Factors Driving Changes to El Yunque National Forest Ecosystem Services: Stakeholder Perspectives Ten Years Later

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Introduction

Ecosystem services—the benefits ecosystems provide to people and other organisms—result from various ecosystem processes and functions. The delivery and availability of ecosystem services depend not only on ecosystem processes and functions but also on policies, regulations, management, and human actions. Understanding the factors that cause changes to an ecosystem and associated services is critical to designing interventions at different levels that promote positive effects and minimize negative ones. Moreover, assessing stakeholder perspectives of the drivers of ecosystem change is essential for identifying common areas of agreement to promote dialogue and strategy development and to identify potential gaps in information and misunderstandings.

In this factsheet, we present stakeholder perspectives regarding the factors driving changes to El Yunque National Forest (El Yunque, hereafter) and its ecosystem services. We also compare findings from data collected between 2009 and 2010 during the first phase of the El Yunque Ecosystem Services Project (López Marrero and Hermansen-Báez 2011a), when El Yunque's ecosystem services drivers of change were first identified by different stakeholders (López Marrero and Hermansen-Báez 2011b). These results can help forest managers and other stakeholders develop and implement initiatives to support El Yunque's ecosystem services and their delivery.

Assessing participant perspectives of El Yunque's ecosystem services drivers of change

Individual interviews were conducted with stakeholders from different groups to document and compare perspectives of factors driving changes to El Yunque's

ecosystem services. Stakeholders include scientists who work in El Yunque, El Yunque's forest managers, municipal planners from the municipalities in which El Yunque is located, community leaders, and residents living near El Yunque (see López Marrero and Hermansen-Báez 2025, for a description of the project's second phase). Some interviews were conducted in person, while others were conducted by phone or video conference due to the COVID-19 pandemic. Data was collected between 2019 and 2021.

As in the first phase of the project (2009–2010), the definition of driver of change was provided to each participant at the beginning of the interview. A driver of change is defined as any natural or human-induced factors that directly or indirectly cause changes in an ecosystem and its services (Millenium Ecosystem Assessment 2003). Each participant was then given a list of drivers of change generated during the first phase of the project (López Marrero and Hermansen-Báez 2011b; see **Table 1**). They were asked to review the list and identify the drivers of change they considered a continuous influence on El Yunque's ecosystem services during the last decade (between the first and second phases of the project). They were also asked to add any additional drivers of change that, in their opinion, influenced forest ecosystem services during that same period.

Key Findings

Negative drivers influencing El Yunque and its ecosystem services

- Land-cover change (with emphasis on urban expansion), waste disposal, lack of knowledge, natural disturbances, and lack of funds (and its effect on all forest operations) were the most frequently mentioned negative drivers of change during the first phase of the project (**Figure 1**, **Box 1**). All groups of stakeholders mentioned these drivers (**Table 2**).
- Some drivers of change were mentioned exclusively by some stakeholder groups during the first phase of the project. These included water use, climate change, scientific research, hydromodification, lack of land-use plans, and telecommunication towers.
- Some of the most mentioned negative drivers of change during the project's first phase were still factors driving change during the second phase.

Box 1. Urban land cover around El Yunque National Forest

Land-cover change, specifically urban expansion, has been consistently mentioned by stakeholders as a negative driver affecting El Yunque and its ecosystem services. In 2023, urban land covered 7,890 hectares (19,498 acres), or 10% of the area of the eight municipalities containing some portion of El Yunque within their boundaries (López Marrero and Hermansen-Báez 2024).

While urban expansion around El Yunque National Forest slowed from 2010 to 2023 (compared to 1998 to 2010), its effect on altering forest processes and functions and fragmenting the landscape are still of concern, as are future urban expansion and its implications for the forest and its ecosystem services.

Photo: Antonio González Toro

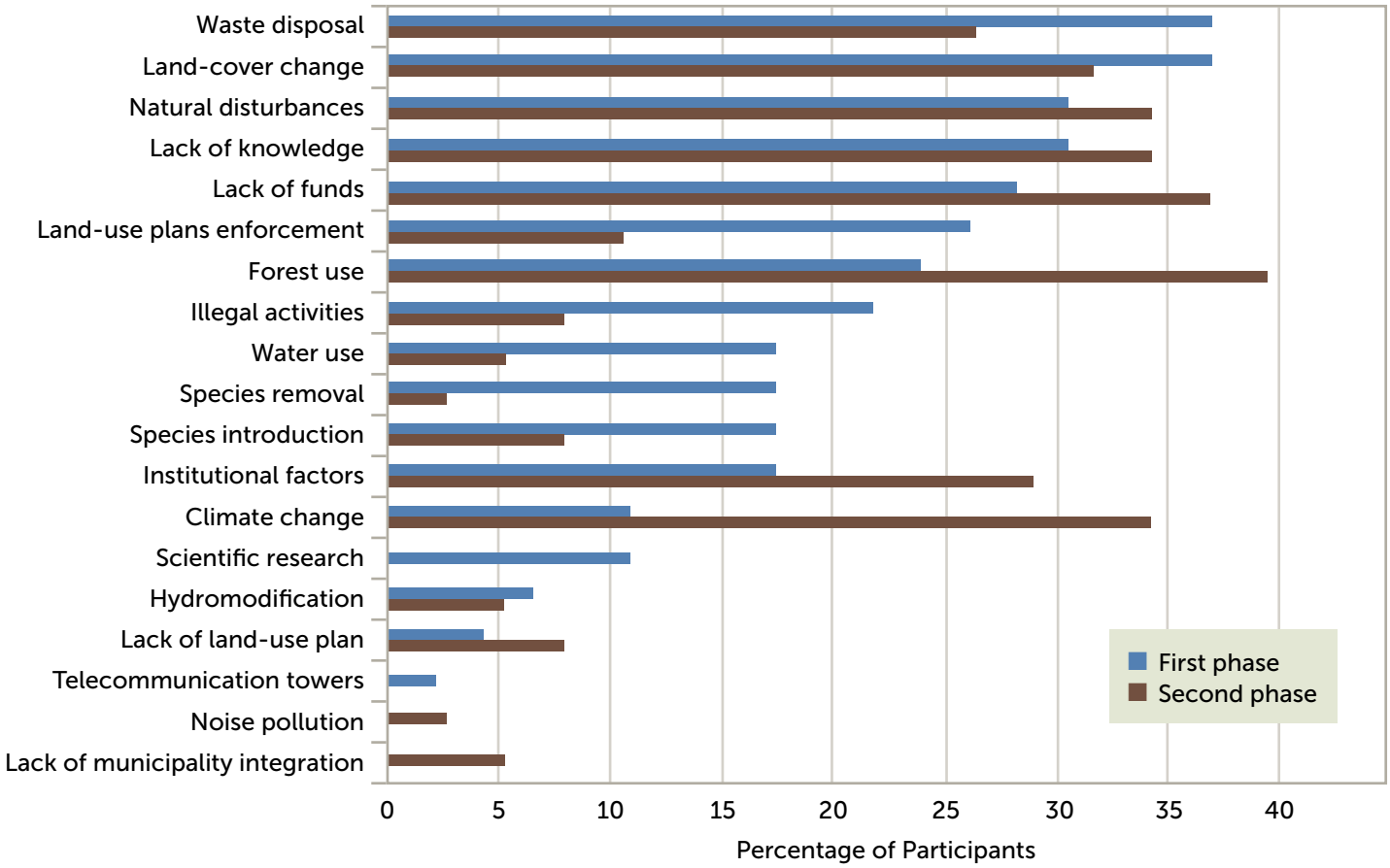
Urban land cover around El Yunque National Forest.

Table 1. List and description of negative and positive drivers of change generated during the project's first phase. This list was used in interviews during the second phase.

Negative driver	Description
Land-cover change	Changes in the vegetation or material covering the land's surface in the periphery of El Yunque, with an emphasis on urban land cover change
Lack of knowledge	Lack or limited knowledge about El Yunque's ecosystem services and how human actions affect the ecosystem's capacity to provide such services
Institutional factors	Forest management, regulations, and decision-making at the institutional level
Land-use plans enforcement	Poor enforcement of existing land-use plans
Lack of funds	Lack or limited funds to carry out daily operations, increase personnel for forest management, and facilities maintenance
Waste disposal	Inadequate waste disposal in forest areas, rivers, and along roads
Forest use	Forest inadequate use and overuse, emphasizing overcrowding of people and vehicles in El Yunque during certain times of the year
Species introduction	Introduction of exotic, invasive, and domestic species
Illegal activities	Lack of security, vandalism, graffiti, and use of all-terrain vehicles within the forest
Species removal	Removal of plants, animals, and aquatic species
Natural disturbances	Negative effects (particularly in the short- and medium-term) of disturbances such as hurricanes, landslides, and droughts
Lack of land-use plan	Lack of comprehensive and updated land-use plans
Telecommunication towers	The presence of telecommunication towers in El Yunque
Climate change	Changes in local, regional, and global climate and climate patterns
Water use	Water over-extraction and overuse
Hydromodification	Change of rivers' natural paths
Scientific research	Research practices conducted in the past—such as testing of radioactive effects on forests—and the perceived potential negative effects on forests and people
Positive driver	**Description**
Protected area	The protection status of El Yunque and associated laws, regulations, and special designations
Recreation	Forest visiting, passive and active recreation
Community involvement	Community participation and involvement in public hearings, cleaning campaigns, and the development of plans, among others
Natural disturbances	Positive effects (particularly in the long-term) on forest and forest processes of disturbances, with special mention of hurricanes
Research and Education	Scientific and social research about El Yunque, along with education efforts, knowledge transfer, and environmental awareness about El Yunque, its services, and the factors influencing it
Existing land-use plans	Existing land-use plans within and around El Yunque
Interagency collaboration	Federal, state, and municipal agencies' collaboration
Reforestation	Natural- and human-induced reforestation in and around El Yunque
Land acquisition	Land acquisition around El Yunque for conservation purposes

The drivers of change do not follow any pre-established descriptions; they were generated by the authors based on the project context and participants' descriptions during data collection.

Figure 1. Negative factors driving change to El Yunque and its ecosystem services, as mentioned by participants during the project's first and second phases.



The percentage (x-axis) was based on 46 and 38 participants during the project's first and second phases, respectively.

Of these, the most mentioned were lack of funds, lack of knowledge, and land-cover change. All stakeholder groups mentioned these drivers (**Table 2**).

- During the project's second phase, all groups identified natural disturbances (**Figure 1**, **Table 2**) primarily related to the passage of Hurricanes Irma and María in 2017 and their effects on the forests. Some, however, also acknowledged the positive effect such disturbances have on the forest, particularly over the long term. In addition, the impacts of droughts on the forest were mentioned as an important and increasingly impactful disturbance.
- During the project's second phase, forest use and climate change were also negative drivers of change that all stakeholder groups identified. Increasing temperatures and decreasing precipitation patterns were noted as associated with climate change.
- Institutional factors (such as forest management, regulations, and institutional decision-making) were another frequent driver mentioned by stakeholder groups during the project's second phase.
- Lack of municipal government integration with governmental agencies (state and federal) and other organizations and noise pollution were additional negative drivers of change mentioned by the interviewees; community members mentioned these drivers.

Table 2. Negative factors driving change to El Yunque and its ecosystem services as viewed by different stakeholder groups during the project's first (▲) and second (■) phases.

Driver of change	Stakeholder group							
	Scientists		El Yunque managers		Municipal planners		Community members	
Land-cover change	▲	■	▲	■	▲	■	▲	■
Lack of knowledge	▲	■	▲	■	▲	■	▲	■
Institutional factors	▲	■	▲	■	▲		▲	■
Land-use plans enforcement	▲	■	▲	■	▲	■	▲	
Lack of funds	▲	■	▲	■	▲	■	▲	■
Waste disposal	▲	■	▲	■	▲	■	▲	■
Forest use	▲	■	▲	■	▲	■	▲	■
Species introduction	▲	■	▲	■	▲	■	▲	
Illegal activities	▲	■	▲	■	▲		▲	
Species removal	▲	■	▲		▲		▲	
Natural disturbances	▲	■	▲	■	▲	■	▲	■
Lack of land-use plan	▲			■		■		■
Telecommunication towers				■			▲	
Climate change	▲	■	▲	■		■		■
Water use	▲	■	▲			■	▲	
Hydromodification	▲	■	▲					
Scientific research					▲		▲	
Lack of municipal integration								■
Noise pollution								■

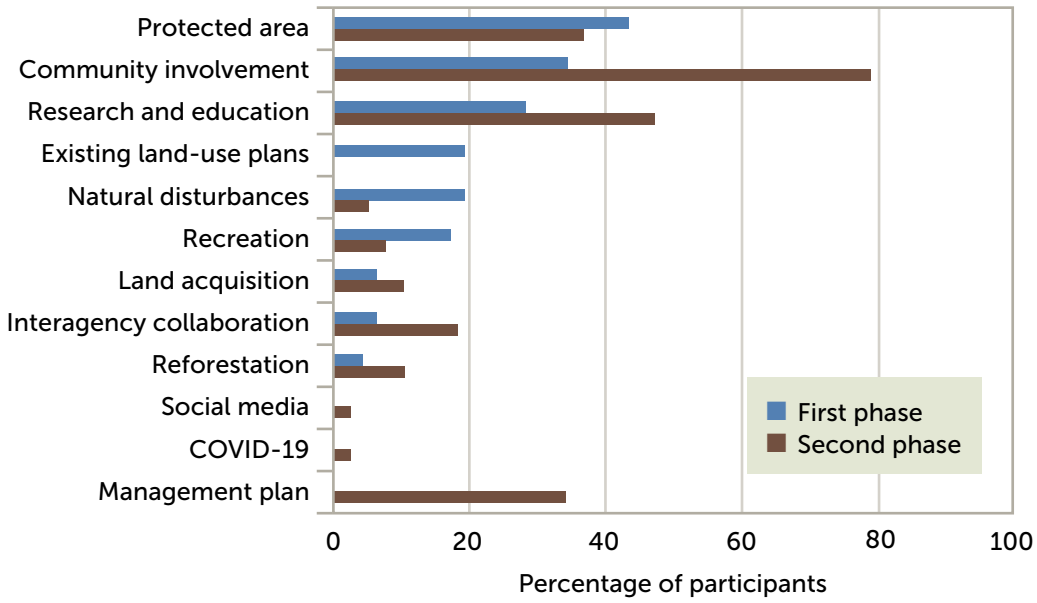
Group mention implies that at least one person in the group mentioned the driver individually.

Positive drivers influencing El Yunque and its ecosystem services

- The most mentioned positive drivers of change during the project's first phase were El Yunque's protection status, community involvement, and research and education (**Figure 2**). All stakeholder groups mentioned these (**Table 3**).
- Community involvement and research and education were the most identified positive drivers during the project's second phase (**Figure 2**) and were mentioned by all stakeholders (**Table 3**).
- Community involvement was related to a change mentioned by interviewees that occurred during the project's second phase: the El Yunque National Forest Revised Land and Resource Management Plan (approved in 2019). All stakeholder groups acknowledged the management plan as a positive driver.
- Regarding research, experiments that enhance our understanding of disturbances and tropical forest functions were mentioned (**Box 2**). Educational initiatives carried out by different groups were also noted. While participants recognized that education and knowledge transfer efforts have increased, they emphasized the need to continue educating and raising awareness about El Yunque, its ecological services, and the factors influencing such services.

- During the project's second phase, some stakeholder groups mentioned COVID-19 and the use of social media as new positive drivers of change, in addition to the land and resource management plan. In the case of COVID-19, the interviewee who mentioned this factor referred to the decrease in the number of people visiting El Yunque during the pandemic and the reduction in the impact on the forest that, in his opinion, occurs when many people visit it.

Figure 2. Positive factors driving change to El Yunque and its ecosystem services, as mentioned by participants during the project's first and second phases.



The percentage (y-axis) was based on 46 and 38 participants during the project's first and second phases, respectively.

Table 3. Positive factors driving change to El Yunque and its ecosystem services as viewed by different stakeholder groups during the during the project's first (▲) and second (■) phases.

Driver of change	Stakeholder group							
	Scientists		El Yunque managers		Municipal planners		Community members	
Protected area	▲	■	▲	■	▲	■	▲	■
Recreation	▲		▲	■	▲	■	▲	■
Community involvement	▲	■	▲	■	▲	■	▲	■
Natural disturbances	▲	■	▲	■	▲		▲	■
Research and education	▲	■	▲	■	▲	■	▲	■
Existing land-use plans	▲		▲		▲		▲	
Interagency collaboration	▲	■	▲	■		■		■
Reforestation	▲			■				■
Land acquisition	▲	■	▲	■		■		■
Management plan		■		■		■		■
COVID-19		■						
Social media				■				

Group mention implies that at least one person in the group mentioned the driver individually.

Box 2. Research and Education in El Yunque National Forest

El Yunque National Forest, also known as the Luquillo Experimental Forest, is well known for its long history of observational, theoretical, and manipulative controlled experimental research (Harris and others 2012; Wood and others 2019).

Research was one of the drivers of change most mentioned by participants of all stakeholder groups as positively influencing El Yunque and peoples' knowledge about forest ecosystem functions. Three manipulative, controlled experiments—where the researcher, either in the field or in a laboratory, manipulates or controls variables to measure their effects—were mentioned as ongoing experiments that enhance our understanding of the effects of disturbance of tropical forests functions: the Canopy Trimming Experiment (González and others 2014; Shiels and González 2014), the Throughfall Exclusion Experiment (Bouskill and others 2013; Wood and Silver 2012; Wood and others 2019), and the Tropical Responses to Altered Climate Experiment (Kimball and others 2018; Wood and others 2019).

Along with research, participants identified education as a positive driver of change in El Yunque; it was also noted that educational initiatives have increased over the last decade. Two examples mentioned were the initiatives of Amigos de El Yunque (a Non-Governmental Organization, https://www.amigosdelyunque.org/) and the Luquillo Long Term Ecological Research Schoolyard Program (a collaborative program between the University of Puerto Rico and the US Forest Service, https://schoolyard.lter.network/). These initiatives provide teachers, students, and other groups with nature immersion experiences, training, and research opportunities related to El Yunque, forest ecology, and socioenvironmental themes. They combine science and art with exploring, learning, discussing, applying, communicating, and sparking creativity.

Photo: Maxwell Farrington / TRACE website

Aerial view of one of the Tropical Responses to Altered Climate Experiment (TRACE) experimental plots. TRACE studies the interactive processes between climate change and hurricane disturbance in tropical forests. (forestwarming.org)

Photo: Noelia Báez Rodríguez

Nature immersion experience coordinated by the Amigos de El Yunque Foundation.

Photo: John Bithorn

Educational and research experience with school students coordinated by the Luquillo Long Term Ecological Research Schoolyard Program.

Conclusion

Stakeholders mentioned different factors influencing El Yunque ecosystem services, both negatively and positively. Forest overuse, climate change, lack of funds, lack of knowledge, natural disturbances, land-cover change, and institutional factors were among the drivers of change all stakeholder groups agreed are negatively influencing El Yunque and its ecosystem services. Community involvement, research and education, and implementation of the new El Yunque management plan were among the positive drivers. The fact that these drivers were acknowledged provides an opportunity to bring stakeholders together to initiate a dialogue about ways to minimize negative effects and maximize positive ones. The fact that stakeholders acknowledge a positive or negative effect of a driver does not necessarily mean people understand how drivers influence an ecosystem and its services. Thus, information exchange and increased knowledge about process-related mechanisms are needed.

Understanding stakeholder perspectives about the factors influencing El Yunque and its ecosystem services is important to identify existing knowledge, areas of agreement and disagreement, and potential gaps in information and information needs. This helps recognize needed actions and interventions and to develop and implement strategies to support El Yunque's ecosystem services. It also assists in identifying themes to trigger dialogue, promote social learning within and between stakeholder groups, and inform management and decision-making at different levels. Additionally, this understanding helps identify topics where knowledge development and transfer of information is needed on different factors and actions influencing the forest, forest functions, and, consequently, the services it provides.

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For more information

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