

Issues of Scale in Spatial Ecology - Part 1

Learning objectives

- Explain the scale dependent nature of pattern and process and why consideration of scale is important
- Describe / define the components of scale
- Employ basic statistical methods for quantifying scale of spatial (temporal) structure

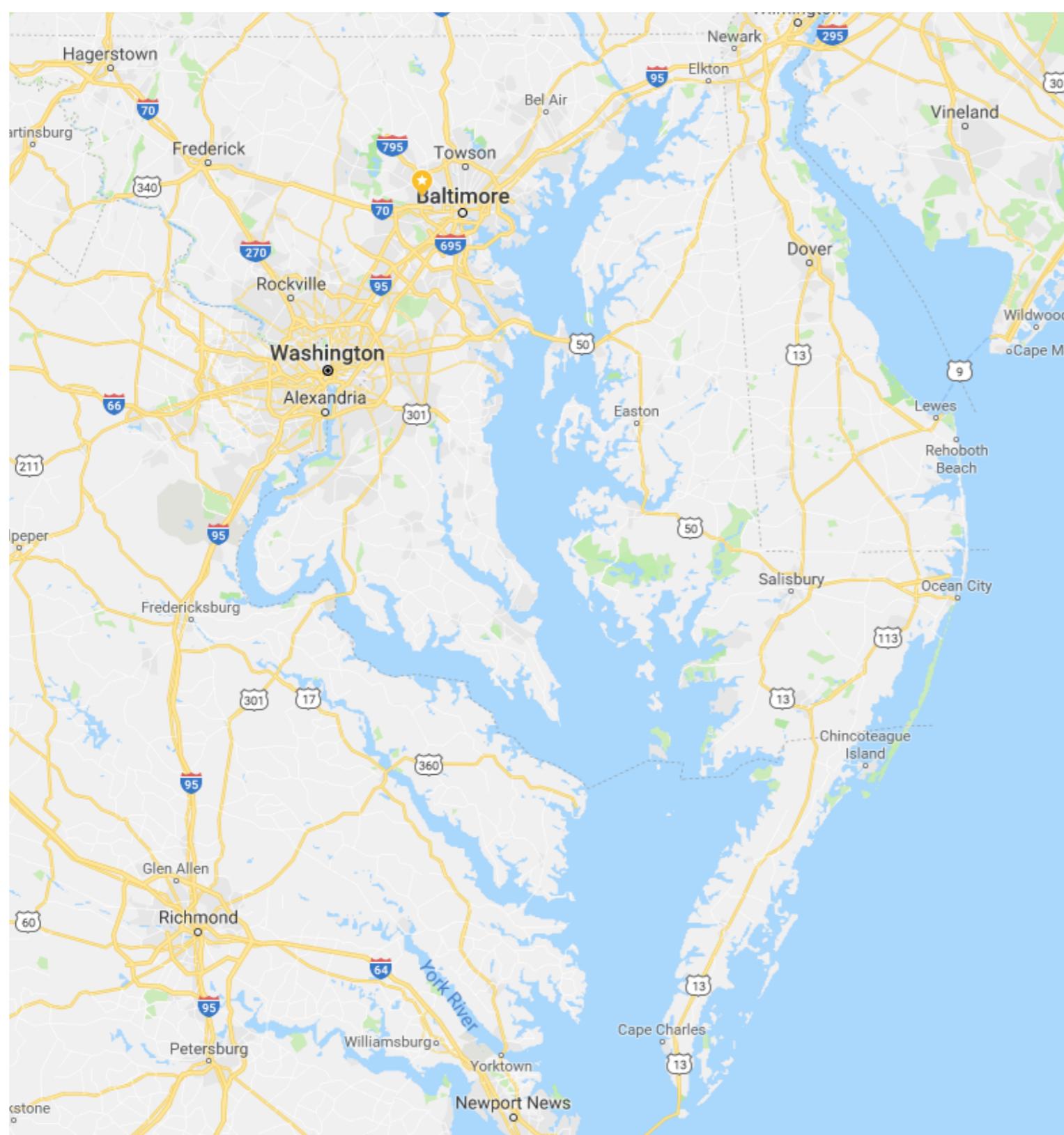


fractals are scale invariant, but most things aren't

Thought experiment #1

How long is the coast of Maryland?

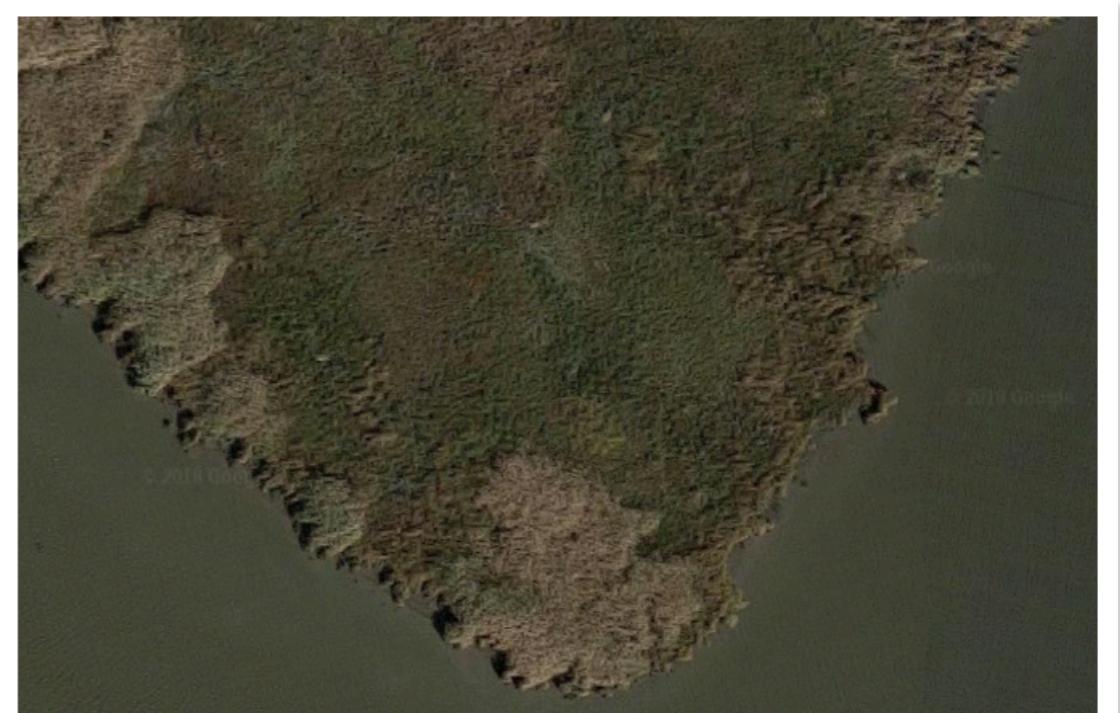
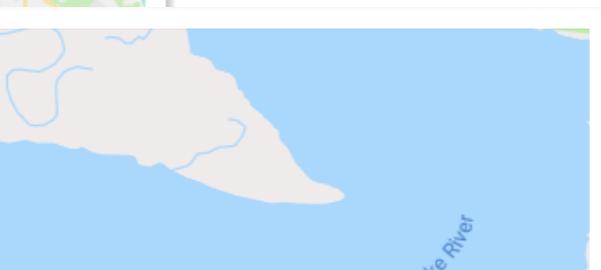
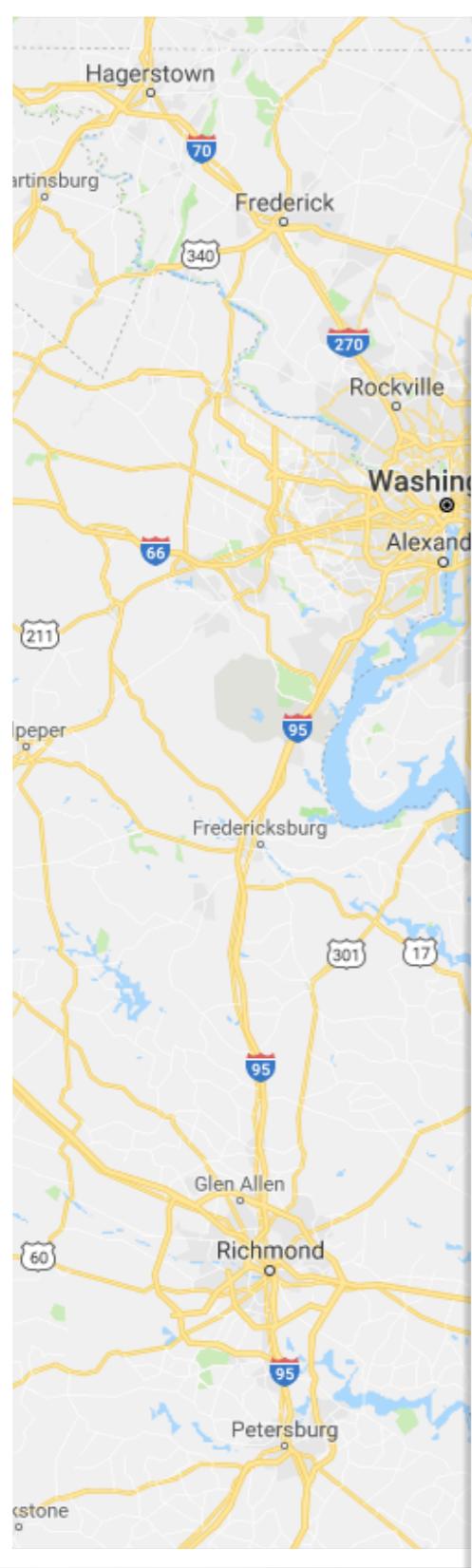
How long is the coast of Maryland?



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How long is the coast of Maryland?

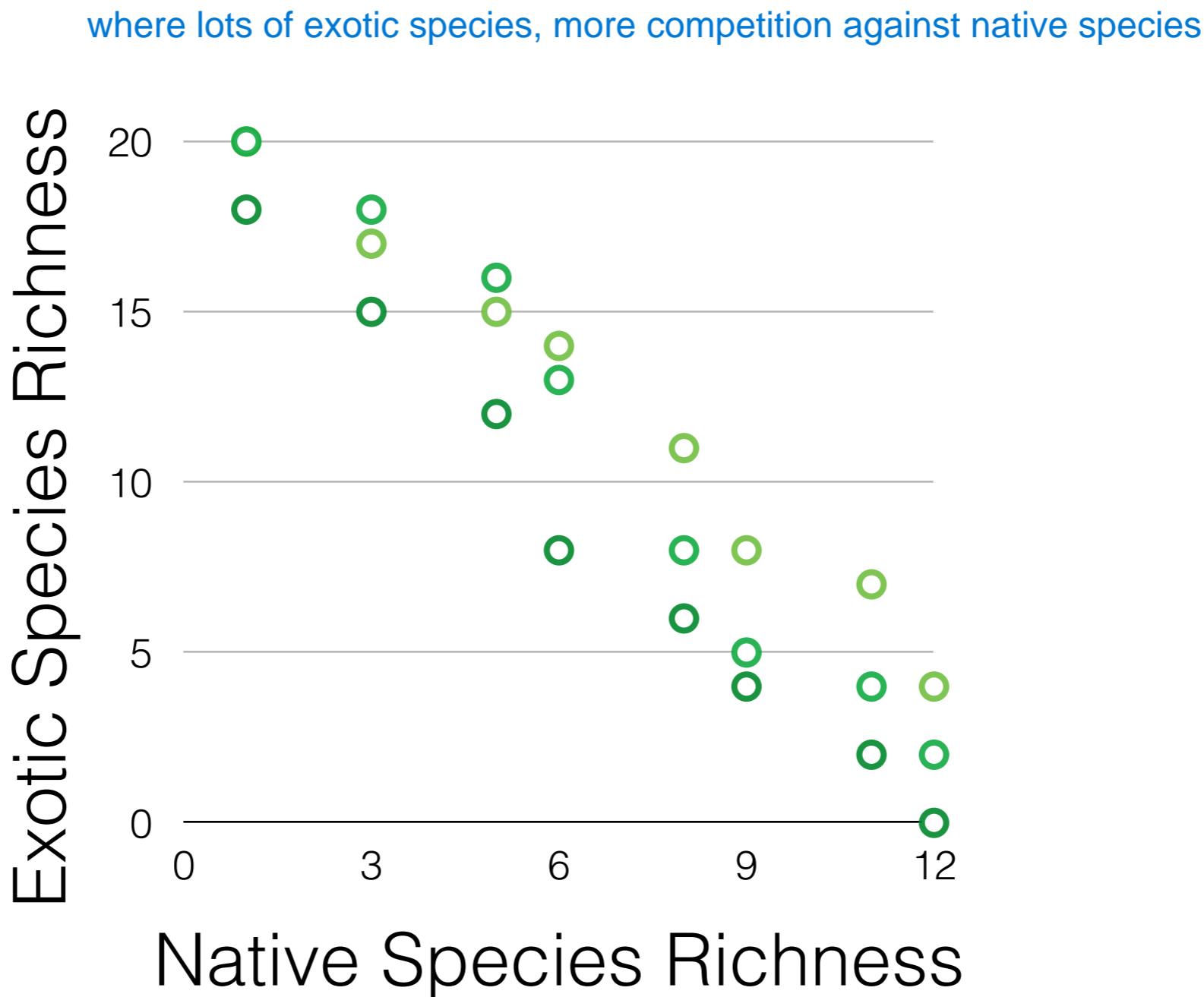


as you zoom in, the coastline appears longer and longer
The right answer depends on the scale you choose

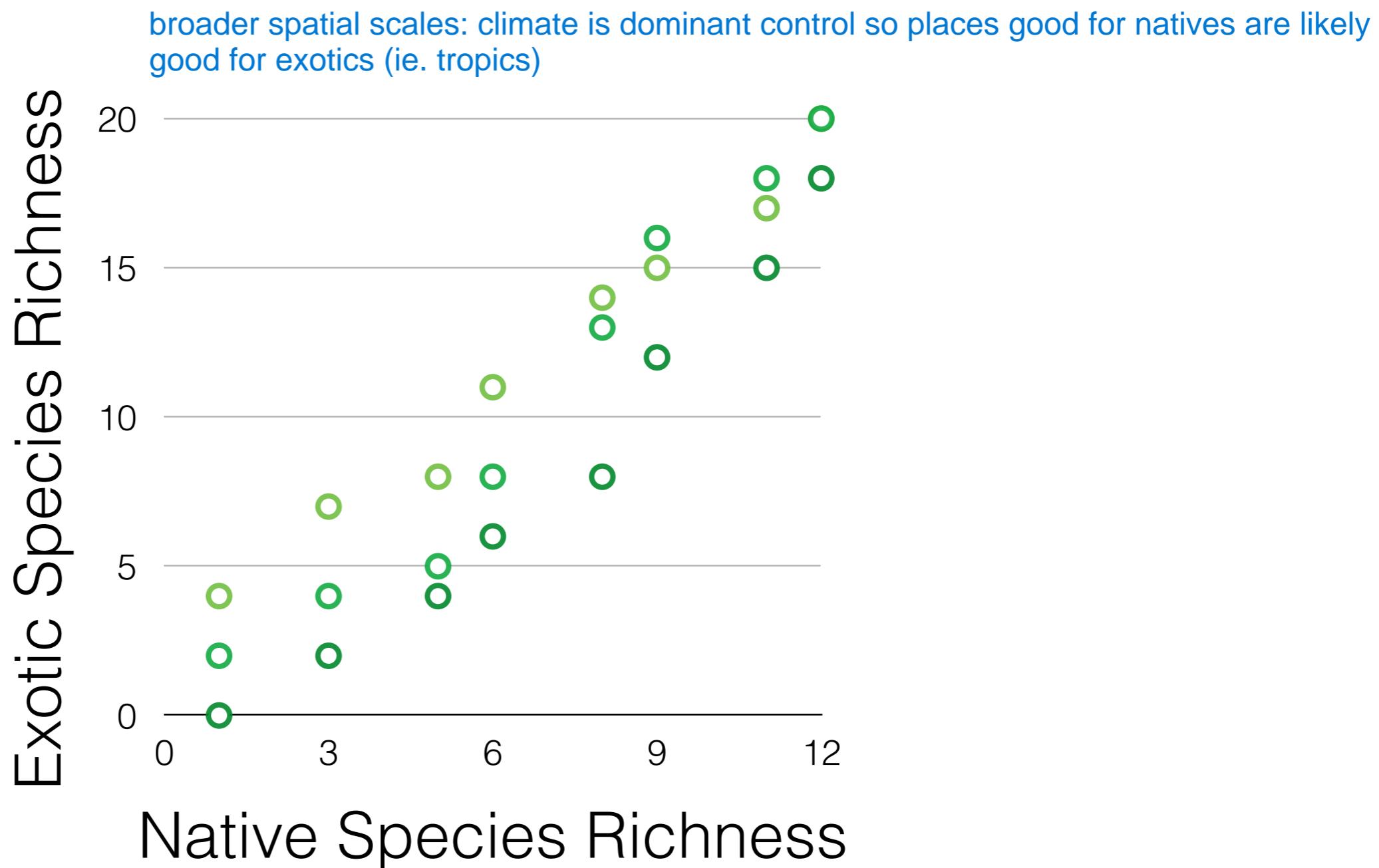
Thought experiment #2

How is exotic plant species richness related to native plant species richness?

How is exotic species richness related to native biodiversity?



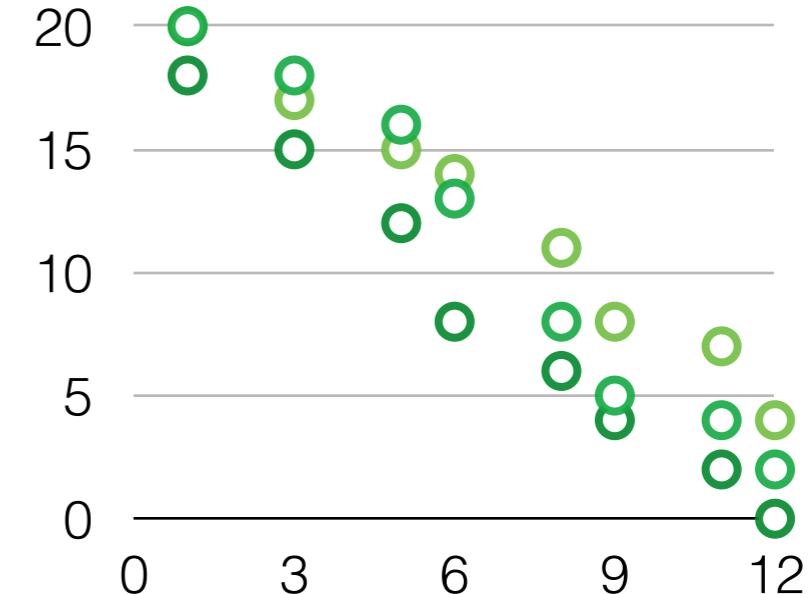
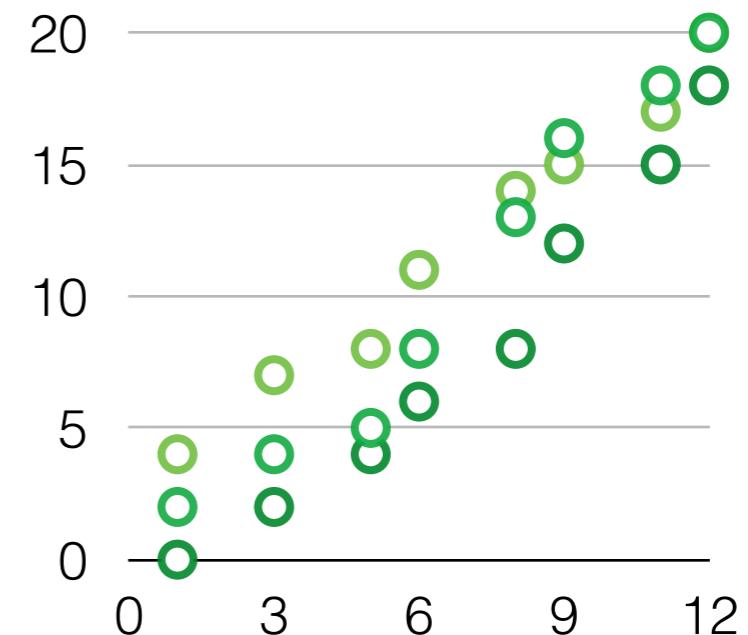
How is exotic species richness related to native biodiversity?



Why is Scale Important?

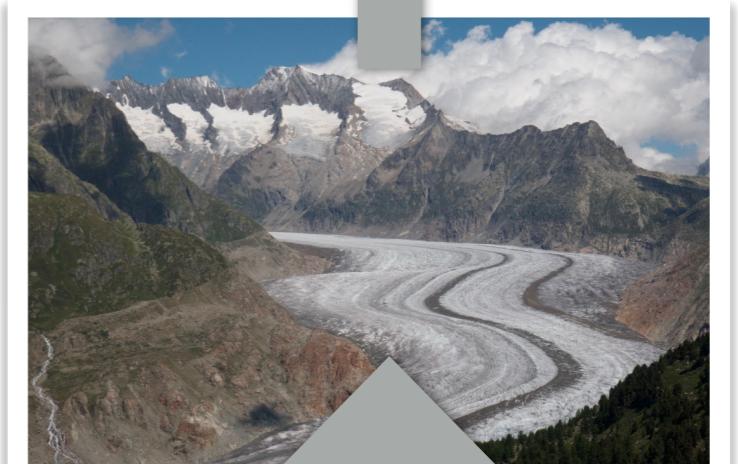
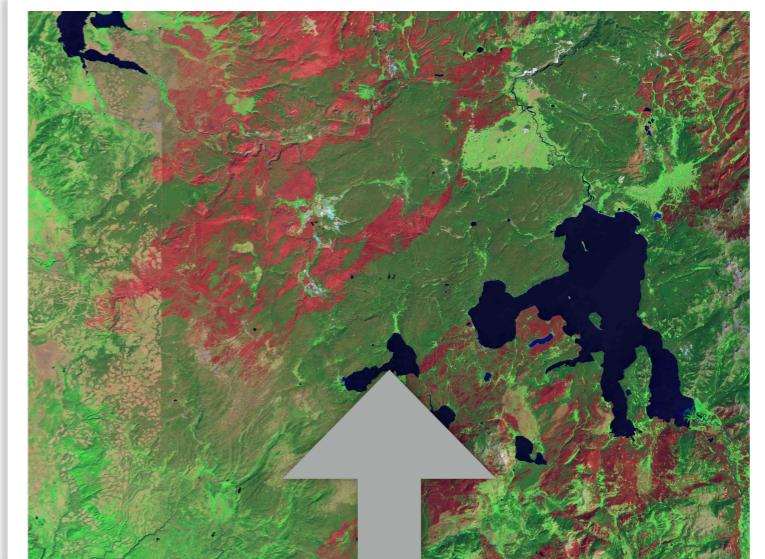
answer depends on the scale

- As one changes the scale of study,
statistical relationships may change



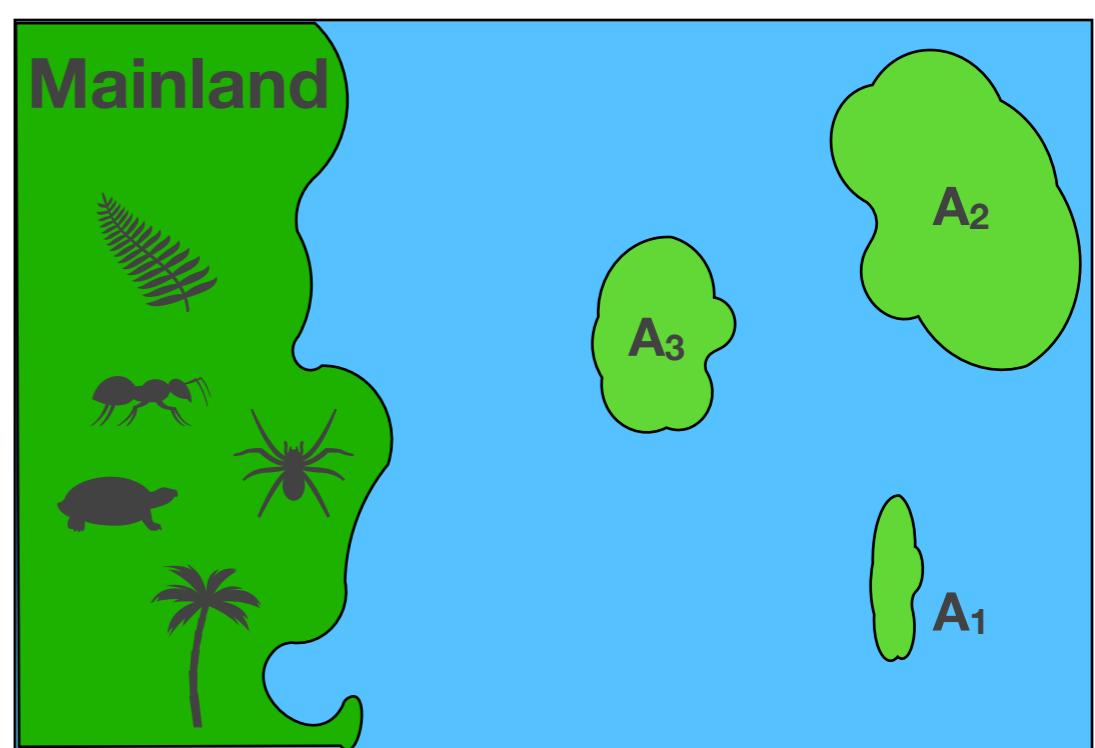
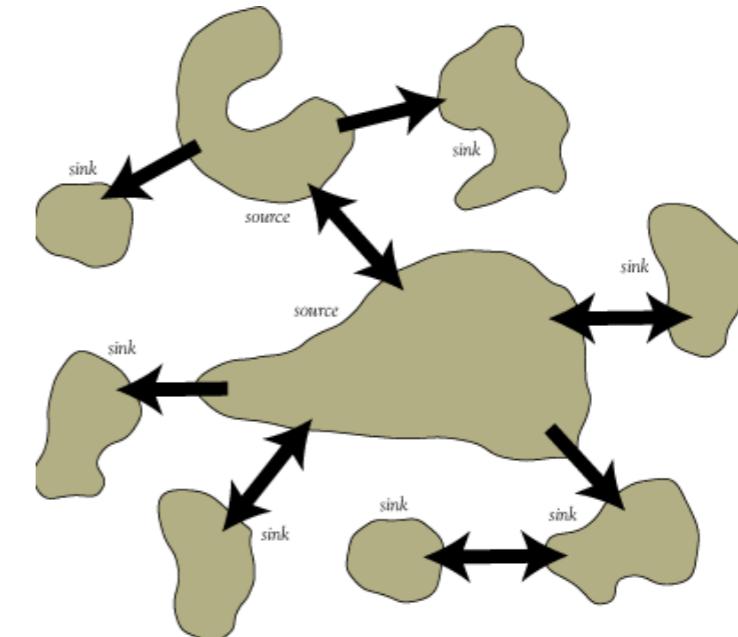
Why is Scale Important?

- As one changes the scale of study,
controls on patterns and process change
- For example, the relationship between climate and vegetation are evident at broad scales, but can disappear at finer scales as biotic processes gain more importance.



Why is Scale Important?

As one changes the scale of study,
systems may switch between
“closed” and “open”

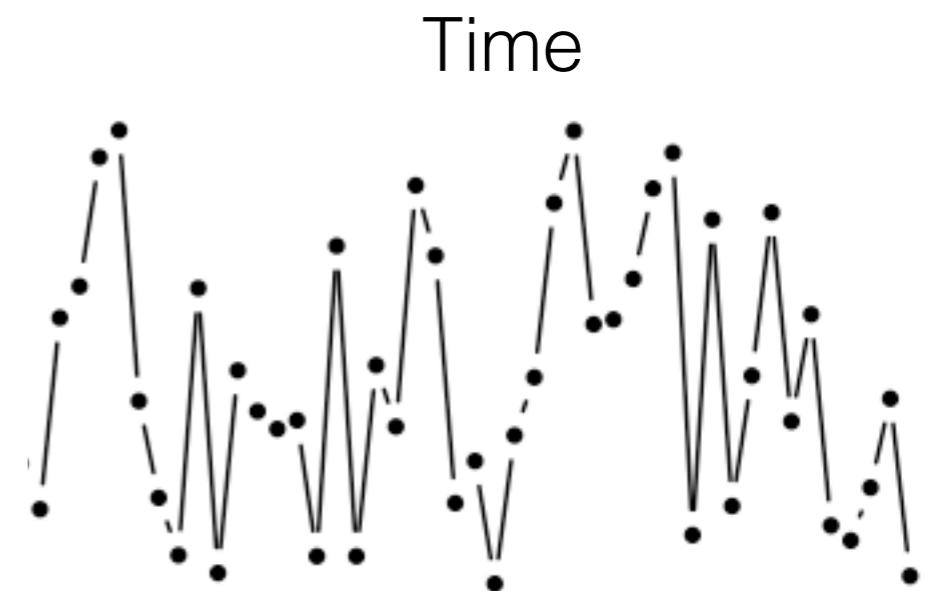
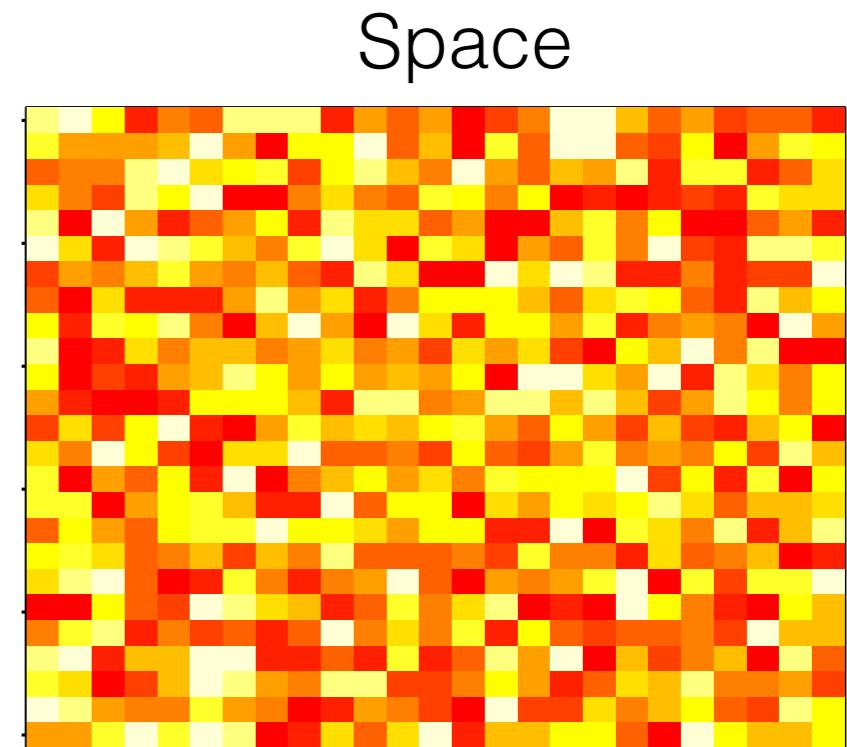


Definition of scale in landscape ecology

“...the spatial or temporal dimensions of an object or process, characterized by both grain and extent.” (Turner and Gardner, 1991)

Components of scale

- **GRAIN** - the minimum resolution of the data (cell/pixel size, quadrat/polygon size; sampling frequency)
- **EXTENT** - the scope or domain of the study area (geographic limits; temporal duration)
- You'll also see:
 - *coverage* - sampling density or proportion of the study area or duration actually sampled
 - *spacing* - distance between two neighboring sampling units; sampling interval; lag

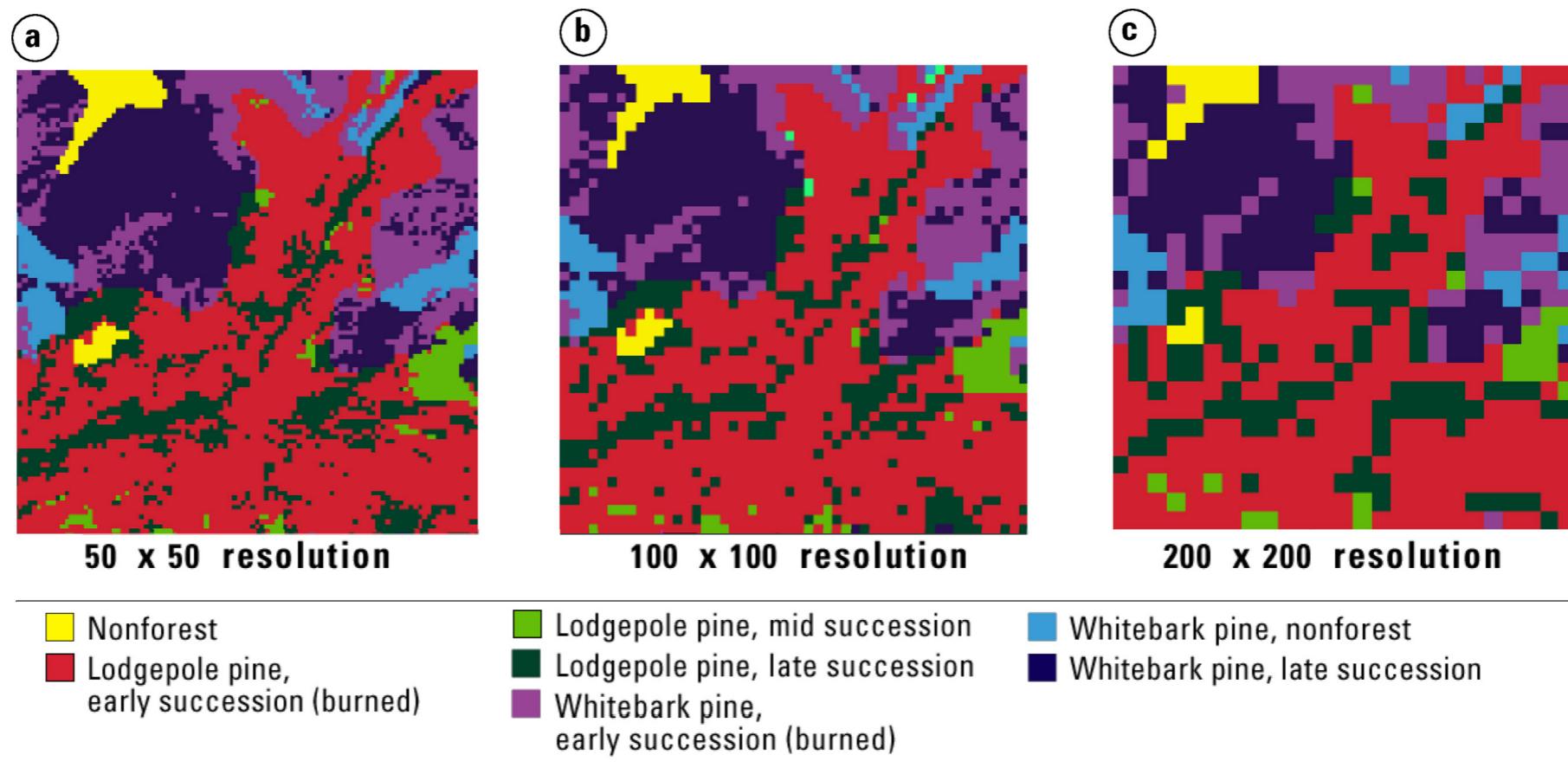


Components of scale

- Grain & extent are correlated
- Information content is correlated with grain

normally small extent is finer grain

up in extent means down in resolution normally



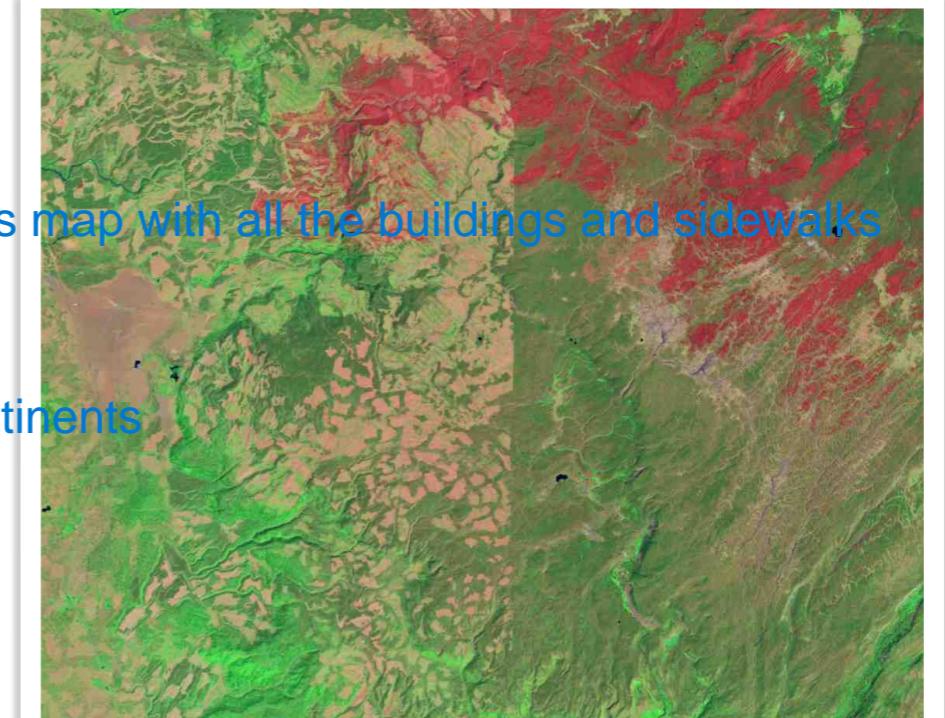
Clarification of scale definitions

In Geography, scale is:

- Ratio of map to real distance
- large-scale map: covers small area with high detail (e.g., a campus map) *counterintuitive. ie. a campus map with all the buildings and sidewalks*
- small-scale map: cover large area with little detail (e.g., global map) *ie. a global map with just the continents*

In Ecology, scale is:

- size (extent) of the landscape under consideration
- broad-scale: large extent (but small scale map)
- fine-grained: small pixels, high resolution

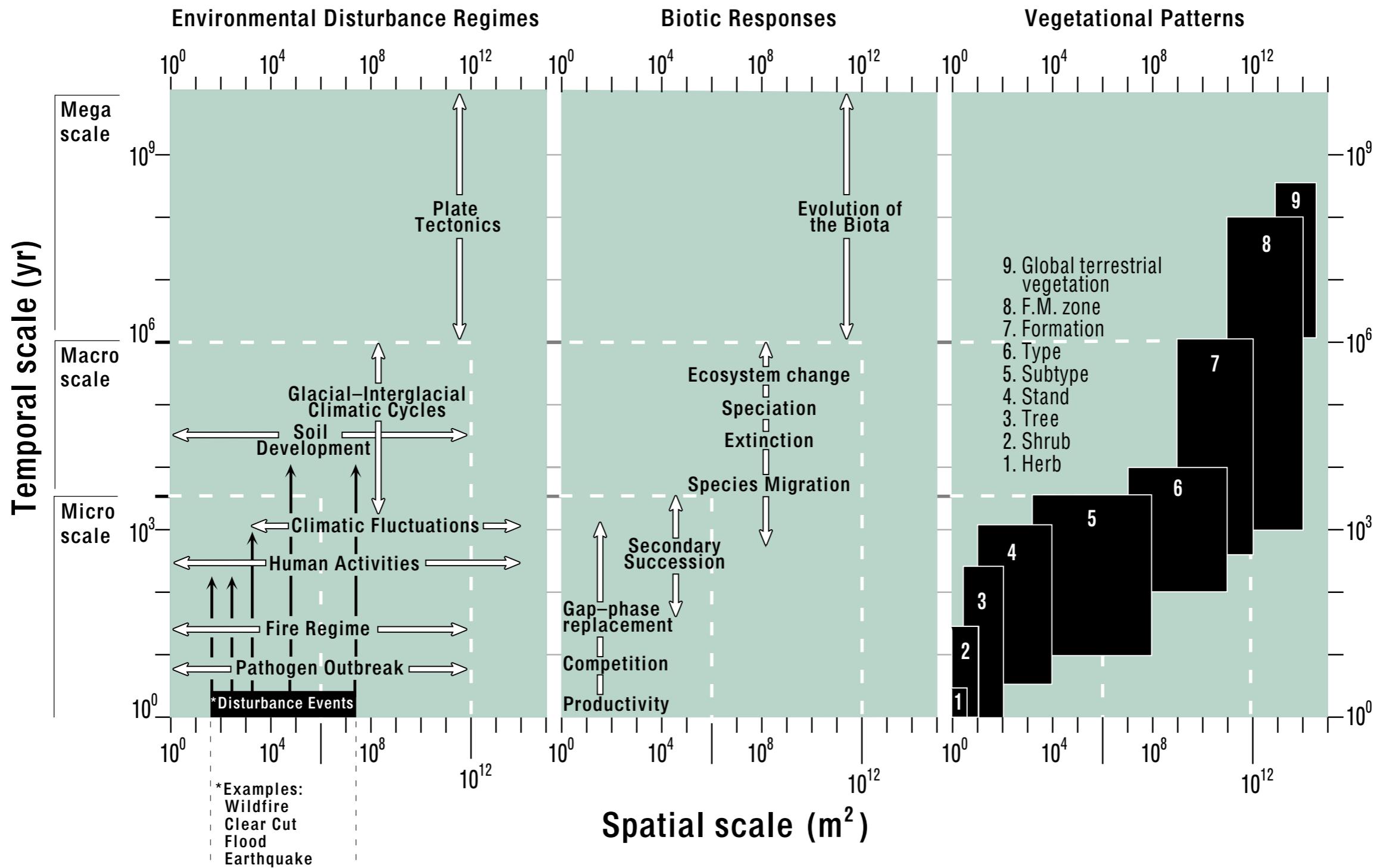


The real world is fine-grained and of large extent - must trade-off grain & extent!

Characteristic Scale

- Ecological phenomena tend to have characteristic spatial and temporal scales, or spatiotemporal domains
 - The “characteristic scale” is the scale at which ***the dominant pattern emerges***
 - Studies of pattern should be addressed at their characteristic scales
- land use, fires, etc.
within a patch will not see how it
varies from surrounding patches

Characteristic Scale



plots the characteristic scales at which processes take place

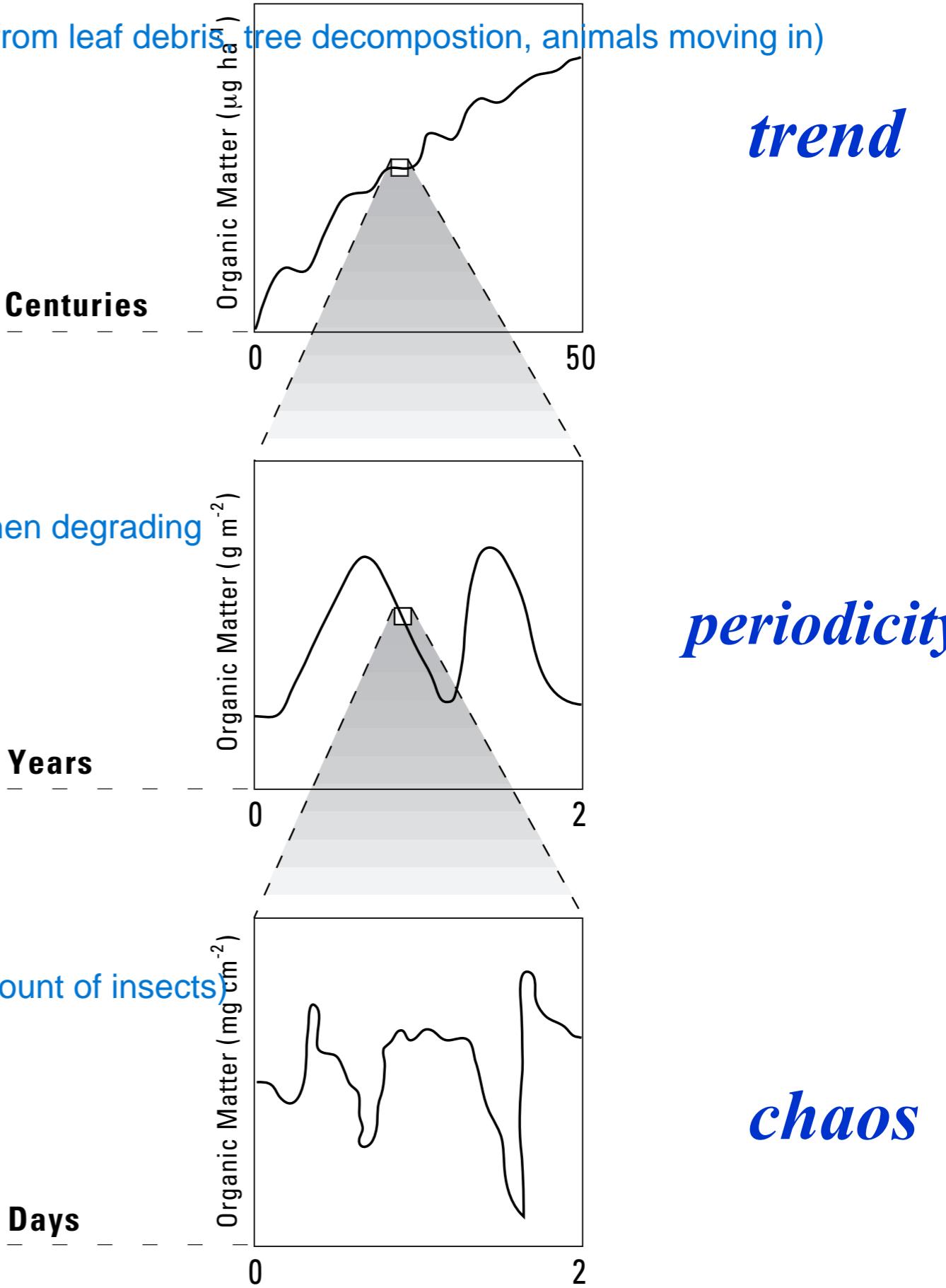
organic matter accumulation measured in forest soils (ie. from leaf debris, tree decomposition, animals moving in)

Changing view with a hierarchy of scales

variation at small scale could be leaves falling in the fall then degrading

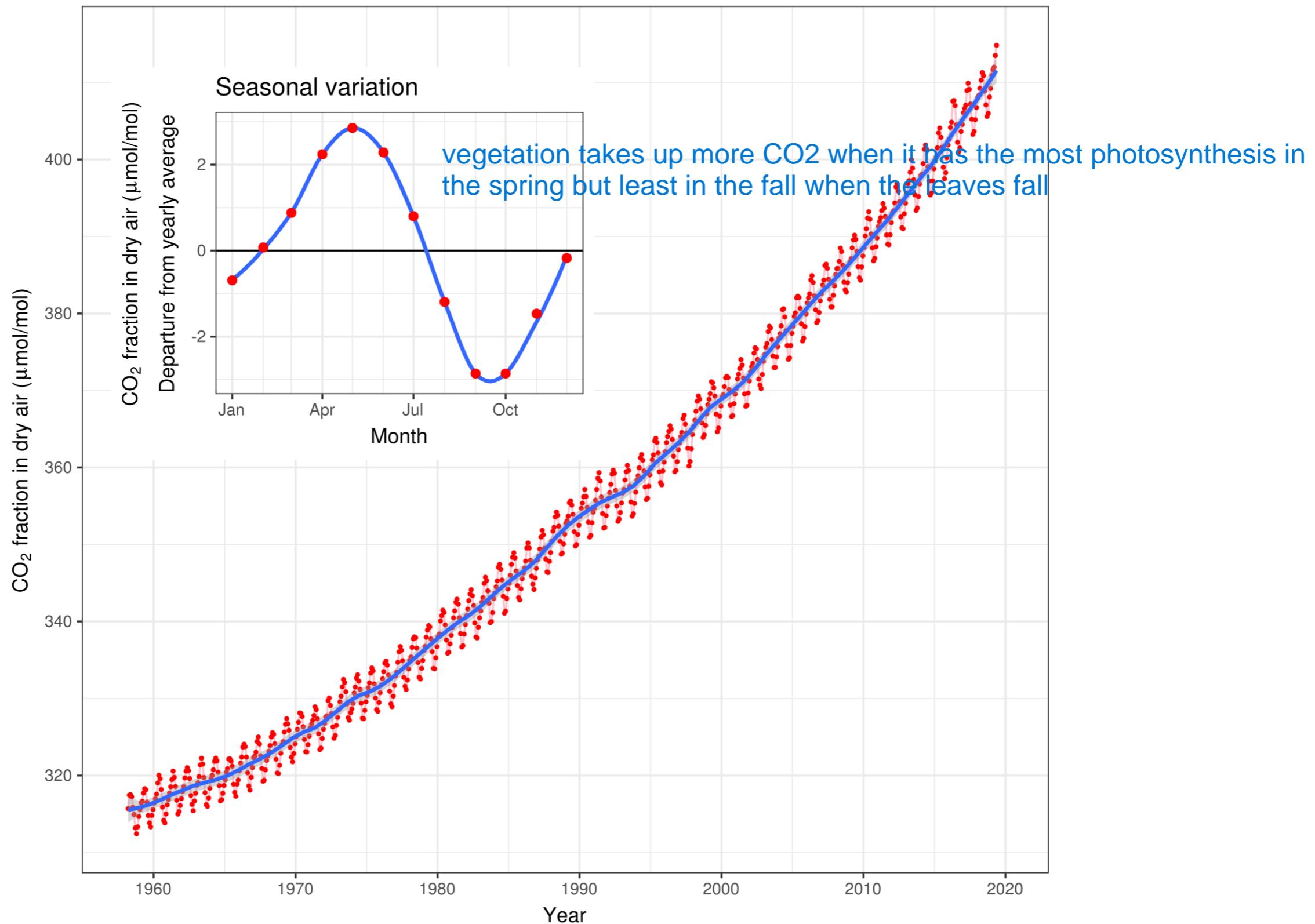
Larger events tend to have slower rates and lower frequencies

zoom in to just days could simply be stochasticity (ie. amount of insects)



Monthly mean CO₂ concentration

Mauna Loa 1958 - 2019



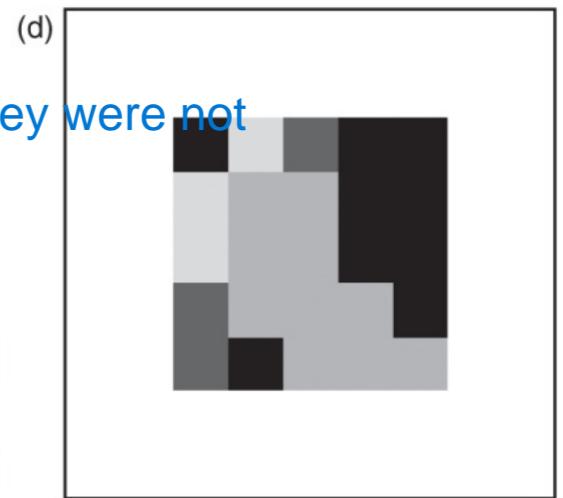
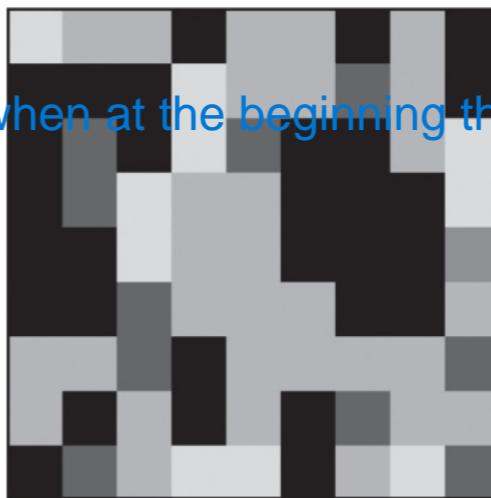
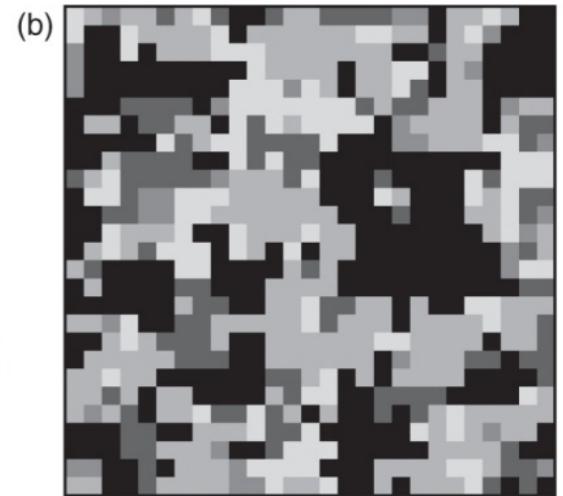
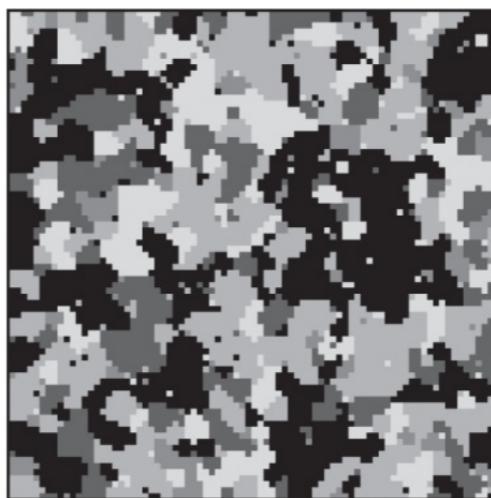
Data : R. F. Keeling, S. J. Walker, S. C. Piper and A. F. Bollenbacher
Scripps CO₂ Program (<http://scrippsc02.ucsd.edu>). Accessed 2019-07-20

Three kinds of error associated with scale

1. Aggregation error (altering scale / renormalization)

- an ever-present problem (not just spatial)
- Disaggregation error

making assumptions about the pixels being homogenous when at the beginning they were not



Aggregation of ecological data

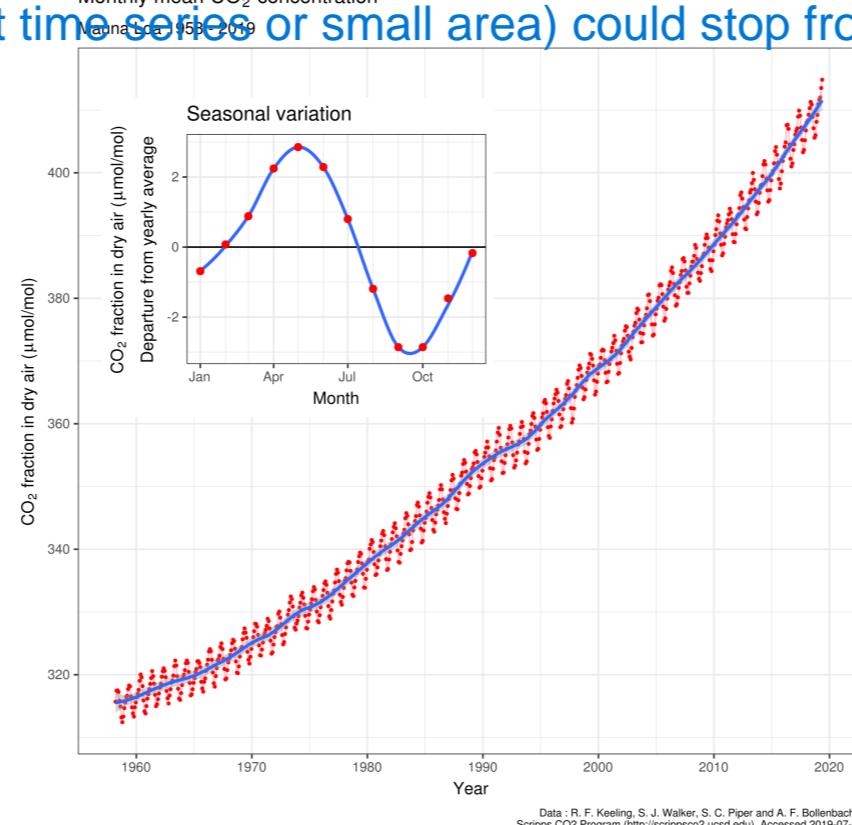
- Stream flow measurements
 - temporally aggregated **by hour or by day**
- Climate data
 - Averaged by **decade, year, month, season, etc**

may mask really important extreme events that actually determine distribution and abundance

Three kinds of error associated with scale

1. Aggregation error (altering scale / renormalization)
 - an ever-present problem (not just spatial)
2. Failure to recognize trends (problem of extent)

if taken at the wrong scale (ie. short time series or small area) could stop from recognizing trend



Three kinds of error associated with scale

1. Aggregation error (altering scale / renormalization)
 - an ever-present problem (not just spatial)
2. Failure to recognize trends (problem of extent)
3. Misidentification of optimal “scale” for measurement
 - Identifying the appropriate scale is the first step in attacking the “scaling problem”