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

# 1 Introduction

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 .
   * 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?

# 2 Methods

## 2.1 Study site

The Biological Dynamics of Forest Fragments Project (BDFFP) is located ~70 km north of Manaus, Brazil (2º30’ S, 60ºW). In addition to large expanses of continuous forest, the BDFFP has forest fragment reserves ranging in size from 1-100 ha (Fig. –). These fragments were isolated from 1980-1984 by felling the trees surrounding the forest patch chosen for isolation and, in most cases, burning the downed trees once they dried. The vegetation regenerating around fragments is cleared periodically to ensure their isolation (Bierregaard et al. 2001). The BDFFP reserves are located in nonflooded (i.e., *terra firme*) tropical lowland forest with a 30-37m tall canopy, emergent trees up to 55m (Rankin-de Merona et al. 1992), and an understory dominated by stemless palms (Scariot 1999). The soils in the reserves are nutrient-poor xanthic ferrosols with poor water retention capacity despite their high clay content. Mean annual temperature in the region is 26º C (range=19–39º C), and annual rainfall at the BDFFP reserves ranges from 1900-2300 mm with a pronounced dry season from June to October (Appendix?).

## 2.2 Focal species

*Heliconia acuminata* (LC Rich.) (Heliconiaceae) is a perennial monocot widely distributed throughout the Central Amazon (Kress 1990), and it is the most abundant understory herb at the BDFFP (Ribeiro et al. 2010). While many *Heliconia* species grow in large patches along forest edges or in disturbed areas, others – such as *H. acuminata* – are found at lower densities in shaded forest understories. Species in this group produce fewer infloresences and are pollinated by traplining hummingbirds that move from one plant to the next rather than defend a territory (Berry and Kress 1991). In our sites *H. acuminata* is pollinated by *Phaeothornis superciliosus* and *P. bourcieri* (Bruna et al. 2004); reproducctive plants will have 1-X flowering shoots , wach of which has an inflorescence with 20–25 flowers (Bruna and Kress 2002). Fruits mature April-May and are consumed by a thrush and several species of manakin (Uriarte et al. 2011). Dispersed seeds (1-3 seeds per fruit, =2) germinate ~6 months after dispersal at the beginning of the rainy season, and have higher rates of germination and seedling establishment in continuous forest than forest fragments (Bruna 1999, 2002). *Heliconia acuminata* is self-incompatible and does not reproduce vegetatively.

## 2.3 Demographic data

In 1997-1998 we established a series of 5000 plots (m) in the BDFFP reserves in which we marked and measured all *H. acuminata*. The plots are located in continuous forest (n=6), 10-ha fragments (n=3), and 1-ha fragments (n=4), with distance between plots ranging from 500 m-41 km. Plots in 1-ha fragments were on one randomly selected half of the fragment, plots in 10-ha fragments were in the fragment center, and plots in continuous forest were placed in locations 500-4000 m from the borders of secondary and mature forest (Fig or Table). Each plot is subdivided into 50 quadrats (m) to simplify surveys, during which we recorded the identity of flowering plants, the number of vegetative shoots each plant had, and the height of each plant to the tallest leaf. Height and shoot number are correlated with leaf area, the probability of flowering, and rates of survivorship (Bruna and Kress 2002, Bruna et al. 2002). In 2008 we mapped the location of all established plants to the nearest 10 cm; in subsequent years we did the same with all new seedlings. There is a seven-fold range in H. acuminata density in the forest plots, with density in several of the plots comparable to that in low-density fragments (Bruna and Kress 2002).

# 3 Results

# 4 Discussion

metapopulation dynamics stuff goes here.

# 5 Conclusion

# 6 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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### 7.0.1 Colophon

This report was generated on 2020-11-20 11:23:19 using the following computational environment and dependencies:

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#> Remote: master @ origin (https://github.com/BrunaLab/HeliconiaDemography)  
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