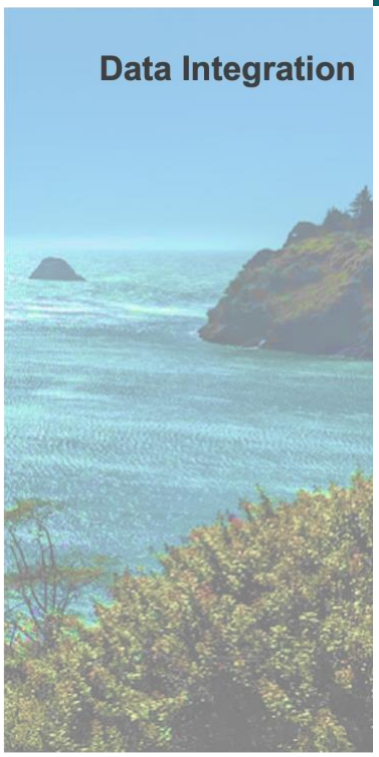
elimia
Biodiversity Data Science

Menu of Services



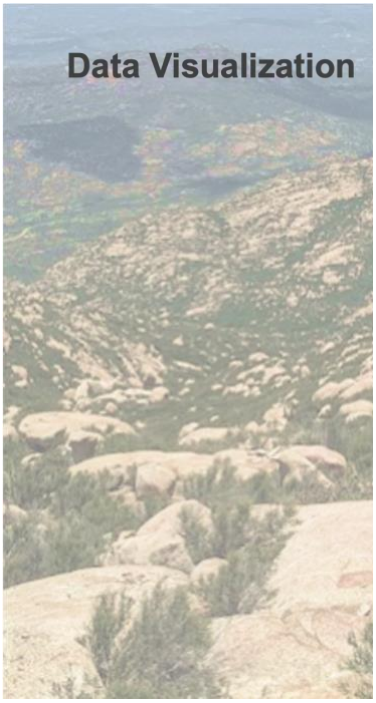
We integrate, synthesize, and mobilize big biodiversity data

- Identify and extract relevant openly available data from online biodiversity data repositories in real-time via Application Programming Interfaces and other methods
- Clean up and process large biodiversity datasets (tabular, spatial vector, or spatial raster data)
- Biodiversity data quality control and checks on taxonomic, spatial, and temporal validity of records
- Taxonomic reconciliation and cross-walks between datasets
- Data standardization

We quantify biodiversity metrics and trends over space and time

- Generate and validate estimates of current range, occupancy and/or abundance of target species from species distribution models or occupancy models using machine learning and other standard approaches
- Estimate historical and potential future changes in species' distributions and population trends in response to environmental changes
- Estimate and analyze species extinction risks

- Estimate historic, current, and potential future trends in the richness, endemism, and rarity of ecological communities using community-level data and methods
- Identify local species and ecosystems at risk of extinction
- Estimate taxonomic, functional, and evolutionary diversity of local ecological communities
- Identify priority areas based on the uniqueness and irreplaceability of local species and ecosystems
- Quantify condition and intactness of local habitats and ecosystems



We convey biodiversity insights through visualizations and tools

- Package outputs and communicate insights using infographics and publication-quality figures
- Build interactive web-based applications to facilitate exploration of outputs
- Generate standardized automated reports
- Create state-of-the-art static or interactive maps

We support reporting on nature-related financial disclosures

- Identify and implement the best available data and methodologies to quantify changes to the state of nature in support of TNFD and SBTN reporting

Example Projects

Data integration

***Example 1**: Assembling an integrated dataset on the geographic distributions, ecological traits, phylogenetic relationships and extinction risk of terrestrial vertebrates in the Americas*

Working with a consortium of applied institutions (International Union for Conservation of Nature, NatureServe) and universities (Stony Brook University, Temple University, University of Wisconsin Madison and Auburn University at Montgomery), Elimia CEO Dr. Rapacciuolo worked on assembling, vetting, and processing the most comprehensive dataset of geographic distributions, ecological traits, phylogenetic relationships and extinction risk for tetrapods of the Americas at the time. This integrated dataset enabled crucial research on the historical and modern drivers of terrestrial vertebrate community composition, as well as key comparative research among the four terrestrial vertebrate groups.

Find out more

Cox N, Young B [and 50 others, including **Rapacciuolo G** as 6th author] (2022). A global reptile assessment highlights shared conservation needs of tetrapods. *Nature* **605**: 285–290.
Find full text

Rapacciuolo G, *et al.* (2019). Species diversity as a surrogate for the conservation of phylogenetic and functional diversity in terrestrial vertebrates across the Americas. *Nature Ecology & Evolution* **3**: 53-61.
Find full text

Marin J, **Rapacciuolo G**, Costa GC, *et al.* (2018). Evolutionary time drives global tetrapod diversity. *Proc. Roy. Soc. B* **285**.
Find full text

Rapacciuolo G, Marin J, Costa GC, *et al.* (2017). The signature of human pressure history on the biogeography of body mass in tetrapods. *Global Ecology and Biogeography* **26**: 1022-1034.
Find full text

Rapacciuolo G (2018). Knowledge of species diversity may be sufficient to preserve other dimensions of biodiversity. *Nature Ecology & Evolution Community Blog*.
Find full text

***Example 2**: Integrating and standardizing data to facilitate comparison among 20th century changes in the geographical distributions of animals and plants across California*

Working with a group of scientists at the University of California Berkeley, Elimia CEO Dr. Rapacciuolo led an effort to integrate and standardize data on recent changes in the

geographical distributions of birds, mammals, butterflies, and plants in California with the goal to facilitate comparison among them. This work has been crucial for understanding the relative influence of climate change on 20th century changes in animal and plant distributions relative to other pressures across California; it has been cited over 200 times, including by policy documents and public reports.

Find out more

Rapacciuolo G, *et al.* (2014). Beyond a warming fingerprint: individualistic biogeographic responses to heterogeneous climate change in California. *Global Change Biology* **20**: 2841 - 2855.
Find full text

Example 3: *Integrating data from systematic field surveys, natural history collections and community science to map at-risk species' distributions and estimate species' population trends*

In data-limited situations – such as when dealing with extremely rare, imperiled, and/or hard-to-detect species – identifying and integrating data from all relevant sources is key. Elimia CEO Dr. Rapacciuolo has worked on a number of projects involving the integration of species occurrence data from disparate sources – primarily systematic field surveys, natural history collections, citizen and community science, remote sensing, and expert knowledge. These integrated datasets have enabled multiple analyses and applications related to understanding past and current distributions and/or historic population trends for at-risk and inconspicuous animal and plant species.

Find out more

Rapacciuolo G, Young A, Johnson R. Deriving indicators of biodiversity change from unstructured community-contributed data. *Oikos* **130**: 1225–1239. Editor's Choice.
Find full text.

Rapacciuolo G, *et al.* (2017). Detecting long-term occupancy changes in Californian odonates from natural history and citizen science records. *Biodiversity and Conservation* **26**: 2933-2949.
Find full text

Zeilinger A, **Rapacciuolo G**, *et al.* (2017). Museum specimen data reveal emergence of a plant disease may be linked to increases in the insect vector population. *Ecological Applications* **27**: 1827-1837.
Find full text

Young BE, et al. (2017). Are pollinating hawk moths declining in the Northeastern United States? An analysis of collection records. *PLoS ONE* **12**: e0185683.
Find full text

Metrics

***Example 1**: A library of species distribution models to support decisions on at-risk species in the US*

Understanding where species at risk of extinction are located is key to guiding decisions aiming to slow down or reverse current extinction trends. During his time as Director of Applied Data Science at NatureServe, Dr. Rapacciuolo led NatureServe's Species Habitat Modeling Program: an initiative to build and maintain a comprehensive and robust library of high-resolution AI models predicting the distributions of all rare and imperiled species of animals and plants in the United States. Dr. Rapacciuolo helped create and mobilize hundreds of model predictions from this library for numerous clients including the Bureau of Land Management, the Department of Defense, the US Fish and Wildlife Service, the US Forest Service, the National Council for Air and Stream Improvement, Inc. (NCASI), and others.

Find out more

NatureServe Map of Biodiversity Importance, **https://www.natureserve.org/map-biodiversity-importance**

Hamilton H, et al. (2021) Increasing taxonomic diversity and spatial resolution clarifies opportunities for protecting US imperiled species. Ecological Applications 32: e2534.
Find full text

AI for Good Webinar by Rapacciuolo, G (2023) "Predicting where endangered animals and plants are via human-AI collaboration".
View here

***Example 2:** Deriving indicators of biodiversity change from unstructured community-contributed data*

Opportunistic and unstructured observations of biodiversity crowdsourced from volunteers, community, and citizen scientists make up an increasingly large proportion of our global biodiversity knowledge. This incredible wealth of information exists in real time at both high resolutions and large extents of space, time, and taxonomy, thus holding huge potential to fill gaps in global biodiversity monitoring coverage in a cost-effective way. Yet, the full potential of these data to provide essential indicators of biodiversity change for both research and management remains mostly unrealized, in large part due to the prevailing perception that the lack of standardization presents an unsurmountable barrier. Elimia CEO Dr. Rapacciuolo worked to develop a series of indicators derived from community-contributed data – such as those provided by eBird and iNaturalist – that can extract ecological signals from the noise in the data, thus providing estimates of species' ranges and yearly population trends. These indicators have been applied by policymakers in California to help monitor the state of natural areas along California's coastline.

Find out more

Rapacciuolo G, Young A, Johnson R. Deriving indicators of biodiversity change from unstructured community-contributed data. *Oikos* **130**: 1225–1239. Editor's Choice.
Find full text

Western Society of Naturalists Meeting Presentation by Rapacciuolo, G (2020), "A Community-Powered Early Warning System for Biodiversity Change on the California Coast".
View here

Dynamic Observatory of Biodiversity on the California Coast Web Apps,
https://grap.shinyapps.io/dob-calcoast-places
https://grap.shinyapps.io/dob-calcoast-species

Example 3: *Taxonomic, functional, evolutionary diversity of vertebrate communities*

Many biodiversity conservation and nature finance efforts use species as their fundamental unit. However, biodiversity is a multidimensional concept that also encompasses genetic diversity and variation in ecological functions. Given this, should all biodiversity dimensions be considered and preserved independently in the face of increasing pressures from human actions or are they interrelated in predictable way? Working with a consortium of applied institutions (IUCN, NatureServe) and universities (Stony Brook University, Temple University, University of Wisconsin Madison and Auburn University at Montgomery), Elimia CEO Dr. Rapacciuolo quantified and compared priority areas across the Americas based on either the species, functional, or evolutionary diversity of their terrestrial vertebrate communities. Findings indicated that selecting a large enough network of areas using species diversity as the target also represented much of the diversity of evolutionary lineages and ecological attributes. These results have key implications for conservation practitioners and policy-makers, indicating that when data on ecological functions and evolutionary relationships are lacking, conservation actions may proceed confident in the assumption that planning to conserve species will provide a robust surrogate for conserving phylogenetic and functional biodiversity.

Find out more

Cox N, Young B [and 50 others, including **Rapacciuolo G** as 6th author] (2022). A global reptile assessment highlights shared conservation needs of tetrapods. *Nature* **605**: 285–290.
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Rapacciuolo G, *et al.* (2019). Species diversity as a surrogate for the conservation of phylogenetic and functional diversity in terrestrial vertebrates across the Americas. *Nature Ecology & Evolution* **3**: 53-61.
Find full text

Rapacciuolo G (2018). Knowledge of species diversity may be sufficient to preserve other dimensions of biodiversity. *Nature Ecology & Evolution Community Blog*.
Find full text

***Example 4**: Supporting the National Wildlife Refuge System to prioritize areas for land acquisition for maximum conservation impact*

The National Wildlife Refuge System (NWRS) of the US Fish and Wildlife Service (FWS) uses the Targeted Resource Acquisition Comparison Tool (TRACT) – a science-based spatially explicit process – to assess and prioritize potential additions to the Refuge System. TRACT provides biological rankings for each area that help FWS staff identify refuges where proposed land acquisition would make significant contributions to conservation. In his previous capacity as Director of Applied Data Science at NatureServe, Elimia CEO Dr. Rapacciuolo devised a process to support the NWRS in making decisions about the location, identity, and number of species at risk of extinction throughout its system of Refuges and potential acquisition areas. To do so, Dr. Rapacciuolo quantified the spatial overlap between the distributions of at-risk species and areas surrounding existing Refuges to rank potential acquisition areas across the continental United States. Dr. Rapacciuolo packaged outputs within a web-based spatially explicit tool that is currently being used by FWS scientists internally to guide decisions about land acquisition.

Data Visualization

***Example 1**: Facilitating expert review of species distribution modeling outputs via NatureServe's Model Outputs Review Tool*

Validation and endorsement by expert biologists is essential to increase trust in AI models predicting the distributions of animal and plant species at risk of extinction. With this in mind, while working for NatureServe, current Elimia CEO Dr. Rapacciuolo built NatureServe's Model Outputs Review Tool (MORT): an interactive web-based application to facilitate the collaborative review of outputs from species distribution models and collect feedback to aid modelers in the revision of outputs. MORT provides a simple interface that enables users to view spatial model predictions in an interactive mapping interface, register general comments, and gather feedback on where model results are and are not consistent with expert knowledge. The tool has led to a marked increase in the trust and applicability of species distribution model outputs generated by NatureServe.

Find out more

NatureServe Model Outputs Review Tool User's Guide,
View here

***Example 2**: NatureServe's Biodiversity in Focus: United States Edition Report*

Elimia CEO Dr. Rapacciuolo was one of the primary contributors on a 2023 report published by NatureServe, which assessed the state of biodiversity in the United States. A first of its kind, the

report *Biodiversity in Focus: United States Edition* uses novel analyses and compelling visualizations to highlight that 34% of plants and 40% of animals are at risk of extinction, and 41% of ecosystems are at risk of range-wide collapse. Conclusions from the report can support decisions by the public and private sectors about how to best invest resources for maximum conservation impact.

Find out more

Biodiversity in Focus: United States Edition Report, NatureServe (2023)
https://www.natureserve.org/bif

***Example 3**: First global assessment of extinction risk in reptiles*

Comprehensive assessments of species' extinction risks constitute fundamental evidence of the state of nature and underpin conservation strategies. Elimia CEO Dr. Rapacciuolo was a major contributor to the first ever global assessment of extinction risk in reptiles (Cox *et al.* 2022). In terms of data visualizations, one of his fundamental contributions is represented by **Figure 2**: a set of maps detailing the regions around the world where each terrestrial vertebrate class is disproportionately threatened compared to the others.

Find out more

Cox N, Young B [and 50 others, including **Rapacciuolo G** as 6th author] (2022). A global reptile assessment highlights shared conservation needs of tetrapods. *Nature* **605**: 285–290.
Find full text
Figure 2

***Example 4**: Rapid Analysis of Rarity and Endangerment Conservation Assessment Tool*

Scientists from across the NatureServe Network produce ongoing assessments of the risk of extinction for all animal and plant species in the US and Canada. Reliable estimates of the range extent and area occupied by a species are fundamental to these assessments of extinction risk. Elimia CEO Dr. Rapacciuolo built an interactive web-based tool to enable the rapid assessment of a species' range extent, area of occupancy, and number of occurrences using Global Biodiversity Information Facility (GBIF) and/or user-provided data. This tool is currently used by NatureServe Network scientists to support more efficient assessments and reassessments of extinction risk for animals and plants in the United States.

Find out more

NatureServe Rapid Analysis of Rarity and Endangerment Conservation Assessment Tool (RARECAT),
View here

***Example 5**: Assessing 20th century climate change across California's floristic regions*

The climate of California has experienced dramatic long-term changes during the 20th century that have been linked with both anthropogenic sources and natural climate cycles. Leading a group of scientists at the University of California Berkeley, Elimia CEO Dr. Rapacciuolo examined the patterns of 20th century climate change in California. A key visualization in the resulting publication involves grouping individual pixels in California according to Jepson Floristic Regions – a widely used phytogeographical classification of California – to better visualize regional patterns of climate change (**Figure 2**). These visualizations of local and regional climate change have since been cited by numerous policy documents and public reports.

Find out more

Rapacciuolo G, *et al.* (2014). Beyond a warming fingerprint: individualistic biogeographic responses to heterogeneous climate change in California. Global Change Biology 20: 2841 - 2855.
Find full text
Figure 2