ES & Multi Criteria Analysis

bc3
BASQUE CENTRE
FOR CLIMATE CHANGE
Klima Aldaketa Ikergai

What is that

- a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making
- conflicting criteria are typical in evaluating options
- cost and benefit criteria can be included
- not a monetary centred methodology (any unit is admitted)

Example: choosing a e-bike

1. Price
2. Weight
3. **Style**
4. Comfort
5. Battery autonomy
6. Activities supported
7. ….

Why in ES modelling

- modeling of multiple ES to quantify ES trade-offs, and hotspots
- support spatial prioritization
- incorporation of social values
- capture different perspectives/preferences

How to use it

- Elicitation of preferences:
  - Interviews and questionnaires
  - Participatory process
  - Role play games
- Use the appropriate methods...

Elections example: Borda Vs Condorcet

1. Borda count is a voting system in which voters rank the candidates in an order of preference. Points are given for the position of a candidate in a voter's rank order. The candidate with the most points wins.
2. A Condorcet winner is the candidate that would win a majority of the vote in all of the head-to-head elections against each of the other candidates.

MCA different methods and their features

- compensatory / non compensatory
- incommensurability
- veto option: some values for certain criteria not admitted
- maximization of benefits vs minimization of costs:
  - e.g. a second best best option can be better that the best one upsetting many preference structures

Evamix

- Combines ordinal and cardinal values
- Computes dominance of alternatives via pairwise comparison

Environment and Planning B, 1982, volume 9, pages 221 - 236

Multicriteria evaluation with mixed qualitative and quantitative data

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H Voogd
University of Technology, Delft, The Netherlands
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Spatial MCA

Zoning Marine Protected Areas through Spatial Multiple-Criteria Analysis: the Case of the Asinara Island National Marine Reserve of Italy

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Total Environment

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Towards globally customizable ecosystem service models

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SMCA section 2.6 of STOTEN paper

- a set of observations with measured variables is ordered according to a concordance or discordance score computed for each different ‘evaluation unit’
- a 0 to 1 score is computed using sets of weights that express the importance of each variable from a particular stakeholder's perspective
- Each perspective is defined by a ‘priority vector’ containing the weights assigned to each variable
- ‘evaluation matrix’ aggregated by variable values and discretized into a number of intervals (by default the system uses 10 intervals).
- As the final output, a map of concordance values ranging from 0 to 1 is produced for each stakeholder, distributing the computed scores to each cell

Stereotyped stakeholders

Table 1
Priority weights (descending from 1 to 10) assigned to four hypothetical stakeholder groups to each potential ecosystem service (ES) supply, used in the Spatial Multi-Criteria Analysis.

Criteria/ES supply	Citizens	Farmers	Local government	Climate activists
Pollination	10	1	5	10
Carbon Storage	10	10	5	1
Outdoor Recreation	1	10	5	10
Flood regulation	1	5	5	5
Sediment regulation	10	2	5	5

The Kailash Sacred Landscape example

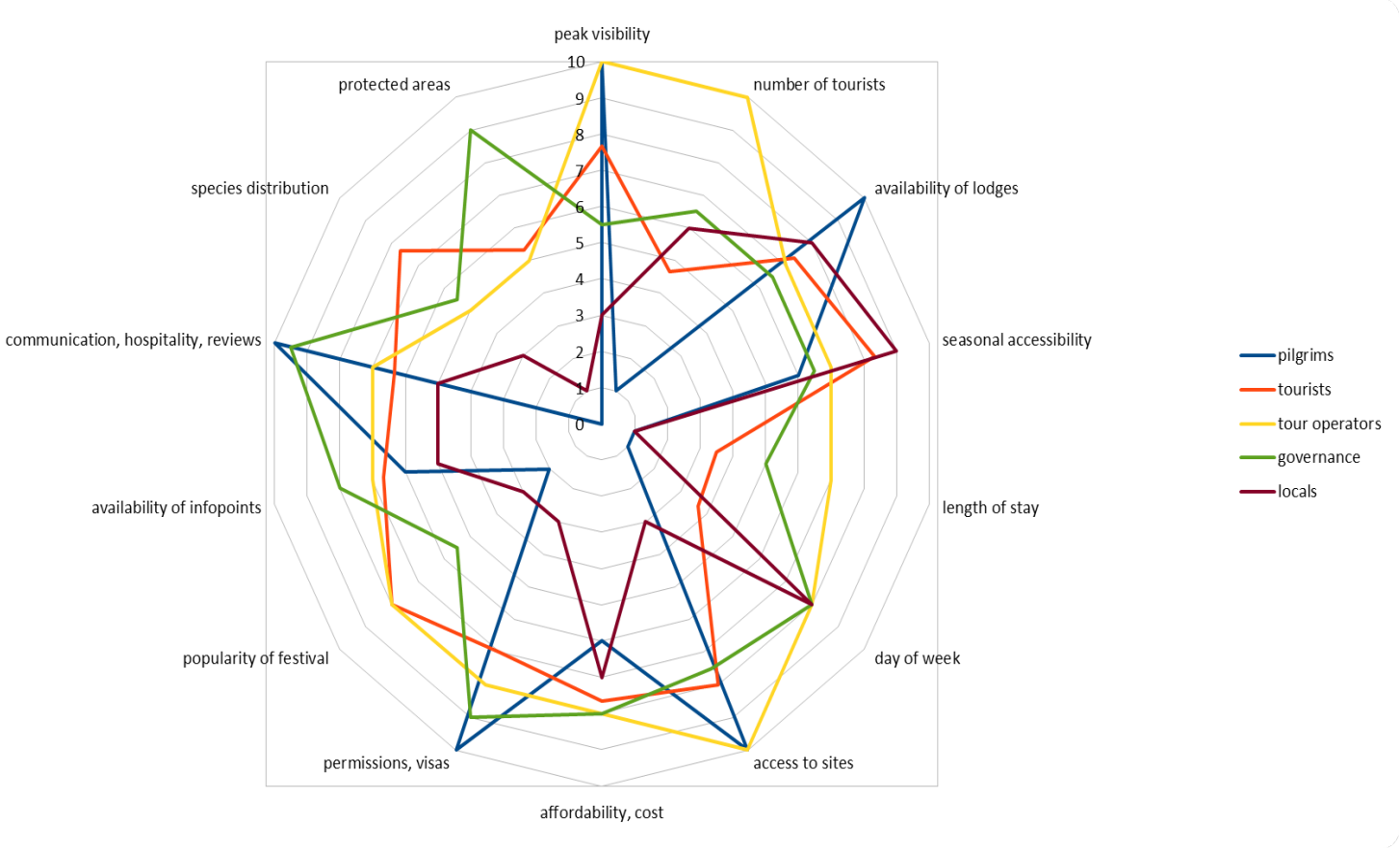
- List of factors for assessing cultural value in KSL for three targeted stakeholders:
  - Pilgrims
  - Local people
  - Tourism related (hikers, tour operators)
- Distinguish between **activities** (hiking, skiing, pray,...) and **features**.
- **Features** can be:
  - Natural
  - Human made

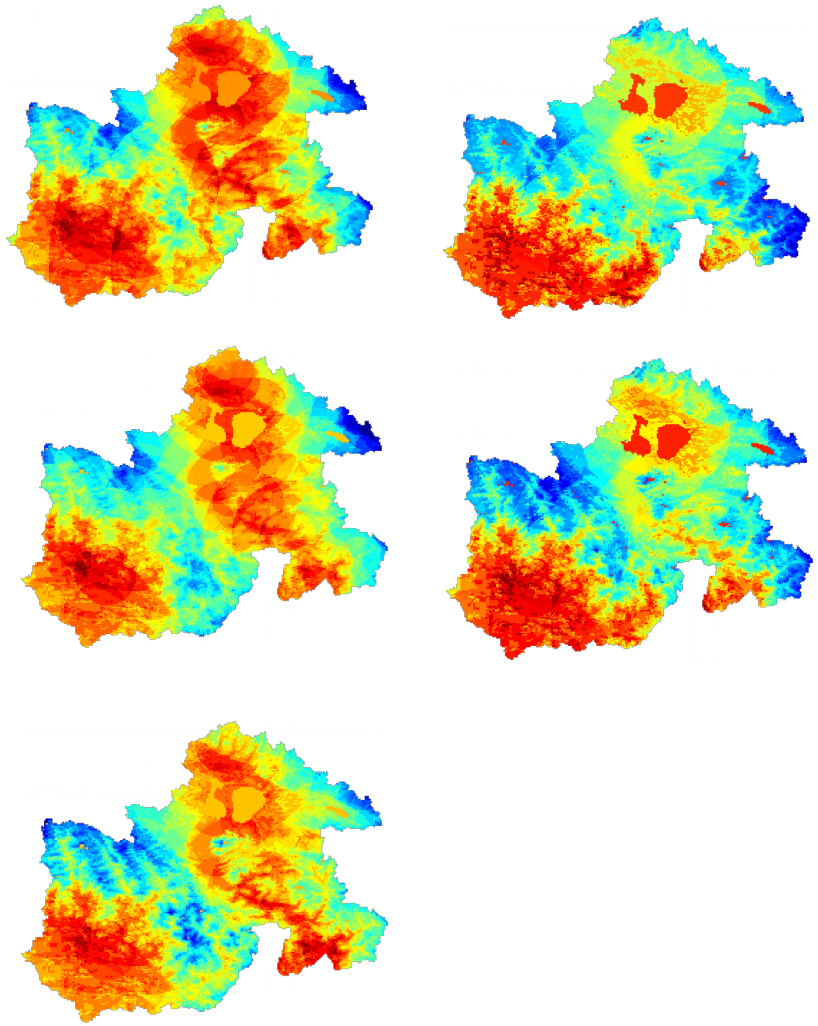
Practical Part (workshop in Kathmandu)

- Participants are divided in groups representing stakeholders and the list with all criteria (using the excel file) is used for assigning marks to them (1-10) or pairwise.
- A facilitator assists each group
- Participants can give individual weights and then compute the average/mode or agree on a common weight.

- Excel files will be merged and radar-plots will be shown representing the different weights assigned to each criteria based on each stakeholder perspective.
- A final discussion on the results and on the possible methodologies/indicators to measure each criteria.

Results


peak visibility
number of tourists
availability of lodges
seasonal accessibility
length of stay
day of week
access to sites
affordability, cost
permissions, visas
popularity of festival
availability of infopoints
communication, hospitality, reviews
species distribution
protected areas
10
9
8
7
6
5
4
3
2
1
0
pilgrims
tourists
tour operators
governance
locals



Participatory coastal management through elicitation of ecosystem service preferences and modelling driven by “coastal squeeze”

aquacross

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Participatory coastal management through elicitation of ecosystem service preferences and modelling driven by “coastal squeeze”

Javier Martínez-López [a,*,1], Heliana Teixeira [b,d,1], Mariana Morgado [b,d], María Almagro [a], Ana I. Sousa [b,d], Ferdinando Villa [a,c], Stefano Balbi [a], Ana Genua-Olmedo [b,d], Antonio J.A. Nogueira [b,d], Ana I. Lillebø [b,d]

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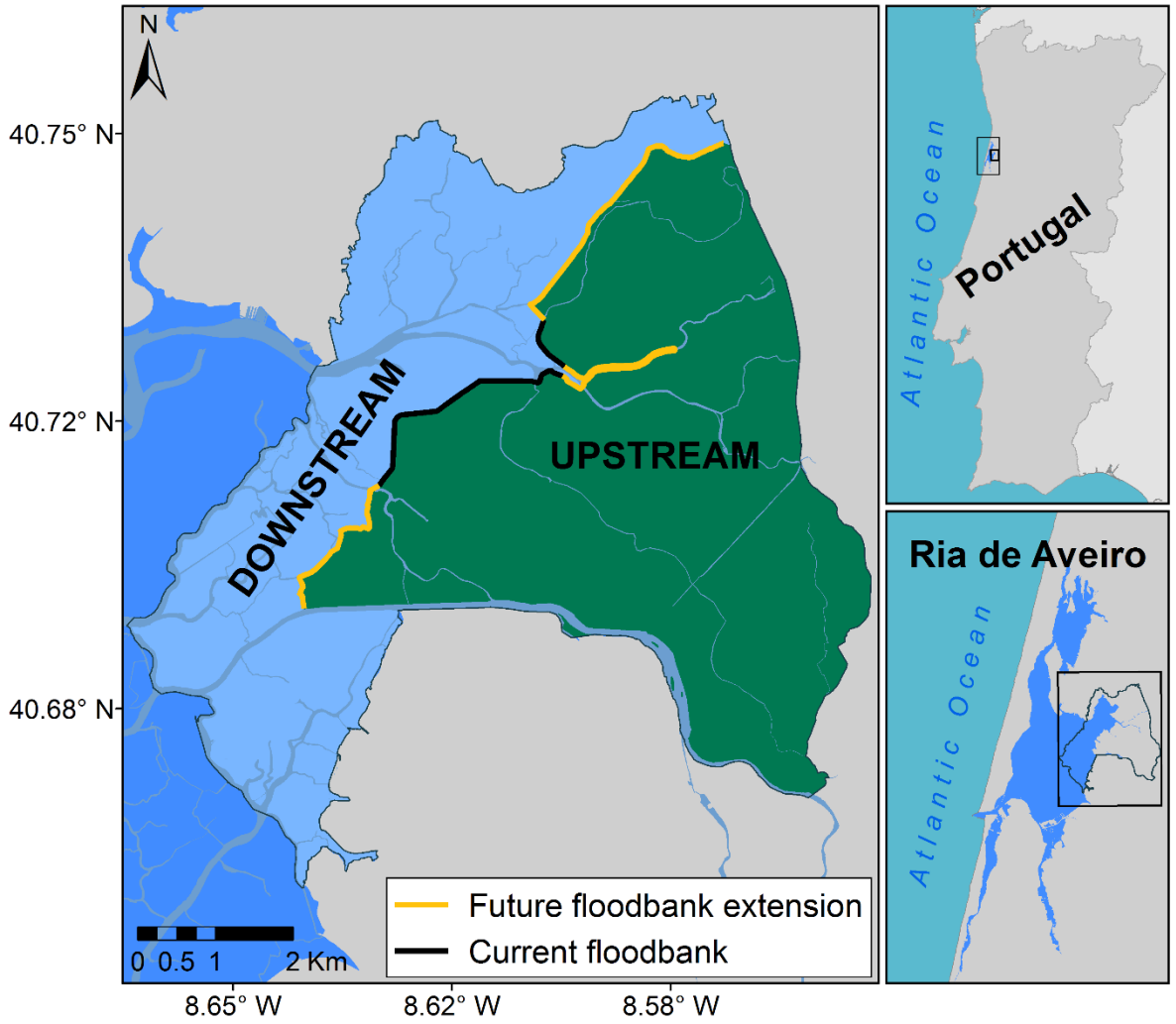
International Spring University on Ecosystem Services Modeling

The Baixo Vouga Lagunar (Ria de Aveiro, PT)

- Special Protection Area under the European Habitats and Birds Directives (5000 ha)
- This system is also very important culturally and socioeconomically for the local communities, taking place several human activities, mostly agriculture.

The Baixo Vouga Lagunar (Ria de Aveiro, PT)

- To prevent surface salt water intrusion from the Ria de Aveiro during high tide periods into agriculture fields, a floodbank was built in the 90's.
- The existing floodbank will be now extended, introducing further changes in the ecological dynamics of the BVL and its adjacent area.
- As a consequence, the water level in the floodbank downstream side is expected to rise, increasing the submersion period in tidal wetlands.

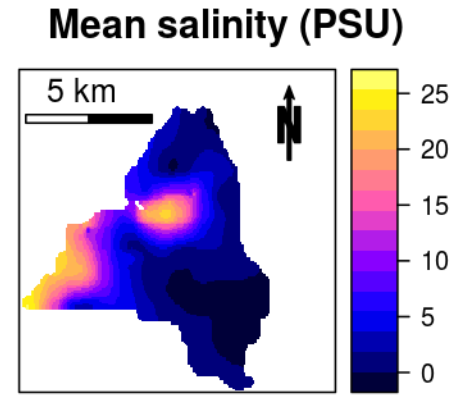


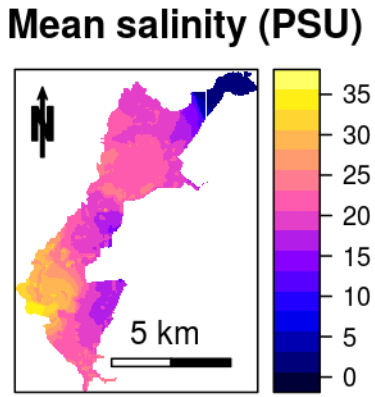
Summary of the Methodology

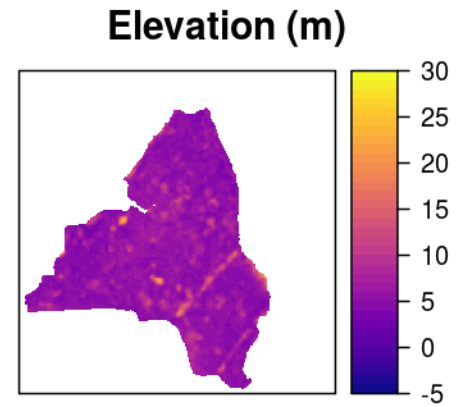
1. We have modelled saltmarsh plant species and habitats under coastal squeeze.
2. Several associated ecosystem services were prioritized by stakeholders elicitation.
3. Key areas for ES provision were established using spatial multi-criteria analysis.

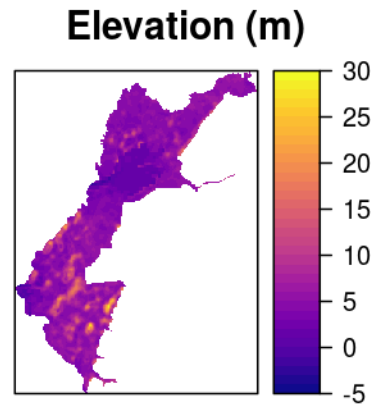
Saltmarsh plant species models

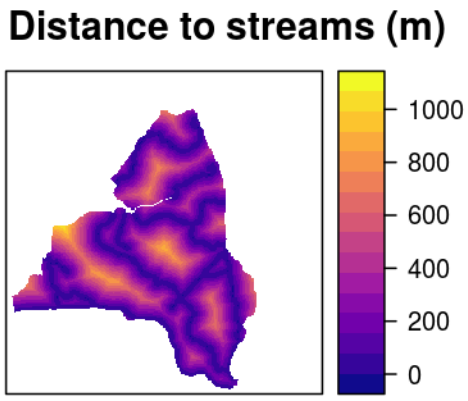
- 4 plant species: *Halimione portulacoides*, *Bolboschoenus maritimus*, *Phragmites australis* and *Juncus maritimus.*
- Input variables:
  - Salinity
  - Elevation/Bathymetry
  - Distance to streams
  - Percentage of tides above critical level yearly (~ submersion period)
- GLM betareg

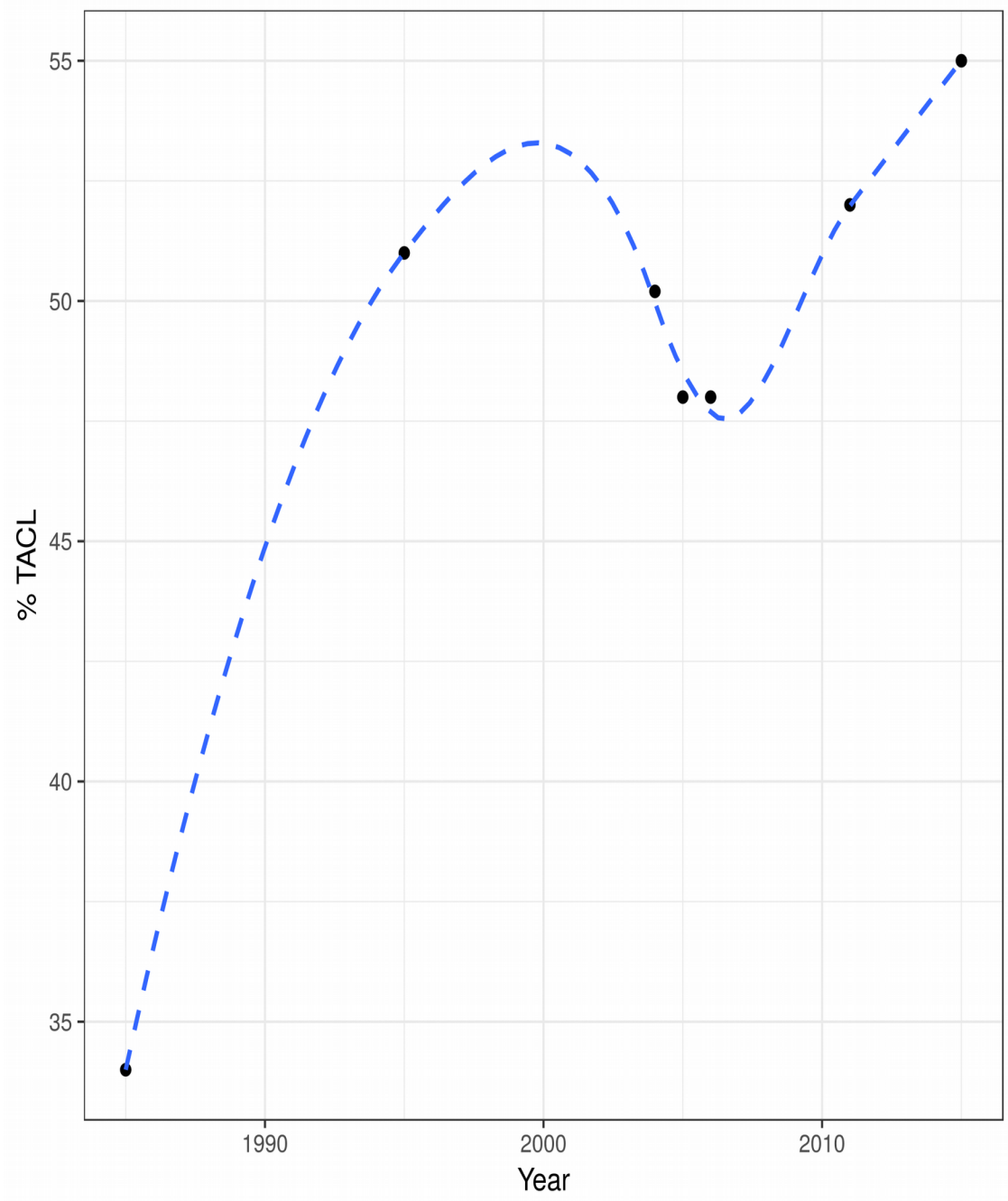

Mean salinity (PSU)
5 km
25
20
15
10
5
0


Mean salinity (PSU)
5 km
35
30
25
20
15
10
5
0

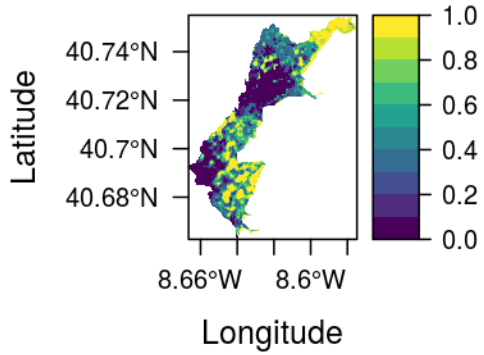

Elevation (m)
30
25
20
15
10
5
0
-5


Elevation (m)
30
25
20
15
10
5
0
-5

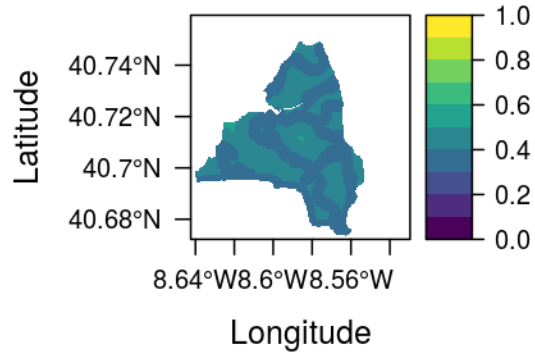

Distance to streams (m)
1000
800
600
400
200
0


55
50
45
40
35
% TACL
1990
2000
2010
Year

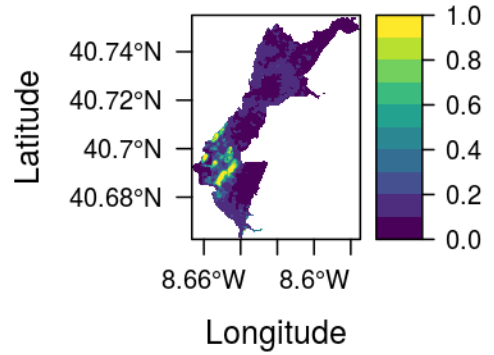
P. australis



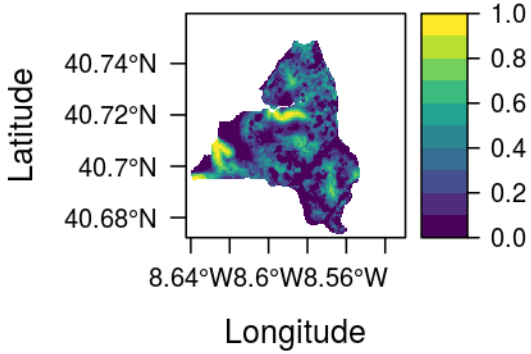
P. australis



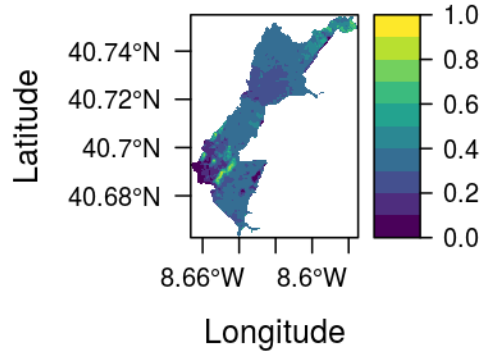
B. maritimus



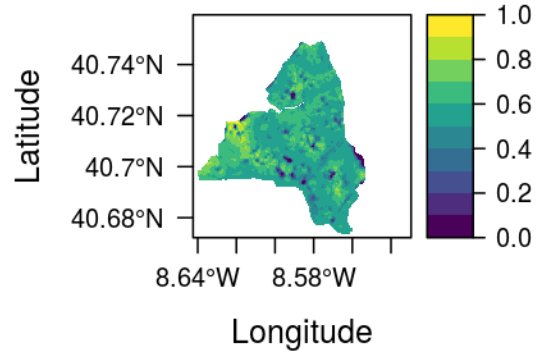
B. maritimus



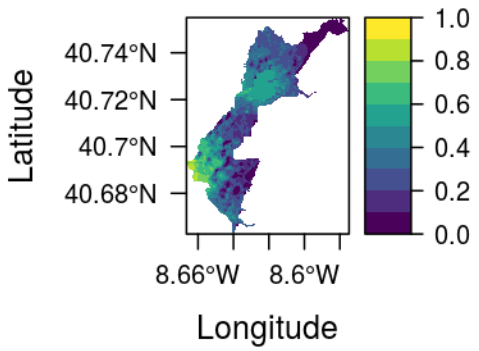
J. maritimus



J. maritimus

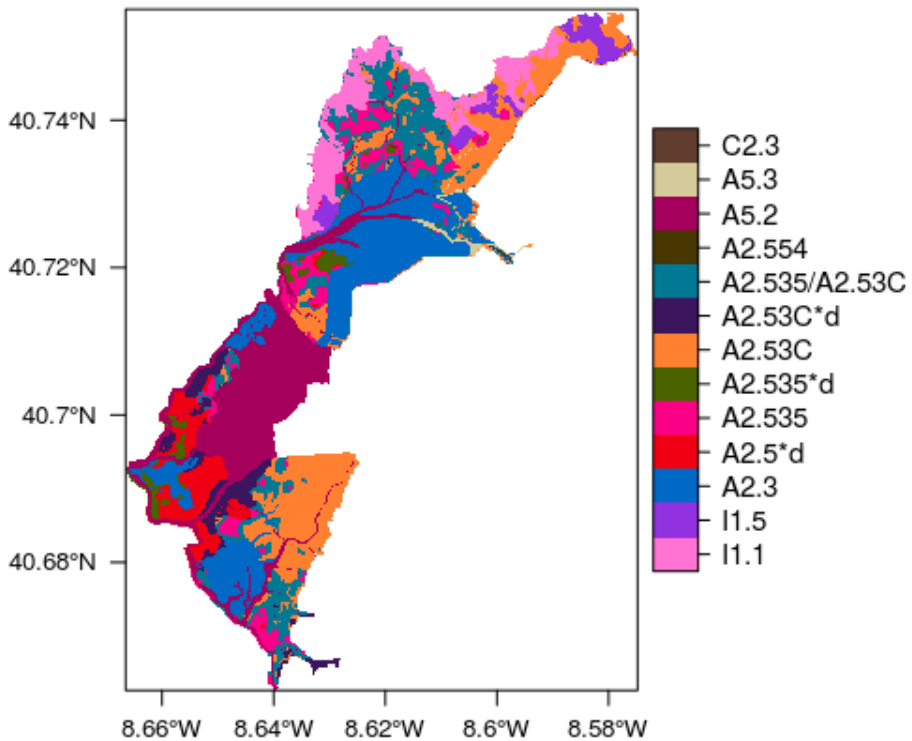


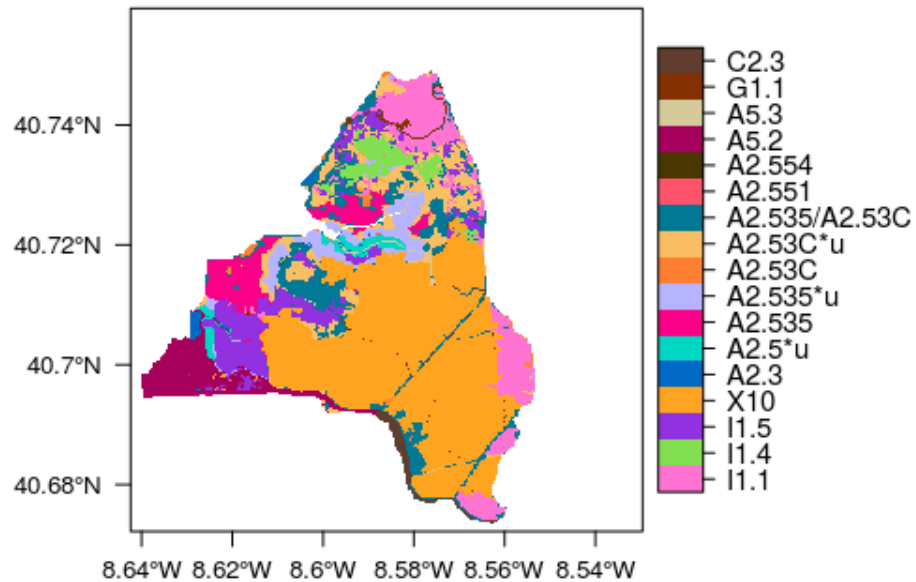
H. portulacoides



Habitats

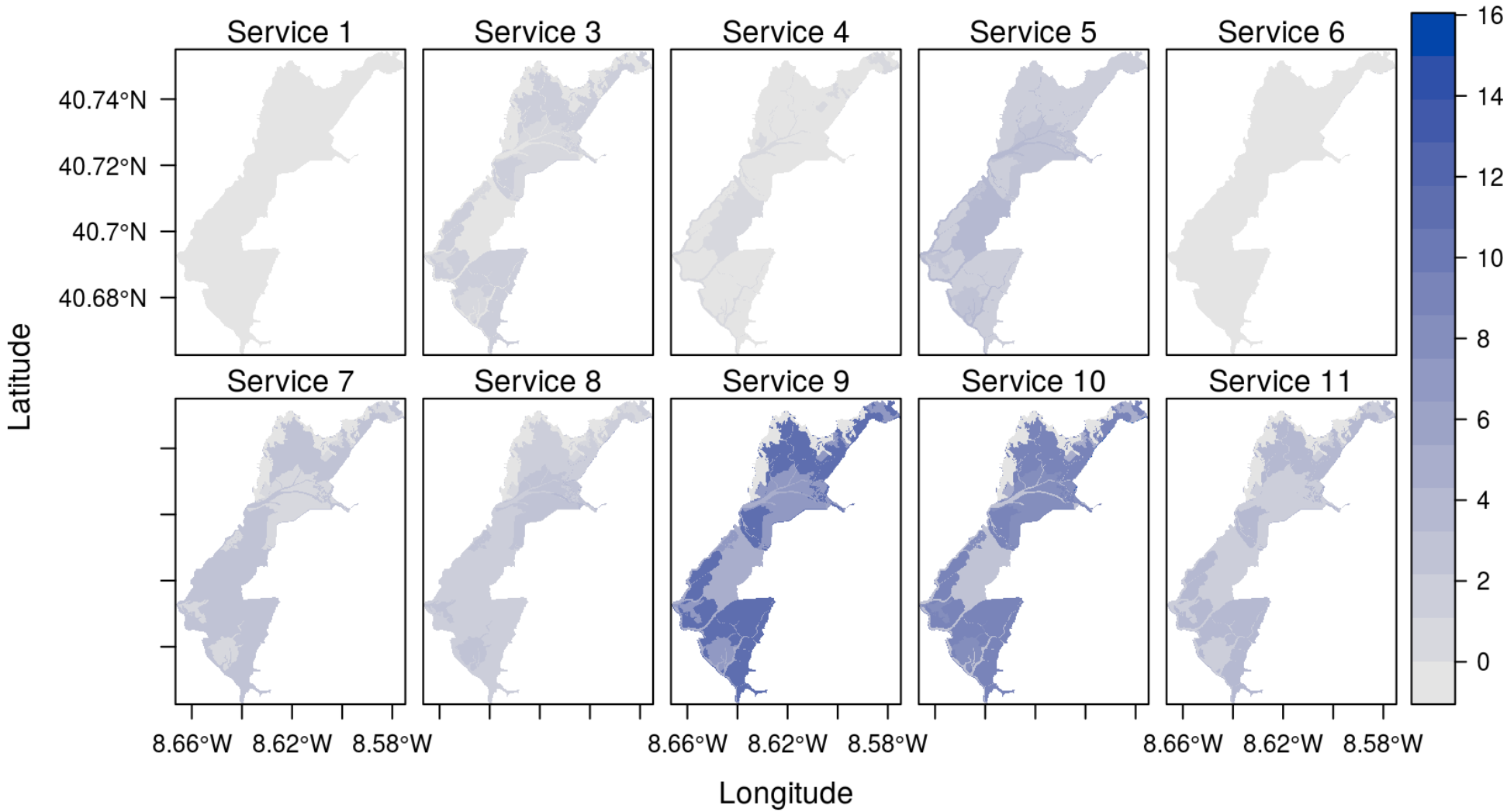
- Adapted from EEA EUNIS habitat classification 2012
- Based on potential abundance of species
- Multivariate classification analysis (hierarchical clustering)
- IndVal analysis (indicator species)

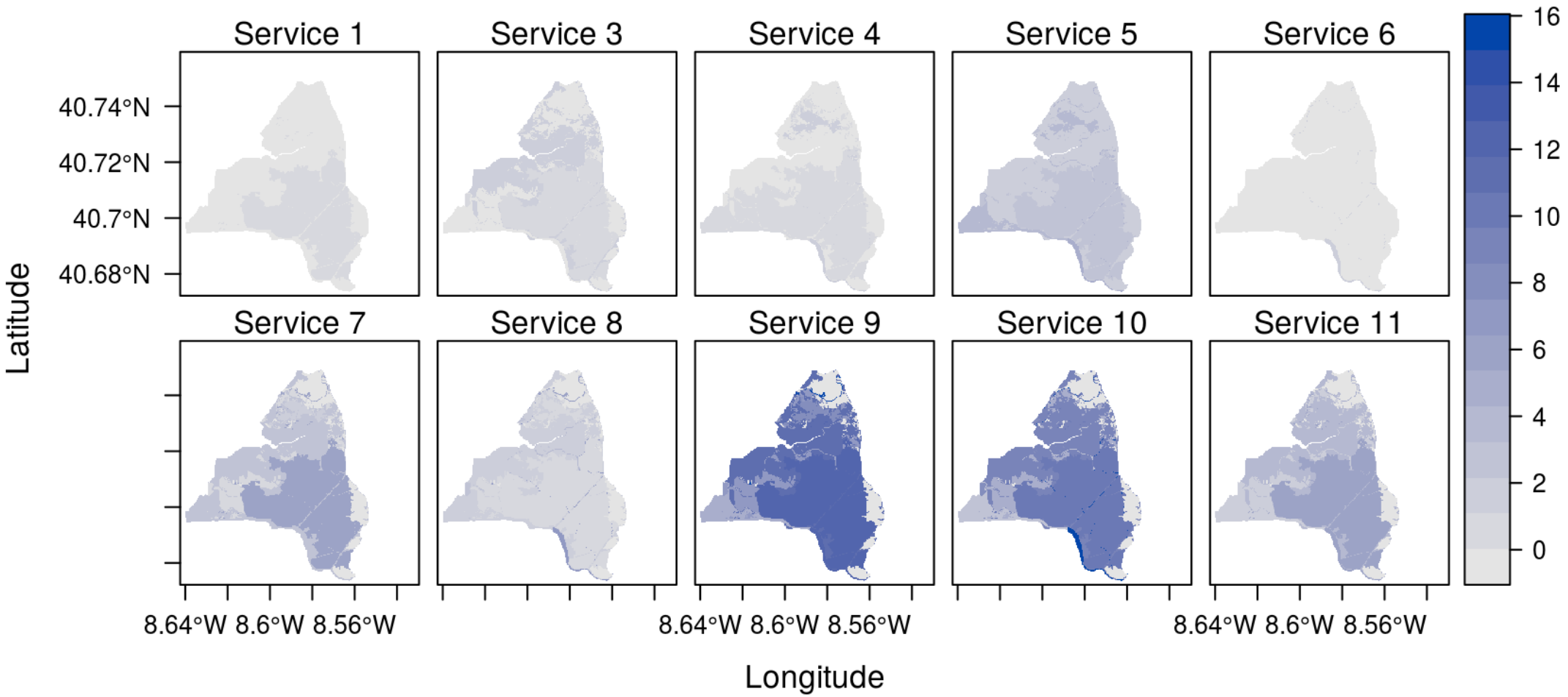

40.74°N
40.72°N
40.7°N
40.68°N
8.66°W
8.64°W
8.62°W
8.6°W
8.58°W
C2.3
A5.3
A5.2
A2.554
A2.535/A2.53C
A2.53C*d
A2.53C
A2.535*d
A2.535
A2.5*d
A2.3
I1.5
I1.1


40.74°N
40.72°N
40.7°N
40.68°N
8.64°W
8.62°W
8.6°W
8.58°W
8.56°W
8.54°W
C2.3
G1.1
A5.3
A5.2
A2.554
A2.551
A2.535/A2.53C
A2.53C*u
A2.53C
A2.535*u
A2.535
A2.5*u
A2.3
X10
I1.5
I1.4
I1.1

Ecosystem service proxies

- CICES classification
- Expert knowledge lookup table based on the contribution of habitats and species
- 23 ES were summarized into 10: (1) Biotic based energy sources; (2-3) biotic/abiotic materials; (4-5) nutritional biotic/abiotic substances; (6) mediation of flows; (7) mediation of waste toxics and other nuisances; (8) maintenance of physical chemical biological conditions; (9) physical and intellectual interactions with biota, ecosystems, land and seascapes environmental settings; (10) spiritual symbolic and other interactions with biota ecosystems and land seascapes environmental settings.


Service 1
Service 3
Service 4
Service 5
Service 6
Service 7
Service 8
Service 9
Service 10
Service 11
40.74°N
40.72°N
40.7°N
40.68°N
8.66°W
8.62°W
8.58°W
Latitude
Longitude
16
14
12
10
8
6
4
2
0


Service 1
Service 3
Service 4
Service 5
Service 6
Service 7
Service 8
Service 9
Service 10
Service 11
40.74°N
40.72°N
40.7°N
40.68°N
Latitude
8.64°W 8.6°W 8.56°W
8.64°W 8.6°W 8.56°W
8.64°W 8.6°W 8.56°W
Longitude
16
14
12
10
8
6
4
2
0

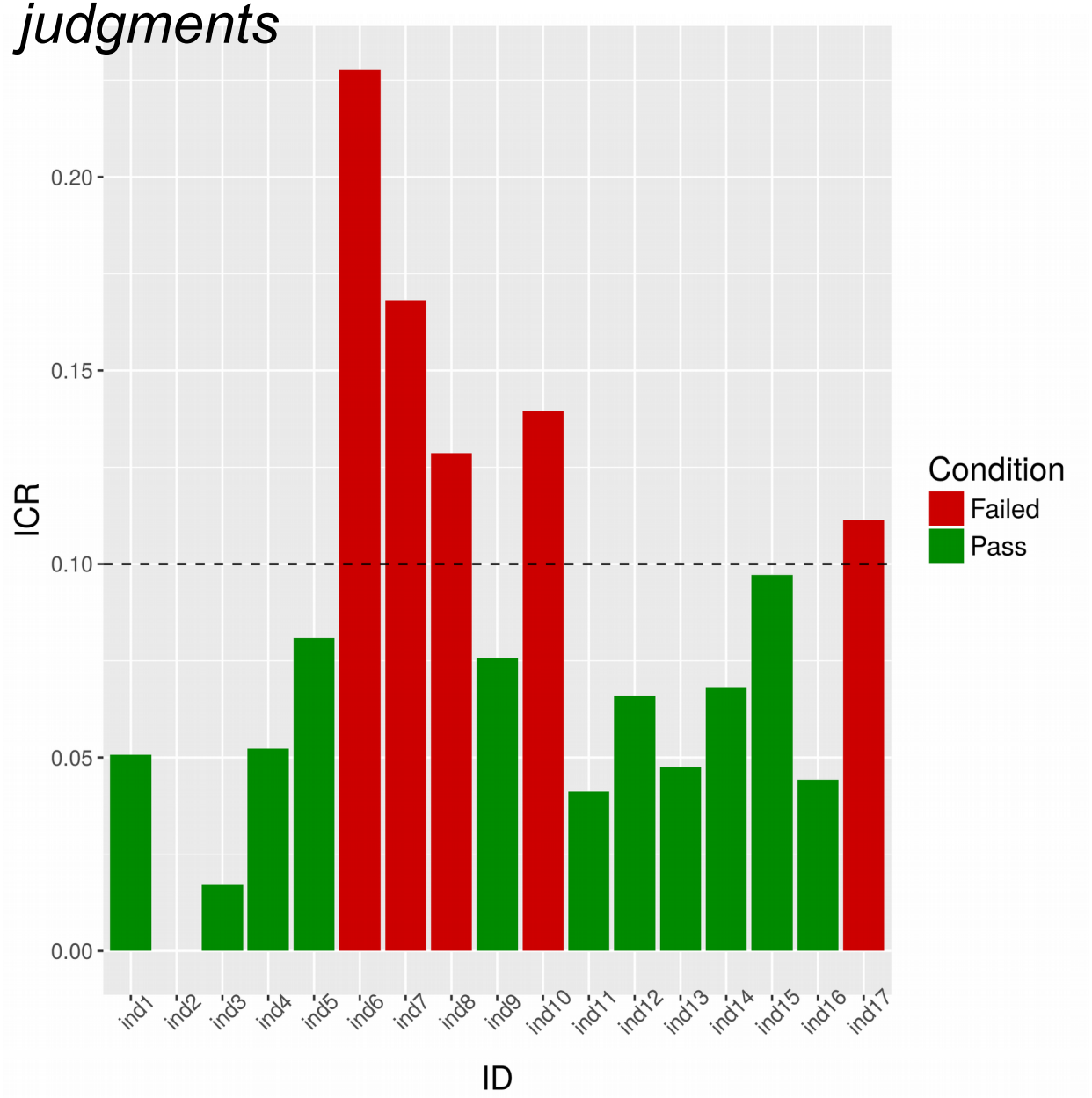
Elicitation of preferences

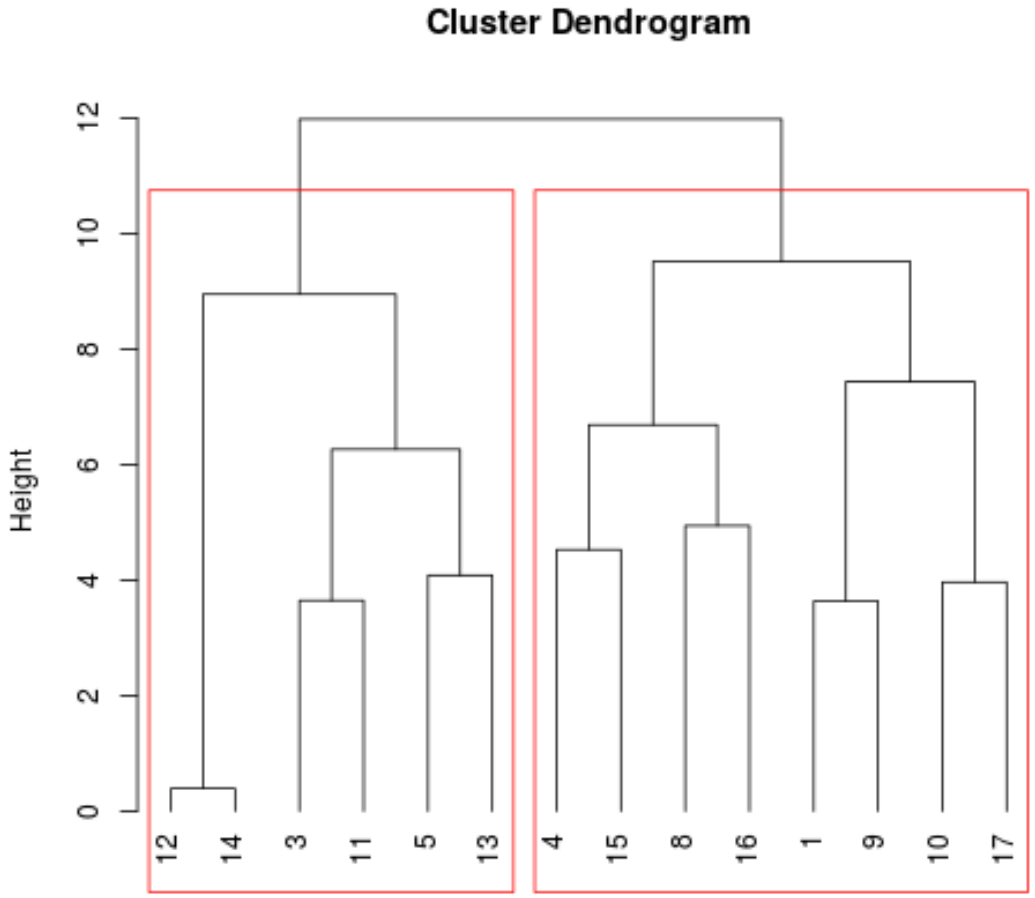
- Workshop with 6 stakeholder groups (17 indiviudals): (1) Policy / Governance, (2) Public Administration, (3) Citizens, (4) Environmental scientists, (5) Interest groups and (6) Business.
- Pairwise comparison of ES (ranking) using and online Google Form
- Analysis of responses (*Consistency ratio of individual judgments; ICR*)
- Multivariate classification analysis of individuals (hierarchical clustering) to identify main groups
- Spatial Multicriteria Analysis to identify priority areas

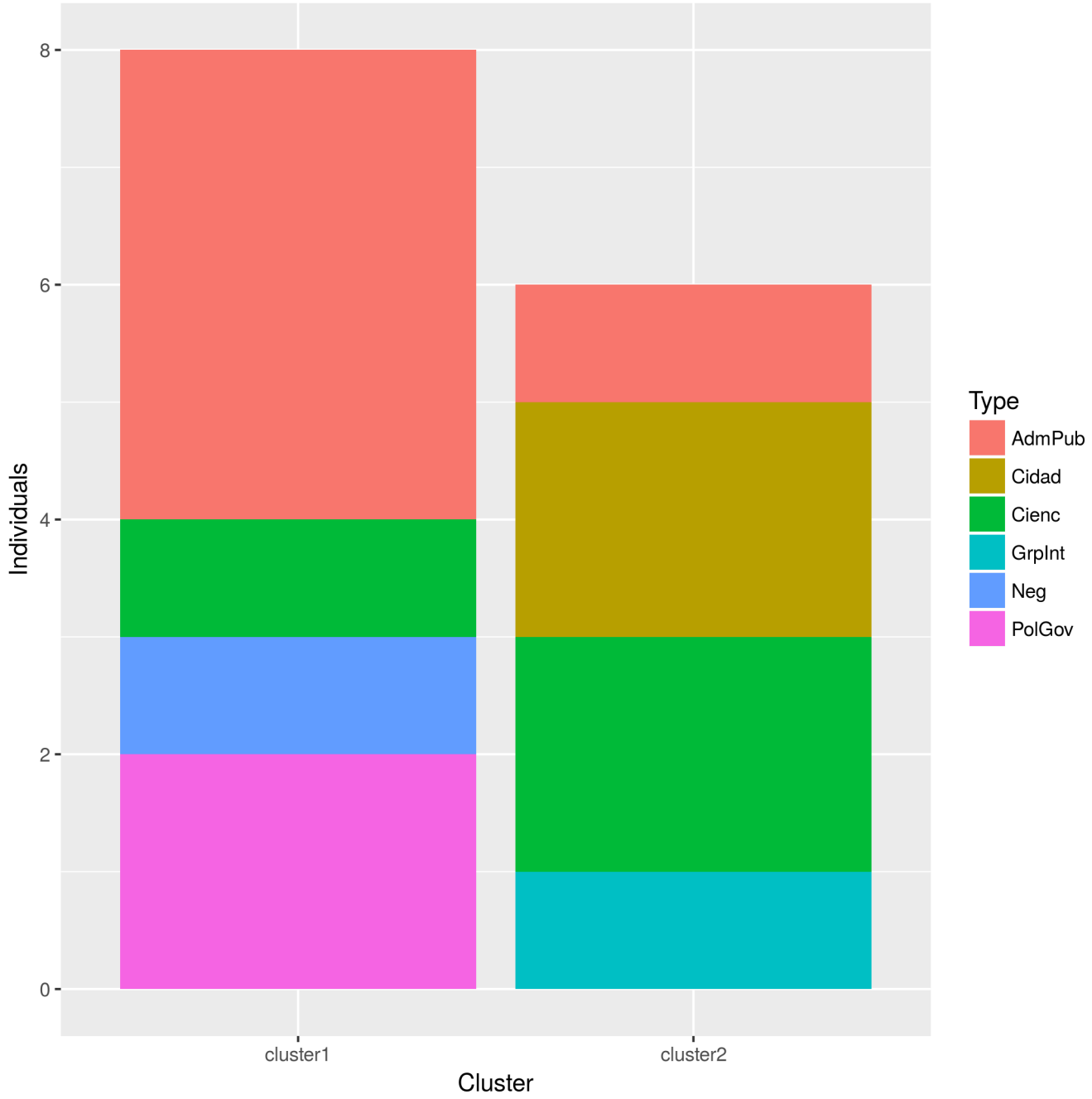
Qual a importância do SE1 "Provisionamento de Energia proveniente de seres vivos" em relação ao... *

	muito menos imp...	menos importante	igualmente impo...	mais importante	muito mais impo...
SE2 Provisionam...	○	○	○	○	○
SE3 Provisionam...	○	○	○	○	○
SE4 Provisionam...	○	○	○	○	○
SE5 Provisionam...	○	○	○	○	○
SE6 Provisionam...	○	○	○	○	○
SE7 Regulação & ...	○	○	○	○	○
SE8 Regulação & ...	○	○	○	○	○
SE9 Regulação & ...	○	○	○	○	○
SE10 Cultural: Int...	○	○	○	○	○

Consistency ratio of individual judgments

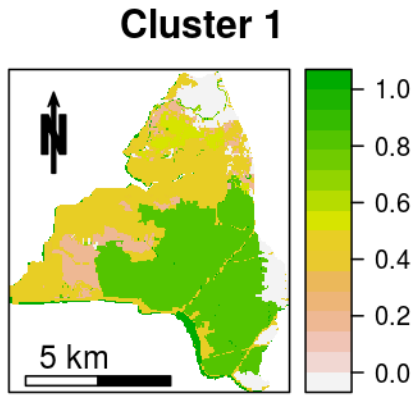


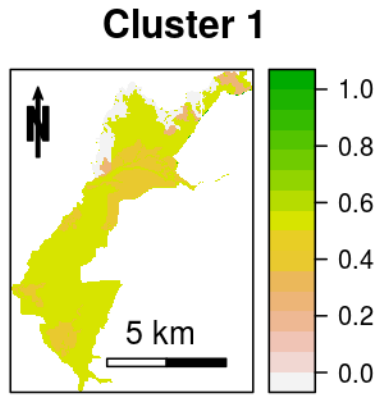

Cluster Dendrogram
Height
0
2
4
6
8
10
12
12
14
3
11
5
13
4
15
8
16
1
9
10
17

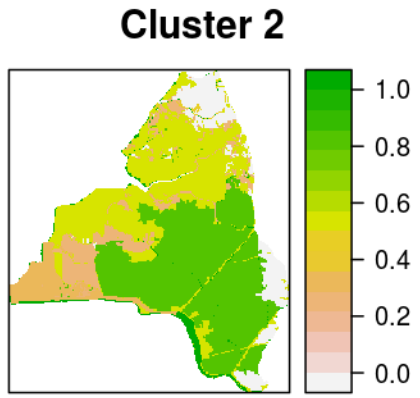

Individuals
0
2
4
6
8
cluster1
cluster2
Cluster
Type
AdmPub
Cidad
Cienc
GrpInt
Neg
PolGov

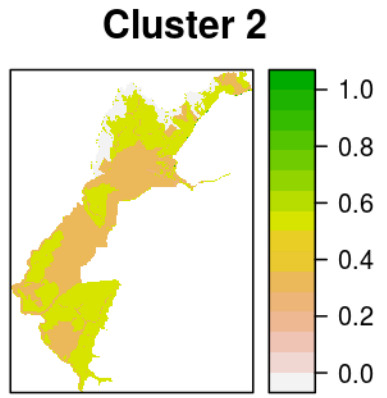
Mean weights of each Ecosystem Service (ES) for the stakeholder clusters. Values from 1 (most important) to 10 (less important).

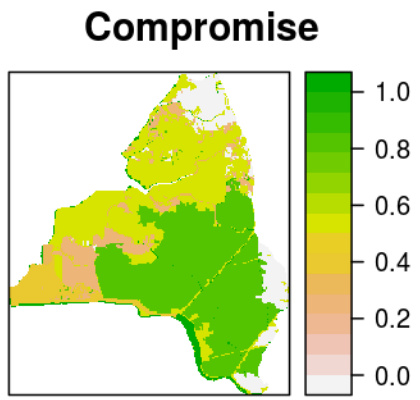
Ecosystem Service	Cluster 1	Cluster 2	Compromise
ES1	4	5.2	4.6
ES3	4.1	3.7	3.9
ES4	5.9	1.6	3.7
ES5	1	10	5.5
ES6	6	1	3.5
ES7	1.4	6.6	4
ES8	4.2	8.5	6.3
ES9	7.1	9.3	8.2
ES10	8	2.1	5.1
ES11	10	1.3	5.7

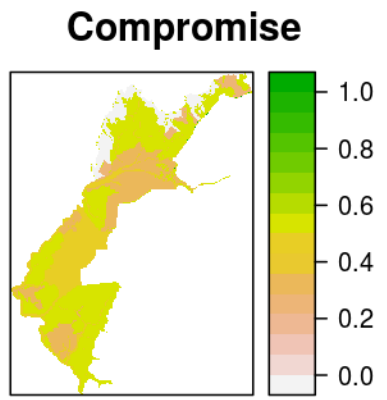












Conclusions

- According to our results, the main areas to be preserved in the BVL were:
  - the traditional agricultural mosaic fields with a woodland element (*bocage*)
  - the freshwater courses and
  - the subtidal estuarine channels.
- By combining ecology with the analysis of social preferences, this study shows how management can be informed to improve the conservation of coastal ecosystems.