McMaster University | SCIENCE Department of Biology

How do small habitat patches support higher biodiversity for an equivalent habitat area?

Erin Ricaloglu, Jurek Kolasa

McMaster University, Hamilton, Canada

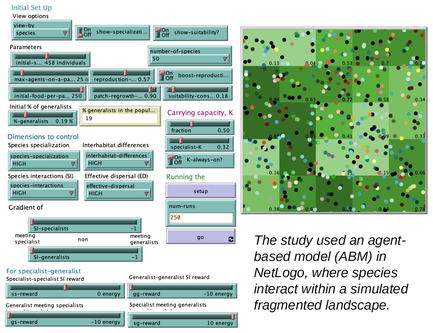
Introduction

- **Conventional conservation thinking** assumes that large, contiguous habitats are always better for biodiversity (SLOSS debate).
- However, **small habitat patches** sometimes **support higher species diversity** than larger ones, challenging this paradigm.
- **Key Question:** Under what conditions do small patches maintain higher biodiversity?
- Specialization matters:
  - Generalists are highly adaptable and thrive in diverse conditions (e.g., raccoons)
  - Specialists rely on specific habitats and resources, making them more vulnerable to environmental changes.
- Fragmentation effects vary by patch size.

Experimental Plan

- **Hypotheses; two potential mechanisms:**
  1. **Increased spatial turnover**—species replacement between patches enhances diversity.
  2. **Species sorting & local stability**—specialists establish **stable** populations in small patches.
- Small patches will have higher species richness and stable turnover.
- Large patches will be dominated by generalists with increasing turnover (species loss over time).

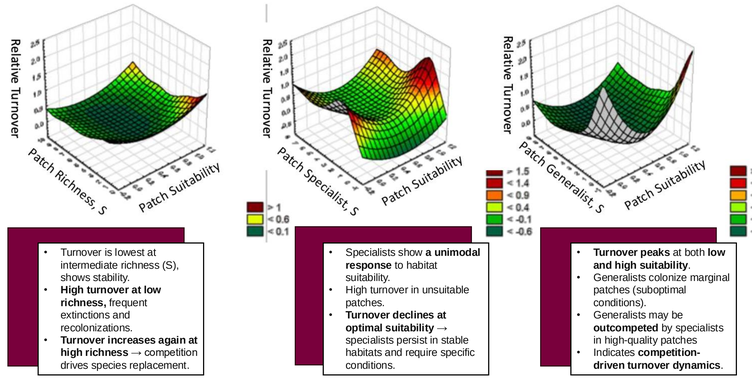
Subjects and Methods



The study used an agent-based model (ABM) in NetLogo, where species interact within a simulated fragmented landscape.

- **Metacommunity model with different patch sizes:**
  - **Small patches:** 289 patches**, Medium patches:** 81 patches**, Large patches**: 25 patches.
- **Controlled parameters:** Resource consumption, species reproduction, movement, interactions, habitat suitability.
- **Measurement focus:**
  - **Species richness:** Specialists (Ss) & Generalists (Sg). Total number of species.
  - **Species turnover:** Weighted by total species count (relative turnover). Rate of species replacement over time.
  - **Simulation details:** 49 replicates per patch size scenario, 50 initial species, no renewal, 250 steps (~5 generations), recorded every 100 steps.

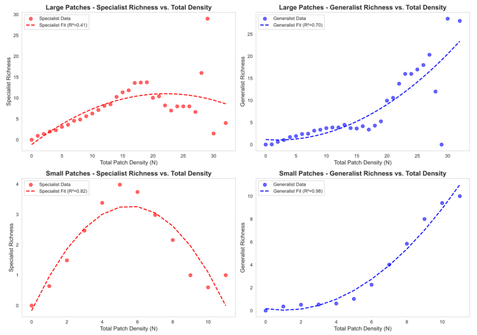
Results



- Turnover is lowest at intermediate richness (S), shows stability.
- **High turnover at low richness,** frequent extinctions and recolonizations.
- **Turnover increases again at high richness** → competition drives species replacement.

- Specialists show **a unimodal response** to habitat suitability.
- High turnover in unsuitable patches.
- **Turnover declines at optimal suitability** → specialists persist in stable habitats and require specific conditions.

- **Turnover peaks** at both **low and high suitability**.
- Generalists colonize marginal patches (suboptimal conditions).
- Generalists may be **outcompeted** by specialists in high-quality patches
- Indicates **competition-driven turnover dynamics**.



- **Large Patches:**
  - Specialist richness increases with total density but is highly variable (R^2 = 0.41).
  - Specialists struggle to establish due to competition with generalists.
  - Generalist richness strongly increases with total density (R^2 = 0.70).
- **Small Patches:**
  - Specialist richness is highly correlated with total density (R^2 = 0.82).
  - Small patches support specialist persistence.
  - Generalist richness is nearly perfectly correlated with total density (R^2 = 0.98).
  - Generalists remain less dominant in small patches, likely due to habitat filtering.

Conclusions

- **Small** patches support twice the species richness of large patches.
- Species sorting stabilizes specialists in small patches.
- Large patches favor generalists through competition, not dispersal.
- Turnover patterns confirm **niche differentiation** by patch size.
- Habitat suitability affects specialists and generalists differently.
- **Stepping-stone small patches** enhance specialist persistence.
- Conserving small-patch networks is as effective as large reserves.
- *How can small-patch networks be integrated into conservation planning to maximize biodiversity retention?*

References

- **Fahrig L.** 2020. Why do several small patches hold more species than few large patches? *Glob Ecol Biogeogr*. 29(4):615-628.
- **Riva F, Fahrig L.** 2023. Several small patches as biodiversity reservoirs: A global perspective. *Conserv Biol*. 37(1):e13945.
- **Dennis RLH, Dapporto L, Fattorini S, Cook LM.** 2011. The generalism-specialism debate: the role of generalists in the life and death of species. *Biol J Linn Soc Lond*. 104(4):725-737.
- **Clavel J, Julliard R, Devictor V.** 2011. Worldwide decline of specialist species: Toward a global functional homogenization? *Front Ecol Environ*. 9(4):222-228.
- **Kolasa J, Northey B, Shaikh M, Hammond M.** 2024. Aggregating taxa and the influence of scale: Potential concerns for analysis of stability using functional measures. *Ecosphere*. 15(2):e4766.

Brighter World

Erin Ricaloglu

Honours Biology, Undergraduate Thesis Student

McMaster University, Faculty of Science

Life Sciences Building

ricaloge@mcmaster.ca, kolasa@mcmaster.ca

+1 905-525-9140 ext. 23100