Improving Biodiversity Monitoring Today for Better Conservation Tomorrow

Dr Marta A. Jarzyna

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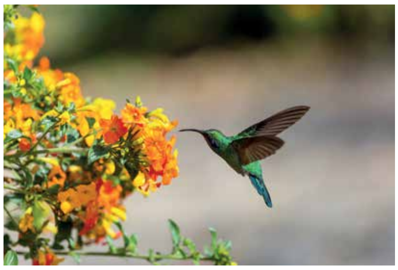
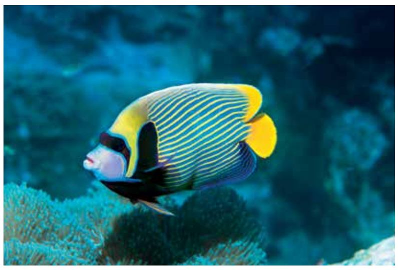
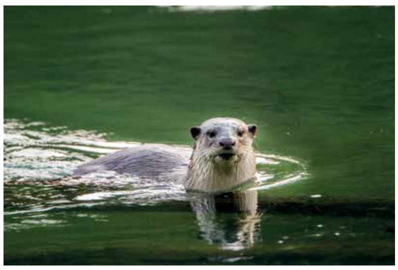
Natural levels of biodiversity support healthy, resilient ecosystems, and thus also support valuable ecosystem services – such as providing clean water. However, pressures from climate change and habitat destruction are altering biodiversity across the globe. Understanding the mechanisms that give rise to biodiversity patterns is imperative to monitoring how it is changing and informing effective conservation strategies. Until recently, these mechanisms have been rarely explored and poorly understood. Dr Marta Jarzyna and her team at The Ohio State University are improving our understanding of biodiversity through extensive research, and developing novel modelling techniques.







Understanding Biodiversity

Human activity has wrought irreversible changes on natural systems across the globe. Climate change – caused by extensive use of fossil fuels and changes in land use – is driving many species to the brink of extinction and altering the habitable ranges of many more. Intensive agricultural practices have a disproportionate effect on insect populations, along with the birds and mammals that rely on them. Natural landscapes converted to farmland and residential or business developments displace many species and cause their populations to dwindle.

'Biodiversity', which describes the natural variety in plant, fungal and animal species within a given habitat, provides a valuable measure of the health of natural systems, because of the functions performed by individual species to keep their ecosystems working optimally. Understanding how biodiversity is changing under human pressures is imperative to informing effective conservation strategies. Additionally, because healthy ecosystems support various ecosystem services – such as agricultural pest control, provision of clean drinking water, and flood mitigation – accurate biodiversity forecasting is important to human societies.

However, despite decades of biodiversity research, no consensus has been reached about the effects and interplay of different processes, the specific ecological and functional attributes of biodiversity, and the scales at which these processes occur. Dr Marta Jarzyna has devoted her research career to illuminating these key interacting factors, developing reliable and accurate characterisations of biodiversity change, and assessing their implications for ecosystems.

Dr Jarzyna and her team in the Jarzyna Lab – part of the Department of Evolution, Ecology and Organismal

Biology at The Ohio State University – tackle four overarching research themes: 1) evidence of biodiversity change; 2) effects of global change on biodiversity; 3) trait-based species and community distributions; and 4) the scale dependence of biodiversity change.

In addition to contributing directly to our understanding of biodiversity across the US and internationally, Dr Jarzyna has also developed novel ecological modelling techniques, which scientists can use to gain deeper, more useful insights in their biodiversity research.

Better Metrics for Better Monitoring

Climate change presents a unique challenge to ecologists and other scientists because of its impacts on natural systems across both space and time. A universal redistribution is being recorded across the globe as species shift their ranges in response to changing climatic zones. The timing of many species' behaviours – such as migration, breeding, and hibernation – is also shifting in response to altering climate patterns.

An accurate characterisation of such temporal and spatial variation in biodiversity is crucial for detecting the influence of human activities and evaluating the implications of biodiversity loss. The quality of biodiversity assessments hinges on our ability to appropriately detect and quantify the species present within an ecological community. Conventionally, these measures have focused on 'taxonomic diversity' – using the traditional definition of species.

However, these measures ignore the evolutionary history and ecological functions of species, and thus, neglect information about ecosystem function and community evolutionary history. A promising alternative involves using biodiversity metrics that include 'phylogenetic diversity', which reflects the evolutionary history of species, and 'functional diversity', which describes the ecological functions of species. This helps researchers to better investigate the processes responsible for the temporal and spatial dynamics of biodiversity.

However, even surveys including all three of these biodiversity 'facets' – taxonomic diversity, phylogenetic diversity and functional diversity – are limited by difficulties in detecting all the species within a given community. Some species may be cryptic and hard to distinguish from similar species without exhaustive molecular studies, others may be particularly shy or elusive, and others may be present in such low numbers as to dramatically reduce the chance of researchers detecting them.

Species detectability may also differ depending on the biodiversity facet used. Therefore, detectability of biodiversity is only rarely constant across space, time, or environments. 'Imperfect detectability of biodiversity will result in erroneous representation of biodiversity change across both space and time,' says Dr Jarzyna, 'ultimately impeding or misleading conservation efforts.'

Accounting for Species Detectability

To address measurement limitations, Dr Jarzyna and her colleague, Dr Walter Jetz from Yale University, developed a rigorous method that accounts for biases introduced through missed species detections based on advanced modelling techniques. Their novel method also has the advantage of being compatible with other modelling and biodiversity techniques.

Demonstrating the efficacy of their approach, Dr Jarzyna and Dr Jetz applied their method to data obtained from the North American Breeding Bird Survey, which included records for around 500 species across five decades, and global records of extinctions. Their goal was to examine the congruency in changes among the three biodiversity facets and their variation across spatial and environmental gradients and scales.

Their analysis demonstrated that all biodiversity facets increased until about 2000, and have since been followed by a slow decline. However, increases in taxonomic diversity were greater than those exhibited by functional and phylogenetic diversity. Community assemblages with a high number of species exhibited smaller changes in functional diversity, and similar patterns

were exhibited towards larger spatial scales. Smaller changes in functional diversity indicate that the corresponding ecosystems may possess some level of functional resilience, through replacement of lost species with others that perform similar ecological functions.

'Gains or apparent stasis at one scale may be fully reconcilable with losses at others, their functional implications will vary by scale and functional component, and both the detection and management of biodiversity change may need to be reconciled with the spatial and temporal scale most relevant to the question,' explains Dr Jarzyna.

The work illustrates the value of measuring multiple facets of biodiversity and accounting for biases introduced by missed species detections. 'Our findings highlight the potential of combining new types of data with novel statistical models to enable a more integrative monitoring and assessment of the multiple facets of biodiversity,' says Dr Jarzyna.

Exploring Functional Trait Resolution

In recent research, Dr Jarzyna and postdoctoral researcher Dr Brooks Kohli have been exploring how the resolution of functional traits can alter the functional structure patterns and causative processes identified during studies of ecological communities, and thus has direct implications for charting the future of biodiversity.

Measurements of functional traits – for example, body size, diet, or breeding behaviours – range from fine-resolution continuous measurements to coarse-resolution binary categories. Despite the knowledge that categorical classification masks functional variability and inflates functional redundancy among species, functional trait resolution has remained critically overlooked.

'Trait resolution often remains beyond the control of investigators, particularly those studying questions at large spatial, temporal, or taxonomic scales, making it essential to understand the implications of trait resolution for detecting ecological processes,' explains Dr Jarzyna.

As demonstrated in her previous research, investigating functional diversity and phylogenetic diversity helps to de-emphasise taxonomic diversity in favour of species' ecological roles, requirements, and evolutionary histories. A trait-based approach also has greater flexibility in investigations, allowing researchers to explore the importance of multiple or opposing processes.

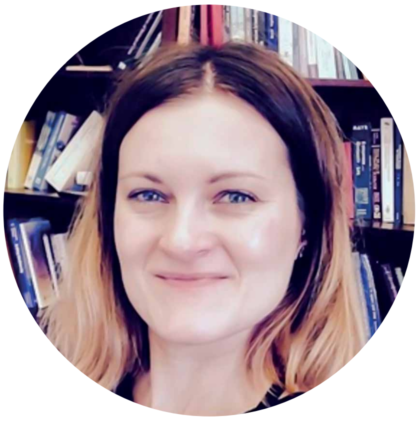
The trait-based approach operates on the assumptions that interactions between species within an ecological community lead to community members with 'divergent' traits – different enough from one another to stably coexist. Meanwhile, if environmental factors are the main drivers behind observed biodiversity the communities should exhibit 'convergent' traits – similar to other community members that need to tolerate the same environmental conditions.

From their preliminary modelling results, Dr Jarzyna and Dr Kohli demonstrated that trait-based tests of interactions between species – measured through divergence of traits – are disproportionately sensitive to trait resolution. They also found that coarser trait resolution may overestimate trait convergence in some systems, leading to erroneous support of environmental factors as the primary drivers behind biodiversity patterns. Therefore, coarse trait resolution introduces pervasive biases into ecological studies.

Addressing the issue of trait resolution bias at its core will require a sustained effort by scientists to identify, collect, and share high-resolution functional trait information across different species and other taxonomic groupings. Ongoing trait databasing efforts aim to facilitate this knowledge collecting and sharing. However, with vast numbers of species to be included, getting anywhere close to completing this effort is a long way off.

In the meantime, simulations like those developed by Dr Jarzyna and Dr Kohli could provide guidance for determining whether a particular ecological investigation may be especially susceptible to trait resolution biases. She recommends that future studies should maximise trait resolution when identifying functional traits for inclusion, but in the absence of fine resolution trait information, this source of bias should be acknowledged and accounted for using measures to mitigate its effects.

Dr Jarzyna concludes, 'By continuing to refine trait-based methods we will improve our understanding of biodiversity and help to create a stronger foundation from which to address and mitigate the biodiversity crisis facing the world.'



Meet the researcher

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Dr Marta A. Jarzyna earned her PhD from Michigan State University, before continuing her postdoctoral research in the Department of Ecology and Evolutionary Biology at Yale University. She currently holds the position of Assistant Professor in the Department of Evolution, Ecology and Organismal Biology and the Translational Data Analytics Institute at The Ohio State University. Research in The Jarzyna Lab focuses on biodiversity and its changes under pressures such as climate change, trait-based ecology and biogeography, and the use of ecological 'big data'. Dr Jarzyna's research has attracted the attention of a wealth of international media and science news outlets, and the larger scientific community. She also devotes time to sharing her knowledge through lectures, seminars and workshops, and has mentored students at every level from undergraduate through to postdoctoral.

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FURTHER READING

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