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The Value, Limitations, and Challenges of Employing Local Experts in Conservation Research

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Abstract: *Evidence suggests that the involvement of local people in conservation work increases a project's chances of success. Involving citizen scientists in research, however, raises questions about data quality. As a tool to better assess potential participants for conservation projects, we developed a knowledge gradient, K, along which community members occupy different positions on the basis of their experience with and knowledge of a research subject. This gradient can be used to refine the citizen-science concept and allow researchers to differentiate between community members with expert knowledge and those with little knowledge. We propose that work would benefit from the inclusion of select local experts because it would allow researchers to harness the benefits of local involvement while maintaining or improving data quality. We used a case study from the DeHoop Nature Preserve, South Africa, in which we conducted multiple interviews, identified and employed a local expert animal tracker, evaluated the expert's knowledge, and analyzed the data collected by the expert. The expert animal tracker J.J. created his own sampling design and gathered data on mammals. He patrolled 4653 km in 214 days and recorded 4684 mammals. He worked from a central location, and his patrols formed overlapping loops; however, his data proved neither spatially nor temporally autocorrelated. The distinctive data collected by J.J. are consistent with the notion that involving local experts can produce reliable data. We developed a conceptual model to help identify the appropriate participants for a given project on the basis of research budget, knowledge or skills needed, technical literacy requirements, and scope of the project.*

Key words: citizen science, community participation, DeHoop Nature Preserve, observer reliability

El Valor, Limitaciones y Retos del Empleo de Expertos Locales en la Investigación sobre Conservación

Resumen: *Las evidencias sugieren que la participación de habitantes locales en el trabajo de conservación incrementa la probabilidad de éxito de un proyecto. Sin embargo, involucrar a científicos ciudadanos genera interrogantes sobre la calidad de los datos. Como una herramienta para evaluar a potenciales participantes en proyectos de conservación, desarrollamos un gradiente de conocimiento, K, en el que los miembros de la comunidad ocupan diferentes posiciones con base en su experiencia y conocimiento de un tema de investigación. Este gradiente puede ser utilizado para refinar el concepto de ciencia-ciudadana y permite que los investigadores diferencien a los miembros de la comunidad con conocimiento experto de los que tienen poco conocimiento. Proponemos que el trabajo se beneficiaría con la inclusión de expertos locales*

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selectos porque permitiría que los investigadores aprovechen los beneficios de la participación local al mismo tiempo que mantienen o incrementan la calidad de los datos. Utilizamos un caso de estudio de la Reserva Natural DeHoop, Sudáfrica, donde realizamos múltiples entrevistas, identificamos y empleamos a un experto local en el rastreo de animales, evaluamos el conocimiento del experto y analizamos los datos recolectados por el experto. El rastreador experto de animales, J.J., creó su propio diseño de muestreo y recolectó datos de mamíferos. J.J. recorrió 4653 km en 214 días y registró 4684 mamíferos. Trabajaba en una localidad central, y sus recorridos formaron círculos sobrepuestos; sin embargo, sus datos no estuvieron autocorrelacionados espacial ni temporalmente. Los datos recolectados por J.J., el experto, son consistentes con la idea de que los expertos locales pueden producir datos confiables. Desarrollamos un modelo conceptual para identificar a participantes apropiados para un proyecto determinado basado en el presupuesto, el conocimiento o habilidades requeridas, los requerimientos de conocimientos técnicos y el alcance del proyecto.

Palabras Clave: ciencia ciudadana, fiabilidad de observadores, participación comunitaria, Reserva Natural DeHoop

Introduction

Community involvement in conservation and research activities is increasing worldwide (Holck 2008), and conservation projects that involve local communities are often more successful at achieving their objectives than those that do not (Brook & McLachlan 2005; Drew 2005; Danielsen et al. 2007). Involving local communities in conservation initiatives increases a community's appreciation for and investment in their local natural resources and is an efficient and lasting form of environmental education (Cooper et al. 2007; Danielsen et al. 2007; Holck 2008). Local communities can also contribute large, enthusiastic, and often volunteer workforces to facilitate data collection at large spatial extents (Delaney et al. 2008; Anadón et al. 2009). The Christmas Bird Count is a well-known example of successful community involvement in conservation monitoring. In its 2008–2009 season, the project engaged close to 60,000 volunteers across North and South America and Antarctica (National Audubon Society 2009).

Community participation in conservation work is often synonymous with "citizen science," a process by which professional scientists engage "a dispersed network of volunteers to assist in professional research" (Cooper et al. 2007:11). Citizen scientists typically lack scientific training and have little, if any, previous research experience (Schnoor 2007). The lack of training among citizen scientists has raised concern about the reliability of their data (Galloway et al. 2006; Nerbonne & Nelson 2008). For example, the ability of volunteers to identify the species and sex of marine crabs can vary as a function of the age of volunteers and their level of education (Delaney et al. 2008), and Sauer et al. (1994) found that the variation among participants' field experience resulted in variation in occupancy and abundance estimates of 183 of 369 species in the United States Breeding Bird Survey. Individuals in a community differ widely in familiarity with the local environment and experience with a research method or topic (Sauer et al. 1994; Bibby et al. 2000; Danielsen et al. 2009), but there exist potential participants with expert knowledge on various methods or topics (e.g., expertise identifying mammal signs [Zuercher et al. 2003]).

We propose that researchers may benefit from refining the current citizen–scientist concept by consciously identifying and engaging knowledgeable community members (i.e., local experts). We present a case study from South Africa to illustrate the strengths, challenges, and limitations of data collected by local experts. We offer some ideas on how such challenges might be addressed. Additionally, we devised a conceptual model to aid in identifying local experts, given the context of a project's objectives, and make recommendations for how researchers might include local experts in their work.

Methods

Defining K and Local Expert

We suggest potential participants in a research project can be organized along a knowledge gradient, K (Fig. 1), that represents each participant's experience with and knowledge of a research method or topic. A low K score indicates a person has little to no experience with research topics (e.g., amateur citizen scientists), must be thoroughly trained prior to executing simple and unambiguous research activities, and may collect low-quality data (Galloway et al. 2006). A high K score, in contrast, indicates a person with substantial experience with the topic, acquired either through formal or informal learning (e.g., local botanists, animal trackers, herbalists, professional scientists). People with high K scores require minimal training, have distinctive skills and knowledge, and could contribute to developing sampling designs, as well as to data acquisition, interpretation, and validation.

Local experts would have high K scores. Here, local experts are different from professional scientists in that they lack formal scientific training and acquired their knowledge through extensive experience over long periods

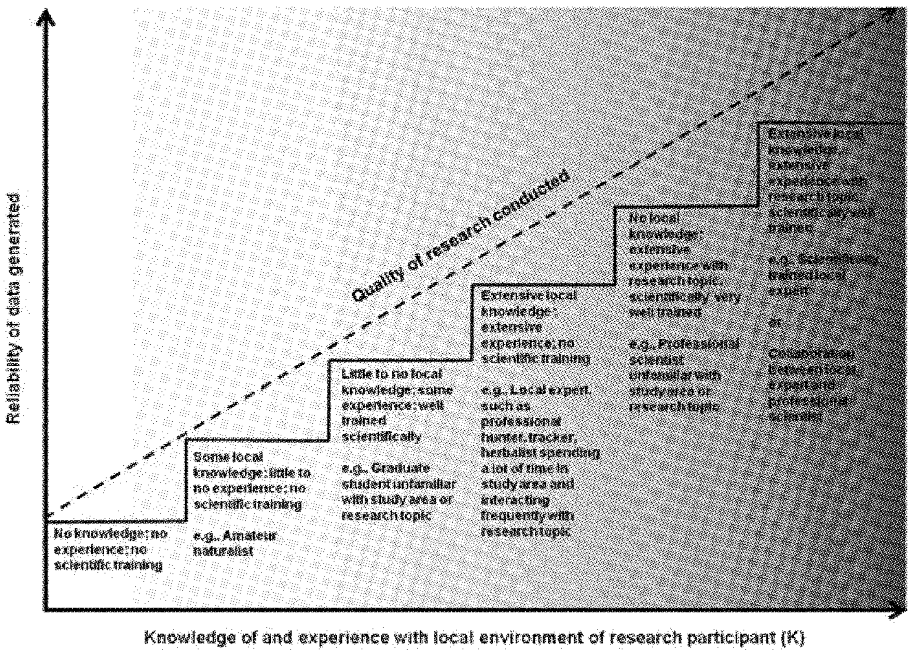

Figure 1. The knowledge (K) gradient, reflecting the variable degrees of knowledge in potential community members and research participants.

(e.g., hunters, traditional healers, carpenters, beekeepers, farmers). By definition, professional scientists who are highly familiar with their study area and research topic are also local experts. Local experts differ from other citizen scientists in that they know more about a given research topic and may use this expertise to earn an income (e.g., hunting guides, herbalists). Local experts may also possess traditional ecological knowledge (Berkes et al. 2000). Traditional ecological knowledge, however, is typically associated with indigenous peoples and cultures, and we do not define local experts on the basis of cultural background (e.g., in Doswald et al. [2007], nonindigenous hunters, rangers, and wardens are local experts).

Identifying a Local Expert and Evaluating *K*

We identified J.J. as a potential animal-tracking expert during interviews with staff in the Karoo National Park, South Africa. We followed protocols similar to Davis and Wagner's (2003) multiple-interview process, in which potential experts were identified by soliciting peer recommendations and then comparing names provided to determine who was recommended most often. In January 1999, we evaluated J.J.'s K, with regard to his animal tracking skills. The evaluation process is described in detail in Evans et al. (2009). In brief, his evaluation had 2 parts. First, J.J. spent 3 days identifying spoor of insects, reptiles, birds, and mammals in the field. Second, J.J. was asked to follow the faint trail left by a black rhinoceros (*Diceros bicornis*) in rocky terrain and to locate the animal. J.J. scored 100% on both portions of the evaluation, exhibiting a high K score. On the basis of his performance and his proximity to the work site, J.J. was the only person asked to participate in the study.

Local-Expert Data Collection

We asked J.J. to record all signs (e.g., footprints, scats) and sightings of animals in the DeHoop Nature Reserve (DHNR) (34,000 ha), South Africa, between May 2002 and October 2003. The DHNR was created in 1957 to protect the largest extension of fynbos, a dense shrubland endemic to the Cape Floristic Province. Eight-six terrestrial mammal species and 260 bird species are known to occur in the DHNR (Cape Nature 2009). Intentionally, J.J. was provided with no further instructions. Thus, he determined the direction and length of his patrols.

J.J. used a handheld computer containing CyberTracker software and a global positioning system (GPS) (Visor PDA [Handspring, Sunnyvale, California] with a Magellan GPS Companion [Magellan, San Dimas, California]) to record data. The software (Cybertracker, Cape Town, South Africa) was programmed by L.L. and was almost completely icon driven. The computer included editable attributes for date; time; latitude and longitude; animal species, age, and gender; type of detection (i.e., direct or indirect); and type of survey (i.e., foot or vehicle patrol). The software was customizable, allowing for deletion and addition of icons. When J.J. encountered animals for which there were no icons, he asked L.L. to update the software. For the purpose of this paper, we only analyzed J.J.'s detections of terrestrial mammals.

Analyses of Local Expert Data

We assessed the quality of J.J.'s data by describing the survey effort in terms of total and average distance (kilometers), time (hours) spent surveying and number of detections. Because J.J. determined the direction and length of his patrols, we tested whether his data were spatially or temporally autocorrelated with Moran's I (Moran 1950). For spatial autocorrelation, we used the distance between detections. For temporal autocorrelation, we used the time (minutes) between detections.

We used linear regression to determine whether survey effort was related to the number of detections. We used analysis of variance to test whether the number of detections varied among months and to test whether there was an effect of survey distance on monthly detection rates. Where significant differences were found, we did a post hoc Tukey pairwise comparison to determine which pairs were significantly different (Zar 1999). Mean species-specific body weights were available for 72 mammals in DHNR (Skinner 2005; Myers et al. 2006). We used linear regression to assess whether detection was a function of body mass or species' activity patterns (i.e., diurnal, nocturnal, or both).

Results

J.J patrolled 4653 km in 214 days (Fig. 2). Patrols varied in length (mean [SD] = 22.7 km [18.9]) and time (351 min [159]). J.J. was primarily restricted to distances that could be traveled by foot, but sometimes he surveyed while perched on the hood of an off-road vehicle. Fifty-six percent of J.J.'s observations were made while he was on a footpath, 24% while on a dirt road, and 20% when he was sitting on a vehicle. Patrol duration was positively correlated with the number of detections ($R^2 = 0.26$, $F = 65.39$, $p = 0.001$). On average, J.J. detected 3.5 animals/km (SD 2.7). The number of mammal detections varied significantly by month ($F = 1.64$, $p < 0.05$); on average more detections occurred in May and November of both years ($F = 1.64, p < 0.05$). However, the number of detections in these months did not differ significantly (Fig. 2). The patrol length did not have a significant effect on the number of detections ($F = 1.64$, $p = 0.06$, no significant differences in Tukey pairwise month comparisons). Ninety percent of detections occurred within 0–5 m of J.J. Detections further away were, on average, within 200 m of J.J. (mean [SD] = 177.4 m [123.9]); the maximum distance at which J.J. detected animals was 700 m.

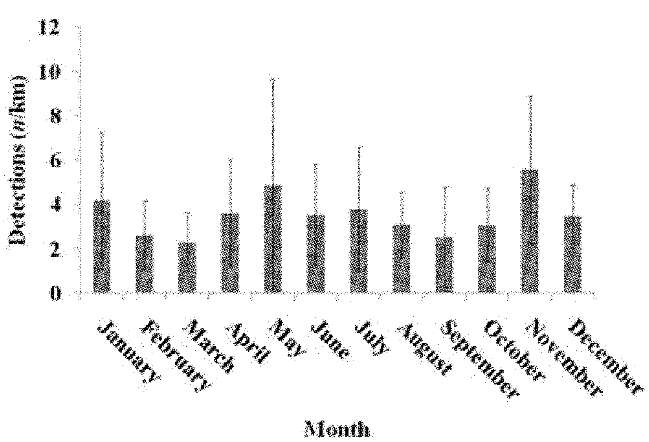

Figure 2. Mean (1 SD) number of observations (i.e., detections) of terrestrial mammals >200 g made by a local expert (J.J.) per month.

J.J. detected a total of 4684 mammals (Supporting Information). The most frequently detected mammals were bontebok (*Damaliscus pygargus*; $n = 1276$) and eland (*Taurotragus oryx*, $n = 832$), both of which are large and diurnal (Supporting Information). J.J. also detected numerous elusive and nocturnal species and 100% of species within DHNR described as diurnal, diurnal and nocturnal, and crepuscular. He detected 93% of strictly nocturnal species.

Species detection was a function of body mass ($R^2 = 0.15$, $F = 42.3, p = 0.02$). The smallest species detected was the yellow mongoose (*Cynictis penicillata*) (average body mass of 679 g). J.J. did not detect 2 of 35 species >200 g that may be present in DHNR: the Cape hare (*Lepus capensis*) and the Cape dune mole rat (*Bathyergus suillus*). J.J., however, was not asked to record data on the mole rat.

The absence of an established sampling protocol resulted in the formation of a wandering rosette, whereby data were opportunistically gathered from a central point (the reserve headquarters) in circular, overlapping loops resembling the petals of a flower (Fig. 3). Detections were neither spatially nor temporally autocorrelated (Moran's $I \leq 0.0001, p = 0.66$; Moran's $I = 0.21, p = 0.14$, respectively).

Discussion

Under the current citizen-science model (e.g., Danielsen et al. 2009), local experts are considered equivalent to every other community member. In reality, however, wide discrepancies exist. Evidence suggests that local skills and knowledge can complement those of professional scientists (Berkes et al. 2000; Drew 2005) and that local experts can sometimes provide higher quality data than professional scientists. For example, locations of Matsutake mushrooms (*Tricholoma matsutake*) provided by local experts result in more reliable models than locations provided by professional scientists (Yang et al. 2006) and models that incorporate local-expert data result in more accurate distribution maps of Eurasian lynx (*Lynx lynx*) than data collected by scientific experts (Doswald et al. 2007).

Results of our case study are consistent with such evidence. For example, J.J. detected, via spoor, 93% of species described as nocturnal, in addition to 100% of species described as crepuscular or diurnal. Observers

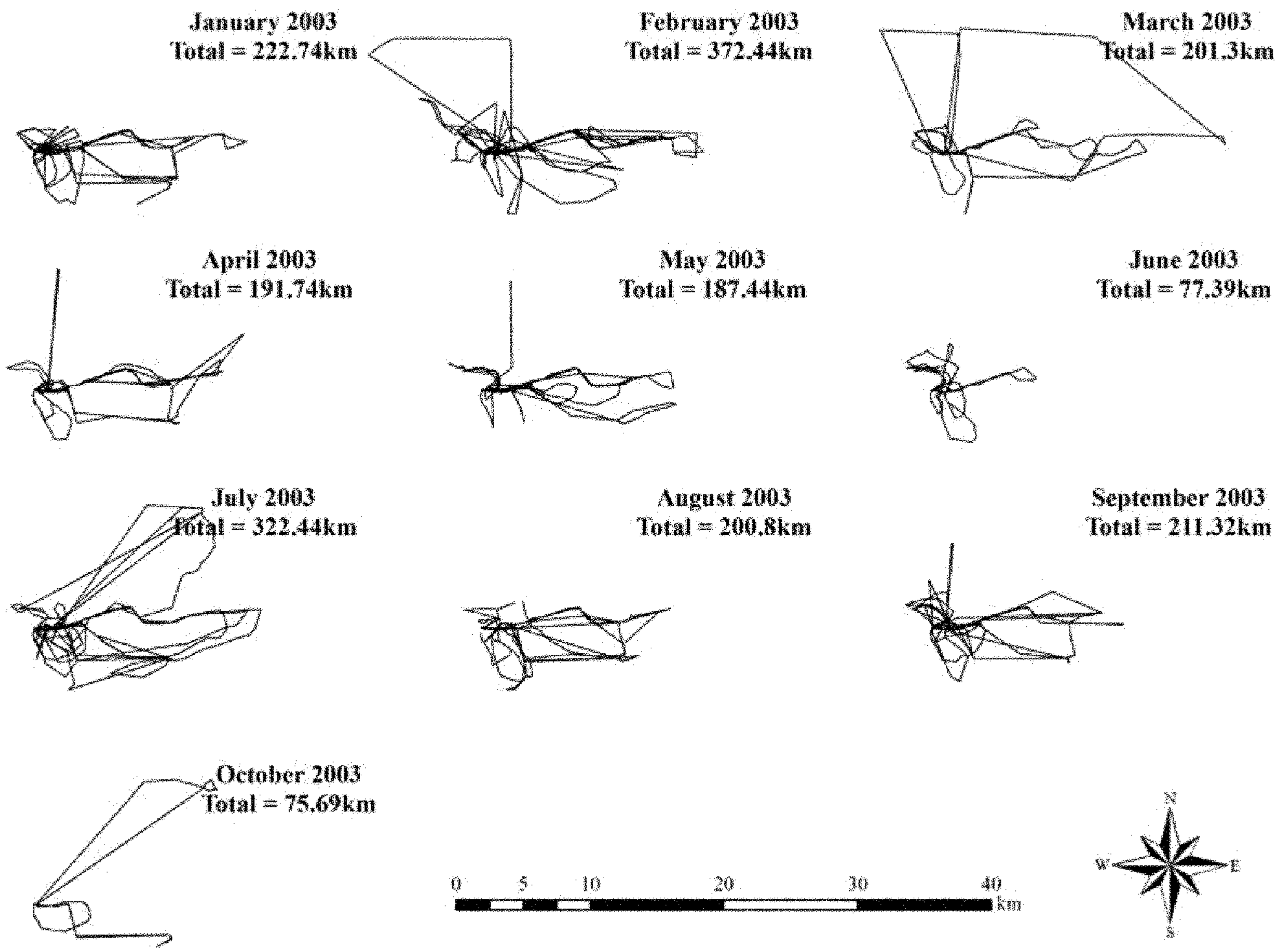

Figure 3. Rosette-like survey loops in different vegetation types made from a central point by a local expert (J.J.) when he was on foot and on a vehicle during January through October 2003.

with low *K* scores may have been able to detect large diurnal species that were common, but fewer mammals and nocturnal species. J.J. also detected 2 species previously unrecorded in the DHNR: the nocturnal aardvark (*Orycteropus afer*), which occurs at very low densities near the reserve (P. Lloyd, personal communication), and the springbok (*Antidorcas marsupialis*), an introduced species that occurs at very low densities (P. Lloyd, personal communication). Via spoor, J.J. detected a male and female leopard (*Panthera pardus*), a species thought to have been extirpated from the reserve for many years (Supporting Information). Few trackers are able to differentiate the gender of an animal from its spoor (Stander et al. 1997), the method for which is described in Liebenberg (1990).

J.J.'s data were more easily verified because he used the data entry software and a GPS in the field. This allowed us to more easily analyze his data and assess the independence of his detections. Ideally, J.J.'s performance would have been compared with that of other research participants with different *K* scores; however, such data were unavailable.

Four Challenges in Working with Local Experts

Our study highlights 4 significant challenges involved in the use of local experts: identifying them, evaluating their knowledge, recording their knowledge or how they record data, and analyzing their data. Not everyone in a community has expert knowledge, but locals often know who the experts are on a given topic. We identified J.J. as an animal-tracking expert following Davis and Wagner's (2003) multiple-interview process. Selecting local experts can introduce bias; thus, it is necessary to report how experts are selected (Davis & Wagner 2003).

Research participants, their data, or both must be systematically evaluated. We evaluated J.J.'s skills with a standardized test that quantified his *K* with regard to identifying and interpreting animal tracks and signs (Evans et al. 2009). J.J. also held a Senior Tracker Certificate (Cyber Tracker Conservation, Cape Town, South Africa), the highest certification category, and one that to date only 20 of >1200 people tested in 3 countries have achieved. J.J.'s results on that test gave us great confidence in the quality of his observations. Field testing, however, is not the only method to determine a person's *K* score. Plant or dung samples collected in the field, or photos of ambiguous samples, can be sent to recognized experts to confirm identification and help determine a person's *K* score (e.g., genetic testing to confirm scat identification by local experts [Zuercher et al. 2003]).

Local experts often lack scientific training and may be illiterate, which makes it difficult to document their *K* score or employ them to gather data (e.g., Begg et al. 2003; Zuercher et al. 2003; Drew 2005). Interviews and questionnaires have been the dominant method for recording the data collected by local experts (Brook & McLachlan 2005; Drew 2005; Anadón et al. 2009). Data gathered through interviews, however, are pulled from memory and can reduce data reliability (Eysenck & Keane 2005). Also, data collected through interviews are typically not spatially explicit (Drew 2005), which makes it difficult to validate the data independently. The development of icon-driven software and handheld computers has revolutionized how local experts record data and allows local experts greater freedom in when and how they collect data (Bazilchuk 2004; Lee et al. 2006; Marvin et al. 2009).

Analyzing data collected by local experts also poses some challenges, many of which are common to all forms of scientific research. When local experts gather data as part of their own daily activities, rather than by following established scientific protocols, the data often violate statistical assumptions. Local experts are more likely to follow a sampling design of convenience or opportunity (Anderson 2001; Luo et al. 2009). This may lead to imperfect detections (MacKenzie 2005) and bias the location (e.g., near roads [Kadmon et al. 2004]) or time (Bas et al. 2008) of sampling. Resampling methods (i.e., bootstrap or jackknife), however, may be used to randomly sample autocorrelated data (Breslow 1996).

Future Directions

Through our study, we identified 3 additional questions that need further scientific attention. First, how does variation in *K* scores affect research findings and how does a spectrum of participant experience influence conservation practice? Second, do the benefits of citizen science (e.g., environmental education [Cooper et al. 2007; Holck 2008]) apply to projects that use local experts, especially when projects employ fewer local experts rather than larger numbers of amateurs? Third, how can local experts and other community members be involved in conservation projects other than as data gatherers, guides, or field assistants (e.g., Dowler 1996; Begg et al. 2003; Zuercher et al. 2003).

Giving local experts tools that encourage independence may introduce biases that limit statistical analyses, but it may foster innovation through development of novel sampling designs and alternative explanations for the results of analyses. In our case study, J.J. was informed from the start that his data would be analyzed to assess what data an expert animal tracker might collect, and this perhaps influenced his performance. We elected not to involve J.J. in data analyses because the analyses were meant to assess his performance, and he lacked the statistical training and literacy to engage in all team communications. It may therefore be unrealistic to aim for incorporation of local experts into the complete research process.

When to Involve Local Experts

Research projects that do not require specialized data are particularly amenable to participation of locals with low *K* scores (e.g., Goffredo et al. 2004; Delaney et al. 2008; National Audubon Society 2009), and there are numerous projects well suited for locals with high *K* scores. We developed a conceptual model that considers 4 attributes of a project's research design that can be used to decide who should participate in a research project: project scope, knowledge base of participants, project budget, and technical complexity of the methods. Project scope is related to a project's extent, including the size of the study area and the time needed to obtain reliable data. Knowledge base incorporates familiarity of participants with the local terrain and the research topic and their ability to record data accurately (e.g., identify species or interpret their field signs and behaviors). Knowledge base refers to existing skills or skills that could be developed through training if the project budget permits. A project's budget limits who and how many participants can be hired (costs more to hire participants with high *K* scores than participants with low *K* scores), the type of equipment used, and costs related to training locals. The complexity of some equipment may determine minimum literacy levels needed to participate, beyond that which simple training can provide (e.g., GIS skills), whereas some complex equipment is more user friendly.

These 4 attributes are interrelated and codependent. For example, research that requires collection of data with highly specialized equipment limits community involvement and favors a team of professional scientists. Involvement of local experts is best suited for projects that operate at larger spatial extents, have small to medium budgets, use relatively simple equipment, and require highly specialized data.

Recommendations for Inclusion of Local Experts in Research

We think conservation science and practice could benefit greatly from more widespread integration of local experts in research and monitoring. Those who would like to incorporate local experts into their research lack readily available guidelines for how to do so. We propose 7 steps for including local experts in a project. First, interview multiple people to identify the skill sets available in local communities and potential local experts (Davis

& Wagner 2003). Second, evaluate the skills and knowledge of potential local experts; develop a method for certifying their skills (e.g., Evans et al. 2009) so that their skills are recognized by future researchers and potential employers. Third, involve local experts in identifying and refining research questions. Fourth, provide training to local experts, particularly in standardized data collection, both to increase the potential value of their data and to involve them in more aspects of the project. Fifth, consult with local experts while interpreting data. Sixth, make project materials and products available to local experts and communities in formats that are consistent with their literacy levels. Seventh, provide respectable incentives for local experts to participate, acknowledge their input in reports and publications, and consider including them as coauthors.

Involving local experts can bolster a project's probability of success and improve data quality. Recognizing that local experts are different from other citizen scientists is an important step in more widespread inclusion of local communities in conservation research, a step that may require a shift away from viewing local participation as solely cost-free citizen scientists, guides, or field assistants.

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Supporting Information

A list of species detected in the DeHoop Natural Reserve (Appendix S1) is available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than the absence of material) should be directed to the corresponding author.

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