

Introduction on Functional Rarity Concepts & Principles

Matthias Grenié – June 16th 2021
CESAB Workshop

The widespreadness of rarity

The widespreadness of rarity

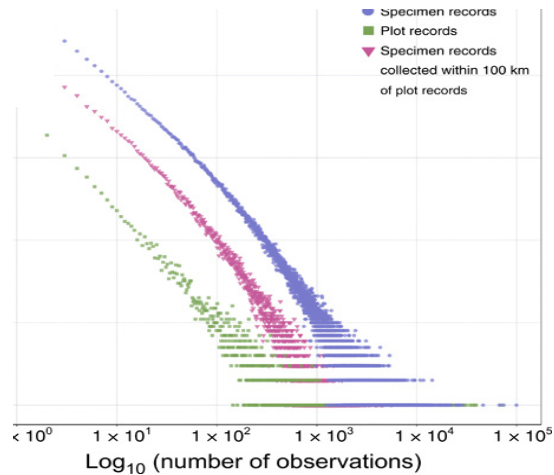
"rarity is the attribute of a vast number of species of all classes"

The widespreadness of rarity

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– Charles Darwin, The Origin of Species 1859

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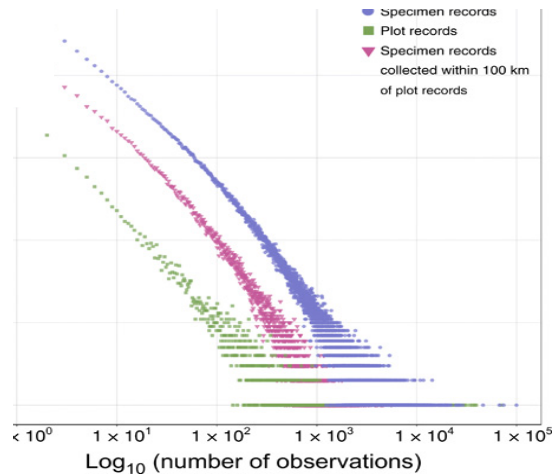
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Enquist et al. 2019
Sci. Adv.

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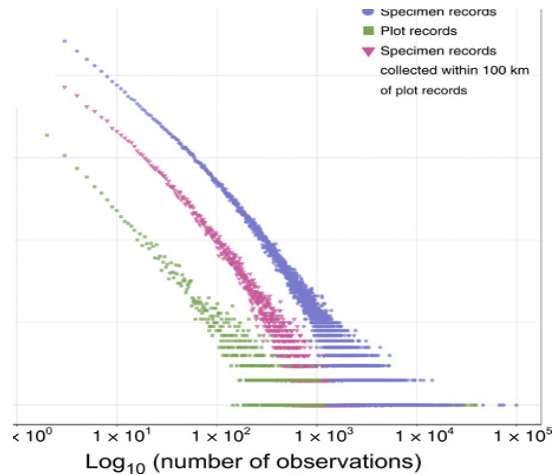


Most species are rare few are common

Enquist et al. 2019
Sci. Adv.

The widespreadness of rarity

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Most species are rare few are common

Yet, ecology generally focuses on common species

Enquist et al. 2019
Sci. Adv.

Different types of Rarity



“Seven forms of rarity” Deborah Rabinowitz 1981

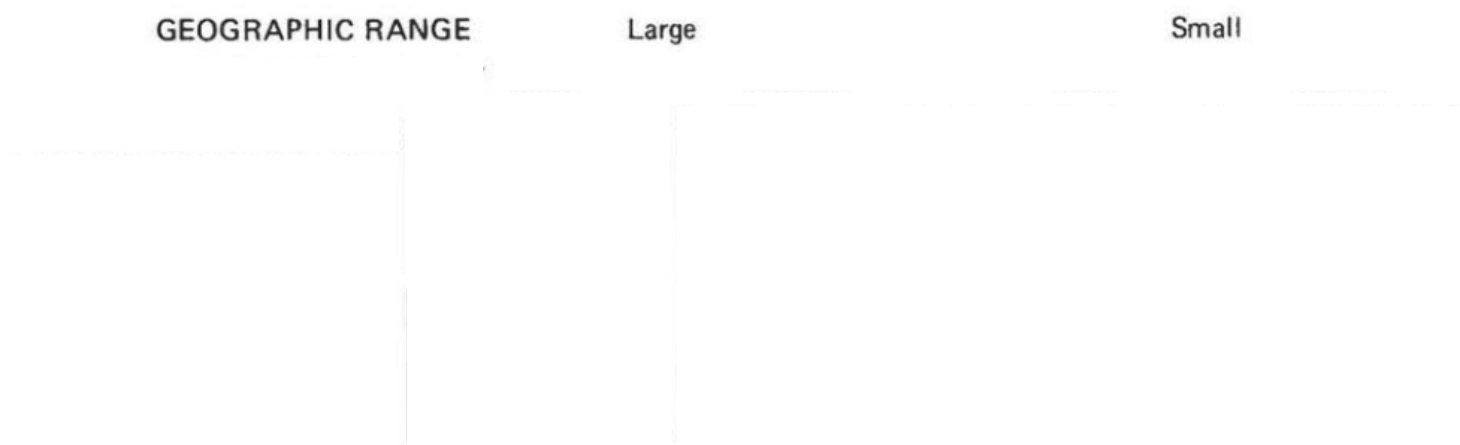
Different types of Rarity

GEOGRAPHIC RANGE



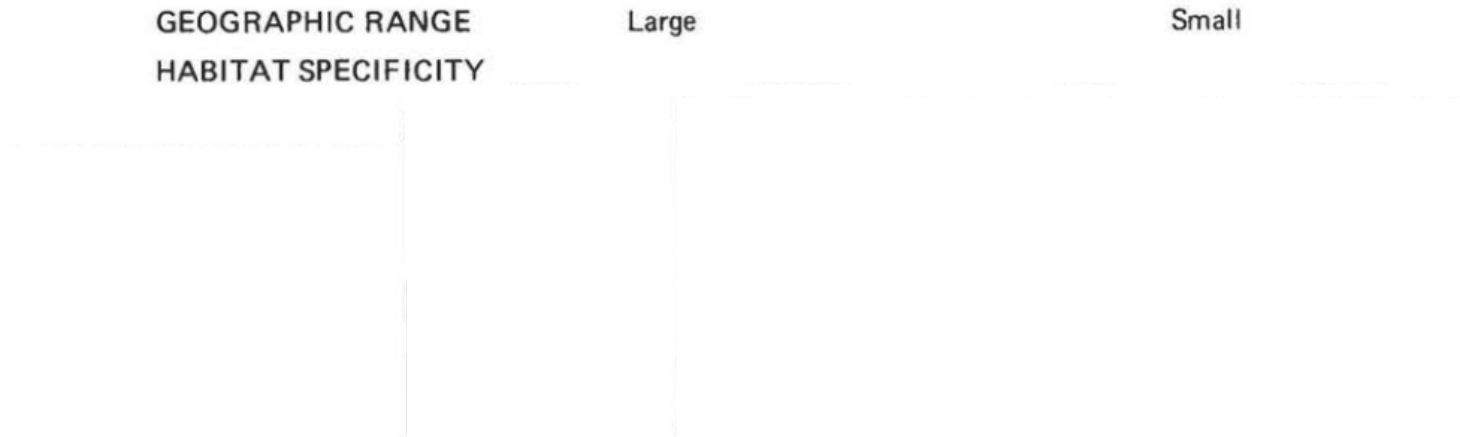
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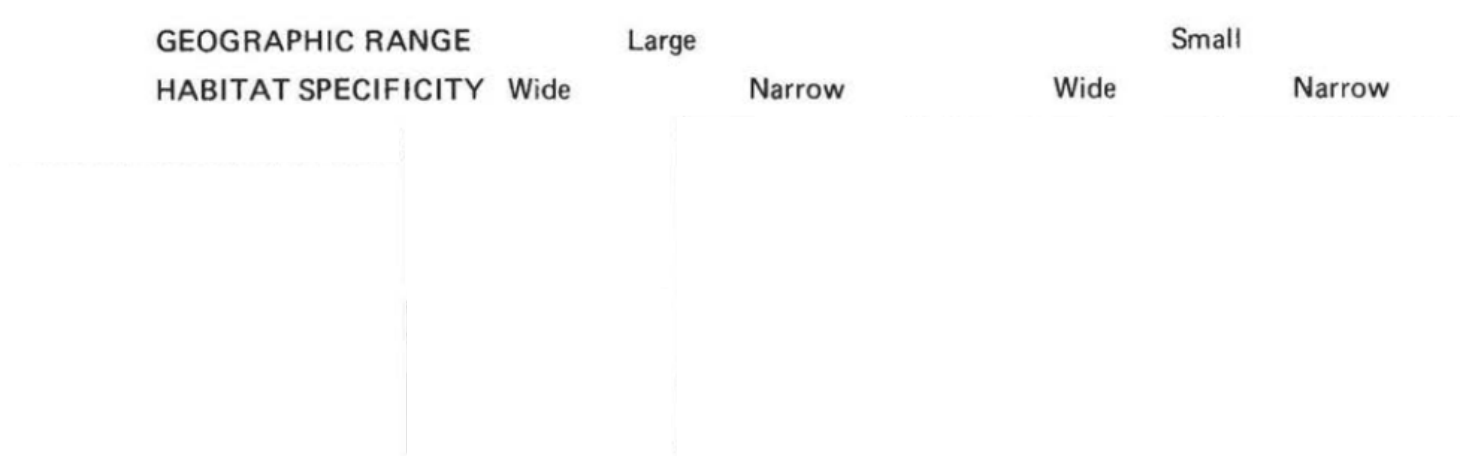
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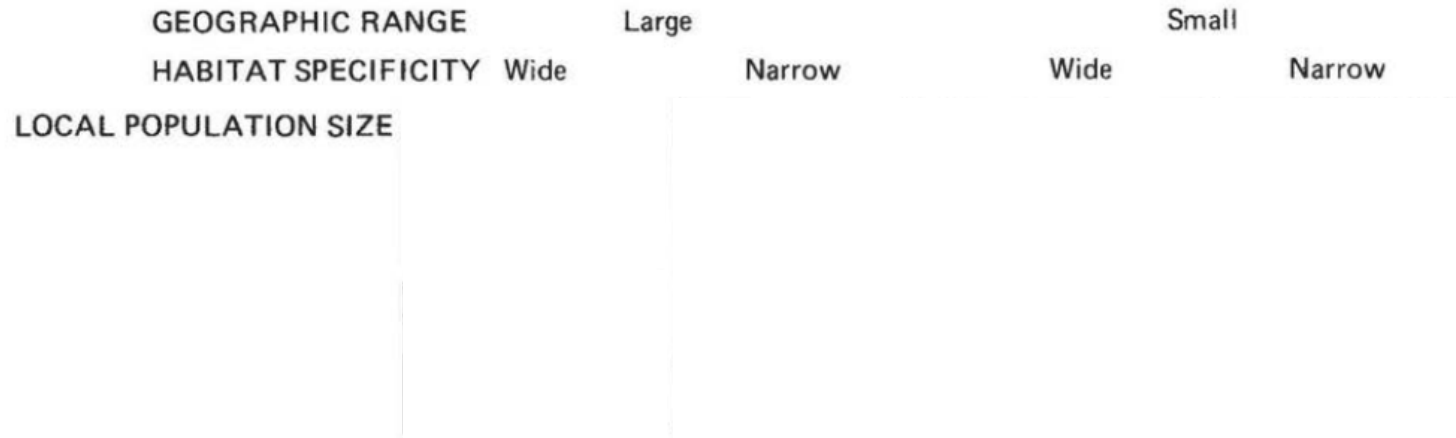
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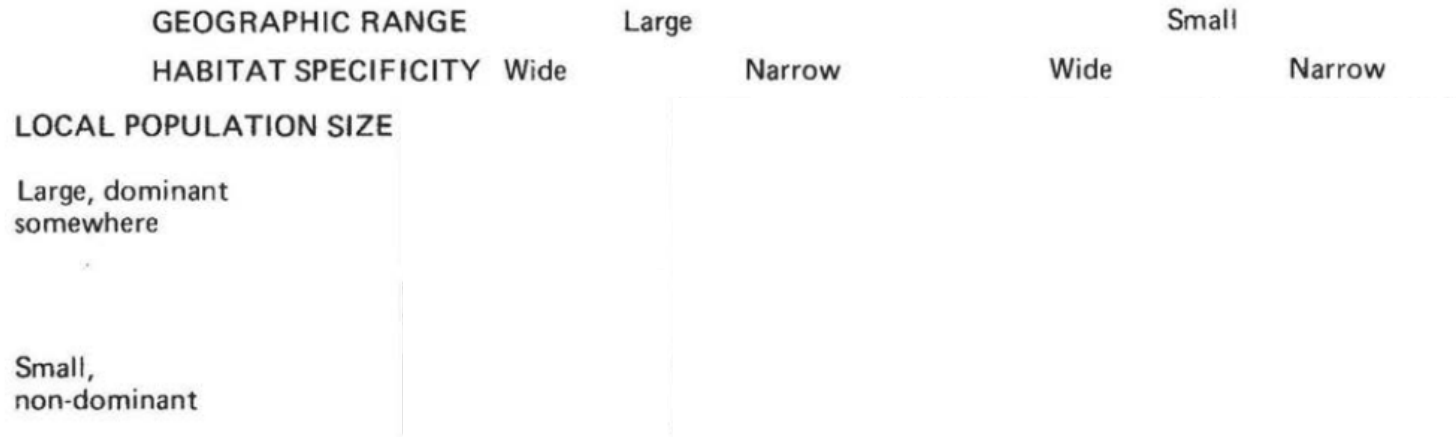
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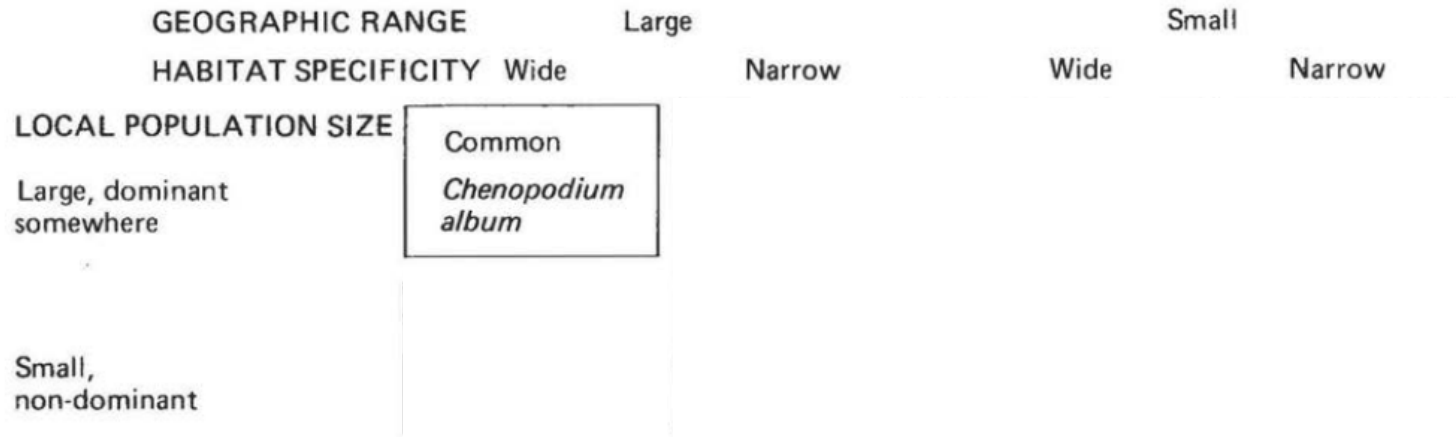
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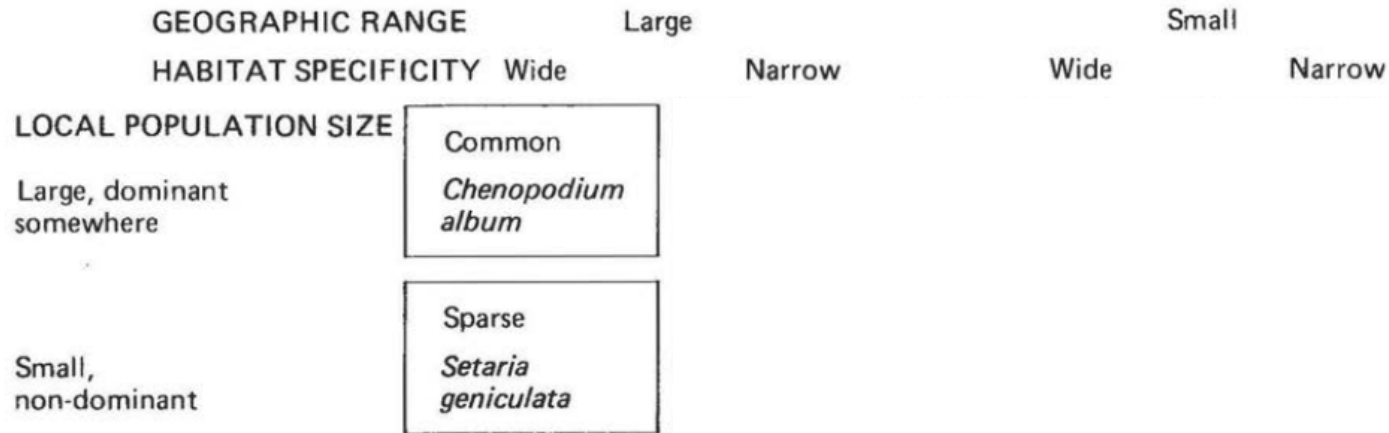
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Different types of Rarity



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Different types of Rarity



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Different types of Rarity

| | | GEOGRAPHIC RANGE | | Small | |
|-----------------------|---|---|--------------------------------------|--|--------|
| | | Large | | Wide | Narrow |
| HABITAT SPECIFICITY | | Wide | Narrow | Wide | Narrow |
| LOCAL POPULATION SIZE | Common <i>Chenopodium album</i> Large, dominant somewhere | Predictable <i>Rhizophora mangle</i> | Unlikely <i>Cupressus pygmaea</i> | Endemics <i>Shortia galacifolia</i> | |
| | Sparse <i>Setaria geniculata</i> Small, non-dominant | <i>Taxus canadensis</i> | Non-existent? | <i>Torreya taxifolia</i> | |

“Seven forms of rarity” Deborah Rabinowitz 1981

From Rarity to Functional Rarity

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Functional Rarity: The Ecology of Outliers

Cyrille Violle,^{1,*} Wilfried Thuiller,² Nicolas Mouquet,^{3,4}
François Munoz,^{5,6} Nathan J.B. Kraft,⁷ Marc W. Cadotte,^{8,9}
Stuart W. Livingstone,¹⁰ and David Moullot^{4,11}

Violle et al. 2017 *Trends in Ecology and Evolution*

From Rarity to Functional Rarity

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Species can also be rare along a **trait dimension**

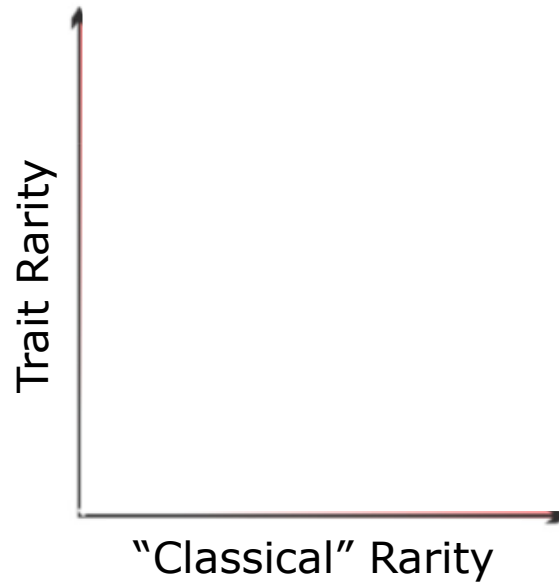
Decomposing Functional Rarity along Two Axes

Functional Rarity = “Classical” Rarity + Trait **Rarity** (= **originality**)

Violle et al. 2017

Decomposing Functional Rarity along Two Axes

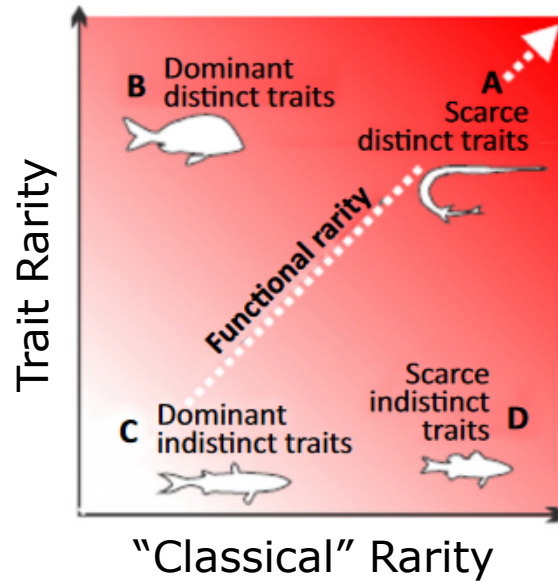
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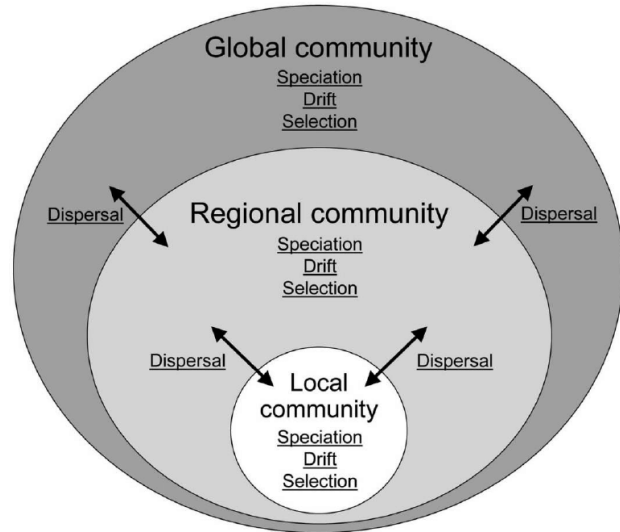
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Original Rabinowitz had two scales: Local & Regional

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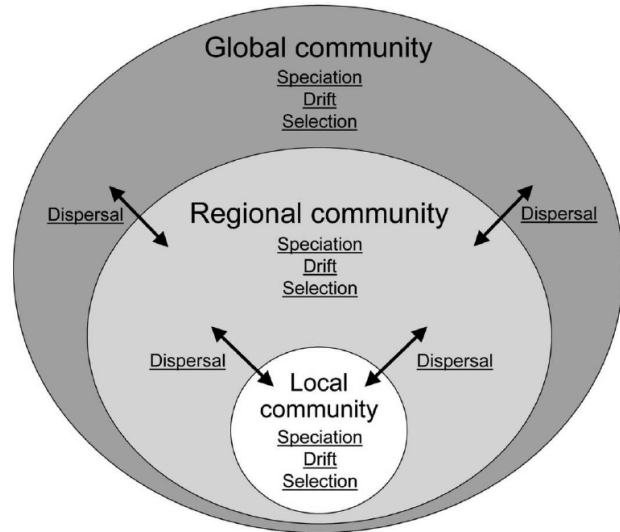
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Vellend 2010 *Quart. Rev. Biol.*

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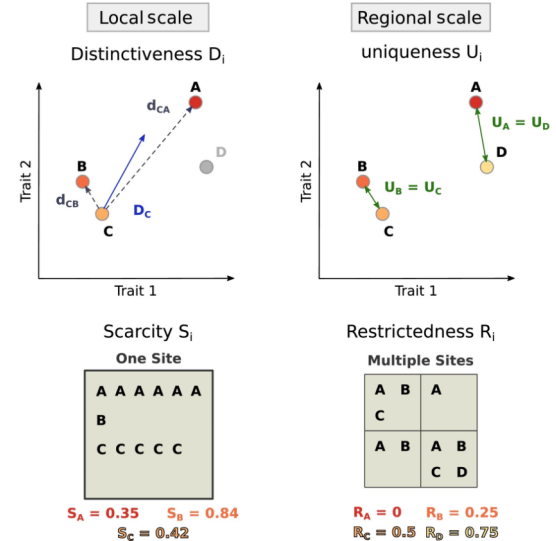
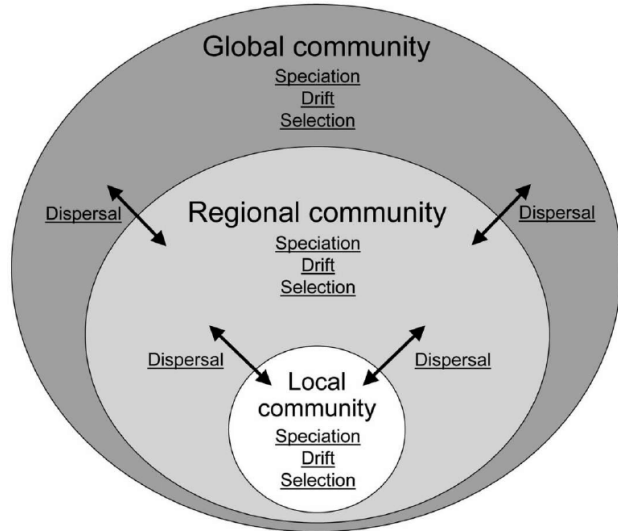


Scale Matters in Ecology

Vellend 2010 *Quart. Rev. Biol.*

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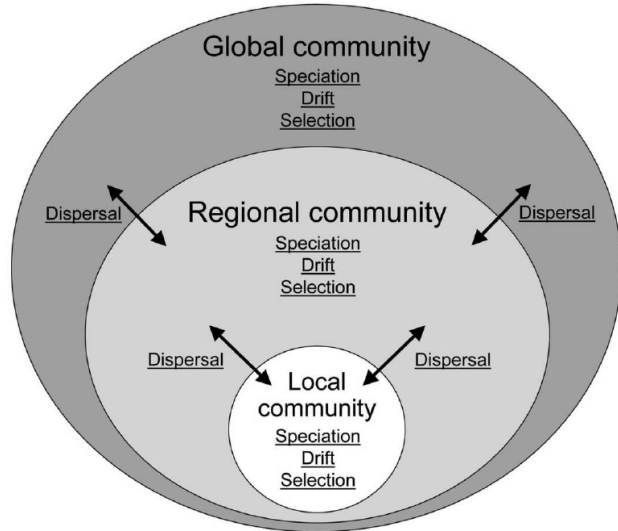


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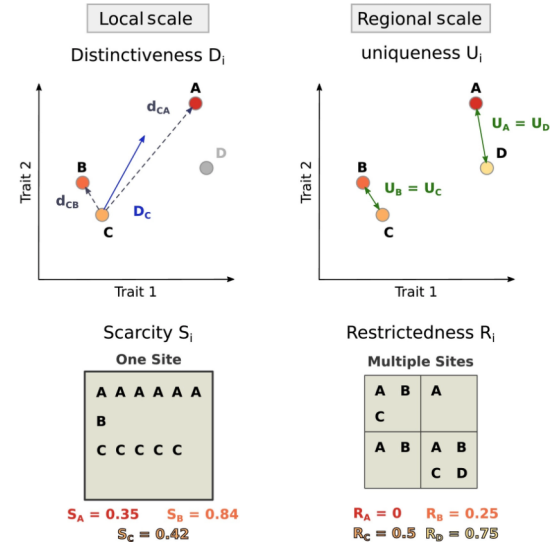
Decomposing Functional Rarity along Two Scales

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Scale Matters in Ecology

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Functional Rarity can be computed along two scales

Grenié et al. 2017 *Div. Distr.*

16 (rather 12) forms of functional rarity

Combining all these answers we can get **functional rarity categories**

Categories are **discrete** but quantification will be **continuous**

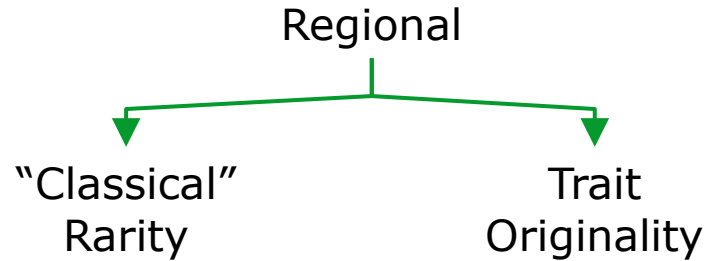
16 (rather 12) forms of functional rarity

Regional

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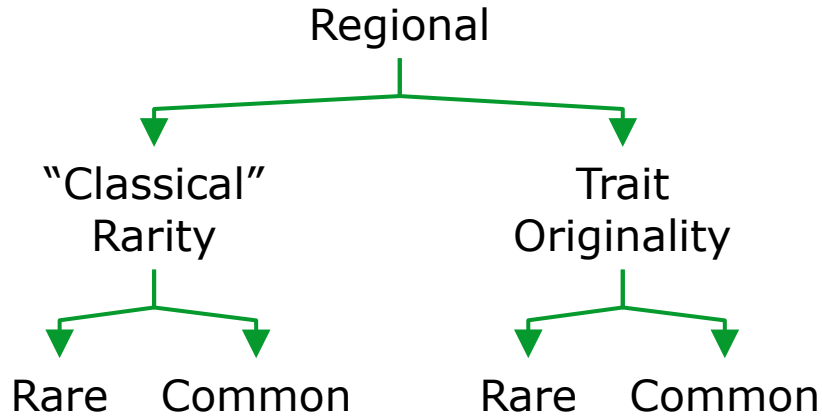
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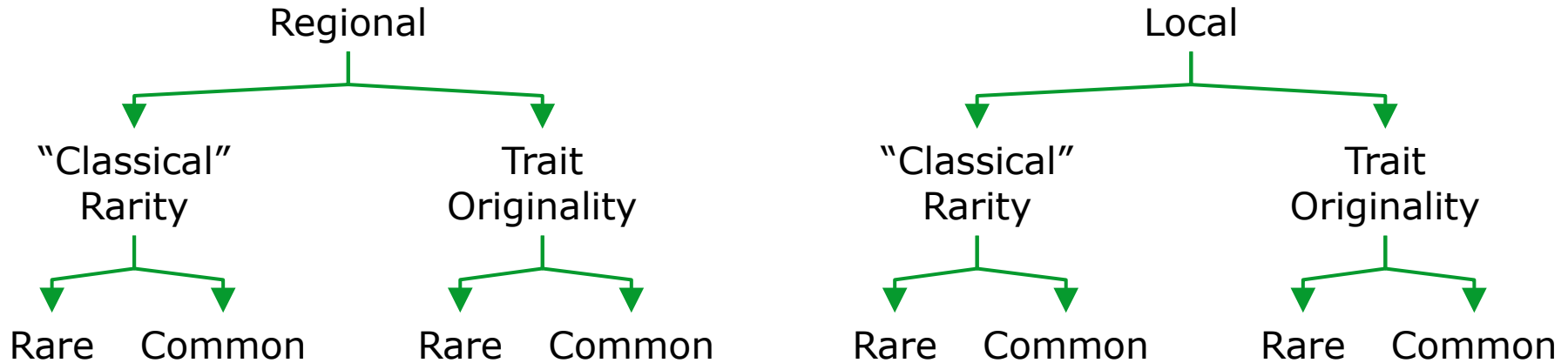
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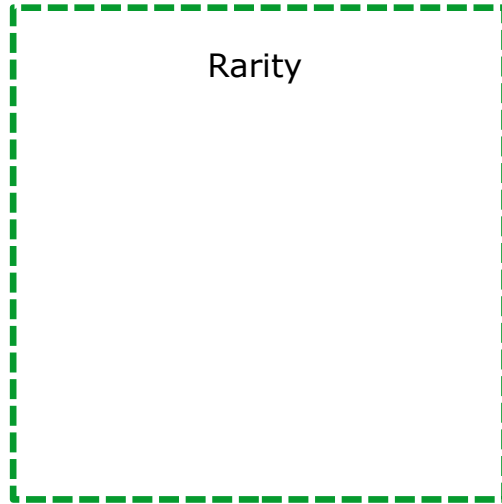
Semantic issues

Semantic issues

Functional Rarity

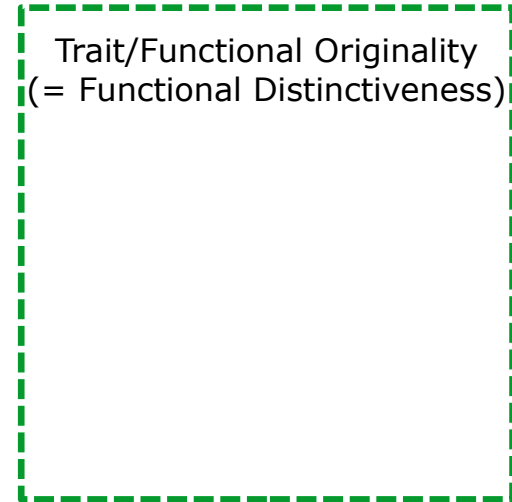
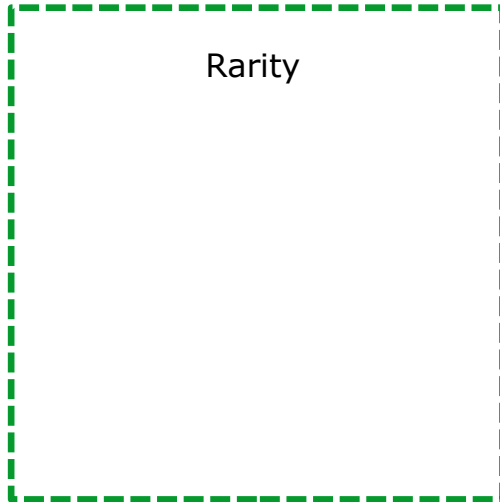
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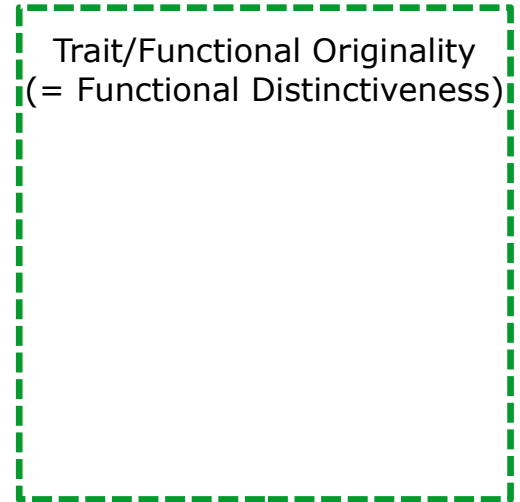
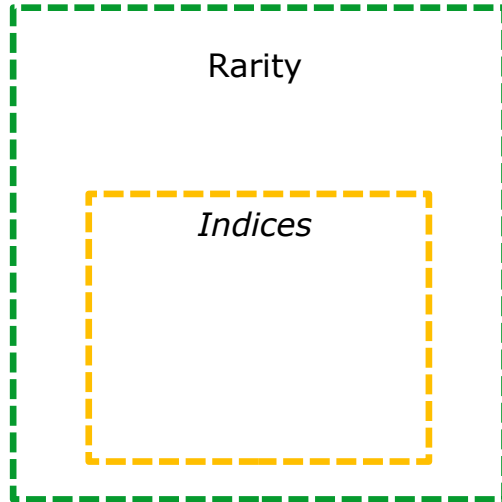
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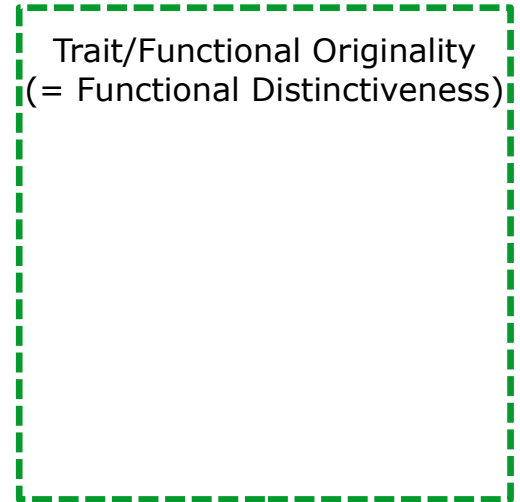
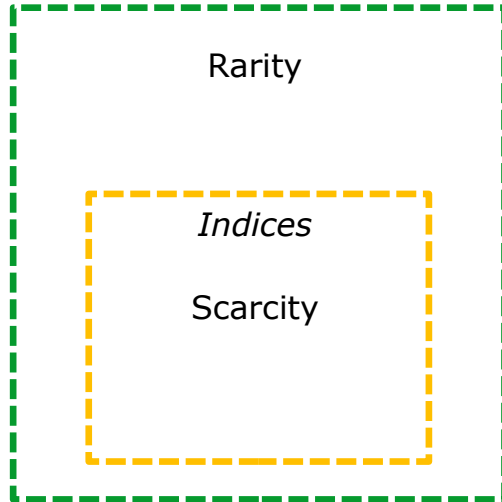
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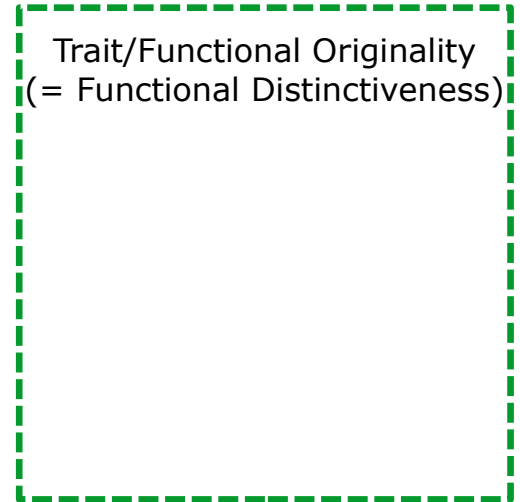
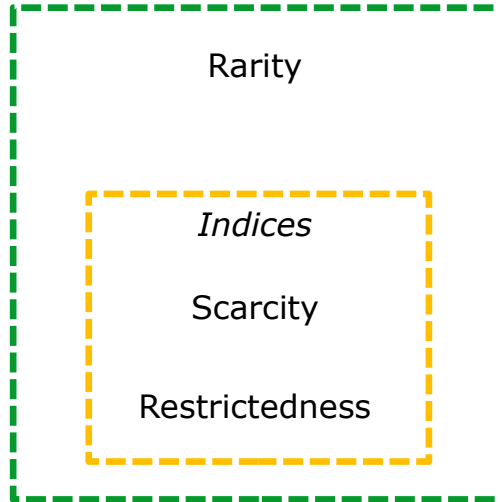
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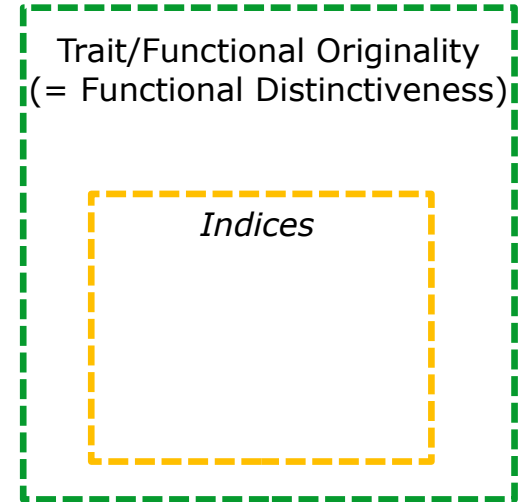
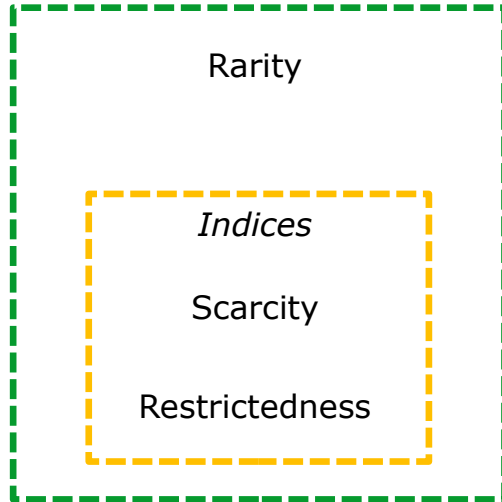
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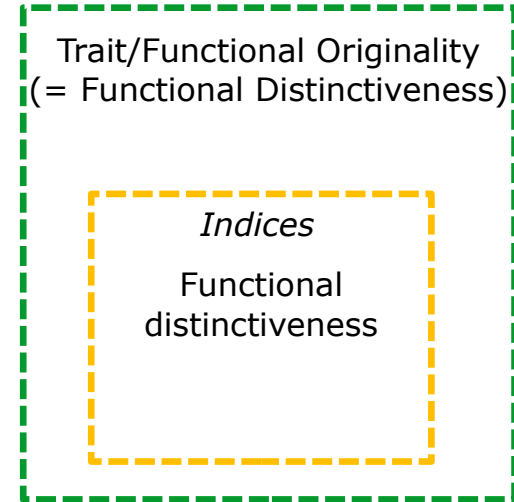
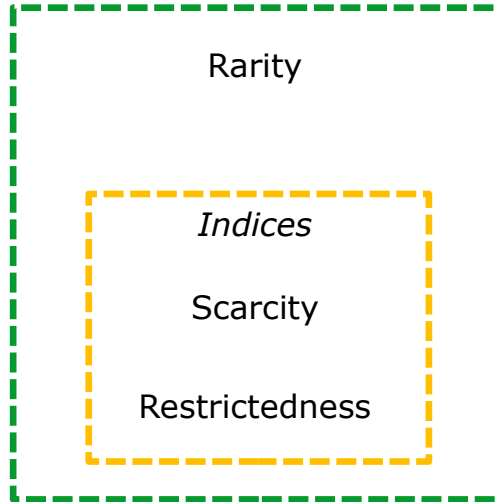
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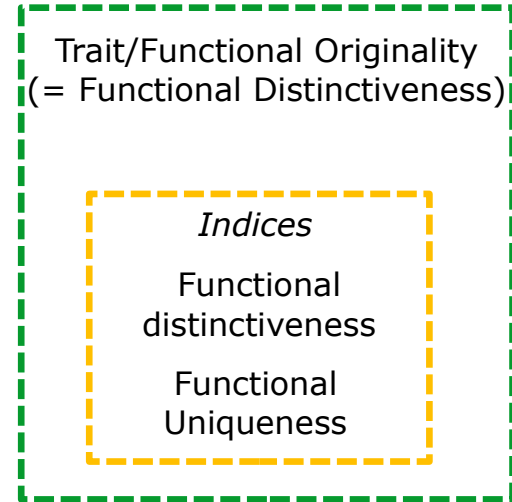
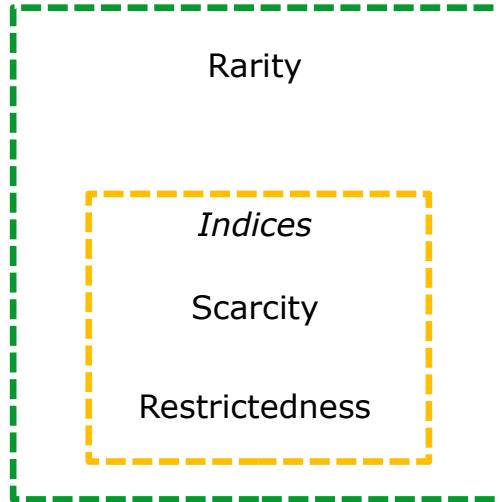
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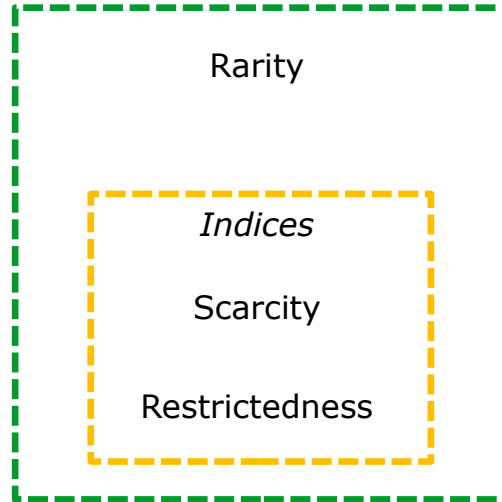
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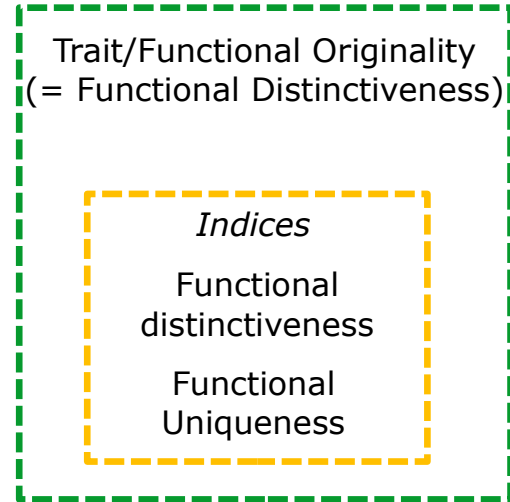


Semantic issues

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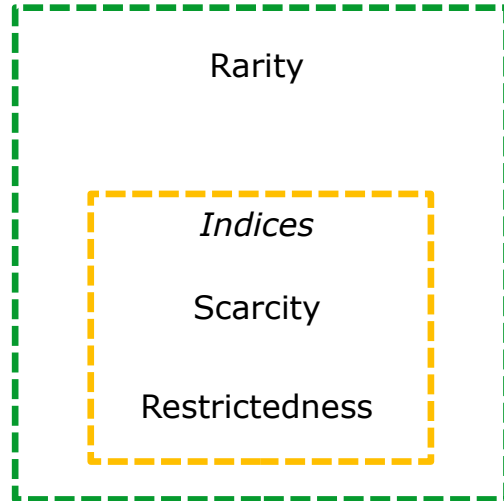


Rare species

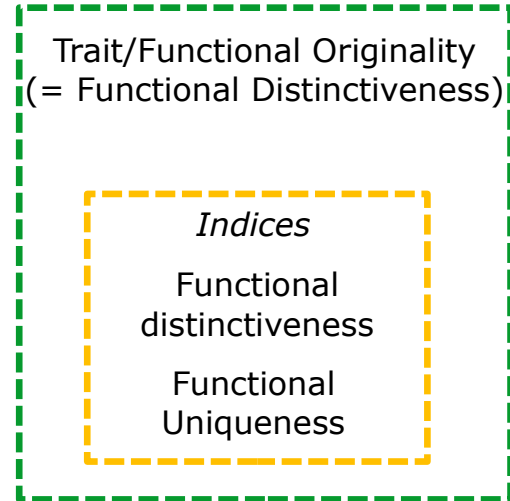


Semantic issues

Functional Rarity



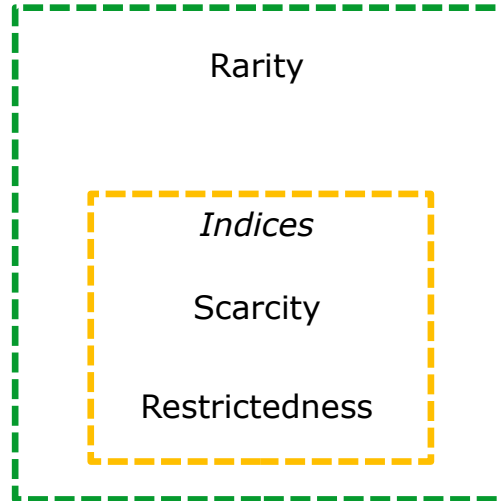
Rare species



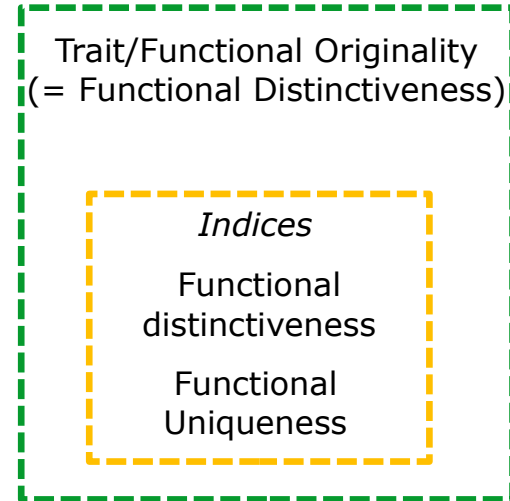
Original Species

Semantic issues

Functional Rarity



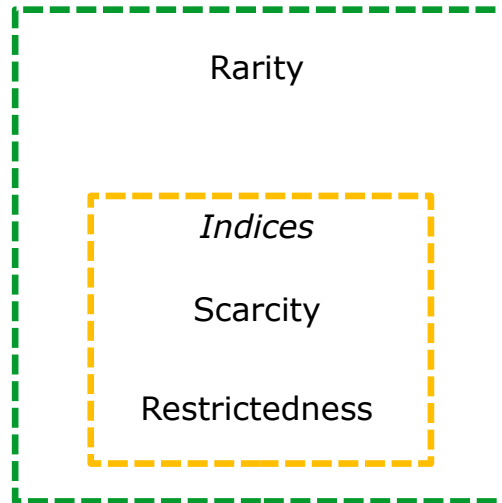
Rare species



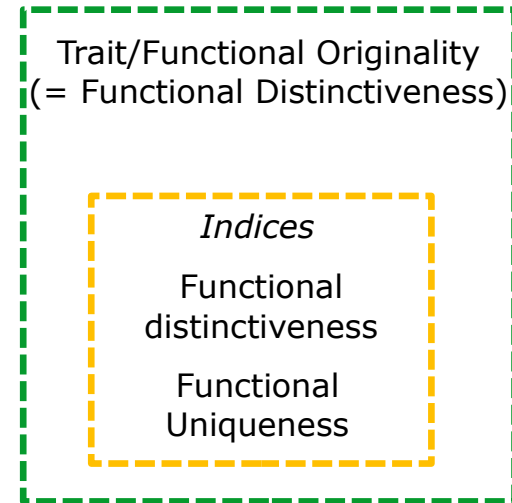
Original Species
Functionally Distinct species

Semantic issues

Functional Rarity



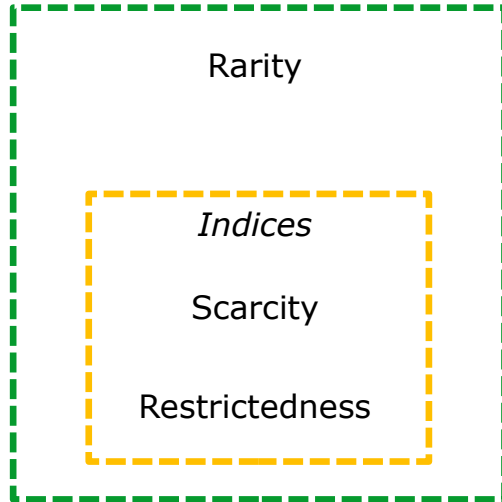
Rare species



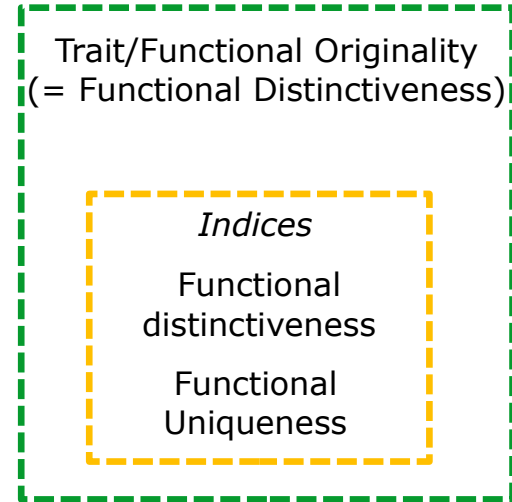
Original Species
Functionally Distinct species
Functional Outlier

Semantic issues

Functional Rarity



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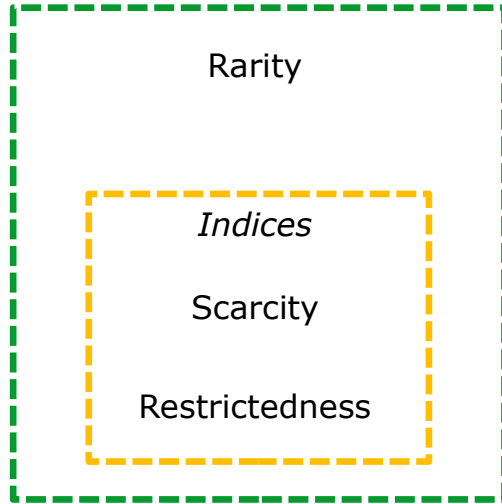


Original Species
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Functional Outlier

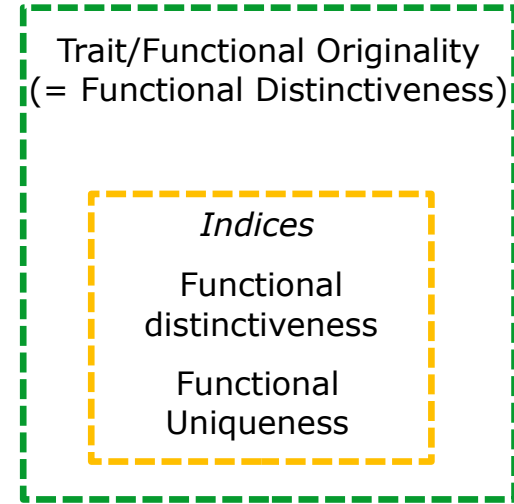
+ Spatial Scales

Semantic issues

Functional Rarity



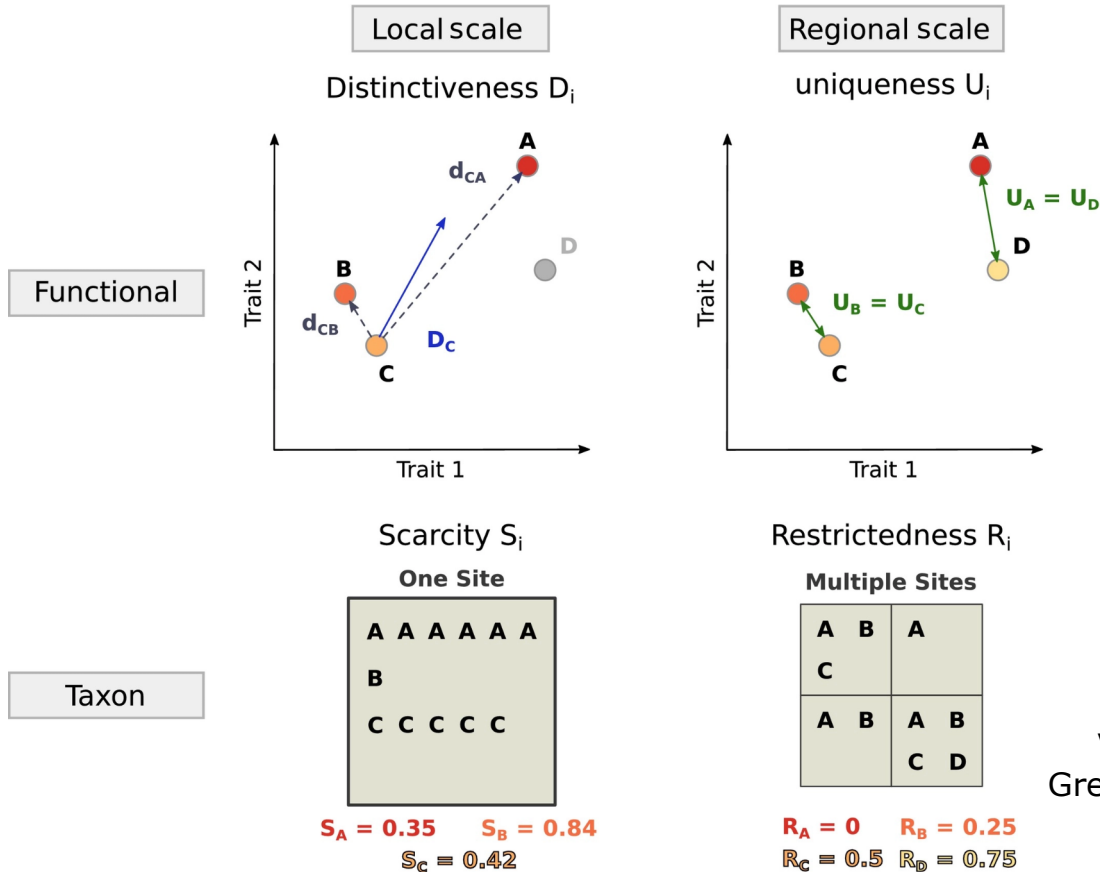
Rare species



Original Species
Functionally Distinct species
Functional Outlier

+ Spatial Scales
e.g. **Local** Functionally Distinct Species

Functional Rarity Indices



Violle et al. 2017 *TREE*
 Grenié et al. 2017 *Div. Distr.*

Some Properties of Functional Rarity Indices

Violle et al. 2017 *TREE*
Grenié et al. 2017 *Div. Distr.*
Kondratyeva et al. 2019 *Biol. Rev.*

Some Properties of Functional Rarity Indices

- One index per species (\neq from diversity indices)

Violle et al. 2017 *TREE*
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- One index per species (\neq from diversity indices)
- “Scales” are abstract concept, you decide (species pools, biomes, regions, etc.)

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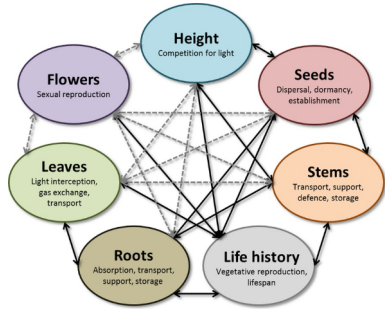
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- One index per species (\neq from diversity indices)
- “Scales” are abstract concept, you decide (species pools, biomes, regions, etc.)
- “Species” can be any biological scale (varieties, individuals, genera, etc.)
- Rarity indices can be seen as decomposition of diversity indices (Kondratyeva et al. 2019)

Violle et al. 2017 *TREE*
Grenié et al. 2017 *Div. Distr.*
Kondratyeva et al. 2019 *Biol. Rev.*

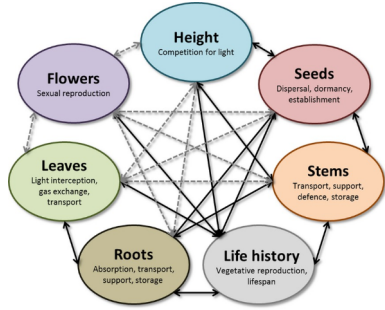
Challenges of Functional Rarity Indices

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Carefully assess which traits you're using to compute functional rarity

Challenges of Functional Rarity Indices

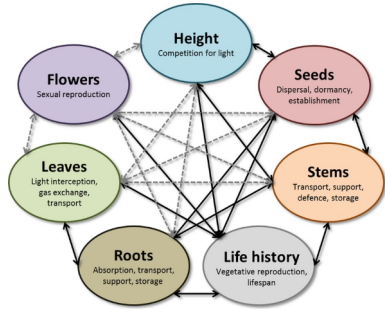


Carefully assess which traits you're using to compute functional rarity

Think about missing trait data (functional rarity indices make no assumptions)

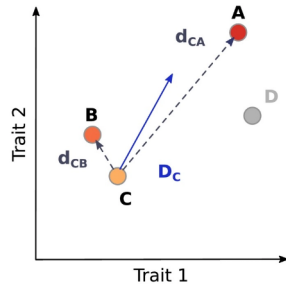


Challenges of Functional Rarity Indices



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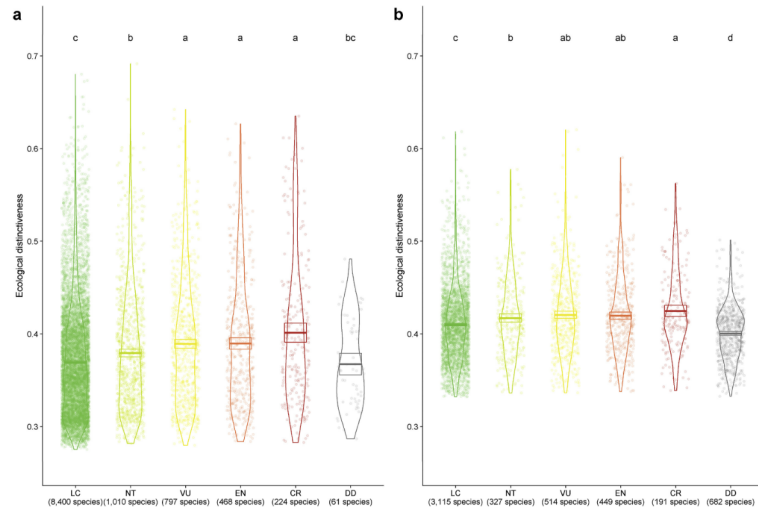
Think about missing trait data (functional rarity indices make no assumptions)



Functional Rarity is **relative to a set**
(Whatever set there will always be functionally rare species **relative** to the others)

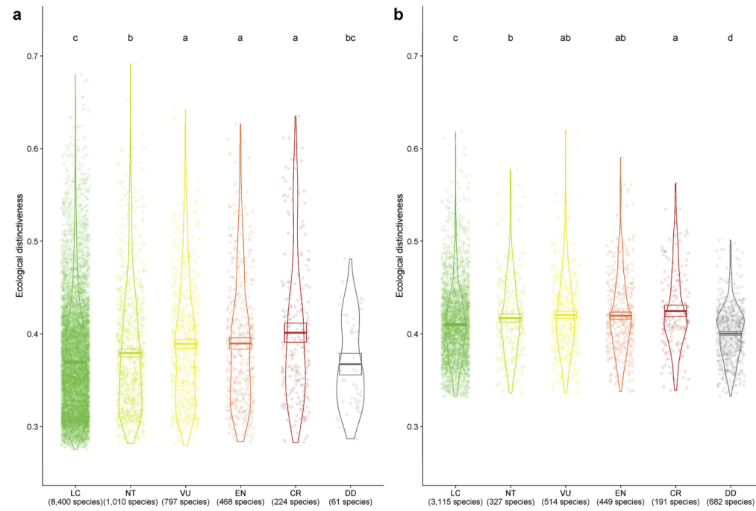
Uses

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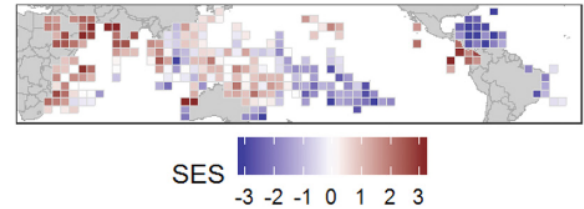


Link IUCN statuses and Functional Rarity
(Cooke et al. 2020)
Mammals & Birds

Uses



B SES of Top Functional Distinctiveness



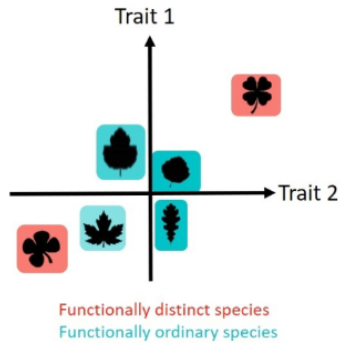
Link IUCN statuses and Functional Rarity
(Cooke et al. 2020)
Mammals & Birds

Hotspots of Functional Distinctiveness
(Grenié et al. 2018)
Coral Reef Fishes

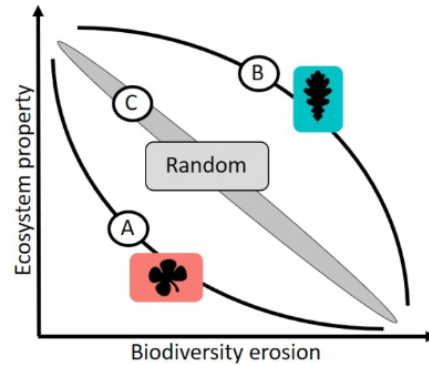
Uses

Uses

A. Functional distinctiveness



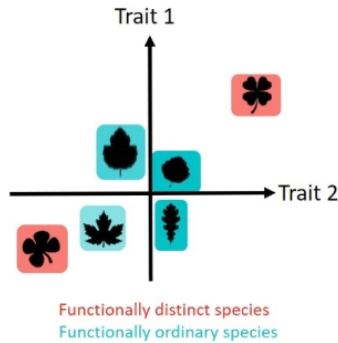
B. Predictions for ecosystem functioning



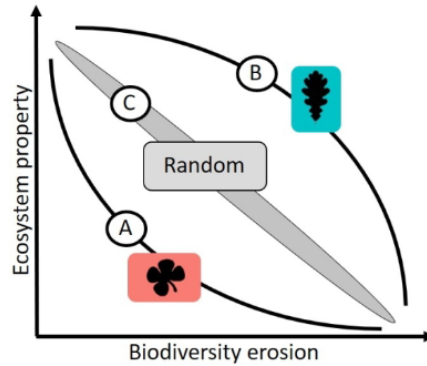
Compare Contributions of Functionally Distinct species to Ecosystem Functioning
(Delalandre et al. 2022)
Trees

Uses

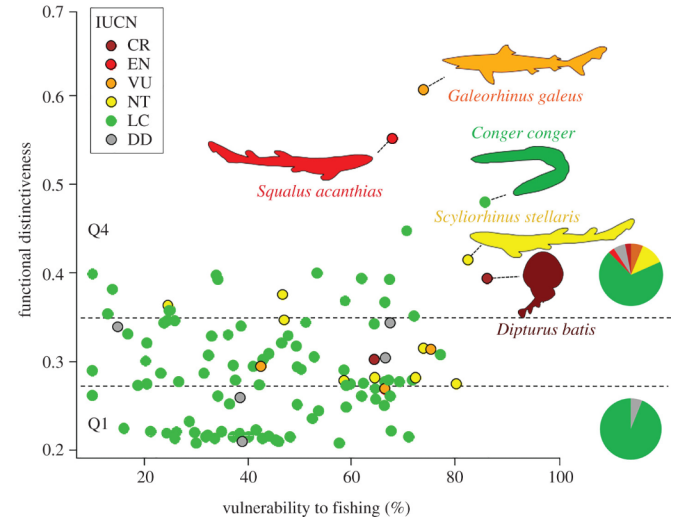
A. Functional distinctiveness



B. Predictions for ecosystem functioning



Compare Contributions of Functionally Distinct species to Ecosystem Functioning (Delalandre et al. 2022)
Trees



Functional Distinctiveness vs. Vulnerability (Murgier et al. 2021)
North Sea Fishes



Your turn to use functional rarity!



www.frb.fr

