Application of the Restoration Barometer in Costa Rica

Progress of ecosystem restoration from 2011 to 2020

Tony Nello, Pavel Rivera, Guillermo Putzeys

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IUCN is pleased to acknowledge the support of its Framework Partners who provide core funding: Ministry of Foreign Affairs, Denmark; Ministry for Foreign Affairs, Finland; Government of France and the French Development Agency (AFD); Ministry of Environment, Republic of Korea; Ministry of the Environment, Climate and Sustainable Development, Grand Duchy of Luxembourg; the Norwegian Agency for Development Cooperation (Norad); the Swedish International Development Cooperation Agency (Sida); the Swiss Agency for Development and Cooperation (SDC) and the United States Department of State.

This publication has been made possible through the generosity of IKI-BMU; through the project: “Restoration Barometer,” financed by German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection.

Published by:	IUCN, Gland, Switzerland
Produced by:	IUCN, Regional Office for Mexico, Central America, and the Caribbean (ORMACC)
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Recommended citation:	Nello, T., Rivera, P. y Putzeys, G. (2023). *Application of the Restoration Barometer in Costa Rica: Progress of ecosystem restoration from 2011 to 2020.* Gland, Switzerland: IUCN.
Design and layout:	Marta Lucía Gómez Zuluaga
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Cover photo:	© Tony Nello

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Foreword

Costa Rica has been recognised as a world leader in ecosystem protection, reversing the loss of forests, reporting by 2021 a forest cover of 57.1% of its continental territory and hosting more than 5% of the world's biodiversity. In addition, Costa Rica has been involved in ecosystem restoration since the 2000s to address the challenges associated with climate change, biodiversity loss, soil degradation, or water degradation and scarcity, and in 2012 established a restoration target of 1,000,000 hectares by 2030 as part of the Bonn Challenge. Since then, while the Government of Costa Rica has made efforts to update the reporting of restored hectares, there has been a lack of an inter-institutional and standardised process to capture the contribution of different sectors to this target. This is the gap that allows the application of the restoration barometer in the country to be addressed.

In 2021, the Costa Rica National Landscape Restoration Strategy 2021-2050 was made official, which sets out 22 goals, 24 indicators, and 72 actions that provide a cross-sectoral and country-wide vision for restoration over the next 30 years. In this sense, there is a specific target that urges the corresponding institutions to have mechanisms for monitoring and evaluation of restoration actions by 2022. By looking back at the progress of restoration over the past decade and encouraging the participation of multiple sectors, the application of the Restoration Barometer provides the basis for establishing a restoration monitoring system that responds to the particularities of Costa Rica and is compatible with global reporting processes. This publication also provides an insight into how progress has been made in the restoration of different landscapes (coastal marine, urban, rural), which can inspire and facilitate the necessary scaling up of efforts within the framework of the 2021-2030 Decade of Ecosystem Restoration.

Landscape restoration should be seen in Costa Rica as a means to address not only environmental but also social issues at the local level, such as unemployment and livelihood improvement. The application of the Restoration Barometer estimated that approximately 76,088 jobs had been generated, generally located in rural and some of the poorest areas of the country. This is of particular relevance when the 2021 National Household Survey finds that the unemployment rate is 40.9% among extremely poor households, while it remains at 7.7% for non-poor households. This shows that landscape restoration has great potential to energise regions with high poverty and unemployment rates.

Thanks to the application of the Barometer, Costa Rica has a solid baseline to focus resources on areas with fewer areas restored during the previous decade, thus ensuring an effective and fair distribution of restoration efforts and benefits associated with restoration at the national scale between now and 2030. In this sense, the Barometer data will also be very useful for current efforts to plan and prioritise sites for restoration at the scale of each of the three major landscapes defined for Costa Rica.

Rafael Gutiérrez, Vice Minister,
Ministry of Environment and Energy, Costa Rica

Foreword

The Restoration Barometer was created in 2016 as a tool to monitor progress towards the restoration commitments acquired within the framework of the Bonn Challenge. This initiative, launched in 2011 and expanded through the United Nations Declaration on Forests at the 2014 Climate Summit, establishes a global commitment to restore 150 million hectares of forests by 2020, and 350 million hectares by 2030.

Since then, the Barometer has expanded its scope to include, in addition to forest ecosystems, all types of terrestrial ecosystems, including coastal landscapes and inland waters, the restoration of which is recognized as an effective means of mitigating climate change, reversing biodiversity and soil loss and responding to various social and economic challenges currently faced by humanity.

The achievements registered and reported through the application of the Restoration Barometer protocol account not only for the progress made within the framework of the Bonn Challenge, but also for the efforts towards other global commitments such as those defined by the UN Decade on Ecosystem Restoration, the Post-2020 Global Framework for Biodiversity, especially its 30x30 target, and the Paris Agreement, among others. In the year 2022, 22 countries globally applied the Barometer to measure the results and scope of their national restoration initiatives. Among these are six Latin American countries: Colombia, El Salvador, Guatemala, Mexico, Peru, and the case analyzed in this publication, Costa Rica.

Ecosystem restoration is a long-term process that requires enabling conditions: policies and institutional and intersectoral agreements, technical planning, financing flows, and solid monitoring systems. These elements are key to generating sustainable impacts in terms of restored areas and associated climate, biodiversity and socioeconomic benefits.

The case of Costa Rica demonstrates this correlation between the creation of an enabling regulatory and institutional framework, and the achievement of results and impacts in terms of restoration. The adoption and implementation of policy, regulatory and programmatic instruments such as Forest Law 7575, through which the Payment for Environmental Services (PSA) Program was established, the National Decarbonization Plan 2018-2050, the National Biodiversity Strategy 2016-2025 and the National Forest Landscape Restoration Strategy 2021-2050, among others, have allowed the restoration of approximately 482,000 hectares of the national territory, the reduction of greenhouse gas emissions by approximately 506,285 tons of CO_2e and the generation between 2012 and 2020 of 34,973 medium-term jobs associated with the different types of restoration.

In addition to these important achievements, the application of the Restoration Barometer in Costa Rica makes it possible to identify challenges and opportunities for the consolidation and sustainability of restoration actions in the country. Thanks to this tool, Costa Rica today has access to information on the current state of restoration, and to a roadmap that promotes coordination between sectors and actors linked to restoration processes.

IUCN will continue, together with its Members and partners, to refine the Restoration Barometer in light of the experiences generated with its application to strengthen decision-making and public policies design and evaluation, so that countries can advance towards their national and global commitments in conservation and development.

Úrsula Parrilla Artiuguina,
Regional Director
Regional Office for Mexico, Central America and the Caribbean
Hub ORMACC-SUR

Executive summary

Ecosystem restoration has been recognized as an effective means of mitigating climate change, reversing biodiversity and soil loss at the same time. The adoption of the decade of ecosystem restoration by the United Nations in 2021 is a sign of the importance of scaling up restoration efforts to respond to the social and environmental issues facing humanity.

However, in order to put into perspective and analyze the new commitments and progress of countries between now and 2030, it is necessary to have a restoration baseline. The Restoration Barometer, originally created to allow countries to report their progress under the Bonn Challenge, provides a tool that adapts to the availability of information and diverse restoration approaches implemented around the world. This report presents Costa Rica's progress in this area, which is summarized below:

- Considering the period 2011–2020, Costa Rica presents 48% progress considering the national goal of restoring 1 million hectares by 2030.
- Public policies and intersectoral planning efforts that allow for joint work between public and private actors have been key success factors in achieving progress to date. Particularly noteworthy is the emblematic program of payments for environmental services of the National Forestry Financing Fund.
- Despite having several systems for monitoring restoration-related programs and initiatives, Costa Rica lacks a unified system for consolidating restorative actions, which, to some extent, has been resolved through the application of the restoration barometer. In fact, the application of the barometer allowed laying the foundations for an inter-institutional reporting process on the progress of restoration on a national scale.
- Restoration has brought economic benefits, generating 41,115 short-term jobs and 34,973 medium-term jobs in 2011 and 2020.
- It is estimated that the restoration actions recorded increased carbon storage and reduced greenhouse gas emissions by approximately 506,285 tons of CO_2e.
- In terms of biodiversity, ecosystem restoration has benefited areas of conservation importance (e.g. protected areas), connectivity (biological corridors) and improved or regenerated the habitat of some 81 endangered species according to the IUCN Red List.

Aknowledgements

IUCN expresses its deep appreciation to the individuals and institutions that made possible and contributed to the application of the Restoration Barometer in Costa Rica by providing access to and guidance on existing restoration modalities in the country: Mario Coto (SINAC), Franklin Paniagua (MINAE), Gilmar Navarrete Chacón (FONAFIFO), Mauricio Chacón (MAG), Jorge Segura Guzman (MAG), Pía Paaby (ACRxS), Sonia Lobo (SINAC), Manuel Guerrero (FUNDECOR), Celene Enriquez (UICN-ORMACC), Miguel Cifuentes (Conservación Internacional – Costa Rica), Rafael Monge Vargas (CENIGA), Luis Gámez (ESPH).

Acronyms

ACRXS	Forever Costa Rica Association
AyA	Costa Rican Institute of Aqueducts and Sewers
ASADA	Administrators Associations of the Aqueduct and Communal Sewer Systems
CI	Conservation International
ESPH	Heredia Public Service Company
FONAFIFO	National Forest Financing Fund
FUNBAM	Environmental Bank Foundation
FUNDECOR	Foundation for the development of the Costa Rican Volcanic Range
ICAFÉ	Costa Rican Coffee Institute
ICE	Costa Rican Electricity Institute
IUCN	International Union for Conservation of Nature and Natural Resources
KBA	Key Biodiversity Areas
MAG	Ministry of Agriculture and Livestock
MIDEPLAN	Ministry of National Planning and Policy
MINAE	Ministry of Environment and Energy
PA	Protected Areas
SIMOCUTE	Monitoring System of Land-use, Coverage and Ecosystems
SINAC	National System of Conservation Areas

1 Introduction

The Restoration Barometer was designed in 2016 to meet the growing demand for a systematic and universally applicable framework to identify, assess and track action on global restoration commitments. At the time, the Barometer was developed primarily as a monitoring protocol for participants in the Bonn Challenge (IUCN, 2021).

The Bonn Challenge is a voluntary initiative launched in 2011 by the International Union for Conservation of Nature and natural resources (IUCN) and the German Government with the support of the Global Partnership on Forest Landscape Restoration as a global effort to support and unite countries committed to landscape restoration through actions that adhere to the Forest Landscape Restoration Principle as a strategy to contribute to the implementation of national priorities such as food and water security, rural development, resilience to climate change and other significant social and economic challenges. At the time of its launch, the goal was to restore 150 million hectares of deforested or degraded land by 2020; this rose to 350 million hectares restored by 2030 in the United Nations Declaration on Forests at the 2014 UN Climate Summit (IUCN, 2021).

Costa Rica committed to the Bonn Challenge to restore one million hectares. Thus, the application of the Barometer in Costa Rica has made it possible to track the progress of the implementation of restoration actions in the country, with the support of key government institutions such as SINAC[1], FONAFIFO[2], the REDD+ Secretariat and MAG[3], public companies(e.g. ESPH[4]), trade associations (Icafé[5]) and NGOs (FUNDECOR[6], CI[7] and ACRxS[8]), who shared information for 2011-2020 on their interventions considered within the Barometer typology as restoration. Such information was presented and validated through a data validation workshop on May 11, 2022.

In Costa Rica, the restoration of ecosystems has been a process led by the Ministry of Environment and Energy (MINAE, for its acronym in Spanish), through its decentralized

1 Sistema Nacional de Áreas de Conservación

2 Fondo Nacional de Financiamiento Forestal

3 Ministerio de Agricultura y Ganadería de Costa Rica

4 Empresa de Servicios Públicos de Heredia

5 Instituto del café de Costa Rica

6 Fundación para el Desarrollo de la Cordillera Volcánica Central

7 Conservación Internacional

8 Asociación Costa Rica por Siempre

entities such as FONAFIFO and SINAC, whose national planning has been based on participatory and intersectoral processes since 2016, with a focus on the protection of the water resource (Raes et al., 2022). To articulate the restoration considering the diversity of actors and landscapes, in 2019, MINAE, SINAC, and MAG formulated in a participatory manner the National Forest Landscape Restoration Strategy 2021-2050 (SINAC, 2020).

The results of the first application of the Restoration Barometer in Costa Rica are presented following the structure of the Protocol, which distinguishes between two key components:

- Action indicators (policies, plans, strategy, financing, monitoring systems).
- Impact indicators (Hectares restored, impact on socio-economy, on the climate, and on biodiversity).

In the following sections, the classification of ecosystems and restoration actions considered by the Barometer is presented, followed by the progress of the restoration in the country, policies, plans and strategies, and monitoring and follow-up mechanisms. In addition, information on financing sources and the impacts or benefits of the implementation of restoration actions in the country (employment, carbon sequestration, and effects on biodiversity) are synthesized and analyzed. Finally, the main conclusions of the process and the results generated are stated.

2 Conceptual Framework of the Restoration Barometer

The Restoration Barometer is a systematic framework of universal application that aims to identify, evaluate and monitor the actions and results of restoration activities in forests and ecosystems (IUCN, 2021).

From its inception, the design of the conceptual and methodological framework of the Barometer included different types of intervention considered in the restoration of ecosystems. The last revision was approved in October 2021[9], which is a defined classification that guides the interventions registry (IUCN, 2021). The data of collected information is classified by its level of precision as described below:

- Level 1: Low level of confidence in the accuracy, when the estimate does not come directly from public records or official documentation for having been estimated indirectly.
- Level 2: Moderate confidence in the accuracy, the estimate is almost complete and accurate even though some sources may have been missed or not considered.
- Level 3: High confidence in the accuracy, when the information is considered complete and accurate, for example, when the restored areas have spatially detailed records.

The intervention categories were selected as reported in the Table 1, based on consultation in the workshop for the presentation of the restoration barometer in Costa Rica[10], and through identifying restoration activities with the participating institutions.

Table 1 Categories of interventions registered in the country and equivalence with restoration categories of the Barometer

Registered categories in the country	Categories of the Restoration Barometer
Protection	Land and water protection/conservation actions
Reforestation	Planted forest and woodlots
Agroforestry systems	Agroforestry systems
Forest management	Silviculture
Regeneration	Natural regeneration
Hydrological restoration	Restore hydrology (Creation of channels, removal or breach of aquaculture walls, unclogging of channels, removal of dams)
Invasive Species control	Control of problematic invasive species

Source: Restoration Intervention Typology for Terrestrial Ecosystems, IUCN (2021).

9 See the original at: https://restorationbarometer.org/knowledge-hub/iucn-restoration-intervention-typology-for-terrestrial-ecosystems/

10 The workshop was held on November 4, 2021. See the list of participants in Annex 5

3 Ecosystem restoration progress in Costa Rica between 2011 and 2020

Between 2011 and 2020, the main actor in the implementation of ecosystem restoration actions was FONAFIFO, supporting the restoration of 333,348 ha in the country (Table 2).

FONAFIFO used payment schemes for different categories restoration practices, which match with the typology of actions defined by the Restoration Barometer indicated in table 1. This represents almost 70% of the total restored. Secondly, SINAC encouraged the conservation of 58,322 ha, representing 12% of the area reported throughout the decade, through the exemption of local taxes established by article 23 of the Forest Law. Additionally, it should be noted that 93% of the reported area meets the highest level of accuracy of information (3), thanks to the data from the monitoring systems of FONAFIFO, FUNDECOR, ESPH, the Environmental Bank Foundation (FUNBAM, for its acronym in Spanish), and Agua Tica.

3.1 Contributions to the restoration by institution

Regarding the total hectares restored during the 2011-2020 period, 3 actors have contributed with 89%, FONAFIFO (69%), SINAC (12%), and FUNDECOR (8%). On the one hand, these contributions were possible thanks to the implementation of silviculture incentive programs directed, specifically, to land and water protection/conservation actions, silviculture, forest plantation, and forest plots.

Table 2 Hectares restored by institution and percentage of participation of the total intervention in Costa Rica and level of precision of the information

Institution	# of intervened hectares	Percentage %	Information accuracy level *
FONAFIFO	333,348	69.16%	3
SINAC	58,322	12.10%	3
FUNDECOR	40,025	8.30%	3
Icafé	24,770	5.14%	1
REDD+ Secretariat	12,167	2.52%	3
Conservation Areas	7,896	1.64%	2
ACRxS & implementing partners	2,442	0.51%	2
Coffee FUNBAM-NAMA	1,066	0.22%	3
Agua Tica	622	0.13%	3
ESPH	859	0.18%	3
Livestock MAG-NAMA	486	0.10%	2
Total	482,000		

Source: Own elaboration with data collected by IUCN and SINAC.

* When the information reported contains geographic references (polygons, points) and has a systematic and consistent reporting process year after year, a high precision level (level 3) is assigned. For information that does not have an explicit geographical reference but is based on official or consolidated tabular records for the Barometer, the level of precision of moderate confidence (level 2) was assigned (Annex 2).

On the other hand, but no less significant, are the contributions of the Nationally Appropriate Mitigation Actions (NAMA) in the coffee and livestock sectors, through institutions such as: Icafé, Livestock MAG-NAMA, and Coffee FUNBAM-NAMA, who jointly have supported the implementation of 26,322 ha of agroforestry systems throughout the country (Table 2). Likewise, private institutions and NGOs such as: Agua Tica, ESPH, and ACRxS, have promoted and implemented, according to table 2, a total of 3923 ha in various actions aimed at restoration processes, management, and protection of water resources and coastal areas.

It is important to mention that the data above are conservative estimates. From the qualitative information and interviews, the contribution is estimated to be more significant than that recorded in this report; however, the lack of data and systematic monitoring processes have limited the quantification for the 2011-2020 study period.

3.2 Ecosystem restoration progress concerning country goals

The total number of hectares intervened and registered between 2011-2020 was 482,000 ha, which corresponds to the accumulated 2011-2020 period and includes various types of restoration activities. Table 3 shows the total of hectares by year, the accumulated progress for the base year (2011), and the country's progress concerning the country's goal of one million hectares committed to the Bonn Challenge. It is possible to show that, concerning the goal established by Costa Rica and considering conservative estimates, the level of progress is 48%. The years 2012-2013 stand out, where the increases were favored by the rise in the area dedicated to land and water protection/conservation actions (51,325 ha and 55,700 ha, respectively) (Annex 1).

About the intervention modalities for the restoration of ecosystems, according to the Barometer classification, the following predominate during the analysis horizon: Land and water protection/conservation actions, which accounted for 63% of the total registered, followed by Agroforestry Systems 11%, and Silviculture 11%. These modalities add up to 85% of the total hectares restored (Table 4).

Figure 1 shows the weight of the "land and water protection/conservation actions" modality, particularly during seven of the ten years evaluated. It is followed by the "Agroforestry Systems" modality, particularly in 2020, as a result of the efforts of the coffee NAMA; in addition to interventions in forest plantations and forest plots for 2011, promoted by silviculture incentives and FONAFIFO silviculture credit program.

3.3 Intervention distribution in the territory

A map of restored areas between 2011 and 2020 was constructed based on the combination of several spatial databases from multiple institutions[11], and a consolidation process that avoids double counting areas[12]. This map allows us to appreciate the geographical distribution of restoration actions.

Table 3 Hectares intervened per year and accumulated from 2011 to 2020

	Accumulative Increase per year		
Year	New ha	Accumulated ha	Country target yearly progress %(1 Mha)
2011	48,428		4.84%
2012	56,057	104,484	5.61%
2013	66,036	170,520	6.60%
2014	12,391	182,911	1.24%
2015	33,723		3.37%
2016	11,974	228,608	1.20%
2017	50,857	279,465	5.09%
2018	61,734	341,199	6.17%
2019	53,207	394,407	5.32%
2020	87,594	482,000	8.76%
		Total country target progress	48.20%

Source: Own elaboration with data collected by IUCN and SINAC.

11 The institutions that shared data with a precision level of level 2 or 3 see table 2.

12 See Anexo 2.

Table 4 Number of hectares accumulated by modality from 2011 to 2020

Barometer Classification	Total hectares	%
Land and water protection/conservation actions	306,002	63.49%
Agroforestry systems	53,805	11.16%
Silviculture	51,506	10.69%
Forest plantation and woodlots	47,187	9.79%
Natural regeneration	23,294	4.83%
Control of problematic invasive species	188	0.04%
Hydrological restoration	18	0.00%
Total	482,000	100%

Source: Own elaboration with data collected by IUCN and SINAC.

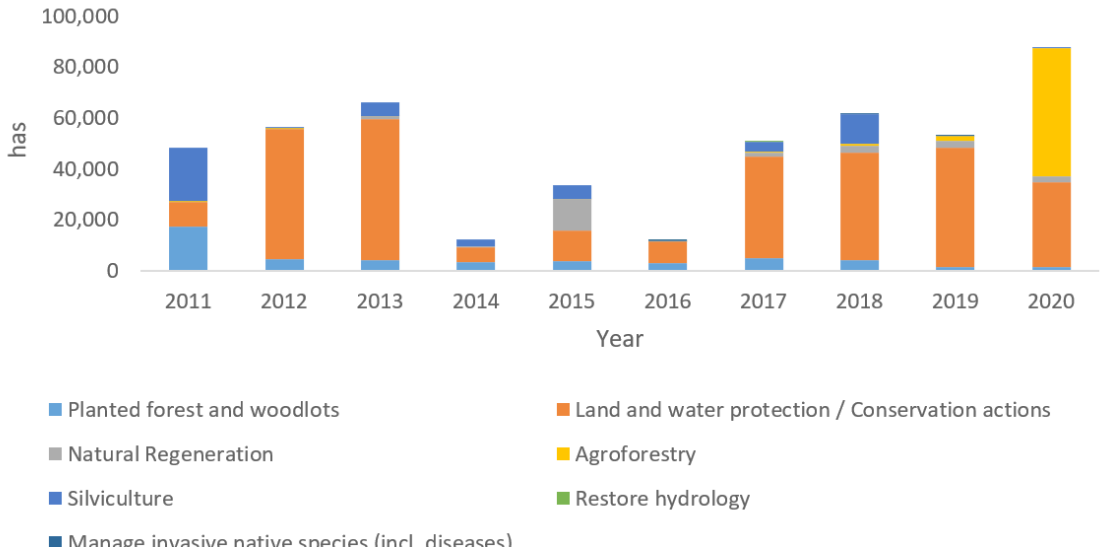


Figure 1 Progress of restoration actions 2011-2020.

Source: Own elaboration with data collected by IUCN and SINAC.

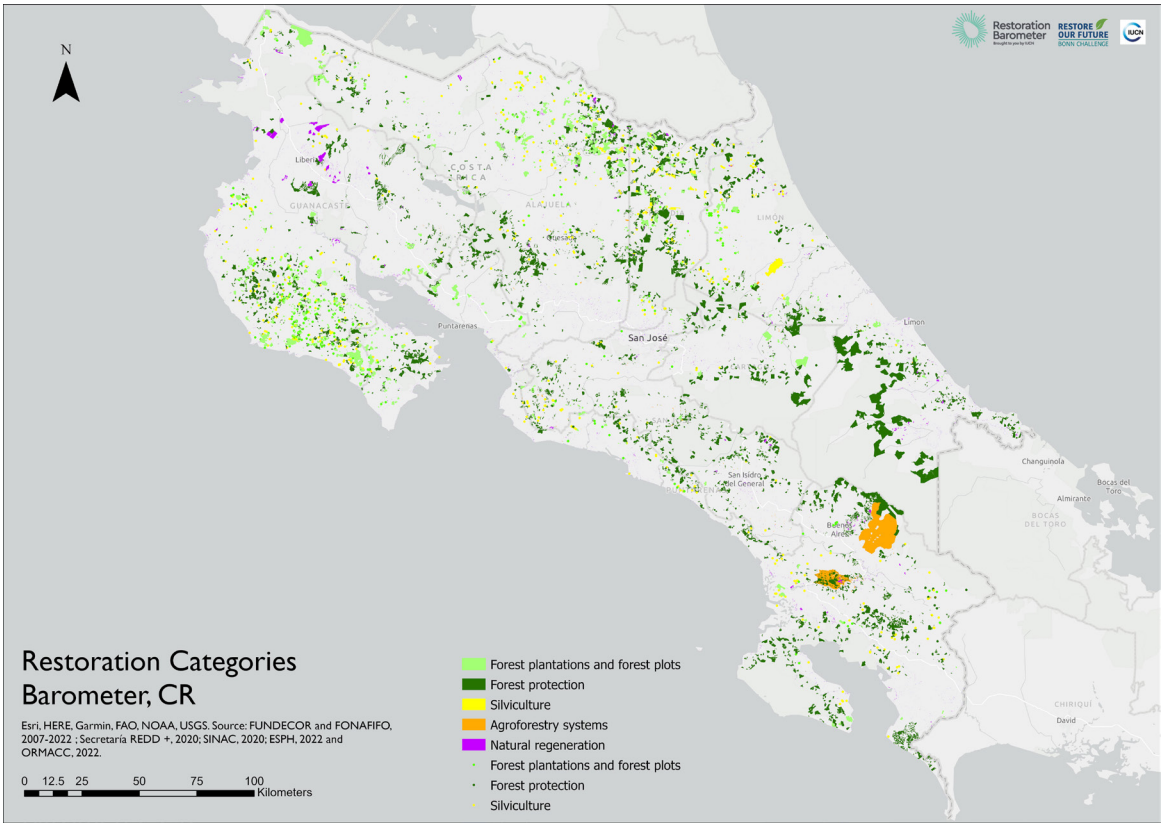
The restored area corresponds to 387,025 ha with a high confidence level, that is polygons, and 58,116.4 ha registered with points (or coordinates, level 2).

Map 1 presents the location of said information, broken down for each barometer category.

The modalities of protection of forests, agroforestry systems, and natural regeneration are dispersed in the national territory. At the same time, the silviculture action is concentrated mainly in the Huetar North and Atlantic regions (Limón). It is worth noting that agroforestry systems represent a significant area of Brunca region in the country's southwest. Similarly, large-scale natural regeneration efforts can be seen in Guanacaste (North Pacific).

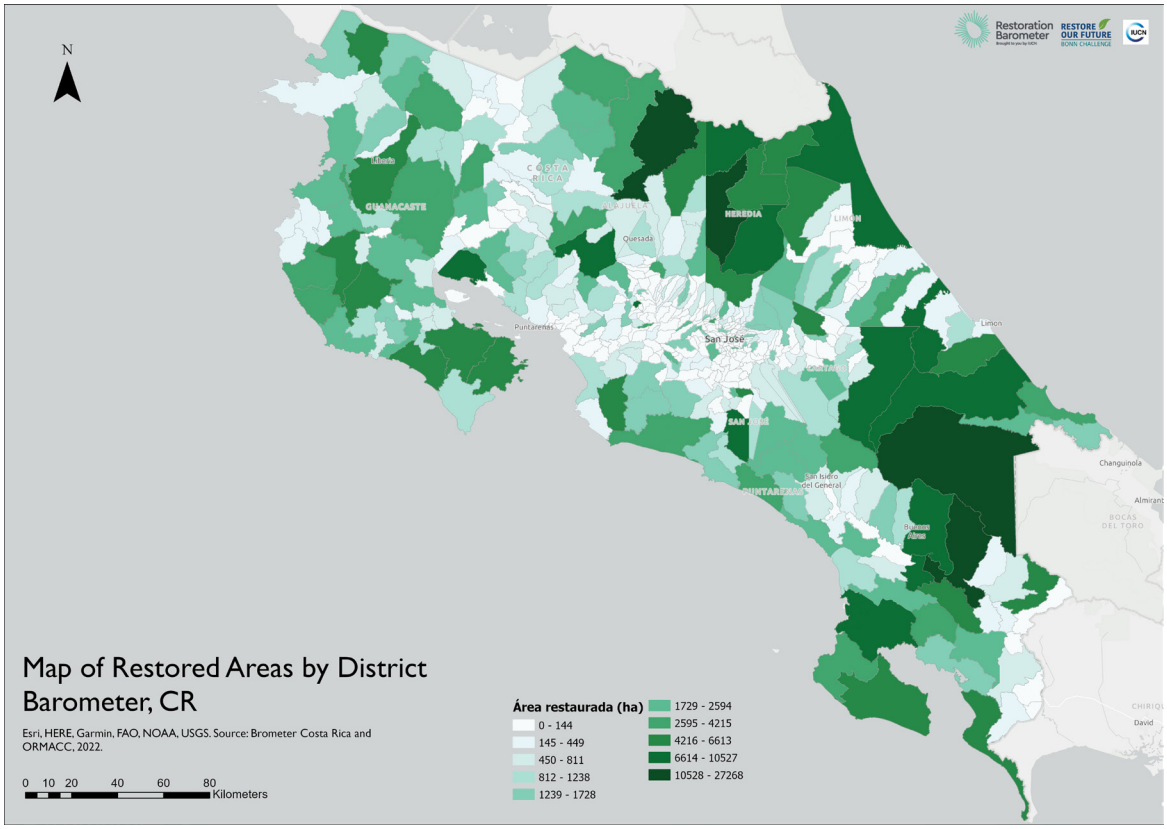
3.4 Map of restoration actions by the district

Map 2 shows the restoration progress at the district level to give a cartographic representation of the restoration actions that include tabular databases where only the administrative unit where a specific implemented activity is reported. Of the 482,000 ha restored, 445,343 are documented with spatial information (polygons or points), while 36,657 ha do not have any type of spatially explicit data. Indeed, not all the information recorded has polygons or points due to the lack of use of geographic information systems in the monitoring systems of various institutions.



Map 1 Restored areas in Costa Rica between 2011-2020

Source: Own elaboration.



Map 2 Area covered by restoration actions classified by the number of intervened hectares per district Period 2011-2020

Source: Own elaboration.

Districts with more restored areas can be seen in dark green. The southern part of the Huetar North and Atlantic regions, and the North Central region present several districts where the restoration has exceeded 6000 hectares. Likewise, it can be determined that the area of San José (South Central region) is where the least area was restored. These findings are significant since they shed light on decision-making on districts that deserve more attention and on which districts should be followed up to ensure the investments started in the 2011-2020 period. In this case, this map indicates that it seems necessary to strengthen the urban restoration planning and monitoring systems since the central part of San José appears with a small restored area. In fact, several institutions have promoted restoration actions in this geographic area (e.g. GEF6 Project with municipalities, National Power and Lightening Company - CNFL) but specific information on restored sites could not be collected as part of this Barometer application in Costa Rica.

Indeed, the district-level restored area map allows districts to be classified based on the amount of area. It was determined that the districts with the most significant area are Potrero Grande (in the canton of Buenos Aires, province of Puntarenas with 27,268 ha), Cutris (in the canton of San Carlos, province of Alajuela with 17,341 ha), Telire (canton of Talamanca, province of Limón with 16,503 ha), La Virgen (in the Sarapiquí canton, province of Heredia with 16,501 ha) and Sierpe (in the Osa canton, province of Puntarenas with 10,527 ha). These 5 districts cover 18% of the area restored in the decade 2011-2020.

Regarding the municipalities with less area, it was determined that there are eight districts where areas were not restored or reported: Oriental (Cartago, Cartago), Catedral (San José, San José), Anslemo Llorente (Tibás, San José), Chacarita (Puntarenas, Puntarenas), Llorente (Flores, Heredia), Isla del Coco (Puntarenas, Puntarenas) and Quebrada Grande (Tilarán, Guanacaste). Likewise, they were determined with the least amount of restored area among the previous eight districts. These districts are: Alajuelita (Alajuelita canton, San José province with 0.09 ha), Desmonte (San Mateo canton, Alajuela province with 0.18 ha), Santa Lucía (Barva canton, Heredia province with 0.45 ha), San Rafael Abajo (Desamparados canton, province of San José with 0.45 ha) and the district of Colima (Tibás canton, province of San José with 0.54 ha). Together, these 5 districts account for less than 0.0003% of the reported area.

4 Progress in the legal framework, plans, and strategies related to ecosystem restoration activities during the period 2011–2020

Ten public policy instruments were selected (Table 5) that have been strengthened and have the scope to contribute in the future to ecosystem restoration processes in Costa Rica. A key instrument that has facilitated the implementation of restoration processes has been the Forest Law 7575 of 1996, with which the payment scheme for environmental services is implemented, the basis of the various restoration actions from 2011 to 2020. Likewise, as instruments that can contribute to restoration actions in the medium and long term, the following stand out: The National Decarbonization Plan 2018-2050, which contributes to restoration processes based on a roadmap to consolidate the decarbonization of the economy in the country. Said policy, through Axis 9, seeks to promote an eco-competitive livestock model and reduction of greenhouse gases, and through Axis 10, seeks to consolidate a management model for rural, urban, and coastal territories that facilitates the increase and maintenance of forest cover and ecosystem services with nature-based solutions (Directorate of Climate Change, 2019).

Table 5 List of plans, policies, and strategies related to ecosystem restoration in Costa Rica

Name	Year	Responsible institution
National Decarbonization Plan 2018-2050	2018-2050	MINAE
National Strategy 5R for Landscape Restoration 2021-2050	2021-2050	SINAC
National Biodiversity Strategy 2016-2025	2016-2025	SINAC
Strategy for low-carbon livestock (LivestockNAMA)	2015	MAG
Forest Law N 7575, art 22 (Payment for Environmental Services)	1996	MINAE
Costa Rica's National Climate Change Adaptation Policy 2018-2030	2018-2030	DCC
Strategy and action plan for the adaptation of the biodiversity sector to climate change	2015-2025	SINAC
Inter-institutional cooperation agreement between MINAE and MAG for the development of comprehensive farms (CV-01-2019-AJ-MAG)	2019	MINAE-MAG
REDD+ Strategy	2015	MINAE
National Policy for Protection Areas of Rivers, Streams, Ravines, and Springs	2020	MINAE

Source: Own elaboration with data collected by IUCN and SINAC.

It is worth mentioning that these axes are also articulated with processes proposed in the 5R National Strategy for Landscape Restoration 2021-2050. Said strategy seeks, through actions aimed at managing resilient and sustainable landscapes, to restore, maintain and conserve the ecological functions of terrestrial ecosystems and coastal marine ecosystems and optimize ecosystem goods and services that contribute to human well-being (SINAC, 2020). However, they are also key, articulating and facilitating processes present in policies or plans that favor mitigation processes, adaptation, and others, such as: Livestock NAMA, the REDD+ Strategy, and the climate change adaptation policy of Costa Rica 2018-2030.

5 Findings on the state of technical support for landscape restoration in Costa Rica

5.1 Progress in restoration planning

In Costa Rica, eight planning exercises for forest landscape restoration were identified, implemented, and briefly described in Table 6. Additionally, methodologies aimed mainly at mitigation were identified, in this case, the NAMAS of various sectors (livestock, coffee, cane, musacea, and rice).

These instruments become facilitators and promoters of various actions that favor different ecosystems restoration through best practices, the use of improved pastures, agroforestry, and silvopastoral systems, among others. These initiatives go hand in hand with productive efficiency and, above all, the sustainable management of the ecosystems linked to said productive activities.

Planning processes aimed at promoting intersectoral coordination were also identified, such as the case of the agro-environment agenda and the urban-environment agenda.

These processes aim to promote an inter-ministerial coordination mechanism to follow up, monitor, and evaluate strategic actions that seek to protect, conserve and manage biodiversity and establish thematic priorities associated with the climate change agenda (MIVAH-MINAE, 2021).

Table 6 Restoration planning exercises in Costa Rica

Name of the Methodology	Main ecosystems included	Description
Methodology for evaluating restoration opportunities in Costa Rica	Agricultural land, protected areas, grasslands and degraded forests	IUCN and MINAE convened a panel of experts to agree on the opportunities and priorities, the restoration activities to be evaluated, and the criteria for the multi-criteria analysis. A total of 575,000 ha was prioritized for 9 restoration activities, aligned with existing sector programs for conservation and good agricultural practices.
Coffee NAMA	Farming land	Sectoral effort to evaluate, pilot, and expand practices supporting mitigation and adaptation to climate change. Good agricultural practices with 50% of producers and SAF (7,500 ha).
Livestock NAMA	Farming lands	Sectoral effort to evaluate, pilot, and expand practices supporting mitigation and adaptation to climate change. In 15 years, it is expected to reach at least 70% of the population and 60% of the area dedicated to livestock.
Musaceae NAMA	Farming lands	Sectoral effort to evaluate, pilot, and expand practices supporting mitigation and adaptation to climate change. This design is to be completed in 2022.
Sugar cane NAMA	Farming lands	
Rice NAMA	Farming lands	
National Urban-Environmental Agenda	Urban	A pilot project between FUNDECOR and FONAFIFO, financing between 200 and 500 ha per year in reforestation plans.
Agro-environment Agenda	Agricultural land, areas protected, grasslands and degraded forests	Identifying, transferring, and adopting practices and technologies to improve efficiency, productivity, competitiveness, and sustainability in harmony with the ecosystems' health is essential for comprehensive landscape management.

Source: Own elaboration with data collected by IUCN and SINAC.

5.2 Forest landscape monitoring methodologies and frameworks

In Costa Rica, eight landscape monitoring systems were identified with a national scope (Table 7), which have the potential to collect data related to restoration actions from various sectors (coffee and livestock). They also collect data from different thematic areas such as coverage and land-use, mitigation processes for emissions from the silviculture sector, municipal tax incentives, and PES. Several of these can incorporate reports of restoration actions in the country. However, its usefulness depends on the competencies of the managing entity to understand what the restoration processes imply and the information that will be important for decision-making in this regard.

Monitoring system of land use, coverage and ecosystems (SIMOCUTE, for its acronym in Spanish) seeks to integrate the inputs generated by the other monitoring systems through thematic roundtables and institutional arrangements that facilitate the exchange and standardization of data between institutions.

Table 7 Monitoring systems of the restoration of ecosystems in Costa Rica up to 2021

Monitoring process for restoration	Managing institution	Geographic scale	What information does it collect?	Does it contribute to the NDC report?
SIMOCUTE Monitoring system of land use, coverage and ecosystems	CENIGA	National	Land coverage and changes in soil coverage	Yes
REDD+ monitoring system	REDD+ Secretariat (FONAFIFO/SINAC)	National	Estimation of the balance of greenhouse gases (GHG)	Yes
Monitoring of payment for environmental services	FONAFIFO	National	Location of Implemented Restoration Activities	Yes
Coffee NAMA	MAG/Icafé	National	GHG balance estimate	Yes
Livestock NAMA	MAG/CORFOGA	National	GHG balance estimate	Yes
SINAMECC (Plan A, monitoring of climate change action at municipal level)	DCC	National / Sub-national	Location of Implemented Restoration Activities	Yes
Record of projects of the voluntary silviculture scheme	SINAC	National	Location of Implemented Restoration Activities	No
Forest type map 2021	SINAC	National	Land coverage and changes in soil coverage	Yes

Source: Own elaboration with data collected by IUCN and SINAC.

6 Analysis of the financial resources mobilized for the implementation of the restoration between 2011 and 2020

Table 8 details the funds invested in restoration actions from the public sector FONAFIFO, MAG, SINAC and international cooperation reported by MAG, MINAE, and MIDEPLAN. The data collected is based on investments identified in different public access reports and databases, associated with restoration actions directly and indirectly, and executed during 2011-2020. The activities supported with public spending include, for example, recognition of environmental benefits, sustainable production incorporating pasture improvement in production systems, the introduction of trees in pastures, fodder banks, and protection of water recharge areas.

About international cooperation, projects aimed at conserving biodiversity through sustainable management in productive landscapes were included, as well as resources for implementing the Livestock NAMA, among others. It was impossible to generate estimates for private investments and the philanthropic sector due to a lack of published information.

In order to measure the meaning of the financing identified, the costs for restoration actions were taken into account (Annex 4). This reference information is critical as it gives an idea of the resource required to implement restoration actions. As the information on resources invested in the private or public sector is generated and made visible, it will be possible to make a more reliable calculation of the investment per hectare in restoration actions. Data is critical for better decision-making and quantification of projections necessary to promote more effective implementation of restoration processes.

Table 8 Investments in ecosystem restoration in Costa Rica by financing source, from 2011 to 2020 (in millions of dollars)

Type of financing	USD amount	Link to data source	Level of accuracy
Domestic public spending			Moderate trust, public information sources, and models
FONAFIFO	218,862,990	https://www.fonafifo.go.cr/es/servicios/estadisticas-de-psa/	
MAG	179,650,810	http://www.mag.go.cr/transparencia/Presupuesto.html	
SINAC	70,415,602	https://www.sinac.go.cr/ES/transprncia/Paginas/default.PAx	
Total domestic public spending	468,929,402		
International cooperation/ Institution responsible for managing the funds			
MAG (UNDP, UNEP, Republic of Korea, State of Japan)	1,560,501	https://www.mideplan.go.cr/SIGECI	
MINAE (IDB, World Bank)	2,390,089	https://www.mideplan.go.cr/SIGECI	
SINAC (IDB, GEF, State of Japan)	23,308,446	https://www.mideplan.go.cr/SIGECI	
Total international cooperation	27,259,036		

Source: Own elaboration with data from the work reports of FONAFIFO, MAG, MIDEPLAN, SINAC, and MINAE.

7 Analysis of the impact of restoration on climate, job creation, and biodiversity between 2011 and 2020

7.1 Impact of ecosystem restoration on climate

According to the fourth national communication of Costa Rica (MINAE, 2021), the country not only decreased the emission levels associated with deforestation and forest degradation, but also positive trends are evident in the increase of forest regeneration in agricultural areas, mainly in grasslands (Aragón, and others, 2021).

For the report on the impact of ecosystem restoration on the mitigation of greenhouse gases (GHG), the official information on emissions from the sectors of agriculture, silviculture, and other land uses (AFOLU) is taken into consideration (MINAE, 2021), as well as that provided by the REDD+ Secretariat (REDD+ Secretariat, 2021) to consistently assess with official reporting processes.

The following methodological PAects should be clarified:

- Carbon absorptions of REDD+ emission levels are considered only from 2015 because a minimum of 4 and 8 years are required to detect regeneration in humid and dry forests, respectively (Córdoba, 2019). Indeed, due to the gap between the restoration action and its detection through remote sensors, conservative estimates will be made since what was restored from 2016 onwards has not yet been detected by the REDD+ system (until 2020, depending on the type of forest). Therefore, the information is considered level 2. Although specific national/regional removal factors are used, the data of hectares to which they are applied do not fully coincide with the reported restored areas.
- Carbon absorptions from agricultural areas where regeneration is detected (Figure 2 labels regeneration in agricultural land as forests) and carbon stock increases in forests are considered.
- Additionally, the increase in carbon stocks reported by both coffee and livestock NAMA monitoring systems is accounted for, even though the estimates are associated with a restored area whose level of accuracy is low (see Table 2) and therefore affects the precision of the carbon estimate (level 1).

Forest conservation contributes the most to carbon sequestration, which increased carbon reserves by approximately 285,411TCO_2e between 2015 and 2020, mostly in humid forests. Forest regeneration in agricultural areas is the second modality that allowed more carbon to be captured (121,707 TCO_2e between 2015 and 2020). Finally, the increase in carbon due to the adoption of agroforestry systems in grasslands and coffee represents 20% of the potential but with low confidence in accuracy. In short, the potential impact of restoration on climate change mitigation over the last decade is estimated at 506,285 TCO_2e.

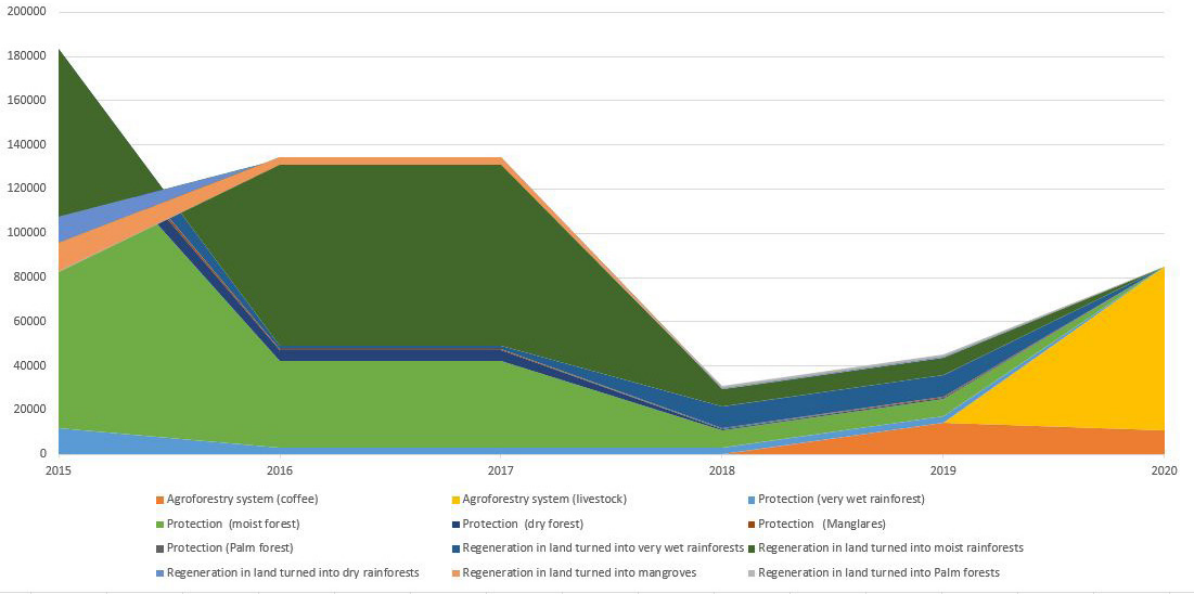


Figure 2 Contribution of restoration to the climate.

Source: Own elaboration based on REDD+ Secretariat, 2021 and MAG 2021.

7.2 Employment generated during the establishment and maintenance of restoration actions

Estimating the jobs created due to the establishment and maintenance of restoration actions is vital, even more so considering the current need for economic reactivation through job creation. Following the Restoration Barometer protocol, the estimation of both short-term jobs (with a maximum duration of one year) and medium and long-term jobs (minimum duration of 2 years) has been considered.

The following steps were taken to estimate jobs:

- Determination of the number of wages/ha by type of intervention, considering both family and employees workforces (Annex 3).
- To calculate the annual Full- time equivalent (FTE) job creation, the assumption based on Bermudez (2015) was used in line with the Ministry of Labor guidelines, which consider annual employment when there are a total of 312 wages in the year.
- To calculate the distribution of full-time equivalent jobs between men and women, the data referred to in the "Gender action plan of the National REDD+ Strategy," where it was estimated that the percentage of participation of men in activities associated with restoration is (84.4%) and the percentage of women is (15.6%). From there, the way in which wages and jobs were distributed by gender was reviewed, and that data was taken for the national calculation (MINAE, 2020).

Based on the assumptions raised above, it was possible to determine that the most considerable amount of short-term employment throughout the analysis period (2011-2020) was generated by natural regeneration, with a total of 11,748 FTE jobs (30% of the total) (Table 9). According to Figure 3, these were mainly generated from 2015, behaving in a more stable manner between 2017 and 2020. These clearly outstanding contributions to job creation, regarding the behavior of other activities and years, have been propitiated by the management of organizations such as FONAFIFO, FUNDECOR, and SINAC. They have promoted them from different lines of action and facilitated and managed the implementation of regeneration processes.

Other activities that have also contributed significantly to the generation of short-term employment are silviculture with 9,853 FTE short-term jobs, and forest plantations and forest plots with 9,027 FTE short-term jobs (Figure 3). Their contribution between 2011-2020 was of 48% of the total (Table 9). Actions that have been promoted, especially in the years 2011 and 2018, from initiatives such as REDD+ and the coffee NAMA, aimed at mitigation processes that have facilitated the promotion of processes such as regeneration through various actions and the implementation agroforestry systems in coffee. For the latter, the high potential of restoration in productive agricultural landscapes to generate green jobs stands out, where 80% of the jobs generated in 2020 by restoration are associated with agricultural lands. Total short-term employment between 2011 and 2020 is 39,582 (Table 9).

Table 9 Number of short-term jobs by type of intervention from 2011 to 2020

Barometer classification	FTE jobs	Percentage
Natural regeneration	11,748.38	30%
Silviculture	9,853.32	25%
Forest plantation and forest plots	9,027.08	23%
Agroforestry systems	8,421.64	21%
Land and water protection/conservation actions	532.18	1%
Total	39,582.60	100%

Source: Own elaboration with data collected by IUCN and SINAC.

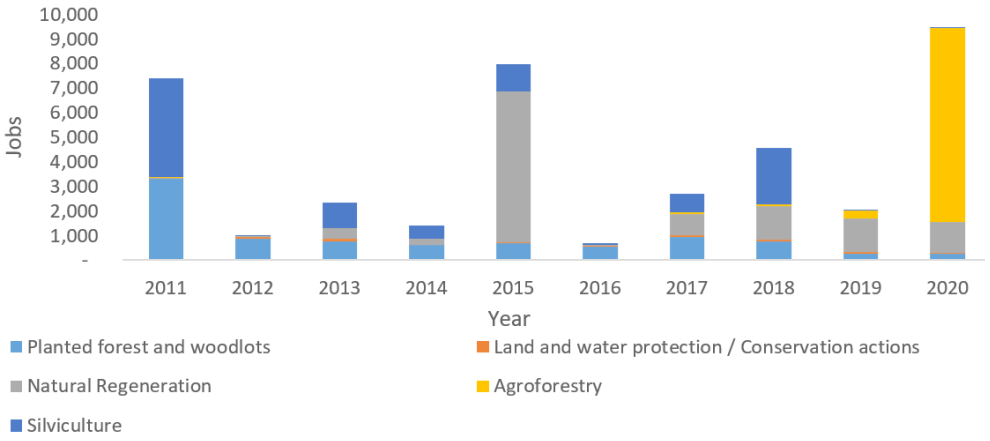


Figure 3 Short-term employment by type of intervention from 2011 to 2020

Source: Own elaboration, based on data collected by IUCN and SINAC.

Based on the assumptions made for the generation of short-term employment and its distribution by gender (MINAE, 2020) (Figure 4), a predominant participation of men was determined in the implementation of restoration actions between the years 2011–2022, with a total of 33,408 jobs generated. While in the case of women, this translated into a total of 6,175 jobs, distributed among all the restoration actions.

Regarding the employment generated during maintenance activities, that is, medium and long-term employment of the different restoration actions identified. Based on the assumptions of wages ha/year used (Annex 3), it is determined that between 2011 and 2020, natural regeneration, silviculture, and the planting of forest and forest plots, are actions that steadily contribute to the generation of employment. (80% of the total) (Figure 5).

This behavior is associated with the constant demand for maintenance work incurred throughout the implementation of these activities, for example, in thinning, pruning, and weed control, among others. It is also possible to quantify an estimate of the generation of employment associated with the activity of agroforestry systems, which is viewed as relevant, according to Figure 5. It provides 4,584 jobs (14% of the total) (Table 10), derived from maintenance activities that are part of agroforestry systems implemented years ago, between 2016-2020, equivalent to 53,610 ha.

As evidenced in Figure 6, between 2011 and 2020, estimates indicate that medium- and long-term employment has been increasing in the case of men and has remained more stable in the case of women.

Figure 5 shows that this increase in employment generation for men between 2011 and 2020 is associated with the demand for labor for maintenance activities in natural regeneration actions (28% of the total) and silviculture (26% of the total).

In addition, it should be added that the contribution of the forest plantation activity and forest plots in the generation of employment in the medium and long term also stands out, also due to the increase in maintenance activities required, according to Table 10, a 26% of the total.

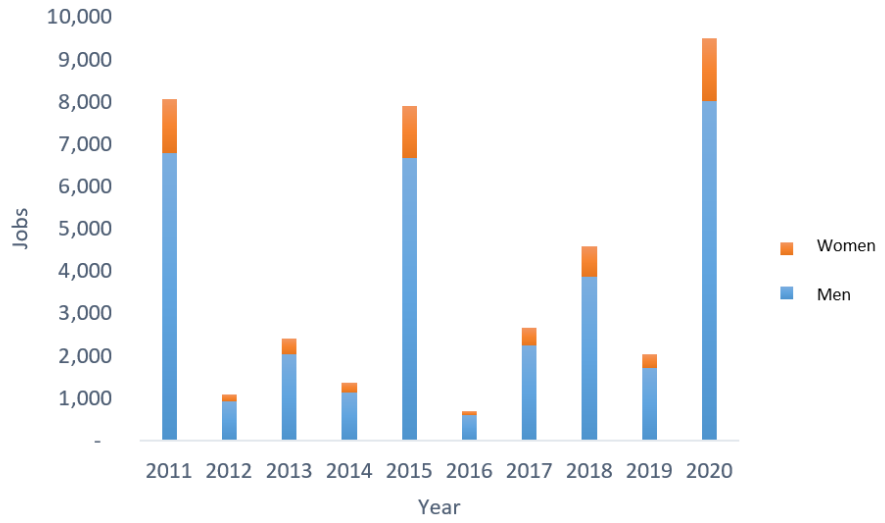


Figure 4 Short-term employment by gender and year from 2011 to 2020.

Source Own: elaboration with data collected by IUCN and SINAC.

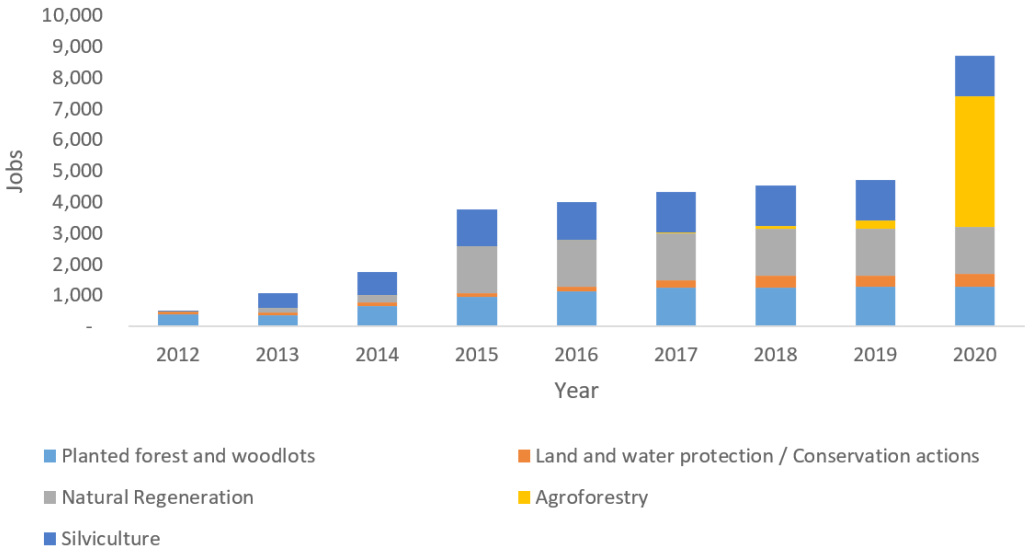


Figure 5 Medium- and long-term employment by type of intervention from 2011 to 2020.

Source: Own elaboration with data collected by IUCN and SINAC.

Table 10 Number of medium- and long-term jobs by type of intervention from 2011 to 2020

Barometer classification	FTE Jobs	Percentage
Natural regeneration	9,450	28.3%
Silviculture	8,850	26.5%
Forest plantation and forest plots	8,543	25.6%
Agroforestry systems	4,584	13.7%
Land and water protection/conservation actions	1938	5.8%
Total	33,365	100%

Source: Own elaboration with data collected by IUCN and SINAC.

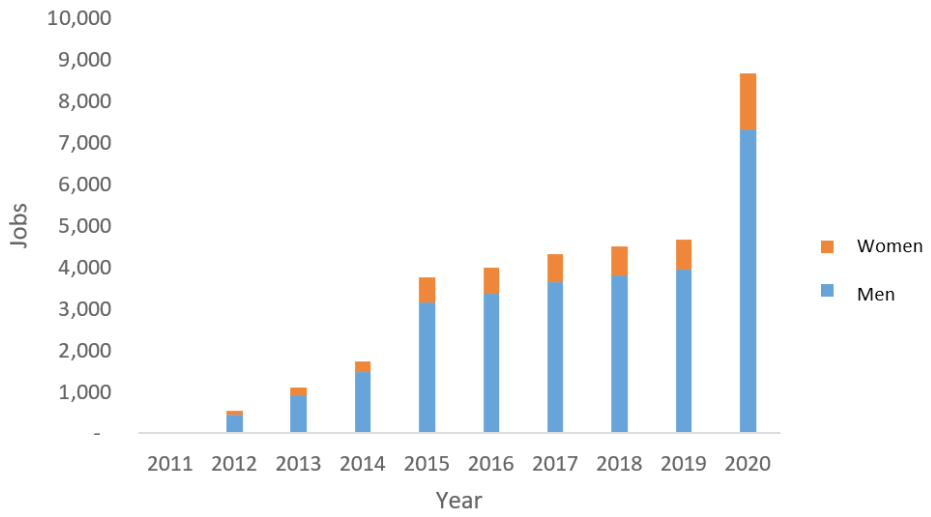


Figure 6 Medium- and long-term employment by gender and year from 2011 to 2020.

Source: Own elaboration with data collected by IUCN and SINAC.

7.3 Impacts on biodiversity

7.3.1 Restoration in biological corridors

Map 4 presents the restored areas according to each category of the Barometer and allows to see their location concerning the biological corridors.

The latter is represented in two colors, a pink line for the new biological corridors[13] (BC) created in the reference period and a dark gray line for the previously established BC. To evaluate the biodiversity indicator in BC, the restoration actions established within the biological corridors were considered, covering 172,401 or 42% of the total restored area.

The total area of the recently created (new) BCs is 573,527 ha. Regarding the restored areas within the new BCs (in pink), the importance in the Guanacaste region can be observed with the new Chorotega BC and the Peninsular BC. Similarly, the San Juan la Selva biological corridor has high coverage of a restored area, mainly through land and water protection/conservation actions and silviculture.

7.3.2 Restoration in protected wildlife areas

Map 5 of restored areas and protected areas[14] (PA) shows the location of the 102,934 ha with restoration actions within PA. This corresponds to 22% of the total restored area. The map shows the North Huetar region where protected areas such as Maquenque have been particularly benefited. Indeed, 28% of the PA Maquenque was restored (11,802 ha in an PA covering a total of 41,751 ha). Due to the limitations in the retrospective reconstruction and registration of the restoration actions implemented in specific Conservation Areas, several PAs, particularly the national parks (management category II), due to State ownership, appear with little restored area. However, this does not mean that these areas have not been subject to restoration or management works, but rather that the registry of said works is not centralized at the Conservation Area level, making it impossible to report it rapidly.

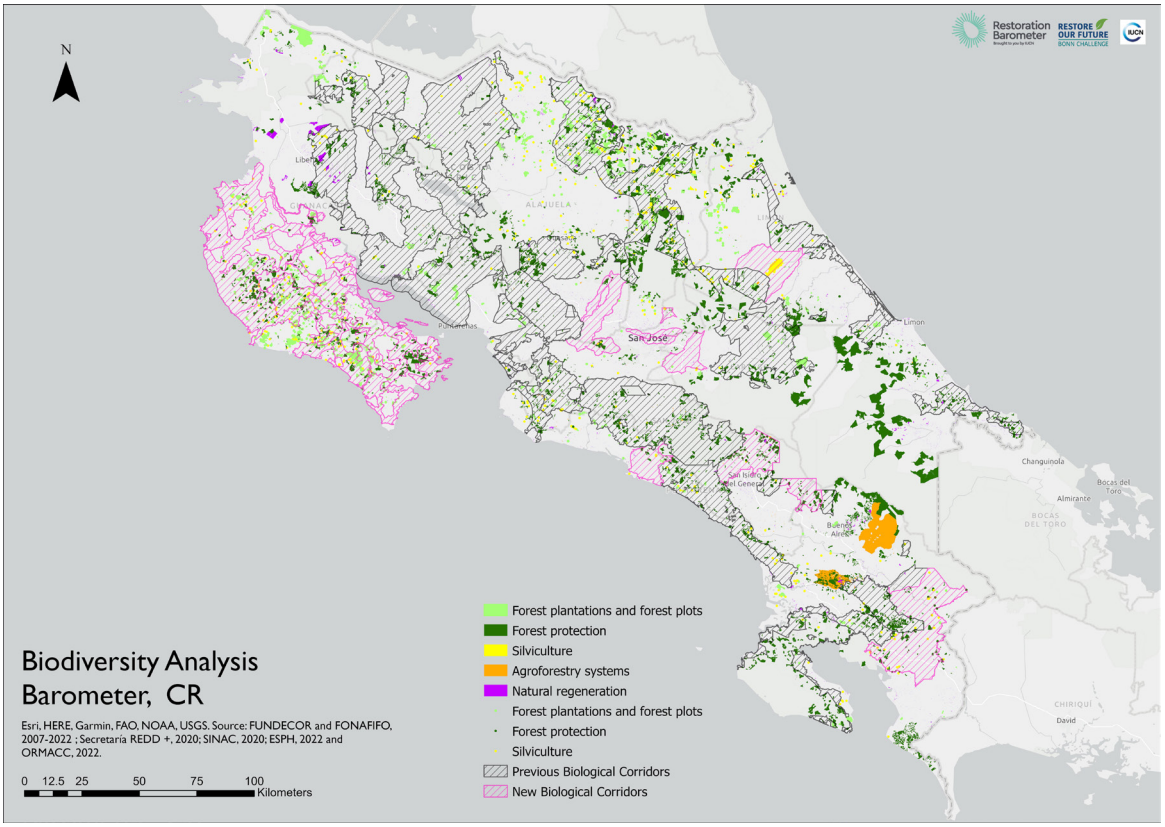
7.3.3 Restoration of Key Biodiversity Areas

Map 3 of restored areas in Key Biodiversity Areas[15] shows that 293,074 ha are registered within KBAs, which represents 71.48 ha% of the registered area in the Barometer application in Costa Rica. Indeed, much of the restored area is located within the limits of the KBAs. Areas such as the so-called; La

13 According to SINAC, biological corridors are defined as "geographic spaces with defined limits destined for human use, which serve as a connection between two ecosystems or important areas of biodiversity to allow the genetic exchange of flora and fauna between the two places and ensure that this biological diversity is maintained over time". https://biocorredores.org/corredoresbiologicos/programa-nacional-de-corredores-biologicos

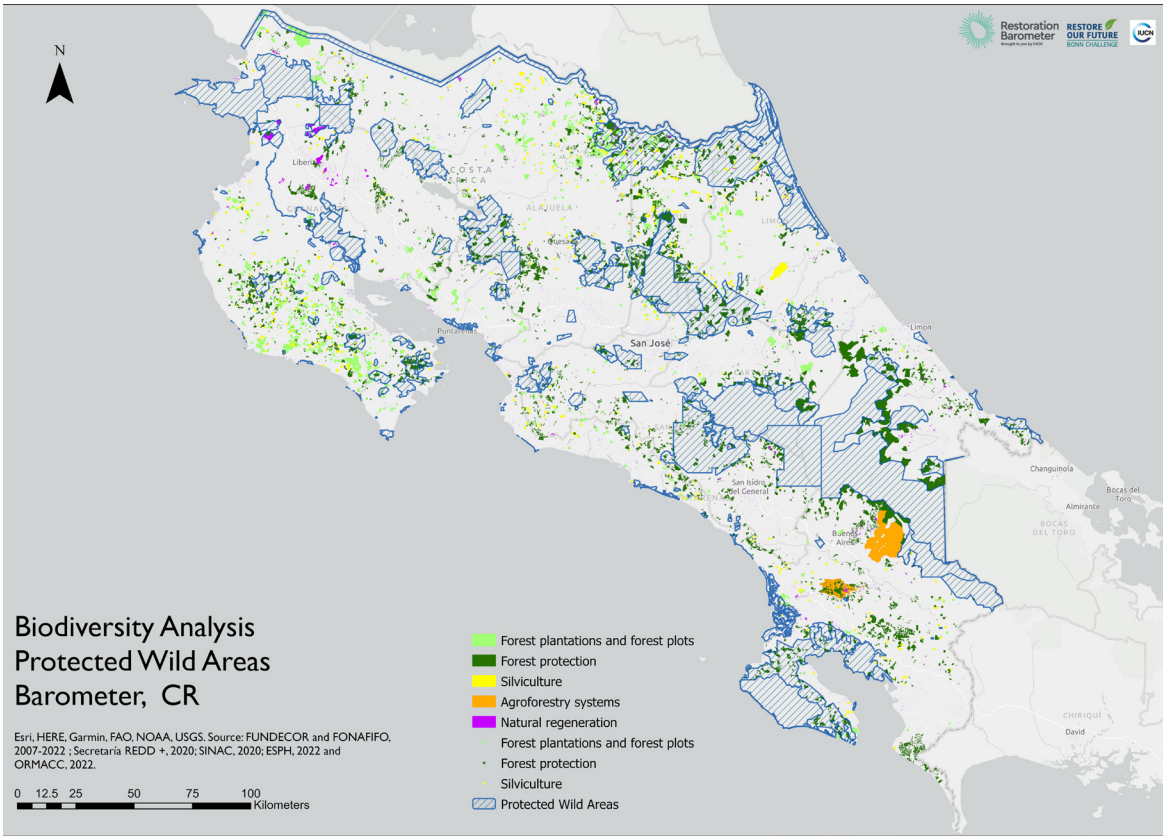
14 Defined geographic space, officially declared and designated with a management category by virtue of its natural, cultural and/or socioeconomic importance, to comply with certain conservation and management objectives". (DE-34433, Reglamento. Ley.Biodiversidad, Art.3, inca)

15 Key Biodiversity Areas have global value for conservation, due to their outstanding ecological integrity, globally important ecosystems or significant populations of animals, fungi and plants. https://www.iucn.org/resources/conservation-tool/key-biodiversity-areas



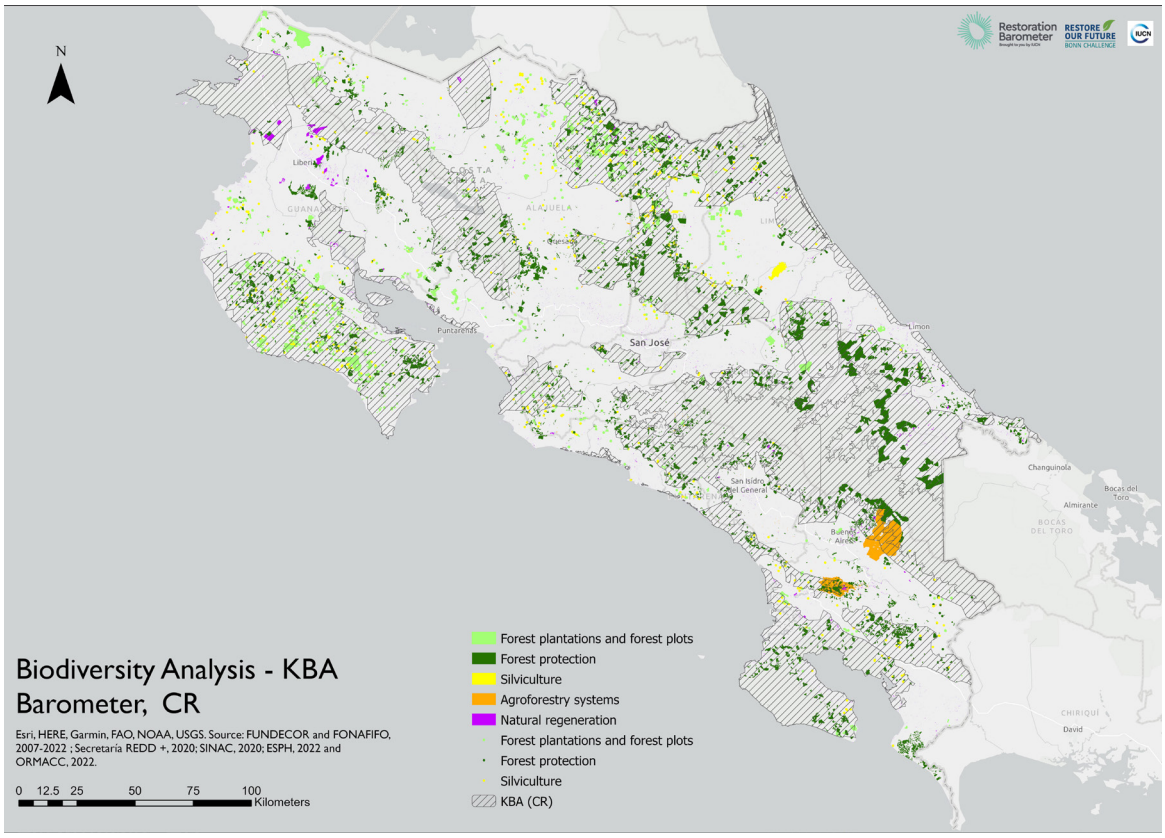
Map 3 Restoration actions and biological corridors.

Source: Own elaboration, based on data collected by IUCN and SINAC.



Map 4 Restoration actions in protected wildlife areas.

Source: Own elaboration.



Map 5 Restoration actions and Key Biodiversity Areas.

Source: Own elaboration.

Amistad, the Nicoya Peninsula, and the Caribbean Plains and Wetlands have benefited from the restoration actions implemented.

7.3.4 Creation or enhancement of existing habitats for Red List species

The potential impact of regeneration and silviculture (sustainable forest management) for the Creation and enhancement of existing habitats for Red List species was assessed based on publicly available spatial information[16]. Indeed, based on the type of restoration activities registered in Costa Rica, it is considered that forest regeneration is the activity that has the most significant potential for habitat regeneration, whether it is a very humid forest, humid forest, dry forest, or mangrove. Likewise, it is considered that silviculture, because it complies with sustainable forest management guidelines (SINAC, 2009), is the type of registered intervention that has the most significant potential to improve the conditions of forests as a habitat for species on the Red List. For future analyses, the potential of agroforestry systems could be added as they are land uses that provide habitat for multiple species (particularly bats and birds), including threatened ones (Harvey & González Villalobos, 2007). Regarding the information on the Red List, the species were considered according to the guidelines described below:

- Only resident species were selected whose origin is native to the area and which are considered present in the regions considered (Red List technical working group, 2018). This assumption implies that birds whose condition is migratory are not counted.
- Four taxonomic groups were considered: reptiles, amphibians, birds, and mammals.
- The analysis was limited to species recorded in terrestrial areas (i.e., marine species are excluded).

Table 11 presents the number of species on the Red List found in areas intervened through both modalities. It highlights that a greater number of species on the Red List could have benefited from the creation of habitat through forest regeneration activities, which is explained by the more significant amount of area (21,690 ha of regeneration vs. 8,069 ha of silviculture) and a wider spread of regenerated areas throughout the country (see map 1). Around 53% of the species that could have benefited belong to the bird taxonomic group, which indicates

16 https://www.iucnredlist.org/resources/spatial-data-download

that the restoration would primarily benefit said taxon[17], considering all species regardless of their risk category on the Red List. If the analysis is restricted to species that are identified as in danger of extinction (i.e., "critically endangered, endangered and vulnerable") (IUCN, 2012), the number of species is considerably reduced, thus allowing a better understanding of to what extent the restoration overlap with the habitat of the species most threatened with extinction (Annex 7). Table 12 shows that the most threatened taxonomic group that could have benefited from the restoration is that of the amphibians, with some 37 species.

In order to link with greater certainty, the benefits of restoration for threatened species, it is recommended to evaluate the availability of information regarding the monitoring of certain species in the restored areas in order to be able to ensure that the habitat area of such species was in the restored area (Mair et al., 2021) and improved as a result of restoration.

In this way, it will be possible to quantify the contribution of the restoration to the conservation of threatened species with the metric for the Species Threat Abatement and Restoration (STAR[18]).

Table 11 Number of species on the Red List by taxonomic groups whose range is in areas of habitat created or with better management

Taxonomic group	Reptiles	Birds	Amphibians	Mammals	TOTAL
Regeneration	182	625	158	204	1169
Silviculture	109	468	93	166	836

Source: Own elaboration based on information from the IUCN Red List*.

* The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. It divides species into nine categories: Not Evaluated, Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild and Extinct.

* Las categorías y criterios de la Lista Roja de la UICN pretenden ser un sistema fácil y ampliamente comprensible para clasificar las especies en alto riesgo de extinción mundial. Divide las especies en nueve categorías: No evaluada, Datos insuficientes, Preocupación menor, Casi amenazada, Vulnerable, En peligro, En peligro crítico, Extinta en estado salvaje y Extinta.

Table 12 Number of species on the Red List in danger of extinction benefited by habitat created or through better management

Taxonomic group:	Reptiles	Birds	Amphibians	Mammals	TOTAL
Regeneration	10	15	28	7	60
Silviculture	1	6	9	5	21

Source: Own elaboration based on information from the Red List.

17 At a global level, of the four taxonomic groups considered, the group that has been studied the most is amphibians, followed by reptiles, birds, and, lastly, mammals. For more information, refer to https://www.iucnredlist.org/statistics

18 More information at: https://www.iucnredlist.org/assessment/star

Conclusions

Applying the barometer of restoration in Costa Rica allowed reporting in a participatory and validated way, considering eight indicators of actions and impact with panels of experts[19] on the progress of restoration actions implemented in the diversity of existing ecosystems in the country between 2011 and 2020. In this way, the Costa Rican government has the inputs required to publish a standard report to inform on its progress under the Bonn Challenge and the decade (2011-2020) of restoration through the use of the portal of the barometer[20].

Based on the inputs generated with the Barometer application, Costa Rica now has a roadmap that promotes coordination between sectors and actors linked to restoration processes. In addition, it seeks to enhance strengths and address weaknesses by monitoring restoration actions in the country. This also favors improved decision-making to promote more significant actions that respond clearly to the sustainable management of ecosystems.

Regarding the action indicators, Costa Rica has a public policy framework with a medium and long-term scope that promotes the restoration of ecosystems, articulating the planning and implementation of activities in urban, rural, and coastal marine landscapes. The latter, considering the particularities present in the different agricultural production sectors (livestock, coffee, musaceae, sugar cane, among others).

Based on published and available data, the public sector has invested the most in the restoration of ecosystems in the last decade, mainly through the FONAFIFO program of payments for environmental services and, to a lesser extent, through the joint work of SINAC and local governments to promote silviculture projects through tax incentives. This demonstrates the commitment of successive governments in Costa Rica in terms of public investment in conservation and restoration of the environment. This situation also shows the need to promote private investment through alternative schemes, such as credit or environmental bonds and public-private alliances where private actors participate more. For example, some initiatives, such as the Green Credit Program of the Livestock NAMA (Chacón, 2019) and the Jaguar Green Bond (Rodríguez, 2020), seek to mobilize more private capital in restoration activities through debt mechanisms. Costa Rica's commitment, which is demonstrated by the high level of public investment, can be an argument for international cooperation to join this effort.

Regarding monitoring systems, there are multiple platforms and monitoring systems that could feed an agile and interinstitutional restoration reporting process and whose articulation could be achieved through the steps described in the roadmap for the Barometer application in Costa Rica (see recommendations).

Considering the impact indicators, from this analysis it is deduced that Costa Rica has achieved the restoration of ecosystems in 482,000 ha, which is equivalent to 48% of the country's goal under the Bonn challenge. Although restoration of forest lands has been the norm in the last decade, with 90% of the area restored, the restoration of agricultural lands has been increasing. It is expected to increase thanks to new sectoral actions such as the musaceae, rice, and sugar cane NAMAs. In addition, Costa Rica has revitalized the silviculture sector through restoration actions such as forest plantations and sustainable forest management. Said sector still requires substantial investments, particularly in the transformation link and marketing of Forest, to guarantee that investments in forest lands are recovered through the differentiated sale of Forest. Although this result is encouraging and allows us to hope that the goal will be achieved by 2030, the situation of public

19 The information validation workshop was implemented on May 11, 2022, see the list of participants in Annex 6.

20 The portal is available online at: https://restorationbarometer.org/

finances due to COVID-19 economic impacts and the continuous growth of fiscal deficit have hindered the progress of the restoration 2020-2021.

Concerning social impacts, it is possible to estimate the critical contribution of the various restoration actions between 2011 and 2020 in the generation of employment, a total of 41,115 in the short term and 34,973 in the medium term. In this sense, it is evident that through the development of mechanisms that promote and articulate restoration actions, social benefits such as job creation can also be generated, particularly for rural and less favored regions. However, the low participation of women in these activities has been evident, leading to the need to promote alternatives, means, or ways in which their contribution is strengthened while minimizing inequality conditions and improving their quality of life.

The restoration contributed significantly to the increase in connectivity, with 40% of the area restored in biological corridors. In line with the national communications on climate change and the forest emissions monitoring system, the increase in carbon in forests achieved through land and water protection/ conservation actions is the greatest carbon sink, followed by natural regeneration processes in agricultural areas. Similarly, the restoration contributed to the consolidation of PA with flexible use modalities (management category III to VI according to the IUCN classification): 22% of the restored area is located in PA.

In addition, it is estimated that restoration have created or improved habitat of 81 species in danger of extinction, which could have benefited those species.

Recommendations

According to Costa Rica's National Landscape Restoration Strategy 2021-2050, a restoration monitoring process should be established. In this sense, in order to update the country report with the restoration barometer without duplicating existing monitoring procedures, the following suggestions are made:

- In order to account for all the activities implemented in the country by SINAC, it is recommended to systematize and standardize information reporting processes for ecosystem restoration on an annual basis at the level of each Conservation Area. This will allow year after year to collect information on restoration actions implemented with communities, local civil society organizations, and the private sector because they are not included in any information reporting process.
- Establish a procedure for exchanging information with the Costa Rican Institute of Aqueducts and Sewers (AyA) for the report of the intervened area with resources generated by the rates for the protection of water resources of the AyA and the Administrators Associations of the Aqueduct and Communal Sewer Systems (ASADAs).
- Similarly, agree with the Costa Rican Electricity Institute (ICE) on the frequency and process of exchanging information to account for the restored areas as part of its watershed and forest recovery program.
- Establish agreements with the SIMOCUTE land table to access information on the progress of agricultural NAMAs, under the legal framework (protection of private data) and in line with the monitoring and evaluation systems of the NAMAs for livestock, coffee, rice, musacea, and cane.
- Articulate mechanisms for exchanging information with the private sector, particularly companies in the agricultural and tourism sectors. Such mechanisms highlight the importance of the contributions they generate for processes such as the restoration barometer and encourage greater participation regarding the possible impacts of these actions.
- Promote ways to implement actions through public-private alliances, which favor the exchange of experiences and strengthen restoration processes in less intervened sectors and areas.
- Make public the information collected for restoration monitoring through the restoration barometer portal and a viewer established on the National Territorial Information System platform.
- Use spatial analyses (e.g., Raes et al. 2022) to inform which areas are priorities in the framework of sectoral restoration planning roundtables (rural, urban and marine-coastal).

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Annexes

Annex 1 Annual hectares restored by intervention from 2011 to 2020

Barometer Classification	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Forest plantation and woodlots	17,222	4,511	4,059	3,262	3,674	2,914	4,860	3,995	1,369	1,321	47,187
Land and water protection/ conservation actions	9,825	51,325	55,700	5,851	12,135	8,499	39,834	42,539	46,985	33,310	306,002
Natural regeneration	66	44	873	458	12,175	90	1739	2,702	2,680	2,466	23,294
Agroforestry systems	167	10	12	0	6	120	444	467	2083	50496	53,805
Silviculture	21,148	167	5393	2819	5733	297	3967	11982	1	0	51,506
Hydrological restoration	0	0	0			5	13				18
Control of problematic invasive species	0	0	0			50		50	88		188
Total	48,428	56,057	66,036	12,391	33,723	11,974	50,857	61,734	53,207	87,594	482,000

Annex 2 Spatial analysis steps

Information received

Six Institutions provide spatial information about restored areas in the reference period :

- FUNDECOR (Cadastre)
- FONAFIFO
- ESPH
- Agua Tica
- REDD + Secretariat
- SINAC

Classification in levels of precision

The information received from the institutions and actors that carry out reforestation was classified based on the following specifications.

- Level 3: greater certainty (spatially explicit polygons).
- Level 2: medium certainty (lines and points or coordinates).
- Level 1: less certainty (no spatial information, only tabular).

This report presents the spatial analysis carried out for the application of the Restoration Barometer in Costa Rica. All the information from the different levels was analyzed, performing spatial analysis for levels 1 and 2. The restored area map was generated at the district level, where all the information is included (levels 1, 2, and 3).

Steps taken to analyze spatially explicit information

The spatial analysis work was divided into two initial parts related to collecting and editing the vector files of restored areas at national level. The first step was the cleaning and editing of files of each institution that implemented restoration actions, and the second corresponded to eliminating duplicate or overlapping areas.

The initial edition of files received by institutions

For the Barometer application in Costa Rica, the actors that registered and took spatial control of the restored areas sent the available information to ORMACC (IUCN). Said information was analyzed and edited to homogenize attributes and then be able to generate a compilation file of all types of actions, institutions, and years to calculate the restored area. The categories of the Barometer in Costa Rica are presented below:

- Forest plantation and woodlots
- Land and water protection/conservation actions
- Natural regeneration
- Silviculture
- Agroforestry systems

From the spatial information received by the institutions that accounted for restoration actions at the national level, the following processes were made to the vector files of each institution:

FUNDECOR: The restoration actions implemented in the reference period were selected with the "select by attributes" tool.

- A column was added (with the "add field" data management tool) to be able to classify the actions according to the barometer categories.

FONAFIFO: Vector files were received for each of the years 2007 and 2020. Only those corresponding to the reference period were selected. The "Union" tool generated a unified file of all FONAFIFO restoration actions. A column was added (with the "add field" data management tool) to be able to classify the actions according to the barometer categories. In total, 371,859.6 hectares were received.

ESPH: A shapefile was received with all the polygons corresponding to payments for registered environmental services. The polygons dated before the year 2011 and after the year 2020 were eliminated. A column was added (with the "add field" tool) to be able to classify the actions according to the barometer categories.

Agua Tica: Polygons dated prior to 2011 were removed. A column was added (using the ArcGIS Pro "add field" tool) to be able to classify actions according to barometer categories.

REDD + Secretariat: The land use rasters for 2015-2019 were considered. The "combine" raster analysis tool was used to determine the types of actions that correspond to a change from non-forest use (agriculture, pasture) to forest use. Added (add field) a column to classify the actions according to the categories of the Barometer.

SINAC: Tabulated information was received in Excel format with coordinates and areas registered at each point where restoration was carried out. A column was added (with the "add field" tool) to be able to classify the actions according to the barometer categories.

Spatial overlap analysis

Spatial overlap analysis was performed to avoid double counting (duplication) of restored areas. This overlapping position occurs internally in institutions and sometimes between two different institutions. The steps and actions taken are summarized below:

1. **FONAFIFO**: There are 21,400.9 ha with superposition of polygons (overlaps). The overlapping occurred in polygons from different years of actions registered by FONAFIFO.

Elimination of overlaps: "delete identical" tool.

2 **FUNDECOR** and **FONAFIFO**: union of vector files (with barometer categories).

- There are 15,529.5 ha with overlap between the two institutions.
- Sort areas based on largest area and assign a name.
- Edition of consolidated vector file columns: institution and overlapping by selecting larger areas.

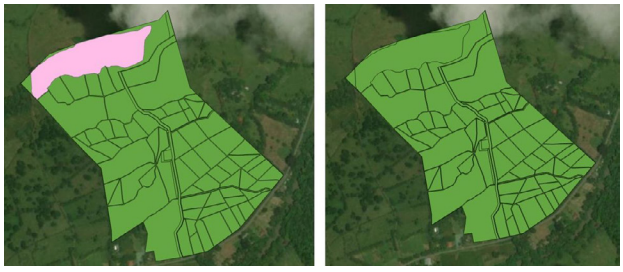


Figure A2.1 Overlap area between two institutions.

Source: Own elaboration.

The previous image illustrates cases of overlapping between two institutions. The process for assigning overlapping areas between FONAFIFO and FUNDECOR to the polygon with the most significant area is detailed below.

- Edition of consolidated vector file columns: institution, modality, and calculate area.
- Remove duplicates: “Delete identical” using polygon geometry.
- Generation of summary tables.

REDD+ Secretariat regeneration pixels

- The “combine” function of the spatial analysis geoprocessing tools was used between the 2015 and 2019 land use rasters (REDD + Secretariat).
- The “raster to polygon” conversion function was used, selecting only the transitions from agricultural land, permanent crops, and other lands to forest use.
- The “erase” function was used to eliminate overlap between the polygons and the regeneration areas from the 2015 - 2019 raster analysis of the REDD + Secretariat. In this way, it was guaranteed not to have duplicates with the rest of the polygons of the other institutions.
- There are 12,167.20 ha without overlapping.

SINAC points

- Analysis of position: elimination of points inside and around polygons.
  - A buffer was generated around 20 meters from the vertices of the polygons.
  - The “select by location” function was used to extract the points that do not fall in the vicinity (switch selection).
- Calculate area without overlapping: 58,116.4 ha.

Homogenization and editing of final vector file

Union of all the polygons (with the “union” analysis tool). The initial steps of adding columns with the Barometer categories, year, and institution allow a suitable union of layers to obtain a vector file with all the registered actions and their attributes.

To analyze the spatially explicit information, with the ArcGIS Pro (2.8.0) program, the calculate field function was used to create an additional column for each intervention carried out under each Barometer restoration modality. The national and official district shape was also used to have information regarding location by province, canton, and district.

- Homogenization and editing of barometer categories according to the type of activity (using the “calculate field” tool).
- “Spatial Join” between the layer of districts and polygons: selecting areas through the location by districts.
- Recalculate the fields using the “calculate field” tool.
- Shapes to excel (data export to fill Barometer format): The areas associated with each of the activities were transferred to the barometer data format (Excel)

Interpretation of restoration maps at the national level

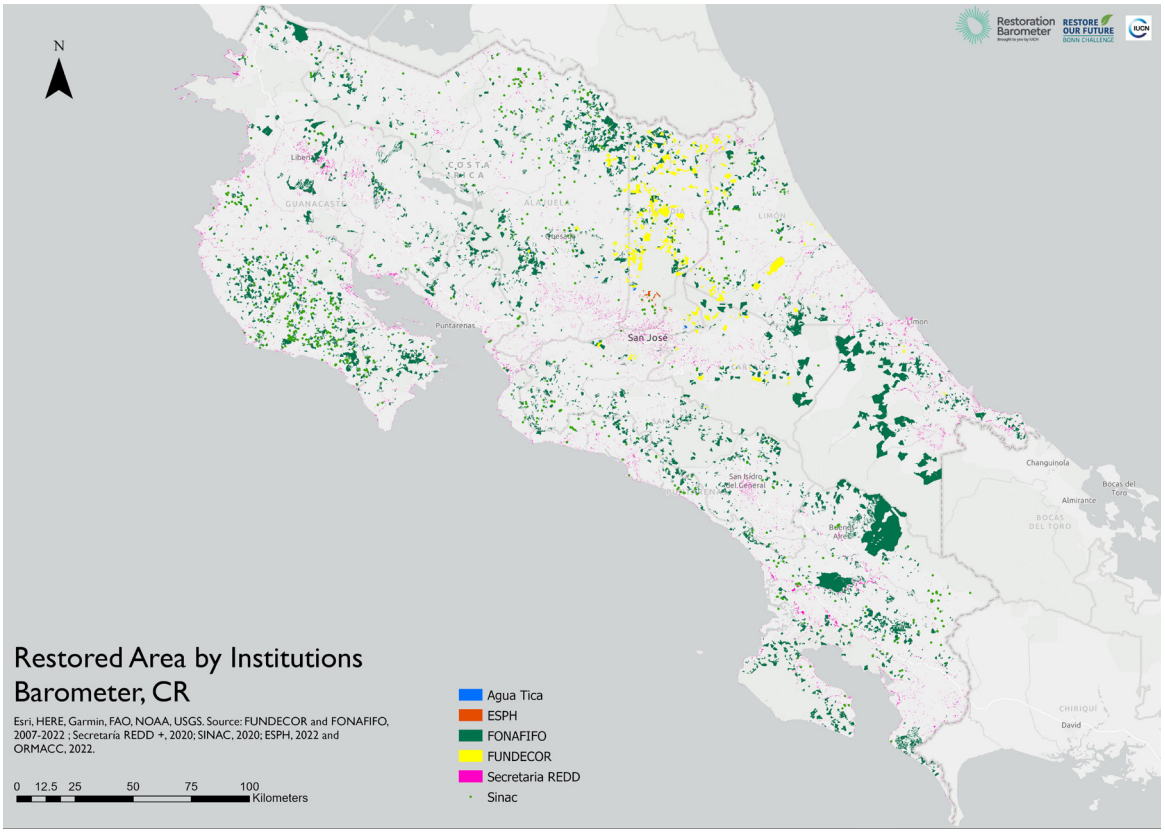
The map of actions restored by the institution allows seeing the spatial location of the activities accounted for by each institution considered in the analysis.

The map shows which institutions have reported the most amount of restored area (FONAFIFO, FUNDECOR, and REDD + Secretariat) and the respective spatial location.

Biodiversity analysis

The spatial information database of the Barometer in Costa Rica generated by the steps explained in annex 2 was used. Then, “the clip” tool was used to cut the areas within protected areas (PA) and biological corridors (BC) as Key Biodiversity Areas.

(KBA). Finally, the area was recalculated to update the restored areas within the two layers of interest for biodiversity (using the "calculate geometry" function). The resulting maps allow to visualize the restoration in different essential areas for biodiversity and are presented below.



Map A2.1 Restored area by institutions.

Source: Own elaboration.

Annex 3 Assumptions in estimating short- and long-term employment by type of intervention

	Implementation	Number of wages per intervention in maintenance							
Barometer classification	**Wage/ha/ year 1**	**Wage/ha/ year 2**	**Wage/ha/ year 3**	**Wage/ha/ year 4**	**Wage/ha/ year 5**	**Wage/ha/ year 6**	**Wage/ha/ year 7**	**Wage/ha/ year 8**	**Wage/ha/ year 9**
Forest plantation and woodlots	22	10	11	9	7	3	0	1	0
Land and water protection/ conservation actions	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Natural regeneration	58	20	20	12	12	0	0	0	0
Agroforestry systems	18	9	9	9	9	9	9	9	9
Silviculture	22	10	11	9	7	3	0	0	0

Source: FUNDECOR.

Annex 4 Cost of implementing ecosystem restoration actions

Barometer classification	Cost/ha/year										Total
	Implementation	Number of wages per intervention in maintenance									
	1	2	3	4	5	6	7	8	9	10	
Planted forests and shrub cover/silviculture (medium/long-term plantations)	861,409	418,890	139,250	82,399	50,827	9,296		9,296	-	9,296	1,580,662
Agroforestry	2,830,412	705,236	640,781								4,176,429
Regeneration	264,000	105,600	79,200	52,800	26,400						528,000
Silviculture (Harvesting and forest PM treatments)	345,000	17,000		12,500				12,500			387,000

Source: FUNDECOR.

Annex 5 List of participants in the workshop to present the restoration barometer in Costa Rica. 4 november 2021

	Name	Institution
1	Celene Enriquez	UICN ORMACC
2	Huberth Méndez	Municipality of Curridabat
3	Tony Nello	UICN ORMACC
4	Jorge Segura	MAG Costa Rica
5	Daniel Gutiérrez González	MINAE
6	UICN Tania Ammour	UICN ORMACC
7	Lucrecia Guillén	FONAFIFO
8	Luis Gamez	ESPH
9	Annia Cordero-	Municipality of La Unión
10	Marcia Carranza	ACRXS
11	Dannia Gamboa	
12	Roxana Gamboa	Nespresso
13	Sergio Feoli Boraschi	CNFL
14	Guillermo Putzeys	UICN ORMACC
15	Carlos A. Salas	Municipality of San Carlos
16	Franklin Paniagua	MINAE
17	Adolfo Artavia	ACRXS
18	Viviana Ramos Sanchez	Instituto Costarricense de Acueductos y Alcantarillados
19	Astrid Michels	GIZ
20	Christian Delgado Segura	Instituto Costarricense de Acueductos y Alcantarillados
21	Madeline Carvajal	Fundación Parques Nacionales
22	Sonia Lobo-Costa Rica	SINAC

Annex 6 List of participants in the information validation workshop. 11 May 2022

Name	Institution
María Pia Hernández	UICN ORMACC
Tania Ammour	UICN ORMACC
Melinka Nájera	UICN ORMACC
Tony Nello	UICN ORMACC
Pavel Rivera	UICN ORMACC
Guillermo Putzeys	UICN ORMACC
Mario Coto Hidalgo	SINACA
Adolfo Artavia	ASCRXS
Ana Lucrecia Guillen	FONAFIFO
Catalina Esquivel	FONAFIFO
Gabriel Villalta	FUNDECOR
Jorge Esteban Segura	MAG
Luis Gámez	ESPH
Marilyn Calvo	IMN
Miguel Cifuentes	CI
Pedro Zúñiga	FUNDECOR
Sara Mora	CENIGA
Wilfredo Segura	ICE
Yasmin Castillo	CORFOGA
Mauricio Chacón	MAG
Rafael Monge Vargas	CENIGA

Annex 7 List of species in danger of extinction that are registered as present in the restored areas by taxonomic group and modality

Table A7.1 List of amphibian species in danger of extinction in areas where regeneration was implemented

Scientific name species	Red List Category
Ecnomiohyla fimbrimembra	VU
Isthmohyla zeteki	VU
Isthmohyla rivularis	EN
Gastrotheca cornuta	EN
Craugastor gulosus	CR
Oedipina poelzi	EN
Duellmanohyla lythrodes	EN
Bolitoglossa minutula	EN
Oedipina alfaroi	VU
Oedipina savagei	VU
Silverstoneia nubicola	VU
Nototriton major	EN
Craugastor rayo	EN
Craugastor chingopetaca	VU
Isthmohyla angustilineata	CR
Incilius chompipe	EN
Bolitoglossa alvaradoi	VU
Bolitoglossa sooyorum	EN
Ptychohyla legleri	EN
Incilius epioticus	VU
Phyllobates vittatus	VU
Oedipina gracilis	EN
Incilius guanacaste	EN
Bolitoglossa compacta	EN
Craugastor ranoides	CR
Craugastor obesus	CR
Oophaga granulifera	VU
Oedipina carablanca	EN

Table A7.2 List of mammal species in danger of extinction in areas where regeneration was implemented

Scientific name species	Red List Category
Ateles geoffroyi	EN
Saimiri oerstedii	EN
Sylvilagus dicei	VU
Alouatta palliata	VU
Tayassu pecari	VU
Leopardus tigrinus	VU
Cebus imitator	VU

Table A7.3 List of birds in danger of extinction in areas where regeneration was implemented

Scientific name species	Red List Category
Laterallus jamaicensis	Endangered
Crax rubra	Vulnerable
Electron carinatum	Vulnerable
Cotinga ridgwayi	Vulnerable
Habia atrimaxillaris	Endangered
Neomorphus geoffroyi	Vulnerable
Patagioenas subvinacea	Vulnerable
Agamia agami	Vulnerable
Amazilia boucardi	Endangered
Amazona auropalliata	Endangered
Ara ambiguus	Critically Endangered
Ardenna creatopus	Vulnerable
Pterodroma phaeopygia	Critically Endangered
Amazilia alfaroana	Critically Endangered
Eupsittula canicularis	Vulnerable

Table A7.4 List of reptile species in danger of extinction in areas where regeneration was implemented

Scientific name species	Red List Category
Anolis datzorum	Endangered
Geophis talamancae	Endangered
Trimetopon simile	Endangered
Trimetopon viquezi	Critically Endangered
Crocodylus acutus	Vulnerable
Lepidochelys olivacea	Vulnerable
Chelonia mydas	Endangered
Eretmochelys imbricata	Critically Endangered
Dermochelys coriacea	Vulnerable
Caretta caretta	Vulnerable

Table A7.5 List of amphibian species in danger of extinction in areas where silviculture was implemented

Scientific name species	Red List Category
Ecnomiohyla fimbrimembra	VU
Bolitoglossa robusta	VU
Isthmohyla pictipes	CR
Isthmohyla zeteki	VU
Duellmanohyla uranochroa	VU
Isthmohyla angustilineata	CR
Bolitoglossa alvaradoi	VU
Oedipina gracilis	EN
Oedipina carablanca	EN

Table A7.6 List of endangered mammal species in areas where silviculture was implemented

Scientific name species	Red List Category
Ateles geoffroyi	EN
Alouatta palliata	VU
Tayassu pecari	VU
Leopardus tigrinus	VU
Cebus imitator	VU

Table A7.7 List of bird species in danger of extinction in areas where silviculture was implemented

Scientific name species	Red List Category
Crax rubra	Vulnerable
Electron carinatum	Vulnerable
Neomorphus geoffroyi	Vulnerable
Patagioenas subvinacea	Vulnerable
Agamia agami	Vulnerable
Ara ambiguus	Critically Endangered

Table A7.8 List of reptile species in danger of extinction in areas where silviculture was implemented

Scientific name species	Red List Category
Crocodylus acutus	Vulnerable

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