Philosophy of globally customizable ES models

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References

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Towards globally customizable ecosystem service models

Javier Martínez-López [a,*], Kenneth J. Bagstad [b], Stefano Balbi [a], Ainhoa Magrach [a], Brian Voigt [c], Ioannis Athanasiadis [d], Marta Pascual [a], Simon Willcock [e], Ferdinando Villa [a,f]

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A user friendly access to ES modelling

1. ES-related user queries in a user-selected spatial and temporal context.
2. Queries can be entered in the Explorer interface as English sentences (or keywords)
3. Keywords call on logical statements (ontologies) that are conceptual models *resolved* with the data and algorithms available in the ARIES semantic web

Why are they needed?

- A conceptualization of ES supply and demand
- Rapid assessment
- No input/data preparation needed
- Models can run in any spatial context of the Earth with seasonal to annual temporal scale
- Customization of data, models and scenarios is currently possible using the k.LAB Modeler
  - soon with ARIES Explorer too

Current Contents

Fully specified model content concerning the following ES problem areas:

- Carbon storage
- Outdoors recreation
- Pollination
- Sediment retention
- Riverine flood regulation

Areas in development for a forthcoming release in the short term include:

- Mariculture suitability
- Water availability (based on hydrological calculations)
- Biodiversity value (based on machine learning of expert opinion)
- Crop yield production
- Forest timber production
- MicroHydro renewable energy production

What they are now

- Ready to use as a baseline but likely delivering a rough picture
- For all the queries, ARIES will build a spatially explicit observation,
  - mostly raster GIS coverage of user-selected resolution.
- The results will reflect the contents of the ARIES semantic web at the time of query
  - nearly all supporting data are currently available at spatial resolution ranging between 1km and 90m.
- Not complexity oriented

  ➔static and aggregated: as per InVEST/Estimap approaches

Global ES models

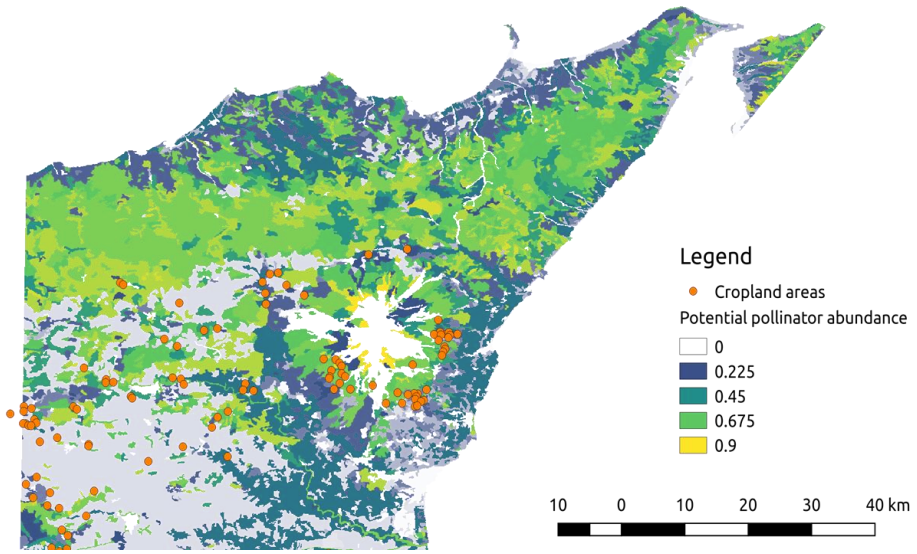
Carbon storage
Key methods:
Ruesch & Gibbs 2008

Pollination
Key methods:
Zulian et al. 2013

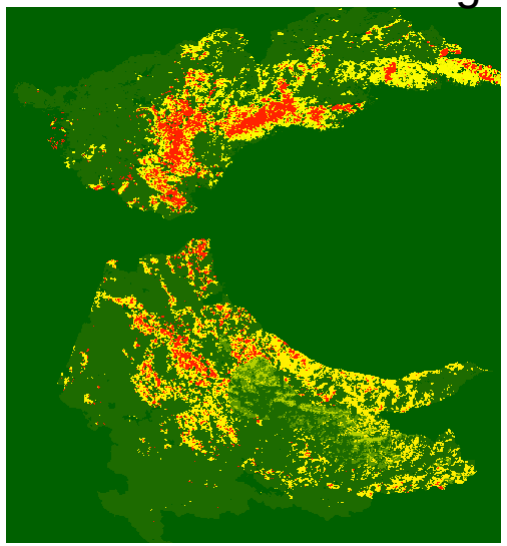
Riverine flood regulation
Key methods:
Di Leo et al. 2011

Recreation
Key methods:
Paracchini et al. 2014

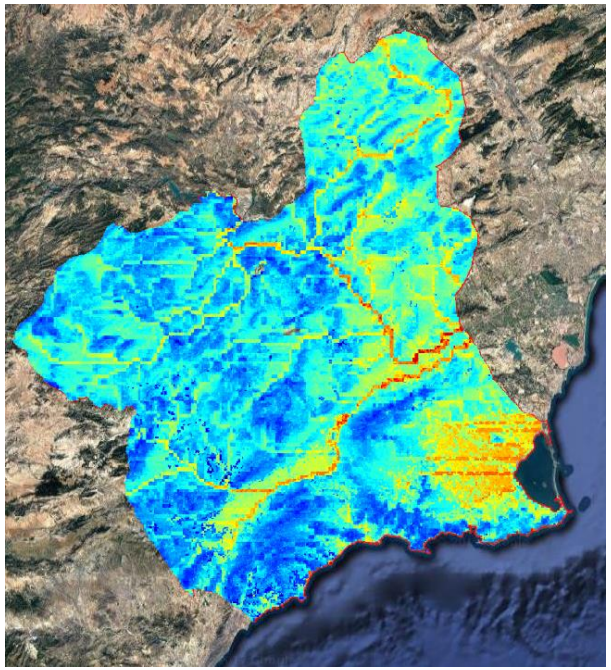
Pollination



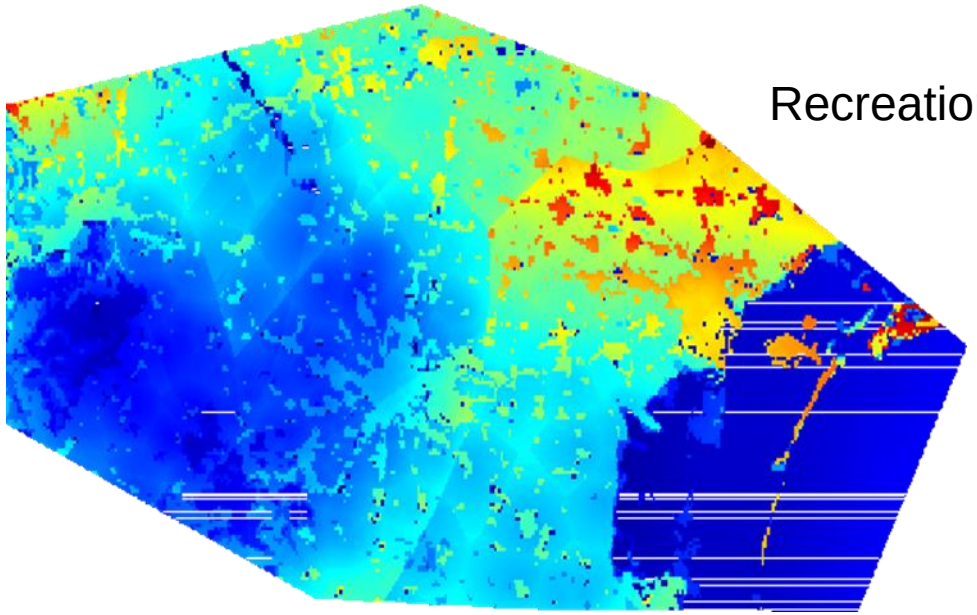
Carbon storage



Flood regulation



Recreation



Scalability, Context Awareness and Crowd-sourced Data

- Waterways

```
@color(blue)
model each earth:Waterway
    "Automatically scales to find the types of settlements most relevant to each scale of observation."
    using
        gis.osm.query(
            feature-type="line",
            equal=("waterway", "river"))
          if [space.scale <= 11],
        gis.osm.query(
            feature-type="line",
            equal=("waterway", ("river", "stream")))
          if [space.scale > 11];
```

- Human Settlements

```
model each infrastructure:HumanSettlement
    "Automatically scales to find the types of settlements most relevant to each scale of observation."
    using
        gis.osm.query(
            feature-type="point",
            equal=("place", "city"))
          if [space.scale <= 5],
        gis.osm.query(
            feature-type="point",
            equal=("place", ("city", "town")))
          if [space.scale > 5 && space.scale < 9],
        gis.osm.query(
            feature-type="point",
            equal=("place", ("city", "town", "village")))
          if [space.scale >= 9];
```

e.g. Zoom Level

Zoom levels

Available languages — *Zoom levels* purge · Aiuto

· Deutsch · **English** · español · français · Nederlands · polski · português · Tiếng Việt · русский · українська

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Aiuto
Blogs
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Strumenti
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Pagine speciali
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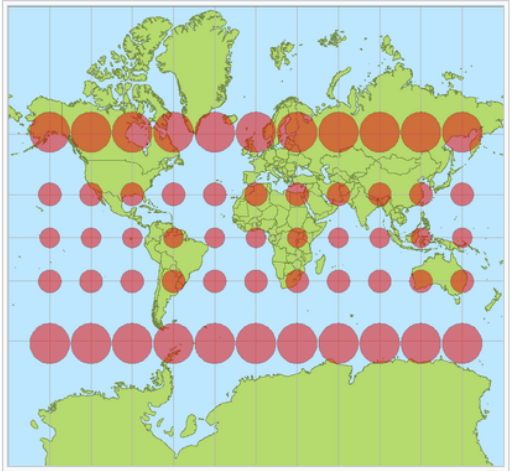
Level	# Tiles	Tile width (° of longitudes)	m / pixel (on Equator)	~ Scale (on screen)	Examples of areas to represent
0	1	360	156 412	1:500 million	whole world
1	4	180	78 206	1:250 million	
2	16	90	39 103	1:150 million	subcontinental area
3	64	45	19 551	1:70 million	largest country
4	256	22.5	9 776	1:35 million	
5	1 024	11.25	4 888	1:15 million	large African country
6	4 096	5.625	2 444	1:10 million	large European country
7	16 384	2.813	1 222	1:4 million	small country, US state
8	65 536	1.406	610.984	1:2 million	
9	262 144	0.703	305.492	1:1 million	wide area, large metropolitan area
10	1 048 576	0.352	152.746	1:500 thousand	metropolitan area
11	4 194 304	0.176	76.373	1:250 thousand	city
12	16 777 216	0.088	38.187	1:150 thousand	town, or city district
13	67 108 864	0.044	19.093	1:70 thousand	village, or suburb
14	268 435 456	0.022	9.547	1:35 thousand	
15	1 073 741 824	0.011	4.773	1:15 thousand	small road
16	4 294 967 296	0.005	2.387	1:8 thousand	street
17	17 179 869 184	0.003	1.193	1:4 thousand	block, park, addresses
18	68 719 476 736	0.001	0.596	1:2 thousand	some buildings, trees
19	274 877 906 944	0.0005	0.298	1:1 thousand	local highway and crossing details

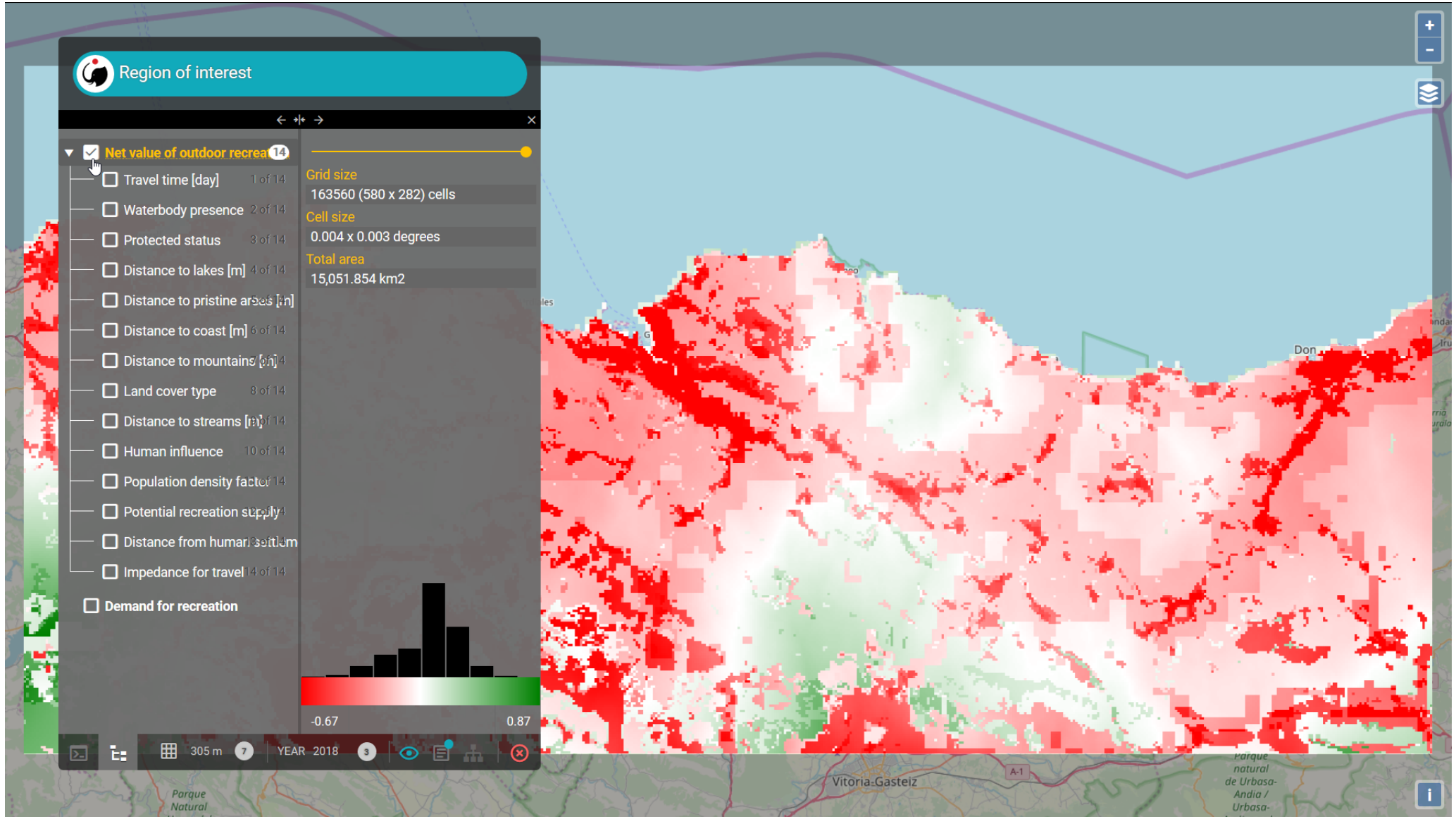
- The "# Tiles" column indicates the number of tiles needed to show the entire world at the given zoom level. This is useful when calculating storage requirements for pre-generated tiles.
- The "° Tile width" column gives the map width in degrees of longitude, for a square tile drawn at that zoom level.
- Values listed in the column "m / pixels" gives the number of meters per pixel at that zoom level. These values for "m / pixel" are calculated with an Earth radius of 6372.7982 km and hold at the Equator; for other latitudes the values must be multiplied by the cosine (approximately assuming a perfect spheric shape of the geoid) of the latitude.
- "~ Scale" is only an approximate size comparison and refers to distances on the Equator. In addition, the given scales assume that 256-pixel wide tiles are rendered and will be dependent on the

Distances per degree of longitude, for the latitudes marked in the picture.

Difference of longitudes	Actual distances			
	at 0° lat.	at 30° lat.	at 60° lat.	at 87.5° lat.
0.01 °	~ 1 000 m	~ 870 m	~ 500 m	~ 43.62 m
0.001 °	~ 100 m	~ 87 m	~ 50 m	~ 4.36 m
0.000 1 °	~ 10 m	~ 8.7 m	~ 5 m	~ 0.44 m
0.000 01 °	~ 1 m	~ 0.87 m	~ 0.5 m	~ 0.04 m



Variation with latitude of represented distances (in degrees or pixels) on the Mercator projection per actual distances (in meters) on Earth surface.


Region of interest
Net value of outdoor recreat 14
Travel time [day] 1 of 14
Waterbody presence 2 of 14
Protected status 3 of 14
Distance to lakes [m] 4 of 14
Distance to pristine areas [m]
Distance to coast [m] 6 of 14
Distance to mountains [m]
Land cover type 8 of 14
Distance to streams [m]
Human influence 10 of 14
Population density factor
Potential recreation supply
Distance from human settlem
Impedance for travel 14 of 14
Demand for recreation
Grid size
163560 (580 x 282) cells
Cell size
0.004 x 0.003 degrees
Total area
15,051.854 km2
-0.67
0.87
305 m
YEAR 2018
Vitoria-Gasteiz
A-1
Parque natural de Urbasa-Andia / Urbasa-
Parque Natural

What they can become

- The model content does not implement monolithic "models" of ES
- Starting point for improvement, also conceptual improvement
- Capture more complexity, including multi-agents networks and dynamic transitions

  → this is the real PTB framework implementation
- We envision a critical role of remotely sensed data in the near future for real time and high frequency assessments