iDiv German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig

Taxonomic Harmonization

A problem you didn't know you had!

Matthias Grenié (matthias.grenie@idiv.de) – GfÖ & NFDI4Biodiversity Winter School
Lecture 8 – Thursday December 8th 2022

NFDI 4 BIODIVERSITY BIODIVERSITY, ECOLOGY & ENVIRONMENTAL DATA

GfÖ The Ecological Society of Germany, Austria and Switzerland

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"Museum of Natural History Cynthiacetus" by Shadowgate - CC BY 2.0

Who am I?

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Postdoctoral Researcher at iDiv
Leipzig, Germany

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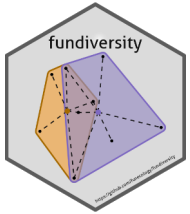
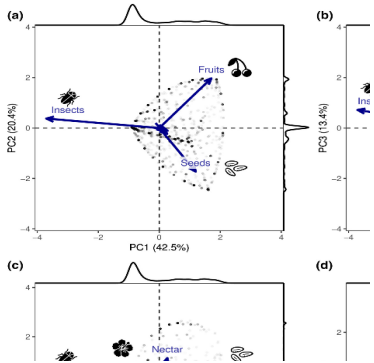
- Trait-based





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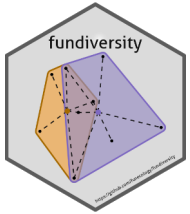

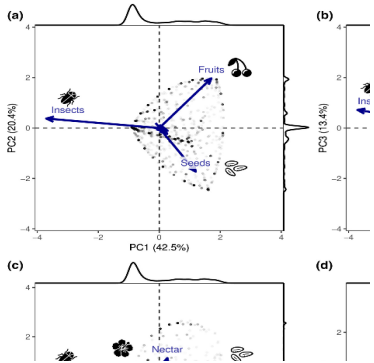

- Invasion

GloNAF
Global Naturalized Alien Flora

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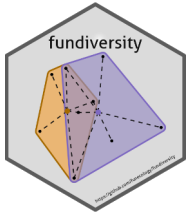

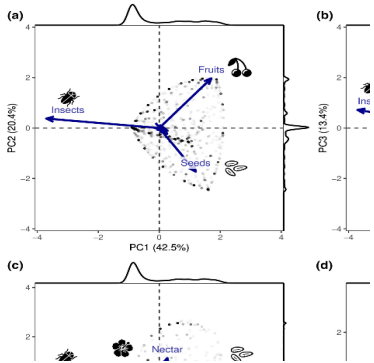

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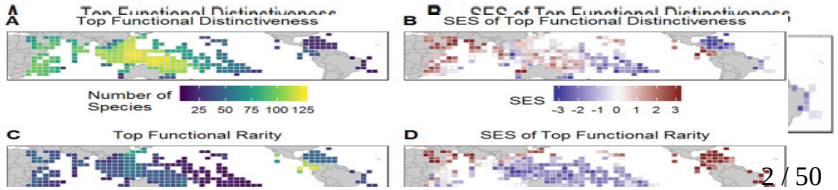
- Macro-ecologist



Contact details

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Why am I in front of you here?

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Methods in Ecology and Evolution BRITISH ECOLOGICAL SOCIETY

REVIEW

Realising the Promise of Large Data and Complex Models

Harmonizing taxon names in biodiversity data: A review of tools, databases and best practices

Matthias Grenié[1,2] | Emilio Berti[1,3] | Juan Carvajal-Quintero[1,2] | Gala Mona Louise Dädlow[1,2] | Alban Sagouis[1,4] | Marten Winter[1,2]

Programme of this lecture

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- What is taxonomy? (Taxonomy 101)

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- What is “taxonomic harmonization”?

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- What is needed to perform taxonomic harmonization?

Programme of this lecture

- What is taxonomy? (Taxonomy 101)
- What is “taxonomic harmonization”?
- What is needed to perform taxonomic harmonization?
- How to perform taxonomic harmonization in practice?

What is Taxonomy?

QUESTION
Who has a formal training in taxonomy?

"Hepaticae–Lebermoose" (1904) by Ernst Haeckel. Original from Library of Congress. Digitally enhanced by rawpixel." CC-BY 2.0.

Taxonomy is the basis of all ecology

"Hepaticae–Lebermoose" (1904) by Ernst Haeckel. Original from Library of Congress. Digitally enhanced by rawpixel." CC-BY 2.0.

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Taxonomy is the basis of all ecology

Need to name things

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Historically taxonomy came before

Why should I care about taxonomy?

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How many species of giraffe are there?

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Implications
for conservation programmes

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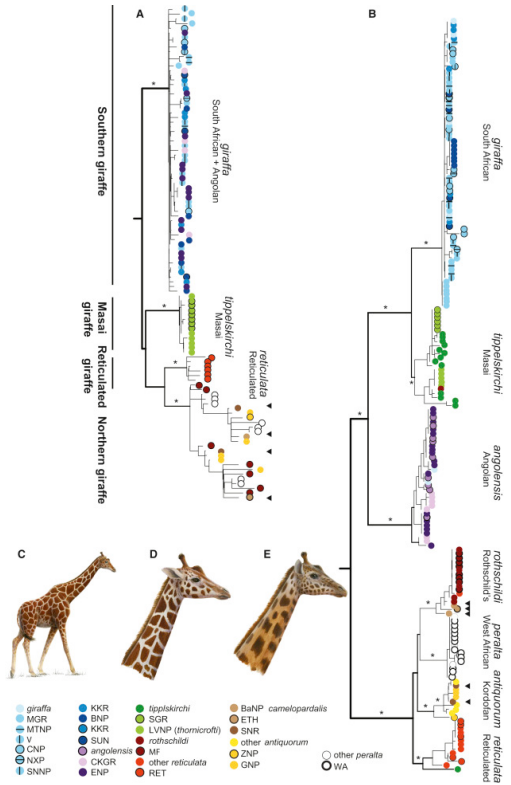

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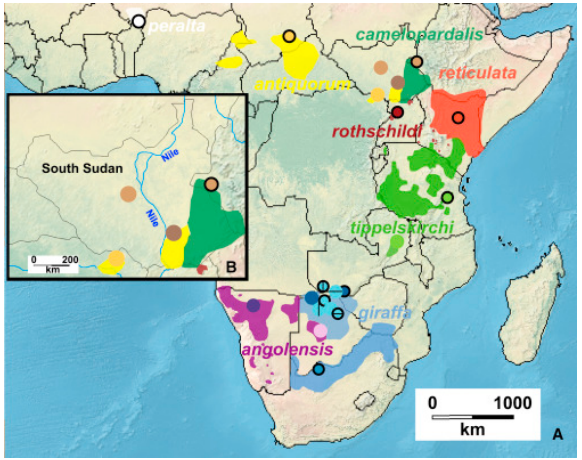

Fennessy et al. 2016 Current Biology

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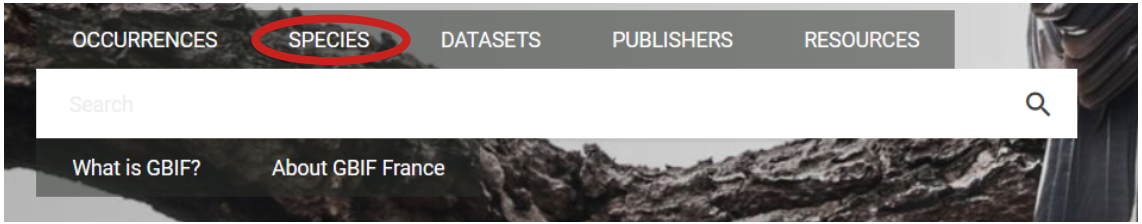
Global Biodiversity Information Facility (GBIF) – Occurrence data



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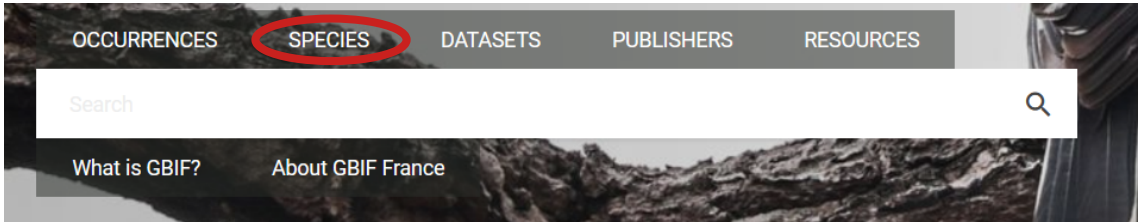

TRY Database – Plant Functional Trait

Recommended way to get data from TRY

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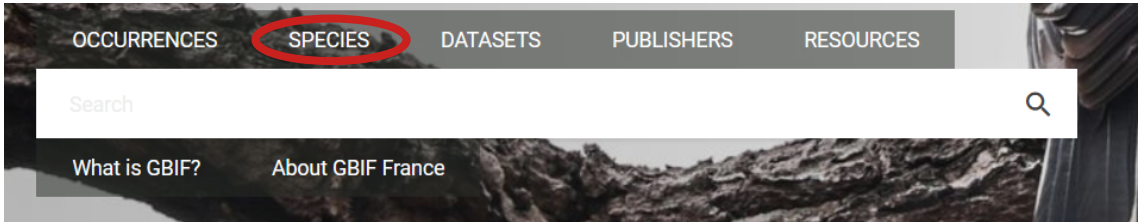

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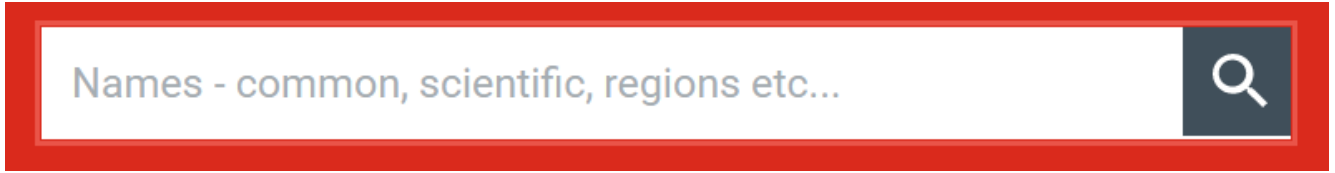
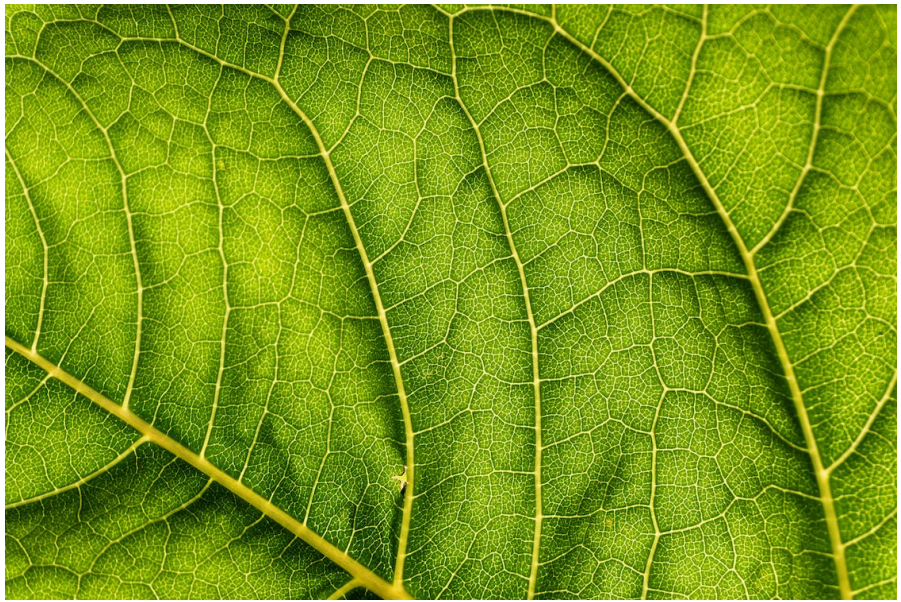
IUCN RedList – Threat Status



Taxonomy 101: how does it work?



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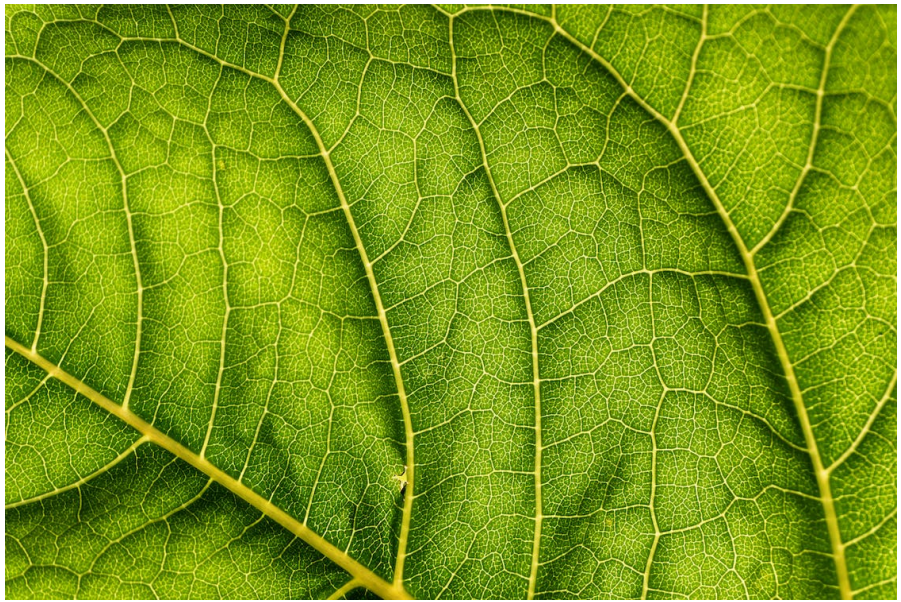

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Multiple Approaches
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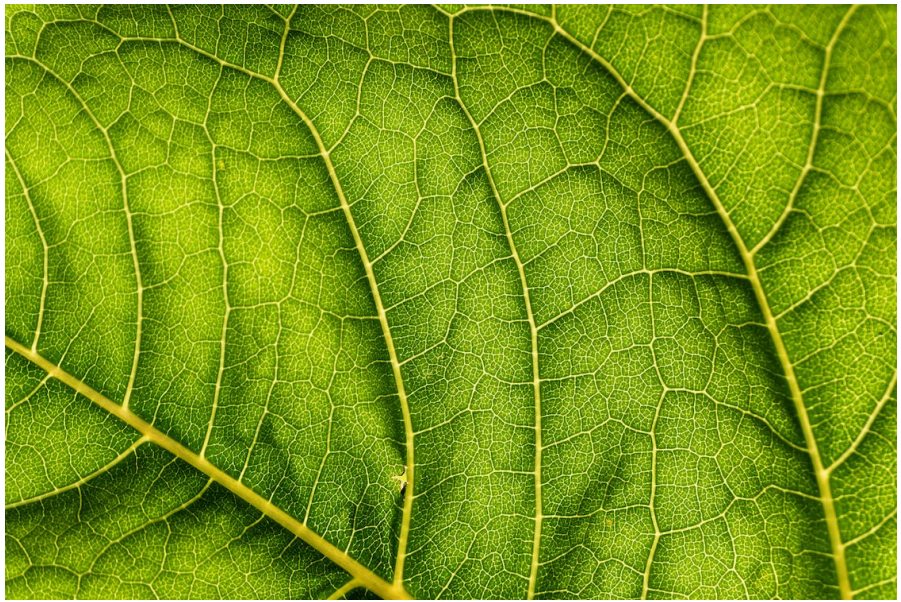

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Establish
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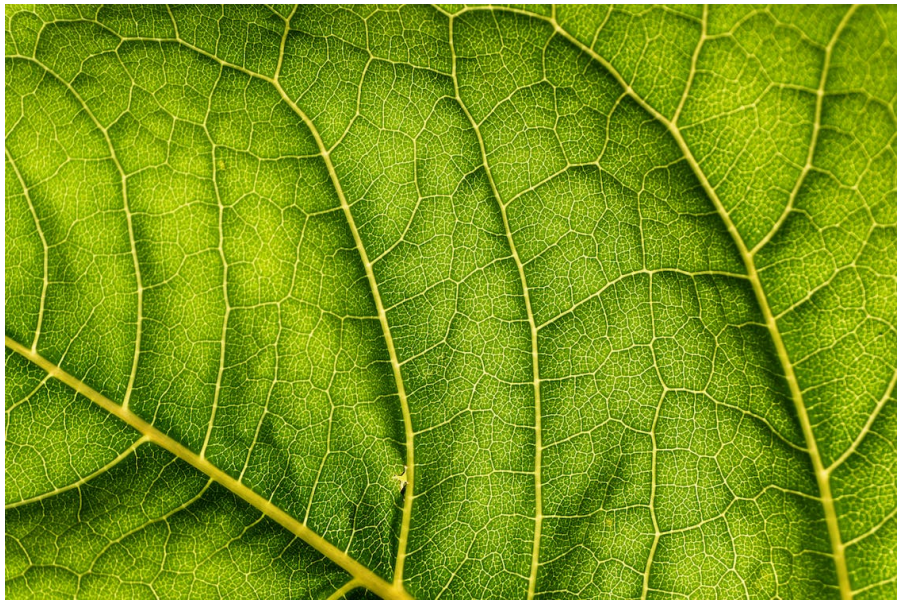

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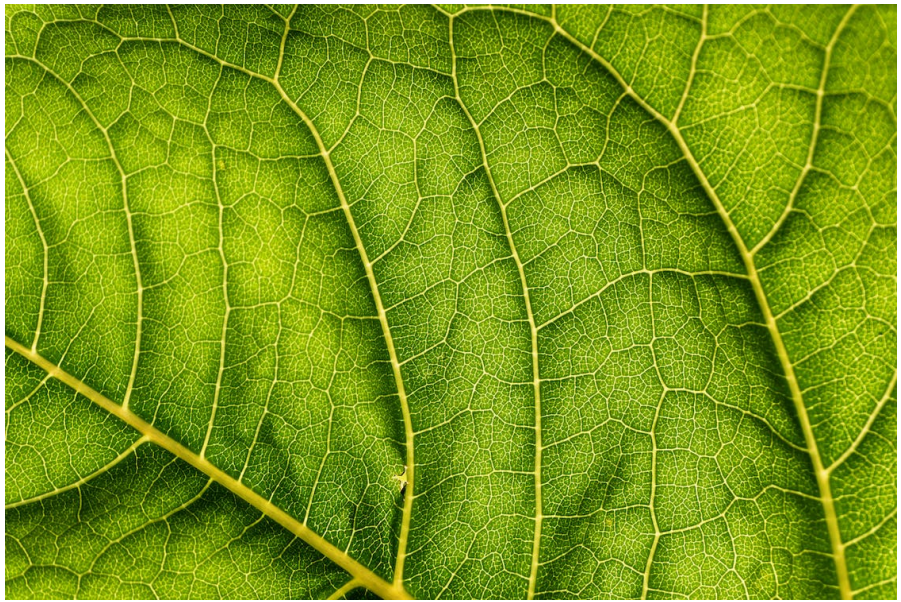

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Discussion and
Consensus Building

Aggregating taxonomic knowledge

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Taxonomic Information is **scattered**

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Need to assemble them

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Taxonomic Databases

Catalogue of Life

WoRMS
World Register of Marine Species

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Taxonomic Databases

Catalogue of Life

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Provide Up-to-date taxonomy

Rely on individual or community curation

Summary of this part

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- **Taxonomy** is at the **basis** of ecology and biodiversity sciences

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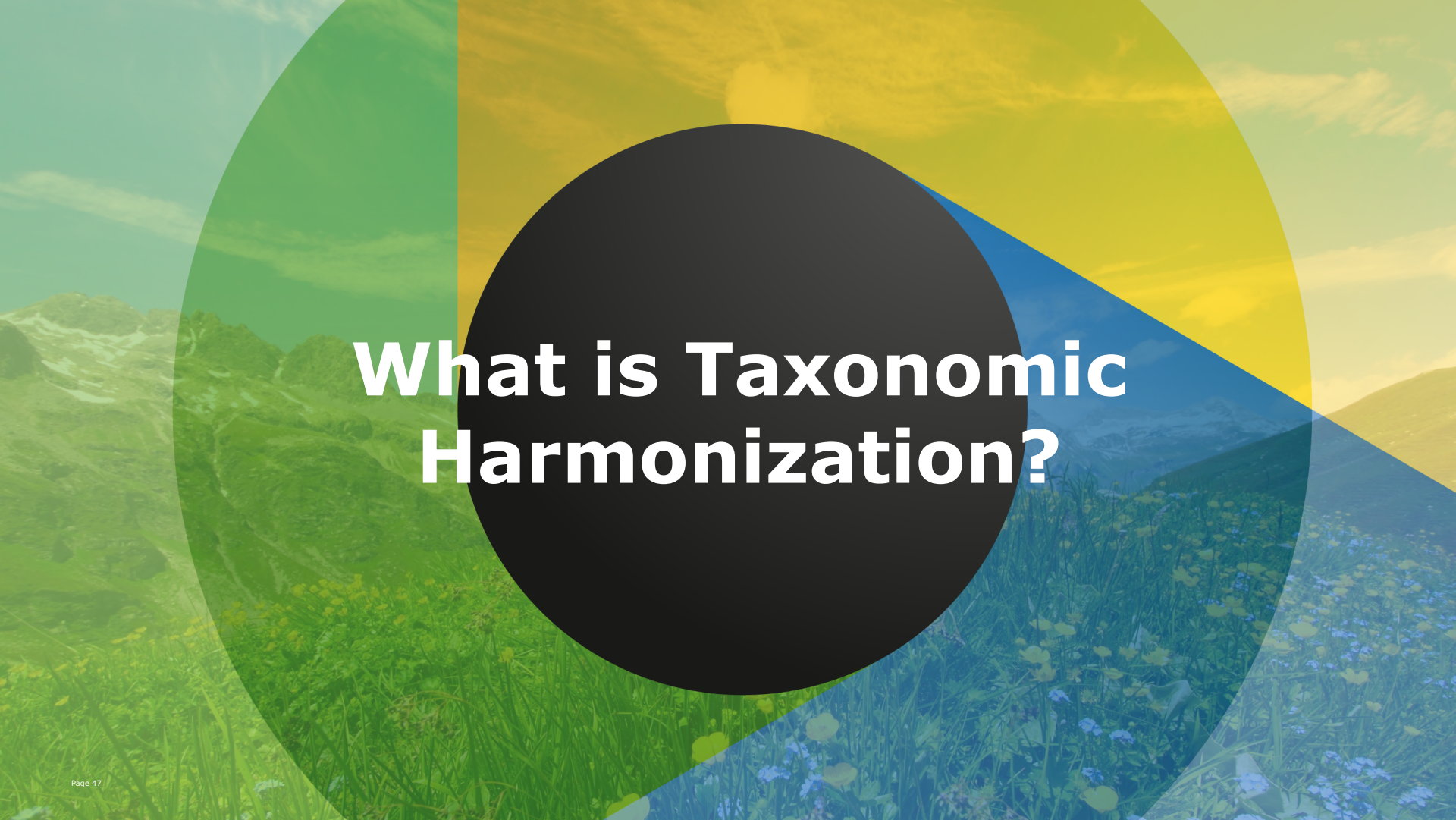
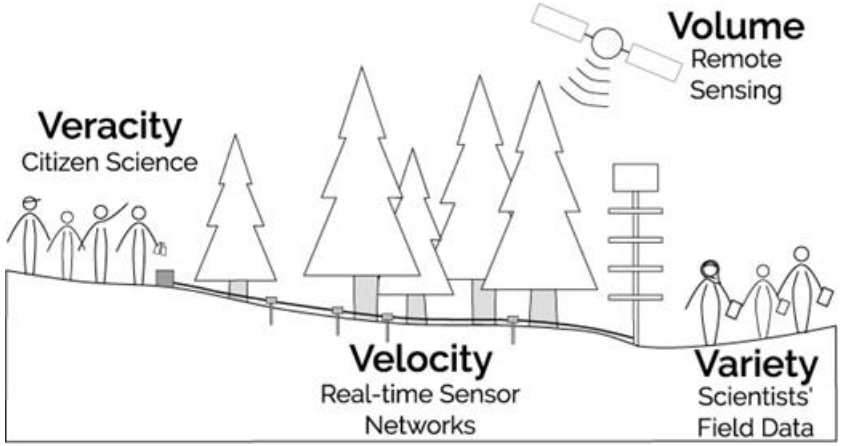
- Its main goal is to **discover** and **distinguish** the different **species**
- **Taxonomic information** (papers) is aggregated into **databases**
- These databases are called **Taxonomic Reference Databases**
- They provide **updated taxonomic backbones** for other data



What is Taxonomic Harmonization?

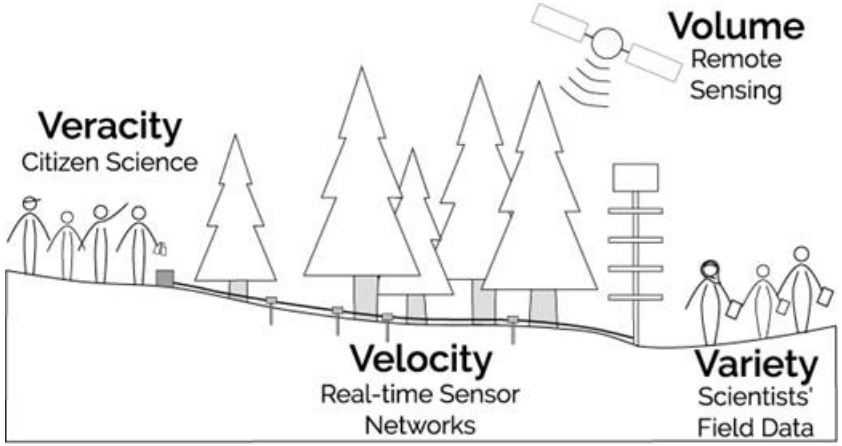
Increasing data size of Ecology



Farley et al. 2018 *BioScience*

Increasing data size of Ecology

Data are getting larger



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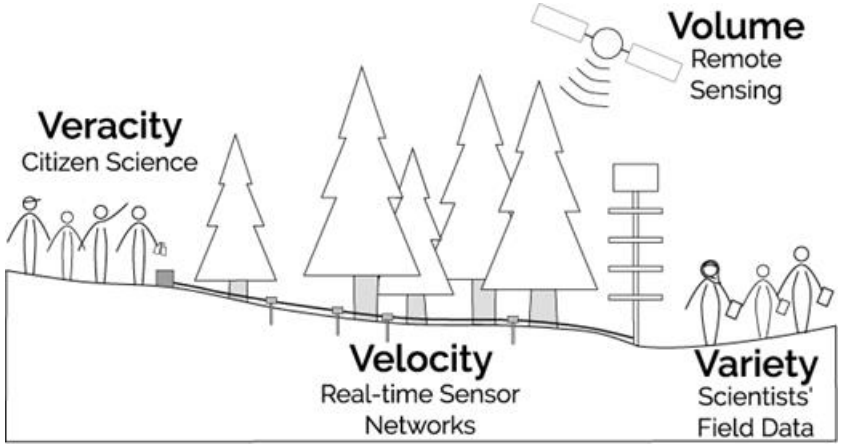

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Some aspects of “big data”

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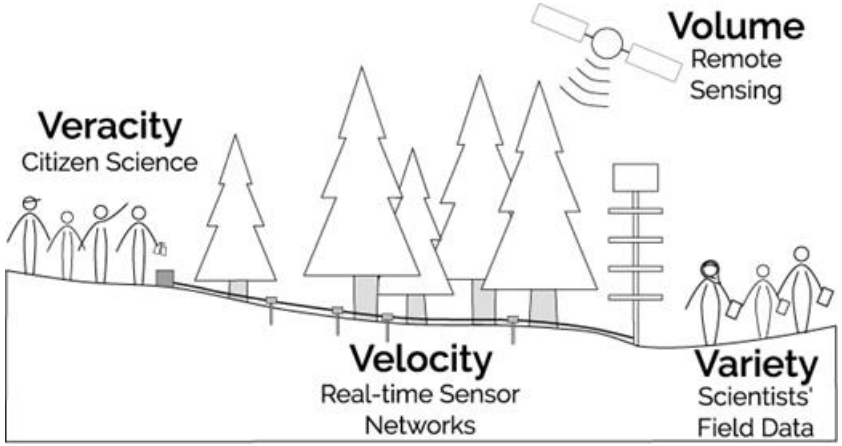

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Some aspects of “big data”

Larger number of species measured

All data indexed by species name!

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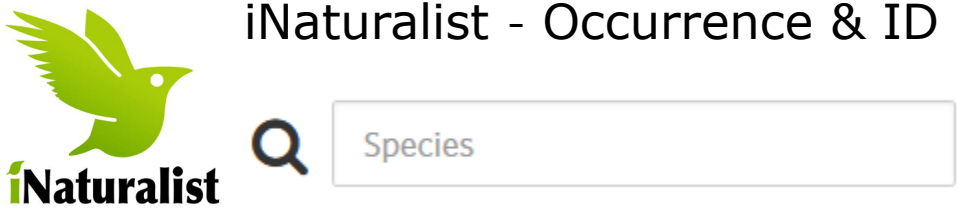

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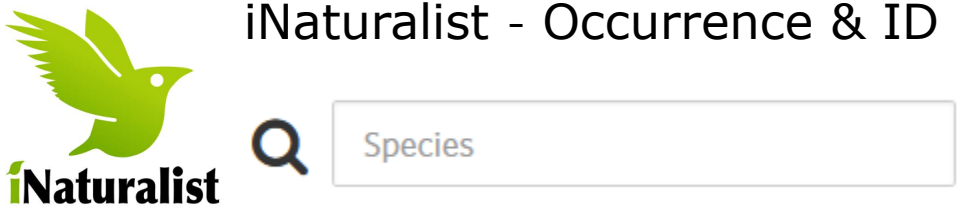
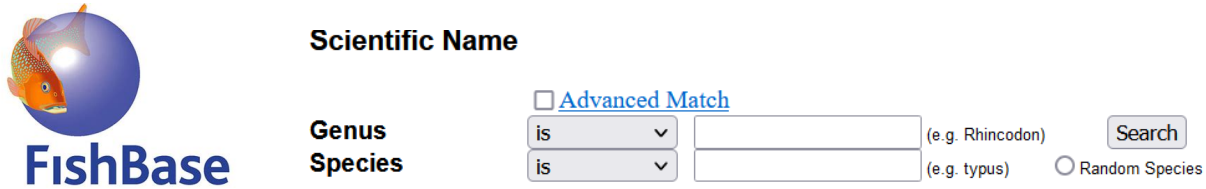
iNaturalist - Occurrence & ID



FishBase - Occurrence & Traits & Pictures & ...



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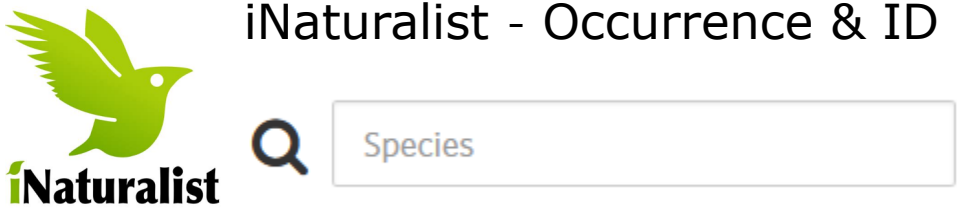

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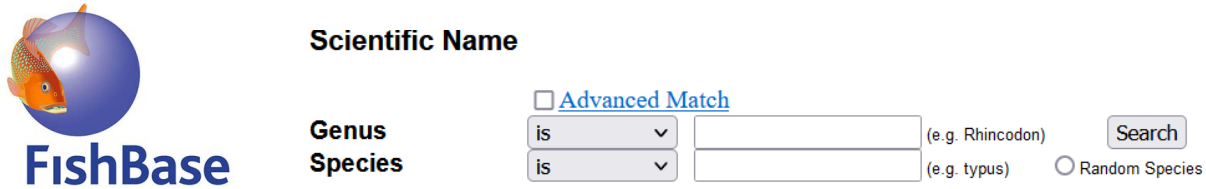

AlgaeBase - Distribution & Pictures & Taxonomy

The process of taxonomic harmonization

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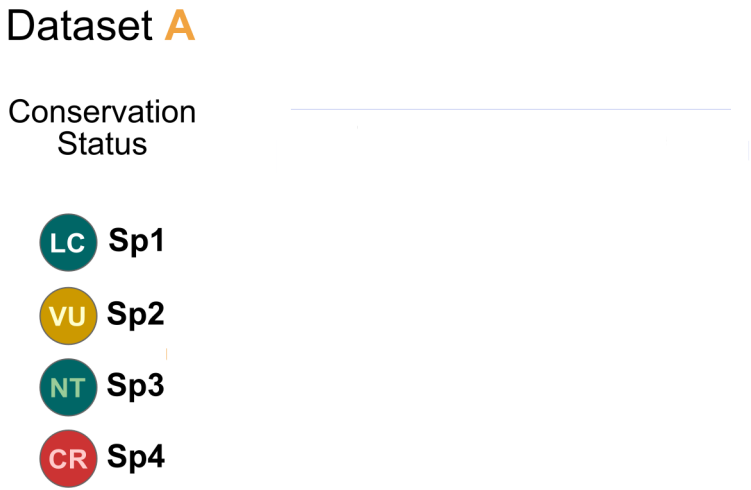

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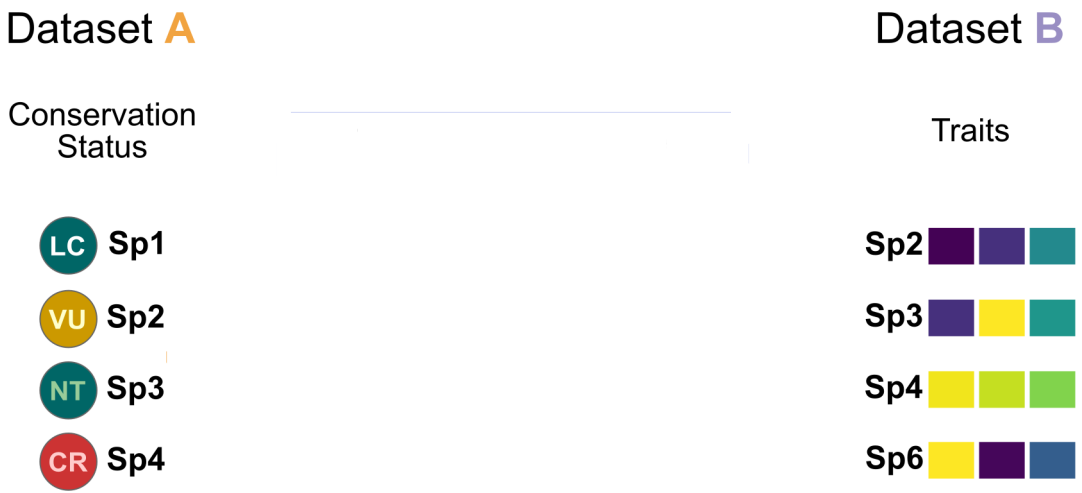

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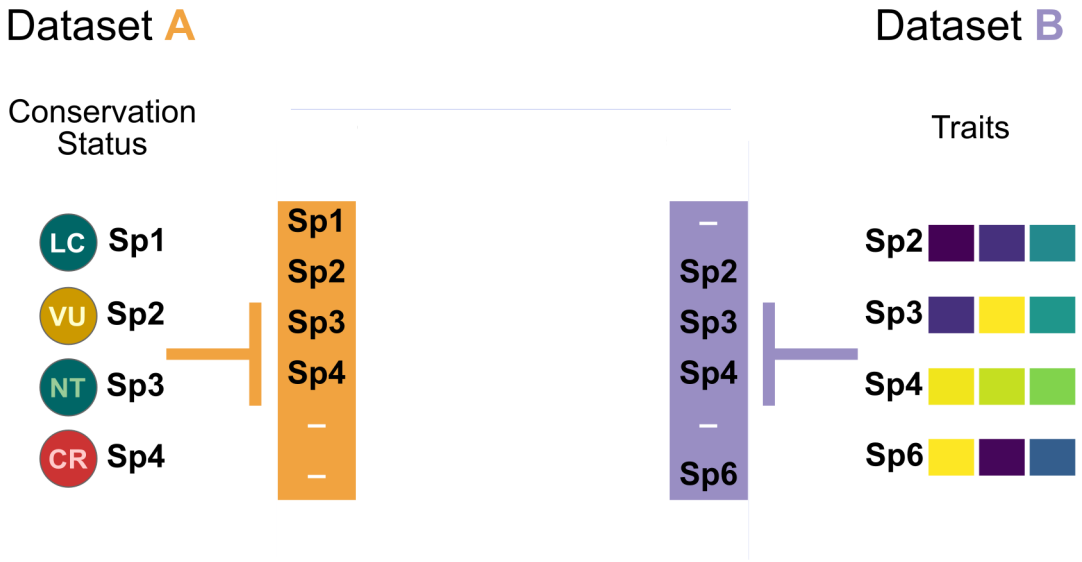

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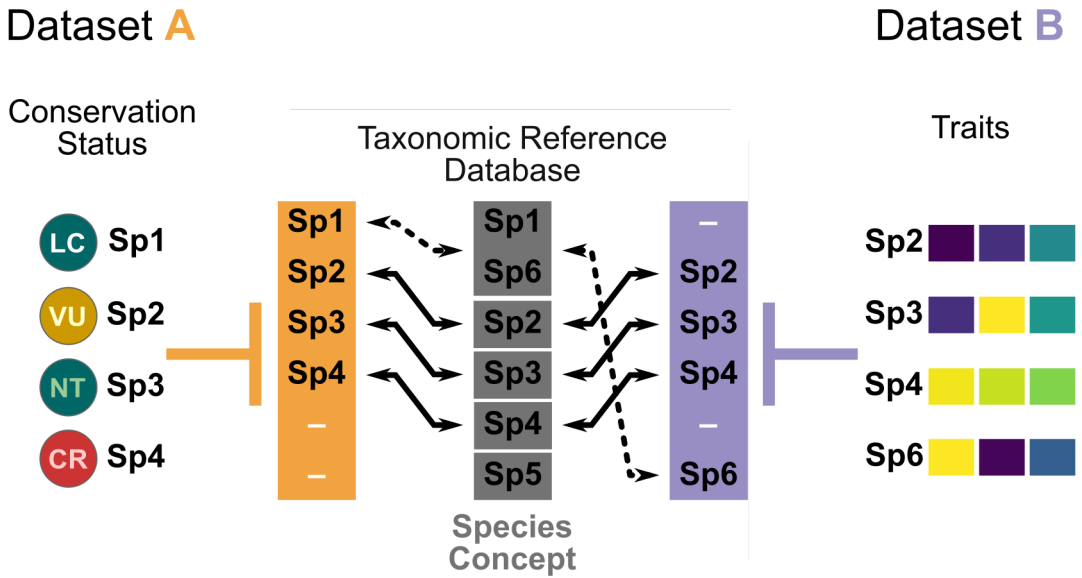

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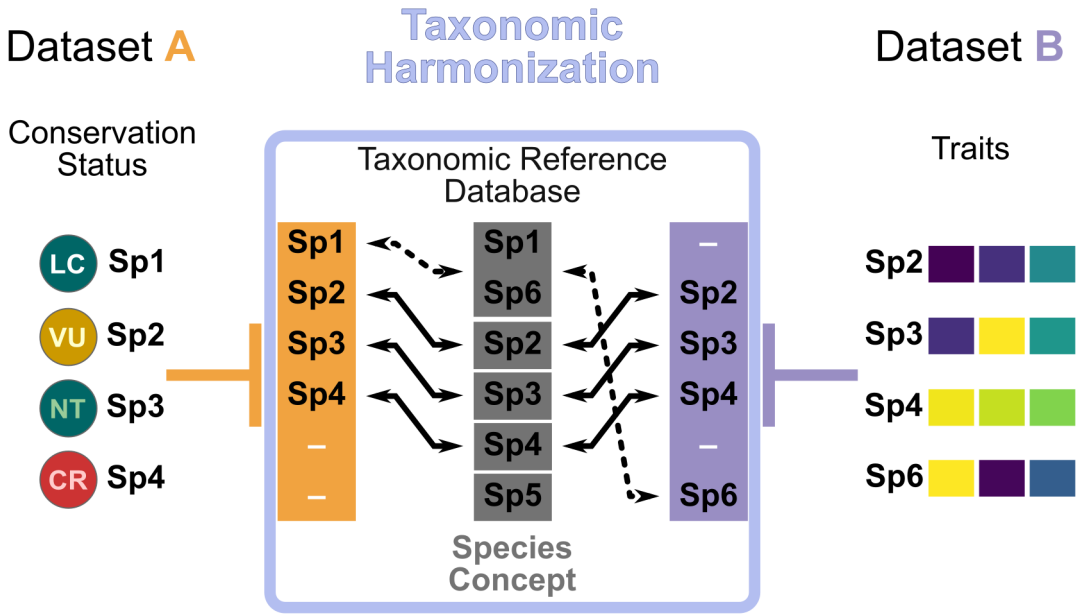

A concrete example: Bird Extinction Risk vs. Biomass

From Norman et al. 2020

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Conservation Status
(IUCN)

Biomass
(EltonTraits)

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Pipile cumanensis
Pipile cujubi
Pipile jacutinga
Megapodius decollatus
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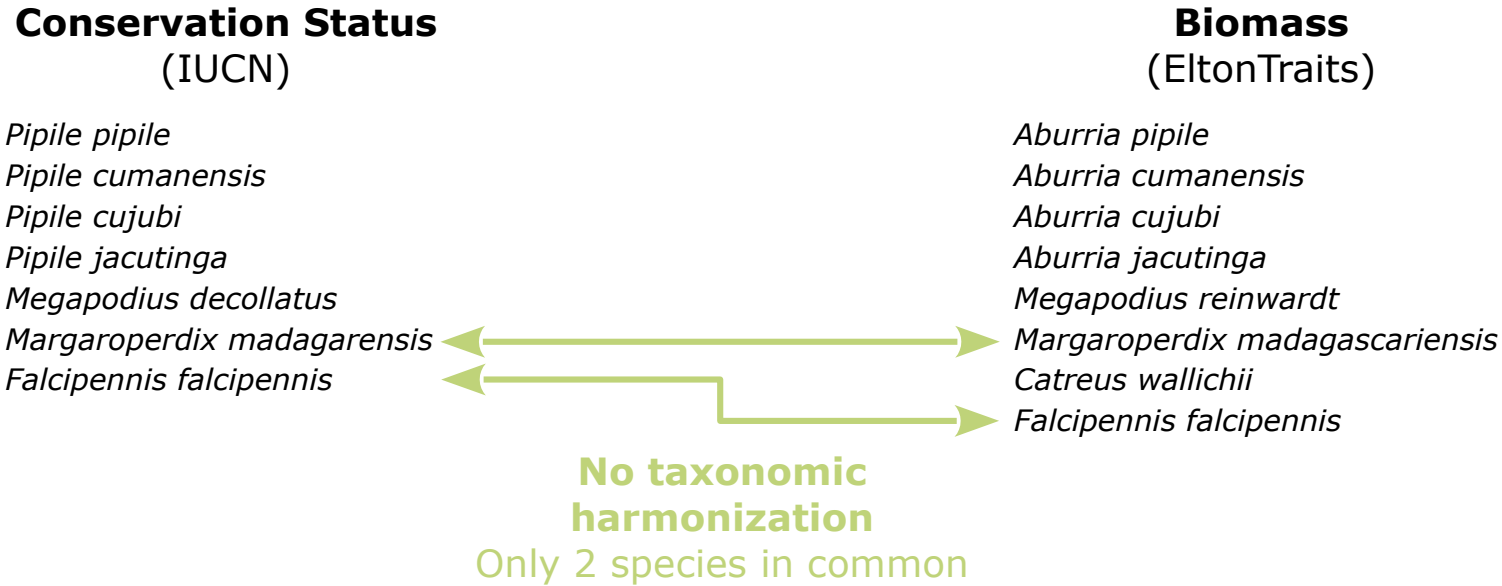

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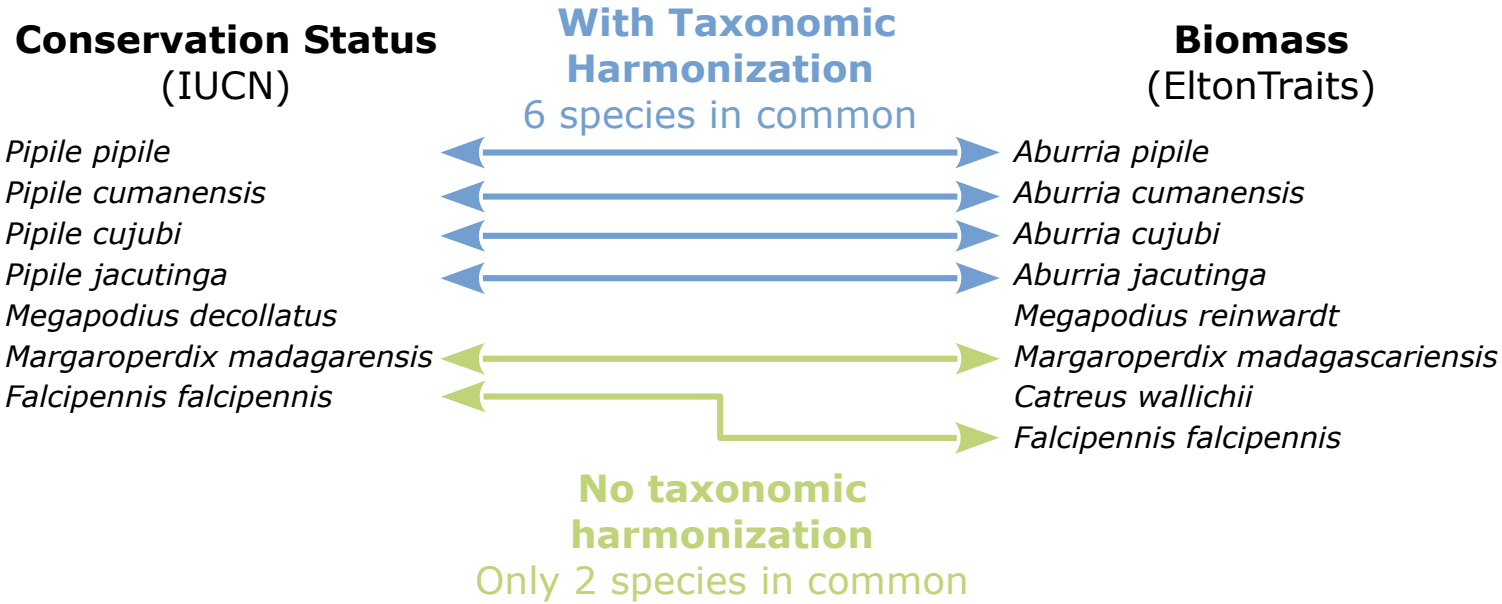
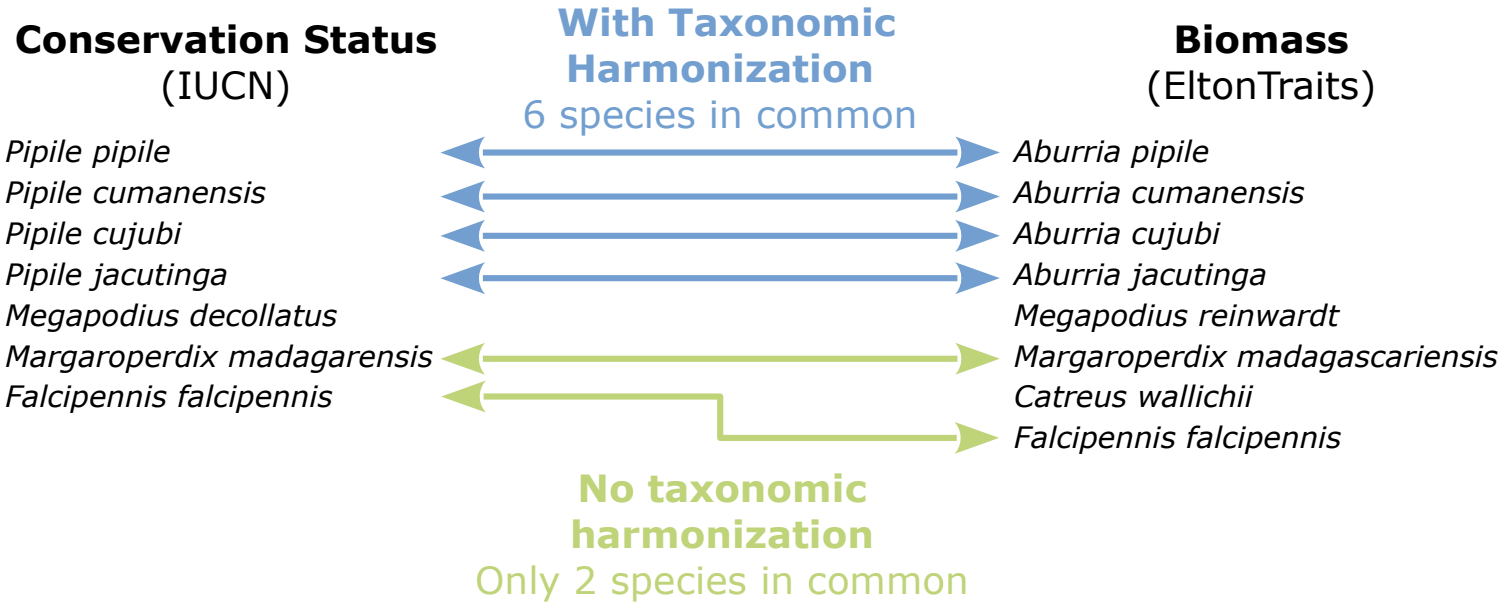


A concrete example: Bird Extinction Risk vs. Biomass

From Norman et al. 2020



Taxonomic harmonization make **datasets comparable**

QUESTION
Were you already aware of this issue?

What should you care?

"Insect drawer Natural History Museum Rose Stainthorp 2010"
by NHM Beetles and Bugs CC-BY 2.0.

What should you care?

Taxonomic Harmonization increases matched names

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The taxonomy could have been updated between datasets

Use the last up-to-date taxonomy for your analyses

"Insect drawer Natural History Museum Rose Stainthorp 2010" by NHM Beetles and Bugs CC-BY 2.0.

Summary of this part

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- **Taxonomic Harmonization** is the matching of species names against species reference databases
- Taxonomic Harmonization is **necessary** with the **increasing size** of datasets in ecology (manual harmonization is too hard)
- With taxonomic harmonization we can resolve **given species names** into updated ones and take care of **synonyms**

What is needed to perform Taxonomic Harmonization?

The sources: Taxonomic Reference Databases

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Taxonomic Reference Database
(also taxonomic backbone, taxonomic checklist, taxonomic authority, etc.)

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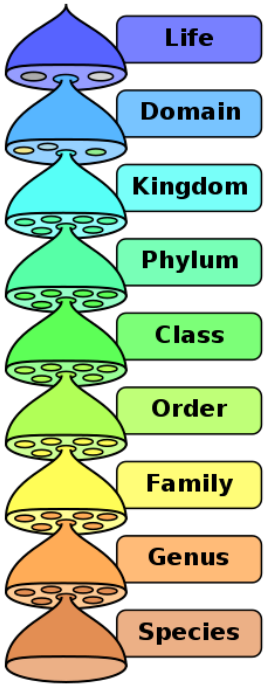
"Centralized repository of nomenclatural information"



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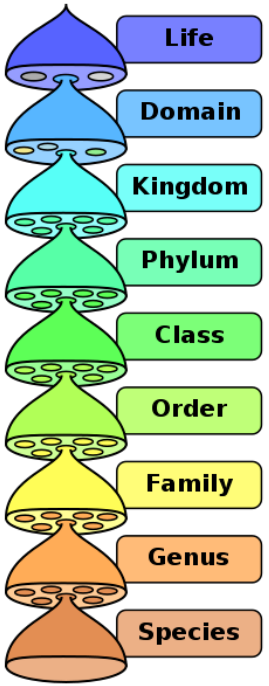
"Centralized repository of nomenclatural information"

+Spelling Correction **+Synonymy Resolution**



Examples of Taxonomic Reference Databases

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Backbone
GBIF (2021)

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No taxonomic restriction

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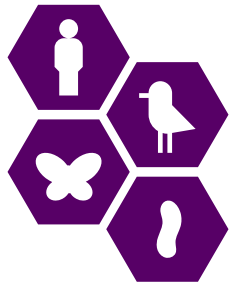

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June 2021
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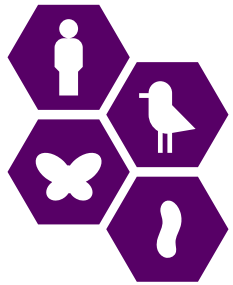

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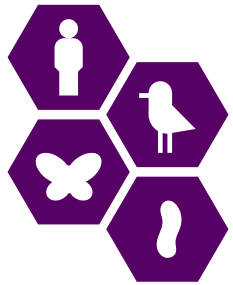

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Global

Vascular Plants

Nov. 2020
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850k synonyms

QUESTION
What taxonomic reference database do you know for your group of interest?
(Microbes excepted)

Database typology: Spatial Scale vs. Taxonomic Breadth

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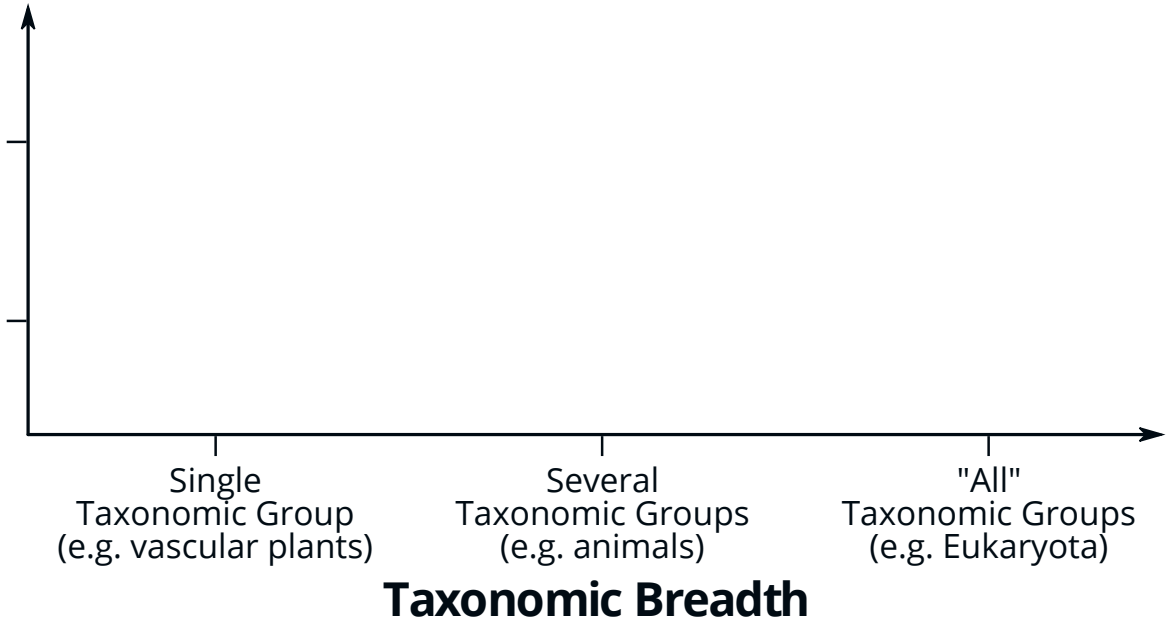

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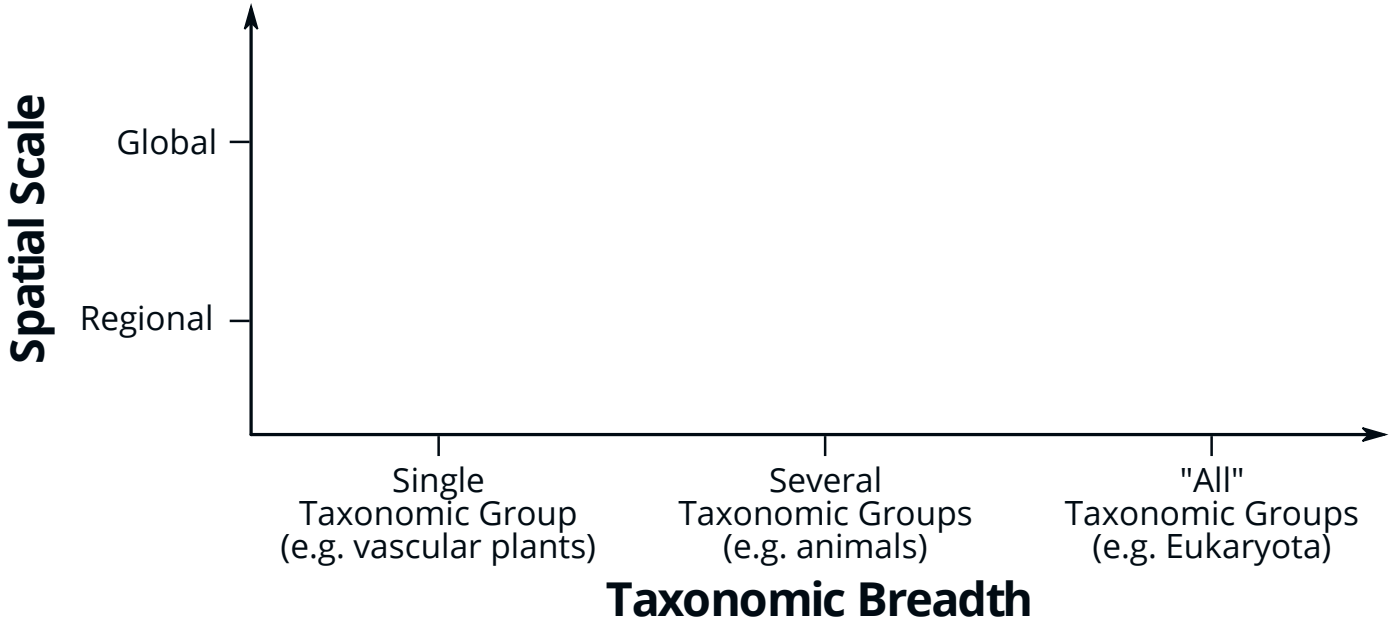

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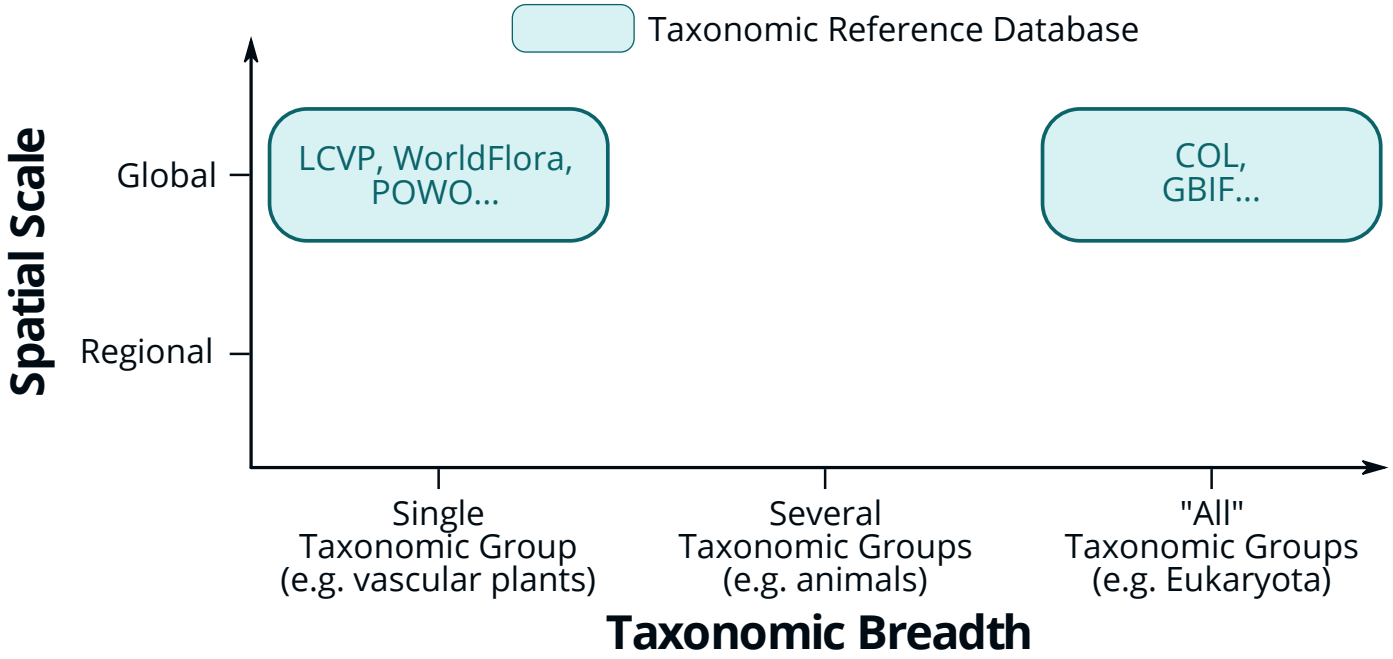

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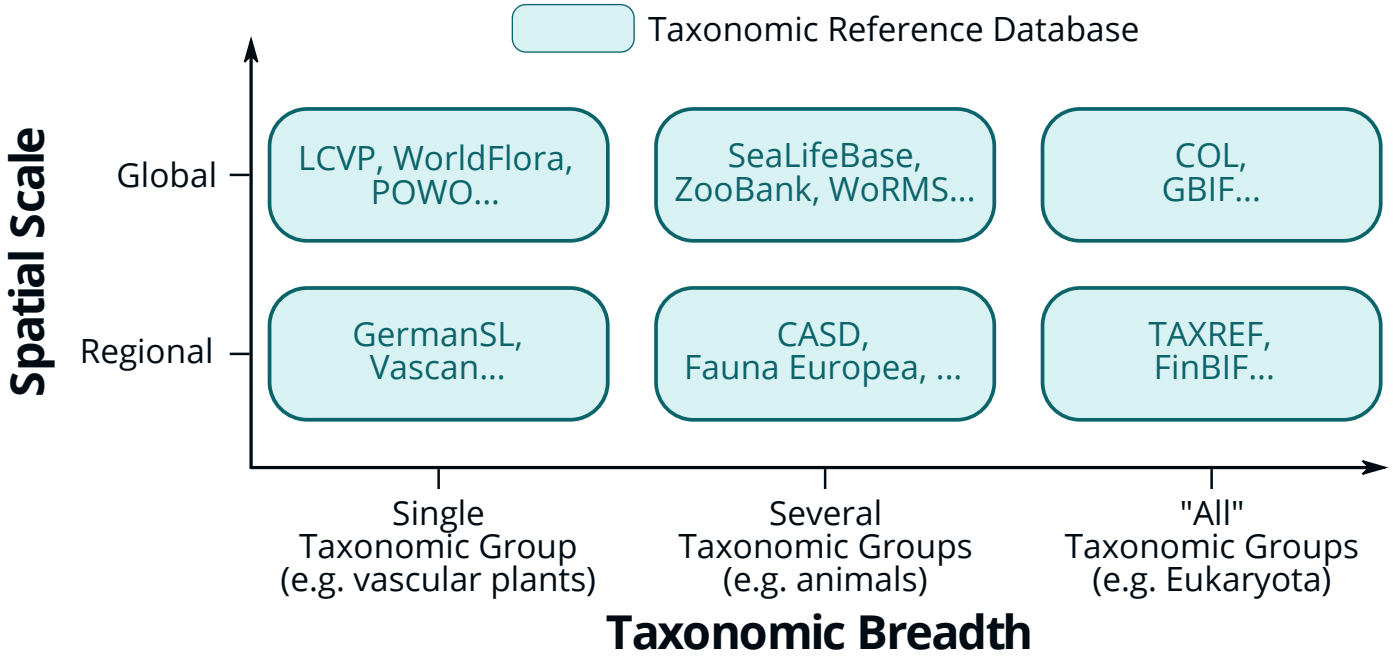

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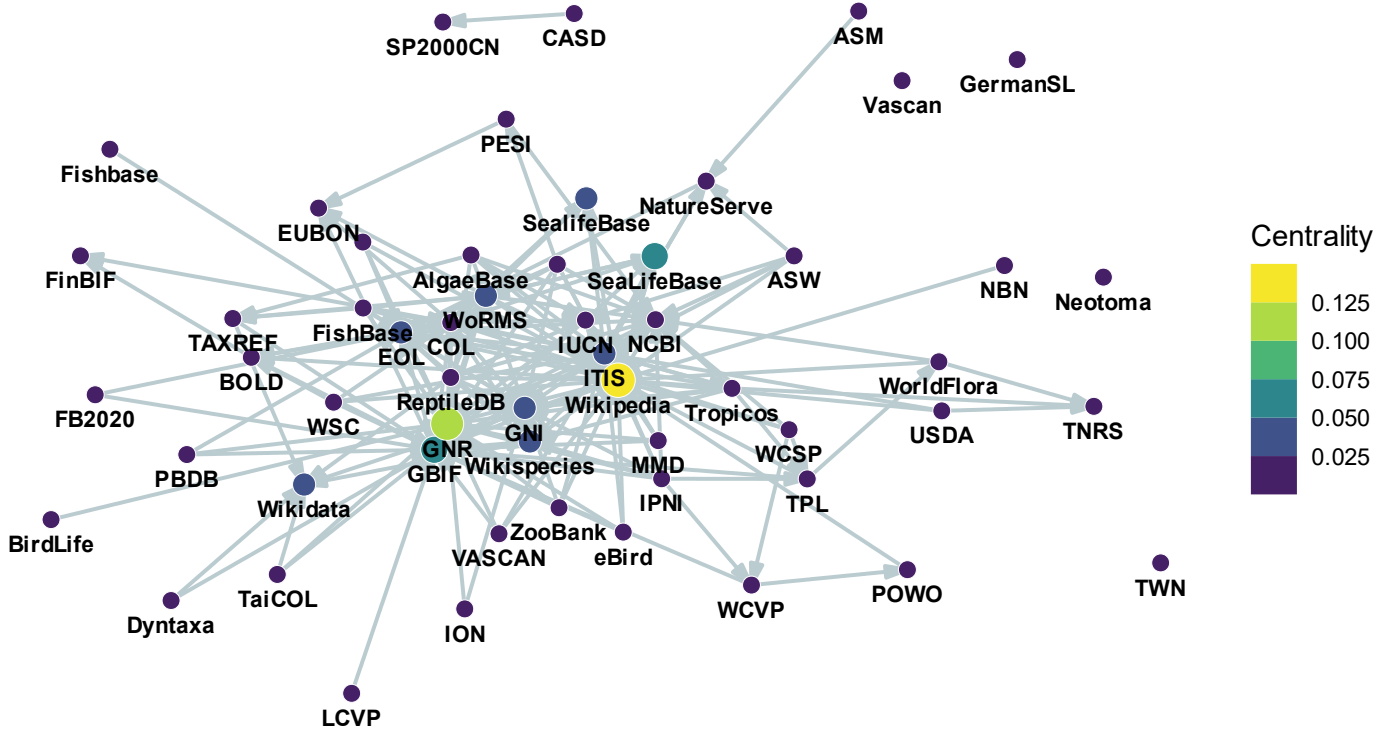
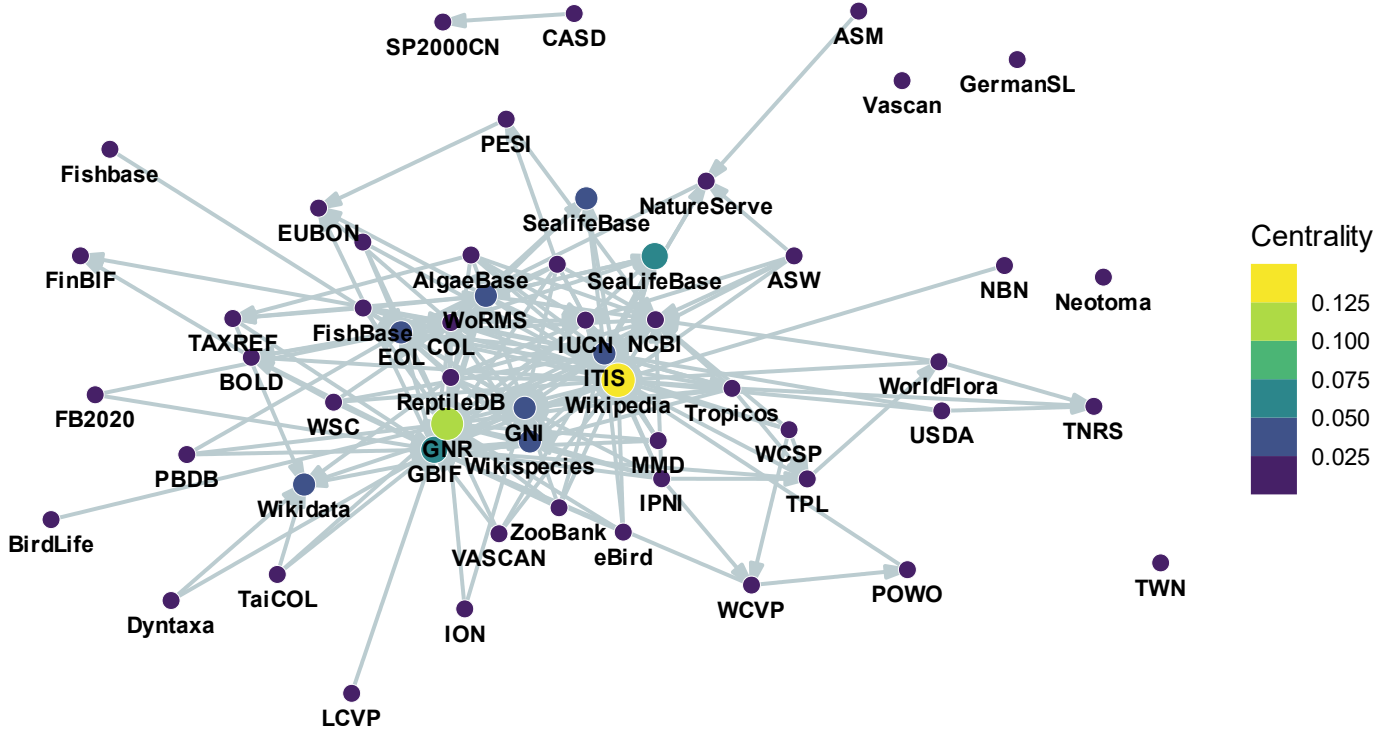


Beware of connections across databases

Relationships
Source → Target



Beware of connections across databases

Relationships
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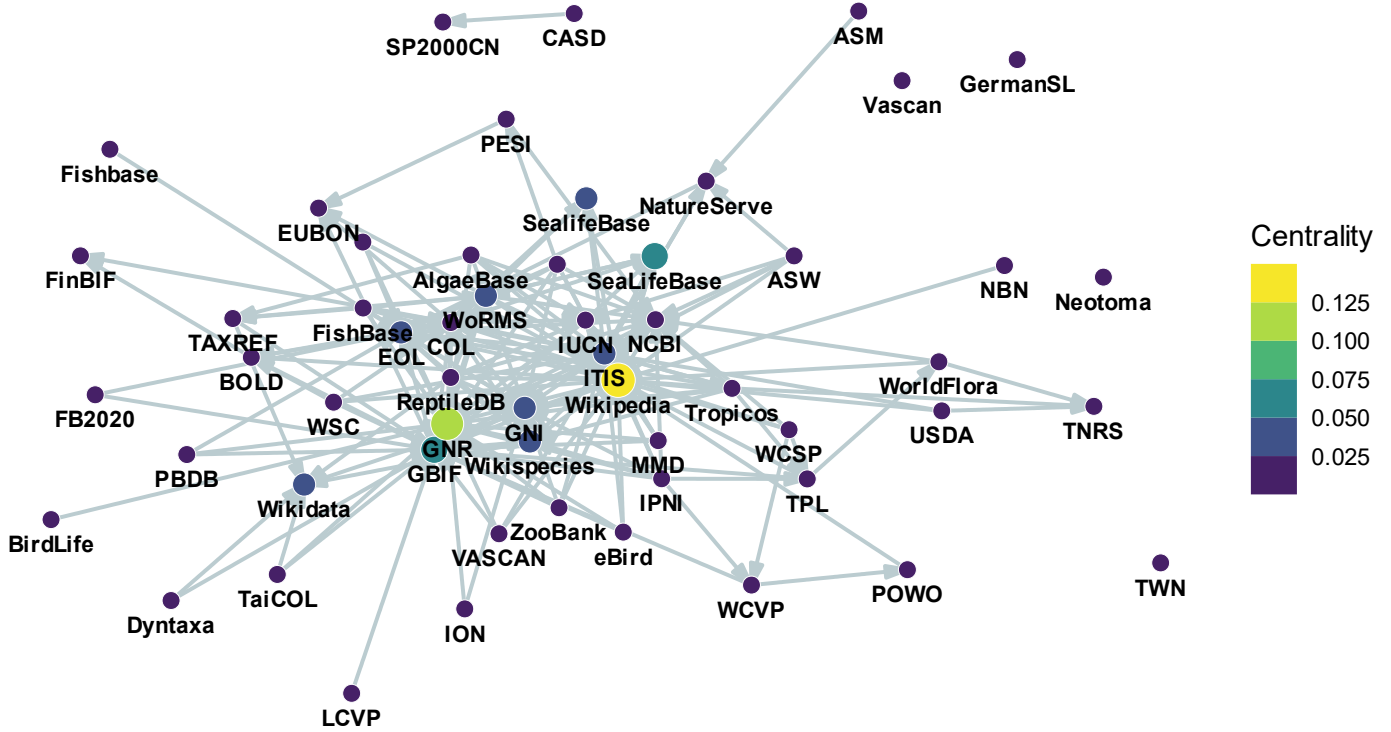
Specific databases
widely reused



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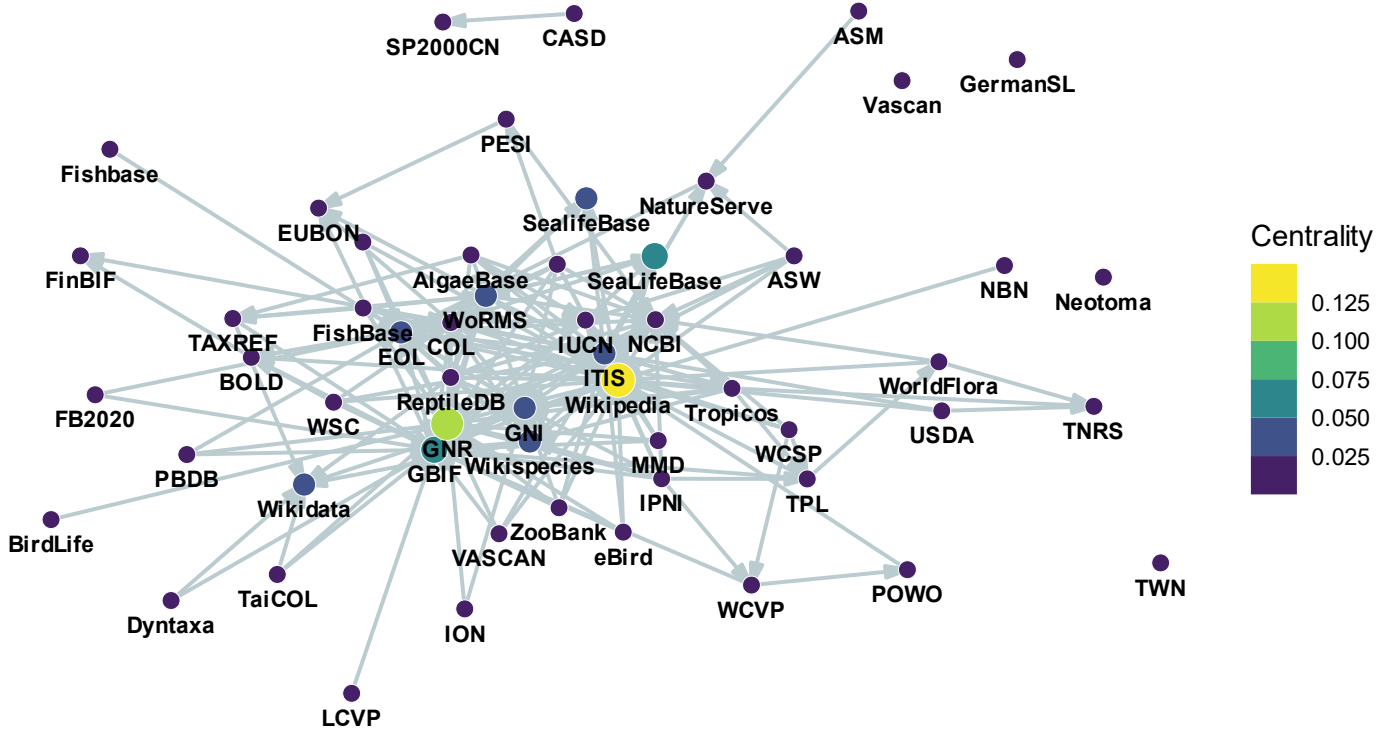
Some "mega-" aggregator databases



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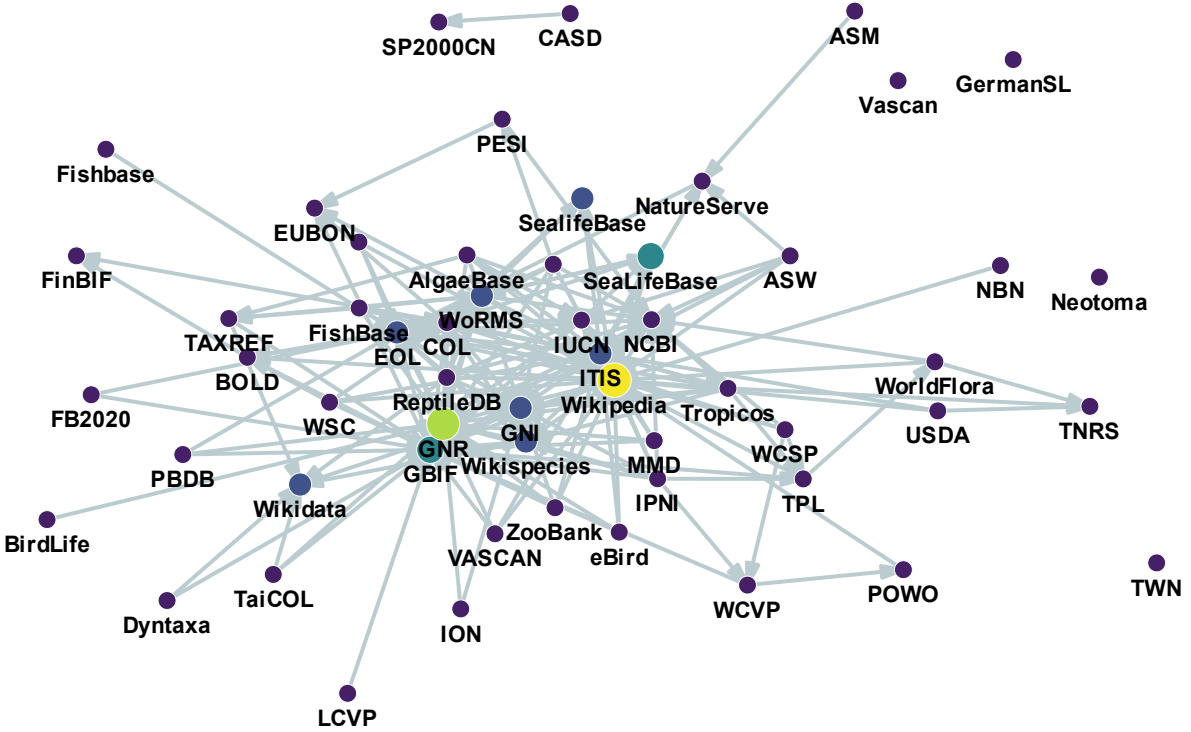

N.B.: This information is **very difficult to gather**
(not even talking quantitatively)

Then we need the tools: R packages

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Review of packages on CRAN + GitHub + Bioconductor

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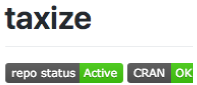
Identified **68 packages** of which **59** were **included**



Packages for different purposes

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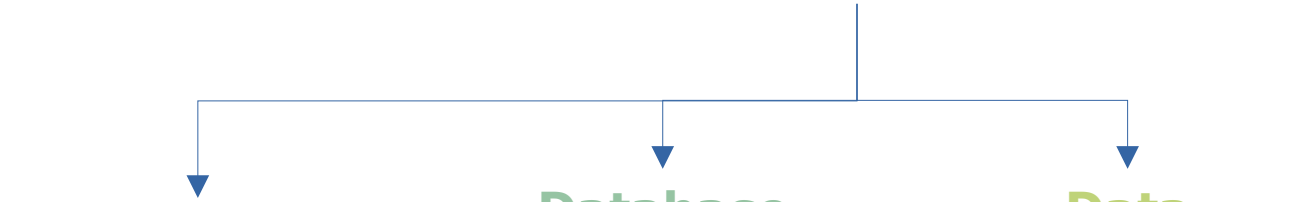

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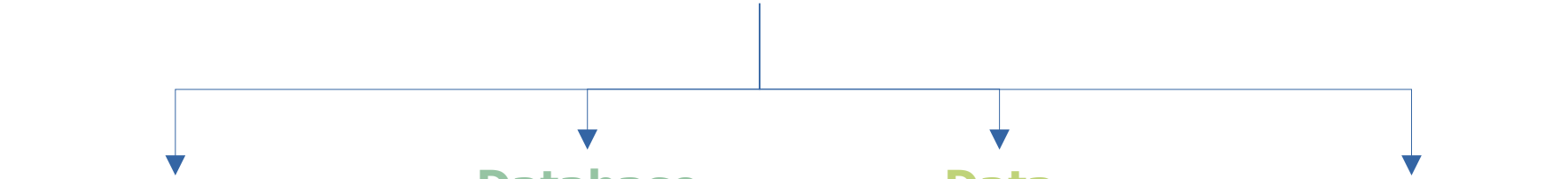

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11 pkgs

rgnparser parses names into components

Visualization

2 pkgs

metacoder displays taxonomy

The Package Dependency Network

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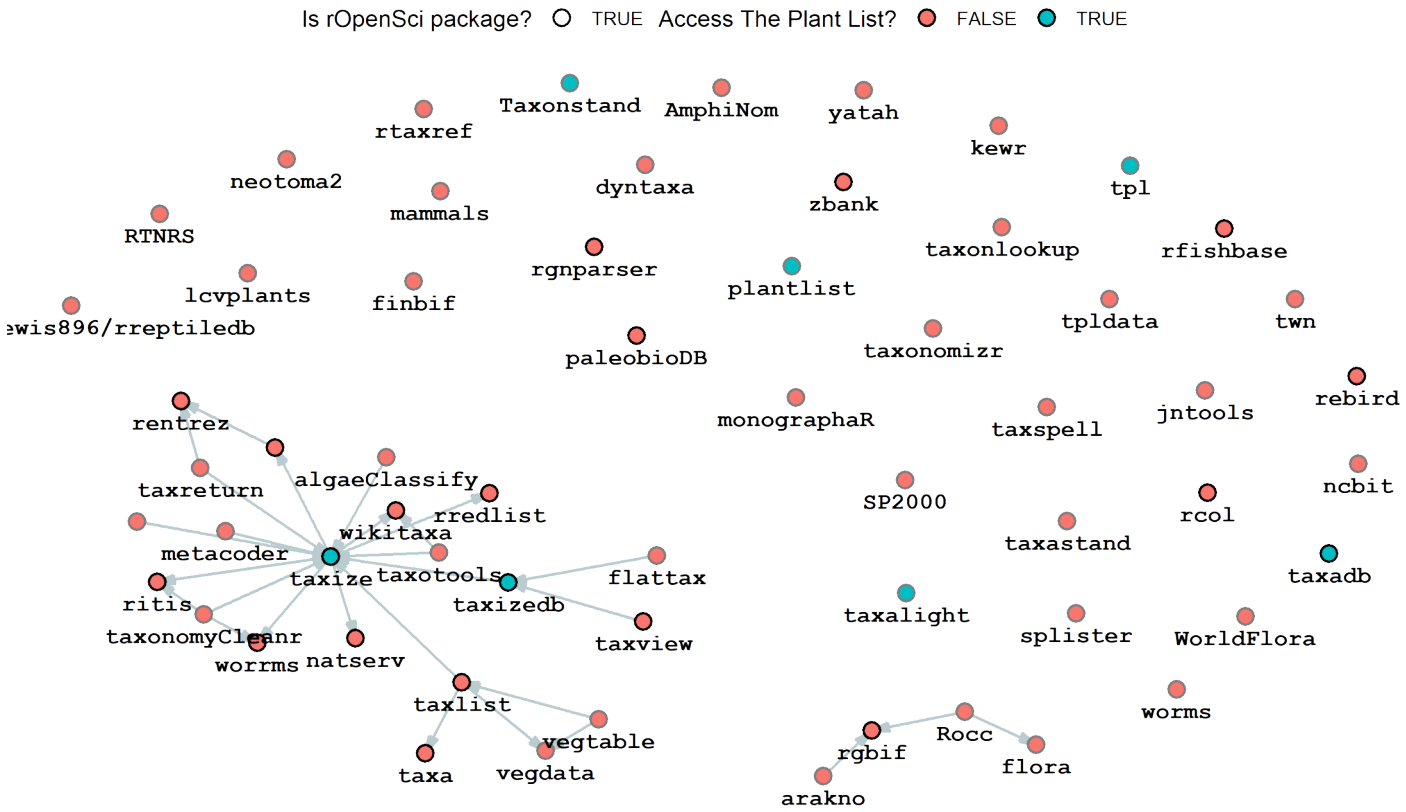
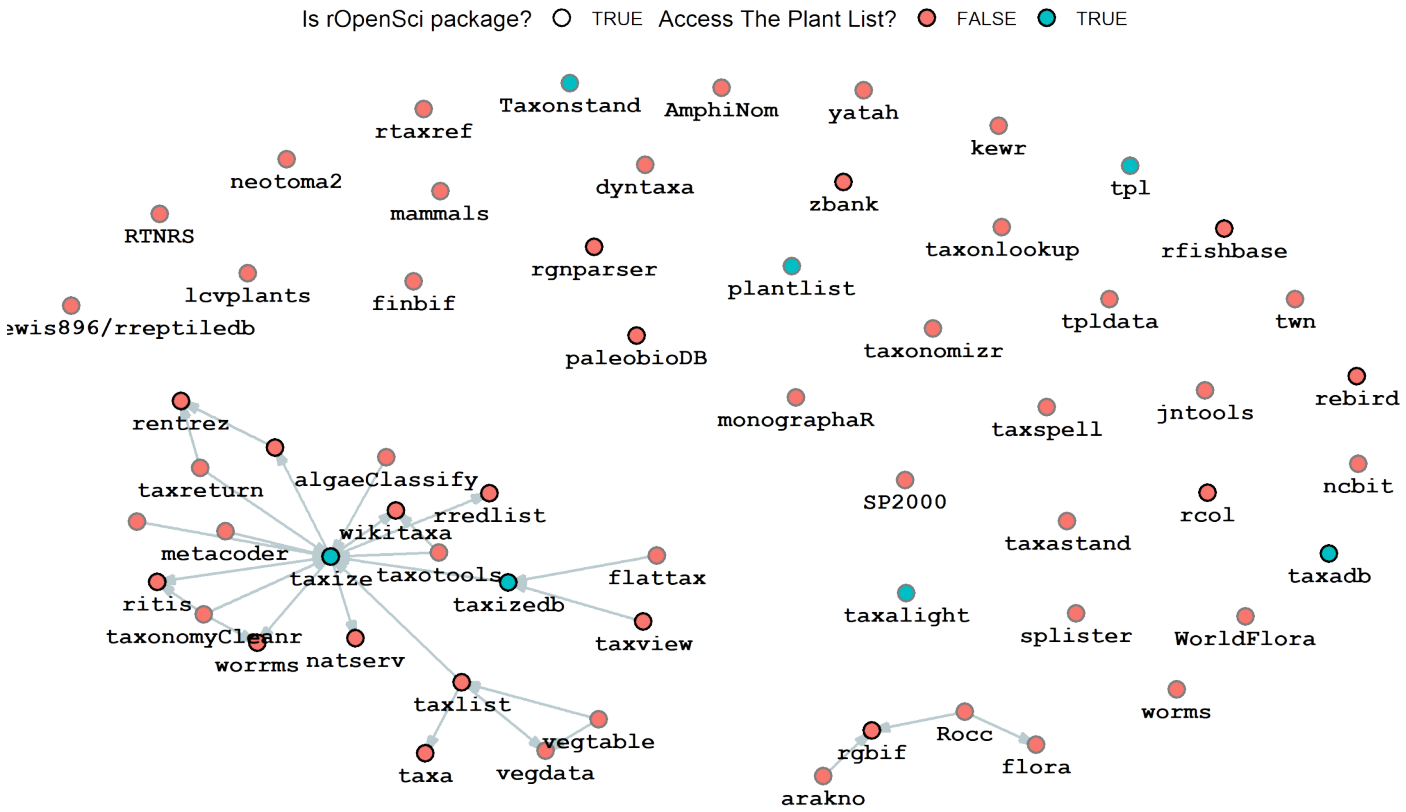


The Package Dependency Network

Disconnected network



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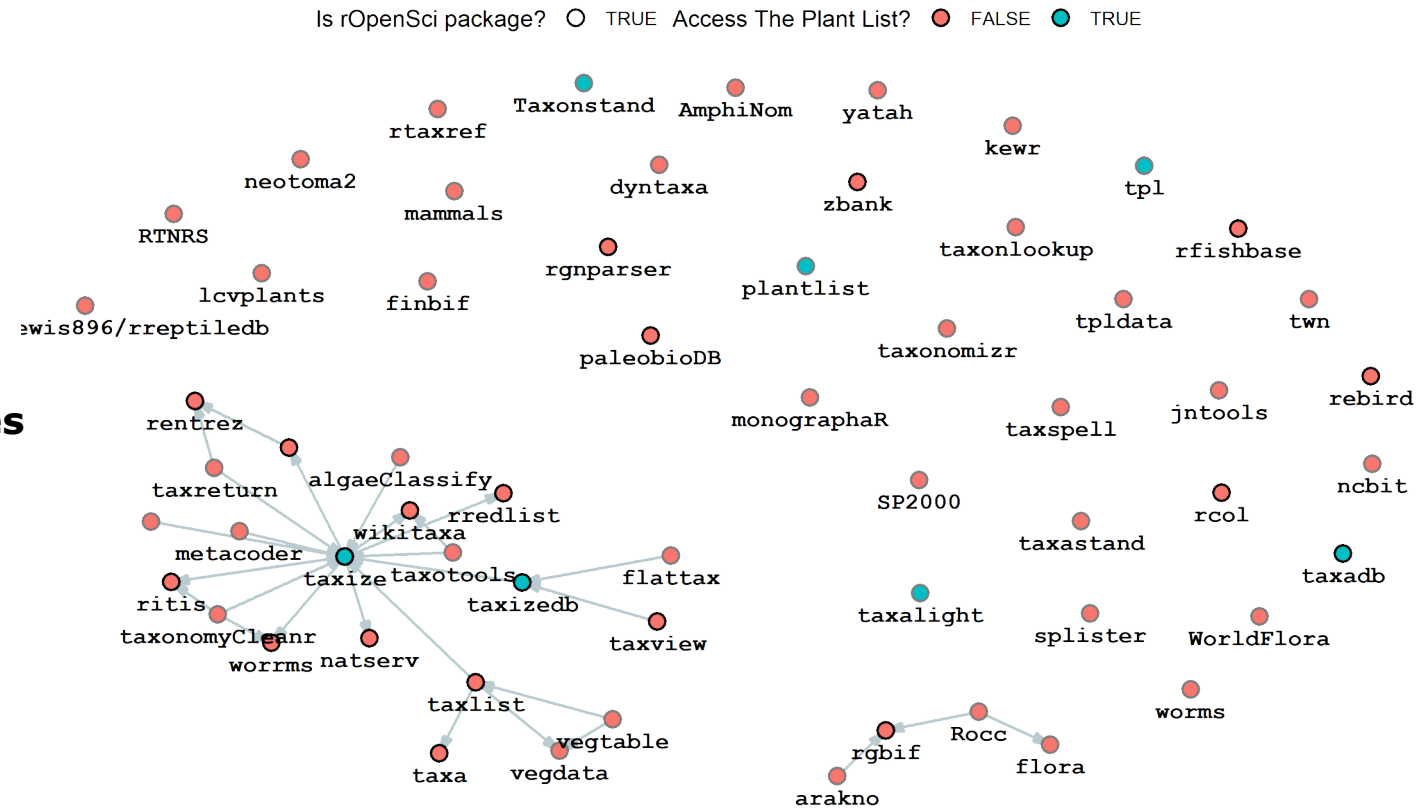
Apart from **rOpenSci packages**

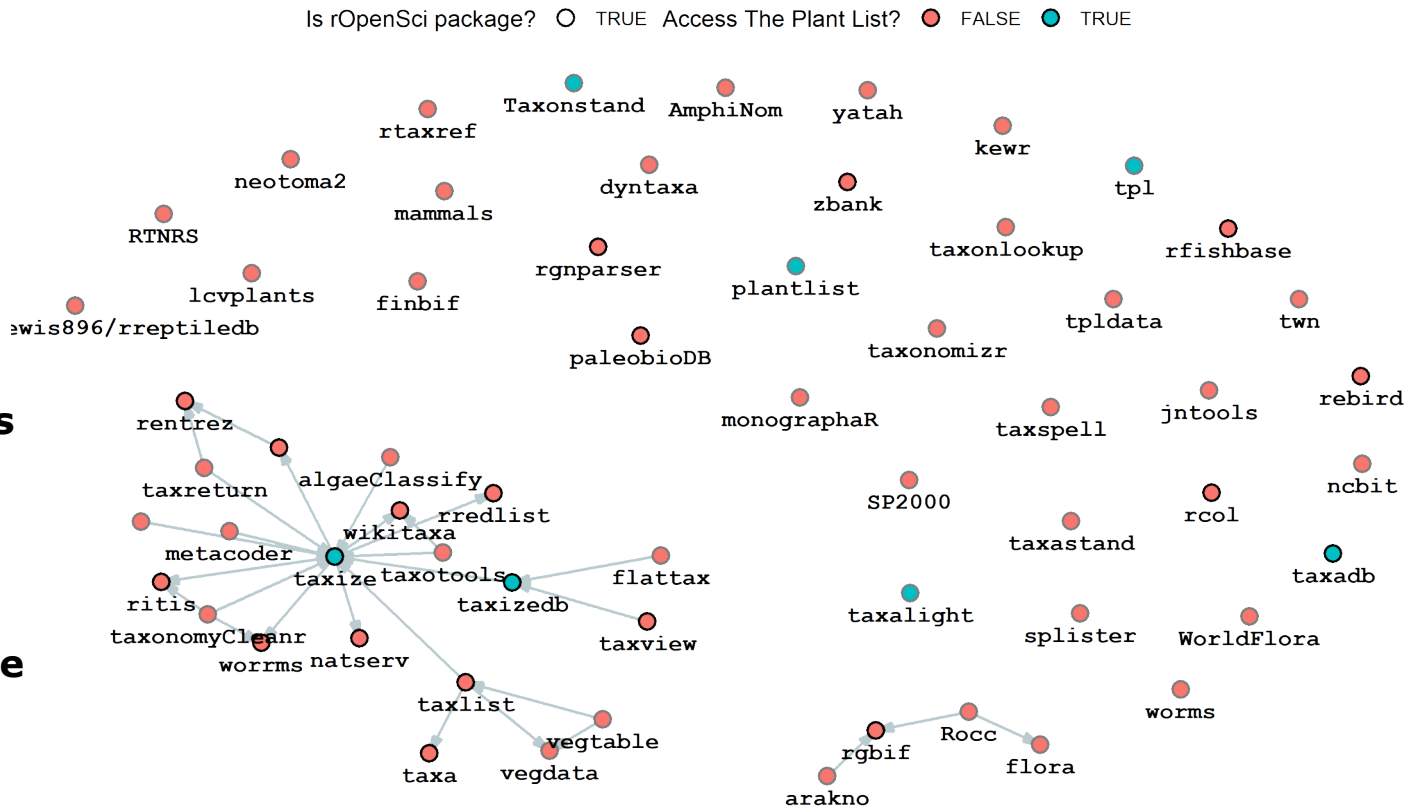


The Package Dependency Network

Disconnected network

Apart from **rOpenSci packages**

Many pkgs provide **same source** (TPL)



Taxharmonizexplorer: Connectining Sources & Packages

DEMO TIME!

https://mgrenie.shinyapps.io/taxharmonizexplorer/

Summary of this part

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Summary of this part

- **Taxonomic Harmonization** requires **taxonomic reference databases**
- These databases cover various **spatial scales** and **taxonomic breadth**
- Some **larger databases** aggregate **smaller databases**
- **Taxonomic harmonization** also rely on tools which are diverse
- Some **R packages** (e.g. taxize) **access many databases**

How to perform Taxonomic Harmonization?

QUESTION
Naively, how would you perform taxonomic harmonization?

Okay, I have species names, how do I proceed?

C. sodalis (LeC)
C. sodalis (LeC.)
C. (*E.*) *sodalis* (LeC)
C. (*E.*) *sodalis* (LeC.)
C. sodalis (Le Conte)
C. sodalis (LeC. 1848)
C. sodalis (LeC., 1848)
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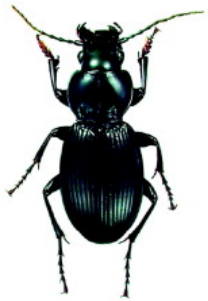

TRENDS in Ecology & Evolution

Patterson et al. 2010 *TREE*

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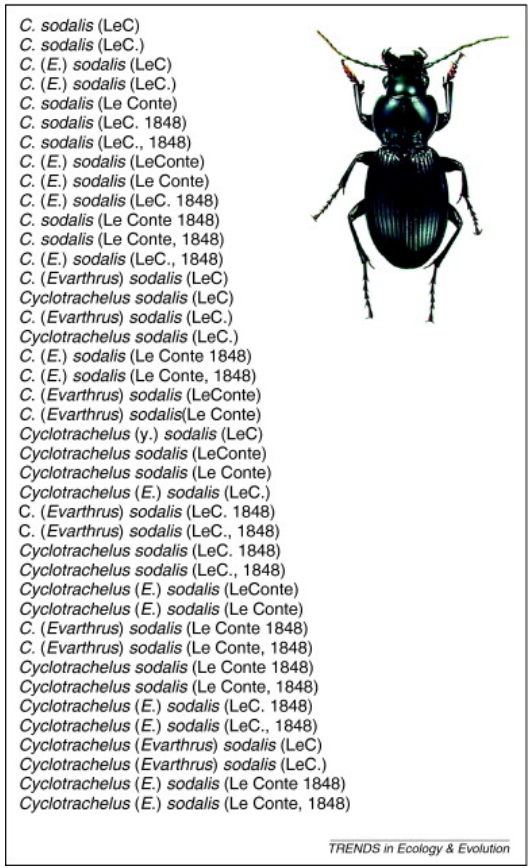

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Diversity of writing **styles**

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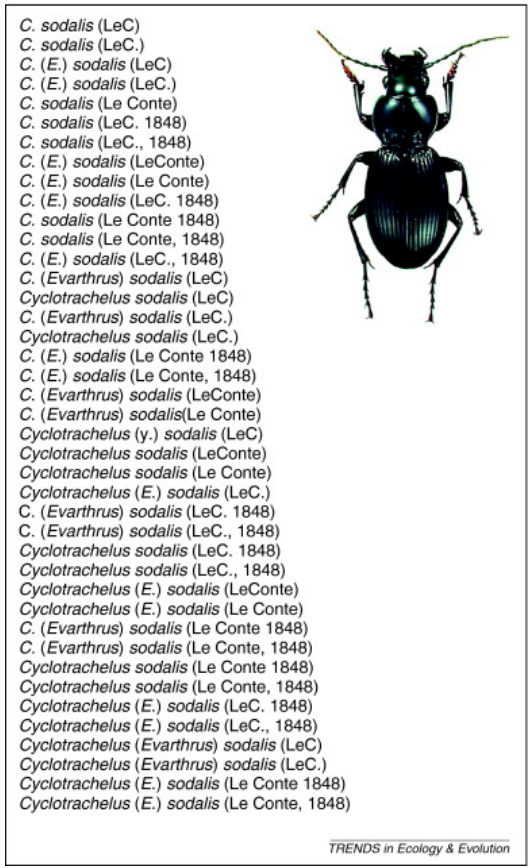

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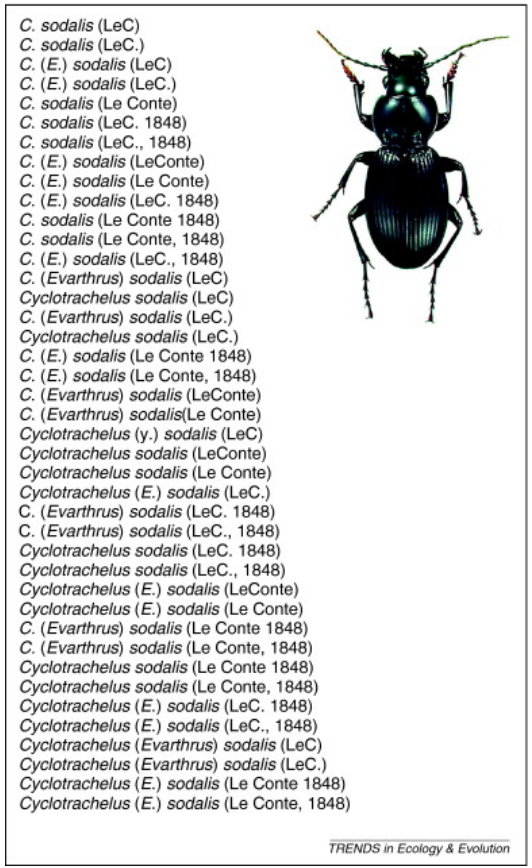

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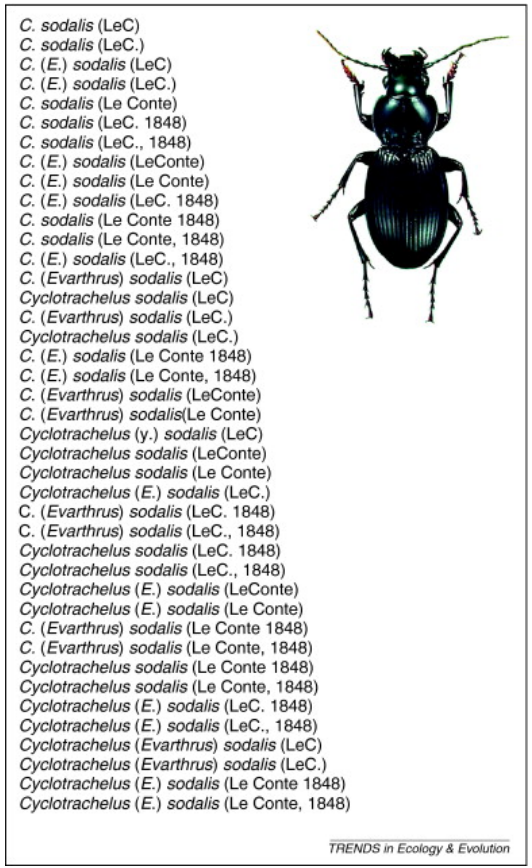

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↓

Standardize **style**

Using Parsers to Identify Components of Names

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https://www.gbif.org/tools/name-parser

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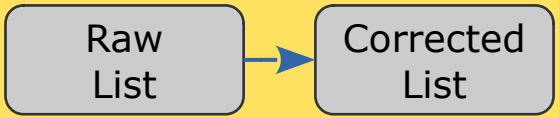

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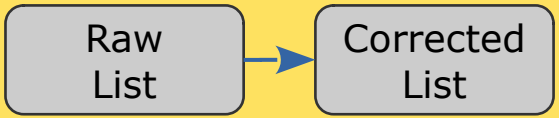
WF1



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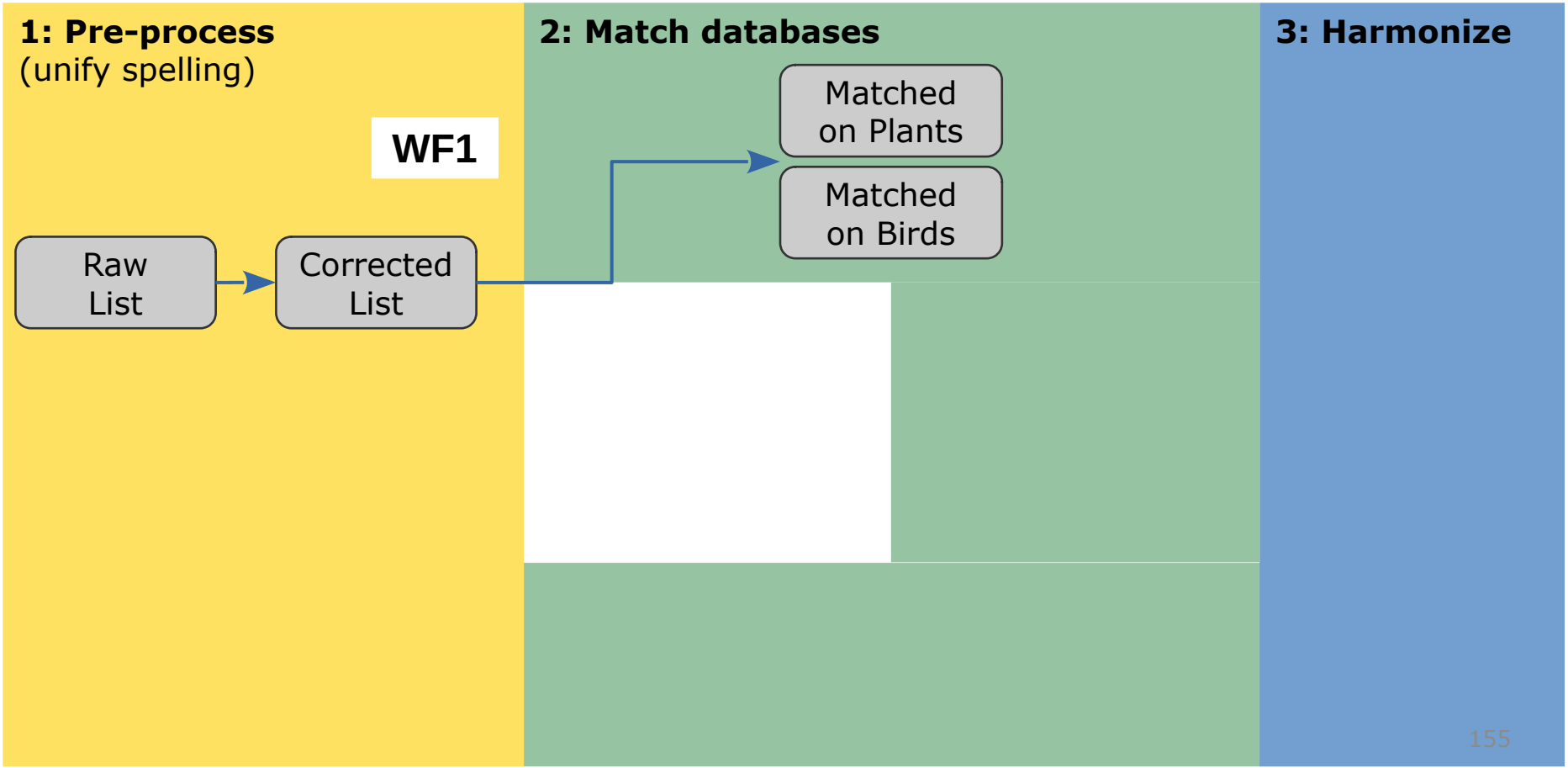

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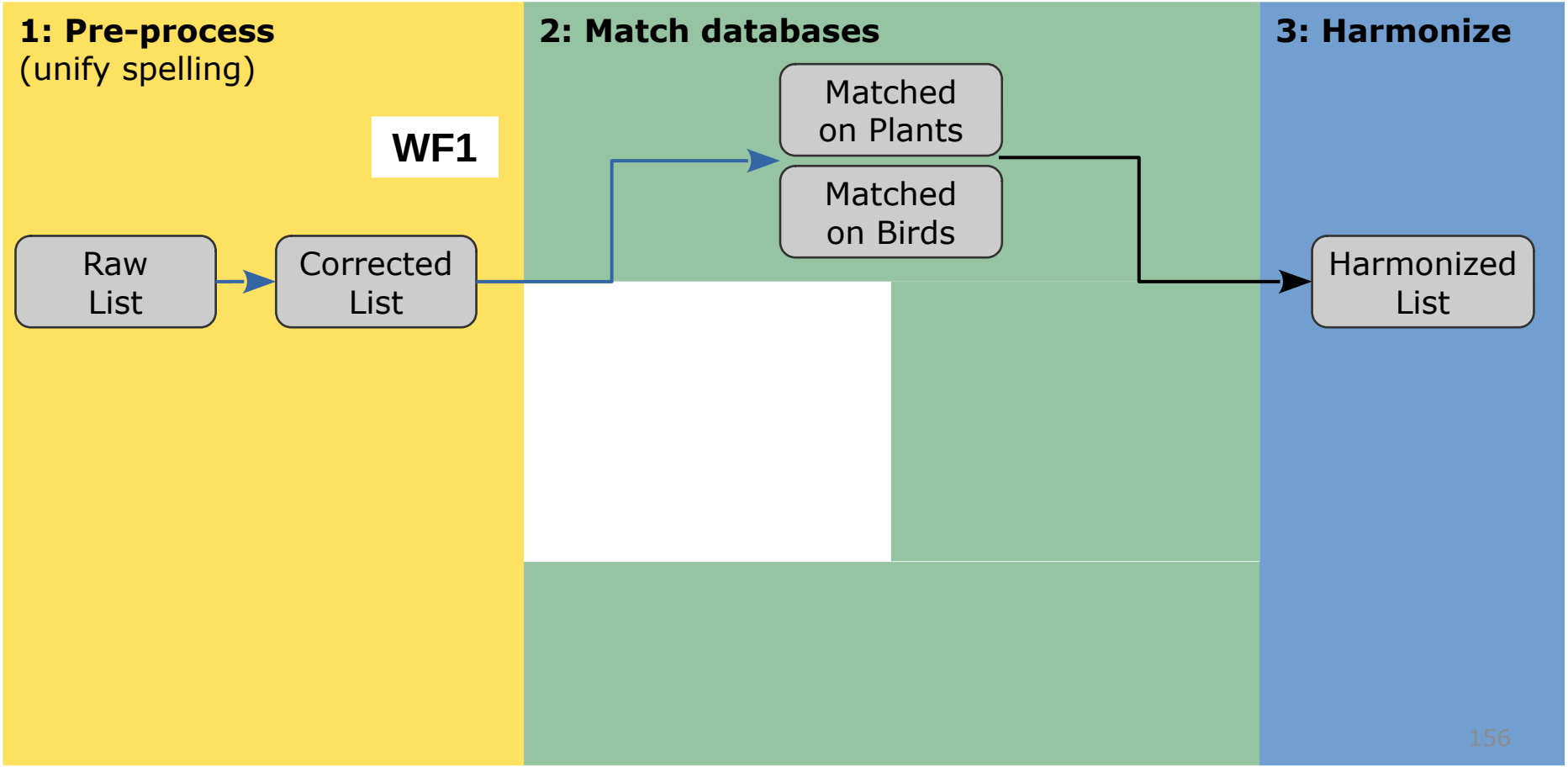

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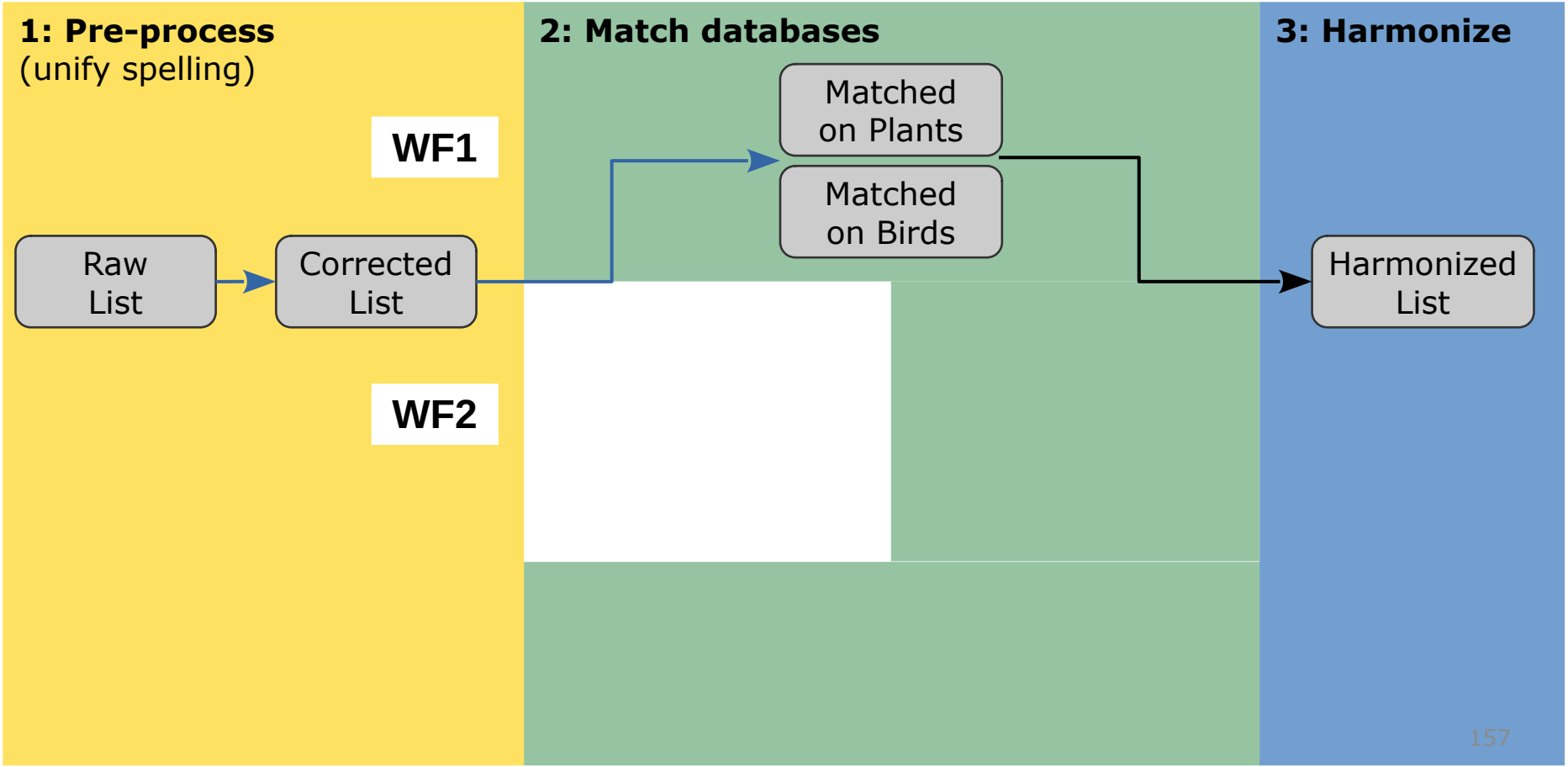

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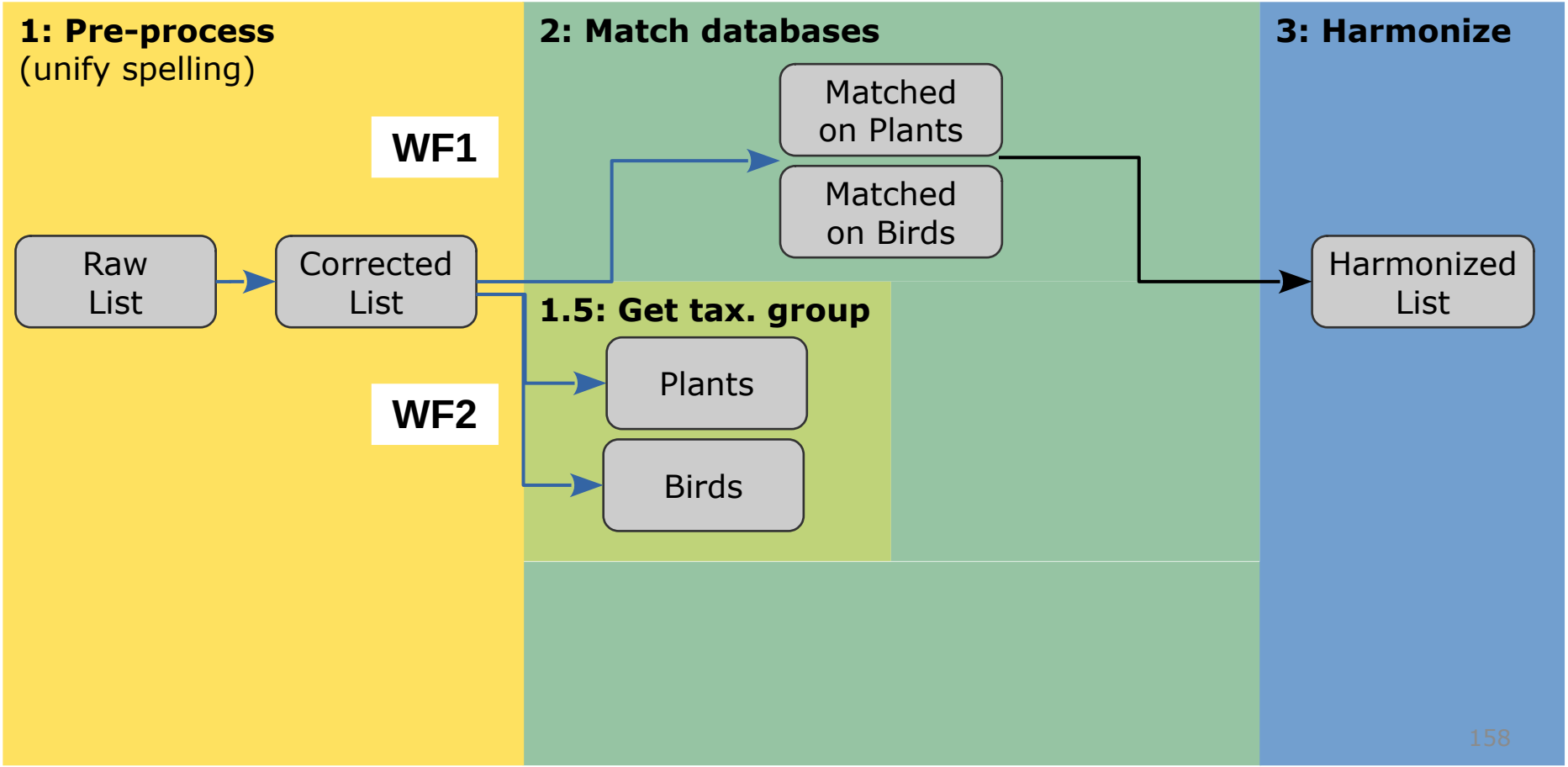

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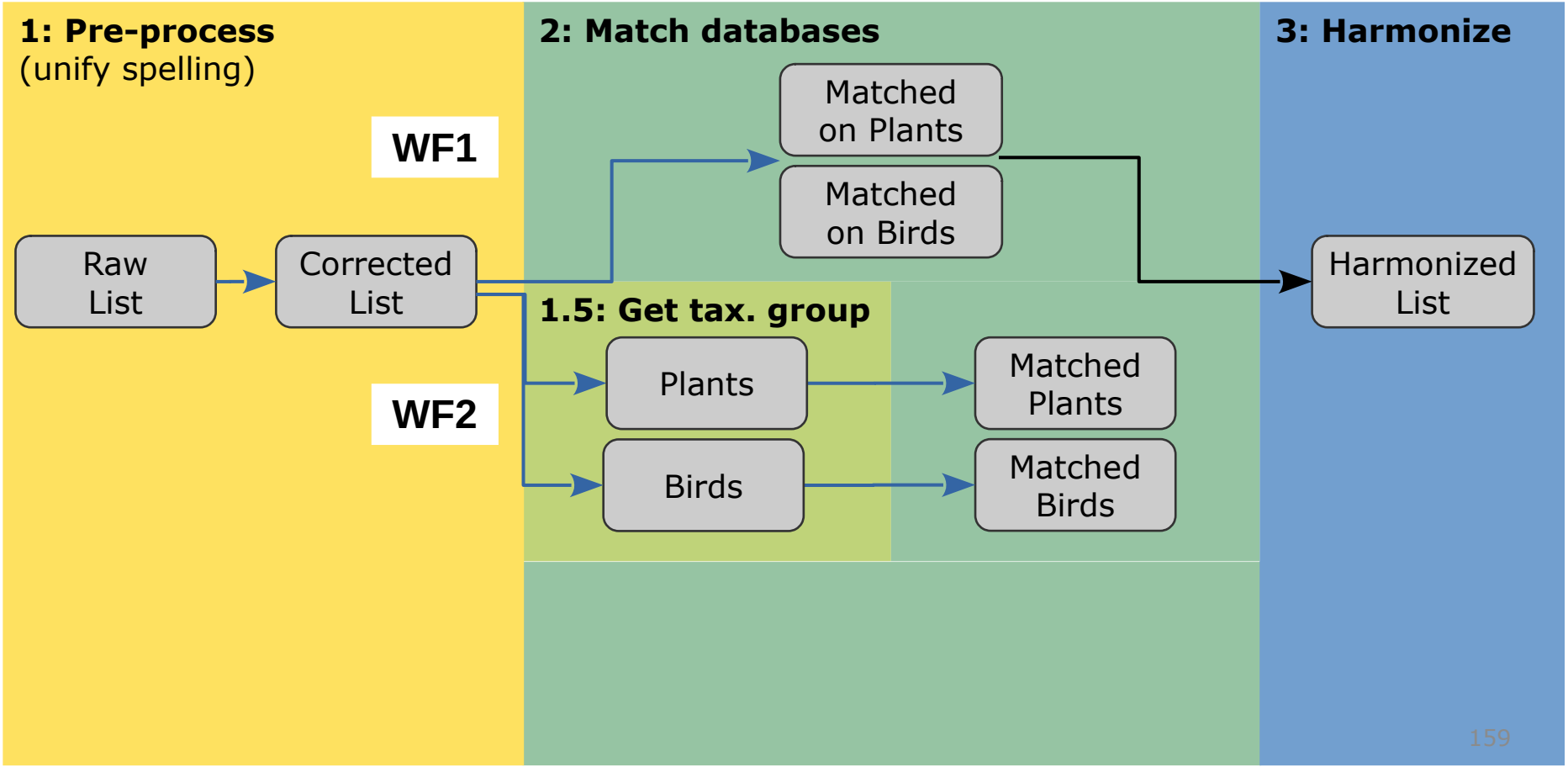

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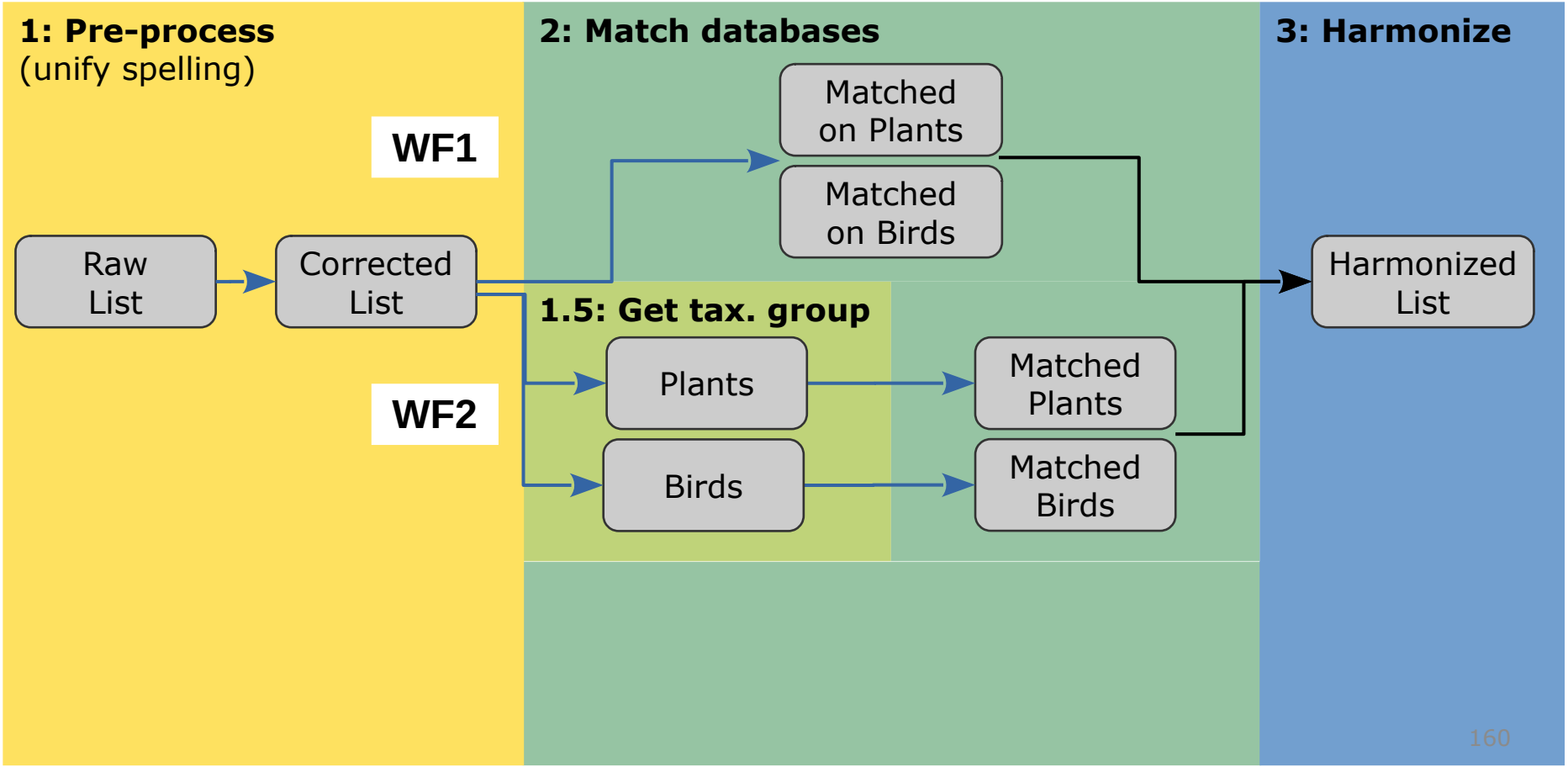

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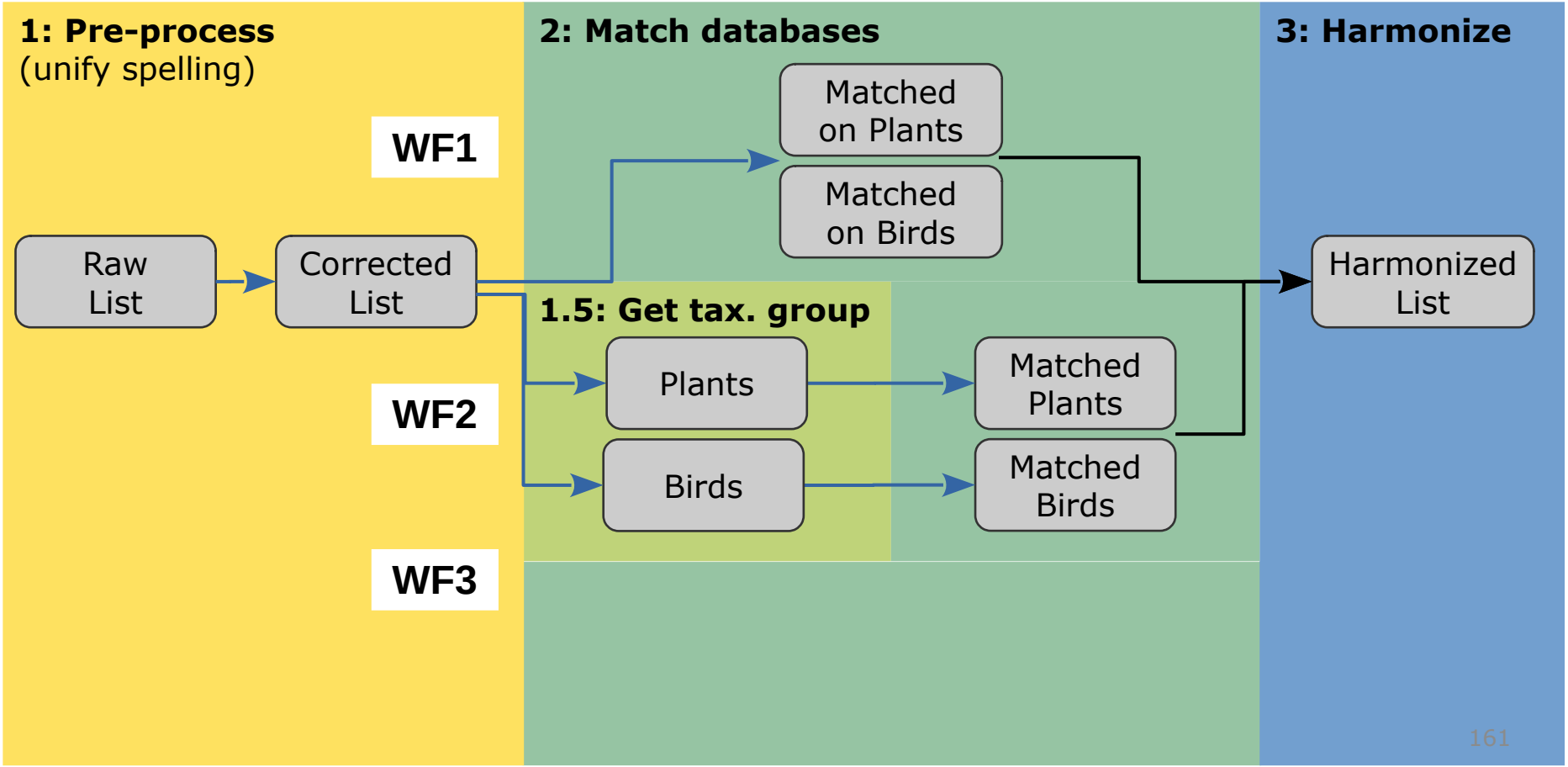

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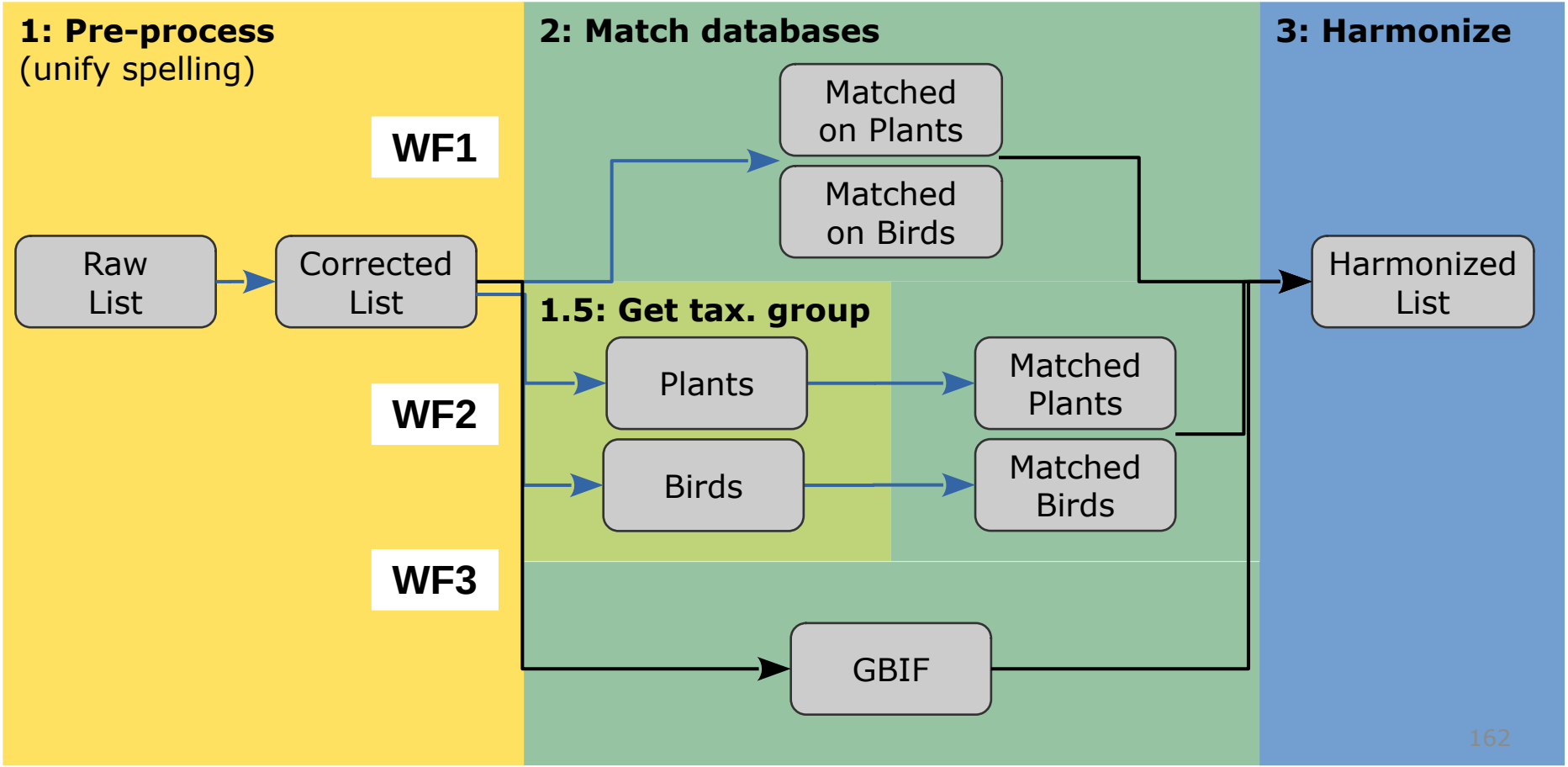

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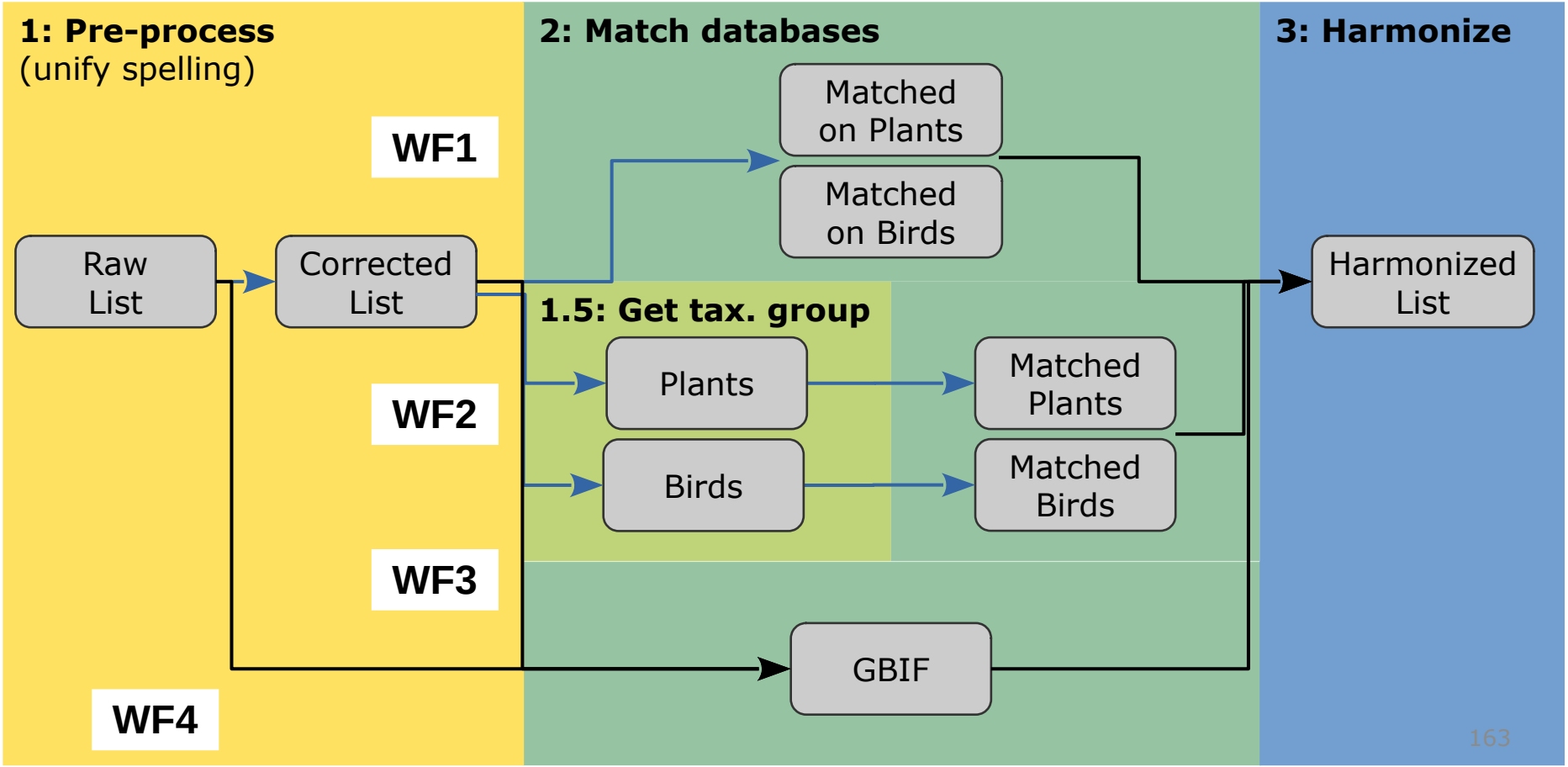

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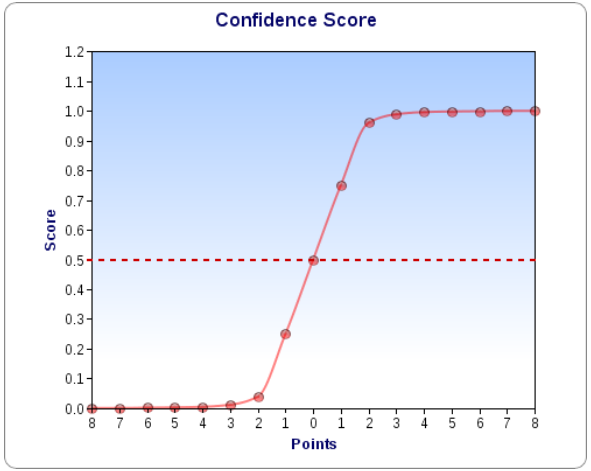
4. Number of synonyms (more synonyms means better resolving)

4. Resolve them

Rubus rubus

Rubus rubus [exact match, Score: 0.988]

CU*STAR



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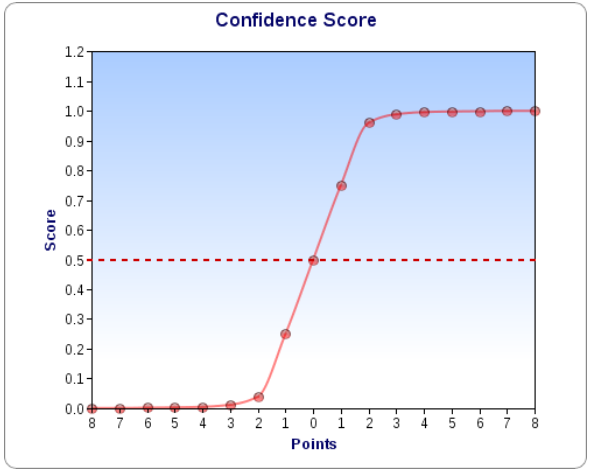

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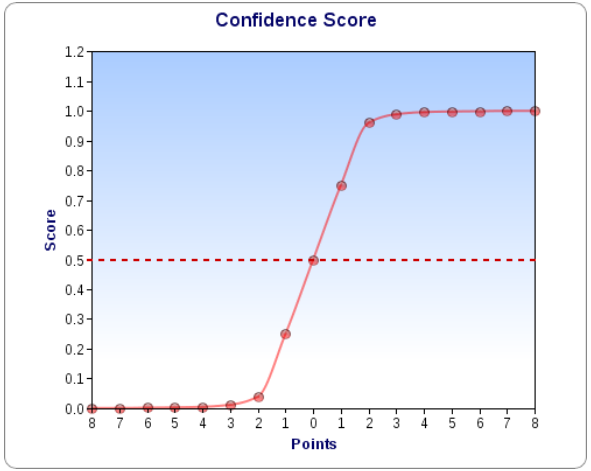

Use **matching scores** to resolve matching names automatically

Not perfect but difficult to achieve with many (>1,000) names

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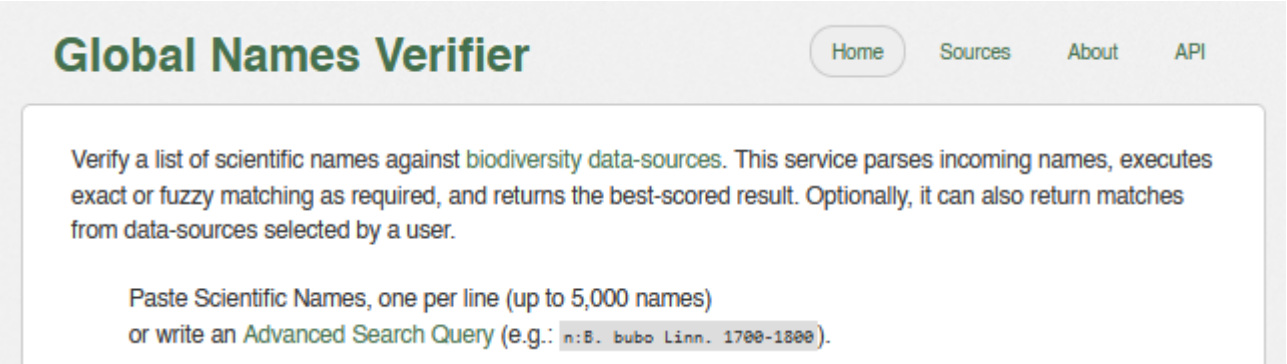
3. Test against “aggregator databases” like Global Names Verifier

https://verifier.globalnames.org/



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→ Whenever possible (not all databases allow it)
include author names

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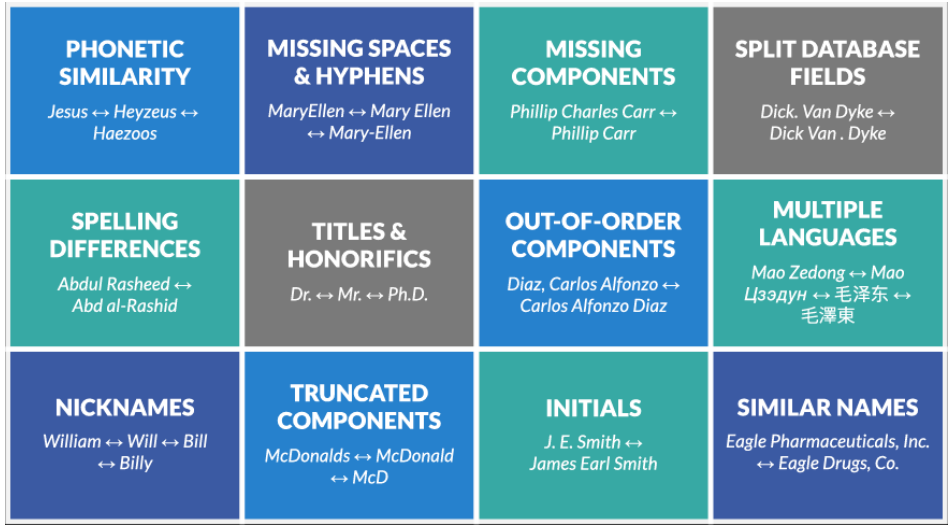

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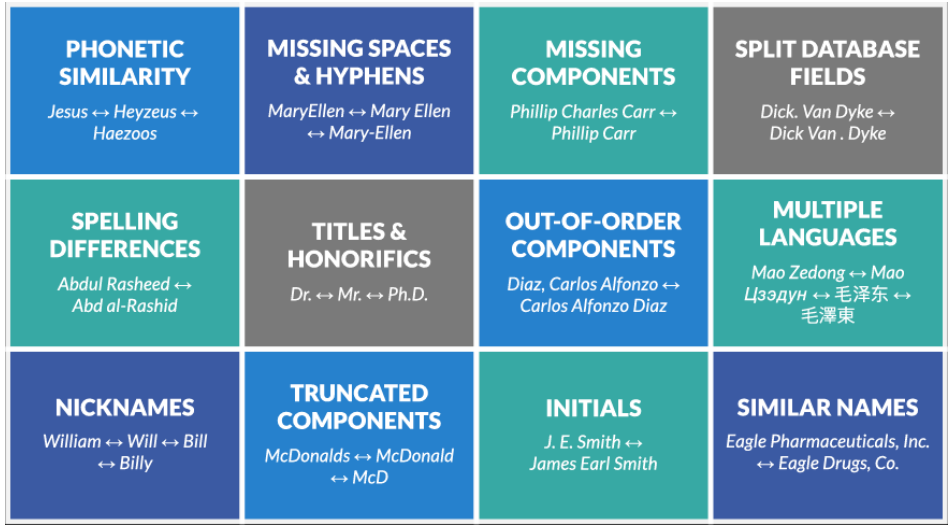

Variety of techniques
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→ Can use it but with care (can match outside taxa or being too loose)

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Take Home Messages and Grand Summary of Things

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- It’s paramount for the data matching process when combining data
- It is supported by databases of different spatial scale and taxonomic breadth, as well as a diversity of tools
- Pre-processing the names is important for harmonizing taxonomy
- Think and decide about the matching process (scores, fuzzy matching, author names, etc.)

Remaining questions?

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Twitter: @LeNematode
Mastodon: @LeNematode@pouet.chapril.org
Website: https://rekyt.github.io

Thank you!

NFDI 4 BIODIVERSITY
BIODIVERSITY, ECOLOGY & ENVIRONMENTAL DATA

GfÖ The Ecological Society of Germany, Austria and Switzerland