

Visual Exploration of the European Red List

S. Jänicke

Leipzig University, Leipzig, Germany

Abstract

The European Red List gives an overview of animal and plant species that are threatened with extinction at the European level. Currently, only prefabricated charts and standard mapping tools are provided to analyze the statuses of threatened species in a visual form. This paper provides a series of visual interfaces that support the construction of dynamic queries, thus, offering new capabilities to investigate geospatial, species-related features and developments. The major goals are to better inform the broad public on the contents of the European Red List, and to improve the capabilities of biodiversity researchers in developing target-oriented conservation strategies.

1. Introduction

The International Union for Conservation of Nature's Red List of Threatened Species has been established in 1964 to inform researchers and the public on the status of threatened species, and to steer actions for biodiversity conservation. Drawn from numerous scientific publications, diverse information on species are brought together forming an indispensable research database. For the entire IUCN Red List of Threatened Species [IUC19b], a few statistical information are shown with basic non-interactive charts. However, species categories cannot be compared and filter operations can only be done in a faceted browsing environment. Further, a map can only be used to filter by polygonal region without communicating the actual geospatial distributions of species.

That interactive visualizations can support biodiversity-related research workflows has already been documented in previous works [SvL13, MGO*14, Jän18]. Following the suggestions made by Kaur et al. [KKKR18], this paper provides a comprehensive visual exploration system for the European Red List [IUC19a] that identifies those species that are threatened with extinction at the European level. The system offers a series of visual interfaces that can be used to define dynamic queries for species categories, threat statuses, trends, habitats and geospatial areas.

2. Visual Interfaces

The proposed exploration system consists of a series of visual interfaces to be used for constructing dynamic queries and inspecting matching results. A screenshot of the system is given in Figure 1. Interactive charts and well-established visualization means are implemented to convey species' characteristics in an intuitive fashion. Further, linking and brushing is used to support a straightforward comprehension of how the system works and of how subsets of the data are related.

2.1. Species Widget

The European Red List lists 11,670 threatened species in 15 different categories. As the totals of species belonging to those categories strongly vary, they have been carefully grouped into six superordinate categories to ease exploring the data:

- *Animals (1031 species)* containing Amphibians & Reptiles (237), Birds (533) and Mammals (261)
- *Fishes (1752)* containing Freshwater Fishes (532) and Marine Fishes (1220)
- *Molluscs (2102)* containing Freshwater Molluscs (868) and Terrestrial Molluscs (1234)
- *Plants (2420)* containing Plants (1826), Medicinal Plants (400) and Lycopods & Ferns (194)
- *Bees (1965)*
- *Insects (2400)* containing Butterflies (483), Dragonflies (142), Grasshoppers & Locusts & Crickets (1082) and Saproxyllic Beetles (693)

A categorial color map was generated using ColorBrewer [HB03], and a color was assigned to each top-level category of species. Those colors are reused in other widgets to discriminate categories in order to highlight similarities and differences. The species widget itself is an interactive bar chart where each category can be selected or filtered out via mouse click, thus, allowing researchers to direct an analysis towards a specific species type.

2.2. Threat Status Widget

Each species included in the European Red List provides an information about its threat assessment status. The following statuses are captured:

- Extinct (EX) after the year 1500 (29 species)

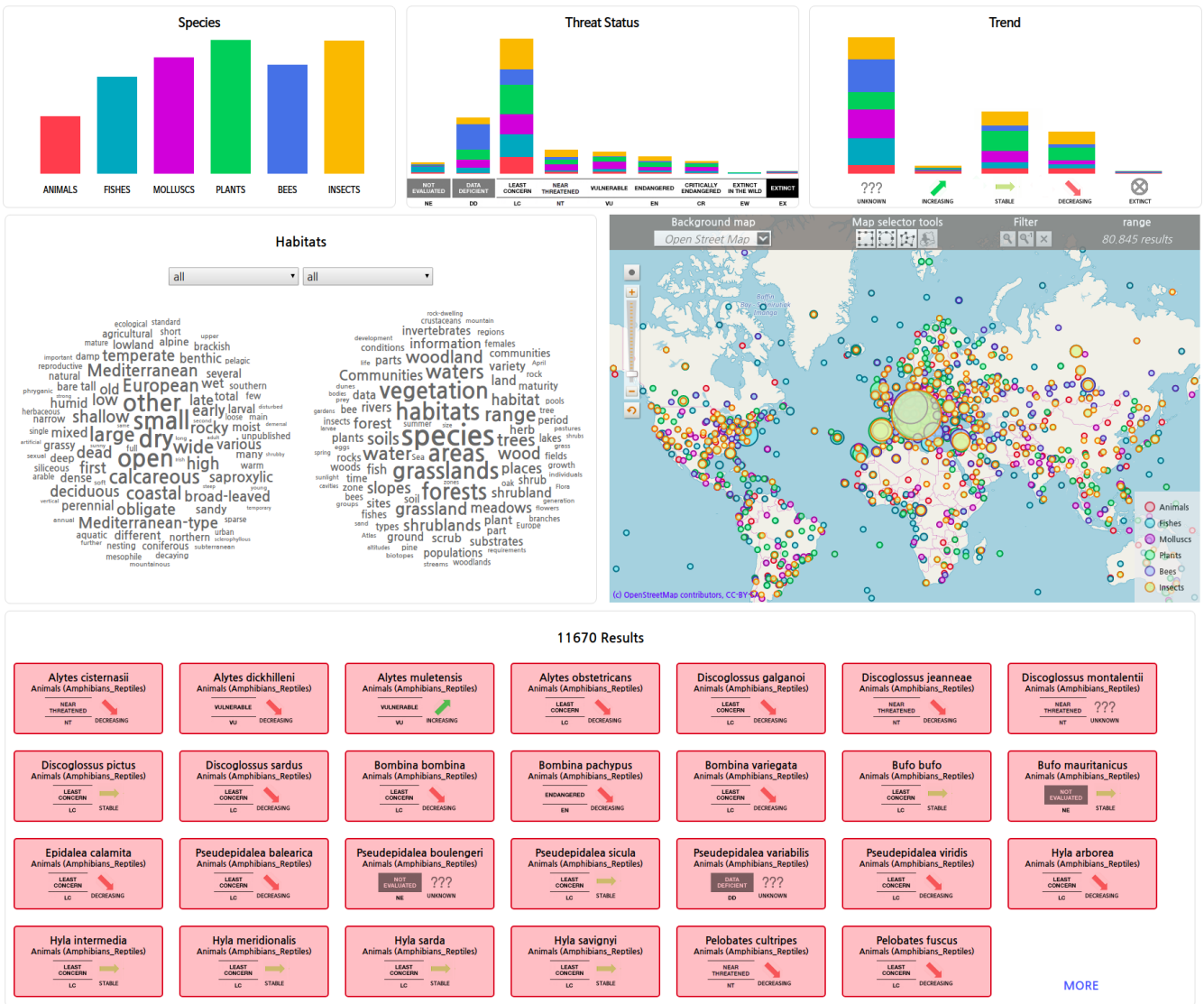


Figure 1: Screenshot of the system.

- Extinct in the Wild (EW) including species listed as regionally extinct (12)
- Critically Endangered (CR) (464)
- Endangered (EN) (687)
- Vulnerable (VU) (885)
- Near Threatened (NT) (964)
- Least Concern (LC) (5,805)
- Data Deficient (DD) means that a threat assessment has been done without a clear status categorization (2,409)
- Not Evaluated (NE) are species for which no threat assessment has been done yet (415)

A stacked interactive bar chart serves to communicate threat assessment statuses. For each threat status, the numbers of threatened species of different categories can be observed and compared to each other. Dynamic queries on the system can depend on specific

threat statuses, e.g., to focus on endangered species first, that can be interactively selected or filtered out via mouse click.

2.3. Trend Widget

The European Red List includes an information on the trend of how the populations of species have changed. For 332 species an increasing population is recorded, 2,893 species have a stable population, for 1,948 species the population decreases, and the trend for 29 species does not change due to extinction. However, for 6,468 species the current population trend is unknown. Nevertheless, offering a filter for trends is valuable as conservation activities might be directed towards species with a decreasing population. As in the previous widgets, filtering and selection is done via mouse click.

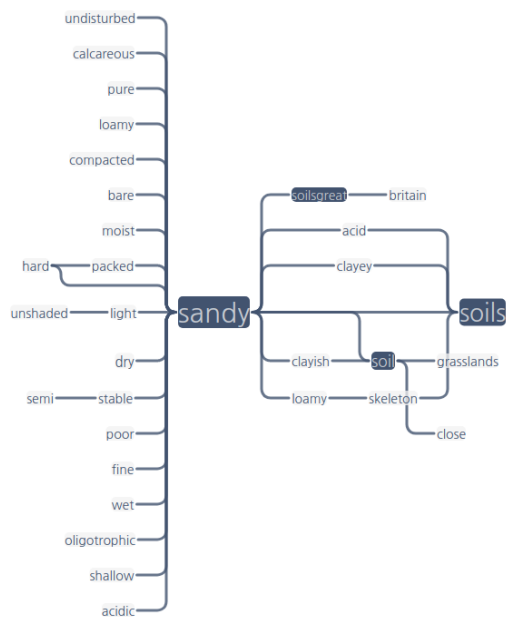


Figure 2: Variant graph for habitats including the adjective *sandy* and the noun *soil*.

2.4. Habitat Widget

For nearly all species, the European Red List provides non-standardized textual information describing the habitats of species. In order to make use of this information for exploration purposes, habitats are automatically extracted. In the habitat descriptions, habitats are most often composed of one or more adjectives followed by one or more nouns, e.g., *humid grasslands* or *phryganean Mediterranean shrublands*. Those patterns are extracted using the Stanford Log-linear Part-Of-Speech Tagger [TKMS03]. Although the results contain some false positives like *first time* and patterns that do not represent habitats but important characteristics of the species like *water-dependent species*, the gathered information is valuable to be used as an entry point to analyze species prevalent in specific habitats. Currently, basic habitat definitions like *meadows* or *beaches* are not considered. This could be done using a controlled vocabulary of habitats, which is not available at the moment.

Initially, the Top 100 adjectives and the Top 100 nouns composing the habitat information can be observed in two juxtaposed tag clouds reflecting frequently occurring terms when describing habitats. In dropdown boxes, certain adjectives and nouns can be chosen to define a habitat filter. All terms that are used at least 20 times in an extracted habitat pattern can be chosen (435 adjectives and 450 nouns). After filtering, the varying habitat patterns including the chosen terms are reflected in a variant graph visualization [JGF*15]. An example is shown in Figure 2. Selecting the adjective *sandy* and the noun *soil* reveals a variety of habitat definitions like *dry sandy soil grasslands* or *hard packed sandy soils*.

2.5. Map Widget

Like for the habitats, the European Red List gives descriptions on the geospatial range of species in textual form. Extracting all places using the Stanford Named Entity Recognizer (NER) [FGM05] delivers 86,276 related place names with a diverse granularity ranging from continents (most often *Europe*) to countries, regions like *Bohemia* or the *Mediterranean*, mountain areas like the *Transdanubian Mountains*, islands and peninsulas like the *Kerch Peninsula*, rivers and cities. Most of the place names could be geo-referenced using MapQuest [Map19]. The map widget of GeoTemCo [JHSS12, JHS13] serves to visualize and interact with the results. For each species category, a non-overlapping set of circles reflecting regional distributions is computed. As can be seen in Figure 1, circles of different categories may overlap.

Next to potential (but few) false positives, the descriptions contain numerous related places outside of Europe that are shown on the map. Nevertheless, most places are located in Europe allowing for a profound analysis of geospatial biodiversity of threatened species. To narrow the amount of species to be analyzed, geospatial filters can be defined in the form of circumcircles and polygons.

2.6. Results View

The species that match current filter criteria are listed in the results view that uses the proposed color scheme to encode the category of species. In addition, the species' subcategory, if any, is shown. By using the same icons as in the Threat Status Widget and the Trend Widget, features relevant during analysis sessions can be quickly determined. By clicking on a species' box, the user is redirected to the corresponding species' IUCN Red List entry.

3. Usage Scenarios

With the proposed system, the user is capable to quickly narrow the European Red List containing 11,670 threatened species to a set of humanly processible species.

The first scenario investigates animals living in *rocky* habitats. By selecting the habitat adjective *rocky* the amount of considerable species is reduced to 585. The further steps are (1) filter out all species except animals, (2) selecting all species with a decreasing or unknown trend, and (3) filter out all species that are of least concern (LC) or near threatened (NT). Each of the steps undertaken reduces the habitat graph revealing more specific habitats like *rocky shores* or *rocky outcrops*. The final set of species contains 19 animals with geographical ranges over all Europe. This indicates that trans-regional and trans-national activities are necessary to preserve the listed species from extinction.

The second scenario looks at regions where species with *alpine meadow* habitats are endemic, thus, that may deserve special consideration. Selecting *alpine* and *meadow* and filtering out species that are of least concern (LC) reduces the list to 38 species. For plants, two main regions (Alps and central-East Sweden) pop out.

4. Summary

Though a cooperation with the Red List Committee is intended, the proposed system has not been developed in collab-

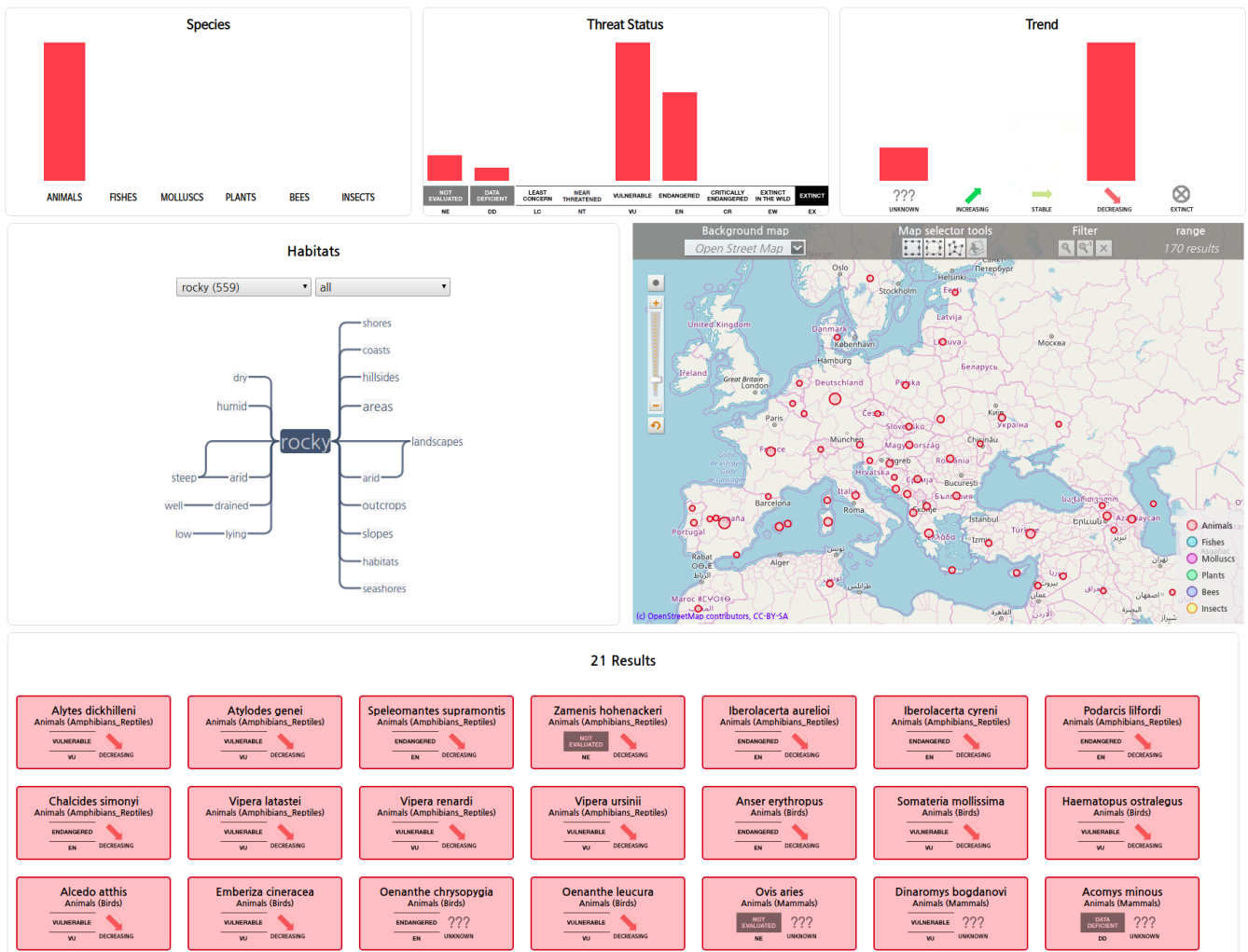


Figure 3: Threatened animals with a decreasing or unknown trend in rocky habitats.

oration with expert users. But, by observing what is currently offered to researchers using the IUCN Red List of Threatened Species [IUC19b] for exploration purposes, it has been shown that dynamic queries composed by the aid of visual interfaces can quickly lead to information potentially relevant for biodiversity research and conservation actions. Interactive bar charts, a habitat graph and an interactive map support analysis tasks that could hardly be performed with priorly existing tools. The potential of the system could further be improved by using controlled vocabulary to reduce the amount of false positive habitats and places, and by applying semi-automated steps to clean the automatically processed data. Next to habitats, information on threats to species and already applied conservation actions that are also provided could be included in the visual exploration system. In addition, the given European Red List database could be enriched with further information from the IUCN Red List.

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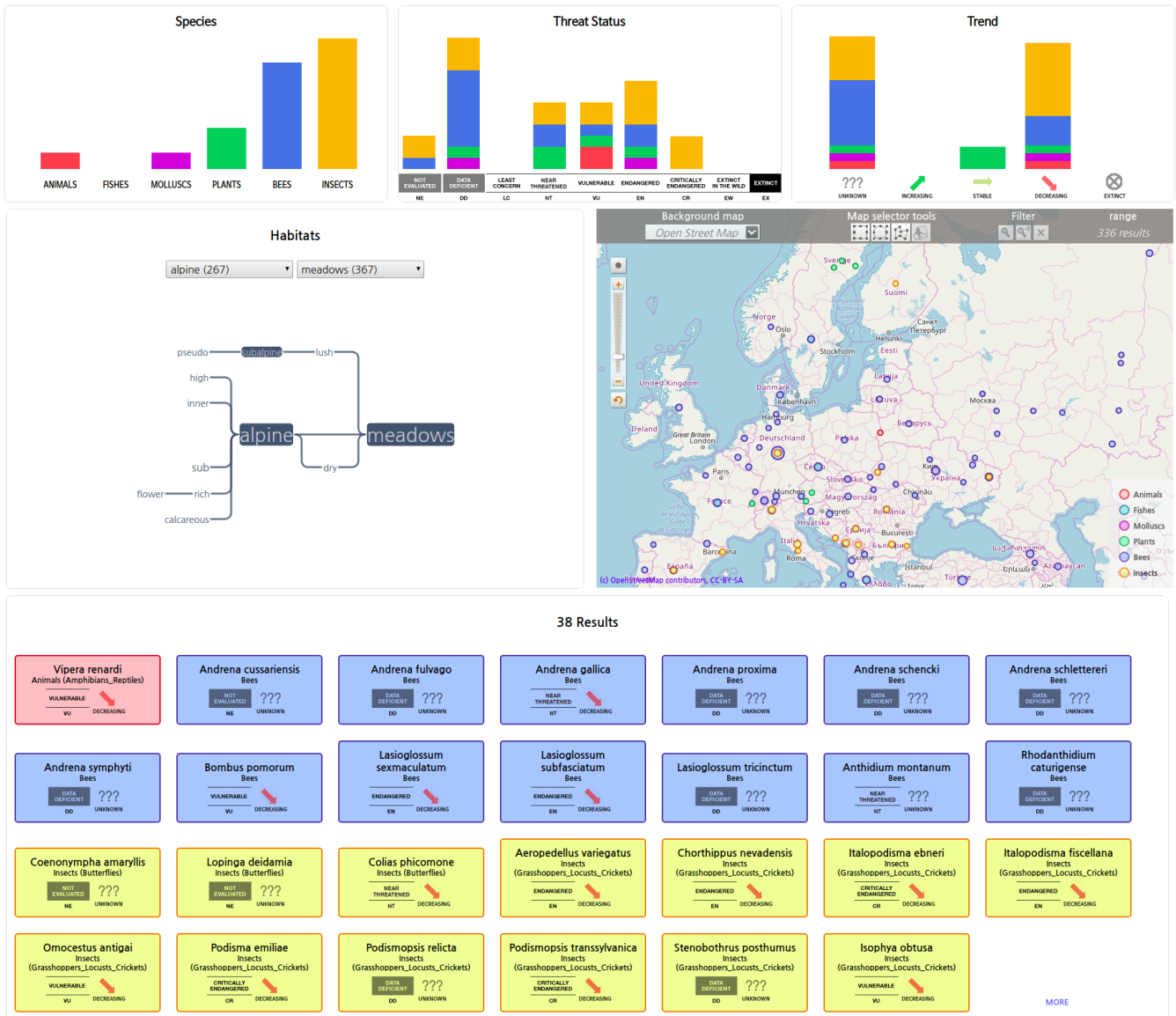


Figure 4: Threatened species having alpine meadows as habitats.

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