Notes for Biogeochemical complexity workgroup: ASM 2006, Estes Park

Session 1: presentations of complexity
Session 2: discussion
Ad hoc afternoon session

Dan: Objectives and goals –
Variety of biogeochemical processes across sites and build a framework and break up into:
-spatially and temporally
-Physical vs. biotic
-Human impacts

Do we like the conceptual scheme?
What are the most important factors that are drivers?
Definitions: do we like it?

Wil: Dynamic vs complexity. Complexity incorporates dynamics… very diverse topics, how do we fit it into a single definition?

David: Looking at indirect effects of biogeochemistry as a measure of biogeochemical complexity

Tiff, Wil, Victor & others: could this be expressed as temporal?
Dynamics and feedback, which do we use, are they the same?
The potential for feedbacks as a measure of complexity; the strength of this proxy is when things start to change.
Complexity vs. feedbacks and combine
Diversity of structure and processes and the concept that those vary as a function of spatial and temporal scales and extent of connectivity.
Should we go bottom up or top down i.e. structure & processes vs. emergent properties that characterize complexity i.e. feedbacks, etc. And can we still use a variety of sites to do this?

Maybe try to normalize such as Energy signatures and look across sites and partition at the temporal scale. Factors that drive the biogeochemical process; heterogeneity across sites, so how do you normalize that? Then we can do comparisons.

Does this complexity exist, is it spatial or temporal, and is dependant upon connectivity?
Nutrient cycle or look at one cycle? Maybe look at dominant cycle for a particular site?
What are the drives that are causing that changes in nutrient cycling?

Spectrum of diversity: biogeochemistry, physical, etc.
Top-down, press –pulse. Think about the planning grant questions related to press and pulse events.

Use the time to reorganize after disturbance and different scales as a measure for complexity. Sites could then be grouped on magnitude of disturbance vs. time.
Steve Carpenter did this and it is nonlinear in biotic. Need residence time 3 divergent times?

Maybe look at rates of change instead of just recovery.
How do they organize after a disturbance, how strong is the force and do sites have different levels of resilience?

Amy: we are getting away from the initial question which is not disturbance

Matt: agrees and suggests % of flux rate of transformation

Amy: each break out and find their own drivers and find biotic driver and the interaction
?: Compare sites, Net N min. same metric…and then what are the drivers. Redundancy of sites. Go simple.

Tom: re: boundaries - multiple biomes within a site or the LTER site, what are we after here?

John: characterize complexity and identify biogeochemistry and then assess dominant drivers and they how would affect biogeochemistry

Daneilla: We could use alpha diversity maybe?
David: these are two groups but are very closely related to each other-systems theory and ecological approaches to complexity
John: change is inherent in complexity

At this point we split into two groups….and reconvened after a break
Summary of break out group discussions –
Camp 2: Focus on phase shifts and feedbacks; Fire, redox, hydrologic changes and feedbacks. Biotic vs. physical are different feedbacks
Camp 1: functional groups within sites? spatial and temporal. N inputs and outputs, internal cycling and storage. What are common measurements at the sites? NPP.

What spatial scale holds most variability?
How does biotic diversity play into identifying complexity? Biological diversity, resource diversity curves, bacterial diversity affects on nutrient cycling; cited paper in PNAS but missed it, pH? Bioturbation? Some plants are N-fixers. Do we need to quantify plant community diversity at each site?
Emergent properties. N or P, C inputs vs. output.
Openness, input output and internal cycling.
What are the pulses or presses at each site? Invasive species. How would you deal with spatial and temporal aspects of complexity?
In sites that are less biogeochemically complex, will they have more spatial scales and vise versa?

A framework would be useful, to get one #, to compare.
Look at just the site, some type of biomass, and biogeochemistry. Look at site as the box. And it should be scalable. So. Max and mix. ?

Suggested that we as a science have been doing this for years, however not in this context. We are adding in feedbacks. Suggested that an index is needed for biogeochemistry to form a basis for comparison.
Daniella: Hot moments across spatial and temporal scales. Like the hurricane in LUQ.
Dan: can be integrated
Tiff: we want to get at the hot spots too.
Matt: we have temporal data that we can compare
Evan: it is good that it (?) is done at each site as a check, and we can compare to that as well
Amy: Dynamic budgets. We add fertilizers at KBS and Cedar creek, how do we account for that in our comparisons across sites?
Amy to Tom: Must you look at the control or could you use fertilized plots as internal checks?
Evan: trends may be the same at different sites.

Can we do stats on this, to see what sites fall out as complex?
How do marine sites fit in? No need to try and fit the site to the model if we are interested in a general model of biogeochemical complexity. What are some more general indices, proxies?
There are systems ecology indices of complexity: throughput, stocks and flows.
Richness and others are thought to be good indices by some, but not others.

Two things, mass balance approach resistance and resilience, and what was the first…..emergent property and lots of individual sites. And get some value.
Can there be a temporal index that we can create….
How much is going on internally until it is exported? Proxy for complexity? Could we use turnover times?
Residence times may change for each thing, is this complex?
Sara: turnover times in the ecosystems, internal cycling in the system
Matt: look at trophic levels.
We can do better than annual averages,
Evan: we can have a diversity of inputs, a lot of fixation and deposition going on at some sites, say as compared to MCM. Look at turnover pools. And then have export mechanisms. Magnitude can trump diversity or not.
Daniela: At LUQ, there is no input and outputs are small.

What is complex, tight cycling vs. loose?
Do we want one big box, or should we have multiple little boxes? Ribbon models?
Sara: Can identify and quantify certain pathways and at different times.
This is an index…a complex model. Throughput is another index. But, need more than one index. Can stoichiometry be used as indicator?

Missed something about feedback.

Complexity index: could it be expressed as a relative proportion?
David: One measure isn't good enough, throughput isn't enough alone. It is a good index of size though. There are other indices: **Size of the system, stability, and indeterminate**. So we need one metric from each, or at least two, size and stability?
We need activity, size and energetic levels.
What else could we use?

[Trying a model on the screen]
Arrows are complexity?
Variance of output is an easy way to get at stability?
Tiff: back to Cadenasso model, does size of the system, stability, and indeterminate behavior analogous to spatial, temporal and connectiveness?

Stability of biogeochemical processes - so do we look at the arrow and boxes sizes? Use a Biodiversity index?
Do we need all the arrows? One idea: **pool divided by turnover**
Could do **number and magnitude of inputs and outputs**
How do we include internal cycling?
Pool size/residence times to get at the internal cycling.

Assigns probability of flows that will take that flow? Need size of flows and stocks.
This is a Shannon weaver essentially

What we need: Inputs, output, turnover and size of box
Maybe the limiting nutrient at each site? Yes use N and P, although P its cycling is limited in form.
The numbers of drivers at each site will be different……
How do they respond to stressors
The input/output ratio = efficiency

Use throughput and efficiency
Should we list stuff, what do we have in terms of data?

See what is available at each site
What are we measuring?
Same number of inputs? Site specific inputs?
What are we measuring? C? N? P?
Look at N at each site

If there are no numbers available then go to the lit.

Efficiency first than throughput
Look at data. N output.

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