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Methods matter: Different biodiversity survey methodologies identify contrasting biodiversity patterns in a human modified rainforest — A case study with amphibians

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ABSTRACT

Understanding how well tropical forest biodiversity can recover following habitat change is often difficult due to conflicting assessments arising from different studies. One often overlooked potentially confounding factor that may influence assessments of biodiversity response to habitat change, is the possibility that different survey methodologies, targeting the same indicator taxon, may identify different patterns and so lead to different conclusions. Here we investigated whether two different but commonly used survey methodologies used to assess amphibian communities, pitfall trapping and nocturnal transects, indicate the same or different responses of amphibian biodiversity to historic human induced habitat change. We did so in a regenerating rainforest study site located in one of the world's most biodiverse and important conservation areas: the Manu Biosphere Reserve. We show that the two survey methodologies tested identified contrasting biodiversity patterns in a human modified rainforest. Nocturnal transect surveys indicated biodiversity differences between forest with different human disturbance histories, whereas pitfall trap surveys suggested no differences between forest disturbance types, except for community composition. This pattern was true for species richness, diversity, overall abundance and community evenness and structure. For some fine scale metrics, such as species specific responses and abundances of family groups, both methods detected differences between disturbance types. However, the direction of differences was inconsistent between methods. We highlight that for assessments of rainforest recovery following disturbance, survey methods do matter and that different biodiversity survey methods can identify contrasting patterns in response to different types of historic disturbance. Our results contribute to a growing body of evidence that arboreal species might be more sensitive indicators than terrestrial communities.

1. Introduction

There is a pressing need to better understand future biodiversity and conservation value of tropical rainforest following human disturbance (Arroyo-Rodríguez et al., 2015; Dent and Wright 2009; Kinnaird et al., 2003; Peres et al., 2006), especially as the Global Forest Resources Assessment (FAO, 2010) classifies just 36% of global forest cover as primary. Despite regenerating landscapes representing the majority of remaining tropical forest, the potential of such human-modified forests to provide important habitat for rainforest biodiversity is contentious (Chazdon et al., 2009a,b; Gibson et al., 2011). As human populations in tropical countries increase and primary forest is converted to agricultural land and later abandoned, some authors suggest that secondary forests will become increasingly important for conservation (Anand et al., 2010; Arroyo-Rodríguez et al., 2015; Chazdon et al., 2009a; Durães et al., 2013; Irwin et al., 2010; Letcher and Chazdon 2009; Norris et al., 2010; Tabarelli et al., 2010), while others suggest that the

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major conservation priority is to protect remaining primary forest (Barlow et al., 2007a; Gibson et al., 2011; Sodhi et al., 2010); a debate that has been widely discussed (Chazdon et al., 2009a; Dent and Wright 2009; Melo et al., 2013).

Determining how well tropical forest biodiversity can recover is difficult (Gardner et al., 2010) as studies from different locations often produce contrasting results. There are many potential reasons for different studies to identify contrasting patterns; including geographic context, study scale, potential on-going human impacts, timeframe since disturbance (Chazdon et al., 2009a) and a tendency to focus on overall species richness patterns (Anand et al., 2010; Barlow et al., 2007a). However, one factor often overlooked is the potential for different survey methodologies, targeting the same indicator taxon (such as amphibians, butterflies and understorey birds), to provide different results on the response of biodiversity to habitat change (Barlow et al., 2007b). In the case of butterflies for example, line transect studies carried out in a number of locations have suggested that butterfly biodiversity does not show a significant degree of difference between human disturbed and primary forest (Devy and Davidar 2001; Kudavidanage et al., 2012; Posa and Sodhi 2006). In contrast, studies using traps undertaken at other sites suggest that butterfly biodiversity does show a significant degree of difference between human disturbed and primary forest (Dumbrell and Hill 2005; Ribeiro and Freitas 2012; Ribeiro et al., 2016). Additionally, bird studies carried out in different locations and based upon different survey methodologies have also found contrasting patterns (Barlow et al., 2007b). In some locations secondary forests display similar biodiversity levels to primary forest based on mist net methodologies (Barlow et al., 2007b; Srinivasan et al., 2015; Waltert et al., 2005), but other studies using point counts have suggested that secondary forest may have significantly lower levels than primary (Barlow et al., 2007b; Carrillo-Rubio et al., 2014). Understanding more about how these contrasting patterns might relate to differences due to survey methodologies can therefore help to improve our ability to assess the true value of regenerating tropical forests and better understand the response of specific communities. Otherwise, assessments of a specific community may under or overestimate the potential biodiversity value for such forests, especially if the results from single surveys are over generalised (Barlow et al., 2007b).

One key taxonomic indicator group utilised to study the impacts of habitat disturbance in tropical forests are amphibians, chosen due to their high conservation importance (31% of evaluated species are threatened with extinction; IUCN, 2015), and because they are key components within their ecosystems (Ficetola et al., 2014; Hocking and Babbitt 2014). Amphibians display a high level of sensitivity to disturbance due to low mobility, limited dispersal capacity and narrow ecological requirements (Lawler et al., 2010). Habitat change is therefore likely to affect amphibians more severely than other vertebrate groups (Ficetola et al., 2014); especially as small changes in vegetation structure can create significant alterations to amphibian communities (Cortés-Gómez et al., 2013). As a result, habitat destruction and fragmentation are among the leading causes of the global threat to amphibians (Catenazzi and von May 2014; Eigenbrod et al., 2008), especially in tropical regions where levels of diversity are highest (Ficetola et al., 2015).

So far, investigations using amphibians to assess rainforest biodiversity response to habitat change often use different survey methodologies and describe contrasting patterns from different locations. Hilje and Aide (2012), for example, utilised diurnal and nocturnal visual searches and acoustic surveys in Costa Rica and found that even young regenerating forest had similar amphibian species richness and composition to primary forest. In contrast, Gardner et al. (2007), using terrestrial traps and diurnal visual searches to target leaf litter amphibians in Brazil, found just two-thirds of primary forest amphibian species in regenerating forest. Finally, Seshadri (2014) utilised quadrats to assess amphibian biodiversity in selectively logged forests of southern India, detecting a 42% lower density of amphibians than in primary forest; and even though species richness and composition were converging with primary forest levels, the effects of logging were still detectable. These results therefore raise the question of whether the lack of a consistent pattern in detected amphibian responses is driven by site specific factors or whether such differences could be caused by different methods that focus on different groups of amphibian communities.

Here we investigate whether two different but commonly used biodiversity survey methodologies, pitfall trapping and nocturnal transects (Doan 2003; Dodd 2010; Heyer et al., 1994), find the same or different responses of amphibian biodiversity in areas with different historic human induced habitat change. We do so in a regenerating rainforest study site located in one of the world's most biodiverse and important conservation areas, the Manu Biosphere Reserve, a UNESCO World Heritage Site designated to protect the globally important Amazon rainforest and its biodiversity. Specifically, we quantified and compared species richness, diversity, abundance, community structure and composition of amphibian communities using both pitfall traps and nocturnal transect surveys, between areas of old regenerating forest, following different types of historic human disturbance. We predict that as each survey methodology likely targets a different subset of the amphibian community, each method will likely show a different degree of biodiversity response to habitat disturbance, or even display responses in opposing directions. Our null hypothesis would find no difference in the degree of difference detected of biodiversity patterns for both survey methodologies.

2. Methods

2.1. Study site

The study was carried out at the Manu Learning Centre (MLC) research station in the Peruvian Amazon (71°23′28″W 12°47′21″S). The site (described in detail in Whitworth et al., 2016a) is within the Manu Biosphere Reserve, which consists of a network of core protected areas surrounded by areas designated as cultural buffer zones due to historically high human impact, including extensive logging or clearance for subsistence agriculture. The study site lay within one of these cultural buffer zones. It consists of ~800 ha of regenerating lowland tropical forest.

Three different anthropogenic disturbance types had occurred: 1) selective logging (SLR – selectively logged and now regenerating forest), 2) complete clearance due to conversion to agriculture for coffee and cacao (CCR – completely cleared and now regenerating forest), and 3) a mixed area that had historically consisted of a mosaic of small completely cleared areas used for agriculture combined with selective logging of the adjacent forest (MXD – mixed disturbance and now regenerating forest). Major human disturbance had started ~50 years prior to the study and lasted for 20 years before systematic human disturbance activities were abandoned in the 1980s. For 30 years following abandonment the site was left to regenerate, and from 2003 the site was actively protected from further human disturbance. At the time of the study the whole area was covered by closed canopy regenerating tropical forest.

2.2. Study approach, sampling design, disturbance history and habitat classification

In order to test whether different methodologies indicate the same or different responses of biodiversity to historic human