LETTER

Testing focus groups as a tool for connecting indigenous and local knowledge on abundance of natural resources with science-based land management systems

Finn Danielsen[1], Per M. Jensen[2], Neil D. Burgess[3,4,5], Indiana Coronado[6], Sune Holt[6], Michael K. Poulsen[7], Ricardo M. Rueda[6], Thomas Skielboe[7], Martin Enghoff[7], Louise H. Hemmingsen[1], Marten Sørensen[2], & Karin Pirhofer-Walzl[1,8]

[1] Nordisk Fond for Miljø og Udvikling, Skindergade 23-III, DK-1159, Copenhagen K, Denmark
[2] Faculty of Science, University of Copenhagen, Thorvaldsensvej 40, DK-1871, Frederiksberg, Denmark
[3] Centre for Macroecology, Evolution and Climate, Biology Department, Copenhagen University, Universitetsparken 15, DK-2100, Copenhagen, Denmark
[4] World Wildlife Fund USA, 1250 24th Street NW, Washington, DC 20037-1193, USA
[5] United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), 219 Huntingdon Road, Cambridge, CB3 0DL, UK
[6] Departamento de Biología, Facultad de Ciencias y Tecnología, Universidad Nacional Autónoma de Nicaragua, Herbario HULE, León, Nicaragua
[7] NORDECO, Skindergade 23, DK-1159, Copenhagen K, Denmark
[8] Institute for Landscape Biogeochemistry, Leibniz Centre for Agricultural Landscape Research, Eberswalder Strasse 84, 15374, Müncheberg, Germany

Keywords
Community-based natural resource management; cross-cultural management; indigenous and local knowledge systems; knowledge integration; Intergovernmental Platform on Biodiversity and Ecosystem Services; multiple evidence base.

Correspondence
Finn Danielsen, Nordisk Fond for Miljø og Udvikling, Skindergade 23-III, DK-1159 Copenhagen K, Denmark. Tel: 0045 2711 6475; fax: 0045 3391 9032. E-mail: fd@nfmu.org

Received
11 September 2013
Accepted
21 March 2014

Editor
Dr. Derek Armitage

doi: 10.1111/conl.12100

Abstract

One of the clearly stated intentions of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) is to bring both “western scientific” and “indigenous and local” knowledge systems within synthetic global, regional, and thematic assessments. A major challenge will be how to use, and quality-assure, information derived from different knowledge systems. We test how indigenous and local knowledge on natural resources in Miskito and Mayangna communities in Nicaragua, validated through focus groups with community members, compares with information collected on line transects by trained scientists. Both provide comparable data on natural resource abundance, but focus groups are eight times cheaper. Such approaches could increase the amount and geographical scope of information available for assessments at all levels, while simultaneously empowering indigenous and local communities who generally have limited engagement in such processes.

Introduction

The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) was established in 2012 by 94 Governments, and by January 2014 had 116 Government Members. One of its functions is to produce assessments of the state of the planet’s environment, while “recogniz(ing) and respect(ing) the contribution of indigenous and local knowledge” so as “to bring (the) different knowledge systems, including indigenous knowledge systems, into the science-policy interface” (UNEP 2012a). This intention will entail the articulation of indigenous and local knowledge (UNEP 2011; 2012b; Turnhout *et al.* 2012).

A key challenge for IPBES will therefore be how to use information generated by different knowledge systems (Huntington 1998; Colfer *et al.* 2005) within synthetic assessments at the science-policy interface (Sutherland *et al.* 2014). While scientific knowledge is validated primarily through peer-review, other knowledge systems have different validation approaches (Tengö *et al.* 2014). Validation of information *within* knowledge systems is well-established, whereas validation *across* knowledge system is a major challenge (Tengö *et al.* 2014). Unidirectional scientific validation of other knowledge systems may compromise the integrity and complexity of the knowledge (Bohensky & Maru 2011; Gratani *et al.* 2011) and promotes power inequality between technocrats and communities (Nadasdy 1999; Bohensky *et al.* 2013). Alternatively, validation of community-based knowledge through a respectful process of collaboration between scientists and community members facilitates mutual learning and empowerment (Cullen-Unsworth *et al*. 2012).

About 370 million indigenous people live on earth—from the tropics to the poles, and include some of the world's poorest and most marginalized communities (United Nations 2009). To participate in decision-making, indigenous people need to translate a well-founded knowledge base on their territories (Dallman *et al*. 2011; UNEP 2013) into a format where it can be heard (Ens *et al*. 2012).

Here, we test a simple approach to document and validate indigenous and local knowledge from Nicaragua using focus group discussions, in comparison with scientific knowledge gathered from line transects.

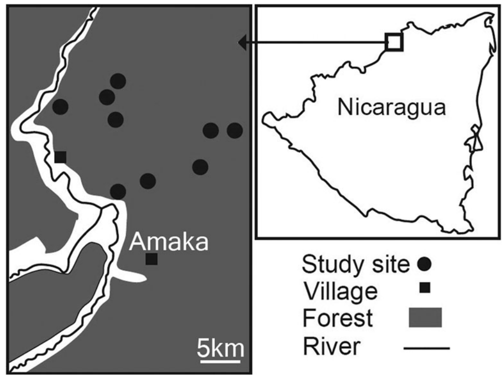

Figure 1 Study area. The location of the nine study sites in the Bosawás Biosphere Reserve, Nicaragua.

Methods

Our study was undertaken in the Bosawás Biosphere Reserve in Nicaragua, inhabited by Miskito and Mayangna communities, who use forest as their principal resource base (Koster 2007; Stocks *et al*. 2007). The area is a global priority for conservation (Miller *et al*. 2001). Conventional scientific knowledge is constrained by difficult access, rugged terrain, and frequent heavy rains.

Conceptual framing

We recognize that indigenous knowledge like scientific knowledge implies a way of viewing the world. It is context-specific, hence may lose meaning when applied in other contexts (Stephenson & Moller 2009). In comparison, knowledge on resource abundance, bound by place and time, does not lose its meaning and is relevant to decisions about natural resource management. Berkes (2012) used "local knowledge" when referring to recent knowledge and "indigenous knowledge" for the local knowledge of indigenous peoples, or local knowledge unique to a culture or society. Here, we use the term "indigenous and local knowledge" to emphasize that knowledge of resource abundance is closely linked with knowledge of the resource management systems and the social institutions the management systems operate within (the "knowledge-practice-belief complex;" Berkes 2012).

While no decision has yet been taken, it seems likely that IPBES will aim to use a multiple (previously called "dual") evidence-based peer-review process (UNEP 2011; Feit *et al.* 2013), where different knowledge systems are viewed as "generating equally valid evidence for interpreting change" (Tengö *et al.* 2014). Many approaches exist to facilitate exchange among knowledge systems (Lynam *et al.* 2007; Raymond *et al.* 2010; Gamborg *et al.* 2012; Padmanaba *et al.* 2013). Central is that "knowledge itself is power" and those who share knowledge should not lose power in the process (Nadasdy 1999).

Our hypothesis is that indigenous and local knowledge on natural resource abundance is valid and can be used in assessment processes, including by IPBES. We test this hypothesis using community-level focus group discussions compared against scientist-executed and community-executed line-transects. Our nine study sites are located opportunistically, 2–15 km from San Andrés and Inipuwás villages, within Bosawás Biosphere Reserve, Nicaragua (Figure 1). Vegetation of all study sites is dense evergreen tropical forest at 50–650 m a.s.l., with various levels of utilization. The area is inhabited by indigenous Miskito and Mayangna who practice subsistence agriculture and harvest nontimber forest products (Appendix S1).

Survey design

Focus groups of community members were established in the same month and year (2007) as line transect routes. Transects were surveyed for animals and plants by community members and trained scientists.

Community members involved in focus groups and line transects lived in the same (indigenous) community and had profound experience of hunting and collecting forest products. When they observe animal tracks, they can identify both the species and the number of individuals. All community members could count and some were literate. All scientists had degrees in natural science and more than 10 years field experience.

Field methods

Prior to transect fieldwork and focus group discussions, scientists and community members agreed on 10 resources important to the communities for food or other uses (Table 1).

Focus groups

Focus groups are not commonly used by biologists (Sodhi & Ehrlich 2010), but are a standard social science methodology (Table 2; Appendix S2) and a form of group interview that capitalizes on communication between participants to generate data (Kitzinger 1995). For our study, communities were contacted through a civil society organization with long experience working with these communities. We met the General Assembly of Miskitas in the two villages to obtain their advice and approval. Community members volunteered for the focus groups, based on the villagers' interest and experience with forest resources. During participatory planning workshops, members of the focus groups were involved in planning the work and deciding on the use of the results. Focus group members included forest product harvesters, hunters, loggers, local park rangers, and both genders. In each village, we established a volunteer group of 10–20 persons, who observed forest resources at study sites between discussions. From April 2007 to September 2009, these persons took part in 2–3 hour meetings every 3 months. The meetings were facilitated by a group of nonindigenous park rangers. We selected the facilitators based on their skills at communicating equitably among knowledge systems in meetings, and there was no detectable political interplay between the facilitators and community members. The facilitators discussed with communities the abundance of each resource at every study sites in each 3-month period. The following abundance categories were used:

(1) "Many individuals": ≥10 individuals of the resource were recorded in 4 hours of morning walks in the forest.
(2) "Some individuals": 1–9 individuals of the resource were recorded in 4 hours of morning walks in the forest.
(3) "Few individuals": More than 4 hours of morning walks in the forest are required to record one individual of the resource, but the resource is still recorded regularly (≥four times during the 3-month period).
(4) "Very few individuals (or none)": Resource only recorded a few times (<four times) during the 3-month period.

During focus group discussions, the four natural resource abundance categories were broadly interpreted as "many daily," "daily," "less than daily," and "rarely." Abundance estimates provided by the community members were discussed in the local Miskito language. Focus groups' validation was a careful process involving time, commitment, and underlying trust. Community members were in control of the process—agreeing what was right and wrong. Community members involved with line transect surveys were not present during the focus group discussions.

Line transects

This is a commonly used scientific method (Peres 1999; Luzar *et al*. 2011). One scientist recorded sightings and signs of wildlife and plants over 2 hours along a predetermined 2 km transect through the forest, once every 3 months. Village leaders helped select community members, based on their interest and experience with hunting and collecting forest products, to complete line transects along the same routes as the scientists, but on different days. Both scientists and community members kept the speed of walking constant at around 1 km/hour (250 m/15 min, by pacing). The starting time was 06.00–06.30 hours.

Survey costs

We estimated the cost of focus groups, community members, and scientist-executed line transects as the actual expenses incurred during the training and field work at each site (Appendices S3–S4).

Analysis

We compared the abundance assigned by the focus groups for each species at each study site over each 3-month period with abundance from the scientists' and community members' transects. Data are provided in Appendix S5.

First, we compared abundance estimates from scientists' transects with community transects, using *t*-tests of the $\log_e$-transformed densities (counts per hour of survey) (under the LSMEANS statement associated with PROC GLM; SAS 9.1; SAS Institute, Cary, NC, USA). Tests were run both for the classes of organisms individually (mammals, birds, flora) and in combination in a full generalized linear model (PROC GLM). Independent variables were (classes of organisms): birds, mammals, or

Table 1 Comparison between number of individuals of mammals, birds, and plants observed by community members and scientists during 43 community members' and 43 trained scientists' 2-hour transect walks in nine study sites between 2007 and 2009 in the Bosawás Biosphere Reserve, Nicaragua

			Number of individuals observed	
Class	Latin name	English/local name	Community member transect walks	Trained scientists transect walks
Mammalia	*Odocoileus virginianus*	White-tailed deer/Venado cola blanca	7	5
	Mazama americana	Red brocket/Cabrito	11	8
	Agouti paca	Paca/Guardiola, tepezcuintle	18	8
	Dasypus novemcinctus	Nine-banded armadillo/Cusuco	21	18
Aves	*Ara ambigua*	Buffon's macaw/Lapa verde	18	21
	Crax rubra	Great curassow/Pavón	36	29
	Ramphastos sulfuratus, *R. swainsonii*, and *Pteroglossus torquatus*	Keel-billed toucan/Tucán pico iris, Chestnut-mandibled toucan/Tucán de swainson, and Collared aracari/Tucancillo	378	312
Flora	*Trichilia quadrijuga* ssp. *cinerascens*	Cacao[a]	646	381
	Protium glabrum and Tetragastris panamensis	Kerosín[a]	740	471
	Castilla tunu	Tuno[a]	1,474	1,348

[a]No English name.

plants; and (observers): scientist or community member. Since scientist and community transects produced largely similar results, we used the mean densities obtained from these two sets of results for comparison with the reports from the focus groups discussions in the villages adjacent to the transect routes.

Second, we compared mean abundance estimates from trained scientists' transects and community transects with abundance categories derived from focus groups, using paired *t*-tests for each class of organism and in combination in a partial generalized linear model, with classes and focus group abundance categories as independent variables (but no interaction). We used Tukey correction for pairwise comparison of densities within classes, under the LSMEANS statement. The correlation between scientists' transects, community member transects, and focus group reports was evaluated using PROC CORR SPEARMAN.

Third, we discussed the preliminary results with the communities. We returned the findings to them so that they could see for themselves how their observations connected with results from other methods, and could be used to promote indigenous and local inputs into reserve management. This two-way process was essential. It helped underline that the study was not information "harvesting" but a collaborative undertaking.

Results

Comparing scientists' and community members' transect results

Our test of different methods of generating knowledge was based on 430 tripled records from focus groups, scientists, and community member transects for the same 10 resources (three plants, three birds, and four mammal taxa), in the same areas (nine sites, Figure 1), and at the same time (3-month period). We first tested differences in the recorded relative abundance of resources between scientists and community member transects. No significant differences were recorded between estimated abundance of mammals ($P = 0.28$; df $= 438$, $t = -1.07$), birds ($P = 0.58$; df $= 328$; $t = -0.54$), or plants ($P = 0.08$; df $= 88$; $t = -1.76$), made by scientists and community members along the same transect routes. We repeated the test using a full generalized model that explained most of the variation in the data ($R^2 = 0.79$; $P < 0.001$). Again, we found that the relative abundance of resources recorded by community member transect surveys match those recorded by scientist transects over a range of forest resources, although there is a tendency ($P < 0.1$) for scientists' transects to count fewer individuals than community member transects (Tables 1 and 3). Likewise, we found a strong positive correlation between the estimates of mammal, bird, and plant abundance emanating from community member and scientist transects ($r_s = 0.78$; $P < 0.001$; $n = 430$).

Comparing transect results with abundance estimates from focus groups

Comparing focus groups and averaged transect results, we found that focus group discussions were unable to differentiate between what community members and scientists considered "very few," "few," and "some individuals," but that resources reported as plentiful ("many

Table 2 Examples of attributes previously assessed with the use of focus groups for collecting data

Discipline	Attribute(s) studied	Study*
Life science	Changes in the composition of plant species grown in home gardens	Sunwar *et al.* 2006; Abay *et al.* 2008
	Contribution of wetland resources to household food security	Turyahabwe *et al.* 2013
	Ethnobotanical knowledge	Ndoro *et al.* 2007; Odugbemi *et al.* 2007; Luziatelli *et al.* 2010; Termote *et al.* 2010; Mekonnen & Lemma 2011; Muthee *et al.* 2011; Grasser *et al.* 2012; Derbile 2013; Hasan *et al.* 2013
	Ethnozoological knowledge	Lohani 2010, 2011; Devi *et al.* 2013
	Ethnopharmacological knowledge	Uprety *et al.* 2010; Maliwichi-Nyirenda *et al.* 2011; Namukobe *et al.* 2011; Mncwangi *et al.* 2012; Muthee *et al.* 2011
	Evaluation of participatory land-use planning in communities	Kaswamila & Songorwa 2009; Yonas *et al.* 2013
	Farmer's views and experiences in shrimp culture activities	Paul & Vogl 2013
	Impacts of fuelwood collection on deforestation	Nagothu 2001
	Local abundance and use of 25 wildlife species	Loucks *et al.* 2009
	Local perceptions of the status of woody species and of the threats to their conservation	Tabuti *et al.* 2009
	Local practices in water quality monitoring and water management	Nare *et al.* 2006; Nhapi 2009
	Poverty and livelihood impacts of a medicinal and aromatic plants project	Rasul *et al.* 2012
	Problems in forest and landscape management operations that could be resolved by the use of remote sensing	Takao *et al.* 2010
	Selection of agrienvironmental indicators	Belanger *et al.* 2012
	The use of nontimber forest products to support local livelihoods	Camou-Guerrero 2008; Challe & Struik 2008; Varghese & Ticktin 2008; Giliba *et al.* 2010; Terer *et al.* 2012
Health and social sciences	Consumption of indigenous forest foods	Msuya *et al.* 2010
	Commonly consumed food and recipes	Ene-Obong *et al.* 2013
	Evaluation of learning methods in communities	Zahidah *et al.* 2011
	Farmers' perspectives on growing perennial "energy'' grasses	Cope *et al.* 2011
	Impacts of biofuel industry on local communities	Selfa *et al.* 2011
	Indigenous communities impression of new established conservation sites	Nkemnyi *et al.* 2013
	Mode of governing natural resources	Ngwenya *et al.* 2012; Bown *et al.* 2013
	People's experiences of disease	Ejobi *et al.* 2007; Legesse *et al.* 2011

*See Appendix S2 for literature cited.

individuals") were significantly different from all other categories for all types of resources (Figure 2; statistics in Table 4). Similar results were obtained when repeating the test using a linear model, which combined all records, adjusted for differences in densities between classes, and explained most of the variation ($R^2 = 0.85$, $P < 0.001$).

The apparent inability of focus group reports to differentiate between the three categories of least abundance was caused by high standard deviation within focus group category 4 ("very few") and fairly even densities of focus group category 3 ("few individuals") and 2 ("some individuals") (see Figure 2). Reducing the number of abundance categories from four to three, by merging "few individuals" and "some individuals," delivered a clearer separation of densities for birds and plants, although not for mammals. Likewise, we found that Spearman correlation coefficients for transect densities and focus group categories were 0.43 ($P < 0.001$), 0.06 ($P = 0.32$), and 0.30 ($P = 0.04$) for birds, mammals, and plants, respectively, suggesting a stepwise reduction in densities against focus group categories for birds and plants, but not for mammals.

Comparing costs of transect surveys and focus groups

Across all nine study sites, measurements through focus group discussions cost significantly less than

Table 3 Results of focus groups' statements of abundance, based on the number of sites and 3-month periods where each statement was provided, and the average abundance indices (number of individuals observed per hour, with SE) from community members' (C) and trained scientists' (S) transect walks of 10 resources recorded between 2007 and 2009 at nine study sites in the Bosawás Biosphere Reserve, Nicaragua

	Counts of focus groups' statements of abundance per index for each type of organisms				Mean abundance indices for community transects (C) and scientists transects (S) (number of individuals observed per hour)			
Focus group abundance index	*Aves* *n* (%)	*Flora* *n* (%)	*Mammalia* *n* (%)	Total *n*		*Aves*	*Flora*	*Mammalia*
"Very few individuals"	13	0	54	67	C	0.46 ± 0.26	0.0	0.06 ± 0.02
	(7%)	(0%)	(24%)		S	0.03 ± 0.03	0.0	0.06 ± 0.02
"Few individuals"	59	14	72	145	C	0.81 ± 0.15	27.5 ± 4.9	0.10 ± 0.03
	(35%)	(31%)	(32%)		S	0.77 ± 0.15	14.5 ± 1.8	0.07 ± 0.03
"Some individuals"	63	25	89	177	C	1.09 ± 0.17	27.6 ± 4.0	0.07 ± 0.02
	(38%)	(55%)	(40%)		S	1.12 ± 0.17	23.7 ± 3.8	0.04 ± 0.01
"Many individuals"	30	6	5	41	C	2.71 ± 0.43	59.4 ± 14.2	0.70 ± 0.25
	(18%)	(13%)	(2%)		S	2.38 ± 0.37	50.9 ± 13.6	0.80 ± 0.40
Total	165	45	220	430				
	(100%)	(100%)	(100%)					

Table 4 Results of paired *t*-tests comparing focus groups' statements of abundance and the average abundance indices (number of individuals observed per hour, with SE) from community members' and trained scientists' transect walks of 10 bird, plant, and mammal resources recorded between 2007 and 2009 at nine study sites in the Bosawás Biosphere Reserve, Nicaragua

Class	Focus group abundance index	Transects, mean no. of individuals observed per hour*	SE	*t*-test†
Aves	"Very few individuals"	0.25	0.37	a,b
$n = 165$	"Few individuals"	0.80	0.17	a,b,c
	"Some individuals"	1.11	0.17	b,c
	"Many individuals"	2.55	0.24	d
Flora	"Very few individuals"	0.0	N.A	N.A.
$n = 45$	"Few individuals"	20.96	5.19	a,b
	"Some individuals"	25.62	3.88	a,b
	"Many individuals"	55.17	7.92	c
Mammalia	"Very few individuals"	0.06	0.03	a,b,c
$n = 220$	"Few individuals"	0.09	0.02	a,b,c
	"Some individuals"	0.06	0.02	a,b,c
	"Many individuals"	0.75	0.09	d

N.A. = not applicable.
*Average abundance indices of community members' and trained scientists' transect walks.
†Means with the same letter are not significantly different ($P < 0.05$).

community members and scientists transects ($P < 0.001$; $n = 9$; Figure 3, Appendices S3–S4). Likewise, community transects were significantly cheaper than scientists transects ($P < 0.001$; $n = 9$).

Discussion

Our results suggest that over a range of life-forms of birds, mammals, and plants, indigenous and local knowledge documented and validated with focus groups provides similar abundance indices of wild species as trained scientists and community members transects. The strongest agreement between focus groups and transects was for birds and plants, with lower agreement for mammals. This might be because mammals were mainly recorded by foot prints and dung along transects, while birds and plants were directly observed; hence, the number of mammals recorded on transects is subject to substantial individual interpretation.

Our findings suggest that for participants in focus groups, the meaning of individual abundance indices varies between taxa. For instance, mammals recorded

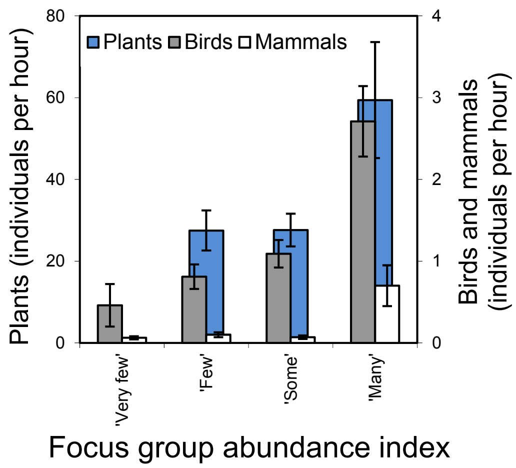

Figure 2 Relationship between focus groups' statements of abundance of 10 plant, bird, and mammal forest resources and the average abundance indices (number of individuals observed per hour, with SE) of the same resources obtained by community members' and trained scientists' transect walks between 2007 and 2009 at nine study sites in the Bosawás Biosphere Reserve, Nicaragua. The figure is based on 430 tripled records from focus groups, scientists', and community members' transects for the same resources, in the same areas, and at the same time (3-month period).

in both scientists' and community members' transects at 0.7–0.8 individuals per hour are considered "many individuals' by the focus groups, whereas birds recorded on transects with the same density are considered to be "few individuals" in the same focus groups (Table 3). Focus groups are thus not reporting relative encounter frequency, but are "automatically" integrating community expectations, i.e., recording something as less abundant when fewer than expected are recorded given its identity (perhaps) size, or interest as food.

In the scientific knowledge system, reliability has two components, conformity to fact (lack of bias) and precision (exactness). Our findings suggest that villagers' focus group assessments of abundance are of similar accuracy (unbiased) to scientists' and community members' transects. We did not examine the precision of the focus groups' assessments, because abundance values from the focus groups are categorical, which hampers assessment of precision.

How representative and broadly applicable are our findings? We know of only one previous study of focus group results with direct counts of natural resources (Mueller *et al.* 2010). This compared assessments of species richness, diversity, and height of grasses and trees by community members from a village in Niger, with direct counts made by scientists. The study found a good match on height and density for grasses and trees and tree species richness, but it found poor correlation on herb species richness and Simpson's *D* value for both trees and grasses. The study does, however, suffer from different temporal scale and different times for community members' focus group discussions and direct counts, thus preventing conclusions on the reliability of the focus group (Danielsen *et al.* 2014).

Are focus groups more or less reliable than individual interviews? It seems certain that some information is lost when data are not written but only memorized (Jones *et al.* 2008). Moreover, focus groups, like other methods, are only as reliable as the participants, and governance structures can always encourage or discourage reliable provision of information (Nielsen & Lund 2012).

In our study area, the community members have good knowledge of the forest (Koster 2007), and the resources studied were of interest to the communities and they knew them well. In our opinion, community members had no incentive to mislead by deliberately providing erroneous information.

Focus groups involve interaction between group members (Gibbs 1997). Although the views of the most powerful members of the group might bias the results of focus groups, our observations were that when potentially inaccurate information was provided by one or a few participants, after discussion, this information was generally corrected. Hence, the conclusion represented the group consensus.

The "process" aspect of the focus groups was perceived to be very important by the community members. Focus group discussions were undertaken in an open learning process, where the community focus group members participated directly with the right to vote and express opinions. They were themselves the "gate keepers" detecting and deciding which data were complete and which were false, or out of context, and therefore should be discarded. Our findings suggest that community members' ownership of the data and information and their control over the knowledge, the validation process, and the application of the knowledge were critical to their sense of empowerment (Stephenson & Moller 2009; Huntington 2011).

In conclusion, our findings suggest that using focus groups for validating indigenous and local knowledge on natural resources could increase the information available for measuring status and trends in natural resources, while at the same time contributing to empower indigenous and local communities. Guidelines describe how to promote the use of indigenous knowledge (Tkarihwaié:ri Code; Convention on Biological Diversity 2011). To aid this process and increase the ability of community focus groups to provide natural resource abundance data which scientists would consider reliable, we propose a series of recommendations (Table 5). The approach should, however, not be rolled out uncritically—representatives of indigenous and local communities should decide whether focus groups on resource abundance can help enable

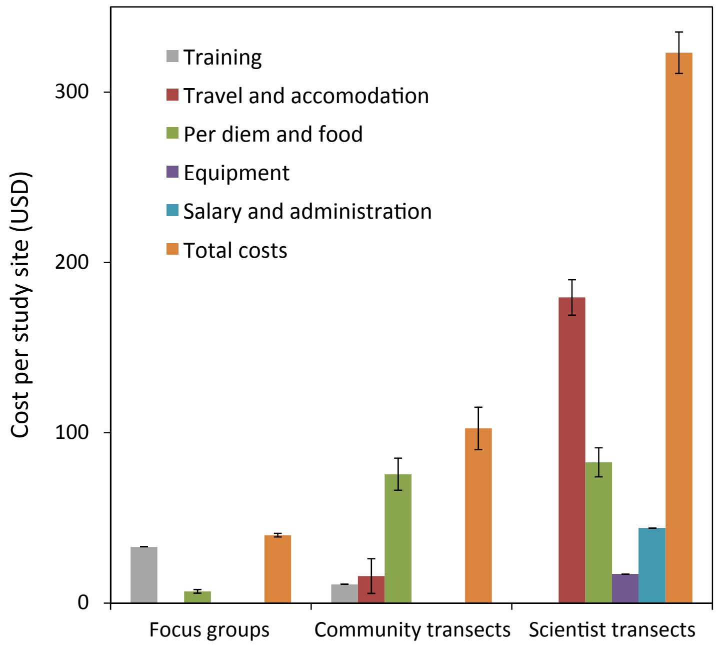

Figure 3 Costs of focus groups, community members' transects, and trained scientists' transects per study site in each 3-month study period (in USD 2013; with SD).

Table 5 Recommendations for how to increase the ability of community focus groups to provide natural resource abundance data which scientists would consider reliable

1. Establish independent focus groups in multiple communities that know resource abundance in the same geographical area (triangulation across communities)
2. Convene regularly, e.g., annually, village meetings to present and discuss data and interpretation and obtain feedback from the entire community (triangulation across community members)
3. Facilitate the collection of auxiliary data through, e.g., community members' direct counts of resources in the same area (triangulation across methods)
4. Include individuals within the focus groups who are themselves directly involved with using and observing natural resources (thereby increasing the number of primary data providers)
5. Use unequivocal categories for resource abundance
6. Ensure that the moderator of the focus group discussions has skills and experience in facilitating dialogues

them be heard. The UN Declaration on the Rights of Indigenous Peoples states that development must take place in accordance with their "Free, Prior and Informed Consent" (United Nations 2008). Focus groups may also represent a useful starting point from which broader regional and national monitoring and assessment programs, tailored to the local conditions, could be designed and implemented.

Promoting approaches such as this could be an important element of the work of IPBES as it seeks to fulfill its mandate to recognize and respect the contribution of indigenous and local knowledge. While IPBES is widely recognized as an assessment process, and needs to draw on information from multiple sources, it also has three other functions: promoting generation of knowledge; delivery of policy support tools and methodologies; and capacity building. IPBES therefore has a potentially strong role to play in promoting the use of new approaches that allow the improved capture of data and information, in promoting means for bringing together data and information from different knowledge systems, and in building capacity to do both. This is therefore an important area of work to develop more formally within the framework of IPBES assessments, not only to feed the IPBES assessments themselves, but so that such approaches are used at all levels.

Acknowledgments

We thank M. Funder, N.J. Johnson, J.P.G. Jones, P. Malmer, M. Schultz, V. Tauli-Corpuz, and M. Tengö for inspiring discussions and J. Harrison and S. Hvalkof for insightful guidance. This work was funded by the Danish Council for Development Research.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Appendix S1. Study area.
Appendix S2. References used for Table 2.

Appendix S3. Details of how the costs of plant, mammal, and bird data from focus group discussions, community members', and trained scientists' transect walks were calculated.

Appendix S4. Cost of focus group discussions, community members' transects and trained scientists' transects (in USD per study site and per 3-month period).

Appendix S5. Data collected in the Bosawás Bioshere Reserve in Nicaragua over the period April 2007 to September 2009.

References

Berkes, F. (2012). *Sacred ecology*, 3rd ed., Routledge, New York.

Bohensky, E.L., Butler, J.R.A. & Davies, J. (2013). Integrating indigenous ecological knowledge and science in natural resource management: perspectives from Australia. *Ecol. Soc.*, **18**, 20.

Bohensky, E.L. & Maru, Y. (2011). Indigenous knowledge, science, and resilience: what have we learned from a decade of international literature on "integration"? *Ecol. Soc.*, **16**, 6.

Colfer, C.J.P., Colchester, M., Joshi, L., Puri, R.K., Nygren, A. & Lopez, C. (2005). Traditional knowledge and human well-being in the 21st century. Pages 173-182 in G. Mery, R. Alfaro, M. Kanninen, M. Lobovikov, editors. *Forests in the global balance—changing paradigms*, Vol. **17**, IUFRO World Series. International Union of Forest Research Organizations, Helsinki, Finland.

Convention on Biological Diversity. (2011). *Tkarihwaié:ri - code of ethical conduct to ensure respect for the cultural and intellectual heritage of indigenous and local communities relevant to the conservation and sustainable use of biological diversity*. Secretariat of the Convention on Biological Diversity, Montreal, Canada. http://www.cbd.int/traditional/code/ethicalconduct-brochure-en.pdf (visited January 15, 2014).

Cullen-Unsworth, L.C., Hill, R., Butler, J.R.A. & Wallace, M. (2012). A research process for integrating Indigenous and scientific knowledge in cultural landscapes: principles and determinants of success in the Wet Tropics World Heritage Area, Australia. *Geogr. J.*, **178**, 351-365.

Dallman, W.K., Peskov, V., Murashko, O.A. & Khmeleva, E. (2011). Reindeer herders in the Timan-Pechora oil province of Northwest Russia: an assessment of interacting environmental, social, and legal challenges. *Pol. Geogr.*, **34**, 229-247.

Danielsen, F., Jensen, P.M., Burgess, N.D., *et al.* (2014). A multicountry assessment of tropical resource monitoring by local communities. *BioScience*, **64**, 236-251.

Ens, E.J., Finlayson, M., Preuss, K., Jackson, S. & Holcombe, S. (2012). Australian approaches for managing 'country' using Indigenous and non-Indigenous knowledge. *Ecol. Manage. Restor.*, **13**, 100-107.

Feit, U., Korn, H. & Paulsch, A., editors. (2013). *Report of the International Expert Workshop connecting diverse Knowledge Systems in the context of IPBES. BfN-Skripten 341*. Bundesamt für Naturschutz, Bonn, Germany.

Gamborg, C., Parsons, R., Puri, R.K. & Sandøe, P. (2012). Ethics and research methodologies for the study of traditional forest-related knowledge. Pages 535-560 in J.A. Parrotta, R.L. Trosper, editors. *Traditional forest-related knowledge: sustaining communities, ecosystems and biocultural diversity*, World Forests, Vol. **12**., Springer, Netherlands.

Gibbs, A. (1997). Focus groups. *Social Res. Update*, **19**. http://sru.soc.surrey.ac.uk/SRU19.html (visited January 15, 2014).

Gratani, M., Butler, J.R.A., Royee, F., *et al.* (2011). Is validation of Indigenous ecological knowledge a disrespectful process? A case study of traditional fishing poisons and invasive fish management from the Wet Tropics, Australia. *Ecol. Soc.*, **16**(3), 25.

Huntington, H.P. (1998). Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. *Arctic*, **51**, 237-242.

Huntington, H.P. (2011). The local perspective. *Nature*, **478**, 182-183.

Jones, J.P., Andriamarovololona, M.M., Hockley, N., Gibbons, J.M. & Milner-Gulland, E.J. (2008). Testing the use of interviews as a tool for monitoring trends in the harvesting of wild species. *J. Appl. Ecol.*, **45**, 1205-1212.

Kitzinger, J. (1995). Qualitative research-introducing focus groups. *Br. Med. J.*, **311**, 299-302.

Koster, J.M. (2007). Hunting and subsistence among the Mayangna and Miskito of Nicaragua's Bosawas Biosphere Reserve. Doctoral dissertation, The Pennsylvania State University.

Luzar, J.B., Silvius, K.M., Overman, H., Giery, S.T., Read, J.M. & Fragoso, J.M.V. (2011). Large-scale environmental monitoring by indigenous people. *BioScience*, **61**, 771-781.

Lynam, T., de Jong, W., Sheil, D., Kusumanto, T. & Evans, K. (2007). A review of tools for incorporating community knowledge, preferences, and values into decision-making in natural resources management. *Ecol. Soc.*, **12**, 5.

Miller, K., Chang, E. & Johnson, N. (2001). *Defining common ground for the Mesoamerican Biological Corridor*. World Resources Institute, Washington, DC.

Mueller, J.G., Assanou, I.H.B., Guimbo, I.D. & Almedom, A.M. (2010). Evaluating rapid participatory rural appraisal as an assessment of ethnoecological knowledge and local biodiversity patterns. *Conserv. Biol.*, **24**, 140-150.

Nadasdy, P. (1999). The politics of TEK: power and the "integration" of knowledge. *Arctic Anthropol.*, **36**, 1-18.

Nielsen M.R. & Lund, J.F. (2012). Seeing white elephants? The production and communication of information in a locally-based monitoring system in Tanzania. *Conserv. Soc.*, **10**, 1-14. http://www.conservationandsociety.org/text.asp?2012/10/1/1/92188 (visited January 15, 2014).

Padmanaba, M., Sheil, D., Basuki, I. & Liswanti, N. (2013). Accessing local knowledge to identify where species of conservation concern occur in a tropical forest landscape. *Environ. Manage.* **52**(2), 348-359.

Peres, C.A. (1999). General guidelines for standardizing line-transect surveys of tropical forest primates. *Neotrop. Prim.*, **7**, 11-16.

Raymond, C.M., Fazey, I., Reed, M.S., Stringer, L.C., Robinson, G.M. & Evely, A.C. (2010). Integrating local and scientific knowledge for environmental management. *J. Environ. Manage.*, **91**, 1766-1777.

Sodhi, N.S. & Ehrlich, P.R., editors. (2010). *Conservation biology for all*. Oxford University Press, New York.

Stephenson, J. & Moller, H. (2009). Cross-cultural environmental research and management: challenges and progress. *J. R. Soc. New Zealand*, **39**, 139-149.

Stocks, A., McMahan, B. & Taber, P. (2007). Indigenous, colonist, and government impacts on Nicaragua's Bosawas Reserve. *Conserv. Biol.*, **21**, 1495-1505.

Sutherland, W.J., Gardner, T.A, Haider, L.J. & Dicks, L.V. (2014). How can local and traditional knowledge be effectively incorporated into international assessments? *Oryx*, **48**, 1-2.

Tengö, M., Brondizio, E., Elmqvist, T., Malmer, P. & Spierenburg, M. (2014). Connecting diverse knowledge systems for enhanced ecosystem governance – the multiple evidence base approach. *Ambio*, DOI 10.1007/s13280-014 -0501-3.

Turnhout, E., Bloomfield, B., Hulme, M., Vogel, J. & Wynne, B. (2012). Listen to the voices of experience. *Nature*, **488**, 454-455.

United Nations. (2008). *Declaration on the Rights of Indigenous Peoples*. United Nations. http://www.un.org/esa/socdev/unpfii/documents/DRIPS_en.pdf (visited January 15, 2014).

United Nations. (2009). *State of the World's Indigenous Peoples. United Nations Department of Economic and Social Affairs, Division for Social Policy and Development, Secretariat of the Permanent Forum on Indigenous Issues ST/ESA/328*. www.un.org/esa/socdev/unpfii/documents/SOWIP_web.pdf (visited January 15, 2014).

UNEP (United Nations Environment Programme). (2011). *Report of an international science workshop on assessments for an intergovernmental science-policy platform on biodiversity and ecosystem services, held in Tokyo from 25 to 29 July 2011*. UNEP/IPBES.MI/1/INF/12. http://ipbes.net/resources/previous-ipbes-meetings/first-session-of-plenary.html (visited February 4, 2014).

UNEP (United Nations Environment Programme). (2012a). *Report of the second session of the plenary meeting to determine modalities and institutional arrangements for an intergovernmental science-policy interface on biodiversity and ecosystem services*. UNEP/IPBES.MI/2/9. http://ipbes.net/resources/previous-ipbes-meetings/second-session-of-plenary.html (visited February 4, 2014)

UNEP (United Nations Environment Programme). (2012b). *Consideration of initial elements: recognizing indigenous and local knowledge and building synergies with science*. IPBES/1/INF/5. http://www.ipbes.net/plenary/ipbes-1.html (visited February 4, 2014).

UNEP (United Nations Environment Programme). (2013). *Indicators relevant for traditional knowledge and customary sustainable use. UNEP/CBD/WG8J/8/9*. https://www.cbd.int/doc/?meeting=WG8J-08 (visited January 15, 2014).

