ESTIMATING TANAGER DENSITIES IN CHAKRA AGROFORESTS IN RELATION TO PLANT SPECIES DIVERSITY AND AREA OF CHAKRA

by

Rebecca Sitar

FACULTY OF NATURAL RESOURCES MANAGEMENT
LAKEHEAD UNIVERSITY
THUNDER BAY, ONTARIO

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Rebecca Sitar

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Major Advisor	Second Reader

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ABSTRACT

Chakra agroforests in the community of Verde Sumaco, Ecuador were surveyed to estimate tanager densities. Distance sampling using transects was the methodology used to record presence of tanager species. Using the data collected, tanager counts were entered into a program called Distance and tanager density was calculated for each individual chakra. The results from this study showed that chakras are suitable habitat for tanagers and provide ample resources required by each species.

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Top Row: Ruth Cushicagua, Lucas Short, Brian McLaren, Rebecca Sitar, Xavier Shiguango Bottom Row: Brenden Voysey, Carlos Grefa, Jairo Calapucha

INTRODUCTION AND OBJECTIVES

Lowland tropical forests provide the most species rich habitats of all terrestrial ecosystems (Turner, 1996). Natural and anthropogenic disturbances and processes in tropical forests greatly impact species biodiversity and population densities. The Ecuadorian Amazonian Region (EAR) is subject to robust pressures that have stimulated the radical transformation of its ecosystems (Hecht, 1985). Forest types, such as primary, secondary and agricultural forests, can influence the area that a species inhabits due to specific habitat requirements and abundance of resources. These forest types can influence a population's density and can be either beneficial or detrimental to the existing inhabitants or a particular species. Indigenous systems of agriculture are based on agroforestry farms, known as chakras, which have biological and social relevance to the surrounding ecosystem (Coq-Huelva et al., 2017). This is important because in Ecuador, approximately 90% of deforested areas have been converted into agricultural areas for crop production over the past two decades (Sierra, 2013).

In many bird species, it has been shown that some bird communities occupy specific habitats and disregard others (Cody, 1974). Individual birds select an area to establish their territory based on specific habitat requirements and characteristics including; food availability, location to resources, and suitable nesting habitat to avoid predators (Klopfer and Hailman, 1965).

Population estimates are a fundamental aspect of applied ecology (Newson et al., 2008). These estimates are crucial in determining rarity of species that may need to be listed as a conservation concern, or species that may be at risk of extinction (IUCN, 2004). The most effective technique for estimating bird abundance is through distance

sampling, a method that uses a transect to count birds detected by sound or by sight (Buckland et al., 2001). The following factors must be taken into account when using this method; the targeted species may be easily detected in one habitat and difficult in another, some birds can be detected at further distances than others, and that time of day has an influence on detectability (Gottschalk and Huettmann, 2010).

This study was conducted in tropical forested areas located in Verde Sumaco, Ecuador. The focal bird species of interest in this study were tanager species, particularly those residing in chakra agroforests. Eleven different chakra agroforests were visited and sampled to collect tanager species counts in order to determine the overall tanager density in each chakra. The aim of this study was to examine the effects chakra agroforests have on tanager species densities, and to determine whether chakras are beneficial or detrimental to tanager densities. Distance sampling using transects was conducted to obtain tanager counts and densities. Within the study areas forest edges including; rivers, roads and the community were observed and related to tanager densities. Through sampling and observations in the study areas, chakras will be shown to be beneficial habitats for tanager densities.

LITERATURE REVIEW

TANAGERS

The tanager family, *Thraupidae*, is a diverse group consisting of primarily Neotropical birds with variations in morphology, feeding behaviours, habitats and plumage patterns (Burns, 1997). There are approximately 242 species in this family, primarily located in South, Central and North America, as well as on Caribbean islands

(Storer, 1970; Burns 1997). Tanagers represent approximately 10% of Neotropical bird species and are one of the most prominent families throughout the Neotropics (Sedano and Burns, 2010).

In the family Thraupidae, approximately one third species belong to the 'core tanager' clade (Burns and Naoki, 2004). This clade is represented by two genera; *Thraupis* and *Tangara*. The *Tangara* genus is characterized by a variety of brightly coloured species with many tanagers displaying nondescript cryptic plumage, and approximately half of the species are sexually dimorphic (Burns, 1997). The core tanagers occupy habitat elevations ranging from sea level to high up in the tree canopy (Sedano and Burns, 2010).

Although many tanager species are frugivores, some species are primarily nectar-feeders or insectivores. Many tanager species have a more generalized diet and do not feed exclusively on one food source (Burns, 1997). Tanagers specific diets will determine the areas in which they inhabit.

CHAKRA AGROFORESTS

Agroforestry is a dynamic, ecologically-based, system that diversifies and sustains production for amplified economic, social and environmental benefits for land users (Mead, 2004). Agroforestry is practiced widely throughout the world and practices differ across geographical regions. A chakra is an indigenous agroforestry system practiced in the western portion of the Amazon that fulfils medicinal, nutritional, and spiritual requirements for indigenous populations (Whitten and Whitten, 2008). Chakras are maintained and managed by local members of the community and provide food and

building materials to families. Chakras have traditionally functioned as modified forests, resembling primary and secondary forests, and have fewer detrimental effects to the ecosystem as opposed to farming (Krause and Ness, 2017). The traditional use of chakras is primarily for producing resources for indigenous communities in the Amazon. The newly formed ecosystem chakras create can be beneficial habitat for wildlife species.

Many indigenous communities in Ecuador have recognized land titles and each community member is assigned an area they can use for crops (Krause and Ness, 2017). Specifically in the community of Verde Sumaco, Aboriginal communities recognize indigenous rights to the land. Voted by an assembly of members from the Quechua peoples of Verde Sumaco, chakras are distributed to local families. The families are able to freely use the land given to them to plant and harvest desired crops, but do not legally own the land. Each chakra is registered under the ministry of Agriculture and Fisheries.

Chakras have both biological and social features that must be understood collectively, and are characterised by interactions between environmental and socio-economic variables (Coq-Huelva et al., 2017; Herrmann and Torri, 2009). The concept of co-evolution is used to describe this biological and social interaction. Co-evolution concentrates on the limits of "pristine natural" evolution and social processes, asserting that transformations in the environment cannot be understood in the absence of social interactions (Coq-Huelva et al., 2017). This approach is similar to the views of indigenous Amazonian communities. Indigenous communities' values mimic the co-evolution approach because it includes people, fauna, flora, ecosystems, and the spiritual aspects and interactions throughout the community (Coq-Huelva et al., 2017).

SAMPLING BIRD POPULATIONS

Estimates of bird population sizes or densities are widely used in bird conservation, and these counts are used to infer change over time in abundance or a difference between habitats (Buckland et al., 2008). When estimating bird abundance there can be inaccuracy associated with sampling methods. Two common causes of inaccuracy are: first, the proportion of birds present and recorded in the survey areas vary in accordance to time and place, and the second is that areas selected for surveying are often not representative of the entire area for which conclusions are made (Buckland et al., 2008).

Buckland et al. (2008) suggest three solutions to these causes of inaccuracy to aid in more efficient sampling. The first consideration when designing fieldwork is to ensure that all individuals within the study area can be assumed detectable. Another solution is to design the survey and the field procedures in order for detectability to be constant across units of space and time (Buckland et al., 2008). The third strategy is estimating detectability so abundance can be estimated without having a complete numbers of individuals on the sample plots.

Multiple sampling techniques have been developed to estimate the abundance/density of wildlife populations. Distance sampling is a method used as an extension of plot sampling, where birds are counted within a sample of the defined area (Buckland et al., 2008). As a result, this method allows for the possibility that some members of the population present in the plot remain undetected. Distance sampling plots can be either long narrow strips, line transect sampling or circular plots, point transect sampling (Buckland et al., 2008).

MATERIALS AND METHODS

This study was conducted in tropical forested areas of Verde Sumaco, Ecuador (Figure 1). With the permission of community members, eleven chakras were sampled to obtain tanager counts (Figure 2). The chakras were accessible by pathways within the community, and by canoes for further sites. Sites where sampled during one of two time frames, 6:30-10:00 am or 16:00-19:00 pm.

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Figure 1. Google Earth image displaying Orellana province, Ecuador, and the study areas indicated by magenta points.

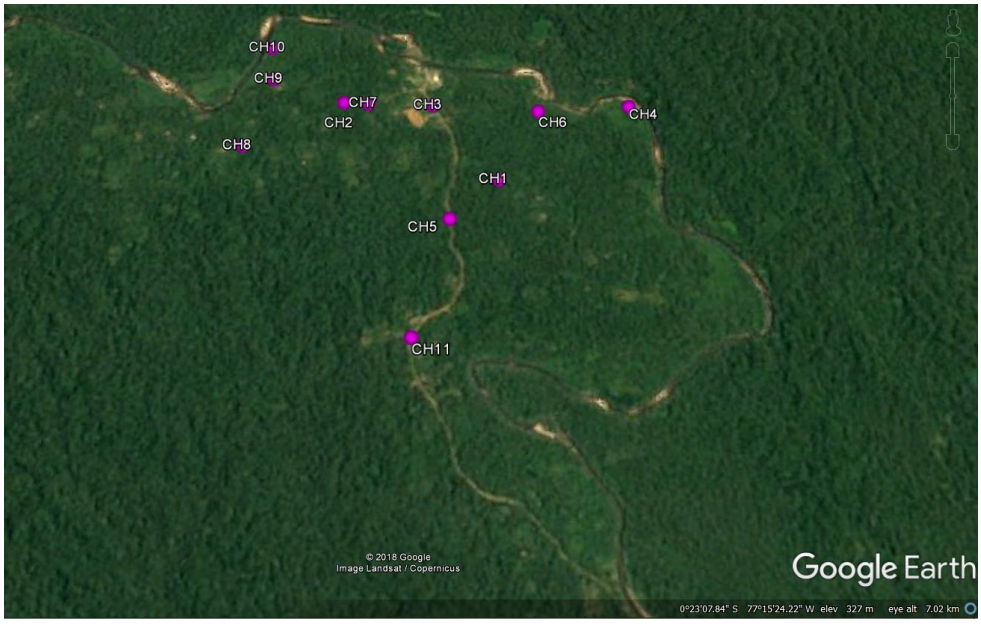

Figure 2. Google Earth image displaying the eleven chakras visited in the community of Verde Sumaco.

At each site, transects were walked in order to observe and count tanagers. The number of transects walked was determine by the size and accessibility of the chakra, and the lengths of each transect was recorded using a GPS unit. The perimeter of each site was also mapped using a GPS to later calculate chakra area in hectares. At each site the following was recorded; UTM coordinates, habitat, observer, weather conditions, date, time, a rough estimate of the percent tree cover, and the time of day (Table 1). As each transect was walked tanager species that were spotted were identified using binoculars, through photos taken, and field guides for neotropical birds in the region. The number of birds of each species was recorded immediately after identification and their behaviours were noted. A perpendicular distance from the transect line to the tree in which the tanager was occupying was taken using a clinometer.

Table 1. Field data sheet used to record tanager abundance.

Tanager Density Sheet							
UTM:	_____		**Observer:**	_____		**Date:**	_____
Habitat:	_____		**Weather:**	_____		**Time:**	_____
						% Tree Cover:	_____
Site ID	Transect ID	T. Length (m)	Species	Distance	Number	Time of Day	Behaviour

Plant species found at each site were also identified and recorded to examine the significance of plant species important to tanagers. Using a density program called Distance, the number of tanagers seen in each site was entered along with the area of the chakra to determine the overall tanager density for each site. The Distance program was obtained from a distance sampling site and was downloaded and installed to complete the data analysis.

RESULTS

Table 2 below contains the raw data collected in the field for chakra site 1. The data for chakra sites 2-11 can be found in Appendix II. The sites that were sampled in the morning displayed more bird activity than those sampled during the evening period.

In general, chakras that were larger in area tended to have greater tanager densities (Figure 3). The sites that contained a higher plant species richness, particularly those containing multiple fruiting plants, had higher tanager densities (Figure 4). Another factor that contributed to tanager abundance was if predatory bird species were present in the chakra during the sampling times.

Table 2. Bird and plant species data collected in chakra one.

UTM: S0° 22.852' W77° 15.010'				**Date:** December 18 2018			
Habitat: Chakra Agroforest				**Time:** 6:43 – 8:00			
Owner: SERGIO SHIGUANGO				**% Tree Cover:** ~10%			
Weather: Overcast							
Site ID	**Transect ID**	**T. Length (m)**	**Species**	**Distance (m)**	**(#)**	**Time of Day**	**Behaviour**
CH1	T1	16.83			0	Morning	
↓	T2	20.80			0	↓	
	T3	25.50	SBTA	45	1		foraging
	T4	14.30	PATA	22	3		foraging
	T5	19.57	BANA	0	1		Flying

PLANT SPECIES PRESENT IN CHAKRA

Number	**Scientific name**	**Common Name**	**Frequency**	**Importance To Tanager**	
				Yes	**No**
1	*Oenocarpus bataua*	Patawa (palm tree spp.)	++	X	
2	*Iriartea deltoidea*	Pambil (palm tree spp.)	+++++++	X	
3	*Grias neuberthii*	Piton tree	+		X
4	*Saccharum officinarum*	Sugarcane	++		X

"Table 2. (continued)."

5	*Manihot esculenta*	Yuca	(+…)	X
6	*Ananas comosus*	Pineapple	+	X
7	*Zea mays*	Corn	+	X
8	*Solanum quitoense*	Naranjilla	+	X
9	*Musa sapientum*	Plantain	++	X
10	*Phytelephas aequatorialis*	Equadorian ivory palm	+	X
11	*Crescentia cujete*	Calabash Tree	+	X
12	*Guarea kunthiana*	Cocora	+	X
13	*Bactris gasipaes*	Peach palm	+	X

Table 3 contains an overall list of tanager species seen throughout the community of Verde Sumaco and identifies the species seen in the chakras. It was observed that most tanager species seen throughout the community were also observed in the chakra agroforests.

Table 3. List of tanager species identified in Verde Sumaco.

TANAGER SPECIES LIST FOR VERDE SUMACO			
Common Name	**Scientific Name**	**Species Code**	**Seen in Chakra (*)**
Palm tanager	*Thraupis palmarum*	PALM	*
Silver-beaked tanager	*Ramphocelus carbo*	SBTA	*
Bananaquit tanager	*Oereba flaveola*	BANA	*
Blue-gray tanager	*Thraupis episcopus*	BGTA	*
Masked Crimson tanager	*Ramphocelus nigrogularis*	CMTA	
Masked tanager	*Tangara nigrocincta*	MATA	
Paradise tanager	*Tangara chilensis*	PATA	*
Swallow tailed tanager	*Tersina viridis*	STTA	*
Fulvous shrike tanager	*Lanio fulvus*	FSTA	*
Flame-crested tanager	*Tachyphonus cristatus*	FCTA	*
White-shouldered tanager	*Tachyphonus luctuosus*	WSTA	
Purple honeycreeper	*Cyanerpes caeruleus*	PUHO	*
Magpie tanager	*Cissopis leverianus*	MAGP	*
Turquoise tanager	*Eriocnemis godini*	TUTA	

Using a program called Distance, tanager densities for each individual chakra was calculated. Table 4 below displays the calculated densities and corresponding site chakra areas in hectares.

Table 4. Tanager densities calculated using the Distance program.

TANAGER DENSITIES		
Chakra	**Density**	**Area (ha)**
CH1	9.358	0.067
CH2	0	0.929
CH3	1.015	1.126
CH4	1.655	1.298
CH5	4.064	1.497
CH6	0	1.042
CH7	0	0.666
CH8	0	0.785
CH9	0	1.105
CH10	4.343	0.094
CH11	11.368	0.955

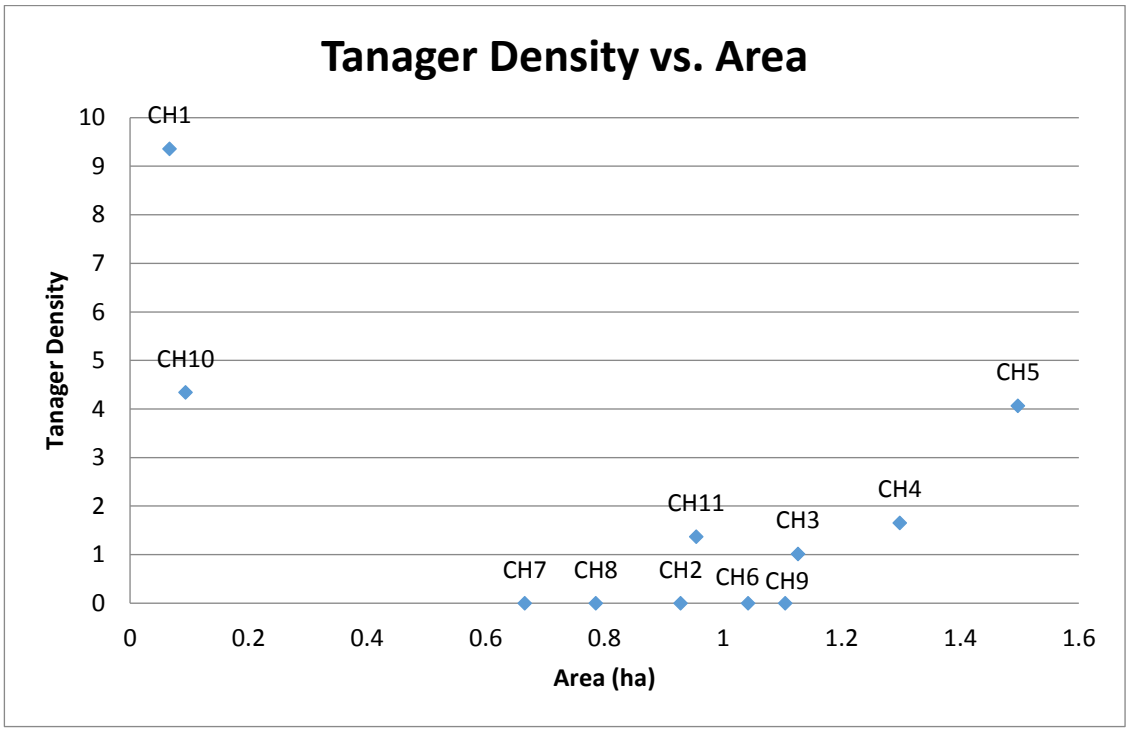

Figure 3. Graph displaying tanager densities in relation to the area of the chakra.

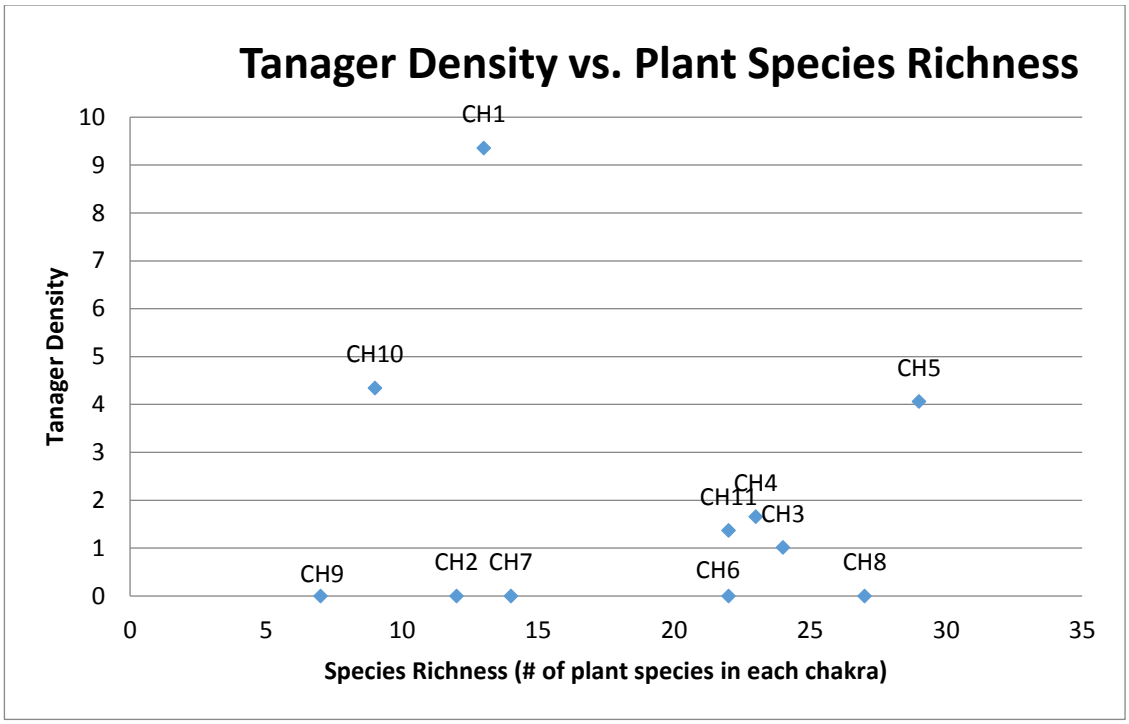

Figure 4. Graph displaying tanager densities in relation to plant species richness.

Accumulated from the raw field data, Table 5 summarizes the plant species that are important to tanagers foraging habitat and habitat. The majority of the significant plant species were either fruiting vegetation or palm tree species.

Table 5. Chakra plant species important to tanager species.

PLANT SPECIES IMPORTANT TO TANAGERS	
Scientific Name	**Common Name**
Oenocarpus bataua	Patawa (palm tree spp.)
Iriartea deltoidea	Pambil (palm tree spp.)
Zea mays	Corn
Musa sapientum	Plantain
Phytelephas aequatorialis	Equadorian ivory palm
Guarea kunthiana	Cocora
Bactris gasipaes	Peach palm
Pouteria caimito	Abiu
Mauritia flexuosa	Moriche palm
Inga edulis	Ice-cream-bean
Carica papaya	Papaya
Inga densiflora	Guaba machetona
Pourouma cecropiifolia	Amazon tree-grape
Ceroxylon echinulatum	Palm spp.
Carludovica palmata	Panama hat plant
Musa acuminata	Banana spp.
Annona cherimilia	Cherimoya
Persea americana	Avocado
Inga sp.	Guabilla
Psidium guajava	Common guava
Pourouma cecropiifolia	Amazon tree-grape
Annona squamosa	Sugar apple
Artocarpus altilis	Breadfruit

In the data obtained, it was also seen that tanager species that consumed a higher percentage of fruit in their diet were more frequently identified in the chakras than those with diets consisting mainly of insects (Table 6).

Table 6. Foraging diets of tanager species found in chakras.

Species Common Name	Species Code	Diet
Palm tanager	PALM	-equal parts fruits and arthropods
Silver-beaked tanager	SBTA	- Diverse diet of fruits, arthropods and nectar
Bananaquit	BANA	-small insects and spiders - fruits and nectar
Blue-grey tanager	BGTA	- mainly fruits and arthropods
Paradise tanager	PATA	- fruits are arthropods - fruits foraged on more commonly
Swallow-tailed tanager	STTA	- fruits and insects, dependant on the season
Fulvous-shrike tanager	FSTA	- primarily insectivorous - feed on some fruit
Flame-crested tanager	FCTA	- mainly terrestrial invertebrates - forage on fruits when descending lower into the canopy
Purple honeycreeper	PUHO	- arthropods and spiders - regularly eating small fruits and nectar
Magpie tanager	MAGP	- primarily foraging on arthropods and fruit

Source: The Cornell Lab of Ornithology Neotropical Birds

DISCUSSION

Based on the research conducted in this study, it was found that the chakra agroforests located in the community of Verde Sumaco Ecuador provided beneficial habitat and resources to the tanager populations in the area. Many of the chakras

contained fruiting crops on which tanagers forage. The plant species planted in the chakras also provide ample habitat for arthropod species that are also important to tanager diets. A general trend seen in Figure 4 was that as plant species richness increases, the abundance of tanagers also increases in many cases. The chakras that contained fewer fruiting crops and/or having more crops used for building materials displayed less tanager activity. The tanager species that consume greater amounts of fruit in their diet were seen more often than the species that consumed more insects than fruit. For example, the palm tanager (10 individuals counted) and the silver-beaked tanager (16 individuals counted) have high fruit consumption in their diets, whereas the flame-crested tanager (1 individual counted) and the purple honeycreeper (1 individual counted) are mainly insectivorous.

Chakras were sampled at one of two periods during the day, the morning period (6:30-10:00) or during the evening period (16:00-19:00). Generally, the chakras sampled during the morning periods displayed more bird activity than those in the evening. Weather also had an effect on our bird counts. The tanagers were more active immediately after rain and in cooler temperatures. When the weather was very warm or when we sampled during a rain, a significant decrease in bird activity was seen.

Although chakras provided a suitable environment for tanager species to forage and inhabit, other frugivorous species and predatory birds also utilized the chakras (see Appendix I). When a predatory bird was present in the chakra, we did not record any sightings of tanagers. When the bird of prey left the site, we started to record tanagers on the site. Other frugivors seen in chakra sites did not affect the presence of tanager species. Although the presence of predatory birds resulted in an absence of tanagers, the chakras

proved to be a beneficial area for tanager feeding behaviours, social interactions and nesting habitat.

Each chakra sample was unique in species composition, location and in size. Chakras 3-5 and 11 were larger (ha) and a higher tanager density was correlated with this (Figure 3). For the remaining chakras, the size of the study area had no correlation with the amount of birds observed. Chakras that had a larger area often had a higher plant species diversity, therefore being more beneficial to tanager species.

Location of the sites must be considered in the analysis of the density results. Sites ranged from lowland, upland, higher elevations, and locations near a river. A number of the sites were located in remote areas, as opposed to sites located within close proximity to the centre of the community. Bird activity in chakras closer to main road access ways may have been influenced by the constant movement of people throughout the community. Habitat requirements are specific to each individual tanager species, and this may influence what species was present in each location. Another consideration when observing birds was the proximity to the river. Two of the chakras were located directly beside the river and the first displayed an abundance of bird activity. In the second chakra were did not record any tanagers, but this may have been a side-effect of the previous rainfall.

An approximate estimate of the percent canopy cover was taken in each plot. Tanagers forage, inhabit and display social interaction in the canopies of mature trees. All tanagers recorded within each site were using the tree canopy at the time of observation. Indigenous families are given these pieces of land to plant and harvest crops of their

choice. It is important to the bird species that representative mature trees are left standing in the cleared area.

CONCLUSION

Chakra agroforests proved to be a beneficial resource to tanager species found in the Amazon. Although tanagers were observed and densities were estimated, specific criteria for chakras must be present to be favourable to this bird family. The purpose of chakra agroforests is to provide resources to families living in Amazonian communities. Although the main purpose is for resources, the surrounding flora and fauna species must be taken into consideration as they are an integral aspect of the ecosystem. For a chakra to benefit tanager species, a substantial amount of fruiting crops must be present. It is crucial that mature trees, for example palm species, are left in these agroforests to provide sites for tanagers to occupy.

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APPENDICES

APPENDIX I

Frugivor and predatory bird species found in each chakra.

CHAKRA	FRUGIVOR SPECIES	PREDATORY BIRDS
CH1	-many banded aracari -russet-backed oropendola -black-crowned tityra -Silver-beaked tanager -bananaquit -paradise tanager -yellow rumped cacique -spix's gwan	-yellow headed caracara (2 individuals)
CH2	-russet-backed oropendola -yellow rumped cacique	N/A
CH3	-Silver-beaked tanager -flame-crested tanager -swallow-tailed tanager -palm tanager -fulvous shrike tanager -black billed seed finch -scaly naped amazon - yellow rumped cacique -russet-backed oropendola	-slate-coloured hawk
CH4	-russet-backed oropendola - yellow rumped cacique -blue headed parrot -palm tanager	-roadside hawk
CH5	-russet-backed oropendola - yellow rumped cacique -silver-beaked tanager -palm tanager -fulvous shrike tanager -blue-grey tanager -mealy amazon -duskey headed parakeet -blue headed parrot -purple honeycreeper -speckled chachalaca	N/A
CH6	-russet-backed oropendola - yellow rumped cacique	-slate-coloured hawk
CH7	-bare-necked umbrellabird - yellow rumped cacique	-black caracara
CH8	-russet-backed oropendola -amazon spp.	-hawk spp.

Frugivor and predatory bird species found in each chakra.

CHAKRA	FRUGIVOR SPECIES	PREDATORY BIRDS
CH9	-russet-backed oropendola - yellow rumped cacique	N/A
CH10	-russet-backed oropendola - yellow rumped cacique -magpie tanager -palm tanager -Euphonia spp. -giant cowbird -silver-beaked tanager	N/A
CH11	-russet-backed oropendola - yellow rumped cacique -greater ani -violacious jay -smooth billed ani -palm tanager -silver-beaked tanager -magpie tanager -black billed seed finch	N/A

APPENDIX II

Bird and plant species data collected in chakra two.

UTM: S0° 22.539' W77° 15.600'				**Date:** December 18 2018			
Habitat: Chakra Agroforest				**Time:** 16:20 – 17:49			
Owner: RICARDOS GREFA				**% Tree Cover:** ~10%			
Weather: After rain							
Site ID	**Transect ID**	**T. Length (m)**	**Species**	**Distance (m)**	**(#)**	**Time of Day**	**Behaviour**
CH2	T1	91.00			0	Evening	
	T2	75.93			0		
	T3	108.07			0		
	T4	113.87			0		
	T5	93.00			0		
	T6	122.06			0		
	T7	98.14			0		
	T8	90.01			0		
	T9	84.17			0		

PLANT SPECIES PRESENT IN CHAKRA

Number	**Scientific name**	**Common Name**	**Frequency**	**Importance To Tanager**	
				Yes	**No**
1	*Oenocarpus bataua*	Patawa (palm tree spp.)	+++	X	
2	*Pouteria caimito*	Abiu	++	X	
3	*Manihot esculenta*	Yuca	(+…)		X
4	*Musa sapientum*	Plantain	++++++++	X	
5	*Bactris gasipaes*	Peach palm	++++++++++ ++++++++++ ++	X	
6	*Citrus nobilis*	Tangor	+		X
7	*Lonchocarpus utilis-nicoi*	Cubé	+		X
8	*Theobroma cacao*	Caoco tree	(+…)		X
9	*Coffea sp.*	Coffee	(+…)		X
10	*Ochroma pyramidale*	Balsa tree	+		X
11	*Cecropia peltata*	Trumpet tree	++		X
12	*Brownea ucayalina*	Palo de cruz	++		X

Bird and plant species data collected in chakra three.

UTM: S0° 22.549' W77° 15.253'				**Date:** December 19 2018			
Habitat: Chakra Agroforest				**Time:** 8:00 – 9:31			
Owner: BARTOLO SHIGUANGO				**% Tree Cover:** ~15%			
Weather: Light rain							
Site ID	**Transect ID**	**T. Length (m)**	**Species**	**Distance (m)**	**(#)**	**Time of Day**	**Behaviour**
CH3	T1	66.21			0	Morning	Hawks present
	T2	69.82			0		Hawks present
	T3	134.87	SBTA	0	1		Foraging
	T4	68.51	STTA	0	1		Flying
	T5	76.40	FCTA	87	1		Perched
	T6	85.71	SBTA	73	1		Perched
	T7	75.42	SBTA	37	1		Perched
	T8	89.93	SBTA	58	1		Singing interaction
			PALM	58	1		Singing interaction
	T9	78.27	SBTA	54	1		Foraging
			SBTA	58	1		Territorial interaction
			FSTA	57	1		Perched
	T10	70.37	SBTA	39	1		perched
			FSTA	39	1		perched

PLANT SPECIES PRESENT IN CHAKRA

Number	**Scientific name**	**Common Name**	**Frequency**	**Importance To Tanager**	
				Yes	**No**
1	*Theobroma cacao*	Caoco tree	(+…)		X
2	*Mauritia flexuosa*	Moriche palm	(+…)	X	
3	*Bactris gasipaes*	Peach palm	++++++++	X	
4	*Musa sapientum*	Plantain	++++++++++++++++	X	
5	*Manihot esculenta*	Yuca	(+…)		X
6	*Inga edulis*	Ice-cream-bean	+++	X	
7	*Carica papaya*	Papaya	+++++	X	
8	*Inga densiflora*	Guaba machetona	+++++	X	

”Bird and plant species data collected in chakra three (continued).”

9	*Herrania nitida*	Guiana chestnut	+	X
10	*Saccharum officinarum*	Sugarcane	+++++	X
11	*Nephelium lappaceum*	Rambutan	++++++	X
12	*Grias neuberthii*	Piton tree	++	X
13	*Laurus nobilis*	Bay laurel	+++	X
14	*Carica cherimoya*	Cherimoya	+	X
15	*Citrus medica*	Citron	+++	X
16	*Calathea lutea*	Calatheas	++	X
17	*Pourouma cecropiifolia*	Amazon tree-grape	++++	X
18	*Pouteria caimito*	Abiu	+	X
19	*Banisteriopsis caapi*	Caapi	+	X
20	*Lonchocarpus utilis-nicoi*	Cubé	++	X
21	*Theobroma bicolor*	Mocambo tree	+	X
22	*Attalea butyracea*	Palm tree spp.	+++	X
23	*Siparuna eriocalyx*	Malaria	+	X
24	*Ceroxylon echinulatum*	Palm spp.	+	X

Bird and plant species data collected in chakra four.

UTM: S0° 22.570' W77° 14.499'				**Date:** December 19 2018			
Habitat: Chakra Agroforest				**Time:** 17:03 – 18:33			
Owner: CÉSAR CALAPUCHA				**% Tree Cover:** ~10%			
Weather: Overcast/ light rain							
Site ID	**Transect ID**	**T. Length (m)**	**Species**	**Distance (m)**	**(#)**	**Time of Day**	**Behaviour**
CH4	T1	52.52			0	Evening	
	T2	39.62			0		
	T3	175.33	PALM	33	3		Perched
	T4	141.00			0		
	T5	131.96	PALM	100	1		perched
	T6	116.61			0		
	T7	101.50			0		
	T8	85.88			0		

PLANT SPECIES PRESENT IN CHAKRA

Number	**Scientific name**	**Common Name**	**Frequency**	**Importance To Tanager**	
				Yes	**No**
1	*Cedrela odorata*	Spanish cedar	++		X
2	*Musa sapientum*	Plantain	++++++++++++	X	
3	*Citrus medica*	Citron	+		X
4	*Crescentia cujete*	Calabash Tree	+		X
5	*Bixa orellana*	Achiote	+		X
6	*Attalea butyracea*	Palm tree spp.	++++++++		X
7	*Calycophyllum spruceanum*	Capirona	++++++++++++		X
8	*Myroxylon balsamum*	Balsam of Peru	++++++++		X
9	*Bactris gasipaes*	Peach palm	++++++++++++++++	X	
10	*Capsicum annuum*	Chili pepper	+		X
11	*Pouteria caimito*	Abiu	+	X	
12	*Citrus nobilis*	Tangor	+		X
13	*Theobroma bicolor*	Mocambo tree	++		X

"Bird and plant species data collected in chakra four (continued)."

14	*Carludovica palmata*	Panama hat plant	+++++++	X
15	*Guadua angustifolia*	Clumping bamboo	(+…)	X
16	*Persea americana*	Avocado	++	X
17	*Carica papaya*	Papaya	++	X
18	*Ilex guayusa*	Caffeinated Holly spp.	+	X
19	*Zea mays*	Corn	(+…)	X
20	*Inga edulis*	Ice-cream-bean	+	X
21	*Stinging nettle*	Stinging nettle	(+…)	X
22	*Musa acuminata*	Banana spp.	(+…)	X
23	*Vochysia leguiana*	Tamburo	++	X

Bird and plant species data collected in chakra five.

UTM: S0° 23.010' W77° 15.210'				**Date:** December 20 2018			
Habitat: Chakra Agroforest				**Time:** 7:15 – 8:13			
Owner: BOLÍVAR CALAPUCHA				**% Tree Cover:** ~15%			
Weather: Overcast							
Site ID	**Transect ID**	**T. Length (m)**	**Species**	**Distance (m)**	**(#)**	**Time of Day**	**Behaviour**
CH5	T1	109.79			0	Morning	
	T2	123.89	FSTA	30	3		Foraging
	T3	99.02	TA spp.		2		Unknown spp.
	T4	110.64	SBTA	5	1		Perched
	T5	106.65	SBTA	22	1		Perched
			PALM	22	2		Perched
			BGTA	22	2		Perched
	T6	68.93	PUHO	0	1		perched
	T7	141.87			0		

PLANT SPECIES PRESENT IN CHAKRA

Number	**Scientific name**	**Common Name**	**Frequency**	**Importance To Tanager**	
				Yes	**No**
1	*Saccharum officinarum*	Sugarcane	++++++++++++		X
2	*Lonchocarpus nicou*	Barbasco	++++++		X
3	*Triplaris cumingiana*	Arenillo	++++++++		X
4	*Cedrela odorata*	Spanish cedar	++		X
5	*Manihot esculenta*	Yuca	(+…)		X
6	*Coffea sp.*	Coffee	(+…)		X
7	*Ananas comosus*	Pineapple	(+…)		X
8	*Lacmellea sp.*	Chicle	+		X
9	*Gossypium herbaceum*	Levant cotton	+		X
10	*Capsicum annuum*	Chili pepper	+		X
11	*Brunfelsia grandiflora*	Royal purple brunfelsia	+		X
12	*Anacardium occidentale*	Cashew	++		X

” Bird and plant species data collected in chakra five (continued).”

13	*Cocos nucifera*	Coconut	+++	X
14	*Triticum*	Wheat	(+…)	X
15	*Inga edulis*	Ice-cream-bean	+++	X
16	*Bactris gasipaes*	Peach palm	++++	X
17	*Carica papaya*	Papaya	++++	X
18	*Zea mays*	Corn	(+…)	X
19	*Musa acuminata*	Banana spp.	(+…)	X
20	*Nephelium lappaceum*	Rambutan	+	X
21	*Solanum sessiliflorum*	Cocona	++	X
22	*Musa sapientum*	Plantain	+++++	X
23	*Cymbopogon citratus*	Lemon grass	+	X
24	*Colocasia esculenta*	Taro	+	X
25	*Annona cherimilia*	Cherimoya	+	X
26	*Bixa orellana*	Achiote	+	X
27	*Citrus sinensis*	Oranges	+	X
28	*Arachis hypogaea*	Peanut	+	X
29	*Rubus ulmifolius*	Wild blackberry	+	X

Bird and plant species data collected in chakra six.

UTM: S0° 22.584' W77° 14.850'				**Date:** December 20 2018			
Habitat: Chakra Agroforest				**Time:** 8:41 – 9:22			
Owner: SERGIO SHIGUANGO				**% Tree Cover:** ~5%			
Weather: Overcast							
Site ID	**Transect ID**	**T. Length (m)**	**Species**	**Distance (m)**	**(#)**	**Time of Day**	**Behaviour**
CH6	T1	93.07			0	Morning	
	T2	86.77			0		
	T3	96.65			0		
	T4	98.99			0		
	T5	66.58			0		
	T6	95.69			0		
	T7	20.15			0		
	T8	58.59			0		

PLANT SPECIES PRESENT IN CHAKRA

Number	Scientific name	Common Name	Frequency	Importance To Tanager	
				Yes	No
1	*Zea mays*	Corn	(+…)		X
2	*Theobroma cacao*	Cacao tree	(+…)		X
3	*Carica papaya*	Papaya	++++++	X	
4	*Calycophyllum spruceanum*	Capirona	+		X
5	*Machaerium millei*	Cabo de hacha	+		X
6	*Astrocaryum chambira*	Chambira palm	++		X
7	*Astrocaryum murumuru*	Palm spp.	++		X
8	*Bactris gasipaes*	Peach palm	+	X	
9	*Wettinia maynensis*	Palm spp.	+		X
10	*Iriartea deltoidea*	Pambil (palm tree spp.)	++++++		X
11	Ceroxylon echinulatum	Palm spp.	+		X
12	*Grias neuberthii*	Piton tree	+		X
13	*Musa acuminata*	Banana spp.	++++++	X	

"Bird and plant species data collected in chakra six (continued)."

14	*Musa sapientum*	Plantain	+++	X
15	*Solanum sessiliflorum*	Cocona	+	X
16	*Impomea batatas*	Sweet potato	+	X
17	*Capsicum annuum*	Chili pepper	+++++++	X
18	*Persea americana*	Avocado	+	X
19	*Triticum*	Wheat	++	X
20	*Arachis hypogea*	Peanut	(+…)	X
21	*Eugenia stipitata*	Araza	++	X
22	*Manihot esculenta*	Yuca	++++++++++++	X

Bird and plant species data collected in chakra seven.

UTM: S0° 22.545' W77° 15.506'				**Date:** December 20 2018			
Habitat: Chakra Agroforest				**Time:** 16:49 – 18:03			
Owner: CAROLINA GREFA				**% Tree Cover:** ~5%			
Weather: Sunny							
Site ID	**Transect ID**	**T. Length (m)**	**Species**	**Distance (m)**	**(#)**	**Time of Day**	**Behaviour**
CH7	T1	71.99			0	Evening	
↓	T2	95.29			0	↓	
	T3	50.62			0		
	T4	79.40			0		
	T5	66.43			0		

PLANT SPECIES PRESENT IN CHAKRA

Number	**Scientific name**	**Common Name**	**Frequency**	**Importance To Tanager**	
				Yes	**No**
1	*Manihot esculenta*	Yuca	(+…)		X
2	*Musa sapientum*	Plantain	++++++++++	X	
3	*Theobroma bicolor*	Mocambo tree	++		X
4	*Heliconia sp.*	Lobster-claws	(+…)		X
5	*Inga sp.*	Guabilla	++++++++++++	X	
6	*Oenocarpus bataua*	Patawa (palm tree spp.)	+		X
7	*Laurus nobilis*	Bay laurel	+		X
8	*Solanum sessiliflorum*	Cocona	+		X
9	*Brownea ucayalina*	Palo de cruz	+		X
10	*Bactris gasipaes*	Peach palm	+++++++++	X	
11	*Coffea sp.*	Coffee	++		X
12	*Ananas comosus*	Pineapple	++++++++++++		X
13	*Virola spp.*	Epená	+		X
14	*Lonchocarpus nicou*	Barbasco	+		X

Bird and plant species data collected in chakra eight.

UTM: S0° 22.704' W77° 15.983'				**Date:** December 21 2018			
Habitat: Chakra Agroforest				**Time:** 8:15 – 8:56			
Owner: CARLOS (MAXI) GREFA				**% Tree Cover:** ~50%			
Weather: Overcast							
Site ID	**Transect ID**	**T. Length (m)**	**Species**	**Distance (m)**	**(#)**	**Time of Day**	**Behaviour**
CH8	T1	59.63			0	Morning	
	T2	36.50			0		
	T3	22.18			0		
	T4	22.36			0		
	T5	85.61			0		
	T6	38.31			0		
	T7	107.19			0		

PLANT SPECIES PRESENT IN CHAKRA

Number	**Scientific name**	**Common Name**	**Frequency**	**Importance To Tanager**	
				Yes	**No**
1	*Coffea sp.*	Coffee	(+…)		X
2	*Musa sapientum*	Plantain	(+…)	X	
3	*Cedrelinga cateniformis*	Chuncho	++		X
4	*Mauritia flexuosa*	Moriche palm	+++	X	
5	*Psidium guajava*	Common guava	++	X	
6	*Bactris gasipaes*	Peach palm	++++++++++	X	
7	*Pouteria caimito*	Abiu	++++	X	
8	*Inga edulis*	Ice-cream-bean	++	X	
9	*Musa acuminata*	Banana spp.	(+…)	X	
10	*Manihot esculenta*	Yuca	(+…)		X
11	*Inga densiflora*	Guaba machetona	++	X	
12	*Laurus nobilis*	Bay laurel	+++++		X
13	*Carludovica palmata*	Panama hat plant	++		X
14	*Colocasia esculenta*	Taro	+++++		X

"Bird and plant species data collected in chakra eight (continued)."

15	*Theobroma bicolor*	Mocambo tree	++	X
16	*Pourouma cecropiifolia*	Amazon tree-grape	++	X
17	*Ilex guayusa*	Caffeinated Holly spp.	+	X
18	*Artocarpus altilis*	Breadfruit	++	X
19	*Grias neuberthii*	Piton tree	+	X
20	*Annona squamosa*	Sugar apple	++	X
21	*Croton lechleri*	Sangre de grado	+	X
22	*Brunfelsia grandiflora*	Royal purple brunfelsia	+	X
23	*Citrus sinensis*	Oranges	+	X
24	*Persea americana*	Avocado	+	X
25	*Gossypium herbaceum*	Levant cotton	+	X
26	*Banisteriopsis caapi*	Caapi	+	X
27	*Nephelium lappaceum*	Rambutan	+	X

Bird and plant species data collected in chakra nine.

UTM: S0° 22.425' W77° 15.868'				**Date:** December 21 2018			
Habitat: Chakra Agroforest				**Time:** 16:58 – 17:19			
Owner: CARLOS (MAXI) GREFA				**% Tree Cover:** ~2%			
Weather: Overcast							
Site ID	**Transect ID**	**T. Length (m)**	**Species**	**Distance (m)**	**(#)**	**Time of Day**	**Behaviour**
CH9	T1	103.71			0	Evening	
	T2	111.13			0		
	T3	98.95			0		
	T4	111.34			0		
	T5	86.07			0		

PLANT SPECIES PRESENT IN CHAKRA

Number	**Scientific name**	**Common Name**	**Frequency**	**Importance To Tanager**	
				Yes	**No**
1	*Heliconia sp.*	Lobster-claws	(+…)		X
2	*Laurus nobilis*	Bay laurel	++++++		X
3	*Pouteria sapota*	Mamey sapote	+		X
4	*Carica papaya*	Papaya	+	X	
5	*Astrocaryum murumuru*	Palm spp.	+++		X
6	*Ficus eslastica*	Rubber fig	+		X
7	*Musa sapientum*	Plantain	+	X	

Bird and plant species data collected in chakra ten.

UTM: S0° 22.292' W77° 15.875'				**Date:** December 21 2018			
Habitat: Chakra Agroforest				**Time:** 17:30 – 18:13			
Owner: OTTO AGUINDA				**% Tree Cover:** ~ 5%			
Weather: Overcast							
Site ID	**Transect ID**	**T. Length (m)**	**Species**	**Distance (m)**	**(#)**	**Time of Day**	**Behaviour**
CH10	T1	22.77			0	Evening	
	T2	28.47	SBTA	40	2		Perched
	T3	23.66			0		
	T4	19.57			0		
	T5	53.15	PALM	0	1		Perched
			MAGP	0	2		perched

PLANT SPECIES PRESENT IN CHAKRA

Number	**Scientific name**	**Common Name**	**Frequency**	**Importance To Tanager**	
				Yes	**No**
1	*Heliconia sp.*	Lobster-claws	(+…)		X
2	*Musa sapientum*	Plantain	(+…)	X	
3	*Carica papaya*	Papaya	++++++	X	
4	*Astrocaryum murumuru*	Palm spp.	+		X
5	*Laurus nobilis*	Bay laurel	+++		X
6	*Ochroma pyramidale*	Balsa tree	++		X
7	*Manihot esculenta*	Yuca	(+…)		X
8	*Bactris gasipaes*	Peach palm	+	X	
9	*Musa acuminata*	Banana spp.	(+…)	X	

Bird and plant species data collected in chakra eleven.

UTM: S0° 23.456' W77° 15.364'				**Date:** December 23 2018			
Habitat: Chakra Agroforest				**Time:** 7:59 – 8:38			
Owner: OLGER CALAPUCHA				**% Tree Cover:** ~40%			
Weather: Overcast							
Site ID	**Transect ID**	**T. Length (m)**	**Species**	**Distance (m)**	**(#)**	**Time of Day**	**Behaviour**
CH11	T1	132.49			0	Morning	
	T2	66.98	SBTA	83	3		Perched
			MAGP	115	2		Perched
			SBTA	0	1		Perched
	T3	47.93			0		
	T4	59.97			0		
	T5	66.26	PALM	63	2		Perched
	T6	51.25			0		
	T7	84.63			0		
	T8	58.66			0		
	T9	64.56	MAGP	39	2		Perched

PLANT SPECIES PRESENT IN CHAKRA

Number	**Scientific name**	**Common Name**	**Frequency**	**Importance To Tanager**	
				Yes	**No**
1	*Thobroma cacao*	Caoco tree	(+…)		X
2	*Carica papaya*	Papaya	(+…)	X	
3	*Manihot esculenta*	Yuca	(+…)		X
4	*Musa sapientum*	Plantain	++++++++++++	X	
5	*Saccharum officinarum*	Sugarcane	(+…)		X
6	*Inga edulis*	Ice-cream-bean	++++++++++	X	
7	*Laurus nobilis*	Bay laurel	++++++++++++++++ +++++++		X
8	*Bactris gasipaes*	Peach palm	++++++++++++++	X	
9	*Mauritia flexuosa*	Moriche palm	++		X
10	*Cedrela odorata*	Spanish cedar	+		X
11	*Lacmellea sp.*	Chicle	++		X
12	*Virola spp.*	Epená	++		X

"Bird and plant species data collected in chakra eleven (continued)."

13	*Pourouma cecropiifolia*	Amazon tree-grape	+	X
14	*Alibertia patinoi*	Borojó	+	X
15	*Musa acuminata*	Banana spp.	++++++++	X
16	*Lonchocarpus utilis-nicoi*	Cubé	(+…)	X
17	*Cedrelinga cateniformis*	Chuncho	+	X
18	*Pouteria caimito*	Abiu	+	X
19	*Grias neuberthii*	Piton tree	+++	X
20	*Artocarpus altilis*	Breadfruit	+	X
21	*Ananas comosus*	Pineapple	++	X
22	*Triplaris cumingiana*	Arenillo	+++	X