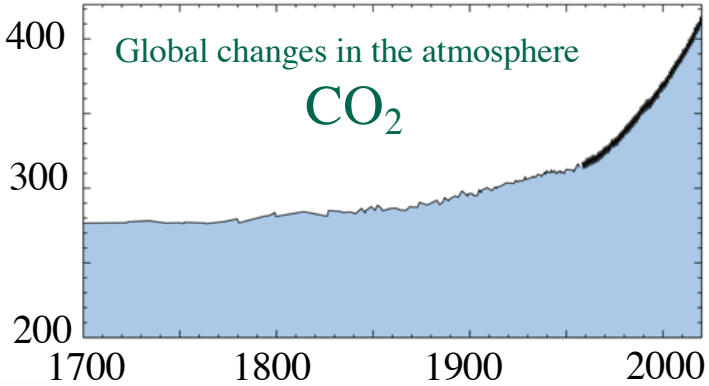


Topic 1

Introduction to Ecology, Adaptation, and the Environment

(4 parts)

Plant Ecology in a Changing World

Jim Ehleringer, University of Utah
http://plantecology.net

What do we cover in this class?

How are you assessed?

Who is the instructor in this class?

Jim Ehleringer

jim.ehleringer@utah.edu
Office: 522 ASB

Office hours: anytime
by appointment

Online discussion hours

Research interests in
- desert ecology
- climate impacts on plants
- stable isotopes

How is this hybrid online course structured?

- 28 different topics are discussed; they broadly represent plant ecology and provide an understanding of how Earth's vegetation is changing as a result of human activities
- Topics are presented as modules in CANVAS
- Topics are presented as a series of 6-7 minute videos that you view online prior to class; each topic has an associated quiz; copies of each slide in a video are provided; additionally, readings are provided
- Required online and in-class time focuses on 3 things:
  - Making sure that you understand the key concepts
  - Data-based discussions with expected participation
  - Optional on-campus field trips to look at vegetation
- Additional optional weekly online discussions where students can direct questions to the instructor and expand on the week's topics
- Student-led online chat and discussion rooms

What topics are covered in this class?

Traditional ecological topics

- World vegetation and relationships with climate
- Ecology of regional landscapes
- Plant adaptations
- Carbon balance, phenology, and life history

Topics central to humankind and our future

- Appreciation of global changes underway
- How global changes are affecting vegetation
- Invasive species and their impacts
- Understanding man's impacts on landscapes
- Urban plant ecology
- A solutions approach to sustainability

We instruct using several approaches

- Online lectures presented in 6-minute segments
- In-person and online group discussions
- Optional self-guided on-campus field trips

We assess student performance using several approaches

- Participation in group discussions
- Seven problem sets
- Two open book, data-based examinations
- A vegetation and climate change paper
- A plant ecology-based policy paper
- A policy debate

Grading in this class focuses on both individual efforts and group (team) participation

(after all, in today's job market most of you will be part of a team; so learning to work in teams is an essential skill)

- Group assignments where students submit a single file; each student earns the same score on that assignment
  - Seven different problem sets (instructor and students select teams)
  - A vegetation and climate change paper (students self-select teams)
  - An ecology-based policy paper (students self-select teams)
  - A policy debate (students self-select teams)
- Individual assignments where students work individually
  - Two open book, data-based exams (students can prepare together)
- Individual level-of-effort participation in group discussions

Participating in a hybrid online course offers you independence, but it requires your regular attention to weekly assignments.

You will be assessed throughout the course based on your

- Participation in discussions
- Understanding of key concepts presented in online videos
- Understanding of key conclusions to assigned readings
- Your ability to problem solve
- Your ability to present data in graphics
- Your ability to research scientific literature, to synthesize and write coherently, and to cite literature as expected in any STEM career job

Our goal is to ensure you have the necessary skills and training to succeed in a STEM career. We are here to help you along that path.

Part 2

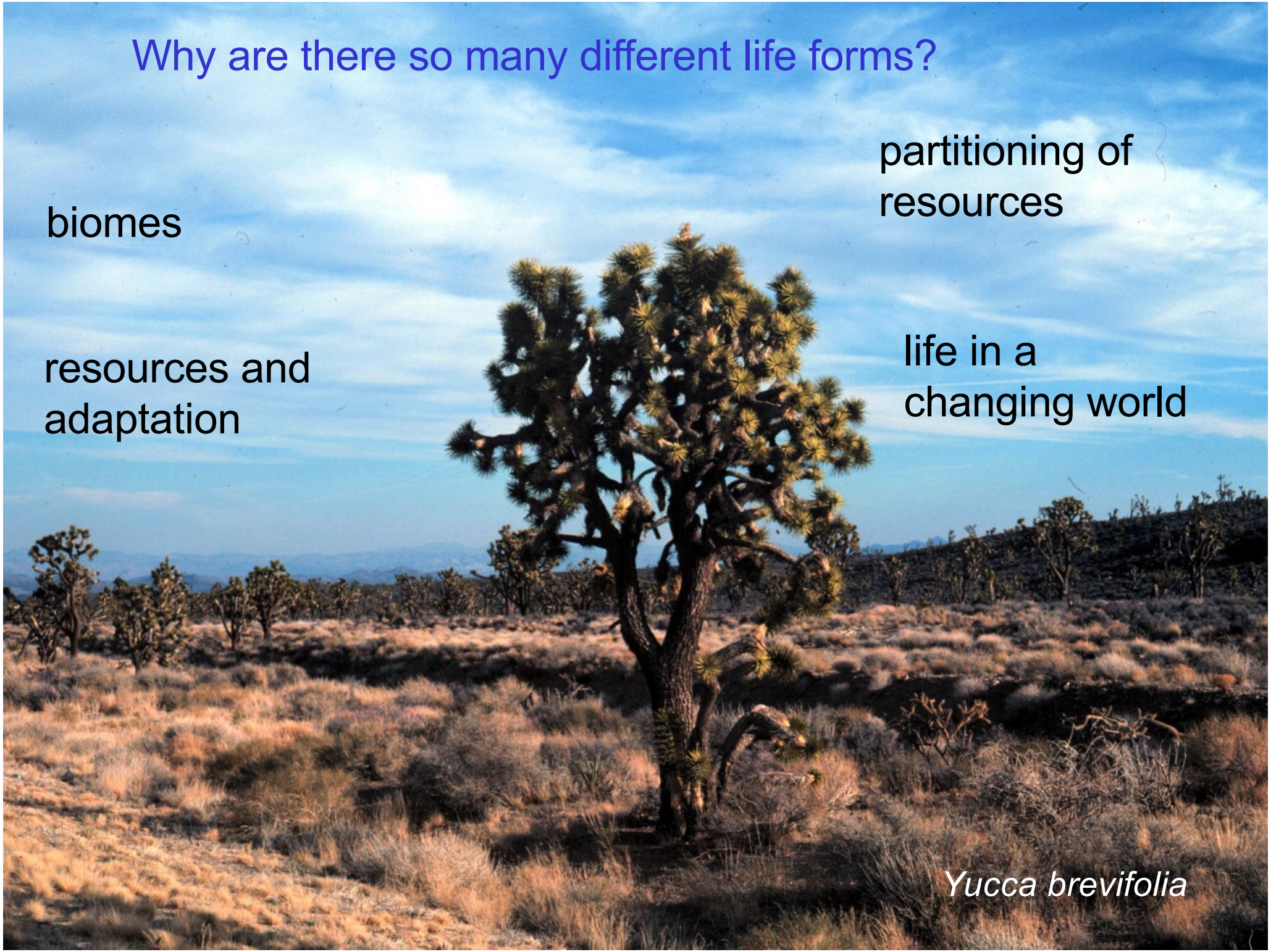
How might one proceed to study plant distributions and adaptations?

Approaches to the science of plant ecology

- Descriptive - observational or analytical
- Experimental - physiology and biochemistry
- Economics - with gains, losses, and tradeoffs
- Consideration of how processes scale
- A genetics approach
- A comparative approach


What is an adaptation?
Eriogonum inflatum

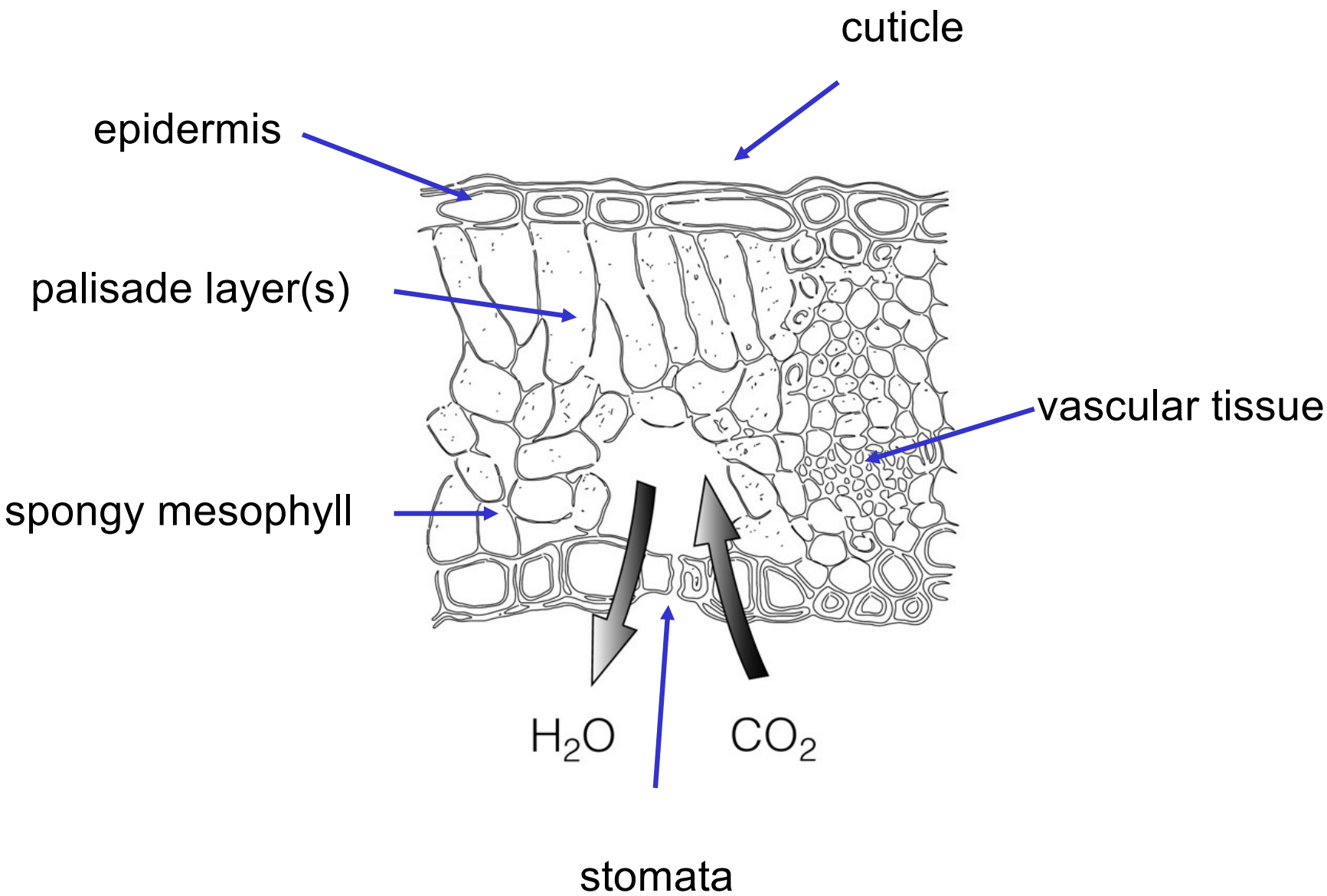

Ramalina menziesii


Why are there so many different life forms?
partitioning of resources
biomes
resources and adaptation
life in a changing world
Yucca brevifolia

We will consider economic analogies:
costs and benefits

- energy and nutrition costs
- lost opportunity costs
- tradeoffs
- net carbon gain approach

Life involves a series of tradeoffs



How do plants work at the whole-plant level?

Consider plants as

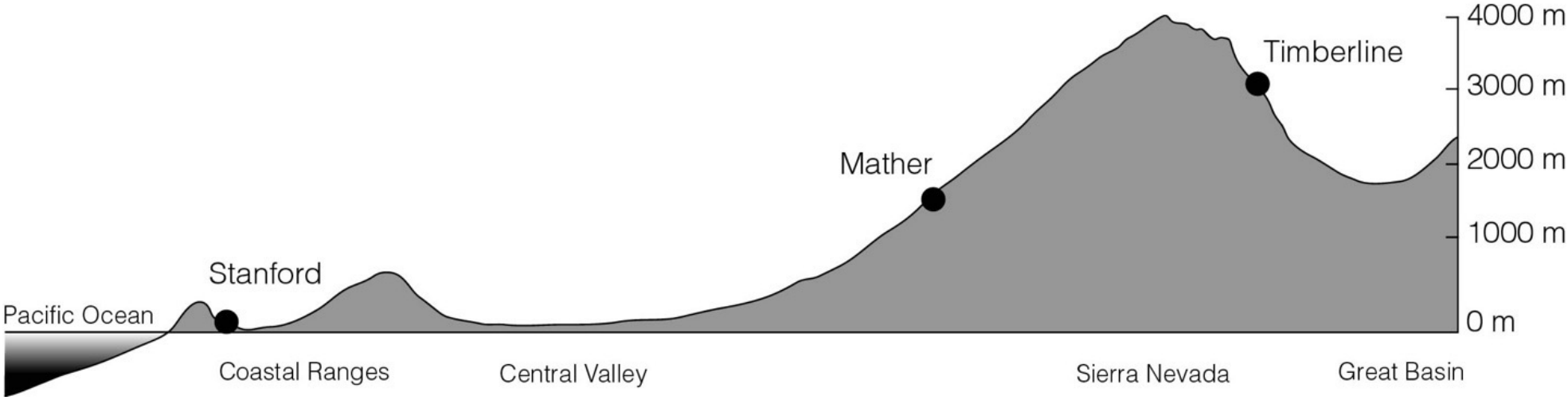
- Repeating, and independent shoot modules
- Coupled, integrated systems

Repeating modules

Comparative approaches are common in ecology

- ecotypes and experimental garden transplants
- environmentally induced changes
- genetic differences and tools
- environmental gradients
- controlled environments
- convergent forms

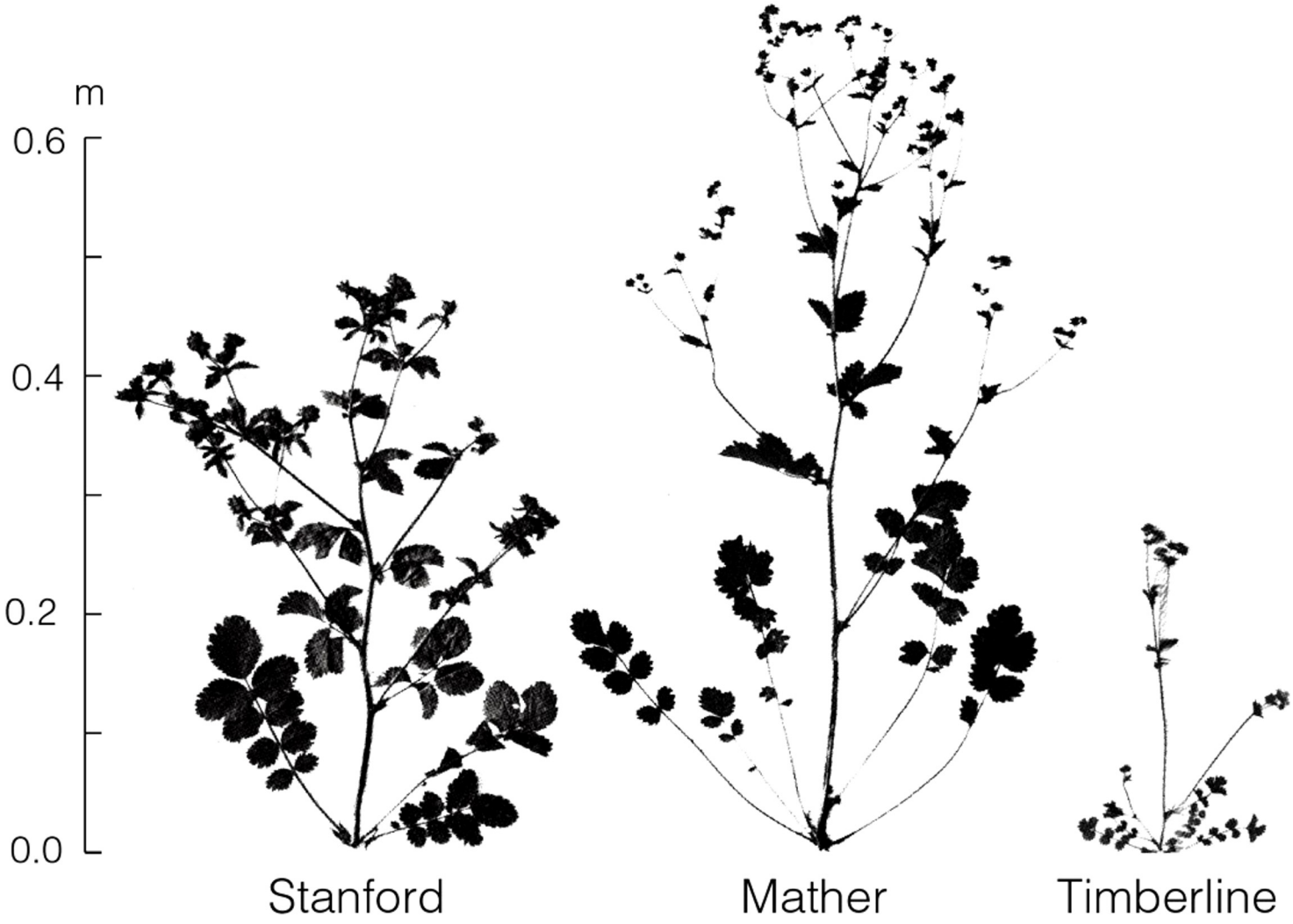
Genetics matters:
Consider *Potentilla glandulosa*,
a common herb in California



A cross-section through central California where *Potentilla* is found

Studies conducted by Clausen, Keck, and Hiesey at the Carnegie Institution of Washington at Stanford University

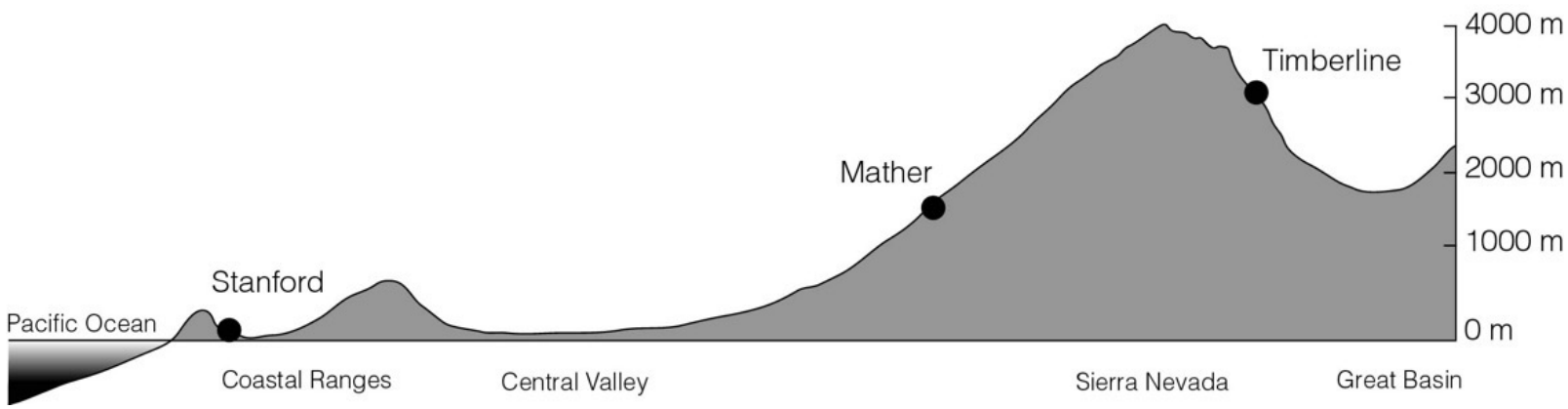
Growth performance of Potentilla glandulosa - a common herb in three different habitats



Studies conducted by Clausen, Keck, and Hiesey at the Carnegie Institution of Washington at Stanford University

Growth of *Potentilla glandulosa* ecotypes

	Common garden location		
Ecotype	Stanford	Mather	Timberline
Stanford	55 cm	35 cm	died
Mather	50 cm	69 cm	11 cm
Timberline	23 cm	44 cm	25 cm

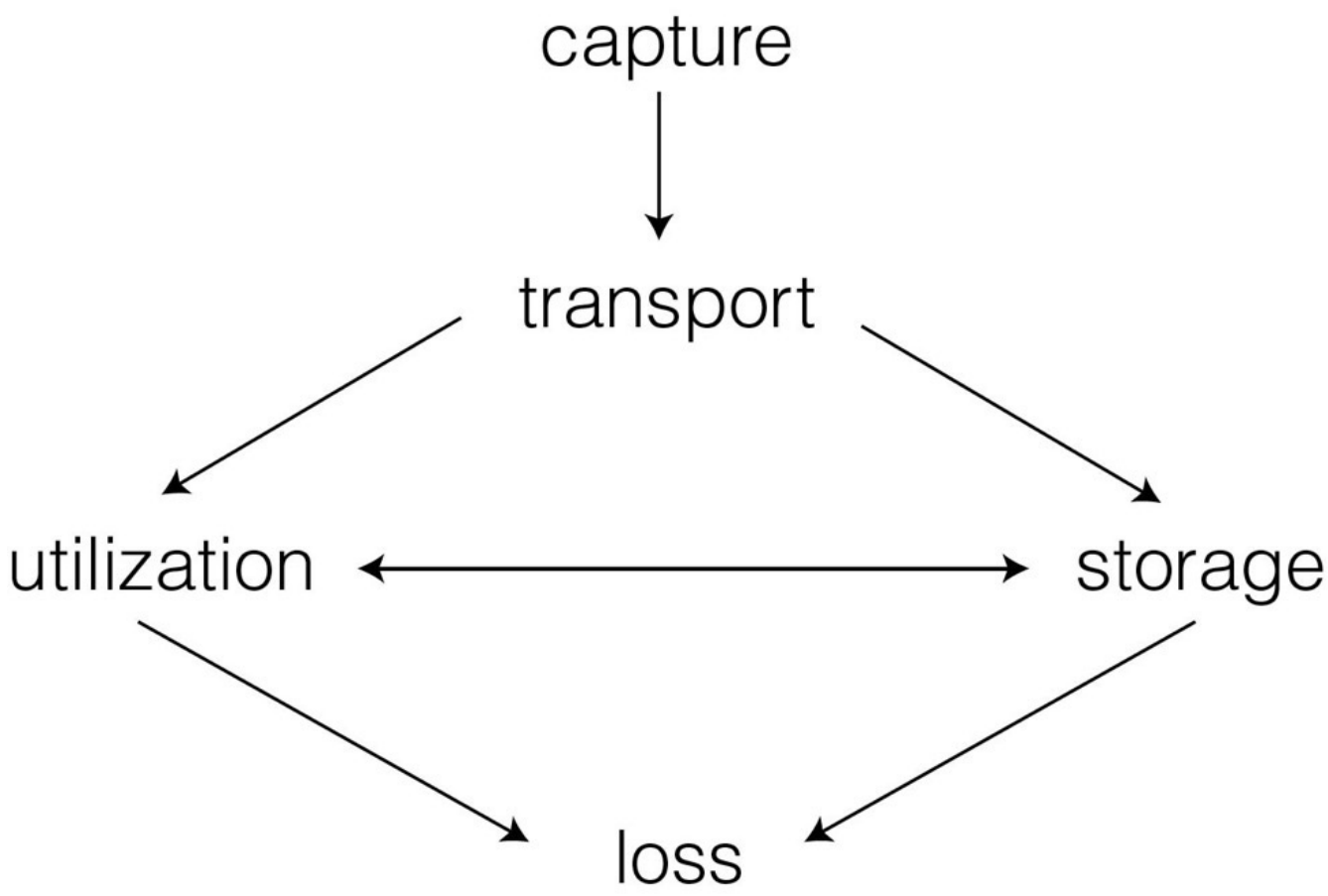


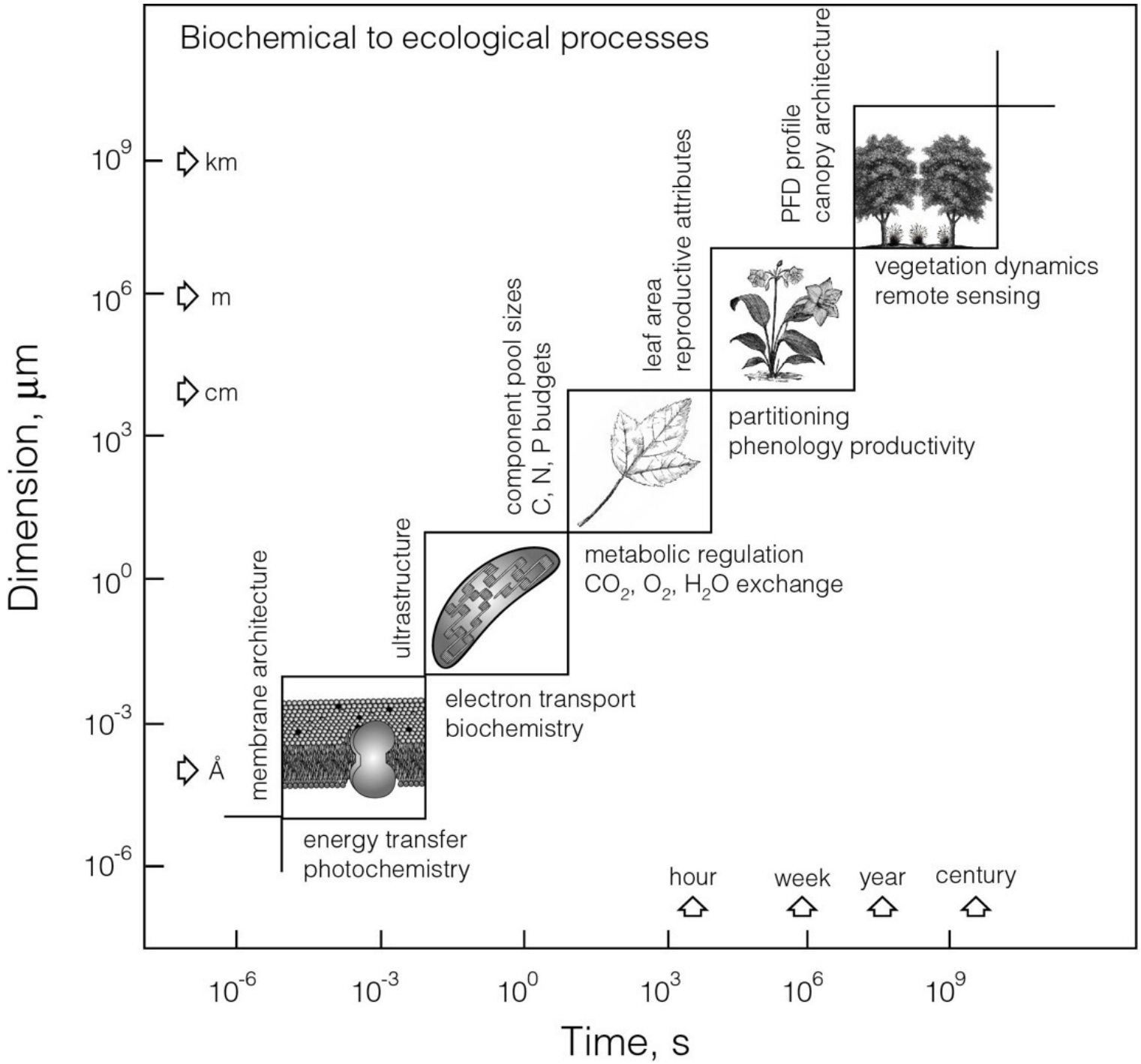
Studies conducted by Clausen, Keck, and Hiesey at the Carnegie Institution of Washington at Stanford University

Part 3

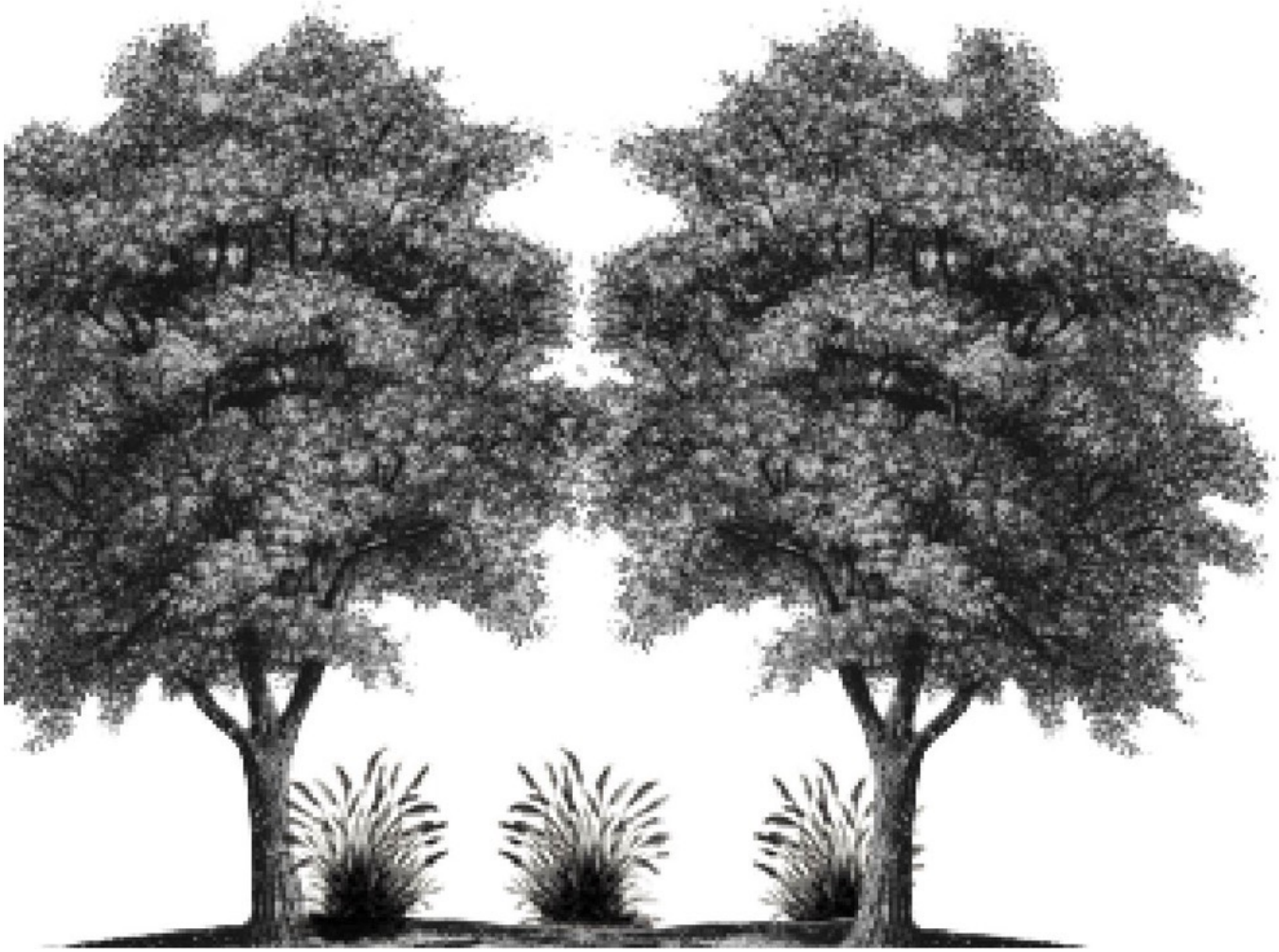
Often a question requires an understanding both time and space

Consideration of whole plant as an integrated system: how are resources used?



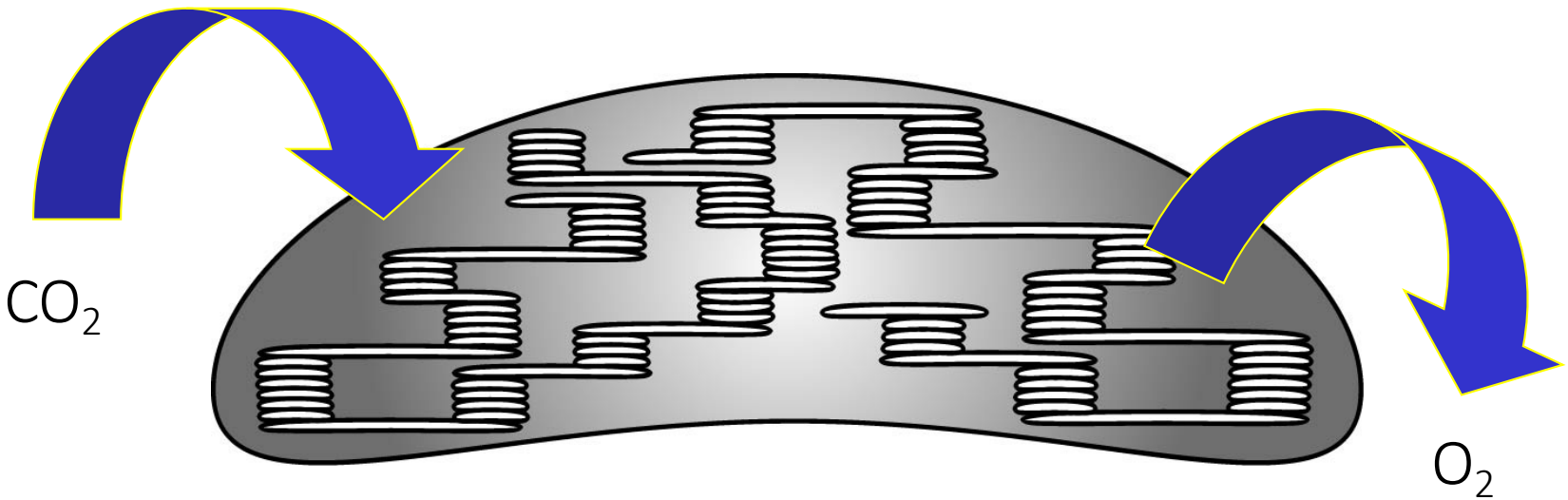

Biochemical to ecological processes
Dimension, µm
10^9
km
10^6
m
cm
10^3
10^0
10^{-3}
Å
10^{-6}
membrane architecture
ultrastructure
component pool sizes
C, N, P budgets
leaf area
reproductive attributes
PFD profile
canopy architecture
energy transfer
photochemistry
electron transport
biochemistry
metabolic regulation
CO_2, O_2, H_2O exchange
partitioning
phenology productivity
vegetation dynamics
remote sensing
hour
week
year
century
10^{-6}
10^{-3}
10^0
10^3
10^6
10^9
Time, s

Trees consist of many leaves conducting photosynthesis, which in turn consist of many chloroplasts.

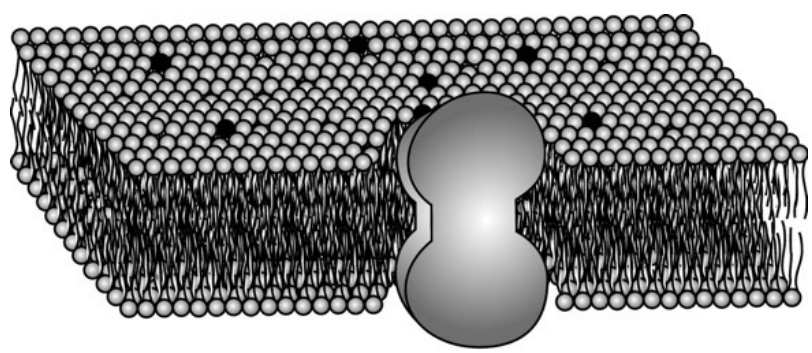


Repeating modules

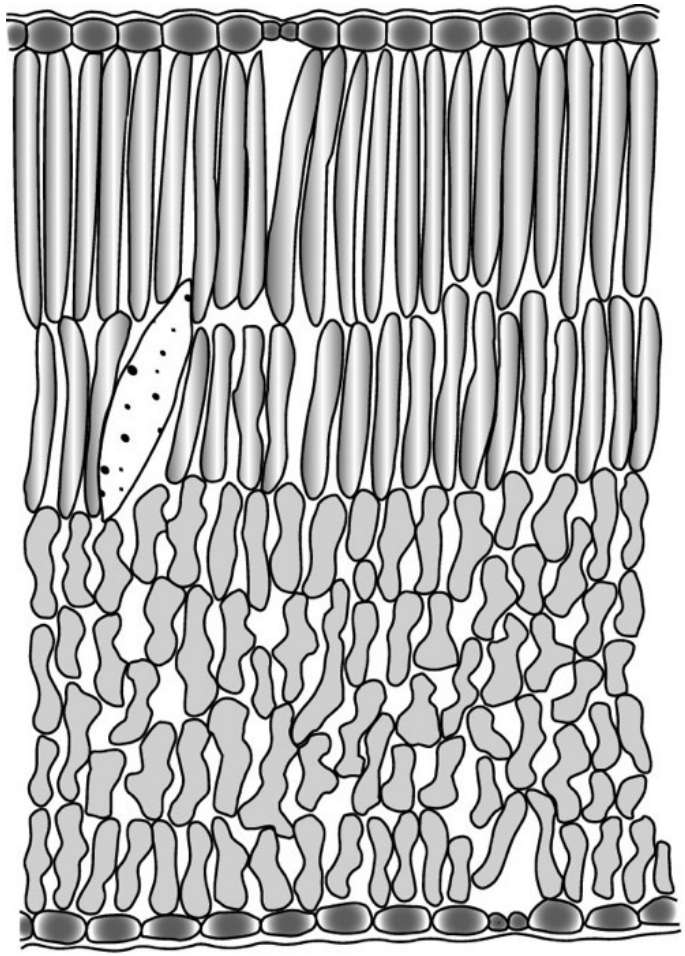
Is what happens at the chloroplast level relevant to higher scales?



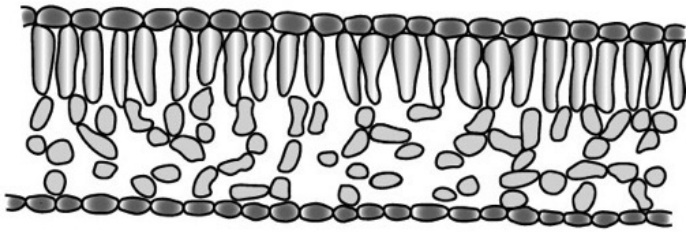
Yes, the scale at which you address your question does matter



Within each of those leaves, acclimation occurs with respect to leaf size, cell size, and chloroplast size.

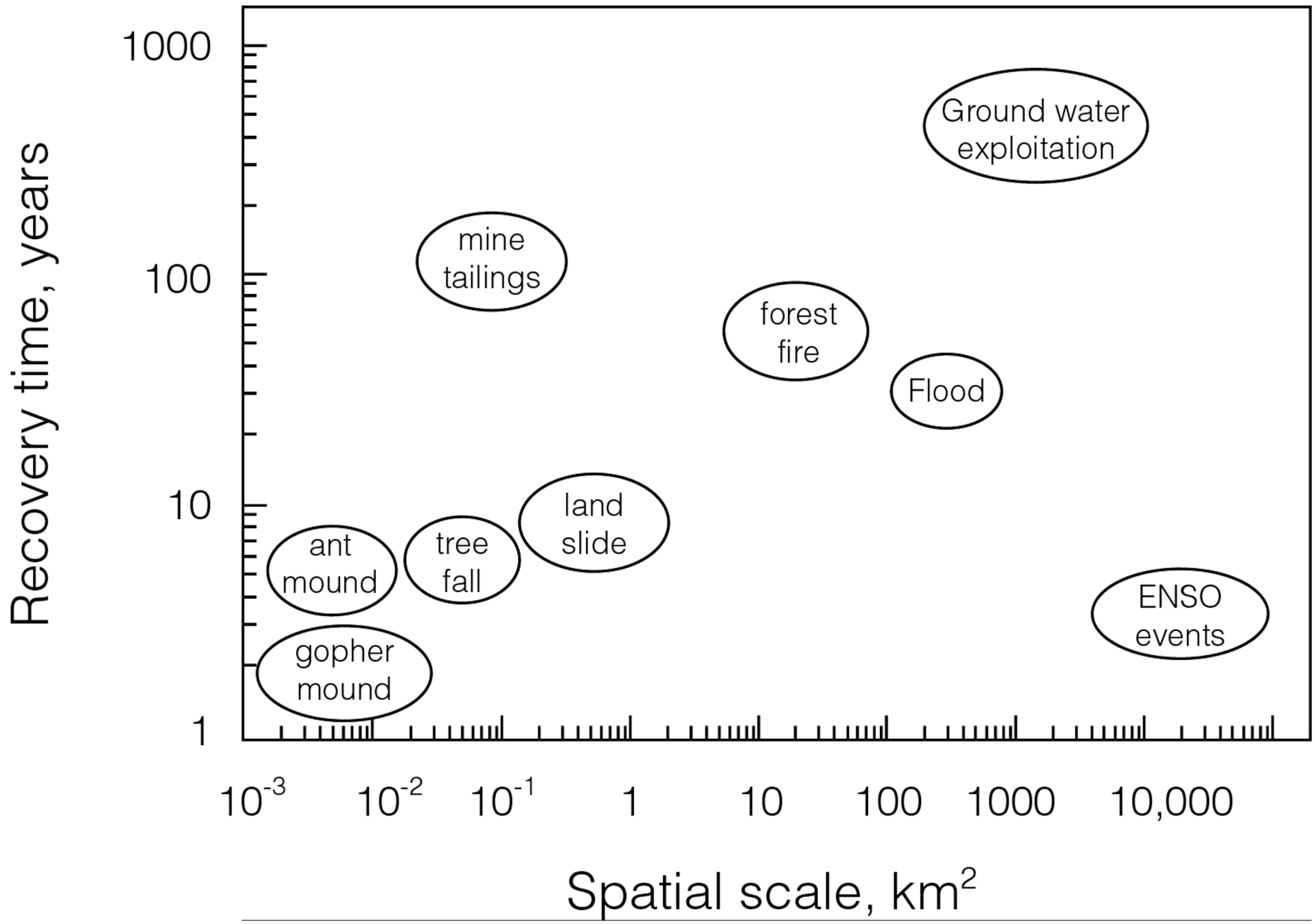


Full sunlight



Deep shade

Equilibrium is a fallacy - the history of vegetation at a site is relevant



Part 4
Understanding ecology in a time of massive global changes

Climate Change

-Warming

- Precipitation change
- Extreme weather events

Atmospheric Composition Change

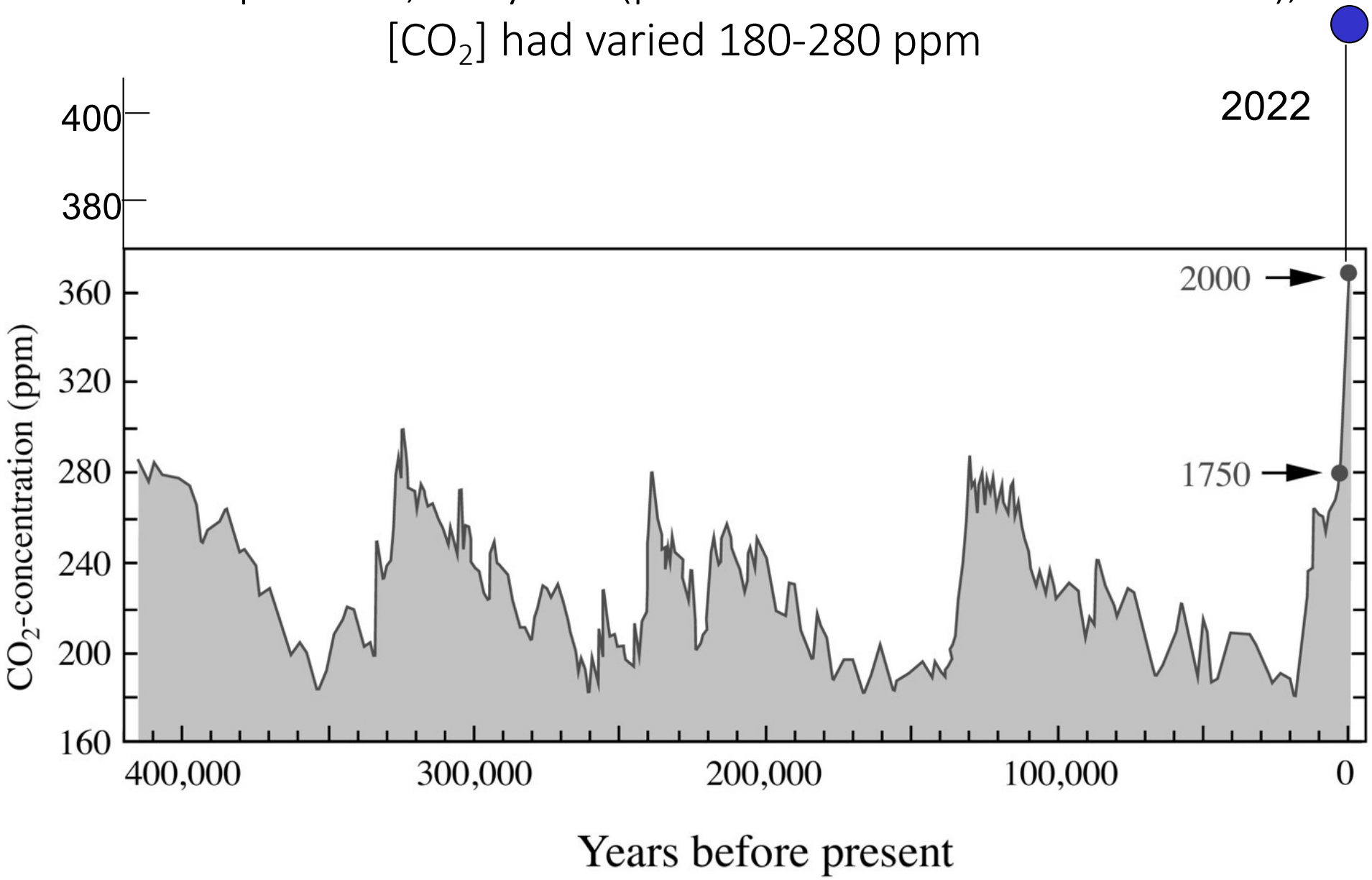
- [CO_2] and other GHG
- Stratospheric ozone

Global Changes are occurring

Land Use and Cover Change

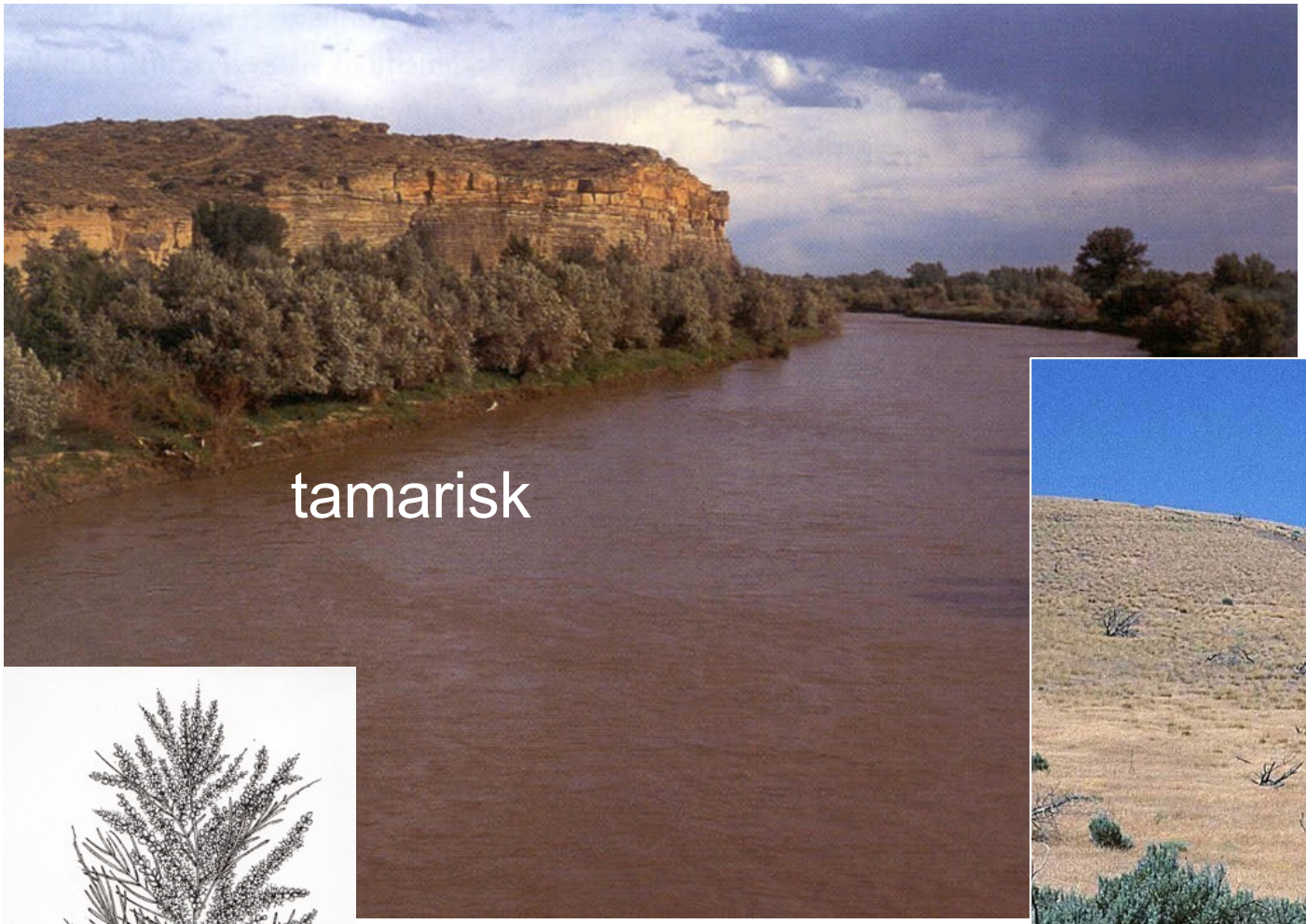
Biological Invasions

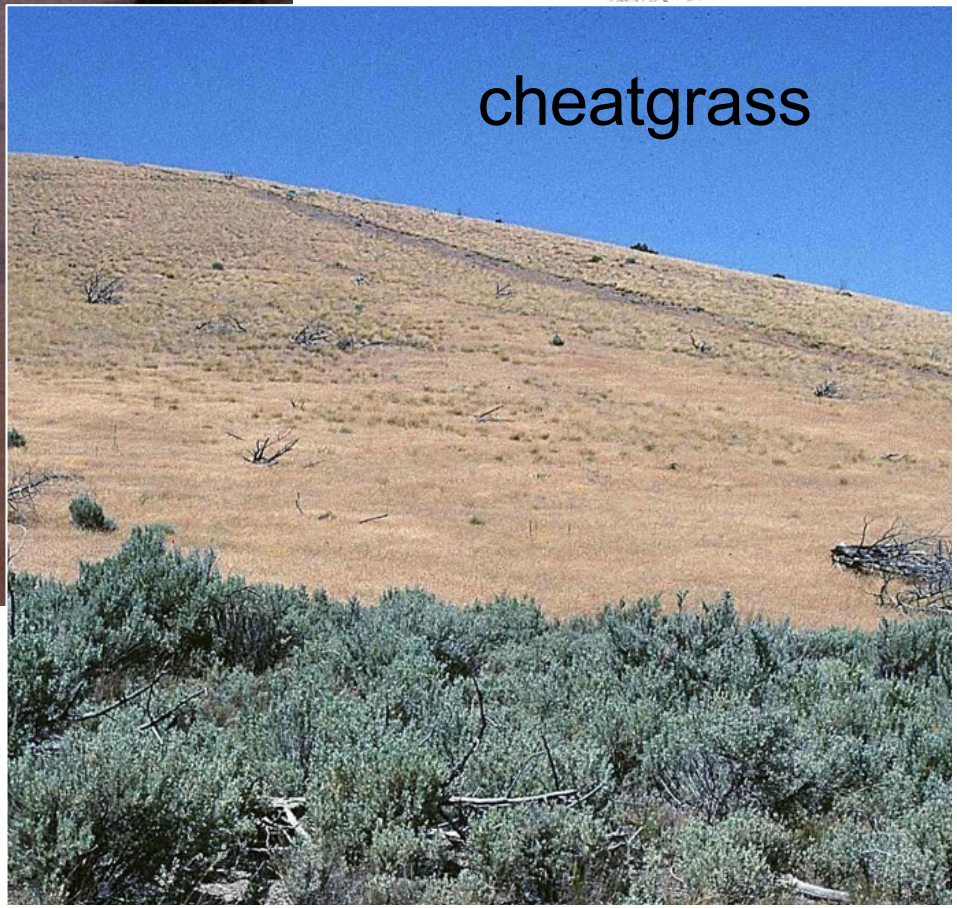
Over the past 400,000 years (prior to the Industrial Revolution), [CO_2] had varied 180-280 ppm



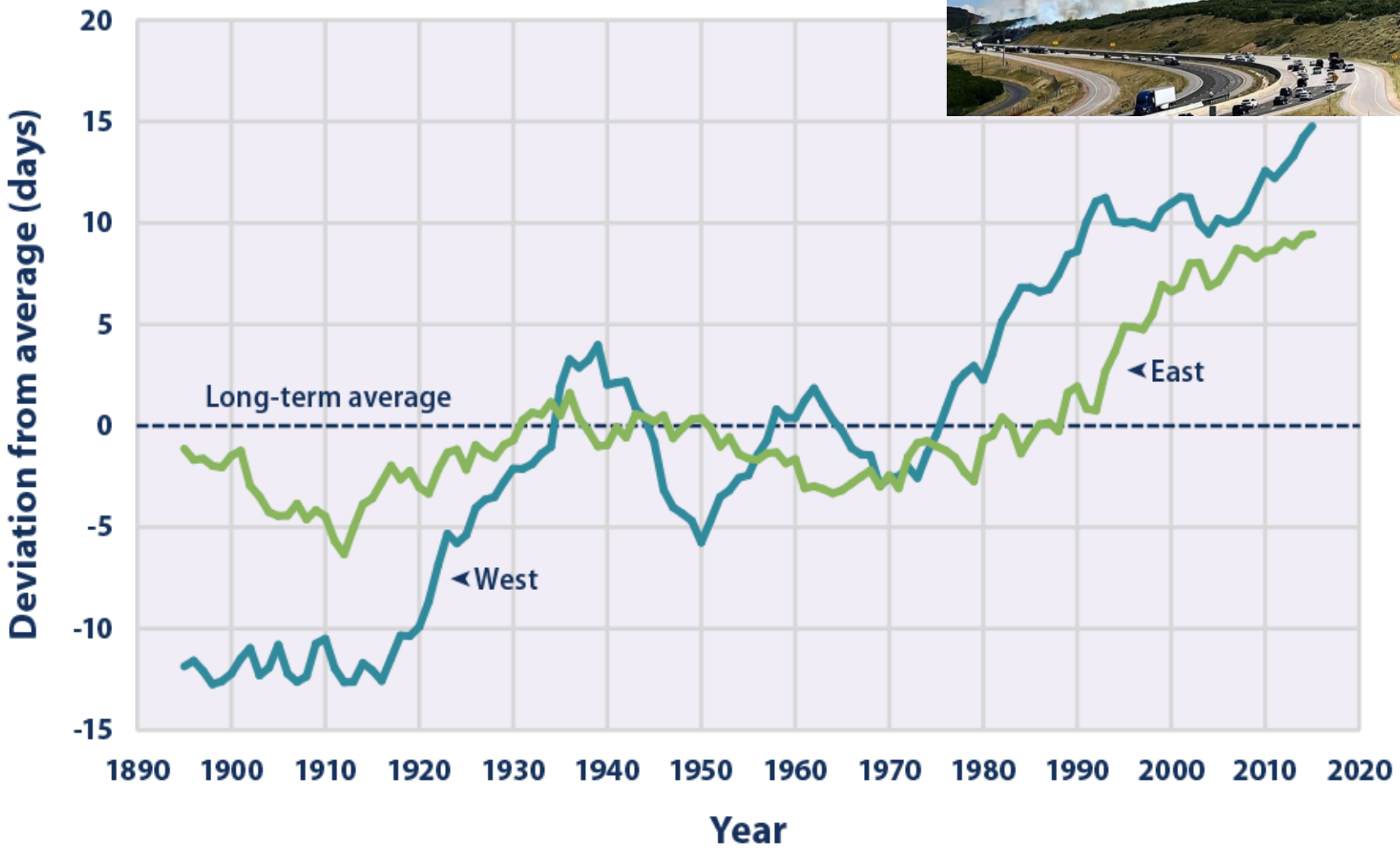
Implications for evolutionary aspects: adaptation, acclimation, exaptation, adaptive radiation

Globalization has led to the spread of invasive species

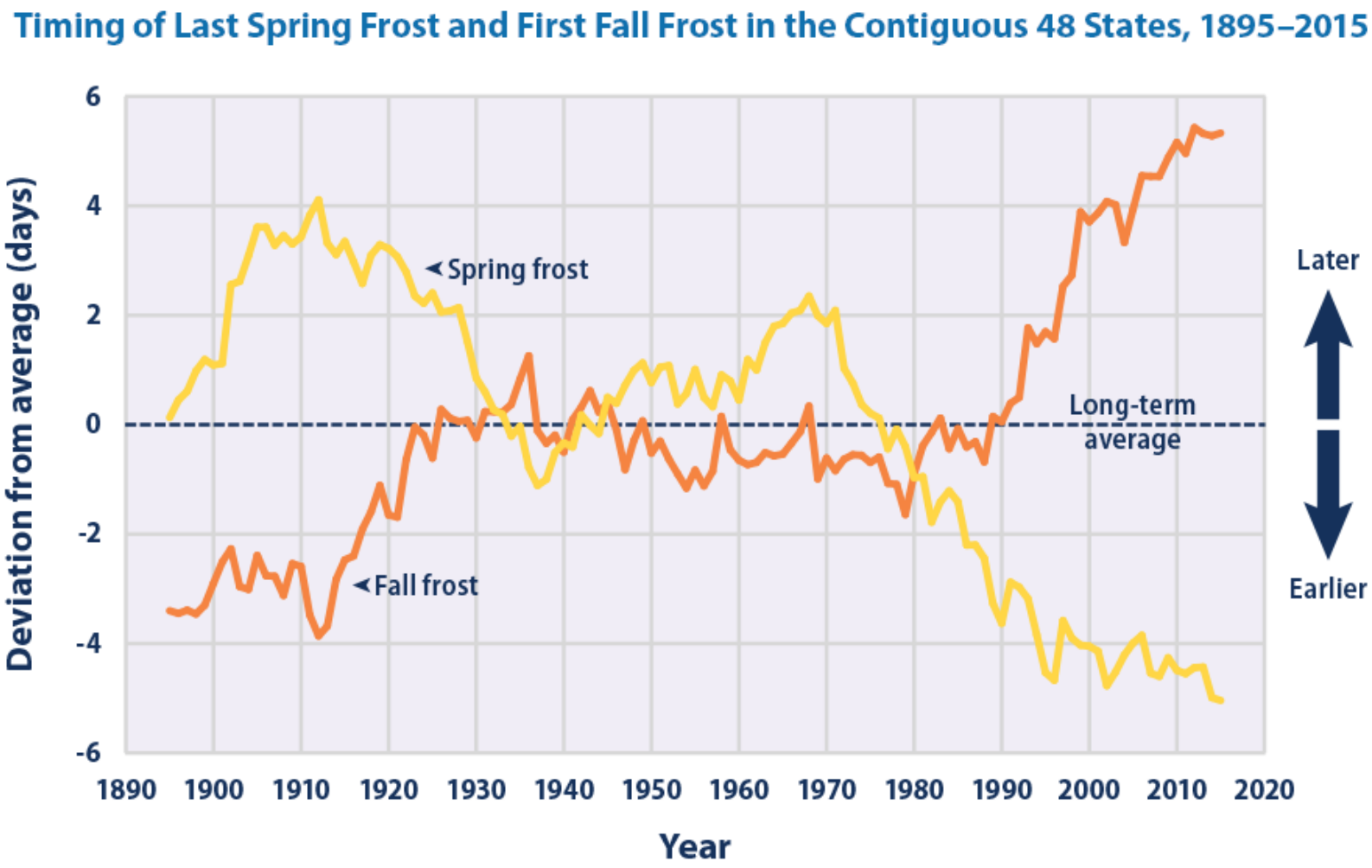




Climate changes are leading to higher temperatures and increases in fire susceptibility



Climate changes are leading to changes in the timing of plant activity (phenology)



Data source: Kunkel, K.E. 2016 update to data originally published in: Kunkel, K.E., D.R. Easterling, K. Hubbard, and K. Redmond. 2004. Temporal variations in frost-free season in the United States: 1895–2000. Geophys. Res. Lett. 31:L03201.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.