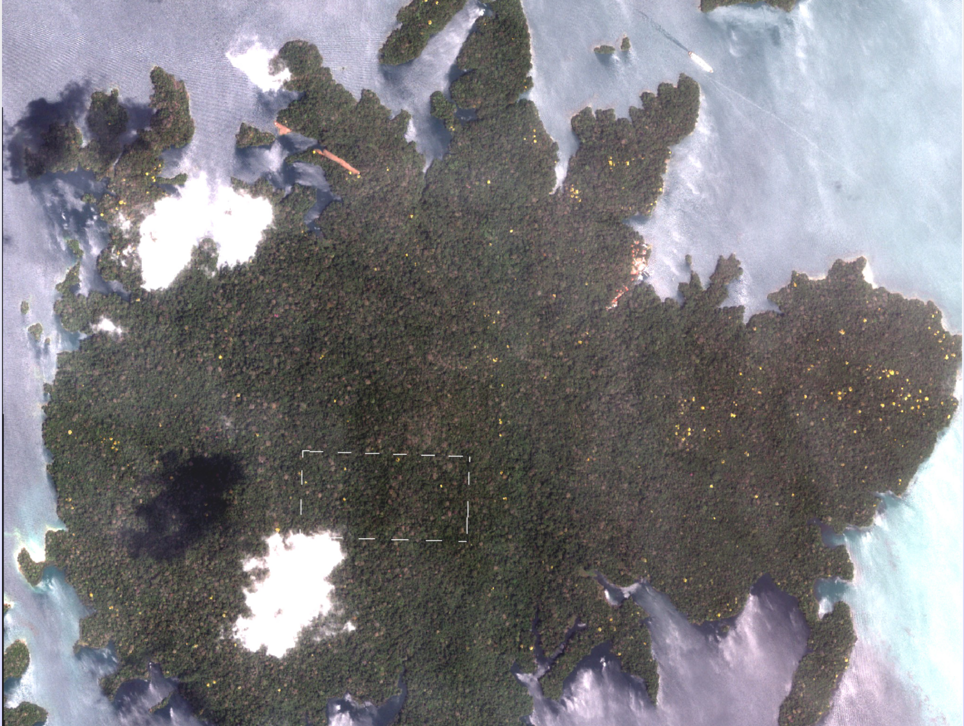
Changing tree populations

Neutral and non-neutral change

Richard Condit

- Commemorative Symposium for the 32nd International Prize for Biology
- The University of Tokyo
- Japan Society for the Promotion of Science

22 November 2016




Hubbell & Foster BCI 50 ha plot

Outline

Tracking populations of tree species long-term

- Abundance
- Focus on individual species

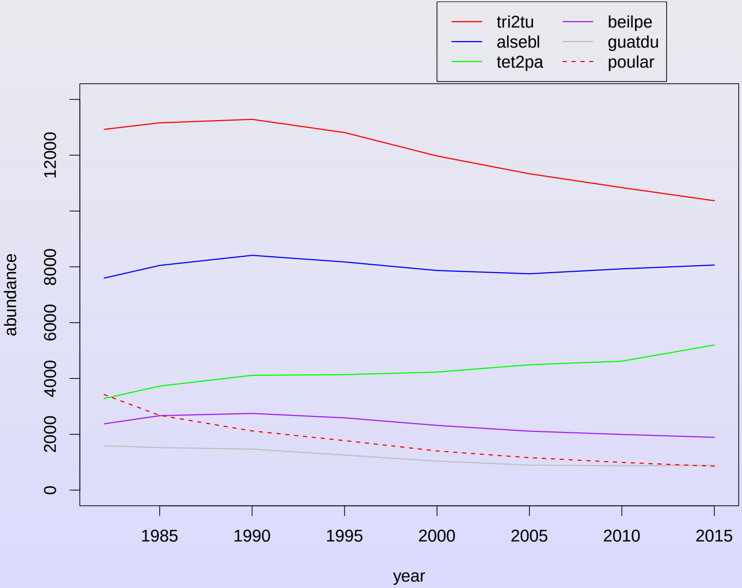
Species performance

- Consistency through time
- Decay in performance correlation

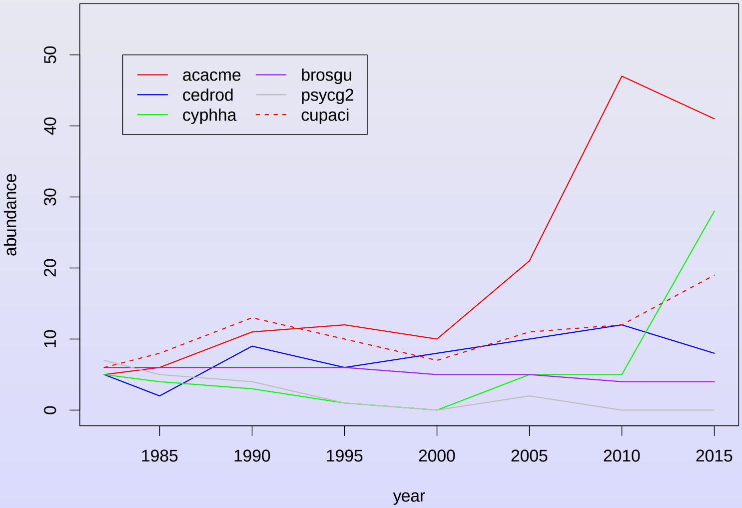
Conclusions and hypotheses

- Abundances vary more than chance
- Periodicity of fluctuations is 10-15 years

Population changes in common species 35 years



Population changes in rare species 35 years



Modeling rates of population change

Discounting stochastic demography

Predicting stochastic fluctuations

- Common species fluctuations small
- Rare species can fluctuate widely

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where

N is population size

0.4 comes from average annual survival
(high survival dampens fluctuations)

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$N = 10$: random fluctuations $\pm 13\%$

$N = 100$: random fluctuations $\pm 4\%$

$N = 1000$: random fluctuations $\pm 1\%$

The Data

spcode	N1	N2	time	little r	date1	date2
acacme	48	44	5.1	-0.0169	24May2010	17Jul2015
acaldi	1138	1562	5.2	0.0615	01Jun2010	27Jul2015
acalma	53	63	5.1	0.0338	16Apr2010	30May2015
ade1tr	146	121	5.1	-0.0365	23May2010	15Jul2015
aegipa	40	26	5.1	-0.0838	18Apr2010	08Jun2015
alchco	320	271	5.1	-0.0324	01Jun2010	17Jul2015
alchla	1	0	5.1	-Inf	26Jan2010	24Feb2015

...

...

etc. for 324 species

* $r = \frac{1}{time}\left(\ln N_2 - \ln N_1\right)$

ECOLOGY LETTERS

Ecology Letters, (2014) doi: 10.1111/ele.12296

LETTER

Temporal variability of forest communities: empirical estimates of population change in 4000 tree species

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Abstract

Long-term surveys of entire communities of species are needed to measure fluctuations in natural populations and elucidate the mechanisms driving population dynamics and community assembly. We analysed changes in abundance of over 4000 tree species in 12 forests across the world over periods of 6–28 years. Abundance fluctuations in all forests are large and consistent with population dynamics models in which temporal environmental variance plays a central role. At some sites we identify clear environmental drivers, such as fire and drought, that could underlie these patterns, but at other sites there is a need for further research to identify drivers. In addition, cross-site comparisons showed that abundance fluctuations were smaller at species-rich sites, consistent with the idea that stable environmental conditions promote higher diversity. Much community ecology theory emphasises demographic variance and niche stabilisation; we encourage the development of theory in which temporal environmental variance plays a central role.

Keywords

Abundance fluctuations, biodiversity, demographic stochasticity, environmental variance, forest dynamics, neutral theory, niche stabilization.

Ecology Letters (2014)

INTRODUCTION

There was a time when the prevailing scientific view was that ecological communities were stable over time, but this is now long past (Connell 1978; Sprugel 1991; Wright 2005; Laurance *et al*. 2009). Climatic shifts alter species assemblages, certainly over glacial cycles (Colinvaux *et al*. 1996), but also with modern anthropogenic climate change (Condit *et al*. 1996). Out-

Two broad classes of stochasticity that may cause species' abundances to fluctuate temporally are environmental and demographic variance (Bjørnstad & Grenfell 2001; Lande *et al*. 2003; Melbourne & Hastings 2008; Gravel *et al*. 2011). Temporal environmental variance (henceforth 'environmental variance') arises from external drivers such as fluctuations in rainfall, temperature, fire and pests. The effect of environmental variance is correlated across individuals within species

OIKOS 63: 48–61. Copenhagen 1992

Short-term dynamics of a neotropical forest: why ecological research matters to tropical conservation and management

Stephen P. Hubbell and Robin B. Foster

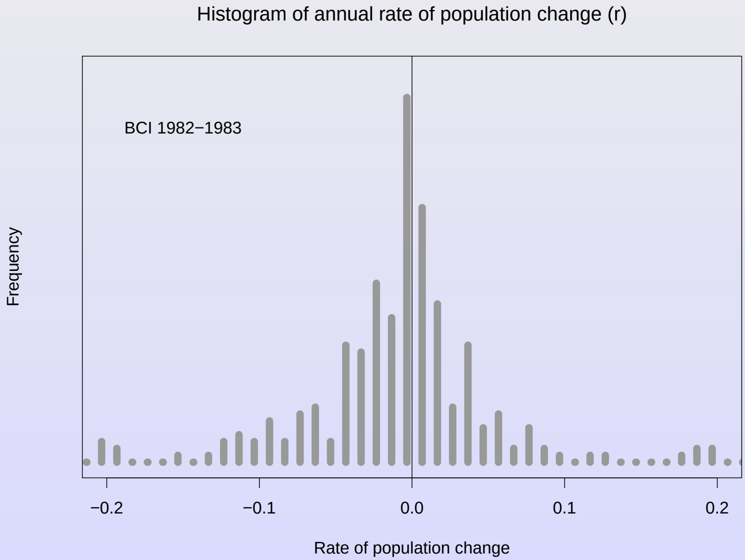
Hubbell, S. P. and Foster, R. B. 1992. Short-term dynamics of a neotropical forest: why ecological research matters to tropical conservation and management. – Oikos 63: 48–61.

Arguments that ecolocial research on species-rich tropical forests is too little, too late, an irrelevancy, and a luxury we can ill afford when time is running out to save tropical forests are wrong. Focused basic and applied ecological research has a vital and cost-effective role to play in tropical forest conservation and management. Sustainable management of natural tropical forests is not possible without a better holistic understanding of how such forests actually work ecologically and interact with humans. Because time is short, however, we must learn "on-the-job" by conducting research as we implement management plans. We base our argument on experience with a large-scale study of the tropical forest on Barro Colorado Island (BCI), Panama. In the space of 5 years, it was possible to collect essential silvics data on stocking levels, growth, yield, survival rates, and microhabitat requirements of a large fraction of the BCI tree community of more than 300 native species. We conclude that a program of comparable studies of representative natural and managed tropical forests at key sites throughout the tropics would rapidly improve the global fund of knowledge on which to base better decisions for the conservation and management of tropical forests. International agencies and foundations should increase their support of mission-oriented, holistic research on the community ecology of tropical forests far beyond the present emphasis on basic inventories of biodiversity.
On one point there is no argument: tropical forests are indeed in big trouble.

S. P. Hubbell, Dept of Ecology and Evolutionary Biology, Princeton Univ., Princeton, NJ 08544, USA. – R. B. Foster, Dept of Botany, Field Museum of Natural History, Chicago, IL 60605, USA.

However, we were unprepared for the magnitude of the change and instability that we found in 1985. Over just a 3-year period, 40% of the 300 BCI species changed by more than 10% in total abundance (Hubbell and Foster 1990b).

Modeling rates of population change



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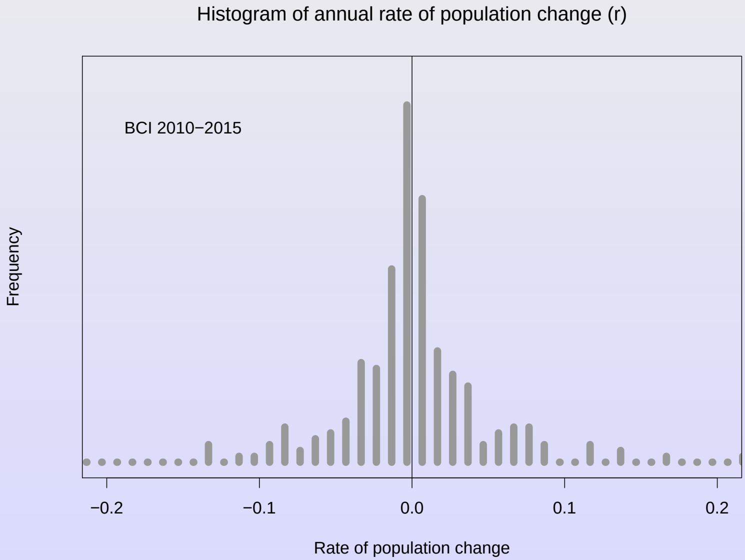

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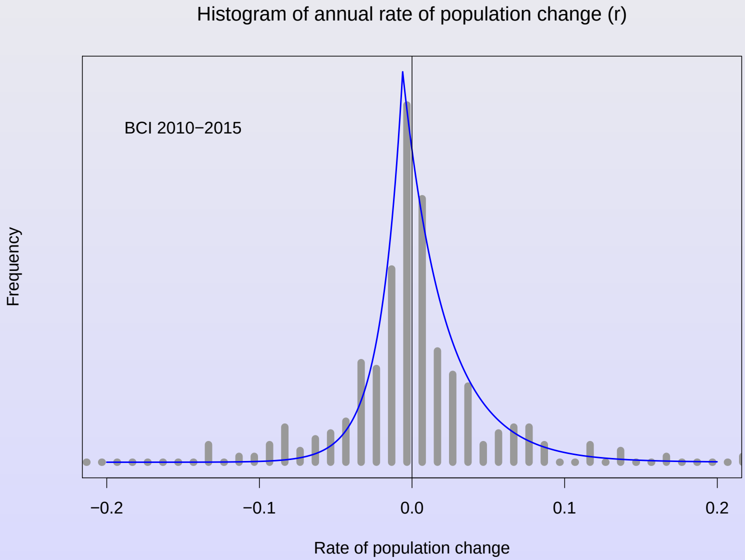
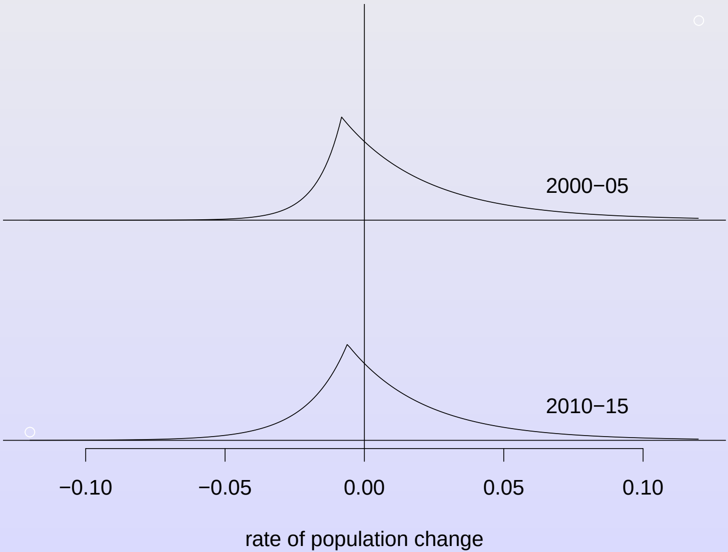


Performance consistency through time



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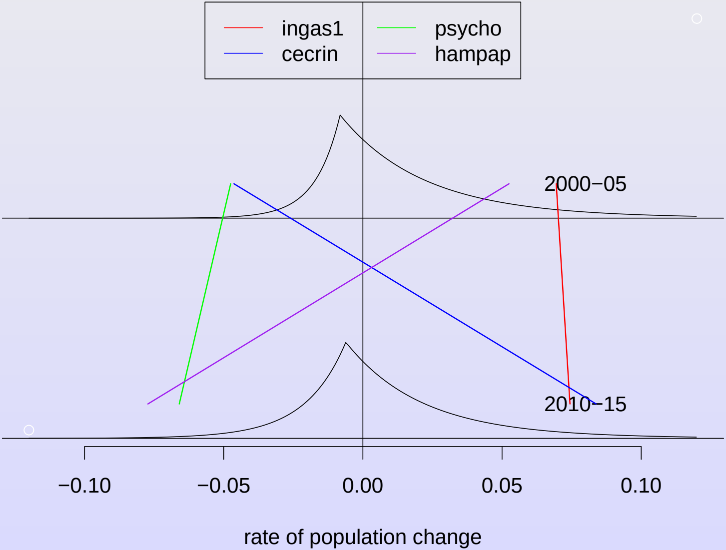

Contrary fluctuations

species	2005	2010	2015
Inga acuminata	430	608	895
Cecropia insignis	1143	889	1371
Hampea appendiculata	142	189	117
Psychotria horizontalis	3120	2455	1742

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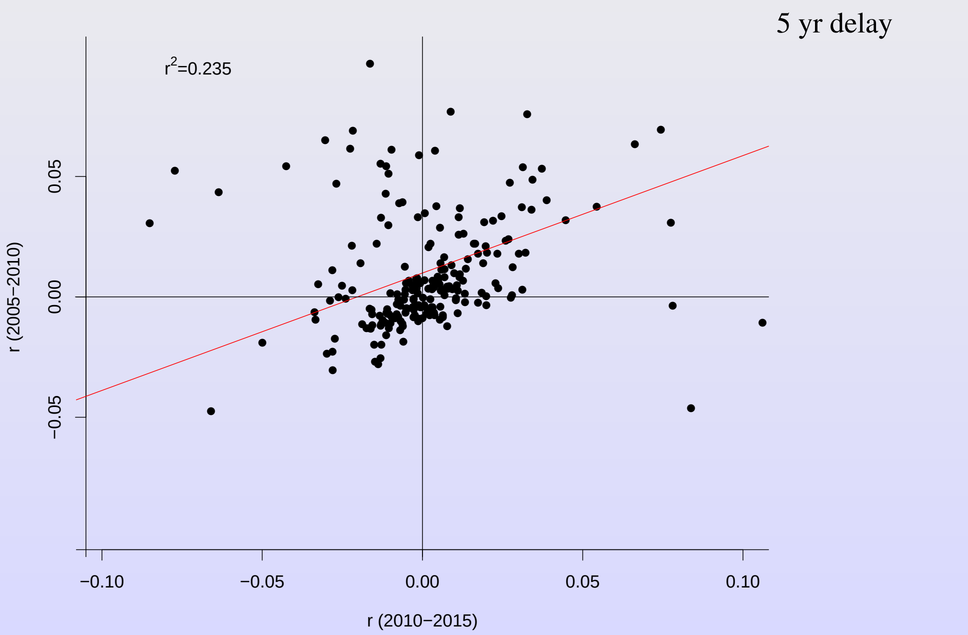

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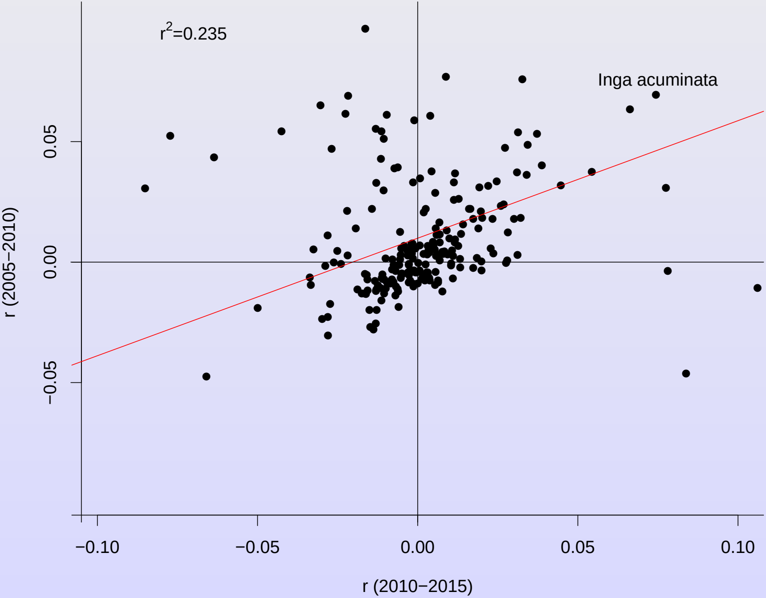
5 yr delay



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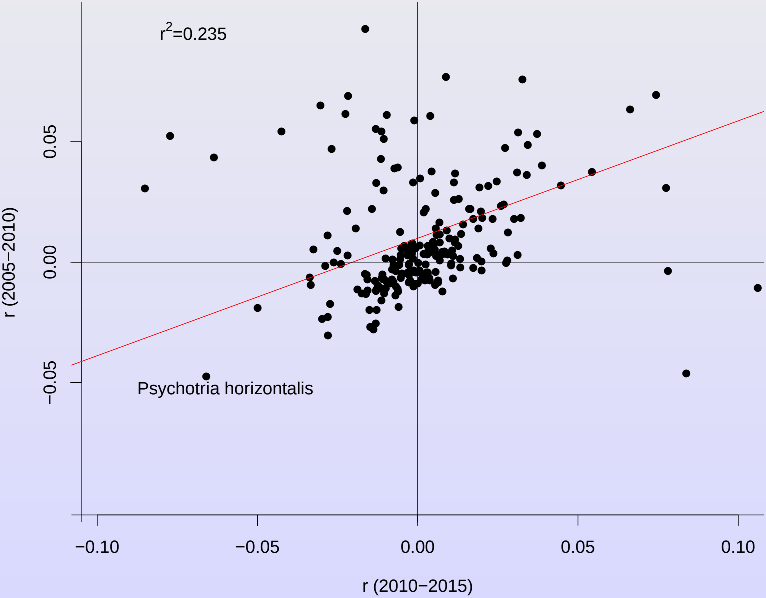

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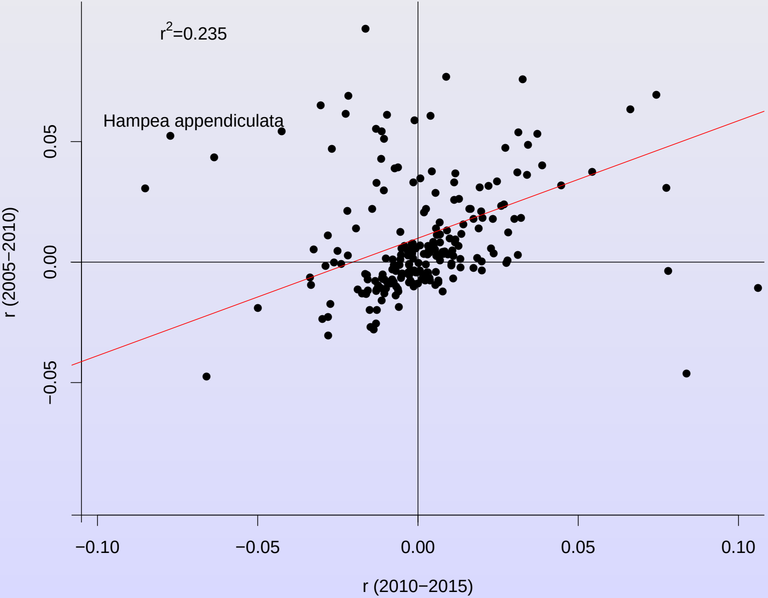

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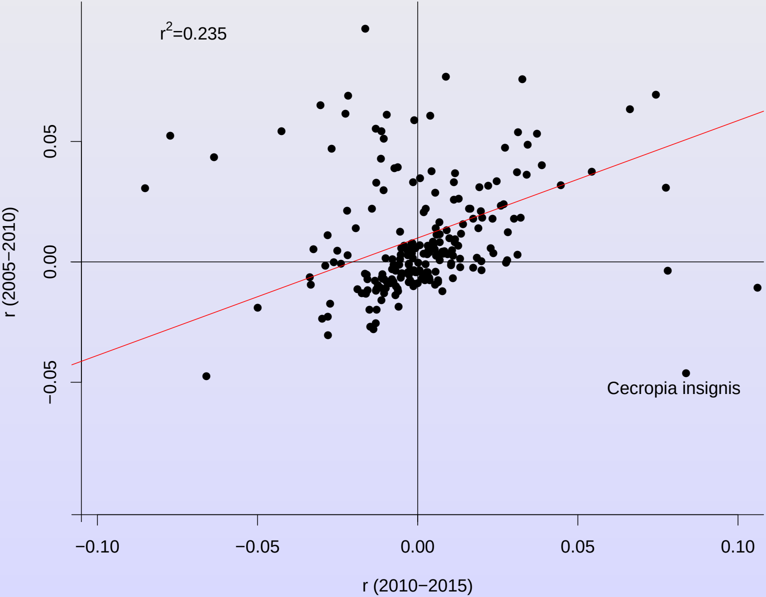

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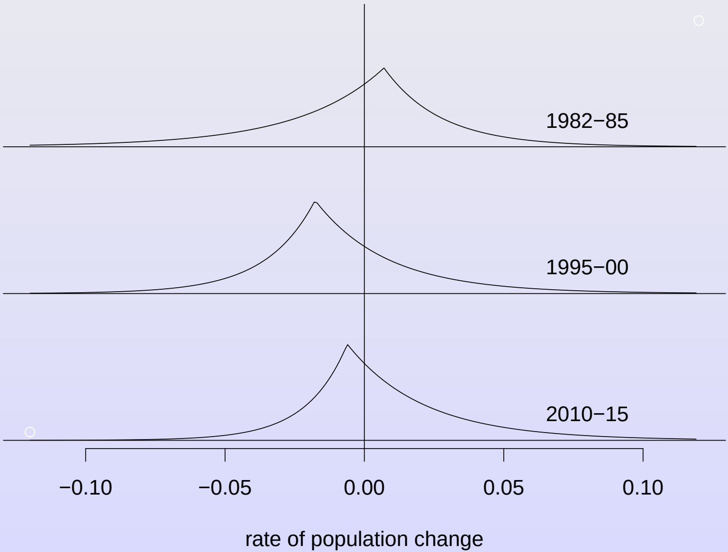

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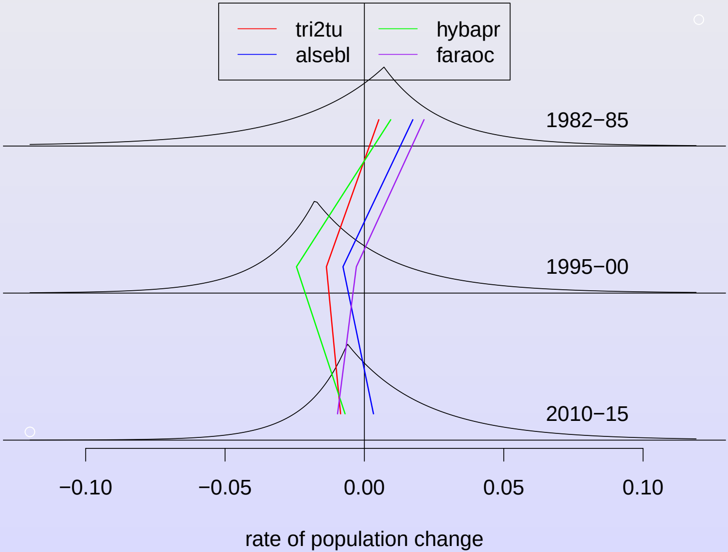

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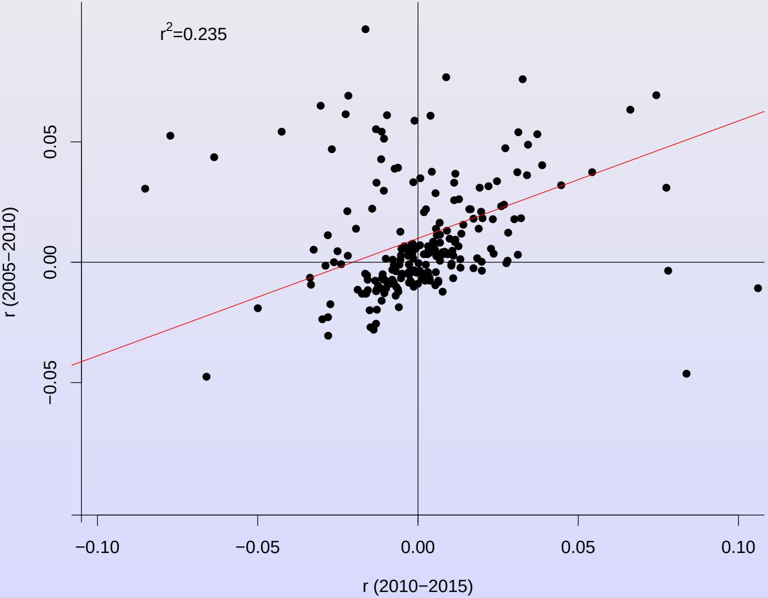
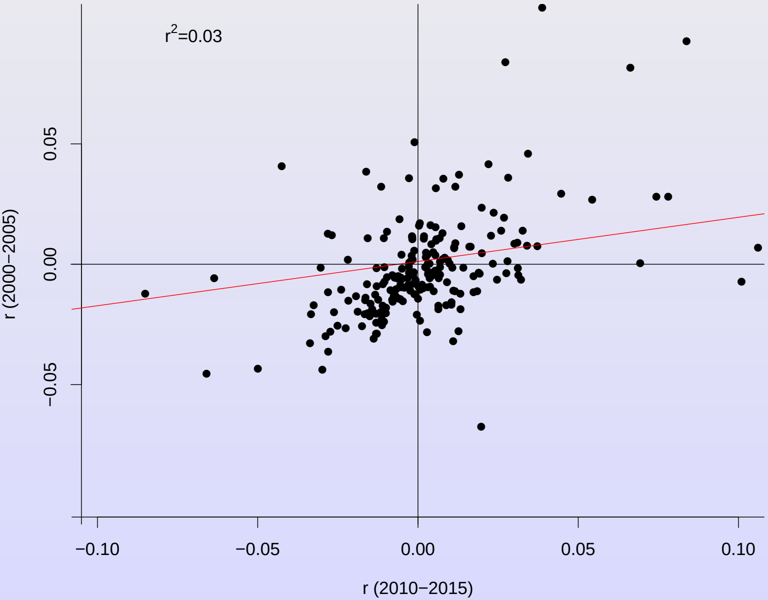


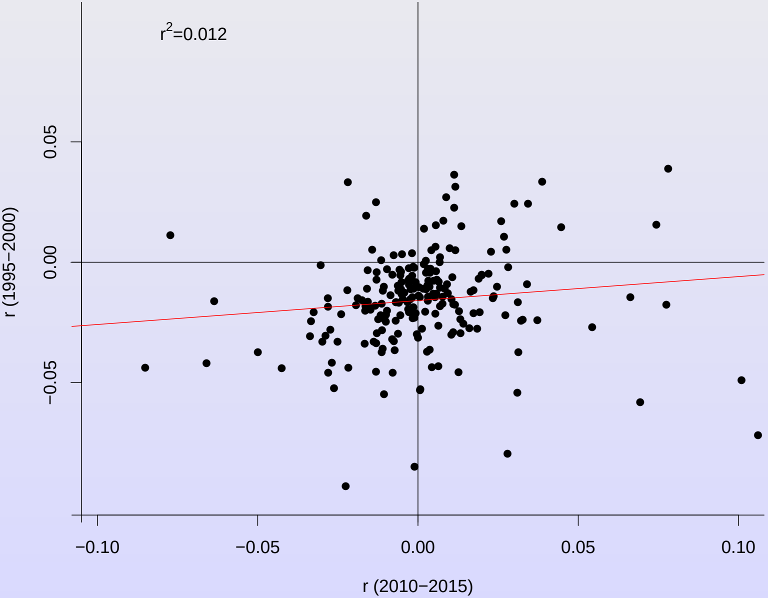
Performance consistency through time

10 yr delay



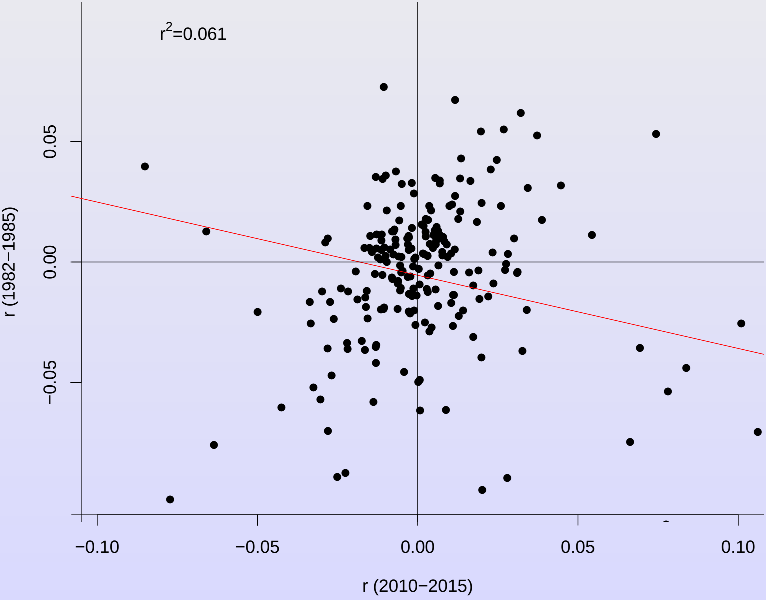
Performance consistency through time

15 yr delay



Performance consistency through time

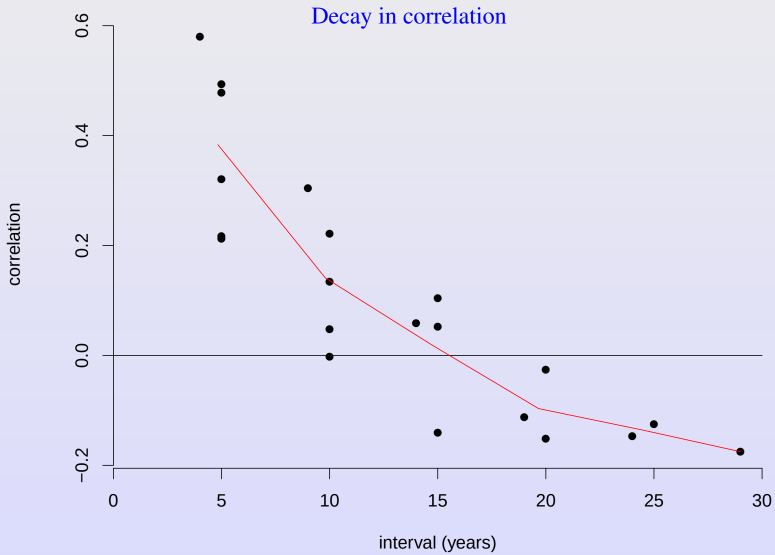
30 yr delay



Performance consistency through time

Decay in correlation

Performance consistency through time



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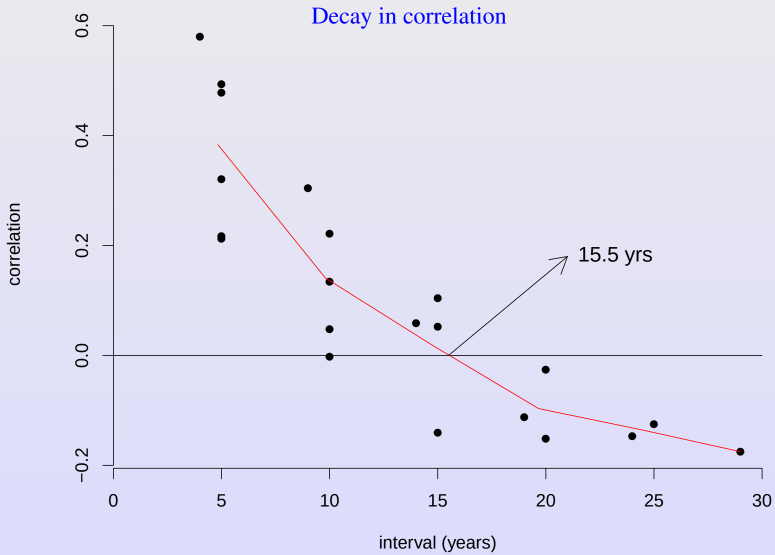

Conclusions and hypotheses for future work

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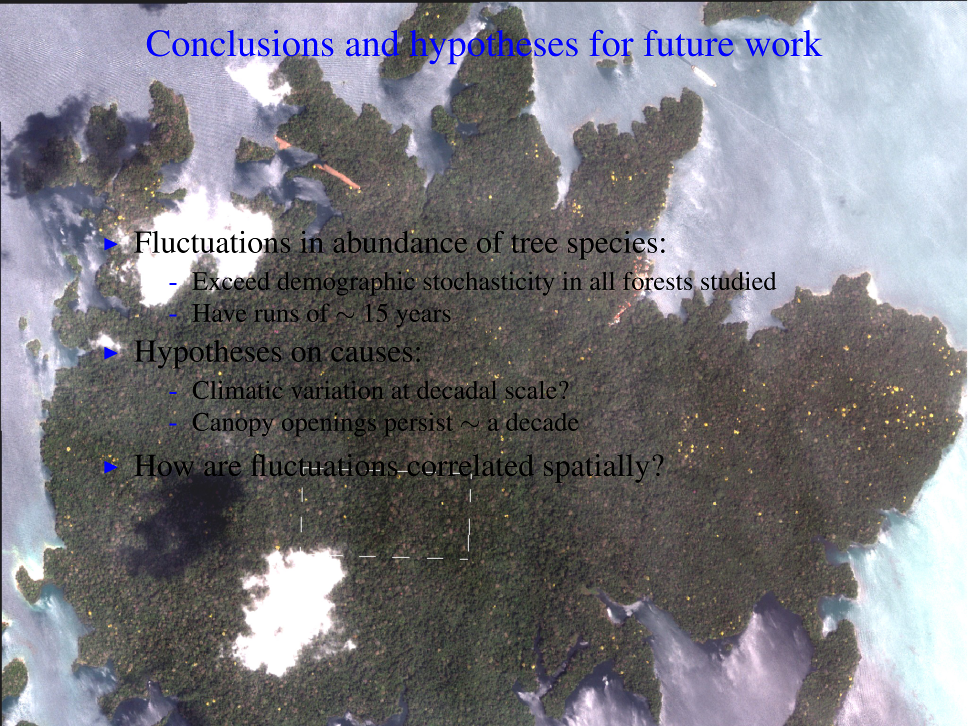

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$\theta \propto J_m V$