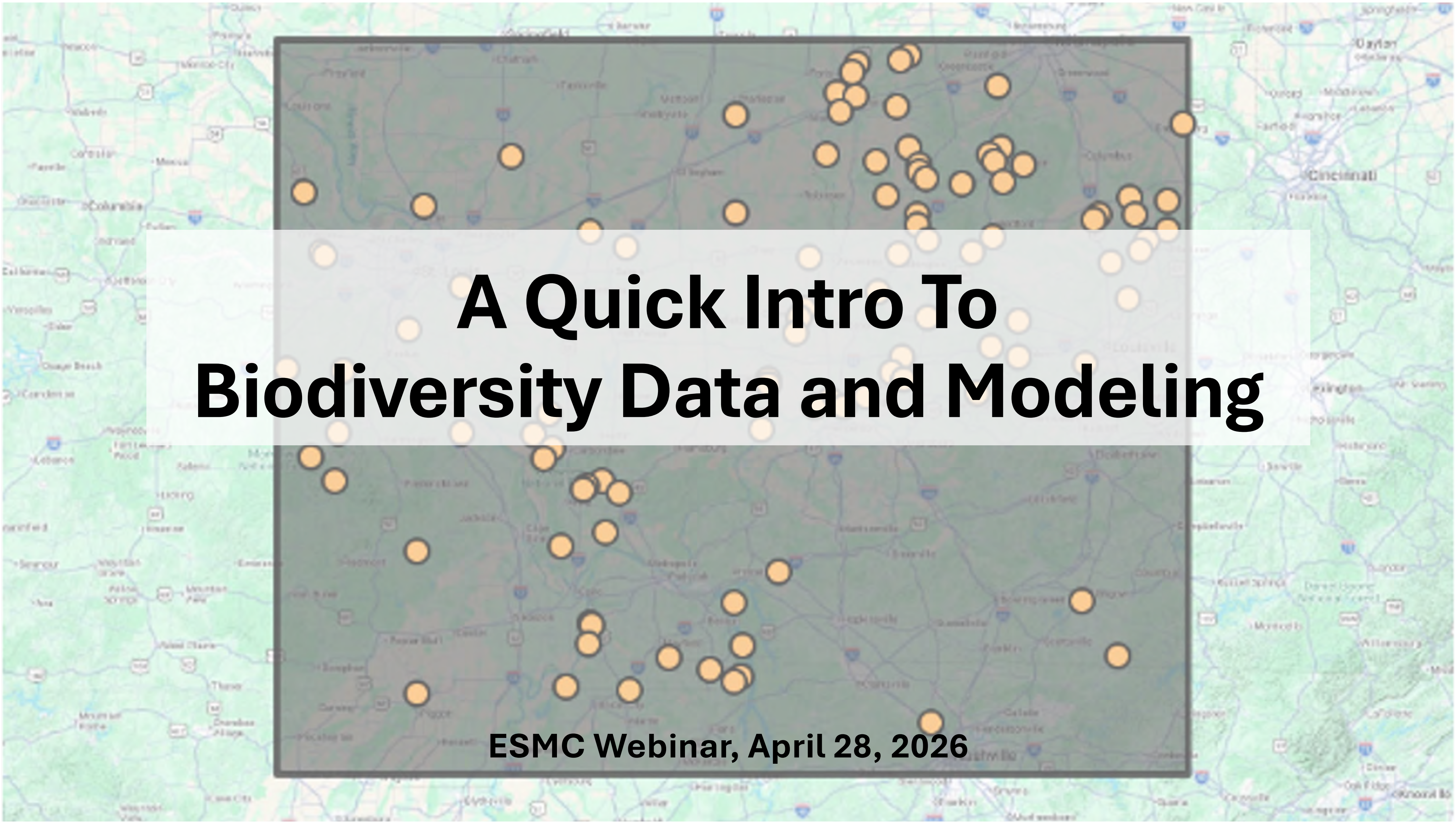


A Quick Intro To Biodiversity Data and Modeling

ESMC Webinar, April 28, 2026

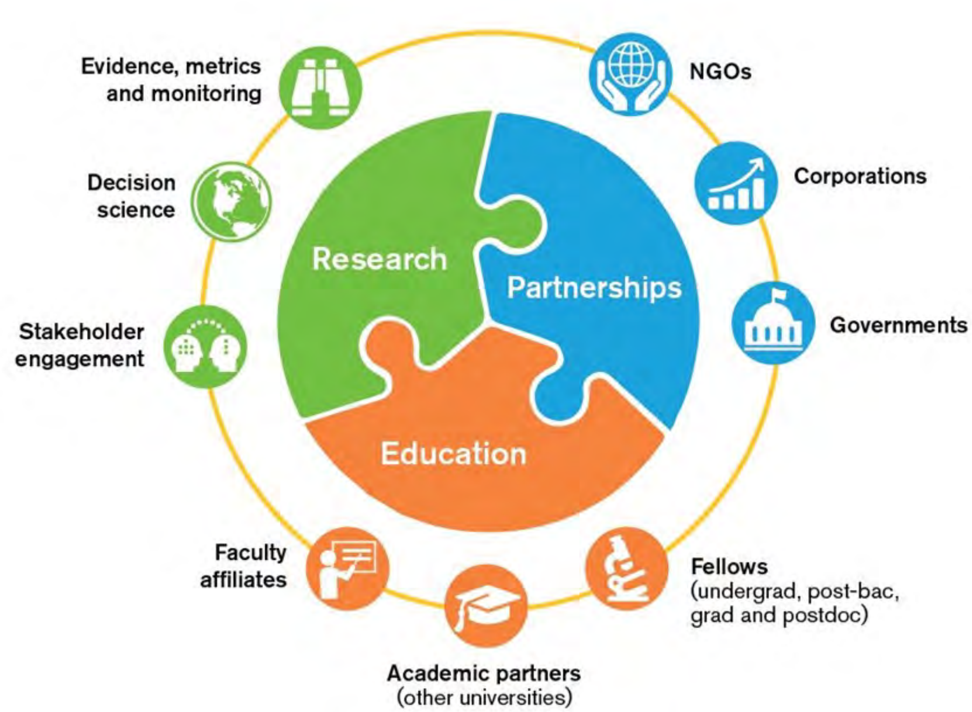
ASU Center for Biodiversity Outcomes

- Bring biodiversity to the center of the world's decision making
  - Many ongoing NGO partnerships

- Transform biodiversity conservation investments and decision-making

Leah Gerber
CBO Director

Shirley-Ann Behravesh
Corporate Engagement Lead



https://globalfutures.asu.edu/center-for-biodiversity-outcomes/

Motivating Questions for ESMC

- What are the benefits of alternative farming practices for biodiversity?
- How can these benefits to biodiversity create benefits to farmers?

In this webinar, I’ll go into more depth on where data about biodiversity comes from and how it can be used in predictive models

What Is Biodiversity Data?

Species Observation Record

Species ID	*Pecari Tajacu (Collared Pecary)*
Date	Sept 15, 2022
Location	Bacanora, Sonora, Mexico
Taxonomy	Mammal Diversity Database Version 1.12
Voucher Source	https://www.inaturalist.org/observations/146710986

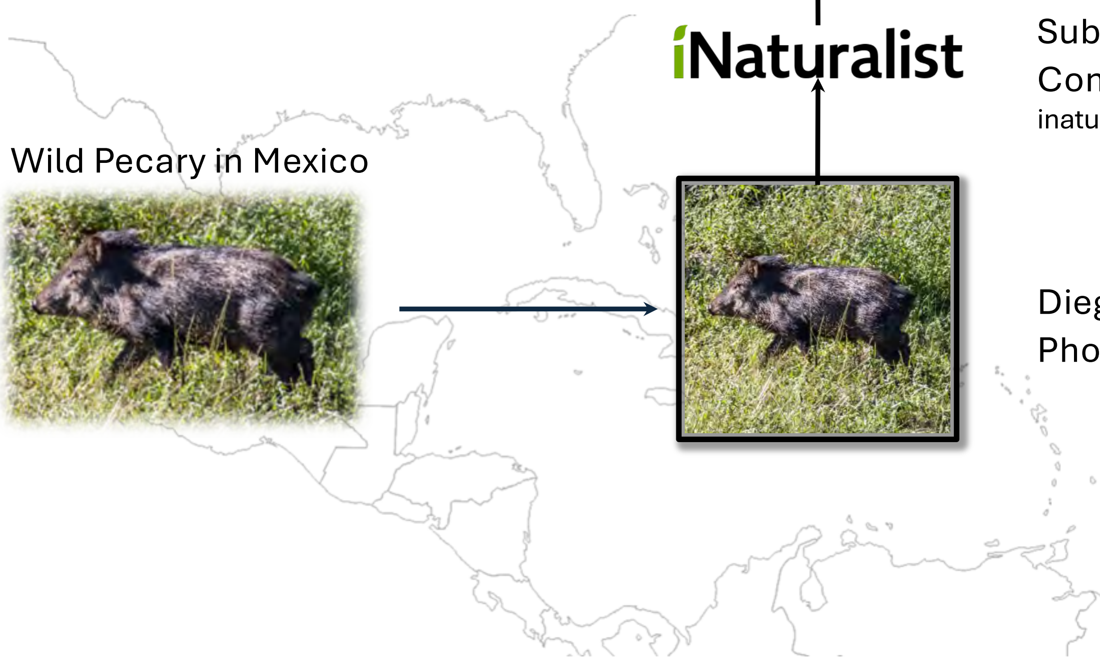
Aggregation by Global Data Portal

GBIF Global Biodiversity Information Facility

iNaturalist

Submission to Community Repository
inaturalist.org/photos/252295402

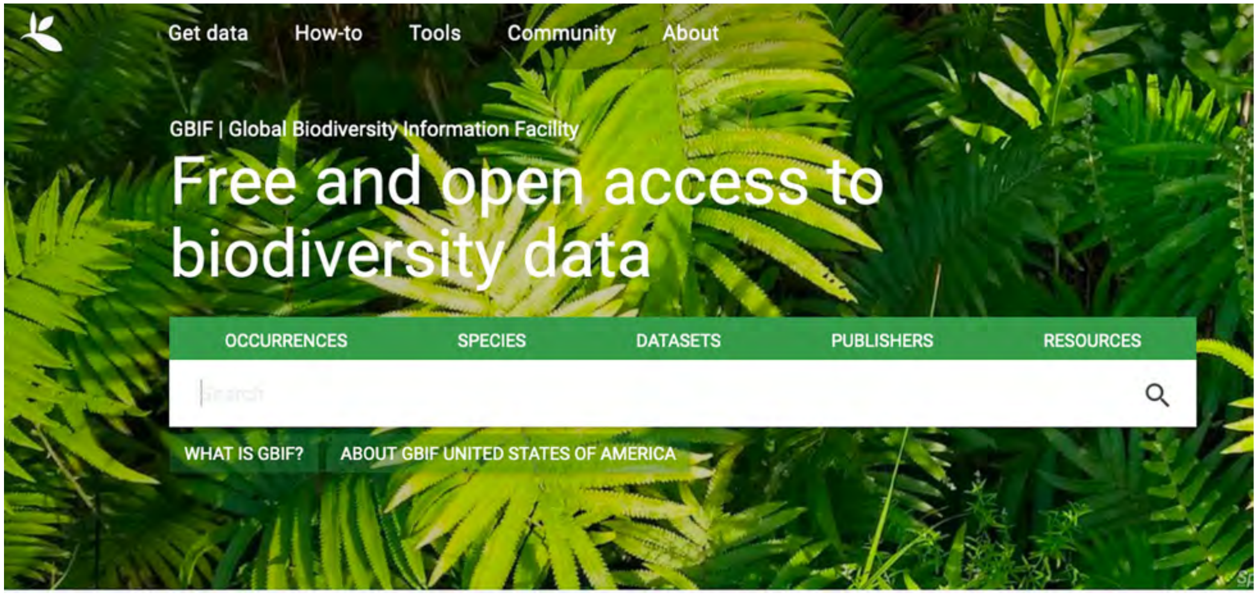
Wild Pecary in Mexico



Diego Barrales's 2022 Photo

Elliott and Sterner, 2025. *EJPS*

Data Repositories: More than Websites



GBIF Global Biodiversity Information Facility

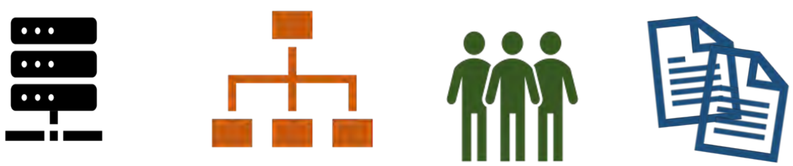
GenBank

Symbiota

iNaturalist

CALIFORNIA ACADEMY OF SCIENCES

NATIONAL GEOGRAPHIC



pooled (meta) data records

formal social organization

people

governance institutions

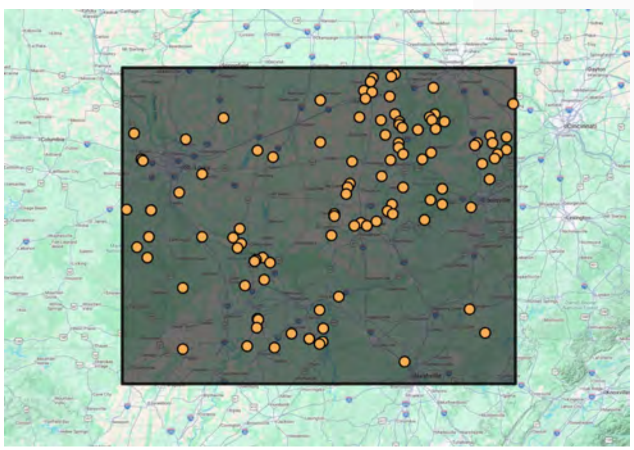
→

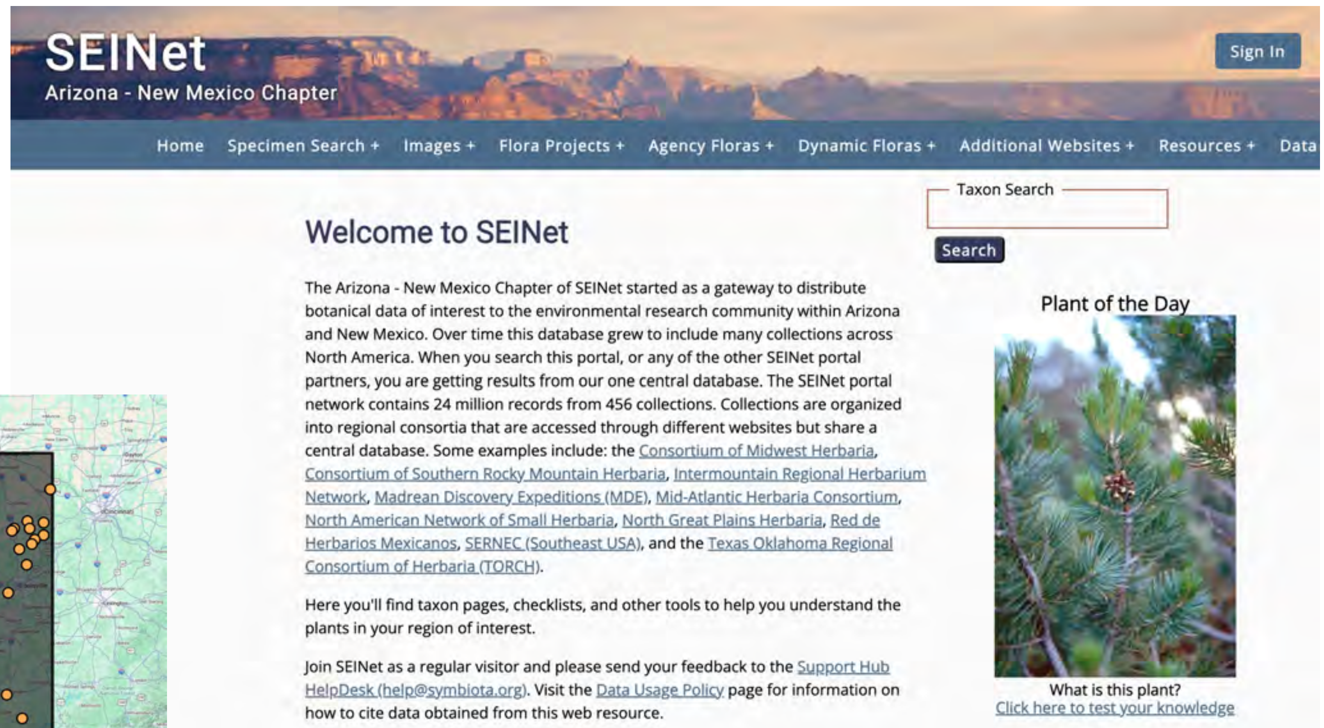
- Manage the operation of the organization
- Set & enforce (meta) data standards
- Integrate & structure information/ knowledge

Example: SEINet Symbiota Portal

A database of 24 million digitized herbarium specimen collections curated primarily by botanists.

Includes map search functions

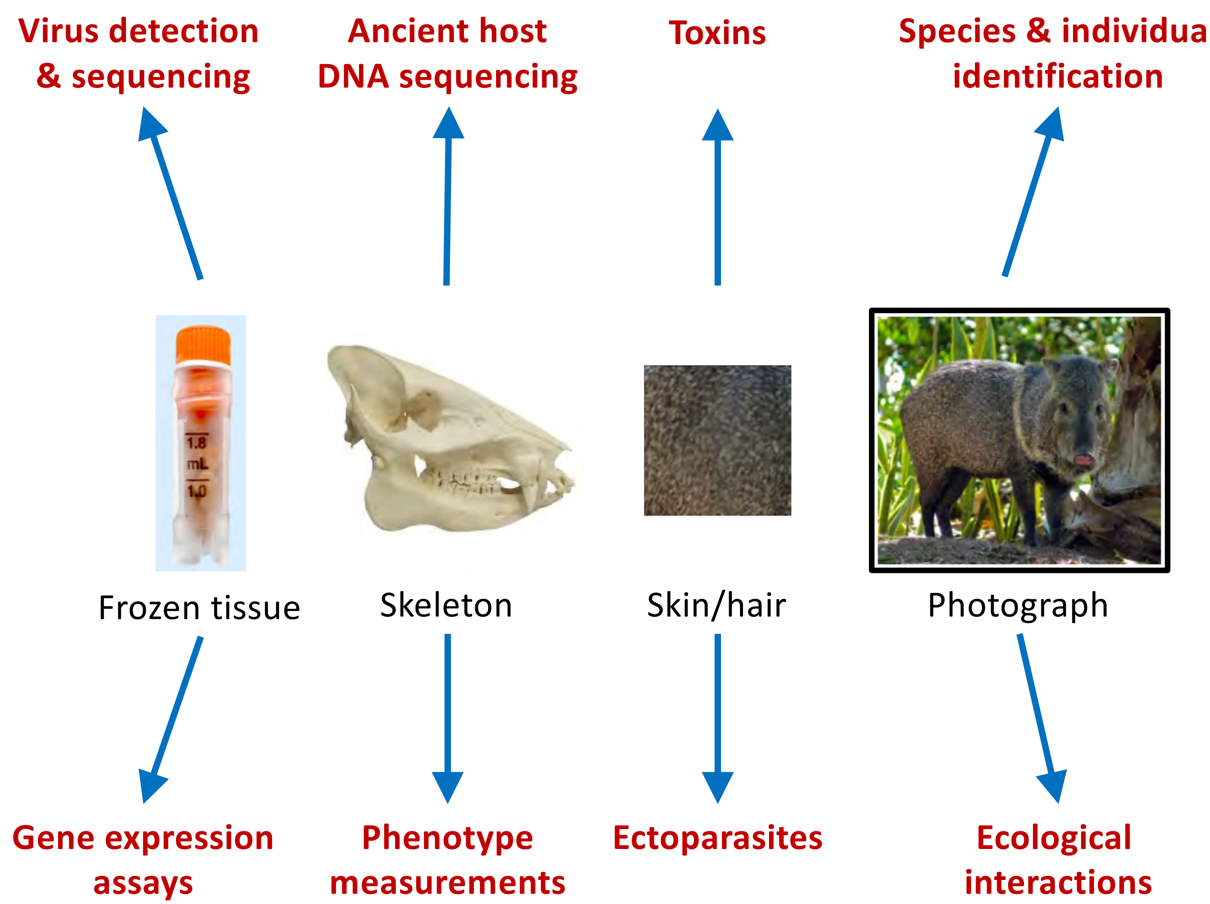




Importance of Vouchers for Biology

Physical and digital vouchers are useful for all sorts of research in biology

Vouchers are stored in research collections for long-term reuse by different projects

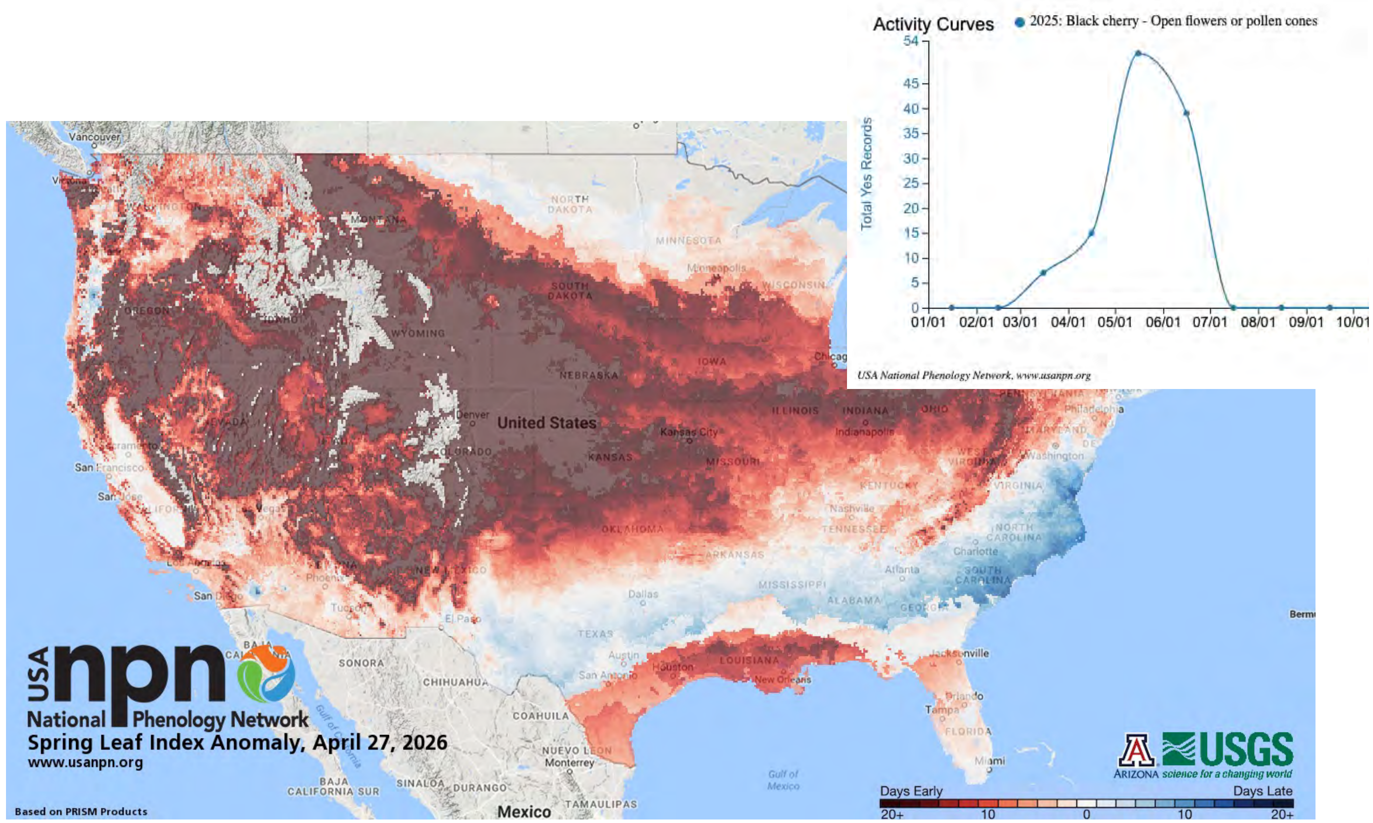


Example: National Phenology Network

Phenology is the seasonal timing of biological events, such as leafing, flowering or insect emergence

Many species are sensitive to climatic factors such as temperature, rainfall, and sunlight

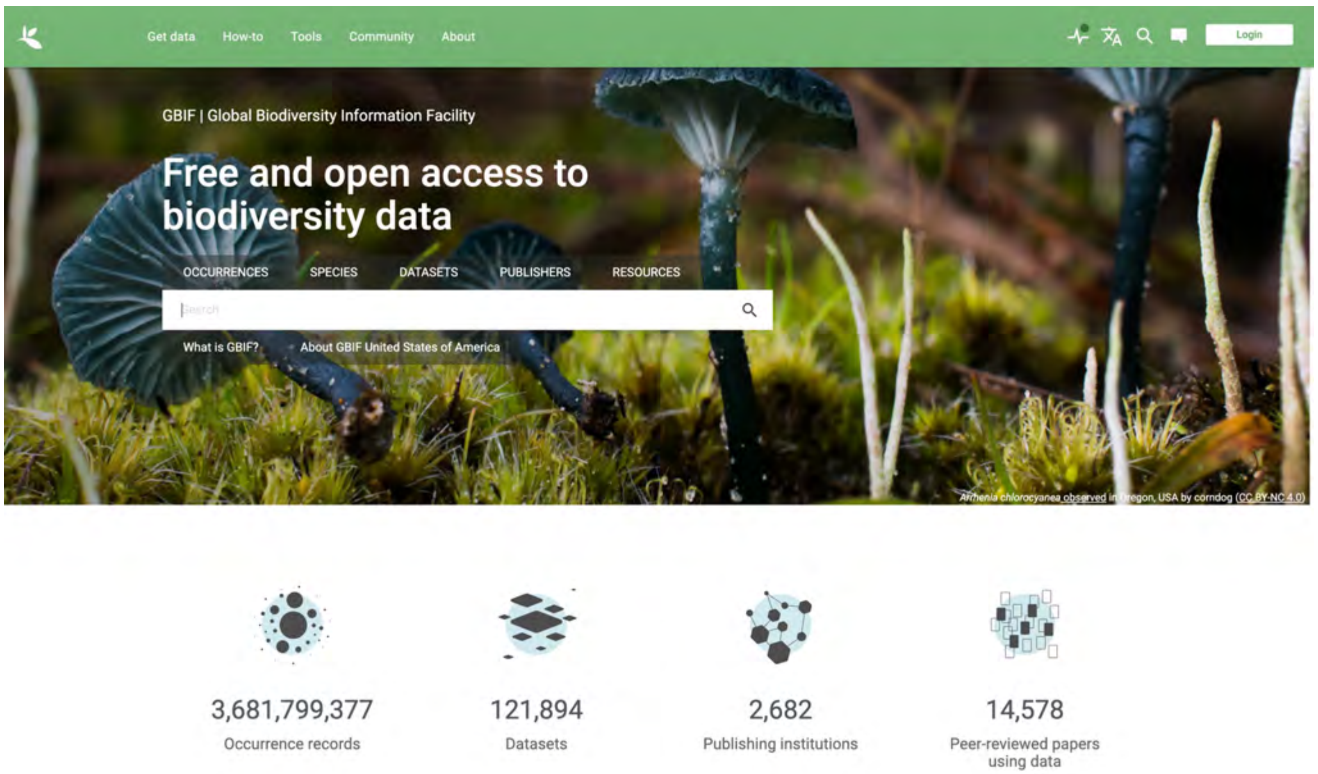
Shifting timelines can disrupt symbiotic relations such as flowering and pollination



https://www.usanpn.org/

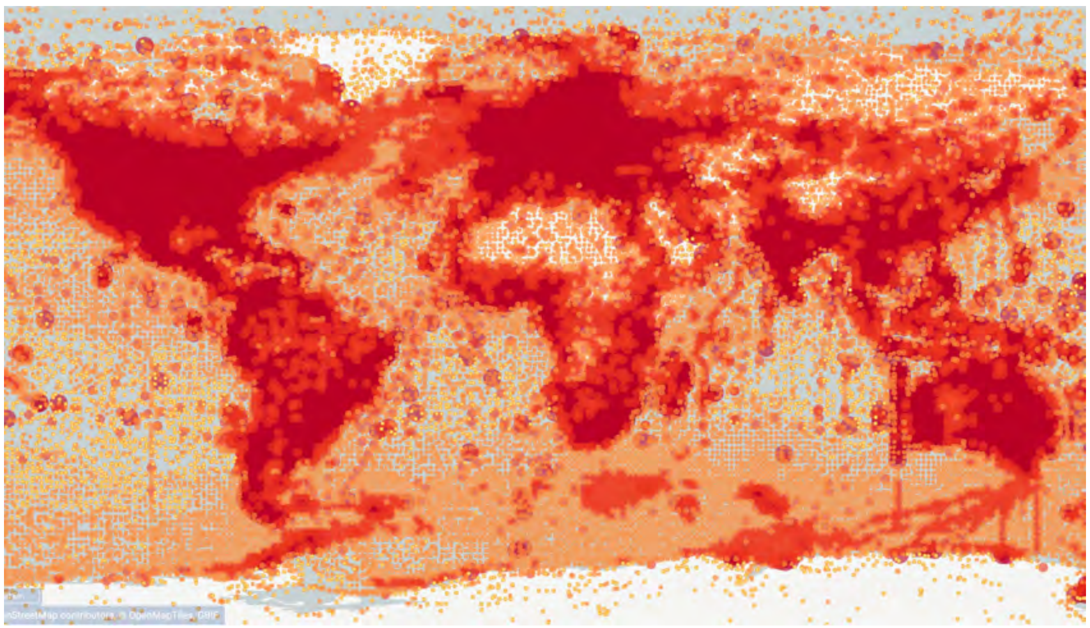
Global Biodiversity Information Facility (GBIF)

What are the geographic distributions of all species?

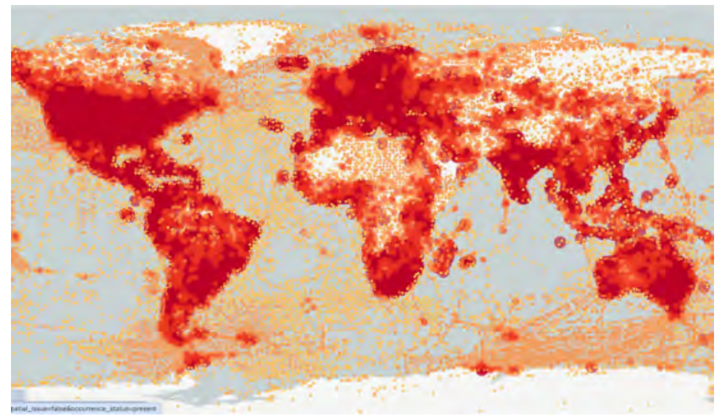


Taxonomic Bias in GBIF Database

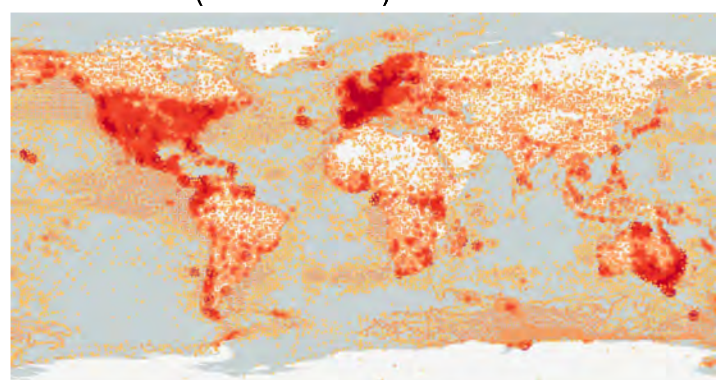
All: **3.7B** occurrences



Birds (Aves): **2.2B** occurrences



Mammals (Mammalia): **41M** occurrences



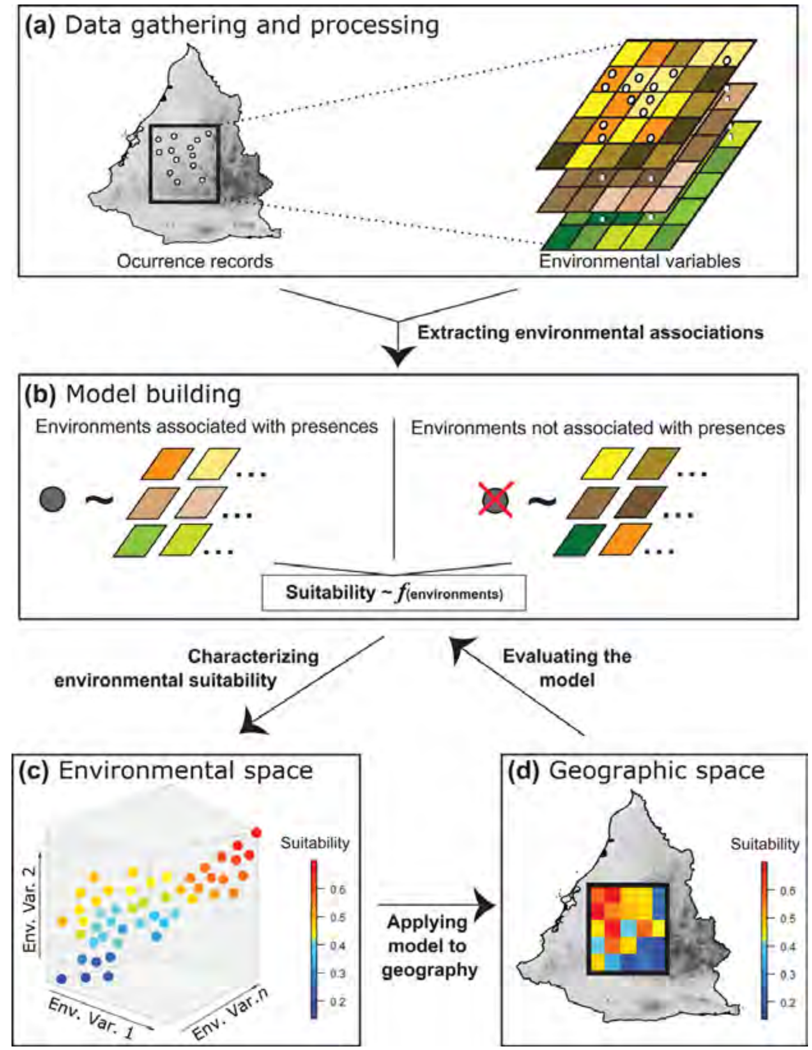
Source: gbif.org

Species Distribution Models

Also called “Ecological Niche Models”

In short: can I infer where a species might be based on observing its presence or absence at particular places?

Models use machine learning methods to correlate species observations with other variables such as climate, geography, other species, etc.

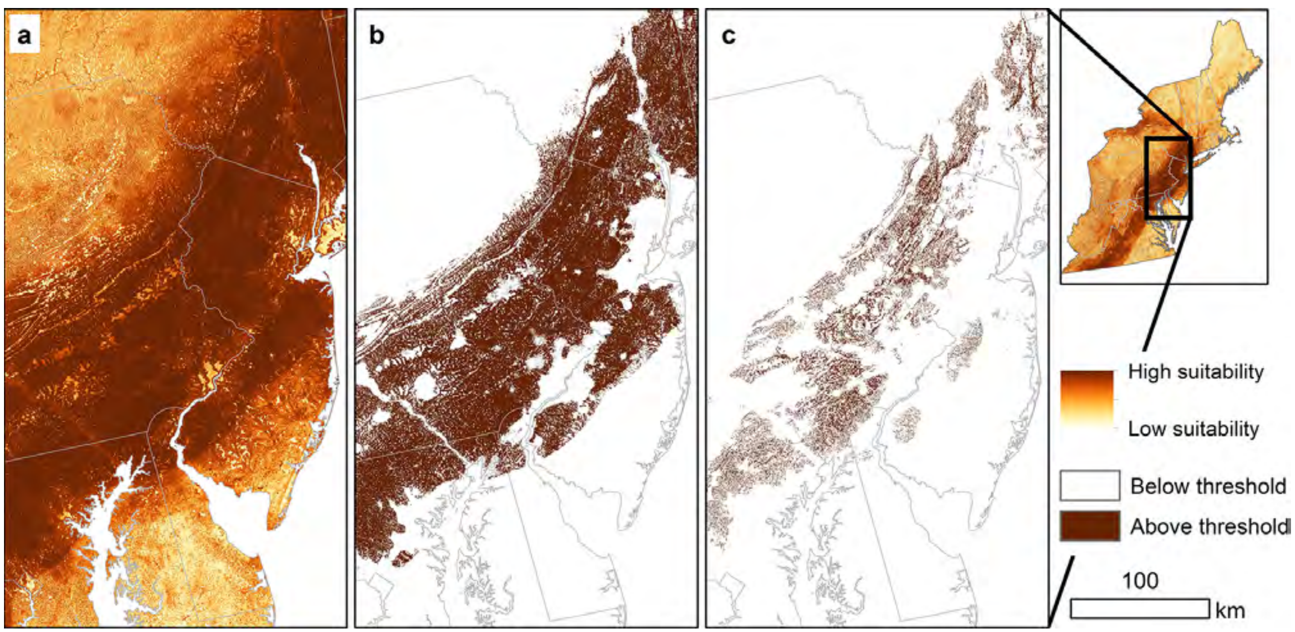


Soley-Guardia et al. 2024; https://doi.org/10.1111/ecog.06852

Example Habitat Model for Threatened Bog Turtle Species

Where is the most likely habitat for Bog Turtles (*Glyptemys muhlenbergii*)?

Full model (a) with low versus high thresholds (b and c) for habitat



But highly sensitive to quality of input data: garbage correlations in -> garbage correlations out

Sofaer et al. 2019; https://doi.org/10.1093/biosci/biz045

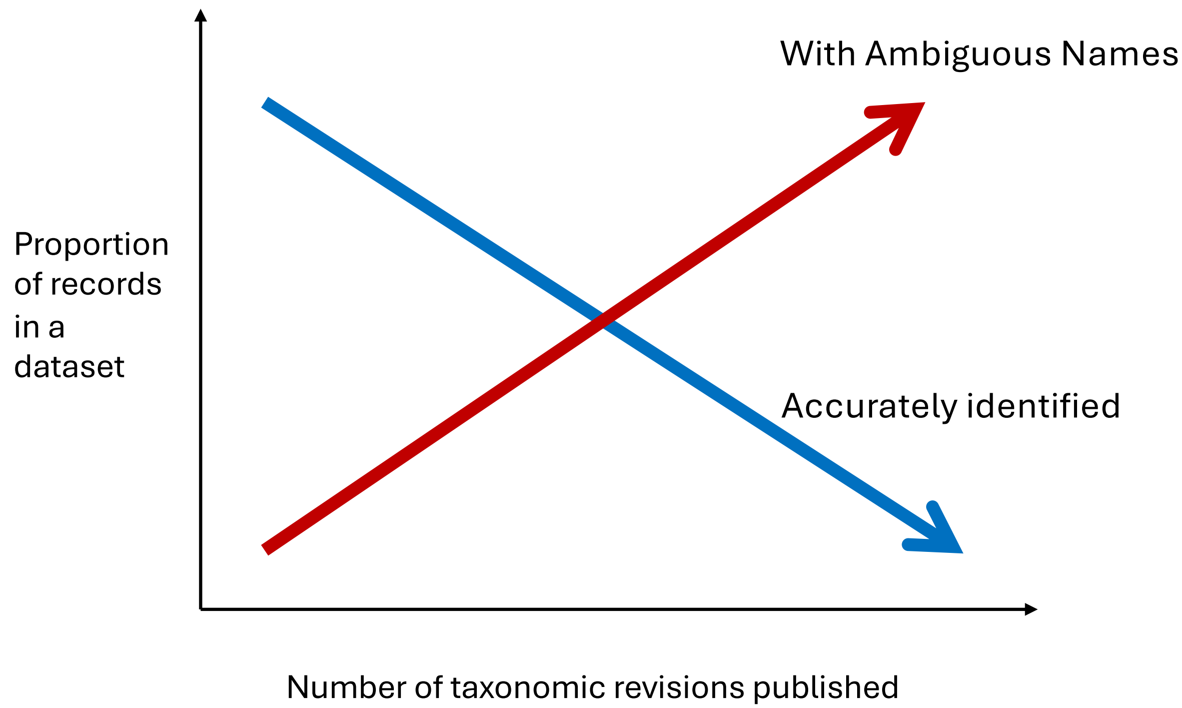
Long-Term Data
Needs Long-Term Care

Every observation is labeled with metadata categories, especially a taxonomic name for the observed species

As categories get revised with time, datasets need their metadata labels updated

Otherwise names for categories tend to become increasingly ambiguous and incorrect

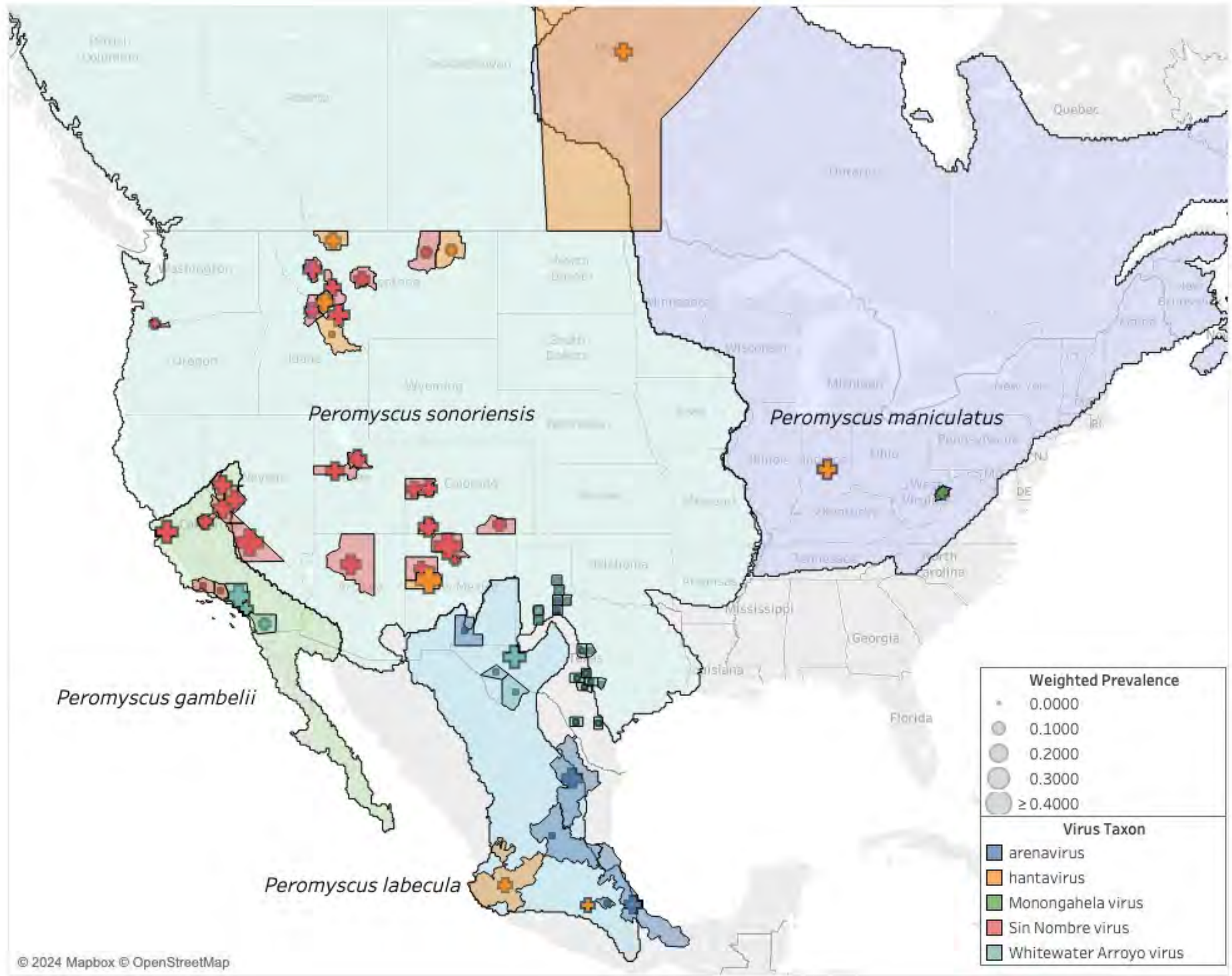
Taxonomic accuracy and ambiguity of biodiversity data records over time



Ecology Example: Rodent Reservoirs Of Hantaviruses

The North American deermouse *Peromyscus maniculatus* was recently split into 4 species

These changes can strongly affect biological conclusions, e.g. about which host species maintain zoonotic pathogens



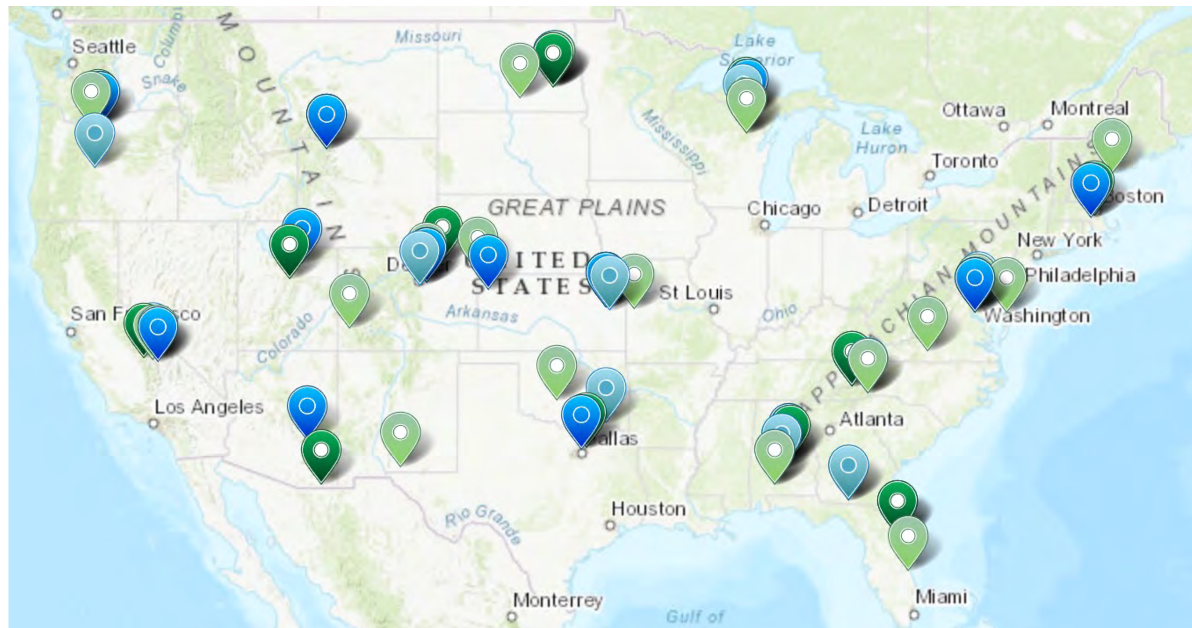
Finkbeiner et al., 2025. *PLoS Pathogens*.

NEON Biorepository

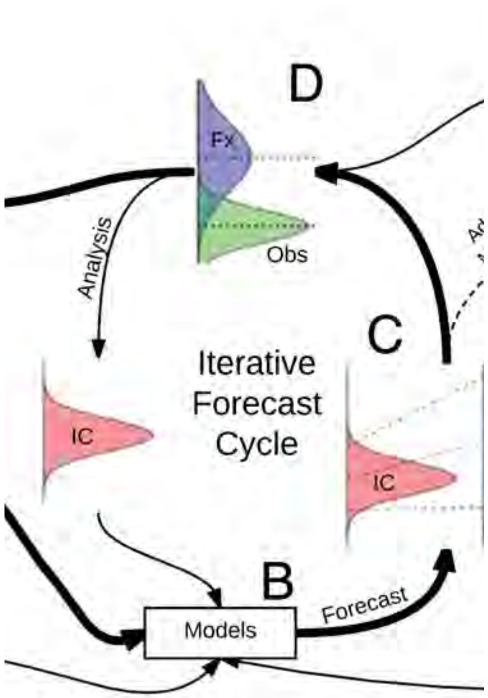
National Ecological Observatory Network (NEON) is NSF's largest investment in long-term biological research infrastructure (**~$500M** annually)

NSF selected ASU as primary repository for >100k material samples annually from >80 sites across nation

Map of NEON Sampling Sites in 48 States



Iterative Forecasting in Ecology



Dietze et al. 2018

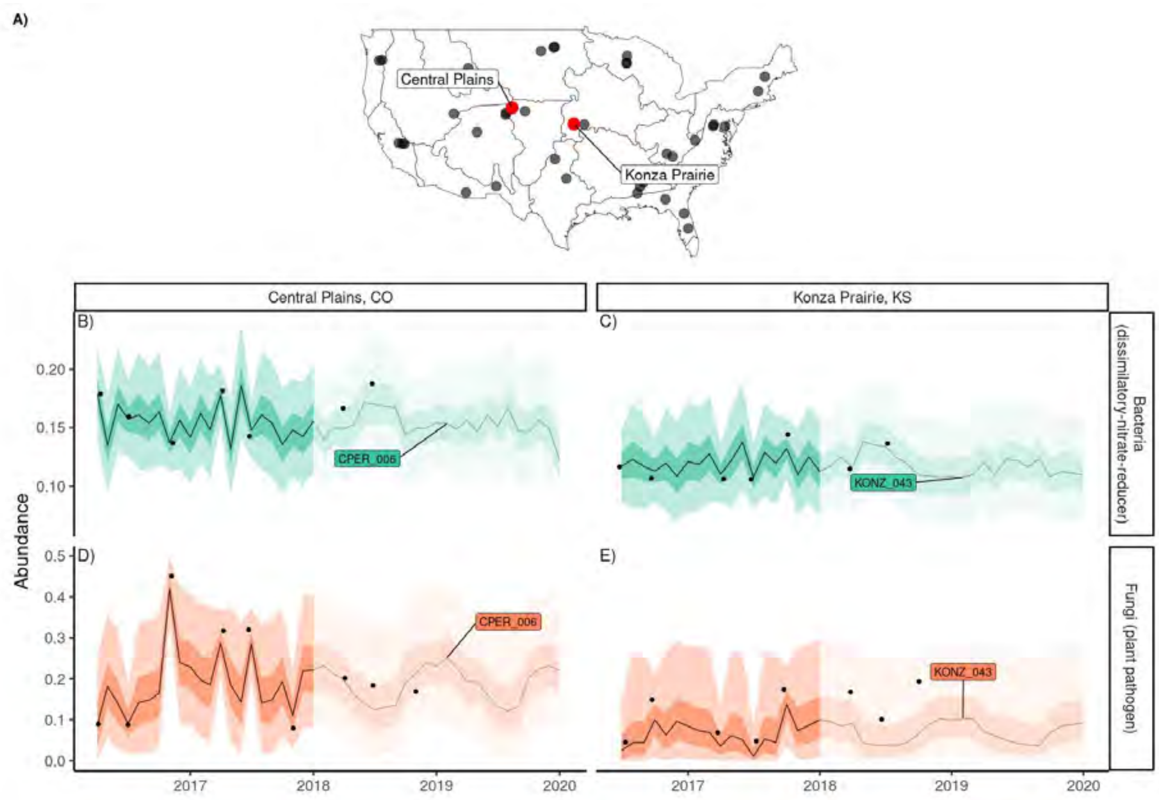
A major shift from site-based, explanatory regression models

Uses iterative updating of model set based on predictive outcomes

Using NEON to Forecast Microbiota

Werbin et al. used soil genomic and environmental surveys from NEON sites to develop the first forecasts of soil microorganisms across biomes and time.

“We find that the abundance of fungi and bacteria can be predicted with 50% and 91% accuracy, respectively, for up to a year ahead of time, by simulating seasonal cycles in taxon abundances.”



Werbin et al. preprint; https://www.researchsquare.com/article/rs-5183308/v1

Conclusion

- Biodiversity data are usually curated by communities before they reach aggregators such as GBIF
- The data enables powerful spatial and temporal models, but take substantial validation and cleaning for high-stakes decisions
- There are many more types of data and models than I covered here!

Acknowledgements

Thanks to you all for coming and listening today!

My work is collaborative with many colleagues and students

Funding

NSF SES-2122818, STS-1827993, STS-2143984

NIH 5R01GM152813, 1R21AI164268

Templeton Foundation Science of Purpose Initiative

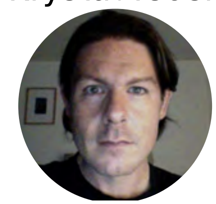
Alfred P. Sloan Foundation

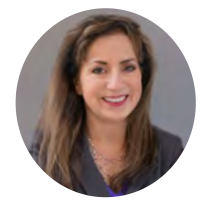
Current Collaborators


Zoe Nyssa


Krystal Tsosie


Steve Elliott


John Fricks


Ute Brady


Petar Jevtic


Nate Upham


Nico Franz

Biodiversity Estimation for Agriculture Tool (BEAT)

A Framework to Quantify Biodiversity Outcomes in Agricultural Systems

Overview

Quantifying Biodiversity

Biodiversity is essential to resilient agricultural systems but it's long been one of the most difficult outcomes to measure, verify, and scale.

To help address this challenge, we're proud to introduce the **Biodiversity Estimation for Agriculture Tool (BEAT)** - a new component of ESMC's EcoHarvest MRV platform.

Separating Biological Response, Realized Impact, and Restoration Opportunity

ESMC

Core Functionality

Habitat Size

Measures the extent of land under biodiversity management.

Habitat Quality

Measures the health and sustainability of habitats.

Time Response

Assesses how quickly ecosystems can adapt and recover.

Weighted Functional Presence

Assesses species presence and their ecological roles.

Comprehensive Assessment

Evaluates multiple biodiversity factors for informed decision-making.

Conservation Priority

Identifies critical areas needing protection and support.

ESMC

Model Design and Practical Strengths

- Purpose-built, not overly complex: Designed to capture core drivers of outcomes, not every micro-detail
- Handles real-world data variability: Highly complex models can become sensitive to small nuances, making results harder to compare across fields and regions
- Ensures consistency and comparability: Simplified structure allows for stable, repeatable outputs across diverse datasets
- Captures what matters most: Focuses on key signals (BMP impact, baseline conditions, scale) rather than noise
- Market-ready outputs: Produces results that are interpretable, scalable, and usable for crediting and reporting

Key Assumptions

- BMP effects are consistent under similar soil, climate, and management conditions
- Baseline is representative of typical system state
- Variability averages out at larger spatial scales
- Model is robust to small input differences
- Focus on primary drivers (BMP, baseline, scale), minimizing noise

ESMC

Retrospective Analyses

ESMC

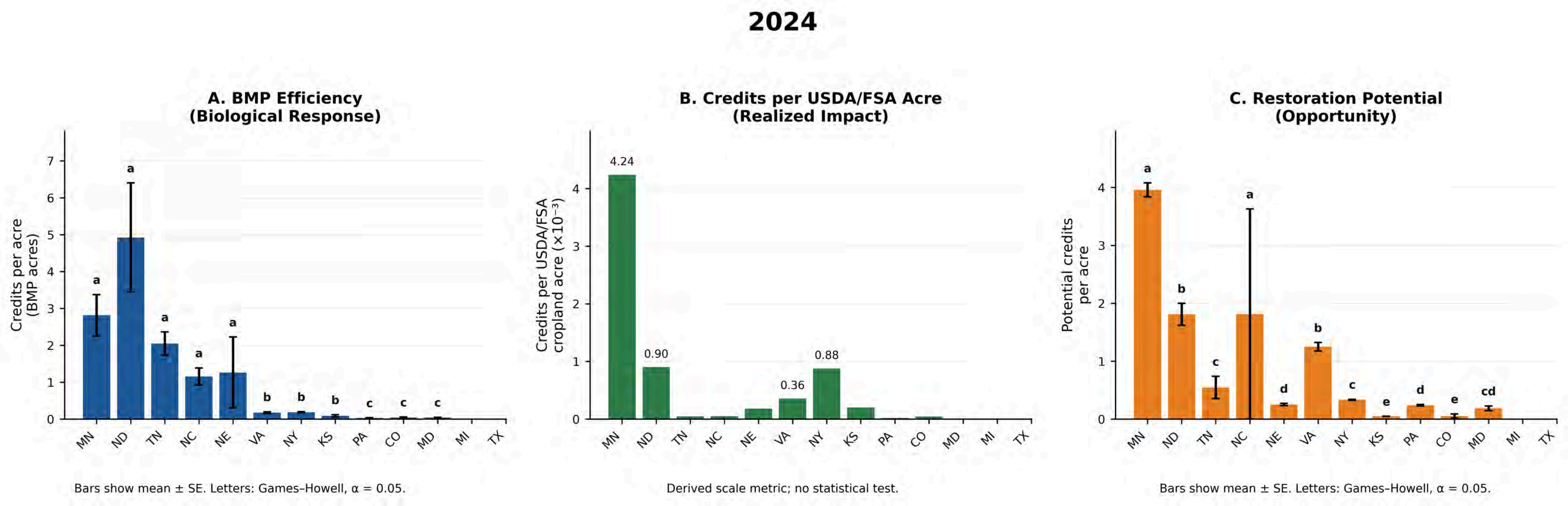
2024 Dataset Overview

- Total fields: 1,169
- States represented: 11
- States with ≥5 fields (used for stats): 9 states
- KS, NY, MN, VA, PA, NE, ND, MD, CO

Total acreage analyzed: ~85,500 acres across 1,169 fields

Statistical analysis coverage: ~85,300 acres (≥5 field states)

ESMC



North Dakota → highest biological response
Minnesota → highest impact + opportunity
Tennessee → high response, low impact

ESMC

2025 Dataset Overview

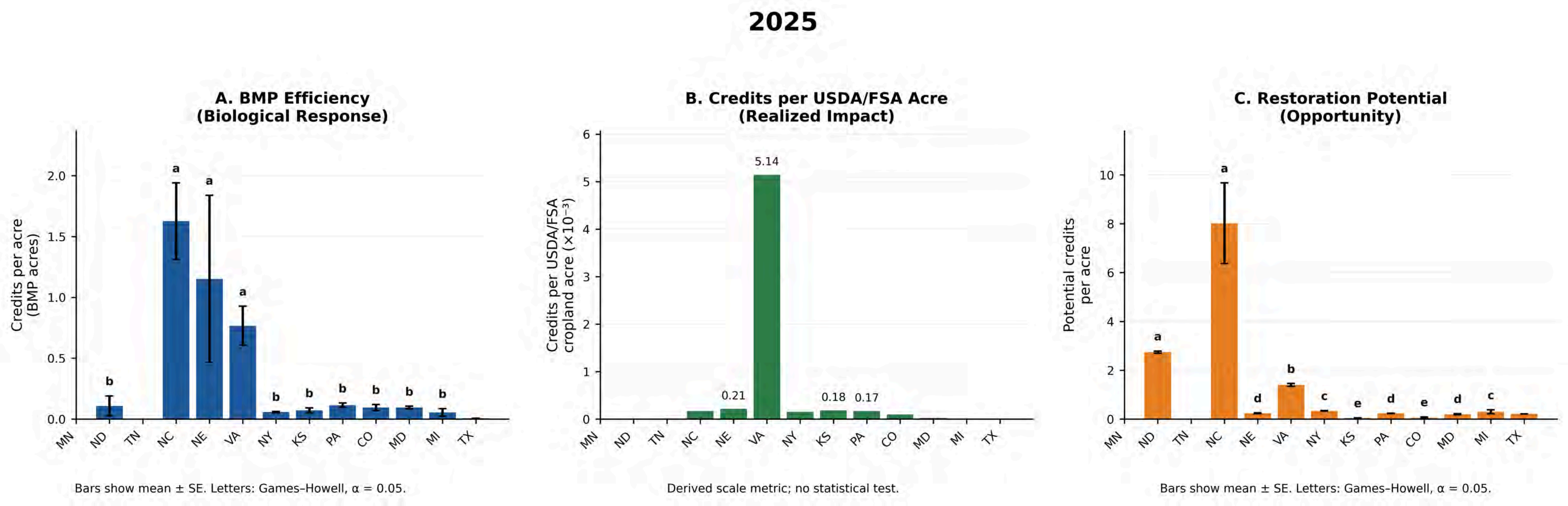
- Scope: Multi-state dataset across all 2025 projects
- Fields: 916 total fields | AGIM_2025: 88 clean fields (from 123)
- Geography: 10+ states (≥5 fields used for statistical testing)
- Total acreage analyzed: ~54,850 acres
- Dataset reflects full portfolio with AGIM quality-filtered

Statistical approach:

Welch ANOVA + Games–Howell post hoc
Significance letters on charts
Bootstrap error bars for key metrics

Data quality:

AGIM fields filtered to high-confidence subset
Final dataset reflects robust, production-ready analysis



North Carolina → highest response + opportunity
Virginia → highest realized impact
Strong divergence between panels

ESMC

BEAT Validation

✓ Captures spatial ecological variation

✓ Separates:

- Biological response
- Implementation scale
- Future opportunity

✓ Matches ecological theory:

- Landscape dependence
- Context-specific response
- Non-linear ecosystem services

ESMC

Scaling is not aligned with impact.

High-efficiency states like Tennessee (~20+ BU/ac), North Dakota (~7 BU/ac), and Minnesota (~5 BU/ac) show the strongest per-acre outcomes but have limited acreage.

Meanwhile, Kansas (~0.05 BU/ac) and Colorado (~0.01 BU/ac) dominate scale despite very low efficiency—leading to suboptimal total credit generation.

BEAT transforms biodiversity accounting from “how many acres” → “how ecosystems respond, perform, and can improve.”

ESMC

Contact Us

Learn more about how BEAT can help you quantify biodiversity outcomes.

ESMC
Ecosystem Services Market Consortium

Website

www.ecosystemservicesmarket.org

Email Address

info@ecosystemservicesmarket.org