

# Liana abundances rebound over a fourteen-year period in a subtropical secondary wet forest: Land-use legacies and hurricane recovery

J. Aaron Hogan<sup>1</sup>, Sylvette Mallorquín\*, Jess K Zimmerman\*, Jill Thompson\*<sup>^</sup> & Nicholas Brokaw\*

<sup>1</sup> International Center for Tropical Botany, Department of Biology, Florida International University, Miami, FL USA

\* Department of Environmental Science, University of Puerto Rico - Rio Piedras, San Juan, Puerto Rico

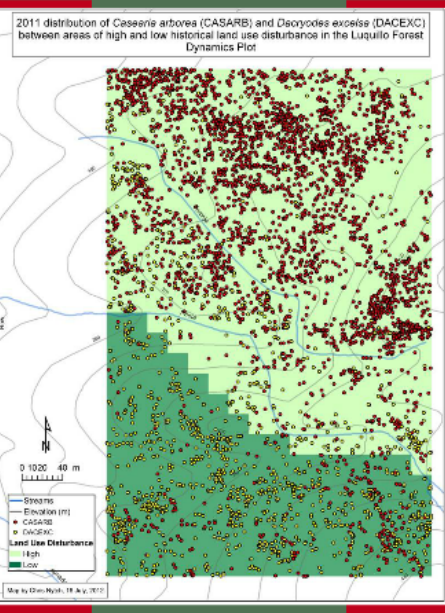
<sup>^</sup> Centre for Ecology and Hydrology - Edinburgh, Midlothian, UK

## What is a Liana?

Woody climbing vines climb trees that develop secondary wood and are rooted in the soil. Considered "structural parasites" using tropical trees to reach the canopy. Long slender stems with increased stem hydraulic conductivity.

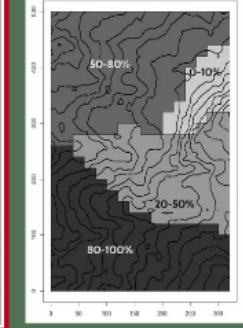


Lianas are important in diversity, structure and biomass in tropical forests. In the LFDP, lianas comprise 12% of woody stems, 25% of woody species, 30% of forest leaf area, but 75% of woody biomass (for the foliage). Lianas form the stem structural support of the demographic (diversity) growth, mortality & recruitment (Jain et al. 2016). In a liana removal experiment in Panama, tree growth increased by 30% (Brokaw, www.lanaproject.org). Lianas are increase in Neotropical Forests (D. Phillips et al. 2002; Neeley et al. 2013; S. Wright et al. 2006; Ecology 83(2):484-491).



## Land-use legacies in the LFDP

Forest cover in 1936 from aerial photographs: (lightest to darkest): 0-10%, 20-50%, 50-80%, 80-100%, 80-100%. DR Foster, Fluet & Boose (1999) Ecological Applications, 9(2), 555-572. J Thompson et al. (2002) Ecological Applications, 12(5), 1344-1363. JA Hogan et al. (2016) Ecosphere, 7(8), e01405



## Lianas & Disturbance

Lianas increase following disturbance (e.g. Hurricanes, canopy damage etc). Avon et al. (2005) Forest Ecology and Management 218(1-2):29-36. Lianas are greatest in secondary forests and increase in density toward forest edges. In 2015, we followed up on liana community demographic data from 2001 for a hurricane-affected forest in Puerto Rico, with post-land-use legacies, to ask:

1. How has liana abundance, biomass, and reproductive effort changed?
2. How has hurricane disturbance interacted with past land to affect liana abundances and reproduction?
3. Does this reflect the Neotropical trend?

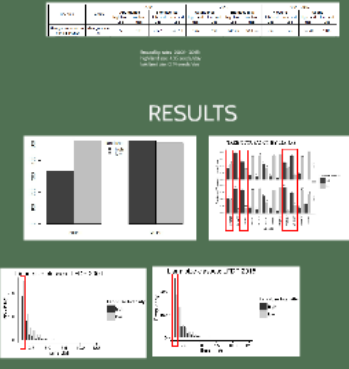
## Conclusions

In comparison with the Neotropical trend & over the 14-year period (2001-2015) lianas increased in abundance and species richness in the LFDP, where liana species diversity increased. Additionally, the liana net contribution to increase in the non-forest forest area of the LFDP where liana species diversity increased. Rapid forested dynamics involved large-scale liana in the Neotropical. Non-forest dynamics (disturbance) were associated with liana abundance and species richness. Differences in demographic patterns in the LFDP are related to legacy effects (disturbance) on liana abundance and species richness and the temporal history of the forest plot in the Neotropical.

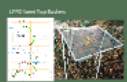
ACKNOWLEDGMENTS  
Sylvette Mallorquín & Nick Brokaw  
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DOI: 10.1002/ecs2.1405

Study Site: The Luquillo Forest Dynamics Plot  
El Verde, Puerto Rico  
TWO HURRICANES  
September 1989- Hugo  
September 1998- Georges

## RESULTS



## Census Methods



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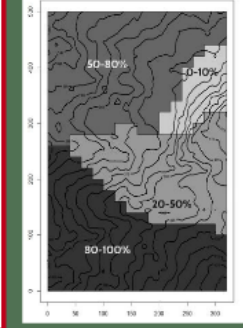
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 woody climbing plant  
 climbs that develop secondary root and are rooted in the soil.  
 considered "stratoparasites" using tropical trees to reach the forest canopy  
 long slender stems with increased stem height to



Lianas are important in diversity structure and biomass in tropical forests.  
 Tropical forests composed of 10% woody lianas, 35% of woody species, 30% of forest leaf area, but 75% of woody biomass (Burslem & Ashton 2004).  
 Lianas have negative impact on all aspects of tree demography (juvenile growth, mortality, stem carbon accumulation).  
 In a liana removal experiment in Panama, tree growth increased by 30% (Scholar & Hubbell 2009).  
**Lianas are Increase in Neotropical Forests**  
 Q. Wright et al. (2002) Nature 416: 710-714  
 S. Wright et al. (2006) Ecology 87:1484-1491

## Land-use legacies in the LFD

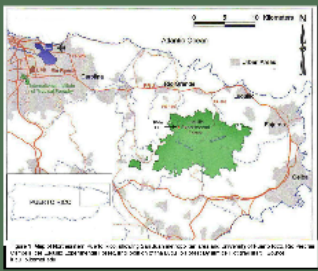
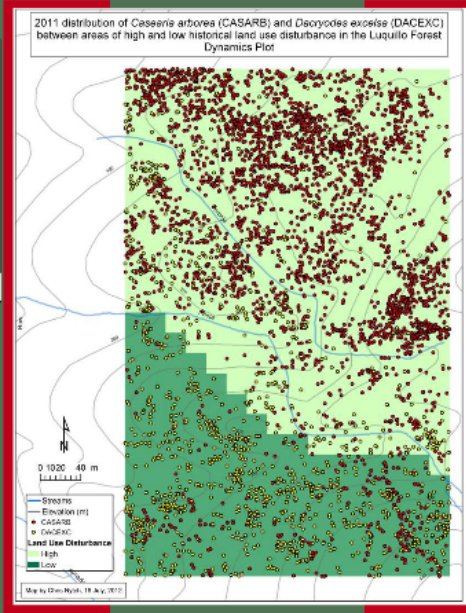
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## Lianas & Disturbance

Lianas increase following disturbance (e.g. hurricanes, canopy damage etc.)  
 Allen et al. (2005) Forest Ecology and Management 218:1228-1240  
 Lianas are greatest in secondary forests and increase in density toward forest edges.  
 In 2015, we followed up on liana community demographic data from 2001 for a hurricane-affected forest in Puerto Rico, with past land-use legacies, to ask:

1. How has liana abundance, biomass, and reproductive effort changed?
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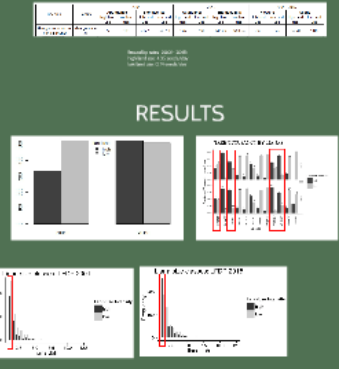


## Conclusions

Forests across the Neotropics rebounded over the 14 year period (2001-2015). Liana abundances increased in a greater degree in the high land-use legacies of the LFD than in secondary forest.  
 Additionally, liana cover was correlated to increase in the canopy layer area of the LFD, where lianas have been previously associated.  
 Results from our first 14 years indicated a significant decline in the canopy layer area of the LFD, which was correlated to the increase in liana cover.  
 There was a significant relationship between liana cover and canopy layer area, suggesting that liana cover may be a proxy for canopy layer area.  
 Differences in demographic between the high and low LFD areas will likely be a result of differences in land-use legacies, and the natural recovery of the entire plot to the Neotropics.

**ACKNOWLEDGMENTS**  
 Sylvette Mallorquín & Nick Brokaw  
 Jill Thompson & Jess Zimmerman  
 NSF 1025077 & 1025042

## RESULTS



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# What is a Liana?

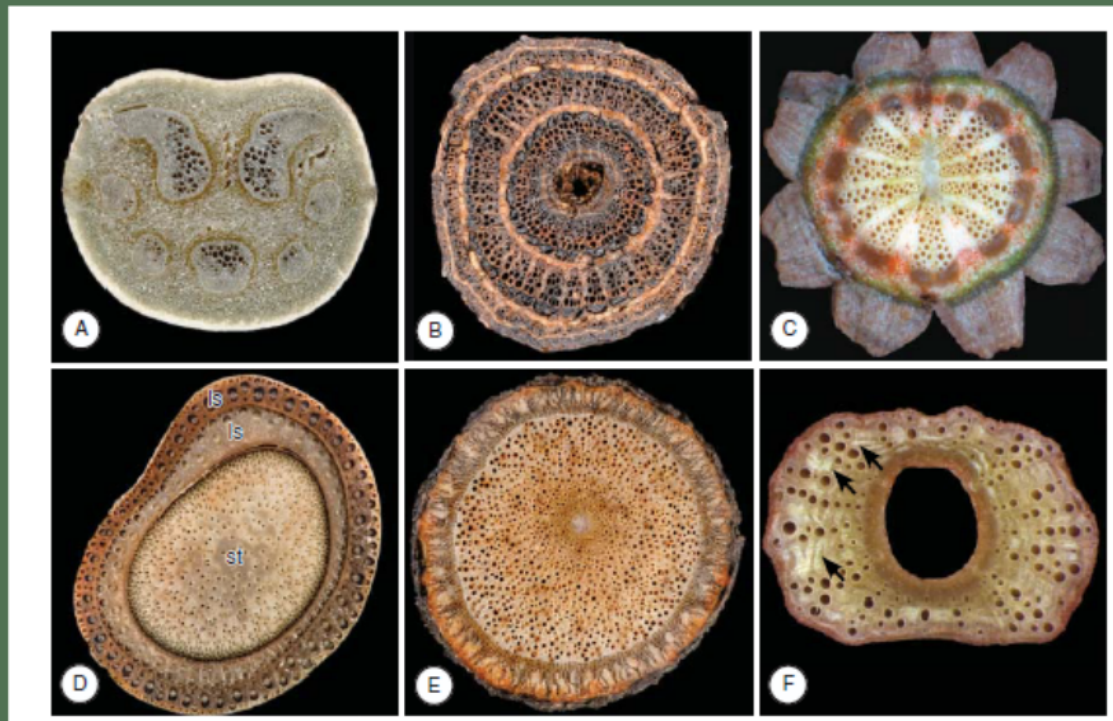
woody, climbing vine

climbers that develop secondary wood and are rooted in the soil.

Ecology of Lianas (2015) eds. Schnitzer, Bongers, Burnham & Putz

considered "structural parasites" using tropical trees to reach the forest canopy

long slender stems with increased stem hydraulics



Angyalossy *et al.* (2015) Liana anatomy: a broad perspective on structural evolution of the vascular system. Ch. 19 (253-287)





*Rourea surinamensis*  
Connaraceae



photos by:  
Fabiola Areces





*Marcgravia  
rectiflora*  
Marcgraviaceae



photos by:  
Fabiola Areces



*Paullinia pinnata*  
Sapindaceae



photos by:  
Fabiola Areces



Lianas are important in diversity, structure and biomass in tropical forests.

e.g.) on BCI, lianas comprise 20% of woody stems, 35% of woody species, 20% of forest leaf area, but <5% of woody biomass (Stefan Schnitzer)

Lianas have negative impacts on all aspects of tree demographics (decreased growth, fecundity, & net carbon accumulation )

In a liana removal experiment in Panama, tree growth increased by 30% (Schnitzer) [www.lianaproject.org](http://www.lianaproject.org)

## Lianas are increase in Neotropical Forests

OL Phillips *et al.* (2002) *Nature* 418: 770-774

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# Lianas & Disturbance

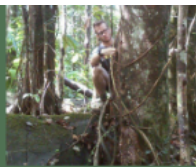
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*Allen et al. (2005) Forest Ecology and Management*  
218(1):259-269.

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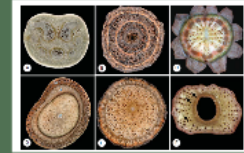
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woody, climbing vine  
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Ecology of Lianas (2011) with Nicholas, Bengers, and others. S.P. 2012  
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Angiloney et al. (2016) and others. Structural Parasitism of the Canopy System. CA. 9/2016-2017

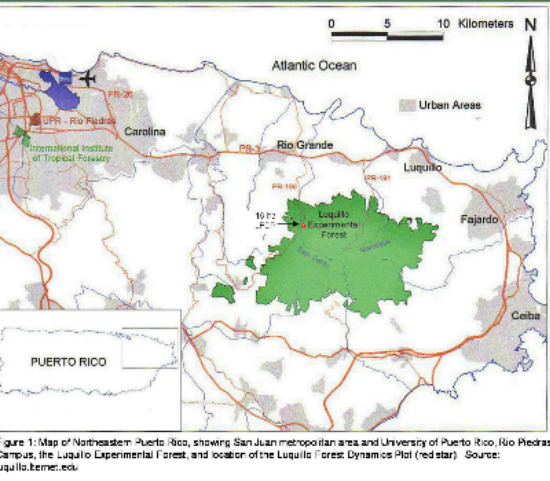
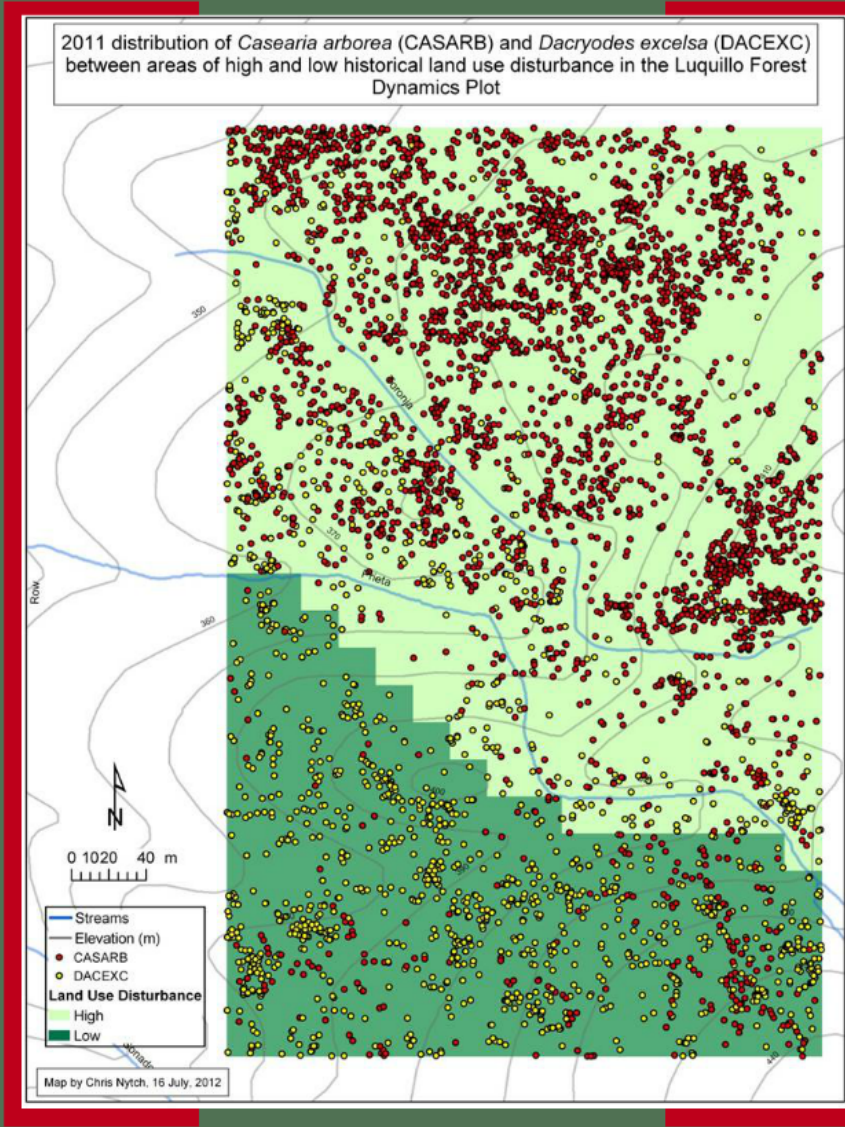
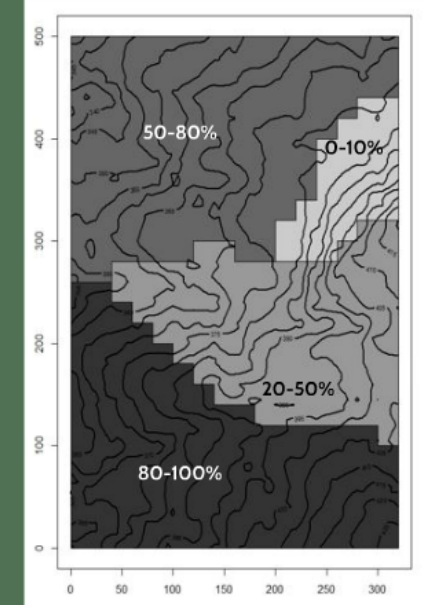


Figure 1: Map of Northeastern Puerto Rico, showing San Juan metropolitan area and University of Puerto Rico, Rio Piedras Campus, the Luquillo Experimental Forest, and location of the Luquillo Forest Dynamics Plot (red star). Source: luquillo.terner.edu



**Land-use legacies in the LFDP**

Forest cover in 1936 from aerial photographs:  
 (lightest to darkest): 0-10%, 20-50%, 50-80%, 80-100%, 80-100%  
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**Study Site: The Luquillo Forest Dynamics Plot**

El Verde, Puerto Rico

**TWO HURRICANES**  
 September 1989- Hugo  
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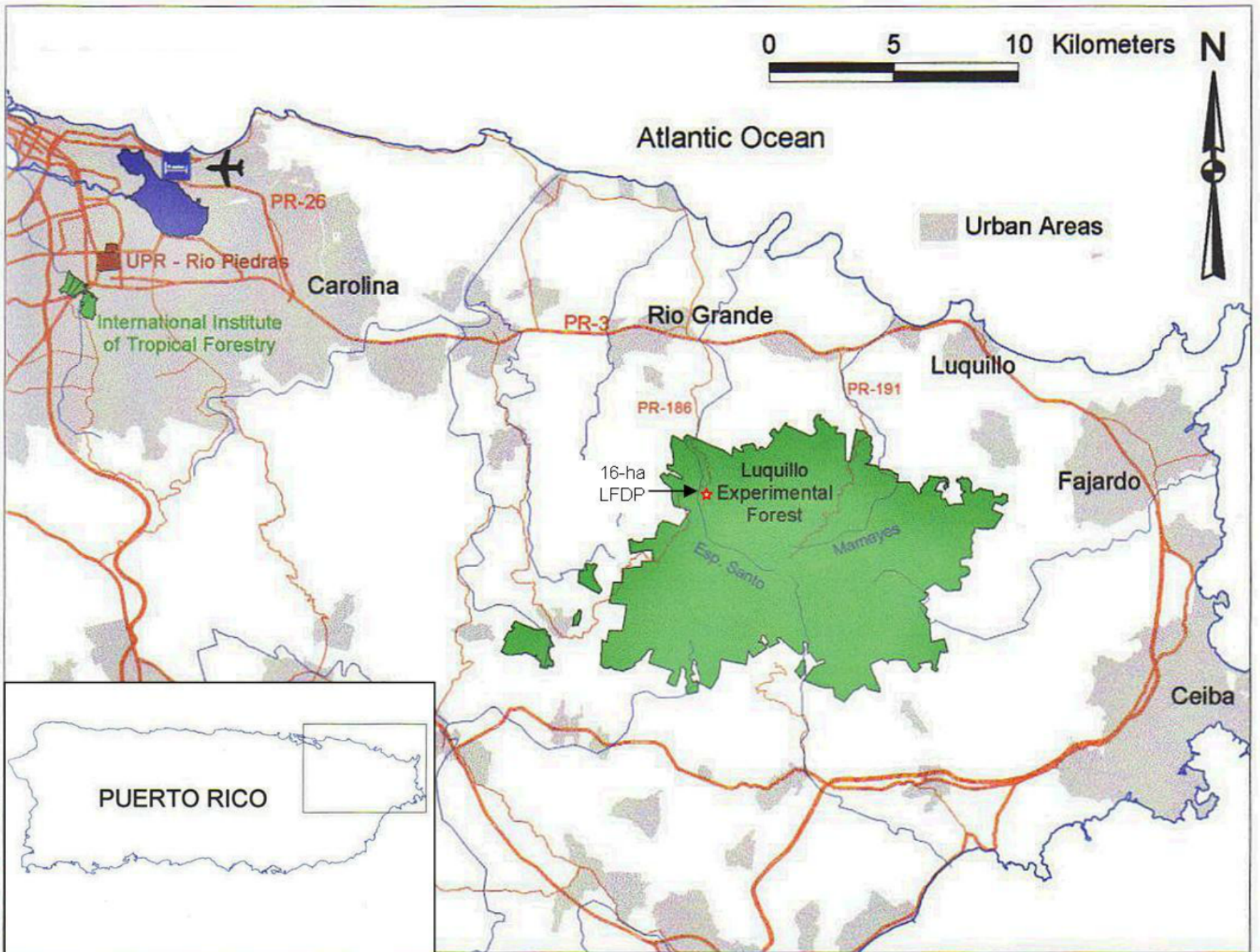


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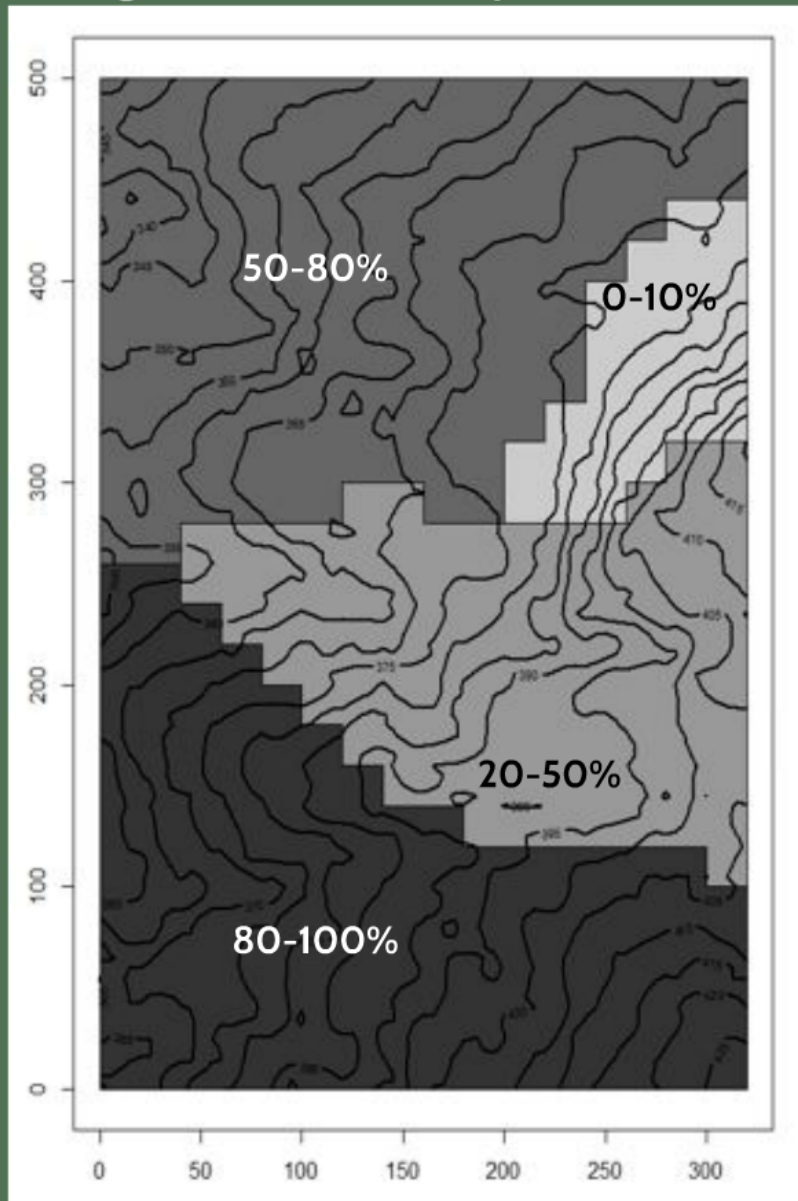
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## Lianas

Lianas increase in density after hurricanes, causing a decrease in tree growth.

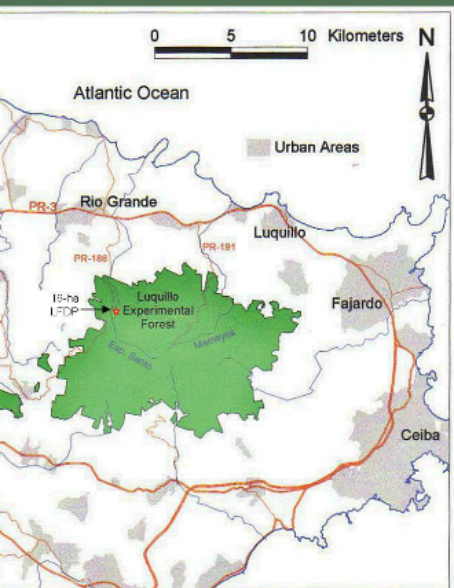
Allen *et al.* (2000) *Ecology*, 81(1):259-269.

Lianas are generally more abundant in areas with a high increase in density.

In 2015, we found that the liana community density was higher for a hurricane in Puerto Rico, with past hurricanes.

1. How has liana density changed since the reproductive effort?
2. How has liana density changed since the hurricane?



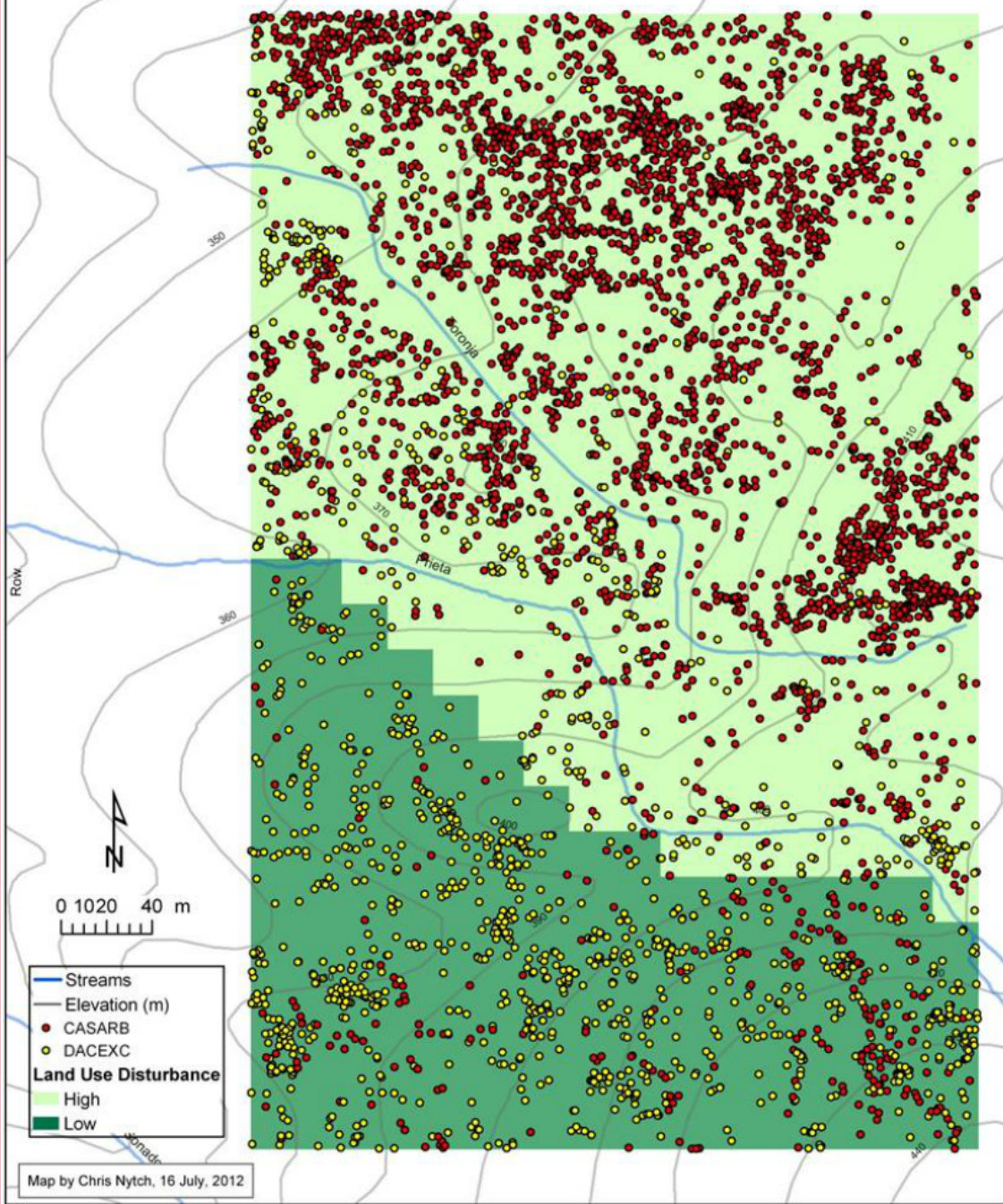


Map showing San Juan metropolitan area and University of Puerto Rico, Rio Piedras location of the Luquillo Forest Dynamics Plot (red star). Source: [unclear]

The Luquillo Forest Dynamics Plot  
 Puerto Rico

AMERICANES  
 1989- Hugo  
 1998- Georges

2011 distribution of *Casearia arborea* (CASARB) and *Dacryodes excelsa* (DACEXC) between areas of high and low historical land use disturbance in the Luquillo Forest Dynamics Plot

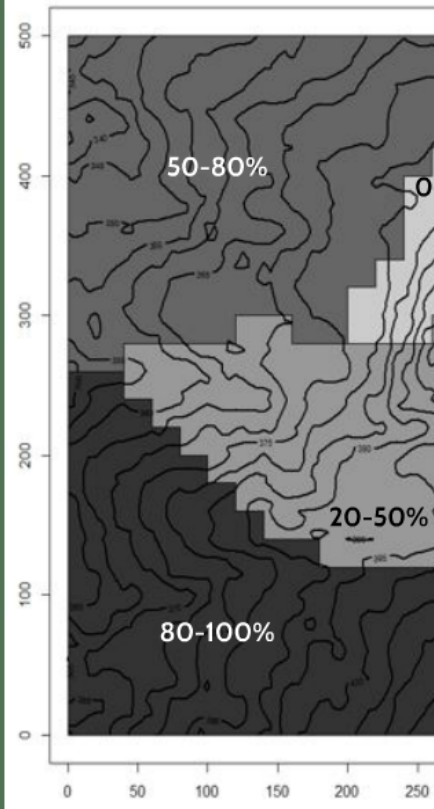


- Streams
- Elevation (m)
- CASARB
- DACEXC
- Land Use Disturbance**
- High
- Low

Map by Chris Nytech, 16 July, 2012

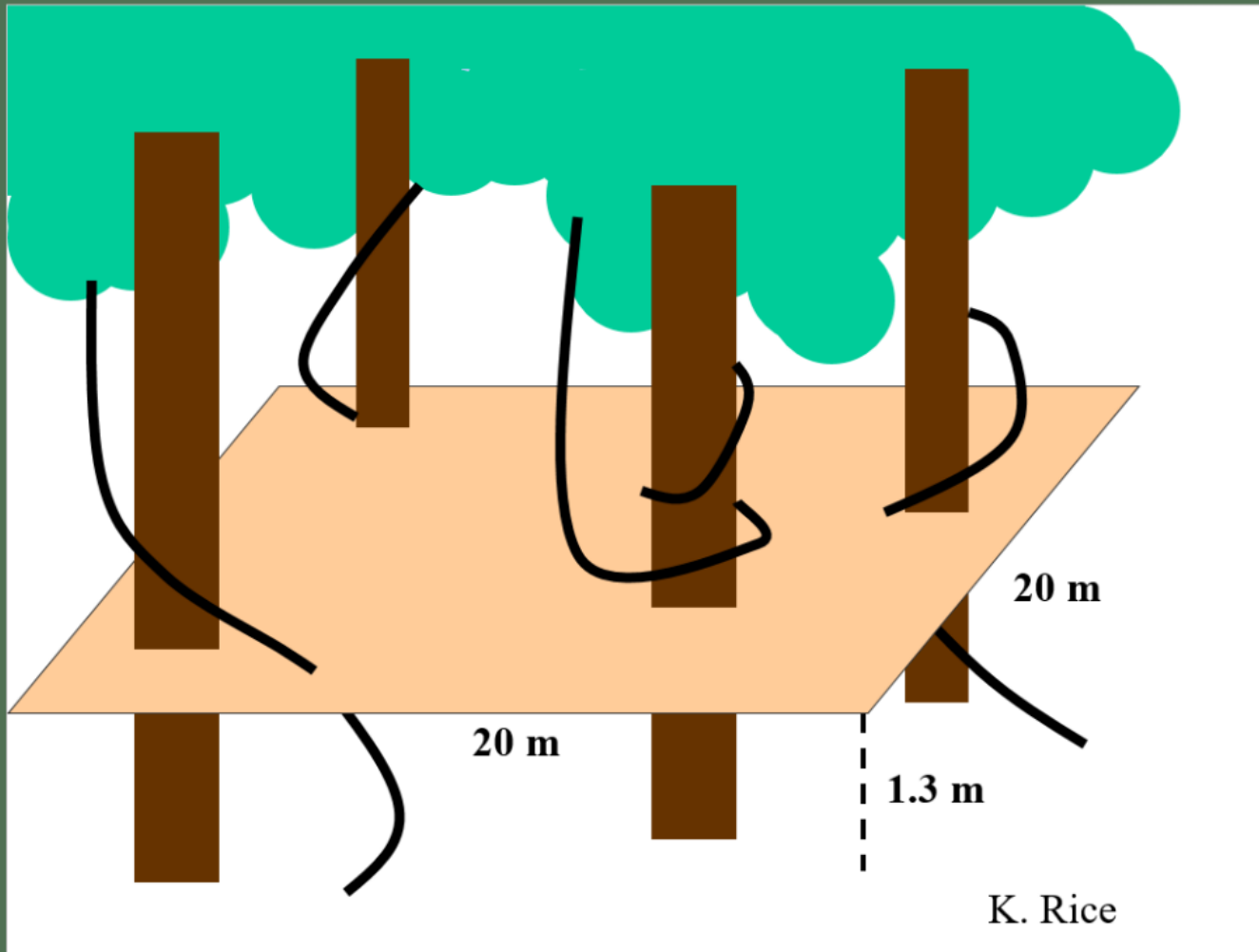
### Land-use legacies in t

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# Census Methods

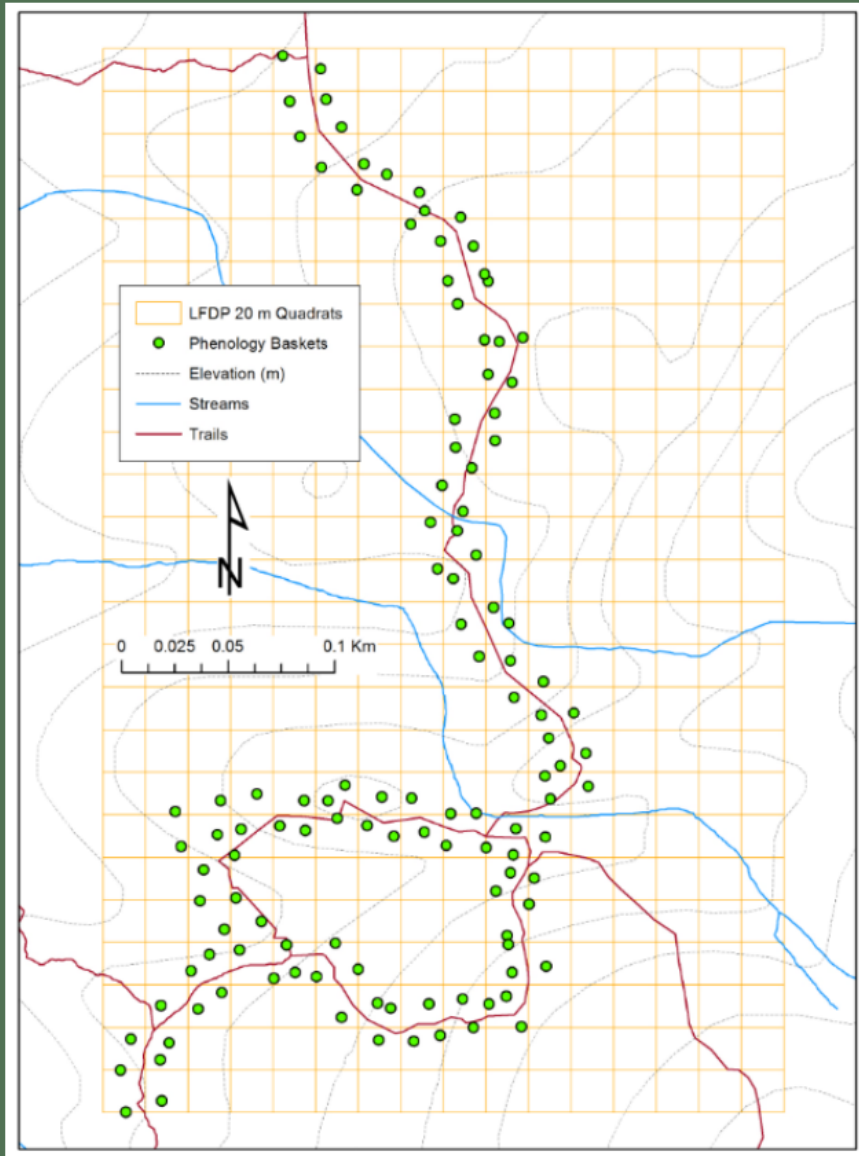
10 quadrats (20x20m) per land-use class



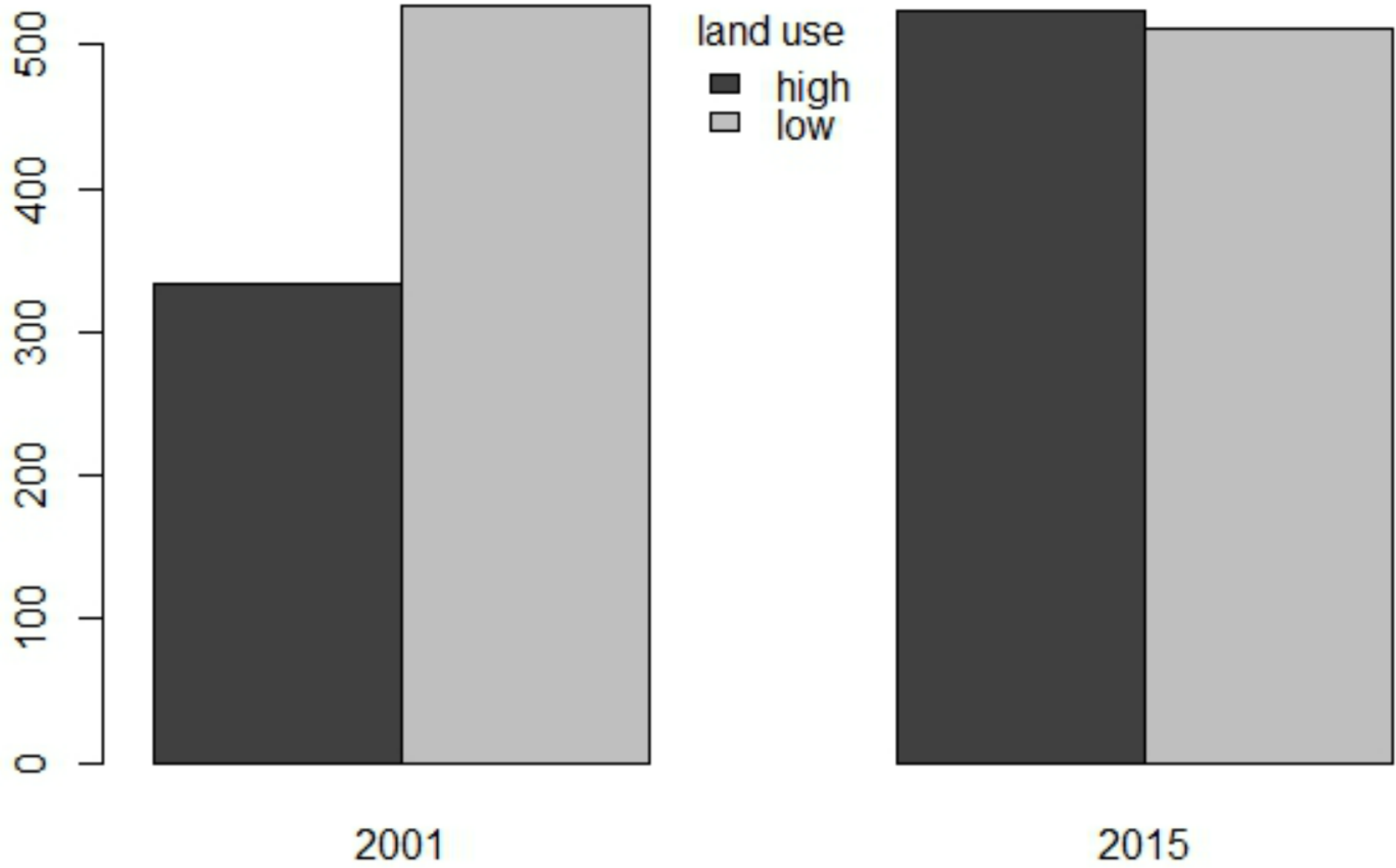
K Rice et al. (2001) *Forest Ecology and Management* 190(1) 33-41



# LFPD Seed Trap Baskets



Methodology follows Wright & Calderone  
(2006) Ecology Letters 9(1):35-44



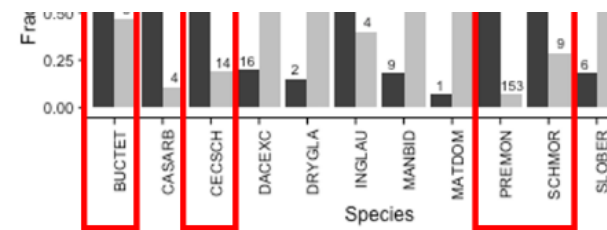




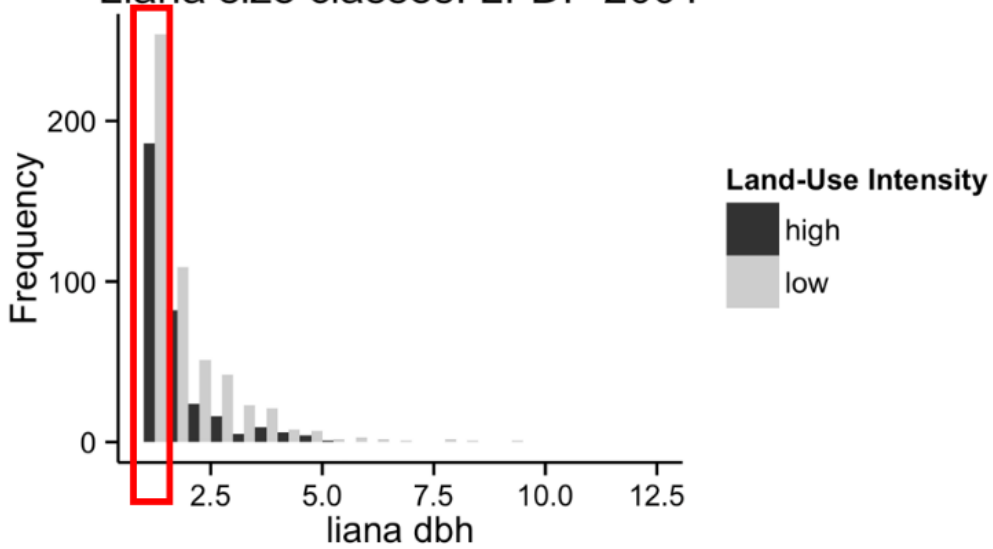
2001



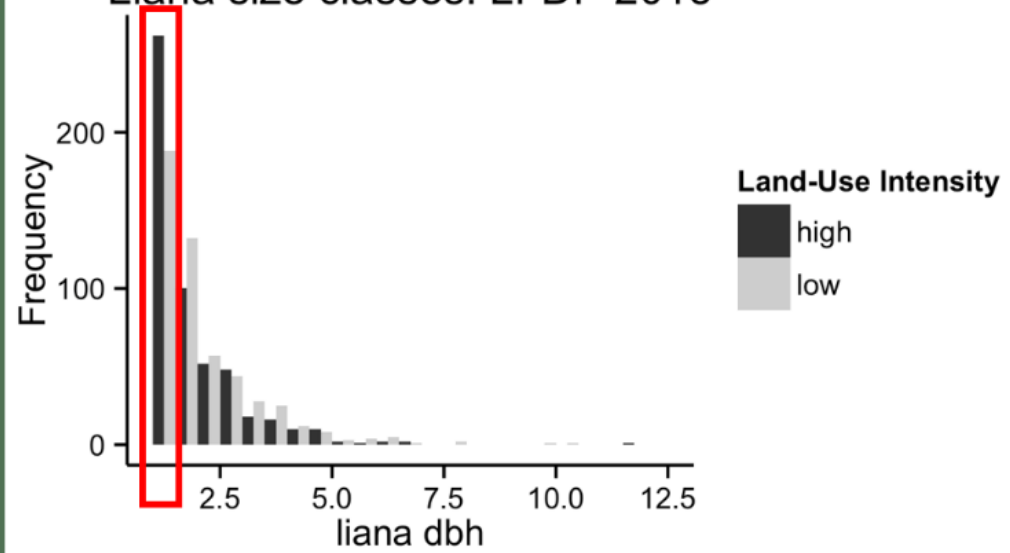
2015



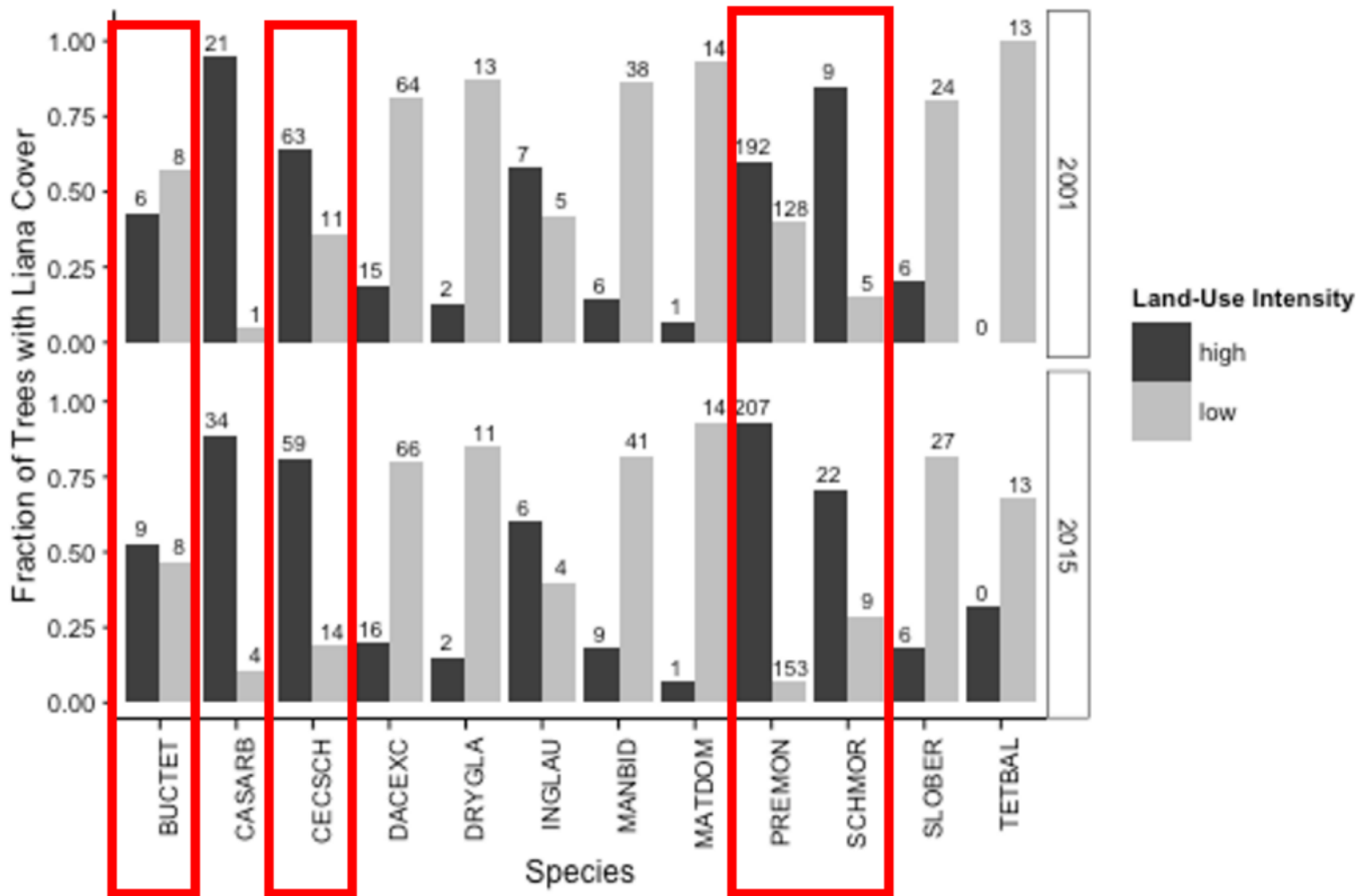
Liana size classes: LFDP 2001



Liana size classes: LFDP 2015



# TREE OCCUPANCY BY LIANAS





Species	Family	2001				2015				2001 - 2015			
		Abundance		Biomass (kg)		Abundance		Biomass (kg)		Flowers		Seeds	
		high land use	low land use	high land use	low land use	high land use	low land use	high land use	low land use	high land use	low land use	high land use	low land use
<i>Marcgravia rectiflora</i> Triana & Planch <i>Marcgravia</i>	Marcgraviaceae	77	111	217.1	248.18	175	198	736.09	648.94	369	239	34934	1109

fecundity rates 2001- 2015:  
high land use: 4.35 seeds/day  
low land use: 0.14 seeds/day

# RESULTS

# Conclusions

In congruence with the Neotropical trend & over the 14-year period (2001 - 2015), liana abundances increased to a greater degree in the high land-use portion of the LFDP (i.e. secondary forest).

Additionally, liana biomass continued to increase in the more-primary forest area of the LFDP, where lianas were previously established.

Trends in recruitment dynamics mirrored demographic trends in the liana community.

Tree community relative stable over time, when compared to the liana community (differential effects of hurricanes on lianas v. trees)

Differences in demographics between the two halves of the LFDP are attributed to forest age differences created by past land-use history, and the compound recovery of the entire plot to the two hurricanes.

## **ACKNOWLEDGEMENTS:**

Sylvette Mallorquin & Nick Brokaw

El Verde REU Program:

NSF 552567 & 602642



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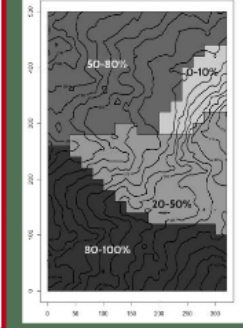
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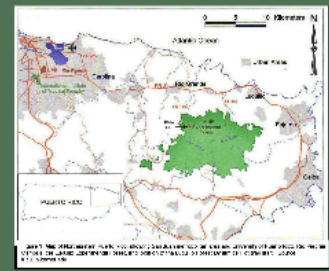
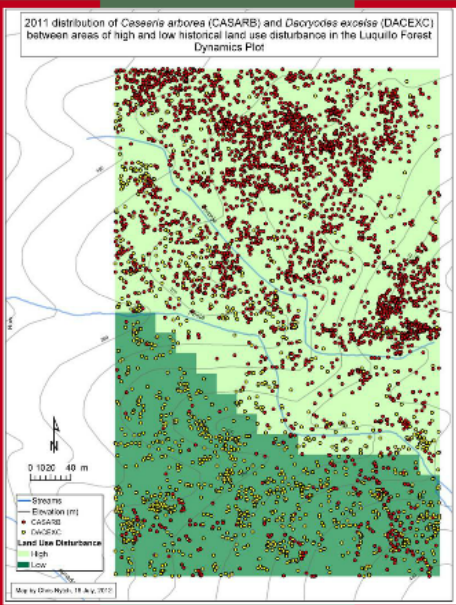
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## Lianas & Disturbance

Lianas increase following disturbance (e.g. hurricanes, canopy damage etc.)  
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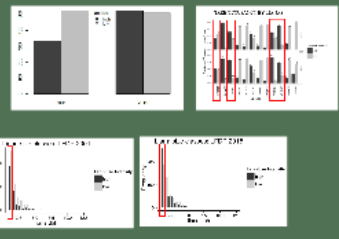
## Conclusions

Forest cover in the Neotropical world is on the decline (2002-2012). In Puerto Rico, forest cover is declining rapidly in the high-land mountains of the LFD. In secondary forest, liana abundance has increased in the mountains of Puerto Rico, where lianas have been previously abundant.  
Lianas are not just a forest edge indicator, although it is still in the Neotropical trend.  
Lianas are important in diversity structure and biomass in tropical forests.  
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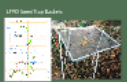
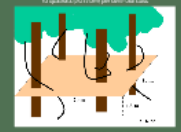
ACKNOWLEDGMENTS  
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Hogan et al. (2016) Ecosphere, 7(8), e01405

Year	1989	1998	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Liandra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stems	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

## RESULTS



## Census Methods



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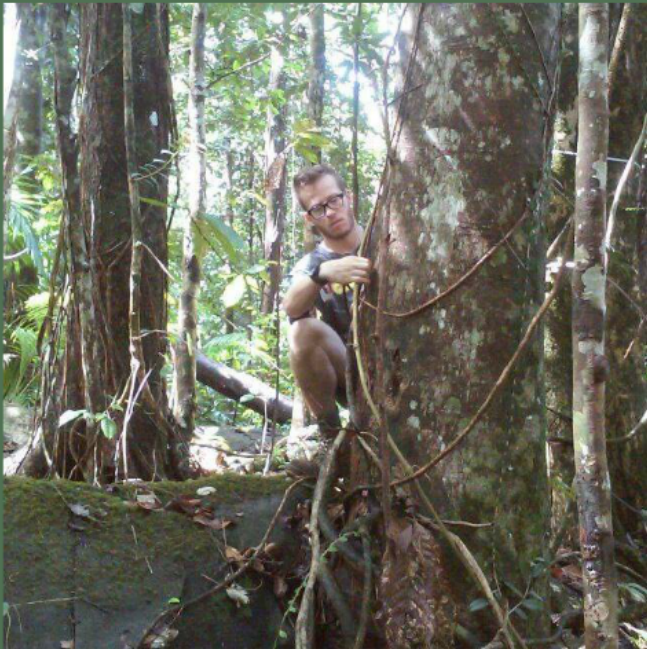


@JAaronHogan



# San Juan, Puerto Rico

J. AARON HOGAN, LUQUILLO 2015



NICK BROKAW, BARRO COLORADO ISLAND 1978



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