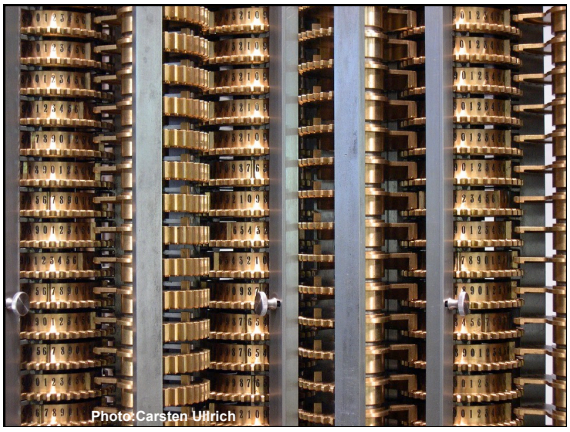
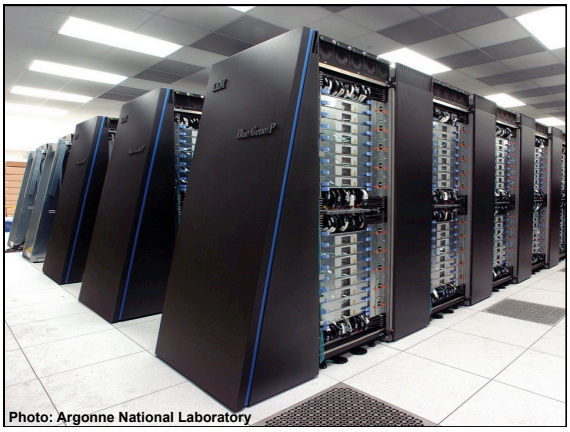
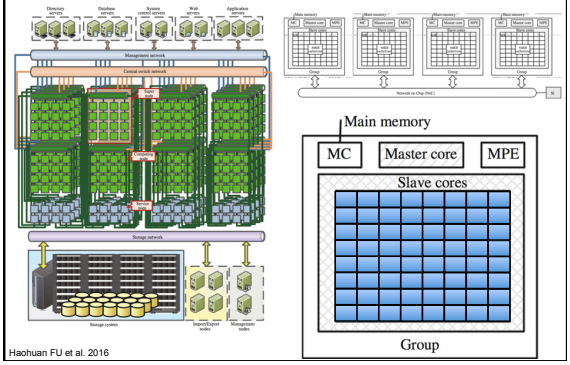
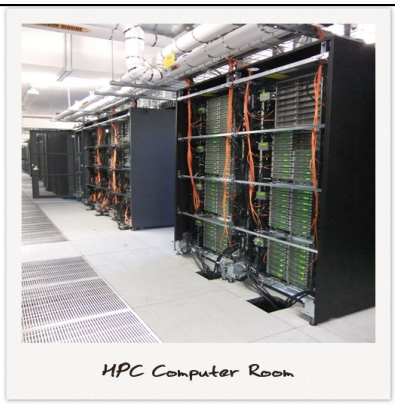




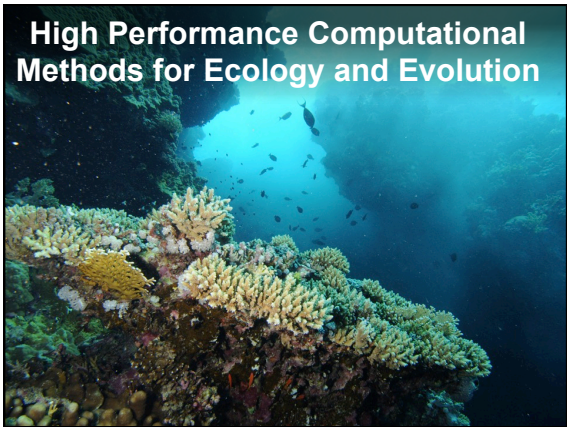
New fastest supercomputer this year
Sunway TaihuLight



Haohuan FU et al. 2016

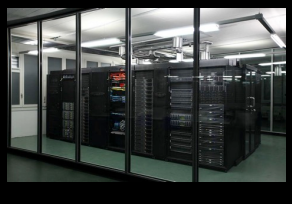


https://www.imperial.ac.uk/admin-services/ict/self-service/research-support/hpc/hpc-service-support/service/



Course objectives

Learn about computers and programing
Good programming practice
Running code in parallel on a cluster
Code optimisation

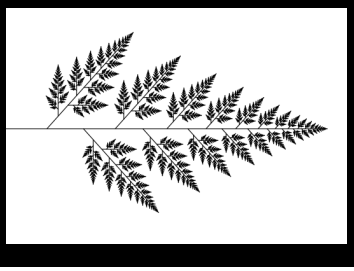


Course objectives

Ecological neutral theory
Stochastic and event based models

Course objectives

Fractals in biology
Iterative functions and chaos



A few other things

- Fewer lectures more practical
- Worksheet to hand in for credit
- J.Rosindell@imperial.ac.uk
- Kennedy building ground floor

Ecological Neutral Theory:

Assumes all individuals are ecologically equivalent

(Caswell 1976)
(Hubbell 1979)
Hubbell 1997)
(Bell 2000)
(Bell 2001)
(Hubbell 2001)

Ecological Neutral Theory: Madness or Misunderstood?

"This flies in the face of years of ecological theory (supported by data) maintaining that species are *not ecologically equivalent*"

Jerry Coyne

"A preoccupation with neutral theory could marginalize biodiversity science, competing for resources with process-based studies, while having little to offer conservation and policy."

Jim Clark

"It's probably the most misunderstood theory in contemporary ecology"

Arne Schroder

Ecological Neutral Theory: Madness or Misunderstood?

1.) What is neutral theory?

2.) The uses and misuses of neutral theory

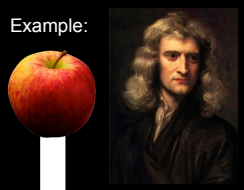
3.) Applications in spatial biodiversity patterns

4.) Applications in island biogeography

A few words about theory in physics …

- Scientific theory conforms with empirical data and puts forward an 'explanation' for observed phenomena

Example:



$$F = G\frac{m_1 m_2}{r^2}$$

A few words about theory in ecology …

Any ecological work that uses mathematical formulas or a computer

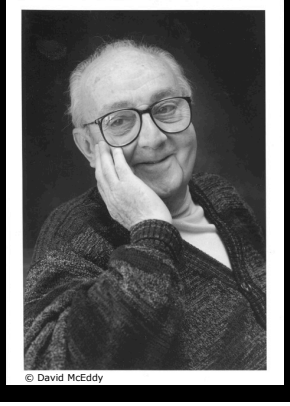
Ecological Neutral Theory

Assumes all individuals are ecologically equivalent

Is not a claim that all individuals are ecologically equivalent

Is about making some assumptions and seeing where they get us

(Caswell 1976)
(Hubbell 1979)
Hubbell 1997)
(Bell 2000)
(Bell 2001)
(Hubbell 2001)



© David McEddy

Essentially, all models are wrong,

but some are useful

George E P Box

(Box & Draper 1987)

Defining ecological neutral theory

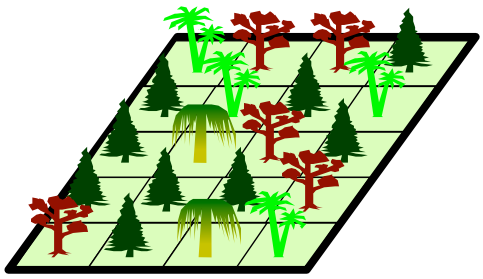
~~'Neutral theory' is a claim that all individuals are ecologically equivalent~~

~~'Neutral theory' refers to the contents of the 2001 book by Hubbell "The Unified Neutral Theory of Biodiversity and Biogeography"~~

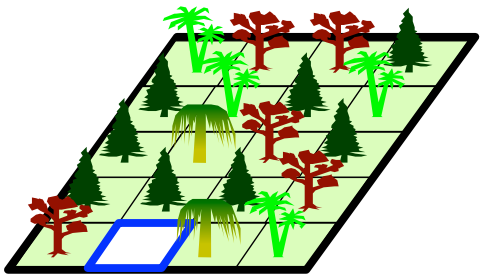
'Neutral theory' refers to a suite of neutral models

Neutral models assume that the properties of an individual organism are independent of its species identity

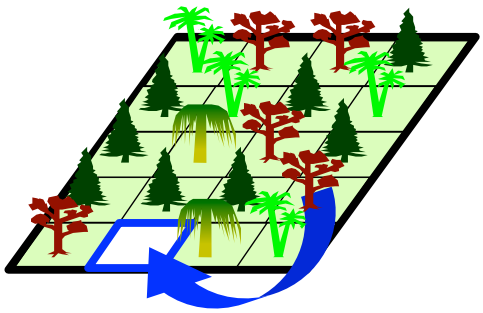
The model rules in brief



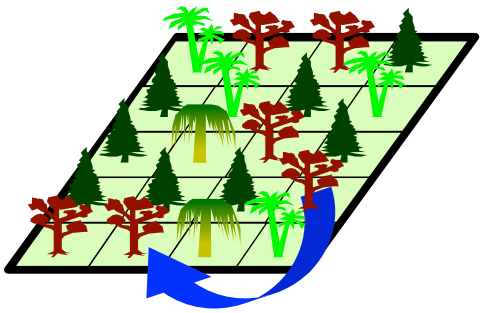
The model rules in brief



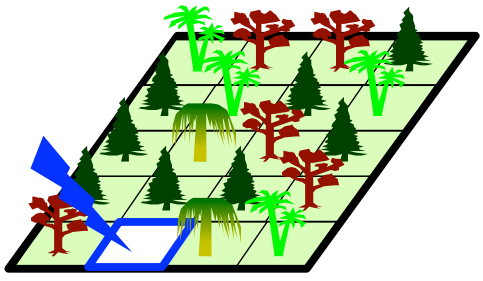
The model rules in brief



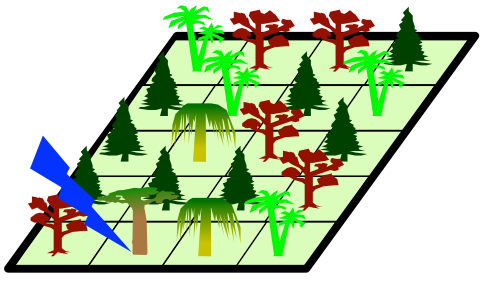
The model rules in brief



The model rules in brief

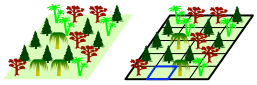


The model rules in brief



Variations on the theme

- The zero sum assumption

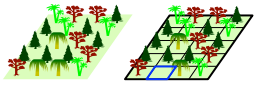


- Speciation mode (none)

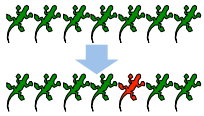
(Caswell 1976)
(Bell 2000)
(Bell 2001)

Variations on the theme

- The zero sum assumption



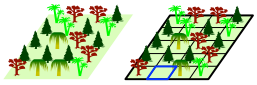
- Speciation mode (point mutation)



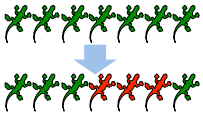
(Hubbell 1997)
(Hubbell 2001)

Variations on the theme

- The zero sum assumption



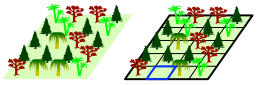
- Speciation mode (random fission)



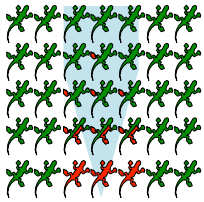
(Hubbell 2001)
(Hubbell & Lake 2002)

Variations on the theme

- The zero sum assumption



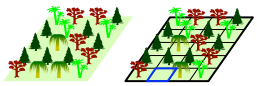
- Speciation mode (protracted)



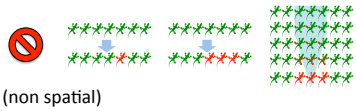
(Rosindell *et al.* 2010)

Variations on the theme

- The zero sum assumption



- Speciation mode

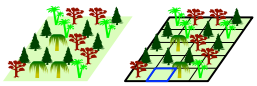


- Spatial structure (non spatial)

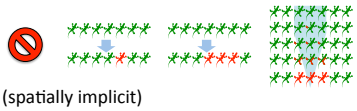
(Caswell 1976)

Variations on the theme

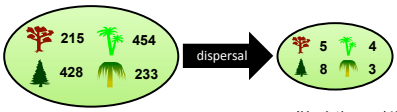
- The zero sum assumption



- Speciation mode



- Spatial structure (spatially implicit)



(MacArthur and Wilson 1963)
(Hubbell 2001)

Variations on the theme

- The zero sum assumption
- Speciation mode
- Spatial structure (spatially explicit network)

(Economo & keitt 2008)
(Warren 2010)
(Vanpeteghem & Haegeman 2010)
(Muneepeerakul *et al.* 2008)

Variations on the theme

- The zero sum assumption
- Speciation mode
- Spatial structure (fully spatially explicit)

(Holley & Liggett 1975)
(Bramson et al. 1998)
(Durett & Levin 1996)
(Hubbell 2001)
(Chave et al. 2002)
(Chave & Leigh 2002)
(Zillio et al. 2005)
(Rosindell & Cornell 2007,2009)
(Pigolotti & Cencini 2009)
(O´Dwyer & Green 2010)
(Etienne & Rosindell 2011)

Variations on the theme

- The zero sum assumption
- Speciation mode
- Spatial structure

Variations on the theme

- The zero sum assumption
- Speciation mode
- Spatial structure

(Hubbell 2001)
(Leigh 2007)
(Leigh *et al.* 2010)

Variations on the theme

- The zero sum assumption
- Speciation mode
- Spatial structure

Your exercise questions

Ecological Neutral Theory: Madness or Misunderstood?

1.) What is neutral theory?

2.) The uses and misuses of neutral theory

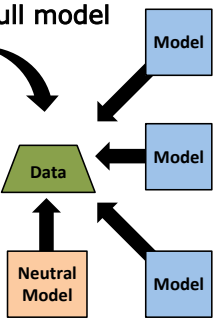
3.) Applications in spatial biodiversity patterns

4.) Applications in island biogeography

The uses of neutral theory

Use as a null model

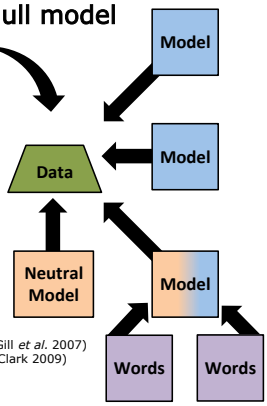
- What is the alternative hypothesis?



(McGill *et al.* 2007)
(Clark 2009)

Use as a null model

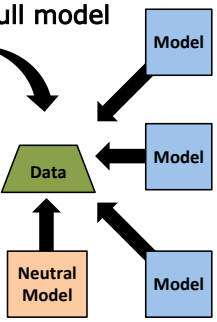
- What is the alternative hypothesis?



(McGill *et al.* 2007)
(Clark 2009)

Use as a null model

- What is the alternative hypothesis?
- This data can be used to infer niches and/or selection



Use as a null model

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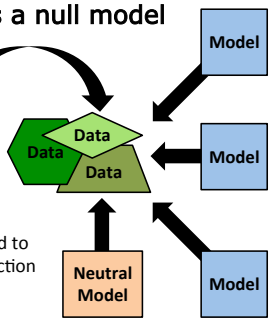

Use as a null model

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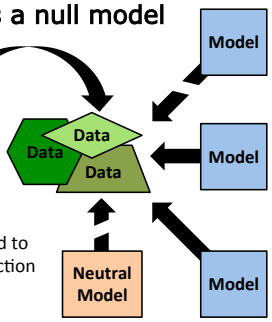
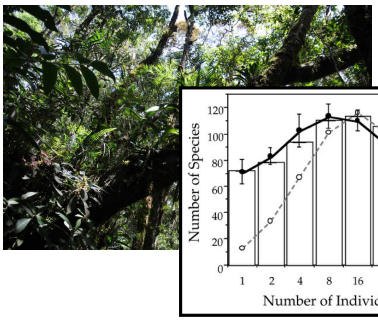


Example data comparison

Species abundance distributions

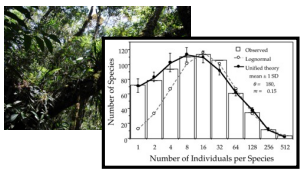


(Hubbell 2001)

Example data comparison

Mean species lifetimes are too short

(Ricklefs 2003, Nee 2005, Ricklefs 2006)

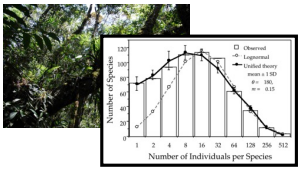


Example data comparison

Mean species lifetimes are too short

(Ricklefs 2003, Nee 2005, Ricklefs 2006)

but that was for point mutation speciation



Protracted Speciation

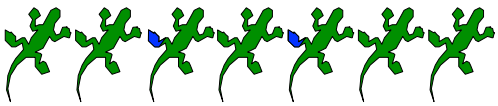
Not an instantaneous event

Protracted Speciation

Not an instantaneous event

Protracted Speciation

Not an instantaneous event



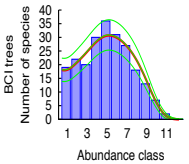
Protracted Speciation

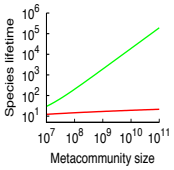
Not an instantaneous event

Protracted Speciation

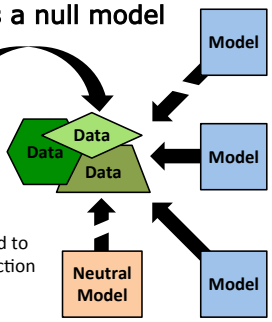
Not an instantaneous event

Tropical Forest Tree Data



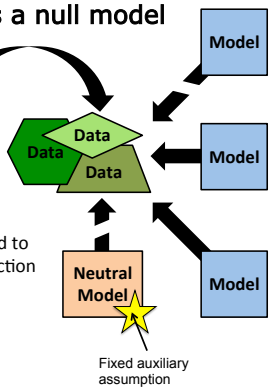


Use as a null model



- What is the alternative hypothesis?
- This data cannot be used to infer niches and/or selection

Use as a null model



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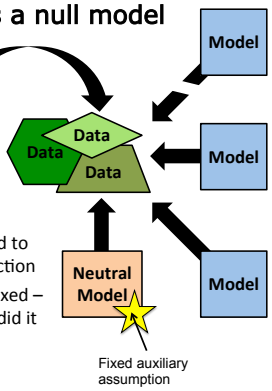
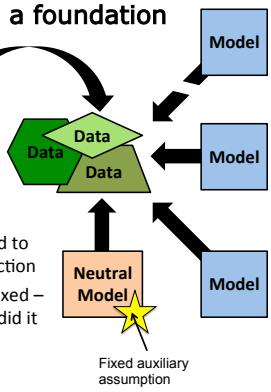
- This data cannot be used to infer niches and/or selection

Use as a null model



- What is the alternative hypothesis?
- This data cannot be used to infer niches and/or selection
- Model can possibly be fixed – what additional factors did it need?

Use as a foundation



- What is the alternative hypothesis?
- This data cannot be used to infer niches and/or selection
- Model can possibly be fixed – what additional factors did it need?

Use as an approximation

Use as an approximation

What are the arguments all about ?

The world is not neutral

Coral Reef Diversity Refutes The Neutral Theory of Biodiversity (Dornelas *et al.* Nature 2006)

Global Correlations in Tropical Tree Species Richness and Abundance Reject Neutrality (Ricklefs & Renner Science 2012)

I Agree !

What are the arguments all about ?

The world is not neutral

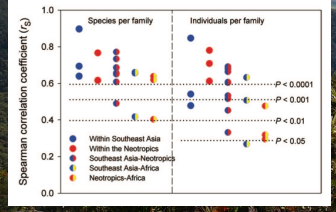
Coral Reef Diversity Refutes The Neutral Theory of Biodiversity (Dornelas *et al.* Nature 2006)

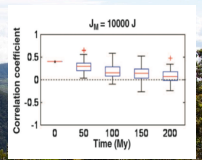
Global Correlations in Tropical Tree Species Richness and Abundance Reject Neutrality (Ricklefs & Renner Science 2012)

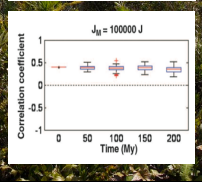
But … let's at least reject neutral theory for the right reasons

But … let's at least reject neutral theory for the right reasons

Global Correlations in Tropical Tree Species Richness and Abundance Reject Neutrality (Ricklefs & Renner Science 2012)







What are the arguments all about ?

Neutral models aren't really neutral

Species still differ in a neutral model, even if only by chance

(Clark 2012)

Semantics !

These are the real issues …

The link between pattern and process
The realism and instrumentalism perspectives
Tradeoff between simplicity and complexity

"In that Empire, the craft of Cartography attained such Perfection that the Map of a Single province covered the space of an entire City, and the Map of the Empire itself an entire Province. In the course of Time, these Extensive maps were found somehow wanting, and so the College of Cartographers evolved a Map of the Empire that was of the same Scale as the Empire and that coincided with it point for point. Less attentive to the Study of Cartography, succeeding Generations came to judge a map of such Magnitude cumbersome, and, not without Irreverence, they abandoned it to the Rigours of sun and Rain. In the western Deserts, tattered Fragments of the Map are still to be found, Sheltering an occasional Beast or beggar; in the whole Nation, no other relic is left of the Discipline of Geography." (Borges 1975).

(Wennekes *et al.* 2012)

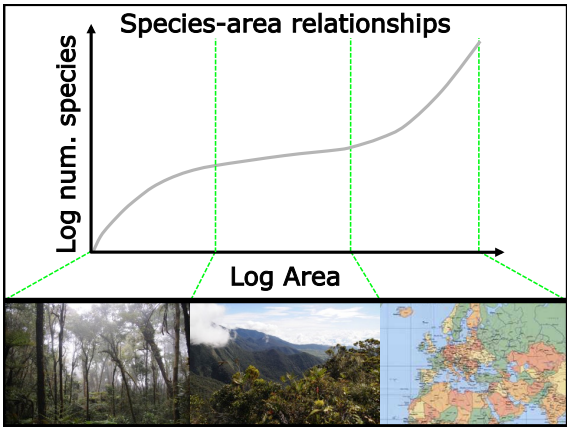
Ecological Neutral Theory: Madness or Misunderstood?

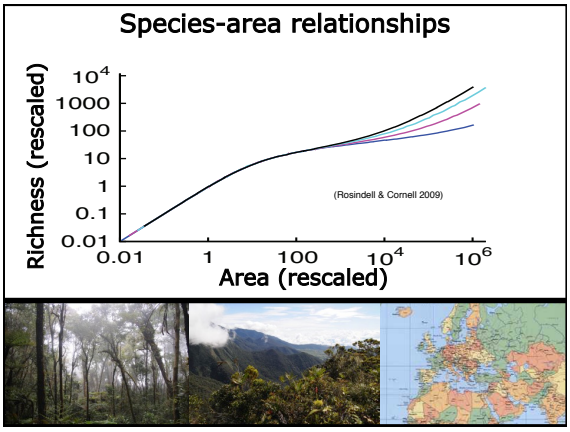
1.) What is neutral theory?

2.) The uses and misuses of neutral theory

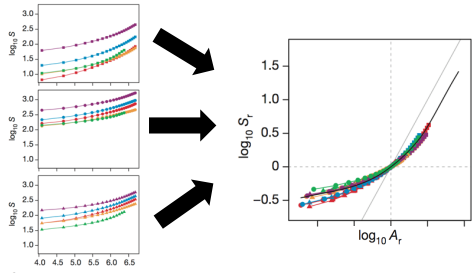
3.) Applications in spatial biodiversity patterns

4.) Applications in island biogeography





'Universal' Species-Area Relationships



□ Amphibians, ○ Birds, △ Mammals
Africa, Eurasia, North America, South America, Australia

(Storch *et al.* 2012)

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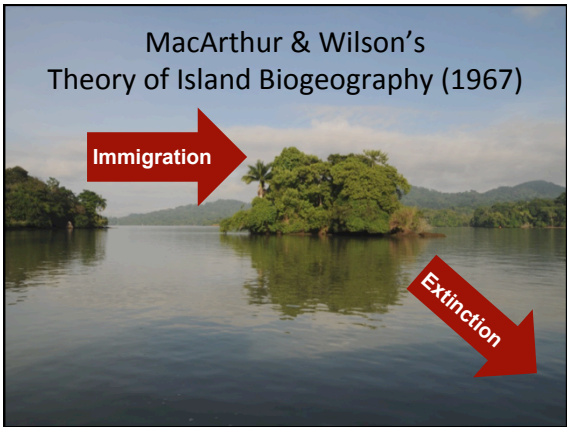
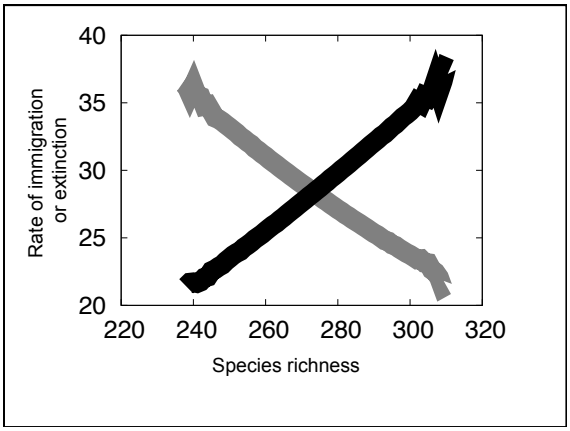
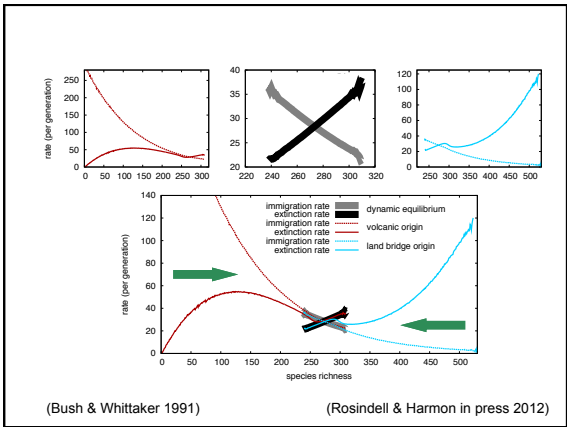
MacArthur & Wilson's Theory of Island Biogeography (1967)



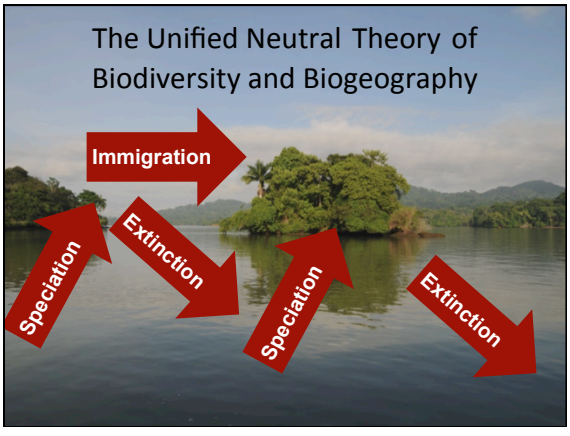




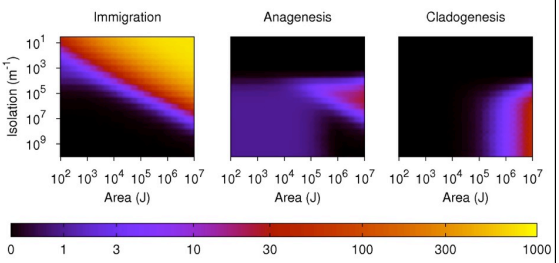
(Bush & Whittaker 1991)

(Rosindell & Harmon in press 2012)

The Unified Neutral Theory of Biodiversity and Biogeography

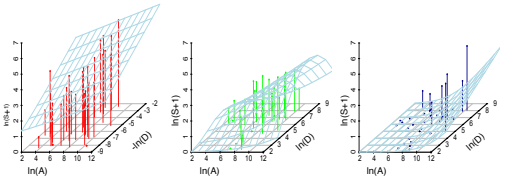


Model results

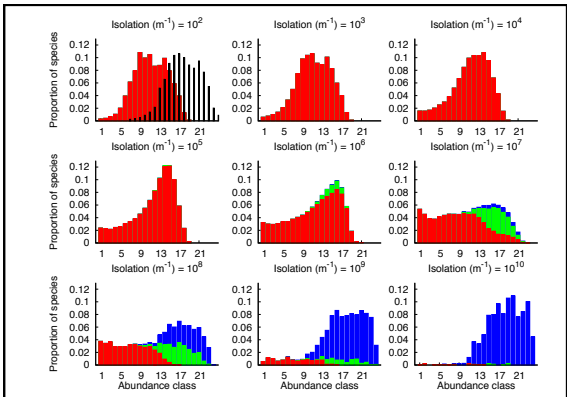


(Rosindell & Phillimore 2011)

Empirical data: island avifauna

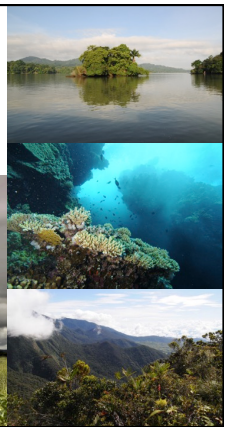


Immigrant Species | Anagenetic Species | Cladogenetic Species



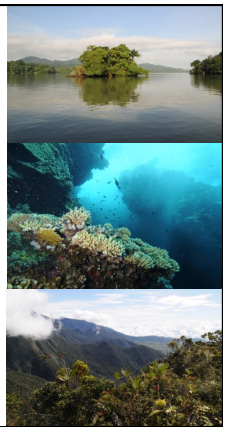
What have we learned about modeling

- John von Neumann "Give me four parameters, and I can fit an elephant. Give me five, and I can wiggle its trunk".



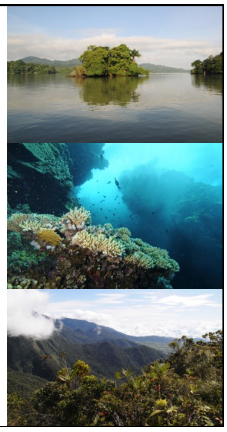
What have we learned about modeling

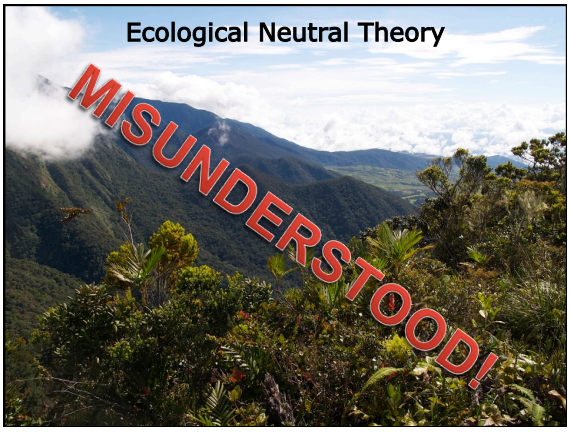
- John von Neumann "Give me four parameters, and I can fit an elephant. Give me five, and I can wiggle its trunk".
- Large numbers of variables can scale away to fewer variables.
- Simplicity vs. complexity – only add complexity when it's needed, use computers when needed.
- Words are one thing, models are another
- Not all patterns are very informative
- Start with the end in mind



Neutral theory conclusions

- Neutral theory is a collection of neutral models assuming ecological equivalence of individuals regardless of their species.
- Uses as a null model or approximation but not both at the same time.
- Explains species area relationships and other spatial biodiversity patterns.
- Makes rich predictions about biodiversity and endemicity on islands.
- Neutral theory is one of the many useful tools you have in your tool box.




Ecological Neutral Theory
MISUNDERSTOOD!