Traditional Ecological Knowledge and Practice and Red List Assessments: Guidelines and Considerations for Integration
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Abstract

Species conservation stands to benefit greatly from including traditional ecological knowledge and practice (TEKP), especially in areas where scientific data are lacking. TEKP holders are local resource users and/or indigenous people who interact intimately with a resource. TEKP includes important historical information on local population dynamics; socioeconomic implications that are accumulated over time, continuously updated, and reinforced with practice; and user buy-in to management processes. IUCN’s Red List Assessments, in particular, could benefit from including TEKP. For some species, TEKP holders might be the only source of ecological and biological information as well as important socio-ecological factors impacting species ecology that are not detectable through natural sciences alone. However, formal guidelines and procedures on how to incorporate TEKP in a meaningful way are lacking. Drawing from examples of TEKP inclusion in polar bear conservation, monitoring medicinal plant use, and fisheries management, we suggest general guidelines and considerations for including TEKP in Red List assessments noting that these will be applicable to any conservation and/or management assessment process.
Table of contents

Abstract.........................................................................................................................2

Introduction ..................................................................................................................4

Traditional and ecological knowledge and practice (TEKP) .................................4

The role of TEKP in local communities .................................................................5

TEKP for conservation ...............................................................................................5

Benefits of including TEKP in Red List assessments ..............................................6

Methods for engaging knowledge holders and learning TEKP...............................6

Flexibility in assessment criteria and governance ......................................................7

Anticipated challenges for TEKP inclusion in Red List assessments .......................8

Inuit TEKP of polar bears in Nunavut, Canada ...........................................................9

TEKP in conservation of medicinal plants in Bangladesh ...........................................10

TEKP in fisheries and implications for management .................................................12

General guidelines for TEKP integration into Red List assessments .......................14

References .....................................................................................................................17
Introduction

Conservation assessments and their applications are typically driven by information gathered through scientific methods and protocols, which, though objective and reliable, do not fully incorporate human dimensions. Stakeholders often demand that management decisions are rooted in rigorous objective (e.g., natural) sciences, especially in controversial scenarios (Giardina et al. 2007). In spite of this, conservation programs that exclude multiple (cultural) knowledge systems continue to inadequately understand and address species conservation within the context of the entire ecosystem, leading to debates over which knowledge or “history” is more important in management (Berkes 2012). Successful conservation requires species management that supports human wellbeing and sustainable economies (Evans and Klinger 2008, Berkes 2012). Failure to incorporate sociocultural risks associated with conservation action can lead to social inequalities (Carothers et al. 2010), reduce resilience and adaptive capacity of affected communities (Gregory and Trousdale 2009), and weaken social and knowledge systems that mitigate ecological risks (Evans and Klinger 2008).

Recognizing that conventional natural sciences alone cannot address the social and political forces that shape management action in conservation (Giardina et al. 2007, Cabin 2007), the International Union for Conservation of Nature (IUCN) has initiated efforts to incorporate traditional ecological knowledge and practice (TEKP) into its Red List of Threatened Species assessments.

Traditional and ecological knowledge and practice (TEKP)

TEKP has come to be known by such terms as: indigenous knowledge, traditional knowledge and wisdom, local traditional knowledge, traditional ecological knowledge, as well as a combination of these terms (Huntington et al. 2004). TEKP holders are local resource users and/or indigenous people who interact intimately with a resource (e.g., a species) and levels of ecological experience and knowledge differ across individuals within these communities (e.g., not everyone in a local community has relevant TEKP). Here, I define TEKP as an experiential knowledge system and practice in that it is continuously gathered and updated through extensive interactions of knowledge holders with the environment and its species (Huntington 2000), and varies according to individual and community-level circumstances and needs (Huntington et al. 2004, Pearce et al. 2009). As TEKP is passed on from generation to generation (Berkes 2000, Berkes et al. 2007) and linked to the high consequences of failure (e.g., sickness, suffering, and/or death), TEKP is precisely shaped through trial and error, where unsuccessful techniques are modified or fade out with memory (Alessa et al. 2015). Unlike most deductive scientific approaches, new observations are analyzed and compared with existing bodies of knowledge to make subsequent decisions; for example, whether or not to go hunting at particular times and/or in certain areas (Alessa et al. 2015). In this vein, TEKP is a dynamic, interconnected web of cause and effect, action and outcome, behavior and consequence associated with people, animals, plants, natural objects, and supernatural entities (Turner et al. 2000). These relationships are linked to each other and the environment through cultural traditions and interactive reciprocal relationships (Turner et al. 2000, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES] 2015, Houde 2007). TEKP is holistic and, thus, cannot be isolated
and fragmented (Turner et al 2000, Alessa et al 2015). Compared to conventional scientific methods and hypothesis testing, where few quantitative variables are used to explain ecological complexities, TEKP considers multiple qualitative variables at the same time; for example, Inuit hunters take into account several observations in deciding whether or not to consume a harvested seal (Berkes 2012).

The role of TEKP in local communities
TEKP is characterized factual observations, management systems, land use, ethics, cultural identity, cosmology and values (Houde 2007, Poe et al 2014). Knowledge is learned and shared through generations of hunting, medicinal gathering, preparing for spiritual ceremonies, and maintaining household economy (Drew 2005, Poe et al 2014), and children gain experience by participating in these events and observing older community members (Turner et al 2000). Local language and terminology are key tools for knowledge formation through conversations, stories, narratives, and oral histories (Huntington et al 2004, Turner et al 2000, Alessa et al 2015, Poe et al 2014). Experiential meaning and relevance is further reinforced through ceremony (e.g., song, art, and prayer; Turner et al 2000, Poe et al 2014, Alessa 2015).

In conserving species, TEKP is shaped by ecological principles in light of adaptive strategies for monitoring, enhancing, and sustaining resources (Turner et al 2000) and mechanisms for governance, decision-making, harvest control, and accessing resources (Poe et al 2014). TEKP can also guided by ethics by means of enforcing sustainable practices, respect for all life forms, and sanctions against those who are wasteful (Turner et al 2000, Poe et al 2014). From a socio-economic standpoint, TEKP is tightly linked with livelihood dynamics, especially when harvesting is more often motivated by sustenance versus sale and/or income (Freeman and Wenzel 2006, Poe et al 2014). At the species level, TEKP includes folk taxonomy and systematics, for example, different species names according to cultural value and use (Drew 2005, Houde 2007).

TEKP for conservation
For formal conservation purposes (or applications steeped in Western science and conservation paradigms), TEKP could certainly shed light on threatening factors, causes, and actions that contribute to species at risk and enrich scientifically based Red List criteria (IUCN 2014). For communities still operating and/or working from their traditional practices, TEKP inclusion as a process of knowledge generation can strengthen knowledge systems that are already embedded within these communities (IPBES 2015), allowing them to emphasize which observations should be made as relevant to daily life (Alessa et al 2015). However, TEKP is not always perfect and does not always operate within the context of conservation; it could in some cases be used to overexploit and cheat rules. Thus, understanding the context through which TEKP operates is important, and identifying motivations for gathering TEKP might suggest opportunities to overlap with conservation frameworks.
Benefits of including TEKP in Red List assessments
The IUCN Red List facilitates species listing under national and/or international legislations (e.g., Convention on International Trade of Endangered Species [CITES]), targeting species of conservation concern to scientists, resource users, and public communities using contemporary scientific approaches to detect population and habitat decline and fragmentation (Baillie et al 2004, IUCN 2014). However, these quantitative data are limited or lacking altogether for some taxa, especially those that are scarce and/or difficult to access (e.g., that are in remote locations). For species that have not been described on a scale that is relevant (or large enough) for Red Listing, local resource users and people who interact with the resource might be the only source of ecological and biological information. Given their holistic view of the environment, indigenous people are likely aware of linkages between ecological processes, multiple species, and abiotic factors that influence species ecology that are not detectable through science alone (Alessa et al 2015, Drew 2005). Harvesters in particular are aware of cultivation and harvest effects on contemporary population and habitat dynamics not yet documented in scientific literature (Drew 2005). Using indigenous knowledge could also reduce measurement error and uncertainty in scientific data by informing alternative strategies for conducting assessments. Strong collaborations with local communities with intact TEKP and governance institutions could support adaptive management of interventions toward socio-ecological resilience, and policy actions amidst environmental and institutional changes (Turner et al 2000, Berkes 2010, Berkes 2012, Alessa et al 2015) and reduce conflict and costs associated with policy negotiation (Evans and Klinger 2008).

Recognizing that information beyond science is necessary for policy makers and conservation practitioners to understand underlying drivers of species decline, I provide guidelines for integrating TEKP into Red List assessments relevant to three themes: methods for recognizing and gathering TEKP; exigencies and considerations surrounding governance; and challenges and ethical considerations for TEKP integration. I describe three cases that incorporate TEKP in light of these themes to enrich our understanding of how TEKP could be gathered and integrated in a meaningful way. Additionally, working directly with scientists can break down many perceived user-group barriers and create opportunities to turn locally important resource users into conservation champions (e.g., Capt. Peter Gladding’s work to assist the creation of Dry Tortugas Ecological Reserves within the Florida Keys National Marine Sanctuary [Lindeman et al., 2000; Cowie-Haskell and Delaney, 2003]). I hope that these guidelines will support and encourage TEKP inclusion in Red List-based programs.

Methods for engaging knowledge holders and learning TEKP
Openness to and respect for diversity in worldviews, working cultures, and knowledge tools can help to set the stage for resilient and sustainable collaborations between natural scientists and TEKP holders. To encourage knowledge co-production, assessment processes should allow a broad range in TEKP participatory scenarios that reflect differences in culture and knowledge claims to surface for negotiation (Berkes et al 2012, Poe et al 2014). Following the conditions through which TEKP operates, Red List assessments should be open to all possible outcomes through a community-based, iterative process (Poe et al 2014). These processes might not resemble or mimic western science or scientifically driven data collection. TEKP learning by scientists or individuals who seek to apply it could take the form of semi-directive interviews
(Huntington 1998, 2000), informal discussions, focus groups, workshops, and/or community consultations. Those who are documenting TEKP should recognize and show deference to the strong probability that the indigenous community has a history of colonization by outsiders (Drew 2005, Houde 2007, Alessa et al 2015) by taking on the role of a “learner” versus “leader”, allowing communities to lead the process. Assessment reports should be communicated in meaningful ways, discussed in advance with influential community leaders, that describe outputs in the context of what matters to communities and rights to use, distribute, and/or benefit from them (Poe et al 2014). For example, visually powerful tools such as interactive maps and diagrams, artwork, books, film, websites, libraries, museums, and databases (with consent and validation) might be preferred over lengthy written reports. These forms of presenting information will be especially effective if led by local communities.

Understanding local social structures—which vary across communities and cultures—will help conservation scientists develop social relationships and knowledge contexts to engage appropriate and relevant individuals (IPBES 2015). TEKP is not evenly distributed among tribes or other groups and, as such, different topics and skills vary from person to person, perhaps according to age, gender and/or socioeconomic status. Further, it is important to recognize that not everything an indigenous person says is TEKP. Knowledge holders are likely respected characters within communities who have been seen “living the knowledge” (IPBES 2015), and can be identified and recruited by community members (Pearce et al 2009, Poe et al 2014). Key informants might comprise hunters, gatherers, agriculturalists, fishers, craft-makers, artists, medicine practitioners, and elders with knowledge of past and/or rare events (IPBES 2015). In many cases, knowledge holders are already actively engaged in community-based assessments; for example, chiefs and specific families in charge of monitoring and controlling particular resources (Turner et al 2000). Interpreters could be employed not only as translators but also research assistants, teachers, guides, and community liaisons between community and non-community members, refining research questions and assessments strategies according to ethically and culturally appropriate contexts (Pearce et al 2009).

**Flexibility in assessment criteria and governance**

Governance concerns the integration of “public” and “private” sectors in solving problems and creating solutions, as well as the politics relevant to distributing rights and responsibilities (Wyborn and Bixler 2013, Berkes 2012). In these contexts, decision-making is inherently complex, requiring social, economic, and administrative considerations beyond science (Berkes 2012, Coombe 2005). These forces interact in response to social and ecological processes that emerge from fundamentally different spatial and temporal scales (Wyborn and Bixler 2013). Thus, cooperation across multiple scales will be necessary for successful conservation action. Including TEKP communities with strong governance institutions in Red List assessments could foster locally adapted ecosystem governance that is nested in broader, larger scale systems of conservation (Berkes 2012). TEKP-based Red List assessments could guide management at larger scales, while subsequent decision-making and management policies operate on more locally relevant, smaller scales (Rodríguez et al 2011). Indeed, Red List assessments aim to foster species classification processes that are consistent and transparent enough to the public to support broad comparisons across a wide range of taxa (IUCN 2012), yet are also specific
enough for applications according to local geographic contexts and decision-making (Rodríguez et al. 2011).

In spite of this, Red List guidelines still discourage assessments within small geographic areas (IUCN 2014), as they tend to produce inaccurate range estimates under scientific frameworks (IUCN 2012). TEKP typically operates on small scales (Berkes 2000, Berkes 2012), and the deeply place-based or contextualized nature of TEKP does not align with scientific principles of large-samples enabling replicability and generalizability (Agrawal 1995, Poe et al. 2014). Red List guidelines also encourage assessments independent of ecological, evolutionary, economic, societal species values; chances of recovery; and actions that are required to protect species (IUCN 2014), whereas TEKP is deeply rooted in these considerations; TEKP-based assessments will need to include these implications as they relate to knowledge holders and human values. These incongruities strongly suggest that a new assessment framework that supports TEKP—as well as people with place-based or contextual knowledge and language facilities—is required to integrate TEKP into the Red List. At the outset, management decisions that are rooted in TEKP-based assessments will likely need to allow for a larger emphasis on inferred information, which are currently discouraged for scientifically based assessments (IUCN 2014). At the same time, TEKP includes “direct observation” data characteristic of valuable scientific-based criteria (IUCN 2014). Further, TEKP is gathered and maintained as it is relevant to individuals and communities and, hence, could be considered unique evidentiary (versus precautionary) criteria (IUCN 2014).

Transparency in the role of TEKP and resilient relationships with communities where TEKP is in place will be necessary to encourage capacity for and sustain local governance over knowledge and resources. Clarifying TEKP roles and ownership, and how resulting decisions will affect TEKP communities, will mitigate any conflicts that arise from uncertainty (Berkes 2012, Peacock et al. 2011, Coombe 2005). This could be achieved through increasing public awareness of TEKP, engaging a broad set of public, scientific, and TEKP communities throughout the process, developing adaptable and flexible governance systems, and linking governing institutions across all scales (Berkes 2012). Establishing strong partnerships is a key component to any endeavor that involves learning about and using TEKP outside its historic use or community of users (Moller et al. 2004, Houde 2007, Motaleb 2010).

**Anticipated challenges for TEKP inclusion in Red List assessments**

If Red Listing criteria are not expected to change in the near future (IUCN 2014), incorporating TEKP—which is rooted in continuously adapting processes—will certainly be challenging. It is unlikely that objective, rigid procedures will support qualitative TEKP in quantitative-based Red List assessments. In many cases, TEKP may not agree with scientific criteria; indeed, many classification systems and assumptions do not travel across different cultures and settings (e.g., Caniago and Siebert). Including TEKP might also implicate revisions of scientifically justified listings that are already in place. Indigenous communities do not always perceive science and decision-making as credible if TEKP and wisdom are lacking and/or they fail in addressing or incorporating community concerns (Moller et al. 2004, Alessa et al. 2015). Identifying and focusing on overlaps between knowledge types and common conservation goals, raising awareness of TEKP in public domains to increase public understanding of it, and acknowledging
differences in data types that could be used to understand the same phenomena will minimize conflict and support integration for these incongruences. The ease of and degree to which TEKP is integrated into Red List assessments will likely depend on the species and local community, including community perceptions of scientific research, management and experience with relevant past conservation initiatives. Species that are of high cultural and political interest will likely pose additional challenges, especially if the species is valued differently among the stakeholders involved, for example, polar bears being valued for research versus subsistence among researchers versus TEKP holders, respectively.

Clear agreements defining terms of interaction and especially ownership of products will be required for TEKP inclusion in species assessments. For indigenous people, knowledge is under the control of their communities and TEKP cannot be separated from TEK holders (Agrawal 2002). Some TEKP is considered intellectual property, in which case sharing with outsiders is not permissible under specific conditions and/or leads to appropriation if it is not shared and published within culturally defined laws and controls (Drew 2005). Intellectual property rights that protect knowledge holders against marketplace offence and confusion, assert origin and conditions of knowledge origin, and respect confidentiality and values are necessary to avoid controversies over political boundaries and rights, especially for indigenous communities (Coombe 2005). In most cases, knowledge and rights are relevant to the physical survival of community members and cannot be isolated in the context of market value (Coombe 2005). Formally acknowledging and compensating knowledge holders can empower local communities and promote sustainable political autonomies and territorial rights that are necessary for indigenous survival (Coombe 2005). It may be elusive or unclear, in forming new collaborative processes, how to compensate community members. These methods and processes require openness and adaptability, and should be documented to support TEKP integration in similar contexts.

In some cases, licensed permits will be necessary following legal procedures and guidelines. Ethical protocols should not only follow institutional, regional, and national requirements, but also community-based procedures, which will likely vary from community to community. Information that is being gathered for assessments must be treated as privileged and/or sacred, and the rights and interests of participating communities must be recognized and supported. As criteria and justification for assessments must be listed in a public domain (IUCN 2014), community consent will be necessary before any information is released, and might require additional discussions with local tribe leaderships (Moller et al 2004, Pearce et al 2009, Alessa et al 2015) to ensure culturally and institutionally appropriate storage of and access to information. Identifying which individuals best represent local community interests and priorities may not be an easy process, especially if community perspectives are broad in scope. This process might require considerable time and effort to build relationships and understand social and cultural contexts within local communities.

Inuit TEKP of polar bears in Nunavut, Canada

TEKP plays a key role in assessing the population status of the polar bear, a Red List species, in Canada. Indigenous traditional knowledge is also integral to conservation and management as a legal requirement through territorial land claims agreements (e.g., The Minister of Indian Affairs and Northern Development and the Tungavik Federation of Nunavut 1993 1993) and is
sanctioned at national (Government of Canada 2002) and international (Government of Canada et al 1973) levels. At the federal level, Canada manages polar bears according to designations under its Species at Risk Act (2002) and the Convention on International Trade of Endangered Species (CITES) categories, as well as partnerships with IUCN. These categories are largely informed by a combination of aerial mark-recapture (e.g., Taylor et al 2006), satellite telemetry (e.g., Bethke et al 1996), and less-invasive biopsy (Pagano et al 2014) and genetic (Van Coeverden de Groot et al 2013) surveys of individual subpopulations (Peacock et al 2011). In Nunavut, where 86% of the harvests occur (Peacock et al 2011), polar bear surveys often include and are led by local (Inuit) hunters, elders, and/or community Hunters and Trappers Organizations (Fernandez-Giminez et al 2006, Peacock et al 2011). Harvest monitoring by the government through salvaged sampling also occurs through collaborations with community hunters and wildlife officers who acquire hunting tags (Peacock et al 2012). Community residents have the opportunity to participate in all types of research and monitoring projects (Vongraven et al 2011, Peacock et al 2011) and all proposed studies are also led by TEKP and hunters and trappers organizations (Vongraven et al 2011, Peacock et al 2011).

For Inuit, polar bears are valued economically, culturally, and socially as a historical source of food, clothing, and artwork, and more recently income through guiding sport hunts (Freeman and Wenzel 2006). Thus, the inclusion of Inuit knowledge-holders in monitoring programs allows communities to inform management decisions that impact a traditional resource that they value. Beyond participation in scientific population studies, Inuit play a key role in co-management by the territorial Nunavut Wildlife Management Board (NWMB; NCLA 1993), regional wildlife and community hunters and trappers organizations, the Government of Nunavut Department of Environment, and Nunavut Tunngavik Inc., an organization that represents all Inuit beneficiaries as per the land claims agreement (NCLA 1993; Dowsley and Wenzel 2008). These territorial, regional, and community wildlife organizations are responsible for allocating harvest quotas, while government staff conduct necessary scientific research (via surveys), document TEKP, and make recommendations to NWMB and other decision-making bodies (Dowsley 2009, Peacock et al 2011). For management consultations (e.g. revision of quotas, allocation of quotas toward sport hunts), TEKP sharing and gathering takes place through public hearings or formal meetings with hunters and trappers within communities (Peacock et al 2011). In this manner, Inuit interests are represented throughout all tiers of polar bear management, from research to informing decisions.

Unfortunately, Canada has been criticized for including TEKP in its decision-making for polar bears; in some jurisdictions, only scientific data are included (Vongraven et al 2011, Clark et al 2013). This may be due in part to incongruences in protection levels across jurisdictions (Parsons and Cormick 2011, Clark et al 2013), lack of understanding in subsistence harvesting by Inuit (Clark et al 2013), media portrayal of commercial hunting by Inuit against an imminent extinction of polar bears (Tyrrell and Clark 2013), and disagreements among TEKP and scientific data (Dyck et al 2007, Stirling et al 2008, Clark et al 2008, Dowsley and Wenzel 2008, Clark et al 2013, Tyrrell and Clark 2014). A well-publicized example is the scientifically-reported population decline in Western Hudson Bay polar bears warranting a decrease in harvest quotas, while Inuit report dangerous human-bear interactions that have increased in frequency in and around communities, necessitating an increase in quotas (Tyrrell 2009, Dowsley and Taylor 2006, Clark et al 2013, Stirling and Derocher 2012). Unethical TEKP acquisition (Gearhead and
Shirley 2007), historical appropriation (Grimwood et al 2012) and perceived marginalization by communities (Peacock et al 2011) have also contributed to mistrust in science by TEKP holders. Lack of efficient research, effective integration of scientific and TEKP views, and confidence in either data types could lead to unsatisfactory decisions for all parties involved (Peacock et al 2011, Vongraven et al 2011). Improving communication of the cultural importance of species harvests and TEKP to stakeholders and public at large, and clearly defining limitations of TEKP and science alike could reduce polarization in perspectives (Peacock et al 2011). For example, clarifying TEKP excludes (scientific) information on physiological and biochemical changes linked to climate change, but emphasizes behavioral effects and ecological relationships (Berkes et al 2007).

The potential for conflicts over TEKP consideration in Red List assessments similar to those that arise in TEKP and polar bear conservation cannot be discounted. But TEKP could certainly be viably integrated in assessments using a range of methods, from survey and monitoring through all (e.g., community, regional, territorial, and national) levels of nested governance, especially in areas that are beyond the scope of science. Knowledge, awareness, and respect for TEKP and the communities where they are in place, appreciation of its unique differences in comparison to science, and comprehensive approaches to TEKP integration from the outset can mitigate any controversies over its inclusion.

**TEKP in conservation of medicinal plants in Bangladesh**

Ethnobiological knowledge is valued for scientific research and conservation management (Berkes et al 2000, Huntington 2000, Ghimire et al 2005). For resource users, medicinal plants form the basis of traditional (e.g., Unani, ayurvedic, homeopathic, and folk) remedies and raw ingredients for western medicines (Mollik et al 2010, Motaleb 2010). Unfortunately, several medicinal plants have suffered abundance decline due to global commercialization, habitat degradation and alteration, lack of support from government and policies, and limited management and institutional structures that insufficiently guard against overharvest (Kunwar et al 2013, Motaleb 2010, Sajem et al 2008). There is also a general lack of organized research and information on indigenous medicinal plant knowledge—especially plants that are least commercially profitable—which might serve as the only source of knowledge for most plants (Sajem et al 2008, Mollik et al 2010). As a response, initiatives that document and preserve medicinal plant TEKP are in place in the Himalayas and central Asia, including identifying large numbers of plant species; parts and chemical constituents used; methods of gathering, preparation, and administration; and diseases or ailments that are targeted (e.g. Kunwar et al 2013, Ragupathy et al 2008, Muthu et al 2006, Ayyanar and Ignacimuthu 2005).

Spending time with local communities and familiarizing oneself with local cultures and traditions can allow for the development of effective research practices, in contrast to scientific methods where studies are isolated from local contexts. Rigorous preliminary studies are successful in shaping subsequent research methods and outputs through a thorough understanding of local language, culture, and economy, including social control over medicinal plants (Ghimire et al 2005). One example is the One Stop Service project (OSS) by IUCN Bangladesh and the Bolipara Nari Kalyan Somity, which conducted a baseline survey a priori to understand the prevalence of traditional practices, followed by structured questionnaires, focus groups, and one-on-one discussions with elders, local community (headmen and kabaries) and
religious (bhante) leaders, Buddhist monks (boiddo), and local community members (Motaleb 2010). Similarly, variation in TEKP use of *Nardostachys grandiflora* and *Neopicrorhiza scrophulariiflora* have been documented in the Shey-Phoksundo National Park in Nepal following preliminary quantitative assessments to acquire general information on levels of knowledge across social groups (Ghimire et al 2005). Preliminary questionnaires have also been used to gather general information on medicinal plant TEKP by healers (kavirajes) in three Bangladesh districts (Mollik et al 2010). Quantitative statistical analyses (e.g., through quantifying informant consensus [Kunwar et al. 2013]) can also be used to determine consistency in initial survey responses (e.g., Singh et al 2012, Ghimire et al 2005). Effective project outputs include user-friendly online databases that detail basic medicinal plant usage, while detailed TEKP information is excluded to safeguard TEKP and ownership (Motaleb 2010). Awareness raising (e.g., workshops, school programs, fairs, brochures in English and native languages) and training initiatives (e.g., through scientific education and exposure visits to research centers; Motaleb 2010) have also together strengthened TEKP and local participatory capacity in these conservation programs. In these contexts, documenting TEKP of local medicinal plant management and use is valuable for potential pharmacological applications.

In far west Nepal, medicinal plant use regulation is under both formal and informal control by local communities, with roles played by *amchi* (representing TEKP institutions), religious heads, and local chiefs who set rules and fines when regulations are not respected (Lama et al 2001, Ghimire et al 2005). Informal regulations historically included rituals that encouraged ethical and respectful use of plants, with social constraints (local customary institutions) that regulate access to plant resources (Ghimire et al 2005). More recently, *amchi* health care centers have been established in areas frequented by commercial collectors; these newer groups still include representatives of older institutions, ensuring visibility of the *amchi* and apprenticeships through training and culturally appropriate health care practices (Kunwar et al 2013, Ghimire et al 2005). These local institutions also raise awareness in medicinal plant TEKP and monitor sustainable harvests that are used through it (Kunwar et al 2013, Ghimire et al 2005). Integrating local institutions of governance could support and preserve traditional mechanisms of resource management through the active engagement of local communities.

Successful monitoring institutions are highly flexible and continuously restructured according to shifting TEKP concepts, challenges, and contemporary use. However, medicinal plants are assigned a value for commercial use that lies beyond local contexts (Ghimire et al 2005), posing unique challenges to their management. Integrating local scales of governance within larger scales of managing commercial harvest is necessary, especially when the majority of medicinal plants are exported (Kunwar et al 2013). Sustainable TEKP integration will likely require larger scales of governance that are adaptable to smaller scale fluctuations, as well as systems that encourage knowledge transfer and persistence. In many cases, TEKP is also transferred from word of mouth, and knowledge transfer that lacks any systematic process could result in a TEKP loss in the future (Singh et al 2012). Indeed, traditional healers are now of old age and there is a general lack of interest among younger generations (Caniago and Siebert 1998, Muthu et al 2006, Kunwar et al 2013). Immersion in typical and local settings (e.g., while conducting household chores or collecting fruits and vegetables; Motaleb 2010) can reveal how TEKP is transferred within (e.g., from parents and mentors to offspring and protégés, respectively) and outside (e.g., to non-government organizations and outside projects) communities (Motaleb et al...
Through including individuals that have high social acceptance and influence on local opinions and decision-making (e.g., local government bodies and schoolteachers) throughout the project (Motaleb 2010), participatory capacity within communities could be encouraged and supported. Younger individuals, youth, and local schools and colleges could also be included to stimulate interest and support long-term local community involvement. For Red List assessments, rigorously documenting TEKP, the methods used to acquire it, and its mechanisms of local transfer could protect TEKP in its commercial applications.

**TEKP in fisheries and implications for management**

TEKP studies have been important in furthering our understanding of fishery dynamics toward solutions to population declines. Logistical challenges in studying spawning events and migration patterns (e.g., gathering in deep water at dusk or at night; Johannes 1981) in wide-ranging marine species often limit scientific ecological data to inform timely management actions. In many cases, local fishers are the only reliable sources for these data. Cuban fishers have gathered information on locations and timing of snapper and grouper spawning aggregations, and interviews with experienced fishers can identify spawning site locations and timing of peak densities (Lindeman et al 2000, Claro and Lindeman 2003). This information is valuable as population degradation, especially at the level of spawning aggregations, threatens the sustainability of fisheries and could lead to long-term economic damage for local communities (Sadovy and Colin 2012). Fishers are also aware of market constraints and technology changes (e.g., fishing gear and success) that influence fish behaviour (Johannes et al 2000, Grant and Berkes 2007). Interviews with experienced fishers and traders can also be cross-referenced to scientific literature reviews, newspaper articles and communication with academics and government officials to identify aggregation areas and nursery grounds requiring seasonal protection and reduce trawling pressure during spawning seasons (Sadovy and Cheung 2003). Similar ecological data have also been gathered through interviews with fishers in China and Hong Kong where the giant yellow croaker (*Bahaba taipingensis*) is valued for swimbladder consumption and medicinal use; fishers record catch information (date, location, and size) of all large fish on an ongoing basis as aggregations are considered significant events (Sadovy and Cheung 2003). However, interviews, questionnaires or surveys that are too structured and/or culturally inappropriate—for example, led and designed by researchers with little local input—have failed to target important and relevant ecological information (Johannes et al 2000), suggesting the importance of local contexts and researcher involvement beyond simply giving surveys in shaping TEKP research.

Traditional harvesting rights are often viewed as obstacles to government policies (Johannes and Yeeting 2000) and an understanding of local systems of governance can overcome barriers to collaborative management initiatives. In Tarawa Atoll, Kiribati, I-Kiribati (local fishermen) have identified the precise location of the last known spawning run of Kiribati bonefish (*Abula glossondotta*), which was previously unidentified by the Tarawa Fisheries Department. This led to corresponding protection by local fishermen without government sanction or interference (Johannes et al 2000). The I-Kiribati have historically possessed a marine conservation ethic, and an awareness that all marine resources are subject to depletion from overharvesting (Johannes and Yeeting 2000). Even beyond fish species, regulations are posed and strictly enforced in the form of taboos and punishment includes public censure, loss of harvesting rights, fines, and threats of supernatural retribution (Johannes and Yeeting 2000). I-Kiribati also imposed bans on
lures that are “too efficient” and damaging to fish species after the arrival of Western fishing technology (Johannes and Yeeting 2000).

Interview methods initiated and led by experienced fishers can detect species compositions of catches and historical systems of governance that are not revealed through government- or scientifically-led research alone (Johannes et al 2000, Fernandez-Giminez et al 2006). However, the inclusion of local fishers in assessments is usually limited by lack of explicit knowledge on how to include them, as well as language and conceptual barriers (Sadovy and Colin 2012). Identifying key informants can be met with additional challenges, as many younger or more easily accessible fishers tend to be less experienced, and studies that include any “local people” could lead to inaccurate portrayals of ecological dynamics (Johannes et al 2000). Allowing local communities to inform and guide research during initial planning stages could be effective in identifying key informants and research questions that are important and relevant. Methods for approaching communities may need to be developed on a case-by-case basis. For Red List assessments, locally established TEKP research could also help dilute mistrust in scientists and government agencies by local communities.

In one such example, multi-generational fishing leaders from the Greater Caribbean were invited to join the global Snapper, Seabream and Grunt Specialist Group when it was formed. These specialist group members contributed valuable comments during the reviews of draft Red List accounts for various species. The fishers had uniquely valuable comments on food web issues and the ability to extrapolate across regions in data-limited situations.

Table 1. Summary of methods of learning TEKP, systems of governance, challenges and lessons for TEKP inclusion in Red List assessments using three examples.

<table>
<thead>
<tr>
<th>Methods of learning TEKP</th>
<th>Inuit and polar bear conservation in Canada</th>
<th>Indigenous knowledge of medicinal plant use</th>
<th>Local fisher knowledge in fishery management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter participation in surveys; harvest sampling; interviews; workshops; focus groups; public consultations</td>
<td>Documenting species and methods of gathering, use, and healing applications; online database of TEKP terms and use</td>
<td>Semi-structured interviews; surveys of species capture histories, spawning areas, and cultural relevance and value</td>
<td></td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Systems of governance</th>
<th>Regulation of research and monitoring activities; distribution and allocation of harvest quotas; co-management wildlife boards; recommendations to higher tiers of management</th>
<th>Establishment of a locally-governed (health center) institution; management and regulations set by local tribe leaderships; awareness raising</th>
<th>Locally or federally set regulations against overharvest; local awareness and enforcement of human-animal relationships</th>
</tr>
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</table>

| Challenges | Contrasting ecological and management perspectives between Inuit and scientists; historical colonialism and lack of trust between Inuit and research communities | Loss of knowledge with older elders and youth lacking interest; integrating scales of governance | Identifying key users; loss of younger fishers; lack of guidelines on how to integrate TEKP |
**Lessons for Red List assessments**

- Focusing on overlaps between TEKP and science; clarifying roles of knowledge holders and outputs throughout process; nested scales of governance
- Immersion in local community culture; learning TEKP within local contexts; engaging youth
- Include user group leaders on advisory panels; allow communities to guide and lead research methods; recognize and respect harvesting rights in management contexts

**General guidelines for TEKP integration into Red List assessments**

A summary of three cases that incorporate TEKP into conservation and management in light of methods of learning TEKP, systems of governance, ongoing challenges, and lessons for Red List assessments is provided in Table 1. TEKP-based assessments should be conducted through partnerships with (versus participation of) key local knowledge holders from local communities. Community members should be involved as much as possible throughout all assessment stages, from initial planning and deciding what is relevant to the study to disseminating and/or using results (Fernandez-Giminez et al 2006). Informal and formal relationships between individuals leading assessments and knowledge holders (Gearhead and Shirley 2007, Pearce et al 2009) will be necessary to foster communication, trust, and cultural exchange and, thus, ensure successful collaborations (Wyborn and Bixler 2013, Pearce et al 2009). As it will likely be difficult to systematically evaluate these interactions, transparency in dialogue and detailed research notes throughout the whole process will be critical. Building flexibility and capacity will require time and will need to occur gradually in order for all local, scientific, public, and decision-making communities to learn and adapt in a dynamic manner (Berkes 2010). These relationships will likely require immersion in the community by non-community members who are conducting the assessments (Moller et al 2004, Pearce et al 2009, Grimwood et al 2012), training for community and non-community members alike, and leadership from communities on how to appropriately incorporate TEKP in species and environmental assessments.

Acknowledging the cultural relevance and importance of a species that is being assessed is critical, especially when Red Lists impact cultural connections to species. This could be facilitated by local partners and is critical from the onset, as species values will differ and potentially frustrate collaborations among scientists, local and/or indigenous communities, and relevant stakeholders who have command over the resource (Berkes 2012). Assessments must consider appropriate time scales; past and present impacts may have cumulative effects for present and future community members (Poe et al 2014). In order for assessments to benefit TEKP communities (and hence encourage their support for and inclusion in assessments), it is also necessary to incorporate community priorities and address any community concerns, even when they conflict with status quo circumstances and metrics of inclusion are unclear. Demonstrating how TEKP relates to management action and rights to food and land will empower indigenous communities to share information that tailors government decisions to local contexts (Moller et al 2004, Coombes et al 2014). This includes communicating openly how species assessments can benefit different community members or groups, how outputs of assessments will affect them, and how knowledge holders can shape the assessment process. Clear communication will also be necessary to allow knowledge holders to understand the nature of quantitative data, how scientific data is collected, and the context through which TEKP will be integrated into Red List assessments. Semantic uncertainty arises when terminology and criteria...
are vague or consistency across different assessments is lacking (IUCN 2012). Uncertainty could be minimized by translating and adapting IUCN’s categories and criteria (IUCN 2012) according to TEKP terminology and language or preferably vice versa. One could begin with local terms and processes and adapt or create relevant IUCN categories and criteria accordingly, especially where terminology does not compare or translate well. Defining mutual conservation goals and benefits (e.g., language preservation, education, and tourism) are the basis for effectively sharing TEKP.

Apart from species assessments, TEKP inclusion will likely shed light on asymmetries in power and politics, gaps in community resources and willingness to engage, colonial histories, and epistemological and scalar differences in management approaches (Agrawal 1995, Berkes 2012), as well as differences in institutional organizations of these systems (Friedlander et al 2013). TEKP integration will require multidisciplinary approaches to decentralize governance, support community-based management practices that are already in place, manage ecosystem services and human well-being according to socio-ecological information, and make informed tradeoffs in decision-making (Berkes 2010). TEKP inclusion in assessments will not only validate but also acknowledge TEKP as equally valuable as Western science in conservation, empowering local communities to regain ownership and control of knowledge where it has been historically appropriated through colonization (Moller et al 2004, Alessa et al 2015). Indigenous TEKP inclusion can also ensure indigenous perspectives and contexts are included in subsequent policy and action, recognizing indigenous roles as the first responders to change (Alessa et al 2015).

Beyond Red List assessments, any conservation initiative will certainly necessitate the inclusion of socio-ecological dimensions that are directly impacted by management, decision-making and policy.
References


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