POLITICS & INTERNATIONAL RELATIONS | RESEARCH ARTICLE

Profitable biodiversity

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Abstract: Business is both the main driver of the planet’s current catastrophic loss of biodiversity and the key to stemming it. To address this challenge, a business strategy is developed wherein firms launch profitable business lines that harness market forces to fund projects that result in the enhancement of biodiversity. This strategy leverages existing systems for managing at-risk ecosystems and introduces a new procedure for minimizing the costs of such projects while maximizing their positive impacts on biodiversity. These business lines are built by first, understanding the political context of a particular biodiversity threat; second, designing a profitable product or service that is tied to a minimum-cost project that enhances biodiversity; and third, reporting the current and future impact of the project to those customers who want to know if their purchases are actually curbing the destruction. A new parameter learning algorithm within a political-ecological system simulator is used to model how the actions of firms change the beliefs of people to the point where they adopt ecosystem-preserving behaviors. The newly developed and available software that implements this procedure is applied to the conservation of white (Ceratotherium simum) and black (Diceros bicornis) rhinoceroses in South Africa.

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1. Introduction
Conserving biodiversity is a major environmental challenge (Ceballos et al., 2015). For instance, Thomas et al. (2004) predict 45% of terrestrial species will be extinct by 2050. Hence, because of

ABOUT THE AUTHOR
The present article is only one part of the author’s larger research agenda. The goals of this agenda are (1) developing sustainable strategies for conserving biodiversity and (2) developing cyber procedures for curbing wildlife trafficking. The first goal is reached when a private enterprise, working hand-in-hand with federal entities, unleashes its resources on initiatives that give people economic alternatives to wildlife poaching. The second goal is reached when law enforcement securely shares criminal intelligence on wildlife traffickers and uses such intelligence to carry out enforcement operations that shutdown their networks. To serve both of these goals, models of those political-ecological systems that host endangered wildlife are being developed and statistically fitted to associated political-ecological datasets.
its irreversibility and pressing nature, it can be argued that biodiversity loss is humankind’s number one environmental problem. Private enterprise is the root cause of this negative trend in global biodiversity (Lenzen et al., 2012). Because private enterprise affects so many of the Earth’s ecosystems, it also holds the key to preserving global biodiversity. Addressing this challenge, however, is complex: In a review of the idea of sustainable development, Haas (2001) notes that long-term protection of an ecosystem works only if management policies are (a) effective at protecting the ecosystem, (b) supported by all ecosystem-affecting countries, and (c) as economically efficient as possible.

This article describes one way that a for-profit firm (hereafter, firm) could develop a product or service that carries an attached project that enhances biodiversity. Hereafter, an offering will refer to a product or service placed on the market by a firm at a set price (Tanner & Raymond, 2012, pp. 183–185). The central tenet of this article is that the way forward is for firms to tightly connect the advertising and pricing strategies of their offerings with biodiversity outcomes that they themselves drive. To be effective at conserving biodiversity, such projects may span multiple countries, and hence, firms running such projects may need to partner with federal entities.

Firms would make money with this biodiversity-connected offering because they would sell it at a premium to the large number of global customers for whom wildlife carries non-use value (Sharp & Kerr, 2005). Non-use value is the sum of a species’ existence value and bequest value. Existence value is the perceived value of knowing that a species exists, and bequest value is the perceived value of conserving a species for future generations (Ressurreição et al., 2012).

1.1. The nature of biodiversity challenges
Lenzen et al. (2012) show that supply chains originating in species-rich countries and ending in developed countries are responsible for most biodiversity loss. This finding alone implies that the heart of the biodiversity challenge is business practice.

Biodiversity is mainly threatened by:

(1) Habitat loss due to farming, ranching, logging, urban sprawl, and spoilage. The latter phenomenon is driven by open-pit mining and the dumping of mine tailings and toxic chemicals on the landscape. Marine habitat spoilage, in particular, is driven by mine and fertilizer runoff.

(2) Poaching of plants, e.g., exotic hardwoods; and animals, e.g., rhinoceros (Ceratotherium simum) for their horns.

Biodiversity loss could be curbed if the following changes occurred: (1) people stopped destroying the habitat of endangered species; (2) damaged habitat was restored; and (3) people stopped poaching endangered species. Often, habitat is destroyed in order to produce the raw materials that feed the supply chains identified in Lenzen et al. (2012). The collective effect of all these supply chains amounts to a classic “tragedy of the commons” (Hardin, 1968) wherein firms have no motivation to protect the biodiversity of a region where they (a) source raw materials for their products, (b) manufacture such products, or (c) execute for-profit services such as operating a resort in an area that contains one or more endangered species. Such areas are often referred to as biodiversity hotspots (Myers et al., 2000). Hereafter, hotspot is used.

What actions would produce these changes? First, firms need to modify their supply chains to reduce their impact on hotspots. Second, money needs to be spent to restore damaged habitat. Third, law enforcement needs to disrupt international wildlife trafficking networks (hereafter, traffickers). Fourth, money needs to be spent on helping people lose interest in consuming wildlife products. And fifth, governments of countries that contain species under pressure from poaching need to (a) increase antipoaching patrols in their hotspots, and (b) encourage people to relocate out of such areas.
1.2. Political aspects of biodiversity conservation

There is an inherent difficulty in attempting to manage at-risk ecosystems: Most of the planet is either privately owned or is under the jurisdiction of a government. Consequently, direct actions to manage either land use or wildlife can only be taken by a relatively small number of individuals within these private or public organizations. In short, the planet’s biodiversity is controlled by a small number of people relative to the size of the planet’s population. Hence, any initiative aimed at protecting/restoring habitat and/or modifying law enforcement practice will need the cooperation of some number of these people. Such cooperation may need to be purchased.

Another political issue is unemployment. There will be between 9.5 and 10 billion people on the planet by the year 2050 (United Nations, 2019). In regions that host many endangered species such as Africa, unemployment among the youth is expected to be about 50% by then (International Labor Organization, 2019). Further, based on the rise of automation, several analysts predict that 30–50% of the planet’s workforce will be unemployable in the few high-technology jobs that remain by then (Harari, 2017; West, 2018). Even if these scenarios turn out to be only half true, it may not be realistic to think that there will be enough liveable-wage jobs offered by firms to lure most of these chronically unemployed from for-profit activities such as poaching and wildlife habitat destruction since, without a job, many of these individuals have no economic alternative to such biodiversity-damaging activities.

One political solution to this problem of unemployment among those living in hotspots is to encourage these people to leave the countryside for cities. Indeed, countryside-to-city migration is why wildlife populations have recovered in Europe (Chapron et al., 2014). In these cities, firms would employ some portion of these people—with many of those remaining existing on state welfare. As a case in point, South Africa already provides social welfare grants to almost half of the country’s households (Moore & Seekings, 2015). Soon, this mega-welfare system will need to provide food, housing, and medical care for about 70% of the country’s population. This large-scale welfare system would be made more efficient if it was administered from centralized locations in large cities. Hence, the need to get people away from hotspots coincides with making enlarged welfare systems more efficient by administering to them within the relatively small confines of cities.

1.3. Example

An example of how biodiversity conservation is driven by political processes is the ongoing poaching of rhinos in South Africa. In Kruger National Park (KNP), 300–800 rhinos are poached annually (Crous, 2020). The South African legislature passed a law in 2004 making the killing of rhinos illegal (Goitom, 2013). There are about 2.3 million black South Africans living in townships adjacent to KNP (Hübschle, 2016). The individuals engaged in the poaching raids are usually residents of these townships or Mozambicans who cross into KNP over its eastern border. These townships are the former “homelands” set up by the former apartheid government for the purpose of separating South Africa’s black population from the rest of the country. Many black South Africans were herded by their government into these places during the years of apartheid rule (King & McCusker, 2007). Refer to black people living in and adjacent to rhino-hosting ecosystems as rural residents.

Based on interviews reported in Hübschle (2016), these people feel they are living in an occupied country. They believe their rightful land, KNP, has been stolen from them, and their rights to harvest animals therein has been abrogated by force. Hence, these people do not believe they are poaching rhinos or doing anything illegal when, from their perspective, they shoot one of their own rhinos on land that belongs to them. And they have much more immediate economic concerns than worrying about the non-use value of a rhino.

In addition to South Africa’s legislation prohibiting the harvesting of rhinos, international non-governmental organizations (NGOs) have funded an extensive military campaign against those
who attempt to harvest them. One component of this military campaign is the running of antipoaching patrols within KNP. During such a patrol, armed rangers often encounter armed bands of poachers at night. A firefight often ensues and usually ends with the killing of many of the poachers. Such incidences have led to at least 400 poachers being shot dead by rangers in KNP between 2010 and 2014 (Hübschle, 2016, p. 13). These patrols have only increased over time so there is no reason to believe this rate of extra-judicial execution has not continued to be around 100 poachers per year. This would mean that about 1,100 poachers have been shot dead by rangers since 2010. None of these deaths have occurred as a result of a fair criminal trial of the suspected poacher. Even if a suspected poacher was to be convicted of poaching, the penalty for poaching is not death—indeed, there is no death penalty in South Africa at all.

Because most of the poachers involved in these firefights are dead, there is usually no way of corroborating the rangers’ declaration that the killings were in self-defense. Antipoaching patrols, however, are reminiscent of South Africa’s apartheid-era counter-insurgency operations in these same locales (Annecke & Masubelele, 2016; Duffy et al., 2019, p. 200). Given the oppression endured by the black population during the apartheid-era, many rural residents assume these killings are a continuation of apartheid practices and, hence, deeply resent them.

1.4. Connecting offerings to biodiversity

De Medeiros and Ribeiro (2017) define a green product as one that is capable of adding long-term benefits, reducing client stress and relieving them from their environmental responsibility, without, however, diminishing products’ satisfying qualities.

The phrase “long-term benefits” refers to long-term environmental protection. Generalizing the idea of a green product, a purchased biodiversity offering is defined to be an offering that contributes to biodiversity enhancement while also satisfying the consumer need that the offering was designed to satisfy. The price of a biodiversity offering includes a premium that is used by the firm to pay for a biodiversity project that the firm has attached to this offering. By advertising that they will apply this biodiversity premium to support a project that enhances biodiversity, the firm attracts a following of customers who in-part, purchase the offering in the hope that something concrete will be done to conserve biodiversity. The firm communicates to these customers its progress on this pledge by maintaining a publicly accessible, real-time biodiversity dashboard that displays data on both the targeted endangered species and the firm’s efforts to conserve it.

Members of this market niche (Andrews and DeVault, 2009) called here, biodiversity-concerned customers, carry some amount of anxiety about the potential loss of biodiversity across the globe. Such customers are willing to pay some portion of the cost of a biodiversity offering for the return of some reduction of their anxiety about losing the non-use value they hold for those species that they perceive to be at-risk of extinction (European Commission, 2019; Haas & Ferreira, 2016b; Hardner & Rice, 2002; Sun et al., 2017). Indeed, one way to view the business model of conservation-focused NGOs is that they are selling anxiety reduction: The NGO offers to do something to conserve biodiversity in return for donations from their biodiversity-concerned customers (Haas & Ferreira, 2016b).

For instance, a study by the Wharton School finds that 90% of the youngest generation of consumers are willing to pay more for sustainable products (Petro, 2022). Tully and Winer (2013) find that there are more consumers who are willing to pay more for products that sustain animals than there are consumers who are willing to pay more for products that sustain the environment. And consumers are indeed, actually, buying sustainable products: Whelan and Kronthal-Sacco (2019), in an extensive study of purchasing behavior using data on checkout barcode scans taken from retail outlets, find that purchases of brands marked as sustainable grew 5.6 times faster from 2013 to 2018 than did purchases of brands not marked as sustainable.

By maintaining biodiversity dashboards attached to biodiversity offerings, firms would give these biodiversity-concerned customers a way to assess what effects their individual purchases are
having on biodiversity. Such detailed, real-time feedback of how a purchase affects biodiversity would help to address the sense of powerlessness that many biodiversity-concerned customers experience when deciding to purchase an environmentally sustainable offering (Seyfang, 2005). It would also help build brand loyalty since customers, through repeated visits to the offering’s dashboard, would be able to verify that the firm is having a continuing, rather than a one-time positive impact on biodiversity.

In related work, Han et al. (2014) describe a biodiversity dashboard that is intended to provide real-time information on the status of worldwide biodiversity. And, Nghiem and Carrasco (2016) call for a real-time monitoring system that can forge a link between companies, deforestation, and land use. These authors argue that once linked, species-distribution and richness maps could be used within species-area relationship models. This combination would result in linking a firm’s activities with changes in the extinction risk of specific endangered species. These authors further argue that combining this real-time information with the barcode-scanning capabilities of current eco-apps would allow consumers to discriminate at point of sale between products that have different effects on biodiversity.

1.5. Biodiversity offerings need to be profitable
Because economic activity is driving biodiversity loss, the actions of firms will ultimately determine future biodiversity. But firms need to be profitable. A long-term solution, then, is where all firms alter their operations and products or services in ways that result in biodiversity gains while maintaining their profit levels. There is evidence that this business model would be profitable: Rosenkranz (2022) reports on a study that shows a positive relationship between a company’s profit and its degree of sustainable practices such as using renewable energy, conserving water, and actively recycling. Several of the present article’s suggestions for biodiversity projects involve one or more of these activities.

Biodiversity-concerned customers would see two utilities in a biodiversity offering: Its immediate utility, e.g., clean clothes from the purchase of a laundry detergent; and a second utility in the reduction of their biodiversity-loss anxiety through their financial support of the offering’s biodiversity project. This second utility represents an enormous but largely untapped source of demand that private enterprise could profitably satisfy with appropriate products or services. Tying biodiversity conservation to the thousands of products and services offered across the globe tops the spending power of many of the planet’s consumers, and also directs towards biodiversity conservation, the considerable resources that firms devote to their marketing campaigns and management of their supply chains.

A firm would continue to market its biodiversity offerings as long as they contributed to the firm’s profit. And making money would ultimately depend on the firm cultivating a niche of customers willing to pay a premium for the firm’s conservation efforts. Otherwise, because such firms would be at a price disadvantage with firms who spend nothing on conservation, firms selling their biodiversity offering at a price that includes a biodiversity premium would eventually fail. And, because customers are sensitive to the size of the biodiversity premium (Bateman et al., 2015; Marris, 2010), reducing this premium would increase the size of the market niche—and vice versa. Hence, for a biodiversity offering to be profitable in the long term, the profit of its attached biodiversity project should be maximized so that the biodiversity premium can be minimized. This optimal project’s profit may indeed be a negative value: The project’s revenue is less than its costs. In other words, the biodiversity offering needs to return a positive profit even if its attached biodiversity project operates at a loss.

Bateman et al. (2015) shows how this can be done with the palm oil ingredient that is present in many packaged items including hand soap, candy bars, ice cream, crackers, and bread. These authors report on a biodiversity-conserving business wherein some land in Sumatra is set aside for biodiversity conservation out of the total acreage available for palm oil trees. The cost of this in-country operation
(ICO) is passed on to the customer as a price premium. Based on a survey, these authors conclude that consumers view biodiversity as a luxury good and will purchase products that include a price premium for biodiversity conservation if (a) they are upper-middle class, (b) the premium is modest, and (c) there are no identical products that have a lower price. Marris (2010) reaches a similar conclusion.

1.6. Article layout
Section 2 contains a road map for developing biodiversity offerings. Section 3 contains an example of how the ecosystem management tool (EMT) of Haas (2018; 2011, pp. 8-10) is used to optimize a biodiversity project so that it is as profitable as possible, politically feasible, and effective at enhancing biodiversity. Aspects of this business-based approach to biodiversity conservation are discussed in Section 4, and conclusions are drawn in Section 5.

2. Biodiversity project development
First priority projects are those that involve the redesign of the offering or its supply chain with an eye towards reducing the sourcing of materials from hotspots of the targeted species (Barbier et al., 2018). For example, a project could be initiated that develops alternative sources in non-hotspot locations and/or uses a smaller footprint at existing locations. Such a project would include habitat remediation at existing locations that contain degraded habitat.

Biodiversity projects can also take the form of firms opening ICOS consisting of manufacturing/assembly facilities or service centers in countries that host-endangered species. Such ICOS would be located near cities in order to draw as many rural residents away from hotspots as possible. In order to encourage such relocation, a firm might subsidize housing near the ICO for each hotspot-dwelling individual they hire.

Potential ICOS include manufacturing, call centers, product assembly, and textiles. See, Dinh et al. (2014) for a summary of how Vietnam used this strategy to jump-start their economy after the Vietnam War. These authors also give roadmaps for those steps politicians and business people need to follow to make such startups happen. Chandra et al. (2012) gives a similar guide to starting a light manufacturing facility in Africa.

Another type of ICO addresses the consumption of wildlife products. The salient example is the running of demand reduction advertising campaigns in countries where wildlife products are consumed as traditional medicines or as status symbols (Dang Vu et al., 2020).

A hybrid ICO is the running of an in-house wildlife crime investigation unit. This unit would use social network analysis to identify trafficker kingpins and take them out of operation by providing law enforcement with the evidence they need to arrest such individuals (Haas, 2022; Haas & Ferreira, 2015). Bribes, as necessary, would be paid to government officials to allow such a private investigative unit to operate (Leithead, 2018). This type of biodiversity project would not require major investment on the part of firms already engaged in similar activities. For example, many insurance companies operate an in-house special investigation unit whose sole purpose is to investigate insurance fraud (Insurance Information Institute, 2020). Such an ICO is a hybrid because its investigators would be involved in species-hosting countries, countries that allow traffickers access to their transport facilities, and countries where wildlife products are retailed.

2.1. City-based manufacturing network
Consider the project of developing a manufacturing facility in a city far removed from a targeted hotspot. This ICO would be composed of one or more manufacturing facilities supported by a network of businesses that may include suppliers, shipping services, trade schools, and exporters. Call this a collection of interconnected businesses, a manufacturing network.

Businesses that are members of a manufacturing network are embedded in several tightly connected supply chains that make up the network. Such a collection of interconnected businesses
creates many employment opportunities and contributes to the persistence of each member-

business since each business is not trying to compete in an isolated market but rather, as

a profitable component in a larger network of businesses. This larger network’s supply chain starts

with its first supplier and continues up through the business that directly interacts with a buyer of

the end-product. Business network theory focuses on understanding how such networks behave

and prosper (Ludmila & Stanislava, 2015).

To clarify, the term “supply chain” is focused on a single firm: Those businesses upstream of the

firm that, through agreements, supply the firm with goods and services. The term “business

network”, on the other hand, is focused on a collection of separate firms that coexist to serve

a common market. Combinations of these firms form cohorts of retailers and suppliers of different

components that make up the market and supply chains within the network. The automotive parts

business network, for example, has tire suppliers and tire retailers who do not compete with

battery suppliers and battery retailers but rather share the same end-customers and carry the

same responsibilities to respond to the requirements of original equipment manufacturers.

2.2. Implementation procedure

How might a firm identify a biodiversity project and attach it to a biodiversity offering? And further, 

once selected, how could the firm make it both maximally profitable and ecologically effective? 

One way to achieve these goals is for the firm to execute the following implementation procedure.

(1) Identify one or more endangered species to conserve. The most-respected and credible way

of determining the status of a species is its rank on the Red List Index (RLI) maintained by

the International Union for the Conservation of Nature (IUCN; Young et al., 2014). The RLI

ranges from 0: Least Concern, 1: Near Threatened, 2: Vulnerable, 3: Endangered, 4: Critically

Endangered, and 5: Extinct. This list is maintained by a large, world-wide group of scientists

who volunteer their time to monitor and assess the status of thousands of plant and animal

species. A firm would select one or more endangered or critically endangered species from

this list.

(2) Identify a biodiversity project that is suited to one of the firm’s areas of expertise. Attach this

project to the offering by having the firm’s marketing department associate the offering with

it, and the firm’s accounting department place the offering and project on the same budget

line.

(3) Using the EMT, build a political-ecological system simulator (hereafter, simulator) of the

political-ecological system that hosts these species. This simulator is a computational,

stochastic model of the interactions through time of all ecosystem-affecting groups and

the affected ecosystem. Use the EMT to statistically fit the simulator’s parameters to a

political-ecological data set (Haas, 2018).

(4) Add the planned biodiversity project to this statistically fitted simulator and solve for the

most practical ecosystem management plan (MPEMP; Haas & Ferreira, 2018). The MPEMP

computation produces an ecosystem management plan that is both politically feasible to

implement and has the highest chance of enhancing biodiversity. The catalyst of this MPEMP

is the firm’s proposed biodiversity project that is both maximally profitable and effective at

enhancing biodiversity.

(5) Create a market for the biodiversity offering by advertising that if the offering is purchased,

the firm will use a portion of the purchase price (its biodiversity premium) to directly

contribute to biodiversity enhancement through the offering’s attached biodiversity project.

Do this by using data analytics to shape demand (Chase, 2013, ch. 9), i.e., execute

a combined strategy that involves pricing, promotions, and an advertising campaign that

emphasizes the biodiversity-enhancing benefits from purchasing the offering. Under this

demand shaping strategy, forecast demand for the offering that trades low price for

biodiversity enhancement. Minimize prices under the constraint that the offering’s projected

profit is positive.
(6) Begin the project. If the project involves operations in one or more species-hosting countries, enter into a partnership with each such country. Do this by hiring in-country liaison consultancies to aid in the development of these partnerships. These liaison consultancies would negotiate any licenses and pay any bribes needed for project implementation.

(7) Establish a feedback relationship with existing and future biodiversity-concerned customers. Do this by maintaining a biodiversity dashboard for the attached biodiversity project that displays in real time, the status of the project and its impact on biodiversity. Stream this dashboard to social networking sites and create media releases to inform existing and potential customers of the project’s impact on biodiversity. Maintain the dashboard’s credibility by hiring an auditing firm to conduct quarterly audits of the accuracy of project data being uploaded to the dashboard. Place a link to these audit reports on the dashboard.

2.2.1. The need for bribes and liaison consultancies

Unfortunately, in some countries, bribes are a necessary part of business transactions (Bahoo et al., 2019; Zhu, 2017). Indeed, one reason that legal efforts to curb wildlife poaching fail is because their sponsors do not pay the necessary bribes to allow their initiatives to be enacted by government authorities. However, traffickers willingly pay these bribes. For instance, efforts to track and disrupt wildlife traffickers operating outside South Africa are consistently denied access to trafficking data that is collected by South African authorities—while all along, these same syndicates bribe certain ministers to allow them to continue operating their wildlife trafficking business (Leithead, 2018).

Firms, through their liaison consultancies, would adopt the behaviors of these syndicates and pay the necessary bribes in order to be allowed to operate biodiversity projects in such countries. This issue of bribes is an example of a political-ecological system in operation: One of the events needing to happen before a particular conservation project can be initiated is the payment of bribes to politicians and other government officials.

An in-country liaison consultancy would also serve to overcome the well-known problem of a foreign firm who, while attempting to set up operations in developing country, encounters hostility by the local population who view them as neo-colonialists (Khan et al., 2010).

2.2.2. Governments and firms work together

Governments could support biodiversity projects in several ways. The most effective arrangement would be where a firm works together with at least two governments: The government where the firm is chartered and the government that hosts the firm’s ICO. As described above, the liaison consultant would work with the project’s government to pay necessary bribes and obtain necessary permits. The government of the firm’s home country would work to incentivize the ICO’s government to keep corrupt officials from shutting down the project. They would do this with a carrot-and-stick strategy. The carrot would consist of authorizing aid to the project’s government as long as the project continues; and the stick would be imposing sanctions on the ICO’s government if the project is threatened. The firm’s government would also contribute environmental monitoring resources through its environmental protection agency.

In addition, the firm’s government would pass legislation to:

(1) provide tax relief to any firm operating an ICO
(2) award small business development grants to small firms who plan to start ICOs
(3) increase aid to species-hosting countries who welcome ICOs

(a) establish an agency that provides free software, technical support, and data storage to firms running ICOs.
This arrangement means that firms would not be alone in their efforts to establish an effective ICO, rather, this would be a coordinated effort on the part of the firm and at least two governments. The new aspect of this arrangement is that a firm, rather than a government or a conservation-focused NGO, would be taking the lead in a project aimed at biodiversity conservation.

2.2.3. The MPEMP
Let \( E_{H}^{(Grp)} \) contain the statistically estimated parameter values of all group influence diagrams (IDs) in the simulator. The \( H \) subscript denotes the word hypothesis and indicates that these parameter values represent all currently accepted hypotheses about how the modeled groups perceive the world and reach decisions. Let \( E_{\text{MPEMP}} \) be those group ID parameter values that cause these group IDs to enact the MPEMP through their actions. The MPEMP is practical because it is the result of implementing a set of minimal changes in the beliefs held by ecosystem-affecting groups (relative to their \( E_{H}^{(Grp)} \) values). These changes are just enough to cause these groups to change their behaviors towards the ecosystem so that it responds in the desired manner.

The vector \( B^{(Eco)} \) contains the ecosystem submodel’s parameters. The values in \( B_{H}^{(Eco)} \) have been statistically estimated. Letting \( B = (B^{(Grp)}, B^{(Eco)}) \), define \( Q(B) \) be a random vector composed of a number of the simulator’s ecosystem metrics. Say that an ecosystem manager desires the ecosystem to be in a particular state at a particular future time point. This desired state is expressed as: \( q_{d} = E[Q(B)] \). For example, the desired state might be to have 1,000 rhinos in KNP in the year 2040. Then \( q_{d} = (E[RhinoAbundance] = 1000)^{t} \).

Let the set \( c_{\text{MPEMP}} \) contain (a) those actions that, if taken, would contribute the most towards the ecosystem submodel producing the values in \( q_{d} \); and (b) those actions that, if ceased, would raise the likelihood of the ecosystem submodel producing the values in \( q_{d} \). Call these two types of actions, MPEMP actions, and MPEMP complement actions, respectively. For example, to achieve the value of \( q_{d} \), above, it is believed that biodiversity-concerned customers need to purchase the biodiversity offering; would-be poachers need to take legal employment that is some distance from KNP; and poachers need to stop poaching rhinos in KNP. In this case,

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c_{\text{MPEMP}} = \{ \text{action}^{(bcust)} = \{ \text{purchase biodiversity offering} \}, \text{action}^{(pchers)} = \{ \text{take distant legal employment} \}, \text{complement action}^{(pchns)} = \{ \text{poach rhino} \} \}
\]

where bcust and pchers are the biodiversity-concerned customer group and the poacher group, respectively.

Let \( f(\gamma) \) be the offerer’s biodiversity premium function and \( \gamma \in B^{(Grp)} \) be the parameters of an agent-based model of the biodiversity project. Let \( \gamma_{pp} \) be the value of \( \gamma \) that maximizes the biodiversity project’s profit at the expense of biodiversity enhancement. The MPEMP algorithm is given in the Supplement (2022).

If a learning mechanism has been programmed that modifies the values of a subset of a group’s ID parameters such that the group changes their behavior to either one that is desired or away from a complement behavior, then that behavior is not expressed as a constraint in \( c_{\text{MPEMP}} \). Instead, the learning algorithm, during the simulation, modifies these parameters so that the desired behavioral change is eventually achieved.

Haas (2020) uses a benchmark function along with two real-world applications to show that the MPEMP algorithm is both scalable and computationally stable (robust).

2.3. Giving customers feedback on a project’s status
A biodiversity dashboard shows the real-time status of the firm’s biodiversity project. This is done by displaying values of the project’s drivers of biodiversity enhancement such as the amount of
relocated rural resident employment and biodiversity outcomes such as species abundance. Ecosystem status is displayed by posting to the dashboard observations and predicted values of the biodiversity metrics used in the simulator’s ecosystem submodel. These predicted values are computed by running the simulator forward in time. Ecosystem observations are read into the dashboard from an external data repository (Haas, 2018) that is responsible for maintaining the integrity of the project’s ecosystem monitoring program.

3. Results
Extending the introductory example and following the implementation procedure, say that a furniture manufacturing firm has decided to help conserve the rhino population in KNP and to this end, has developed a simulator of the political-ecological system surrounding the poaching of these animals. Call this firm, “Elegant Furniture.” This firm decides that a project that is suited to their expertise is to run an ICO consisting of two furniture manufacturing facilities in Johannesburg, South Africa—purposely far from KNP and within the largest city in South Africa. Elegant Furniture plans to attach this project to a biodiversity offering that consists of a line of eco-furniture. A manufacturing network would emerge around these two facilities consisting of component suppliers, service providers, trade schools, and exporters.

Elegant Furniture would hire only relocated rural residents. In order to make the move from the KNP area to Johannesburg feasible, Elegant Furniture would pay 50% of the relocated rural resident’s housing costs for the duration of their employment with the firm. Such housing subsidies would be funded by revenue from the biodiversity premium. To make such a restrictive hiring policy legal, the liaison consultancy hired by Elegant Furniture would work with the South African government to designate rural residents as a special protected group that are granted priority hiring within Gauteng province under South African labor laws. In addition, Elegant Furniture would encourage suppliers to hire relocated rural residents by making their bid price for supplies a positive function of the supplier’s percentage of employees who are relocated rural residents. Again, the costs of this supplier incentive program would be paid for with biodiversity premium revenue.

With this new manufacturing network, there are now two business networks attempting to recruit new employees from the same rural resident population. The first is a trafficker engaged in the business of illegally harvesting rhino horn for the traditional medicine market in Southeast Asia. This conglomerate seeks to hire rural residents to join poaching parties, become couriers, or become middlemen. The second is the manufacturing network located in Johannesburg.

The biodiversity benefit of the manufacturing network is a drop in poaching due to a draw-down of the rural resident population. Those relocated rural residents now working in this Johannesburg manufacturing network, however, have no less desire to gain quick cash from rhino poaching. And, they also continue to feel anger about their expulsion from their rightful lands and the denial of their right to harvest animals there. But now, these people find it more difficult financially and time-wise to travel back to KNP to poach rhinos. Further, their day-to-day economic needs are largely satisfied by their new jobs in the manufacturing network.

Although Elegant Furniture can only directly control employment and wages of their ICO, because of the supplier incentive program, increasing the number of biodiversity-concerned buyers causes a cascade of relocated rural resident employment along the network’s chain of businesses outside of the ICO. This happens because as the number of buyers grows, suppliers receive more orders from Elegant Furniture’s two in-country manufacturing facilities.

3.1. Simulator description
There are four submodels in the original South African rhino simulator of Haas and Ferreira (2016a): A rhino horn trader group (composed of both legal and illegal traders), poacher group, antipoaching unit group, and an ecosystem submodel of KNP’s rhino population realized as a stochastic and dynamic individual-based model (IBM).
The trader group ID represents the decision-making of legal traders, illegal traders (traffickers), and Southeast Asian rhino horn consumers. For the results reported herein, however, the effects of legal trading in rhino horn are not simulated. This original simulator is extended by adding to it a group running a manufacturing network in Johannesburg. The original set of input actions is carried over to this extended simulator.

3.1.1. The manufacturing network submodel
This submodel interacts with the simulator’s other submodels through its ID representation (Figure 1). Within this ID, the network is modeled as a set of interacting stochastic agents (Figure 2). Ferreira and Borenstein (2011), Mele et al. (2006), and Craven and Krejci (2017) demonstrate similar agent-based models of supply chains. This submodel is made up of furniture buyer agents (hereafter buyer agents) and business agents. Business agents consist of manufacturing facilities and suppliers to these facilities. The two manufacturing facilities owned by Elegant Furniture are a bedroom furniture manufacturing facility (hereafter bedroom facility) and a table lamp manufacturing facility (hereafter lamp facility). Buyers interact exclusively with these two facilities. Each facility is supplied by a component part supplier who carries an unlimited inventory and a service provider such as a shipper who carries no inventory.

Figure 1. Manufacturing network influence diagram.

Figure 2. Agents defining the manufacturing network.
3.1.2. Agent mechanisms
The manufacturing network is simulated by having each agent performs a sequence of decision-making activities at each time point, \( t_i, i = 1, \ldots, N \). Call such a sequence, an update. At each time point, all buyer agents update in a random order. Then, all buyer-facing business agents update in a random order. Finally, all supplier business agents update in a random order. An order placed by an agent during time step \( i \) is filled in time step \( i + 1 \).

A buyer agent’s update consists of deciding on which facility to buy one unit of product from. All business agents have customers and a workforce. Buyer-facing business agents set prices that were determined in the demand shaping campaign (step 5 of the implementation procedure) and have inventories that they replenish from suppliers.

The update performed by a buyer agent appears in Figure 3. Based on the agent-based economic decision-making model of Catullo (2013), each business agent has two goals: make a profit, and grow—as indicated by increased revenue and a larger staff size (Haas & Ferreira, 2016a). Figures 4, and 5 contain the updated flowcharts of a facility agent, and supplier agent, respectively.

3.2. Biodiversity premium function
The biodiversity-concerned customer group submodel, were it to exist, would have hypothesis parameter values that represent their perception that a biodiversity offering would be an attractive purchase if its biodiversity premium was zero. However, in order to avoid the construction of a complex submodel of biodiversity-concerned customer decision-making, a proxy is used instead. This proxy is the offering’s biodiversity premium function. Minimizing the biodiversity premium is equivalent to finding parameter values in a biodiversity-concerned customer group submodel that are similar to their hypothesis values but cause these customers to purchase the biodiversity offering that carries a non-zero biodiversity premium.

When Elegant Furniture uses part of its biodiversity premium revenue to fund its ICO, maximizing the ICO’s profit function can help reduce the biodiversity premium. Here, this is done by

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Figure 3. Decision-making flowchart of a buyer agent.
defining the second component of the MPEMP algorithm’s multiobjective function (Supplement, 2022) to be the negative of ICO profit.

3.2.1. Profit function of the ICO

This function’s constants are as follows.

$y_{\text{min}}$: the minimum number of buyers in one year that, in Elegant Furniture’s judgment, would make the ICO viable.

$y_{\text{max}}$: the maximum number of buyers in one year that the ICO could satisfy without breaking negotiated upper limits on facility production capacity.

$s_{\text{max}}$: maximum possible buyers’ reserve price.

$w_{\text{min}}$: the South African Upper Bound Poverty Line (UBPL) taken from Maluleke (2020). This is the annual income of an individual living at the South African poverty line. In 2019, its value was R14,724.

$c_{\text{max}}$: upper limit on the number of people that can be employed at a facility.

Let $n$ be the number of businesses that collectively, make up the manufacturing network. Index these businesses with $i = 1, \ldots, n$. Let $m$ be the number of businesses that constitute Elegant

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**Figure 4. Decision-making flow-chart of a facility business agent.**
Furniture’s ICO. Index these businesses with \( j = 1, \ldots, m \). The function’s decision variables are those variables that Elegant Furniture can manipulate to improve the ICO’s profit. These are as follows.

- **\( y \)**: forecast of next year’s number of buyers.
- **\( r_s \)**: buyers’ reserve price for one production unit.
- **\( r_r \)**: reserve price of an ICO agent for one production unit from a supplier.
- **\( w_i \)**: weekly wage paid to an employee of the manufacturing network’s \( i \)th business.
- **\( e \)**: learning parameter.

The variables \( y \) and \( r_s \) are decision variables under the assumption that demand can be shaped by advertising (Chase, 2013, ch. 9).

Variables that are functions of the decision variables are as follows.

- **\( b_{jk} \)**: the amount spent by buyer \( j \) during week \( k \) at ICO businesses.
  \[
  b_k = \frac{1}{q_k} \sum_{j=1}^{q_k} b_{jk} \quad \text{the average amount spent by buyers at ICO businesses during week } k \text{ where}\]
  \( q_k \) is the number of buyers during week \( k \). The values \( q_1, \ldots, q_{52} \) are uniformly distributed random integers under the constraints that \( 10 < q_k < y_{\text{max}} / 52, \) \( k = 1, \ldots, 52 \), and \( \sum_{k=1}^{52} q_k = y \).

- **\( z_i \)**: number of employees in manufacturing network business \( i \) during week \( k \). This value is updated at each time step (one week) by the \( i \)th business agent where it is assumed that all new hires are relocated rural residents.
\[ z_i = (1/52) \sum_{n=1}^{52} z_{ni} \text{: average weekly employment in manufacturing network business } i. \]

The mathematical form of an ICO's profit function is described in the Supplement (2022).

3.3. The manufacturing network's effect on poaching

The variables, \( z_1, \ldots, z_n \), and \( w_1, \ldots, w_n \), indirectly affect the rhino's extinction probability (and hence the MPEMP's objective function) through their effect on poaching event probabilities. The mechanisms that implement this effect are described next.

3.3.1. Traffickers group submodel

Traffickers do not shoot rhinos themselves. Rather, they place orders with middlemen for rhino horn. It is assumed here that traffickers always receive a filled order back from a middleman wherein any shortfall in genuine rhino horn has been made up with buffalo horn or other substitutes. This is done by first posting the trafficker-requested number of animals to poach \((O_n)\) and the trafficker's bid price. The middleman submodel reads these values and posts the value of \( O_n \) along with their own, reduced, bid price. The poacher submodel reads both these values and any actions that have been taken by the antipoaching unit submodel. The poacher submodel then decides on a number of rhinos to poach at the current time step and posts this filled-order. The rhino IBM then reads this poacher-produced number of rhinos to be harvested and kills them.

Because traffickers outsource their rhino horn production to poachers, their production capacity equals their ability to recruit poachers. An indicator of this ability is the recent behavior of poachers. Changes in this ability at each time step are modeled by first setting the value of a trafficker submodel parameter, \( h \), to \( \text{true} \) when the poacher submodel posts \( \text{poach a few rhino}, \) \( \text{poach several rhino}, \) or \( \text{poach many rhino} \) and to \( \text{false} \), otherwise. Trafficker production capacity is increased only if \( h = \text{true} \).

3.3.2. Poachers group submodel

There are two mechanisms within the group decision-making ID theory of Haas (2011, pp. 83–92) that can be used to model behavior change: (1) change the group's perceived, causal model of the situation and scenarios; and (2) change the group's goals and/or goal priorities. A management plan that forces a group to take on additional costs for particular (output) actions implements the first mechanism since it changes the group's perception of the future consequences of a contemplated action. Examples include the Scenario Immediate Interaction with Police (SIIWP) node, and the added cost to mount a KNP poaching raid due to living and working in Johannesburg rather than living in a township adjacent to KNP. This additional cost includes (a) travel from Johannesburg to KNP, (b) lost wages from taking time off work, and (c) the anxiety of jeopardizing the job itself due to the time off.

The poacher group submodel action, \( \text{take distant legal employment} \), means to accept a job in the Johannesburg manufacturing network. Let \( w_p \) be the wage paid to a poacher, i.e., the middleman's bid price. Middlemen and manufacturing network businesses post their current values of \( w_p \) and \( w_{\text{mnet}} \) to the simulator's bulletin board, respectively. Let a learning parameter, \( l \) be the poachers' attraction towards a legal, Johannesburg-based job relative to joining a rhino poaching party. Here, \( l = w_{\text{mnet}} / (w_p + w_{\text{mnet}}) \). As part of the poachers group submodel's decision computation, \( l \) is updated when the posted values of \( w_p \) and \( w_{\text{mnet}} \) change. This updated value of \( l \) is used to perform a learning update of the conditional probability tables (CPTs) of the Scenario Family (SF) and the Scenario Pursue Career Goal (SPCG) nodes (Table 1). This parameter learning mechanism, wherein one group ID updates its parameter values based on the actions of another group ID, is new.

Modifying the SPCG node addresses a poacher's desire for a career (Hübschle, 2016; Pelser et al., 2013). The desire for a career is driven mainly by social needs rather than basic survival needs as
up to 95% of residents in townships surrounding KNP report supermarkets as their main source of food (Ngomane, 2012). Such a career, however, is lacking for most young black men living in townships adjacent to KNP due to chronic unemployment in these areas (Gwonyma, 2010; Pienaar & Von Fintel, 2013). The attendant social frustrations caused by their lack of a legal career can drive these rural residents to adopt poaching as a career replacement.

Thus, providing rural residents with job opportunities that are far removed from KNP might dissuade them from poaching rhinos because, although the price for rhino horn in Beijing is at least 30,000 USD per kilogram (Eikelboom et al., 2020), a middleman typically offers to pay a rural resident no more than about 200 USD to poach one set of rhino horns (about 5 kg; City Press, 2013). Say that this person participates in one poaching raid every two weeks. Hence, if a job in Johannesburg was offered to this person at about 400 USD per month, it might be more attractive to them than risking their life to poach rhino horn. See Haas and Ferreira (2018) for the risk versus reward calculation a rural resident might make in deciding to join a poaching party or not.

### Table 1. Learning update of the poacher group submodel nodes SF (and SPCG).
The value of \( \lambda \) has been recomputed using the most recent values of \( \gamma_{np} \) and \( \gamma_{npnet} \). The symbols \( p_1, p_2, \) and \( p_3 \) indicate the current values of a node’s conditional probability distribution. The parameter \( r \) governs the learning rate and is set to the value 0.6 for all results reported herein.

| Node value                  | Action: take distant legal employment                                      | Action: poach rhinos                                      |
|----------------------------|--------------------------------------------------------------------------------|-----------------------------------------------------------|
| Dissatisfied (unattained)  | \( p_1 = p_1 + (1 - r)[p_1(1 - \lambda)] \)                                | \( p_1 = 1 - p_1 - p_2 \)                                 |
| Ambivalent (middling)      | \( p_2 = p_2 + (1 - r)[p_2(1 - \lambda)] \)                                | \( p_2 = p_2 + (1 - r)[p_2(1 - \lambda)] \)              |
| Satisfied (attained)       | \( p_3 = 1 - p_1 - p_2 \)                                                    | \( p_3 = 1 - p_3 \)                                      |

3.4. Ecosystem management plans

A buyer’s reserve price is found by a pricing study conducted in developed countries on people interested in buying furniture. This study uses demand shaping (the implementation procedure’s step 5) to identify a target value of \( y \) that is in-part, a function of the advertised maximum price a buyer will have to pay for one unit of furniture, e.g., one lamp. It is then assumed that buyers adopt this value as their reserve price. To increase demand, the demand shaping strategy advertises a reduced maximum price that a buyer will be required to pay for one unit of production.

3.4.1. Pure profit versus maximum employment

One way to increase the manufacturing network’s total employment of relocated rural residents is to increase the number of buyer purchases. Doing so increases the number of orders placed to suppliers outside of the ICO. This can be accomplished by using the demand shaping strategy to encourage buyers to adopt a lower reserve price as discussed above. Then, to assure that all buyer orders are filled, i.e., suppliers always accept bid prices, ICO businesses would maintain a reserve price that is always above the supplier’s asking price—even if this reserve price is above the buyers’ reserve price. Doing so can cause the ICO to operate at a loss. This loss is paid for with monies from the offering’s biodiversity premium.

As an example of this management strategy, say that the maximum number of purchases that an ICO business could fill per year is 10,000. And, say that Elegant Furniture’s demand shaping campaign has created a market of about 10,000 buyers each having a reserve price of 20 USD. Say that the current value of the manufacturing network’s \( i \)-th business, \( w_i \), is 1500 USD. Using these values, the agent-based submodel of the manufacturing network is run over one year under two different management strategies: First, a pure profit strategy wherein the ICO keeps its reserve price at 50% of the buyers’ reserve price, and then second, a maximum employment strategy
wherein it keeps its reserve price at 95% of the buyers’ reserve price. Figure 6 shows the time series of the manufacturing network’s total employment and the ICO’s profit under these two strategies. Figure 6 indicates that employment is higher under the maximum employment strategy relative to the pure profit strategy. This higher employment comes at the expense of the ICO’s weekly profit. Profit is equal under both strategies at time points where there are no orders placed by ICO businesses to their suppliers since in these cases, the ICO’s profit is equal to its revenue—and this revenue is the same under both strategies because the buyers’ reserve price is constant across the two strategies.

3.4.2. MPEMP solution
The value of $c_{MPEMP}$ used here is described in the MPEMP section, above. The planning horizon extends from 2015 to 2040. ICO wage is adjusted to find the MPEMP. Its value under a pure profit management strategy is 59.0. At this value, the MPEMP multiobjective function equals $-86.31$. After 20 function evaluations run within an optimization algorithm, this function increases 96% to $-3.58$ at an ICO wage of 1245.58. The MPEMP then consists of setting the ICO wage to 1245.58.

**Figure 6.** Time series of ICO profit (top) and supplier total employment (bottom) over one year under (a) ICO reserve price maintained at 50% of the buyers’ reserve price (red), and (b) ICO reserve price maintained at 95% of buyers’ reserve price (green). The plot displays nine realizations of the stochastic, temporal, agent-based submodel of the manufacturing network.
Figure 7 shows model output of the poachers learning parameter $l$, number of rhinos poached, and realizations of rhino abundance. These variables are plotted under first, the pure profit strategy and then under the MPEMP. The causal chain that this plot depicts is as follows: Changes in poacher group perceptions cause changes in their behaviors that, in-turn, cause changes in the ecosystem. Rhino extinction is avoided under the MPEMP but not under the pure profit strategy.

3.5. The project’s biodiversity dashboard

Elegant Furniture maintains a biodiversity dashboard for their rhino conservation project. The dashboard depicts the effect of Elegant Furniture’s biodiversity project on poacher behavior and that behavior’s effect on the survival of the South African rhino (Figure 8). By looking at this...
Figure 8. Elegant Furniture’s biodiversity dashboard of its rhino conservation project. The dashboard’s top, middle, and bottom charts are ICO employment of relocated rural residents by time \(X(t)\), number of poaching events by time \(Y(t)\), and rhino abundance by time \(Z(t)\), respectively. Thus, the direction of causality is from top to bottom. All three charts display 10 years of historical data, and 10 years of predicted values under the assumption that the MPEMP is implemented. The bands surrounding \(X(t)\) and \(Y(t)\) indicate the degree of data veracity at each time point: Veracity increases as a band narrows. The uncertainty of the project’s model-based predictions of rhino abundance is depicted by plotting nine deviates of model output on the abundance chart. Sampling variability of the monitoring-based estimates of abundance amplifies the spread of these deviates. The audit information link is fictitious.

dashboard, biodiversity-concerned customers can immediately see for themselves if Elegant Furniture’s efforts are doing any good.

3.5.1. Data veracity

Veracity bands for data on the number of employees who are relocated rural residents and the number of poaching events are assigned by an auditor hired by Elegant Furniture during the implementation procedure’s step 7. The dashboard contains a link to this auditor’s contact information.

The veracity of a reported data point can be diminished by subjective value assignment, deceptive assignment, or the use of estimates rather than direct observation (Lukoianova & Rubin, 2014). One way to quantify data veracity is as follows: An auditor performs an audit of the veracity of the dashboard’s data on the two variables, \(X(t)\) and \(Y(t)\). The auditor writes a report and, from that report, assigns veracity bounds \(\{L_X(t), U_X(t)\}\) and \(\{L_Y(t), U_Y(t)\}\) to each reported value on \(X(t)\), and \(Y(t)\), respectively. These bounds reflect the auditor’s judgment of where the true value of that variable might be at time \(t\).

For example, veracity bounds on a value of \(X(t)\) would be wide if the value was no more than a rough estimate made by counting employees leaving the building in the evening. The bounds would narrow if the value was a self-report by the ICO or if the value was the result of the auditor using a federally sanctioned method for counting employees such as the one given in the United States Family and Medical Leave Act of 1993 (Code of Federal Regulations, 2021). Values of \(Y(t)\) are
subject to deceptive reporting because some audiences inside and outside South Africa view high poaching numbers negatively (Fynn & Kolawole, 2020).

4. Discussion
An argument can be made that most environmental issues are really about luxury items: charismatic mammals, picturesque coral reefs, or clean air. Because of its luxury status, it does not appear likely that a global perception of impending biodiversity loss alone will trigger world-wide actions to stem it. Most people can get by without biodiversity. Assuming, however, that there is latent demand for the luxury item of biodiversity, one might ask: How could this demand be profitably met? It has been argued herein that in order to make money in such a market, a firm would need to develop a niche of customers willing to pay a biodiversity premium for the firm’s offering as long as the firm delivers a verifiable conservation success.

Many in the conservation community think that if changing people's beliefs towards the environment does not work, then coercion in the form of environmental laws enforced by governments is the ultimate solution (Hitt, 2019). Coercion, however, works only as long as the coercing government is in power. But consider two events: (a) the United States Environmental Protection Agency was being systematically dismantled by the president of the United States during years 2016–2021 (Dillon et al., 2018), and (b) the UK has exited the European Union (EU)—leaving behind an extensive set of environmental protection requirements that EU members are held to. Whether the UK will replace those laws with a suite equally as strong is open to debate (Morris & Emden, 2018). Just how persistent, then, are such coercion systems? By way of contrast, a system to conserve biodiversity that is based on the distributed efforts of many firms would be resilient to changes in governments and to the impermanent nature of individual firms.

Running an ICO within a developing country as advocated herein, however, carries some challenges: lack of infrastructure, the need for expensive training of workers in these countries, and the (possibly) high transportation costs to keep such a (possibly) remote operation running. These roadblocks may negatively impact the ICO’s profit potential and, hence, ultimately cause the failure of the associated biodiversity project.

This article proposes a business-centered solution to biodiversity loss that consists of marketing products that have attached biodiversity projects that customers pay for. But is there any theoretical justification for this theory of consumer behavior? One well-known theory of behavior is the Health Belief Model (HBM; Morris et al., 2012; Rakshanderou et al., 2020). This is a theory of why individuals decide to take certain actions regarding their health. To apply this theory, say that the angst and anxiety certain individuals feel when they hear reports of biodiversity losses is a mental health problem for these people. HBM postulates that these individuals will engage in behaviors (such as purchasing a biodiversity offering) that they believe will reduce this anxiety in the future.

Future work will include extending this article’s biodiversity-enhancing business model to firms who only sell to other firms.

5. Conclusions
This article has developed an implementation procedure for involving the private sector in biodiversity enhancement. This procedure addresses the root cause of biodiversity loss—economic activity, and, through a profit-seeking strategy, unlocks the resources of private enterprise to remedy this wildlife conservation challenge. An example has been given of how the EMT can be used to find a maximally profitable, politically feasible, and ecologically effective biodiversity project. The project’s biodiversity dashboard encourages customer loyalty by closing the feedback loop starting at the customer’s initial purchase of the biodiversity offering, through the project, and finally back to that customer.
A new mechanism within the EMT was demonstrated: A group, after learning a new belief system from the actions of firms, shifts their behaviors away from those that harm an ecosystem. This mechanism is, ultimately, the foundation of sustainable biodiversity.

**Article highlights**

A procedure is developed for involving the private sector in biodiversity enhancement. This procedure addresses the root cause of biodiversity loss – economic activity, and, through a profit-seeking strategy, unlocks the resources of private enterprise to remedy this wildlife conservation challenge. The procedure consists of a firm offering a product or service that is tied to a biodiversity project that enhances biodiversity. The project’s biodiversity dashboard encourages customer loyalty by closing the feedback loop starting at the customer’s initial purchase of the offering, through the project, and finally back to that customer. Combating rhino poaching is used as an example of how a maximally profitable, politically feasible, and ecologically effective biodiversity project can be found.

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