A web-based GIS tool for exploring the world's biodiversity: The Global Biodiversity Information Facility Mapping and Analysis Portal Application (GBIF-MAPA)

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Keywords:
Biodiversity mapping, Online Geographic Information Systems, Species richness, Survey gap analysis, Global Biodiversity Information Facility

1. Introduction

„*Overall, we are locked into a race. We must hurry to acquire the knowledge on which a wise policy of conservation and development can be based for centuries to come“.* E.O. Wilson (1988)

In the quote, Wilson (1988) urges the global biodiversity community to develop a wise set of policies for biological conservation.

-Wisdom: is the top portion of a hierarchy, includes data, information and knowledge
-In order to achieve wisdom, one must first have data — raw observations and measurements.

The raw data formuch of biodiversity research are specimen occurrence records — when and where species are found.

- GBIF (Global Biodiversity Information Facility)- has developed an infrastructure by which museums and herbaria can publish their databases to a global network of biodiversity data.
As of March 2007, provides GBIF access over the Internet to approximately 120 million species occurrence records from over 1000 separate collections.

- EstimateS provide estimations of species richness

- DIVA-GIS provide GIS capabilities and a suite of biodiversity analysis modules

- GBIF-MAPA- a web-based biodiversity workflow tool that provides users the means to semi-automate raw biodiversity data acquisition, geospatial visualization and deployment of core biodiversity analyses

2. Case studies

- The point of developing GBIF-MAPA was to provide a means for users to select any region in the world and ask core biodiversity research questions like:
    - Is there enough existing biodiversity data to determine accurate measures of species richness?
    - “Where is the most likely spot to survey for more biodiversity given the current species occurrences and environmental conditions?

- Case study 1: **Survey Gap Analysis tool** (SGA) = Best location for field survey depending on previous study sites.

- Case study 2: **Species Richness Analysis tool** (SRA) = Find the best sites with high species richness.

- Case study criteria:
    Criteria 1:The regions and taxa were not ones with which we were intimately familiar.
    Criteria 2:The regions are known to be hotspots for biodiversity.

(FLEMONS et al. 2007)

Case study 1: „Where to look for new frog and toad species on Madagascar?”

- The amphibian Order Anura (frogs and toads) was chosen for this case study because there are only a few Anura records from the GBIF data cache on mainland Madagascar.

- This distribution suggests that there may be undiscovered anuran species on Madagascar (Case study criteria 1: Taxa not well researched)

- We used the Survey Gap Analysis tool to determine best survey locations on Madagascar for anurans

(FLEMONS et al. 2007)

General workflow

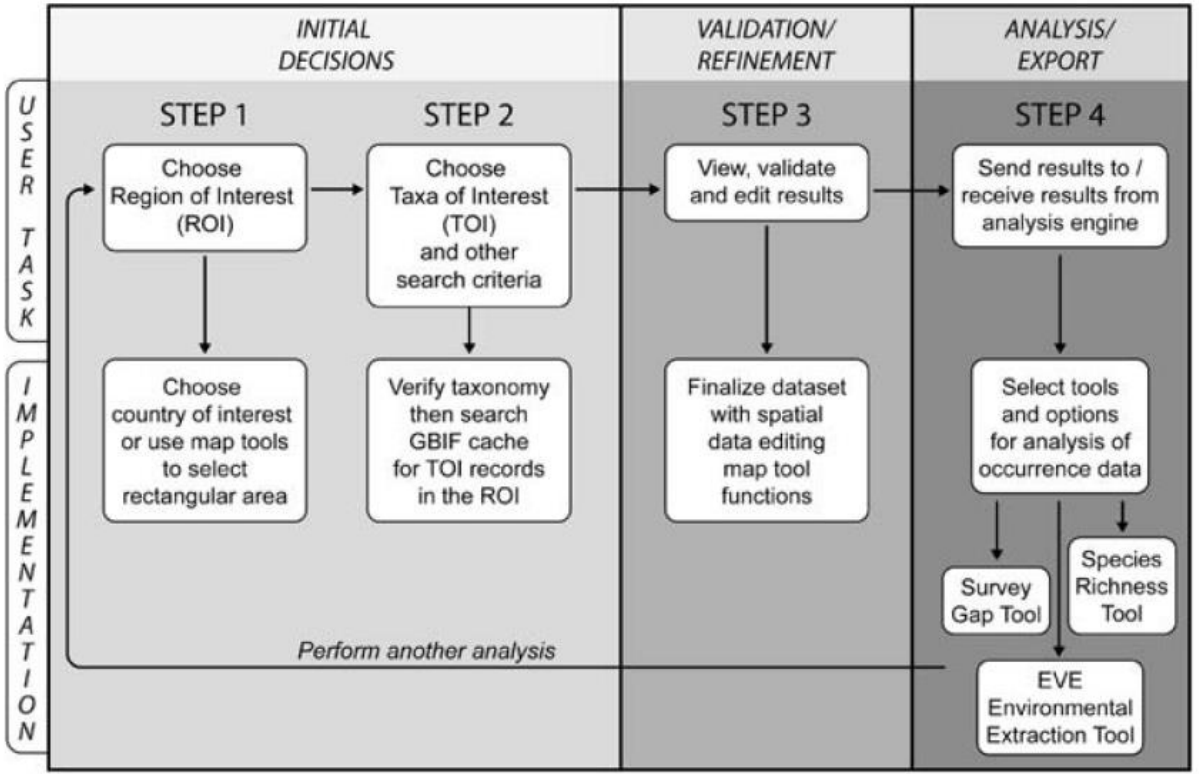


Fig. 1 – Diagram showing the user tasks and how they are implemented in the Global Biodiversity Information Facility Mapping and Analysis Portal. The tasks include: making initial decisions about the region of interest and taxon of interest; validating and refining the record set by mapping and checking records; performing one of three biodiversity analyses (species richness assessment, survey gap analysis and environmental extraction) and exporting results.

(FLEMONS et al. 2007)

Application Interface

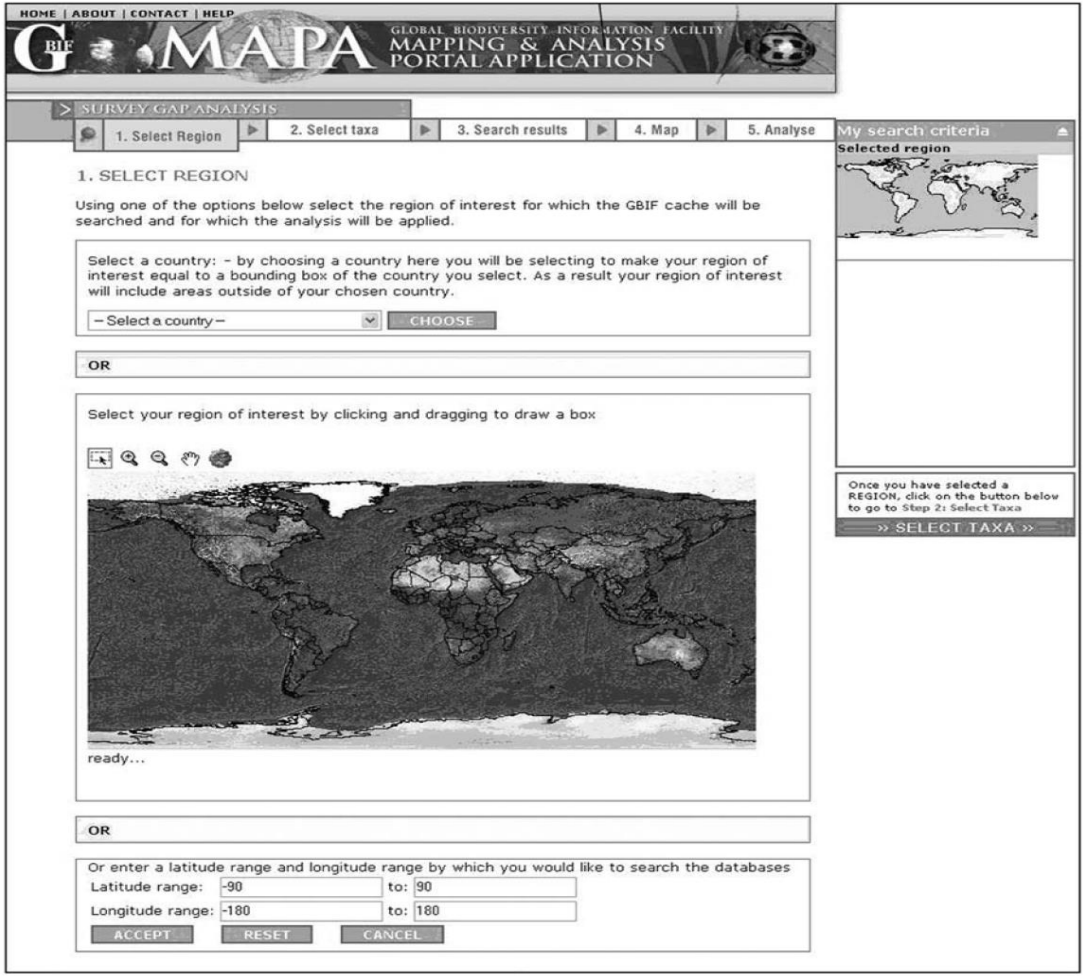


Fig. 2 – GBIF-MAPA interface showing GUI design methods for maximizing user certainty. At the top of the screen under the GBIF-MAPA banner is the "process flow bar" and on the right of the page is the "search criteria summary box".

(FLEMONS et al. 2007)

Workflow for case study 1

I. Initial decisions:

Step 1: ROI = Madagascar

Step 2: TOI = Anura

II. Validation/Refinement:

Step 3: View and validate results

→ Delete anura taxa occurring in the sea

III. Analysis/Export

Step 4: Tool selection = Survey Gap Analysis

→ Data extraction (Best study sites to search for anura)

(FLEMONS et al. 2007)

Results of Survey Gap Analysis

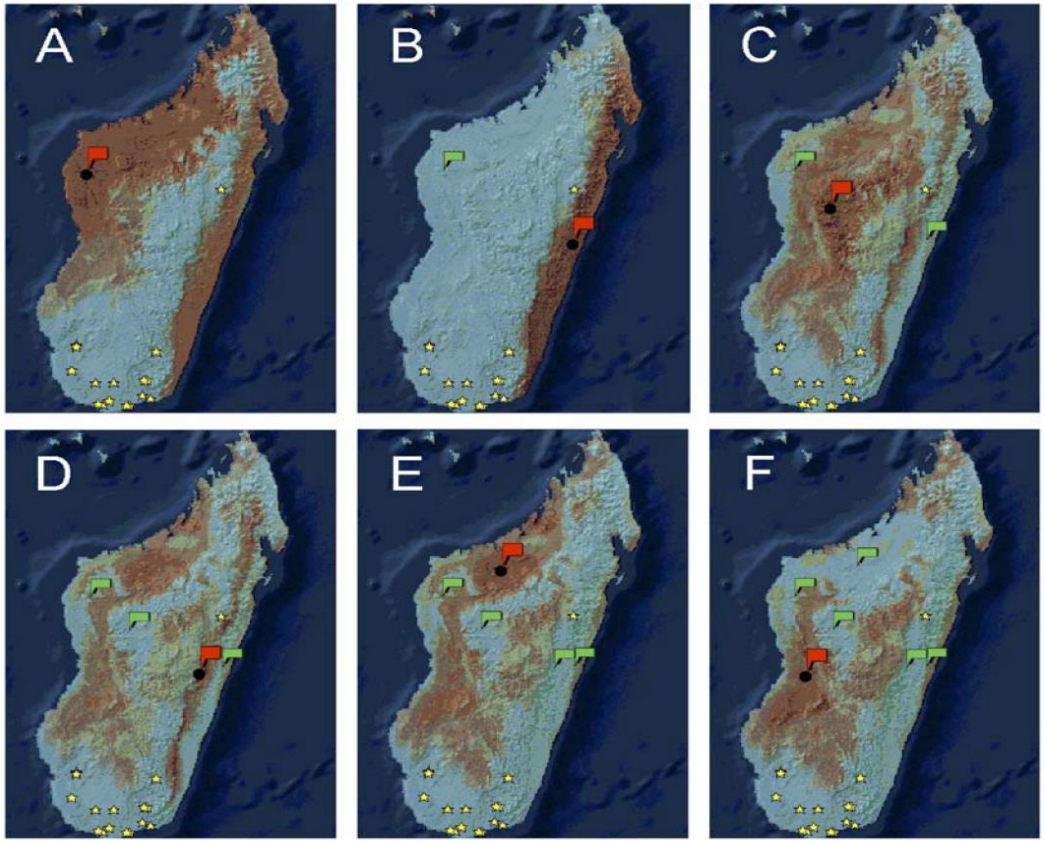


Fig. 4–Panel of maps showing the results of the iterative selection of points by the Survey Gap Analysis algorithm. The colour gradation from blue to brown indicates areas of low complementarity to high complementarity. The red flags represent the optimal survey location in terms of most complementing existing survey effort. The green flags mark previously chosen new survey locations. A — Red flag marks the location of the site of highest complementarity value relative to the existing survey effort (yellow stars) B to F — addition of one new site per iteration, each iteration identifies the next highest site of complementarity. Each green flag represents a previously chosen new survey location. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

(FLEMONS et al. 2007)

Case study 2: “Can Ethiopian rodent species richness be estimated using GBIF data?”

-The case study for species richness assessment is rodent richness in the country Ethiopia.

-The country comprises the Ethiopian Highlands, which is one of thirty four global biodiversity hotspots. (Case study criteria 2: High biodiversity)

-It is also an area of global conservation concern given high species richness and number of endemics, and given increasing and dramatic human impact on the area.

(FLEMONS et al. 2007)

Workflow for case study 2

I. Initial decisions:

Step 1: ROI = Ethiopia

Step 2: TOI = Rodentia

II. Validation/Refinement:

Step 3: View and validate results (delete unfitting entries)
→1053 specimen occurrence records
→ delete uncompleted entries

III. Analysis/Export

Step 4: Tool selection = Species Richness Analysis
→ Data extraction

(FLEMONS et al. 2007)

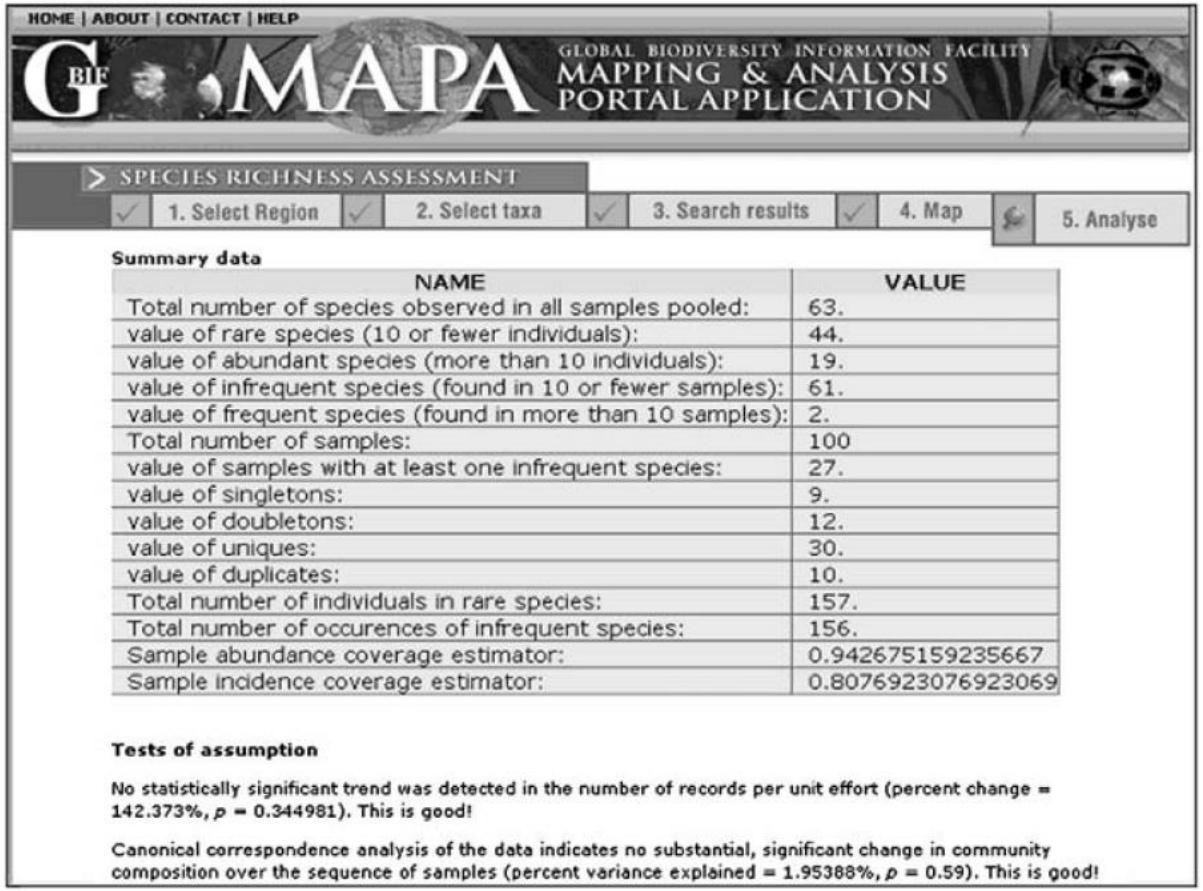


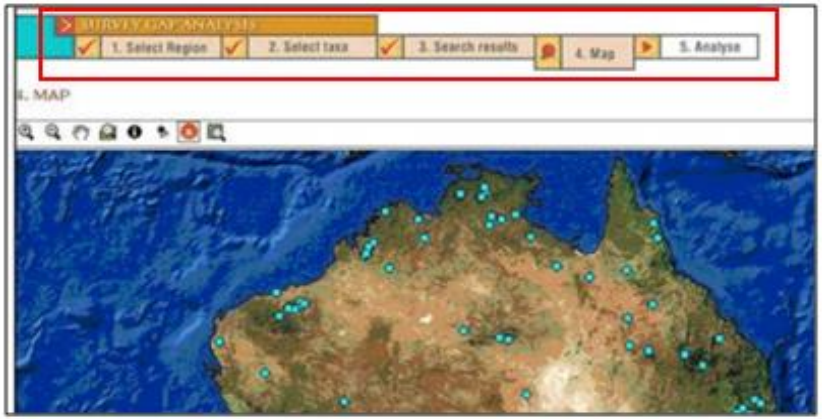
Fig. 5 – Tabular summary output from the species richness analysis (SRA) of rodents in Ethiopia as generated from GBIF-MAPA. After validation, there were 998 usable species occurrence data points from the GBIF data cache. The summary data is part of a much larger set of output from SRA.

Species Richness Analysis

(FLEMONS et al. 2007)

GENERAL TECHNICAL ISSUES

	Issue	→	Challenge	→	Solution	→	Implementation
max. user certainty	Speed of application and user feedback		Bad feedback reduces the app's acceptance/usability		fast architecture and user interfaces that meet user expectation		same servers for app and databases
	Intuitive and linear process flow		UI that effectively guides users through necessary steps		linear processes and cleary defined steps for immediate comfort		5 specific steps; 4 common to every analysis & the last is unique



(FLEMONS et al. 2007)

TECHNICAL ISSUES OF THE WORKFLOW

	Step	Challenge	Solution	Implementation
1	ROI	ability to select a meaningful ROI	3 approaches: 1. Database field 2. Bounding box 3. Polygonal bounding area	-
2	TOI	Large amount of data, exponentially increasing loading times	Local JDBC (Java Database Connectivity)	MAPA app is installed directly into GBIF portals
3	map/validate species occurences	effectively view multiple taxa on multiple base layers	allow user selection of symbology view or hide different basemap layers	e. g. drop-down list of symbols for each taxon
4	Data analysis & results	Select tools that are needed & simple to implement	select tools that are already in use & well known among the biodiversity researchers	implement two main tools (SRA & SGA)

(FLEMONS et al. 2007)

a. What were the main questions (or objectives) addressed?

- Supporting research, conversation management, and education with high quality global diversity data
- How to build tools which use the GBIF data portal, giving access to researchers to allow to use the whole spectrum of available data

(FLEMONS et al. 2007)

b. How did the authors tackle them? (what did they do?)

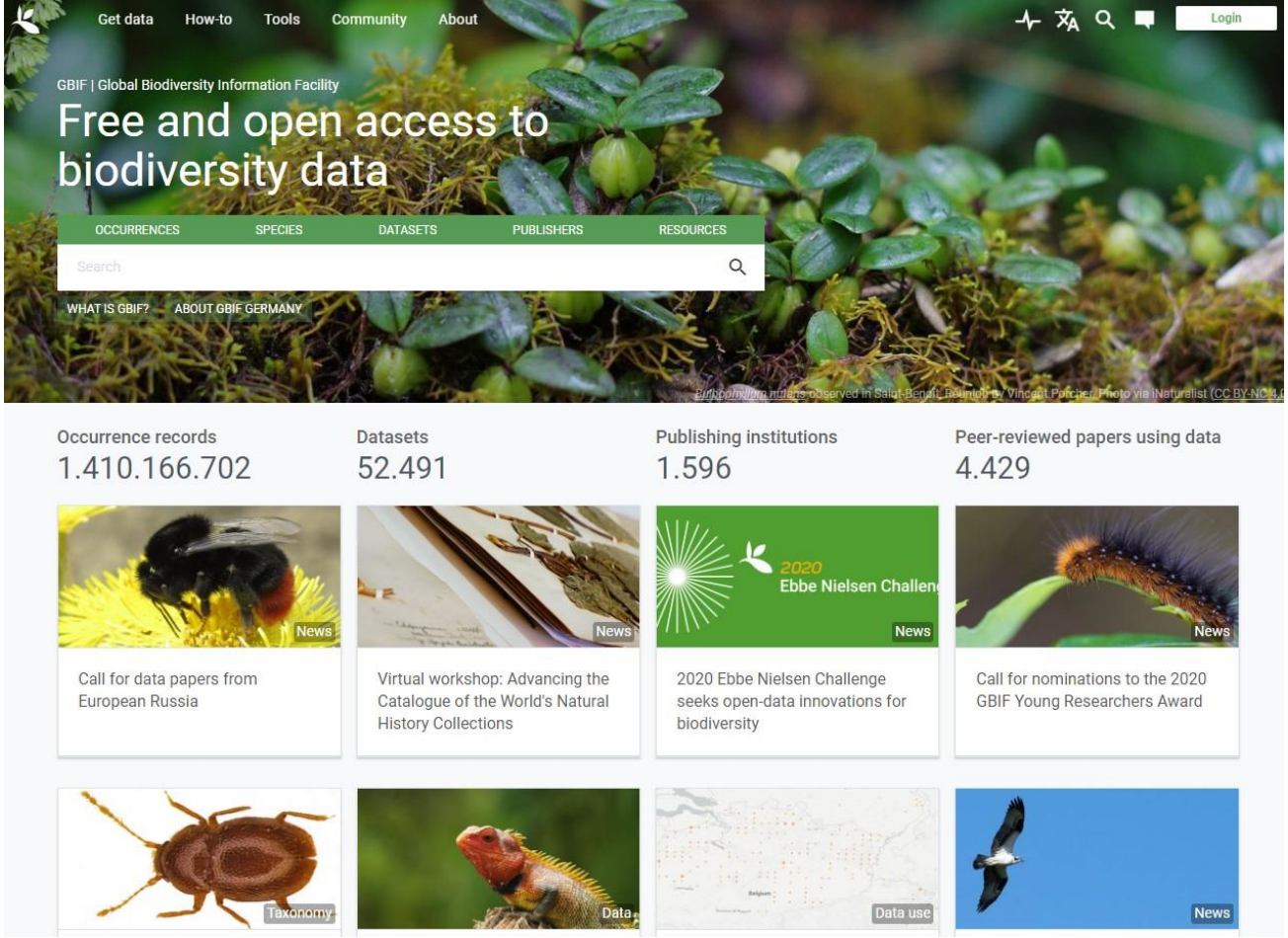
Building a tool to perform biodiversity analysis with a end-to-end workflow

- Three types of analyses:
  - environmental extraction
  - survey gap analysis
  - species richness assessment
- Focusing on:
  - user-friendly interface
  - speed
  - flexibility in designing output

(FLEMONS et al. 2007)

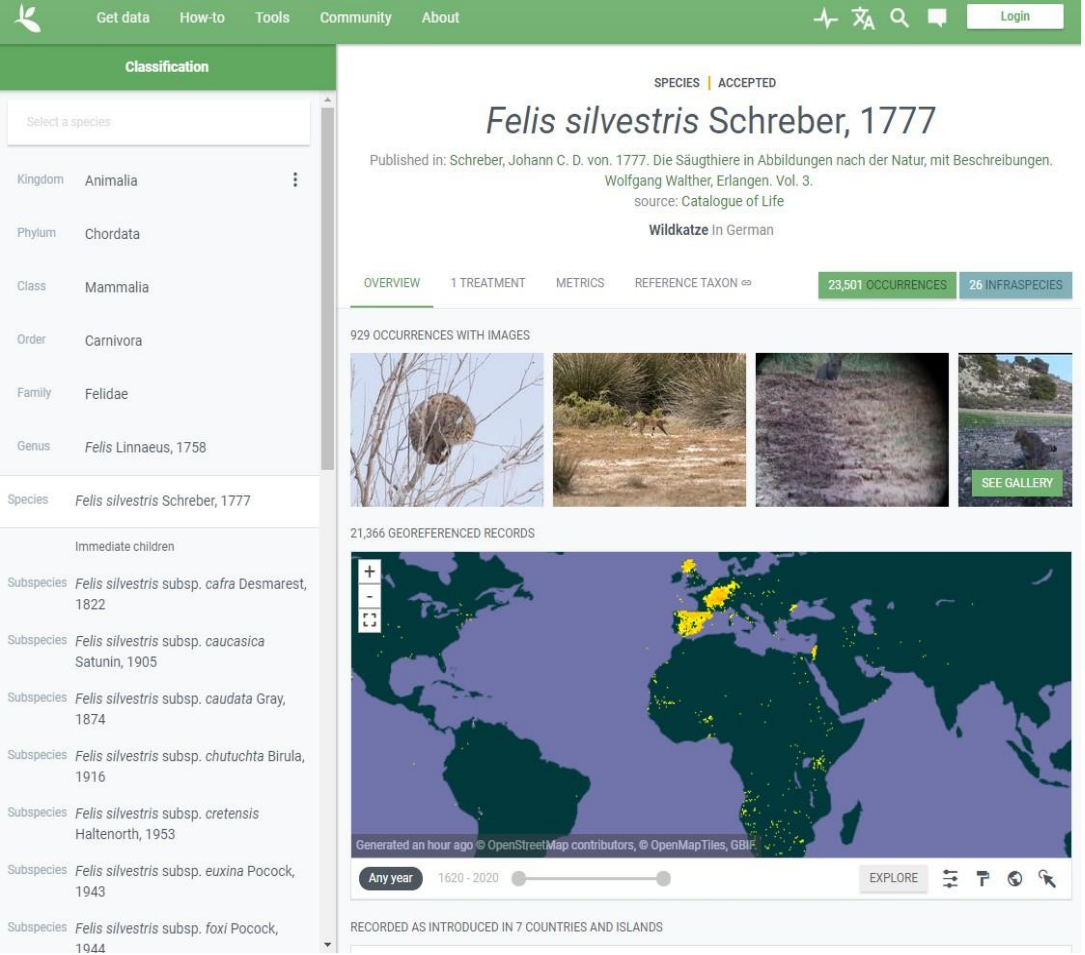
c. What aspects could be added/done differently/problems?

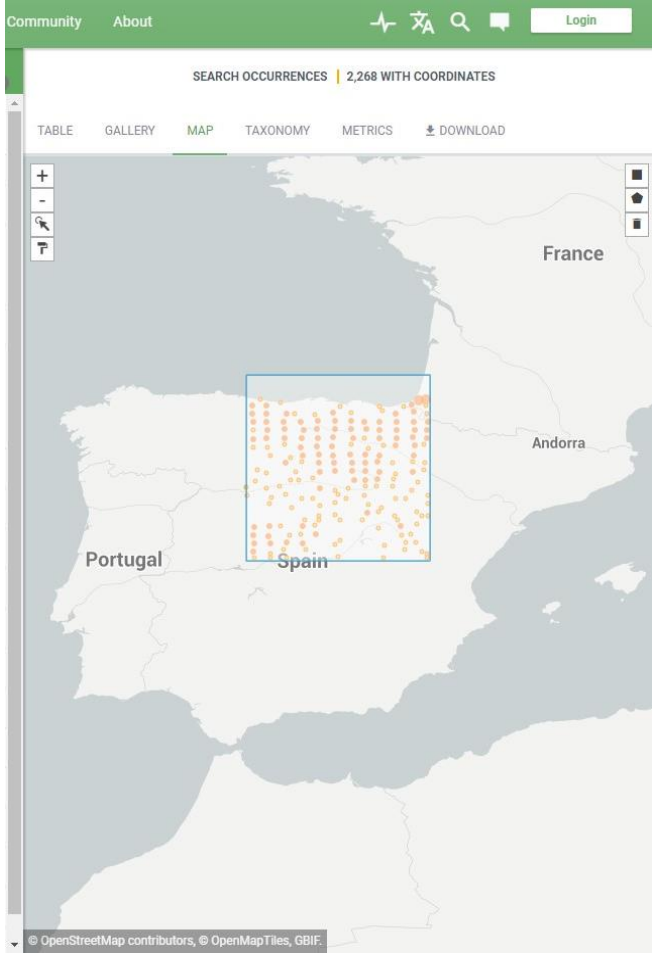
- Paper was published in 2007, outdated
- MAPA webpage is not available, only reference screenshots in the paper
- No possibility to try it out, hard to visualize technical issues and service
- No information how gbif.org looked like back then
- In second case study, incomprehensible what quality the output has



- Able to search after species, occurrences, data sets
- Tables, pictures of occurrences

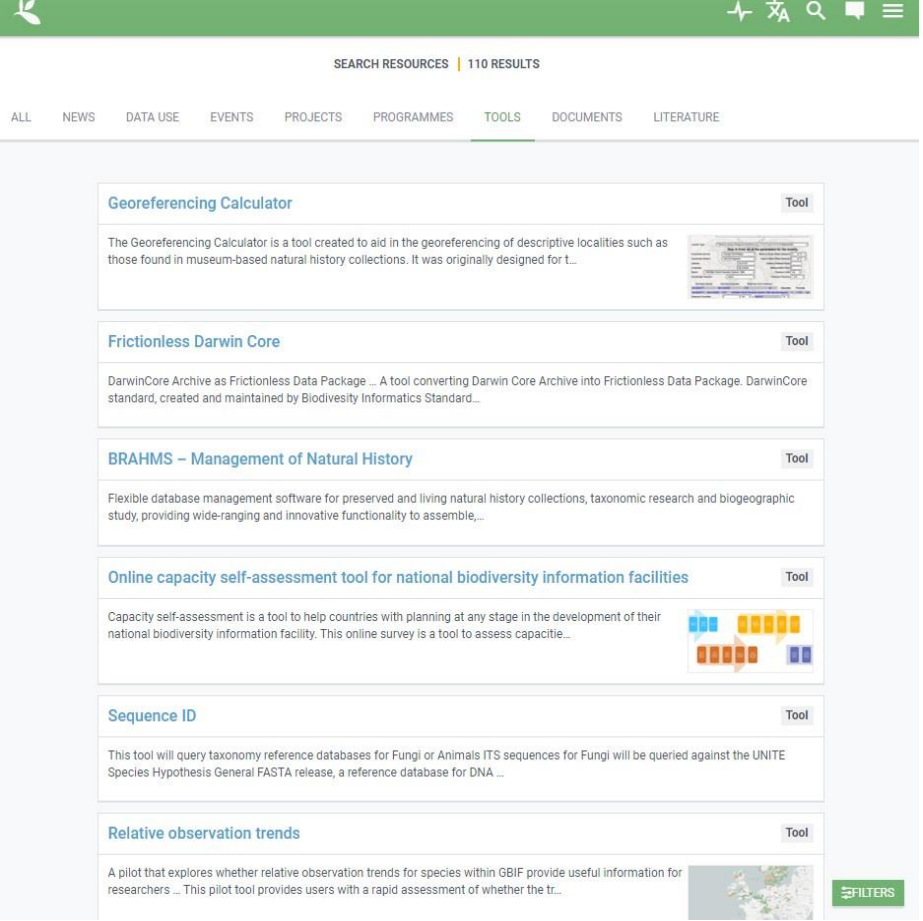
(GBIF.ORG 2020)

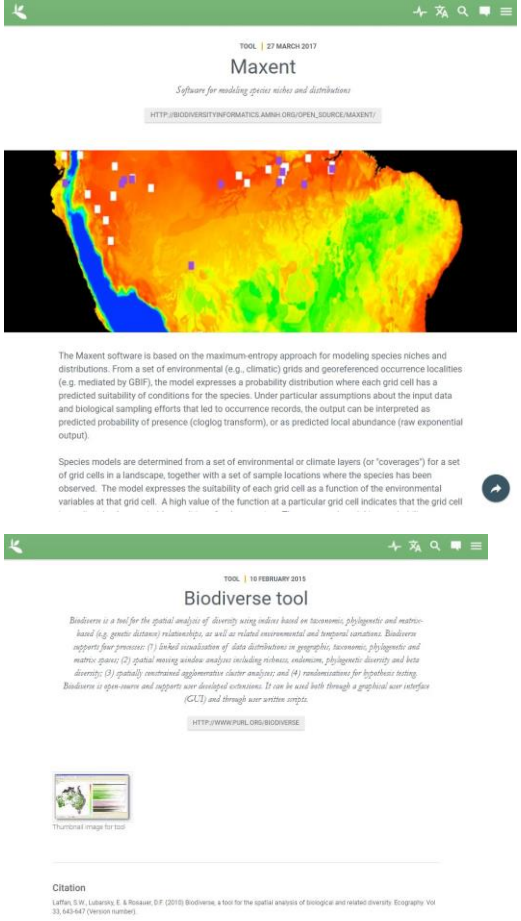




- Gbif has an interactive map
- Able to look into particular regions

(GBIF.ORG 2020)





- A lot of tools for cleaning and validating data
- Now more tools for SDM and predicting survey locations: MaxEnt, Biodiverse, Rpackages, OpenModeller, etc.

(GBIF.ORG 2020)

References

FLEMONS, P., GURALNICK, R., KRIEGER, J., RANIPETA, A. & NEUFELD, D. (2007): A web-based GIS tool for exploring the world's biodiversity: the global biodiversity information facility mapping and analysis portal application (GBIF-MAPA). *Ecological Informatics*, **2**, 49– 60.