

Indigenous Use of Tropical Biodiversity and Ecosystem Domestication

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Abstract People have long-induced modifications of ecosystems to enhance the suitable conditions for useful plant species; similar to plant domestication, these modifications can be regarded as a continuum of use and management. In tropical forests, indigenous people have contributed to these modifications by using ecosystems both actively and passively through a process called *ecosystem domestication*. In this chapter, we explore the gradient of ecosystem domestication and its implications to biodiversity. Historically, indigenous societies actively managed ecosystems to make their livelihoods possible in areas otherwise inadequate; the effects of such past management systems are still observable in present biodiversity. Currently, indigenous people continue to modify the ecosystems in which they live, using a diverse range of management practices (e.g., forest gardens, fallow improvement, and agroforestry techniques) which can be equated to different degrees of anthropogenic disturbances. These practices have deep consequences for overall biodiversity, often enhancing it. Therefore, areas inhabited by indigenous people show a high potential for new approaches of biocultural conservation.

In studying human-plant interactions, researchers acknowledge that plant domestication is better understood as a continuum which ranges from wild species and varieties to fully domesticated and even genetically modified crops, containing a wide range of species and varieties with different levels of domestication in between (Clement et al. 2010). However, what is often less considered is that plant domestication has not occurred alone, but rather has also involved a deep modification of the biophysical environment—a process Michon and De Foresta (1997) called *artificialization* and of which *cultivation* represents the ultimate degree. Similar to what happens at the species level, modifications of the environment leading to artificialization have to be understood as a gradient: people have modified the ecosystems in which they live from less to more active degrees to enhance or create suitable conditions for plants of interest. Thus, in addition to the cultivation of a particular plant

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species, a continuum of actions—at different scales—modify ecosystem conditions (Wiersum 2004), resulting in *ecosystem domestication* (Michon et al. 2007). Such actions have profound consequences on the overall biodiversity of the ecosystem and not only for the favored species.

The livelihoods of indigenous societies living not only in the past but also nowadays have been based on different forms of the use and management of ecosystems. Such variety allows for the study of the continuum of ecosystem domestication, from zero management to fully agricultural systems, and its impacts on biodiversity.

Research on historical ecology has shown that, worldwide, large tropical areas and the biodiversity they shelter have been shaped by millennia of active management (Smith and Wishnie 2000; van Gemerden et al. 2003; Sheil et al. 2012). For example, in the Amazon, past indigenous societies built earthworks, such as canals, ditches, and raised fields for agriculture, in areas where flooding would have otherwise hindered settlement and cultivation (Denevan 1966; Erickson 2008). These human transformations have contributed to create different ecosystems, such as forest islands (Heckenberger et al. 2007; Lombardo et al. 2015), still observable nowadays. All across the Amazon, large areas of *terra preta* (Amazonian dark earths) are also observable. Such soils originated from repeated burning in past societies (McMichael et al. 2014) and support forest with different composition from forest found in non-dark sites (Quintero-Vallejo et al. 2015), thus representing another example of long-lasting impact on current biodiversity by past ecosystem management.

As in the past, contemporary indigenous societies continue to modify the environment in which they live, mostly in their effort to maintain their livelihood. Through such interactions, indigenous people have developed knowledge, beliefs, and practices not only about particular species but also about larger ecological units (Posey 1985). The pathways through which indigenous people modify tropical forest diversity are varied and range along a gradient of use-management intensity from minimal management to the engineering of ecosystems (Smith and Wishnie 2000). Although the effects of current landscape management practices on ecosystem artificialization are not always predictable, it is important to note that ecosystem use and management practices can be equated to other anthropogenic disturbances and as such play an important role in maintaining biological diversity in ecosystems (White and Jentsch 2001). Thus, different forms of forest management can be related to different levels of forest biodiversity (see Gueze et al. 2015), since anthropogenic disturbances in tropical forests can range from severe modifications of forest structure (e.g., logging or clearing of forest for agriculture) to smaller-scale below-canopy disturbances that do not necessarily imply structural changes, such as slashing around some trees of interest, sapling transplantation, and hunting (Peres et al. 2006).

Sacred forests provide a good example of minor management forms that do not always imply structural changes of the forest. People's dynamic social and political norms and beliefs are directly associated with management practices of sacred forested areas, hence with biodiversity (Sheridan 2008). The relationship between cultural management and biodiversity conservation within sacred forests is complex,

and much debate is left on the role of these forests as conservation elements, particularly in fragmented landscapes where sacred groves do not always show significant differences in biodiversity with surrounding elements of the landscape (Bhagwat et al. 2005). While certain sacred groves are just a fraction of a forested area associated with dangerous spirits and thus intended to completely prevent the human presence, as it is the case among the Tsimane' of Bolivia (Huanca 2008), others are maintained to shelter a relatively high level of biodiversity and also contain many useful species and are thus designed to provide some basics of people's daily life, such as food, fibers, and firewood (Nyamweru et al. 2008).

Other forms of forest management, such as management for daily uses, represent intermediate stages in artificialization. Although forest management by hunter-gatherers is debated (Gadgil et al. 1993), the gathering of species that appear "wild" to Western conceptualization, such as wild yams for the Baka of the Congo Basin (Yasuoka 2006) and sago palms for the Punan of Borneo (Sellato 1994), seems to include other management practices similar to agricultural practices (Dounias 1994). Among other indigenous peoples that are not only hunter-gatherers but also agriculturalists, the literature provides many examples of indigenous agroforestry and forest gardens—the management of useful species in situ, often involving enrichment planting (Peters 2000; Wiersum 2004). Similarly, researchers have documented that people purposefully maintain species or groups of species within created or managed forests, something known as "domestic forests" (Michon et al. 2007). In the example of benzoin forests among the Batak Toba of Sumatra, people progressively include benzoin trees and manage forest mainly by selective cuts to allow young benzoin trees to develop (García-Fernández et al. 2003). The benzoin forest system thus involves mostly nonstructural disturbances, whereas other kinds of domestic forests are, in fact, secondary forest regrowths or "enriched fallows," involving a first stage of clear-cutting the forest for agricultural purposes. Both the management of the forest itself and the management of surrounding non-forest elements, such as agricultural fields or home gardens, lead to the creation of mosaics of ecosystems which, taken as a whole, enhance biodiversity at the landscape level (Gadgil et al. 1993).

The mosaics of ecosystems created by the combination of areas under different levels of disturbance represent what some researchers have termed *cultural landscapes* or areas where traditional ecological knowledge and biodiversity are closely interrelated through the incorporation of culturally valued biodiversity (Cocks and Wiersum 2014). Such biodiversity value can stem from the way people use species for material purposes or from the sacred or religious value they attribute to species and ecosystems. For example, Mulyoutami et al. (2009) have shown that many of the social norms of the Dayak of Borneo are highly interconnected with the management of different elements of the landscape, such as enriched fallows. As well, indigenous people have developed classification systems for landscape elements, which show the importance they attribute not only to species but also to the whole ecosystems (Hunn and Meilleur 2010; Riu-Bosoms et al. 2014).

Understanding the process of ecosystem artificialization has important implications in the light of biocultural conservation. The perception that tropical forests are

“pristine” natural areas, without human intervention, still prevails among some ecologists, conservationists, and the general public. Although more research is needed to understand the interaction between indigenous people and ecosystems (e.g., on different spatial scales), this perception has led to conservation schemes—such as exclusionary protections—that often fail to effectively protect biodiversity (Vermeulen and Sheil 2007). Rather, growing evidence shows that primary forests appear to be a chimera and that conservation plans designed to conserve the “untouched” and restore the “damaged” are biased (Vandermeer and Perfecto 2014); areas inhabited by indigenous people seem more appropriate for biodiversity conservation (Porter-Bolland et al. 2012). Tropical forests should be seen as ecosystems used and managed in a dynamic way by the people who inhabit them; since indigenous people depend on tropical forests to survive, they have the need to conserve them, and bottom-up approaches to conservation, such as community-based strategies, should be prioritized.

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