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To climb or to fell? Identification of social-ecological conditions that promote sustainable fruit harvesting in Lowland Amazon palm swamps

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Supplementary material for this article is available [online](#)

Abstract

A well-documented environmental threat in the Amazonian region of Loreto, Peru involves harvesting the fruit from the dominant palm *Mauritia flexuosa* by chopping fruit-bearing females growing in carbon-dense peat swamps. Numerous conservation interventions have been proposed to protect the swamps, such as encouraging harvest of fruits by climbing the palms to preserve the resource instead of cutting them. These efforts have produced mixed success; some communities have embraced sustainable harvest methods, while others have not, despite the obvious benefits of climbing and the simple technology required. In this study, we aim to understand why some communities opt to harvest fruit sustainably while others do not, and to assess whether the experience of communities sustainably harvesting offers broader lessons for ecosystem management. Nine communities were visited in Loreto, where in-depth interviews were performed to identify economic, institutional, and cultural elements linked to fruit extraction practices. Field measurements were produced to evaluate ecological characteristics in harvested swamps nearby communities that mostly climb or mostly chop. The five communities that mostly climb placed high importance on the fruit, had resource management rules, and derived significant material benefit from the fruit. In contrast, the four communities that mostly chop derived only a marginal economic benefit from the fruit and tended to face obstacles to building systems of sustainable management of common property, such as poverty and problems associated with pollution from the oil industry. One community embraced climbing 30 years ago and observed remarkable social, economic, and environmental benefits. Through sustained support from NGOs and the regional government, this community was empowered to build a system of sustainable resource management on its own terms. Its capacity to develop and enforce its rules of harvest, ensured through robust communal trust, was key to its success.

1. Introduction

Anthropogenic changes to the planet have become so profound that some scientists have proposed that the current geologic epoch, the Holocene, has been eclipsed by a new epoch, the Anthropocene (Crutzen 2002). The scale of environmental degradation can produce pessimism about the world's future, thus inhibiting positive change (Robbins and Moore 2013). However, examples of positive environmental change abound and could be considered 'seeds of a good Anthropocene' (Bennett *et al* 2016). It is important to highlight these cases to confront pessimism that precipitates dysfunction. Many successful cases of local, bottom-up

initiatives throughout the Amazon have been identified that could be described as transformative pathways to sustainability (Londres *et al* 2023). These examples could also be described as ‘seeds,’ defined as ‘initiatives that exist, at least in prototype form... [that are] social-ecological bright spots that could, given the correct conditions, benefit both environmental conditions and human well-being’ (Bennett *et al* 2016). While Londres *et al* (2023) reviewed 157 cases of such cases throughout the Brazilian and Peruvian amazon, none were in Loreto, Peru, a region of high importance to the global climate (Hastie *et al* 2022) facing numerous environmental threats (Roucoux *et al* 2017), but also many locally and regionally led initiatives to promote sustainability.

The palm swamps of the Peruvian Amazon, locally known as ‘aguajales,’ are an ecosystem that supports considerable biodiversity (Endress *et al* 2013) and are known to sequester vast quantities of carbon (C) (Hastie *et al* 2022). An area of 6.9 ± 0.1 Mha of palm swamps overlying C-dense peat soil are believed to exist in the region (Marcus *et al* 2024), mostly in the province of Loreto. The palm swamps face various threats, such as oil drilling, oil spills, and road construction (Roucoux *et al* 2017, Lawson *et al* 2022). Additionally, the fruits produced by the dominant palm in the swamps, *Mauritia flexuosa*, locally known as ‘aguaje,’ are mostly harvested in a destructive manner in which fruiting female palms are chopped down to collect the fruit (Horn *et al* 2018, Romulo *et al* 2022). This practice has surged over the last 3 decades as the market for the fruit has expanded, mostly driven by increasing demand in Loreto’s capital city of Iquitos (Horn *et al* 2018).

Some community groups have advocated for practicing sustainable fruit harvesting techniques (Hidalgo Pizango *et al* 2022, Romulo *et al* 2022). For example, at least 15 different non-governmental organizations (NGOs) have been active throughout Loreto attempting to encourage climbing the palms to extract the fruit instead of felling, thus sparing the tree for future harvesting, reducing forest degradation and preserving local peoples’ livelihoods (Romulo *et al* 2022). Despite this rare case of a win-win situation, efforts to promote climbing in aguaje harvesting communities have not always been consistent. While a small number of communities have abandoned felling for climbing, others have increased the share of harvest through climbing but occasionally chop, but the majority still mostly or exclusively cut the palms for harvest (*ibid.*). This study aims to address the overarching question of why some communities successfully adopt sustainable harvest practices while many more do not, despite the relatively simple technology required for sustainable harvest and the seemingly obvious long-term benefits of preserving fruiting trees for future yields. This paper specifically asks (1) how constraints and opportunities experienced by different communities interact to influence sustainable management outcomes? (2) what are the demographic indicators of aguaje ecosystem integrity near communities that have successfully adopted sustainable harvesting techniques, compared to those that have not adopted such techniques? And (3) what broader insights from the experience of communities sustainably managing their aguajales can productively contribute to the knowledge of sustainable management of land systems? In other words, can the experience of communities that have successfully adopted climbing as an aguaje harvest technique serve as a ‘seed of a good Anthropocene’ referent that offers hope and insight to other communities dedicated to harvesting a non-timber forest product?

2. Methods

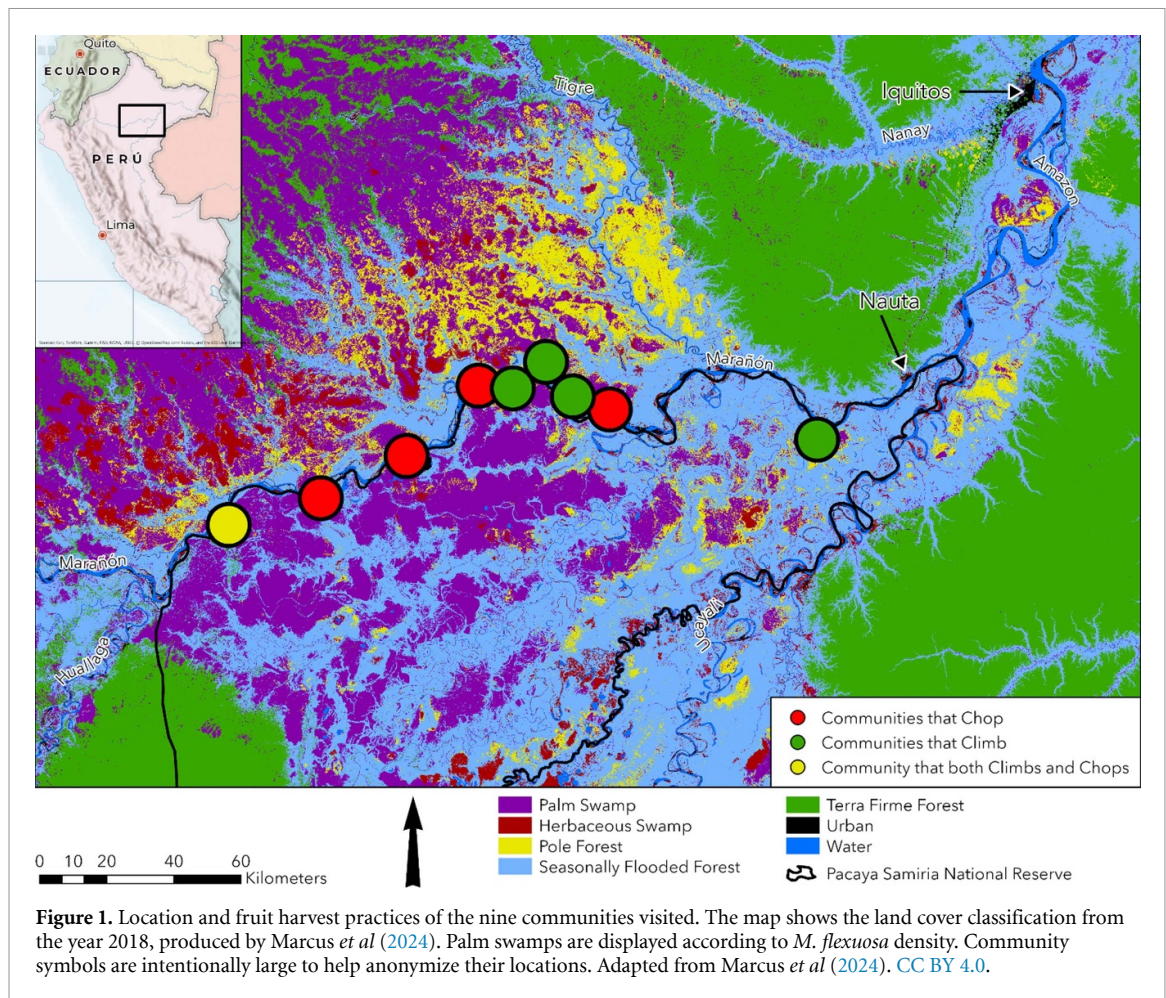
2.1. Study area

The study area is located within the Marañón River watershed in the northeast Peruvian Amazon region of Loreto (figure 1). Over 883 000 people resided in Loreto in 2017, of which approximately 500 000 resided in the capital Iquitos (INEI 2017). The remaining population lived in rural communities (*ibid.*), mostly along rivers. Rural communities are overall small, comprised of a median population of 144 people (Romulo *et al* 2022).

In July 2022, nine communities were visited along the Marañón River where aguaje is harvested (figure 1). These communities were selected in consultation with local scientists to provide the most geographically representative sample of harvesting communities in terms of locations along the river and their distance from the port city of Nauta, given time and resource constraints. Harvesting practices were not known *a priori*, except for Community 1, which is well known to only harvest by climbing.

2.2. Social-ecological system (SES) framework

This research draws upon the concept of the SES (Ostrom 2007, 2009), which provides a framework for analyzing complex coupled human-natural systems. The framework is premised on the notion that simple predictive models of such systems cannot produce universal solutions to problems of ecosystem management and sustainable resource use. This is because human-natural systems are deeply complex and unique. Each system exhibits its own ecological peculiarities and is embedded in different socioeconomic contexts that impact the system at different scales. A SES is composed of a set of multi-nested factors, containing on the top-level resource systems, resource units, resource users and governance systems, and more precise



subdivisions below, (such as the aguajal, a specific forest ecosystem, the aguaje fruit, community harvesters, and community rules of harvest). Interactions between factors occur and produce outcomes at different scales. Recent scholarship in the field of sustainability science conceives of a ‘meso-level,’ or focal-level scale (the community in this study), a micro-level scale below consisting of individuals, and a macro-level above, consisting of the region, the state, and broader economic forces (Clark and Harley 2020). By conceiving an SES in this multi-tier manner, a researcher can interrogate the unique factors that either promote or inhibit its sustainable management.

2.3. Field data collection and processing

Interviews: upon arriving in a community, we asked the community leader, or *Apu*, for permission to visit the community, and to be introduced to a community member who harvests aguaje. This individual was offered 50 soles to lead the researcher and a field assistant into the aguajales where harvest occurs to collect ecological field data. Upon returning to the village the local guide was interviewed. Additional interviews were conducted in all communities except for communities 3, 5, and 9, where it was not logistically feasible to conduct more. Interviewees ranged in age from young adults to the elderly and comprised both women and men. One aguaje street vendor woman (an *aguajera*) and a member of the Loreto regional government involved in the ‘Proyecto Aguaje,’ an initiative to formalize the full chain of production of the fruit, were also interviewed in Iquitos. Additionally, 3 regional experts on the SES of aguaje in Loreto were interviewed in Iquitos. Questions were designed to gauge people’s perspectives on aguaje harvesting, the methods of harvest used in each village and the reasons for doing so, the market of aguaje, and on environmental issues in the region more broadly. Interviews were semi-structured and open-ended. An Institutional Review Board from Temple University approved the questions and methods prior to data collection. Free, prior, and informed consent was obtained before each interview, and all names of people and communities were anonymized.

Interviews were recorded, transcribed, translated, and then coded using the Atlas.ti 8 (Atlas.ti 2017) software. Similar to Romulo *et al* (2022), second-level variables from Ostrom (2009) were used as codes to identify emerging themes by assigning statements from interviewees to the most relevant second-level variable. These groups were further subdivided into values of positive/negative, or presence/absence of the

variable in question. For example, a statement about leadership was coded into whether the context suggested leadership was present and benefiting the community, or whether leadership was absent. Twenty-one interviews in total were conducted. Given the low number of communities visited and people interviewed, no quantitative data analysis was performed; rather, data was descriptively analyzed to evaluate the SES of the aguajales.

Ecological measurements: the fieldwork was designed to evaluate the level of degradation within the aguajales used for fruit harvesting. We would enter an aguajal led by a local guide to a location where harvesting occurs. Using a compass, GPS device, and measuring tape, we established a one hectare (ha) transect (500 m long $\times$ 10 m wide on each side) starting from where aguaje began to dominate the canopy. From this point, we advanced from the edge of the swamp towards its center. We collected the following data along the transect: counts of adult aguajes (height $> \sim 10$ m and with flowers and/or fruits present), counts of adult males and females identified by the presence of flowers and fruits, and counts of juvenile aguajes (height between 1 and 10 m with flowers and fruits not present; additionally, while very rare, any individual taller than ~ 10 m without fruits or flowers would be considered a juvenile). Heights were estimated visually by a field guide trained in tropical forestry with experience conducting fieldwork for other related projects (e.g. Hastie *et al* 2022, Hidalgo Pizango *et al* 2022). Additionally, we established three 3×3 m quadrats at the beginning, middle, and end points of the transects to count aguaje seedlings (< 1 m in height).

We set up one transect in each community, except for Communities 2 and 7, where two transects were established. These additional transects were located on the opposite side of the Marañón River from the community where, according to community members, aguaje harvesting used to occur, thus providing a more robust sample of previous impact of those communities' on land cover. The data was tabulated and analyzed to extract ecological demographic variables describing the density of adults, male: female ratio, female density, juvenile density, and seedling density for communities that mostly climb versus communities that mostly chop.

The data was analyzed to compare ecological conditions of communities that mostly climb for harvest and those that mostly chop, and also to compare the conditions of Community 1 with all others. The latter comparison was done because Community 1 has been engaged in sustainable harvest far longer than any other community and its aguajal has had more time to recover ecologically. *T*-tests were performed for each variable to compare groups of communities by harvest method. An ecologically healthy aguajal will have a male: female ratio near to 1:1 (Horn *et al* 2012). Densities of adult aguajes exhibit a wide natural variance across the landscape (Hergoualc'h *et al* 2017), and therefore are not applicable in directly determining ecological health of an aguajal, however they are useful in establishing baseline ecological conditions for comparison between swamps experiencing different harvest methods. For example, it is important to assess whether the sustainable or unsustainable exploitation of an aguajal is related to unique local conditions such as an adult density significantly different from the average. Furthermore, higher female density is associated with greater seedling density (Horn *et al* 2012), an indication of ecological health.

3. Results

3.1. Interviews

Of the nine communities visited, four are currently harvesting aguaje exclusively by climbing (although the length of time they have done so varies from a few years to nearly three decades), four are harvesting only by chopping female palms, and one sometimes climbs and sometimes chops for harvest (figure 1). These nine communities were divided into two groups for analysis of the qualitative data: communities that 'mostly climb,' which includes the four that exclusively climb and the one that both climbs and chops, and communities that 'mostly chop,' which includes the four where chopping is the predominant method of harvest (table 1). Table 1 presents the communities as they are coded in this analysis. Communities 1–5 are in the 'mostly climb' category, and communities 6–9 are in the 'mostly chop' category. Table 1 also includes data taken from table 1 in Romulo *et al* (2022) to provide additional context to these communities. Romulo *et al* (2022) performed their study in 2015, seven years before the data was collected for this study. Since the communities studied by Romulo *et al* (2022) were anonymized in their study, the communities visited in this study were not influenced by whether Romulo *et al* (2022) had visited them. After returning from the field, Romulo revealed to us privately the identities of the communities she visited (C. Romulo, personal communication, 26 July 2023). Ultimately, it was useful to have visited many of the same communities, as this demonstrated whether communities that formerly chopped for harvest had made progress towards sustainable harvest in the time between field work of both studies.

Table 2 details information about the 16 interviews conducted in the communities.

Table 1. Communities visited in July 2022.

Comm # in this study	Comm # in Romulo <i>et al</i> (2022)*	% Households that harvest <i>M. flexuosa</i> *	% Harvester households that only climb*	% Harvester households that climb and cut*	% Harvester households that only cut*	Inside Reserve?	Climb or cut in 2022?	Category
1	1	82%	100%	0%	0%	Yes	Climb	Mostly climb
2	NA**	—	—	—	—	Yes	Climb	
3	6	90%	0%	0%	100%	No	Climb	
4	8	100%	5%	25%	70%	No	Climb	
5	NA**	—	—	—	—	Yes	Climb/cut	
6	17	60%	0%	17%	83%	No	Cut	Mostly cut
7	3	85%	0%	29%	71%	Yes	Cut	
8	21	20%	0%	25%	75%	No	Cut	
9	22	90%	0%	5%	95%	No	Cut	

* Data from Romulo *et al* (2022).** Communities not included in the analysis by Romulo *et al* (2022).

Table 2. Interviews conducted in the communities.

Harvest method	Number of interviews	Interviewees
Mostly climb	9	• 5 local field guides (men) • 2 local leaders (men) • 1 woman in business of selling aguaje to middlemen • an elderly woman
Mostly chop	7	• 4 local field guides (men) • 2 men who occasionally harvest aguaje • 1 local leader (woman)

3.2. Emerging themes

Of the themes that emerged from interviews, 14 were deemed to be illustrative of whether a community opts for climbing or not as a means of harvesting aguaje. Of these, seven were deemed to be indicative of fostering a tendency towards sustainable harvest, and seven were assumed to be fostering a tendency towards unsustainable harvest (table 3).

As shown in figure 2, clear differences emerged between the two classes of community, demonstrating that the harvest methods are associated with different factors, such as economic conditions, government/NGO support, local leadership, and others. As expected, themes that were assumed *a priori* to be associated with sustainable harvest were commonly discussed in communities that mostly climb, and themes assumed to be associated with unsustainable harvest were commonly discussed in communities that mostly chop.

3.2.1. Access rules, collective choice rules, and sanctions

All communities indicated a clear understanding of what lands surrounding their community ‘belonged’ to the community, and what lands in the area belonged to other communities. In many cases, communities possessed formal title to their lands, with official government maps clearly demarcating the aguajales from which they are entitled to harvest. Even when this was not the case, communities tended to have a strong sense of lands they were entitled to exploit and lands they were not. Therefore, all communities developed rules for accessing their surrounding aguajales designed to prevent outsiders from exploiting them. These rules included the requirement that outsiders request permission to enter a community’s land, pay entry fees, and fines if caught breaking the rules. For example, Community 1, which is inside the Pacaya–Samiria National Reserve near a park ranger surveillance point, requires any outsiders who enter their lands to have formal permission from SERNANP (the national park service), or else they will be expelled. This unique factor of Community 1 certainly provides an advantage of managing and surveilling their land that other communities lack. Additionally, Communities 1 and 2 developed rules for their own community members on accessing aguajales. For example, Community 1 manages 3 aguajales in the vicinity of the village and divides harvesters into several associations which are each given permission to access, and responsibility to manage, an aguajal. Community 2 permits each aguaje harvester to develop and maintain their own path into the aguajales, along which they have access to harvest.

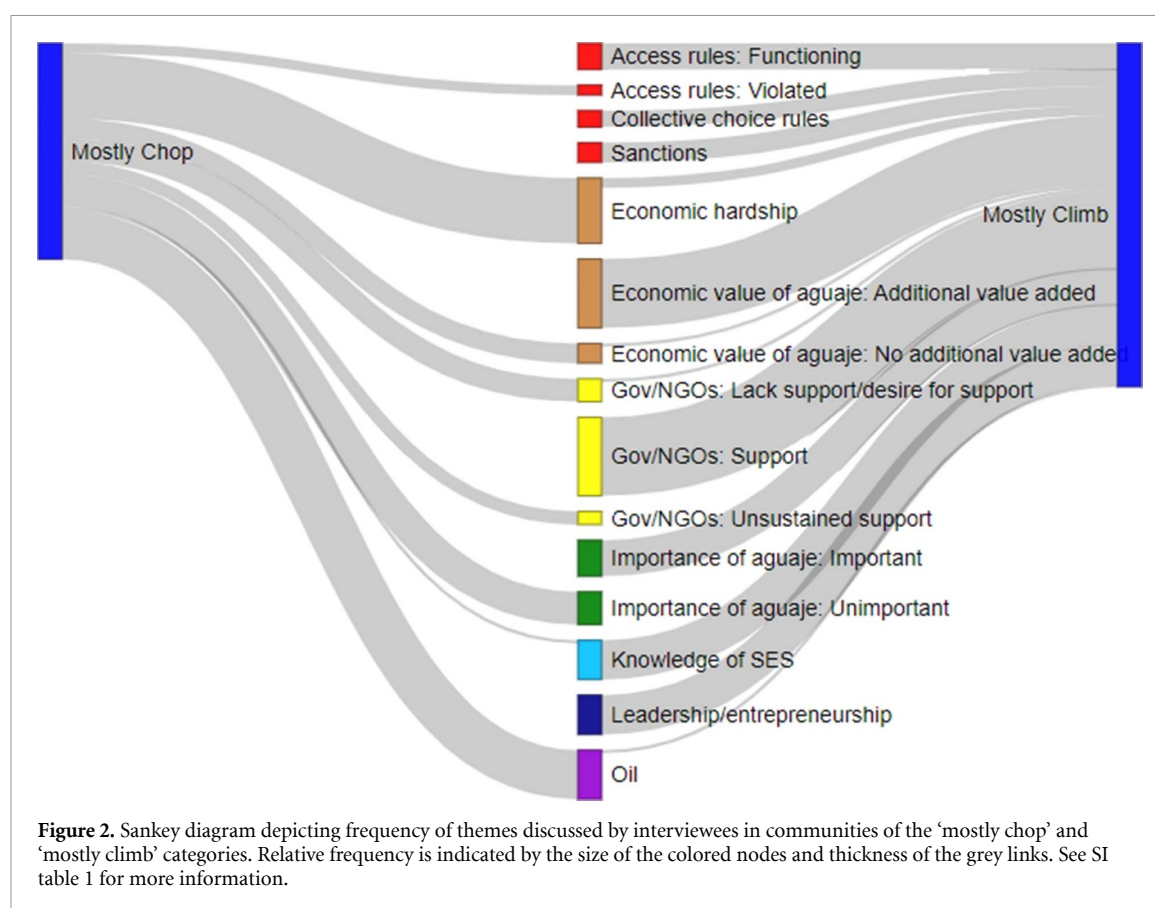
Some interviewees from mostly chop communities indicated that their access rules are violated, at least occasionally. Two interviewees in Community 6 lamented the frequent ‘invasions’ of outsiders from a nearby community. Evidently, these people enter their aguajal without permission to exploit resources. Community members intervene to remove them, but conflicts emerge. An interviewee in Community 8 expressed disdain for the fact that his grove of bolaina, a valuable timber tree, is frequently encroached upon and his trees chopped and stolen. While this particular case does not involve aguaje palms, it speaks to a larger problem of violating access rules in this community.

Communities 1 and 2 (mostly climb) described having collective choice rules, or at least systems of collectively making decisions, regarding resource management. For example, as previously mentioned, Community 1 developed a system of dividing harvesters into associations which then are granted access to specific aguajales. In some years, however, some aguajales will produce abundant quantities of aguaje, while others produce little. This dynamic led to problems in the past when some people were entitled to harvest only in swamps with little production, while others had access to a bounty. The community, along with help from SERNANP, developed a comprehensive management plan, to outline the rules and procedures in such situations.

Table 3. Themes that emerged from interviews, divided by whether they were assumed to refer to sustainable or unsustainable harvest of aguaje.

Themes		Notes
Tendency towards sustainable harvest	Tendency towards unsustainable harvest	
Access rules: functioning	Access rules: violated	Refers to clarity of system boundaries i.e. whether a community's access rules to their aguajales are being respected or violated by outsiders (RS2 in Ostrom 2009)
Collective choice rules		Refers to whether a community has developed a system of rules to make collective decisions regarding resource harvest/use (GS5 in Ostrom 2009)
Sanctions		Refers to system of punishments that occur if people break the rules of SES management agreed upon by a community (GS8 in Ostrom 2009)
	Economic hardship	Refers generally to economic challenges faced by people, such as low incomes, scarce employment opportunities, or layoffs
Economic value of aguaje: additional value added	Economic value of aguaje: no additional value	Refers to economic value i.e. whether aguaje is generating additional value in a community beyond selling the fruit itself to middlemen (RU4 in Ostrom 2009)
Government/NGO support	Lack of /unsustained support of government/NGO	Refers to government organizations and NGO support. Unsustained support refers to cases where such entities initiated projects in the past that were short-term (GS1 and GS2 in Ostrom 2009)
Importance of aguaje: important	Importance of aguaje: unimportant	Refers to resource importance; i.e. whether community members believed that aguaje was an important resource beyond simply a source of occasional supplemental income (U8 in Ostrom 2009)
Knowledge of SES		Refers to how well people understand the nuances of the aguajal ecosystem (U6 in Ostrom 2009)
Leadership/entrepreneurship		Refers to whether a community's leaders articulate a vision of sustainable harvest and communicate its importance. (U5 in Ostrom 2009)
	Oil	Refers to negative impacts from the oil industry, in particular the numerous oil spills in the region

Communities 1 and 2 also described a robust system of sanctions for breaking community rules. A local leader of the community's aguaje association in Community 2 explained how once the community established their access and harvesting rules (such as prohibiting chopping), he now has the responsibility to report rulebreakers to SERNANP. He noted how he has never had to do that as the community is working well under the management plan. Rulebreakers in Community 1 can expect to face sanctions from the aguaje



associations and the community in general, although interviewees did not elaborate on the specific details of the penalties one would face.

3.2.2. *Economic hardship; economic value of aguaje*

All communities labeled as mostly chop report economic hardship and aguaje extraction as a secondary economic activity. Two interviewees in Community 8 describe a difficult economic climate in the community. Most employment there is in the oil sector, but at the time of visit, most oil production was halted due to frequent spills, producing an unstable economic situation. Many people there resorted to small-scale farming to make a living. Fishing was once likely a lucrative alternative, however, fish stocks have plummeted in recent years due to oil spills, as reported by many interviewees in several communities. Harvesting aguaje is done for supplemental income in this community when workers are laid off and money is scarce.

Another interviewee in Community 8 lamented that earning a sufficient living growing crops and raising animals was increasingly difficult. He also noted how in the past he and his father would harvest aguaje in a sustainable manner, but when his father fell ill, this practice was abandoned. A significant drop in fish stocks was a major point of economic stress felt in Community 6, as fishing was once a significant source of income for many villagers. Additionally, a local leader of Community 6 explained how harvesting aguaje in that community is hardly worth the economic gain received. Prices received there are too low to even justify the effort of harvesting, especially given that the history of destructive harvest has severely reduced fruiting females nearby; harvest therefore requires a long trek into the swamps to find fruiting females.

The field guide in Community 9 described a bleak economic environment in his community. Fish stocks are collapsing, and a government project was promised to build pools for raising fish in the community that never came to fruition, leading to frustration with local leaders.

All communities labeled as mostly climb report active aguaje management and aguaje processing as a central economic activity. They also show a direct engagement with the market. Communities 1, 2, and 3 have several projects in place or planned that will deliver additional value to the aguaje harvested by manufacturing aguaje derivatives. For example, all three communities have a processing plant that removes the pulp from the fruits, which can be sold for more profit than the fruits themselves. Pulp is used in the production of ice cream, candies, soft drinks, and other foods which are popular in the region. Community 1 has a plant that produces aguaje oil, soap, and flour, all products that generate extra profit. At the time of the visit, Community 2 was in the process of developing a similar capacity. Additionally, interviewees in

Community 2 described a planned project to construct a platform that will extend into the aguajal and allow for fruits to be hauled back to the village with a wagon, where an aguaje warehouse will be located. Both Communities 1 and 2 have signed contracts with a soft drink company, Aje, which buys their fruit for a guaranteed price of 36 soles per sack, higher than most communities typically enjoy. The partnership with Aje brings the additional benefit of increased demand stability for the fruit, a necessary condition for planning the future management of the resource. Finally, Community 1 is involved in the program Proyecto Aguaje run by the Regional Government of Loreto (GOREL), in which the government purchases sustainably harvested fruits to be sold directly to the aguajeras (women who sell aguaje fruit in the streets of Iquitos) enrolled in the program for a mutually beneficial price. By cutting out the middlemen, who buy aguaje for very low prices in villages, and sell them for enormous markups in Iquitos, Proyecto Aguaje allows villages to earn more for their labor, and for the aguajeras to pay less for their products. Working with companies like AJE and with Proyecto Aguaje requires communities develop a management plan that details how they will sustainably manage their lands, rules for sustainable harvest, and who bears responsibility for enforcement.

Most aguaje felling communities did not enjoy earning any added value from their aguaje harvest, but rather could only sell the fruits directly to middlemen. This economic arrangement typically yields at most 30 soles per sack, or approximately \$8 USD, but often less than 30 soles. Middlemen are usually able to sell these sacks of aguaje for 120 soles or more, reaping nearly all the profit. This dynamic is likely a major factor in a community's choice to invest time and resources into learning how to sustainably harvest or not. For example, in Community 6, harvesting aguaje is a marginal activity for this reason. As a local leader explained how she feels that her community would have an interest in learning sustainable harvest techniques, but only if the economic conditions were more favorable to their community.

3.2.3. Government/NGO support

Most aguaje felling communities expressed reduced government engagement. Interviewees in Communities 6 and 8 expressed frustration at the lack of state support they receive. The leader of Community 6 indicated a wish for the state to intervene in creating a sustainable market for aguaje in her community. Interviewees in Community 8 expressed a desire for training workshops on climbing techniques from either state entities or NGOs, but also a lack of confidence that such an effort would ever happen there.

Similarly, the interviewee in Community 7 expressed significant mistrust of the state helping in any way. When asked what he would like regional legislators to know about environmental issues his community faces, he noted that *'they do not listen to us'* because *'we are low level,'* revealing a dynamic of mistrust felt by many rural people in Loreto against perceived urban elites who run the government (Gonzalez 2021).

A theme of short-term government/NGO support emerged in communities that only fell, where small projects were attempted but without a long-term investment. Such projects were frequently mentioned in Community 8. SERNANP apparently once led an aguaje planting campaign there, and once led a field campaign into an aguajal where ecological restoration work was done. Evidently, they led a team of villagers into the swamp to clear older aguaje palms to allow for natural regeneration of aguaje. Several other small-scale projects were attempted in this community, such as helping people afford animals to raise or agricultural equipment to facilitate harvest and food processing. However, an interviewee there expressed deep frustration with these projects and felt they hardly helped the community at all. It left him feeling distrustful of outsider-led projects in his community.

Some communities that practice climbing (1, 2, 4, and 5) noted a more positive experience with the government and NGOs (interviewees in community 3 did not mention government or NGOs). Several NGOs had been working in Community 1 for nearly 3 decades encouraging sustainable harvest, holding training workshops and meetings, and investing in equipment. Furthermore, they receive support from the state in the form of direct purchases of their fruits through Proyecto Aguaje, and in protecting their land from unwanted intrusion as they are located within the Pacaya–Samiria reserve. They pay the state 30 cents (Peruvian sol) per sack of aguaje they sell and receive these benefits in exchange, an arrangement people there seemed to support. Community members were at first distrustful of the NGO's presence when it arrived in the early 1990s, but over time came to appreciate the support they received. As the local field guide and aguaje harvester of Community 1 said, *'We hated the NGO at first. But the community became aware [of the importance/benefits of sustainable management]. We have asked about 3 million apologies.'* When asked what helped change the mentality in Community 1 to appreciate the benefits of harvesting sustainably, and what could inspire other communities to do the same, the interviewee remarked, *'The NGO held workshops, held meetings constantly, constantly, constantly. So we learned that what other communities are missing is workshops.'* Peru's National Forest Service (SERFOR) has been working in Communities 2, 4, and 5, helping fund the acquisition of climbing gear, and in Community 2's case, financing the construction of the platform and warehouse mentioned earlier.



Figure 3. A member of Community 1 climbing an aguaje palm to harvest fruits. Climbing a palm to harvest its fruit is a skill that requires considerable practice to master. Mature aguaje palms reach heights of 35–40 m (Draper *et al* 2014). Photo credit Matthew Marcus.

3.2.4. Aguaje importance

The importance of aguaje to a community was closely linked to whether the fruit brought significant wealth and contributed to improving livelihoods. It also was related to whether a community had other resources or economic options apart from harvesting aguaje. For example, Community 5, which both climbs and chops for aguaje fruit, is a relatively isolated community with modest means compared to the others visited. It appeared during the visit that climbing for harvest there is a relatively new practice, but that the community is making progress towards using this method more frequently. This may be due to the understanding that harvesting aguaje presents an opportunity in a place where other options are scarce.

Aguaje harvest is a marginal activity in Communities 6 and 8. While aguaje harvest was once common in Community 7, harvest seems to have ceased completely there as the fruiting females have been so devastated. A community member of Community 6 captured the sentiment of how his community values aguaje with this comment: *'People threw the aguaje out of the boat when they had no one to sell it to.'*

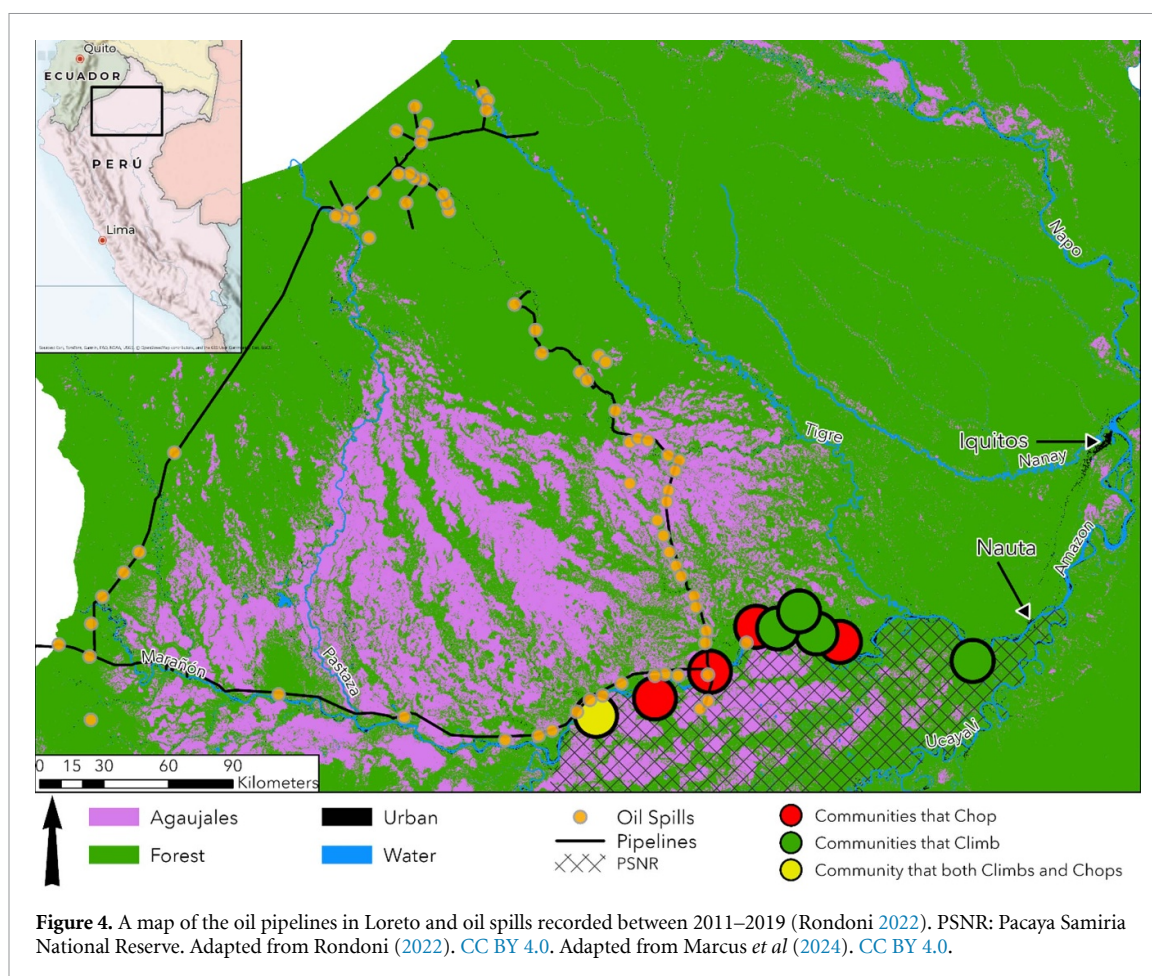
3.2.5. Knowledge of SES

Communities that practice climbing express a deep understanding of the ecology and management of aguaje. Community 1 demonstrated a deep knowledge of the aguaje SES, understanding the unique spatial-temporal fruiting dynamics of the three aguajales around their village. They understand the SES so well, they know exactly where to locate specific fruiting palms at any given time to fulfill large orders of several hundred sacks of aguaje within one day (figure 3). Typically, other communities would require several days' notice to harvest that quantity.

Interviewees in Communities 2, 3, 4, and 5 all demonstrated an understanding of the spatial-temporal fruiting patterns as well. Examples of such deep ecological knowledge were less common in the 'mostly chop' communities, however, people there always understood the seasonal fruiting dynamics of local aguajales, an ecological factor that varies across the landscape.

3.2.6. Leadership/entrepreneurship

Leadership that promoted a shift to sustainable harvest was an important factor in Communities 1 and 2. Themes of leadership did not emerge in other communities. In Community 1, there was resistance against making the shift at first and against the NGOs that were promoting it. A villager elder who was interviewed and was the village leader at the time explained that convincing the community to trust the NGO and to see the importance of preserving aguaje trees required great effort and was achieved over years.



Similarly, the current leader of the aguaje association of Community 2 explained how he promoted the idea of sustainable harvest to a skeptical community. Additionally, he has pushed to develop business training skills for young people in the community, recognizing the need for managers as the aguaje business grows there. His articulation of a vision of sustainable aguaje harvest to benefit his community was critical in the community abandoning chopping and adopting climbing as the exclusive method of harvest.

3.2.7. Oil spills

Oil extraction has been a major economic activity in Loreto since the 1970s when oil deposits were discovered. By 2014, Loreto accounted for nearly 75% of Peru's territory granted for energy extraction (Rondoni 2022). Over this time, oil spills have become increasingly common, and have precipitated grave environmental consequences (figures 4 and 5). Interviewees in communities 6 and 8 were deeply concerned with the issue, in no small part due to the collapse in fish stocks, which studies have linked to oil spills (Azevedo-Santos *et al* 2016). Communities near the spills receive compensation from the oil companies, according to several interviews. However, communities downstream from spills suffer from the toxicity, yet typically receive no compensation from the oil companies as they are located far from where the spills occurred. The impacts of oil spills produce economic hardship for the communities affected, and these concerns were discussed overwhelmingly in communities that mostly chop for aguaje harvest.

3.3. Ecological demographic data of aguajales

Figure 6 presents the ecological characteristics of the palm swamps sampled as bar graphs to compare the impacts of harvest method to each other. Table 4 provides the results of *T*-tests performed for each variable comparing mostly climb to mostly chop communities. The two groups had significantly different densities of adult palms, however the two groups did not differ significantly at the $p < 0.05$ level for the other variables. Female density was significant at the $p < 0.1$ level. Adult density ranged from 157 to 259 ha^{-1} (mean of 190.6 ha^{-1}) in mostly climb communities and from 97 to 147 ha^{-1} (mean of 121.1 ha^{-1}) in mostly chop communities. Female density ranged from 22 to 82 ha^{-1} (mean of 47.6 ha^{-1}) in mostly climb communities and from 12 to 32 ha^{-1} (mean of 20.9 ha^{-1}) in mostly chop communities.



Figure 5. Photographs of oil spills in Loreto that occurred in 2022 and entered the Chambira and Marañón rivers near Community 6 (S. Flores, personal communication, 6 September 2023). Photos courtesy of S. Flores.

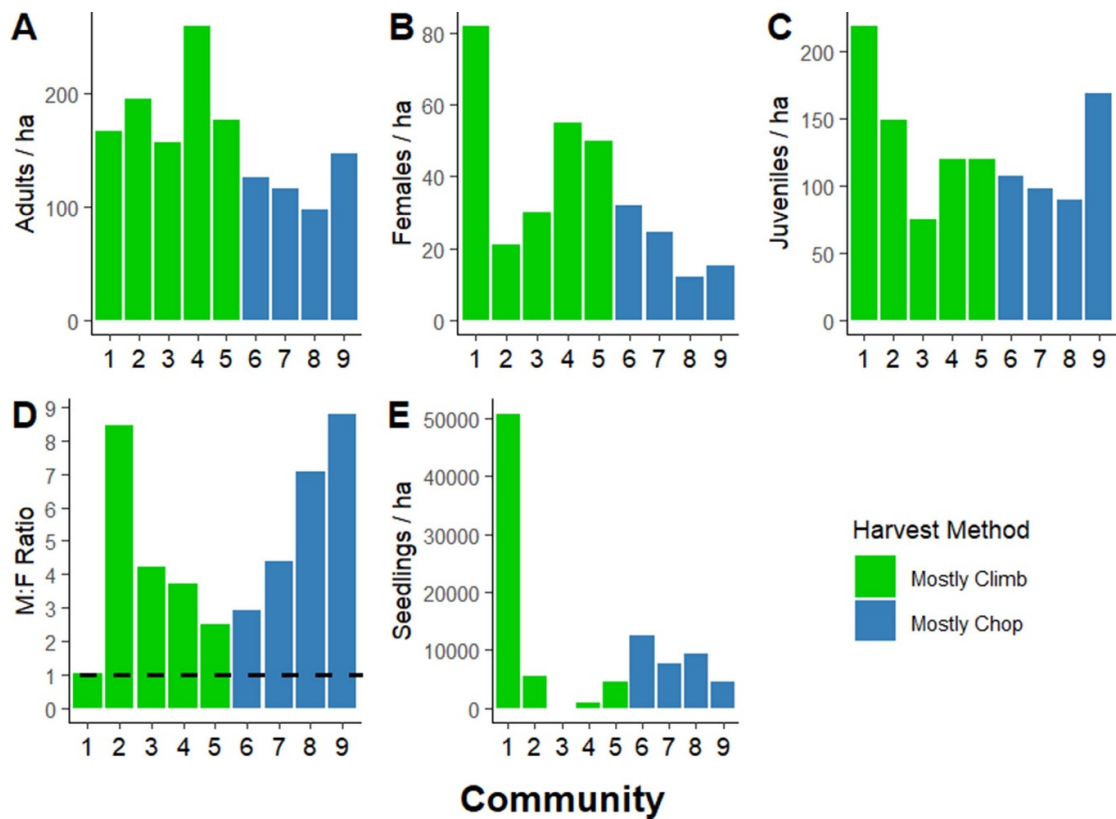
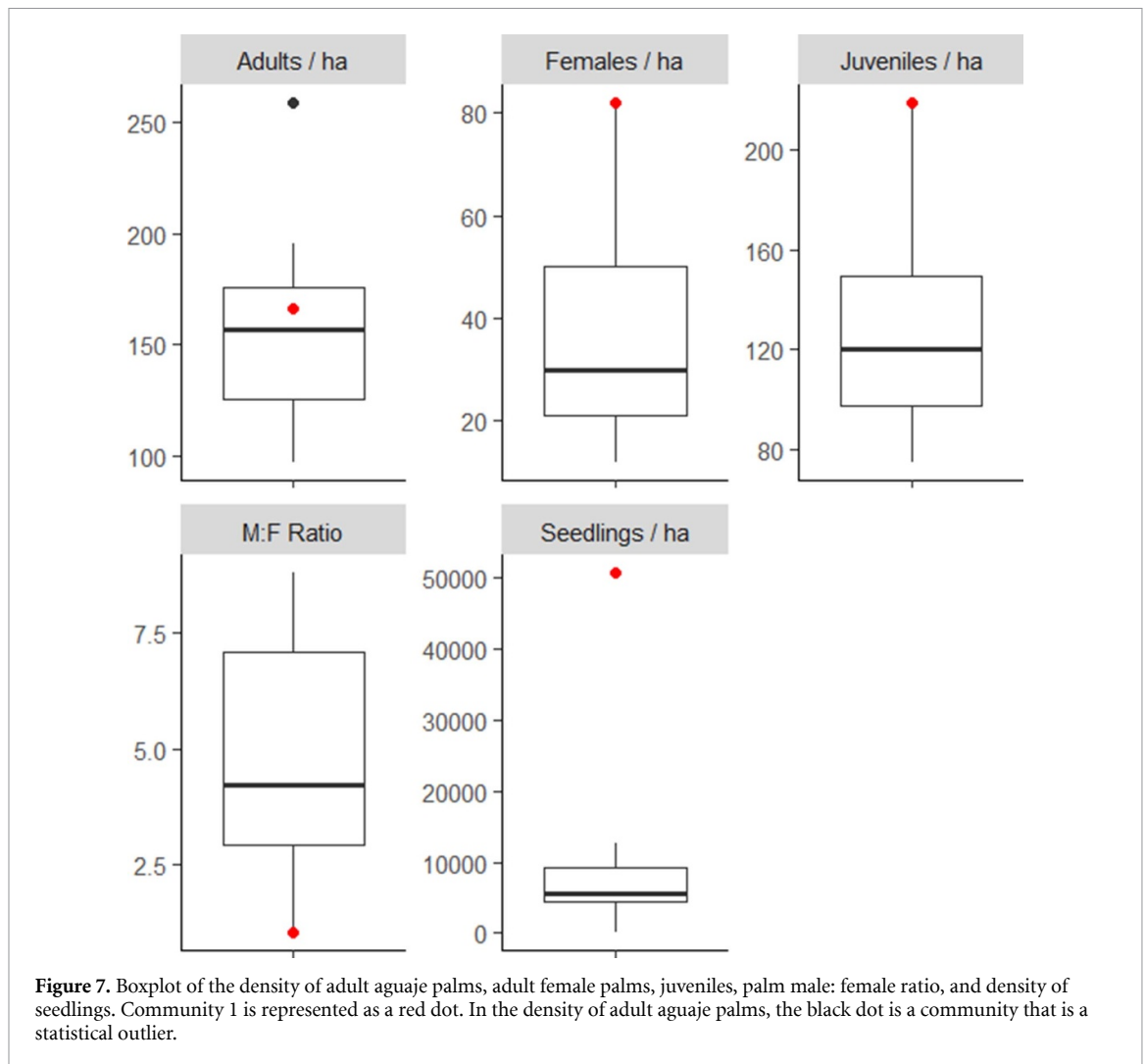


Figure 6. Bar graphs of ecological characteristics from each community. (A) is adult density; (B) is female density; (C) is juvenile density; (D) is the male: female ratio. The dotted black line shows a male: female ratio of 1, which represents a healthy ecological state; (E) is seedling density. Data from communities 2 and 7 are the mean of the two transects observed in those communities. See SI table 2 for more information.

Table 4. Results of *T*-tests for each variable comparing mostly climb with mostly chop communities.

Variable	<i>T</i> -value	<i>p</i> -value
Adult density	−3.3104	0.016
Female density	−2.3095	0.065
Juvenile density	−0.7044	0.504
Male: female ratio	0.99951	0.352
Seedling density	−0.38954	0.716



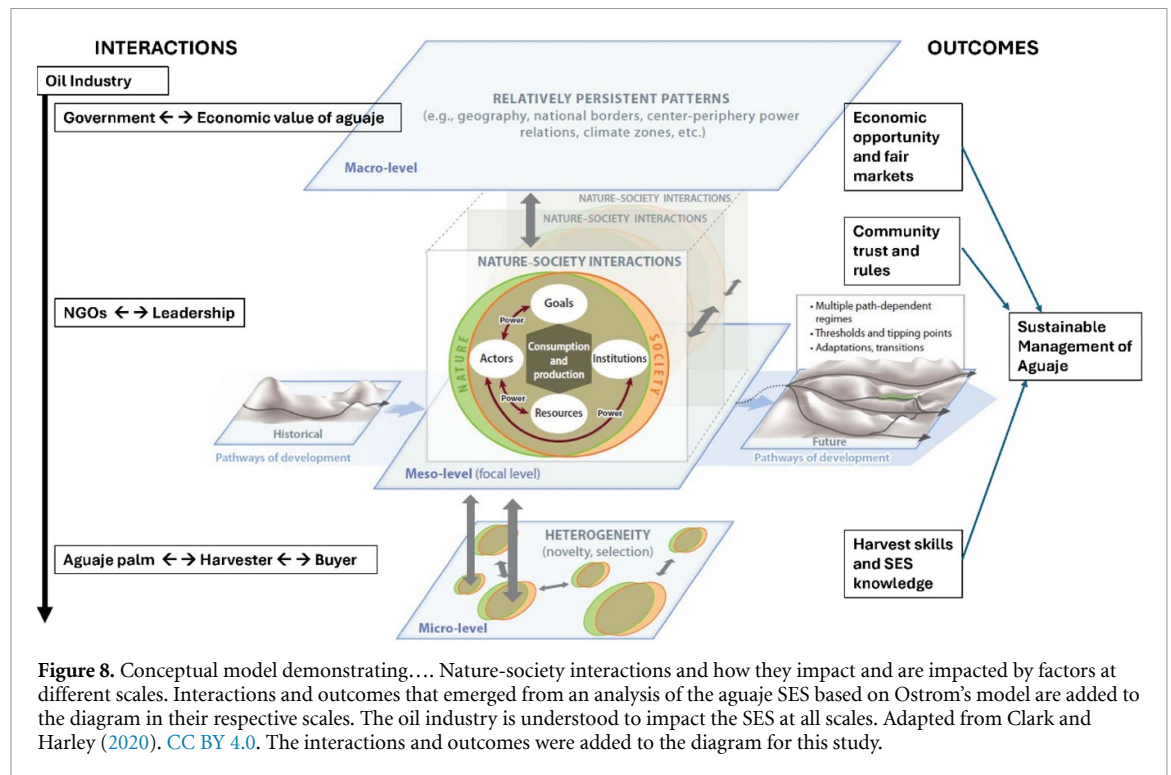
Seedling density in the aguajal of Community 1 ($50\,740\text{ ha}^{-1}$) was a statistical outlier (beyond 1.5 X the interquartile range). Community 1 exhibited the highest female density (82 ha^{-1}), male: female ratio ($1.02:1$), and juvenile density (219 ha^{-1}). The adult density of Community 1 (166 ha^{-1}) fell within the interquartile range (figure 7).

4. Discussion

4.1. Using sustainability science to assess the factors that enable the sustainable management of aguaje

Through the use of an SES framework, this study analyzed several variables identified in Ostrom (2007, 2009) to note how these variables interact and produce three outcomes we argue are necessary for the sustainable management of the aguaje SES: (1) economic opportunity and fair markets; (2) community trust and rules; and (3) harvest skills and SES knowledge.

Recent scholarship in sustainability science has expanded SES theory to explicitly include scale in models of complex coupled human-natural systems. Clark and Harley (2020) present a new model that sets nature-society interactions at a focal, or meso-level. This level would constitute here an aguaje harvesting community. The highest scale is the macro-level, which in this case would include the region of Loreto, the Peruvian state, and climate change policy, among other factors. The smallest scale, the micro-level, would include individual harvesters, aguaje palms, middlemen, and other actors. Three interactions that emerged as critical are: (1) government policies and the economic value of the fruit; (2) NGOs and leadership; and (3) individual aguaje palms and the harvesters, and harvesters and the buyers (figure 8). Government policy and the market value of aguaje are here conceived as interacting at the macro-level, a scale that influences the overall context of the aguaje SES in which communities are embedded but have no agency to impact. We argue that the interaction between government and the economic value of the fruit produces an outcome of economic opportunity and fair markets. The interaction between NGOs and leadership is here conceived as



occurring at the focal level, within the communities themselves. In two cases where local leaders successfully advocated for their constituents to acquire new harvest skills and facilitated the building of trust with outside groups teaching those skills, greater community trust was fostered resulting in communal success of developing harvest rules. Finally, the interactions of individual harvesters with the aguaje palms and with the purchasers of fruit (usually middlemen) produce an outcome of improving harvesting skills and deepening knowledge of the SES. This is conceived as occurring at the micro-level or within individuals. These three outcomes come together to produce an ultimate outcome of sustainable (or unsustainable) aguaje management.

Economic opportunity and fair markets: A fair market is one in which communities have agency to sell at better prices and to keep more of their profits without losing them to middlemen. Most communities do not enjoy access to markets that can be described as fair. As an expert of the aguaje market in Iquitos explained (F. Vacalla, personal communication, 29 July 2022), and several interviews in communities confirmed, it is not economically feasible for harvesters to travel to the ports of Nauta or Iquitos to sell their fruits directly and so must rely on selling to middlemen. The geography of the region is such that the supply of aguaje fruits is vast and dispersed across the landscape while the demand is mostly concentrated in Iquitos (Padoch 1988, Penn 2017). This dynamic empowers the middlemen to organize themselves and to collude in keeping prices low but disempowers communities from organizing in response. Should an aguaje seller in a community attempt to counteroffer a middleman with a fairer price, the buyer could easily reject the offer and buy from another community. Meanwhile, aguaje fruits rot within five days of harvest, so a seller cannot even make such a counteroffer in practice, as the transaction in question may be the only opportunity to sell before the fruit expires. This power imbalance reduces the possibility of deriving more economic opportunities from aguaje harvesting. Communities that have forged arrangements to achieve fairer access to markets, such as Communities 1 and 2, are more empowered to manage their SES. Addressing these power imbalances will require interventions at the macro level. For example, GOREL's Proyecto Aguaje initiated such efforts, as an employee of GOREL explained (S. Soplin, personal communication, 1 August 2022). The program seeks to formalize the chain of production of aguaje by providing documentation for sustainably harvested aguaje and to connect these products to buyers. It is assisting communities in developing management plans and providing workshops and climbing gear. As of the interview, 16 communities in Loreto were involved in the program. To enter the program, communities must demonstrate their desire and capacity to sell sustainably harvested aguaje by forming an aguaje association and being willing to pay small taxes on the fruit they sell. The program attempts to guarantee fairer prices for communities by cutting out middlemen and discouraging buyers of aguaje from purchasing destructively harvested fruit. With more communities selling aguaje with documented proof of sustainable harvest, GOREL will be able to better regulate unsustainably

harvested fruit. Through partnerships with GOREL and Aje, a soft drink company, Communities 1 and 2 earn more money per sack of fruit than most other communities and have a relatively stable source of demand.

In a study of an SES of small-scale agricultural producers in Nicaragua, Starobin (2021) describes how these producers formed a ‘Trademark of Trust,’ in which agricultural goods are produced in a sustainable manner and bear the trademark. The producers certify each other as sustainable producers and work together to share best practices and knowledge. Achieving a similar model in Loreto would be a challenge, as the region is vast and communities dispersed; however, forming a regional association of aguaje producers that incorporates distributors may yield a productive arrangement that shifts economic power towards communities. It seems unlikely that this could be managed without some entity assisting at a larger scale than the communities, be that a state agency, NGO, or other entity with power and influence. Furthermore, it seems reasonable to assume that a significant barrier to developing such an association has been the capacity for communities to communicate over the vast territory. This barrier is shrinking as telecommunications towers are erected throughout Loreto. We were surprised to discover that cell coverage with reliable internet data was available in most communities visited in 2022. Cell phone access has been a boon to smallholder cooperatives in other contexts (Zimmerer *et al* 2018), and perhaps may prove useful in Loreto as well. Future work should investigate whether improved communication capacity between villages facilitates collective organization between them.

Several studies of SESs in the Peruvian Amazon demonstrate that communities with more diversified economic production and larger incomes are associated with more sustainable management of their environmental resources. Andrieu *et al* (2019) found that households in Ucayali with more diversified agricultural output were most well-off economically exhibiting improved food security with reduced levels of deforestation. Furthermore, Honorio-Coronado *et al* (2017), in a study of two Loreto communities (including Community 1 detailed here) that only climb for aguaje harvest, found that these communities earned far higher incomes than most other communities in the area, were engaged in more diversified economic activities, and clear ecological recovery in their palm swamps was underway.

On the contrary, communities facing poverty and a lack of economic opportunities or access to fair markets face a disincentive to invest in sustainable harvesting skills and in developing a management plan. When prices for the fruits are low, sustainable harvest becomes unprofitable (Honorio-Coronado *et al*, 2017), and therefore untenable for communities already struggling economically. In the context of another SES in the Peruvian Amazon, smallholder farmers in remote areas of Ucayali were more likely to harvest timber unsustainably when their only access to markets permitted the sale of unprocessed timber for low wages (Porro *et al* 2015). The decision to enter the aguajal and harvest by whatever means is available is a logical choice. For people such as the local guide of Community 9, harvesting aguaje is likely a marginal activity to derive a source of supplemental income, but not a sufficient level of income to justify the investment in learning sustainable harvest techniques.

Community trust and rules: Community trust, both amongst members within a community and between communities and outside organizations, is required to collectively develop the rules of sustainable management and for community members to monitor each other to ensure that rules are followed. Leadership is necessary (but likely not sufficient) in fostering community trust, especially between a community and outside groups. Over a period of several years, trust was established between Community 1 and an NGO, leading to sustainable harvest training and the community developing its management plan. The observation that NGOs were successful in helping Community 1 transition towards sustainable harvest is not to imply that communities have no agency in organizing themselves without outside help. Rather, it is to suggest strong trust within the community is necessary for the development of a sustainable SES, and that the interaction between the NGO and Community 1’s leadership was instrumental in producing that outcome in this case. That being said, a study of community rulemaking in Loreto showed that communities were most likely to engage in collective rulemaking to govern sustainable aguaje harvest when their communities were part of broader networks linked with outside forestry professionals such as NGOs or the state (van der Zon *et al* 2025). Critically, these networks succeeded when relationships between communities and outside groups were horizontal and based on mutual respect. Our study was unable to determine which of the communities possessed legal title to their lands. It would be reasonable to acquire this information in future studies as it seems plausible this factor may influence a community’s capacity to trust outsiders.

Conversely, trust between communities and outside groups is less tenable in the face of challenges such as poverty, the perceived status of marginalized citizenship, especially in indigenous communities who feel neglected by the state (Gonzalez 2022), food insecurity (Rondoni 2022), and widespread contamination from the oil industry (Gonzalez 2021). While a direct link of causality between oil contamination and aguaje harvest practices cannot be claimed, it is notable that oil spills were discussed almost exclusively in communities that chop for harvest (figure 2). Oil spills and associated contamination are widespread

throughout Loreto (León and Zúñiga 2021, Rondoni 2022) (figures 4 and 5), resulting in health impacts and reduced fish stocks, an important source of food and income. Decades of environmental injustice have persisted without redress, leading to a reduction of trust between impacted communities and the state (Gonzalez 2021, 2022). These factors all contribute to producing additional economic, environmental, and social stress on communities, potentially impairing their capacity to build systems of sustainable management of common property resources.

The oil industry impacts the aguaje SES at all scales. The industry dominates the economic and political climate of Loreto, receiving state support and minimal consequences for contamination (Andueza *et al* 2023). Many communities are negatively impacted by pollution, but in some cases, like Community 8, oil companies provide employment and donated electricity access, producing political support for the industry. In this oil dependent community, aguaje is harvested during periods when oil jobs are scarce by people without the resources or incentives to build the systems required to sustainably manage this common resource. Future research should further investigate a possible link between oil contamination and land management practices.

Harvest skills and SES knowledge: Acquiring the skills and knowledge for sustainable harvest occurs at the micro level. Community-level factors enable individual empowerment. For example, trust is necessary for community members to benefit from any capacity training provided by outside organizations, whether that be from government officials or NGOs. Here, leadership (meso-level) is also important in communicating to the people the potential benefits that could be derived from the workshops and training offered by outside organizations. As community members acquire knowledge of the SES and experience in harvest (via their interaction with the palm itself) they will share that knowledge with other members of the community. Interactions between harvesters and aguaje buyers produce deeper individual knowledge of the SES (micro), informing people of best management practices, fluctuating fruit prices, and potential economic opportunities for aguaje.

4.2. Ecological demographic data of aguajales

With the exceptions of Communities 2 and 7, only one transect was collected per community. Ideally, more transects distributed further across the ecosystem should be collected. Future fieldwork ought to collect additional transects to develop a more representative sample of ecosystem health. While a single transect cannot fully represent an ecosystem, the data are still useful descriptively.

Adult aguaje densities vary naturally across the landscape, and different sampling methods can produce widely varying results of this statistic, however numerous studies have shown that densities decrease with increasing degradation of the aguajal. For example, Hergoualc'h *et al* (2017) found adult densities of 402 ± 30 , 128 ± 4 , and $46 \pm 13 \text{ ha}^{-1}$ for aguajales of low, medium, and high levels of degradation, respectively. Horn *et al* (2012) found densities ranging from above 900 decreasing to $\sim 200 \text{ ha}^{-1}$ with increasing degradation. Freitas *et al* (2006) found 280 ha^{-1} in a dense stand, and Honorio Coronado *et al* (2015) found $208 \pm 43 \text{ ha}^{-1}$ across six dense stands. Our results of adult density fall below the density of low degradation but closer to the densities of medium and high levels of degradation observed in Hergoualc'h *et al* (2017). Our results are comparable to Freitas *et al* (2006) and Honorio Coronado *et al* (2015), but far below the observations in Horn *et al* (2012). The latter may be explained by the fact that Horn *et al* (2012) collected their data in smaller palm swamps in a different part of the Loreto region, near the Napo River, whereas the data from this study, Freitas *et al* (2006), Honorio Coronado *et al* (2015), and Hergoualc'h *et al* (2017) were collected along the Marañón.

Across most tested ecological conditions, the differences between aguajales in mostly climb versus mostly chop communities were not significant, except for adult density ($p < 0.05$) and female density ($p < 0.1$). Apart from Community 1, the other mostly climb communities have only transitioned to sustainable harvesting within seven years of the time fieldwork was conducted (Romulo *et al* 2022), and therefore those aguajales have had little time for ecological recovery. Future studies should return to Communities 2–5 to evaluate the progress of recovery there. Community 1 exhibited the healthiest ecosystem characteristics observed, with a male: female ratio of nearly 1:1, and relatively high female and seedling densities. This community has managed its aguajales for nearly three decades, far longer than any other. This included a seven year period in which no aguaje was harvested, allowing for natural regeneration to occur.

The possibility that some biophysical factor unique to the aguajales near Community 1 that makes the production of aguaje there more suitable, and therefore, more advantageous for a community to manage it must be considered. The density of adults in the Community 1 transect (166 ha^{-1}) fell within the interquartile range of all transects observed, and was lower than other adult densities of intact swamps reported in the literature (Freitas *et al* 2006, Honorio Coronado *et al* 2015, Hergoualc'h *et al* 2017). This suggests that this aguajal is not unique, at least in terms of this biophysical factor. Another factor that merits further consideration is the quality of the fruits produced in Community 1 versus other locations. Multiple

aguaje varieties exist of varying qualities, including the common variety, and the shambo, the variety of the highest quality (Manzi and Coomes 2009). The field guide in Community 1 mentioned how shambo is found there, but most of the fruits they harvest are of the common variety. This suggests that the aguaje fruit quality found near Community 1 is not remarkable compared to fruits commonly found elsewhere. Other biophysical factors not considered in this study may potentially provide unique advantages to the aguajales of Community 1. Future work should consider the possibility of a unique flooding regime in this location that renders relatively easy access to the palms compared to other locations, and seasonal fruiting dynamics that may uniquely privilege this location. We observed in the field during July of 2022 significant aguaje harvesting taking place, whereas the other communities visited noted that palms in their vicinity would not produce ripe fruit for several more months. Fruiting dynamics are known to vary across the landscape (Virapongse *et al* 2017), but it is unclear if the aguajales near Community 1 are advantaged in this regard.

Apart from Community 1, Community 2 appeared to have the most developed system of sustainable aguajal management. Interestingly, regeneration appears to be robust in Community 2 (in the transect nearest to the community) where a high juvenile density was observed (233 ha^{-1}), despite a high male:female ratio (8.9) and low female density (14 ha^{-1}). More data would be needed to confirm these curious results, however, there exists an intriguing possibility that ecosystem management practices employed by the community are encouraging regeneration. Community 2 had recently planted a field of aguaje saplings near the community for future harvest, demonstrating their knowledge and capacity of managing the species. No information in interviews confirmed efforts to encourage regeneration in the aguajal, so future fieldwork should investigate this possibility. Little ecological data on aguajal regeneration has been reported in the literature. However, one study that examined three sites, an intact swamp, and swamps of medium and high degradation, found that the swamp of medium degradation, which was in a process of recovery, exhibited a higher juvenile density than both the highly degraded and intact sites (Dezzeb *et al* 2021). More research is needed to assess the ecological characteristics of aguajal recovery, and Community 2 seems to be a logical place for such research.

4.3. The experience of the mostly climb communities as a ‘bright spot’ of the Anthropocene

Three decades ago, Community 1 was harvesting aguaje by chopping the female palms, contributing to ecological degradation over critical peat soils and undermining its future well-being. Today, the community identifies itself in terms of sustainable aguaje harvest. Most people there are involved in the aguaje trade and take great pride in the sustainable management of their lands. The ecological data collected for this research strongly indicates superior ecological conditions in the aguajales surrounding Community 1, compared to the other communities. While economic data was not ascertained in this research, employment opportunities appeared to be relatively strong in Community 1 compared to others. This was certainly true concerning aguaje, where people were employed both in the harvest and processing of fruits into derivatives such as soaps, oils, and pulp. Even a nascent ecotourism sector existed there, catering to visitors exploring the flooded forests.

Communities 2–5 appear to be in varying stages along the trajectory towards sustainable management of their palm swamps. While future work will be necessary to verify if these trends continue, the prognosis seems hopeful that positive change is happening with regards to managing this critical ecosystem better. The factors that contribute to the success of Community 1, and that are emerging in Communities 2–5, can help illuminate the conditions that facilitate the emergence of new seeds. Community 1’s success stems from developing a robust common property resource management system where rules of access and use were developed communally. Local leadership advocated for the importance of acquiring new harvest skills, giving legitimacy to outside groups teaching those skills. NGOs played a key role in this case, catalyzing a process of learning new harvesting skills and providing a forum for the community to develop its rules of harvest. Over time, individuals have developed competence with their harvest skills and in their entrepreneurial knowledge of negotiating for better prices and developing more profitable aguaje products. Additionally, GOREL’s Proyecto Aguaje has connected Community 1 to fairer prices for their sustainably harvested fruits.

The experience of Community 1 demonstrates that positive environmental and socioeconomic change is achievable in forest communities when they are empowered to manage and benefit from their SES. Critically, Community 1 was empowered to develop an SES based on its own values, without outside values being imposed upon it. Social values, such as a community’s notion of a good life, equity, communal responsibility, and a community’s views on appropriate conservation efforts, are recognized as key factors present in successful sustainability initiatives (Chan *et al* 2020). The process of developing a sustainable SES entailed frequent community deliberations where such values were debated and produced. Environmental NGOs played a facilitating role in this process, fostering discussion but not imposing values. Ultimately, the community was able to create a system suited to its own goals, comprised of rules it invented that are enforced by community members themselves. This is an indispensable aspect of their success, and likely critical in

other examples of seeds. This observation is consistent with conservation theory. Hayes and Ostrom (2005) found that the most important factor in successful forest management was whether local communities were able to participate in rulemaking, monitoring, and enforcement of their rules. Forestry programs that enhance local people's rights were found to be associated with better ecological outcomes and higher incomes (Hajjar *et al* 2021). Furthermore, Dawson *et al* (2021) find that embedding the institutions of indigenous peoples and local communities into conservation governance leads to better ecological and social outcomes.

A recent study comparing examples of seeds in the Seeds of a Good Anthropocene database demonstrated that the most common feature of successful sustainability transformations was whether a community embedded in an SES was well-networked (Tuckey *et al* 2023). In other words, communities engaged in broad networks of support with actors and resources across different spatial and temporal scales were most likely to succeed in transforming their SES into a more sustainable system. Results from this study support this finding. Community 1 has been engaged in broad networks of support longer than most other communities and has produced a remarkable SES transformation. As other communities are developing their own networks of support, through climbing training programs and fairer market access via connections to different actors, sustainable harvest practices are becoming more prevalent throughout the region. A potential avenue for further progress would be for communities to network with each other by sharing best practices, and by building a fairer aguaje distribution network. As previously stated, recently installed telecommunications technology in the region may serve to link the communities in new ways, allowing them to deepen mutual networks of support and to promote a sustainable transition.

4.4. Recommendations for future work

The results from the qualitative data provide a general description of the factors that influence whether communities opt to harvest and manage aguaje sustainably versus harvesting destructively. The sampling design was intended to acquire data from as many communities across as large a distance as was possible to gain insight into how harvest practices vary over space. Given time and resource constraints, only a few individuals per community were interviewed. Therefore, a broad sense of regional variance in harvest practices was revealed at the expense of deeper specificity per community. This tradeoff was deemed acceptable for the goal of producing a general description of the SES throughout the region; however, it entails the risk that the few individuals interviewed in each community are not representative of their communities and may therefore bias results. Future work ought to collect more qualitative data from fewer communities. Given the results of this general study, focusing more precisely on Communities 1 and 2 of the mostly climb category and Community 8 of the mostly chop category would seem a productive strategy to guide future fieldwork.

5. Conclusion

The choice to chop aguaje palms to harvest their fruit is not one made of ignorance; rather, it is a logical practice given the socio-economic context of many communities. Several communities have managed a remarkable transition towards a sustainable SES of aguaje harvest. Future research should monitor the progress of these communities and the ecological recovery in their palm swamps. Future interventions in communities where chopping is predominant must address the issues of fostering community trust and connecting communities to fair markets. Positive change appears to be spreading through the region of Loreto. Communities 2–5 appear to be in varying stages of transition towards developing sustainable aguaje management systems. The impressive success achieved in these communities, and the environmental and social benefits that could come from their lessons being more widely shared across the region, comprise a case deserving of recognition as a bright spot in the Anthropocene.

Data availability statement

The data that supports the findings of this study are openly available in the supplementary files of this article.

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