

Supplemental Materials for: A Holistic Land Acquisition Process for the Expansion of El Yunque National Forest

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Sponsoring Agency: The United States Forest Service

This report represents work of WPI undergraduate students submitted to the faculty as evidence of a degree requirement. WPI routinely publishes these on its web site without editorial or peer review. For more information about the projects program at WPI, see <http://www.wpi.edu/Academics/projects>.

Supplemental Materials for: A Holistic Land Acquisition Process for the Expansion of El Yunque National Forest

An Interactive Qualifying Project
Submitted to the faculty of
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirement for the
Degree of Bachelor of Science

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Date: 13th of May 2021

Report Submitted To:

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Worcester Polytechnic Institute

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Glossary and Naming Convention for Interviews

Holistic process: One that includes, respects, and balances the goals and priorities of all major stakeholder groups. Holistic processes easily translate to land acquisition given stakeholder groups almost always have different land value perceptions and land use preferences (e.g. community members may want to timber land with high forest cover while a public conservation agency may want to moderate public access).

Urbanization: The process of concentrating high population densities into small land areas (Gao et al., 2020).

Urban land cover: Land areas with eighty percent or more impervious surfaces, such as concrete and cement (López-Marrero et al., 2011).

Urban expansion: The process of increasing urban land cover, peer-reviewed literature suggests current urban expansion is induced by increasing urbanization trends. Meaning, as high population densities move into the same small land area, the land area must expand upwards and outwards to accommodate the growing population (Gao et al., 2020).

El Yunque National Forest (EYNF): A twenty-nine thousand arce, or one-hundred seventeen square kilometer, protected area in northeastern Puerto Rico. El Yunque is owned and managed by the U.S. Forest Service (USFS).

Buffer Zone: A twenty-six thousand arce, or one-hundred five square kilometer, plot of land surrounding El Yunque. Currently, land areas in the buffer zone are owned by private citizens. In 1950, the U.S. Forest Service received Congressional approval to purchase land areas in the buffer zone for conservation purposes. The purchased land areas expand the borders of El Yunque (U.S. Department of Agriculture, Forest Service, 2018).

Luquillo: A municipality that contains parts of the Northeast Ecological Corridor and El Yunque. Luquillo sits on the northeastern side of the park and is roughly fifty kilometers away from San Juan. The municipality also has one of the most accessible park entrances, along PR-191. Hence, Luquillo is a popular tourist destination, especially for international visitors flying into the San Juan Airport.

Sabana: The barrio in Luquillo that directly intersects with El Yunque. Parts of Sabana are actually in El Yunque's buffer zone. Please note, there is also a town called Sabana in this barrio. The town of Sabana, mentioned in the final report and below, is just outside of the buffer zone.

Northeast Ecological Corridor (NEC): A protected area on the northeastern coast of Puerto Rico, owned and maintained by state-level agencies. The U.S. Forest Service would like to create an ecological corridor connecting El Yunque to the NEC.

Naguabo: A municipality that contains the southern part of El Yunque and El Yunque's buffer zone. Naguabo sees fewer international visitors due to its distance from San Juan and lack of easily accessible park entrances. This municipality is also under less development pressure as compared to Luquillo.

Río Blanco: The barrio in Naguabo that directly intersects with El Yunque. Parts of Río Blanco are actually in the buffer zone. Please note, there is a major river and watershed, the Río Blanco, which flows through this barrio and drains into the Atlantic Ocean. Conservation and restoration of the Río Blanco watershed is a major organizational priority for the U.S. Forest Service.

Fee-Simple Acquisition, or Acquisition: Outright transfer of land ownership rights and resource use on the land area in question. For fee-simple acquisition to expand El Yunque, a private landowner must first come to the U.S. Forest Service and indicate a willingness to sell. Afterwhich, the U.S. Forest Service must organize a fair appraisal process. This process can take years to complete.

Conservation Easements: No transfer of land ownership, but the landowner now has restrictions on development. In exchange, they receive a significant tax benefit (Gerber & Rissman, 2012).

In SM-B and SM-C, our interview numbers follow the convention below.

INTERVIEW # Letter - #

Where the first number represents the themes we intended to capture during the interview. Each associate theme and targeted stakeholder is mentioned in our methodology.

The letter represents the municipality discussed during the interview. Letter A indicates Luquillo, and letter B indicated Naguabo. If there is no associated letter, we discussed both municipalities.

The second number represents how many stakeholders were interviewed using the same question types. If there is no second letter, we interviewed one stakeholder.

For example, INTERVIEW 2A-1 was the first interview we conducted with a U.S. Forest Service stakeholder to discuss Luquillo's ecological climate. INTERVIEW 2A-2 was another interview we conducted with a separate U.S. Forest Service stakeholder to discuss Luquillo's ecological climate.

SM-A Consent Scripts

After gauging and confirming interest in our research project, we invited individuals to participate in interviews and focus groups using the emails drafted below. We adapted emails based on the individual's connection to our project goals and objectives. Emails below are edited to remove any identifying information (e.g. contact name and dates of their interviews and focus groups).

Consent Email for Community Member in Buffer Zone Areas of Luquillo and Naguabo

Dear Mx. [Contact Name],

Hello! We are a four-person team of students from Worcester Polytechnic Institute, a small university in Massachusetts, U.S.A. We are working with two faculty advisors, Professors Alex Sphar and Lorraine Higgins, and the United States Forest Service to create opportunities for more community involvement in El Yunque National Forest. Your thoughts and opinions will be incorporated into future land management plans for the forest. Our group is particularly interested in forest expansion, and we would like to hear how you use and interact with the land near El Yunque. We are very interested to hear your perspective, and we invite you to participate in a one hour interview. Two team members will join you for your interview. We will open a space for you to discuss and map your ideas. Following the interview, we invite you to participate in a one hour focus group. We will also invite a small number of your peers and colleagues to discuss and map your ideas together. Focus group members may be members of the U.S. Forest Service, community leaders, local businessmen and women, and peers. Four team members will help moderate your group discussion. We will intervene if the dialogue becomes uncomfortable or disrespectful. We want all participants to feel safe and welcome throughout the entire process.

We will take your feedback to the U.S. Forest Service and recommend ways to respect and implement your thoughts and opinions in future land acquisition plans. The research will be published in a Worcester Polytechnic Institute online database, and the general public will have access to this research. Your thoughts, opinions, and ideas will be shared only for research purposes, and your anonymity will be maintained. The entire process is voluntary, and you may stop at any time. Questions before the interview and focus group are welcome. If you have any questions, comments, concerns, please feel free to reach out at gr-LAP_ElYunque_PR_C21@wpi.edu. We look forward to working with you.

Best Regards,

Isabella Ferrari, Sarah Piela, Justin Riley, and Calvin Thomas

Researcher's Name and Signature

Date

Participant's Name and Signature

Date

Consent Email for Community Member in Buffer Zone Areas of Luquillo and Naguabo

Dear Mx. [Contact Name],

Hello, we are a four person team of students from Worcester Polytechnic Institute, a small university in Massachusetts, U.S.A. We are working with two faculty advisors, Professors Alex Sphar and Lorraine Higgins, and the United States Forest Service to create opportunities for more community involvement in El Yunque National Forest. Your thoughts and opinions will be incorporated into future land management plans for the forest. Our group is particularly interested in forest expansion, and we would like to gauge your thoughts about El Yunque's current management and the climate in El Yunque's buffer zone. We are very interested to hear your perspective, and we invite you to participate in a one hour interview. Two team members will join you for your interview. We will open a space for you to discuss and map your ideas together. Following the interview, we invite you to participate in a one hour focus group. We will also invite a small number of your peers and colleagues to discuss and map your ideas. Focus group members may be members of the U.S. Forest Service, community leaders, local businessmen and women, and peers. Four team members will help moderate your group discussion. We will intervene if the dialogue becomes uncomfortable or disrespectful. We want all participants to feel safe and welcome throughout the entire process.

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Best Regards,

Isabella Ferrari, Sarah Piela, Justin Riley, and Calvin Thomas

Researcher's Name and Signature

Date

Participant's Name and Signature

Date

SM-B U.S Forest Service Interview Summaries and Annotated Maps

Interview 1

One interview that was conducted in the first objective of our project focused on the regions of Luquillo and Naguabo. For the region of Luquillo they mentioned a regional interconnecting trail and the Northeast Ecological Corridor (NEC) that was a focus for the USFS. In the region of Naguabo there is a focus on watershed conservation and protection. They noted that it has been awhile since they've worked with the demographics of the region and recommended that we look at census data to get more accurate data. There are different options depending on the community and region (e.g. land trust, development, or US Forest Service). Recommended using CRIMPR database (<https://www.crimpr.net/CMS/28>) which is a municipal tax database and allows different land parcels to be shown. Also gave three additional contacts that could benefit our research.

No map created

Interview 2A-1

This interview started off with an initial snowball sampling of people they recommended we should talk to in the future. They were then shown a map of Luquillo and asked to identify areas with ecological value. When looking at the map of Luquillo they mapped a rough outline of the NEC. This guided much of the discussion, the NEC has had no surveys conducted throughout it. The area is a mix of heavy forest and rural areas containing communities. It was estimated that fifty percent of the community was not connected to a sewage system and was relying on septic tanks that have poor maintenance records. A discussion was had about the Puerto Rican Parrot, an endangered species residing in El Yunque, and its location. This discussion led to the type of habitat that is best for the parrot and its migration habits. Puerto Rican parrots don't breed well in the rainforest climate that exists in El Yunque, they are also timid of humans in their area and tend to avoid those areas. It was found that a different region of the island is better for the parrot. While analyzing the map the interviewee said they would like to see the NEC expanded and have it connected from El Yunque to the coast. Noted that the coastal region is under the greatest threat from development. While looking at GIS maps after the interview we found that there is a protected area on the coast that could be connected to El Yunque. After this we discussed what makes El Yunque a rainforest and the harmful effects that urbanization around the coastal region could have. Next we discussed how land acquisitions are done and important things to remember when analyzing land. It is important to not displace people while acquiring land and think about the economic effects it could have on the region. Towards the end of the interview we discussed the struggles the USFS is currently having with management of the forest. This struggle is caused by a few different problems. The first is due to budget cuts caused by the pandemic, this causes the USFS to not have the forest open seven days a week. There is also only one road into the visitor center which is being rebuilt due to hurricane Maria. The capacity of certain sections of the park are hit and this causes them to have to close the park to more visitors. The interviewee said this could be solved by having more entrances with opportunities around the entrances for people to interact with the forest.

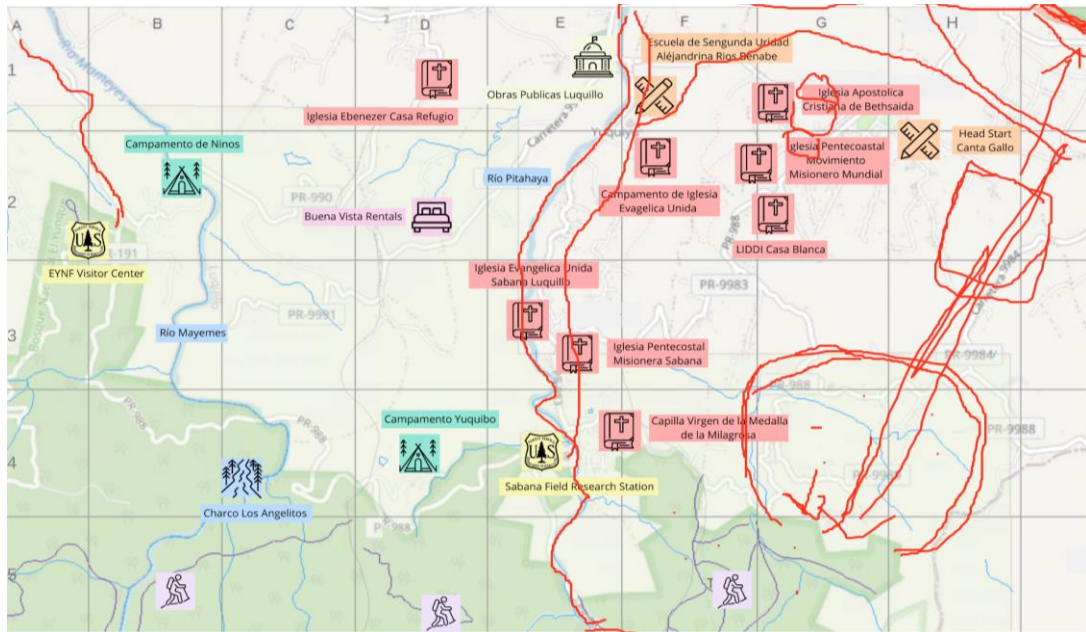


Fig. 1. Annotated Luquillo map from interview 2A-1 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). Annotations determine locations of particular value. This map indicated the location of a potential hiking trail in the NEC.



Fig. 2. Annotated Luquillo GIS map from interview 2A-1 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This map is adapted from figure 1 with the red and blue areas having significant value and therefore good places to acquire according to the participant that made the annotations. The map was generated using GIS software which allowed for area calculation.

Table 1. Acquisition Suitability and Associated Difficulties for Commonly Mapped Land Areas of Luquillo as perceived by the U.S. Forest Service in Interview 2A-1.

Land Area	Spatial Location	Approximate Size (km ²)	Criteria that makes area suitable for acquisition	Acquisition Difficulties in Land Area
Area to Expand Northeastern Corridor	G4, H4	2.4	Expansion of NEC	Some urban development in the region (two neighborhoods)
Predicted Hiking Trail	E2, E3, E4, E5	1	Create new hiking trails	Flooding in the area along the river

Interview 2A-2

During this interview we focused on general conservation in the area of Luquillo as this was the area they were most familiar with. They discussed how forest planning is moving towards having community involvement in the process. While looking at the GIS map that was created they identified that by the Sabana research station there is a community there. They also notified us of a dam on the river and that future damming of the river could affect the biodiversity of the river. This is due to separating the river and blocking off migratory paths. Given the region they thought that watershed protection should be a primary goal. The reasons for watershed protection being a primary goal is because rivers run through and eventually into different ecosystems. Protecting rivers in as many areas as possible allows for protection in that area but also protection from pollutants in other areas downstream. They believed that the community members near the research station would be open to conservation in the area especially if it focused on watersheds. The Sabana community has a problem with pollution because of septic wells that overflow when there is heavy rain. For areas to acquire they recommended similar areas to interview 2A-1. The NEC and the area around the Sabana river are both at risk of urbanization. They believed that the region could benefit economically from grassroots and ecological conservation and weren't too concerned about development in the region as long as it is sustainable. For choosing additional areas for acquisition they said it depends largely on the areas at risk to urbanization.

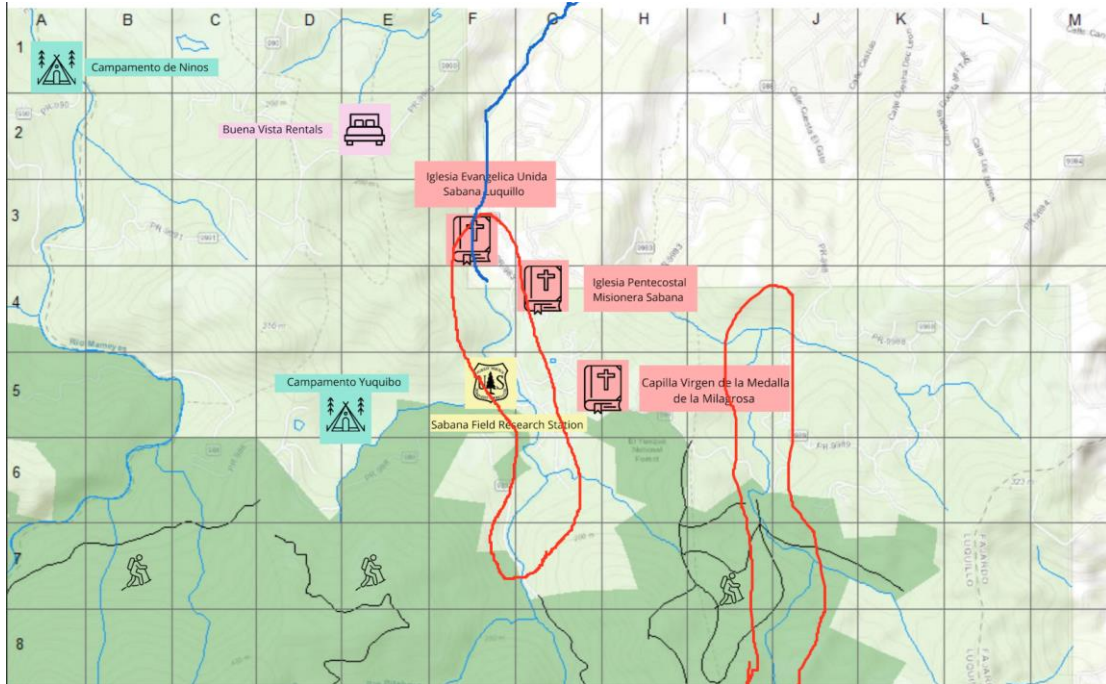


Fig. 3. Annotated Luquillo map from interview 2A-2 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). Participant from interview 2A-2 indicated ecological value in the red outlined regions. These locations have important watersheds that could benefit from conservative action. .

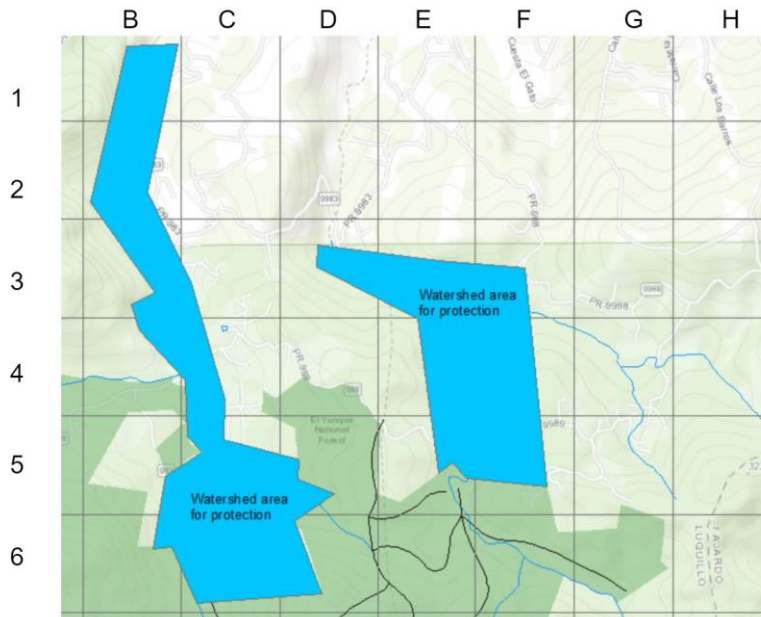


Fig. 4. Annotated Luquillo GIS map from interview 2A-2 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This map was adapted from figure 3 using GIS software to better identify given regions for acquisition.

Table 2. Acquisition Suitability and Associated Difficulties for Commonly Mapped Land Areas of Luquillo as perceived by the U.S. Forest Service in Interview 2A-2

Land Area	Spatial Location	Approximate Size (km ²)	Criteria that makes area suitable for acquisition	Acquisition Difficulties in Land Area
Left watershed	F2, F3, F4, G5, G6, G7	1.05	Watershed preservation and land connectivity	Community presence along the river
Right watershed	H4, I4, J4, I5, J5, I6, J6	0.72	Watershed preservation and expansion of NEC	Community presence in some regions

Interview 2B

For this interview we focused on Naguabo because we wanted to gain more knowledge on different techniques used in landslide prevention. The interviewee was chosen for this interview because of their extensive knowledge on the forest landscape and plantlife. The ecological climate of Naguabo is a secondary forest and considered more mature. The area is more sandy and prone to landslides. Landslides block roads and disrupt river flow occasionally. Certain tree species are used to solidify soil and stabilize the soil, these are frequently native palm trees such as coconut palms, royal palms, sierra palms, and other species that the U.S Forest Service can get. Many of these trees are kept on standby in greenhouses, this allows them to be available to be planted quickly. The whole area is better for more experienced hikers because of the terrain and dangerous conditions that the landscape has. Important takeaways from the conversation held was that agencies and organizations need more communication amongst each other. These entities need to work together to protect the forest and healthy coordination is needed. An example of needed collaboration was in the aftermath of hurricane Maria there was abundant tree cover destroyed and ground temperatures rose which impacted water cycles in the area.

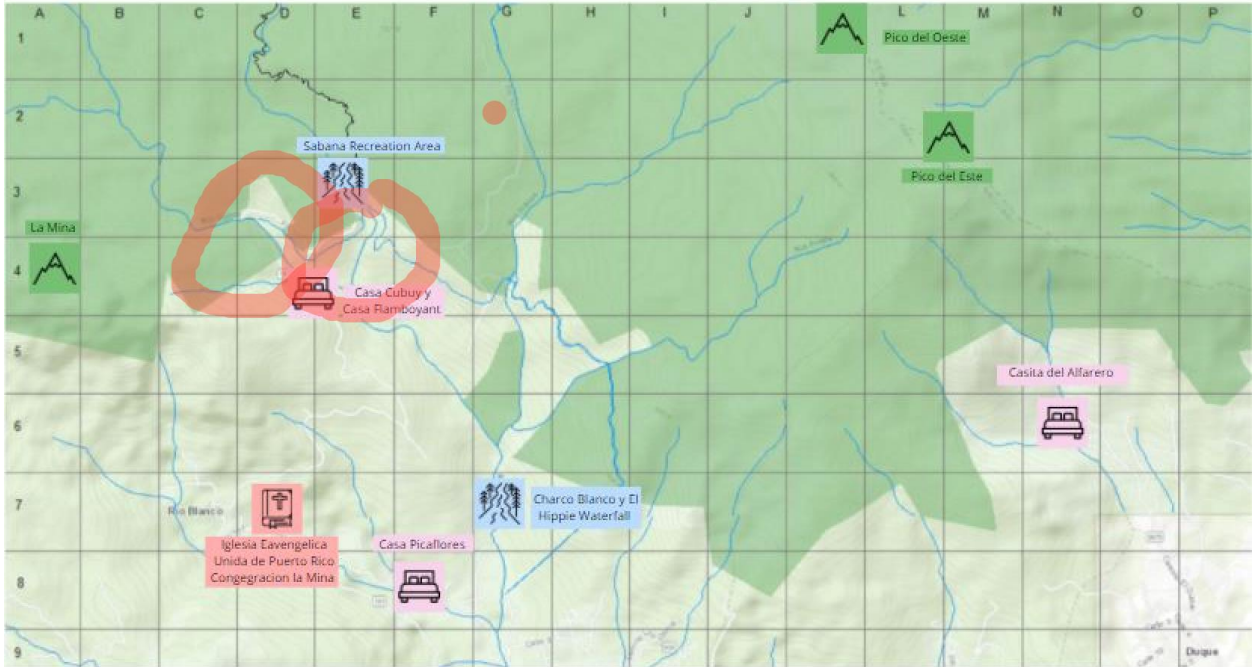


Fig. 5. Annotated Luquillo map from interview 2B (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). Participant from interview 2B annotated this map indicating the most value in the Sabana recreational area.

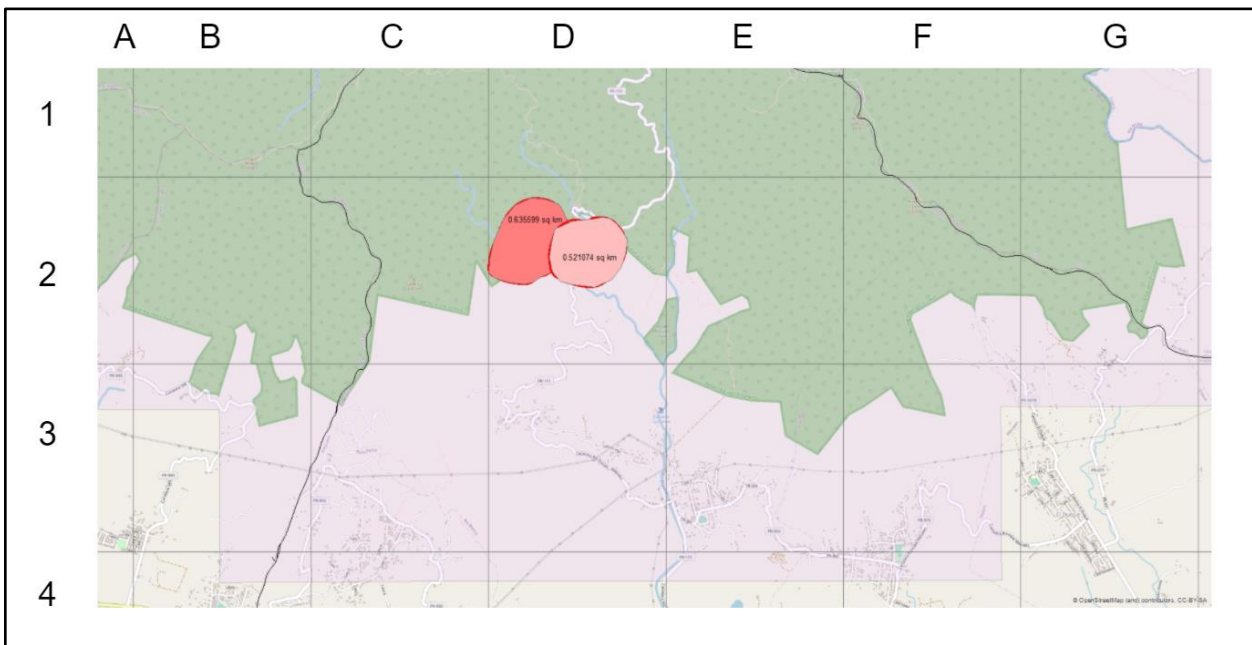


Fig. 6. Annotated Luquillo GIS map from interview 2B (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This is the adapted version of figure 5 made in GIS.

Table 3. Acquisition Suitability and Associated Difficulties for Commonly Mapped Land Areas of Naguabo as perceived by the U.S. Forest Service in Interview 2B

Land Area	Spatial Location	Approximate Size (km ²)	Criteria that makes area suitable for acquisition	Acquisition Difficulties in Land Area
East of Sabana Recreational Area	D3, D4	0.635	Needs attention for landslide management and preservation	Steep and Landslides
South of Sabana Recreational area	E4	0.521	Needs attention for landslide management and preservation	Steep and Landslides

Interview 3

This interviewee was chosen because of their vast knowledge of the areas of Luquillo and Naguabo. They also have worked in ecology and land planning in the past. The interview started with some background information where we discussed different types of GIS maps and how to analyze that information. We also discussed how to find information on ecosystems. Talked about the NEC and the viability of it and how it could be connected to the coast. There was then a discussion on what to look for with regards to permits. Any areas with permits such as environmental or building permits should be avoided because it means that there are already projects being built and acquisition of those lands would be difficult. Recommended that we look for areas zoned for agricultural use. Told us about the trail that is connecting El Yunque to the coast. They also warned us of a possible age gap when it comes to conservation. The interview ended with them telling us to look for government land that could create economic value.

No map created

Interview 4

This interview was held with the project sponsor and was geared towards more logistical approaches to this project and community dynamics of Luquillo and Naguabo. Major takeaways from this interview were the differences in the two municipalities. These differences being that Naguabo is a less tourist avid area, Naguabo is full of more locals who do a lot of work in agriculture and similar industries. This area has a more secluded feel where the edge of the forest is steeper than other places and has significant ecological value. The Naguabo part of El Yunque is less accessible and has less hiking trails for novice hikers. This area is prime for the advanced explorers and not for the faint of heart. The culture in this area reflects that and deeper connection to the forest compared to Luquillo. Luquillo being a slightly more commercialized place that hosts the tourists from the coast and capital. Luquillo also has more accessible entrances to the forest making it easier for these tourists. Luquillo also hosts the Northeast ecological

Corridor (NEC) which is of interest to the U.S Forest Service because of its potential to connect to another protected region on the coast. During the interview it was also established that much of the U.S Forest Service and affiliates would like to see the forest rounded out. This aligns with some of the data collected from other interviews with U.S Forest Service members.

No map created

Interview 5

This individual was chosen for this interview because of their knowledge of the area. They believe that the best method to complete this land acquisition is to get community involvement because the previous methods that failed were more centralized. One of the threats that they mentioned was the loss of some revenue for mayors in the area and some fiscal harm is possible for some municipalities. However, the major benefits besides ecosystem services is outdoor recreation boost and decreasing the private over use of some land. The interviewee got into immense detail about helpful ways for the team to suggest benefits to the community. They also supplied information on the state of Luquillo and Naguabo after looking at the maps presented. They focused on the terrain that Luquillo has, referencing how it is not as steep as Naguabo. It is also more built up with more roads and infrastructure. There is some damage in water runoff as well. Watershed protection is a major concern as a result of this, therefore there is an urge to obtain jurisdiction and protect these areas.

No map created

SM-C Community Interview Summaries and Annotated Maps

Interview 6

This interviewee was chosen because of their relationship with the community as a community leader. The interviewee has a lot of experience with tourism in Puerto Rico, they worked at a Puerto Rican tourism company for six years. They provided context on Naguabo and Luquillo's relationship between tourism and the local community. They stated that the political status of Puerto Rico has led to a lot of unfair financial statuses and situations for many. There is a long history of corruption with Puerto Rico among the federal government and therefore many communities and Puerto Rican's do not trust the federal government which includes the United States Forest Service. They also mentioned that Puerto Rico has not had a huge emphasis on conservation, it is not part of Puerto Rico's DNA. Therefore, more initiative is needed to refocus the communities and get them to appreciate as well as sustain nature which includes El Yunque National Forest. The interviewee has many Contacts around the forest that are helpful in elaborating on these state of conservation efforts. These Contacts are also useful for obtaining a viewpoint on the acquisition process.

No map created

Interview 7

This interviewee works at a local conservation group responsible for conserving nature throughout Puerto Rico. Much of the work they do is in the eastern part of the island and El Yunque. This interviewee was chosen for this interview because of their familiarity with the regions of Luquillo and Naguabo, mostly focusing on the state of the region's health. Their conservation background makes them a qualified candidate to speak on the dangers or concerns that are raised for the landscape around El Yunque. During the interview, the participant gave ample information regarding the watersheds in the forest that are important for the surrounding communities. Prioritizing these regions' health would be of the most concern for the forest however the rest of the proclamation area and forest are of no concern. Following this discussion, the interviewee elaborated on community relationships with the forest and U.S Forest Service. A notable point is that many locals use the forest for resources such as leaves, branches, full plants, berries, seeds, and nuts. They use these for various wants and needs, so a method for appeasing the community is allowing unrequited access to these resources for their land if need be. Yet at the same time, acquiring parcels throughout the surrounding communities may not be necessary if the goal is to preserve a given plot of land. The U.S Forest Service does not have to deal with these issues alone, so a collaboration with other organizations may be the better solution. Owning the land isn't the best way every time, other forms of diplomacy might be. On top of all of this the interviewee finished by explaining the complex history that the U.S Forest Service has with the forest and community. There is still some misunderstanding and distrust between the two groups so further action must be in the direction of appeasement.

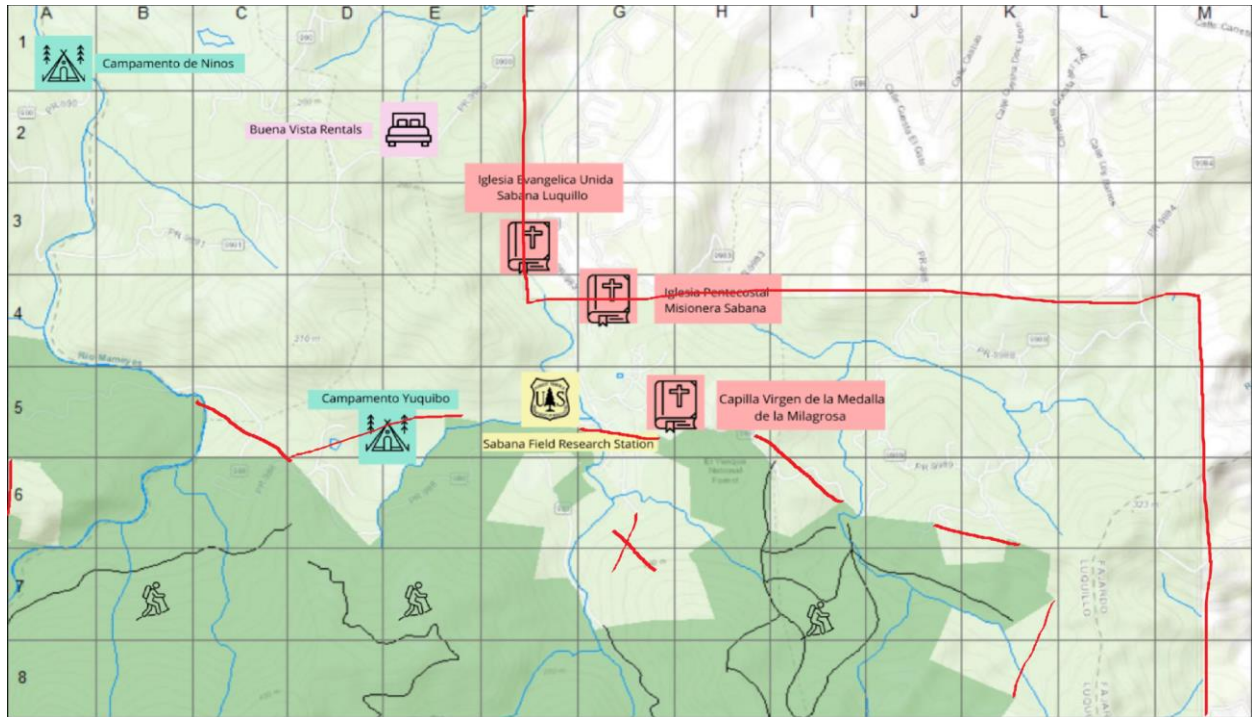


Fig. 7. Annotated Luquillo map from interview 7 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). Participant from this interview recommended that the forest be rounded out and have the pockets acquired.

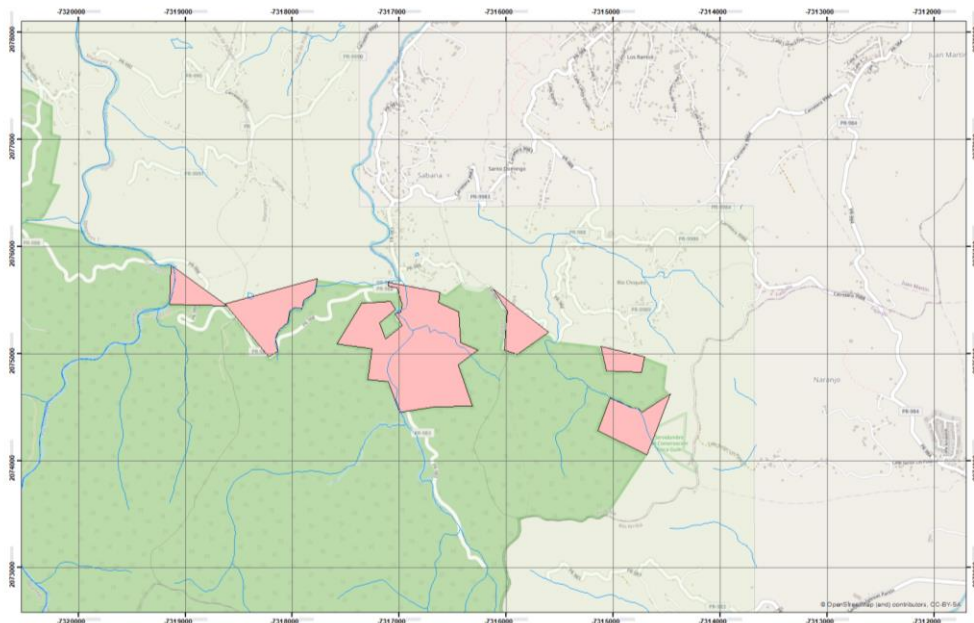


Fig. 8. Annotated GIS Luquillo map from interview 7 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This is the GIS adapted map from figure 7. The pockets of the forest were filled in to round out the forest.

Table 4. Acquisition Suitability and Associated Difficulties for Commonly Mapped Land Areas of Luquillo as perceived by the Community in Interview 7

Land Area	Spatial Location	Approximate Size (km ²)	What does the participant do there/Want to see there?	Land Value(s) Based on Current and Future Land Use	Could El Yunque's expansion address what the participant wants to see there?
West Campamento Yuquibo	A5, B5	0.099	Acquisition to fill up inconsistencies	Ecological	Yes
East Campamento Yuquibo	B5	0.259	Acquisition to fill up inconsistencies	Ecological	Yes
South of Research station	C5, D5, C6, D6	0.9023	Acquisition to fill up inconsistencies	Ecological	Yes
East of Research station	E5	0.1182	Acquisition to fill up inconsistencies	Ecological	Yes
East of Capilla Virgen de la Medalla de la Milagrosa	F6	0.067467	Acquisition to fill up inconsistencies	Ecological	Yes
South of Capilla Virgen de la Medalla de la Milagrosa	F6	0.197303	Acquisition to fill up inconsistencies	Ecological	Yes

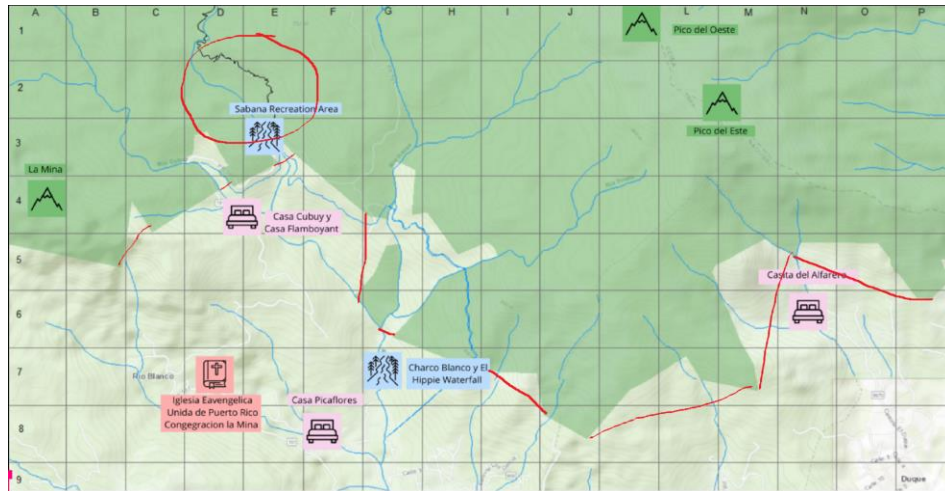


Fig. 9. Annotated Naguabo map from interview 7 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). Similar to Luquillo maps, this participant wants to fill in the pockets of the forest.

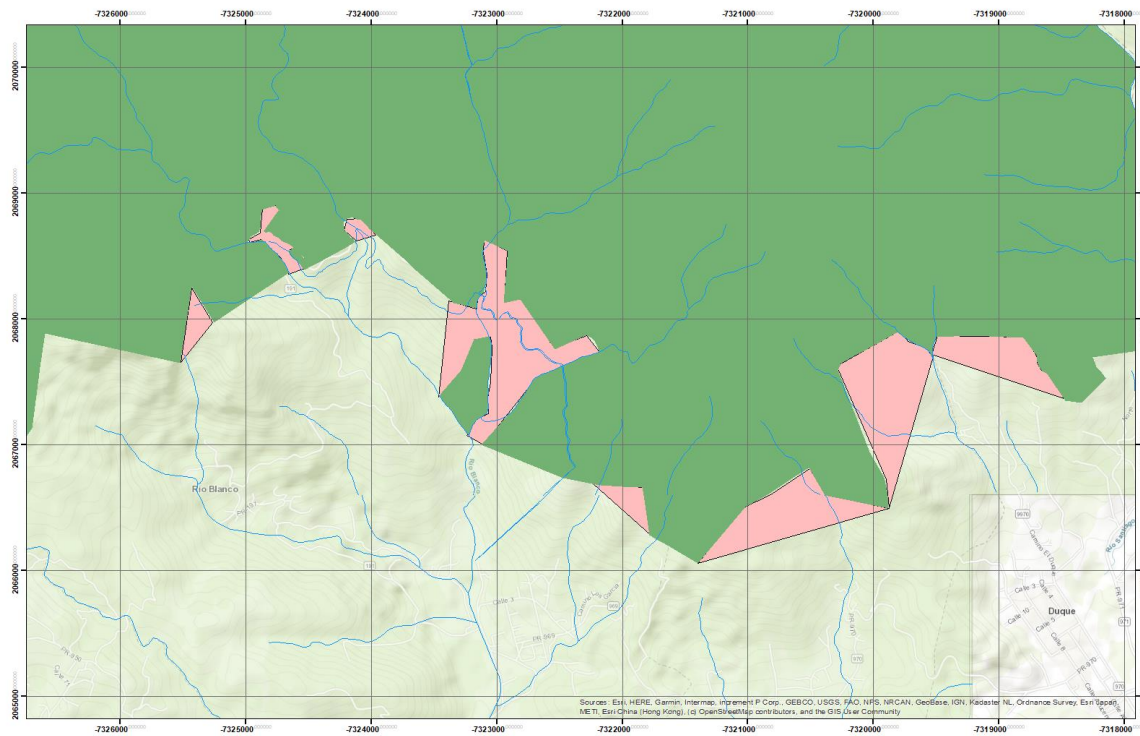


Fig. 10. Annotated Naguabo GIS map from interview 7 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This is the GIS adapted map from figure 9 with the pockets filled.

Table 5. Acquisition Suitability and Associated Difficulties for Commonly Mapped Land Areas of Naguabo as perceived by the Community in Interview 7

Land Area	Spatial Location	Approximate Size (km ²)	What does the participant do there/Want to see there?	Land Value(s) Based on Current and Future Land Use	Could El Yunque's expansion address what the participant wants to see there?
Near Sabana Recreational area	B7	0.062282	Acquisition to fill up inconsistencies	Ecological	Yes
Near Sabana Recreational area	C6	0.100872	Acquisition to fill up inconsistencies	Ecological	Yes
Near Sabana Recreational area	C6	0.028	Acquisition to fill up inconsistencies	Ecological	Yes
North of Charco Blanco	D6, E6, D7, E7	0.6687	Acquisition to fill up inconsistencies	Ecological	Yes
East of Charco Blanco	E8, F8	0.07536	Acquisition to fill up inconsistencies	Ecological	Yes
East of Charco Blanco	F8, G8	0.3879	Acquisition to fill up inconsistencies	Ecological	Yes
West of Casita Alfarero	G7, H7	0.4976	Acquisition to fill up inconsistencies	Ecological	Yes
West of Casita Alfarero	H7, I7	0.2547	Acquisition to fill up inconsistencies	Ecological	Yes

Interview 8A

This interviewee was chosen because of their connection to Luquillo which helped to shape our area of focus. It was recommended to us that we look at lands underdevelopment before choosing a path. Lands with permits will be harder to acquire near. We were also informed of a 5 meter buffer area from the edge of rivers out and this would allow for river protection. This water protection is something that the people of Sabana are passionate about. One issue is that the river does go through some private residences and it is unclear if that land is owned by the government or the land owner. Learned that much of the area is made up of low

income housing developments. The interviewee sent an email later in the day with a list of people to contact.

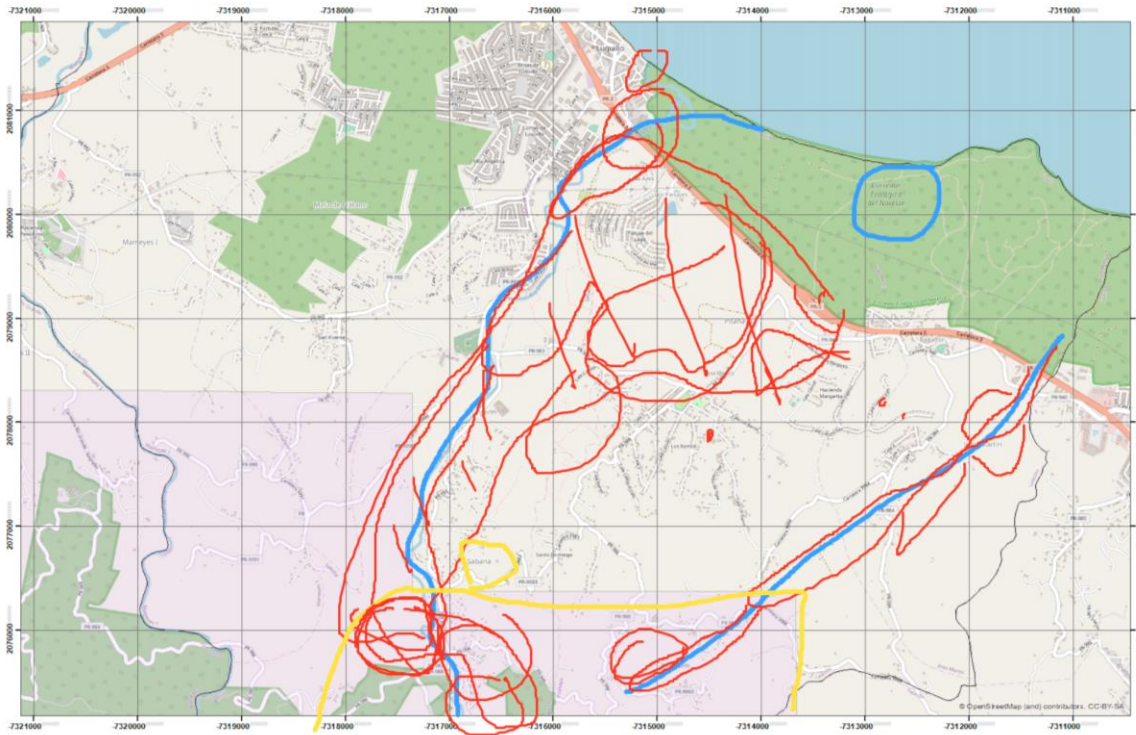


Fig. 11. Annotated Luquillo map from interview 8A (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). The participant from this interview indicated the feasibility of connecting the coastal protection area to El Yunque through the NEC.

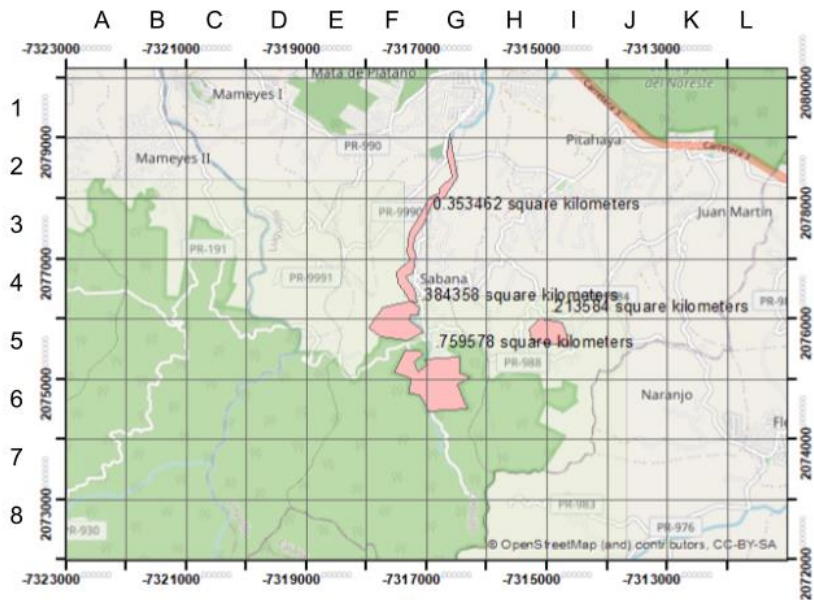


Fig. 12. Annotated Luquillo GIS map from interview 8A (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This is the GIS adapted version of figure 11 with a few areas selected for acquisition as a stepping stone to connecting the coast and the forest.

Table 6. Acquisition Suitability and Associated Difficulties for Commonly Mapped Land Areas of Luquillo as perceived by the U.S. Forest Service in Interview 8A

Land Area	Spatial Location	Approximate Size (km ²)	What does the participant do there/Want to see there?	Land Value(s) Based on Current and Future Land Use	Could El Yunque's expansion address what the participant wants to see there?
Along the Sabana river	G2, F3, F4	0.3535	Conservation and local enforcement of conservation efforts	Social and economic value from recreational opportunities	Yes
River basin entrance to El Yunque	F4, F5	0.3844	Conservation and local enforcement of conservation efforts	Social and economic value from recreational opportunities	Yes
Pocket region south of the Sabana river	F5, G5, G6	0.7596	Conservation and local enforcement of conservation efforts	Social and economic value from recreational opportunities	Yes
Satellite location outside of forest boundaries	H5, I5	0.2136	Conservation and local enforcement of conservation efforts	Social and economic value from recreational opportunities	Yes

Interview 8B

This interviewee was recommended to us for an interview regarding community relations. They participate heavily in the protection of the rainforest. Ideally, they wanted to show organizations why they're protecting the rainforest. Much of their organization's work was done in the Sabana recreational area working with trails in the forest as well as monitoring the watershed status in the area. Naguabo is primarily a region for extreme hikers or those that are more experienced compared to Luquillo. They would like to see a hiking trail connect the northern part of the forest down towards the Sabana recreational area. Overall, the sentiment that the interviewee expressed was positive in the U.S Forest Service acquiring parcels of land in the locations described.

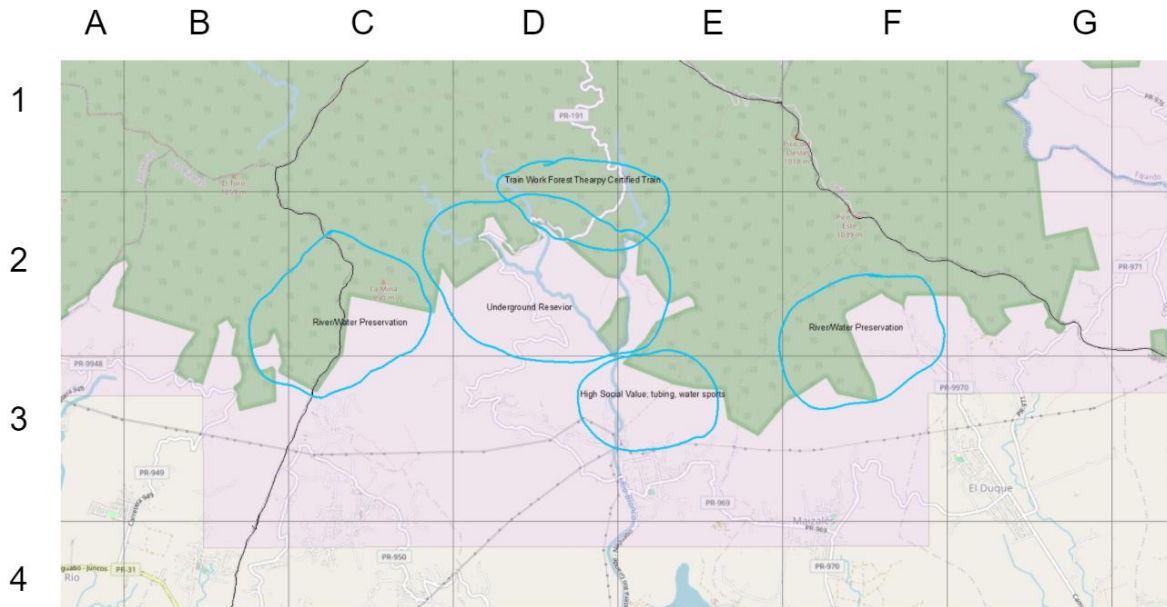


Fig. 13. Annotated Naguabo map from interview 8B (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This map shows heavy emphasis on the value of watersheds and the surrounding areas near Sabana recreational Area.

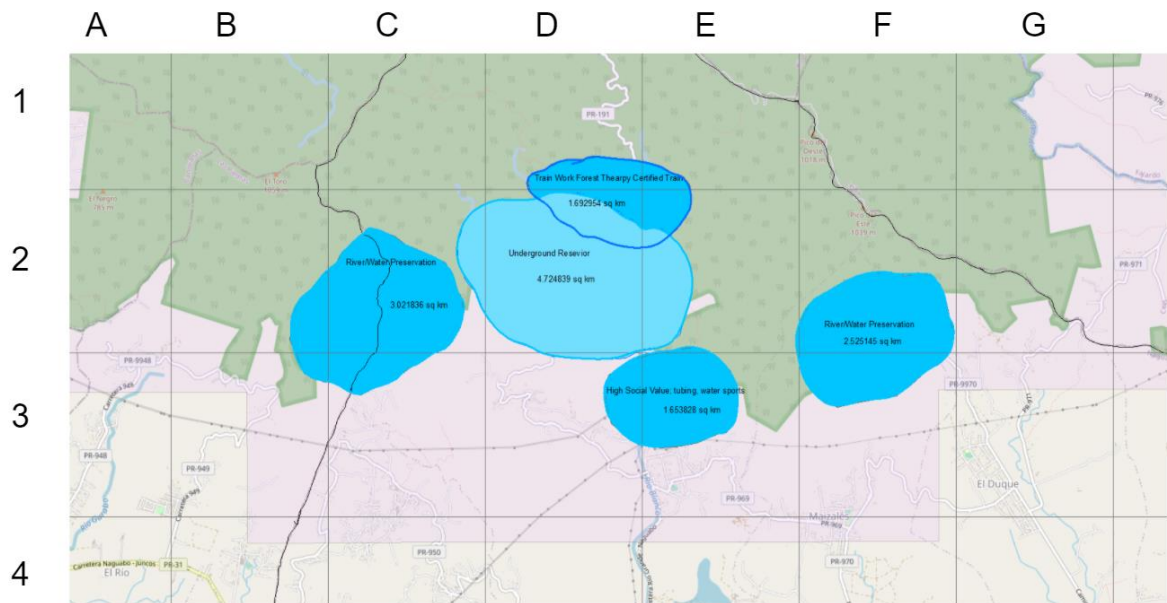


Fig. 14. Annotated Naguabo GIS map from interview 8B (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This is the GIS adapted version of figure 13, the areas of the selected parcels are displayed as well.

Table 7. Acquisition Suitability and Associated Difficulties for Commonly Mapped Land Areas of Naguabo as perceived by the Community in Interview 8B

Land Area	Spatial Location	Approximate Size (km ²)	What does the participant do there/Want to see there?	Land Value(s) Based on Current and Future Land Use	Could El Yunque's expansion address what the participant wants to see there?
Sabana Recreational Area	D2	1.692954	Therapy certified trail and hiking	Underground reservoir, and watershed	Yes, acquiring this space preserves it
Near El Hippie Waterfall	E3	1.653828	Recreational activities, tubing, swimming, education	River access	Yes, preservation of the river
Casita del Alfarero	F2	2.525145	River use	Water supply to local area	Yes, protect the water here
West of Sabana Recreational Area	C2	3.021836	Underground reservoir	Water supply to local area	Yes, protect the water supply
Sabana Recreational Area	D2	4.724839	Underground reservoir	Water supply to local area	Yes, protect the water supply

Interview 9A-1

The interview started with him giving a brief description of the region and how it has evolved since the 19th century. They talked about how factories have changed the region and how community members use the area around them to sustain. After seeing the map of Luquillo they talked about how the community is a mix of people who have lived there for many years and the younger generation. There is also a poor economy in the region with a constant flood of tourists. They expressed the need for agencies to work with the community more to allow for protected areas to be used economically by the community. It was also expressed that there is a distrust in the U.S. Forest Service that could be addressed with more community outreach. When asked about expansion they said that people will feel like the land is being taken from them. They also talked about how tourism is out of San Juan due to the cost of the permits, this gives less opportunity to the community members outside of San Juan. There are many young people who need work, this could be addressed if the USFS brought these individuals in as guides for hikes or allowed them to work on farms that won't damage the ecology of the forest. They mentioned how Sabana is passionate about water protection and that urbanization would be good if it does not affect the forest.

No map created

Interview 9B-1

This interview was centered around Naguabo and the processes of the U.S Forest Service. The major takeaways from this interview were the ecological and social value of the upper area of the buffer zone that closely borders the forest. These areas have heavy tourism and relative importance to the community. The interviewee was skeptical of U.S Forest Service involvement and the benefit that they could provide to the area. However, the more transparent all stakeholders are, the more likely the acquisition process is to happen without pushback. The interviewee elaborated on the importance of preserving the culture and history in this area too. In previous years, large federal entities have not respected the culture of locals as much as they could. Overall, the sentiment of the interviewee was distrustful of the Forest Service but their view could be persuaded with better management. As for other valuable locations, the regions that are in the most need of preservation are the land parcels that are north of casa picaflores. This region is the most lush for being outside of the forest itself. Yet no major damage is being done here, the future is uncertain and rising climate change as well as development could be a potential threat.

No map created

Interview 9B-2

The interview was held with an employee of the Friends of El Yunque Foundation. The interviewee is the project coordinator and works closely with the forest. Much of the work that this organization does is controlling the invasive species coverage in El Yunque. The areas of interest in Naguabo that the interviewee mentioned have been having this issue for a relatively long time and more aid from other agencies could be very effective. In fact, this interviewee made clear that the entirety of southern El Yunque is very valuable not only economically but socially to the community. A U.S Forest Service presence would be a good thing and helpful to the health of El Yunque as well as the future of the community there. Having this organization have more jurisdiction in the area could be very beneficial not only for land preservation but also water preservation such as the various rivers running through the forest that supply water to nearby communities.

No map created

Interview 10A

For this interview a member of the community was selected who had knowledge of Luquillo and could represent public opinions on the area bordering El Yunque. They talked about how community members have knowledge about the forest but they don't feel like they have an active relationship with the forest manager. While looking at the map of Luquillo they recommended some areas for acquisition and supported acquiring up the river for the hiking trail. They talked about using some of the old dams and plantations as an area to show how the forest used to be used. This would be an opportunity to educate locals about the forest and conservation. This could also be done on guided tours which would bring economic value to the land. They talked about how the RíoPitahaya is already used by locals for recreational activities such as swimming. They talked about expanding north of the Sabana Research Center, this was because the land cover to the north is largely forest cover. They were also shown a map of

Naguabo and asked their thoughts on expansion in the area. They recommended rounding out the forest border and keeping expansion in the northern area. On the steep land they thought it would be a good opportunity for mountain biking. A main take away from the interview was the need for a more involved relationship with the USFS that fosters communication.

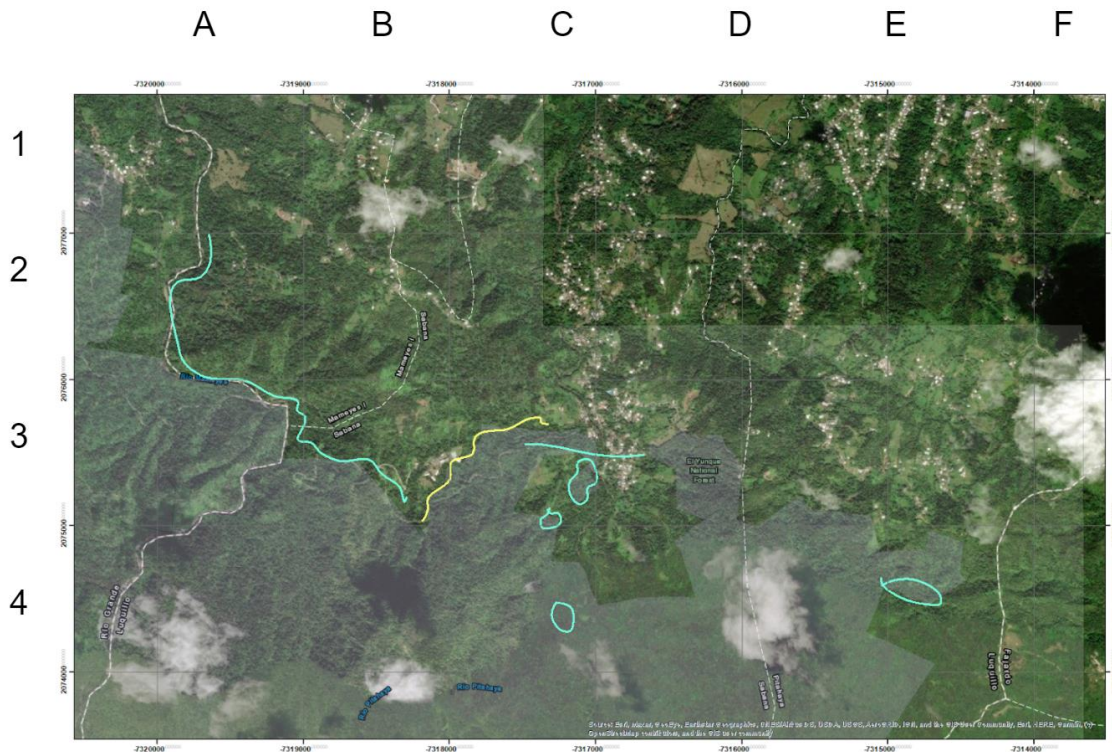


Fig. 15. Annotated Luquillo map from interview 10A (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This satellite map was annotated during interview 10A and outlines the locations of old plantations. The participant would recommend using these places for educational purposes.

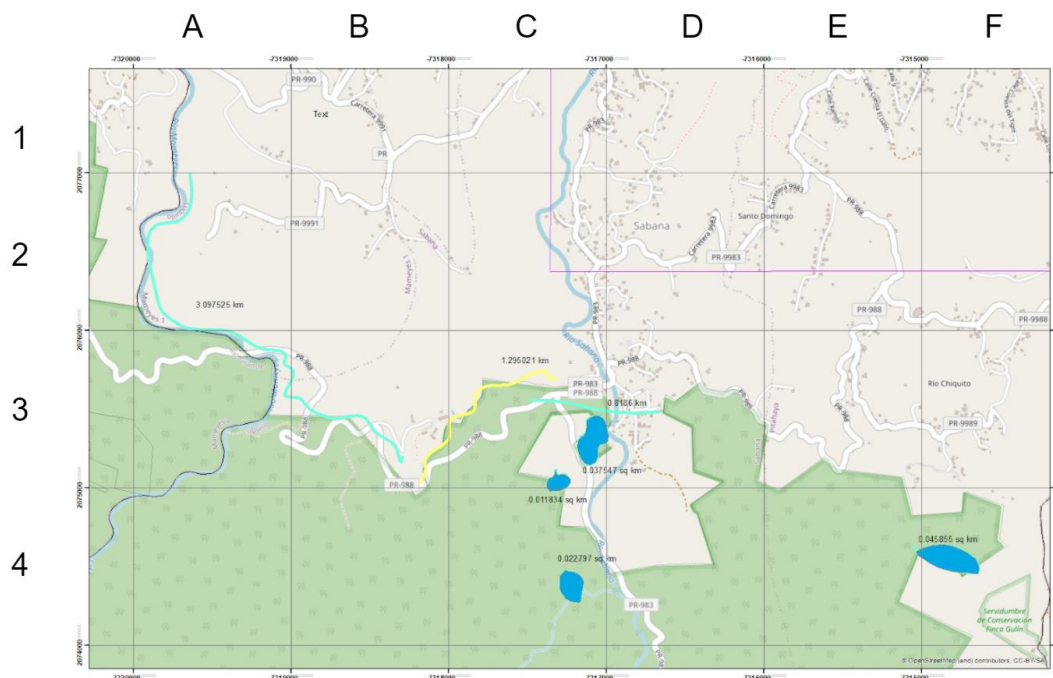


Fig. 16. Annotated Luquillo GIS map from interview 10A (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This map is the GIS adapted version of figure 15.

Table 8. Acquisition Suitability and Associated Difficulties for Commonly Mapped Land Areas of Luquillo as perceived by the U.S. Forest Service in Interview 10A

Land Area	Spatial Location	Approximate Size (km ²)	What does the participant do there/Want to see there?	Land Value(s) Based on Current and Future Land Use	Could El Yunque's expansion address what the participant wants to see there?
Marked areas are believed locations of old plantations	C3, C4, F4	N/A	Location of old plantations where the participant would like to be used for education purposes	Social and economic	N/A

Interview 10B

This interview was centered around Naguabo and the processes of the U.S Forest Service. The major takeaways from this interview were the ecological and social value of the upper area of the buffer zone that closely borders the forest. These areas have heavy tourism and relative importance to the community. The interviewee was skeptical of U.S Forest Service involvement and the benefit that they could provide to the area. However, the more transparent all stakeholders are, the more likely the acquisition process is to happen without pushback. The interviewee elaborated on the importance of preserving the culture and history in this area too. In previous years, large federal entities have not respected the culture of locals as much as they could. Overall, the sentiment of the interviewee was distrustful of the Forest Service but their view could be persuaded with better management. As for other valuable locations, the regions that are in the most need of preservation are the land parcels that are north of casa picaflores. This region is the most lush for being outside of the forest itself. Yet no major damage is being done here, the future is uncertain and rising climate change as well as development could be a potential threat.

No map created

SM-D Focus Group Summaries and ArcGIS Scored Maps

Focus Group 1: USFS Luquillo

This focus group was held with three U.S Forest Service members who are familiar with the Luquillo region and well versed in conservation matters. Overall the group felt that the strategy for community outreach should be more focused on selecting criteria for acquisition as opposed to actually identifying specific parcels to acquire. Selecting the parcels is something that can be done by the U.S Forest Service based upon the criteria established by the community members. Otherwise, when presented with the map, the group agreed that the most feasible and ideal parcels to acquire are the pocket parcels such as areas 2, 3, 4, and 7. These parcels have minimal residential development or any communities which makes it ideal for minimizing conflict with the local people. The U.S Forest Service has also been looking into area 7 for a while and thinking about acquisition. This area was given relative importance because it is near the Sabana Research Station and expanding the land around that can be beneficial for that institution. The focus group discussed that other areas such as 1, 5, and 6 are of less concern because they do not need significant conservation attention. The group noted that area 5, which will likely host parts of the proposed hiking trails, has some dangerous flood regions that are subject to occasional flash floods. Using this area for a hiking trail may not be the best idea. The group included that more parcels in these pocketed areas should be acquired and those would be a greater priority than some of the other areas marked. Another note was made that large parcels with one owner should be prioritized because of ease for the acquisition team. Smaller parcels take just as long to acquire but require the same amount of work, making the acquisition of these less worthwhile.

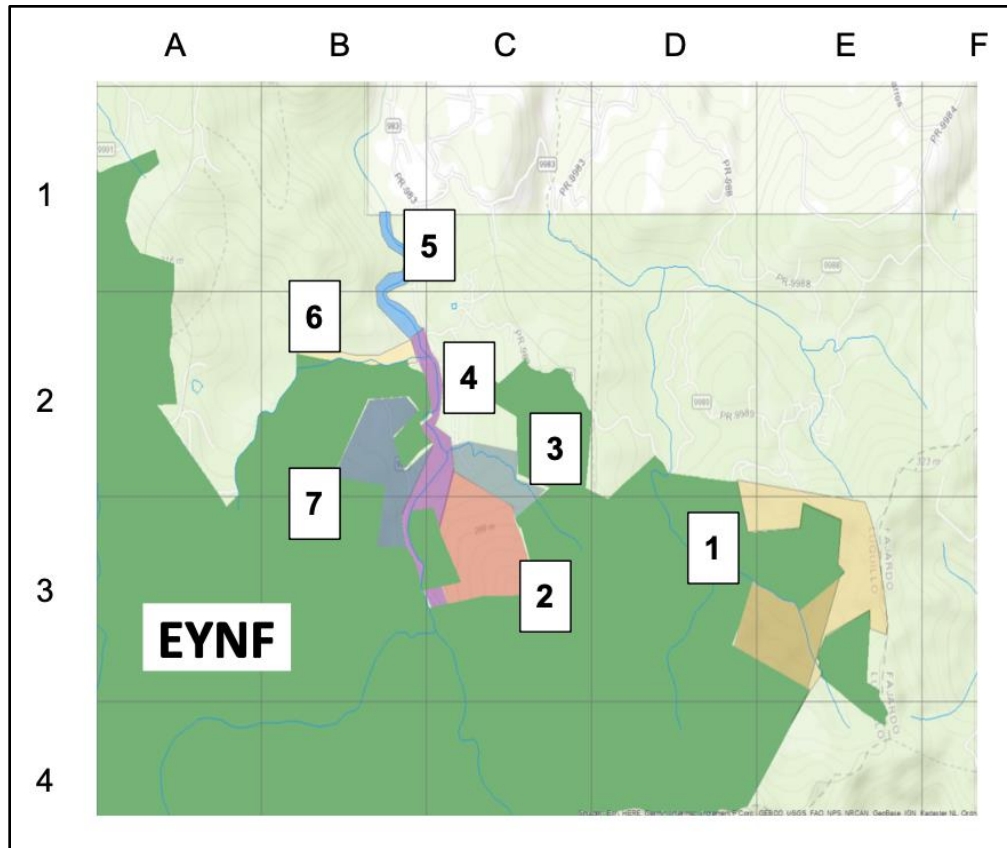


Fig. 17. Map shown to focus group 1 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This GIS map of Luquillo shows the proposed selection of land areas that have been combined from objective 1 and 2.

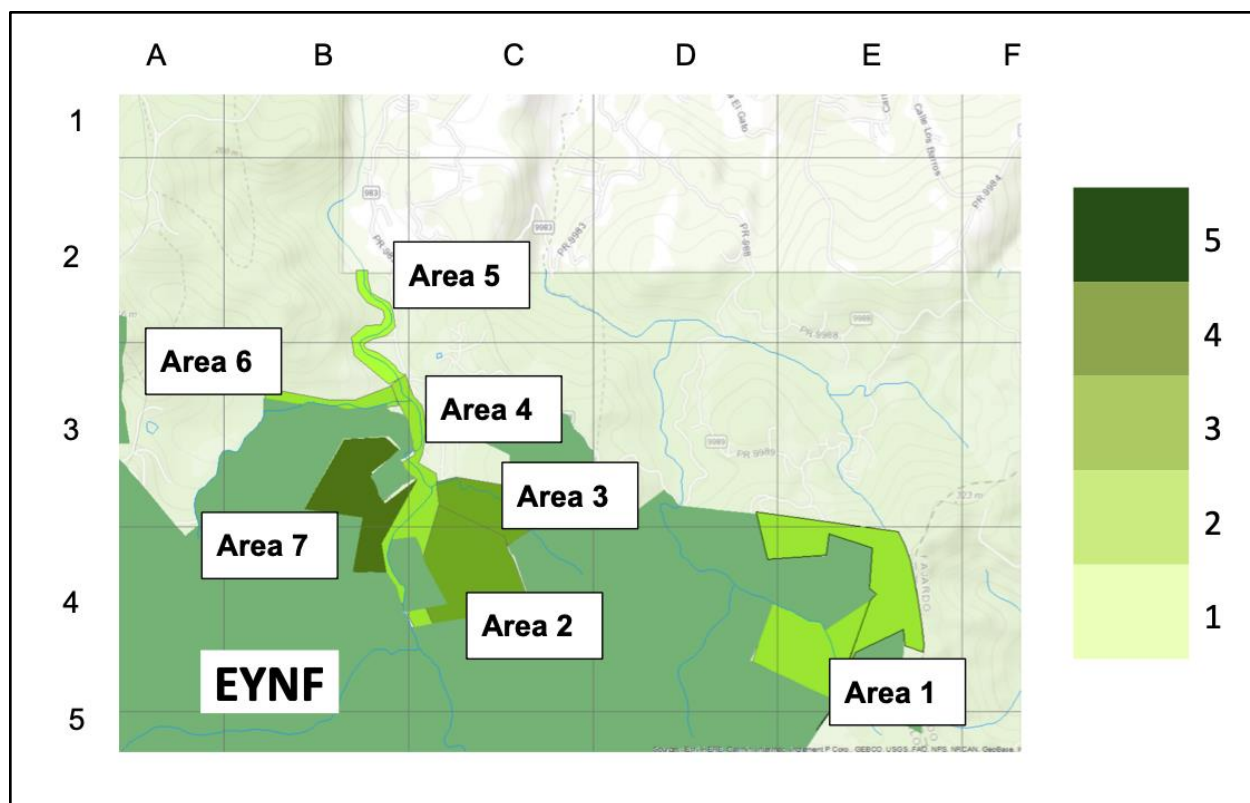


Fig. 18. Scoring map from focus group 1 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This map of Luquillo shows the color coordinated scoring of the areas shown to focus group 1.

Table 9. Qualitative Data Coding of Luquillo USFS Focus Group

Land Area	Spatial Location	Approximate Size (km ²)	Focus Groups' Thoughts on Using this Land Area to Expand El Yunque (i.e. U.S. Forest Service will own land)	Is there a group consensus?	Average Score (1-5)
1	D2, E2, D3, E3		The upper border of the land area in D2 and E2 has some private residences; acquisition needs to stay strictly below the residences and offer some form of conservation easement. Group was neutral about acquisition here, and they wanted to ensure acquisition did not displace existing community members.	There was consensus. One group member felt strongly about acquisition because it would ensure land connectivity and some watershed protection because it housed tributaries in the Río Pitahaya watershed.	3
2	C2, C3		Group believed acquisition here would ensure land connectivity. One group member looked at satellite images to confirm impervious surface presence and found very few buildings and	All group members agreed. They believed the U.S. Forest Service could use acquisition with some easements. As one member said, they need to use all	4

			private residences Thus, the group supported acquisition here.	the tools in their conservation toolbox.	
3	C2, C3		Similar to land area 2, acquisition of this land area ensures connectivity. Presence of the Río Sabana added to the ecological value of this land area.	There was a group consensus, the group focused mostly on the ecological value of the land and did not mention much socioeconomic development.	4
4	B2, C2, B3, C3		Group was initially apprehensive about acquisition here. They were concerned about the small parcel size. When we suggested partnership with the Puerto Rican government for publicly owned lands and confirmed acquisition would stay within the buffer zone, they felt more positive.	The group was mostly aligned. They liked that the acquisition piece stayed within the upper most bound of the forest and did not go outside of the buffer zone. Again, they felt trail easements might be more feasible if this area were to support part of the regional hiking trail.	3
5	B1, B2		Similar to land area 4, the group was apprehensive about acquisition here. Because this land area extended past the existing border of El Yunque and approached Sabana, they felt acquisition could create tensions with the community.	Though the group was generally apprehensive about acquisition here, one member felt easements in this area could help advance the regional hiking trail project.	2
6	B2		Because this piece is so close to the existing border of the forest, the group did not spend much time discussing this area. They indicated it would be feasible to acquire if the area was undeveloped and land owners were willing to sell.	There was group consensus. They all felt acquisition would	3
7	B2, B3		Group members had the most positive response to this land area, believing it would help expand the Sabana Field Research Station. Again, the group member with satellite maps confirmed there were very few private residences in the area.	Group agreed outright acquisition here could be feasible and successful.	5

Focus Group 2: Community Luquillo:

This focus group was held with members of a few local conservation groups that operate in and around El Yunque National Forest. Specifically this group was assessed for their knowledge on Luquillo and the state of development in the areas that are identified for potential acquisition. The participants agreed that the biggest obstacle for this acquisition is ensuring that the people within these land areas are provided new methods of land easements or options for allowing their land to be acquired. Much of the typical methods for land acquisition seen in the continental U.S don't work well for Puerto Rico, land trusts and similar styles are seen as privileged. Overall, acquisition is seen as a good thing by these community leaders in the parcels that border the Rio Sabana and creep deeper into the forest. However, the areas that house more residential patches warrant more caution or even complete abstinence from acquisition. The team scored the Rio Sabana areas 4 and 5 as 5 and 4 respectively. The blue and purple highlights are of high acceptance for acquisition. The less sought after areas that have more residential patches, areas 2 and 3, both scored 2 meaning they have a lower return for acquisition. Not only would most methods of easement be difficult here, but community pushback would likely be too great. After discussing the feasibility of most of these areas' acquisition, the participants mentioned their priority for recreation as a pseudo form of easement to the community. Applying these hiking trails or areas for recreational activity are a great way to stimulate agreement from the locals. The presence of more of these can be a way to please the community stakeholders in the long run. This may also provide better opportunities for ecotourism boosts that aid the financial state of the surrounding communities. The remaining land areas 1, 6, and 7 had mediocre support from the participants. They scored 4, 3, and 3 respectively.

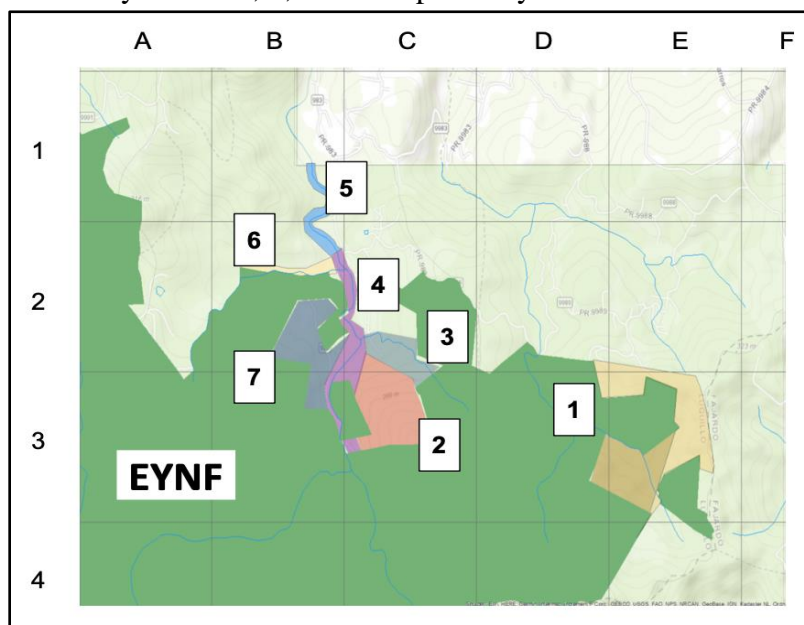


Fig. 19. Map shown to focus group 1 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This GIS map of Luquillo shows the proposed selection of land areas that have been combined from objective 1 and 2.

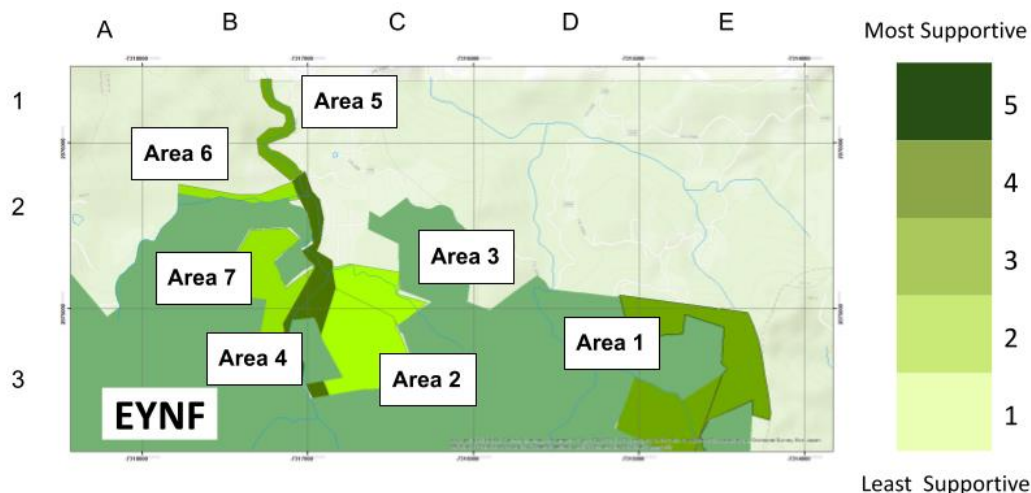


Fig. 20. Community member scores for potential acquisition of each land area (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012).

Table 10. Summary of Luquillo Community Focus Group’s Perspective on Land Acquisition in the Seven Land Areas

Land Area	Spatial Location	Approximate Size (km ²)	Focus Groups’ Thoughts on Using this Land Area to Expand El Yunque (i.e. U.S. Forest Service will own land)	Is there a group consensus?	Average Score (1-5)
1	D2, E2, D3, E3	0.92 km ²	Group liked the idea of rounding out park borders and ensuring connectivity to the nearby conservation trust. They stated that acquisition here would be easy, classifying it as a “low hanging fruit” given the area had forest land cover and few developments. Interestingly, the group did not mention anything about using acquisition in this land area to start an ecological corridor to the Reserva Natural Corredor Ecológico del Noreste, something U.S. Forest Service stakeholders liked about land area 1.	There was a group census. Both focus group members thought acquisition would be a good starting point. But they recommended investigating land ownership records and pursuing conservation easements if we saw occurrences of joint ownership.	4
2	C2, C3	0.29 km ²	The group did not support acquisition here. Even though the satellite base map showed few residences, both focus group members were acquisition deterrents. Furthermore, this land area is currently used for mud bogging, or off-	Both focus group members thought acquisition here would be challenging due to current land use.	2

			roading. The off-roading activities have destroyed most of the infrastructure in this land area (e.g fences and walkways) and community members who currently use the area for mud-bogging would not be interested in U.S Forest Service presence.		
3	C2, C3	0.10 km ²	The group did not support acquisition here. In addition to the increased mud-bogging and off-roading activity, they noted most of the parcels in this land area are jointly-owned by family members. If the U.S. Forest Service were to acquire land in this area, they would need full support from every one of the family member(s) who own the parcel. They implied that many families in this region would not be interested in an increased U.S. Forest Service presence.	Both focus group members thought acquisition would be both challenging and unpopular.	2
4	B2, C2, B3, C3	0.19 km ²	Both group members supported acquisition here. One member outright stated his support for U.S. Forest Service presence alongside the Río Sabana. Both focus group members agreed community members along the Río Sabana need economic support, and the local business to visitor interface created by a hiking trail alongside the Río Sabana would be very popular with the community. One member stated how this land area already supports some community made hiking trails. The area also borders historic plantations and aqueducts. They stated how acquisition here would benefit both the U.S. Forest Service with land and hydrological connectivity and community members with recreational and economic opportunities.	Both focus group members supported U.S. Forest Service presence. But, they indicated the Puerto Rican government's ownership in the twenty meter buffer alongside the river is not as official as it seems on paper. They recommended the U.S. Forest Service approach acquisition here in tandem with local and municipal governments.	5
5	B1, B2	0.06 km ²	Similar to land area 4, both members liked the potential for recreational and economic opportunities. They both spoke highly of Para la Naturaleza, a Puerto Rican land trust who manages some state owned protected areas on the island, and the agency's proposed hiking trail. They both agreed that the U.S. Forest Service should work with Para la Naturaleza, local governments, and	Similar to land area, both focus group members supported U.S. Forest Service presence here. But, they agreed that the U.S. Forest Service should first focus its attention on the southernmost part of the Río Sabana (land area 4)	4

			municipal governments if they want to acquire in this area.		
6	B2	0.05 km ²	The focus group did not spend much time discussing this land area. Both focus group members agreed acquisition here would be a “low hanging fruit” given the small size and the proximity to the current forest borders.	Both focus group members were neutral about acquisition here, indicating the U.S. Forest Service should focus on land areas inside of the hook formed at the Sabana Field Research Station (B2 in Figure 19).	3
7	B2, B3	0.21 km ²	Both focus group members thought acquisition here would be feasible given the high forest land cover and lack of development. Though the area borders some historic plantations and the Sabana Field Research Station, they did not think a hiking trail would be slightly difficult to build and maintain given the steeper elevation in this land area.	Both focus group members agreed acquisition here would be a great way to round out park borders, but the social and economic opportunities would be limited as compared to land areas 4 and 5.	3

Focus Group 3: USFS Naguabo

This focus group was held with the intent of accumulating thoughts on specific Naguabo parcels from U.S Forest Service members. The participants of the group were informed on the identified regions from previous interviews and the context of each one. The yellow (1) parcel from Naguabo is listed on zillow for just under 2 million dollars and would be very easy for acquisition. That being said the participants agreed that this parcel would be logistically good for future U.S Forest Service land management plans. This parcel is located on the steep slopes of El Yunque’s edge which could use restoration attention. This parcel received a score 4 meaning it would be suitable for acquisition. The eastern parcels such as the purple one (2) pink one (4), received scores of 5 because they contain valuable bodies of water that supply to the surrounding area. These areas will be recommended for acquisition and will likely hold the higher property. The turquoise (3) area was considered the least desirable and was given a score of 3 based on the response given. The turquoise area is owned by many different landowners making it a difficult place to acquire, on top of that it lacks desirable characteristics. This area lacks the environmental concerns that the other parcels have as well as water resources.

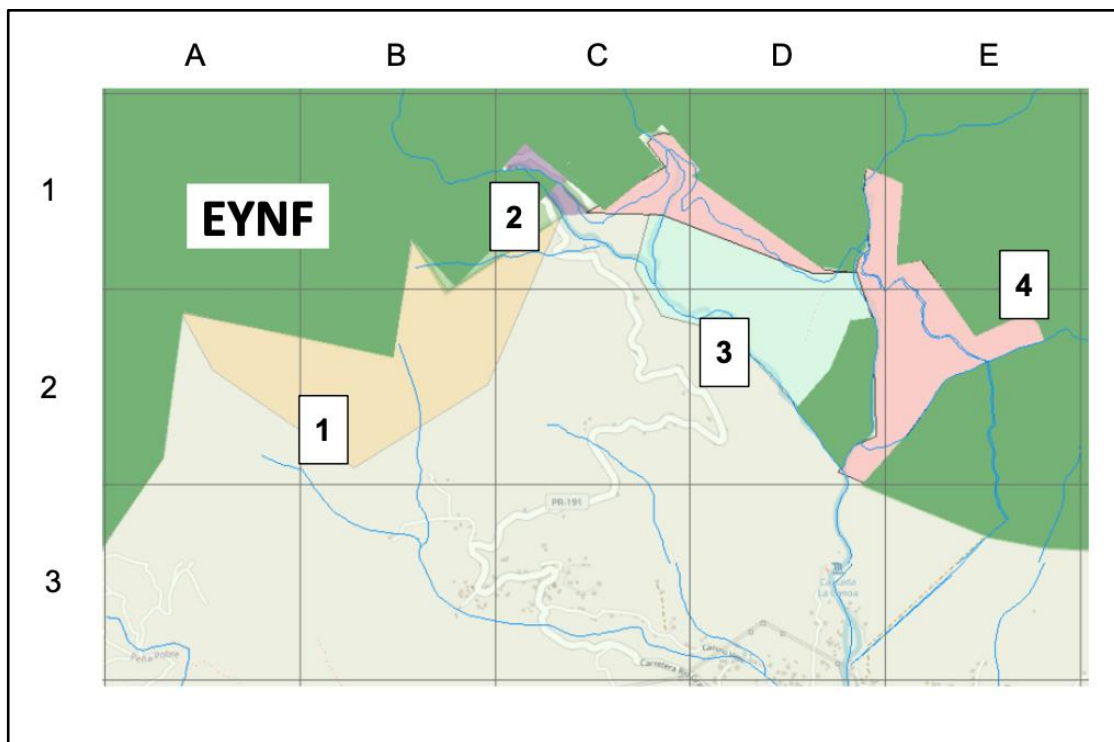


Fig. 21. Map shown to focus group 3 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This GIS map of Naguabo shows the proposed selection of land areas that have been combined from objective 1 and 2.

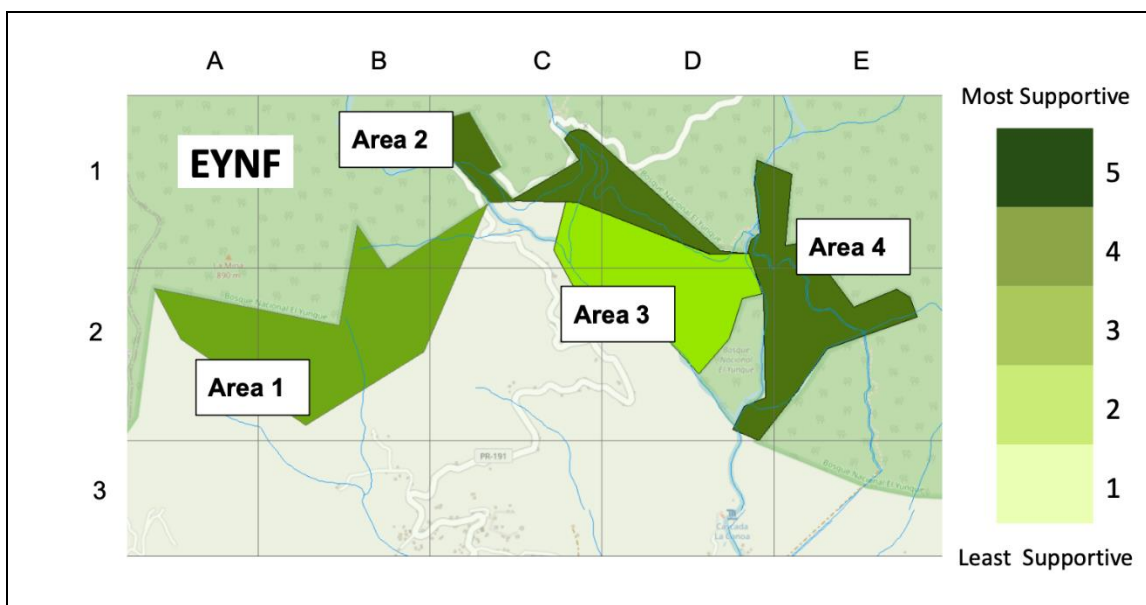


Fig. 22. Scoring map from focus group 3 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This map of Naguabo shows the color coordinated scoring of the areas shown to focus group 3.

Table 11. Qualitative Data Coding of Naguabo USFS Focus Group

Land Area	Spatial Location	Approximate Size (km ²)	Focus Groups' Thoughts on Using this Land Area to Expand El Yunque (i.e. U.S. Forest Service will own land)	Is there a group consensus?	Average Score (1-5)
1	A2, B1, B2, C1, C2	0.90 km ²	Land area would be a great opportunity to begin wide-scale landslide cleanup and riparian corridor restoration. The U.S. Forest Service employee thought acquisition here would create an effective buffer against the encroaching urban land cover. They stated how the land area could support some mountain biking and canyoneering trails, but any infrastructure to build these trails would need to be maintained by the community. The employee stated how the size of the land area was a double-edged sword; the maintenance of the area might be difficult given the current staff numbers and resources.	N/A	4
2	C1	0.087 km ²	The U.S. Forest Service employee supported acquisition in this land area. They expressed how density of rivers and streams is a good metric to determine acquisition priority. They believed acquisition here would help moderate access to the Sabana Recreation Area because some community members can access the area even when it is closed.	N/A	5
3	C1, C2, D1, D2	0.58 km ²	The U.S. Forest Service employee indicated acquisition here would also help moderate access to the Sabana Recreation Area. They were more interested, however, in land area 4.	N/A	3
4	C1, D1, D2, E1, E2	0.8 km ²	The U.S. Forest Service employee supported acquisition here because of the high density of rivers and streams; they also liked the idea of working closely with El Hippy Waterfall.	N/A	5

Focus Group 4: Community Naguabo

This focus group was focused on Naguabo with community members providing input. The group agreed that the important parcels were the ones that contained valuable water resources and those that required environmental attention such as the steep slopes susceptible to landslides. The group would like to see a U.S Forest Service acquisition of the yellow, pink, and purple parcels (1, 2, and 4) with the turquoise parcel (4) trailing in concern. There is a sense of indifference for this piece of land. Overall the majority of the proposed parcels are acceptable for acquisition in the event that conflict is minimized between the locals and the U.S Forest Service. The group participants greatly value the environmental aspects of these parcels and maintenance of that is of the utmost importance even more so than the community conflict that could ensue. Participants expressed that their main concern is the preservation of the waterways near the southern region of El Yunque. These provide some of the greatest services to the community and are in the most immediate danger of destruction or pollution. It is also important to note that participants see parcel 1 as a desirable acquisition mostly because it is currently on sale.

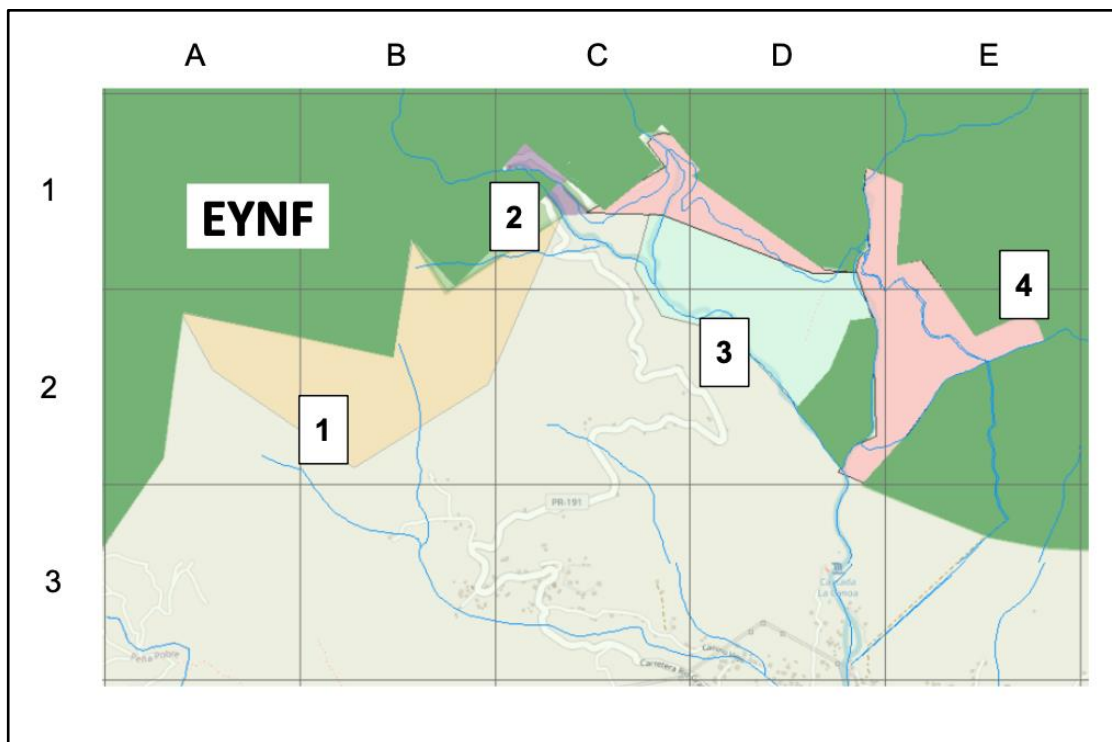


Fig. 23. Map shown to focus group 4 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This GIS map of Naguabo shows the proposed selection of land areas that have been combined from objective 1 and 2.

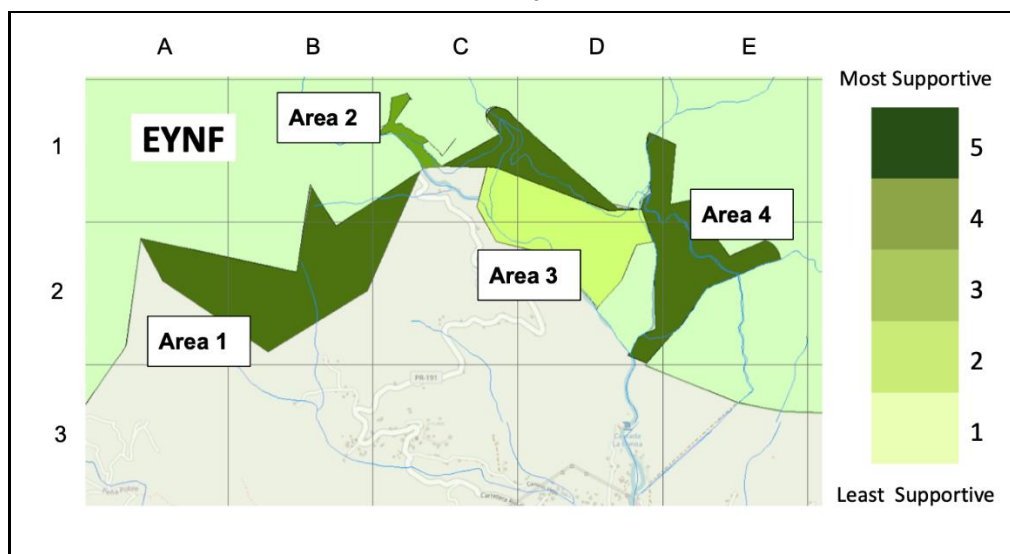


Fig. 24. Scoring map from focus group 4 (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This map of Naguabo shows the color coordinated scoring of the areas shown to focus group 4.

Table 12. Qualitative Data Coding of Naguabo Community Focus Group

Land Area	Spatial Location	Approximate Size (km ²)	Focus Groups' Thoughts on Using this Land Area to Expand El Yunque (i.e. U.S. Forest Service will own land)	Is there a group consensus?	Average Score (1-5)
1	A2, B1, B2, C1, C2	0.90 km ²	The community member really supported acquisition in this area. They indicated the area does not have many private residences or development. In fact, half of the land area is an undeveloped lot. They thought acquisition here would create opportunities for landslide cleanup from Hurricane Maria, something the community members are still doing. But without U.S. Forest Service help, they can really only clean one to two landslides a week. They thought if the U.S. Forest Service acquired land area 1 first and helped with clean-up efforts, they would have a lot of community support for acquisition in land areas 2 and 4.	N/A	5
2	C1	0.087 km ²	The community member thought acquisition here would help with riparian corridor restoration. They thought this would be a great land area to acquire after land area 1.	N/A	4
3	C1, C2, D1, D2	0.58 km ²	The community member did not think acquisition here would garner local support. Instead, they indicated the community would see acquisition of land area 3 as a threat because it is closer to the town line of Florida.	N/A	2
4	C1, D1, D2, E1, E2	0.8 km ²	The community member thought this land area was another great opportunity to implement the all-lands approach. Community members really want to see more support of local ecotourism and agritourism businesses.	N/A	5

SM-E GIS Mapping Process

We used ArcGIS, specifically the ArcMAP function, to build the maps of Luquillo and Naguabo. We used the OpenStreetMap layer available through ESRI to create each map's base layer. The base layer shows towns and roads in a view similar to the GPS maps available online and through phones. We used the base layer because of its ability to highlight recognizable landmarks (e.g. schools, churches, stores). When creating the maps for the first project objective, we wanted map layers which orient the individual (e.g. the participant recognizes a labelled hiking trail). Thus, we built on the highlighted landmarks in the base layer. We used Google Maps to supplement and complement the landmarks highlighted in the base layer. Overlapping landmarks in both Google Maps and the OpenStreetMap base layer helped align major landmarks in the maps that were presented during the first project objective stage. The process of using the base layer and Google Maps is visually represented in Figure 23, where we identified the Iglesia de Dios Primitiva in different spatial programs.

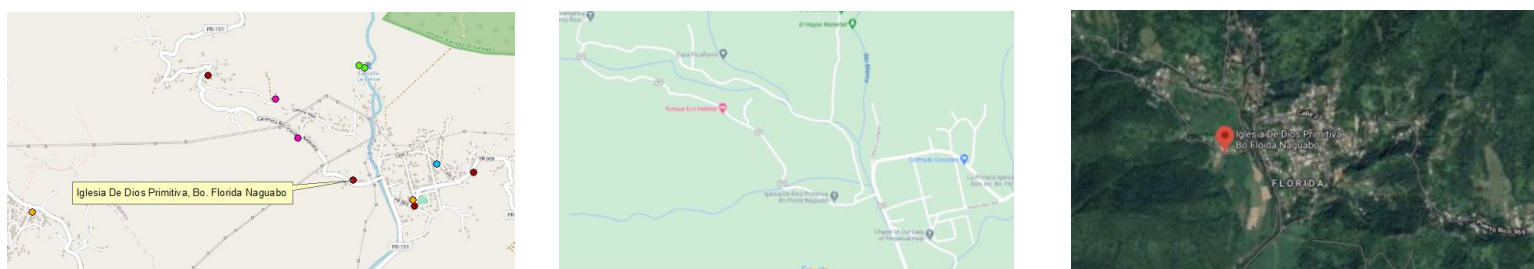


Fig. 25. Image A, on the far left, shows Iglesia de Dios Primitiva in Florida, Naguabo in ArcMAP. Image B, in the middle, shows the same church in street view in Google Maps (Google Maps, 2021). Image C, on the far right, shows the same church indicated by a red marker in satellite view in Google Maps.

We built additional features on top of the base layers. We received the additional features as GIS layers from the U.S. Forest Service. The additional layers include spatially accurate river and stream locations, timbering zones, hiking trails, and scenic areas surrounding El Yunque National Forest. To complete our maps, we downloaded census data, conservation areas outside of the buffer zone, and popular tourist areas from the Puerto Rican government website. To make the maps more user friendly for the first and third project objectives, we used the program Canva and chose recognizable icons to symbolize major landmarks. For example, we symbolized churches with an icon of the Bible, we symbolized hotels with a bed, and we symbolized camps with a tent. The more interviewees are able to recognize their communities from an aerial view, the more accurately they are able to recognize land areas that are socially, economically and ecologically valuable to them.

We uploaded annotated maps of Luquillo and Naguabo after the interviews for the first, second, and third project objectives. We uploaded the annotations as an additional GIS map layer. We calculated the area of the annotations using the area feature on ArcMAP. We added grid lines at every one thousand meters to improve the spatial accuracy of the annotations. We compared the annotations of our focus groups to parcel maps of the region to gauge the legal difficulties associated with acquisition, i.e. acquisition areas with more private landowners will be more difficult to acquire.

For more detail we also created satellite GIS maps such as Figure 24. These maps were made by selecting the satellite option for the ArcMAP function and then applying our areas of interest. The highlighted regions were uploaded from previously generated maps and translated them to the satellite version. We also included the outline of the existing forest boundaries and the buffer zone. It was important to ensure that the scale is kept consistent to reflect spatially accurate regions. With the satellite maps the land cover can more clearly be seen and the proximity of urban cover can be better realized.



Fig. 26. Satellite image of Luquillo generated by the Puerto Rican Government (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). The color coding is not consistent with Figure A; we were not able to change colors for individual land area annotations. We used this figure to confirm land cover, spatial locations of each identified land area, topography and the major roads.



Fig. 27. Satellite image of Figure 22 generated by the Puerto Rican government (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). The bottom halves of land areas 2 and 3 fall in relatively undeveloped regions with heavy forest cover, making it advantageous for acquisition. Based on our findings in this stage, we believe the priority acquisition areas are south of Sabana.

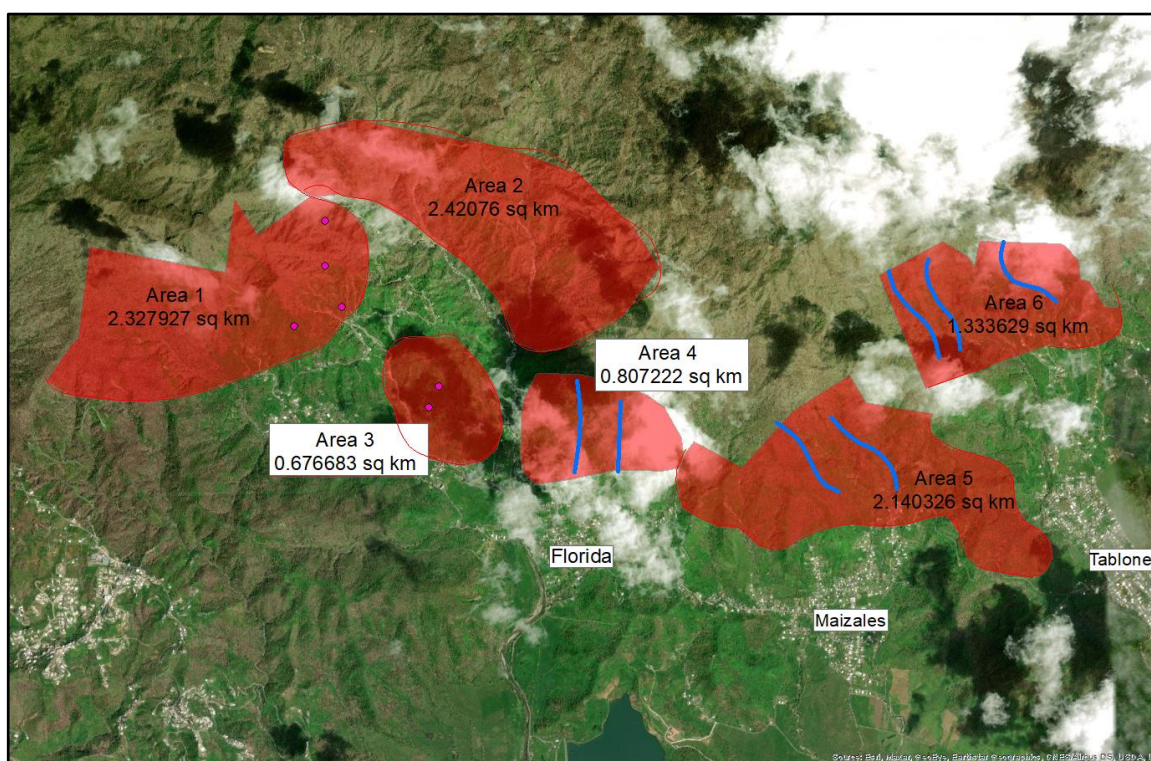


Fig. 28. Satellite image of Figure 24 generated by the Puerto Rican Government (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). We used Figure 25 to confirm land cover, spatial locations of each identified land area, topography, and the major roads. Land areas 1, 2, 3, and 4 border Florida. Land areas 5 and 6 border Maizales and Tablones.

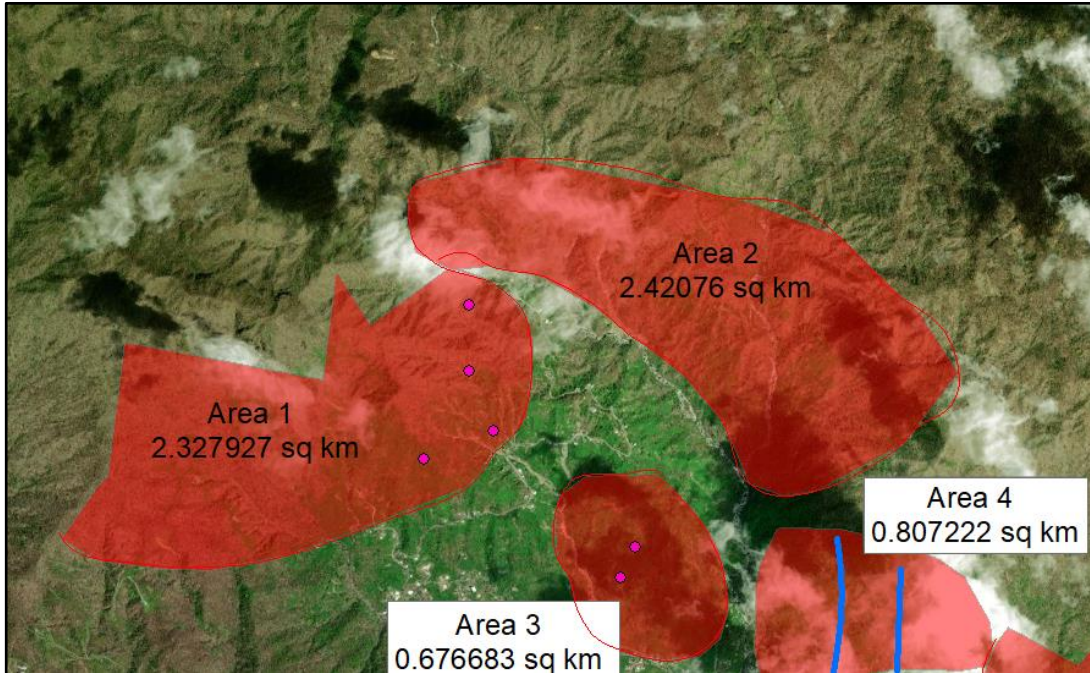


Fig. 29. Satellite image of Figure 26 generated by the Puerto Rican Government (adapted from ESRI; U.S Department of Agriculture, U.S Forest Service, 2012). This figure shows the land cover and topography of the potential acquisition areas.

SM-F Baseline Scripts for Interviews and Other Materials to Replicate Our Process

Interview Scripts for U.S. Forest Service Employees about Management Plans in Luquillo and Naguabo Buffer Zones to Address the Second Project Objective

The interviews conducted with the U.S. Forest Service employees followed a similar process to those conducted with local community members. We used the same introductions, conclusions, and consent scripts. The overall process is below.

Basic Process for Interviews with the U.S. Forest Service Employees

Consent Script (5 minutes)

“Hello! We are third year students from Worcester Polytechnic Institute, a small technical university in Massachusetts. [Each team member greets the interviewee and introduces themselves]. We are working with the U.S. Forest Service to create more opportunities for community involvement in El Yunque National Forest. Your ideas will be incorporated into future management plans for the forest. We want to speak with you about expanding El Yunque. Today, we want to get a better understanding of the ecological climates in potential acquisition areas. We are particularly interested in the municipalities: Luquillo and Naguabo. We would appreciate an hour of your time to speak with you about ecological data you have for buffer zone areas in Naguabo. If you feel uncomfortable at any time, please let us know. Your thoughts, opinions, and ideas will be shared only for research purposes, and your anonymity will be maintained. Are there any questions, comments, or concerns before we begin?”

[Wait for interviewee to respond; if there are questions, answer appropriately]. “If you have any questions after our interview, please feel free to reach out to us at gr-LAP_ElYunque_PR_C21@wpi.edu.” [Type email into the chat box].

“Is it ok for us to record this interview session? The recording would be shared with our fellow team members for research purposes.” [Wait for interviewee to respond. Regardless of the response, make interviewee feel comfortable -- it is ok if the interview is not recorded just be sure each team member is taking diligent notes NOT analyzing while transcribing].

Introductions (5 minutes)

“We want to start our interview today getting to know each other a little better. [Each team member will tell the interviewee about themselves (1) Name (2) School Year/Major (3) Hobbies/Interests]. Could you tell us a little about yourself, specifically your role in the U.S. Forest Service?” [important to note their position in the USFS]

Interview Content (40 minutes)

Dependent on interviewee.

Snowball Sampling Phase (5 minutes)

“Are there any individuals besides yourself who have additional information about these regions?”

[wait for response, may schedule to have another meeting with interviewee and individual they recommend]

“Would they be interested in working with us? We would love to hear their thoughts on these land areas.” [offer contact information if appropriate, this question is crucial for snowball sampling and will help build our focus groups for objective 3].

Conclusions (5 minutes)

“We want to sincerely thank you for your time today. Do you have any questions, comments, or concerns for us as we wrap up our interview today? If you have any questions or comments after today, please feel free to reach out to use with the email in the chat”

“Would you be willing to share your thoughts and ideas with a group of peers in two weeks' time? We would like to conduct a one hour focus group to discuss land value and create a space for you to help further improve land management plans for El Yunque. If you are interested, we would like to invite you and anyone you believe would be interested in the discussion. We can send details and more information in the following days to help prepare for the discussion.”

We determined land value perception by considering previous management plans, census data, future goals, ecological climates, and land use changes. Thus, the interview content varied based on the participant. The content scripts for each interview are below.

Interview Scripts for Local Community Members in Buffer Zone Areas of Luquillo and Naguabo to Address the Second Project Objective

The second project objective requires direct contact and engagement with community members in the buffer zone areas of Luquillo and Naguabo. Our sampling frame consisted of regular consumers of El Yunque National Forest who reside in the Luquillo and Naguabo buffer zones. We conducted interviews following a semi-structured format. The questions for each participant varied based on the participant's occupation and hobbies. The script below represents the general format followed for each interview to address the first project objective. The text in brackets is not spoken.

Basic Process for Interviews with the Community Members

Consent Script (5 minutes)

“Hello! We are third year students from Worcester Polytechnic Institute, a small technical university in Massachusetts. [Each team member greets the interviewee and introduces themselves]. We are working with the U.S. Forest Service to create more opportunities for community involvement in El Yunque National Forest. Your ideas will be incorporated into future management plans for the forest. Today, we want to speak with you about expanding El Yunque. We want to hear your thoughts on potential acquisition areas, specifically your interactions with these land areas [explain interaction meaning where they work, any areas they believe are good spots for recreation, any places they avoid]. We would appreciate an hour of your time to ask you some questions about yourself and map land areas of interest to you. If you feel uncomfortable at any time, please let us know. Your thoughts, opinions, and ideas will be shared only for research purposes, and your anonymity will be maintained. Are there any questions, comments, or concerns before we begin?”

[Wait for interviewee to respond; if there are questions, answer appropriately]. “If you have any questions after our interview, please feel free to reach out to us at gr-LAP_ElYunque_PR_C21@wpi.edu.” [Type email into the chat box].

“Is it ok for us to record this interview session? The recording would be shared with our fellow team members for research purposes.” [Wait for interviewee to respond. Regardless of the response, make interviewee feel comfortable -- it is ok if the interview is not recorded just be sure each team member is taking diligent notes NOT analyzing while transcribing].

Introductions (5 minutes)

“We want to start our interview today getting to know each other a little better. [Each team member will tell the interviewee about themselves (1) Name (2) School Year/Major (3) Hobbies/Interests]. Could you tell us a little about yourself?”

[Do not proceed until the interviewee has given information about their occupation, their hobbies, and connection to El Yunque. If they do not give this information, respectfully ask probing questions such as: “Is there anything you enjoy doing outside of work?” Alternate team members when asking probing questions]

Introduction to Map (5 minutes)

For community members from the Luquillo buffer zone, share one of the GIS maps of Luquillo. For community members from the Naguabo buffer zone, share one of the GIS maps of Naguabo.

“The U.S. Forest Service is interested in the community’s thoughts on this map. This is a map of [Luquillo or Naguabo buffer zones depending on where the interviewee is from]. Pictured here are some of the major landmarks [address specific landmarks depending on which municipality the map is of]. The scale of the map is where one square represents one square kilometer. There should be an option for you to draw on the screen, would you mind trying this out. The option to annotate should be in the control bar, the annotate icon is a pencil.” [Ensure interviewee can use the annotate tool properly].

Map Interaction Phase (20-25 minutes)

“Great! Now that we can share the map and interact with it, we’d love to talk about some of these areas pictured here. Now, you mentioned you [talk about interviewee’s occupation and try to connect occupation to local scenery and landscape]. Is there a specific location you [insert occupation]? If so, would you mind circling the rough location on the map, it does not need to be spatially accurate, we want to get a rough estimate of the location.” [follow with questions to address the how and why, for example if the interviewee runs a zipline company, ask how many people visit, where do you like to take your customers and why?]

[Once circled]. “Now, for these areas you circled. How often do you say you visit them? Is there anything in particular you like or dislike about them?” [follow with probing questions as appropriate to answer the how and why questions].

“Do you [hobbies the interviewee mentioned] on any areas on the map? Would you mind circling these areas on the map in a different color?” [Ask interviewee to circle the areas, following the same process as above, garnering the frequency of visiting the areas, the likes, the dislikes, and why they feel the way they do about the land area].

“Is there anything we missed, or another location you like to visit frequently? Would you mind circling these areas on the map in a different color?” [always follow with probing questions as appropriate to answer the how and why questions].

“Are there any land areas we have circled that you would like to see become a part of El Yunque National Forest? [ask the how and why questions as appropriate]

[Give the interviewee time to fill in the map as they desire, keep track of the color coding -- which one is occupation, hobbies, and other].

“Thank you for your contributions, would you mind if we take a picture of your map for our research? We would like to upload the image into a mapping software. Your name, photo, and any identifying information will not be included in the photo of your map.” [If interviewee does not give permission, try to sketch the approximates of their map and general themes from the conversations during their circling].

Next Steps in Mapping Phase (10-15 minutes)

“Now, for the areas we’ve circled here, are there any that you think would make a valuable addition to El Yunque?” [always follow with probing questions as appropriate to answer the how and why questions].

“For the areas we’ve circled, are there any individuals you know besides yourself who use these spaces frequently?” [follow with questions like, “What do they do in these areas/How do they use these land areas?”] “Would they be interested in working with us? We would love to hear their thoughts on these land areas.” [offer contact information if appropriate, this question is crucial for snowball sampling and will help build our focus groups for objective 3].

Conclusions (5 minutes)

“We want to sincerely thank you for your time today. Do you have any questions, comments, or concerns for us as we wrap up our interview today? If you have any questions or comments after today, please feel free to reach out to use with the email in the chat [ensure email is in the chat and send again if the interviewee cannot see it]”

“Would you be willing to share your thoughts and ideas with a group of peers in two weeks' time? We would like to conduct a one hour focus group to discuss land value and create a space for you to help further improve land management plans for El Yunque. If you are interested, we would like to invite you and anyone you believe would be interested in the discussion. We can send details and more information in the following days to help prepare for the discussion.”

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