Bringing the Coconut to Kayapó Villages of the Amazon: Evaluation of a Sustainable Development Project

RODOLFO SALM
Universidade Federal do Pará, Faculdade de Ciências Biológicas, Rua Coronel José Porfírio, no. 2515, CEP 68372-040, Altamira, Pará, Brazil
rodolfosalm@ufpa.br

LISA FEDER
Academy of Art University, Department of Liberal Arts, 451 Post Street, San Francisco, CA 94102 USA
lkfeder@gmail.com

In this article, we attempt a critical evaluation of our own eight-year project in Brazil of planting coconuts in Kayapó Indian villages aiming to improve their livelihoods and support their role in tropical forest conservation. Between 2006 and 2007 we delivered a total of 1400 coconut seedlings to Aukre village. Seven years later, the coconut plants are beginning to mature, and we had the opportunity to visit Aukre and assess the fate of the plants. Mortality rate was higher than 95%, but the 54 surviving, fruiting coconuts grown from our delivery of seedlings were responsible for a 300% increase in the adult population of this species.

We advocate that the expansion of coconut (*Cocos nucifera*) culivation in indigenous villages in the Amazon could be an important step for biodiversity conservation, mainly because it would contribute to nutrition and hydration for the indigenous people who defend the land from non-sustainable developers (Salm et al. 2007, 2010). Our main argument is that the potential for increased production of coconut could help to mitigate the negative impact of rapid human population growth in these areas by simultaneously increasing (coconut) tree populations and improving indigenous nutrition. Here we give an evaluation of our sustainable development project to plant

coconut palms in Kayapó Indian villages of southern Pará, Brazil, as a strategy for forest conservation and food security. We examine both the success rate of the coconuts and the Kayapó opinion of the project.

Coconuts are one of the most useful plants in the tropical world. The people of the islands in the Pacific Ocean domesticated and use all parts of coconut trees for numerous daily necessities – food, drink, oil, medicine, fiber, timber, thatch, mats, fuel and domestic utensils (Harries 1979). The European travelers of the sixteenth century were amazed by the uses of coconuts in eastern India. They facilitated the expansion of this species to its current pan-tropical distribution by taking fruits for food and drink during oceanic journeys (Harries 1979). Today, this palm is an important source for subsistence nutrition, and coconut culture bolsters the economy in nearly one hundred countries around the tropics with the production of dozens of products (Cuenca 1997).

The culture of coconuts has been substantially expanding in Brazil due to the domestic demand for coconut water. This drink is widely consumed in Brazilian cities, where people are eager to pay more for coconut water than for industrialized drinks. Coconut fruits are also used in cuisine. In the form of dried coconut, for example, it may complement tapioca, a traditional indigenous food made from manioc

1. Fruit-producing coconut palm grown from our program's seedling. Aukre Village, Kayapó Area.

2. Cluster of coconut palms grown through our program's seedlings bordering the Aukre village's airport.

(Okwu 2001). Coconut milk, a generic term for the highly nutritious aqueous extract of the solid coconut endosperm, plays an important role in the gastronomy of several tropical countries (Seow & Gwee 1997). Furthermore, the leaves of coconut palms can also be used for thatching (Johnson & Nair 1985).

In Brazil, the Kayapó were once semi-nomadic and their mobile lifestyle afforded them a diverse supply of food (Vidal 1977). They moved through the forest, hunting and gathering as they went and planting crops for the future when they returned. They sometimes trekked for years before they returning to a previously inhabited site (Posey 1981). However, missionaries and the Brazilian government, then represented by the SPI (Service of Indian Protection), induced them to settle into permanent villages, mostly in the 1970s (Turner 1992).

In the long run, permanent settlements cause problems for the Kayapó. Because they overhunt and gather in the forest immediately surrounding the village, the forest does not have time to recover as it did when the people were trekking. Nevertheless, seen as a whole, the Kayapó Territory is a remarkable example of the importance of indigenous lands for conservation. This area spans more than 13 million hectares in the Xingu River Basin, and effectively protects seasonally dry Amazonian forests and natural savannahs. Within this area the Kayapó contain the spread of the chief environmental threats to the region, such as the construction of paved roads and hydroelectric dams, and the clearing of forests for pastures and soybean plantations (Zimmerman et al. 2001).

Nevertheless, the Kayapó have already earned and spent several million dollars from the illegal sale of timber, which nearly exhausted the natural stocks of mahogany (*Swietenia macrophylla*). Although this business did bring some communal benefits, leaders frequently abused the illegal deals to provide themselves with airplanes, houses, cars etc., in frontier towns adjacent to the Kayapó reserves (Zimmerman et al. 2001). They also made goldmine concessions, which contaminated important rivers (Barbosa et al. 1998) and introduced malaria and other diseases. During this time, the Kayapó also went through a population explosion. For certain groups, the annual population growth rates reached 5%. In some villages, the population doubled every

Table 1- Abundance of young and adult coconut palms in Aukre village houses before (1997) and after (2014) the first results of our coconut seedlings distribution program.

	Young (Kayapó)	Young (by us)	Adults (Kayapó)	Adults (by us)	Total adults
2007	18	98	23	-	23
2014	8	4	21	54	75

Table 2. Distribution of adult coconut trees among Aukre village houses before (1997) and after (2014) the first results of our coconut seedlings distribution program.

	No. of houses (%) without any adult coconut	No of coconuts (%) owned by the 3 (10%) richest houses	Pielou Equitability for adult coconut distribution	Dominance D for adult coconut distribution
2007	23 (69.6)	13 (56.5)	0.601	0.15
2014	13 (41.9)	28 (37.3)	0.775	0.08

14 years (Verswijver 1992). If such a situation continues, the negative impact that the Indians have upon their land will be likely to grow, and their nutritional problems will only increase.

We present a quantitative evaluation of our coconut culture project. This assessment is based on a coconut census made in Aukre village in 2014 in comparison to the data that we had in 2006/2007. Our program delivered a total of 600 coconut seedlings to Aukre village in April 2006 and 800 seedlings in November 2007. Because the region is seasonally dry, the time of year in which seedlings are planted is crucial, as coconut seedlings require lots of water during establishment. At the forest management farm Marajoara, 130 km from Aukre, annual precipitation between 1995 and 2001 ranged from 1636 to 2170 mm, with >90% falling between November and May; in some years no rain fell for three or four months during the dry season (Grogan 2001). The climate in Aukre is slightly wetter with average rainfall close to 2200 mm yearly.

In 2014, Aukre village celebrated its 35th anniversary with a population of 380 people. This is just 17% more than what we found seven years ago, and does not coincide with the observed 5% per year year growth typical of some Kayapó groups (Verswijver 1992). However, in the meantime Aukre spawned a new village called Ngo-meití (meaning "the village with good water"), 20 km northeast of it and downstream from the village's main river, composed of 120 people from Aukre. If the populations of both villages are added, the total of 500 Indians fits almost perfectly with the expected 5% per year.

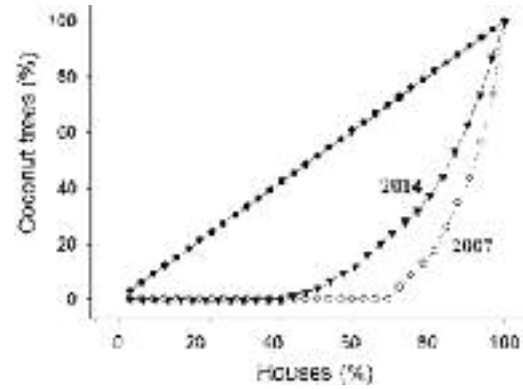
The Kayapó village houses are traditionally disposed around an open circle, or plaza, around the warrior-house (called "*ngobe*"), a sort of parliament at the center of the village. The "property" of space in a typical Kayapó village is roughly divided in slices that depart from the center of the plaza, pass through the houses and extend towards the surrounding forest. As such "slices" go further beyond the village houses, they progressively lose meaning until a point when the territory is considered public. Areas directly behind each house are considered the private property of the corresponding house such that, if a coconut tree is planted there, the coconuts belong only to the people of that household. Agricultural plots, both on the outskirts and behind houses are considered private property, but anything that falls outside of that domain is free for anyone to harvest. Agricultural zones on the village outskirts have become important for Kayapó sustenance, and households also cultivate some edible plants and fruit trees in the vicinities behind their houses (Salm et al. 2010).

We searched the village household by household. With the assistance of a fluent Portuguese-speaking Kayapó man, we interviewed representatives from each household, taking note of who owned each coconut palm, and classifying the plants as young or adult, and if they were originally obtained by the Kayapó themselves or by our program. The palms we brought were easily distinguished, as they were all even-sized and had a general similar character; all of our saplings originated in the Brazilian Agricultural Research Corporation (Embrapa) coconut seedling farm in Aracajú, Brazil. The coconuts palms belonging to each household are necessarily planted on the territorial slice corresponding to that house. However, to make a proper assessment of palm property distributions, we questioned the Indians about the ownership of coconuts that fell between neighboring houses.

Results

On the visit that we made to Aukre in August 2014, we found a total of 54 adult palms grown from coconut seedlings brought by our program (Figs. 1 & 2). The coconut census,

compared to the one that we had made in 2007, revealed that the adult coconut population in that village increased 326% exclusively due to the growth of the seedlings brought by our program (Tab. 1). Accordingly, each house now owns a larger number of adult coconut palms that it had before. At the same time, there are fewer houses without any coconut trees and a more even distribution of adult palm property among all the houses (Tab. 2; Fig. 3).



3. Graphical representation of the cumulative distribution (the Lorenz curve) of coconut trees at Aukre village in 2007 (open circles) and 2014 (filled triangles). The diagonal straight line (filled circles) represents perfect equality in distribution of coconut trees between all households.

Discussion

The population of adult coconuts in Aukre probably dates back to the village's creation 35 years ago. The Indians, recognizing the positive benefits of the palms, probably brought from the outside world in the earlier times and took care of them because they were so difficult to obtain.

When our small airplane landed in Aukre on 5 August 2014, we could see the coconut palms that grew from the seedlings that we brought; they were beginning to produce their first fruits. We observed children drinking coconut fruits, and the new palms created shade that many families used as a resting place to seek shelter from the heat of the sun. We were also concerned: people were drinking coconut water from small, unripe fruits. The water from immature coconut fruits is not as sweet as that from mature fruits, so the fact that these fruits are used indicates that this village needs more coconut palms to satisfy demand.

If our first observed impressions about the outcome of our project was of undoubted success, the quantitative analysis based on the coconut palm census was less straightforward.

4. Kayapó mother giving a child coconut water to drink.

The numbers may show success: a three-fold increase in the adult coconut population in this village. The same numbers, on the other hand, could be read as evidence of failure, as our 54 adult coconut palms were the survivors of a mortality rate higher than 95%. Coconut seedlings in urban areas or plantations elsewhere in Brazil have a much higher survival rate than this. The causes of such a high mortality rate among the coconut seedlings in Aukre village are diverse, but we suggest several reasons. First, local commitment, or lack thereof, to taking care of seedlings affected their survival particularly in watering, protecting them from being trampled and keeping them free from weeds. Although unmeasured, insufficient irrigation was certainly a chief cause of the high mortality among the coconut palms seedlings.

As we pointed out above, the climate is seasonally dry and coconuts are water-demanding palms. Due to FUNAI's bureaucratic delays, our first shipment of seedlings was not delivered to Kayapó villages until April 2006, near the end of the rainy season. The seedlings had a very short time to establish themselves before the rainy season ended (generally in May). In 2007, the coconut seedlings were planted at the appropriate time, in November, at the beginning of the rainy season. Still, from the 600 seedlings brought in 2006 to Aukre, 80 (13%) were still alive in November 2007, more than a year later. We could not tell in 2014 which of the 54 surviving adults have grown from 2006 or 2007 seedlings, as they were roughly even in size, but these data suggest that mortality from drought or other reasons continued to be significant after the seedling stage.

We surmised that children playing with the leaves of young palms was also a cause of death. We were also told by the local population that pacas (*Cuniculus paca*) like eating the sweet endocarp of recently planted coconuts. These rodents are certainly rare around a village packed with paca hunters, at least by day. A mapping of cultivated trees in the Kayapó villages of Kokraimoro and Pykararankre revealed that the Indians generally planted coconuts very close to their houses, where competition with a variety of other cultivated trees, mainly mango, may have hindered the palms' survival (Salm et al. 2010). Furthermore, the area in and surrounding the village consists mostly of red soil exposed to sun and packed fairly hard. It is mostly devoid of any vegetation and may not be conducive to palm growth and survival.

It is clear to us by now that we were quite optimistic when we projected that we could have a population of 1200 adult coconuts growing in Aukre village by 2025, providing coconut water for all the local population on a daily basis (Salm et al. 2007). In reality, the first imported palms are reaching maturity now, seven to eight years after planting, rather than the four years expected for maturity in other regions of Brazil with better water and soil conditions. Worse than that, the actual rate of seedlings survival to adulthood was approximately half of our worst-case scenario (Salm et al. 2007). The assumption that the Indians would save and replant 10% of the fruits was also clearly unrealistic. As a matter of fact, the Kayapó are not even waiting for the fruits to reach maturity before harvesting them for drinking water. Also significant is the fact that in 2006, before the beginning of our project, Aukre village had a total of 18 young coconut palms that the villagers had procured themselves, while in 2014 this number dropped to eight. The numbers are too low for a proper interpretation, but it is clear that our investment did not encourage villagers to cultivate seedlings themselves.

When we delivered the first round of coconuts in 2006, we took every opportunity to talk with villagers about various uses of coconuts, the best ways to plant and take care of the seedlings, and how to increase local seedling production. In November 2007, when we took the second coconut seedling shipment to the Kayapó lands, we conducted a coconut workshop in Kikretum village in which we attempted to disseminate non-native ways in which to use coconut products with crops indigenous to the Kayapó diet, namely, manioc. For doing so, we brought dried and shredded coconut and tapioca starch (made from the manioc root) from the city and made tapioca pancakes, fried with butter and rolled in shredded coconut. Our intention was to increase Kayapó appreciation of coconuts by exemplifying other potential ways in which to use the fruits other than merely drinking the coconut water (Salm et al. 2010). Apart from being a fun activity for both the participating Kayapó and us, we do not believe that this workshop had any effect on how the local population took care of the coconut seedlings, nor how they consumed them.

On our next trip to Aukre, there are several socio-ecological questions we would like to explore that focus on the overarching question: How does our project affect Kayapó

livelihood? Would the Kayapó accept more saplings if we were able to finance another shipment? Did our shipment make them less willing to cultivate their own coconut trees because they could count on ours? We are also curious to know if the Kayapó ever exploit the nutritional value of the meat extracted from ripe fruits, and if they had more coconuts, would they? Furthermore, would they use coconut leaves for thatching, considering that the native palm *Attalea maripa*, which are what they normally harvest for thatching, are becoming increasingly rarer close to the village (A. Jerozolimski, pers. comm.)?

Our argument is that coconut production is beneficial to Kayapó nutrition and that sustained good health of the local population contributes to protection and health of the forest and savannah in this region. Considering that each of the 23 adult coconut palms could produce around 100 coconuts per year, in the village of Aukre each of the 325 villagers in 2006/2007 could consume only seven fruits per year from their trees. Thus, the low annual production of coconut fruits indicated that coconuts did not represent a relevant source of hydration or nutritional value for the Kayapó at the time. Today, even after we tripled the coconut population, the figure is not much better than that, since villagers cannot even consume one coconut fruit per day for a single month of the year. Still, they appreciate having coconut palms around their houses, and the children especially love drinking the water of their unripen fruits (Fig. 4). They also appreciate eating dried coconut when we bring it and are always happy to receive coconut seedlings to plant around their houses. While the Kayapó leaders may not choose to invest in coconuts themselves, they are happy recipients of coconut seedlings. We hope to raise funds for the continuity of coconut seedling shipments to Aukre and other villages and that the Kayapó themselves become more prone to save a mature fruit and make a seedling for replanting. We hope these trees will be useful to help Kayapó livelihood in a future of environmental, social and economic uncertainty.

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