Climate Change and Biodiversity: Getting Beyond Predictions

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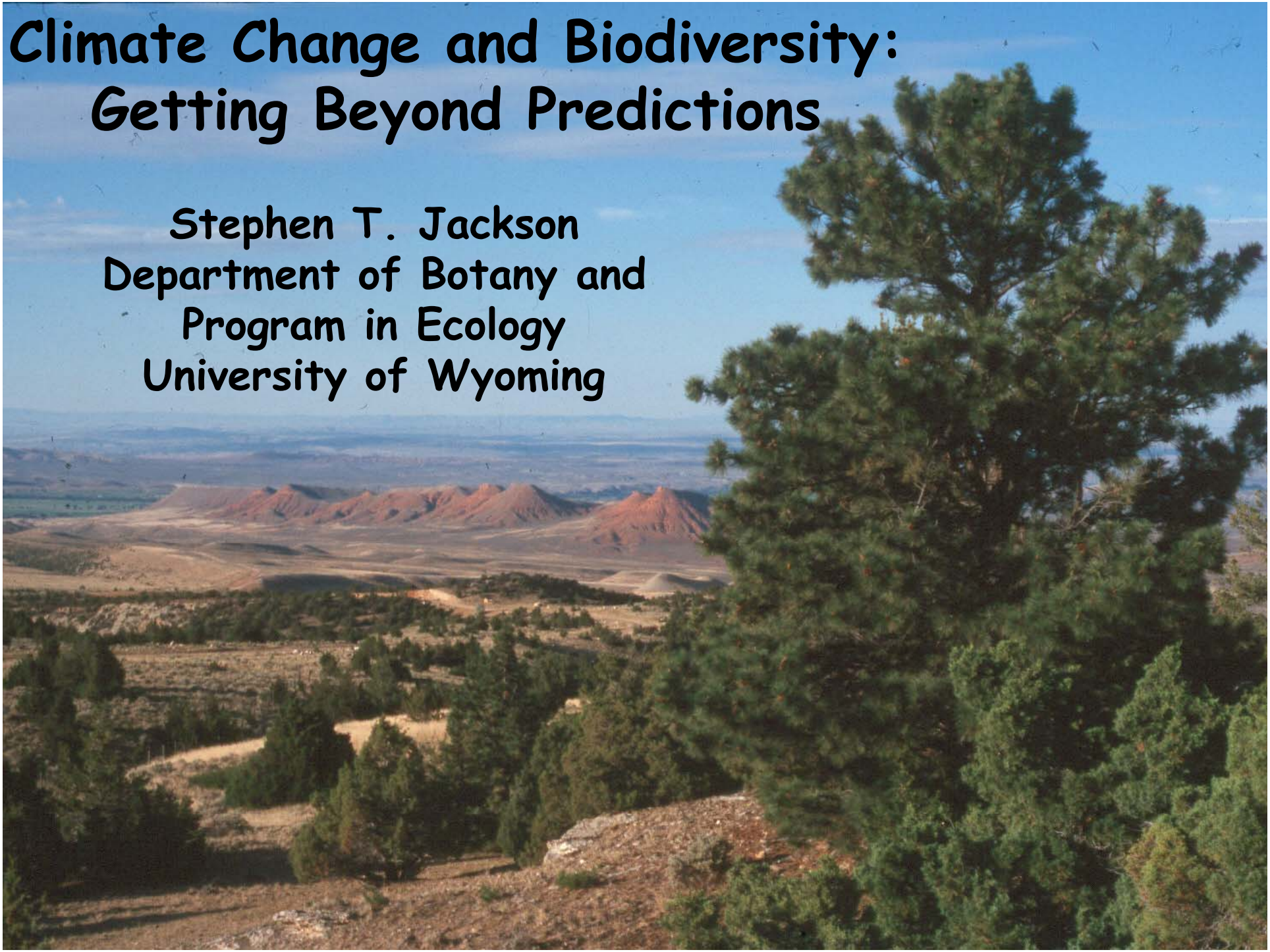
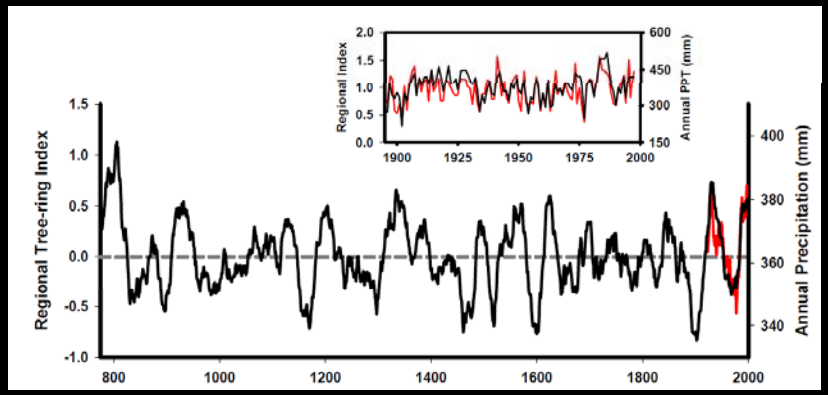
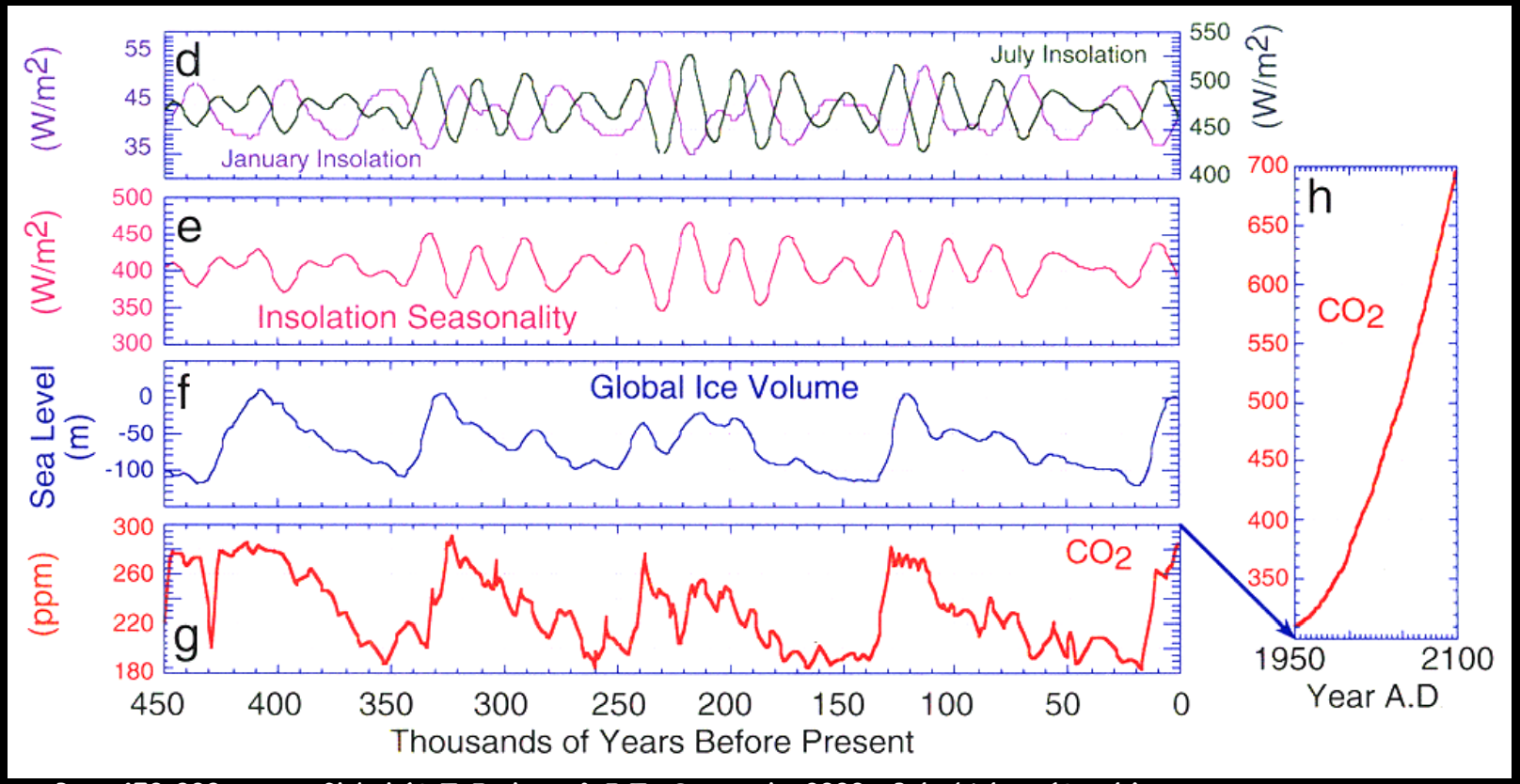


Planet of Change



Past 1200 years: Upper Colorado River Basin (Jackson *et al.* 2009. *PNAS* (after Meko *et al.* 2007))

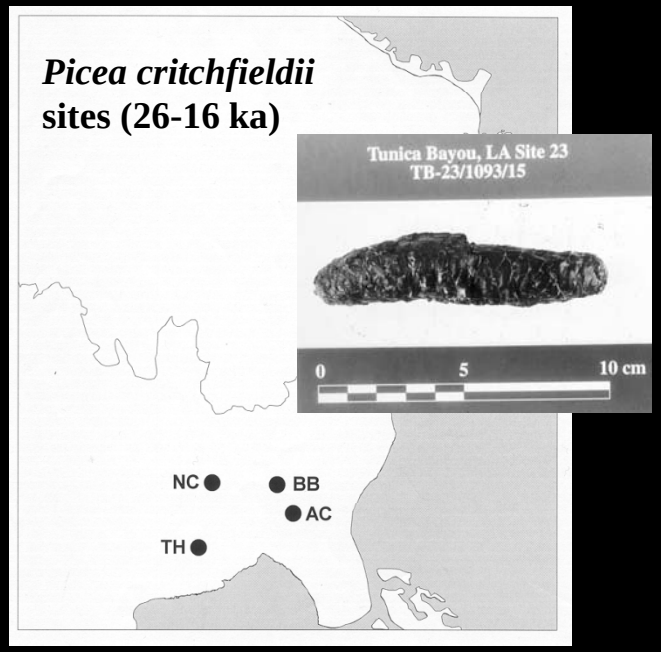


Past 450,000 years: Global (S.T Jackson & J.T. Overpeck. 2000. *Paleobiology (Suppl.)*

Planet of Doom

A.D. Barnosky. 1986. *Quat. Res.*

F.T. Ledig & M.T. Conkle. 1983. *Evolution*

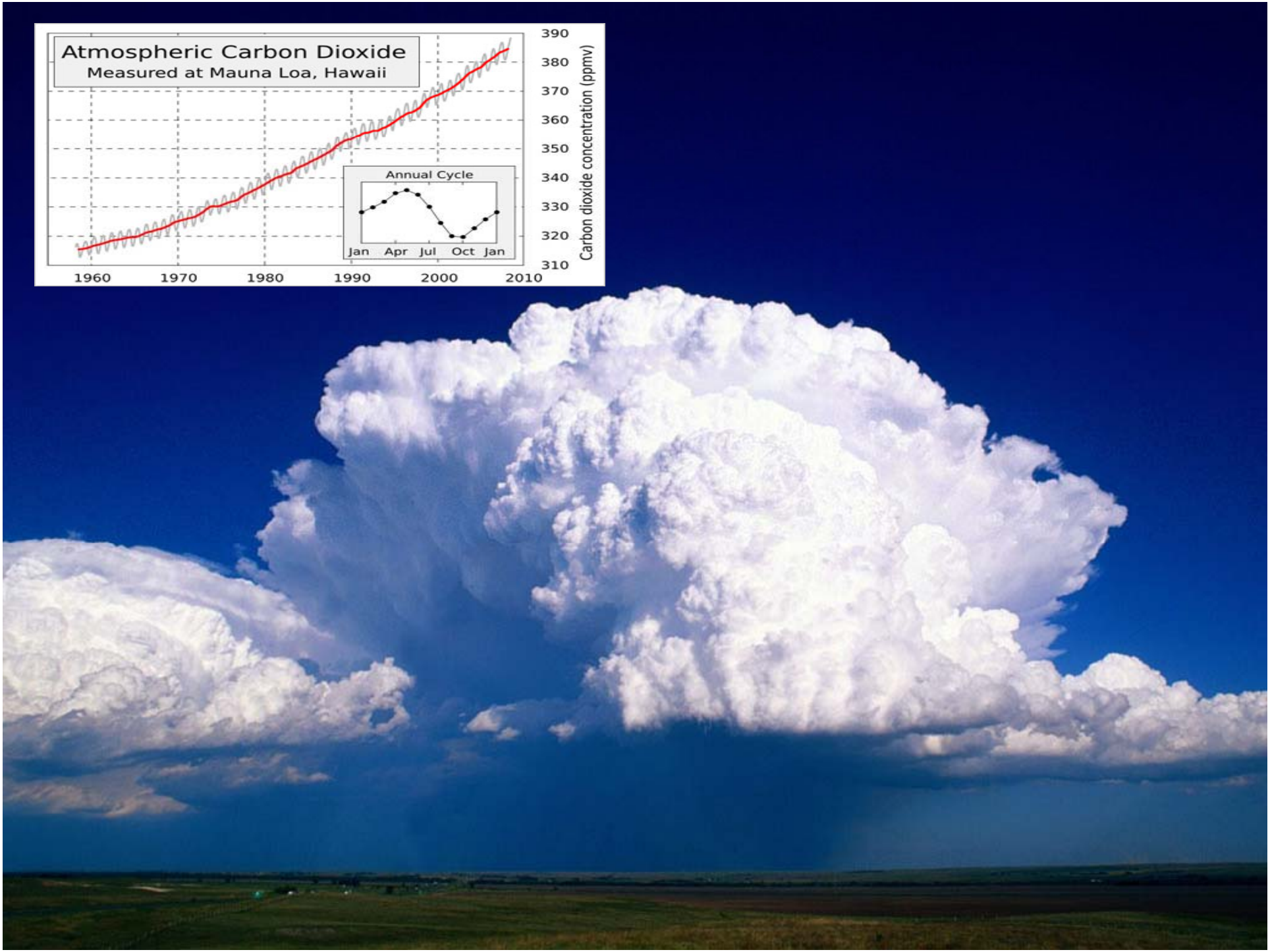


S.T. Jackson & C. Weng, 1999. *PNAS*

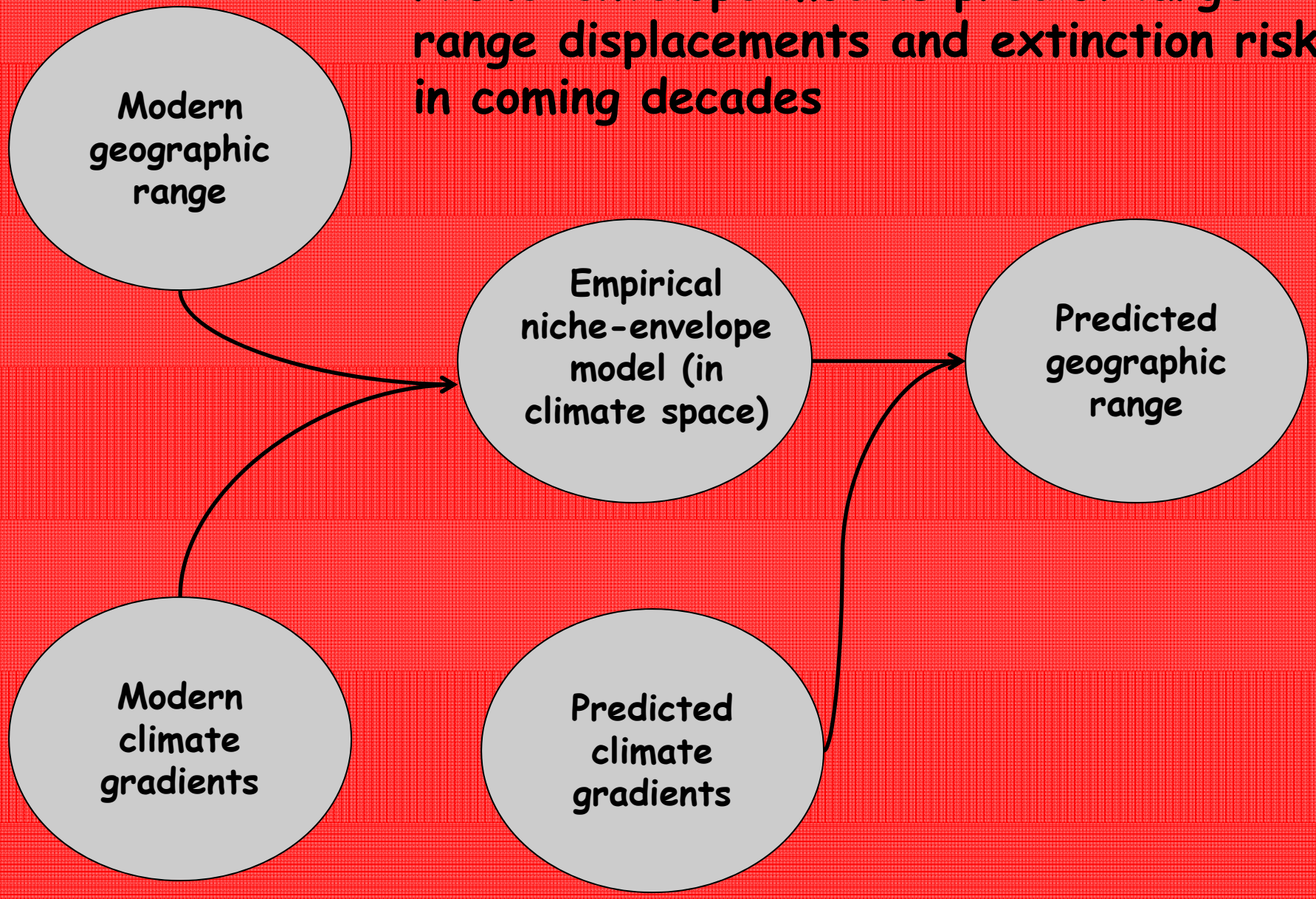
J. Boys *et al.* 2005. *Amer. J. Bot.*

K.J. Hundtermark *et al.* 2002. *Mol. Phylogen. Evol.*

Planet of Survivors


Atmospheric Carbon Dioxide
Measured at Mauna Loa, Hawaii
Annual Cycle
Jan
Apr
Jul
Oct
Jan
1960
1970
1980
1990
2000
2010
390
380
370
360
350
340
330
320
310
Carbon dioxide concentration (ppmv)

Niche-envelope models predict large range displacements and extinction risk in coming decades



Climate change → Range shift

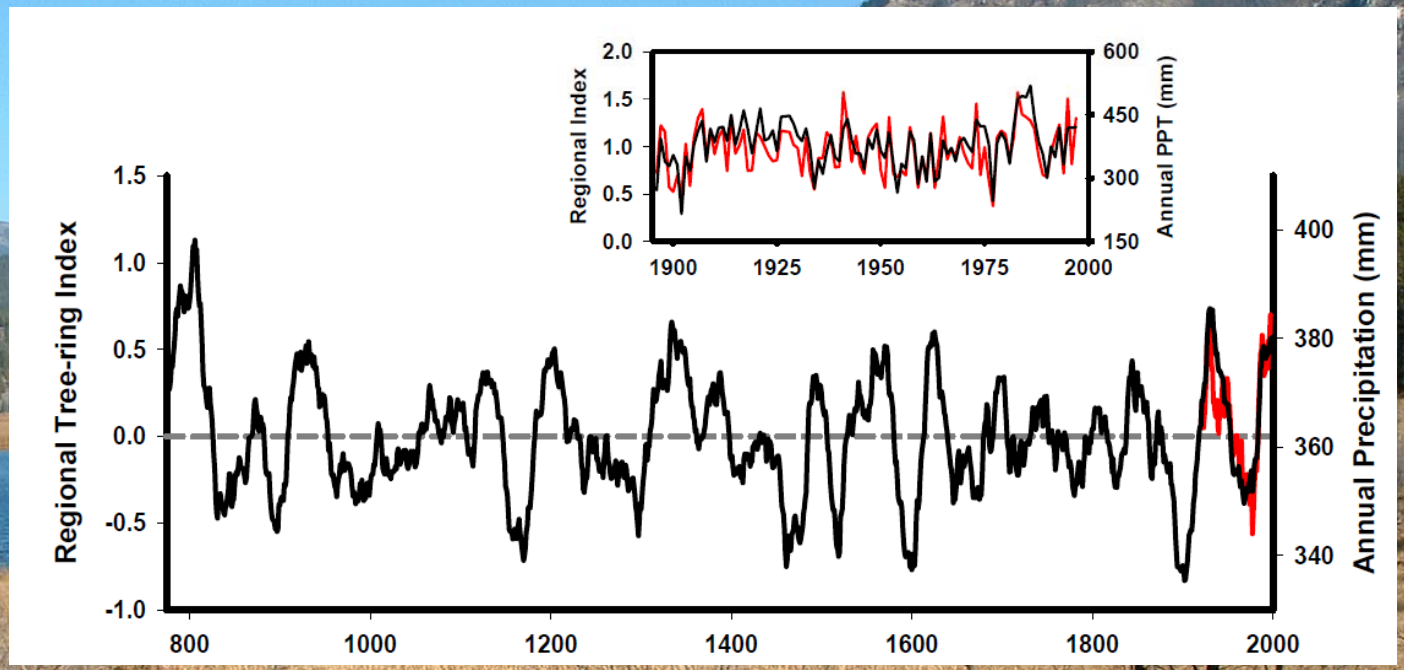
Climate change → A lot of ecological and biological processes → Range shift

Climate change

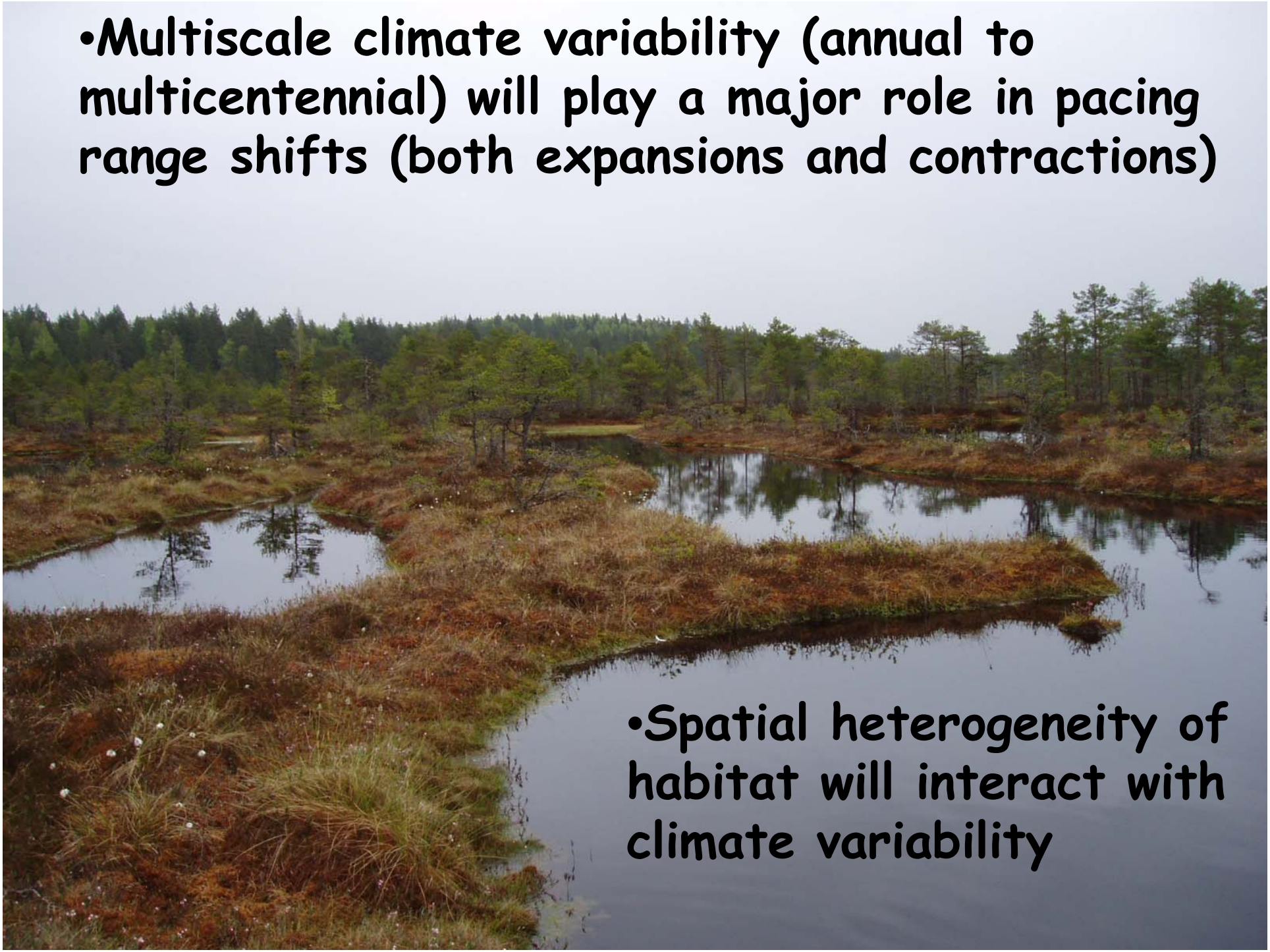
	Favorable	Unfavorable	Any kind
Individual	Establishment	Weakening	Phenotypic adjustment
Population	Colonization	Decline	Various consequences
Range	Expansion	Fragmentation	Change or stasis

Individual	Growth; reproduction	Mortality	Live long & prosper, or not…
Population	Increase	Extirpation	Evolution
Range	Infilling	Retreat	Change or stasis

Climate change of the coming decade will be episodic, not smooth

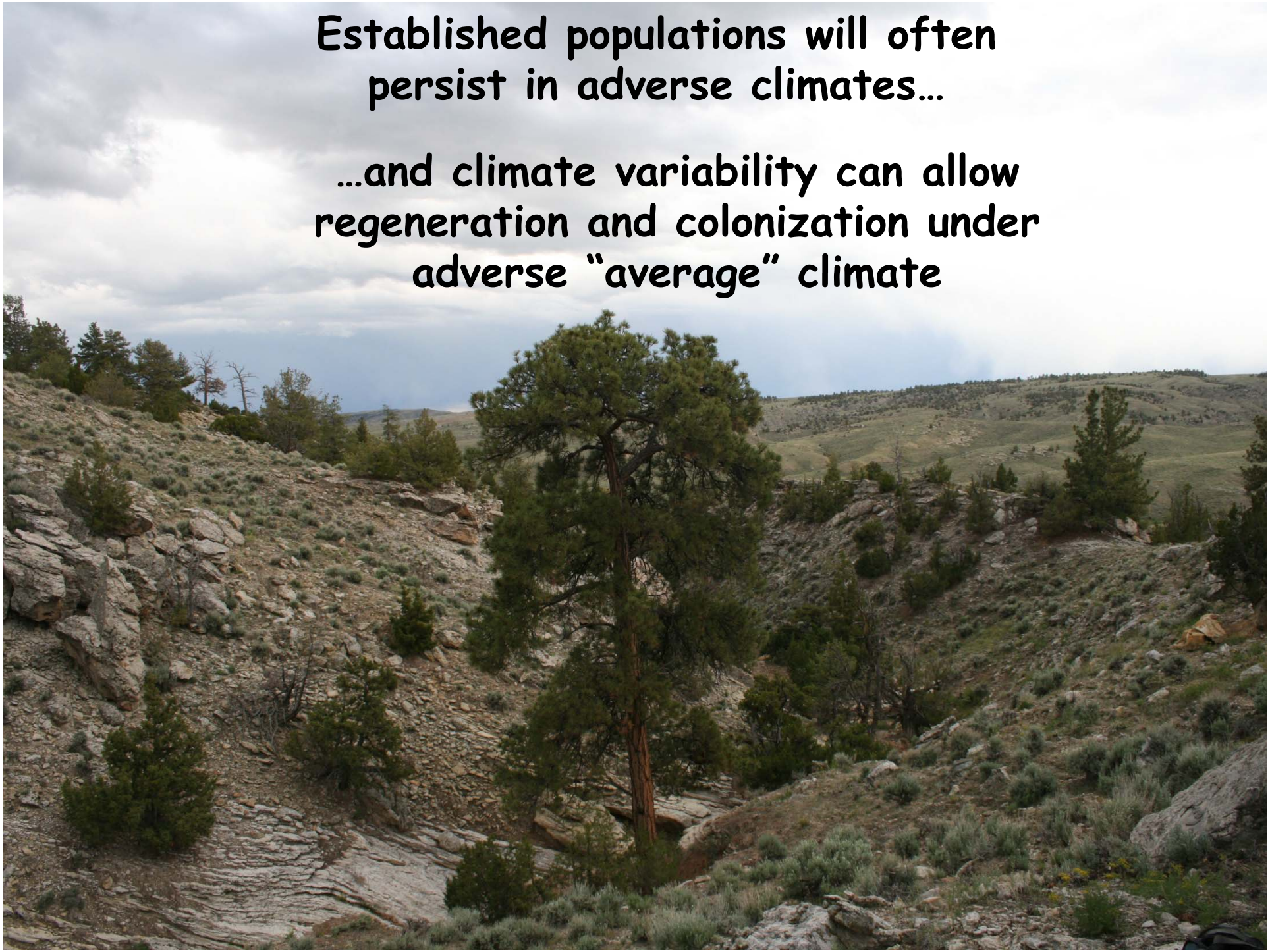


- Multiscale climate variability (annual to multicentennial) will play a major role in pacing range shifts (both expansions and contractions)



- Spatial heterogeneity of habitat will interact with climate variability

- Colonization and extirpation events will be contingency-laden

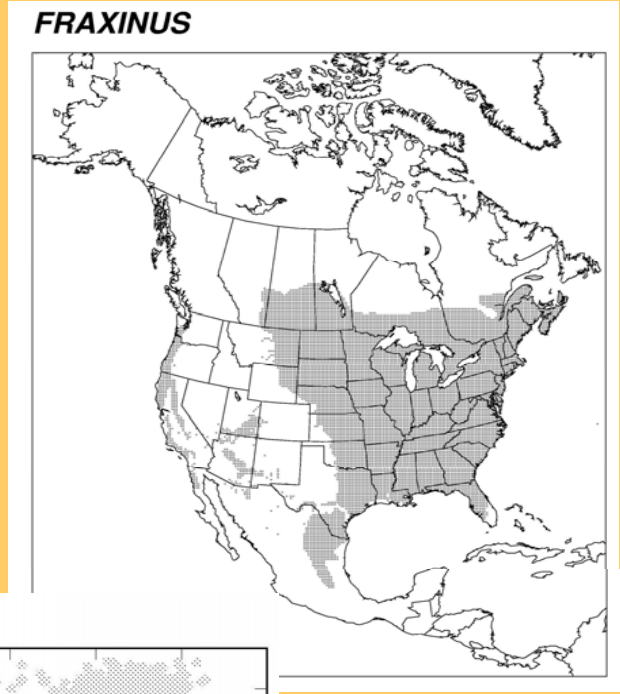

Established populations will often persist in adverse climates…
…and climate variability can allow regeneration and colonization under adverse "average" climate

Species interactions will play important roles in dynamics

- Competition
- Dispersers
- Herbivores
- Pests & pathogens

Beetle-killed *Pinus contorta* forest, Shell Canyon, Bighorn Mts., Wyoming. June 2007.

Challenges and surprises will arise from emergence of novel climates



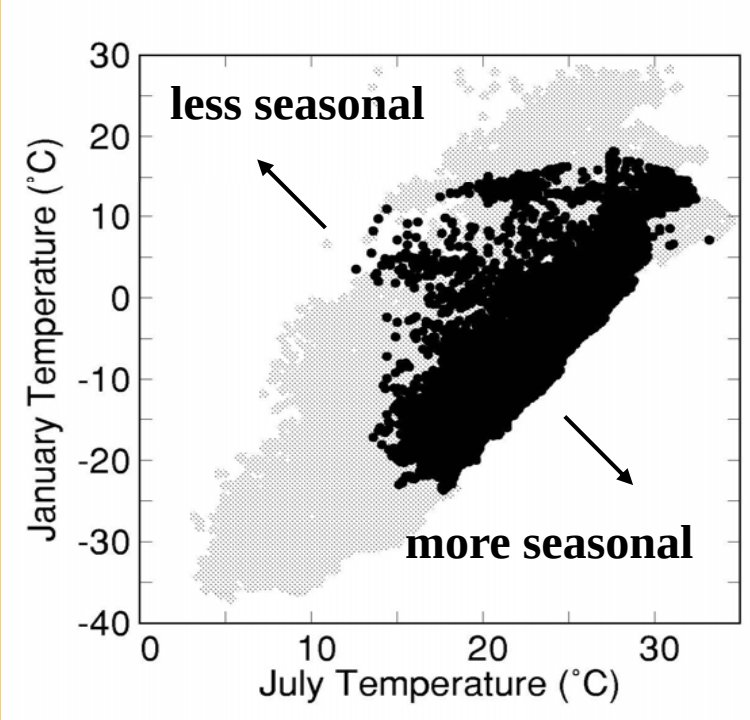
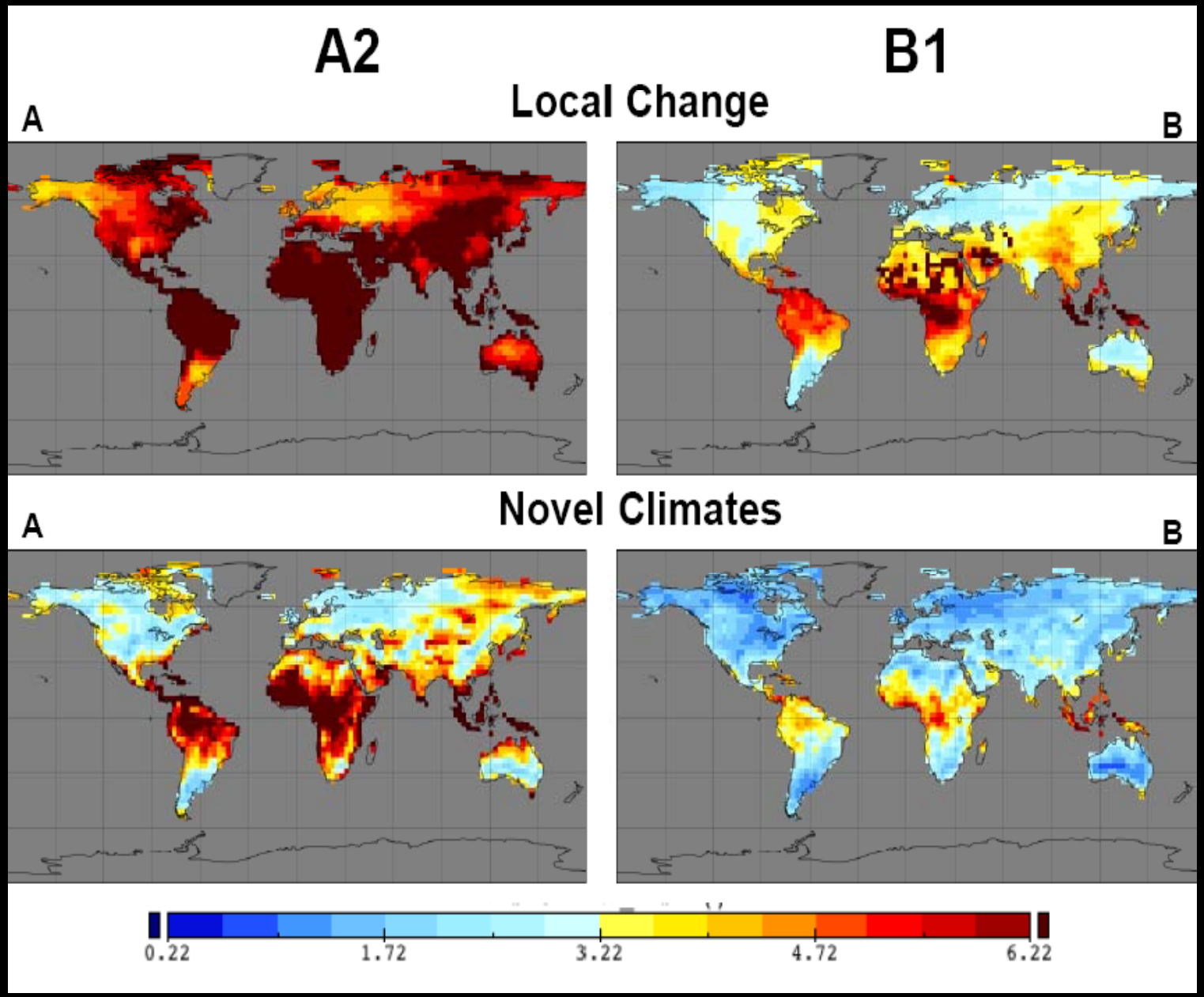


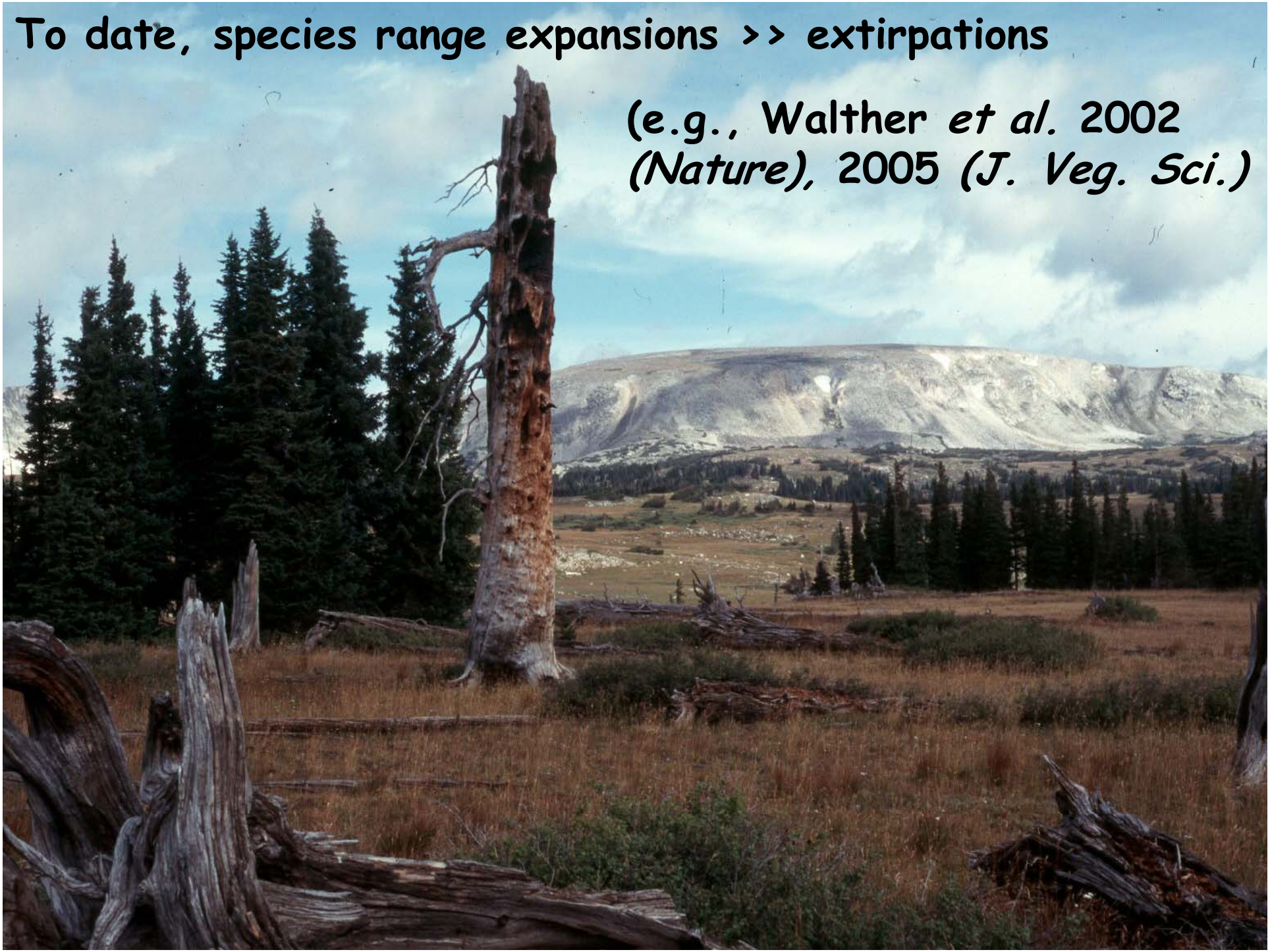
Illustration from C.S. Sargent. 1894. *The Silva of North America. Vol. VI.*

J.W. Williams & S.T. Jackson. 2007. *Frontiers in Ecology and the Environment.*



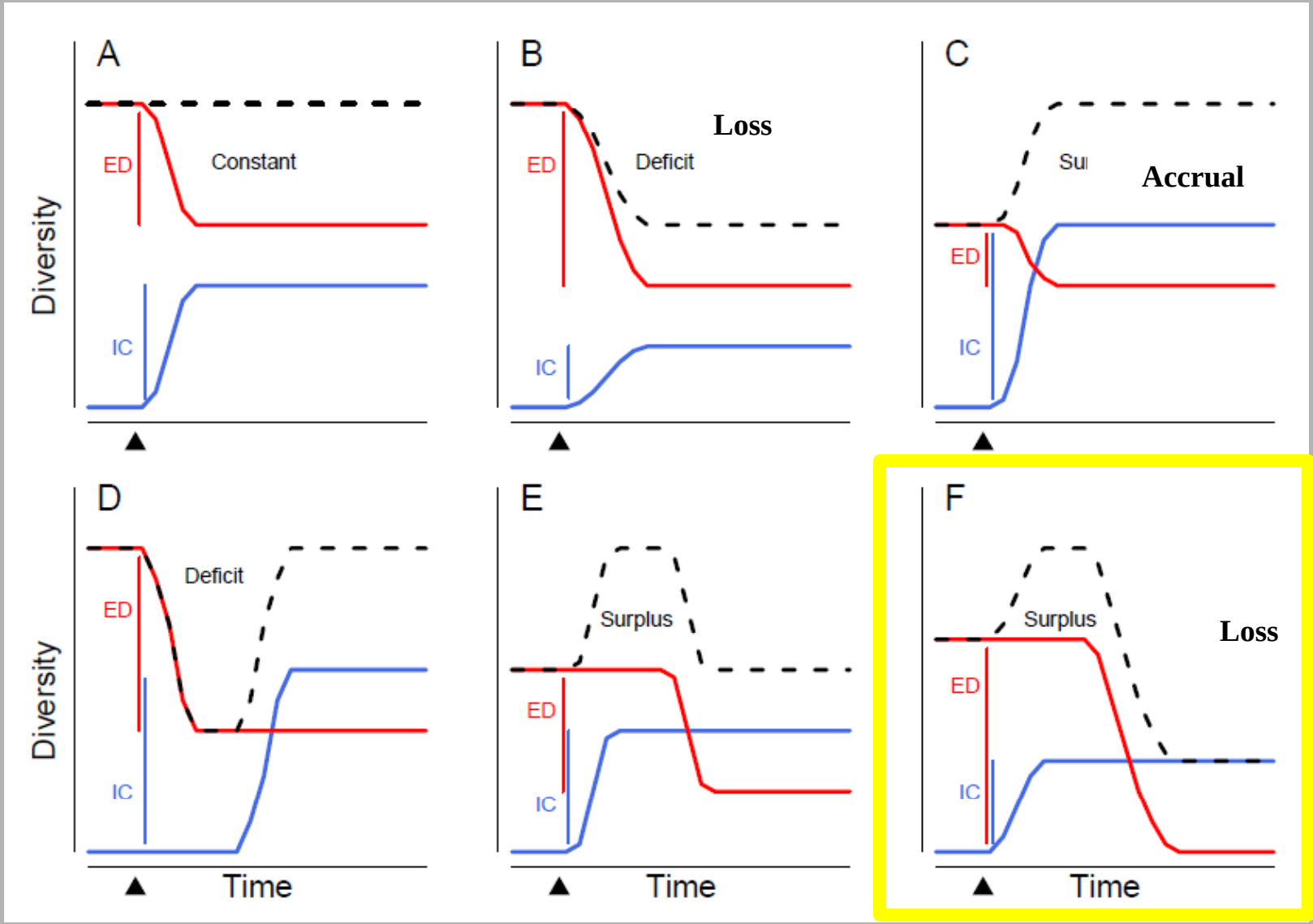
J.W. Williams, S.T. Jackson & J.E. Kutzbach. 2007. *PNAS.*

Many species appear to have capacity for:
•Phenotypic adjustment
•Habitat shift within regions
•Adaptation *in situ*


To date, species range expansions >> extirpations
(e.g., Walther *et al.* 2002 *(Nature)*, 2005 *(J. Veg. Sci.)*

Current dearth of extirpations may stem from response lags (i.e., transient diversity surpluses)

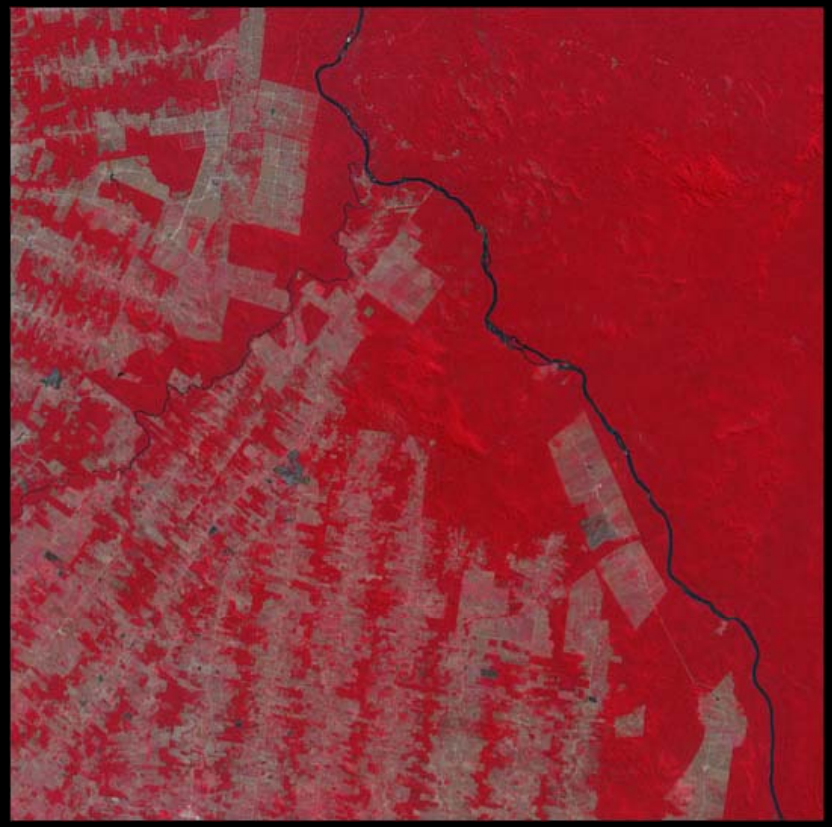
ED = Extinction debt IC = Immigration Credit

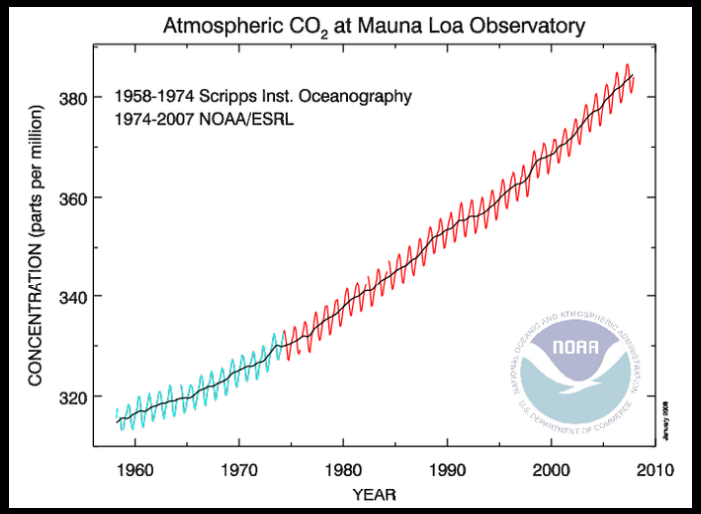


S.T. Jackson & D.F. Sax. 2010. *TREE*.

But it may also indicate natural resilience
(at least for the time being)

So far, biodiversity losses from habitat destruction and transformation far exceed those from climate change

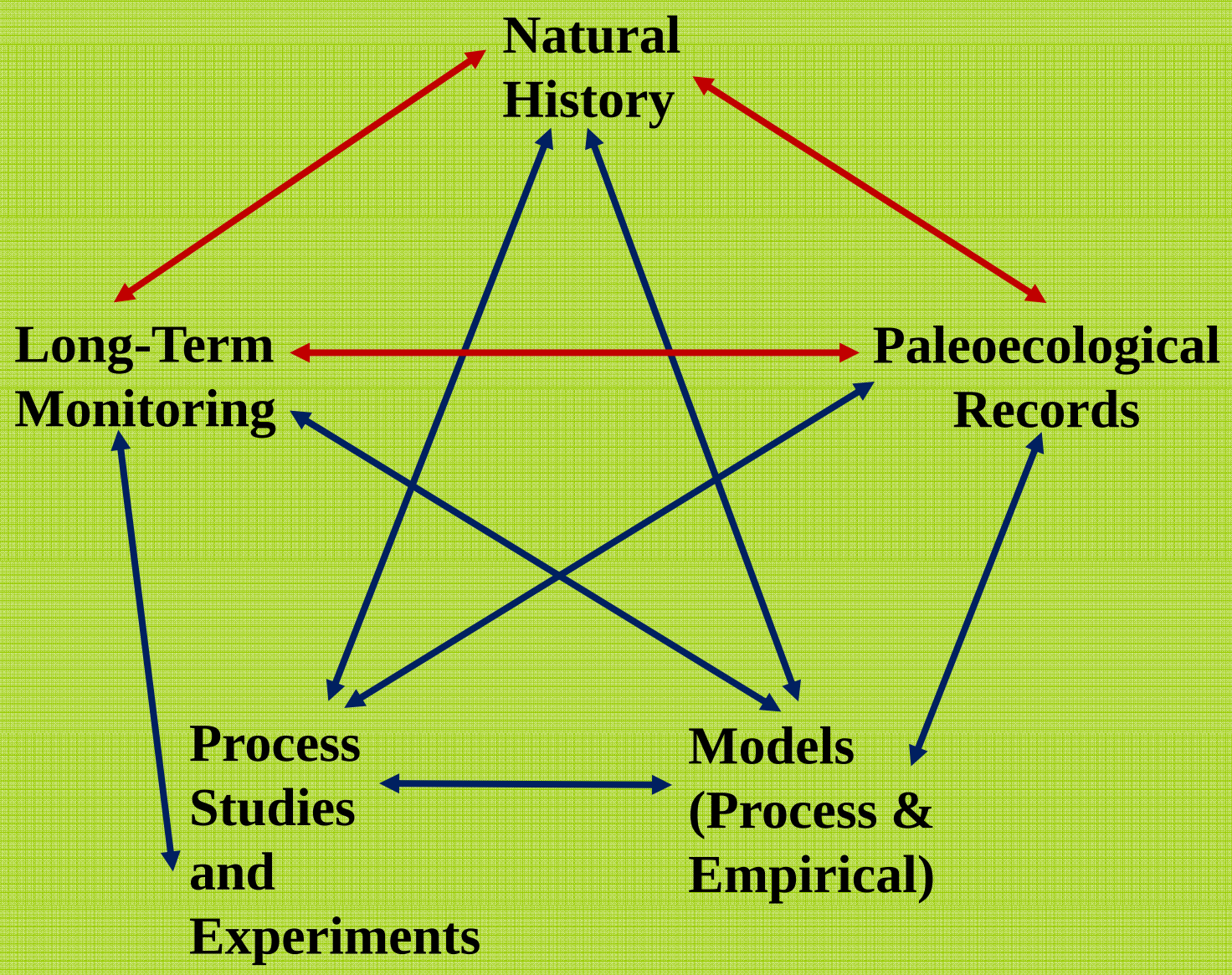




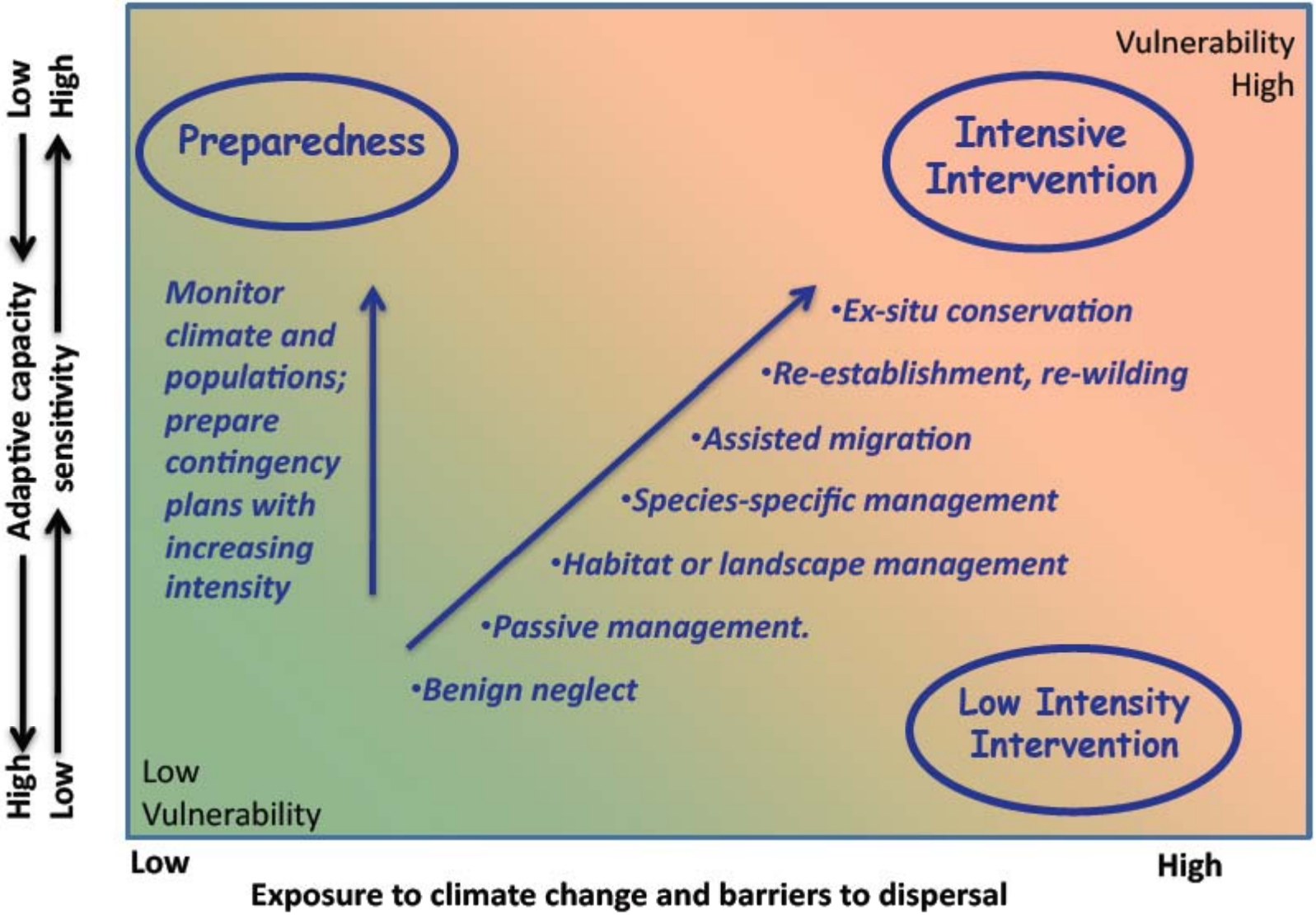
In view of finite resources for conservation, we need to:

- Increase the knowledge base
- Keep options open as long as possible
- Determine what needs doing now and what can wait
- Prepare for inevitable surprises…

Need better knowledge and multiple tools

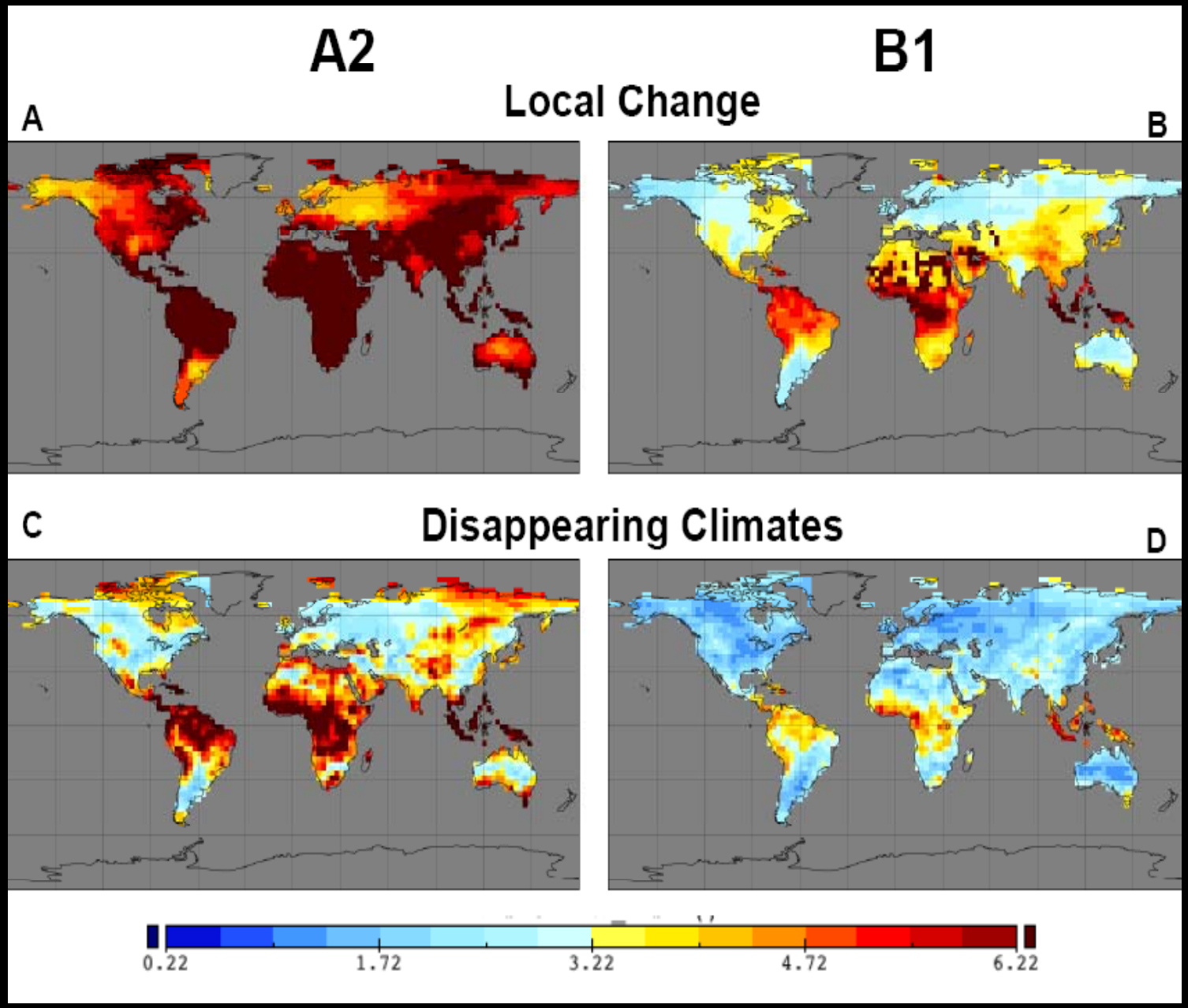


Integrated Climate-Change Ecology



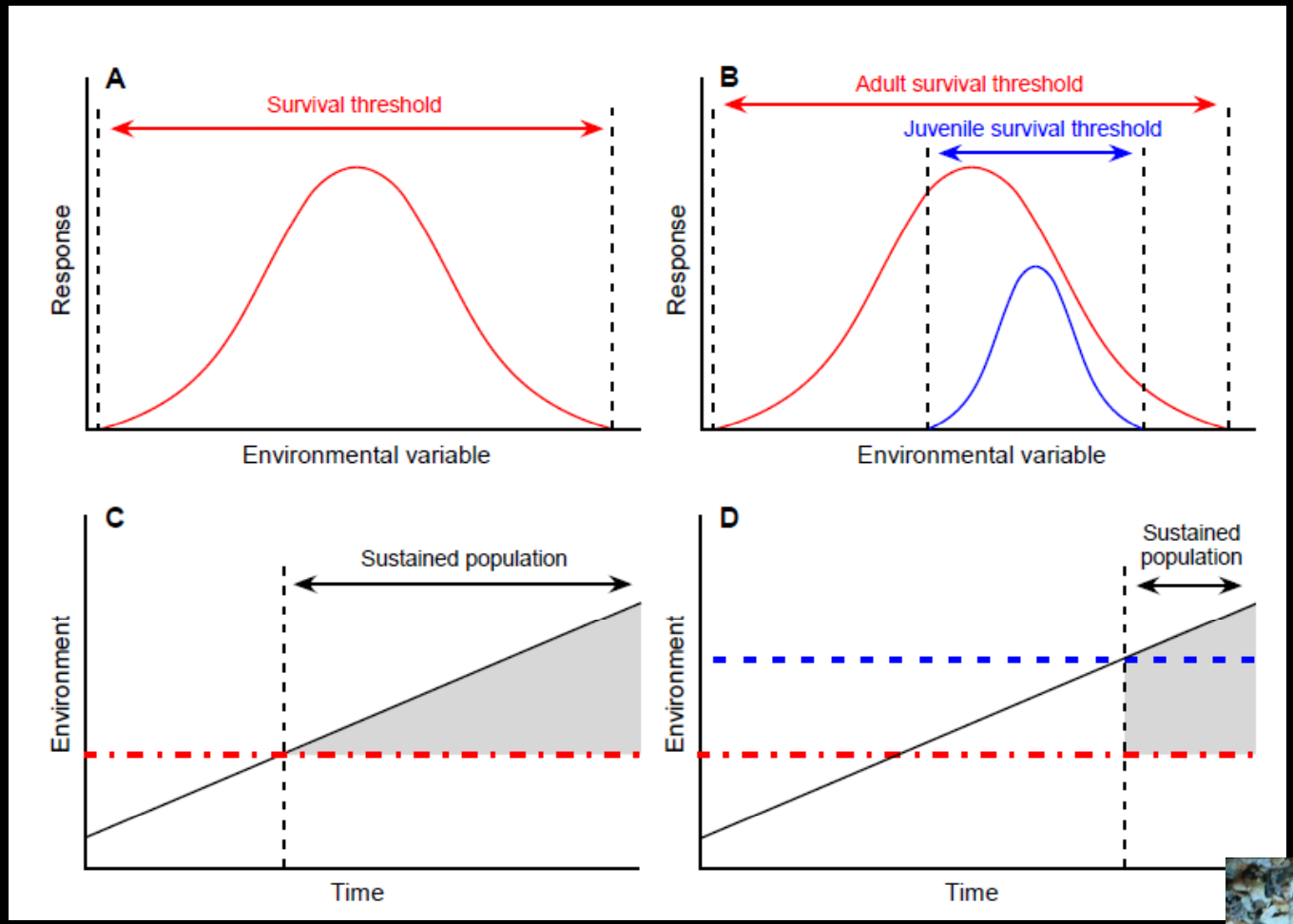
T.P. Dawson, S.T. Jackson, J.I. House, I.C. Prentice & G.M. Mace. 2010. *Manuscript in limbo.*

Vincent van Gogh. ***Wheat Field With Crows*****. 1890**



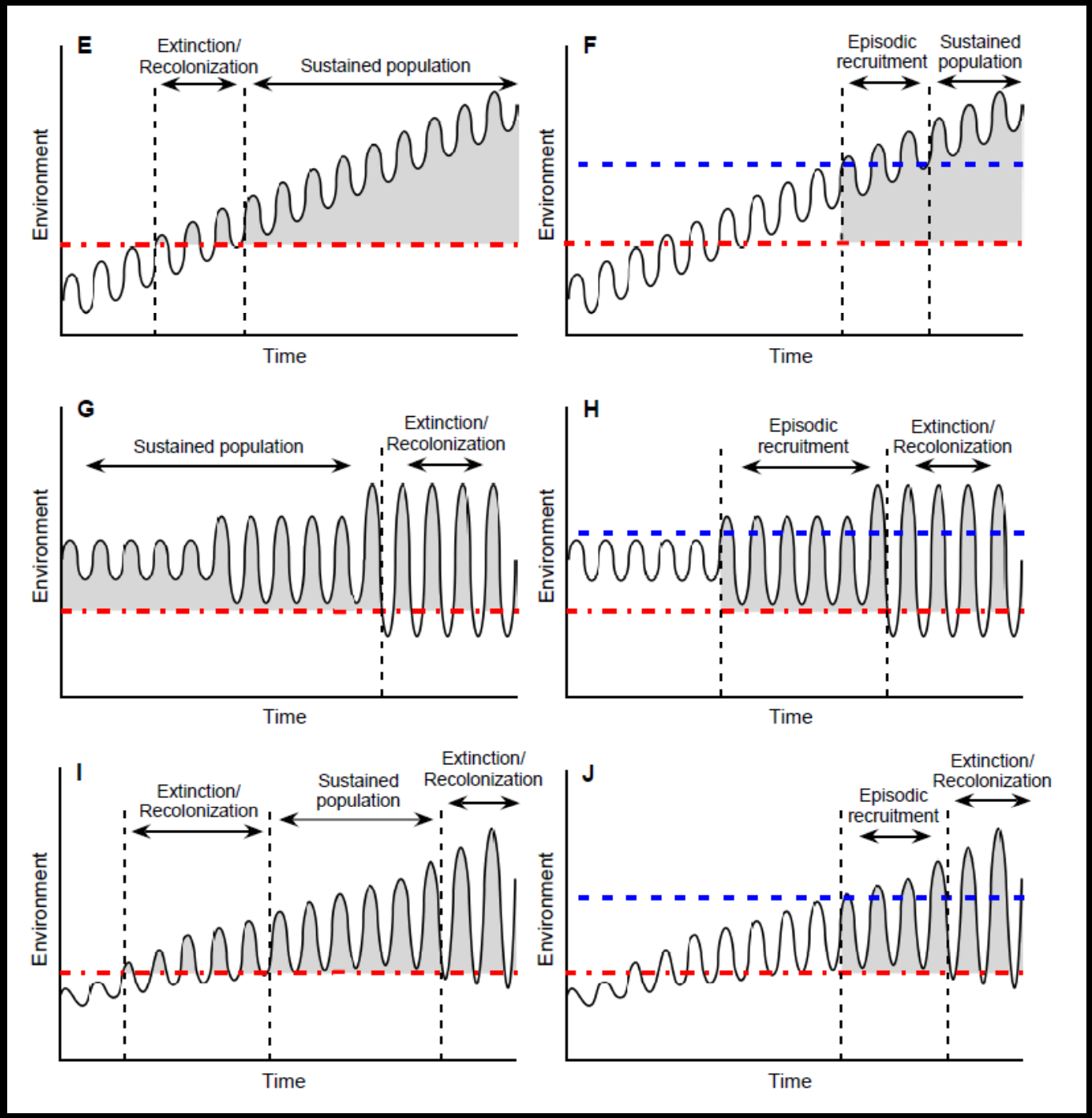
J.W. Williams, S.T. Jackson & J.E. Kutzbach. 2007. *PNAS.*

The underappreciated regeneration niche…



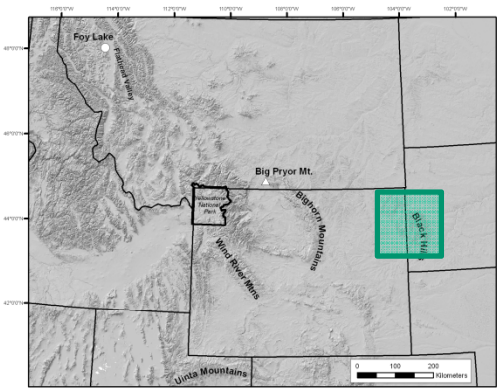
S.T. Jackson *et al.* 2009. *PNAS.*

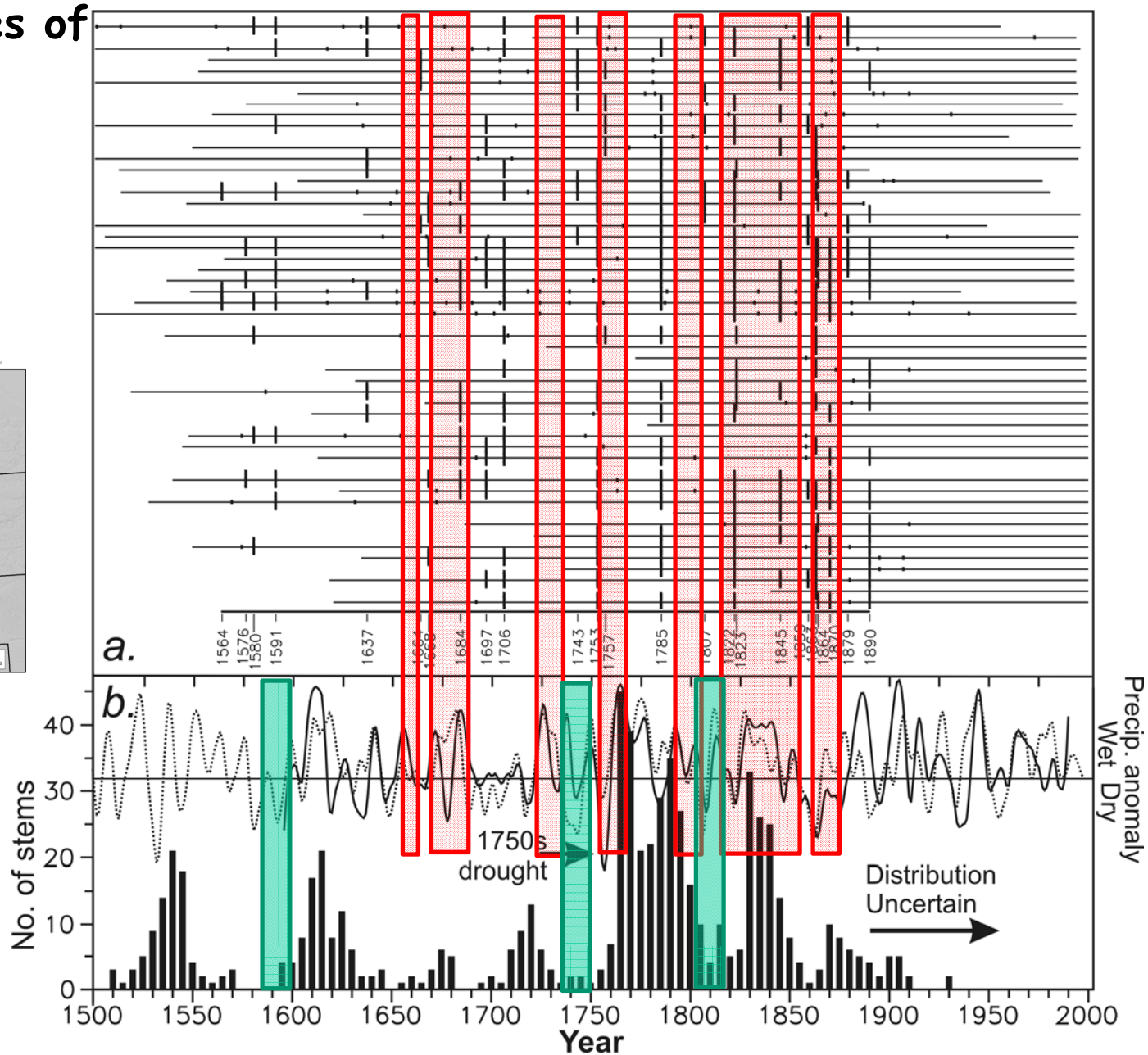
…and its consequences



S.T. Jackson *et al.* 2009. *PNAS* .

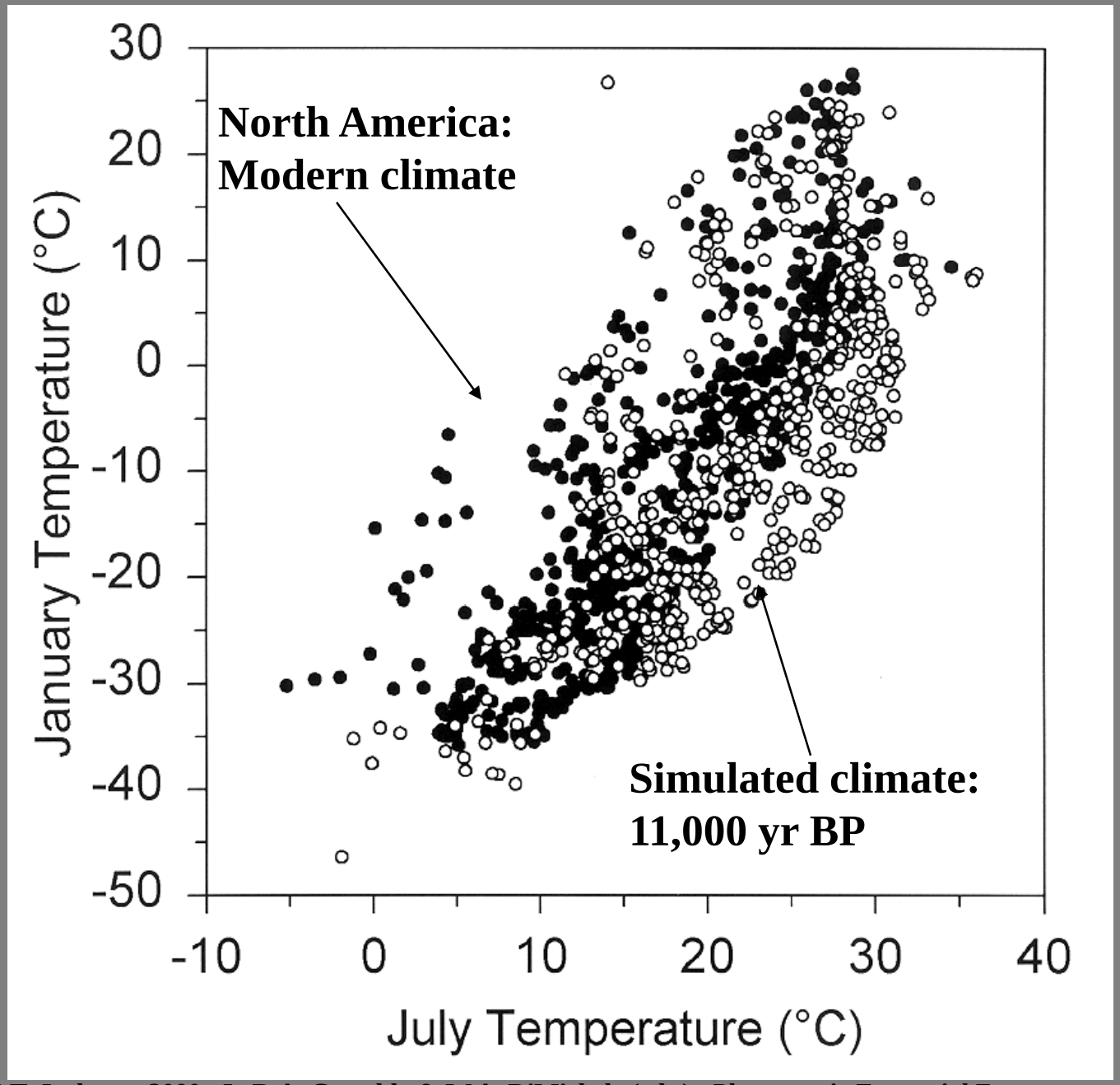
Future vegetation and ecosystem realizations will be contingent on particular sequences of climate-mediated disturbance and recruitment events



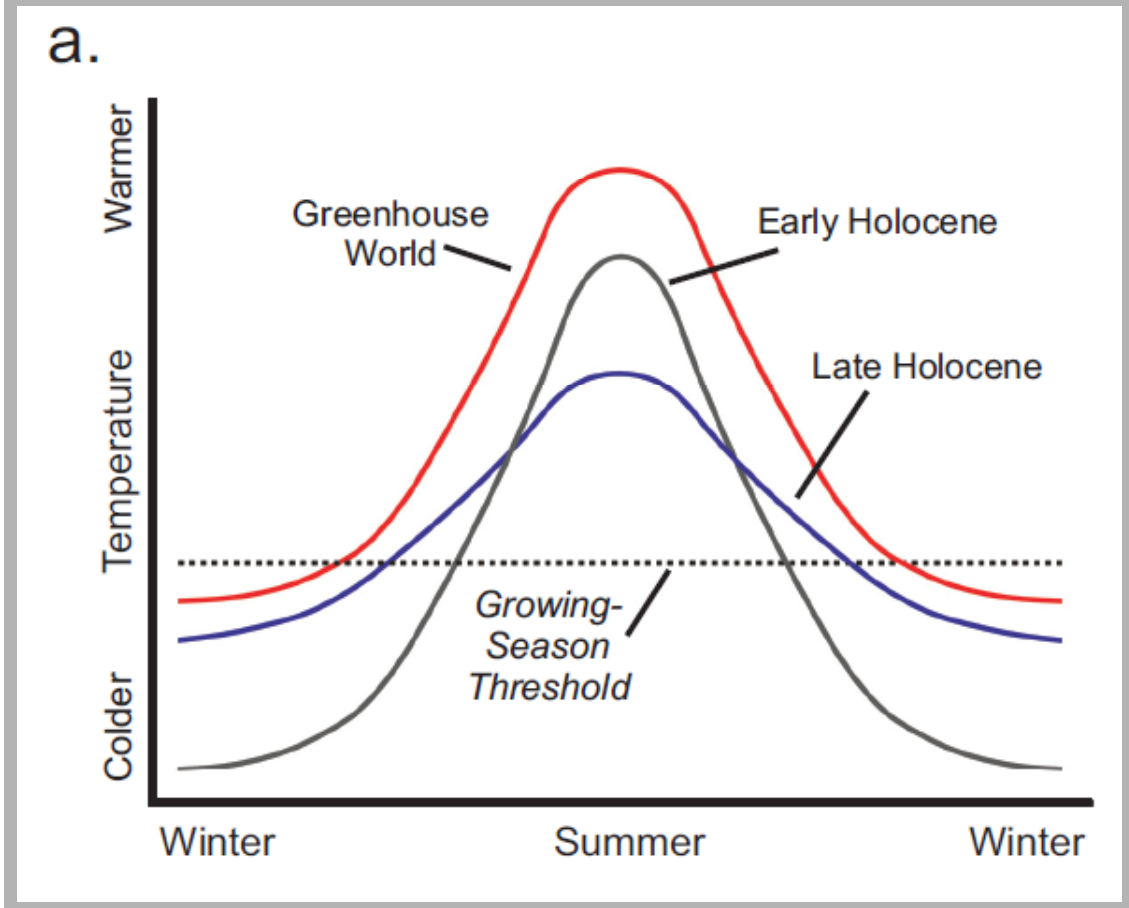


P.M. Brown. 2006. *Ecology.*

Consequences of a multivariate environment

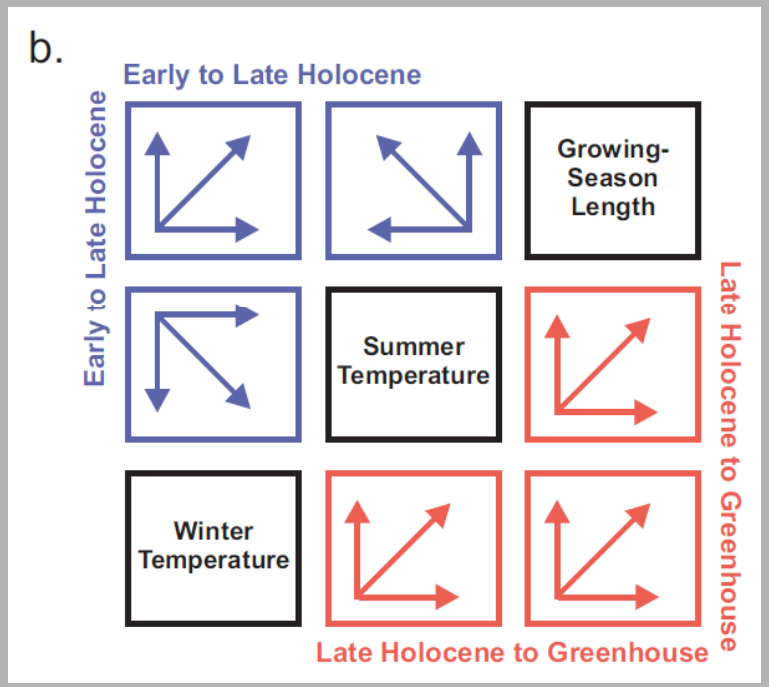


S.T. Jackson. 2000. *In* R.A. Gastaldo & W.A. DiMichele (eds.). *Phanerozoic Terrestrial Ecosystems*.



Thus we bank on covariance structure (in space) –

But covariance structure may not be conserved in time…



S.T. Jackson *et al.* *2009.* PNAS.