

Results: Systematic review of how we measure functional diversity (FD)

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Set up the markdown cache, set your working directory, and load the libraries.

Read-in data

1 Basic information about the dataset

```
## [1] "149 accepted studies in the dataset"
```

```
## [1] 149
```

```
## [1] 149
```

```
## integer(0)
```

```
## [1] "62.42 % of studies were published last year"
```

There are 149 accepted studies in the dataset. In the most recent year, 2014, 93 were published, which is 62.42 % of the total dataset.

2 What types of locations, ecosystems, and taxa have been the focus of FD calculations?

2.1 Countries

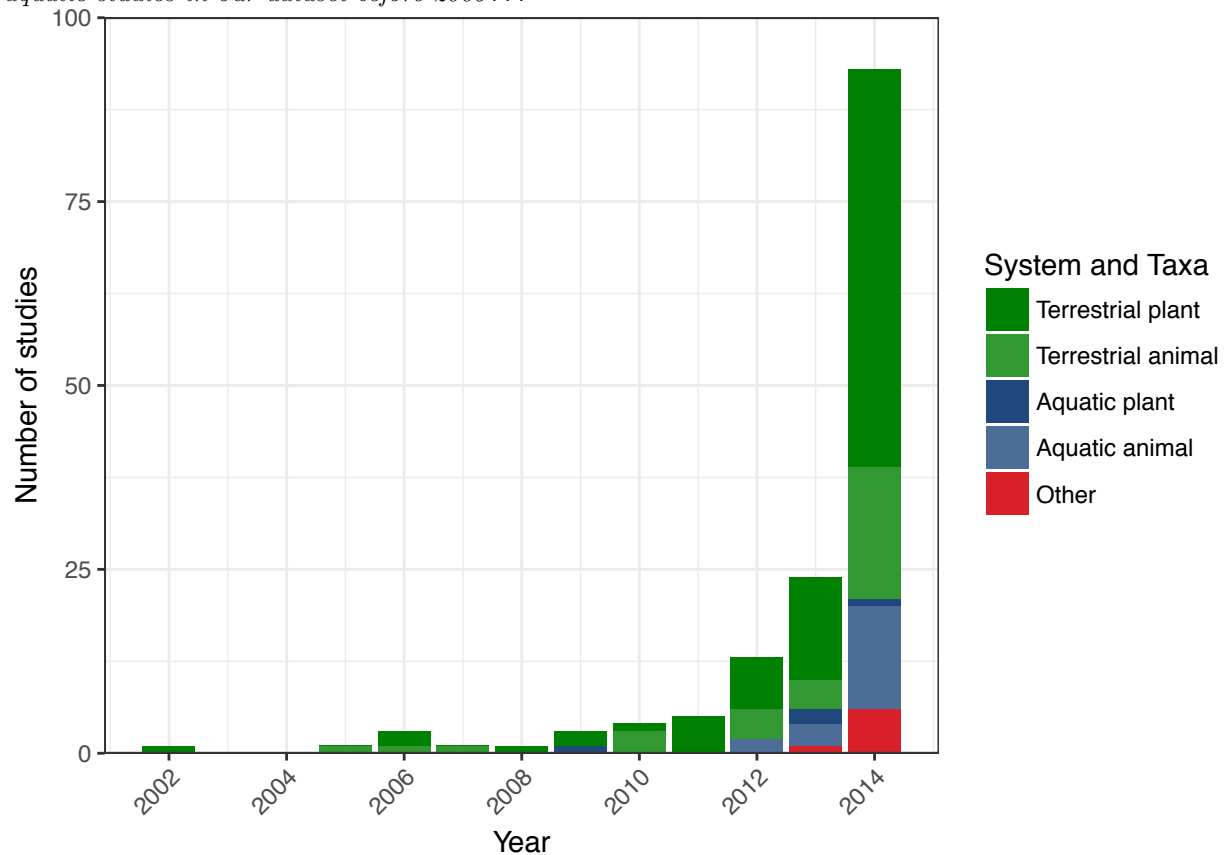
The top 5 countries that produce these FD studies are, in decreasing order, FRA, USA, CHN, DEU, GBR.

2.2 Terrestrial/Aquatic

```
##          sys1Grp nID
## 1 terrestrial plants 87
## 2 terrestrial animals 32
## 3    aquatic plants  4
## 4    aquatic animals 19
## 5          other    7
```

The majority of studies include terrestrial systems, which make up 83.89 %. Of the studies that look at terrestrial systems, 87 studies or 58.39% of the full dataset specifically measure the FD of terrestrial plants.

The number of studies published on FD has dramatically increased over time and, in the past few years, more studies have focused on aquatic systems and have included multiple systems/taxa (other). *Are there really no aquatic studies in our dataset before 2009???*



2.3 Habitat

Grasslands are the most commonly-studied habitats and are included in

24.83 % of studies in our dataset. For aquatic systems, coastal regions are studied most frequently. Check out the imbedded code chunk for more detail.

2.4 Taxa

Not surprisingly, plants are the most highly-studied type of organism.

Among plants, understory plant groups such as forbs and grasses are most commonly studied. Among vertebrates, fish are the most commonly studied taxa, followed by birds.

3 What are the different ways that FD has been measured?

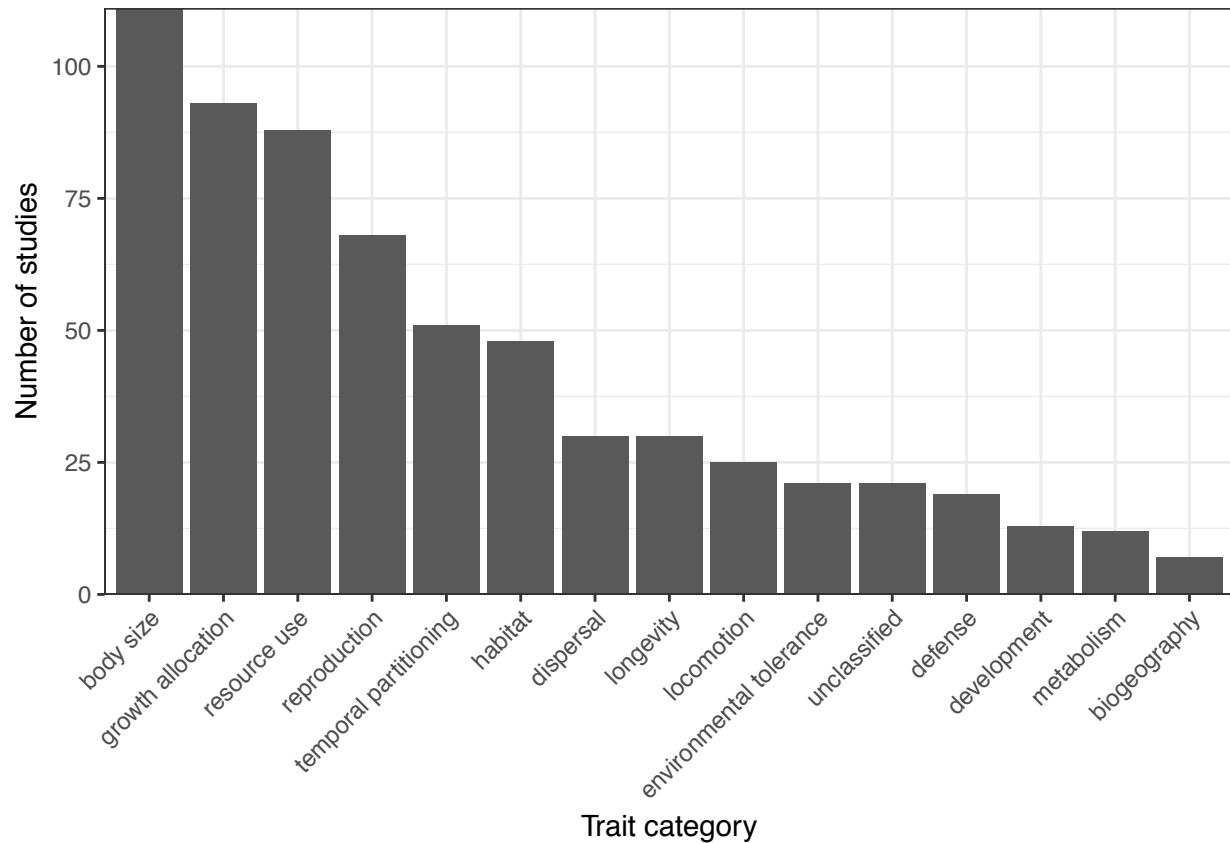
3.1 Number of species

```
## [1] "Median = 76"
```

Overall, each study looks at about 76 species (median value). There were two studies with >1000 species – these were excluded from the calculation of the median number of species per study and the plot.

3.2 Traits

Traits were classified into 14 trait categories that generalize ways in which a trait might describe the functioning of an organism in an ecosystem.



The top five trait categories that are represented in this dataset are (1) body size, (2) growth allocation, (3) resource use, (4) reproduction, and (5) temporal partitioning.

Characteristic traits within each trait category include... (1) body size: height, body size, max height, canopy height, body length (2) growth allocation: specific leaf area, leaf dry matter content, leaf size, wood density (3) resource use: diet, foraging method, foraging substrate, N fixation, root type (4) reproduction: seed mass, clonality, reproduction mode, pollen vector, flowering period

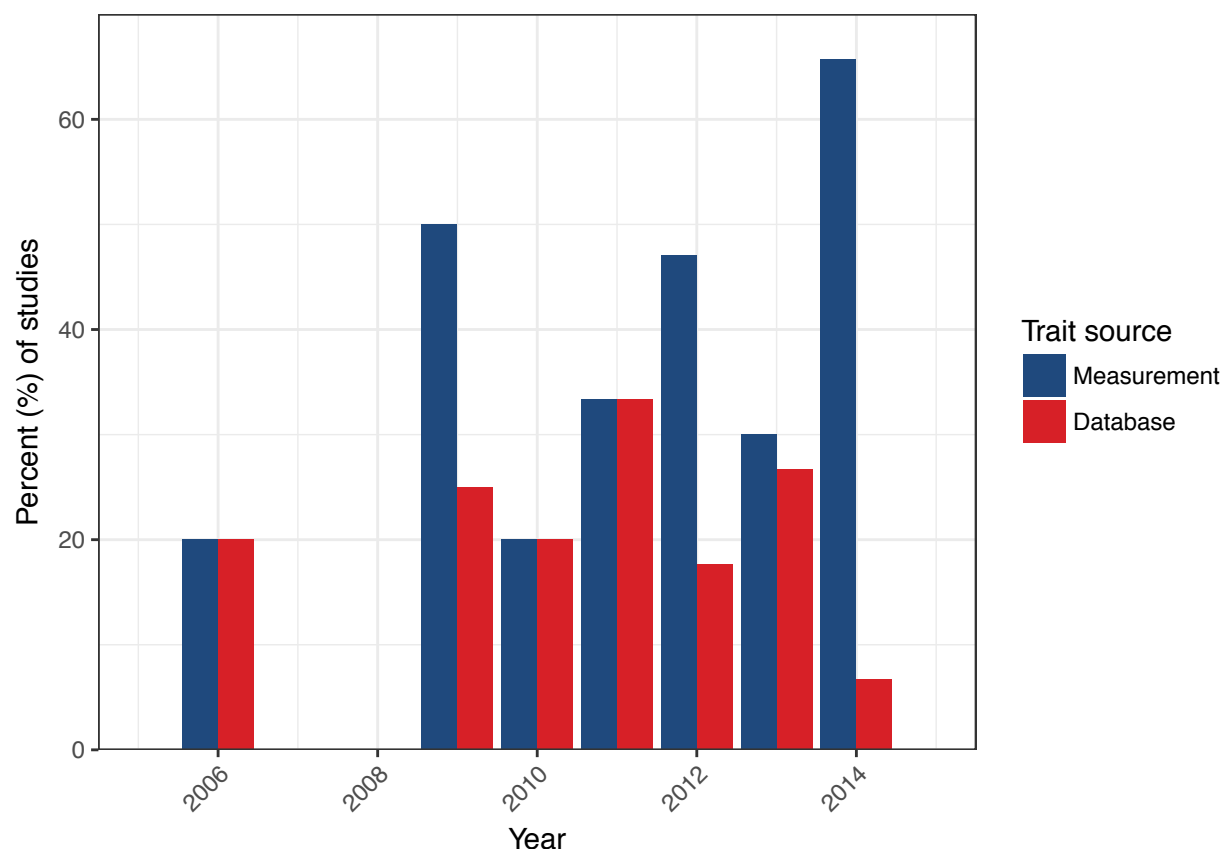
Note: These plots only include traits that show up in 5 or more studies.

Typically, studies include 7 traits and 4 trait categories (median values).

3.3 Trait sources

Most studies (64%) measure at least some of their own traits. The next most common trait sources are from literature and trait databases. Only 16% of studies use trait database data.

Only 18.24% of studies use >1 trait source. Of the studies that use only 1 trait source, 64% measure their own traits and 28% use trait databases.



Although there has been a recent push to contribute to trait databases, there does not appear to be a rise in the use of trait databases in the current literature. Studies continue to rely primarily on their own trait measurements. Note: To make this figure, I removed year x trait source categories with less than 2 observations because a percentage made up of less than 2 observations is pretty silly.

3.4 FD metrics

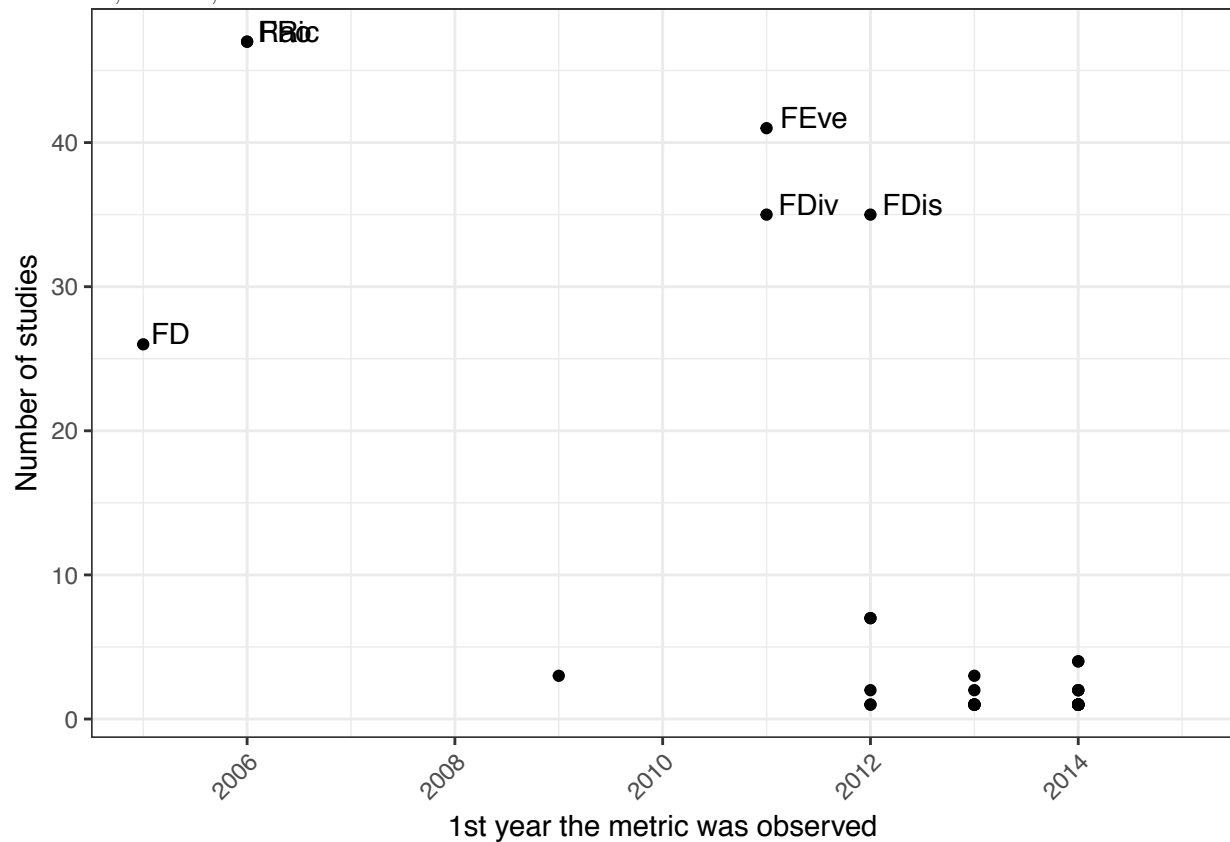
```
## [1] betweenSpRao    Clust-Evenness  Clust-MPD      Clust-Rao
## [5] Clust-ShannonsH  EED             FAD1           FAD2
## [9] Fbeta           Fbeta_FDis     FD             FD-C
## [13] FDC            FDis          FDiv          FDP
## [17] FEq           FEve          FOR           FRic
## [21] FRq           FSpe          FV            HED
## [25] iFD           KSI           M-NND         M-NND_beta
## [29] MFAD          MFPD          MPD           MPD_beta
## [33] MPDTw         MPDTw_beta    OFRO          PEI
## [37] Rao           Rao_alpha     Rao_beta      Rao_gamma
## [41] RaoB          RaoR          SD-NND        wFDc
## [45] withinSpRao
## 45 Levels: betweenSpRao Clust-Evenness Clust-MPD ... withinSpRao

##   code nID      Dim      Meth Abund minYear
## 20 FRic  47  richness  ordinate   no    2006
## 37 Rao   47 divergence distance-only yes    2006
## 18 FEve  41  evenness  ordinate   yes    2011
## 14 FDis  35 divergence  ordinate   yes    2012
## 15 FDiv  35 divergence  ordinate   yes    2011
```

```
## 11  FD  26  richness      cluster  no    2005
## [1] 149
## [[1]]
## [1] "32 % of studies use nRao"
##
## [[2]]
## [1] "32 % of studies use nFRic"
##
## [[3]]
## [1] "28 % of studies use nFEve"
##
## [[4]]
## [1] "23 % of studies use nFDis"
##
## [[5]]
## [1] "23 % of studies use nFDiv"
##
## [[6]]
## [1] "17 % of studies use nFD"
```

The majority of studies (87.92%) use a least 1 FD metric from the top 6 metrics. - 32 % of studies use nRao - 32 % of studies use nFRic - 28 % of studies use nFEve - 23 % of studies use nFDis - 23 % of studies use nFDiv - 17 % of studies use nFD

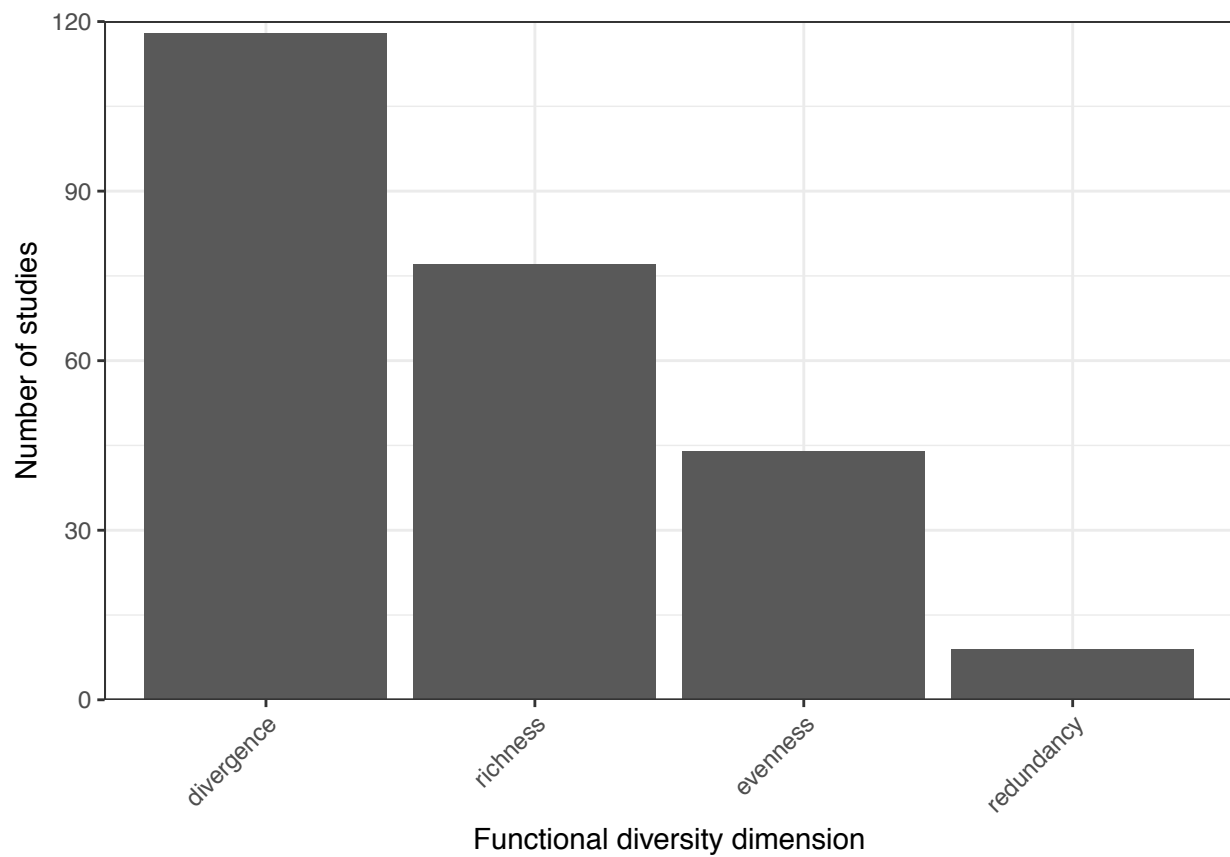
There have been a number of metrics that have been proposed in the past couple of years, but we don't know yet whether their use will spread. Some of the first-appearing metrics continue to dominate the current literature, i.e. FD, FRic.

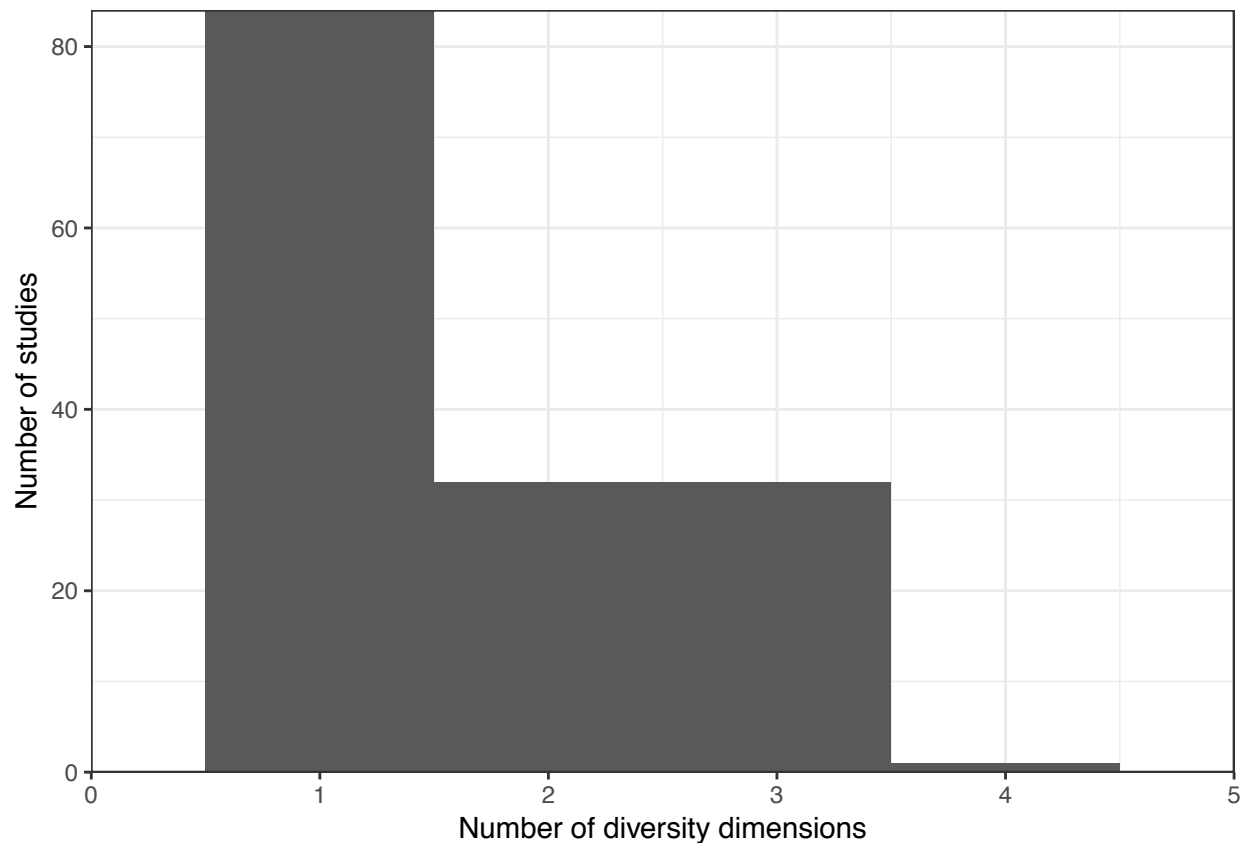


```
## [1] 2
## [1] 9
## [1] 2.020134
## [1] 72
## [1] 149
## [1] "48 % of studies use only 1 functional diversity metric"
## [1] "52 % of studies use >1 functional diversity metric"
## [1] "Of the studies that use only 1 FD metric, 35 % use Rao"
```

Each study typically includes 2 FD metrics (median value). 52% of studies use more than 1 FD metric. Of the studies that use only one FD metric, the majority (35%) use Rao.

3.5 Diversity dimensions





```
## [1] 84
## [1] 149
## [1] "56 % of studies use only 1 dimension of functional diversity, e.g. divergence, richness, etc."
## [1] "44 % of studies use >1 dimension of functional diversity, e.g. divergence, richness, etc."
## [1] 84
## [1] "Of the studies that use only 1 FD dimension, 67 % use divergence"
```

The majority of studies include FD metrics that examine functional divergence, followed in order by richness, evenness, and redundancy. Most studies look at just 1 dimension of diversity (56%), e.g. divergence, richness, etc. However, 84% of studies that use more than one FD metric, look at more than one dimension of diversity. Of the studies that look at only one dimension of diversity, 67% look at divergence.

```
## [1] "73 % of studies incorporate abundance into at least 1 of their functional diversity metrics"
```

Last, 73% of studies incorporate species abundance into at least 1 FD metric.

3.6 Multivariate method

```
## [1] "79 % of studies use only 1 multivariate method to calculate functional diversity, e.g. ordination"
## [1] "42 % of studies that use >1 FD metric, use >1 multivariate method for calculating functional diversity"
## [1] 32
## [1] 77
## [1] "Of the studies that use only 1 FD method, 50 % use ordination"
```



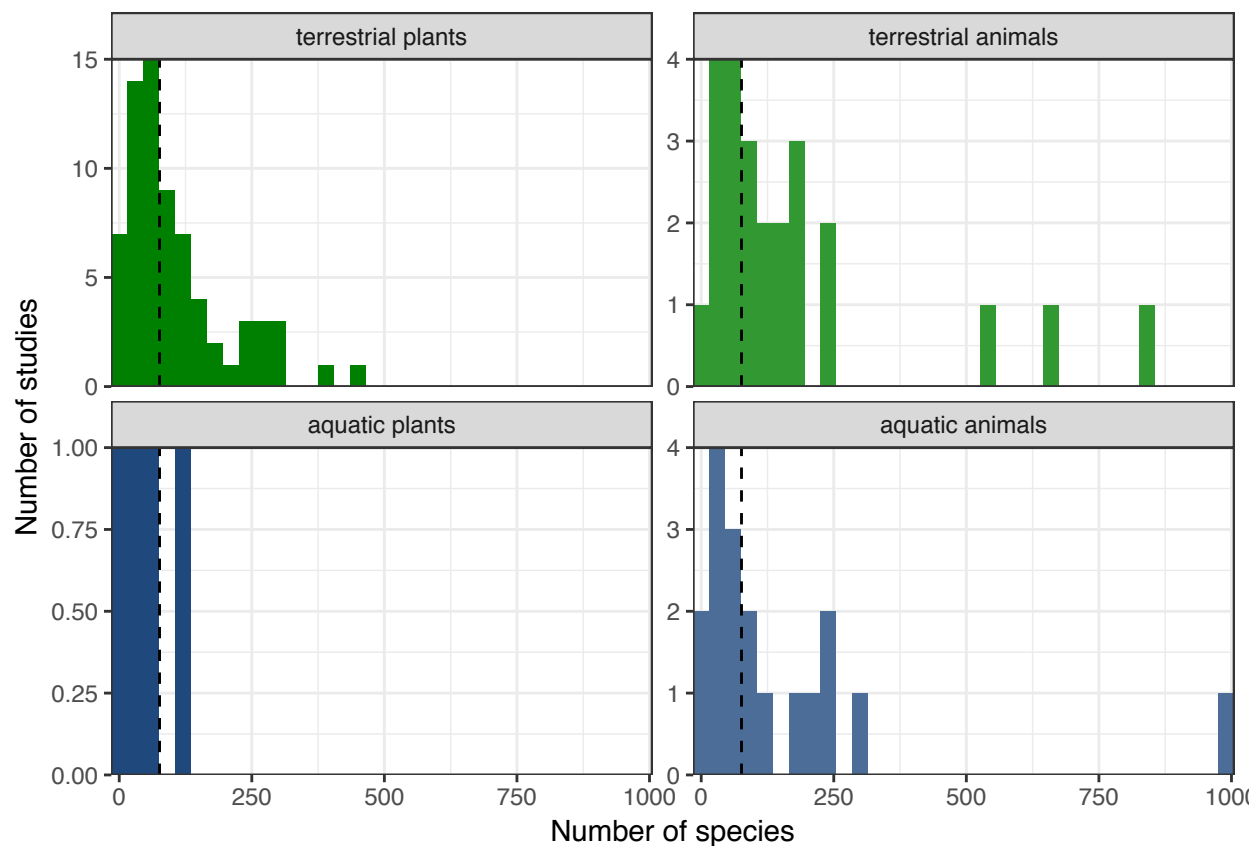
```
## CAT_multivarMethod nID
## 3      ordinate 58
## 2      distance-only 36
## 1      cluster 23
## [1] 117
```

The majority of studies use FD metrics that rely on ordination, followed by distance-only and cluster based methods. Most studies use only 1 multivariate method per study. Of the studies that present more than one FD metric, 58% use more than one multivariate method. Of the studies that use only one multivariate method (79), 50% use ordination.

4 Are there systematic differences in characterizing FD depending on the focal ecosystem or taxa? What are they?

4.1 Number of species

```
## sys1Grp n med min max
## 1 terrestrial plants 70 71.0 4 443
## 2 terrestrial animals 24 113.5 11 844
## 3 aquatic plants 4 31.5 6 124
## 4 aquatic animals 18 76.0 5 993
## 5 other 4 39.0 4 574
```

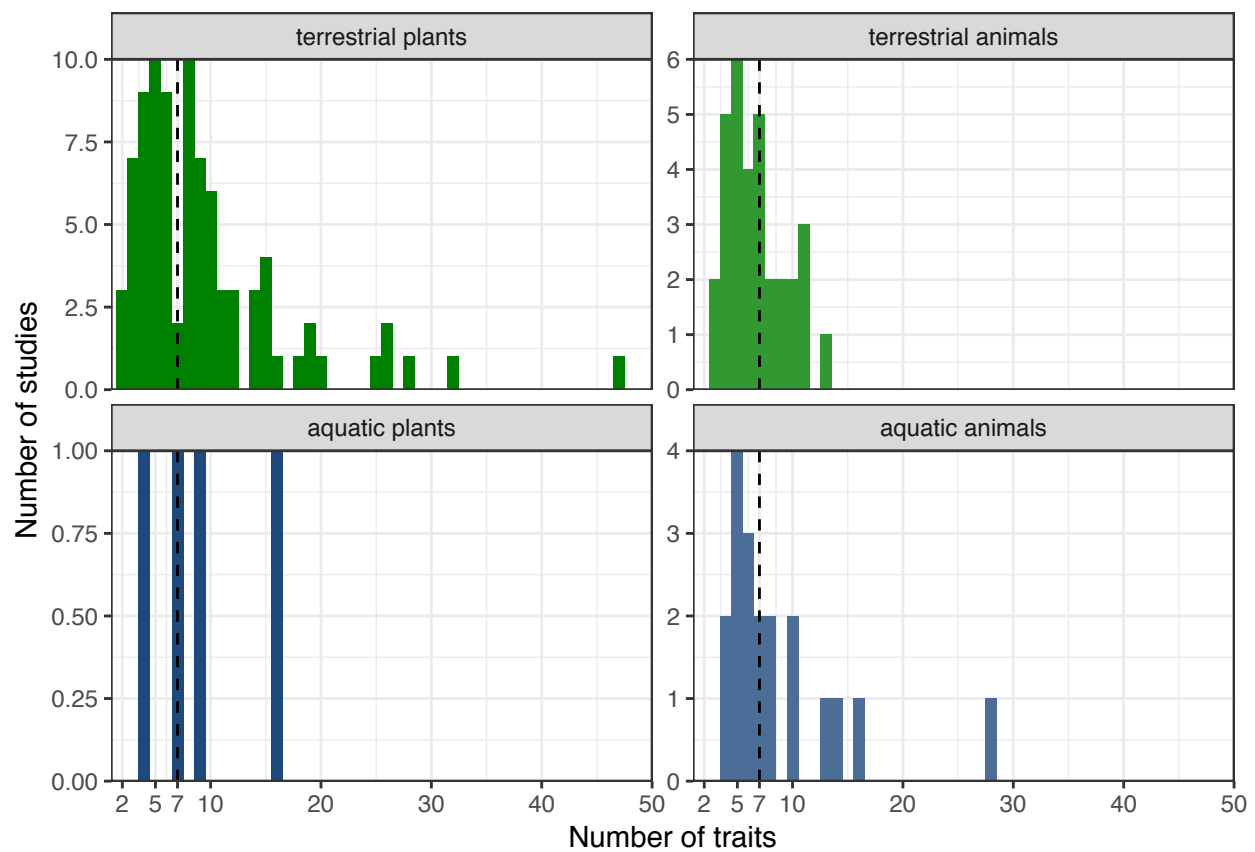


4.2 Number of traits

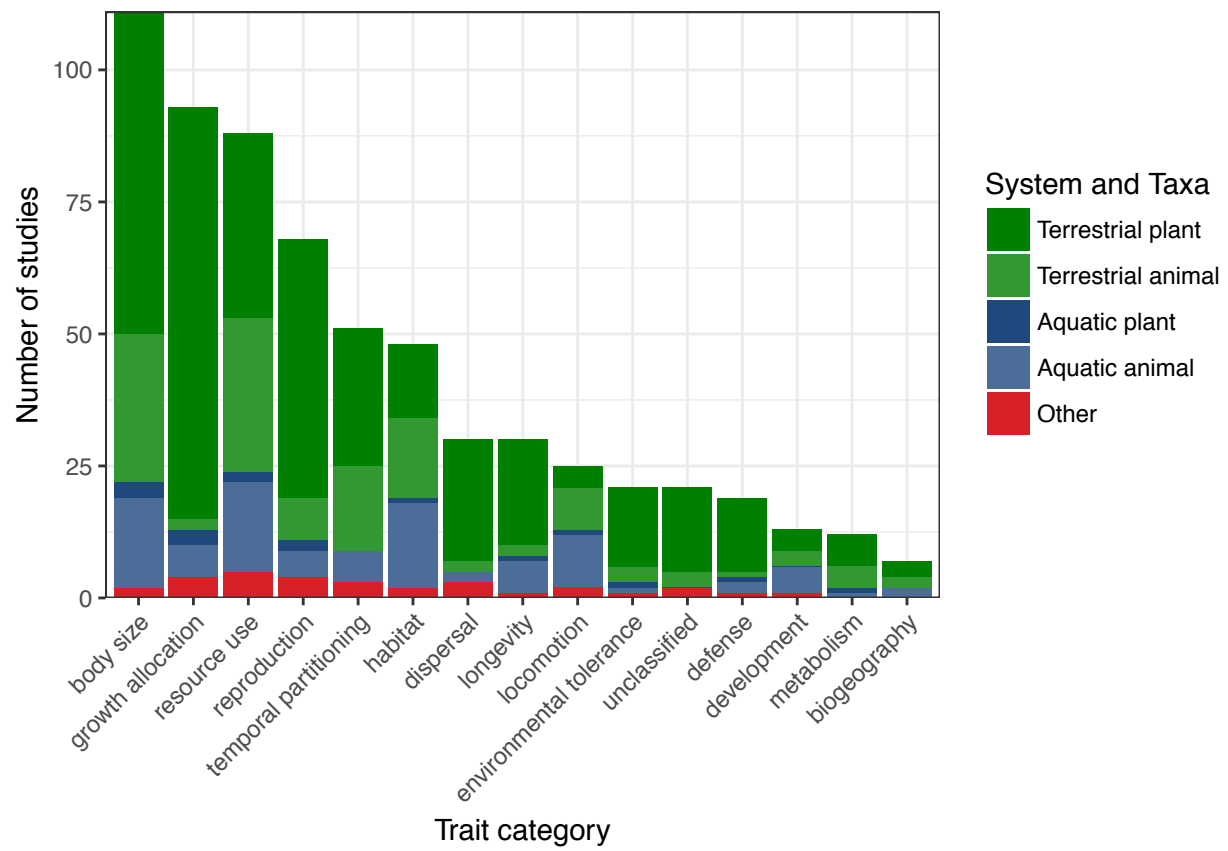
```
##          sys1Grp      mean med min max
## 1 terrestrial plants 9.551724  8  2  47
## 2 terrestrial animals 6.718750  6  3  13
## 3    aquatic plants 9.000000  8  4  16
## 4    aquatic animals 8.789474  7  4  28
## 5              other 7.714286  4  2  23
```

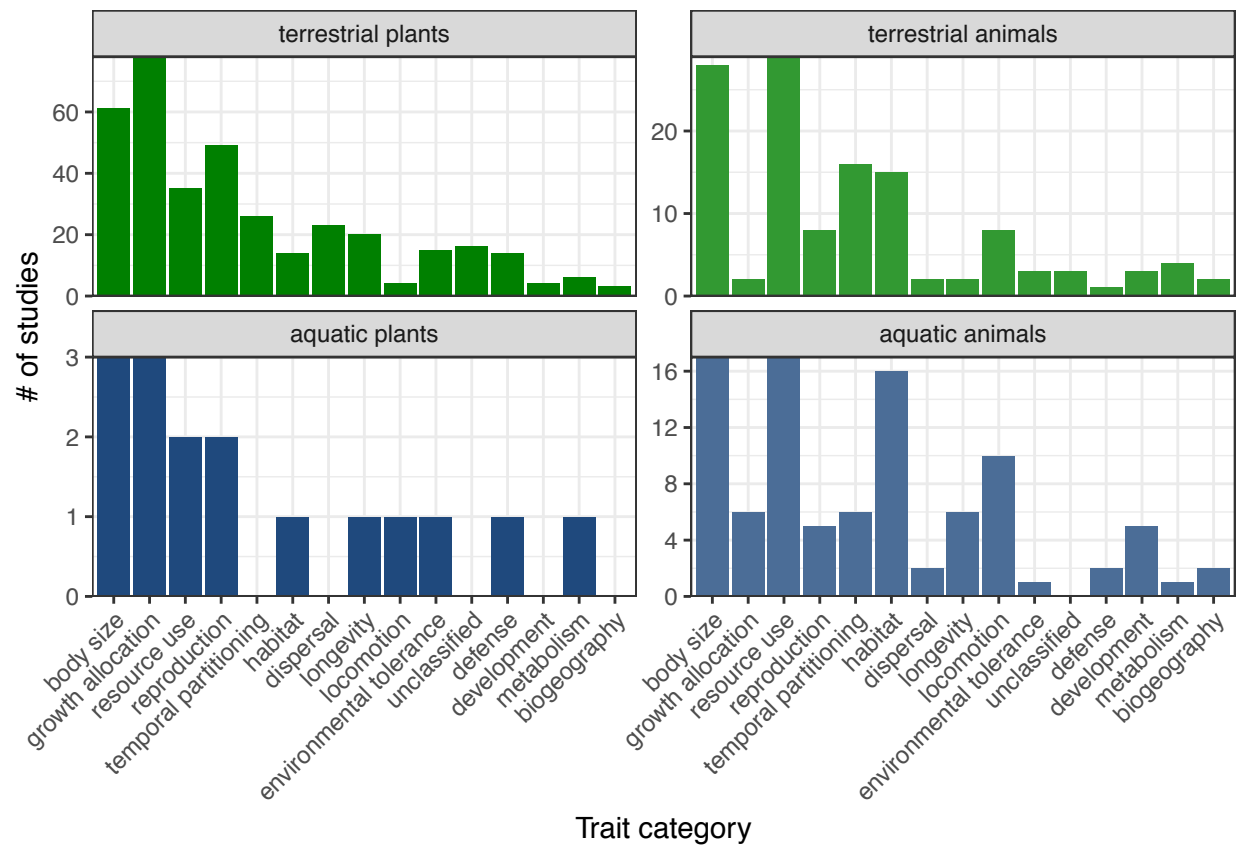
```
##    aquatic      mean med min max
## 1      no 8.730159   7  2  47
## 2     yes 8.826087   7  4  28
```

```
##    terrestrial      mean med min max
## 1        no 8.566667  6.5  2  28
## 2        yes 8.789916  7.0  2  47
```



4.3 Trait categories





##		sys1Grp	mean	med	min	max
## 1	terrestrial	plants	4.229885	4.0	1	10
## 2	terrestrial	animals	3.937500	4.0	1	8
## 3	aquatic	plants	4.000000	4.5	2	5
## 4	aquatic	animals	5.052632	4.0	3	8
## 5		other	4.428571	3.0	1	9

4.4 FD metrics

