Reconstructing the Patterns of Alien Plant Species Habitat Niche Expansion

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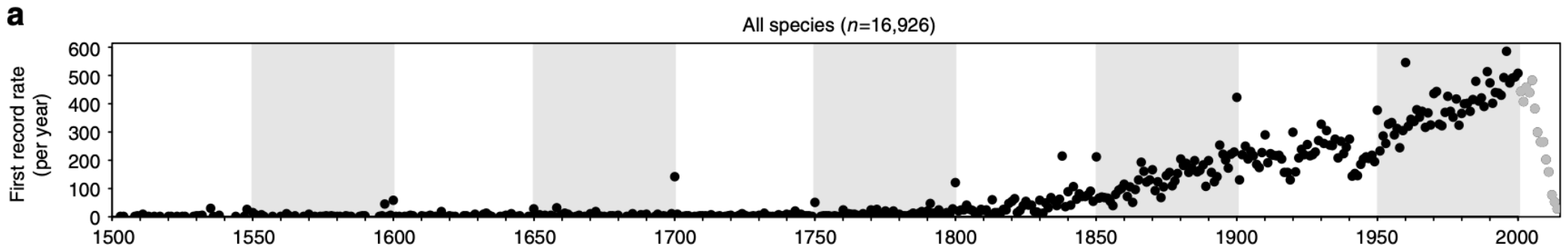
No Signs of Saturation



ARTICLE

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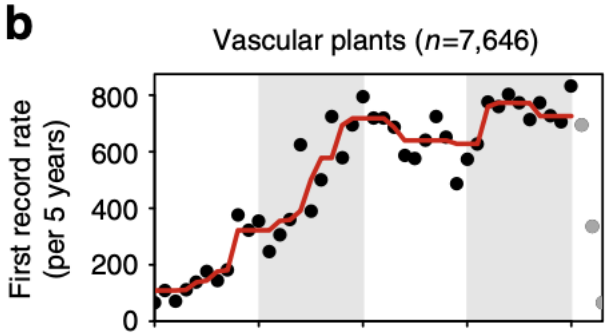
No saturation in the accumulation of alien species worldwide

Hanno Seebens *et al.*#



Corollary

- **Regional accumulation** of alien species well-documented (Juozaitienė et al., 2023; Seebens et al., 2017) but **local-scale** effects **less explored**

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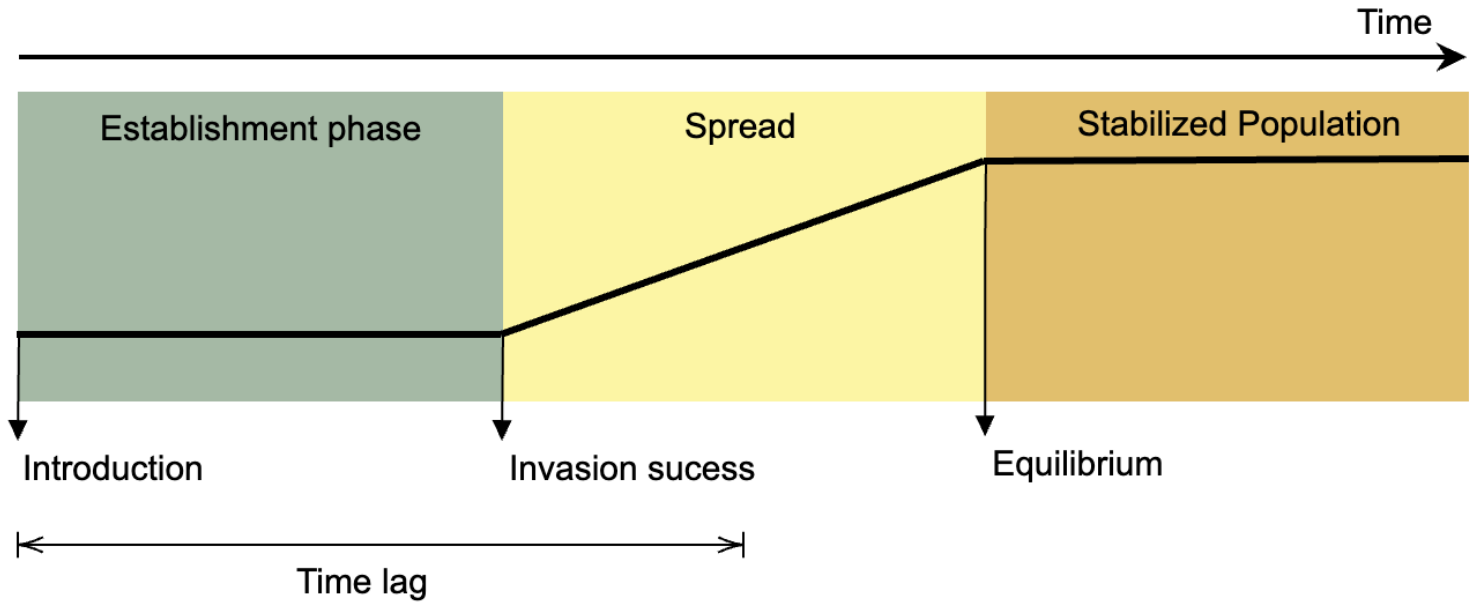
- **High numbers** of aliens in **regional** species pools, but **low representation** in **local** communities, mostly a **time-lag phenomenon**



European Perspective - Habitat Origins

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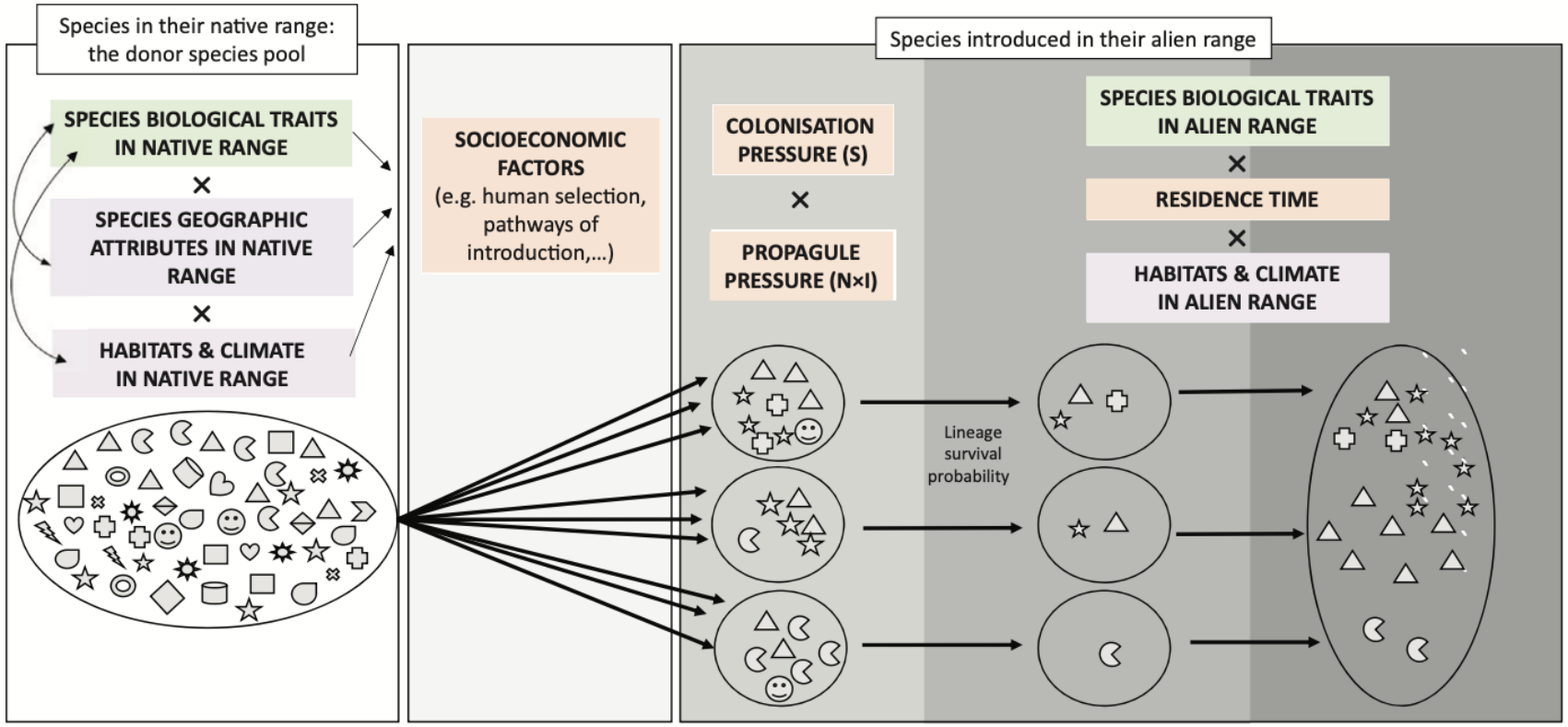
- **Habitats shaped by disturbance** and environmental **variability,** (coasts, floodplains, and urban margins) → **main entry points** for alien species. (Kalusová et al. 2013)
- Interconnected habitats **likely facilitate expansion** of alien species **into new habitat types**

Residence Time and Habitat Expansion



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http://neobiota.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
NeoBiota
Advancing research on alien species and biological invasions

MAcroecological Framework for Invasive Aliens (MAFIA): disentangling large-scale context dependence in biological invasions

ALIEN MACROECOLOGY:
Richness, distribution, abundance, spatial & trait relationships of alien biota at large scales

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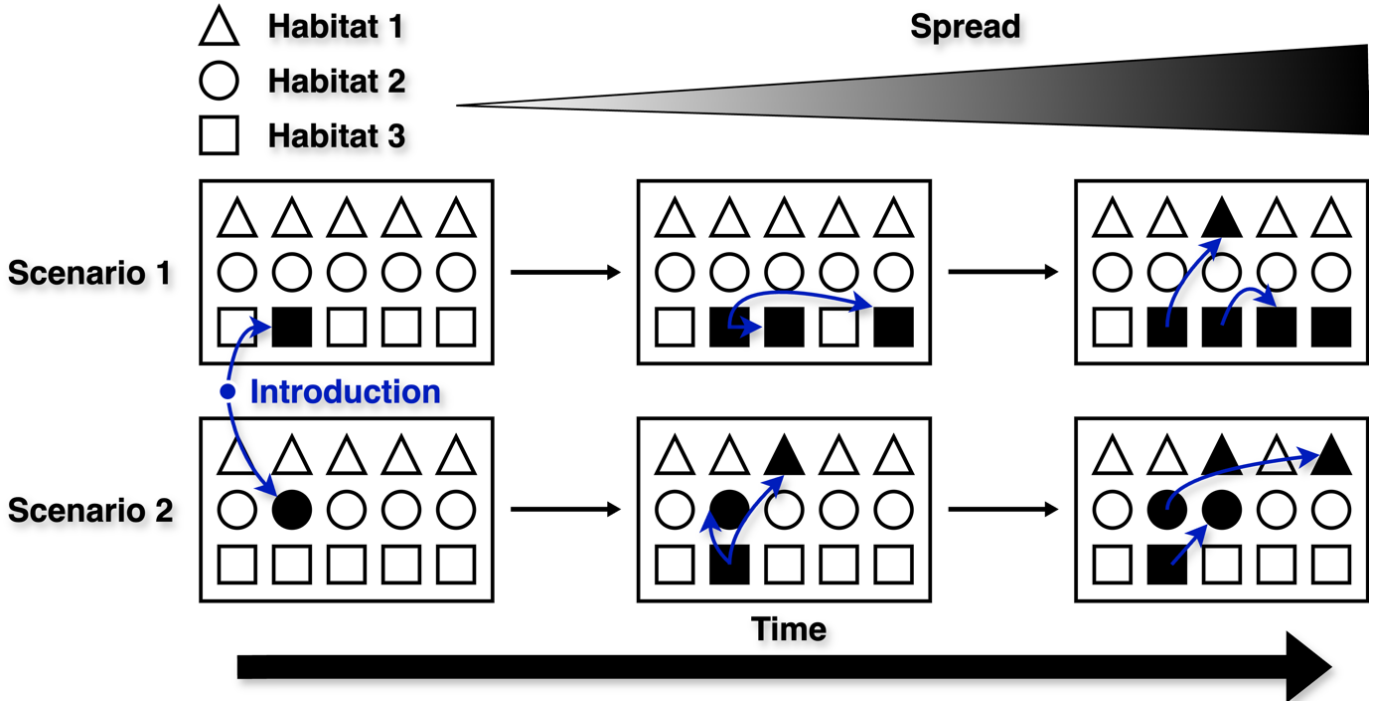
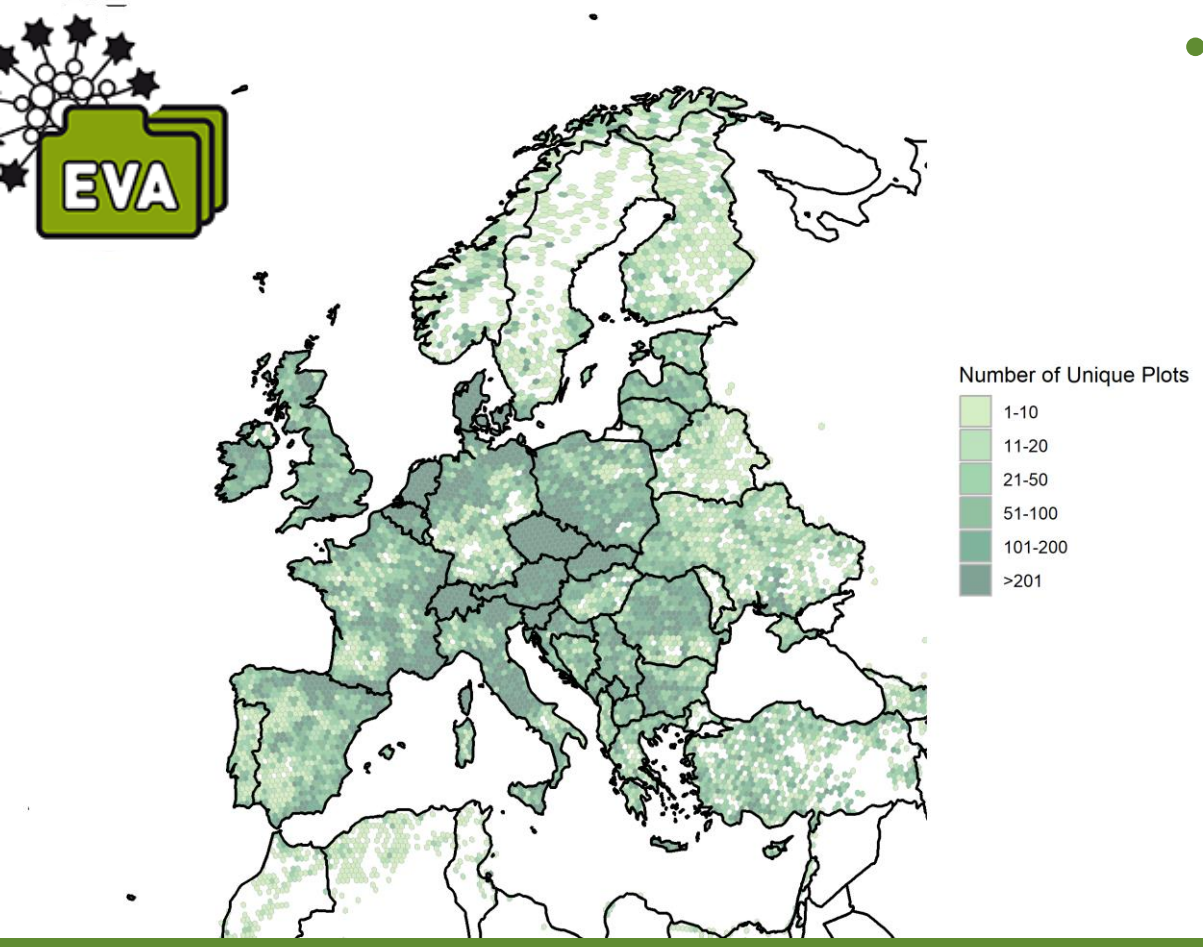
  (b) **more local communities of different** habitat **types**.



Dataset

- **EVA** (The European Vegetation Archive)



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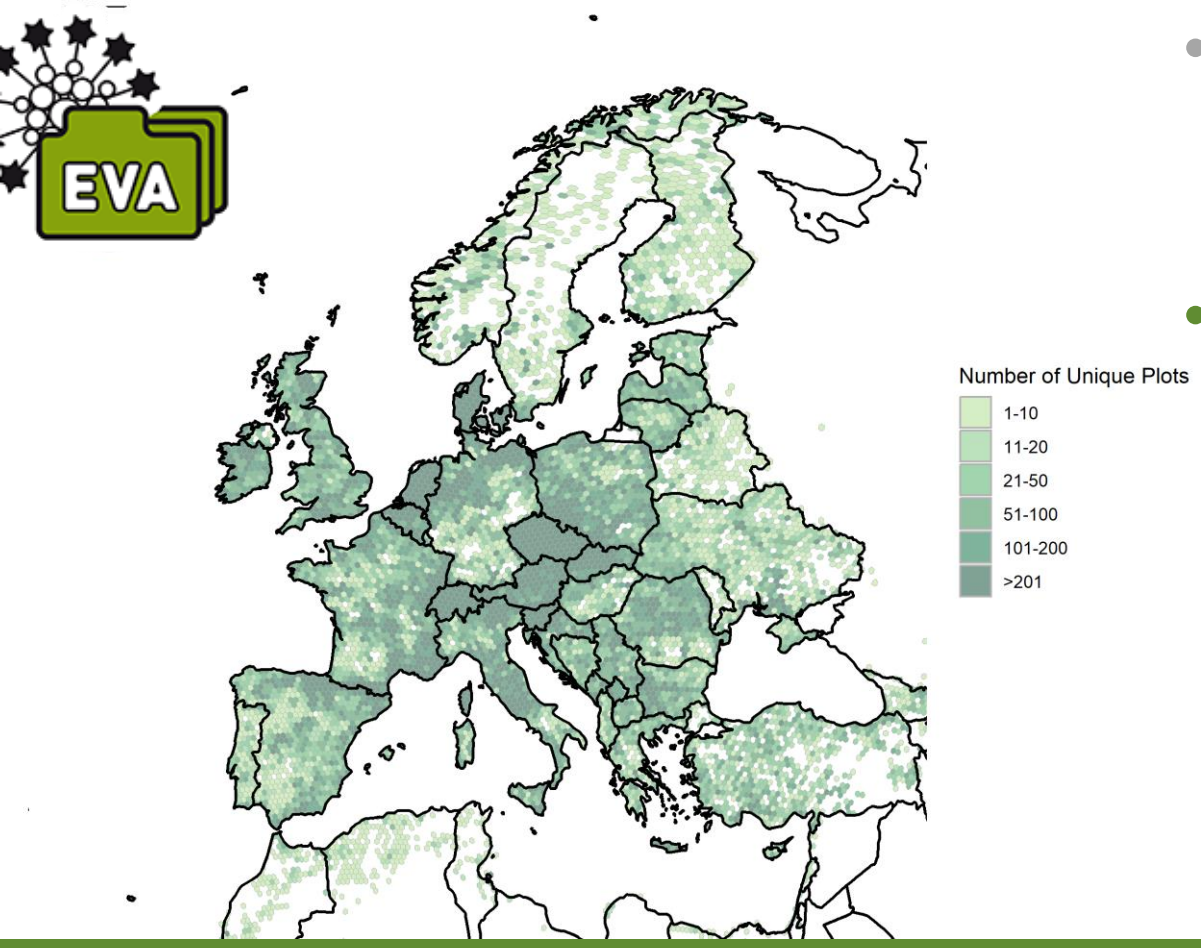

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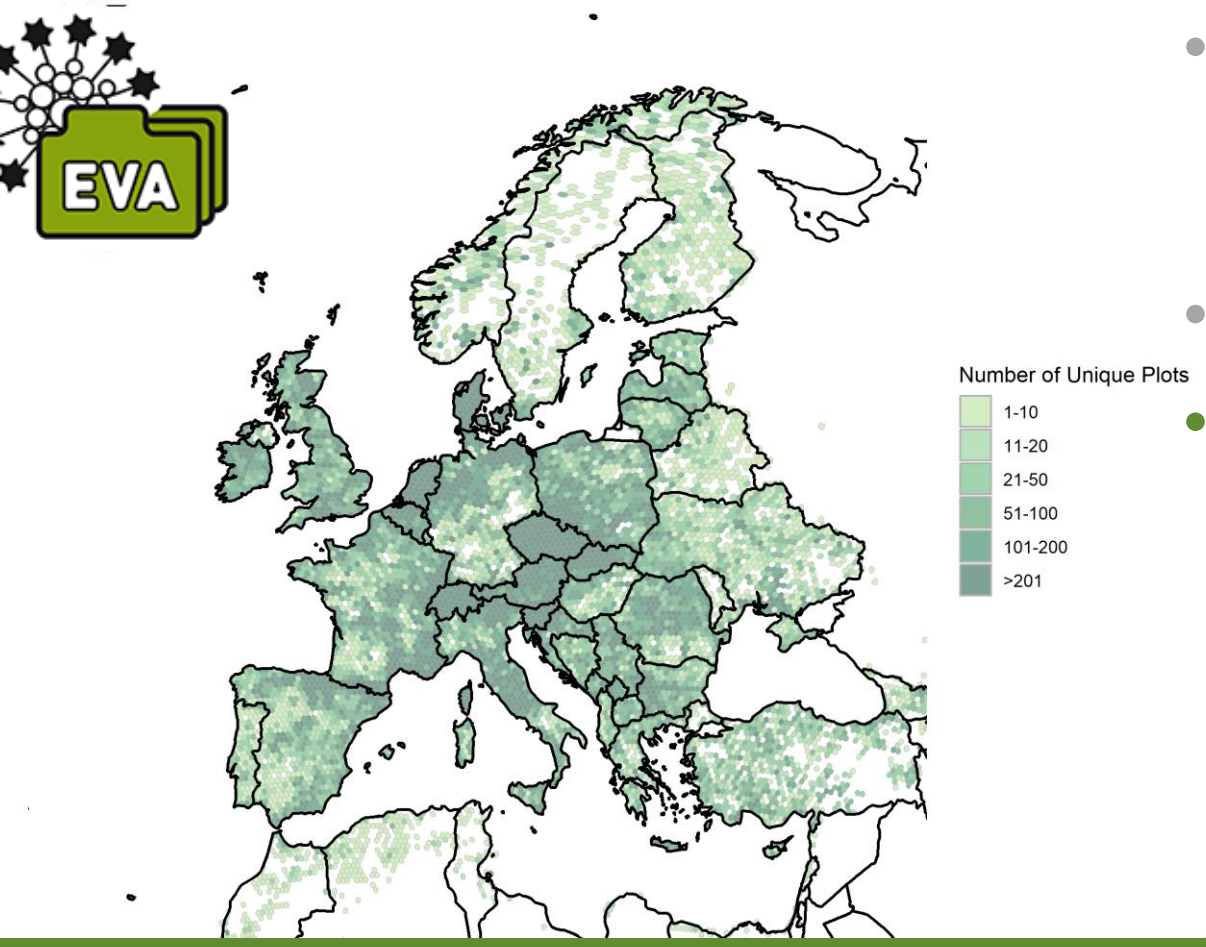

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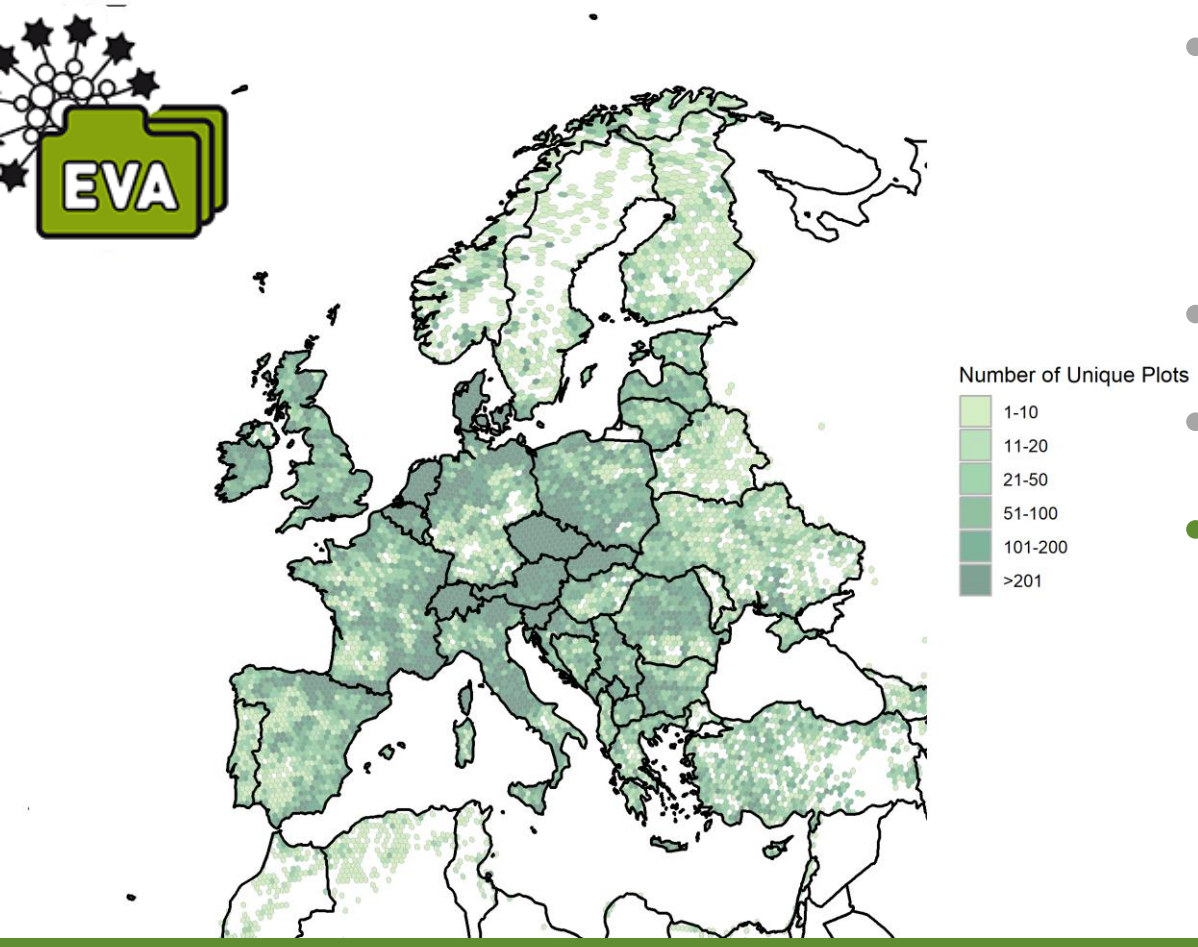

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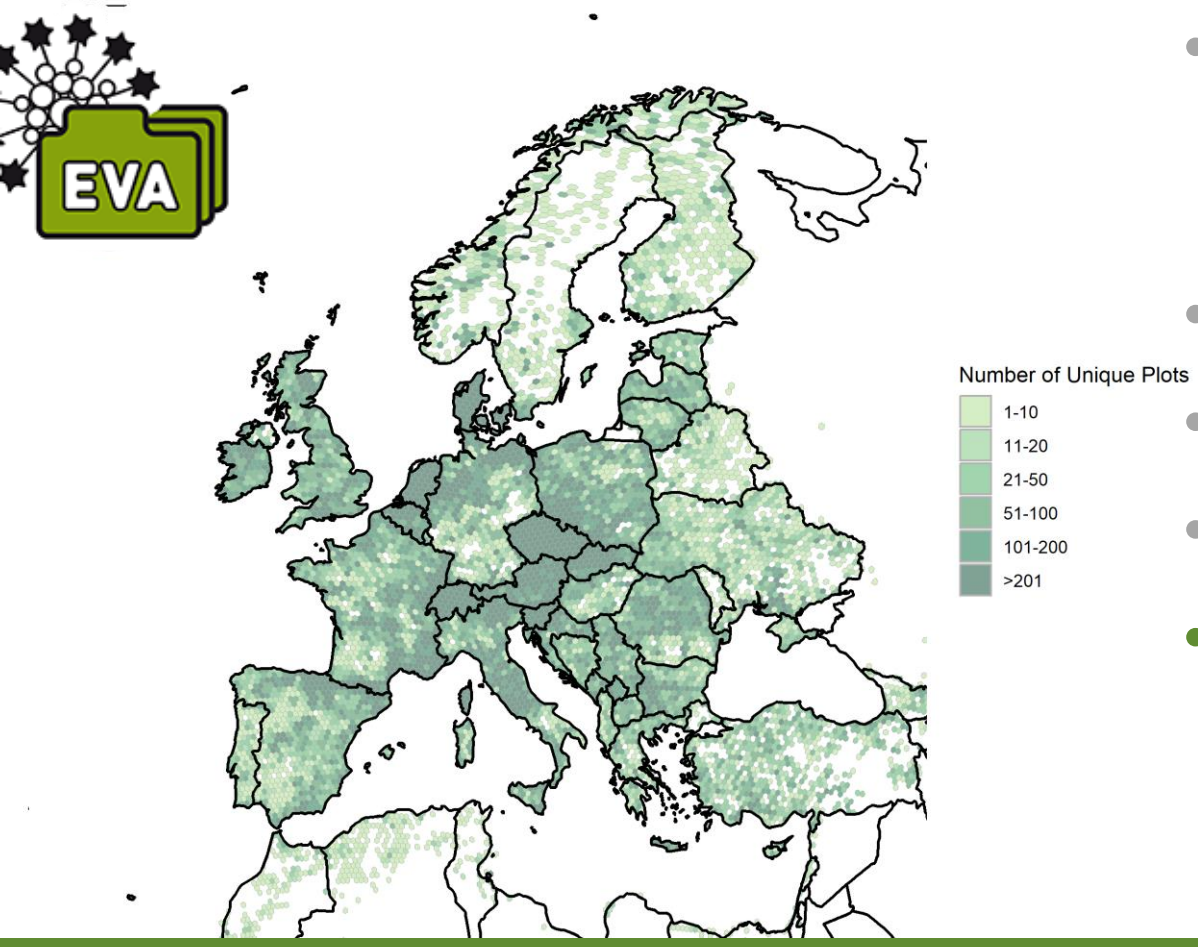

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- **EUNIS classification**

Habitat Classification

- EUNIS Level 2 aggregated into 18 habitats

Group	Examples
Man-made & ruderal	Arable, gardens, artificial grasslands
Broadleaved deciduous	Temperate deciduous forests
Mesic & wet grasslands	Hay meadows, wet grasslands
Dry grasslands	Xerophytic grasslands
Alpine & subalpine	High-altitude grasslands
Bogs & poor mires	Peat-accumulating wetlands

Intermediate resolution: Level 1 too coarse, Level 2 too detailed

The Problem with Counting Habitats

- If we *observe a species* in **grasslands and wetlands**…

  a) is it: **Habitat preference**, or **sampling** where it is common?
  b) Raw **occurrence** conflates distribution with **habitat availability**
  c) EVA is **sampled opportunistically**: some habitats heavily, some sparse

  Need: Compare species **to *local* habitat availability**

How to measure Habitat profiles?

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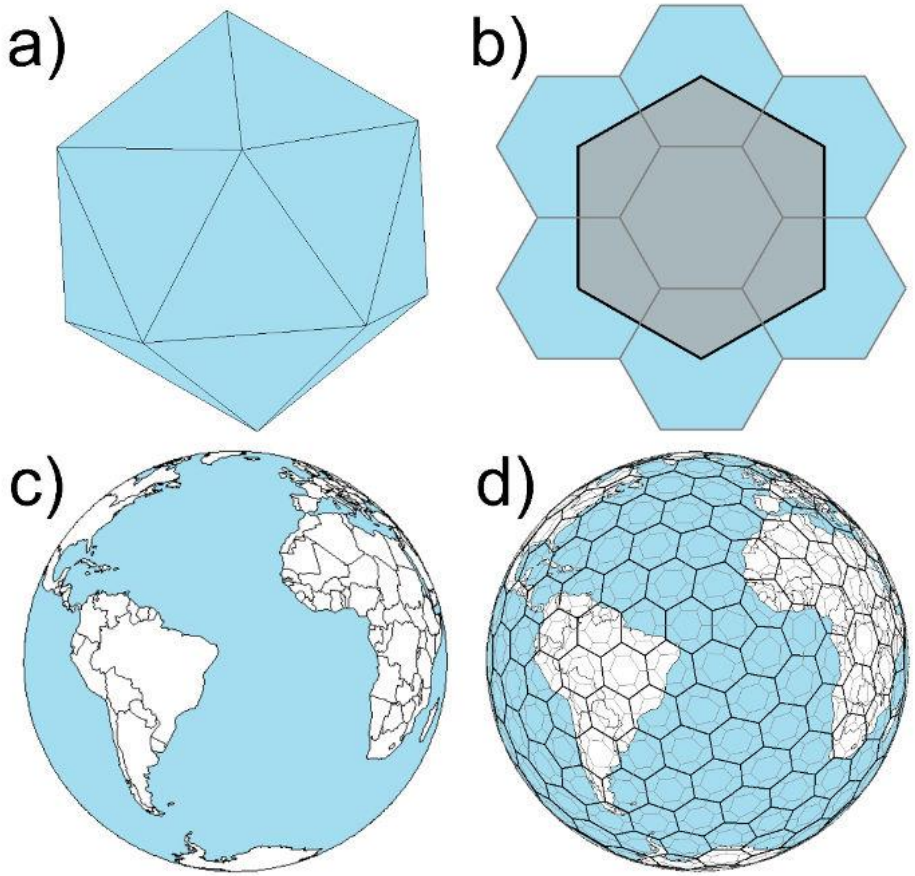
- **Problems** within EVA data:
  - **Denominators unstable** when habitats **sampled unevenly**
  - **Shannon diversity increases** with **sample size** regardless of true distribution and isn't well defined for "habitat diversity"
  - Does **not answer**: "Is the **species more common than random chance** given local availability?"

Methods

Comparing Habitat use across 863 km2 x 10 years hexcells



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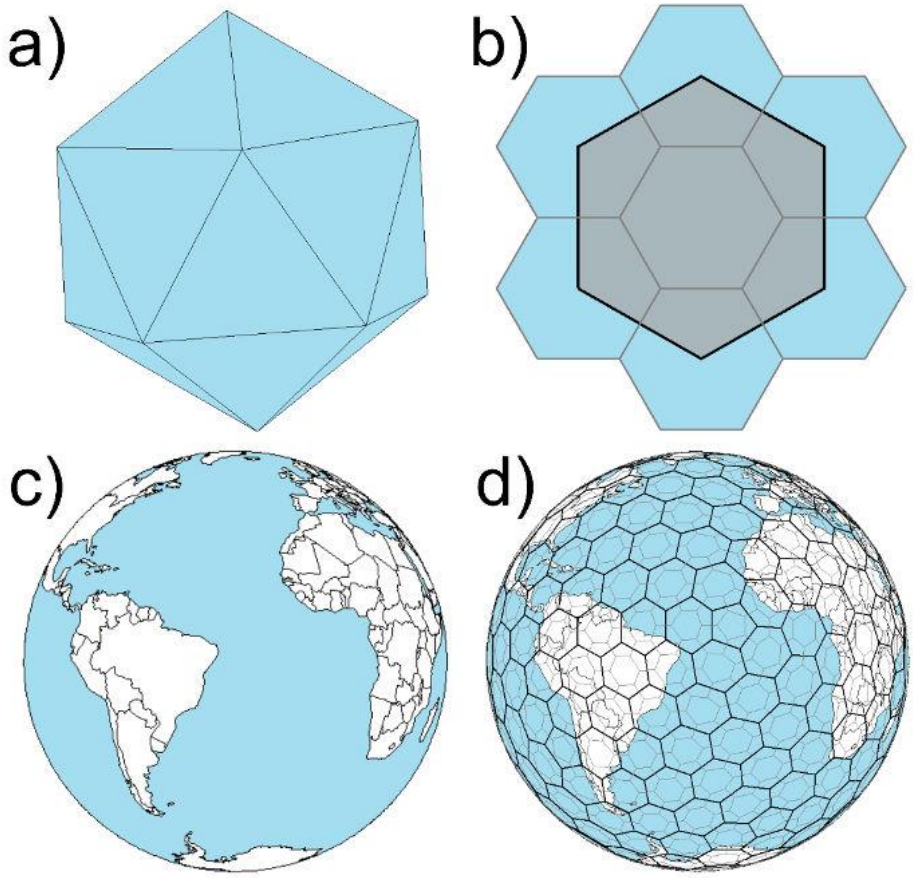

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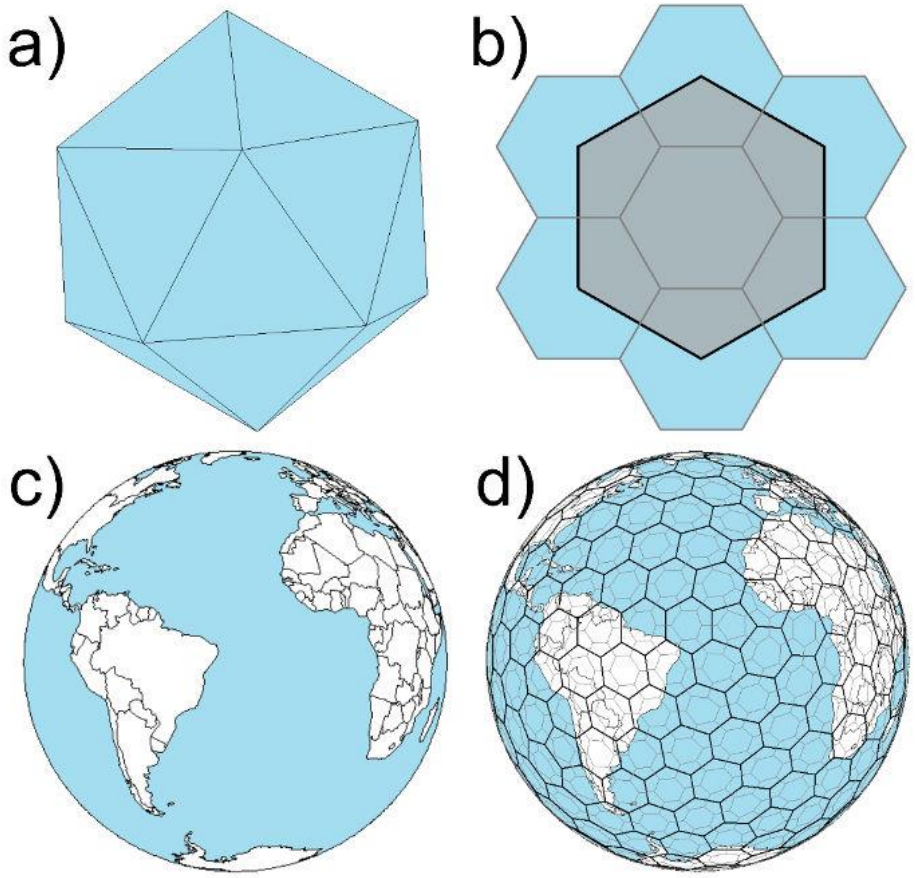

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- Within each **hexcell** we collect:
  - **Neophyte** habitat distribution (**p**)
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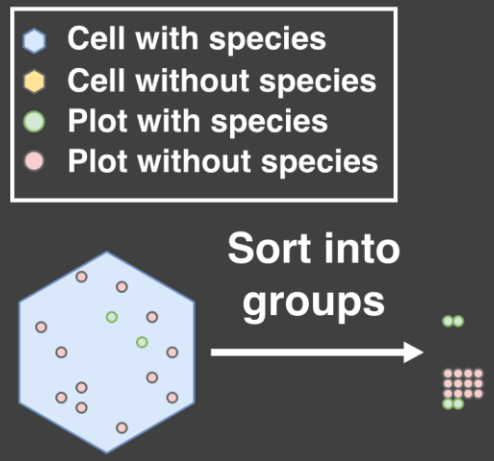
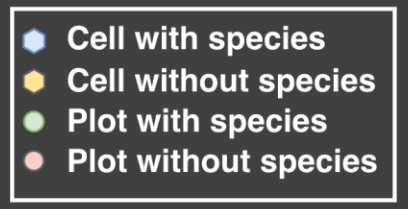
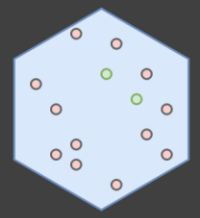
- Within each habitat (per decade):
  - Null-model: **p ≈ q**
  - Overrepresented: **p > q**

Methods


Cell with species
Cell without species
Plot with species
Plot without species
Sort into groups

Methods





Sort into groups

Cell ID	Plot IDs	Decade
Cell X	ID_XX, ID_XY	Decade X
...	...	...

Record Plots per cell across decades

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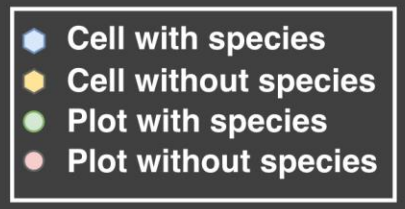

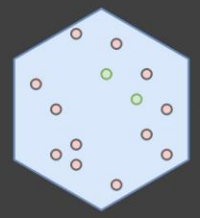

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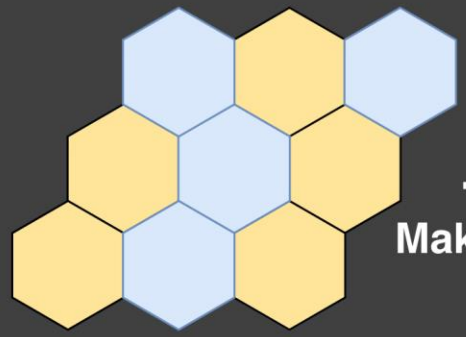
Record across all cells with species presence



Make habitat profile per species

Habitat 1	Habitat 2
Decade 1 - Background	Decade 1 - Background
Decade 1 - Species	Decade 1 - Species
Decade 2 - Background	Decade 2 - Background
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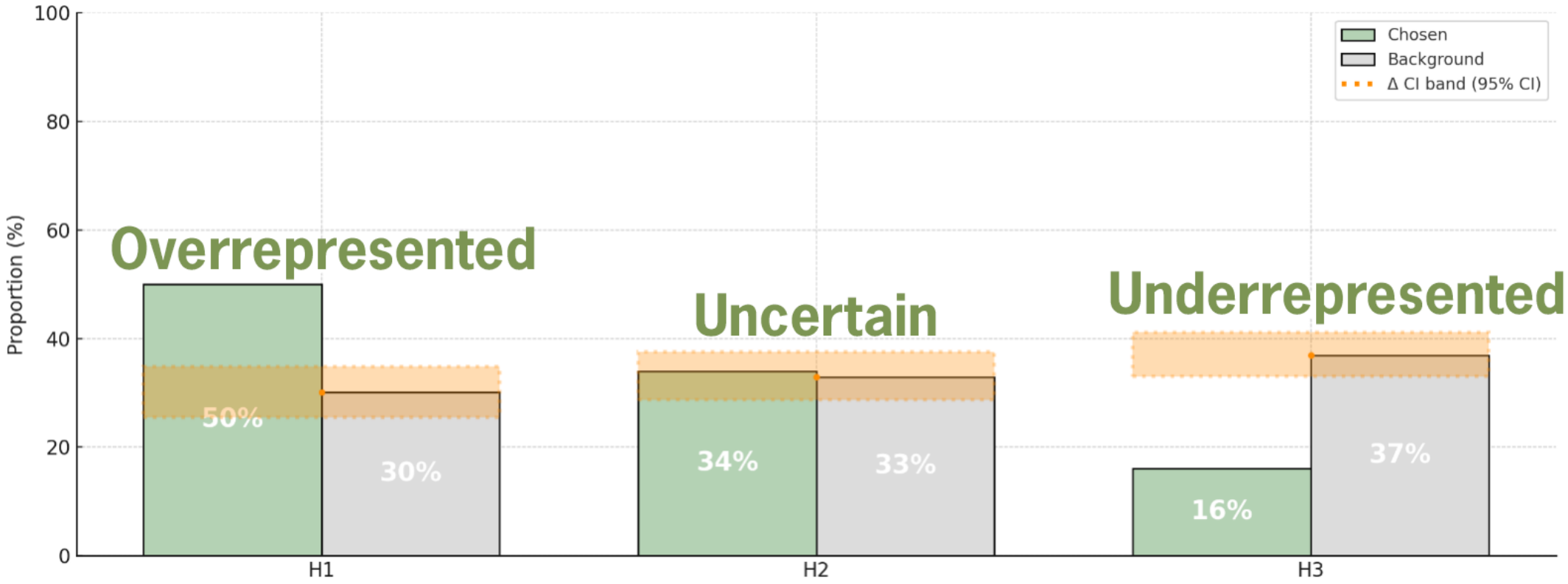
...	...

...

Methods



Species (green) vs **background (grey)** with **95% CI band**

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  - Unlike diversity indices, we test against **defined expectation**
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- **Categorical output**
  - Species is overrepresented **(1) or not (0)** per habitat
  - Directly **usable as response**

Methods

Biologically, two distinct processes are involved:

1. **Can** the species **extend beyond one habitat?** (generalist potential vs. specialist constraint)
   - Many species remain constraint
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2. **How many** additional **habitats** does it occupy once it expands?
   - Given expansion, what determines breath?
   - Outcome: Counts (number of additional habitats)

Methods

$$Y_i \sim \text{TruncHurdleNegBin}(\pi_i, \mu_i, \phi)$$

- **Hurdle** component (logit link)

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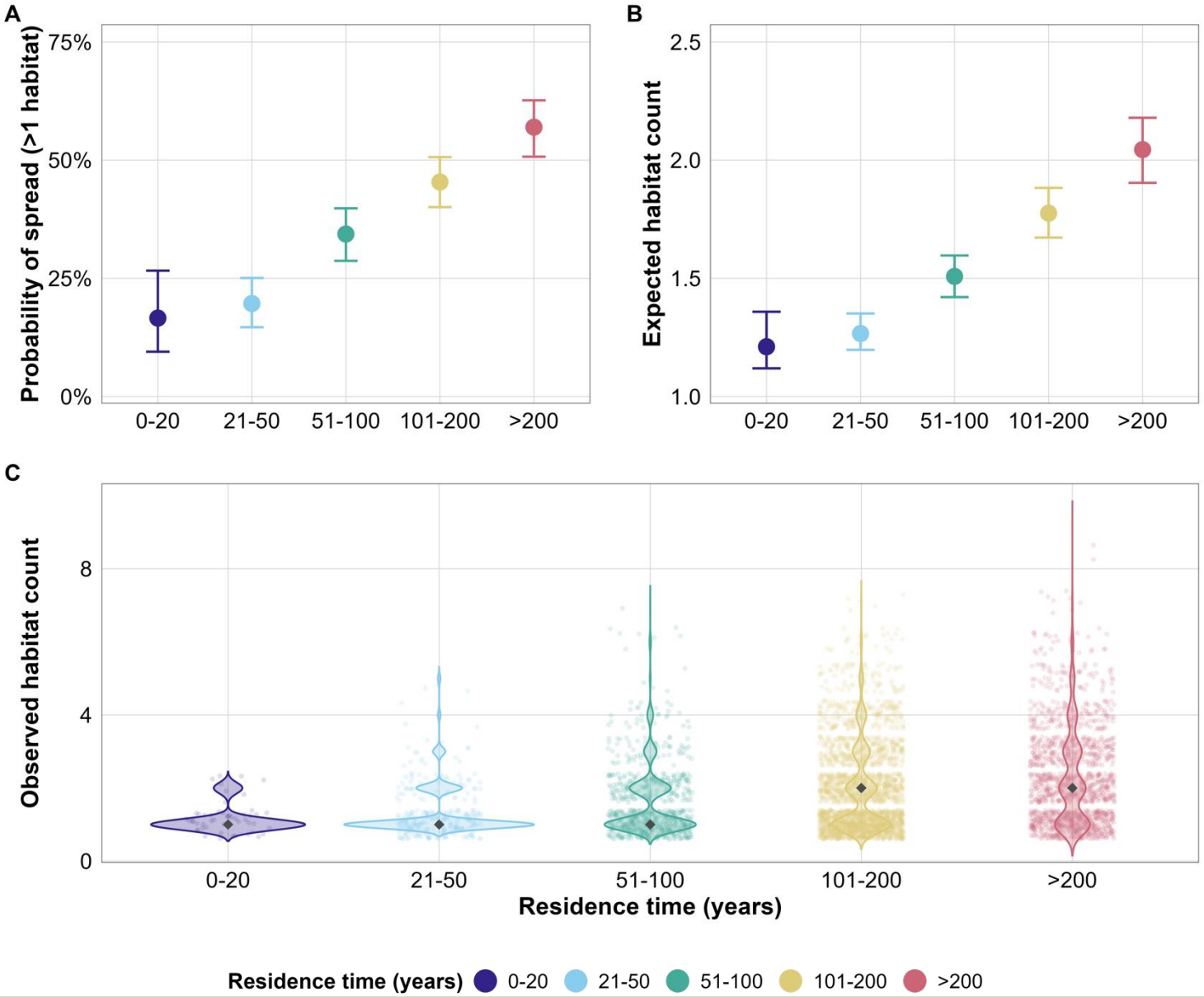
- **Random effects:** country intercepts

Results



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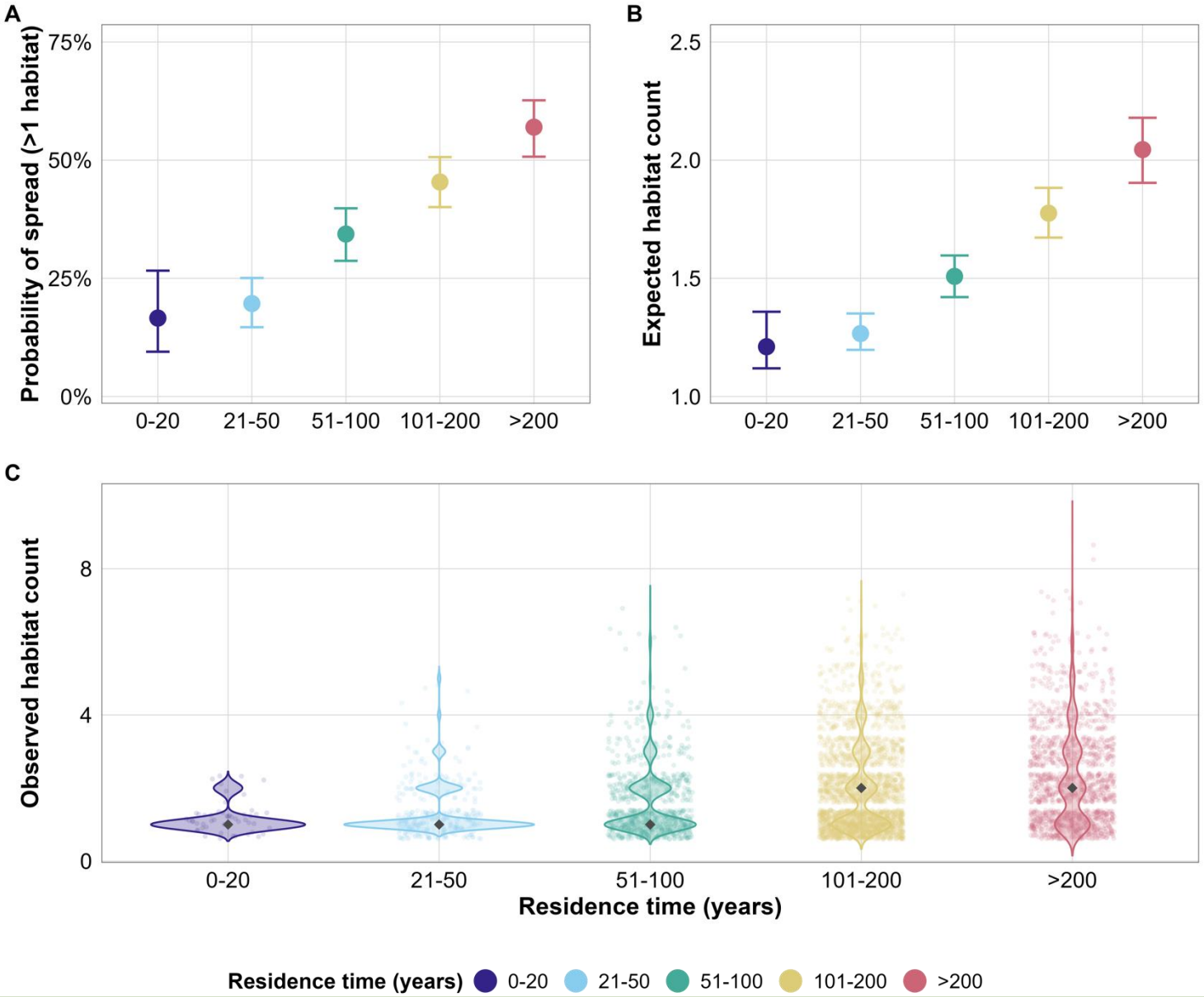

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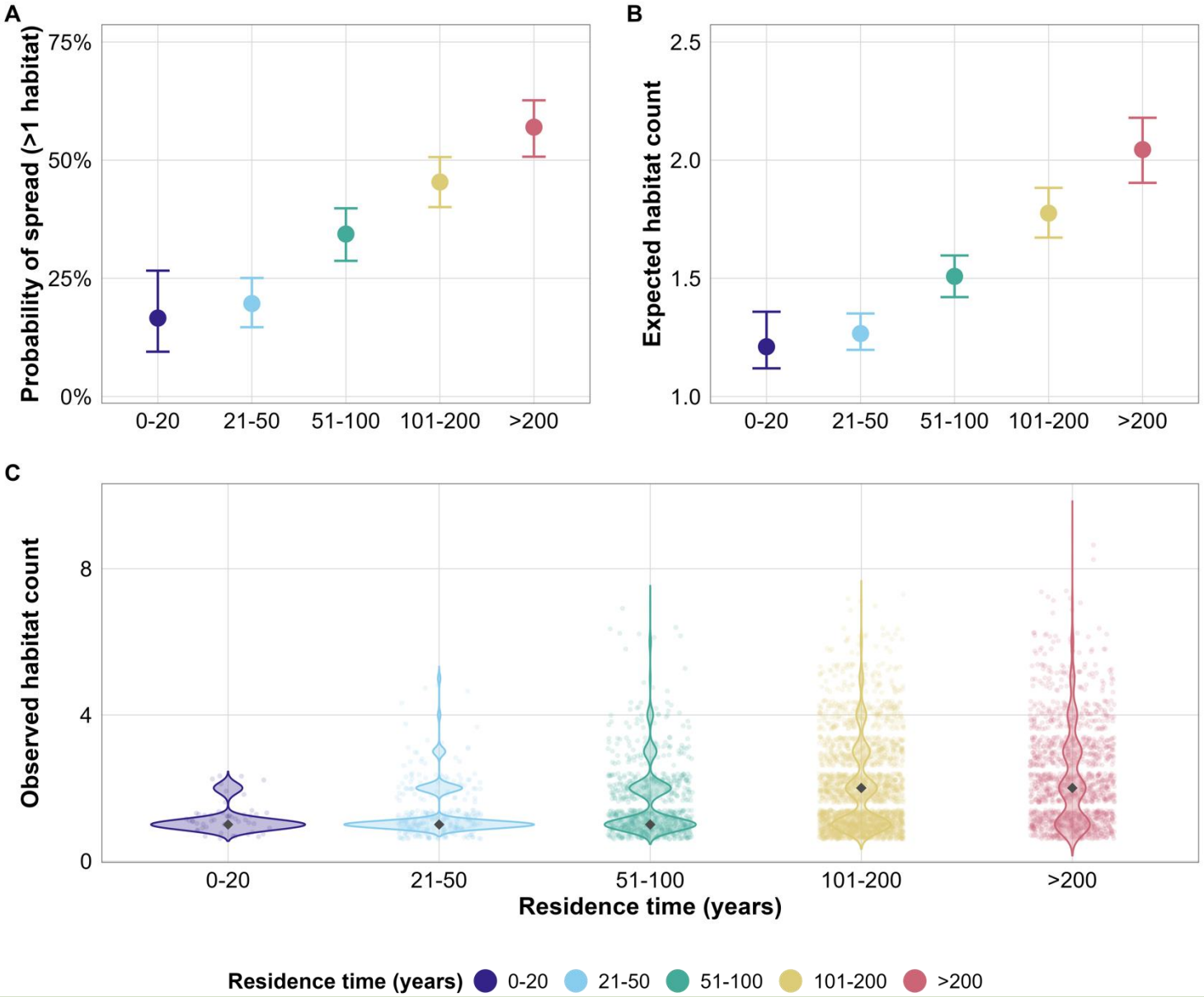

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- Most pairwise contrasts **significant**

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- **Hurdle** component (P of > 1 habitat)
  - Trees, vines: reduced prob. (OR 0.57-0.69)
  - Long-lived perennials: reduced prob. (OR 0.55)
  - Human-mediated dispersal: reduced prob. (OR 0.73)

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- **Count** component (expected habitats given > 1)
  - Long-lived perennials: +43% more habitats (IRR 1.43)
  - Medium-lived perennials: +20% more habitats (IRR 1.20)

*OR = Odds ratio, IRR = Incidence Rate Ratio

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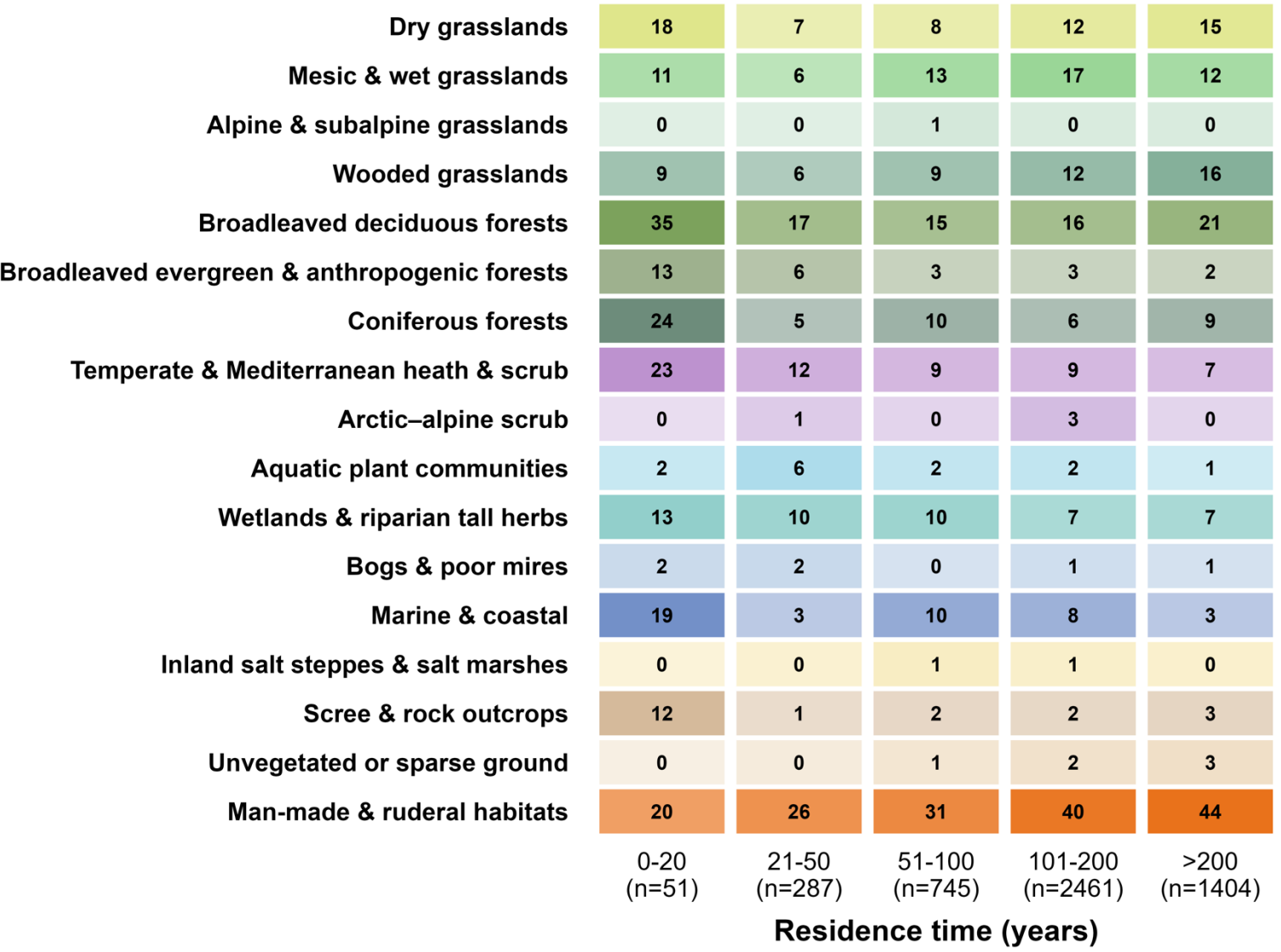

- **High Invasion:**
  - Man made & ruderal
- **High Resistance:**
  - Alpine grasslands
  - Bogs & poor mires
- **Intermediate**
  - Mesic grasslands
  - Deciduous forests

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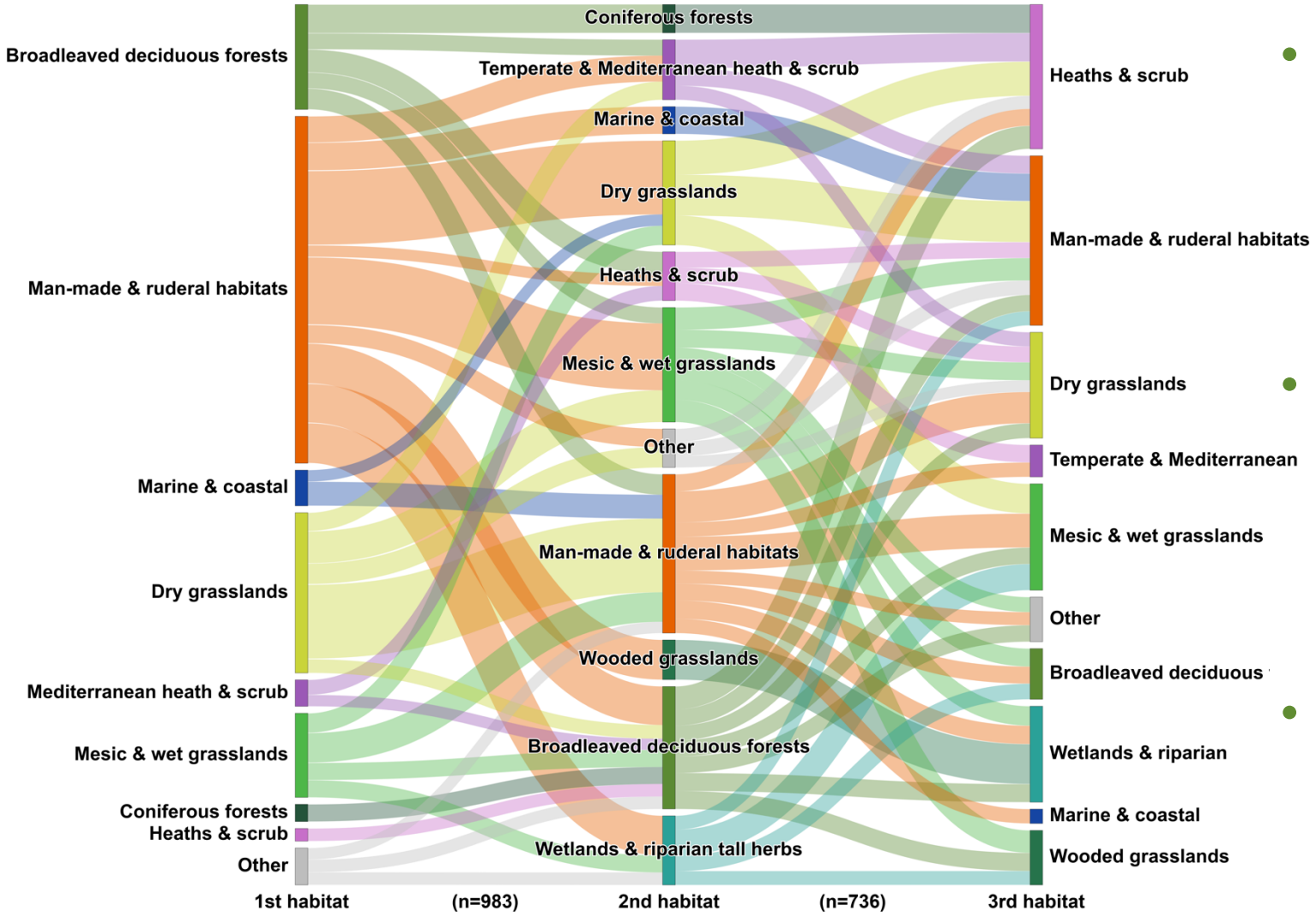

- **First habitat:**
  - Man-made & ruderal (31%)
  - Dry grasslands (16%)
  - Broadleaved dec. (12%)
- **Common Establishment Patterns:**
  - Dry grasslands ↔ man-made
  - Man-made → mesic
  - Man-made → wetlands
- **Third habitat**
  - Mesic & wet grasslands = common tertiary site

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- **Transition analysis**
  - Continental aggregation, no local colonization pathways
  - Species are introduced independent across regions

Take Home

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- **Invasion debt**
  - The residence time effect continues up to >200 years → no sign of equilibrium


Thank you