A constraint-based model of dynamic island biogeography in the face of global change

"mountain island in a desert sea" – Dodge 1943

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Island biogeography theory

Species richness, $R_i$, of an island is a function of:

$$R_i = C - E$$

$C = $ Colonization
$E = $ Extinction
But how does area and connectivity change over glacial cycles?

Art by Trevor Fristoe
A Constraint-based model of Dynamic Island Biogeography (C-DIB)

Motivating question
How do species traits predict insular biodiversity as islands cycle through time?
A Constraint-based model of Dynamic Island Biogeography (C-DIB)

Motivating question
How do species traits predict insular biodiversity as islands cycle through time?

1. Populations of a single species

2. Candidate species for community assembly
Populations of a single species

Traits:

1. Influence *colonization* probability.

   *Habitat suitability* between island and source.

   *Dispersal/physiological tolerance*

2. Influence *extinction* probability.

   *Minimum area* required to sustain population.

   *Body size/trophic level*
Populations of a single species
Populations of a single species
Populations of a single species
Populations of a single species

Suitability

No  Yes

Minimum area

A  B  C  D

T3
Populations of a single species

- **Suitability**
  - No
  - Yes

- **Minimum area**

The diagram shows the distribution of populations with different suitability levels and minimum area requirements.
Populations of a single species
Populations of a single species

T4 Same environment as T2...

...But different distributions
Populations of a single species

T4 Same environment as T2...

...But different distributions
Island process

**Extinction** – influenced by min area to sustain population
Island process

**Extinction** – influenced by min area to sustain population

**Colonization** – influenced by habitat suitability
Species

Area requirement
1 2 3 3 4

Connectivity requirement

Cycle

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<th>Time</th>
<th>Area</th>
<th>Conn.</th>
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<tr>
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Island Dynamics

Area

Connectivity

T1a

T2a

T3a

T4a

T5a
### Cycle

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**Island Dynamics**

- **T1a**
- **T2a**
- **T3a**
- **T4a**
- **T5a**

**Species**

- Area requirement: 1, 2, 3, 3, 4
- Connectivity requirement

**Hysteresis**
How do we test this, really?

- **Allometric scaling**: population size, abundance and generation

\[ D \propto M^{-3/4} \]

- **Species distribution modeling**: present, past and future environments

[Map by Gonzalo Pinilla-Buitrago]
Assumptions and caveats

1. No stochasticity

2. Time lags (extinction debts or colonization credits)

3. No biotic interactions

4. No evolution (i.e., niche conservatism)
15 to 20% of all reptile and mammal diversity at risk from climate change
But...are US Madrean bird populations new colonizations?
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Elegant trogon
Chiricahua mnts
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Artist

MAYA R. STAHL
Breakout Session Notes

• Discussion Question: How can we leverage existing tools from diverse disciplines to further sky island biodiversity research and conservation (e.g., theory, biodiversity data, computation, field science, collaborative science)? What tools are currently lacking?
A. Continental island

B. Habitat island

C. Fragmentation island

Glacial time scales

Shorter time scales

Burger et al. 2019 Frontiers of Biogeography
What are the past dynamics that lead to biodiversity on sky islands today?