

Q'eqchi' Maya healers' traditional knowledge in prioritizing conservation of medicinal plants: culturally relative conservation in sustaining traditional holistic health promotion

Todd Pesek · Marc Abramiuk · Nick Fini · Marco Otarola Rojas · Sean Collins · Victor Cal · Pablo Sanchez · Luis Poveda · John Arnason

Received: 11 February 2009 / Accepted: 5 July 2009 / Published online: 30 July 2009
© Springer Science+Business Media B.V. 2009

Abstract This ethnobotanical study in the spirit of transdisciplinarity, and in collaboration with Q'eqchi' Maya traditional healers, compares traditional Q'eqchi' Maya ecosystem constructs or environmental zones with scientific ecosystems. To determine which categorization method better accommodates Q'eqchi' Maya medicinal plant diversity, we analyzed 26 transects representing 160 medicinal plant occurrences. Our transect array encompasses a representative sampling of Q'eqchi' Maya medicinal plant repertoire with use values broadly distributed over 17 usage categories. With a cumulative frequency of 2,235 medicinal plants through ecological zones, we conducted one-way ANOVA on the mean number of medicinal plant species identified in transects of the two conceptual schemes being contested. Our analysis reveals the Q'eqchi' Maya environmental zones are the most salient. That is, knowledge of the Q'eqchi' Maya environmental zones improves one's ability to predict whether there will be a high or low abundance of Q'eqchi' Maya medicinal plant species in a particular region, whereas knowledge of scientific ecosystems does not accomplish this feat as well. This is a notable finding as it suggests that if indeed Q'eqchi' Maya medicinal plant diversity is better accounted for by the zones as envisioned by the Q'eqchi' Maya, then it

T. Pesek (✉)

Department of Health Sciences, Center for Healing Across Cultures, Cleveland State University,
2121 Euclid Avenue—HS 101, Cleveland, OH 44115, USA
e-mail: t.pesek@csuohio.edu

M. Abramiuk

Department of Anthropology, Case Western Reserve University, Cleveland, OH, USA

N. Fini

Naturaleza Foundation, Lakewood, OH 44107, USA

M. O. Rojas · P. Sanchez · L. Poveda

Herbario Juvenal Valerio Rodriguez, Universidad Nacional, Heredia, Costa Rica

S. Collins · J. Arnason

Department of Biology, University of Ottawa, Ottawa, Canada

V. Cal

Belize Indigenous Training Institute (BITI), Punta Gorda, Belize

should be this mode of conceptualization that should be adopted by scientists and conservationists when trying to locate and protect regional Q'eqchi' Maya medicinal plant diversity. These efforts serve as a model internationally in the conservation of medicinal plant biodiversity supportive of culturally relative holistic health promotion.

Keywords Traditional knowledge · Q'eqchi' Maya healers · Culturally relative conservation · Medicinal plants · Ecology · Sustaining holistic healthcare

Introduction

The remote and rugged Maya Mountains of Belize, Central America (Fig. 1), support a large area of semievergreen tropical rainforest with a variety of local ecosystems present. Through good conservation practices coupled with local ecosystem management the rainforest of the region represents one of the most intact and diverse expanses of tropical rainforest in Central America (Meerman 2008). Species richness is high and promoted by high levels of regional precipitation to the south of the main divide where there exist habitats supporting unique guilds of species (Hartshorn et al. 1984; Balick et al. 2001; Pesek et al. 2006a; Meerman 2008). The unique geomorphology also plays a substantive role in the diversity of the area (Dixon 1956; Bateson and Hall 1977; Abramiuk and Meurer 2006; Pesek et al. 2006a). The region is considered a biodiversity hotspot based on high endemism (Myers et al. 2000).

Four major scientific ecosystems predominate in the Maya Mountains region (Fig. 2; Meerman 2008) which rise in the south of Belize and then extend roughly 60 miles in a southwest-northeast direction with a westward extension toward the northernmost end (Hartshorn et al. 1984; Balick et al. 2001). The range is mainly granitic-volcanic with an onlap of limestone that has weathered to form limestone spires in close juxtaposition to the multitude of alluvial valleys of varying depth. Limestone plain borders the range to the east. The Maya Mountains peak around 1,000 m and descend gradually to a western plateau of approximately 500 m in elevation. The rain shadow on the western/northern slope occurs because prevailing winds from the Caribbean drop their precipitation on the southern/eastern slope of the Maya Mountains, this effect contributes much to the floristic diversity and differential between the northern and southern slopes and regions (Balick et al. 2001). Annual regional rainfall ranges from ~431.8 cm in the south to ~127 cm in the north (Hartshorn et al. 1984; Balick et al. 2001). North of the divide, two ecosystems predominate: lowland broad-leaved moist forest and submontane broad-leaved moist forest. The more southern regions (to the south of the main divide) are dominated by the other two of the four main ecosystems: submontane broad-leaved wet forest and lowland broad-leaved wet forest (Fig. 2). There are major differences between the northern and southern ecosystems and the floral diversity disparity from north to south is supported by greater rainfall and correlative floral diversity within the southern regions. The present study focuses on the regions of these four scientific ecosystem zones and compares them with how the local peoples, the Q'eqchi' Maya, view their surroundings.

Several recent surveys of the Maya Mountains have demonstrated new records of botanical species which might include those new to science (Ironmonger et al. 1995; Pesek et al. 2006a). This biodiversity hotspot also provides the environment for the rich cultural traditions in the area as well and thus represents a bio-cultural hotspot. This finding is consistent with the observation that traditions persist in mountainous regions (Stepp et al.

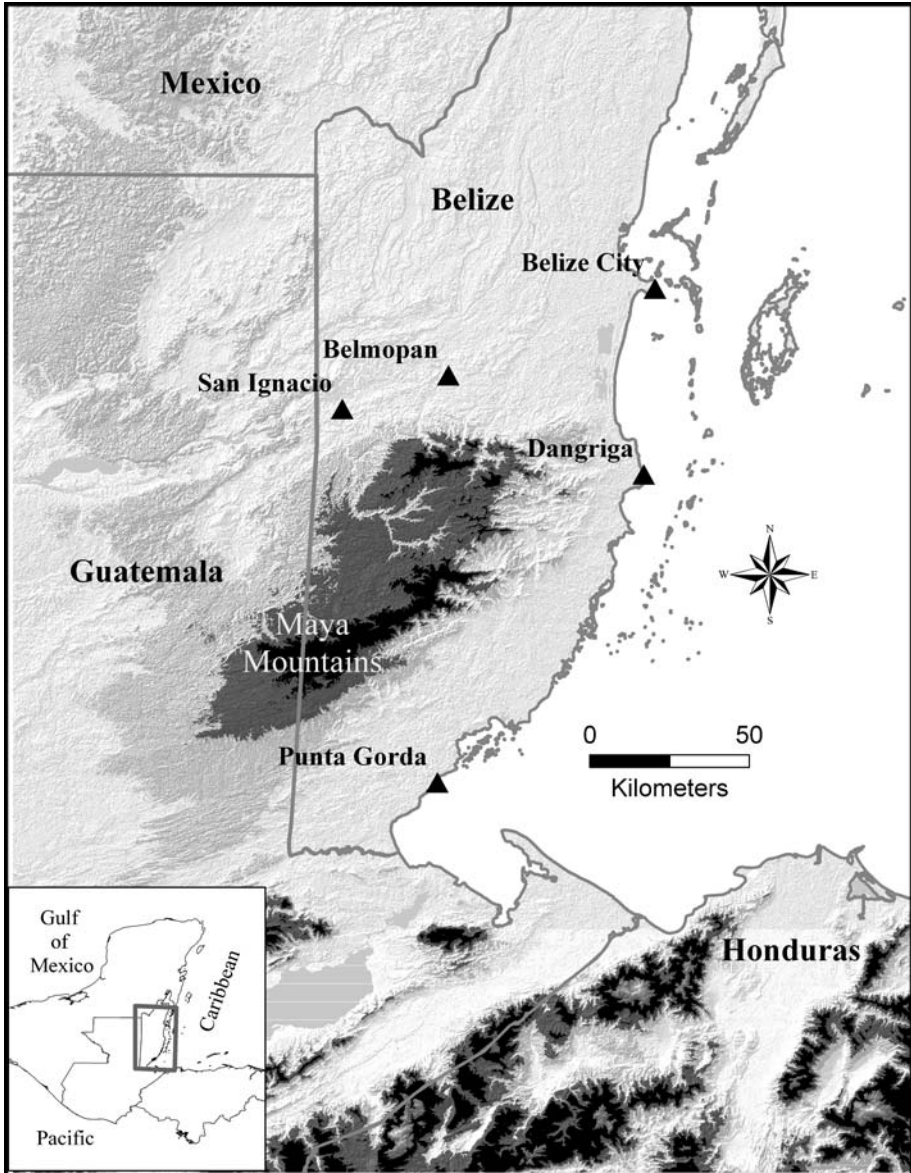


Fig. 1 Maya Mountains Region: Maya Mountains Ethnobotany and Ecology Project Map. 1:1,544,427. GIS Data Sources: CGIAR Consortium for Spatial Information. 2008. <http://srtm.csi.cgiar.org/>, and, BioGeo Berkley. 2008. <http://biogeoberkeley.edu/bgm/gdata.php> [GIS and spatial data warehouses]; Pesek L. 2008. Using: ArcView GIS [GIS Software]. Version 9.3. Redlands, CA: Environmental Systems Research Institute, Inc., 2008

2005). The intact cultural traditions of the area include traditional healing practices of the Q'eqchi' Maya of the southern Maya Mountains.

The Government of Belize has entered into an initiative for regional co-management with local Maya inhabitants, an exemplary model in support of conservation, sustainable

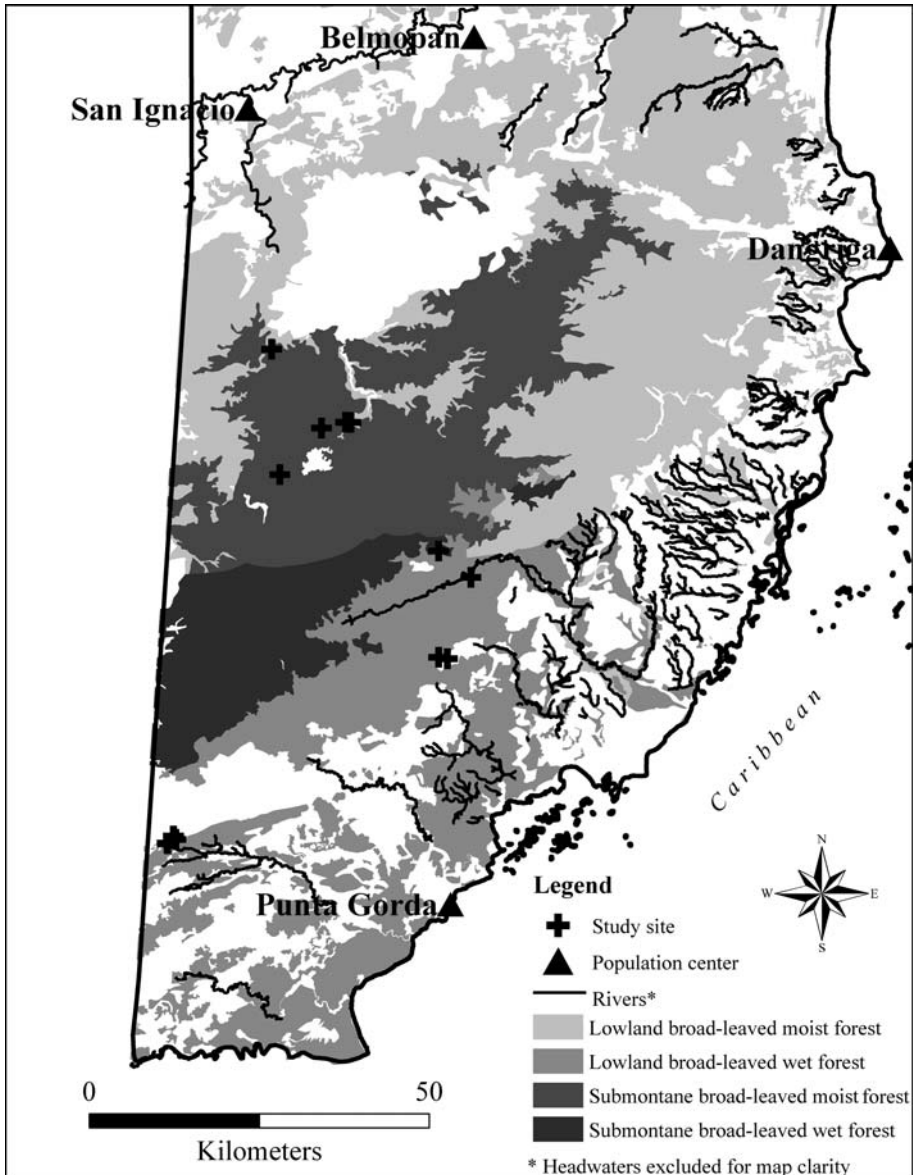


Fig. 2 Maya Mountains Scientific Ecosystem Representation: Maya Mountains Ethnobotany and Ecology Project Map. 1:619,792. GIS Data Sources: BERDS. 2008. <http://www.biodiversity.bz>, and, BioGeo Berkley. 2008. <http://bioge.berkeley.edu/bgm/gdata.php> [GIS and spatial data warehouses]; Pesek L. 2008. Using: ArcView GIS [GIS Software]. Version 9.3. Redlands, CA: Environmental Systems Research Institute, Inc., 2008

land use, and forest management. There is an urgent need, however, for innovative trans-disciplinary approaches toward facilitating these types of complex, innovative strategies practically, scientifically, and economically feasibly for the benefit of health, wellness, and sustainability (Wilcox et al. 2004a, b; Wilcox 2008; Pesek et al. 2006b). Participatory

research enabling scientific analysis describing the efficacy of inclusion of local indigenous peoples' traditional knowledge in delineating and prioritizing conservation programming will be essential in this regard (Pesek et al. 2006a, b, 2007, 2009). It has been argued that conservation programming oftentimes alienates indigenous peoples (Chapin 2004). Culturally relative conservation programming could work to alleviate these types of concern. It is also well known that regional indigenous peoples know their natural resources through their traditional knowledge which could then bring much positive benefit on a variety of fronts including health, wellness, conservation, and sustainable economic development. These types of applications are urgently needed since biodiversity is being lost exponentially (World Wildlife Fund 2004; Hanski 2005) and that the rate of resource exploitation and destructive patterns visited upon our rainforest ecosystems is not sustainable (United Nations Food and Agricultural Organization 2000). These destructive actions are rooted in perceived human need and supplanted by complex economics (Lawn 2008; Rosales 2008).

In addition, cultural diversity is disappearing at alarming rates along with the natural areas upon which these cultural ideations are built. Language diversity trends can be extrapolated to quantify the disappearance of cultural diversity which includes traditional healing practices, ecosystems concepts, and an understanding of nature's utility (Maffi 2001a, b; Buenz 2005; Sutherland 2003). Globally, languages are vanishing at alarming rates. Of the 15,000 languages which were spoken just 70 years ago, there are only approximately 6,000 still being spoken today (Grimes 1996; Davis 1999; Maffi 2001b; Buenz 2005; Sutherland 2003).

It has been noted by Jeffrey McNeely, chief scientist for IUCN, at the recent Biodiversity and Health Conference, that the preservation of tropical forests and the human cultures living therein can only be accomplished concurrently (Arnason et al. 2005). One strategy to apply in accomplishing this concurrent conservation could be culturally relative conservation via strategic application of traditional knowledge. In particular, the promotion of respect and selective inclusion of traditional healing in national healthcare and wellness promotion (World Health Organization 2002; Arnason et al. 2004; Pesek et al. 2006a, b, 2007, 2009). A strategy such as this could generate reproducible patterns of in situ conservation and ex situ conservation via protected areas and sustainably managed agroforestry reserves and appropriately placed community gardens. It could also generate fresh revenues for the conservation of biodiversity and culture, and promote individual and community holistic health and wellness and thus alleviate health disparities. One important component to this strategy is the promise of linking ecology with economy via sustainable trade in nontimber forest species like medicinal plants. This is a viable strategy in the context of well governed development since such development would not necessarily presuppose the loss of forest resources including medicinal plants (Buenz 2005).

In the spirit of transdisciplinarity, the present study compares traditional Q'eqchi' Maya ecosystem constructs or environmental zones with those aforementioned of the scientific community (Fig. 2) in an effort to determine which system better describes species distribution and thus conservation possibilities for Q'eqchi' Maya medicinal plants. This is a much-needed exercise given our need globally for answers to complex questions on health, wellness and interdependent conservation of biological and cultural diversity.

Q'eqchi' Maya healers traditional knowledge

Given the remoteness of the Maya Mountains and the intact nature of their regional rainforests, many components of Q'eqchi' Maya traditional knowledge have survived and

continue to be maintained well there. The Q'eqchi' Maya maintain an intact traditional healing system to this day as demonstrated by high consensus on medicinal plant use by local practitioners (Treyvaud-Amiguet et al. 2005). These local practitioners are commendably proactive in the conservation of their rich heritage and interdependent biodiversities (Arnason et al. 2004; Pesek et al. 2006a, 2007, 2009). Local Q'eqchi' Maya populations preferentially gravitate to these traditional healers for healthcare as well and so they actively access their knowledge within their traditional environmental settings in an ongoing basis. Indeed, these healers serve as primary care providers in the approximately thirty-five Maya villages in southern Belize. This is very much in keeping with global realities that approximately 80% of the world's population rely heavily on traditional healers for primary healthcare (Farnsworth et al. 1985; World Health Organization 2002).

Q'eqchi' Maya medicinal plants and environmental categories

Research in cognitive science shows that humans as well as many other animals construct and maintain cognitive maps of their environment (Hirtle and Jonides 1985; Herman et al. 1987). For the Q'eqchi' Maya, these cognitive maps represent the regions in their natural environment through which they move and in which they collect medicinal plants. Cognitive maps function as concepts which supplant their traditional knowledge web, in particular where specific medicinal plants exist. For example, they can go precisely to an area where they remember there being specific medicinal plants present and to areas where they believe based on their traditional knowledge web, that certain plants may be present (Pesek et al. 2009). They view their surrounding environment via constructs of their traditional knowledge web and they then use this categorical knowledge in efficient navigation as they collect medicinal plants (Pesek et al. 2009). Specifically, the Q'eqchi' Maya healers note four descriptive environmental categories in which medicinal plants grow: cool areas under high forest with much humus, warm areas under low forest, hot and warm areas on rocks and cliffs, and riversides (Fig. 3; Pesek et al. 2009).

Traditional knowledge driven cognitive maps bring a useful way of representing the concepts by which the Maya move through their natural environment to their medicinal plant destinations. In the present study, we use the cognitive maps delineating their perceived four environmental zones to account for the concepts that make up Q'eqchi' Maya traditional knowledge regarding where medicinal plants are located. We then contest these to scientific ecosystems categories in order to learn which categorical methodology more accurately reflects medicinal plant distributions.

Methods

Informed consent and ethics

Our study and informed consent protocol was approved by the Institutional Review Board of Cleveland State University, Cleveland, Ohio, USA, and the Institutional Review Board and Ethics Committee of University of Ottawa, Ottawa, Canada. This study was undertaken with informed consent of the Maya who collaborate with us as a participatory research team. Their identities are not revealed due to ethical guidelines in ethnobotanical research. This study was supported by the Government of Belize via permits issued through Forest Department. The informed consent and support of the healers, bushmasters,

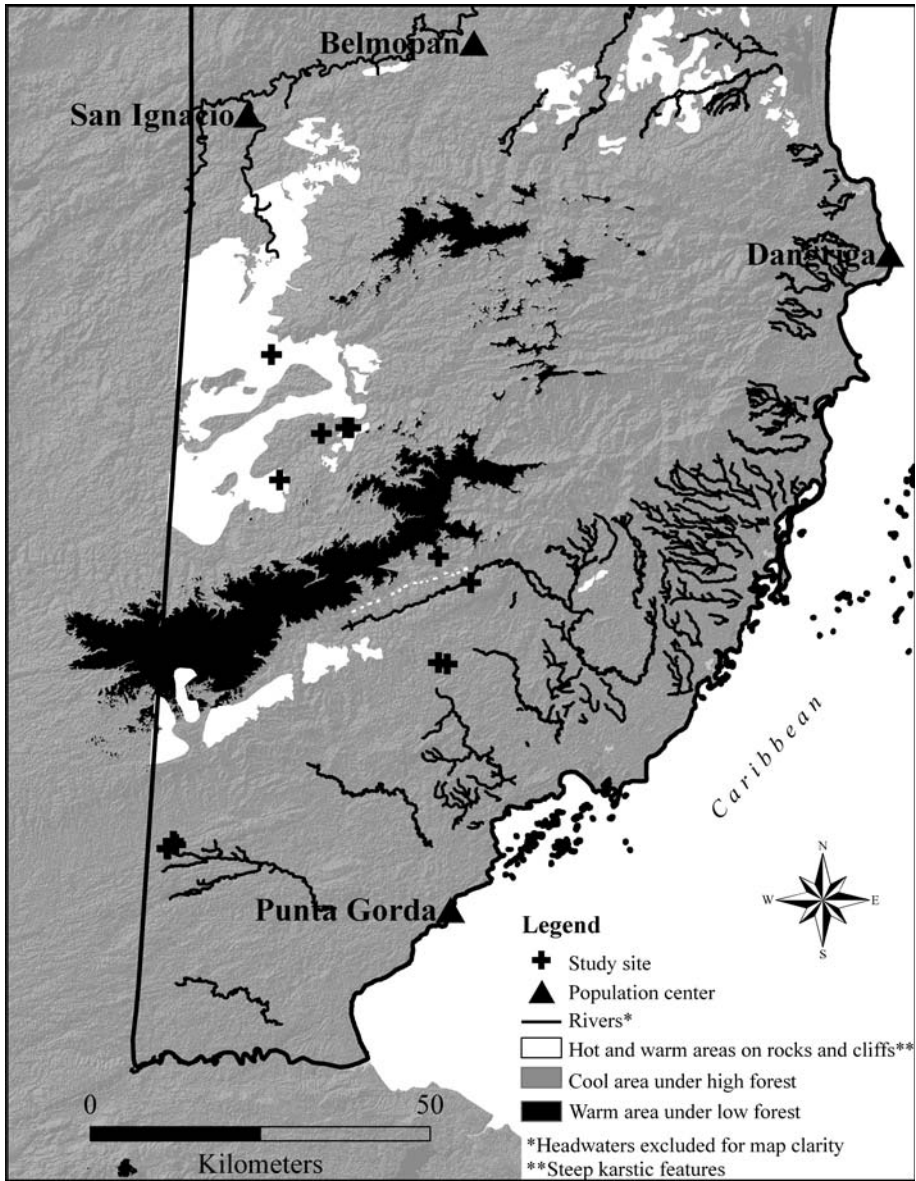


Fig. 3 Maya Mountains Q’eqchi’ Maya Environmental Zones Representation: Maya Mountains Ethnobotany and Ecology Project Map: 1:619,792. GIS Data Sources: BERDS. 2008. <http://www.biodiversity.bz>. CGIAR Consortium for Spatial Information. 2008. <http://srtm.csi.cgiar.org/>, and, BioGeo Berkley. 2008. <http://biogeo.berkeley.edu/bgm/gdata.php> [GIS and spatial data warehouses]: Pesek L. 2008. Using: Arc-View GIS [GIS Software]. Version 9.3. Redlands, CA: Environmental Systems Research Institute, Inc., 2008

and their communities was sought through a series of workshops which were initiated by collaborating entity Belize Indigenous Training Institute (BITI), a Belizean incorporated non-governmental organization founded in 1998 by local indigenous groups under the

guidance and assistance of Inuit Circumpolar Conference (Inuit Canada, Greenland, Alaska and Siberia). BITI is governed by a Board of Directors with representatives from local indigenous peoples cultural councils including Q'eqchi' Council of Belize, Toledo Maya Cultural Council, National Garifuna Council, and Xunantunich Organization. BITI provides practical training to local peoples in developing income generation and employment for communities. And, they provide capacity building training in the areas of traditional knowledge and cultural heritage. The Q'eqchi' Healers Association (QHA), an organized group of traditional Q'eqchi' Maya healers, is one community association affiliated with and assisted by BITI. The use of Q'eqchi' Maya medicinal plants is the intellectual property of the Q'eqchi' Maya healers and has been registered with the appropriate Belizean office. Species are not associated with specific use to protect their intellectual property.

Study loci and team

The study areas where the ethnobotanical surveys were conducted were within the remote and rugged, heavily forested regions of the Maya Mountains, Belize (Fig. 1). The study was carried out over 4 years comprised of a spring and fall field stint that ranged from 2 to 4 weeks in duration and which was then followed up with data processing and analyses. Our field research and expedition team varied in size and multidisciplinary complexity over the 4 years, but each expedition consisted of our core ethnobotanical participatory research team including ethnobotanist, ethnographer (Maya descent), three Q'eqchi' Maya bushmasters (guides), two representative and well-known senior practicing Q'eqchi' Maya traditional healers and spiritual guides (four other healers often joined us, but, these two healers on our core team were selected by their peers to represent the QHA and were on every expedition), and a navigator/mapping specialist.

The healers' and bushmasters' input was sought at our outset and in the development of our core objectives. To fully integrate their input, they were trained early on in map interpretation with specific site destination and site monitoring foci.

Mapping and GIS constructs

Provisional maps of the natural vegetation and ecological communities were composed and evaluated for potential routes (which usually meant navigable riparian corridors) to various regions representative of diverse niches throughout the mountains.

The mapping tools employed include existing topographic, ecosystem and vegetation maps; remote sensing imagery, primarily Landsat Thematic Mapper and aerial photographs; USGS DTED; BERDS GIS datasets (Meerman 2008); and CGIAR GIS datasets (CGIAR 2008). From these and other sources, a preliminary vegetation classification of the habitat based on ecosystems constructs of the region was developed to ensure a well distributed sampling technique with comprehensive coverage and statistically significant sampling in each of the four scientific ecosystems niches (Fig. 2) and each of the four Maya environmental zones throughout the mountains (Fig. 3).

The scientific ecosystems representation (Fig. 2) is developed from GIS data also used for the Central American Ecosystems Map produced by Belize Tropical Forest Studies. This classification standard is actively utilized in science and policy throughout Belize and internationally via The Biodiversity & Environmental Resource Data System of Belize (Meerman 2008). This classification standard differs from earlier classifications in that the broader divisions in the hierarchy are based first on vegetation structure followed by

seasonality, altitudinal aspects, vegetation type, ground-water specifics and ultimately underlying geology and soil. These ecosystems all find their roots in earlier classifications including 1995 classification scheme done by Iremonger and Brokaw and the UNESCO ecosystem classification scheme.

The Q'eqchi' Maya environmental zones representation is developed from this same GIS data as well as 90 m DEM from CGIAR (CGIAR 2008). Since there is no extant layer data for Q'eqchi' Maya environmental zones these zones were approximated based on elevation and slope differentials as well as natural landmarks. This approximation has been demonstrated to be accurate (Pesek et al. 2009). In both scientific ecosystems and Q'eqchi' Maya environmental zones classifications, however, our field data took precedence over GPS loci and GIS layer datasets in classifying the transect regions.

Site selection

Using the extant maps and those which we constructed as well as healer expert consultations and ground observations based on our rapid ethnobotanical survey (RES) pilot study where we crossed the Maya Mountains main divide in Spring 2005 (Pesek et al. 2006a), we chose 26 field sites based primarily on the independent variable of geomorphologic distinctiveness. Geomorphology and mineral composition profoundly affects the kinds of soils there are in proximity, which in turn affects the kinds of plants that grow of those soils. On this premise, inserting transects in each of the various geological regions controls for much of the variation which inherently arises from soil differences. We chose to study the four main geological regions common to Belize: limestones, volcanics, volcanoclastics, and granites. Limestones predominate in Belize, occurring at lower altitudes (e.g. the foothills of the Maya Mountains). Volcanics and volcanoclastics occur only along the Bladen Branch (Abramiuk and Meurer 2006). And finally, the granites are found in any one of three plutons or batholiths in Belize. The one we concentrated on was the Mountain Pine Ridge pluton located in the Cayo District where the RES pilot began. Multiple transects were inserted in each of these geologically distinctive regions to meet each of the following conditions: (1) each of the four scientific ecosystems was sampled in sufficient number, (2) each of the four Q'eqchi' Maya environmental zones was sampled in sufficient number, (3) there was a broad geographical spread of sample locations secured, (4), there was a comprehensive geologic spread of sample locations obtained.

Procedure for sampling and collecting

After the geomorphologic loci to be sampled had been determined, we traveled to the general regions and laid out multiple representative transects. Each of the twenty-six transects were 30 m × 30 m with a 1 m × 10 m core which was then analyzed in detail, we asked the healers to identify the different Q'eqchi' Maya medicinal plants found within the transect core and we recorded this information. Specimens of each were collected in triplet according to standard botanical and ethnobotanical protocols. One specimen of each was deposited at the Belize National Herbarium for identification and analysis and others were sent to Universidad Nacional, Costa Rica for analysis by tropical botanical experts Luis Poveda and Pablo Sanchez. The remaining specimens are housed in our project reference collection.

It is important to note that our sampling array was based primarily on geomorphology. While we were sure to obtain statistically significant numbers of transects in each of the scientific ecosystems and each of the Maya environmental zones, we did not specifically

seek out transect loci based on these classifications (they were sought based on geomorphology). However, there is unavoidable bias in our methodology given the fact that the traditional knowledge webs of the Q'eqchi' Maya were utilized for selecting areas to collect medicinal plants within these geomorphologic regions. In other words, these data were collected in a spatially non-random scheme by letting the Maya healers choose specific locations within the geomorphologic regions. This technique, despite the fact that it brings bias, was necessary since the focus of the study is on species representative of the Q'eqchi' healing plants repertoire. Controlling for this bias was done by arbitrarily selecting locations within regions of geomorphologic distinctiveness and having the healers select transect locations in close juxtaposition to the arbitrarily selected points. And, control transects became impractical since without accession of the Q'eqchi' Maya traditional knowledge there were not statistically significant numbers of Q'eqchi' Maya healing plants occurring within transects.

Ethnobotanical terminology

In this study, a record of use resulting from ethnobotanical interviews of the healers in their field and forest context is termed a “use report.” “Usage” is defined as use of a plant to maintain or improve health (via treating a specific ailment). A “usage category” is a group of usages that improves or maintains the health of a particular system. This system follows the standard for categorizing symptoms and ailments developed by Cook (1995). Further, the category “culture bound syndromes” (Weller et al. 2002) is used to classify folk illnesses that are not recognized by biomedicine as disease states. The use reports uncovered in the present study were sorted into the following 17 usage categories: circulatory system disorders (CIR), culture bound syndromes (CUL), digestive system disorders (DIG), endocrine system disorders (END), genitourinary system disorders (GEN), infections (INF), injuries (INJ), mental disorders (MEN), metabolic system disorders (MET), musculoskeletal system disorders (MUS), nervous system disorders (NER), nutritional disorders (NUT), poisonings (POI), pregnancy and birthing (PRE), respiratory system disorders (RES), sensory system disorders (SEN), and skin and subcutaneous disorders (SKI).

Ecological zones

The *ecological zones* (“both scientific ecosystems and Q'eqchi' environmental zones”) conceptualized by scientists and Q'eqchi' Maya are not only mental concepts in the minds of scientists and Q'eqchi' Maya but they are “real” zones with naturally delimited boundaries and characteristics which distinguish them from one another. For example, submontane broad-leaved moist forests are distinguished from lowland broad-leaved moist forests by altitudinal differences, and broad-leaved moist forests are distinguished from broad-leaved wet forests by variations in the amount of rainfall the two regions receive. Similarly, the Q'eqchi' Maya distinguish high cool forest and low warm forests by temperature differences, humus content, and by the height of the trees in the two regions. Riversides and rock surfaces are also highly distinguishable from one another in a physical sense.

Ecological zone classifications, such as that used by scientists or by Q'eqchi' Maya healers, have a specific function for the user. The function of such conceptual schemes is a practical one; they help one to locate specific regions where certain plants or ecologies should be found. More recently these schemes have been used by ecologists to identify and advance areas of ecological integrity. For example, conservation planning and policy development prioritized in association with “biodiversity hotspots” (Myers et al. 2000).

Ecologists, for instance, have used the categories: submontane, lowland, wet, and moist forest to delineate areas of varying biodiversities. These areas of delineated biodiversity have, in turn, been used to propose or argue for the protection of some of these ecological zones in a variety of fashions. This function and the usefulness of the scientific and Q'eqchi' Maya constructs in identifying and prioritizing ecosystems and environmental zones for potential use in conservation of Q'eqchi' healing plant resources will be investigated in the following statistical analysis.

Investigating the saliency of the ecological zones

An intuitive external index for Q'eqchi' Maya medicinal plant diversity is the number of species of medicinal plants used by the Q'eqchi'. We choose the number of species rather than a more standard measure of biodiversity such as Shannon Index, which assesses entropy or randomness of a closed system, since we are looking at one component of an overall biodiversity system. Also, since we are contesting systems components statistically we needed to minimize levels of abstraction in considering these data. With number of Q'eqchi' medicinal plant species operating as our index reflecting Q'eqchi' Maya medicinal plant diversity, the objective of our analysis is straightforward. The objective is to determine whether the ecological zones conceptualized by scientists or those by the Q'eqchi' Maya are more salient—saliency, in this case, referring to the situation in which each zone comprises regions containing *different* numbers of Q'eqchi' medicinal plant species. In other words, we wish to investigate under which ecological zonal scheme is Q'eqchi' Maya medicinal plant diversity better accommodated: the categories as envisioned by the Q'eqchi' Maya healers or those envisioned by scientists. We hypothesize that it is the zonal scheme envisioned by the Q'eqchi' Maya. This may seem intuitive that this would be the case, but conservationists for years have been using scientific zonal schemes for prioritizing areas for conservation.

To operate as a useful ecological zonal scheme for identifying regions of varying Q'eqchi' Maya medicinal plant diversity, the ecological zones should be easily distinguished from one another based on the differences in the number of Q'eqchi' Maya medicinal plant species that occur in each of the zones. That is, the ecological zonal scheme considered must be sufficiently salient with regard to its capacity to reflect differences in the mean numbers of Q'eqchi' medicinal plant species in each zone.

To address this issue, we conducted one-way ANOVA on the mean number of medicinal plant species identified in our 26 transects of the ecological/environmental zones in the two conceptual schemes being contested. Here, the *F*-ratio was computed for each scheme. The *F*-ratio, in our case, denotes the ratio of species frequency variation between each of the zones to species frequency variation within each of the zones. The higher the *F*-ratio, the more salient are the zones in the scheme. ANOVA was conducted on both the Q'eqchi' and scientific zones. The results are discussed below.

Results

General ethnobotany

We analyzed 26 transects representing 160 medicinal plant occurrences with cumulative frequency of 2235 medicinal plants (Tables 1 and 2). Of these 160 medicinal plant occurrences there were 85 unique species (some occurring in more than 1 transect). Of

Table 1 Transect classifications: scientific ecosystems and Q'eqchi' Maya environmental zones

Transect No.	Scientific ecosystem	Q'eqchi' environmental zones
1	Submontane broad-leaved wet forest	Cool area under high forest with much humus
2	Submontane broad-leaved wet forest	Cool area under high forest with much humus
3	Lowland broad-leaved wet forest	Riverside
4	Lowland broad-leaved wet forest	Hot and warm area on rocks and cliffs
5	Lowland broad-leaved wet forest	Hot and warm area on rocks and cliffs
6	Submontane broad-leaved wet forest	Cool area under high forest with much humus
7	Submontane broad-leaved wet forest	Riverside
8	Lowland broad-leaved moist forest	Warm area under low forest
9	Submontane broad-leaved moist forest	Warm area under low forest
10	Submontane broad-leaved wet forest	Cool area under high forest with much humus
11	Submontane broad-leaved wet forest	Riverside
12	Lowland broad-leaved wet forest	Riverside
13	Lowland broad-leaved wet forest	Hot and warm area on rocks and cliffs
14	Lowland broad-leaved wet forest	Hot and warm area on rocks and cliffs
15	Submontane broad-leaved moist forest	Cool area under high forest with much humus
16	Submontane broad-leaved moist forest	Cool area under high forest with much humus
17	Submontane broad-leaved moist forest	Cool area under high forest with much humus
18	Submontane broad-leaved moist forest	Riverside
19	Submontane broad-leaved moist forest	Riverside
20	Submontane broad-leaved moist forest	Riverside
21	Lowland broad-leaved moist forest	Cool area under high forest with much humus
22	Lowland broad-leaved moist forest	Cool area under high forest with much humus
23	Lowland broad-leaved moist forest	Cool area under high forest with much humus
24	Lowland broad-leaved wet forest	Warm area under low forest
25	Lowland broad-leaved wet forest	Warm area under low forest
26	Lowland broad-leaved wet forest	Warm area under low forest

these 85 unique species, 72 have been systematically identified to genus with a majority to species (Table 3). There is significant species overlap between these findings and those of the prior regional consensus study (Treyvaud-Amiguet et al. 2005), i.e., we have looked at a majority of these 106 earlier reported consensus plants in our transect arrays.

The 72 species represent 39 families and 120 use values. The top two frequently used plant families were Piperaceae and Rubiaceae a finding consistent with prior studies (Treyvaud-Amiguet et al. 2006). The use values are broadly distributed over the 17 usage categories and the categories with the highest number of use values are NER, INF, and DIG (Table 4). This finding is also consistent with prior studies as they are the same top three categories determined by prior consensus study (Treyvaud-Amiguet et al. 2005). The consistency of these data demonstrate a representative sampling of Q'eqchi' Maya medicinal plant repertoire in our transect sampling array.

Saliency of the ecological zones

These data, as depicted in Table 1, Transect Classifications, and Table 2, Transect Data, were first analyzed for normality and homogeneity of variance. A Kolmogorov-Smirnov

Table 2 Transect data: Q'eqchi' Maya species and frequency

Transect	Q'eqchi' name	Frequency	Transect	Q'eqchi' name	Frequency
1	Ch'ok pim	37	14	Ch'ok pim	800
1	K'am pom	6	14	Ro'ok chwan	3
1	Sa' jolom chakmut	5	14	K'u' uk mox	32
1	Kuxsawi	3	14	Ruk ma'us	30
1	Chajom k'ajam	1	14	Uxbi or Xilix	1
1	Rixixul	1	14	Marak pim	9
2	Sa' jolom chakmut	17	14	Pa ulul	1
2	Sak' i' puchuch	3	14	Rok xan	2
2	K'am pom	8	14	Sa' jolom chakmut	1
2	Sak' i' kejen	5	14	K'am pom	1
3	Hub'ub'	47	14	Chak b'day	14
3	Ik bolay pim	3	14	Mahogany	1
3	Sa' jolom chakmut	1	15	K'ootz	1
3	Ruk ma'us	3	15	Ruk ma'us	2
3	Ch'ok pim	76	15	Purk kejen	1
3	Rax' ik' che	1	16	Na' i' chaj	15
3	Ch'un	1	16	Kurux k'ix	1
3	Re chakbolay	4	16	Ch'up kan yuaj	1
4	Xak' pek	34	16	Chi'bayal	1
4	May pim	7	16	Corona k'ch	1
4	Rubel sa' i' xul	8	16	Tziritok	4
4	Re chakbolay	7	16	Chunak kejen	1
4	None	10	17	Rixixul	1
4	Puuchu re tzul	8	17	Sak' i' baych	1
4	Chu che	2	17	Nokte	5
4	None	1	17	Na' i' chaj	3
4	Ruxbi k'ak	3	17	Corona k'ch	2
5	Kwa' i' xul	25	17	Chunak kejen	1
5	Xak' pek	34	18	Jom che	1
5	Ch'ok pim	7	18	Biritak	7
5	Re chak bolay	4	18	Krux	4
5	Puuchu re tzul	7	18	Chup' i' al	2
5	Tzul che'	2	18	Pa ulul	20
5	Ruk ma'us	3	18	Ix kwaribali chok'l	4
6	Xu' kuy kok'	33	18	Ix tye'ajpak	1
6	Rokmu k'uy	20	18	Se ru' i' xul	4
6	Us'ano	73	18	Kurux k'ix	1
6	Ix kwaribali chok'l	7	18	Kaak ukuub	50
6	K'u' uk pim	78	18	Mul tzi	2
6	Xtia pek	13	19	Rox chik kuan	15
7	Rekuaxu	35	19	Tyut' it' puchuch	5
7	K'u' uk mox	16	19	Kaak ukuub	14
7	A'tza	2	19	Mul tzi	27

Table 2 continued

Transect	Q'eqchi' name	Frequency	Transect	Q'eqchi' name	Frequency
8	Tziritok	11	20	Tyut' it' puchuch	1
8	Chich mui	1	20	Kuw kub kejen	9
8	Kumum	9	20	Tziritok	14
8	Subin	2	20	Chunak kejen	7
8	Pens	1	20	Mul tzi	10
9	Krux	17	20	Keenk maus	1
9	Kolars	16	21	Puuchu re tzul	2
9	Kumum	16	21	Tziritok	2
9	Bolon ti'ok	1	21	Jolobob kejen	13
10	Puuchu re tzul	1	22	Ruk ma'us	1
10	Lolisam	2	22	Uxbi or Xilix	1
10	Tziritok	2	22	Pens	1
10	Ch'un	4	22	Pon te	1
10	Ruxbi k'ak	2	22	Bak pim	2
10	None	10	22	Subin	2
10	Re chakbolay	1	23	Rok' zaak	2
11	Tyut' it' puchuch	16	23	Chup' i' al	2
11	Jolobob kejen	6	23	Chelek sak	15
12	Ch'ok pim	69	23	Wara kix	5
12	Chak b'day	11	23	Chajom k'ajam	8
12	Che chem	2	24	Sa' jolom chakmut	3
12	Kuxsawi	3	24	Obel	2
12	May pim	1	24	Tyut' it' pim	5
12	Xak' pek	1	24	Chup' i' al	5
12	Ruk ma'us	12	24	Chajom k'ajam	11
12	Chu che	1	24	None	3
13	Rubel sa' i' xul	3	24	Corona k'ch	1
13	Ch'ok pim	16	24	Chelek sak	5
13	Chak b'day	11	24	Pajla	1
13	Xak pek	5	24	Birritak (red)	1
13	Puuchu re tzul	4	25	Chelek sak	20
13	Lectz'eb'	11	25	Tulux	11
13	Sa' jolom chakmut	4	25	None	1
13	Kuxsawi	4	25	Chu che	9
13	Rok xan	1	26	Kaak ukuub	8
13	Kwa' i' xul	10	26	Rok xan	5
13	Ruk ma'us	1			
13	Xak' pek	3			

test revealed that the data were normally distributed ($Z = 0.696$, $p = 0.717 > 0.05$). The Levene statistic was determined to be 1.443 ($p = 0.257 > 0.05$) for the Q'eqchi' Maya scheme and 0.896 ($p = 0.459 > 0.05$) for the scientific scheme, indicating that in both cases the variances were homogeneous.

The one-way ANOVA on the mean number of medicinal plant species varies significantly across the ecological zones of the conceptual environmental scheme being used by the Maya: $F = 3.949$ ($p = 0.021 < 0.05$; $df = 3$), but the model does not show significant variation for the scientific ecosystems: $F = 2.451$ ($p = 0.090 > 0.05$; $df = 3$), (see Table 5, Descriptive Statistics). The results show that the environmental zones conceptualized by the Q'eqchi' Maya healers reflect Q'eqchi' medicinal plant species diversity more saliently than do the ecosystems identified by scientists. This is because the Q'eqchi' Maya environmental zones are markedly different from one another in terms of the numbers of plant species they contain, whereas the numbers of medicinal plant species in each of the scientific ecosystems are not significantly different from one another.

Table 3 Taxonomy of Q'eqchi' Maya medicinal species occurring in transects (those not identified to Genus are not included)

Family	Genus species	Q'eqchi' name
Acanthaceae	<i>Aphelandra aurantiaca</i> (Scheidw.) Lindl.	Sa' jolom chakmut
Acanthaceae	<i>Justicia aff.fimbriata</i> (Nees) V.A.W. Graham	Sa' jolom chakmut
Acanthaceae	<i>Justicia pectoralis</i> Jacq.	Xu' kuy kok' (one type)
Acanthaceae	<i>Justicia</i> sp.	Kuuw kub kejen (one type)
Adiantaceae	<i>Adiantum</i> sp.	Rox chik kuan
Adiantaceae	<i>Pteris pungens</i> Willd.	Ro'ok chwan
Amaranthaceae	<i>Iresine diffusa</i> Willd.	Birritak (red)
Araceae	<i>Philodendron</i> sp.	Marak pim
Araceae	<i>Syngonium</i> sp.	Ruk ma'us
Araliaceae	<i>Oreopanax obtusifolius</i> L. O. Williams	Bak pim
Arecaceae	<i>Sabal</i> sp.	Kumum
Aspleniaceae	<i>Asplenium serratum</i> L.	Rixixul (one type)
Aspleniaceae	<i>Elaphoglossum herminieri</i> (Bory ex Fée) T. Moore	Rubel sa' i' xul
Asteraceae	<i>Baccharis trinervis</i> Pers.	Chelek sak
Asteraceae	<i>Chromolaena odorata</i> (Lam.) R. M. King & H. Rab.	None
Begoniaceae	<i>Begonia glabra</i> Aubl. var. <i>Glabra</i>	Pa ulul (one type)
Begoniaceae	<i>Begonia heracleifolia</i> Schltldl. & Cham.	Xak' pek
Bignoniaceae	<i>Tynanthus guatemalensis</i> Donn. Sm.	Chi'bayal
Burseraceae	<i>Protium glabrum</i> (Rose) Pittier	Pon te
Caesalpinaceae	<i>Senna hayesiana</i> (Britton & Rose) H. S. Irwin & Barneby	Keen maus
Combretaceae	<i>Combretum fruticosum</i> (Loefl.) Stuntz	Jolobob kejen
Costaceae	<i>Costus laevis</i> Ruiz. & Pav.	Ch'un
Euphorbiaceae	<i>Acalypha arvensis</i> Poepp.	Kaak ukuub
Euphorbiaceae	<i>Croton xalapensis</i> H. B. K.	Nokte
Fabaceae	<i>Machaerium</i> sp.	Purk kejen
Gesneraceae	<i>Columnnea sulfurea</i> Donn. Sm.	K'u' uk pim
Loganiaceae	<i>Spigelia humboldtiana</i> Cham. & Schltldl.	Se ru' i' xul
Loganiaceae	<i>Strychnos brachistantha</i> Standl.	Kurux k'ix
Malvaceae	<i>Heliocarpus mexicanus</i> (Turcz.) Sprague	Sak' i' baych
Malvaceae	<i>Pavonia paniculata</i> Cav.	Mul tzi

Table 3 continued

Family	Genus species	Q'eqchi' name
Marantaceae	<i>Calathea</i> sp.	K'u' uk mox
Margraviaceae	<i>Souroubea gilgii</i> V.A. Richt.	Hub'ub'
Melastomataceae	<i>Arthrostemma ciliatum</i> Pav. ex D. Don	Rok' zaak
Melastomataceae	<i>Miconia</i> sp.	Rokmu k'uy
Meliaceae	<i>Switennia macrophylla</i> King	Mahogany
Menispermaceae	<i>Cissampelos tropaeolifolia</i> DC.	Chup' i' al (one type)
Mimosaceae	<i>Acacia</i> sp.	Subin
Mimosaceae	<i>Mimosa pudica</i> L.	Wara kix
Monimiaceae	<i>Mollimedia guatemalensis</i> Perkins	Sak' i' kejen
Monimiaceae	<i>Siparuna thecaphora</i> (Poepp. & Endl.) A. DC.	Chu che
Moraceae	<i>Dorstenia contrajerva</i> L.	Xak pek
Moraceae	<i>Dorstonia</i> sp.	Chak b'day
Myrtaceae	<i>Pimenta guatemalensis</i> (Lundell) Lundell	Pens
Piperaceae	<i>Peperomia hispidula</i> (Sw.) A. Dietr.	Kwa' i' xul
Piperaceae	<i>Peperomia</i> sp.	Mai pim (one type)
Piperaceae	<i>Peperomia tetraphylla</i> (G. Forst.) Hook. & Arm.	Puuchu re tzul (one type)
Piperaceae	<i>Piper aequale</i> Vahl	Puuchu re tzul (one type)
Piperaceae	<i>Piper amalago</i> L.	Tziritok
Piperaceae	<i>Piper arboreum</i> Aubl.	Sak' i' puchuch
Piperaceae	<i>Piper hispidum</i> Sw.	K'am pom
Piperaceae	<i>Piper peltatum</i> L.	Tyut' it' pim
Piperaceae	<i>Piper schiedeanum</i> Steud.	Tyut' it' puchuch
Piperaceae	<i>Piper</i> sp.	Puuchuch
Piperaceae	<i>Piper tuerckeimii</i> C.DC. ex Donn. Sm.	Kuxsawi
Piperaceae	<i>Piper umbellatum</i> L.	Obel
Polygalaceae	<i>Securidaca diversifolia</i> (L.) S. F. Blake	Ch'up kan yuaj
Polypodiaceae	<i>Campyloneurum brevifolium</i> (Lodd.ex Link) Link	Rixixul (one type)
Rhamnaceae	<i>Gouania polygama</i> (Jacq.) Urb.	Chajom k'ajam (one type)
Rubiaceae	<i>Chiococca belizensis</i> Lundell	Chunak kejen
Rubiaceae	<i>Gonzalagunia panamensis</i> (Cav.) K. Schum.	Tzul che'
Rubiaceae	<i>Posoqueria latifolia</i> (Rudge)	Jom che
Rubiaceae	<i>Psychotria</i> sp.	Kolars
Rubiaceae	<i>Spermacoce assurgens</i> Ruiz & Pav.	Ix kwaribali chok'l
Sapindaceae	<i>Paullinia</i> sp.	Corona k'ch
Schizaeaceae	<i>Lygodium venustum</i> Sw.	Ruxbi k'ak (second type)
Selaginelliaceae	<i>Selaginella umbrosa</i> Lem. Ex Hieron.	Ch'ok pim
Smilacaceae	<i>Smilax</i> sp.	Bolon tiok
Solanaceae	<i>Solanum rudepanum</i> Dunal	Pajla
Verbenaceae	<i>Aegiphila monstrosa</i> Moldenke	Rok xan (one type)
Verbenaceae	<i>Cornutia grandifolia</i> (Schltdl. & Cham.) Schauer	Rok xan (one type)
Verbenaceae	<i>Lantana trifolia</i> L.	Tulux
Verbenaceae	<i>Stachytarpheta frantzii</i> Pol.	Ix tye'ajpak

Table 4 Distribution of Q'eqchi' Maya medicinal plant species among the 17 usage categories

Use category	No. of species
NER	22
INF	13
DIG	10
MEN	10
MUS	10
POI	9
SKI	9
CIR	8
PRE	6
GEN	5
SEN	4
CUL	3
END	3
MET	3
NUT	2
RES	2
INJ	1
Total	120

Table 5 Descriptive Statistics: Mean and standard deviation of the number of medicinal plant species observed in the Maya environmental zones and the scientific ecosystems (dependent variable: No. Species)

Ecosystem	Mean	Standard deviation	No. of transects
Q'eqchi environmental zones			
CHF	5.30	1.49	10
RIV	6.00	3.21	7
HRC	10.0	2.45	4
HLF	5.00	3.00	5
Total	6.15	2.89	26
Scientific ecosystems			
SBW	4.67	1.97	6
LBW	8.00	3.35	9
SBM	5.85	2.67	7
LBM	4.75	1.25	4
Total	6.15	2.89	26

The last column displays the number of transects studied in each of the ecological zones. Here, *CHF* cool high forest, *RIV* riversides, *HRC* hot rocks and cliffs, *HLF* warm low forest; *SBW* submontane broadleaf wet forest, *LBW* lowland broadleaf wet forest, *SBM* submontane broadleaf moist forest, *LBM* lowland broadleaf moist forest

Discussion

The implications of this study are clear: knowledge of the Q'eqchi' Maya environmental zones improves one's ability to predict whether there will be a high or low abundance of Q'eqchi' Maya medicinal plant species in a particular region, whereas knowledge of scientific ecological schemes does not accomplish this feat as well. One explanation for this result is simply that the Q'eqchi' Maya environmental zone scheme was designed for locating regions laden with plants used traditionally whereas the scientific scheme was not. For conservation purposes, though, the implication is that the Q'eqchi' Maya environmental zones are better suited to locate medicinal plant diversity hotspots, which may then be prioritized for protection. An interesting and plausible strategy given the saliency of the Maya environmental zones, this could involve local traditional knowledge in affixing importance to conservation tracts. This would also promote responsible sustainable management of resources which could ultimately lead to community health and wellness possibilities as well as fresh revenue streams via culturally appropriate microenterprise development based on fair trade, green, indigenously branded natural health products. This strategy effects conservation from both in situ and ex situ perspectives via a multitude of mutually beneficial modalities including community-based, sustainable agroforestry initiatives and indigenous medicinal gardens which effect a decrease in wild harvesting pressures while promoting community health and conservation of traditional knowledge. Directly applicable to Belize given the contextual nature of the study, these findings could also be generalized internationally in broader applications as a model. IUCN's Identification and Gap Analysis of Key Biodiversity Areas: Targets for Comprehensive Protected Area Systems, which is enabling conservation practice advancement commensurate with scientific theory (Langhammer et al. 2007), for example, could well add Important Medicinal Plant Areas supportive of community health and suggested by indigenous peoples and traditional botanical knowledge perspectives through this model.

We must effectively learn from traditional knowledge (Pesek et al. 2006b). This practice brings a number of practical implications including community health and wellness and the conservation of biodiversity and culture (Arnason et al. 2004; Pesek et al. 2006a, 2007, 2008, 2009). This study is a step toward proposing constructive collaboration between scientific and traditional knowledge in identifying regions where medicinal plants are likely to be concentrated. This can inform appropriate prioritization in applying conservation strategies which can protect these plants. As this occurs, we can continue to work with the healers to accurately record and understand their intrinsic notions such as ecosystems and environmental concepts and the basis of their traditional knowledge to more specific constituents like their pharmacopoeias and the biological activity of their floras, cultural contexts of their healing, sustainable resource management paradigms, and indigenous worldviews. These activities bring strong potential to contribute to the generation of economic and environmental stability for the local Q'eqchi' Maya people and for Belize, through conservation of biodiversity and culture via culturally relative methods and sustainable resource management and use. At the same time, these efforts aid in passing plant healing knowledge and other folk knowledge constructs to younger generations of Maya—a necessity before it is lost. It also opens venues for, via concurrent programming, alleviation of the pressure on harvesting plants from the wild. This can be done through strategic, concurrent programming in in situ and ex situ conservation of medicinal plant resources via culturally relative healing centers in conjunction with natural resources management, agroforestry efforts and indigenous medicinal plant gardens such as Itzama (Pesek et al. 2007). Plants, their

intrinsic utility and their healing properties make up a significant part of Maya culture and heritage. When these plants disappear, so do the cultural traditions which utilize the plants.

These applications could well bring substantial import to a multitude of timely cutting-edge efforts in sustainable subsistence and use patterns, sustainable resource exploitation and exchange practices, holistic community health and wellness, propagation of knowledge and culturally relative conservation.

Acknowledgments This work was supported by Cleveland State University, College of Science, International Development Research Center (IDRC), and Naturaleza Foundation.

References

- Abramiuk MA, Meurer W (2006) A preliminary geoarchaeological examination of ground stone artifacts in and around the Maya Mountains, Toledo District, Belize. *Lat Am Antiq* 17(3):335–354
- Arnason J, Cal V, Assinewe V, Poveda L, Waldram J, Cameron S, Pesek T, Cal M, Jones N (2004) Visioning our traditional health care: workshop on Q'eqchi' Healers center, botanical garden and medicinal plant biodiversity project in Southern Belize. Final report to IDRC, Ottawa
- Arnason J, Catling P, Small E, Dang P, Lambert J (eds) (2005) *Biodiversity and Health: focusing Research to Policy*. Proceedings of the international symposium held in Ottawa, Canada, October 25–28, 2003. NRC Research Press, Ottawa
- Balick M, Nee M, Atha D (2001) Checklist of vascular plants of Belize, with common names and uses. New York Botanical Garden Press, New York
- Bateson J, Hall I (1977) The geology of the Maya Mountains, Belize (Overseas Memoir 3). Her Majesty's Stationery Office, London
- Buenz E (2005) Country development does not presuppose the loss of forest resources for traditional medicine use. *J Ethnopharmacol* 100:118–123
- CGIAR Consortium for Spatial Information (2008) World Wide Web electronic publication. <http://srtm.csi.cgiar.org/> v.December 2008
- Chapin M (2004) A Challenge to Conservationists. *World Watch Magazine* November/December 2004, World Watch Institute
- Cook F (1995) Economic botany data collection standard. Royal Botanic Gardens Kew, Kent
- Davis W (1999) *Clouded leopard*. Douglas and MacIntyre Publishing Group, Vancouver
- Dixon C (1956) *Geology of Southern British Honduras with notes on adjacent areas*. Government Printing Office, Belize City
- Farnsworth N, Akerele O, Bingel A, Soejarto D, Guo Z (1985) Medicinal plants in therapy. *Bull World Health Organ* 63(6):965–981
- Grimes B (1996) *Ethnologue: languages of the world*, 13th edn. Summer Institute of Linguistics, Dallas
- Hanski I (2005) Landscape fragmentation, biodiversity loss and the societal response. *EMBO Rep* 6(5):388–392
- Hartshorn G, Nicolait L, Hartshorne L, Bevier G, Brightman R, Cal J, Cawich A, Davidson W, DuBois R, Dyer C, Gibson J, Hawley W, Leonard J, Nicolait R, Weyer D, White H, Wright C (1984) Belize, country environmental profile. Trejos Hnos, San Jose
- Herman JF, Blomquist SL, Klein CA (1987) Children's and adults cognitive maps of very large unfamiliar environments. *Br J Dev Psychol* 5:61–72
- Hirtle SC, Jonides J (1985) Evidence of hierarchies in cognitive maps. *Mem Cognit* 3:208–217
- Ironmonger S, Leisnerm R, Sayre R (1995) Plant records from the natural forest communities in the Bladen Nature Reserve, Maya Mountains, Belize. *Carib J Sci* 3:30–48
- Langhammer P, Bakarr M, Bennun L, Brooks T, Clay R, Darwall W, DeSilva N, Edgar G, Eken G, Fishpool L, DaFonseca G, Foster M, Knox D, Matiku P, Radford E, Rodrigues A, Salaman P, Sechrest W, Tordoff A (2007) Identification and gap analysis of key biodiversity areas: targets for comprehensive protected area systems. IUCN, Gland
- Lawn P (2008) Macroeconomic policy, growth, and biodiversity conservation. *Conserv Biol* 22(6):1418–1423
- Maffi L (ed) (2001a) *On biological and cultural diversity*. Smithsonian Institution Press, Washington and London

- Maffi L (2001b) Language, knowledge, and indigenous heritage rights. In: Maffi L (ed) On biological and cultural diversity. Smithsonian Institution Press, Washington and London, pp 412–432
- Meerman JC, Clabaugh J (eds) (2008) Biodiversity & environmental resource data system (BERDS). World Wide Web electronic publication. <http://www.biodiversity.bz> v.December 2008
- Myers N, Mittermeier R, Mittermeier C, da Fonseca G, Kent J (2000) Biodiversity hotspots for conservation priorities. *Nature* 403:853–858
- Pesek T, Cal M, Cal V, Fini N, Minty C, Dunham P, Arnason J (2006a) Rapid Ethnobotanical survey of the maya mountains range in Southern Belize: a pilot study. *Trees Life J* 1(10):1–12
- Pesek T, Helton L, Nair M (2006b) Healing across cultures: learning from traditions. *EcoHealth* 3(2):114–118
- Pesek T, Cal V, Fini N, Cal M, Rojas M, Sanchez P, Poveda L, Collins S, Knight K, Arnason J (2007) Itzama: revival of traditional healing by the Q'eqchi' Maya of Southern Belize. *HerbalGram*. 76:34–43
- Pesek T, Helton L, Reminick R, Kannan D, Nair M (2008) Healing traditions of Southern India and the conservation of culture and biodiversity: a preliminary study. *Ethnobot Res Appl* 6:471–479
- Pesek T, Abramiuk M, Garagic D, Fini N, Meerman J, Cal V (2009) Sustaining plants and people: traditional Q'eqchi' Maya botanical knowledge and interactive spatial modeling in prioritizing conservation of medicinal plants for culturally relative health promotion. *EcoHealth*. doi:10.1007/s10393-009-0224-2
- Rosales J (2008) Economic growth, climate change, biodiversity loss: distributive justice for the global North and South. *Conserv Biol* 22(6):1409–1417
- Stepp J, Castaneda H, Cervone S (2005) Mountains and biocultural diversity. *Mount Res Dev* 25(3):223–227
- Sutherland W (2003) Parallel extinction risk and global distribution of languages and species. *Nature* 423:276–279
- Treyvaud-Amiguet V, Arnason J, Maquin P, Cal V, Sanchez-Vindaz P, Poveda L (2005) A consensus ethnobotany of the Q'eqchi' Maya of southern Belize. *Econ Bot* 59(1):29–42
- Treyvaud-Amiguet V, Arnason J, Maquin P, Cal V, Sanchez-Vindaz P, Poveda L (2006) A régression analysis of Q'eqchi' Maya medicinal plants from southern Belize. *Econ Bot* 60(1):24–38
- United Nations Food and Agricultural Organization (2000) Global forest resources assessment, 2000. FAO Forestry Paper 140. Available at: <http://www.fao.org/forestry/fo/fra/main/>. Accessed 3 August, 2005
- Weller S, Baer R, De Alba Garcia J, Glazer M, Trotter R, Pachter L, Klein R (2002) Regional variation in Latino descriptions of Susto. *Cult Med Psychiatry* 26:449–472
- Wilcox B (2008) Transdisciplinarity in EcoHealth: status and future prospects. *EcoHealth* 5:1–3
- Wilcox B, Aguirre A, Daszak P, Horwitz P, Martens P, Parkes M, Patz J, Waltner-Toews D (2004a) EcoHealth: a transdisciplinary imperative for a sustainable future. *EcoHealth* 1(1):3–5
- Wilcox B, Aguirre A, Daszak P, Horwitz P, Howard J, Lanigan R, Martens P, Parkes M, Patz J, Rapport D, Waltner-Toews D (2004b) EcoHealth: a transdisciplinary imperative for a sustainable future. *EcoHealth* 1(1):1–2
- World Health Organization (2002) WHO traditional medicine strategy 2002–2005. World Health Organization, Geneva
- World Wildlife Fund (2004) Living planet report 2004. World Wildlife Fund, Gland