Interactive effects of drought and habitat fragmentation on vital rates of an understory tropical plant

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Text of abstract

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Highlights: These are the highlights

# Introduction

Habitat fragmentation and drought are major threats to biodiversity, and it has been hypothesized that they could act synergistically to further reduce population viability in fragmented landscapes, particularly in the tropics (Didham and Lawton 1999, Laurance et al. 2001). Forest fragmentation is widespread and has resulted in 70% of the Earth’s remaining forest being within 1km of forest edge (Haddad et al. 2015). In the tropics… . Near edges, tropical forests experience increased solar radiation, increased temperature, and decreased humidity and soil moisture due to reduced microclimate buffering (Didham and Lawton 1999, Ewers and Banks-Leite 2013). This decrease in microclimate buffering could exacerbate the effects of drought in fragments compared to intact forest.

To date, however, this hypothesis remains untested for three primary reasons. First, most studies elucidating how tropical plants respond to fragmentation have studied either juvenile (i.e., seed, seedling) or larger, reproductive plants. . . Additionally, while most studies of tropical plant demography focus on trees, little is known about the understory plants that comprise up to \_\_\_\_% of biomass in tropical forests and are ecologically important .

Second, there is a growing literature on how tropical plants respond to severe droughts, but few studies have compared the responses of plants in continuous forest with those in fragments. Laurance et al. (2001) found that the increase in tree (>10 cm DBH) mortality during a drought were exacerbated in fragments, but the decline in mortality after the drought was also stronger in fragments. However, in a temperate system… (Forner et al. 2020).

Finally, the long-term data needed to test population-level hypotheses about climate change-fragmentation synergies are scant, especially for tropical systems (Crone et al. 2011, Salguero-Gomez et al. 2015). However, without multi-decadal sampling one cannot capture enough droughts to quantify their ecological impact, nor the variation in vital rates needed to parameterize demographic models of long-lived species in changing climates (Morris and Doak 2002, Teller et al. 2016). Long-term data are also needed because while some demographic effects of fragmentation or drought on can be detected immediately, others may take years to manifest.

1. Organisms experience multiple sources of natural and anthropogenic stress simultaneously. However, the impacts of multiple sources of stress on population dynamics are not well understood (Tye et al. 2016).
   * Cite Pedro F. Quintana-Ascencio in intro—he will likely be a reviewer.
   * Cite Jennifer Williams
   * Emphasize demography. We know about interactions on physiology and other stuff, but we don’t know as much about how demography of plants is shaped by how populations respond to multiple stresses, increasingly anthropogenic.
   * Especially difficult when lagged effects are expected. Part of the challenge in doing this modeling is the statistics are new . “Move beyond the statistical shackles of interaction terms”.LOL
2. As a result of intense deforestation, tropical lowland forests are becoming an increasingly fragmented landscape. This is especially true in the Amazon basin where \_\_\_\_ km2 forest are within 100m of a forest edge .
   * “Over 70000 km of new forest edges are being created annually in the Brazilian Amazon by human activities (Broadbent et al., 2008)”
   * also cite: Kapos 1989, Lovejoy et al. 1986, Kapos et al. 1997?
   * This can result in …
3. Simultaneously, these fragmented habitats are experiencing increased drought stress as a result of climate change. The northern Amazon has been experiencing a drying trend since the mid 1970s and ensemble climate models predict substantial decreases in dry season precipitation in southern Amazonia for the 21st century (Malhi et al. 2008). Additionally, El Niño Southern Oscillation (ENSO)-induced droughts are predicted to increase in frequency and severity (Cai et al. 2014).
   * 1997 ENSO drought (Williamson et al. 2000)
   * 2005 ENSO drought (Marengo et al. 2008, Phillips et al. 2009)
   * 2010 drought (Lewis et al. 2011)
   * Drought is bad because…
   * Combined environmental stresses, such as drought and fragmentation, have the potential to exacerbate or dampen effects on population dynamics (Tye et al. 2016).
4. Plant populations may be more susceptible to drought in fragmented forests. Fragmentation results in changes in forest microclimate that could exacerbate the effects of drought on plant populations. Near edges, tropical forests experience increased solar radiation, increased temperature, and decreased humidity and soil moisture due to reduced microclimate buffering (Didham and Lawton 1999, Ewers and Banks-Leite 2013).
   * Trees near forest edges experience increased mortality after droughts compared to forest interiors (Laurance et al. 2001, Schwartz et al. 2019).
   * Increased mortality after droughts disproportionately affects large trees.
5. Alternatively, plant individuals that are more susceptible to desiccation may not have survived fragmentation, resulting in populations in fragments which are more resilient to drought.
   * (Betts et al. 2019).

* In addition to variation among vital rates, responses to drought and fragmentation could depend on life history stage or plant size. Large established adults could respond differently than seedlings. This is unknown because there are very few systems where we have data on entire life history in a climate change or fragmentation context.
  + Fragmentation affects plant size (in *Heliconia* (Bruna and Oli 2005) and trees (Schwartz et al. 2019)). Smaller/larger plants might be more susceptible to drought. So differential effects of drought in fragments and continuous forest could be due to an interaction between drought and plant size.

1. We investigated the effects of drought on the growth, survival, reproduction, and recruitment of an understory plant in an experimentally fragmented landscape. Specifically, we want to know 1) Does drought increase or decrease the growth, survival, and fertility rates of plant populations in continuous forest? 2) Are the effects of drought on the vital rates of populations in fragments similar in direction and magnitude to those in continuous forest? 3) Are the effects of drought and fragmentation on vital rates consistent across life-history stages?

# Methods

*Heliconia acuminata* (Heliconiaceae) is a perennial, self-incompatible understory monocot native to the nonflooded rainforests of central Amazonia. *Heliconia* are rhizomatious, but clonal reproduction via underground runners is rare in *H. acuminata*, unlike other congeners (Bruna et al. 2004). Vegetative shoots grow from the rhizome as well as one or more flowering shoots when plants reproduce. Each flowering shoot has a single inflorescence of 20–25 flowers (Bruna and Kress 2002). Flowers are pollinated nearly exclusively by two species of hummingbirds at this site . Pollinated ovaries develop into fleshy fruits containing a maximum of 3 seeds which are dispersed exclusively by birds (Uriarte et al. 2011, Bruna 2014).

## Site

* All field data were collected at the Biological Dynamics of Forest Fragments Project (BDFFP)—a long term experimental site located about 80km north of Manaus (2º30’ S, 60ºW) (Bierregaard, et al. 1992, Laurance et al. 2002, 2011). The experimental plots are located in BDFFP reserves in nonflooded tropical lowland rainforest with nutrient-poor, well-draining, xanthic ferrosols.
* Something about seasonality
* BDFFP is comprised of replicated forest fragments of 1, 10, and 100ha as well as continuous forest plots that were established between 1980 and 1984. Fragments were maintained by clearing secondary growth around fragments occasionally . Demographic plots (m) were established in to track the growth, reproduction, and survival of *Heliconia acuminata*. Six of these plots were established in continuous forest, four were in 1-ha fragments, and three were in 10-ha fragments. The plots in continuous forest were established at haphazardly chosen locations 500–4000m from any mature forest borders, plots in 1-ha fragments were established on a randomly selected half of the fragment, and plots in 10-ha fragments were established in the center.

# Results

# Discussion

metapopulation dynamics stuff goes here.

# Conclusion

# Acknowledgments

If TRMM data is used, they suggest: “The TMPA data were provided by the  
NASA/Goddard Space Flight Center’s Mesoscale Atmospheric Processes Laboratory and  
PPS, which develop and compute the TMPA as a contribution to TRMM.”

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### Colophon

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