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Article

On Using Mental Model Interviews to Improve Camera Trapping: Adapting Research to Costeño Environmental Knowledge

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Abstract

In many regions, including our study area along the Caribbean coast of Nicaragua, it is necessary to apply traditional or local environmental knowledge in biological research projects based in Western scientific knowledge. In such projects, it is important for both researchers and local people that the integration of the two knowledge systems: a) produces scientifically rigorous reports, and b) justly benefits local people. As every knowledge system is unique, there is no universal list of best-practices that will attain these two goals. To discover the best-practices for a particular project, it is necessary to develop the unique relationship between the two knowledge systems and related research methodologies based on personal experience. To gain this experience in the context of our camera trapping project that integrates traditional environmental knowledge, we undertook mental model interviews with local people. Interview results revealed the environmental knowledge our local assistants are most likely to share with us. We used this information to refine our sampling methodology to ensure scientifically rigorous results, and to appropriately engage locals to ensure the project yielded locally desirable benefits. This or a similar technique could be used by other researchers in comparable contexts to yield more comprehensively beneficial results.

Keywords: camera trap, cognitive-map, conservation biology, mental models, mixed-methods, Traditional Environmental Knowledge, Nicaragua

INTRODUCTION

The last remote regions of the globe are quickly becoming connected to, and influenced by, global forces. These regions, which also tend to be some of the most biodiverse areas, are experiencing rapid increases in development with the potential to substantially alter local and global ecosystems (Kramer et al. 2009). For development to be sustainable, ecological research in, and monitoring of, these areas to understand how recent changes and connections affect biodiversity are essential (Kramer et al. 2009).

In such remote regions, infrastructure for Western scientific research is often scarce and Western scientists are typically few and far between. Rather, there are typically many local, often indigenous, people, who possess extensive environmental knowledge generated through a lifetime of subsistence activities. Therefore Western scientists who wish, or are asked, to undertake ecological research or monitoring in these contexts often look to these local experts to hire as assistants, field technicians, and collaborators (Luzar et al. 2011). In so doing, these scientists include what is termed local environmental knowledge (LEK) or, in the case of indigenous people, traditional environmental knowledge (TEK) into their research process. This relationship is sometimes governed by local or national laws and regulations (i.e., GNWT 2005).

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Pairing bodies of LEK or TEK with bodies of Western scientific knowledge (WSK) in the same project is not typically a straightforward endeavour. There can be cultural differences in processes such as knowledge generation, transmission, and retention that can, for instance, make certain practices or concepts seem essential and valid to Western scientists, yet unnecessary or irrelevant to local people, and vice versa. At the same time, it is essential for Western scientists and global conservation that the knowledge of local assistants is included in research in a manner that results in papers, grant applications, and reports that are intelligible to scientists, and conservation and grant agencies. If this goal is to be achieved, the bodies of TEK or LEK that are paired with WSK, similar to the case with citizen science in the United States of America, have to be included into projects in a way that does not completely undermine the controls and rigid research designs of WSK required by international conservation and government agencies and institutions. This is also becoming increasingly essential for the indigenous people in the remote region explored in this study—the Southern Atlantic Autonomous Region of Nicaragua (RAAS). Indeed, as global conservation dialogues from non-governmental organisations (NGOs), government agencies, and international resource extraction companies addressing global warming, sustainable development, payments for environmental services (PES), and ecotourism increasingly penetrate the RAAS, the interest of its communities' members in obtaining conservation or resource management grants is growing. Additionally, this means that their interaction with these organisations regarding resource management and resource-use regulations is on the rise. National and international researchers as well as local governments and community members therefore perceive as increasingly important the capacitation of local people to participate in related environmental policy discussions and in decision-making processes. Indeed, as global forces and dialogues are thrust upon them by governments and NGOs, it is perceived as critical that local people have the capacity to ensure their continued autonomy and land-use rights. This would require that local people be trained to communicate their environmental knowledge, including ideas and beliefs about their ecosystems, such that it is represented truly and also articulated in a manner appropriate for national and international forums, which are often governed by WSK (Ellis 2005).

At the same time, even in projects without primary objectives directly related to TEK or LEK, it is unjust to simply appropriate the LEK or TEK that meets the requirements of the WSK, integrate it into research to ensure the production of scientific reports and conference material intelligible to Western scientists, and call it a day (Ellis 2005; Shackeroff and Campbell 2007). Indeed, this often results in the subjugation of the local people and the discounting of important components of their knowledge, including "myths, practices, values, beliefs, and other contextual knowledge" (Ellis 2005: 6). Due to this, when incorporating local knowledge into ecological research, it is equally important for Western researchers to consider issues of local capacitation and empowerment, local autonomy—in particular the rights of local people to direct their own environmental education pathway, and cultural survival and conservation. Without doing so, Western researchers may force assimilation into a world of Western values and beliefs onto the local people (Agrawal 1995).

To assist researchers in simultaneously attaining these two goals—scholarly publication on the one hand and support of local autonomy with regards to LEK or TEK on the other—many scholars have published articles, papers, and reviews to inform practitioners of general practices and philosophies for using LEK or TEK and WSK systems in complementary ways that enhance data collection, ensure local cultural survival or both (Stevens 1997; Calamia 1999; Ellis 2005; Berkes 2008; Gagnon and Berteaux 2009). At the same time, it is often acknowledged that there are no overarching best practices for this type of bicultural project (see Moller et al. 2009; Stephenson and Moller 2009; and related forum). Indeed, most agree that the best practices for effectively and respectfully engaging with and jointly applying, LEK or TEK alongside WSK in an appropriate manner will be specific to the context of the research. This is due to the fact that there exists no general, rigid divide between LEK, TEK, and WSK (Agrawal 1995). Each person and community has accumulated their LEK/TEK system in, and adapted that system to, a unique, changing landscape. Likewise, each different Western researcher and/or conservationist has developed their WSK system through a unique educational process inspired by a unique set of objectives. It follows logically that the best practices for a research project that jointly applies two of these unique knowledge systems, as well as the results of that collaboration, will also be unique. Huntington (1998) argues that for biological and ecological researchers who wish to fairly combine two knowledge systems in data collection, one means to determine these context-specific best practices is to use techniques based in the social sciences to inform the biological science aspects of the project.

This paper supports Huntington's (1998) argument by reporting on our efforts to use results from mental model interviews of TEK to inform an ongoing camera trap study in the RAAS. One of the key objectives of this study is to analyse the effects of local development on terrestrial biodiversity. Given that the local indigenous and afro-descendent people are the only available research assistants in the region with enough knowledge of local forests to successfully guide us through them, our camera trap data collection methodology necessarily includes both their TEK and our WSK. Here we briefly outline how an analysis of the mental model interview results largely in the context of a framework proposed by Gagnon and Berteaux (2009) provided us with information about the nature of the TEK of our local assistants that we subsequently used to increase the efficiency and rigour of the camera trap research by maintaining the type of ecological sampling mandated by WSK. It also describes how the same interview results helped shape our efforts to use the research project to capacitate local people in WSK wildlife monitoring skills and data analysis, and to reinforce autonomy of local TEK transmission. Shortcomings of the project and ideas for project expansion are briefly discussed.

MATERIALS AND METHODS

Study area

The 27,000 sq. km RAAS comprises more than 20% of Nicaragua, the largest country in Central America. Yet with approximately 400,000 people, it holds less than 7% of its population. The RAAS was historically unconnected to the Pacific side of the country and to its predominantly *Mestizo* culture, which is characterised by its mix of indigenous Nicaraguan and Spanish descent and traditions, including the capacity to speak only Spanish. This resulted in the conservation of the indigenous and traditional cultures that are greatly distinct from the *Mestizo* culture. The small communities dotting the coast are of five main ethnicities—the Rama, the Ulwa-Mayangna, the Miskito indigenous people, the Garifuna with roots in Honduras and Caribbean Islands, and the Nicaraguan Kriol. They are sometimes referred to jointly as Costeños. Together these groups speak seven languages—Miskito, Kriol English, Spanish, Mayangna, Ulwa, Rama, and Garifuna. The latter four are the most uncommon and more rarely heard. Individual Costeños are generally proficient in between 2 and 4 languages. Isolation from the Pacific coast not only entailed cultural remoteness during this time, but also economical and political isolation for many years, as the areas around Managua comprise the nation's economic hub. National and international companies essentially only visited the RAAS to exploit the abundant natural resources for their own gain. Aside from some basic education initiatives, government entities never frequented the coast. It was, and in many locations remains, a remote region of extreme poverty with minimal development throughout much of history (Jamieson 1999; Christie et al. 2000).

Despite its historic isolation, the region and its people are now becoming increasingly connected to the Pacific coast. An agricultural frontier has been moving from west to east across Nicaragua, thus a growing number of RAAS communities are now *Mestizo*. From roughly the 1950s through the 1970s these *Mestizo* communities came to the coast intermittently as a result of government programs (Jamieson 2011). Nowadays they come in greater numbers seeking land for farms and cattle pasture; economic opportunities they cannot find in the more densely populated western part of the country. While indigenous agriculture is traditionally of the swidden horticulture variety and incorporates large patches of forest into landscape level land-use, *Mestizo* practices are considered much less sustainable and include clearing forests entirely to raise cattle or to sell land. *Mestizo* colonisation and development causes a high degree of animosity and conflict between indigenous coastal residents and *Mestizo* migrants because, according to the Autonomy Statute of 1987, the Constitution drafted in 1995, the Demarcation Law 445 approved in 2002, and local tradition coastal communities have legal, communal tenure over the land under *Mestizo* settlement (Goett 2004). In rural areas, only a small minority of *Mestizos* with many years in the region who have adopted the land practices of the traditional inhabitants are accepted as true Costeños.

A distinct type of connection between the RAAS and the Pacific coast was established in 2007 when a road was completed to the small town of Pearl Lagoon, effectively linking it to the markets of the river port city of El Rama and thereby Managua (Schmitt and Kramer 2009). Since then, local economies have started to shift away from the traditional focus on subsistence activities, and *Mestizo* culture appears to be making stronger inroads and holding greater influence as an increasing number of *Mestizos* bring their businesses to the RAAS. In addition to this, government agencies and environmental NGOs have an increased presence throughout the region. This has included a rise in environmental education workshops and environmental regulatory action. Meetings regarding resource policy and regulations held with Costeño community members are often acrimonious, and local people's complaints of inadequate representation of their desires and customs are common. Thus, there appears to be a need for greater capacitation of RAAS citizens in order for them to engage with all of these groups on a more level playing field and to include their traditions and beliefs as fundamental components of the processes of connection and development.

While the road has affected many of the coast's previously remote coastal communities, its influence is certainly not uniform. For instance, there is no road network in the RAAS, so the members of most communities outside of Pearl Lagoon must travel by water to reach the new markets. The cost of making this trip is often prohibitive. This obstacle appears to buffer the effects of the new road; those communities at greater distances from Pearl Lagoon appear to be changing at a less rapid rate (Schmitt and Kramer 2009).

However there has been considerable change, and development is likely to continue, including substantial land cover change to the region's expansive lowland tropical rainforests, mangrove forests, and seasonally flooded swamp forests due to increased *Mestizo* cultural and physical predominance. Indeed, as in similar cases in other regions of the globe, new roads have resulted in extensive deforestation and cultural assimilation (Laurance et al. 2009). As *Mestizo* culture makes more inroads, the traditional resource use practices of the Costeño are expected to decline further, especially if better higher education opportunities for the youth continue to require that they leave their homes to attend Spanish language schools in nearby cities. We initiated a 5 year interdisciplinary research project in this context in 2008. Research efforts include broad socioeconomic surveys, analyses of social networks, interviews on local politics, and ecological monitoring. All components of the project were discussed with local community governments and adjusted to comply with their requirements and desires. Subsequent to this, formal agreements were reached and research initiated. The principle investigators periodically travel to all communities to discuss research results, the progress of the project, and collect the feedback from, and the suggestions of, the community members. All community members are invited to these meetings; a majority of the community members attend these meetings. The project is a collaborative effort by researchers from Michigan State University (MSU) with between 2 and 20 years of experience in the region, and highly experienced Nicaraguan researchers from the University of the Autonomous Regions of Nicaragua's Caribbean Coast (la Universidad de la Regiones Autónomas de la Costa Caribe Nicaragüense; URACCAN), a Nicaraguan university located in Bluefields, the capital city of the RAAS. The combination of community government inputs in conjunction with inputs from URACCAN and MSU researchers with knowledge of communities and extensive experience living and working in the region ensured to a large extent that our methodologies were locally pertinent and desirable. The project has several goals, including the generation of the type of information needed to help guide local development, such that local cultures and environments are conserved without inhibiting economic and educational growth, and the production of scientific reports and articles. It is important to note that we are not affiliated with conservation NGOs or government agencies, and are gathering data primarily as a means of increasing understanding of the connection of remote communities in the scientific community and in the RAAS. Indeed, the purpose of our research is to provide information that communities currently lack, not participate actively in decision-making processes. However, when our assistance has been explicitly requested by communities or local government representatives, we have accompanied them in meetings with NGOs and/or provided written reports for them to reference in their communications with the national government and NGOs.

The camera trap monitoring program was initiated in May 2009, as one component of this larger project, to evaluate the relationship between terrestrial wildlife occurrence and local development. In this work, we hire indigenous and Kriol local people to work as our forest guides as they are some of the few ecological experts in a rural area of a country with universally poor infrastructure for science. We rely on their knowledge of the local forests in two primary ways. First, their spatial and environmental knowledge is critical to our navigating the landscape safely. Second, we collaborate closely with guides and discuss their knowledge of local flora and fauna to select locations for camera placement that will produce photos of the highest diversity of animals possible. To ensure that the incorporation of the TEK was of benefit to camera trapping and as fair as possible to local people we endeavoured to collect sufficient data to gain a basic understanding of the TEK being shared with us. To this end, mental model interviews were conducted in nine Costeño communities, either in Kriol, Miskito, or Rama, listed here as they are locally known—Haulover, Kahkabila, Brown Bank, Orinoco, Corn River, Bangkukuk, Monkey Point, Kara, and Karawala. Spanish translations of community names may be found on some maps, but even the *Mestizo* people in the RAAS rarely refer to these communities in Spanish. The population size and ethnicity of communities vary (Table 1), but the majority of adults in each site engage in subsistence fishing and farming activities to earn their livelihoods. The same is not necessarily true for the youngest generations, who are much more likely to leave home for work or school, or to solely engage in commercial fishing. No *Mestizo* individuals were interviewed as *Mestizo* settlements are located more inland along the agricultural frontier. This in no way discounts their environmental knowledge but rather reflects the geographic scope of the collaborative research effort of MSU and URACCAN, which is situated in coastal communities. Indeed, despite this, efforts have since been made to include the *Mestizos* in research and outreach efforts.

Table 1
Summary of important community characteristics

Community	Ethnicity	Distance to Pearl Lagoon (km)	Population
Haulover	Kriol	<5	~600
Kahkabila	Miskito	8.32	497
Brown Bank	Garifuna/Kriol	13.7	202
Orinoco	Garifuna/Kriol	23.9	1,010
Karawala	Ulwa	65.6	1,700
Kara	Ulwa	61.9	~200
Corn River	Rama/Kriol	120.0	~40
Monkey Point	Rama/Kriol	82.5	~60
Bangkukuk	Rama/Kriol	85.0	~70

Mental model interview process

The lead author carried out mental model interviews (n = 34) in nine different RAAS communities to explore the structure and composition of the local forest knowledge most likely to be shared by local guides during our camera trap work. Interviewees were selected using a variant of the peer review technique described by Davis and Wagner (2003). Key community members including local government leaders and persons previously employed as forest guides were individually asked to free-list other men and women that they considered experts in their knowledge about the forest. The men and women mentioned most frequently were subsequently interviewed. Interviews were conducted primarily in English and/or Spanish, and also frequently included portions in Miskito and Kriol. Each interview was digitally recorded for analysis with the interviewee's permission. As implied by Davis and Wagner (2003), the selection of more powerful community members as gatekeepers can influence interview results, but it was necessary in most communities. Indeed, community members were generally unwilling to 'name names' without first consulting their leaders. Throughout the interview process we followed the protocol approved by MSU's Social Science Institutional Review Board (IRB#10–251; r038332), and thus gave each interviewee a description of the interview, its affiliation with the larger MSU/URACCAN project, and the general goals of both, and then informed them of their right

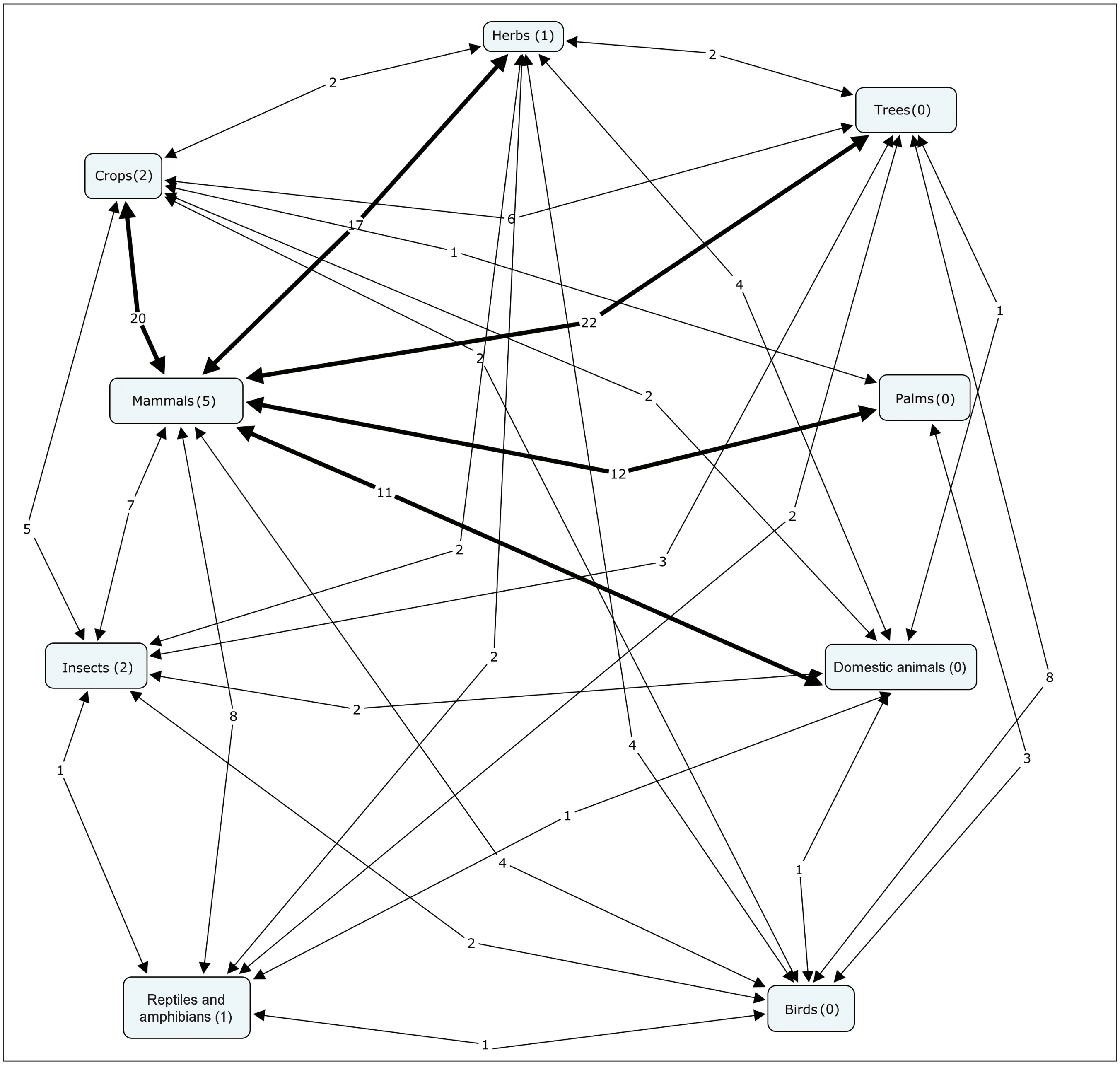


Figure 1

Cognitive Map 1 displays the different knowledge subdomains explored in this paper and the important interactions between them according to local people. Numbers superimposed on arrows indicate the number of interviews in which a particular interaction was described. Numbers within subdomain nodes refer to the number of interviews in which a species was described as interacting with another species from the same subdomain (i.e., a mammal species interacting with a different mammal species). These tie strengths range from 0 to 22.

to refuse to participate before the interview process began. Interviewees were not compensated for participation.

Morgan et al. (2002) suggest that the mental model interviewers use an expert model to guide the mental model interview process. An expert model is a carefully researched map of all of the knowledge about the interview topic that an expert in said topic would be expected to hold. These maps typically are visualisations (similar in style to Figure 1) that describe all of the information domains related to the main topic, tangentially related ideas and concepts, and how all of this interacts to form the expert's understanding of the topic. The map is subsequently used as a source of prompts throughout the interview. The objective of a mental model interview is to get the interviewee discussing the chosen topic without exerting significant influence over his/her comments. This allows the researcher to subsequently use interview comments to build a similar map of the interviewee's understanding of the interview topic. Interviewee maps are typically drawn and directly compared to the expert model to assess any gaps in the layperson's understanding[1].

However, we decided that creating an expert model of indigenous knowledge was unwise. In a general sense, the power hierarchy common to many WSK—TEK holder relationships often results in a tendency for Western scientists to assign characteristics to TEK systems based on incorrect assumptions and conclusions from prior academic publications; this can lead to misunderstandings and even cultural or physical harm to TEK holders (Shackeroff and Campbell 2007; Davis and Ruddle 2010). We considered that there was a risk of doing this, even unintentionally, in the context of the creation of an expert model of the TEK. Thus we decided to use what we termed a 'researcher's framework' as our guide. This framework simply outlined broad knowledge domains and subcategories we hypothesised would be pertinent. Under each domain we wrote lists of follow-up questions (see below). After a thorough review of the TEK literature, we based our framework on Zent and Maffi's (2008) cosmopolitan TEK domain list, which they created as a general foundation for studies of TEK loss and retention. Zent (2010: 2) defines these knowledge domains as "delimited fields of meaning and action that appear to be identifiable in a wide number of biocultural situations throughout the world". We altered the original list to more directly apply to forested ecosystems and to address additional research questions regarding the RAAS political and cultural ecological knowledge. The appendix contains the final list of knowledge domains used for the researcher's framework.

The interview process had two main stages. In stage one, we prompted the interviewee to discuss forests, but did so with as little leading as possible to ensure we were not influencing responses. For instance, the opening prompt was: 'What I'd like to ask you to do is to just talk to me about what you know about the forest: that is, tell me all the different things you know and how you use that knowledge'. As was necessary to keep the interviewee engaged and discussing pertinent topics, this initial prompt was reinforced by several equally inexplicit planned phrases, such as: 'Anything else? It doesn't matter if you think it is right or wrong; just tell me what comes to your mind about the forest.' Throughout this stage, the 'researcher's framework' was used for taking notes. If and when an interviewee mentioned a domain in the framework, it was marked with a check and planned follow-up questions corresponding to that domain were asked to explore the breadth of knowledge associated with it. For example, if an interviewee enumerated several different tree species, we asked, 'Can you tell me more about how you tell the different classes of trees apart?'

At some point, each interviewee ceased to mention new domains. This is where stage two of the interview began, in which the domains from the researcher's framework that remained unexplored were more explicitly presented to the interviewee. This was still done with neutral language to avoid influencing responses. For instance, we often used statements such as, 'Have you ever heard any one speak about rules for using the forest? Do you know anything about this?' The data sheet was once again utilised in the same manner and follow-up questions asked when appropriate. We concluded each interview by asking the interviewee to describe any aspects of forest knowledge that they thought the interview process failed to touch on. From March to August 2010, this process was replicated with 34 individuals, between 2 and 8 members from each of the 9 communities, and lasted from 20 minutes to 1 hour per individual.

Focus group workshops

In June 2010 after completing the majority of interviews and a preliminary analysis, two multi-day focus group workshops were conducted in the community of Kahkabila. To organise the focus groups, the lead author held a community meeting in which all available adult community members participated (approximately 60), and were asked to select six men and six women considered local experts in forest knowledge. Over the next week three 5-hour sessions were held with the men, and then three 5-hour sessions were held with the women. The meetings consisted of three distinct stages, only two of which are pertinent here. In session one, participants were tasked with thinking about the forest and then listing the 40 trees, 40 herbs, 40 crops, and 100 animals they considered the most important to know about. These limits were chosen based on the suggestions of Zent (2010)—to make the task less daunting given the extremely high diversity of neotropical flora and fauna, and to ensure that participants ruminated on which species to include as the most important to know about. Then in sessions two and three, each particular plant and animal species on their lists was individually re-visited, and participants were asked to share the knowledge they held about it. Participants described uses, physical plant and animal characteristics, stories, behaviours, and pertinent activities and interactions in rich detail. All information was recorded on a poster board.

The focus group results pertinent to this paper included gender specific, thoroughly annotated lists of 40 trees, 40 herbs, 40 crops, and 100 animal species. Each group worked on documenting their knowledge of forest plants and animals for approximately 15 hours over three days. The extra time and ability to interact in a group led to greater attention being paid to a number of ecological interactions, anecdotes, lores, and jokes that were infrequently mentioned in the much more rapid mental models interviews. We coded each group's set of data as if it had come from one additional mental model interview (see A note on coding). The focus group approach elicits much more detailed data than the mental model technique. We include the results in this analysis because we believe that they present a more accurate picture of the breadth of the local TEK. Nonetheless, we did not weight them more heavily than a mental model interview so that the important nuances of the mental model interview results were not overshadowed, and so that the data were not overly representative of the TEK most common in Kahkabila. While we hypothesise that basic environmental knowledge composition is similar to a high degree across communities due to the similarity of all community members' subsistence resource extraction activities, this weighting prevents our analyses from being dependent on this hypothesis. Neither in the mental model interviews nor in the focus group workshops do we presume to have collected sufficient data to understand all of the complexities of the TEK in the RAAS. Rather, it is important to underscore that we sought to capture and believe to have captured the TEK that our local assistants are most willing to share with outsiders, such as us during fieldwork for our camera trapping project.

A note on coding

We conducted a preliminary analysis of the data, and adjusted the knowledge domains and subcategories from the initial researcher's framework (Appendix) to describe the forest ecosystem mainly in terms of forest plants and animals. More specifically, we used interview comments to first create a framework with plants on the one hand and animals on the other. Then we broke these down into subdomains. The plant subdomains included: crops, herbs, trees, and palms. The animal subdomains included mammals, insects, birds, reptiles and amphibians, and domestic animals. Then we broke each subdomain into two categories of comments: characteristic and life history information and information about use. Each of these comment categories, in turn, had subcategories—the former consisted of morphology, habitat information, planting information, harvest information, the organism's diet, the organism's behaviour, risks associated with the organism, ways the organism can be harvested, spiritual or cultural information, political information, and other information related to life history. The latter consisted of information on—food uses, medicinal uses, uses as a tool, spiritual or cultural uses, uses in construction, uses for labour, uses for fuel, commercial uses, uses in craft or ornament making, uses for social process, and uses as an indicator.

Although this rearrangement may make the local TEK corpus appear less complex in the figures below than is actually the case (for example, information on soil types is embedded within the habitat subcategory of plant and animal subdomains, rather than included as a separate domain), the strategy, as well as the construction of simple diagrams in general, helped us to more easily conceptualise and apply the interview results.

After modifying the researcher's framework, the interviews were reviewed a final time and the different statements within each one were coded to specify the domain, subdomain, category, and subcategory to which they corresponded. Interactions between subdomains described by interviewees were also noted. The subsidiary information associated with each species on the focus group lists was also reviewed and coded with the same methodology. Citations of 'different' subcategories with reference to the same subdomain were coded as unique events (for instance, a description of the construction uses of maypole trees in minute 3 of the interview and the medicinal uses of locas trees in minute 7). However, many individual interviewees contributed two or more comments that were coded into the same subcategory within the same knowledge subdomain (for instance, by describing the construction uses of 'maypole' trees in minute 3 of the interview and the construction uses of 'mahogany' trees in minute 7). After coding all interviews, we decided not to differentiate between these interviews and those in which the same subcategory within the same subdomain was only touched upon a single time. In other words, for each interview, each subcategory in each subdomain was either given a 1 if it was mentioned or a 0 if not. This was done to avoid mistakenly interpreting gregariousness of one individual as an indicator of a component of the TEK most likely to be shared with us by Costeños. Thus, each subcategory within each subdomain has a maximum value of 36, the total number of interviews, while each subdomain has a higher maximum value that represents the sum of all its subcategory values. We differentiate between interviews (maximum value=36) and citations (highest maximum value=262) in the results and discussion to keep this distinction clear.

Cognitive maps

Cognitive maps were created using Concept Map (CMAP) tools, a free software created by the Institute for Human and Machine Cognition (IHMC 2010). We drafted an initial map describing the interactions between subdomains that were described by interviewees. Then we created a set of more detailed, embedded maps describing each subdomain according to its subcategories. Together, these maps represent the aggregation of the data from all interviews; they are composite maps that describe the knowledge about local forest plants and animals that a typical Costeño is most willing to share with a Western researcher. In our particular context in which we work with many different local guides for camera trapping research, aggregate maps were deemed a potentially more helpful tool than over 30 sets of individual maps. Further, although interviewees were ethnically distinct and varied in age, the similarities in livelihood activities led to considerable homogeneity in responses, which offered additional support for our decision to build aggregate maps. Despite this, the diagrams should not be interpreted as a comprehensive depiction of the TEK in the RAAS, as TEK is much more complex, with nuances unexplored by our interviews that vary between communities and individuals for political, religious, and economic reasons.

RESULTS

Interviews

Mental model interview comments provide a picture of Costeño relations with, and knowledge about, the forest that are most likely to be shared with us during camera trapping research. In certain instances, some of which are noted below, the interview content agreed to a great extent with the content described in the literature available on the RAAS natural history and the region's history of resource exploitation. We believe this supports our conclusion that interviewee responses reflect the TEK that Costeños are most apt to share with us, and further contend that other outside forest ecosystem researchers would likely receive similar types of information throughout the course of collaborative research.

Tree knowledge (262 citations) was the most frequently cited knowledge subdomain in both the mental model and focus group interviews. Multiple tree subcategories were mentioned in more than one-third of the interviews. Trees, for example, were commonly described as important for local subsistence activities—as lumber for building houses (31 interviews), as material for dugout canoes and tools such as harpoons and paddles (21 interviews), and as sources of firewood and charcoal (11 interviews). Local people also consider trees commercially valuable (11 interviews), which resonates with the historical literature on the coast—throughout much of the twentieth century, multiple foreign companies came to the region and extracted large quantities of precious woods, including mahogany (*Swietenia macrophylla*), Spanish cedar (*Cedrela odorata*), and Caribbean pine (*Pinus caribaea*) (Christie et al. 2000). Costeños were frequently employed by these companies (Christie et al. 2000).

Costeños also revealed a broad knowledge of tree ecology, including tree identification (21 interviews) and tree distribution across the landscape (22 interviews). Multiple interviewees described how the timber-boom years, in conjunction with the expansive deforestation caused by Hurricane Joan in 1988, have made both the most profitable and locally useful tree species quite rare. This has apparently focused local attention on aspects of tree natural history such as reforestation patterns and growth rates (21 interviews). It has also made these trees into political symbols. When it is one of the last few standing and threatened by the chainsaws of the *Mestizos* encroaching onto local territory from the Pacific side of the country, a large mahogany tree is much more than simply a tree (13 interviews).

Ecological interactions involving trees were infrequently mentioned except in the context of wild mammals eating from, and gravitating towards, fruit trees (22 interviews), and intercropping fruit and timber trees with other food plants in farm fields (6 interviews).

Mammal knowledge (256 citations) was the second most frequently cited subdomain. As in the case of trees, multiple mammal subcategories were described in numerous interviews. Most frequently mentioned was the contribution of mammal meat to the local diet (31 interviews). Mammals are also commercially important (19 interviews) given the active market for bush meat described by several interviewees. Knowledge of other mammal uses, however, was less frequently cited.

Given that Costeños described successfully hunting or capturing animals and preventing animals from raiding crops (18 interviews) as vital to their livelihoods, both in terms of household economy and subsistence, it is unsurprising that all interviewees revealed a broad knowledge of mammal characteristics and ecology. This knowledge includes behaviour (27 interviews), habitat preferences (28 interviews), seasonal activities (22 interviews), and species of seeds, fruits, crops, and herbs commonly eaten by game animals (32 interviews).

Ecological interactions involving mammals were extremely common; it was by far the most densely connected subdomain. The most frequently mentioned mammal interactions with other animals generally involved predation or competition. The most frequently mentioned mammal interactions with plants generally involved shelter or dietary information.

Herb knowledge (145 citations) is the third most frequently mentioned subdomain. The use of medicinal herbs (29 interviews) was described in interviews as important to the wellbeing by many of Costeños. A variety of common ailments such as colds, headaches, general pain, and 'kidney' problems are treated with herbs that the general population knows well and often plants in home gardens (33 interviews; also Barrett 1994; Coe and Anderson 2005; Coe 2008). The economic value of herbs was less commonly cited (7 interviews) than the economic value of trees and mammals. Interviewee comments addressed this—so-called bush-doctors or *sukias* who are highly respected for their knowledge in combating serious illnesses, especially those caused by evil spirits, as well as for their ability to prescribe cures for illnesses through a type of controlled dreaming, are generally the only Costeños paid for herbal knowledge. Other local doctors who can cure people suffering from venomous snakebites are also sometimes paid. Yet both are very protective of their knowledge, sharing it with very few people. In this sense, they hold a monopoly over the herbal economy. The typical Costeño therefore either does not personally ascribe economic importance to herbs or is less apt to share this information about other community members, with outsiders.

Costeños hold substantial knowledge of common herb habitat (27 interviews) and reproduction (33 interviews). However, ecological knowledge of herbs was less commonly mentioned than ecological knowledge of trees and mammals. Aside from its food value for mammals, descriptions of ecological interactions involving herbs were uncommon.

As with the other frequently mentioned subdomains, crops were described in the context of their obviously important contribution to subsistence (33 interviews); however crops were less frequently described in terms of their commercial value (5 interviews). This agrees with analyses describing local markets; fish are more commonly sold than crops (Schmitt and Kramer 2009).

Despite the apparent lack of significant commercial value, interviewees revealed substantial information relating to crop ecology. Information on planting (33 interviews), harvesting (22 interviews), and suitable crop habitat (27 interviews) was common in interviews and described in great detail. Ecological interactions involving crops were not commonly discussed, except for crop—mammal interactions (20 interviews) and crop—insect interactions (5 interviews). In both cases the interactions predominantly described certain mammal and insect species as pests that can consume certain crops and ruin their harvest.

There was a lack of salient patterns in interview comments about the other subdomains that limits a similar overview of the content. Perhaps the only exception to this is birds, as the food value of the great curassow (*Crax rubra*) and crested guan (*Penelope purpurascens*) was often mentioned (10 interviews). Nonetheless, in general, the subdomain of birds was much less frequently discussed, as displayed in the cognitive maps below. This extends to comments about ecological interactions involving birds, which, aside from those with mammals, were uncommon.

Cognitive maps

The interaction map (Figure 1) displays the subdomains of knowledge considered in this study, and the interactions between organisms mentioned by the interviewees. The numbers superimposed on each interaction arrow represent the number of interviews in which an example of that interaction was explicitly described. For example, the 1 on the arrow connecting 'Domestic Animals' and 'Trees' indicates that an interaction between a domestic animal species and a tree species was described in only one interview. The numbers in parentheses within the subdomain nodes themselves refer to the number of interviews in which an interaction within a subdomain was mentioned. For instance, the number 5 underneath 'Mammals' indicates that a wild mammal species was described as interacting with another wild mammal species in 5 different interviews. The values associated with interactions are herein referred to as 'tie-strength' and range from 0 to 22. Tie-strength values above 10 are in bold to highlight those most frequently mentioned. Within subdomain tie-strength values only ranged from 0 to 5. It is clear that 'Mammals' is the most densely connected subdomain.

The second set of maps is at a finer scale within a particular subdomain (Figure 2). Each describes one subdomain according to the different subcategories associated with it by interviewees. Each subdomain has between 11 ('Insects') and18 ('Trees') subcategories associated with it. The numbers within the different subcategory nodes indicate the number of interviews in which that subcategory was referenced in the context of the associated subdomain. These values range from 1 to 33. The numbers within the principle subdomain nodes indicate the cumulative number of citations that each received in interviews, irrespective of subcategory. These range from 'Insects' with only 37 citations to 'Trees' with 262. It is important to interpret these models as 'submaps' embedded within the previous interaction map.

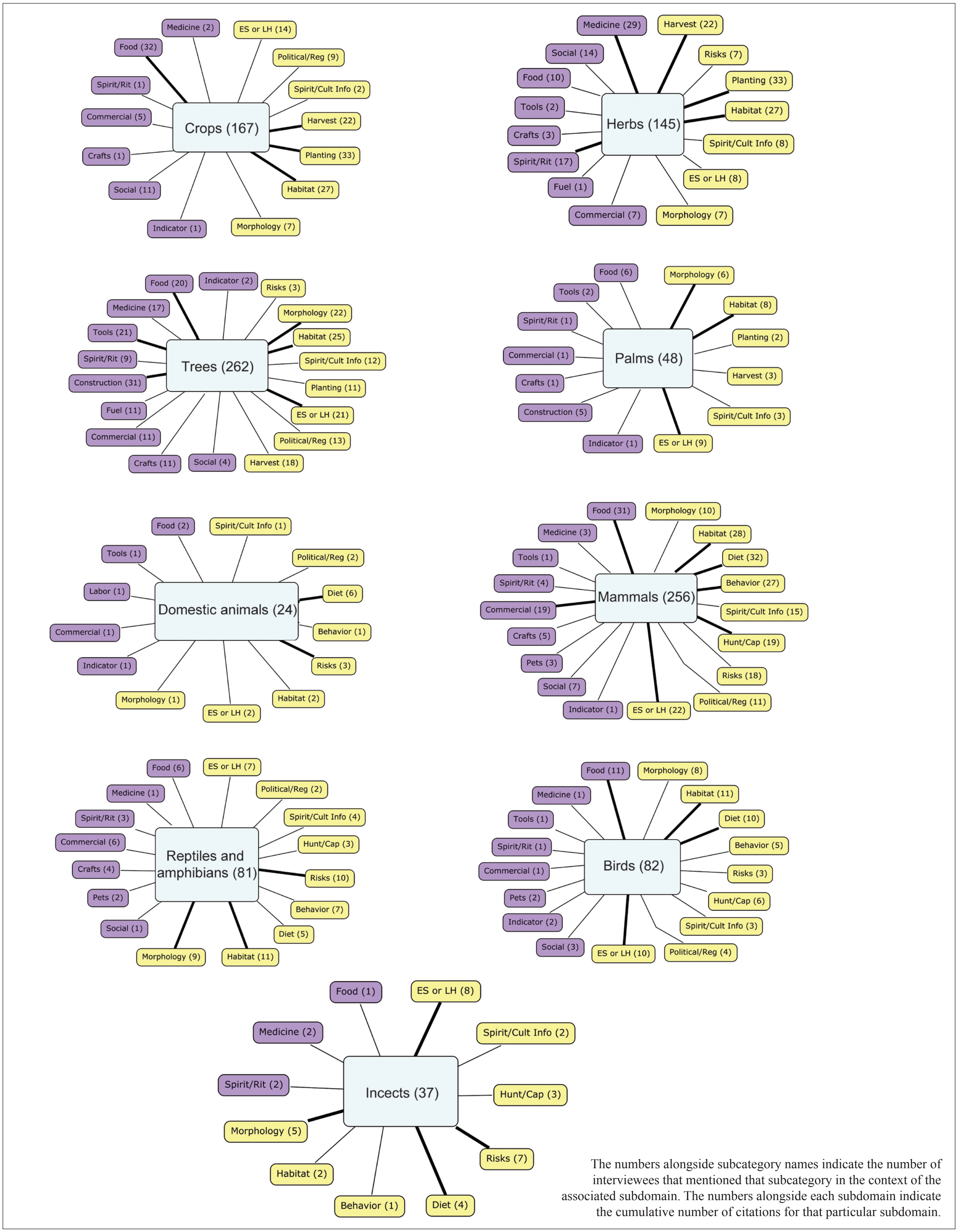
DISCUSSION

Interview content

Gagnon and Berteaux (2009) reported on what they consider a general trend in research that aims to gather the data embedded within TEK systems. They posit that the "level of the local community's interest in, and contact with, a given species influences the ease with which it is possible to gather TEK" about it (Gagnon and Berteaux 2009: 6). In particular, they hypothesize that when a community "has little interest in, or contact with, a given species, e.g., some cryptic insects, TEK is low, and therefore cannot be gathered productively" (Gagnon and Berteaux 2009: 6). They also hypothesize that "when the community is highly interested in a species, issues surrounding this species can be locally strongly politically charged… and TEK can become difficult to acquire without bias" (Gagnon and Berteaux 2009: 6). They conclude that the most readily gathered, unbiased TEK, i.e. that TEK most likely to be discussed by indigenous people in interviews and collaborations—will be about species of high local interest that are often interacted with, but in no way contentious.

In general, our results confirm that the pattern of increase in interest in, and contact with, a species makes the TEK associated with it more readily discussed by local people. For instance, the four subdomains most commonly cited: trees, crops, herbs, and mammals, were frequently described in interviews in terms of how Costeños use species within these groups to make them directly beneficial to household economics and subsistence. In other words, the interviewees clearly have high interest in, and high rates of contact with, these subdomains. This is underscored by the fact that interviewees revealed more detailed knowledge of them. For instance, these more frequently cited subdomains were also those with the highest mean tie strengths. Knowledge about these subdomains, which are locally perceived as highly important, are therefore most likely to emerge in the greatest detail in research collaborating with Costeño TEK of forests as they are the first that come to mind in interviews and fieldwork. It is also possible that local people consider that researchers share their view of these subdomains as highly important, and therefore choose to share knowledge about them first and foremost.

In contrast to this, insects are not consumed or sold in the RAAS, and although they are important for pollination, this is unlikely to be an obvious process that many local people observe and interact with frequently. Reptiles, amphibians, and birds do have historical commercial value, and there are certain forest-associated, rare species of both that contribute to local diets, but these are less commonly sold and eaten respectively in contemporary times, making a detailed TEK about them less critical for Costeños. The scarcity of these species likewise limits contact with them. In accordance with the Gagnon and Berteaux (2009) framework, evidence suggests that Costeños have lower interest in, and lower rates of direct, meaningful contact with, these subdomains of less subsistence value, knowledge about them should be less likely to emerge in interviews and research collaborations between Western scientists and RAAS citizens. Indeed, in our interviews, we received fewer, less detailed citations regarding this knowledge. It is important to underscore, however, that this in no way confirms the absence of this type of knowledge in the local TEK corpus. If researchers wanted to seek information about these subdomains, more direct interview techniques would be needed.



The numbers alongside subcategory names indicate the number of interviewees that mentioned that subcategory in the context of the associated subdomain. The numbers alongside each subdomain indicate the cumulative number of citations for that particular subdomain.

Figure 2

A series of submaps describing each subdomain according to the subcategory interviews associated with it

A similar pattern is also evident if ecosystem interactions are considered in and of themselves. For example, comments about mammal—crop/fruit tree interactions (35 interviews) were more frequent than mammal—palm interactions (12 interviews) or mammal—forest tree interactions (10 interviews). The mammal—plant interactions off farms were only described in the context of animal habitat use; however the mammal—plant interactions on farms were described in the context of threats posed by animals to crops, hunting, and animal habitat use. Again, the interviewees appear to have higher interest in, and higher rates of contact with, the interaction of higher subsistence value, mammal—crop/fruit tree interactions, and this interaction emerged more frequently in interviews. Thus, we should expect knowledge about these interactions to emerge more frequently in our research collaborations that include Costeño TEK of forests.

Although our results generally support the Gagnon and Berteaux (2009) hypothesis, they also include additional nuances. For example, in the context of our results, infrequent citation of a domain may have an alternative explanation—the domain is not strongly associated with the forest. This likely explains the dearth of palm comments. Multiple palm species are locally important for subsistence, as roofs in these communities are commonly thatched with palm species. In certain communities, *Raphia taedigera* palm fruits are also consumed as a seasonal dietary supplement. Additionally, palms are widely considered commercially valuable in light of a market-oriented oil palm plantation near the majority of study communities, and an active market for *Acoeloraphe wrightii*, which is used to stake lobster traps. Thus, it would seem likely that interviewees would commonly describe their TEK of palms. Yet this was not the case. However, it was common for interviewees to describe palms as growing in 'swamps', which were referred to in a way that made it seem as if local people classify swamps as a land-class distinct from forests. Perhaps palm knowledge would have been discussed more frequently in an interview on swamp environmental knowledge. This hypothesis is supported by the relatively high mean tie-strength of palms. This result does not serve to undermine the Gagnon and Berteaux (2009) argument, but rather as a cautionary note for researchers seeking to understand characteristics of a TEK system using results from interviews that only explore specific domains of the local TEK.

On a similar note, and underscored by the comments and results described in the previous two paragraphs, our results are not comprehensive enough to determine if TEK about the less frequently cited subdomains is "low" as the Gagnon and Berteaux (2009) framework suggests. This is in part because our results are only informative about knowledge of these subdomains in the context of forests. They say nothing about the broader knowledge of them. For instance, green turtles have been harvested for centuries in Miskito communities and the sharing of their meat has been a ritual that maintains social structure (Nietschmann 1973). Thus a more general interview about TEK that included marine ecosystems would have unquestionably included many references to reptiles. Furthermore, as the interviewees probably considered the information they shared to be of high importance to their communities, they likely assumed that it would be the information of greatest interest to us as well. This means that it could have been included to the exclusion of other information that they thought would have been of less interest to us. That our interview method was rather rapid makes this more likely. To truly make conclusions about the *levels* (author emphasis) of TEK about different organisms would require long-term ethnographic fieldwork or the creation of some type of aptitude test based on long-term observation and collaboration (i.e., Zent and Maffi 2008).

Finally, politically charged information did emerge in the interviews, and often included denigrating comments about *Mestizo* land-use practices and/or hunting philosophies. They were described as having a much more negative effect on forest resources than the practices typical of coastal communities. The Gagnon and Berteaux (2009) framework suggests that information provided in this context should be highly biased. We have no means of systematically comparing the impact of *Mestizo* and Costeño practices, but anecdotal evidence, including anecdotal evidence from unsystematic wildlife observations, gained from visiting farms pertaining to individuals from both groups supports interviewees' statements. Furthermore, analyses carried out on wildlife camera photos provide evidence of a strong negative effect of *Mestizo* farms on terrestrial mammal and bird activity (Jordan and Roe Hulse 2010). Nonetheless, it was more important for our fieldwork to understand that this type of comment would be frequently shared with us throughout our collaboration with local people instead of testing and judging its bias.

Application in camera trap research

The general patterns revealed through this analysis assisted our camera trapping research. A brief description of some details of the camera trapping research facilitates an explanation of how the interview results helped our research. Given that a large portion of the study area constitutes forests actively managed by Costeños, agricultural fields, or impenetrable swamps, we need to rely on guides to direct us toward forested areas that are at least plausibly accessible. Thus a sampling grid of 2 sq. km cells was overlain on maps of the local forested ecosystems surrounding each community and the centroid points of those cells were labelled and randomly numbered. In the field, the protocol is to walk as close to the lowest numbered centroid point that a guide considers accessible as possible. Then we ask him in clear terms to walk to the closest area, within the same 2 sq. km cell, where he believes the most different wildlife species will traffic. The guides choose the general location for the camera based on their knowledge of local wildlife, and then we select a precise location in the general vicinity that has a favourable structure and adequate light conditions for installing the device.

Initially, it was assumed that bringing a guide to a random centroid point before carrying out this process would ensure that we met our aim to install cameras at an ecologically diverse set of sites. For example, we assumed that the randomness would ensure that camera sites would be located at a variety of distances from agriculture and thereby enable us to build models to assess the impacts of local subsistence activities on wildlife. It rapidly became evident, however, that after we approached the centroid point, many guides actively searched for areas close to a farm, sometimes passing on more densely forested areas with fruiting trees and shrubs important for wildlife. Why, exactly, did this occur? First, it is a reflection of our poor diction; edge habitat *is* potentially where the most different species of wildlife will traffic. Second, it appears that the higher interest in, and higher contact with, wildlife—crop/fruit tree interactions (35 interviews) than with wildlife—forest tree or wildlife—palm interactions (10 total interviews[2]) meant that our guides were more likely to consider the former interaction during camera placement than either of the latter two. In other words, it seems that guides had higher contact with the former interaction and were therefore perhaps more confident placing a camera near a farm with wildlife food resources than near a fruiting forest tree or palm at a greater distance from the farm. As our interest was to sample various sites with various ecological characteristics in order to relate our measure of site diversity to different degrees of forest degradation and land-use, it took a slight adaptation of the protocol and additional explanation to attain a variety of edge and core forest camera sites. Although we may have noticed and tried to address this problem without carrying out social science interviews, the interview results helped us notice the problem rapidly before the issue undermined our goal of understanding landscape scale patterns in biodiversity and also helped us explain the bias. In this same vein, the results helped us to avoid the assumption that Costeños did not hold a great deal of knowledge on wildlife activity in the forest and thereby avoid misrepresenting and underestimating their knowledge in the field and in publications.

As we caught the problem early on, we do not have data to adequately compare diversity indices from cameras placed before and after the protocol change. Returning to study communities now to test the benefit of making this change in our camera placement protocol by using the original protocol to place additional cameras within each site with new local assistants and then comparing diversity indices between the new and old cameras is cost and time prohibitive. Further, it may not work as most community members in each study community are now very familiar with the camera trap research. However, the results of a different project offer indirect evidence that the difference in diversity would be substantial. During our initial camera placement, we placed approximately 104 cameras along the coast of the RAAS. Of these cameras, only four yielded photos of Baird's tapir (*Tapirus bairdii*), a species that the International Union for Conservation of Nature (IUCN) described as extirpated throughout much of the study area before our camera trapping results proved otherwise (IUCN 2011). After discussing tapirs with our local guides, we sought funding to initiate research focusing on their distribution in the RAAS. This project also has a camera trapping component and a similar camera placement protocol as the broader camera trapping effort. However, in each of our initial camera sites, the guide is asked to choose the place that he considers the most likely that a tapir will pass, rather than the highest diversity of species. Although the project is ongoing, of the first 56 cameras placed for tapirs, 14 cameras yielded tapirs. Even if the additional camera sites which have not yet been sampled with cameras for tapirs are removed from consideration, and we account for imperfect detection, the tapir detection rate of 'tapir cameras' when a tapir is present (44%) is substantially higher than the tapir detection rate of 'regular cameras' (13%).[3] Future, detailed publications on this project are forthcoming (Jordan et al. 2011). To us, this confirms our interview results that our Costeño assistants have a complex understanding of their ecosystem and understand which components are utilised by which organisms. Furthermore, it suggests that our change in protocol likely altered the results of the camera trapping, and enabled a sampling design that yielded results that are more representative of the entire forest surrounding the communities.

The details from the interview comments also helped in more basic ways—descriptions of key animal habitat, areas of primary forest, and areas of intense resource exploitation were almost always spatially referenced and given with their local toponyms. This enlightened us to new potential areas for camera trap sampling and facilitated our arriving at those locations.

The details from interview comments also allowed us to refine the covariates we originally hypothesised would significantly affect wildlife occupancy. For example, we now intend to separate seeds and fruits harvested for human consumption from those not harvested for human consumption into distinct covariates. This will, in theory, improve the fit of our models by better accounting for human disturbance, and in conjunction with harvest data allow us to better explore original hypotheses about the impacts of subsistence communities on wildlife.

Application in building rapport and capacitation of RAAS citizens

Again, the interviews underscored the political significance of forest resources, particularly of mammals (11 interviews) and trees (13 interviews). Most political comments referred to the agricultural frontier and associated natural resource threats, outside attempts to regulate local resources, or a within-community effort to protect community resources. Additionally, many interviewees described plants and animals as having 'spirit owners' (49 citations). These supernatural beings, rather than representing benevolent regulators of natural resources, appear to symbolise selfishness and individualism, and a distrust of certain outsiders, who have previously entered community lands to engage in unfair dealings (Jamieson 2010). The Caribbean coast of Nicaragua has had a politically and economically tumultuous history during which many Costeños have suffered economic, cultural, and physical distress. Indeed, whether or not the environmental information supplied regarding politically and spiritually charged entities was biased, as Gagnon and Berteaux (2009) hypothesise, given that these political and spiritual topics were discussed in detail in greater than 1/3 of interviews, the interview results quickly led us to conclude that the project would benefit if we held meetings with the whole community in each study community to clarify that the objectives of the camera work are unrelated to regulating resource extraction and that the researchers are unaffiliated with government resource agencies. Previously we had done this only with community leaders. To further ensure goodwill and a long-term trusting relationship, it was decided early on to also distribute all wildlife photos taken in and around each community to its members and to periodically seek feedback and suggestions for the project. We believe our efforts to include whole communities in the work have fostered a sense of community pride in the project in many areas, though we did not formally evaluate them. This pride, in turn encourages community members to protect the cameras when we leave them in the field, which in general leads to fewer stolen or disturbed cameras and the collection of more data. In the community of Kara, for instance, a man from a different, nearby village stole a camera and tried to sell it in a third village. News of the sale reached Kara and one of our forest guides aggressively pursued the man; he was castigated for his actions and the camera was returned to us; he is currently wanted in Kara and has been sentenced to manual labour in absentia.

Local people have also benefitted more directly from our scientific research being more culturally sensitive and based in a basic understanding of the TEK they share with us. Indeed, our efforts to work fairly with local assistants have encouraged many of them to take ownership of the project to the extent that they have become comfortable with requesting more formal training in camera setup, programming, and installation. In the communities of Haulover, Kahkabila, Karawala, and Orinoco, our assistants are now able to undertake this work independently. Furthermore, in Kahkabila and Pueblo Nuevo, assistants have requested and received cameras to monitor the activity of particular species—jaguars (*Panthera onca*) and collared peccaries (*Pecari tajacu*), respectively—of interest to community members. In Haulover, a local assistant plans to use the photos in a community meeting to discuss hunting regulations. Throughout the course of the research, assistants from these same communities have also been trained in the use of GPS technologies. Indeed, it is clear that local people are becoming capacitated in the technology to a degree sufficient for them to use the data as a tool in their interactions with local authorities. Kahkabila residents began planning to use camera trap results in grant applications for additional forest conservation and forest patrolling projects suggested in community meetings[4]. Similarly, in Monkey Point, territorial leaders asked us to draft a report describing camera trapping results for them to use in meetings concerning the construction of a deep-water port in the bay by their community (Jordan 2011). Without our initial efforts to work more closely with entire communities—which was informed by interview result analyses—these activities and phenomena would likely not have occurred as rapidly if at all. This also underscores the fact that WSK projects that apply TEK, and the information such projects generate are inherently political, and that the simple integration of TEK without actions and activities to keep indigenous people engaged in the project will yield less comprehensively beneficial results and limit the researchers' capacity to attain the second objective presented in the 'Introduction'.

Interview results also provided material for a forest wildlife guide that has been distributed to communities as an educational tool for the youth (Jordan and Urquhart 2011). Throughout interviews, interviewees lamented that the knowledge their children have of wildlife is declining. Most comments indicate that the primary reason for this trend is a decline in the forest activities undertaken by RAAS youth. Youths are reported to spend less time in the forest as their time in school both in and outside of their home community increases. While elder community members wish the TEK they hold was transmitted to their children, they also want their children to remain in school. Thus, after discussing the idea with local people, contributing a wildlife guide inclusive of both WSK and TEK for use in local schools and households was decreed desirable. The first edition was published in English with local input and distributed without charge in 2011 (Jordan and Urquhart 2011). The first editions in Spanish and Miskito were published in 2012, and second editions in 2013, and distributed in coastal communities free of charge (Jordan and Urquhart 2012; Simons et al. 2012). It is important to note that myths, beliefs, values, and other types of contextual information not found in typical wildlife field guides *was* included in this publication after further consultation with members of several communities. An edition in Mayangna is currently in the planning stages. Although the guide was created with our assistance, we believe it provides a novel way for local people to transmit their knowledge, and therefore increases their options for autonomously guiding processes related to TEK in their communities. Other collaborative TEK projects and workshops are currently in the planning stages.

Although it should not be assumed that local, independent analysis of species' presence and absence across the landscape has not occurred, perhaps the largest deficiency in the project thus far is that we have not used the rapport we have generated to involve local assistants in formal Western scientific analysis of the photos or in publication of the results. This is a problem common to many projects that include both TEK and WSK (Ellis 2005). We intend to rectify this in coming years with those assistants that are most active in this project. Despite this, undergraduate students from two of the study communities who attend URACCAN have analysed, interpreted, and written about the camera data for a thesis project supervised by the lead author. One of these students also helped in the translation of the Miskito edition of the wildlife guide (Simons et al. 2012). The lead author and an URACCAN research collaborator born in the RAAS have also jointly published on camera trap findings in a national journal, an international newsletter and presented a similar paper at an international conference (Jordan et al. 2010, Jordan and Roe 2010, Jordan and Roe Hulse 2011). These efforts are clearly not a substitute for more formal analysis and publication with local assistants. Indeed, it has been shown that capacitating university educated community members is not an effective way to ensure capacity building and representation within rural communities (i.e., Ellis 2005). Nonetheless, these activities are a step in the right direction toward a more fully just relationship with local communities and assistants, and have fostered a relationship that would permit such expansion of capacitation efforts. At such a time, the mental model interview results will be used to help guide the design of workshops and to help ensure that the format of data is applicable to locally important contexts.

Broader conservation potential

Lastly, much of the same information that has been helpful to research efforts has additional potential to inform practicing conservationists of how to create better partnerships with these RAAS communities. For instance, in the design of conservation initiatives or protected areas, it would be invaluable to know that the prevailing belief amongst Costeños is that their farmland is not categorically distinct from, but an important component of, the forest. Attempts in the RAAS to forge a conservation partnership based on notions of sustainable use and a matrix-concept inclusive of swidden horticulture would be much more successful than one based solely on an exclusive protected area concept that included rigid regulations and fines. Similar beliefs and research showing the benefit of swidden agriculture from other regions are not uncommon in Latin America. It is never wise, however, to make assumptions in applied conservation, thus making it important to explore the issue in the particular context of a project. The mental model interview results provide the necessary evidence. Also, the political environment of this legally autonomous area that was made evident in many interviews dictates that priority must be given to local consultation in any conservation initiative. In the RAAS, the judgments that the autonomous local people and their leaders make regarding a project instituted by an NGO or government agency are instrumental in determining its success or failure. First contact, first meetings, and equity in consultations would have to be much more carefully regulated than may be the case elsewhere.

The cultural information revealed in interviews could also be used more creatively. Understanding which species and areas are considered spiritually (48 citations) or politically (41 citations) important versus those that are considered risks to personal health or agricultural pests (51 citations) would allow for the proposal of more culturally sensitive and feasible regulations and help guide local collaboration and communication in this regard. It may make sense, for instance, to work with a suite of species popularised in local myths, e.g., Baird's tapirs, Central American agoutis (*Dasyprocta punctata*), mantled howler monkeys (*Alouatta palliata*), etc., in conservation discussions rather than those considered dangerous or mischievous, e.g., white-nosed coati (*Nasua narica*), tayra (*Eira barbara*), etc. These same ideas could also be applied in order to design more engaging environmental education initiatives inclusive of both WSK and TEK. The specific applications would largely depend on the objectives of the project, the social, cultural, and economic contexts, and the desire of Costeños (Shackeroff and Campbell 2007).

Concluding remarks

Recent trends in conservation biology suggest that collaborations and partnerships that apply two distinct knowledge systems in data collection are likely to continue increasing. Such projects are often challenging when WSK is involved, as the work must meet the dual goals of producing scientific reports, articles, and papers; and respecting and including the disparate knowledge system in a just manner that respectfully supports its autonomy. The challenging nature is partly due to the fact that each different collaboration, as it is comprised of two unique knowledge systems, will have *context specific* best practices for justly working with the two systems and achieving these goals in the same project. Huntington (1998) argues that arriving at, and implementing, these best-practices for each project are greatly facilitated when WSK researchers couple their biological investigations with research techniques based in social science that access, document, and provide them an understanding of the other knowledge system.

This paper provides support for Huntington's (1998) view. Our analysis of mental model interviews concerning Costeño forest knowledge using a framework proposed by Gagnon and Berteaux (2009), has helped in clarifying our understanding of the TEK our local assistants were sharing with us and has helped us tread a path towards attaining the two goals outlined above. In the context of the first goal, creating cognitive maps allowed us to consider the TEK of our local assistants with greater awareness, which in turn enabled us to improve the sampling methodology of a camera trapping study of neotropical mammal occupancy. The results of the study have since resulted in publications, presentations, and additional grant applications (Jordan et al. 2010; Jordan and Roe Hulse 2010; Jordan 2011; Jordan and Roe Hulse 2011), generated potentially useful conservation suggestions and helped avoid undesirable cultural pitfalls of strictly filtering the TEK into data (Shackeroff and Campbell 2007).

Additionally, our mental model interviews documented certain components of the TEK of forests in an area that is rapidly changing due to the establishment of recent connections to external markets and multiple development initiatives. As Moller et al. (2009) argue, cultural diversity is under just as much a threat as biological diversity in these contexts, and they work to document TEK, as a means of supporting TEK transmission can help prevent further losses. In these contexts, it is essential for local people to have the WSK and the TEK resources necessary for them to autonomously choose which conservation and resource-use conversations to engage in, to communicate as equals with other parties involved in those conversations, and to choose the knowledge they and their families are exposed to most frequently. Indeed, ex-situ conservation of TEK is not sufficient for cultural conservation (Agrawal 1995). We believe that our written overviews of interview results, and especially the behaviours and activities stemming from them, including the capacitation of local assistants, and the publication of a wildlife guide that includes a variety of TEK not included in typical wildlife guides (Jordan and Urquhart 2011, 2012; Simons et al. 2012) have helped local people to take some of the steps required, and/or provided resources to, help achieve such autonomy. Further plans to use interview results to help design training and education workshops will advance this progress.

Although many biologists will likely argue that there is not sufficient time to add a social science component to their research, a practical understanding of the entire context in which research is carried out is often essential for a project to be efficient and to fully attain its objectives. Therefore, if a project includes the integration of two knowledge systems, such as TEK and WSK, undertaking interviews for an hour each day before or after field work with the purpose of attaining that understanding is more than worth the effort. Working in conjunction with a trained social scientist and increasing sample size would, of course, yield even greater benefits and insights (Shackeroff and Campbell 2007). Indeed, our methodology and sample size are clearly incapable of yielding a comprehensive understanding of the TEK of Costeños. However, we believe that undertaking such interviews to the extent possible is better than nothing. The partial understanding of the TEK that Costeños are most likely to share with us—that we gained through mapping mental model interviews—was adequate to make our project more culturally sensitive and scientifically rigorous, and to support local autonomy with regards to TEK. Ecological studies and monitoring programs conceptually based in WSK that apply components of TEK systems have been, and continue to be, contentious and political, yet in many contexts it is the only format in which such efforts are feasible (Luzar et al. 2011). Applying research components based in social science to complement biological research can help scientists undertake such projects to better understand their relationship and work with indigenous and other rural people. Even in projects with objectives that are ostensibly unrelated to TEK, such an understanding can help in increasing the efficacy of the project as a whole, including improvements in scientific data collection and in community outreach and capacitation.

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Notes

1. It should be clarified that the topics discussed in Morgan et al. (2002) are unrelated to issues of indigeneity or natural resource management. The authors address topics such as the public's misconceptions of radon gas. Thus their use of the word 'expert', much disparaged in TEK research and ecosystem management, should not be viewed in a negative light.
2. These numbers may confuse the reader as tree—mammal interactions (22) are greater than crop—mammal interactions (20), but many of the tree—animal interactions mentioned involved fruit trees planted on farms and in communities. Only 10 interviews referred to trees likely to only occur in more primary forest.
3. Program Presence v2.4. 2009. http://www.mbr–pwrc.usgs.gov/software/presence.shtml. Accessed on 10 September, 2011.
4. It is important to note that researchers did not attend these meetings. Rather, they were held in the typical community meeting format, with local leaders presiding and offering an introduction to the meeting and other attendees given the opportunity to provide their input about the topics of discussion.

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APPENDIX

Researcher's framework for mental model interviews

1. **Conceptual knowledge**
   - A. Empirical plant domain:
     - i. Taxonomic names and classifications,
     - ii. Use: edible, medicinal, construction, fuel, commercial, crafts/ornament
     - iii. Characteristics: morphology, life history
   - B. Empirical animal domain:
     - i. Taxonomic names and classifications
     - ii. Use: edible, medicinal, labour, commercial, ornamental/crafts
     - iii. Characteristics: morphology, life history
   - C. Empirical ecosystem domain:
     - i. Plant and animal relationships: type of relationship, effect of relationship
     - ii. Biotopes/landscape units: names, characteristics, use
     - iii. Soils: names, characteristics, use
     - iv. Climate: elements, seasonal periods, seasonal activities
   - D. Metaphysical ecosystem domain:
     - i. Political: boundaries and tenure, rules and regulations
     - ii. Cultural: specific myths, taboos, social processes
     - iii. Spiritual knowledge: spirits, demons, religiosity
2. **Practical skills and knowledge**
   - A. Primary resource production or procurement domain: agriculture, herding, hunting, fishing, collection
   - B. Food preparation or processing domain
   - C. Ethno-medical preparations and applications
   - D. Craft and tool making domain
   - E. Architecture and construction domain
3. **Practical metaphysical knowledge**
   - A. Political processes
   - B. Cultural processes
   - C. Processes of spiritual engagement

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