Response: Commentary: Anthropogenic disturbances jeopardize biodiversity conservation within tropical rainforest reserves

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A commentary on

Commentary: Anthropogenic disturbances jeopardize biodiversity conservation within tropical rainforest reserves
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In their commentary on our recent paper (Martínez-Ramos et al., 2016), Arroyo-Rodríguez and Melo (2016, hereafter referred to as A-R&M) present imprecisions that need clarification to avoid misleading the readership of FEE regarding the contribution of our paper.

First, we focused on analyzing the effects of anthropogenic disturbances affecting a medium-sized (640 ha) tropical rainforest reserve (the Los Tuxtlas Research Station, protected by the National Autonomous University of Mexico, LTS). Our study was not designed to document landscape-level variation in the abundance of the palm Astrocaryum mexicanum among fragments in the Los Tuxtlas region (250,000 ha). Within LTS, we established a network of permanent plots to study this palm’s demography, starting in 1975 when human impact, within and outside the reserve, was lower than in the subsequent years. Along 40 years, we observed a dramatic population outburst of the palm (Figure 1), with cascading consequences on biodiversity (reduction in abundance and diversity, and composition shifts of understory tree assemblages) and ecosystem functioning (changes in biomass and litter-fall processes). Using empirical, experimental, and modeling approaches, we show that such extraordinary palm population growth responded to anthropogenic activities (deforestation and defaunation) occurring in the surroundings of the LTS (Martínez-Ramos et al., 2016). This favored palm fecundity, seedling recruitment, and the survival and growth of juvenile and immature palms within a protected area immersed in a landscape of anthropogenic impact.

Second, we challenge A-R&M’s comment regarding the robustness of our study. We employed eight plots (0.06 ha each), taking advantage of the high local abundance of A. mexicanum in LTS. Indeed, in 1975 we tagged (and then followed) more than 2300 individuals including seedlings, juveniles, and adults. Our plots were large enough to derive robust estimates of size-specific demographic rates (survival, growth, and reproduction) and of the population growth rate per plot.
the exponential growth of height. This is a critical drawback because we uncovered palms, younger than 35–50 years (densities within LTS with those in forest fragments outside widespread throughout this small reserve.

Fourth, it is unfitting to compare our palm population densities within LTS with those in forest fragments outside the reserve, as done by AR&M. Theirs are unprotected fragments exposed to multiple anthropogenic impacts (human and livestock trampling, cattle grazing, fires, logging, fruit harvesting) that directly affect the population dynamics of A. mexicanum. For example, the palm’s inflorescences are avidly consumed by local people, and are extensively harvested for sale in markets (Quero, 1992; Centurión-Hidalgo et al., 2009). Furthermore, people harvest the stems of large adult palms for use as agricultural tools, killing the single-stemmed palms. These activities have strong negative demographic consequences, reducing fruit production, seedling recruitment, and increasing adult mortality, thus reducing overall palm population density. By contrast, within the LTS these extractive activities are not allowed. It is therefore not surprising that in unprotected fragments, as those used by AR&M, palm population densities are varied, and often very low.

Fifth, it is also not surprising to find a positive relationship between tree species diversity and density of palms in the unprotected fragments studied by A-R&M. This relationship readily arises if tree species diversity varies across fragments while palm population density decrease with the intensity of anthropogenic disturbance in the fragments. The A. mexicanum populations of A-R&M were studied using single-time, static counts, making it impossible to know to what extent palm population density and tree assemblages have changed over time in their fragments. In contrast, we used a baseline population from 1975, followed for 4 decades, from which palm demography and the causes and consequences of the population explosion were assessed while we quantified the structure, composition and attributes of the ecosystem through time.

These arguments make it clear that A-R&M confused the essence of our article and, unfortunately, in so doing, provided a misleading view of the population dynamics of A. mexicanum both inside and outside the LTS reserve. Nevertheless, we concur with them that more efforts should be made to reach a comprehensive picture of the nuanced, frequently cryptic effects of anthropogenic activities on biodiversity. In this sense, studies like ours in PNAS and those mentioned by A-R&M are complementary and necessary to fully assess the condition of biodiversity in human modified landscapes. Finally, in accordance with Laurance et al. (2012) we emphasize the urgent need to monitor the health of ecosystems protected within reserves in the face of anthropogenic impacts occurring in their periphery.

**AUTHOR CONTRIBUTIONS**

MM, wrote the first version of the paper; IO, DP, RD, and JS reviewed and gave feedback on the writing of the paper.

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