The use of herpetofauna and cultural values to identify priority conservation forests on Malaita, Solomon Islands

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Due to limited financial and technical resources, there is a pressing need to identify priority areas and strategies for conservation globally. This study aims to prioritize important forest areas for conservation on the island of Malaita, Solomon Islands. Five different forest types were sampled to quantify biodiversity using the species richness of frogs and lizards (herpetofauna) as a biological indicator of conservation status. Unlogged coastal, unlogged lowland and unlogged upland forests have minimal disturbance whereas logged lowland forests and plantation teak forests are heavily disturbed. Subsequently, the effects of human modification on forest systems are also quantified based on anthropogenic disturbance. Interviews with local community members were conducted to gather associated local traditional knowledge on the cultural importance of frogs, lizards and forest habitats. Prioritization methods based on species richness, species uniqueness, cultural importance and threatened status are used to identify key forest areas. The four main results found are: 1) unlogged lowland forests have the greatest biodiversity value, 2) unlogged lowland forests also have the highest cultural value based on local uses, 3) logged lowland forests are biologically important, and 4) unlogged coastal forests and unlogged lowland forests are under the greatest threat from anthropogenic activities. Based on these results, the conservation of unlogged lowland forests on Malaita should be prioritized. These results also highlight the importance of combining biological sampling with cultural information to improve the efficiency and long-term success of conservation actions.

Key words: conservation prioritization, Solomon Islands, herpetofauna, traditional cultural values

INTRODUCTION

CONSERVATION effort needs to be focused due to the limited financial and technical resources available globally (Myers *et al.* 2000, Bottrill *et al.* 2008, Wilson *et al.* 2009). Therefore, there is a pressing need to identify priority areas and strategies for conservation action to "effectively and efficiently" achieve at least some preservation of biodiversity within the limited resources and funds available (Margules *et al.* 2002, Wilson *et al.* 2009). An important challenge facing tropical biodiversity conservation is determining methods to prioritize and then implement effective conservation in the identified priority areas (Becker *et al.* 2010).

Conservation prioritization is based on a number of inter-related principles including irreplaceability and vulnerability (Margules *et al.* 2002, Wilson *et al.* 2009). Irreplaceable areas contain unique species and habitats and are considered a high priority for conservation planning (Margules *et al.* 2002). Vulnerability is influenced by: the rarity of, the level of threat faced by, and the ecological importance of the species or habitats (Fa *et al.* 2004). Margules *et al.* (2002) believe that priority conservation areas should also have two roles; areas should represent the biodiversity of the region, and areas should separate the biodiversity from the processes that threaten it.

To address questions regarding the health and integrity of ecological landscapes, a particular species or taxonomic group is often selected to act as a surrogate or indicator for the whole species assemblage and the ecosystem (Hilty and Merenlender 2000). Herpetofauna (especially amphibians) are often cited as an ideal indicator group for ecological studies, because of their sensitivity to changes in moisture and temperature regimes, amphibious life cycle, diversity in reproductive methods and weak dispersal abilities (Pineda and Halffter 2004, Smith and Rissler 2010). Amphibians are abundant and functionally important in many ecosystems around the world, most are easily identified and are of global conservation concern because of their well-documented, widespread decline (Bennett 1999, Stuart *et al.* 2004, Smith and Rissler 2010, Bishop *et al.* 2012).

Traditional knowledge (TK) provides a foundation for successful living in natural environments; and this knowledge with its beliefs and customs form the 'glue' that creates social cohesiveness and cultural identity (Bennet 2000, Dutfield 2006, Thaman *et al.* 2010, FAO 2011). In Melanesia TK and cultural practices and values have developed and evolved over time resulting in interactions and relationships with the environment that are based on qualitative, holistic, oral approaches (Merculieff 2000, Caillaud *et al.* 2004, Walker Painemilla *et al.* 2010).

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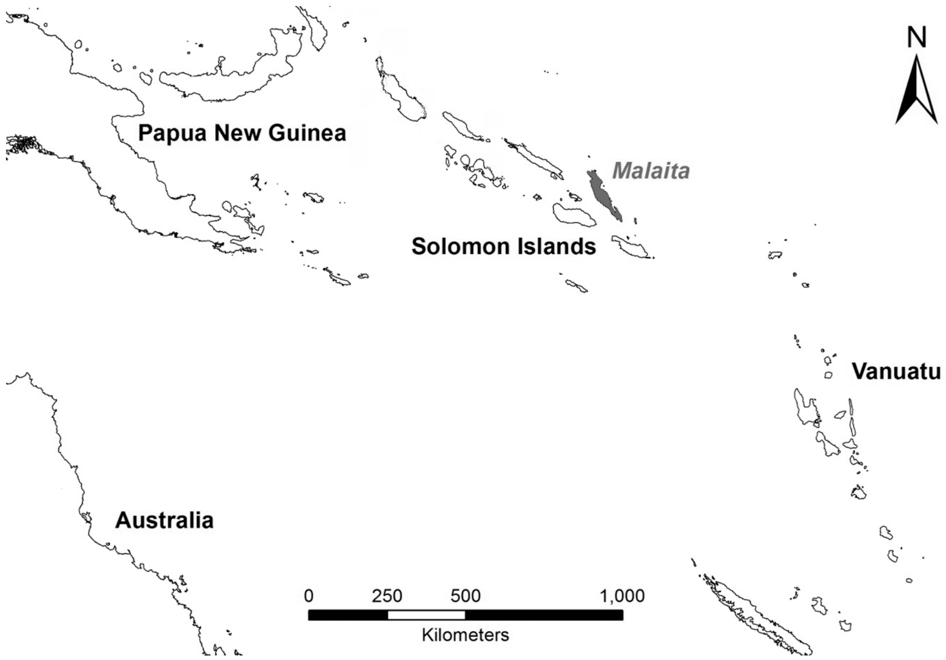

Fig. 1. Map showing the location of Malaita Island in the Solomon Islands.

Effective prioritization requires sound information on the conservation status of species and ecosystems, including the vulnerabilities of, and threats to biodiversity (Beebee and Griffiths 2005, Wilson *et al.* 2005). Effective prioritization also requires the effective combination of scientific methods, community engagement and traditional knowledge (Collins and Storfer 2003). Consequently, the primary aim of this study was to integrate both biodiversity and cultural values of forest and herpetofauna as a basis for identifying priority conservation forest habitats on Malaita. More specifically, the objectives were to combine the results of field-based biodiversity surveys of herpetofauna with questionnaire-based surveys of local communities regarding the cultural value of different forest habitats to rank the habitats based on their conservation importance.

METHODS

Malaita Island

The Solomon Islands, the third largest archipelago in the South Pacific, is located between 6–12ºS and 155–168ºE (Figure 1) and is composed of a double chain of approximately one thousand islands extending over 1450 km in a south-eastern direction (Mueller-Dombois and Fosberg 1998). The total land area of the Solomon Islands is around 28,785 km^2 and the country has rich marine resources and a total marine area of around 1.3 million km^2 (Gough *et al.* 2010). Malaita Island is the third largest and fourth highest island in the Solomon Islands (~190 km in length, highest point 1433 m.a.s.l) with the centre located at 9°S and 161°E (Polhemus *et al.* 2008). Malaita is divided into 14 language group areas with the 'Are'Are language area in the south covering the largest land area on the island (Figure 2). The Tai Ward within the 'Are'Are area was selected as the study area because (i) it has a relatively low population density and (ii) native vegetation was relatively intact until the commencement of logging

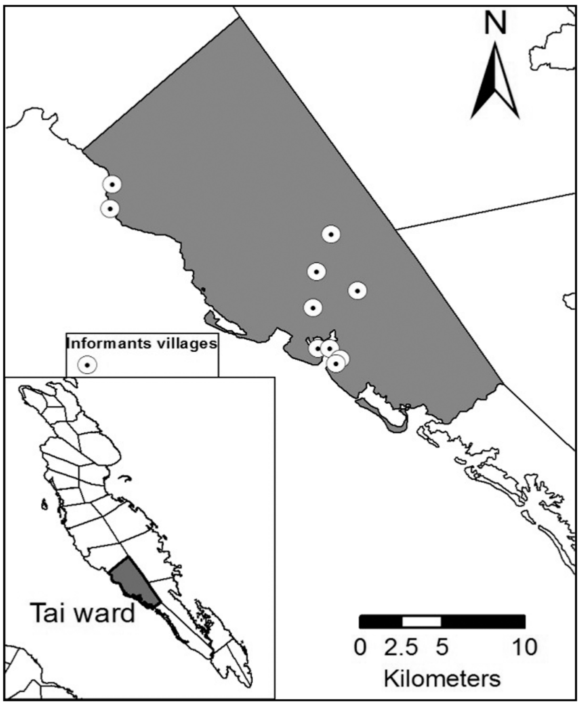

Fig. 2. Malaita and Tai ward study site including informants' villages.

operations in the early 2000s, after which heavy forest degradation occurred throughout the region. Despite the extensive degradation there remain fragments of pristine forest, especially further inland and at higher altitudes, which house the most pristine representations of Malaita's native flora and fauna.

Five forest habitats (unlogged coastal, unlogged lowland, unlogged upland, logged lowland and teak plantation forests) were surveyed in this study (Table 1). These habitats were selected as being the most common forest habitat types covering the largest land area, generally easy to access, and being important not only for biodiversity but also for the local indigenous people.

Herpetofauna surveys

Frogs belonging to the order Anura and lizards belonging to the families Gekkonidae (geckos) and family Scincidae (skinks) were the target herpetofauna taxa for this study. Standard nocturnal Visual Encounter Surveys (VES) as per Heyer *et al.* (1994) along 500 × 6 m line transects were used to survey frogs and nocturnal reptiles. All transects were located at least 100 m from the forest edge. Transects within the same forest habitat types were separated by a minimum distance of 200 m and separated by a minimum of 500 m from transects in different forest habitat types. This was done to minimize the problems of edge effects and pseudo-replication. Sampling began around sunset at 1830 hrs and covered two line transects of the same habitat type per evening at a fixed effort of 2 man hours per transect (2 persons × 1 hour).

Active searching of 10 × 10 m quadrats was used to survey diurnal reptiles. Three quadrats were randomly placed in each site using the 'randomized walk' method where the observer uses pre-determined compass directions and distances for the placement of the quadrats (Heyer *et al.* 1994). All quadrats were located at least 100 m from the forest edge to avoid edge effects and by a minimum distance of 50 m within the same forest habitat type. They were separated by a minimum of 500 m from quadrats in different forest habitat types. Searches of the quadrats occurred in the mornings with 3 quadrats surveyed per day at a fixed effort of 1 person-hour per quadrat (2 persons × 0.5 hours).

Individual animals encountered were recorded with species name, specific habitat and micro-habitat, whether vocalizing or not (in the case of frogs) and if captured or not. Captured animals were placed in sealed bags for closer inspection and photographing. Species identifications were confirmed using identification keys and species descriptions in McCoy (2006) and Pikacha *et al.* (2008) before being released at the site of capture.

A pilot survey to trial the field methods was conducted in August 2011. Three additional field trips were conducted throughout the year (September 2011, December 2011 and March 2012) to take into account the effects of seasonality on species abundance. Given the relatively limited differences between seasons in the Solomon Islands, these field trips were considered sufficient to capture seasonal variation. On each field trip each habitat type

Table 1. Description of forest habitats sampled and number of transects and quadrats in each habitat type.

Forest habitat type	Habitat description	No. of transects	No. of quadrats
Unlogged coastal	Located on flat land close to, and in many cases, adjacent to the coast with many coconut trees and other large trees; well-draining substrate, usually sand or gravel, where strong human influence is evident	12	18
Unlogged lowland	Characterized by a thick canopy with many large trees over 20 m high; adjacent to waterways and along slopes at elevations below 300 m.a.s.l; soils are relatively rich in humus and dark in colour	24	36
Unlogged upland	Characterized by a reduced canopy of trees around 15 m tall; moss and lichen species common; found along ridge tops, usually areas above 500 m.a.s.l.; moist substrate due to high precipitation and lower temperatures; evidence of past human habitation	16	24
Logged lowland	Forests have undergone mass transformation resulting from large-scale logging; characterized by open canopy with very few tall trees and thick undergrowth usually dominated by invasive vine species and new shrubs; have forested remnants and areas that have been turned into gardens; soils in exposed areas are dry	18	27
Teak plantation	Formerly lowland forest that has been transformed into mono-cultured, homogenous uniform rows of teak; thick canopy cover, thick leaf litter with generally sparse undergrowth.	10	15
Total		80	120

Table 2. Summary of the four categories of conservation prioritisation used in this study with descriptions based on Singh *et al.* (2000).

Categories used for conservation prioritization	General description	Specific description of method used in the current study
1. Richness	Refers to the number and density of species in an area, with the greater richness the higher priority.	'Species richness value' (SRV). This category refers to the total and mean species richness per transect/quadrat.
2. Important species	Refers to ecologically, economically and symbolically important species and can also refer to endemic, threatened and keystone species with areas with more of these species having higher priority.	'Important species value' (ISV). This category refers to presence of near-threatened, rare, and totem species encountered in each habitat type. Near-threatened species are classed by the IUCN Red List criteria, rare species are locally rare, while totem species are those described by local communities in questionnaires.
3. Level of threat	Refers to the level and type of pressures that the site is under.	'Cultural threat value' (CTV). The threat and the pressure that locals place on the forests as perceived by informants. The forest threat value is calculated based on the informant's descriptions of the current status of the described uses and their impact on the forest habitat types.
4. Combined	Refers to a combination of the above categories.	'Combined rank value' (CRV). It is based on the combination of the different prioritization types to achieve a holistic and inclusive approach to prioritization setting for conservation areas.

was surveyed with 6 transects and 9 quadrats amounting to a total of 90 transects (6 transects × 5 habitats × 3 trips) and 135 quadrats (9 quadrats × 5 habitats × 3 trips). Due to limited availability of teak, coastal and upland forests fewer transects and quadrats were conducted in these habitat types (see Table 1 for details). It is important to note that these five habitats are mutually exclusive.

Cultural interviews

Documenting patterns of human use and local knowledge of biodiversity is an important aspect of conservation research projects and rich species-specific data can be collected through systematic surveying of local community members (Heyer *et al.* 1994). Questionnaire surveys were designed and carried out to record the perceptions, knowledge and use that local people have of herpetofauna and forest habitats. A pilot study trialling the questionnaire was conducted in August 2011 and the modified questionnaire survey conducted in September 2011, December 2011 and March 2012. Ten villages within study areas that were located adjacent to surveyed forests were selected for questionnaire surveys (Figure 2, Online Appendix 1). A total of 30 questionnaires were administered which amounted to 10 questionnaires to persons over the age of 60, 10 between the ages of 30 and 60 and 10 to persons under the age of 30, with a gender ratio of 15 females and 15 males. All participants were selected at random from the local communities. Herpetofauna species were identified based on local descriptions by interviewers, pictures shown to them and standard taxonomic keys (McCoy 2006, Pikacha *et al.* 2008). While the questionnaires covered a larger range of issues than those covered in this paper (see Online Appendix 2 for questionnaire), there were several questions that specifically covered perceptions of threat due to cultural use and the cultural importance of different species as totem species.

Prioritization methods

Four categories were used in this study to determine the conservation priority of each forest habitat type (Table 2). These categories constitute the 'methods' used for conservation prioritization. Under each of the four categories there are sub-categories (see Table 2 for details) and each habitat type was assigned a value for each sub-category. These values were ranked from 1 to 5 with 1 being the most important habitat and 5 the least important habitat for each sub-category. Each category was given a final rank value (again from 1–5) for determining priority conservation habitats based on the sum of the ranks of each sub-category. This method was created for the purposes of this study and is not based on any other known studies. It is also important to note that each category and subsequent sub-category had equal weighting.

RESULTS

Unlogged lowland forest was the forest type of highest conservation value based on species richness and total number of species, whilst

Table 3. Species richness values (total species + mean species richness) with lower SRV ranks having greater conservation priority. SRV = species richness value.

Forest habitat type	Total species	Mean species richness per transect/quadrat (nocturnal and diurnal combined)	SRV ranking (sum of sub-category ranks)
Unlogged coastal	9 = 5th	3.5 = 5th	5th (5+5 = 10)
Unlogged lowland	18 = 1st	6.7 = 1st	1st (1+1 = 2)
Unlogged upland	14 = 3rd	5.4 = 3rd	3rd (3+3 = 6)
Logged lowland	15 = 2nd	5.7 = 2nd	2nd (2+2 = 4)
Teak plantation	10 = 4th	5.4 = 3rd	4th (4+3 = 7)

Table 4. Important species values (number of "near-threatened", "totem", and "rare" species per habitat type) with lower rank values having greater conservation priority. Near threatened refers to IUCN Red Listed species, totem refers to species of cultural value and rare refers to species that were hard to find during field surveys. ISV = important species value.

Forest habitat type	No. of near-threatened species	No. of totem species	No. of rare species	ISV ranking (sum of sub-category ranks)
Unlogged coastal	0 = 4th	3 = 2nd	1 = 3rd	4th (4+2+3 = 9)
Unlogged lowland	2 = 1st	5 = 1st	2 = 2nd	1st (1+1+2 = 4)
Unlogged upland	0 = 4th	3 = 2nd	3 = 1st	2nd (4+2+1 = 7)
Logged lowland	1 = 2nd	3 = 2nd	1 = 3rd	2nd (2+2+3 = 7)
Teak plantation	1 = 2nd	1 = 5th	1 = 3rd	5th (2+5+3 = 10)

Table 5. Cultural threat values calculated from uses described by interviewees. 1, 2, 3 represent threat levels from least to most threatening. Shaded uses = modern commercial unsustainable practices (multiplied by 2 to indicate much greater impacts).CTV = cultural threat value.

Forest habitat type	Destroys habitat (3)			Degrades habitat (2)	Disturbs habitat (1)							CTV rank (Total CTV)
	Creating plantations (x2)	Timber extraction (x2)	Creating new settlements	Gardening	Canoe building	Building materials and traditional items	Wild food gathering	Burial sites	Pig farming	Hunting	Collection of ornamental plants	
Unlogged coastal	6	6	3	2	1	1	1	1	1	1		1st (23)
Unlogged lowland	6	6	3	2	1	1	1		1	1	1	1st (23)
Unlogged upland						1	1	1		1		5th (4)
Logged lowland	6		3	2		1	1					3rd (13)
Teak plantation		6							1			4th (7)

unlogged coastal forest was the least important based on rankings (Table 3). Unlogged lowland forest also had the highest conservation value based on important species i.e. near-threatened species, totem species and rare species (Table 4). Unlogged coastal forest and teak plantation forests had the lowest conservation value based on these species.

Based on informant surveys, the associated uses described for the five different forest habitat types can be divided into three threat levels: 1) destroys habitat, 2) degrades habitat, and 3) disturbs habitat (Table 5). The uses of greatest concern are those that destroy habitat and are also of a commercial, unsustainable nature, specifically the creation of plantations and the extraction of timber or logging. Based on the overall calculated forest threat value, unlogged coastal forests and unlogged lowland forests are the most threatened (Table 5). Logged lowland forests, plantation teak forests and unlogged upland forests are considered less threatened by interviewees.

A combined rank value was determined by adding the SRV, ISV and CTV totals (Table 6). Unlogged lowland forest habitats were ranked highest in all prioritization methods making it clearly the forest type of highest conservation priority. Logged lowland forest, despite its modified state, was still of high conservation priority due to high species richness and was the second highest conservation priority. Unlogged

Table 6. Combined rank value (sum of the three category values for conservation prioritization) for each forest habitat type with lower values having the highest conservation priority. SRV = species richness value, ISV = important species value, CTV = cultural threat value, CRV = combined rank value.

Forest habitat type	SRV	ISV	CTV	CRV ranking (sum of sub-category ranks)
Unlogged coastal	5th	4th	1st	3rd (5+4+1 = 10)
Unlogged lowland	1st	1st	1st	1st (1+1+1 = 3)
Unlogged upland	3rd	2nd	5th	3rd (3+2+5 = 10)
Logged lowland	2nd	3rd	3rd	2nd (2+3+3 = 8)
Teak plantation	4th	5th	4th	5th (4+5+4 = 13)

upland forests were the third conservation priority with high SRV and ISV values. Unlogged coastal forests were the most threatened habitat type but only ranked fourth overall in conservation priority due to low SRV and ISV. Teak plantation forests are of the least conservation priority for biodiversity conservation due to low values for all prioritization methods.

DISCUSSION

The use of species richness as a proxy for habitat biodiversity comparison is very common (Kerr 1997, Gascon *et al.* 1999, Gardner *et al.* 2007, Uehara-Prado *et al.* 2007, Thaman 2008). In this study unlogged lowland forest was the priority forest habitat for conservation based on species richness followed by logged lowland forest. This result is supported by Gardner *et al.* (2007) who found high species richness in similar 'primary' forest and Vonesh (2001) who found greater species richness in 'logged' forests and concluded logged forest habitats were still biologically important. However, a straight comparison of the number of species in each habitat may not always be a true reflection of the conservation importance of an area as it does not take into account the relative importance of individual species i.e. the high number of species in more degraded habitats may be due to the presence of invasive or non-native species.

The use of 'important species' to assess conservation priority takes into account differences in the conservation importance of different species that is not considered in direct species richness comparisons. Previous studies of conservation prioritization based on the IUCN Red Listed species (Eken *et al.* 2004, Darwall and Vie 2005, Pleguezuelosa *et al.* 2010) and indicator or keystone species (Darwall and Vie 2005) are common, however the use of 'culturally important' species as defined by Lohani (2011) is rare. The current study utilized a combination of three individual species sub-categories (Red-Listed, rare and culturally important) to take into account both biologically and culturally important species. Unlogged lowland forest was identified as the priority conservation habitat based on 'important species' due to high numbers of both totem species and biologically important species. Unlogged upland forest (high numbers of rare species) and logged lowland forests (medium numbers rare and near-threatened species) were ranked equal second. Teak forests were the lowest ranked habitat type due to low numbers of important species in all sub-categories.

The use of cultural, traditional or social values as a basis for conservation management and planning is historically rare, but becoming more frequently used as shown by the studies of Pedroso-Junior and Sato (2005), Chazdon *et al.* (2009), Raymond *et al.* (2009) and Bryan *et al.* (2011). This can involve both the cultural importance of a habitat and threats based on cultural use. The current study found that unlogged coastal and unlogged lowland forest were the most vulnerable habitat types based on cultural threats to forests and therefore priority forest types for conservation. Site accessibility and close human habitation are the two main contributing factors to the vulnerability of these habitat types (Burgess *et al.* 2006, Cannon *et al.* 2007). It is important to note that there are additional threats to forest habitats that locals may not know about, such as invasive species and global climate change. Since locals maintain strong ties with their surrounding biodiversity, their associated knowledge of the biodiversity is vital for conservation planning and prioritization (Pedroso-Junior and Sato 2005, Walker Painemilla *et al.* 2010). However, care must be taken with the use of cultural knowledge as shown by Bryan *et al.* (2011) working in Australia who found a negative correlation between the social value of areas as defined by locals and the corresponding ecological values.

The use of combined values for habitat biodiversity comparison is relatively common and strongly recommended (Eken *et al.* 2004, Burgess *et al.* 2006, Chazdon *et al.* 2009). For example, other studies have combined a measure of irreplaceability (e.g. endemic species) and vulnerability (e.g. threats) (see Reyers 2004, Burgess *et al.* 2006). Some studies have combined scientific and local knowledge (Raymond *et al.* 2009, 2010) while Wilson *et al.*

(2009) recommended that the prioritization of conservation decision-making should include data on biodiversity, threats and cost. The use of a 'combined value' to identify forest conservation priority areas makes this study invaluable to conservation practitioners and decision makers in the Solomon Islands trying to prioritize conservation efforts and the allocation of scarce resources. Based on a combined rank value of species richness, important species, and cultural threat values, unlogged lowland forest is the overall priority habitat for conservation on Malaita. Similarly, Burgess *et al.* (2006) used the integration of biological values and threats for the entire continent of Africa and found lowland forests as conservation priorities due to their globally significant biological values and high threats.

A surprising result was that logged lowland forest was the second highest forest conservation priority based on the combined value. This was primarily due to high rankings for species richness and medium rankings for important species and forest threats. According to Gardner *et al.* (2007), Herrera-Montes and Brokaw (2010) and Gibson *et al.* (2011) logged or secondary forests do not provide an adequate substitute for primary forests, however some species may find these modified habitats favourable making them a valuable addition to forest conservation.

Teak plantations were the least important habitat types for conservation priority due to low rankings in all categories. This result is unsurprising given that this forest type provides poor habitat for herpetofauna (particularly frogs) due to its dry nature and sparse undergrowth and has little cultural value for local communities (albeit it has a high commercial value).

Recommendations

A core objective of this study was to integrate both biodiversity and cultural values of forests and herpetofauna as a basis for conservation decision making, which should result in the preservation of both biological cultural diversity and resilience. It is important that future studies involve both biological surveys and investigations of traditional ecological knowledge and cultural values to better understand the often complex dynamics between biodiversity conservation and traditional use of natural resources by local communities. Focusing primarily on the ecological importance of habitats and species can result in the exclusion of local communities from traditional areas and/or practices (Coad *et al.* 2008, Agrawal and Redford 2009) while focusing on cultural importance may result in inadequate protection of keystone species and processes (Pegas and Stronza 2010). This blend of natural and social sciences can be achieved by the inclusion of scientific researchers, social scientists and local community members on research teams as well as in all stages of conservation decision making. By contributing to the inclusion of traditional practices and community benefits, culturally supportive conservation initiatives can lead to long-term community support (Berkes 1999) and improved sustainability of conservation programs.

To ensure the sustainability of conservation initiatives, research findings and environmental conservation knowledge must be made available and user-friendly to locals. It is important to communicate in values and units that are understood by local resource owners for example, the unit of habitat type may be less understood than traditional land boundaries and units of tribal lands. It is also important to communicate in a language, preferably a local vernacular 'language of the land' that is understood by all locals, which will substantially strengthen the chances of common understanding and common expectations. To be successful conservation must be driven, understood and owned by locals and cannot be seen as being imposed from outside. Locals must have a complete knowledge of costs and benefits of any conservation actions in order to remove any misconceptions. To increase the robustness of such exercises the inclusion of extra taxonomic groups is also recommended.

Collaboration is important and external stakeholders, governments, non-government organizations, financial and academic institutions and external researchers should be engaged to improve conservation effectiveness. Training, capacity building, involvement in research and knowledge sharing with locals are of all utmost importance. It is therefore essential to include landowners in biodiversity research, planning and monitoring to ensure the long-term sustainability of conservation projects and knowledge sharing between locals and external stakeholders.

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