

UNIVERSITY OF HELSINKI

FACULTY OF BIOLOGICAL AND ENVIRONMENTAL SCIENCES

# Measuring protection equality



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High-performance geocomputing workshop, CSC 2016

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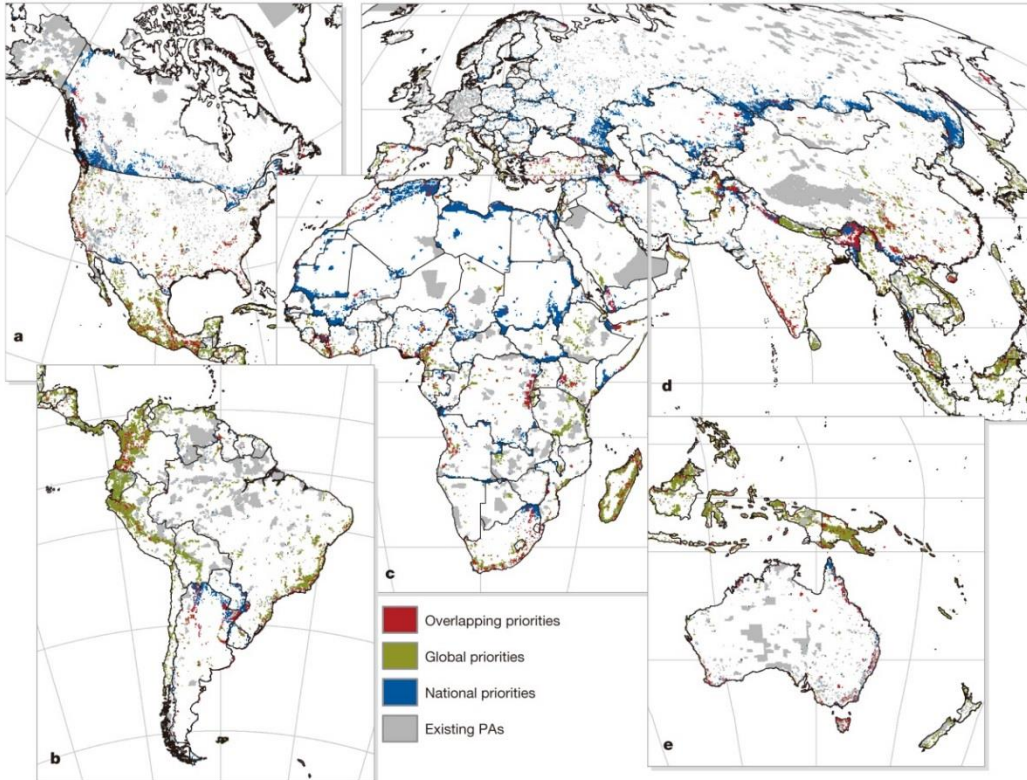
# Global scale conservation prioritization analyses



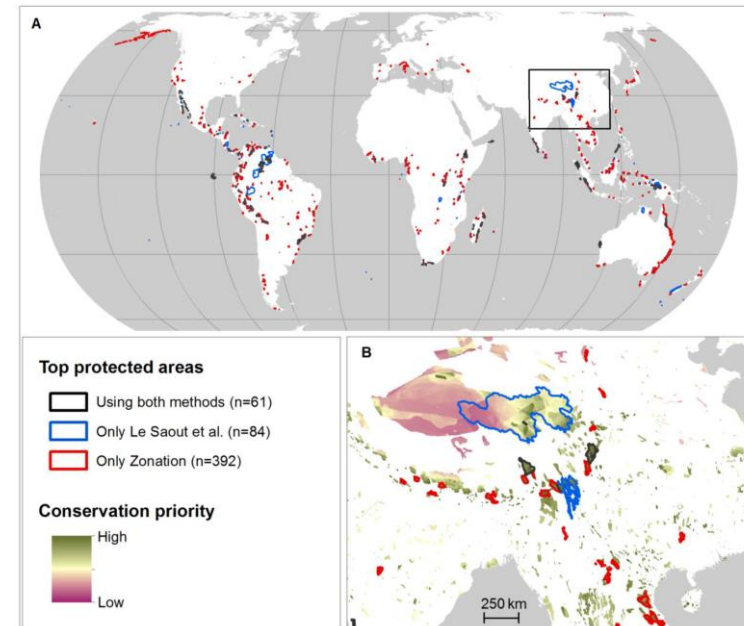
Prof. Atte  
Moilanen



Dr. Tuuli  
Toivonen



Pouzols et al. 2015

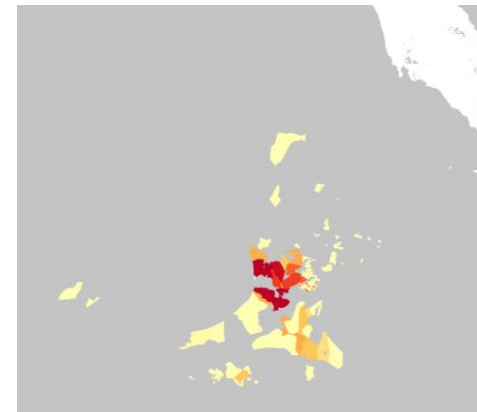
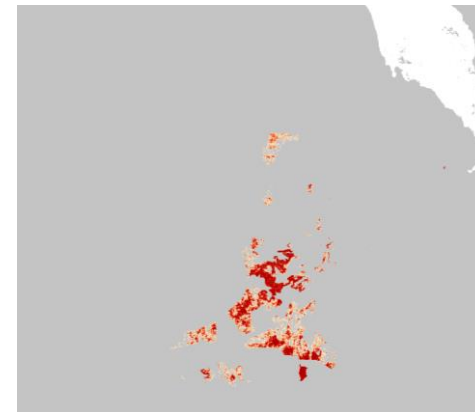
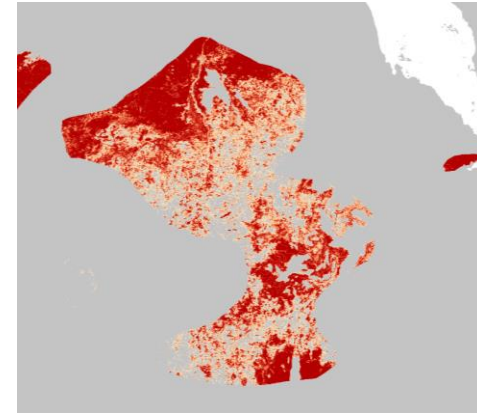


Kullberg et al. 2016

# Global scale conservation prioritization analyses

- Very large conservation prioritization analyses using Zonation software
  - Multipole large input data layers: > 20 000 rasters, > 200 000 000 pixels each
  - Single core long runs: 2 – 10 days
  - Lots of ram: 25- 250 GB
  - different parameter combinations > Array jobs on Taito
  - Parallel runs for processing input data

*Acomys cineraceus*



## AICHI TARGET 11:

“By 2020, at least **17 per cent of terrestrial** and inland water, and 10 per cent of coastal and marine areas ... are conserved through **effectively and equitably managed,** **ecologically representative** and **well connected** systems of protected areas ...”

CBD COP10 /2



# How could we measure representativeness of protected area networks?

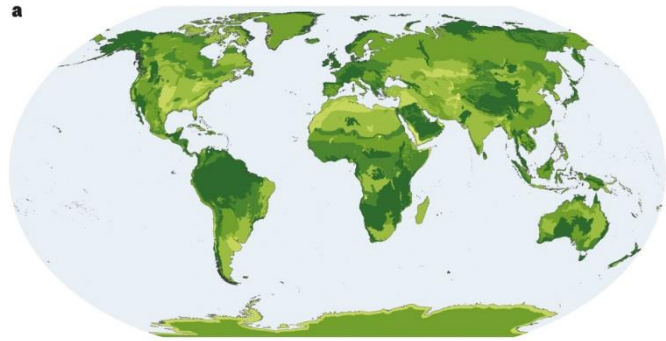


18,2

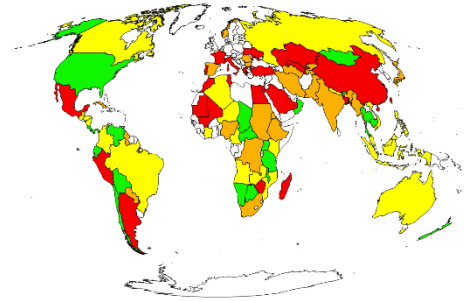
13,4

1,2

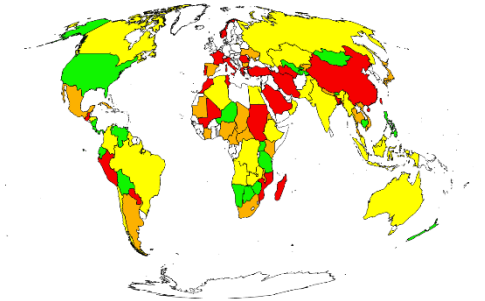
7,2



Proportion protected  
 0% <1% 1-5% 5-10% 10-17% >17%



a) Total protected



b) Mean protected

## REVIEW

doi:10.1038/nature13947

# The performance and potential of protected areas

James E. M. Watson<sup>1,2,3</sup>, Nigel Dudley<sup>1,4</sup>, Daniel B. Segan<sup>2,3</sup> & Marc Hockings<sup>1,5</sup>

Originally conceived to conserve iconic landscapes and wildlife, protected areas are now expected to achieve an increasingly diverse set of conservation, social and economic objectives. The amount of land and sea designated as formally protected has markedly increased over the past century, but there is still a major shortfall in political commitments to enhance the coverage and effectiveness of protected areas. Financial support for protected areas is dwarfed by the benefits that they provide, but these returns depend on effective management. A step change involving increased recognition, funding, planning and enforcement is urgently needed if protected areas are going to fulfil their potential.

The past few decades have seen protected areas undergo a pronounced expansion, geographically and conceptually. The collective decisions of governments, publicly funded bodies and local communities have created the rapid growth of protected areas throughout the world<sup>1</sup>; land and sea management has

### The protected area movement

Protected areas are not a modern concept. In different forms, they have been around for millennia, whether they are sacred sites guarded by indigenous communities, 'tapu' areas for communal resource use in the Pacific island region or hunting areas set aside to benefit the ruling

Watson et al. 2014 Nature 515

OPEN ACCESS Freely available online

PLOS one

# A New Way to Measure the World's Protected Area Coverage

Lissa M. Barr<sup>1\*</sup>, Robert L. Pressey<sup>2</sup>, Richard A. Fuller<sup>1,3</sup>, Daniel B. Segan<sup>1</sup>, Eve McDonald-Madden<sup>1,3</sup>, Hugh P. Possingham<sup>1</sup>

<sup>1</sup> School of Biological Sciences, University of Queensland, Brisbane, Australia, <sup>2</sup> Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, <sup>3</sup> CSIRO Climate Adaptation Flagship and CSIRO Ecosystem Sciences, Dutton Park, Australia

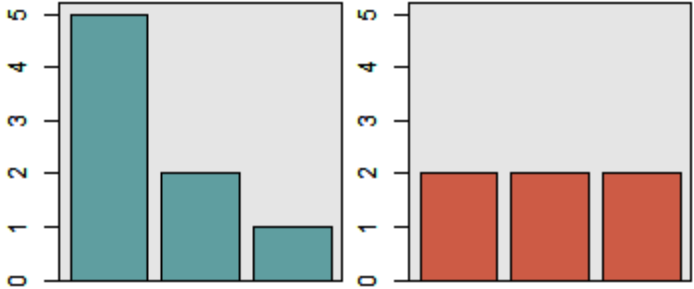
## Abstract

Protected areas are effective at stopping biodiversity loss, but their placement is constrained by the needs of people. Consequently protected areas are often biased toward areas that are unattractive for other human uses. Current reporting metrics that emphasise the total area protected do not account for this bias. To address this problem we propose that the distribution of protected areas be evaluated with an economic metric used to quantify inequality in income—the Gini coefficient. Using a modified version of this measure we discover that 73% of countries have inequitably protected their biodiversity and that common measures of protected area coverage do not adequately reveal this bias. Used in combination with total percentage protection, the Gini coefficient will improve the effectiveness of reporting on the growth of protected area coverage, paving the way for better representation of the world's biodiversity.

Citation: Barr LM, Pressey RL, Fuller RA, Segan DB, McDonald-Madden E, et al. (2011) A New Way to Measure the World's Protected Area Coverage. PLoS ONE 6(9): e25222. doi:10.1371/journal.pone.025222

Barr et al. 2011 PLOSone

# Ecological representativeness = conservation evenness



generalized diversity

$${}^qD(p) = \sum \frac{1}{\sqrt[q-1]{\sum p_i p_i^{q-1}}}$$

Quantify biodiversity:  
 - Ecoregions  
 - Species ranges

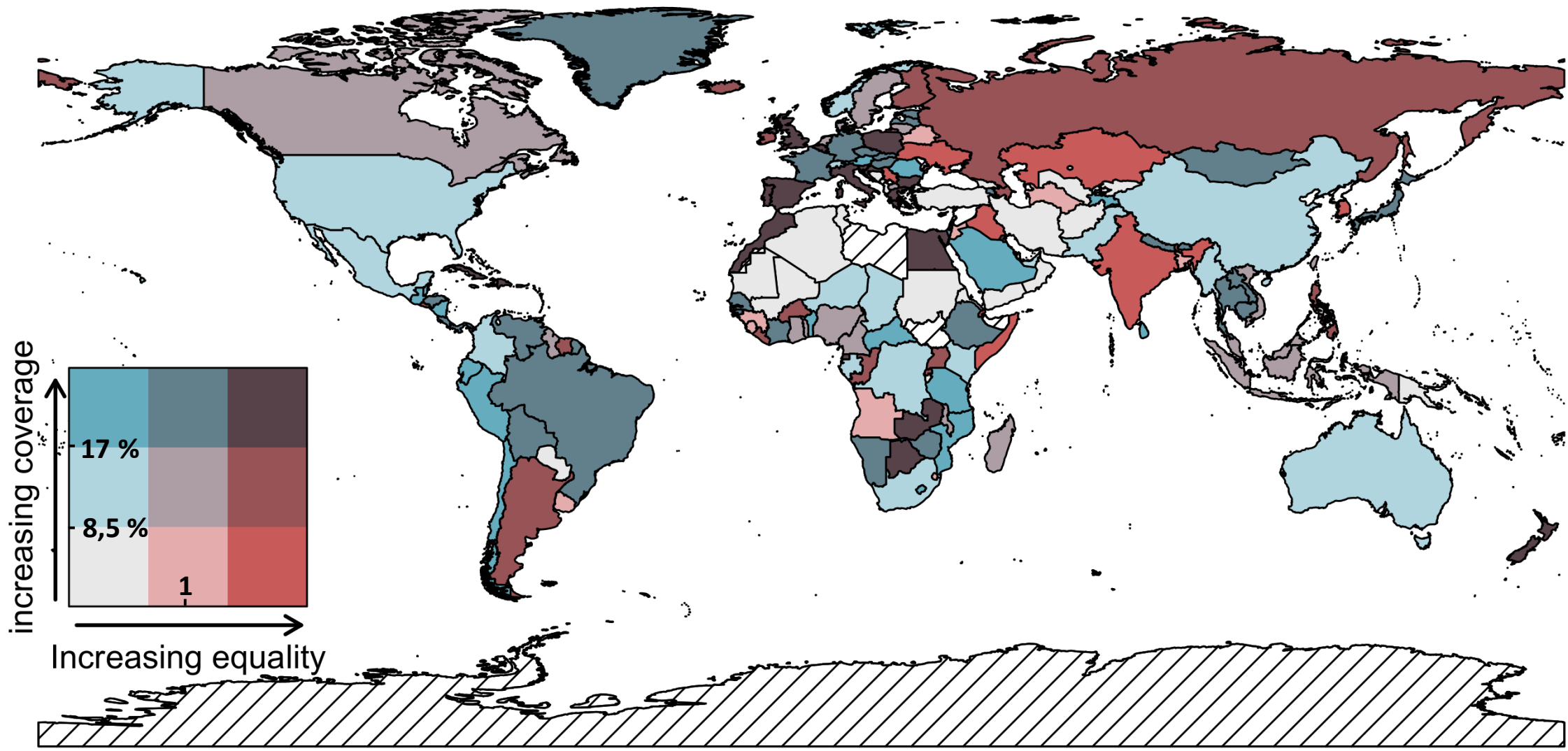
Evenness metric:  
 - Generalized diversity  
 - Different q-values

Measuring evenness of protection over selected features

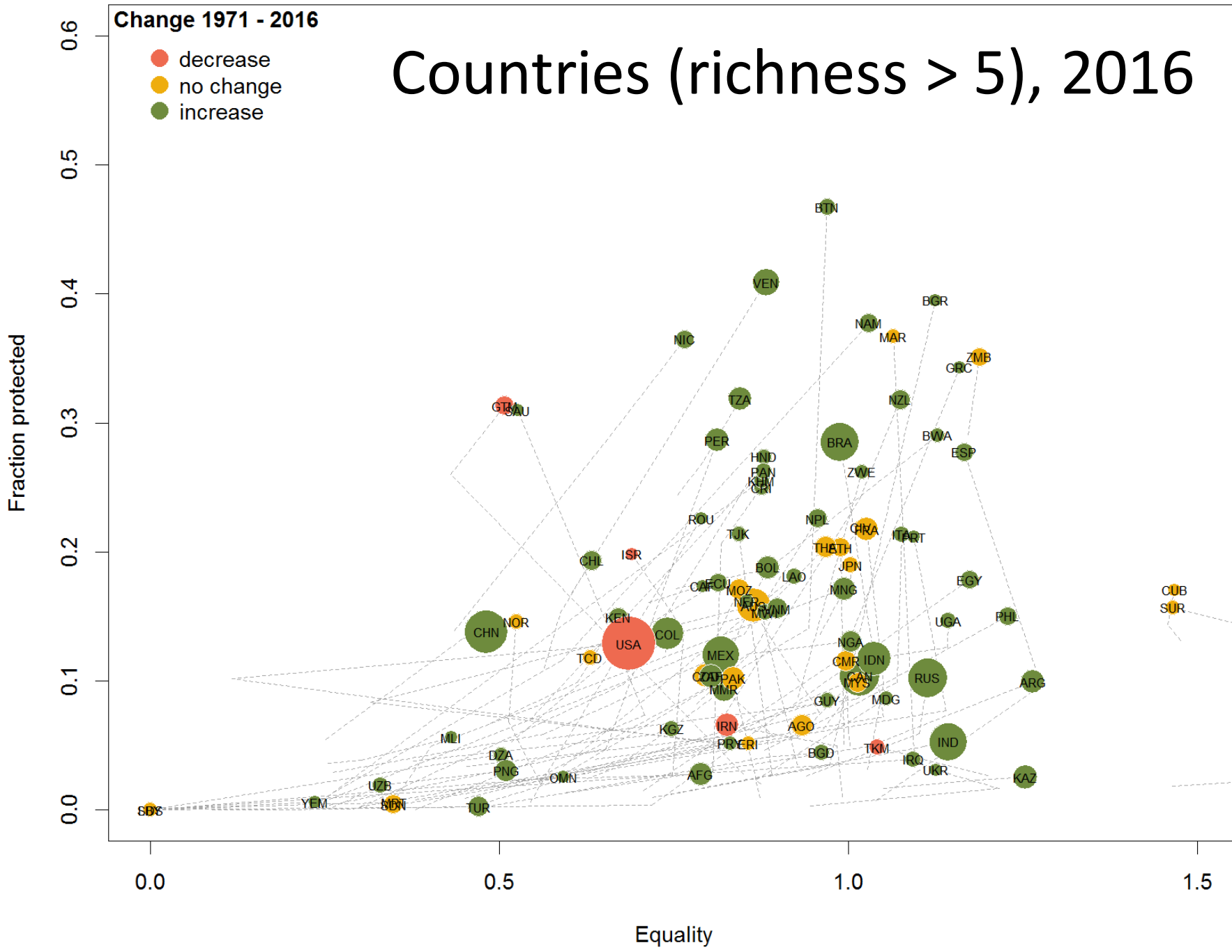
PAs > **0,4**

Total > **0,8**

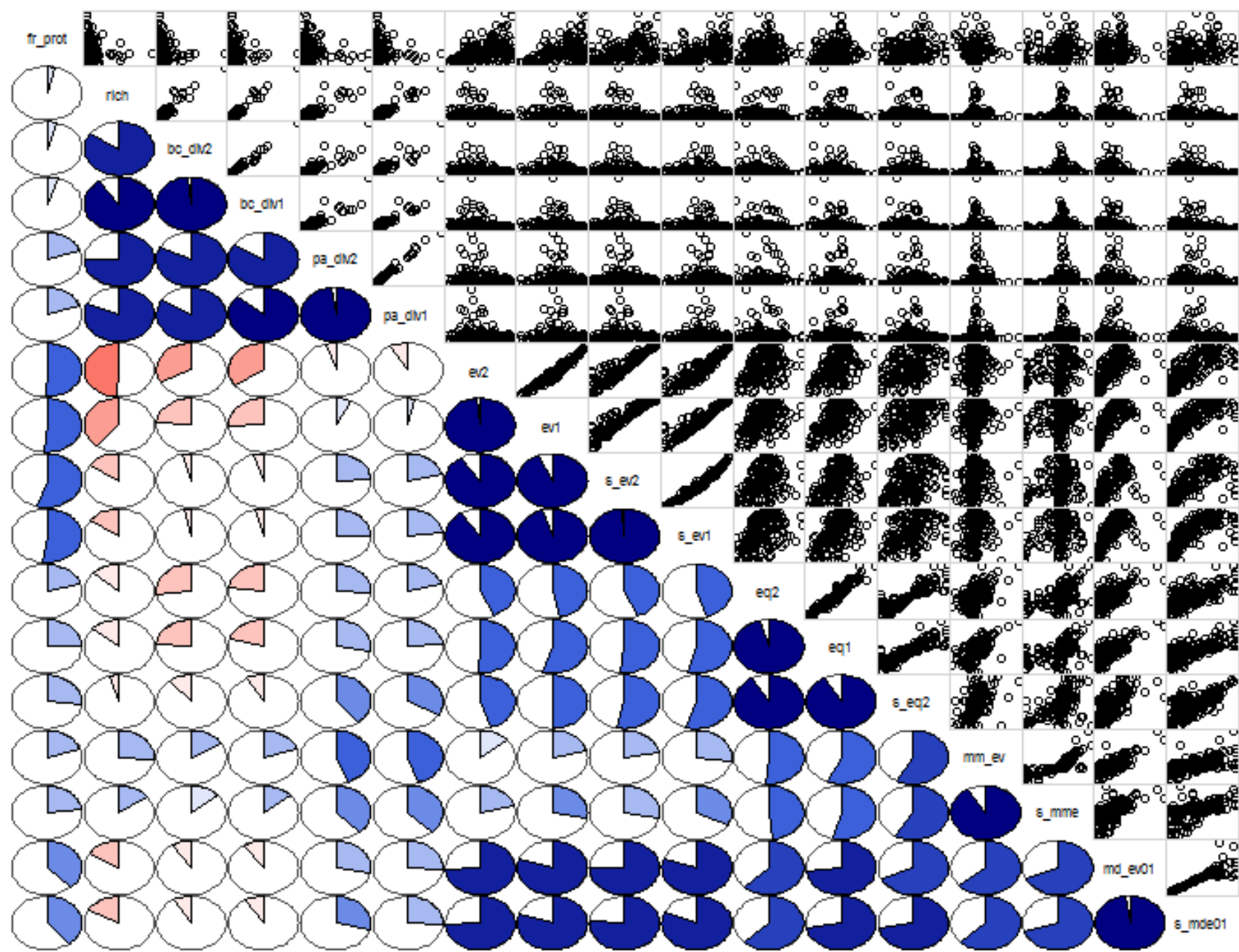
Diversity fraction > **0,5**



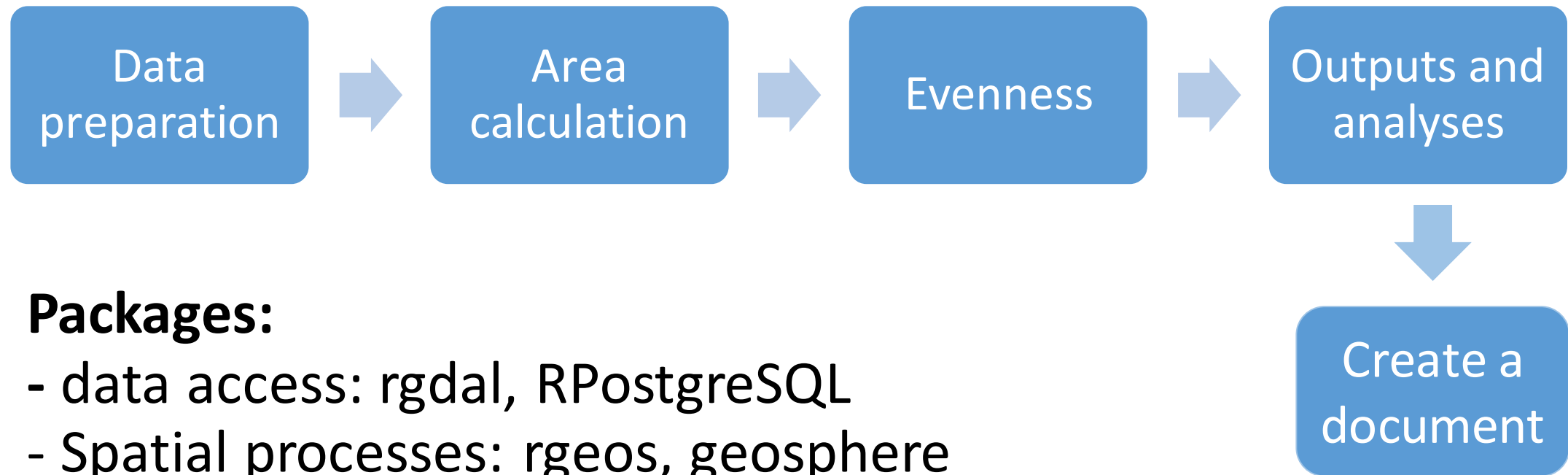




	Median country	
	Cov	Equality
1971	0.027	0.624
1992	0.074	0.865
2016	0.153	0.881



# R implementation



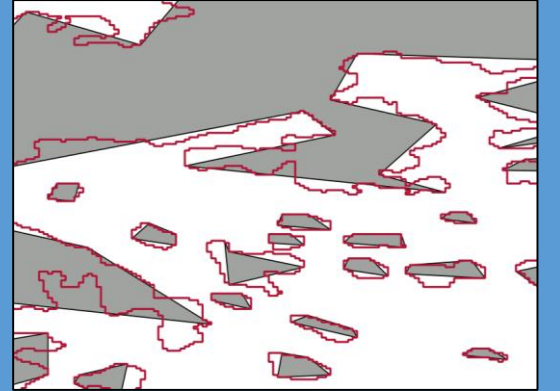
## **Packages:**

- data access: rgdal, RPostgreSQL
- Spatial processes: rgeos, geosphere
- parallelization: foreach, doParallel (doMPI)
- Creating document: Rmarkdown, Panzer, knitr
- And many more for visualization and analyses

# Data and preprocessing

## “EASY DATA”:

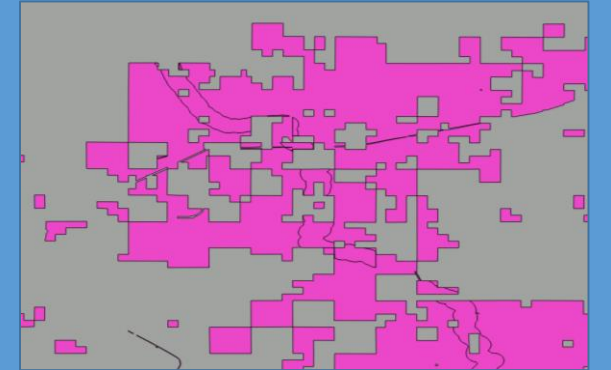
- 1) GADM – country borders: level 0
  - 2) WWF ecoregions
  - 3) Species range maps
- `gBuffer(Ecor_clean, byid=TRUE, width=0)`
  - `ST_simplify(geog, 0.05)` (in PostGIS)



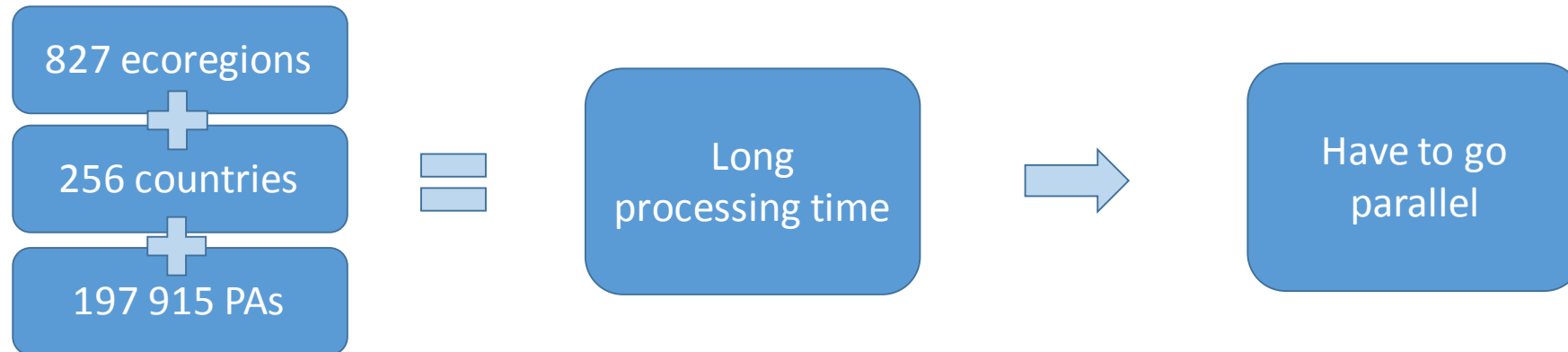
## “DIFFICULT DATA”:

WDPA – World Database on Protected Areas

- `tryCatch(gIsValid(Ecor), error = function(e) FALSE)`



# Parallelization and PostGIS



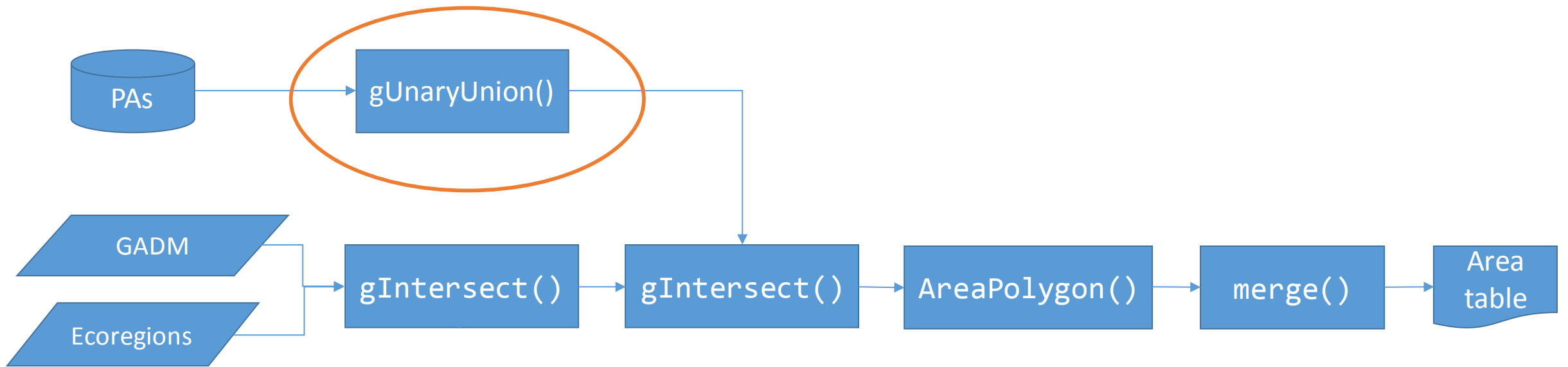
Foreach with doParallel backend:

```
registerDoParallel(cores = 30)
E_area <- foreach(hex_i = country_list, .combine = rbind,
  .errorhandling = "remove", .packages = c("raster", "rgeos", "sp",
    "geosphere", "RPostgreSQL")) %dopar% {
  Hexa_Ecor_cover_par(hex_i, Ecor_clean_fix, quer = "SELECT wdpaid,
geog FROM wdpa.wdpa_poly WHERE marine <> '2' AND status =
'Designated'") }
```

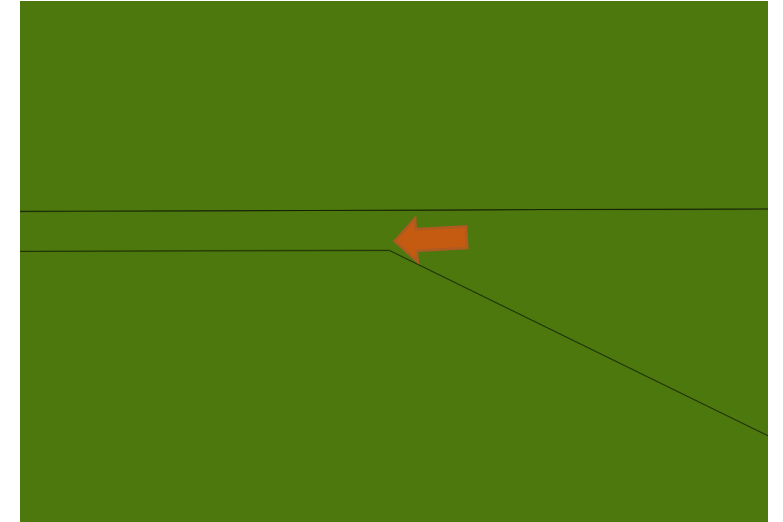
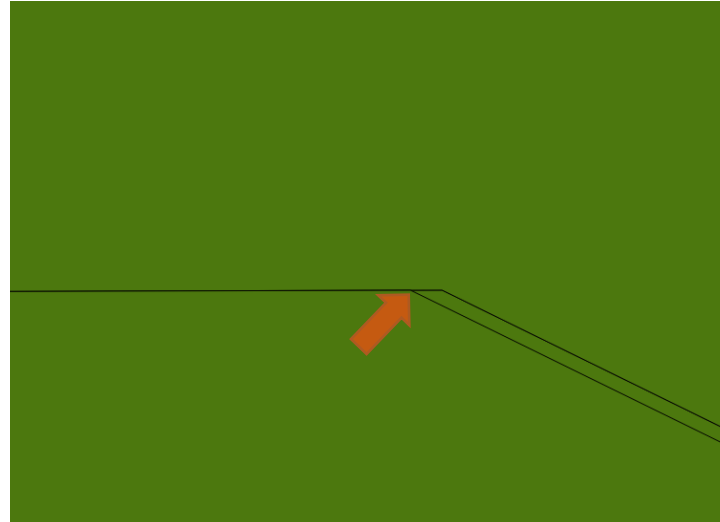
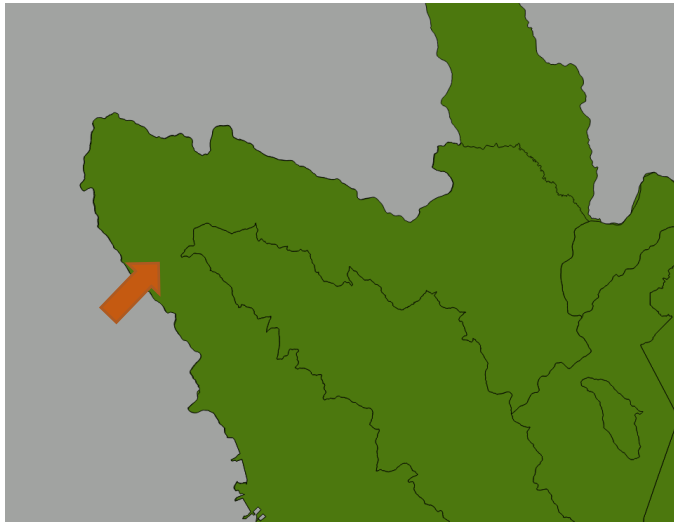
# Subset polygons: RPostgreSQL and rgdal

```
read_PA <- function(window, query) {  
  c_ISO <- as.character(window@data$ISO)  
  
  #Set connection and query  
  drv <- dbDriver('PostgreSQL')  
  con <- dbConnect(drv, dbname = "gis", host = "localhost", port = 5432,  
  user = "user", password = "password")  
  sql <- paste(query, "AND ISO3= '", c_ISO, "'", sep="")  
  dsn <- "PG: dbname='gis' host='localhost' port='5432' user='user'  
  password = 'password'"  
  
  # Create a view with selected PAs  
  read_ogr_pa_temp <- gsub("/", "", tempfile("read_ogr_pa_", tmpdir = ""),  
  fixed = T)  
  CreateView_sql = paste("CREATE VIEW", read_ogr_pa_temp, "AS", sql)  
  dbSendQuery(con, CreateView_sql)  
  
  # read data and close connection  
  PA_data = readOGR(dsn = dsn, layer = read_ogr_pa_temp)  
  dbSendQuery(con, paste("DROP VIEW", read_ogr_pa_temp, ";"))  
  dbDisconnect(con)  
  return(PA_data)  
}
```

# Calculating areas



Error: TopologyException: found non-noded intersection between LINESTRING (-74.0824 -11.3561, -74.0829 -11.3561) and ...





# A dirty fix – but it works:

## Precision reduction loop:

```
setScale(1e+15)
while ((!exists("UPAs") | !Robust_gIsValid(UPAs, c_location)) &
      getScale() > 10000) {
  setScale(getScale()/10)
  tryCatch(UPAs <- gUnaryUnion(PAs_in))
}
```

## And the dirty buffer fix:

```
if (exists("UPAs") & !Robust_gIsValid(UPAs, c_location))
  UPAs <- gBuffer(UPAs, width = 0)
}
```

Diversity fraction can be used to describe the representativeness of a protected area network

**BUT**

No single true and “right” measure;  
Data quality sets limits

**BUT**

Metric as a boundary object; Helps to define targets and actions