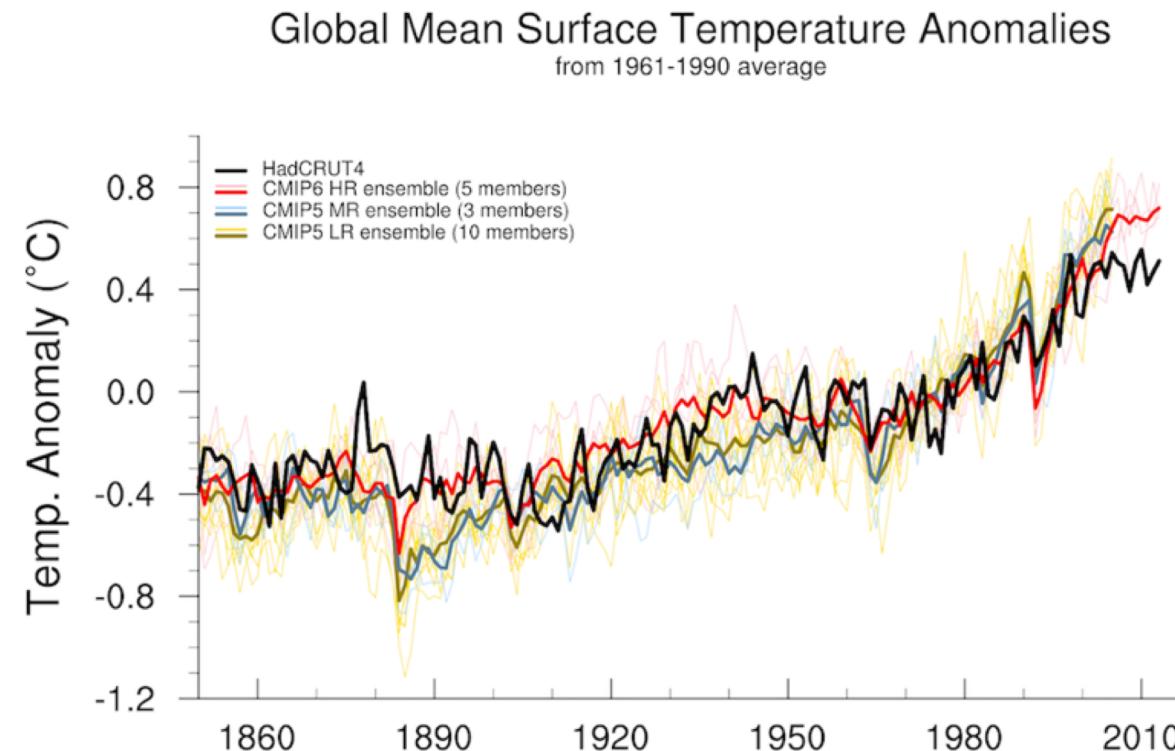
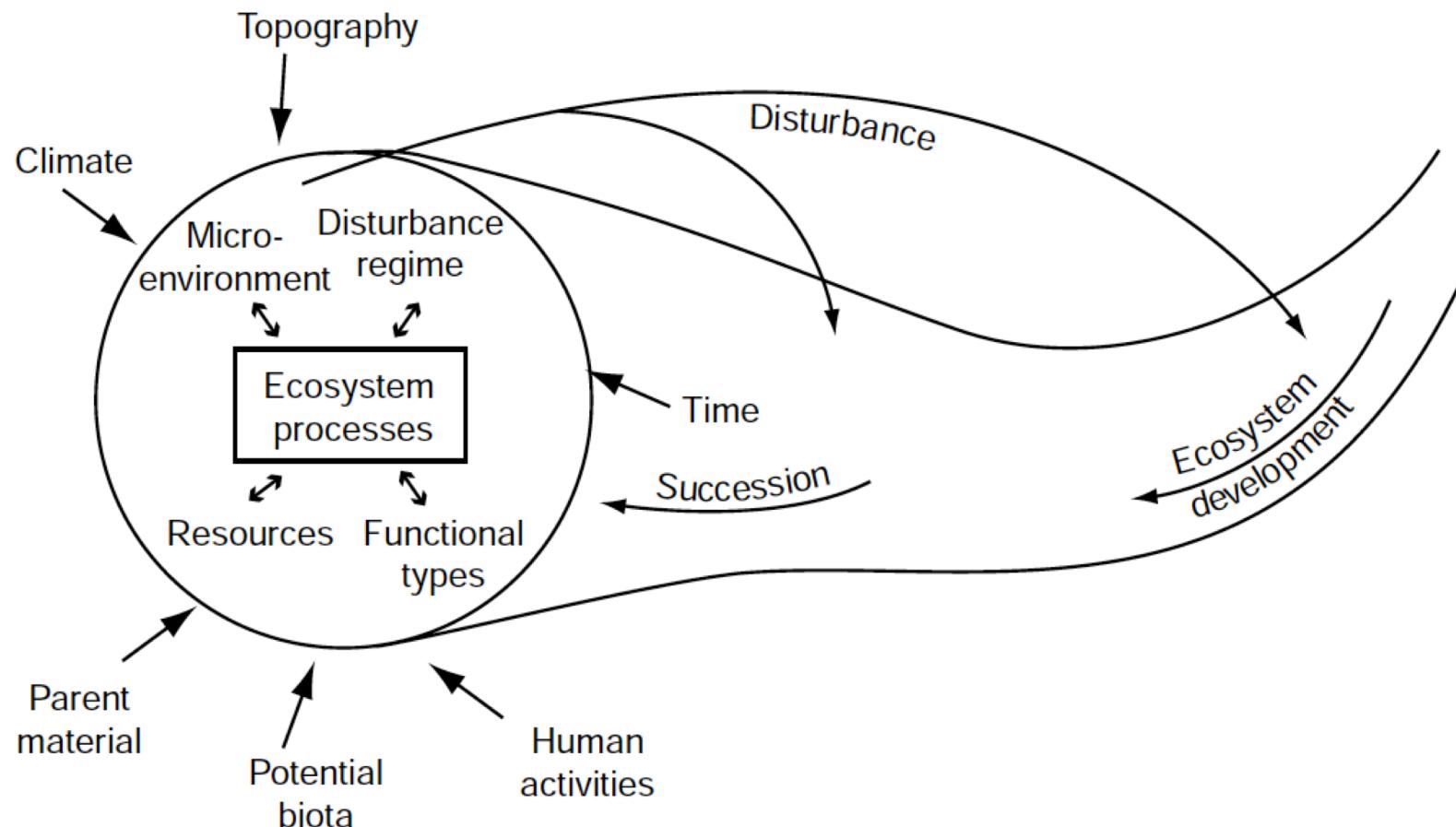


Temporal dynamics

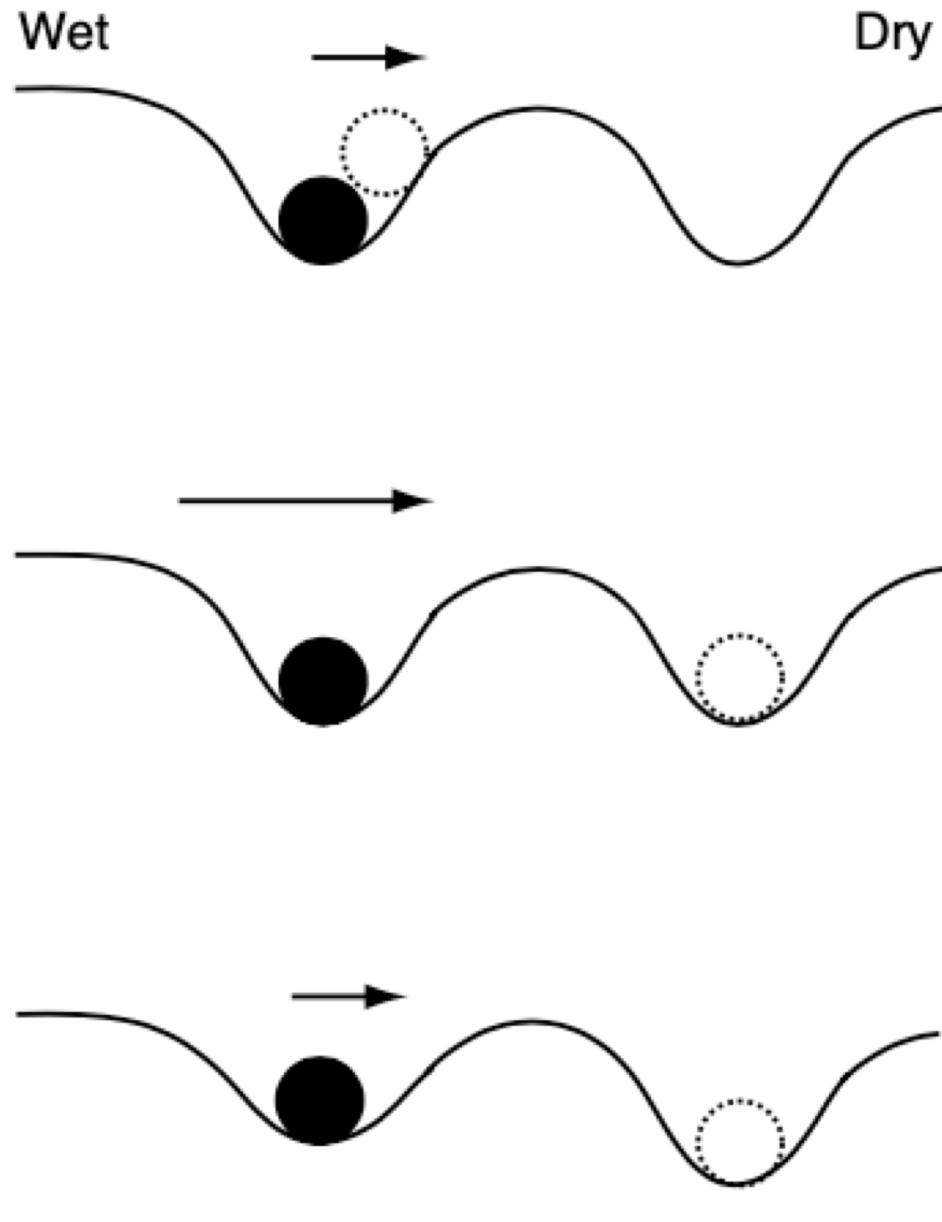


What drives changes in
ecosystem processes over time?



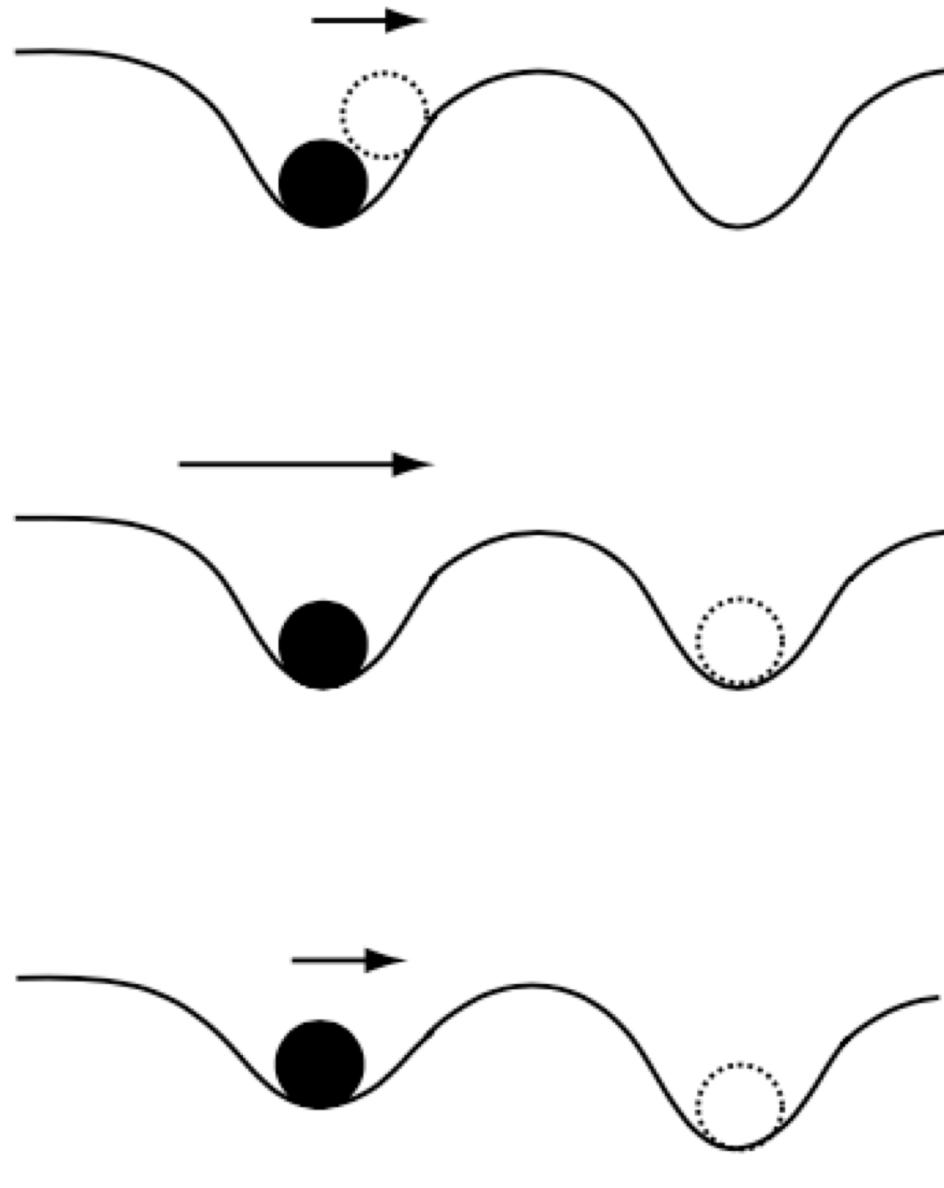
In your book, but modified from Chapin et al. (2006)

Temporal dynamics: Resilience



Depth of cup defines resilience
of ecosystem

Length of arrow defines the
strength of disturbance



Resilient, weak disturbance

Resilient, strong disturbance

Not resilient, weak disturbance

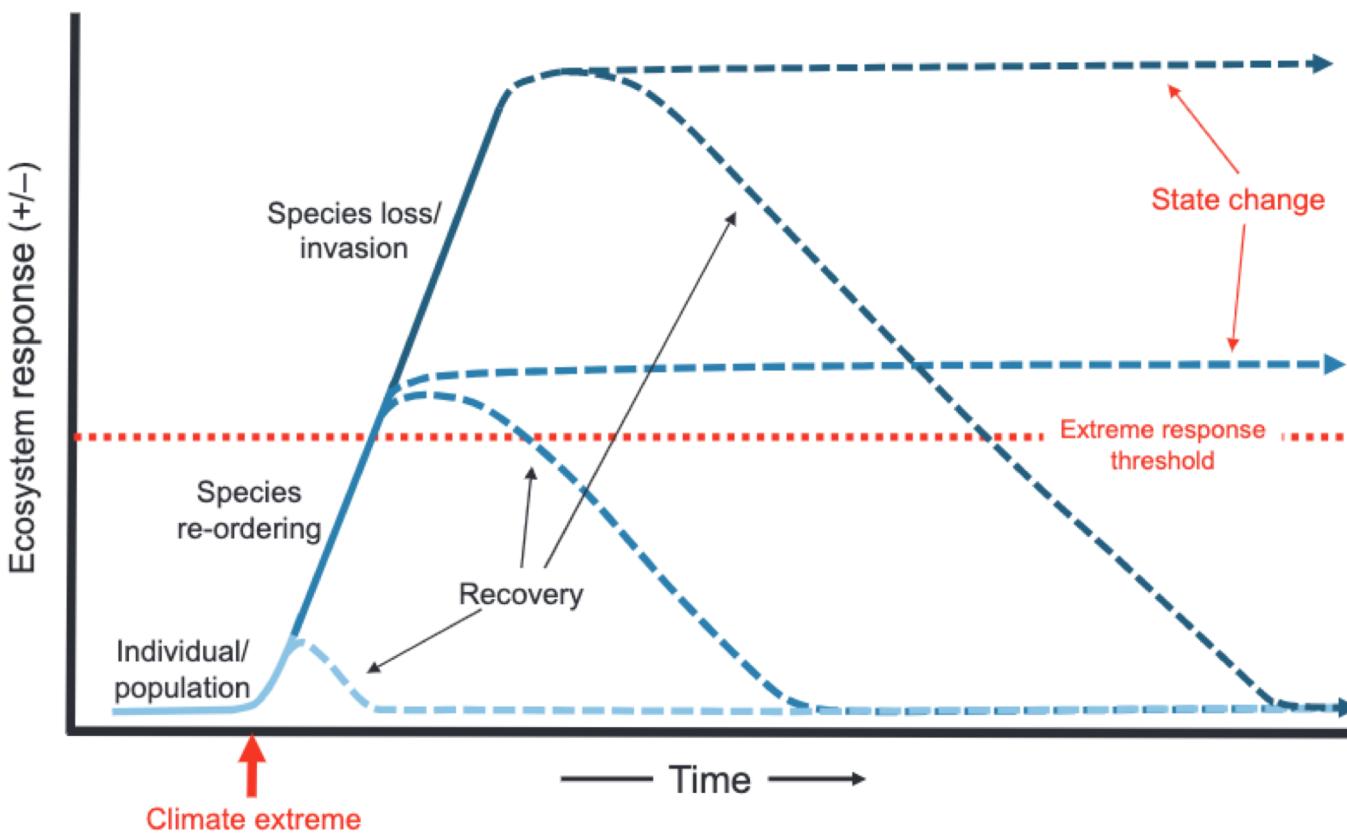
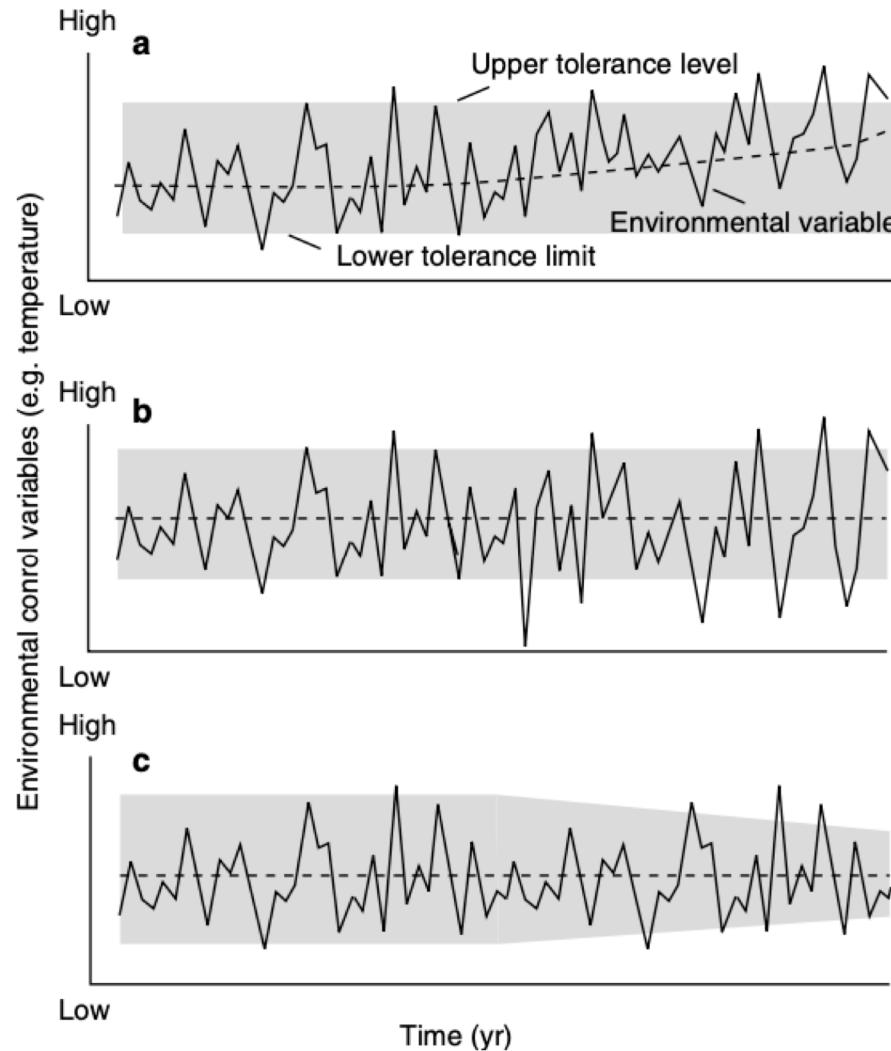


Fig. 2. A mechanistic framework for assessing responses to climate extremes. A period of climate extremity that primarily affects individual-level responses (physiology, growth, fitness) of particular organisms or populations will have a smaller effect (positive or negative) on ecosystem processes (i.e. productivity, nutrient cycling) than one that results in large shifts in species abundances (species re-ordering), or in local extinction of species or invasion by others. An ‘extreme climatic event’ is an episode or occurrence in which a period of statistical climate extremity alters ecosystem structure and/or function outside the bounds of what is considered typical or normal variability, as a consequence of crossing an extreme response threshold (dotted red line) in which individual-level effects cascade to higher hierarchical levels to result in significant changes in community structure and large ecosystem impacts. These alterations may be characterized by prolonged recovery and/or hysteresis, or may even lead to persistent state changes.

Range of resilience defines response

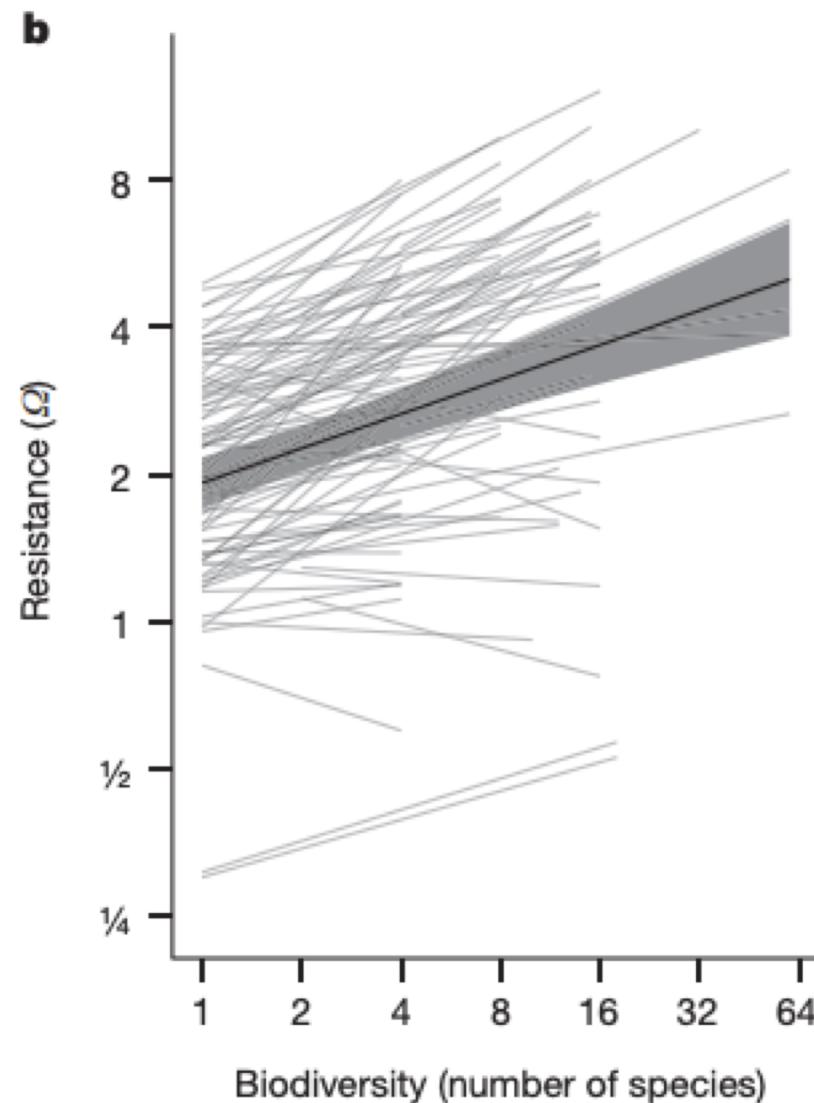


Directional shift in env. = more time outside range

More variable env. = more time outside range

Change in range = more time outside range

Ecological community defines response



Temporal dynamics: History

It is important to understand the natural trajectory of a system to fully understand impact of a change

It is important to understand the natural trajectory
of a system to fully understand impact of a change

Journal of Applied Ecology



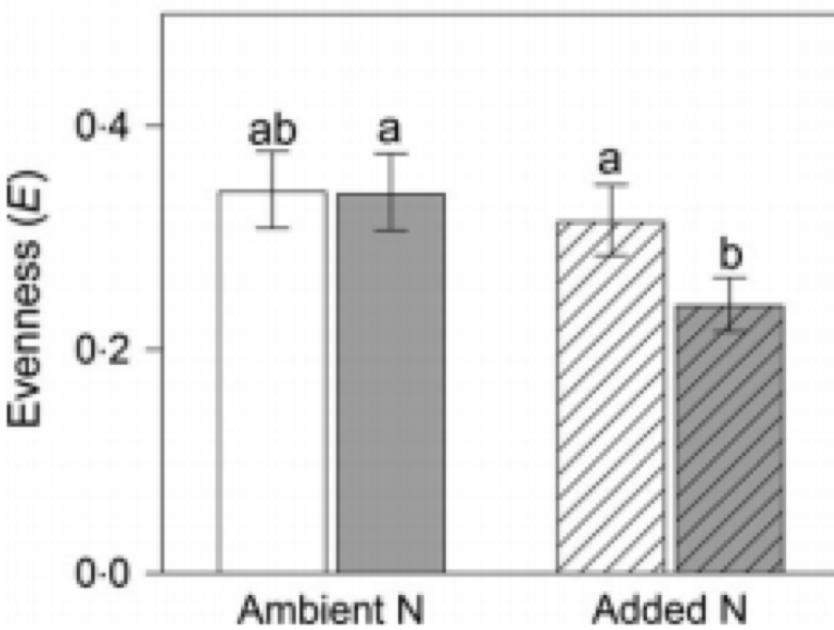
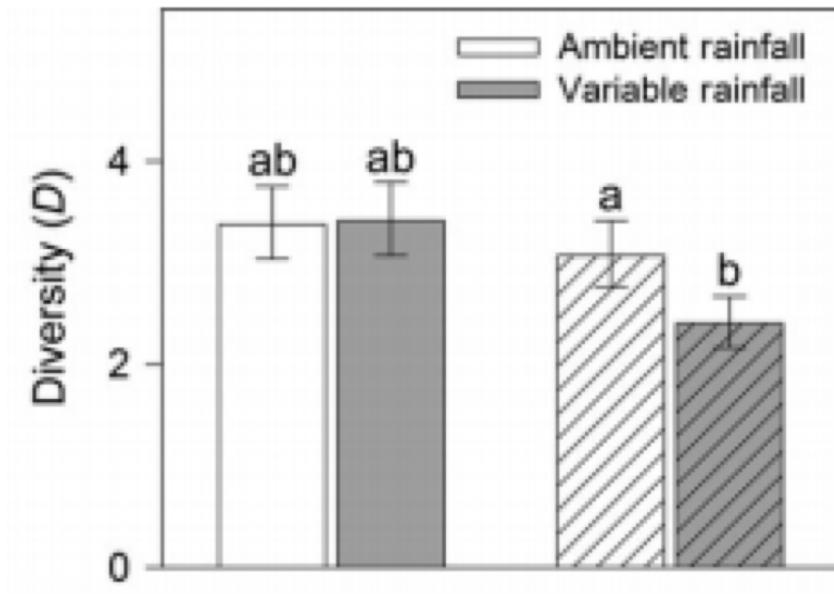
British Ecological Society

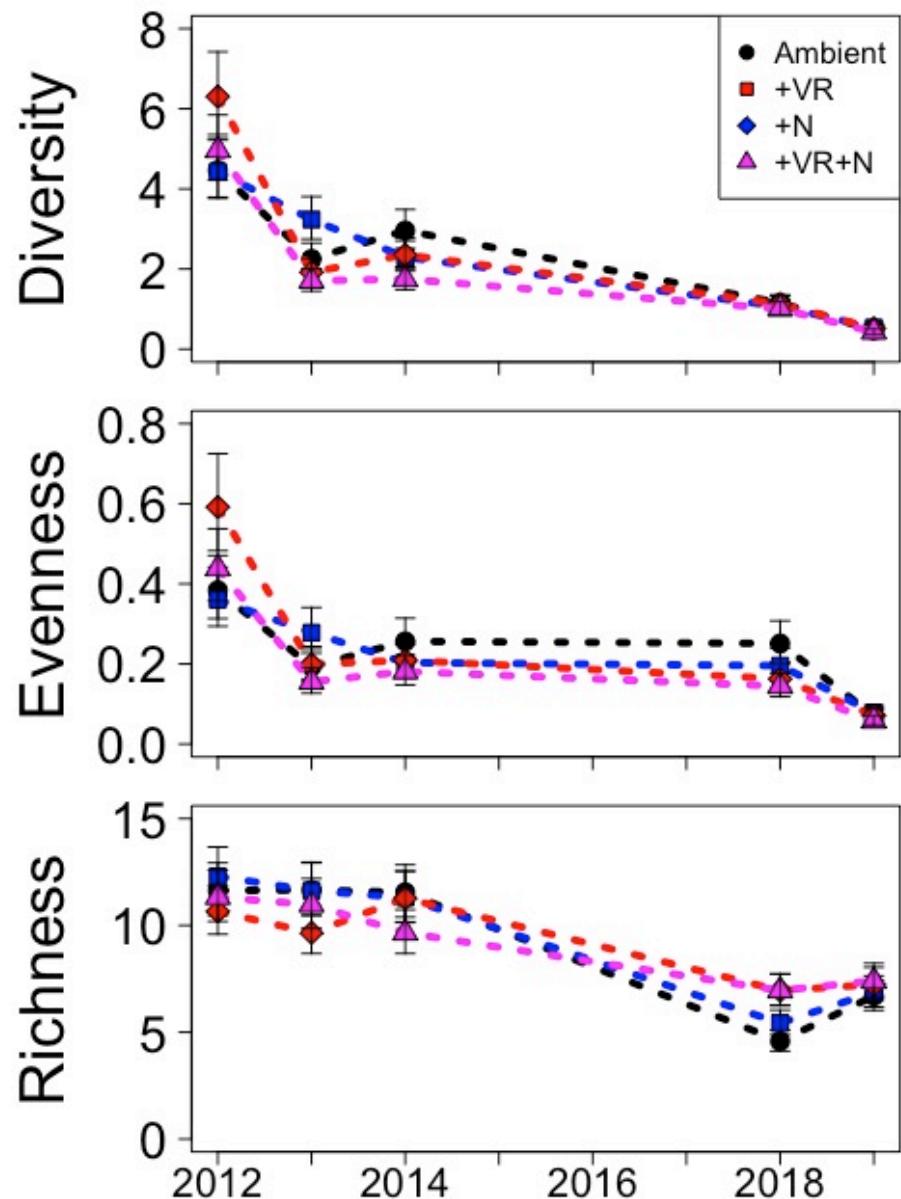
Journal of Applied Ecology 2016, 53, 579–586

doi: 10.1111/1365-2664.12593

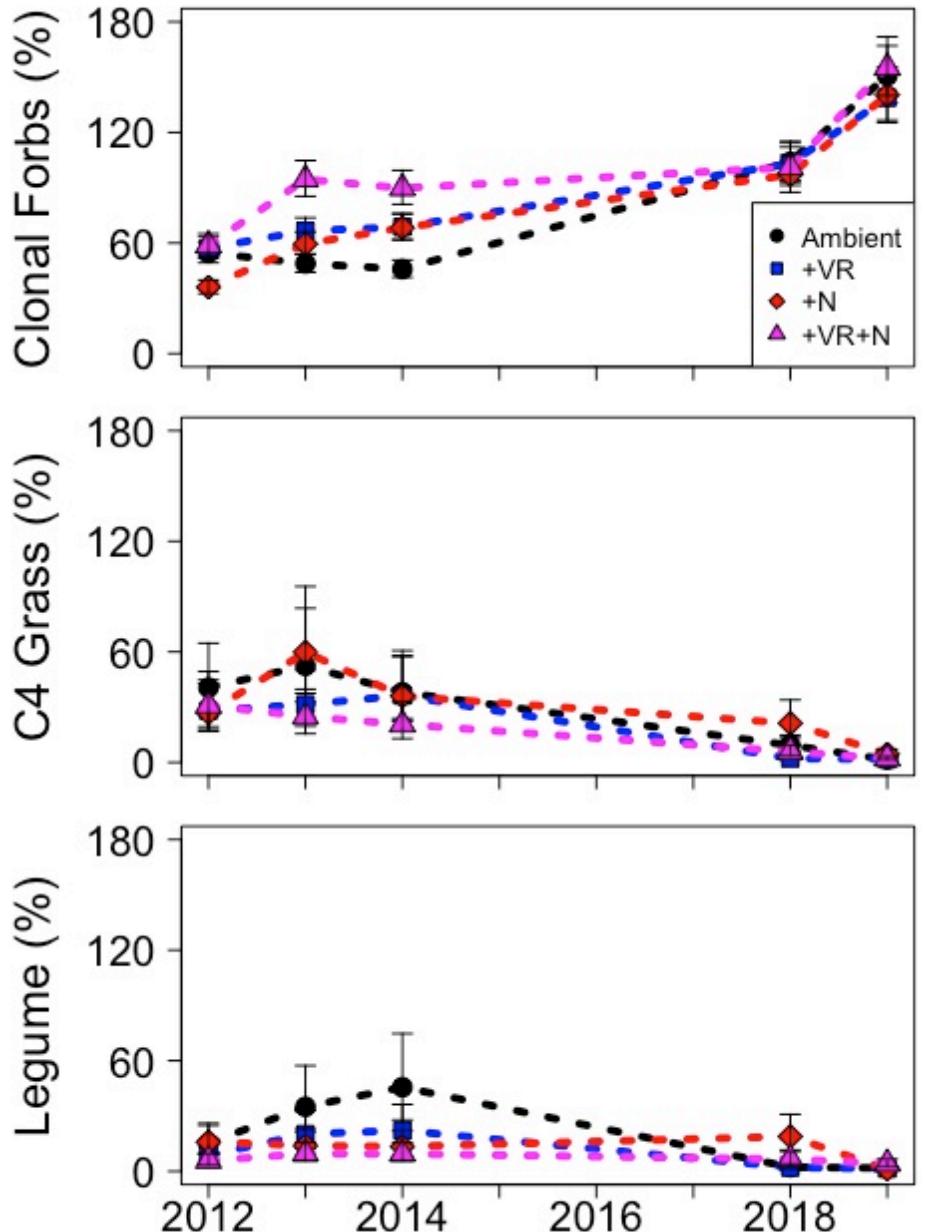
Rainfall variability and nitrogen addition synergistically reduce plant diversity in a restored tallgrass prairie

Nicholas G. Smith^{1,2*†}, Michael J. Schuster^{3†} and Jeffrey S. Dukes^{1,2,3}





Treatments initially decreased diversity, but whole system was headed in that direction



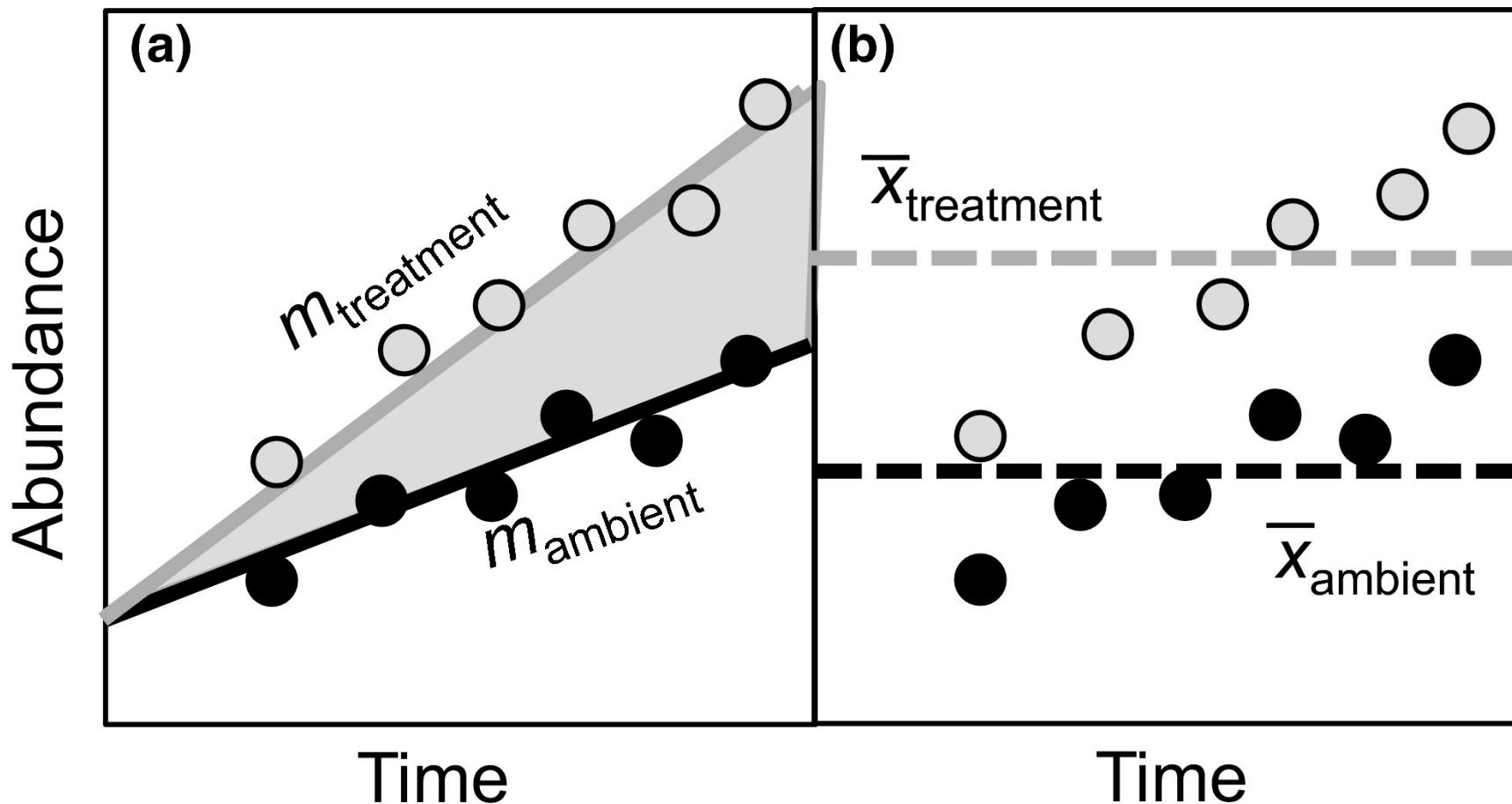
Treatments initially decreased diversity, but whole system was headed in that direction

PRIMARY RESEARCH ARTICLE

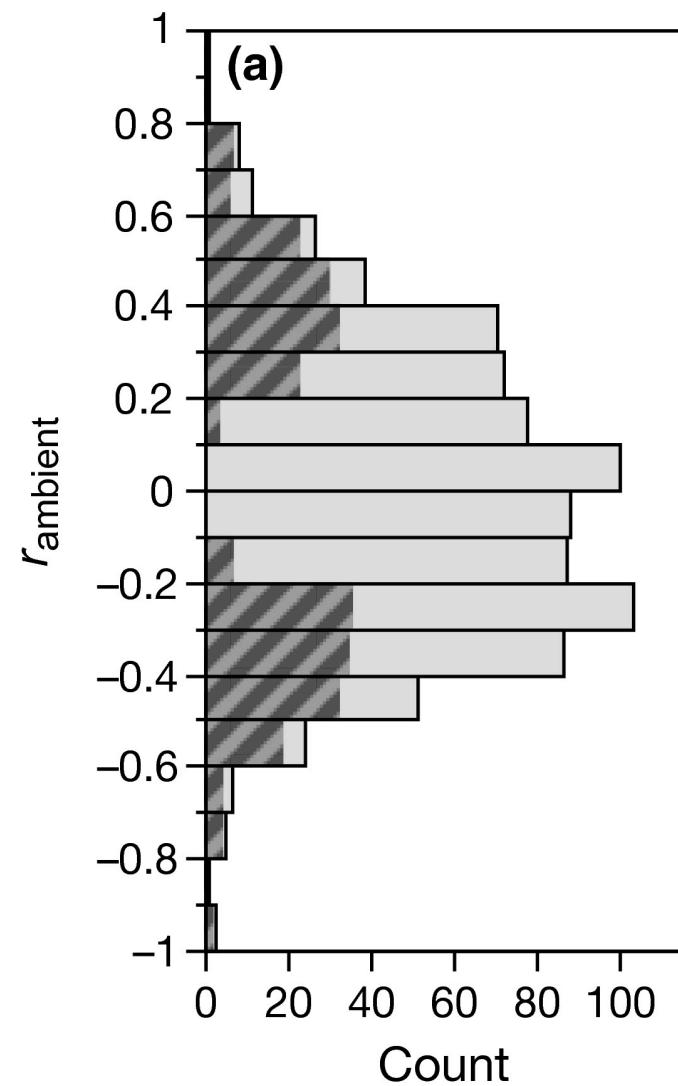
Ambient changes exceed treatment effects on plant species abundance in global change experiments

J. Adam Langley¹  | Samantha K. Chapman¹ | Kimberly J. La Pierre^{2,*}  | Meghan Avolio^{3,*} | William D. Bowman⁴ | David S. Johnson⁵ | Forest Isbell⁶ | Kevin R. Wilcox⁷  | Bryan L. Foster⁸ | Mark J. Hovenden⁹  | Alan K. Knapp¹⁰ | Sally E. Koerner¹¹ | Christopher J. Lortie¹² | James P. Megonigal² | Paul C. D. Newton¹³  | Peter B. Reich^{14,15} | Melinda D. Smith¹⁰ | Kenwyn B. Suttle¹⁶ | David Tilman⁶

Ecosystems are always in flux

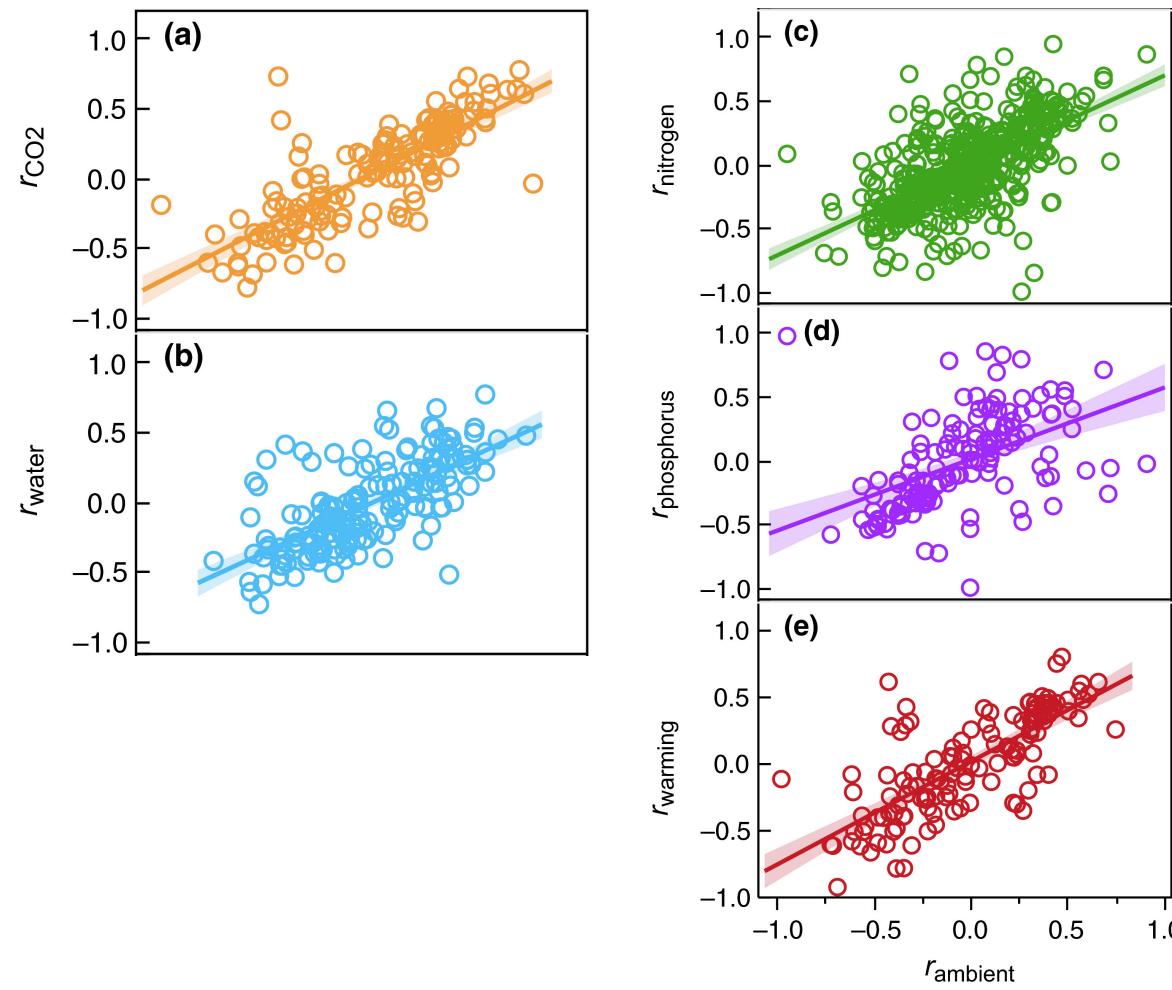


Ecosystems are always in flux



r_{ambient} = change in species composition over time in ambient plots

Natural fluctuations > response to treatments



Change under ambient conditions (x-axis) outpaces change in response to treatments (y-axis). That is, all slopes are <1 .

Temporal dynamics: Disturbance

A photograph of a massive forest fire. The sky is filled with thick, billowing smoke and fire, appearing in shades of orange, yellow, and black. In the foreground and middle ground, the dark silhouettes of tall evergreen trees stand against the bright flames. The fire appears to be at a high intensity, with large plumes of smoke rising into the air.

Is disturbance bad
for ecosystems?

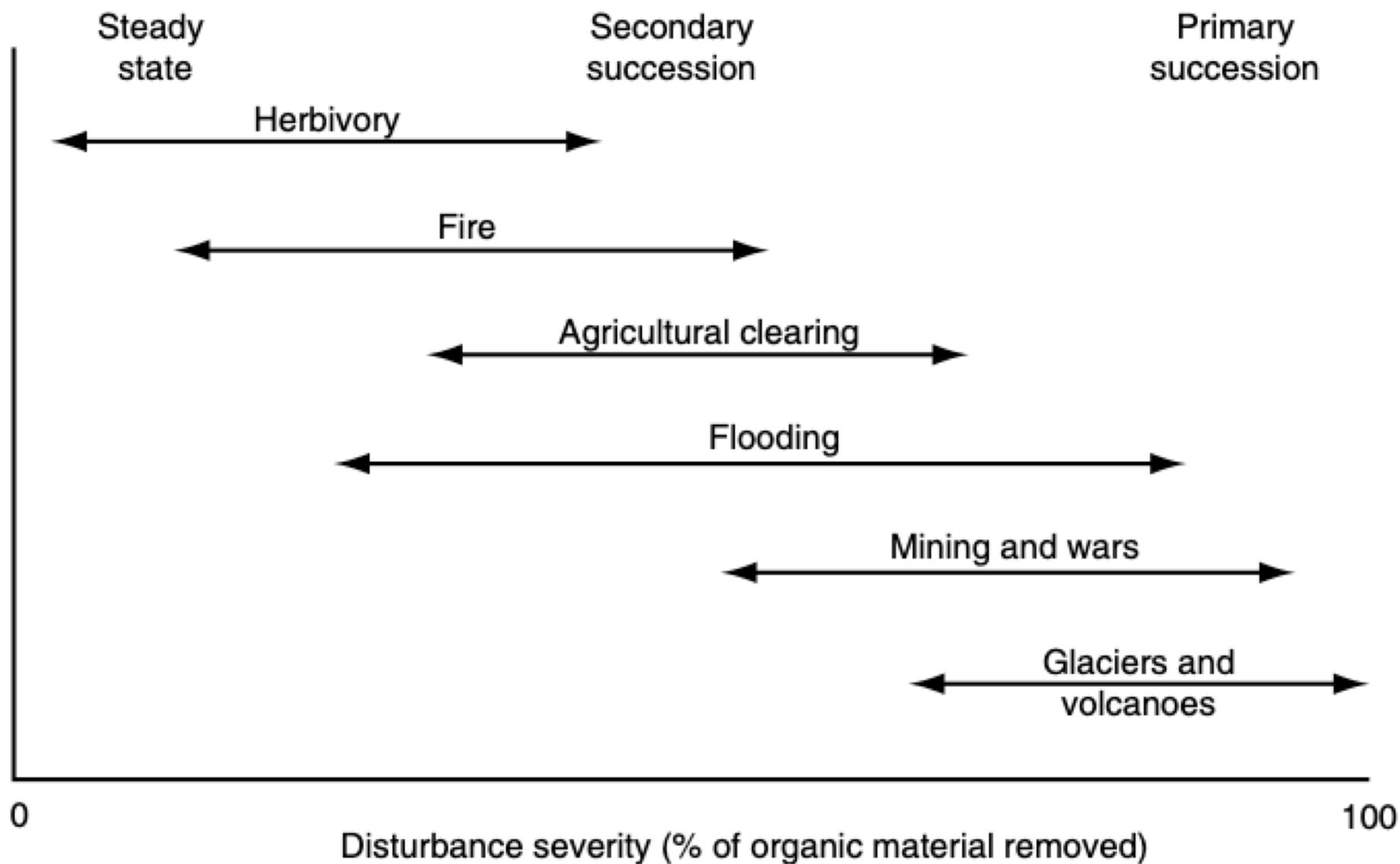
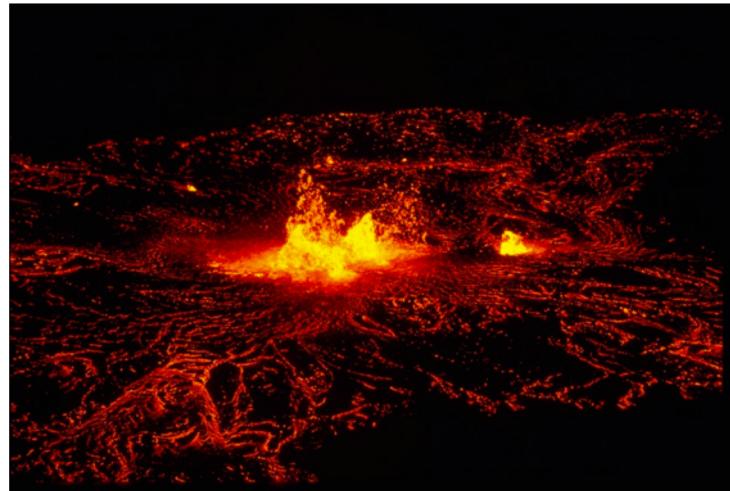


Fig. 12.7 Spectrum of disturbance severity associated with major types of disturbance, ranging from normal steady-state functioning of ecosystems to primary succession

Types of succession

- Primary
 - All organic matter is removed
 - Very little starting material
 - E.g., volcano, glacier
- Secondary
 - Some organic matter remains
 - Some starting material
 - Happening all the time
 - E.g., fire, herbivory



An ecosystem's disturbance regime

- Type of disturbance
 - What happens?
- Severity of disturbance
 - How much change does it cause?
- Frequency of disturbance
 - How often does it happen?

Global change is impacting disturbance regimes

October heat wave breaks records, closes schools

The scorching heat is expected to continue Wednesday with temperatures from the South to the Mid-Atlantic forecast to be 10 to 20 degrees above average.

NBC (10/02/19)

California wildfires trigger statewide emergency and force nearly 200,000 people to evacuate

The Kincade fire in Sonoma County and the Tick fire in Los Angeles County had burned about 35,000 acres.

NBC (10/27/19)

AP/CBS

2011 was Texas' driest year on record

JANUARY 7, 2012 / 9:34 AM / AP

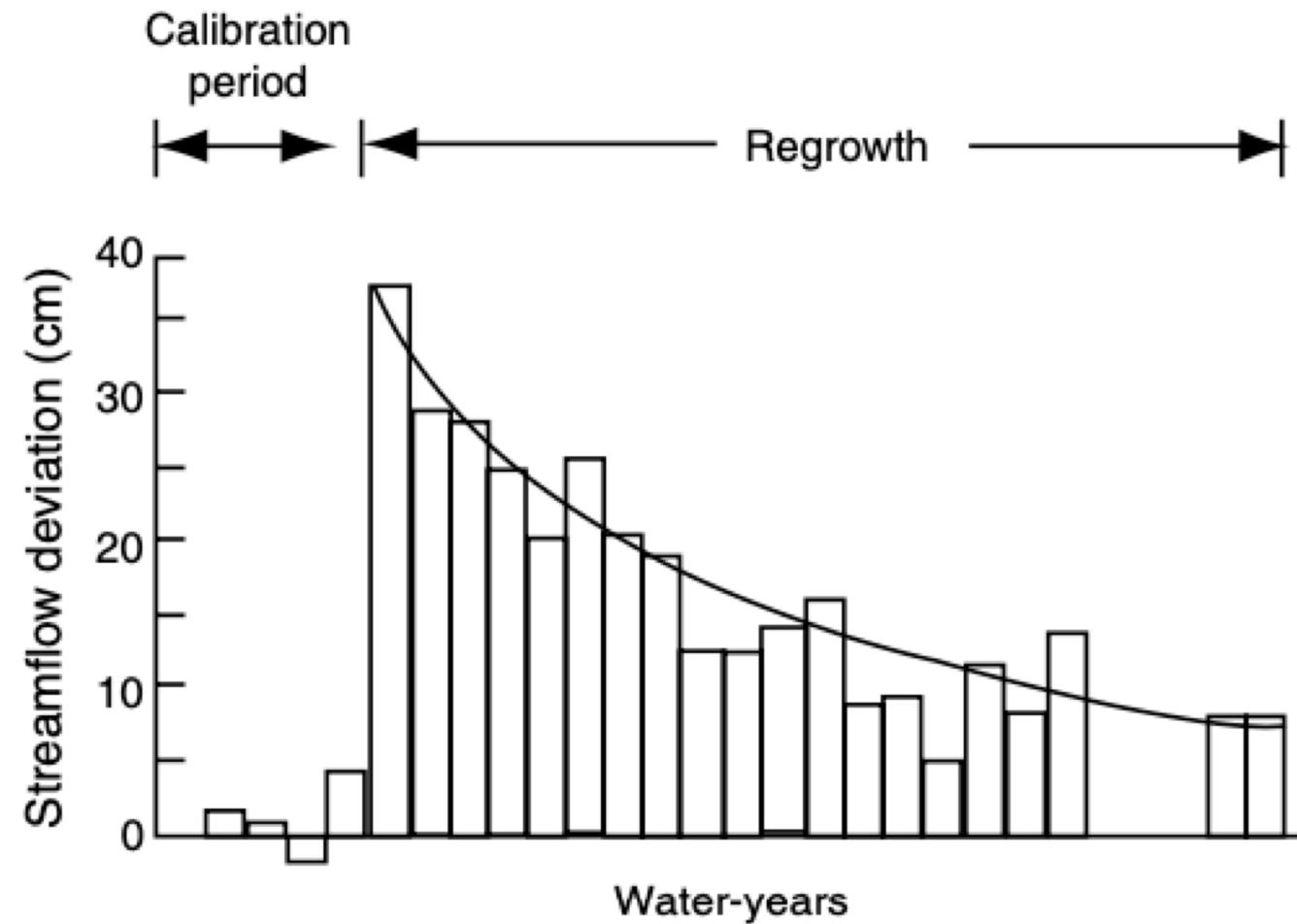


Puerto Rico battered by Hurricane Maria: 'Devastation - it's everywhere'

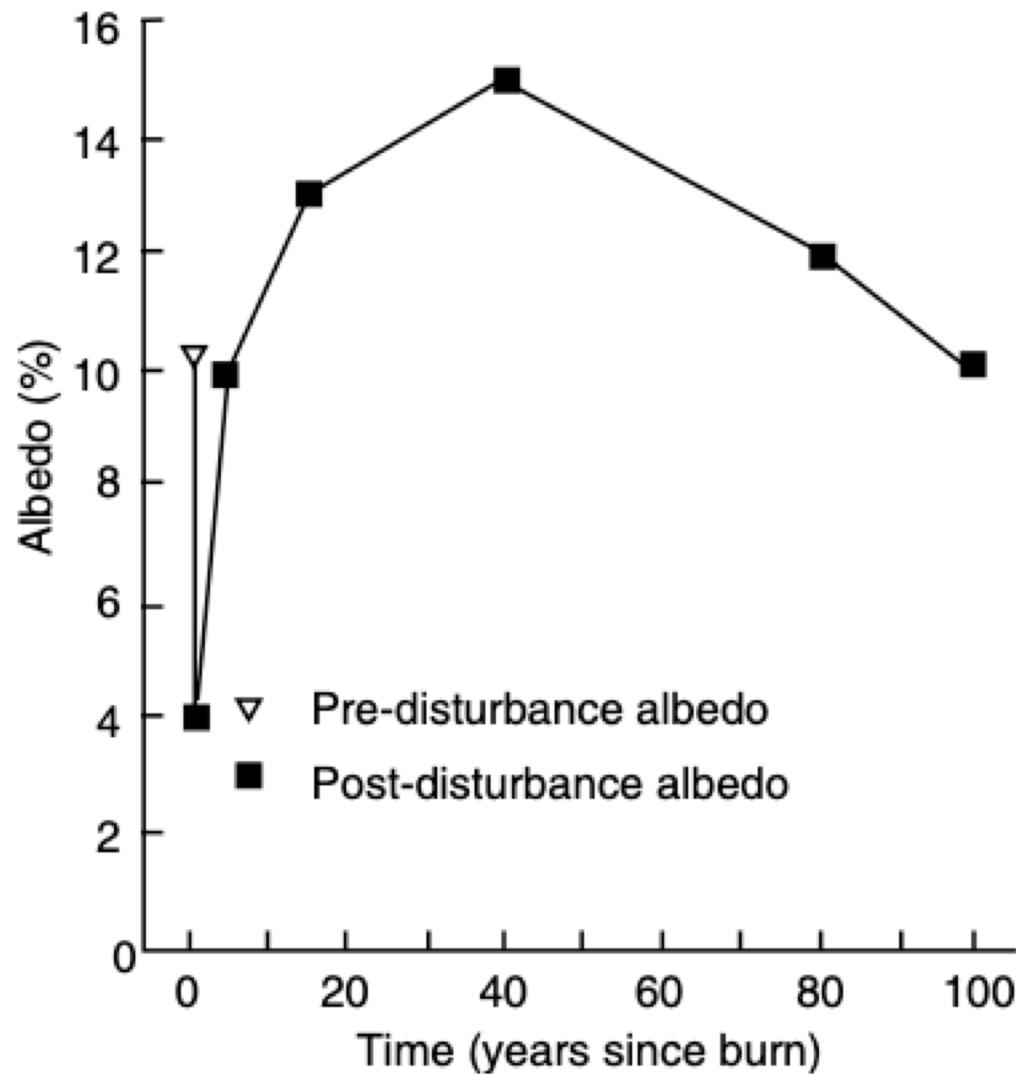
- Worst storm to hit Puerto Rico in 80 years felled trees and smashed buildings
- Governor's spokesman describes scene of 'total devastation'

Guardian (09/21/17)

Ecosystem impacts of disturbance - water



Ecosystem impacts of disturbance - energy



Ecosystem impacts of disturbance - carbon

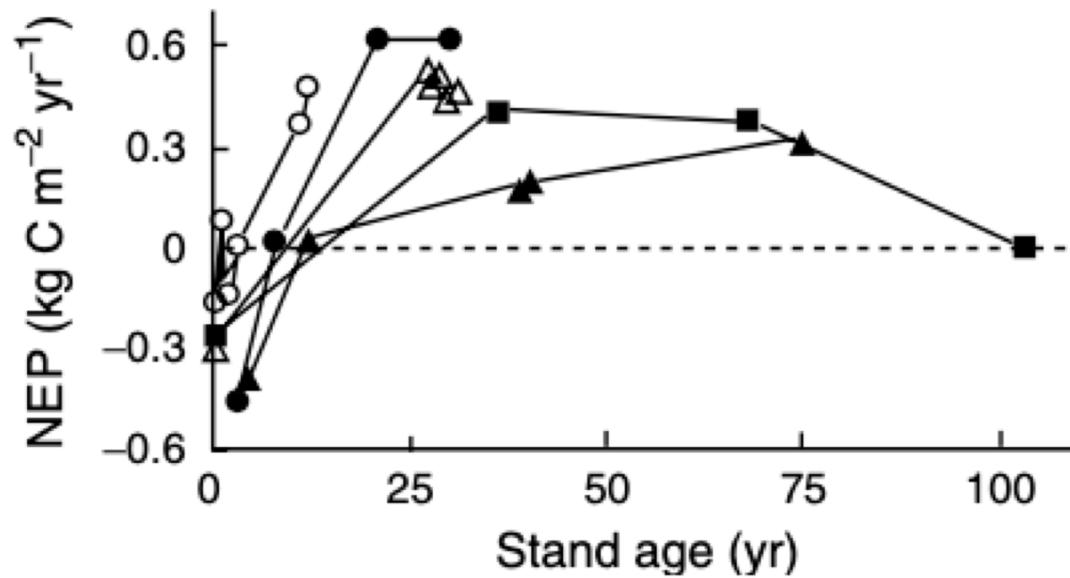
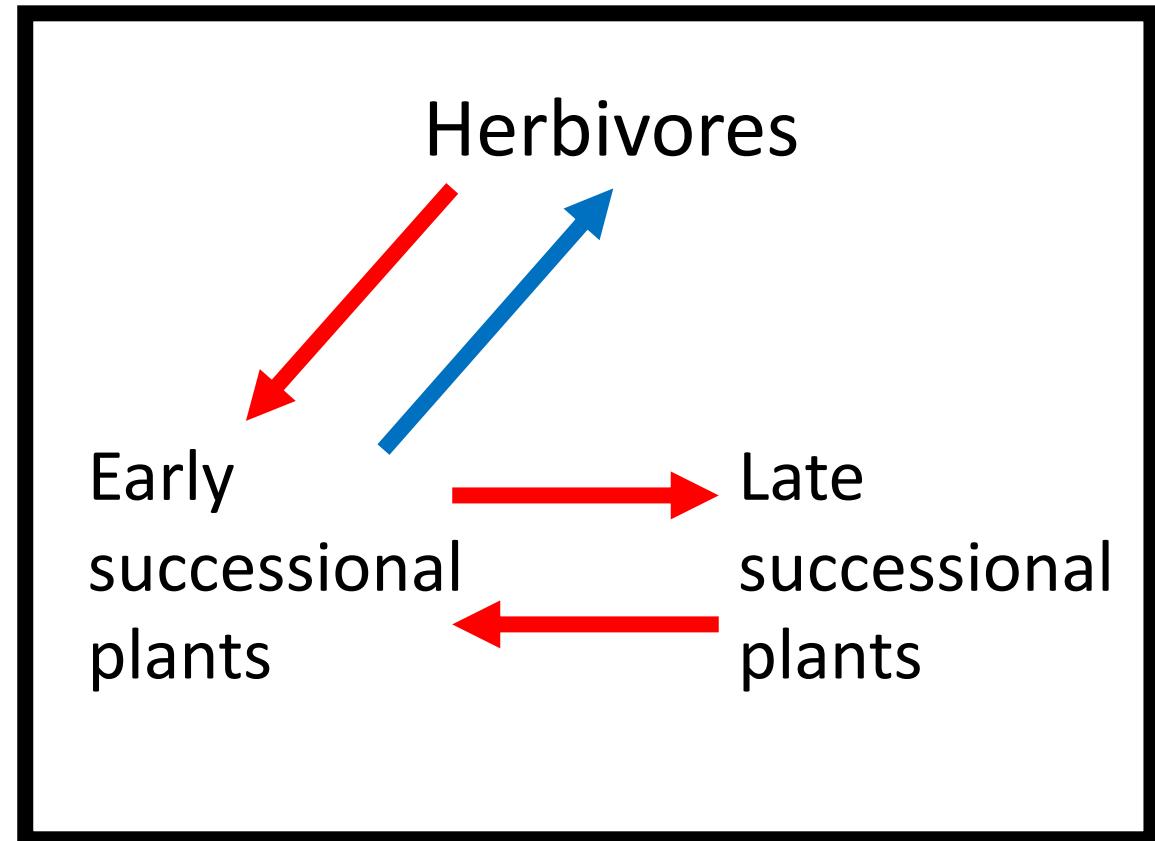


Fig. 12.17 Successional changes in NEP of European forests measured by CO_2 exchange. *Black circles*, *Picea sitkensis*; *white triangles*, *Pinus pinaster*; *gray squares*, *Pinus sylvestris*; *black triangles*, *Pinus sylvestris*; *white circles*, *Quercus cerris*. Redrawn from Magnani et al. (2007)

Ecosystem impacts of disturbance - **herbivory**

Ecosystem impacts of disturbance - **herbivory**

- Herbivory is highest during mid succession
 - Plant biomass is high
 - Plants investing in growth, not defense
- Herbivores can enhance succession
 - Might not be good for them!



Why is it important to consider
the time scale of a study?

