From restoration to resilience ecology: Do we need a new paradigm*?

*** And what can we do about it?**

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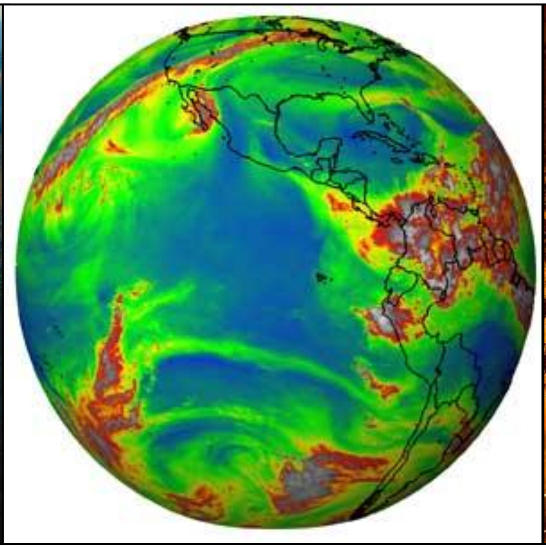


Annual Meeting, November 2015
Society for Ecological Restoration Southwest Chapter

We have relied on natural recovery or the practice of ecological restoration to heal damaged landscapes

- ***Ecological restoration:*** the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. – *SER International Primer on Ecological Restoration* (2004)

- ***Restoration ecology:*** the study of the relationships among organisms and their environment in a restoration context. – Falk *et al.* 2006

Millar et al. 2007; Hobbs et al. 2013; Higgs et al. 2014; www.ser.org


Corta Alloza, Spain


Pune, India


Costa Rica


Port Elizabeth, South Africa


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Pune, India

Costa Rica

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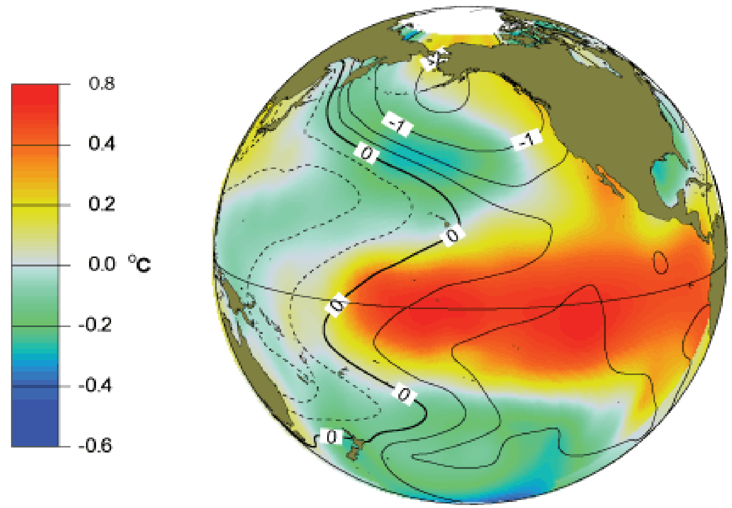
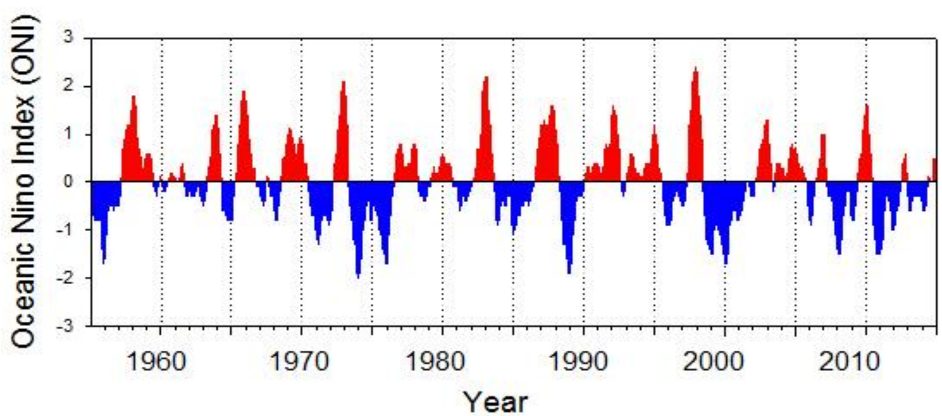
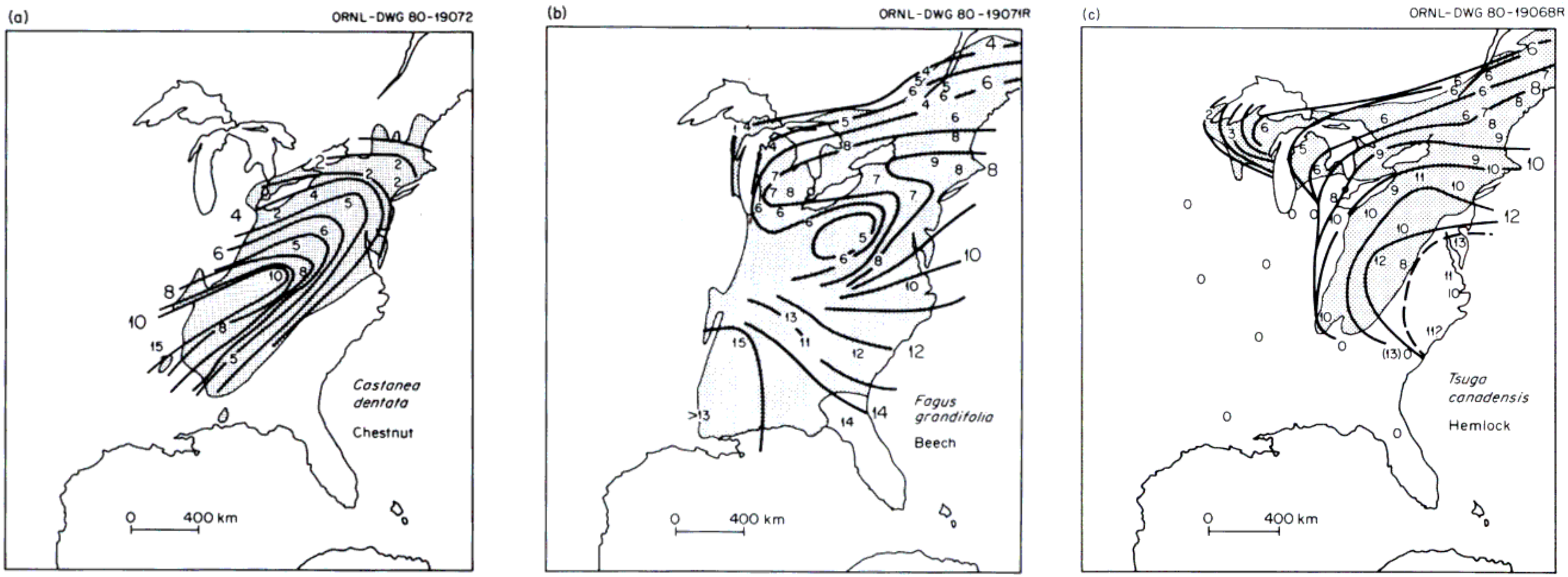
All species and ecosystems are adapted to high-frequency (interannual to decadal change)



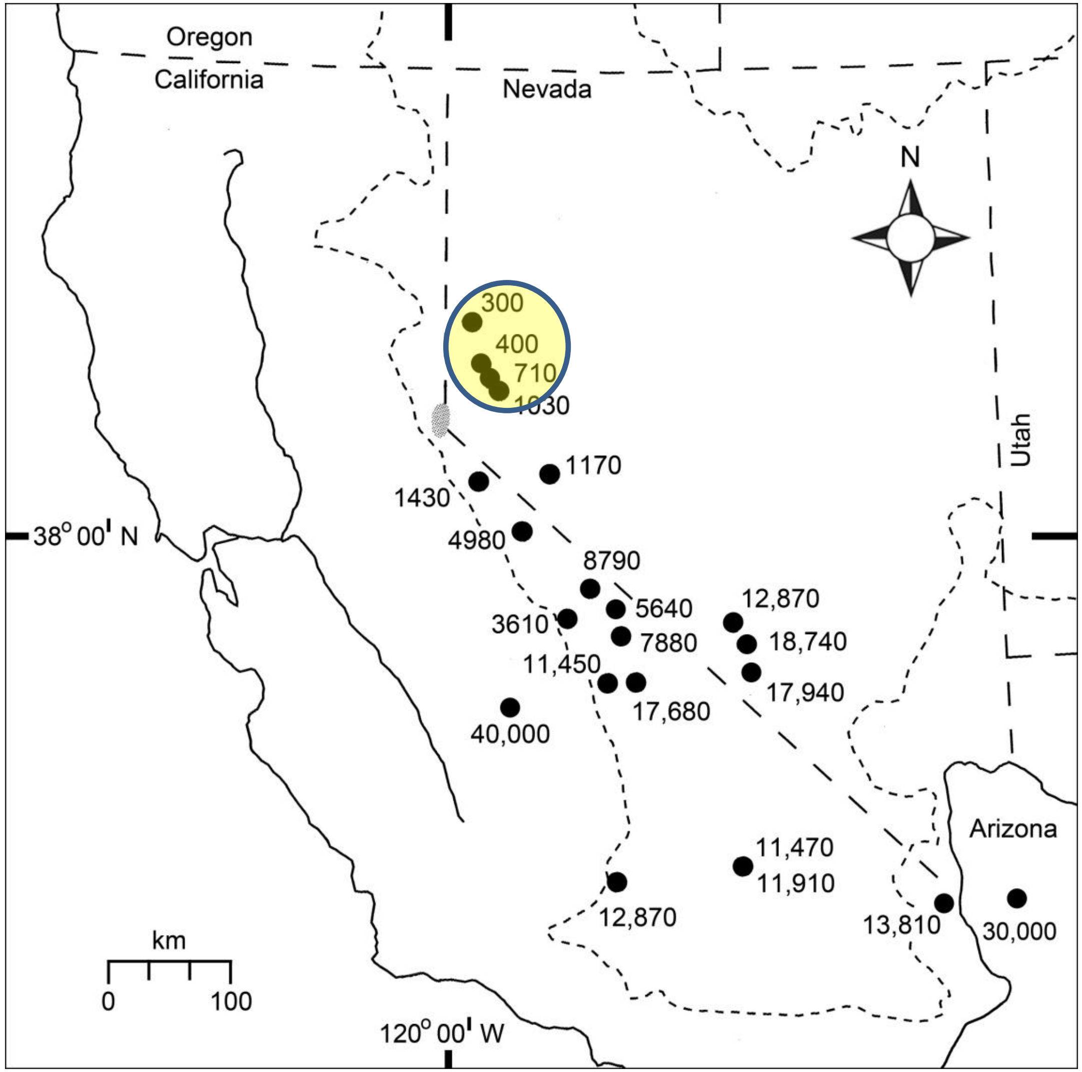
Warm Phase ENSO



Climate variation has always kept many species in climatic disequilibrium



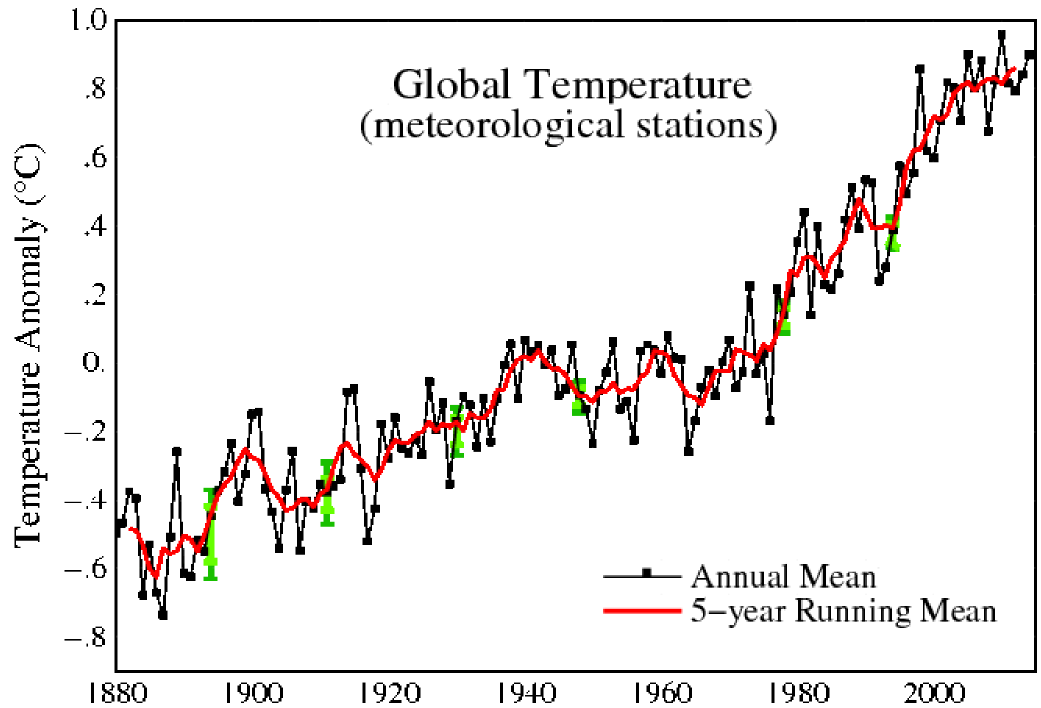
Range shifts of chestnut (*Castanea dentata*), beech (Fagus grandifolia) and eastern hemlock (*Tsuga canadensis*) in eastern North America tracking changing temperatures following the Last Glacial Maximum. From Davis 1981.



Arrival (years before present) of single-leaf piñon (*Pinus monophylla*) as temperatures warmed from the last glacial maximum. From DK Grayson (2011), *The Great Basin: A Natural Prehistory*. University of California Press. Millar and Woolfenden (in press).

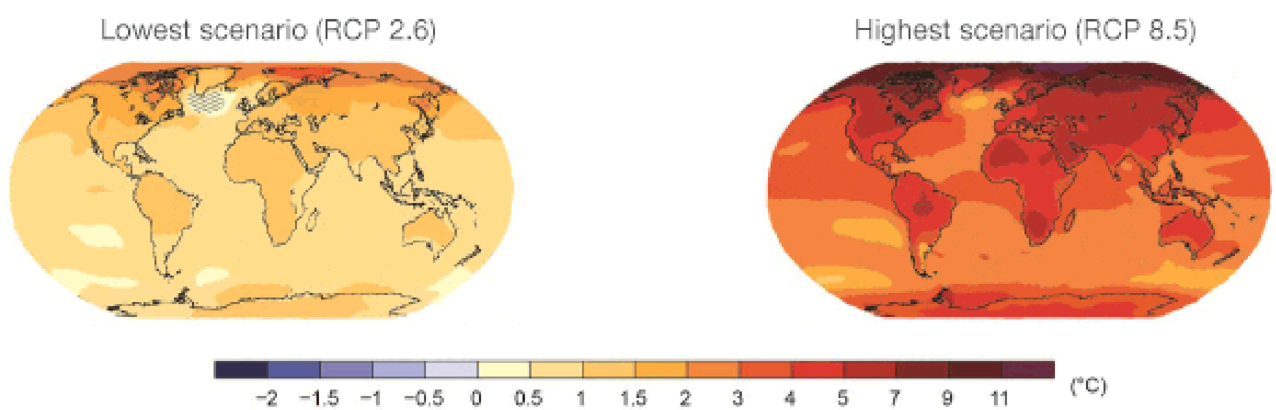
So what has changed? Why are we* so worried?

* 97% of scientists



Predicted temperature increases under two scenarios

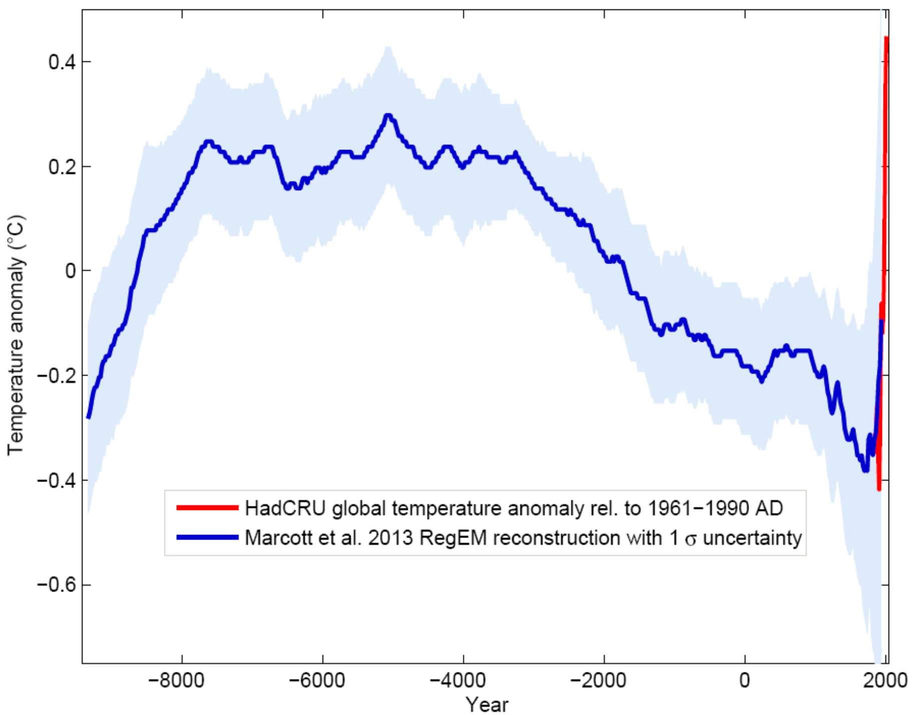
Rise in average surface temperature by 2081-2100*

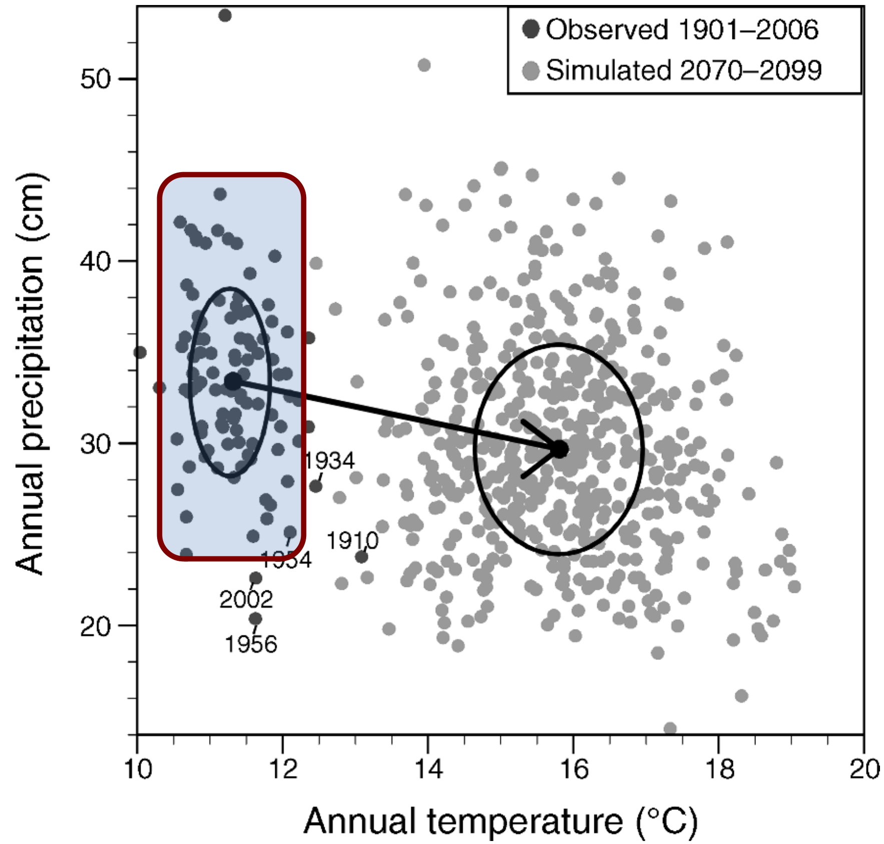


*Predicted change from period 1986-2005

Source: IPCC

Changes in the global climate system are driving direct ecosystem effects that are rapid, substantial, and out of phase with natural dynamics

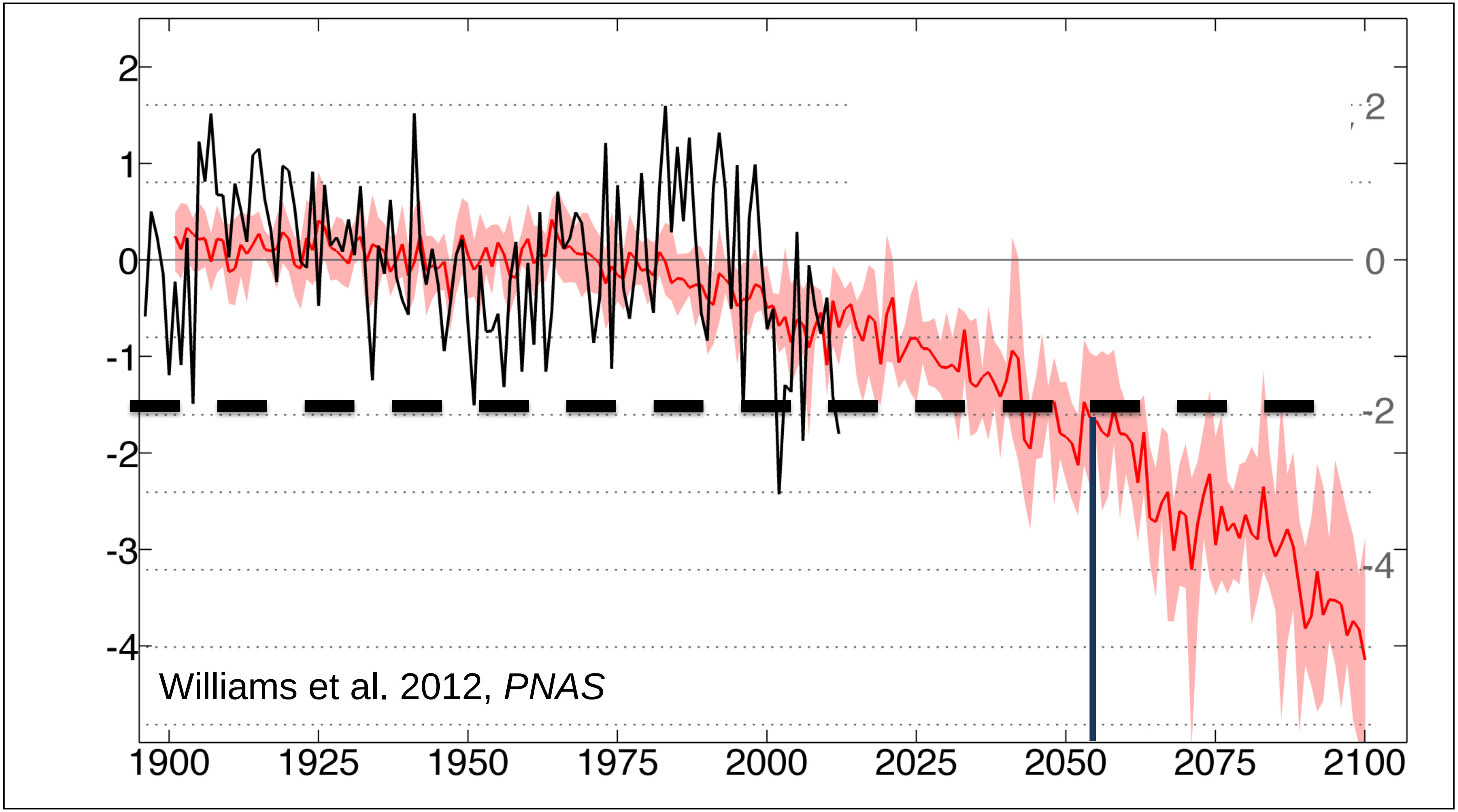




Left: Holocene temperature (Marcott et al. 2013). Right: 20th cf. 21st century precipitation and temperature (Notaro et al. 2012).

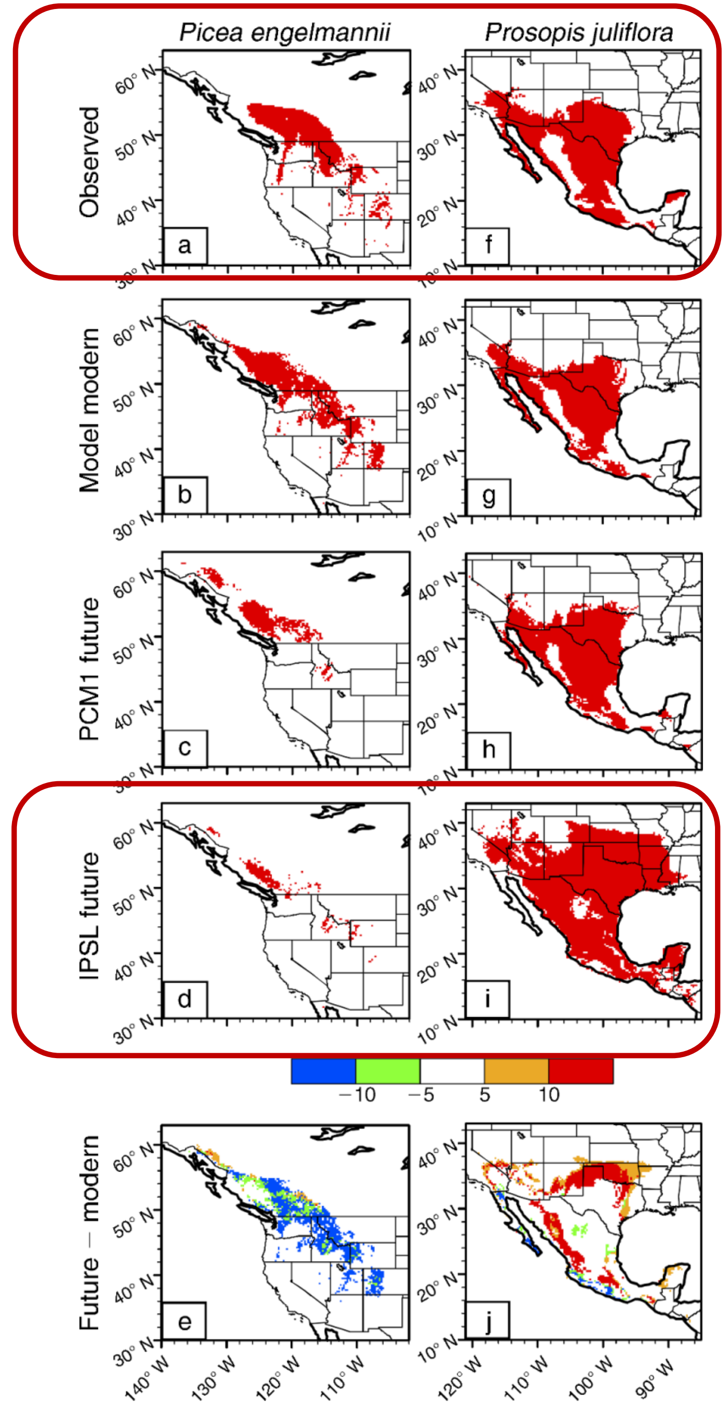
Drought stress appears to be heading for unremittingly severe levels

Dashed line: Most negative FDSI in last 1,000 yr



Projected species range shifts in response to 21st century warming

- Poleward migration ~10 – 80 (160) km century^{-1}
- Upslope movement ~ 60 – 100 m century^{-1}
- Winners and losers at all scales



Parmesan and Yohe 2003; Colwell and Rangell 2009; Chen et al. 2011; Notaro et al. 2012

The central scientific <u>and</u> management challenge of our time:

How will organisms and ecosystems adapt to rapid reorganization of the Earth system?

Do we need to adopt more flexible paradigms of ecosystem conservation and management?

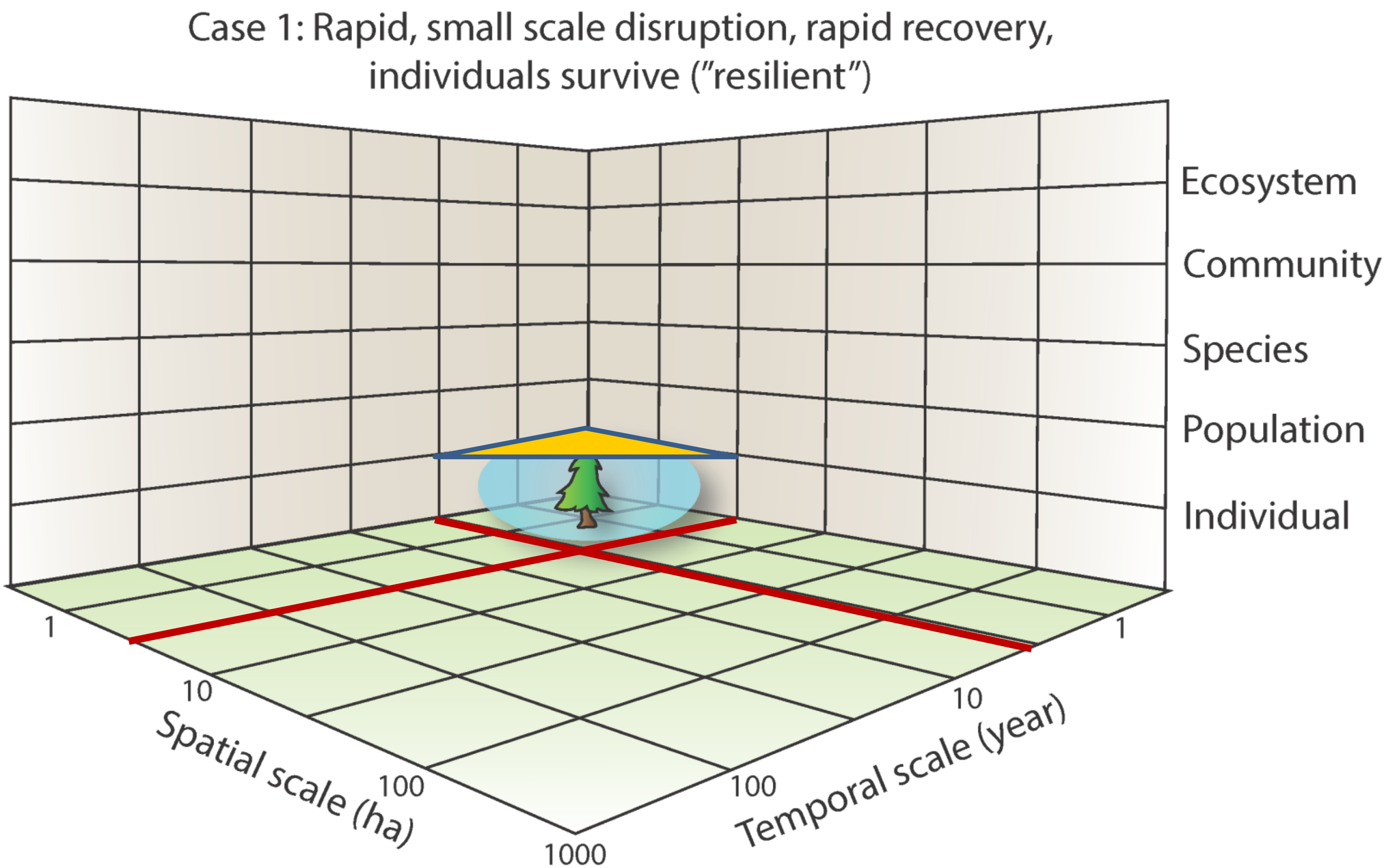
What is “ecological resilience”?

Hobbs and Suding 2009

“The capacity of an ecosystem to recover to its pre-disturbance composition, structure, and/or function over time.”

- **Departs from ecological restoration by relaxing the constraint to return to historical conditions**
- **Even these concepts may be inadequate to the challenge of adapting to a changing world.**

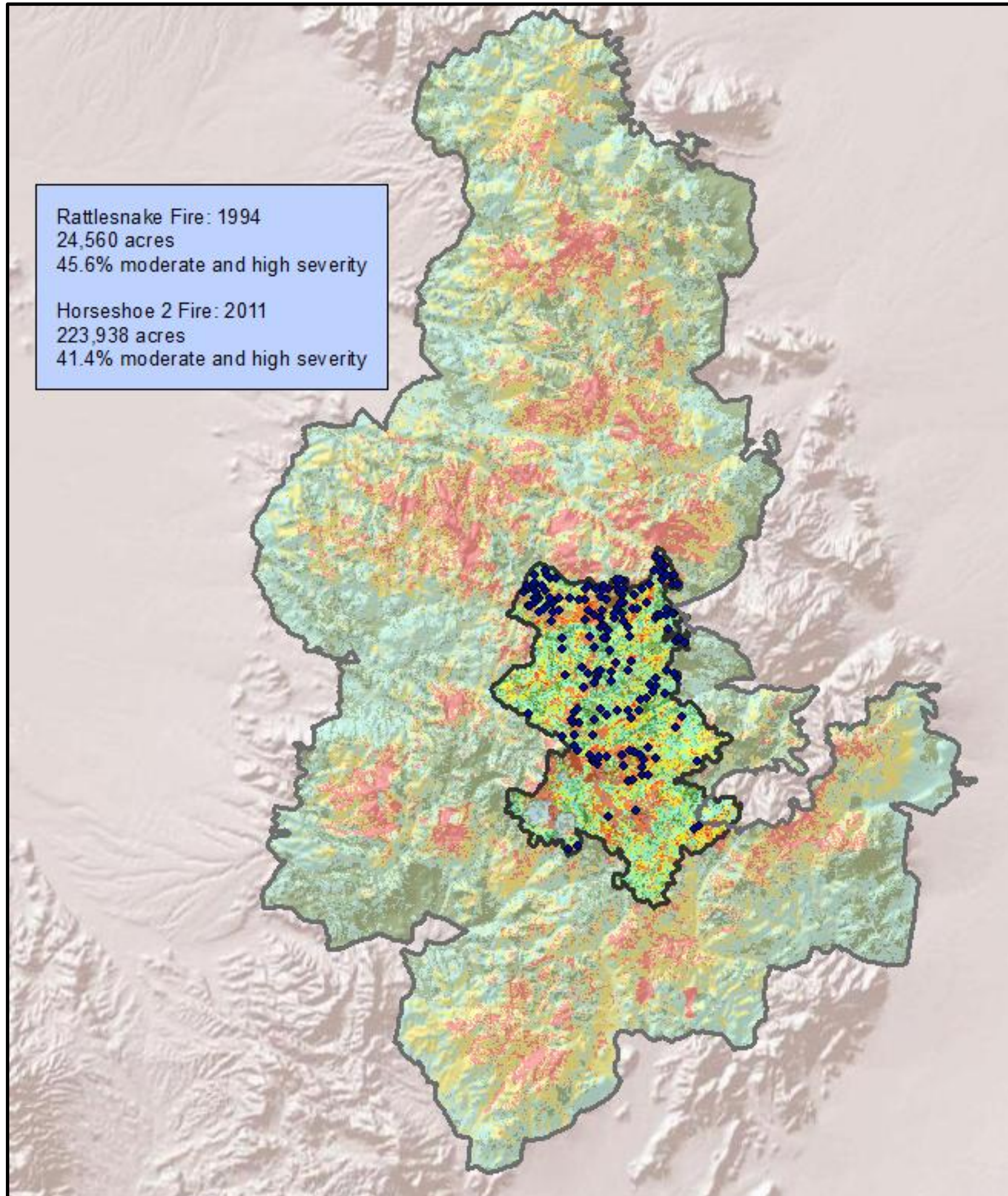
Small scale disruption, rapid recovery, individuals survive (**persistence** dominates)



Landscape re-burns in the Chiricahua Mountains, a Madrean "Sky Island"

Nested sequences of fire severity (U,L,M,H) in 2 events

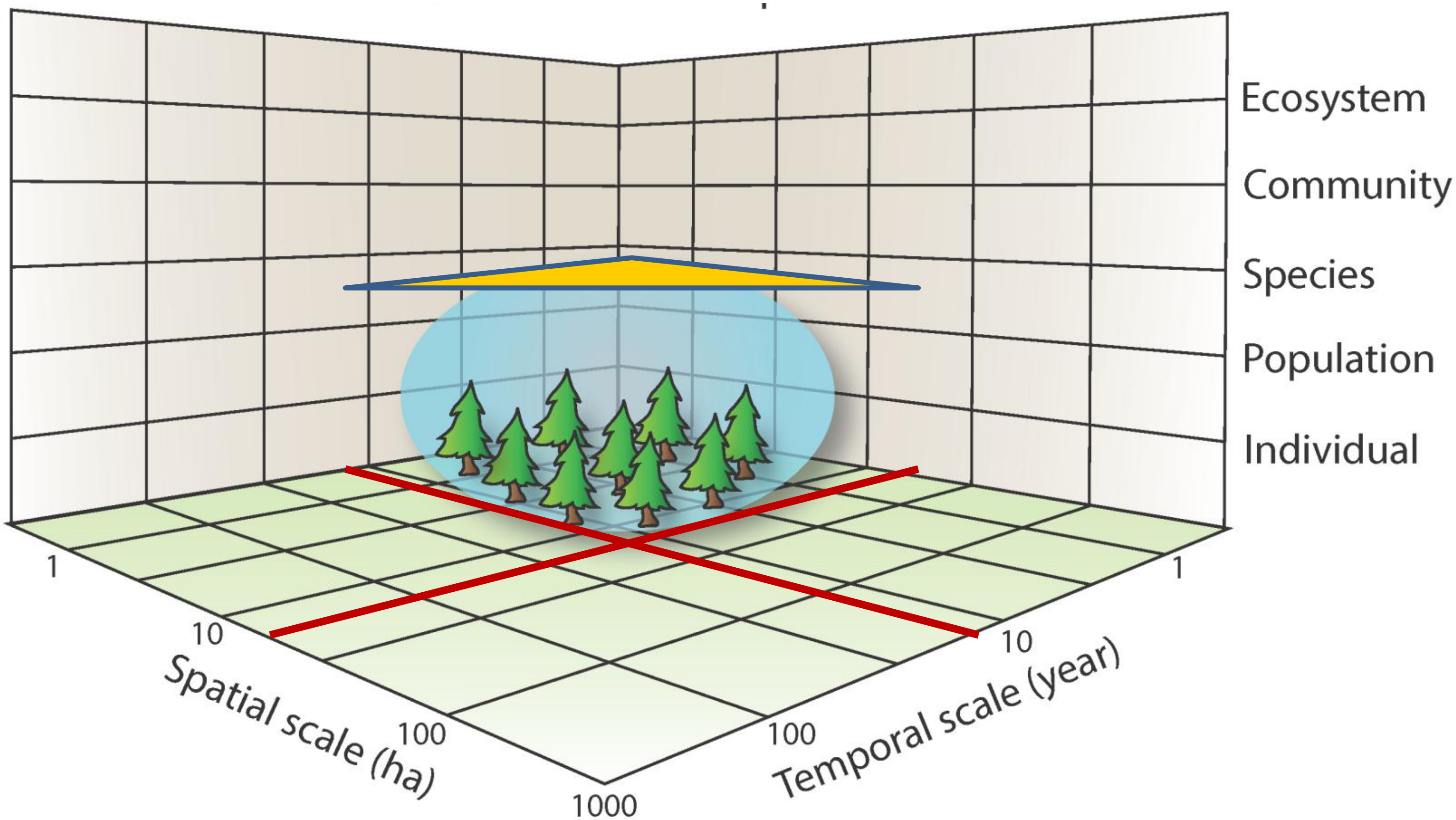
Chiricahua maps and images: Jesse Minor, U.Arizona



Post-fire succession in the Chiricahuas after two events

Photo points, J. Minor

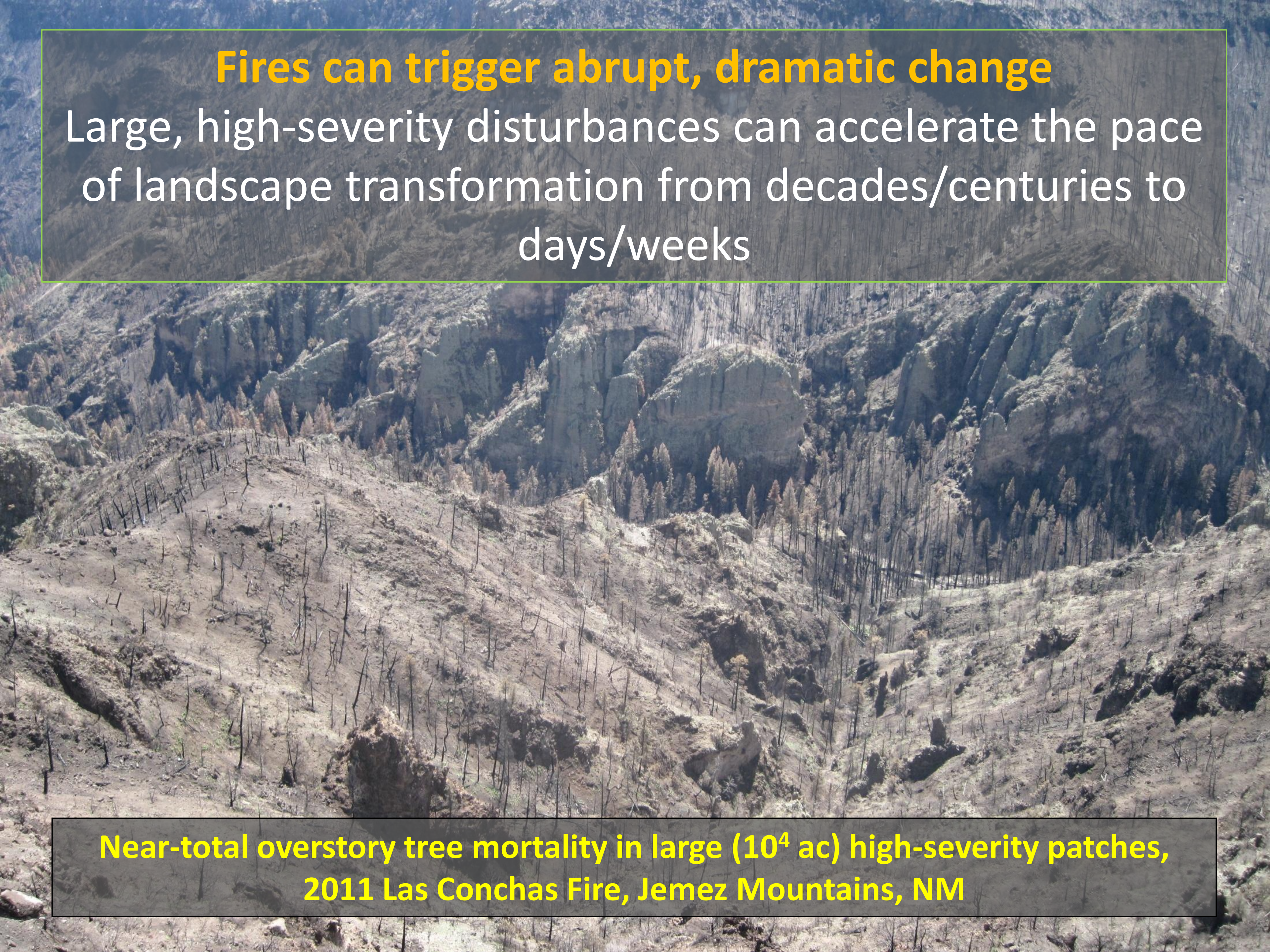
Moderate-scale disruption, decadal recovery, some turnover in species (**recovery** processes)



2006 Nuttall-Gibson Complex, Pinaleño Mts.
Courtesy USFS and SW Fire Science Consortium

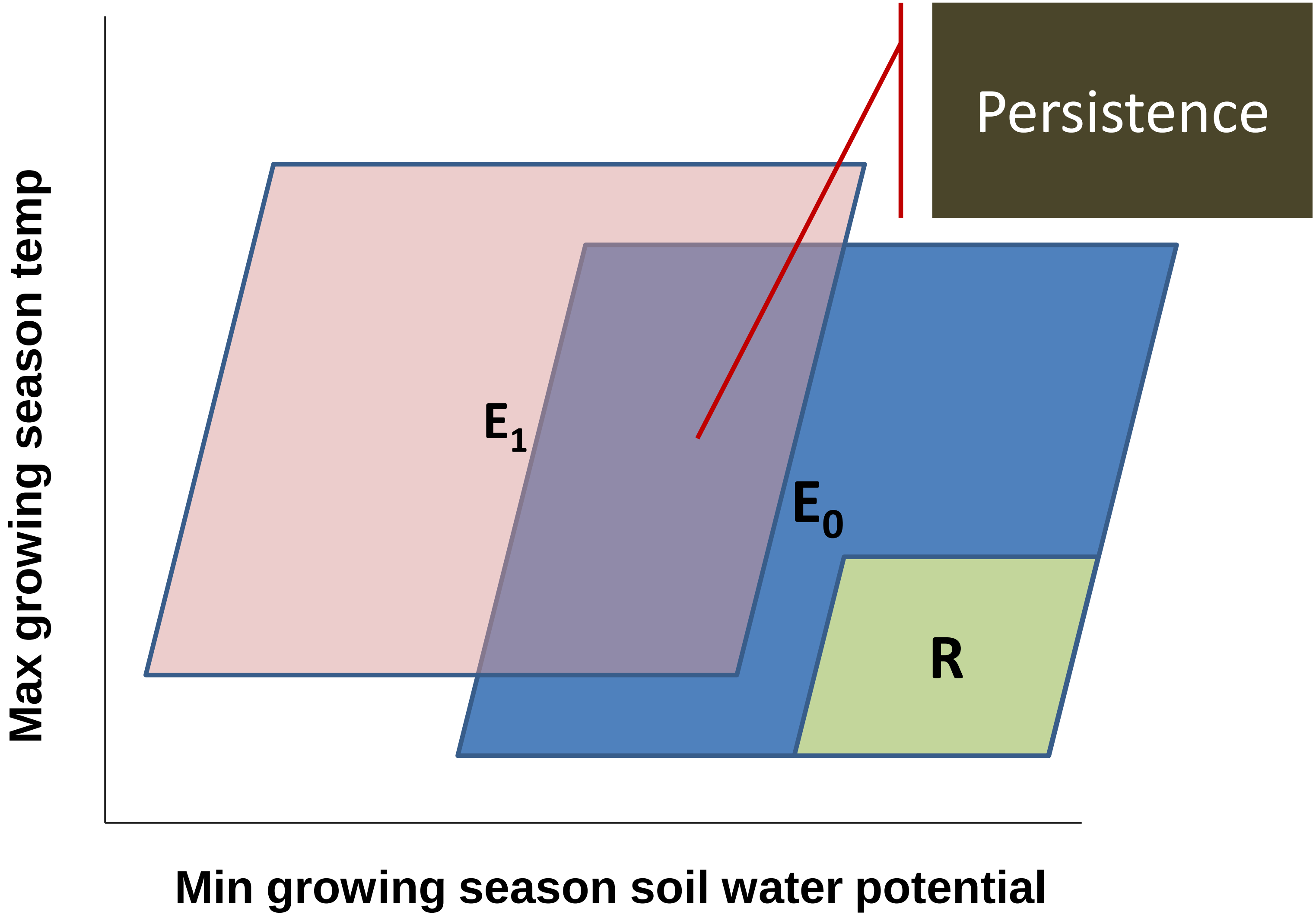
Fires can trigger abrupt, dramatic change

Large, high-severity disturbances can accelerate the pace of landscape transformation from decades/centuries to days/weeks



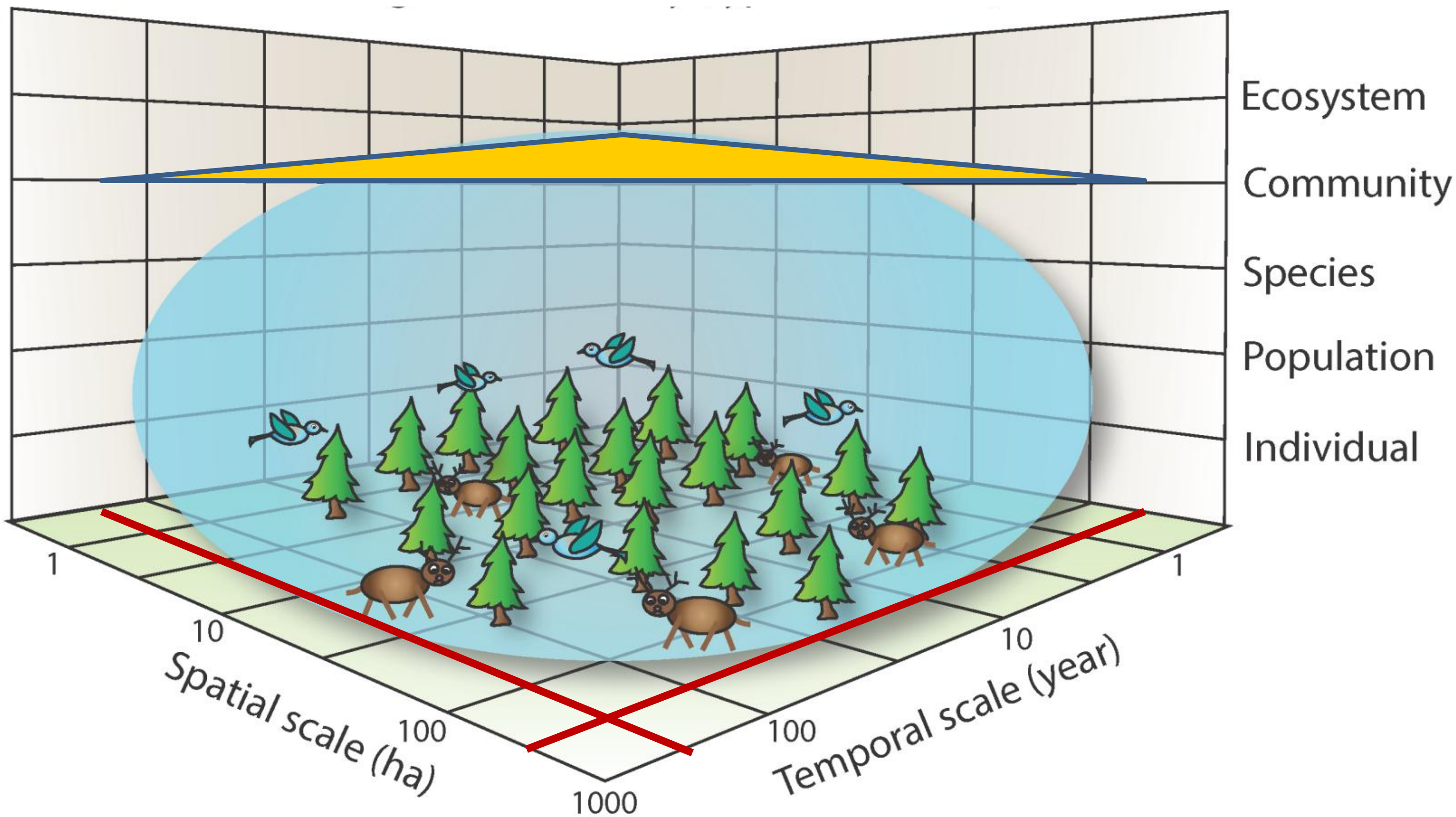
Near-total overstory tree mortality in large (10^4 ac) high-severity patches, 2011 Las Conchas Fire, Jemez Mountains, NM

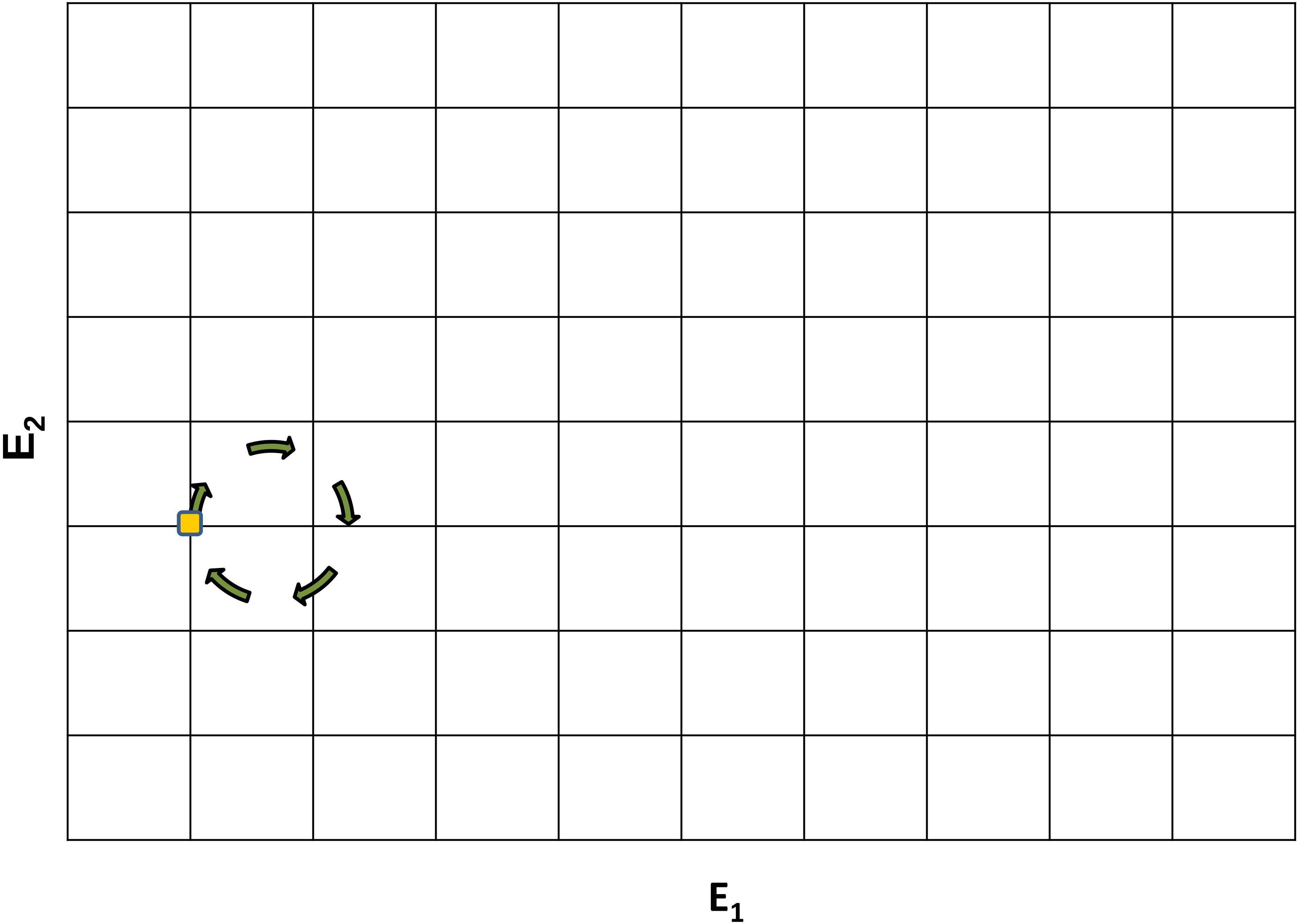
Following mortality events, species persistence is dependent on recruitment, but climate may preclude establishment.



Colwell and Rangel 2009; Jackson et al. 2009

Large scale disruption, multi-decadal response, change in community (type conversion, **reorganization**)

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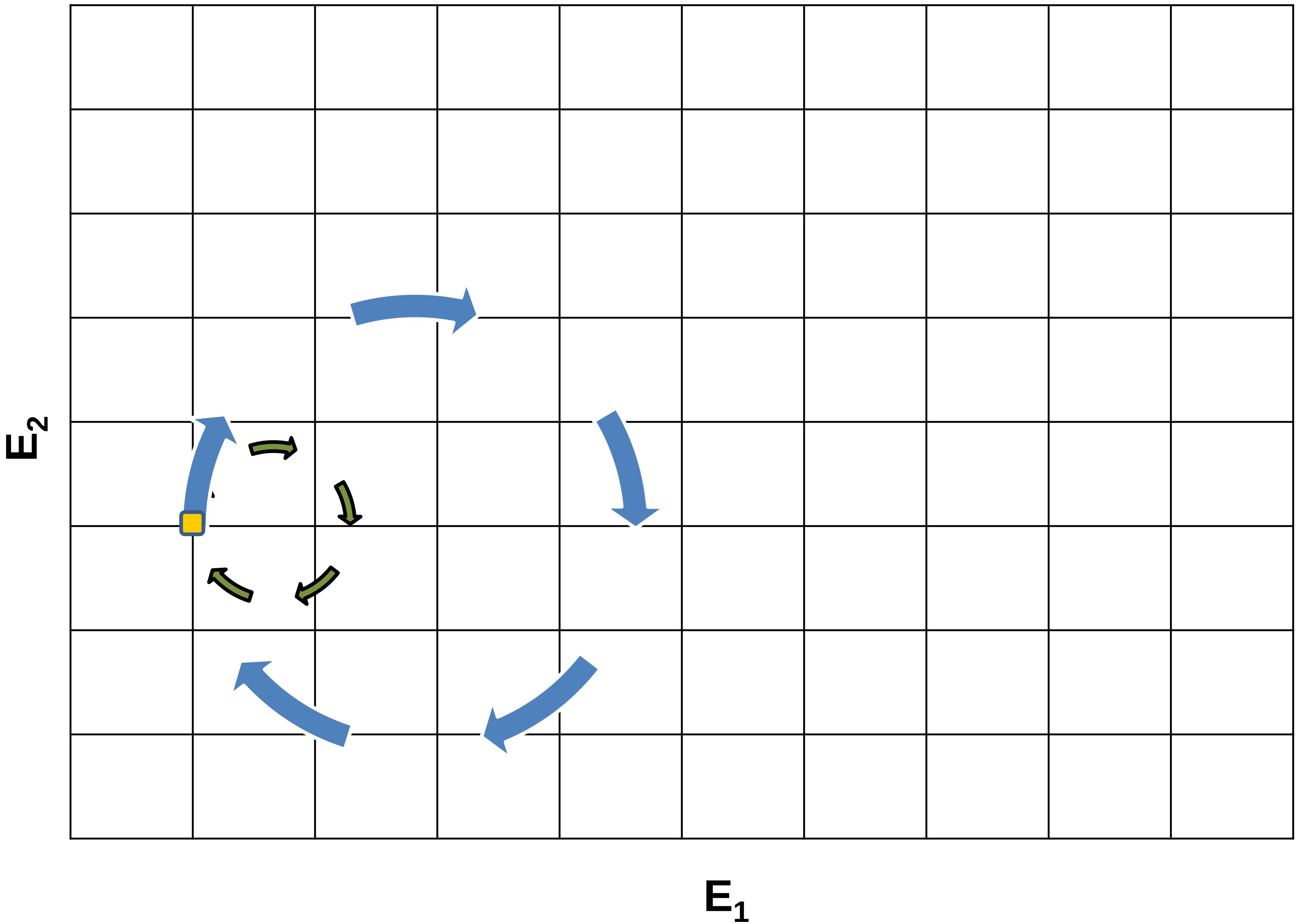
E_1



E2
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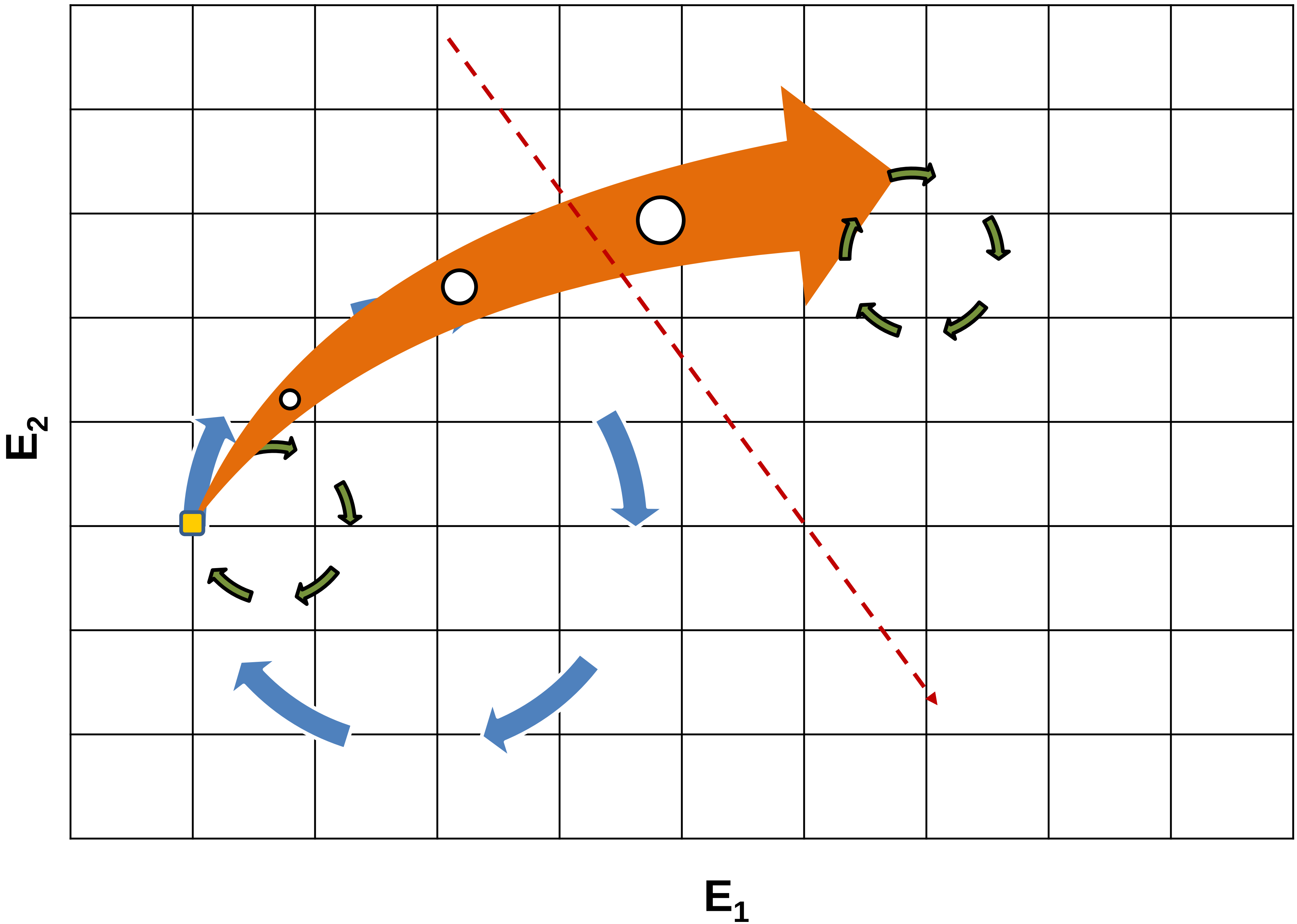
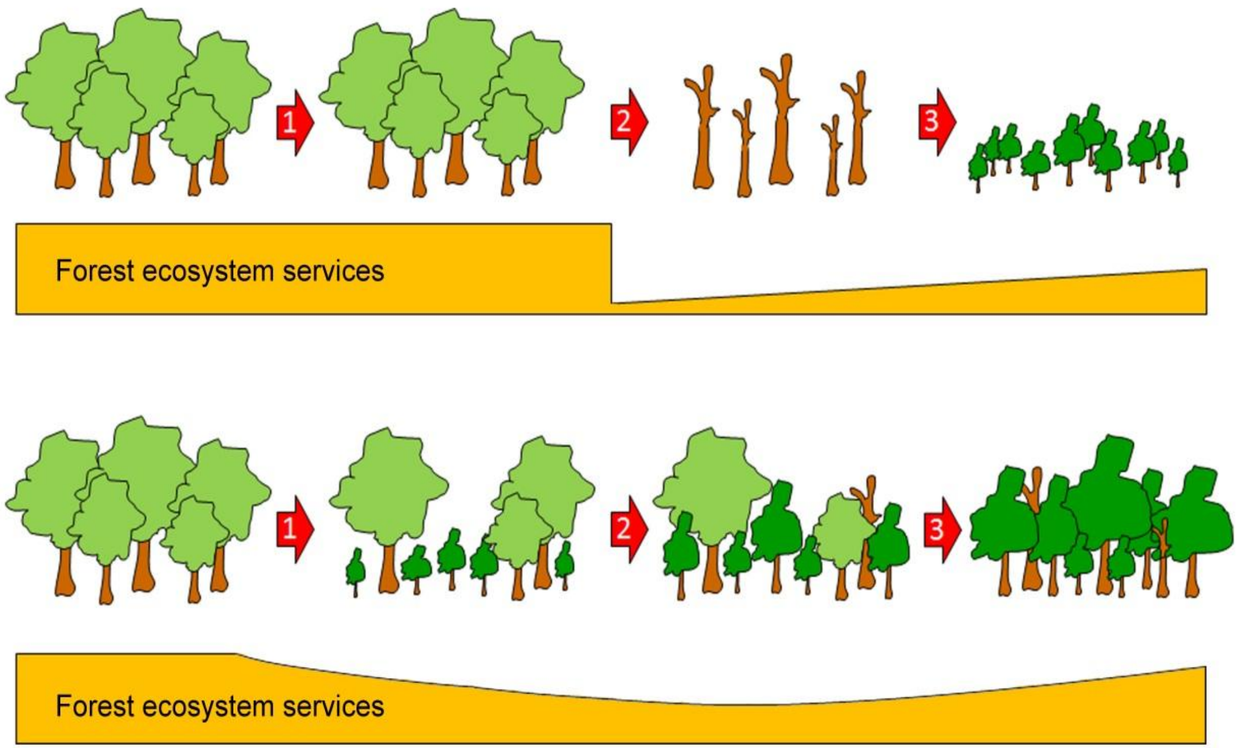

E2
E1

Restoration and management options must anticipate inevitable ecosystem change



Millar and Stephenson 2015, *Science*

Thus, in addition to its traditional roles, restoration can also enhance:

1. **Resistance**: Ability to endure external stressors without changing state.
2. **Resilience**: Return to the pre-disruption state after exposure to external stressors.
3. **Response (adaptation)**: Change some properties in response to external stressors while retaining essential characteristics.

Drever et al. 2005; Millar et al. 2007; Benson et al. 2011

Resilience means accepting change

1. Which kinds and degrees of **change** are **adaptive**, and which are **destructive** of biodiversity and ecosystems?
2. How does a resilience framework affect **decisions and actions on the ground**?
3. Are we prepared to **let go of some current ecosystems**, or would doing so violate our core principles?

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