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Bridging the Gaps Between Ecological and Economic Value Assessments: Principles, Data, and Measurement

Lien Nguyen (lien@mit.edu)

Supervisor: Evan Coleman (ecol@mit.edu)

Abstract

Global biodiversity is continuously declining at a concerning rate with 68% of animal populations lost in the last 50 years (Lewis, 2020). Losses in biodiversity put ecosystems at risk of collapsing, and without healthy ecosystems, humankind and many other species will lose essential services and functions that they depend on to survive (Isbell, 2010). The impact on our economies, societies, and livelihoods is expected to be significant (Isbell, 2010). Yet, even though international groups like The United Nations have acknowledged the importance of conserving the environment, poor choices are consistently made, resulting in its further degradation. These choices may stem from the need for more awareness and the lack of benefits to doing business sustainably. To determine what can incentivize countries, companies, and communities to choose biodiversity conservation over current land use practices, an analysis of the potential mechanisms and downstream effects of ascribing economic value to biodiversity was conducted. By the end of this report, an attempt to understand whether an economic value on ecosystems could, in theory, promote biodiversity conservation will be done by evaluating how society and industries currently value and use biodiversity, what are the advantages and disadvantages of such a system, and how it could be improved by utilizing meta datasets.

Introduction

Before discussing how ascribing value to biodiversity can be a solution to incentivizing biodiversity conservation, an understanding of the definition and significance of biodiversity is needed. Biodiversity is the variability of species in an area, but knowing how many species are present is insufficient on its own to determine the health of an ecosystem. As a result, when evaluating biodiversity, ecologists and policymakers have to account for other metrics including but not limited to species abundance, genetic diversity, phylogenetic diversity, habitat attributes, and biomass (Marshall et al., 2020). To demonstrate, a study measuring species richness and relative abundance in old-growth forests revealed that species composition, which includes both richness and abundance, recovers much more slowly (Roswell et al., 2021). This means if based only on species richness, which responds more quickly to interventions, it could be assumed that the forest has recovered and achieved the biodiversity levels it had before; however, based on the low species abundance, the forest's health has not completely recuperated. Therefore, biodiversity should not be calculated based on only species richness, especially if this measurement is for quantifying the overall health of an ecosystem. Because of complex variables in determining the health of varying ecosystems, there are currently no existing universal standards for properly calculating biodiversity.

Quantitative

There are a few methods that scientists currently use for quantifying biodiversity. One is to go into the field and count species. Ecologists utilize two different methods to count species in an orderly way. The first, called individual-based accumulation, is counting the number of species in random patches of area in a given region (Gotelli & Colwell, 2001). The second is sample-based accumulation where the given region will be split into even patches of area and then ecologists will count through each patch (Gotelli & Colwell, 2001). Afterward, the data collected will be compiled and used to create taxon sampling curves as seen in Figure 1. These curves show the accumulation of species identification over numerous samples (Gotelli & Colwell, 2001). As more and more samples are added to the curve, the number of new, or unique, species encountered becomes less frequent. Ideally, the curve will create an asymptote, indicating that the curve is approaching the maximum number of species in the area. Taxon sampling curves can also be made through rarefaction or coverage (Roswell et al., 2021).

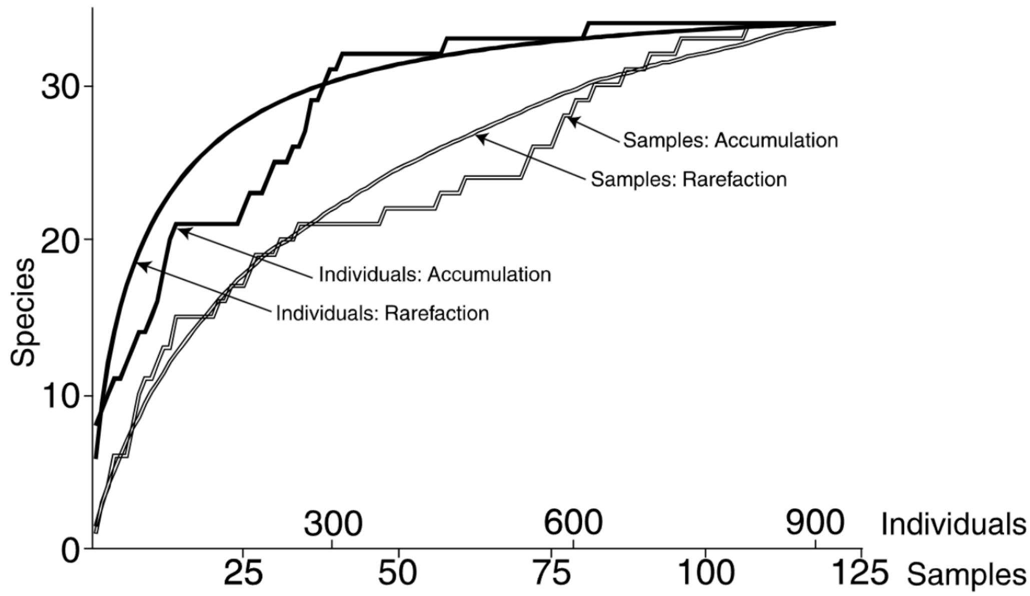


Figure 1 (Gotelli & Colwell, 2001)

Though these curves are generally accurate, there are some problems. Creating taxon curves requires expertise, and it is time-consuming. Even with accessible software that can automatically generate taxon curves based on the user's data input, the data collection process is still taxing (Gotelli & Colwell, 2001). Furthermore, for taxon sampling curves to be appropriately used for analysis, an asymptote must be reached; however, it can be difficult to reach this asymptote in environments that are highly dense in species like tropical habitats. The reason is that these dense environments usually contain many species that are still unidentified or rare (Gotelli & Colwell, 2001). Though it is not appropriate to compare these curves when incomplete, there are methods to create appropriate comparisons for analyzing the samples collected including the Shannon index, Simpson index, and Hill diversity (Roswell et al., 2021). Therefore, although getting true richness is not always possible, ecologists can still compare sample richness between ecosystems when standardized correctly.

Aside from the traditional method of counting, there are two other methods undergoing development for quantifying biodiversity: acoustic soundscapes and metabarcoding. Acoustic soundscapes require placing a device that can record sounds in a fixed location for a certain period. Based on the sound recordings, experts can identify the species in the area. The goal of this device is to provide a simpler, cheaper, and standardized way to measure biodiversity (Jörg Müller et al., 2023). Though the device currently requires expertise and human involvement to maintain its accuracy in species identification, there is ongoing research on utilizing AI (Jörg Müller et al., 2023). By using AI models like Convolutional Neural Networks (CNN), which can process images, audio, and sounds with high accuracy, there are acoustic platforms, including BirdNET and Abimon, that can use these models to identify species through only sounds (Jörg Müller et al., 2023). Unfortunately, using AI is still inaccurate as it requires large amounts of data.

Then there is metabarcoding, generally used by entomology ecologists to study small invertebrates such as arthropods. Ecologists would capture these insects with traps. Then the insects will be sorted into large and small groups. These groups will run through a process of DNA extraction, DNA amplification with PCR, and DNA sequencing (Berkeley Rausser, 2023). The data will then be analyzed to identify the different species and their abundance within the groups.

Ascribing Value

Conserving biodiversity, thus our environment, provides industries with the biological resources they need to create their products. Many medications originate in plants with medicinal properties, such as aspirin, a pain reliever, and taxol, a breast cancer drug (*Revaluing Ecosystems*

Conference, 2013). Similarly, food, beverages, agriculture, and personal care, are all industries that rely on the cultivation of resources from around the world. Thus, degrading the environment will mean losing access to these resources, and industries must forgo producing related products. In some cases, the livelihoods of communities will be significantly affected. For instance, when polluted water enters fisheries, the millions of people who depend on fish for protein may have to resort to other sources, and these sources can be expensive or unobtainable. Aside from resources, ecosystems also provide important services. Watersheds are useful for generating energy for homes, bringing in income from recreational activities, providing clean drinking and cooking water, and buffering the impacts of natural disasters (Burke & Garris, 2013).

Additionally, the rate of biodiversity loss is closely connected to climate change (Stephen et al., 2015). The Holocene epoch has the right conditions for humankind and other species to flourish; however, with the Earth's living conditions slowly moving away from that of the Holocene epoch, losing biodiversity will leave ecosystems more vulnerable as they will become unable to adapt to these changing conditions. (Stephen et al., 2015). Therefore, to continue keeping life on Earth alive and thriving, minimizing the loss of biodiversity is a must.

For all these reasons, there is an urgent need to conserve biodiversity, and one method proposed is to evaluate the value of ecological functions and services. The hope is by allowing people to see the value of the environment, companies and communities will not take these functions and services 'for granted'. Because of its recognized value, people will want to protect their ecosystems. For this to work, there has to be a way to quantify how much ecosystems are worth and determine if this amount will be enough to incentivize companies and countries to put in the effort to protect them. In short, the answer is yes to both concerns. To comprehend how much money ecosystems are worth, in China, environmental damages alone harmed their economy by 9% of their annual GDP (Burke & Garris, 2013). Take the shrimp farms in Thailand as another example. A landowner can decide to turn one hectare of land into a shrimp farm and make around $9,632 (Burke & Garris, 2013). Initially, this is promising, but if environmental damages are included, the land owner will lose around $1,000 from pollution, $12,392 for ecosystem services such as food and medicine, and $9,318 for restoring the land after the shrimp farm is no longer productive (Burke & Garris, 2013).

Ascribing value allows people to see the effects of degradation on a familiar scale. It is one thing for people to hear about forests being cut down to clear land for a new neighborhood, but it is another thing when people learn about all the negative effects that add up to a large check (Burke & Garris, 2013). Unfortunately, as things are now, it is challenging for communities to attribute value to ecosystems until actual disasters occur, and the communities face difficulties without the environment's services.

There is a growing interest among consumers to buy natural products like skincare and medications from plants, and green products from companies that are known to be eco-friendly (Pearce & Moran, 1994). As people increasingly grow aware of companies' environmental impacts, companies must transition to environmentally friendly operations to maintain their reputation. To improve their likeability, companies have been seen to hop on trends. An example is companies changing their logo during Pride Month to support the LGBTQ+ community.

The idea of improving a company's reputation, ethicality, and quality of products can be seen through a rating for their Environmental, Social, and Governance (ESG) performance. Oftentimes, companies will go to an agency and receive an ESG rating using the agency's metrics, and investors or consumers will use these ratings to help with their financial decisions (Ioannou & Serafeim, 2017). The issue lies in the ESG rating itself as it is not standardized and varies from agency to agency (Berg et al., 2019). One company can receive drastically different scores depending on what basis an agency rates them on (Berg et al., 2019). As a result, ESG ratings may not be the most reliable when determining the value of a company's sustainability and social welfare efforts.

Regardless, it is important that there is a way to rate a company's performances because of consumer and employee interest. It is found that companies that invest in sustainability and social welfare efforts on a consistent basis build a strong foundation of trust. This trust helps reel in profit, increase loyalty among consumers, and attract talented employees (Reichheld, 2023).

Another motive for companies is to acquire a green pass on their projects by complying with legislation (OECD, 2016). Enforced sustainable development may be a requirement for companies to include before implementing their projects. Though these policies in theory work, what happens is that they often lack proper enforcement. For instance, the Louisiana Department of Environmental Quality will fine companies that release toxic emissions, but due to their slow responses, some companies have been found to falsify reports and get away with not adhering to emission regulations (Paradise, 2021).

Initially, the idea of ascribing value to biodiversity may seem unrealistic. Since biodiversity represents an abstract concept, it requires distilling complex ecosystem functions into a single variable rather than being concrete and easily quantifiable. Attempts to understand the value of a rare species or that of something irreplaceable yet abundant like clean air raise many questions. To figure out a way to ascribe value, economists currently use the following formula: (Pearce & Moran, 1994)

$$\text{Total Economic Value} = \text{Use Value} + \text{Non-Use Value}; \ TEV = UV + NUV$$

Here, the ascribed value, known as Total Economic Value (TEV), consists of adding two parts: the Use Value (UV) and Non-Use Value (NUV). These two parts are then further broken down into multiple sub-parts.

UV includes Direct Use Values (DUV), Indirect Use Values (IUV), and Option Values (OV). DUV refers to actual costs in the market such as the value of a certain type of wood. IUV is what the ecosystem function provides such as how much money is saved from the benefits of a watershed. OV acts as insurance, taking into account how much someone is willing to pay to protect this resource.

In the NUV category, it is split into Bequest Value (BV) and Existence, or 'Passive', Use Value (XV). BV is the value that others may potentially benefit from the resource in the future. XV is how much someone is willing to pay for this resource only based on its existence and not use. An example of this is how much someone who will never see a tiger in their life is still willing to pay for its conservation. After breaking down the two parts, the equation can be rewritten as follows (Pearce & Moran, 1994):

$$TEV = (DUV + IUV + OV) + (BV + XV)$$

Even with a formula, finding the ascribed value of biological resources, species, or ecosystems is still a complicated task as many of these sub-parts are rough estimates. How would the potential income that ecosystems can provide in the future be determined without actually being in the future and seeing it for ourselves? How can a value be placed on species without knowing exactly all the advantages and disadvantages that it brings to the environment? As a result, the ascribed value tends to be underestimated.

Fortunately, estimating UV costs can mostly be directly quantified from the market. As for NUV, the sub-parts are not as concrete, but there are some methods used by scientists and economists to estimate NUV. The first is using surveys and questionnaires to find a representative cost (Pearce & Moran, 1994). The purpose of these surveys is to ask randomly selected participants how much they are willing to pay for a certain service. This service, related to biodiversity conservation, can be increasing an endangered species' population or restoring a damaged ecosystem. One popular method to surveying is the Contingent Valuation Method which consists of giving a scenario for the service and asking follow-up questions. Though these surveys do help with understanding what society values, they are time-consuming and contain biases. If surveys in urban areas are conducted more than surveys in rural areas, it might not properly represent the value of species in the corresponding region. Other biases can be introduced based on how interviewers word their questions and how respondents might be incentivized to answer correctly.

Another way for ascribing NUV is travel costs (Pearce & Moran, 1994). This method works well for regions with ecotourism as it tries to answer how much people are willing to spend to travel to a recreational site. In consideration, the method also takes into account the total amount of time spent traveling and at the site as time is seen as lost income when the consumer could have been working instead of traveling (Pearce & Moran, 1994). Adding the lost income with the actual costs from transportation, fees, and tickets gives a rough estimate of travel costs.

Then there is the dose-response technique where damage to the ecosystem such as pollution is multiplied by a unit price to get a monetary damage function (Pearce & Moran, 1994). However, finding such functions to determine accurate costs requires precise experimental data on the relationships between damages and their environmental impacts. As a result, this technique takes time to establish these functions based on the relationships (Pearce &

Moran, 1994). On the other hand, if the functions already exist, calculating prices with the dose-response technique requires little time to estimate costs.

Next is the replacement cost technique, which is the easiest to estimate total costs since it takes the costs to restore the service or ecosystem directly (Pearce & Moran, 1994). Because this technique only considers restoration efforts, it will always undervalue the value of ecosystems unless it also takes into account long-term benefits and earnings.

The methods discussed were for how scientists and economists ascribe value to biodiversity, but how do other people attribute value to the ecosystem? It is evident that society values the environment for a few reasons. First, consumers are increasingly interested in being more sustainable by buying environmentally friendly products (Pearce & Moran, 1994). Second, numerous international legislations have happened over the years to increase conservation, cut carbon and methane emissions, and enforce ownership and trading of biological and naturally-derived resources.

Though the values society puts on ecosystems are used in determining NUV, these values can be unreliable since society has a strong bias, favoring commonly known species like large terrestrial mammals over other species that may have a more important role in maintaining a healthy ecosystem like microorganisms (Pearce & Moran, 1994). This is not to say that large terrestrial mammals are unimportant, but relying on society's favoritism can result in many species and ecosystems that are not as well-known to receive inadequate conservation efforts required to protect them.

Access and Benefit Sharing

Most of the world's biodiversity is in developing countries. Because of this, developed countries, or the 'North', seek ways to gain access to the resources in the developing countries, or the 'South' (Wynberg, 2023). To prevent exploitation and provide proper management of these resources, numerous policies were implemented.

The first of these policies is the Nagoya Protocol, an international policy created to enforce biopiracy. Biopiracy, also known as Columbus Syndrome, is the act of claiming and using another country's biological resources without their consent or credit to the country of origin (Nuwer, 2023). This claim usually ends up as a patent and the resulting intellectual property is developed for profit. Under the Nagoya Protocol, the North has to trade benefits, services, knowledge, or technologies to gain access to biological resources provided by the South (Convention on Biological Diversity, 2024). An example of access and benefit sharing under the Nagoya Protocol is between the companies Merck & Co, a pharmaceutical, and INBio, the National Biodiversity Institute of Costa Rica (Pearce & Moran, 1994). INBio will collect plants, insects, and soil samples for Merck. In return, for every successive drug Merck develops from these biological resources, INBio will receive $1 million plus a share of royalties (Pearce & Moran, 1994).

The second policy-relevant organization is the World Intellectual Property Organization (WIPO). When people apply for patents, some of these 'discoveries' have been taken from and have been used traditionally by Indigenous groups in undeveloped countries (Wynberg, 2023). The WIPO has passed policies to stop the approval of these patent applications that may be committing biopiracy charges (World Intellectual Property Organization, 2024).

The third policy is the Trade-Related Aspects of Intellectual Property Rights (TRIPS). TRIPS is an agreement regulating geographical indications (GI) (World Trade Organization, 2024). By enforcing GIs, TRIPS prevents companies from misleading the public about a product's country of origin. This is important because GIs indicate additional information on products that consumers could be looking for. For instance, wine depends on where it originated from due to the differences in metabolites in plants that can affect aroma, color, and flavor (Luis et al., 2021). These metabolites are studied in metabolomics and have been used to both authenticate the origin of products and prevent GI fraud (Luis et al., 2021). With all of these policies combined, they run how biological resources around the world are being marketed, owned, and traded.

Biodiversity Offsetting

Another way to put a value on biodiversity is through offsetting, but compared to the term 'carbon offsetting' which is more prevalent in the news, market, and educational environments, many people may be confused on what is 'biodiversity offsetting'. When initially introduced about the idea of biodiversity offsetting, it was puzzling as to why it was necessary to have two different types of credits in the market that seemingly have the same goal: environmental preservation. While carbon offsetting addresses global warming, biodiversity offsetting addresses the degradation of the environment due to anthropogenic activities. This means that biodiversity offsets aim for a no net loss, and even a net gain, in conservation efforts (*Biodiversity Offsets*, 2022). Such conservation efforts include conserving biodiversity, maintaining ecosystem services, and promoting sustainable practices (IFC, 2012). However, this does not mean that the two offsets, carbon and biodiversity, are completely independent of one another. In fact, they are intertwined in many cases since healthier ecosystems such as thriving forests are natural buffers for carbon emissions. This can be seen in improving sustainable practices in agriculture like sequestering more carbon in soil and reducing pesticide use is a win-win for both carbon emissions and biodiversity conservation (Lovett, 2021).

Regardless of the incentive, the impacts that some projects cause on the environment are unavoidable. Though this is understandable, the problem with biodiversity offsetting is in its misuse as many companies would claim to be offsetting when in reality, they are not. In one specific case, a project was proposed for implementation in Mühlenburger Loch, a protected area in Germany. It was rejected by the EU Commission because developers did not include sufficient measures for alternative locations and compensation for possible damages (Bull et al., 2013). Unfortunately, in many cases, projects with insufficient evaluations do end up being implemented.

Mitigation Hierarchy

Many industries such as mining and fossil fuels are irreplaceable for the economy and society, but they are incredibly destructive to the environment (*Biodiversity Offsets*, 2022). In one study regarding the impacts of the mining industry in Australia, it was found to cause detrimental effects, going as far as losing up to 88% of the Redgum rough-barked apple forest and 60% of the Superb lyrebird if left unenforced (Kujala et al., 2015). To address these damages, companies look for ways to compensate, and some decide on biodiversity offsetting without being aware of other steps they can take before or during the implementation of their project that would reduce the time used, money spent, and damages done. This process is called the Mitigation Hierarchy, and it can be broken down into four steps: avoidance, minimization, restoration or rehabilitation, and offsetting.

Beginning with the first step, avoidance, companies should plan their projects with the mindset of trying to not cause harm to the environment as this is the easiest and cheapest way to prevent biodiversity degradation (*The Biodiversity Consultancy*, 2024). An example of utilizing avoidance is for companies to consider the location and timing of building infrastructure to reduce disruption to the environment. This can include avoiding implementing projects in breeding grounds and rare habitats (*The Biodiversity Consultancy*, 2024). One specific instance is the Makatea phosphate mine. To prevent additional damages, they made sure to avoid mining certain areas of the mine that are vital to endemic animals (*The Biodiversity Consultancy*, 2018). If after considerations of avoidance have been made, companies can move onto the second step, minimization.

In minimization, companies should consider ways to lessen the damages that have already been done by finding ways to prevent further damages. This step is usually taken during or after the project has been completed, and examples include installing wildlife crossings on roads or developing power lines that will not harm birds (*The Biodiversity Consultancy*, 2024). Bringing back the phosphate mine example, they reduced their project's impact by enforcing policies to prevent invasive species (*The Biodiversity Consultancy*, 2018). After all attempts at minimizing damages are taken, companies can move on to the third step, restoration or rehabilitation.

The third step has two options: restoration and rehabilitation. The former focuses on returning an area back to its original state, and the latter focuses on restoring ecological functions. Since this step regards improving the project site, it is usually taken into consideration after the project has been completed. Examples of this step include replanting vegetation, especially native plants, and restabilizing the soil by rotating crops or reducing tillage and other harmful farming practices (*The Biodiversity Consultancy*, 2024). In the phosphate mine, the workers would crush rocks and walls to make space for restoring vegetation (*The Biodiversity Consultancy*, 2018). After this and all previous steps have been exhausted, companies can move on to the final step.

Before going into the final step, it is strongly encouraged that companies put all their efforts into implementing prior steps. This final step should only be done as a last resort if all other attempts at the previous steps prove to be futile or the damages done will be unavoidable (*The Biodiversity Consultancy*, 2024). As a reminder, this step is considered the most expensive and time-consuming as biodiversity offsetting is a committed long-term project estimated to last around 50 to 70 years (Bull et al., 2013). A couple of examples of how companies can go about this step is by restoring forests and wetlands or helping endangered species recover (*The Biodiversity Consultancy*, 2024).

Unfortunately, there will be times when trying to restore an ecosystem or species population is not possible, so companies will resort to counterproductive methods like averted loss offsetting, a method that inaccurately calculates biodiversity by doing it in a relative way instead of by actual biodiversity. Suppose a company implements a project that damages a forest. The company then wants to utilize biodiversity offsetting to compensate for their damages, so they decide to set up fences around the forest to prevent further biodiversity loss. By the company attempting to protect the forest, they consider this as ‘compensation’ for their causing damages because it prevents ‘future possible damages’. Though this logically makes sense, the issue is that overall, there have been no efforts to improve or restore the biodiversity that they destroyed. In reality, there is an actual net loss. This happened in Naisoso when a developer, though correctly followed the Mitigation Hierarchy for implementing a project on a mangrove, used averted loss offsetting because offsetting their damages was not possible (*The Biodiversity Consultancy*, 2018). Their only option was to preserve the remaining mangrove. This means the damages from their project were irreversible, and there was an overall biodiversity loss. In a study about mining impacts, they found that when using protection to offset, "there was a 22% cumulative loss of original biodiversity value, whereas offsetting entirely with restoration was the only strategy that could potentially maintain or improve biodiversity value compared to pre-development conditions" (Kujala et al., 2015).

Problems

Ascribing value and offsetting can improve the rate of biodiversity conservation, but as beneficial as these systems sound, problems still exist. Beginning with the former, when landowners are given the choice between developing their land for use or for conservation, many reasons will sway them to choose land use. The first of these reasons is market failure in which the total costs do not include the costs of polluting and degrading the environment (Pearce & Moran, 1994). A company who dumps harmful chemicals into the nearby river will not be charged for harming the environment. Because these damages, called externality costs, are excluded from the total cost, the company will continue polluting the river as it is a free way to discard their wastes. On the other hand, adding the damages to the total cost will incentivize companies to stop polluting.

The second failure is allowing damaging government intervention (Pearce & Moran, 1994). Even with good intentions such as providing subsidies for local farmers to run their businesses, the problem is when these subsidies make environmentally harmful activities cheap and profitable (Pearce & Moran, 1994). It is estimated that the World Bank subsidizes $1.2 trillion in environmentally harmful activities with roughly $500 billion in incentives allocated to cheap fossil fuel, $300 billion to cheap water, and $400 billion to fishing and farming (Burke & Garris, 2013). Many of these subsidies are necessary because they provide people with basic needs, but the problem is offering incentives without having a mechanism in place to enforce sustainable behaviors.

The third is global appropriation failure. Consider the case of a tropical rainforest in an undeveloped country. This ecosystem brings many benefits: removing carbon dioxide from the atmosphere, providing vital biological resources, and being home to millions of species (Pillay et al., 2021). These benefits will also apply to countries across the globe because everyone relies on the rainforest in one way or another; however, even though these other countries are benefitting, they are not contributing to conserving the rainforest (Pearce & Moran, 1994). Furthermore, the undeveloped country where the rainforest resides may lack the resources and funds necessary to conserve the rainforest. The country may want to even cut down parts of the ecosystem for land development. As a result, there is an unfair balance between who benefits and who is paying for them. To counter this, countries need to work together to conserve all biodiversity even if it is not within their nation.

Aside from these failures, a major reason why land development is prioritized over biodiversity conservation is because of the immediate profit. This phenomenon is known as discounting where getting the money now is more rewarding than waiting and getting the money later, but what landowners may fail to recognize is that the amount of money later is most likely to be more than the amount of money now (Pearce & Moran, 1994). For instance, Vietnam spent

$1.1 million on restoring its mangrove. This investment saves them $7.3 million per year (Burke & Garris, 2013). It is also important to acknowledge that even if people are aware of future profits, waiting is difficult, especially for those who need the money now to satisfy their basic needs.

In addition to these failures, there are moral issues with ascribing an economic value to biodiversity. Some groups have strong cultural, spiritual, or aesthetic values on the environment (Pearce & Moran, 1994). Others will claim that conserving nature is a moral duty, arguing that it is wrong to choose biodiversity conservation for the sake of money (Burke & Garris, 2013).

As mentioned before, biopiracy is a prevalent issue when it comes to the trading of biological resources and knowledge. One example is Iboga, a plant with psychedelic effects found in West African shrubs (Barsuglia et al., 2018). For a long time, the plant was traditionally used in ritual rites to connect with ancestors spiritually (Barsuglia et al., 2018). It was also used by tribes as an all-purpose medication, treating fatigue, fevers, headaches, and high blood pressure (Corkery, 2018). Recently, interest in Iboga has grown because of its anti-addictive properties against alcohol, nicotine, opioids, and other addictive substances (Corkery, 2018). In response to this growing interest, African countries registered Iboga under the Nagoya Protocol, making it the first psychedelic to ever be traded under this policy (Nuwer, 2023). By doing this, tribes are given ownership in cultivating and distributing the plant, and this industry has improved the livelihoods of many communities (Nuwer, 2023). Despite this, Iboga plants are still being smuggled and sold illegally online, violating the Nagoya Protocol, disrespecting African culture, and misleading people who are seeking anti-addiction treatment (Nuwer, 2023). The case with Iboga is only one of many cases of biopiracy.

Many problems stand in the way of ascribing economic value to biodiversity, but what happens if this value can be appropriately measured? Placing a value on biodiversity will mean that when given the options of land use or conservation, those same landowners now have the option of choosing conservation without losing a living. Having these landowners be aware of the long-term benefits and being able to reap those benefits because biodiversity is an acknowledged ‘currency’ will incentivize more people to use their land sustainably. Furthermore, having an economic value for biodiversity means it will be easy to implement it at market costs. Companies will be motivated to implement sustainable practices in their projects to avoid paying additional costs for environmental damages. People will be cautious of what products they buy as products that degrade the environment will become expensive.

Despite all the good that comes with being able to measure biodiversity, there are still some problems. It so happens that existing notions of growth compete with being green (Burke & Garris, 2013). In the coming years, it is predicted that not only will the human population increase, but also that more people will come out of poverty due to better living conditions and higher incomes (Burke & Garris, 2013). When this happens, there will be more mouths to feed. This means more water, food, and space is needed to accommodate a larger population. Moreover, there will be more consumption as people desire luxury items such as cars, meat, and houses. As the human population grows, the environment shrinks in relative proportion. Additionally, having a price tag on biodiversity could mean taking the free aspect of nature away from people. This can include having to pay an entry fee every time someone visits a nearby park to go hiking or having to pay to have access to clean air and water.

Offsetting also faces many problems. The policies surrounding biodiversity offsetting seemed promising as there were many free and available guidelines online for companies to choose from. One possible choice is The Performance Standard 6, influenced by the Convention on Biological Diversity (IFC, 2012). Their goal is to provide such guidelines for companies to implement conservation efforts and sustainable developments in their projects. Therefore, if there are guidelines out there, why is biodiversity offsetting not working?

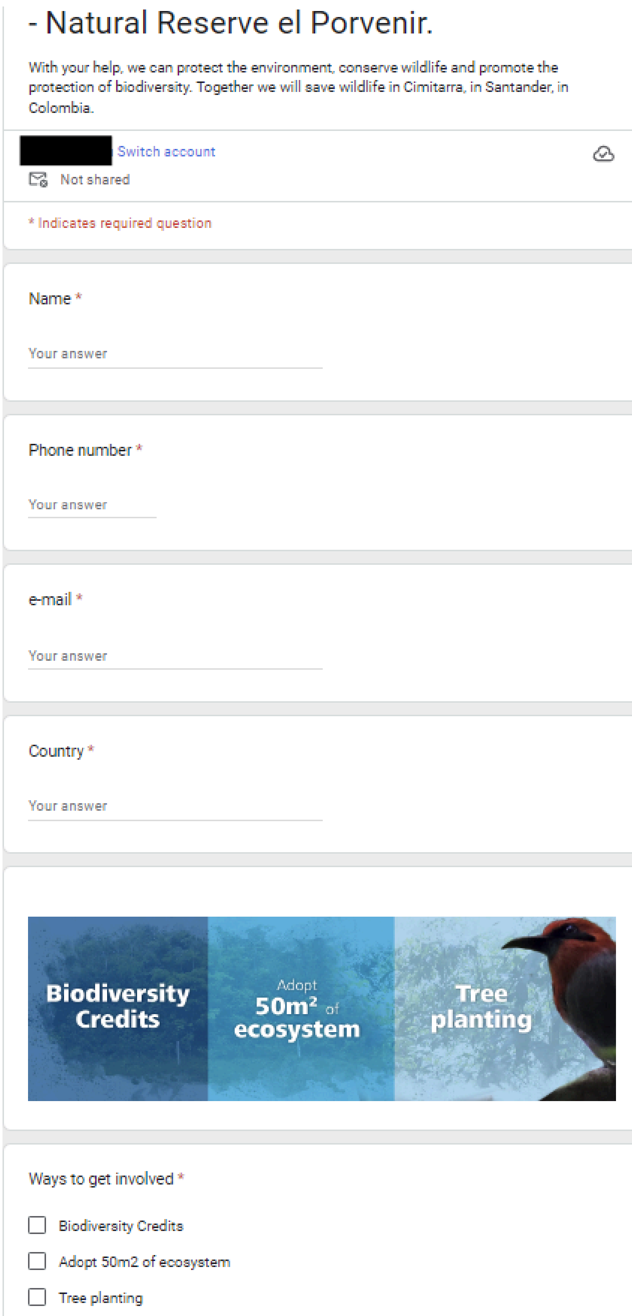
First, there is no universal standard for quantifying biodiversity. On one side are ecologists who mainly use species richness for measuring biodiversity, which, as already discussed, requires time and resources. The metric itself is inadequate to quantify biodiversity, especially for offsetting since that requires additional metrics to determine the ecosystem's overall health. On the other side are policymakers who often use simpler metrics than species richness like area of habitat. To note, the area of habitat only concerns the region where species roam. As a result, this metric alone is not a good indicator of biodiversity either, much less the health of an ecosystem (Bull et al., 2013). Therefore, even though there is technically a common method that ecologists and policymakers use to quantify biodiversity, there needs to be a more rigorous and defined standard for offsetting. Without this, how do businesses and policymakers know what they are measuring is accurate if it varies from agency to agency? Since they do not know, how can they determine whether or not they are achieving their goal of no net loss in biodiversity?

The second reason why biodiversity offsetting is not working is that many countries do not require the use of the Mitigation Hierarchy or any sustainable development in their projects. As a matter of fact, only 10 countries in the world have policies to require this (IUCN, 2019). Even then, uncertainty lies within these countries about whether their policies are enforced since many companies still get away without including these practices.

Lastly, the biodiversity offsetting industry is filled with skepticism. How can there be confirmation that offset credits are real? One major distributor of biodiversity offsetting credits is an organization called South Pole. Though the company was founded on good intentions and led many successful and essential projects in conserving the environment, there have been reports of overestimated, or fake, credits distributed (Blake, 2023). To further investigate the integrity of the organization, an examination of a few of their projects was done: the Alto Huayabamba Conservation and Biodiversity Bank: El Porvenir Nature Reserve. A quick glimpse of the website's overview of these projects raised no suspicion, but a few observations should be noted. For the first project, there were acknowledgments for implementing sustainable quinoa and honey production on the website, yet this implementation was hardly discussed in the draft pipeline document. As for the second project, which focused more on biodiversity offsetting than carbon emissions, there were no explicit mentions of any registered registry that evaluated the projects. All in all, it seems as if the stated facts and numbers were pulled out of nowhere with nothing backing its legitimacy.

Furthermore, the embedded website within the South Pole's website page did not look professional. This includes a Google Form link at the end of every paragraph in the embedded website requesting donations with no explanation of where the money is going. This can be seen by Figure 2. South Pole also has a carbon footprint calculator that can be used to determine someone's footprint and then buy carbon credits to compensate. The process was filled with suspicion. After using the calculator, Figure 3 shows how the website immediately leads to picking out a carbon credit and to the checkout page with no explanation of what a carbon credit is, why different locations are priced differently, and how your contributions are helping.

Overall, it seems as if the company is trying to reel in funds without providing adequate explanations of the legitimacy of their business.


- Natural Reserve el Porvenir.

With your help, we can protect the environment, conserve wildlife and promote the protection of biodiversity. Together we will save wildlife in Cimitarra, in Santander, in Colombia.

[redacted] Switch account

Not shared

* Indicates required question

Name *

Your answer

Phone number *

Your answer

e-mail *

Your answer

Country *

Your answer

Biodiversity Credits

Adopt 50m² of ecosystem

Tree planting

Ways to get involved *

- [ ] Biodiversity Credits
- [ ] Adopt 50m2 of ecosystem
- [ ] Tree planting

Figure 2

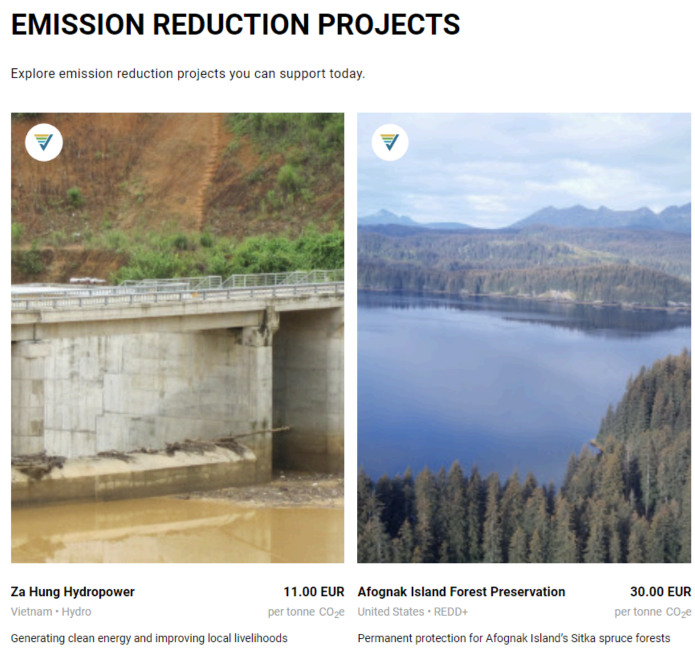


Figure 3

Aside from South Pole, the Taskforce on Nature-related Financial Disclosures (TNFD) is known as the to-go place for finding proper guidance on assessing biodiversity. As professional as the organization seems, it was strange to find an undeveloped and unprofessional website called Co$tingNature as part of its tools catalog seen in Figure 4.

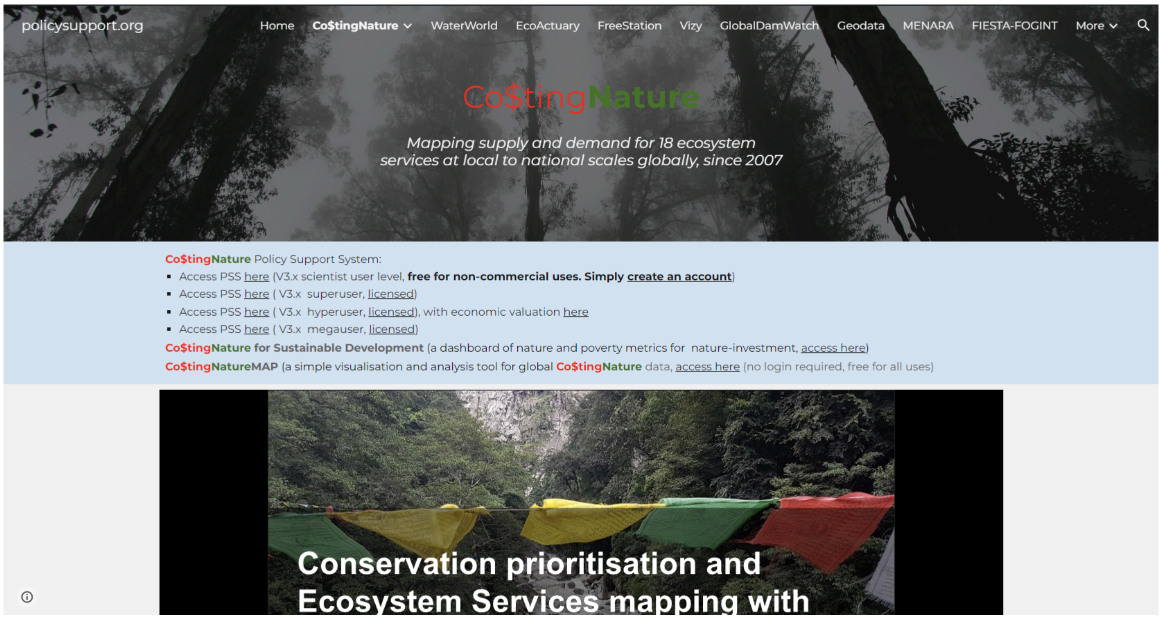


Figure 4

Finally, there was an evaluation of Landscale, a monitoring tool for companies to keep track of their sustainability performance. According to their framework document, they evaluate biodiversity by looking at area of habitat, which as mentioned earlier is not a good indicator of biodiversity. This means that companies who use the platform would be given inaccurate performance scores that do not properly reflect the impacts of their projects.

Now, these observations are not meant to undermine these organizations, but they are to demonstrate that there are still a lot of improvements that need to be made. Biodiversity offsetting is something that should be taken more seriously and professionally. It is understandable that not as much research has been conducted, but in order to build a stronger foundation and reputation for the offsetting market, these front-running organizations need to be cautious of their claims.

Interestingly enough, South Africa was mentioned by multiple sources about how well they deal with biodiversity offsetting. It is important to acknowledge that South Africa is the third most biologically diverse country in the world (Brownlie et al., 2017). This may explain why the country has a stronger incentive to push forth conservation efforts. The South African government has a department in charge of biodiversity, ensuring provincial policies are consistent with those of the national level (Brownlie et al., 2017). Under the National Environmental Management Act of 1998, offsetting requires authorization, and the country has implemented the Polluters Pay principle where companies have to pay for any damages done from polluting (Brownlie et al., 2017). Additionally, they have an organization called the South African National Biodiversity Institute (SANBI), whose main task is to map out the biodiversity in the country (Brownlie et al., 2017). This includes the status of biodiversity throughout the nation, which areas should be protected, and what areas companies are allowed to offset in. With all of this effort, South Africa aims to achieve a no net loss in biodiversity and to ensure endemic species do not go endangered. They measure this by looking at the threat status of an ecosystem, most likely based on the SANBI in addition to considering habitat conditions, threatened species, special habitats, and ecologically important areas and services. Unfortunately, it seems the country tends to use averted loss offsetting because restoring ecosystems is often not feasible.

Regardless, implemented policies have led them to more successful biodiversity offsetting than many countries; however, many improvements can still be made. Though they do have national policies, the uncertainty within these policies makes it unclear as to what is the standard. Because of this, some projects including mining and public infrastructure that should have been rejected due to their impacts on irreplaceable biodiversity were allowed to pass under offsetting. For instance, a colliery that was closed for non-compliance with environmental regulations was allowed to reopen under weak conditions and an offset agreement (Brownlie et al., 2017). Another improvement that needs to be made is acquiring more funding and resources for the department in charge of biodiversity efforts to enforce national policies. Finally, companies should not underestimate the amount of time it takes to implement sustainable practices. When they find themselves out of time, companies usually end up deciding to omit these practices from the final project. In one particular case, a disagreement over a trust fund led to the Western Cape Road offset being delayed for years (Brownlie et al., 2017). Oftentimes than not, these offsets end up not happening at all as they are removed from the project.

As of right now, it may be better that biodiversity offsetting should not be done as there is no way to tell if companies are accomplishing the offsets they promise. Due to this ambiguity in quantifying biodiversity, offsetting will only continue to be misused under the impression of doing good for the environment. Until a standardized way is put in place to appropriately and accurately measure biodiversity, companies should be strongly encouraged to, at the very least, strictly utilize the Mitigation Hierarchy.

Additionally, there is a major flaw in how biodiversity is measured. Although the traditional method of going out and counting is currently the most accurate as compared to the other methods, there is still a disproportionate bias in the data. It is clear that there is no modern method to obtain the exact number of species in an area or the world as many are still unidentified, so is it right to continue doing biodiversity offsetting when there is obscurity in our data? It may happen that unidentified species are not identifiable because they occupy niches that evade measurement. On the other hand, the species observed are usually easy-to-be-found like birds that fly in the air and large mammals wandering in plain sight. This can explain why there is a large collection of incomplete data for reptiles as opposed to aves and mammals (Pillay et al., 2021). As a result of this, the way biodiversity is currently measured is subjected to inaccuracy as only one extreme of the species spectrum is accounted for, specifically the ones that are easily observed with the human eyes and ears. Therefore, even the most accurate method of measuring biodiversity does not appear to be accurate at all.

Though biodiversity offsetting is not the best option as of right now, it still has a lot of potential if used correctly. Plus, this is a way for companies to make a positive impact on society and the environment while gaining benefits of their own. First and foremost, companies need to recognize that biodiversity is not a one-time thing and it is done with. It takes time and it will cost money as is the case for many things, but offsetting will take even more time and more money if companies do not do them properly like going through the Mitigation Hierarchy before deciding they want to offset.

Discussion

After analyzing the problems with placing an economic value on biodiversity, it is necessary to discuss what improvements can be made. It is important to acknowledge that no universal standards exist for measuring biodiversity. There are many helpful guidelines and tools out there, but without one accurate and easy way that everyone can agree on, it is difficult to determine what is the true value of biodiversity when they differ. With these standards unclear, how can companies still sustainably implement their projects? To attempt to answer this question, one possible approach is “The Backwards Approach” for companies to incorporate sustainable practices in their development, specifically for offsetting. This approach is contradictory to being universally applicable as there is no one-solution-fits-all methodology, but this means the approach is personal and specific to each company's project for calculating biodiversity. Before going into the details, there are a few things companies should be aware of. For one, every project has to start with being 'green' in mind. Companies cannot decide midway that they want to include restoration or preservation because oftentimes, companies underestimate the amount of time and effort it takes to prepare for these tasks. Moreover, having sustainable development in projects will require a commitment to long-term maintenance. In addition to this, are companies willing to pay? Monitoring tools like Landscale cost at least $7,500 to use their platform, and companies will have to pay for other resources like expertise. Furthermore, offsetting is not always an option. Biodiversity offsets work best when the project site being restored is complementary, or similar, to the damaged site (Kujala et al., 2015). This means if a project site degrades a rare habitat or species, it is impossible to offset those damages.

With that being said, the best thing to do is for companies to take the following steps. First, they should utilize maps made to show what project sites are available and pick the most complementary site. Secondly, companies should develop sustainable practices by discussing them with an expert. Here they should define specific goals and determine the best combination of metrics needed to measure and evaluate progress. Then, companies can finally determine what is the best tool to measure biodiversity. Examples include acoustic soundscapes, metabarcoding, or camera trapping. By working together with an expert, companies can recognize the amount of damages they will make and be able to understand what is the best way to compensate for those damages. Why this approach is different than what is going on right now is that instead of trying to find how to quantify biodiversity on a scientific side to then have it be translated into the policy-business side, it is better for the two to work together to determine what is the best method for the project. How to quantify biodiversity is still an incredibly hard question to answer since there is still uncertainty to the accuracy of current measurements, and it is much harder when both scientists and policy-business have different goals in mind. Additionally, every project is different in its own way and has to follow different local policies. Therefore, The "Backwards Approach" will allow companies and experts to first look at how projects are degrading the environment and in turn, choose the best personalized method for companies to improve the environment.

Conclusion

The "Backwards Approach" is useful as a short-term solution for the current inadequacy of standardization. It is possible that with the help of metadata sets, there can be a more efficient way to ascribe value to biodiversity. Before going into how these metadata sets can be used, it is important to discuss how they are currently being collected and analyzed. The first method has already been discussed: counting. The second is utilizing technology like DNA sampling and satellite imaging (The Royal Society, 2024). The third is with the use of citizen science. Citizen science allows everyday people who are not experts to contribute to research by collecting biodiversity data for validation (Johnston et al., 2019). By doing this, scientists can broaden the diversity and quantity of data they collect quickly.

Many platforms like iNaturalist and eBird currently are collecting large amounts of biodiversity data by utilizing citizen science to record species occurrences from all over the world. Users can sign up on these platforms and register species they have observed. This in turn, however, means that the data can be unreliable and full of bias. For instance, users will only be recording species near their location, so occurrences of species will be disproportionate

(Johnston et al., 2019). Moreover, users may only be observing species they want to find as opposed to being open and searching for other kinds of species that are not as interesting to the user (Johnston et al., 2019). These platforms will use either the community or experts to validate observations before the data is processed and allowed to be used for research. Citizen science platforms and official institutional groups like universities will then feed their data into a larger data network like the Global Biodiversity Information Facility, a platform that collects and sorts out all of this biodiversity data. This data has been used by the IUCN Red List of Threatened Species, IPCC, and IPBES, and the sharing of this data is standardized by the Darwin Core and Essential Biodiversity Variables (GBIF, 2024).

Some platforms collect biodiversity data, specifically species occurrences, but what does this mean? The idea is that perhaps there is a way to use these open-source data sets to be implemented in quantifying the economic value of biodiversity. Ecologists and companies already have to pour time and money into figuring out the framework for a sustainable project but using these pre-existing data will save them those resources. When discussing methods to ascribe NUV a while back, the dose-response technique was suggested. This technique relies on biodiversity data to create a function for quantifying the value of damages done to an ecosystem. When these functions already exist, it saves future scenarios with similar damages a lot more time to assess these costs (Pearce & Moran, 1994). As a result, if these functions are accumulated ahead of time, they will be accessible for saving companies time and money to calculate the costs of their damages.

Gathering more data has the potential to slow down the decline in biodiversity. There is a growing need for biodiversity conservation, and it is possible that through more research and standardization, a society where choosing to be sustainable in the long term will be the better decision.

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