A computational approach to biodiversity change

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Vertebrates on the brink as indicators of biological annihilation and the sixth mass extinction

Gerardo Ceballos[a,1], Paul R. Ehrlich[b], and Peter H. Raven[c]

"Biodiversity Crisis"

Accelerated modern human–induced species losses: Entering the sixth mass extinction

Gerardo Ceballos,[1]* Paul R. Ehrlich,[2] Anthony D. Barnosky,[3] Andrés García,[4] Robert M. Pringle,[5] Todd M. Palmer[6]

Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines

Gerardo Ceballos[a,1], Paul R. Ehrlich[b,1], and Rodolfo Dirzo[b]


CLIMATE CHANGE


HABITAT LOSS


INVASIVE SPECIES


OVEREXPLOITATION

Biome

Ecosystem

Community

Population

Individual

Biome

Ecosystem

Community

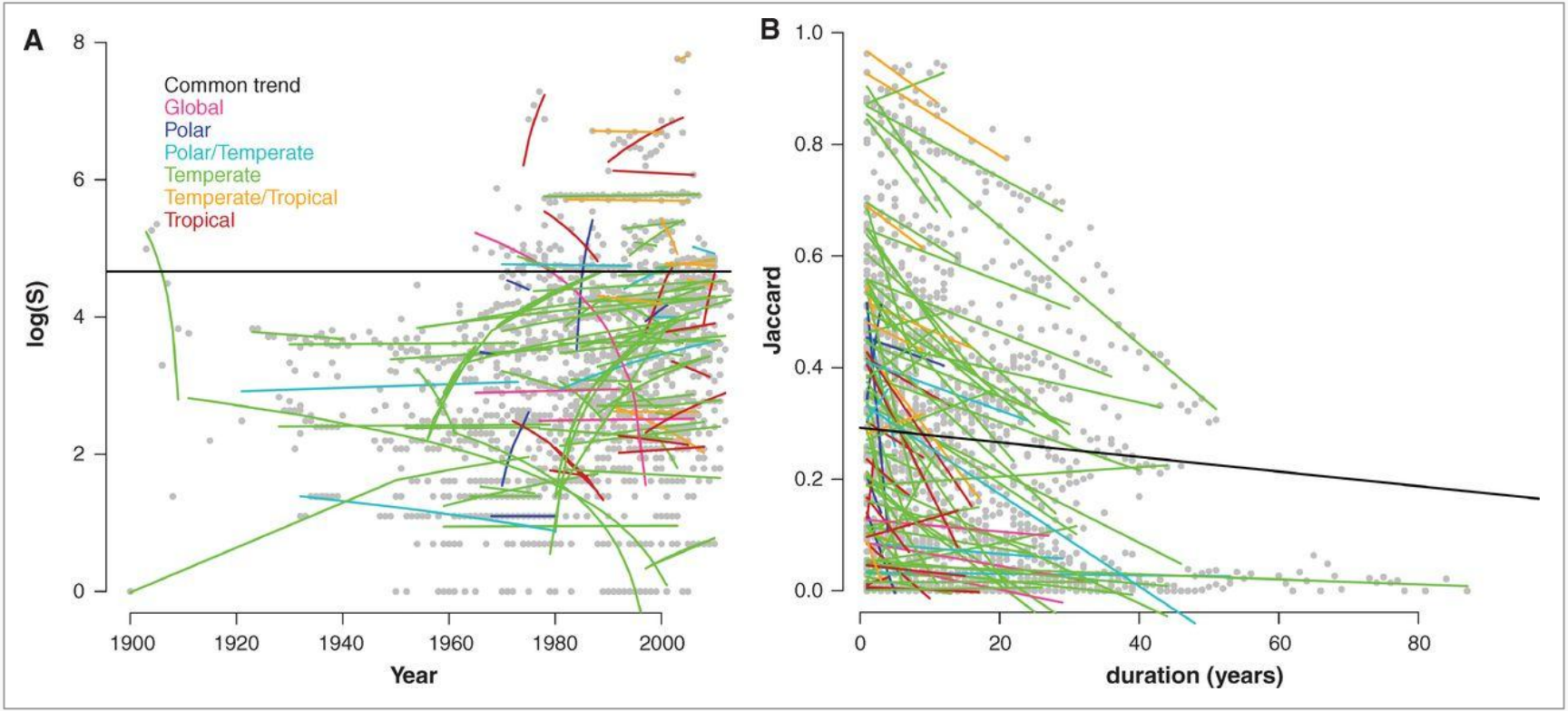
Species Richness, *S*

Species Diversity $D = \frac{1}{\sum p_i^2}$

Population

Individual

Do species-based metrics capture change?



Dornelas et al 2014

Functional diversity as lens for biodiversity change

"morpho-physio phenological traits which impact fitness indirectly via their effects on growth, reproduction and survival"
(Violle 2007)

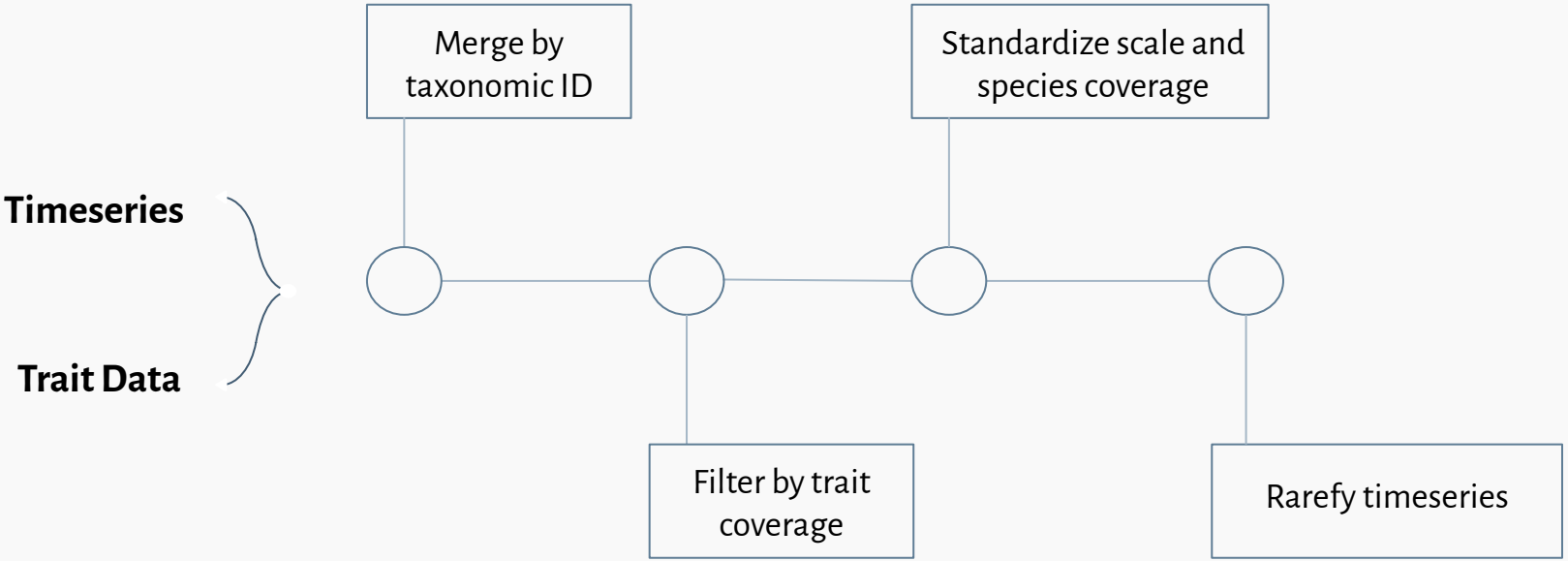
Does a functional approach detect change beyond species-based metrics?

Bridging species and functional trait data

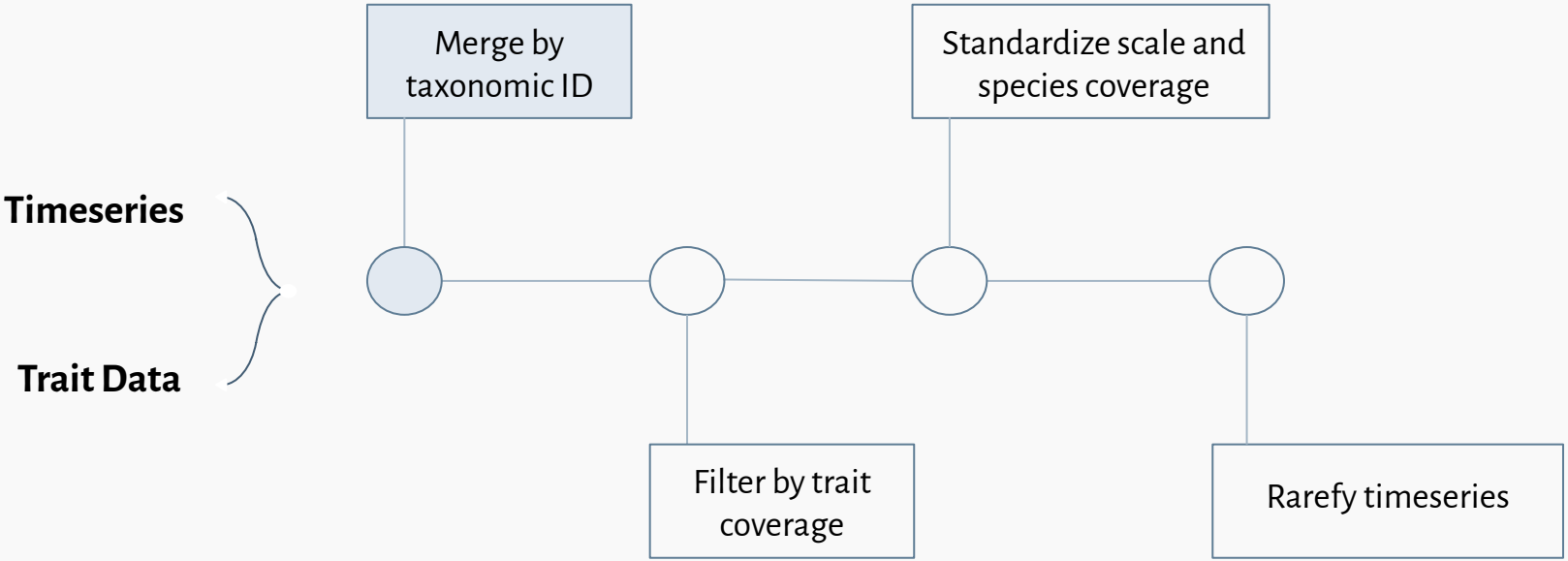
Assemblage timeseries

Functional trait databases

- Amphibio (amphibians)
- Elton Traits (mammals, birds)
- Bien (plants)
- Fishbase (fish)
- Fishtraits (fish)
- Marine Traits (fish)



Data processing pipeline



Data processing pipeline

- Get taxonomic ID's for all species via taxadb
- Resolve species with more than one accepted ID

Taxadb: A high-performance local taxonomic database interface

- Taxonomic inconsistencies (synonyms, splits, etc) can lead to significant mismatches in synthesis work (some hidden, some obvious)
- Previous API approaches for interfacing with taxonomic data are not tractable for large datasets

IUCN Name	Category
Pipile pipile	CR
Pipile cumanensis	LC
Pipile cujubi	LC
Pipile jacutinga	EN
Megapodius decollatus	LC
Scleroptila gutturalis	LC
Margaroperdix madagarensis	LC
Falcipennis falcipennis	NT

Table 1: IUCN database example

Elton Name	Mass
Aburria pipile	1,816.59
Aburria cumanensis	1,239.22
Aburria cujubi	1,195.82
Aburria jacutinga	1,240.96
Megapodius reinwardt	666.34
Francolinus levalliantoides	376.69
Margaroperdix madagascariensis	245.00
Catreus wallichii	1,436.88
Falcipennis falcipennis	685.61
Falcipennis canadensis	473.65

Table 2: Elton trait database example

(Norman, Chamberlain & Boettiger, 2020)

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Table 2: Elton trait database example

Elton Name	Mass	Category
Aburria pipile	1,816.59	–
Aburria cumanensis	1,239.22	–
Aburria cujubi	1,195.82	–
Aburria jacutinga	1,240.96	–
Megapodius reinwardt	666.34	–
Francolinus levalliantoides	376.69	–
Margaroperdix madagascariensis	245.00	–
Catreus wallichii	1,436.88	–
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Megapodius decollatus	–	LC
Scleroptila gutturalis	–	LC
Margaroperdix madagarensis	–	LC

Table 3: Merge by species names

(Norman, Chamberlain & Boettiger, 2020)

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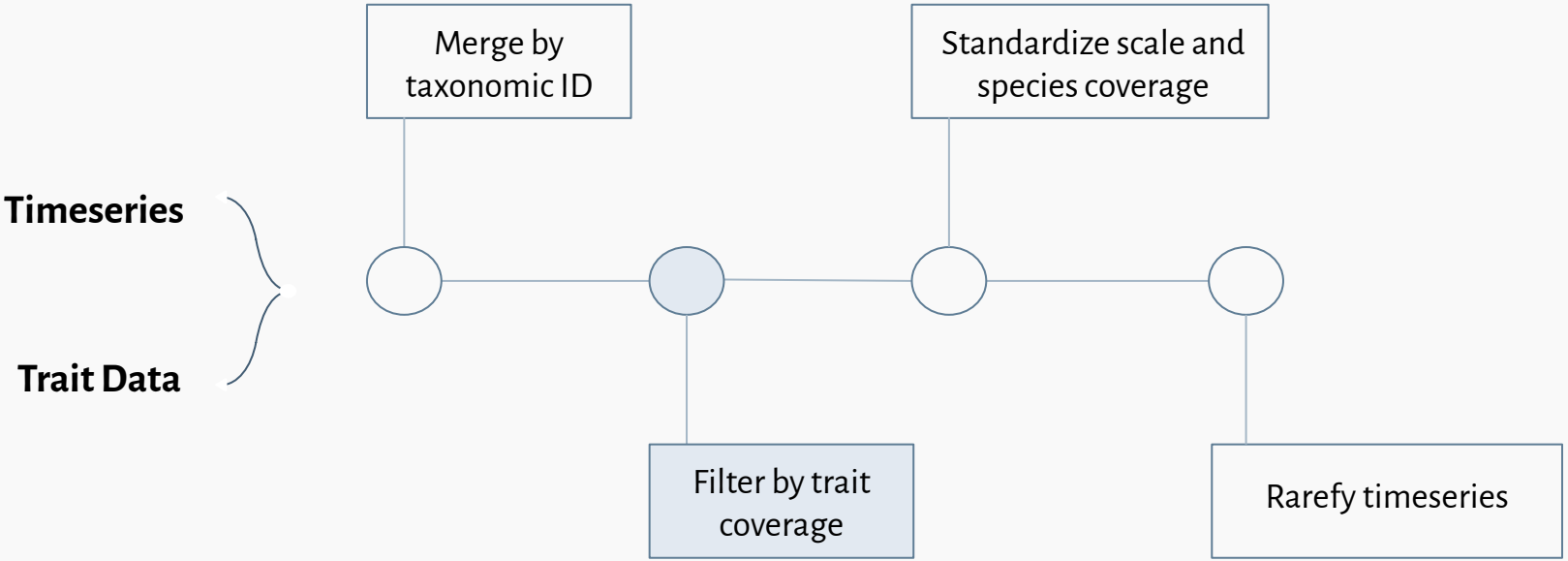
Table 2: Elton trait database example

Elton Name	*IUCN Name*	Mass	Category	id
Aburria pipile	*Pipile pipile*	1,816.59	CR	COL:35517887
Aburria cumanensis	*Pipile cumanensis*	1,239.22	LC	COL:35537158
Aburria cujubi	*Pipile cujubi*	1,195.82	LC	COL:35537159
Aburria jacutinga	*Pipile jacutinga*	1,240.96	EN	COL:35517886
Megapodius reinwardt	–	666.34	–	COL:35521309
Francolinus levalliantoides	–	376.69	–	COL:35518087
Margaroperdix madagascariensis	*Margaroperdix madagarensis*	245.00	LC	COL:35521355
Catreus wallichii	–	1,436.88	–	COL:35518185
Falcipennis falcipennis	*Falcipennis falcipennis*	685.61	NT	COL:35521380
Falcipennis canadensis	–	473.65	–	COL:35521381
–	*Megapodius decollatus*	–	LC	COL:35537166
–	*Scleroptila gutturalis*	–	LC	–

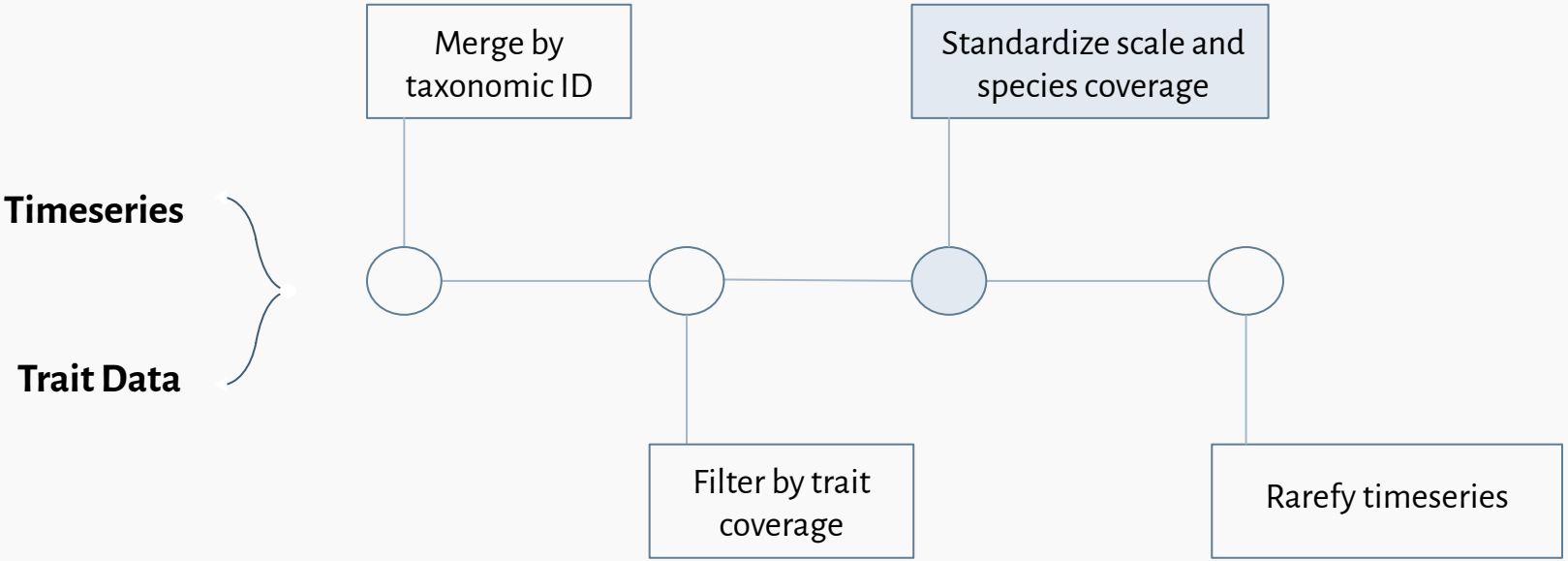
Table 3: Merge by species ID's

(Norman, Chamberlain & Boettiger, 2020)



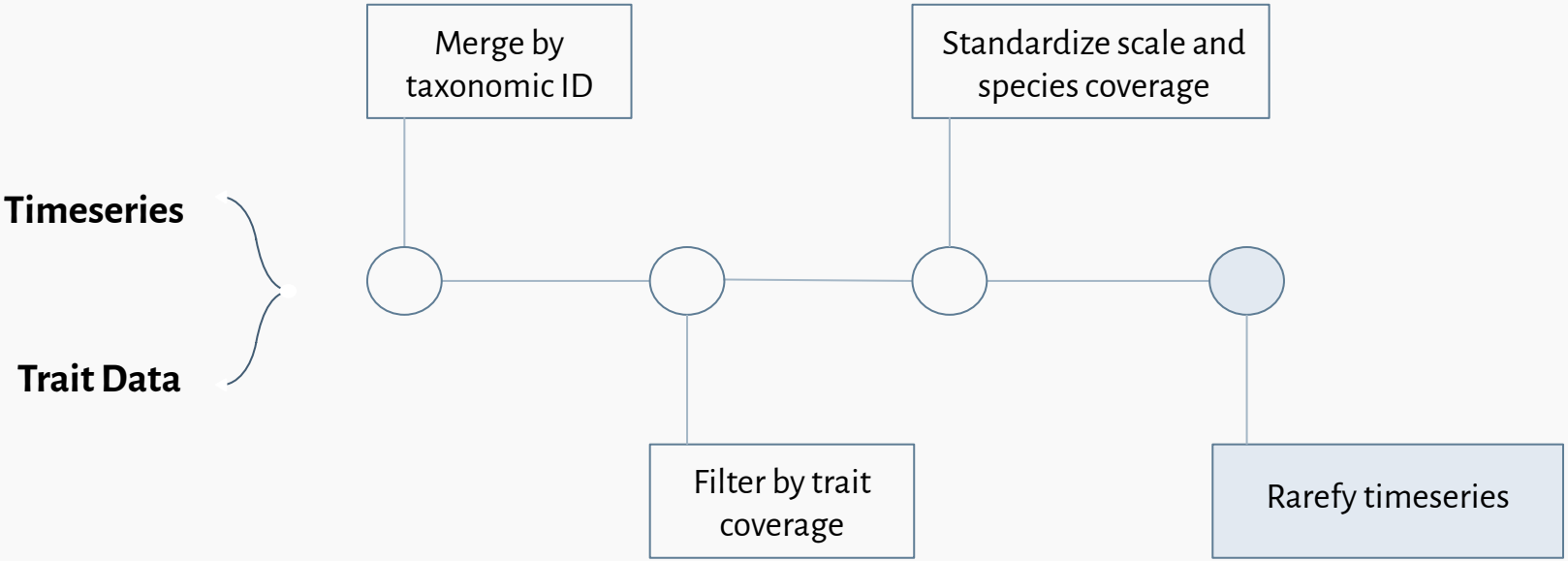
Data processing pipeline

- Remove timeseries with < 85% trait coverage



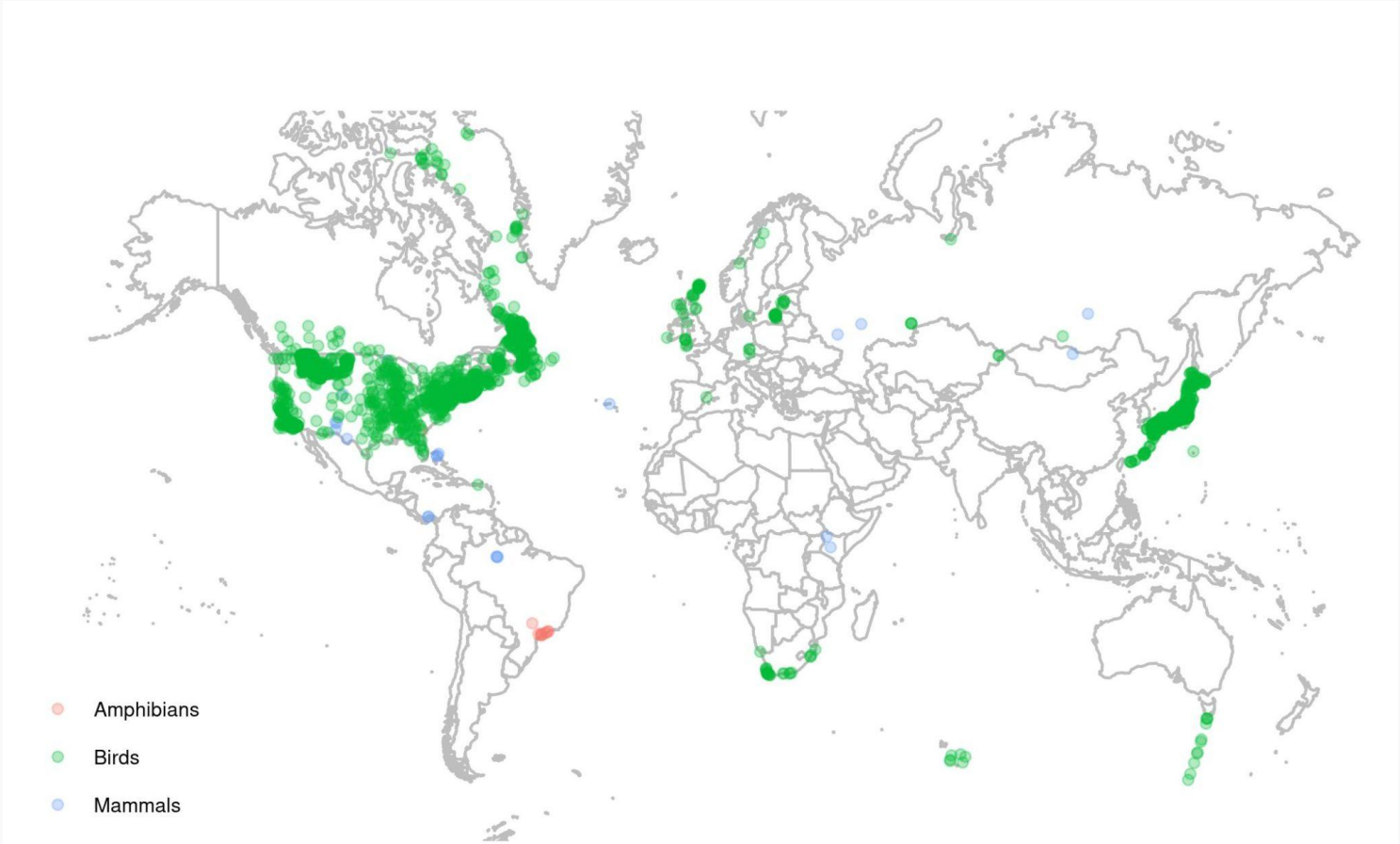
Data processing pipeline

- Define an individual timeseries based on grid cell
- Cell size defined by (mean + sd) of the extent of single location studies, ~74 sq km



Data processing pipeline

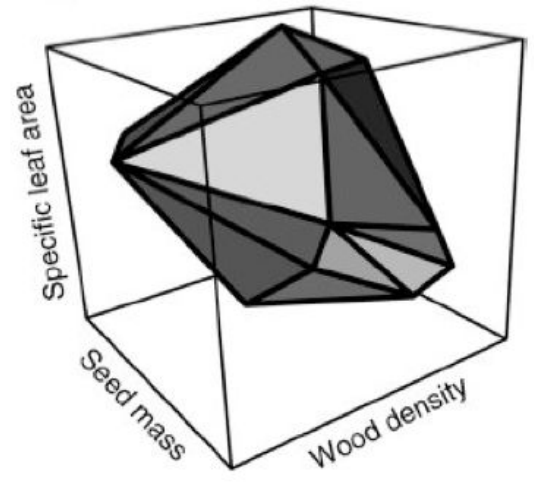
- Account for inconsistent sampling within years by bootstrap resampling the minimum number of samples in a year for each timeseries.



53 studies and 2443 individual timeseries.

Functional Diversity Metrics

Richness

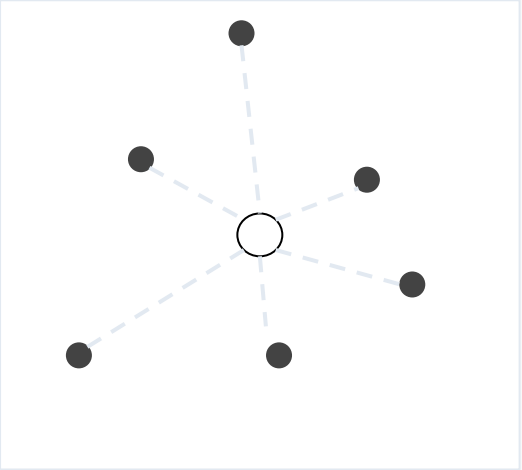


FRic

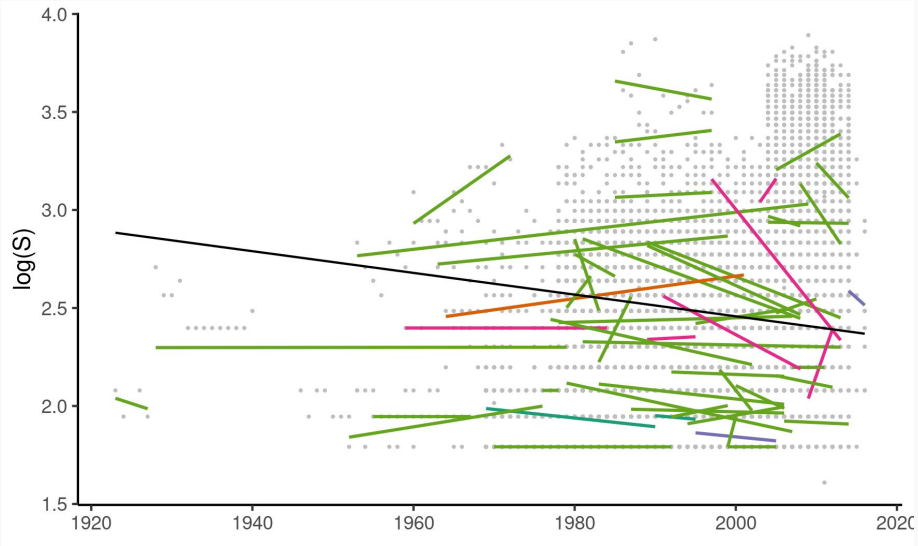
Evenness

FEve

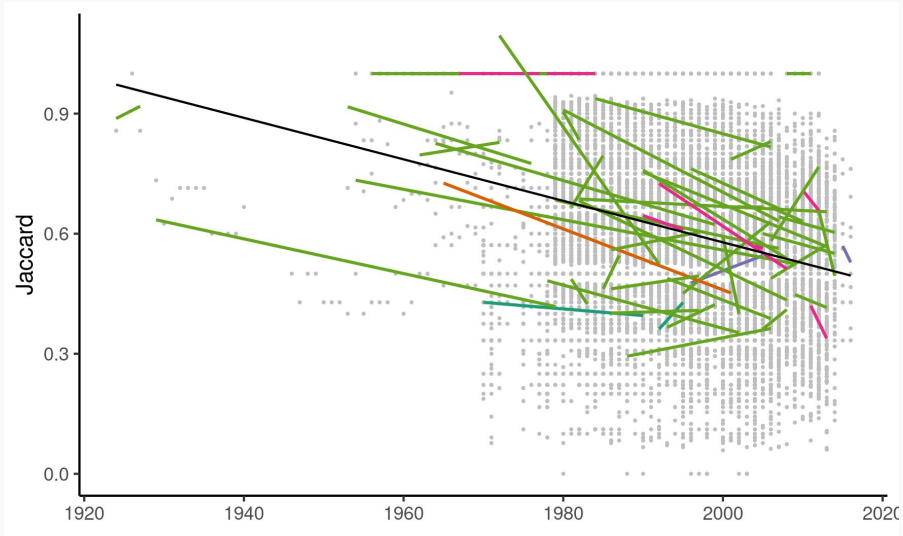
Divergence



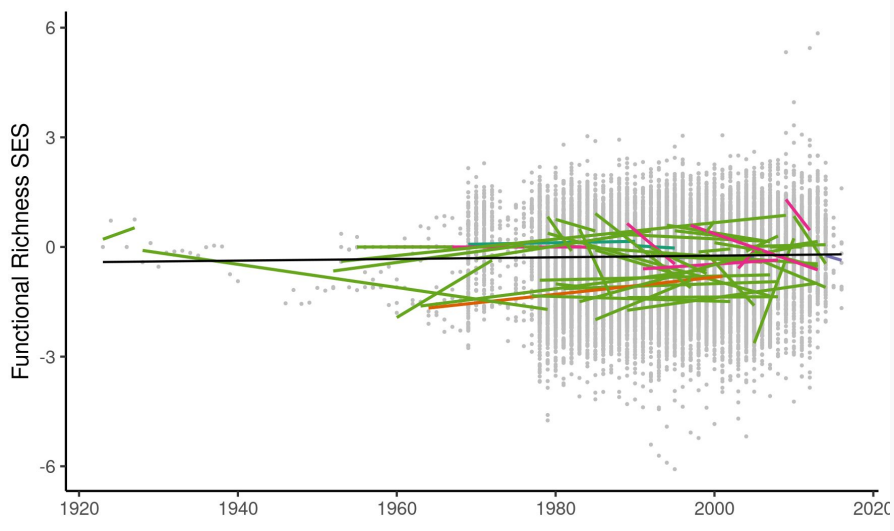
FDiv



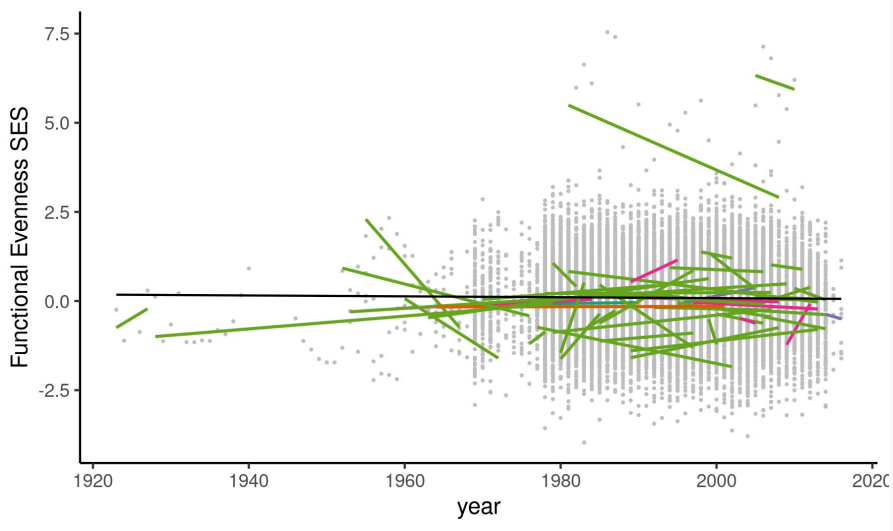
Non significant
(slope: -0.06, p-value = 0.16)



Significantly decreasing
(slope: -0.05, p-value = ~0)



Non significant
(slope: 0.02, p-value = 0.54)



Non significant
(slope: -0.01, p-value = 0.65)

Conclusions

While some communities are experiencing significant functional losses, others are experiencing significant gains.

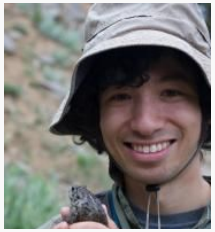
Is the lack of trend due data limitations, or a true reflection of the ecology?

Are there general rules that predict scenarios in which functional loss accompanies particular species level shifts?

Acknowledgements

Advisor: Dr Carl Boettiger

Dr Perry de Valpine



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