# PriorCon Tool

A tool-set that incorporates graph community detection methods into systematic conservation planning.


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UKRI

MarinePlan

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MarinePlan Final Event| Online, 29-30 September 2025

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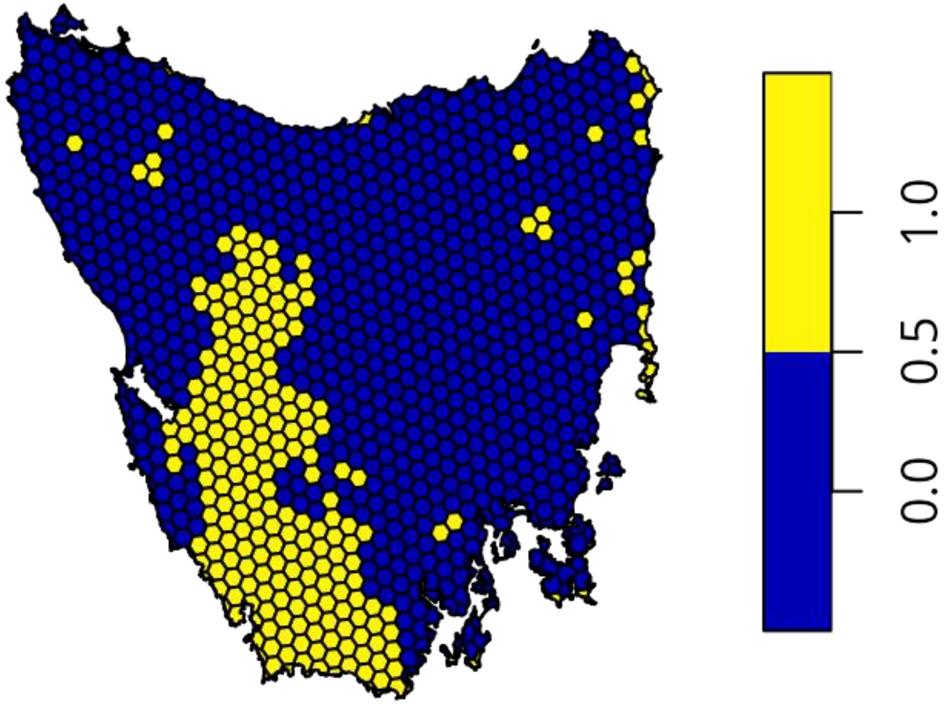
# R package : Prioritization & Graphs

# Prioritization & Graphs

Prioritizr
Example

Protected area coverage



# Prioritization & Graphs

**Min set objective**

This objective can be expressed mathematically for a set of planning units ($I$ indexed by $i$) and a set of features ($J$ indexed by $j$) as:

Protect the features (e.g. 17%)

$$\mathit{Minimize} \sum_{i=1}^{I} x_i c_i$$

$$\mathit{subject\ to}$$

$$\sum_{i=1}^{I} x_i r_{ij} \geq T_j \; \forall \; j \in J$$

Minimizing the cost

Here, $x_i$ is the decisions variable (e.g., specifying whether planning unit $i$ has been selected (1) or not (0)), $c_i$ is the cost of planning unit $i$, $r_{ij}$ is the amount of feature $j$ in planning unit $i$, and $T_j$ is the target for feature $j$. The first term is the objective function and the second is the set of constraints. In words this says find the set of planning units that meets all the representation targets while minimizing the overall cost.

# Prioritization & Graphs

**Max utility objective**

This objective can be expressed mathematically for a set of planning units ($I$ indexed by $i$) and a set of features ($J$ indexed by $j$) as:

$$\mathit{Maximize} \sum_{i=1}^{I} -s\ c_i\ x_i + \sum_{j=1}^{J} a_j w_j$$

$$\mathit{subject\ to}$$

$$a_j = \sum_{i=1}^{I} x_i r_{ij}\ \forall j \in J$$

$$\sum_{i=1}^{I} x_i c_i \leq B$$

Maximize the utility (features)

Under a budget constrain (e.g. 1mln)

Here, $x_i$ is the decisions variable (e.g., specifying whether planning unit $i$ has been selected (1) or not (0)), $r_{ij}$ is the amount of feature $j$ in planning unit $i$, $A_j$ is the amount of feature $j$ represented in in the solution, and $w_j$ is the weight for feature $j$ (defaults to 1 for all features; see `add_feature_weights()` to specify weights). Additionally, $B$ is the budget allocated for the solution, $c_i$ is the cost of planning unit $i$, and $s$ is a scaling factor used to shrink the costs so that the problem will return a cheapest solution when there are multiple solutions that represent the same amount of all features within the budget.

# Prioritization & Graphs

fragmentation

Test Shiny PrioritizeR

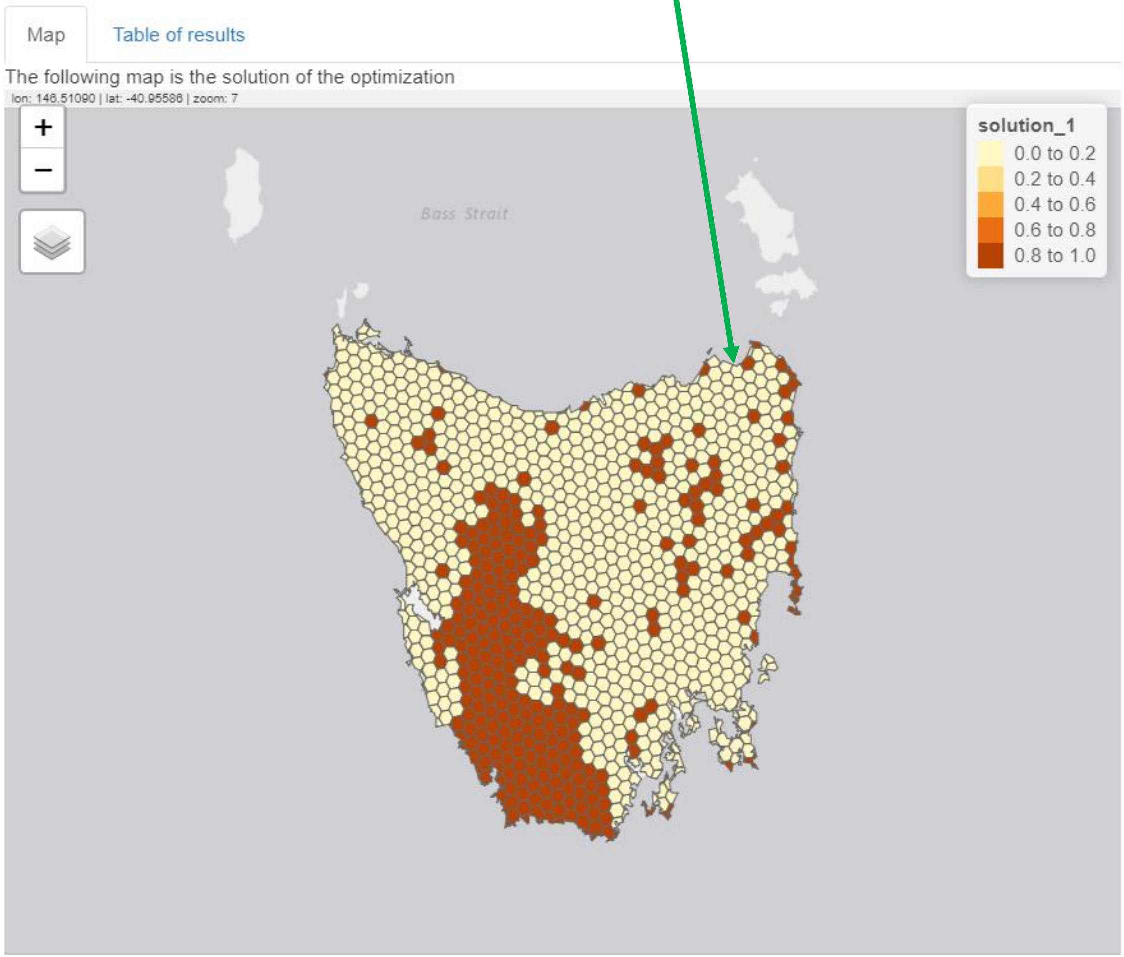
**Set Parameters**

penalty to reduce fragmentation

0.00

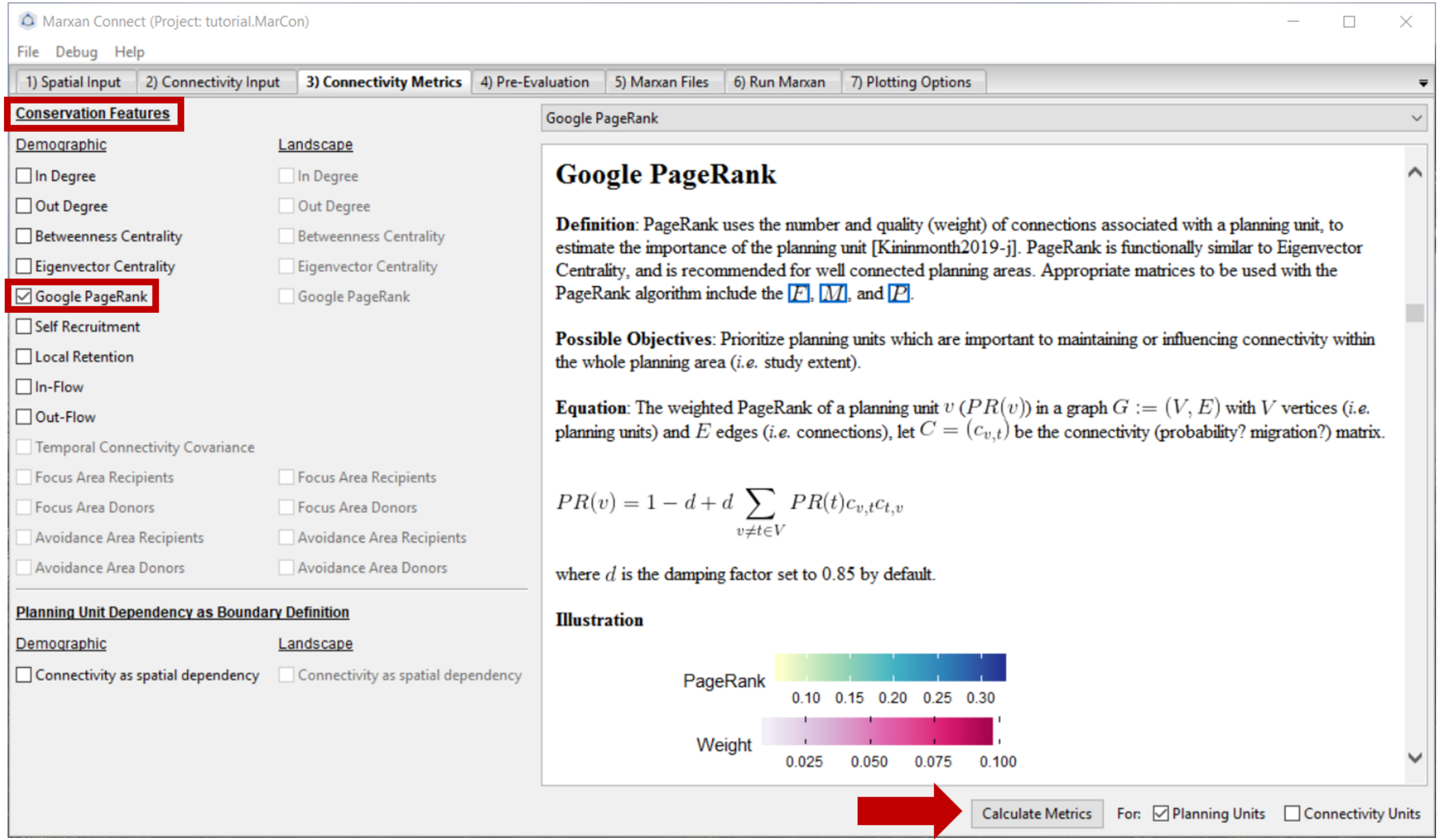
we specify targets to ensure at least 17% of the spatial extent of each vegetation community

0.17




The features are protected, but they are not connected!

# Prioritization & Graphs




Marxan Connect

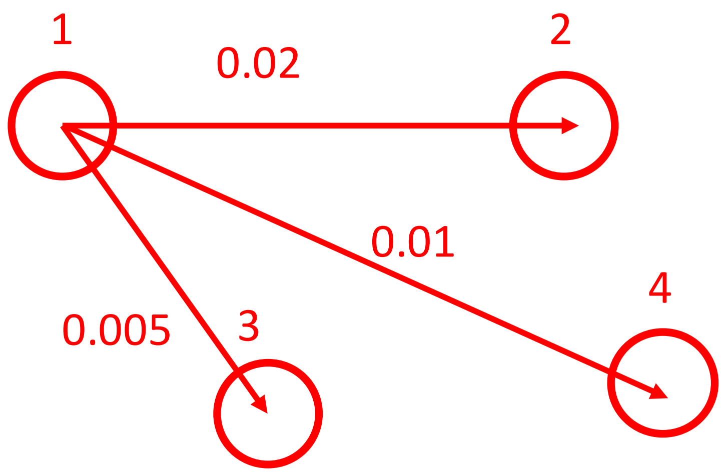
# Prioritization & Graphs

Matrix

| | 1 | 2 | 3 | 4 | ... |
|---|---|---|---|---|---|
| 1 | 0.1 | 0.02 | 0.005 | 0.01 | ... |
| 2 | 0.006 | 0.2 | 0.007 | 0.009 | ... |
| 3 | 0.01 | 0.003 | 0.25 | 0.02 | ... |
| 4 | 0.022 | 0.017 | 0.001 | 0.2 | ... |

Edge list

| id1 | id2 | value |
|---|---|---|
| 1 | 1 | 0.1 |
| 1 | 2 | 0.02 |
| 1 | 3 | 0.005 |
| 1 | 4 | 0.01 |
| ... | ... | ... |



# Prioritization & Graphs

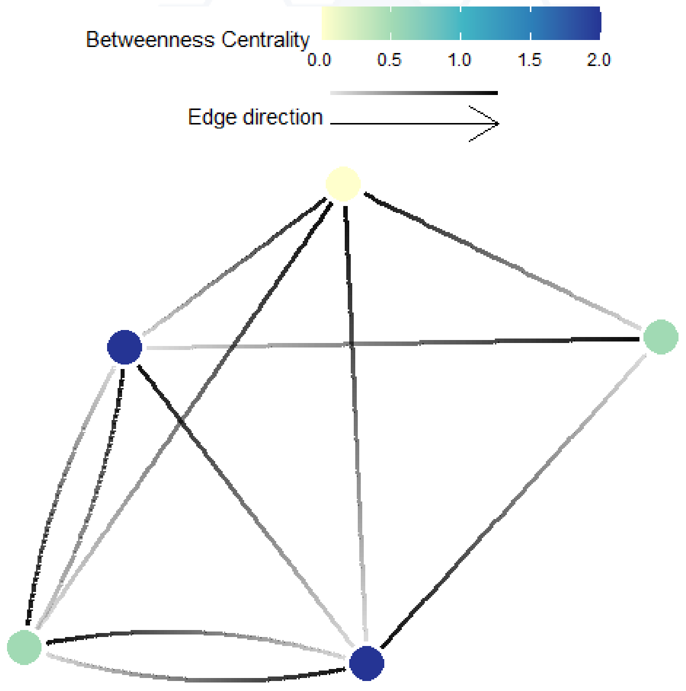
**Equation:** The betweenness centrality of a planning unit $v$ ($BC(v)$) in a graph $G := (V, E)$ with $V$ vertices (*i.e.* planning units) and $E$ edges (*i.e.* connections) is

$$BC(v) = \sum_{s \neq v \neq t \in V} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

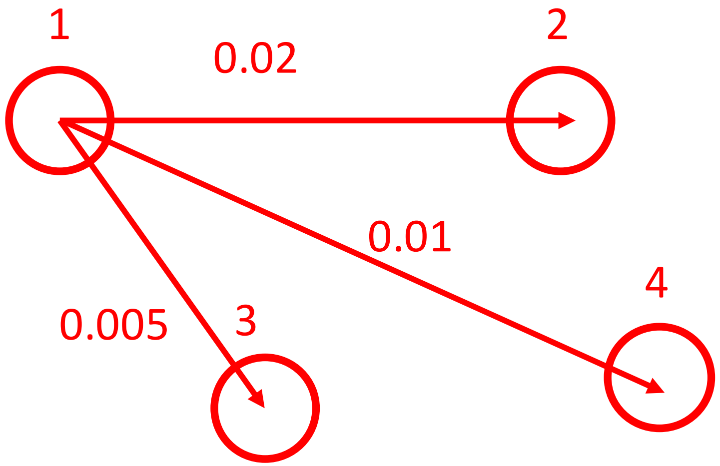


where $\sigma_{st}$ is total number of shortest paths from planning unit $s$ to planning unit $t$ and $\sigma_{st}(v)$ is the number of those paths that pass through $v$.

**Illustration**

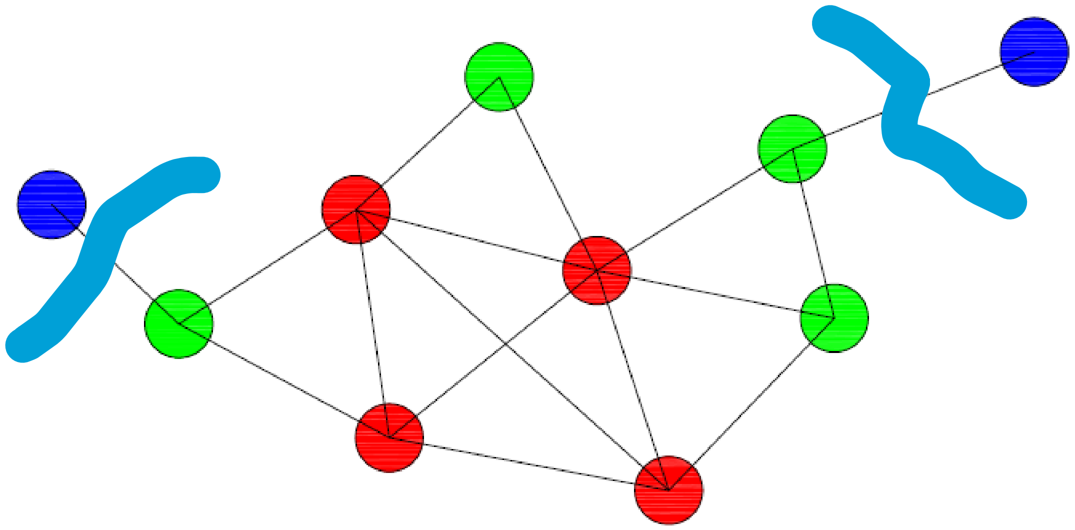



Betweenness Centrality



# Prioritization & Graphs

Community detection

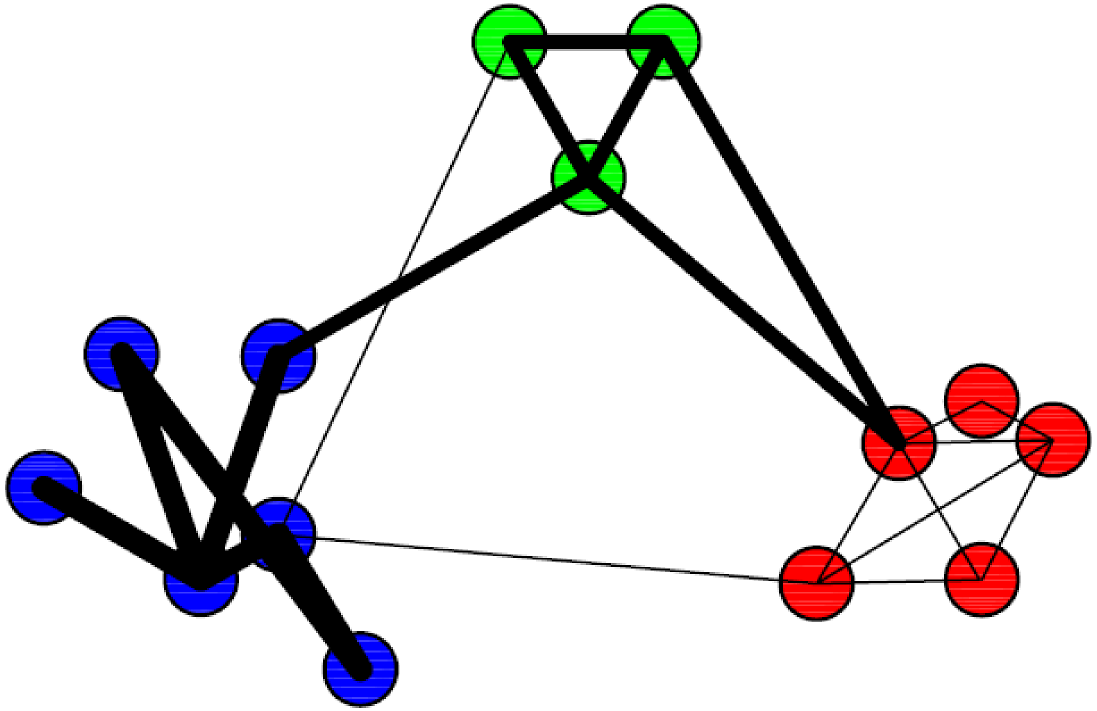


k-core graph. The nodes represent planning units and the edges features’ connections. The blue nodes belong to core k=1, the green nodes to core k=2 and the red nodes to core k=3. Every node of each core has a degree of at least k.

S-core decomposition

S-core operates similarly to k-core, but handles weights as well

# Prioritization & Graphs



A graph with 3 clusters (blue red and green). The nodes represent planning unitsThe widths of the edges represent the weights of the edges. The weighted edges represent connections. The cardinality of the blue cluster is 6, the cardinality of the red cluster is 5 and the cardinality of the green cluster is 3.

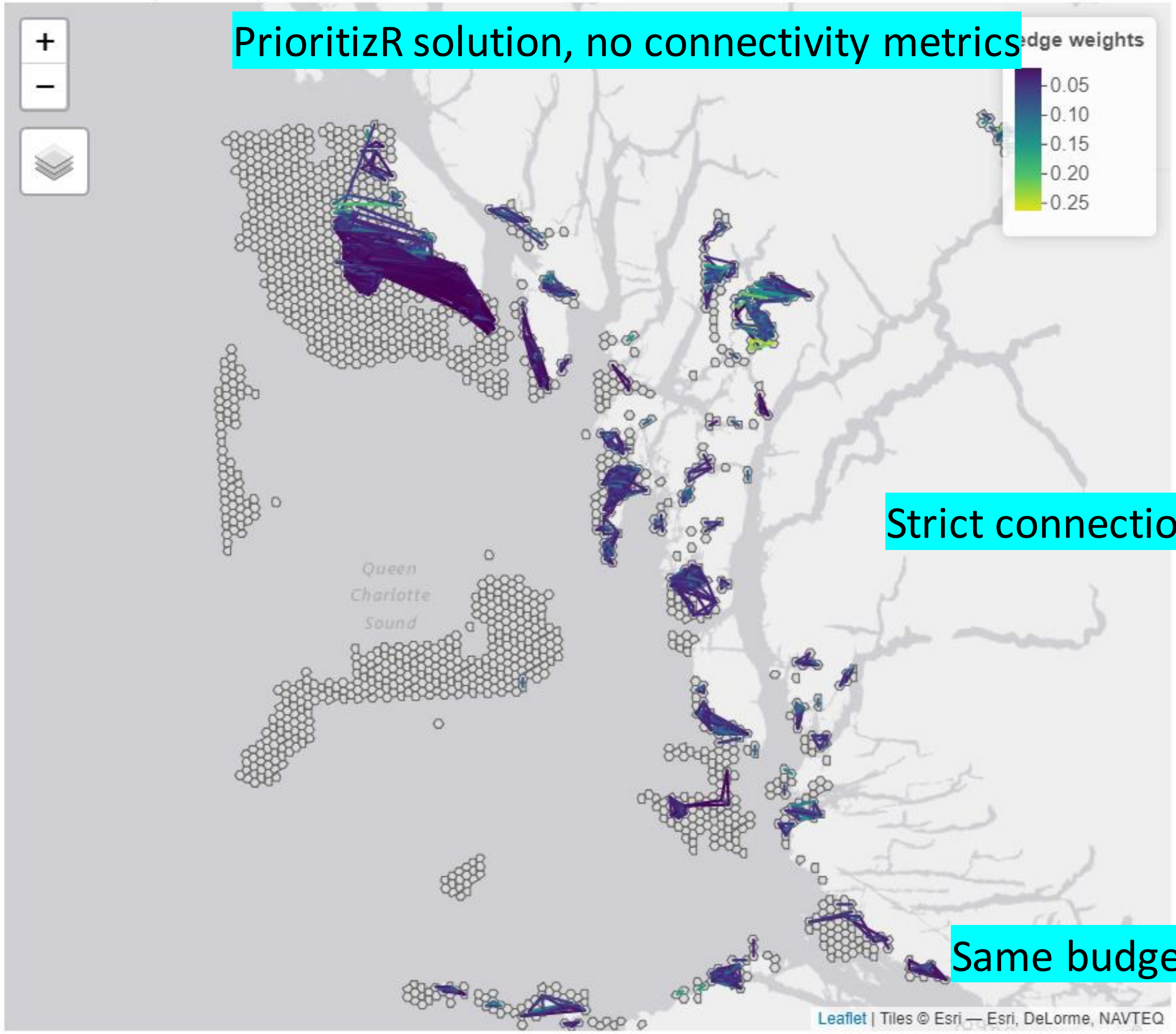
Graph Clustering

➔ Louvain Algorithm:
Maximizes cluster's modularity

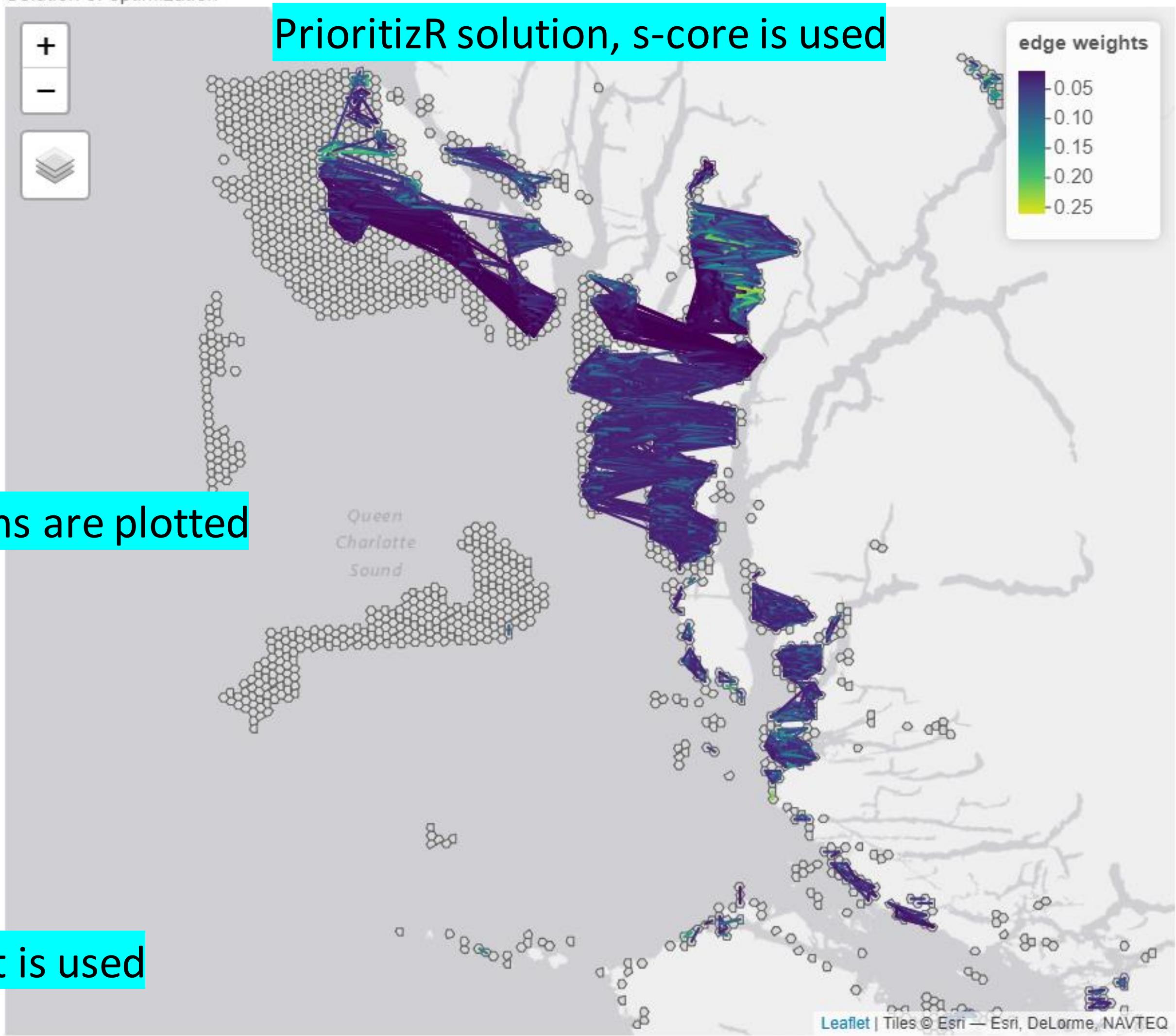
➔ Walktrap Algorithm:
Random walks in the graph

# Prioritization & Graphs

PrioritizR solution, no connectivity metrics



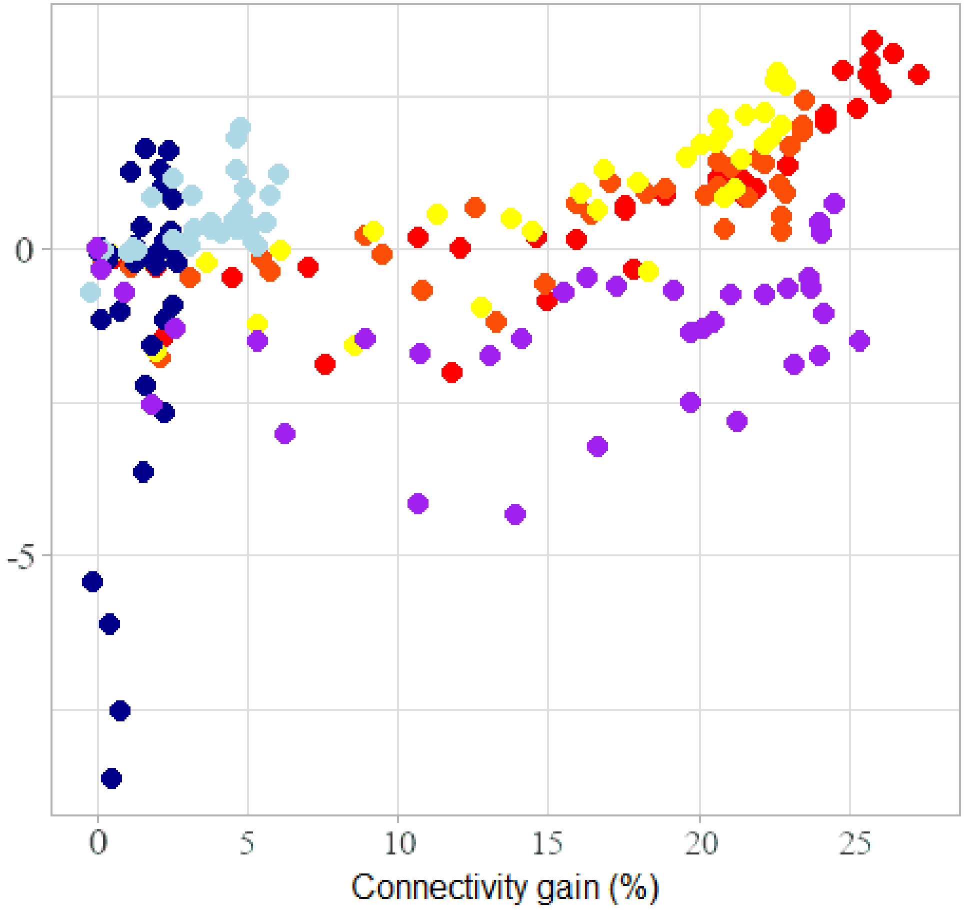

PrioritizR solution, s-core is used

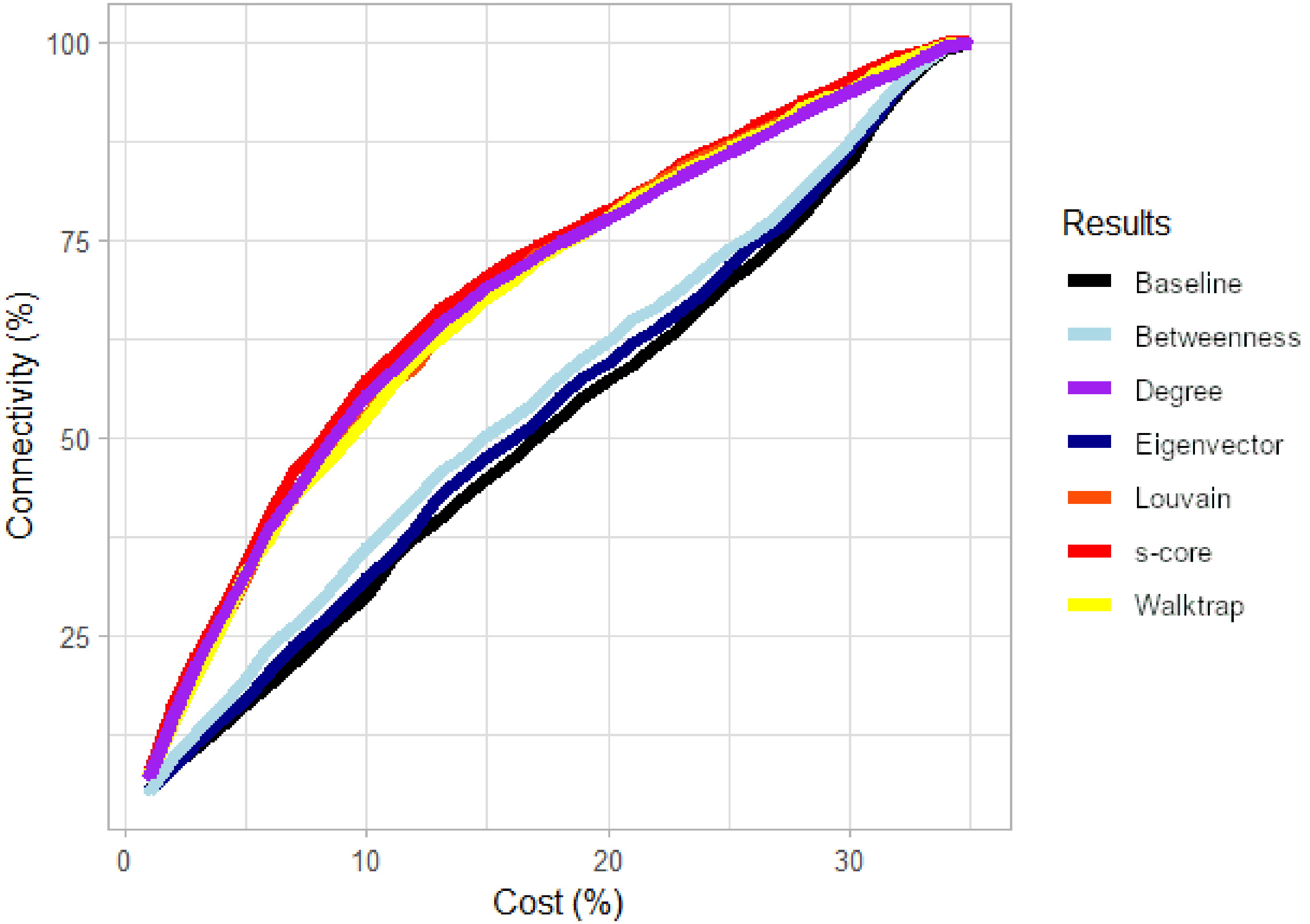



Strict connections are plotted

Same budget is used

# Case study & Results



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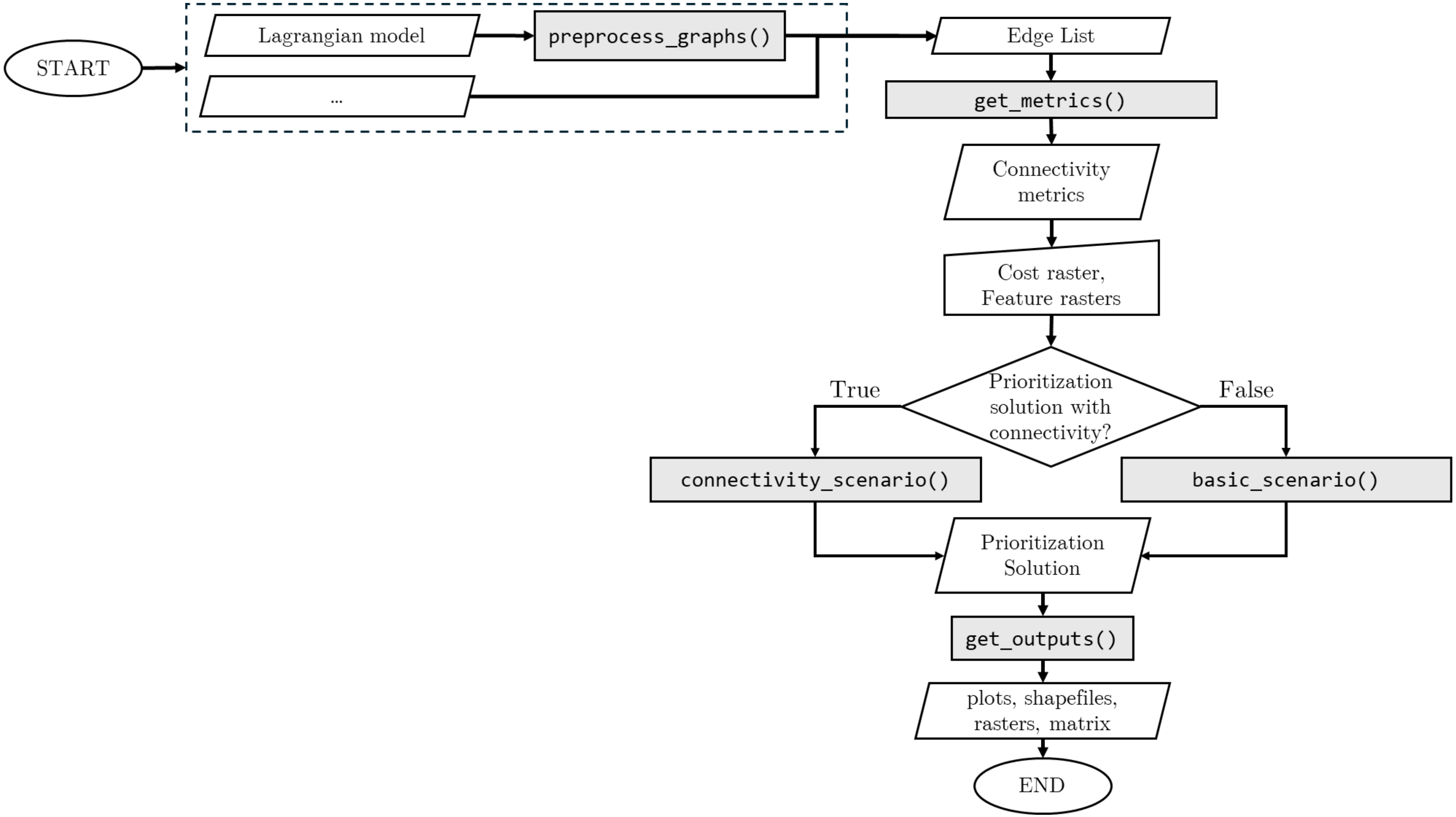
# R package : Cran & Interface

# R package :

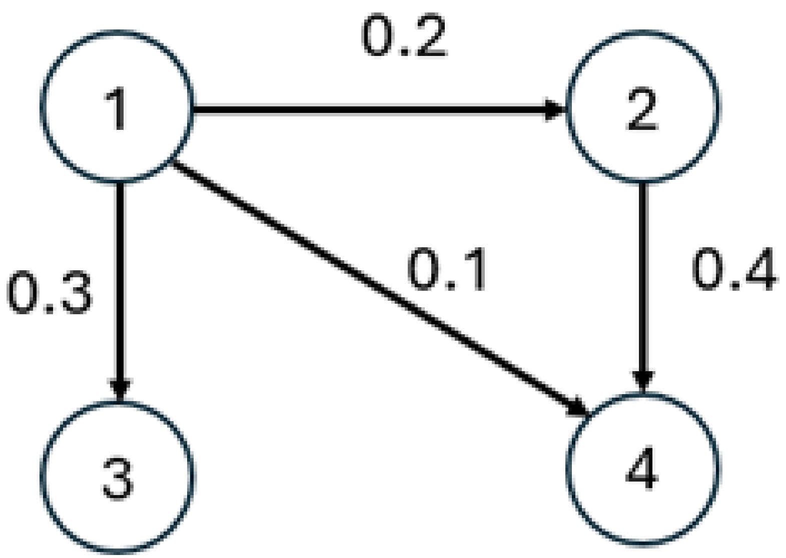
**priorCON: Graph Community Detection Methods into Systematic Conservation Planning**

An innovative tool-set that incorporates graph community detection methods into systematic conservation planning. It is designed to enhance spatial prioritization by focusing on the protection of areas with high ecological connectivity. Unlike traditional approaches that prioritize individual planning units, 'priorCON' focuses on clusters of features that exhibit strong ecological linkages. The 'priorCON' package is built upon the 'prioritizr' package <doi:10.32614/CRAN.package.prioritizr>, using commercial and open-source exact algorithm solvers that ensure optimal solutions to prioritization problems.

# R package :

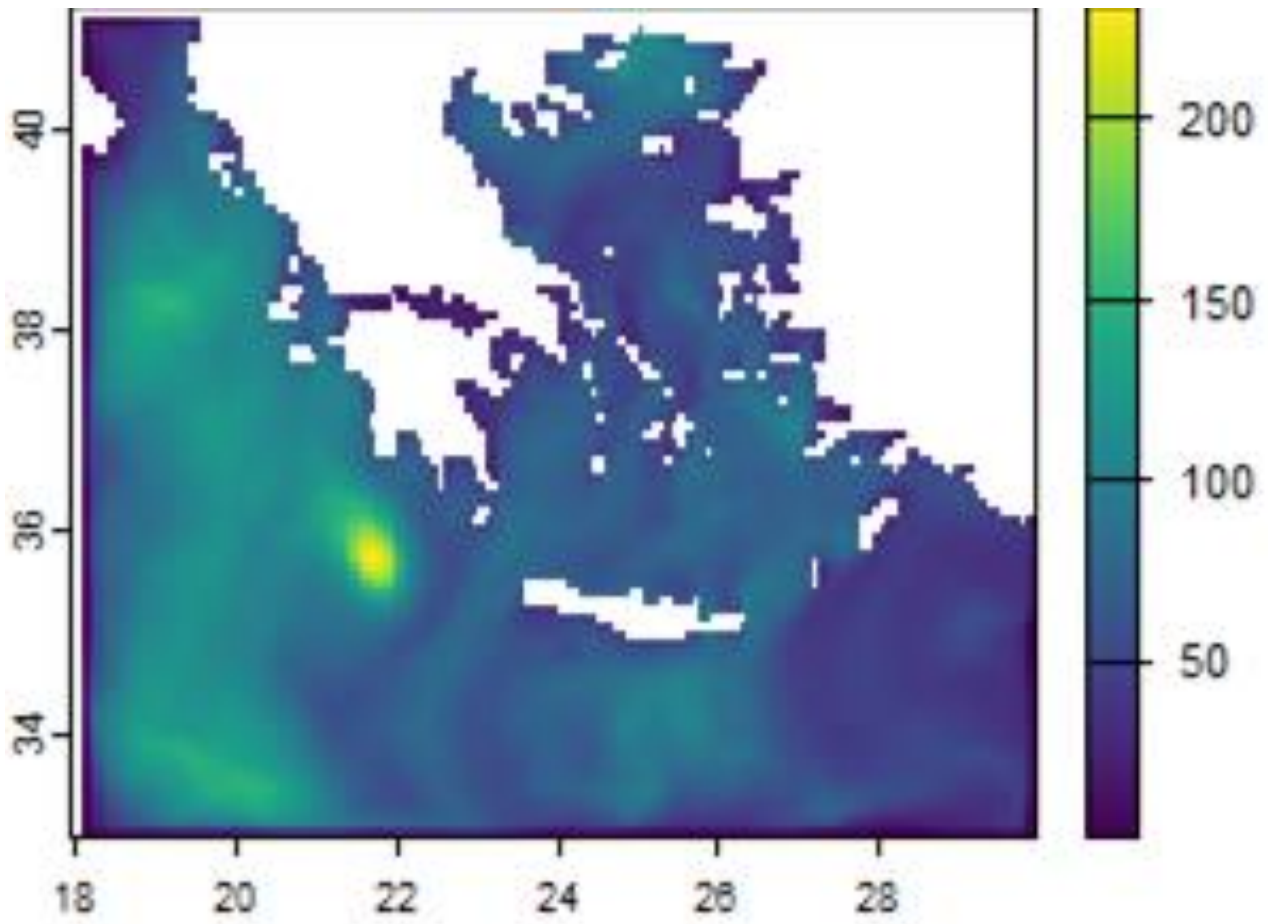

START
Lagrangian model
preprocess_graphs()
...
Edge List
get_metrics()
Connectivity metrics
Cost raster, Feature rasters
Prioritization solution with connectivity?
True
False
connectivity_scenario()
basic_scenario()
Prioritization Solution
get_outputs()
plots, shapefiles, rasters, matrix
END

# R package :

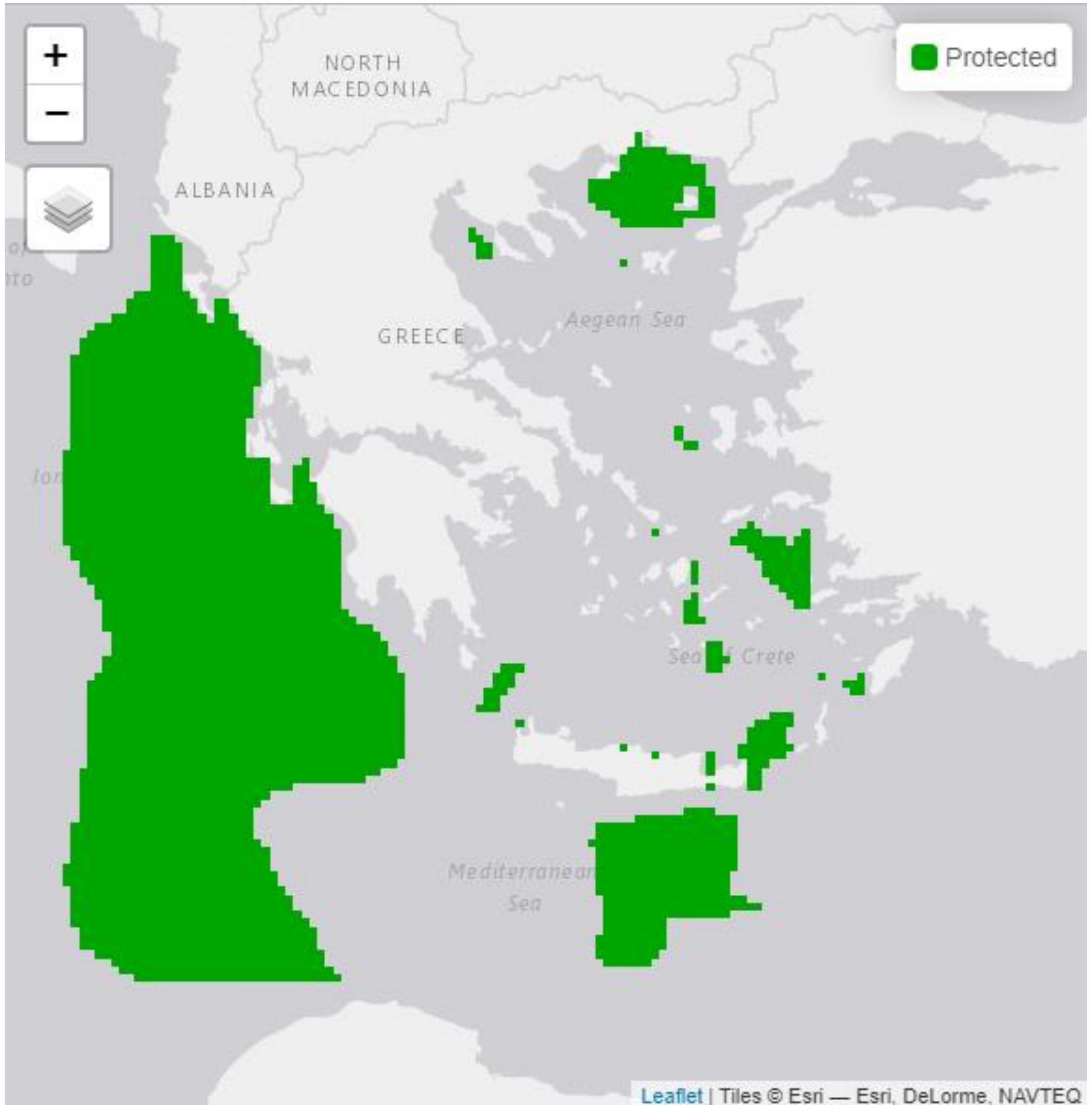



| From | To | Value |
|---|---|---|
| 1 | 2 | 0.2 |
| 1 | 3 | 0.3 |
| 1 | 4 | 0.1 |
| 2 | 4 | 0.4 |

# R package :



# R package :



+
−
Protected
NORTH
MACEDONIA
ALBANIA
GREECE
Aegean Sea
Mediterranean
Sea
Leaflet | Tiles © Esri — Esri, DeLorme, NAVTEQ

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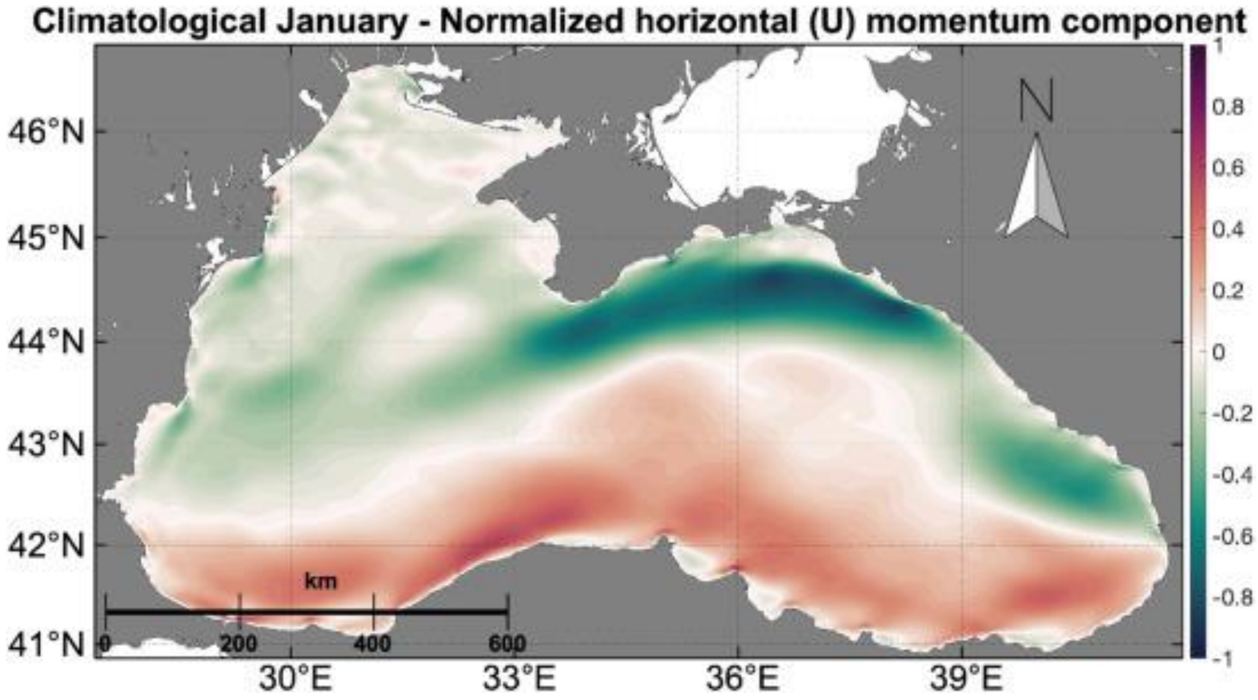
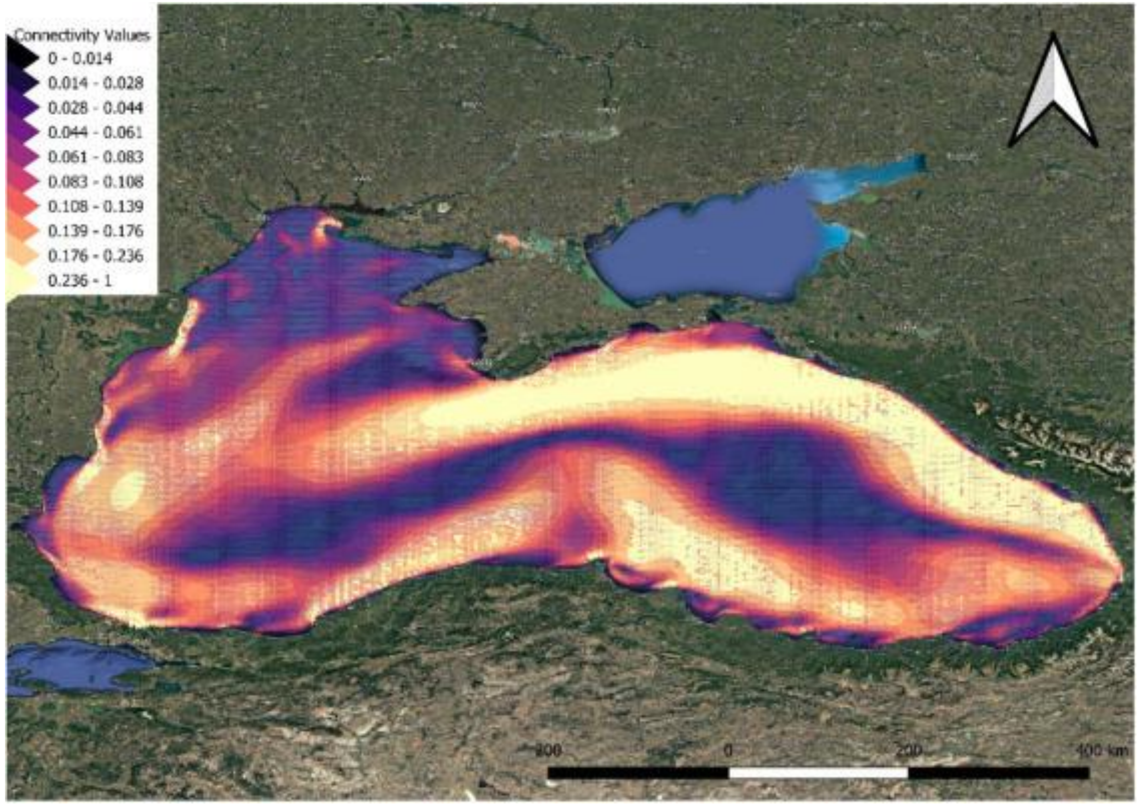
# Sea graph : Cran & Interface

# Sea graph

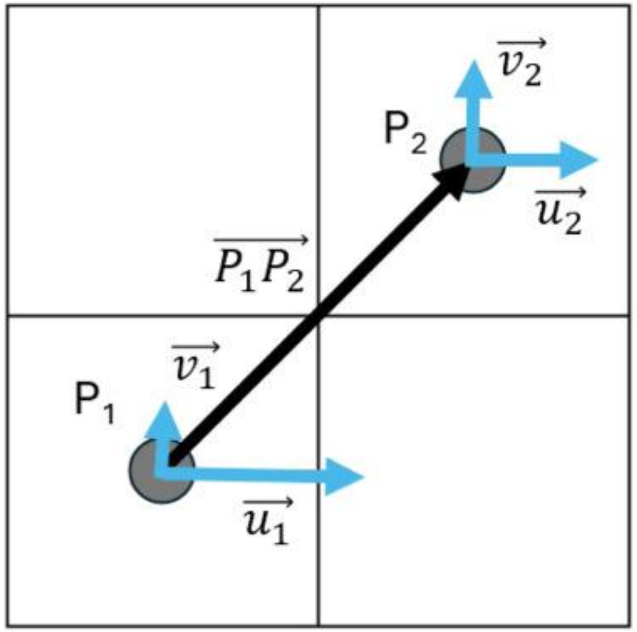
Sea currents -> Connectivity

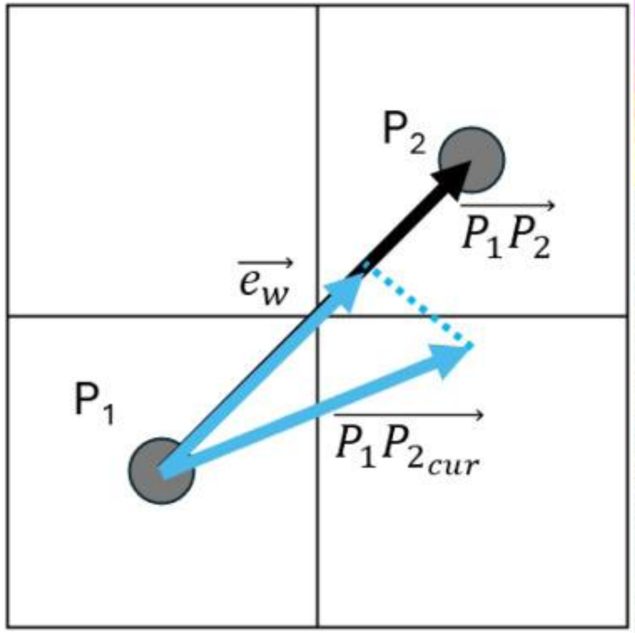


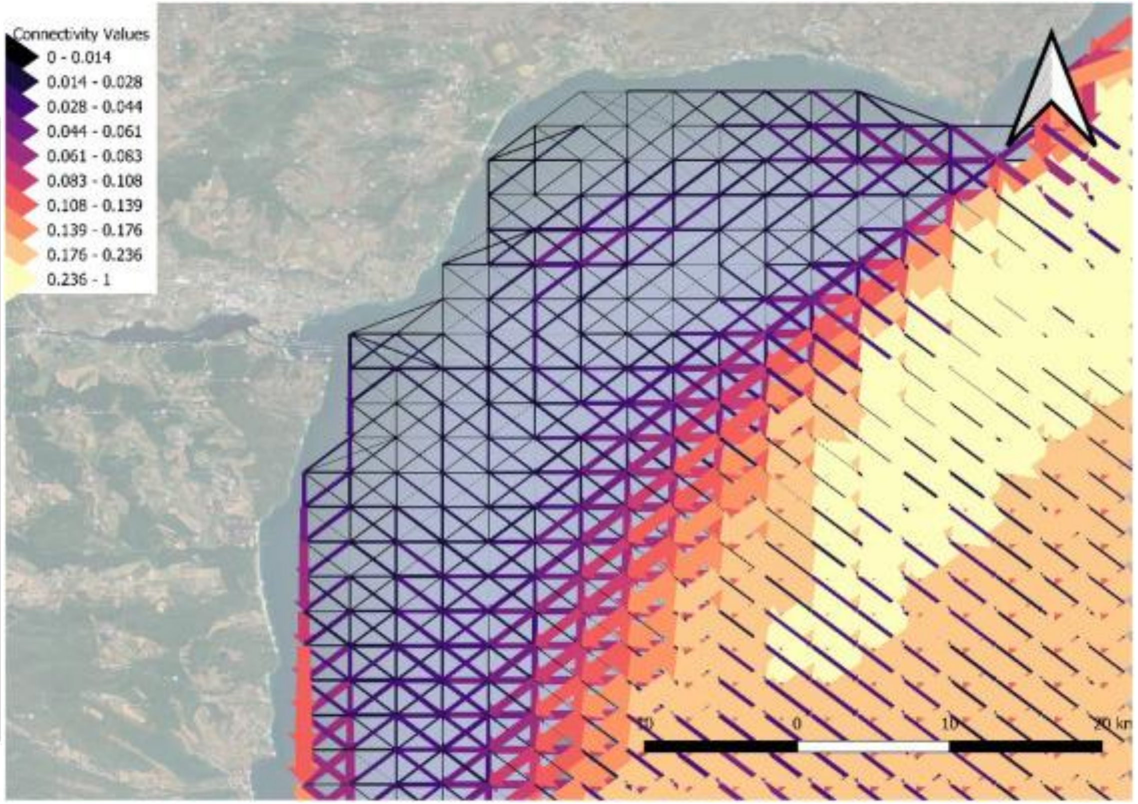



# Sea graph

Sea currents -> Connectivity



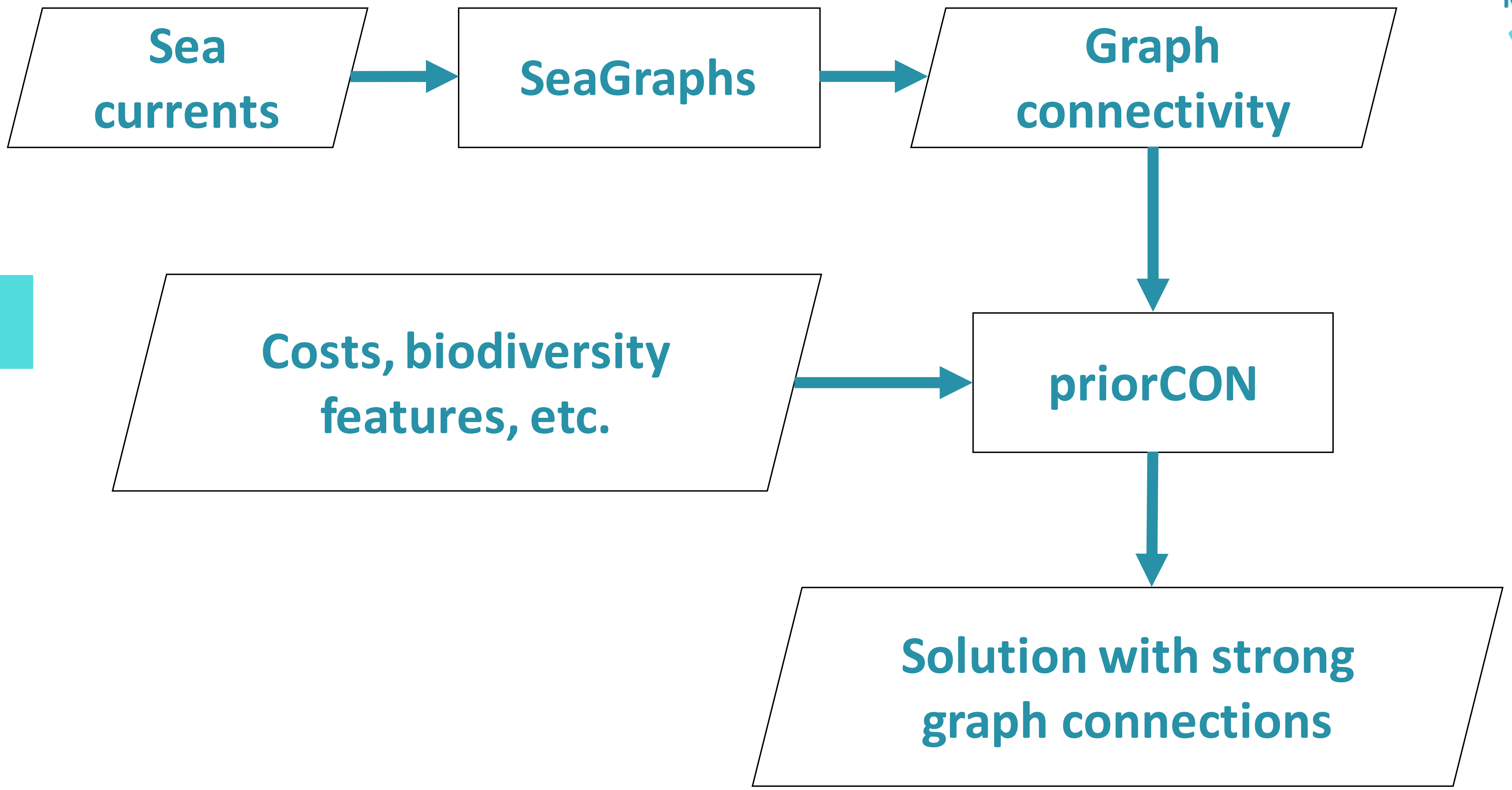



# Sea graph

```
SeaGraphs: Sea Currents to Connectivity
Transformation
```

Transformation of sea currents to connectivity data. Two files of horizontal and vertical currents flows are transformed into connectivity data in the form of 'sfnetwork', shapefile, edge list and adjacency matrix. An application example is shown at Nagkoulis et al. (2025) <doi:10.1016/j.dib.2024.111268>.


Sea currents
SeaGraphs
Graph connectivity
Costs, biodiversity features, etc.
priorCON
Solution with strong graph connections

# Publications

**Research Papers:**

Nagkoulis, N., Papazekou, M., Katsanevakis, S., & Mazaris, A. (2025). Spatial conservation planning: Proposing clustering methods to improve connectivity protection. *Methods in Ecology and Evolution*, *16*(2), 377-387.

Nagkoulis, N., Adam, C., Mamoutos, I., Katsanevakis, S., & Mazaris, A. D. (2025). An ecological connectivity dataset for Black Sea obtained from sea currents. *Data in Brief*, *58*, 111268.

**CRAN packages**

Adam, C., Doxa, A., Nagkoulis, N., Papazekou, M., Mazaris, A. D., & Katsanevakis, S. (2025). *priorCON: Graph community detection methods into systematic conservation planning* (R package version 0.1.6). Retrieved from https://cran.r-project.org/web/packages/priorCON/index.htm

Nagkoulis, N., Adam, C., Mamoutos, I., Mazaris, A. D., & Katsanevakis, S. (2025). *SeaGraphs: Sea currents to connectivity transformation* (R package version 0.1.3) [PDF manual]. Retrieved from https://cran.r-project.org/web/packages/SeaGraphs/SeaGraphs.pdf

# Thank you!

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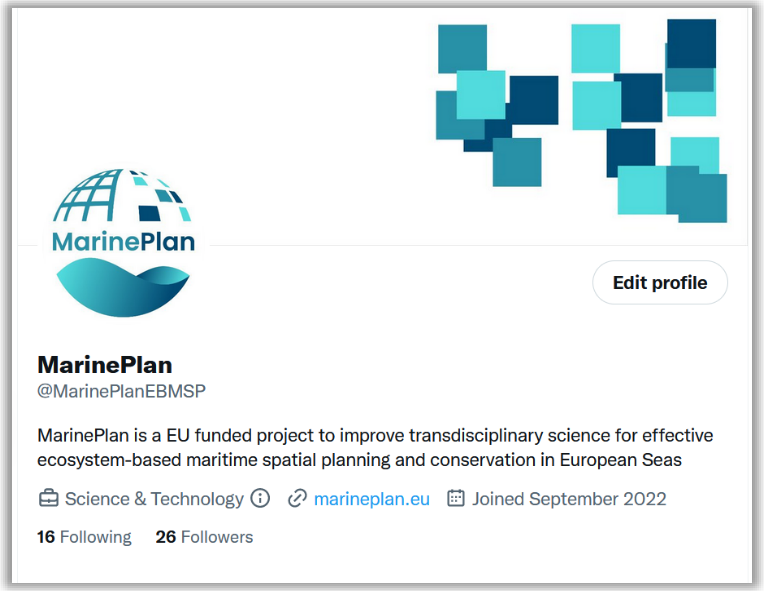


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