Responses of Wild Life to Recent Climate Change: the Limits of Adaptation and Implications for the Future of Biodiversity

COP15, Copenhagen, 2009

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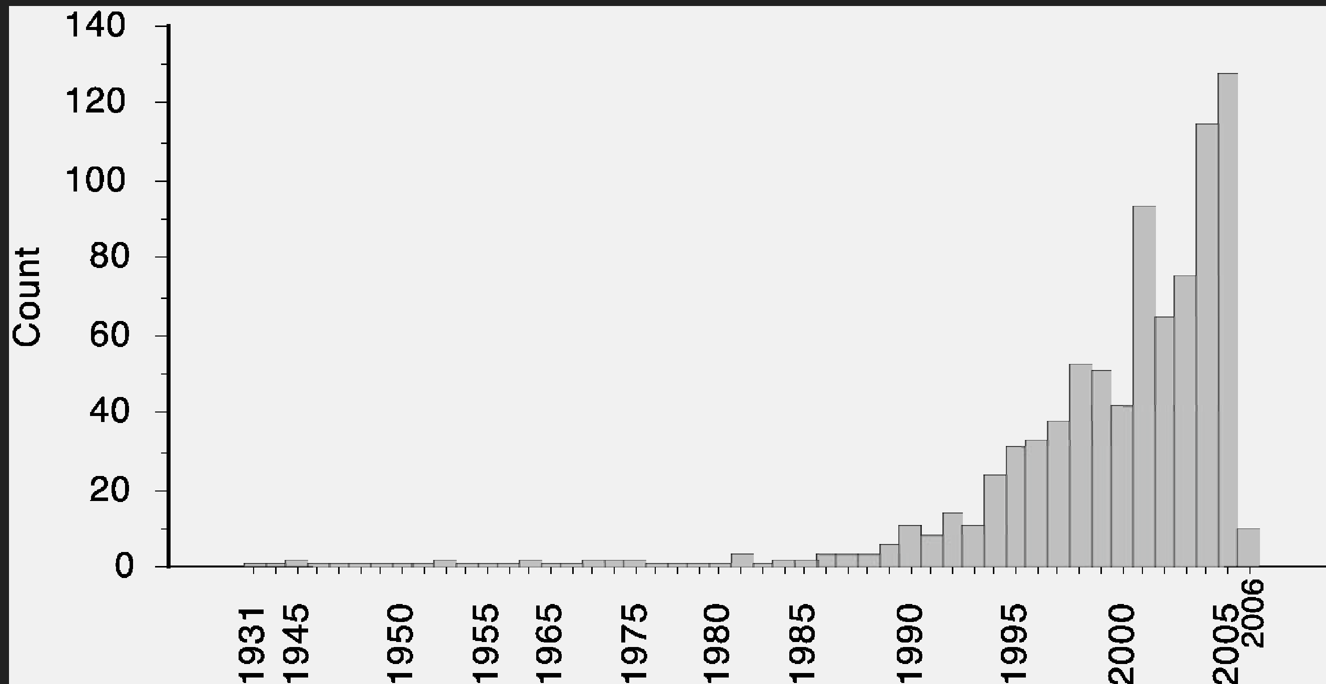
2006 review of global biological impacts

#publications = 866

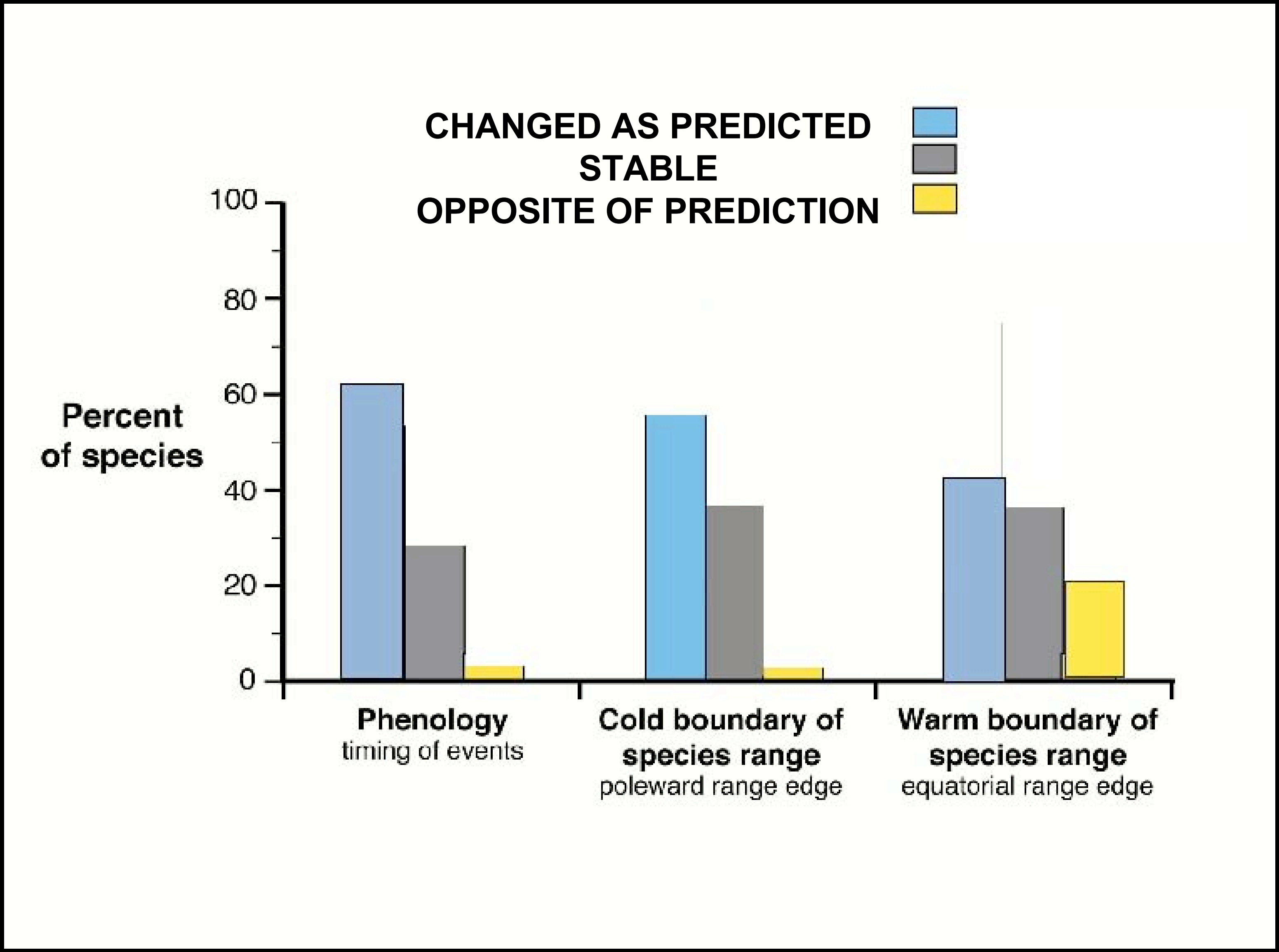
#species = several thousand



Number of publications documenting a response of a species, community or system to recent climate change

Parmesan 2006, *Annual Reviews Ecology Evolution and Systematics*

Observed Changes in Wild Plants and Animals



Parmesan & Yohe, *Nature* 2003

Summary of Observed Responses
0.7° C rise globally since 1900

- ~ **52 %** of species studied have shifted their ranges poleward and/or upward

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

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

- Impacts on every continent, in every major ocean
- Northward range shifts from 50 - 1600 km, upward shifts of up to 400 m

Parmesan & Yohe 2003 *Nature*; Parmesan, C. 2006 *Annual Reviews of Ecology and Systematics* 37:637-669; IPCC 2007

Ecological Responses Dominate - Evolution has not Appeared to Affect Species' Fundamental Climate Niches

Evidence for Micro-evolution - several !

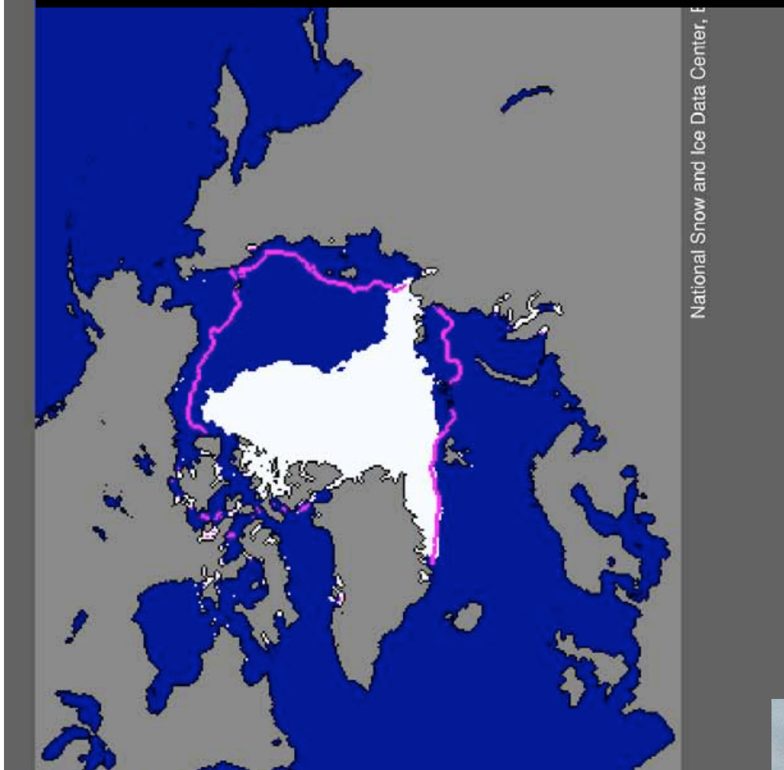
No evidence for Macro-evolution:

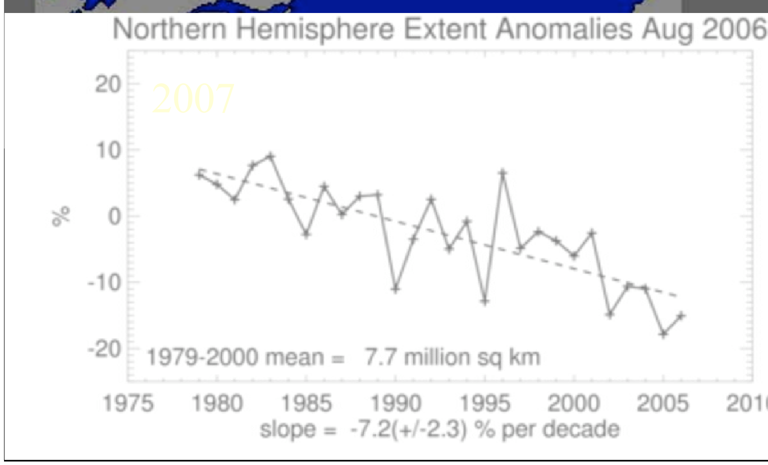
- No evidence for new "super-hot-adapted" mutations
- No response to artificial selection to tolerate more extreme climatic conditions than found in wild

(fruit flies, butterflies)

(Hoffmann et al 2003, Crozier 2003 a,b; Jordano et al 2000)

Arctic Sea Ice down by 40% in 2007,similar in 2008;   ~2-4° C rise in Arctic

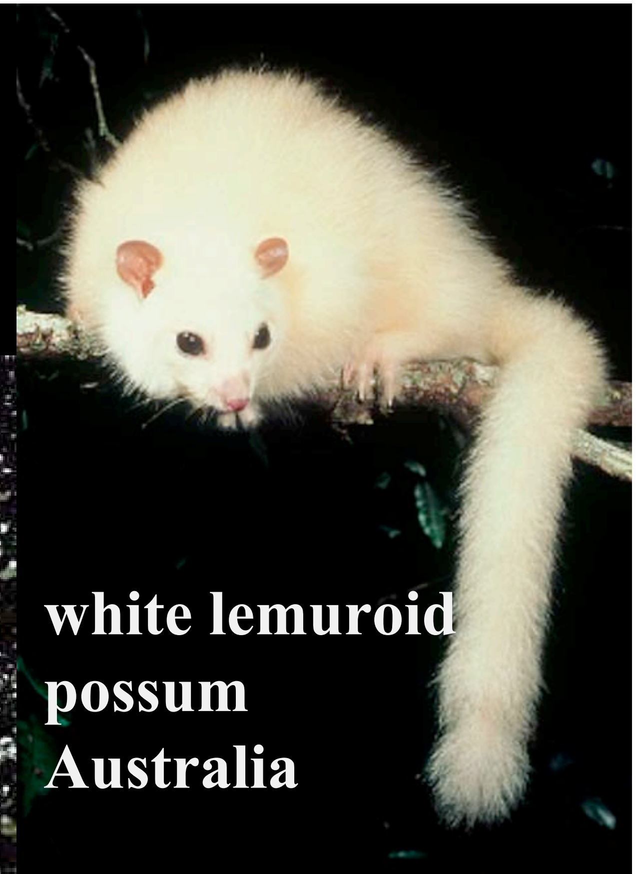




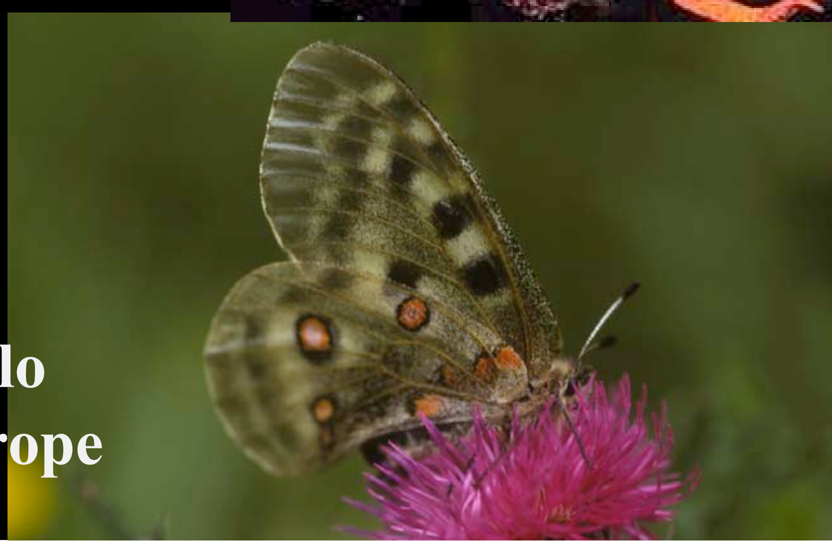
Mountaintop Species

- Many species have contracted upward
- First extinctions

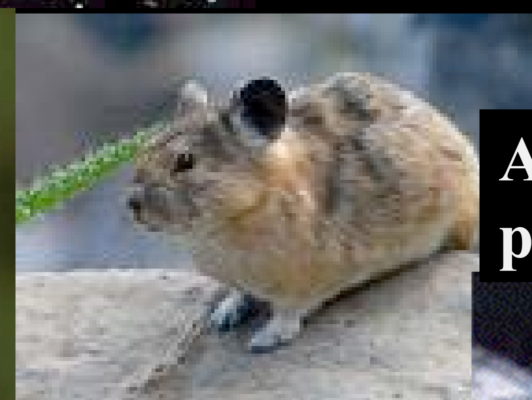
golden toad
Costa Rica



white lemuroid possum
Australia



Apollo
Europe



American pika, USA

Habitat Loss Coupled with Climate Change

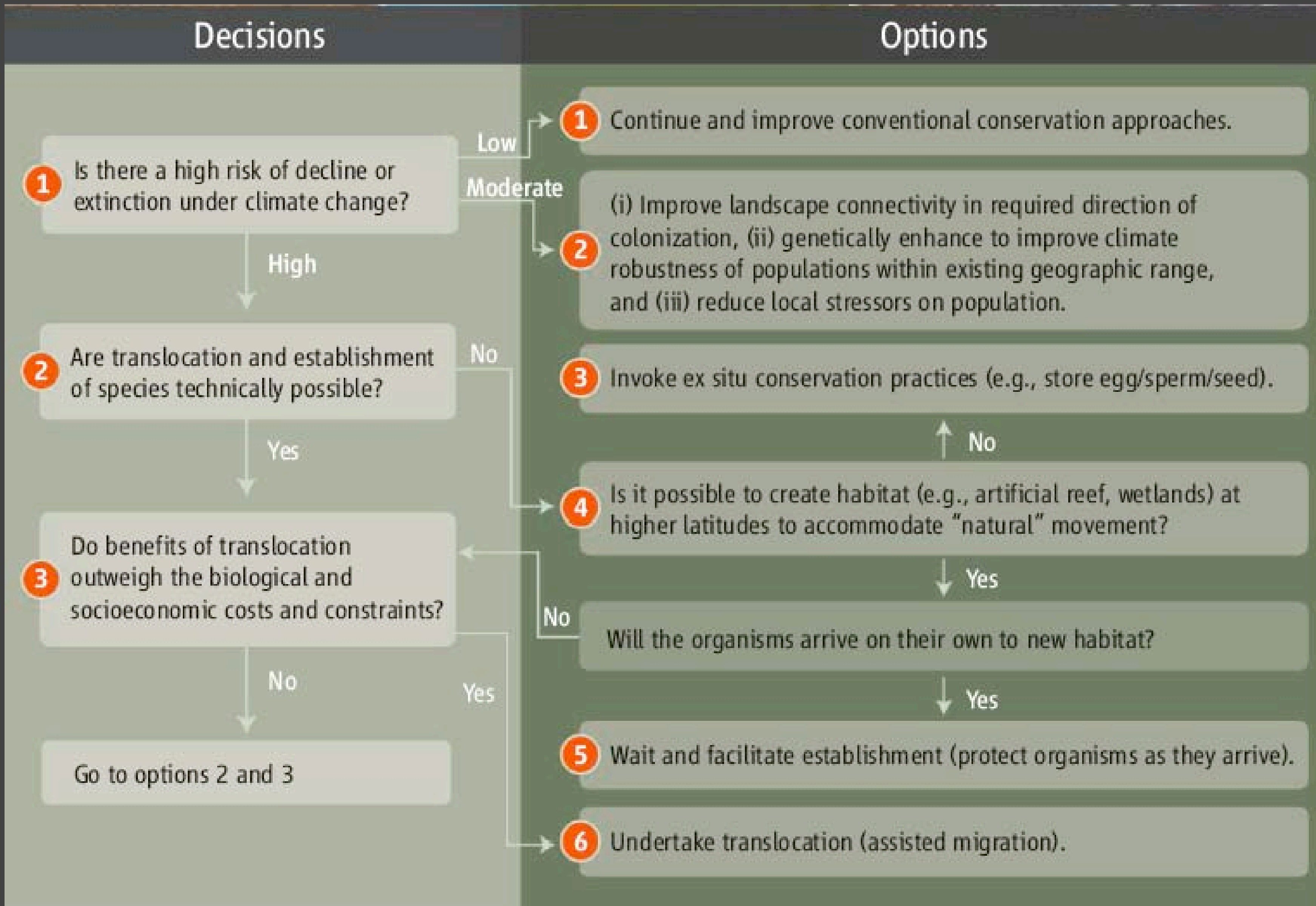
Endangered
Quino checkerspot
(E. editha quino)

extinctions due to
habitat loss

extinctions due to
climate change

Apparently suitable
habitat, being degraded
by climate change

Assisted Colonization? A Decision Framework



Hoegh-guldberg *et al. Science* 2008

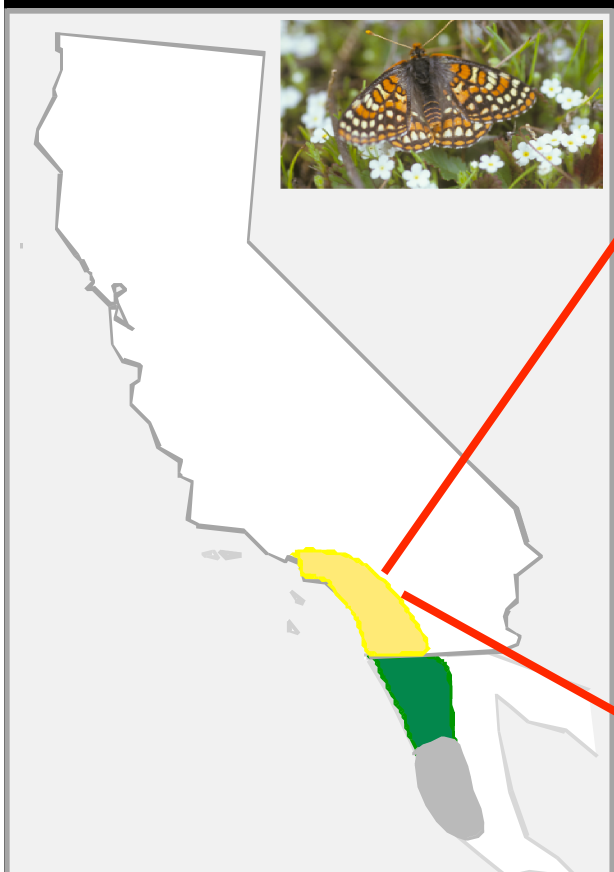
Conservation Laws and Tools do not provide for Climate Change Adaptation

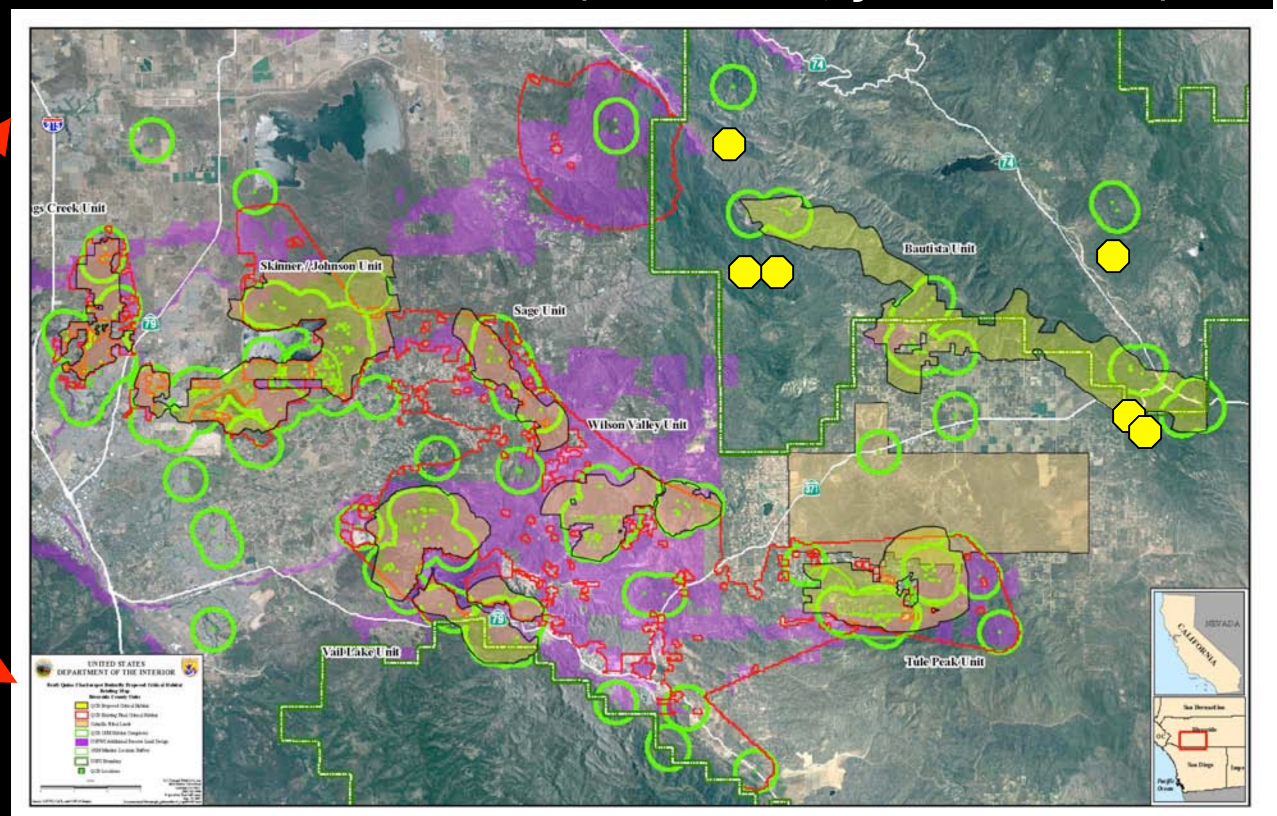
- Focus is on historic species range
  - Past declines may underestimate future risk
  - Back to historic conditions may not be best goal
- Focus is on historically occupied areas
  - Areas never occupied may become crucial to survival of some species

Climate Change Drove a Shift in Lands Deserving Highest Conservation Priority

E.e. quino - The only existing populations with historic densities are newly discovered sites further east and at higher elevations than historically-recorded distribution

(> 4500 ft, yellow circles)





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

Restoration of Vernal Pool habitats in southern California

USFWS, Recon Environmental Inc.

Photos courtesy Mark Dodero, Project Manager & Sr Biologist

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

YEAR 3

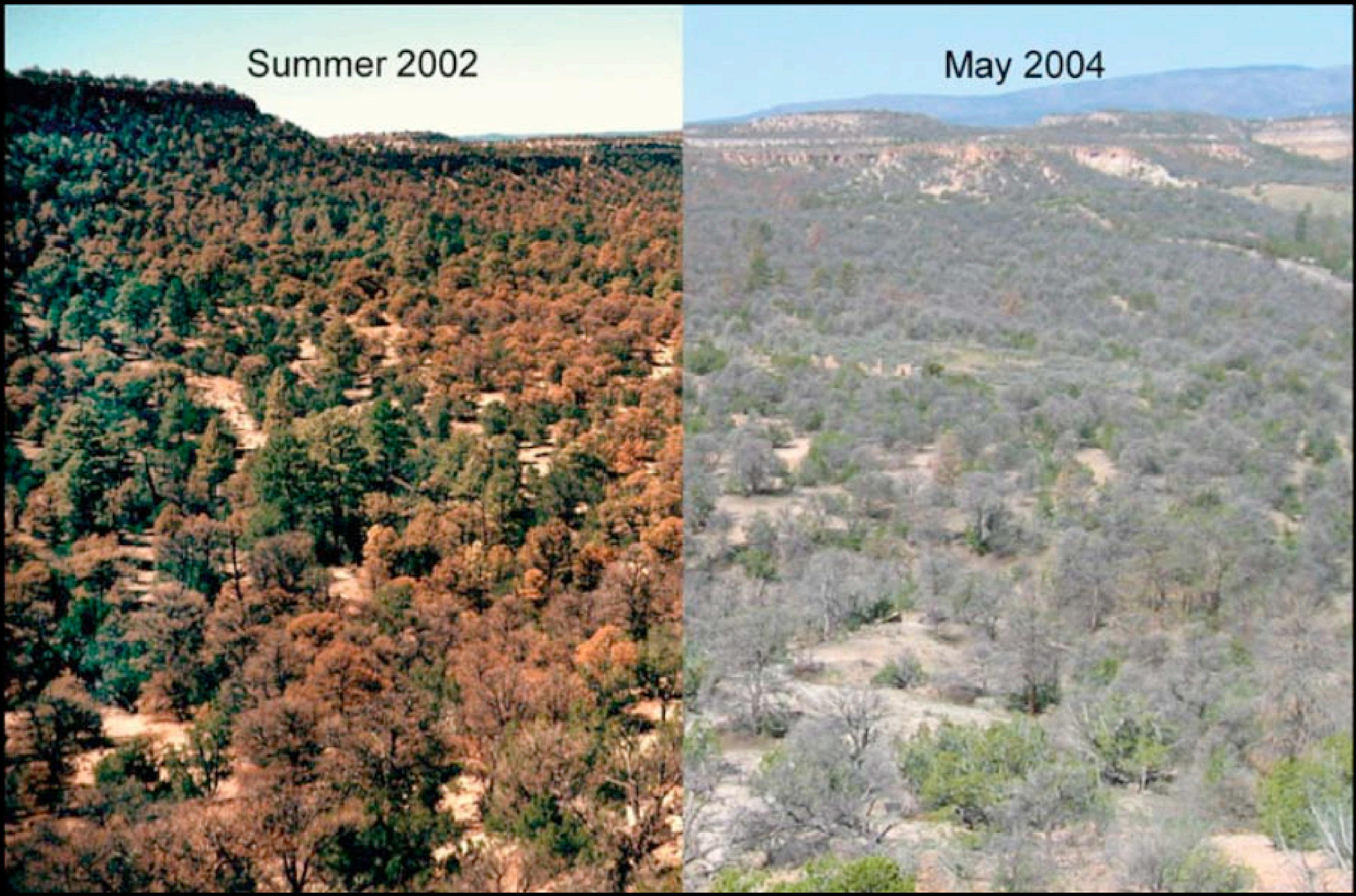
- Self-sustaining
- Some weeding needed to keep out exotics
- Habitat for 5 endangered vernal pool species
- Cost: $ 1m/acre

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

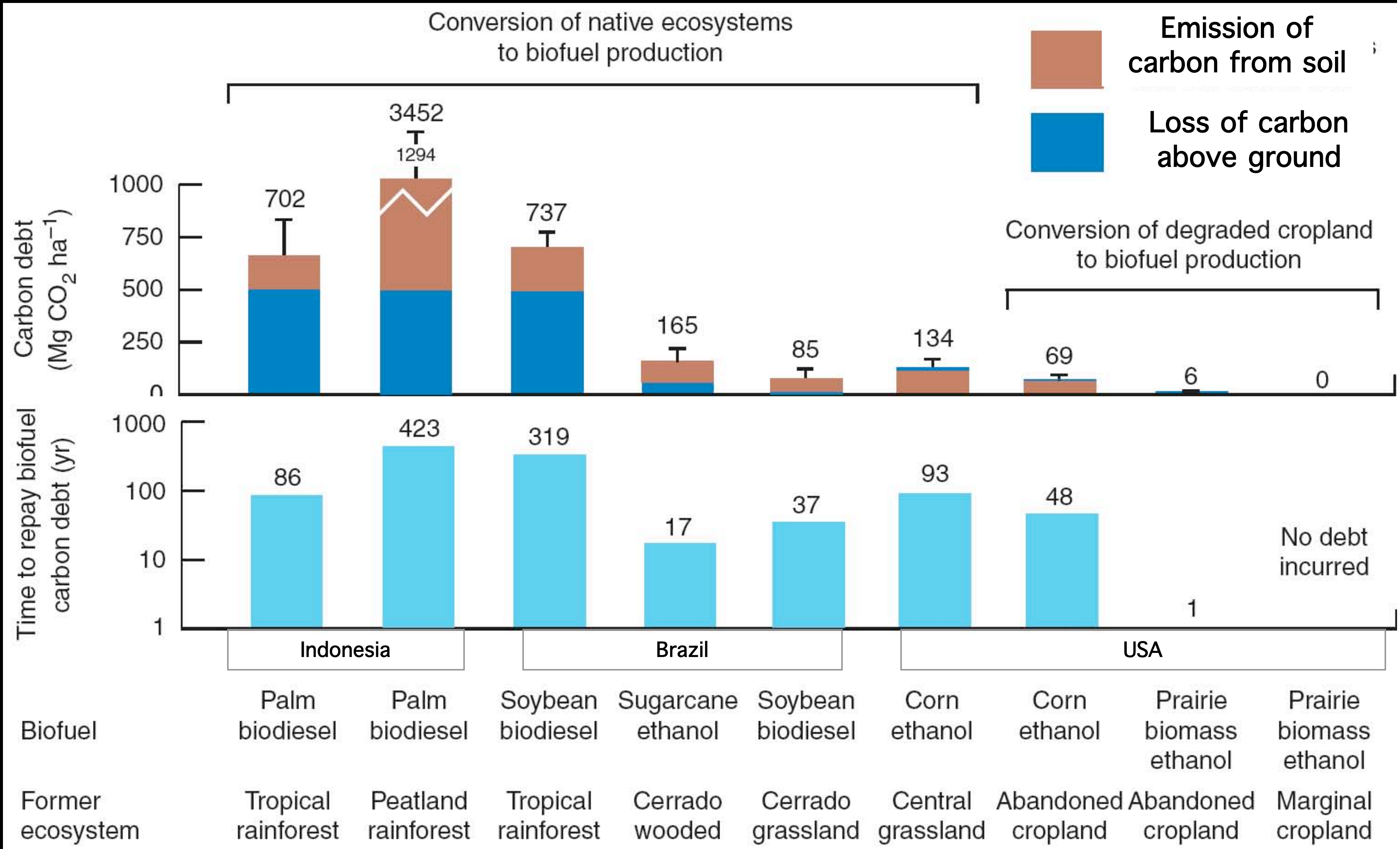
Restoration?

12,000 sq km area

40% - 90% of trees died



Full Carbon Budget for Conversion of Lands to Biofuel Production

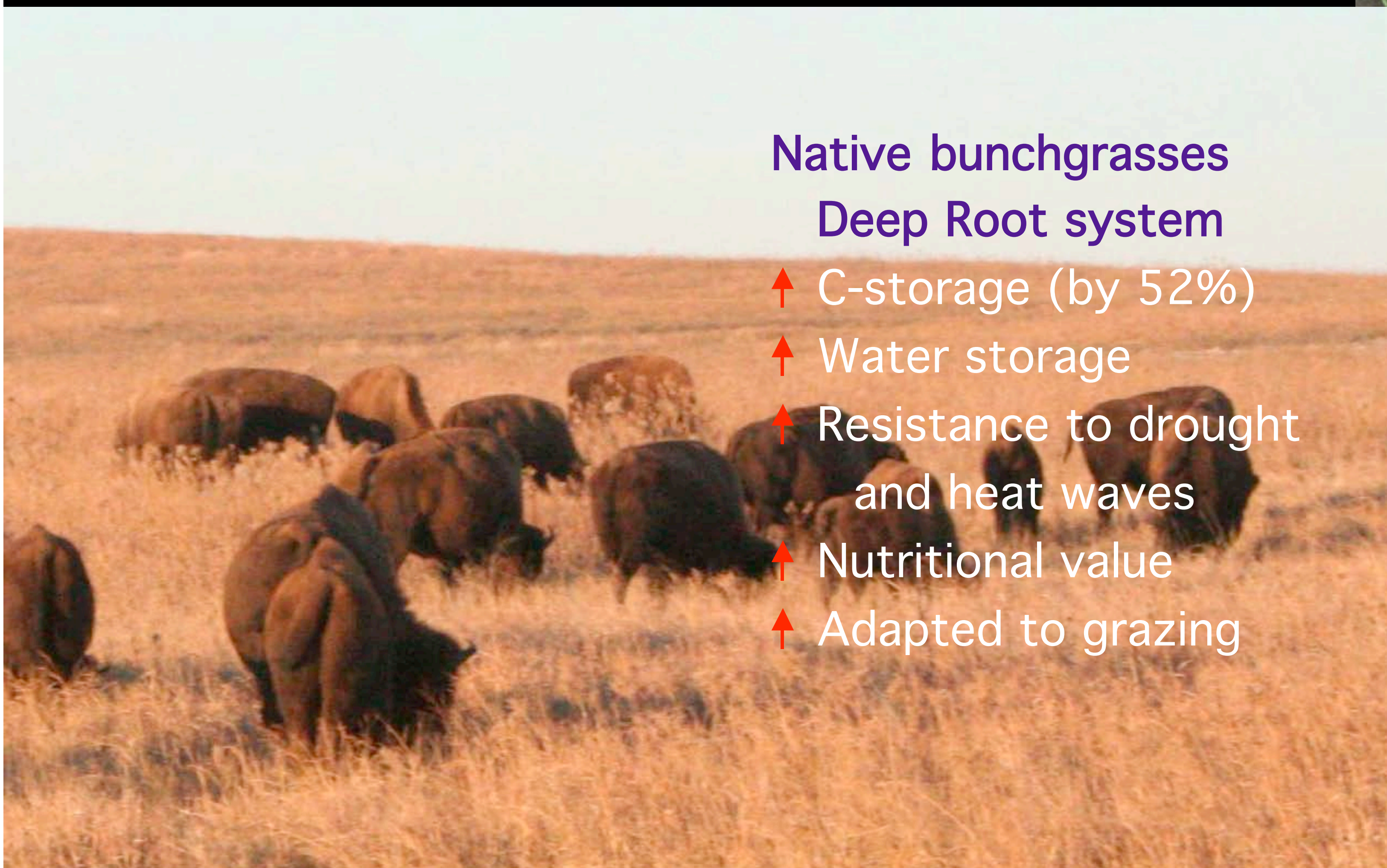


Fargione *et al.* 2008 *Science*

Native Grasslands Sustain High Biodiversity

Restoration of Native American Prairie

A Win/Win Scenario



Native bunchgrasses

Deep Root system

- ↑ C-storage (by 52%)
- ↑ Water storage
- ↑ Resistance to drought and heat waves
- ↑ Nutritional value
- ↑ Adapted to grazing

Franzluebbers 2005, Poteet unpubl,

[redacted]

Long-term increases in frequencies of warm-adapted genotypes

- *Drosophila melanogaster* (4 deg. latitude shift in alcohol dehydrogenase genes)
- *D. subobscura* (Europe, N & S America)
- *D. robusta* (USA)
- Pitcher plant mosquito *(Wyeomyia smithii)* (shift in photoperiod cue for diapause, USA)

(Rodriguez-trelles & Rodriguez 1998; Balanya *et al.* 2003, Gilcrest; Levitan et al. 2003, Bradshaw & Holzapfel 2001; Hoffmann *et al*. 2003)

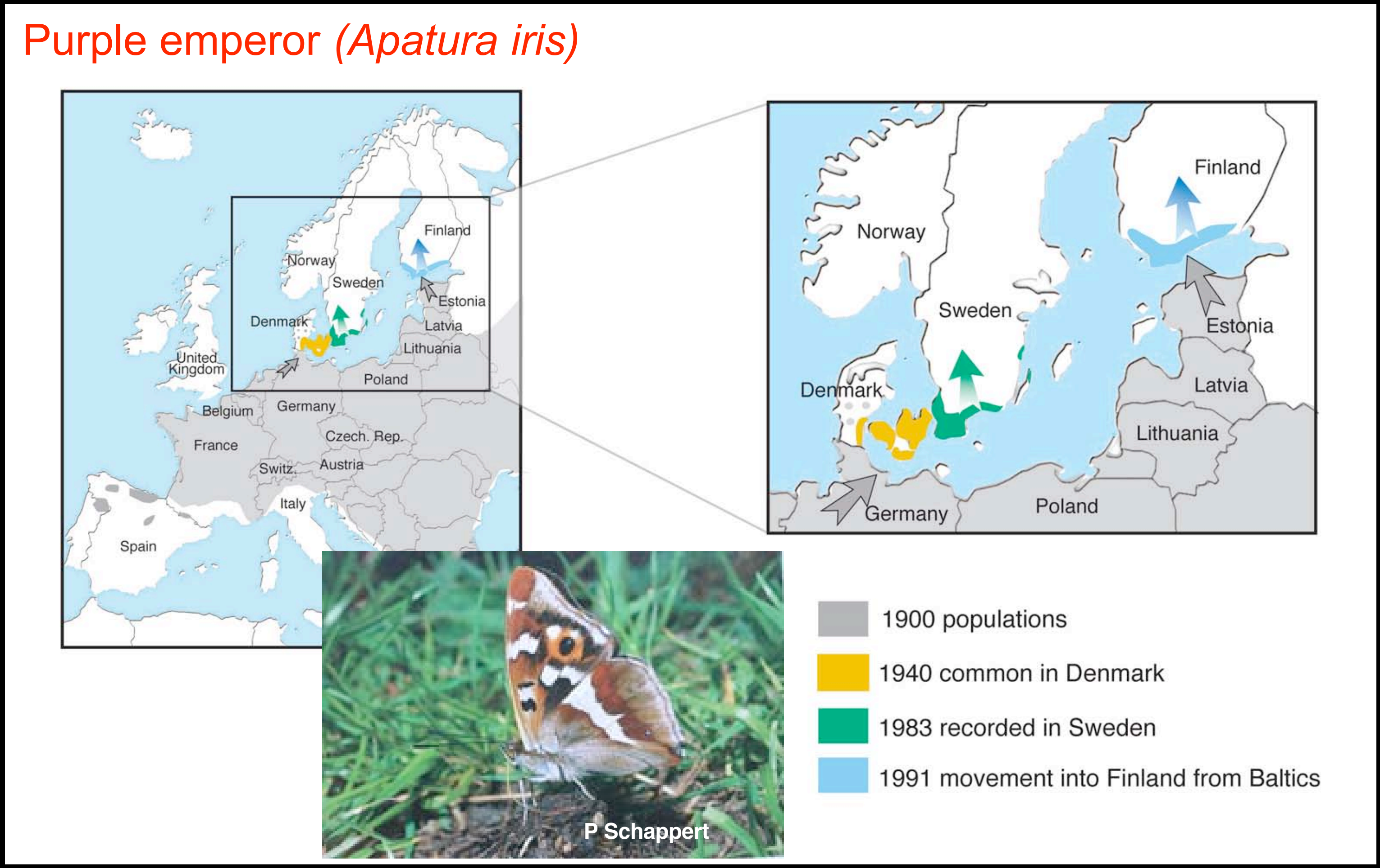
Selection for high dispersal genotypes at expanding range boundaries:

- Increase in frequencies of long-winged morphs along northern colonizing wave in 2 sp. of bush cricket

(Thomas et al 2001)

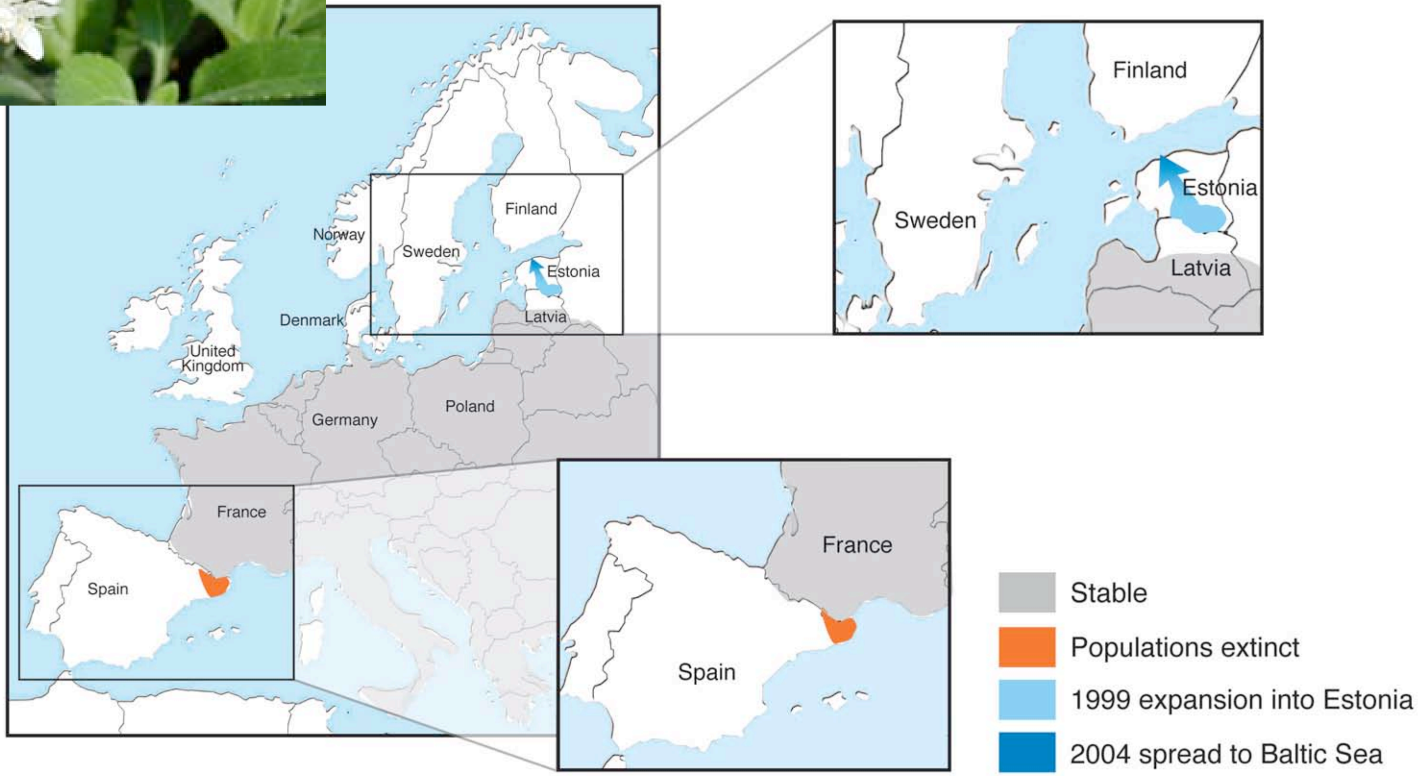
65 % of 52 butterfly species had colonized northward at northern range boundary

(30-200 km, 30-100 years, 0.6° C warming)



Parmesan *et al. Nature*, 1999; Henriksen & Kreutzer 1982; Ryrholm unpub.; Kaila & Kullberg pers. comm.

22 % of 40 species contracted at southern range boundaries
* 1 species range reduction



Sooty copper *(Heodes tityrus)*

Parmesan *et al. Nature*, 1999

Toomas Tammaru, pers. Comm.