

Remote sensing of biodiversity: measuring ecological complexity from space

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Outline

1 Introduction

2 Estimation of taxonomic diversity

3 Species Distribution Modelling

4 Uncertainty

5 Conclusion

Networks

[Home](#) [Archive](#) [About](#)



[CEOS SBA Biodiversity Workshop](#) [read more](#)

[CEOS SBA Biodiversity Workshop](#)

Content

- [Our Aims](#)
- [First Steps](#)
- [Remote Sensing](#)
- [Conservation](#)
- [Diversity](#)
- [Networks](#)
- [Software](#)
- [Visualisation](#)
- [Literature](#)
- [FAQ](#)

User needs assessment: EO for Biodiversity and Conservation

This survey aims to obtain information from ecologists, conservationists and remote sensing scientists working in the interdisciplinary field of remote sensing within biodiversity and conservation in order to understand the needs and challenges of remote sensing applications. Through this user needs assessment we will be able to understand the status quo and future needs. The results will be communicated to decision makers e.g. CEOS, as well as the GEO framework, e.g. GEO BON, where all space agencies and other related research organisations coordinate activities.

[Read more on User needs assessment EO for Biodiversity and Conservation](#)

Conservation Remote Sensing Workshop in Myanmar

A strategic planning workshop (by invitation only) will take place in Naypyidaw, Myanmar from 17-21 June, 2013 in order to discuss the potential of geospatial technologies such as remote sensing to monitor and analyse changes of Myanmars natural resources.

[Read more: Conservation Remote Sensing Workshop in Myanmar](#)

Workshop on Remote Sensing for Conservation

This by invitation only workshop on Remote Sensing for Conservation will be held from 30th of September to 2nd of October 2013 at JRC in Ispra, Italy. The topic will be the application of Remote Sensing for Conservation, application and aims of discussing shortcomings and potential of remote sensing. A special focus will be on the needs of organizations in peri-tropical countries. Members from different research and conservation

Courtesy: Dr. Martin Wegmann

Networks



GEO BON



GEO Home



GEO BON: Biodiversity Observation Network

- Aims
- Contributors
- Meeting agenda
- Missions
- Essential Biodiversity Variables
- Biodiversity
- Outreach
- Observation
- Laws
- Centres



Highlights

Adequacy of Biodiversity Observation Systems

In response to a decision taken last November at the COP15 conference of the Convention on Biological Diversity, GEO BON has produced and submitted to the CBD a report entitled "Adequacy of Biodiversity Observation Systems to support the CBD 2020 Targets". [\[link\]](http://www.un-bonn.de/16190.html)

EC JRC launches DOFA, a Digital Observatory for Protected Areas

The Joint Research Centre of the European Commission has launched the Digital Observatory for Protected Areas (DOFA). A GEO BON contribution to the monitoring of biodiversity, the DOFA is designed as set of distributed web services to assess the state of, and pressure on, Protected Areas and to prioritize them accordingly in order to support decision-making and fund allocation processes. It is also conceived as a monitoring and ecological forecasting service.

DOFA is supported by the European projects EuroGEOSIS and InforMED and developed in collaboration with GEF, UNDP-WOC, British International, ISGFN and others. Read [\[link\]](#) a description of the use of DOFA for Africa presented at MapAfrica, 23-26 November 2010, Cape Town, South Africa.

More information about DOFA can be found at [\[link\]](http://www.jrc.ec.europa.eu/dofa/).

[\[link\]](#) more information on GEO BON online for biodiversity assessment

GEO BON

Biodiversity Observation Network

The Group on Earth Observations Biodiversity Observation Network – GEO BON – coordinates activities relating to the Biodiversity Axis (BAX) on Biodiversity of the Global Earth Observation System of Systems (GEOSS), some 100 governments, intergovernmental and non-governmental organizations are collaborating through GEO BON to regulate and improve terrestrial, freshwater and marine biodiversity observations globally and make their biodiversity data, information and forecasts more readily accessible to practitioners, managers, experts and other users. Moreover, GEO BON has been recognized by the Parties to the Convention on Biological Diversity.

The Biodiversity Observation Network is both a Community of Practice and a Task in the GEO Work Plan. It is a voluntary partnership that is guided by a steering committee comprising the key stakeholders, including DMC/ISCP, GEF, IUCN, NASA, UNEP-WOC and others. GEO BON draws on GEO's work on data-sharing principles to promote full and open exchange of data, and on the GEOSS Common Infrastructure to enable interoperability through adoption of consistent standards.

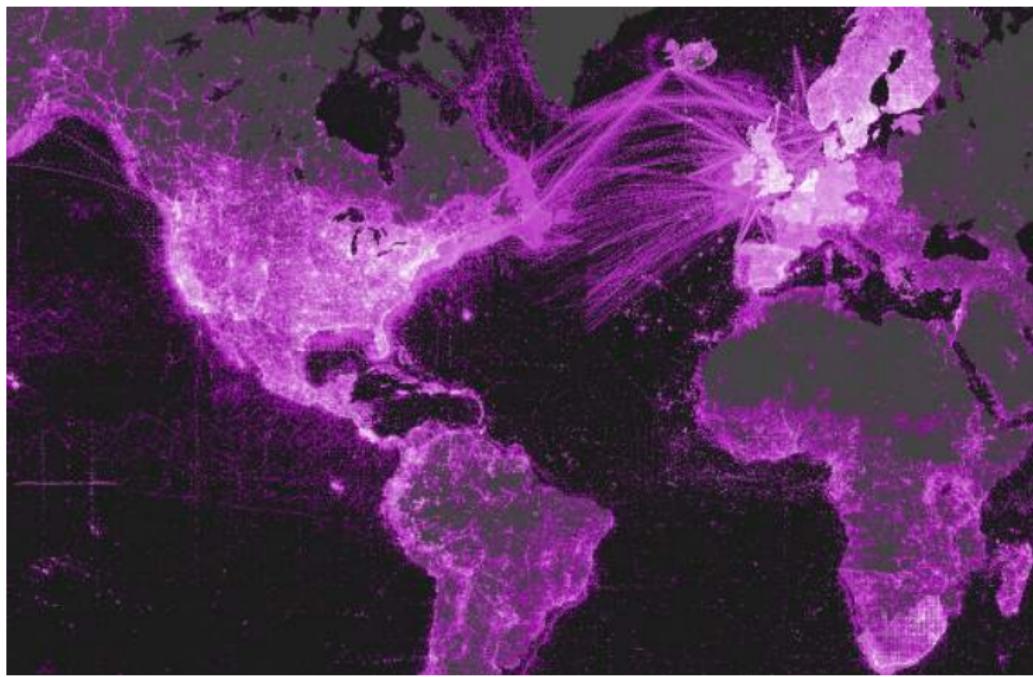
To assist both holders and users of biodiversity information to engage with GEO BON, this website contains links to information resources, activities and GEO BON documents, meetings and other resources.

Courtesy: Dr. Martin Wegmann

Networks



Networks



The power of remote sensing



"Reflectances variability over an area should result in a positive outcome when dealing with biodiversity evaluation, strictly related to ecosystem entropy. In particular, when aiming to locate heterogeneous environments one might make use of external information suspected to be correlated with species richness."

Rocchini (Remote Sens. Environ., 2007)

Aim of this seminar

Remote sensing power to improve:

- Estimation of taxonomic diversity
- Species Distribution Modelling
- Uncertainty



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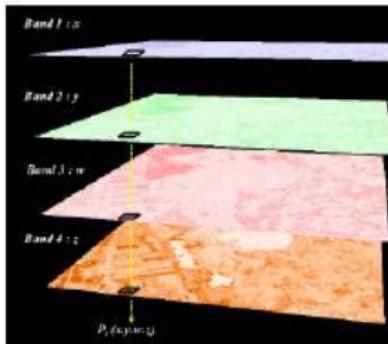
Local species diversity estimate (α – diversity)

ENVIRON METRICS

Environmetrics 2002; 13: 121–137 (DOI: 10.1002/env.516)

Quantitative tools for perfecting species lists

Michael W. Palmer^{1,2,†}, Peter G. Earls¹, Bruce W. Hoagland²,
Peter S. White^{3,4}, Thomas Wohlgemuth⁵

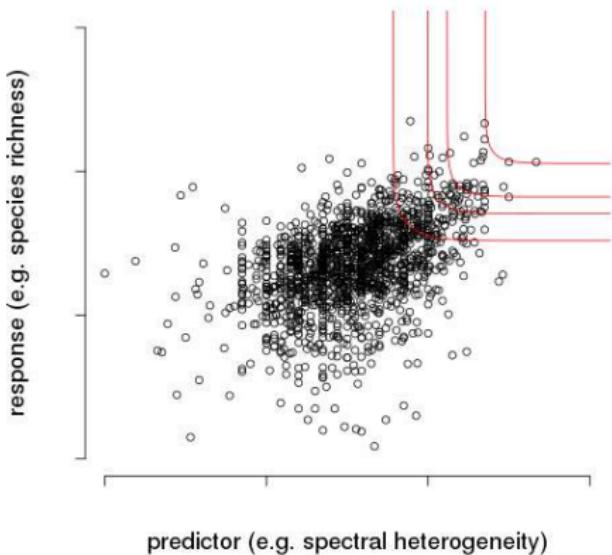


- SPECTRAL VARIATION HYPOTHESIS**

“Spatial variation (e.g. expressed as standard deviation of reflectance) is likely to be correlated with spatial variation in the environment [which is] likely to be correlated with species richness”

(Palmer et al., Environmetrics, 2002)

Local species diversity estimate (α – diversity)



evd: - Functions for extreme value distributions - R package

Extends simulation, distribution, quantile and density functions to univariate and multivariate parametric extreme value distributions, and provides fitting functions which calculate maximum likelihood estimates for univariate and bivariate maxima models, and for univariate and bivariate threshold models.

Local species diversity estimate (α – diversity)

 Biodiversity and Conservation 15: 2599–2621, 2006.
© 2006 Kluwer Academic Publishers. Printed in the Netherlands.

Mapping the spatial distribution of plant diversity indices in a tropical forest using multi-spectral satellite image classification and field measurements

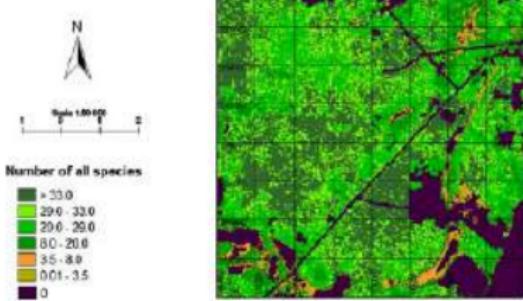
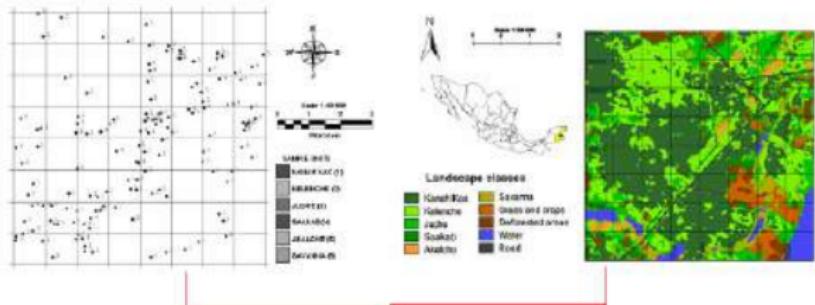
J. LUIS HERNANDEZ-STEFANONI¹ and RAUL PONCE-HERNANDEZ^{1,2,*}

Biotropica Letters (2007) 14: 3127–3135
DOI 10.1007/s10531-007-9182-6

ORIGINAL PAPER

Mapping species density of trees, shrubs and vines in a tropical forest, using field measurements, satellite multispectral imagery and spatial interpolation

J. Luis Hernandez-Stefanoni · Juan Manuel Díazay



Local species diversity estimate (α – diversity)

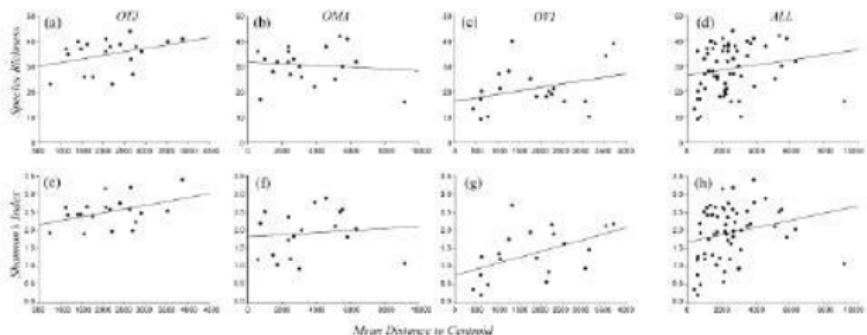
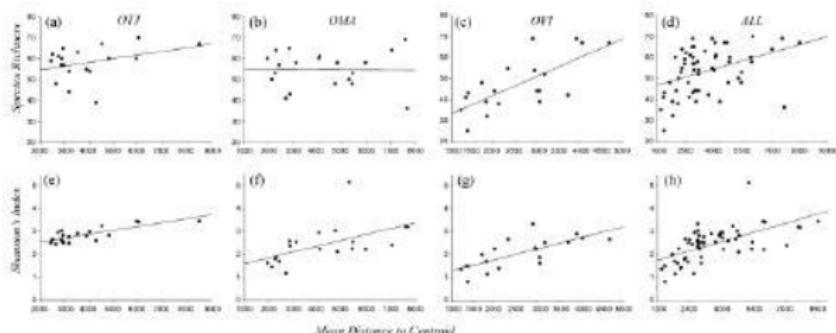


Fig. 3. Species richness and Shannon Index versus spectral variability for the three test sites on the scale 10 m × 10 m.



Oldeland et al. (Ecol. indic., 2010)

Local species diversity estimate (α – diversity)

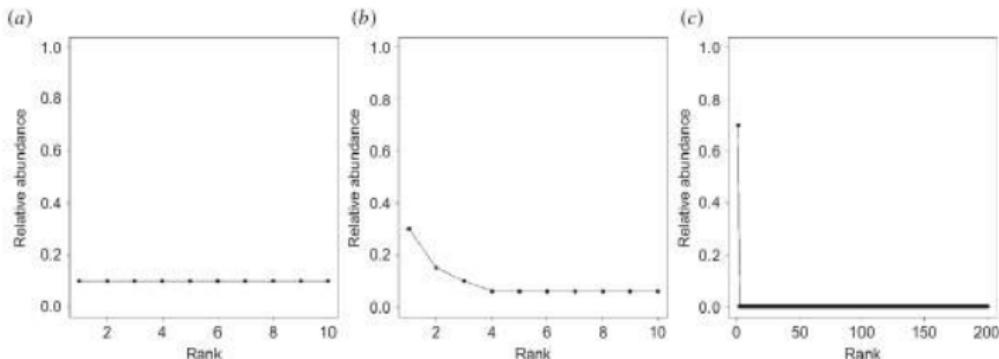


Figure 2. Rank–abundance diagrams derived from three different situations. (a) Array A: richness = 10 DN values, complete equitability. (b) Array B: richness = 10 DN values, with 3 values being more abundant. (c) Array C: richness = 200 DN values, with 1 dominant DN value. Notice that although the images are different in terms of richness or relative abundance, the Shannon entropy index H is very similar equalling 2.3, 2.11 and 2.2 for images (a), (b) and (c), respectively. We refer to the main text for major explanations.

Rocchini and Neteler (Int. J. Remote Sens., 2012)

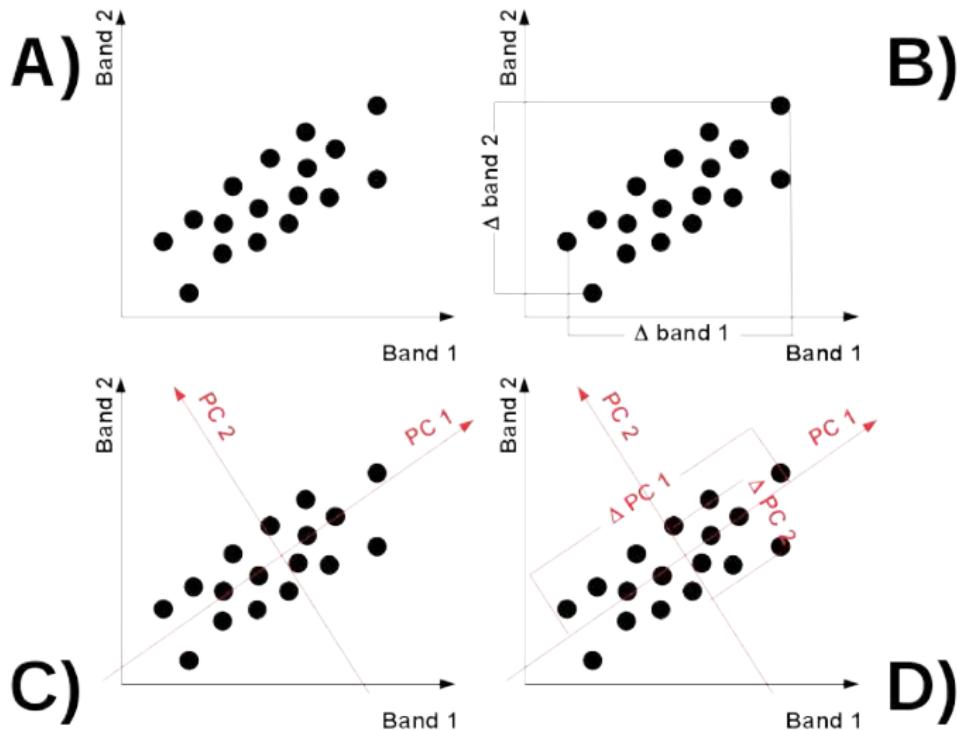
Local species diversity estimate (α – diversity)

Rényi (1970) generalised entropy:

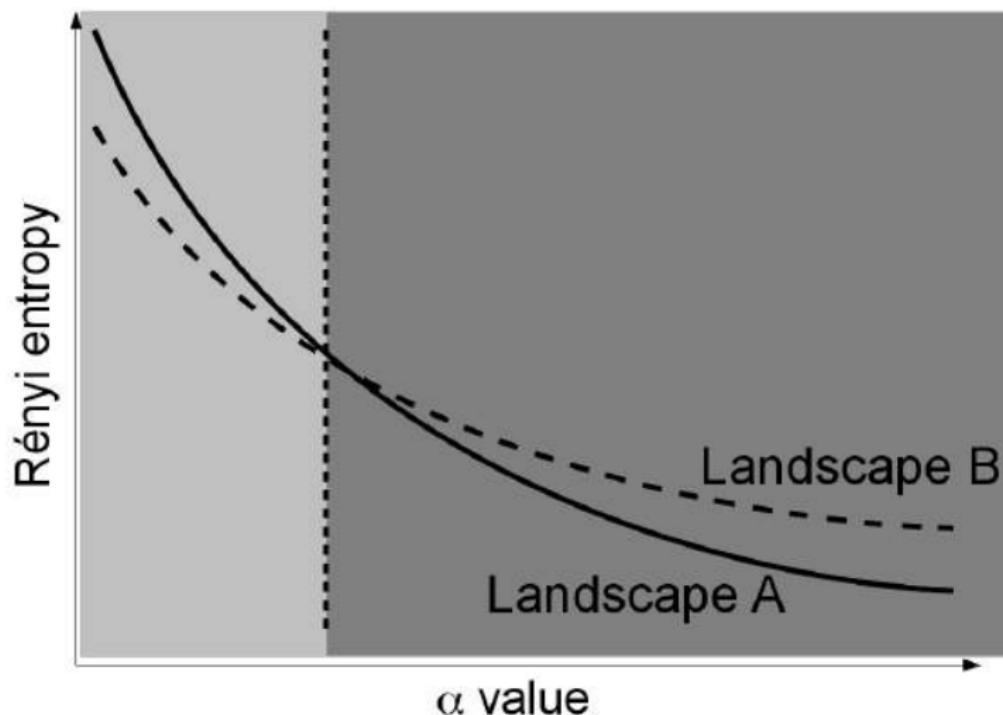
$$H_\alpha = \frac{1}{1-\alpha} \ln \sum p^\alpha \quad (1)$$

where p =relative abundance of each spectral reflectance value (DN). Such measure is extremely flexible and powerful since many popular diversity indices are simply special cases of H_α .

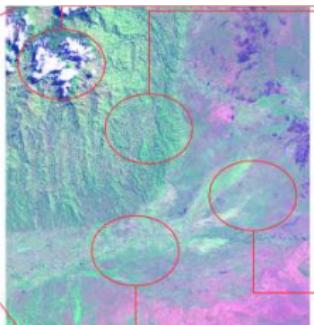
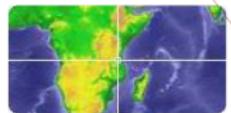
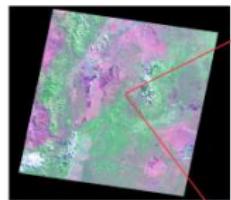
Local species diversity estimate (α – diversity)



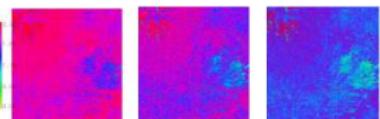
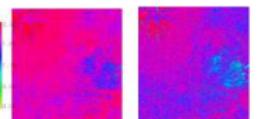
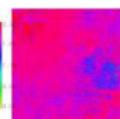
Local species diversity estimate ($\alpha - diversity$)



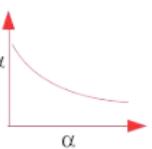
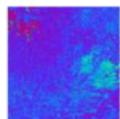
Local species diversity estimate (α – diversity)



r.diversity input=map method=renyi out=renyi size=3
alpha=0,1,2,...,∞



[...]



$$H_\alpha = \frac{1}{1-\alpha} \ln \sum p^\alpha \quad \text{Increasing alpha parameter}$$

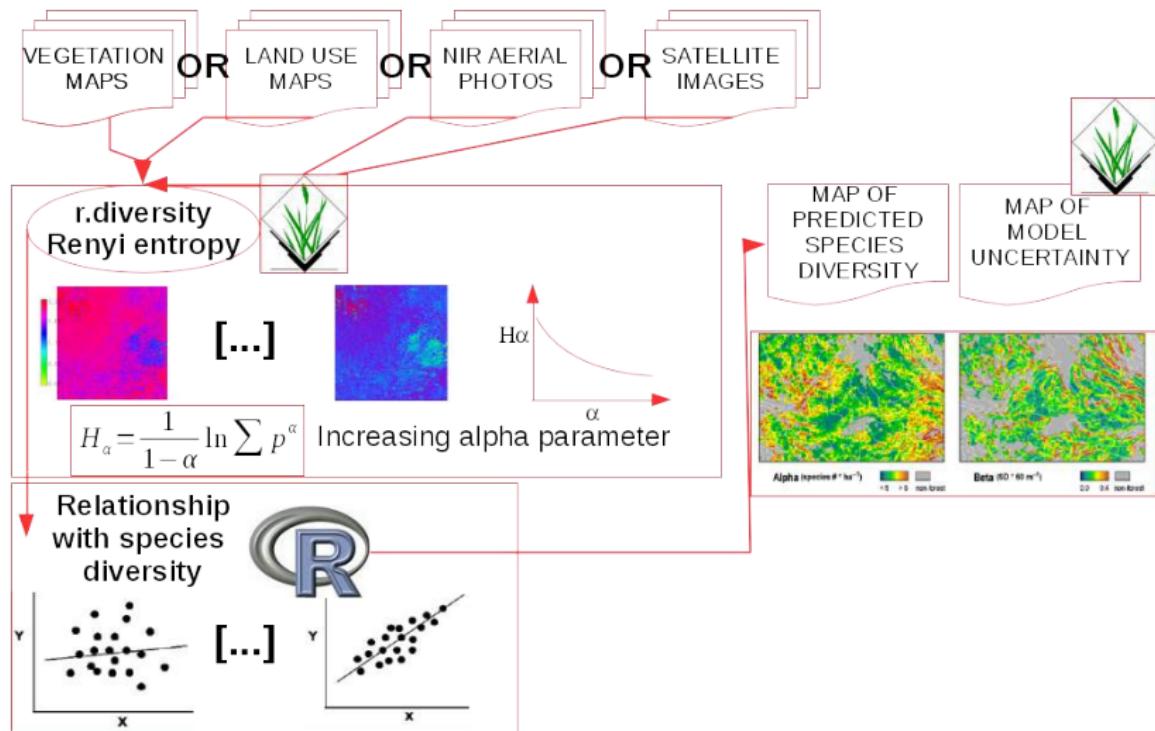


Saintpaulia Sterculia appendiculata Antiaris toxicaria



Antiaris toxicaria

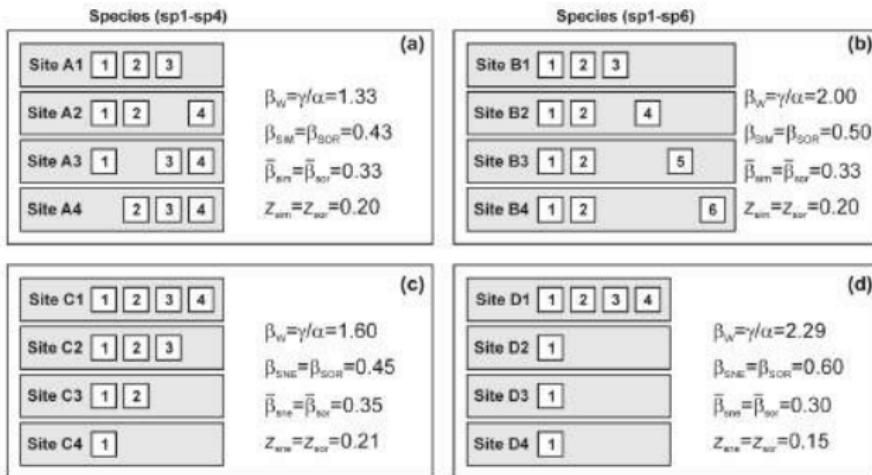
Local species diversity estimate (α – diversity)



Species turnover estimate ($\beta - diversity$)



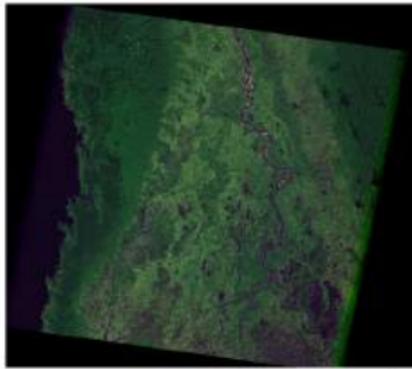
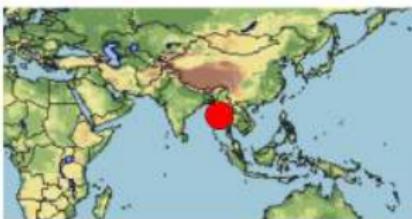
Species turnover estimate (β – diversity)



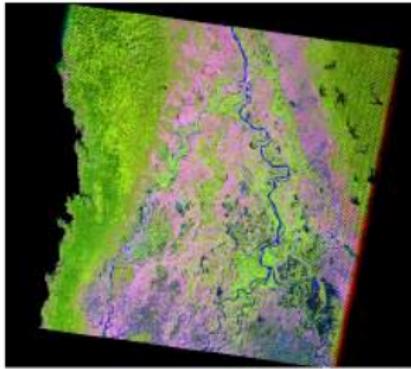
Baselga, A., 2013. Multiple site dissimilarity quantifies compositional heterogeneity among several sites, while average pairwise dissimilarity may be misleading. Ecography 36, 124-128.

Species turnover estimate ($\beta - diversity$)

i.colors.enhance - Performs auto-balancing of colors for RGB images.



(a)



(b)

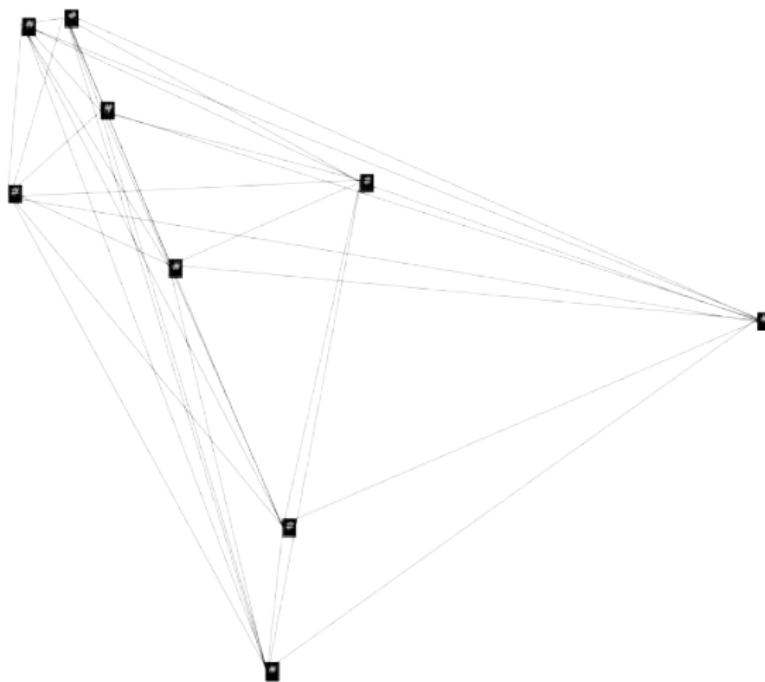
i.colors.enhance
red=L71133048_04820051230_B50 green=L71133048_04820051230_B40
blue=L71133048_04820051230_B30

Species turnover estimate (β – diversity)

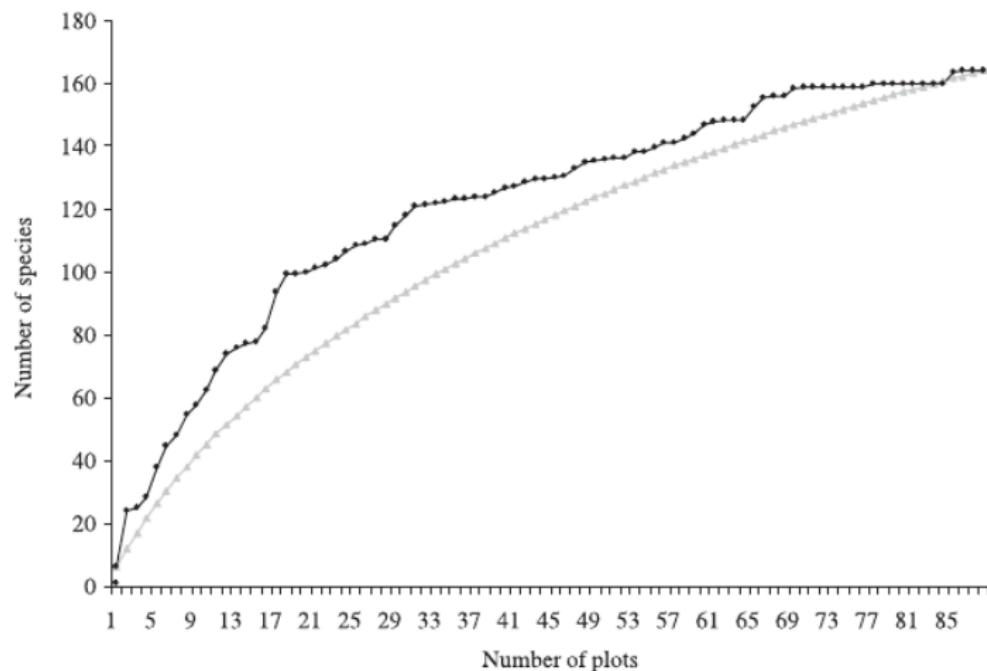
$$M_d = \begin{pmatrix} d_{1,1} & d_{1,2} & d_{1,3} & \cdots & d_{1,n} \\ d_{2,1} & d_{2,2} & d_{2,3} & \cdots & d_{2,n} \\ d_{3,1} & d_{3,2} & d_{3,3} & \cdots & d_{3,n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ d_{n,1} & d_{n,2} & d_{n,3} & \cdots & d_{n,n} \end{pmatrix} \quad (2)$$

or more simply $123[2ex]123n123n123n$, once n plots are considered, based on an *a-priori* defined statistical sampling design.

Species turnover estimate (β – diversity)



Species turnover estimate (β – diversity)

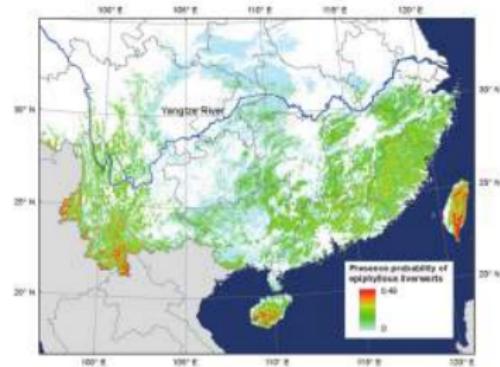


Rocchini, D., Andreini Butini, S., Chiarucci, A. (2005). Maximizing plant species inventory efficiency by means of remotely sensed spectral distances. **Global Ecology and Biogeography**, 14: 431-437.

Outline

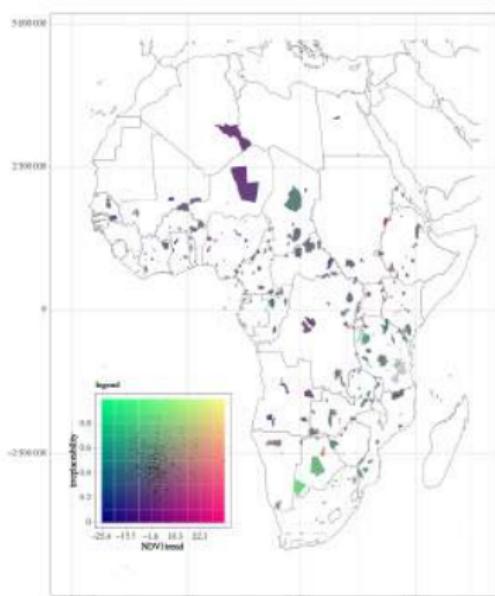
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Species Distribution Modelling



Yanbin Jiang, C.A.J.M. de Bie, Tiejun Wang, A.K. Skidmore, Xuehua Liu, Shanshan Song and Xiaoming Shao Hyper-temporal remote sensing helps in relating epiphyllous liverworts and evergreen forests (pages 214–226) journal of vegetation Scinece.

Species Distribution Modelling



Wegmann, M., Santini, L., Leutner, B., Safi, K., Rocchini, D., Bevanda, M., Latifi, H., Dech, S., Rondinini, C. (2014). Role of African protected areas in maintaining connectivity for large mammals. **Philosophical Transactions of the Royal Society B-Biological Sciences**, 369: 20130193.

Species Distribution Modelling

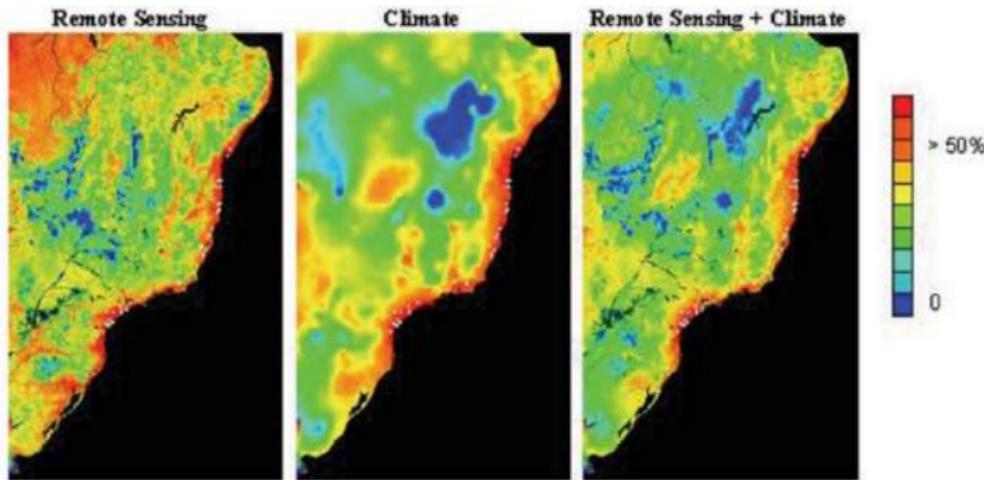


Figure 3 Maxent model of *Carpornis melanoleuca* (Black-Headed Berryeater) in Brazil using remote sensing data, climate data, and a combination of both remote sensing and climate data.

Gillespie, T.W., Foody, G.M., Rocchini, D., Giorgi, A.P., Saatchi, S. (2008). Measuring and modeling biodiversity from space. **Progress in Physical Geography**, 32: 203-221.

Outline

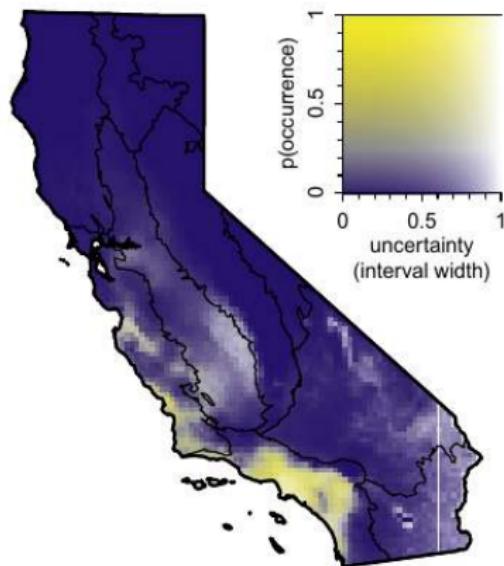
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Uncertainty

$$\text{Decision} = \begin{pmatrix} < E_m | > I & < E_m | < I \\ > E_m | > I & > E_m | < I \end{pmatrix} \quad (3)$$

where $E_m = \text{modelerror (or uncertainty)}$, $I = \text{potential invasion}$

Uncertainty



"Including such estimates alongside mean projections gives a "map of ignorance" as called for by Rocchini et al. (2011), highlighting areas where knowledge is lacking and could be improved with additional sampling effort or the inclusion of additional covariates." [Swanson et al., Global Ecol. Biogeogr., 2013]

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Concluding remarks

- Assessment of biodiversity at local and regional scales often relies on fieldwork-based data collection .
- Species assessment in relatively large areas has always been a challenging task for ecologists.
- Large spatial scales
- Remote sensing data sources and techniques are being rapidly developed, but quantitative tests need to be carried out to assess diversity using these data and techniques.
- Improving theoretical and empirical measurements of diversity by remote sensing should help to find the ecological gradients shaping diversity on a large spatial scale.
- Studying genetic structure at the landscape scale is a promising field of research which could provide us with a better understanding of species dispersal and gene flow across habitats.

Ecological informatics



- “The increasing availability of **open ecological data** [...] makes it increasingly possible to test cutting-edge ecological theories, such as dark diversity, evolutionary paths and climate change scenarios.”
- “In using a shared **open-source code** [...] researchers can be sure that their results are **reliable** and also that the code they have used is **robust**”

Rocchini, D., Neteler, M. (2012). Let the four freedoms paradigm apply to ecology. **Trends in Ecology & Evolution**, 27: 310–311.

Thank you!

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