Investigating the population and harvest sustainability of the Brazil Nut Trees in Madre De Dios

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Abstract

Maintaining a healthy population and harvest of the Brazil Nut (Bertholletia excetsa) is essential to conservation because of the economic incentives the precious nuts create for locals. To investigate its population sustainability, data was gathered from concessions in Madre De Dios region, Peru and the mortality rate was found to be 9.1/1000 trees (±2.7), natural recruitment rate rate 5.9/1000 trees (±2.6), and therefore the necessary replanting rate 3/1000 trees (±2.5). Volatility was found within the market for nuts, where the price for a bag of nuts can half or double depending on the year. Under these circumstances, and the institutional failure to manage illegal resource extractive pursuits, maintaining a concession does not always make clear economic sense. The future of the harvest will both depend on harvester's efforts to reforest, and market and social stability.

Introduction

As the Amazon rainforest faces many threats from resource extractive pursuits, the Brazil Nut Tree (Bertholletia excetsa), often called the "pinnacle of conservation" provides locals with a sustainable economic incentive for conservation. While some conservation advocates continue to call for limitations to human activity in protected areas (Terborgh, 1999, Oates, 1999), the expansion of the World Conservation Union's classification system to include Category IV (managed resource protected areas) highlights the growing notion that local communities could play a central role in conservation through sustainable use. One of the most accredited sustainable uses of the forest, is through non-timber forest products (NTFP), which the Brazil nut is widely recognized as a success model, for its longstanding economic success in the international market. This single species is accredited for the protection of millions of hectares of intact forest in Brazil, Bolivia and Peru (Ortiz, 2002) where its commercial harvest and marketing represents a major income for rural and peri-urban collectors and processors. (Stoian, 2005). The government has allocated Brazil Nut concessions, contracts that grant rights to harvest within the forest, on the condition that the area is otherwise left conserved. This important clause effectively conserves the area without restricting locals' need for

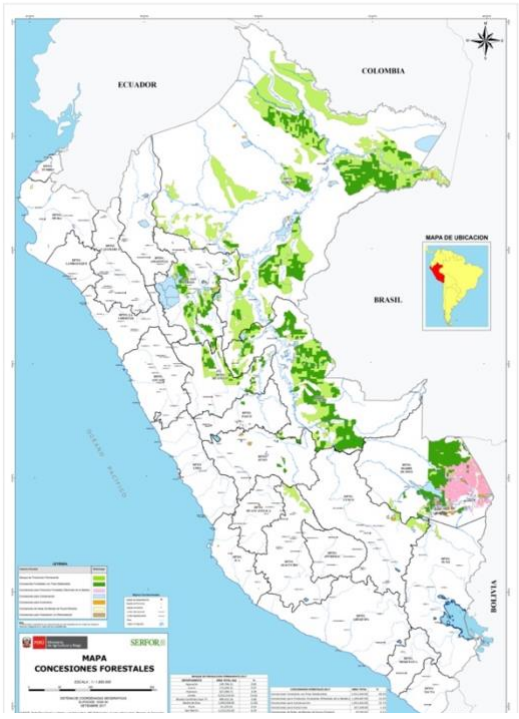

Figure 1. A map of the forestry concessions in Peru. Green is for timber concessions (69.5%), light blue for conservation (15.7%), orange for ecotourism (1.6%) and pink for NTFP concessions (12%), mostly Brazil Nuts, found in the Madre de Dios region. Source: SEFOR. 2017

economic productivity. The *B. excetsa* grows most densely within the "Brazil Nut Corridors", an area spreading across Brazil, Bolivia, and southwestern Peru, where almost all of the world's Brazil Nuts are sourced from. The Madre De Dios Region in Peru hosts almost all of Peru's NTFP concessions (Fig 1) and is the third most important economic activity after gold mining and lodging. For an Amazonian resident, the collection and sale of Brazil nuts from mature forests can provide up to 43% of household income (Duchelle Et al. 2011). With the expansion of the Transoceanic highway, stretching from Brazil's Atlantic coast to Peru through the Amazon jungle and the Madre De Dios region, lodging and gold mining has increased significantly. This has increased the cost of living for those not taking part in the expansion, including concessionaires, creating economic pressure on the forest (Fraser, B. 2009). As reported by Escobal and Aldana (2003), there are higher (76%) levels of poverty for Brazil Nut concessionaires than the average of an Amazonian resident (61%), and that since Brazil Nut gathering takes place over just 3 months, many concessionaires engage in non-sustainable activities for the rest of the year. This lack of resources could explain the overharvesting and lack of replanting from harvesters reported by Peres et al (2003), predicting a "population bottleneck", as the nuts are harvested before the Agouti, its natural seed disperser has a chance to take them. If the population is under decline, and the cost of living is increasing, there might be far greater returns on the land by using it for other extractive pursuits such as lodging, mining, or animal agriculture. Maintaining a healthy population of Brazil nuts, and a sustainable economic return on the land, is therefore essential to the conservation of the amazon.

Recent scientific literature has produced varying results of whether there is a demographic threat to the species, indicating that there might be several different demographic developments of the species according to geography and climate. Some studies report no correlation between human activity and juvenile recruitment rates and conclude that harvesting may permit population persistence (Bertwell et al (2017), Zuidema and Boot (2003), Ticktin (2004)). Contradictory to these findings was an Amazon-wide basin study reporting that more intensively collected population over decades, showed clear signs of regeneration failure (Peres et al, 2003), and L.H.O. Wadt et. al. (2007) reported unexplained differences between site conditions and Brazil nut seedling densities. We can therefore say little with certainty about the current state of each population, but most studies agree on the need for monitoring and studies within each region and cite the importance of socioeconomic sustainability when it comes to greater conservation implications.

Contributing to this debate, I sought to investigate the population sustainability of the Brazil nut tree and harvest in the Madre de Dios region, Peru. The region is of great importance, as it hosts almost all of Peru's Brazil Nut concessions, and is changing rapidly, partly due to the economic expansion following the Transoceanic highway building, and other road expansion. The questions I seek to answer is separated into 3 parts, as a part of a holistic approach to sustainability:

(1): Under a "business as usual" scenario, is the B. excetsa population declining within concessions?
(2): If so, what is the minimum necessary replanting rate to sustain the population long term?
(3): Are the socioeconomic conditions of concessionaires sustainable?

Methods

This research was conducted by retrieving data from Brazil Nut concessionaires living in the Madre De Dios state. 7 interviews were carried out in the span of 5 days under the oversight of Joanna Reyes Quintes, social psychologist. An additional interview was made with Candela, a company that buys and sells Brazil Nuts and other products from farmers. Participant's responses are held anonymous and was personal information not collected. The questions were 18 in total and most of them focused on how many trees had died, why, how many trees are planted, costs, income, and perceptions of the future. After the interviews were conducted, the data was used to calculate several values.

Model parameter	**Value**
Mortality rate	0.0091 (SD:0.0061), must =<1 and >1
Recruitment rate	0.005955 (SD:0.006), must =>0 and >1
Min. recruitment rate	0.003125 (SD: 0.0056)
Historic decline rate	0.003815 (SD: 0.0016)
Initial population	2270
Number of time steps	50

Mortality rate was calculated by dividing the total amount of reported deaths with the population and restricted to rates above 0 and below 1. The recruitment rate was defined as the total trees

that started producing this year, divided by the total population, and restricted to values between 0 and 1. The difference between the two is the minimum necessary replanting rate to sustain the population. To model the future population dynamics, a model was constructed in R, with stochasticity added from the standard deviation of the mortality and recruitment rates.In the simulation, generations were discrete and non-overlapping. The initial population size was 2270 and each simulation lasted 50 years .

$$P_{t+1} = P_t + Recruitment\ rate * P_t - Mortality\ rate * P_t$$

$$Pop\ Historic_{t+1} = P_t + (Hist.Decl.\ rate\ * P)$$

A total of 100 simulations were carried out and plotted. There was one outlier in the data with way above SD mortality and recruitment rates that was taken out from the mortality modeling. The historic decline rate was also calculated, by taking the difference of the population at the start of the concession, and the population now, and dividing it by the years that the concessions has been in place. The same loop was carried out and plotted onto the model. Additional analysis was carried out, and separated into 3 parts, population sustainability, market and financial sustainability, and social and governance sustainability.

Results

Population sustainability

The 7 harvesters interviewed own a total of 3195 hectares, and 2788 trees Within the population, there is on average a mortality rate of 9.1 per 1000 trees (±2.7). The natural recruitment rate, the

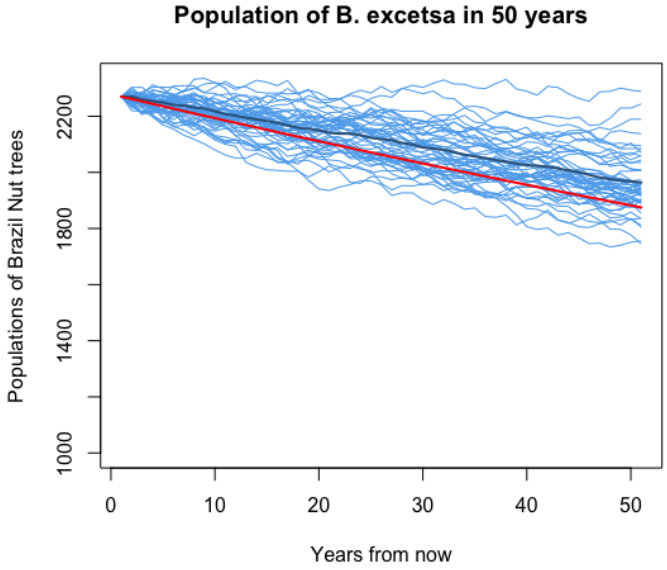

Figure 2. Projected population of the original 2270 trees measured, given the mortality rate and recruitment rate. The model was let run 50 times, showing the possible scenarios, with the darker line in the middle showing the average decline according to current mortality rates, and the red line showing the historic

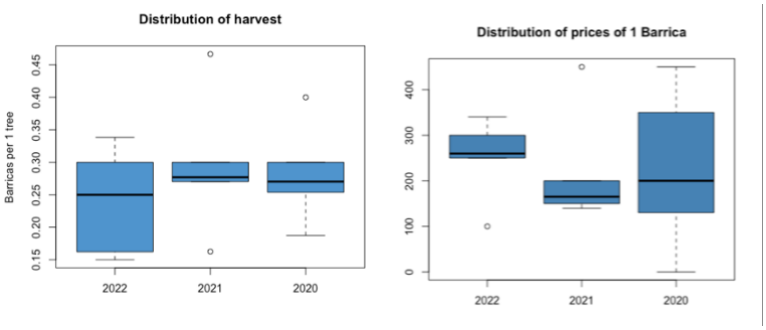

Figure 3. Distributions of the reported tree productivity (number of barricas harvested / trees in concession) (left), and the reported price per barrica, in Soles (right).

it is necessary to plant, yearly, 3 trees per 1000 trees (±2.5) to maintain the population, assuming that the mortality rate is stable. When asked about why the trees were dying, the most credited reason was old age, wind, and lightning rays, in order of frequency. Using the mortality and recruitment rate parameters to predict the population gives us the following result. (Fig 1), where the population is predicted to decrease by 13% in the next 50 years. When the historical decline were plotted (shown in red, Fig 2), the decline lined up within the model's parameters. Therefore, it can be concluded that there is some significance in the decline, as both ways of measuring the decline have yielded similar results. However, this model does not include the replanting already being done by harvesters, which 5/7 harvesters are already doing, planting up to 100 plants a year, all way past the 3/1000 minimum rate.

Market for nuts and financial sustainability

When harvesters were asked about the tree productivity (barricas, or bags, harvested each year), the numbers had high standard deviations, harvesters seeing a twofold increase or decrease between years, from unpredicted reasons (Figure 3, right). When asked about the price received for each barrica, the values had even higher standard deviations, especially in the year 2020, when some harvesters didn't manage to sell their nuts. respectively (Figure 3, left). The maximum recalled price was 1000 /S., which 3 harvesters reported in 2017, when the harvest had been low. The minimum reported price harvesters remember was from 60-80 S/., harvesters noting that the price tends to decrease when the harvest goes well. The combined volatility of tree productivity and market prices suggest that there is volatility in the market for Brazil Nuts. When the return on investment was calculated (Table 1), merely half made above 30% profits..

Governance and social sustainability.

There is significantly little oversight or aid done by the government given the important role the concessions play in

	2022	2021	2020
Net profits	15271 /S. (±7429)	8771.8(±4990)	5841(±10739)
Net profit per 1 barrica	116 /S. (±27)	92/S. (±57)	96/S. (±89)
Net profit per 1 tree	29 /S. (±9)	28/S. (±17)	30/S. (±25)
Net profit per 100 hectares	2020 /S. (±759)	1383(±753)	1621(±1581)
Production per 100 hectares (barr.)	15(±3)	17(±2)	17(±2)
Return on Income	**47% (±8%)**	**40% (±12%)**	**30% (±13%)**

Table 1. Various notable results from the questionnaire and analysis. The numbers are a mean and include the standard error.

protecting the land. Almost every harvester responded differently, when asked "Do you know if anyone is obliging you to replant trees?" Some answered yes, others no, others mentioning various fees for a failure to comply, others saying they know nothing about it. When asked if they would be interested in replanting, 6/7 said yes, with some already taking part in replanting. When asked if they would be interested in working together to germinate and make seedlings, 6/7 replied no, some noting that they preferred working alone, others saying that they already knew how to germinate seeds and did not see a purpose in it. Companies like Candela have said that they are working with 60% of their organic farmers on replanting, where they provide farmers with already made seedlings, and assist in planting and monitoring. However, it is notable that when asked if Candela was aiming for a certain number for their reforestation efforts, the response was negative. Their replanting was 30,000 this year, and 20,000 last year. When harvesters were asked what the major challenges ahead were, there was not a common answer that stuck out. Some mentioned price instability, others mentioned people maintaining the property, lack of capital, disappearance of bees and pollinators, the changing timing of the harvest, or others said that there was no problem, that nature "takes care of things". When asked who was responsible for solving these problems, they cited either the government, who is said to "not care" about their issues, or companies, for fixing the price instability.

Discussion

The sustainability and longevity of the Brazil Nut harvest was investigated and split into 3 parts, population, economical, and governance and social sustainability. Volatility was found within each sector, where there is population is in decline without human intervention, prices and profits are unstable, and there is an institutional gap that the government fails to fill.

Regarding the population, the major fault in the study must be attributed to sample size and data accuracy, as the and juvenile recruitments are self-reported harvesters. It is highly possible that in the forest there are trees that they don't know about. However, given how closely the historic decline and projected population decline match up, there must be some weight given to the conclusion. For the minimum replanting rate, I suggest 6/1000 (higher, to account for standard error), or one tree planted per 150 trees owned, per year. As harvesters expressed a negative result towards working together, the problem of replanting, the solution does not lie within increased cooperation, but rather with education and better access to resources. Obliging companies to be responsible for replanting might even be a policy solution, as Candela's replanting efforts have been very successful. As for the economical state of the harvest, the volatility found in the market was of unexpected magnitude. In some years, the price one harvesters was getting for 1 barrica was double that of the next one. That might be a factor of how the price changes according to the timing (price is high in the beginning of the harvest, low at the end of the harvest), which several harvesters mentioned. That however also creates volatility, as the timing of the harvest is not always the same, and it can create a competition of who can get their nuts to the seller first. People with more access to capital, and can pay workers beforehand, are immediately at an advantage. The average harvest lasts up to 4 months, to complete everything from collecting the nuts, opening them, letting them dry, transporting, and paperwork. By dividing the yearly profits in 4, that can be thought of as monthly income. Harvesters receive on the average, 4443, 4684, 2574 for the years 2022, 2021, and 2020, respectively (Fig 4), but with some harvesters never made above 1500 a month. Comparing this with the average monthly income of a timber worker, 2000 soles, or for a timber driver, 4000 soles (100 and 200 S/ a day respectively, obtained from local sources), going through all the trouble of owning and maintaining a concession does not make clear economic sense. Likewise, when the return on the land (Net profit per 100

hectares) and return of each tree (Net profit per 1 tree) is calculated, one gains an insight into the internal decision making of a concessionaire. If the land is returning <2500 /S. per year, it can seem attractive to turn towards other alternative pursuits, such as agriculture, lodging, or mining. Although those pursuits would not bring high returns on the same plot of land for long, and that in government allocated concessions it is illegal to do so, there is little oversight, and the rising cost of living might prompt someone into doing so. Many concessionaires did not make >30% return on income in some years, which is widely regarded as the minimum ROI for a business to be considered profitable. Creating situations where the harvester can have guaranteed profits above 30% for the next years, is therefore essential for the conservation of the region, and well-being of harvesters. Regarding policy, I would suggest a government implied price floor to prevent the price going down below humane standards. A similar tactic has been applied for potato harvesters in Peru, where a price floor of 1 S/. per bag was implemented to improve the sustainability of the farming. Currently, companies harvest nuts in Bolivia, Brazil and Peru, mix all of them together, even though Peru's nuts are of a higher quality and are more expensive. Because they are more expensive, companies go into Bolivia and Brazil first and buy all the nuts there, and then they buy the remainder in Peru, creating the price instability. An alternative solution might be separating the nuts according to quality, selling the nuts in Madre De Dios as higher quality nuts. Raising the price in Peru might however have unintended consequences for harvesters in Brazil and Bolivia, which is why the best thing to do would be to create a trade agreement, where all nations recognize the importance of the export, and create standard practices to ensure price fairness, equity, and sustainability. One thing that sticks out to me is that harvesters mention within their negative attitude of the government, that the "people in Lima" are the ones creating policy but haven't stepped a foot inside of the region. One reason for inaction might be that if you take the averages of everything, it might look stable (a steady ~40% return on investment), things look all right, but individual cases are extremely volatile, a harvesters' income possibly doubling or halving within a year.

In conclusion, the future of the harvest and the conservation of the area, will probably depend more on market factors than previously thought. Although the decline is happening, given local education programs and Candela's replanting, the steady replanting seems to outweigh the decline. Other resource extracting pursuits compete with the harvest at increasing rates, which might be enough to tip the scales for the worse.

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