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# Visualizing National Threat Assessments of Tree Species

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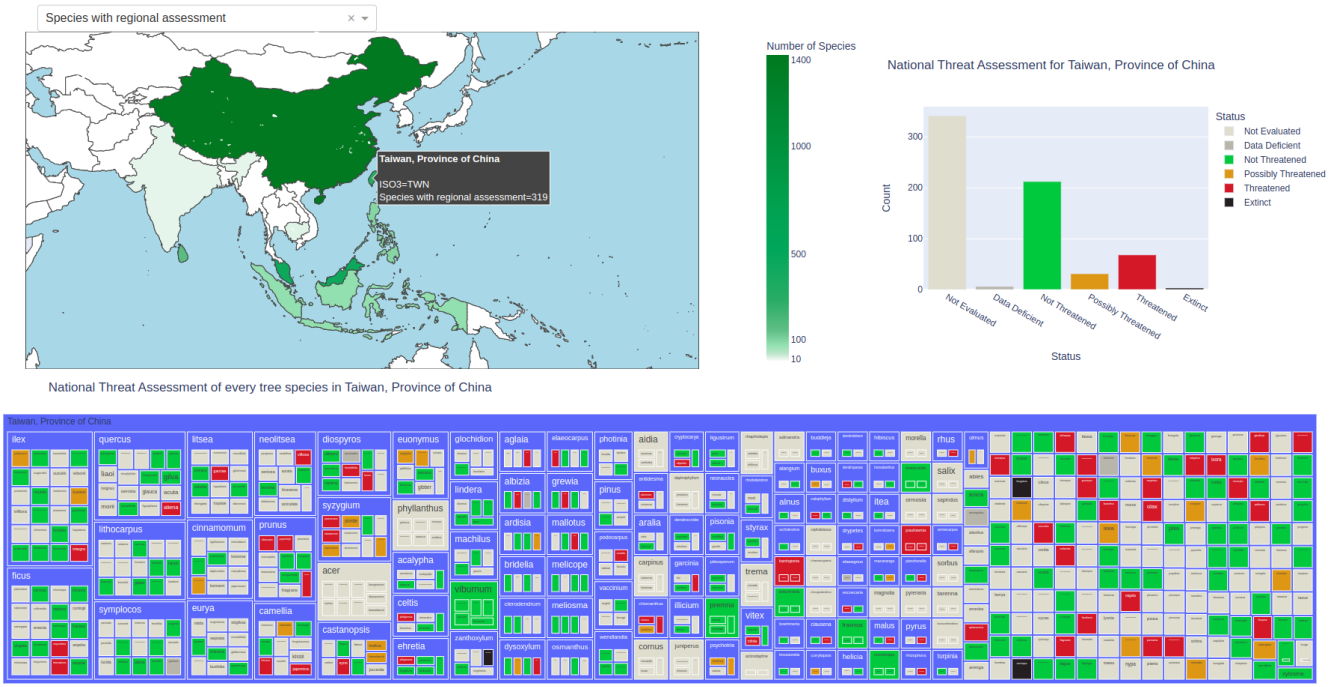


**Figure 1:** *National-level threat assessment view for Taiwan, Province of China. National assessments exist for 319 tree species that are native to the province, and the bar chart shows their distribution. Around one third of these nationally assessed species are possibly threatened, threatened, or extinct, and for more than 300 species, no nation-level assessment has been made. The tree map visualization supports directing the domain expert to particular genera and species.*

## Abstract

*Trees are important to ecosystems around the world, and therefore it is vital to know which species are in particular need of conservation. The GlobalTree Portal primarily focuses on threat assessments at the global level, but nation-level investigations of threat assessments are not yet supported. Regional or national assessments are also displayed, even if the species was not evaluated in a country. This paper presents a visualization framework that enables domain experts to analyze national assessments inspired by the GlobalTree Portal. This visualization first provides a global overview of nation-level threat assessment efforts by highlighting those with many national assessments on a choropleth map. For a selected country, the experts can inspect how the tree species assessments are distributed across BGCI's threat level categories Not Evaluated, Data Deficient, Not Threatened, Possibly Threatened, Threatened, and Extinct. The core component is a tree map visualization that displays the genera and the species within the selected country. These are color-coded according to the BGCI threat level, and thus, provide a quick overview of nation-level threat assessments at species and genus levels. The system was developed in close collaboration with biologists from BGCI, who evaluated the visualizations on a regular basis to fit their needs. The results certify the value of our solution for gaining quantitative insights about threat assessments on a national level, and BGCI researchers included the system in their work routines to impact decision making processes on national conservation actions.*





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## 1. Introduction

Trees are essential for the well-being and diversity of other living organisms like animals and other plants around the globe. Trees have ecological, economic, and cultural significance [New08]. However, many tree species are threatened with extinction, if they have not already become extinct [NLBL*20]. The main threats to tree species are agricultural expansion, logging, and urbanisation, as well as fire and mining. Pests and diseases, as well as climate change, are becoming emerging factors according to [BGC21]. Some conservation efforts have been made, but more steps should be taken to prevent the loss of tree species worldwide [Old09].

The first assessment of trees was published in 1998, and the result of the report was that around 8,000 tree species were threatened with extinction [OLM98]. The Global Tree Assessment is an initiative to assess the conservation status of the world's tree species. As part of this project, the trees of Europe were assessed [RBB*19]. 168 of the 454 native tree species are considered Vulnerable, Endangered or Critically Endangered, while 57 Species are Data Deficient. If these 57 species are found to be threatened, then nearly 50% of the tree species in Europe are considered threatened.

While global assessments (covering the whole distribution of the species) have been a priority, few monitoring efforts have been made on a national level. A tree species might not be globally threatened, but may be threatened with extinction in one of its native countries. Botanic Gardens Conservation International's (BGCI) ThreatSearch [BGC23b] database collates assessments of plants on any scale, global, regional, national, etc. ThreatSearch contains over 250 sources including the IUCN Red List, National Red List and many national and regional publications. As various sources use different classification systems, BGCI categorises them into their own assessment system using these categories: Not Evaluated, Data Deficient, Not Threatened, Possibly Threatened, Threatened, Extinct. Data Deficient means there is not enough information about the given species to determine its threat status [BGC21]. BGCI also provides visualization for the global assessments of tree species in the GloabalTree Portal [BGC22a], with both a global overview, and the threat status of all species in a given country. Data on non-global/national assessments is currently aggregated and not mapped and visualized by region or country.

In collaboration between visualization experts and biologists from BGCI, we developed a system that sheds light on national-level threat assessments to support targeted decision making processes at country level. This quantitative information is not yet easily accessible to domain experts to inform policy makers on national-level conservation agendas. Although the coverage of these assessments is limited, the enabled visual analysis is of particular importance for tree conservation because it reduces the number of involved authorities, enabling a quicker implementation of a conservation action plan on a national level.

## 2. Related work

Visualization as a means to display threats to species has been an important instrument for research purposes and for raising awareness of our continuing biodiversity loss. Many studies focus on animals [VH23, Gon18], and typically, assessments and reports are made for regional scales, e.g., for mites in Poland [NKPB18], spiders in South Africa [FDSH*20] or birds in Columbia [RAVB20]. Analyzing the biodiversity of a whole region, however becomes more and more important [MIH*15, Jän19, RPS*22], for example, to predict the effects of interventions on a habitat such as the Nestos River basin in Greece [LZ22]. Other studies particularly focus on plant species, and investigate their distribution in a geographical area, usually visualized using maps of different kinds [SL13]. Slezák et al. [SDŠ*22] use topographic maps to predict the diversity of Red List and non-native plant species in human-altered riparian ecosystems in Slovakia. Saiz et al. [SLGB15] use heat maps to show the density of threatened vascular plants in Spain. Dot maps are also often used in this context, usually to depict individual observations of plant species [BBES14].

Few works study global aspects of threats to biodiversity using visualization. A particular focus on botanic gardens is given by Mounce et al. [MSB17], who study the worldwide ex situ conservation of plant diversity. TreeeX supports investigating threats to tree species that have been globally assessed [JBR19]. However, national assessments are excluded from the analysis. A detailed analysis of tree species, their distribution, and threat statuses is enabled through the GlobalTree Portal [BGC22a]. It differentiates, just like TreeeX, between globally assessed tree species and an aggregate of all threat assessments. When focusing on a particular country, this then associates regional assessments of the threat status of species done in other countries, bearing risks for misinterpretations. To mitigate this issue, this paper presents a platform that particularly provides access to national-level threat assessments.

## 3. Design

We developed our system iteratively in a participatory design process [JKKS20] involving visualization scholars as well as biologists from BGCI. The design outlined below is the final result at the point of submission, but will be subject to future revisions induced by the daily work of domain experts.

**Data.** The project builds on data collected on a daily basis by BGCI researchers. The central database used is ThreatSearch [BGC23b], which contains all conservation assessments registered at BGCI, currently more than 300,000. The database entails the following information: BGCI-scope (geographical scope of the assessment), year of assessment, IUCN threat status, BGCI threat status, Reference (that certifies the assessment/s done), and taxon name. The BGCI-scope is humanly generated and thus contains inconsistent spellings of the scope, such as "not global", "global", "endemic", "unknown", "global Equador", "global/European", "not global Luxembourg", and many more. Our data processing mapped these cleanly to two columns, which we refer to as country and global status. The global status contains information from the BGCI-scope. The country-column contains the country, which in some of the assessments is in the BGCI-scope, some others were taken from the Reference-column. Next to the ThreatSearch database, we also acquired data for every tree species contained within each country from the GlobalTreeSearch [BGC23a], which helped us connect the threat assessments to the native country distribution of a tree species. This way, the trees with a national assessment could be compared to the trees without a national assessment in each coun-


**Figure 2:** *Nation-level assessments for Buxus sempervirens. The domain expert quickly sees that many countries have not evaluated the threat to the species on a national level. No other country has listed the species as threatened.*

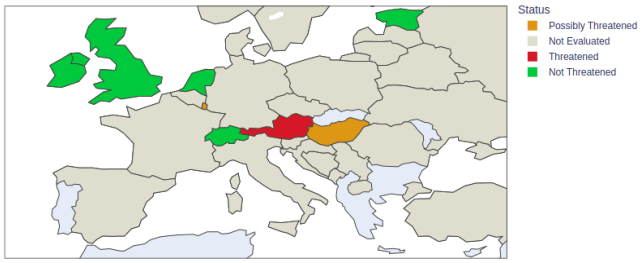


**Figure 3:** *Nation-level assessments for Betula pubescens. The results of national assessments vary across Europe, i.e., the geospatially close countries Switzerland, Austria, and Hungary have different threat statuses.*

try. To create maps, we made use of the ISO3-names for every given country.

**Visual Interfaces.** The layout of the user interface is inspired by the GlobalTree Portal [BGC22a], with a clickable map, and threat assessments as a bar chart. An overview of the system, which implements the visual information seeking mantra [Shn96] to allow exploring at different levels of granularity, can be seen in Figure 1. In detail, the components are:

- **National threat assessments map:** The choropleth world map can either show the total number of all tree species per country or only those with national assessments. Alternatively, the percentage of tree species with national assessments can be displayed. It uses a color gradient from white to dark green that is scaled so that countries with a low number of species or assessments can still be seen and differ enough from countries with zero values (white).
  *Supported User Tasks:* Biologists quickly gain an overview of the status of national tree assessments per country or larger regions. The map further suits as an intuitive filter by clicking countries of interest, which displays detailed information in the other visual interfaces.
- **Threat statistics bar chart:** Next to the map, a bar chart shows the different threat levels and how the species are distributed across the categories. These threat levels are color-coded using a categorical color map used in BGCI's "State of the World's Trees" report [BGC21]. It is colored beige for species that are Not Evaluated, gray for Data Deficient, bright green for Not Threatened, orange for Possibly Threatened, red for Threatened, and black for tree species assessed nationally as Extinct.
  *Supported User Tasks:* The status of threats to trees native to a country is quickly discernible. The view also serves as a legend for the tree map visualization.
- **National threats tree map:** Below the choropleth map and bar chart, a tree map, inspired by Pereira et al. [PFP16], is used to show the hierarchical tree species data. The first level shows the different genera native to a chosen country; the second shows the individual species of a genus. Each tree species is colored using the same color codes as in the bar chart. Differing assessments for species native to the chosen country or for species of a genus are indicated with a blue background.
  *Supported User Tasks:* The tree map gives a quick overview of the status of national threat assessments. One is able to quickly spot genera for which no assessments have been done yet or for which each species has been assessed. Thus, we can quickly direct domain experts to tree species that should be taken into account for assessments or conservation action. Clicking on a species allows for the inspection of its worldwide threat assessments on a national level.
- **Tree species national assessment browser:** Below the treemap, two tables show all the species in the selected country. The first shows the species that have a national threat assessment, and the second shows the species that are found in the country but have not been evaluated. Next to the tables, a world map displays the global distribution of the species chosen in the tree map using the same color code as previously used in the tree map and bar chart.
  *Supported User Tasks:* This interface is necessary to inspect which countries national assessments have been made for a particular tree species. Of particular importance is the ability to quickly see differing assessments in geospatially close countries, those in a similar or different climate zone, variance across continents, etc.

## 4. A Use Case on Luxembourg

In contrast to the bar chart offered currently by the GlobalTree Portal [BGC22b], our system's bar chart (see Figure 4) shows how important it is to review national assessments quantitatively, because some species are threatened on a national level. Because the threat search at the moment is on a larger scale, countries might not take the necessary steps to protect their threatened species if only global or regional assessments are available. The same difference in distribution is also found in Armenia, where most species are not evaluated on the national level, however, only 14 out of 134 are displayed as not evaluated based on the data at a global level.

Figure 5 displays the genera together with their species. It does not show the density of individual trees, it indicates how many tree species of a certain genus are native to Luxembourg. In contrast to Taiwan (see Figure 1), the majority of tree species native to Luxembourg are not threatened on a national level, however, *Buxus sempervirens*, the only representative of the *Buxus* genus in Luxembourg, is threatened. Inspecting the species further reveals that

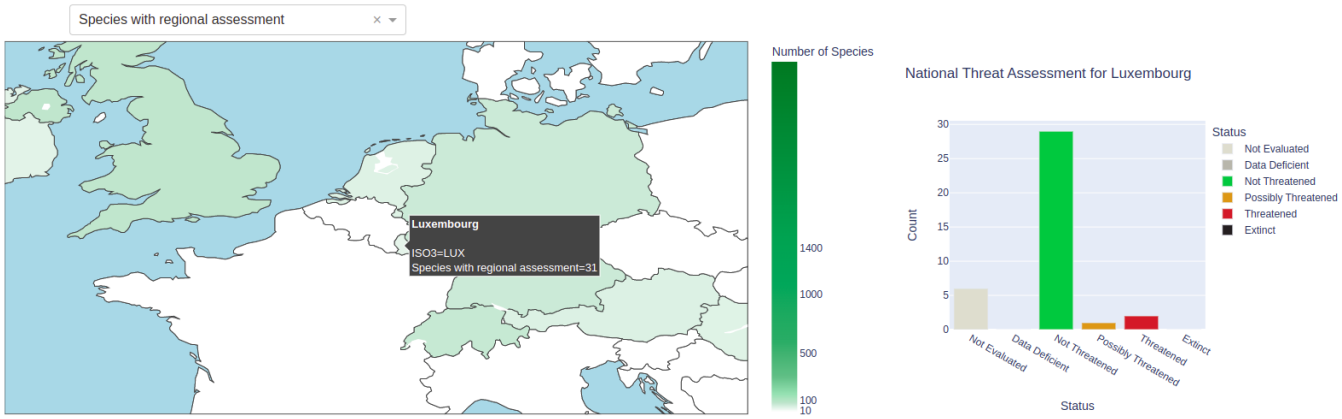


**Figure 4:** *The top part of our visual user interfaces shows a world map that can show two types of information: the number of "Species with regional assessment" and "All Species" native to a country; the former option is selected. By clicking on a country, here Luxembourg, the bar chart displays the distribution of conservation assessments across all species native to that country. In Luxembourg, six species are Not Evaluated, 29 species are Not Threatened, one species is Possibly Threatened and two species are Threatened.*


**Figure 5:** *Tree map visualization of the tree species native to Luxembourg. The boxes represent each genus, and enclosed we can see the corresponding species. The colors correspond to those of the bar chart, with blue representing mixed assessments.*

**Table of tree species in Luxembourg**

| s with National Assessment | Year of latest assessment | Current status |
|---|---|---|
| filter data... | | |
| Acer campestre | 2005 | Not Threatened |
| Betula pendula | 2005 | Not Threatened |
| Betula pubescens | 2005 | Possibly Threa… |
| Fraxinus excelsior | 2005 | Not Threatened |
| Ilex aquifolium | 2005 | Not Threatened |
| Malus sylvestris | 2005 | Not Threatened |
| Populus tremula | 2005 | Not Threatened |
| Prunus avium | 2005 | Not Threatened |
| Prunus mahaleb | 2005 | Threatened |
| Prunus padus | 2005 | Not Threatened |
| Prunus spinosa | 2005 | Not Threatened |
| Quercus robur | 2005 | Not Threatened |
| Rhamnus cathartica | 2005 | Not Threatened |
| Salix purpurea | 2005 | Not Threatened |

| es without National Assessment |
|---|
| filter data... |
| Hippophae rhamnoides |
| Pyrus communis |
| Pyrus nivalis |
| Populus nigra |
| Salix daphnoides |
| Staphylea pinnata |

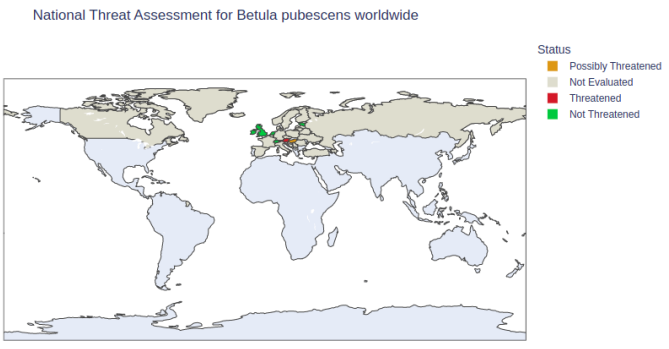


**Figure 6:** *Tables of species native to the selected country (Luxembourg) and a map connected to the tree map. The first table contains the species with a national assessment, the assessed threat status, and the year the assessment was made. The second table contains species without a national assessment. The map displays the worldwide distribution of Betula pubescens and the respective national assessments.*

Luxembourg is the only country in which it is assessed as threatened, which can be seen in Figure 2.

Turning our focus on the possibly threatened species *Betula pubescens* in Figure 6, we discover diverse assessments on a national level. Zooming in shows that many countries in Central Europe have not yet assessed the species nationally 3, but the Threatened assessment for Austria calls for European conservation actions.

Working in combination with tree map and tables shown in Figures 5 and 6 provides different possibilities for deciding which species to assess or reassess. If one wants to update the current assessments, the table would be preferred, and filters would be used to select the criteria the user wants. It could be reevaluating the oldest assessments or the ones with the highest threat level. The tree map may be used when wanting to evaluate a species that has not been evaluated yet. One might pick a species that is not evaluated but is closely related to multiple species with a high threat level.

## 5. Domain Expert Feedback

After including our system in the BGCI's daily workflows, we asked for a statement to summarize the utility of our approach. The lead researchers replied:

*"This visualisation of national level conservation assessments is highly valuable for national-level conservation. Many conservation decisions are taken on the country-level and this novel way of displaying the national conservation assessment information will be useful for prioritising conservation action on the national level. Although in order to avoid species extinction often a global perspective is taken, it is however also essential to look at what is happening to biodiversity on a regional or national level. Biodiversity loss or decline on a national scale will impact the ecosystems in which these trees are supporting a range of ecological, economic and cultural services. In addition, biodiversity loss on a national level still impact the global status of a species, as it could result in losses of genetic diversity of a species, which in turn may impact a species ability to adapt to environmental change. Therefore this national level visualisation can be a very useful tool to help prioritise and plan for conservation action of trees on a national level."*

Our system's capability to steer and influence conservation actions on a national level will however be shown in the future.

## 6. Conclusion

Our project fills a gap in the current portfolio of tools that biologists at the BGCI use for their tasks related to conservation assessment. Our system suits to highlight country-level threat assessments, thus, prioritizing local threats to a tree species over the global perspective, which researchers already have established tools to work with.

Many countries have not comprehensively assessed all their tree flora, and if these are not only missing in the database but missing entirely, this vital information that may aid in the evaluation of the ecosystem and ecological conditions is not available, and therefore the necessary steps to conserve cannot be taken. This national visualization adds a new layer to the data in the GlobalTree Portal and provides new insights into the finer-scale threats to trees. Based on the available data, we fear that more species are threatened with extinction than the record shows, as there might be more nationally threatened species. The threatened species can potentially have a direct ecological and economic impact on humans in the given country, making national monitoring of tree species important.

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