**NASA Biodiversity and Ecological Forecasting Team meeting**

**May 8 Breakout Notes**

**Terrestrial Research group – research questions for the next decade**

Note: We had a long list of questions (see end of this document) and then organized/ consolidated them into the themes below. We also had some other ideas we wanted to capture.

**Themes/questions**

*What processes develop/create, maintain, and change biodiversity?*

* What are the controls on biodiversity? (climatic controls, soil controls, anthropogenic, species interactions, etc.)
* What are the patterns of biodiversity? (scale, spatial and temporal patterns)
* What are the spatial and temporal scaling of the relationships between biodiversity, ecosystem function and ecosystem resilience?
* What is driving biodiversity loss and how can we better understand the attribution of those causes? (from both the anthropogenic and natural sides)
* How does biodiversity respond to change? What are the characteristics that make biodiversity more vulnerable to anthropogenic changes?

*What are the consequences of biodiversity? (both natural and anthropogenic systems)*

* How does biodiversity affect climate, hydrology, etc. (see above)?
* How does biodiversity affect human systems?
* How does it make ecosystems more resilient, how does it affect ecosystem services, how does it affect natural systems (hydrology, climate)?

*How do we respond as a society to changes in biodiversity?*

* What are the cultural attributes/characteristics that influence how societies respond to biodiversity change (in terms of policy, etc.)?
* How do global changes (climate change, food security, water security, disease, political instability/conflict) affect human behaviors that affect biodiversity?

**General things to consider**

* How do we hindcast and forecast biodiversity?
* Can we predict biodiversity patterns?

**Notes about the context for questions**

* Most questions apply to biodiversity in general (all life on planet Earth)
* These questions are all interconnected
* What do we mean by biodiversity? Not just species, it’s genetic/functional/ecosystem diversity; it’s the processes which are biotic and abiotic; also dynamics within species (demography, population dynamics, physiology, phenology); dimensions of biodiversity

**What’s new**

I asked people to consider how our questions now differ from the questions we would ask 10 years ago. The stars indicate areas that people felt were particularly important.

* \*\*Question of scale: the ability to measure processes at finer scales – closer to the scale where the processes are actually happening; improved ability to observe and model ecological processes
* Have similar information everywhere – can model across large spatial extents
* Smaller grain, larger extent, greater spectral resolution
* Linking it to societal responses – decision-making kinds of tools
* \*\*Have a good idea of the past (genomic data) and in terms of intra-specific diversity, the types of approaches that can be used to map genomics, reduced costs, greater availability, non-invasive techniques; being able to link intra-specific; can do adaptive genomics
* Data availability
* 3D mapping of vegetation structure
* Brought species distribution models closer to the actual physiological processes (rather than farther out proxies)
* Ability to move from static to dynamic
* Have a wealth of information from the past, can hindcast to test models and then use to predict
	+ Better data, better models
* Acceptance and incorporation of citizen science and crowd-sourcing

**List of questions** that were brainstormed during the breakout group, which were then consolidated to the above themes/questions.They are in no particular order.

1. What is the relative role of mean condition versus interannual/seasonal variation on species distribution?
2. What is relationship between climate factors, mean variability, phenology on trees
3. What are the effects of changes of vegetation on the water budget
4. Systematic approach to address the most pressing issues (climate change, vegetation responses) – mechanistic basis; what are the mechanisms that drive ecosystems
5. Separate on a pixel by pixel basis the effect of climate change versus all other factors; how do you attribute ecosystem changes due to climate change v. other factors v. natural factors
6. How do we develop higher resolution climate models for biodiversity research?
7. Describe species distribution and diversity, make mechanism predictions, why that might be and how that might change in the future
8. How do you value (cost) biodiversity ecosystems
9. What are the unique scales of ecosystems and biodiversity processes?
10. How does tropical vegetation distribution drive fauna distribution?
11. Describe and understand the abundance, demography and phenology of taxa both linnean and functional in relation to their climatalogical biological and anthropogenic environment
12. How are tropical ecosystems being affected by climate change (separate from human land use change)
13. What are the long term global trends in land change and consequent impacts on habitat and species distributions?
14. Are there certain climatic abiotic/biotic factors that predict ecosystem resilience or adaptive capacity?
15. What ecological processes drive and maintain the edges of species geographic ranges and do these change the spatial scale
16. Where species move and what factors go into those decisions
17. Which abiotic factors are most important in controlling distribution and abundance of species and how are those factors changing? x2
18. What is the relative importance of local and regional mechanisms that create, maintain and disrupt freshwater biodiversity?
19. What are the plant functional attributes and mechanisms that allow biodiversity to be detected remotely?
20. What are the physiologic signatures that can be detected by remote sensing that directly relate to biodiversity?
21. What is the influence of the increasing built environment on biodiversity loss?
22. Can we model community composition change as a function of land use and climate change?
23. What are the climatic controls on plant nitrogen concentrations?
24. How do we measure the success of conservation intervention?
25. How are changes in the water balance affecting biodiversity and productivity?
26. How do various dimensions of biodiversity affect ecosystem services? (genetic, functional, taxanomic, etc.)
27. What are the consequences of biodiversity loss, are there different thresholds for loss, and how do we place a valuation on that?
28. What consequences do biodiversity patterns and changes to biodiversity have on the environment (climate, hydrology, biogeochemistry)?
29. How do we delineate between ecosystems and identify novel ecosystems? What novel communities are assembling?
30. What specific environmental conditions make biodiversity more or less vulnerable to climate change/land use change and why?
31. How does biodiversity contribute to ecosystem resilience/resistance to environmental change?
32. How do we measure biodiversity at multiple spatial and temporal scales?
33. How do we determine appropriate breaks between scales?
34. What should the societal responses be to these changes? What is the societal context that intervenes in all these natural interactions?
35. What are the changes in terrestrial diversity that are leading to changes in the aquatic environment?
36. How do global changes (climate change, food security, water security, disease, political instability/conflict) affect human behaviors that affect biodiversity?
37. How do we measure socioeconomic variables using remote sensing?
38. How do we combine remote sensing data with indigenous knowledge?
39. What are the factors that affect the invasability of an ecosystem?
40. Combining information about contemporary climates and physiological tolerances to be able to infer evolutionary consequences of former climates on present day biodiversity patterns
41. How do we define the role of pathogens as they affect major ecosystem structure and composition?