

Diversity Patterns II

Today's Agenda:

- Quiz
- Species-Area Relationship
 - Island Biogeography
- Species-Abundance Distribution

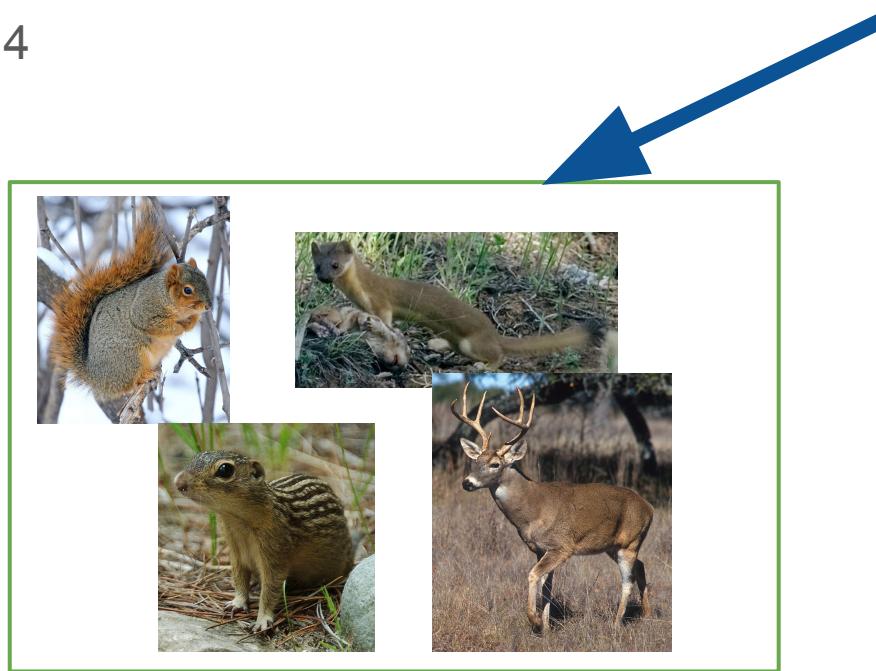
How to we measure diversity?

- Species Richness = 4



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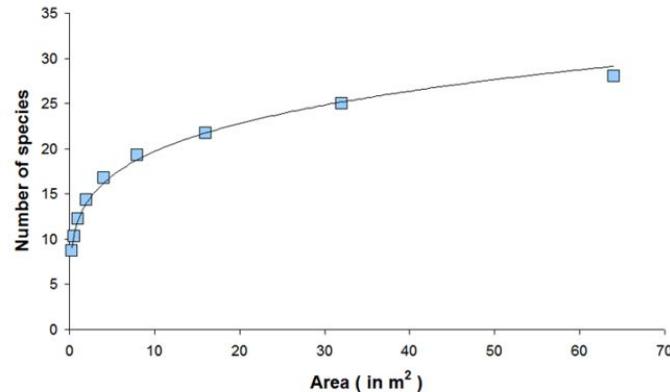
Species-Area Relationship



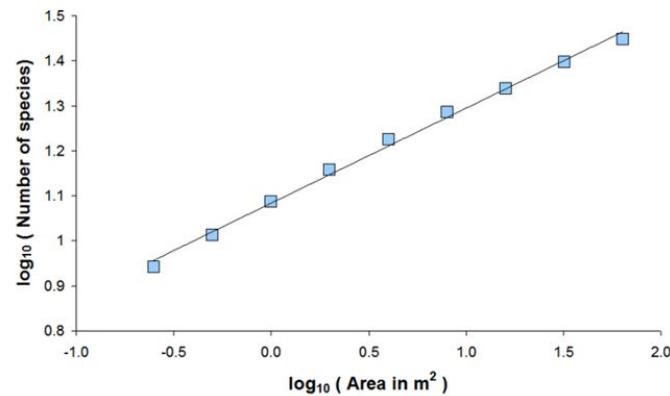
Species-Area Relationship



Species-area Relationship on Arithmetic Axes



Species-area Relationship on Log-log Axes

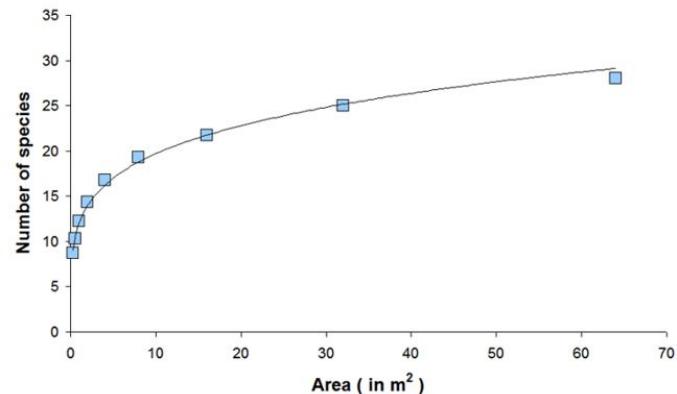


Species-Area Relationship

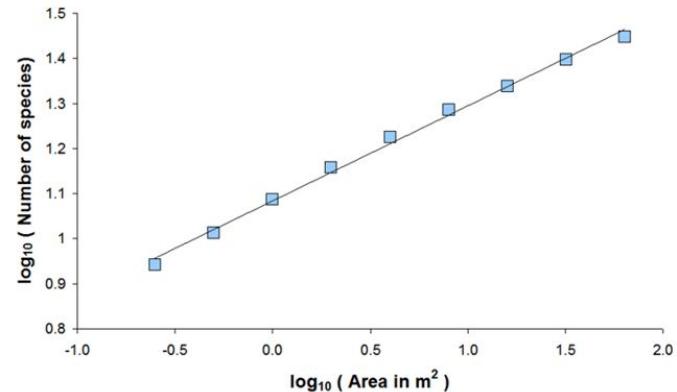
- A general pattern in ecology
- Can be used to standardize measurements
(or can use similar-sized plots)

Why might you NEED to use different sized plots?

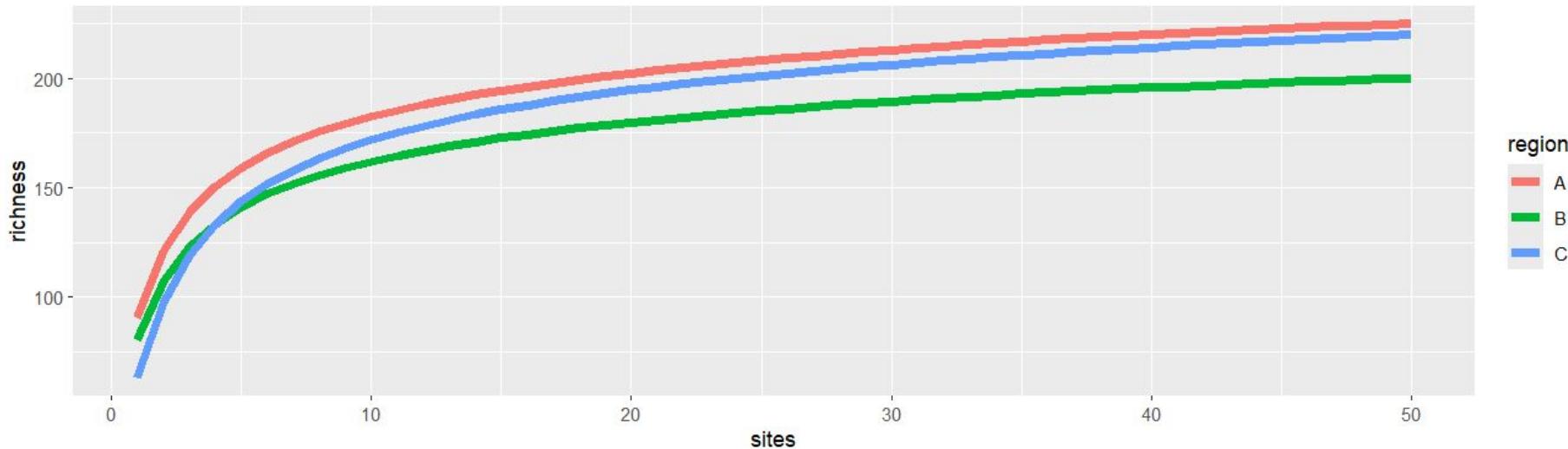
Species-area Relationship on Arithmetic Axes



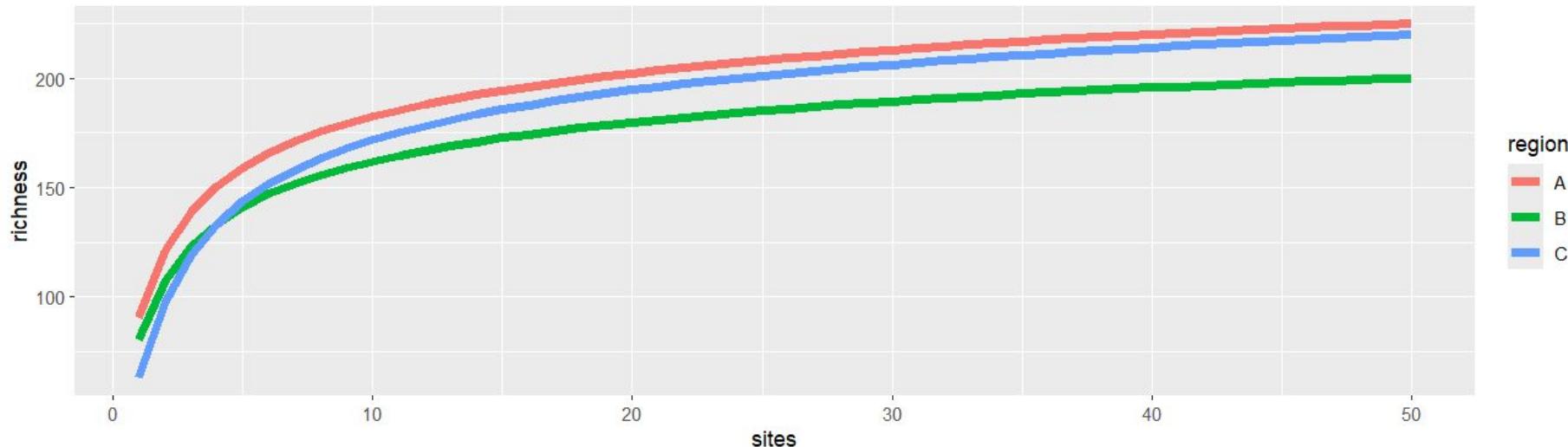
Species-area Relationship on Log-log Axes



SARs - What can they tell us?

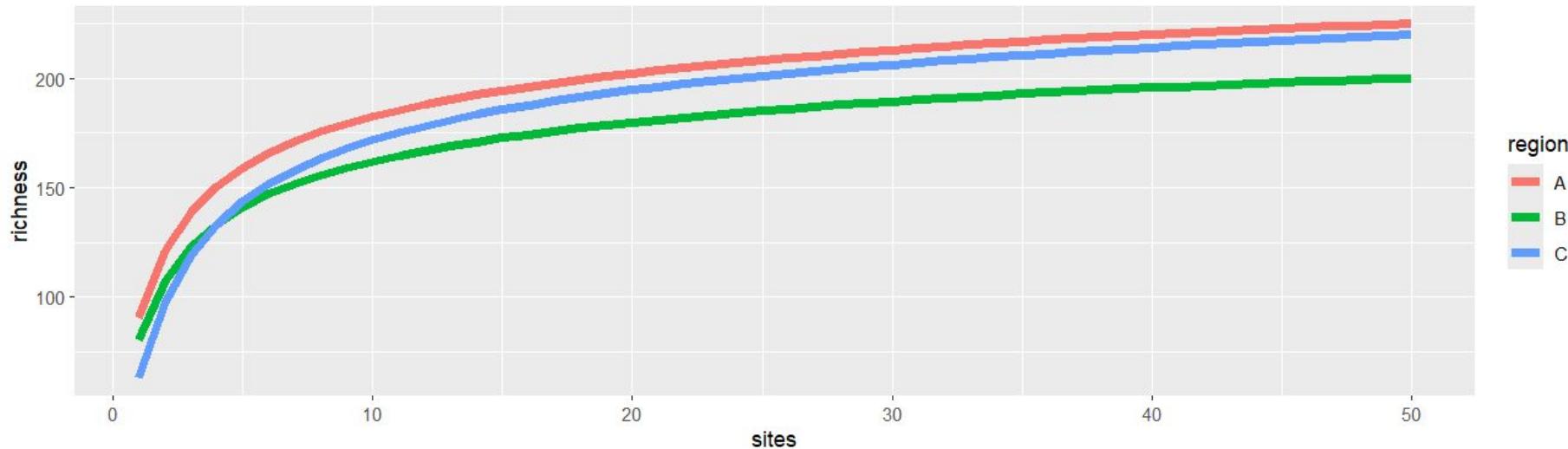


SARs - What can they tell us?



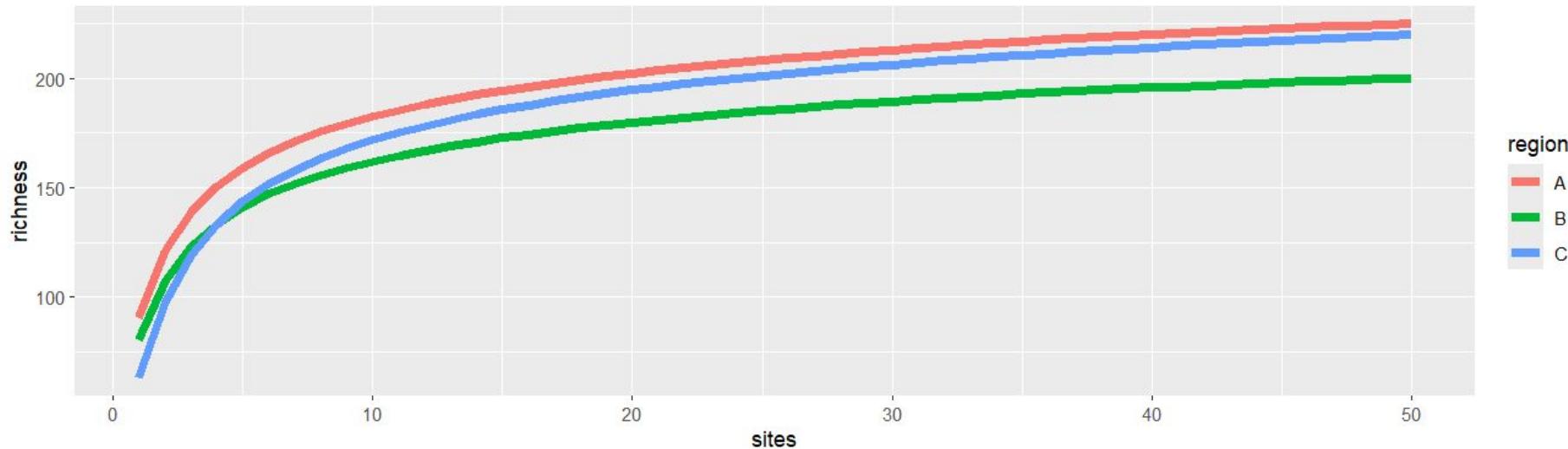
Q: Why does the curve level out as sample size increases?

SARs - What can they tell us?



Q: How does this relate to alpha and gamma diversity?

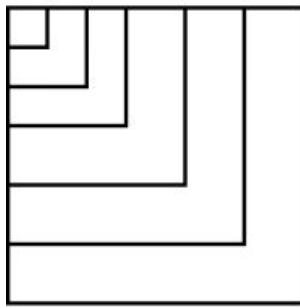
SARs - What can they tell us?



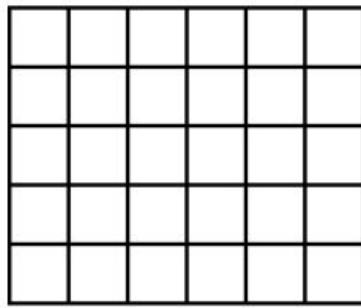
Q: How does this relate to beta diversity?

6 types of SAR

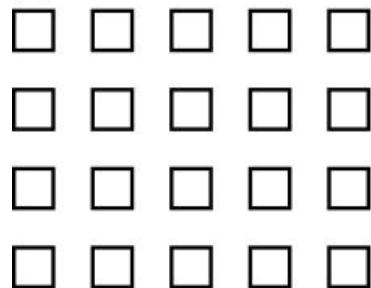
(a)



(b)



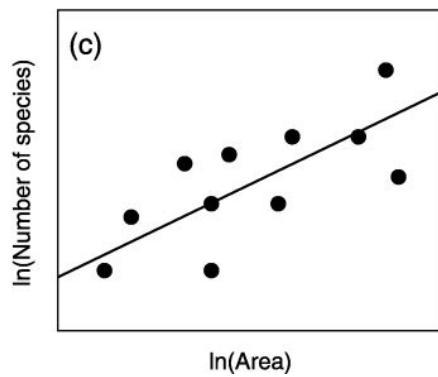
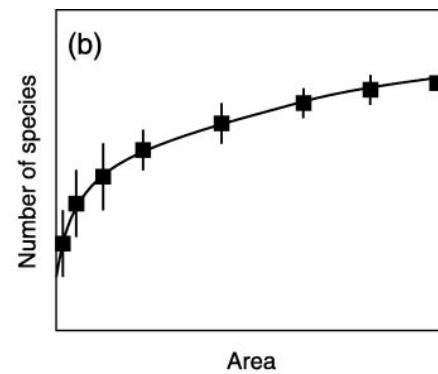
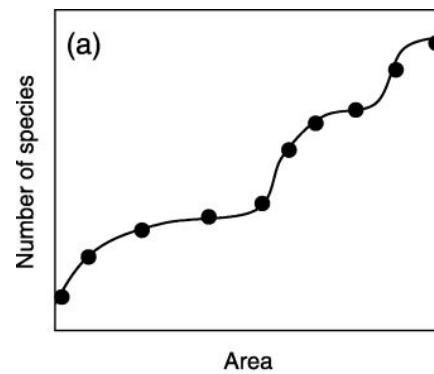
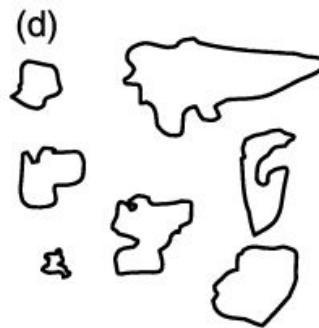
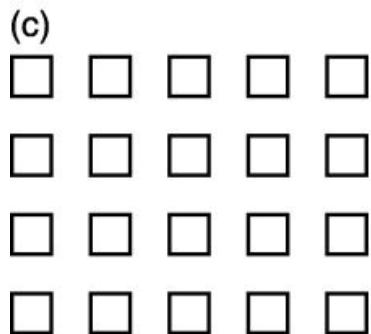
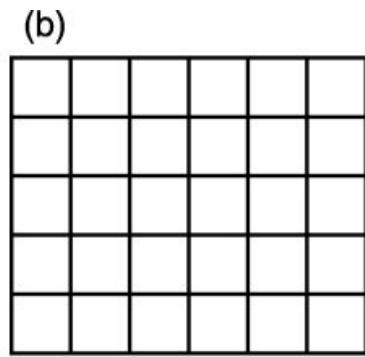
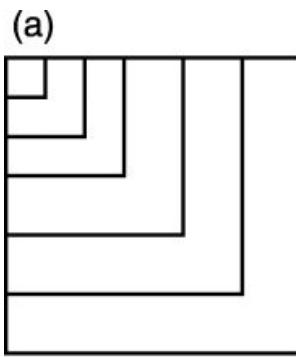
(c)



(d)



6 types of SAR



Modelling the SAR

Often fit using the equation:

$$S = cA^z$$

S = # Species

A = Area

c = fitted parameter

z = fitted parameter

Modelling the SAR

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Or, on a log-scale:

$$\log(S) = z^* \log(A) + \log(c)$$

Modelling the SAR

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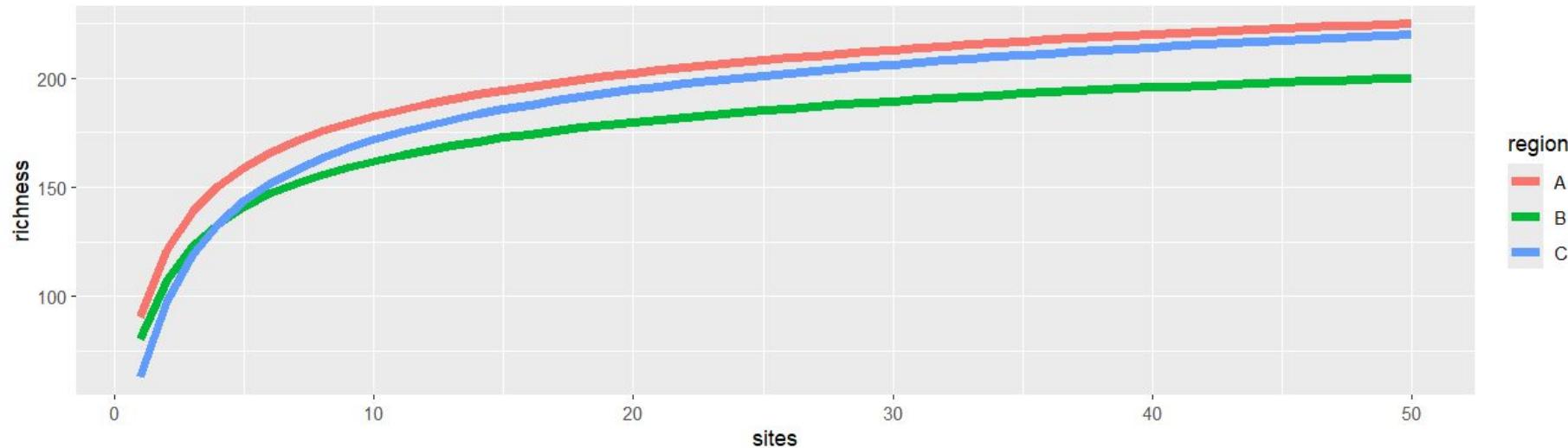
Or, on a log-scale:

$$\log(S) = z * \log(A) + \log(c)$$

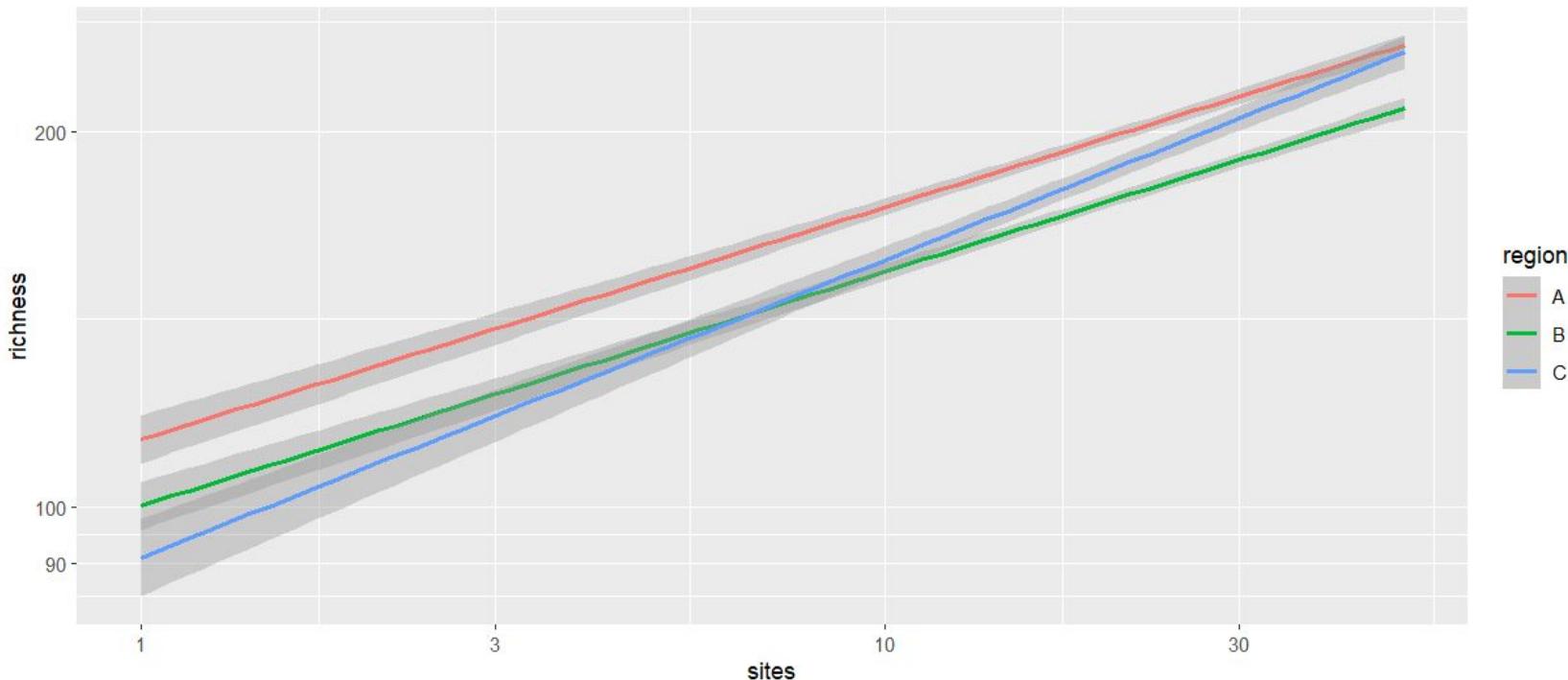
$$y = mx + b$$

So, on a log scale, z = slope, c = intercept

Modelling the SAR



Modelling the SAR



Interpreting the SAR

Or, on a log-scale:

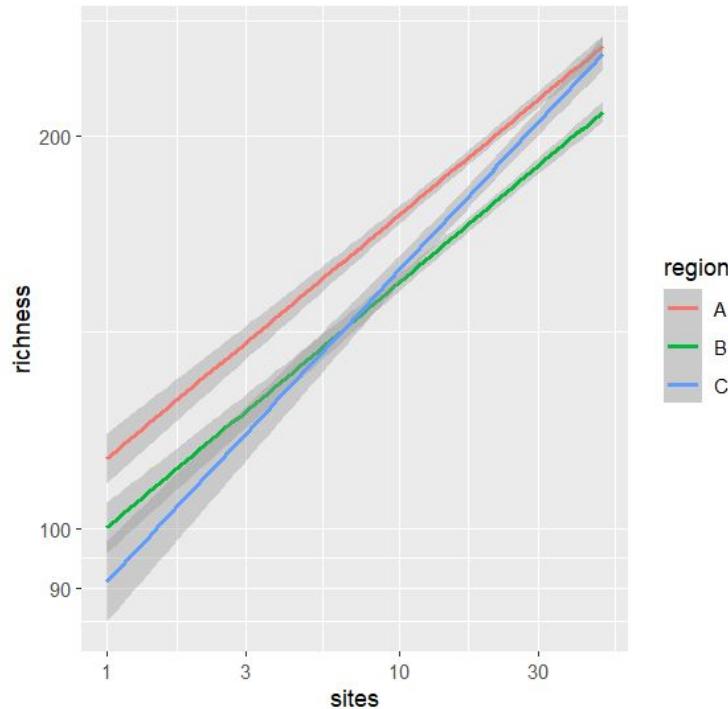
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z = related to beta diversity

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Causes of the SAR

Why might larger areas (or larger samples) contain more species?

Causes of the SAR

Why might larger areas (or larger samples) contain more species?

1. More habitats
2. Lower likelihood of extinction
3. Higher colonization rate
4. By chance

Causes of the SAR: habitat diversity

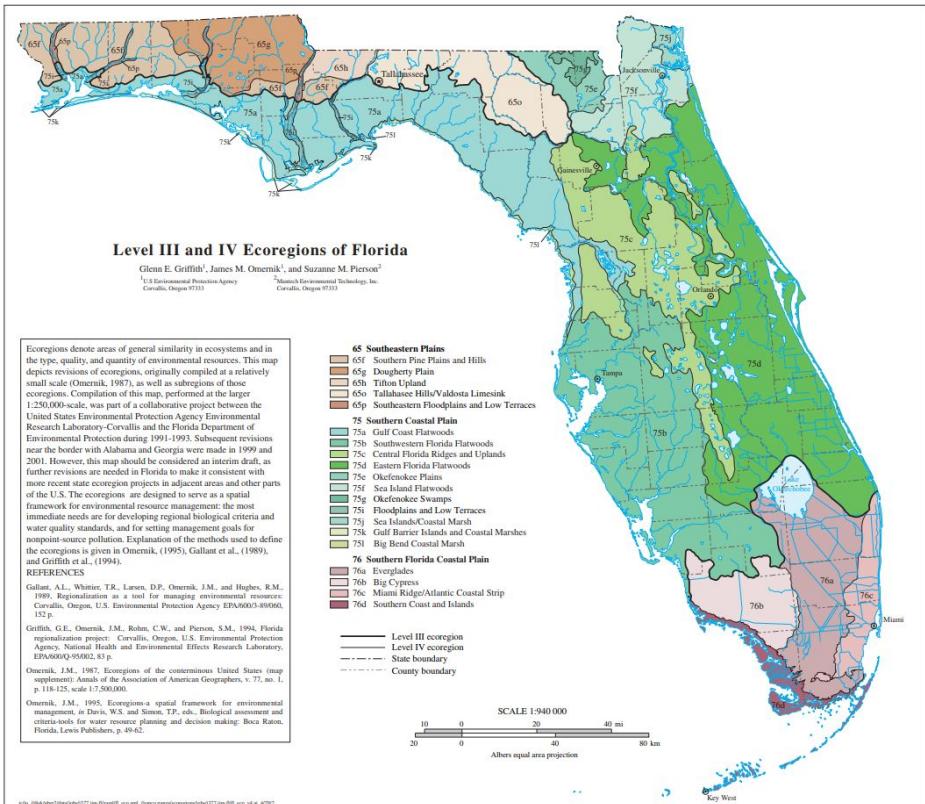
Nearby areas tend to have similar habitats (= spatial autocorrelation)

A larger area increases the variation within the sample

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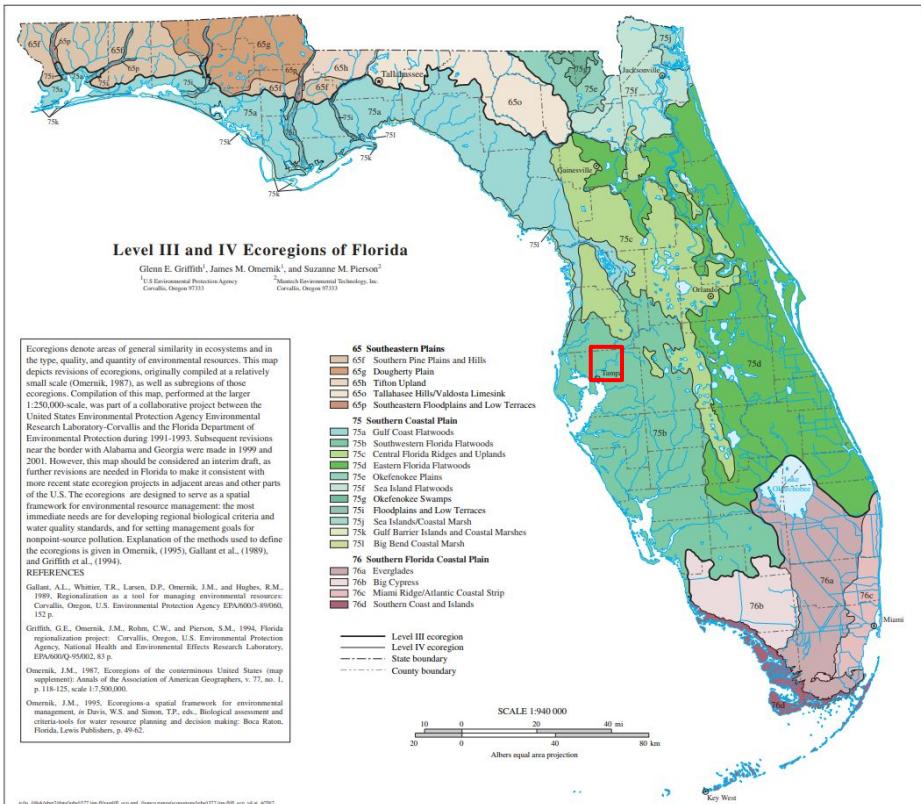
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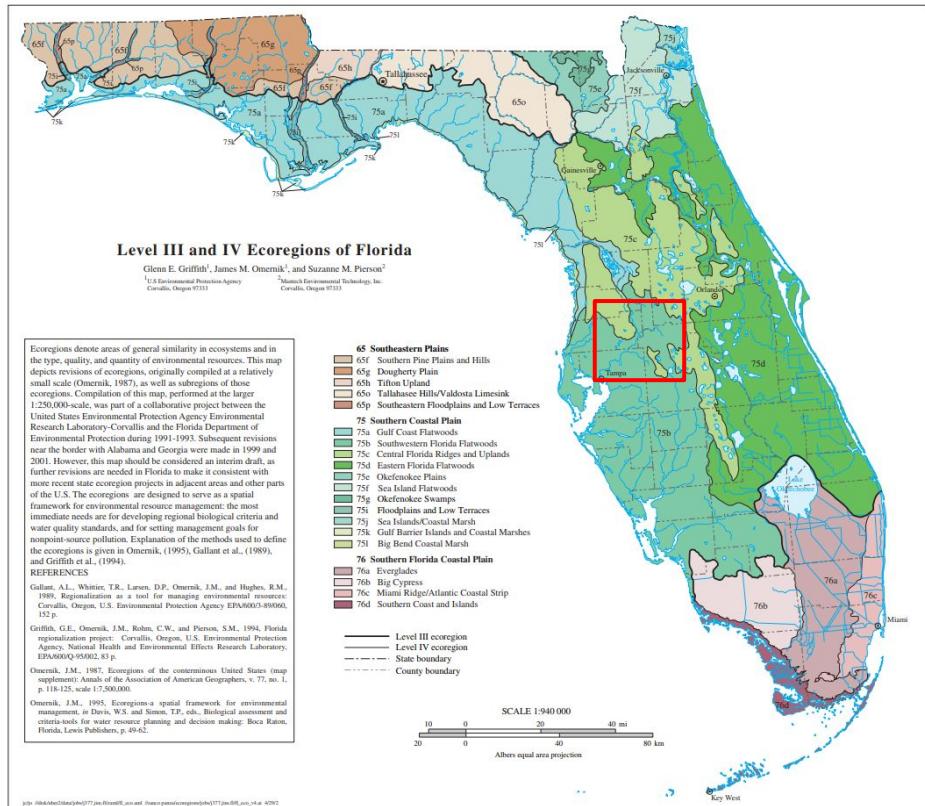
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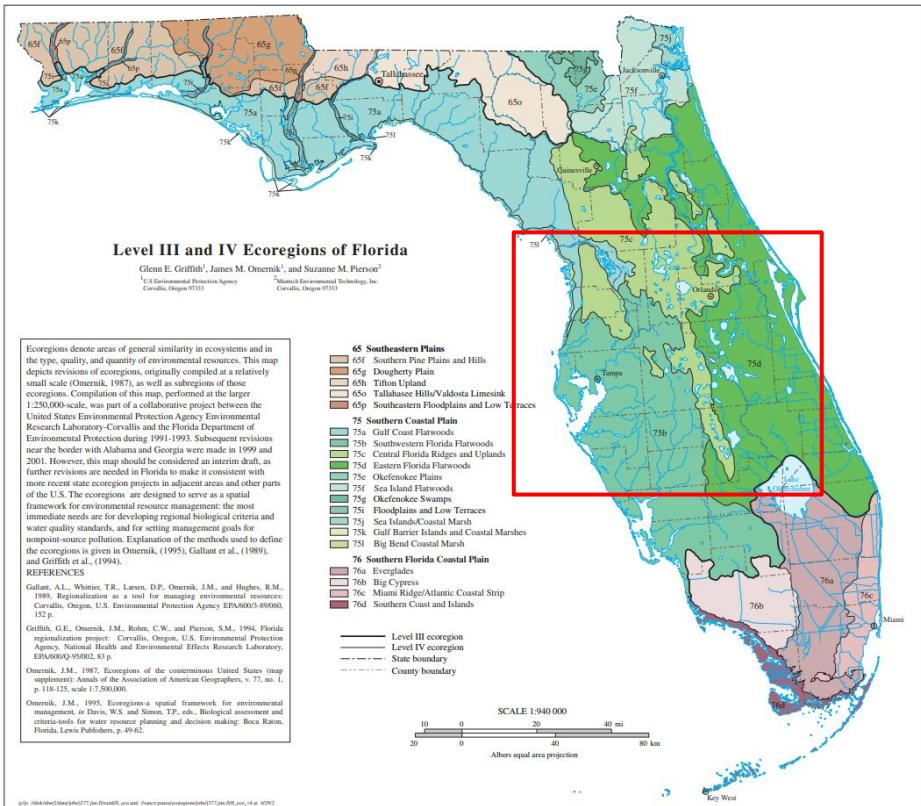
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Causes of the SAR: habitat diversity

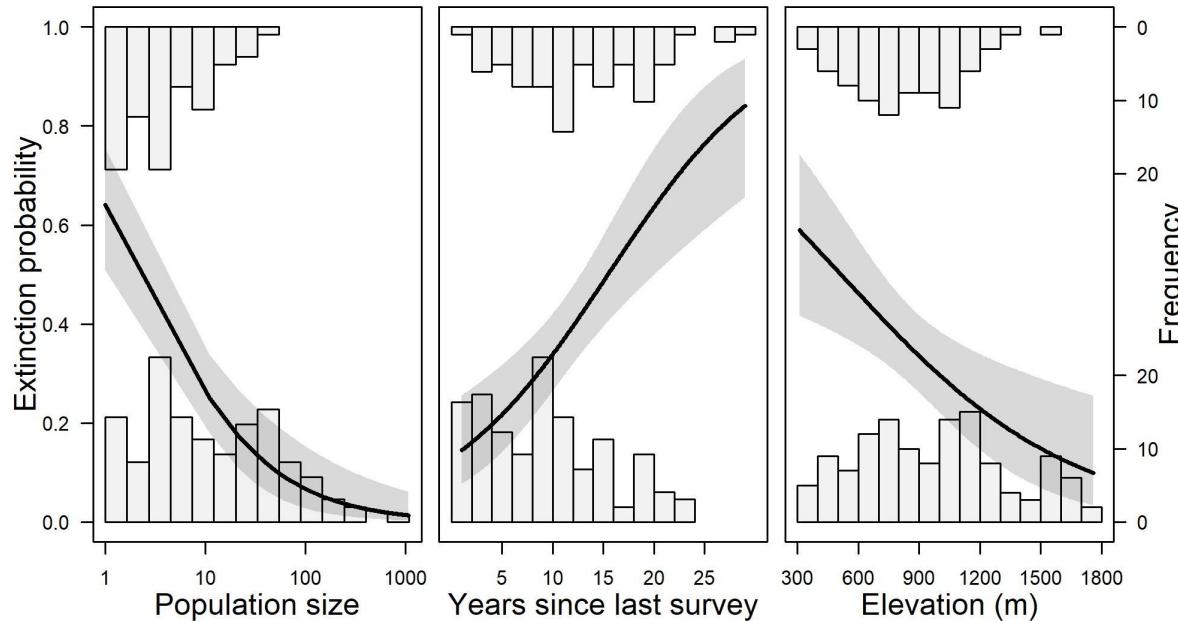
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Causes of the SAR: Extinctions

- Larger areas = larger population sizes
- Population size = major predictor of extinction risk



OPEN ACCESS PEER-REVIEWED
RESEARCH ARTICLE

Population extinctions driven by climate change, population size, and time since observation may make rare species databases inaccurate

Thomas N. Kaye, Matt A. Bahm, Andrea S. Thorpe, Erin C. Gray, Ian Pfingsten, Chelsea Waddell

Published: October 17, 2019 • <https://doi.org/10.1371/journal.pone.0210378>

See the preprint

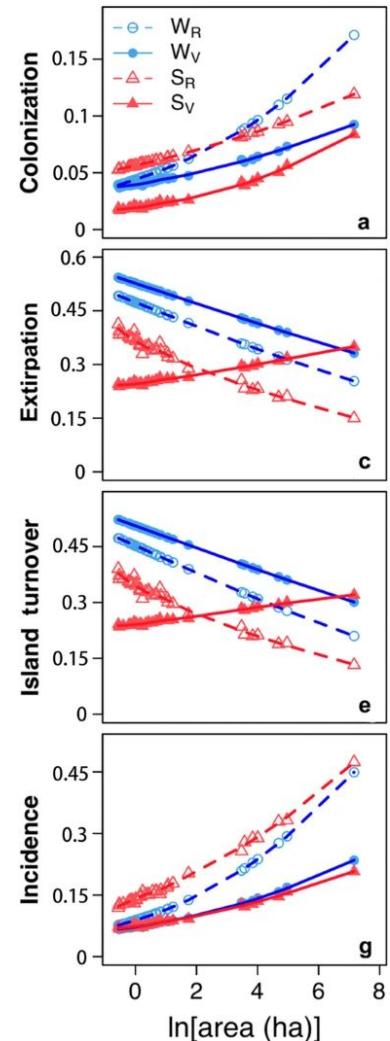
Causes of the SAR: Colonization

- Larger areas = bigger targets

Spatiotemporal distribution of seasonal bird assemblages on land-bridge islands: linking dynamic and static views of metacommunities

Chuanwu Chen, Marcel Holyoak, Yanping Wang, Xingfeng Si & Ping Ding 

Avian Research 10, Article number: 25 (2019) | [Cite this article](#)

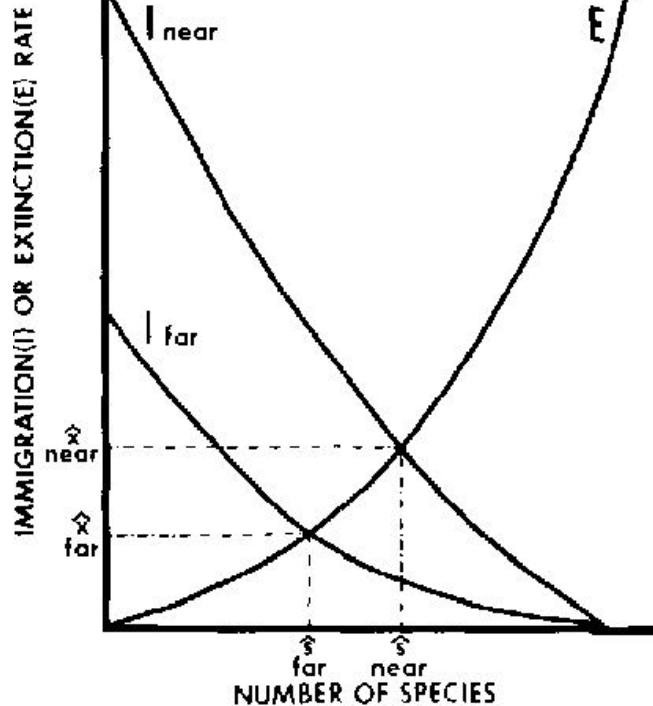


Causes of the SAR: Chance

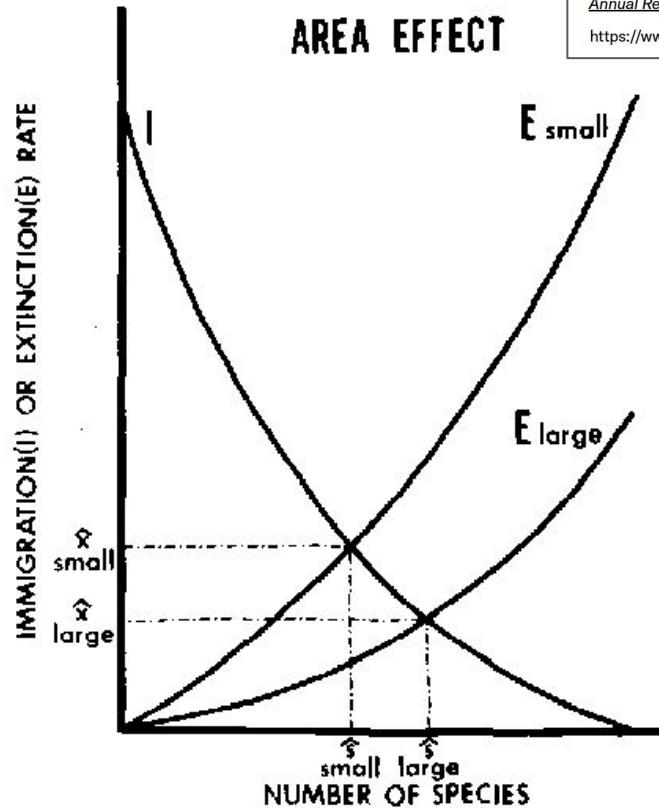
- Species are not uniformly distributed in suitable habitats
- A particular species may be missed due to chance
- We'll see an example of this later

Theory of Island Biogeography

DISTANCE EFFECT



AREA EFFECT

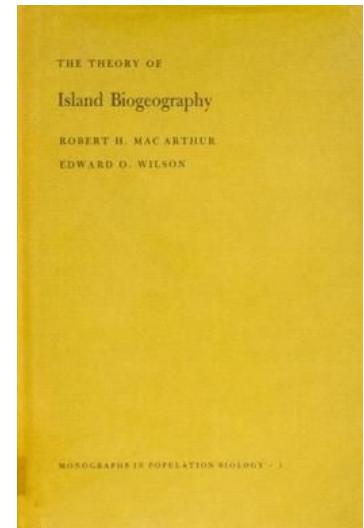


Equilibrium Theory of Island Biogeography and Ecology

Daniel S. Simberloff

Annual Review of Ecology and Systematics, Vol. 5 (1974), pp. 161-182 (22 pages)

<https://www.jstor.org/stable/2096885>



Island Biogeography Demo

https://www.netlogoweb.org/launch#https://raw.githubusercontent.com/bmaitner/Community_ecology_course/refs/heads/main/NetLogo_demos/island_biogeo.nlogo

Variation in SARs

Or, on a log-scale:

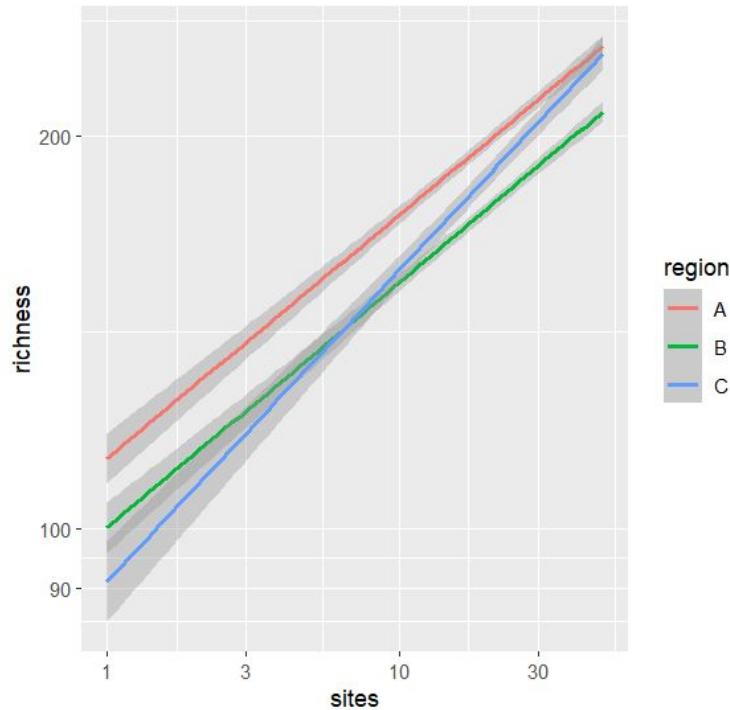
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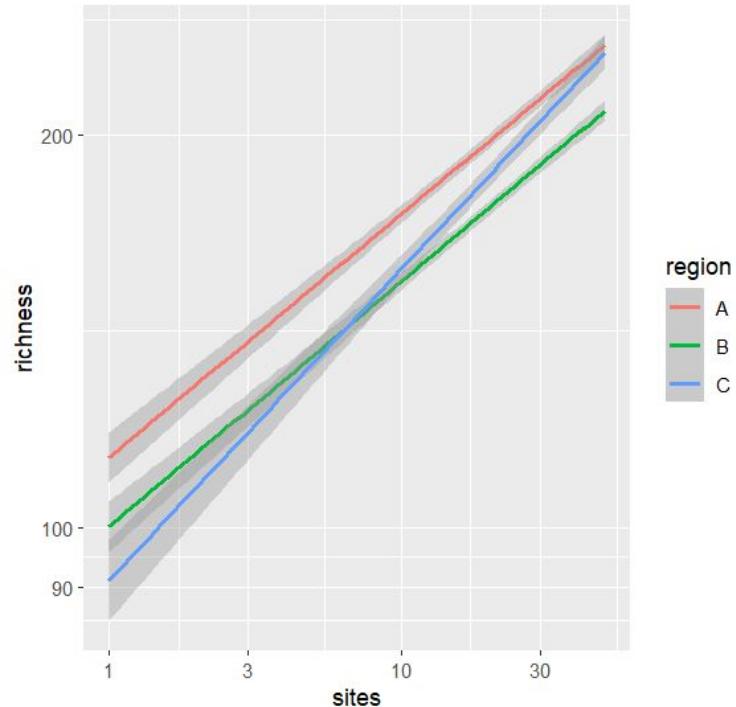
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Variation in SARs

- Closer to the equator, species accumulate relatively faster
- Larger species accumulate relatively faster
 - Small species have flat SARs
- Tied to species abundance distributions

Ecology Letters, (2006) 9: 215–227 doi: 10.1111/j.1461-0248.2005.00848.x

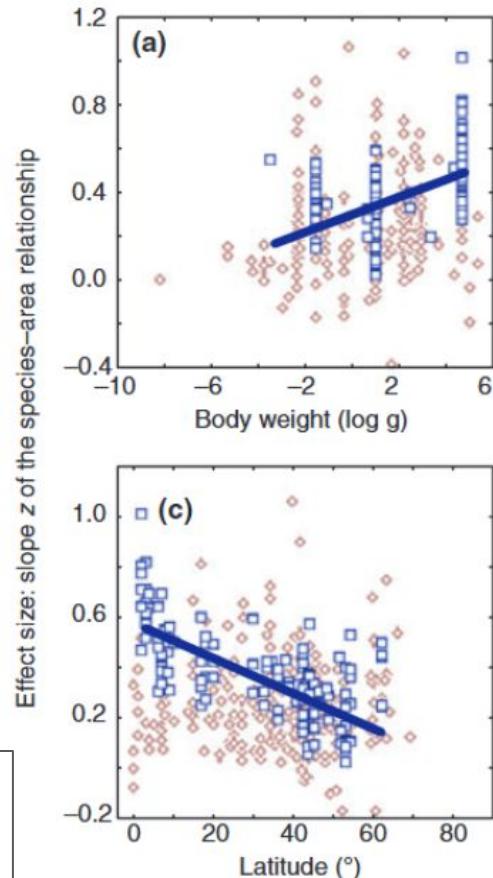
REVIEWS AND SYNTHESES

The imprint of the geographical, evolutionary and ecological context on species-area relationships

Abstract

Stina Drakare,^{1,2} Jack J. Lennon³ and Helmut Hillebrand^{2,4*}

Species-area relationships (SAR) are fundamental in the understanding of biodiversity patterns and of critical importance for predicting species extinction risk worldwide.



Species Abundance Distribution

- Another general pattern in ecology

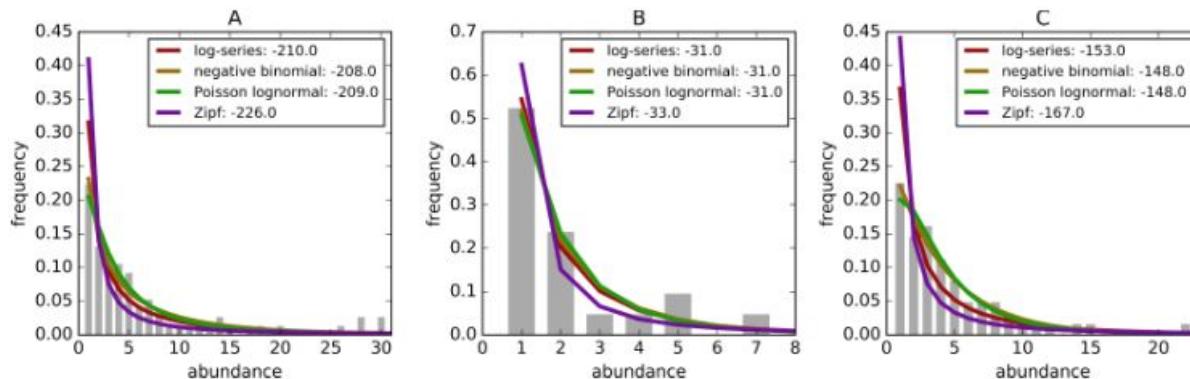


Figure 1 Example species-abundance distributions including the empirical distributions (grey bars) and the best fitting log-series: maroon, negative binomial: brown, poisson lognormal: green, and Zipf: purple. Distributions are for (A) Breeding Bird Survey—Route 36 in New York, (B) Forest Inventory and Analysis—Unit 4, County 57, Plot 12 in Alabama, and (C) Gentry—Araracuara High Campina site in Colombia. Log-likelihoods of the models are included after the colon in the legend.

An extensive comparison of species-abundance distribution models

Elita Baldridge^{1,2}, David J. Harris³, Xiao Xiao^{1,2,4,5} and Ethan P. White^{1,2,3,6}

¹ Department of Biology, Utah State University, Logan, UT, United States

² Ecology Center, Utah State University, Logan, UT, United States

³ Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL, United States

⁴ School of Biology and Ecology, University of Maine, Orono, ME, United States

⁵ Senator George J. Mitchell Center for Sustainability Solutions, University of Maine, Orono, ME, United States

⁶ Informatics Institute, University of Florida, Gainesville, FL, United States

Species Abundance Distribution

- Holds at large taxonomic/spatial scales as well

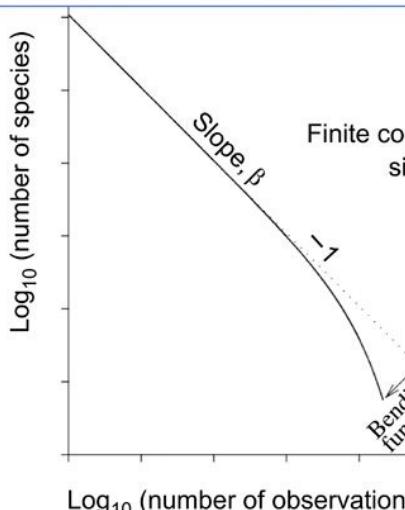
A

gSAD distribution predictions:

- (i) Neutral theory and niche theory: gSAD will be best fit by log-series distribution;
- (ii) Central limit theorem: gSAD will be best fit by lognormal distribution

gSAD slope predictions:

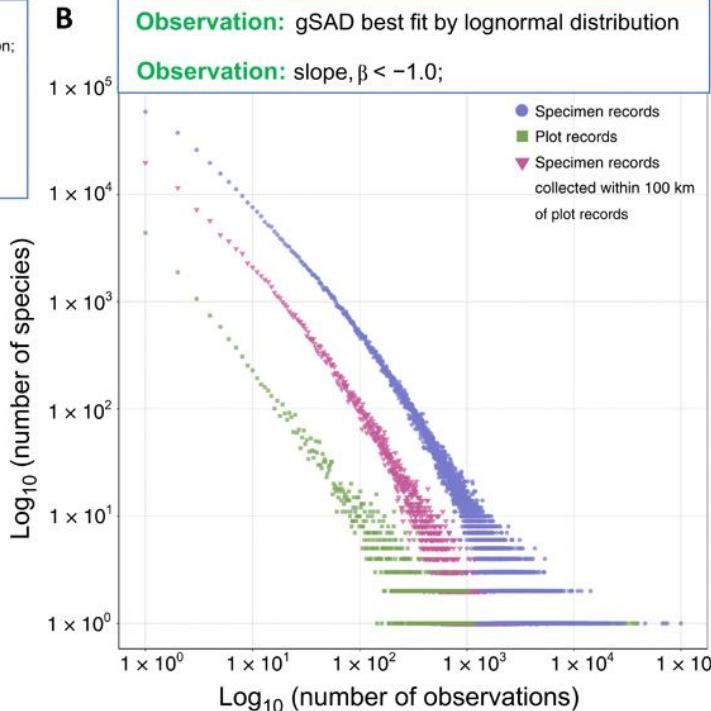
- (i) Neutral theory slope, $\beta = -1.0$;
- (ii) Non-neutral processes generating more rare species; slope, $\beta < -1.0$
- (iii) Non-neutral processes generating more common species; slope, $\beta > -1.0$



B

Observation: gSAD best fit by lognormal distribution

Observation: slope, $\beta < -1.0$;



SCIENCE ADVANCES | RESEARCH ARTICLE

ECOLOGY

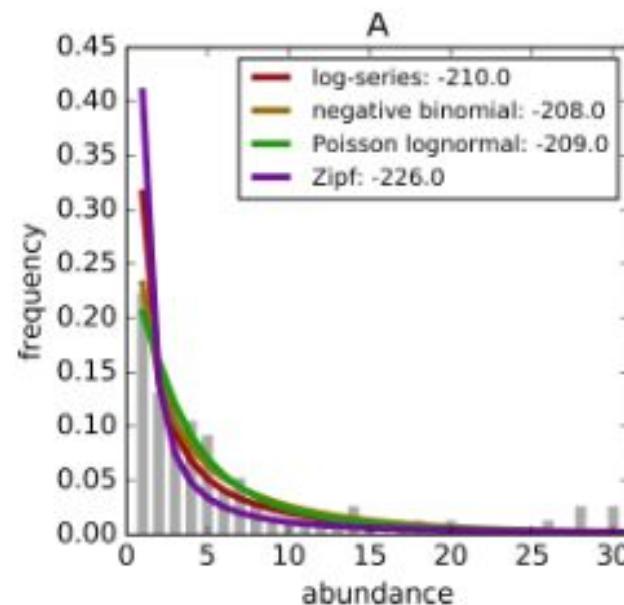
The commonness of rarity: Global and future distribution of rarity across land plants

Brian J. Enquist^{1,2*}, Xiao Feng³, Brad Boyle³, Brian Maltner¹, Erica A. Newman^{1,3}, Peter Møller Jørgensen⁴, Patrick R. Roehrdanz², Barbara M. Thiers⁵, Joseph R. Burger³, Richard T. Corlett⁶, Thomas L. P. Couvreur⁸, Gilles Dauby⁹, John C. Donoghue¹⁰, Wendy Foden¹¹, Jon C. Lovett^{12,13}, Pablo A. Marquet^{2,14,15}, Cory Merow¹⁶, Guy Midgley¹⁷, Nala Mourta-Holme¹⁸, Danilo M. Neves¹⁹, Ary T. Oliveira-Filho¹⁹, Nathan J. B. Kraft²⁰, Daniel S. Park²¹, Robert K. Peet²², Michel Pillet¹, Josep M. Serra-Díaz²³, Brody Sandel²⁴, Mark Schlesinger², Irena Simova^{26,27}, Cyrilie Violette²⁸, Jan J. Wieringa²⁹, Susan K. Wiser³⁰, Lee Hannah¹, Jens-Christian Svenning¹, Brian J. McGill³¹

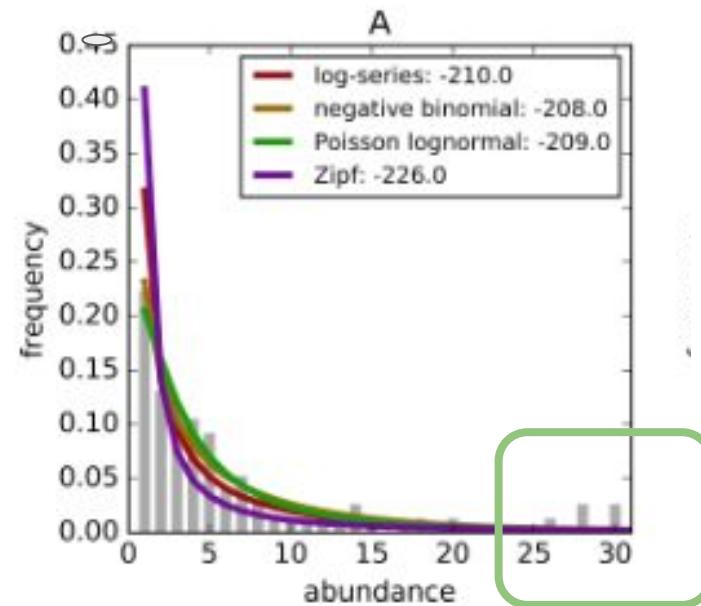
SAD in brief

- Common species are rare, rare species are common

Impact of SADs

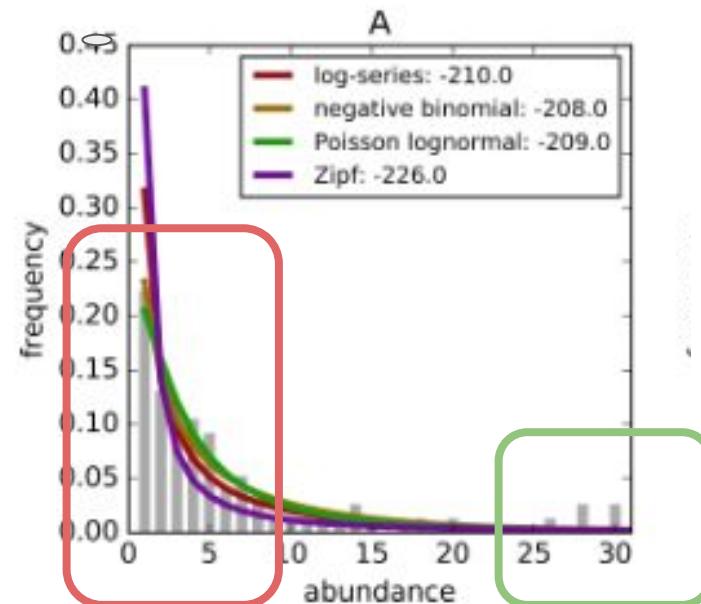


Impact of SADs



Present in many plots

Impact of SADs

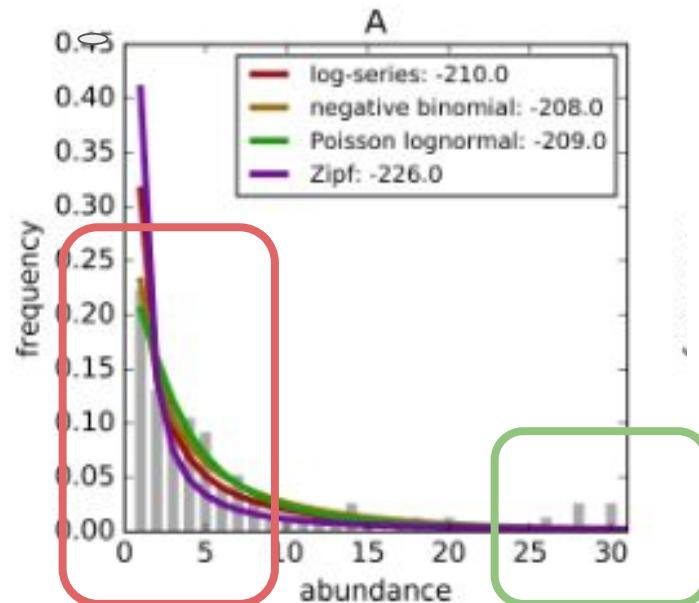


Present in one/few plots

Present in many plots

Impact of SADs

Variation in abundance (evenness) will correspond to rate of encountering species and hence the shape of the SAR



Present in one/few plots

Present in many plots

SAD and SAR demo

https://www.netlogoweb.org/launch#https://raw.githubusercontent.com/bmaitner/Community_ecology_course/refs/heads/main/NetLogo_demos/SAR_SAD.nlogo

Next Class: Drivers of Diversity