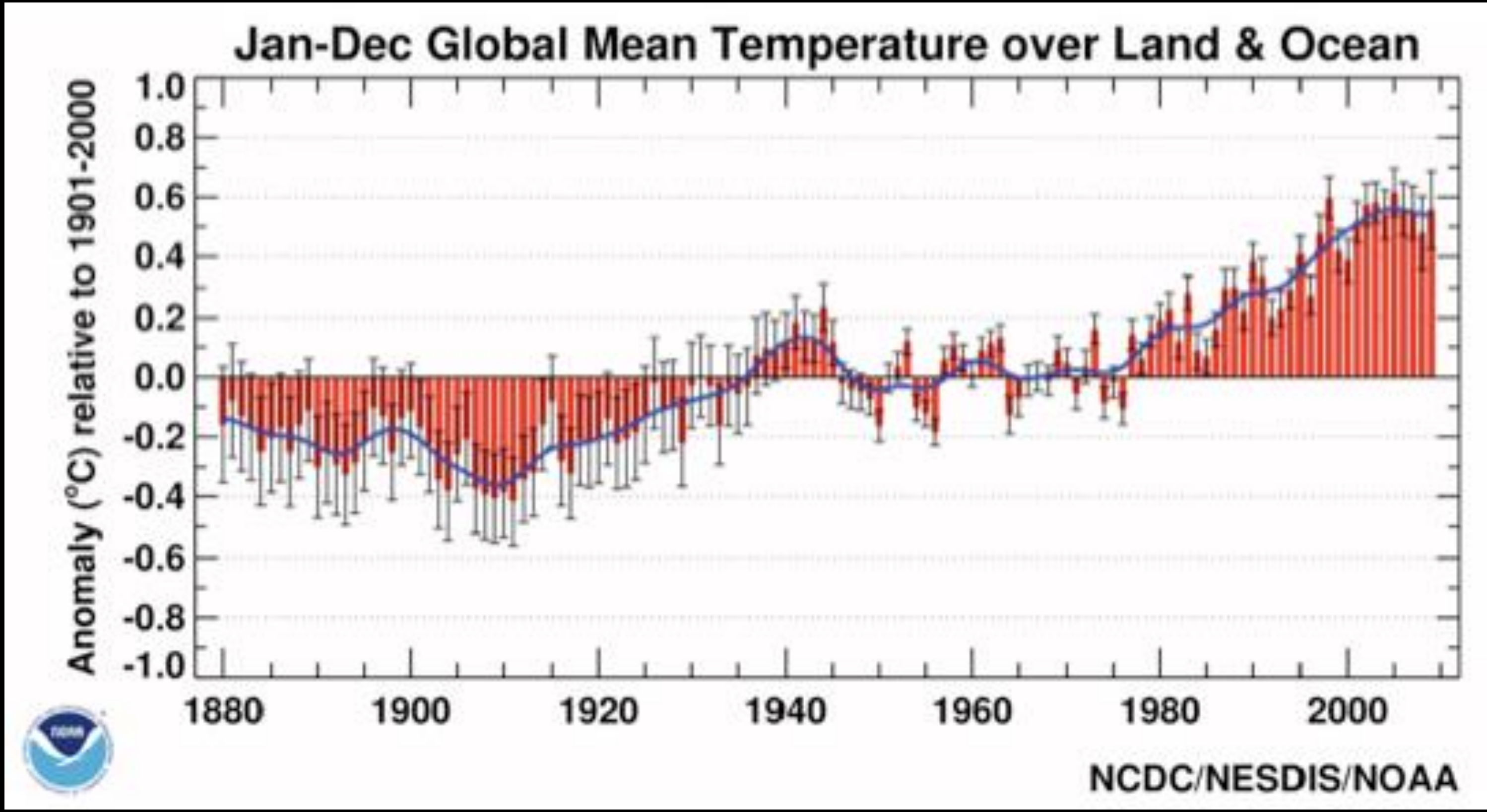
# Departures from global average temperatures for all Januaries (1880-2010)




National Climatic Data Center / National Oceanic and Atmospheric Administration 2009

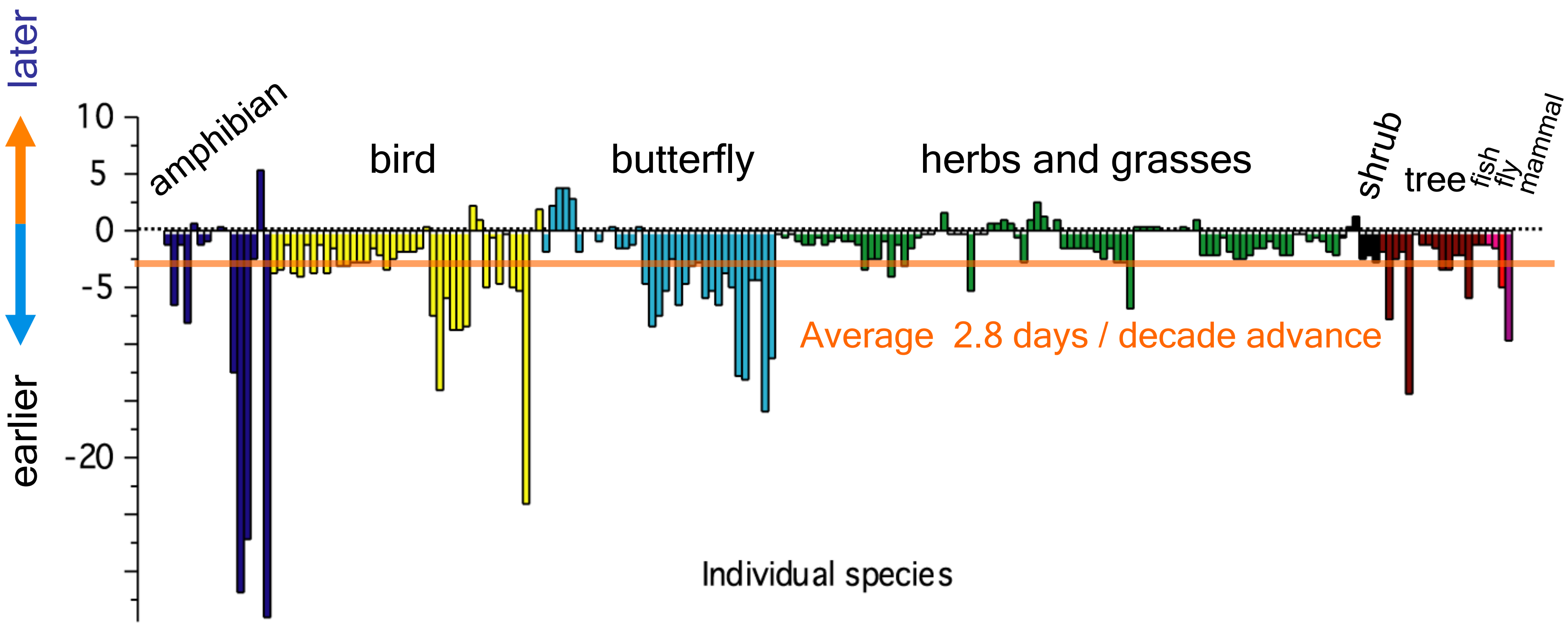
# National Climatic Data Center: Report 2010

- 2010: ties with 2005 for hottest year on record
- 2009: fifth hottest year on record
- 2001-2010: warmest decade on record
- Each year in 2000's hotter than 1990 average






# Trends in timing of spring events among northern temperate species



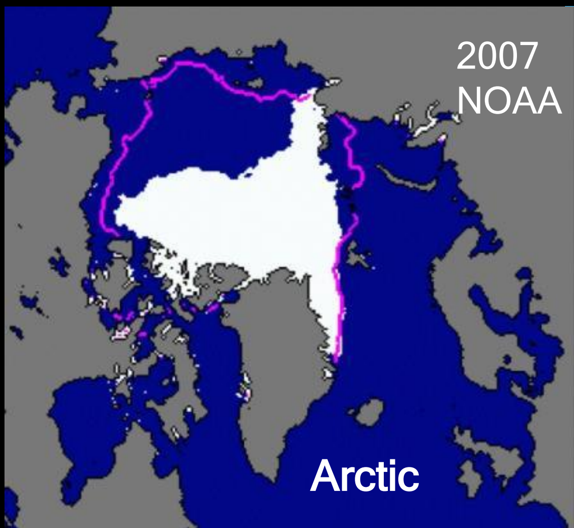

n = 203    Time span = 17 to 99 years

Parmesan (2007)

# Whole Range Study of 57 Species Across Europe

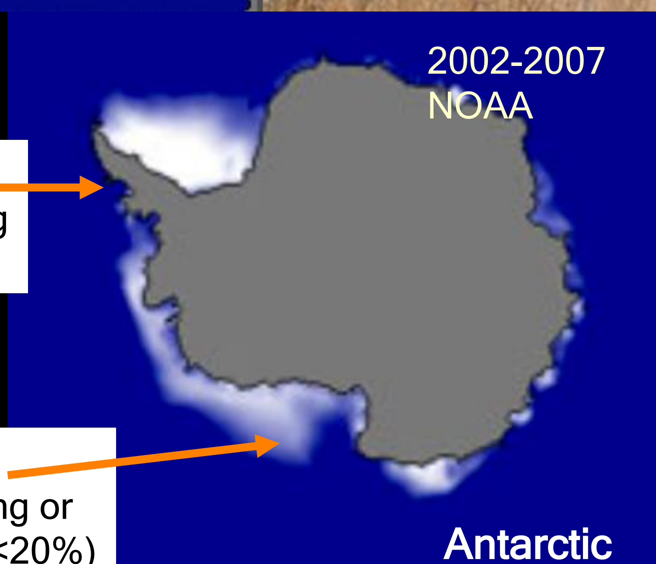
Parmesan *et al.* 1999

# Declines and Range Contractions of Sea Ice-Species in Arctic and Antarctic





Ice-dependent penguins declining by 70 - 95%




Ice-dependent penguins increasing or smaller declines (<20%)

Adelie & Emperor penguins

Smith *et al.*, 1999; Fraser *et al.*, 1992; Emslie *et al.*,1998

# Mountaintop Species

- Many species have contracted upward
- First extinctions

golden toad, Costa Rica

white lemuroid possum , Australia

apollo, Europe & Nepal

pika,

USA & Nepal

IUCN: 23% amphibians at risk of extinction from climate change (1431 sp)

Parmesan, 2006

# Longer growing season, warm winters & pests

Warmer winters, northward ranges shifts of moths and beetles, and extended growing seasons have resulted in increased pest outbreaks, tree deaths, and associated loss of productivity in forests


- Mountain pine beetle (Colorado, British Columbia)
- Spruce bark beetle (3.8 million acres killed in Alaska)
- Pine Processionary moth (Italy, France)
- Beetles in Siberia

Parmesan & Yohe 2003; Root *et al.* 2003; Parmesan 2007
IPCC 2001; Logan *et al.* 2003; Battisti *et al.* 2005

# Koalas and climate change

## Responses to decreases in plant nutritional value

- Iconic Australian marsupial. Both a habitat and a food specialist.
- Increased atmospheric $CO_2$ causes *Eucalyptus* leaves to be tougher and less nutritious.
- Koalas losing weight, likely culprit is malnutrition.

Courtesy: Wendy Foden, International Union for Conservation of Nature

# Global Coherence of Observed responses to climate change (0.7° C)

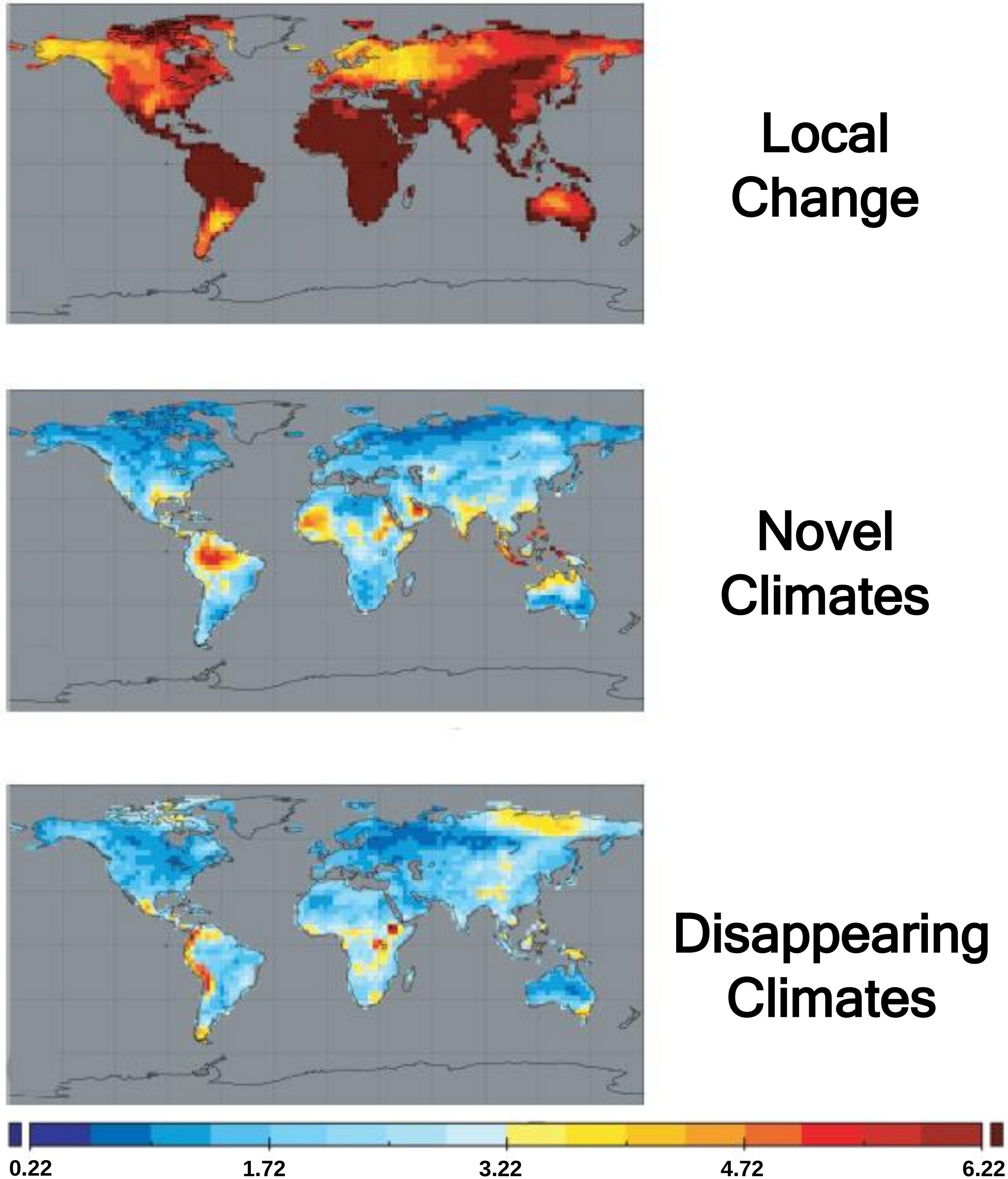
- ~ **52 %** of species studied have shifted their ranges poleward (by 50 - 1600 km) and/or upward (by up to 400 m)

- ~ **62 %** of species studied have shifted towards earlier spring breeding, migrating, leafing, blooming, etc.

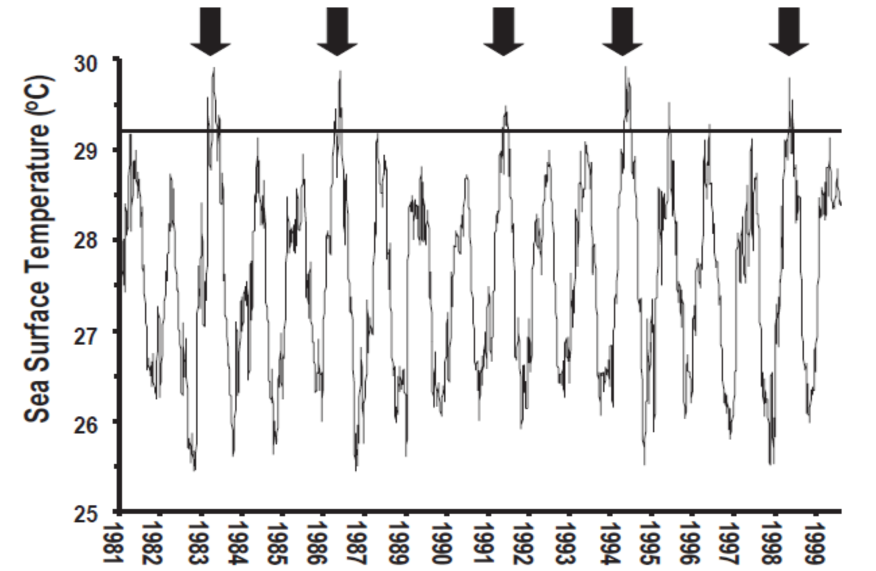
- Every major group studied has been affected - trees, herbs, butterflies, birds, mammals, amphibians, marine corals, invertebrates, fish & plankton

- Impacts have occurred on every major continent and in every major ocean

Parmesan & Yohe 2003; Parmesan 2006; IPCC 2007




Williams *et al.* 2007




Hoegh-guldberg *Marine Freshwater Research* 1999

# Exceeding sea surface temperature thresholds (SST) causes bleaching

- ~30 % of world's coral reefs have disappeared after multiple extreme SST events
- Stressed reefs - lower recovery after bleaching
- How much would we have lost if all reefs had been healthy?

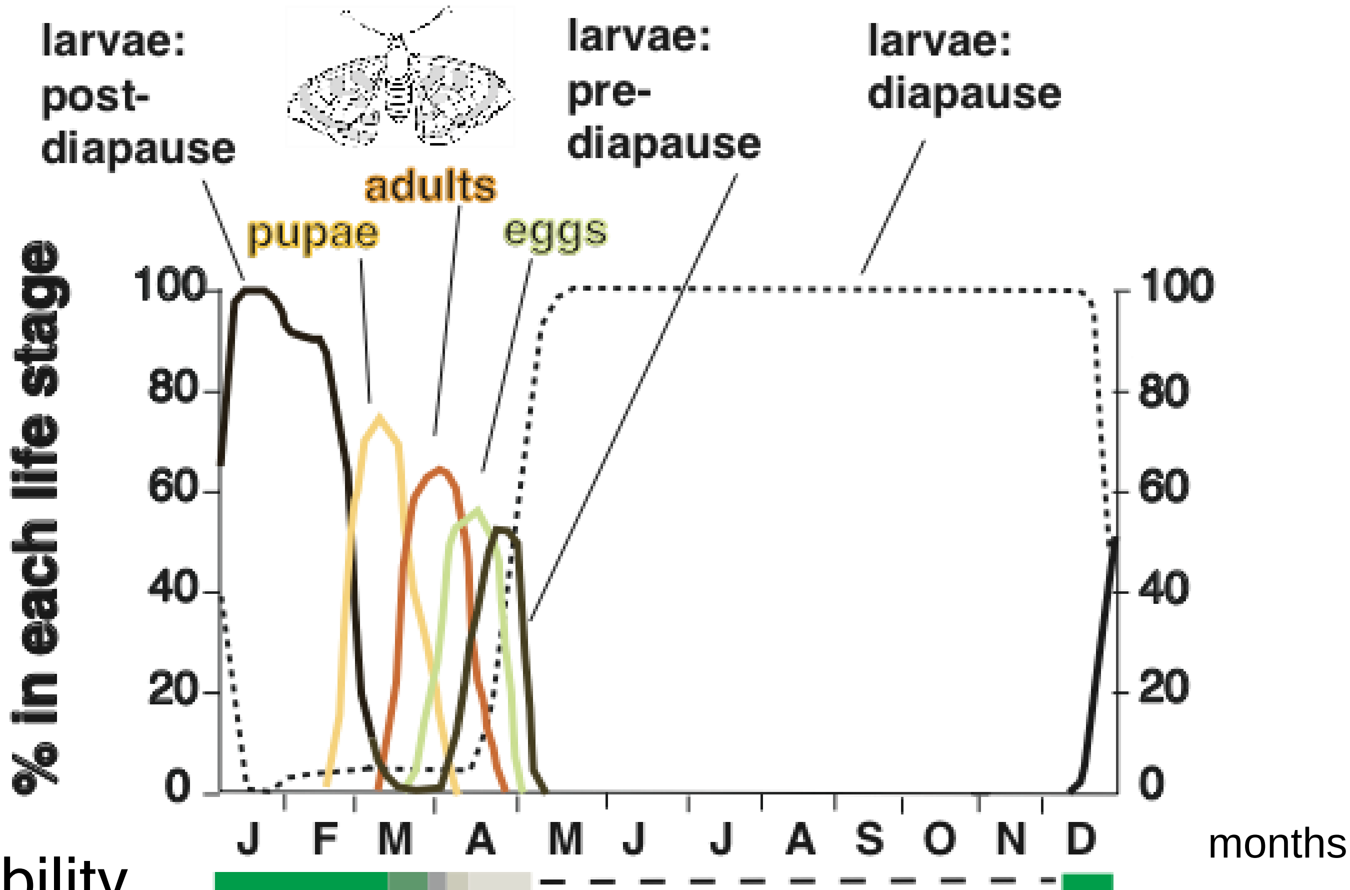
Endangered species

Bay checkerspot

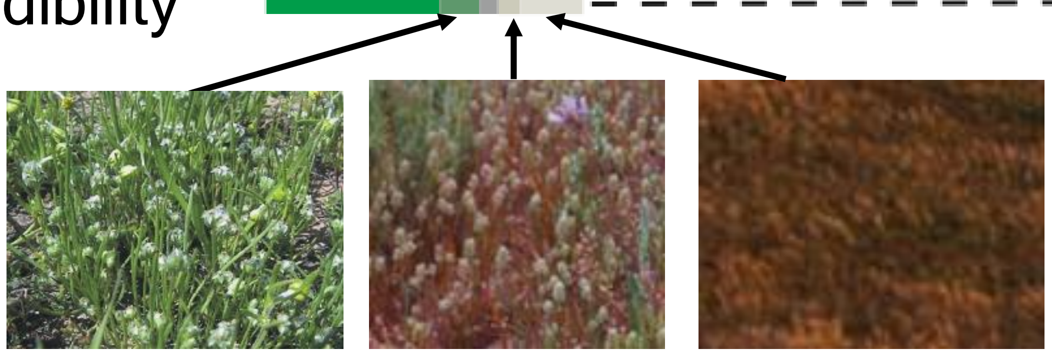
*(E.e. bayensis)*

- San Francisco Bay
- Serpentine outcrops
- Annual host plant
  *Plantago erecta*

# The life of Edith's Checkerspot butterflies




Plant edibility



# Changes in spring timing driving range shift in Edith's Checkerspot *(Euphydryas editha)*

## -----    Warming Increases Asynchrony

- 2° C experimental warming increases timing mismatch (3 independent field experiments)
- Host plants dry up 3-7 days earlier
- caterpillars starve
- 'normal' 90-95% mortality goes to 100%
- whole populations go extinct

Singer 1972; Parmesan 1996; Weiss *et al.* 1988, 1993; Boughton *et al.* 1999; Hellman *et al.* 2004

# Extinction of Bay Checkerspot in a Preserve

## Global warming

- Beginning in 1971: Rainfall increased in variability.
- 1998: Jasper Ridge at Stanford (JR) populations go extinct

## Habitat loss

- 1960s & 70s: Massive habitat loss caused many populations to go extinct.  JR becomes isolated.

## Nitrogen rain

- 1980s & 90s: N-fertilization allows invasive plants to spread into butterfly habitat.  Preserved areas degraded.

Last nail in coffin was climate change, but population already in poor health and no other populations around to ‘rescue’ it

Harrison *et al.* 1988;  Weiss 1999; McLaughlin *et al.* 2002

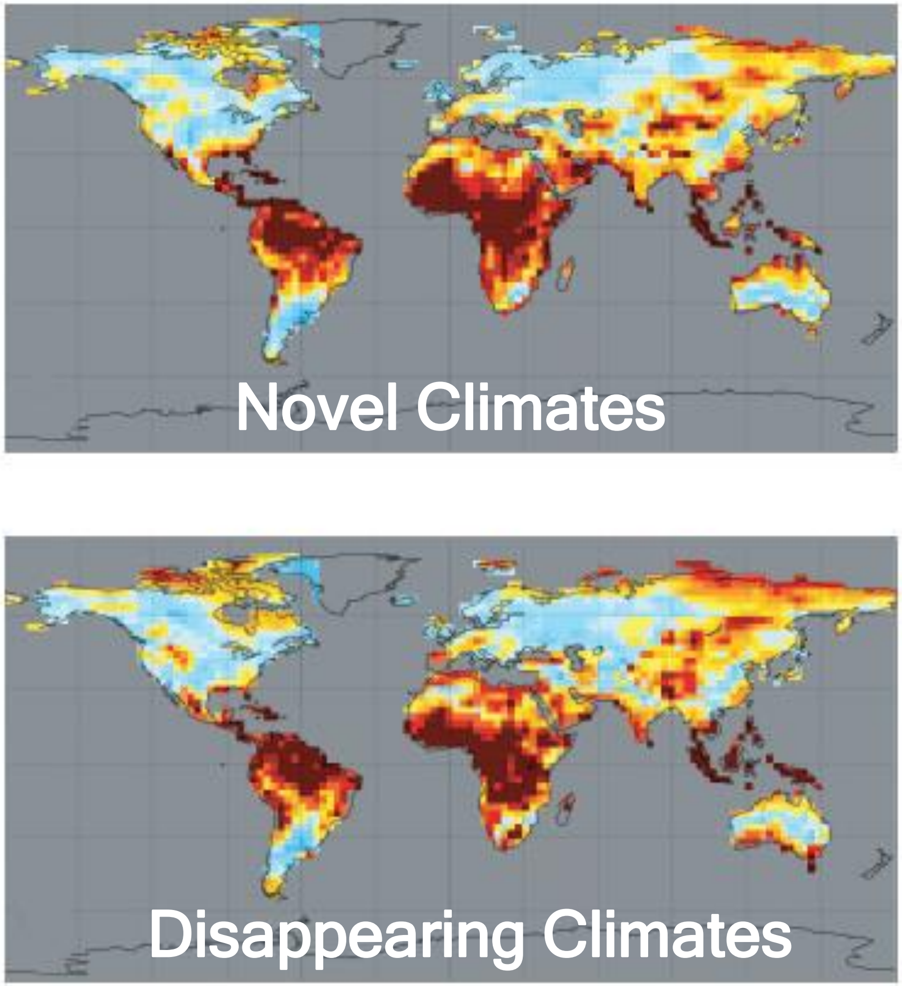
# Complexity and Conservation

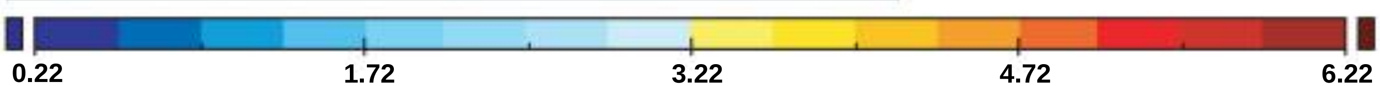
- Ultimately, impacts of anthropogenic climate change depend on:
  - current health of the population
  - specific species or system (how sensitive is it?)
  - environmental context (what else is going on?)

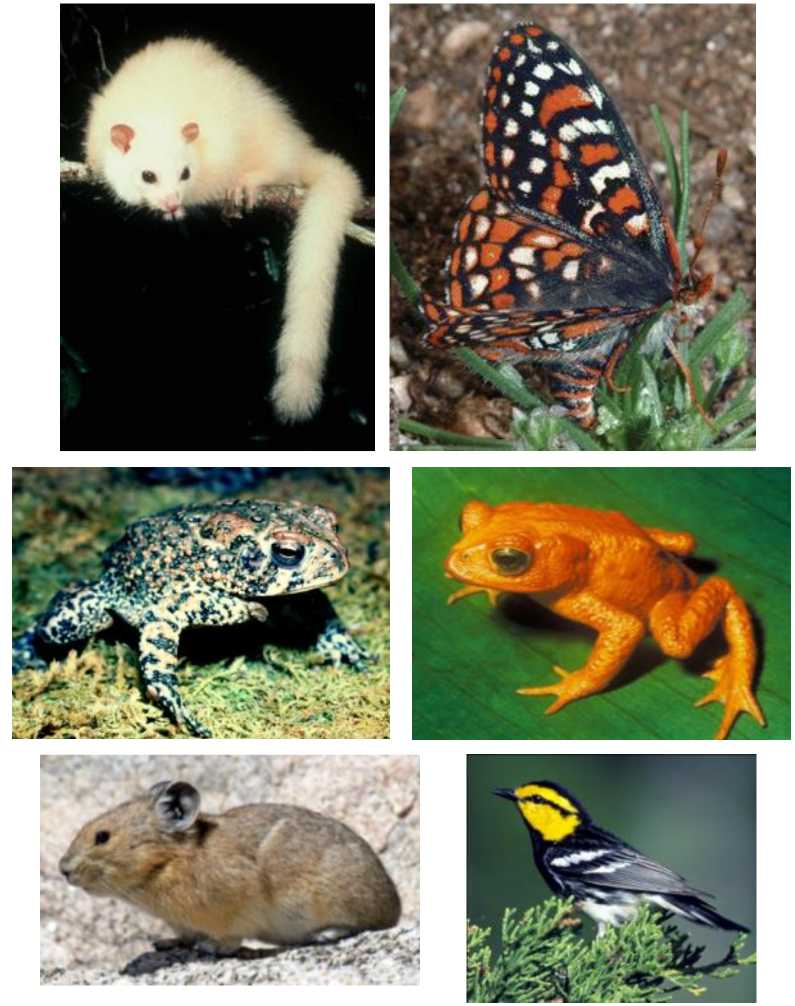
- Moral?
  - Think globally about what climate change means for your region
  - Act locally to reduce stressors and improve species' or systems' health

Parmesan *et al.* 2011

# Novel and Disappearing climates by 2100 - calculated within 500 km



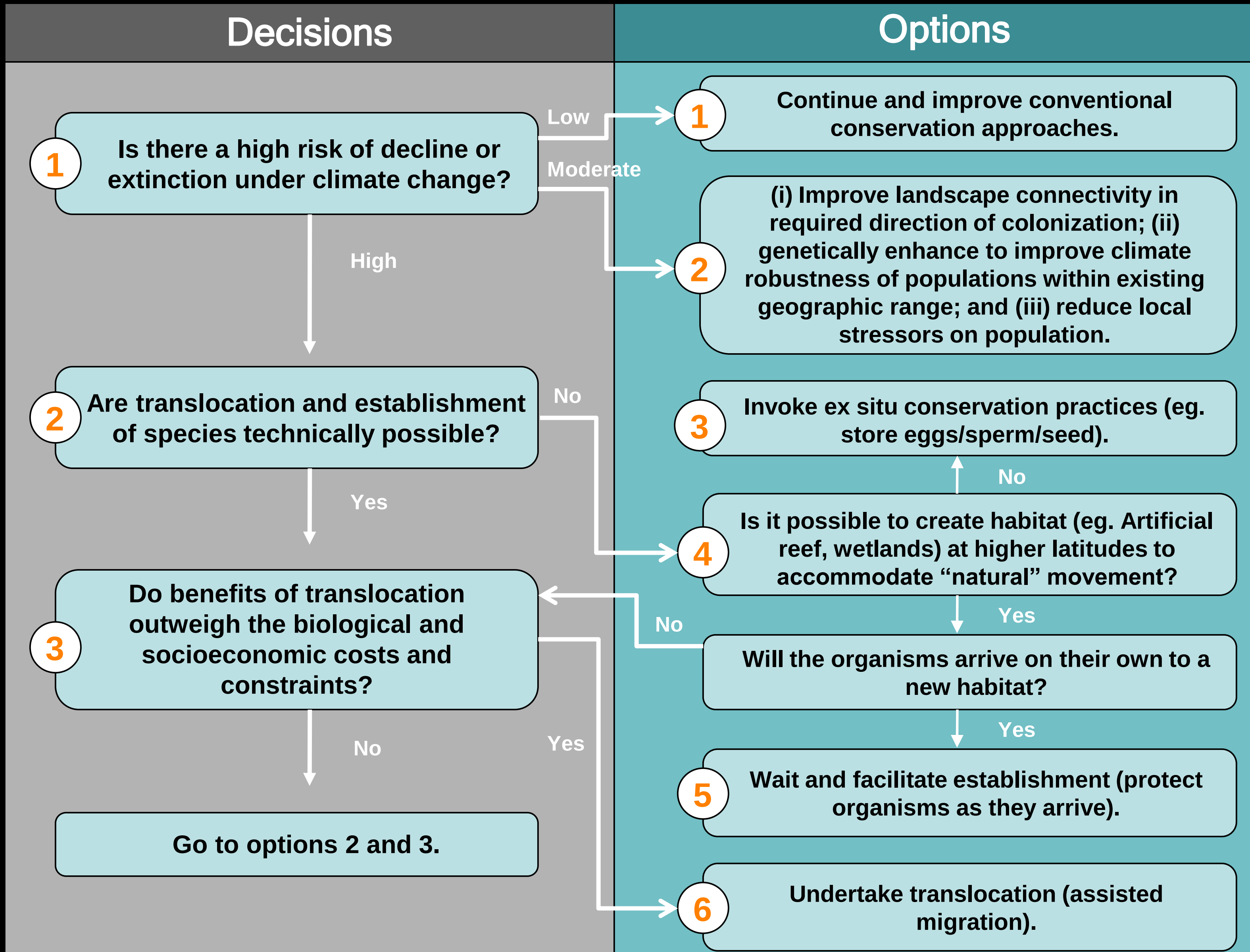



Williams *et al.* 2007

# Assisted Colonization

# Assisted Colonization? A Decision Framework




Hoegh-Guldberg *et al.* 2008

# Best Candidates for Assisted Colonization / Migration /Translocation

- High risk of extinction if nothing done
- Low probability of doing harm to recipient community
  - NOT a predator / parasite
  - Relatively poor competitor
  - non-aggressive (behavior or growth)
  - Resource specialist
- Easy & cheap to capture, culture & move
- High inherent biological or societal value

Hoegh-Guldberg *et al.* 2008

*Euphydryas gilletti:*

successful ‘assisted colonization’


- In 1977, Ehrlich moved from native Wyoming to outside of range in Colorado
- Same climate, same host plant (honeysuckle)
- Established with few egg clusters
- No recorded negative impacts on native ecosystem
- Range has been contracting northward and upward

Boggs *et al.* 2006; Ernest Williams unpublished

# Restoration of Vernal Pool Habitats in California

## USFWS & Recon Environmental Inc.



- Landscape topography molded (shallow depression created)
- Appropriate soils brought in (clay lens)
- Water storage, filtration & flow altered

Photos: Mark Dodero

YEAR 3

- Self-sustaining
- Occasional weeding needed to keep out exotics
- Habitat for 5 endangered vernal pool species
- Cost: $ 1m/acre

# Native systems store more carbon than degraded systems

## ~ 1/6 global $CO^2$ from degradation /destruction



Mahli & Grace 2000; H. Joosten COP15

# Native systems store more carbon than degraded systems

~ 1/6 global $CO_2$ from degradation /destruction

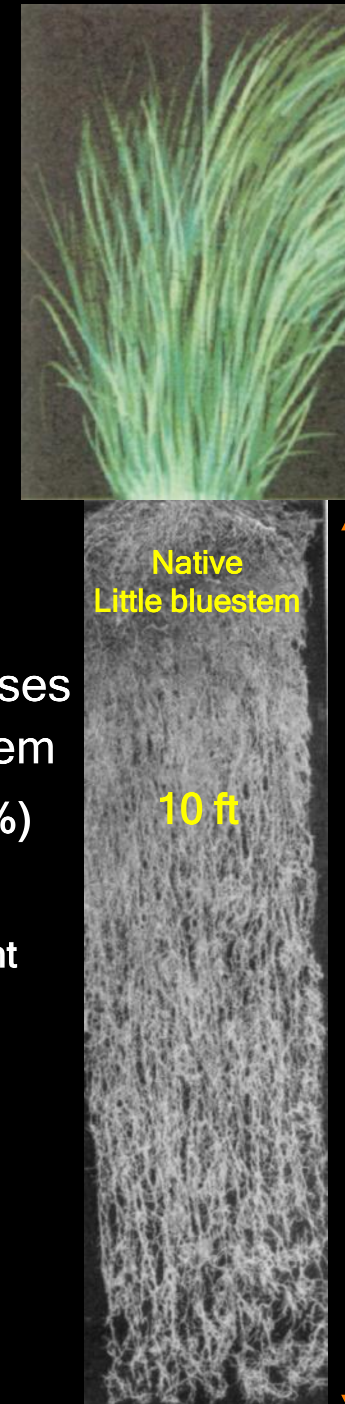

Native bunchgrasses
Deep Root system

↑ C-storage (by 52%)

↑ Water storage

↑ Resistance to drought and heat waves

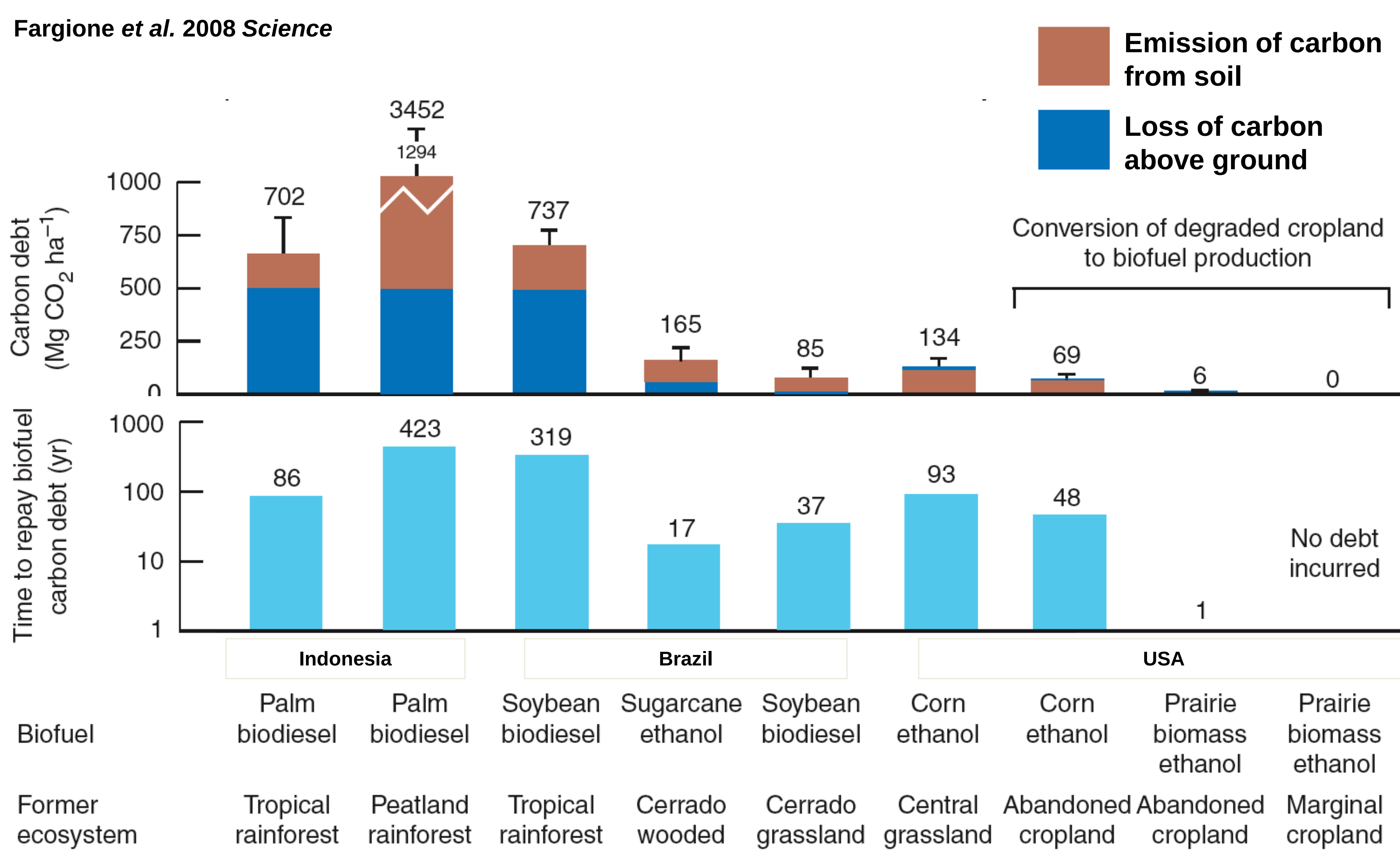
↑ Nutritional value




Mahaney WM et al 2008 Oecologia 157:295-305.H. Joosten COP15

# Full carbon budget shows prairie carbon-neutral

## Conversion of lands to biofuel production



# Restoration of Native American Prairie

- Better adapted to climate extremes than invasives
- Creates corridors - helps biodiversity cope with rapid shifts in climate
- Helps mitigate climate change

**Native bunchgrasses**
Deep Root system
↑ C-storage (by 52%)
↑ Water storage
↑ Resistance to drought and heat waves
↑ Nutritional value
Adapted to grazing
**Only carbon-neutral biofuel**

Franzluebbers 2005; Fargione *et al.* 2008; Poteet unpublished

# Society for Ecological Restoration International Primer on ER (2004):

- *"Restoration attempts to return an ecosystem to its historic trajectory."*
- A reference system expresses *"one of many potential states that fall within the historic range of variation of that ecosystem."*
- Material for seeding/planting/colonizing should come from genetically similar, or geographically close populations

# Pinyon Pine Die-Offs after Drought + Heat Wave + Beetles

# Restoration?

12,000 sq km area

40% - 90% of trees died

Photo: Craig Allen (USGS)

# Global changes in set of climates available for species to inhabit

4 - 48 % area loss of existing climate

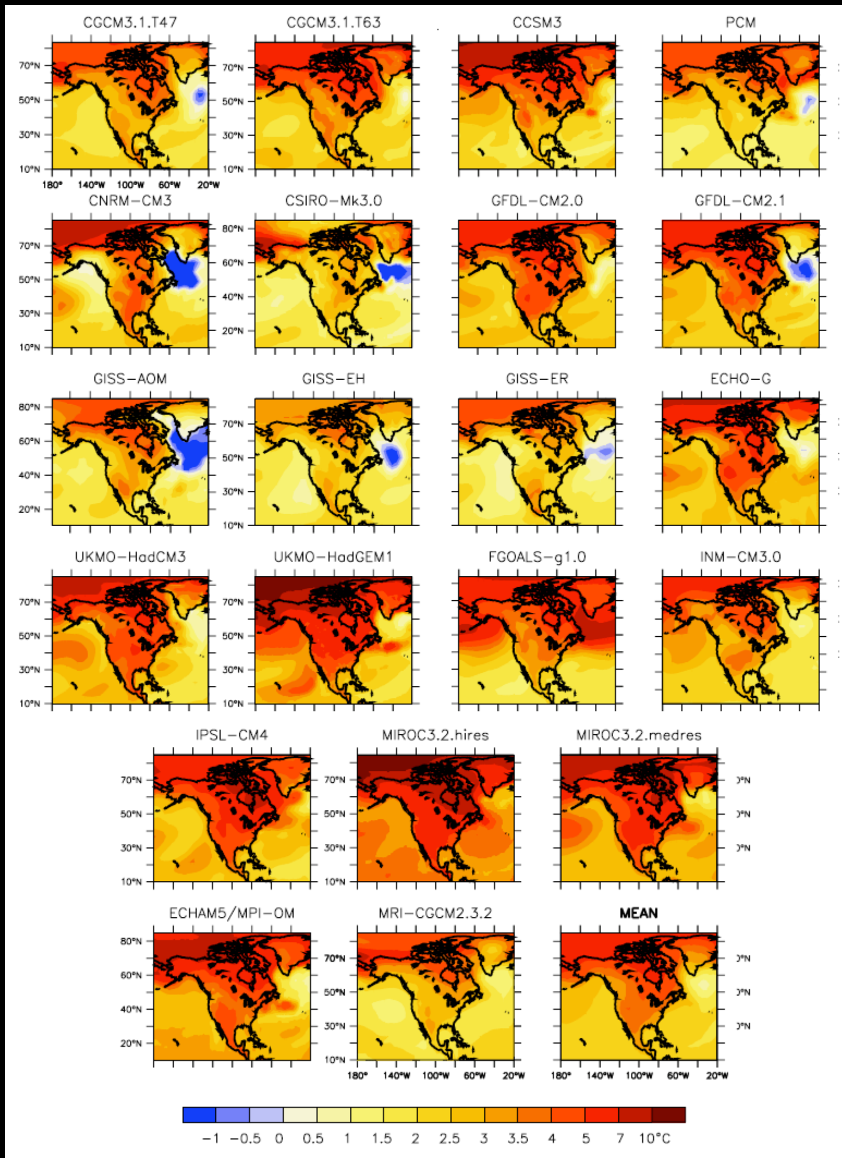
4 - 39 % area gains of novel climate

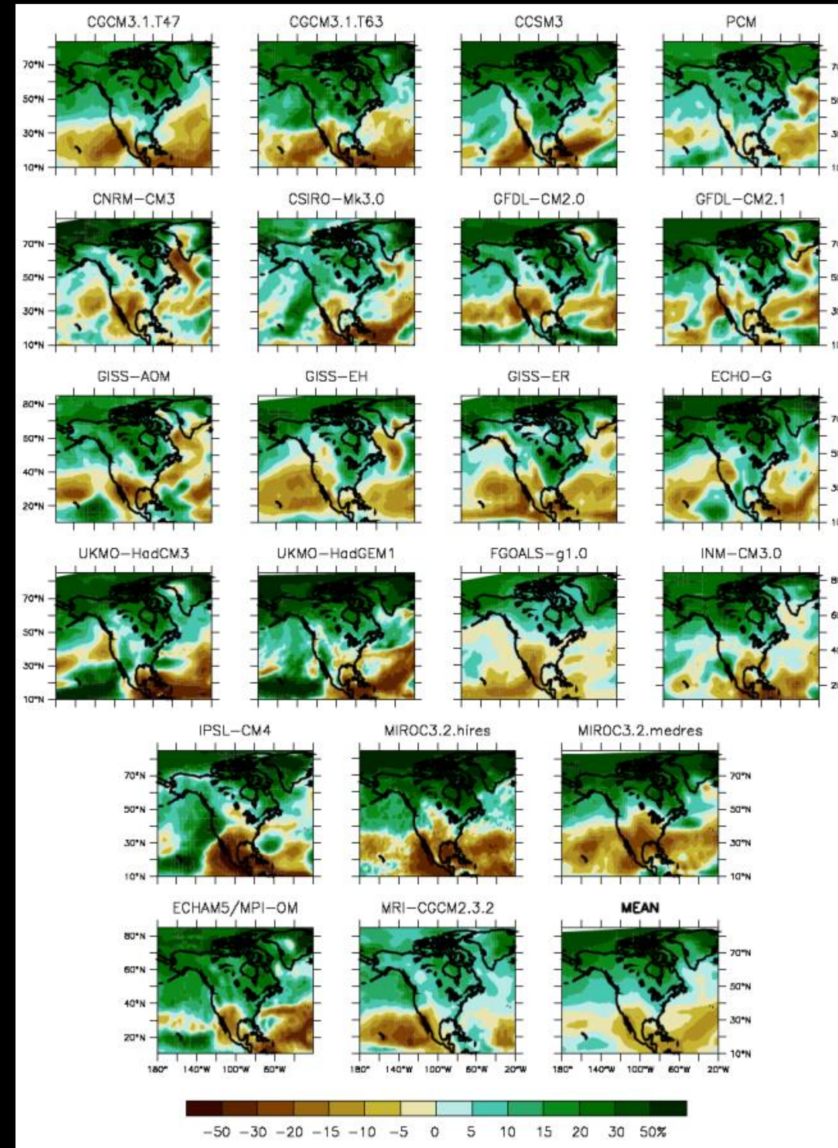
Restoration ⟶ Creation

- Existing communities no longer stable due to different responses to changed and novel climates
- A new goal? - maximize specific services, e.g. carbon sequestration - Re the "Blue Carbon" initiative
- Calls for flexible conservation approaches

# Changes in temperature and precipitation by 2099

- 21 global climate models
- A1B emission scenario (less than current emissions)



# Diversity of European meadows driven by traditional human management

# *Problem:* Species' Forced Out of Traditional Homelands and Protected Areas

*Solutions:*

- Assisted Colonization
- Restoration to create habitat corridors & improve C-sequestration
- Creation of new habitats adapted to future climate

*Impediments:* Conservation laws & tools focus on return to historic state

Hoegh-Guldberg *et al.* 2008

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