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LETTER

Ecosystem indices to support global biodiversity conservation

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Abstract
Governments have committed to global targets to slow biodiversity loss and sustain ecosystem services. Biodiversity state indicators that measure progress toward these targets mostly focus on species, while indicators synthesizing ecosystem change are largely lacking. We fill this gap with three indices quantifying past and projected changes in ecosystems using data from the International Union for Conservation of Nature (IUCN) Red List of Ecosystems. Our indices quantify changes in risk of ecosystem collapse, ecosystem area and ecological processes, and capture variation in underlying patterns among ecosystems. We apply the indices to three case studies of regional and national assessments (American/Caribbean forests, terrestrial ecosystems of Colombia, and terrestrial ecosystems of South Africa) to illustrate the indices' complementarity and versatility in revealing patterns of interest for users across sectors. Our indices have the potential to fill the recognized need for ecosystem indicators to inform conservation targets, guide policy, and prioritize management actions.

KEYWORDS
biodiversity indicators, conservation actions, conservation management, ecosystem collapse, ecosystem risk assessment, global biodiversity conventions, IUCN Red List of Ecosystems, United Nations Sustainable Development Goals

1 | INTRODUCTION

Minimizing biodiversity loss is a key challenge highlighted in the Convention on Biological Diversity's (CBD) Aichi Targets (CBD 2010) and the United Nations Sustainable Development Goals (SDGs (ICSU, 2015). Biodiversity indicators (see Supporting Information Appendix A) measure progress toward these targets (Tittensor et al., 2014), show impacts of policies on biodiversity, and guide management. Mace et al. (2018) identified three fundamental metrics for measuring change in species biodiversity: extinction risk (Red List Index (RLI); Butchart et al., 2007), abundance (Living Planet Index; Collen et al., 2008), and biotic health (Biodiversity Intactness Index; Newbold et al., 2016). There are no comparable indicators for capturing change in ecosystem-level biodiversity across biomes at the global scale. Yet conserving ecosystems is critical in global conventions (CBD 2010; ICSU, 2015) as it is essential for safeguarding species, ecosystem processes, and the ecosystem services humans rely on (Haines-Young & Potschin 2010).

Metrics for the distribution and health of ecosystems provide key measures of the likelihood an ecosystem will persist (Mace, 2005). Existing data on the distribution and health of ecosystems (Rowland et al., 2018) have not been collated into indicators to measure change at standardized timeframes and classification scales (local to global). Most ecosystem indicators monitor specific ecosystem types (e.g., wetlands: Darrah et al., 2019; forests: Hansen et al., 2013; marine ecosystems: Halpern et al., 2012), leaving gaps in indicator coverage.

Informative indicators require standardized data and a logical formula structure (Jones et al., 2011). The International Union for Conservation of Nature (IUCN) Red List of Ecosystems (RLE) is a valuable data source on ecosystem status (Brooks et al., 2016; Figure 1). Over 2,800 assessments have been conducted in 100 countries across all continents (Bland et al., 2019). Assessments examine key symptoms of decline to estimate ecosystem collapse risk (Bland, Keith, Miller, Murray, & Rodríguez, et al., 2017; Figure 1; Supporting Information Appendix A). Assessments provide insights into the extent and severity of past and predicted future changes in distribution and environmental and biological processes, using diverse data types and sources (Rowland et al., 2018) to allow consistent monitoring among ecosystems at local to global scales (Keith et al., 2015).

We introduce three complementary ecosystem indices to quantify spatial and ecological change using information from RLE assessments. The Red List Index of Ecosystems (RLIE) provides an overview of status in ecosystem collapse risk. The Ecosystem Area Index (EAI) quantifies the relative risk of collapse due to declines in distribution. The Ecosystem Health Index (EHI) measures changes in ecological processes to quantify the relative risk of ecosystem collapse from biotic or environmental degradation.

We apply the indices to three case studies: American and Caribbean forests and terrestrial ecosystems of Colombia and of South Africa. We explore similarities and complementarities among indices in providing an informative picture of ecosystem risk. Our case studies illustrate the indices' versatility in revealing different patterns of interest and synthesizing complex information to highlight areas and ecosystems most at risk. The proposed indices have the potential to fill the recognized need for ecosystem indicators to inform conservation targets, guide policy, and prioritize management actions.

2 | ECOSYSTEM INDICES

2.1 | Red List Index of Ecosystems of Ecosystems

The RLIE complements the RLI of species survival (Butchart et al., 2007), providing comparable information about ecosystems risk. It measures trends in ecosystem collapse risk based on the proportion of ecosystems in each risk category. The RLIE is calculated for the overall risk category and separately for each criterion (Figure 1; Supporting Information Methods, Supporting Information Appendix B).

The RLIE is the mean of ordinal ranks assigned to each risk category and is defined as:

$$\mathrm{RLIE}_t = 1 - \frac{\sum_{i=1}^{n} W_{c_{(i,\,t)}}}{W_{\mathrm{CO}}\, n},$$

where $W_{c_{(i,\,t)}}$ is the risk category rank for ecosystem i in year t (Collapsed = 5, Critically Endangered = 4, Endangered = 3, Vulnerable = 2, Near Threatened = 1, Least Concern = 0; following Butchart et al., 2007), W_{CO} is the maximum category rank (Collapsed = 5), and n is the total number of ecosystems excluding Data-Deficient or Not Evaluated ecosystems. The RLIE ranges from 0 (all ecosystems Collapsed) to 1 (all Least Concern) (Figure 2).

The RLIE provides a snapshot of trends among ecosystems. It can show temporal trends in risk status using consecutive assessments (e.g., Bland et al., 2018) using the same approach as the RLI of species survival where changes over time must be due to genuine improvements or deterioration in the ecosystem, rather than due to new information or reclassification of ecosystems/species (Hoffmann et al., 2008).

2.2 | Ecosystem Area Index

The spatially explicit distribution of an ecosystem (Likens, 1992) can affect its ability to maintain an ecological community. Area declines can reduce carrying capacity, niche diversity, and spatial partitioning of resources, reducing native biota abundance (Harpole & Tilman 2007; Shi, Ma, Wang, Zhao, & He, 2010). While defining an ecosystem

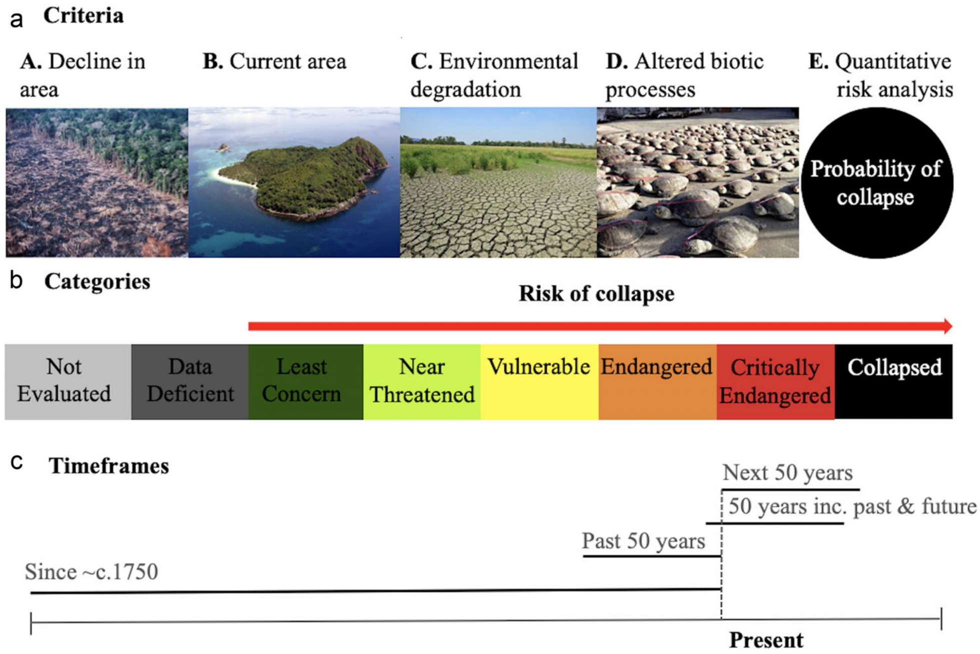

FIGURE 1 The key elements on an IUCN Red List of Ecosystems assessment including (a) the five quantitative criteria used to examine spatial and ecological symptom of decline toward collapse; (b) the risk categories assigned to each criteria and to the ecosystem overall (highest risk category across criteria) that are defined based on numerical decision thresholds that specify the conditions required to trigger management decisions; and (c) the three timeframes over which temporal change in the area (criterion A) and ecological processes (criteria C and D) is measured. Criterion A: Photo by Axel Fassio/CIFOR; Criterion B: Photo by Kelvin Servigon; Criterion C: Photo by NASA Goddard Space Flight Centre; Criterion D: Photo by John Payne

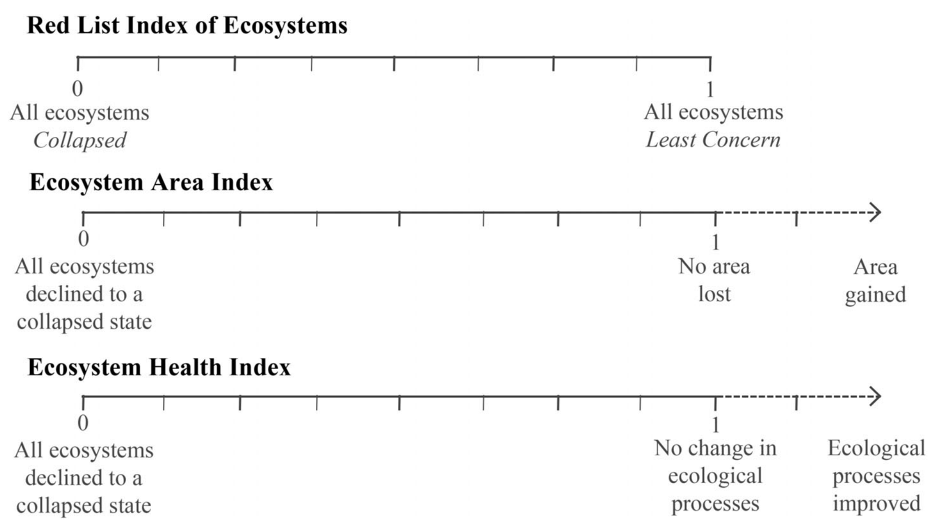

FIGURE 2 Range of values for each index

distribution can be challenging, mapping is a common and informative practice across marine (Murray et al., 2019), terrestrial (Zhang, Kang, Han, & Sakurai, 2011), and freshwater ecosystems (Darrah et al., 2019).

The EAI measures trends in changes in ecosystem area toward ecosystem collapse. The EAI is the geometric mean (Supporting Information Appendices B and C) of the proportion of ecosystem area remaining over a given timeframe relative to the initial area and an ecosystem-specific collapse threshold. We defined the EAI as:

$$EAI = \sqrt[n]{\prod_{i=1}^{n}(1 - A_i)},$$

where A_i is the proportion of area lost relative to the loss required for ecosystem i to collapse (i.e., where decline in area exceeds the collapse threshold and the ecosystem transitions into a collapsed state) and n is the total number of ecosystems. The index is constrained to EAI ≥ 0, where EAI $= 0$ indicates that all ecosystems have lost all their area, EAI = 1 represents no change in area, and EAI > 1 shows that ecosystems have increased in area (Figure 2). The EAI uses data from RLE criterion A. Separate EAIs can be calculated to compare trends across past and future timeframes (Figure 1). Where reassessments are available, trends in the EAI can show changes in ecosystem area toward or away from collapse over time.

2.3 | Ecosystem Health Index

Ecosystems are defined based on the native ecological community and environmental conditions that support them (Tansley, 1935). Environmental degradation (e.g., altered water regimes) can reduce habitat quality or suitability for native biota (Noss, 1990). Disruption of biotic processes can diminish ecosystem resilience and its ability to maintain its ecological community (Cardinale et al., 2012), including the loss of important species (e.g., foundation species), interactions among species (e.g., competition), and interactions between species and the environment (e.g., dispersal corridors).

The EHI measures temporal changes in environmental conditions and biotic processes/interactions (hereafter collectively, ecological processes; Supporting Information Appendices A and B). The EHI uses relative severity of change in ecosystem-specific variables and extent of the ecosystem affected to quantify transitions toward or away from ecosystem collapse. The index represents the geometric mean (Supporting Information Appendix C) of the relative value of decline (Supporting Information Appendix E) defined as:

$$EHI = \sqrt[n]{\prod_{i=1}^{n}(1 - s_i e_i)},$$

where s is the relative severity of change in an ecological variable compared to level of degradation indicating collapse (i.e., where change exceeds the collapse threshold and the ecosystem transitions into a collapsed state; Supporting Information Appendix A) (Bland, Keith, et al., 2017) and e is the proportion of area affected in ecosystem i. The index is constrained to EHI ≥ 0, where EHI = 0 indicates that all ecosystems have degraded to a collapsed state, EHI = 1 represents no change in ecological processes, and EHI > 1 shows ecosystem condition has improved (Figure 2).

The EHI uses data from RLE criteria C/D (Figure 1). Change in ecological variables are standardized to a relative severity of decline to allow use of ecosystem-specific variables capturing key features/processes rather than generic variables (e.g., species richness), which are often inadequate for capturing status among ecosystem types. The variable for each ecosystem used to calculate the EHI is the one showing the largest declines over time. Distinct EHI values are calculated for past and future timeframes, and temporal changes in the EHI can be calculated using the same method as the EAI.

2.4 | Representing variability

Understanding the message from an index in the context of underlying data variability is critical for appropriately interpreting ecosystem change. We present intervals that represent the 2.5th and 97.5th percentiles, capturing the middle 95% of data for each index. Percentiles produce asymmetrical intervals and are robust to the effects of outliers and skewed distributions (Quinn & Keough, 2002) in our datasets.

3 | CASE STUDIES

We present the ecosystem indices using case studies of national and continental scales to demonstrate their versatility across scales and in revealing different patterns of interest for users (e.g., based on typology, geographic regions, and protection level; Supporting Information Appendix B).

3.1 | American and Caribbean forests

We applied the indices to the continental-scale RLE assessments of 136 temperate and tropical forests across 51 countries/territories in the Caribbean and Americas (Ferrer-Paris et al., 2018). Our results provide an overview of trends among similar forests grouped in eight forest formations (Faber-langendoen et al., 2014) (Figure 3; Supporting Information Appendix D).

The RLIE revealed that tropical dry forest/woodlands were most at risk and mangroves least at risk, with substantial variation within forest formations. Change in area was a primary factor contributing to risk across all formations, although forest distributions were generally large enough for restricted area not to be a major risk. Most deforestation happened between 1700 and 2000. On average, 24–48% (EAI) of distributions in 1700 remained in 2000. The EAI suggests that deforestation will continue at slightly lower rates than previously. The RLIE showed varied risk among formations from degradation of biological processes and environmental degradation. The EHI and EAI revealed lower past declines in ecological processes compared to area. Degradation is expected to become more acute between 2000 and 2050, particularly in warm temperate forests.

Our results showed the variable impact of historically extensive deforestation across formations. Given the high variability of risk and declines among forests, attention should be paid to the highly deforested formations, as further large-scale degradation is predicted under climate change along with increased exploitation of forests that are already substantially cleared.

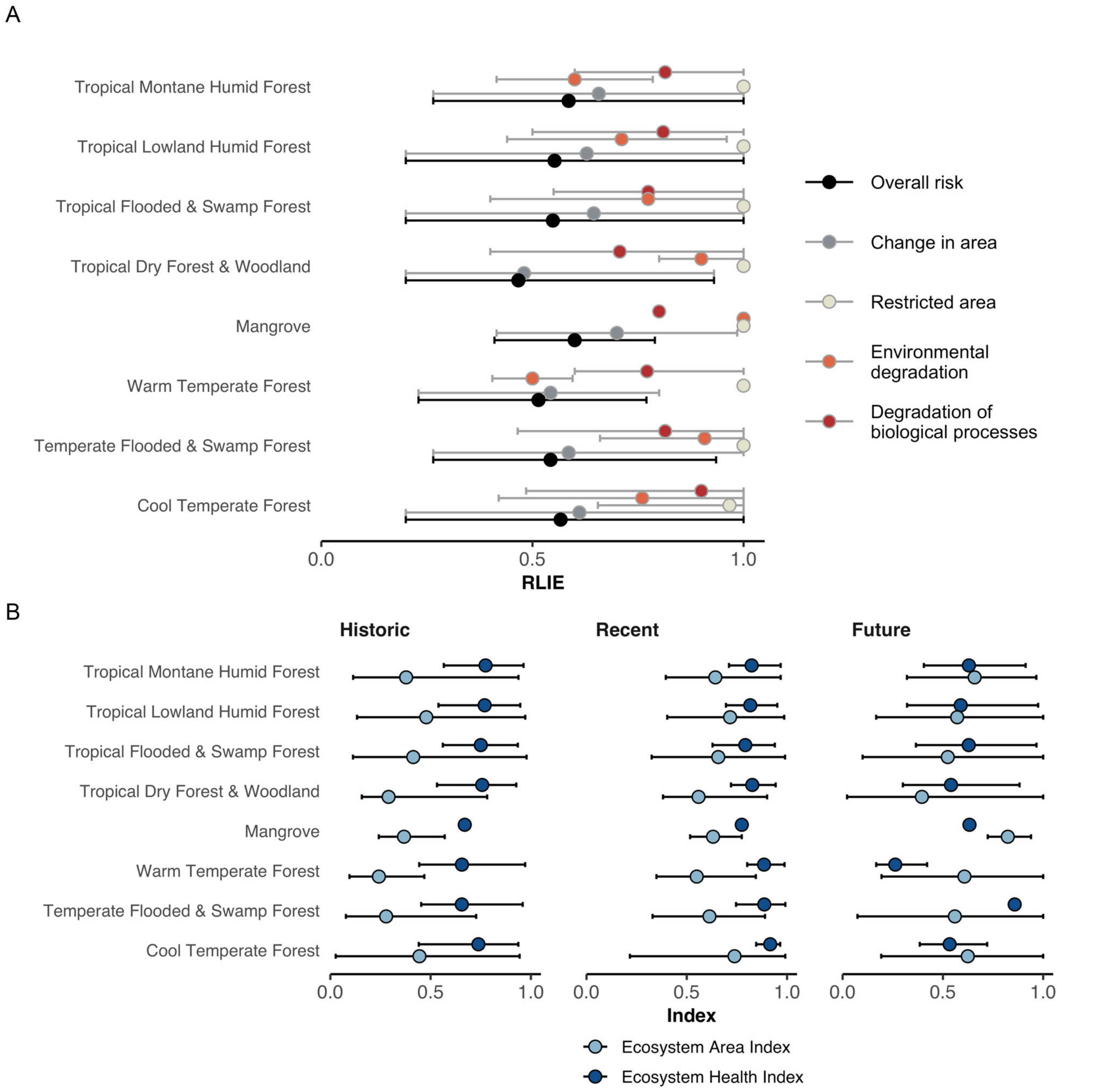

FIGURE 3 Indices for American and Caribbean forest formations. (a) The Red List Index of Ecosystems (RLIE) for the overall risk and for each symptom of decline, and (b) the Ecosystem Area Index and Ecosystem Health Index for historic (since 1700), recent (past 50 years), and predicted future (next 50 years) timeframes. Intervals were calculated using the 2.5th and 97.5th percentiles to represent the middle 95% of the data. See Tables S1 and S2 for values

3.2 | Colombian ecosystems

Colombia is a mega-diverse country (Myers, et al. 2000) characterized by five biogeographic regions with differing colonization patterns. We applied the indices to RLE assessments of Colombia's 81 terrestrial ecosystems (Etter, et al. 2017) to provide a national overview of geographic patterns (IUCN 2012) (Figure 4; Supporting Information Appendix D) and among biomes (Supporting Information Appendix F).

The RLIE revealed that Caribbean ecosystems had the highest mean overall risk, while Pacific and Amazon ecosystems had lower average risk from changes in area, and degradation of biological processes (e.g., water availability) threatened Caribbean and Orinoco regions. The EAI and EHI showed varied risk among regions but revealed that area losses often coincided with comparable degradation. Andean and Caribbean ecosystems underwent substantial clearing and degradation, although some ecosystems remain relatively intact. Area declines of 7–38% (EAI) on average are expected

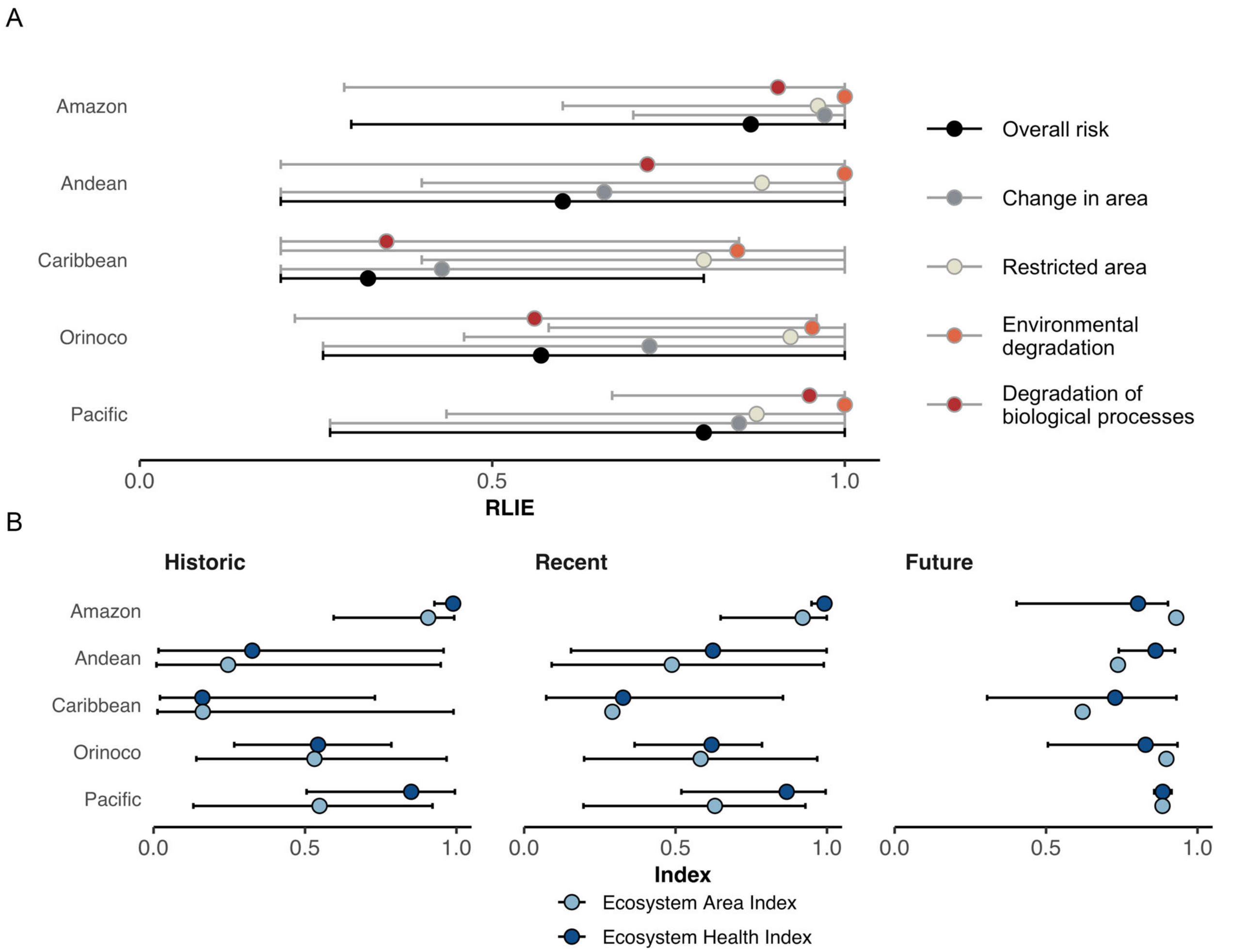

FIGURE 4 Indices for terrestrial ecosystems of Colombia grouped by biogeographic region. (a) The Red List Index of Ecosystems (RLIE) for the overall risk and for each symptom of decline, and (b) the Ecosystem Area Index and Ecosystem Health Index for historic (since 1750), recent (past 50 years), and predicted future (next 50 years) timeframes. Intervals were calculated using the 2.5th and 97.5th percentiles to represent the middle 95% of the data. See Tables S3 and S4 for values

across all regions between 2015 and 2065. However, some ecosystems may increase in area, particularly Pacific ecosystems. Climate change will likely cause considerable degradation toward collapse by 17–27% (EHI) on average in the Caribbean, Amazon, and Orinoco regions.

Our results reveal the greatest impacts on biodiversity have occurred in highly urbanized/industrialized regions with high population densities (Etter et al., 2008). This suggests that limiting further clearing alone is insufficient to halt biodiversity decline; management actions must consider the risks of degradation in remaining areas.

3.3 | South African ecosystems

South Africa is characterized by high plant species diversity and endemism (Cowling, Richardson, & Pierce, 2004). Over 450 terrestrial ecosystem types were identified in 10 distinct biomes (Mucina et al. 2018). South Africa has targets for the proportion of each ecosystem type to be covered by protected areas (Driver et al., 2012; Reyers et al., 2007), with each assigned a Protection Level (from Not-Protected to Well-Protected) based on progress toward the target. We summarized trends among Protection Levels to examine congruence between protection and risk (Figure 5; Supporting Information Appendix D) and among biomes (Supporting Information Appendix F).

The RLIE revealed mean overall risk was highest for Not-Protected ecosystems and lowest for Well-Protected ecosystems. Change in area was the largest risk factor for Not-Protected and Poorly-Protected ecosystems; many were also at high risk from having a restricted area. Degradation of biological processes was a negligible risk (for the limited ecosystems assessed under this criterion) across most protection levels, although risk was higher for Not-Protected ecosystems. Risk to Well-Protected and Moderately-Protected ecosystems varied, largely due to variation in risk from having a restricted area. The EAI and EHI showed that the mean and variability in area loss among ecosystems increased as protection level

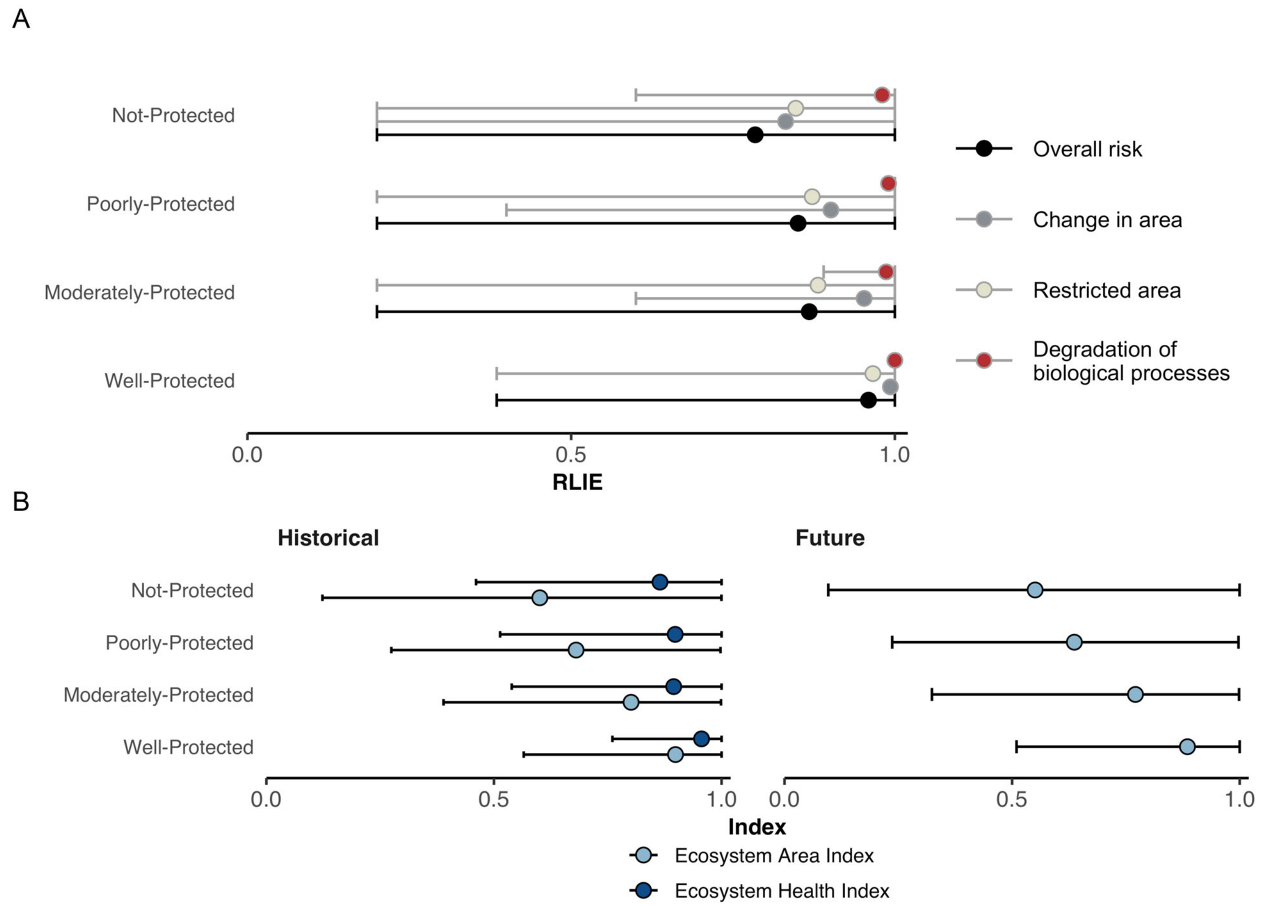

FIGURE 5 Indices for terrestrial ecosystems of South Africa grouped by protection level. (a) The Red List Index of Ecosystems (RLIE) for the overall risk and for each symptom of decline, and (b) the Ecosystem Area Index and Ecosystem Health Index for historic (since 1750) and predicted future (next 50 years) timeframes. Intervals were calculated using the 2.5th and 97.5th percentiles to represent the middle 95% of the data. See Tables S5 and S6 for values

decreased, that is, ecosystems with less protection experienced higher area losses and degradation and were at a greater risk of future area losses.

Our results highlight that ecosystems most at risk are not sufficiently represented within the protected areas network, which is consistent with studies showing that protected areas tend to be established on non-arable lands (Pressey et al., 1996). To better conserve biodiversity, decision makers should focus future protected areas on ecosystems listed as Poorly-Protected and Not-Protected that are most at risk.

4 | EXPLORING THE ECOSYSTEM INDICES

4.1 | Complementarity among indices

The indices provide a complementary picture of ecosystem status. The RLIE summarizes risk among ecosystems and provides insights into the symptoms driving risk; it will likely be most frequently calculated as it complements the RLI of species survival. The coarseness of risk categories means that ecosystems must face extensive changes before moving between categories, limiting the sensitivity of the RLIE. For example, an ecosystem is Endangered (thus has the same value in the index) if it loses 50% up to 79% of its area over 50 years. However, this coarseness reduces the impact of uncertainty on the index.

The EAI and EHI use detailed data underpinning RLE assessments, rather than the resulting risk categories. Any change in area or health will affect the EAI and EHI, respectively. Changes in area and health are placed in the context of a meaningful reference point for each ecosystem (ecosystem collapse), setting our indices apart from other area- and health-based indicators (Hansen et al., 2013; Newbold et al., 2016). The EAI measures proximity to collapse due to loss of area available to support native biota and processes, providing a simple proxy for carrying capacity (Keith et al., 2013). The EHI reveals changes in ecological processes and thus ecosystem viability, which may not be detected by area-based measures (Bland, et al., 2017).

Ecosystems are highly complex and no single metric is informative about the health of all ecosystem types (Hill et al., 2016). A strength of the EHI is its flexibility to use ecological variables that are informative of each ecosystem's status, allowing comparisons among diverse ecosystems by standardizing change according to an initial baseline and an ecosystem collapse threshold. Careful interpretation of the EHI based on the ecological variables used is important. Some variables capture changes in features/processes underpinning ecosystem area (e.g., abundance of foundation species); the EHI would be lower than the EAI if sections of ecosystems undergo degradation to foundation species but have not yet locally collapsed, resulting in area losses. Other variables are not directly reflected by area changes; the EHI and EAI will become more independent as the indices capture different processes of ecosystem decline.

Data on ecological variables are often limited or unavailable (Rowland et al., 2018). For instance, many South African ecosystems lacked sufficient data to assess RLE criteria C/D and thus support an EHI; work is in progress to enhance the current data available on ecosystem condition to improve the RLE assessments and indices, as risk from degradation is likely to be high across the country. Data completeness must be considered when interpreting the indices. Ideally, the most sensitive ecological variables should be used in the EHI. Often, a single generic variable (e.g., annual rainfall) that does not fully capture ecological changes may be assessed (Bland et al., 2018). Consequently, the EHI may be unreliable and underestimate changes if generic or insensitive variables are used. A global typology of ecosystems is currently being developed to inform consistent ecosystem definitions and variable selection among RLE assessments. Consistency in RLE application assessors is critical to reduce bias and uncertainty in the ecosystem indices, as with the RLI of species survival; a growing toolkit is available to aid consistency of application (e.g., REMAP: Murray, et al., 2018; redlistr: Lee, et al., 2019).

4.2 | Understanding variation among ecosystems

Intervals can capture variability in the underlying data or uncertainty in the representativeness of index values. We used intervals to represent variation among ecosystems used to calculate the indices, rather than to measure uncertainty that the index values are generalizable beyond the ecosystems assessed. Representing variation in each index provides insights into the processes causing loss and prospects for interventions. Measures of variation have two important features. First, the interval width expresses the level of variation in change experienced by ecosystems. A narrow range indicates consistent rates of loss among ecosystems, potentially reflecting a widespread process affecting all areas and ecosystems. A wide range may reflect localized or ecosystem-specific losses, such as consistent historical area losses among Andean ecosystems (Figure 4). Second, the skewness of variation is reflected in the relative position of the index value in the intervals. Skewed intervals can differentiate instances where an index is affected by a few highly degraded ecosystems from cases where all ecosystems are similarly degraded. Understanding the nuances of risk among ecosystems can inform appropriate management actions and prioritization (Ferrer-Paris et al., 2018).

4.3 | Versatility for users

Synthesizing the status of the world's ecosystems is critical to allow clear communication with decision makers, managers, and the public. Our indices provide standardized measures of ecosystem status at different spatial scales. Indicators calculated at national scales inform national conservation legislation, policy, planning, and reporting (Jones et al., 2011). Most RLE assessments are at the national level and used to inform decision making and reporting the status of threatened ecosystems against the National Biodiversity Strategies and Action Plans (NBSAPs) (Bland et al., 2019). Continental- and global-level indicators provide broader information about biodiversity loss and can increase public awareness (Jones et al., 2011). In theory, the indices could be weighted, for example, to reflect values (e.g., distinctiveness, area, and ecosystem services); however, weightings should be applied with explicit reporting goals in mind and caution to ensure the indicator remains robust.

Our indices can be disaggregated to reveal various patterns for users (Table 1), such as among ecosystem types, jurisdictional/geographical boundaries, or timeframes. The extensive historical deforestation in American and Caribbean forests suggests that the Aichi Target 5 to reduce the rate of habitat loss (CBD 2010) is unlikely to be met by 2020 unless there are substantial shifts in land use. In South Africa, grouping ecosystems by Protection Level indicated that ecosystems with lower protection levels have a greater a collapse risk, highlighting important gaps in protection coverage of ecosystems most at risk.

4.4 | Future outlook

Our indices constitute an important step toward a versatile, complementary set of biodiversity indicators to meaningfully synthesize the state of nature. The lack of status-based indicators representing the full scope of biodiversity remains a central limitation in biodiversity monitoring and reporting (IPBES 2019), and risks biasing conservation efforts by basing decisions on inadequate/inappropriate information (Baillie, Collen, & Amin, 2008). When applied at appropriate scales, our indices could fill the gap in ecosystem indicators to inform the monitoring and guide decision makers across government, NGOs, and private and financial sectors

TABLE 1 Potential end users and examples of potential use of ecosystems indices

Relevance of ecosystem indices to end-users	Example
Intergovernmental conventions and global assessments	
Reporting the trends and status of biodiversity. Monitor progress toward meeting global conservation targets and goals.	Convention on Biological Diversity Aichi Biodiversity Targets, such as Target 5 (reduce loss and degradation of natural habitats). National Biodiversity Strategies and Action Plans. Convention on Biological Diversity's Global Biodiversity Outlook report. United Nations Sustainable Development Goals, such as target 15.5 (reduce degradation and loss of natural habitats). Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services assessments, such as land degradation and restoration assessments.
Governments: Local to national	
Guide conservation priority setting, resource allocation, and land/water use and development planning. Measure effectiveness of policy and management strategies. Report progress toward meeting international commitments.	Highlight areas or ecosystem types most at risk to plan conservation actions. Measure relative status and trends among ecosystems. Monitoring ecosystem status and effectiveness of conservation actions. Inform spatial prioritization and design and monitor effectiveness of protected areas networks.
Private and financial sector	
Inform biodiversity risk of companies and investors. Inform planning and application of the mitigation hierarchy, including biodiversity-offsetting practices. Measure impacts of business decisions.	High level risk assessments of investments and resource exploration. Inform impact assessments and the design of mitigation measures. Synthesize impacts of past biodiversity management interventions. Compare projected future indices to assess future potential and cumulative impacts. Tracking change in areas identified as Critical Habitat under the International Financial Corporation Performance Standard 6 (IFCPS6).
Nongovernmental organizations (NGOs)	
Guide conservation priority setting and resource allocation.	Highlight areas or ecosystem types most at risk to plan conservation actions. Monitoring ecosystem status and effectiveness of conservation actions. Inform spatial prioritizations and design of protected areas networks.

(Table 1) (Bland et al., 2019). In particular, indicators based on change in ecosystem area and health are strongly aligned with targets under the CBD and SDGs and associated indicators based on the retention of intact ecosystems (Maron, Simmonds, & Watson, 2018) and goals surrounding restoration.

The dataset of RLE assessments to support the indices is rapidly growing (Bland et al., 2019); subsequent assessments will further enhance the value of indices in monitoring temporal changes in the world's ecosystems. Planned RLE assessments of all ecosystems and new global typology will allow for globally comparable indicators for reporting toward the post-2020 biodiversity framework. National-level data can be used to calculate national-level indices for reporting (e.g., NBSAPs). Our proposed indices will allow for greater comparison across countries, and more informative prioritization of ecosystem-level conservation.

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CONFLICT OF INTERSET

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

JAR, LMB, DAK, and EN contributed to the conception of the indices. AE, JRF-P, and ALS contributed the data for the case studies. JAR wrote the code to calculate the indices and produce the figures, analyzed the data, and wrote the paper. All co-authors contributed to editing and refining the concepts and text in the manuscript. All authors have seen and approved the final manuscript.

DATA AVAILABILITY

Data for the forests of the Americas and Caribbean will be available as summary tables in figshare [https://doi.org/10.6084/m9.figshare.7488872]. The vegetation map used in the South African assessment is freely and publicly available via the stable handle http://bgis.sanbi.org. The South African National Biodiversity Institute is currently finalizing the

National Biodiversity Assessment (NAB) and the information pertaining to the Red List of Ecosystems and Protection Level assessments will be made available at http://bgis.sanbi.org on completion of the NBA report; scheduled for May 2019. All other input data for South Africa linked to the assessment are available on request from the authors. Data for the ecosystems of Colombia will be available on request from the authors.

CODE AVAILABILITY

Code to calculate each index will be available on the Red List of Ecosystems GitHub (https://github.com/red-list-ecosystem).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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