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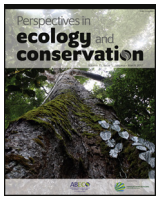

Essays and Perspectives

Humans as niche constructors: Revisiting the concept of chronic anthropogenic disturbances in ecology

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ABSTRACT

The ecology has witnessed a strong conceptual shift regarding the transition from human-free to human-dominated ecosystems. Nevertheless, human beings are still treated as exogenous factors in many ecological studies. Human activity can reasonably be assumed to influence many processes and patterns studied in ecology at different spatial and temporal scales. Thus, trying to predict the future of ecosystems while ignoring the influence of human activities is neither realistic nor useful. We argue that a successful integration effort in traditional ecology must result from a theoretical and/or conceptual change. A logical and intuitive theoretical leap should be one that considers human actions in light of an integrative scenario. In the first part of this article, we discuss the need for conceptual, theoretical, and methodological changes in studies focusing on the idea of chronic anthropogenic disturbances. In the second part, we introduce the Niche Construction Theory (NCT) as an integrative scenario accommodating these theoretical and conceptual changes in studies that investigate human actions in the environment. To exemplify our argument, we present a case study resulting from our research and focusing on the cascading effects of human activities and their multilevel and multiscale influences in the landscape.

Introduction

In recent years, the ecology has witnessed a strong conceptual shift regarding the transition from human-free to human-dominated ecosystems. Although an understanding of the implications this transition imposes on biodiversity conservation is not new (Noble and Dirzo, 1997), humans are still treated as exogenous factors, or the anthropogenic influences on ecological process is disregarded in many ecological studies (Liu, 2001). This treatment results in the inevitable questioning of the utility of this traditional approach in ecology. A major change in ecology would thus consist in effectively integrating human activity into ecological research (Alberti et al., 2003).

Most of the terrestrial biomes have been altered by human societies, thus we have generated major pressures on other lifeforms in the planet at a surprising scale, influencing selective pressures and driving the evolution of many species (Alberti et al., 2003; Boivin et al., 2016; Ellis, 2015; Palumbi, 2001). Therefore, the challenge lies in understanding the underlying mechanisms of human behavior that are involved in the interaction between humans and the environment and other species (Liu, 2001). Many processes and patterns studied in ecology are influenced by human activity at different spatial and temporal scales. Consequently, predicting the future of ecosystems while ignoring such activities is neither realistic nor useful.

The adoption of a shift from human-free ecosystems to human-dominated ecosystems (human-altered or human-induced) has apparently been superficial and has not resulted in a real change in ecological practice. We argue that it is imperative to acknowledge the advancements of the archeological and paleoenvironmental

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researches that undermine the pristine ecosystems viewpoint. There are increasing evidences that extensive non-fragmented forest areas or even the deserts are not pristine ecosystems. Instead, prehistoric societies have transformed the ecosystems consistently through domestication processes (including the agriculture and the livestock), soil and water resources management, tree species overexploitation to use as firewood, overhunting and overfishing (Bishop et al., 2015; Colonese et al., 2011; Huebert and Allen, 2016; Neves and Petersen, 2006; Levis et al., 2017; Schmidt et al., 2014; Westaway et al., 2017; Wright, 2017). Therefore, the current composition and the structure of the ecosystems are not determined only by climatic and edaphic factors, but are, in a great extension, influenced by human activities.

When we study a nonhuman species in its habitat, we discuss the "activities" that it performs. By discussing "activities," we intellectualize the complex interactions between this organism and its environment. In this sense, humans should be considered subjects in ecological experimentation (Alberti et al., 2003). This treatment would enable predicting human behavior and the impact of this behavior on habitats, populations, communities, and ecosystems (Liu, 2001). Otherwise, if there is no paradigm shift, some questions that have motivated researchers for decades will remain unresolved or poorly answered, such as "Why, how, when, where, and to what extent do humans affect other organisms and their abiotic environment? What novel approaches should be developed to answer these questions?" (Liu, 2001).

In this article, we argue that a successful integration effort, starting from traditional ecology, must result from a theoretical and/or conceptual change, and consequently, from changes in the experimental designs of the studies. A logical and intuitive theoretical leap should be one that considers human actions in light of an integrative scenario. Thus, we first discuss conceptual, theoretical, and methodological changes in studies focusing on the concept of "chronic anthropogenic disturbances". Subsequently, we introduce the Niche Construction Theory (NCT) as an integrative scenario accommodating this theoretical and conceptual change in studies on human actions in the environment.

Chronic anthropogenic disturbances and their relevance for ecology

In forest ecology, the concept of disturbance refers to phenomena that in some way disturbs the stability of a community or an ecosystem. Most of the phenomena considered as disturbances are those caused by the action of climatic or geological factors, such as winds, hurricanes, fires, droughts, rains, frost, snow, floods, earthquakes, landslides, and volcanic eruptions. However, there are also biotic factors considered as disturbances in forest ecosystems, such as outbreaks of plant pathogens, the development of herbivore superpopulations, bioinvasions and human action (Attiwill, 1994). In general, these climatic and geological disturbances are considered inherent processes to ecosystems and shape the composition and structure of forests (Attiwill, 1994).

There is a large set of ecological literature that has investigated the processes by which forest ecosystems can restore themselves after drastic environmental changes caused by human actions such as agriculture, logging, and anthropogenic fires (Costa et al., 2015; D'Oliveira et al., 2013; Francos et al., 2016; García-Orenes et al., 2017; Jang et al., 2016; Mamede and Araújo, 2008; Sobrinho et al., 2016). More recently, ecologists have sought to understand the consequences of more subtle human actions that do not result in drastic and sudden changes in the environment (usually named chronic anthropogenic disturbances; see Singh, 1998), such as wood collection for building houses and fences or for use as fuelwood, the extractivism of fruits, leaves or tree bark for food, medicinal or commercial purposes, extensive livestock, hunting and fishing (Bhuyan et al., 2003; Hinz et al., 2009; Marinho et al., 2016; Martorell and Peters, 2005; Ribeiro et al., 2015; Ribeiro-Neto et al., 2016; Ureta and Martorell, 2009). Although we believe that other human actions could fit within the scope of the definition of chronic anthropogenic disturbances, we will discuss only the aforementioned actions because they are the ones that literature usually considers and because they are the most widespread uses of forest resources on a global scale.

There are few explicit tests that evidence the ecological consequences of such human actions in the long term. However, some studies about patterns of forest resource uses provide some evidences of such consequences. For instance, wood collection for fuelwood demands large amounts of plant biomass (Medeiros et al., 2011; Ramos et al., 2008; Specht et al., 2015) because it is a resource used daily by low income rural populations from developing countries. Thus, some studies suggest that in the long run this activity may alter species composition (if some species are preferentially used), and decrease the density and total basal area of the tree populations, and consequently decrease the productivity of ecosystems (Lung and Espira, 2015; Rüger et al., 2008; Specht et al., 2015).

On the other hand, the wood collection for houses and fences building has a different dynamic, in which people usually use wood of a few particular tree species whose trunks possess great resistance and durability (Dahdouh-Guebas et al., 2000; Gaugris and Van Rooyen, 2009; Kakudidi, 2007; Medeiros et al., 2011; Nascimento et al., 2009; Oliveira and Hanazaki, 2011). This is because the time of replacement of the wood used on these structures tends to be long (over a decade) (Medeiros et al., 2011). This pattern of selective collection is an indication that, in the long term, this activity may decrease the density of the preferentially used species, leading to changes in the diversity of the local vegetation.

The collection of Non-Timber Forest Products (NTFP) is generally considered to be less harmful to ecosystems because it usually does not lead to the immediate death of the target individuals. However, the excessive collection of fruits and leaves can alter the phenology and fruit yield of the targeted individuals or decrease the recruitment rate, and consequently alter the age structure of the populations (Gaoue and Ticktin, 2007, 2008; Gaoue et al., 2014; Guilherme et al., 2015; Jimoh et al., 2013). In regions where human populations collect tree bark for medicinal or commercial purposes, excessive exploitation of these resources may lead to death of individuals that are mostly intensively collected, which also modifies the age structure and the density of the targeted populations (Feitosa et al., 2014; Ferreira Júnior et al., 2012; Soldati and Albuquerque, 2012). The damage recorded in the reproduction or renewal of the resource targeted for collection has led to the implementation of legal measures that regulate and restrict collections, thus generating conflicts between human societies and the environment.

Moreover, the act of extracting a specific resource, whether wood or another resource, may generate rapid or slow cascading effects on other forest species by changing their life conditions. These changes can result from (a) the formation of trails and forest clearings, which alter microhabitat characteristics such as the amount of light reaching the soil, which can create or eliminate physiological restrictions; (b) people walking in the forest while foraging for resources, thereby inducing unintentional damage and mortality to recently germinated seedlings and saplings; and (c) the sounds produced by people while collecting, which affects the behavior of forest animals (pollinators, dispersers, etc.) (Kissling et al., 2009).

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