Diversity, Stability and Disturbance
Part 1: What is stability??

Questions:
1. Are speciose systems (high S) more stable than low S systems?
2. What ecological mechanisms contribute to stability?
3. What happens to a community if S is reduced? (a major conservation question)

STABILITY
Plausible arguments and theory that:
- Diverse systems are MORE stable (more connections, buffer)
- Diverse systems are LESS stable (more specialized → more sensitive)
- S doesn’t matter (redundancy)

Stability can be assessed for individual species or for properties of communities, but stability at these two levels are NOT linked. Variation in abundance (or other trait) at the species-level does not necessarily translate into variation at the community-level.

We focus on the community level in this class.
Examples: Large mammals grazing in grasslands:

Serengeti

Yellowstone

These 2 examples give contrary patterns...partly because they assess different components of stability.
The Many Definitions of Stability
(or: components of stability)
(& apply to any level of study)

1. **Constancy** – may reflect intrinsic dynamics of (lack of) response in the face of a perturbation OR the environment may be constant.

2. **Persistence** – how long a state lasts

3. **Resistance** – to perturbation

4. **Resilience** – how quickly a system returns to pre-disturbance conditions. The resilience of a community depends on the *least* resilient species.
5. **Amplitude** – ecological ‘space’ over which a system is stable.

   **a. Local stability** – a community can return to a given state after a small perturbation

   **b. Global stability** – community can return to original state after a large perturbation (robust)

- If a system is only locally stable, then it is “**fragile**”.
- If a system is globally stable, then it is “**robust**”.
- A fragile system might shift to an alternate state with a large enough disturbance.

**c. Alternative States** – each with its own local stability. The community in any location may change between two (or more) alternative states if the environment changes. If alternative states are stable, they are called Alternative Stable States.

Examples of alternative states and from this class:

- Predation
- Herbivory
- Overfishing
- Nutrients
Alternative States – or Alternative Stable States??

It is this really hard to demonstrate that particular ecosystem state is stable, because the necessary experimental conditions are very difficult for me. This has been debated for ~30 years!

The question is to see if the switch between communities is relatively "easy" or not.

i) Alternative States: the switch in community types happens at about the same conditions going from one community to the other regardless of the direction of change.

ii) Alternate Stable States: the switch between communities is difficult because it happens at different conditions depending on the state of the community.

Here are two examples that might be alternative stable states.

1) Sea otters, kelps and sea urchins (Estes and Salomon - draft manuscript)

a. As sea otter abundance declines, the system changes from kelp to urchin-dominated at ~6 otters/km (solid line).
b. As sea otter abundance increases, it takes ~12 otters/km to switch back to a kelp forest.
2) Whelks and Lobsters (S. Africa). See Morin and slides.

(There is also some very recent evidence that the wolf-willow-stream system in Yellowstone might be an example of alternative stable states. See the Marshall reference given below.)

Note: some recent papers about alternative stable states have changed some definitions on earlier pages. In particular, they now conflate "resilience" and "resistance". I think this happened because it is not possible to decide which is the "original" state of the system if there are alternative stable states. For purposes of this class though, stick with the definitions that I've given you.

**Why is this important?**
Knowing that a particular ecosystem has multiple stable states is also important for management. It may “help to design strategies to prevent a catastrophic shift” from one state to another state; "second, it may help to find smart ways invoking a shift back" to a different state (Scheffer 2010).

Some useful references:


Scheffer et al. 2001 Catastrophic shifts in ecosystems. Nature 413: 591-596