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

1. Little is known about how organisms respond to multiple anthropogenic stresses simultaneously
2. The Amazon Basin, an important place, has been fragmented, and although deforestation has slowed in recent years, it is continuing.
   1. fragmentation is bad because…
3. Simultaneously, there is a drying trend in the Amazon and also increasing intensity and frequency of droughts caused by ENSO (wet-season) and sea surface warming (dry-season).
   1. Drought is bad because…
4. The effects of drought and fragmentation could be additive, or interactive.
   1. The effects of drought could be more severe in fragments because of reduced microclimate buffering.
   2. Alternatively, plants in fragmented habitats could be more resilient to drought because the individuals surviving in fragmented forests are already resilient in the face of a relatively dry and variable climate, even in non-drought years.
   3. 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.
5. We investigated the effects of drought on the growth, survival, reproduction, and recruitment of an understory plant in an experimentally fragmented landscape.
6. Specifically, we want to know 1) Does drought have different impacts on plants in forest fragments compared to intact forest? 2) Do the magnitudes and directions of these effects differ among vital rates? 3) Do the effects of drought, fragmentation, and their interaction vary with plant size

# Notes for Introduction (first attempt at outline):

Habitat fragmentation is bad, pervasive, and getting worse

* stats about global land use change
* stats about amazon deforestation (Malhi et al. 2008)
* stats about how much land is near an edge (refs in Schwartz et al and betts 2019)
* Why fragmentation bad
  + microclimate changes (Ewers and Banks-Leite 2013)
  + metapopulation and connectivity stuff (necessary?)
* Plants in the tropics are less well adapted to fragmentation because lack of historical distrubance and less variable climate (Betts et al. 2019)

## Climate change and drought

* 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).
* The El Niño–Southern Oscillation (ENSO) reduces wet-season rainfall in the Amazon . ENSO-induced droughts are predicted to increase in frequency and severity. (Cai et al. 2014).
* Also sea surface temperature related drought. Warming of north Atlantic results longer and more intense dry season in southern and eastern Amazonia (Malhi et al. 2008, Phillips et al. 2009)
* drought effects on plant vital rates
* 1997 ENSO drought (Williamson et al. 2000)
* 2005 ENSO drought (Marengo et al. 2008, Phillips et al. 2009)
* 2010 drought (Lewis et al. 2011)
* (Zeng et al. 2008)

## Interactions

* However, our understanding of how climate change and habitat fragmentation might interact to impact organisms is limited.
* (Schwartz et al. 2019) (mention how tree size classes affected differently, but we don’t know if this is also true for understory herbaceous plants.
* (Malhi et al. 2008)
* The 1997–1998 ENSO drought caused greater tree mortality and increased leaf litter fall in experimentally fragmented forests compared to intact forest in the Amazon (Laurance and Williamson 2001).
* Furthermore, the interactive effects of fragmentation and drought may be difficult to detect in long-lived species (e.g. Heliconia) [bruna paper that shows growth is reduced after 10 years slightly, but impacts reproduction]

## This experiment

* The “fragmentation drought hypothesis” expects drought to have stronger impacts on forest fragments because of reduced microclimate buffering. Under this hypothesis we would expect drought to reduce growth, survival, reproduction and recruitment more in fragmented landscapes compared to intact forest.
* It’s also possible that plants in fragments have already been filtered such that the survivors are already adapted to more variable and desiccating conditions associated with forest edges (Schwartz et al. 2019). This may result in drought having a less noticeable impact on plants in fragments, although we would expect fragmentation to still have an impact on survival, growth, and reproduction.
* We set out to answer the following questions: 1) Does drought have different impacts on plants in forest fragments compared to intact forest? 2) Do the magnitudes and directions of these effects differ among vital rates? 3) Do the effects of drought, fragmentation, and their interaction vary with plant size (Tredennick et al. 2018) ?

# Background

# 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

# 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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