Bioclimatic Ecosystem Resilience Index

Simon Ferrier[1*], Thomas D Harwood[2], Chris Ware[1], Andrew J Hoskins[1]

[1]CSIRO Environment, Australia

[2]University of Oxford, UK

[*]Contact: simon.ferrier@csiro.au

A global indicator of the capacity of natural ecosystems to retain species diversity in the face of climate change, as a function of ecosystem extent, integrity, and connectivity

What is the purpose of this indicator, and how is it derived?

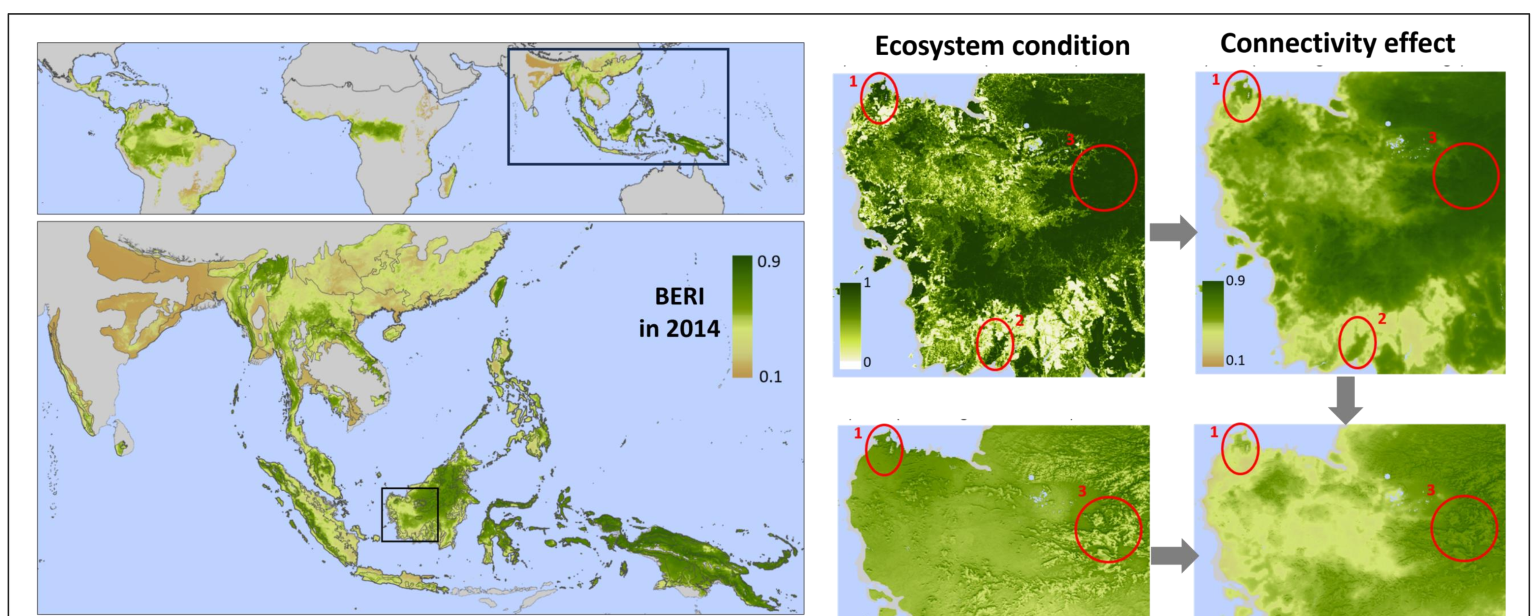
Development of the Bioclimatic Ecosystem Resilience Index (BERI) was funded initially by the Biodiversity Indicator Partnership's 'Mind the Gap' initiative (in 2017) to fill a high-priority gap identified in the CBD's Aichi Target indicator framework. The indicator assesses the impact that changes in the integrity and connectivity of natural ecosystems across a landscape are expected to have on the capacity of that landscape to retain native species in the face of climate change.

The BERI is generated from two main inputs:

- A spatial grid indicating the condition, or integrity, of the natural ecosystem (habitat) associated with each cell across the spatial domain of interest. The current global implementation of the indicator employs 1km grid-resolution mapping of ecosystem condition, but this can be replaced with finer-resolution data, where available, for national-scale application (e.g. ecosystem condition data from UN SEEA Ecosystem Accounts).
- Pre-derived modelling of spatial variation in the species composition of ecological communities across this same grid, and of potential shifts in species composition over time under a plausible range of climate scenarios. This modelling is based on data for over 400,000 species of plants, invertebrates and vertebrates extracted from the Global Biodiversity Information Facility (GBIF).

These two inputs are used to assess the extent to which each cell in the grid is functionally connected (through least-cost-path analysis) to areas of natural habitat in the surrounding landscape which are projected to support a similar assemblage of species under climate change to that currently associated with the cell of interest. To derive the cell's BERI value, the effective amount of this connected habitat expected under climate change is then expressed as a proportion of the maximum possible amount of connected habitat if the cell were surrounded by a continuous expanse of intact natural ecosystems, and not subjected to any change in climate. The aggregate value of the BERI for any larger spatial reporting unit of interest (e.g. an ecosystem type, a country, or the entire planet) can then be derived as a weighted average of the values of all cells within that unit (with the contribution of individual cells weighted by ecological uniqueness).

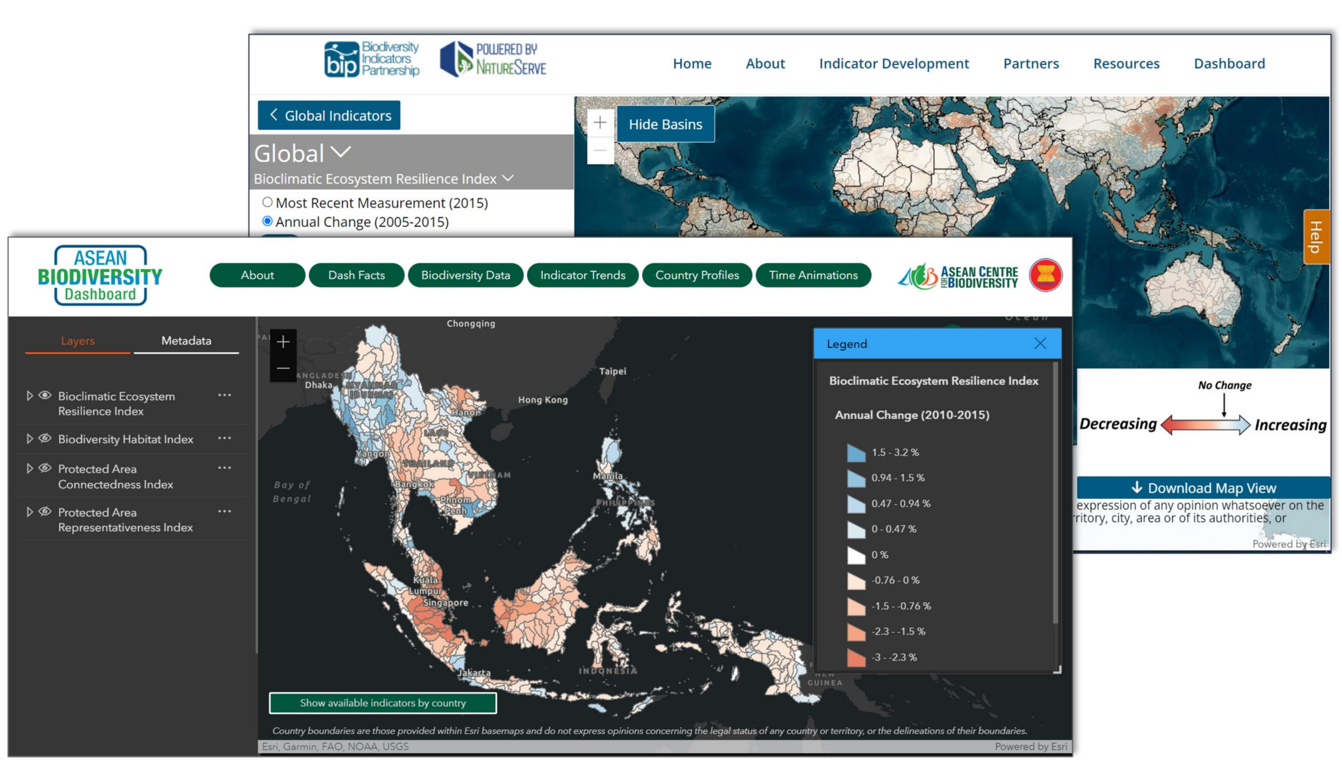
The BERI was originally generated just for the Moist Tropical Forest Biome using an ecosystem-condition time series derived from the Global Forest Change dataset [1]:



The four panels on the right illustrate (for south-west Borneo) how the BERI is shaped by interactions between ecosystem connectivity and climate velocity. The "connectivity effect" map depicts a hypothetical variant of BERI assuming no future change in climate, while the "climate-velocity effect" variant instead assumes perfect ecosystem condition for all cells.

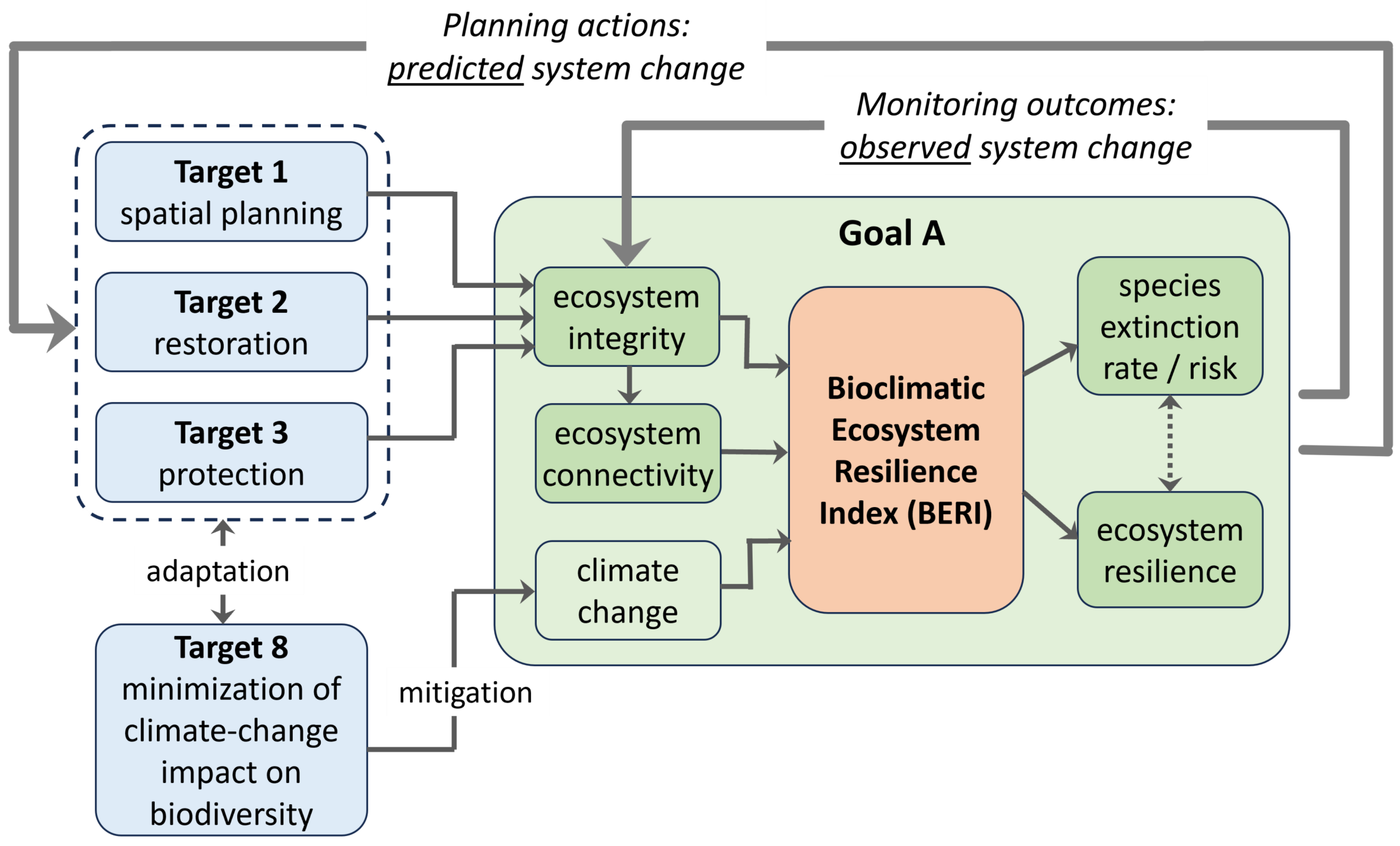
Highlighted areas 1 and 2 exhibit a similar level of ecosystem connectivity yet area 1 achieves higher BERI scores than area 2 due to differences in climate velocity between these two areas – i.e. to track changes in climate, species would need to disperse longer distances across the relatively flat plain of area 2 than they would across the more dissected terrain of area 1. Highlighted area 3 further illustrates the importance of local topography in shaping the capacity of ecosystems to retain biological diversity in the face of climate change – i.e. within this continuous expanse of natural forest, lower slopes and gullies exhibit higher BERI values than ridge and mountain tops.

The BERI has since been expanded to cover the entire land surface of the planet, using an ecosystem-condition time series derived by combining CSIRO's statistical downscaling of annual land-use change and the Natural History Museum's meta-analysis of land-use impacts on local retention of species diversity (the PREDICTS project) [2]:

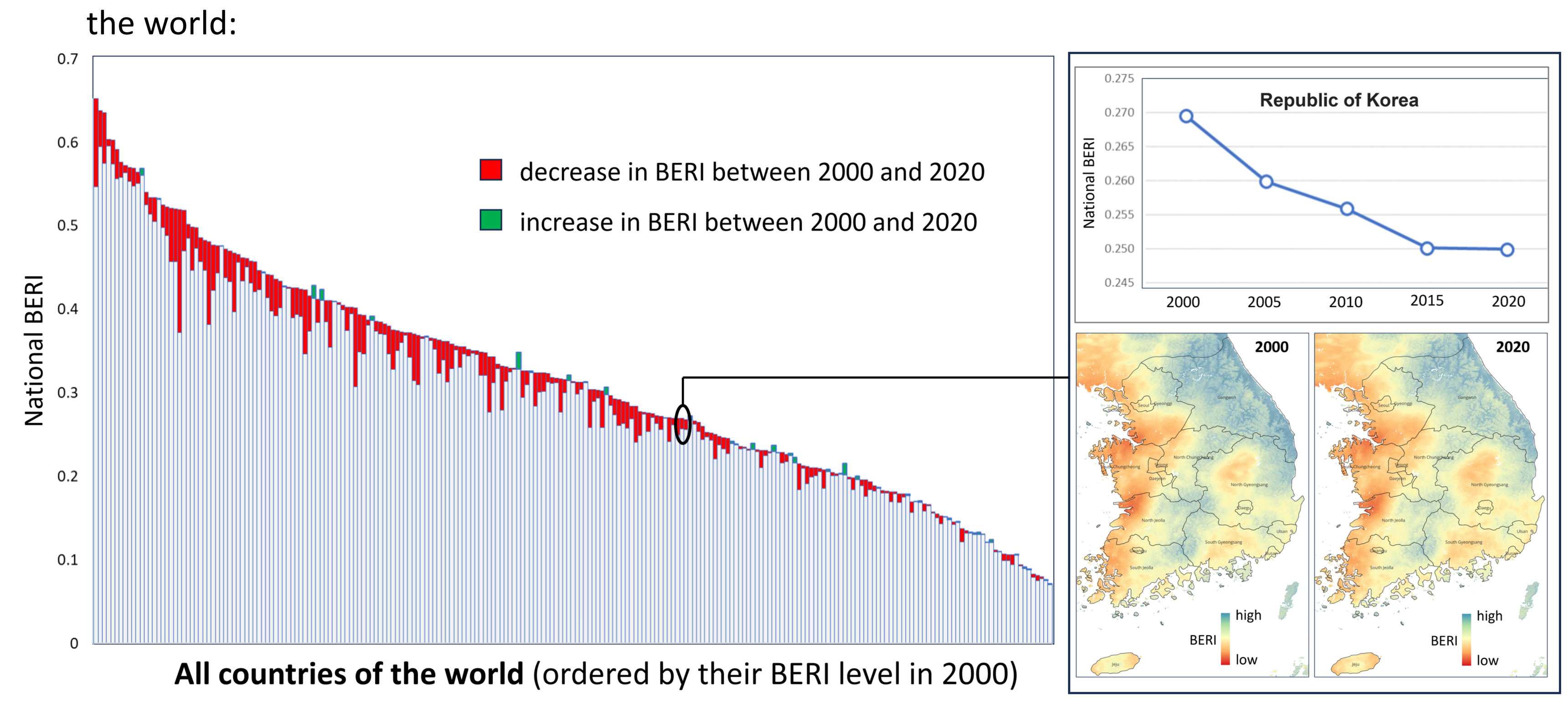


What can it contribute to implementation of the GBF?

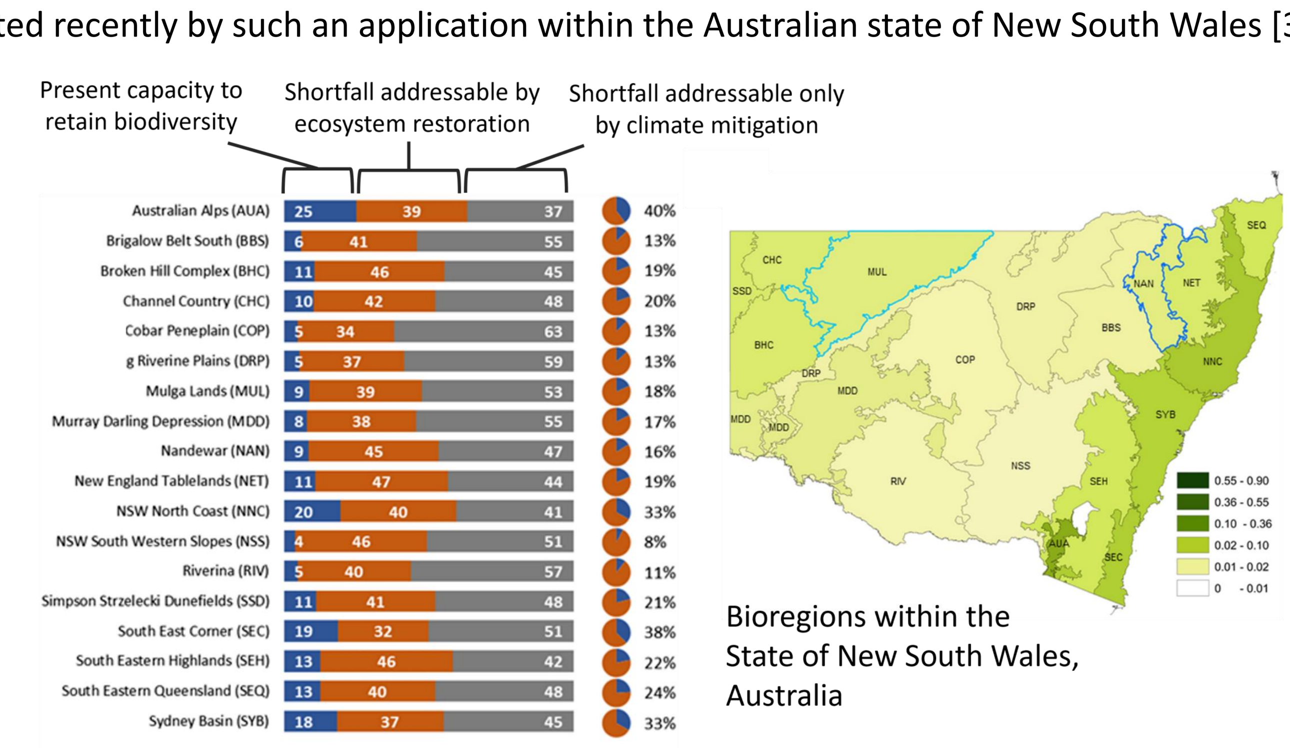
Within the monitoring framework for the CBD's Kunming-Montreal Global Biodiversity Framework (GBF), the BERI is recognized as a component indicator for Target 8 *"Minimize the impact of climate change and ocean acidification on biodiversity and increase its resilience through mitigation, adaptation, and disaster risk reduction actions …"*. However, due to its highly integrative nature, the BERI offers considerable potential to play a more extensive role in GBF implementation, by addressing interlinkages between Target 8, the area-based action Targets 1 (spatial planning), 2 (restoration) and 3 (protection), and the ecosystem-focused and species-focused components of Goal A [2]:



In relation to Goal A, the BERI offers a powerful means by which to translate observed changes in ecosystem integrity (e.g. from remote sensing), and associated changes in connectivity, into expected consequences for the capacity of ecosystems to retain species diversity in the face of climate change. This is the underpinning foundation for using the BERI to monitor change in the effectiveness with which the integrity and connectivity of terrestrial ecosystems are expected to *"minimize the impact of climate change … on biodiversity"* under Target 8, across all countries of the world:



The BERI can also serve as a leading indicator for assessing the contribution that proposed or implemented area-based actions under Targets 1, 2 and 3 are expected to make to enhancing the present capacity of landscapes to retain species diversity in the face of climate change. This will allow actions under these targets to be better linked both to the achievement of Target 8, and to achieving outcomes under Goal A, thereby providing a stronger foundation for strategic prioritisation of such actions by member countries. The power of this approach can be further enhanced by incorporating higher-quality environmental and biological data into derivation of the BERI at national or subnational scales, as demonstrated recently by such an application within the Australian state of New South Wales [3]:



Bioregions within the State of New South Wales, Australia

CSIRO is now exploring potential avenues for giving CBD member countries direct access to the cloud-computing capability needed to derive the BERI for themselves, using best-available national data.

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REFERENCES

1. Ferrier, S., Harwood, T.D., Ware, C., Hoskins, A.J. (2020) A globally applicable indicator of the capacity of terrestrial ecosystems to retain biological diversity under climate change: the Bioclimatic Ecosystem Resilience Index. *Ecological Indicators* 117: 106554.
2. UNEP-WCMC (2023) *Indicators for the Kunming-Montreal Global Biodiversity Framework: Bioclimatic Ecosystem Resilience Index*. https://www.post-2020indicators.org/metadata/other/8-4-C
3. Harwood, T., Love, J., Drielsma, M., Brandon, C., Ferrier, S. (2022) Staying connected: assessing the capacity of landscapes to retain biodiversity in a changing climate. *Landscape Ecology* 37: 3123-3139.