PEOPLE in NATURE

WORKING PAPER #4

THE SIXAOLA RIVER BASIN, COSTA RICA / PANAMA

PEOPLE IN NATURE INTERDISCIPLINARY SITUATION ANALYSIS

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EXECUTIVE SUMMARY

The overarching objectives of People in Nature (PiN) are to provide resource managers at different scales (Indigenous peoples, local communities, government and non-governmental agencies, etc.) with mechanisms to identify and document material and cultural uses of nature; to influence conservation and development planning; and to develop strategies to scale up and enhance their influence in decision making. PiN also aims to provide analysis and a platform to facilitate opportunities to learn from, communicate and exchange experiences with other resource managers (Davidson-Hunt et al., 2016). A goal of PiN is to develop a better understanding of the material contribution of nature and the symbolic interrelationships expressed through cultural narratives and ceremony. Contributors to PiN are in the process of building a landscape assessment methodology, which constitutes the means for PiN to collect, analyse and present data pertaining to specific sites and regions. The interdisciplinary situation analysis (ISA) represents the first phase of the landscape assessment workflow, and comprises the tasks of collating and analysing secondary data that is relevant to the chosen assessment area (Idrobo et al., 2016). The ISA phase represents a rapid study of secondary data pertaining to the study area and the ISA report aims to report on an analysis of existing data, and point to gaps in the secondary data record that may be addressed during the second phase of the PiN methodological workflow.

The PiN team and the IUCN ORMACC region selected the Sixaola river basin as one of the pilot landscape assessment sites for PIN development. Within this geographical area, work is being conducted with Bribri communities in Costa Rica and Panama. The ISA presented in this document is the first of its kind and pilots various analyses of secondary data that may be drawn upon to inform the second phase of the landscape assessment, which involves primary data collection. This is the first analysis of its kind and has been performed with PiN methodological development in mind, thus its format will likely see changes as progress is made on different PiN pilot site studies.

Secondary data from ethnobotanical literature, grey literature, reports, management plans and university theses were used along with data from the IUCN Species Information Service (SIS) on species use, trade and conservation status. The analysis is presented in this document in three major sections pertaining to 1) assessment area description, 2) documented uses of biodiversity, and 3) risks to biodiversity, livelihoods and resources.

The analysis revealed a total of approximately 221 documented species, subspecies and agricultural varieties or cultivars with known uses within the indigenous livelihood system. Of these, 182 records had known species and subspecies-level scientific names, allowing for linkages to be made across other datasets, including the SIS. Ninety-three species had records within the SIS, and 69 had associated SIS data on conservation status and threats. Data on habitats in which species were known to be harvested were aggregated into habitat types which were then used to analyse provenance of species within different types of landscape mosaics. Likewise, Holdridge life zones – widely used in Costa Rica as ecological units – were mapped onto the river basin and used to perform a coarse spatial analysis of risks to species within the Sixaola basin.

This secondary data analysis flows from consideration of risks to species and ecosystems to an assessment of risks to livelihoods and ability to respond to globalised change that may be experienced by local communities and households. The analysis found that the use of biodiversity that constitutes parts of the indigenous land use and livelihoods system have been shaped in the recent past by land use change, institutional constraints, vulnerability to natural disasters, crop disease and market fluctuations and remoteness.

With perhaps several exceptions, that may be looked into with communities during the primary data collection phase, direct use of species by local people did not appear to contribute to risks to their future use. An analysis of conservation status of species performed using SIS data revealed few threatened species and few risks related to direct use. On the other hand, while most animals had been assessed in the SIS, large data gaps existed regarding plants used.

The analysis revealed risks to availability and stability of populations of species within particular areas or within landscape mosaics of the Sixaola river basin. In particular, indigenous territories in which communities exercise the greatest degree of control over use of biodiversity are sandwiched between the low-lying areas, characterised by a trend of expanding plantain monoculture, and an extensive array of protected areas with rules restricting biodiversity use, which extend into the highland areas of the Sixaola river basin. Low-lying areas correspond ecologically with tropical moist and wet forest life zones, which were found to be associated with the highest number of species with known uses. Risks to the diversity of habitats in these low-lying zones from expanding monoculture threaten availability and stability of populations of these species. The findings of this secondary data analysis, particularly those with spatial implications may feed into subsequent inquiry on the biodiversity-based system in the second phase of the PiN landscape assessment.

1 Now the shelter domain, this domain was initially broader in scope at the time this analysis was conducted, and included a range of material uses that are not captured within the current shelter domain.

Development of PiN may be informed by lessons from this pilot application of the ISA. In particular, discussion is required on the need to take on such a broadly-scoped analysis of use of biodiversity in future PiN assessment areas. The purpose of PiN landscape assessments may be served by a focus on a narrowed set of goals at the start of each study. This trial run of the ISA methodology can inform work with the IUCN Species Programme on linkages between PiN and SIS data, and can point to a potential database structure that could support interlinkages of these datasets. In addition, suitable standards for working with habitat and ecosystem data may be of use.

SITUATION ANALYSIS WORKFLOW AND DATA SOURCES

The PiN situation analysis aims to provide an analysis based on secondary data alone, which can be used to inform a study of the biodiversity based system, which constitutes the second phase of the PiN landscape assessment (Idrobo et al., 2016). This secondary data analysis may point to potential risks to traditional land use systems of remote, rural communities that can be further analysed using a participatory study design during the second phase. The situation analysis workflow also aims to point to gaps in the existing data that may be addressed during primary data collection.

A team, comprising PiN working group members and staff at the IUCN ORMACC office, Costa Rica, began gathering sources and spatial data prior to a PiN meeting in Costa Rica and visit to the Sixaola pilot site in March, 2015. Data sources were sought describing ecological, social and economic dimensions of the assessment area. Project plans, scientific literature, protected area management plans and grey literature were consulted. Socio-economic reports and planning literature were gathered, including the nutrition data for Costa Rica, local planning documents and protected areas management plans and socio-economic development literature. Holdridge life zones for the Sixaola river basin were available as spatial layers, as were protected area and indigenous reserve boundaries (see appendix III).

Original data sources and documents were archived in folders accessible to team members on the IUCN Union Portal. Sources were tagged using standardised keywords developed at a later date (see appendix I). A Microsoft Access database was created to store data extracted from data sources.

Alongside biodiversity, the analysis considers risks to water availability, stability and access. This inclusion reflects an interest by PiN developers in people's interrelationships with water as a critical part of nature for livelihoods and well-being.

Use of species and agricultural varieties

PiN has taken an initial focus on direct use of biodiversity, where biodiversity is understood to possess properties that make it useful for various provisioning functions. The first task involved collating a list of all species and varieties with known uses that have been documented within the study area. The intent was to characterise the total known potential of biodiversity (U) for the study area, (Davidson-Hunt et al., 2016), including biodiversity use that was documented by studies undertaken in the past, which may not feature in contemporary local livelihood systems. Ethnobiology literature, university theses and other datasets were reviewed and text on use of species was extracted. It was important to find species-level scientific names and accepted names for varieties or cultivars if they were available in the sources reviewed. This list was entered into the Microsoft Access database. Species names were recorded when possible, otherwise a genus, local or variety name was used. The terminology to describe species use differed between sources. Use data were grouped according to PiN domains – ***food and nutrition, medicine and health, energy, shelter, income, ceremony and trade.*** The IUCN Species Information Service (SIS) database was consulted and species uses were added to the Access database from the SIS Use & Trade module. The food and medicine domains presented few problems, as data was usually readily available on species used for food and medicine. If a species was listed in SIS as having more than local subsistence use in the *end use* dataset (i.e. local, national and international markets), the species was reported to contribute to the ***trade*** domain. Likewise, this domain was flagged if other secondary data sources reported a species or variety as having market value, or as being important in terms of its contribution to household income. If a species was listed as being used for heating or cooking, it was added to the ***energy*** domain. Species used for construction, clothing and artisanship were categorised in the ***shelter and materials*** domain.[1] The ***ceremony*** domain aggregates species and varieties harvested and prepared for ceremonial purposes. Two datasets consulted contained data on ceremonial uses of species. Table 1 shows how data in ethnobiology datasets and in the SIS were aggregated under different PiN use domain categories.

Factors influencing availability, stability, access and perception

PiN uses four variables – *availability, stability, access and perception* – to describe and analyse processes that shape use of biodiversity (see Davidson-Hunt et al. 2016). While availability and stability are used to describe biological and ecological processes that affect species abundance over time, the variables access and perception concern social and cultural factors that shape and constrain use.

Data on conservation status of – and threats to – species were brought in to inform the analysis on risks to availability and stability of biodiversity. The compiled list of species with

Table 1: PiN domains compared with use categories for major sources consulted

PiN domain	Borge (2011)	Córdova (2004)	Dubois (2007)	Garcia-Serrano and Del Monte (2004)	SIS Use and Trade module
Food and nutrition	Consumo humano; comestible; alimento humano	comestible	alimentación	Food	Food – human
Medicine and health	Medicinal	medicinal	medicinal	Medicinal	Medicine – human & veterinary
Trade	comercio	comercio	venta	N/A	Local, national, international markets
Energy	Dendroenergético	combustible	leña	Firewood	Fuels
Shelter and materials	Construcción; artesanía; ornamental; botes; tinte	Artisanal, construcción; ornamental; tintes	Madera; hojas para hacer techos, artesanía	Textile; Construction; Craft; Cosmetics	Construction or structural materials; Fibre; Handicrafts, jewellery, etc.; Wearing apparel, accessories; Poisons; Manufacturing chemicals
Ceremony	Ceremonial	N/A	N/A	Ceremonial	N/A

known uses was checked against the SIS database and conservation status of species was recorded in the Microsoft Access database. No national red list or national-level species at risk dataset was found for Costa Rica. As such, conservation status and threats data from the SIS must be taken to apply to the full global extent of a species' range. Nonetheless, data on specific threats to species and their habitats were recorded and used in this analysis. An extract of data on the complete list of species and varieties from the SIS database are presented in appendix II.

Some documents and datasets included data on specific ecosystems and habitats in which species were harvested. However, datasets on threats to ecosystems and habitats were not found and no IUCN Red List of Ecosystems assessment data have been published yet for the area of interest. Both use and habitat data were sometimes located within the main body text of documents, rather than being displayed in a tabular format. In these cases, data became harder to detect, but was used when found.[2]

The Holdridge system of life zones represents the predom-

Table 2: Holdridge life zones found within the Sixaola river basin

Spanish: Zona de vida	English: Life zone
Bosque húmedo tropical	Tropical moist forest
Bosque muy húmedo tropical	Tropical wet forest
Bosque muy húmedo premontano	Premontane wet forest
Bosque pluvial premontano	Premontane rain forest
Bosque muy húmedo montano bajo	Lower montane wet forest
Bosque pluvial montano bajo	Lower montane rain forest
Bosque pluvial montano	Montane rain forest
Paramo pluvial subalpino	Subalpine rain paramo
Bosque muy húmedo premontano transición a basal	Premontane wet forest lowland transition

2 This points to the difficulty of extracting or "mining" data from these sources for a large number of species and agricultural varieties that are potentially found in such assessments. A combination of data mining and crowdsourcing techniques is recommended in order to render this data more immeidately available for use within the assessment methodology (see Deutsch et al, 2016b).

inant system for biophysical and ecological classification in Costa Rica. Life zones of the Sixaola river basin are listed in Table 2 in Spanish with English translations., following García-Serrano and Del Monte (2004). Holdridge life zones were used in this situation analysis to map species to ecological areas, which in turn could be mapped spatially onto the landscape of the Sixaola river basin (see Figure 1). A site-level analysis of risks associated with different life zones was made possible by spatially overlaying information on land uses over a map of the Holdridge life zones.

Social, cultural and economic information was reviewed in order to analyse temporal and spatial patterns, legal instrument, institutions, and trends that influence access to land, species and ecosystems and to describe drivers of change affecting landscapes in assessment area. An important part of this analysis consists of understanding the relative contribution of access conditions to shaping use of biodiversity (Davidson-Hunt et al., 2016). Another aspect concerns the relative contribution of biodiversity to livelihoods, with a focus on non-cultivated or wild species..

DESCRIPTION OF THE ASSESSMENT AREA

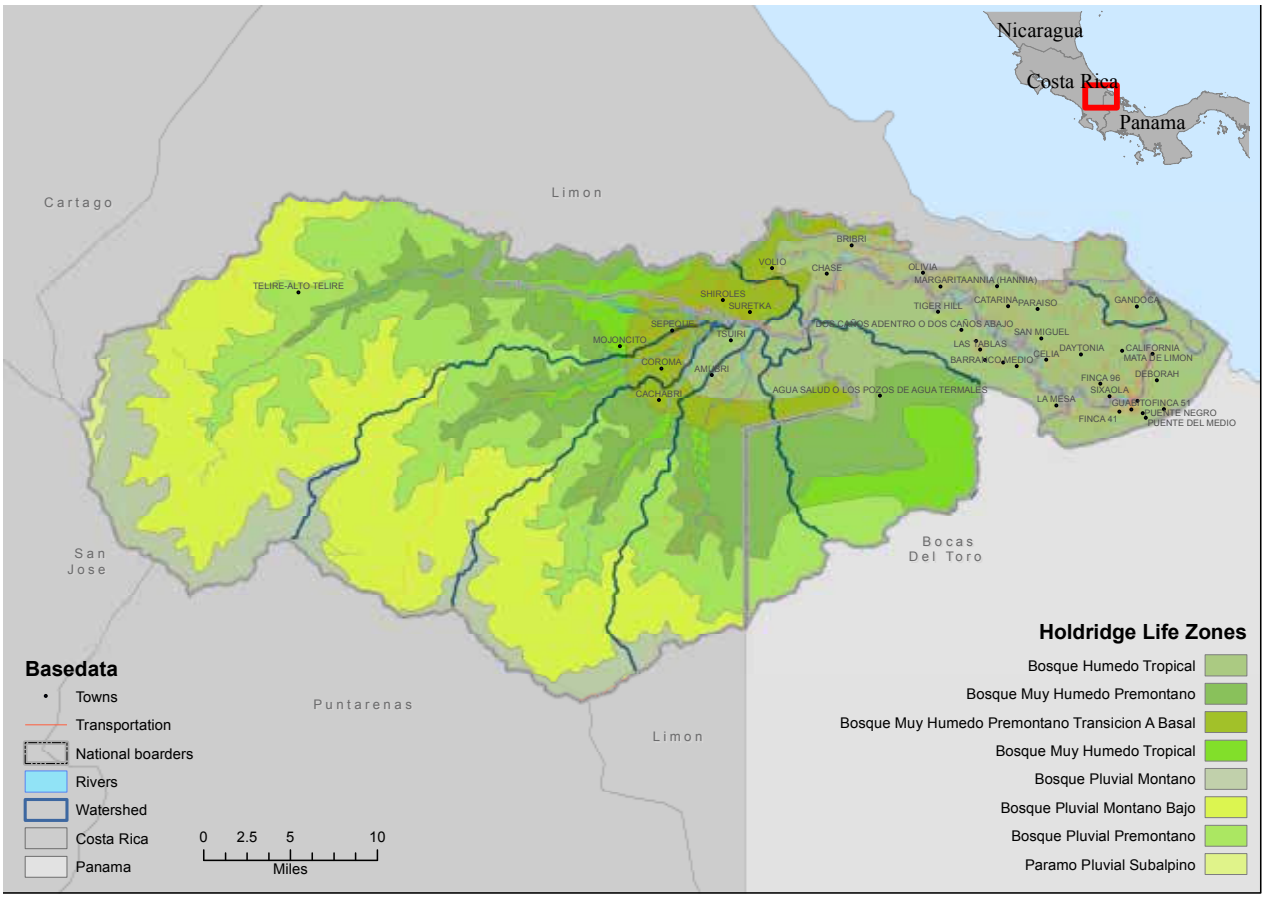
Physical site description

The project area has been defined to match the watershed boundaries of the Sixaola River basin, which contains land in both Costa Rica and Panama. The area includes the canton of Talamanca in the province of Limón in Costa Rica. On the Panamanian side, the watershed overlaps with the district of Changuinola in the province of Bocas del Toro. This pilot area has been selected as it overlaps with the site boundaries and communities involved in ongoing projects of the IUCN ORMACC regional office. An IUCN project document described the river basin as follows:

The Binational Sixaola River basin, shared between Panama and Costa Rica, extends over approximately 280.000 ha, with 81% of the land belonging to Costa Rica and 19% to Panama. From the basin's highest point, located on the Talamanca mountain line at 3.700 meters above sea level, to the Caribbean Coast, the basin stretches over 100 linear km (IUCN, 2011a).

The Sixaola river basin contains a low elevation alluvial flood plain beginning at the confluence of the Telire and Yorkín

Figure 1: Holdridge life zones of the Sixaola river basin



rivers and drains to the Caribbean Sea. Its upland portion contains numerous smaller watersheds, is mountainous and presents physical access problems to people travelling up and down waterways, roads and paths. The lowland areas of the basin are much more heavily populated and intensively used for agricultural production.

The indigenous land use system

The indigenous land-use system contributes significantly to land cover of the Sixaola basin, although quantitative estimates or GIS spatial layers were not found for land use and land cover. The ethnobiology literature provided several datasets that contained data on habitats that could be associated with different species. For instance, Borge (2011) proposes a general classification of the polyculture land-use system that contains the following habitat typology: plantain, banana, cacao, banana-cacao, grains, roots and tubers, silvopastoral, and secondary forest. The terms polyculture and agroforestry are often used interchangeably. These types of land cover are used along with fallow (slash and burn or slash and mulch) plots. Important subsistence crops are planted in home gardens near dwellings, whereas both subsistence and commercial crops are planted at greater distances from homes. Forestry and livestock raising are also potential land uses (Borge, 1997 in Posas, 2013).

Aggregate habitat categories were created from these datasets in order to group habitat types found in different sources and original habitat data were conserved in the Access database. Land uses that were commonly used in the literature to describe the indigenous system can be generalised to include the following types:

- cacao agroforestry/polyculture,
- banana agroforestry/polyculture,
- mixed agroforestry/polyculture (plantain, banana, cacao),
- banana or plantain monoculture,
- slash-and-burn plots usually used for cultivation of grains,
- primary forests, and
- secondary forest (regrowth from slash and burn and abandoned polyculture plots).

In reality, however, the landscape mosaic presents an overall complexity and continuity between land uses of different types, such that different covers merge and distinct types are not always easily evident (Borge, 2011). Polyculture plots are contiguous with small secondary forests, low bush and riparian landscape types. It is also difficult to distinguish where secondary and primary forest blend (Borge, 2011). The same may be said about the boundaries between the indigenous polyculture system and primary forest. Agroforestry systems may contain commercial agriculture plots (banana, plantain, cacao especially), where the dominant cover tree is laurel (*Cordia alliodora* and *Cordia gerascanthus*) (SINAC, 2012). Different types of agroforestry are also found near homes and are used in home gardens (Quiroga, 2009), such that these land uses are sometimes considered together. García-Serrano and Del Monte (2004), however, consider plantain polyculture to be managed in a way similar to home gardens: planting density is low to allow for other species to grow and species diversity is greater than in the slash-and-burn system but less so than home gardens.

Polyculture, primary and secondary forest, which are located further from settlement sites, provide for a range of plants and animals and slash-and-burn fallows are important places for both hunting of animals and harvesting of non-cultivated species for around 12 years after a plot has been abandoned (García-Serrano and Del Monte, 2004). Traditionally, Bribri people have used large spaces for shifting agriculture, hunting, gathering of wild plants and fishing and spaces used for livelihood activities and habitation were delimited by natural boundaries, such as ridgelines, waterways and trees.[3]

At the situation analysis phase, given the range of traditional land uses and the difficulty in clearly distinguishing land cover types, it was possible to take a gross cut at habitat classifications by aggregating land use into major types found across the literature (see Table 3). As such, some preliminary observations could be drawn about species associations with particular habitats. It was not possible to tie every species to habitats, but this was done where information was available (see Appendix II for complete records of aggregate habitat types by species).

Social, cultural and economic drivers and globalised change

The following section focusses primarily on changes in the agricultural economy and associated changes in peoples' livelihoods. These can be described broadly as the expansion of the intensive plantain economy and concomitant risks to cacao and organic banana agroforestry; outmigration from remote rural communities; and biodiversity conservation through management of extensive protected areas. The institutional and legal contexts are also reported on in the description of the assessment area, below. The aim of this section is to contribute secondary literature and data to the analysis of variables that shape use of biodiversity.

Indigenous peoples, historical and contemporary migration

Costa Rica's population is 1.7% indigenous, but in the province of Limón where the Sixaola river basin is located,

3 http://wwwunesco.org.uy/phi/aguaycultura/es/paises/costa-rica/pueblo-bribri.html

Table 3: Habitat typologies compared across sources consulted

Aggregated habitat typology	Arias and Campregher (2010)	Borge (2011)	Córdova (2004)	Dubois (2007)	Garcia-Serrano and Del Monte (2004)	Guiracocha et al. (2001)	Harvey et al. (2006)
Agricultural land			Finca, parcela				
Secondary forest			Bosque secundario			En bosque	Forests
Freshwater		(all fish and crustaceans)					
Near dwellings / Home garden	jardín	Huerto indígena	Huerto, jardín		Home garden		
Monoculture	cacao	Monocultivo de plátanos			Plantain monoculture		Plantain monocultures
Polyculture		Polycultivo de cacao y banano, cacaotales de multiestrato		sistemas agroforestales con árboles de cacao	Plantain polyculture	En cacao, en banano	Cacao / banana agroforestry systems
Primary forest / Forest		bosques con manejo no maderable de los piemontes	Bosque primario		Primary forest		
Riparian	bosque ribereño						
Roadside	orilla de camino						
Slash and burn, shifting agriculture (phases)			Tacotal (early regrowth)		Trabajadero, rotating slash-and-burn		

39% of the national indigenous population can be found (EPYPSA, 2011). In the canton of Talamanca, Ngäbe (Guaymí), Buglé (Bokotá), Bribri, Cabécar, Teribe (Térraba, also Naso in Panama), and Boruca (Brunca) are major indigenous groups (Borge, 2011). The most numerous indigenous groups, including Bribri, Cabécar, and Ngöbe in Costa Rica's southeast and Panama's northeast, share cultural origins and characteristics of farming systems, social and linguistic similarities (Borge & Martínez, 2009; EPYPSA, 2011). Bribri and Cabécar Indigenous people share the Chibchan language family and once shared political and religious organisation and leadership but approximately 300 years of restricted interaction has led to divergence of these groups (Borge & Villalobos, 1995; Bozzoli, 1975; Barrantes et al., 1986 in Posas, 2013).

Currently, Bribri of different communities are typically located near rivers and streams for transportation, fishing and other activities. The main indigenous groups at middle and higher elevations are Bribri, Talamancan Bribri, Telirean Cabécar, Talamancan Cabécar and Naso, whereas in the lower valley, Bribri groups that have come from Kekoldi and Ngöbe predominate (IUCN, 2011b).

For Bribri, a major historic population decline (from 25 000 in 1638 to under 2000 in 1895) related to diseases borne by European colonists and conflict. In the early 20th century, in a very short timeframe, the United Fruit Company violently forced Bribri off their land and murdered important Bribri leaders (Borge and Villalobos, 1995 in Posas, 2013) and consequently, Bribri people fled to the mountains away from the valley. The Company deforested the lower valley and replaced the landscape with banana monocultures (Posas, 2013). In the 1960s, some Bribri began to return to, and settle in the valley, some remaining to seasonally work for the Company (Posas, 2013). Communities located higher in the river basin tend to be more homogeneous, with a higher percentage of households speaking an indigenous

language, whereas households lower in the valley tend to speak more Spanish and communities are more ethnically mixed (Whelan, 2005). Generally speaking, Indigenous peoples of Costa Rica figure both low in development indices and high in poverty (Borge and Martínez, 2009).

Indigenous Ngäbe migrations from Panama to Costa Rica began in the 1950's (D'Ambrosio, nd). There is also an immigrant population of more recent origins in the area, including mestiza, Afro-Caribbean, and Nicaraguan people (IUCN, 2011; Matamoros, 2014). Most migration is understood to be tied to labour, as in the case of banana plantations and the tourism sector (Matamoros, 2014). The overall estimated population of the Sixaola river basin is 33 500 people (IUCN, 2011a).

Governance and decision making in indigenous territories

Governance of indigenous territories is guided by the General Assembly, the Board of Directors of the Asociaciones de Desarrollo Integral (ADI), and the Junta de Vecinos or neighbourhood boards (Murillo et al., 2014). ADIs are recognised as political and executive bodies, and are supported by national and international legislation, including Convention 169 of the International Labour Organisation (ILO) (Murillo et al. 2014). Indigenous territorial authorities have their own sets of rules that are recognised by the state.

The management structure of ADIs is based on the pre-existing customary management system and has a mandate of natural resource development and conservation of natural heritage. Differences between customary decision-making structures of indigenous groups and the formal governance structure involving ADIs related to recognised indigenous territories have brought into question the role of consultation with Governing Boards of the ADIs, for example in cases related to REDD+ programmes (IWGIA, 2015). International and national legal and normative frameworks are available to safeguard indigenous rights in Costa Rica. Costa Rica ratified ILO Convention 169, although recognition of indigenous rights by the country does not necessarily follow, such as in the case of rights to consultation (IWGIA, 2015).

ADITIBRI (Asociación de Desarrollo Integral de Talamanca) was created following article 2 of ILO convention 169, the national Indigenous Law 6172 (November 16, 1977) and the Forest Law of 1977 (Madrigal, 2011). Similarly, ADITICA, the Association of Integral Development of the Cabecar-Talamanca indigenous territory, was created in 1985 (Murillo et al., 2014). These associations constitute legal governing bodies for Bribri and Cabecar Territories. ADITICA covers 22 Bribri and 7 Cabécar communities with a total population between 10 000 and 12 000 inhabitants and brings together their community councils.[4]

In Panama, indigenous Bribri do not have recognition from the state. Nonetheless, the Bribri do not recognize the international border, and there are existing mechanisms for coordinated decision making between bordering communities (IUCN, 2011b).[5] Binational collaboration within the Sixaola basin between Panama and Costa Rica has been institutionalised through binational commissions:

> Costa Rica and Panama have signed a Cooperation Agreement which allows them to create thematic commissions to implement development projects all along the border between both countries. At the end of 2010 the Binational Commission for the Sixaola River Basin was created, with the goal of conserving biodiversity, promoting sustainable production methods and strengthening the binational institutional framework. The Commission has become important because it institutionalises good governance in the Sixaola River basin (IUCN, 2011a: 6).

Land use change

For the Bribri of Talamanca, the commercial economy is based primarily on agriculture, specifically production of plantain, banana, cacao, however, tourism also plays an important role in local economies. The catchment can be subdivided along both an environmental and socio-economic gradient from valley floor to the mountain slopes of the high Talamanca and La Amistad National Park (Whelan et al. 2008). A gradient can be described that spans from the valley floor to highland communities in terms of types of cultivation, distance to market, labour opportunities, size of farms per household, the vicinity of (primary) forests and protected areas.

Whelan et al. (2008) arbitrarily divides Bribri and Cabécar communities of Talamanca into three zones along this altitudinal gradient, demarcated by differences in access to major population centres, land holding size and type of production. For higher altitude communities, including San José Cabécar, Alto Cohen and Orochico (all above 500m), average land holdings were approximately 86 ha per household and 93% of households reported sufficient land for cultivation (Whelan et al. 2008). Subsistence production of rice, maize, beans and bananas predominates.

Small and medium sized local producers are concentrated in the lower and middle parts of the Sixoala river basin. In

4 Similar numbers for ADITIBRI could not be found in sources consulted or on the internet.

5 This is noted to be the case in IUCN (2011b) for the communities of the Lower Yorkin River, including Yorkin and Shuabb in Costa Rica, and El Guabo and Dacles in Panama.

the mid-elevation zone (Mojoncito, Sepeque), agricultural holdings averaged 27 ha and 69% of households reported insufficient land for farming. The main types of cultivation included plantain monoculture, but the predominant land use was banana agroforestry. The mid-elevation zone is predominantly cultivated by Indigenous people, and organic production systems centred on cacao and bananas are certified and benefit from merchandizing organisations (IUCN 2011a; 2011b). The Association of Small Producers of Talamanca (APPTA) is a locally-based marketing organisation that buys and markets organic agricultural products. Local production and consumption of grain complements commercial planting of the main commercial crops.

In the lower part of the watershed, commercial activity is centred on plantain cultivation for export. This zone is most accessible to markets and plantain production is most intensive of the three zones. In this area, households held an average of 6.8 ha, and 72% of households reported insufficient land for farming (Whelan et al., 2008). Small land holdings are generally concentrated in the lower parts of the valley. Whelan (2005) also notes a marked decrease in access to forested lands in locations at lower elevations, where forest flora and fauna have traditionally contributed significantly to peoples' livelihoods. Harvey et al. (2006) identify interconnectedness of forest patches with small fields and small size of agroforestry plots (less than 2ha) as probable factors explaining the high occurrence of wild mammals that may be harvested and areassociated with the indigenous land-use system and polyculture, in contrast to low diversity of species in plantain monocultures.

In all three zones, banana production features prominently, and varieties include Gran Michel cultivar (*Musa* AAA), and two Cavendish cultivars (*Musa* AAA), however, Whelan (2005) points out that while banana tends to be cultivated organically in mixed polyculture plots, many farmers in lower and mid elevation zones are switching their polyculture plots to plantain monoculture.

This shift is associated with several prominent processes. Whelan (2005) describes a process by which farmers in mid and low elevation zones become 'locked into' converting their plots to plantain monocultures. Small holders may find themselves unable to obtain organic agriculture certification because of proximity to neighbouring monoculture plots that use agrochemical inputs. Meanwhile, important shocks and stresses affecting livelihoods in the Sixaola basin have in recent memory included severe flooding (1970, 1991, 2005), earthquakes (1991) and monilia – frosty pod rot in cacao (*Moniliophthora roreri*) (Whelan, 2008). Monilia first appeared in 1978 and widely affected cacao production (Borge & Castillo, 1997 in Posas, 2013). A drop of 80% in cacao production is associated with the fungus. Land-use change from cacao to other economies has followed – predominantly a shift from cacao cultivation to plantain and banana.

Increased variability and changes in precipitation patterns (in turn, associated with flooding) are associated with increased vulnerability due to climate change (Madrigal, 2011). Areas that had been cleared for monoculture were most affected by the 1991 earthquake and flooding, leading to further loss of livelihoods. Communities typically cultivate grains for household consumption in low-lying areas, making them vulnerable to losses from flooding. As such, agrobiodiversity loss may be very high in years of extreme rainfall (IUCN, 2011a).

Pressure from mining, hydroelectricity and petroleum production projects constitute additional risks to traditional land use in Bribri and Cabécar territories in the Talamanca range (SINAC, 2012). In recent history, petroleum production has had an important impact. The RECOPE petroleum company were present in the 1980s and prospected for petroleum deposits in indigenous territories. This played an important role in transformation of the rural economy, making way for market penetration into more remote areas of the reserve.

These severe events and changes have contributed to land use change and are driving factors in outmigration from farming areas higher in the river basin, along with seasonal migration to lowland areas for wage labour associated with plantain.

Land ownership, gender and agricultural labour

Bribri communities feature matrilineal clans and matrilineal descent, and households typically have matrilocal residence (Rojas, 2009). Bribri female household heads are common and men and women share tasks, food and shelter. Women tend to have ownership over the home (Rojas, 2009).

Communal labour is a feature of Bribri community organisation (Whelan et al. 2008) and land is traditionally commonly held as a form of clan property. Land is held by the maternal line of clan and by husbands of women of the clan. However, this traditional system seems to be changing toward family rather than clan ownership of agricultural land. Women and men possess both common and individual parcels of land (Posas, 2001 in Posas, 2013). Communal land may be managed by a tribunal of indigenous leaders (Posas, 2013). On reserves, the Asociación de Desarrollo Integral holds title to the land, not individuals (Murillo et al. 2014), thus, land tenure is considered to be communal on indigenous reserves. Small non-indigenous communities also may be located on reserves in communities (SINAC, 2012).

According to Borge (2011), labour in non-traditional, intensive agricultural production – for production of goods for the market – is based on labour performed predominantly by

men. Both men and women, as well as older and younger generations share work in the indigenous polyculture system of the Bribri and Cabécar (Borge, 2011). Nonetheless, women and men keep their own domestic animals (Rojas, 2009). Differences between genders exist in terms of knowledge of different spaces and different species: women were more knowledgeable about species that grow in home gardens and small land holdings. Women are also more knowledgeable about minor, non-staple species used for food, condiments and medicine, whereas men had greater knowledge of plants found in forests (Córdova, 2004).

In terms of wage labour, intensive banana and plantain cultivation for international markets and cattle ranching offer jobs in the surrounding area. There is an ongoing and active process of migration towards the mid and lower parts of the Sixaola river basin by populations in the upper sections (SINAC, 2012). The Bocas Fruit Company, Dole, and six other independent banana producers collectively generate 6100 jobs in Changuinola, Panama (GEF, 2008 in Madrigal, 2011). As men or women leave the village to work for wages or for better access to education, they can no longer participate in communal labour, and lose representation within the community, including rights of access to communal property (Rojas, 2009). As people begin to take labour outside communities, they risk becoming outsiders. Women are particularly vulnerable to losing roles and representation within communities. Despite labour commitments outside the villages, women are still primarily responsible for meal preparation, caring for young children, household cleanliness and laundry (Rojas, 2009).

Transportation difficulties make engagement outside villages problematic to integrate with village activities and responsibilities (Rojas, 2009). Younger generations are also more committed to life outside villages, contributing to loss of communal labour (Rojas, 2009). Agricultural labour contributes more significantly to household income lower in the valley, where plantain cultivation surpasses other types of cultivation as an income source for land owners.

Biodiversity conservation, parks and protected areas

At the national level, Costa Rica contains 5% of Earth's biodiversity in 0.03% of its surface area, making it the world's most biodiverse country per square kilometre. Costa Rica has a total of 500 000 plant and animal species (INBIO, 2014 in Mendiola Fernández, 2014). Approximately 26.1% of Costa Rica's terrestrial surface area is covered within protected areas (Mendiola Fernández, 2014).[6]

The river basin overlaps with a complex of protected areas that is recognised internationally for its role in biodiversity conservation. The area overlaps a Conservation International designated Conservation Hotspot, a World Wildlife Fund (WWF) Global 200 Eco-region, a WWF/International Union for the Conservation of Nature (IUCN) Centre of Plant Diversity, and a BirdLife-designated Endemic Bird Area. It also overlaps a Ramsar wetland of international importance and two UNESCO Biosphere Reserves (UNEP, 2009 in Posas, 2013). Six indigenous reserves overlap with the Sixaola river basin and the Biosphere Reserves (see Figure 1). Indigenous territories have been acknowledged for their contribution to biodiversity of the Biosphere Reserve complex. For instance, the Bribri-Cabecar territory contains over 70% forest cover. (Borge & Martínez, 2009)

The Parque Internacional La Amistad is a transboundary protected area created in 1982 on the Costa Rican side, and in 1988 in Panama for a total area of 401 000 ha. La Amistad became part of La Amistad Biosphere Reserve and in 1983, was granted world heritage status by UNESCO. A 15 km buffer zone, which allows agricultural production and subsistence farming, surrounds the Reserve. The world heritage site contains an area of 570 045 ha (221 000 in Panama).[7] In Costa Rica, the core protected area of the biosphere reserve amounts to approximately 200 000 ha, whereas indigenous territories contribute over 260 000 ha to the biosphere reserve (SINAC, 2012). The Sistema Nacional de Áreas de Conservación – Ministerio de Ambiente y Energía (SINAC – MINAE) is the main institutional actor responsible for management of the core protected areas while the National Commission of Indian Affairs (CONAI) is the part of government responsible for indigenous reserves.

The region of study is dominated by moist and wet tropical forests found at lower elevations of the river basin (Whelan et al., 2008). However, the UNESCO site is highly ecologically varied and contains at least 9 out of 12 life zones found in the tropics (Posas, 2013). In the higher areas, rainforest predominates (Madrigal, 2012). Eight or nine of the 12 Holdridge life zones for Costa Rica can be found in within the Bribri and Cabécar indigenous reserves. The Talamanca indigenous territory alone counts six Holdridge life zones. Figure 2 shows the spatial extent of protected areas and indigenous reserves contained within the Sixaola river basin.

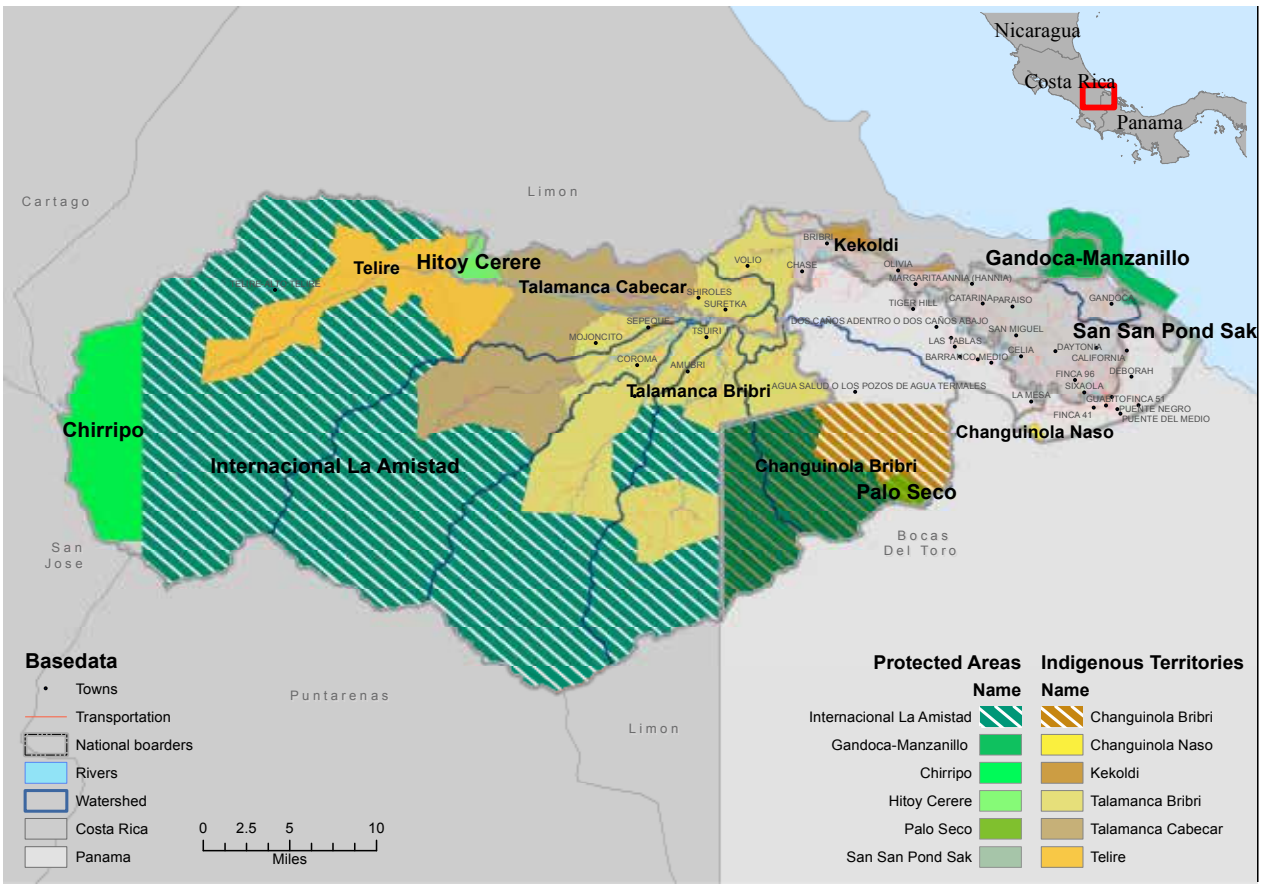
DOCUMENTED USES OF BIODIVERSITY

Two hundred and twenty-one records of species and agricultural varieties were included in this analysis. Each record has been associated with one or more PiN domains. Total

6 Also see http://www.inbio.ac.cr/pila/parque_contexto.htm

7 http://whc.unesco.org/en/list/205

Figure 2: Governance of protected areas and Indigenous territories in the Sixaola river basin



numbers of species and varieties used, organised by PiN domain is illustrated in Figure 3 below. Figure 4 shows these uses broken down by aggregate habitat categories. Figure 5 shows conservation status of all species included in the analysis. Notably, the number of species assessed in the SIS varies significantly by major type, i.e., wild mammal species found in our datasets have been completely assessed, whereas only a minority of all plant species (along the spectrum from wild to domesticated) have been assessed.

Food and nutrition

Costa Rica has generally low levels of nutrient deficiency related to child and maternal health. Six percent of children under 5 experience stunting, 19% of women of reproductive age with anaemia and 5% of children aged 6-59 months have vitamin A deficiency (Global Nutrition Report, 2015).

Non-cultivated and wild food sources may contribute significantly to nutrition in the study area. A study undertaken with six communities of the Reserve Indígena Talamanca in 2006-07 showed that in 51% of occasions on which meat was consumed, it was procured from wild species (Altrichter, 2011). Estimates vary regarding how many species, landraces and cultivars may be used. Borge and Castillo (1997) hold that Bribri farms may maintain a range of 80-150 cultivated species of plants. Ramos and Del Monte (2004) show Bribri and Cabécar diet to be based on 84 species.

An analysis of nutritional composition of species in an initial dataset on species used by Bribri for food is provided in Deutsch et al. (2016b). Food composition data may be found in nutrition datasets and has been used in the aforementioned case study to analyse the potential nutritional contributions of biodiversity to Bribri diets. This analysis shows higher nutritional content for non-cultivated species than their more popular counterparts that may be raised for subsistence or available on the market. Table 4 shows that the majority of these species come from home gardens or polyculture plots, although several can be found in forested landscapes, including primary forest. Such non-cultivated foods or 'minor' crops may make valuable contributions to food and nutrition security under certain conditions and during periodic times of dearth.

Traditional varieties of species, including maize, chili, coffee, papaya, banana, yam, yucca, beans, citrus fruits, rice,

Figure 3: Species use by PIN domain

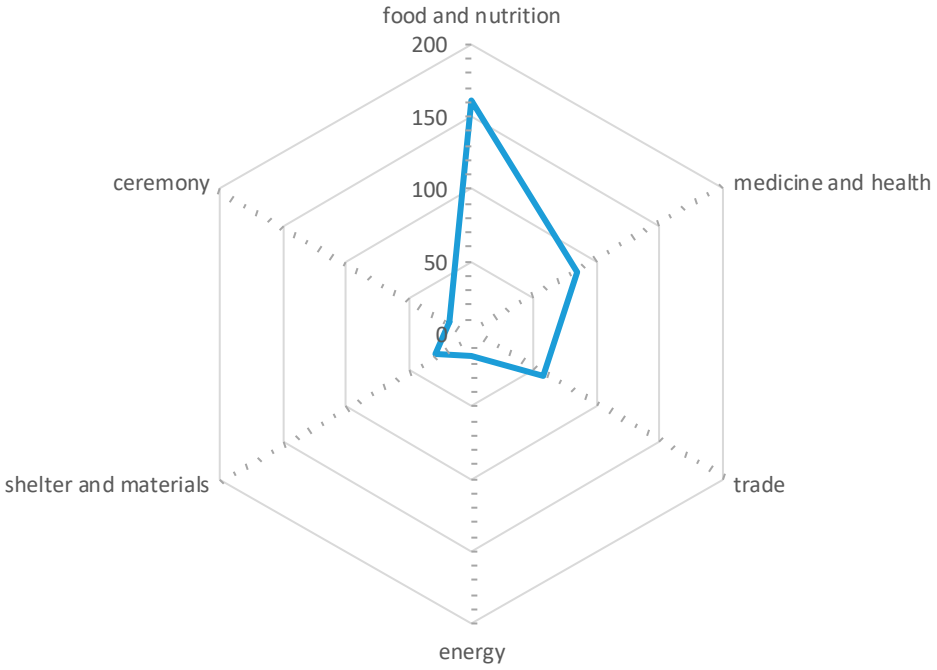


Figure 4: Analysis of use domains by habitat

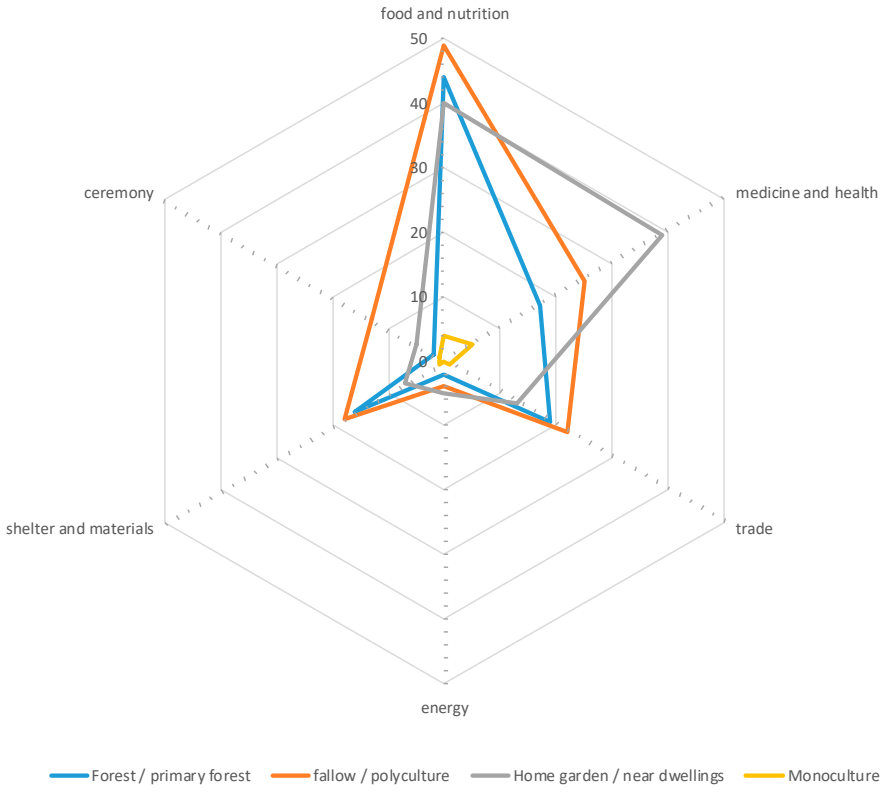
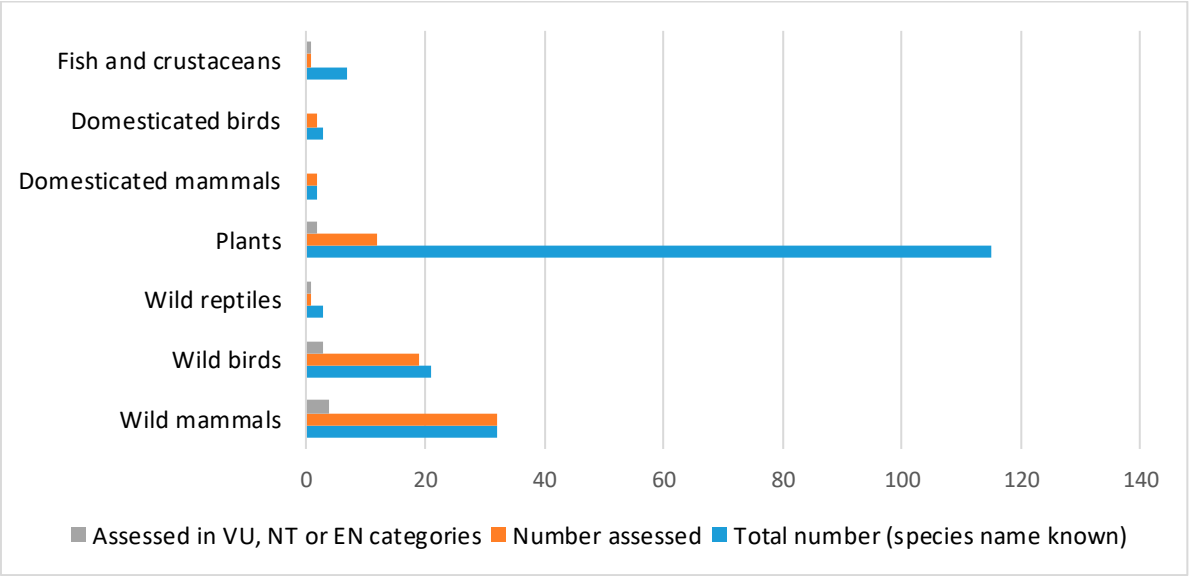


Figure 5: Number of species known to species or subspecies-level name that have been assessed for conservation status in SIS, and number of species at risk (Vulnerable, Near Threatened or Endangered).



sugar cane, squash, and peach palm, may be found in agricultural plots of Bribri households (Borge, 2011). Borge (2011) found eight banana varieties in smallholder agroforestry plots. Some of these are noted as ancestral landraces that are autochthonous. Posas (2001) found up to 200 cultivars per farm.[8] One reference was found in the literature to historical reports on indigenous landraces: Skinner (1920 in Posas, 2013) reported red, white, blue, yellow, black, and purple corn under cultivation by the Bribri in the early 20th century. However, apart from their mention in the literature, no datasets were found that listed agricultural landraces and associated risks to their continued availability. Sale and exchange of seed is regulated in Costa Rica, but de facto arrangements appear to persist in this area:

> In Costa Rica, two kinds of seed are produced: certified seed and craft seed. The University of Costa Rica and the Ministry of Agriculture and Livestock are the two institutions in charge of producing certified seed while most of the farmers and association of farmers produce craft seed. However, in the south of the country, the control over certified seed is difficult.[9]

Medicine and health

Over 400 medicinal plant species in 106 genera have been recorded in Costa Rica (Ocampo, 1997). Our list contains 78 species associated with medicinal use. Thirty-seven of these species were also recorded to have significance in terms of food and nutrition (nearly 50%). A single article (Rodié, 2012) provided the majority of data relative to medicinal plant usage in relation to habitats associated with the indigenous cacao polyculture system.

A diversity of land use types within the landscape mosaic, including home gardens, cacao plantations and forested areas and roadsides were found to be important for provision of medicinal plants (Arias & Campregher, 2010). Monoculture plots (of cacao) were found to have exceptionally low medicinal plant diversity compared to other land use types (Arias and Campregher, 2010).

Energy

Of sixteen species used for energy, one (*Cedrala odorata*) is listed in the SIS as vulnerable (VU) due to extensive harvesting in its range. No species was listed as occurring solely in either primary or secondary forest, and energy species were usually associated with polyculture (including home garden) habitats. All species, which were associated with Holdridge life zones in datasets, occurred in tropical moist and wet forests, with the exception of *Theobroma bicolor*, which could also be found in premontane wet forest.

Shelter[10]

Certain palms are used widely for construction. Palm fronds are used for thatching of roofs. Suita (*Asterogyne martiana*) is commonly used for this purpose (Gutiérrez, 2013). Suita grows in very humid forests between 0-1000m, and

8 This figure likely includes commercial cultivars of plants that are important for the market such as plantain, banana and cacao.

9 https://msu.edu/~bernsten/beanatlas/Country%20Pages--withGIS/Costa%20Rica/1.SubsectorOverview/costa_rica_text_subsector_overview.2.htm accessed 20/04/2016

10 In this section, we report only on the species flagged for shelter and materials usage that have relevance for construction of dwellings.

Table 4: Nutritionally important cultivated and non-cultivated species and habitat associations (modified from Deutsch et al. 2016b)

Scientific name	common name (English)	SIS assessment	Calcium	Iron	Zinc	SIS use	SIS use value	Habitat
Carica papaya (Caricaceae)	Papaya	not yet assessed	20	0.25	0.08			HG, P, SB
Artocarpus altilis (Moraceae)	Breadfruit (fruta pan)	not yet assessed	17-61	0.54-3.67	0.12-0.9			N/A
Musa sp.	Banana/plantain	not yet assessed	3-10	0.58-60	0.13-0.14			HG, P, M
Pouteria sapota (Sapotaceae)	Mamey sapote (zapote)	not in SIS	18	0.78	0.19			P
Chameadorea tepejilote (Arecaceae)	Pacaya palm (pacaya)	not in SIS	18-58	1.69-3.13	1.15-3.73			PF, HG
Cyathea sp. (Cyatheaceae)	Fiddlehead ferns (quelites)	no species level name	32	1.31	0.83			SB
Phytolacca rivinoides (Phytolaccaceae)	Pokeweed or pokeberry (calalu)	Not in SIS	53	1.2-1.7	0.19-0.24			PF, SB
Gallus gallus	Chicken	Won't be assessed	12	0.89	1.54			HG, P
Odontophorus erythrops	Quail	LC	13	4.51	2.7	Food-human	subsistence, national	N/A
Columbina spp.	Ground dove	no species level name	17	5.91	3.83			N/A
Proechimys semispinosus	Tome's spiny rat	LC	190	7.8	5.3			N/A

HG=home garden, SB=slash and burn, PF=primary forest, P=polyculture, M=monoculture

is abundant in Costa Rica (it is not assessed in the SIS). Chonta (*Socratea exorrhiza*) and jira palms (*Socratea durissima*) are used for walls and floors in Talamanca. This later species is also valued for parquet production (Gutiérrez, 2013). It is not known what proportion of the population, nor the geographical locations of communities that are most dependent on these resources for shelter. Common agroforestry species that predominate in polyculture plots are used for construction, including laurel (*Cordia alliodora* and *Cordia gerascanthus*). Only one plant, cedro (*Cedrala odorata*), also used for energy is considered to be vulnerable to extinction. All plants listed as important for construction had multiple uses, often for food in the case of heart of palm harvested from palms mentioned above.

Ceremony

Sixteen species were documented as being harvested for ceremonial purposes. Some of these species were significant subsistence and commercial agricultural species, including three Theobroma species, domesticated pig (*Sus domesticus*) and domesticated cow (*Bos taurus*). Other domesticated plants with ceremonial uses are peach palm (*Bactris gasipaes*) and achiote (*Bixa orellana*). Cacao (*Theobroma cacao*) polyculture is a major feature in the indigenous agricultural landscape and cacao is important for trade. The cacao plant is important symbolically and ceremonially and continues to be at risk within the landscape due to frosty pod rot. Trees cannot be cut according to customary practice, which has implications in terms of change in the landscape. Trees may remain, as do other species associated with cacao polyculture, even though the cacao economy is not viable in some cases.

Most species with ceremonial importance could be found in home gardens and polyculture plots, with the exception of *Theobroma angustifolium* (cacao de mono/ cacao de mon-

taña), which could be found both in polyculture systems and in primary forest. Only Northern naked-tailed armadillo (Cabassous centralis), noted as having both medicinal and ceremonial use, was documented to occur in forest habitat only. Only the tree ocelot (*Leopardus wiedii*) was listed as near threatened (NT) in the SIS.

Trade

Forty-five species were noted in secondary sources to have value in terms of sale on the market. These included 15 plant species, 16 wild birds and 10 wild mammals. Of these, 33 species had SIS data on trade, and 27 of these were known to have market value at local, national or international levels. However, none of these species were only considered to have value in terms of income, and all had value in terms of food and nutrition. Available SIS data on use and trade is shown in Figure 6 below. Literature on local species use did not indicate significant sale of animals or wild birds on national or international markets.

Twenty-five species with importance for trade were associated with data on habitats (see Figure 4). Out of these, four species were found to be associated only with forest, forest margin or primary forest, while the others were associated with agricultural land use. Eight species were found to be associated with home gardens, polyculture and shifting agriculture. Species associated with monoculture were primary species of economic interest, although these were also equally associated with polyculture and home garden agroforestry systems (e.g. *Musa sp.*, *Theobroma cacao*).

An analysis of the relative importance of trade in these species compared to other sources of household income was not found, and an analysis of this relationship was not considered to be feasible, given data available.

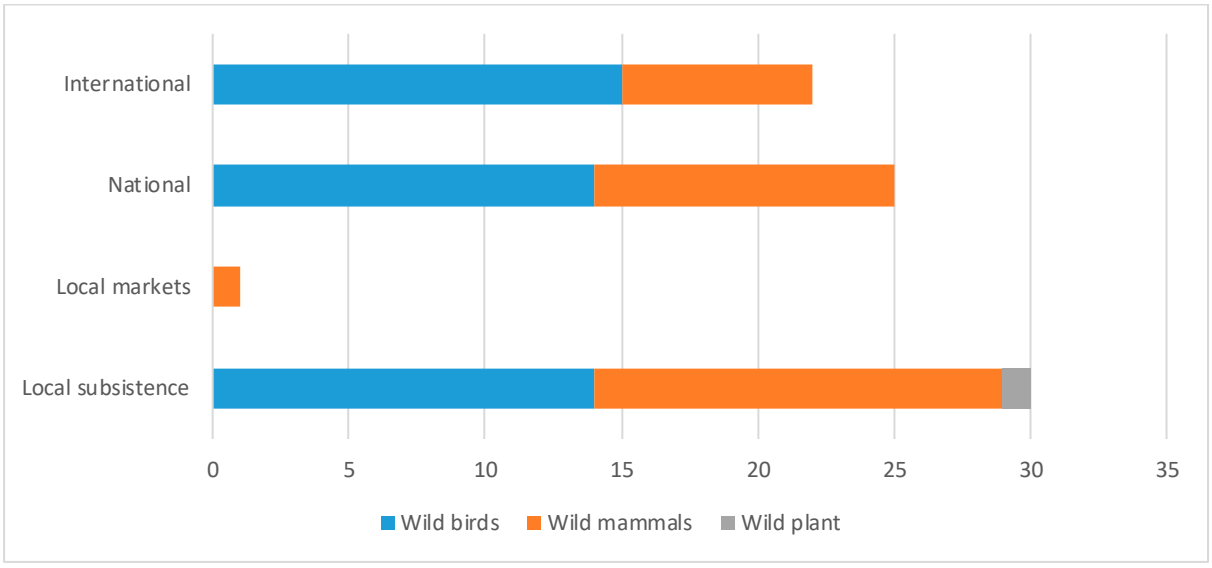
RISKS TO BIODIVERSITY, LIVELIHOODS AND RESOURCES

Land use change

Disasters and livelihood shocks, as well as longer term processes of land use change may significantly influence the availability and stability of species with known uses. In the lower part of the river basin, published information describes a tendency away from structurally diversified land uses (e.g. primary and secondary forests, agroforestry with cacao) in favour of plantain and banana cultivation, including banana agroforestry and silvopastoral land, but also plantain monoculture (Whelan 2008). Cacao trees in polyculture are important symbolically/culturally and economically, yet continue to be affected by monilia. Cacao polyculture (and also banana polyculture) is additionally important as a major habitat type that is known to host numerous other plant and animal species, meaning conversion of polyculture plots is a significant factor influencing availability of other species with direct use values within the domains listed above. Threats to availability and stability of species that are used traditionally thus may include further expansion of the plantain economy, as plantain monoculture constitutes a land use associated with a low diversity of useful species.

Nine of eleven threatened or near threatened species and subspecies that were found in the SIS could be associated with data on habitats. Table 5 lists threats to these species that were extracted from the SIS database. The results in-

Figure 6: Analysis of the number of species with information in SIS Use & Trade module



dicate threats to local habitats that may be contradictory to local knowledge, and may not point usefully to actual threats to species availability and stability experienced locally. For instance, in some cases, small-holder agriculture is indicated as a threat, yet species are known to be harvested from polyculture or agroforestry parcels. On the other hand, landscape mosaics with significant presence of small-holder plantain monoculture plots may be unhospitable to these species. In these cases, primary data collection may be recommended to better understand local perception of risks to livelihood resources.

The Holdridge life zones form an obvious gradient, (seen in Figure 1, above, and again in Figure 8, below) associated

Table 5: Habitats and threats associated with threatened and near threatened species (source: SIS)

Scientific name	Conservation status	Habitat	threats
Alouatta palliata ssp *aequatorialis*	VU	N/A	Housing & urban areas; Annual & perennial non-timber crops; Logging & wood harvesting; Livestock farming & ranching; Hunting & trapping terrestrial animals
Anguilla rostrata	EN	Freshwater	Fishing & harvesting aquatic resources; Dams (size unknown); Invasive non-native/alien species; Domestic & urban waste water; Industrial & military effluents; Agricultural & forestry effluents; Habitat shifting & alteration
Bertholletia excels	VU	Home garden	Housing & urban areas; Annual & perennial non-timber crops; Livestock farming & ranching; Logging & wood harvesting; Fire & fire suppression
Cedrela odorata	VU	Primary forest, River edge, Roadside	Logging & wood harvesting
Chelydra rossignonii	VU	Freshwater, River edge	Housing & urban areas; Fishing & harvesting aquatic resources
Crax rubra	VU	Forest margin, Forest	Fire & fire suppression; Annual & perennial non-timber crops; Hunting & trapping terrestrial animals (intentional use); Logging & wood harvesting
Leopardus wiedii	NT	Polyculture, Forest	Housing & urban areas; Commercial & industrial areas; Agro-industry farming; Agro-industry plantations; Agro-industry grazing, ranching or farming; Mining & quarrying; Roads & railroads; Hunting & trapping terrestrial animals (persecution/control); Logging & wood harvesting; Recreational activities; Fire & fire suppression; Dams (size unknown); Invasive non-native/ alien species; Problematic native species; Industrial & military effluents
Ramphastos ambiguous	NT	Agricultural land, Forest margin, Forest	Livestock farming & ranching; Annual & perennial non-timber crops; Hunting & trapping terrestrial animals (intentional use)
Tapirus bairdii	EN	Agricultural land, Forest margin, Forest	Housing & urban areas; Mining & quarrying; Roads & railroads; Annual & perennial non-timber crops (small-holder farming); Logging & wood harvesting; Livestock farming & ranching (Small-holder grazing, ranching or farming); Hunting & trapping terrestrial animals (intentional use); Agro-industry plantations; Agro-industry farming
Tayassu pecari	VU	Slash and burn, shifting agriculture, Forest	Housing & urban areas; Logging & wood harvesting; Hunting & trapping terrestrial animals (intentional use); Small-holder grazing, ranching or farming; Agro-industry grazing, ranching or farming; Small-holder farming; Agro-industry farming
Tinamus major	NT	N/A	Agro-industry grazing, ranching or farming; Hunting & trapping terrestrial animals (intentional use); Agro-industry farming

with altitude of the slope of the river basin. We were able to find sources that tied species to specific life zones, allowing us to perform some spatial analysis at the level of the basin (see Figure 7).

Settlement patterns closely follow this altitudinal gradient – and hence also the gradient of life zones – where settlement locations are much denser at lower elevations. The majority of useful species are found in the tropical moist and wet forests and thus are found within lower elevation life zones.

Zones with the highest percentage of primary forest exist primarily in mountainous areas far from communities and within protected areas. La Amistad has a total surface area of 93% covered by primary forest (SINAC, 2012). Costa Rican national parks must recognize peoples' traditional forest management practices (Ley de Biodiversidad 7788), but policy directives on how to do so are limited (Cajiao Jiménez, 2002 in Sylvester et al., 2012). Forest cover predominates in indigenous reserves in Talamanca. The 1996 Forest Law (No. 7575) banned clearing forested lands and set out a national programme for payment for ecosystem services (Murillo et al., 2014). About 20% of this programme's budget is allocated to indigenous territories. Communal title to forest lands means PES within territories is managed by the governing body of indigenous territories, not by individuals (Murillo et al. 2014). Whelan (2005) points to additional institutional factors that strictly limit cutting of trees within indigenous territories, where timber allocation is controlled by ADIs.

García-Serrano and Del Monte (2004) state that use of the primary forest has become less important than in the past. As such, we may use this analysis to question whether norms and regulations associated with protected areas have shaped use of biodiversity higher in the valley through constraints on access to these areas by indigenous people. Figure 8 overlays spatial institutions, including protected areas and indigenous reserves on the spatial extent of Holdridge life zones. From this map, it is possible to see the large extent of tropical moist forest outside these institutional boundaries to the east. This area, while supplying a large number of species with known use, is at risk of land use change due to extensive conversion to plantain monoculture.

Risks to species from direct use

Direct use through hunting pressure on some animal populations may constitute a risk to continued availability of these species (Harvey et al., 2006 in Posas, 2013). The species most hunted are *Mazama americana*, *Odocoileus virginianus*, *Cuniculus paca*, *Pecari tajacu*, and these are hunted in or near indigenous agroforestry or polyculture systems as opposed to the primary forests within protected areas (SINAC, 2012). Mammals legally hunted in the park for subsistence purposes include tapir, peccary (*Tayassu peccary*) and primates (SINAC, 2012). Meanwhile, indigenous customs and taboos, and strict wildlife management regulations prohibit hunting of animals such as tapir (*Tapirus bairdii*) and jaguar (Posas, 2013; SINAC, 2012). Other restrictions on hunting derive from park regulations, e.g., on hunting of danta or tapir (*Tapirus Bairdii*) that tend to be respected by people living near strict protected areas (SINAC, 2012). Non indigenous hunters pose a small threat in some areas bordering the park (SINAC, 2012). Direct use is also cited as a threat to abundance of cedro (*Cedrela odorata*), used for construction of housing and canoes. This species

Figure 7: Species use associated with Holdridge life zones

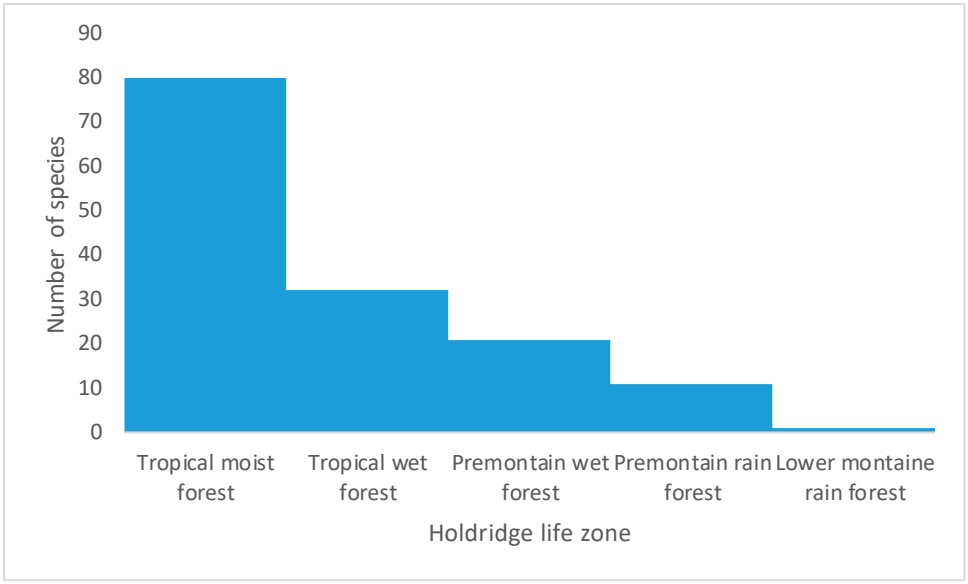
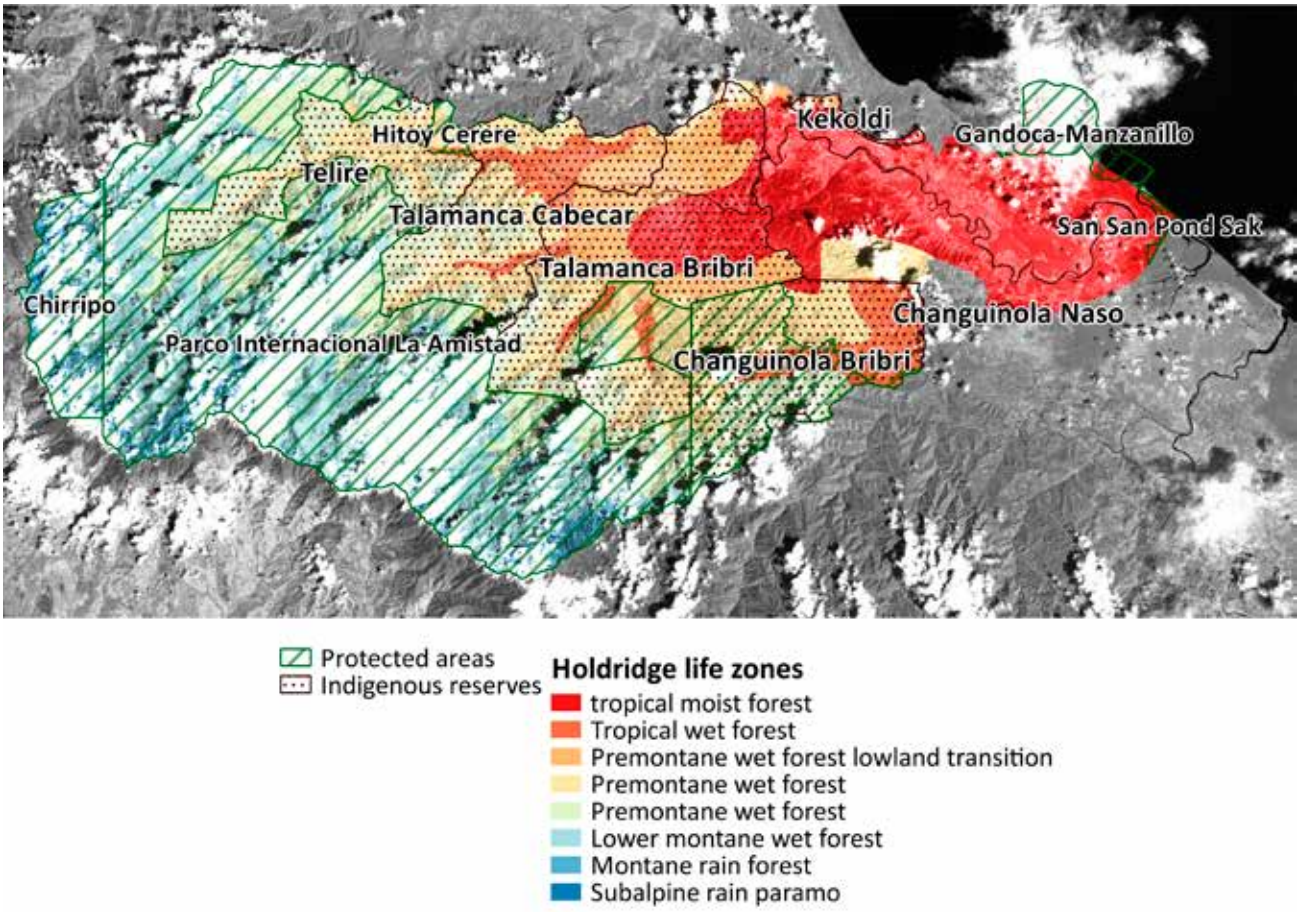


Figure 8: Life zones with institutional overlay showing locations of parks and protected areas and indigenous territories



is listed as vulnerable (VU) in the SIS. SIS data on threats to species are broken down in table 6 to illustrate land use change risks to species along with other threats to species in the SIS database that may be of relevance in the Sixaola river basin.

Legal and institutional processes that shape access to resources

Some protected areas, or zones within parks are managed to prohibit any type of harvesting. Nonetheless, Indigenous People have the right to practice traditional harvesting activities as guaranteed in national and international law, i.e. ILO Convention 169 (SINAC, 2012). Market access may shape land-use choices by some families. Decreasing crop diversity on farms was found to be associated with "availability of salary income, the general market orientation of the family group or neighbourhood, and closeness to accessible roads" (Posas, 2001 in Posas, 2013: 53).

Risks to water availability, stability and access

In addition to analysis of factors that shape biodiversity use, PiN has also taken an interest in water use and sanitation, although details of how water relates to other PiN domains, and to the biodiversity-based system framework has not yet been developed (Idrobo et al. 2016). In this pilot ISA report, we include a brief discussion on findings related to water and sanitation, particularly in relation to availability of drinking water and water for other purposes such as agriculture, variability in water supply over time, including seasonal availability issues (stability), and access to (clean) water.

An ample regional precipitation regime means that water is readily available in the Sixaola river basin. Water quality concerns thus predominate over water quantity concerns, along with concerns over flooding and erosion. Traditional habitations are located near water such that water is readily accessible to people from their homes. Waterways constitute important transport routes for accessing difficult-to-reach communities.

Rapid development in some areas has led to a change in water use, where wells have slowly substituted use of naturally occurring surface water, which has also led to an alteration in factors determining location of housing.[11] Threats are posed by ranching practices at higher elevations in

11 Borges and Villalobos (1998), cited in http://www.unesco.org.uy/phi/aguaycultura/es/paises/costa-rica/pueblo-bribri.html

Table 6: Threats data for species assessed for the IUCN Red List of Threatened Species (Modified from Deutsch et al., 2016b)

Threat category	Number of species listed as LC or DD	Number of Threatened and Near Threatened species	Total
Agriculture and aquaculture	13	6	19
Of which smallholder grazing, ranching, farming or shifting agriculture	9	2	11
Biological resource use	19	9	28
Of which intentional use, persecution, control of species	18	1 (subsistence use) + 8 (species is target)	27
Energy production and mining	1	2	2
Human intrusion and disturbance	1 (recreation)	1 (recreation)	2
Natural systems modification	5	3	8
Pollution	2	2	4
Residential and commercial development	7	5	12
Transportation and services corridors	6	2	7
Invasive species	5	2	7
Climate change and severe weather	1 (only *Odocoileus virginianus* listed as threatened by drought)	1 (*Anguilla rostrate* listed as threatened by habitat shifting & alteration)	2
Total number of species assessed	58	11	69

terms of erosion and land-use change. Deforestation of ecosystems on steep slopes for agricultural activities threatens water protection surfaces (IUCN, 2011b).[12] Access to clean water is cited as a factor influencing internal migration. Accessibility of uncontaminated water is potentially a problem where the landscape has been significantly altered in favour of plantain and banana monoculture. In these landscapes, there is higher prevalence of intestinal helminths transmitted by ingestion of contaminated food or water.[13]

Additionally, concerns over hydroelectricity development projects constitute a potential threat to water quality and other land uses. Over 80% of energy consumed in Costa Rica comes from hydroelectricity (Bonilla, 2011 in Mendiola Fernández, 2014).

Climate change scenarios for the area include strong variations in precipitation. Impacts on precipitation and extreme events could create vulnerability for communities. An IUCN project funded by BMU has aimed to strengthen adaptive capacity of communities confronting climate change (IUCN, 2011b). A concern is that fluctuation in the precipitation regime can increase the number of extreme events that can cause serious damage in the mid and lower parts of the watershed. Risks include increased soil erosion, flooding, sedimentation, loss of crops, damage to local infrastructure and increase in respiratory disease. Floods can cause clogging of aquifers with contaminated water mainly due to

13 Barrantes (1993), cited in http://www.unesco.org.uy/phi/aguaycultura/es/paises/costa-rica/pueblo-bribri.html

12 Borge and Castillo (1997), cited in http://www.unesco.org.uy/phi/aguaycultura/es/paises/costa-rica/pueblo-bribri.html accessed 12/04/2016

lack of protective vegetation in water recharge areas (IUCN, 2011a). The last major flood in late 2008 and early 2009 was unprecedented in the memory of the area's inhabitants (IUCN, 2011a).

Perception and biodiversity use

The indigenous land use system traditionally featured clan ownership and plot sizes that were larger in area than those currently available in mid and low elevation area. In Whelan's (2005) study, he purports that shifts in land use from polyculture and secondary forest to plantain monoculture in these lower parts of the Sixaola river basin are not necessarily welcomed by the families that make the changes. Rather, Bribri cosmology holds a perception of the larger landscape characterised by a mosaic of 'near' and 'far' places that are both important for different activities (Ramos and Del Monte 2004 in Posas, 2013).

The near space, which is the indigenous, humanized space, can be modified and shaped, while the far space, or natural, primary forest space, is seen not to belong to humans and can only be used by observing strict rules (Posas, 2013: 49).

As such, socio-economic and environmental constraints were held to be responsible for changing land use which was perceived negatively (Whelan, 2005). Garcia-Serrano and Del Monte (2004) identify four spaces in which Bribri and Cabecar people of Talamanca carry out their activities. These are home gardens, slash-and-burn plots, plantain polyculture and monoculture. These constitute the "near space", while primary forest constitutes the 'far space' (Garcia-Serrano and Del Monte, 2004). As such, cultural norms and rules may shape use in the far zone, but the concurrent presence of strict protected areas may also affect peoples' ability to harvest in forests located within parks.

Some studies indicate that age and generation are important factors that predict the crop diversity of a family farm (Borge & Villalobos, 1995; Posas, 2001 in Posas, 2013). Younger generations with less access to land may again have been forced to cultivate monocultures, contributing to this trend. Some, but not all communities were said to prefer organic farming methods (Posas, 2001; Whatley, 2008 in Posas, 2013), which is compatible with the indigenous agroforestry system, but again, access to land suitable for organic agriculture plays an important role in making choices about the destination of small-holdings.

In the area of agricultural biodiversity, the BMU funded IUCN project (IUCN, 2011a;b) promoted exchange of farmer's varieties or landrace seeds among different settlements and indigenous territories in a transboundary context. IUCN is attempting to increase the perception that seed exchanges can increase adaptive capacity and are beneficial to biodiversity conservation.

CONCLUSIONS

Although no large-scale development or conservation project plans were found that posed contemporary risks to biodiversity use, socio-economic and environmental drivers were found to be associated with large-scale habitat conversion or change. The indigenous land-use system in low-lying parts of the river basin appear to face a gradual shift towards plantain monoculture. This shift was flagged as a threat to indigenous livelihoods and the traditional agroforestry system by some authors. This shift was tied to migration out of more remote rural areas towards valley bottoms and gradual loss of the indigenous land-use mosaic. This situation analysis concludes that risks to the indigenous land-use system require further analysis in order to better understand impacts on plants and animals supported by indigenous land uses that hold the potential to help communities cope with and adapt to globalised change.

Future ISAs may contain a more analysis of 1) agricultural varieties and their uses, and 2) socio-economic variables and indicators in relation to traditional land uses, including analysis of quantitative data on the relative contribute of biodiversity to local livelihoods. In this analysis of the Sixaola river basin, these types of information were not found to be available, however, this may not be the case in future studies concerning other areas.

Lessons learned and recommendations for PIN development:

1. It will be worthwhile to work on a set of suitable standards for working with habitat data, as this will be highly useful for correlating species with spatial land use and ecosystem data such that PiN may develop spatially explicit tools and analysis.
2. This trial run was used to construct a Microsoft Access database that can form the basis for experimentation with database structure and linkages to the SIS. Work with the Species Programme on this provisional database structure may help identify where parts of the SIS data structure can be used or altered to store PiN data (e.g. parts of the Use and Trade module).
3. A further area of integration would be with the SIS habitats module, as this could potentially supply habitats data that can be used alongside 'endogenous' habitat categories that emerge from other datasets.
4. This pilot ISA can be used to inform discussions about the ability of this PiN phase to indentify knowledge gaps. In particular, is this type of broad analysis useful, or should the PiN ISA be focussed on more narrow goals? A useful exercise might consider the secondary data findings of this ISA and how future ISAs should proceed.
5. Of all 182 records with species level names, 93 were in

found the SIS (51%). These were predominantly mammals (all mammals had records in the SIS). This information can potentially be used to drive new collaborative efforts across IUCN knowledge products and across Commissions (e.g. between CEESP and SSC) to fill in gaps that are potentially highly relevant to the Sustainable Development Goals (SDGs). This is also tied to the ability of this ISA to inform discussions about ways the SIS can be used to more effectively inform communities about risks to biodiversity that is useful to them, and how their livelihoods may be affected through processes of globalised change.

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APPENDIX I: EXAMPLE OF LITERATURE METADATA TAG APPLICATION

These metadata tags are experimental and may change before they are stabilised to facilitate data searches on documents:

Use:
- Trade
- Medicine and health
- Food and nutrition
- Energy
- Shelter
- Ceremony
- Water

Land use:
- Planning
- Agricultural productivity
- Orthophoto
- Satellite image
- Ecology and habitats
- Water
- Spatial

Governance:
- Legal rules and regulations
- Customary/traditional rules and regulations
- Community protocols
- Management plan
- Protected areas
- Territorial development
- Water

Threats:
- To be merged with Species Information Service threats categories

Socio-economic:
- Markets
- Labour
- Gender
- Age
- Ethnicity

Example of application of tags to sources used within the Sixaola river basin ISA:

Source	tags
Alrichter (2011)	Use:Food and nutrition
Borge (2011)	Socio-economic:Labour Socio-economic:Gender Use:Trade Use:Medicine and health Use:Food and nutrition Use:Shelter and materials Land use:Ecology and habitats
Córdova (2004)	Use:Trade Land use:Ecology and habitats Socio-economic:Gender
Dubois (2007)	
Rojas (2009)	Socio-economic:Gender Socio-economic:Labour

APPENDIX II: SPECIES AND VARIETY-LEVEL BIODIVERSITY WITH KNOWN USES

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
	Boca Negra	Fish and crustaceans	Borge (2011)	Food and nutrition	Freshwater		
Agonostomus monticola	Lisa/tepemechín	Fish and crustaceans	Borge (2011)	Food and nutrition	Freshwater		
Alfaro cultratus	Olomina	Fish and crustaceans	Borge (2011)	Food and nutrition	Freshwater		
Alouatta palliata	Mono congo	Wild mammal	Sylvester, Harvey et al. (2006)	Food and nutrition	Polyculture		LC
Alouatta palliata ssp aequatorialis		Wild mammal		Food and nutrition			VU
Amaurolimnas concolor		Wild bird	Borge (2011)	Food and nutrition			LC
Amazilia sp.		Wild bird	Borge (2011)	Food and nutrition			
Amazona sp.	Loros	Wild bird	Sylvester, Borge (2011)	Food and nutrition, Ceremony	Polyculture		
Anacardium occidentale L.		Cultivated plant	Sylvester, Garcia and del Monte (2004)	Food and nutrition	Home garden	Tropical moist forest	
Ananas comosus (Stickm.) Merr.		Cultivated plant	EOL, Garcia and Del Monte (2004)	Food and nutrition, Shelter and materials, Household income, Medicine	Home garden	Tropical moist forest	
Anguilla rostrata	Anguila	Fish and crustaceans	Borge (2011)	Food and nutrition	Freshwater		EN
Annona muricata		Cultivated plant	Sylvester, Arias & Campregher (2010), Dubois (2007), Córdova (2004)	Food and nutrition, Household income, Medicine	Home garden, Polyculture	Premontane wet forest	
Annona reticulata L.		Wild/Cultivated plant	EOL, Garcia and del Monte (2004)	Food and nutrition, Medicine	Home garden, Primary forest	Tropical moist forest, Tropical wet forest	
Aratinga sp.		Wild bird	Borge (2011)	Food and nutrition			
Archocentrus myrnae	Mojarra/chogorra	Fish and crustaceans	Borge (2011)	Food and nutrition	Freshwater		
Artibeus sp.	Murciélagos	Wild mammal	Borge (2011)	Ceremony	Polyculture		
Artocarpus altilis (Moraceae)	Fruta pan	Cultivated plant	Sylvester	Food and nutrition			
Artocarpus communis J. R. & G. Forst	Arbol de pan	Cultivated plant	Garcia and del Monte (2004)	Food and nutrition	Home garden	Tropical moist forest, Tropical wet forest	

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
Asterogyne martiana	Suita	Wild plant, Cultivated palnt	Gutiérrez (2013), Sylvester et al. (2012)	Shelter and materials	Forest	Tropical wet forest	
Astrocaryum standleyanum	palmito de chonta	Unknown plant	Garcia-Serrano and Del Monte (2004)	Shelter and materials	Slash and burn, shifting ag		
Astyanax aeneus	Sardina	Fish and crustaceans	Borge (2011)	Food and nutrition	Freshwater		
Averrhoa carambola (Oxalidaceae)	carombola	Cultivated plant	Sylvester, Garcia and del Monte (2004), Dubois (2007), Córdova (2004)	Food and nutrition, Household income	Home garden, Polyculture	Tropical moist forest, Tropical wet forest	
Azadirachta indica A. Juss.		Cultivated plant, Wild plant	Arias and Campregher (2010), EOL	Shelter and materials, Medicine	Forest margin	Tropical moist forest	
Bactris gasipaes (Arecaceae)	pejibaye	Cultivated plant	Sylvester, Garcia and del Monte (2004), Córdova (2004)	Food and nutrition, Energy, Shelter and materials, Household income, Ceremony, Medicine	Home garden, Polyculture, Slash and burn, shifting ag	Tropical moist forest, Tropical wet forest	
Bertholletia excelsa Humb. et Bompi.	Castana	Cultivated plant	Garcia and del Monte, 2004	Food and nutrition	Home garden	Tropical moist forest	VU
Bixa orellana L.	Achiote	Cultivated plant	Garcia and del Monte (2004), Arias and Campregher (2010) EOL	Food and nutrition, Shelter and materials, Household income, Ceremony	Home garden, Polyculture	Tropical moist forest	
Boa constrictor		Wild reptile	Sylvester	Food and nutrition, Medicine			
Bos taurus (Bos indicus)	Vaca	Domesticated animal	Sylvester, Borge (2011)	Food and nutrition, Household income, Ceremony	Polyculture		
Bradypus variegatus		Wild mammal	Sylvester	Food and nutrition, Household income, Medicine	Forest margin, Forest		LC
Brosimum alicastrum		Wild plant	Garcia and del Monte (2004), EOL	Food and nutrition, Shelter and materials, Household income	Primary forest	Tropical moist forest, Tropical wet forest, Premontane rain forest	
Brosimum costaricanum		Wild plant	Garcia and del Monte (2004)	Food and nutrition, Shelter and materials	Primary forest, Slash and burn, shifting ag, Forest	Tropical wet forest, Premontane wet forest,	

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
						Premontane rain forest	
Brosimum utile		Wild plant	Garcia and del Monte (2004) EOL		Primary forest	Tropical moist forest, Premontane wet forest, Premontane rain forest	
Bursera simaruba	indio desnudo, jinocuabe, jinote	Unknown plant	Borge (2011)	Medicine	Polyculture		
Cabassous centralis		Wild mammal	Altrichter (2011) EOL	Food and nutrition, Ceremony, Medicine	Forest		DD
Caesalpinia pulcherrima		Unknown plant	Arias and Campregher (2010), EOL	Medicine	Forest margin	Tropical moist forest	
Cajanus cajan (Fabaceae)	gandul	Cultivated plant	Sylvester	Food and nutrition			
Campephilus guatemalensis		Wild bird	Borge (2011)	Food and nutrition			LC
Capsicum sp. (Solanaceae)		Cultivated plant	Sylvester	Food and nutrition	Home garden	Tropical moist forest	
Capsicum sp. (Solanaceae)		Cultivated plant	Sylvester	Food and nutrition			
Carica papaya (Caricaceae)		Cultivated plant	Sylvester, Arias & Campregher (2010)	Food and nutrition, Medicine	Home garden, Polyculture, Slash and burn, shifting ag	Tropical moist forest	
Carludovica palmata		Wild plant, Cultivated plant	Garcia and del Monte (2004)	Food and nutrition, Shelter and materials	Primary forest, Monoculture, Slash and burn, shifting ag, Forest	Tropical moist forest, Tropical wet forest, Premontane wet forest, Premontane rain forest	LC
Carludovica sp.	estococa	Wild plant	Sylvester	Food and nutrition	Primary forest, Forest, Near dwellings	Tropical wet forest, Premontane wet forest	
Carollia perspicillata	Murciélagos	Wild mammal	Borge (2011)	Ceremony	Polyculture		LC

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
Castilla elastica		Unknown plant	Arias and Campregher (2010), Dubois (2007)	Medicine	Polyculture, River edge	Tropical moist forest	
Cebus capucinus	Mono cariblanco	Wild mammal	Altrichter (2011)	Food and nutrition			LC
Cedrela odorata	cedro, cedro rojo	Wild plant	Arias and Campregher (2010), Córdoba (2004)	Energy, Shelter and materials, Medicine	Primary forest, River edge, Roadside	Tropical moist forest	VU
Ceiba pentandra		Cultivated plant	Borge (2011)	Shelter and materials			
Cestrum racemosum Ruiz & Pav.		Wild plant	Arias and Campregher (2010)	Medicine	Roadside	Tropical moist forest	
Chameadorea tepejilote	pacaya	Wild plant	Sylvester	Food and nutrition, Medicine	Primary forest, Forest, Near dwellings	Tropical moist forest, Tropical wet forest	
Chelydra rossignonii		Wild reptile	Sylvester	Food and nutrition, Medicine	Freshwater, River edge		VU
Choloepus hoffmanni		Wild mammal	Sylvester	Food and nutrition, Medicine	Forest margin, Forest		LC
Cichlasoma sp.	Guapote	Fish and crustaceans	Borge (2011)	Food and nutrition	Freshwater		
Citrus limmeta	Limon dulce	Cultivated plant	Sylvester, Dubois (2007), Córdova (2004)	Food and nutrition, Household income	Home garden, Polyculture, Slash and burn, shifting ag	Tropical moist forest, Tropical wet forest, Premontane wet forest	
Citrus reticulata	mandarina	Cultivated plant	Sylvester, Dubois (2007)	Food and nutrition	Home garden, Polyculture, Slash and burn, shifting ag	Tropical moist forest, Tropical wet forest, Premontane wet forest	
Citrus sp.	limon criollo	Cultivated plant	Sylvester	Food and nutrition			
Citrus sp.		Cultivated plant	Sylvester	Food and nutrition			
Cocos nucifera (Arecaceae)	coco	Cultivated plant	Sylvester, Dubois (2007)	Food and nutrition, Energy, Medicine	Home garden, Polyculture	Tropical moist forest, Tropical wet forest	
Coffea arabica (Rubiaceae)		Cultivated plant	Sylvester, Dubois (2007)	Food and nutrition, Household income	Home garden, Polyculture	Tropical wet forest, Premontane wet forest, Premontane rain forest	

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
Coffea canephora (Rubiaceae)		Cultivated plant	Borge (2011)	Food and nutrition			
Coffea sp. (Rubiaceae)	Café de los ancestros	Cultivated plant	Sylvester	Food and nutrition, Household income			
Colocasia esculenta	Yampi	Cultivated plant	Posas (2013)	Food and nutrition			LC
Columbina spp.		Wild bird	Altrichter (2011)	Food and nutrition			
Conepatus semistriatus	Zorro meón/hediondo	Wild mammal	Borge (2011)	Medicine	Polyculture, Forest		LC
Cordia alliodora	Laurel blanco	Cultivated plant	Borge (2011), Dubois (2007), Córdova (2004)	Food and nutrition, Energy, Shelter and materials	Polyculture		LC
Cordia gerascanthus	Laurel negro	Cultivated plant	Borge (2011)	Food and nutrition, Energy, Shelter and materials	Polyculture		
Costus spp.		Wild plant	Arias and Campregher (2010)	Medicine	Home garden	Tropical moist forest	
Couroupita sp.	zapote cabeza mono	Cultivated plant	Borge (2011)	Food and nutrition, Energy	Polyculture		
Crax rubra		Wild bird	Sylvester	Food and nutrition, Household income	Forest margin, Forest		VU
Crescentia cujete		Cultivated plant	Arias and Campregher (2010), Dubois (2007)	Food and nutrition, Shelter and materials, Medicine	Home garden, Polyculture	Tropical moist forest	
Cryosophila warscewiczii		Wild plant	Sylvester	Food and nutrition, Medicine			
Crypturellus soui		Wild bird	Sylvester	Food and nutrition, Household income			LC
Cucurbita pepo (Cucurbitaceae)	chayote, ayote	Cultivated plant	Sylvester, Arias & Campregher (2010)	Food and nutrition, Medicine	Home garden, Polyculture, River edge	Tropical moist forest, Tropical wet forest, Premontane wet forest	LC
Cuniculus paca	Tepezcuintle	Wild mammal	Sylvester, Guiracocha et al. (2001)	Food and nutrition, Household income	Primary forest, Polyculture, Agricultural land, Forest margin		LC
Cupania cinerea	cola pavo	Unknown plant	Borge (2011)	Energy	Polyculture		
Cyanthula spp.		Unknown plant	Arias and Campregher (2010)		Monoculture,		

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
					Agricultural land		
Cyathea sp.	quelites	Wild plant	Sylvester	Food and nutrition	Slash and burn, shifting ag		
Cymbopogon citratus		Unknown plant	Arias and Campregher (2010)	Shelter and materials, Medicine	Home garden	Tropical moist forest	
Dasyprocta punctata	Guatusa, cherenga	Wild mammal	Sylvester, Alrichter (2011), Harvey et al. (2006), Guiracocha et al. (2001)	Food and nutrition, Household income	Primary forest, Polyculture, Agricultural land, Forest margin, Forest		LC
Dasypus novemcinctus	armado, cuzuco	Wild mammal	Sylvester, Alrichter (2011), Harvey et al. (2006), Guiracocha et al. (2001)	Food and nutrition, Shelter and materials, Household income, Medicine	Polyculture, Agricultural land, Forest margin, Forest	Tropical moist forest	LC
Desmodium spp.		Unknown plant	Arias and Campregher (2010)		Roadside		
Dicliptera unguiculata		Unknown plant	Arias and Campregher (2010)	Medicine	Home garden	Tropical moist forest	
Didelphis marsupiales	Zorro pelón/Zaraigüella	Wild mammal	Borge (2011)	Ceremony	Polyculture		LC
Dioscorea sp.		Wild plant	Sylvester, Arias & Campregher (2010)	Food and nutrition, Medicine	Home garden	Tropical moist forest, Tropical wet forest, Premontane wet forest, Premontane rain forest, Lower montane rain forest	
Eira barbara	Tolomuco, Cabeza De Mate, Amingo, Gato Negro	Wild mammal	Borge (2011)	Ceremony	Polyculture		LC
Erythrina spp.		Unknown plant	Arias and Campregher (2010)	Medicine	Monoculture, Agricultural land, Roadside	Tropical moist forest	
Eugenia stipitata		Cultivated plant	Sylvester, Arias & Campregher (2010)	Food and nutrition, Household income, Medicine	Home garden		

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
Euterpe precatoria		Wild plant	Ocampo-Sanchez (1994), Garcia and del Monte (2004)	Food and nutrition, Shelter and materials	Primary forest	Tropical moist forest, Tropical wet forest, Premontane wet forest, Premontane rain forest	
Gallus gallus ssp domesticus		Domesticated animal	Sylvester	Food and nutrition, Household income			
Geonoma edulis		Wild plant	Sylvester et al. (2012)	Food and nutrition			
Geotrygon montana		Wild bird	Altrichter (2011)	Food and nutrition, Household income			LC
Gliricidia sepium	Madero negro	Unknown plant	Arias and Campregher (2010), Dubois (2007)	Medicine	Home garden, Polyculture	Tropical moist forest	
Gobiomorus dormitor		Fish		Food and nutrition	Freshwater		LC
Goethalsia meiantha		Unknown plant	Arias and Campregher (2010)	Medicine	River edge	Tropical moist forest	
Gynerium sagittatum	cana blanca	Unknown plant	Garcia and Del Monte (2004), Dubois (2007)	Food and nutrition	Polyculture, Slash and burn, shifting ag		
Hamelia patens		Unknown plant	Arias and Campregher (2010)	Medicine	Home garden, River edge	Tropical moist forest	
Hampea appendiculata		Unknown plant	Arias and Campregher (2010)	Medicine	River edge	Tropical moist forest	
Heliconia sp.		Wild plant	Sylvester, Garcia and del Monte (2004)	Food and nutrition	Primary forest, Forest margin	Tropical wet forest, Premontane wet forest, Premontane rain forest	
Herpailurus yagouaroundi	tolomuco	Wild mammal	Sylvester, Guiracocha et al. (2001)	Food and nutrition	Polyculture, Forest		LC
Herrania purpurea	cacao de montana	Wild plant	Sylvester	Food and nutrition			
Hetromys sp.		Wild mammal	Altrichter (2011)	Food and nutrition			
Hibiscus rosa-sinensis		Unknown plant	Arias and Campregher (2010), EOL	Medicine	Home garden	Tropical moist forest	
Hoplomys gymnurus		Wild mammal	Sylvester	Food and nutrition			LC

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
Iguana iguana		Wild reptile	Sylvester	Food and nutrition	River edge		
Inga edulis (Fabaceae)	guaba	Cultivated plant	Sylvester, Dubois (2007)	Food and nutrition, Energy, Shelter and materials	Home garden, Polyculture, Slash and burn, shifting ag	Tropical moist forest, Tropical wet forest	
Iriartea deltoidea	jira, chonta	Wild plant	Sylvester, Córdoba (2004)	Food and nutrition, Shelter and materials, Household income	Primary forest, Slash and burn, shifting ag, Forest		LC
Jacaratia dolichaula	papayilla, papaya de venado	Wild plant	Sylvester	Food and nutrition	Forest, Near dwellings		LC
Lantana camara		Unknown plant	Arias and Campregher (2010), EOL	Medicine	Roadside	Tropical moist forest	
Leopardus pardalis	manigordo	Wild mammal	Sylvester, Guiracocha et al. (2001)	Food and nutrition, Shelter and materials, Household income	Agricultural land, Forest margin, Forest		LC
Leopardus wiedii	Tigrillo platanero, Gato Montés, Caucel, Gato Pintado, Tigrillo	Wild mammal	Borge (2011)	Ceremony	Polyculture, Forest		NT
Leucaena leucocephala		Unknown plant	Arias and Campregher (2010)	Medicine	Monoculture	Tropical moist forest	
Lippia alba		Unknown plant	Arias and Campregher (2010)	Medicine	Home garden	Tropical moist forest	
Lippia graveolens		Unknown plant	Arias and Campregher (2010)	Medicine	Home garden	Tropical moist forest	
Ludwigia spp.		Unknown plant	Arias and Campregher (2010)	Medicine	Home garden, Roadside	Tropical moist forest	
Macrobrachium sp.	Camarón	Fish and crustaceans	Borge (2011)	Food and nutrition, Medicine	Freshwater		
Mammea americana (Calophyllaceae)		Cultivated plant	Borge (2011), Garcia and del Monte (2004), Córdova (2004)	Food and nutrition, Household income	Home garden	Tropical moist forest	
Mangifera indica		Cultivated plant	Arias and Campregher (2010), Dubois (2007)	Food and nutrition, Medicine	Home garden, Polyculture	Tropical moist forest	DD

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
Manihot esculenta (Euphorbiaceae)		Cultivated plant	Sylvester, Arias & Campregher (2010), Córdova (2004)	Food and nutrition, Household income, Medicine	Home garden, Polyculture, Slash and burn, shifting ag	Tropical moist forest, Tropical wet forest, Premontane wet forest	
Mazama americana	Cabro del monte	Wild mammal	Sylvester, Altrichter (2011), Guiracocha et al. (2001)	Food and nutrition, Shelter and materials	Polyculture, Forest margin, Forest		DD
Megarhynchus pitangua		Wild bird	Borge (2011)	Food and nutrition			LC
Melanomys caliginosus		Wild mammal	Borge (2011)	Food and nutrition			LC
Meleagris gallopavo		Domesticated animal	Sylvester	Food and nutrition, Household income			LC
Mimosa pudica		Unknown plant	Arias and Campregher (2010)	Medicine	River edge, Roadside	Tropical moist forest	LC
Momordica charantia		Unknown plant	Arias and Campregher (2010), EOL	Food and nutrition, Medicine	Home garden, Monoculture	Tropical moist forest	
Morinda citrifolia		Unknown plant	Arias and Campregher (2010), EOL	Food and nutrition, Medicine	Home garden	Tropical moist forest	
Morus alba		Unknown plant	Arias and Campregher (2010), EOL	Food and nutrition, Medicine	Home garden	Tropical moist forest	
Musa acuminata (Musaceae)	pilipita	Cultivated plant	Sylvester	Food and nutrition			
Musa acuminata (Musaceae)	chopo (there is also a chopo morado that is used as medicine in Córdova)	Cultivated plant	Sylvester, Córdova (2004)	Food and nutrition, Household income, Medicine			
Musa acuminata (Musaceae)	primitivo	Cultivated plant	Sylvester	Food and nutrition			
Musa acuminata (Musaceae)	cuadrado	Cultivated plant	Sylvester	Food and nutrition			
Musa acuminata (Musaceae)		Cultivated plant	Sylvester	Food and nutrition, Household income			
Musa acuminata (Musaceae)		Cultivated plant	Sylvester	Food and nutrition, Household income			

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
Musa acuminata (Musaceae)		Cultivated plant	Sylvester	Food and nutrition, Household income			
Musa paradisiaca AAB (Musaceae)		Cultivated plant	Borge (2011), Garcia and del Monte (2004)	Food and nutrition	Home garden, Polyculture, Monoculture	Tropical moist forest, Tropical wet forest, Premontane wet forest	
Musa sp. (Musaceae)	platano propio	Cultivated plant	Sylvester	Food and nutrition			
Musa sp. (Musaceae)	Platano	Cultivated plant	Sylvester, Córdova (2004)	Food and nutrition, Household income			
Mustela frenata	Comadreja	Wild mammal	Borge (2011)	Ceremony, Medicine	Freshwater, Polyculture, River edge		LC
Nasua narica	pizote	Wild mammal	Sylvester, Altrichter (2011), Guiracocha et al. (2001)	Food and nutrition, Shelter and materials, Household income	Polyculture, Agricultural land, Forest margin, Forest		LC
Nephelium lappaceum (Sapindaceae)	mamon chino	Cultivated plant	Sylvester, Córdova (2004), Borge (2011)	Food and nutrition, Energy, Household income			LC
Occipode sp.	Cangrejo	Fish and crustaceans	Borge (2011)	Food and nutrition	Freshwater		
Ochroma pyramidale		Unknown plant	Garcia-Serrano and Del Monte (2004)		Slash and burn, shifting ag		
Odocoileus virginianus	Venado cola blanco	Wild mammal	Sylvester, Alrichter (2011), Harvey et al. (2006)	Food and nutrition	Polyculture, Slash and burn, shifting ag, Forest		LC
Odontophorus erythrops		Wild bird	Altrichter (2011)	Food and nutrition, Household income			LC
Opuntia cochenillifera (In SIS as Nopalea cochenillifera)		Unknown plant	Arias and Campregher (2010)	Medicine	Roadside	Tropical moist forest	DD
Ortalis cinereiceps		Wild bird	Altrichter (2011) Borge (2011)	Food and nutrition, Household income			LC
Ortalis vetula		Wild bird	Borge (2011)	Food and nutrition, Household income			LC
Oryza sativa (Poaceae)	Arroz	Cultivated plant	Sylvester	Food and nutrition, Household income	Slash and burn, shifting ag	Tropical moist forest,	

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
						Tropical wet forest	
Passiflora ambigua (Passifloraceae)		Cultivated plant	Arias & Campregher (2010) Borge (2011)	Food and nutrition, Medicine	Roadside		
Passiflora vitifolia		Wild plant	Garcia-Serrano and Del Monte (2004)	Food and nutrition	Primary forest		
Pecari tajacu	Saino, sajino	Wild mammal	Sylvester, García-Serrano and Del Monte (2004), Harvey et al. (2006), Guiracocha et al. (2001)	Food and nutrition, Shelter and materials, Household income	Slash and burn, shifting ag, Agricultural land, Forest margin, Forest		LC
Penelope purpurascens		Wild bird	Sylvester	Food and nutrition, Household income			LC
Persea americana (Lauraceae)	aguacate	Cultivated plant	Sylvester, Arias & Campregher (2010), Dubois (2007), Córdova (2004)	Food and nutrition, Energy, Household income, Medicine	Home garden, Polyculture	Tropical moist forest, Tropical wet forest	
Phalacrocorax brasilianus		Wild bird	Sylvester	Food and nutrition, Household income	River edge		LC
Phaseolus sp. (Fabaceae)		Cultivated plant	Sylvester	Food and nutrition			
Phaseolus vulgaris (Fabaceae)	frijol negro	Cultivated plant	Sylvester	Food and nutrition, Household income	Home garden, Slash and burn, shifting ag	Tropical moist forest, Tropical wet forest	
Philander opossum	Zorro cuatro ojos	Wild mammal	Borge (2011)	Medicine	Polyculture		LC
Phthirusa pyrifolia	Matapalo	Unknown plant	Borge (2011)	Medicine	Polyculture		
Phyllantus urinaria-niruri		Unknown plant	Arias and Campregher (2010)	Medicine	Home garden, River edge, Roadside	Tropical moist forest	
Phytolacca rivinoides	calalú	Wild plant	Sylvester, EOL, García-Serrano and Del Monte (2004)	Food and nutrition, Medicine	Primary forest, Slash and burn, shifting ag	Tropical wet forest, Premontane wet forest, Premontane rain forest	

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
Pionus menstruus		Wild bird	Sylvester	Food and nutrition, Household income	Agricultural land, Forest margin, Forest		LC
Pionus senili		Wild bird	Sylvester	Food and nutrition, Household income	Agricultural land, Forest margin, Forest		LC
Piper auritum		Unknown plant	Arias and Campregher (2010)	Medicine	River edge	Tropical moist forest	
Piper peltatum		Unknown plant	Arias and Campregher (2010)	Medicine	Home garden, River edge	Tropical moist forest	
Poecilia gilli	Pipón	Fish and crustaceans	Borge (2011)	Food and nutrition	Freshwater		
Portulaca oleracea		Unknown plant	Arias and Campregher (2010)	Medicine	Roadside	Tropical moist forest	
Posoqueria latifolia		Unknown plant	Arias and Campregher (2010)	Medicine	River edge	Tropical moist forest	
Potos flavus		Wild mammal	Sylvester, Altrichter (2011), Harvey et al. (2006)	Food and nutrition, Shelter and materials, Household income	Polyculture, Agricultural land, Forest margin, Forest		LC
Pouteria sapota (Sapotaceae)	zapote	Cultivated plant	Sylvester, Borge (2011)	Food and nutrition, Energy	Polyculture		
Prestoea acuminata	Palmito, palmito dulce, palmito morado	Wild plant	Sylvester et al. (2012)	Food and nutrition, Household income, Medicine	Forest		
Proechimys semispinosus		Wild mammal	Sylvester	Food and nutrition	Forest		LC
Protium spp.		Unknown plant	Arias and Campregher (2010)	Medicine	River edge	Tropical moist forest	
Psarocolius wagleri		Wild bird	Sylvester	Food and nutrition, Household income			LC
Pseudelephantophus spicatus		Unknown plant	Arias and Campregher (2010)	Medicine	Home garden	Tropical moist forest	
Psidium guajava (Myrtaceae)	Guyaba	Cultivated plant	Sylvester, Arias & Campregher (2010)	Food and nutrition, Energy, Medicine	Home garden, Roadside		
Pteroglossus torquatus		Wild bird	Sylvester	Food and nutrition, Household income	Agricultural land, Forest		LC

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
					margin, Forest		
Quararibea cordata (Malvaceae)	Sapote colombiana	Cultivated plant	Sylvester	Food and nutrition			
Quassia amara		Unknown plant	Arias and Campregher (2010), Dubois (2007)	Medicine	Home garden, Polyculture	Tropical moist forest	
Ramphastos ambiguus		Wild bird	Sylvester	Food and nutrition, Household income	Agricultural land, Forest margin, Forest		NT
Ramphastos sulfuratus		Wild bird	Sylvester	Food and nutrition, Household income	Agricultural land, Forest margin, Forest		LC
Ramphocelus passerinii		Wild bird	Borge (2011)	Food and nutrition, Household income			LC
Renealmia alpinia		Wild plant	Sylvester, EOL	Food and nutrition, Shelter and materials, Medicine	Primary forest, Polyculture, Near dwellings	Tropical wet forest, Premontane wet forest, Premontane rain forest	
Rhandia sp	Barbudo	Fish and crustaceans	Borge (2011)	Food and nutrition	Freshwater		
Rivina humilis		Unknown plant	Arias and campregher (2010)	Medicine	Monoculture, Roadside	Tropical moist forest	
Rollinia mucosa (Annonaceae)	biriba	Cultivated plant	Sylvester, Córdova (2004)	Food and nutrition, Energy			
Sabal palmetto		Cultivated plant	Posas (2013)	Food and nutrition			
Saccharum sp. (Poaceae)	cana de azucar	Cultivated plant	Sylvester	Food and nutrition			
Sciurus sp.		Wild mammal	Sylvester	Food and nutrition			
Sciurus variegatoides	Ardilla	Wild mammal	Sylvester, Borge (2011)	Food and nutrition, Medicine	Polyculture, Agricultural land, Forest margin, Forest		LC
Sechium tacaco		Wild plant	Garcia-Serrano and Del Monte (2004)	Food and nutrition	Primary forest		
Selenidera spectabilis		Wild bird	Sylvester	Food and nutrition	Agricultural land, Forest		LC

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
					margin, Forest		
Sida acuta		Unknown plant	Arias and Campregher (2010)	Medicine	Roadside	Tropical moist forest	
Socratea durissima	Jira	Wild plant	Gutiérrez (2013), Dubois (2007)	Shelter and materials	Polyculture, Forest		
Socratea exorrhiza	chonta	Wild plant	Sylvester, EOL, Gutiérrez (2013)	Food and nutrition, Energy, Shelter and materials, Household income, Medicine		Tropical moist forest	
Solanum americanum		Unknown plant	Arias and Campregher (2010)	Medicine	River edge	Tropical moist forest	
Solanum mammosum		Unknown plant	Arias and Campregher (2010)	Medicine	River edge	Tropical moist forest	
Solanum siparunoides	Tomatillo	Plant					
Solanum wendlandii	Quelite	Unknown plant	Córdova (2004)	Food and nutrition			
Sphiggurus mexicanus		Wild mammal	Altrichter (2011)	Food and nutrition			LC
Spondias mombin		Unknown plant	Arias and Campregher (2010)	Medicine	River edge	Tropical moist forest	
Spondias purpurea (Anacardiaceae)	Jocote	Cultivated plant	Sylvester, http://www.worldagroforestry.org/treedb/AFTPDFS/Spondias_purpurea.pdf Arias & Campregher (2010)	Food and nutrition, Medicine	Home garden, Slash and burn, shifting ag		
Sus domesticus	Cerdo	Domesticated animal	Sylvester, Borge (2011)	Food and nutrition, Household income, Ceremony	Polyculture		
Sylvilagus brasiliensis	Tapeti, conejo	Wild mammal	Sylvester, Borge (2011)	Food and nutrition, Medicine	Polyculture, Agricultural land, Forest margin, Forest		LC
Syzygium malaccense (Myrtaceae)	Manzana de agua	Cultivated plant	Sylvester, Córdova (2004)	Food and nutrition, Household income			
Tamandua Mexicana		Wild mammal	Sylvester	Food and nutrition, Medicine	Forest		LC
Tapirus bairdii	Danta	Wild mammal	Sylvester	Food and nutrition, Household income	Agricultural land, Forest		EN

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
					margin, Forest		
Tayassu pecari	Chancho de monte	Wild mammal	Sylvester, Guiracocha et al. (2001)	Food and nutrition, Shelter and materials, Household income	Slash and burn, shifting ag, Forest		VU
Tecoma stans		Unknown plant	Arias and Campregher (2010)	Medicine	Roadside	Tropical moist forest	
Theobroma angustifolium (Malvaceae)	cacao silvestre, cacao de mono, cacao de montaña	Cultivated plant	Borge (2011), Garcia and del Monte (2004)	Food and nutrition, Ceremony, Medicine	Home garden, Primary forest	Tropical moist forest, Tropical wet forest, Premontane wet forest	
Theobroma bicolor (Malvaceae)	pataste	Cultivated plant	Sylvester, Garcia and del Monte (2004), Córdova (2004)	Food and nutrition, Energy, Ceremony, Medicine	Home garden, Primary forest	Tropical moist forest, Tropical wet forest, Premontane wet forest	
Theobroma cacao (Malvaceae)	Cacao, Cacao negro o primitivo	Cultivated plant	Sylvester, Arias & Campregher (2010), Garcia and del Monte (2004)	Food and nutrition, Household income, Ceremony, Medicine	Home garden, Polyculture, Monocultur e	Tropical moist forest, Tropical wet forest, Premontane wet forest	
Thunbergia fragans		Unknown plant	Arias and Campregher (2010)	Medicine	Monocultur e	Tropical moist forest	
Tinamus major		Wild bird	Sylvester	Food and nutrition, Household income			NT
Turdus grayi	Yigüirro	Wild bird	Borge (2011)	Ceremony	Polyculture		LC
Uncaria tomentosa	uña de gato	Unknown plant	Arias and Campregher (2010)	Medicine		Tropical moist forest	
Urera baccifera		Wild plant	Sylvester, Garcia and del Monte (2004), Arias & Campregher (2010)	Food and nutrition, Medicine	Home garden, Primary forest, Polyculture, Near dwellings	Tropical moist forest, Tropical wet forest, Premontane wet forest, Premontane rain forest	
Urera laciniata		Wild plant	Borge (2011)	Food and nutrition, Medicine			
Welfia regia	Corozo	Wild plant	Ocampo-Sanchez (1994), INBIO, Sylvester et al. (2012)	Food and nutrition			

Scientific name	Common Name (local)	Type	Sources	PIN domains (U)	Habitat	Holdridge life zones	Conservation status
Xanthosoma sp.	nampi	Cultivated plant	Sylvester, Córdova (2004)	Food and nutrition, Household income			
Xanthosoma violaceum (Araceae)		Cultivated plant	Borge (2011), Garcia and del Monte (2004)	Food and nutrition	Home garden, Polyculture, Slash and burn, shifting ag	Tropical moist forest, Tropical wet forest	
Zea mays (multiple varieties; Poaceae)		Cultivated plant	Sylvester	Food and nutrition, Household income	Slash and burn, shifting ag	Tropical moist forest, Tropical wet forest, Premontane wet forest	
Zingiber officinale		Unknown plant	Arias and Campregher (2010)	Medicine	Home garden	Tropical moist forest	
Zygia longifolia		Unknown plant	Arias and Campregher (2010), Rodié (2012)	Energy, Medicine	Home garden, River edge	Tropical moist forest	

APPENDIX III: SPATIAL LAYERS

Spatial data layers available at ORMACC, San José used for producing maps in this situation analysis.

Data needs	File(s) available	notes
hydrology, waterways, watersheds including Sixaola Basin	Subcuencas_rio_sixaola_utm17n	Sixaola sub-basins polygon
	Areas_de_influencia_cuenca_rio_sixaola_utm17n	Other catchment areas (surrounding Sixaola)
	rios_linea_sixaola_utm_17n_final	Waterways line for labelling purposes
	rios_poligono_utm17n_final	Major rivers polygon
Protected areas	areas_protegidas_sixaola_utm17n	Protected areas
soils and possibly agricultural potential	capacidad_uso_cuenca_sixaola_utm17n	Land use capacity USDA system
	Suelos_cuenca_sixaola_utm17n	Soils polygon SOTERLAC V2.0
Climate, meteorology	estaciones_precipitacion_sixaola_utm17n	Meteorological stations in Sixaola basin + annual precip data.
	estaciones_temperatura_sixaola_utm17n	Weather stations + temperature data
	isotermas_cuenca_sixaola_utm17n	Annual mean isotherms (temperature)
	isoyetas_cuenca_sixaola_utm17n	Annual isohyets (precipitation)
Geology	geologia_cuenca_sixaola_utm17n	geology
digital elevation model (DEM), terrain	hipsometria_cuenca_sixaola_utm17n	Elevation (topographic map)
	hlsd_imp	Shaded relief (for easy visualisation of hills and valleys)
	puntos_altos_cuenca_rio_sixaola_utm17n	Point elevation of highest points
air/sat imagery	imagen_landsat_feb2011_sixaola_utm17n.tif	Landsat land-cover (poor resolution)
	Sixaola high resolution	Very good aerial image of Sixaola and immediate surrounding area
	Composite map of Sixaola basin	Variable resolution aerial imagery of basin
governance, political boundaries, indigenous territories	reservas_indigenas_cuenca_sixaola_utm17n	Indigenous territories polygon
	division_politica_cr_panama_utm17	Admin boundaries + population and housing from census
populated places, socio-economic baseline data	poblados_cuenca_sixaola_con_datos_utm17n	Populated places + some census data from year 2000
	servicios_salud_cuenca_rio_sixaola_utm17n	Health services points
transportation and corridors	vias_de_comunicacion_cuenca_sixaola_utm17n	Roads/communication

Vulnerability	vulnerabililidad_cuenca_sixaola_erosion_deslizamientos_utm17n	Vulnerability to erosion and landslides
	vulnerabilidad_inundaciones_sixaola_utm17n	Vulnerability to flooding
	pendiente_cuenca_sixaola_utm17n	Slope (percent)
ecosystem/habitat classifications	zonas_de_vida_sixaola_utm17n	Holdridge life zones.
Land cover, land use classification		No layers available
Zoning/management units		No layers available
projected major infrastructure projects and developments (e.g. corridors, hydro power generation, mining)		No layers available

IUCN is a membership Union composed of both government and civil society organisations. It harnesses the experience, resources and reach of its 1,300 Member organisations and the input of some 15,000 experts. IUCN is the global authority on the status of the natural world and the measures needed to safeguard it.

CEESP, the IUCN Commission on Environmental, Economic and Social Policy, is an inter-disciplinary network of professionals whose mission is to act as a source of advice on the environmental, economic, social and cultural factors that affect natural resources and biological diversity and to provide guidance and support towards effective policies and practices in environmental conservation and sustainable development.

The People in Nature (PiN) Knowledge Basket is an initiative established by the IUCN programme of work and whose development is led by a steering group composed of representatives from CEESP, IUCN secretariat and IUCN members. As described in the 2017-2020 CEESP mandate, PiN will promote learning to improve our understanding of how nature contributes to local livelihoods and well-being. It will focus on material use while recognising that use is embedded within worldviews that include deep-seated cultural norms, values, and understandings. It will also consider symbolic interrelationships with nature expressed through cultural narratives, language, and traditions, including diverse understandings of sacred and divine aspects of nature and our relationship with natural resources. This work will contribute to valuing and conserving nature through understanding the value of nature to human societies.