IDENTIFYING ALTERNATIVE INDICATORS FOR THE DETECTION OF ABRUPT TRANSITIONS IN ECOSYSTEMS: A CONSIDERATION OF TIME SCALE AND COMMUNITY PARAMETERS

2012 LTER ASM

Our goals:

1. **Selection of indicators and comparison of multiple measures of response variables**
2. **System/driver comparisons**
3. **Recommendation for time scale and significance of contextual information**

Q1: What indicators or response variables are the best/ideal/used for detecting abrupt transitions in ecosystems? Are they tractable? Under what time scale do they operate?

How did Bestelmeyer *et al.* select indicators?

Already knew transition occurred and had the necessary data
Used existing datasets from understood systems

What circumstances would benefit from considering functional traits?

Depends on the scale that you care about (used as a proxy for community)
Biological index not necessarily related to species ID

Set up *a priori* hypotheses about shifts across LTER sites (Ruth Gates)

Important to track as many parameters as possible

Scheffer: as a system approaches a tipping point, indicator variability increases
Complementary indicator (mean change and variable changes)

Scheffer's limitation: alternate stable states don't necessarily exist

Issues with hysteresis claims – difficult to prove
Do we need to assume alternate stable states? NO, if we are looking for relationship between driver and indicator

Stay away from implicit value judgments (*i.e.* jargon like regime shift)

We could test alternate stable states with paleo data but no one wants to go there!
We are still in the descriptive phase; we don't want to get stuck so we must aim for the future, predictive phase

Importance of contextual information

Good understanding of mechanism behind shift (must be measured concurrently with other time series
Must be used to mechanistically frame the transition

We can use this discussion to re-evaluate the collection of LTER data

Are we limiting our future predictive work by collecting non-autocorrellated data? Should we be measuring different things on different time scales?

Constraints on datasets

- Analyses work best when indicators are autocorrelated with drivers
  - These data may be hard to get because of bias among ecologists -> critical disconnect (Aaron Ellison)
  - Temporally-dense data (*i.e.* from sensors) would be useful
  - Challenge for data available?
- Frequency of sampling for time series (indicators and drivers)
  - Mismatch of time scale could be really problematic
  - Consider when selecting data
- Do time series need to match up (time of sampling)? (Aaron Ellison)
  - Different ways of gap filling (*i.e.* modeling)
  - Be transparent about your method
  - Necessary to line up data points for driver vs. indicator

IDEAS

- Ultimate goal: to predict when transitions will occur and how they affect ecosystem function
  - We are not ready to try predicting future transitions yet but we could go back to see if we could predict transitions that already occurred
- Measure energy budget for tree stress (Luquillo)
  - Proximal causes of mortality (insects) occur when energy budget is negative
- Combine species diversity and dominance
  - Identify impacts for dominant species
- Trait-based indicators to use for ecosystem comparisons
- Relative patterns in diversity (Ruth Gates)
  - Micro vs. macro taxonomic scale
  - How these scales assemble
- Rational common denominators for ecosystem function (*i.e.* community diversity, productivity
- Connect different levels (population to individual/physiological processes)
  - Difficult
  - How do lambda values/physiological values connect? (Pete Edmunds)
  - Terry Hughes called for demographic analyses of coral (12th ICRS)
- Community/population indicators that match time scale of metabolic indicator
  - Plant reproductive success
  - Animal preferences/behaviors
- ***Using several metrics should increase the ability to detect transitions
  - Importance of contextual information

- ***When choosing indicators to recommend for future work, keep in mind the utility of these indicators for managers, *i.e.* counting seeds
- ***Scale may be specific and dependent upon the organism and driver

Summary of discussion of Q1

Indicator	*Time Scale*
Individual (molecular)	
Metabolic rate	Hours-weeks
Energy budget	*Depends on organism*
Oxidative state	
Photosynthetic capacity	
Population	
Abundance of a single species	Weeks-years
**across diff. life spans*	*Depends on organism*
Reproductive success	
Behaviors	
Size structure	
Community	
Species diversity	Weeks-years
Species evenness/relative	*Depends on organism*
Functional diversity (trait-based)	
Species interactions	
Primary productivity	
Unusual Events/Triggers	
Physiology- community level	

Q2: At your LTER site or external research site, what are transitions in ecosystems that have already been identified? What datasets do you know of that may satisfy the requirements of this analysis?

Bestelmeyer and coauthors started with the EcoTrends database and then talked to individual PIs

They see value in accumulating and analyzing additional datasets

Scheffer: you don't know you have a state change until there are 2 or more transitions (*i.e.* sea cucumbers)…do these examples exist?

Alternatively, we could use artificial datasets to figure out which types of data are needed for our planned analyses

PLOSone paper discussing this topic – Dakos *et al.* 2010

Moving outside of LTER data

Modeling to fill in gaps (plausible scenarios)

Paleo data

Compare Eastern Hemlock with American Chestnut (blight)

Utility of separating types of transitions

i.e. combination of drivers vs. discrete trigger

but can you actually separate the influence of these two drivers

Mining invasive species – Ray Callaway

Jill Barron (NWT, USGS): threshold of algae/phytoplankton

Everglades National Park – disturbance response

Adirondacks monitored by EPA

Luquillo – microbes and decomposition

Cedar Creek - savannah

Follow-up on context, mechanistic understanding of transition

Need to be able to quantify difference in the relationship between driver and response in different states

FIA (Forest Inventory and Analysis) – potential data source; FLUX network

Luquillo – MCR: tropical parallels, but terrestrial?

Summary of discussion of Q2

LTER / External Site	Ecosystem	Transition	Driver(s)
SBC (Santa Barbara Coastal)	Kelp forest	Macroalgae -> sea cucumber	Wave height
PAL (Palmer)	Polar marine	Adelie penguin -> Chinstrap and Gentoo penguins	Temperature and sea ice cover
CCE (California Current)	Pelagic ocean	Krill abundance	Pacific Decadal Oscillation (PDO)
JRN (Jornada Desert)	Desert	Grasses -> shrubs	Grazing, drought
Coweeta	Forest	Eastern hemlock -> other plants	Insects
Niwot	Alpine/ lakes	Phytoplankton/algae community	
Everglades National Park			
Konza			
Africa			
PIE	Beavers		
Adirondacks, NY (EPA)			Acidification of lakes
Luquillo	Microbes		

Cedar Creek	Savannah	Consumer productivity	

**Rows in grey were the original datasets used in Bestelmeyer *et al.* 2011.