National-Level Costs of Implementing 30x30 in Latin America and the Caribbean:

Meeting Countries Biodiversity Goals

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Lead author, chapters 1–3, 5–7
Dr. Anthony Waldron (Working Ant Consultancy Cambridge Ltd.)

Lead authors, chapter 4
Dr. Jerome Guiet (UCLA)
Dr. Ryan Heneghan (Griffith University)

Coauthor, chapter 4
Dr. Anthony Waldron (Working Ant Consultancy Cambridge Ltd.)

Lead contributors
Gregory Watson and Frida Arriaga Cinta (IDB)

Contributors
Joan Pratts, Maria Pia Zanetti, Santiago Bucaram and Juan Manuel Murguía (IDB)

Inter-American Development Bank
1300 New York Avenue, N.W.
Washington, D.C. 20577
www.iadb.org

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Foreword

This study aligns with the objectives of the Natural Capital and Biodiversity Mainstreaming Action Plan of the Inter-American Development Bank (IDB) Group (IDB, IDB Lab, and IDB Invest). To support the plan's goal of integrating biodiversity dimensions into country dialogues, the study provides information about the costs associated with implementing Target 3 of the Kunming-Montreal Global Biodiversity Framework (GBF) as a relevant input to mainstreaming protected areas in financial decision-making. This study aims to be a valuable tool for making policy decisions about 30x30 commitments and the fulfillment of the GBF.

Additionally, this study generates country-specific knowledge for the 26 IDB member countries to support effective biodiversity mainstreaming as well as the generation of estimates of annual management costs for expanding the protected areas systems, one-time establishment costs for new protected areas, and opportunity costs associated with protected area expansion.

Finally, this study promotes the mobilization of public and private resources toward biodiversity/natural capital in LAC. Although a set of innovative financial solutions are emerging, a fundamental question related to financing regional conservation strategies is the magnitude of the need. Estimating the cost of protecting 30 percent of the ocean and land in LAC is a key input needed to assess sustainable financing needs and elaborate a strategic plan for providing financial support to LAC countries in implementing Target 3 of the GBF, as well as to debt management offices to incorporate these supports into debt management and borrowing strategies.

Abbreviations

ARIMA	Autoregressive Integrated Moving Average
AIS	Automatic Identification System
BAU	Business as Usual
BOATS	Bioeconomic Marine Trophic Size-Spectrum Global Marine System Model
COP15	Fifteenth Meeting of the Conference of the Parties to The Convention On Biological Diversity
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization of the United Nations
GBF	Kunming-Montreal Global Biodiversity Framework
GDP	Gross Domestic Product
ICCAs	Indigenous Community Conserved Areas
IDB	Inter-American Development Bank
IIASA	International Institute for Applied Systems Analysis
InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs
IPLC	Indigenous Peoples and Local Communities
LAC	Latin America and the Caribbean
MPAs	Marine Protected Areas
OECM	Other Effective Area-Based Conservation Measures
Open IEEM	Open Integrated Economic-Environmental Model
PCAs	Protected and Conserved Areas
PPP	Purchasing Power Parity
RCP	Representative Concentration Pathways
SEEA	System of Environmental Economic Accounting
SSP	Shared Socioeconomic Pathways
SST	Sea Surface Temperature
SSS	Stratified Societies
TPAs	Terrestrial Protected Areas
TSS	Towards Sustainability

Executive Summary

Study Purpose: Estimating 30x30 Costs in Latin America and the Caribbean

In December 2022 at COP15 (the 15th meeting of the Conference of the Parties to the Convention on Biological Diversity), 196 countries—including all Latin America and the Caribbean (LAC) countries—agreed to halt and reverse biodiversity loss by 2030 through a set of international biodiversity targets in the Kunming-Montreal Global Biodiversity Framework (GBF).[1] Target 3 of the GBF is the commitment to "conserve 30 percent of land, waters, and seas" by 2030, which is also known as "30x30" or "30 by 30" (hereafter, 30x30).

The signatories' commitments to the GBF and Target 3 in particular are motivated by biological and economic concerns: species and ecosystems are rapidly declining, which is being labeled as a biodiversity crisis, and the declines are placing natural capital at risk, which threatens global economic stability.[2–4] A robust natural capital is important because it offers multiple economic benefits to countries, people, and governments, such as protecting nature's role in stabilizing the global climate,[5] protecting increasingly fragile water supplies, protecting vulnerable coastal areas from the increasing levels of storm damage, generating higher GDP growth,[6] and increasing cash and foreign exchange income from nature tourism, which is a major and rapidly growing global industry.[3,7] But the steep natural capital declines have spurred recent efforts in the finance sector, including among central and international banks, to recognize and work to mitigate the substantial financial risks that follow such losses.[8,9]

Yet while the compelling benefits of protecting natural capital are clear, the investment (forward-looking expenditure) required to achieve them can be substantial.[7] Plus, protections may reduce economic production in certain industries.[7] The 30 percent conservation goal represents an approximate doubling of protected and conserved areas (PCAs) on land and almost a quadrupling of marine areas.[1] This large expansion implies potentially large costs, but the actual costs remain unknown for individual countries. Therefore, this report, commissioned by the Inter-American Development Bank (IDB), focuses on quantifying the projected costs of 30x30 for the 26 IDB borrowing countries in

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1. All coverage statistics are taken from the UNEP-WCMC World Database on Protected Areas, which is freely accessible online and regularly updated at protectedplanet.net.

new PCAs, and **management costs**, which are the ongoing annual cost of managing PCAs. These explicit costs are typically met by government expenditure,[10] so sufficient information is needed to plan for such large additional expenditure, especially in cases where financial resources are limited and debt is high.[11,12] The third type of cost to implement 30x30 is **opportunity costs**, which stem from conserving new, large areas of land and sea. These costs represent the potential losses in economic output resulting from protections that limit production, and they accrue to industries that are likely to exploit natural spaces post-2030, such as fisheries and agriculture.[7] Given the important role of fisheries and agriculture in LAC, any economic downside to those sectors caused by 30x30 need to be anticipated and mitigated. This report therefore quantifies the opportunity costs for those sectors where possible.

It is also important to place these opportunity costs in the context of the broader economy and of time, as the protection of natural areas creates economic wins and losses. For example, a major report for COP15[7] that tested the global economic impact of six 30x30 scenarios found that the agricultural sector would experience small, uncertain output changes (about 1 percent or less in either direction) while the fisheries sector would face a mix of early losses and later gains. However, there would be economic gains in other economic sectors, such nature tourism and global forestry[7] (even without considering additional benefits such as those accruing to the water utility and insurance sectors).

Therefore, seen from the whole-economy perspective, the gains from 30x30 outweighed the losses. In addition, most losses are projected to be only short term, turning into benefits over the longer term. For example, a report by World Bank economists suggested that 30x30 might cause a fall in global GDP of 0.1 percent in the short term (in 2030 itself), but in the midterm, better nature protection could prevent the loss of US$2.7 trillion of global GDP per year (which is 2.4 percent of current GDP).[4]

Study Approach: Using Scenarios to Project 30x30 Costs in LAC

The costs of 30x30 will depend on where PCAs will be located, but since many locations have not been determined, it is necessary to develop scenarios to model PCA costs. To encompass a meaningfully large range of possible economic outcomes, which can typically be achieved by varying the political and economic decision frameworks that might determine final locations,[7] three scenarios are applied to the marine and terrestrial realms:

- **Scenario 1. Biodiversity priority** assumes that governments would add new PCAs in high-biodiversity areas that remain unprotected, with no consideration of possible economic downsides (opportunity costs).

- **Scenario 2. Economic priority** assumes that governments will aim to avoid opportunity costs as much as possible. Although biodiversity importance plays a role in site selection, economic needs (opportunity costs) are given priority.

- **Scenario 3. Biodiversity/economic compromise** blends scenarios 1 and 2.

The three types of costs (establishment, management, and opportunity) are then projected for each of the three scenarios, including considerations of how costs might evolve. Because of the available data and data models, the projected costs typically refer to terrestrial protected areas (TPAs), which are often state-owned, rather than PCAs, which often have non-state or alternative ownership and management structures. However, "PCA" is used when appropriate to describe marine and terrestrial protected areas and protected area systems post-2030.

Note that this study differs from many previous studies of 30x30, as it projects protections for exactly 30 percent of each country's land area and 30 percent of the exclusive economic zone (EEZ) in each country that is not landlocked.

Main Results

The most important results per type of cost follow, but additional results are found in each chapter.

Establishment Costs

When aggregating at the regional level, the highest explicit costs for 30x30 are potentially the **terrestrial establishment costs**. This is because a large expansion of PCAs could imply purchasing millions of hectares of land to create new parks, and land prices of thousands of dollars per hectare are common in LAC. However, the final establishment cost may be much smaller if a large proportion of 30x30 can be achieved without land purchase. For example, some new PCAs may already be on government land. Land purchase for cases where Indigenous peoples and local communities (IPLC) have freely agreed to have their lands included in 30x30 would also be unnecessary (and inappropriate). **Marine establishment costs** for 30x30 are very small in comparison (often less than US$1million per country), not least because ocean areas do not need to be purchased to create marine protected areas (MPAs).

Management Costs

Terrestrial management costs of 30x30 vary widely across LAC countries, from US$1 million per year in Guyana to over US$2 billion per year in Brazil. Costs are strongly driven by local pressures, such as from the potential agricultural value of the protected land, because natural land with high economic potential is costlier to defend (and more likely to be encroached upon). The effect of economic potential on cost also depends on the national context: PCA system costs are higher if expansion of the system implies setting aside some of the last remaining land in the country suitable for agriculture or development, such as in Chile, Colombia, or Ecuador.

Marine management costs of 30x30 are much more modest than terrestrial costs, such as US$153 million–US$245 million per year for Brazilian MPA systems (against the US$2 billion TPA cost). Beyond the obvious effect of system size influencing cost, MPA costs are mainly driven by GDP per capita in nearby coastal regions, which increases pressures and input costs for local MPA managers, and the relative fisheries catch available in the MPA vicinity, which increases pressure from fishing vessels on the MPA. Allowing limited fishing in MPAs significantly increases costs because managing detailed regulatory compliance across thousands of small fishing vessels is more costly than simply declaring and enforcing a no-take zone. However, some of the no-take cost advantages may be lost if strict regulations are imposed without stakeholder consultation, because infractors may largely continue as before but in harder-to-detect ways.

Notably, over time, all management costs will typically fall as a percentage of GDP, even if they increase in simple terms.

Opportunity Costs

Terrestrial opportunity costs from 30x30 are minimal in many LAC countries. This may seem counterintuitive, but it arises because PCA creation on land redirects future agricultural expansion toward land that is not so biodiversity-critical, often with little loss of profit. In countries where alternative lands for agriculture exist, opportunity costs from PCA creation can indeed be zero. But in countries where there are few land alternatives for new agriculture, such as in Chile, Colombia, or Ecuador, opportunity costs can be very high.

Marine opportunity costs can be extremely high initially, as they could potentially reduce fisheries catches from 2030 to 2035 by thousands of metric tons per year in many LAC countries. That temporary economic shock occurs because new MPAs can directly impinge upon areas that are already used for fishing, confining the fishing effort to a smaller ocean space. However, from 2040 or 2050 onwards, a benefit is projected, often considerably larger than the original loss, as fish stocks recover in MPAs and fisheries profits increase to higher levels. If MPA protection levels are strict, both the initial shock and the long-term benefit are larger in magnitude. Some of the initial loss in catch could be offset by increasing prices, but it is important to note that because most of the market price is determined outside LAC (and especially in Asia), LAC-specific profit effects cannot be calculated in a regional study.

Policy Implications

The primary policy implications per cost type follow, but additional policy implications are found in each chapter.

Establishment costs. To mitigate the very high costs that would arise if land had to be purchased for multiple new parks, governments can identify where high-biodiversity unprotected land might become part of 30x30 without the need for land purchase (for example, public land, or, when the community freely agrees, IPLC land). However, it is important not to locate new PCAs on solely where land is inexpensive. The cheapest land can often have a low-biodiversity value (e.g., remote deserts), which does not fulfill the Target 30 commitment to protect lands with biodiversity importance.

If establishment costs are still high after seeking lower-cost options, then concessional finance (borrowing at favorable rates for globally important programs) may be necessary. International donors may also need to help with these costs to avoid adding further public debt.

Management costs. Terrestrial management costs for adequately implementing 30x30 may be high, but if they are not met, 30x30 will simply create "paper parks"[2] that fail to achieve their biodiversity objectives (so they may effectively waste money). Finance solutions should therefore be sought for proper, consistent funding of the TPA network.

For large countries such as Brazil, large terrestrial costs can be accepted as consistent with a large system size. However, costs can also be high in some countries with less extensive needs (Chile, Ecuador, and Uruguay) because protecting 30 percent of their area would disproportionately reduce the stock of future agricultural land, putting particularly high pressures on the system. In such countries, placing some new PCAs in wilderness areas rather than species-rich areas would greatly reduce costs. However, biodiversity conservation is usually understood as conserving areas rich in species, so using such wilderness approaches may attract some criticisms.

Throughout LAC, marine management costs are low enough to allow governments to embrace fully funded conservation of marine high-biodiversity areas with few financial reservations.

Opportunity costs. Terrestrial opportunity costs in many countries are low or zero, contradicting the common intuition that PCAs harm economic output. Historically, this intuition has caused governments to place much of their PCA system on remote, unproductive land, away from people and their economic actions. However, this study's

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[2] Paper parks are areas with a mismatch between protection status on paper and the ground. They are legally designated but ineffectively managed.[13]

results indicate that in most cases, placing new PCAs closer to people would bring few of the expected costs but many benefits, as both ecosystem services and tourism values depend on proximity to people. To maximize net economic gain from 30x30, countries should scientifically assess their opportunity costs, compare them to benefits such as tourism and ecosystem services, and where appropriate, place PCAs much closer than expected to where people live.

There are winners and losers, however, suggesting a need for a more equitable approach than a universal 30 percent allotment. Countries with little new land for agriculture have disproportionately high opportunity costs when trying to protect a full 30 percent of national territory. Preventing the conversion of the few remaining areas available would also increase food prices throughout the region, and without an obvious gain for regional biodiversity outcomes. It may be worth exploring a system where such countries are allowed to conserve less than 30 percent for the benefit of regional food security, perhaps with offsets by other countries conserving more than 30 percent (especially if they have extensive land of biodiversity importance).

Marine opportunity costs. Allowing fishing in MPAs has been the primary strategy for reducing marine opportunity costs. This indeed reduces short-term fisheries losses when 30x30 is first implemented. However, this study's results indicate that if governments wish to capture the full, long-term benefits of 30x30 to fisheries, fully protected MPAs often give better outcomes. Allowing extensive fishing (also called exploitation) of MPAs now will sabotage the chance of large future benefits. It may therefore be more economically efficient to implement stricter MPA protection now, while compensating fishers for their short-term losses, so that fisheries stakeholders can attain the larger economic benefits of such protection in the medium term. Otherwise, many fishers may struggle to remain profitable by mid-century, because the continued high levels of exploitation and ocean warming are causing fish populations to decline too quickly.

Introduction

The 196 signatory countries of the GBF, including all LAC countries, have committed to a set of international biodiversity targets,[1] among which is Target 3, to conserve 30 percent of land and sea for nature by 2030[3]. This target signifies a major increase in conservation ambition—representing an approximate doubling of terrestrial PCAs and an approximate quadrupling of MPAs.[2] It also acts a key pillar of attempts to mitigate the global biodiversity and climate crises,[2,3] because the speed at which species and ecosystems are being lost remains very high.[4–6] For example, the *Living Planet Report 2024* shows that since 1970, LAC has experienced a 95 percent decline—the worst of any region—in species' populations, caused primarily by habitat loss and overexploitation.[6,7,8]

A growing number of studies have also emphasized that nature is a key part of the economy, with over half of all global GDP (>US$50 trillion/year) being highly or moderately dependent on nature,[9] including such basic economic needs as the provision of food, fiber, fuel, and building materials for human needs (i.e., provisioning services).[9,10] Nature tourism and recreation (ranging from tours of the Amazon or the Mesoamerican Reef, to local parks and unspoiled coastlines) is one of the fastest growing leisure sectors globally,[2,11–17] and the importance of these green spaces seems likely to increase as more and more human beings come to live in cities.[18] Ecosystems, such as forests, wetlands, and mangroves, are also fundamental to providing clean water, flood protection, and coastal security (i.e., regulating services), and they do this at a much cheaper cost than technical equivalents such as filtration plants, flood defenses, building concrete barriers along long expanses of coastline, and high insurance premiums.[10]

Because the global economy strongly depends on nature, it follows that its loss and depletion is likely to cause financial losses on a very large scale. For example, mangroves act as effective storm-surge barriers, so the removal of mangroves from coastlines can lead to salt water flooding of buildings, agricultural fields, and energy infrastructure, threatening the value of financial investments, increasing the risk of loan defaults, and raising risks for insurance and reinsurance companies, as well as causing economic losses to local businesses and inhabitants.[19,20]

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3. "Ensure and enable that by 2030 at least 30 per cent of terrestrial and inland water areas, and of marine and coastal areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures, recognizing Indigenous and traditional territories, where applicable, and integrated into wider landscapes, seascapes and the ocean, while ensuring that any sustainable use, where appropriate in such areas, is fully consistent with conservation outcomes, recognizing and respecting the rights of Indigenous peoples and local communities, including over their traditional territories."[1]

Much of an area's local weather and rainfall also depends on the state of nature in the area.[21] For example, tree cover reduces extreme temperatures, diminishing water stress[1] and the need for energy-intensive cooling systems.[22] Large tree-covered areas such as the Amazon generate up to 50 percent of the rainfall and moisture needed to sustain South American agriculture and commodity production (including the beef and soy production that drives a substantial portion of the region's export economy).[23–25] Natural environments also play a key role in mitigating and slowing climate change,[26,27] which itself threatens to reduce GDP by 5 percent every year, according to the ***Stern Review on the Economics of Climate Change*** (hereafter, Stern Review).[28] Central Banks, financial institutions, and major insurers, who between them manage trillions of dollars, have therefore been urgently assessing their exposure to the negative impacts of nature loss.[19,20]

While global economic and financial systems derive a monetary benefit from conserving nature, and humans gain non-monetary benefits from nature, land and sea conservation also has costs. There are three main types of cost, most of which are immediate or short term. The first two are explicit costs: (a) the management of new PCAs, which mostly falls to public budgets,[29] and (b) one-off establishment costs whenever new PCAs need to be created.[2,30] The third type of cost is implicit, because conserving an area implies opportunity costs for some affected economic sectors.[2,31,32] For example, conserving a forest implies that forestry industries can no longer exploit the timber there at will, or that cattle ranching can no longer fell the forest to expand the area of pasture for their operations. In some cases (and particularly in marine spaces), a new PCA or MPA may even imply that existing economic activity, such as fishing, has to move out of the area and find alternative sites for commercial exploitation.

Irrespective of the predicted long-term benefits of nature conservation, the basic problem is that these short-term costs are typically more visible and more certain, and, therefore conservation action can be sometimes be more difficult to justify on political timescales (which prioritize the short term over the long term).[33–36] Further, even though robust ecosystem service valuation models exist (for example SEEA, InVest, or the IDB's Open IEEM), the true value of nature may not be reflected in national accounts or in decision-making.

Also, governments may simply have insufficient fiscal headroom to cover the additional expenditure needed for 30x30. The scale of the funding difficulty in developing countries has been addressed in part by the COP15 commitment for wealthier donor countries to provide US$30 billion per year of international assistance, by 2030, for the GBF targets.[1] Yet increasing environmental expenditures may require transferring money from other social priorities, which generates opposition, particularly if large proportions of constrained budgets are already earmarked for other social needs such as health, education, and support for low-income families. Nor are most governments likely to ignore the potential economic downside from opportunity costs, no matter how short term, to their key national industries. These opportunity costs can also lead to intense political opposition from important industries or increased noncompliance with environmental restrictions.

Uncertainty around possible costs can be even more of a barrier to action. For Target 3, there is something of a worst-case combination: certainty that costs must increase under 30x30, paired with major uncertainty about how large those increases may be. This sense of an unpredictably large downside is psychologically demotivating for individuals and governments alike. Moreover, the vacuum in information about cost-related risks is often filled by estimates that may be unreliable for a number of reasons, ranging from commercial interests (relating to opportunity costs) to risk aversion (using high-side estimates out of a sense of precaution).

The key point is that if short-term costs are a barrier to action, then uncertain or overestimated short-term costs are an even bigger barrier. When decision-makers debate how to implement the 30x30 commitment in national legislation, the key first step is to have information about the broad possible cost of that implementation, and even the relative costs of different options. Projections of costs for individual countries are also valuable in guiding international assistance and philanthropy efforts around the GBF, including the US$30 billion per year from wealthier countries. Similarly, opportunity cost projections support policy planning that addresses the whole-economy consequences of GBF commitments, allowing governments and international development agencies to collaborate to manage the broader economic changes caused by 30x30.

To provide some of the foundational information necessary for policy development, this study uses a range of economic models to project the costs and economic implications of expanding protected areas in LAC to 30 percent of land and sea.[4] Because the specific ways in which most countries plan to implement 30x30 are unknown, the projected costs represent approximations, especially at the level of individual countries. Nonetheless, the approximations provide a reliable starting point because they are not estimates tied to only one specific, future pathway that may never occur. Further, the scenarios and cost approaches are conceptually designed around the fuzzy approach,[37,38] so the projected estimates remain reasonably valid and informative regardless of the uncertainty in multiple elements of future decision-making and any policy decisions that diverge from the 30x30 scenarios used to generate them.

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[4] Argentina, The Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, and Venezuela.

BOX 1 The Three Types of PCA Costs

In this report, PCA estimates are derived from three types of costs: management, establishment, and opportunity.[31]

Management costs are the repeated, annual operational costs of running a PCA (or a national protected area system). They can represent individual cost lines for many activities that managers carry out, such as patrolling, community outreach and livelihood support, visitor management and access, office costs, and species and ecosystem management, among others. For a national system, they also include the central costs for processes such as high-level coordination and payroll.

Establishment costs are the one-off costs involved in creating a new protected area. The acquisition of land rights is by far the largest component of this cost for TPAs (with non-purchase incentives such as conservation easements also having high cost).[48] However, establishing a new protected area implies other, highly varied activities such as legal costs, setting up signage, or informing and consulting with the local community. In the few studies that report such costs, it is not always clear precisely which activities are being included under the term "establishment." For example, transaction costs may apply to many of the legal activities involved, but it is unclear how far they are included in cost estimates.

MPA establishment costs, which do not require a purchase, are typically smaller.

Opportunity costs refer to the potential benefits that might have been enjoyed by an industry (or actor) but cannot be realized because an area is declared protected. The benefits most typically studied in the literature are the economic ones, such as forgone income-earning or revenue-earning potential. Notably, these analyses of opportunity costs usually address impacts on a single economic sector, and so are partial estimates only, capturing the point of view of individual stakeholders or sectors. For example, commercial forestry may become the topic of an opportunity cost analysis because commercial foresters may experience opportunity costs when a forest is protected. But from an all-of-economy perspective, protecting nature generates both winners and losers, and it is important to try to assess the balance of all interests involved. Even so, particular industry sectors, such as agricultural sector or fisheries sector, often enjoy political prominence due to their economic and food security importance, and are therefore a frequent subject of opportunity cost analyses.

In most cases, this report specifically addresses new costs to attain 30x30. For example, it does not attempt to retrospectively define establishment costs for PCAs that have been in existence for many years, and it does not seek to quantify the economic benefits of protecting 30 percent of each national area. Previous studies have quantified benefits of different approaches to 30x30 (see references 2 and 39), and where appropriate, the projected costs in this study are compared to those benefits in a more qualitative fashion. Note that there is significant work being done separately by the IDB and others on PCA-driven economic benefits.[2]

For costing purposes, a full range of possible management approaches (and ownership structures) to protected areas, PCAs, and MPAs is used for all types of conservation areas. In the past, most PCAs have been run by state or parastatal authorities, carrying out activities such as patrolling, community relations, species and ecological management, and, for many PCA managers, a number of cash-generating activities such as concessions or entry-ticketing booths.[40] However, alternative, non-state ownership and management structures such as community reserves, ICCAs (Indigenous community conserved areas),[41] and OECMs (other effective area-based conservation measures)[41–43] all have an explicit and important potential contribution to 30x30 that is recognized in the GBF and in this report.

Recent GBF discussions[44] address the opportunity to further involve IPLC in 30x30. Embracing this opportunity could imply various new or different costs for governments and other principal funders, ranging from simple financial recognition of PCA management activities carried out by IPLC actors, to financial support to maintain the very ways of life and cultural traditions that often underpin a long-standing history of ecological stewardship by IPLC. The difficulty, however, is that there is still no robust way of modeling the potential costs of Indigenous conservation areas or OECMs for multiple countries in a large geographic region. Of necessity, this report therefore uses the existing data on protected area budgets as the basis for statistical modeling, and then comments on how the cost outputs could vary if a proportion of the new PCAs needed by 2030 are in classes such as ICCAs or OECMs.

Any discussion of IPLC involvement in 30x30, even from a costing point of view, also needs to acknowledge that protected-area expansion can adversely impact IPLC if it is not implemented in a way that respects their rights and livelihoods.[3,45–47] Even after a broad rights-based and FPIC-based (free prior and informed consent) approach has been implemented, it can still be necessary to agree detailed arrangements for shared-objective land uses.

IPLC can also experience benefits as well as costs from PCAs, just as national economies can see both benefits and costs from expanded nature protection. For example, classing an area as protected forest could help protect a traditional way of life for forest-dwelling human groups by giving them powerful state allies to resist powerful external actors such as loggers or developers. Again, this potential benefit is realized only if the authority that creates the forest reserve also formally respects the rights of the forest inhabitants to their way of life inside the reserve. More generally, any benefits that these groups experience from expanded nature protection, including benefits from possible additional funding for involvement in 30x30, need to be balanced against the potential downsides, with the balance (and conclusions drawn) likely to be different for every individual group affected.

The remainder of this report proceeds as follows: Chapter 1 explains the research approach and the scenarios used for the 30x30 cost modeling; Chapters 2 through 4 discuss MPA management costs, establishment costs, and opportunity costs, respectively; and Chapters 5 through 7 discuss TPA management costs, establishment costs, and opportunity costs, respectively. Each of these chapters discusses methodology in an appendix called "Appendix Methods."[5] The second to last chapter discusses the IDB support for LAC countries working toward 30x30, and the final chapter concludes the report.

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[5] All calculations in this publication are made by the authors, which is why there are no sources after each figure or table in this report.

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Research Approach: Using Scenarios to Project 30x30 Costs in LAC

To project the future costs for implementing 30x30 in LAC, it is necessary to assess the three types of cost associated with having 30 percent TPA and MPA coverage: management costs, establishment costs, and opportunity costs. Yet each of these costs depends on where the areas are located and how they are managed. For example, the enormous variability of land prices means the purchase cost of a new park or nature reserve strongly depends on location. Similarly, management approaches inform management costs, so an MPA that allows some fishing has considerably higher management costs than those that do not, because of the burden of enforcing complex catch and fishing gear regulations.[1] Likewise, opportunity costs depend on whether a TPA or MPA's area has high economic value, such as high-value agricultural or fishing areas, if not protected.

Such cost factors may explain why so many of today's TPAs are in deserts, on mountaintops, or in areas far from productive agricultural heartlands.[2,3] And they may explain why marine opportunity costs are as strongly influenced by management approach as by location: many MPA system managers follow the widespread practice of allowing unrestricted commercial, extractive fishing inside MPAs, albeit with some restrictions.[4] To avoid such paper parks, where what is being protected is of minimal natural value, it is important to cost out systems such as 30x30 regardless of the economic value of the land or knowledge of how they will be managed.

Since these cost projections are often needed well in advance of location decisions being made, and often as guides to the decision-making process itself, this study avoids the problem of missing inputs for projection models by using scenarios. Three scenarios were developed to provide essential inputs to the model and allow for a range of outputs on possible costs and how the scenarios designs affect the costs,[5,6] and each scenario is then applied to terrestrial and marine areas.

Multiple authors have shown that it is possible to develop statistical models that predict protected-area finance needs with high degrees of accuracy (despite the high variability in management costs and financial needs).[19 -21] However, most of these predictive models relate to the cost of an individual protected area,[22-23] whereas 30x30 implies entire national PCA systems made up of multiple individual PCAs, in an unknown configuration. Using models designed for individual protected areas to cost entire national PCA system expansions presents significant difficulties. Not only would the (unknown) characteristics of every single new PCA need to be assumed, but variation in those (hundreds of) assumptions also causes very large variation in national cost estimates.[24] This report therefore uses instead the predictive model in Waldron et al.[20], whose models have the advantage that they generate direct estimates for entire national systems in the future, based on statistical analysis of historical reports of the finance needs for entire national systems.

To capture the broad political and economic trade-offs between economic and biodiversity priorities, scenario 1 always focuses purely on biodiversity protection, ignoring all other economic considerations such as opportunity costs. Scenario 2 always seeks to preemptively avoid future economic downsides when creating new PCAs, or at least minimize the downside. In other words, scenario 2 prioritizes avoiding opportunity costs as much as possible. Scenario 3 is always a compromise between scenarios 1 and 2.

A baseline is also provided for each realm. The baseline represents the configuration of PCAs (including TPAs and MPAs) as of 2025 and acts as a counterfactual to the three scenarios. Having a counterfactual reveals opportunity costs, which are the difference between 30x30 and the baseline, and provides a reference point for establishment costs, since the cost of future 30x30 expansion does not include the historical cost of establishing the present PCA system.

The scenarios therefore represent the operational realities of terrestrial and marine PCAs after 2030. To operationalize terrestrial scenario 1, which aims to protect the areas in each LAC country with the highest biodiversity and no current protection, it is plausible that TPAs would be established in areas with relatively intact natural ecosystems, such as forests. Then, to avoid protecting forests that will later be converted to agriculture, scenario 2 excludes protection for land that will be needed for future agricultural production while otherwise protecting high-biodiversity areas. And since it would be unusual for new TPAs to be established on land that has already been put into intensive agricultural production, scenario 3 places some but not all future agricultural land out of reach of TPAs and otherwise protects biodiversity as before. Overall, the majority of new TPAs can be expected to be in areas of unconverted natural habitat.

Applying the scenarios to LAC's marine realm is not so straightforward. It is wholly possible to create new marine parks in ocean areas where fishers are currently operating—the marine equivalent of an intensive agricultural field. This means that scenario 1, which strictly bans any major extractive use, can cause immediate economic harms to any fishers that happen to be operating in those marine spaces in 2030, 2035, 2040, and beyond.

Moreover, the mobility of fish and fishers makes it infeasible to create an equivalent of the terrestrial scenario 2. It would be infeasible (and inadvisable) to define "areas where fishing will expand its area of operation after 2030" and assume that these will be static throughout time in a moving ocean. Avoiding future fishing areas is therefore not practicable. Nor does it reflect the different nature of marine conservation. Given the impracticability of defining static ocean areas, the MPA scenarios instead operationalize scenario 2 by adopting the same practice used by current MPA system managers: allowing some fishing in MPAs. Scenario 2 therefore allows 50 percent of the MPA area in each country to be sustainably fished (see Chapter 4 for how this is operationalized in practice in cost modeling). This approach uses models that may not precisely define which 50 percent of the MPA will produce the outputs. In other words, policymakers could make a wide variety of choices about where to allow fishing without affecting the cost projections to any major degree, which will be discussed further in the chapters on marine costs.

The marine area of each country is also unusual in that the relative vulnerability of different human groups to opportunity costs has a highly distinctive spatial pattern. The most vulnerable fisher groups are small-scale fishers, who almost entirely operate closer to shore (inshore, or EEZ areas), because of small engine and boat capacities.[7–10] The more distant, offshore areas (international waters) are almost entirely used by much larger industrial actors, such as large fishing vessels.

And finally, for MPAs, scenario 3 demonstrates a particular vulnerability. It allows sustainable fishing (which would automatically include most small-scale fishers) in 50 percent of the inshore MPA area, providing an equal mix of inshore areas where important nurseries are protected and where current ocean livelihoods can still be pursued normally. The remaining, unprotected 70 percent of the inshore part still remains available for free-access fishing, and indeed livelihood-based use in general. The biodiversity side of the compromise is then expressed in the offshore part, by asking industrial vessels to fish in only the 70 percent of the offshore area that is defined as open access and avoid the 30 percent that represents critical areas for marine biodiversity (including sea mounts, for example).

1.1 MPA Scenarios

Chapters 2, 3, and 4 discuss the three types of costs to attain 30x30 in marine areas, and Table 1 summarizes the scenarios used to model those costs.

TABLE 1 The Three MPA Scenarios

SCENARIO NAME	DESCRIPTION
None (counterfactual)	The baseline for the three scenarios uses the MPA configuration as of 2025 and assumes no future expansion. Existing MPAs are modelled to receive the fully adequate level of funding. Existing MPAs that are not currently fully highly protected, are assumed to achieve medium protection (sustainable exploitation). Existing fully highly protected MPAs are assumed to have effective high protection.
SCENARIO 1 **Biodiversity priority**	MPA coverage is extended to 30 percent of the EEZ and prioritizes very stringent conservation: no exploitation (fishing) is permitted in existing and new MPAs, which are added in places with the highest biodiversity importance. The remaining 70 percent of the EEZ is still open-access (for exploitation).
SCENARIO 2 **Economic priority**	MPA coverage is extended to 30 percent of the EEZ but prioritizes economic needs. Half of the MPA (15 percent of total EEZ area) prohibits exploitation (fishing), but the other half (15 percent) allows sustainable exploitation. The remaining 70 percent of the EEZ is still open-access (for exploitation), so 85 percent of the EEZ allows some type of exploitation.
SCENARIO 3 **Biodiversity/ economic compromise**	MPA coverage is extended to 30 percent of the EEZ and allows a trade-off between economic and conservation needs. The trade-off favors more vulnerable human groups. In inshore areas, 50 percent of the new MPA area is modelled as high protection, and 50 percent as medium protection (where small-scale fishers typically operate), allowing exploitation in half of the areas but reserve the other half for conservation. Existing MPAs preserve their current protection level. Offshore MPAs, where industrial fleets typically operate, become no-take/conservation areas, excepting any existing offshore MPAs that are not fully highly protected retain their existing classification. The remaining 70 percent of the EEZ is still open-access (for exploitation).

1.2 TPA Scenarios

Chapters 5, 6, and 7 discuss the three types of costs to attain 30x30 in terrestrial areas, and Table 2 summarizes the scenarios used to model those costs.

TABLE 2 The Three TPA Scenarios

SCENARIO NAME	DESCRIPTION
None (Counterfactual)	The baseline for the three scenarios uses the TPA/PCA configuration as of 2025 and assumes no future expansion.
SCENARIO 1 **Biodiversity priority**	The current TPA system is expanded to reach 30 percent of land coverage by adding the most biodiverse unprotected grid cells in the country, in rank order and without consideration for economic consequences. As far as possible, 30 percent of each biome in each country is covered.
SCENARIO 2 **Economic priority**	The current TPA system is expanded to reach 30 percent of land coverage while prioritizing rural economic needs. Rural areas of natural habitat in the country that are projected to be optimal for future agricultural expansion needs cannot be protected. With those areas masked out, grid cells are added to the existing TPA system in order of species diversity as before, until 30 percent coverage is reached. As far as possible, 30 percent of each biome in each country is covered.
SCENARIO 3 **Biodiversity/ economic compromise**	The current TPA system is expanded to reach 30 percent of land coverage while compromising on biodiversity and economic needs. One-third of the rural area of natural habitat in scenario 2 (the top third on the basis of potential agricultural production) are masked out and cannot be protected; once that is done, grid cells are added to the existing system in rank order of biodiversity as before. As far as possible, 30 percent of each biome in each country is covered.

1.3 Appendix. Methods

This appendix discusses the methodology for determining the three scenarios for MPAs and the three for PCAs.

1.3.1 MPA Scenarios

Unlike on land, where PCAs are not generally established in areas of intensive production, it would potentially be impossible to find a large enough area of ocean that is not yet exploited and could be used to meet the need for the several million square kilometers (km) of ocean that are needed to achieve 30 percent MPA coverage per country. Furthermore, fish stocks themselves are highly mobile, making it hard to define a static area for post-2030 fishing to expand into. Consequently, the marine scenarios in this report approach the trade-off between economic need and biodiversity value by using a common strategy that is already in use: variation in the level of fishing allowed inside different MPAs.[4]

A further concern for developing countries with ocean-based economies is the economic vulnerability of small-scale fishers, such as artisanal fishing groups. The majority of national fisheries GDP comes from industrial fishing fleets, but in some countries, a large number of economically marginal fishers such as small-scale fishers also depend heavily on fish for protein and income. Small-scale fishers generate only a small part of the total fisheries contribution to the GDP,[15] but the impact of any loss of fishing livelihoods upon them could be very large. Typically, Small-scale fishers lack the capital and technical capacity to replicate the long-distance, multiday offshore fishing excursions that industrial fleets are capable of. They therefore cluster spatially in the inshore area.

The consequence of this spatial arrangement is that inshore MPAs are likely to have disproportionately large effects on small-scale fishers, whereas more offshore MPAs are likely to primarily affect industrial fishing fleets. The scenarios therefore vary the levels of fishing allowed in ways that reflect this offshore/inshore disparity in economic vulnerability.

As shown in Table 1, scenario 1 (biodiversity) focuses entirely on protecting the ocean areas of highest biodiversity importance, irrespective of economic consequence or costs. Scenario 2 (economic) allows the highest level of fishing of all the scenarios, composed of sustainable fishing in half of all MPAs (15 percent of the EEZ) plus unregulated fishing in the open-access area (70 percent of the EEZ, totaling 85 percent of fishable EEZ area). Scenario 3 (compromise) allows this same high level of fishing (85 percent total) in inshore areas, where small-scale fishers are more likely to operate, but imposes no-take rules in any new offshore MPAs, mostly affecting industrial fleets.

All three scenarios begin from the current extent of MPAs (downloaded from the World Database of Protected Areas), then expand the system in each country to achieve 30 percent coverage of the EEZ. The authors first divided the EEZ into cells of 1 km^2 and identified which cells were already protected.

To select additional cells to reach the 30 percent coverage goal in each LAC country, the authors started from the biodiversity-priority spatial layer from Sala et al.,[16] which provides a ranked raster of conservation values for each grid cell in the global ocean. Specifically, the authors identified which grid cells would be most effective at achieving multiple biodiversity conservation goals, including minimizing species extinction risk, maintaining diverse species traits in ecosystems, and preserving the evolutionary history of marine life, while ensuring biogeographical representation. Each cell is given a biodiversity ranking, which indicates the highest-ranking cells up to the 30 percent target.

The Sala et al.[16] ranking system uses equal-area cells of ~3,000 km^2 (i.e., grid cells of ~54.8 km on each side), and some of these will span the boundary between an EEZ and the high seas. The authors therefore downscaled the original rasters to 1 km resolution and clipped them to the borders of EEZs. (Spatial EEZ outlines are taken from the World EEZ v11 product at marineregions.org.) The authors then added 1 km cells to the existing MPA system in order of their cell values. If, in the last iteration of this addition process, the cropped 3,000 km^2 cell with the next highest value contained more 1 km cells than were needed to achieve 30 percent target, the authors preserved contiguity between cells in space (to reflect political and operational realities) by adding the 1 km cells contiguously in a west–east direction until the 30 percent target was reached and discarding the remainder. The spatial output from this process is referred to as the "Sala et al. base layer for 30 percent protection per country."

To create the three scenarios, the authors adapted the Sala et al. base layer in three ways, reflecting the three overall scenario concepts. The authors first defined two standardized levels of protection/strictness. The first category is "high protection" areas, which exclude all fishing exploitation (similar to Horta e Costa et al.'s Fully Protected Area category,[17] also called "no-take areas"). The second category is "medium protection" areas, which allow a low/sustainable level of fishing (similar to Moderately Protected in Horta e Costa[17]).

For scenario 1 (biodiversity), all Sala et al. base layer cells were assigned high protection status, including MPAs that already exist. To create scenario 2 (economic), the authors divided the entire base layer (per country) evenly between medium and high protection (i.e., 50 percent of each level of protection in the offshore part, and the same in the inshore part). For scenario 3 (compromise), the authors used different rules in the offshore and inshore parts. In this latter areas where small-scale fishers are likely to operate, 50 percent of the MPA area was given medium protection (which allows fishing) and 50 percent was assigned high protection. In the more distant offshore areas where vulnerable small-scale fishers are less likely to be found, all new MPAs added to achieve the 30 percent goal were assigned high protection; however, MPAs that already exist but currently allow fishing were assigned medium protection, and MPAs that already exist and are currently no-take areas (a minority) were assigned high protection. For the reference scenario, the authors allocated high protection to all current MPAs classed as Fully/Highly Protected in Sala et al.[16] and medium protection to all other current MPAs.

Some current MPAs have insufficient protection to be classed as medium protection (for example, they may still be unsustainably fished), and this is often associated with very large funding shortfalls for their management.[18] In these cases, the baseline itself should be regarded as an ambition for the future, in which all current MPAs are fully funded and each can successfully achieve either sustainable exploitation or high protection, depending on the wishes of the respective MPA authorities.

It is important to note that scenario design and cost models do not represent the final likely decision with any certainty. They are merely used because an illustrative set of PCAs is needed to be able to run cost models. Additionally, the scenarios and models need to be designed so that they do not become invalid and uninformative if decision-makers move away from the scenario. Although it is common for scenarios to very precisely imagine a set of MPAs, of exact size and placement, such an approach runs a particularly high risk of producing misleading cost estimates if the decision-maker diverges from the precise scenario.

The research protocol for this report is explicitly designed to apply a fuzzy approach so that cost estimates remain valid and informative under several possible future decisions (and not merely for the very specific conditions of the scenario itself). In this study's approach, the costing models have been designed so that protection is imagined at broader spatial resolutions. Even if the scenario rasters themselves suggest certain sites for protection, the models generally interpret those sites at much coarser resolutions (as will be discussed in other chapters).

Consequently, variations in local PCA site selection for the scenarios will often generate the same set of projected costs, or at least very similar projections. This leaves national authorities with the ability to make the final decision about where to implement 30x30 spatially while generating a reasonable projection of the likely costs and consequences of their decision.

1.3.2 TPA Scenarios

For the terrestrial realm, scenario 1 (biodiversity) simply captures the most unprotected biodiversity possible. Biodiversity is multidimensional (measured in many different ways, with each way giving a different spatial pattern of how biodiversity is distributed). However, the scenarios are intended to broadly approximate possible pathways to policymaking decisions (see Table 2). The authors assumed that if governments in LAC wish to focus on protecting high-biodiversity areas when adding new TPAs, they might use fairly straightforward maps of biodiversity, such as heat maps of species richness, to define where "unprotected biodiversity" lay in their countries.

Given the small size of some of the countries, a high-resolution map of species richness is needed. The authors used a high-resolution spatial layer of the total species richness for all mapped birds and mammals[11] as a fine-scale approximation of the biodiversity importance of each terrestrial area in each country. The authors started by downloading and merging the separate rasters for each taxon to generate a single spatial grid of species diversity, in which the grid cell values are ranked from most diverse to least diverse.

In theory, new TPAs in scenario 1 might simply be positioned on the highest-ranking, unprotected grid cells until 30 percent coverage is reached (perhaps adjusting so that individual protected areas remain as contiguous as possible). The authors indeed started from this principle, sorting raster cells for addition to national 30x30 areas by rank order and adding a spatial programming adjustment to maximize cell contiguity.

However, using national-level species diversity cell rankings will tend to focus entirely on the highest-biodiversity biomes and generate little protection for less species-rich biomes. For example, in Brazil, raw species diversity would prioritize the Amazon (a high-diversity rainforest) and deprioritize more arid lands such as the Cerrado (a biodiverse tropical savanna). This would lead to underrepresentation of many biomes, contradicting the "representativeness" requirement in GBF Target 3.

The authors therefore applied the 30 percent requirement within each country at the scale of national biomes, allocating the land area that needs protection in proportion to the percentage coverage of each biome in the country. Wherever current biome-specific PCA coverage fell short of its target value, additional PCA grid cells were added nationally in order (from highest to lowest diversity) until the coverage target was reached. Where ties existed, priority was given to cells that adjoin a protected cell, to minimize the probability of very small individual parks being created and ensure connectivity. To define biomes spatially, the authors used the Olson et al. WWF Ecoregions.[12]

Scenario 2 (economic) starts by defining areas of each country where the creation of new PCAs is likely to conflict with areas that will be needed for future conversion to agriculture, in order to meet future demand for agricultural commodities. This procedure focuses on the fact that new protected areas would typically be created in intact natural areas, for which the competing future land use would be agriculture. The authors used the Asia-Pacific Integrated Model (AIM)[13] projection of the areas that are most likely to be converted to agriculture by 2050, taken from Waldron et al.[5]

In building the scenario, those areas were excluded from potential protection status a priori (by masking them out) before running the same pixel selection process for countries and biomes used in scenario 1. Ties were resolved in the same way. The scenarios are also relatively fuzzy in approach because the masked-out AIM cells are half-degree resolution, but the cell values in AIM indicate a proportion of the cell that will be converted in future. When high-biodiversity and high-agricultural importance coincided spatially in a half-degree cell, it was therefore possible to use part of the cell for biodiversity protection and the remainder for potential conversion to agriculture (with a maximum set on biodiversity protection of the cell proportion output by AIM).

Since complete half-degree cells are approximately 56 kilometers on each side (at the equator), this means that future agriculturalists and conservationists essentially have a broad choice of where conversion and biodiversity protection will happen in an area of over 3,000 square kilometers, without affecting the cost projections. Ties were resolved as in scenario 1, but this time also seeking to connect the protected cell fractions as extensively as possible.

In scenario 3 (compromise), areas for PCAs are chosen according to a mixed set of priorities, both biodiversity and economic. Earlier work on Target 3[5] found evidence that net agricultural output under a scenario of absolute biodiversity priority was often less than one percentage point different from net output under a scenario of absolute economic priority. At the same time, the ancillary benefits for people were considerably higher under a biodiversity priority scenario than under the economic priority one.[5]

Given this imbalance in upsides and downsides, the authors weighted the compromise in favor of the biodiversity priority by a ratio of two-thirds to one-third. This was operationalized by masking out from protection one-third of the land needed for future agricultural expansion in scenario 2, then adding cells to the protected portions of biomes and countries in rank order until 30 percent coverage was achieved (as in scenarios 1 and 2).

To guide the choice of which one-third to remove, the authors overlaid the AIM rasters with Carrasco et al.'s raster of net agricultural rent—a measure of the economic value that would be derived from the natural land if it is converted to agriculture.[14] Any residual ties arising when selecting AIM cell fractions with net agricultural rent rasters were resolved in favor of the cells with the highest biodiversity ranking.

2

Marine Management Costs

Each MPA may have a range of different activities, such as day-to-day patrolling, wildlife monitoring (and possible interventions), visitor management, and community relationship management, and each activity has a cost. The recurrent annual costs to manage an MPA are called management costs.[1,2] Most LAC governments will need to increase conserved marine areas in the near future to achieve 30 percent coverage of national waters, in line with GBF Target 3[3]—Chile and Colombia have already protected 30 percent of their oceans.[6] The scope of the necessary increases often implies a need for multiple new MPAs as well as higher funding levels than those relied on currently.[4–6]

At the national-system level, the addition of several new MPA management budgets, and the need to increase spending per hectare for both existing and new MPAs, could necessitate a large increase in government funds. To appropriately prepare public budgets and polices despite uncertainty about undecided MPA details such as location, management rules, or future pressures that could increase costs,[7] three scenarios (see Chapter 1 and Table 1) are used to explore the available options for the country's MPA system. Predictive costing models applied to those scenarios generate cost the requisite projections, as this chapter discusses.

Following previous research, this chapter projects the cost of *effective* operation rather than the cost of current operation, since current MPA budgets are generally too low to achieve basic management effectiveness.[4,5] The system cost will therefore have two components: the cost of effectively managing the basic requirements of all new 30x30 MPAs, plus the cost of bringing the budgets of existing MPAs up to a basic level of effectiveness.

2.1 Modeling MPA Management Costs

This study uses the Waldron et al. predictive statistical models of MPA management costs[7,8] to predict national-level system costs. The models are able to predict known costs with 90 percent accuracy ($R^2 = 0.9$), suggesting that they should perform well when applied to predict costs for unknown national systems. Also, the models have several apparent advantages over older models, which predict costs for individual MPAs well[1,9] but can potentially generate system cost predictions that are up to 10 times too high or low.[8]

Notably, the Waldron et al.[7,8] models applied in previous studies have found that MPA system costs decrease with system size (areal extent in km^2) but increase with two measures of coastal pressures on MPAs: mean GDP per capita in coastal areas that are close to MPAs, and the relative amount of fish that can be caught along the MPA boundaries (relative catch). For example, if an MPA is close to an economically vibrant coastal city with high GDP per capita, MPA pressures and MPA staff and input costs are both likely to be higher, increasing the

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[6] See World Database on Protected Areas at www.protectedplanet.net.

overall budget need. The relative catch term also makes economic sense. If an MPA is in a region of little fisheries interest (i.e., with few commercially valuable fish), then fishing vessels are unlikely to crowd around the MPA borders, and MPA managers do not need to carry out regular, intensive monitoring and patrolling. However, in an area of high fisheries value, much greater demands will typically be made upon MPA management teams, increasing their costs. These terms (size, local GDP per capita, and relative catch) subsumed all other terms tested, such as distance offshore or local human population sizes.

In addition, the Waldron et al.[7,8] models recognize that a greatly expanded system that will meet the 30x30 requirements is likely to protect a much larger portion of distant, offshore areas than has historically been the case. Those offshore areas present very different management propositions than inshore areas, both because of their remoteness and because they are mostly under potential extractive threat from large, industrial fishing vessels rather than the multiple small vessels that tend to operate closer to shore. Several long-distance or remote-monitoring management techniques may therefore be needed, and the technological options to achieve distant management control are developing rapidly.[12–18] In contrast, inshore areas (e.g., within 12 nautical miles of the coast), where many current MPAs are located, would retain many of the same management activities used today. The models therefore divide the national systems into inshore and offshore areas and apply different models to each to reflect the different management needs.

As Waldron et al.[7,8] also point out, previous cost models implicitly provided predictions for MPAs that had low levels of protection, whereas the 30x30 commitment stipulates that MPAs have high levels of protection.[3,19–21] Waldron et al.[7,8] therefore built in cost adjustments depending on the level of protection, based on a mixture of empirical observation and expert assessment. These cost adjustments for strictness of protection are particularly important for costing the scenarios, which have varying protection levels.

Previous modeling also suggested that MPAs that generate higher levels of site-based revenue (typically from having tourism operations) had higher budget needs. However, data on site-based revenue of national MPA systems is rarely collated, so the term could not be included in a full model and would not be useful in other applications of the model.

For this research, the models were applied to the three 30x30 scenarios to project the costs of each: Scenario 1 (biodiversity) focuses purely on biodiversity protection goals, scenario 2 (economic) allows industrial fleets and small-scale fishers to sustainably fish in half of the national MPA system, and scenario 3 (compromise) allows sustainable fishing in half of inshore MPAs (to focus on preserving the livelihoods of small-scale fishers) but imposes no-take fishing restrictions in new offshore MPAs (to preserve part of the marine ecosystem). The focus on small-scale fishers arises because social and economic groups can vary in their ability to withstand economic constraints and possible downsides: small-scale fishers operating nearer to shore are often economically marginal,[10,11] so they may be more severely affected by additional economic constraints.

Because the two main coastal-pressure-related predictors of cost—relative catch levels near the MPA borders and coastal GDP per capita—are likely to change between 2030 (the start year of 30x30) and the second half of the 21st century, the predictors need to be input into the costing model at regular intervals rather than just once. The results will show the evolution of management costs (and avoid the implicit assumption that costs in 2030 can be projected by using predictor values from today), even though the precise pattern of future change of these cost predictors into the mid-century and beyond is necessarily uncertain as a model input.

To address this uncertainty, three possible trajectories for the temporal change in the two MPA cost predictors are created by using shared socioeconomic pathways (SSPs), which are depictions of possible broad future pathways that human-environmental systems can take, that have been widely used in modeling future large-scale system changes.[23–27] For this research, three SSPs for marine environments (sometimes called "oceanic system pathways"[22]) are combined with three comparable terrestrial SSPs to describe the possible pathways for the evolution of the first time-sensitive cost predictor (GDP per capita in coastal zones). Possible trajectories for the second time-sensitive cost predictor (future catch) were modeled by using a global marine system model (BOATS, from BiOeconomic mArine Trophic Size-spectrum, which is discussed in Chapter 4) for this study's three scenarios, under three pathways of climate forcing and change in fisheries management.

Notably, these marine pathways include modeling of how future fisheries catches along MPA boundaries will change due a "spillover," which occurs when new, well-protected MPAs cause the fish stocks inside them to recover.[19,28–31] A point is reached when the more abundant stocks start to spill over from the MPA into the surrounding open-access areas. Spillover from MPAs can increase fisheries catches by as much as 84 percent in a small part of the open-access areas that lies directly alongside MPA boundaries.[28] Fishing vessels are highly aware that this happens, and that it can greatly boost their profits. Vessels therefore cluster in large numbers along the edges of MPAs with spillover (known as "fishing the line"),[19,28–31] generating greater challenges and costs for the MPA managers themselves. The costing models therefore track the interaction between time, spillover, and management costs.

Year-specific future predictor values were used as inputs to the predictive cost models at each five-year timestep into the future, from 2030 to 2060 (Figures 1-3). The statistically predicted costs are therefore calculated with wide variation by considering different patterns for climate and economic growth, different scenarios of political trade-offs when implementing 30x30, and altered parameters in the model used for sensitivity testing (see 2.4 methods appendix). In total, 81 cost projections per year are generated for each LAC country, making a total of 13,041 cost projections for LAC through time, as discussed in the next section.

2.2 Main Results

Across all the LAC countries assessed, the total annual regional cost of implementing 30 percent MPA coverage was US$1.4 billion–US$1.7 billion for 2030 (using SSP2 and depending on scenario). As a regional budget, this is notably modest, being equivalent to just 0.02 percent of LAC's GDP in 2023.

TABLE 3 Annual MPA System Management Costs per Scenario

Country	Budget need 2030 scenario 1 (US$ millions)	Budget need 2030 scenario 2 (US$ millions)	Budget need 2030 scenario 3 (US$ millions)	Percentage change in relative cost by 2060 scenario 1	Percentage change in relative cost by 2060 scenario 2	Percentage change in relative cost by 2060 scenario 3	MPA system size in 2030 (km^2 millions)
Argentina	123.57	177.25	173.92	-64.16	-64.62	-64.12	0.325
The Bahamas	71.62	112.5	100.52	-78.48	-80.44	-78.41	0.179
Barbados	30.56	43.78	42.6	-59.69	-60.32	-59.43	0.056
Belize	14.77	20.42	20.35	-52.68	-52.45	-52.36	0.011
Bolivia	NA	NA	NA	NA	NA	NA	0
Brazil	153.16	245.01	212.94	-63.26	-66.76	-62.93	1.102
Chile	158.68	222.84	220.39	-60.3	-60.29	-59.97	1.097
Colombia	32.68	44.96	44.2	-57.29	-57.72	-57.21	0.219
Costa Rica	18.38	26.32	25.65	-65.79	-66.22	-65.56	0.173
Dominican Republic	4.62	6.36	6.36	-61.63	-60.9	-60.9	0.081
Ecuador	88.91	132.35	128.29	-52.2	-53.16	-52.15	0.324
El Salvador	2.35	4.06	3.11	-35.09	-44.64	-32.53	0.028
Guatemala	14.54	20.68	20.13	-52.75	-53.31	-52.52	0.036
Guyana	30.74	44.31	42.95	-30.1	-31.33	-29.89	0.041
Haiti	NA	NA	NA	NA	NA	NA	0.037
Honduras	2.94	5.62	3.98	-51.23	-60.11	-49.89	0.066
Jamaica	12.06	16.97	16.8	-43.04	-42.92	-42.49	0.074
Mexico	42.64	72.83	57.5	-62.52	-67.76	-61.28	0.985
Nicaragua	8.05	11.91	11.11	-36.98	-38.85	-36.55	0.067

Country	Budget need 2030 scenario 1 (US$ millions)	Budget need 2030 scenario 2 (US$ millions)	Budget need 2030 scenario 3 (US$ millions)	Percentage change in relative cost by 2060 scenario 1	Percentage change in relative cost by 2060 scenario 2	Percentage change in relative cost by 2060 scenario 3	MPA system size in 2030 (km^2 millions)
Panama	11.01	20.18	15.31	-65.86	-71.83	-65.5	0.1
Paraguay	NA	NA	NA	NA	NA	NA	0
Peru	96.57	143.75	136.01	-52.54	-54.23	-52.5	0.251
Suriname	107.71	152.59	152.11	-66.55	-66.59	-66.52	0.039
Trinidad and Tobago	108.01	152.84	152.13	-93.18	-93.2	-93.18	0.023
Uruguay	49.31	70.81	70.21	-69.73	-69.83	-69.64	0.039
Venezuela	411.76	590.28	580.5	-81.5	-81.72	-81.49	0.142

Notes: Scenario 1 = biodiversity priority, scenario 2 = economic priority, scenario 3 = biodiversity/economic compromise. Only midpoint projected costs are shown; see figures for ranges around the midpoint. Also shown are the percentage declines in relative cost over time ("relative" in the sense of taking costs in future years as a percentage of GDP, using SSP2 for GDP growth). The final column shows the system size implied by 30 percent coverage of each country's marine area, which is a major driver of system management costs.

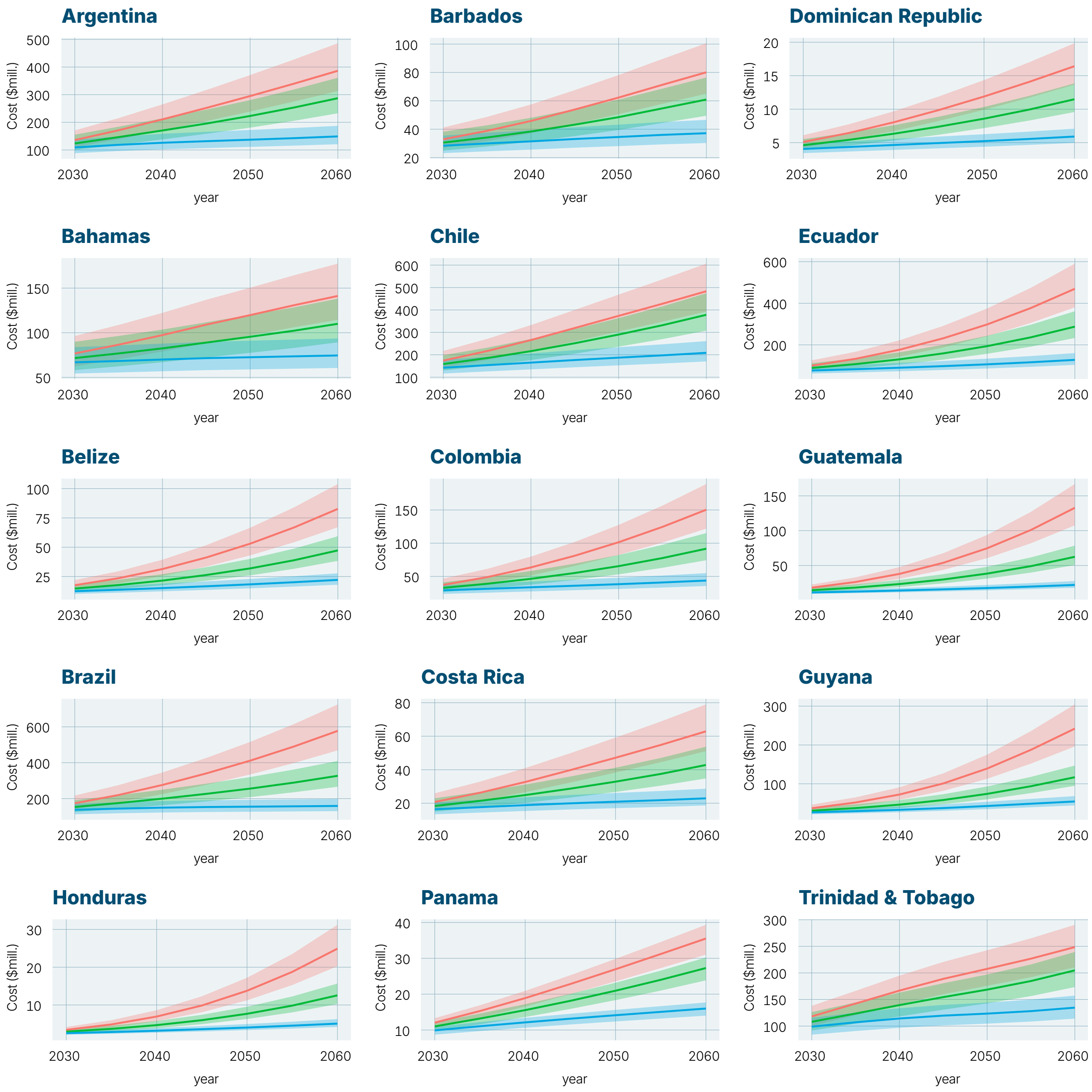
Calculated as a raw dollar amount, the budget need (the annual cost) was projected to rise over time, simply because the coastal cost drivers (coastal GDP per capita and relative fisheries catch along MPA borders) are also expected to rise (Figure 1-3). However, to appropriately interpret these raw increases, decision-makers would need to view them in the context of future growth. For example, GDP in LAC countries is projected to grow between 2030 and 2060, so it is more appropriate to express future, growing MPA budgets as a percentage of future, growing government budgets (proxied by GDP). When viewed in this context, MPA budgets are projected to fall by over 50 percent on average between 2030 and 2060 as a percentage of GDP, which even larger reductions in some countries. Notably, the projected GDP increases for Guyana were modeled before the discovery of substantial oil reserves, so the future costs for Guyana are likely to be considerably lower than shown (because GDP would grow even faster, further lowering the relative value of MPA costs as a percentage of government revenues).

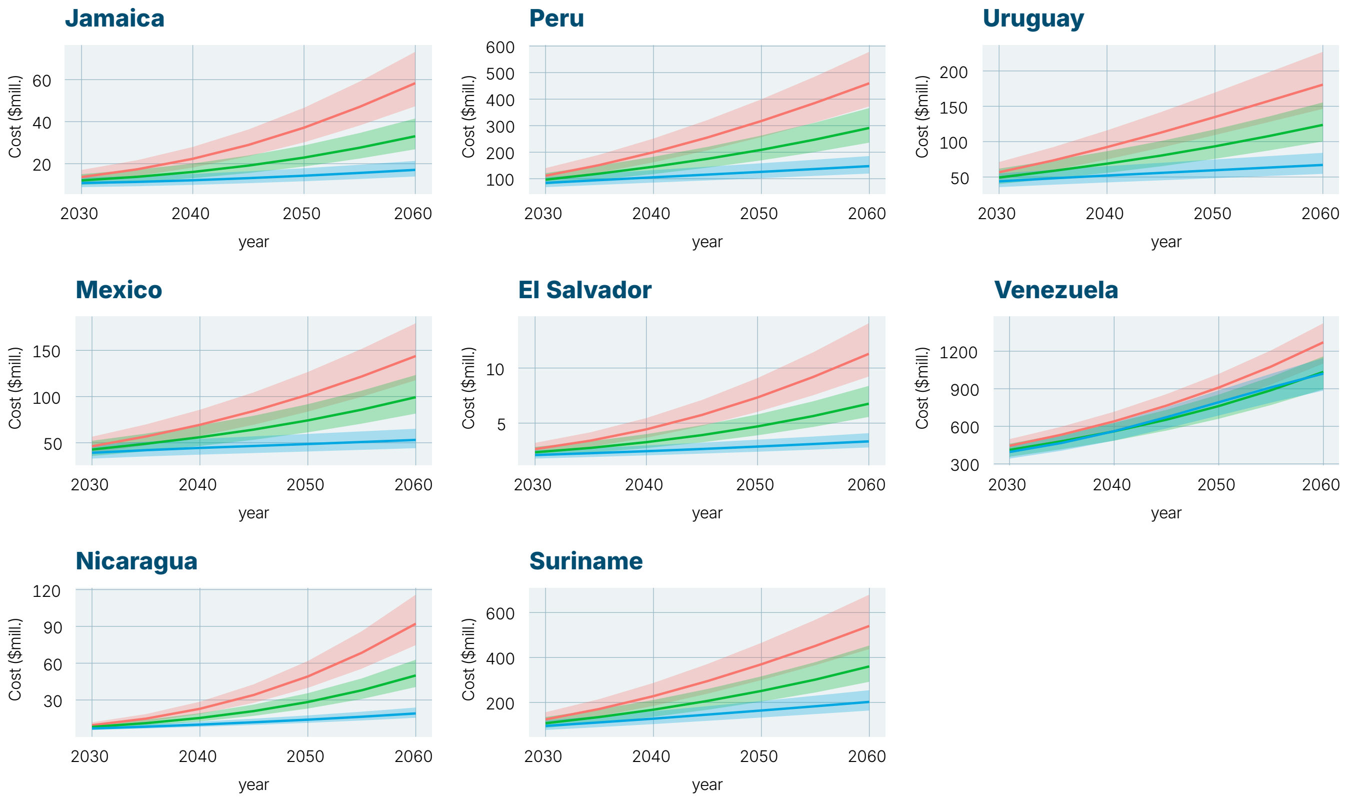
The cost differences between the scenarios, and the reasons behind them, are also potentially valuable for policy decisions around 30x30 (see Table 3). Scenario 2 (economic) was designed to strongly reduce the economic (fisheries) costs of 30x30, whereas scenario 1 ignored such costs. And yet, in terms of annual management costs, scenario 2 was the most expensive and scenario 1, the cheapest. On average, scenario 2 was 1.5 times more expensive than scenario 1. Scenario 3 (compromise), which focused on protecting small-scale fishers and biodiversity, was 1.39

times more expensive than scenario 1 (Table 3). A trade-off therefore exists: in attempting to reduce shorter-term opportunity costs from MPAs through permissive fishing regimes, governments will increase the perpetually repeating cost of managing the MPA system itself and forgo most of the midterm, economic, and tax-take benefits of MPAs (see Chapter 4). That additional, perpetual cost may nevertheless be judged worthwhile if it is achieving other social outcomes, such as the protection of economically vulnerable groups and broader food security for coastal peoples.[19]

It is also possible that scenario 2 is not as expensive as modeled, compared to scenario 1. The lower costs of scenario 1 are based on data showing that it is easier to manage an area that simply allows no fishing and more expensive to manage an MPA system requiring widespread compliance with detailed fishing regulations. However, if scenario 1's ban on fishing in MPAs causes extensive compliance issues in its own right (as could occur if the ban was imposed with inadequate community consultation), then the managers of a marine park may need more financial resources than before to manage thousands of ocean users who may be creatively evading the new restrictions, invisibly performing the actions that they previously performed visibly.

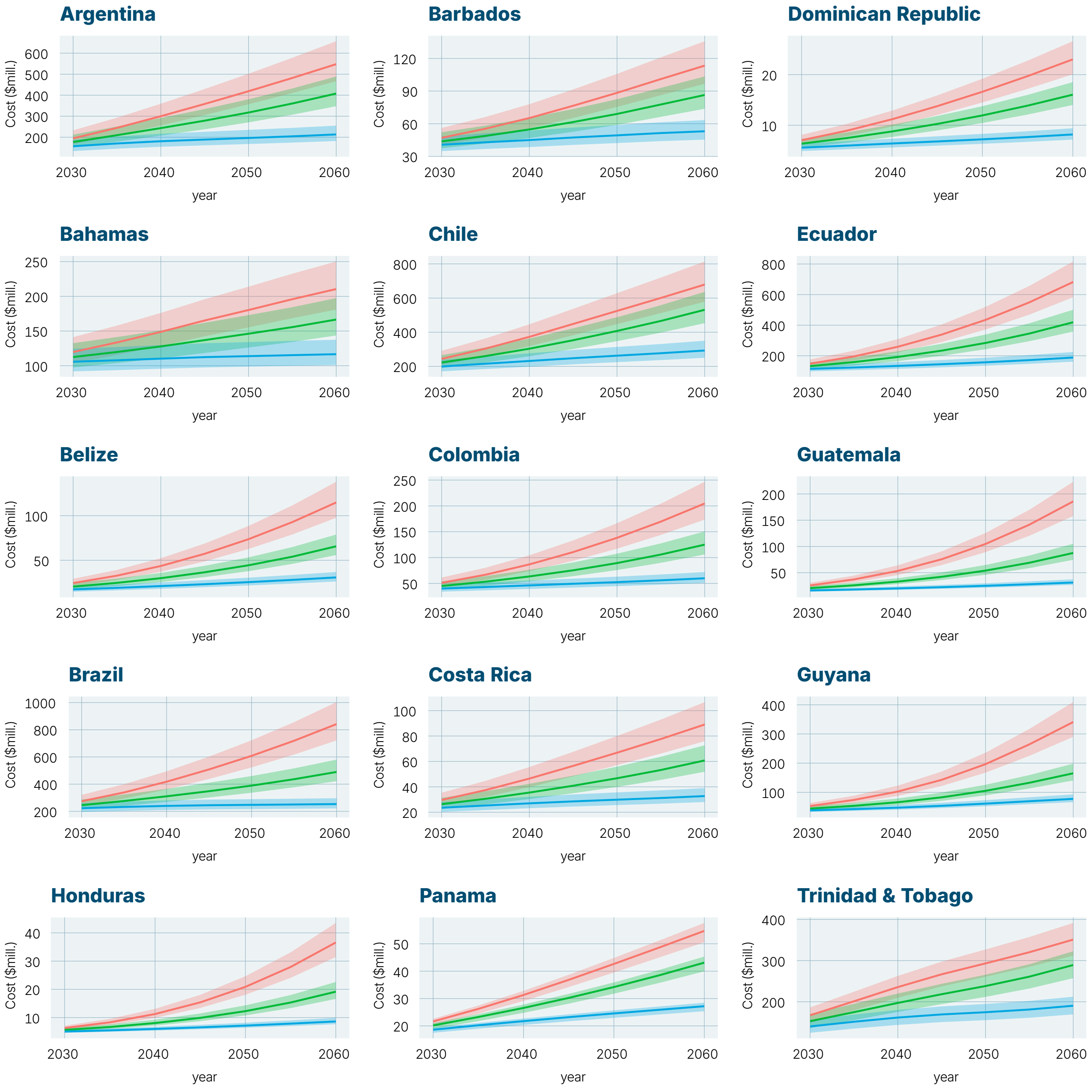
FIGURE 1 Annual MPA Management Costs for Scenario 1

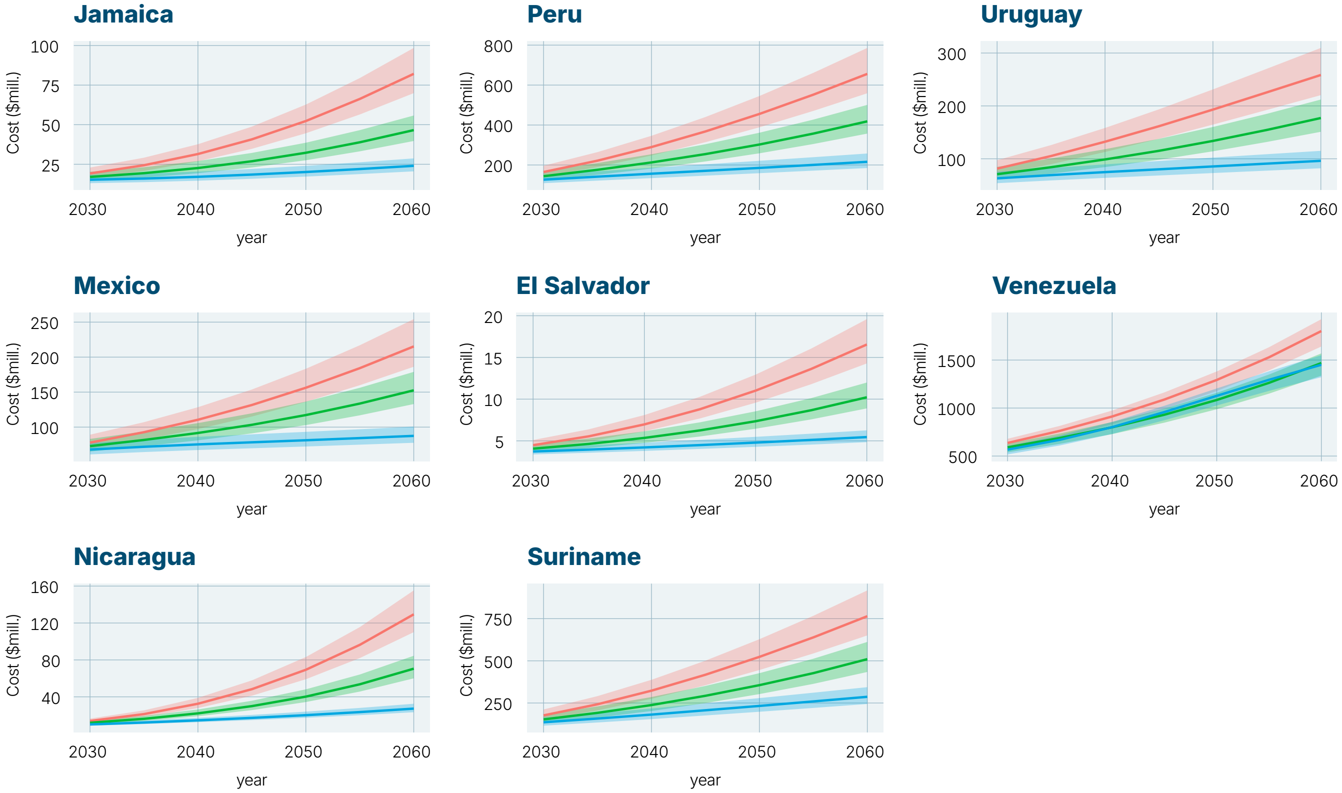




Notes: Costs are shown in constant 2024 US$ millions. Increases are real and not nominal but do not account for economic growth, which makes them more affordable over time. A range of projected values is shown (lighter bands) around the midpoint (solid lines). Three cost trajectories are shown, representing outcomes under three SSPs: SSP1 = red, SSP2 = blue, and SSP3 = green.

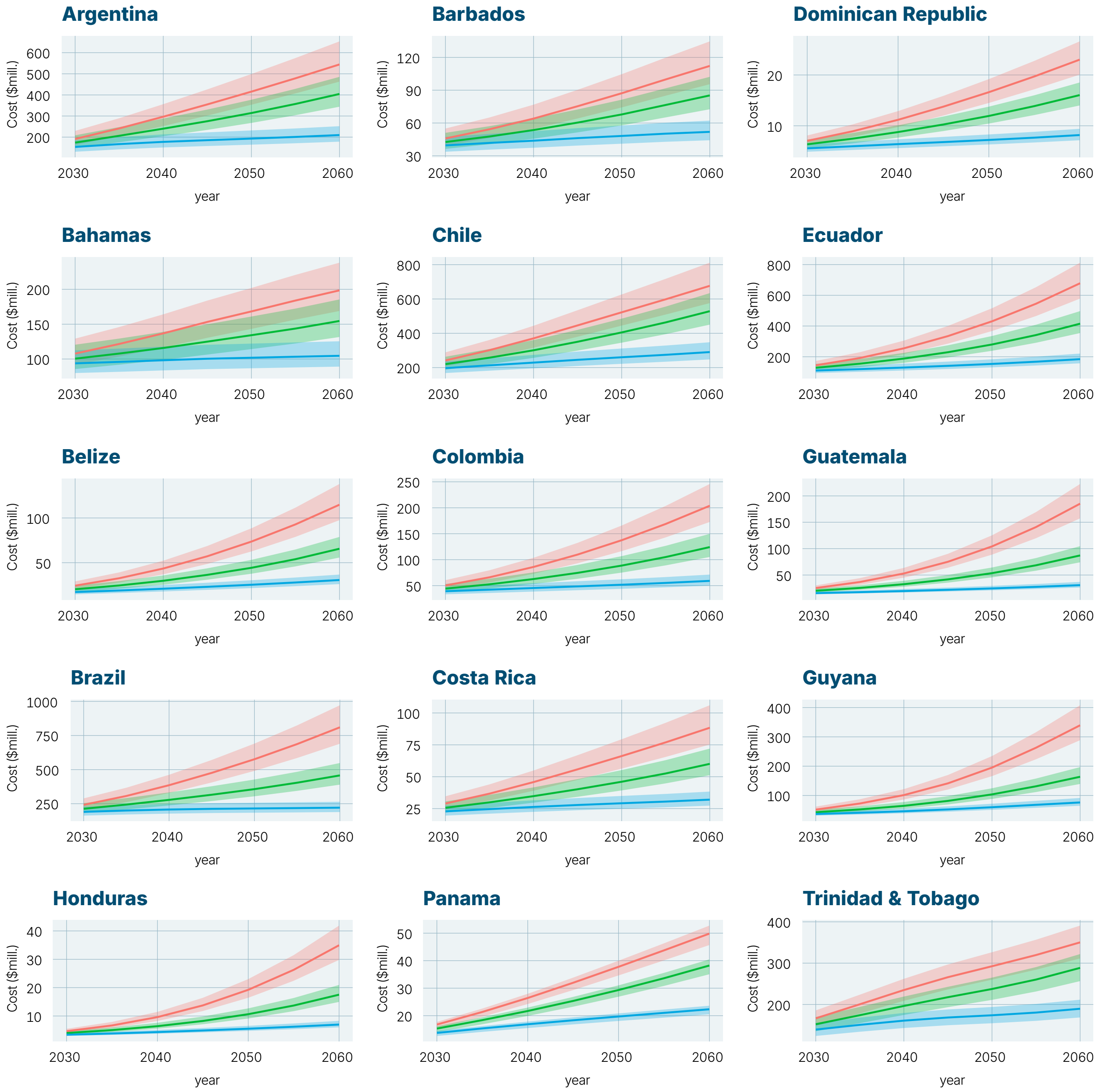
FIGURE 2 Annual MPA Management Costs for Scenario 2





Notes: Costs are shown in constant 2024 US$ millions. Increases are real and not nominal but do not account for economic growth, which makes them more affordable over time. A range of projected values is shown (lighter bands) around the midpoint (solid lines). Three cost trajectories are shown, representing outcomes under three SSPs: SSP1 = red, SSP2 = blue, and SSP3 = green.

FIGURE 3 Annual MPA Management Costs for Scenario 3


Argentina

Barbados

Dominican Republic

Bahamas

Chile

Ecuador

Belize

Colombia

Guatemala

Brazil

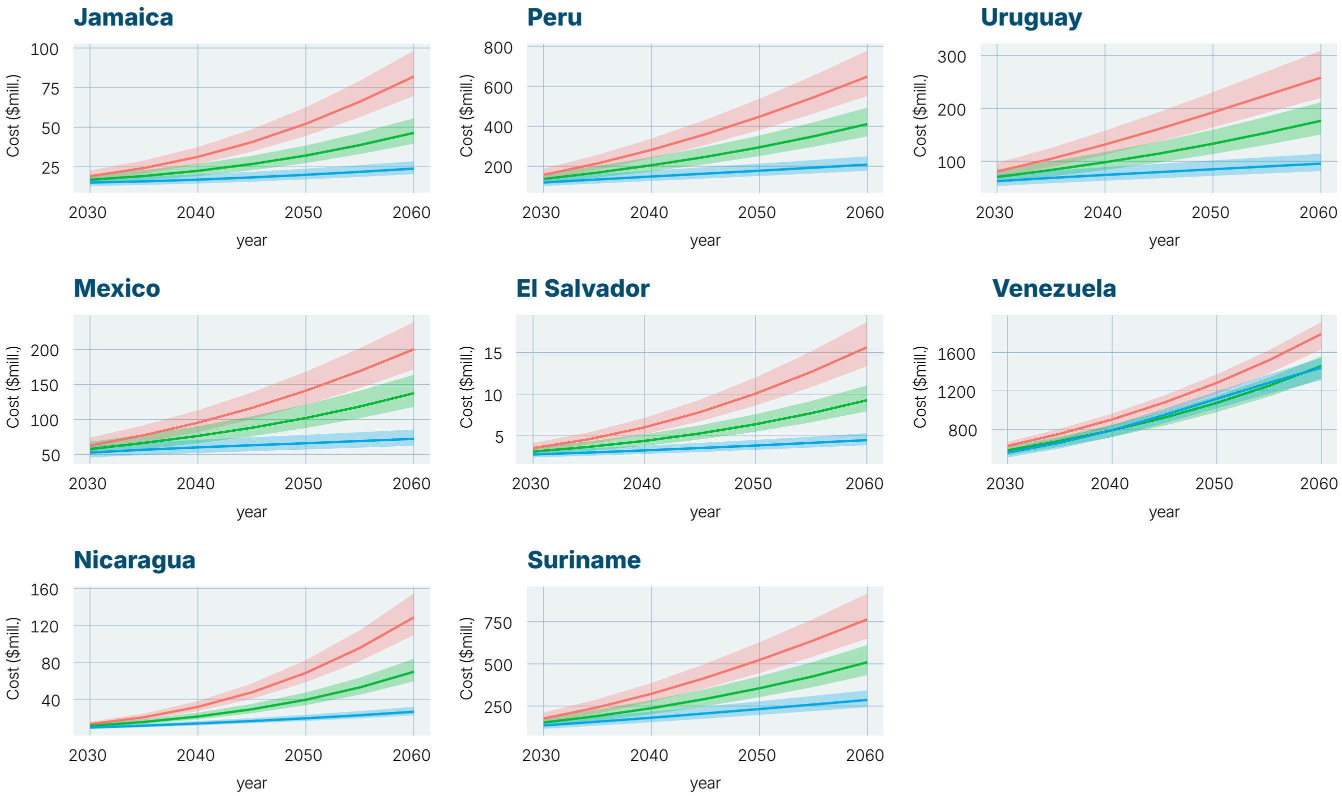
Costa Rica

Guyana

Honduras

Panama

Trinidad & Tobago



Notes: Costs are shown in constant 2024 US$ millions. Increases are real and not nominal but do not account for economic growth, which makes them more affordable over time. A range of projected values is shown (lighter bands) around the midpoint (solid lines). Three cost trajectories are shown, representing outcomes under three SSPs: SSP1 = red, SSP2 = blue, and SSP3 = green.

Also, in general, offshore areas were considerably cheaper to manage in the modeling outputs because remote monitoring technology[12] can be used to guide a small number of long-distance patrol craft in their dealings with large industrial vessels, saving costs in several ways. Offshore costs were similar in both no-take and sustainable-fishing MPA zones, with the main budget difference being the additional burden of monitoring industrial catches in the permitted-fishing areas through relatively low-cost approaches such as remote electronic monitoring.[18,32]

Yet it is important to remember that all the cost projections presented are indicative, based on applying cost models to scenarios for LAC's forthcoming, undetermined 30x30 system. Even so, by using the fuzzy modeling approach, the cost projections are designed to remain largely robust if (when) governments decide to configure their new MPA systems differently from what the scenarios envisage.[7] Similarly, technology changes may also affect costs in ways that modeling cannot anticipate, particularly given the increased use of drones (unpiloted aerial vehicles and unpiloted underwater vehicles) for both biodiversity and compliance monitoring.[13–16,33] Such technology will add new costs but also make operations more cost-effective, so the available savings will lie in the trade-off between those two effects.

2.3 Policy Implications

Annual MPA management costs of 30x30 are extremely modest, representing 0.02 percent of the regional GDP. They are projected to increase over time, but at a slower rate than GDP, making MPAs progressively cheaper. MPA systems that protect economically vulnerable coastal communities, and fishers more generally, may be about 60 percent more expensive, but they are also likely to be more effective (and more cost-effective).[34–36] Any policy that enhances compliance, by working with the needs of fishers and local communities, is likely to bring costs down over time. Furthermore, MPAs bring long-term benefits, including to local fishers, because they often allow fish stocks to regenerate, increasing future catches, profits, and food security.

However, for those benefits to arise, it is important for the MPA system to contain a substantial proportion of highly protected areas (that do not allow exploitation). It is also important that those areas are adequately funded, which has generally not been the case so far.[4] Sometimes, well-funded and well-managed MPAs can also return money to the government as a result of those benefits (for example, through increasing fisheries profits and overall coastal economic incomes, including in the tourism industry). Conversely, governments could also sometimes find that pursuing other economic or social goals negatively affects MPA management costs, such as how lighter MPA regulations, meant to avoid opportunity costs, actually increase management costs.

Nevertheless, MPA system management costs for 30x30 are so modest in national budget terms that it would seem inadvisable to allow the even smaller cost differences between scenarios to determine policy approaches to 30x30. The final message should be that the management costs are likely to be small regardless of the approach taken. When the direct financial cost is so low, there should be fewer impediments to implementing the marine 30x30 commitment in LAC with adequate funding, and in ways that genuinely addresses marine biodiversity needs as well as social needs.

2.4 Appendix. Methods

To project the annual cost of operating an entire national MPA system, this study projects the cost of *effective operations*, as current operating budgets are widely known to be too small to meet basic management needs.[4,37] The cost of a system with 30 percent coverage will therefore have two components: the cost of effectively managing the basic needs of all new MPAs created, plus the cost of bringing the budgets of existing MPAs up to effectively manage basic needs.

To project the effective management costs for an expanded system, four existing approaches were considered. The first approach is simply to estimate a fixed cost per hectare, irrespective of the number of hectares being newly protected. This approach is highly inaccurate, mainly because the cost per hectare is known to go down as the size of the protected area goes up (the widely documented economy-of-scale effect[6,9,37–39]), so it will substantially overestimate the new system cost.

The second approach uses Balmford et al.'s[38] 2003 regression model of the operating cost for an individual MPA. However, Balmford et al.'s cost variation is driven by individual MPA size. Every researcher who attempted to use this model to cost system expansions has therefore been forced to make multiple assumptions about the size of every future MPA in a system—something that cannot be known in advance.[40] This need for multiple assumptions is now known to create a major problem: The cost estimates derived can vary by hundreds of percent, not because of underlying mechanisms, but simply because of the assumptions made by the researcher.[8] Such results will be unsatisfactory for decision-makers.

In addition, the model, and many of its successors, have no method to account for the mixture of higher and lower levels of protection within modern MPAs (see https://mpatlas.org/), which is particularly important for costing since these different protection levels have different costs.[2] This oversight likely results from the vast majority of MPAs having low levels of protection in the late 1990s and early 2000s, the period of Balmford et al.'s data. But for 30x30 to be implemented effectively and contribute to the overall GBF mission of reducing biodiversity loss, system-wide MPA protection levels will need to be much stronger than they have been in the past.[7]

The third approach relies on line-item accounting. Since it is possible to ask the manager of an individual MPA to estimate the budget needed to effectively manage that MPA, one could similarly divide a hypothetical 30 percent scenario into all the constituent, individual MPAs and use accountancy procedures to imagine how managers of new MPAs would answer the same question. This has been attempted once (for Ireland).[41] However, that experience shows that the procedure is enormously resource-intensive for just one developed country, and would be even more so if attempted for the entire LAC region. Moreover, line-accounting approaches for putative future MPA systems still rely on a number of assumptions, and this can effectively cancel out any perceived accuracy advantage that line-accounting methods would have over predictive statistical methods.

The fourth approach, and the one adopted for this study, has the advantages of a predictive statistical model approach and overcomes many of the problems associated with individual-MPA-based costing models on hypothetical MPA systems. The approach, developed by Waldron et al.[7-8] is based on a statistical model of empirical data on the costs of entire national MPA systems. When applied, it permits the analyst to estimate the cost of a different national MPA system without needing to make multiple assumptions about each individual MPA.

The Waldron et al.[7, 8] data on budget needs comes from a variety of literature and sources, including confidential government finance information. Most sources are from a high-level, usually governmental agency, and represent the finance needs of a national system, or, in a few instances, the need for a major subsystem within a national system. Note that because budget need is often assessed at "basic" (the minimum budget needed to maintain core management activities adequately) and "optimal" (the estimated cost of managers fully achieving the protected areas' goals)[9,42] levels, and sources more frequently reported optimal than basic needs, optimal needs are analyzed for this study.

To identify the best fitting models to predict optimal MPA management cost budgets, Waldron et al. [7, 8] tested the ability of various regression models, each using a different set or subset of the variables listed, to predict the data. Because of the data having a hollow-curve frequency distribution that generated issues of overdispersion and unrealistic negative costs in linear regression, the regression analysis used mixed generalized linear models with a negative binomial error structure, a log link, and a random effect for region (via the intercept). Both of the possible statistical estimation methods for such a structure were tested: the adaptive Gauss-Hermite quadrature approximation and the Laplace approximation.

A set of candidate regression models was then created, each with a different set of possible cost predictors. When models were ranked by AICc values (the second-order

Akaike Information Criterion value adjusted for sample size) in an information-theoretic model selection approach,[43] two best fitting models emerged, one for each estimation method (Table A2.1). The model using the Laplace approximation found that costs could best be predicted by using a combination of the national MPA system size, GDP per capita in the areas adjacent to the national system, and the ratio between the mean fisheries catch in a 25 km buffer around the borders of the MPA system and the fisheries catch in the EEZ. Plots of cost against site-based revenue per hectare (largely a measure of tourism activities in MPAs) also strongly suggested a positive relationship with management costs. However, data were only available for six countries, so this term was omitted in order to avoid comparing all possible predictive regression models using just six data points.

With regard to the effects of the variables on management costs, the models found that MPA costs per hectare went down as system size increased, reflecting economies of scale.[1,2,9,39] Costs also increased as GDP per capita in adjacent areas increased, and as the relative fisheries catch increased, likely indicating an effect of pressures on management costs. An alternative specification of the same model using the adaptive Gauss-Hermite quadrature did not converge for this best fitting model, but a comparison of converged models with additional terms suggested that the Gauss-Hermite quadrature method may have preferred a similar model, but without the fisheries catch term.

Therefore, to account for possible catch term uncertainty in this study, costs were modeled with and without the relative catch term. Cost predictions from models without the relative catch term had been approximately 25 percent higher than predictions from models with the term, but the delta AICc for the two models (which both converged using the Laplace approximation) was 14.1, strongly suggesting that inclusion of the catch term provided a considerably better fit for the empirical data. As a result, this chapter has shown results from the model with the fisheries term.

TABLE A2.1 Statistical Models Predicting the Optimal Budget per Hectare for a National MPA System

	Intercept	National-system size in km² (ln)	Mean GDP per capita in 25 km buffers surrounding the MPA system (ln + 1)	Mean fisheries catch in areas surrounding MPA relative to mean of the EEZ
Model 1	-3.75	-0.70	1.484	0.371
Model 2	-2.51	-0.70	1.40	NA

Next, budget need was input at purchasing power parity (PPP) and ln-transformed. Values indicate the model coefficients but note that they cannot be used as a simple mathematical equation to predict costs; instead, cost prediction needs to be done directly from the negative binomial mixed generalized linear model with a random effect for country. See supplementary material for similar results using a different estimator software. The regression model was a mixed effects generalized linear model with negative binomial errors, a log link, and a random intercept term for region.

All earlier studies had used regression models such as the one generated here to project costs per hectare for the entire expanded national MPA system proposed for 30x30.[1,39] However, after developing the statistical model above for national MPA systems, Waldron et al.[7] went on to argue that future systems expanded to 30 percent coverage are likely to include a much larger proportion of offshore areas (e.g., beyond the 12 nautical mile limit) than current MPA systems do. Offshore MPAs mostly require management of large industrial vessels that have remote tracking systems for monitoring and control, which is a very different proposition for MPA systems that, empirically, have tended to be closer to shore. Accordingly, intensive, shorter-range approaches are needed to monitor and manage multiple pressures from multiple, often-small-scale coastal actors who may impact on those MPAs.[44]

On the other hand, industrial fleets in offshore parts of the EEZ are most efficiently controlled by a combination of remote monitoring technologies[12,44] such as tracking of ship courses, independently checked onboard CCTV cameras, and sensors that detect fishing gear use,[12,44,45] along with long-distance patrol vessels that can bring human enforcement action if remote technologies observe a likely infraction (noting that the rules of evidence in law would often require more than a simple statement that, for example, an Automatic Identification System (AIS) had detected a suspicious pattern of movement that was likely to be indicative of fishing activity).

This difference between future and past configurations creates a problem of applicability for the regression model, because that model was mostly parameterized on inshore MPA systems. To operationalize the difference between offshore and inshore management and costs in modeling terms, Waldron et al.[7] split the costing model into two parts: an inshore component, which was estimated using the regression model, and an offshore component.

For the offshore component, they reviewed management cost data from very large offshore MPAs (such as observed costs of remote tracking and long-distance patrol vessels) and supplemented these with cost data about the long-distance enforcement costs of large offshore fishing grounds. They then extracted the size of the industrial fleets operating in each EEZ from Tidd et al.[46] and calculated the combined cost of installing and administering remote sensing, remote monitoring via onboard cameras for that fishing fleet (with recordings independently verified by a paid professional), and a patrol fleet similar to that used in fisheries and very large MPA enforcement to date. Since budgetary capacities can be limited and different offshore areas may need different patrolling efforts, they carried out three separate calculations of the patrol cost, assuming respectively one long-range patrol boat per 400,000 km^2, 500,000 km^2, and 600,000 km^2.

For the purposes of this study, future MPA management of both distant ecological conditions and distant potential infractors may also use a range of unpiloted aerial vehicles and unpiloted marine vehicles ("drones"),[13–16,33] although this technology and its cost are both nascent and rapidly developing, so they could not be included. However, consultations between the authors of this report and experts in the field over possible future use and costs of drones are ongoing. This study assumes that remote electronic monitoring was applied only when fishing was allowed inside MPAs.

To define the portion of the 30x30 scenario area that would be costed by the inshore and offshore approaches, the grid of cells occupied by MPAs in each scenario is divided into an inshore component and an offshore component for each EEZ. To avoid arbitrariness in the choice of where these two components occur in marine space, three separate definitions of the limit line between inshore and offshore (essentially, three sub-scenarios for each management cost scenario) are created. The first has the inshore/offshore limit line at the internationally mapped, 12 nautical mile limit. The second position of the dividing line is based on the mean of the empirical MPA area contained inside the 12 nautical mile limit (47 percent); if the same percentage is applied to the base MPA layer used in all the scenarios, the dividing line becomes located at ~24-25 nautical miles offshore. The third dividing line is at 50 nautical miles offshore (a point at which small-scale fishers are likely to be reduced to very low frequency.[47]

These different limit-line definitions essentially represent alternative options for a management decision about how far offshore it is worth continuing to apply the more expensive inshore management approaches. For example, the further offshore one goes, the fewer small actors are likely to be present (because of differences in feasible sailing distances and engine power). There will therefore be a point (a distance) offshore at which the managing agency decides it is no longer worth using intensive inshore management techniques and switches to more at-a-distance offshore techniques.

It is known that managing a lower-protection MPA is more costly than one with high protection, because lower protection requires a large number of intensive patrols and controls to check whether every individual in a large fleet of users is compliant with the fishing rules, whereas a high protection system requires only that patrolling units check that no fishing is occurring (perhaps excepting recreational or low-intensity fishing).[2] The cost implications of this difference were explored by Ban et al.,[2] where surveyed experts indicated that management costs would be 1.69 times higher for a lower-protection system and models suggested 1.96 times higher. The three scenarios developed in this research constitute a mixture of lower- and full-protection MPAs.

This study therefore followed the methods in Waldron et al.,[7,8] who started from the observation that the data on which the predictive statistical model of management costs was defined and parameterized would have come almost entirely from systems with lower protection, then created three sub-scenarios of how costs in more highly protected parts of a national system might differ, based on the Ban et al. study (1.96; 1.69; and the average of those two values). To calculate the offshore component, the offshore costing model from Waldron et al.[8] was applied.

The majority of the elements in that model are likely to be unaffected by the 30x30 scenarios (e.g., satellite hire costs or the use of one or two long-distance patrol vessels). Therefore, the model was generally applied without further adjustments for the scenarios context, excepting that three alternative values for the costs were generated by varying the patrol area and assuming that a single long-distance patrol boat could cover by 25 percent higher or lower than the empirically-derived estimate (see Waldron et al.[7,8] for details). It may sometimes be possible to apply both intensive and at-a-distance techniques in inshore environments. However, simultaneous application of both approaches is unlikely to change the cost estimates materially because small inshore vessels generally do not carry the technology that allows them to be remotely tracked, and any larger vessels that do move close to shore will already have had their tracking costs factored in as part of the offshore model.

Overall, both the inshore and offshore costing models therefore generate multiple alternative cost projections for each scenario, with three different assumptions about change in cost with strictness of protection and three separate assumptions about the distance from shore at which offshore approaches will replace inshore approaches, and also three different estimates of the offshore costs themselves, making nine estimates for each of the three scenarios. However, some of the terms driving the costs in the models are expected to evolve between 2030 and 2060, with several possible pathways for that evolution. To account for this, three further alternative pathways were created to control for how the variables affecting costs will evolve, based on the land[23–27] and marine SSPs.[8,22]

Thus, each of the three scenarios of 30x30 for each country has a total of 27 cost projections in all years after 2030, and a total of 81 different cost projections per year per country. In the main chapter, these are simplified to express each cost as a range with a midpoint, but the 81 different results are also available as spreadsheets.

Over time, the first predictor variable that is likely to change is the ratio between the fisheries catch in a 25 km area surrounding the MPA and the mean fisheries catch in a country's waters (the national mean). This is likely to change significantly after the implementation of widespread, well-protected MPAs due to the spillover effect.[19,28–31] The change in the catch ratio is modeled by first assuming that the vast majority of spillover benefit is exploited by fishers inside the 25 km buffer around, an assumption supported by empirical studies.[28–30]

Therefore, the change in the ratio is largely predictable from the way that spillover changes the catch in the 25 km buffer, calculable by differencing the 30x30 and reference scenarios. For example, if spillover were found to be increasing catch in the buffer by 10 percent in a specific post-2030 year, then that increase will alter the value of the predictive model's ratio variable by an amount corresponding to an additional 10 percent in the numerator. (Specifically, the assumption is that without spillover, catch in the fisheries-accessible part of national waters may change directionally, but the spatial pattern of catch across different parts of that accessible area will change stochastically; spillover is therefore the main source of directional change that is suitable for modeling directional changes in the ratio).

Spillover effects will unfold in a complex way over time, especially in scenarios 2 and 3, where MPAs are a mixture of no-take zones and sustainable-fishing zones, each of which will have different spillover effects. To capture this complexity, BOATS outputs are used (see Chapter 4), because BOATS projects the evolution of fish stocks and fisher economic responses, post 30x30, using a combination of ecological ocean environment modeling, biodiversity modeling, and fisheries modeling. It also incorporates three climate forcing assumptions and three sets of assumptions about marine SSPs, as applied to the fisheries sectors.

For this study, marine SSPs were defined as possible pathways that future fisheries management approaches could take, combined with possible future levels of climate forcing as it affects ocean warming, marine life, and the fisheries economy[22,23] (see Chapter 4). The three marine SSPs can be simplified as three outlooks: optimistic, midpoint, and pessimistic. Using these, each set of outputs is repeated three times, reflecting different possible future pathways and the different effects each might have. For this study, BOATS was run twice, once with spillover effects and once without. The difference between those two runs was defined as the size of the spillover effect, noting that there is a different effect for each of the three marine SSPs.

However, overspill calculations in BOATS have a secondary balancing property in correcting catch outputs for known issues in the exponential change-in-catchability parameter, which would sometimes generate areas of zero catch if left unbalanced.[48] This balancing property means that for small countries in particular, spillover values taken in isolation (i.e., without accounting for balancing function) may be higher than is likely in practice. When spillover parameter estimates are used in the predictive statistical model for management costs, the balancing function means that BOATS-derived parameters could generate slightly exaggerated management cost projections.

To adjust for that possibility, a model of maximum expected overspill was developed, based on recent large-scale spillover studies by Di Lorenzo,[28] Lynham and Villasenor-

Derbez,[29] and Francseshini et al.[30] More specifically, three possible maximum spillover expectations were developed for each of the five-year increments from 2030, where the three expectations mirrored the nature of the three combined SSPs. Any overspill from the BOATS outputs that exceeded the relevant expectation for the future year and combined SSPs was then capped at the maximum expectation.

This is important because recent empirical studies have found overspill effects at relatively large distances from MPAs, namely 100 nautical miles (nm) in two studies,[29,30] as well as 5 to 150 km,[49] 100m to 100 km,[50] 50 km,[51] and in an entire area of ten harbors.[31] By way of contrast, a meta-analysis in which most of the MPAs were very small suggested that the spillover zone can be as small as 0.2–1.0 km beyond the MPA border.[28] This finding is supported by a report from the European Union that studied multiple MPAs, many of them also small, and found mixed spillover results.[52]

Given that most spillover would occur as a result of propagule pressure from the ecologically recovering core of the MPA, it is to be expected that small MPAs, with their very high perimeter-to-core ratio, would generate less spillover across less distance. If the MPA is depicted as a series of concentric circles, then an accelerating wave of propagule pressure, with up to exponential growth rate, will build up as fish spill over from the innermost circle into the next innermost circle, adding to the pressure already present in the second circle, and so on iteratively until the MPA boundary is reached. Larger MPAs have more concentric circles, so considerably higher potential propagule pressure.

Further, an MPA system covering 30 percent of the EEZ is more likely to generate the type of spillover seen in large MPAs, such as those in the study by Lynham and Villasenor-Derbez or Franceschini et al.[29,30] These two studies give spillover effects in an area up to 100 nm around MPA boundaries and register residual spillover as far as 175 nm away. The Lynham and Villasenor-Derbez study also measures spillover in terms of catch per unit effort rather than catch. Using catch per unit effort rather than raw catch data is useful because spillover effects are partly driven by ecological recovery in MPAs, but also partly by changes in fishers' behavior around MPAs.[51]

Therefore, for this study, the estimators created for maximum spillover expectation are closer to the spillover parameters reported in the Lynham and Villasenor-Derbez study.[29] The difficulty is that the main spillover zone reported by Lynham and Villasenor-Derbez (100 nm)[29] could imply a spillover zone for a 30 percent system that is larger than the entire EEZ of some of the smaller LAC countries, such as Caribbean island nations. Moreover, spillover effects decay over distance,[28,30,53] so the 12 percent catch per unit effort increase reported for a 100 nm zone outside an MPA's borders is likely to be composed of a mixture of lower benefits at 100 nm away from the MPA and higher benefits closer to the MPA (where the higher values may be more comparable to the 54–84 percent biomass increase reported by Di Lorenzo et al. within 200 meters of MPAs),[28] or the 65 percent increase in catch modeled for large MPAs, and in a 50 km buffer zone, by Sève et al.[53]

Even for a midsized MPA cluster (the survey area in Belackova et al.,[31] comprising multiple harbors and their fishing grounds), the change in income per unit effort was 22 percent under spillover, almost double the 12 percent catch per unit effort–effect observed over the very large areas in Lynham and Villasenor-Derbez. Data in Lynham and Villasenor-Derbez[29] also suggests that the spillover effect for large MPAs is relatively homogeneous across the 50 nm of the 100 nm zone closest to the MPA, but may be much lower in the next 50 nm. Their decay data for distance indeed indicate that the effect size in the closer 50 nm may be 40–100 percent larger than the effect size in the more distant 50 nm (so 12 percent effect size would be a weighted average of a larger and a smaller effect, potentially with the weights representing both differences in sample size and differences in mean effect size for sub-areas).

All this evidence suggests that spillover in the 25 km buffer is likely to be substantially more than 12 percent, and indeed is more likely to be at least 50 percent. However, it seems unlikely to exceed 85 percent, at least over the first few decades. Although the BOATS overestimates caused by the balancing function could not be exactly removed mathematically, some of them exceeded 85 percent by a large margin (this happens particularly in BOATS outputs for small countries, where the exponential catchability parameter can reach particularly low levels, requiring particularly high balancing). Therefore, for 30x30 purposes, while it may be necessary to accept small distortions in the catch ratio parameter caused by the balancing, the spillover effect behind the ratio should not exceed known empirical maxima.

To operationalize this, a cap (maximum) for modeled spillover is defined to prevent it exceeding the known empirical maxima. To allow for spatial uncertainty and for confidence intervals around published empirical spillover rates, three spillover caps are used, to correspond to the three marine SSPs. For the midpoint combined SSP, the maximum spillover value (the cap) in the 25 km zone around MPAs is set to 70 percent. For the pessimistic and optimistic equivalents, 50 percent and 85 percent caps, respectively, are used.

These maxima were applied to 2060 spillover values, but earlier years are likely to have lower spillover than later years,[28–30,53] often because the rate of spillover is slower for fish species with slower life histories.[30] Therefore, the time response for spillover empirically observed for large MPAs in Lynham and Villasenor-Derbez is used to reduce spillover in earlier timesteps accordingly, following a linear regression formula (derived from the empirical data) that effect size = 1.281e-02 * yr + -3.070e-04 * yr^2, where yr indicates the number of years after MPA creation. Spillover in 2030 was assumed to be zero, following widespread demonstration of a lag period between MPA creation and the start of spillover effects.[28–30,53] It is important to note that variation in the choice of cap would likely represent a very small error, because it is being used only to place an upper feasible limit on a set of model outputs being used to define the change over time of a single ratio parameter in a predictive statistical model.

The second variable in the predictive statistical model that will evolve over time is GDP per capita (at PPP). Future values for this parameter have been projected as part of the SSP research theme, again with different values per country depending on the pathway envisaged. To align with the way that catch ratio evolution was being modeled using three marine SSPs, equivalent SSPs are used to generate three possible sets of values for future GDP per capita.

The terrestrial SSP1 is set as optimistic, SSP2 is the midpoint, and SSP3 is pessimistic.[23–27] Projected future values of GDP per capita PPP were downloaded from the database maintained by International Institute for Applied Systems Analysis, IIASA (version 2). SSPs cannot project GDP per capita at the resolution of local areas in the vicinity of MPAs, so the ratio between the national values projected for each time step (e.g., the ratio between GDP in 2035 and 2030) are calculated, and those ratios are used to generate an approximate change in the value of local coastal GDP in the buffers surrounding MPAs.

Note that local values may change by more or less than the national average, and this would then cause the projected management costs to vary. However, the projected costs for future years are specified as indicative rather than precise, with wide variation around the projections to account for uncertainty.

In summary, matrixes of predictor-variable values were created for each year in which future costs were being projected (2030–2060 at five-year intervals), with three variations showing three possible future pathways. The predictive regression model was then applied, using the relevant matrix for the year, to project the inshore MPA system costs for that year, for each of the three scenarios, with nine variations to capture a range of uncertainty. The offshore costs were similarly projected by using the offshore model, with variation to capture some of the uncertainties.

However, the technology that is being developed for potential remote management activities in offshore MPA areas is rapidly evolving, as are its costs, so it was not possible to project how the technologies and costs were likely to change for a given year, such as 2060. The offshore and inshore costs were then put together to generate a range of possible future costs for each country for each future year, across the different possible pathways. These are presented as a range and midpoint of costs in the first three sections of this chapter, but all results (81 per country per year) are available as spreadsheet outputs.

3

Marine Establishment Costs

Establishment costs are the one-off costs involved in creating a new protected area or set of protected areas. McCrae-Strub et al.[1] describes how data on establishment costs, and indeed the set of activities that can be described as "MPA establishment costs," are challenging to collect and define. However, in general, they include the costs associated with activities such as developing project proposals, a legal framework for designation, a management plan, and community and stakeholder compensation schemes (including alternative- income-generating activities and fisher buy-out); conducting ecological and socioeconomic research, management and enforcement trainings, and outreach to local community and stakeholder groups; and building infrastructure (including buildings, equipment, and site delineation).

A further complication is that individual MPAs or national MPA systems may need (or choose) to undertake different subsets of those activities, making the use of a line-accounting approach for every possible MPA that has been scenario-modeled across the entire LAC region infeasible. Therefore, for rapid, large-scale estimates of costs, statistical models are needed.

3.1 Modeling MPA Establishment Costs

Both McCrea-Strub et al. and Binet et al. (2015)[2] explore possible statistical models through regression of known costs on possible predictors of cost, and both find that the longer MPA creation takes, the higher the cost (the two models are similar but differ in their precise formulation, specifically for coefficients). McCrea-Strub et al. also find that MPA size is a strong positive predictor of establishment costs (R^2= 0.76 for single-variable regression and 0.95 for a model incorporating both size and creation time).[1] Binet et al., which is the more recent study, finds that creation time is by far the main predictor (r = 0.8) and that area is a relatively poor predictor (correlation coefficient r = -0.34). Binet et al. use this weak relationship with area to reject use of McCrea-Strub et al. models that include size effects and prefer a model only using creation time. [2]

An analysis of the figures in McCrea-Strub et al. done as part of this study also suggests that there is a very strong correlation between an MPA's size and its creation time. When such collinearity exists between two predictor variables (e.g., size and creation time), it is not statistically robust to predict costs from a model that contains both of those variables simultaneously.[3] Binet et al.[2] do not comment on this collinearity, but if it exists (as it appears to), then their decision not to use the McCrea-Strub et al. models would be further supported.

The McCrea-Strub et al. model and the Binet et al. model are both designed to predict the establishment costs of an individual MPA. To apply them to an entire system expansion, involving an unknown number of MPAs, authors have typically had to make a number of assumptions regarding the number of MPAs and their individual sizes and creation times[4]. The difficulty is that the creation times and sizes for future MPAs is unknown (and that the coefficient relating cost to creation period can be highly uncertain, varying greatly with the dataset).[1,2]

To date, researchers have therefore tended to upscale models of individual MPA costs by making a reasoned but essentially arbitrary assumption (in the statistical sense of being the choice of the researcher) about unknown parameters such as the frequency distribution of MPA sizes, with the number of MPAs being an implicit further output that emerges from this arbitrary assumption.[4,5] This can sometimes lead to extremely high estimates of establishment costs.[4] The more assumptions that need to be made, the higher the probability that a model designed for individual MPAs will create highly variable (and potentially unreliable) estimates when applied to the entire national system.

Additionally, an important problem of assumption dependency exists. If the establishment cost estimates are highly dependent on the assumptions made but the final system actually implemented does not match those assumptions, the modeled costs will be misleading and unhelpful. It is better to have an estimate that minimizes the assumptions made, so that when a government does something different from what was anticipated, the modeled estimate remains usefully robust to that change.

Binet et al. give an average (mean) establishment cost of 42,646 euros for a single MPA at PPP (PPP range = 29,930 to 50,075 euros).[2] The simplest approach, which also circumvents the issue of highly variable coefficients, is therefore to assume that statistically, costs can be described as being symmetrically distributed about the mean (an assumption supported by similarity between mean and median). Then, the cost for a national system can be reasonably approximated as the mean cost per MPA multiplied by the number of MPAs. In this case, the only free parameter to estimate is the number of MPAs in the system, eliminating the need to assume not only the number of MPAs in each future national system, but also the respective sizes and creation times for each future MPA in LAC. Dollarized establishment costs can then be extracted by converting euros PPP to US$ and deflating the results to account for the age of the Binet et al. data (exchange rate was 1.33 and deflation factor was 1.32).[2]

This approach was used in this study because it satisfies the requirement for minimizing the number of assumptions being made: the only modeled parameter that needs to correspond realistically with future government decisions is the number of new MPAs. Importantly, Waldron et al. also found that the number of MPAs does not increase linearly with system size—something commonly but wrongly assumed by mathematical approaches. Instead, individual MPAs tend to get bigger as the entire system gets bigger.[6]

Accordingly, as also carried out in 2020 by Waldron et al.,[6] this report estimates the likely number of MPAs using a statistical analysis of the empirical relationship between the size (areal extent) of national MPA systems and the number of MPAs in those systems. Additionally, the costing model in this report assumes that new protected areas outside of the 24 nautical mile (nm) line would essentially be managed as a single very large MPA. In other words, the number of MPAs for the cost estimation uses the statistical relationship between system size and MPA number inside the 24 nm line, and then adds an additional very large MPA for protected areas outside the 24 nm line. To account for uncertainty in an establishment cost model based on the number of MPAs that might be added to the system, this study derives 95 percent confidence intervals for the number of MPAs and use these to generate upper and lower bounds for the establishment cost estimates.

Most studies of establishment costs only report the value of a single, one-off expenditure, as if the entire cost of establishment was taken out of budgets at the moment it was incurred. However, it is important to note that this cost can also be financed, including by borrowing funds that are repaid over a longer period. Therefore, both a paid-immediately cost and an amortized cost are calculated. For example, the rate for 30 years at 5 percent interest is calculated, representing a long loan or bond (since there may be budgetary pressure to keep annual repayments low) and an illustrative interest rate in broad alignment with recent bond rates. Amortized costs for different periods and different rates can easily be calculated by taking the one-off payment values and applying a compound interest rate formula with the desired period and rate parameters.

3.2 Main Results

Results from the cost model show that, across the 24 IDB borrowing countries in LAC that have national ocean territories (i.e., excluding landlocked countries), marine establishment costs would be modest and in some cases, either zero or very small in terms of government budgets. If the costs are met up-front, the total regional[7] cost is estimated at US$21.3 million dollars (confidence interval US$15.6 million–US$29.3 million, with all dollar values deflated to constant 2024 dollars). Regional costs are low because by 2025, most of the countries had already protected 30 percent (Chile, Colombia) or close to it (e.g., Costa Rica 28.4 percent, Brazil 26.7 percent, Panama 26.3 percent, Mexico 22.6 percent), so relatively few new MPAs needed to be created to achieve 30 percent coverage. Costs for individual countries were often less than one million dollars (Table 4), again reflecting how a limited need for new MPAs and a modest cost per new MPA, when combined together, can generate low national-system costs overall. This finding concurs with McCrea-Strub et al.'s estimate that establishment costs are 3.71 times smaller than a single year's annual management cost (at the intercept).[1]

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[7] For the 24 countries.

TABLE 4 MPA Establishment Costs for IDB Borrowing Countries

Country	Estab. cost	Estab. cost lower bound	Estab. cost upper bound	Estab. cost amortized 30 years @ 5%	Amortized estab. cost lower bound	Amortized estab. cost upper bound
Argentina	1.46	1.00	2.06	2.84	1.96	4.02
The Bahamas	1.73	1.28	2.33	3.37	2.49	4.55
Belize	0.39	0.30	0.47	0.75	0.59	0.92
Bolivia	0	0	0	0	0	0
Brazil	0.92	0.67	1.21	1.79	1.30	2.36
Barbados	1.17	0.89	1.58	2.28	1.74	3.08
Chile	0	0	0	0	0	0
Colombia	0	0	0	0	0	0
Costa Rica	0.6	0.49	0.76	1.16	0.95	1.48
Dominican Republic	0.72	0.51	0.96	1.40	1.00	1.87
Ecuador	0.72	0.56	0.96	1.41	1.10	1.88
Guatemala	0.75	0.57	0.98	1.47	1.10	1.91
Guyana	0.95	0.7	1.28	1.85	1.37	2.49
Honduras	0.83	0.6	1.13	1.62	1.18	2.21
Haiti	0.90	0.66	1.24	1.75	1.28	2.43
Jamaica	1.06	0.77	1.49	2.08	1.50	2.91
Mexico	0.98	0.71	1.38	1.92	1.38	2.69
Nicaragua	0.62	0.47	0.86	1.21	0.93	1.68
Panama	0.92	0.69	1.19	1.79	1.34	2.33
Peru	1.19	0.83	1.76	2.32	1.62	3.44
Paraguay	0	0	0	0	0	0
El Salvador	0.74	0.56	1.00	1.45	1.09	1.96
Suriname	0.91	0.66	1.24	1.78	1.29	2.42
Trinidad and Tobago	0.86	0.65	1.18	1.67	1.27	2.31
Uruguay	0.55	0.44	0.66	1.07	0.86	1.28
Venezuela	2.26	1.53	3.38	4.40	2.98	6.60

Notes: All costs are shown in 2024 US$ millions. Both the total value of a one-off payment and the total value of a payment amortized over 30 years at 5 percent interest are shown. Upper bound and lower bound show 95 percent confidence intervals. Estab.cost = establishment cost, MPA = marine protected area. Also shown are the number of new MPAs ("no. new MPAs") that the model calculates are needed to achieve 30 percent coverage nationally, again with the upper and lower bound of confidence interval. Bolivia and Paraguay are landlocked and therefore have no marine values.

3.3 Policy Implications

The figures above give the raw cost. However, if the total cost were amortized over 30 years at 5 percent interest, it would be almost twice as high (1.95 times the raw cost, Table 4). (Note that this interest rate is purely illustrative, since it would not be possible to report costs under all possible rates and periods for 26 countries—for example, Ecuador funds Galapagos conservation with a Blue Bond paying a coupon rate of 5.645 percent,[7] and Barbados swapped some of its debt for blue bonds having a 3.8 percent rate of interest.[8]) Therefore, the policy implication is that governments should potentially consider whether to fund the establishment costs up-front (without borrowing), especially when relatively few new MPAs need to be created and the costs are low.

If up-front funding is out of reach for particular governments, international assistance might fill the gap rather than allowing often-small establishment costs to add to national debts. Indeed, for the countries studied in McCrea-Strub et al.,[1] data indicate that international assistance (bilateral and multilateral funding from governments, NGOs, private enterprise, and voluntary contributions) accounted for a mean 53 percent of establishment costs in the MPAs belonging to developing countries, and up to a maximum of 100 percent. Those data include one example from LAC (Colombia) where the Seaflower MPA was 45 percent funded by international assistance.

It is important to note that collating financial data for establishment costs is challenging enough to raise the possibility that some costs have been missed (creating underestimates).[1] Similarly, if it were indeed true that larger MPAs have larger establishment costs, then the positive correlation between system size and the mean of individual MPA sizes would imply that the true cost could be slightly higher than the models would suggest. Even so, it seems unlikely that the magnitude of the missing data, or the size of the underestimate, is large enough to alter the conclusion that marine establishment costs are a relatively small part of the total financial impact of 30x30. By implication, any inaccuracies in the estimation of establishment costs should not have a large enough impact on the total cost calculated to raise any major concern. Nevertheless, readers should interpret the cost results as being *between the lower and upper estimate*, rather than the cost being the simple midpoint estimate.

3.4 Appendix. Methods

Establishment costs for new MPAs in an expanding system are a one-off expenditure related to the initial creation of new protected areas. However, it is important to note that this cost can also be financed, including by borrowing funds that are paid off over a longer period, so both a paid-immediately cost and an amortized cost are calculated.

Calculating the establishment costs for the expansion of an entire national system suffers from the same problems as older management cost models. There are two well-known models of establishment costs, the McCrea-Strub et al. model and the Binet et al. model,[1,2] but both describe the cost of establishing a single MPA. To apply them to an entire system expansion, involving an unknown number of MPAs, it is necessary to make a number of assumptions about the number of MPAs and their sizes and the time it takes to establish them. This can lead to extremely high (and potentially unrealistic) estimates (e.g., see [4]), and the more assumptions that need to be made, the higher the probability that the individual-based model will create unrealistic estimates.

Additionally, the same problem of scenario-dependence observed with management costs can occur with establishment costs. If the establishment cost estimate is highly dependent on the assumptions made by a scenario designer, and the system implemented by the government is different from the scenario, then the establishment costs (which were based on the scenario) will be misleading and unhelpful. It is therefore useful to have an estimate that varies as little as possible from the assumptions made, so the modeled estimate remains usefully robust to change.

The Binet model is more recent and requires only one assumption (about the number of MPAs), and analysis by the authors of this study suggest that it gives results reasonably similar to those of the model of McCrea-Strub et al. So to minimize the number of assumptions, the Binet model is applied for this study. Previous assumptions about number of MPAs have often been somewhat arbitrary, such as being randomly based on a mathematical system. This study's estimate of the likely number of MPAs is based on statistical analysis of the empirical relationship between the size (areal extent) of any national MPA system and the number of MPAs there. This method was followed in Waldron et al. as part of the original study on the costs of 30x30 for COP 15. That analysis took all protected areas marked as "marine" from the November 2019 iteration of the World Database on Protected Areas (protectedplanet.net) and, for each country, extracted the number of MPAs and their total size.

Plotting these two variables against each other suggested an increasing but heteroscedastic relationship. Importantly, the graphical plot also suggested that the number of MPAs does not increase linearly with system size—a common but incorrect assumption in mathematical approaches. Instead, individual MPAs tend to get bigger as the entire system gets bigger.

To extract a numerical statistical relationship that accounted for the heteroscedasticity, the analysis used quantile regression.[9] The observed relationship took the form (ln (number of MPAs +1) = 0.604 + 0.277 * ln (size of national MPA system)), noting that these are quantile regression coefficients derived from the 50th percentile of the distribution.

To work out the number of new MPAs implied by each national system, the proposed extent of ocean that would be protected inside the 24 nautical mile line (i.e., excluding currently protected areas) is used to derive a prediction of the number of new MPAs from the quantile regression model (using package quantreg[10] in R[11]), along with the prediction confidence limits. Three predictions were made, representing the model expectation and the upper and lower confidence bounds, and rounded to the nearest integer. Then, the result is increased by one in each country, representing an assumption that all offshore MPAs beyond the 24 nm line would essentially be managed as a single area.

4

Marine Opportunity Costs

In the context of 30x30, an opportunity cost is an implied economic loss to groups or sectors that arises from creating new PCAs and MPAs.[1–3] For a national MPA system, an opportunity cost refers to any future economic loss that a national industry suffers as a specific result of new MPAs being created.

Fishing is the most common profession in Latin America, making it an important source of income, and fisheries serve as a key source of local protein, supporting food security.[4] The region has traditionally been a major exporter of fish and especially fishmeal, with exported volumes exceeding domestic consumption,[5] a sector-specific trade surplus,[4] and an annual growth rate of 7.7 percent.[6] However, fisheries production in the region has also seen notable declines: for example, a 2024 study documented a decline from 19.8 million metric tons in 2000 to 10.8 million metric tons by 2014, largely driven by the decline in pelagic fisheries off the costs of Chile and Peru,[4] with a small recovery to about 2010 levels since then.[6]

Fisheries declines are related to two main issues: overfishing and warming of the oceans, which reduces reproduction capacity.[7,8] For example, the Peruvian anchoveta fishery was the largest single-species fishery in the world, but it collapsed between 1970 and 1980 after overfishing effects were exacerbated by El Niño ocean warming.[9] Because of these effects, and if all current conditions remain (including current fishing effort), LAC is likely to see generalized declines in fisheries catch and output in the near- and midterm future.[10]

Opportunity costs of MPAs are therefore potentially important for the region, because any closure of part of the ocean to exploitation naturally raises an objection that the closure is likely to harm fishers.[11] For individual countries, the highest opportunity costs will likely be in EEZs, which combine accessibility from shore with high fish biomass and national fishing rights.[12] Limiting or banning fishing in 30 percent of the EEZ area could therefore cause fishers to lose a large part of their original fishing grounds, have to travel further, or fish more intensively and for longer to achieve the same catch levels as before.[13,14] A ban could therefore lead to lower catches and higher costs—revealing a classic opportunity cost.

However, fisheries do not automatically or permanently experience an economic loss when a new MPA is created. Instead, MPAs with limited or complete fishing bans can act as a form of fisheries management by returning fisheries to sustainability by allowing a portion of the fish stocks to recover[15]—and some mathematical models suggest that MPAs could economically benefit fisheries for this reason.[16] Moreover, recovering stocks can benefit fisheries because overspill (as increasing stocks migrate into areas where fishers can access them) generates higher catch with less effort.[17,18]

The resulting sustainability (and long-term catch and profit) gains achieved by using MPAs as a system-wide management tool could be important in LAC, where, in 2024, 66.7 percent of the Pacific fishing area and 41.2 percent of the Atlantic area were judged by the Food and Agriculture Organization of the United Nations

(FAO) to be in an unsustainable condition.[6] These figures are considerably worse than the global average of 37.7 percent,[6] and they may yet worsen with ocean warming.[19]

For fishers and the fisheries sector in LAC, MPAs therefore have a mix of advantages and disadvantages, based on both theory and experience. For example, the benefits of greater sustainability and overspill should be weighed against the costs of reducing the area accessible for fishing. MPAs will not cause an opportunity cost if fishing fleets can source the same (or better) catch elsewhere[20] (and a lack of any negative impact on catch has indeed been documented for the large, fully protected Revillagigedo National Park in Mexico[11]). The balance of advantages and disadvantages will also unfold over time. The initial closure of any large portion of fishing grounds can act as an economic shock, which is likely to cause immediate losses in the short term. As the fish stocks recover and the fishing fleets adjust their fishing patterns accordingly, the benefits may start overcoming the losses. The more an area was overfished in the past, the larger the benefits of allowing stock recovery in MPAs are likely to be.

Yet it is difficult to intuit the way this pattern of positive and negative consequences will unfold, particularly because it depends on previous levels of overfishing and the reactions of all other fishers in the area. This uncertainty is particularly relevant when considering how 30x30 policy options today may cause as-yet-unknown changes in the fisheries system decades into the future. Therefore, projecting the likely impact of 30x30, with its large-scale creation of MPAs, requires complex system models that can track and simulate several factors: how fish and fishers interact over time, how MPAs may alter both fish stocks and fisher behaviors (and thus, fishing outcomes), how changes in technological efficiency and management will alter the fishing outcomes in the future, how ocean warming affects both the fish and the fisheries outcomes, and how MPA-associated closures, partial fishing constraints, sustainability gains and overspill balance each other out to ultimately affect catch and income. Such complex systems are generally modeled using marine ecosystem models,[21,22] a precedent that this study follows.

4.1 Modeling MPA Opportunity Costs

This study models 30x30 fisheries outcomes using the BiOeconomic mArine Trophic Size-spectrum (BOATS) marine ecosystem model, which is one of the main models in use.[22–24] BOATS has been widely used to analyze the historical development of global fisheries, and, using a model fitted to these historical data, project future outcomes of various fisheries policy initiatives,[22] including in LAC.[25,26] For this study, the BOATS forcing and model features were further adapted address the specific question of 30x30 and its impact on national fisheries sectors, namely: (a) 30 percent of each EEZ was allocated to MPAs, such that each country's EEZ comprised a mixture of no-take MPAs, open-access areas, and MPAs that allowed regulated fishing to a sustainable level only; (b) overspill was added to the model, such that fish started to move from MPAs and into open-access (exploitable) areas as the stock recovered; and (c) the results were aggregated to the country level—even though the model works in "fleet space" (one-degree grid cells of ocean)—to be politically informative. All MPAs were assumed to become operational in 2030.

For each of the three 30x30 MPA scenarios and the baseline (see Table 1 and Chapter 1), fishing activity and fish stock changes were simulated in BOATS, using modeled projections of future catch based on assumptions about the trajectory and impact of global ocean warming (where greater warming reduces fisheries revenues[19]) and how fisheries management will evolve. BOATS was therefore run three times per scenario, for three separate pathways of how the future may unfold in terms of assumptions about ocean warming and MPA management over time.

These assumptions are made according to what is known as marine shared socioeconomic pathways (MSPs), the use of which is common in modeling numerous large-scale systems, including models for economic growth, food security, and biodiversity (see the appendix for more on MSPs).[21,27] The MSPs used in this study are defined as follows:

- MSP1 is optimistic, assuming low levels of global warming and increasing sustainability of fisheries management;
- MSP2 is middle-of-the-road, assuming more moderate levels of global warming than MSP3, but similar management evolution to MSP3; and
- MSP3 is pessimistic, assuming high levels of global warming and no improvements in management sustainability (thereby allowing unregulated fishing in open-access areas).

This chapter reports the MSP2 results and comments on any difference from other MSPs, but the results for MSP1 and MSP3 are shown in Appendix 4.5, and Box 2 further discusses the model.

Initially, BOATS was run to give projections to 2100, but there are obvious increases in uncertainty when generating projections 75 years ahead, so 2030–2060 is the study's main focus. Two countries (Chile and Colombia) have already implemented more than 30 percent MPA coverage of their marine area. Nevertheless, BOATS is run for those countries to project the consequences of differing potential management approaches in those two MPA systems.

BOX 2 Modeling the Consequences of 30 Percent MPA Coverage on Fisheries

The BOATS (BiOeconomic mArine Trophic Size-spectrum) model takes a macroecological approach, founded on a well-developed body of theory and empirical parameterizations that have been shown to explain many aspects of organisms as a function of size and body temperature. The model simultaneously tracks the change in time of fish stocks and the response of fishers to those changes, converted into landed catch measured in grams. The model also tracks the effort required to achieve that catch, measured in watts (i.e., energy expended, which can then be converted into a change in cost), where cost includes investment, repair and maintenance of fishing infrastructure, fuel consumption, and labor cost in bringing the fish to market.[22–24] The model generates a projected output for each year, and this study runs it out to the year 2100.

The base model operates at the resolution of one-degree cells (i.e., the global ocean is divided into a grid at one-degree resolution). For this study, those cells are divided into three classes to reflect the three levels of permitted fishing in the 30x30 scenarios. The first class is open access, where no restrictions on fishing are assumed to exist except for market forces (for example, fishers will cease to expend effort if the value of catch is no longer compensating for being in that part of the sea). The second class is a moderately protected MPA in which sustainable fishing is permitted (see Appendix for the calculation of sustainable levels). The third class is a fully protected MPA in which no fishing is allowed at all (no-take). Although fishers are not allowed to fish in no-take MPAs, fish stocks in those highly protected areas are likely to recover to a point where they will begin to spill over into areas where fishing is permitted; the model was adapted to incorporate such spillover, adding to the fish biomass available to fishers in the first two classes of area.

The model was then used to project the catch and fishing effort out to 2100 in all cells that contained some part of the EEZ of country from the LAC region. The impact of 30x30 was estimated by taking the difference in outputs between the baseline (no further expansion of MPAs) and the outputs from each of the three 30x30 scenarios.

Notably, the model outputs should be regarded as *projections based on the model structure* rather than as exact predictions. One particular caveat is that future changes in the price that fishers receive, on the global market, would affect their fishing choices (for example, by making it worthwhile to exert more effort at the margin). However, future global fish prices depend heavily on how the rest of the world implements the commitment to a marine 30 percent and how governments in regions such as Asia (which is the largest fishing region) respond through subsidies or regulations. The prices could also change if terrestrial implementation of 30x30 makes meat less available or more expensive. Such future effects are highly complex, and impossible to robustly incorporate in a model based on LAC fisheries. The model therefore assumes a fixed price, and any departure from this assumption in the future would alter the results.

A second caveat is that projected environmental changes are uncertain at the one-degree cell resolution, introducing uncertainties in estimated fish production available to fisheries, particularly within the smallest EEZs. The results should therefore be interpreted broadly to *show an early decline before a later recovery in catch, until catch surpasses what would have occurred otherwise*, rather than as exact numerical predictions.

4.1.1 Changes in Fisheries Catch

Profit—the price paid for catch minus costs—may be seen as the ultimate measure of fisheries opportunity cost, at least for commercial fishers. However, for other fishers (and especially small-scale or subsistence fishers), the food security impact represented by catch itself can still be more important than commercial profit.[1] In economic theory and practice, a sustained period of catch losses (or higher costs) would often cause an increase in the prices, meaning that some of the initial catch losses may be offset by a rise in the price fishers are paid for their catch. Further, demand for fish is highly robust in the face of price changes,[8] and fish has the lowest own-price elasticity of all the major proteins[28]. This means that if global fishers all experienced short-term catch losses or cost increases from 30x30, then on aggregate, they would be likely to offset some of those losses through price increases. Improving incomes in LAC in the future[29] is also likely to increase the demand for fish (income elasticity of demand),[30,31] again improving the price that fishers can command for their catch.

The expectation is therefore that loss of profit may be smaller than loss of catch. However, the prices that underpin profits and input costs are set on the international market, so any

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8. Inelastic, meaning that it changes little when the price changes.

change in price (and profit) in LAC, including those caused by 30x30, depends strongly on the actions of fishers, consumers, and markets in regions other than LAC. For example, 63.4 percent of capture fisheries production was in Asia (and 3.7 percent in the Americas) in 2024.[6] If Asia (or more generally, if all non-LAC regions) implements 30x30 in a way that increases prices for fishers and fish consumers, the change will likely drive an increase in the market price that fishers receive in LAC, or a change in the costs per unit input in LAC.

Similar issues arise for costs in LAC, many of which depend on the global market prices of the inputs needed to capture fisheries revenues, such as the future price of oil for 2030 and beyond. Indeed, these two uncertainties complement one another: distant non-LAC fishers are likely to increase the prices charged for fish if their costs have gone up. However, because modeling a global effect is outside this study's scope, this study does not use information on how non-LAC regions may implement 30x30 or the effect they may have on the global market price, or the market cost of inputs.

Because profit cannot be meaningfully calculated for this study, the change in catch achieved by fishers becomes a natural metric of opportunity cost. Catch is both the fundamental unit of food security and a principal driver of net economic output (profit). In this chapter, the focus is on changes in catch due to the implementation of 30x30, although it is important to note that changes in catch may exaggerate changes in profit (because price might be expected to buffer biomass changes). The catch results should therefore be interpreted as the worst-case scenario for any losses. Changes in effort are also tracked, which is expressed in energetic terms, namely the number of kilowatts expended in a year in each country's waters to achieve the catch, in the three 30x30 scenarios and for the baseline.

The projected changes in catch caused by 30x30 implementation (in 2030) are shown for each country, over time, in Figure 4 and Appendix Figures A4.1-A4.2. Each country-specific plot shows the percentage difference in catch between the baseline and each of the three 30x30 scenarios, showing a range of values based on different assumptions (see 4.5 methods appendix).

Across countries and scenarios, the results suggest a broadly consistent, three-phase response to the rapid expansion of MPAs to 30 percent coverage in 2030 (with some exceptions). In phase 1, immediately after new MPAs are created, an economic shock occurs in which catch generally declines. In phase 2, often within five or fewer years, a period of recovery begins, as the shock unwinds and catch starts to increase again. Then in phase 3, which starts mostly between 2040 and 2060, catch becomes higher than it would have been without the MPA expansion to 30 percent.

Beyond 2065, models suggest that the catch benefit continues to increase, although the precise quantitative outcomes become less certain at this larger temporal remove, so they are not explicitly included in Figure 4 and Appendix Figures A4.1-A4.2. Nevertheless, the magnitude of the projected positive outcome is large enough to give good confidence in the qualitative finding that a midterm benefit will be enjoyed (Figure 4).

Comparison across the scenarios is also informative. Of the three scenarios, scenario 1 (biodiversity) imposes the most severe fishing restrictions, allowing no harvesting anywhere in each national system. Interestingly, this scenario is nevertheless the one that produces the largest improvement in mid-century catch levels for some of the major fishing countries in the region (by biomass), such as Argentina, Chile, Mexico, and Peru (Figure 4 and Appendix Figures A4.1-A4.2). However, these particularly large midterm gains are also associated with particularly large short-term economic shocks (Figure 4). This effect likely reflects the fact that no-take MPAs allow the strongest stock recovery in the medium term[16] but generate the largest initial downside for fishers in the short term. It is also noteworthy that scenario 1 has a more sustainable gain in catch over time. Even though scenario 2 (economic) and scenario 3 (compromise) sometimes generate a higher short-term boost, that boost often declines to near-zero in later years, whereas scenario 1 continues to add to catch consistently over time (Figure 4 and Appendix Figures A4.1-A4.2).

For the two countries that have already protected 30 percent of their seas (Chile and Colombia), the scenarios cannot represent opportunity costs in the same way, but they do illustrate the projected outcomes of different possible management approaches in those two countries. Chile is projected to experience large catch benefits under scenario 1 but little change in catch under scenarios 2 and 3 (Figure 4 and Appendix Figures A4.1-A4.2). Colombia is projected to suffer substantial catch losses under full no-take protection in scenario 1 but a small midterm benefit under mixed protection in scenario 2 and 3. As regards differences between the MSPs themselves, MSP1 (optimistic) differs from MSP2 (midpoint) in having stocks recover to a higher level, and often more quickly, whereas the opposite is true of MSP3 (pessimistic) (see Appendix Figures A4.1-A4.2).

Figure 4 and Appendix Figures A4.1-A4.2 omit some countries with small EEZs (El Salvador, Guatemala, Guyana, Haiti, Panama, Trinidad and Tobago, and Uruguay). This is because accurately projecting fisheries consequences with a global system model can be challenging when EEZs are smaller and fall predominantly within the coastal zone. While environmental forcings from ecosystem models capture the historical dynamics of the global climate system, they often fail to represent finest-scale environmental variability in coastal zones, thereby potentially underestimating primary production or temperature gradients.[32] These can lead to spatial mismatches between simulated fish production and observed fishing effort over the historical period. In larger EEZs, such mismatches can be absorbed through the redistribution of fishing effort across the region, but in EEZs made up of only few grid cells, they may result in unrealistic over- or under-exploitation, making for a potentially misleading interpretation of the catch time series over the historical and projection periods.

For this study, to balance the need for information against the importance of robustness, it is preferable to report qualitative results for these seven small-EEZ countries rather than graphing (potentially misleading) quantitative model outputs. Therefore, the qualitative patterns show that for five of the seven countries (Guyana, Haiti, Panama, Trinidad and Tobago, and Uruguay), there was a relatively robust expectation that a pattern of short-term economic shock but long-term increase in catches will be observed (relative to the baseline), although the period and magnitude of these trends was less clear. For El Salvador and Guatemala, outcomes were particularly difficult to robustly model and are best regarded as agnostic.

Change in effort also did not show clear patterns, but this is partly expected. Effort is measuring two things simultaneously: the distance that fishers have to travel to catch fish (a cost), plus the fact that vessels can spend more time fishing an area if fish are more abundant there (a benefit). Effort is therefore not a clear, unambiguous indicator of opportunity cost, and its uninformative results (represented in an additional 72 graphs) are not shown.

In addition, since price increases may balance out some catch losses in the early post-2030 years while other catch disruptions may exceed the ability of global price changes to mitigate them, some form of short-term financial support to address the initial economic shock may be necessary. At the national level, the size and duration of short-term profit shocks will be different for each country. If the international market price tracks the average global size of the shock, as might be expected in an efficient market, then countries with larger-than-average catch losses might be expected to experience larger-than-average profit downsides. Because the shocks are particularly large on average for scenario 1 (biodiversity), it is important to focus this discussion on that scenario.

In particular, some of the LAC countries that stand out as having such disproportionately large losses during the initial shock period (immediately post-2030) are The Bahamas, Costa Rica, and Ecuador (Table 5), and possibly Suriname, although the large loss here is less certain because the EEZ is close in resolution to the model cell size. Also, if Colombia's existing system is fully closed to fishing, it is also projected to suffer catch losses that are likely to overwhelm any possible mitigation from price effects.

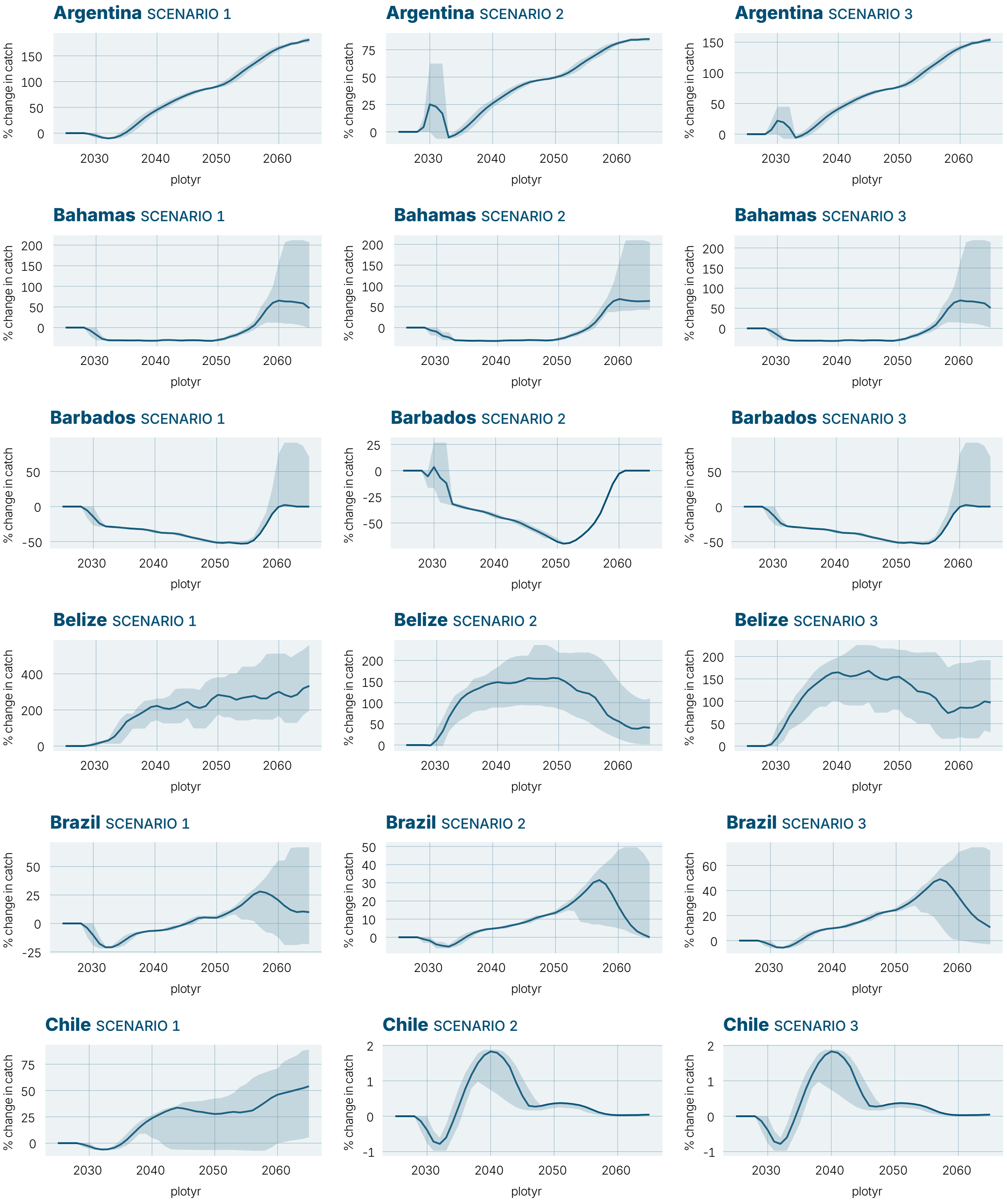
At the subnational level, small-scale fishers are often likely to have less access to credit and less financial buffer. Any fishers who operate at a subsistence level would, by definition, receive no help from price increases at all and would simply face the decline in catch. These economically vulnerable groups could be monitored for possible economic distress, or allowed to continue fishing at a low-intensity, sustainable rate (even in a subset of no-take areas), on the assumption that the impact on MPAs would be minor. Beyond the fishing sector itself, governments may also need to track any economic distress caused to domestic consumers by increases in the price of fish and react accordingly.

4.2 Main Results

To close the discussion on MPA opportunity costs, there are a few points to remember. First, the implementation of 30x30 is likely to cause an initial shock to fisheries followed by a substantial benefit. Second, stricter levels of protection in MPAs (scenario 1) lead to larger initial shocks but also bring larger midterm benefits. Third, the widespread practice of allowing substantial fishing in MPAs[33] can reduce the shock, but it will also reduce the benefits, particularly in sustainability of the MPA over time (Figure 4, Appendix Figures A4.1-A4.2, Table 5). Fourth, the economic implication is therefore that for long-term economic growth, stricter MPAs would be a more effective strategy for most countries. And fifth, to capture that longer-term benefit, governments and financial institutions may need to organize financial assistance during the initial shock, but this expenditure represents investment in growth.

That said, the terms of reference for this study were largely economic, so this report focuses on the economic forms of opportunity cost, but several, less monetary opportunity costs are also possible. These include qualitative social impacts[1] such as changes in control (leading to changes in human dimensions such as the sense of dignity, hope, or meaning), change in community organization (which can have multiple knock-on effects on social cohesion), and change in property rights (which is both potentially disempowering for communities and a driver of inefficiency for community-managed MPAs[,34–39]). It is important to note that these noneconomic, social costs may still have important, second-order economic impacts, such as changes in employment or food security.[1] Similarly, this report highlights that some 30x30 impacts might be disproportionately harder to bear for more economically vulnerable social groups, or indeed for some countries in LAC, but there is a notable limitation: the models cannot quantify the socioeconomic impact of 30x30 for specific, more vulnerable subgroups such as small-scale fishers.

FIGURE 4 MSP2 Change in Fisheries Catch by Scenario, Compared to Baseline (percentage)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Argentina SCENARIO 2
Argentina SCENARIO 3
Bahamas SCENARIO 1
Bahamas SCENARIO 2
Bahamas SCENARIO 3
Barbados SCENARIO 1
Barbados SCENARIO 2
Barbados SCENARIO 3
Belize SCENARIO 1
Belize SCENARIO 2
Belize SCENARIO 3
Brazil SCENARIO 1
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Chile SCENARIO 1
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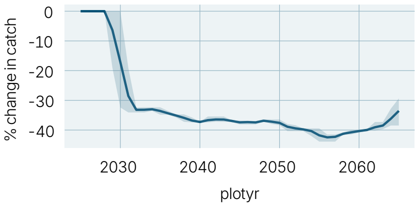
Chile SCENARIO 3

Colombia SCENARIO 1



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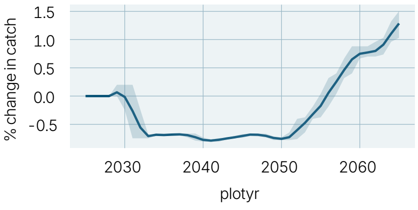

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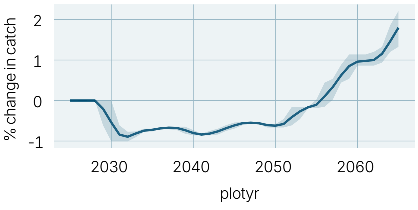

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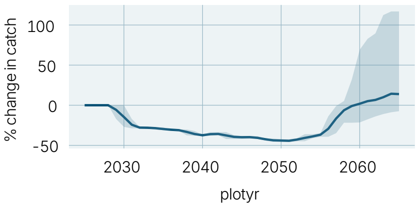

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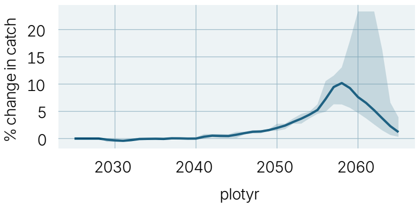

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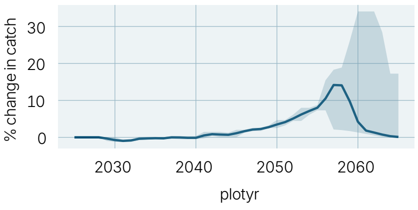

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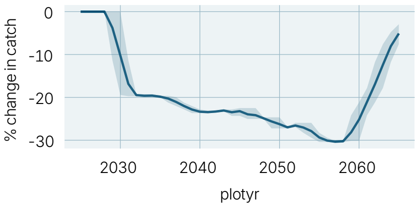

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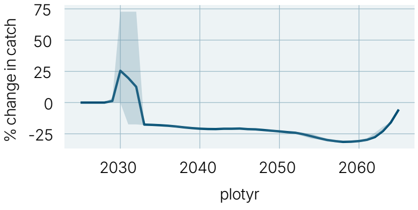

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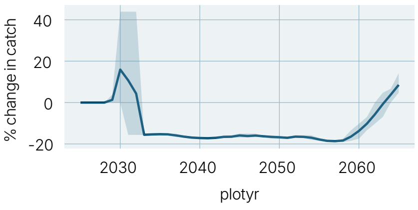

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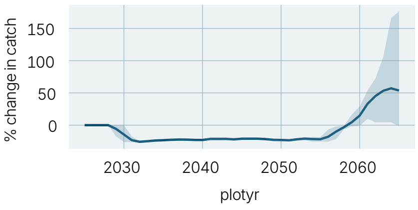

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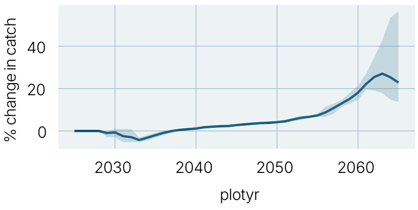

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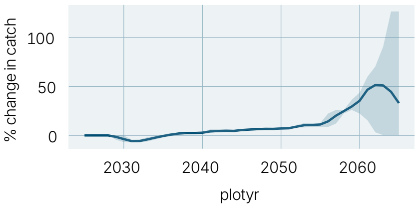

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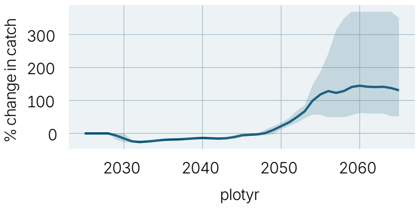

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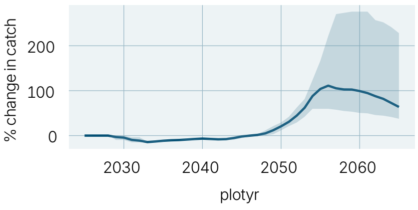

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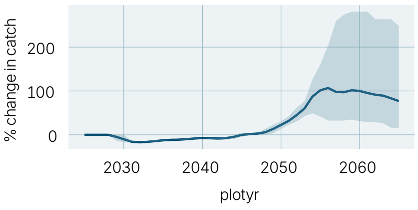

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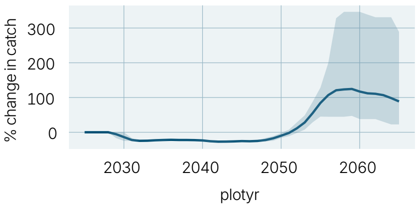

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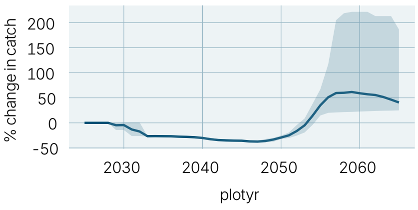

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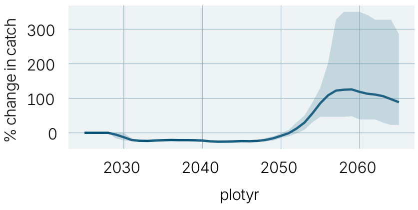
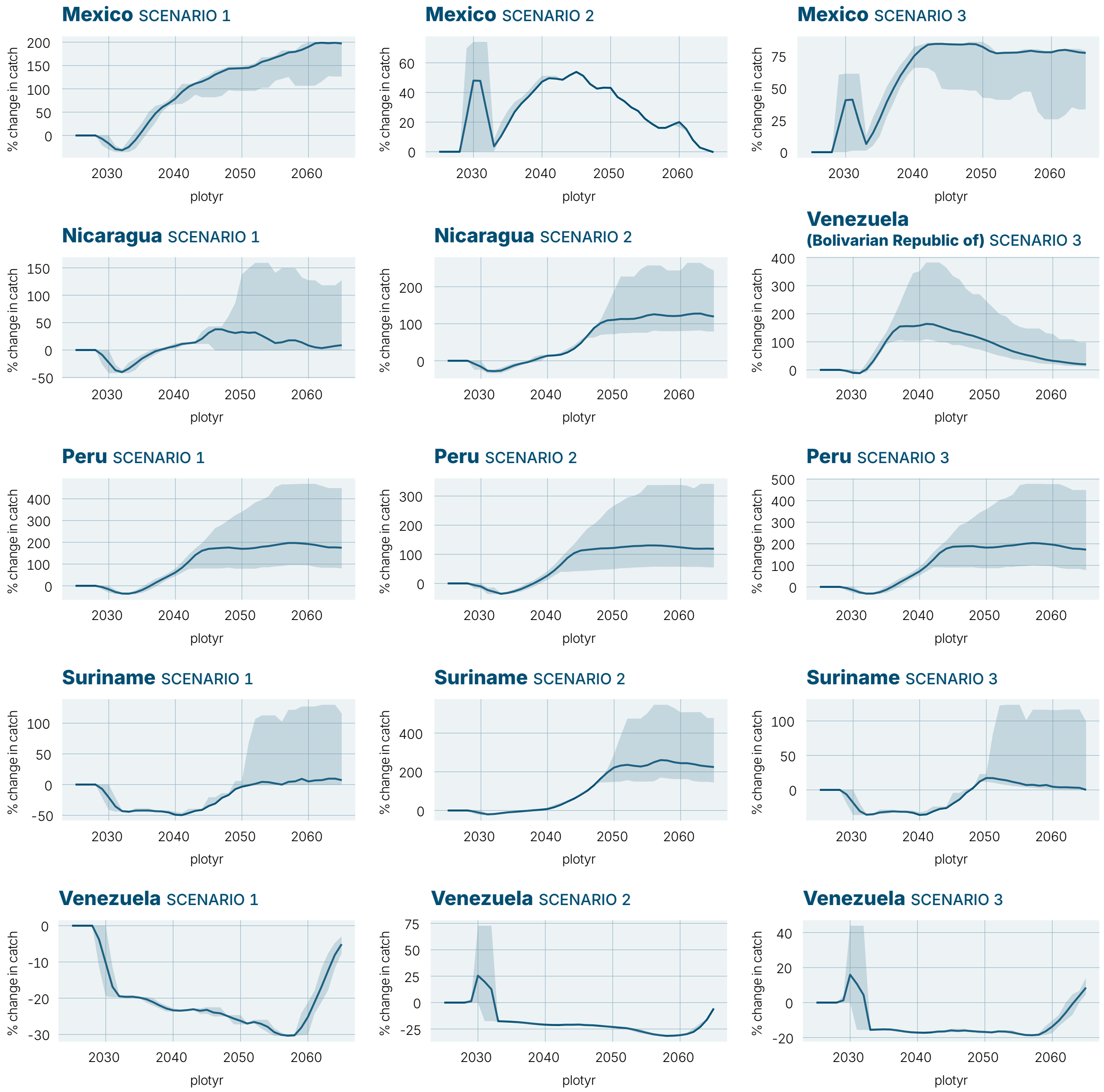




Notes: Scenario 1 = biodiversity priority, scenario 2 = economic priority, scenario 3 = biodiversity/economic compromise. Results are shown for MSP2, which is the middle-of-the-road scenario pathway for climate change and future fisheries management change; see Appendix Figures A4.1 and A4.2 for MSP1 and MSP3. Solid line shows a 10 percent catch floor, upper and lower bounds show 5 and 15 percent catch floors (see 4.5 methods appendix); plotyr = year from the model projection (first year of three-year moving average). All new MPAs were modeled as being put into place in 2030. Note that projections for certain countries' particularly small EEZs relatively to the model's spatial grid are less reliable, so the results for seven such countries (El Salvador, Guatemala, Guyana, Haiti, Panama, Trinidad and Tobago, and Uruguay) are described qualitatively in the text rather than presenting a potentially misleading quantitative projection in the figures.

TABLE 5 MSP2 Change in Fisheries Catch by Scenario, Compared to Baseline (percentage)

Country	Scenario 1 (percentage change)	Scenario 2 (percentage change)	Scenario 3 (percentage change)
Argentina	6.44	11.23	13.98
The Bahamas	-29.40	-27.27	-28.80
Barbados	-28.53	-27.11	-28.42
Belize	108.22	97.91	104.33
Bolivia	NA	NA	NA
Brazil	-14.3	-0.98	0.83
Chile	2.14	0.28	0.28
Colombia	-32.08	-0.57	-0.73
Costa Rica	-28.41	-0.12	-0.39
Dominican Republic	-19.18	-7.38	-7.99
Ecuador	-8.29	-1.50	-1.46
El Salvador	+	+	+
Guatemala	-	-	-
Guyana	-	-	-
Haiti	-	-	-
Honduras	-20.04	-10.09	-12.72
Jamaica	-21.92	-22.56	-20.87
Mexico	10.14	29.27	36.80
Nicaragua	-17.98	-13.10	-10.26
Panama	+	+	+
Paraguay	NA	NA	NA
Peru	-8.23	-17.28	-2.40
Suriname	-40.33	-8.33	-31.31
Trinidad and Tobago	-	-	-
Uruguay	+	+	+
Venezuela	-27.54	103.92	78.27

Notes: Results are shown for MSP2, which is the middle-of-the-road scenario pathway for climate change and future fisheries management change. Mean percentage change in catch during the main shock period for 30x30 (2030–2039) is shown. Scenario 1 = biodiversity priority, scenario 2 = economic priority, scenario 3 = biodiversity/economic compromise. Negative numbers are losses, positive numbers are gains in catch. Countries with a very large MPA increase in a small EEZ area have more uncertain outcomes and are simply represented as a gain or a loss compared to the baseline (+ or -). NA indicates landlocked countries.

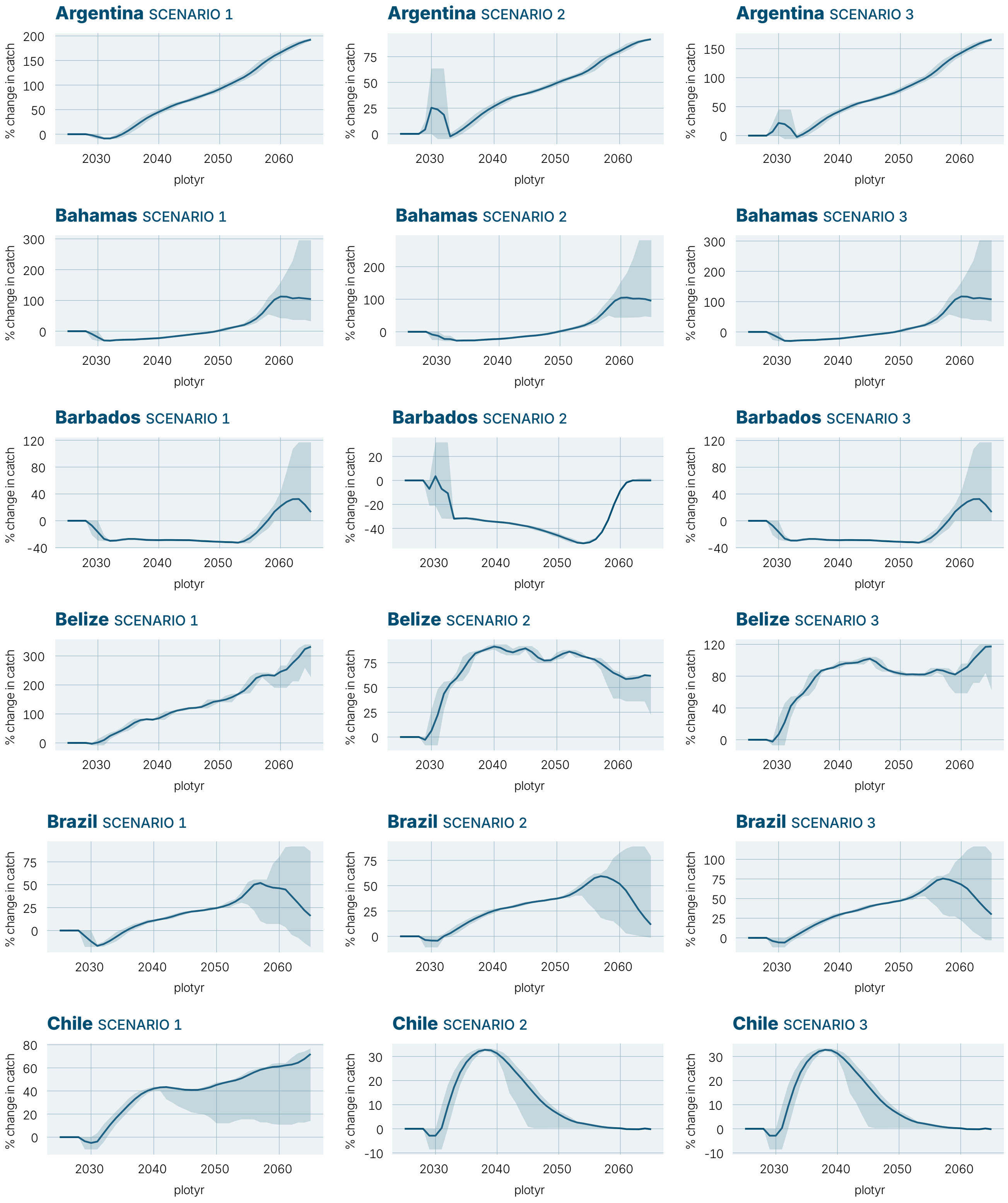
4.3 Policy Implications

Fisheries are not the only economic sector that will interact with MPAs. Some sectors, such as the visitor economy for coastal and maritime areas and all the support services driven by it, are likely to experience economic benefits from better protection of ocean and coastal areas. In the broader economic picture, the short-term shock to fisheries may be counterbalanced by rapid economic gains in these other sectors. Indeed, protected areas drive billions of dollars of visitor spending worldwide, much of it in foreign exchange.[25,40] At the governmental and societal level, therefore, the benefit to the tourism sector (and the upstream and downstream benefits that follow) needs to be weighed against any early losses experienced in the fisheries sector.

Finally, it is important to note that fisheries benefits depend on MPAs protecting marine areas of high biodiversity, where primary productivity is often high and fish populations can grow rapidly. This study's scenarios placed new MPAs in high-biodiversity areas and assumed strong, effective management of strict no-take areas, as has been empirically observed for most existing no-take areas.[41] If governments place MPAs in low-abundance marine areas, following an instinct to avoid placing MPAs where fishers might go, or if they underfund MPAs so that management is less effective,[42] then much less fish stock recovery would be expected. Spillover has been shown to extend over 100 nautical miles,[43] so the impact of weaker MPA stock recoveries would be felt throughout most EEZs. Although it may seem politically attractive to protect areas of low interest to fisheries, the result of any such action could be negative in the long run—for fisheries, food security, GDP, and biodiversity.

4.4 Appendix. Figures

TABLE A4.1 MSP1 Change in Fisheries Catch, by Scenario (percentage)



Argentina SCENARIO 1

Argentina SCENARIO 2

Argentina SCENARIO 3

Bahamas SCENARIO 1

Bahamas SCENARIO 2

Bahamas SCENARIO 3

Barbados SCENARIO 1

Barbados SCENARIO 2

Barbados SCENARIO 3

Belize SCENARIO 1

Belize SCENARIO 2

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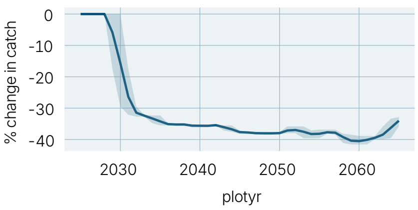
Chile SCENARIO 3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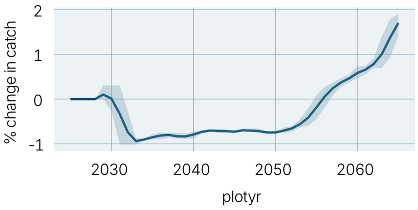
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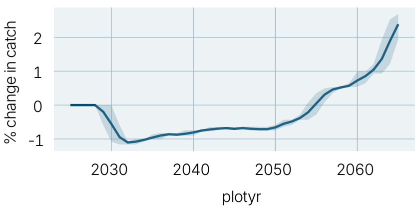
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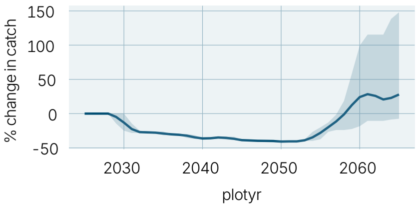
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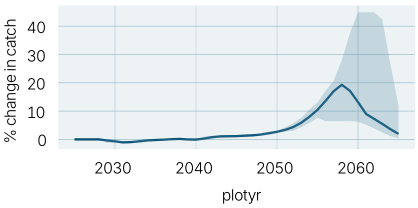
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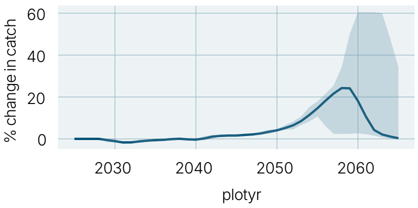
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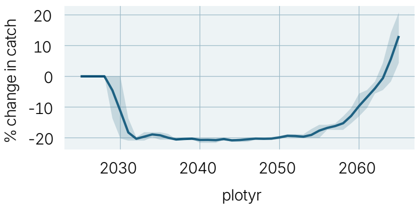
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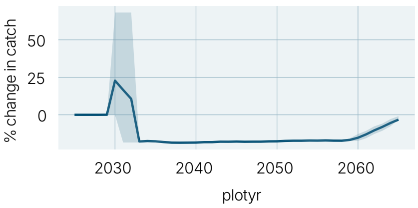
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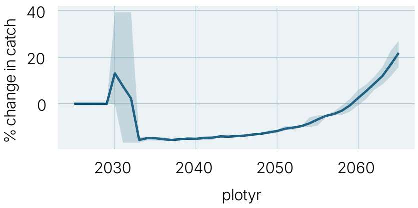
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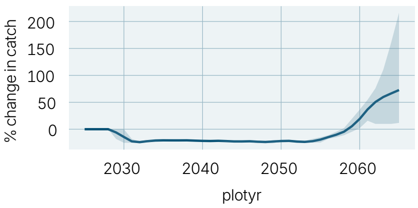
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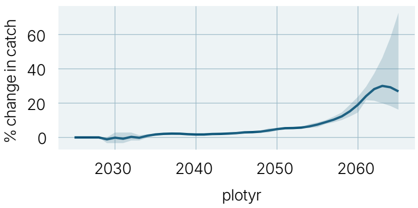
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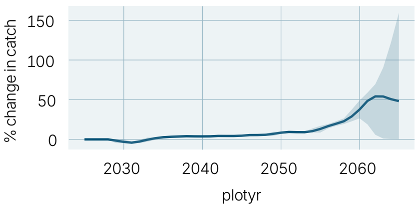
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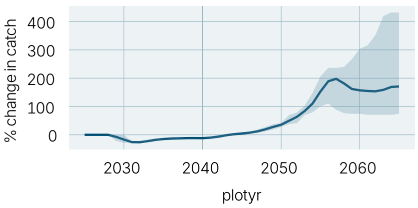
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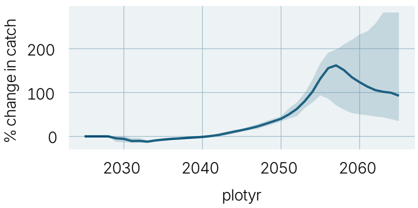
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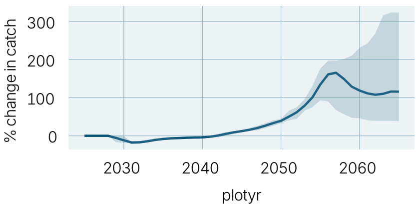
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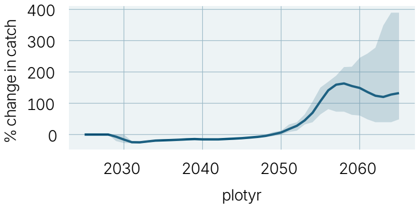
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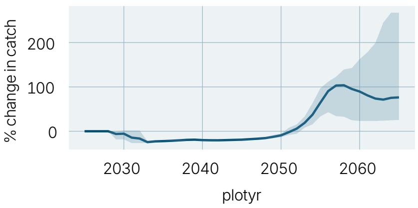
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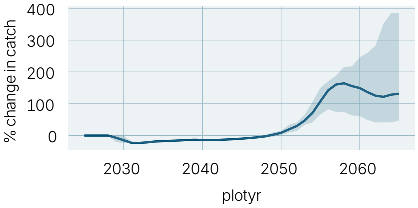
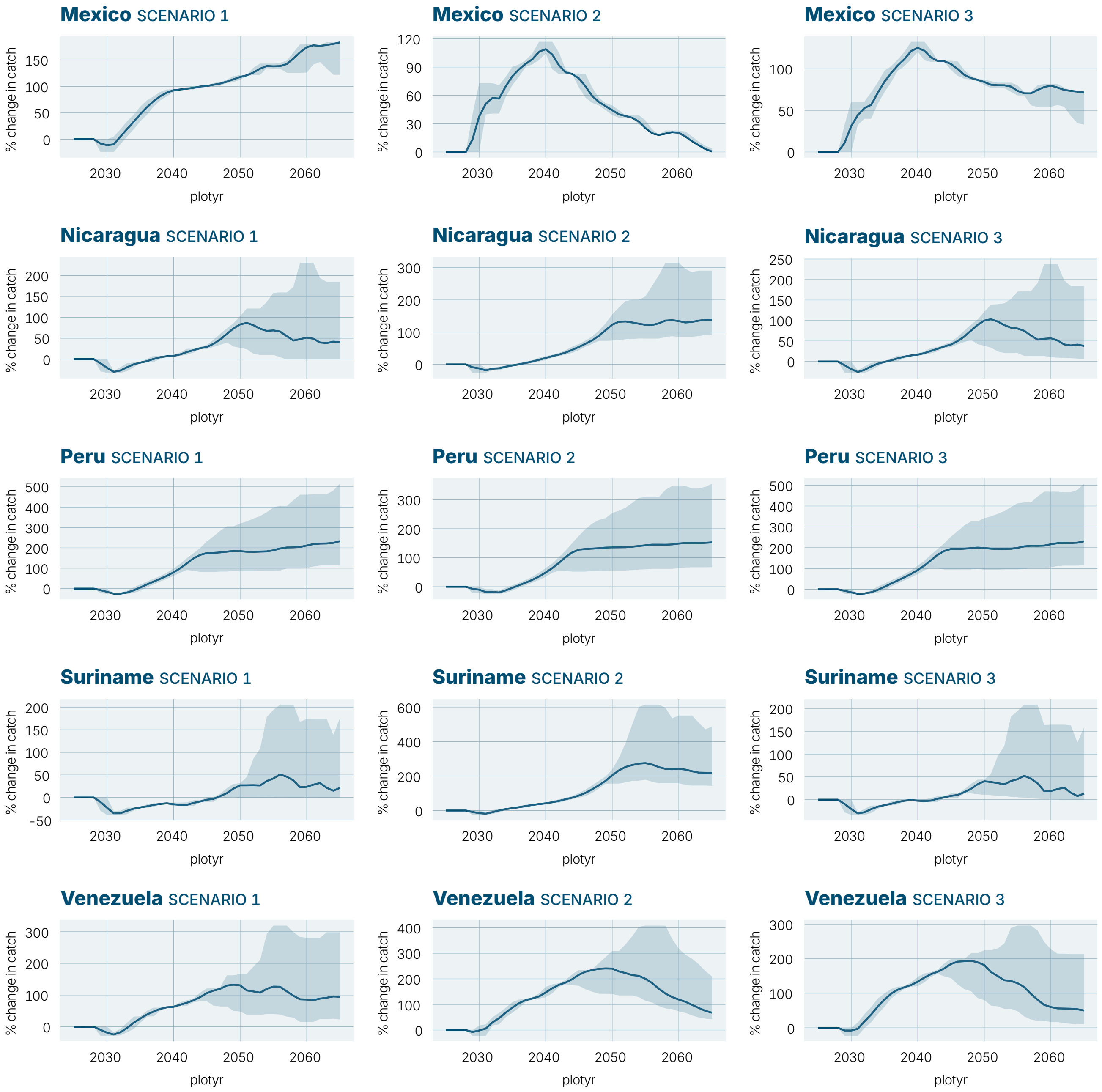

Jamaica SCENARIO 3



Mexico SCENARIO 1

Mexico SCENARIO 2

Mexico SCENARIO 3

Nicaragua SCENARIO 1

Nicaragua SCENARIO 2

Nicaragua SCENARIO 3

Peru SCENARIO 1

Peru SCENARIO 2

Peru SCENARIO 3

Suriname SCENARIO 1

Suriname SCENARIO 2

Suriname SCENARIO 3

Venezuela SCENARIO 1

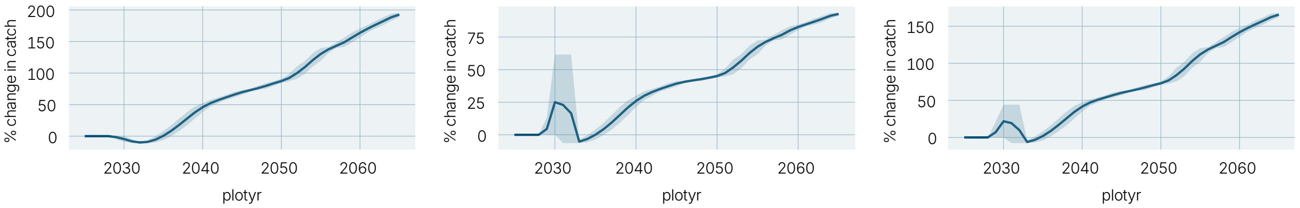
Venezuela SCENARIO 2

Venezuela SCENARIO 3

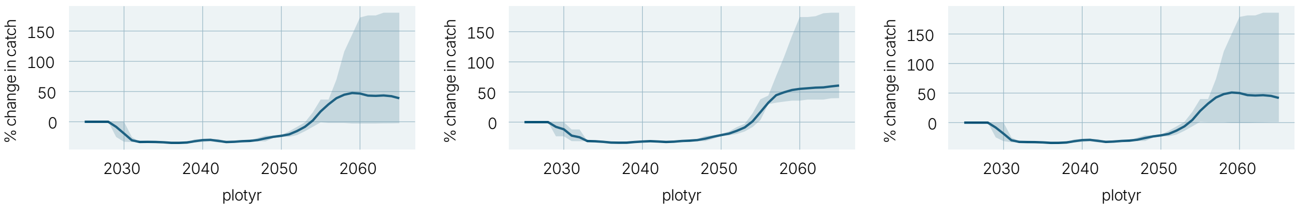
Notes: MSP1 = optimistic, low levels of global warming and sustainable management. Scenario 1 = biodiversity priority, scenario 2 = economic priority, scenario 3 = biodiversity/economic compromise. Solid line shows a 10 percent catch floor, upper and lower bounds show 5 and 15 percent catch floors (see 4.5 methods appendix); plotyr = year from the model projection (first year of three-year moving average). All new MPAs were modeled as being put into place in 2030. Note that projections for certain countries' particularly small EEZs relatively to the model's spatial grid are less reliable, so results for seven such countries (El Salvador, Guatemala, Guyana, Haiti, Panama, Trinidad and Tobago, and Uruguay) are described qualitatively in the text rather than presenting a potentially misleading quantitative projection in the figures.

TABLE A4.2 MSP3 Change in Fisheries Catch by Scenario, Compared to Baseline (percentage)

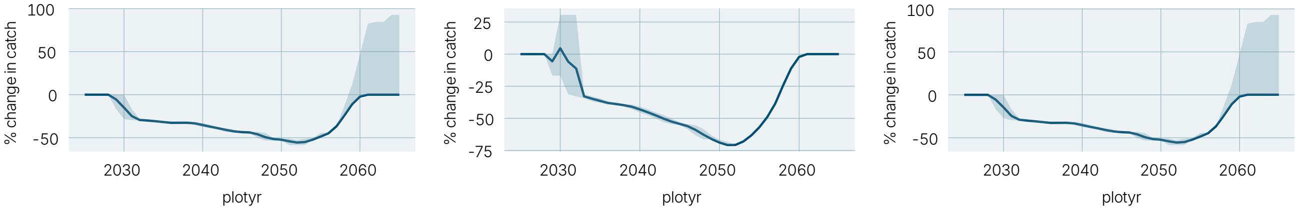
Argentina SCENARIO 1 | **Argentina** SCENARIO 2 | **Argentina** SCENARIO 3



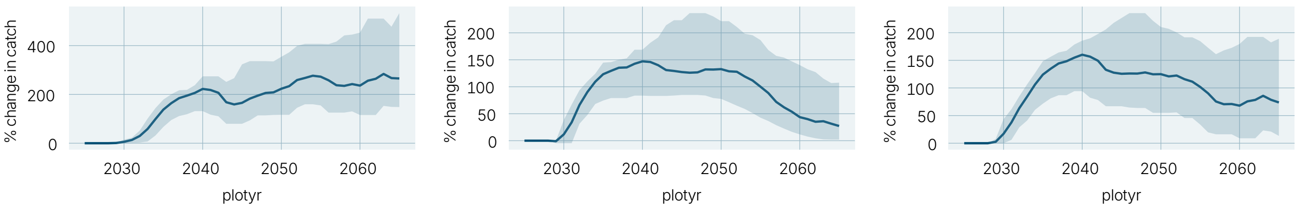
Bahamas SCENARIO 1 | **Bahamas** SCENARIO 2 | **Bahamas** SCENARIO 3



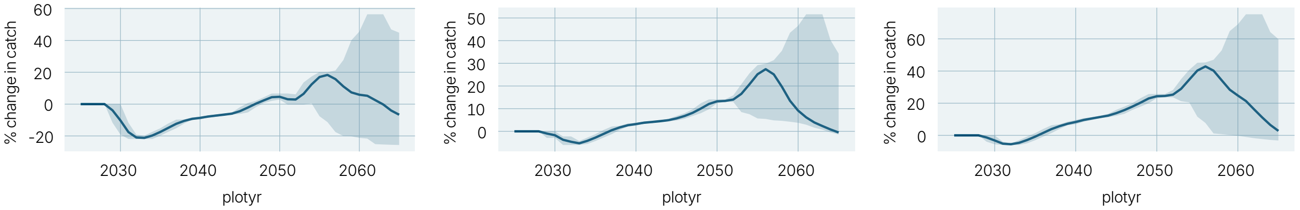
Barbados SCENARIO 1 | **Barbados** SCENARIO 2 | **Barbados** SCENARIO 3



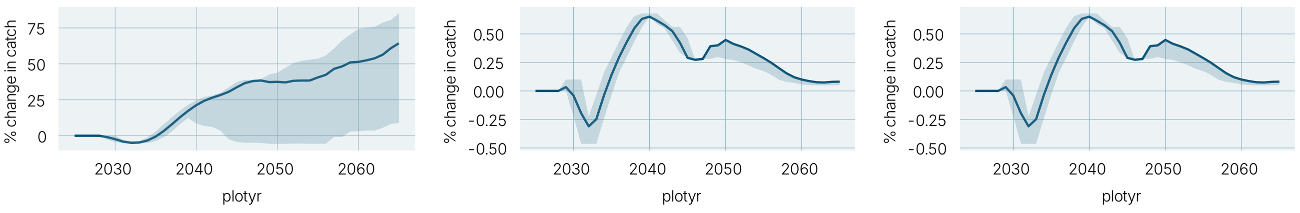
Belize SCENARIO 1 | **Belize** SCENARIO 2 | **Belize** SCENARIO 3



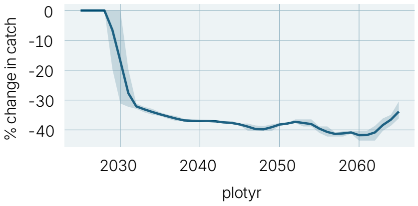
Brazil SCENARIO 1 | **Brazil** SCENARIO 2 | **Brazil** SCENARIO 3



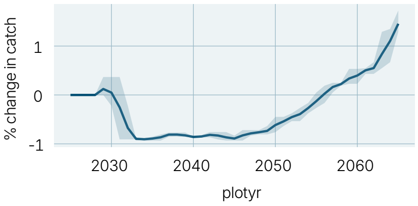
Chile SCENARIO 1 | **Chile** SCENARIO 2 | **Chile** SCENARIO 3



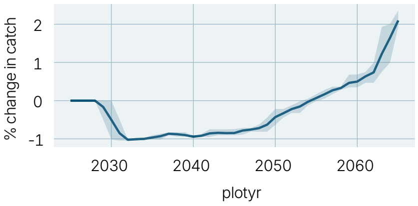
Colombia SCENARIO 1



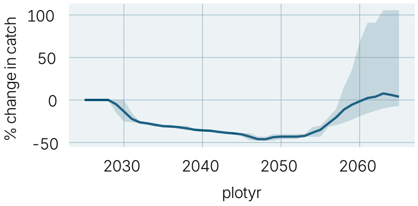
Colombia SCENARIO 2



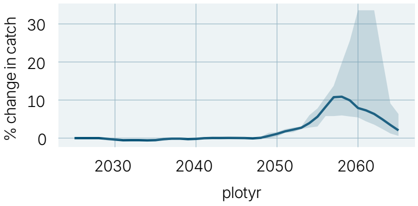
Colombia SCENARIO 3



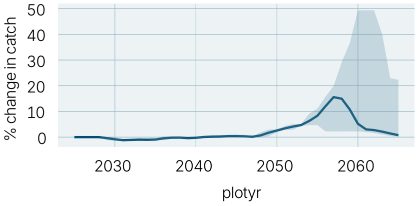
Costa Rica SCENARIO 1



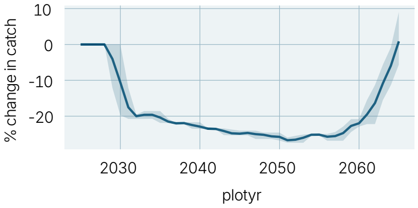
Costa Rica SCENARIO 2



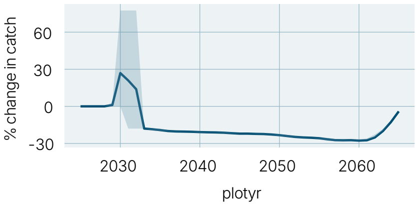
Costa Rica SCENARIO 3



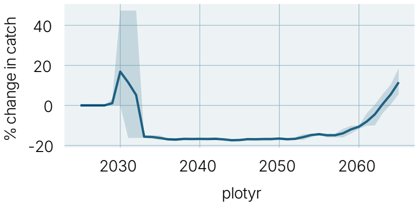
Dominican Republic SCENARIO 1



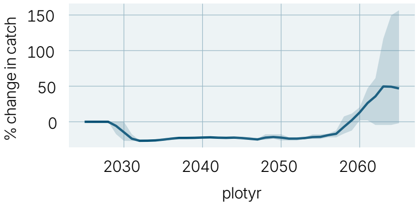
Dominican Republic SCENARIO 2



Dominican Republic SCENARIO 3



Ecuador SCENARIO 1



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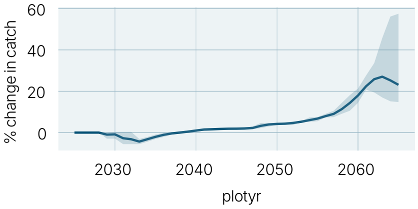

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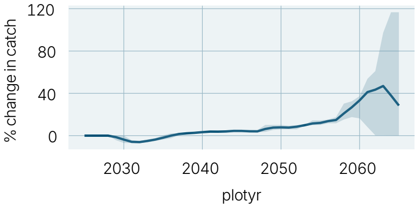
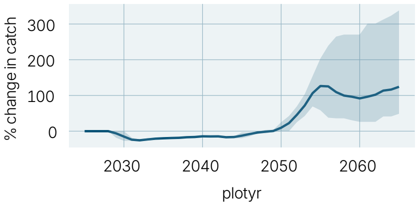


Honduras SCENARIO 1



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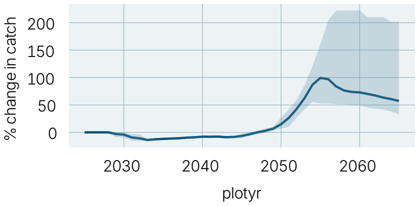

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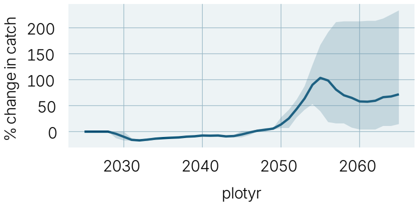
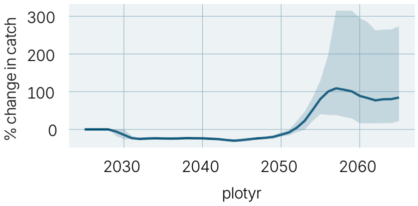
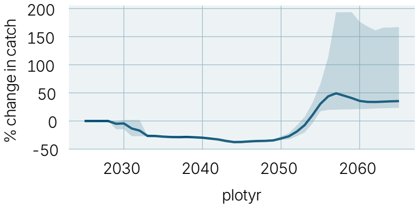


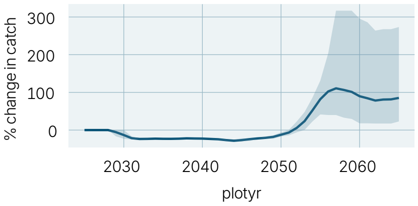
Jamaica SCENARIO 1

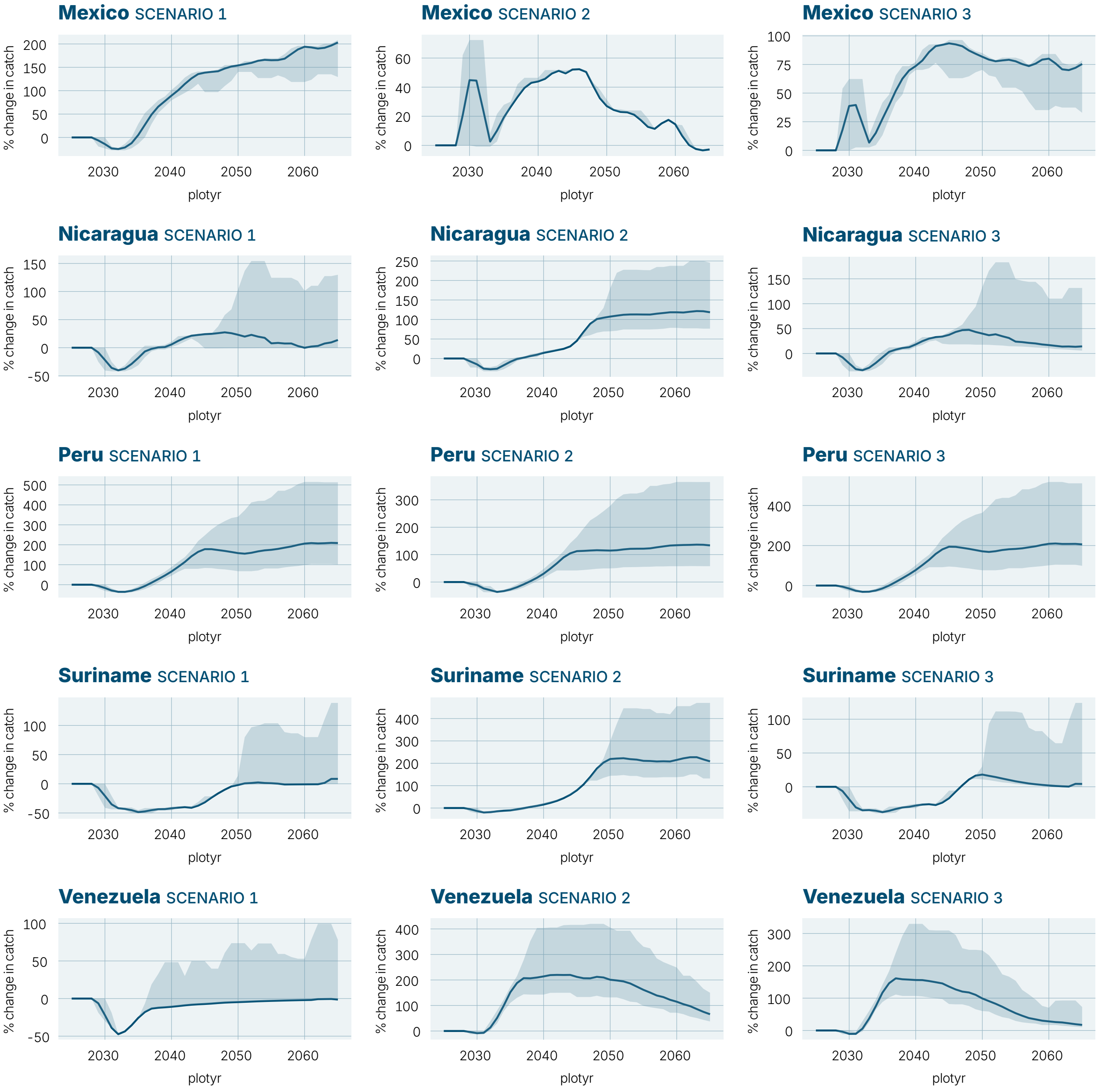


Jamaica SCENARIO 2



Jamaica SCENARIO 3




Mexico SCENARIO 1

Mexico SCENARIO 2

Mexico SCENARIO 3

Nicaragua SCENARIO 1

Nicaragua SCENARIO 2

Nicaragua SCENARIO 3

Peru SCENARIO 1

Peru SCENARIO 2

Peru SCENARIO 3

Suriname SCENARIO 1

Suriname SCENARIO 2

Suriname SCENARIO 3

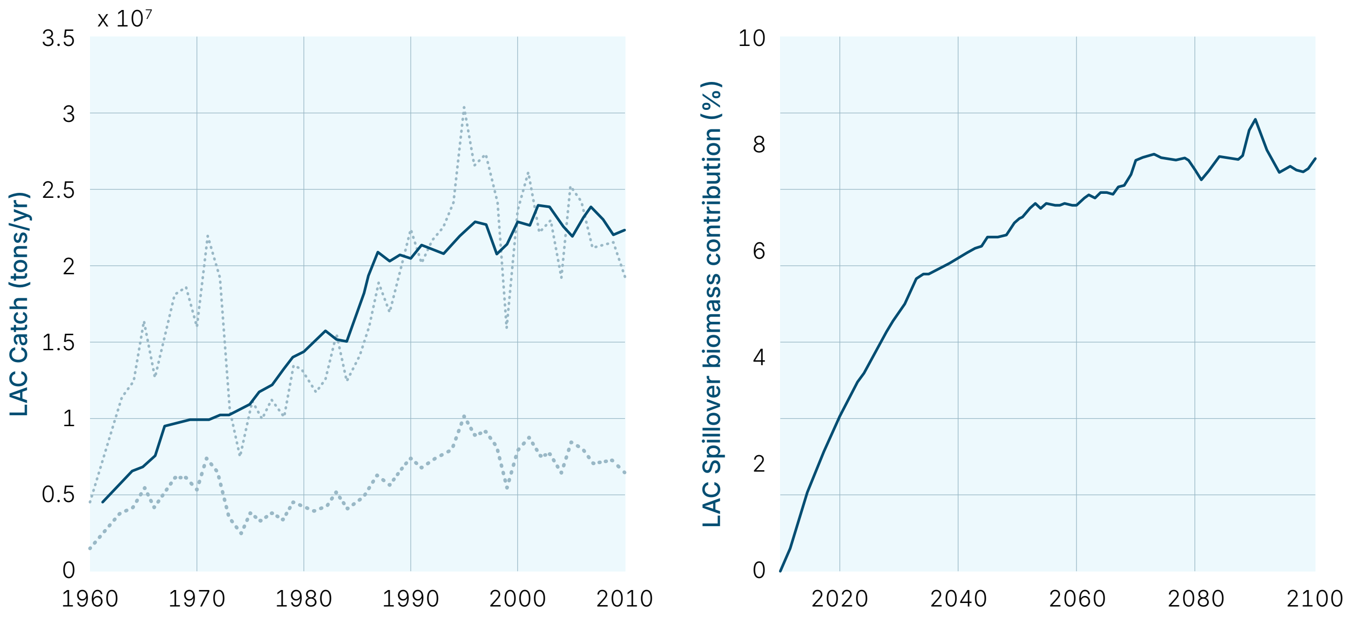
Venezuela SCENARIO 1

Venezuela SCENARIO 2

Venezuela SCENARIO 3

Notes: MSP3 = pessimistic, with high levels of global warming and no sustainable management. Scenario 1 = biodiversity priority, scenario 2 = economic priority, scenario 3 = biodiversity/economic compromise. Solid line shows a 10 percent catch floor, upper and lower bounds show 5 percent and 15 percent catch floors (see 4.5 methods appendix); plotyr = year from the model projection (first year of three-year moving average). All new MPAs were modeled as being put into place in 2030. Note that projections for certain countries' particularly small EEZs relatively to the model's spatial grid are less reliable, so results for seven such countries (El Salvador, Guatemala, Guyana, Haiti, Panama, Trinidad and Tobago, and Uruguay) are described qualitatively in the text rather than presenting a potentially misleading quantitative projection in the figures.

TABLE A4.3 Model Assessment of Regional Historical Catch



Notes: Left panel: BOATS simulation (in red) compared to SAU44 observation (+/- 50 percent uncertainty range as in Carozza et al. 2017). Note that the simulation tends toward the higher estimate of catch in recent years, but when applied, this is consistent across both the reference scenario and the 30x30 scenarios, so the opportunity cost calculation is unaffected. Right panel: Future biomass contribution by spillover in the aggregated BOATS simulations (in percentage).

4.5 Appendix. Methods

Opportunity costs arise from the creation of an MPA, and in this study they refer to the economic impact of prioritizing conservation over fisheries in MPAs. That is not to say that other sectors would not be affected. But calculating opportunity costs for mining and offshore drilling, for example, would require highly speculative—and inadvisable—guesswork about the value and location of mineral or oil discoveries, the likelihood of the discoveries being in an MPA, and the probability that an MPA "blocking" a major discovery would not simply be degazetted (have its protection removed). (Note that shipping might also be affected by an MPA, but MPAs can, and generally do, allow innocent passage to ships so long as they do not exploit or damage the area as they pass through.)

This study therefore focuses on the interaction of fisheries and MPAs. Put simply, a sector can suffer losses if it is not allowed to use its most preferred area for harvesting and exploitation of a natural resource and instead has to exploit the next most favorable area that is not protected. MPAs are often created in areas that are already being fished, causing clear and immediate potential opportunity costs to fishers (and the fisheries sector).

The approach taken in this study to assess opportunity costs is designed to consider that even if there were no new MPAs to impose fishing restrictions, fisheries catches for many areas are expected to fall in the future because of overfishing and climate change.[45] In other words, opportunity cost must be defined as the difference between the year-by-year catch (or its net value) that would be achieved if no further MPAs were created, which may itself show a decline, and the catch (or its net value) that would be achieved if 30 percent of the EEZ is protected.

To understand the effect of having no further MPAs, a baseline is documented. It represents the current extent of MPA coverage (with no further expansion), and the scenario of 30 percent protection is modeled using three possible scenarios for the fishing patterns permitted under an expanded national MPA system.

The economic impacts (opportunity costs) of MPA expansion can be positive or negative (or sometimes neutral).[11,16,25,46] On the negative side, closing or regulating certain fishing areas generates an instinctive expectation that catch will be lost.[20] On the positive side, new MPAs can allow overfished stocks to recover, boosting fisheries catches.[47] If the MPA is no-take, stocks will recover faster and to an even higher biomass.[16] However, much of the recovering biomass remains off-limits inside the MPA. The boost to fisheries is captured when recovering fish biomass overspills into the open-access area of the ocean, causing vessels to cluster near the borders of an MPA (the practice known as "fishing the line").[18,48] There may also be benefits to fisheries through the way MPAs act as a fisheries management tool, altering the economic incentives for exploitation (or overexploitation) in the first place. The economic consequences of MPA creation therefore unfold over time as a balance between these negative and positive effects.

To represent that process, this study uses a marine ecosystem model that resolves how fish biomass and catch dynamically responds to environmental and socioeconomic conditions, combined with a range of MSPs that represent possible trajectories of future climate change, fisheries practices and technologies.[27] The model used is BOATS,[22–24] which has been used in multiple projects to test opportunity costs of a MPAs worldwide, including in LAC.[25,26]

BOATS is a dynamic size-spectrum model that represents all commercial marine biomass ranging from 10 g to 100 kg, along with its interactions with fishing activities. The model iterates through time at a monthly timestep and simulates the spatiotemporal distribution of animal biomass, driven by vertically integrated net primary production and sea surface temperature (here SST). The exact same model formulation and parameterization as detailed in BOATS definition papers are used,[22–24] with the only changes being in the environmental forcings, provided by an Earth System Model, and the use of observed nominal fishing effort (see reference data in Github).

With its parameterization, BOATS can reproduce the dominant features of historical fish catches and robustly project future catch scenarios,[22–24] including the impact of various MPA scenarios. BOATS simulations often rely on a set of five replicates. The analysis for replicate EM1 (see Galbraith et al.[18]) is completed, providing the best match with global catch observations. Other parameters, particularly the homogeneous parameterization of costs and price, are based on global average estimates (see Galbraith et al.[18]).

In this study, fishing effort is first forced with observed values[49] within EEZs up to the year 2010, to initialize the system. While all ecological and economic model parameters are kept identical to other BOATS formulations,[22,23] a single parameter, the reference catchability level indirectly determining the onset of fisheries, was adjusted such that simulated regional historical catch best match observations (see Figure A4.3 for total catch in LAC region).

Then, from 2010 to 2100, effort evolves under different conditions depending on MPA status: (1) open access to the fish biomass resource (as in Carozza et al.); (2) a level of sustainable exploitation only, defined as regulated fishing (as in Scherrer et al.),[50] where fishing effort is nudged toward a target level (Etarg) or a fraction of it (i.e., 1.0 or 0.7 × Etarg), Here, Etarg represents the effort that achieves 70 percent of maximum sustainable yield; or (3) zero effort in no-fishing MPAs. Note that for regulated fishing, a societal enforcement parameter of 0.5 is adopted when regulation is applied (see Scherrer et al.). Here, this parameter modulates the transition from open-access to regulated fishing, and it is chosen to smooth discontinuities in the time series when regulation is activated. Regulation is triggered when catches for a fish group fall below 75 percent of the maximum simulated yield, sometimes causing effort to shift abruptly toward remaining open-access regions.

Moreover, to preserve total fishing effort in EEZs when zero effort or sustainably fished MPAs are created in 2030, this study conserves and reallocates effort regionally to open-access regions within each EEZ. Redistribution is proportional to the relative distribution of net primary production across the EEZ, under the assumption that more productive regions can sustain higher fishing pressure. Three possible floors are set to the percentage loss of catch in any year (5 percent, 10 percent, and 15 percent), to derive a range of possible effects and avoid unrealistic outcomes. The floor was calculated in each time step by using a five-year rolling average for the open-access area. In the figures, the midpoint line is 10 percent, the upper shaded range shows a 5 percent floor, and the lower shaded range, a 15 percent floor.

In its default configuration, BOATS does not account for biomass spillover from protected to exploitable areas. To address this, the model is modified to include redistribution of biomass at the EEZ level from protected to open-access areas. In BOATS, prior to fishing, fish growth is limited by per capita net primary production ($\xi=\xi\mathrm{NPP}$). When fishing depletes fish abundance, the net primary production available per individual increases, allowing growth to approach a biological maximum ($\xi=\xi\mathrm{max}>\xi\mathrm{NPP}$) in the absence of food limitation.

To simulate spillover during ecosystem recovery (i.e., when fishing is reduced and competition increases, lowering ξ from $\xi\mathrm{max}$ back toward $\xi\mathrm{NPP}$), a fraction of fish biomass is redistributed proportionally to $0.5\times(\xi\mathrm{max}-\xi)$. Under this formulation, spillover increases as ecosystems recover, shifting a small amount of biomass from recovering MPAs to open-access regions. Given the lack of data on biomass spillover and the wide variation in the level of spillover reported,[17,43,51–54] it is not possible to precisely determine the redistributed fraction of biomass production, whether from small species remaining near the closed MPAs or from large pelagic predators that migrate over long distances.

Under this study's formulation, spillover increases as ecosystems recover, shifting a few percentage points of biomass from recovering MPAs to open-access regions, up to a maximum contribution of ~8 percent across LAC (see Appendix Figure A4.3). This proportional fraction of excess biomass that is redistributed was selected, after a number of trials, as the one that generates biomass increases similar to those empirically observed for large pelagic, high-value predator species boosted by large closed areas (4.8 percent to 12 percent),[55] noting that the upper end of this range is also the catch per unit effort spillover benefit reported by Lynham and Villasenor-Derbez[43] for large MPAs and tuna purse seine fisheries.

BOATS does not attempt to model the changing mix of nationalities in the fleets operating in each grid square between 2030 and 2100. Nor does it attempt to predict the price of oil (or inputs more generally) in future years out to 2100, assuming that petrofuels will even be the main fuel used by fishing boats in the future, because such predictions are likely to be unrealistic.

Instead, BOATS simplifies input costs to an average, acknowledging that individual vessels may deviate from that average. However, as a global systems model, it is the aggregate activity in each grid cell that is being modeled, not the multiple separate activities of individual vessels of simulated national identity and type that will all be using different mixes of inputs. The total cost of effort expended, in a given cell at a given time, is therefore calculated as the total effort expended in the cell over that time, multiplied by the average cost of a unit of effort (1.85×10^{-7} US$/W/s or 5.85 US$/W/yr, see Galbraith et al.[22]). The effects of future technical enhancements on those input costs are modeled by changing the effort required to fish in future years, rather than the cost of input itself.

The authors implemented the scenarios in BOATS by assuming that new MPAs are created from 2030 (i.e., a lag of five years to identify suitable sites and make them operational). The level of ocean productivity depends on sea temperatures and atmospheric and oceanic warming, and projections of future fisheries outcomes therefore require a set of spatially explicit projections from climate models. Here, projections from GFDL-MOM6-COBALT2 are used, since this model has been bias corrected based on historical observations.[56] This model only has simulations up to 2010, so for 2010–2100 the relative change (compared to 2010 levels) in outputs from GFDL-ESM4 is used to project GFDL-MOM6-COBALT2 outputs forward to 2100. Outcomes are also likely to change as technological capacity and fisheries management attitudes evolve.

Neither the climate effects nor the management effects can be precisely forecast, so this study uses the common approach of creating MSPs,[27] which combine a scenario about warming (based on the representative concentration pathways, or RCPs[9]), with a scenario about management evolution. MSP1 assumed low climate forcing where global temperature stabilizes <2°C above preindustrial levels by 2100 (RCP2.6) and fisheries sustainability strongly increases in future decades. Specifically, fishing effort in open-access areas was steered back to sustainable levels thanks to strong management, defined as 70 percent of maximum sustainable yield.

Using a 70 percent maximum sustainable yield ceiling on catches in MSP1 provides a safety margin to account for uncertainty in the estimation of maximum sustainable yield, and the natural variability of fish populations.[57] MSP2 assumes a middle-of-the-road future for the climate (~2.7°C of warming by 2100 in RCP3.7) and unregulated fishing in open-access areas. Finally, MSP3 assumes an even higher level of climate change the (~3.5°C of warming from RCP8.5) with no regulation in open-access areas (similar to MSP2).

In summary, nine possible outcomes for a marine 30x30 are projected: three scenarios, and three MSPs per scenario. The model was run for each, with the redistribution of fishing effort from 2030 as described, and

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[9] See https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=welcome.

catch and effort (along with various other derived parameters) are calculated each year until 2100, to allow for effects to stabilize. Opportunity costs were calculated on the basis of the differences between the catch projected without any new MPAs and the catch projected under each of the three 30x30 scenarios, where all values were calculated using a three-year moving average.

5

Terrestrial Management Costs

Terrestrial management costs refer to the recurrent expenditures needed for the day-to-day operation of a terrestrial protected area (TPA) or TPA system.[1] All protected areas are created and maintained with multiple objectives in mind, so these costs can be highly variable.[2] For example, a manager may need to fund patrols, which implies both staff and vehicle costs; habitat maintenance and improvement; and infrastructure such as signage, fencing, trails, access roads, staff buildings, visitor centers, and perhaps ticket sale and concession sale buildings.[3]

These expenditures relate to the simple objectives of maintaining protected area ecosystems and the amenity value (visitor experience). However, effective protected area management also includes multiple additional actions, potentially including the development and maintenance of good community relations around the park; education and communication activities to increase understanding of (and compliance with) park goals; livelihood programs for local communities and stakeholders; veterinary activities; monitoring; financial planning and applications for funding; among others.[2,3] Some protected areas will carry out activities that others do not, for example when they have objectives or social contexts that are different. For all these reasons, the management costs themselves can vary across orders of magnitude.[2]

Strictly speaking, 30x30 will consist of PCAs,[4–6] but there is insufficient data on the potential cost differences between these alternative structures and TPAs to model the costs of the alternative structures. Accordingly, this chapter shows TPA costs for 30x30 and comments on possible (because of the unknown) differences from the alternatives. Moreover, this report uses the predictive model in Waldron et al.[8], to generate direct estimates for entire national systems in the future, rather than discrete protected area costs projected by other models, to provide robust approximations for entire national systems.

The Waldron et al.[8] statistical models are based on historical data on finance needs, comprising multiple reports with a median date of 2015, with several reports from LAC countries: Argentina, Belize, Bolivia, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Grenada, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, and Venezuela. Many of those data were shared on a strictly confidential basis with the senior authors of Waldron et al.[8], but the reports were typically carried out by government departments or experts in each of the reporting countries. Data on protected areas costs and finance needs are typically harder to source for smaller Caribbean island countries, but a more recent detailed report has also been made for The Bahamas (of mixed marine and terrestrial needs).[11]

Waldron et al. showed that it was possible to accurately predict national-system finance needs using common drivers of budget differences. In particular, they found that in general, larger systems need larger budgets; comparatively less expensive countries with lower overall costs need lower budgets; protected area systems under higher human pressure cost more to maintain; stronger rule of law in a country can reduce costs; and systems that incorporate business aspects (such as ticket and gift sales, visitor centers, etc.) need higher budgets than systems with little such activity.[8]

Each of those broad factors is used (parameterized) in a quantitative form in the predictive costing model. System size is simply measured as the areal extent of the national protected area system. The intuition of a "lower cost base for operations in lower-cost countries" is captured by expressing all financial values at PPP. Governance was quantified using the governance indicator "government effectiveness" from the governance indicators dataset.[12] As a quantitative measure of business activity, the model uses data on the site-based revenues earned within each national system, largely derived from confidential national reports.[8]

Then, for metrics of human pressure, the model uses two spatial datasets: (1) the human footprint, which combines measures of local development, road development, and human population to give a footprint value to each grid cell globally;[13,14] and (2) net agricultural rent, which measures the value of the protected land if it was converted to agriculture or livestock, net of the costs of producing those commodities and bringing them to market, and including any value of timber that might be extracted in the process of conversion.[15] However, Waldron et al.[8] also found that footprint and agricultural rent acted as much better predictors if they were expressed relative to the national average. For example, a country may have poor agricultural land or undeveloped transport for commodities in general, so agricultural rent values will be low nearly everywhere. Therefore, what would matter to agriculturalists seeking to convert natural habitat is not the raw value of an extractable commodity (which is always likely to be low in this case), but whether the value is high relative to all other land available in the country. Both footprint and rent for protected areas were consequently scaled against the mean value in the country, referred to as "relative agricultural rent" and "relative footprint."

5.1 Modeling TPA Management Costs

To project TPA system management costs in IDB LAC countries, the Waldron et al.[8] models are applied to the three 30x30 scenarios (see Chapter 2). For countries with more than 30 percent already protected, the current value was used. The main year of focus for the finance need was 2030, but the model also allows for the exploration of how costs could change post-2030. Future management costs were then projected out from 2030 to 2060 in five-year intervals.

Three possible trajectories have been created—high, mid, and low—as sub-scenarios for post-2030 projections, with each reflecting the possible ways in which cost could change as the predictor variables used by the model evolve. Notably, many of the predictor variables are relative terms, such as the ratio between the footprint around the TPAs and the mean national footprint, and the same ratio for net agricultural rent.

Although it is highly likely that the human footprint overall will continue to increase post-2030, an overall increase in a national footprint over time does not necessarily mean that the ratio between the two parts of that footprint will change. Indeed, it is equally possible that ratio values could decrease, even if the underlying driver is increasing. For example, a country may be developing its urban areas faster, so the ratio of rural footprint to average national footprint would actually decrease as overall national footprint increased.

The authors therefore used the sub-scenarios in modeling changes in the ratio variables (footprint and agricultural rent), or indeed a zero-sum outcome (see 5.5 methods appendix). The high sub-scenario assumes a moderate increase in the ratio over time of 1 percent per five years and a one-off increase of 5 percent associated with potential greater TPA business costs per hectare; the low sub-scenario assumes a moderate decrease in the ratio over time at the same rate, and a one-off decrease of 5 percent in business costs per hectare; and the mid scenario assumes that the effects cancel each other out and leave a state of no change over time in the ratio (and therefore in the cost).

In total, therefore, there are nine finance need estimates per country: the three 30x30 scenarios with three sub-scenarios each (the high models' costs increase over time and the lows decrease). Note that the sub-scenarios should be seen as illustrative rather than predictive, because other rates of increase and decrease could potentially occur post-2030, particularly with regard to the ratios.

5.2 Main Results

Across the 26 LAC IDB countries, the 2030 annual management cost for the three terrestrial scenarios ranged from US$1.2 million per year for Guyana to over US$2 billion for Brazil (all finance values given in constant 2024 US$). This large difference between countries was primarily driven by two factors. The first was the size of the country (and therefore the size of 30 percent of the country), since larger systems need larger budgets. The second was the human pressures on the TPA system implied by the scenarios, and countries where these pressures were higher tended to have higher costs.

Historically, TPAs have been situated in areas of relatively low economic importance, such as remote lands, deserts, or mountaintops, which also have low pressures and low land values (agricultural rents).[16,17] Although this "wilderness-style" approach may have been motivated by a desire to avoid opportunity costs, it has prevented TPA systems from capturing much of the important biodiversity and ecosystem services in each country.[18,19] It is often commented that that historical tendency needs to change, so that TPAs protect more of the critical biodiversity remaining (see for example[18–22]).

The results here show that across LAC, unprotected high-biodiversity areas were often on land that has higher agricultural value and higher human footprints than is true of current systems. Therefore, focusing on biodiversity will satisfy the requirements of GBF Target 3 to protect areas of importance for biodiversity, but that focus is likely to increase overall system management costs.

One way of visualizing the management cost impact of placing new TPAs on higher-value (or higher-footprint) land is to create a "hypothetical imaginary" system, in which agricultural land value and human pressure remain unchanged as the system expands. (These are imaginary because they are modeled irrespective of whether a very large wilderness-style system is physically and geographically possible in each country). Specifically, agricultural rent and human footprint—the two human pressure predictors—are artificially kept at the same as the value in the current system in the model, and only the size of the area protected changes.

The authors used the statistical predictive model to project finance needs for such a hypothetical imaginary, then compared the projected costs (for 2030) to the three main scenario outcomes. The three scenarios were 2.1, 2.0, and 2.2 times more expensive, respectively, than the hypothetical imaginary (median cost difference per country, see Table A5.7). These multiples give a sense of how much the spatial overlap between high biodiversity and high potential land value (or footprint) increases the management cost.

For countries with current TPA systems that are particularly wilderness-focused, the increase implied by the post-2030 scenarios can be much larger than those median values. Chile, in particular, has a strong current focus on very remote or wilderness-type TPAs. If new, post-2030 Chilean TPAs follow the scenarios in protecting high-biodiversity areas instead, which are also located closer to areas of human development in Chile, then the pressures on the system would more than triple (as measured by footprint and agricultural value). The effect of this can be seen in comparing the cost of the hypothetical imaginary for Chile—which is US$73 million per year–with its costs under scenarios 1–3, which exceed US$1 billion per year (Table A5.7).

Yet Chile presents an extreme example. The financial impact of protecting high-biodiversity areas is sometimes more modest, and in a small number of countries (Colombia, Guatemala, Jamaica, and Uruguay), protecting the high-biodiversity areas is actually cheaper than it would be for the hypothetical imaginary (Table A5.7), implying a win-win in which high-biodiversity areas do not compete with economic priorities.

Although quantifying a cost:benefit balance for specific IDB LAC countries was outside the scope of this report, the costs here cannot be tabulated without at least a mention of the benefits that, essentially, are being invested in by meeting those costs. TPAs provide many ecosystem services,[22–25] such as more secure water supplies,[26] pollination and pest control,[27] local weather benefits, recreation,[8,28] and health and productivity gains.[29–31] These can be quantified using tools such as IDB's Open IEEM or the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) tools. TPAs are also a major driver of revenue in the nature tourism sector, with revenues that are several times larger than TPA system costs in most countries.[28,32] Nature tourism, often associated with the presence of parks such as national parks, is indeed a major economic sector in LAC, and one that is likely to grow particularly rapidly in future years.[32,33]

Such benefits are particularly relevant when considering the problem of the high cost of managing conserved land in areas of high human use (footprint) and high productive value. On its own, the high management cost of high-biodiversity but high-economic-activity areas may seem to imply that financially, it is preferable to avoid protecting such areas. However, proximity to people and their economic activities also increases the TPA system's economic benefits: the closer TPAs are to people and agricultural production areas, the higher the economic value of TPA-related contributions such as clean water, pollination and pest control, or health and productivity gains. Indeed, in other studies, the value of benefits have been shown to outweigh the cost of providing them.[8]

An increasingly common tendency is to cost TPA system needs (including for 30x30) by using an accountancy approach. In that approach, rules are created and assumed about the number of staff, vehicles, and other inputs needed per hectare, and those rules are then converted into line-item lists per TPA, with costs for each (e.g.[34–36]) to calculate a total finance need. Often, the underlying rules are fixed, presumably based on experience of the current TPA system. Costs derived from the predictive statistical models often closely replicate the results of accountancy-approach methods, but they also reveal where accountancy approaches may become inaccurate or misleading about future budget needs.

Notably, in countries where the 30x30 scenarios imply that the government needs to shift away from wilderness approaches toward biodiversity protection in human-used areas, costs calculated using line-item accounting approaches will miss the cost increase implied by that shift. These incorrectly low accounting estimates would be unhelpful for policy planning.

TABLE 6 TPA Management Costs for Scenario 1, with Mid Sub-scenario

Country	2030	2035	2040	2045	2050	2055	2060	Area protected (km^2)
Argentina	246.92	246.92	246.92	246.92	246.92	246.92	246.92	835598.4
The Bahamas	18.89	18.89	18.89	18.89	18.89	18.89	18.89	4310
Barbados	10.66	10.66	10.66	10.66	10.66	10.66	10.66	133.2
Belize	37.72	37.72	37.72	37.72	37.72	37.72	37.72	8239
Bolivia	187.39	187.39	187.39	187.39	187.39	187.39	187.39	334507
Brazil	2386.64	2386.64	2386.64	2386.64	2386.64	2386.64	2386.64	2593200
Chile	1684.98	1684.98	1684.98	1684.98	1684.98	1684.98	1684.98	227946.3
Colombia	127.59	127.59	127.59	127.59	127.59	127.59	127.59	343509.9
Costa Rica	229.53	229.53	229.53	229.53	229.53	229.53	229.53	15490.8
Dominican Republic	95.9	95.9	95.9	95.9	95.9	95.9	95.9	14553
Ecuador	228.69	228.69	228.69	228.69	228.69	228.69	228.69	77441.7
El Salvador	24.29	24.29	24.29	24.29	24.29	24.29	24.29	6171.9
Guatemala	80.94	80.94	80.94	80.94	80.94	80.94	80.94	32976.6
Guyana	1.22	1.22	1.22	1.22	1.22	1.22	1.22	63360
Haiti	12.77	12.77	12.77	12.77	12.77	12.77	12.77	8217
Honduras	22.78	22.78	22.78	22.78	22.78	22.78	22.78	33987.3
Jamaica	26.96	26.96	26.96	26.96	26.96	26.96	26.96	3317.7
Mexico	562.65	562.65	562.65	562.65	562.65	562.65	562.65	589.585.50
Nicaragua	41.7	41.7	41.7	41.7	41.7	41.7	41.7	38766.6
Panama	61.08	61.08	61.08	61.08	61.08	61.08	61.08	23378
Paraguay	803.48	803.48	803.48	803.48	803.48	803.48	803.48	120449.4
Peru	492.31	492.31	492.31	492.31	492.31	492.31	492.31	389561.1
Suriname	51.72	51.72	51.72	51.72	51.72	51.72	51.72	44267.4
Trinidad and Tobago	4.81	4.81	4.81	4.81	4.81	4.81	4.81	1572
Uruguay	63.8	63.8	63.8	63.8	63.8	63.8	63.8	53538
Venezuela	334.44	334.44	334.44	334.44	334.44	334.44	334.44	518161

Notes: Costs are shown in constant 2024 US$ millions. The mid sub-scenario envisages a future in which the drivers of PCA costs remain constant over time. Area protected under 30x30 is shown in km^2, either 30 percent of land area or the size of the current TPA system, whichever is larger.

TABLE 7 TPA Management Costs for Scenario 2, with Mid Sub-scenario

Country	2030	2035	2040	2045	2050	2055	2060	Area protected (km²)
Argentina	425.6	425.6	418.69	411.96	405.41	399.02	392.8	835598.4
The Bahamas	18.89	18.89	18.59	18.29	17.99	17.71	17.43	4310
Barbados	10.66	10.66	10.66	10.66	10.66	10.66	10.66	133.2
Belize	37.72	37.72	37.11	36.51	35.93	35.36	34.81	8239
Bolivia	135.32	135.32	133.49	131.71	129.96	128.26	126.6	334507
Brazil	2481.73	2481.73	2451.28	2421.51	2392.39	2363.9	2336.04	2593200
Chile	1794.22	1794.22	1794.22	1794.22	1794.22	1794.22	1794.22	227946.3
Colombia	149.07	149.07	147.07	145.12	143.21	141.35	139.53	343509.9
Costa Rica	247.31	247.31	242.95	238.72	234.6	230.59	226.69	15490.8
Dominican Republic	94.54	94.54	92.99	91.49	90.03	88.6	87.21	14553
Ecuador	231.1	231.1	227.37	223.73	220.19	216.73	213.37	77441.7
El Salvador	25.99	25.99	25.99	25.99	25.99	25.99	25.99	6171.9
Guatemala	79.09	79.09	77.82	76.58	75.38	74.2	73.06	32976.6
Guyana	1.22	1.22	1.22	1.22	1.22	1.22	1.22	63360
Haiti	12.6	12.6	12.4	12.21	12.03	11.85	11.67	8217
Honduras	22.52	22.52	22.16	21.81	21.47	21.13	20.81	33987.3
Jamaica	26.27	26.27	25.85	25.45	25.06	24.68	24.31	3317.7
Mexico	534.58	534.58	525.51	516.68	508.09	499.73	491.58	589585.5
Nicaragua	41.77	41.77	41.1	40.44	39.8	39.18	38.58	38766.6
Panama	61.08	61.08	60.05	59.04	58.06	57.11	56.18	23378
Paraguay	774.73	774.73	761.94	749.49	737.37	725.56	714.06	120449.4
Peru	462.54	462.54	462.54	462.54	462.54	462.54	462.54	389561.1
Suriname	57.84	57.84	56.85	55.89	54.95	54.03	53.14	44267.4
Trinidad and Tobago	4.81	4.81	4.74	4.66	4.59	4.52	4.45	1572
Uruguay	64.49	64.49	63.49	62.52	61.57	60.64	59.74	53538
Venezuela	336.4	336.4	331.75	327.2	322.76	318.43	314.2	518161

Notes: Costs are shown in constant 2024 US$ millions. The mid sub-scenario envisages a future in which the drivers of PCA costs remain constant over time. Area protected under 30x30 is shown in km², either 30 percent of land area or the size of the current TPA system, whichever is larger.

TABLE 8 Management Costs for Scenario 3, Mid Sub-scenario

Country	2030	2035	2040	2045	2050	2055	2060	Area protected (km²)
Argentina	615.61	615.61	615.61	615.61	615.61	615.61	615.61	835598.4
The Bahamas	18.89	18.89	18.89	18.89	18.89	18.89	18.89	4310
Barbados	10.66	10.66	10.66	10.66	10.66	10.66	10.66	133.2
Belize	37.72	37.72	37.72	37.72	37.72	37.72	37.72	8239
Bolivia	147.05	147.05	147.05	147.05	147.05	147.05	147.05	334507
Brazil	2512.08	2512.08	2512.08	2512.08	2512.08	2512.08	2512.08	2593200
Chile	1684.98	1684.98	1684.98	1684.98	1684.98	1684.98	1684.98	227946.3
Colombia	137.76	137.76	137.76	137.76	137.76	137.76	137.76	343509.9
Costa Rica	240.85	240.85	240.85	240.85	240.85	240.85	240.85	15490.8
Dominican Republic	94.51	94.51	94.51	94.51	94.51	94.51	94.51	14553
Ecuador	231.53	231.53	231.53	231.53	231.53	231.53	231.53	77441.7
El Salvador	24.29	24.29	24.29	24.29	24.29	24.29	24.29	6171.9
Guatemala	79.71	79.71	79.71	79.71	79.71	79.71	79.71	32976.6
Guyana	1.22	1.22	1.22	1.22	1.22	1.22	1.22	63360
Haiti	12.43	12.43	12.43	12.43	12.43	12.43	12.43	8217
Honduras	21.67	21.67	21.67	21.67	21.67	21.67	21.67	33987.3
Jamaica	26.66	26.66	26.66	26.66	26.66	26.66	26.66	3317.7
Mexico	663.31	663.31	663.31	663.31	663.31	663.31	663.31	589585.5
Nicaragua	41.74	41.74	41.74	41.74	41.74	41.74	41.74	38766.6
Panama	61.08	61.08	61.08	61.08	61.08	61.08	61.08	23378
Paraguay	836.58	836.58	836.58	836.58	836.58	836.58	836.58	120449.4
Peru	648.76	648.76	648.76	648.76	648.76	648.76	648.76	389561.1
Suriname	59.31	59.31	59.31	59.31	59.31	59.31	59.31	44267.4
Trinidad and Tobago	4.81	4.81	4.81	4.81	4.81	4.81	4.81	1572
Uruguay	65.75	65.75	65.75	65.75	65.75	65.75	65.75	53538
Venezuela	336.17	336.17	336.17	336.17	336.17	336.17	336.17	518161

Notes: Costs are shown in constant 2024 US$ millions. The mid sub-scenario envisages a future in which the drivers of PCA costs remain constant over time. Area protected under 30x30 is shown in km^2, either 30 percent of land area or the size of the current TPA system, whichever is larger.

TABLE 9 TPA Management Costs in 2030 Under the Three Scenarios

Country	scenario 1	scenario 2	scenario 3
Argentina	246.92	392.8	615.61
The Bahamas	18.89	17.43	18.89
Barbados	10.66	10.66	10.66
Belize	37.72	34.81	37.72
Bolivia	187.39	126.6	147.05
Brazil	2386.64	2336.04	2512.08
Chile	1684.98	1794.22	1684.98
Colombia	127.59	139.53	137.76
Costa Rica	229.53	226.69	240.85
Dominican Republic	95.9	87.21	94.51
Ecuador	228.69	213.37	231.53
El Salvador	24.29	25.99	24.29
Guatemala	80.94	73.06	79.71
Guyana	1.22	1.22	1.22
Haiti	12.77	11.67	12.43
Honduras	22.78	20.81	21.67
Jamaica	26.96	24.31	26.66
Mexico	562.65	491.58	663.31
Nicaragua	41.7	38.58	41.74
Panama	61.08	56.18	61.08
Paraguay	803.48	714.06	836.58
Peru	492.31	462.54	648.76
Suriname	51.72	53.14	59.31
Trinidad and Tobago	4.81	4.45	4.81
Uruguay	63.8	59.74	65.75
Venezuela	334.44	314.2	336.17

Notes: Costs are shown in millions of constant 2024 US$. Scenario 1 = biodiversity priority, scenario 2 = economic priority, scenario 3 = biodiversity/economic compromise.

5.3 Policy Implications

Because the precise configuration of 30x30 PCA systems remains unknown, the three scenarios were created to project a range of possible costs. Given that the projected costs for scenarios in a large majority of countries studied are within 10 percent of each other (Table 9), projected costs remain relatively stable even when background conditions vary.

However, the implications of the differences between the scenarios is also interesting. Across all countries, scenario 1 (biodiversity) is generally cheaper than both scenarios 2 and 3 (economic and compromise, respectively). Scenario 2 is also always cheaper than, or the same cost as, scenario 3. Given that scenario 1 was designed to focus solely on biodiversity importance, with no consideration of the negative economic consequences of conservation, it is interesting to note that scenario 1 is the cheapest in terms of management budgets. This implies a trade-off between opportunity costs (which would be higher in scenario 1, see chapter 7) and management costs (which are lowest in scenario 1).

And although the low cost of scenario 1 is sometimes particularly striking, such as in Argentina where it would cost less than half of scenario 3 (Table 9), that is not to say that the scenario cannot also be the most expensive. Scenario 1 was the most expensive in Bolivia, suggesting a particularly acute spatial conflict in that country between places needed for development/agriculture and places rich in biodiversity.

5.3.1 Possible Future Changes for Management Costs

The low and high sub-scenarios explored how the costs projected for 2030 may change. The low sub-scenario explores how future costs could change if economic and infrastructure development proceeds more slowly near TPAs than in the rest of the country (see 5.5 methods appendix). Under those conditions, the projected costs of the TPA system fall by an average of 10–11 percent between 2030 and 2060, across the three scenarios (Tables A5.1-A5.3). At the individual country level, projected cost reductions are greatest in Chile (e.g., 26 percent reduction for scenario 1), Barbados (25 percent), and Peru (14 percent), and most modest in Argentina (7 percent) and Brazil (7 percent) (Table A5.1). Again, note that these potential cost reductions are meant to be illustrative, based on a particular set of assumptions per sub-scenario, since the final cost reductions could be different.

Conversely, the high sub-scenario explores the cost implications of a situation in which development around TPAs occurs at a greater rate than in the rest of the country. In the high results, TPA management costs rise by 10–11 percent between 2030 and 2060 (again depending on the scenario, see Tables A5.4-A5.6). Similar countries would experience greater-than-average or less-than-average rates of increase. For example, in scenario 1, Chile and Barbados are projected to have 38 percent and 36 percent increases, respectively, over the 30 years (2030–2060), whereas Argentina is projected to have a 7 percent increase and Guyana a <1 percent increase. Again, note that these changes are illustrative and would be different if different assumptions about future changes are made.

It may be useful to specify some of the mechanisms that could lead to these cost increases or decreases, since many of the mechanisms can be caused or mitigated by policy decisions. Cost decreases are primarily driven by low rates of development around TPAs (the low sub-scenario), and buffer zones[37,38] (i.e., areas that are not part of the core TPA but still place some limits on development and human activities) around TPAs would increase the likelihood that development remained limited. Buffer zones have often been shown to effectively preserve the ecological intactness of the core TPA,[37,38] but the results here suggest that they have the added benefit of bringing significant cost savings over time. Keeping future agricultural rent low in the areas around TPAs, as envisaged in the low sub-scenario, would become more likely if policymakers limited future infrastructure development near TPA boundaries. Doing so would decrease agricultural rent (and therefore pressures on the TPA) by increasing the cost of bringing commodities from the TPA borders to market, thereby reducing the attractiveness of the land for conversion.

In contrast, cost increases over time are associated with high rates of local development around TPAs. These have been observed, for example, when the TPA drives a highly successful new tourism economy.[39,40] The influence of nature tourism in pushing up management costs implies a need for a nuanced policy approach to tourism as part of the cost management strategy. Nature tourism can be a major economic source of income in a rural area that otherwise lacks high-revenue economic opportunity.[41]

However, it is important that governments and managers realize that high tourism flows imply higher TPA management costs, so budgets need to be adjusted accordingly. This additional budget pressure operates both directly, by increasing the need for visitor-management investment, and indirectly, by bringing more people and infrastructure to the edges of protected areas (and thus increasing the need to defend against the associated pressures). Possible policy solutions include levying tourism fees that contribute to conservation running costs (as already occurs in several countries[1,42]), or even direct involvement of commercial tourism enterprises in preserving the ecological integrity of the area. Unusually fast development near TPA borders, which raises future costs, could also occur if TPA borders are the only areas still available for cost-effective development in the country. This may describe the situation in a number of smaller countries, particularly those where historical habitat loss has removed most of the former forest, such as Haiti.[43]

Larger economic effects of 30x30 may also drive increases in management costs over time. Increases in potential agricultural production values for land could occur as a direct result of 30x30, if protecting large areas constrains land and food supply, driving up farm-gate prices[8] and making unconverted land (included protected land) more attractive for productive use. If TPAs are on land with an unusually high potential agricultural rent during such a supply tightening, as the scenarios show they often would be, TPA managers will experience particularly large increases in pressure and incur higher costs. Crises such as the COVID-19 pandemic have shown how a food shortage drives an increase in the human use of TPAs for food and livelihood support, including in the LAC region.[44–46] However, increasing food prices and tightening supply could be mitigated by policy or technical interventions. Governments that are forewarned of this possible 30x30 effect could act to stabilize the price of food or incentivize the agricultural sector to develop innovations that reduce food costs.

Also, the models project substantial management cost reductions if governance effectiveness and respect for the rule of law increase. Local improvements in governance effectiveness and rules-compliance for protected areas are often associated with management approaches that involve and respect local communities around the TPA in close and relatively equal partnership.[47–49] These approaches have also been shown to be cheaper than systems where conservation acts without local involvement, including where the state attempts to enforce TPA regulations in opposition to local needs.[49–51] These types of results add an extra dimension to the observed benefits of working in partnership with communities around a TPA: this approach brings cost savings that increase over time. Conversely, the models suggest that any decline in the effectiveness of governance or in respect to the rule of law would raise the future costs of effective management.

It is important to note that the countries and governments that provided the data on which the statistical predictive models of TPA system costs are built were, in all likelihood, referring to TPA systems under management and ownership arrangements that are typical of state-run TPAs. However, PCAs for 30x30 may include other alternatives, such as Indigenous conservation areas or other effective area-based conservation measures (OECMs). If those alternative structures have different management costs from the TPAs used to parameterize the statistical models, each country's total cost for 30x30 would clearly differ from the projections here.

Even so, there is insufficient data to know the size of that difference. First, there is no global sense of how the costs of these alternative management and ownership structures differ. Second, the final cost difference would depend on the proportion of the new TPA system (added to reach 30x30) that was owned or managed under alternative arrangements. That proportion remains unknown. For scientific reasons, this report therefore limits itself to showcasing the cost modeling results from the available models of national-system cost and can only note that these may be different if a proportion of alternative structures in used in 30x30.

Further, it is incorrect to presume that conservation areas including those owned and managed by Indigenous peoples or local communities and OECMs have zero management costs. Inputs by all forms of management should be equitably recognized financially. There are indeed several financial needs associated with Indigenous and community-managed conservation areas (and potentially OECMs), from clarifying and legally codifying tenure,[52] to costs of fairly universal management activities such as patrolling or visitor management, to more context-specific costs such as the need to maintain an entire base of cultural tradition, knowledge, and practice that underpins successful conservation management.[53,54] And even though Indigenous, community, or local management can be highly effective on a day-to-day basis, additional state support may nevertheless be needed in extreme cases, such as invasion of the area by powerful outside actors.

5.3.2 Uncertainty in the Cost Projections

It is important to emphasize that the costs given for the scenarios should by no means be regarded as exact, since they are projections derived from a model, so the true values may be higher or lower than the values shown in Tables 6-9 and A5.1-A5.6. When interpreting the results, it is important to account for this relative level of uncertainty in the cost projections and the sources of that uncertainty. Also, some countries have higher levels of uncertainty than others.

To start with, the country-specific component of the predictive model—that is, the way the model adjusts the global average cost to each specific country—depends on the accuracy of each country's earlier assessments of their funding needs (see 5.5 methods appendix for this chapter). For most countries, sensitivity testing showed that the implied error has a small practical impact on the projected cost. Under some circumstances, however, the uncertainty around the cost projection, or the possible error associated with it, can be relatively larger. Knowing which countries have multiple, known drivers of potential inaccuracy can help stakeholders appreciate the relative level of variability (Bayesian confidence) around each country-specific projection, so the patterns of uncertainty are described here.

The sources of higher uncertainty for certain countries are twofold. At a deeper scientific level, it is known that certain conditions drive inaccuracies and uncertainties in all human estimation activities. Research suggests that any human-made estimate is prone to greater inaccuracy if the number involved is very small, very large, or very different from current baselines.[55–60] By extension, cost projections derived from statistical predictive models that use human finance need estimates (as input) are likely to be less accurate if the original finance need estimate is particularly large, small, or far from the current budget.

For example, Guyana's finance need is likely to be disproportionately uncertain because the existing estimate of finance need is very low (GY$ 2.1 per hectare[61]) and because pressures on TPAs in the scenarios are 93 percent less than in the current system, combining a small (uncertain) value and a large difference from the baseline. Countries where data is old or where futures are more uncertain, such as Haiti, Paraguay, Uruguay, and Venezuela, are also more difficult to project future costs for because the baseline is so different.

Also important is the rate at which those common estimation biases and inaccuracies can build on themselves to create large potential budget inaccuracies. A trivial example is system size (as a close proxy for budget size). A projected budget need of billions of dollars could have an uncertainty in the hundreds of millions of dollars. Small, unknown inaccuracies in the predictor variables, such as footprint and agricultural rent, can also multiply into large uncertainties at the national level. In particular, when the cost per hectare (or one of its predictor) is small, such as the GY$ 2.1 for Guyana, an apparently insignificant change or uncertainty in that value, such as GY$ .50, can represent a large change in percentage terms, leading to a large potential inaccuracy at national budget level.

The standout country that combines all these possible biases and bias multipliers in one perfect storm is Chile, which has one of the largest differences from baseline (a very large change in finance need) because of the way the post-2030 scenario moves from a low-cost, wilderness-based system to a high-cost system that is both three times larger and located much closer to human developments. The pre-existing estimate of finance need per hectare (the basis of the predictive model) is also one of the smallest, making it both hard to estimate and sensitive to very small changes. And Chile has a post-2030 system area that is 11 times the average (median) for the countries studied, magnifying inaccuracies in the underlying estimates of finance need. To illustrate the impact of this perfect storm of uncertainties, the authors of this study calculate that an inaccuracy of just US$.76 per hectare in the earlier Chilean estimate of TPA finance needs would reduce Chile's projected 30x30 need by a factor of 3 (from US$1.6 billion per year to US$520 million per year). A consultancy that estimated 30x30 needs in Chile in a different way (and without the same adjustment for higher pressures) also generated estimates that varied by a factor of three,[34] of up to US$495 million per year.

The purpose of discussing individual countries with high potential projection-variability, such as Chile and Guyana, is to transparently alert stakeholders to particular cases where uncertainties are unusually large, as not all country estimates are highly uncertain. Overall, projected management costs for most of the countries are stable across scenarios and have relatively lower uncertainty. Indeed, the model projections in this study concur closely with estimates from several other studies that used very different methods (bearing in mind that costs per hectare can both increase and decrease in 30x30 scenarios compared to earlier TPA systems).

The finance need estimate per hectare for Colombia is US$3.71–US$4.34, which is comparable to an independent estimate by Londoño Zapata of US$3.54–US$4.76.[62] This study's estimate of US$9.2–US$9.7 per hectare for Brazil compares to an inflation-adjusted estimate of US$7.9 by the United Nations Development Programme in 2008[1] and a more recent estimate of US$11.3 by da Silva et al.[63] This study's post-2030 estimate for Costa Rica of US$148–US$160 per hectare is comparable to an earlier finance need estimate by Costa Rica itself of US$133.16[64] (figure corrected for inflation), noting that the post-2030 system would have higher human pressures. Similarly, in comparing the post-2030 finance need estimate for Ecuador with one made for the 2013 system,[65] the estimate envisages a system that has 2.6 times the human pressures and 2.25 times the cost per hectare (i.e., US$29.5–US$30.0 per hectare versus an inflation-adjusted US$13.1).

Although some of the finance needs may seem very high, they are very much expected when 30x30 implies an ambitious expansion of TPAs, into more expensive, higher-biodiversity areas, while closing significant funding shortfalls for the existing system. The projected needs are also generated by a model that gives reasonable predictions of known data, all of which gives confidence in the plausibility of the results.

5.4 Appendix. Figures

TABLE A5.1 TPA Management Costs for Scenario 1, with High Sub-scenario

Country	2030	2035	2040	2045	2050	2055	2060	Area protected (km^2)
Argentina	249.68	252.42	255.22	258.08	261	263.98	267.03	835598.4
The Bahamas	18.89	19.21	19.53	19.86	20.2	20.55	20.9	4310
Barbados	10.66	11.2	11.78	12.39	13.04	13.73	14.47	133.2
Belize	38.63	39.27	39.93	40.6	41.29	42	42.73	8239
Bolivia	187.65	190.84	194.11	197.48	200.93	204.49	208.14	334507
Brazil	2397.87	2426.71	2456.18	2486.32	2517.13	2548.63	2580.85	2593200
Chile	1693.97	1784.5	1880.84	1983.43	2092.72	2209.23	2333.48	227946.3
Colombia	129.22	130.78	132.36	133.99	135.65	137.34	139.08	343509.9
Costa Rica	234.86	238.89	243.03	247.29	251.66	256.16	260.78	15490.8
Dominican Republic	98.19	99.84	101.52	103.26	105.04	106.87	108.75	14553
Ecuador	230.83	234.59	238.46	242.43	246.51	250.7	255	77441.7
El Salvador	24.64	25.18	25.74	26.31	26.91	27.52	28.16	6171.9
Guatemala	82.23	83.59	84.99	86.42	87.9	89.41	90.97	32976.6
Guyana	1.22	1.22	1.22	1.22	1.22	1.22	1.22	63360
Haiti	12.77	12.97	13.18	13.39	13.61	13.84	14.07	8217
Honduras	23	23.38	23.77	24.17	24.58	25	25.43	33987.3
Jamaica	27.47	27.91	28.37	28.84	29.32	29.82	30.32	3317.7
Mexico	566.73	576.81	587.16	597.81	608.77	620.03	631.62	589585.5
Nicaragua	42.01	42.7	43.4	44.12	44.87	45.63	46.41	38766.6
Panama	61.8	62.86	63.95	65.08	66.23	67.42	68.64	23378
Paraguay	803.53	817.31	831.47	846.01	860.96	876.33	892.13	120449.4
Peru	495.94	509.29	523.14	537.5	552.41	567.89	583.97	389561.1
Suriname	51.72	52.56	53.43	54.31	55.23	56.16	57.12	44267.4
Trinidad and Tobago	4.81	4.89	4.97	5.05	5.14	5.22	5.31	1572
Uruguay	64.38	65.38	66.42	67.47	68.56	69.67	70.82	53538
Venezuela	341.45	346.22	351.1	356.11	361.24	366.49	371.87	518161

Notes: Costs are shown in millions of constant 2024 US$. The high sub-scenario envisages a future in which the drivers of TPA costs increase over time, causing an increase over time in the costs themselves. The cost increases are based on a specific set of assumptions about how the drivers change over time and should not be taken as forecasts, because other future changes in drivers are possible. Area protected under 30x30 is shown in km^2, either 30 percent of land area or the size of the current TPA system, whichever is larger.

TABLE A5.2 TPA Management Costs for Scenario 2, with High Sub-scenario

Country	2030	2035	2040	2045	2050	2055	2060	Area protected (km²)
Argentina	425.6	432.62	439.83	447.23	454.83	462.64	470.67	835598.4
The Bahamas	18.89	19.21	19.53	19.86	20.2	20.55	20.9	4310
Barbados	10.66	11.2	11.78	12.39	13.04	13.73	14.47	133.2
Belize	37.72	38.35	38.99	39.65	40.32	41.02	41.73	8239
Bolivia	135.32	137.17	139.06	141	142.99	145.03	147.11	334507
Brazil	2481.73	2512.55	2544.08	2576.31	2609.29	2643.02	2677.54	2593200
Chile	1794.22	1891.29	1994.66	2104.8	2222.23	2347.47	2481.13	227946.3
Colombia	149.07	151.1	153.17	155.3	157.47	159.7	161.98	343509.9
Costa Rica	247.31	251.74	256.29	260.98	265.8	270.76	275.86	15490.8
Dominican Republic	94.54	96.11	97.72	99.37	101.07	102.81	104.61	14553
Ecuador	231.1	234.9	238.8	242.8	246.91	251.13	255.47	77441.7
El Salvador	25.99	26.58	27.19	27.81	28.46	29.13	29.83	6171.9
Guatemala	79.09	80.38	81.7	83.07	84.46	85.9	87.37	32976.6
Guyana	1.22	1.22	1.22	1.22	1.22	1.22	1.22	63360
Haiti	12.6	12.8	13	13.21	13.42	13.64	13.87	8217
Honduras	22.52	22.89	23.27	23.66	24.05	24.46	24.88	33987.3
Jamaica	26.27	26.69	27.11	27.56	28.01	28.47	28.95	3317.7
Mexico	534.58	543.8	553.28	563.02	573.03	583.33	593.91	589585.5
Nicaragua	41.77	42.45	43.15	43.87	44.61	45.37	46.15	38766.6
Panama	61.08	62.13	63.21	64.32	65.46	66.64	67.84	23378
Paraguay	774.73	787.72	801.07	814.79	828.87	843.35	858.23	120449.4
Peru	462.54	474.69	487.29	500.35	513.9	527.96	542.55	389561.1
Suriname	57.84	58.85	59.88	60.95	62.04	63.17	64.32	44267.4
Trinidad and Tobago	4.81	4.89	4.97	5.05	5.14	5.22	5.31	1572
Uruguay	64.49	65.5	66.54	67.61	68.7	69.83	70.98	53538
Venezuela	336.4	341.12	345.96	350.91	355.98	361.18	366.51	518161

Notes: Costs are shown in millions of constant 2024 US$. The high sub-scenario envisages a future in which the drivers of TPA costs increase over time, causing an increase over time in the costs themselves. The cost increases are based on a specific set of assumptions about how the drivers change over time and should not be taken as forecasts, because other future changes in drivers are possible. Area protected under 30x30 is shown in km^2, either 30 percent of land area or the size of the current TPA system, whichever is larger.

TABLE A5.3 TPA Management Costs for Scenario 3, with High Sub-scenario

Country	2030	2035	2040	2045	2050	2055	2060	Area protected (km²)
Argentina	622.49	635.1	648.1	661.49	675.3	689.55	704.23	835598.4
The Bahamas	18.89	19.21	19.53	19.86	20.2	20.55	20.9	4310
Barbados	10.66	11.2	11.78	12.39	13.04	13.73	14.47	133.2
Belize	38.63	39.27	39.93	40.6	41.29	42	42.73	8239
Bolivia	147.25	149.39	151.58	153.83	156.13	158.49	160.91	334507
Brazil	2523.9	2555.56	2587.94	2621.06	2654.94	2689.61	2725.08	2593200
Chile	1693.97	1784.5	1880.84	1983.43	2092.72	2209.23	2333.48	227946.3
Colombia	139.52	141.31	143.14	145	146.92	148.87	150.87	343509.9
Costa Rica	246.45	250.8	255.27	259.86	264.59	269.45	274.46	15490.8
Dominican Republic	96.78	98.38	100.03	101.72	103.46	105.25	107.09	14553
Ecuador	233.7	237.54	241.49	245.54	249.7	253.97	258.36	77441.7
El Salvador	24.64	25.18	25.74	26.31	26.91	27.52	28.16	6171.9
Guatemala	80.97	82.3	83.66	85.06	86.5	87.98	89.5	32976.6
Guyana	1.22	1.22	1.22	1.22	1.22	1.22	1.22	63360
Haiti	12.43	12.62	12.82	13.03	13.24	13.45	13.67	8217
Honduras	21.88	22.23	22.59	22.95	23.33	23.72	24.11	33987.3
Jamaica	27.17	27.6	28.05	28.51	28.98	29.47	29.97	3317.7
Mexico	668.12	681.12	694.5	708.29	722.49	737.12	752.2	589585.5
Nicaragua	42.05	42.74	43.44	44.16	44.91	45.67	46.46	38766.6
Panama	61.8	62.86	63.95	65.08	66.23	67.42	68.64	23378
Paraguay	836.63	851.32	866.42	881.94	897.9	914.31	931.19	120449.4
Peru	653.56	673	693.23	714.27	736.18	758.98	782.73	389561.1
Suriname	59.31	60.36	61.44	62.55	63.69	64.86	66.06	44267.4
Trinidad and Tobago	4.81	4.89	4.97	5.05	5.14	5.22	5.31	1572
Uruguay	66.35	67.41	68.49	69.61	70.75	71.92	73.12	53538
Venezuela	343.21	348.02	352.95	358	363.18	368.48	373.91	518161

Notes: Costs are shown in millions of constant 2024 US$. The high sub-scenario envisages a future in which the drivers of TPA costs increase over time, causing an increase over time in the costs themselves. The cost increases are based on a specific set of assumptions about how the drivers change over time and should not be taken as forecasts, because other future changes in drivers are possible. Area protected under 30x30 is shown in km², either 30 percent of land area or the size of the current TPA system, whichever is larger.

TABLE A5.4 TPA Management Costs for Scenario 1, with Low Sub-scenario

Country	2030	2035	2040	2045	2050	2055	2060	Area protected (km^2)
Argentina	244.13	241.48	238.88	236.34	233.85	231.41	229.02	835598.4
The Bahamas	18.89	18.59	18.29	17.99	17.71	17.43	17.16	4310
Barbados	10.66	10.14	9.65	9.19	8.76	8.35	7.97	133.2
Belize	36.8	36.2	35.62	35.05	34.49	33.95	33.43	8239
Bolivia	187.13	184	180.96	178	175.11	172.3	169.56	334507
Brazil	2375.36	2347.13	2319.52	2292.51	2266.07	2240.2	2214.88	2593200
Chile	1675.94	1590.92	1511	1435.83	1365.1	1298.51	1235.79	227946.3
Colombia	125.94	124.44	122.98	121.55	120.15	118.78	117.44	343509.9
Costa Rica	224.08	220.3	216.62	213.04	209.55	206.15	202.84	15490.8
Dominican Republic	93.55	92.01	90.51	89.05	87.63	86.24	84.89	14553
Ecuador	226.54	222.9	219.36	215.9	212.54	209.26	206.06	77441.7
El Salvador	23.94	23.43	22.93	22.45	21.98	21.52	21.08	6171.9
Guatemala	79.64	78.35	77.08	75.85	74.65	73.48	72.35	32976.6
Guyana	1.22	1.22	1.22	1.22	1.22	1.22	1.22	63360
Haiti	12.77	12.57	12.37	12.18	12	11.82	11.64	8217
Honduras	22.55	22.19	21.83	21.49	21.15	20.82	20.5	33987.3
Jamaica	26.44	26.01	25.6	25.2	24.81	24.43	24.06	3317.7
Mexico	558.55	548.79	539.3	530.07	521.08	512.34	503.82	589585.5
Nicaragua	41.39	40.72	40.08	39.44	38.83	38.23	37.65	38766.6
Panama	60.36	59.34	58.34	57.37	56.43	55.52	54.62	23378
Paraguay	803.43	789.89	776.7	763.86	751.37	739.19	727.34	120449.4
Peru	488.63	475.83	463.48	451.57	440.09	429	418.3	389561.1
Suriname	51.72	50.89	50.08	49.3	48.53	47.78	47.05	44267.4
Trinidad and Tobago	4.81	4.74	4.66	4.59	4.52	4.45	4.39	1572
Uruguay	63.21	62.24	61.29	60.36	59.46	58.59	57.73	53538
Venezuela	327.3	322.79	318.39	314.08	309.88	305.78	301.77	518161

Notes: Costs are shown in millions of constant 2024 US$. The low sub-scenario envisages a future in which the drivers of TPA costs decrease over time, causing a decrease over time in the costs themselves. The cost reductions are based on a specific set of assumptions about how the drivers change over time and should not be taken as forecasts, because other future changes in drivers are possible. Area protected under 30x30 is shown in km^2, either 30 percent of land area or the size of the current TPA system, whichever is larger.

TABLE A5.5 TPA Management Costs for Scenario 2, with Low Sub-scenario

Country	2030	2035	2040	2045	2050	2055	2060	Area protected (km²)
Argentina	420.79	413.96	407.31	400.83	394.51	388.36	382.36	835598.4
The Bahamas	18.89	18.59	18.29	17.99	17.71	17.43	17.16	4310
Barbados	10.66	10.14	9.65	9.19	8.76	8.35	7.97	133.2
Belize	36.8	36.2	35.62	35.05	34.49	33.95	33.43	8239
Bolivia	135.13	133.3	131.52	129.78	128.08	126.42	124.8	334507
Brazil	2470	2439.7	2410.06	2381.08	2352.73	2325	2297.86	2593200
Chile	1784.58	1692.99	1606.94	1526.06	1450	1378.44	1311.07	227946.3
Colombia	147.14	145.17	143.24	141.36	139.52	137.72	135.96	343509.9
Costa Rica	241.44	237.19	233.05	229.03	225.12	221.31	217.6	15490.8
Dominican Republic	92.22	90.72	89.25	87.83	86.43	85.08	83.76	14553
Ecuador	228.93	225.23	221.62	218.11	214.69	211.36	208.11	77441.7
El Salvador	25.61	25.05	24.5	23.97	23.45	22.95	22.47	6171.9
Guatemala	77.82	76.57	75.35	74.16	73.01	71.88	70.78	32976.6
Guyana	1.22	1.22	1.22	1.22	1.22	1.22	1.22	63360
Haiti	12.6	12.4	12.21	12.03	11.85	11.67	11.5	8217
Honduras	22.3	21.94	21.59	21.25	20.92	20.6	20.29	33987.3
Jamaica	25.76	25.35	24.96	24.58	24.2	23.84	23.48	3317.7
Mexico	530.68	521.67	512.91	504.38	496.08	487.99	480.12	589585.5
Nicaragua	41.45	40.79	40.14	39.5	38.89	38.29	37.7	38766.6
Panama	60.36	59.34	58.34	57.37	56.43	55.52	54.62	23378
Paraguay	774.68	761.89	749.45	737.33	725.52	714.01	702.8	120449.4
Peru	459.09	447.34	436	425.06	414.49	404.3	394.45	389561.1
Suriname	57.84	56.85	55.89	54.95	54.03	53.14	52.28	44267.4
Trinidad and Tobago	4.81	4.74	4.66	4.59	4.52	4.45	4.39	1572
Uruguay	63.89	62.9	61.94	61	60.08	59.19	58.32	53538
Venezuela	329.22	324.66	320.22	315.87	311.63	307.49	303.44	518161

Notes: Costs are shown in millions of constant 2024 US$. The low sub-scenario envisages a future in which the drivers of TPA costs decrease over time, causing a decrease over time in the costs themselves. The cost reductions are based on a specific set of assumptions about how the drivers change over time and should not be taken as forecasts, because other future changes in drivers are possible. Area protected under 30x30 is shown in km², either 30 percent of land area or the size of the current TPA system, whichever is larger.

TABLE A5.6 TPA Management Costs for Scenario 3, with Low Sub-scenario

Country	2030	2035	2040	2045	2050	2055	2060	Area protected (km²)
Argentina	608.66	596.57	584.85	573.46	562.41	551.68	541.26	835598.4
The Bahamas	18.89	18.59	18.29	17.99	17.71	17.43	17.16	4310
Barbados	10.66	10.14	9.65	9.19	8.76	8.35	7.97	133.2
Belize	36.8	36.2	35.62	35.05	34.49	33.95	33.43	8239
Bolivia	146.84	144.74	142.69	140.69	138.73	136.82	134.96	334507
Brazil	2500.21	2469.23	2438.95	2409.33	2380.36	2352.03	2324.31	2593200
Chile	1675.94	1590.92	1511	1435.83	1365.1	1298.51	1235.79	227946.3
Colombia	135.98	134.26	132.58	130.94	129.33	127.76	126.23	343509.9
Costa Rica	235.13	231.05	227.08	223.22	219.47	215.81	212.25	15490.8
Dominican Republic	92.2	90.7	89.23	87.81	86.42	85.06	83.74	14553
Ecuador	229.36	225.64	222.03	218.51	215.08	211.73	208.47	77441.7
El Salvador	23.94	23.43	22.93	22.45	21.98	21.52	21.08	6171.9
Guatemala	78.43	77.16	75.93	74.73	73.56	72.42	71.3	32976.6
Guyana	1.22	1.22	1.22	1.22	1.22	1.22	1.22	63360
Haiti	12.43	12.24	12.05	11.87	11.69	11.52	11.35	8217
Honduras	21.45	21.12	20.79	20.47	20.16	19.85	19.56	33987.3
Jamaica	26.14	25.73	25.33	24.93	24.55	24.18	23.81	3317.7
Mexico	658.48	645.91	633.71	621.85	610.34	599.14	588.27	589585.5
Nicaragua	41.43	40.76	40.11	39.48	38.86	38.26	37.68	38766.6
Panama	60.36	59.34	58.34	57.37	56.43	55.52	54.62	23378
Paraguay	836.53	822.09	808.05	794.38	781.07	768.12	755.51	120449.4
Peru	643.93	625.32	607.43	590.23	573.68	557.75	542.41	389561.1
Suriname	59.31	58.28	57.28	56.3	55.36	54.43	53.53	44267.4
Trinidad and Tobago	4.81	4.74	4.66	4.59	4.52	4.45	4.39	1572
Uruguay	65.14	64.12	63.13	62.16	61.21	60.29	59.39	53538
Venezuela	328.99	324.44	320	315.66	311.42	307.28	303.24	518161

Notes: Costs are shown in millions of constant 2024 US$. The low sub-scenario envisages a future in which the drivers of TPA costs decrease over time, causing a decrease over time in the costs themselves. The cost reductions are based on a specific set of assumptions about how the drivers change over time and should not be taken as forecasts, because other future changes in drivers are possible. Area protected under 30x30 is shown in km^2, either 30 percent of land area or the size of the current TPA system, whichever is larger.

TABLE A5.7 Cross-Scenario Comparison of TPA Management Costs

Country	Scenario 1	Scenario 2	Scenario 3	Hypothetical imaginary scenario
Argentina	246.92	425.6	615.61	150.36
The Bahamas	18.89	18.89	18.89	12.68
Barbados	10.66	10.66	10.66	NA
Belize	37.72	37.72	37.72	23.22
Bolivia	187.39	135.32	147.05	71
Brazil	2386.64	2481.73	2512.08	1038.84
Chile	1684.98	1794.22	1684.98	73.05
Colombia	127.59	149.07	137.76	151.3
Costa Rica	229.53	247.31	240.85	111.64
Dominican Republic	95.9	94.54	94.51	63.54
Ecuador	228.69	231.1	231.53	84.06
El Salvador	24.29	25.99	24.29	NA
Guatemala	80.94	79.09	79.71	37.9
Guyana	1.22	1.22	1.22	5.21
Haiti	12.77	12.6	12.43	18.39
Honduras	22.78	22.52	21.67	9.89
Jamaica	26.96	26.27	26.66	19.75
Mexico	562.65	534.58	663.31	235.79
Nicaragua	41.7	41.77	41.74	15.85
Panama	61.08	61.08	61.08	29.25
Paraguay	803.48	774.73	836.58	228.98
Peru	492.31	462.54	648.76	68.9
Suriname	51.72	57.84	59.31	NA
Trinidad and Tobago	4.81	4.81	4.81	Inf
Uruguay	63.8	64.49	65.75	52.09
Venezuela	334.44	336.4	336.17	133

Notes: Table includes a comparison with a hypothetical imaginary scenario in which all new TPAs have, on average, the same level of human pressure as the existing (2020) TPA system. Costs are shown in millions of constant 2024 US$. Four countries are not applicable (NA) in the hypothetical because no data were available for the 2020 report.[8] Scenario 1 = biodiversity priority, scenario 2 = economic priority, scenario 3 = biodiversity/economic compromise.

5.5 Appendix. Methods

Protecting 30 Percent of the Planet for Nature: Costs, Benefits and Economic Implications (hereafter, Waldron Report)[8] shows that historical data on national protected-area finance needs can be statistically predicted to a high degree of accuracy (at least on a log scale) from the broad underlying causes of higher or lower finance needs. Several LAC countries (Argentina, Belize, Bolivia, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Grenada, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, and Venezuela) confidentially provided the historical data from reports with a median date of 2015 written by government agencies or local experts. Data on protected area costs and finance needs are typically harder to source for smaller Caribbean island countries, but a more recent detailed report has been made for The Bahamas.[11]

The predictive models derived from these data show that in general, larger systems need larger budgets; countries with cheaper overall costs need lower budgets; protected area systems under high human pressure cost more to maintain; stronger rule of law in the country can reduce costs; and systems that bring in extensive revenue from business activities, such as ticket and gift sales, visitor centers etc., need proportionally higher budgets.[8]

To find these results, each of those broad factors is used in a quantitative form in the statistical model. System size is simply measured as the areal extent of the national TPA system. The intuition of "cheaper operations" is captured by expressing all financial values at PPP. Governance is quantified using the governance indicator "government effectiveness" from the governance indicators dataset.[12] And as a quantitative measure of business activity, the model uses data on the site-based revenues earned (per hectare) within each national system, also at PPP.[8] As metrics of human pressure, the model uses two spatial datasets: (1) the human footprint, which combines measures of local development, road development, and human population to give a footprint value to each grid cell globally;[13,14] and (2) net agricultural rent, which measures the value of the protected land if it was converted to agriculture or livestock, net of the costs of producing those commodities and bringing them to market, and including any value of timber that might be extracted in the process of conversion.[15]

The Waldron Report[8] found that footprint and agricultural rent acted as much better predictors if they were expressed relative to the national average. For example, a country may have poor agricultural land or undeveloped transport for commodities in general, so agricultural rent values will be low nearly everywhere. What would matter to agriculturalists seeking to convert natural habitat is not the raw value of the commodity that is extractable (which is always likely to be low in this case), but whether the value is high relative to all other land available in the country. Both footprint and rent for protected areas were therefore scaled against the mean value in the country, referred to as "relative agricultural rent" and "relative footprint."

Several predictive regression models were tested by Waldron et al.[8] The best fitting model, from an information-theoretic framework,[66] is a generalized negative binomial linear mixed model that takes the form (Cost per hectare (PPP) = intercept + ln(system area) + relative net agricultural rent + (ln (site based revenue PPP + 1)), with a log link and country-specific random effects. However, relative net agricultural rent is not always easy to calculate and can be missing more often than footprint. For such situations, an alternative model exists: (Cost per hectare (PPP) = intercept + ln(system area) + relative human footprint*government effectiveness + (ln (site-based revenue PPP + 1), with a negative binomial error family (* indicates where terms interact). The first model predicts the known finance needs with 84.4 percent accuracy (pseudo $R^2 = 0.844$) but has the lower second-order Akaike Information Criterion score (AICc). The second model has $R^2 = 0.865$ but a delta AICc of 17.11, suggesting the rent-based model is the better fit under an information-theoretic approach.[66]

To project the potential terrestrial management costs of national TPA systems in IDB LAC countries, the authors of this report applied the rent-based model to the three 30x30 scenarios and gap-filled predictions for countries that lacked agricultural rent data with predictions from the alternative model. To generate the data for the scenarios, the area variable was set at 30 percent of national land area or the current TPA extent (whichever was greater). The 2030 values of relative footprint and relative agricultural rent were calculated directly by spatial analysis of the three scenarios. The authors note that these 2030 values make the necessary simplification that for both these terms, the ratio between TPA values and national values (i.e., the relative value of each term) will be little affected by any changes that occur in the underlying values between the year in which footprint and agricultural rent were measured (2016 and 2017) and 2030. Government effectiveness is a national-level data point, and its values in 2030 were assumed to be similar in 2030 to the values used in the original predictive regression testing by Waldron et al.,[8] not least because it was not possible to robustly project changes in this metric over time (see below). All costs were expressed in constant 2024 US$. The finance need projections include the country-specific effects for any countries that provided earlier estimates of finance needs for an earlier system. The authors also set a floor to projected finance needs so that they could not fall below estimates of need for the current system.

The authors caution, therefore, that the country-specific component of the predictive model—that is, the way the model adjusts the statistical expectation of cost to each specific country—depends on the accuracy of each country's own earlier assessments of their funding needs (applied to smaller systems than 30x30). Additionally, four countries (Barbados, El Salvador, Suriname, and Trinidad and Tobago) lacked any earlier assessment, negating the possibility of a country-specific effect. The authors therefore used the model expectation of finance needs for those four countries.

For site-based revenue in 2030 (and beyond), the key question is whether a space-for-time proxy is appropriate. The predictive models show that at present, countries with higher site-based revenue have higher management costs, as would be logical if securing revenue from visitors and consumers imposes business costs, and if countries that are more invested in such revenue opportunities had higher costs. A report from Colombia suggests that "sustainable use" TPAs, which are largely defined as such based on ecotourism activities for that system, indeed have higher costs.[62] This is a pattern over space. However, what is less clear is whether an increase in visitors/consumers over time, in a single country, would generate an increase in costs per hectare, comparable to the pattern in space.

In many cases, it seems unlikely that a time-for-space proxy would be appropriate in the case of this variable. For example, it would seem entirely possible that a 10 percent increase in visitors could be managed by existing ticketing and retail sales infrastructure in a TPA system, with no additional cost in-country. In other words, the pattern over time in a single country is unlikely to be well predicted (usefully proxied) from the pattern in space. Modeling possible future changes in site-based revenue in 2030 and beyond would therefore need a different approach.

For the 2030 system, the authors took the simplifying assumption that the creation and management of revenue-generating activities in new TPAs (in an expanded system) would be carried out in the same way in each country as the management activities in the current system and therefore, that the proxy predictor should remain the same. To explore the impacts of this assumption, the authors then varied the value of the proxy by 5 percent upward and downward, in two alternative versions of each scenario called "high" and "low," respectively. Increases could occur because new TPAs are closer to people, requiring an eventual expansion in ticketing and visitor control staff and infrastructure, for example. Possible mechanisms by which business costs fall could include efficiencies due to technology, such as remote or smartphone-based ticketing and monitoring. A mid sub-scenario set then scenario-modeled the assumption that the costs per hectare associated with revenue-generating activity were the same in new TPAs as in existing TPAs.

Site-based revenue data per hectare were not available for Barbados, Suriname, or Trinidad and Tobago. This may be because such revenue was minimal (thus not officially tracked). Nevertheless, the authors tested whether it was possible to predict the revenue levels by building a predictive model parameterized on the data for the remaining 23 LAC IDB countries. The authors found that (ln-transformed) known revenue could indeed be predicted with relatively high accuracy (R^2 of 0.77) by a generalized additive model containing the number of international arrivals (ln-transformed), a tensor (nonlinear effect) applied to the same government effective score as the costing model, and relative accessibility (mean access time to the TPA system divided by mean access time to all grid cells in the country, where access is measured from conurbations of greater than 50,000 population).[67] The gamma parameter was changed to 2.25 in order to smooth a highly local nonlinear effect with the default gamma because the authors considered the local effect to not be representative of the overall trend. The regression formula took the form ln(site-based revenue) = -20.0249 + 11.5749 * relative accessibility + 2.043 * ln(international arrivals), and with a decreasing rising response to government effectiveness.

The authors used this model to estimate the revenue for the three missing countries, converting the result to revenue per hectare by dividing by the TPA system extents. Given the way the authors were already varying the estimates of 30x30 cost nine times per country (three scenarios with three sub-scenarios each), and the fact that the three missing countries were likely to have relatively small finance needs, the authors chose not to also vary the imputed site-based revenue for those three countries, merely using the statistical expectation. Notably, system size was not a predictor of system revenue in the best fitting model, although his may be partly due to the relationship between system size and system accessibility (Pearson correlation statistic = -0.285). In other words, the more of a country that is covered by TPAs, the shorter the travel time to TPAs becomes from that country's conurbations.

Next, although the most immediate point of interest is the set of national costs expected in 2030 (the year in which most new TPAs are likely to be created to meet the Kunming-Montreal Global Biodiversity Framework commitment), costs may change in subsequent years. To explore possible trajectories of costs through time, the authors used the sub-scenarios to also create three possible scenario projections for costs in 2030, 2035, 2040, 2045, 2050, 2055 and 2060 (noting that projected costs toward 2060 should be seen as less certain than those in 2030, owing to the greater unpredictability of more distant events). The authors then applied the same statistical predictive model to project the finance needs for each country in each of the target years and for each of the scenarios and their three respective sub-scenarios (high, mid, and low).

For future system area, the authors used the 2030 value in all years from 2030 to 2060 (i.e., 30 percent of land area or the current [May 2025] extent of TPAs taken from the UNEP-WCMC World Database on Protected Areas [protectedplanet.net], whichever was greater). The authors note that there have been calls to protect 50 percent of the planet by 2050,[68,69] but the magnitude of this ambition makes it less likely that coverage beyond 30 percent can be achieved by standard protected area approaches, not least because that would seem to imply that up to half of each country's land area could no longer be used for unconstrained economic production, including food and commodities production.

Our assumption is therefore that after nearly doubling the protected area estate on land in less than five years (as a global average), there may be several years in which no further expansion of the standard TPA takes place. If there are expansions in the later years of this study's time series (e.g., in 2050 and beyond), the management cost of the system will rise beyond what the models predict. Theoretically, the models can also be applied to project costs for systems that grow beyond 2030. However, it would require an entire set of new scenarios of how much each country protected in each future year, plus a set of highly uncertain long-distance forecasts for predictor variables, to generate projected costs in such a situation of continued TPA system growth. Such work is outside the scope of this project, and the uncertainties around such cost projections would be considerable.

Beyond 2030, temporal changes in relative footprint and relative agricultural rent are difficult to predict because their future values depend on how development around TPAs differs from development in the rest of the country (noting that "relative" refers to mean footprint and rent values immediately adjacent to TPAs divided by the corresponding mean values nationally). Three hypothetical trajectories are possible for these variables. First, the creation of new protected areas could slow development rates around parks relative to development rates in the rest of the country (especially road networks, on which both footprint and the cost of bringing agricultural commodities to market depend). Such a trajectory would imply that relative footprint and relative agricultural rent will fall over time. Second, a combination of an enhanced visitor economy and general economic boosts around new TPAs, plus any policy motivation to create and improve access for new (and existing) TPAs, plus a potential displacement effect where constraints on development in parks could cause increased density of development adjacent to parks, could all cause development and road networks to grow faster near new TPAs than in the rest of the country. Third, these two effects cancel each other out, and the relative footprint and net agricultural rent ratios remain unchanged over time.

To reflect these three alternative possibilities, the authors used the high sub-scenarios to scenario-model the increase in relative values of 1 percent every five years, the low sub-scenarios to model a decrease of the same rate and magnitude, and the mid sub-scenarios to scenario-model the situation where the effects cancel each other out and there is no change over time in the relative values. These sub-scenarios should be regarded as scenarios rather than as predictions, illustrating the impact on costs when rates of development vary across each country.

Moreover, government effectiveness has varied historically, but for the great majority of countries, this variation is highly volatile, making it unlikely that any forecasting of future governance changes out to 2060 would be accurate. Indeed, it is noteworthy that government effectiveness both increases and decreases over time in each country (https://www.worldbank.org/en/publication/worldwide-governance-indicators/interactive-data-access), so typical trend forecasting models would be highly unlikely to generate meaningful results.

The authors therefore took the simplifying assumption that in all forecasted years from 2030, the government effectiveness score would remain the same as the score used to parameterize the original regression model (the mean score for 2012–2017). The authors note that across countries, governance is correlated with GDP per capita, and it is possible that the governance variable therefore captures a mixture of both economic and governance effects on protected-area management costs. If that were the case, then increases in GDP per capita into the future may cause the model to underestimate future costs slightly, although the size of the underestimate itself would not be predictable given the model specifications. It would also be a complex and uncertain exercise to attempt to predict statistically the pattern of increased visitor/consumer management costs out to 2060—and beyond the scope of this report. For the projection of cost changes after 2030, the authors therefore retained the 5 percent increase, 5 percent decrease, and no-change sub-scenarios for the costs per hectare associated with revenue-generating business activity through to 2060.

There is a broad tendency historically for protected areas to be placed in areas of low economic value and little human development, such as wildernesses, deserts and mountaintops,[16,17] leading to a situation where TPA systems often fail to capture (to protect) large amounts of significant biodiversity.[18,22] However, our scenarios were all designed around the concept that, with some constraints for lands with high economic and agricultural value, the expanded TPA system post-2030 should capture as many of the high-biodiversity areas in the country as possible, in rank order of their level of diversity (see Chapter 1).

Given the historical patterns, this created a clear a priori expectation that the scenario-based post-2030 TPA systems would contain much more land that was of potential agricultural value, or land that was in areas of human development, than occurs in the current system. This expectation is important because the cost model is strongly driven by agricultural value and human footprint (a measure of development), so higher values of those for TPAs are expected to raise finance needs, perhaps to a high degree. Psychologically, much higher finance need projections are likely to trigger a need for deeper explanation in managers and stakeholders accustomed to the more wilderness-based, current system of TPAs.

One means to visualize how less-remote TPAs drive up finance needs is to create a hypothetical imaginary post-2030 system in which the level of remoteness is the same as the current one (whether or not such a system is physically and geographically feasible, and noting that even if it were, it may well continue the trend of not protecting key biodiversity areas). The authors therefore applied the predictive statistical model, but this time using agricultural rent and footprint data from the current system rather than from the scenarios. The authors then calculated how much more expensive the scenario-based system is, as compared to the hypothetical imaginary system.

6

Terrestrial Establishment Costs

Establishment costs are the one-off costs involved in creating new TPAs.[1–3] Expanding a national protected area system can involve a number of individual one-off costs, ranging from initial public and government consultation, all the way to the final setting up of signage. But when considering the total finance need, one cost dominates all others: the cost of purchasing new lands for conservation. Purchase (or "acquisition") cost tends to dwarf any other cost item because land values are so high. It is not uncommon for rural land prices to reach thousands of dollars per hectare in LAC.[4–7]

Therefore, when the expansion of a national conservation system for 30x30 implies acquiring millions of hectares of land, the potential acquisition cost could run into the tens of billions of dollars. If a portion of the new TPAs are created in urban or peri-urban zones, where land prices reflect housing and industrial land use options, purchase costs are even higher.[8] Acquisition costs for protected areas are mostly likely to involve undeveloped land (with natural or semi-natural habitats), which may be cheaper than developed land, such as agricultural holdings. Even so, the cost of acquiring very large areas of undeveloped land is likely to be extremely high. To illustrate the magnitude of these purchase costs, James et al. took data on conservation land purchases and calculated that the acquisition cost could be approximately 50 times the annual management cost of a TPA.[3]

For this reason, typical approaches to planning for terrestrial establishment costs focus primarily on acquisition cost, as other costs such as signage are likely to be trivial in comparison.[3,9–12] That said, one exception is legal and notary fees (transaction costs), which data suggest are likely to represent a maximum of 10 percent of the acquisition cost (and may be less than that).[13] The total establishment cost can therefore be approximated as 110 percent of the acquisition cost. In most cases, adding the additional 10 percent likely covers both transaction costs and smaller non-acquisition costs, such as signage, with some margin of error.

Sometimes, however, no land purchase is needed to establish a new PCA. For example, much of the existing protected area system is on government-owned or donated land in Latin America[14–16] and globally.[10,17,18] Land purchase is unnecessary if the government (or other authority) creating the new TPA already owns the land. If the foremost concern of PCA development is the cost to government, then privately owned protected areas, which currently represent 3.4 percent of all global land under protection,[19] could be cost-free to the government (except interactions such as conservation easement arrangements[20,21] or reduced taxation for conservation-purposed land).

Additionally, there may be cases where land purchase is judged to be politically inappropriate or as an unnecessary expenditure. In particular, Indigenous community conserved areas (ICCAs)[22] may be included in the lands counting toward the 30 percent target—a possibility that is indeed recognized in the GBF.[23] In countries where recognition of Indigenous lands is a national issue, it might be judged highly politically problematic for governments to attempt to "buy back" any lands that have been given into Indigenous ownership, in order to turn them into state-managed protected areas. And when many Indigenous peoples and local communities (IPLC) have shown themselves to be as good at protecting biodiversity as the state,[24,25] any costs associated with hypothetically taking IPLC land and its management into government hands could also represent unnecessary government expenditure, particularly in a situation where government budgets are already likely to be stretched.[10]

6.1 Modeling TPA Establishment Costs

It is therefore likely that for most (or all) countries, the cost of TPA expansion is only a fraction of the total land value involved. This could reduce establishment costs by tens of billions of dollars in some cases. And yet, land costs are so high that, even with these savings, the total land value could still represent a substantial demand on government budgets. For the purposes of scenario-based projections of establishment cost, estimation can therefore proceed in two steps. The first step is to value the land on which new TPAs might be placed (i.e., 100 percent of the potential acquisition cost). The second step is to ask how the final cost to government would differ if only a fraction of the land needed purchasing.

There is extensive knowledge on the valuation of real estate, including rural land, although this knowledge typically lies in professional practice and not in academic literature, and two of the main methods are the sales comparison approach and the income capitalization approach.[26–28] Any lay reader who has purchased a house will be familiar with the sales comparison approach: one simply looks for similar properties in the area that have sold recently and makes a valuation estimate based upon them. This can work well locally for developed land (such as housing or farms), but when trying to estimate the unknown value of millions of hectares of mostly undeveloped land across the whole of LAC, the analysis can quickly become intractable.

The income approach is less known to the lay reader, but it is actually the most commonly used by real estate professionals.[27] The income approach for rural properties is commonly applied by using the income capitalization method,[2] which states that the value of the land is equal to the annual net operating income divided by the capitalization rate (often abbreviated as "cap rate")[29] (see Box 3). In

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[10] This is not to suggest that Indigenous peoples and local communities (IPLC) should not receive any financial compensation for their contributions to 30x30, and there is both a moral and practical case that they will need additional funding. This is mentioned merely to point out that in countries where IPLC lands already function as effective conservation areas, purchase of those areas by the government seems an unlikely step.

most rural appraisals, net operating income is proxied as the annual rent that can be charged when a farm is leased.[30] The cap rate is a complex term that captures the risk-adjusted return on investment that the purchaser can expect to achieve.[30]

The cap rate itself depends on the risk-free return on money (such as the yield on US Treasuries), the rate of income growth of the property (which then informs the expected future flow of income to which the rights are being purchased), the relative volatilities (variability) of annual farm income and market returns (where market refers to investments such as the S&P 500), the growth rate of the market, and the risk-adjusted return of the market.[30] Put simply, the cap rate becomes smaller when rural property achieves a higher risk-adjusted rate of return than the investor could achieve by investing in government bonds or the market. The rate also becomes smaller when future financial returns from the land are expected to grow quickly. Smaller cap rates then translate into higher land values. The highest land values combine a high net annual income with a small cap rate. Importantly, professional property investment approaches also recognize that income-based valuations are very sensitive to the cap rate (or similarly, to the expected level of future net income, which forms part of the cap rate derivation).[26]

The nuance for new TPAs is that in most cases, one would not expect natural habitat that is about to be protected for its high-biodiversity values to have already been converted to income-generating farmland (or indeed any other use). To apply professional rural land valuation techniques to future protected areas, one therefore needs to estimate what the assumed net income and cap rate would be if the land were put on the market. Property investment statistics such as cap rates are often recorded at national scale, giving an average value that is most typically applicable to investments such as commercial buildings, such as Colliers' LATAM Cap Rates.[11] This average is often provided commercially as a useful indication of the likely cap rate for any particular commercial investment being considered.

Following this practice, valuation of possible future conservation land therefore has to begin by estimating (average) capitalization rates and net operating incomes for the mostly rural land where conservation purchases are likely to occur, which is what occurs in commercial real estate. Adjustments then need to be made to account for likely local deviations from the average, and for price differences associated with the undeveloped nature of much natural habitat, compared to working or potentially working farmland (see 6.4 methods appendix).

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[11] https://latamcaprates.colliers.com/home/https://latamcaprates.colliers.com/home/

BOX 3 Professional Land Valuation from Income Capitalization

The income capitalization method for land valuation uses a base formula to estimate real estate values per hectare, with the form

estimated value = annual operating income / capitalization rate.

The annual operating income for rural land is typically derived by the annual cash rent per hectare that an agricultural land area for sale can command (where more productive land is able to command a higher rent, so more productive farms have higher real estate values).

The capitalization (cap) rate is a more complex term that reflects several aspects of risk-adjusted return for both the land and the financial markets, plus a consideration of the growth in income that might be expected in the future. Stokes[29-30] derives the formula for cap rate (based on earlier work by Tuvey[62]) as

$$\text{cap rate} = r + \beta_{RM} * (\mu_M - r) - \mu_R$$

where r is the risk-free rate, M represents market returns such as those achievable by investing in the S&P 500, R is a cash rent, μ is a natural rate of growth, and β_{RM} is a premium associated with the relative risks associated with investing in the land purchase rather than investing in the financial markets. Thus, the value of agricultural land at any point in time *t* is expressible as

$$R / (r - \delta_R),$$

where the denominator is the cap rate and the value itself is a cash rent perpetuity growing at a constant risk-neutral rate δ_R and discounted at the riskless rate r.

To apply Stokes's formula, the value for r is the rate on the US 10-year Treasury, taking an average value over a relatively short time (e.g., three years) if there has been, or if there is expected to be, volatility in the rate. μ_M is the rate of growth in an investment on the financial markets, such as the S&P 500; Stokes uses the rate of growth over time for the past 40 years. μ_R is the expected rate of natural growth in the cash rent, which is estimated using the historical rate of growth in past rents over time. β_{RM} is derived from $\sigma_R / \sigma_M * \rho_{RM}$, where σ_R and σ_M represent risk in the investments in the land or the market and ρ scales the excess market return per unit of risk by the correlation between farm real estate returns and market returns. Stokes gives the value of σ_M (the volatility in the S&P 500 for 1980–2020) as 16.4 percent and ρ_{RM} as 0.1211, but the values may need recalculating if using a different period or set of farm real estate returns. Finally, σ_R is the historical volatility (i.e., the standard deviation) in the growth rates of cash rents over the period.

This report therefore uses the income capitalization approach for rural land as the basis for national estimates of establishment costs. However, cap rates for rural lands in LAC are much less widely reported than commercial urban rates (and rural cap rates are also likely to be very different from urban ones).[29] It is therefore necessary to use land-valuation analytical techniques to estimate the cap rates for the rural areas where new land might be purchased. The analytical formula for rural cap rates is given by Stokes,[29] and this formula for estimations is applied (see Box 3). Then the analytically derived cap rate estimates are combined with FAO data on agricultural production values to generate a baseline of average rural land values in each LAC country.

To test whether these modeled land value results correspond with known land values, the models are cross-checked against listings available for land sales in individual countries. The results are found to be close (see 6.4 methods appendix and 6.2 main results). Then, the land value is calculated for specific potential conservation lands by using spatial information to model how local sites values vary from average national values. The conservation land valuations are also adjusted to reflect estimates of how the value of unconverted land could be different from the value of working agricultural land (see 6.4 methods appendix.)

Synthesizing the above, there are two major sources of uncertainty in this way of modeling protected area acquisition costs. The first, and possibly the larger, is the unknown fraction of newly protected land that will require purchase (or comparable compensation to the current landowner). The second is the sensitivity of the land value estimate to the assumed income and cap rate terms in the capitalization method formula. Therefore, this report presents the projected establishment cost for various possible "purchase fractions," and bracket all dollar estimates with a large range of uncertainty that reflects possible differences in land values.

6.2 Main Results

The results for this chapter center on three topics: establishment cost variability, the plausibility of modeled establishment costs, and payment option pros and cons.

6.2.1 Establishment Cost Variability

Since the fraction of land needing purchase is known, the model starts from an imaginary circumstance where every hectare of new conservation land for the 30x30 scenarios needed purchasing, national acquisition and establishment costs would vary from relatively small sums (e.g., less than US$1 billion) to over US$100 billion, depending on the country (see 100 percent column in Tables 10–12). If smaller proportions than 100 percent of the land requires purchasing, then those costs decline accordingly. For example, if 25 percent of the land needs purchasing, then the cost is 25 percent of the full-purchase estimate (Tables 10-12).

The first and main reason these costs vary so much is that countries require very different amounts of new land to meet 30x30. Some LAC countries have already exceeded 30 percent TPA coverage, according to the World Database of Protected Areas,[31] at the date of writing, so no further establishment costs are implied. These are The Bahamas, Belize, Bolivia, Brazil, Panama, Trinidad and Tobago, and Venezuela. Similarly, some countries would require relatively little more land to achieve 30 percent PCA coverage, so the establishment costs are low for the few TPAs still needed (Tables 10–12). For example, Costa Rica has 26.5 percent coverage. Some small countries simply have a small land area that would need protecting for any coverage target, so the cost is smaller than for other countries. For example, El Salvador's very small national land area means that its budget need is even lower than that of Costa Rica, at just over US$1 billion (Tables 10–12), despite El Salvador having less current protected area coverage than Costa Rica.

At the other end of the spectrum, establishment costs are particularly high in countries that need a large amount of extra land to achieve 30 percent coverage (Argentina, Colombia, Mexico), when a relatively small percentage of land is protected, or when there is a combination of both. For example, Colombia has one of the larger land areas of the region and 17.1 percent coverage. Achieving 30 percent coverage requires an additional 14.91 million hectares of land, generating a very high potential establishment cost (e.g., US$26.1 billion for 100 percent purchase in scenario 1). Other countries have potential establishment costs of over US$10 billion for similar reasons, including Argentina, Chile, and Peru (see Tables 10-12). Guyana has only 8.4 percent coverage currently, meaning that despite its relatively low cost base (national price level), so much new land would be needed that establishment costs could still be high (for example, $28 billion to $63 billion for 100 percent purchase, depending on scenario; see Guyana values in the '100% column' in Tables 10 and 11).

Crucially, however, the final establishment costs for 30x30 can be much lower if a large portion of all the new land needed can be acquired without purchase. For example, if 75 percent of the new lands required by Colombia could be acquired without commercial purchase (e.g., lands already owned by the Colombian government, privately donated land, or ICCAs), then establishment cost falls in scenario 1 fall from US$26.1 billion to US$6.5 billion, and costs in other scenarios could be even lower (Tables 10-12). Purchasing a fraction of the land is clearly more politically and economically feasible than purchasing 100 percent of it, and various options exist to decrease the fraction of land that needs purchasing. However, there is insufficient public information about the spatial pattern of land ownership across LAC to determine what fraction of the total land value for 30x30 would need a land purchase expenditure.

It may seem that an immediate policy suggestion would therefore be that each country calculate this figure from land records, but the danger is that free or low-cost lands present a possible perverse incentive. If governments choose to create protected areas based simply on establishment costs (rather than biodiversity values), then there is a risk that some of that land will not be effective for biodiversity conservation. Protecting lands of little biodiversity value would meet the target of 30 percent but violate many other biodiversity conservation agreements, including the text of GBF Target 3, which states that the 30 percent should protect "especially areas of importance for biodiversity and ecosystem functions and services."[23]

It is also important to note that the range of uncertainty around the modeled establishment costs estimates is wide (Tables 10-12) because of the deliberate introduction of a wide range of uncertainty in the underlying parameters. Namely, the denominator of the valuation formula (the cap rate) varies by up to 25 percent in either direction, plus the potential discount enjoyed by natural habitat over converted farmland varies 14.3 percent in either direction (where those two variations interact). Also, the cap rate variation was made particularly wide in order to capture other possible uncertainties, such as local differences in land prices or local differences-from-average in the financial returns on the land. The three scenarios also suggest different land values because they imagine protecting different locations (with differences in potential agricultural yield). Therefore, when combined with major uncertainty about the percentage of land to be purchased, the establishment cost estimates here (and indeed, any establishment cost estimate) need to be interpreted as a broad guide to some of the financial sums rather than a precise prediction.

TABLE 10 30x30 Establishment Costs in LAC Under Scenario 1

Country	25%	50%	75%	100%	Additional land needed (ha million)
Argentina	44.52 (30.53-67.84)	89.04 (61.05-135.68)	133.56 (91.58-203.51)	178.07 (122.11-271.35)	59,04
The Bahamas	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Barbados	0.09 (0.06-0.14)	0.18 (0.13-0.28)	0.28 (0.19-0.42)	0.37 (0.25-0.56)	0,01
Belize	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Bolivia	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Brazil	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Chile	12.19 (8.36-18.58)	24.38 (16.72-37.16)	36.58 (25.08-55.74)	48.77 (33.44-74.31)	6,54
Colombia	6.52 (4.47-9.94)	13.05 (8.95-19.88)	19.57 (13.42-29.82)	26.1 (17.89-39.76)	14,91
Costa Rica	0.33 (0.23-0.51)	0.66 (0.46-1.01)	1 (0.68-1.52)	1.33 (0.91-2.03)	0,19
Dominican Republic	0.61 (0.42-0.93)	1.21 (0.83-1.85)	1.82 (1.25-2.78)	2.43 (1.67-3.7)	0,19
Ecuador	3.78 (2.59-5.75)	7.55 (5.18-11.51)	11.33 (7.77-17.26)	15.11 (10.36-23.02)	1,71
El Salvador	0.28 (0.19-0.43)	0.57 (0.39-0.87)	0.85 (0.58-1.3)	1.14 (0.78-1.73)	0,45
Guatemala	7.31 (5.01-11.14)	14.62 (10.03-22.28)	21.93 (15.04-33.42)	29.24 (20.05-44.56)	1,11
Guyana	15.79 (10.83-24.07)	31.59 (21.66-48.13)	47.38 (32.49-72.2)	63.17 (43.32-96.26)	4,56
Haiti	0.21 (0.15-0.32)	0.43 (0.29-0.65)	0.64 (0.44-0.97)	0.85 (0.58-1.3)	0,59
Honduras	0.44 (0.3-0.67)	0.88 (0.6-1.34)	1.32 (0.91-2.01)	1.76 (1.21-2.68)	0,78
Jamaica	0.15 (0.1-0.23)	0.3 (0.21-0.46)	0.45 (0.31-0.69)	0.6 (0.41-0.91)	0,11
Mexico	22.84 (15.66-34.81)	45.68 (31.33-69.61)	68.53 (46.99-104.42)	91.37 (62.65-139.23)	29,02
Nicaragua	3.31 (2.27-5.05)	6.63 (4.54-10.1)	9.94 (6.81-15.14)	13.25 (9.09-20.19)	1,16
Panama	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Paraguay	1.7 (1.17-2.6)	3.41 (2.34-5.19)	5.11 (3.5-7.79)	6.81 (4.67-10.38)	6,11
Peru	20.81 (14.27-31.71)	41.62 (28.54-63.43)	62.44 (42.81-95.14)	83.25 (57.08-126.85)	9,85
Suriname	2.91 (1.99-4.43)	5.82 (3.99-8.87)	8.73 (5.98-13.3)	11.64 (7.98-17.73)	2,3
Trinidad and Tobago	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Uruguay	4.9 (3.36-7.47)	9.81 (6.73-14.95)	14.71 (10.09-22.42)	19.62 (13.45-29.89)	4,81
Venezuela	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0

Notes: Values are in US$ billions at 2024 constant values. The percentage columns (25, 50, 75, and 100) show a projected value if that percentage is the amount of new land needed for purchase. Numbers not in parentheses show midpoint estimate; numbers in parentheses show bottom and top of the range of projected estimates. Zeros indicate that a country already protects over 30 percent of its land area, so no further cost is needed. Additional land is the difference (in millions of hectares) between 30 percent coverage and the coverage in 2025. See 6.4 methods appendix for all input data and calculation details; country-level results dataset can be consulted in the accompanying dashboard of this report online.

TABLE 11 30x30 Establishment Costs in LAC Under Scenario 2

Country	25%	50%	75%	100%	Additional land needed (ha million)
Argentina	41.63 (28.55-28.55)	83.27 (57.1-57.1)	124.9 (85.64-85.64)	166.53 (114.19-114.19)	59,04
The Bahamas	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Barbados	0.09 (0.06-0.06)	0.18 (0.13-0.13)	0.28 (0.19-0.19)	0.37 (0.25-0.25)	0,01
Belize	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Bolivia	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Brazil	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Chile	13.35 (9.15-9.15)	26.69 (18.3-18.3)	40.04 (27.45-27.45)	53.38 (36.6-36.6)	6,54
Colombia	2.82 (1.93-1.93)	5.64 (3.87-3.87)	8.46 (5.8-5.8)	11.28 (7.74-7.74)	14,91
Costa Rica	0.41 (0.28-0.28)	0.83 (0.57-0.57)	1.24 (0.85-0.85)	1.65 (1.13-1.13)	0,19
Dominican Republic	0.61 (0.42-0.42)	1.21 (0.83-0.83)	1.82 (1.25-1.25)	2.43 (1.67-1.67)	0,19
Ecuador	4.19 (2.88-2.88)	8.39 (5.75-5.75)	12.58 (8.63-8.63)	16.77 (11.5-11.5)	1,71
El Salvador	0.28 (0.2-0.2)	0.57 (0.39-0.39)	0.85 (0.59-0.59)	1.14 (0.78-0.78)	0,45
Guatemala	7.37 (5.05-5.05)	14.73 (10.1-10.1)	22.1 (15.15-15.15)	29.46 (20.2-20.2)	1,11
Guyana	7.09 (4.86-4.86)	14.18 (9.73-9.73)	21.28 (14.59-14.59)	28.37 (19.45-19.45)	4,56
Haiti	0.21 (0.15-0.15)	0.43 (0.29-0.29)	0.64 (0.44-0.44)	0.86 (0.59-0.59)	0,59
Honduras	0.44 (0.3-0.3)	0.88 (0.61-0.61)	1.32 (0.91-0.91)	1.77 (1.21-1.21)	0,78
Jamaica	0.15 (0.1-0.1)	0.3 (0.21-0.21)	0.45 (0.31-0.31)	0.6 (0.41-0.41)	0,11
Mexico	20.97 (14.38-14.38)	41.94 (28.76-28.76)	62.9 (43.13-43.13)	83.87 (57.51-57.51)	29,02
Nicaragua	3.3 (2.26-2.26)	6.6 (4.52-4.52)	9.9 (6.79-6.79)	13.2 (9.05-9.05)	1,16
Panama	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Paraguay	1.45 (1-1)	2.91 (2-2)	4.36 (2.99-2.99)	5.82 (3.99-3.99)	6,11
Peru	30.2 (20.71-20.71)	60.4 (41.42-41.42)	90.6 (62.12-62.12)	120.79 (82.83-82.83)	9,85
Suriname	2.93 (2.01-2.01)	5.87 (4.02-4.02)	8.8 (6.04-6.04)	11.73 (8.05-8.05)	2,3
Trinidad and Tobago	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Uruguay	5.27 (3.62-3.62)	10.55 (7.23-7.23)	15.82 (10.85-10.85)	21.1 (14.47-14.47)	4,81
Venezuela	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0

Notes: Values are in US$ billions at 2024 constant values. The percentage columns (25, 50, 75, and 100) show a projected value if that percentage is the amount of new land needed for purchase. Numbers not in parentheses show midpoint estimate; numbers in parentheses show bottom and top of the range of projected estimates. Zeros indicate that a country already protects over 30 percent of its land area, so no further cost is needed. Additional land is the difference (in millions of hectares) between 30 percent coverage and the coverage in 2025. See 6.4 methods appendix for all input data and calculation details; country-level results dataset can be consulted in the accompanying dashboard of this report online.

TABLE 12 30x30 Establishment Costs in LAC Under Scenario 3

Country	25%	50%	75%	100%	Additional land needed (ha million)
Argentina	40.47 (30.53-61.67)	80.94 (61.05-123.34)	121.41 (91.58-185.01)	161.89 (122.11-246.68)	59,04
The Bahamas	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Barbados	0.08 (0.06-0.13)	0.17 (0.13-0.26)	0.25 (0.19-0.38)	0.34 (0.25-0.51)	0,01
Belize	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Bolivia	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Brazil	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Chile	11.08 (8.36-16.89)	22.17 (16.72-33.78)	33.25 (25.08-50.67)	44.33 (33.44-67.56)	6,54
Colombia	5.93 (4.47-9.04)	11.86 (8.95-18.07)	17.79 (13.42-27.11)	23.72 (17.89-36.15)	14,91
Costa Rica	0.3 (0.23-0.46)	0.6 (0.46-0.92)	0.91 (0.68-1.38)	1.21 (0.91-1.84)	0,19
Dominican Republic	0.55 (0.42-0.84)	1.1 (0.83-1.68)	1.66 (1.25-2.52)	2.21 (1.67-3.37)	0,19
Ecuador	3.43 (2.59-5.23)	6.87 (5.18-10.46)	10.3 (7.77-15.69)	13.73 (10.36-20.93)	1,71
El Salvador	0.26 (0.19-0.39)	0.52 (0.39-0.79)	0.77 (0.58-1.18)	1.03 (0.78-1.57)	0,45
Guatemala	6.65 (5.01-10.13)	13.29 (10.03-20.25)	19.94 (15.04-30.38)	26.58 (20.05-40.51)	1,11
Guyana	14.36 (10.83-21.88)	28.71 (21.66-43.75)	43.07 (32.49-65.63)	57.43 (43.32-87.51)	4,56
Haiti	0.19 (0.15-0.3)	0.39 (0.29-0.59)	0.58 (0.44-0.89)	0.78 (0.58-1.18)	0,59
Honduras	0.4 (0.3-0.61)	0.8 (0.6-1.22)	1.2 (0.91-1.83)	1.6 (1.21-2.44)	0,78
Jamaica	0.14 (0.1-0.21)	0.27 (0.21-0.42)	0.41 (0.31-0.62)	0.55 (0.41-0.83)	0,11
Mexico	20.77 (15.66-31.64)	41.53 (31.33-63.29)	62.3 (46.99-94.93)	83.06 (62.65-126.57)	29,02
Nicaragua	3.01 (2.27-4.59)	6.02 (4.54-9.18)	9.03 (6.81-13.77)	12.05 (9.09-18.36)	1,16
Panama	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Paraguay	1.55 (1.17-2.36)	3.1 (2.34-4.72)	4.65 (3.5-7.08)	6.19 (4.67-9.44)	6,11
Peru	18.92 (14.27-28.83)	37.84 (28.54-57.66)	56.76 (42.81-86.49)	75.68 (57.08-115.32)	9,85
Suriname	2.64 (1.99-4.03)	5.29 (3.99-8.06)	7.93 (5.98-12.09)	10.58 (7.98-16.12)	2,3
Trinidad and Tobago	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0
Uruguay	4.46 (3.36-6.79)	8.92 (6.73-13.59)	13.38 (10.09-20.38)	17.83 (13.45-27.18)	4,81
Venezuela	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0

Notes: Values are in US$ billions at 2024 constant values. The percentage columns (25, 50, 75, and 100) show a projected value if that percentage is the amount of new land needed for purchase. Numbers not in parentheses show midpoint estimate; numbers in parentheses show bottom and top of the range of projected estimates. Zeros indicate that a country already protects over 30 percent of its land area, so no further cost is needed. Additional land is the difference (in millions of hectares) between 30 percent coverage and the coverage in 2025. See 6.4 methods appendix for all input data and calculation details; country-level results dataset can be consulted in the accompanying dashboard of this report online.

6.2.2 The Plausibility of Modeled Establishment Costs

Before accepting the results of the income approach modeling at face value, the reasonableness of the predictions is tested against available data on land values and cap rates. If the modeled values are similar to available data, then the plausibility of the results from the professional real estate valuation model is strengthened. Note, however, that one would not expect exact parity between modeled conservation land values and current agricultural land values. Conservation lands lack the clearance, land preparation, infrastructure development, and proof of business concept that working agricultural holdings have. Natural habitat areas (conservation lands) will therefore be cheaper than comparable agricultural lands for purchase. So if the real estate models are giving plausible results, modeled conservation land values will be similar but generally lower than known commercial agricultural land values.

Also, because rural land values vary widely, robust comparisons need to be made with national statistics derived from real estate agents who have a deep market share and database, or at least from sales listings where a number of listings for a particular country are available and those listings do not show extreme variation. Ideally, comparisons with listings for undeveloped land would also be available.

Savills (a large international real estate firm) carried out a broad study on 2020 agricultural land values for three LAC countries that are a major investment foci: Argentina, Brazil, and Uruguay.[4] For Uruguay, Savills lists 2020 land values of US$3,342 per hectare (which would be US$4,129 if expressed using this report's standard of constant 2024 US$ values), giving a cap rate of 1.24 percent. This study's model suggested protected area land values of US$3,700–US$4,000 and a cap rate of 1.07 percent. For Brazil, Savills gives 2020 agricultural land values of US$4,183 per hectare (US$5,099 per hectare in constant 2024 dollars), representing a cap rate of 1.94 percent. This study's model suggested that average conservation land costs in this study's scenarios would be approximately US$4,500 per hectare in constant 2024 dollars, representing a cap rate of 1.95 percent. However, in Argentina, comparisons are difficult because there are unusually severe restrictions on the sale of land to foreign buyers (which is the sales data that Savills uses for its national average values), thinning of the database, and extremely volatile currency exchange rates. Given those caveats, the Savills estimate of agricultural land value is US$5,558 per hectare, which is notably higher than the approximately US$3000 per hectare estimated for the value of conservation land.

However, conservation land (for 30x30) in Argentina is indeed likely to be markedly cheaper than agricultural land. The highest national biodiversity is mostly found in the forested subtropical north, which has much lower land values, whereas the Savills figures are dominated by land costs in the high-yielding agricultural heartlands of the Pampas. Nevertheless, the variation in Argentina also illustrates why the estimates of conservation land values are bracketed with wide confidence intervals (Tables 10–12). Of note, there is one other country (Ecuador) that was not in the Savills report but has a data source meeting the criteria of several land listings being available, with reasonably low variation in value and including both converted agricultural land and undeveloped rural land. In this source, Ecuadorean agricultural land values in the range of US$6,000–US$10,000 per hectare and sometimes higher. At time of inquiry, the agent also had three undeveloped plots available, with values per hectare at US$6,000, US$6,600, and US$6,626, which compare favorably with this study's modeled estimate for Ecuador's average conservation land value of US$6,632 per hectare.

All the comparisons above are between the known value of developed agricultural land and the modeled value of undeveloped conservation land, so a more like-for-like comparison would be modeled conservation land values against known values of conservation land. The only recent estimate of conservation land values available for LAC was in Colombia, by Nolte et al.,[5] and that study suggested that values paid for conservation land were US$1,173 per hectare on average (median). This study's estimate values across the three scenarios were US$1,173 per hectare for scenario 1 and rising to US$1,950 per hectare for scenario 3 (which notably locates new TPAs on higher-value pieces of potential agricultural land than is currently the case).

The exact match between Nolte et al.'s figure and this study's modeled figure should not be overinterpreted. However, the way in which this study's modeled estimates for conservation land values are closely comparable to empirical values in both real estate data and a study of Colombian conservation land purchases, plus the way this study's modeled estimates predict comparable but slightly lower costs for natural habitat than for working agricultural properties, suggests that models using the income capitalization approach provide robust and reasonable results.

The results here also confirm the findings of previous authors[11,32] that the rule of thumb by which establishment costs are estimated, as approximately 50 times annual management costs,[3] is unlikely to be universally applicable. For example, applying that rule here would suggest a cost of only US$261–US$282 per hectare for Colombia, which is less than a quarter of the US$1,173 per hectare value that that this study's model generates, and which Nolte et al. also found empirically for Colombian conservation land purchases.[5]

Professional land valuation techniques recognize the almost self-evident fact that rural land purchase costs depend on the (potential) value of the agricultural output that can be extracted from that land.[26,27,29] Nevertheless, a number of conservation academics have criticized the use of gross agricultural rent[12] values to project conservation land values, including by showing weak

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[12] Gross agricultural rent is the value (per hectare) of all agricultural production derived from a piece of land, at farm-gate prices.

correlations between gross agricultural rent and conservation land costs.[5,18,33] This criticism arose because gross agricultural rent became widely used as a value proxy in academic conservation literature after 2008.[10,33–37]

However, any land valuation approach that uses only gross agricultural rent, in isolation, is inherently generating a biased and highly incomplete approximation of the professional income capitalization estimate (see 6.4 methods appendix). The income capitalization method merely includes, as one of its many terms, a nonlinear proxy of gross agricultural rent (namely, the cash rent). There are several other non-rent terms in the formula, capturing relative values and risk premiums compared across both agriculture and financial markets, particularly including the cap rate. None of those other terms are considered by gross agricultural rent methods, nor is the nonlinearity of the cash rent relationship. It is therefore unsurprising that techniques using agricultural rent, on its own, fail to make accurate predictions of purchase costs. Professional valuation techniques, particularly those including income capitalization methods, have indeed been validated by their widespread use over decades in trillion-dollar real estate markets, suggesting they yield reasonable, operable results in practice.

6.2.3 Payment Option Pros and Cons

Even with fractional purchase, acquisition and establishment costs are often so large that they represent a major challenge for developing countries in LAC when treated as a one-off expenditure item. Many countries may therefore seek to amortize those costs. At a national level, amortization converts the large one-off cost into a series of smaller annual government expenditures that are more fiscally manageable, for example by issuing a long-dated bond. As an example, the potential US$6.5 billion one-off cost for Colombia would equate to a (more manageable) annual cost of approximately 0.05 to 0.10 percent of Colombia's 2023 GDP (depending on the bond or borrowing rate) if spread over a long bond period such as 30 years.

Nevertheless, average government borrowing costs (bond yields) in LAC are 7–8 percent [38] and sometimes much higher, which makes the interest payment terms relatively costly when borrowing such large sums, adds to increasing debt burdens, and exacerbates any existing debt repayment issues.[38,39] For example, if one were to apply an illustrative concessional interest rate of 5 percent over 30 years, the total establishment cost would be almost double the costs/expenditures shown in Tables 10–12 (1.95 times larger). This example equates to doubling an already large expenditure, which would add a substantial future debt burden to countries that may already require billions of dollars in extra funding for other aspects of 30x30.

Yet it may be possible to lower those interest rates by using concessional finance (e.g., lower-interest loans) and blended finance,[40] as already occurs with climate finance.[41] For example, many countries in LAC have already entered into some form of debt-for-nature swaps, including Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Honduras, Jamaica, and Peru[42–49] (see also www.greenfdc.org). For instance, Ecuador funds Galapagos conservation with a Blue Bond paying a coupon rate of 5.645 percent,[50] and Barbados swapped some of its debt with an average 7.2 percent cost for bonds with a 3.8 percent rate of interest.[51] The attraction of those swaps often lies in how they make existing government debt cheaper in exchange for improved nature funding.[45]

But for large 30x30 establishment costs, there may be cases where governments have no choice but to issue new debt, thus increasing indebtedness regardless of the interest rate. Nature-related finance is potentially a different proposition, however, since it still increases national debt interest payments rather than reducing them. (Note that debt swap arrangements can also be controversial and are not without their problems.[40,52–54] They are used here as an example of a common approach to concessional finance for biodiversity policy targets. This is not to suggest that they are the main or only concessional finance possible, and the climate experience may guide broader biodiversity finance options here.[41])

An assessment of the pros and cons of borrowing at interest to pay for environmental policy changes are complex and beyond the scope of this report. However, it is important to be cognizant of the issues around how to meet potentially very high one-off costs of nature and climate protection, particularly since that protection may be important for future economic well-being[55,56] even though securing it has high costs in the present.

6.3 Policy Implications

The cost of purchasing land is typically substantial, so acquisition costs for expanding TPA systems could potentially be extremely high. However, if part of the newly protected or conserved land does not require commercial purchase, then the final cost to government could be considerably lower than the total land value. Examples of non-purchasable land include government-owned lands or IPLC lands where landowners or managers have negotiated an agreement to become partners in the 30x30 commitment. That said, free or low-cost lands should not be acquired to fulfill PCA requirements based on price alone: Target 3 requires that PCAs meet biodiversity needs.

Although ICCAs are a potential example of PCAs with zero acquisition costs, it is also important to note that non-state structures of PCA ownership and management, such as ICCAs or OECMs may still require work to establish them as effective conservation areas.[22,40] For example, Indigenous-managed areas that freely consent after open consultation to be included in 30x30 lands may need infrastructure, staff training, or formalization, which may start with securing formal tenure to the land (for a very low costs compared to land purchase).[57–60] Similarly, an OECM that is already owned requires no purchase to convert it to formal PCA use, but management, legal, and physical infrastructures may need to be established, all of which have unknown costs. At minimum, ICCAs and OECMs may therefore be regarded as having their own form of establishment costs, even without the element of an acquisition cost. Until context-specific information is available on what these other setup costs may be, it may be advisable to assume that at least 10 percent of an equivalent establishment cost, calculated using a land purchase cost, may be needed.

A further PCA option comes from alternatives to the purchase of private lands such as conservation easements,[20,21] although calculating the cost difference between an easement and a land purchase is complex[21] (not least because purchase is a one-off cost whereas the national costs of easements, such as foregone tax, may apply in perpetuity). However, because easement costs are likely to make up very small the proportion of the total national cost, the potential use of easements is not likely to strongly affect the projected establishment costs per country.

Some related suggestions for implementing 30x30 follow. The first step in helping individual governments protect a country's natural capital—in the most appropriate places for PCAs at the lowest possible acquisition costs—is to map biodiversity priorities and ownership status of high-priority areas. Having biodiversity and landownership information on all sites that are candidates for protection allows governments to define establishment-cost finance needs for each 30x30 spatial option.

One evident policy strategy is to protect sites where biodiversity priorities align with low-cost (or free) land availability. Then, where sites in need of protection are under private ownership, governments may need to discuss purchase or negotiate for collaborative nature conservation with the current owners. And they can then meaningfully address how to balance out ideal biodiversity solutions against financial feasibility, for example using spatial conservation planning.[34,61]

Finally, if the land choices that best satisfy the need to protect important biodiversity areas are prohibitively expensive for national government budgets, international institutions and donors can be approached for financial assistance. The approach would include a concrete rationale and a well-defined monetary need, based on the sequence of modeling steps listed.

6.4 Appendix. Methods

To estimate the potential value of lands that might be added to national PCA systems in order to achieve 30 percent coverage, this report started with the assumption that the majority of such lands would be in rural rather than urban or peri-urban areas. This assumption follows the logic of scenarios themselves, which are based on the highest-ranking areas for species richness (avian and mammalian) in each country, noting that the vast majority of high-ranking areas would indeed be away from cities and their suburban peripheries. The appropriate model for estimating land value would therefore be one applicable to rural land.

However, it is likely that some adjustments to results would need to be made to account for differences between agricultural land, which is the type of rural land most typically valued, and natural habitats being bought for PCA status. In particular, agricultural lands (and human-converted rural land use classes in general) may have higher values because of the existing preparation of the land for production and the relative security of knowing its production history. This intuition was confirmed in the literature[5,10,18] and by comparing developed and undeveloped parcels of rural land for sale on the websites of international land agents.

Professional land valuers have a long experience of estimating land values, and the most commonly used approach is the income valuation method, which is often applied by using the income capitalization method, also known as "direct capitalization" or "capitalization rate valuation."[26–30] In this method, land value is estimated as the ratio between the net annual operating income derived from the land (as the numerator) and the capitalization rate or "cap rate" (as the denominator). The model therefore requires, as parameters, estimates of the net operating income and the cap rate. For rural land, Jansen and Stokes[30] give a detailed description of how the cap rate is derived from multiple parameters, based on an earlier model by Tuvey.[62] The parameters are the risk-free rate (the return on US Treasuries): the rate of growth in an investment placed on the market (such as an investment in the S&P 500), the natural rate of growth in the net operating income, and a complex term describing the relative volatilities in market and agricultural returns.

The net operating income, in Jansen and Stokes and elsewhere, is typically calculated using the cash rents achievable from a property. These are typically a relatively small percentage of the total value of production per hectare from the land, but that percentage can vary across countries. (The authors note that there is potential confusion between "rent" in the sense of a cash rent, namely the lease paid by a tenant, and "rent" in the sense of the value of agricultural production itself, as used by many conservation researchers who work on protected areas). Jansen and Stokes use a regression model that accurately predicts cash rents from the elements of production value (yield and price paid for that yield). The regression equation has separate coefficients for these terms.

This study used a Monte Carlo approach, creating a matrix that contained a large number of possible values for both terms, in all possible combinations of the two terms, and then used the coefficients from the Jansen and Stokes regression model (which has an R^2 value of 0.82) to derive the statistical expectation of net income for each of those combinations. This process gives a large dataset of operating incomes, which can then be regressed directly on the Monte Carlo production values to generate a statistical relationship between production value and net operating income. The relationship was nonlinear (a decelerating increase), so this report used a generalized additive model with a tensor spline to quantify the nonlinear statistical relationship, noting that the model has an R^2 of 99 percent (0.99).

The authors then took statistics for 1961–2023 for value of agricultural production per hectare from the FAO database FAOSTAT[63] and applied the generalized additive model to predictively generate the corresponding cash rents required by Jansen and Stokes' valuation model. For information, the nonlinear model can be approximated without using a tensor spline by using a linear model with a quadratic term, of the form (cash rent per hectare = output value per hectare * 0.1382 + (output value per hectare ^2) * -1.616e-06, forced through the origin because land with zero value must have exactly zero potential cash rent. This model was applied to derive parallel cash rent rates for all levels of output value over time in the FAO output value data.

The authors then calculated the mean natural rate of growth in the cash rates and the standard deviation of that growth rate, using the time period 2001–2023 (following Jansen and Stokes' own use of relatively long periods to derive more stable estimates). As the risk-free rate, this study took the mean 10-year US Treasury rate for the last three years, following Jansen and Stokes' finding that a three-year average (rather than a very long-term average) was important for predictive accuracy when Treasury rates are volatile over a period of years. The market return and its standard deviation were taken from Jansen and Stokes' previous calculations. Applying all these parameter estimates to the Jansen and Stokes formula gave the estimate of the cap rate. The authors then took the 2023 estimates for the value of agricultural output per hectare from the FAO data and divided them by the cap rate to generate an estimate of the value of rural land per hectare, averaged at national levels.

Even though the land needed to achieve 30 percent PCA coverage might often represent a substantial fraction of the total national area, making large-scale estimates broadly appropriate, there are two ways in which the potential cost of purchasing land could vary from these national averages. The first is when the potential value of agricultural production on land of interest to conservation is different from the national average. In the past, this has often been true because conservation lands were specifically placed in areas where there was a relatively low potential economic output.[64,65] Our 30x30 scenarios aim to focus more closely on areas of high-biodiversity importance (high-diversity rankings) which may be expected to often have high potential yield, because of the relationship between natural primary productivity, potential production productivity, and species richness.[66] But even so, the high-biodiversity land pixels that would need to be added to the current protected area system to achieve the 30x30 scenarios may still have different potential agricultural values from the average.

To capture this more detailed spatial variation, it would need higher-resolution, gridded spatial datasets showing the potential agricultural value of lands that often are not currently agricultural. This study used the spatial dataset of Carrasco et al. that estimates the net agricultural rent (the net potential value of production per hectare) in quarter-degree grid cells across the world,[67] noting that this dataset has the advantage over the pioneering agricultural rent maps of Naidoo and Iwamura[35] because it is more recent, it accounts for costs (so that the rent is net rather than gross), and it includes the potential net gain from currently natural lands that include the profit from clearing the land in the first place, such as if timber has to be removed. The Carrasco et al. maps (spatial layers) are still estimates, but they are internally consistent estimates based on known production data and price data. They should therefore provide a robust estimate of how local values vary, with the benefit that the variation can be expressed as the ratio between the values of different cells, all calculated using the same method, thus giving a more robust indication than if the raw rent values were used.

The authors therefore divided the rents for the lands inside the protected area 30 percent scenarios by the national mean rent for each country, and used this to adjust the net operating income, modeled at national average, to a spatially explicit grid that showed a higher-resolution, gridded system of the potential net operating incomes. That grid was then overlaid on the rasters for the scenario-generated protected pixels to estimate how the land value of new pixels may diverge, in percentage terms, from the national average. One country had no rent data to calculate the ratio (Barbados), so this study took the value for The Bahamas.

This report acknowledges that the Carrasco et al. spatial layers reflect net output PPP and that the corresponding component in FAO data being used to construct cash rents (the FAO data on production value per hectare PPP) is calculated using the farm-gate price. When aligning the two datasets, this difference may create small deviations in the ratios between relative values in different spatial cells, representing the difference between the ratios in farm-gate values and the ratios in net values, which will then generate error scatter around the estimates. However, a spatially explicit, up-to-date grid of Carrasco spatial data that instead shows the potential farm-gate value that might be extracted from land that is currently natural habitat was not available.

By definition (in the formula construction), the land values generated by the capitalization approach are sensitive to the operating income and cap rate estimates. The cap rate estimate, being typically very small (only a few percent), and much smaller than the operating-income numerator, would have by far the most powerful effect on causing variation. To conservatively represent a wide range of uncertainty around our land value estimates, the authors therefore created two new sets of estimates to bracket the midpoint estimated generated from the methods above; the low estimate, which increases the estimated cap rate by 25 percent (reducing the value estimate), and the high estimate, which decreases the cap rate by 25 percent. All values were set to constant 2024 US$.

The second source of uncertainty regarding land costs differing from the national average that should be modeled is the difference between the value of land of conservation interest (which is typically unconverted to production) and the value of more typical agricultural land. Work by Sutton et al.[18], Nolte et al.[5,8], and Le Bouille et al.[10, 33], all suggest that conservation lands may have values between 60 percent and 80 percent of the average values for agricultural land in the same locations.

A test of this principle where one international land agent listed both "agriculture-ready" lands and lands that were still in their state of natural habitat gives the same result: the more natural lands were about 60–80 percent the cost per hectare of the listed agricultural lands (sourced in June 2025 from MLS Ecuador). To represent a range for this effect of relative cheapness, the authors took the bracketing estimates of value generated by varying the cap rate and varied those estimates to reflect this latter uncertainty, by using different multipliers on the estimates of rural land value from the agricultural model. The authors applied a 0.7 multiplier to the midpoint estimate of agricultural land value, a 0.6 multiplier to the low estimate, and a 0.8 multiplier to the high estimate. Finally, all estimates of the cost per hectare were multiplied by the difference between the number of hectares in the current TPA system for each country (as of June 2025, taken from the World Database of Protected Areas), and the number of hectares implied by 30 percent coverage of PCAs in each country. Thus, any country that already had 30 percent or greater coverage had its establishment cost automatically set to zero. To account for the approximately 10 percent of establishment costs that are not captured in the value of the land itself, most of which are transaction costs,[13] the authors multiplied the acquisition costs estimated above by 1.1.

To test the predictions of the model, this report sourced data on both land values and conservation land purchase values in LAC (or the equivalent, namely rural land that is in an essentially natural state rather than being converted already to agricultural use). These sources are listed in the main text. As also stated in the main text, perhaps the largest uncertainty in national establishment costs is the fraction of the new land that would need to be purchased in the first place, rather than being essentially free (e.g., government land) or inappropriate for purchase. Lacking complete maps of the pattern of land ownership in each country, this fraction remains unknown. The authors therefore calculated the establishment costs associated with a range of possible fractions in each country. The results in the Tables 10–12 show the values for a 25 percent fraction, a 50 percent fraction, a 75 percent fraction, and a 100 percent fraction.

7

Terrestrial Opportunity Costs

The term “opportunity costs” generally refers to forgone income or profits. For protected areas, the basic concept is that the act of protecting land today prevents certain stakeholders from being able to convert natural habitat to productive, profitable use in the future.[1–4] The removal of this potential opportunity for future conversion is then argued to represent a quantifiable financial loss, hence the term “opportunity cost.” For protected areas, which are generally in rural areas, the opportunity cost is nearly always measured as a potential income loss in the rural economy—the value of potential but forgone agricultural production.[2,3,5]

Thus, creating a new TPA or terrestrial PCA does not immediately cause a loss of income or profit to agriculture. Rather, it creates a change in the potential to earn income from the land in the future. More specifically, a future income could theoretically be expected from putting some of that land into production in a particular future year (after 2030). When assessing the opportunity cost, it is important that the scale of this theoretical, time-specific future act of putting land into production should be reasonable. For example, when 30 percent of the planet is protected, some writers and stakeholders may argue that the financial loss is equivalent to the potential agricultural production value for the entire 30 percent. However, there is no market demand for converting an additional 30 percent of all global forests and natural grasslands to food and fiber production (an act that would nearly double the amount of cultivated land overnight). Indeed, if such an agricultural expansion were to occur, it would cause economically devastating overproduction, forcing prices severely downward and driving many farmers and ranchers out of business.

A more realistic scale of opportunity cost is therefore needed than “the potential value of the entire protected system.” The main economic impact of protecting land today is that, when the agricultural sector wishes to expand in the future, there will be certain places it is not allowed to expand into. Faced with that restriction, the agricultural sector would typically meet demand by expanding onto the most profitable part of the total pool of available, unprotected land. Sometimes, the next most profitable area will generate a lower net income than the producer would have achieved if they had converted the now-protected area. The opportunity cost can therefore be defined, as the difference between the net income that would have been achieved in the absence of protection (such as 30x30) and the net income that is actually achieved.[5] At a national scale, the opportunity cost is therefore the difference in total national agricultural output value, calculated by comparing output from a 30x30 scenario against output from the counterfactual baseline in which 30x30 does not take place.

7.1 Modeling TPA Opportunity Costs

Opportunity costs are based on an estimate of what the agricultural sector might have done at specific points in the future. Consequently, any calculation of opportunity costs also requires a clear time horizon, specifying the exact future years of interest. Otherwise, the opportunity cost is implicitly calculated for an infinite number of future years, which would be of limited usefulness politically and economically and be controversial in terms of moral debate about the rights of distant future generations.[6,7] The FAO provides projections for future agricultural production values in 2035, 2040, and 2050,[8] which is useful in providing context for any opportunity cost estimate. For example, it is useful to compare the dollar value of the opportunity cost for 2050 with the dollar value of national agricultural output for 2050. To align with the FAO data and reporting years for these projections, this report models terrestrial opportunity costs of 30x30 in 2035, 2040, and 2050.[13]

Integrated assessment models have been used to identify the agricultural expansion likely to be needed out to 2050 and the land areas where that expansion would be most profitable (see Waldron et al.).[5] Opportunity costs for 30x30 can therefore be projected by testing how agricultural expansion deviates from that maximally profitable pattern as a result of 30x30 (and the economic consequences of that deviation). In other words, the opportunity cost for a specific year (e.g., 2050) is the value of agricultural production in the most-profitable-expansion framework for that year, minus the value of production in a scenario where some of the most profitable areas are no longer available in that future year because they became protected (e.g., 20) years earlier, so different land has to be used instead.

To project the location of the land that would be needed for future agriculture up to 2050, the baseline (counterfactual) land use projections from the Asia-Pacific Integrated Model (AIM)[9,10] model in Waldron et al.[5] are used. AIM has also been used by the Intergovernmental Panel on Climate Change for global and regional land use projections[9,10] and various publications on the future of biodiversity, including *Bending the Curve*.[11] Because the final areas that will be included in 30x30 are unknown, three scenarios are used to model possible placements of the 30 percent PCA coverage in 2030 (see Table 1 and Table 2). The scenarios are configured to account for future agricultural expansion needs in different ways. Scenario 2 (economic) explicitly vetoes any PCA

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13. Note that, unusually, the marine opportunity costs were modeled out past 2060 in this report. However, this was necessary because MPAs actively remove producers from areas that they are currently exploiting, and recovering from that shock can take 20–30 years, with subsequent gains in profitability sometimes occurring after 2050. However, new TPAs in LAC will typically be placed on areas of natural habitat that are, by definition, not being exploited to any degree of intensity. There is therefore no comparable shock at national level, and opportunity costs can meaningfully be measured out to 2050.

expansion onto land that will be needed for future agricultural expansion out to 2050, so it has zero opportunity cost in all years up to 2050. Scenario 1 (biodiversity) expands protected areas to capture the highest-ranking biodiversity areas that remain unprotected in 2025 with no constraints on whether land will be needed for future agriculture, so it has a non-zero opportunity cost. Scenario 3 (compromise) retains much but not all of the area needed for future agricultural expansion as "unprotected," so it will have a non-zero opportunity cost, but a lower cost than scenario 1.

Since scenario 2 (economic) is the zero-opportunity-cost baseline, the opportunity cost of the two other scenarios can be calculated by comparing them with scenario 2. For example, if one imagines a map of LAC with a grid of square cells laid over the top of it, a potential opportunity cost will arise when cells that were reserved for future agricultural expansion in scenario 2 become overwritten by new protected areas in scenarios 1 and 3. To retain the same level of agricultural output, the future agricultural production for those cells then has to be moved to a different location or locations, chosen from all locations that remain unprotected. The potential opportunity cost becomes crystallized, as an actual financial loss, if the net income from converting those new cells to agriculture is lower than the net income expected from converting the original scenario 2 cells.

The methodological difficulty is that the cells in question are currently natural habitat. To create an estimate for the agricultural income that the cells would generate if they were converted in the future (or in economic parlance, potential agricultural rent),[12] one has to estimate the potential production per hectare using environmental and market data. This study uses Carrasco et al.'s maps of potential agricultural rent[12] (for 2016), in coordination with subsequent FAO estimates of the empirical value of agricultural production per hectare per country for 2016 (see 7.4 methods appendix). Next, production values per hectare are projected to derive opportunity costs for the years 2035, 2040, and 2050. Again, because opportunity costs are calculated for the specific policy action of expanding the TPA system to 30 percent, countries with lower coverage levels in 2025 will usually have higher opportunity costs, and countries at or above 30 percent coverage will have no opportunity costs.

The final projected opportunity costs are presented in two ways. First, the raw cost is simply the dollar value of the difference in national agricultural production, net of costs, that is caused by a 30x30 scenario. Raw costs often seem large in absolute terms (e.g., many millions of dollars), but agricultural GDP is often measured in the hundreds of billions of dollars,[8] so a change of several million dollars represents a very small change to national output. Second, to put opportunity costs into the appropriate context, this report additionally expresses opportunity costs as a percentage of the total projected value of future agricultural output in each country, using three FAO scenario-based projections of future outputs in the absence of 30x30.[8] Each FAO scenario generates a different estimate of the likely value of national agricultural output in 2035, 2040, and 2050 (at least for most countries), and these are used as the denominator of the percentage change calculations.[14]

7.2 Main Results

The overall pattern of projected national opportunity costs shows three broad categories of outcomes. The first category consists of a group of countries that have no projected opportunity costs in one or both scenarios (i.e., scenarios 1 and 3) (Tables 13 and 14). The second category groups together countries for which the projected opportunity costs are a few tens of millions of dollars per year, representing a very small proportion of their total projected agricultural output (e.g., Guatemala, Honduras, and Nicaragua in scenario 1) (Table 13).
For a third category of countries, however, opportunity costs were more substantial, particularly for scenario 1 (biodiversity), which has the highest expected costs. For example, scenario 1 was projected to cause a loss in net output value for Chile of US$2.6 billion–US$2.75 billion in 2050, equivalent to between 7.6 percent and 10.6 percent of total projected output for that year; up to 4 percent (US$63 million/year) for Guayana; of 2.7 percent–3.1 percent (US$674 million–US$685 million/year) for Ecuador; and 1.8 percent (US$214 million–US$223 million) for Costa Rica.

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[14] The three FAO projections essentially scenario-model three possible futures for the evolution of agriculture and human consumption: Business As Usual (BAU), Towards Sustainability (TSS), and Stratified Societies (SSS). BAU envisages no change in approaches to agriculture or societal sustainability in the food system; TSS envisages rising consumer awareness of food production issues, leading to lower animal protein intake, less food waste, and an overall push for sustainability in farming methods; and SSS envisages largely the opposite—an unequal economy in which waste and animal protein consumption increase globally and sustainability becomes sidelined.

TABLE 13 30x30 TPA Opportunity Costs of Scenario 1 for Rural Agricultural Sector

Country	2035	2040	2050	2035 lower bound	2040 lower bound	2050 lower bound	2035 upper bound	2040 upper bound	2050 upper bound
Argentina	0	0	0	0	0	0	0	0	0
The Bahamas	0	0	0	0	0	0	0	0	0
Barbados	1.5	1.3	1.2	0.8	0.5	0.4	2.2	2.2	2.1
Belize	0	0	0	0	0	0	0	0	0
Bolivia	0	0	0	0	0	0	0	0	0
Brazil	0	0	0	0	0	0	0	0	0
Chile	2609	2732.4	2753.4	2150.1	1965.7	1845.5	3067.9	3499	3661.4
Colombia	0	0	0	0	0	0	0	0	0
Costa Rica	223.1	219.1	214.4	187.7	176.9	170.8	258.5	261.4	257.9
Dominican Republic	72.4	79	80.2	57.4	53.6	50.3	87.3	104.4	110.1
Ecuador	567.5	550	535.5	450.3	412.1	393.6	684.8	688	677.4
El Salvador	0	0	0	0	0	0	0	0	0
Guatemala	48.2	45.8	43.3	33.3	19.7	12.8	63	71.9	73.7
Guyana	62.8	59.4	56.1	46.6	40.8	37.5	79.1	78.1	74.6
Haiti	8.8	7.7	7.1	6.2	4.3	3.6	11.4	11	10.5
Honduras	51.4	49.5	47.8	40	36	34	62.9	63	61.5
Jamaica	5.8	5.3	5	5.1	4.6	4.2	6.5	6.1	5.7
Mexico	0	0	0	0	0	0	0	0	0
Nicaragua	14.1	13.3	12.5	10.7	9.3	8.5	17.6	17.2	16.4
Panama	0	0	0	0	0	0	0	0	0
Paraguay	0	0	0	0	0	0	0	0	0
Peru	1.3	0	0	1.1	0	0	1.5	0	0
Suriname	0	0	0	0	0	0	0	0	0
Trinidad and Tobago	0	0	0	0	0	0	0	0	0
Uruguay	0	0	0	0	0	0	0	0	0
Venezuela	0	0	0	0	0	0	0	0	0

Notes: All values are in constant 2024 US$ millions. By definition, all opportunity costs for scenario 2 are zero.

TABLE 14 30x30 TPA Opportunity Costs of Scenario 3 for Rural Agricultural Sector

Country	2035 USD mill.	2040 USD mill.	2050 USD mill.	2035 lower bound USD mill.	2040 lower bound USD mill.	2050 lower bound USD mill.	2035 upper bound USD mill.	2040 upper bound USD mill.	2050 upper bound USD mill.
Argentina	0	0	0	0	0	0	0	0	0
Bahamas	0	0	0	0	0	0	0	0	0
Barbados	0	0	0	0	0	0	0	0	0
Belize	0	0	0	0	0	0	0	0	0
Bolivia	0	0	0	0	0	0	0	0	0
Brazil	0	0	0	0	0	0	0	0	0
Chile	196.9	189.6	181	162.3	136.4	121.3	231.5	242.8	240.7
Colombia	0	0	0	0	0	0	0	0	0
Costa Rica	31.4	28.2	26.1	26.4	22.8	20.8	36.4	33.7	31.4
Dominican Republic	0	0	0	0	0	0	0	0	0
Ecuador	83.5	75.8	70.8	66.3	56.8	52.1	100.8	94.8	89.6
El Salvador	0	0	0	0	0	0	0	0	0
Guatemala	0	0	0	0	0	0	0	0	0
Guyana	0	0	0	0	0	0	0	0	0
Honduras	0	0	0	0	0	0	0	0	0
Haiti	0	0	0	0	0	0	0	0	0
Jamaica	0	0	0	0	0	0	0	0	0
Mexico	0	0	0	0	0	0	0	0	0
Nicaragua	0	0	0	0	0	0	0	0	0
Panama	0	0	0	0	0	0	0	0	0
Paraguay	0	0	0	0	0	0	0	0	0
Peru	0	0	0	0	0	0	0	0	0
Suriname	4.7	0.1	0	3.3	0	0	6.2	0.1	0
Trinidad and Tobago	0	0	0	0	0	0	0	0	0
Uruguay	77.6	73.5	70.7	61.8	55.6	52.5	93.4	91.4	88.9
Venezuela	0	0	0	0	0	0	0	0	0

Notes: All values are in constant 2024 US$ millions. By definition, all opportunity costs for scenario 2 are zero.

Scenario 3 (compromise) generally had lower costs (and more countries with zero cost) than scenario 1, as would be expected since scenario 3 takes agricultural needs into account more than scenario 1. For example, in scenario 3, the cost for Chile was reduced to less than US$0.2 billion or 0.5–0.7 percent of total output, and the cost for Guatemala, Guyana, Honduras, and Nicaragua was reduced to zero. Notably, the cost for Uruguay in scenario 3 (0.43–0.55 percent of total output value) was second only to that of Chile.

The large number of countries with low or zero opportunity costs may seem surprising given that achieving the 30x30 commitment often requires the protection of large amounts of additional natural habitat, removing that land from potential agricultural production.

However, it is important to reiterate that the opportunity costs of a national TPA system are not the entire *potential* agricultural production of all land in that system. A TPA simply asks producers that, when they choose where to expand their operations in future, they avoid converting the country's most critical high-biodiversity natural habitat areas (which are instead made into protected/conserved areas). In many cases, avoiding critical sites may lead to no opportunity cost at all, so long as the same future production can be achieved by converting noncritical sites instead. In other cases, avoiding critical sites may increase some costs, such as when a producer has to convert more area to achieve the same production levels, thus reducing gross margins.

7.2.1 Drivers and Consequences of Opportunity Costs

Certain drivers affect the magnitude of opportunity costs post-2030. First, the costs depend on how far high-biodiversity areas overlap with optimal future areas for agriculture. If the overlap is high, then protecting biodiversity-critical sites is highly likely to displace future agricultural conversion sites to another area. The more this displacement occurs, the higher the potential opportunity costs. Second, the size of the pool of potential agricultural land that remains after expanding protected areas to 30 percent coverage drives opportunity costs. The more that alternative sites for future production remain unprotected after 30x30 is implemented, the lower the likelihood that an opportunity cost will be experienced. Conversely, if the pool of alternatives is small, the odds of an opportunity cost are increased.

Further, two circumstances can lead to a country having only a small pool of alternative sites for potential future agricultural conversion. First, the pool of potential sites (which is generally natural habitat such as forests) may be small before 2030, so any additional habitat protection will absorb much of the remaining pool of potential productive land. For example, the most likely explanation for higher opportunity costs in Chile and Costa Rica is that most of the land best suited to crops and livestock has already been converted from its natural state. In Chile, much of the unprotected, high-biodiversity natural land is in the central regions, which are also the most promising regions for agriculture. If the unprotected land of high-biodiversity value is protected under 30x30, there is limited opportunity to displace future agricultural conversions to other regions, particularly because of the deserts in the northern regions and remote, challenging environments in the southern regions.

The second circumstance limiting alternative sites occurs when the baseline (2025) national protected area coverage is very limited. In such cases, achieving 30 percent coverage means protecting a large amount of extra land and removing an unusually large proportion of potential future agricultural land from the pool. For example, 27 percent of all national land area would need to be converted to TPAs in Uruguay, 29 percent in Barbados, and 21.5 percent in Haiti, which increases the likelihood that at least some of that land would have been needed for future agricultural expansion.

These two effects interact: the more additional land that is needed to achieve 30x30, the worse the constraint becomes of having only a few high potential areas left for future agriculture. Uruguay and Haiti both have low levels of current TPA coverage, so they need large expansions. However, both countries have already converted much of their land area to productive use,[13–15] so the protection of the little-remaining natural habitat generates a doubly high likelihood of opportunity costs. A similar interaction may be occurring in Ecuador, where about 20 percent more protected area is needed to achieve 30x30, but most non-Amazonian natural habitat has either been converted or has low productive potential (e.g., páramo). As a result, future agricultural expansion must often overlap with Amazonian biodiversity hotspots.

These results highlight many of the classic trade-offs involved in large-scale land conservation. If a country has sufficient natural habitat to both expand the TPA network and satisfy its future production needs, then opportunity costs will be zero. However, where such ideal conditions do not exist, there will be competition between land needed for biodiversity and for future agriculture, so difficult decisions about trade-offs and priorities need to be made.

Those decisions also need to factor in the question of who pays the opportunity costs. TPA opportunity costs generally fall on the producers themselves (with the exception of changes to the tax take). In some cases, producers may be able to pass on those opportunity costs to consumers in the form of price increases. But in an international market, a country with unusually large opportunity costs will not be able to use the price-increase strategy without becoming uncompetitive.

In response, the two main policy alternatives would be government support of producers or deliberate avoidance of the worst opportunity costs in the first place. For a country such as Costa Rica, where the support needed is a few hundred million dollars per year and extensive environmental-protection payments are already embedded in the system,[16,17] additional support may be a feasible policy strategy. But for Chile, it is hard to envisage a viable policy that could compensate for the very large opportunity costs of scenario 1. In such cases, a compromise may be needed, such as the application of scenario 3 rather than scenario 1, to substantially reduce opportunity costs by allocating land through a compromise between current conservation needs and future production needs.

7.3 Policy Implications

Across all 26 countries, the total opportunity costs for 2050 are projected to be approximately US$3.75 billion per year in scenario 1 and US$0.35 billion per year in scenario 3. However, these figures should be compared to a total production value of between US$738 billion and US$792 billion for the LAC region, as projected by the FAO (see Tables 15-16).[8] The percentage reduction in overall agricultural profit (net output value) is therefore <0.5 percent in the worst-case scenario (scenario 1), and potentially as little as 0.04 percent (in scenario 3) or even 0 percent (in scenario 2). These results concur with the results in Waldron et al., who found that 30x30 would cause changes of about 0 to 1 percent in net output value for the global agricultural sector,[5] under full integrated assessment modeling by multiple modeling teams. LAC opportunity costs are therefore confidently projected to be very modest, when placed in the context of the agricultural sector's size.

TABLE 15 30x30 TPA Opportunity Costs of Scenario 1 for Rural Agricultural Sector Under Three FAO Scenarios

Country	Percentage of output - 2035 - BAU	Percentage of output - 2035 - TSS	Percentage of output - 2035 - SSS	Percentage of output - 2040 - BAU	Percentage of output - 2040 - TSS	Percentage of output - 2040 - SSS	Percentage of output - 2050 - BAU	Percentage of output - 2050 - TSS	Percentage of output - 2050 - SSS
Argentina	0	0	0	0	0	0	0	0	0
The Bahamas	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barbados	NA	NA	NA	NA	NA	NA	NA	NA	NA
Belize	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bolivia	0	0	0	0	0	0	0	0	0
Brazil	0	0	0	0	0	0	0	0	0
Chile	9.34	11.07	8.46	9.21	11.02	8.23	8.7	10.59	7.56
Colombia	0	0	0	0	0	0	0	0	0
Costa Rica	2.03	2.09	2.04	1.95	2.01	1.96	1.78	1.82	1.78
Dominican Rep.	0.81	0.86	0.82	0.83	0.89	0.84	0.81	0.89	0.83
Ecuador	2.68	3.12	2.68	2.52	2.98	2.51	2.21	2.68	2.18
El Salvador	0	0	0	0	0	0	0	0	0
Guatemala	0.35	0.36	0.36	0.33	0.34	0.35	0.28	0.29	0.3
Guyana	4.9	4.99	5.1	4.58	4.62	4.82	3.77	3.72	4.05
Haiti	0.25	0.25	0.26	0.22	0.22	0.23	0.17	0.17	0.18
Honduras	0.72	0.73	0.75	0.69	0.69	0.72	0.6	0.6	0.64
Jamaica	0.34	0.35	0.34	0.32	0.33	0.32	0.26	0.27	0.27
Mexico	0	0	0	0	0	0	0	0	0
Nicaragua	0.24	0.23	0.24	0.22	0.21	0.22	0.17	0.16	0.17
Panama	0	0	0	0	0	0	0	0	0
Paraguay	0	0	0	0	0	0	0	0	0
Peru	0	0	0	0	0	0	0	0	0
Suriname	0	0	0	0	0	0	0	0	0
Trinidad and Tobago	0	0	0	0	0	0	0	0	0
Uruguay	0	0	0	0	0	0	0	0	0
Venezuela	0	0	0	0	0	0	0	0	0

Notes: Costs (net losses compared to a baseline in which 30x30 is not implemented) are shown as a percentage of projected future agricultural output value in 2035, 2040, and 2050 under three FAO scenarios: BAU (Business as Usual), TSS (Towards Sustainability), and SSS (Stratified Societies). Note that all opportunity costs for scenario 2 are zero, by definition. NA indicates that the FAO gave no estimate for future production values in that country.

TABLE 15 30x30 TPA Opportunity Costs of Scenario 3 for Rural Agricultural Sector Under Three FAO Scenarios

Country	Percentage of output - 2035 - BAU	Percentage of output - 2035 - TSS	Percentage of output - 2035 - SSS	Percentage of output - 2040 - BAU	Percentage of output - 2040 - TSS	Percentage of output - 2040 - SSS	Percentage of output - 2050 - BAU	Percentage of output - 2050 - TSS	Percentage of output - 2050 - SSS
Argentina	0	0	0	0	0	0	0	0	0
The Bahamas	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barbados	NA	NA	NA	NA	NA	NA	NA	NA	NA
Belize	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bolivia	0	0	0	0	0	0	0	0	0
Brazil	0	0	0	0	0	0	0	0	0
Chile	0.71	0.84	0.64	0.67	0.8	0.59	0.57	0.7	0.5
Colombia	0	0	0	0	0	0	0	0	0
Costa Rica	0.29	0.29	0.29	0.26	0.27	0.26	0.22	0.22	0.22
Dominican Rep.	0	0	0	0	0	0	0	0	0
Ecuador	0.39	0.46	0.39	0.36	0.42	0.36	0.29	0.35	0.29
El Salvador	0	0	0	0	0	0	0	0	0
Guatemala	0	0	0	0	0	0	0	0	0
Guyana	0	0	0	0	0	0	0	0	0
Haiti	0	0	0	0	0	0	0	0	0
Honduras	0	0	0	0	0	0	0	0	0
Jamaica	0	0	0	0	0	0	0	0	0
Mexico	0	0	0	0	0	0	0	0	0
Nicaragua	0	0	0	0	0	0	0	0	0
Panama	0	0	0	0	0	0	0	0	0
Paraguay	0	0	0	0	0	0	0	0	0
Peru	0	0	0	0	0	0	0	0	0
Suriname	1.15	1.17	1.14	0.5	0.5	0.49	0	0	0
Trinidad and Tobago	0	0	0	0	0	0	0	0	0
Uruguay	0.57	0.62	0.54	0.53	0.6	0.5	0.46	0.55	0.43
Venezuela	0	0	0	0	0	0	0	0	0

Notes: Costs (net losses compared to a baseline in which 30x30 is not implemented) are shown as a percentage of projected future agricultural output value in 2035, 2040, and 2050 under three FAO scenarios: BAU (Business as Usual), TSS (Towards Sustainability), and SSS (Stratified Societies). Note that all opportunity costs for scenario 2 are zero, by definition. NA indicates that the FAO gave no estimate for future production values in that country.

These very small opportunity costs (see Tables 15-16) contradict a natural intuition that the opportunity costs of conservation must be high because potentially productive land is being set aside. Such an instinct has already caused existing PCAs to be placed in remote areas with little productive potential, usually at the expense of effectiveness in actual species and ecosystem protection.[23,24] This study's findings suggest that for many countries in LAC, GBF Target 3 does not imply a conflict with economic wellbeing in their rural economies, despite the natural intuition. Wherever scenario 1 (the scenario that would best reflect the Target 3 requirement) has zero or very low opportunity costs, countries could expand their PCA systems to capture high national biodiversity and ecosystem values with little or no economic downside.

Perhaps more surprisingly, if governments ignore low opportunity costs and persist in placing new PCAs in remote, low-biodiversity (or low-biodiversity-threat) areas, the PCAs could actually generate negative outcomes for the overall national economy. PCAs provide direct cash revenue from the nature visitor economy[5,25] and multiple indirect economic benefits through ecosystem services, such as ensuring a consistent flow of clean water (including to agriculture itself) or multimillion dollar values of protection for coastal infrastructure and communities.[26] Remote PCAs are therefore not as cost effective, since people need to be near them to benefit from ecosystem services, and they are less likely to be visited, which also implies higher costs and lower incomes. Further, because remote placement achieves no gain for the national agricultural sector but causes losses in other sectors, the net result will be negative outcomes for GDP and human welfare. So, ironically, the instinctive act of trying to avoid opportunity costs by establishing remote PCAs could generate the biggest opportunity cost of all, for the national GDP and nature.

Conversely, when a PCA option such as scenario 1 can capture all of a country's most important biodiversity sites, bring higher economic returns overall, and generate minimal opportunity costs for agriculture, the option likely provides an obvious policy win. This study therefore recommends that countries with zero or minimal opportunity costs be particularly wary of placing new PCAs on remote lands and should assess the cost–benefit ratio of doing so before making decisions.

On the other hand, for countries facing much higher opportunity costs, careful consideration of trade-offs is required. Unusually high opportunity costs may need to trade some biodiversity protection for more agricultural production, at least in the absence of economic biodiversity incentives coming from international sources.

It is worth noting that many of the harsher national opportunity costs in this study arise from the specification that each country protect exactly 30 percent of its national territory. By obliging each country to protect the same relative area irrespective of global biodiversity priorities, the 30-percent-each stipulation forces some countries to set aside areas that would otherwise support globally important future food and fiber production. A 30-percent-each system therefore limits the possibilities for Ricardian comparative advantage[18,19] to operate in both agricultural and biodiversity protection. From a conservation biologist's point of view, for example, it makes more sense for Brazil to protect the entire intact portion of the Amazon basin, even though this would be greater than 30 percent of its land area. Other countries could then protect less to retain balance.

Notably, this study shows that there is also an economic rationale (perhaps counterintuitively) to some countries protecting more than 30 percent of land. Results show that protecting exactly 30 percent can drive large agricultural losses in some countries, affecting the efficiency of the entire global trade system in agricultural commodities and causing avoidable increases in food prices and avoidable harm to rural livelihoods.

An alternative (envisaged by Waldron et al.[8] and subsequent authors(5,20) is that different countries may protect different percentages of their land area, under the aegis of some form of international conservation trading system or opportunity-cost trading system. The possibility of differentiated targets and a conservation trading mechanism should be explored. Measures of cost equitability for 30x30 have already been quantified, so they can be used as the basis for an exchange system that maximizes biodiversity gain while avoiding unnecessary economic losses.[21] Future work by this report's authors may indeed suggest a detailed structure for such an exchange system, assuming political willingness to adopt one.

7.4 Appendix. Methods

The amount of land needed for agriculture is projected to increase in future years, to satisfy increasing human consumption.[27,28] The most efficient way to expand is to use land that has the highest net agricultural output, which is the highest projected profitability after the land is converted to agricultural use. Any departure from that pattern of maximally efficient areas, including a departure driven by the creation of new TPAs, generates an opportunity cost because some part of the agricultural land matrix becomes economically suboptimal. Here, opportunity cost refers to the cost of land used to meet the 30x30 target.[22]

To define the maximally efficient baseline for where future agricultural expansion would take place, the authors used future land use modeling undertaken by the Asia-Pacific Integrated Model (AIM[9,10]) on behalf of the Waldron Report.[5] The authors assume that as of 2030, all protected area expansion is new, and it is only after 2030 that future increases in consumption will drive future needs for conversion of natural habitats.

Therefore, opportunity cost starts at zero for 2030 and rises over time, as human populations and their consumption continue to increase.[28] The authors focus on opportunity costs in 2035, 2040, and 2050, to align with FAO modeling of future agricultural output that focuses on those years.[8] In this way, the local opportunity costs caused by TPA expansion can be expressed as a percentage of the total agricultural output value for each country, in the same set of future years. Since costs are estimated across a span of 25 years, the authors standardized all opportunity cost values to constant 2024 US$ to account for inflation.

The fact that natural habitats will not need to be converted to agriculture until the need arises also implies a relatively orderly unfolding of opportunity cost over time. Since there are no major expected shocks or high levels of volatility in this unfolding, the period between today and 2050 should also illustrate the opportunity costs for a politically relevant time period.[15]

Since the location of new protected areas in 2030 remains unknown, the authors use three scenarios (see Chapter 1 and Table 1 and 2) to project opportunity costs. Scenario 2 (economic) avoids protecting any land identified by the AIM model as necessary for maximally efficient conversion to future agricultural production by 2050, so opportunity cost for scenario 2 is zero in all years from 2030 to 2050. Scenarios 1 and 3, however,

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[15] In this respect, terrestrial opportunity costs differ from the marine opportunity costs projected elsewhere in this report. MPAs may often restrict (or prevent) commercial production by fishers that is already taking place (fishers may have been fishing in areas that will be declared to be protected in 2030), so they will suffer an economic shock from the sudden loss of free access to those fishing grounds. That shock causes an initial decline in production output, and several decades are needed for the economic benefits of marine protected areas to be realized. Despite the uncertainties involved, marine opportunity costs were therefore modeled out to 2100. For terrestrial opportunity costs, there is no sudden shock, so it is not necessary to model out into the distant future.

were permitted to occupy some of that maximally efficient agriculture land. Therefore, scenarios 1 and 3 will have the same or higher opportunity cost than scenario 2.

Mathematically, scenario 2 can be simplified to a pair of objects in geometric space: a single block of land, L2, adjacent to a smaller block, A, where A is the total land required for maximally efficient conversion to agriculture by 2050 and L2 is the area of land protected to achieve 30 percent coverage. By definition, there is no overlap between L2 and A in scenario 2. Scenarios 1 and 3 can be represented by a different block of land, L1 and L3, respectively. Since scenarios 1 and 3 do not have the same constraint on the use of future agricultural land as scenario 2, part of A is likely to be overlapped by L1 or L3. When L1 and L3 take away a part of A in this way, to maintain the same level of national agricultural output, the missing area for future conversion has to be found somewhere else instead—somewhere unprotected.

Therefore, define Lx as the block of land that is protected in scenario X (here, X can be 1 or 3), and L2 as the block of protected area land in scenario 2. Given the commonalities in their basic underlying construction rules, Lx and L2 will have many areas (map grid cells) in common. The difference between Lx and L2 can therefore be simplified to a process in which Lx substitutes out a portion of land in L2, adding a new area, Z, onto L2 that overlaps with some part of A and, to retain 30 percent protected area coverage, subtracting the same amount of land, P, from L2 in another place.

In the agricultural portion of the national land use matrix, the output lost by subtracting Z from A needs to be replaced, in the future, by converting a different future area, Q, to agriculture instead. Production on Q will naturally seek to achieve the same output as would have been achieved on Z. If production on Q is equally efficient as it would have been on Z, there is no opportunity cost (agriculturalists have avoided critical biodiversity areas when creating new farmland or ranch land in future, but without any loss of production efficiency). However, if production on Q is less efficient, then it costs more to achieve the same output, as a direct consequence of the protected area system expansion, and the additional cost is the opportunity cost. In the present day, both P and Q are not yet converted, so they are likely to be natural habitat. P and Q therefore have a potential value of agricultural output if they were converted to production, rather than an empirical current value. For maximum efficiency, Q will be placed on land with the highest potential output, outside the TPA system.

Next, define z, p, and q as the total output value of areas Z, P, and Q. Compared to scenario 2, the total potential output value in the protected area system in scenarios 1 and 3 has changed by $z - p$ and in the agricultural system, the total output has changed by $z - q$. Since p will always be located on the most efficient land possible (and q has no such constraint), the maximal opportunity cost is generally given by $q = p$ and can therefore be calculated from $z - p$. However, given the rules of scenario designs, z – p is simply the difference between the total potential outputs for Lx and L2. Thus, if V_2 is the gross output value in scenario 2 and V_x is the gross output value in scenario X,

(1) $$O_x = (V_2 - V_x) * C \qquad (1)$$

where O_x is the maximum opportunity cost and C is a multiplier that converts the change (loss) in gross output into a measure of the cost of replacing that lost gross output.

Smaller opportunity costs are possible than the maximal value in equation (1). However, given the uncertainties around the future location of TPAs and around the potential output value of natural habitat, the authors report the maximum possible cost. Preparing for the maximum possible cost gives a margin of safety for policymakers, and true costs are unlikely to differ strongly from the maximum cost, owing to spatial congruence between natural areas that currently have high primary productivity and biodiversity, and natural areas that, if converted, would have high potential agricultural yield (including P).[29,30]

To apply equation (1), the authors first need an estimate of the total potential agricultural output value in each scenario (V). The potential output value per hectare (net agricultural rent) was estimated for 2016 by Carrasco et al.,[12] who also provide a spatially explicit grid of values. Since the date of generation of that data (which represents estimates for 2016), the FAO has also published data collated from respondents on the value of agricultural production per hectare (dataset "Value of agricultural production (Int. $) per Area" in FAOStat).[31] The FAO data are at the level of national averages, but those averages should correlate with the Carrasco et al. average value for each country. Examination of both datasets suggests that this is broadly true, but that Carrasco et al. may have consistently overestimated the on-the-ground values.

In other words, the Carrasco et al. data have the advantage that they can be used to show relative values of potential output in particular parts of a country's land area (such as a TPA system), but the disadvantage that the data values themselves are modeled and may be consistent overestimates. The FAO data provides no spatially explicit grid, but the values are derived from empirical surveys.

Since the Carrasco et al.[12] data are derived using the same methodology, the relative values of production in different cells (different areas of the country) can be assumed to be a reasonable model of how yield potentials differ across different parts of a country, even if the total values themselves are overestimates. The authors therefore combined the two data sources by converting the Carrasco et al. estimates to a relativity matrix, re-expressing each grid cell value as a relative multiplier (cell value/the national average value). The authors then applied the multipliers from that relativity matrix to the empirical FAO average, for all areas that are inside TPA scenarios, to estimate the potential agricultural value per hectare for map cells that lie inside the TPA scenarios. Multiplying the value per hectare by the areal extent of the cells being valued (in hectares) then gives the total potential agricultural value in any scenario. The authors note that this approach is again consistent with the rule of estimating the maximum possible agricultural opportunity cost from biodiversity conservation because the FAO national average value per hectare is based on areas that have been historically selected for agricultural use, whereas the mean baseline in the relativity matrix is the mean potential value for all areas including those that have not yet been converted, which will typically be lower.

Agricultural output values in years from 2030 to 2050 may differ from the 2016 value, affecting future opportunity cost estimates. Future yield per hectare may improve, and 30x30 may cause changes (and most likely, increases) in the price paid per metric ton to agricultural producers.[5,11] The authors therefore created a projection of how output value per hectare might evolve by taking the time series of FAO data on value of production per hectare[31] and carrying out a time series analysis of the full dataset (1961 to 2023) using autoregressive integrated moving average (ARIMA) models to account for temporal autocorrelation,[32,33] validating the model with the Ljung-Box test, and then applying the model to project changes in value out to 2050.

To get a spatially explicit estimation of future potential output values in the TPA scenario areas, the authors again used the relativity matrix but applied it to the FAO projected values for 2035, 2040, and 2050 (noting the assumption that the relativity matrix values will be largely conserved over 35 years, even if the overall output per hectare increases at the country level).

The authors then varied these projected values to account for possible 30x30-specific price impacts, following the Waldron Report.[5] In that report, protecting more land can increase scarcity in the supply of agricultural land after 2030, sometimes driving an increase in the farm-gate prices paid to agricultural producers (and therefore the value of output). At times, however, the opposite effect is projected, as scarcity combines with technological progress to motivate innovation and lower prices. The price changes projected to result from these processes were modeled by the AIM integrated assessment model in the Waldron Report, for scenarios where each country protected a different percentage of its land area.

Re-running integrated assessment models to project price effects under a 30 percent-per-country set of scenarios was outside the scope of this report, but the price changes implied in the Waldron Report are very small (a median of one-quarter of one percentage point). The authors therefore applied the Waldron Report price changes for 2035, 2040, and 2050 to projected output values from the current models, pairing the scenarios in this report to the scenarios in the Waldron Report scenarios as follows: scenario 1 = SSE, scenario 2 = BPC, and scenario 3 = HPR. Thus, scenario 1 projected output values were multiplied by 0.9971 for 2050, 0.9968 for 2040, and 0.9997 for 2035; scenario 2 projected output values were multiplied by 0.9952 for 2050, 0.9967 for 2040, and 0.9972 for 2035; and scenario 3 projected output values were multiplied by 1.0008 for 2050, 1.0007 for 2040, and 1.0004 for 2035.

Having projected future agricultural output values (the V terms in equation (1)) for each target year (2050, 2040, and 2035), the authors then subtracted the values in each year for scenarios 1 and 3 from the corresponding value in scenario 2 to get the maximum agricultural output value that has been removed from the expanded TPA system as a result of 30x30. The opportunity cost of 30x30 is then the cost of replacing that lost output from alternative, unprotected land. The output replacement cost is the total output that needs replacing, multiplied by the cost of producing that output or in agricultural economics terms, (gross output value – agricultural value added) / gross output value, where gross output value is the total value of production before production costs and value added is the gross output value minus the production costs (the cost of the intermediate inputs required to generate the output). Thus, the additional or opportunity cost can be calculated by taking the ratios between production costs and gross output values (hereafter, cost ratio) and multiplying the differenced scenario output values by the cost ratios.

The authors carried out these cost ratio calculations using FAO data. Agricultural value added was taken from the FAOStat data on Value Added (Agriculture) where possible, or Value Added (Agriculture, Forestry and Fisheries), which is broad-sense agriculture where the FAO does not report agriculture-only value added. The corresponding gross output value (Gross Output (Agriculture), or Gross Output (Agriculture, Forestry and Fishing)) was downloaded from the same source. The last year on which there is complete data for both across the relevant LAC countries is 2020, so the authors derived the cost ratio for that year.

FAO data on gross output and value added were unavailable for several small Central American and Caribbean nations (Dominican Republic, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, and Suriname), but cost ratios for comparable countries in the region (Belize, El Salvador, Guatemala) were grouped between 0.43 and 0.46, with Costa Rica an outlier at 0.51 as befits its upper-middle income status. The authors therefore applied a flat cost ratio of 0.45 for those missing countries, noting that the observed variation around that value would make a relatively small difference to opportunity costs (assuming a similar variation of 1 or 2 percent around the mean). Similarly, the cost ratio could not be calculated directly for Argentina, but it is 0.45 for Brazil and 0.46 for Paraguay, so the authors again used 0.45 for Argentina.

In summary, the authors estimated the midpoint raw opportunity cost for each scenario, in each country, in each of the future target years, by taking the projected output differences between scenarios (compared to scenario 2) and multiplying those differences by the cost ratios, following equation (1). To bracket the midpoint opportunity cost by a range of uncertainty, the authors took the 95 percent confidence interval of the original ARIMA projections for future agricultural output value and applied the same sequence of steps described above. Each scenario therefore has a mean, upper, and lower value for each target year.

Although the raw opportunity costs are of interest, it is important to place them in context. For example, to the lay reader, an opportunity cost of tens of millions of dollars may sound high, but such sums become relatively minor when placed in the context that agricultural GDP in LAC is over 400 billion international dollars as of 2024 and may exceed half a trillion international dollars by 2050.[34] The authors therefore also expressed the agricultural opportunity cost of 30x30 as a percentage of the projected value of agricultural output, per country, in future years.

Projected total output values require another set of scenario-models (because this study's models project the value per hectare only, without accounting for possible expansion in the number of hectares). The FAO provides three projections (FAO scenarios) for future agricultural production in most countries in 2035, 2040 and 2050,[8] called Business as Usual (BAU), Towards Sustainability (TSS), and Stratified Societies (SSS). The TSS scenario envisages rising consumer awareness of food production issues, leading to lower animal protein intake, less food waste, and an overall push for sustainability in farming methods. SSS envisages largely the opposite: an unequal economy in which waste and animal protein consumption increase globally and sustainability becomes sidelined.

The authors took the projected value of agricultural production in each country for 2035, 2040, and 2050 from the FAO data for each of the three alternatives (BAU, TSS, and SSS) and divided the projected opportunity costs for the same three years by the total production value from those FAO scenarios. Put simply, the authors expressed agricultural opportunity costs as a percentage of future agricultural production value, with all values converted to constant 2024 dollars to maintain comparability. This approach generates three different possible values for each of the three years of interest (a total of nine costs per country). The authors note that the approach used for projecting changes in output from 30x30 is not identical to the approach used for projecting growth in output in the FAO scenarios, including the fact that the FAO scenarios do not model potential changes in output values caused by 30x30 itself. Further, the AIM model in 30x30 used SSP2 (shared socioeconomic pathway 2) for its projections of future land use,[11] which is similar to the FAO scenario for Business As Usual but will differ from the other FAO scenarios.

For the comparison to be reasonably useful, one would nevertheless expect the growth rate in value per hectare in the ARIMA model to be broadly similar to the growth rate in output value in the FAO scenarios. The authors tested this and found that the ARIMA growth rates ranged from 0.65 percent/year to 1.03 percent/year, whereas the FAO growth rates ranged from 0.64 to 0.88 percent. This broad consensus suggests that although the percentage-based opportunity costs are not exact, they are likely to be sufficiently good approximations as to be informative, especially given the inherent uncertainties in scenario modeling. However, the authors note that the difference in rates is partly due to the FAO consistently projecting a slowdown in output rates in the later part of their 2012–2050 modeling period, whereas the ARIMA growth lates remain more linear over time. If future growth rates in value per hectare slow, then the opportunity costs closer to 2050 will be lower than those projected in this study.

How the IDB Can Support Member Countries in Achieving 30x30

In the case of **management and establishment costs**, the IDB can directly support countries with baseline research, data, and knowledge products. For instance, applying the Open IEEM (Integrated Economic-Environmental Model) to estimate scenarios on the economy, society, natural capital, and ecosystem services for decision-making, policymaking, and investments.

The IDB can also facilitate sector dialogues with borrowing member countries on the development and implementation of their National Biodiversity Strategies and Action Plans, as well as associated financing plans.

For finance solutions such as concessional finance, the IDB can provide support by working with its own facilities and with concessional funds such as the Global Environment Facility, the Green Climate Fund, and the Climate Investment Funds. These concessional funds can provide grants and concessional loans to finance programs of sustainable management. As an executing agency of these funds, the IDB can also provide technical cooperation to ensure additional support.

Additionally, there are several finance instruments that the IDB can help implement, but these should be assessed case by case while considering national contexts. Some examples include but are not limited to loans, bonds, or more innovative instruments, such as debt-for-nature conversions. Also, establishment and management activities of protected areas can also be included in policy matrixes as part of financial operations, as well as being linked to the National Biodiversity Strategies and Action Plans and national strategies (such as development plans), in addition to Conservation Trust Funds' activities.

In the case of **opportunity costs**, the IDB can support countries to transition to become nature-positive. An example is through measuring and assessing the effects of agricultural subsidies on biodiversity and natural capital. The IDB can also help demonstrate economic co-benefits of conservation through, for instance, developing bioeconomy strategies, using the Open IEEM to find out more about the economic links with ecosystem services, and assessing potential economic impacts.

Finally, to support productive sectors and ministries, the IDB can facilitate sector dialogues on mainstreaming biodiversity and natural capital.

Conclusion

Achieving the 30x30 conservation target in LAC will require substantial but manageable investments, with costs and trade-offs that vary significantly across terrestrial and marine areas. Terrestrial establishment costs potentially represent the largest financial cost, primarily because expanding PCAs often involves purchasing large areas of land. These costs, however, can be greatly reduced when expansion occurs on public lands or when purchase is unnecessary, for example on IPLC lands that can contribute to 30x30. Marine establishment costs, by contrast, remain comparatively low since ocean areas do not require acquisition.

Terrestrial management costs vary widely and are strongly influenced by the size of each country and the economic pressures such as agricultural value and national land scarcity. In some countries—particularly those with limited remaining land suitable for agriculture—ensuring effective protection of new areas could be especially costly. Meanwhile, marine management costs are modest and mainly driven by GDP per capita in nearby coastal regions, although they rise when MPAs allow regulated fishing, which requires more intensive enforcement.

Contrary to popular belief, terrestrial opportunity costs for many countries are low or even zero, as new TPAs often redirect agricultural expansion toward less biodiversity-critical land with limited economic sacrifice. Yet in countries with scarce agricultural frontiers, these costs can be substantial. Marine opportunity costs, on the other hand, can be high at first, particularly because of short-term reductions in fisheries catches. However, over the long term, fisheries are projected to benefit significantly as stocks recover—especially under strict protection regimes of the MPAs—and deliver mid- and long-term gains that outweigh short-term losses.

These findings highlight that effective implementation of 30x30 will require a mix of financial planning, strategic spatial decisions, and social and economic considerations. Identifying land that can be protected without costly purchase, securing concessional finance where needed, and ensuring that management budgets are sufficient to avoid ineffective paper parks will be essential steps. The region can also benefit from placing some protected areas closer to people, where ecosystem services and tourism benefits are higher and where opportunity costs are often lower than expected.

Finally, countries with limited agricultural land will face disproportionately high costs in meeting a uniform 30 percent target, so developing a coordinated regional approach could help balance biodiversity goals with food security needs. Similarly, for marine systems, adopting stricter protection now while compensating fishers for short-term losses can generate far greater long-term benefits and help sustain coastal livelihoods as climate pressures intensify.

Overall, the pathway to 30x30 in LAC is feasible and financially justifiable, but it requires thoughtful design and planning, targeted investment, and regionally coordinated strategies to ensure that biodiversity gains are achieved alongside economic resilience and social equity.

Executive Summary
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Chapter 7
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