Pressing questions in biology where remote sensing can advance ecosystem science, macrosystems ecology and sustainability of Earth's life support systems in the Anthropocene.

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KISS: Unlocking a New Era in Biodiversity Sciences
Pasadena, CA
October 1-5, 2018

Pressing Questions and NSF Strategies to Enable Convergent Research and Transformative Science

- **Ecosystems** Core Programs
  - Genes to Ecosystem Fluxes – Structure to Function, 4-D scaling
- **Macrosystems** Special Programs
  - Ecological-systems to Macrosystems – Structure, function, scaling (cross, multi), context, connectivity
- **Dynamics of Coupled Human and Natural Systems** Convergent, Cross Directorate
  - Environmental and human systems – convergence, dynamics, connectivity, context
- **Rules of Life – Big Ideas**
  - Linking levels of biological organization, general principals governing key properties of life
- **Infrastructure (Centers, Networks, NEON, Data, Human)**

Terrestrial Ecosystems

Genes to Ecosystem Fluxes – Structure to Function, 4-D scaling

- What are the structuring processes that determine the temporal dynamics and spatial structure of ecosystems? Are these processes scale dependent? How do these processes vary across the continent or at continental margins?

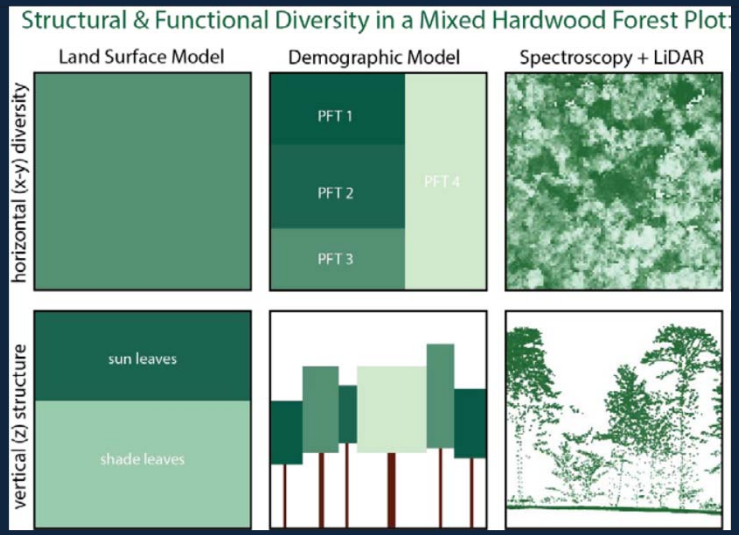
- What is the impact of "connectivity" (local patterns and processes affecting broad-scale ecological dynamics) on the global environment? What are the strong and weak forces that connect or influence ecosystems?

- How does climate change affect watershed/ecosystem temperature, hydrology, and drought severity, and what influences are predicted for species distributions and interactions, phenology, evolution, or biosphere productivity and biogeochemistry?

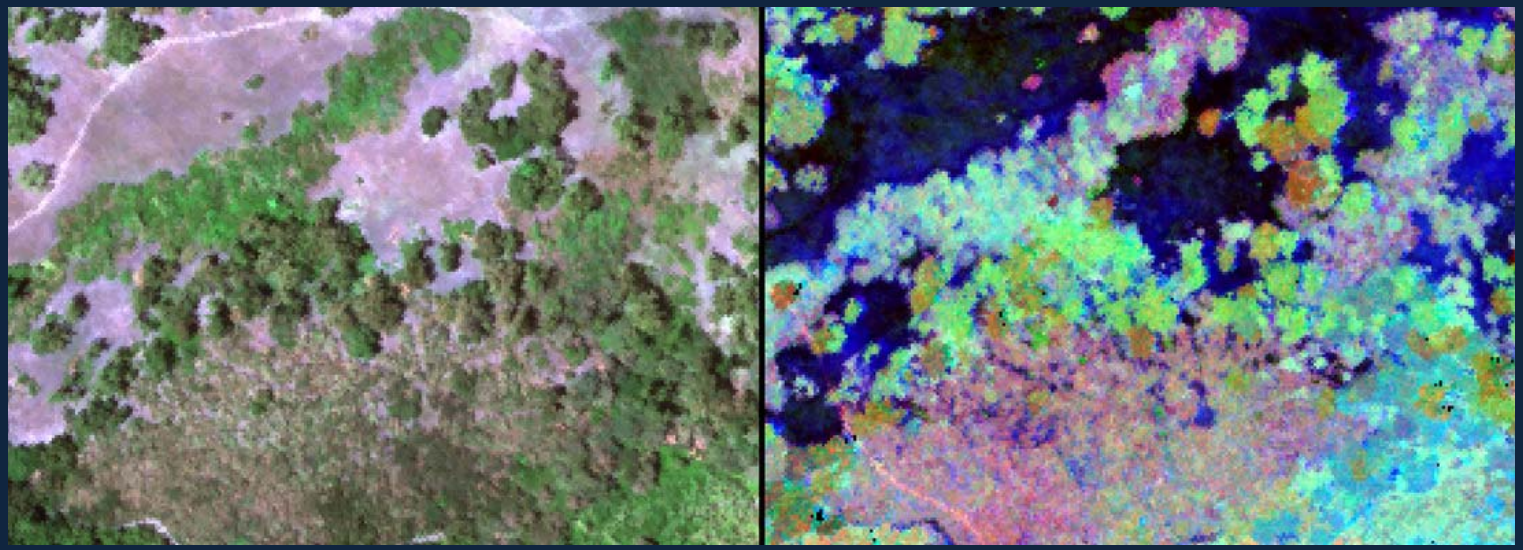
Early Career Awards

Innovative NEON tools: Using AOP to assess function and biodiversity

"MSB-ECA: Ecosystems in four dimensions: Measuring changes to forest structure and function in the Anthropocene"
(Dahlin: Michigan State University, EF-1702379)



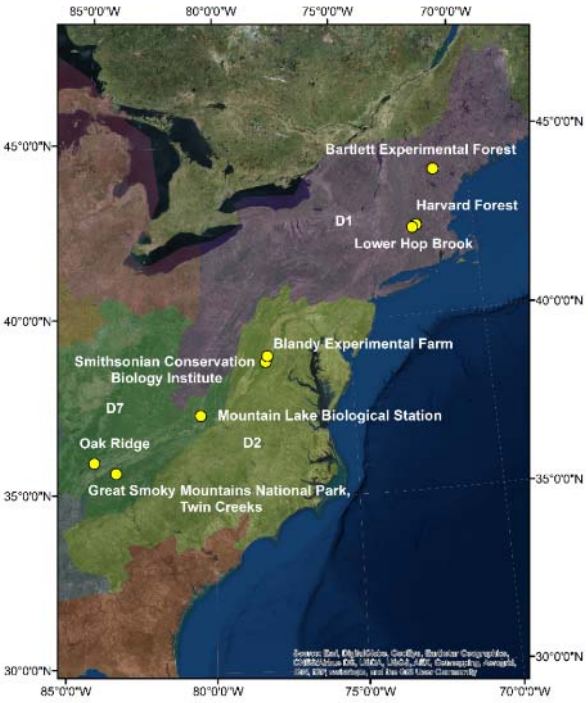
Uses AOP and flux data from 5 NEON sites to test hypotheses about forest structure and function and how to scale to regions



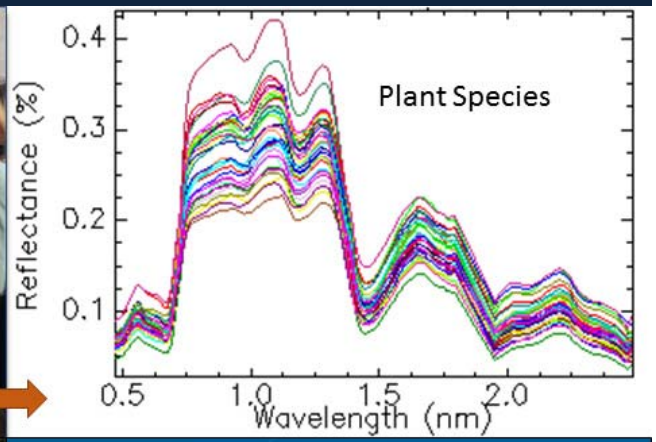
Early Career Awards

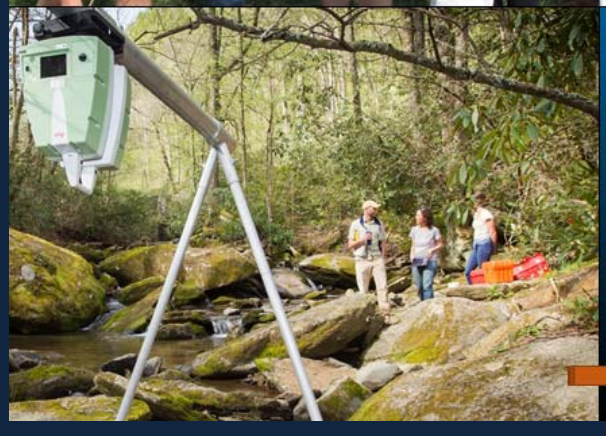
Innovative NEON tools: Using AOP to assess function and biodiversity

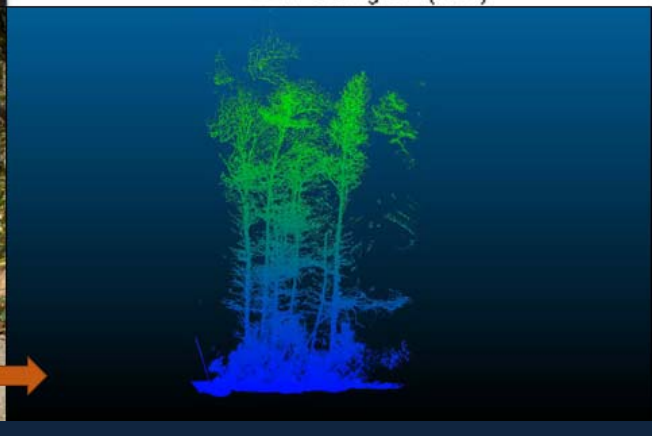
"MSB-ECA: Leveraging NEON data to investigate remote sensing of biodiversity variables and scaling implications"
(Mitchell: Appalachian State University, EF-1703062)



Uses AOP and vegetation data from 8 NEON sites to test hypotheses about plant biodiversity







Macrosystems

Ecological-systems to Macrosystems – Structure, function, scaling (cross, multi), context, connectivity

- What are the structuring processes that determine the temporal dynamics and spatial structure of regional systems? Are these processes scale dependent? How do these processes vary across the continent or at continental margins?
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- How does climate change affect regional temperature, hydrology, and drought severity, and what influences are predicted for species distributions and interactions, phenology, evolution, or biosphere productivity and biogeochemistry?

Terrestrial Macrosystems
From Genes to Continental Scale Forest Productivity

Genotype to Functional Traits

Foliar, growth, and fluxes

Harvard & SERC

"Forest function from genes to canopies: disentangling the fine scale spatio-temporal variation in gene expression and tree growth"
(Swenson)

ENS

Foliar Functional Traits

Relating traits to remote sensing

30 Forested NEON locations

"Foliar traits and ecosystem variability across NEON domains"
(Townsend)

Genome-Phenome-Population-Ecosystem

Phenome-Community-Ecosystem

Traits - Diversity – land/atmosphere Exchange

Traits, remote sensing, fluxes

Entire US Forests including NEON

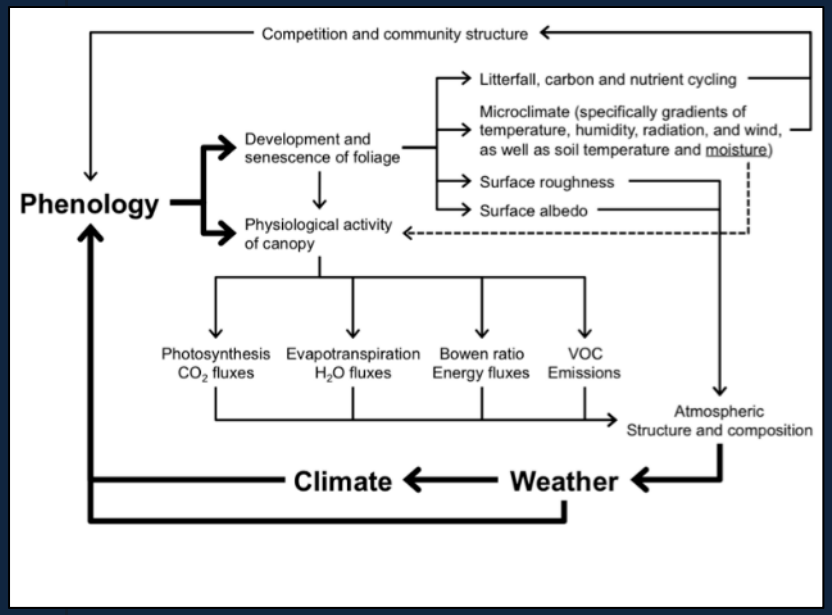
"The influence of biological diversity on land-atmosphere exchange in forests: confronting theory with data" (Ollinger)

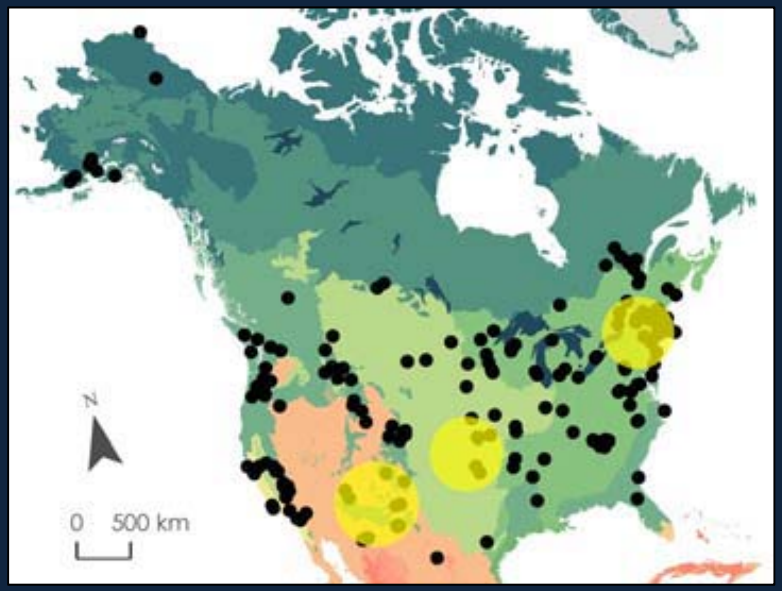
Phenome-Community-Ecosystem-Macrosystem

Terrestrial Macrosystems
"Scaling" using Phenology and Citizen Science

"Improved Understanding of Feedbacks between Ecosystem Phenology and the Weather-Environment Nexus at Local-to-Continental Scales" (Richardson EF 1702697)

Vegetation phenology regulates ecosystem processes and plays a role in feedbacks of ecosystems to the atmosphere, local-to-continental weather and climate.





Approach: Leverage ecosystem ecology, meteorology and climatology, earth system modeling, and remote sensing

Aquatic Macrosystems

- How do climate and land-use changes impact hydrology, physical processes (e.g. temperature) and nutrient/carbon cycling in lakes and streams, and what is their effect on aquatic metabolism? How do these changes alter the connectivity among regions or regional feedbacks to climate?

- How are dust, nutrient, or biological source and deposition regions (connected through air and water vectors) related to patterns of human activity or land use, and how do the biosphere structure, function, and services respond to changes in loadings resulting from changing human activity or land use?

Aquatic Macrosystems

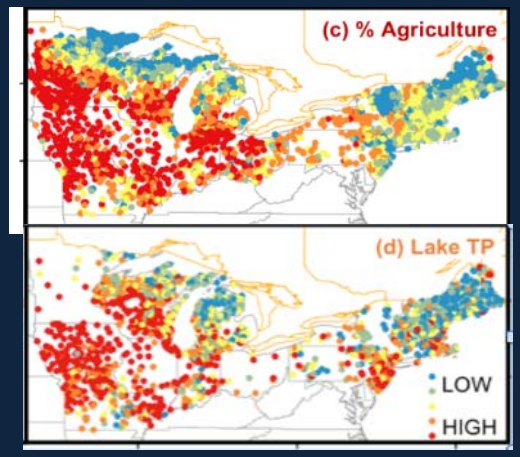
"A macrosystems ecology framework for continental-scale prediction and understanding of lakes"
(Soranno: EF-1638679)

C, N, P pools and fluxes at regional to continental scales are affected by:

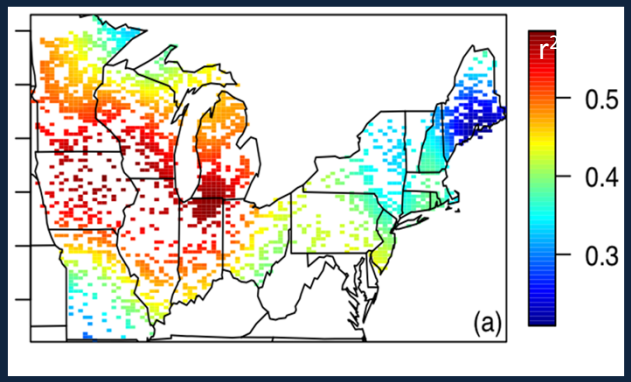
1. Ecological Context
2. Coupling/decoupling of nutrient cycles
3. Cross-scale interactions
4. Novelty

Additional Outcomes:

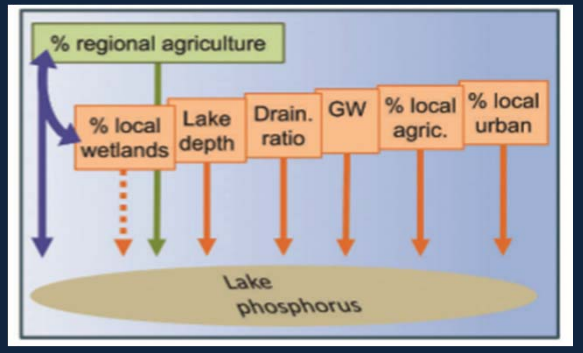
- A national-scale database (LAGOS-US) of lakes
- Analytical tools that leverage advanced statistics and computer science methods.
- Training in a highly collaborative interdisciplinary, team-science environment.



Ecological Context



Coupling of nitrogen and phosphorus



Cross-scale interactions

Macrosystems – Organisms and Disease

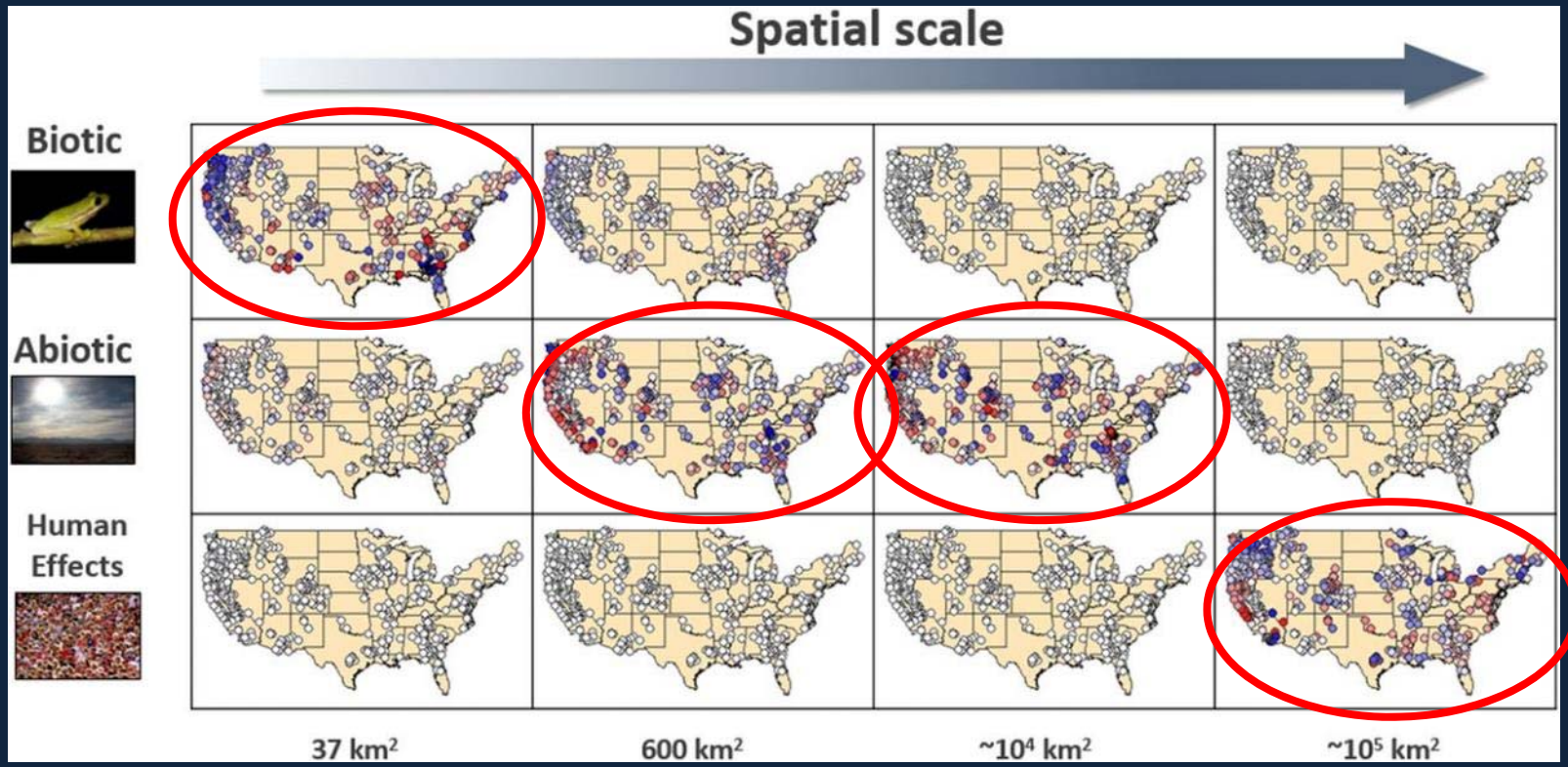
- How are local and regional scale process of invasion and disease transmission shaped by continental scale patterns of connectivity? How can continental scale data inform forecasts of disease outbreaks and invasions? How do invasive species or emerging diseases arrive at a new location?

- How do changes in intensity, spatial distribution and frequency of extreme events affect regional systems and their attributes? How will changes in regional systems affect other regions or their connectivity (e.g. soil erosion and airborne dust, water retention, nutrient export, invasive species)?

Organismal Macrosystems: Research Highlights

"The Influence of Temporal and Spatial Scales on Drivers of Host-Parasite Interactions"

(Jason Rohr, U. FL)

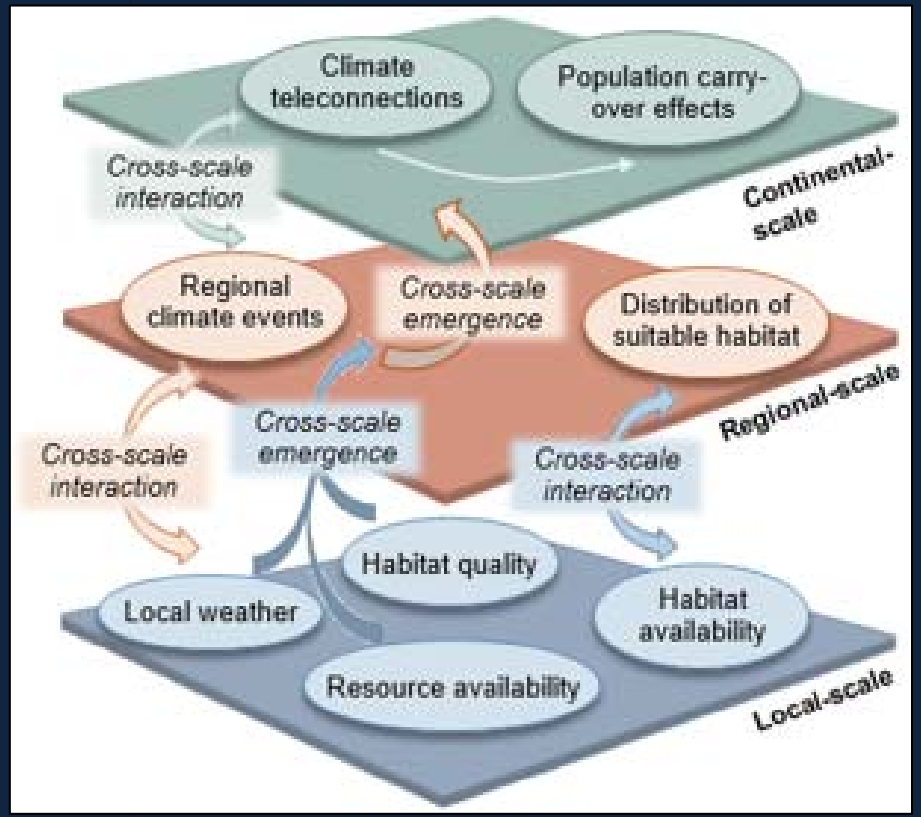


Different processes control Chytrid distribution at different scales

Jeremy M. Cohen et al. PNAS doi:10.1073/pnas.1521657113

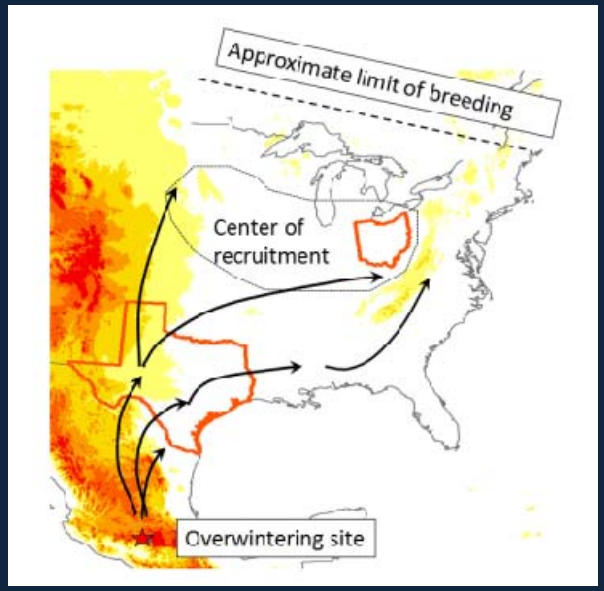
Organismal Macrosystems
"Scaling" using Phenology and Citizen Science

Multi-scale Modeling Framework



"ECA-A multi-scale framework to quantify and forecast population changes and associated uncertainties"
(Zipkin: EF 1702635) Foundation List

Modeling cross-seasonal processes affecting monarch butterfly populations to forecast population changes at multiple scales under future climate and resource availability scenarios.

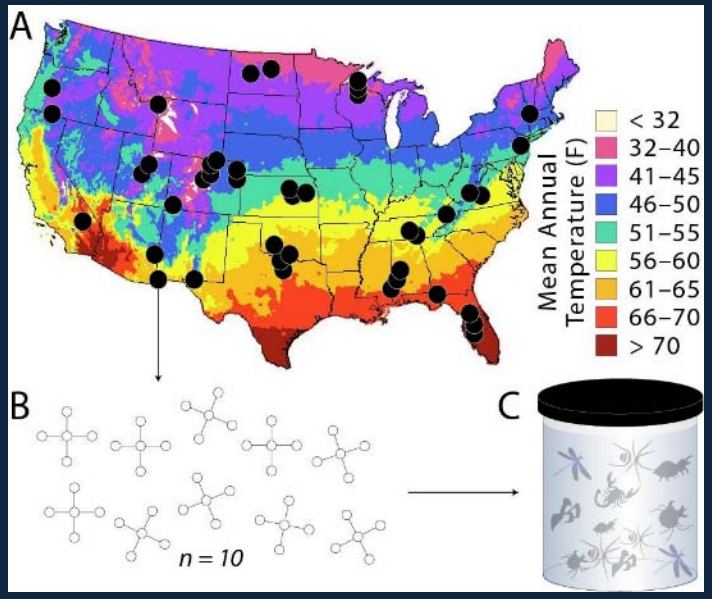


Organismal Macrosystems
Use of NEON "by-catch"

"Testing abiotic drivers of activity, abundance, and diversity of ground-dwelling arthropod communities at a continental scale"
(Kaspari: University of Oklahoma, EF- 1702426)

Geographical Ecology of Arthropods

Abundance, activity, size, and diversity are functions of temperature, precipitation, and biogeochemistry



Location of 47 NEON pitfall traps

Approach:

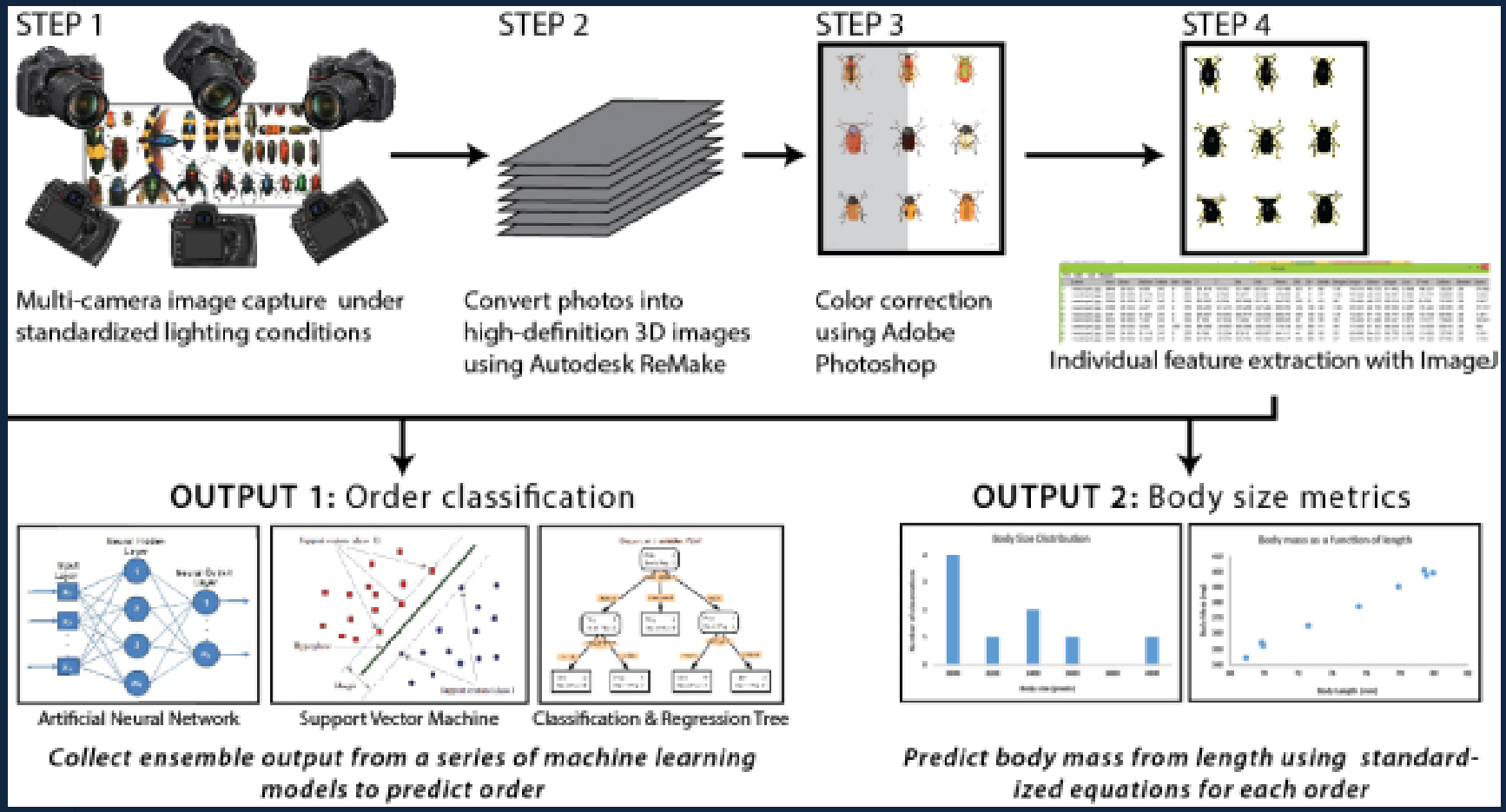
- Bycatch from NEON pitfall traps
- Automated image analysis
- Environmental barcoding

Broader Impacts:

- Continental map of ground arthropods
- Tool development (data pipeline, invasive monitoring)
- Geographical Ecology curricula

Kaspari EF- 1702426

Tool development (data pipeline, invasive monitoring)



- **Dynamics of Coupled Human and Natural Systems**
  - Environmental and human systems – convergence, dynamics, connectivity, context
  - What are the ecological and socio-ecological consequences of local land-use changes at regional and continental scales? What are the spatial and temporal patterns in human activity within a region and their consequences to the biosphere?
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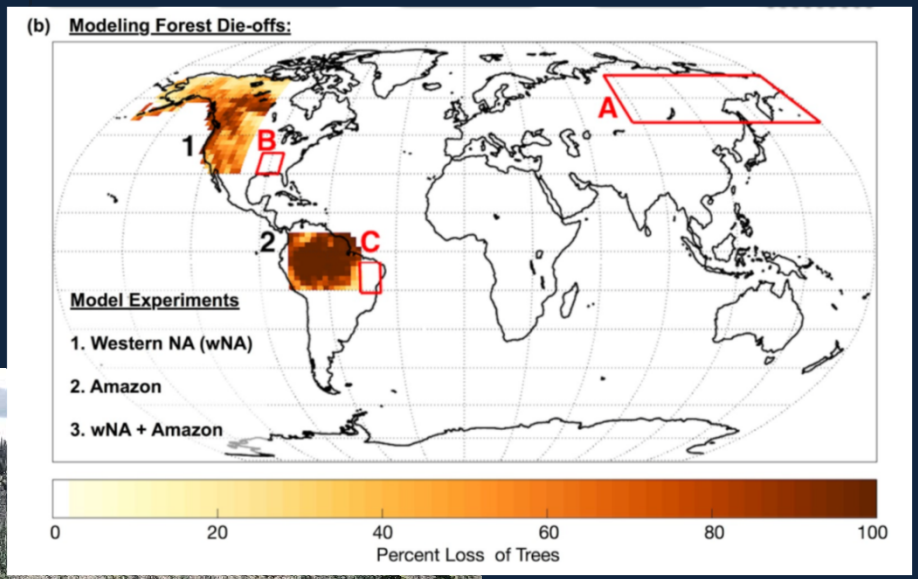
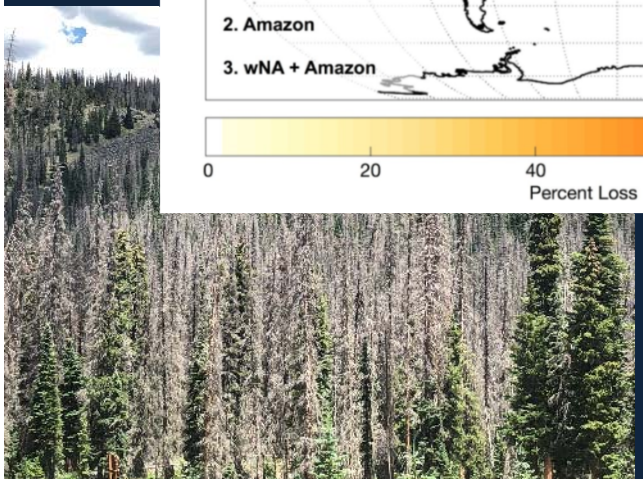
CNH and MSB Awards on Teleconnections

Ecoclimate Teleconnections between Amazonia and Temperate North America: Cross-Region Feedbacks among Tree Mortality, Land Use Change, and the Atmosphere

Revealing the Hidden Ecoclimate Teleconnections Between Forest and Agriculture in the U.S. Enables Novel Governance Strategies for a Telecoupled World





- Modeled climate and ecological teleconnections
- Assessed effects of forest loss in Amazonia and Western North America on distant climate and ecology
- Found that forest productivity declined in Eurasia, but increased in SE US

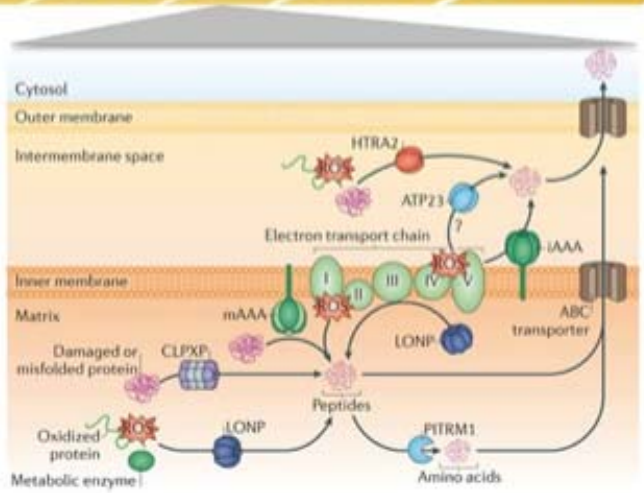
(David Breshears, University of Arizona, EF-1340624; DEB-1824796)

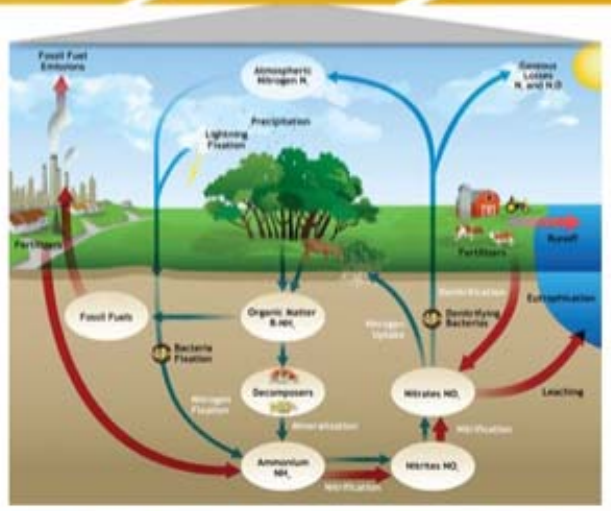
Garcia et al. (2016) – PLOS ONE

Pressing Questions and NSF Strategies to Enable Convergent Research and Transformative Science

- **Rules of Life**
  - Linking levels of biological organization, general principals governing key properties of life
  - How will the biosphere respond to changes in natural- and human-induced forces such as climate, land use, and invasive species across a range of spatial and temporal scales? What is the pace and pattern of the responses? What is the effect on biosphere services at local, regional, and continental scales?
  - What are the causes and consequences of regional synchrony in dynamics of populations? Are there continental scale drivers that entrain regional and local patterns of population growth, dispersal, speciation, or diversification?
  - Metabolic Theory, Maximum Entropy Theory, STAR theory

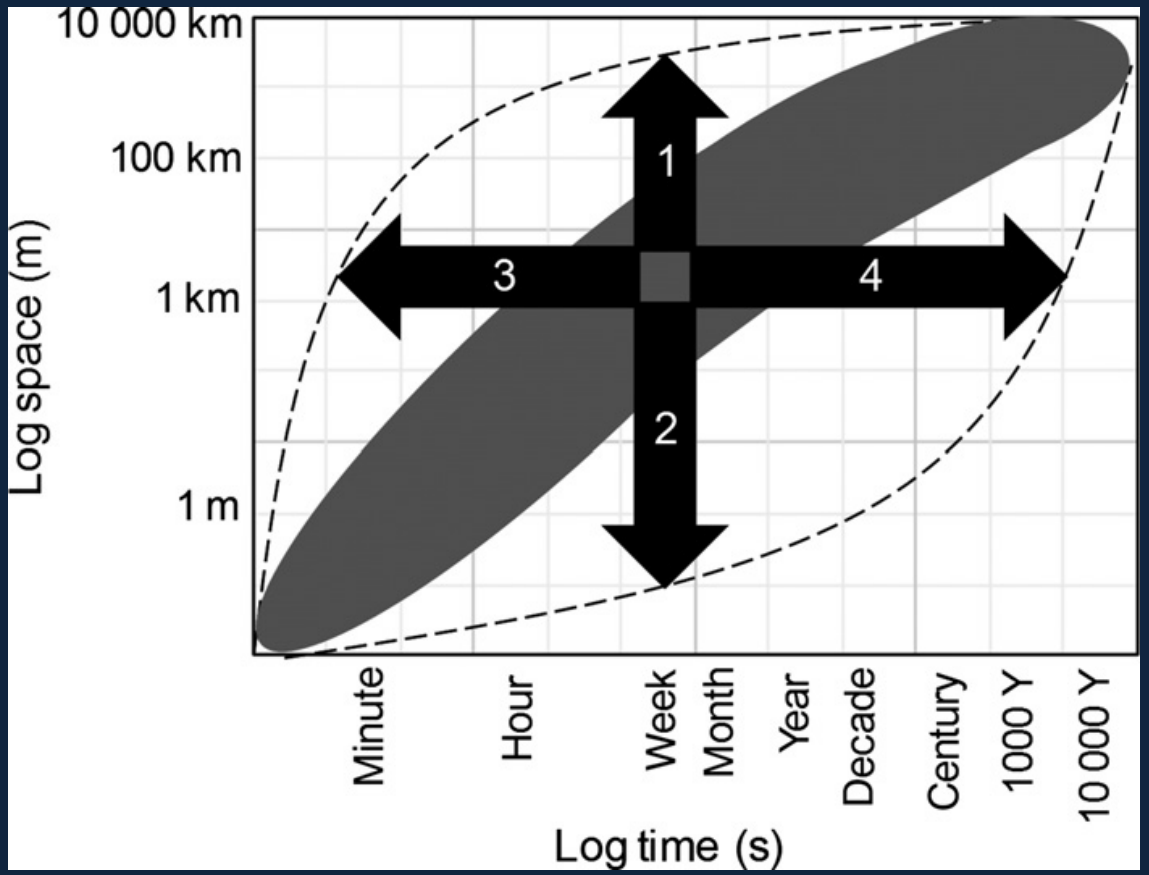
Understanding the Rules of Life: Predicting Phenotype

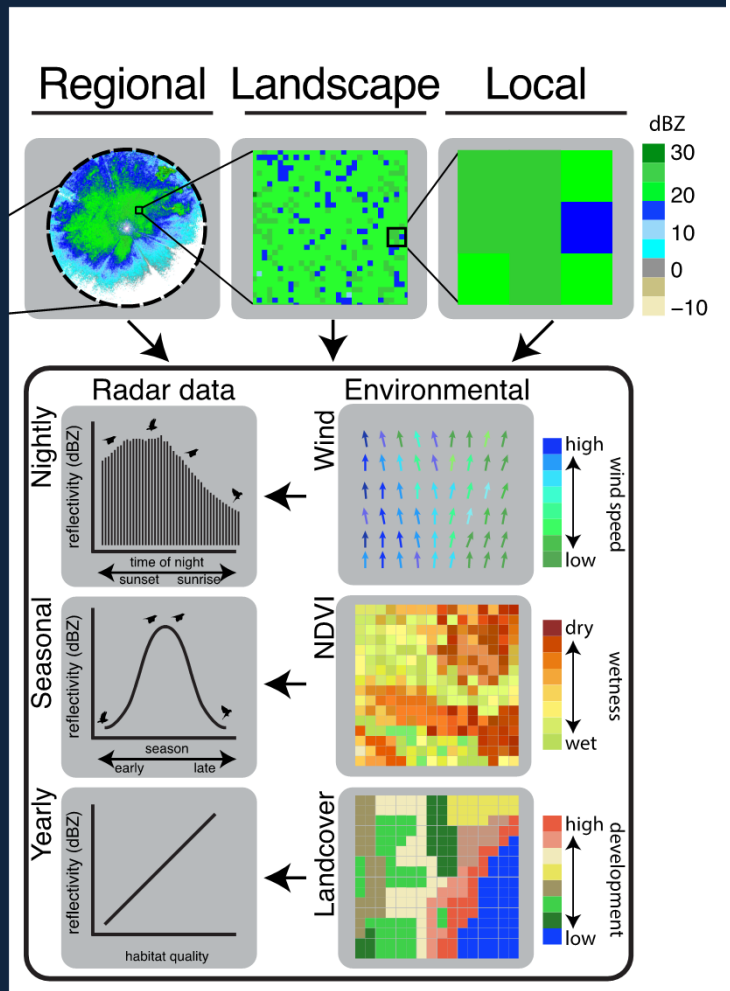




STAR Hypothesis

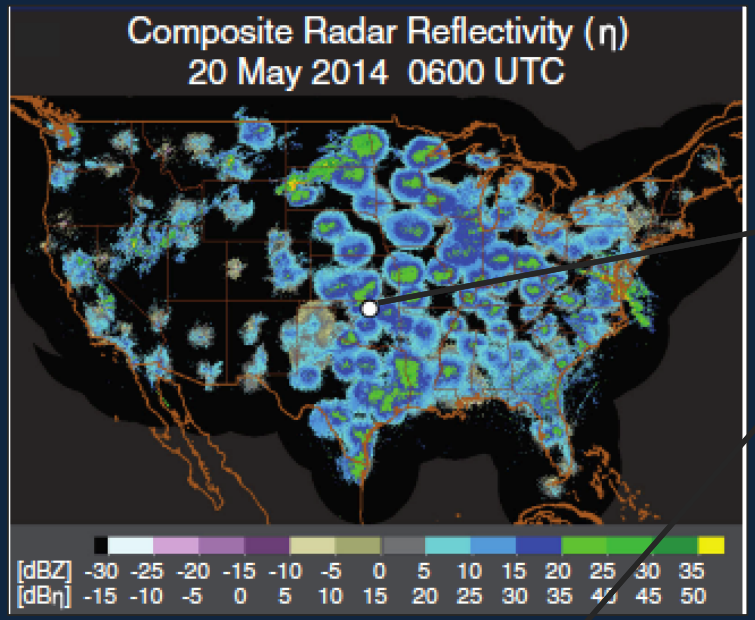
- The spatio-temporal anthropogenic rescaling (STAR) hypothesis suggests that human activities are altering the scales of ecological processes, resulting in interactions at novel space–time scale combinations that are diverse and predictable.

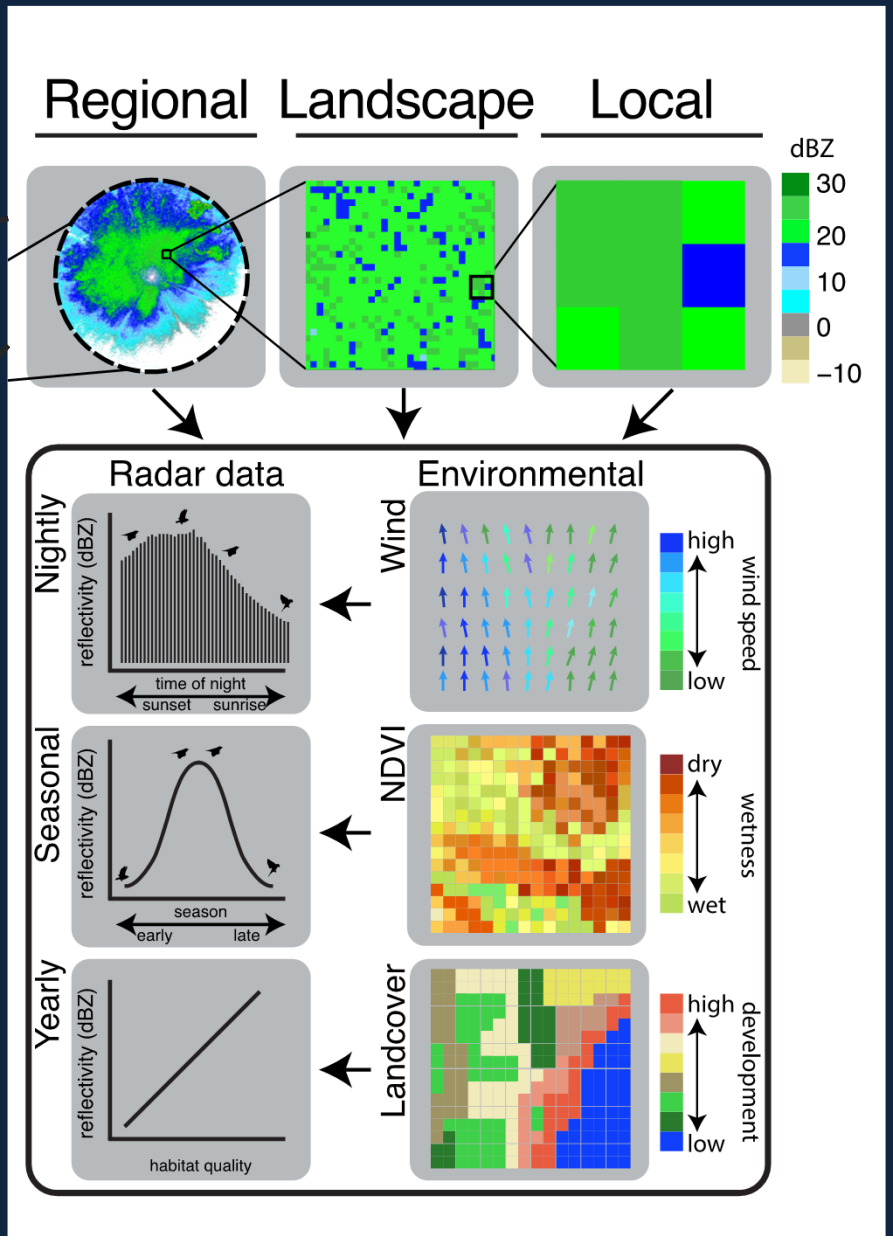




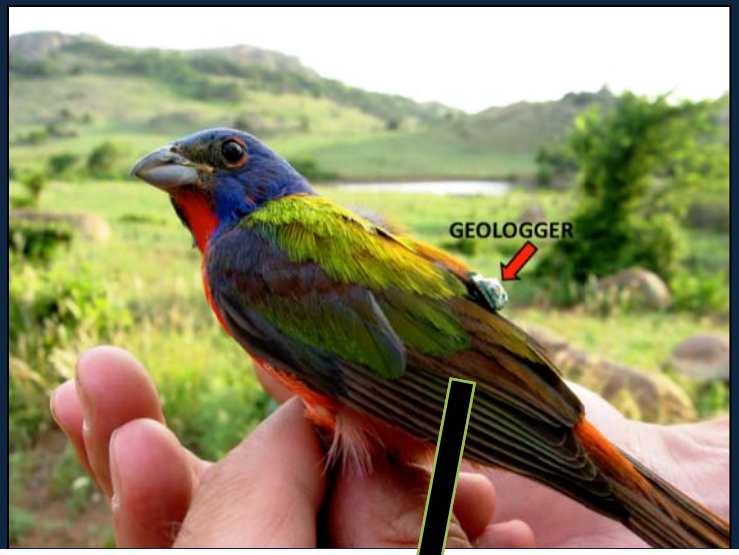
Rose et. al Ecology Letters (2017) 20: 147–157

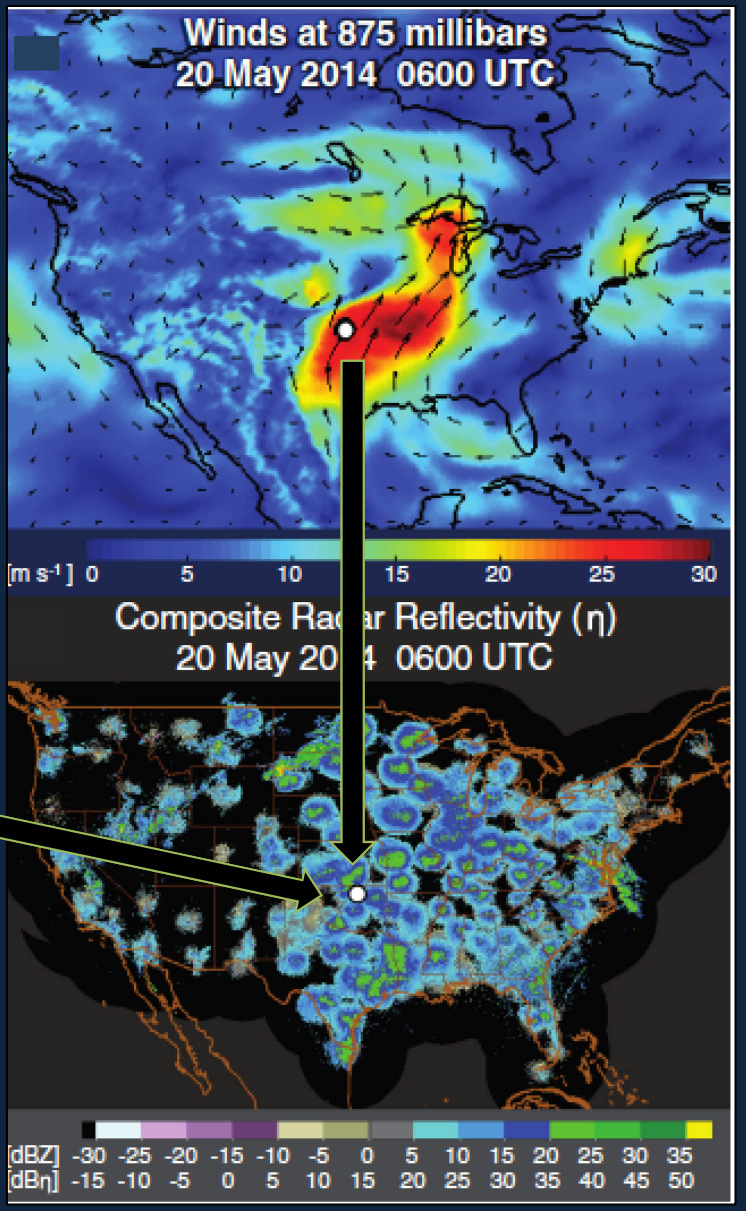
Data Integration to Understand Anthropogenic Rescaling of Migration In Response to Environmental Change

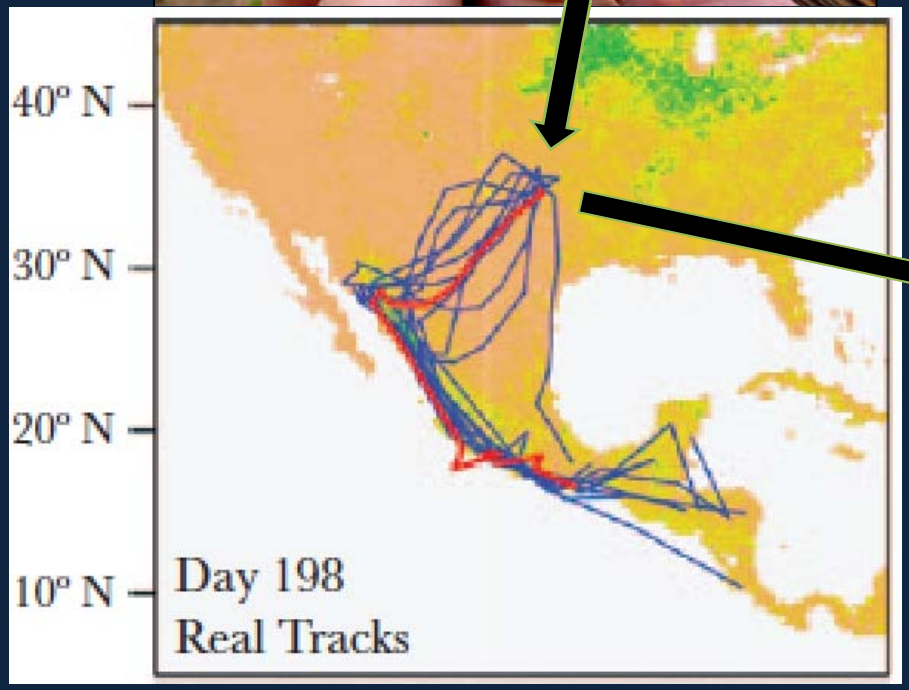




Scaling-up to Understand Rescaling of Migration Timing



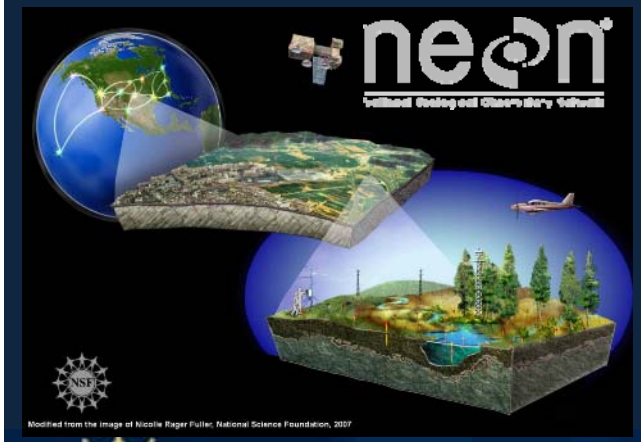




Technological Revolution

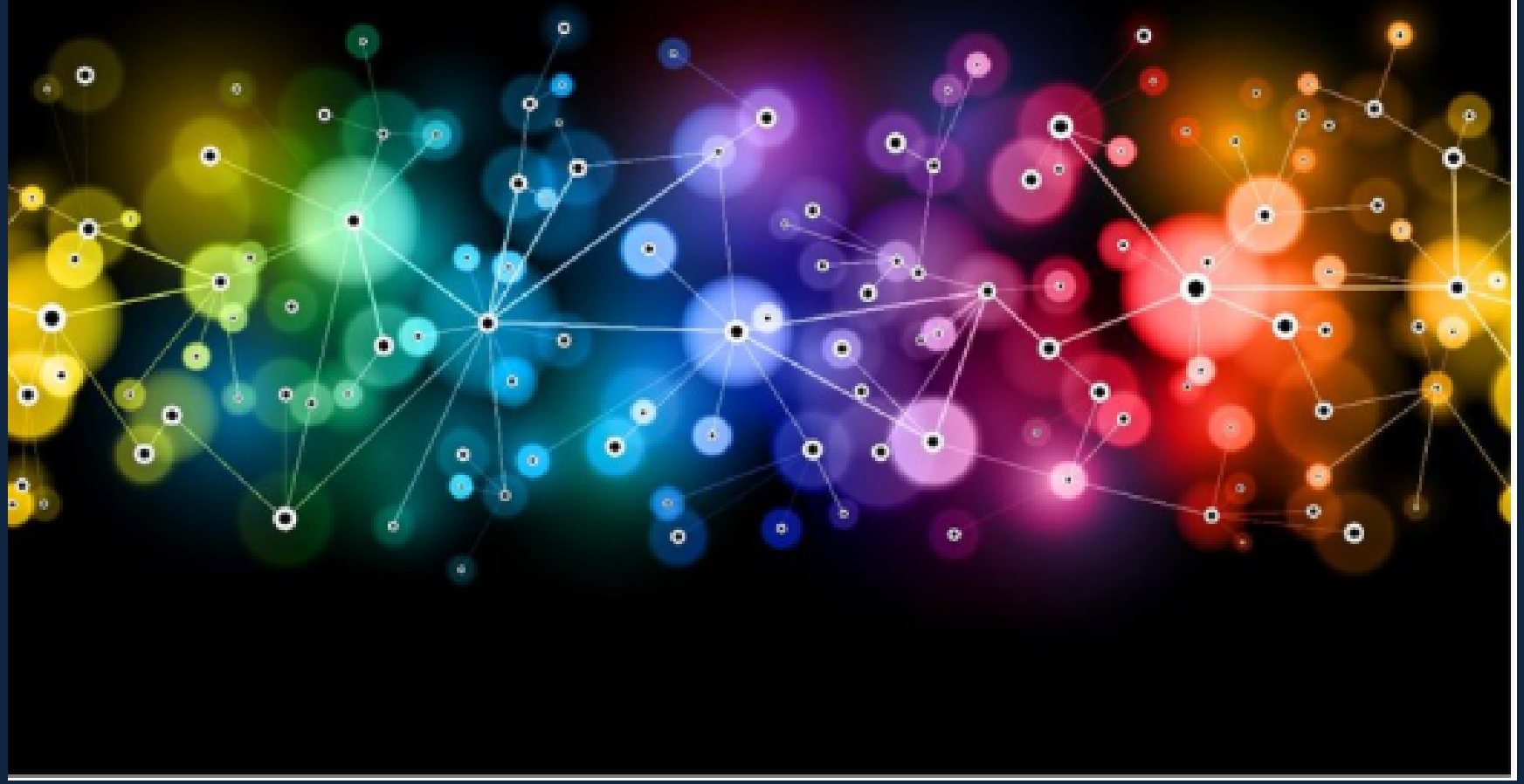
New technologies are fusing the physical, digital, and biological worlds

earth microbiome project

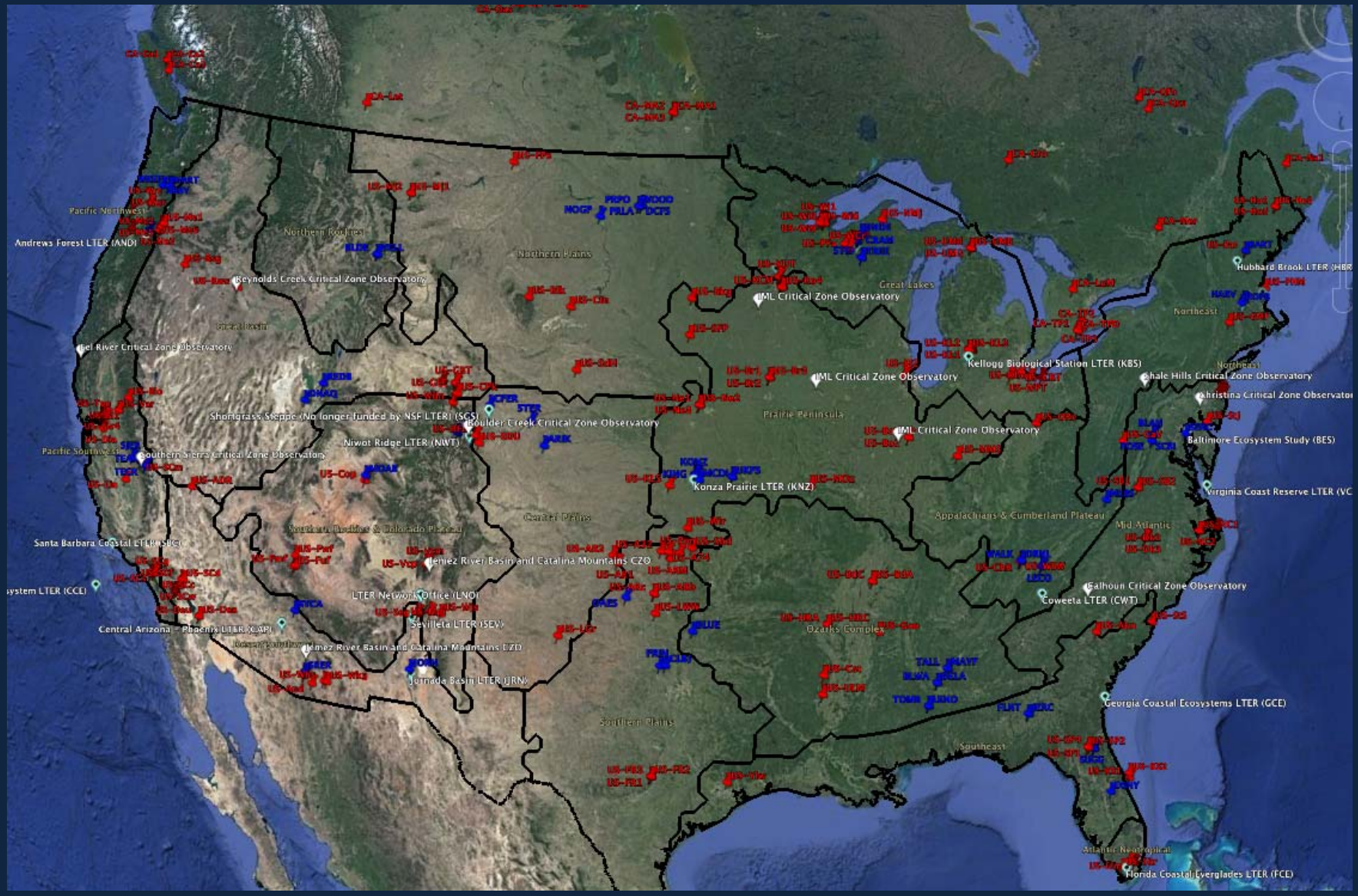


NSF

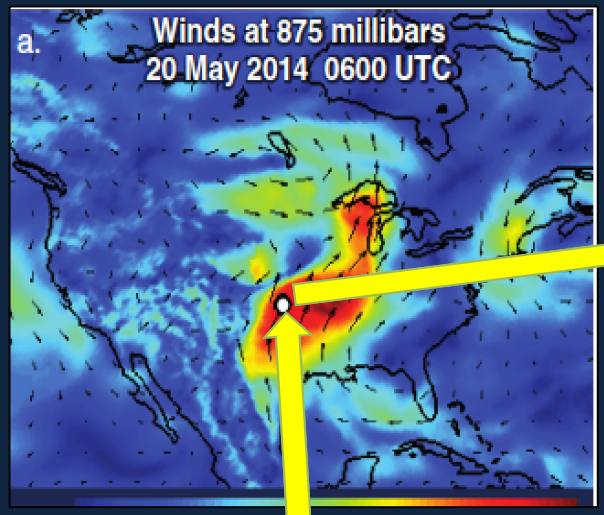
Questions?

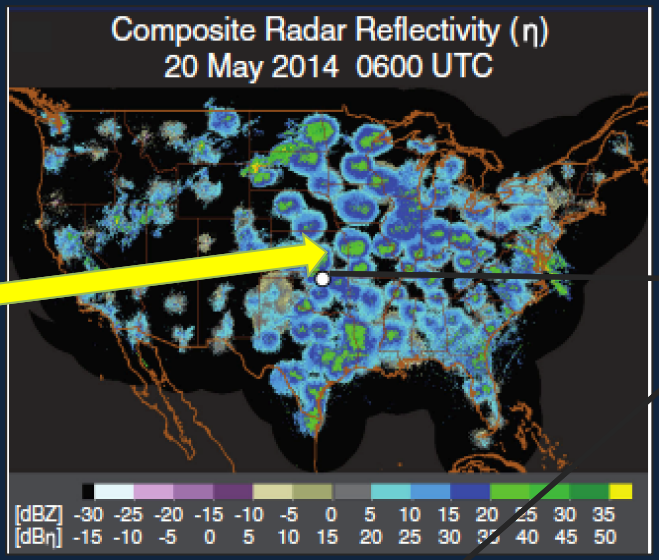


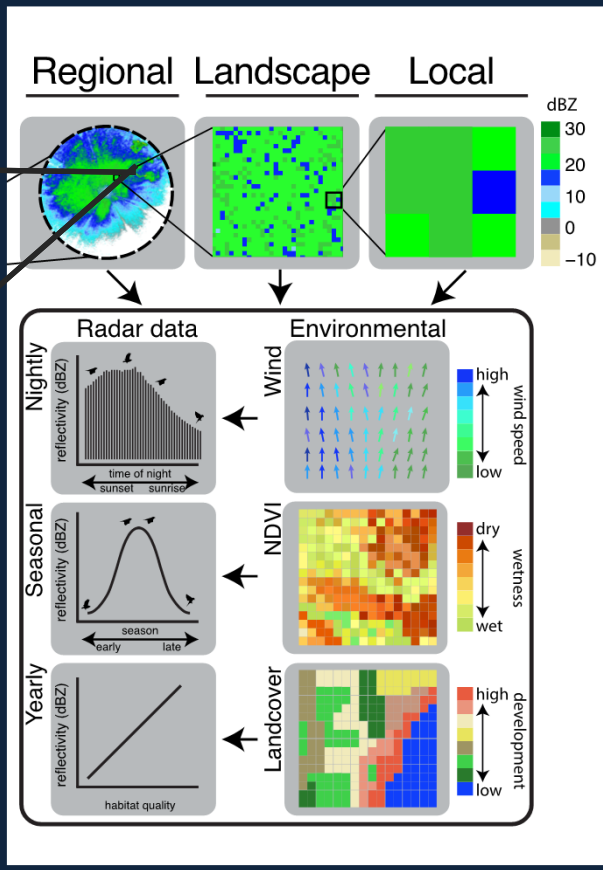
Leveraging Networks, Observatories, and Agency Infrastructure

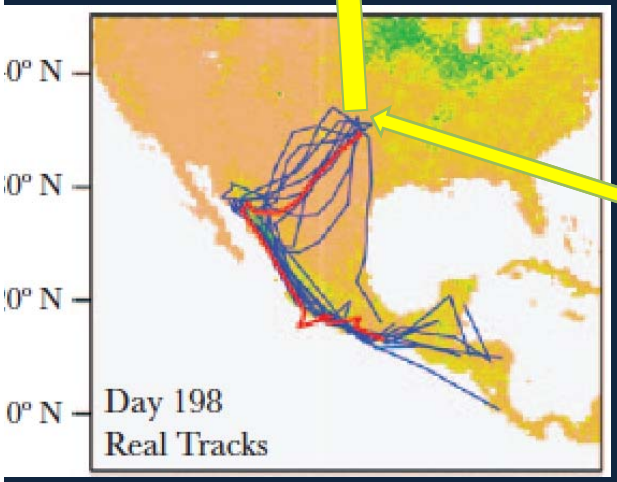


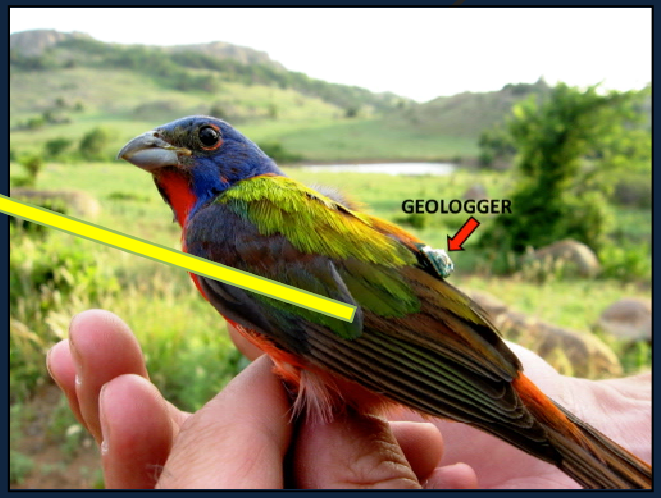
Scaling-up to Understand Rescaling of Migration Timing and Response to Environmental Change











Data Integration to Understand Anthropogenic Rescaling of Migration In Response to Environmental Change

Kelly EF - 1840230