El Yunque National Forest Ecosystem Services: Stakeholder Perspectives Ten Years Later

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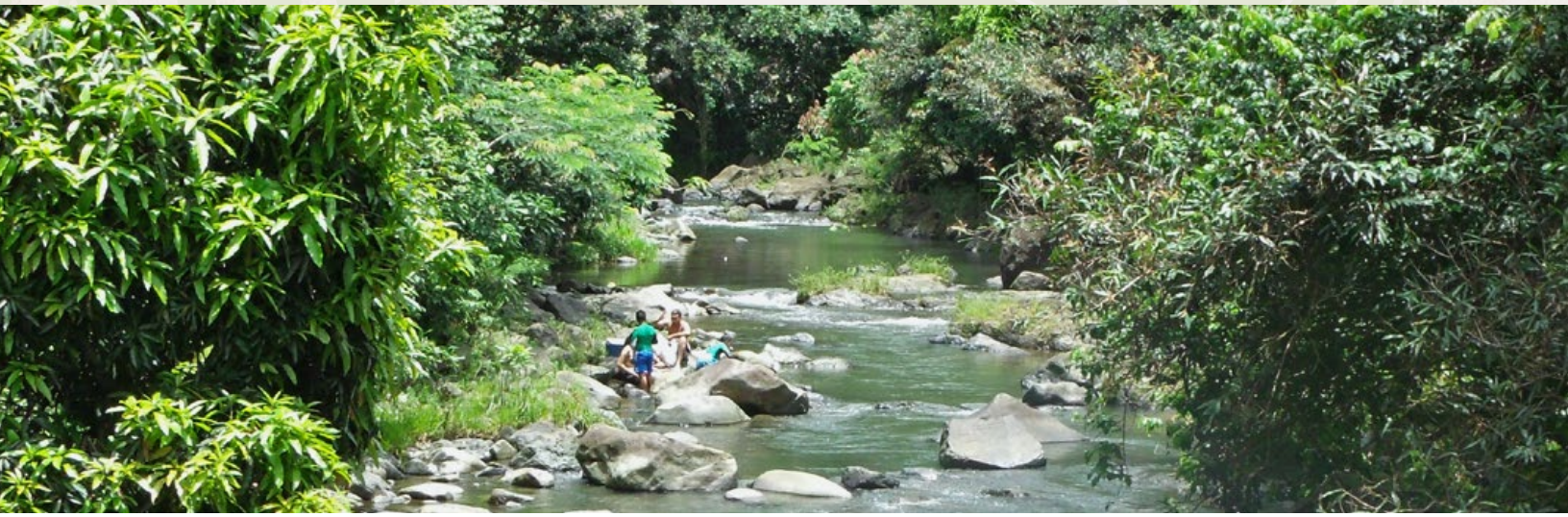

Introduction

Assessing ecosystem services—the benefits that the processes and functions of ecosystems provide to people and other organisms—needs a broad socioecological approach. Moreover, engaging different stakeholders is necessary as decision-making regarding ecosystem services takes place at various levels, from the local to the regional and national. Promoting the involvement of different stakeholders and identifying their perspectives, knowledge, and the values they attribute to ecosystem services are necessary to initiate dialogue among stakeholder groups. This dialogue helps engage people in the conservation, planning, and management of ecosystems and their services.

In this factsheet, we present the perspectives of different stakeholders regarding the ecosystem services provided by El Yunque National Forest (El Yunque, hereafter). 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 services provided by El Yunque were first identified by stakeholders (López Marrero and Hermansen-Báez 2011b). These results can help identify ways to foster dialogue among stakeholders and enable them to share, think, act, and engage in the use, planning, management, and conservation of El Yunque's ecosystem services. They can also help identify information needs regarding the forest and its ecosystem services.

Assessing participant perspectives of El Yunque's ecosystem services

Individual interviews were conducted with stakeholders to document and compare their perspectives of 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, and 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 and categorization of ecosystem services were provided to each participant at the beginning of the interview (**Box 1**). Each participant was then given a list of ecosystem services generated during the first phase of the project (López Marrero and Hermansen-Báez 2011b, see **Table 1**). Participants were asked to review the list and add any additional ecosystem services they believed were provided by El Yunque. After reviewing the list of ecosystem services, participants were asked to identify what they perceived to be the three most important ecosystem services provided by El Yunque and to rank them from most important to least important. Participants were also asked to share their knowledge about whether the provision of the three identified ecosystem systems has improved or increased, degraded or decreased, or remained the same during the last decade (between the first and second phases of the project).

Box 1. Terms and definitions*

Ecosystem services are the benefits that ecosystem functions provide to people and other organisms. These services have been classified into four groups of benefits: provisioning, regulating, sociocultural, and supporting.

- **Provisioning services** are the products and goods produced by ecosystems and obtained directly from them. These are the most tangible benefits derived from ecosystems.
- **Regulating services** are the benefits obtained through the natural regulation of ecosystem processes.
- **Sociocultural services** are the benefits to human well-being that are received from ecosystems. Most of these benefits are non-material, and sometimes they are intangible.
- **Supporting services** are the ecosystem processes necessary for the production and delivery of all other ecosystem services. Their benefits are indirect and play out through the capacity of ecosystems to supply all other services.

*Source: Millenium Ecosystem Assessment (2003).

Key Findings

El Yunque's ecosystem services: stakeholder perspectives during the first phase of the project

- Many of the ecosystem services provided by El Yunque—such as clean water, habitat for flora and fauna, air purification, recreation, and scenic value—were known by participants from all stakeholder groups. Certain ecosystem services were only identified by scientists and forest managers. These ecosystem services fell under two categories—regulating and supporting—and included carbon sequestration, soil erosion control, nutrient cycling, soil formation, and maintenance of biodiversity (López Marrero and Hermansen-Báez 2011b).
- Of the ecosystem services mentioned, most participants ranked water as most important (**Figure 1**). Habitat for flora and fauna and air purification were considered the second and third most important services.
- Variations occurred in the ecosystem services mentioned and their relative importance among stakeholder groups (**Table 2**). Most scientists identified provisioning and supporting services among the three most important; most forest managers, municipal planners, and community members identified provisioning and sociocultural

Table 1. Categorization and description of El Yunque ecosystem services.

Ecosystem service group	Ecosystem service	Description*
Provisioning	Water	Water from rivers and streams for human consumption and recreation
	Flora and fauna	Vegetation and animals that live in the forest, including endemic, endangered, and vulnerable species
	Forest products	Forest and plant products, including wood, fiber, seeds, vines, ornamental plants, medicinal plants, and food (e.g., fruit, vegetables, fisheries)
Regulating	Water purification	Cleaning and purification of water through sediment reduction and water pollutants filtration
	Air purification	Filtering and absorption of air pollutants
	Temperature regulation	Shade, cool air, reduction of temperature
	Natural hazard moderation	Protection against, and damage reduction from, natural hazards, including tropical storms, flooding, and landslides
	Carbon sequestration	Capture and storage of carbon dioxide and their role in reducing climate warming and change
	Soil erosion control	Soil retention and prevention of soil loss due to rain and wind
Sociocultural	Scenic value	Natural beauty, pleasing landscapes, beautiful views
	Spiritual value	Religious practices and beliefs associated with the forest; a place to pray, meditate, and seek spiritual fulfillment
	Human well-being	Mental and physical health, including therapy, tranquility, relaxation, peace, contact with nature, space for sociability, physical exercise
	Recreation	Passive and active recreation, including hiking, camping, water play, bird watching, tours, picnics, family get-togethers
	National patrimony	Forest as a national symbol, historic importance, cultural identity, sense of place, folklore, artistic expression
	Research and education	Advance of scientific knowledge and knowledge transfer; forest use for educational activities, learning about nature; "natural" laboratory, hands-on activities
	Economic development	Direct and indirect income-generating activities, including tourism, guided tours, art, craft, and food selling
Supporting	Rainfall	Production and regulation of precipitation, humidity, and evapotranspiration
	Oxygen production	Production of air; named by some as "the lung" of the region
	Soil formation	Soil production through the weathering of parental material and decomposition of organic matter
	Nutrient cycling	Flow and recycling of nutrients through processes such as decomposition and absorption
	Habitat for flora and fauna	Plant and animal habitat, refuge, shelter, and reserve for species protection
	Maintenance of biodiversity	Processes that support the diversity of plants and animals, such as reforestation, restoration, natural succession, pollination, genetic variability, evolution, migration, and ecological interaction

* The description of each ecosystem service is based on how participants described the services; hence, the descriptions do not necessarily follow any pre-established definitions.

Photo: Antonio González Toro

Figure 1. Water is considered one of the most important ecosystem services of El Yunque.

services. Forest managers also chose supporting services as most important.

- For scientists, water ranked as the most important ecosystem service, followed by habitat for flora and fauna and maintenance of biodiversity.
- Water was also the most important ecosystem service for forest managers, followed by maintenance of biodiversity and recreation.
- Municipal planners also chose water as the most important ecosystem service; flora and fauna and economic development were second and third.
- As for the other groups, community members ranked water as most important, followed by air purification and economic development.

El Yunque's ecosystem services: stakeholder perspectives during the second phase of the project

- All participants agreed on the ecosystem services provided by El Yunque, as listed during the project's first phase (**Table 1**); the interviewees added no new ecosystem services. During the second phase, participants from each stakeholder group

Table 2. Most important ecosystem services as ranked by the majority of participants from each group during the first (▲) and second (■) phases.

Ecosystem service group	Ecosystem service	Stakeholder group							
		Scientists		El Yunque managers		Municipal planners		Community members	
Provisioning	Water	▲	■	▲	■	▲	■	▲	■
	Flora and fauna					▲	■		
Regulating	Air purification						■	▲	
	Temperature regulation		■						
Sociocultural	Human well-being								■
	Recreation			▲	■				
	National patrimony								■
	Economic development					▲		▲	
Supporting	Habitat for flora and fauna	▲							
	Maintenance of biodiversity	▲	■	▲	■				

identified many ecosystem services among those they thought most important.

- Consistent with the findings of the study's first phase, most participants identified water as the most important ecosystem service provided by El Yunque. Maintenance of biodiversity and human well-being were second and third (**Figure 2**).
- As in the first phase of the project, there were variations between stakeholder groups regarding the relative importance attributed to the ecosystem services provided by El Yunque (**Table 2**). In this phase, most scientists focused on provisioning, supporting, and regulating services as the most important. Besides provisioning and supporting services, most forest managers also identified sociocultural ones. Most municipal planners identified provisioning and regulating services, whereas most community members identified provisioning and sociocultural aspects.
- In the scientist group, water ranked as the most important ecosystem service, followed by maintenance of biodiversity and temperature regulation.
- As in the project's first phase, water, biodiversity maintenance, and recreation were the three most important ecosystem services for forest managers.
- For municipal planners, water was the most important; flora and fauna and air purification were second and third.
- For community members, water was also the most important ecosystem service; human well-being and national patrimony followed as second and third (**Figure 3**).

Ecosystem services delivery over time

- While several of El Yunque's ecosystem services were identified as important by participants, there was limited knowledge regarding their delivery over time.
- Many participants believed that service delivery remained constant during the last decade (between the first and second phases of the project), particularly within forest boundaries and except for events such as hurricanes and droughts.
- Water and precipitation, research and education, recreation, economic development, and human well-being were the ecosystem services for which participants provided insights concerning delivery over time (described next). In many cases, however, participants noted that their opinions were

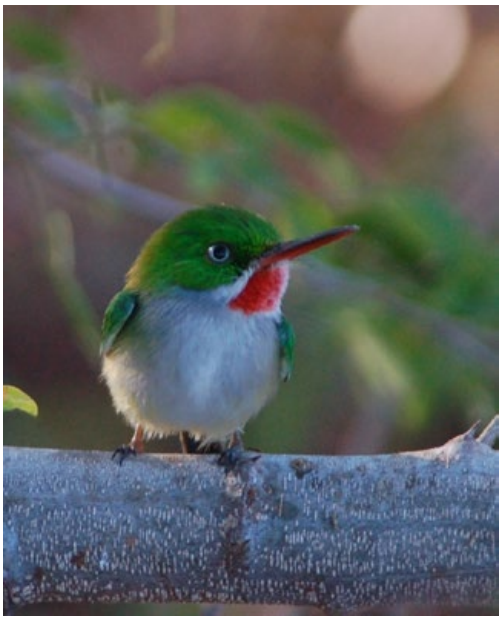

Photo: Iván Vicéns

Figure 2. Habitat for flora and fauna and biodiversity maintenance are important ecosystem services El Yunque provides.

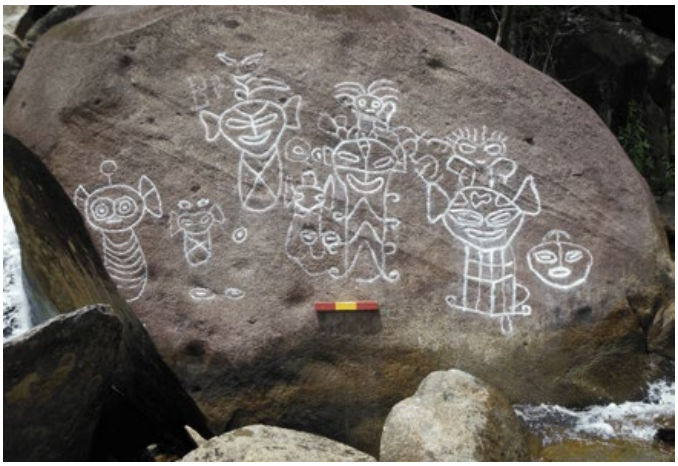

Photo: Raymond Feliciano

Figure 3. Petroglyphs located in El Yunque are part of the national patrimony, cultural, and historical patrimony recognized by participants.

based on perception, not necessarily on data or direct experience.

- Regarding water and precipitation, scientists and forest managers stated precipitation patterns have changed, with a tendency of decreasing precipitation. Some associated these trends with climate change. They also mentioned the occurrence of extreme events—for example, intense hurricanes (like Irma and María in 2017) and droughts (like the one in 2014–2015)—and their effects on lower water quality and quantity. Changing precipitation patterns were also acknowledged by community members. Municipal planners perceived that the quantity and quality of water resources have decreased outside forest boundaries. They related this trend to soil erosion and deforestation; they also acknowledged the potential effects of climate change.
- All stakeholder groups agreed that research and education have increased over time (**Figure 4**). They indicated that climate change was one topic being addressed. They also acknowledged that the gap between research being conducted in El Yunque and the transfer of such knowledge has decreased, as such topics are being discussed in schools and community initiatives. They emphasized, however, that more effort needs to be made.

Photo: Gary Potts

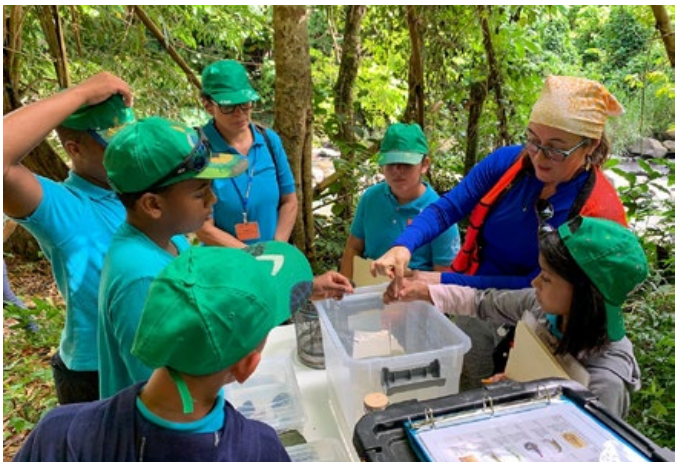

Figure 4. At the Sabana River in El Yunque, elementary school students learn about freshwater shrimps and their importance to all streams and rivers.

- For forest managers, municipal planners, and community members, recreation, economic development, and human well-being have increased over the last decade, although not consistently for everyone and not during specific events (like hurricanes Irma and María in 2017).

Conclusion

Participants from all groups of stakeholders knew and valued many of the ecosystem services provided by El Yunque National Forest. This common knowledge can be used to foster dialogue and actions for ecosystem services decision-making and management. For instance, all groups identified water as the most important ecosystem service provided by El Yunque. The topic of water can thus be used as a starting point to exchange information, promote learning, and initiate collaborative projects and actions that maximize sustainable water use and minimize factors adversely affecting the resource.

While there was a general understanding and recognition of the ecosystem services provided by El Yunque, there were variations between stakeholder groups in their acknowledgement of the importance of these services. For instance, sociocultural ecosystem services were viewed as relatively more important by some groups than by others. This finding reflects the importance of incorporating all types of ecosystem services in initiatives related to their management and conservation. Excluding the range of ecosystem services (provisioning, regulating, sociocultural, and supporting) can result in limits to participation, interest, and involvement of different stakeholders.

Furthermore, the lack of knowledge of ecosystem service delivery over time can also affect decision-making and management; hence, increasing this knowledge is imperative. There is a wealth of research on El Yunque and its ecosystem services. Providing this information and transferring it to various groups allows for effective integration of science,

policy, decision-making, and action at different levels. Identifying gaps in information also helps to identify topics to be considered in future research, education, and awareness-raising efforts.

Understanding the varying perspectives and knowledge of ecosystem services can help forest managers, natural resource managers, and others develop and implement initiatives that promote decision-making, management, and conservation. In addition, it can broaden participation and support from different groups for initiatives that support forest ecosystems and the services they provide.

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For more information

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