

Visualizing Lemur Survival Data

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ABSTRACT

Madagascar is home to ninety-nine species of lemur that can be found nowhere else in the world. But lemur populations are declining at an alarming rate due to corporate or government-sanctioned deforestation of species habitats. At present, lack of support for understanding and visualizing this information makes it all too easy for policy-makers to ignore this dangerous trend and continue to allow clear-cutting in vital habitats.

This paper describes a new visualization depicting lemur species dependence on Madagascar's remaining forests. The goal of this tool is to communicate the facts of the lemur population crisis in the hopes of supporting forest preservation.

1 INTRODUCTION

Madagascar is an island country located off the coast of Africa. As an island community, Madagascar's ecosystem flourished in isolation, giving birth to thousands of species that exist nowhere else in the world. It is therefore known as the "eighth continent," a hotpost of biodiversity (Figure 1).

Lemurs are one of Madagascar's groups of endemic species. But since the 1950s, total lemur population has taken a drastic downward turn. Since the arrival of humans on Madagascar, at least 50% of the overall lemur population has died out, and at least 17 species have gone extinct since. Almost all the remaining ninety-nine lemur species are classified as rare, vulnerable or endangered (Figure 2).

Besides the impact on the species themselves and local ecosystems, loss of lemur populations profoundly affects the Malagasy people as well. Madagascar's difficult climate, political instability and poverty all contribute to the lack of food resources there, and lemurs are a viable food source. Therefore, although it is illegal in many parts to hunt lemurs because of their threatened status, hunting is unfortunately difficult to avoid. Lemurs are also often poached for sale in other counties, further contributing to the problem.

However, the single biggest cause by far of lemur species loss is the drastic amount of deforestation that has taken place since the arrival of humans on Madagascar. Commercial logging is an important source of revenue for the country, and it is estimated that up to 90% of the original forest habitats have been cut.

Anthropologists, conservationists and other experts are well aware of the lemur population crisis, as well as the likely effects that further habitat destruction would have. But it is government policy makers and other non-experts who make the decisions about whether to protect or allow logging in forest regions. And while the general fact that lemurs are in danger is well known, their dependence on specific regions is difficult to communicate concretely. One of the reasons for this difficulty is that population data for the different lemur species is unreliable at best, and often nonexistent. Further, even assuming that a comprehensive data set is available, there is little support for visualizing the dependence of lemurs on the remaining forest land. Given that there are ninety-nine species

of lemur and lots of forest regions that could potentially be of interest, the task of understanding the situation confronting Madagascar's lemur species is not something that can be easily done with raw datasheets. Specifically, the severity of the lemur population loss, the threat status of different species, and the effects of further habitat destruction would be very labor-intensive to understand without the help of a visual tool to cohere and visualize the data.

There is therefore a need to communicate the situation visually to policy-makers and other non-experts in a comprehensive and cohesive way. Given the lemur population crisis, it is crucial that what data exists about the importance of the remaining forest habitats in Madagascar be made easily accessible, both in terms of availability and usability.

Therefore, in this paper we present a visualization of lemur species dependence on Madagascar's remaining habitats. Our visualization is based on lemur threat levels, as well as habitat ranges. We hope this visualization can be used to communicate the crucial need for forest conservation.

2 RELATED WORK

To our knowledge, there are no existing visualizations implementing the above mentioned objectives. However, there are several related sources that inspire and influence the design of our visualization. The most relevant of these sources is the *All the World's Primates* group [1].

2.1 All the World's Primates

All the World's Primates is an organization that collects species data for primates from experts all over the world [1]. Their goal is to provide a comprehensive database for students and researchers. This database has been an invaluable resource for our project data.

Furthermore, while visualization is not the group's primary focus, the site does have a map visualization that is relevant to our work. The visualization is an interactive map linked to a search window. The viewer can search for a species, select it, and then upload its habitat range onto the map (Figure 3).

This visualization makes it possible to see a lemur species's habitat range, which is relevant to our goals. Range one types of data that is in fact available for lemurs, and this visualization suggests how ranges can be utilized through shapefiles in an easy-to-use, accessible web application format. Shapefiles are a common data format for vector graphics.

However, there are several ways in which our application needs to diverge from this visualization. First, the process for viewing an animal's range involves searching and selecting that animal from a list. This may seem like a subtle point, but it has the effect of requiring the viewer to already know either which lemur she is interested in, or which lemur lives in the region she is interested in. In other words, she has the responsibility to know what she is looking for prior to using the visualization. This is a type of expertise, and our goal is to make a visualization that requires no expertise, and facilitates open-ended, exploratory interaction. Incidentally, this search and load process also slows down interaction and increases cognition time when switching between species.

Second, it appears that only one species habitat can be viewed at a time (there is an option to add more species, but it does not seem to work). This makes it difficult to get a big-picture view of the data, and specifically of how important different regions are to

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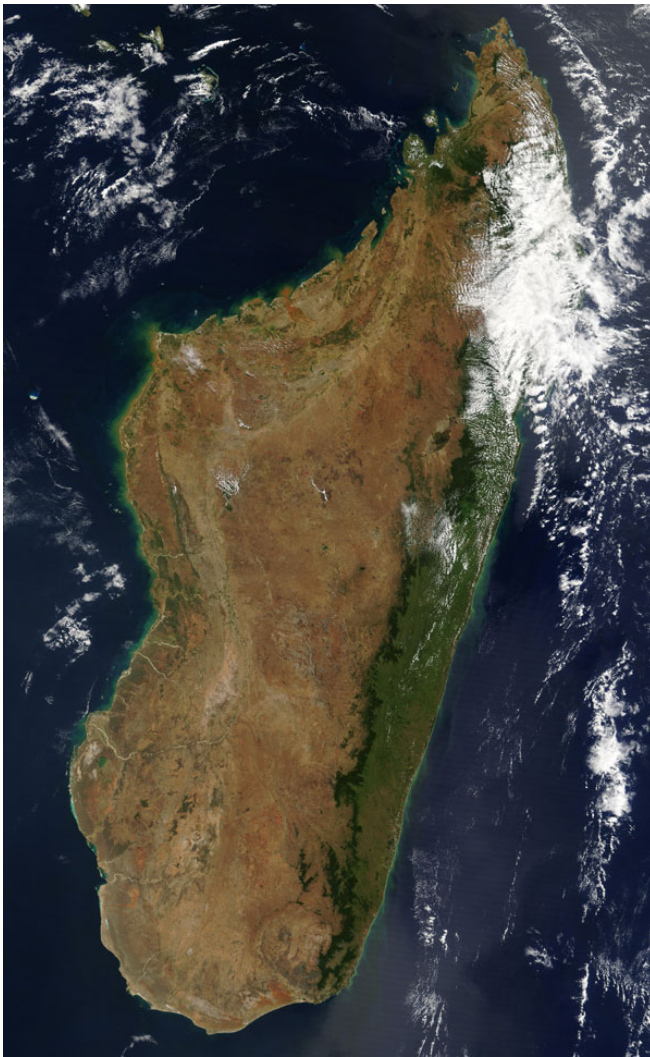


Figure 1: Satellite map of Madagascar.

lemurs as a group. In this work, we wish to communicate regions in terms of effects on many species.

Finally, the data is not abstracted to include any further species information other than range. Range alone will not be able to communicate the species risk of extinction, which will again make it difficult to convey the importance of the land.

2.2 Cartography

A major goal of this work is to support the decision-making process for someone tasked with making policy to protect or allow deforestation in a given area. To support this process directly, the visualization must link data to a map. This required a review of the basic principles and challenges of cartographic visualizations.

Speckmann and Verbeek's presentation of Necklace Maps was a valuable introduction to cartography practice, and to the challenges of different approaches to thematic maps [2].

Specifically, our review began with the three basic types of thematic maps:

- 1) *cartogram*: map regions scaled by corresponding data,
- 2) *choropleth*: map regions colored by corresponding data,
- 3) *proportional symbol map*: map regions overlaid with abstract symbols representing corresponding data.



Figure 2: Ring-tailed lemur, also known as *Lemur Catta*, one of Madagascar's at risk species of lemur.

Necklace Map's discussion helped us decide against cartograms because of the distortion of geographic regions [2]. In our project, the map must reflect the true geography so the viewer can relate to specific locations and forest regions of interest.

Necklace Maps also helped illuminate early on problems that commonly occur when small map regions are associated with large data values [2]. In proportional symbols maps, this situation results in overlapping symbols, which are difficult to separate and to associate with their corresponding regions. Knowing this problem early allowed us to choose a vector-based approach where the viewer can zoom into the map while keeping the symbol size constant. As will be discussed in detail below, increasing the resolution in this way solves the problem.

Dykes and Brunson was also a valuable reference in our cartography review [3]. This work described ways to show maps at different scales using linked views and a varying weighting parameter. While it is not the direct goal of this project to show different scales, the spatial weighting did demonstrate different ways the map data could be interpreted. Some of these ideas are slated for future work, as are the suggestions for linked views. Also, this paper made clear some of the complications of overlapping regions. This point helped us decide against relying solely on choropleths, which can result in ambiguous color mappings and occluded data when overlapping regions are involved.

3 APPROACH

The goal of this project is to create a simple, easy-to-use visualization to communicate the dependence of lemur species on Madagascar's remaining forests. It should support the task of understanding the current population crisis, and it should support decisions about forest preservation versus clear-cutting. The visualization should be comprehensive and cohesive, showing data across species in a combined big-picture view. It should be easily usable and understandable by non-experts, and should not require the viewer to know any information ahead of time, or to upload her own data.

Perhaps the most natural approach to designing such a visual-



Figure 3: *All the World's Primates* online map visualization.

ization would be to visualize population statistics spatially, perhaps over time, which would illustrate the population trend as more deforestation took place. However, many species of lemur live in areas that are not accessible to humans due to climate, difficult terrain, etc, so counting them is difficult. In most cases, population numbers are estimated with a high level of uncertainty, or they simply don't exist.

This lack of data was a big constraint in the design process. However, not having population numbers to rely on focused our design on the more fundamental information to be communicated. During the process of making a decision about preserving a given piece of land based on lemur population criteria, it is necessary to know how important that land is to lemur species. One basic way to characterize this level of importance would be to look at 1) which lemur species live in this region (if any), 2) what portion of the population is located in this region, and 3) how at risk the population is.

This information can be displayed by the combination of species habitat range, and species threat level. Our visualization is built around this data.

4 SOLUTION

Our visualization solution is a dynamic color-coded proportional-symbol map, with views of specific species habitat ranges enabled with interaction.

The view is built onto a zoom- and pan-enabled map of the world. Each lemur species is represented by a circle symbol located at the center of the species' habitat. The area of the circle represents a *rough estimate* of the species population based on the size of the remaining habitat. This estimate is built from the assumption that different species live at roughly the same density, and is discussed further below.

The colors of the circle symbols encode the IUCN Red List threat level classification of each species [4]. These threat levels are calculated from a wide range of criterion, described in detail on the Red List site [4]. Ordered from highest to lowest risk, the categories consist of:

- 1) *critically endangered*
- 2) *endangered*
- 3) *vulnerable*
- 4) *near threatened*
- 5) *least concern*

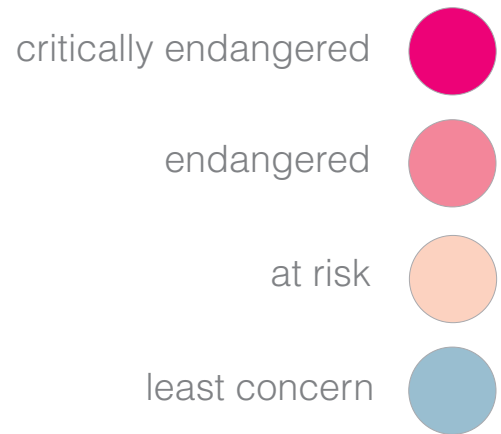


Figure 4: Hue/lightness encoding for species threat level. Blue represents a species of *least concern*, and pink represent species in the other categories, with lightness increasing as species risk level decreases.

In our visualization, we code the ordered levels of threat with lightness of the same hue, where the darkest represents the highest level of threat, *critically endangered*. The next lighter level represents *endangered*, and so on. In addition, we choose to distinguish between populations of *least concern* and all other categories, considering this an important distinction between a healthy and an unhealthy population. This is done by encoding the *least concern* category with blue, and the other categories in pink, with levels of lightness representing the levels of threat as described.

We also aggregate the two categories *near threatened* and *vulnerable* into a new category we term *at risk*. This is done to cut down the number of levels of color to ease viewer cognitive load. See Figure 4 for a visual summary of our hue and lightness abstraction.

Interaction provides further information for a given species. For example, if the viewer hovers over a circle, the corresponding species' scientific name will appear above the mouse. Clicking on a circle highlights the species' habitat in the map, colored to correspond to the described threat level encoding.

As mentioned previously, proportional symbol maps can suffer from occlusion and overlapping symbols. To deal with this problem, vector graphics are used so that resolution can be increased in cases of occlusion. For example, if one circle is occluding another circle or an area of interest on the map, the viewer can zoom in. Zooming increases the resolution of the map but leaves the symbol sizes unchanged, so any desired level of detail is possible. This scalable nature of the display means that the viewer is never in a position where an occlusion can not be resolved.

In summary: our visualization provides a combined view of habitat, threat level, and estimated population for all lemur species, displayed geographically. The viewer can hover/select to display species name and habitat, as well as pan, and zoom. Vector graphics are used to support data at multiple resolutions.

5 IMPLEMENTATION

One goal of this work is to make lemur species data easily accessible to anyone who wishes to view it. For this reason, it is important that the application be easy to share on the web. It should also not require any special installations or downloads.

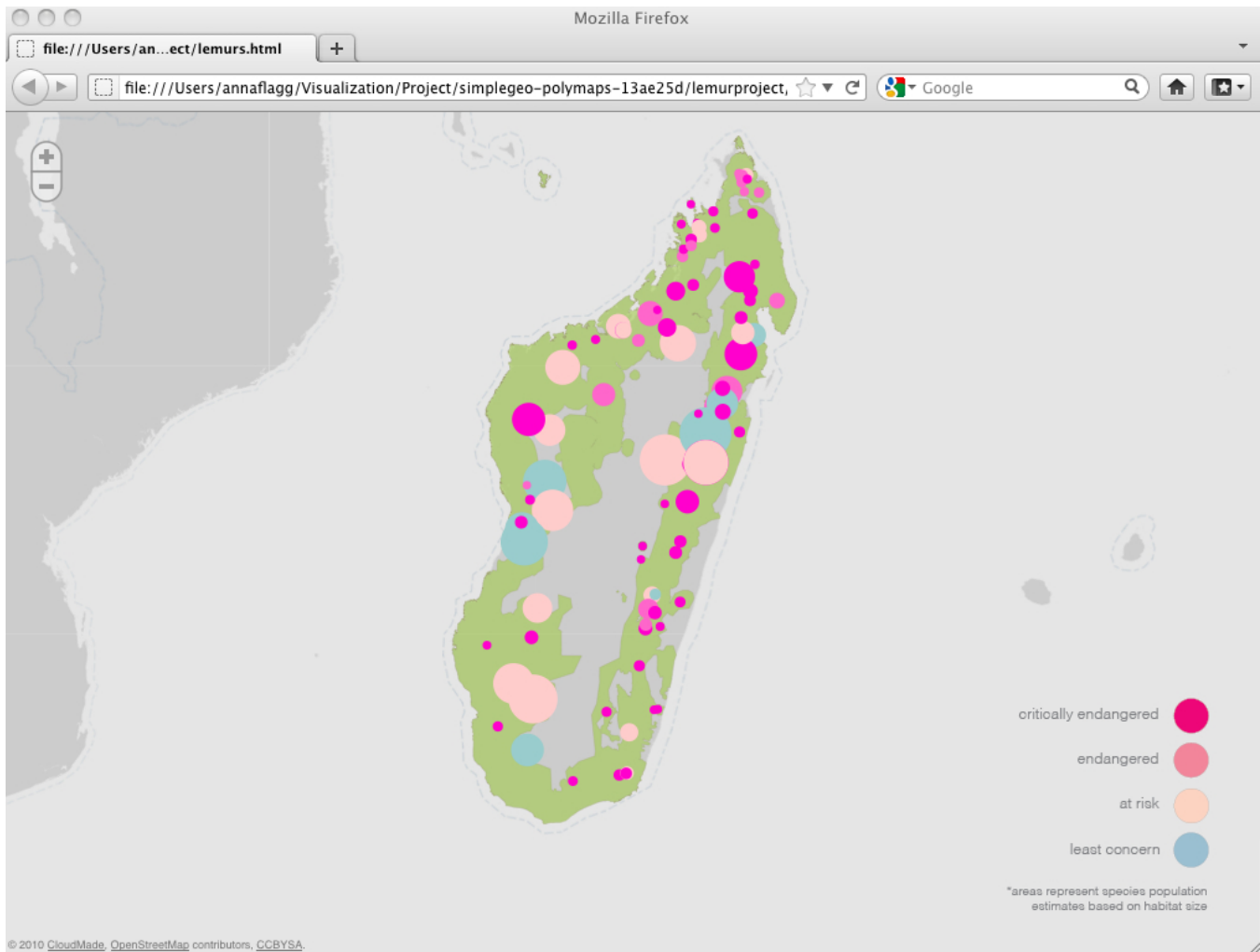


Figure 5: Opening view of the visualization.

5.1 Tools

Given our requirements, a web application is a natural choice. We develop in html, css, SVG, and JavaScript, making use of the JavaScript library Polymaps [5]. Polymaps provides support for visualizing vector graphics on interactive maps, and is a key part of our implementation. In Polymaps we can put our data in its true geographic context, thus offloading our backend map functionality.

5.2 Data

Our species habitat data is in the form of ESRI shapefiles, a common format for vector graphics. Before loading it into Polymaps, we perform some processing. First, we import it into Quantum GIS, an open-source GIS software for analyzing and editing geographic data [6]. In Quantum GIS (QGIS) we are able to join the shapefile habitat data to other attributes describing the species. We can therefore connect species name, identifier, threat level, etc to its range. We are also able to calculate centroids of the ranges, as well as their areas.

We output the new augmented shapefile and convert it to JSON, a data-interchange format readable by Polymaps [7, 5]. This is the data we use to build our visualization.

5.3 Code

The high-level code structure of our application is as follows:

Project directory

lemurs.html

lemurs.js

JSON-formatted data

Polymaps libraries

polymaps.js

example.cs

Our code is in *lemurs.html* and *lemurs.js*.

In the *lemurs.html* file, we define the structure of the page components, as well as the basic non-dynamic element stylings.

In *lemurs.js*, we build the interactive parts of the map. Polymaps works with layering, which allows us to add data as JSON layers, and access species data individually. We load two layers, a *polygon* layer that describes geometry of a species range, and a *point* layer that describes the centers of the habitats. This is done so that we can show specific geographic ranges dynamically, as well as overlay circles representing each species as described above. This results in an interactive layered proportional symbol map.

We can access the features of both these layers, and style individual layers in each according to viewer interaction. The circle symbols listen for interaction events affecting a given species. For instance, if the viewer clicks on a circle in the point layer, the circle's *click()* function notices the interaction and references the corresponding species' habitat range in the polygon layer. This struc-

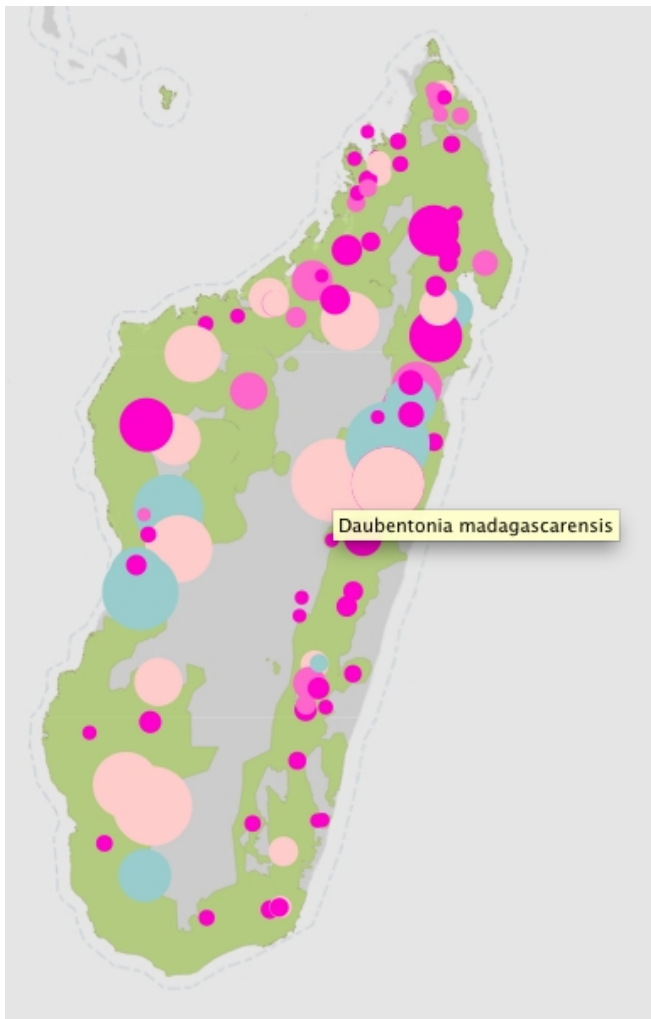


Figure 6: Hovering pops up the scientific name of the species.

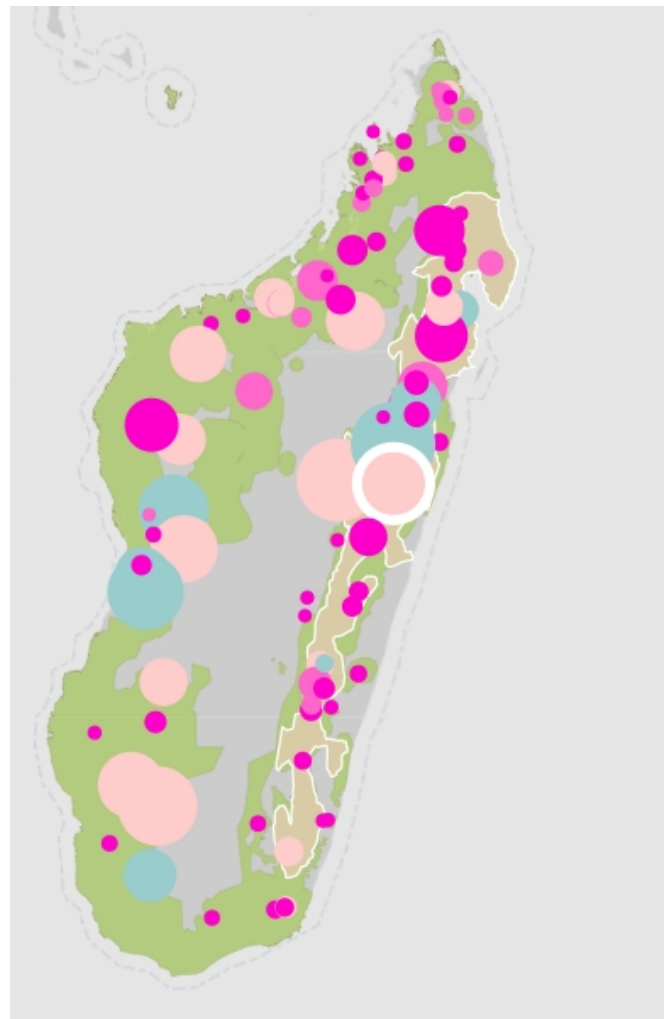


Figure 7: Clicking.

ture allows us to implement some simple interactive behaviors, such as highlighting species and ranges dynamically, popping up species details, etc.

Underneath our data, a background map from CloudMade is loaded to provide geographic context [8]. CloudMade is a popular platform for styling and rendering custom maps at many scales.

6 RESULTS

The application opens up with a map view centered in Madagascar (Figure 5). Data for all species is encoded in circle symbols, then overlaid at the geographic center of the corresponding species' habitat.

Hovering over a circle displays the species' scientific name (Figure 6). As will be discussed below, future work will involve displaying more species details on hover events.

Clicking on a circle highlights the geographic range of the corresponding species (Figure 7). Similar to the circle, the range is color coded to show the species threat level.

Polymaps makes use of vector graphics to render data dynamically at different scales. If map data is ever occluded, zooming in to the view increases the resolution of the map while keeping sizes of the data symbols constant. This allows the viewer to see detailed species distributions (Figure 8), as well as high-resolution habitat regions (Figure 9).

7 DISCUSSION

Our application combines data for all known lemur species into one big-picture visualization, linking species directly to their underlying geographic distributions, and encoding them in the context of their level of risk.

This design supports the task of understanding the lemur population crisis, because we believe it is straightforward to see that almost all the species are shown in some shade of pink, which signifies a population in danger. Also, the importance of the remaining forest land can be seen at a broad level by the wide distribution of lemurs across the whole of Madagascar, particularly the coastal forested areas.

Supporting policy-makers debating whether to preserve a given piece of land was also one of our goals. We believe that our visualization does indeed support this task due to its contextualization of the data within a functional map, and the ability it gives the viewer to see individual species habitats that intersect with the region in question.

The relationship between circle size and color is, we believe, also fairly immediate. Specifically, the biggest circles tend to be either blue or the lightest shade of pink, and as circles get smaller, they get darker. This shows the link between dwindling habitat and species level of risk. Namely, the smaller an area a species occupies, the more likely it is to be endangered.

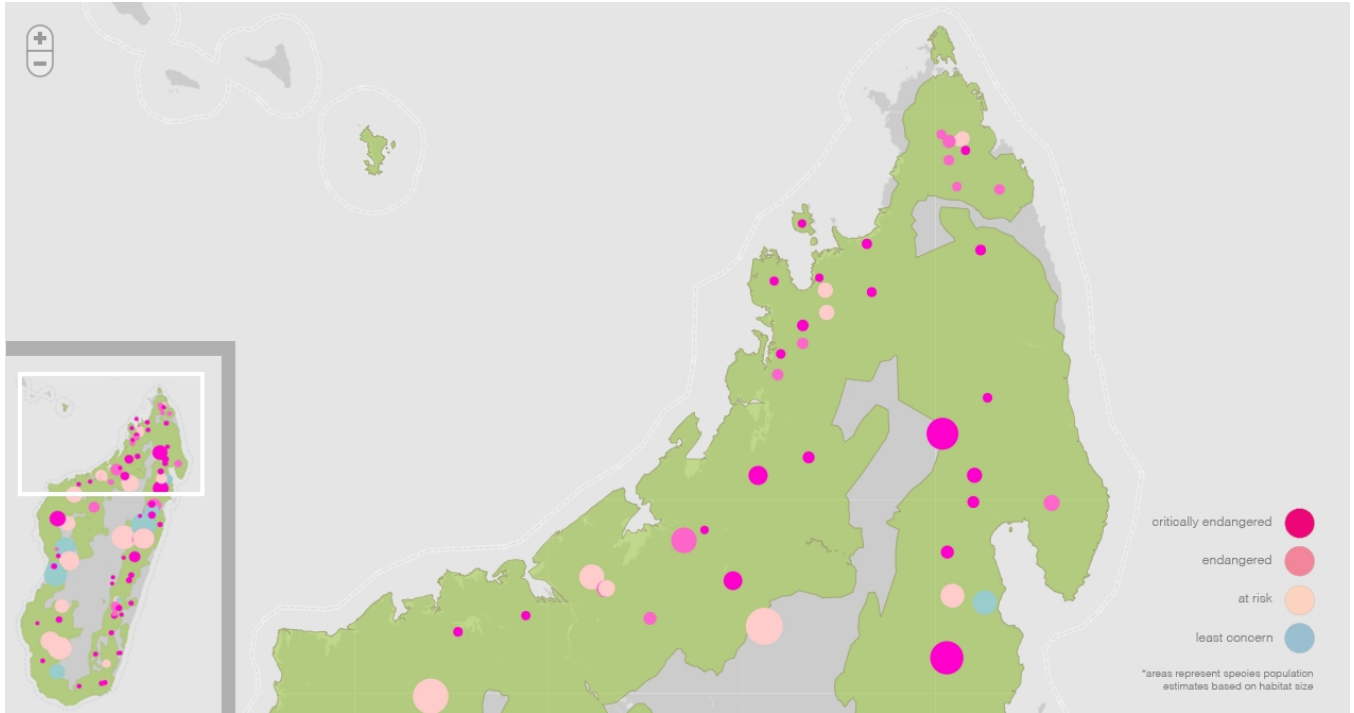


Figure 8: Zooming in shows detailed species point distributions.

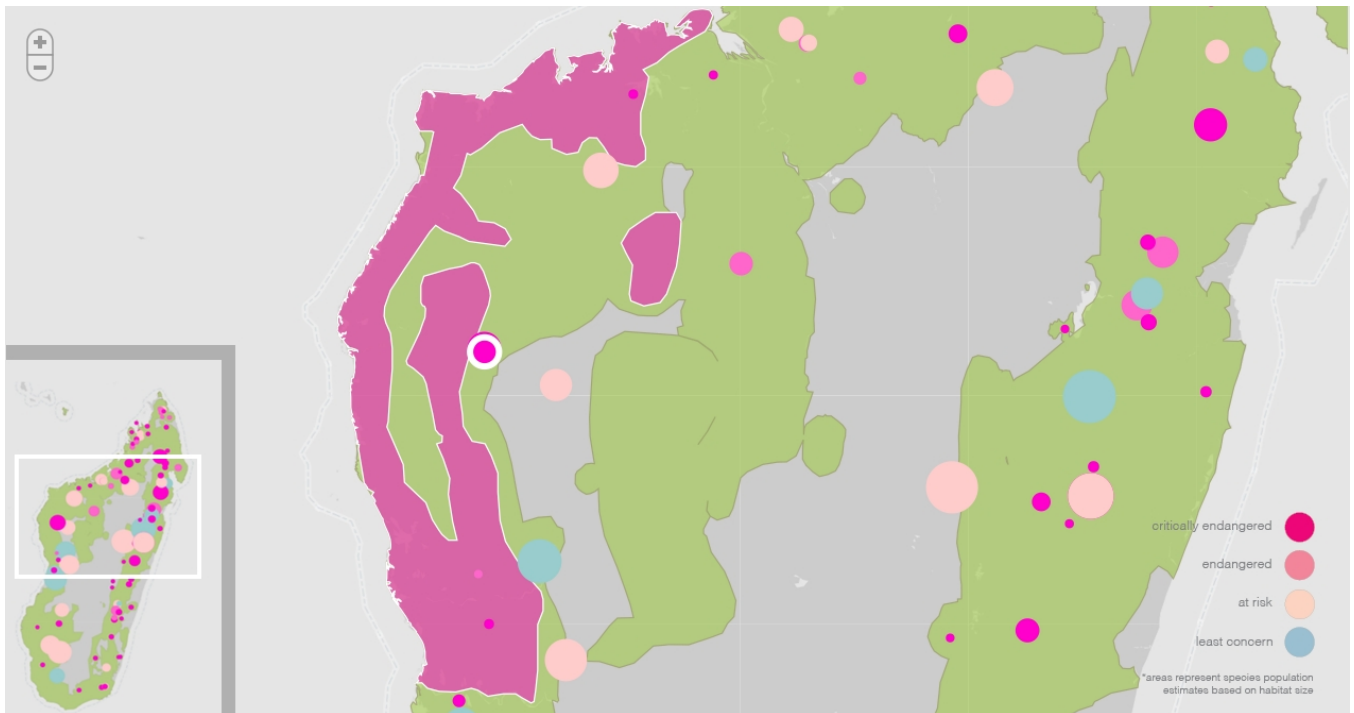


Figure 9: Species habitats can be seen at high resolutions.

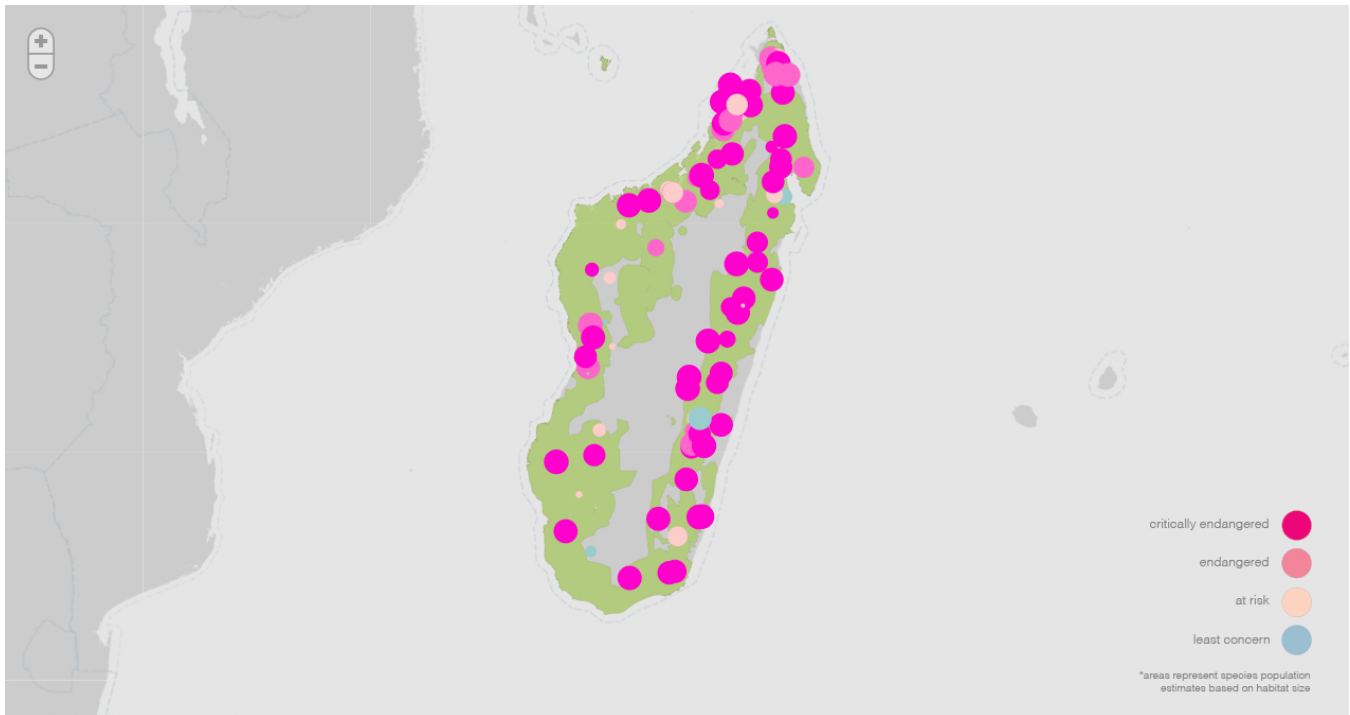


Figure 10: Alternate design where circle areas are proportional to the inverse of the species' habitat area. This could be done to emphasize species at highest risk.

The visualization is simple. We believe it will be easy to use, and understandable for a general audience. It does not assume the viewer knows yet what she is looking for, and in this way it supports exploratory analysis by non-experts. And it does not require input of any specialized knowledge, or any viewer-supplied data.

Perhaps most importantly, the visualization provides one cohesive view of a dataset that is historically highly scattered, and difficult to communicate. It also suggests a way of visualizing the effects of potential habitat destruction on lemur species in a meaningful way, despite the lack of reliable population statistics.

There are also some limitations to the design. First, the application is not catered towards experts, and there is a minimal level of detail for a given species available on drill-down. For this reason, anyone looking for information about a species beyond location, distribution, and threat level will not find the visualization useful. We discuss adding more detailed species data to the application in the next section.

Next, we mention above that circle areas indicate an estimate of a species' population based on the calculated size of its habitat. This estimate is made assuming that different species live at approximately the same density. We believe this assumption is a reasonable one to make in order to give a broad estimate of species population sizes to the viewer, and it is a necessary simplification. Living densities are not known for most species, and in fact are not even known to be constant within a species. More work will be needed to establish how justified this assumption is for the purposes of our visualization, and we discuss this further below.

Another issue with encoding the circle sizes proportionally to the habitat size is that since smaller habitats lead to smaller circles, and smaller habitats tend to accompany species at risk, the species most at risk are represented with the smallest symbols. Thus, the species we most need to draw attention to are rendered with the smallest amount of screen real-estate, which is counter-productive to our visualization's goals. Our design attempts to deal with this by coloring species of high risk in a darker, more distinct color.

However, we are also interested in other possible circle encodings that might remedy this issue. We discuss possible ideas in the next section.

Finally, there is a level of uncertainty in our IUCN Red List threat level data, and in our primate habitat data from *All the World's Primates* [1, 4]. However, how much uncertainty exists in the data is not clear, and for this reason we do not attempt to communicate uncertainty at all in our visualization.

8 FUTURE WORK

There are several improvements we wish to make to our visualization. First, we would like to add more species details so that the tool can communicate more about a species than just name, location, habitat and threat level.

We also need to screen our color choices to make sure they are color-blind safe, and alter them if necessary.

Next, we need to explore whether the assumption that different species live at roughly the same density is justified for our purposes. Consulting further with anthropologists will give us some insight. If it is decided that this simplification is misleading, then we will remove the population estimate encodings, and render all the circles the same size.

Our next possible improvement also has to do with circle size encodings. As we mentioned above, relating circle area to estimated population de-emphasizes the species that are most at risk. A possible remedy for that problem is to size the circles inversely proportional to the estimated population, such as in Figure 10. This view emphasizes species in the most danger. However, we need to counter this benefit with the possible difficulty the viewer might have resolving that bigger circle areas correlate with smaller habitat areas. We plan to demonstrate both versions to our audience to help decide.

That leads us to the next step in our design process, which will be to show our visualization to both experts and non-experts, and

evaluate how well it meets our goals.

9 CONCLUSION

We have presented a new visualization of lemur species risk of extinction, contextualized within a map of the forest habitats they depend on. After making the improvements mentioned above and evaluating our work, we plan to share the application on the web.

We hope that through this process, our visualization will be able to communicate the facts about the lemur population crisis, and the crucial importance of preserving Madagascar's remaining forests. It is our hope that making this information easily accessible to the public will aid in the conservation movement.

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