QUANTIFIYING BIODIVERSITY LOSS RISK

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Species Metrics

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ABSTRACT

This research paper investigates the pros, cons, and use cases of two biodiversity measurements that assess the richness of ecosystems in rare and threatened species and the impact of protective measures: Rarity Weighted Richness (RWR) and Species Threat Abatement and Restoration (STAR). RWR measures the specific richness of an ecosystem by weighting species according to their rarity, emphasizing ecosystems rare species that are more vulnerable to environmental and human pressures. Conversely, STAR was designed to quantify the impact and contribution of actions to restore habitats and preserve rare and endangered species, as well as broader biodiversity.

This paper explores the strengths and limitations of these two complementary metrics and their modeling. By critically assessing these indicators, this study aims to refine ecological assessment tools and guide researchers and finance practitioners in selecting appropriate measurements for their projects. Although not directly created for finance practitioners, we believe these metrics can help them understand the importance of assessing the conservation status of rare species and the impact of protective measures on specific projects.

KEY FINDINGS

Our paper focuses on two biodiversity measurements centered on quantifying and protecting rare species: **Rarity Weighted Richness** (**RWR**) and **Species Threat Abatement and Restoration** (**STAR**).

These metrics have distinct strengths, weaknesses, and limitations, but are complementary and valuable for helping financial institutions, investors, and companies assess project impacts and develop holistic biodiversity conservation strategies.

RWR prioritizes rare and uncommon species within an ecosystem, quantifying an area's biodiversity by weighting species by their rarity. Unlike standard biodiversity metrics, it recognizes that conservation value is determined by rarity as well as abundance, making it useful for identifying and prioritizing fragile ecosystems that need protection.

STAR, on the other hand, quantifies the potential contributions of management and habitat restoration actions to reduce threats to rare species. This metric helps economic stakeholders identify investments and projects that positively impact biodiversity by restoring habitats and reducing threats, ensuring a positive impact on rare species conservation. Unlike RWR, STAR provides a numerical value indicating species' threat levels, with critically endangered species weighted more heavily.

However, both metrics often rely on imprecise data on the distribution and abundance of lesser-studied species. Despite their limitations, combining these metrics is recommended for evaluating the impact of human activity on ecosystem health, biodiversity, and rare species.

KEY WORDS

- BIODIVERSITY RISK METRICS
- SPECIES METRICS
- SPECIES THREAT ABATEMENT AND RESTORATION
- STAR
- RARITY-WEIGHTED RICHNESS
- RWR

INTRODUCTION

There is no universally defined or accepted criteria among international organizations for classifying an animal or plant species as rare. However, studies identify **key characteristics of rarity**. A species is usually considered rare if its population is small (typically fewer than 10,000 individuals) and its geographical range is restricted.

A GROWING NUMBER OF SPECIES ARE GLOBALLY THREATENED

The classification "rare species" differs from "endangered" or "threatened," although a threatened species can also be rare. The International Union for Conservation of Nature (IUCN) compiles a global inventory of plant and animal conservation status, with its Red List serving as a key indicator for assessing extinction risk and tracking biodiversity.

In the latest Red List (2023.1), of the 157,190 species assessed, 44,016 were classified as threatened (vulnerable, endangered, or critically endangered). These evaluations, based on rigorous criteria, cover only a fraction of the 1.8 million known and described species **[1]**.

Other estimates, like those from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), suggest that "1 million animal and plant species are now threatened with extinction, more than ever before in human history **[2]**."

THE ESSENTIAL ROLE OF RARE SPECIES IN MAINTAINING BIODIVERSITY

Rare species are crucial for the planet, humans, and the economy. In 2019, an international team, including researchers from Clermont Auvergne University, National Institute of Agronomic Research (INRA) and the French National Center of Scientific Research (CNRS), highlighted the **importance of rare species in maintaining multifunctional ecosystems**. Studying 123 sites worldwide, they demonstrated the necessity of conserving rare species to preserve ecosystem integrity **[3]**.

Researchers from the Center for Synthesis and Analysis of Biodiversity (Cesab), CNRS, University of Grenoble Alpes, and University of Montpellier analyzed databases of nearly 15,000 terrestrial mammals and birds to map ecologically rare species globally. Their findings show that **rare species play a more significant role in ecosystems than others**. According to their analyses, "rarity does not only relate to the mere abundance or geographic extent of species but also to their functional distinctiveness. If rare species are not redundant with other species and instead hold unique combinations of traits, they will likely contribute disproportionately to ecosystem functioning and associated services **[4]**."

These studies emphasize the concept of "functional rarity of species." The unique ecological roles of rare species make them irreplaceable for ecosystem health. Nicolas Mouquet, Scientific Director of Cesab, urges businesses, organizations, and governments to recognize "the role these species play in their ecosystem and how they contribute to its functioning **[5]**."

THE SEVERE CONSEQUENCES OF RARE SPECIES AND BIODIVERSITY LOSS

Natural habitat loss and degradation, climate change, invasive species, overexploitation of resources, and pollution severely impact species, especially rare ones. Small populations are more vulnerable to ecological disasters and pressures on their endemic ranges, compounded by risks like genetic diversity loss and inbreeding.

Given their importance for ecosystem functioning, **the loss of rare species would accelerate biodiversity degradation**. Beyond environmental consequences, the economic impact could be substantial. Approximately $44 trillion of economic value generation, over half the world's GDP, is moderately or highly dependent on nature and its services. Biodiversity also provides nearly twice the value in goods and services of what humans produce annually **[6]**. Its collapse would entail significant medium- and long-term economic costs for governments, economic actors, and citizens.

THE NEED TO QUANTIFY HUMAN ACTIVITY & ITS IMPACTS ON RARE SPECIES

The concept of "biodiversity risk" has emerged in recent years in the financial sector, referring to the financial threats and opportunities posed by biodiversity loss to global economic, financial, and geopolitical stability. It includes the responses and solutions implemented by financial institutions, investors, and companies. For instance, the Taskforce on Nature-related Financial Disclosures (TNFD), an international working group on nature-related financial risk disclosure and transparency, focuses on the impact and dependence of financial institutions on nature. Indeed, we first need to understand dependence of financed companies on ecosystem services and how a loss of biodiversity could impact their cashflows and, more generally, their financial stability. We also need to assess the impact of economic activities on ecosystems.

Many financial players now recognize the importance of assessing and integrating this risk into their processes, policies, decisions, and products. However, measuring and fully understanding this risk remains complex. **Quantifying the impact of human activity on biodiversity, particularly on rare species, is challenging due to the many interconnected factors and the complexity of biodiversity itself**, which encompasses species, ecosystems, genes, and ecological functions. This quantification requires combining field data including population measurements of rare species in specific territories, expert reports, economic analyses, and ecological modeling to simulate human activity impacts.

Our first paper, "**Quantifying Biodiversity Loss Risk – Biodiversity Intactness Indices**", focused on measuring ecosystems intactness compared to a reference state: the undisturbed state **[7]**. One of the paper's conclusions is that the most commonly used intactness indices, those that are typically used to measure companies' biodiversity footprints, equally weigh all species. Hence, most of them don't take into account species rarity or extinction risks. The paper also concludes that no single metric is sufficient for assessing ecosystems health: "Instead, their complementary nature emphasizes the importance of employing them together to achieve a more comprehensive understanding and a more robust biodiversity evaluation."

This paper takes a deep dive into two metrics used to assess ecosystems richness in rare species and in species threatened with extinction. These metrics could complement a holistic approach of biodiversity impact assessment.

This is the second in a series of papers aiming to contribute to the development of methodologies and tools to quantify biodiversity risks in financing portfolios.

LITTERATURE REVIEW

Several papers study the biodiversity species rarity metrics discussed in this paper.

In 2019, Astudillo-Scalia et al. **[8]** noted that traditional species richness metrics, while commonly used to measure biodiversity loss, are not always the most effective. Species richness may not indicate a site's importance for species representation. Instead, Astudillo-Scalia focused on rarity metrics, which often yield better results in conservation planning. Rarity is related to geographic range, habitat specificity, and local abundance. A species is typically considered rare if its geographical range or abundance falls below a specific threshold. Rarity can be assessed as the inverse of the number of sites where a species is present, while the rarity-weighted richness (RWR) of a site is the sum of rarity scores for all species at that site. Astudillo-Scalia found that RWR performed exceptionally well in quantifying the representation of vertebrates and plants in tropical and temperate environments.

In 2015, Fabio Albuquerque and Paul Beier also examined the RWR metric **[9]**. Their goal was to model RWR for areas lacking biodiversity data. They computed RWR for sites with available species inventories and used a random forest model to predict RWR for other sites.

More recently, in 2021, the International Union for Conservation of Nature (IUCN) and a consortium of biodiversity experts introduced the Species Threat Abatement and Restoration (STAR) metric **[10]**. This metric uses data on species' extinction risk, distributions, and threats from global red lists to quantify the potential impact of threat abatement and habitat restoration activities. A primary data source for STAR is the IUCN Red List, which contains information on over 44,000 species threatened with extinction.

Rarity-based metrics provide a spatially explicit way to quantify species representation, playing a critical role in enabling governments, financial institutions, and other stakeholders to prioritize actions, set targets, and measure progress towards species extinction risk goals.

TWO KEY INDICATORS TO FOSTER THE PROTECTION OF RARE SPECIES

This paper highlights two indicators contributing to the assessment and consideration of "biodiversity risk" and shedding light on rarity: **Rarity Weighted Richness (RWR) and Species Threat Abatement and Restoration (STAR)**. These two metrics support a more holistic conservation strategy.

Rarity Weighted Richness (RWR) measures an ecosystem's specific richness by weighting species according to their rarity, emphasizing ecosystems with rare species. For businesses and investors, RWR is crucial for identifying projects in high conservation value areas.

Species Threat Abatement and Restoration (STAR) quantifies the contributions of threat abatement and habitat restoration in reducing species' risk of extinction.

While most of the existing literature presents or dives into the features of one of species metrics, our paper aims to analyze the two most commonly used metrics and compare their pros, cons, and use cases.

RARITY WEIGHTED RICHNESS (RWR)

Rarity Weighted Richness (RWR) is a biodiversity metric that assigns greater importance to rare and uncommon species within an ecosystem, unlike standard biodiversity metrics that primarily focus on species abundance. RWR recognizes that a species' conservation in a given habitat is influenced by its rarity, not just by its abundance.

A high RWR value indicates that a site has many rare species, whereas a low RWR value indicates that the site contains very common species found elsewhere.

The RWR formula involves weighting species based on their rarity. Mathematically, it can be expressed as follows:

Let c_i be the number of sites occupied by species i, and the values are summed for the n species that occur in that site.

The formula of **RWR** is presented below **[11]**:

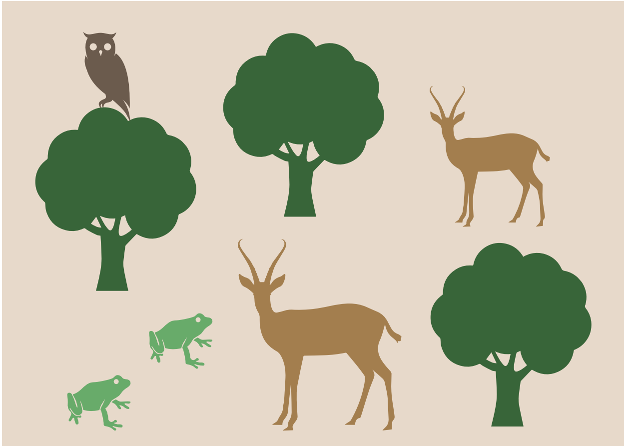
$$\mathrm{RWR} = \sum_{i=1}^{n} \left(\frac{1}{ci}\right)$$

This approach ensures that rare species contribute more significantly to the overall richness value.

We will be computing the RWR metric for the site below, in a very simple ecosystem.

We suppose that, globally, there are 10 sites sheltering the same species of gazelles (as shown in the site shown in Figure 1 above), 5 sites sheltering the same species of owls, 10 sites sheltering the same species of trees, and 4 sites sheltering the same species of frogs.

FIGURE 1: SIMPLIFIED EXAMPLE OF AN ECOSYSTEM FOR RWR CALCULATION



The RWR metric of the site above is equal to:

$$\mathrm{RWR} = \frac{1}{10} + \frac{1}{5} + \frac{1}{10} + \frac{1}{4} = 0{,}65$$

This metric is hence always positive. There is no upper bound limit to its values like for biodiversity intactness indices studied in the I. Ben Rejeb-Mzah et al., 2024 paper **[7]** that are built to be within [0,1] range. Furthermore, the bigger RWR is, the rarer the species sheltered in the analyzed ecosystem.

ADVANTAGES AND LIMITATIONS OF RWR

Pros: Rarity Weighted Richness (RWR) offers several advantages in biodiversity assessment. It is sensitive to rarity, helping quantify the significance of conserving an area by assigning a value that reflects the rarity of the species present. By emphasizing the importance of maintaining rare species within ecosystems, RWR contributes to a more holistic conservation strategy. Additionally, the RWR formula is simple, making the metric easy to understand.

Cons: However, this methodology has challenges. It relies heavily on accurate data about species geographical distribution, posing a significant hurdle for less-studied species. Furthermore, the metric's sensitivity to the chosen weighting scheme for rarity, assigning a weight of 1 for each species, can be problematic. Finally, all sites have equal weights in this computation. For instance, this metric does not consider the abundance of species at the site. For example, if black rhinos are present in two different sites (500 rhinos in site A and 2 rhinos in site B), they will contribute equally to the RWR of both sites, even though site A is much more critical for black rhino conservation.

MODELING RWR

Given the data constraints related to this metric, it is crucial to model this metric as a function of accessible features.

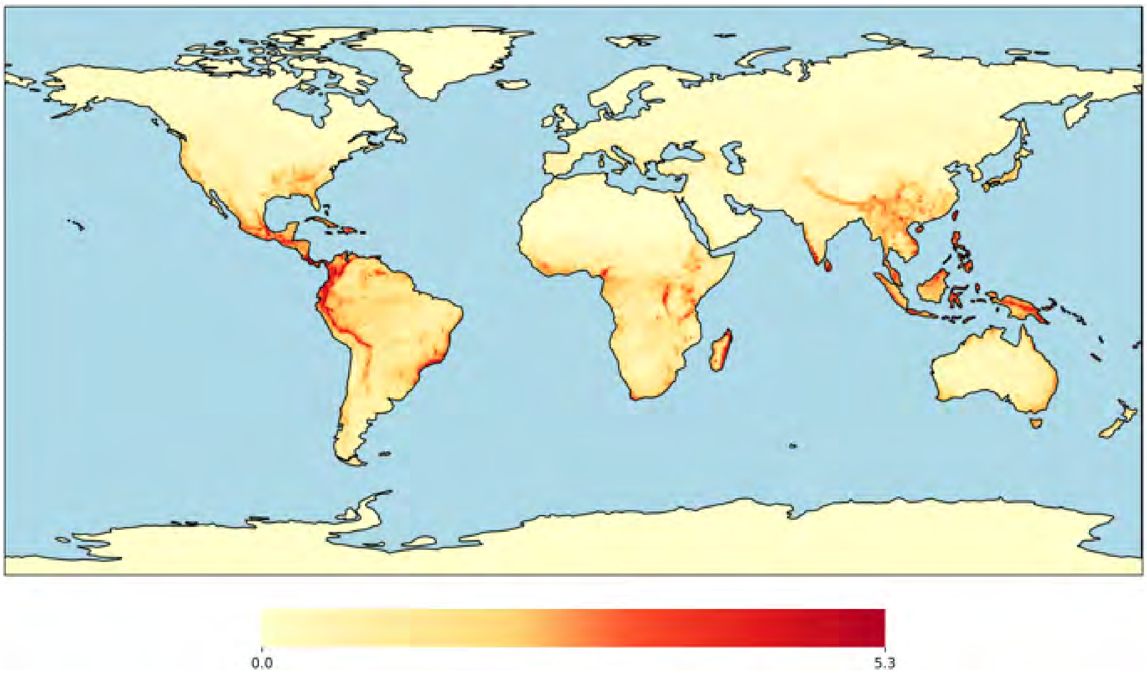
As we did for the previous metrics **[7]**, in this section we present a way to model the **RWR metric** using ecological features of the site of interest. This model was developed by Fábio Albuquerque, Paul Beier and published in 2016 **[11]**.

The aim of this model is to compute the **RWR metric** using features such as temperature variables, precipitation variables, sunshine variables, elevation, slope, PET (potential evapotranspiration), land cover diversity, and NDVI (normalized difference vegetation index). These features were chosen because they are freely available for all regions of the world. **Random Forest model** was preferred over other models because it can model nonlinear correlations between features and the target value, resulting in better predictions.

The following global RWR map, was generated using IBAT spatial data **[12]**. It considers mammals, birds, amphibians, crabs, crayfishes and shrimps.

As we can see on the map, Southeast Asia has some of the highest RWR values, primarily due to the presence of rare species such as Javan Rhinos, Sumatran Orangutans, and the Tooth-Billed Pigeon. Additionally, the western part of South America also shows high RWR values. This is because many rare species, like the Ecuadorian Sac-Winged Bat and the Short-Tailed Chinchilla, which are listed as endangered by the IUCN, still inhabit this region.

FIGURE 2: RWR GLOBAL DISTRIBUTION



SPECIES THREAT ABATEMENT AND RESTORATION (STAR)

This metric "**assesses the potential of biodiversity threat abatement and habitat restoration actions to yield benefits for threatened species. STAR enables investors and companies to quantify their contributions to biodiversity preservation**" **[13]**.

STAR is a metric that defines two scores for each region: the STAR Threat Abatement score (**$STAR_T$**) and the STAR Restoration score (**$STAR_R$**). These scores are computed separately to provide insight into the contributions of threat abatement and habitat restoration in reducing species' risk of extinction.

$STAR_T$ is calculated by weighting each species' **Global IUCN Red List** status by the proportion of their **Area of Habitat (AOH)** within the region. The IUCN weights increase with the extinction risk of the species (Near Threatened = 100, Vulnerable = 200, Endangered = 300, and Critically Endangered = 400).

For a site S:

$$STAR_T(S) = \sum_{i=1}^{N} P_{S,i} * W_i$$

Where:

N is the number of species in the region ***S***

$P_{S,i}$ is the share of species i's total **AOH** that S represents

W_i denotes the **IUCN Red List** threat status of specie ***i***, it ranges from **100** to **400**.

Like RWR, this metric is always positive and does not have an upper bound limit. Furthermore, the bigger **$STAR_T$** is, the more threatened species on IUCN Red List, the analyzed ecosystem shelters.

Let us see an example of how to compute **$STAR_T$**.

Let us consider a dummy site S. Its composition includes 2 imaginary endemic species *(Ghost Eagle and Great Mountain Iguana)* and 2 species *(Hunting Cat and Leaping Frog)* which have half of their AOH within the site. These species' Red List categories are different; thus, their weightings vary.

FIGURE 3: COMPUTATION OF $STAR_T$ SCORE FOR THE HYPOTHETIC COUNTRY **[14]**

	Ps,i	Wi		$STAR_T(S)_{species}$
Species	% Species current AOH	Species red list category	Species weighting	Contribution to the site's $STAR_T$
Ghost Eagle	100	Vulnerable (VU)	200	200
Great Mountain Iguana	100	Endangered (EN)	300	300
Hunting Cat	50	Near Threatened (NT)	100	50
Leaping Frog	50	Critically Endangered (CR)	400	200

For the *Hunting Cat*, half of its AOH is within the site, therefore $P_{S,i}$= 50%. Its Red List category is Near Threatened, therefore its weighing is W_i= 100. Its contribution to the site's $\mathbf{STAR_T}$ is given by the following formula:

$$STAR_T(S)_{\text{Hunting Cat}} = 50\% * 100 = \mathbf{50}$$

We can compute these scores for each species and sum them to get the total $\mathbf{STAR_T}$ value of site S. In the end, we get a final Species Threat Abatement score of 750, which describes the potential of reducing the risk of extinction of a species by abating existing pressures on the site. The higher the site's $\mathbf{STAR_T}$ is, the more it contains threatened species and the more it contributes to species extinction risk abatement.

Now let us have a look at the **STAR** Restoration component: $\mathbf{STAR_R}$ quantifies how much contributing to habitat restoration could reduce the risk of species extinction **[15]**.

$$STAR_R(S) = \sum_{i=1}^{N} H_{S,i} * W_i * M_{S,i}$$

Where $H_{S,i}$ is the extent of restorable **AOH** for species i at location S expressed as a percentage of the global species' current **AOH**. We consider only locations previously occupied by the species. For instance, let's consider a species whose **AOH** within S constitutes 20% of the whole area. Half of this species' current **AOH** is located within S. Before any human pressure on the site, this species occupied its current **AOH** and another 30% of the area of S, for a total of 50% of S.

$$H_{S,i} = \frac{\text{Previous AOH within S not occupied now}}{\text{Total current AOH}} = \frac{30\% \text{ of S}}{20\% \text{ of S} * 2} = \frac{30\%}{40\%} = \mathbf{0.75}$$

M_S is a multiplier that represents the recovery rate of the habitat at site S. The recovery rate describes how much an ecosystem returns to its original state before any human pressure. We usually use a global value for M_S which is 0.29. This stems from a global meta-analysis about restoration of damaged ecosystems **[16]**. **This study found that most recovery rates ranged between 1% and 10% with a median equal to 2.9% per year**, whether it be an active restoration (with human intervention) or a passive restoration (without human intervention). When computing $\mathbf{STAR_R}$, we use the median of the recovery rate and assume that the restoration will be underway for 10 years, hence why M_S = 0.29. This multiplier gives an initial estimate of the potential of extinction risk reduction entailed by habitat restoration and should be modified to carry out the site's specificities.

MODELING STAR

STAR is modeled using publicly available datasets. It requires information on the level of threat species are facing and their area of habitat. The threat level data is available from the **IUCN Red List**. **STAR** also uses data from national red lists for endemic species not assessed globally.

The area of habitat is estimated using habitat associations, species' range, digital elevation models, and land cover maps (current and historical).

The following **STAR$_T$** and **STAR$_R$** maps generated using IBAT spatial data (see figures 4 and 5) show the global distribution of threatened amphibians, birds and mammals species assessed in IUCN Red List on a global scale **[12]**.

FIGURE 4: THE GLOBAL DISTRIBUTION OF STAR$_T$ SCORES

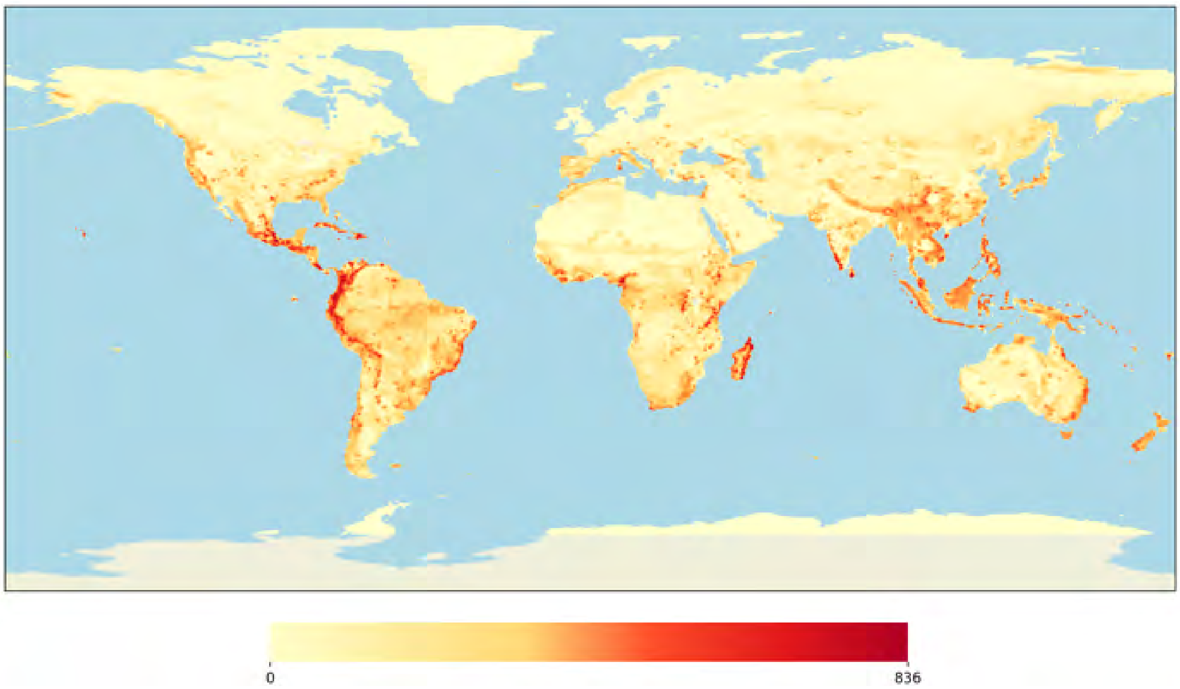
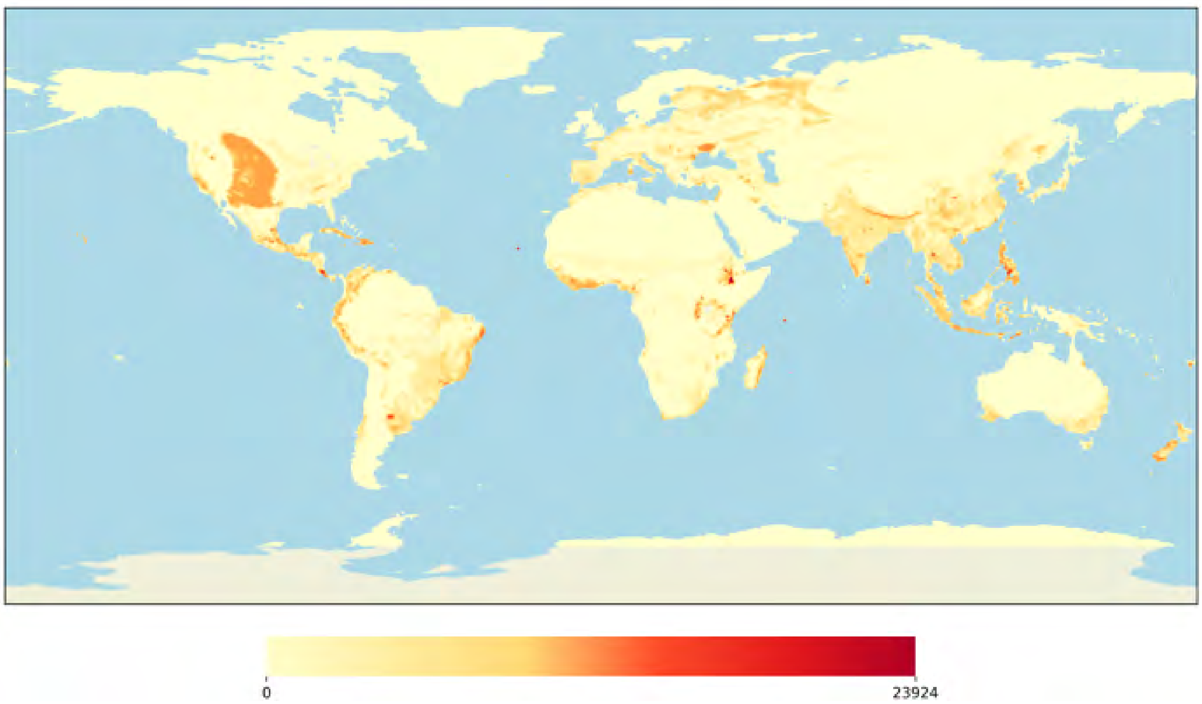


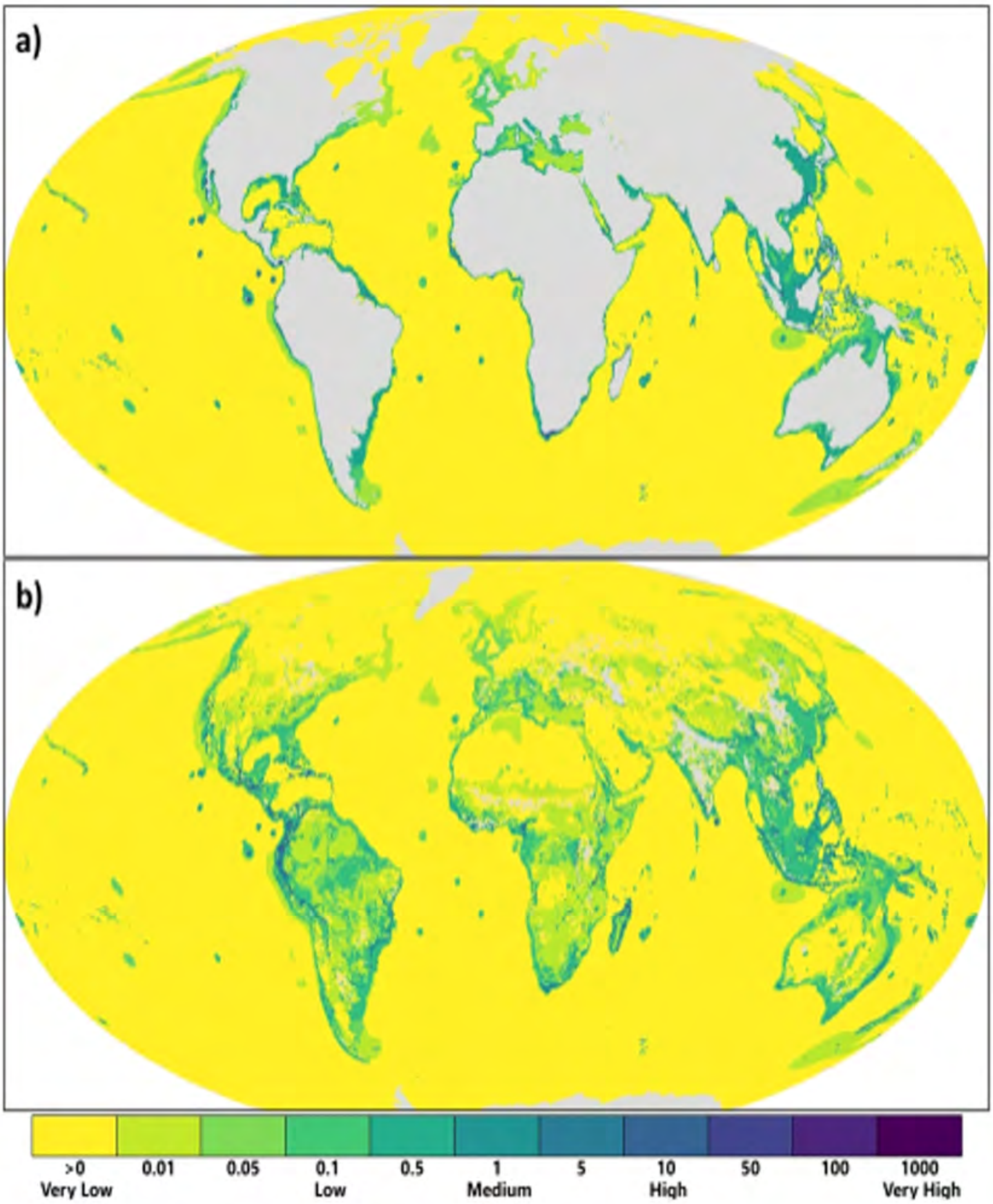
FIGURE 5: THE GLOBAL DISTRIBUTION OF STAR$_R$ SCORES



We can observe a high correlation between the distribution of the restoration score ($STAR_R$) and the threat abatement score ($STAR_T$). This correlation arises because species that are threatened often lose part of their **Area of Habitat** (AOH) in the same regions. However, this is not always true as a significant part of the United States shows a high $STAR_R$ score but a low $STAR_T$ score. This is likely due to areas like Texas, New Mexico, Colorado, and Oklahoma, where oil production disrupts migratory pathways, degrades habitats, and causes oil spills, forcing species to leave their habitats. Hence, while these regions currently represent a very small portion of the AOH of many threatened species, their restoration could significantly increase their future AOH and ultimately reduce their extinction risk.

Furthermore, to complement the study of endangered terrestrial species, the STAR metric has been modeled in 2024 for marine species, using the data of 1646 threatened species.

FIGURE 6: A - THE GLOBAL MARINE DISTRIBUTION OF $STAR_T$ SCORES,
B - PLANET-WIDE DISTRIBUTION OF $STAR_T$ SCORES **[17]**



ADVANTAGES AND LIMITATIONS OF STAR

PROS

The Species Threat Abatement and Restoration (STAR) provides a numerical value that indicates how many highly or mildly threatened species a given area contains. Like RWR, it highlights species rarity, but it also considers the level of threat, giving more weight to critically endangered species than to those of least concern. Additionally, STAR accounts for the proportion of the site occupied by the species, correlating positively with their local abundance, making it more precise than RWR, where all occupied sites are considered equal.

STAR offers insight into how threatened species are in each region and identifies where conservation efforts should be prioritized. As the STAR analysis identifies which threats apply to the species at a particular site, companies operating at that site can take rapid action to moderate these threats and reduce the risk of species extinction.

Currently, STAR includes amphibians, mammals, birds, and, as of January 2024, marine animals.

As more data becomes available, STAR will become increasingly comprehensive.

CONS

The STAR metric faces challenges due to data accuracy constraints, requiring it to be modeled like RWR and many other biodiversity metrics (MSA, BII, PDF) **[7]**. One of the main data challenges of this metric is the uncertainties regarding areas of habitat.

National red lists are excluded from STAR computation as non-globally assessed species could skew the distribution of STAR values to places where species in a taxon had been reviewed. More generally speaking, all non-assessed species in the IUCN Red List are excluded from the metric, as these are data-deficient species whose extinction risk and AOH cannot be accurately categorized (specifically, the information that leads to an estimation of their AOH such as their range, elevation, and distribution)[1].

Additionally, like RWR, STAR does not consider species abundance directly. While we could expect a positive correlation in average between AOH proportion and abundance, this isn't always true. Issues arise in cases of habitat fragmentation, species colonization of new areas, or when abundance is measured in atypical regions, such as species clustering around water sources in desert areas.

However, companies can use STAR in phases, where the Estimated STAR value shows where companies could act to reduce extinction risk, using modelled and published data, and the Calibrated STAR phase gives companies the means to use locally corrected data on population sizes and the importance of threats at particular sites.

1 - Range: the area where species can be found during their lifetime.
Elevation: the height above sea surface, it is similar to the range vertically.
Distribution: the way species are spatially arranged.

ANALYZING STAR AND RWR METRICS CORRELATION

It is worth noting a high similarity between the global distributions of RWR and START. This similarity is due to two main reasons. Firstly, STAR describes the potential to reduce species' risk of extinction and uses the level of endangerment as a parameter, which correlates positively with fewer regions a species can occupy, hence its rarity. Secondly, RWR and START have similar calculation approaches, differing mainly by the IUCN Red List index weights added in the latter. In a way, it considers the species' threat level twice **[18]**.

Let's compare **STAR_T** and **RWR** computation formulas:

$$\text{STAR}_T(S) = \sum_{i=1}^{N} P_{S,i} * W_i$$

$$\text{RWR} = \sum_{i=1}^{n} \left(\frac{1}{ci}\right)$$

Where c_i is the number of sites occupied by species i. One can see a high correlation between $1/c_i$ and $P_{S,i}$. In fact, having a low c_i means a higher $1/c_i$, this embodies the species' rareness and implies that the considered site represents a relatively important part of its AOH. $P_{S,i}$ describes the same idea with more details as we don't consider the number of sites the species occupies specifically, but directly the size of its AOH.

DISCUSSION

The RWR and STAR metrics offer complementary approaches to biodiversity assessment, particularly for rare species. RWR's emphasis on rarity provides a unique lens through which conservation priorities can be set, emphasizing ecosystems that harbor rare species and thereby supporting a more nuanced approach to conservation. Furthermore, the RWR metric includes more species than STAR as it is not constrained by only including globally assessed taxa. However, this introduces biases as if only some taxa of plants are included, as they are the only ones with range maps, the area where those plants occur will have a higher RWR value. Another limitation of RWR is its disregard for species abundance within the site which could skew conservation priorities when large populations of rare species are concentrated in a few areas.

On the other hand, STAR's inclusion of the IUCN Red List status allows it to factor in the threat level, providing a more comprehensive view of species' conservation needs. This dual focus on threat abatement and habitat restoration offers actionable insights for targeted conservation efforts. Nevertheless, the reliance on accurate and complete data from the IUCN Red List presents a challenge, particularly for species that are less studied or data deficient. Additionally, like RWR, STAR does not directly account for species abundance. It also doesn't account either for the spatial difference of the level of threat on the same species, which can lead to potential inaccuracies in conservation prioritization.

Future research should focus on integrating abundance data and improving species distribution models to enhance the accuracy and applicability of these metrics. Their accuracy and the service that they provide also depend on the progress of research into rare species, many of which have not even been cataloged yet.

These improvements would help ensure that conservation efforts are both efficient and effective, ultimately contributing to the preservation of rare species and global biodiversity.

This article only compares STAR and RWR global scores features. However, it should be noted that an additional modeling effort is used to disaggregate START by threat, which allows for the quantification of positive impacts on biodiversity actions that remove or mitigate the considered threats **[16]**. Indeed, pressures removal impacts quantification is one of the main methodological blocks needed to define science-based nature conservation targets.

Given the importance of driving rapid conservation action by companies, STAR provides a quick way for companies to see what threats apply in places where conservation action is likely to be most effective, and to act to reduce them. **Results of STAR-driven activities can be added up across sites or within company footprints or over administrative units, providing a means for governments and policymakers to understand who can and should be making contributions to the Global Diversity Framework (GBF) within certain jurisdictions, or for companies to demonstrate the cumulative action at a portfolio of sites**. The purpose of STAR is therefore different from RWR one. The latter can only be used to identify places where rare species are concentrated.

CONCLUSION

Rare species play a more significant role in ecosystems than others [4]. Given their importance for ecosystem functioning, their loss would accelerate biodiversity degradation with substantial environmental and economic consequences.

For investors, financial institutions, and companies, it was therefore necessary to be able to rely on metrics capable of quantifying and assessing the conservation status of rare species, as well as evaluating the actions implemented to protect rare species and restore the habitats in which they live.

RWR and STAR metrics can inform conservation policies and financial strategies, helping decision-makers in prioritizing areas for rare species' preservation and restoration efforts. They complement metrics focused on quantifying ecosystems integrity, such as Mean Species Abundance (MSA), Biodiversity Intactness Index (BII) and Potentially Disappeared Fraction of species (PDF). Indeed, these ecosystems' intactness indices are modeled at a very large scale which does not allow users to identify places where species or ecosystems have particular conservation importance, nor what actions are necessary to deliver outcomes for the Global Biodiversity Framework.

Despite their limitations, RWR and STAR metrics serve as valuable tools in biodiversity conservation. By highlighting different aspects of rarity and threat, together, they both offer a more holistic view of ecosystem health and species conservation needs.

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