The Dynamic Use of Biodiversity Richness in the Bribri Indigenous Territory

by

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ABSTRACT

This research took place in two Bribri indigenous communities situated on the border between Costa Rica and Panama. Indigenous Peoples, including Bribri people, are often portrayed as holders of a body of traditional knowledge, the loss of which is measured by their declining use of biodiversity. As much has been written on this, in this thesis, I chose to use a strength-based framing and focus on the Bribri as skillful and creative agents. I investigated how Bribri people use the biodiversity richness of their territory to adapt to a changing environment. This is not to deny the outside impacts produced by globalized change, but to reveal the strategies used by Bribri people for responding to a dynamic environment and being resilient instead of being the passive subjects of shocks and disruptors. I did this through the following research questions:

1) Is the narrative of decline and loss in biodiversity richness, measured against what was used in at some point in the past the only way to think about the relationship between Bribri People and the biodiversity of their territory?
2) How have Bribri people drawn upon their social ecological memory to respond to the invasion of fungal pathogens in their commercial lands?
3) How can stakeholders and researchers co-produce livelihood opportunities by drawing upon the capabilities of Bribri cacao agroforestry systems?

To answer these questions, I used three areas of literature: ethnobiology, resilience, and co-production of knowledge. The qualitative approach I used for data collection consisted of conducting participant observation, life history interviews, semi-structured interviews, and transect walks. My results suggest that Bribri actively express their agency in responding to a dynamic environment by; 1) reconfiguring their use of biodiversity to meet livelihood needs, 2) negotiating causes of environmental change, 3) accessing biological materials and social memory to reorganize following a disturbance, 4) drawing upon the capabilities of their biocultural heritage to meet contemporary livelihoods and lay the foundation for meaningful futures. Thesis findings have relevance for the Bribri people as their strengths, agency, and creativity are highlighted as they produce knowledge through their responses to a dynamic environment.

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I want to thank the community members of Yorkin and Guabo. It was a privilege to live with you, hear your stories, and learn from your experiences. Thank you very much for your patience and for your friendship.

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To René, the most beautiful outcome of this journey

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CHAPTER 1 INTRODUCTION

My motivation for writing this dissertation stems from my interest in the theory and practice of ethnobiology as well as my engagement with resilience thinking. I have always been interested in the study of relationships amongst peoples, biota, and environment. This interest was cultivated by my grandparents, who raised animals and produced several plants to support themselves and their families. Although I was born and raised in Mexico City, I always felt a connection to rural areas and Indigenous Peoples. These interests motivated me to move to the Yucatan Peninsula of Mexico for my master studies. During my master studies in Human Ecology, I studied the sociocultural elements that sustain hunting practices in the Mayan community of Los Petenes. This experience led me to continue studying the relationships between humans and their environment during my doctoral program by integrating emerging conceptual approaches such as resilience and co-production of knowledge.

Resilience is a pluralistic concept with multiple meanings and interpretations (Brown 2016). Resilience is used in everyday discourse to talk about the ability of individuals and communities to respond to trauma caused by dramatic events, such as natural disasters (Brown 2016). Resilience has also been explained in terms of responding to uncertainty while retaining essential functions (Walker et al. 2004; Folke 2006). Other scholars suggest that resilience should also consider the role of positive transformation (Davidson 2010; Béné 2014; Scott 2014; Brown 2016). Transformability is defined as "the system´s capacity to create a fundamentally new system when ecological, economic, or social conditions make the existing system untenable" (Walker et al. 2004, p.1). For the purpose of this dissertation, resilience refers to the ability of a social ecological system to bounce-back, adapt to uncertainty, and go through positive transformation when necessary (Brown 2016).

From my perspective, resilience thinking offers two main contributions to the study of human-environment relationships (e.g., ethnobiology). First, it suggests that systems, such as social-ecological systems, are affected by multiple and interacting stressors (Folke et al. 2003), sometimes originating in distant regions (Carrasco et al. 2017). Second, it recognizes that social-ecological systems co-evolve and behave as complex adaptive systems characterized by cycles and uncertainty (Folke et al. 2006). Resilience thinking replaces the idea of systems characterized by equilibrium, linearity, and boundaries (Holling 1973).

Despite its potential to explain the complex interactions between humans and their environment, resilience thinking has been criticized for its lack of conceptual depth in its approach to social dynamics (Davidson 2010; Fabinyi et al. 2014; Merçon et al. 2019). A specific critique is that resilience does not pay sufficient attention to human agency by obscuring the capacities that individuals and societies have to negotiate and make decisions impacting their lives, including those related to adaptation strategies in response to change (Coulthard 2012). In this regard, my research purpose was to develop thinking around an idea of resilience that recognizes Bribri people´s agency in responding to a dynamic environment. In this thesis I consider agency as the attributes that allow people to plan, persist and adapt in the face of change in response to a dynamic environment (Brown and Westaway 2011).

One of the attributes that has not been extensively studied in the documentation of responses to change is Social Ecological Memory (SEM). In this research, SEM is defined as the accumulated experiences and history of ecosystem management collectively held by a community in a social–ecological system (Barthel et al.2010; Nykvist and Von Heland 2014). In resilience thinking, SEM is considered a source of self-organization that emerges after a crisis (Folke et al. 2003). Despite the relevance that SEM seems to play in the resilience of social ecological systems, the relationship between resilience and SEM has received limited attention in the literature, although exceptions include Nazarea (2006), Barthel et al. (2010), Nykvist and Von Heland (2014), Wilson et al. (2017), and Kim et al. (2017).

In sustainability science, co-production refers to the interaction of different actors to solve specific problems (Miller and Wyborn 2017). Research in co-production is focused on diagnosing problems with current scientific practice (e.g., Lemos et al. 2012; Berkes 2017) and identifying conditions for co-producing knowledge (e.g., Schuttenberg and Guth 2015). While the later approaches outline some guidelines of how to conduct collaborative research (e.g., inclusion of different types of knowledge, participation of different actors, and development of trust between participants), the actual processes by which these activities are undertaken is not well documented (Meadow et al 2015). "The ways in which co-production is conducted, actors are identified, problems are framed, and goals are achieved, are important to the ultimate goal of supporting sustainable development" (Miller and Wyborn 2017 p. 5).

Biocultural design refers to as the intentional and collaborative process in which people with different knowledge, skills, and experiences work together to design new products or services by drawing upon the adaptive capacity of biocultural heritage (Davidson-Hunt et al. 2012). The term biocultural was used in the 1990s to recognize links between natural and cultural systems (Maffi and Woodley 2005). Early biocultural work focused on documenting beliefs, values and practices of people living within diversity (Maffi 2005). Currently, the concept includes conceptual frameworks that involve local communities in process of conservation (e.g., Arambiza and Painter 2006), community biocultural protocols (e.g., Swiderska et al., 2012), biocultural indicators (e.g., Dacks et al. 2019), and heritage creation (e.g., Davidson-Hunt et al. 2012). Central to these approaches are the abilities and rights of resource dependent communities to shape processes of adaptation (e.g., Swiderska 2006; Cocks 2010) and meet sustainable development objectives through the creative potential of biocultural heritage (Davidson-Hunt et al. 2012). Biocultural design provides a framework to support collaborative approaches rooted in indigenous values, identities, and knowledge to support self-determination processes (Davidson-Hunt et al. 2012). The implementation of biocultural design projects in Bribri communities has the potential of generating insights for the co-production literature and for the implementation of conservation and development initiatives in the area.

PURPOSE AND RESEARCH QUESTIONS

The purpose of my research was to understand how people in two Bribri indigenous communities use the biodiversity of their territory to respond to a dynamic environment. In this thesis I do this through the following research questions:

1) Is the narrative of decline and loss in biodiversity richness, measured against what was used in at some point in the past the only way to think about the relationship between Bribri People and the biodiversity of their territory?
2) How have Bribri people drawn upon their social ecological memory to respond to the invasion of fungal pathogens in their commercial lands?
3) How can stakeholders and researchers co-produce livelihood opportunities by drawing upon the capabilities of Bribri cacao agroforestry systems?

RESEARCH METHODOLOGY

Study area

The Bribri are one of the largest indigenous group in Costa Rica with a population of 8198 (Costa Rican Census 2011). The Bribri word comes from the element *blí*, which means "ditch" (García Segura 2019). *Blí-Blí* (plural) reflects the topography of the Cordillera of Talamanca which is characterized by hills, creeks, and rivers.

Bribri people live on both sides of the Cordillera of Talamanca; on the Atlantic side in the reserves of Talamanca-Bribri and Cocles (*KeköLdi*) and on the Pacific side in the reserves of Salitre and Cabarga (Figure 1.1). These reserves belong to La Amistad Biosphere Reserve. There are twelve Holdridge life zones, five altitudinal zones, and nine protected areas in La Amistad Biosphere Reserve (SINAC 2012). La Amistad Biosphere Reserve provides niches for a wide variety of species, including 10,000 flowering plants, over 4,000 non-vascular plants, approximately 1,000 fern species, and about 900 lichens (UNEP 2009).

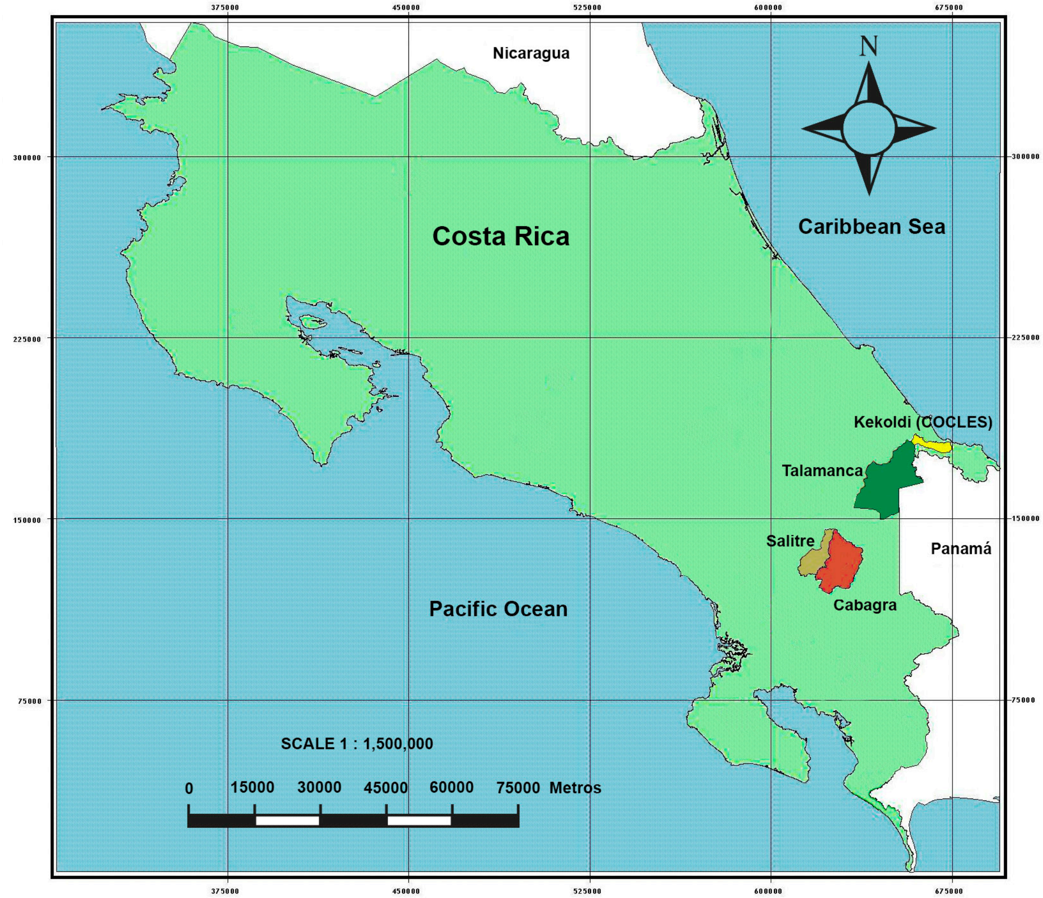
Nicaragua
N
Costa Rica
Caribbean Sea
Kekoldi (COCLES)
Talamanca
Salitre
Panamá
Cabagra
Pacific Ocean
SCALE 1 : 1,500,000
0 15000 30000 45000 60000 75000 Metros
375000
450000
525000
600000
675000
300000
225000
150000
75000

Figure 1.1 Bribri Indigenous Reserves

The Bribri language belongs to the South American Chibcha language group. Chibcha refers to a geographical area that includes the Caribbean part of Honduras, the Caribbean part of Nicaragua, Costa Rica (without the Chorotega part), Panama, Colombia and part of Venezuela (Constenla-Umaña 2010). Most Bribri are bilingual, speaking Bribri and Spanish. There are approximately 6,991 Bribri language speakers in the four Bribri indigenous reserves (INEC 2011).

The Bribri are a matrilineal society of clans, meaning that clan membership and right to land ownership is inherited through the mother (Bozzoli 1979). Clans are named after animals, plants, geographical elements, and objects (Jara Murillo and García Segura 2014). For example, *Kabékwak* is the clan of the magnificent quetzal (*Pharomachrus moccinno*); *Mèkichawak* is the clan of the calabash tree (*Crescentia* *cujete*); *Mulùriwak* is the clan of the streams; and *Sëbaliwak* is the clan of the central pole of a sacred house (Jara Murillo and García Segura 2014). Bozzoli (1979) documented 63 clans in the Bribri reserve of Talamanca.

The traditional social organization of the Bribri consists of several occupations as shown in Table 1.1. The religious figure of *Usékol* and the political figure of *Bulu´* are not currently practiced as roles within contemporary Bribri societies while the others have persisted up to the present (Jara Murillo and García Segura 2014). Each Bribri Indigenous Reserve has a development association that is in charge of resolving land issues and undertaking development projects. Moreover, every village has a number of voluntary committees that are responsible for improving roads, water infrastructure, and organizing sport and cultural events (Bozzoli et al. 2013).

Table 1.1 List of Bribri traditional occupations.

Uséköl	Maximum religious figure
Bulu'	Maximum political figure
Bikili´	Interpreter
Tsö́köl	Master of ceremonies
Bikákala	Guide in the afterlife
Óköm	Person allowed to touch a dead body
Awá	Traditional doctor
Sĩõ'tãmĩ	Women in charge of protecting the healing stones of an awá
Tsuru´óköm	Women in charge of preparing cacao for ceremonial purposes

Bribri ontology is complex, and it shapes the practices and behaviors of Bribri in relation to their environment (Bozzoli 1979). To understand the Bribri ontology, it is important to understand the concept of *siwo´. Siwo´* refers to the teachings taught by *Sibö,* the Bribri creator. *Siwo´* is transmitted down by oral tradition and it is expressed in stories and chants (Jara Murillo and García Segura 2014). In these narratives, Bribri people learn that all things have a custodian. For example, *sàlpu* is the custodian of eagles; *chìchi* is the custodian of dogs; and *bika´* is the custodian of baskets. Resources, or in the Bribri worldview beings, such as plants, animals and objects, belong to custodians. Therefore, Bribri need to borrow these resources by asking for the permission of the custodians, by giving them something in exchange, or by deceiving them (Garcia Serrano and Del Monte 2004; Sault 2010). Instead of saying "I am going to hunt, a Bribri would say "I am going to harvest beans" or "I am going to the mountain." Some plants and animals are considered the relatives of the Bribri and must be treated respectfully (Bozzoli 1979). The tapir (*Tapirus bairdii*), for example, is rarely consumed by the Bribri because is believed to be the sister of *Sibö*. Members of the clans *TubuLwak, Sinikichawak and Urikiwak* are the only ones authorized to eat tapir (Borge and Castillo 1997). Moreover, animals such as jaguar (*Panthera onca*), swainson's hawk (*Buteo swainsoni*) and harpy eagle (*Harpia harpyja*) are rarely hunted because they helped *Sibö* to create the world (Borge and Castillo 1997). Those who disrespect these teachings incur consequences such as getting a disease or getting lost in the forest. For the Bribri, the land, objects, and living things need to be protected to ensure their existence, as well as the existence of other human and non-human beings (Sault 2010).

In addition to its role as staple beverage, cacao is an integral part of Bribri culture and identity, as made clear in their mythology and worldview (Bozoli 1979; Borge 2011). In the Bribri origin of the earth story, *Sibö* offered chocolate to the entities that witnessed the creation of the earth. To create the earth, *Sibö* sacrificed a girl and four types of cacao emerged from the tears of the mother´s girl (Borge 2011). To compensate the girl´s mother, *Sibö* allowed her to eat cacao (Borge 2011). In the cacao story (Appendix 1), *Sibö* choose *Tsuru´* as his life partner. Cacao is also used in different rituals of passage to purify Bribri people from *ñá* (Interview with Noemi Rojas May 05, 2016). *Ñá* is an invisible impurity that is present at the moment of birth, death, and when a woman is menstruating (Jara Murillo and García Segura 2014). In Bribri ontology, cacao represents the blood of Bribri people, and it is considered a sacred plant that has purifying virtues.

Bribri are traditional agroforesters (Bozzoli 2013). Prior to the early 1940s, Bribri based their economy and diet on subsistence agriculture of basic grains (e.g., corn, rice) along with the trade of coffee. These activities were complemented by gathering forest products, fishing, and hunting. Today, the Bribri economy is a combination of subsistence and monetary income (Dahlquist et al. 2007). Cacao (*Theobroma cacao*), banana (*Musa spp*.), and plantains (*Musa spp*.) are the cash-crops of the Bribri. Hunting and fishing have always supplemented agriculture. However, hunting is less practiced in recent times because of government restrictions, changes in people's food preferences, and lack of time and skills in young generations (Sylvester et al. 2016). Wild plants still provide medicines, foods, and materials for construction and crafts. Some Bribri people earn cash income as teachers, government employees and welfare. The diet of contemporary Bribri consists of grains (e.g., rice, corn), tubers (e.g., yams, cassava), fruits (e.g., oranges, plantains, pineapple), meat (e.g., chicken, pig, ducks) and beverages (cacao and coffee) (Garcia Serrano and Del Monte 2004). While some beverages and food staples such as rice, beans, and coffee are bought in local stores (Sylvester 2016), most accompanying foods (tubers, fruits, and meat) are obtained from local landscapes.

Full rights to the territory, as a productive and cultural space, have always been the most urgent political demands of the Bribri indigenous population (Delgado Morales 2017). At the beginning of the twentieth century, Bribri people were pushed to remote areas when the Costa Rican government let The United Fruit Company establish banana plantations in the Valley of Talamanca. The Costa Rican government also allowed foreign and national mining companies to prospect in the Indigenous territory for petroleum and mineral deposits on multiple occasions (Borge and Villalobos 1994). Bribri livelihoods and sociopolitical organization began to change radically in the second half of the 20th century with the introduction of “modern” education, national health care and Christian missionaries (Nygren 1998). These outside impacts have led to a change in the traditional Bribri values and behaviors toward the environment, jeopardizing the sustainability of social and ecological systems (e.g., substitution of cacao agroforestry systems for plantain monocultures) (Dahlquist et al.2007; Orcheton 2012). Despite these impacts, Bribri people have managed to protect their cultural identity and territory by reconstructing ancient cosmological narratives (Nygren 1998), orienting many of their rituals and ceremonies toward protecting their territory from outside forces (Ibarra Rojas 1991), and sustaining elements of traditional agricultural practices (Posas 2013).

I conducted this research in two Bribri communities: Yorkin and Guabo. These communities are located on the border between Costa Rica and Panama on the Atlantic side of the Cordillera of Talamanca (Figure 1.2). In 2016, the community of Yorkin had a population of 232 and Guabo had a population of 58 (Rodríguez field notes July 26, 2016).

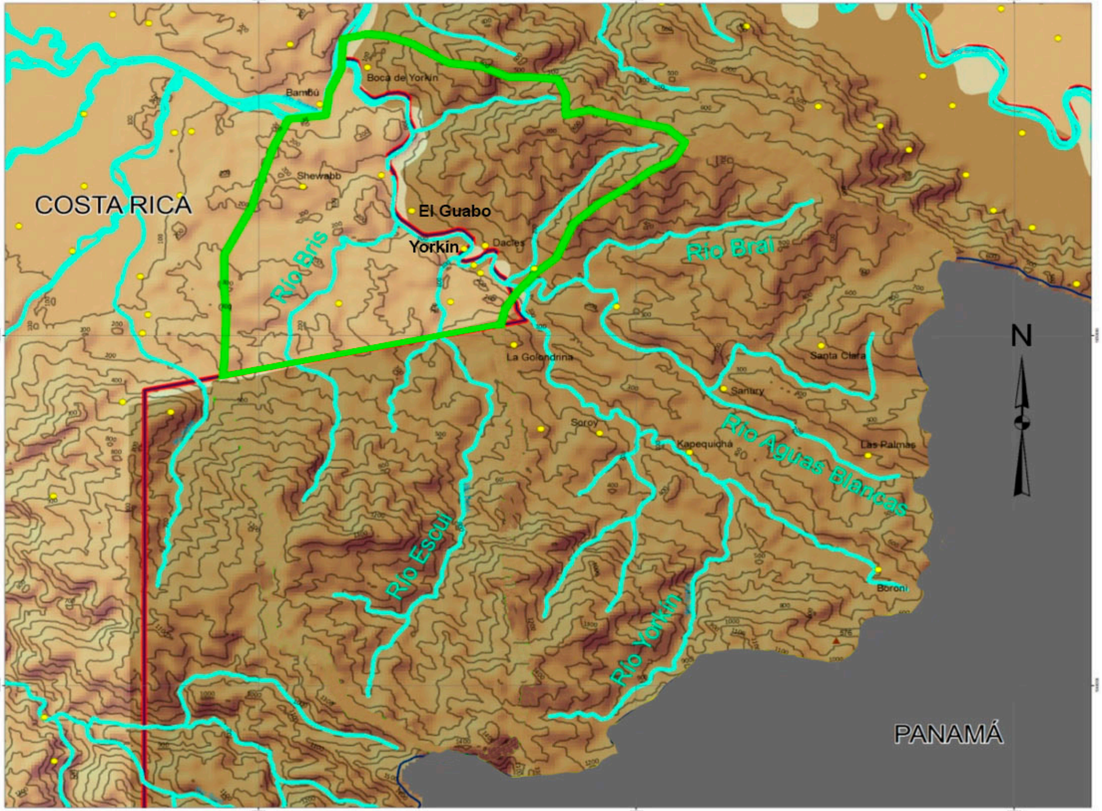
COSTA RICA
Bambú
Boca de Yorkín
Shewabb
El Guabo
Yorkín
Dacles
Río Bris
Río Brai
La Golondrina
Santa Clara
Sanury
Soroy
Kapequicha
Las Palmas
Río Aguas Blancas
Río Escui
Río Yorkín
Boroni
N
PANAMÁ

Figure 1.2 Location of Yorkin and Guabo. The green line indicates the area of study. The blue lines indicate the main rivers in the area.

The local landscape is a mix of primary forest, agroforestry systems, swiddens and plantain monocultures (Figure 1.3-1.7). These landscapes provide habitat for a variety of biological species (Table 1.2).

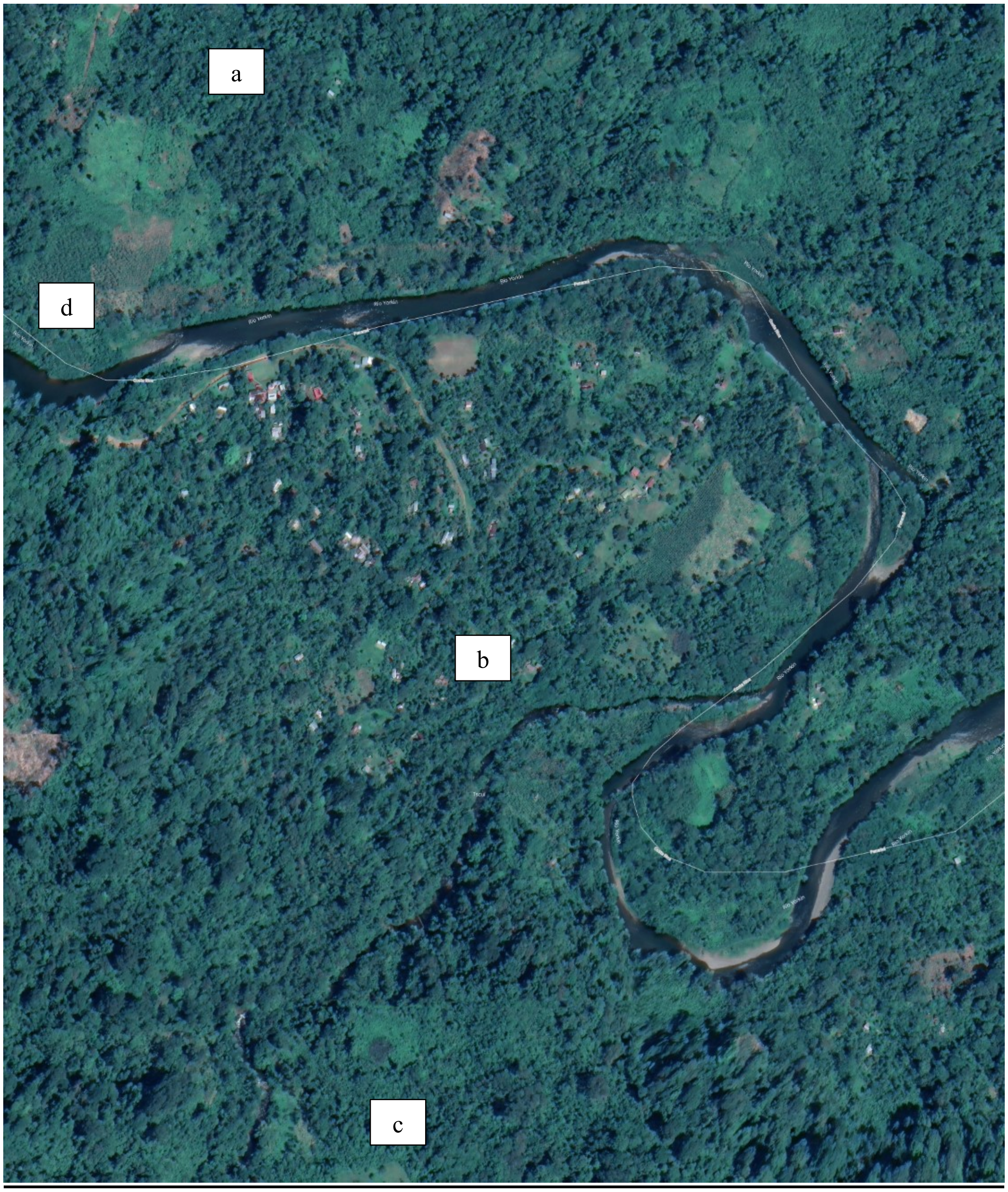

Figure 1.3 Spatial image of the local landscape patches in Yorkin and Guabo (a) primary forest; (b) agroforestry systems; (c) swidden; (d) plantain monocultures (Image credit Google Maps 2021.

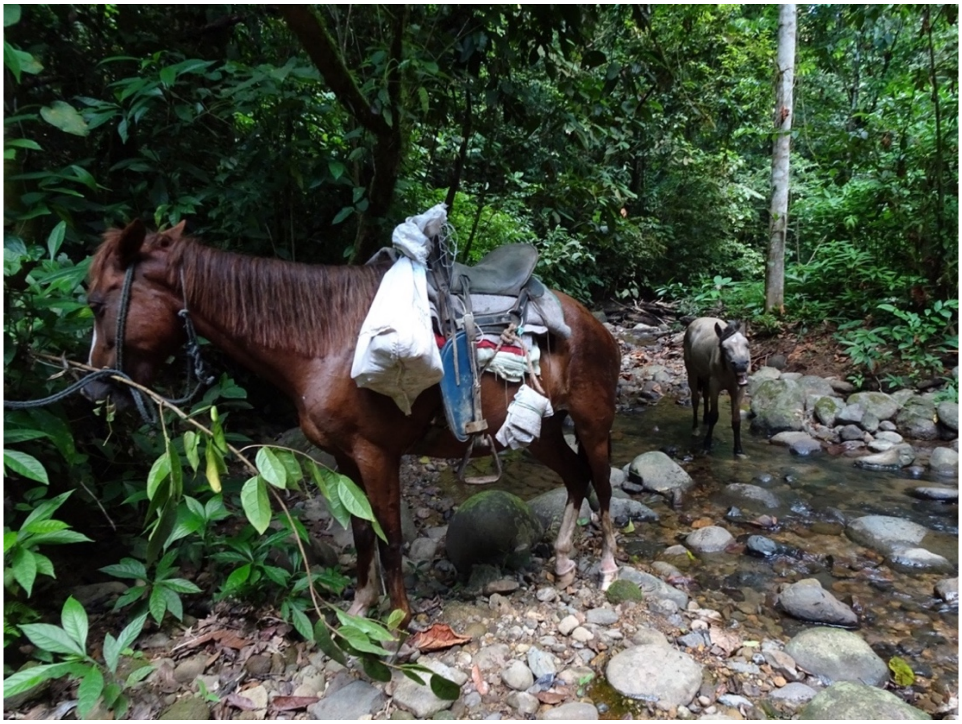

Figure 1.4 Primary forest

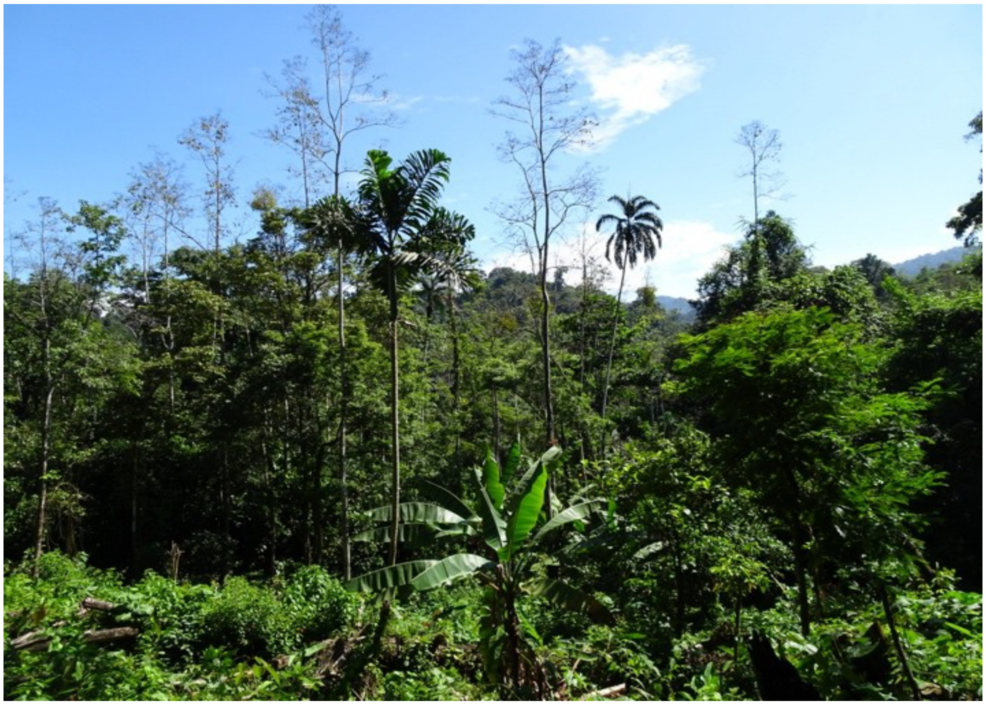

Figure 1.5 Cacao agroforestry systems

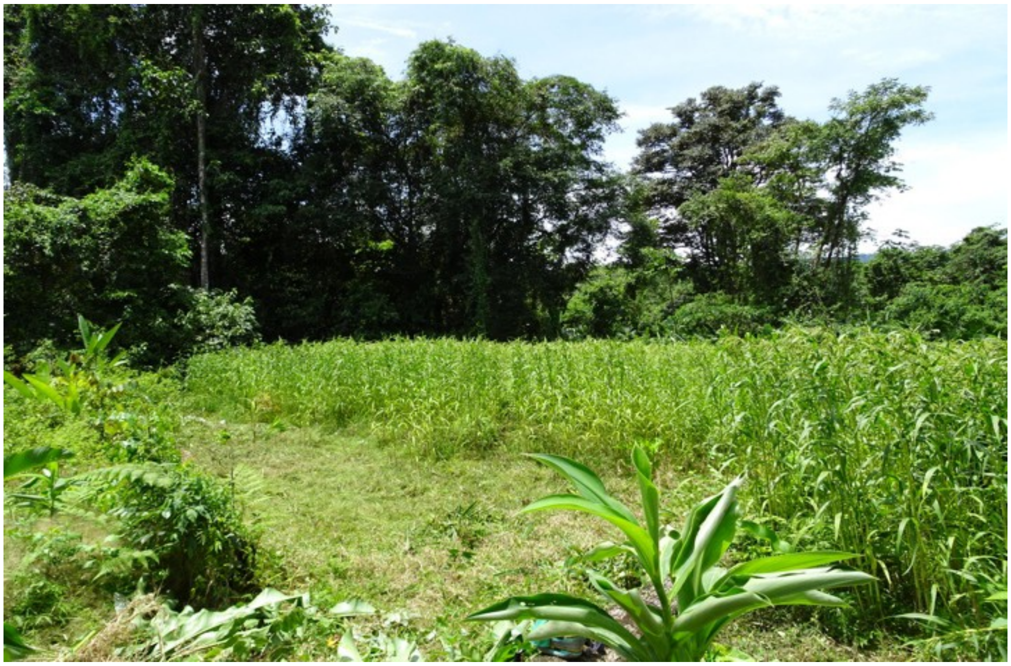

Figure 1.6 Rice swidden

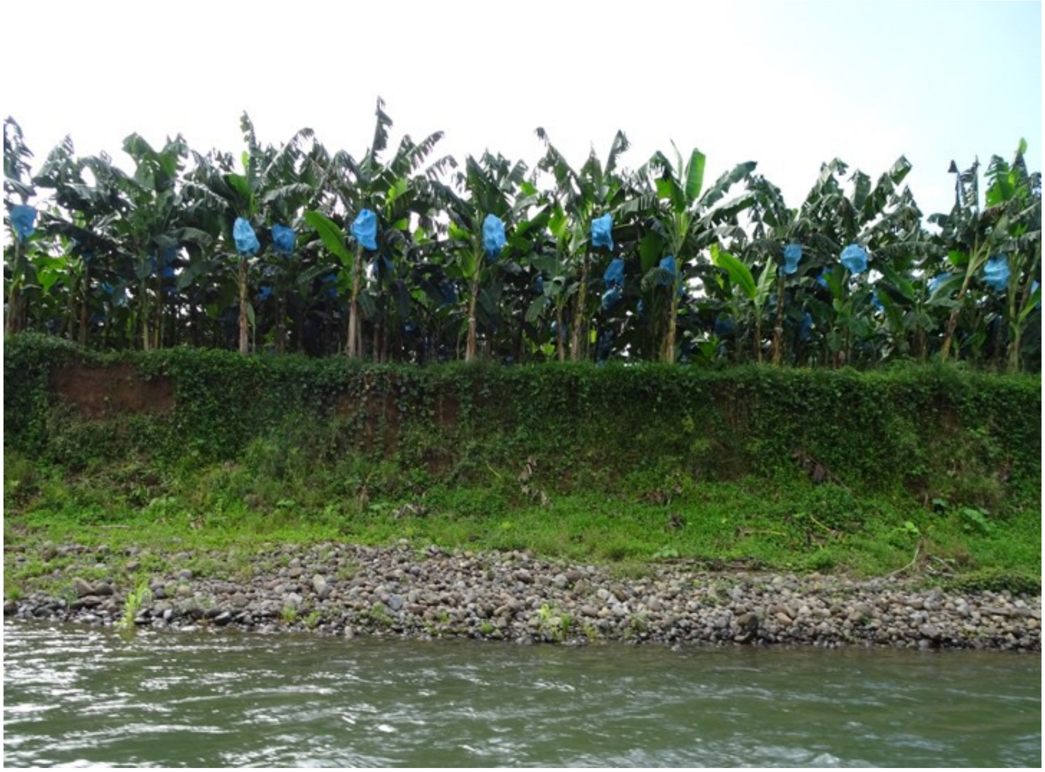

Figure 1.7 Plantain monoculture

Table 1.2 Characteristics and abundant species for local landscape patches

	Primary forest	Cacao agroforestry systems	Banana polyculture	Plantain monoculture	Swidden
Ecological features	Four different vegetation strata	Similar ecological characteristics than primary forest. Four different vegetation strata. High plant density.	Similar structure to cacao agroforestry systems. Low plantain and banana density	Two different vegetation strata. High plant density. Low plant diversity.	Three different vegetation strata. Low plant density. High plant genetic diversity
Abundant tree species	*Iriartea deltoidea, Pentaclethra macroloba, Poulsenia armata*	*Cordia alliodora, Spondias mombin, Nephelium lappaceum, Bactris gasipaes, Inga edulis*	*Cordia alliodora*	N/a	N/a
Abundant bird species	*Phaethornis longirostris, Thamnophilus atrinucha, Myrmeciza exsul, querula purpurea, Habia fuscicauda*	*Glaucis aenea* *Phaethornis longirostris* *Xiphorhynchus susurrans* *Pitangus sulphuratus* *Hylophilus decurtatus* *Dendroica pensylvanica* *Saltator maximus*		*Psarocolius Montezuma, Tangara larvata, Thraupis episcopus, Aratinga finschi, Hylophilus decurtatus*	N/a
Abundant terrestrial mammals	*Dasypus novemcintus, Dasyprocta punctata, Procyon lotor, Agouti paca*	*Procyon lotor, Dasyprocta punctata, Didelphis marsupialis, Dasypus novemcintus*	*Procyon lotor, Didelphis marsupialis, Dasypus novemcintus*	*Didelphis marsupialis, Procyon lotor*	*Odocoileus virginianus, Agouti paca, Tayassu tajacu*

Source: Harvey et al. 2006; Wilsley et al 2006; Garcia Serrano and Del Monte 2004.

The regional climate is warm with a daily average temperature of 25.9ºC and a mean annual rainfall of 2,370 mm (IMN 2010). Although the rainfall is relatively homogeneously distributed, there are two short dry seasons in March–April and in September–October (Herrera 1985).

Fishing, gathering and hunting, supplemented by banana and cocoa agriculture, have traditionally been the main livelihood strategy for most of the Yorkin and el Guabo residents. However, cultural tourism has grown into an important economic sector in the community over the last 35 years (Amoroso 2008). The chocolate tour, for example, is one of the main attractions offered by the local inhabitants engaged in tourist activities Here, visitors have the opportunity to make chocolate with cocoa beans collected on the spot (Figure 1.8). There are two community-based tourism operations in Yorkin and one in Guabo. In 2016, Yorkin received approximately 2,600 tourists annually. Most visitors are tourists from France, Spain and Germany (Rodriguez Valencia Field notes October 12, 2015). Approximately 70 community residents are directly involved in the tourists operations (Rodriguez Valencia Field notes October 12, 2015).

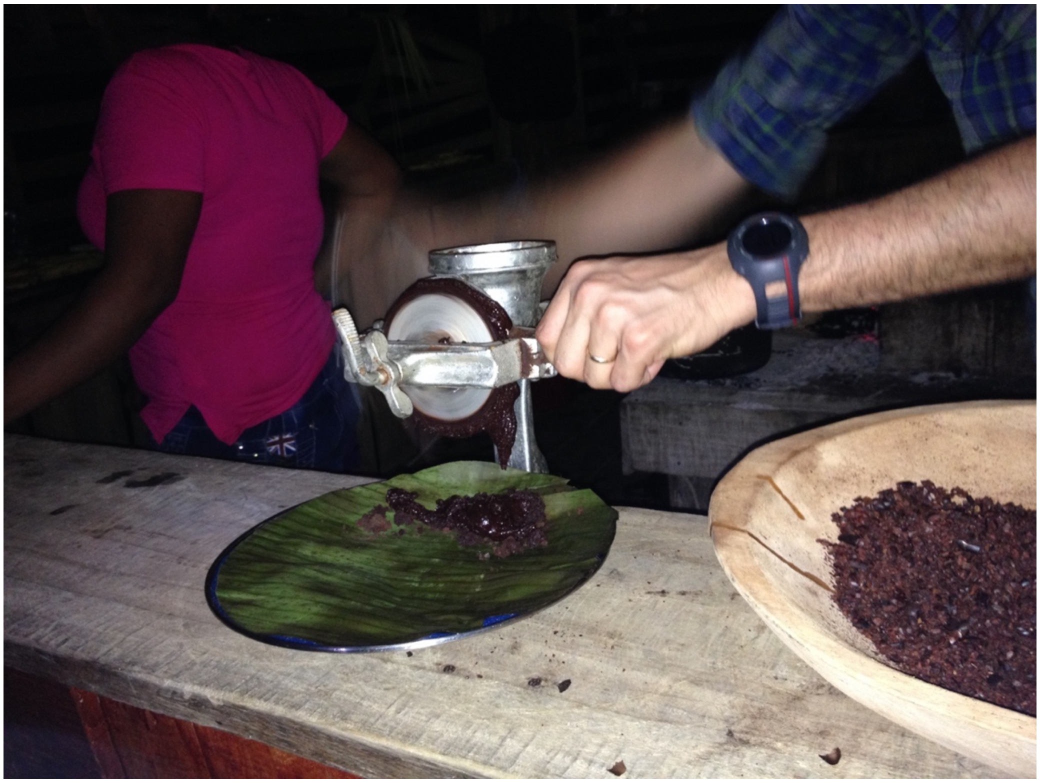

Figure 1.8 Tourist taking part of the cholate tour in Yorkin

Some Yorkin and Guabo residents are bilingual Bribri/Spanish speakers. However, Spanish is the main the language spoken in both communities (Arias-Hidalgo and Méndez Estrada 2015). The Bribri language is now being taught in local schools, and teachers must be Bribri. Yorkin has a kindergarten, an elementary school, and a high school. There are no schools in Guabo.

I used three criteria to select Yorkin and Guabo as my field site. First, I looked for a place where my research could generate information for the early application of the People in Nature (PIN) initiative led by the International Union for Conservation of Nature (IUCN). Second, I looked for a field site where community members were interested in my research. Third, I selected a location where there was a lack of studies explaining the ability of Bribri people to respond to a dynamic environment. To meet these criteria, two technical officers from IUCN-Mesoamerica and I visited five Bribri Indigenous communities in the Sixaola watershed of Costa Rica and Panama in August of 2014. Based on this trip, we decided to select Yorkin and Guabo as my field sites for the following reasons; 1) the communities´ livelihoods relied heavily on the use of natural resources, and the PIN´s goal was to offer a better understanding of the use and reliance on ecosystem services and their contribution to local livelihoods, and 2) some local residents expressed their interest to be engaged in projects that would allow them to *“revalorize their culture and conserve their natural resources”* (President of the ESTIBRAWPA association, field notes August 6, 2014).

Paradigm and strategy of inquiry

Paradigms and strategies of inquiry complement each other and are inseparable (Creswell 2007). A paradigm refers to a “system of beliefs and practices that influence how researchers select questions and methods to create knowledge” (Creswell 2014, p. 11). A strategy of inquiry is understood as models that “provide specific direction for procedures in a research design” (Creswell 2014, p. 11).

Creswell (2014) identified three paradigms in social sciences: the positivistic, the metaphysical and the pragmatic. These paradigms differ in their ontological, epistemological and methodological principles and match, according to their principles, with qualitative, quantitative, or mixed strategies of inquiry (Table 1.3).

Table 1.3 Main differences between positive, metaphysical and pragmatic paradigms

	PARADIGMS		
	Positive	Metaphysical	Pragmatic
Ontology (Nature of reality)	Objective	Recognition of multiple and subjective realities	Assumption of a single "real world" interpreted by all individuals in their own and unique way.
Epistemology (Relationship between scholars and participants)	Bring participants to laboratories .	Face-to-face interactions in natural environments.	Collaboration among scholars-participants in natural settings
Methodology (methods and data collection procedures)	Use of quantitative data/methods and a deductive logic that looks for a generalization of results	Use of qualitative data/methods within a specific context.	Qualitative and quantitative data/methods
Strategies of inquiry in social sciences	Quantitative: experimental and non-experimental designs	Qualitative: narrative, case study, ethnographies	Mixed: sequential, concurrent, and transformative

Table adapted and modified from the "Philosophical assumptions with implications for practice" by Creswell (2007). Source: Creswell (2007) and Morgan (2007).

For my research that focuses on the use of biodiversity richness to respond to a dynamic environment, I opted for a pragmatic worldview and a qualitative strategy of inquiry (Creswell 2014). I selected this worldview and strategy of inquiry because; 1) I assumed there are multiple realities interpreted by all individuals in their own and unique way, 2) I conducted my research in the participants' natural setting without privileging top-down ontological assumptions, 3) I used a variety of qualitative methods to gain an in-depth understanding of the Bribri´s capacity to respond to, and shape change, and 4) I collaborated with Bribri community members to solve specific problems.

Research methods

This research included the involvement of 54 research participants (Table 1.4). Since the Bribri are a matrilineal society of clans, I decided to involve as much as possible an equal number of female and male participants. Most part of the results of this thesis express the perspectives of Bribri people. However, I also included the opinions of non-governmental, governmental, and academic representatives. Contrary to many of the studies done in Yorkin and Guabo, this research also considered the opinions of community members that are not involved in tourist activities.

My research relied heavily on four qualitative methods: participant observation, life history interviews, transect walks, and semi-structured interviews (Table 1.4). I used field notes, photographs, and an audio recording device to document the data related to my research questions. All data were collected in Spanish. Ali García, a Bribri collaborator form the University of Costa Rica, aided me to record the Bribri names of biodiversity used in both Bribri communities

Table 1.4. Research participants by gender and stakeholder type

Gender	
Female	23
Male	31
Total	54
Stakeholder type	
Bribri people directly involved in tourism	18
Bribri agroforesters	31
Bribri people holding traditional occupations	2
Non-Governmental Organization representative	4
Governmental representative	1
Academic representative	2
Total	54

Participant observation (Madden 2010) was a key method I used for the gathering of data while in the field. From September–December 2015 and March-August 2016, I lived in the town of Yorkin and I made bi-weekly visits to Guabo (See Appendix 2 for a detailed list of the people involved in the participant observation activities). This strategy allowed me to meet several community members, participate in everyday activities (e.g., fishing, cacao/banana production, cooking, timber harvesting), and generate trust relationships with the participants of this study. Participant observation also allowed me to gain a general idea of the contemporary land use context, biodiversity richness associated with the local landscape, main management strategies used to prevent and control the pathogens affecting cacao, banana, and plantain farms, and the needs, aspirations, and values that Bribri community members have regarding the commercialization of cacao. The observations of my participant observation activities were recorded in field notes.

Table 1.5 Summary of data collection techniques per research question

Research question	Interviewees	Methods	Specific products
What is the relationship between Indigenous Peoples and the biodiversity of their territory?	Fourteen community members	Life history interviews	Narratives of local notions of change and responses used to overcome the perceived impacts/disruptors.
How have Bribri people drawn upon ecological and social memory to respond to fungal pathogens in the commercial lands?	- Community members from eleven households - Fourteen community members - Representatives of research institutes (1), NGO´s (3) and government (1)	- Transect walks - Life history interviews - Semi-structured interviews	- List of biodiversity richness used in the area - Timeline of the historic use of biodiversity. List of management strategies used to control fungal diseases in commercial lands - Goals and activities of the main conservation and development initiatives applied in the area
How to co-produce livelihood opportunities by drawing upon the capabilities of cacao agroforestry systems?	Nine community members	Participant observation	Narratives about local struggles to commercialize cacao. List of ideas to create alternative income by using the capabilities associated to cacao

I undertook fourteen life history interviews (Brannen 2013) to identify the plants and animals historically used in the study area, as well as the notions of changes in the use of these resources during the last 80 years. I decided to set a time frame of 80 years because most of the participants could not remember the events that affected the community before 1935. The criteria to select the participants consisted of including an equal number of female and male participants, from a range of ages (40-90 years at the time of the interview) and committed to various livelihood activities during their lives (e.g., subsistence farming, hunting, fishing, cultural tourism) (See Appendix 2 for a detailed list of the people interviewed). Information related to livelihood activities, motivations for different land uses, main changes in the community livelihoods, and the history of the farms (Appendix 3) was audio recorded. Life history interviews allowed me to record the dynamic interplay regarding the use of biodiversity over time, the main changes affecting the community, and Bribri understandings of why these changes in the resident´s livelihoods occurred.

Transect walks (De Leon and Cohen 2005) were used to document the biodiversity richness of the cacao-banana plots, swidden plots, plantain farms, and the areas of primary forest managed by eleven households. The selected households had a diversified land use. In this regard, each household was managing several plots at the same time, and each plot was dedicated to the production of different crops. The participants selected one or two knowledgeable people in their family. These people decided the best route to follow in their property and took me on a walk to show me the plants located in their plots. The participants also shared with me stories about the wildlife seen in each plot, and the ways in which they were managing their land. I recorded the information in notes, and I took photographs of each plant and animal footprint/feces. The use of transect walks allowed me to document data about the Bribri landscape, management strategies, and the location of the plants and animals used in Yorkin and Guabo.

I conducted five semi-structured interviews (Bernard 2006) to identify the goals and activities of the main conservation and development initiatives applied in the area in the last 30 years. To identify the interviewees, I asked members of the community for the programs/projects that existed in the area. Taking into consideration the participants' responses, I interviewed one representative of the Tropical Agricultural Research and Higher Education Center (CATIE), three representatives from different development organizations (La Asociación de Nuevos Alquimistas, Fundación Wilombe, and ACAPRO), and one representative of the ministry of agriculture in Costa Rica. During the interviews, the participants shared with me the history and mission of their organizations, their goals, and the values behind the development and conservation project (Appendix 4).

Coding and data analysis

Data analysis involves "bringing order, structure, and meaning to the mass of collected data" (Marshal and Rossman 1989:112). I used the software NVivo to manage, organize and analyze the data gathered during my fieldwork. To do so, I transcribed the data gathered across my research methods. Then, I coded the data by topics. The topics were predefined according to my thesis research questions. Subsequently, I further grouped each research question into nodes. As an example, the entire dataset was sorted by the following research question: How have Bribri people drawn upon ecological and social memory to respond following the invasion of fungal pathogens in their commercial lands? Then, I further grouped the response to this research question according to biodiversity change events, farmers' responses, memories about resources used in the past (nodes). When necessary, I subdivided each subcategory, to better reflect the nuance and richness of the data. The same applied for the other research questions (Appendix 5). Despite the time invested in digitizing and coding the data, the use of the software NVivo was useful in assisting me to synthesize and identified relevant emerging analytical patterns.

Ethical considerations

Doing research with Indigenous Peoples demands attention to cultural norms for consent procedures, data collection, and the dissemination of results (Haggerty 2004).

Therefore, I followed the ethical guidelines proposed by the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (2014). To mitigate possible risks in my fieldwork, I included a free, prior and informed consent form (Appendix 6). In this consent form, I shared with the participants my research questions, activities, and the participants right to withdraw from the research. To validate the interpretation of the findings, I conducted verification sessions with eleven community members in August 2016 and May 2017. The later, allowed the participants to add more information to my results and to clarify my interpretations. This research project was also approved by the University of Manitoba Institutional Review Board Protocol Number: HS18831 (J2015:093).

Dissemination of results

The results of my research have been disseminated mainly in two spaces: the academic and in a policy platform. I have presented the results of my research in; 1) The World Conservation Conference - IUCN (August 2016), 2) The Forest & Livelihoods: Assessment, Research, and Engagement Conference (December 2017), and 3) The Ethnobiology Conference (May 2019). I also published my results in three academic journals (chapter 2 to 4) and on the IUCN website (Rodriguez Valencia 2017).

ORGANIZATION OF THE THESIS

The remainder of this dissertation is organized in five chapters. Chapter 1 provides the context of my research and the research questions. In this section, I also present the research philosophy, methodology and data collection procedures I used to document, analyze, and interpret the field data I gathered in my research.

Chapter 2 responds to my first research question: Is the narrative of decline and loss in biodiversity richness, measured against what was used in at some point in the past, the only way to think about the relationship between Indigenous Peoples and the biodiversity of their territory? In this chapter, I used resilience thinking to understand how Bribri people have used the biodiversity of their territories to reorganize after being impacted by multiple social, environmental and economic disruptors. The use of biodiversity in Yorkin is a dynamic process, and although it stabilizes at points in time, new patterns of biodiversity use emerge as some items are set aside, new ones brought in, and some uses are intensified, leading to a new configuration that once again stabilizes for a period. The discussion of this chapter is centered on the implications of the findings for understanding the use of biodiversity by Indigenous Peoples. Indigenous Peoples, such as the Bribri of Yorkin, are actively using their ecological knowledge to create new patterns of biodiversity use, as well as to negotiate causes of environmental change to influence change.

Chapter 3 responds to my second research question; How have Bribri people drawn upon social and ecological memory (SEM) to respond following the invasion of fungal pathogens in their commercial lands? In this chapter, I examined the role of SEM to consider the ways by which people can draw upon biological materials and social memory to respond to the impact of invasive pathogens in their commercial crops. I found that there are internal (e.g., diversification, protection of biodiversity) and external practices and knowledge (e.g., adoption of new germplasm and management practices) nurturing the SEM of Yorkin. The results suggest that people draw upon the knowledge saved in their collective memory, as well as in external reservoirs of memory in their responses to the invasion of fungal pathogens in their commercial lands.

Chapter 4 responds to my third research question: How can stakeholders and researchers co-produce livelihood opportunities by drawing upon the capabilities of Bribri cacao agroforestry systems? I use a biocultural design framework to co-produce cacao value added products and services with community members. I did this by identifying areas of opportunity to stablish collaborations, understanding the ways in which Bribri people frame problems, co-imagining ideas to solve problems, and co-executing desirable, feasible and viable ideas. The results suggest that Biocultural design provides a strength-based approach that allows creativity to emerge out of the capabilities found within biocultural heritage of cacao agroforestry systems to implement changes in livelihoods.

In chapter 5, I conclude this dissertation by summarizing my main findings. I also reflect upon the theoretical and methodological contributions of my research. Finally, I provide some avenues for future research.

CONTRIBUTIONS OF AUTHORS

The body of this dissertation is a collection of manuscripts (Chapter 2 to 4). Some of these chapters are multi-authored (Chapters 2-3). The multi-authored chapters reflect the contribution of the co-authors to the conceptualization of the manuscripts. Nevertheless, I was the lead author on these manuscripts, and I was responsible for data collection, analysis, interpretation and writing.

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INTERCONNECTIONS AMONG CHAPTERS

Chapter 2 provides an overview of how Bribri people use the biodiversity richness of their territory to deal with a dynamic environment. This chapter offers critical information to my overall thesis goal; develop thinking around an idea of resilience that recognizes Bribri people´s agency in responding to a dynamic environment. Here, I present data on the disruptors impacting the livelihoods of the Bribri people in the last 80 years. I also illustrate how Bribri people responded to disruptors through their use of biodiversity. My results support the idea that Bribri people are skillful in creating new and productive livelihoods through a dynamic use of biodiversity, as well as negotiating causes of environmental change. Understanding the dynamic use of biodiversity in the Bribri community of Yorkin strengthens my discussion on the responses of Bribri people following the invasion of fungal pathogens in their commercial lands (Chapter 3).

Figure 1.9 *Theobroma* seeds. Illustration: Connor Jandreau

CHAPTER 2 RESILIENCE AND THE DYNAMIC USE OF BIODIVERSITY IN A BRIBRI COMMUNITY OF COSTA RICA[1]

ABSTRACT

The relationship between Indigenous communities and the biodiversity of their territories is often cast as a story of decline. Resilience thinking opens the possibility of a different narrative through the inclusion of cycles. We use this lens to consider how the use of biodiversity by Bribri people in one community of Costa Rica has changed over an 80-year period. Our qualitative methods allow us to identify four social-ecological cycles and how the richness of biodiversity utilized was reconfigured by the Bribri to respond to different types of disruptions. The richness of biodiversity used for food, commercial and construction stabilizes at various points in time, but then goes through periods of decline and growth as new social-ecological systems emerge. Bribri people respond to disruptors as they change the use of certain species to reconfigure their livelihoods. Resilience thinking offers a narrative in which Bribri actively express their agency in reconfiguring their use of biodiversity to meet livelihood needs.

KEYWORDS: Biodiversity richness, Bribri Indigenous Peoples, livelihoods, social-ecological systems, resilience

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INTRODUCTION

In biological conservation, the total number of species in a defined area is a measure of biodiversity richness (Deheuvels et al. 2014). Tracking richness indicates whether there is a change in biodiversity within an area over time from a defined baseline at a point in time. While there is some debate in the literature, new species that enter an area are considered invasive so that change in the richness of biodiversity can only be framed as decline. Many studies have documented a decline in the richness of biodiversity used within Indigenous territories worldwide (Cardinale et al. 2012) and specifically in home-gardens (Bisseleua et al. 2009), farms (Ruf 2011), and forests (Guèze et al. 2015). Such studies suggest that this decline is due to cultural changes resulting from the integration of Indigenous Peoples into market economies and associated interactions with outsiders (García-Serrano and Del-Monte 2004). Recently, this decline in richness of biodiversity use has also been linked to the diminishment of Indigenous Peoples' ability to respond to globalized change as the number of species utilized is seen as providing opportunities for adapting to global drivers of change (Rice and Greenberg 2000; Cardinale et al. 2012). We argue that this narrative of decline and loss in biodiversity richness, measured against what was used at some point in the past, is not the only way to think about the relationship between Indigenous Peoples and the biodiversity within their territories.

Davidson-Hunt et al. (2016) propose that richness could be utilized to understand the dynamics of biodiversity used by rural and remote communities in relation to what is available to them in their territory. If richness is the total number of species available within an Indigenous territory, then use would be a proportion of that total used for different purposes such as food or shelter and could be tracked over time. They then draw upon resilience thinking to open the possibility of a different narrative in which Indigenous Peoples and other populations of rural and remote regions respond creatively to disruptions within their environment. This dynamic use of biodiversity draws from the reservoir of biodiversity accessed within their territories and through external linkages with people of other territories and organizations (Rodríguez et al. 2019).

Resilience thinking suggests that change in social-ecological systems (SES), such as those that use biodiversity, is a dynamic and often cyclic process (Gunderson and Holling 2002). Seen from the perspective of resilience, we should expect that in a changing resource management system, some species will be gained, and some will be lost over time (Davidson-Hunt et al. 2016). This should hold true in Western food production systems as well as in Indigenous ones. Indigenous Peoples, rather than being seen as skillful in creating new and productive SES through a dynamic use of biodiversity, are often considered to be undergoing an erosion of their knowledge based upon changes in the use of biodiversity. As Nazarea states, this framing could be considered an "*alarmist call to create mass hysteria, or a charismatic lure to generate funding and sell books*" (2006:318).

In the next section, we present an overview of the study area and research methodology and describe the socioeconomic context of Yorkin community. We then present the four different configurations of crops (SES) identified by the participants, and the changes in the biodiversity richness utilized for food, shelter, and trade. We conclude with a discussion of the implications of our approach and findings for further inquiry into the role of the dynamic use of biodiversity by Indigenous Peoples.

STUDY AREA AND RESEARCH METHODOLOGY

Study Area

Yorkin is a Bribri Indigenous community located in the Talamanca Bribri Indigenous Territory, on the border between Costa Rica and Panama (Figure 2.1). The daily average temperature is 25.9 °C and the mean annual rainfall 2370 mm (IMN 2016). Even though the distribution of precipitation is relatively homogeneous, Yorkin residents recognize two short dry seasons in March–April and in September–October (Rodríguez field notes September 19, 2015).

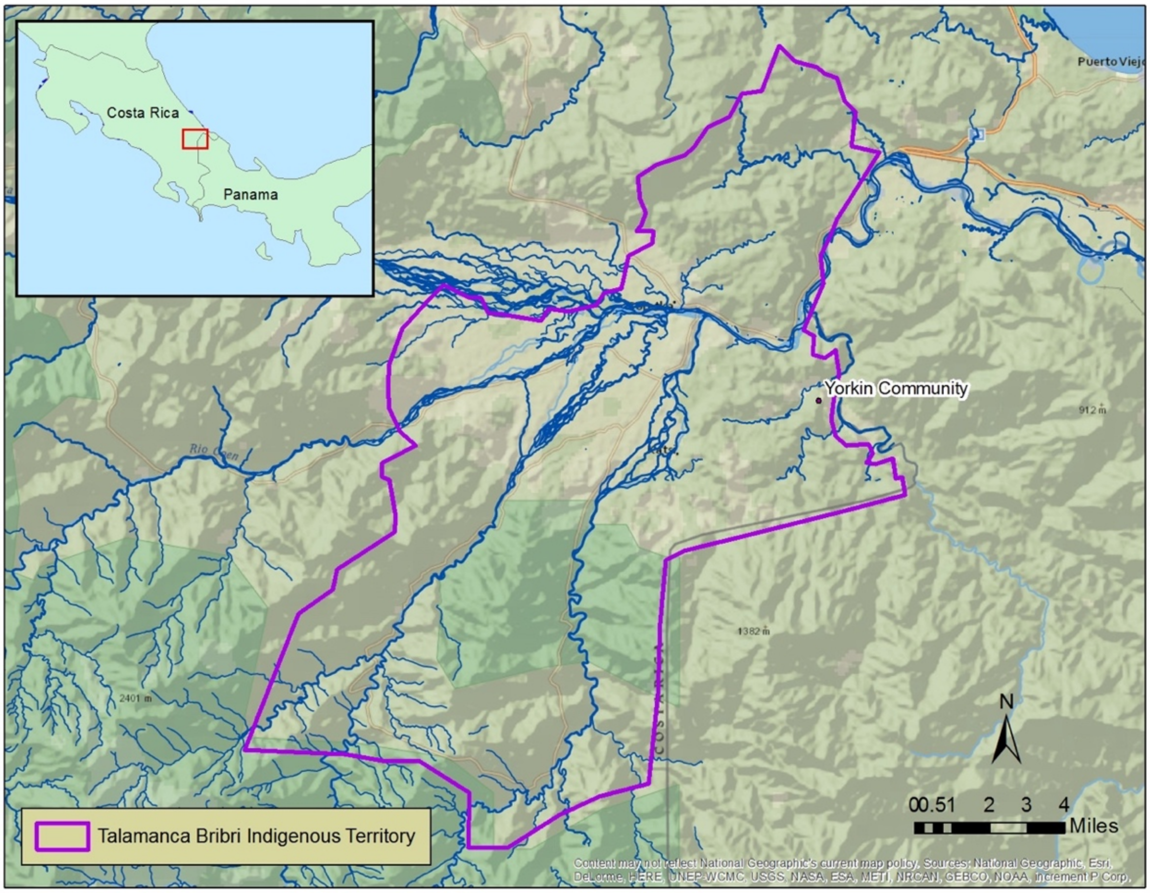
Costa Rica
Panama
Puerto Viejo
Yorkin Community
Río Coen
912 m
1382 m
2401 m
COSTA RICA
N
0 0.5 1 2 3 4
Miles
Talamanca Bribri Indigenous Territory
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Figure 2.1 Approximate location of Yorkin, Costa Rica.

In 2016, Yorkin had a population of 232 people (Rodríguez field notes July 26, 2016). Fishing, gathering, and hunting, supplemented by commercial production of banana (*Musa* spp.) and cacao (*Theobroma cacao*) have traditionally been the primary livelihood strategies in the community (Borge and Castillo 1997). However, cultural tourism and commercial production of plantain (*Musa spp*.) have grown into significant economic sectors over recent years.

The Yorkin landscape is characterized by the presence of floodplains surrounded by foothills. As is the case throughout Bribri territory, differences in soil type and slope are correlated with the current land use (Dahlquist et al. 2007). The fertile soils found in the Yorkin floodplain are mainly used to grow plantains in what are locally referred to as fincas de plátano (plantain farms). Plantain is currently the most important cash crop in the region, and it is being grown in either a polyculture or monoculture system (García-Serrano and Del-Monte 2004). In Yorkin, plantains are mainly grown in combination with other plant species used for food such as cassava (*Manihot esculenta*) and pepper (*Capsicum* sp.), and timber species such as laurel (*Cordia alliodora*) and guava (*Inga spp.*) (Rodríguez field notes August 25, 2015). In the community's foothills, cacao and banana are grown commercially in association with palms (e.g., *Bactris gasipaes* and *Iriartea deltoidea*), fruit trees (e.g., *Citrus spp., Cocos nucifera, Persea americana*), and legume trees (e.g., *Inga spp*.) (Somarriba et al. 2014) (hereafter referred as home gardens). The Bribri grow basic grains - rice (*Oryza sativa*), beans (*Phaseolus vulgaris*), and corn (*Zea mays*) - for home consumption in swidden farms (García-Serrano and Del-Monte 2004), locally known as rastrojos.

The forest surrounding the community is locally known as montaña, from which Yorkin residents obtain materials for construction (e.g., *Geonoma congesta and Minquartia guianensis*), resources for they use for medicinal purposes (e.g., *Quassia amara, Tracttinickia aspera*) (Rodríguez field notes August 9, 2015), as well as wildlife hunted for food (e.g., *Tayassu pecari* and *Mazama americana*) (Sylvester et al. 2016). Yorkin residents also have access to diverse rivers and creeks from which they catch several species of fish: Titi (*Sicydium spp*.), Bobo mullet (*Joturus pichardi)*, and Burro grunt (*Pomadasys crocro*) are the most commonly caught (McLarney et al. 2002).

Methodology

Prior to undertaking fieldwork, Rodríguez made two short visits to the community of Yorkin to develop trust with the residents. She stayed in the town during two field seasons, August–December 2015 and March–August 2016. The research involved the use of qualitative methods and utilized a combination of participant observation, transect walks, and life story interviews. During participant observation (Creswell 2009), Rodríguez engaged in the livelihood activities carried out in the community (e.g., fishing, cacao/banana production, timber harvesting). This allowed her to have a general understanding of the different landscape patches managed in Yorkin, as well as of the biodiversity richness associated with each landscape patch. The life story interviews (Brannen 2013) involved conversations with an equal number of male and female Yorkin residents (14 in total) about the plants and animals historically used in the village, and perceptions of changes in the use of these resources during the last 80 years. The transect walks (DeLeon and Cohen 2005) in the farms of 11 households allowed the identification of the diverse biological species currently used for food, trade, and construction purposes.

The data collected during the fieldwork were transcribed and coded by themes (disruptors/disturbances, farmers' responses, biodiversity richness per landscape patch) allowing us to identify four distinct plant use patterns (SES) used by Bribri people over an 80-year period.

RESULTS

Social-Ecological System 1: The Withdrawal of the United Fruit Company (1931–1945)

> My dad was Chiricano. He came here. He was poor. Back in those times, he worked with my grandparents. My grandparents were farmers. Then he [the interviewee's dad] came here [to Talamanca] to look for a job at the banana company. He was working for the company and then the banana company left this area because the rivers broke [flooded], all the bridges were destroyed, and then the company left the area. So, he stayed here working with the people from here…
> (Adolfo Celles, interview Sept 10, 2015).

Between 1914 and 1931, the United Fruit Company (UFCO) produced bananas in the Talamanca valley and exported them to the United States, Canada, and the United Kingdom (Boza Villareal 2014). However, in 1931, the Chiriqui Land Company, a subsidiary of the UFCO in Costa Rica, stopped its operations in Talamanca. According to interviewees, UFCO moved its operations to the Atlantic coast of Costa Rica due to the impacts of flooding. The cause of the flooding is controversial (Boza Villareal 2014).

It has been reported that it occurred because through its deforestation of the area, the company altered the courses of the rivers (Boza Villareal 2014). However, the Bribri maintain that the flooding was because Uséköl, a Bribri spiritual guide, put a spell on the company to recover the lands that it had taken from them (Jara Murillo and Garcia Segura 2008).

After the UFCO abandoned Talamanca, the Bribri who had moved when the Chiriqui Land Company took over their lands returned to the Talamanca valley to reclaim them (Borge and Villalobos 1994). At the same time, a large number of non-Bribri UFCO workers from Panama moved to the Talamanca mountains and remained in the area.

Responses to the Withdrawal of the United Fruit Company

> Our people has always raised few pigs and few hens. Our parents liked to have coffee and cacao trees, and they were used to cultivate a bit of corn, tubers, plantain and bananas. That was our diet when we were kids. We also ate beans, but we were getting the beans from the mountain, not from our fields. I started eating rice when my mom married my stepdad. He was from Chiriqui (Panama) and he was used to grow rice and beans. When he moved here, he started to grow rice and beans. By that time, it was easier to grow our food than buying it. The rice was for our consumption and to feed our hens…
>
> (Guillermo Torres, interview Dec 2, 2015) (Figure 2.2)

Between 1931 and 1945, these new Panamanian settlers married into the local community and participated along with the Bribri in using and managing the regional biodiversity to meet their household needs. For example, they built their houses with timber from the surrounding forests, notably jira (*Iriartea deltoidea*), suita (*Geonoma congesta*), and manwood (*Minquartia guianensis*) species with which the Bribri were familiar and which they harvested with machetes.

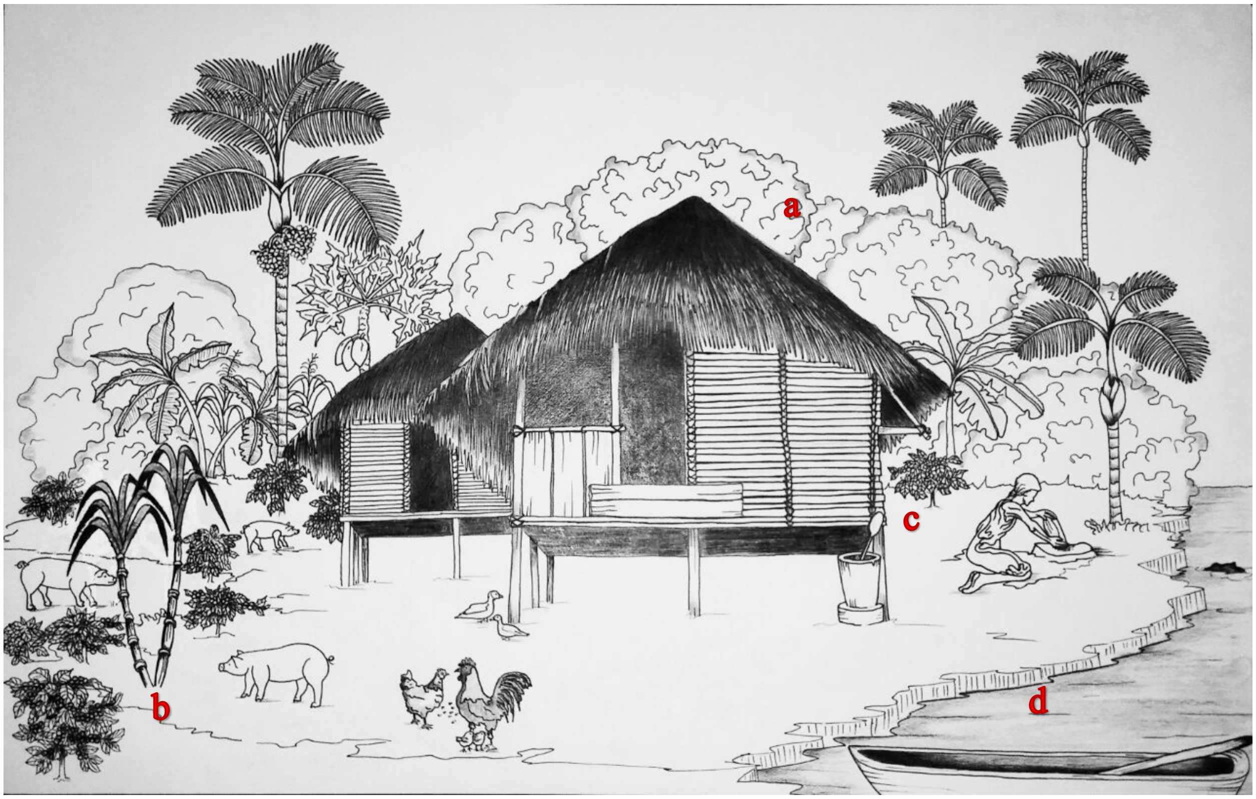

Figure 2.2 Graphic representation of Social Ecological System 1 (**a**) forestry area; (**b**) home garden; (**c**) swidden farm; (**d**) Yorkin river (Image credit: Mariana Rodríguez and Francine Gómez Calderón).

Both the settlers and the Bribri community harvested wild resources for food, including fish (e.g., bobo mullet) from the Yorkin River and wild pigs and deer hunted in the forests, and cultivated corn, beans, and squash (*Cucurbita sp.*) on their swidden farms. This diet was complemented with pork and chicken raised by families in their home gardens. According to some interviewees, the diet in Yorkin differed from the rest of Talamanca because the settlers from Panama were used to eating rice and adlay (*Coix lacryma-jobi*) and began to cultivate them on their swidden farms and the Bribri followed suit. The Bribri of Yorkin adopted these plants because they were tasty, easy to keep, and it was easier to grow them rather than to buy them. To generate cash to purchase products such as kerosene, soap, and clothes, the Panamanian settlers of Yorkin grew coffee (*Coffea arabica*) in their home gardens and traded it with their networks and friends in Panamá. Overall, livelihoods in Yorkin during this time relied heavily on the use of local biological richness. People reported the following uses for this plant and animal diversity: food (N =53), commercial (N = 1), and construction (N = 3) (Table 2.1). The use of 59 species from the local landscape patches, as well as from Panamá, allowed the new settlers to establish homes and livelihoods in Yorkin (Figure 2.3).

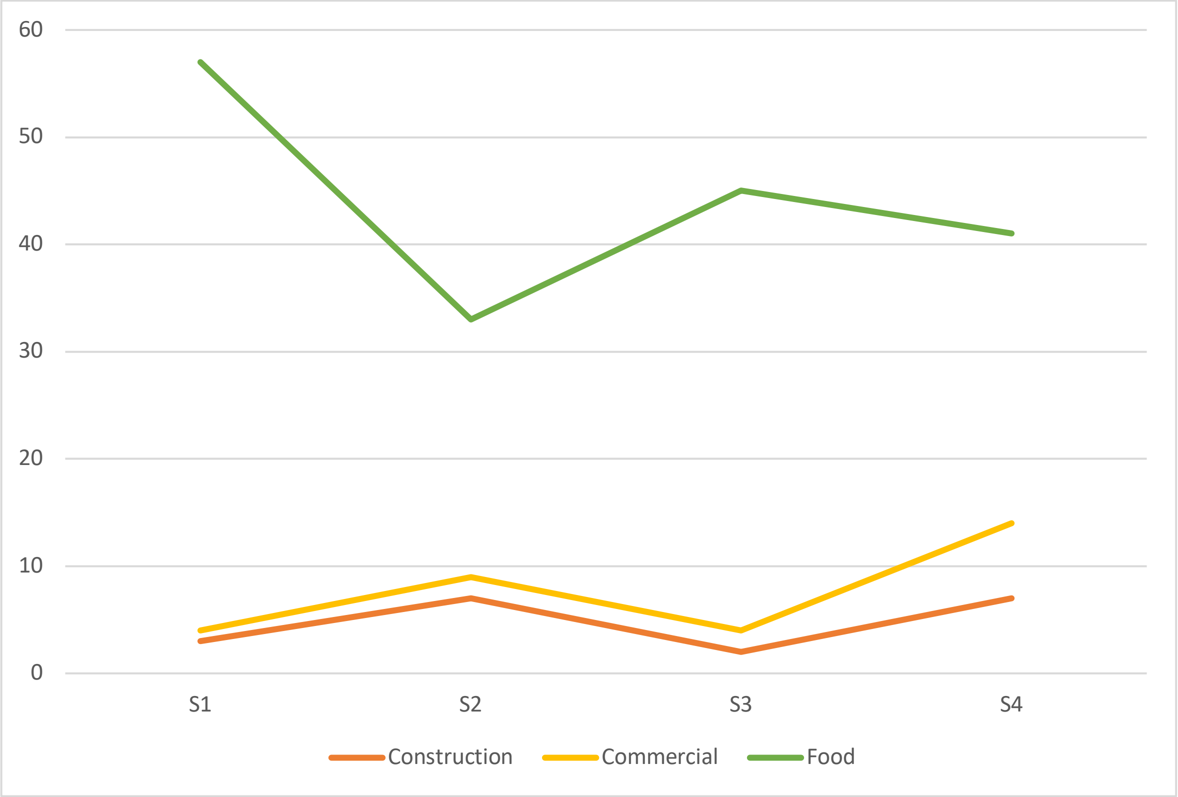

Figure 2.3 Number of species used by the Bribri for food, commercial and construction purposes in four different SES. Consult appendix 7 for a detailed list of the species reported

Social-Ecological System 2. The Global Demand for Cacao (1945–1979)

> Interviewer: And why did they start to grow cacao? Response: It seems they told them [the elders] that it was a good opportunity. And it was true. We all grew up with that, so we would not have to think what we would eat, right? Because with the cacao they were selling, they were buying food and clothes [for us].
>
> (Perfecta Morales, interview August 4, 2016)

Around 1941, two main events impacted Yorkin residents' use of biodiversity. After the Second World War, the international price of cacao rose, encouraging communities on the Caribbean coast of Costa Rica to produce cacao (Quesada-Camacho 1978). The UFCO and other intermediaries took advantage of this market opportunity and increased production of cacao in the area (Quesada-Camacho 1978). In the early 1950s the construction of the road that connects Yorkin to the commercial town of Bambú also contributed to the expansion of cacao farms in Yorkin. Both events influenced Yorkin farmers' decision to initially replace their coffee farms with cacao trees and eventually to expand their cacao plantations over forested areas surrounding the community. By the end of this SES in 1979, people had also established cattle ranches (Fig. 2.4)

Responses to the Global Demand for Cacao

> Yes mam, my dad started with few hectares but with the time he ended up with 20 hectares of cacao and a cattle ranch that had 20 hectares. I always helped him. First, I helped him by selecting the best cacao seeds to expand to grow more cacao. I also helped him to clear the land for his livestock. When I got older my job was to weed the cacao trees and to transport the seeds from Yorkin to Puerto Viejo
>
> (Adán Moreno interview December 03, 2015)

The increased demand for cacao caused the Yorkin community to shift from a diverse biodiversity portfolio to a specialized one: the commercial production of cacao. This transition happened gradually in three stages. In the first stage, Yorkin farmers continued using almost all of the biodiversity richness used previously during the first SES, but they substituted some of their coffee trees with cacao plants, using seeds used from the UFCO abandoned farms in the belief that the UCFO cocoa trees were

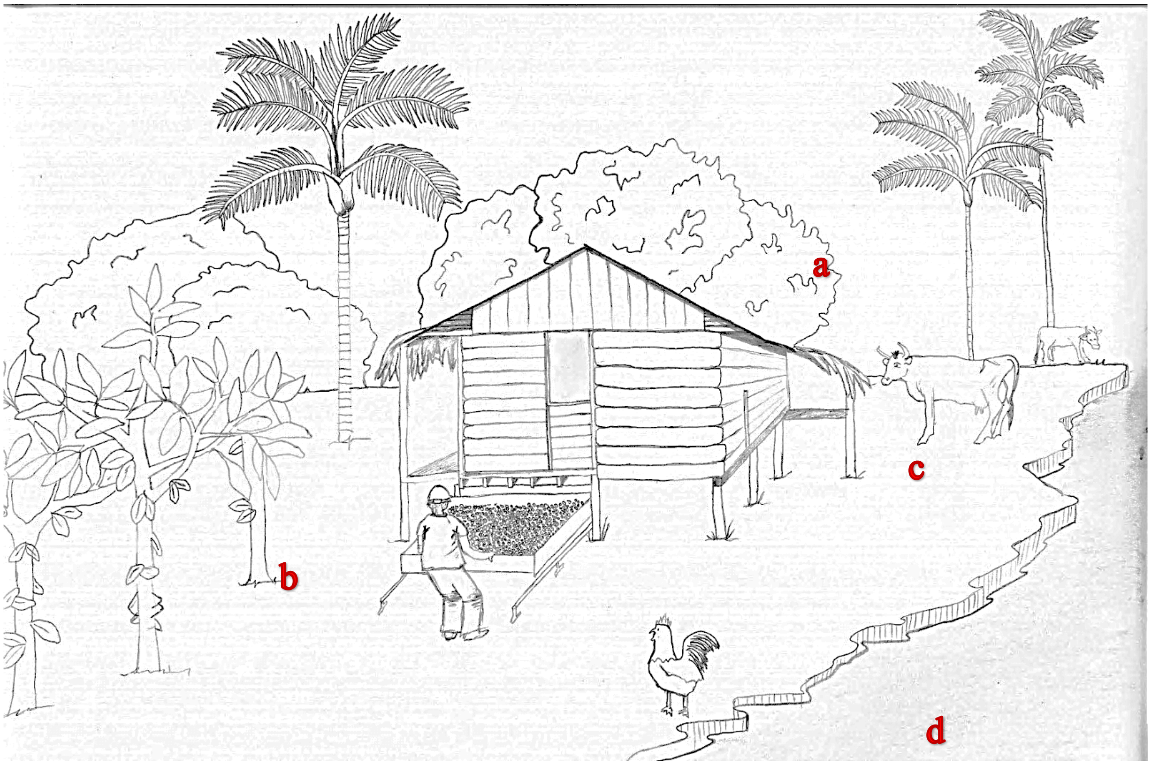

Figure 2.4 Graphic representation of Social Ecological System 2 (**a**) forestry area; (**b**) home garden; (**c**) cattle ranch; (**d**) Yorkin river (Image credit: Mariana Rodríguez and Jennifer Bergen).

more productive than the local varieties of cacao. In the second stage, farmers spent less time on growing rice, hunting, and fishing, and more time in cacao production, while expanding cacao plantations into the forest. They also learned to select the most productive cacao seeds and grew cacao trees in the middle of the remnants of the forestry areas. Managing shade, as well as growing the cacao trees on black soils, were essential elements in the establishment and management of new cacao farms. Finally, in the third stage, cattle ranches, with 10–50 cattle, were established in forest areas (Fig. 2.3).

Changes in the Use of the Biodiversity Richness in Yorkin.

The integration of Yorkin farmers into the global cacao market impacted the local use of biodiversity richness for the provision of construction materials and food. In the case of the former, the money generated by the sale of cacao allowed Yorkin people to buy tools (e.g., chainsaws, tools, nails) that allowed them to use wood that had not previously been extensively used to replace, for example, laurel, pilón (*Hieronyma alchorneoides*) and others. Most of the harvested trees came from forest areas that were transformed into ranches.

The diet of Yorkin farmers changed for the same reason. The swidden farms, for example, were downsized as people did not have time to grow the basic grains (rice, corn, beans, as well as adlay), which they now bought. During this time, fishing and hunting were still common activities locally, and people continued raising chickens and pigs in home-gardens. However, people spent most part of their time producing cacao. Even with cacao as a major new livelihood activity, Yorkin residents included 24 species of plants and animals in their diet, used 7 plant species for construction, and produced 2 plants for commercial purposes (Figure 2.3).

Social-Ecological System 3: The Monilia Crisis (1979–1985)

In 1979, the boom in the cacao production in Talamanca was disrupted by the impact of a major cacao disease outbreak:

> One day we saw an infected pod, and after that, all the cacao pods got infected very quickly. That year we did not have cacao, not even for our consumption! It was bad! It extended very fast! ...Then, I was thinking. Where did that come from? And how it was spread? Because you see one infected pod on this farm, and it suddenly appears there where nothing was infected before. Does the wind carry it, or how does it jump? It is unknown what it is, but I think it has no cure.
>
> (Adán Moreno interview December 03, 2015)

Phillips-Mora (2003: 75) reported: *Moniliophthora roreri* (Cif.) is the causal agent of moniliasis or frosty pod, a serious disease with the capability to infect pods of *Theobroma* spp. and *Herrania* spp. Until 1956, the monilia fungus was geographically restricted to Colombia, Ecuador, and Venezuela. However, in the early 1950s it arrived in Panama and spread in 1978 to Costa Rica. According to the scientific literature, *M. roreri* was probably introduced to Costa Rica by humans (Phillips-Mora 2003). However, according to some Bribri, the fungus was a “maldad” (spell) that affected their cacao farms because Sibö, the Bribri religious figure, did not agree with the commercialization of the cacao (Rodríguez field notes August 31, 2016). Between 1978 and 1983, the spread of *M. roreri* affected almost all the cacao plantations on both coasts of Costa Rica, and production declined by 72%, forcing many farmers to abandon their cacao farms in search of other livelihood opportunities (Phillips-Mora 2003).

Responses to the Impact of the Fungus

> In 1979 the monilia arrived and it did not stop. That is when all of us ended up being the same again. The ones that had money slowly spent it and ended up like the rest of us. We did not have a job and we did not know what to do… I was fortunate because my wife got a job outside. Life was not easy by that time…
>
> (Roberto Morales interview December 05, 2015)

People in Yorkin responded to the impact of fungus in three ways: first by trying to control its spread, second by migrating in search of new livelihood opportunities, and third by reengaging with the livelihood strategies from the first SES. The initial reaction was to save their cacao trees. People remember cutting infected pods and burying them. Farmers also cut cacao shade trees because they had heard that the fungus would die in open, sunny areas. When this strategy failed, they sold livestock to support themselves and their families. However, when it was clear that the cacao trees were not recovering, and they had no more livestock to sell, most cacao producers abandoned their farms and migrated in search of new sources of income. For example, many men from the community worked for Refinadora Costarricense de Petróleo (RECOPE) as unskilled workers. Yorkin women worked as domestic employees in San Jose, the capital of Costa Rica, or in towns closer to Yorkin. By 1983, many of the people who had migrated out had returned to Yorkin, but their cacao farms were still infected.

Changes in the Use of the Biodiversity Richness

Residents who returned to Yorkin between 1983 and 1985 began to revive livelihood activities last used during the first SES (1935–1955). Interviewees recall this revitalization entailing fishing, hunting, raising pigs, and producing adlay and rice for household consumption. For cash, a new commercial crop was adopted: the plantain. However, plantain cultivation, carried out on the shores of rivers and creeks, did not last long as the land quickly eroded, and it proved too expensive for the farmers to buy the needed agrochemical supplies. Interviewees reported the following uses for plant and animal diversity after when they returned to the community after the impact of the monilia: food (N = 41), commercial (N = 2), and construction (N = 2) (Fig. 2.3). The use of biodiversity changed again, as new actors, arrived into the area and new policies were implemented.

Social-Ecological System 4: The Conservation and Development Narratives (1985–2016)

> Well, we have three goals since the beginning [of the organization] that guide our work. One is to take care of biodiversity ... another is to rescue the culture, and the last one is to strengthen the economy of Yorkin. Interviewer: And how do you take care of biodiversity? Response: Well, most members of our group have a piece of mountain. Then, the idea is that the people in the community work here [in tourism activities] and stop destroying the forest... (Deysi Peterson interview July 26, 2016).

In the early 1990s, Yorkin residents' use of biodiversity shifted again. This happened partially in response to conservation and development ideas promoted mainly by two associations: La Asociación de Nuevos Alquimistas (ANAI) and Fundación Wilombe. Residents in Yorkin believe that these associations arrived because they wanted to help Talamanca to recover from the monilia epidemic and, at the same time, to do business on the basis of the biological richness found in the area. ANAI's and Wilombe's co-founders told us that their goal was to support the economic and environmental development of the area. Their projects promoted the biological diversification of cacao farms, the introduction of cacao hybrids, the production of organic cacao and bananas, and the establishment of ecotourism projects (Figure 2.5).

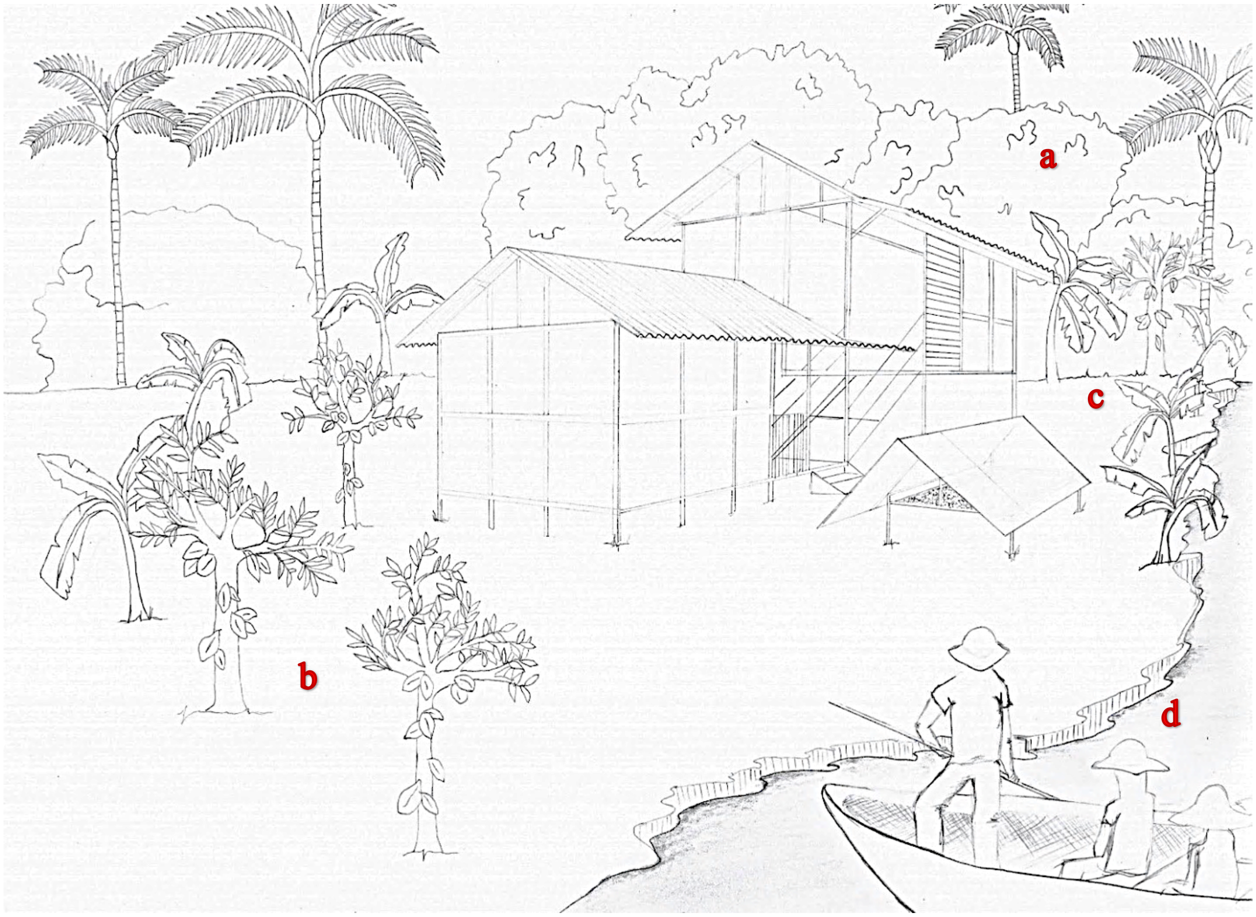

Figure 2.5 Graphic representation of Social Ecological System 4 (**a**) forestry area; (**b**) home garden; (**c**) plantain farm; (**d**) Yorkin river (Image credit: Mariana Rodríguez and Jennifer Bergen).

Responses to the Conservation and Development Narratives Promoted in the Area

> We were the ones that started bringing tourists here, but the neighbors did not agree with us. I remember that in one of the meetings our neighbors told us they were afraid of tourists bringing drugs to our community, they were also afraid that tourists will be

> naked in our rivers… I told them that that would not happen and only few of us started with the project.
>
> (Otilia Torres, interview November 24, 2015)

Initially, people in Yorkin were resistant to the diverse projects the associations implemented in the area. However, in time most people accepted the new conservation and development ideas and incorporated them into their daily lives. The ecotourism initiative provides a clear example. At first, Yorkin residents resisted the idea of bringing tourists into the community because they thought it would cause many problems. However, after several rounds of negotiations, ecotourism became an accepted activity. Its acceptance was consolidated in 2008 after the community was affected by a flood, and tourism organizers/workers quickly reconstituted damaged infrastructure thanks to their networks with outsiders. Yorkin residents who decided not to participate, or were excluded, from ecotourism activities became engaged in the commercial production of bananas.

Changes in the Use of the Biodiversity Richness in Yorkin

Conservation narratives first introduced to Yorkin in the mid-1990s have had some impacts on local uses of biodiversity richness (Fig. 2.5). The swidden have been reduced in response to the idea of "conserving lands" by avoiding swidden production systems. Further, the purchase of grains outside the community (e.g., the commercial town of Changuinola in Panama) proved cheaper. Patio/home gardens have been enriched with diverse plant species donated by NGO projects in recent years. At the time of this research (2016), it was common to find exotic fruits in home gardens, such as passion fruit (*Passiflora edulis*), rambutan (*Nephelium lappaceum*), and arazá (*Eugenia stipitata*). The cacao germplasm currently grown in Yorkin comes from the hybrid and grafted materials introduced to Talamanca by associations, NGOs and research institutes, and the trees are mused as an attraction for the tourists visiting the community. The production of chickens in the home gardens of Yorkin is common. Eggs and chicken meat are mainly used for household consumption and are occasionally prepared for tourists. Raising pigs for household consumption is less common; this is related to religious affiliations to some degree (e.g., Adventists prohibit the consumption of pork), as well as people's preference to avoid potential conflicts with their neighbors (e.g., free range pigs can cause damage in the home gardens of the community). Fishing and hunting are practiced, but apparently not as commonly as before. Instead of hunting, the primary forestry areas are mainly used for ecotours (e.g., walks in the forest, bird watching activities). Some young people express a lack of interest in hunting as they believe it is not an ethical activity (Rodríguez field notes May 5, 2017).

Species used for construction have also changed somewhat. Houses designed and made by local people are similar in design and materials to the houses built in SES 2. However, accessing the timber to build these houses has become complicated. People need to locate the preferred trees in the mountains and then get permission from local authorities to harvest them, following the passage of the Decreto Ejecutivo No. 27800, enforced by the Costa Rican government since 1999 with the intention of protecting the environment. Houses donated by the Costa Rican government have different designs and use tree species that are not necessarily harvested locally. Houses built to host tourists are made with the plant species that come from the forest areas surrounding the communities and their design is like the houses of SES 1.

People in Yorkin are producing and harvesting several plant species for commercial purposes. The production of banana started in the early 1990s when Fundación Wilombe supported the Bribri by organizing a cooperative to market their bananas. Initially, farmers intercropped banana plants with cacao, but as demand increased, new areas for the exclusive production of banana were opened up. In some cases, cacao farms were replaced by banana plantations. The production of cacao remains low, but people are still selling their seeds/chocolate to a cooperative in Talamanca, and to the tourists visiting the community. Plantain has recently become very profitable, and as prices increase, people have begun to grow this crop in new areas called fincas de plátano.

Finally, tourist souvenirs are made with the seeds harvested in the forestry areas and the patios of the community (e.g., *Cydista sp., Erythrina lanceolata*). Between 1985 and 2016, the people of Yorkin used the biological richness found in the area, as well as that brought by outsiders, to respond to the arrival of tourists and to satisfy the banana demand. According to transect walks, the following uses for plant and animal diversity were found in Yorkin: food (N = 27), commercial (N = 7), and construction purposes (N= 7) (Figure 2.3).

DISCUSSION

We have described how the Bribri people of Yorkin have adapted the uses of biodiversity for trade, food, and shelter/construction through four cycles over an 80-year period. Contrary to the conventional narrative of biodiversity as a history of constant decline (Davidson-Hunt et al. 2016), we found that the use of biodiversity richness is dynamic. In a given area, the use of biodiversity richness at a certain point in time is a subset of those biological species available locally or from other areas (Folke et al. 2003; Nazarea 2006). Thus, resources used at any one point in time are constantly changing and may only be a subset of the resources potentially available. Snapshots in time can be misleading in terms of apparent biodiversity loss. Resource use is often tied to political, economic, and cultural factors, and resources can return in historic time (Winter 2012).

In the Yorkin case, the use of biodiversity resources for trade, food, and shelter stabilizes at points in time, but patterns of biodiversity use reconfigure as some items are set aside, new ones brought in, and some uses are intensified, leading to the emergence of a new SES that once again stabilizes for a period. In the case of food, there was an intensification in the use of edible species after the abandonment of the UFCO (SES1) and the spread of the monilia fungus on the cacao farms (SES3), contributing to Bribri food security in times of uncertainty. The number of species used for construction also show a dynamic over time. These species increased in SES 2, decreased in SES3, and increased again in SES 4 (Figure 2.2). The use of species for construction purposes has been tied to political (e.g., access to species located in forestry areas), economic (e.g., access to technology), and cultural factors (e.g., preferred species to build houses). Finally, the number of species used for commercial purposes, rather than showing a decline over time, have increased in recent years. The development of touristic activities has contributed to an increase in the number of species used for commercial purposes in the last SES. Similar patterns of resource use, with successive cycles, have also been observed elsewhere (Seixas and Berkes 2003). Such reconfigurations rely heavily on peoples' ecological knowledge (Berkes 2013).

The dynamic use of biodiversity richness in Yorkin also suggests that the Bribri people are actively using their ecological knowledge to negotiate the causes of environmental change, as well as their worldview to explain the behaviors and norms that have the potential to influence change (Nazarea 2006). From a Bribri perspective, the impact of some disruptors (drivers) is not necessarily the consequence of physical laws, but the consequence of respecting (or not) appropriate cultural behaviors, principles, values, and local authorities. For example, the withdrawal of UFCO from Talamanca, according to the Bribri, was due to the role of their spiritual guide, Useköl, in helping them recover their lands. The lack of respect for Bribri values, such as the commodification of a sacred plant (cacao), led to social sanctions, such as the devastating impact of the monilia fungus on the cacao farms. The narratives offered by the participants in this research emphasize the active role that the Bribri play in understanding and influencing the dynamics of their environment.

The impact of the conservation and development discourses in Yorkin is still under negotiations that are the result of community debates. In this research, we identified two contrasting ideas. There is a perspective that the acceptance of the conservation and development narratives brought to them by outsiders can lead to a successful life. On the other hand, another perspective suggests that responses should be rooted in Bribri customs and their own efforts. This latter does not preclude ideas from the outside, but such ideas should be considered by the Bribri, and their choice in their use (or not) as part of a response should be determined by Bribri.

While much attention is given to the singularity of disruptions, Bribri colleagues paint a more complicated canvas of change. The disruptors impacting the use of biodiversity richness in Yorkin are a combination of environmental (e.g., pest outbreaks, floods), social (e.g., development projects), and economic changes (e.g., market demands), at different temporal and spatial scales (Dahlquist et al. 2007). Some of these changes/drivers, such as global market demands, originate in distant regions (Carrasco et al. 2017).

The responses to the disruptors affecting the Bribri of Yorkin tend to be absorptive (coping) in the short term, and/or require adaptations in the medium and long-term (Béné et al. 2014). These changes have not required a transformation of the SES at Yorkin from a mixed subsistence and commercial agriculture and rural biodiversity use into something completely different (Gunderson and Holling 2002; Berkes et al. 2003). Rather, they have involved reconfigurations of biodiversity use over four cycles; that is why they can be depicted as four different configurations of basically the same SES. The Bribri people of Yorkin responded over the last 80 years to global drivers of change by reconfiguring their use of biodiversity to support contemporary livelihoods. Therefore, we argue that the use of biodiversity by Indigenous Peoples is often a cyclical process, not a declining and eroding one, as it is usually framed.

CONCLUSION

This research focused on the dynamic relationship between a Bribri community and their utilization of the biodiversity of their territory. To be more specific, we draw upon Bribri narratives to understand the main disruptors that have changed their uses of biodiversity over the last 80 years, their responses to the disruptors identified, and the adaptations in their uses of local biodiversity richness. The narratives expressed by our interviewees represent a unique view of the environmental dynamics in their community. These collective notions are embedded in specific cultural systems (Miller and Davidson 2013) and in political practices (Nazarea 2006). Paying attention to the local narratives of environmental change and biodiversity management acknowledges Yorkin residents' trajectories of social construction of reality (McIntosh 2000). This study illuminated our understanding of how people respond to global drivers of change. These responses tend to be absorptive in the short term and adaptive in the medium and long term (Béné et al. 2014). The Bribri of Yorkin have drawn upon their knowledge to resist, adopt, and sustain elements of biodiversity and through their response reconfigure their SES as they seek livelihoods to meet their needs and create meaningful futures.

The use of biodiversity for commercial, construction, and food purposes in the Bribri community of Yorkin is not a constant declining process. Resilience thinking shifts our attention from biodiversity richness utilized at a point in time to one in which biodiversity acts as a reservoir of adaptive possibilities for rural and remote Indigenous communities as they respond to disruptions from globalized change and act creatively within dynamic local environments. The diversity of local and external landscape patches and species has provided the Bribri with the potential of re-organization after the impact of diverse disruptors over the last 80 years.

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INTERCONNECTIONS AMONG CHAPTERS

Chapter 3 illustrates how Bribri people drew upon social and ecological memory (SEM) to reorganize following the invasion of fungal pathogens in their commercial lands. This chapter expands my understanding of the complexity of Indigenous Peoples' use of biodiversity by illustrating how Bribri people access biodiversity, environmental management practices, and technologies (e.g., agrochemicals) to deal with change. My results suggest Indigenous Peoples' traditional practices, in addition to linkages with other sources of knowledge need to be nurtured to support resilience in agroforestry systems. The results of this chapter confirm and complement my discussion on the dynamic use of the biodiversity richness by Bribri people to deal with a dynamic environment (Chapter 2).

Figure 2.6 Theobroma cacao. Illustration: Connor Jandreau

CHAPTER 3 SOCIAL–ECOLOGICAL MEMORY AND RESPONSES TO BIODIVERSITY CHANGE IN A BRIBRI COMMUNITY OF COSTA RICA[2]

ABSTRACT

Social–ecological memory (SEM) is an analytical construct used to consider the ways by which people can draw upon biological materials and social memory to reorganize following a disturbance. Since its introduction into the literature, there have been few cases that have considered its use. We use qualitative methods to study Bribri people's commercial crops that have been invaded by different fungal pathogens and have undergone several disturbance recovery cycles. We show how the Bribri have used social memory and ecological memory together, dynamic interactions of legacies and reservoirs, and the role of mobile links for reorganization following the impact of fungal diseases. Insights from the Bribri indicate that protection of biodiversity, management practices, and adoption of new species and varieties are all crucial. The SEM concept extends the understanding of Indigenous knowledge, to include linkages to other peoples' memory and to landscapes as reservoirs of SEM. An understanding of how people use SEM to respond to disturbances is necessary as biodiversity changes are expected to become more pronounced in the future.

Keywords: Bribri Indigenous Peoples, Fungal pathogens, Resilience, Social–ecological memory

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INTRODUCTION

Changes in biodiversity, such as the invasion of fungal pathogens in tropical agricultural lands, are occurring at an ever-faster pace (Mace et al. 2005, IPBES 2019), as many drivers that result from globalization and environmental factors interact (Leichenko and O'Brien 2008). The study of agricultural biodiversity change is challenging in many ways. The invasions of fungal pathogens in tropical agricultural lands are complex, nonlinear, and multi-scalar and have the potential to lead to livelihood transformations (Zimmerer et al. 2015). Here we use resilience thinking (Gunderson and Holling 2002) and aim to understand how sources of resilience can be identified and nurtured (Folke et al. 2005). We deal with agricultural systems in our study area as complex social ecological systems—the integrated concept of humans in nature in which the social and ecological systems are in a two-way feedback relationship (Berkes and Folke 1998). We consider that the memory in these social–ecological systems enables change in response to perturbations (Folke et al. 2003) and define social–ecological memory (SEM) as the accumulated experiences and history of ecosystem management collectively held by a community in a social–ecological system (Barthel et al. 2010; Nykvist and Von Heland 2014).

In the Talamanca region of Costa Rica, multiple cycles of fungal pathogen invasions, such as Panama disease (*Fusarium oxysporum* Schlecht f. sp. cubense), Black Sigatoka (*Mycosphaerella fijiensis* M. Morelet), and Monilia (*Moniliophthora roreri* (Cif.), have affected banana (*Musa* sp.), plantain (*Musa* sp.), and cacao (*Theobroma cacao* L.) yields. They have also affected the livelihoods of the Bribri people who have traditionally relied on these crops to sustain their families (Borge and Villalobos 1994). While the commercialization of these crops provides monetary income to Bribri people, plantains, which are starchy and are typically cooked before eating, as well as bananas, are major staples for the Bribri diet. The cacao tree plays an important role in the Bribri worldview (Borge 2011). Little is known about the mechanisms of Bribri people's historical responses to biodiversity change resulting from the invasion of fungal pathogens in their commercial crops.

A better understanding of how Bribri people have historically responded to fungal pathogens in their commercial crops is necessary, as some of these changes are expected to become more pronounced in the future. For example, Witches Broom (*Crinipellis perniciosa* Stahel Aime & Phillips-Mora) and Panama disease Tropical Race four have the potential of affecting cacao (Meinhardt et al. 2008) and banana production in Costa Rica (Marquardt 2001). Here, we use the concept of SEM to analyze how the Bribri have dealt with multiple cycles of pathogen invasions and still retained the resilience of their commercial crops.

The Holling notion of resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Holling et al. 1995; Walker et al. 2004). Used in resilience thinking, SEM is considered crucial in providing the basic material and memory by which a social–ecological system reorganizes following a disturbance. SEM includes both ecological memory and social memory in the system and provides alternatives for re-organization after a disturbance or crisis (Folke et al. 2003). Indigenous knowledge (IK) or traditional ecological knowledge (Berkes 2018) is part of SEM.

The conceptual approach used in this research was based on the following considerations about SEM from Fig. 14.3 of Folke et al. (2003). First, we assumed that the ability of communities to rebuild after a disruption (or disturbance or crisis) is partly dependent on the use and management of the species richness available in a given area (Davidson-Hunt and Berkes 2010; Davidson-Hunt et al. 2016). Second, we examined the idea that locally available biodiversity richness is a function of biological and social legacies (species, knowledge, practice, institutions and beliefs/worldview that persist in the area despite the disruption). Third, we considered that the use of biodiversity in the area after the disruption is also a function of reservoirs, both of ecological and social memory. These are reservoirs of biodiversity from support areas, and knowledge/practice for resource use that are transmitted from one area to another.

Memories of other groups and landscapes can function as reservoirs of SEM (Turner et al. 2003; Crona and Bodin 2006).

Transmission of knowledge takes place by internal processes, such as the participation of individuals of a cultural group in activities and rituals, elders' teachings and stories (e.g., Turner et al. 2003). Transmission also takes place by external processes, such as linkages and exchanges of information through social networks (Barthel et al. 2010; Nykvist and Von Heland 2014). Legacies and reservoirs are connected by mobile links, agents that provide the connections. The dynamic interactions of legacies and reservoirs provide the potential for renewal and reorganization after being affected by changes in biodiversity.

More broadly, SEM is crucial for the resilience of the system, its ability to change and persist in the face of disturbance (Gunderson and Holling 2002). The relationship between resilience and SEM has received limited attention in the literature, considering its importance. Exceptions include Nazarea (2006), Barthel et al. (2010), Nykvist and Von Heland (2014), Wilson et al. (2017), and Kim et al. (2017).

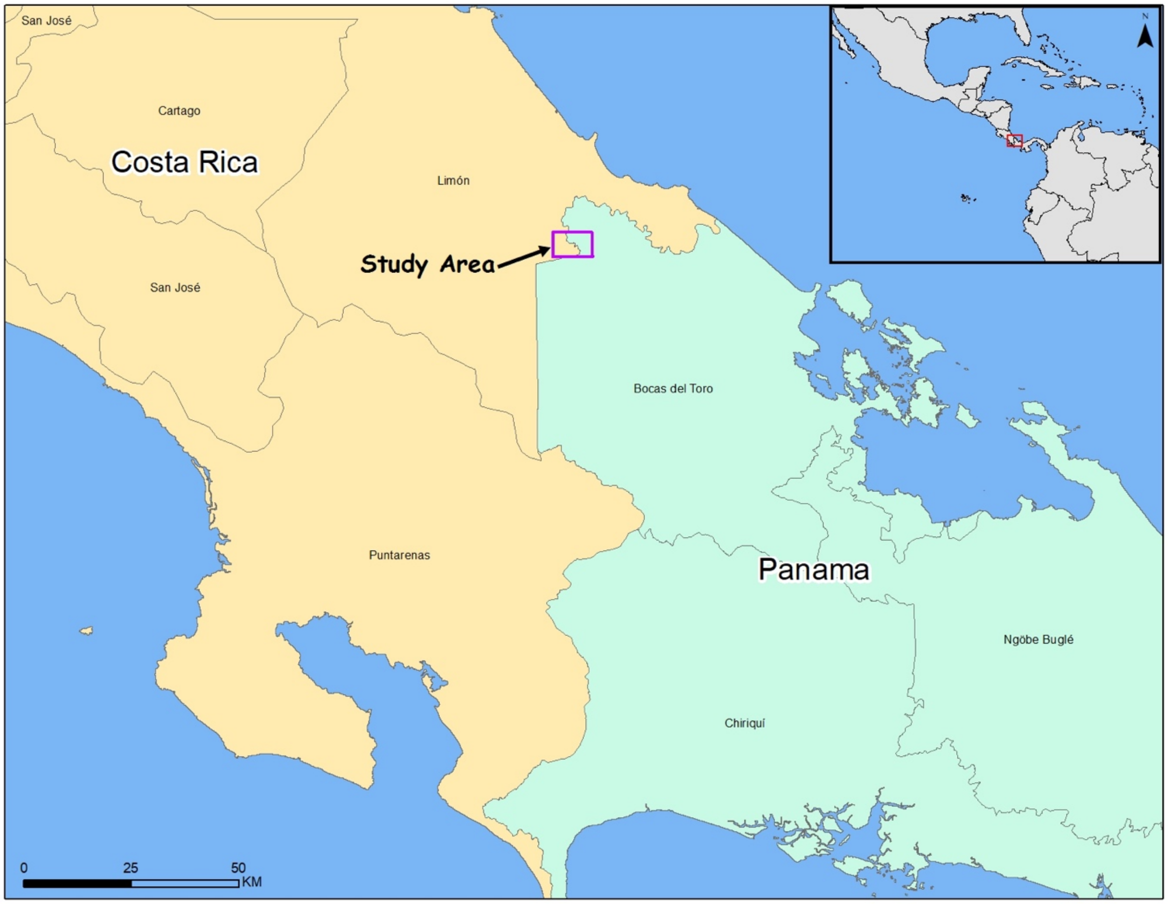
The primary objective of this article is to understand the role of SEM in peoples' responses to biodiversity change. Specifically, we consider how Bribri people in Yorkin have used their SEM to respond to the impact of invasive pathogens in their commercial crops. Seen through the SEM lens, we should expect that (1) the practices nurturing the SEM of a community will be a combination of internal processes (e.g., diversification, protection of biodiversity) and external processes (e.g., transmitted memory from other communities), and (2) the knowledge for the use of biodiversity is produced and reproduced through Bribri engagement with disruptions, and their actions in reconfiguring their commercial crops at different points in time. These processes suggest that SEM is not a static corpus of biological organisms, skill, practice, and values but something that is continuously constructed through the creativity and skill of people living within dynamic environments (Bateson 1972; Ingold 2000). At times, however, this is punctuated by significant events like new incursions of pathogens, leading people to draw upon both the legacies and reservoirs of biodiversity in their responses.

The next part of the article begins by providing a background on the study area and the research context. Next, we present the methods used in the 9 months of fieldwork in Yorkin. We then present the results of the fieldwork, where we focus on how people have drawn upon their SEM to respond to the impact of invasive pathogens in the three commercial crops that currently sustain the Bribri livelihoods, cacao, banana, and plantain. In the last section, we discuss the implications of our approach and findings for further inquiry into the role of SEM and biodiversity change.

RESEARCH CONTEXT AND METHODOLOGY

Our study area is located in the Talamanca Indigenous Reserve (TIR). The TIR is located in the Province of Limón in the southeastern region of Costa Rica (Figure 3.1). It has a tropical climate, with two short dry seasons per year and the average annual rainfall of 2370 mm (Instituto Meteorológico Nacional, IMN 2016). The TIR is one of 22 national indigenous reserves established in 1977 by the Costa Rican Government to protect the national native lands and cultures, including the Bribri (Borge and Villalobos 1994). The Bribri are the second largest indigenous group in Costa Rica with a population of nearly 8198 (Costa Rican Census 2011). Since pre-colonial times, the Bribri have had interactions with Indigenous Peoples from South America and North America (Stone 1961). The Bribri contact with these groups influenced the Bribri production system, religion, oral tradition, and mythology (Stone 1961). Bribri livelihoods have evolved in many ways in recent years. However, the production of cacao, banana, and plantain has been the primary source of income in the region in the last 50 years (Borge 2011).

The community of Yorkin is located in the transboundary area of Costa Rica and Panama (Figure 3.1). In 2016, the population of Yorkin was 232 people (Rodríguez field notes July 26, 2016). As well as in many places of Talamanca, the Bribri are traditional cacao–banana agroforesters, along with subsistence fishing, hunting, cultural tourism, and the commercial production of plantain.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Panama
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Figure 3.1 Approximate location of the study area.

The Yorkin landscape can be described as a mix of different land patches (Rodríguez and Davidson-Hunt 2018). In the floodplains, people produce plantain for their consumption and commercial purposes. In the foothills, people grow banana and cacao in agroforestry systems. Likewise, people produce rice, corn, and beans in swidden plots, harvest medicinal plants and hunt wildlife from the forestry areas that surround the community.

This research was undertaken with the consent of the Yorkin authorities “mesa de vecinos” and ethics approval from the Joint Faculty Research Ethics Board of the University of Manitoba (Protocol #J2015:093 HS 18831).

We used qualitative research approaches to draw upon the memory of participants to identify how people have responded to the invasion of pathogens in their commercial crops. This information was obtained by conducting participant observation, life history interviews, unstructured interviews, and transect walks (See the methods section of this dissertation for a detailed description of the methods and the participants engaged in this project). Participant observation (Bernard 2006) (September–December 2015 and March–August 2016), undertaken by Rodríguez Valencia, allowed her to generate trust relationships with the participants of this study by being part of the community’s daily life activities.

Participant observation activities also allowed her to understand the land use context and the primary management strategies used to prevent and control the pathogens affecting cacao, banana, and plantain farms. Unstructured interviews (Bernard 2006) were conducted with representatives of research institutes (N=1), development organizations (N=2), and government organizations (N=1). These interviews covered the goals and activities of the primary conservation and development projects applied in Yorkin in the last 30 years. Life history interviews (Brannen 2013) were applied to an equal number of male and female Yorkin residents (14 in total), with the intention of understanding the main changes in biodiversity in their farms, as well as people’s responses to the disruptions. Transect walks (De Leon and Cohen 2005) were conducted in the cacao, banana, and plantain farms of 11 households to document the biodiversity richness of their farms.

We used a qualitative approach because we were interested in having an in-depth understanding of the role of SEM as a source for re-organization following the outbreak of fungal pathogens in the Bribri farms (Creswell 2009). The information documented during the fieldwork was transcribed and coded by theme (e.g., biodiversity change events, farmers’ responses, memories about resources used in the past). The use of computer software, NVivo, supported qualitative analysis. We identified relevant patterns regarding changes in biodiversity, such as the invasion of crop pathogens, as well as the responses to mitigate and control them. To validate the interpretation of the findings, Rodríguez conducted verification sessions in May 2017.

RESULTS

The cacao case

> … And my dad taught me because I was a kid, he helped me to take care of his cacao farm… he taught me how to prune and to weed the cacao trees, all of that he taught me. It is an education I learned on my parent’s farm. Then there was a project that started with the establishment of some nurseries, and we decided to grow hybrid cacao trees… Later on, ANAI (development organization) came and gave us a technique of how to prune, to check the shape of the tree, the orientation of the branches, and I went somewhere else to study. They trained us on how to manage the farms, new ways and different types of pruning… APPTA (cacao cooperative in Talamanca) offered me many workshops, and I learned not only about my farm but also about how to work with the people of my community. I also saw how the cacao was managed, the importance of the organic cacao production. Then we got the organic certification. I learned about the quality of the cacao. (Longino Celles interview July 13, 2016)

The Bribri people have produced and harvested cacao since time immemorial (Borge 2011). Before 1950, Bribri people mainly used the cacao for subsistence, medicinal, and ritual purposes (Borge 2011). People in Yorkin remember producing this crop for commercial purposes around1950 as the Costa Rican Government built a road that connected Yorkin to other towns, and there were several intermediaries in the area buying this crop (Rodríguez and Davidson-Hunt 2018). The production of cacao became the primary livelihood activity for Yorkin families in 1960–1979.

In 1979, the cacao industry shrunk as the cacao farms in Costa Rica were hit by *M. roreri*. This is a fungal pathogen that causes frosty pod rot, or monilia, in several species of the genus Theobroma and Herrania (Phillips-Mora 2003). This disease had been confined to South America until 1950. However, it caused an outbreak in Costa Rica in 1979 because of human-mediated dispersion (Phillips-Mora 2003). The prevention and control of monilia are complicated because the pathogen survives under different environmental conditions, has rapid dispersal, and affects several cacao commercial genotypes (Phillips-Mora and Wilkinson 2007).

After the impact of monilia, Bribri people remember using several immediate strategies to get rid of the pathogen (Rodríguez and Davidson-Hunt 2018). Some of the strategies included the removal of infected pods and the elimination of the trees that used to provide shade for the cacao (e.g., *Dipteryx oleifera*, *Virola koschnyi*). The farmers' objective was to promote an environment that would stop the spread of the pathogen. These actions were costly and labor-intensive, discouraging producers to continue growing cacao, encouraging people to search for alternative approaches.

One of the alternatives mentioned by the interviewees consisted of finding cacao trees resistant to monilia. This was done in two different ways. On the one hand, people requested the help of the Asociación de Nuevos Alquimistas (ANAI) to support them in finding cultivars that showed resistance (Rodríguez field notes June 26, 2016). On the other hand, people identified the trees that produced healthy pods in their farms, despite being affected by monilia, and protected them by controlling their shade, by weeding them, and pruning them. ANAI supported Yorkin farmers by buying hybrids from the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) and by distributing these in the community in the late 1990s. CATIE produced hybrids by placing the pollen of a parental stock on the stigma of a flower of a different cultivar (Young 2007), and people in Yorkin used these trees to start new farms or to substitute the cacao trees they identified as being nonresistant to monilia.

Yorkin farmers not only adopted the hybrid cacao varieties, but also adopted new management practices. For instance, some residents learned to graft and used this knowledge to control the incidence of the disease. Others mastered other techniques such as different pruning techniques (e.g., cutting back old trees and removal of suckers), weeding, and the control of excessive shade.

Currently, people categorize the cacao trees in their farms as criollos, hybrids, and “injertos” (cloned germplasm) (Figure xx). The criollo trees are the ones that were grown by the Bribri people during the cacao boom (1955–1979). These trees are appreciated in Yorkin for the amount of butter in their seeds. The hybrid trees are the ones that ANAI distributed in Talamanca during the 1990s and are noted for their productivity. The injertos are the latest cacao trees adopted in the area. The injerto cacaos were the result of a research program conducted by the CATIE whose objective was to select productive cacao clones resistant to monilia (Phillips-Mora et al. 2012). These trees are noted as they mature and produce fruit in a very short period (ca. 2 years). Although the seeds of all the trees are mixed and sold to intermediaries, people prefer to harvest the seeds of the criollo variety to extract its butter which is used by the Bribri for medicinal and ritual purposes (Rodríguez fieldnotes July 14, 2016).

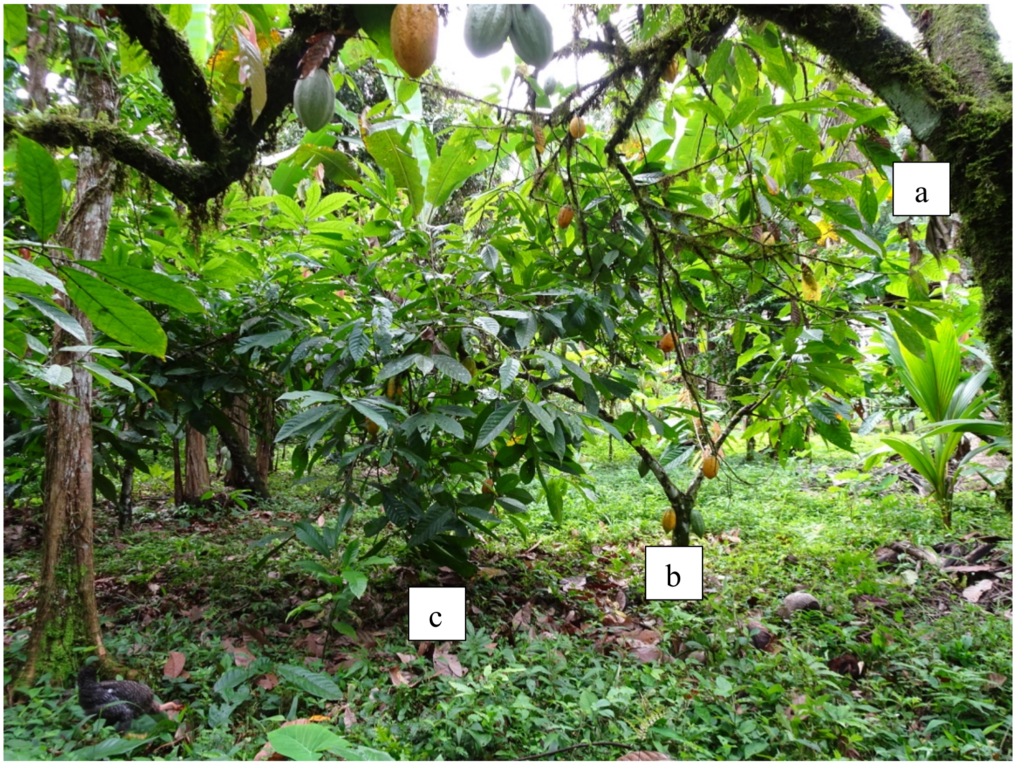


Figure 3.2 Types of cacao trees identified by Bribri people (a) criollo; (b) hybrids; (c) injertos (clones)

Bribri knowledge of criollo seeds, cultural practices to control the incidence of the monilia (e.g., removal of infected pods), as well as the adoption of new cacao germplasm and new management strategies, have allowed Yorkin farmers to continue producing cacao after the impact of the monilia (Table 3.1). The yields might not be as high as they used to be during the cacao boom, but cacao still sustains a part of their livelihoods. For example, an interviewee remembers harvesting 30–60 sacs (1 sac= 40 kg) of raw cacao in a 2 ha. farm before the monilia arrived into the area. Currently, he harvests between 2 and 8 sacs from the same area. In 2015, the income received by the producers was US$ 0.66 per kg of raw cacao (Rodríguez field notes June 05, 2016).

According to the circumstances, the area designated to grow cacao has varied over the years, increasing in some periods while declining in others. Cacao farms have been as large as 14 ha in periods without pests (1935–1979) and as small as half a hectare when the incidence of pests has not been manageable (1979–1985). In the latter case, people grew other commercial crops, such as banana and plantain, to substitute for the lost income.

Table 3.1 Cacao management practices

Spanish and folk name	Number of households with cacao germplasm in 2016 (*N*=11)	Uses	Local management practices utilized for the three types of cacao germplasm
Criollo	9	Commercial, subsistence, medicinal and ritual	Control of shade. Weeding and pruning practices. Removal of infected pods. Selection of trees resistant to monilia by observation and by grafting resistant germplasm into old cacao trees
Hybrid	5	Commercial & subsistence	
Clones	7	Commercial & subsistence	

The banana and plantain case

> Well, there are many banana varieties. We have Gros Michel, Lacatan alto, congo -alto called Lacatan bajo-, chopo morado y chopo verde, primitivo, cocoquı´, and yurchumo. The Yurchumo variety is very similar to the chopo verde. Yurchumo is a Bribri word that in Spanish means banana from the river. We also have one that is very similar to congo, but it is not, and I got it from… well, I can't remember. But that information is not important; the point is that we have it here. We also have the cuadrado and filipita. The cuadrado is an ancient type of banana, and the filipita recently arrived into the community. There are many plantains too, but we don't have them all. We have the

> common one, the small one - one for patacones (fried banana)-. The newest one is producing very large plantains, and the fruits are heavy. I don't know how this plantain ended up in Yorkin. I believe one neighbor brought it from Las Delicias (Panama). There used to be a small dominico, but I haven't seen it in a long time. Conversation with Don Cirilo (Rodríguez field notes July 29, 2016)

In Talamanca, the Gros Michel banana variety has been produced since 1900 by corporate agricultural enterprises, as well as by small-scale farmers (Boza Villarreal 2014). Before 1920, the Chiriquí Land Company, a subsidiary of the United Fruit Company (UFCo), occupied the traditional lands of the Bribri Indigenous Peoples to produce bananas in monoculture plantations to export them to several countries in North America and Europe (Marquardt 2001).

In 1916, the UFCo realized that their Gros Michel plantations were affected by the Panama disease (Mal de Panama in Spanish) (Marquardt 2001). The origin of the pathogen is unknown but widely believed to be from Central America. It quickly spread to other countries because of the substantial movement of workers and tools throughout the UFCo operations (Marquardt 2001).

The UFCo tried controlling the Panama disease by using several management strategies. For example, it (1) invested in creating drainage infrastructure, (2) flooded infected soils, (3) changed the acidity of the soils, and (4) expanded its operations into forestry areas (Marquardt 2001). None of these were successful and the UFCo closed its operations in Talamanca in the late 1920s (Boza Villarreal 2014). Some of the Panamenian workers who lost their UFCo jobs decided to stay in the region, married Bribri women, and became commercial agroforesters.

During this reorganization, the livelihoods strategies of the Yorkin residents were a combination of the Bribri subsistence and the ex-UFCo workers' economic practices (Rodríguez and Davidson-Hunt 2018). According to the interviewees, the livelihoods of the Yorkin households relied on Bribri resource management such as hunting (*Mazama* *americana, Ramphastos sp., Tayassu tajacu*), fishing (*Joturus pichardi, Sicydium spp.*), harvesting (*Licania platypus, Phytolacca rivinoides*) local resources, and growing several types of bananas in agroforestry systems (Table 3.2). The livelihoods of the Yorkin households relied as well on the new residents' agricultural practices that consisted of growing different landraces of rice (*Oryza sativa* L.) in swidden plots. The consumption of rice, several types of bananas, plantains, and other plants became an essential part of the interviewee's livelihoods after the UFCo ceased its operations in Talamanca (Table 3.2).

In the early 1990s people started to produce plantains and bananas to compensate for reduced cacao income due to monilia. People decided to grow plantains because intermediaries from Nicaragua were buying the product. Also, the Wilombe Foundation supported Bribri farmers to create a cooperative to market two banana varieties, and new buyers arrived into the area. Since then, the Bribri people of Yorkin have produced plantain and two types of banana: Gros Michel and the banana Lacatan. The Lacatan banana is a variety resistant to Panama disease and was introduced to solve the problem of this pathogen (Marquardt 2001).

However, the Lacatan banana, as well as the plantain, are affected by the Black Sigatoka disease. The Black Sigatoka is a fungal disease caused by *M. fijiensis* M. Morelet. This disease was first reported in Fiji in 1963 and has spread in the last 55 years to several countries worldwide (e.g., Tahiti, Hawai'i, Bhutan). In Latin America, the fungus has been reported in Guatemala, Belize, Mexico, El Salvador, Nicaragua, Costa Rica, Panama, Colombia, Ecuador, Peru, and Bolivia (Arango-Isaza et al. 2016). It is believed that the movement of infected plants throughout banana farms, as well as the spread of spores by wind, disseminates the Black Sigatoka fungus (Mourichon et al. 1997).

Table 3.2 List of species used in Yorkin after the withdraw of the UFCO.

English names	Spanish names	Bribri names	Scientific names	Use	Presence in the community in 2016
Rice*	Arroz	-	*Oryza sativa* L.	Food	Yes
Banana	Banano	*Mát*	*Musa acuminata* Colla	Food	Yes
Bobo mullet	Bobo	*Namà ichö́k*	*Joturus pichardi* Poey	Food	Yes
Cocoa	Cacao	*Tsuru’*	*Theobroma cacao* L.	Food	Yes
Coffee*	Café	*Kápi*	*Coffea arabica* L.	Food and trade	Yes
Squash	Calabaza	*Mè*	*Cucurbita* sp.	Food	Yes
Shrimp	Camarón	*Só*	*Cryphiops* spp.	Food	Yes
Sugarcane*	Caña de azucar	*Páköl*	*Saccharum officinarum* L.	Food	Yes
Pig	Chancho	*Kö̀chi*	*Sus* sp.	Food and trade	Yes
Collard peccary	Chancho de monte	*Kásir*	*Tayassu tajacu* L.	Food	Yes
Nettle flower	Ortiga (flor)	*Sànalwö (para ortiga) y para flor: chi'*	*Urera baccifera* (L.) Gaudich. ex Wedd	Food	Yes, but the flower is not consumed
Beans	Frijol	*Átu*	*Phaseolus vulgaris* L.	Food	Yes
Hens	Gallinas	*Krò*	*Gallus* sp.	Food	Yes
Rubber tree	Hule	*Tsìni*	*Castilla elastica* Sessé ex Cerv	Food and trade	Yes, but it is not currently harvested
Corn	Maíz	*Ikuwö̀*	*Zea mays* L.	Food	Yes

English names	Spanish names	Bribri names	Scientific names	Use	Presence in the community in 2016
Central American Agouti	Ñeque	*Shulë̀*	*Dasyprocta punctate* Gray	Food	Yes, but it is not consumed
Peach palm	Pejibaye	*Dikó*	*Bactris gasipaes* Kunth	Food	Yes
-	Platanilla	*Ppő*	*Heliconia* sp.	Food	Yes
Plantain	Plátano	*Kalö́m*	*Musa acuminata* Colla	Food	Yes
Fiddleheads	Rabo de mono	*Shpö̀*	*Cyathea* sp.	Food	Yes
Atlantic grunt	Ronco	*Sichík*	*Pomadasys crocro* Cuvier	Food	Yes
-	Titi	*Nés*	*Sicydium* spp.	Food	Yes
Adlay	Trigo	-	*Coix lacryma-jobi* L.	Food	Yes
Toucan	Tucan	*Tsíö*	*Ramphastos* sp.	Food	Yes, but it is not consumed
Red Brocket	Cabro de monte	*Sülï mát*	*Mazama americana* Erxleben	Food	Yes
Cassava	Yuca	*Ali'*	*Manihot esculenta* Crantz	Food	Yes
-	Cabeza de mono	-	*Licania platypus* (Hemsl.) Fritsch	Food	Yes
Venezuela Pokeweed	Calalú	-	*Phytolacca rivinoides* Kunth & C.D. Bouché	Food and medicine	Yes

People responded to the impact of the Sigatoka fungus in diverse ways. In the case of the plantain, which is usually grown in monocultures along the shores of rivers and creeks, people have tried to control the disease by using two types of fungicide: propiconazole and difenoconazole (Polidoro et al. 2007). However, not all the farmers used them as they are relatively expensive. This is the main reason why people stopped growing plantains for commercial purposes in the 1990s. Other reasons mentioned by the interviewees included land erosion, lack of access to plantain buyers, and peoples' easy access to banana buyers.

The production of plantains started again around 2010 as new buyers from Panama arrived in the area. Yorkin residents like to grow plantain as the price is higher than the price for cacao beans or banana. Yet, the number of people engaged in the commercialization of plantain in the first semester of 2015 was approximately three times lower than the number of people selling bananas during the same period of time (Rodriguez field notes October 14, 2015).

In the banana case, buyers had suggested using compost and other techniques to control the fungal pathogen (Rodríguez field notes December 9, 2015). People in Yorkin have not adopted these practices; instead, they have opted to use their knowledge to manage the incidence of the Sigatoka disease. This included building drainage systems in each plot, cleaning their tools before and after they work in the plots, and starting new plots when the ones they are using are infected (Table 3.3). Intercropping bananas and cacao in the same area has also been a strategy to manage the pathogen and to supplement livelihoods (Figure 3.3). In the latter case, people not only keep the commercial varieties of bananas and plantains but also other customary cultivars that allow them to satisfy their household food needs (Figure 3.4) (Table 3.3).

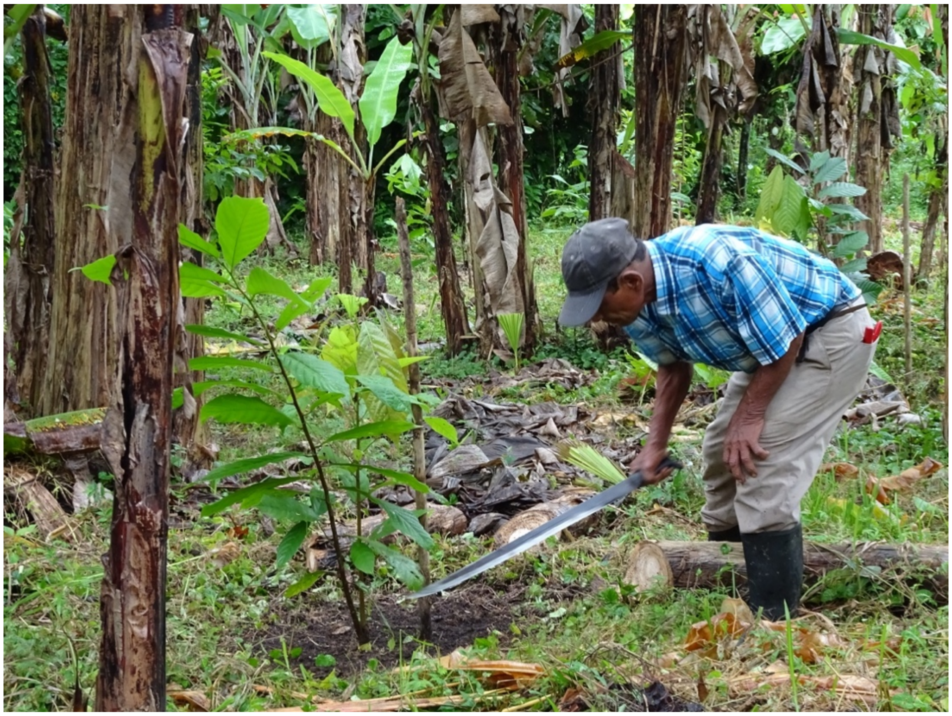


Figure 3.3 Local farmer intercropping cacao and banana in the same area.

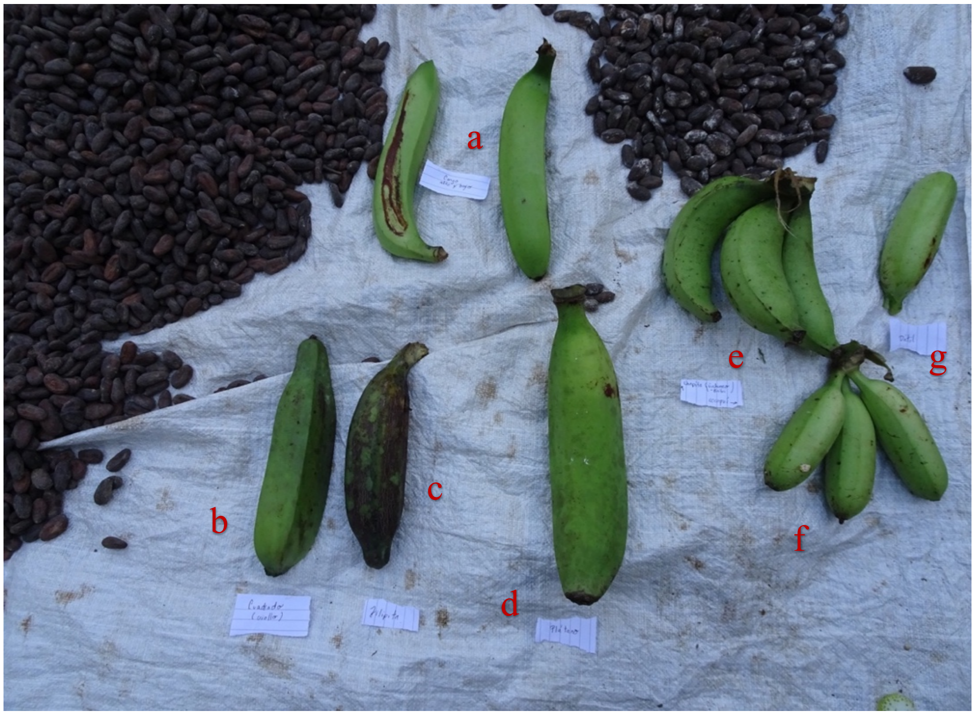

a
e
g
b
c
f
d
Cuadrado
Filipita
Plátano

Figure 3.4 Local names of *Musa* varieties (a) congo; (b) cuadrado; (c) filipita; (d) platano; (e) yurchumo; (f) cocoqui; (g) datil

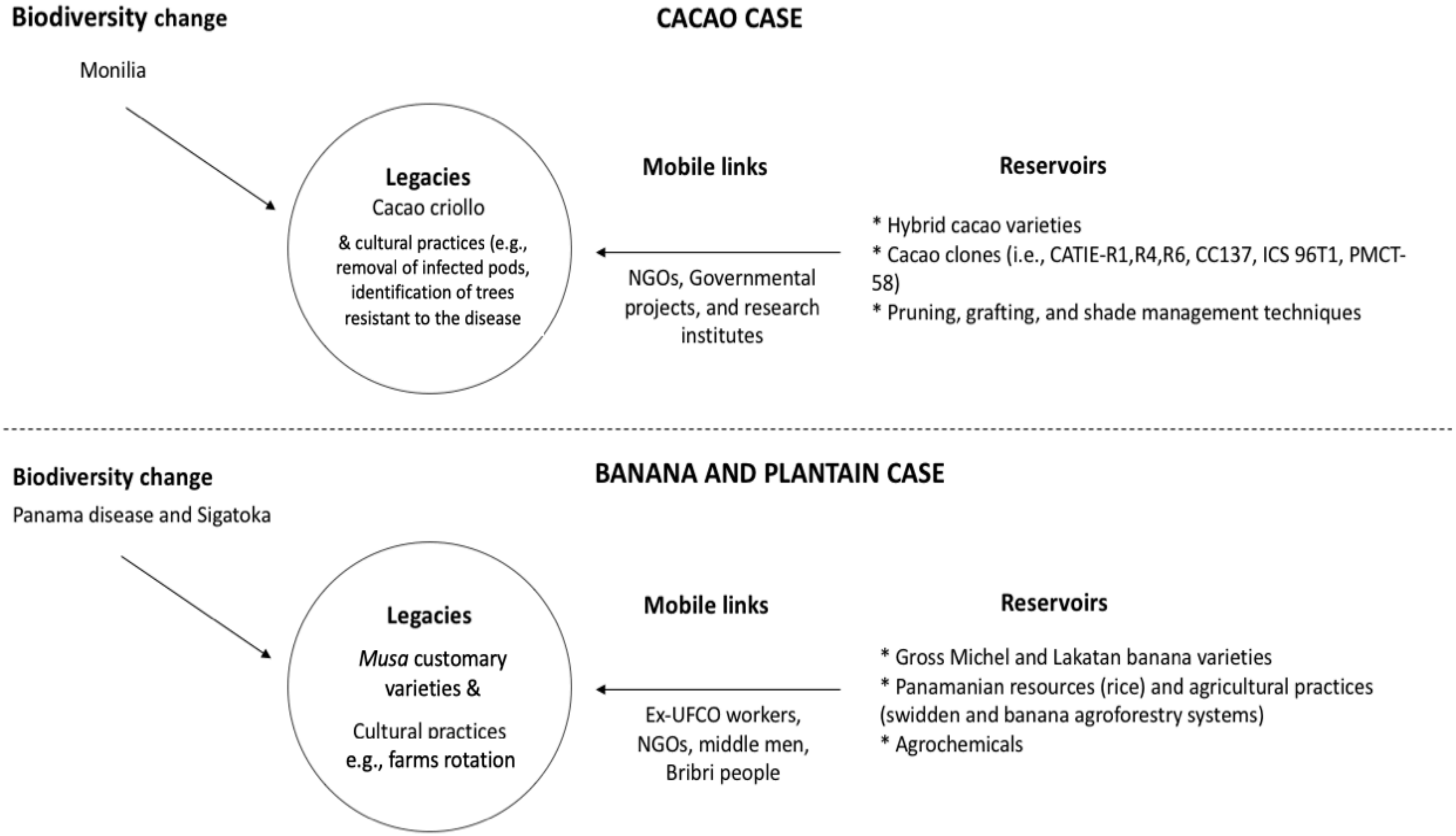
Table 3.3 Musa species management practices

Spanish and folk names	Bribri names	Number of households with varieties (N=11)	Uses	Management practices
Banano Chopo Morado	*Mát*	3	Subsistence. Consumed cooked (grilled)	For all banana varieties: Intercropping banana other plant species in the same area. Weeding & pruning practices (e.g., (removal of infected plants) Additionally, for commercial varieties: Disinfection of tools with chlorine Disinfection of shoots planted with limestone.
Banano Chopo Verde	*Mát*	4	Subsistence. Consumed cooked (boiled)	
Banano Cocoqui		3	Subsistence. Consumed cooked. It is used to make “picadillo.” Picadillo is a dish made with chopped vegetables mixed with banana.	
Banano Cuadrado	*Shòo*	8	Subsistence. Consumed cooked (boiled and fried). It can also be dried, grind, and used to prepare beverages.	
Banano Congo	*Chãmu*	4	Subsistence. Consumed cooked (boiled)	
Banano Manzano		1	Subsistence. Consumed fresh. It needs to be ripe.	
Banano Primitivo		7	Subsistence/Consumed cooked (boiled and fried)	
Banano Chirique		0	Subsistence/ consumed fresh and cooked, delicate flavour/some people consider it plantain, other people consider it banana.	
Banano Gros Michel	*Chamù*	11	Commercial and	

Spanish and folk names	Bribri names	Number of households with varieties (*N*=11)	Uses	Management practices
	Surùri		Subsistence/consumed raw	Construction of draining systems.
Banano Lacatan		11	Commercial and subsistence. Consumed fresh.	
Plantain Filipita		2	Subsistence/consumed cooked	For all plantain varieties: Weeding, pruning practices (e.g., (removal of infected plants) and shade control Additionally, for commercial varieties: Use of pesticides Crop rotation when the disease is not manageable
Plantain Tapona		1	Subsistence/ consumed cooked	
Plantain Azul/Morado		0	Subsistence/sweet and delicate flavour	
Plátano Dominico		1	Consumed cooked (boiled and grilled). It has a delicate flavour. It is used to feed the household´s animals (pigs, hens, turkeys)	
Plátano/Curaré		11	Commercial and subsistence/Consumed cooked (boiled and grilled). It is used to prepare beverages. Since it is a tall plant, some residents use it to provide shade to cacao trees. The fruits are used to feed the household´s animals (pigs, hens, turkeys)	

The Bribri of Yorkin keep growing non-commercial banana and plantain cultivars for several reasons. First, these plants require little care. Second, these cultivars produce large quantities of bananas that can be used to feed the hens and pigs raised by the households. Moreover, some cultivars produce fruits with a delicate and sweet flavor, making it an ideal fruit to complement the Bribri diet on a daily basis. Third, the leaves of non-commercial *Musas* are used to provide shade to cacao, to get fibers (e.g., *Musa textilis* is locally used to make ropes and string fibers), and as wrappers for cooking food. The use of cultural practices (e.g., use of drainage systems, plot rotation, conservation of customary banana and plantain cultivars) to manage the incidence of fungal pathogens in the banana farms has allowed Yorkin farmers to obtain organic certification, and to sell their products on the international market. In 2015, households in Yorkin were selling between 20 and 520 kg of banana biweekly (Rodriguez field notes October 14, 2015). In 2016, around 46 households were selling on average 10 000 kg of banana biweekly to two of the three main intermediaries buying banana in the community (Rodríguez field notes July 4, 2016). The income received in 2016 by the producers was US$ 0.11 per banana kg (Rodríguez field notes July 4, 2016) (Figure 3.2).

Figure 3.5 Summary of the social-ecological memory involved in the cacao case and banana and plantain case, indicating the reservoirs of SEM, the mobile links involved, and the legacies


Biodiversity change
Monilia
CACAO CASE
Legacies
Cacao criollo
& cultural practices (e.g., removal of infected pods, identification of trees resistant to the disease
Mobile links
NGOs, Governmental projects, and research institutes
Reservoirs
* Hybrid cacao varieties
* Cacao clones (i.e., CATIE-R1,R4,R6, CC137, ICS 96T1, PMCT-58)
* Pruning, grafting, and shade management techniques
Biodiversity change
Panama disease and Sigatoka
BANANA AND PLANTAIN CASE
Legacies
Musa customary varieties &
Cultural practices e.g., farms rotation
Mobile links
Ex-UFCO workers, NGOs, middle men, Bribri people
Reservoirs
* Gross Michel and Lakatan banana varieties
* Panamanian resources (rice) and agricultural practices (swidden and banana agroforestry systems)
* Agrochemicals

DISCUSSION

Focusing on cacao, banana, and plantain of the Bribri, and the impact of fungal pathogens on them, we find resilient agroforestry systems that change in a cyclic way and persist. Given the rapid change in biodiversity and the environment, and the ever-increasing pace of fungal pathogen invasions in tropical agricultural lands (Mace et al. 2005), it is important to identify and nurture sources of resilience that enable these systems to persist (Folke et al. 2005).

Using the resilience concept of SEM helps understand how the people react to changes: first by using their own knowledge, and second by learning from the outside, often through their social networks. The dynamic interactions of legacies and reservoirs that serve as a repository of choices have provided for the Bribri the potential for re-organization following the impact of fungal diseases on their crops. The continuous use of some crop varieties, such as the criollo ones and non-commercial ones, seems to be sustained, among other factors, by (1) the knowledge to produce these plants in agroforestry systems, (2) the knowledge to control the incidence of fungal pathogens (with cultural practices), and (3) the knowledge to transform these plants into food for the table (e.g., fried, grilled plantains, chocolate beverages) (Table 3.3), medicines (e.g., cacao butter) and food for animals (several types of bananas and plantains) (Table 3.3). The accumulated experience and history of ecosystem management collectively held by the community (Barthel et al. 2010), have allowed the Bribri to use their biocultural diversity to respond to a complex, unpredictable and variable environment.

Second, the Bribri have also responded to the changing environment by drawing on the "archived memory" of other communities. These responses have included:

(1) the adoption of new management practices (e.g., grafting) and new crop varieties (e.g., cacao hybrids and several types of banana and plantain, see Tables 3.1 and 3.3) to enrich their agroforestry systems through their networks with other Bribri groups, and non-Bribri people from other communities (e.g., Panama), as well as with associations/foundations, and research institutes;

(2) the adoption and substitution of new biological species for other plants with similar characteristics. Species that were not needed for cash income during certain periods (e.g., banana Gros Michel) became significant after the impact of disturbance such as the monilia, demonstrating the idea that particular species that seem ecologically unimportant may become important following a disturbance (Holling et al. 1995; Sylvester et al. 2016).

The use of biodiversity richness in Yorkin has been continuous but also flexible (Rodríguez and Davidson-Hunt 2018). As our data show, for example, the Bribri have relied on cacao, which diminished due to new pathogens but then when responses were found to those pathogens, they turned to cacao again. Likewise, with plantain. The use of some biological species varies over the years (Rodríguez and Davidson-Hunt 2018). The SEM associated with specific biological resources are not fixed in time but are emergent from the environment where people live and continuously make an agricultural livelihood for families and communities.

Measuring the use of a particular species at a point in time and comparing that to use in the past does not account for the possibility of future use from the legacies and reservoirs of biodiversity (Davidson-Hunt et al. 2016). Bribri knowledge is not a diminishing resource but one that is actively being produced over time (Rodríguez and Davidson-Hunt 2018). In this regard, the concept of SEM is silent on the agency of people in elaborating new knowledge, institutions, and relationships. The potential for using SEM in responding to environmental change should not just focus on what is being used at a given point in time. We should also pay attention to the access and availability that people have to their reservoirs of SEM transmitted across generations (e.g., Cristancho and Vining 2009; Calvet-Mir et al. 2015), as well as the reservoirs of knowledge of their neighbors (species and management knowledge shared through different mobile links: neighbors, associations/foundations, and networks in general) (Turner et al. 2003; Crona and Bodin 2006; Barthel et al. 2010), and the creativity of people to solve problems by accessing these legacies and reservoirs.

Use of biodiversity emerges through creative responses of people as they experience dynamic environments and pursue their livelihoods. By considering how the Bribri people of Yorkin have responded to biodiversity change, we find some loss (e.g., absence of some banana/plantain cultivars within the community, see Table 3.2) but also an active and intentional reconfiguration in the use of biodiversity.

CONCLUSION

Using resilience thinking and the concept of SEM, we have focused on how Bribri people draw upon their knowledge saved in their collective memory and external reservoirs (including networks) in their responses to pathogens in their commercial crops. Biodiversity is continuously changing, and new fungal pathogens in Bribri agroforestry systems appear from time to time and require creative responses. As people rely more and more on specific crops, as crop densities increase, and as the genetic variability of commercial crops decreases, agricultural systems become more susceptible to disease outbreaks, affecting livelihoods (Zimmerer 2010). It is important to keep in mind both the potential of SEM and the factors that may reduce its potential use over time as a source of creative responses to biodiversity change.

The study of Yorkin residents' SEM illuminates our understanding of how people respond to biodiversity change. Our results suggest that SEM is a dynamic process through which biological resources, and people's traditional knowledge, practices, values, and skills (legacies), and when needed their networks (to access reservoirs of outside knowledge), are creatively used to respond to an ever-changing environment. Yorkin responses to biodiversity change are nonlinear and complex, enabling them to stay resilient and not to abandon their farms. Resilience in this case includes people's capacity to resist, or to adapt, and/or to transform their social–ecological systems, depending on the circumstances (Been et al. 2014). Understanding people's responses to biodiversity change in a specific context is vital, as changes are expected to accelerate in the future (Mace et al. 2005).

Insights from SEM in Yorkin indicate that the protection of preferred species (criollo, non-commercial plants, and commercial plants), diversification processes (growing different banana, plantain, and cacao germplasm), and networks that provide access to new species and management practices, are all crucial. This approach has allowed Bribri people in Yorkin to respond to the impact of pathogens and sustain their livelihoods.

Use of the SEM concept extends the understanding of IK and allows us to consider how other peoples' memory and landscapes act as reservoirs of SEM, and how linkages (mobile links) allow biological materials and associated information from a reservoir to become part of IK and, through this process, become a legacy for future generations. Given potential future challenges from biodiversity change, more engagement is needed across literature studies considering knowledge and adaptation and the possible contribution that using an analytical framework like SEM can provide in supporting community responses.

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INTERCONNECTIONS AMONG CHAPTERS

Chapter 4 considers how Bribri people draw upon the capabilities of their biocultural heritage to meet contemporary livelihoods and lay the foundation for meaningful futures. This chapter expands my understanding of the complexity of Indigenous Peoples' use of biodiversity by illustrating how Bribri people strategized, planned, and found ways to move forward their ideas to design cacao value added products by recognizing that some products are not desirable, feasible or viable. My results support the idea that Bribri people are not just keepers, but also creators of knowledge. The results of this chapter confirm previous findings that recognize the relevance of; 1) access to biological richness (Chapter 2), 2) use of specialized place-based knowledge and placed-based practices (Chapter 2), and strategic alliances with key actors to gain access to sources of knowledge (Chapter 3) as key characteristics of people's responses to change. At the same time, the results of this chapter recognize the importance of inventiveness and attachment to plants of cultural importance to deal with a dynamic environment.

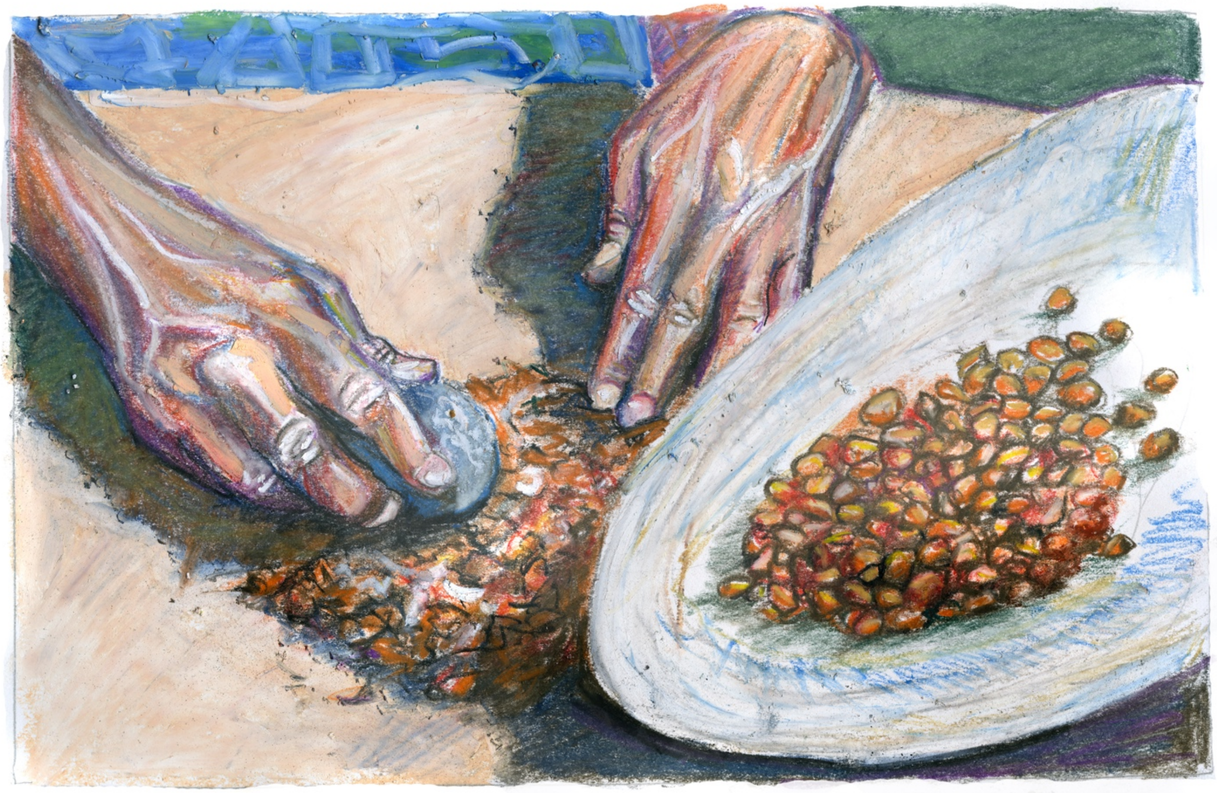

Figure 3.6 Shelling cacao seeds. Illustration: Connor Jandreau

CHAPTER 4 The practice of co-production through biocultural design, a case study among the Bribri People of Costa Rica and Panama[3]

ABSTRACT

Research in co-production has given rise to a rich scientific literature in sustainability science. The processes by which co-production occurs are not well documented. Here, I present my work with Bribri people to undertake a biocultural design project. Biocultural design is a process that begins with understanding participants' aspirations to support their livelihoods. The process is collaborative, imagining ideas and executing products and services by drawing upon the capabilities of the participant´s biocultural heritage. In the Bribri territory, the biocultural heritage associated with cacao agroforestry systems is considered significant for the Bribri livelihoods. Bribri people´s aspirations to grow cacao go beyond increasing cacao yields and include the respect for cultural teachings and social relationships. The participants of this project designed cacao value added products (e.g., cacao jam, cacao butter) and services (e.g., showcase farm) by identifying viable ways to execute their ideas. Biocultural design offers a guide to co-imagine and co-execute ideas to solve specific problems and contributes to the practice of co-production by offering an approach that recognizes the value of science, while respecting the knowledge, aspirations and values of other actors.

Keywords: Co-production, biocultural design, Bribri people, biocultural heritage, cacao agroforestry systems

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INTRODUCTION

In sustainability science, co-production refers to the interaction of different actors to solve specific problems (Miller and Wyborn 2018). Research on co-production has given rise to a rich literature focused on diagnosing problems with current scientific practice (Lemos et al. 2012; Hel S.V.D 2016), identifying conditions for co-producing knowledge (Schuttenberg and Guth 2015; Berkes 2017; Schneider et al. 2019) and developing approaches to co-produce knowledge (Armitage 2015). While the later approaches outline some guidelines on how to conduct collaborative research (e.g., reflexivity, developing trust relationships, inclusiveness), the actual processes by which these activities are undertaken is not well documented (Meadow et al. 2015). Given the ultimate goal of “creating a new sustainability science that is more inclusive and more attentive to the process of co-production” (Miller and Wyborn 2018 p. 5), It is important to examine the methods in which collaboration is conducted. For example, we should explore how actors are identified, the ways in which problems are framed, and how we measure the success of any collaborative project.

Biocultural design is an emergent approach for supporting self-determination and sustainable economic development in Indigenous communities. Biocultural design is an intentional and collaborative process in which people with different knowledge, skills, and experiences work together to design new products or services (Davidson Hunt et al. 2012). In like manner to the co-production literature, biocultural design emphasizes that the solution of specific problems, such as the identification of economic opportunities in indigenous communities, should be rooted in indigenous values, identities, and knowledge. Moreover, biocultural design offers an approach for co-generating ideas and co-executing prototypes by building upon the adaptive potential of the stakeholder’s biocultural heritage.

Biocultural heritage includes “the collective knowledge, practices, and innovations of indigenous or small-scale societies that have been passed down from generation to generation and that are linked to traditional resources and territories” (Swiderska 2006

p. 3). In the Bribri traditional lands located on the border of Costa Rica and Panama, cacao (*Theobroma cacao* L.) agroforestry systems are a type of managed and multi-strata ecosystem of significance for the creation, reproduction, and transmission of Bribri biocultural heritage (Posas 2013). Bribri biocultural heritage associated with cacao agroforestry systems have allowed Bribri people to satisfy part of their alimentary needs (Garcia Serrano and Del Monte 2004) and generate moderate-income in contexts of stability (Cerda et al. 2014) and change (Posas 2013; Rodríguez Valencia 2018).

Cacao agroforestry systems are also considered an important tool for biological conservation. Cacao agroforestry systems provide habitat for diverse species and are reservoirs of agrobiodiversity (Harver et al. 2006). Deheuvels et al. (2012), for example, documented similar values of alpha diversity for small mammals, reptiles, and litter macro-invertebrates in Bribri cacao agroforestry systems and surrounding patches of natural forest. Similarly, Rodriguez et al. (2019) documented four species of *Theobroma* and fifteen varieties of *Musa* in Bribri cacao agroforestry systems. Bribri cacao agroforestry systems are a reservoir of plant and animal diversity (Cerda et al. 2014; Rodríguez Valencia 2019).

Development and conservation initiatives have recognized the importance of cacao agroforestry systems for the protection of Bribri biocultural heritage and the conservation of biodiversity, leading to the implementation of external programs focused on increasing cacao yields. Despite these efforts, cacao agroforestry systems have spatially declined in Bribri territory as plantain monocultures gain prominence (Dahlquist et al. 2007) . The abandonment of cacao agroforestry systems has been attributed to the impact of crop diseases in the cacao farms (e.g., frosty pod), market fluxes, and Bribri people's aspiration to have access to a constant flow of cash throughout the year (Posas 2013; Dahlquist et al. 2007).

This research project applies the biocultural design framework to identify new livelihood opportunities by drawing upon the capabilities of cacao agroforestry systems. I opted to follow the principles of the biocultural design framework because it offers an approach for co-generating ideas and co-executing prototypes by building upon the adaptive potential of the stakeholder's biocultural heritage (Davidson Hunt et al. 2012). Moreover, biocultural design centers its attention on the inclusion of human needs and aspirations to solve problems (Kuzivanova and Davidson Hunt 2017), and it uses ideas from the capability approach to prioritize and expand on the resources of the people participating in a design project (Oosterlaken 2009).

In the next section, I present an overview of the study area where I implemented a biocultural design project. Then, I summarize the research methodology I used during the nine-months fieldwork in two Bribri communities. Subsequently, I present the results of the design journey through three phases: inspiration (documentation participant´s aspirations and identification of areas of opportunity for collaborations), ideation (generation of ideas to create cacao added value products/services), and implementation (execution of prototypes). I conclude this paper by discussing the implications of using biocultural design for promoting cacao agroforestry systems as a viable livelihood strategy for the Bribri. I also discuss the contributions of biocultural design to the theory and practice of co-production in sustainability science.

RESEARCH METHODOLOGY

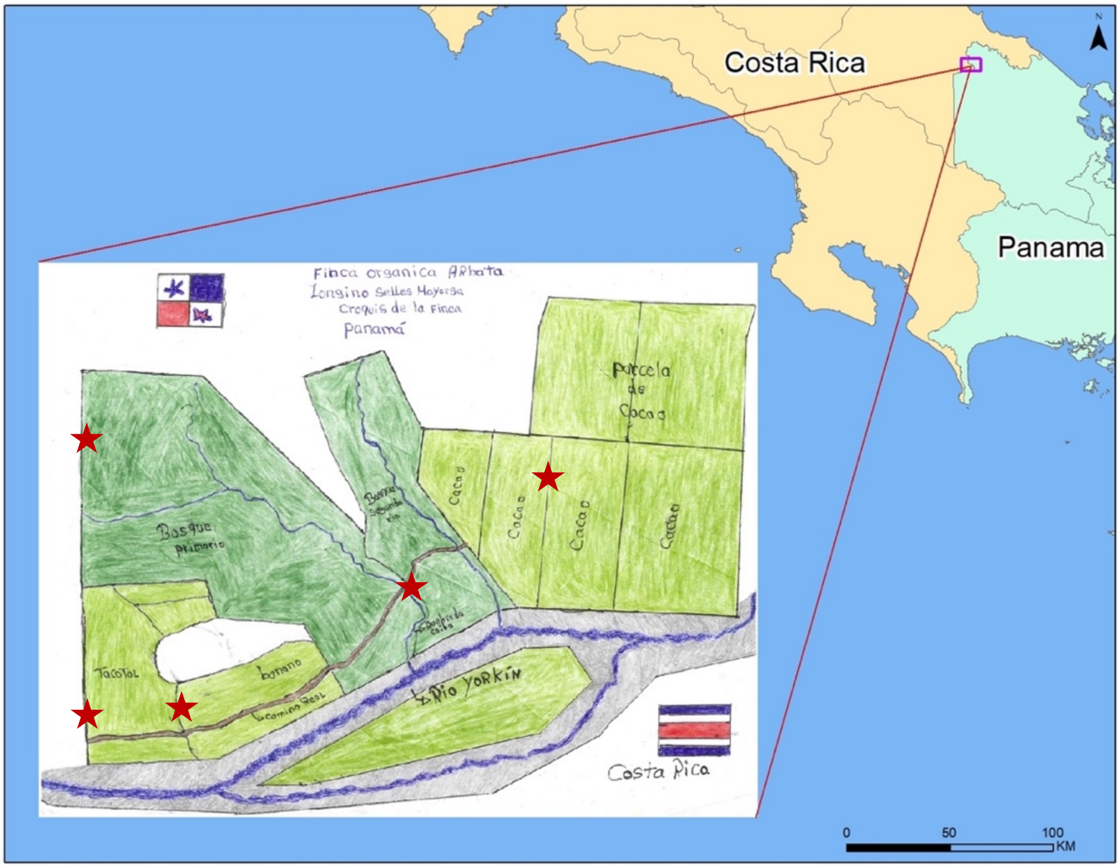
Study Site

The Bribri are an Indigenous People living in the southeastern border between Costa Rica and Panama. It is estimated that 7,772 Bribri live in the province of Limón, making them one of the most numerous Indigenous groups in Costa Rica (Costa Rican Census 2011) The Bribri practice agroforestry, which has persisted to date, despite the impact of several fungal diseases in their commercial lands (Rodríguez Valencia 2019).

I conducted this research in two Bribri communities located in the southeastern region of Costa Rica and the northeastern region of Panama (Figure 1.). Yorkin (population 232 in 2016) and Guabo (population 57 in 2006) are situated alongside the Yorkin River

(Rodriguez Valencia field notes July 26, 2016). Although cultural tourism has grown into an important sector over the last decades in both communities, the commercial production of cacao, banana, and plantain remain as an essential economic activity for most part of the community residents (Rodríguez and Davidson Hunt 2018).

Figure 4.1 Approximate location of Yorkin (Costa Rica) and Guabo (Panama). The red stars indicate the estimated location of the trees that will be showcased on the land of one of the participants of a biocultural design project. Map elaborated by Longino Celles.


Costa Rica
Panama
N
Finca organica ARbata
Longino Selles Mayorga
Croquis de la Finca
Panamá
Parcela de Cacao
Cacao
Cacao
Cacao
Cacao
Bosque Segundario
Bosque primorio
Quebrada Ceiba
Tacotal
banano
Camino Real
Rio Yorkin
Costa Rica
0
50
100
KM

In August 2014, I consulted representatives of five Bribri communities to explain the general purpose of my doctoral research; to understand how Bribri people use the biodiversity richness of their territory in making choices to respond to a dynamic environment. I conducted this research in the communities of Yorkin and Guabo because community representatives expressed their interest in being engaged in projects that will allow them to “revalorize their culture and conserve their natural resources” (Rodríguez Valencia field notes August 6, 2014). This research was undertaken with the authorization of the Bribri local authority *Asociación de Desarrollo Integral del Territorio Indígena Bribri* (Development Association of the Indigenous Territory Bribri, Costa Rica) and obtained ethics approval from the Joint Faculty Research Ethics Board of the University of Manitoba (Protocol #J2015:093 HS 18831).

I started the field component of my research in September 2015. During the first three months of my fieldwork, I used the snowball technique to identify community members knowledgeable in the production of cacao. I identified 23 community residents knowledgeable in the production of cacao and I had informal conversations with them to document their interest of being engaged, or not, in designing cacao products and services. I did this because I believed biocultural design would allow me to fulfill my research purpose while respecting the principle of self-determination (UN 2000) . While often researchers only report on those who chose to be involved in a research project, keeping with the principle of self-determination it should be noted that:

- The majority of people I talked to were not interested in designing cacao products and services (N=14).
- Some community members were not part of this project because they were busy with other activities (e.g., working on their banana/plantain farms) (N=8),
- A couple of people expected me to teach them “something new” (N=2)
- Other community members were interested in different type of projects (e.g., people wanted to be part of projects unrelated to the production of cacao) (N=4).

Nine community members chose to be engaged in the biocultural design project. These community members are recognized by their neighbors as knowledgeable and passionate about the production of cacao; “To be honest, she (one of the main participants) is one of the most knowledgeable women about cacao in this community” (Rodriguez Valencia field notes September 20, 2015). Five members of the Morales family (three elders and two young people) and four members of the Celles family (two elders and two young people) were part of this project. The Morales family and I commenced working on the design project when they taught me how to make cacao jam and we talked about the possibility of using this idea to create a cacao value-added product. The Celles family and I commenced working on the design project when one of the family members requested my help to design a showcase farm. After this, the participants and I refined the original ideas and imagined other ways to generate alternative income by drawing upon the capabilities of their cacao agroforestry systems. We examined each one of the ideas generated through the lens of desirability (what makes sense to people), feasibility (what is functionally possible), and viability (what is likely to become part of a business model congruent with the Bribri knowledge and values) (Brown 2009).

I used case study research approach to explore in depth the process of co-designing cacao value added products and services with the participants of this project. I collected detailed information about the biocultural design process by using three data collection procedures over a period of nine months: participant observation, un-structured interviews, and participation. Participant observation was undertaken from September-December 2015 to document local cacao production practices involving mainly the transformation, and commercialization of the cacao beans. During this period, I conducted un-structured interviews with the participants of this project to understand the local struggles to commercialise cacao, and the reasons for continuing growing cacao or wanting to re-connect with the practice. From April-August 2016, the participants and I executed some prototypes and reflected about the benefits of designing new cacao value added products.

I documented the design process in my field notes. I transcribed and coded my field notes using key terms such as “inspiration phase,” “ideation phase,” “implementation phase,” “values,” “aspirations,” “knowledge,” etc. The use of qualitative software NVivo facilitated the analysis of qualitative data. To check the validity of my interpretations, I held verification sessions with the participants in August 2016.

RESULTS

Inspiration phase

During my participant observation activities, Bribri colleagues taught me the everyday routines of harvesting, selling, and consuming cacao. In the Bribri territory, cacao is principally harvested from December to January and from June-August (Deheuvels et al. 2014). To harvest cacao, it is necessary to cut the mature pods with a machete. Then, the pods are collected in baskets and dumped in piles, where the cacao seeds are removed after the pods are cracked. The majority of the scooped seeds (known as wet beans) are sold to a local cooperative, who sells them to the international market as a high-quality input to make chocolate bars. The rest of the seeds are locally transformed into cacao mass.

Transforming cacao seeds into cacao mass is a time-consuming process. First, the scooped seeds are left in the sac for six days to be fermented. Following the fermentation, the cacao beans are dried, to subsequently be roasted, winnowed and grinded. In Yorkin and Guabo, the cacao mass is either mixed with condensed milk to be sold as chocolate treats to the 1,300 tourist that visit the communities annually, or it is mixed with water to prepare chocolate beverages that are consumed locally on a daily basis.

The participants identified several problems in growing and commercializing cacao. Bribri people are still recovering from the impact of the frosty pod (*Moniliophthora roreri* Cif.), an outbreak of a pest that severely impacted the cacao farms starting in the late 1980´s. Another challenge is the lack of profitability of selling cacao; “People come here and ask us to grow cacao. But what they do not understand is that sometimes we end up investing more money and labour than what we earn by selling the cacao seeds. This is not a good business for us.” (Interview with Emilio October 27, 2015). People also feel discontent with their relationship with the local buyer and with the implementation of projects in the area; “There are many problems but what I don´t like is that buyers are not formal. For example, sometimes they do not pay on time. I stopped believing in them because they told us they could not give us a better price for our cacao seeds. Later on, they paid us more only because the new company offered us a better price. Then they called us traitors because we were selling our seeds to the other company. Moreover, they want us to grow their *sikua* (Bribri word that means “from outside”) plants and not our criollo (Spanish word that means “local”) trees” (Rodriguez Valencia field notes December 8, 2015).

While most part of the Bribri people have dealt with their discontent by switching to different livelihood activities (e.g., growing plantains, offering agro-tours), some of the participants continue growing cacao despite these constraints. “ I will only abandon my cacao trees when I die, my parents raised me with cacao, and I cannot abandon my farm.” (Rodríguez Valencia field notes August 21, 2015). These participants feel nostalgic and respectful for an earlier period when the production of cacao allowed their families to travel, get recognition, and sustain themselves (1950’s-1980’s). Other participants want to re-engage with the practice of growing cacao because they perceive an opportunity to diversify their livelihoods by showcasing the biodiversity of their farms; “My dad passed away and left this piece of land for me. I did not know what to do with this piece of land. Then, I had the opportunity to study community tourism. As part of my studies, I decided to design a showcase farm. In this way, I can do what I like to generate some extra cash. People visit me to learn about our culture and our plants. For example, I show the visitors how to make chocolate with the seeds I produce here.” (Interview with Ballarino Oniel December 9, 2015).

Ideation phase

In the ideation phase, the participants and I generated some ideas to expand on the participants biocultural heritage to identify new value-added cacao products/services (Table 4.1). For example, we planned on creating a trail mix with the seeds of the trees located in the cacao agroforestry systems (e.g., *Anacardium occidentale* L., *Nephelium lappaceum* L., *Dipteryx oleifera* Benth., *Theobroma angostifolium* D.C.).

Table 4.1 Ideas generated during the ideation phase of the biocultural design project.

Desirable ideas [a]	**Feasibility of ideas** [b] **and challenges to overcome**	**Strategies used to solve the challenges**	**Viability of ideas** [c]
Trail mix made with seeds of the trees located in the CAFS	This idea was not feasible because the availability of seeds was seasonal, and we did not have access to the necessary infrastructure to store the seeds for long periods.		
Chocolate bars	This idea was not feasible because we did not have the knowledge and infrastructure (e.g., thermometers, refrigerator, tempering machines) to transform the cacao mass into chocolate bars.		
Fried plantains	This idea was feasible. However, we did not work on it as we were focused on the elaboration of other products.		
Chocolate beverages with seeds of different	This idea was feasible because we have access to the seeds of the trees and the participants had the knowledge to	We grew the seeds in a nursery. Then, we made a plan to transfer the plants in different landscape patches	This idea has to potential of being viable. However, it

Theobroma species	elaborate the beverages. However, we could not further develop the products because we did not have access to enough seeds.	to mitigate the impact of fungal diseases in the trees.	requires more time to become part of a business model.
Showcase farm intercropping cacao/banana in the same area	The idea was feasible. However, we changed our original design after learning about the white cacao and the cacao Bribri cultural narrative. For the development of this idea, we faced the following challenges: 1) It took us a long time to find the seeds of the trees we needed. 2) Once we got the seeds, we needed to figure out the best way to grow them to avoid the incidence of the monilia.	The participants consulted neighbors and relatives to get the location of the trees. I contacted other researchers to learn the scientific and Bribri names of the trees.	The idea has to potential of being viable. However, it requires more time to become part of a business model.
Cacao jam	The elaboration of cacao jam was feasible. However, we faced the following challenges: 1) The fermentation process was interrupted, and the participants could not sell the seeds to the local cooperative.	1) We used the fermented seeds to develop a second product: cacao butter. 2) The participants consulted neighbors for the traditional method to extract cacao butter.	This idea was viable because: - The participants have access to the cacao seeds and to the knowledge to prepare cacao jam. - The participants had access to other sources of

	2) The participants could not remember how to extract the butter 3) We did not have containers to package the product. 4) We did not know how to sell this product to the tourists visiting the community.	3) The participants and I bought glass containers to package the product. 4) We shared the ideas of the project with some community visitors, and they demanded the product. The participants shared our products with other community members, and they traded for other products (e.g., wood, sugar, rice)	knowledge, which allowed them to remember how to extract cacao butter. - The participants had the freedom to select the containers and final design for their product - The participants decided the price of the product and agreed on how to trade the product for other merchandises (e.g., rice, firewood, beans) with neighbors

[a] Desirability: What makes sense to people (Brown 2009)

[b] Feasibility: What is functionally possible (Brown 2009)

[c] Viability: What is likely to become part of a business model that is congruent with the Bribri knowledge and values (Brown 2009)

However, we could not design this product because the fruits of these trees are seasonal, and we did not have access to the seeds at the same time. Another idea was to make chocolate bars. Nevertheless, we did not know how to make chocolate bars nor the technology (e.g., thermometers, refrigerators, tempering machines), and the optimal environmental conditions (e.g., humidity, temperature) to develop this product. I also proposed working on a collection of jellies made with the different varieties plants located in the cacao agroforestry systems. This idea was functionally possible, but the participants were not interested in working on this product. They believed consumers would not be interested in buying small portions of each jam flavour.

Using ideation as an approach allowed participants to put forward any idea that came to mind and then undertake a structured preliminary reflection on its desirability, feasibility and viability. Through this process we were able to identify the main constraints to develop these ideas, such as the lack of; 1) specialized infrastructure equipment and technical resources, 2) constant availability of seeds, and 3) knowledge to elaborate products such as chocolate bars. This first phase encourages participants to bring forward nascent ideas and then winnow them through structured reflection resulting in the most desirable, feasible and viable idea to be taken forward into the phase of implementation.

Implementation phase

Developing and implementing products with the Morales family

The Morales family and I decided to work on the elaboration of cacao jam in April 2016. The cacao jam is made by using a part of the cacao that is not typically used in the community: the white mucilage that surrounds the cacao beans (Figure 4.1). To make cacao jam it is necessary to boil the white mucilage that surrounds the cacao beans with sugar and with a local type of cinnamon (plant not identified) (Figure 4.2). The result is a sugary product with a fruity flavour (Figure 4.3). With this idea, the participants were able to generate a product that was adding value to the commercialization of cacao. However, there were two main problems. First, the participants were not able to sell the leftover cacao seeds from the jam because the fermentation process was interrupted. Second, the participants did not have a package for the product.

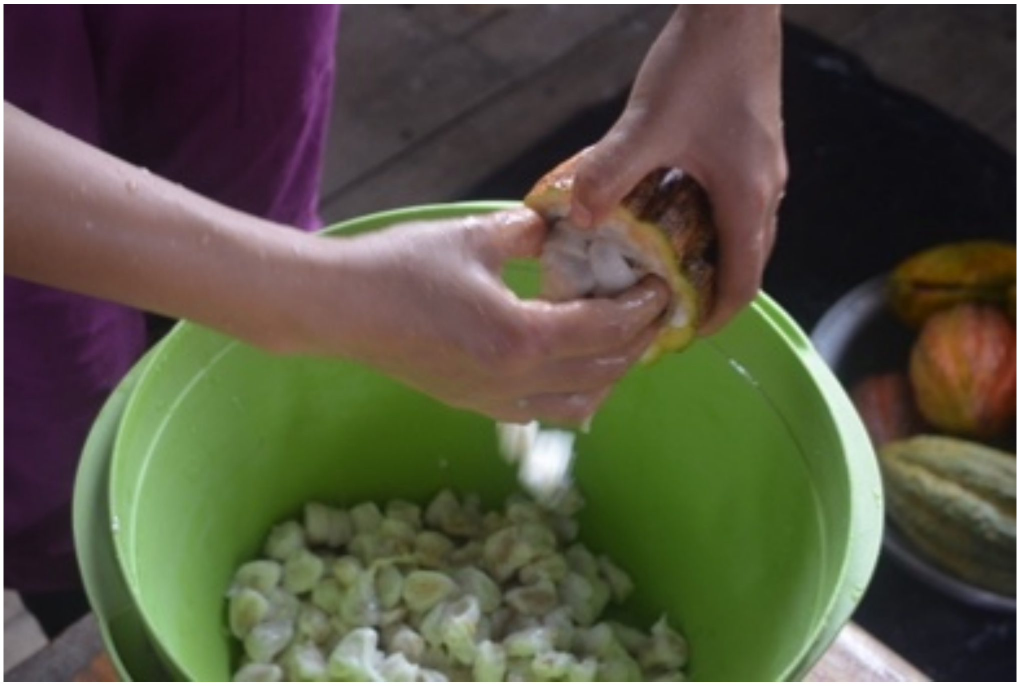


Figure 4.2 Extraction of cacao seeds from the fresh pod

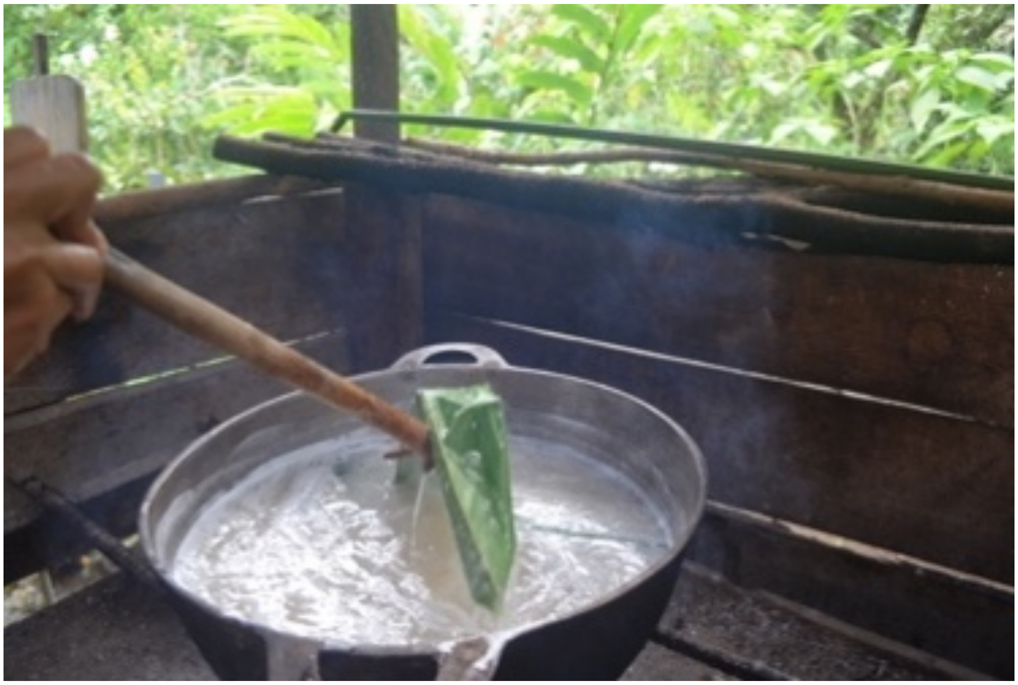


Figure 4.3 boiling the cacao pulp, water, sugar and cinnamon

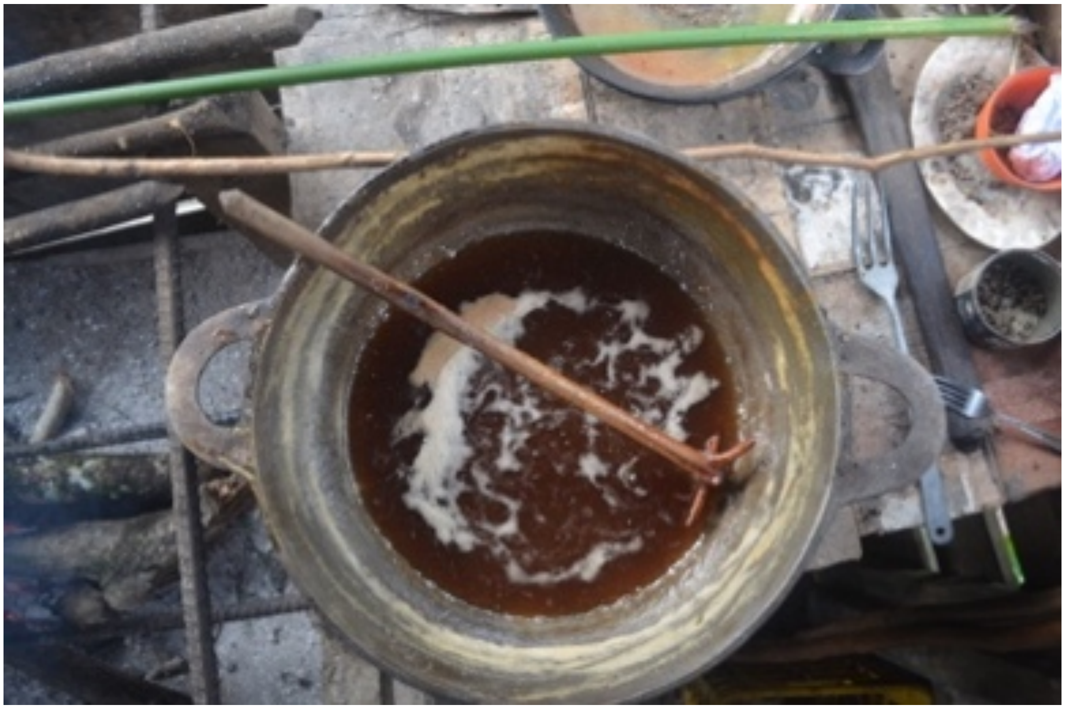


Figure 4.4 Cacao jam

Eventually, one of the participants realized we could use the leftover cacao beans from the jam to extract cacao butter and create a second product. Cacao butter is used in Bribri communities for medicinal and ritual purposes; “Well, my mom used to extract cacao butter. She used it to heal our skin when we were sunburned” (Rodriguez Valencia field notes May 2016). “The Bribri use cacao butter to purify the soul of people when they are born and when they die. These are very sacred processes…” (Interview with Noemi Rojas May 05, 2016).

We decided to work on this idea, however, the participants could not remember how to extract the butter from the cacao seeds. To solve this problem, I looked on the internet for some methods to extract cacao butter. The methods I found were expensive as they required the use of complex machines. The participants visited their neighbors and asked them for advice. Then, we tested the technique they learned, and we created a second product (Figure 4.5 a, b, c).

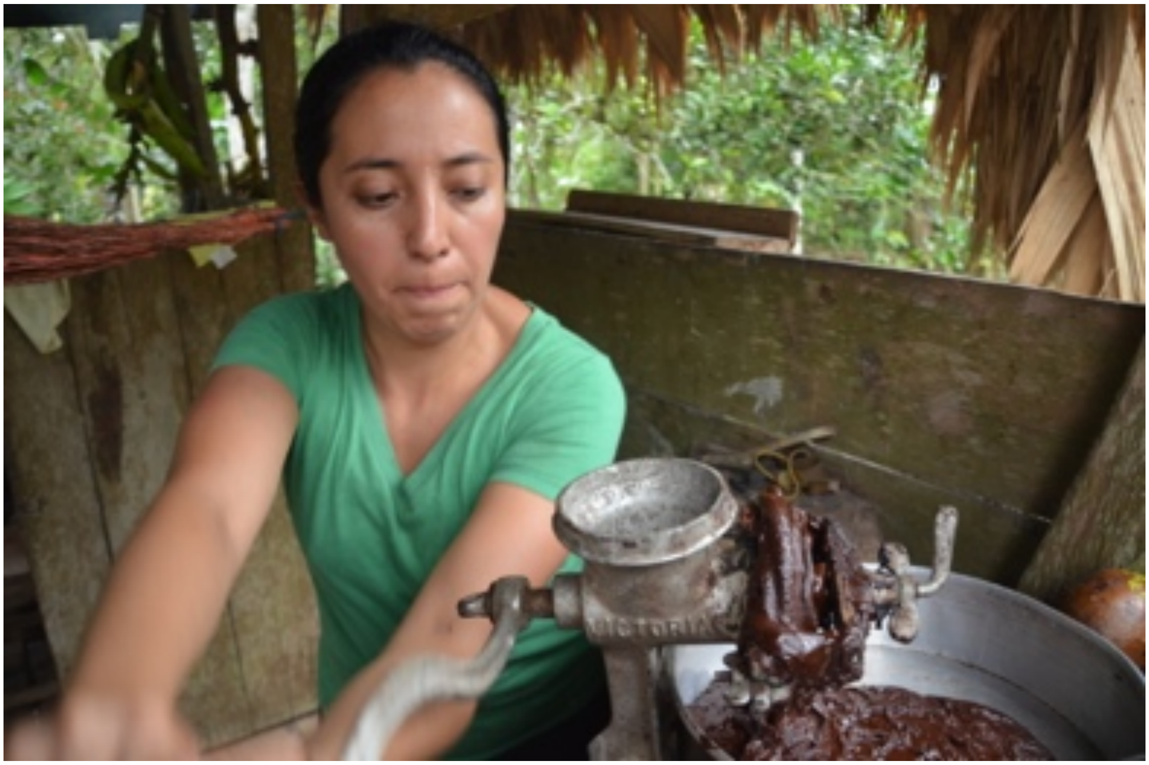


Figure 4.5 Extraction of cacao butter (**a**) Grinding cacao beans to obtain cacao mass

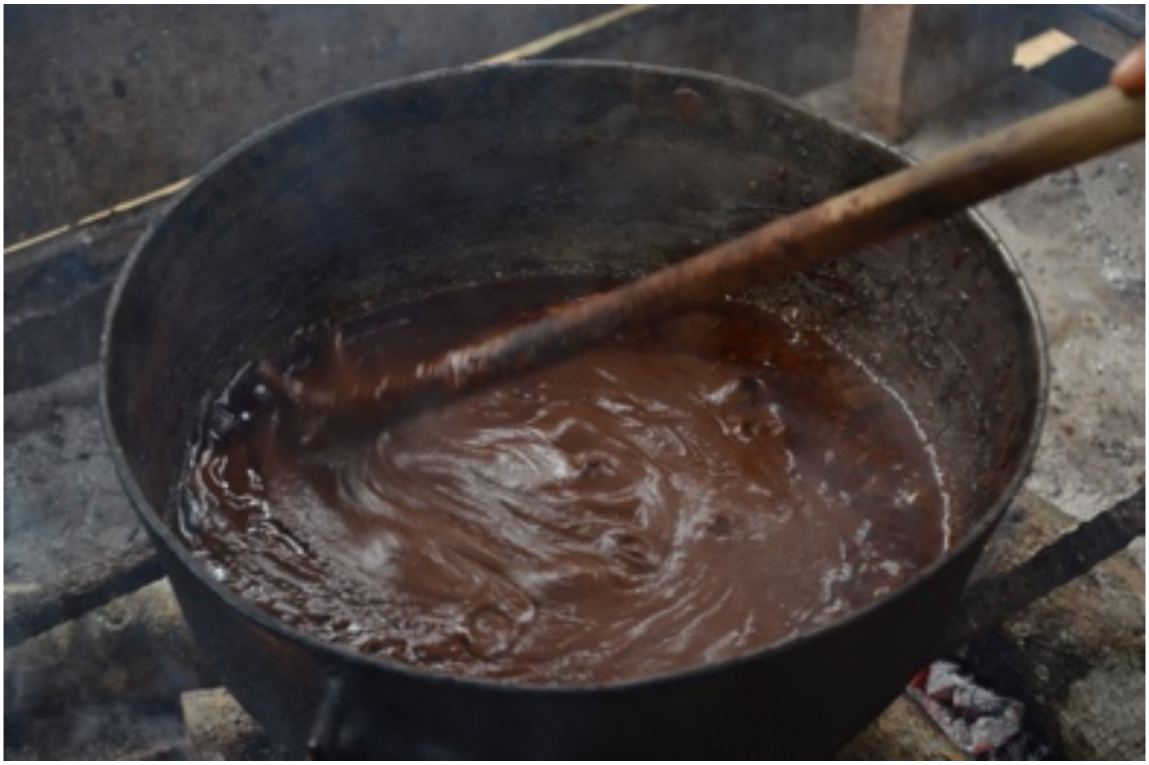


Figure 4.5 Extraction of cacao butter (**b**) cacao mass boiling

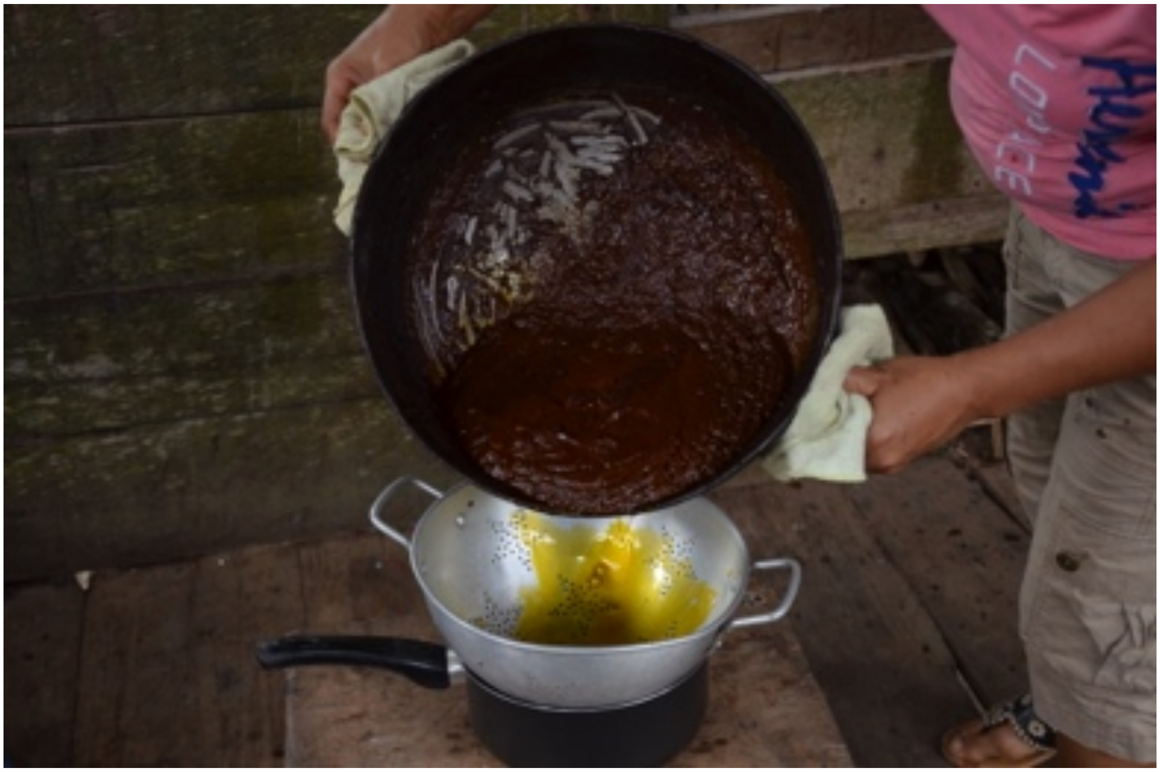


Figure 4.5 Etraction of cacao butte **(c)** participant pouring cacao butter into a container

After extracting the cacao butter from the seeds, I realized there was a remnant of cacao mass and I proposed to use it to elaborate chocolate candies by adding condensed milk and other spices (e.g., cinnamon, ginger). By using this remnant, I thought we could add more value to the same amount of cacao that was used to make the jam and the butter. The participants disagreed with my idea and decided to use the cacao mass for their own consumption and for sharing it with their neighbors.

By mid-July 2016, we had mastered the elaboration of cacao jam and the cacao butter. However, we did not know how to package the product. Two of the participants and I travelled to the town of Limon in Costa Rica to find containers. On our way to Limon, we stopped for a cup of hot chocolate in the touristic town of Puerto Viejo. When one of the participants realized a cup of hot chocolate cost the same as one kilo of raw cacao seeds, she mentioned: “This is enough, they need to respect my cacao trees! How come they are not paying me more for my cacao seeds?" (Rodríguez Valencia field notes May 25, 2016). After this situation, this participant became very active in the rest of the project.

To improve the appearance of the jam, we decorated the glass contained with the leaf of a non-commercial type of plantain (*Musa textilis* L.) (Figure 4.6). The cacao butter was packed in the container without any other aesthetic component (Figure 4.7).

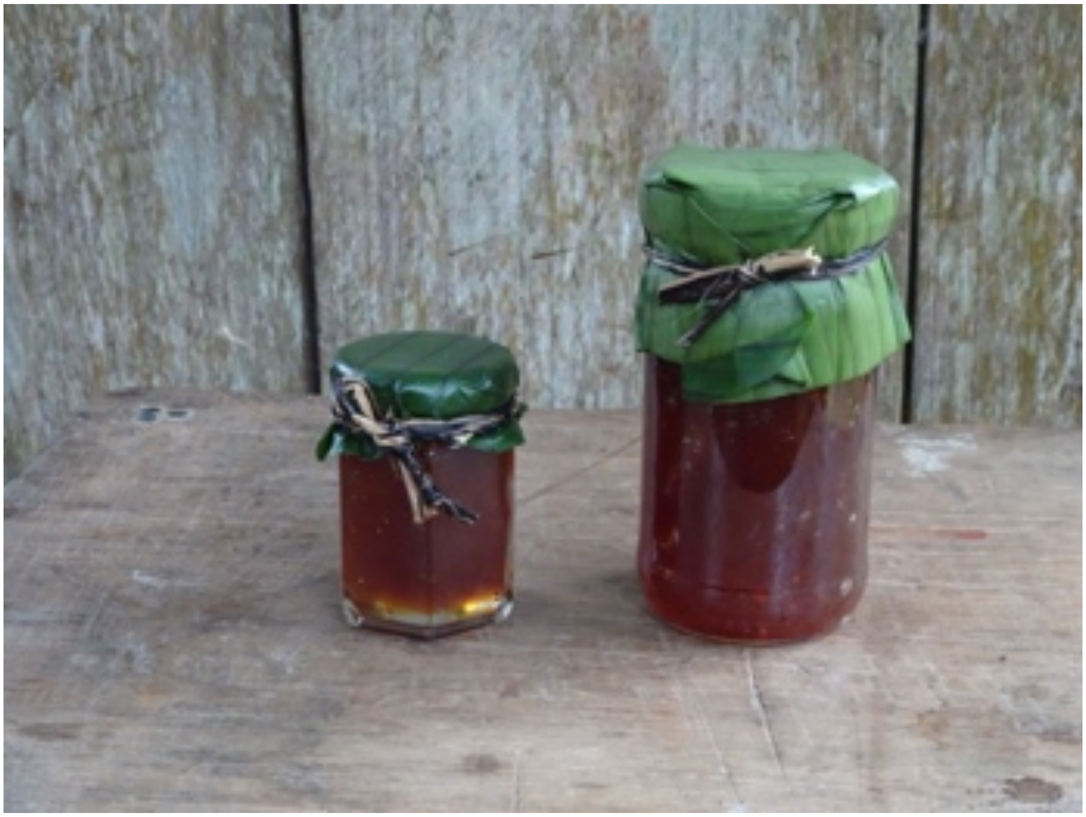


Figure 4.6 Final design of cacao jam

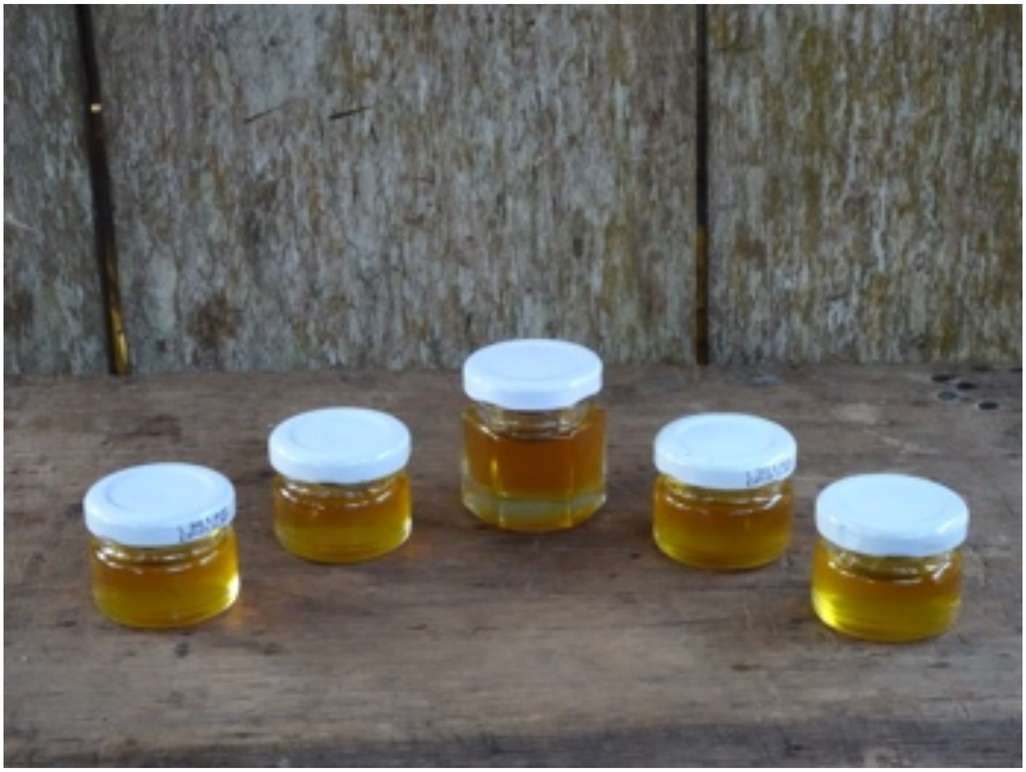


Figure 4.7 Final design of cacao butter

The Morales family and I did not know how to sell the products we designed. On July 2016, I had breakfast with some tourists, and I told them I spent the last evening making cacao jam. The tourists were curious about the product and subsequently visited the Morales family to try the jam. The Morales family used this opportunity to show the visitors the jars of cacao butter. The tourists expressed their satisfaction and bought all the containers we prepared; “Mariana, you should have seen the tourists, they were fighting for our products!” (Rodríguez Valencia field notes July 9, 2016). The participants and I prepared more product and other community members traded the products for other merchandises (e.g., firewood, rice).

At this point, one of the participants was very excited about the project as she realized she had significantly increased the value of one kg of cacao. Instead of earning USD $1.00 by selling one kilogram of wet beans to the cooperative, she was earning USD$58.00 by selling the cacao jam and butter. One participant calculated the amount of money she could earn by spending more time making the products. An elder stopped her and said, “we were able to make an alternative little business, and that is good. However, you need to remember that you will not have the capacity for making a big amount of product. Also, what are you going to make with all the cacao that we have in the farm? It is better to use the cacao not only for jam, but for our consumption, and to sell to the cooperative” (Rodríguez Valencia field notes July 9, 2016).

I visited the Morales family for the last time on August 7, 2016. We had dinner together and talked about the benefits of working on the products. The participants were satisfied with creating products that reflected their knowledge and practices. They were also pleased about the economic potential of being able to generate a regular cash income by selling the cacao products during the low season and continue selling cacao seeds to the local cooperative during the high season. This strategy was allowing them to diversify their livelihood portfolio and, at the same time, become more independent from the local cacao buyers. Finally, they realized our products were only a few of the multiple ideas that could be developed. In this regard, they developed other products after I finished my fieldwork. The participants have been selling and trading some of these products (e.g., coconut oil) since August 2016. Other products, such as the hats made with *Musa* leaves are in the development phase (Interview with Saulin Morales March 15, 2020).

Developing and implementing products with the Celles family

One Celles family member and I decided to work on the development of a showcase farm by undertaking a botanical inventory of his cacao plot. The participant´s original idea was to design a farm to showcase the botanical richness of the area, as well as to offer tours to university students to present information about the local strategies to grow organic cacao; “Everything started one year ago (2015) when I was invited to a workshop organized by the university of Costa Rica. The workshop was held at the farm of a producer that had all sort of plants in the same plot. After this workshop, I thought it would be a good idea to do something similar with my farm. In this way, I could continue growing plantain, banana, and cacao at the same time. I got very excited with this idea and now it is my goal to work on it in the following years” (interview with Longino Celles, 13 July 2016). While working on the botanical inventory, the participant told me it would be important to include in his farm a “cacao criollo tree”. The cacao criollo, he told me, was the original cacao in the area, a tree resistant to the frosty pod disease.

We visited the participant´s uncle in a nearby community to learn more about the criollo cacao. The elder was confused when we asked him about this cacao variety. The only cacao criollo he knew was the one his parents obtained from the United Fruit Company, an American corporation that produced bananas in Latin America in the early and mid-20th century. Then, he asked us if we were looking for the “cacao blanco” (white cacao in English). The elder told us that the white cacao was a tree that existed in the forestry areas surrounding the community. This tree looked very similar to the cacao trees located on the farms, but the beans were white, instead of violet. During this visit, the elder showed us a tree with small cacao-like pods. The tree he showed us was a wild variety of the genus *Theobroma*. After this visit, the participant´s uncle became part of this project and his role was to guide us to understand the diversity and location of wild varieties of cacao in the area.

In the subsequent months, the main participant of this project and I searched for the white cacao tree. Following the advice of the Celles´ family members we searched for the tree in abandoned farms and forestry areas. While doing this, we found other wild varieties of cacao, locally known as the cacao sisters (Figure 4.8-4.12).

The participant´s relatives told us that in the past, people used the seeds of the cacao wild relatives to make chocolate beverages. However, the Bribri people cut down these trees because they believed they were responsible for spreading frosty pod in the cacao farms.

The Celles family and I solicited the counsel from other Bribri people, and non-Bribri people, to learn the names of the trees we found, as well as the cultural importance of the cacao sisters. From Alí García (a Bribri researcher working at the National University of Costa Rica), as well as from W. Phillips-Mora (a researcher from the

International Cacao Collection of the Tropical Agricultural Research and Higher Education Center, CATIE), we realized that we had located the following wild varieties of cacao: 1) *Solo´* (*Theobroma angustifolium* D.C.), 2) *Skuálöm* (*Theobroma bicolor* Bonpl.), 3) *Wèrö* (*Theobroma simiarum* Donn. Sm.), and 4) *Chuwál* (*Theobroma bernoullii* Pitier) (Figure 4.4).

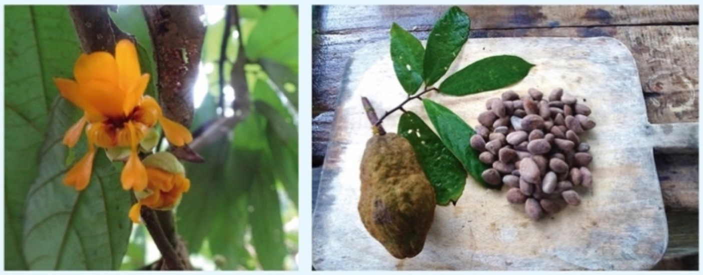
From our conversations with an *awá* (Bribri medicinal man) and a *tsuru´ókö̈m* (Bribri women in charge of purifying people with cacao), we learned that the wild varieties of cacao were part of a Bribri narrative that guides the behaviour of the Bribri with other human, and not humans (Bozzoli 1977) (Appendix 1) . According to the awá, these trees represent the failed attempts of Sibö (Bribri cultural hero) to create cacao, the perfect plant. In the Bribri worldview, Bribri people are considered by Sibö as cacao trees (Murillo and García Segura 2014). The participants and I concluded that by including these trees in the showcase farm, we had the potential of honoring the Bribri worldview and its history.

From our conversations with W. Phillips-Mora, we learned that it would be very unlikely to find a criollo cacao in the area because this type of agricultural race is not very resistant to the frosty pod. Although we did not find the criollo cacao, we realized there are some cacao trees in the area that have some traits of the criollo genetic material. These traits include the presence of white coca beans and a non-bitter flavor.

Once we harvested the seeds of the cacao sisters, we decided to work on other design ideas. For example, we elaborated beverages with the seeds we harvested. The beverages we elaborated were not as bitter as the beverages made with cacao. We could not continue working on this idea because we were constrained by the low quantity of seeds we harvested. Our second idea was to grow the seeds in a nursery to design a farm showcasing the wild varieties of cacao.

The cacao sisters

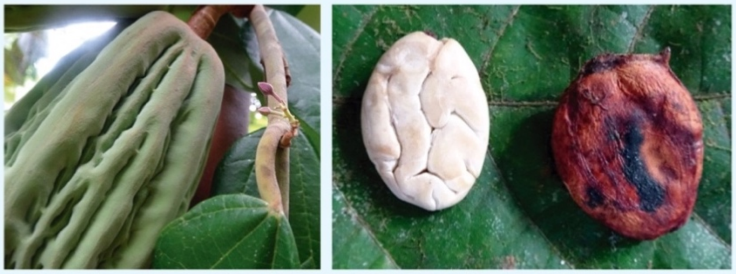
Sɔlo´ (*Theobroma angustifolium* D.C.)



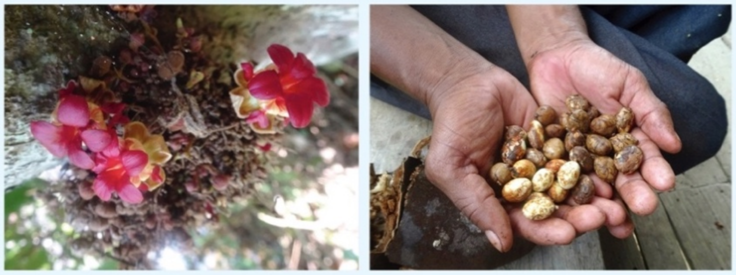
Today we weeded cacao trees for four hours. While doing this job, I perceived a strong smell. It was a sweet and fruity smell. I asked where the smell was coming from. They pointed me to the *solo´* tree. Then, the elder told me that her family cut down the *solo´* trees many years ago to avoid the spread of the frosty pod on the cacao trees. She also mentioned feeling pity for *solo´*. She was sure it was not *solo´s* fault. She harvested few *solo´* seeds without telling her parents. Then, she grew them on her plot... (Rodríguez Valencia fieldnotes October 9, 2015).

Skuálöm (*Theobroma bicolor* Bonpl.)

I asked him about the *Skuálöm* tree. He told me that the *Skuálöm* seeds do not need to be fermented. He also told me that his parents used to clean the seeds on the shore of the rivers to remove their shells. Once the seeds were shelled, his parents were making beverages. Later on, his daughter took me to the river. On the way to the river she showed me two *Skuálöm* trees; a liso (smooth texture) and a corrochudo (bumpy texture). I can´t wait to try the seeds! (Rodriguez Valencia fieldnotes October 23, 2025).



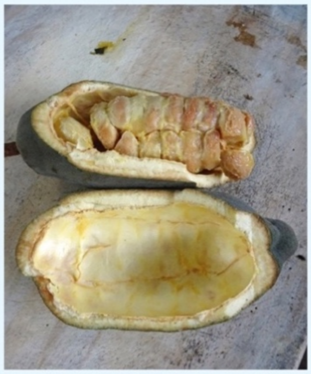
Wèrö (*Theobroma simiarum* Donn. Sm.)



His uncle took us to his finca (cacao farm). He showed us two trees and called them "cacao colorado." He called them "colorados" because the trees have red flowers. The tree produces cacao-like pods. I wonder what type of trees this is. His uncle told me this was an indigenous tree, and that people used it to make beverages with its seeds. I am amazed by the beauty of its flowers (Rodríguez Valencia fieldnotes December 3, 2015).

Chuwál (*Theobroma bernoullii* Pitier).

We went to the mountain in search of the famous white cacao. Our guide asked us not to talk because the mountain doesn't like to be disturbed... We walked for four hours and suddenly he showed us a tree with cacao like pods. I believe it is the "green cacao" we have heard about! We harvested a pod, but the fruits were not ripe. I took some pictures and we continued walking... When we arrived back to his place, his mom feed us. We showed her the fruits and she was very surprised. Later on, I visited the elder to show her the fruits we harvested. She was very confused... she looked at the pod and tasted the pulp of the fruit. She told me they tasted exactly as cacao seeds. Then she asked me to save seeds for her. I am not surprised. She loves to have all sort of trees at her farm. (Rodriguez Valencia fieldnotes May 12, 2016)



Meeting the cacao sisters

During the last months we have been searching for the white cacao and we just realized that all the Theobroma species have white seeds but *T. cacao*! Then I told them that it seemed the cacao sisters trick us because they wanted to be seen again. They (the participants) smiled and agreed with me (Rodriguez Valencia fieldnotes August 5, 2016).

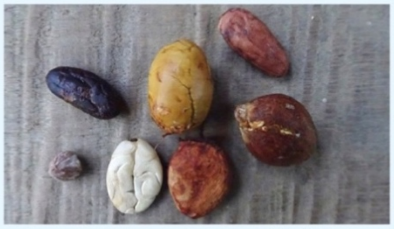


Figure 4.8 Cacao sisters

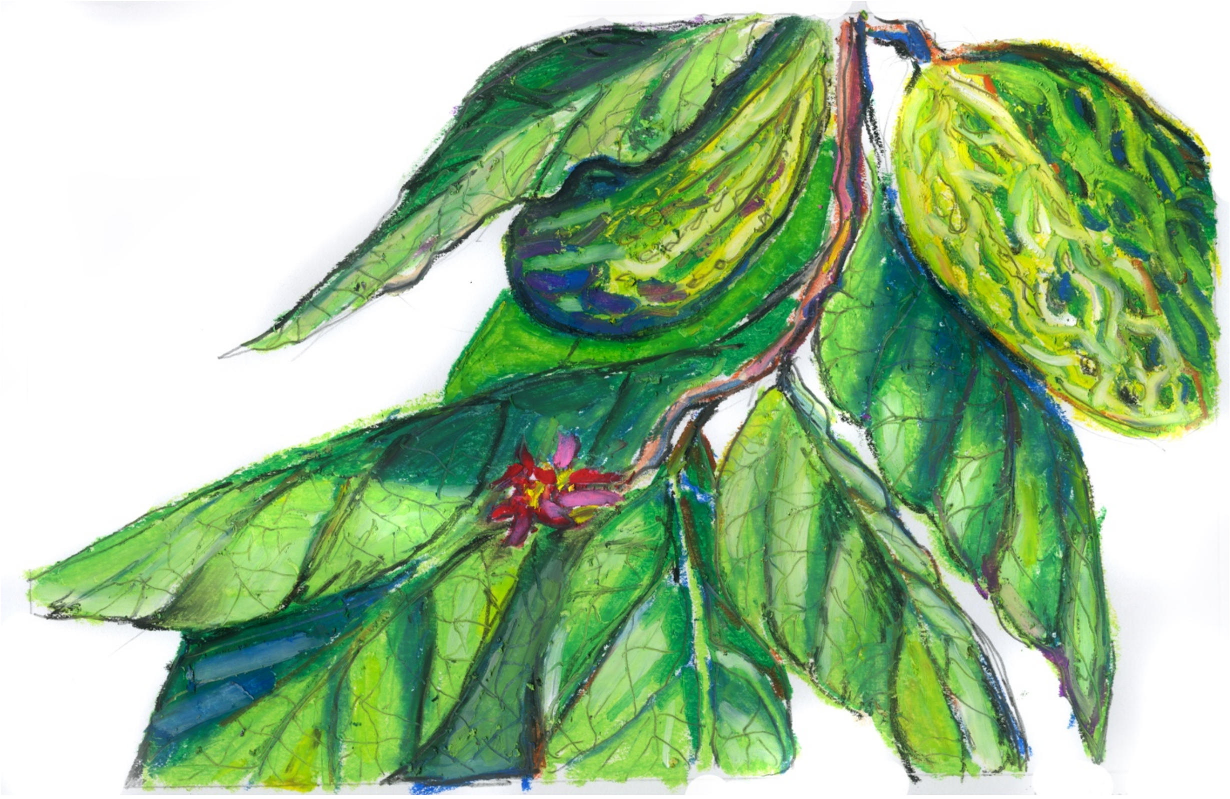


Figure 4.9 *Skualöm* (*Theobroma bicolor*). Illustration: Connor Jandreau

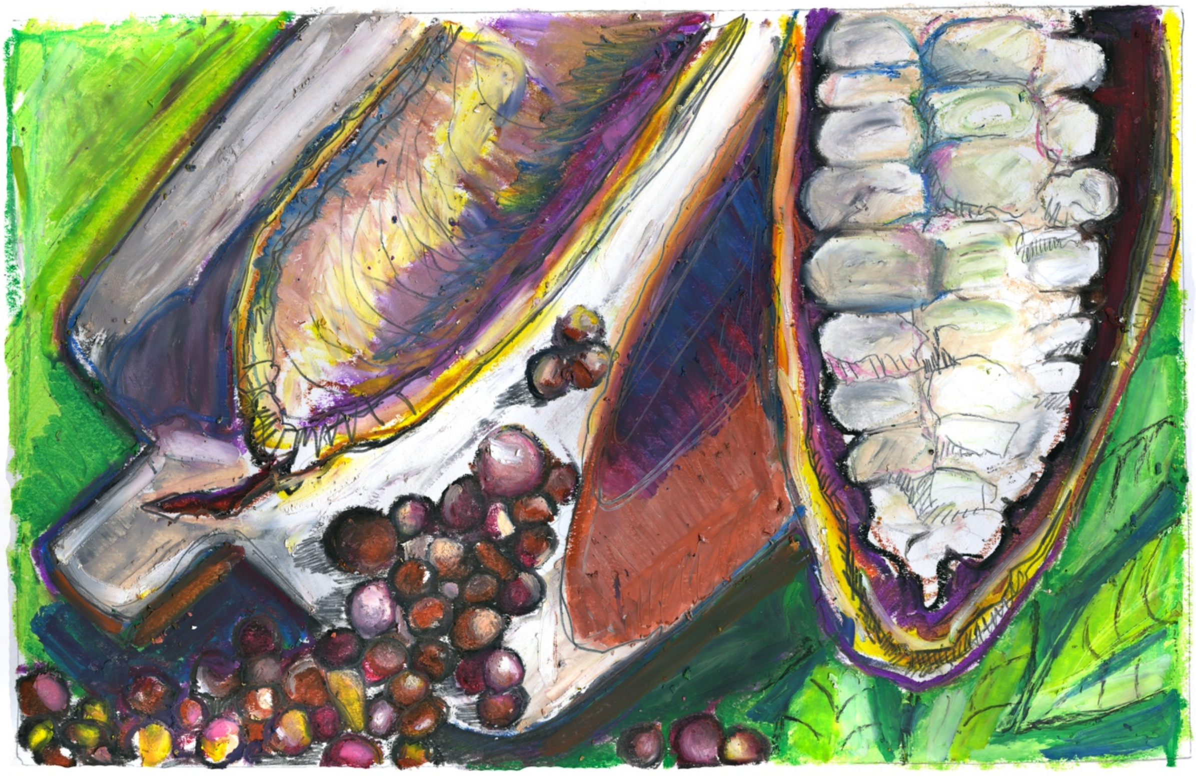


Figure 4.10 *Wèröm* (*Theobroma simiarum*). Illustration: Connor Jandreau

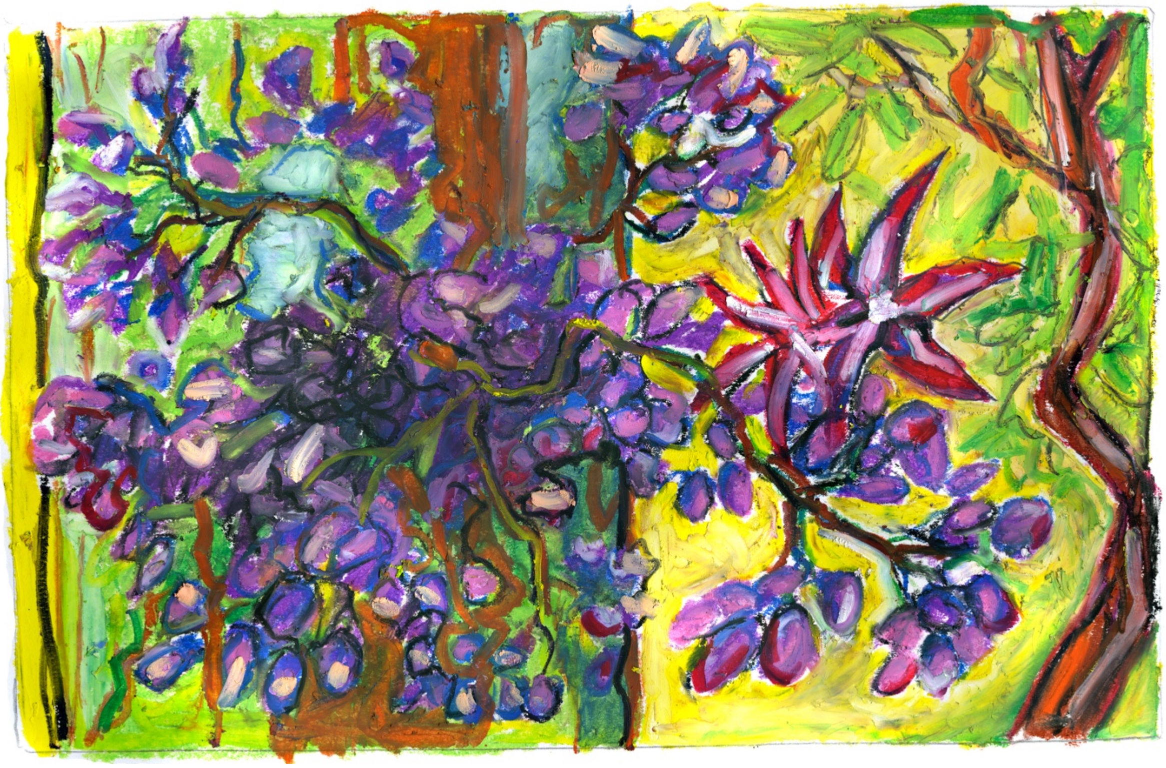


Figure 4.11 *Chuwál* (*Theobroma bernoullii*). Illustration: Connor Jandreau

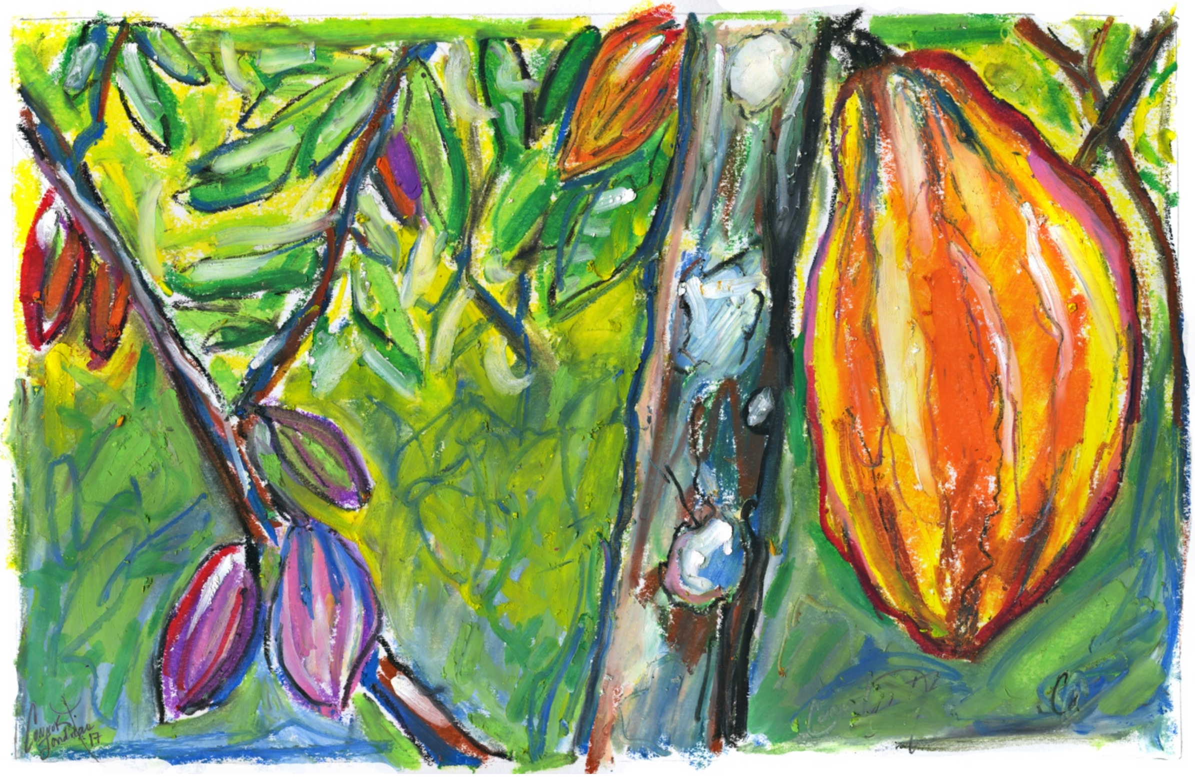


Figure 4.12 *Tsuru* (*Theobroma cacao*) Illustration: Connor Jandreau

During August 2016, the main participant of this project and I noticed that some of the *Theobroma* species found were not infected by the frosty pod fungus. We hypothesized that these plants were not infected because they were located far away from the infected cacao farms or, they were located in higher altitudes, where the temperature was lower. With these hypotheses in mind, we discussed a plan to grow the seeds obtained in the main participant´s farm (Figure 1). We used a participatory mapping technique to record the approximate location of the seeds he needed to plant. This technique helped us to have a long conversation on how to potentially manage the incidence of the monilia fungus on a landscape level.

In an interview with the main participant of this project on July 13, 2016. He told me what he imagined his showcase farm would look like in the future; “My showcase farm will be an important place to conserve all the types of cacao that we had found and that my people were forgetting. Now I am very curious about these trees. I hope that in the future people come to learn about these trees, and I am not only thinking about outsiders but also about our kids. They need to learn about our culture and our history” (Interview to Longino Celles July 13, 2016).

The Celles family and I generated a few ideas to attract tourists to the showcase farm. Some of the ideas included to; 1) search for other plants of cultural importance to enrich the farm (e.g., *Crescentia* sp., *Pouteria* sp.), 2) make an alliance with the tourism associations that already existed in the area, 3) request funding from governmental agencies to continue the project, and 4) make alliances with development organizations to be trained in receiving tourists. I had the opportunity to visit the community in May 2017 and learned that the Celles family had requested funding from the Panamanian government to develop the showcase farm. I have not been in touch with the Celles family since. However, I heard from a member of the Morales family that the trees the participant planted have not produced cacao pods yet (Interview with Saulin Morales March 15, 2020).

4. DISCUSSION

I have described my experience in co-designing products/services with community members of Yorkin and Guabo. I described how this project emerged, who was involved, what conversations emerged between the participants and how decision were taken. In contrast to co-production practice, which puts emphasis on documenting the unintended consequences of scientific progress, biocultural design contributes to co-production theory by offering a solution-oriented approach to co-imagine and co-execute ideas to specific problems. This approach, that consist of developing the most desirable, feasible and viable ideas that emerge from the interaction from community members and outside actors, not only takes into consideration the participants knowledge about resources and practices, but also their needs, aspirations, and values.

Biocultural design contributes to coproduction practice by offering an approach that recognizes the value of science, while also respecting the values of other actors. In the case described in this paper, the participants received private value in the form of cash flow by selling the cacao value added products to tourists. Consumers (e.g., tourists and neighbors) received value in the form of having access to valuable products. Sustainability science, in general, will hopefully see its value in the form of new knowledge that has the potential to support the implementation of initiatives that take into consideration the Bribri needs, aspirations and values. Contrary to the idea that the “products” of a coproduction process are exclusively public goods “consumed” by society as a collective (i.e., knowledge, practices, institutional arrangements), the products that result from a co-production process entail diverse outcomes which result and may constitute one or more of private or public value (Alford 2014).

While increasing cacao yields have received the most attention in the Bribri territory, the participants expressed interest in pursuing additional goals such as diversifying their livelihoods and living up to cultural ideals (e.g., honoring Bribri worldview). The latter acknowledges that the participants’ aspirations go beyond the instrumental objective of maximizing short term economic inputs. The conversion of resources into new functionings, defined by Sen (1999) as things that a person values doing or being, is influenced by personal, social and environmental factors. Assumptions of growth and development are not automatically correlated to increased capabilities or functionings (Oosterlaken 2009). Unlike the dominant development approaches that centres on economic value, for the Bribri it is but one facet that must be considered, balanced and weighed off against other dimensions of value such as cultural teachings and social relationships.

Biocultural design provides a strength-based approach that allows creativity to emerge out of the capabilities found within biocultural heritage to implement changes in livelihoods. In this project, these capabilities were informed by a set of resources that the participants commanded to perform different functionings. These resources included:

- Access and availability of materials (e.g., diversity of *Theobroma* and other plant species)
- Specialized place-based knowledge (e.g., location and use of biological resources, Bribri cultural narratives)
- Placed-based practices (e.g., techniques to transform plants into dishes and medicines)
- Strategic alliances with key actors to gain access sources knowledge (e.g., neighbors, researchers, Bribri traditional authorities) and access to markets (e.g., touristic operation)
- Strong attachment to biological resources tied to the Bribri identity (e.g., cacao)

Biocultural design moves away the identification of a one size fits all approach to solutions and focuses on the creation of new possibilities. In this project, the participants and I imagined and put into practice a different way to address their problems and open new opportunities; instead of focusing on a narrow approach to maximizing economic returns through yield, we created an alternative system based on the idea of creating cacao added value products, as well as generating direct links between producers and consumers (e.g., tourists). This process opened a new relationship between producers and consumers, a relationship in which Bribri people are not only producers, but also entrepreneurs. In this regard, the participants continued designing new products (e.g., coconut oil, hats with palm leaves) to further diversify their livelihoods without major economic and technological investments.

The implementation and development of this project indicates that biocultural design “is an approach that requires time to realize the benefits” (Kuzivanova and Davidson- Hunt 2017 p. 28). In this case, the execution of the showcase farm, as well as elaboration of beverages with wild relatives of cacao, have the potential of becoming viable ideas. However, the implementation of these ideas will require more time and more resources if they are to be generated and controlled by the Bribri as opposed to the more conventional and colonial outcomes, such as international cacao supply chains, which emerge from and are controlled by people outside of the community.

In reflecting upon the implementation and development of this biocultural design project and others review of this work, ideas emerged that could have enriched the project in several ways. For example, I could have tried to replicate the elaboration of cacao value added products in other communities. This does not mean that this particular case, with its specific context, could have been reproduced. This means that I could have further researched about the participants wishes to establish collaborations with other Bribri people to develop products. Moreover, I could have conducted a marketing study before the development of this project to inform the participants about the availability of markets for their products. This strategy, perhaps, could have motivated more people to participate. Additionally, I could have provided the participants with information to develop marketing strategies to reach other consumers. Although the use of these ideas and strategies can be incorporated into the practice of biocultural design to enrich its practice, I believe that the role of a researcher in a biocultural design project goes beyond researching and sharing information with stakeholders to; 1) ensuring the development of the design process while balancing power inequalities between the participants (e.g. researchers, stakeholders, consumers), and 2) building capabilities through biocultural heritage so that participants feel more confident in developing their ideas and new possibilities.

5. CONCLUSION

This research focused on the practice of co-production in two Bribri communities. To be more specific, I used a biocultural design approach to co-design cacao value added products and services with Bribri community members by drawing upon the capabilities of their cacao agroforestry systems. The participants of this project, including myself, strategized, planned, and found ways to move forward our ideas to design products and services by recognizing that some products are not desirable, feasible or viable. Ultimately, we understood that at times action had to be taken to improve situations and often key resources such as biological materials, placed-based knowledge, and placed-based practices need to be used in an innovative way. When needed, we complemented our capabilities by turning to others who could provide guidance, alternative ideas, information, and resources. The results of this case study confirm previous findings that recognize the importance of; 1) developing trust relationships with stakeholders (Berkes 2017) , 2) including different types of knowledge (Armitage 2015) and reflecting about the process of co-producing knowledge (Miller and Wyborn 2018). At the same time, the findings of this study provide new information to the practice of co-production by offering a guide to co-imagine and co-execute ideas to solve specific problems. Further research in biocultural design is necessary for consolidating and replicating similar projects to support sustainable economic development in other indigenous communities.

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CHAPTER 5 CONCLUSIONS

My goal during this research was to develop thinking around an idea of resilience that recognizes Bribri people´s ability to negotiate and make decisions related to responses to social and environmental change. To do so, I used three areas of literature: ethnobiology, resilience, and co-production of knowledge. Beyond documenting the loss of local knowledge, which is often the focus of an ethnobiologist, I used ideas from resilience thinking (e.g., recognition of temporal and spatial cross-scale interactions, recognition of multiple stressors and drivers interacting on systems, social ecological memory) to understand how Bribri people are actively using the knowledge and memory linked to biodiversity richness to meet livelihood needs and deal with change. In contrast to much co-production work, which puts emphasis on diagnosing problems with current scientific practice, I used a biocultural design approach to support the livelihoods of some Bribri community members by drawing upon the capabilities of their biocultural heritage. This concluding chapter presents an integrated discussion of the findings reported in the previous chapters. I also elaborate on the theoretical and practical contributions of this thesis. Finally, I provide some avenues for future research.

MAIN FINDINGS AND SIGNIFICANCE OR RESULTS BY RESEARCH QUESTION

Is the narrative of decline and loss in biodiversity richness the only way to think about the relationship between Bribri people and the biodiversity of their territory?

In Chapter 3, I documented how Bribri people have used the biodiversity of their territory to respond to a dynamic environment. I did this because researchers and policymakers have recognized the importance of Indigenous Peoples´ knowledge in the conservation of biodiversity, as well as in the contribution of rural livelihoods (Maffi and Woodley 2010). However, Indigenous Peoples are often considered to be undergoing an erosion of their knowledge as societies modernize and there are changes in their use of biodiversity (e.g., Cardinale et al. 2012; Guèze et al. 2015). The idea that indigenous knowledge (IK) is a crucial element of the adaptive capacity of Indigenous Peoples has been discussed in the resilience literature for some time (e.g., Berkes et al. 2000). However, there is a limited understanding of how long-term loss, or adaptation of IK occurs in terms of biodiversity use (Bussmann et al. 2018). Exceptions include Posas (2013) and Bussmann et al. (2018).

My results support the idea that Bribri people are highly adaptive and skillful in responding to different disruptors through dynamic use of biodiversity. My analysis shows that Bribri people respond to disruptors by making a reconfiguration of their livelihoods. The use of biodiversity for trade, food, and shelter, for example, stabilizes at points in time, but patterns of biodiversity use reconfigure as Bribri people set aside some items, bring in new ones, and make continuous use of certain plants and animals (Appendix 7). The use of biodiversity in Yorkin is a dynamic process, and not necessarily a declining process as it is usually portrayed.

Similar patterns of long-term resource use, with successive cycles, have been observed in other indigenous communities. The dynamic use of biodiversity has been reported in the abundance of a particular species and in genetic diversity (Davidson-Hunt et al. 2016). Winter (2012) examined the dynamics of taro (*Colocasia esculenta* L.) varieties in the Hawaiian culture and found that it has experienced an increase and a decrease over the past 1,000 years. Bussmann et al. (2018) reported a similar pattern in the number of biodiversity richness utilized over a period of 66 years among the Chacobo Indigenous communities in Bolivia. Other examples of cyclic resource utilization over time include Seixas and Berkes (2003), Ekblom (2012) and Bhat et al. (2013).

The use of different methodologies to track biodiversity richness could be the main factor causing the perception of biodiversity loss in other studies (Bussmann et al. 2018). Changes in diversity richness are often captured by comparing the biodiversity use from a defined baseline at a point in time (e.g., Moonen and Bàrberi 2008;

Deheuvels et al. 2014). I suggest documenting biodiversity richness at different points in time to avoid the perception of biodiversity loss. Tracing biodiversity richness can be done by either analyzing people's narratives of biodiversity change (such as in this study), or by comparing the use of biodiversity reported in previous studies (e.g., Posas 2013). Since the use of biodiversity richness is seen as providing opportunities for adapting to global drivers of change (Rice and Greenberg 2000; Cardinale et al. 2012), Albuquerque (2006) suggests documenting not only the species that are used at one point in time (mass knowledge), but also the species referred as known, but not used (stock knowledge). The rationale of this proposal is that species that seem unimportant at one moment, may become important following a disturbance, allowing people to respond to a dynamic environment (Holling et al. 1995; Albuquerque 2006).

Alongside identifying the Bribri responses to a dynamic environment, I documented the Bribri explanations that exist around the dynamics of their environment. I did this because local narratives of change can permit researchers to have a better understanding of how the past is recalled or reconstructed by marginalized individuals or groups within society (McInosh 2000; Nazarea 2006; Rotarangi and Rusell 2009; Miller and Davidson-Hunt 2013). Moreover, using scientific approaches in different cultural contexts can result in communication problems (Miller and Davidson-Hunt 2013), limiting researchers understanding of people's struggles when dealing with change (Brown 2016).

While much attention is given to the singularity of disruptions, Bribri participants paint a more complicated canvas of change. The disruptors impacting the use of biodiversity richness in Yorkin are a bricolage of environmental (e.g., pest outbreaks, floods), social (e.g., introduction of development projects and land grabbing processes) and economic changes (e.g., market demands), at different temporal and spatial scales (Table 5.1). These disruptors have affected the Bribri people over long term and its impacts have been worsened by the effect of "slow burn stresses" such as poverty, racial injustice, and cultural marginality (Whelan 2005). This demonstrates the idea that there are multiple multiple-stressors and cross-scale interactions that explain the temporal and spatial dynamics of social-ecological systems (Gunderson and Holling 2002). The study of the dynamic use of biodiversity allowed for an understanding of the common perspectives on change in Yorkin.

Table 5.1 Disruptors affecting the Bribri use of biodiversity.

Year	**Main livelihood activity**	**Disruptors**	**Landscape patches impacted**	**Number of species used for different purposes**
1931–1945	Predominately subsistence	Regional and global demand for cacao	Spatial reduction of swidden plots. Expansion of cacao farms and establishment of cattle ranches	F[a]: 53 C[b]:3 T[c]: 1
1945–1979	Cash-based economy	Invasion of monilia fungus in cacao farms	Abandonment of cacao farms and cattle ranches. Expansion of swidden plots	F: 24 C: 7 T: 2
1980–1983	Predominately subsistence	Regional demand for plantain	Establishment of plantain plots	F: 41 C: 2 T: 2
1985-2016	Predominantly cashed based	Adoption of conservation narratives and new commercial crops (e.g., banana)	Rehabilitation of cacao farms. Establishment banana agroforestry systems. Expansion of forestry areas and plantain monocultures.	F: 27 C: 7 T: 7

[a] Food, [b] Construction, [c] Trade

My results also suggest that Bribri people are actively using their agency to negotiate causes of environmental change, as well as their worldview to explain the behaviors and norms that have the potential to influence change. For example, Bribri people were able to recover their lands from the UFCO thanks to the prayers done by their spiritual leaders. Bribri people have not been able to recover from the impact of the monilia because they extensively commodify cacao, a plant considered sacred in the Bribri worldview. While some scholars believe that the disruptors affecting the use of biodiversity are the consequence of physical laws, Bribri people believe some of the disruptors affecting the use of biodiversity in Yorkin are the consequence of respecting, or not, appropriate behaviors, principles, and values (Ibarra Rojas 1991).

Local notions of environmental dynamics are usually different from western perspectives (Gómez-Baggethun et al. 2013), and are not considered valid because they are subjective, unreliable, and inaccurate (Radstone 2000). By validating local causes of environmental change, scholars can: 1) move beyond the instrumental goal of implementing resource management strategies, 2) open the space for pluralistic perspectives of change around different values, beliefs, and practices, and 3) re-assess their understanding of relationships between humans and environment (Brown 2016). By exploring non-western perceptions of change, it is possible to promote "cross-cultural partnerships directed toward fostering resilience" (Miller and Davidson-Hunt 2013 p.1).

How have Bribri people drawn upon their social ecological memory following the invasion of fungal pathogens in their commercial lands?

In Chapter 4, I investigated how Bribri people have re-organized following the invasion of fungal pathogens in their commercial lands. I did this for two reasons. First, biodiversity change, such as the invasion of fungal pathogens in agroforestry systems, is expected to become more pronounced in the future (Marquardt 2001; Meinhardt et al. 2008), potentially affecting the livelihoods of the people who have traditionally relied on the production of cacao, banana, and plantain to sustain their families. Second, Indigenous Peoples are often considered to respond to environmental change by either using their ecological knowledge transmitted across generations (e.g., Cristancho and Vinnign 2009; Calvet-Mir et al. 2015) or from other areas (e.g., Turner et al. 2003; Crona and Bodin 2006). Few studies have examined how Indigenous Peoples solve problems by accessing both sources of knowledge at the same time, known in the social-ecological literature as social and ecological memory (SEM). Exceptions include Barthel et al. (2010), Nykvist and Von Heland (2014), and Wilson et al. (2017).

Bribri people have responded in the last 80 years to multiple cycles of fungal pathogen invasions in their commercial lands by using their social and ecological memory (SEM). Bribri people first respond to fungal pathogens by using their own knowledge (e.g., construction of drainage systems) and by making a continuous use of biological resources (e.g., criollo varieties, non-commercial species). Then, they respond by using the knowledge transmitted from other people (e.g., management practices to enrich their agroforestry systems) that are part of their social networks (e.g., neighbors, NGOs, middlemen, governmental agencies) (Table 5.2). Bribri responses to fungal pathogens have sometimes been rooted in traditional practices (e.g., cultivation of non-commercial crops in agroforestry systems). Bribri response to fungal pathogens have also required adaptations (e.g., adoption of new biological species). The adoption of technologies and biological resources have allowed Indigenous populations to increase the diversity of resources to support their livelihoods (Turner et al. 2003; Barthel et al. 2010).

As suggested by my research, new crops and management practices demonstrate that Bribri people hold onto, reflect about, and create knowledge, which both keeps and enhances the bio-cultural diversity of commercial plots. On October 13, 2015 Ms. Miriam Morales explained to me the benefits of being receptive to new information in this way: Bribri people accept new crops, cultivars, and knowledge, and examine if these are useful for them. On several occasions, Bribri people have showed outsiders how local plants and practices are better than the ones brought from other areas. For example, Bribri had showed outsiders that is possible to grow Gross Michel bananas by using their traditional practices (e.g., agroforestry), despite the impact of the Panama disease in their plantations. Bribri people also reject ideas (e.g., management practice) that are not easy to implement, or are incongruent with traditional practices. For example, banana buyers had proposed Bribri people to use compost and to intensify the density of banana plants in their commercial plots (Rodríguez field notes December 9, 2015). Many people in Yorkin and Guabo have not adopted these practices. Instead, they prefer to use their traditional practices to produce banana through a polyculture system and to control the incidence of fungal diseases in their farms by rotating plots, constructing drainage systems, and intercropping multiple species in an area.

On other occasions, Bribri people have adopted new crops and management practices because it allows them to achieve specific goals. For example, Bribri people are controlling the incidence of the monilia disease in their commercial lands by learning how to graft resistant germplasm into old cacao trees. Over time, some of the useful crops and practices become part of Bribri habits, or what Bribri people would call "*criollo*." Criollo refers to a plant or a practice that has been used for a long time and to which people feel attachment (Rodriguez Valencia field notes December 1, 2015). For example, the seeds of the cacao trees locally known as criollo were obtained from the United Fruit Company´s farms (Interview with Adan Celles December 03, 2015). The interaction of criollo and adopted crops and management practices validates the expertise of Bribri people and broadens Bribri´s access to resources and knowledge that can be drawn upon for responding to environmental change.

The adoption of new crops and management practices is not automatically beneficial for Indigenous communities. Specially, if there is a dependency on outside forces. The reliance of indigenous communities on conservation and development programs, for example, can lead to an erosion of local knowledge and loss of biocultural diversity as new values (e.g., increases in forest cover and spatial reduction of swiddens) and preferences emerge (e.g., preferences for store bought processed food), affecting communities´ food autarky and autonomy to take decisions about their territories (D´Ambrosio and Puri 2016). On June 30, 2016 Ms. Dominga Morales explained it this way: accepting "aids" (*ayudas* in Spanish) can have a negative effect for Indigenous Peoples. For example, people become less creative as they get used to have someone

Table 5.2 Summary of the social-ecological memory involved in the cacao case and banana and plantain case, indicating the reservoirs of SEM, the mobile links involved, and the legacies.

Disruptors	Crop affected	Response (legacies)	Responses (reservoirs)	Mobile links
Panama disease	Banana Gross Michel	- Livelihoods diversification (e.g., hunting, fishing, gathering) - Cultivation of different Musa landraces	- Adoption of new subsistence crops (e.g., rice, adlay)	- Neighbors (Bribri people and Panamanian people)
Monilia	Cacao	- Removal of infected pods - Shade control - Identification of trees resistant to the fungal disease	- Adoption of cultivars resistant to monilia (e.g., hybrids and grafted material) - Adoption of new management strategies (e.g., grafting, pruning, diversification) - Adoption of new economic activity (commercial cultivation of banana Gross Michel)	- NGOs (e.g., ANAI) - Research institutes (e.g., CATIE) - Governmental institutions (e.g., Costa Rica agricultural department)
Sigatoka	Different varieties of Musa	- Use of fungicides - Construction of drainage systems - Disinfection of tools - Plot rotation - Intercropping practices - Continuous use of customary *Musa* cultivars	- Adoption of new Musa cultivars used for commercial purposes (e.g., banana lacatan and different types of plantain)	- NGOs (e.g., ANAI, Wilombe foundation) - Middle men - Governmental institutions

else (e.g., non-profits, government) solving their problems. Communities´ ability to strike the “right balance” between keeping local practices and adopting new information (Wilson 2012) and make autonomous decisions regarding the management of their resources and identity (Berkes and Davidson-Hunt 2007), are key elements for community resilience.

Since people in Yorkin still rely on a mix of subsistence and commercial agriculture, the impact of fungal pathogens has not required transformations. The dynamic interactions of both sources of knowledge, known in the literature as legacies and reservoirs, have provided the Bribri with the potential for re-organization following the impact of fungal diseases on their crops, enabling them to stay resilient and not to abandon their farms.

The results of this chapter confirm the idea that the use of biodiversity in Yorkin is a dynamic process. Moreover, I expand by explaining how people access biodiversity, environmental management practices, and technologies (e.g., agrochemicals) to deal with change. My results suggest Indigenous Peoples’ traditional practices, in addition to linkages with other sources of knowledge need to be nurtured to support resilience in agroforestry systems. The acceptance of new ideas, as well as the adoption of new resources shared by outsiders (e.g., new technologies, genetic material), is a constitutive right and the choices made by the Bribri in shaping their cultural system should be respected as a strength and not a framed by outsiders as a sign of weakness. Local and external sources or memory are necessary to respond in an efficient way to change. My results suggest that linkages with, and not dependence on external organizations can support Bribri responses to disruptions in their commercial plots.

How can stakeholders and researchers co-produce livelihood opportunities by drawing upon the capabilities of Bribri cacao agroforestry systems?

In chapter 4, I implemented and developed a biocultural design project to support the goal of Bribri community members of generating an alternative source of income by drawing upon the capabilities of their cacao agroforestry systems.

Bribri people perceive several problems in growing and commercializing cacao. These problems include the impact of fungal diseases in their cacao farms, market fluxes, and a lack of trust towards local buyers and providers of development projects. While many community residents have dealt with this discomfort through their engagement in different livelihood activities, the participants of this project imagined the creation of cacao added value products (e.g., cacao jelly, trail mix with seeds of trees located in agroforestry systems) and services (e.g., showcase farm) to support their livelihoods. The participants of this project, including myself, strategized, planned, and found ways to move forward desirable, feasible, and viable ideas into products by drawing upon biological resources and practices tied to Bribri identity (e.g., cacao and other *Theobroma* species) and guided by recognizing that some products are not feasible or viable. We understood that at times action had to be taken to improve the situation and often key resources (e.g., biological materials, placed-based knowledge, placed-based practices) needed to be used in an innovative way. When necessary, we complemented our capabilities by turning to others who could provide necessary ideas, information or resources needed to develop a product or service. The use of biodiversity by Bribri people to respond to a dynamic environment is not only having access to key biological resources, but also about the ability of Bribri people to display action and inventiveness.

In chapter 4, I put emphasis on the agency of the participants to 1) articulate cultural norms (what cannot or should not be acceptable) to guide product development, 2) imagine products or services that do not yet exist and, 3) recognize feasible and viable ways of getting things to happen. The results of this chapter confirm previous findings that recognize resourcefulness (access to material assets and people´s capacity to use these resources at the right time and in the right way) (Brown 2016) and inventiveness as key characteristics of people’s responses to change (Solnit 2010). The results of this chapter also confirm the idea that several benefits derived from ecosystems (e.g., use, economic incentives, cultural dimensions), as well as attitudes and values need to be considered in management interventions to achieve sustainable outcomes (Masterçon et al. 2019). At the same time, the findings of this chapter provide new information to the practice of co-production by offering a guide to 1) co-imagine and co-execute ideas to solve specific problems, and 2) create different types of value for stakeholders (e.g., cash flow by selling the cacao value added products to tourists), science (e.g., new knowledge to support the implementation of initiatives that take into consideration the Bribri needs, aspirations and values), and society in general (e.g., access to products rooted in Bribri knowledge, practices and innovations).

LIMITATIONS

A more nuanced description of agents that provide action (mobile links) in Chapter 3 could have contributed to understand the role of non-human agency in influencing social and ecological outcomes, as well as the political implications of development and conservation initiatives in the area. Resilience thinking has recently included discussions about the intentionality and actions of humans in shaping structures (Berkes and Ross 2013), social relations (Coulthard 2012;) and their own well-being (Brown and Westaway 2011). In this discussion, however, there has been little discussion of the ontologies of indigenous communities regarding agency and resilience (Miller and Davidson-Hunt 2013). In many Indigenous communities, agency is enacted through an actor's relations to the material components of society (e.g., plants, animals, objects) (ojalehto et al. 2017). Within this framing, material objects exert agency in a similar manner to humans (Dwiartama and Rosin 2014) and cycles of disturbance and renewal are maintained through relationships of reciprocity and cooperation between humans and other non-human agents (Miller and Davidson-Hunt 2012; ojalehto et al. 2015). The description of non-human mobile links in this research could have added to this debate by understanding:

- The role of non-human mobile links, such as rivers and birds, in shaping social ecological systems (e.g., impacts in local ecology, allocation of agricultural plots and houses)
- The materials, ideas, concepts and knowledge carried by non-human mobile links
- The relationships between Bribri people and non-human beings (e.g., reciprocal vs competitive relationships)

A more nuanced description of mobile links in this research could have also contributed to understand the political dimensions of the resilience in Bribri communities. The resilience of social ecological systems underplays the dynamics of social difference and limits the understanding of people's struggles when dealing with change (Davoudii et al. 2012; MacKinnon and Derickson 2013). In this regard, a more detailed description of mobile links could have contributed to understand if mobile links:

- shared the same views, perspectives and values as Bribri people when implementing conservation and development initiatives
- addressed local priorities of different sectors of society
- modified cultural norms and values because of interventions
- led to different impacts for different sectors of society
- promoted people's own adaptation strategies and preparedness

To sum up, the description of mobile links in this research could have contributed to "overcome social-ecological dichotomies within the notion of social ecological systems," (Brown 2016 p. 199), have a better understanding the Bribri notions of resilience, and understand the political dimensions of the resilience in Bribri communities.

THEORETICAL CONTRIBUTIONS

This thesis contributes knowledge to build theory in ethnobiology, resilience and co-production of knowledge. First, this thesis expands our understanding of the complexity of Indigenous Peoples' use of biodiversity. Ethnobiologists have recognized that the relationship between Indigenous Peoples and the biodiversity of their territories are complex, non-linear and multi-scalar (Zimmerer 2010). However, there are few studies in the published literature that use resilience ideas to examine the temporal and spatial dynamics around the use of biodiversity in Bribri indigenous communities. Most commonly, research on the use of biodiversity by Bribri Indigenous Peoples has focused on documenting scientific and folk names of the plants and animals´ that are produced, harvested or hunted in specific landscape patches at certain points in time (e.g., McLarney et al. 2003; García-Serrano and Del Monte 2004; Montoya-Greenheck 2011), as well as documenting the intergenerational transmission of indigenous knowledge associated with traditional species (e.g., Borge and Castillo 1997; Orcherton 2005).

The thesis also brings attention to the dynamics that exist around the use of biodiversity in Indigenous populations. In this regard, my results support the following ideas:

- The use of biodiversity by Indigenous Peoples is a dynamic process, and not a static corpus of biological organisms, knowledge, and practices as it is usually framed (Chapter 2).
- Indigenous Peoples use local and external sources of biodiversity richness, knowledge, and management practices to respond to biodiversity change (Chapter 3).
- Indigenous Peoples are not just keepers of knowledge but also creators of knowledge (Chapter 4).

In addition, this research expands our understanding of Bribri´s people agency to deal with change. Scholars have recognized the relevance of understanding the social dynamics of social ecological systems (Davoudi et al. 2012). Despite this call, there are few studies in the Bribri literature that recognizes the agency of Bribri people to respond to change. Most commonly, research on the use of biodiversity by Bribri Indigenous Peoples has focused on; 1) documenting loss of Indigenous Knowledge and traditional practices (García-Serrano and Del Monte 2004; Orcherton 2005); recording the structural forces constraining Bribri people´s capacity to deal with change (Dahlquist et al. 2007; Cole Villalobos 2009, Montoya Greenheck 2011), and 3) implementing pre-packaged projects focused on improving cocoa yields (e.g., Phillips-Mora et al. 2012).

This thesis also brings attention to the creative responses that Bribri people use to respond to a dynamic environment and shape change. In this regard, Bribri people have responded to a dynamic environment and have pursued their livelihoods by:

- using their traditional knowledge, practices, values, and skills to reconfigure their use of biodiversity (Chapter 2-4)
- using their worldview to shape change (Chapter 2)
- accessing reservoirs of outside knowledge, biological resources and management practices through their networks to respond to change (Chapter 3) and,
- recombining existing resources and capabilities to achieve contemporary goals and choose future pathways (Chapter 4).

Finally, the overall contribution of the thesis expands our understanding of Bribri people's agency to safeguard their heritage in ways that are relevant for them. Scholars have recognized the relevance of understanding the values, beliefs and perspectives of Indigenous People (Cocks, Vetter and Wiersum 2017) for a broader transformative impact for local and global sustainability (Merçon et al. 2019). It is possible that the use of deficit-based approaches to understand people's ability to deal with change has contributed to a predominance of frameworks that document how people lose knowledge at the expense of how they also create knowledge. By using a framework focusing on agency, social-ecological dynamics, and knowledge co-production, this thesis contributes to emerging approaches that focus upon Indigenous Peoples strengths and capabilities, rooted in biocultural heritage, and supporting Indigenous People's constitutive right of self-determination to create new futures (Davidson-Hunt et al. 2012; Cocks Vetter and Wiersum 2017). In this regard, this thesis expands on the co-production literature by offering a guide to co-imagine and co-execute ideas to solve specific problems, balancing the value of science, with the values of other actors.

METHODOLOGICAL CONTRIBUTIONS

This dissertation suggests several points of intervention to support Bribri people's capacity to respond to change:

- When tracking the use of biodiversity richness in an area, it is important to consider several points in time. Snapshots in time can be misleading in terms of apparent loss of biodiversity knowledge.
- In understanding peoples´ responses to change, it is important to consider the access and availability that people have to their reservoirs of social ecological memory transmitted across time, as well as the reservoirs of knowledge from their neighbors.
- In co-producing knowledge with Indigenous Peoples, it is important not only to co-create knowledge that can be used to implement development and conservation initiatives, but also to create other types of value for stakeholders (e.g., cash flow for stakeholders).

AVENUES FOR FUTURE RESEARCH

My thesis uncovers multiple avenues for future research regarding the study of use of biodiversity in Indigenous communities. First, my analysis reveals the need to analyze the temporal dynamics in the use of biodiversity in Indigenous communities. Increasing awareness of these dynamics is crucial to recognize the agency that Indigenous Peoples have to negotiate and to respond to change. Considering the complexity that exist between people and their use of biodiversity, my work has the potential of being followed up with an analysis of the temporal dynamics that exist in in the use of biodiversity at a genetic level. During my fieldwork, people were concerned about their current lack of access to a number of varieties/landraces of plants such as rice, avocado, corn, and pejibaye. Understanding the temporal dynamics that exist in the use of biodiversity at genetic level is necessary considering the number of species and local varieties that are threatened with extinction (IPBES’ 2019 Global Assessment Report on Biodiversity and Ecosystem Services).

Second, my analysis reveals the need to understand different spatial dynamics in the use of biodiversity. Increasing awareness of these dynamics is crucial to understand how people reorganize following the impact of a disruptor. In this regard, my work has the potential of being followed up with an analysis of 1) the bi-directional flows that characterize the exchanges of materials, knowledge and practices between the Bribri and their networks, 2) the contribution of other areas of literature (e.g., sociology, anthropology) to the understanding of the social ecological memory framework in supporting community responses to change. This discussion is necessary considering the multiple initiatives supporting environmental adaptation amongst Indigenous Peoples.

Third, my work has the potential to be followed up with a more detailed description of the individual levels of resilience in Bribri communities. For example, it would be interesting to analyze why some voices are heard and why some voices are not heard, how people are differentially affected by the same shocks, and how they respond in a different way according to their capabilities and opportunities. Considering that people's responses to environmental and socio-economic changes differ by gender, class, caste, and ethnicity (Arora-Jonsson 2011), an explicit recognition of gender aspects in the social ecological resilience literature should be taken into consideration (Bhattarai et al. 2015). Such analysis would offer a more detailed understanding of social dynamics of resilience.

Fourth, while writing up the results of my research, I became aware of other design approaches that speak to some of the challenges I found in doing my research. For example, I wondered how this project could have contributed to the self-determination of Bribri livelihoods. Manzini (2015) and Escobar (2018) suggest several strategies for local initiatives to have large-scale effects. One of these strategies refers to the efforts to consolidate and inspire other ideas. This does not mean that each particular case, with its specific context, needs to be reproduced. This means that the idea that resulted from the design journey (e.g., elaboration of cacao added value products) can be an inspiration for other Bribri in different local contexts. Scaling out rather than scaling up in recognition of the autonomous value integral to Bribri worldview. Another strategy refers to the efforts of connecting small initiatives to opportunities occurring in the broader economic, political, legal or cultural context. This can be done by creating a favorable environment for an idea to succeed autonomously (e.g., access to other markets). The identification of innovative ways to implement these strategies could be incorporated into the practice of biocultural design to support sustainable economic, and self-determined, development in rural and indigenous communities at a wider scale.

CONCLUDING THOUGHT

Indigenous communities in Latin America have been facing several challenges at they confront the COVID-19 pandemic. Some of these challenges include the disruption of food supply chains, mobility disruptions, and the return of large numbers of people from major cities and tourist sites to their communities of origin (Wight 2020). In Yorkin and Guabo, COVID-19 affected the touristic activities carried out locally, as well as the market of the plantains grow locally (interview with Saulin Morales March 15, 2020). These impacts have affected the incomes of the families relaying on these activities. According to my results, Bribri people possess resilient attributes that will help them to deal with the effects of COVID-19. In this regard, the approach developed in this research can be useful in tracking how people respond in resource dependent communities to COVID-19. Specifically, in terms of how their relationship with their environment may change as they need to draw more upon local resources and knowledge to satisfy basic necessities and food security.

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Appendices

Appendix 1. The history of Cacao. Storied shared with Mariana Rodriguez Valencia by Miriam Morales in Bribri and Spanish. Translation from Spanish to English are my own.

Tsuru' sté ta

Këweta Tsuru'dor alàkölpa iepa doKal shcél wañe, serkera ù élwe ëa, eta sibo dor ibekeiseto´su ye tö iepa kapowewa, eta Sibö mikë iepa ichakok. Tö, ye Ratse ata kapök, iepa tö Sibö a iche tö ver dör woke suluë e`kë kiane sa ua. Eta alàKöl bata dör iche Sibö a. Besko ye´tsa we ye kapoke, e bata Sibö Kapowa buaë. E´ ukoki Tsuru' wöbetse Sibö wa, Sobö a te senuk ieta, eta ielpa tso Sibö suluchofe. Etökichata Sibö mia bularme Kuok ditkata iepa mia iweblök, eto ieapa i suwa tó sibo dor buaë keró sulue, e Keshkato Sibö dor iépa sulachelo, e´kueki Tsuru' ejte ke sadle yiwa, sa bribriwak e wa isudle, e´kuekita Tsuru' dor buaë iyiuliteneki, ena sudle ulitenewa ka wame ki. Sa´ towa repa Koro, Skuàlö, Salo', Wë̀röm ena Wë̀shwö

Tsuru' tiene su historia

Al inicio había cuatro mujeres cacao, ellas vivían en una sola casa. Un día Sibö pensó, "haré que estas mujeres se duerman, mientras eso iré a pedirles posada para quedarme con ellas." Al llegar Dios a pedirles posada ellas lo rechazaron y se burlaron de él diciéndole que era viejo y feo, por eso no lo dejaban entrar a la casa de ellas. Sin embargo, la hermana menor, quien tuvo lástima de verlo sin techo para pasar la noche, le presto un lugar en su cuarto y así Sibö pudo pasar la noche bien. Después, la pequeña hermana se enamoró del invitado y Dios se quedó viviendo con ella. El resto de las hermanas se enojaron y hablaron mal de él. Una mañana, Dios fue a bañarse al rio y el resto de las hermanas, al espiarlo, se enteraron del secreto del invitado. En ese momento se dieron cuenta que Sibö no era feo. Los que Sibö quería saber era que tan buenas eran esas mujeres. De esta manera Sibö eligió a la mujer cacao y la bendijo. Por esta razón, la mujer cacao es reconocida por todo el mundo y es una planta muy útil. En cambio, muy pocas personas, incluyendo a los Bribris, conocen a las otras mujeres cacao y no son tan deliciosos como Tsuru'. Los nombres de las cuatro plantas de cacao son: Skuàlö, Salo', Wë̀röm ena Wë̀shwö

The Tsuru' history

When everything started, there were four cocoa women, all of them shared a house. One day Sibö though, "I will make these women to sleep, and I will ask them if I can stay with them." When Sibö arrived in their place to ask them if he could stay, the cocoa women rejected him he was old and ugly. That is why they did not allow him to stay with them. However, the youngest sister, who felt bad about seeing the poor man without a place where to stay, allowed him to stay in a place, at her room. That's how Sibö could have a good night. Then, the youngest sister fell in love with the guest and Sibö stayed with her and they decided to live together. The rest of the sisters were mad and mad some gossips about the guest. One day, Sibö went to the river for a shower, and the rest of the sisters, realized he was not an ugly man and that he was Sibö. They also realized that Sibö only wanted to know if they were good women. This is how Sibö chose the youngest sister as the women cocoa and he blessed her. That is why, Tsuru' (cocoa) is worldwide known and it is a very useful plant. Instead, few people, including the Bribri, know the rest of the cocoa plants and they are not as delicious as Tsuru'. The name of the four cocoa plants are: Skuàlö, Salo', Wȅröm ena Wȅshwö

Appendix 2. List of the people who participated in this research (Life history interviews)

Name	**Gender**	**Age at the time of the interview**	**Interview location**	**Date**
Justa Morales	Female	73	Guabo, Costa Rica	August 4, 2016
Dominga Morales	Female	70	Yorkin, Costa Rica	October 10, 2016
Reyna Morales	Female	71	Dacles, Panama	December 2, 2015
Fabiana Morales	Female	71	Yorkin, Costa Rica	May 13, 2016
Miriam Morales	Female	50	Yorkin, Costa Rica	August 1, 2016
Saulin Morales	Female	43	Yorkin, Costa Rica	May 8, 2016
Deisy Peterson	Female	40	Yorkin, Costa Rica	July 26, 2016
Adan Celles	Male	90	Dacles, Panama	December 3, 2015
Adolfo Celles	Male	85	Yorkin, Costa Rica	September 10, 2015
Cirilo	Male	76	Guabo, Panama	April 19, 2016
Roberto Morales	Male	75	Yorkin, Costa Rica	September 07, 2015
Guillermo Torres	Male	69	Yorkin, Costa Rica	December 2, 2015
Longino Celles	Male	46	Yorkin, Costa Rica	July 13, 2016

Emilio	Male	40	Yorkin, Costa Rica	May 27, 2016

List of people who participated in this research (Transect walks)

Name	Gender	Plots visited	Interview location	Date
Rodrigo Morales	Male	Primary forest and cacao farm	Guabo, Panama	May 10, 2016
Saulin Morales	Female	Swidden plot, cacao and banana farm, primary forest	Yorkin, Costa Rica and Dacles, Panama	May 23, 206
Maura Morales	Female	Swidden plot, cacao and banana farm, primary forest	Yorkin, Costa Rica	December 2, 2015
Hilda	Female	Swidden plot, cacao and banana farm, primary forest and plantain plot	Guabo, Panama	May 13, 2016
Sonia	Female	Cacao, coffee and banana farm,	Guabo, Panamá	August 1, 2016
Justa Morales	Female	Cacao and banana farm, primary forest	Guabo, Panama	May 8, 2016
Sixta Celles	Female	Cacao and banana farm, primary forest	Guabo, Panama	August 2, 2016

Longino Celles	Male	Cacao and banana farm, primary forest	Guabo, Panama	November 24, 2015
Freddy	Male	cacao and banana farm, primary forest	Yorkin, Costa Rica	August 23, 2015 and a follow up walk on July 4, 2016
Emilio	Male	cacao and banana farm	Yorkin, Costa Rica	April 19, 2016
Valencia	Female	cacao and banana farm	Yorkin, Costa Rica	August 10, 2015

List of people who participated in this research (Semi-structured interviews)

Name	**Affiliation**	**Interview location**	**Date**
Wilbert Phillips	Tropical Agricultural Research and Higher Education Center	Turrialba, Costa Rica	July 20, 2016
Roberto Mack and Diego Lynch	The new alchemist association (ANAI)	San José, Costa Rica	June 26, 2016
Silica	Fundación Wilombe	Phone	May 25, 2017
Cristian	Fundación ACOPRO	Home Creek, Costa Rica	Junio 27, 2016 and follow up May 13, 2017
Jonás	Ministry of Agriculture, Costa Rica	Yorkin, Costa Rica	November 17, 205

Appendix 3. Guide of interview for life histories of Yorkin farmers

Natural resources institute
University of Manitoba

Date: _________/____________/__________
Year Day Month

Place of the interview_____________________________

Interviewer __________________________________

I. Personal information of the interviewee

1. Name ____
2. Age ______________________________
3. Male/Female
4. Years living in the community ____
5. Education level ____
(Years of formal studies)

II. Guide of questions

Category	Example of questions
Birth and family origin	What do you remember most about your parents and grandparents? What was their main work and where they did it? What was going on in your community when you were born?

Livelihood activities	What have been the main livelihood activities you have done through your life? Have you worked outside of Yorkin? Why did you decide to work outside of Yorkin? What happened to your farm when you were not in Yorkin?
Farm	Are you the owner of this land? How did you obtain it? How big is it? Has the size changed in the last 30 years? Who decided what to grow in the farm? Who helps you to maintain the farm and how they contribute to maintain it?
Historical events and periods	In what ways has your farm changed in the last 30 years? Does your farm have approximately the same type and number of trees than in the past? Yes, no, why? What have been the main challenges to produce crops and how did you solve it? What where the crucial decisions in your life regarding your farm? What is different or unique about your farm and the other ones in the community? Do you remember any program in the community that had helped you to improve the production of cacao/banana(plantain in your farm? Who offered it? Is this program still working? What did you learn in that program? What have you done to contribute to your community? What is your biggest worried now regarding your farm?

Vision of the future	How do you see your farm in 30 years? Do you have any advice for younger generations regarding their farms?

III. General observations

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Appendix 4. Guide of interview for conservation and development organizations/research institutes/governmental agencies

Natural resources institute
University of Manitoba

Date: _________/____________/__________
Year Day Month

Place of the interview______________________________

Interviewer ___________________________________

I. Personal information of the interviewee

1. Name

____

2. Years working in organization

____

3. Main responsibilities in the organization/research institute

____

____

____

II. Guide of questions

1. Can you please tell me the history of your organization?
2. How, who and when did it started?
3. What is the mission/vision of your organization?
4. Have the mission/vision change since the organizations started operations?
5. What have been the main challenges of your organization?

6. Can you please describe the main initiatives applied in Bribri communities? (Goals, funding, outcomes)

III. General observations

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Appendix 5. Codebook

Is the narrative of decline and loss in biodiversity richness, measured against what was used in at some point in the past the only way to think about the relationship between Bribri People and the biodiversity of their territory?

Node	Sub-node 1	Sub-node 2	Sub-node 3
Biodiversity richness per landscape patch.	Mountain Swidden farms River Home garden Cattel ranch Banana farms Plantain monocultures		
Disruptors affecting the livelihoods of the interviewers in the last 80 years	Description of the Withdrawal of the United Fruit Company (1931–1945)	Local narratives	
		Explanations found in the literature	
	Description of the Global Demand for Cacao (1945–1979)	Local narratives	
		Explanations found in the literature	
	The Monilia Crisis (1979–1985)	Local narratives	
		Explanations found in the literature	
	The Conservation and development Narratives (1985–2016)	Local narratives	
		Personal observations	

Responses to disruptors	Responses to the Withdrawal of the United Fruit Company (1931–1945	Copping responses	Name of plants and animals used for construction, food and commercial purposes from 1931-1945
		Adapting responses	
	Responses to the Global Demand for Cacao (1945–1979)	Copping responses	Name of plant and animals used for construction, food and commercial purposes from 1945-1979
		Adapting responses	
	Responses to the Monilia Crisis (1979–1985)	Copping responses	Name of plant and animals used for construction, food and commercial purposes from 1979-1985
		Adapting responses	
	Responses to the Conservation and development Narratives (1985–2016)	Copping responses	Name of plant and animals used for construction, food and commercial purposes from 1985-2016
		Adapting responses	

How have Bribri people drawn upon their social ecological memory to respond to the invasion of fungal pathogens in their commercial lands?

Node	Sub-node 1	Sub-node 2	Sub-node 3	Sub-node 4
Biodiversity change in the last 80 years (Events)	Event 1. Monilia	Responses to monilia	Species and landraces or varieties	Legacies, Reservoirs, mobile links
			Biodiversity use	Legacies, Reservoirs, mobile links
			Management practices	Legacies, Reservoirs, mobile links
	Event 2. Panama disease	Responses to panama disease	Species and landraces or varieties	Legacies, Reservoirs, mobile links
			Biodiversity use	Legacies, Reservoirs, mobile links
			Management practices	Legacies, Reservoirs, mobile links
	Event 3. Black sigatoka disease	Responses to sigatoka disease	Species and landraces or varieties	Legacies, Reservoirs, mobile links
			Biodiversity use	Legacies, Reservoirs, mobile links
			Management practices	Legacies, mobile links and reservoirs

How can stakeholders and researchers co-produce livelihood opportunities by drawing upon the capabilities of Bribri cacao agroforestry systems?

Node	Sub-node 1	Sub-node 2	Sub-node 3
Inspiration phase	Morales Family	Problems perceived and aspirations	
		Areas of opportunity for collaboration	
	Celles family	Problems perceived and aspirations	
Ideation phase	Morales Family	Desirable ideas Feasible ideas Viable ideas	
	Celles family	Desirable ideas Feasible ideas Viable ideas	
Implementation phase	Morales Family	Capabilities	Species, Knowledge, practices, attachment to species/practices

			Access to external sources of knowledge
		Values	
		Perceived benefits	
	Celles family	Capabilities	Species, Knowledge, practices, attachment to species/practices Access to external sources of knowledge
		Values	
		Perceived benefits	

Appendix 6. Consent forms

Formato de consentimiento informado a agricultores en Yorkin: Historias de vida – Versión en Español

Proyecto de investigación: El tour del cacao: 35 años de respuestas a cambios en la comunidad Bribri de Yorkin
Investigadora: Mariana Rodríguez Valencia
Proyecto patrocinado por el Consejo Nacional de Ciencia y Tecnología (Conacyt-México) y el Social Science and Humanities Research Council of Canada (SSHRC), a través de los fondos Dr. Iain Davidson-Hunt

Con este formato de consentimiento informado, el cual usted recibirá una copia, espero darle una idea sobre los objetivos de mi investigación y de lo que implica su participación. Si usted desea más información o tiene alguna duda, por favor siéntase libre de preguntarme. Asimismo, le agradezco se tome el tiempo de entender este formato cuidadosamente y de comprender cualquier información adjunta.

Objetivos y propósito de la investigación. La presente investigación es parte de mis estudios de doctorado en el programa de Manejo de Recursos Naturales, ofrecido por la Universidad de Manitoba, Canadá. El objetivo principal de esta investigación es explorar los aspectos que han facilitado la producción de cacao en Yorkin, a pesar de haber sufrido impactos ambientales y cambios socio-económicos en los últimos 35 años. Para entender este tema, busco responder a preguntas como: ¿Por qué algunos agricultores Yorkin, pero no en otros, usan sus tierras para producir cacao? ¿Qué acciones se han tomado individual y colectivamente para mantener las plantaciones de cacao en Yorkin en los últimos 35 años? Esta investigación se llevará a cabo de agosto 2015 a junio 2016 y este formato se ha diseñado para proporcionarle información sobre los objetivos, métodos, posibles riesgos y beneficios, así como los resultados esperados en esta investigación.

Su participación. Su participación es voluntaria. Si usted decide participar, puede retirarse del estudio en cualquier momento con solo confirmarme su decisión antes de la publicación de mi tesis (fecha estimada de publicación Septiembre 2018). Por otra parte, si usted decide retirarse de esta investigación, toda su información será destruida a menos que usted me indique que los datos pueden ser parte de mi estudio. Si usted se retira de esta investigación, se hará todo lo posible para eliminar y destruir sus contribuciones. Usted también tiene el derecho de omitir cualquier pregunta (s) o procedimiento (s) que deseé. Si usted acepta participar, se le pedirá su colaboración en este proyecto por un período máximo de 2 meses (Octubre-Noviembre 2015). Usted será invitado a participar en una entrevista conocida como historia de vida, a su discreción y conveniencia. En promedio, esta actividad tendrá una duración de una hora y no excederán dos horas por sesión.

Obtención de la información: Durante mi estancia en Yorkin, le pediré su participación voluntaria en una entrevista llamada historia de vida. Usted tiene el derecho a decidir si la entrevista pueden ser grabada con una grabadora digital, o si profiere que registre sus respuestas en notas de campo. Usted siempre será informado si estoy documentando información que puede ser potencialmente utilizada en esta investigación. Para asegurarme que usted está plenamente consciente sobre la información que utilizaré, repasaré con usted sus respuestas después de cada entrevista para confirmar que he entendido sus ideas correctamente.

El objetivo de una historia de vida es identificar los eventos que han afectado las fincas de cacao, así como las respuestas que los habitantes de Yorkin han tenido para afrontar las crisis percibidas. En esta entrevista se le preguntará información referente a la historia de su finca (por ejemplo, el origen de su tierra, el área dedicada a ciertos cultivos a través del tiempo, etc.), las principales actividades productivas realizadas en su vida, y los motivos para definir los cultivos en su finca. Las entrevistas serán documentadas como usted decida; usando una grabadora digital o en notas de campo.

Anonimato y confidencialidad: Usted decidirá si desea utilizar su nombre real o si desea permanecer en el anonimato. Si usted solicita el anonimato, se le dará un pseudónimo y toda la información que lo identifique potencialmente será removida de cualquier producto generado en esta investigación; únicamente yo tendré acceso a los nombres reales de los participantes anónimos. Asimismo, toda la información obtenida en esta investigación será confidencial y el acceso será limitado a mi y a mi asesor de tesis. Las notas de campo y grabaciones serán almacenadas y protegidas en con un candado durante la etapa de recopilación, análisis y redacción. Los datos primarios se mantendrán en el anonimato y la información de identificación será removida de las transcripciones y/o grabaciones.

La información generada en esta investigación será destruida después de haber publicado los resultados en una tesis, publicaciones académicas, informes y presentaciones con fines educativos, o tres años después de haber finalizado mi tesis. En la sección final de este documento, se le pedirá que proporcione su consentimiento informado con respecto a: 1) su autorización para usar sus contribuciones de forma pública, 2) su autorización para citar directamente sus contribuciones y utilizarlas públicamente, y 3) su decisión para usar o no usar información que lo identifique antes de que lo entreviste. Finalmente, usted puede solicitarme cualquiera de sus contribuciones y/o otra información no confidencial en cualquier momento de la investigación.

Riesgos y beneficios. Su participación en esta investigación no contempla riesgos físicos o económicos. Sin embargo, es posible que usted se sienta perturbado al recordar las dificultades que ha sufrido para producir cacao y mantener a su familia. Para mitigar este riesgo, le recuerdo que usted tiende derecho a omitir cualquier pregunta que lo haga sentir incomodo y que en caso de ser necesario, usted puede retirarse de esta investigación en cualquier momento. Asimismo, en caso que usted decida compartir información que potencialmente lo identifique, yo mantendré la confidencialidad de esta información durante todo el proceso de investigación. Por ejemplo, usted será referido en mis notas de campo y otros archivos con un código confidencial. Asimismo, los archivos digitales generados será bloqueados con una contraseña y todas las entrevistas se llevarán a cabo de forma individual, a menos que usted solicite lo contrario.

Además, le recuerdo que su participación es voluntaria, usted puede cancelar este consentimiento en cualquier momento, y usted tiene el derecho a permanecer en el anonimato. Esta investigación tiene como objetivo documentar parte de la historia de su comunidad y reconocer las habilidades, conocimientos y creatividad de los habitantes de Yorkin para superar crisis. Los resultados de esta investigación estarán disponibles para usted y para otras organización(es) comunales. La información generada en esta investigación podrá ser utilizada con fines educativos y como base para futuros proyectos relacionados con el manejo de las fincas en su comunidad.

Compensación Esta investigación no contempla ninguna compensación económica. Sin embargo, es mi intención hacer trabajo voluntario en su finca participando en sus actividades diarias tales como limpieza, cosecha, procesamiento de alimentos. Además, espero que esta actividad me permita recibir su retroalimentación respecto a mis objetivos y la forma en la que estoy conduciendo esta investigación.

Retroalimentación y publicación de los resultados: Usted será invitado a expresar sus intereses y preocupaciones en cualquier momento de esta investigación. Además, después de cada entrevista regresaré con usted para verificar que la interpretación de mis resultados sea correcta. Los resultados no confidenciales generados en este proyecto serán accesibles a los participantes aproximadamente tres meses después de haber terminado mi proyecto de investigación. Usted tiene el derecho a preguntar por una copia de los resultados al final de esta investigación. Asimismo, se le dará una copia a representantes de la comunidad (escuelas, consejos, asociaciones). De solicitarlo, usted también podrá tener una copia impresa de las transcripciones de su entrevista.

Además, se le pedirá que proporcione su consentimiento informado para hacer pública la información obtenida en esta investigación en uno o mas de los siguientes productos académicos/artísticos: una tesis escrita, publicaciones académicas, informes, sitios web con fines académicos, presentaciones, conferencias e investigaciones. Los datos no analizados se mantendrán en el anonimato y cualquier información que lo identifique será retirada de cualquier documento público. Asimismo, la información obtenida en esta investigación será destruida después de haber completado las publicaciones correspondientes, o tres años después de haber completado mis estudios de doctorado.

Información de contacto:

Mariana Rodriguez Valencia Estudiante de Doctorado Universidad de Manitoba, Canadá Teléfono en Costa Rica 85 82 02 47 E-mail: rodrig13@myumanitoba.ca	Dr. Iain Davidson-Hunt Asesor de investigación Universidad de Manitoba, Canadá Teléfono en Canadá +1(204)-474-8680 E-mail: Iain.DavidsonHunt@umanitoba.ca

La Universidad de Manitoba podrá acceder a sus contribuciones para verificar que esta investigación se esta conduciendo de una manera segura y adecuada. Esta investigación ha sido aprobada por el Comité de Ética de la Universidad de Manitoba - JFREB. Si usted tiene alguna inquietud o queja sobre este proyecto puede comunicarse con cualquiera de las personas mencionadas anteriormente o con la Coordinadora de Ética en Humanos (HEC) al teléfono +1 (204) 474-7122, o al siguiente correo electrónico: margaret_bowman@umanitoba.ca. Usted recibirá una copia de este formulario para su referencia.

Consentimiento: Se le pedirá que proporcione su consentimiento informado para múltiples aspectos de esta investigación, ya sea por escrito o en una grabación de audio. El consentimiento cubre todo el periodo de la investigación, por lo tanto, una vez que se ha dado, también puede ser retirado.

¿Tiene usted alguna pregunta respecto a este formato o esta investigación?

Si/No	1. He leído, o se me han leído este formulario de consentimiento.
Si/No	2. Mis preguntas han sido respondidas.
Si/No	3. Acepto que mi entrevista sea grabada en audio
Si/No	4. Deseo permanecer en el anonimato en todos los aspectos de esta investigación.
	5. Estoy de acuerdo en el uso público de ...
Si/No	citas que me identifiquen personalmente
Si/No	citas anónimas
	... En los productos generados en esta investigación (e.g., tesis escrita, publicaciones académicas, informes, sitios web con fines académicos, presentaciones, conferencias e investigaciones relacionadas con fines académicos/artísticos).
	6. Estoy de acuerdo en que el uso de mis contribuciones sea utilizado en un informe o presentaciones preparados para:
Si/No	a. Organizaciones que promueven la conservación de la naturaleza
Si/No	b. Autoridades u organizaciones comunitarias
Si/No	7. Deseo recibir un resumen de los resultados de la investigación
Si/No	8. Deseo recibir copias impresas de las transcripciones generadas en este ejercicio de investigación
Si/No	9. Solicito que la información que me identifique personalmente se omita de mis contribuciones antes de ser almacenada cuando esta investigación termine.

Su firma en este formulario indica que usted ha entendido, esta satisfecho con la información recibida y esta de acuerdo en participar en esta investigación. Firmar este formulario no implica de ninguna manera que usted renuncia a sus derechos legales, ni a liberara los investigadores, patrocinadores o instituciones participantes de sus responsabilidades legales y profesionales. Usted es libre de retirarse del estudio en cualquier momento, y / o de abstenerse de responder a cualquier pregunta que usted prefiera omitir, sin perjuicio o consecuencia. Su continua participación en el proyecto debe de ser informada y consentida por usted en todo momento. Por lo tanto, usted debe sentirse libre de pedir aclaraciones o información nueva a lo largo de su participación.

Firma del participante Fecha

Firma del participante Fecha

Para consentimiento registrado oral, por favor, repita: "Estoy de acuerdo en participar en esta investigación."

Formato de consentimiento informado para agricultores de Yorkin: Entrevistas etnobotánicas– Spanish version

Proyecto de investigación: El tour del cacao: 35 años de respuestas a cambios en la comunidad Bribri de Yorkin
Investigadora: Mariana Rodríguez Valencia
Proyecto patrocinado por el Consejo Nacional de Ciencia y Tecnología (Conacyt-México) y el Social Science and Humanities Research Council of Canada (SSHRC), a través de los fondos Dr. Iain Davidson-Hunt

Con este formato de consentimiento informado, el cual usted recibirá una copia, espero darle una idea sobre los objetivos de mi investigación y de lo que implica su participación. Si usted desea más información o tiene alguna duda, por favor siéntase libre de preguntarme. Asimismo, le agradezco se tome el tiempo de leer o entender este formato cuidadosamente y de comprender cualquier información adjunta.

Objetivos y propósito de la investigación. La presente investigación es parte de mis estudios de doctorado en el programa de Manejo de Recursos Naturales, ofrecido por la Universidad de Manitoba, Canadá. El objetivo principal de esta investigación es explorar los aspectos que han facilitado la producción de cacao en Yorkin, a pesar de haber sufrido impactos ambientales y cambios socio-económicos en los últimos 35 años. Para entender este tema, busco responder a preguntas como: ¿Por qué algunos agricultores Yorkin, pero no otros, usan sus tierras para producir cacao?¿Cuál es la riqueza biológica de las fincas en Yorkin? Esta investigación se llevará a cabo de agosto 2015 a junio 2016 y este formato se ha diseñado para proporcionarle información sobre los objetivos, métodos, posibles riesgos y beneficios, así como los resultados esperados en esta investigación.

Su participación. Su participación es voluntaria. Si usted decide participar, puede retirarse del estudio en cualquier momento. Si usted se retira de esta investigación, se hará todo lo posible para eliminar y destruir sus contribuciones. Usted también tiene el derecho de omitir cualquier pregunta (s) o procedimiento (s) que deseé. Si usted acepta participar, se le pedirá su colaboración en este proyecto por un período máximo de 3 meses (Enero-Marzo 2016). Su participación consistirá en permitirme a mi caminar con usted en su finca y hacer una lista de las plantas encontradas ahí.

Obtención de la información: Durante mi estancia en Yorkin, le pediré su participación voluntaria para ser entrevistado. Usted siempre será informado si estoy documentando información que puede ser potencialmente utilizada en esta investigación. Para asegurarme que usted está plenamente consciente sobre la información que utilizaré, repasaré con usted sus respuestas después de cada entrevista para confirmar que he entendido sus ideas correctamente.

He diseñado un instrumento de investigación preliminar para conocer a) algunas de sus características socio-económicas (por ejemplo, su edad, nivel de educación, tamaño familiar), b) el tamaño de su finca y 3) las plantas que se encuentran en su finca (diversidad biológica). Esta entrevista se aplicará a los dueños de la finca y esta diseñada para durar dos horas por sesión. Los resultados se registraran en un cuaderno, y después de cada entrevista, se hará una copia de seguridad en un archivo electrónico, que será protegido con una contraseña. Para ilustrar la riqueza botánica de sus fincas, pediré también su permiso para tomar fotografías de las plantas encontradas.

Anonimato y confidencialidad: Usted decidirá si desea utilizar su nombre real o si desea permanecer en el anonimato. Si usted solicita el anonimato, se le dará un pseudónimo y toda la información que lo identifique potencialmente será removida de cualquier producto generado en esta investigación; únicamente yo y mi asesor tendremos acceso a los nombres reales de los participantes anónimos. Las notas de campo, grabaciones y/o fotografías serán almacenadas y protegidas en con llave durante la etapa de recopilación, análisis y redacción. Los datos primarios se mantendrán en el anonimato y la información de identificación será removida de las notas de campo y/o fotografías.

La información generada en esta investigación será destruida después de haber publicado los resultados en una tesis, publicaciones académicas, informes y presentaciones con fines educativos, o tres años después de haber finalizado mi tesis. En la sección final de este documento, se le pedirá que proporcione su consentimiento informado con respecto a: 1) su autorización para usar sus contribuciones de forma pública, 2) su autorización para citar directamente sus contribuciones y utilizarlas públicamente, y 3) su decisión para usar o no usar información que lo identifique antes de que lo entreviste. Usted puede solicitarme cualquiera de sus contribuciones y/o otra información no confidencial en cualquier momento de la investigación. Usted puede omitir sus respuestas o abandonar esta investigación en cualquier momento que lo decida. En caso que usted decida retirarse, sus contribuciones serán eliminadas de las notas de campo, archivos electrónicos y/o fotografías.

Riesgos y beneficios. Su participación en esta investigación no contempla riesgos físicos o económicos. La descripción etnobotánica de su finca, esta diseñada para proteger sus derechos de propiedad intelectual mediante la identificación de las plantas en su finca, en vez de recolectar y de enviar los especímenes a un herbario. Asimismo, tengo contemplado documentar el uso de las plantas utilizando amplias categorías de uso (por ejemplo, construcción, alimentos, ceremonias). La confidencialidad de la información generada en esta investigación se mantendrá en todo momento. En mis notas de campo y otros archivos, usted será referido con un código. Asimismo, los archivos digitales generados será bloqueados con una contraseña y todas las entrevistas se llevarán a cabo de forma individual, a menos que usted solicite lo contrario.

Además, le recuerdo que su participación es voluntaria, usted puede cancelar este consentimiento en cualquier momento, y usted tiene el derecho a permanecer en el anonimato. Esta investigación tiene como objetivo documentar parte de la historia de su comunidad y reconocer la diversidad biológica encontrada en Yorkin y los conocimientos que los habitantes de Yorkin tienen. Los resultados de esta investigación estarán disponibles para usted y para otras organización(es) comunales y/o de conservación de la naturaleza. La información generada en esta investigación podrá ser utilizada con fines educativos y como base para futuros proyectos relacionados con el manejo de las fincas en su comunidad.

Compensación No proporcionaré ninguna compensación monetaria para los participantes de esta actividad de investigación. Sin embargo, es mi intención hacer trabajo voluntario en su finca participando en actividades tales como limpieza, cosecha, procesamiento de alimentos. Además, espero que esta actividad me permita recibir su retroalimentación respecto a mis objetivos y la forma en la que estoy conduciendo esta investigación.

Retroalimentación y publicación de los resultados: Usted será invitado a expresar sus intereses y preocupaciones en cualquier momento de esta investigación. Además, después de cada entrevista regresaré con usted para verificar que la interpretación de mis resultados sea correcta. Los resultados no confidenciales generados en este proyecto serán accesibles a los participantes aproximadamente tres meses después de haber terminado mi proyecto de investigación. Usted tiene el derecho a preguntar por una copia de los resultados al final de esta investigación. Asimismo, se le dará un resumen de los resultados de esta investigación a representantes de la comunidad (escuelas, consejos, asociaciones). De solicitarlo, usted también podrá tener una copia impresa de las transcripciones de su entrevista (favor de indicar su interés en la parte final de este documento).

Además, se le pedirá que proporcione su consentimiento informado para hacer pública la información obtenida en esta investigación en los productos de esta investigación (por ejemplo; una tesis escrita, publicaciones académicas, informes, sitios web con fines académicos, presentaciones, conferencias e investigaciones relacionadas con fines académicos/artísticos). Los datos no analizados se mantendrán en el anonimato y cualquier información que lo identifique será retirada de cualquier documento público. Asimismo, la información obtenida en esta investigación será destruida después de haber completado las publicaciones correspondientes, o tres años después de haber completado mis estudios de doctorado.

Información de contacto:

Mariana Rodriguez Valencia Estudiante de Doctorado Universidad de Manitoba, Canadá	Dr. Iain Davidson-Hunt Asesor de investigación Universidad de Manitoba, Canadá

85 82 02 47 E-mail: rodrig13@myumanitoba.ca	Teléfono en Canadá +1(204)-474-8680 E-mail: Iain.DavidsonHunt@umanitoba.ca

La Universidad de Manitoba podrá acceder a sus contribuciones para verificar que esta investigación se esta conduciendo de una manera segura y adecuada. Esta investigación ha sido aprobada por el Comité de Ética de la Universidad de Manitoba - JFREB. Si usted tiene alguna inquietud o queja sobre este proyecto puede comunicarse con cualquiera de las personas mencionadas anteriormente o con la Coordinadora de Ética en Humanos (HEC) al teléfono +1 (204) 474-7122, o al siguiente correo electrónico: margaret_bowman@umanitoba.ca. Usted recibirá una copia de este formulario para su referencia.

Consentimiento: Se le pedirá que proporcione su consentimiento informado para múltiples aspectos de esta investigación, ya sea por escrito o en una grabación de audio. El consentimiento cubre todo el periodo de la investigación, por lo tanto, una vez que se ha dado, también puede ser retirado.

¿Tiene usted alguna pregunta respecto a este formato o esta investigación?

Si/No	1. He leído, o se me han leído este formulario de consentimiento.
Si/No	2. Mis preguntas han sido respondidas.
Si/No	3. Deseo permanecer en el anonimato en todos los aspectos de esta investigación.
	4. Estoy de acuerdo en que el uso de mis contribuciones sea utilizado en un informe o presentaciones preparados para:
Si/No	a. Organizaciones que promueven la conservación de la naturaleza
Si/No	b. Autoridades comunitarias
Si/No	5. Autorizo que las plantas localizadas en mi finca sean fotografiadas y sean usadas en los productos de esta investigación

Si/No	6. Deseo recibir un resumen de los resultados de la investigación
Si/No	7. Deseo recibir copias impresas de los resultados generados en este ejercicio de investigación (fotografías y/o transcripciones)
Si/No	8. Solicito que la información que me identifique personalmente se omita de mis contribuciones antes de ser almacenada cuando esta investigación termine.

Su firma en este formulario indica que usted ha entendido, esta satisfecho con la información recibida y esta de acuerdo en participar en esta investigación. Firmar este formulario no implica de ninguna manera que usted renuncia a sus derechos legales, ni a liberara los investigadores, patrocinadores o instituciones participantes de sus responsabilidades legales y profesionales. Usted es libre de retirarse del estudio en cualquier momento, y / o de abstenerse de responder a cualquier pregunta que usted prefiera omitir, sin perjuicio o consecuencia. Su continua participación en el proyecto debe de ser informada y consentida por usted en todo momento. Por lo tanto, usted debe sentirse libre de pedir aclaraciones o información nueva a lo largo de su participación.

Firma del participante Fecha

Firma del participante Fecha

Para consentimiento registrado oral, por favor, repita: "Estoy de acuerdo en participar en esta investigación”

Appendix 7. List of species reported by each social-ecological system.

Legend
____ Use of biodiversity richness at the community level
…… Use of biodiversity richness at the individual level
Absence of the specie(s) in the Yorkin territory
* Non-identified species

Landscape unit	Spanish name	English name	Bribri name	Family	Scientific name	Main use	SES 1	SES 2	SES 3	SES 4
Forest	Manu	Manwood	*Tsulë'*	Olacaceae	*Minquartia guianensis* Aubl.	Shelter	……	____	……	____
Forest	Casha		*Kasha*	Fabaceae	*Abarema idiopoda* (S.F.Blake) Barneby & J.W.Grimes	Shelter	……	____	……	____
Forest	Suita		*Ùkö*	Arecaceae	*Geonoma congesta* H.Wendl. ex Spruce	Shelter	____	……	……	____
Forest	Jira		*Kõ'*	Arecaceae	*Iriartea deltoidea* Ruiz & Pav.	Shelter	____	……	……	____
Forest	Almendro	Tonka Bean		Leguminosae	*Dipteryx oleifera* Benth.	Shelter	……	____	……	……
Forest	Oreja de mula			Asteraceae	*Pseudelephantopus spicatus* (Juss. ex Aubl.) Rohr	Shelter	……	____	……	……
Forest	Fruta dorada			Myrtaceae	*Virola koschnyi* Warb.	Shelter	……	……	……	……

Forest	Bejuco real		*Sȅmaña*		*Monstera* sp.	Shelter
Home garden	Laurel	Manjack	*Yuwȅ*	Boraginaceae	*Cordia alliodora* (Ruiz & Pav.) Oken	Shelter
River	Caña blanca		*Kuàköl*	Poaceae	*Gynerium* sp.	Shelter
Forest	Cabro de monte	Red Brocket	*Kàl-sũlĩ*	Cervidae	*Mazama americana* (Erxleben, 1777)	Food
Forest	Chancho de monte	White-lipped Peccary	*Sini´*	Tayassuidae	*Tayassu pecari* (Link, 1795)	Food
Forest	Gallina de monte		*Tchù*	Cracidae		Food
Forest	Pavo de monte		*Dúsiãl*		*Chaemapetes unicolor*	Food
Forest	Sahíno	Peccary	*Kàsir*	Tayassuidae	*Pecari tajacu* (Linnaeus, 1758)	Food
Forest	Guatuza	Central American Agouti	*Shulȅ*	Dasyproctidae	*Dasyprocta punctata*	Food
Forest	Picote	Toucan	*Tsiȍ*	Rhampastidae	*Ramphastos sp.*	Food
Home garden	Banano chopo	Banana	*Mát*	Musaceae	*Musa acuminata Colla*	Food
Home garden	Banano cuadrado	Banana	*Shòo*	Musaceae	*Musa acuminata Colla*	Food
Home garden	Plátano	Plantain	*Kalṍm*	Musaceae	*Musa acuminata Colla*	Food

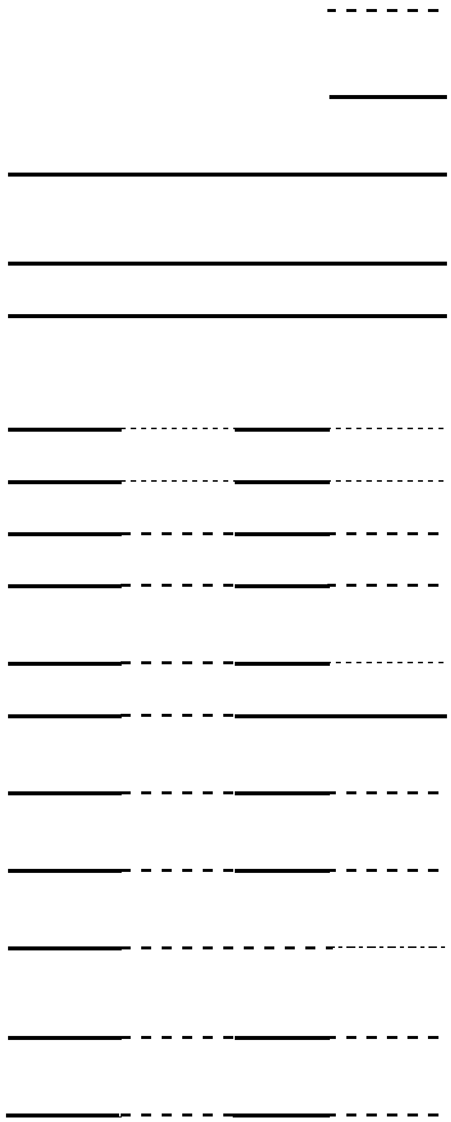
Home garden	Gallinas	Hen	*Krò*	Phasianidae	*Gallus gallus* (Linnaeus, 1758)	Food
Home garden	Piña	Pineapple	*Amù̀wö*	Bromeliaceae	*Ananas comosus* (L.) Merr.	Food
Home garden	Naranja	Orange	*Àsh*	Rutaceae	*Citrus* × *aurantium* L.	Food
Home garden	Guanabana	Soursop	*Tsö̀wö*	Annonaceae	*Annona muricata* L.	Food
Home garden	Cabeza de mono		*Bakṍn*	Chrysobalanaceae	*Licania platypus* (Hemsl.) Fritsch	Food
Home garden	Limón dulce		*Àsh blóblo*	Rutaceae	*Citrus limmeta* Risso	Food
Home garden	Guayaba	Guava	*Shũlẽ́*	Myrtaceae	*Psidium guajava* L.	Food
Home garden	Zapote	Sapota	*Kalóm*	Sapotaceae	*Pouteria sapota* (Jacq.) H.E. Moore & Stearn	Food
Home garden	Chile	Chili pepper	*Dapa'*	Solanaceae	*Capsicum sp.*	Food
Home garden	Yuca	Cassava	*Ali'*	Euphorbiaceae	*Manihot esculenta* Crantz.	Food
Home garden	Ñampi		*Skã́tù*	Arecaceae	*Xanthosoma sp.*	Food
Home garden	Café	Coffee	*Kápi*	Rubiaceae	*Coffea arabica* L.	Food

Home garden	Caña de azucar	Sugar cane	*Pákölpásh*	Poaceae	*Saccharum officinarum* L.	Food
Home garden	Chancho	Pig	*Kö̀chi*	Suidae	*Sus sp.*	Food
Home garden	Pataste	Cacao pataste	*Skuàlö*	Malvaceae	*Theobroma bicolor* Bonpl.	Food
Home garden	Cacaito de monte		*Wë̀shwö*	Malvaceae	*Herrania purpurea* (Pittier) R.E. Schult	Food
Home garden	Bribri	Monkey Tail	*Suwë*	Fabaceae	*Inga edulis* Mart.	Food
Home garden	Ortiga (flor)	Scratchbush (flower)	*Chi'*	Urticaceae	*Urera baccifera* (L.) Gaud.	Food
Home garden	Cacao de mico		*Salo'*	Malvaceae	*Theobroma angustifolium* [Moc. & Sesse] ex DC.	Food
Home garden	Teta de negra		*Wë̀röm*	Malvaceae	*Theobroma simiarum* Donn. Sm.	Food
Home garden	Aguacate (fruit)	Avocado	*Jamo'*	Lauraceae	*Persea americana* Mill.	Food
Home garden	Pejibaye (fruit)	Peach palm	*Dikó*	Arecaceae	*Bactris gasipaes* Kunth.	Food
Home garden	Caimol de Dairen			Sapotaceae	*Pouteria caimito* (Ruiz & Pav.) Radlk.	Food
Home garden	Limon de David	Lemon from David		Rutaceae	*Citrus sp.*	Food

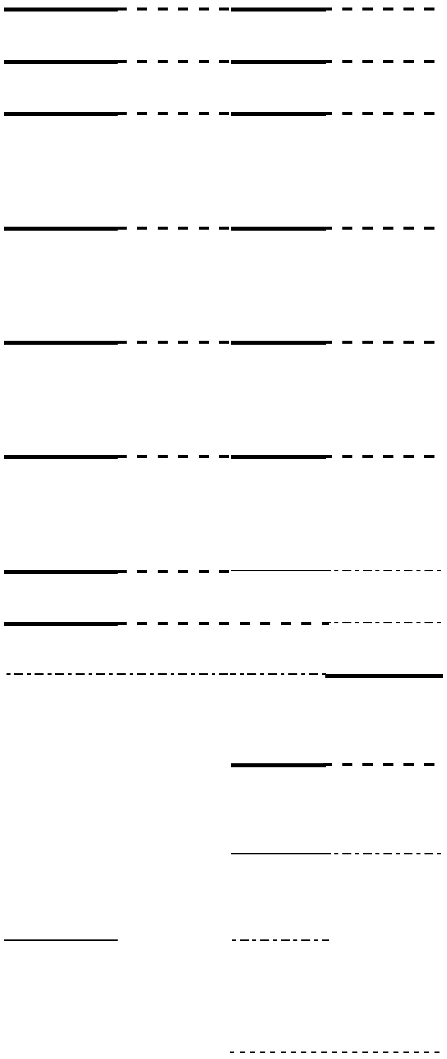
Home garden	Mandarina de David	Mandarin from David	Rutaceae	*Citrus sp.*	Food
Home garden	Naranjilla de David		Solanaceae	*Solanum sp.*	Food
Home garden	Arazá	Araza	Myrtaceae	*Eugenia stipitata* McVaugh	Food
Home garden	Mandarina chivo	Mandarin	Rutaceae	*Citrus reticulata* L.	Food
Home garden	Coco amarillo	Coconut	Arecaceae	*Cocos nucifera* L.	Food
Home garden	Fruta pan	Breadfruit	Moraceae	*Artocarpus altilis* (Parkinson) Fosberg	Food
Home garden	Carambola	Five fingers	Oxalidaceae	*Averrhoa carambola* L.	Food
Home garden	Bilimbi	Bilimbi	Oxalidaceae	*Averrhoa bilimbi* L.	Food
Home garden	Cas	Wild Guava	Myrtaceae	*Psidium friedrichsthalianum* (O. Berg) Nied.	Food
Home garden	Chupeta	Santol	Meliaceae	*Sandoricum koetjape* (Burm. f.) Merr.	Food
Home garden	Jackfruit	Jackfruit	Moraceae	*Artocarpus heterophyllus* Lam.	Food
Home garden	Manzana rosa	Rose apple	Myrtaceae	*Syzygium jambos* (L.) Alston	Food

Home garden	Mamón chino	Rambutan	Sapindaceae	*Nephelium lappaceum* L.	Food
Home garden	Mangosteen		Clusiaceae	*Garcinia* × *mangostana* L.	Food
Home garden	Manzana de agua	Watery rose apple	Myrtaceae	*Syzygium aqueum* (Burm. f.) Alston	Food
Home garden	Maracuya	Passion fruit	Passifloraceae	*Passiflora edulis* fo. flavicarpa O. Deg.	Food
Home garden	Caimito	Star apple	Sapotaceae	*Chrysophyllum cainito* L.	Food
Home garden	Seso vegetal	Akee	Sapindaceae	*Blighia sapida* K.D. Koenig	Food
Home garden	Yuplón	Golden apple	Anacardiaceae	*Spondias cytherea* Sonn.	Food
Home garden	Uva de la india	Amazon tree-grape	Urticaceae	*Pourouma cecropiifolia* Mart.	Food
Home garden	Zapote Colombiano		Malvaceae	*Quararibea cordata* (Bonpl.) Vischer	Food
Home garden	Bay-rum	Bayrum Tree	Myrtaceae	*Pimenta racemosa* (Mill.) J.W. Moore	Food
Home garden	Chaya		Euphorbiaceae	*Cnidoscolus chayamansa* McVaugh	Food
Home garden	Kaktu			*	Food

Home garden	Tamarindo	Tamarind		Fabaceae	*Tamarindus indica* L.	Food
Home garden	Pepino	Cucumber		Cucurbitaceae	*Cucumis sativus L.*	Food
Swidden	Ñame	Water yam	*Tsa LíLöm*	Dioscoreaceae	*Dioscorea* sp.	Food
Swidden	Chayote	Chayote squash		Cucurbitaceae	*Sechium edule* (Jacq.) Swartz	Food
Swidden	Auyama	Squash		Cucurbitaceae	*Cucurbita* sp.	Food
Swidden	Calalú	Venezuela Pokeweed	*Bròkö*	Phytolaccaceae	*Phytolacca rivinoides* Kunth & C.D. Bouché	Food
Swidden	Urmene				*	Food
Swidden	Papaya	Papaya	*Kichö'*	Cichlidae	*Carica papaya* L.	Food
Swidden	Arroz	Rice		Poaceae	*Oryza sativa L.*	Food
Swidden	Frijol	Beans	*Átu*	Fabaceae	*Phaseolus vulgaris* L.	Food
Swidden	Maíz	Corn	*Ikuwö̀*	Poaceae	*Zea mays L.*	Food
Swidden	Rabo de mono	Fiddle-head fern	*Shpö̀*	Cyatheaceae	*Cyathea sp.*	Food
Swidden	Trigo	Adlay		Poaceae	*Coix lacryma-jobi* L.	Food
Swidden	Platanilla		*Ppö́*	Heliconeaceae	*Heliconia mariae Hook. f.*	Food
Swidden	Pacaya	Pacaya palm	*Iáwö*	Arecaceae	*Chamaedorea tepejilote* Liebm.	Food
Swidden	Tepezcuintle	Agouti	*Kano'*	Cuniculidae	*Cuniculus paca* L.	Food



River	Guabina	Bigmouth Sleeper	*Shuwa'*	Eleotridae	*Gobiomorus dormitor* Lacepède, 1800	Food
River	Sardina		*Dakòr*	Characidae	*Astyanax* spp.	Food
River	Titi		*Nés*	Gobiidae	*Sicydium* spp.	Food
River	Bobo (nombre panama)	Bobo mullet	*Namà ichö́k*	Mugilidae	*Joturus pichardi* Poey, 1860	Food
River	Lisa	Mountain mullet	*Mulũ̀wak*	Mugilidae	*Agonostomus monticola* (Bancroft, 1834)	Food
River	Mojarra	Topaz cichlid	*Rrós*	Cichlidae	*Amatitlania myrnae* (Loiselle, 1997)	Food
River	Ronco	Atlantic grunt	*Sichík*	Haemulidae	*Pomadasys crocro* (Cuvier, 1830)	Food
River	Cangrejo	Crab	Yui'			Food
River	Camarón	Prawn	*Só*		*Cryphiops spp.*	Food
Forest	Corazón	Nicker bean		Fabaceae	*Entada gigas (*L.) Fawc. & Rendle	Trade
Forest	Ajo de montaña			Bignoniaceae	*Cydista* sp.	Trade
Home garden	Café	Coffee	*Kápi*	Rubiaceae	*Coffea arabica* L.	Trade
Home garden	Poró		*Blò*	Fabaceae	*Erythrina lanceolata* Standl.	Trade
Home garden	Meno				*	Trade



Home garden	Cacao	Cacao	*Tsuru'*	Malvaceae	*Theobroma cacao* L.	Trade
Cattle ranch	Ganado				*Bos* sp.	Trade
Plantain field	Plátano	Plantain	*Kalö́m*	Musaceae	*Musa acuminata Colla*	Trade
Banana field	Banano	Banana	*Chamù*	Musaceae	*Musa acuminata* Colla	Trade
River	Ojo de venado				*	Trade