The role of scientific and grassroots indicators in conservation of neotropical rainforests

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Abstract

Tropical ecosystems are under severe threat of biodiversity loss. At the current rate of extinction, creative measures need to be implemented to ensure sustainability of resources for indigenous communities and biodiversity conservation for global environmental health. Each region of the tropics experiences its own unique suite of threats and challenges that may best be addressed with a combination of modern ecological principles and traditional ecological knowledge. The Neotropics are facing numerous anthropogenic pressures which threaten the integrity of rainforest ecosystems and their local and global ecosystem services. Examples of grassroots and top-down conservation practices from around the world can help inform Neotropical rainforest conservation; combining grassroots and scientific principles may improve conservation effectiveness.

Keywords: Neotropics, biodiversity conservation, indigenous ecological knowledge, traditional ecological knowledge, climate

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The tropic zone is the warmest on Earth, and is defined as the equatorial region delimited by the latitudinal lines Tropic of Cancer and Tropic of Capricorn (23°N and 23°S respectively), however tropical ecosystems may exist beyond those boundaries (Smith & Smith, 2001). Tropical ecosystems include rainforest, dry forest, wetlands, savannah, and coral reefs (Bradshaw, Sodhi, & Brook, 2009; Maass et al., 2005). Tropical ecosystems are known for their contribution to global ecosystem services such as carbon sequestration, biodiversity, and provision of timber and non-timber forest products such as medicine, food, and spices (Maass et al., 2005). Ecosystem services may also be more site specific, for example: fresh water, small scale climate regulation, maintenance of soil fertility, shoreline protection, erosion control, recreation, and scenic beauty (Maass et al., 2005; Moberg & Folke, 1999).

Because of the confluence of geographical, geological and climatological factors that influence species richness, the majority of global biodiversity hotspots are found in tropical regions (Bradshaw et al., 2009; Myers, Mittermeier, Mittermeier, Da Fonseca, & Kent, 2000; Smith & Smith, 2001). Researchers are still working to gain a better understanding of the patterns of species richness; possible factors include temporal climate stability, ecosystem productivity, spatial heterogeneity, rate of speciation, and disturbance events (Hammond, 2005; Kricher, 1999; McGinley, 2014; Smith & Smith, 2001).

Rainforest Diversity

Rainforests are the most species rich terrestrial habitats on the planet. For example, the Neotropics exhibit the highest level of vertebrate endemism in the world (Smith and Smith, 2001). Typical rainforests experience an average annual rainfall of 2180mm, average temperature of 25.2℃, and a 3-4 month dry season. Trends in the last half of the 20th century show an annual increase in temperature of 0.26℃. However, trends in precipitation and dry season severity in the Neotropics are not as obvious due to regional variation (Mahli & Wright, 2004). Geographical landscape features such as mountain ranges may affect local climates and species distribution

(Maass et al., 2005; Mahli & Wright, 2004; Smith & Smith, 2001), while regional weather patterns such as El Niño may have further reaching effects (Mahli & Wright, 2004). Localized variations in climate and species distribution are important factors to consider for conservation planning.

Threats to Rainforests

The productivity and attractiveness of rainforest ecosystems draws a number of anthropogenic threats, both global and local in origin, such as poaching and building of roads and other infrastructure. Some of these threats arise from everyday use of rainforest resources, but are exacerbated through the increase in human population density or modernization (Mistry, Berardi, & Simpson, 2008; Laurance, 2009). Additionally, increased access to tropical rainforests has increased the likelihood of invasive species transmission (EPA Guyana, 2011) which can cause localized impacts by reducing native biodiversity (Vilà et al., 2011). Deforestation is an often cited threat to Neotropical rainforests (Barlow et al., 2007; Foley et al., 2007; Wright, 2005), as its negative effects on biomass and biodiversity can affect global and local ecosystem services. Wright (2005) mentions that while deforestation is at an all time high, secondary succession has aided in reforesting some of these areas. This reforestation may contribute to the global carbon cycle, but it may make limited improvement to local biodiversity (Barlow et al., 2007; Wright, 2005). Secondary forest and agricultural lands are able to support a number of animal species, however, the original plant diversity of primary forest is rarely recovered once cleared (Barlow et al., 2007).

Neotropical rainforests support a number of indigenous communities such as the Makushi and Wapishana of Guyana (Allicock, 2003; Watkins, 2011; Griffiths & Anselmo, 2010). Sanford and Horn (2000) raise the point that past human activity may have had just as much impact on rainforest ecosystems as current activity, whether positive or negative. For example, past human habitation in Neotropical rainforests may have changed soil properties, affecting future plant and animal biodiversity, while agricultural and cultural processes have resulted in wider distribution of plant species (Sanford & Horn, 2000). They suggest that historical habitat disturbance by humans may have had a positive impact on current species richness in lowland tropical rainforest. Historic land clearing and fires may have had similar effects as tree falls and other natural disturbances in that they opened the forest canopy, facilitating growth and distribution of plant species (Kennedy & Horn, 2008). It becomes clear that numerous factors (e.g. spatial, temporal, and cultural) need to be considered when managing and conserving Neotropical forests.

Conservation Approaches

Modern ecologists and conservation efforts utilize a number of techniques to classify the roles of species in their habitats and help the community recognize their importance. For example, *keystone species* are those with a disproportionate effect on their ecosystem compared to their population size. Much like the keystone in an arch, these species help support balance in their ecosystems (Paine, 1969a, 1969b). *Umbrella species* are those species which are chosen because efforts directed at their conservation can benefit numerous other species that occupy the same range. Common choices for umbrella species include large mammals and birds, because they typically have wide ranges (Roberge & Angelstam, 2004). While *flagship species* are not necessarily linked to specific ecological roles they are well-known and recognizable species that are chosen to be ambassadors for conservation; a classic example is the panda which has become the logo for the World Wildlife Federation (worldwildlife.org) (World Wildlife Fund, 2015). *Indicator* species are selected for specific purposes, such as monitoring ecosystem health, and therefore are relevant only in context (Carignan & Villard, 2001). Birds, butterflies, and insects are often selected as taxa for indicator species in tropical regions (Pearson & Cassola, 1992; Wood & Gillman, 1998). Pearson and Cassola (1992) suggest that tiger beetles (*Cicindelidae*) are suitable indicator species because they are nearly ubiquitous, and require shorter research time periods to achieve the same quality data as from birds or butterflies. However, Mistry et al. (2008) indicate that birds can be an effective and appropriate indicator species in areas like the North Rupununi wetlands in Guyana, despite the amount of time required to collect adequate data, because monitoring can become feasible by combining it with existing sustainable livelihood activities like bird watching.

Conservation managers utilize single species concepts as a means to efficiently monitor large conservation units. Distribution, abundance, and behaviour of target conservation species may make monitoring them either time consuming or costly. Therefore, indicator species, which can be more efficiently studied, are chosen as a proxy for health of the species or ecosystem in question (Carignan & Villard, 2002; Dale & Beyeler, 2001). Indicators can provide a snapshot view of the status of an ecosystem or species, or help monitor long term trends (Dale & Beyeler, 2001). The complexity of the target conservation unit (e.g. organism or landscape) should be reflected in the chosen suite of indicators which should address “structure, function, and composition” of the conservation target (Dale & Beyeler, 2001, p. 4).

Despite all of these tools, ecological features should not be the only consideration in conservation planning. In fact, the use of indicator species and other single species concepts for conservation has come under criticism (Barlow et al., 2007; Simberloff, 1998; Roberge & Anglestam, 2004). To remedy this, others offer solutions incorporating local cultures and their knowledge in conservation design (Berkes, 2009; Oba & Kotile, 2001; Platten & Henfrey, 2009). Indigenous cultures around the world have developed their own methods for monitoring and managing resources (Berkes, 1993), in some cases even enhancing their environments (Gadgil, Berkes, & Folke, 1993). This collection of knowledge and beliefs is known as traditional ecological knowledge or indigenous ecological knowledge (IEK) (Berkes, 1993). Indigenous communities, and their relationship with the ecosystem, are significant elements that should be factored into the conservation equation. Additionally, regional variation in climate, environment, and society require local perspective for well-rounded conservation plans (Berkes, 1993; Berkes, 2009). This paper will discuss single species concepts for conservation in terrestrial tropical environments, while considering the value of collaboration between modern science and indigenous communities.

Discussion

Indigenous peoples and conservation

Global examples*.* While methods may vary from culture to culture, the key aspect of IEK is the continued connection of these cultures to their surroundings and their ability to recognize critical changes in the environment (Berkes, 2009; Watkins, 2011). Examples from around the world provide possible solutions for grassroots conservation in the Neotropics. Pastoralists in the Booran region of Ethiopia assess landscapes for their grazing suitability and rate them for the herd they can best support (Oba & Kotile, 2001). Similarly, nomadic herders in Mongolia use a traditional rating system for pastoral lands to help them decide where herds should be grazed, and where their communities should move (Fernandez-Gimenez, 2000). Watershed conservation in Hawaii is an important part of local culture and indigenous practices (Gadgil, Berkes, & Folke, 1993). Agroforestry management by Runa Indians in Ecuador has been shown to increase plant species diversity by cultivating secondary forest species (Gadgil, Berkes, & Folke, 1993). Although IEK may not satisfy all the needs of modern science as it tends to be intuitive, spiritual, and qualitative, those features can make IEK a valuable component of holistic conservation and sustainable development when the needs of local stakeholders are incorporated (Berkes, 1993; Angura, 1996).

Grassroots indicators*.* While scientific ecological indicators are usually designed to monitor or assess the environment, indigenous ecological knowledge is often motivated by the desire for sustainable harvesting (Berkes, 2009). Grassroots indicators are species or environmental signals chosen by native communities to monitor ecosystem status and are often linked to time of harvest. The Teso people of Northeastern Uganda have evolved the use of a number of grassroots indicators linked to weather, astronomy, and animal behaviour that help them understand when to undertake vital agricultural practices (Orone, 1996). The Langi in Northern Uganda use grass species distribution as an indicator of soil fertility, which helps them determine which areas to plant, and which to develop (Angura, 1996). Much like scientific indicators, birds and insects are also very important grassroots indicators, leading local communities to know when to plant or harvest crops (Angura, 1996). While their motivations for doing so may sometimes be different than researchers, indigenous cultures have shown, through time, their desire to manage their local resources (Berkes, 1993).

Cultural Keystones. Cultural keystones, or keystone complexes, refer to species and associated practices that are integral to maintaining indigenous society (Platten & Henfrey, 2009). These complexes may have less significance for monitoring ecology using IEK, but have implications for how conservation planning should be implemented. In Guyana, Wapishana society is intrinsically linked to the harvest, processing, and consumption of bitter cassava through many different activities (Platten & Henfrey, 2009). Removing bitter cassava as a food source would not be detrimental to the tribe's diet, but it would be to their customs (Platten & Henfrey, 2009). The coca plant is another example of a cultural keystone, which is important to the Letuama people of the Columbian Amazon. Coca is used as a building material, religious offering, and medicine (Christancho & Vining, 2004). As with the Wapishana and bitter cassava, use of coca has helped form the structure of Letuama society. Christancho and Vining (2004) recorded a representative of the Letuama community as saying "please tell them this is too sacred for us… we won't allow them to clear cut our coca crops as they have done elsewhere" (p. 158). This appeal raises the relevance of including IEK and culturally important species in conservation planning in the Neotropics.

Conservation partnerships

Examples from the tropics. A unique perspective may be needed to assist in incorporating science and IEK. Local or regional institutions that have earned public support are ideal partners for collaboration. They can help ensure that the indigenous voice is not overshadowed by science (Watkins, 2011) and that scientific endeavours are adequately informed by local knowledge.The Iwokrama International Centre for Rainforest Conservation and Development (IIC) in Guyana is an excellent example of these principles in action. Programs at the IIC are managed by the Iwokrama Act, which aims to ensure that efforts support sustainable development in Guyana and have the best interests of indigenous communities at heart (Allicock, 2003). Partnership between IIC and the North Rupununi District Development Board (NRDDB) helped form the

Makushi Research Unit, which is a group of women that chronicles and disseminates Makushi IEK (Allicock, 2003). In addition to the social benefits for the women themselves, the work of the Makushi Research Unit helps outside parties better understand their culture. Amerindians see development as a means of progress, but also as a way to ensure integrity of their lands, where they obtain most of their resources (Griffiths & Anselmo, 2010). Understanding the significance of Amerindian society in Neotropical development and conservation initiatives could make the difference for project success.

Conclusion

Tropical ecosystems are rich and varied. Although much of the variation stems from climate or geology, the presence of indigenous societies can also contribute to variation in biodiversity. The global significance of these ecosystems attracts many international researchers and conservation groups who aim to monitor and conserve Neotropical biodiversity. Many solutions for ecological monitoring exist, yet managers who use them in isolation risk excluding valuable information that impacts how indigenous communities interact with tropical environments. Examples of grassroots conservation concepts from around the world can be put into practice in the Neotropics. Therefore, IEK and ecological data can be used in collaboration to monitor and manage tropical ecosystems. Partnerships between indigenous groups and regional or international organizations can help facilitate conservation planning.

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