**TITLE**. Abundance and demography of the understory herb *Heliconia acuminata* (Heliconiaceae) in an experimentally fragmented landscape in the Central Amazon (1997-2009)

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**Abstract**

**key words**

Amazon

Annual census

Brazil

deforestation

demography

edge effects

flowering

forest fragments

growth

habitat fragmentation

population dynamics

vital rates

**METADATA**

**CLASS I. DATA SET DESCRIPTORS**

**A. Data set identity:** This database contains X dataset – annual census data (1997-2009) from 13 populations of *Heliconia acuminata* in an experimentally fragmented landscape in the Central Amazon – and the metadata for each file.

**B. Data set identification code:** \_\_\_\_\_\_.csv (demographic data), \_\_\_\_\_\_\_.csv (site info?)

**C. Data set description**

**1. Principal Investigators:**

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**2. Abstract:** Descriptive abstract summarizing research objectives, data contents (including temporal, spatial, and thematic domain), context and potential uses of

data set)

The data set is 12 years (1997-2009) of annual censuses of 13 populations of the Amazonian understory herb *Heliconia acuminata* (LC Rich.) at the Biological Dynamics of Forest Fragments Project north of Manaus, Brazil. The plants are located in 50 x 100 m permanent plots located in forest fragments of different sizes (four 1-ha fragments and three 10-ha fragments) as well as 6 continuous forest sites. The population in each plot was censused annually, at which time we recorded the mortality of any previously marked plants and the size of surviving plants. We also marked and measured new seedlings. During the flowering season we also recorded the identity of flowering plants and how many inflorescences each of them produced. The data set can be used to study the ecological factors influencing the demography and population dynamics of tropical plants, as well as the consequences for plant demography and population dynamics of anthropogenic impacts such as deforestation or climate change. Sampling is ongoing and data will be added over time.

**D. Key words:**

Amazon, annual census, Brazil, deforestation, demography, edge effects, flowering, forest fragments, growth, habitat fragmentation, population dynamics, vital rates

**CLASS II. RESEARCH ORIGIN DESCRIPTORS**

**A. Overall project description:**

**1. Identity:** Annual census data (1997-2009) from 13 populations of *Heliconia acuminata* in the experimentally fragmented landscape of the Biological Dynamics of Forest Fragments Project (Manaus, AM, Brazil)

**2. Originator(s):** Emilio M. Bruna, W. John Kress, and Maria Uriarte

**3. Period of study:** 1997-2009

**4. Objectives:** To compate the demography and population dynamics of the Amazonian understory herb *Heliconia acuminata* (Heliconiaceae) in experimentally isolated forest fragments and continuous forest.

**5. Abstract:**

**6. Source(s) of funding:** The initial establishment of plots and 1998-2002 surveys were supported by the Smithsonian Institution (Graduate Student Research Award to E. M. Bruna), the University of California, Davis (Center for Population Biology and M. E. Mathias Graduate Research Grants to E. M. Bruna), the Biological Dynamics of Forest Fragments Project (Graduate Student Logistics Grant to E. M. Bruna), the National Science Foundation (Dissertation Improvement Grant INT 98-06351 to E. M. Bruna), and the Ford Foundation (Dissertation Year Fellowship to E. M. Bruna). The 2001-2005 surveys were supported grants from the National Science Foundation (Research Starter Grant DEB-0309819to E. M. Bruna). The 2006-2009 surveys were supported by grants from the National Science Foundation (DEB-0614149 to E. M. Bruna and DEB-0614339 to M. Uriarte).

**B. Subproject description:** The core of the *Heliconia* Demography Project is annual censuses of *H. acuminata* populations found in either continuous forest or the BDFFP’s experimentally isolated forest fragments. In addition to recording the reproduction, growth, and survivorship of established plants, newly recruited seedlings are marked, measured, and assigned their own unique identification number. These data can be used for a broad range of analyses, but the primary purpose behind their collection was to parameterize models with which to compare the demography and population dynamics of *H. acuminata* populations in fragments and continuous forest.

**1. Site description**

1. **Study Site**: The data were collected at the Biological Dynamics of Forest Fragments Project (BDFFP), located approximately 70 km north of Manaus, Amazonas, Brazil (2°30’S, 60°W). The BDFFP is a 1000-km mosaic of lowland forest, forest fragments, secondary forests, and pastures (Bierregaard et al. 2001). It is currently administered collaboratively by the Smithsonian Tropical Research Institute and Brazil’s Instituto Nacional de Pesquisas da Amazônia (INPA).

The BDFFP landscape is an area of often rugged topography ranging from 50-150 m elevation (Gascon and Bierregaard Jr. 2001) and includes catchments of the Urubu, Cuieiras, and Preto da Eva rivers (Nessimian et al. 2008). The canopy in the sites reaches a height of ~30–35 m, with emergents up to ~55 m tall. The tree community at the BDFFP is highly diverse, comprising approximately 1300 species (Laurance 2001), with some locations having over 280 tree species ha-1 (de Oliveira and Mori 1999). The understory is dominated by stemless palms (Scariot 1999); over 50 species of understory herbaceous plants are found in the BDFFP landscape (Ribeiro et al. 2010). Soils are nutrient-poor xanthic ferralsols, known as yellow latosols in the Brazilian soil classification system. They have poor water-retention capacity despite their high clay content (Fearnside and Leal Filho, 2002).

All *Heliconia* Demographic plots are located in non-flooded (i.e., *terra firme*) forest and none are bisected by streams.

1. **Climate:** Mean annual temperature at the site is 26°C (range 19-39°C). Annual rainfall ranging from 1900-2300 mm (BDFFP records), with a pronounced dry season from June-December (<100 mm rain per month).
2. **Site history:** A complete history of the BDFFP can be found in Gascon and Bierregaard Jr. (2001). Briefly, the BDFFP fragments were created from 1980-1984 by felling the trees surrounding the forest to be isolated (Lovejoy et al. 1986). For some fragments, this was followed by burning the felled trees and planting pasture grasses. Fragments were fenced to prevent incursion by cattle from the surrounding pastures. To ensure fragments remain isolated, a 100m strip around each fragment is regularly cleared of the secondary growth (BDFFP records). The structure and species composition of the secondary growth that surrounds a fragment, which is strongly dependent on whether fire was used to clear land (Mesquita et al. 2001), can have large effects on the biological dynamics and abiotic conditions in fragments (Laurance et al. 2002, Laurance et al. 2011).

**2. Study design**

1. **Focal species:** *Heliconia acuminata* (Heliconiaceae) is a perennial, self-incompatible monocot native to Amazonia (Kress 1990) and widely distributed throughout the Amazon basin (Berry and Kress 1991). Although many species of *Heliconia* grow in large aggregations on roadsides, gaps, and in other disturbed habitats, others, such as *H. acuminata*, grow primarily in the shaded forest understory (Kress 1983). It is the most abundant understory herb throughout much of the BDFFP (Ribeiro et al. 2010).

Although *Heliconia acuminata* can be propagated by segmenting the rhizome (Berry and Kress 1991), vegetative reproduction in the field is limited and recruitment primarily via seed (Bruna 1999, 2002). *Heliconia acuminata* flowers during the rainy season, when reproductive plants produce 1 or more bracts subtending up to 25 flowers each (Bruna and Kress 2002). Flowers are pollinated by the ‘traplining’ hummingbirds *Phaeothornis superciliosus* and *P. bourcieri* (Bruna et al. 2004)*.* Flowers are open only 1 day and visitation rates are low.Fruits produced by successfully pollinated flowers have up to three seeds and are dispersed by birds. In our sites these dispersers are primarily a thrush and several manakins (Uriarte et al. 2011). Seeds germinate 6-7 months after dispersal at the onset of the rainy season (Bruna 1999, 2002).

*Heliconia acuminata* leaves are sometimes damaged by the hispine beetle *Cephaloleia nigriceps* Baly (Staines and Garcia-Robledo 2014), but the amount of leaf tissue removed is minimal (Bruna et al. 2002, Bruna and Ribeiro 2005). However, the beetles can cause extensive damage to the bracts, ovaries, and developing fruits. Experiments also indicate post-dispersal seed predation is very low and that *H. acuminata* has no seed bank (Bruna 1999, 2002); the lack of a seed bank could be due to limited seed viability, mortality resulting from burial under leaf-litter, or both (Bruna and Nogueira Ribeiro 2005).

1. **Taxonomy, systematics, and voucher specimens:** *Heliconia* is the only genus in the family Heliconiaceae. This family is distinguished from the others in the order Zingiberales by inverted flowers, having a single staminode, and fruits that are drupes. It is estimated that there are 200-250 speciesof *Heliconia, almost all of which are native to the Neotropics*. *Heliconia acuminata* L. C. (Rich.) (Richard 1831) is one of the approximately 20 *Heliconia* species found in the Brazilian Amazon (Kress 1990).

Voucher specimens of *H. acuminata* collected at the BDFFP as part of this study can be found at the UC Davis and INPA Herbaria (accession numbers DAV 69391-69396 and INPA 189569-189573, respectively).

1. **Study Design**: The study consists of 13 demographic plots distributed across the BDFFP landscape (Bruna and Kress 2002). Six plots are in continuous forest, four are in 1-ha fragments, and three are in 10-ha fragments. Each demographic plot was 50m x 100m and subdivided into 10 x 10 m subplots to facilitate the initial surveys and locating plants in subsequent years. Plots in 1-ha fragments were established in a randomly selected half of the fragment, plots in 10-ha fragments were established in the fragment center, and plots in continuous forest sites were haphazardly placed at locations 500-4000 m from any secondary forest/mature forest borders. The plots furthest apart were separated by ~65 km.

[FIG 1 of BDFFP Landscape with location of plots]

[Table 1 with general characteristics of each plot]

[FIG 2 maps of individual plot locations with subplots]

Plots 1-ha fragments, 10-ha fragments, and three of the continuous forest sites were established from January-April 1997, the remaining three plots in continuous forest were established in January 1998. To mark the plants, a team of 2-3 people slowly walked through each subplot and located all *Heliconia acuminata* and marked them with a wooden stake to which was attached an individually numbered aluminum tag (Racetrack Aluminum Tags, Forestry Suppliers). Each plant was then measured by (1) by counting the number of vegetative shoots it had and (2) measuring the height of the plant from its base of the its highest point above the ground. Three additional plots were established in continuous forest sites in 1998 (CF 4-6); all plants in these plots were tagged and measuring in the same way as in other plots.

1. **Annual Demographic surveys**: Plots were censused annually with the onset of the rainy season and seedling establishment (generally late January to February). The exception to this was the three continuous forest plots established in August 1998, which were censused in August 1999. During each census, team members recorded the size of all surviving plants, marked and measured all new seedlings, and measured all surviving plants. Regular visits were made to all 13 plots throughout the rainy season to identify reproductive individuals, at which time we recorded the number of inflorescences.

Plants were marked with individually numbered tags. The height of plants to the tallest leaf was measured to the nearest millimeter with tape measures.

1. **Project personnel:** In addition to the Principal Investigators, key personnel included Lead Technicians responsible for coordinating the annual census, BDFFP Staff Technicians that assisted with multiple surveys and plot maintenance, and undergraduate and postgraduate field assistants hired that assisted with individual surveys.

*Lead Technicians:* Paulo Rubim (years), Maria Rosa Darrigo (years), Simone Benedet (2004), Cris Follman Jurinitz (2003), Maria Beatriz Nogueira (2002), Sylvia Heredia (2001-2002).

*BDFFP Staff Technicians:* Osmaildo Ferreira da Silva, Francsico Marques, Alaercio Marajó dos Reis

*Field Assistants:* Wesley Dáttilo da Cruz (2007), Jefferson José Valsko da Silva (2007), Elisabete Marques da Costa (2006), Bruno Turbiani (2005), Cristina Escate (2004), Cris Follman Jurinitz, David M. Lapola (2003), Denise Cruz (2003), Maria Beatriz Nogueira, Obed Garcia (2001), Olavo Nardy (2000),

**CLASS III. DATA SET STATUS AND ACCESSIBILITY**

**A. Status**

**1. Latest update:** January 31, 2019

**2. Latest archive date:** January 31, 2019

**3. Metadata status**: January 31, 2019

**4. Data verification:** Status of data quality assurance checking

**B. Accessibility**

**1. Storage location and medium:**

(Ecological Society of America data archives [Ecological Archives], URL published in each issue of its journals).

**2. Contact person(s):**

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**3. Copyright restrictions:** None

**4. Proprietary restrictions:**

None. However, we request that authors of publications using these data (1) cite the data paper as per Ecological Archives policy, (2) register the publication as part of the BDFFP Technical Series by contacting the BDFFP Director or E. Bruna, and (3) provide E. Bruna with a copy of their article upon acceptance. This allows us to track the dataset’s usage, advise users of any corrections, report articles using the data to the funding agencies that provided support, and document that different ways in which the scientific community uses the data.

**a. Release date:** N/A

**b. Citation: How** data may be appropriately cited:

As per the guidelines of the ESA archives policy…….

**c. Disclaimer(s):** None

**5. Costs to use the data:** None

**CLASS IV. DATA STRUCTURAL DESCRIPTORS**

**A. Data set file**

**1. Identity:** Unique file names or codes

--------.csv

**2. Size:** Number of records, record length, total number of bytes, etc.

----- rows (including header), --- kilobytes.

**3. Format and storage mode:** ASCII text, comma delimited. No compression scheme used.

**4. Header information:** The first row of the file contains the carriable names below.

**5. Alphanumeric attributes:** Mixed.

**6. Special characters/fields:** Methods used to denote comments, ‘‘flag’’ modified or questionable data, etc.

**B. Variable information**

**1. Variable identity, definition, storage type (**Integer, floating point, character, string, etc.)**, unit of measurement (if applicable), List and definition of variable codes (**Description of any codes associated with variables**:** Unique variable name or code), **Range for numeric values:** Minimum, maximum, **e. Precision:** Number of significant digits

plot

the unique identification code assigned to each *Heliconia* plot.

string

size

ranch  
bdffp\_reserve\_no  
  
tag\_number: the plants in a plot have unique identification numbers.  
  
row: each plot is subdivided into 50 contiguous subplots arranged in a 5 x 10 grid. “row” identifies the first axis of this grid   
  
column: each plot is subdivided into 50 contiguous subplots arranged in a 5 x 10 grid. “row” identifies the second axis of this grid

storage type: string

year: calendar year in which a survey was conducted  
storage type: integer

ht: the distance from the ground to the maximum height of the tallest leaf.

Units: cm.   
storage type: integer

Significant digits:

shts: the number of vegetative shoots a plant has at the time it is censused Integer  
  
infl: the number of inforesenceces produced during a flowering season.

storage type: integer

Minimum=0.

Precision: 1 significant digit.  
  
code.notes  
  
code2

**4. Data type**

**a. Storage type:**

**d. Missing value codes:** Missing values are represented with NA

**5. Data format**

**a. Fixed, variable length**

**b. Columns**: Start column: -------, end column: ------

**C. Data anomalies:** Description of missing data, anomalous data, calibration errors, etc.

**CLASS V. SUPPLEMENTAL DESCRIPTORS**

**A. Data acquisition**

**1. Location of completed data forms:** Original completed data sheets and data files reside with E. M. Bruna. Scanned versions of the datasheets and copies of the digital files are saved on the servers of UF’s Department of Wildlife Ecology Conservation (backed up daily) and a commercial cloud-based storage site.

**3. Data entry verification procedures:** Procedures employed to verify that digital data set is error free

**B. Quality assurance/quality control procedures:** Identification and treatment of outliers, description of quality assessments, calibration of reference standards, equipment performance results, etc.

**D. Computer programs and data-processing algorithms:** Description or listing of any algorithms used in deriving, processing, or transforming data

**E. Archiving**

**1. Archival procedures:** Description of how data are archived for long-term storage and access

**2. Redundant archival sites:** Locations and procedures followed

**F. Publications and results:** The following list includes only those articles that used part or all of the data collected as part of the annual *Heliconia acuminata* census in their analyses.

Bruna, E. M. and W. J. Kress. 2002*.* Habitat fragmentation and the demographic structure of an Amazonian understory herb (*Heliconia acuminata*). *Conservation Biology,* 16(5): 1256-1266*.*

Bruna, E. M., O. Nardy, S. Y. Strauss, and S. P. Harrison. 2002. Experimental assessment of *Heliconia acuminata* growth in a fragmented Amazonian landscape. *Journal of Ecology*, 90(4): 639-649.

Bruna, E. M. 2002. Effects of forest fragmentation on *Heliconia acuminata* seedling recruitment in the central Amazon. *Oecologia*, 132:235-243*.*

Bruna, E. M. 2003. Are plant populations in fragmented habitats recruitment limited? Tests with an Amazonian herb. *Ecology*, 84(4): 932-947.

Bruna, E. M. 2004. Biological impacts of deforestation and fragmentation. Pages 85-90 in *The Encyclopaedia of Forest Sciences*. J. Burley, J Evans, and J Youngquist, (eds.). Elsevier Press, London.

Morris, W. F., C. A. Pfister, S. Tuljapurkar, C. V. Haridas, C. Boggs, M. S. Boyce, E. M. Bruna, D. R. Church, T. Coulson, D. F. Doak,, S. Forsyth, J-M. Gaillard, C. C. Horvitz, S. Kalisz, B. E. Kendall, T. M. Knight, C. T. Lee, E. S. Menges. 2008*.* Longevity can buffer plant and animal populations against changing climatic variability. *Ecology* 89(1): 19-25.

Fiske, I., E. M. Bruna, and B. M. Bolker. 2008*.* Effect of sample size on estimates of population growth rates calculated with matrix models. *PLoS ONE* 3(8): e3080.

Fiske, I. and E. M. Bruna. 2010*.* Alternative spatial sampling in studies of plant demography: consequences for estimates of population growth rate. *Plant Ecology* 207(2) 213-225.

Uriarte, M., E. M. Bruna, P. Rubim, M. Anciaes, and I. Jonckeeere. 2010*.* Effects of forest fragmentation on seedling recruitment of an understory herb: assessing seed vs. safe-site limitation. *Ecology* 91(5):1317-1328.

Gagnon, P. R., E. M. Bruna, P. Rubim, M. R. Darrigo, R. C. Littlel, M. Uriarte, and W. J. Kress. 2011*.* The growth of an understory herb is chronically reduced in Amazonian forest fragments. *Biological Conservation* 144: 830-835*.*

Uriarte, M. Anciães, M. T.B. da Silva, P. Rubim, E. Johnson, and E. M. Bruna. 2011*.* Disentangling the drivers of reduced long-distance seed dispersal by birds in an experimentally fragmented landscape. *Ecology* 92(4): 924-93.

Côrtes, M., M. Uriarte, M. Lemes, R. Gribel, W. J. Kress, P. Smouse, E. M. Bruna. 2013*.* Low plant density enhances gene flow in the Amazonian understory herb *Heliconia acuminata*. *Molecular Ecology* 22: 5716-5729.

**ACKNOWLEDGMENTS**

-------- . This is publication -- -- -- in the BDFFP Technical Series.

**Literature cited**

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Bruna, E. M., and W. J. Kress. 2002. Habitat fragmentation and the demographic structure of an Amazonian understory herb (*Heliconia acuminata*). Conservation Biology **16**:1256-1266.

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Laurance, W. F. 2001. The hyper-diverse flora of the central Amazon. Pages 47-53 *in* R. O. Bierregaard Jr., C. Gascon, T. E. Lovejoy, and R. Mesquita, editors. Lessons from Amazonia: The ecology conservation of a fragmented forest. Yale University Press, New Haven.

Laurance, W. F., J. L. C. Camargo, R. C. C. Luizao, S. G. Laurance, S. L. Pimm, E. M. Bruna, P. C. Stouffer, G. B. Williamson, J. Benitez-Malvido, H. L. Vasconcelos, K. S. Van Houtan, C. E. Zartman, S. A. Boyle, R. K. Didham, A. Andrade, and T. E. Lovejoy. 2011. The fate of Amazonian forest fragments: A 32-year investigation. Biological Conservation **144**:56-67.

Laurance, W. F., T. E. Lovejoy, H. L. Vasconcelos, E. M. Bruna, R. K. Didham, P. C. Stouffer, C. Gascon, R. O. Bierregaard Jr., S. G. Laurance, and E. Sampaio. 2002. Ecosystem decay of Amazonian forest fragments, a 22 year investigation. Conservation Biology **16**:605-618.

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**Tables, figures, and appendices.** Tables and figures should be embedded in the metadata where appropriate. Tables should be in HTML and figures should be embedded .JPG, .GIF, or .PNG files. Appendices are not acceptable parts of data papers.

Plot

FF-1

FF-2

FF-3

FF-4

FF-5

FF-6

FF-7

CF-1

CF-2

CF-3

CF-4

CF-5

CF-6

Habitat Type

1-ha

1-ha

1-ha

1-ha

10-ha

10-ha

10-ha

CF

CF

CF

CF

CF

CF

BDFFP Year Reserve No.

2107

2108

1104

3114

2206

1202

3209

1301

1501

1501

-

-

-

Isolated

1984

1984

1980

1983

1984

1980

1983

Ranch

Abbreviations: 1-ha=1-ha fragments, 10-ha=10-ha fragments, CF=continuous forest.

CF-4 and 5 have no BDFFP numbers, therefore I used the name ranch in which they are located instead.

cFrom Bruna and Kress (2002).