Assessment of the Area of Coincidence of IUCN Endangered Species Habitat and Global Mine Sites

Kylie Wright
May 2016
GEO386G

1. Introduction

The International Union for the Conservation of Nature (IUCN) and the World Wildlife Fund (WWF) categorize endangered species as those likely to become extinct in the near future. There are over 41,000 species on the IUCN Red List that details globally threatened species of both plants and animals. Over 16,000 of these species are listed as endangered, and the number continues to grow every year. A 2004 study indicates that there is a direct connection between increasing human population density and infrastructure and the endangerment of species. This study suggests that two major negative controls on biodiversity are anthropogenic changes and large scale encroachments on species' habitats (McKee *et al.*, 2004). Another study states that both habitat destruction and degradation, where habitats are irrevocably destroyed and converted quickly (deforestation, dredging, etc.) or are slowly diminished (pollution, dam construction, etc.), are the most pervasive causes of biodiversity loss (Ayyad, 2003).

As the global population increases, so goes global infrastructure. Many of the materials needed to build and power this infrastructure must be mined from the earth and refined. Our demand for the minerals, metals, and hydrocarbons we extract from the earth is almost insatiable and ever expanding, leading to an increase in the total number of mine sites (Fig. 1). As the number of mine sites grows to supply our need, many of the habitats that were previously protected from the negative impacts of mining, are now subject to the large scale disturbance and pollution inextricable from mining practices. As disturbing as this is, modern society cannot be untangled from mining and will continue to impact global habitat distribution for decades to come. Given this, it is imperative to quantitatively constrain the regions of overlap between mine sites around the world and the species that are most likely to be negatively impacted by them.

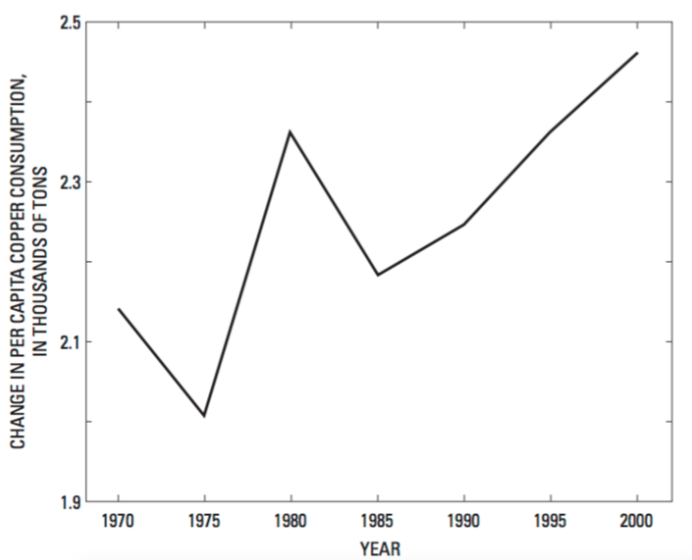

Figure 1. (Kesler, 2007) Global change in copper consumption from years 1970-2000.

IUCN has developed an extensive GIS dataset on threatened species that delineates probable habitat boundaries according to each species, and the USGS Mineral Resources Data System provides a compilation of global metallic and non-metallic mineral resources (Fig. 2). Using these two datasets, I generated areas of intersection using the buffer and intersect tools. The report presents a case study of data in Australia, a keystone species in Africa, and highly threatened species in Asia, Africa, and South America.

2. Data Collection

a. Data was collected from the IUCN Red List website.

Geographic Coordinate System: GCS: WGS84.

Metadata was present online, and attribute tables associated with species indicate the majority of the data is from 2008. The IUCN website provides spatial data downloads for mammals, amphibians, reptiles, marine groups, and freshwater groups. It does not provide data on birds.

I only used the "Terrestrial_Mammal" subgroup download, and narrowed down the relevant species for my project using ArcMap processing. The data came in the form of shapefile polygons outlining the boundaries of species ranges.

http://www.iucnredlist.org/technical-documents/spatial-data#mammals

http://www.iucnredlist.org/initiatives/mammals/description/download-gis-data

b. Data was also collected from the USGS Mineral Resources Data System website.

Geographic Coordinate System: GCS: WGS84.

Metadata was present for the data and can be found in the link below, the data was published in 2005. It includes descriptions of codes for deposit type, positional accuracy, country abbreviations, authors, etc. The MRDS website provides global mineral resources data based on commodity that can be easily selected by country. I selected a global mineral dataset which included an MRDS layer package that provided mineral occurrence and mine site point shapefiles.

http://mrdata.usgs.gov/mrds/

http://mrdata.usgs.gov/metadata/mrds.html

3. ArcGIS Pre-Processing and Data Selection

The data required minimal preprocessing. Both the MRDS and IUCN datasets required map projection from GCS: WGS84 to WGS84 Mercator such that accurate areas (in m^2) could be extracted after processing.

The data were numerous, the IUCN Terrestrial Mammals download had over 41,000 records, and MRDS layer package had over 300,000 records (Fig. 2). The large quantity of data was overwhelming the computer, and drawing all of the polygons and points took approximately two minutes. Before processing, I had to develop a way to limit the data to a workable amount of records such that processing did not take an unreasonable amount of time and overwhelm the computer. MRDS data was described separated into six categories in the metadata: "unknown," "occurrence," "producer," "past producer," "prospect," and "plant." Because "prospect," "unknown," and "occurrence" point types would not necessarily be developed, they would also not have an area of impact on habitat. I thus selected only "producers," "past producers," and "plants" to investigate in this project.

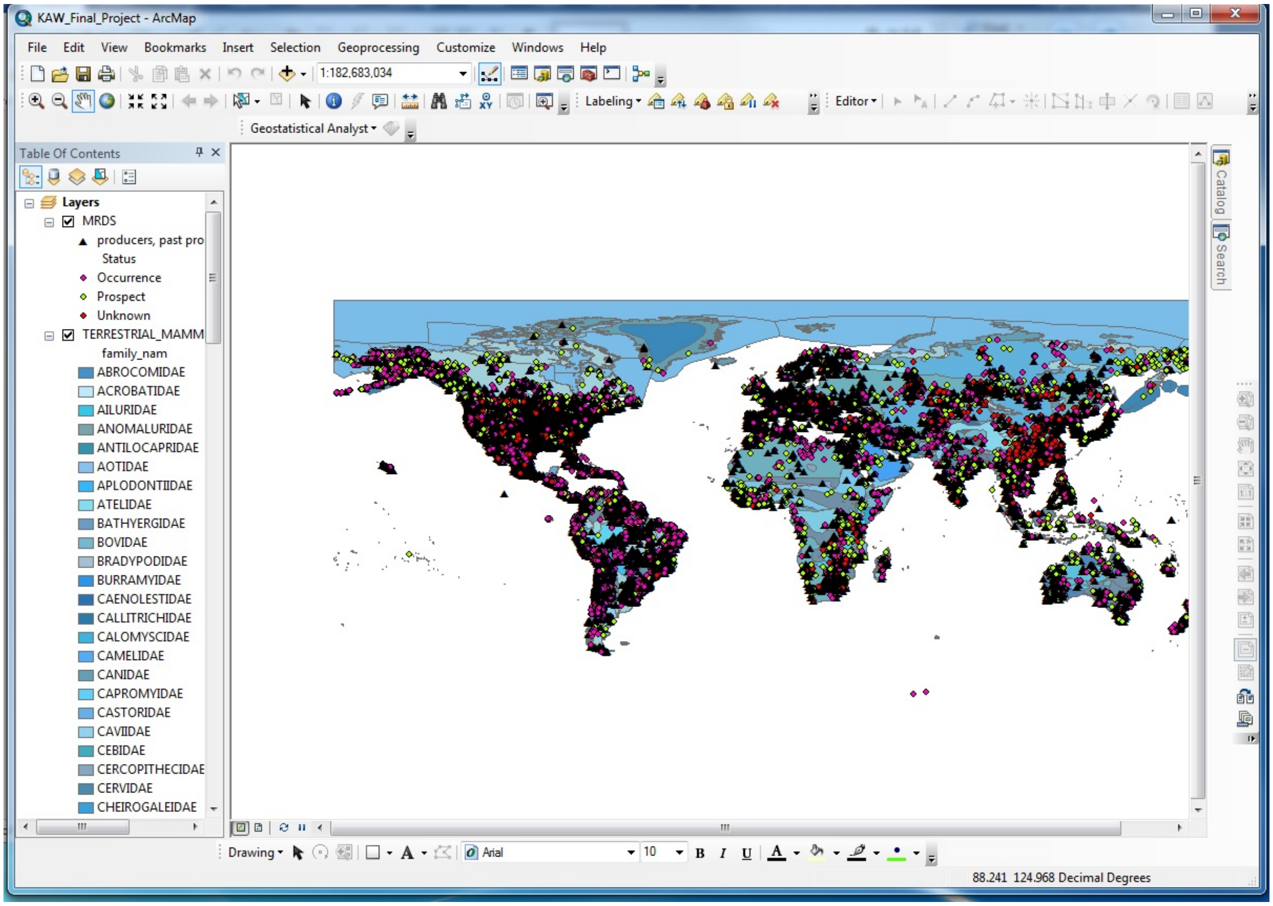

Figure 2. All data represented before selections. Terrestrial Mammal IUCN polygons in blue shades. MRDS producers/plants/past producers in black; occurrence in purple, prospect in green, and unknown in pink.

The IUCN data contains information on over 70 families of mammals. It is important to note that some of the IUCN data was incorrect or out of date according to their website and the WWF website. This is to be expected as the data has not been re-collected in almost a decade and in many cases, animals have become increasingly threatened. To constrain this data, I compared the IUCN data to the WWF list of most endangered species and, when available, selected the data on those species represented by genus level data to constrain computational time, such that some groups include data on more than one species (e.g. oryx, panthera, and paradoxurus). I applied these species in a general investigation of mine site-habitat overlap (Table 1).

Scientific Name	***Common Name***	***Threat Level***	***Continent***
oryx dammah	scimmitar oryx	EW	Africa
panthera pardus orientalis	amur leopard	CR	Asia
diceros bicornis	black rhino	CR	Asia
gorilla gorilla dielhi	cross river gorilla	CR	Africa
rhinoceros siondaicus	javan rhino	CR	Asia
gorilla beringei beringei	mountain gorilla	CR	Africa
pseudoryx nghetinhensis	saola	CR	Asia

panthera tigris amoyensis	south China tiger	CR	Asia
pongo abeli	Sumatran orangutan	CR	Asia
dicerorhinus sumatrensis	Sumatran rhino	CR	Asia
panthera tigris sumatrae	Sumatran tiger	CR	Asia
gorilla gorilla gorilla	western lowland gorilla	CR	Africa
smutsia gigantea	giant pangolin	CR	Africa
saiga tartarica	saiga	CR	Asia
addax nasomaculatus	addax	CR	Africa
manis pentadactyla	Chinese pangolin	CR	Asia
manis javanica	Sunda pangolin	CR	Asia
camelus ferus	wild Bactrian camel	CR	Asia
lycaon pictus	African wild dog	EN	Africa
panthera tigris altaica	Amur tiger	EN	Asia
elephas maximus indicus	Asian elephant	EN	Asia
panthera tigris tigris	Bengal tiger	EN	Asia
pan paniscus	bonobo	EN	Asia
pongo pygmaeus	Bornean orangutan	EN	Asia
elephas maximus borneensis	Bornean pygmy elephant	EN	Asia
pan troglodytes	chimpanzee	EN	Africa
gorilla beringei graueri	eastern lowland gorilla	EN	Africa
ailuropoda melanoleuca	giant panda	EN	Asia
panthera tigris corbetti	Indochinese tiger	EN	Asia
panthera tigris jacksoni	Malayan tiger	EN	Asia
panthera uncia	snow leopard	EN	Asia
elephas maximus maximus	Sri Lankan elephant	EN	Asia
pantholops hodgsonii	chiru	EN	Asia
manis crassicaudata	Indian pangolin	EN	Asia
loxodonta africana	African elephant	VU	Africa
rhinoceros unicornis	greater one-horned rhino	VU	Asia
ailurus fulgens	red panda	VU	Asia
phataginus tricuspis	tree pangolin	VU	Asia
tremarctos ornatus	spectacled bear	VU	South America
oryx leucoryx	Arabian oryx	VU	Africa
paradoxurus zeylonensis	golden palm civet	VU	Asia
panthera onca	jaguar	NT	South America
Rousettus madagascariensis	Madagascan rousette bat	NT	Africa

Table 1. Species investigated in this study, their scientific names, common names, threat level, and primary continent. These species were grouped by larger genera categories in the study to make data processing more efficient. CR= critically endangered. EN= endangered. VU= vulnerable. NT= near threatened.

I investigated a threatened keystone species in Africa (Loxodonta africana) and all threatened species in Australia (that IUCN included in their data) (Bond, 1994). This data was used to generate a case study on African Elephants, a keystone species in the savannah. Another case study on Australia was completed, as Australia is a leader in the global mining industry, mines a wide variety of commodities across the majority of the continent, and has a high degree of biodiversity (over 100 species represented in this study) (Fig. 3). An interesting future area of study should take other classes into consideration like birds and amphibians as both can be tremendously sensitive to habitat destruction and pollution.

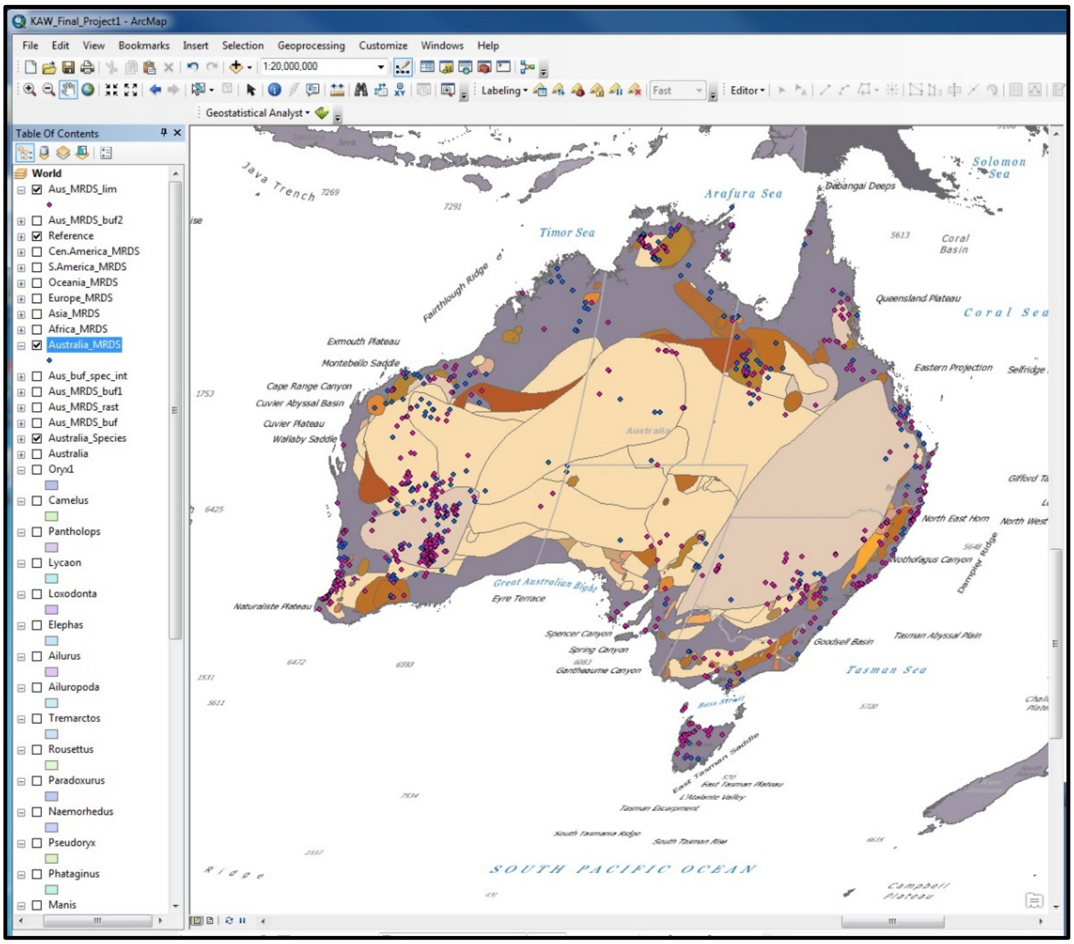

Figure 3. ArcGIS map of Australia with undeveloped mineral occurrences in blue, mine sites or plants in purple, and species habitats in brown(s) polygons.

4. ArcGIS Processing

a. Data for the genera or place of interest were selected from the “Terrestrial Mammals” attribute table and the data was exported as individual feature classes (Fig. 4).

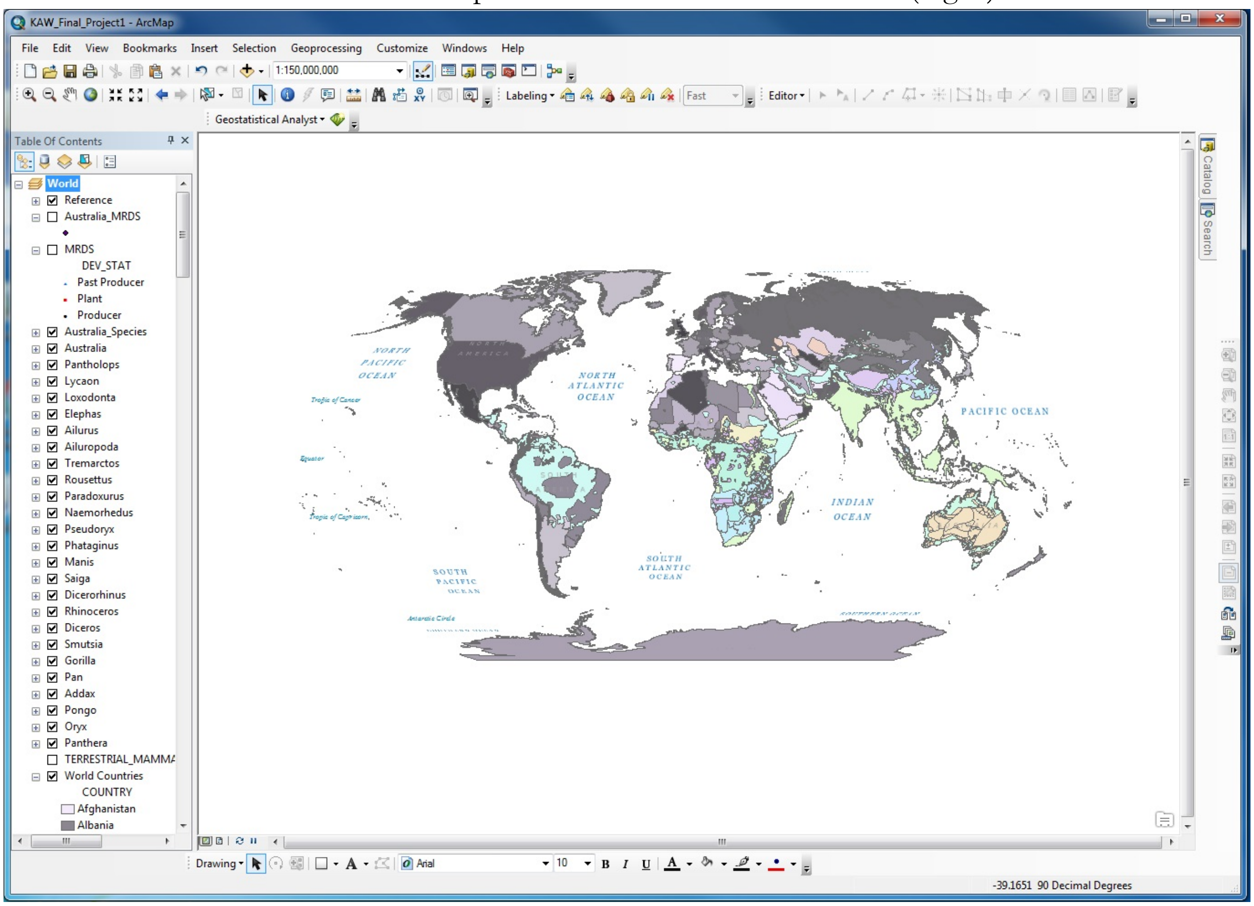

Figure 4. Polygons for genera of interest overlaid on world map. Some polygons overlap at this point.

b. Genera polygons were selected and merged using the “Select by location” and “Merge” tools, to limit the selection based on continent data from the World Countries basemap.

c. MRDS data for producers, past producers, and plants within each continent were selected using the “Select by location” tool. To select by continent, I selected the countries comprising each continent and enabled a “use selected features” filter on the source layer that limited the MRDS data found within the world countries layer to be within a specific continent.

d. MRDS data for each continent was buffered using a circular zone around each mine site to account for mine site infrastructure, pollution effects, and the common sense likelihood that endangered wild species would prefer to be a large distance away from anthropogenic disturbances (Figs. 5,6). A dissolve type “all” constraint was used when buffering to ensure all point types were buffered into a single group. Australian data was processed using 10, 20, 25, 35, and 50 km buffer zone diameters to provide a more detailed data analysis. Keystone species and general data were processed with a 50 km buffer zone.

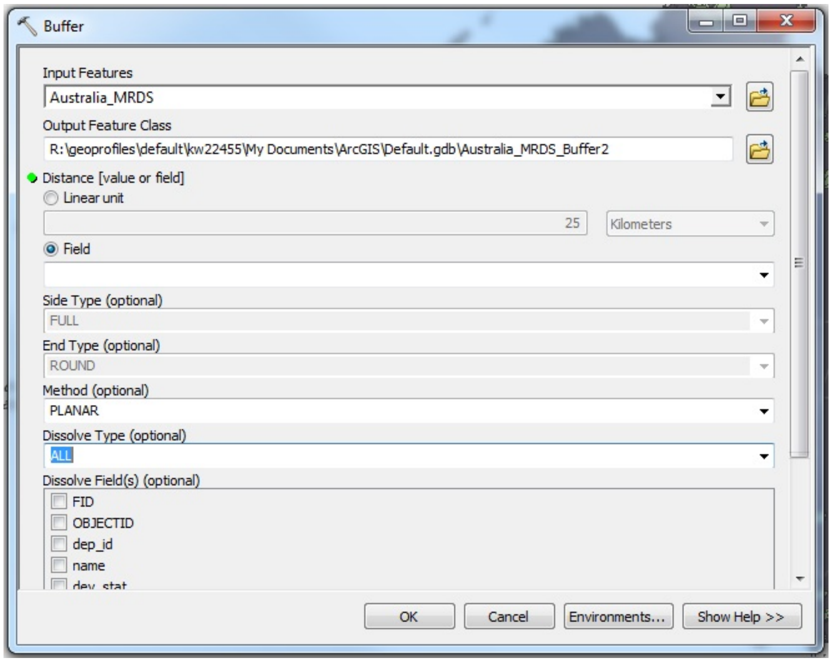

Figure 5. Buffer tool with Australian MRDS data input, yet to have a 50 km buffer tool specified in the "distance" field. Dissolve type "all" is highlighted in blue such that all fields merge.

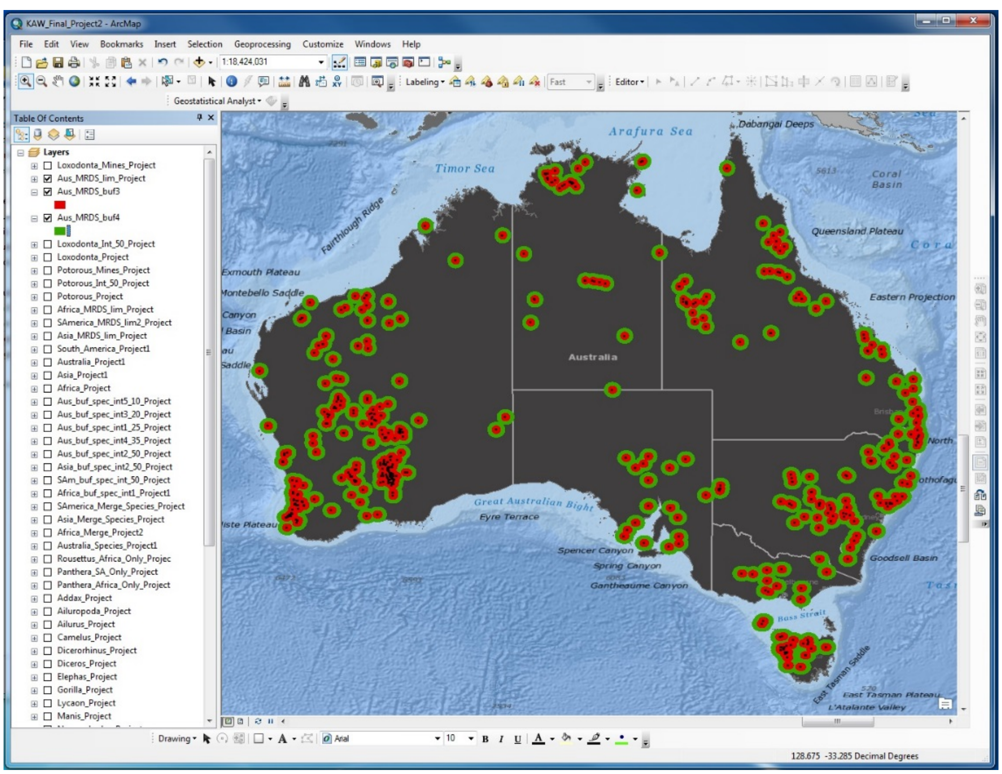

Figure 6. Map of Australia where black points are mine sites, the red halo is a 25 km buffer zone, and the green halo is a 50 km buffer zone.

e. Each buffer zone generated was then intersected with the associated species merged polygon for that continent using the "Intersect" tool (Figs. 7, 8).

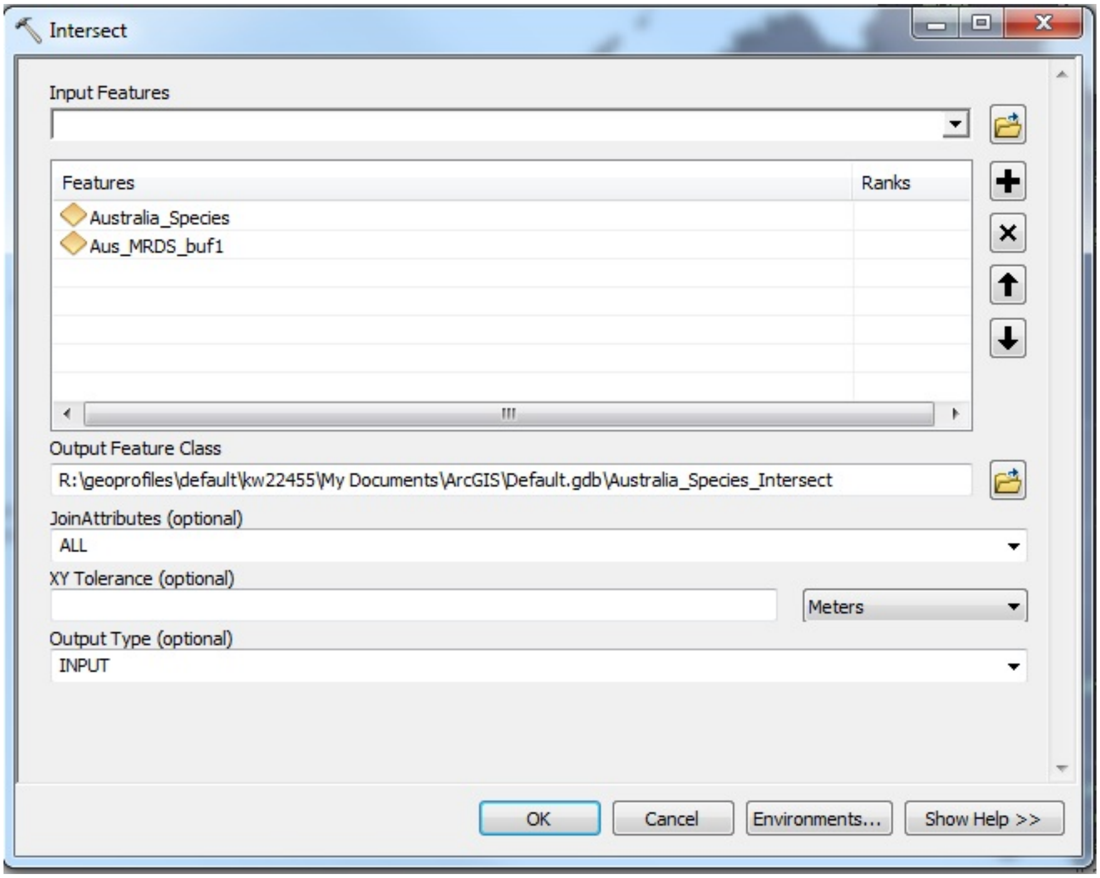

Figure 7. Intersect tool showing the merged Australian species polygon and the buffered Australian mines, with all attributes being joined and the output feature class the same as the input. XY tolerance was disregarded.

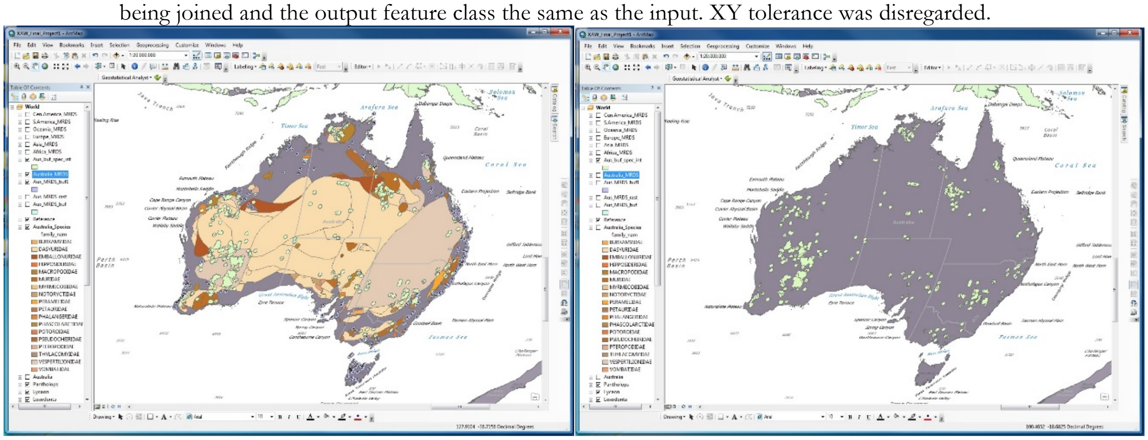

Figure 8. Map of Australia showing mine sites as purple points, mine buffer zones as purple haloes, and intersect areas between species habitat and mine buffer zones as green haloes (left and right).

f. To combine data to calculate species area, the merge tool was used to join relevant species polygons for each continent. Then the dissolve tool was used to dissolve the redundancies in area data using a dissolve by "kingdom" function.

5. Results

A. Case Study: Australia

Australia is an interesting case study in both biodiversity and mineral resources as it has a high concentration of both (Fig. 9). Table 2 shows the total species area compared to the buffer zone areas for all species in Australia. In the direst of circumstances, where a mine site affects a buffer zone of 50 km around it, up to approximately 18% of endangered species habitat can be affected. It is likely that in an area as highly developed as Western Australia, near Perth, the relative impact of mine sites on habitats increases possibly two-fold based on the concentration of mines in the area (Fig. 10).

Australia	**Buffer Zone Diameter *(km)***	**Buffer Zone Area *(km²)***	**Buffer Zone % Species Area**
Species Area (km^2)	10	97,256	1.429
6,803,484.51	20	306,284	4.501
	25	437,485	6.430
	35	732,709	10.77
	50	1,201,544	17.66

Table 2. Australia species data.

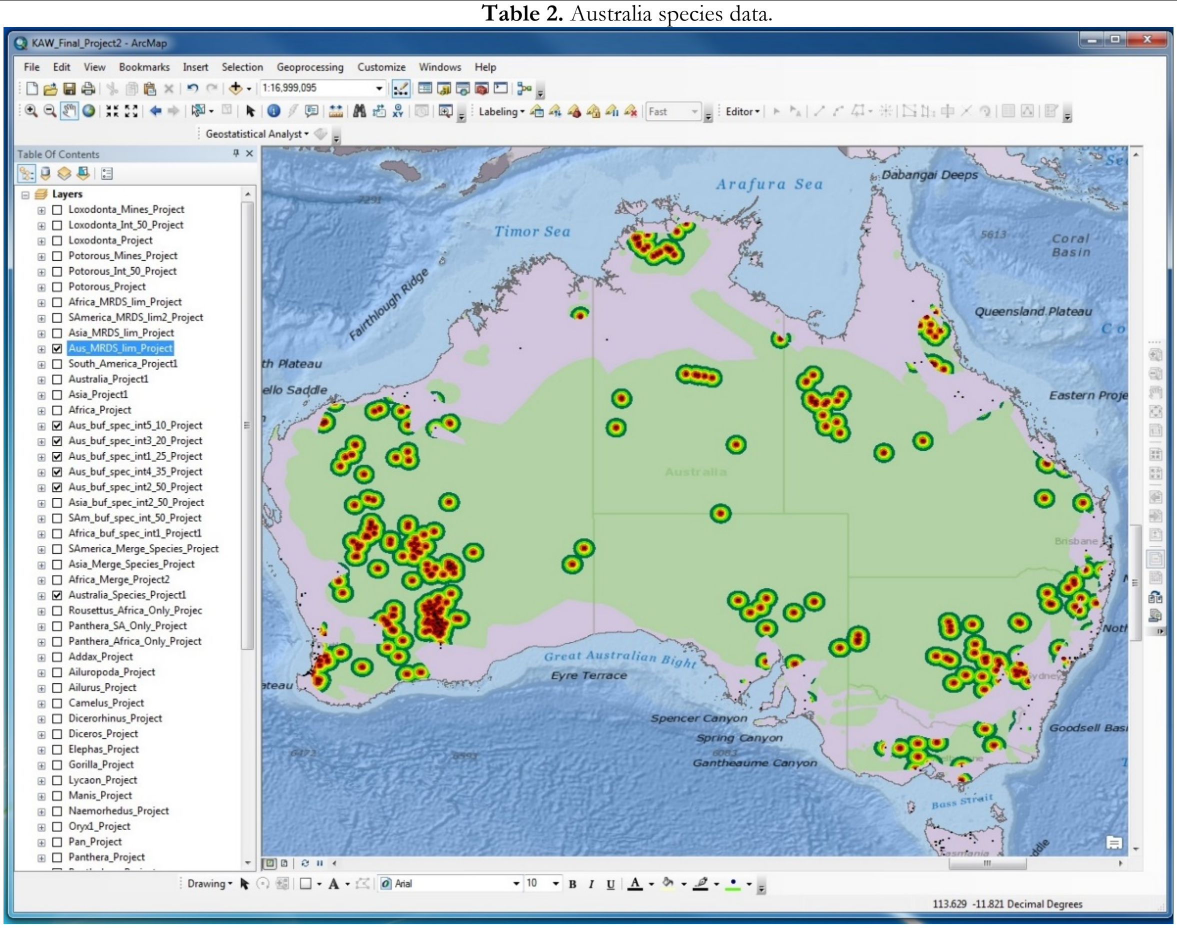

Figure 9. Map of Australia showing species extent in light green mask. Buffer regions are shown around the mine sites (black) as 10 km (red), 20 km (orange), 25 km (yellow), 35 km (lime green), 50 km (dark green).

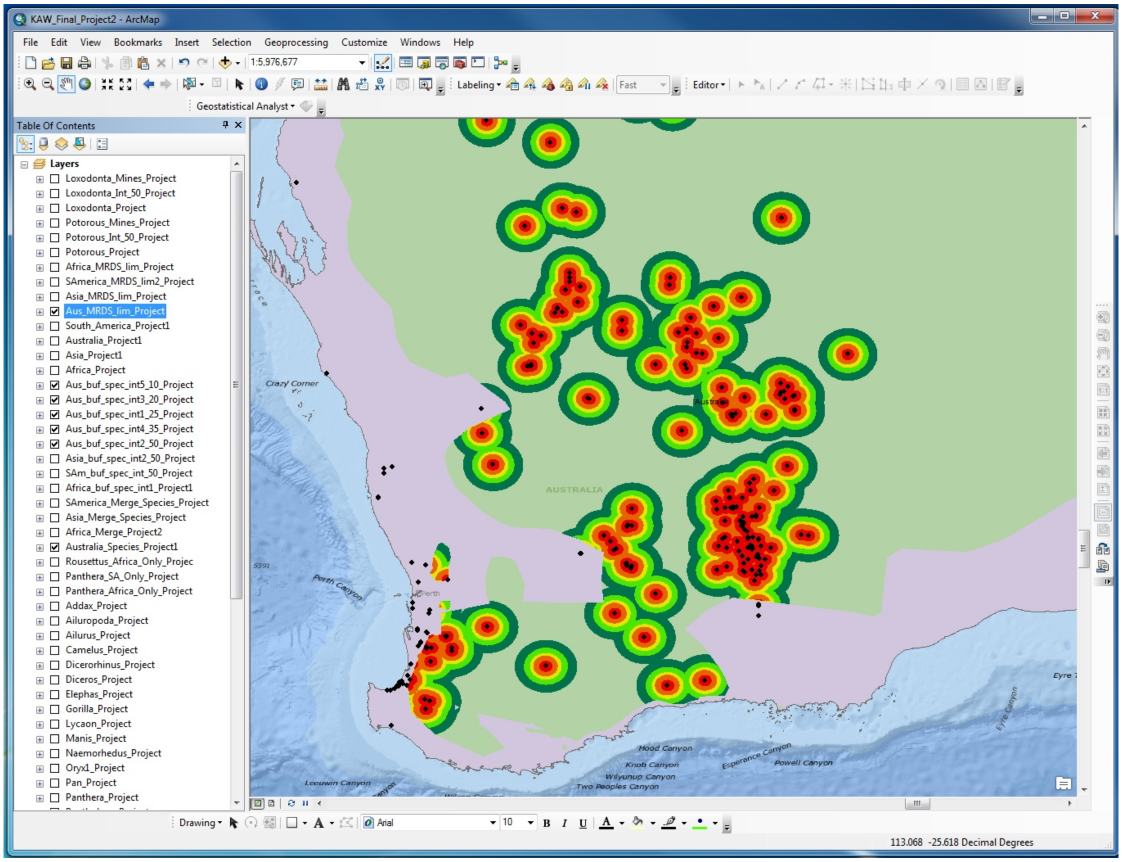

Figure 10. Zoomed in map of Australia near Perth and Western Australia mining districts (Au, Ag, Cu, Fe, Ni), showing species extent in light green mask. Buffer regions are shown around the mine sites (black) as 10 km (red), 20 km (orange), 25 km (yellow), 35 km (lime green), 50 km (dark green). A large portion of endangered species habitat is coincident with mine sites in this area as buffer regions are fairly contiguous across the whole corner. This area could provide a useful study on animal migration through infrastructure constrained natural corridors.

B. *Case Study: Loxodonta*

A keystone species is one that has an incommensurate effect on the environment it lives in, thus plays a large role in ecosystem maintenance. The African elephant (Loxodonta Africana) is a major keystone species in sub-Saharan Africa. As elephants migrate across vast distances they greatly affect the land they subsist on through uprooting trees to return forest to savannah, routing out water rich roots of vegetation to destabilize soil, or digging up large areas of earth to affect water drainage (Bond, 1994). African elephants are facing increasing threat levels due to poaching and habitat destruction. Some of this destruction is due to the mining industry; as shown in Table 3, at least 6% of the already sparse and fractured Loxodonta habitat is in direct conflict with mine sites (Fig. 11).

Loxodonta	**Species Area (km^2)**	**50 km Buffer Zone Area (km^2)**	**Buffer Zone % of Species Area (km^2)**
	3,473,205.30	205,182.71	5.907589403

Table 3. Loxodonta Africana species data.

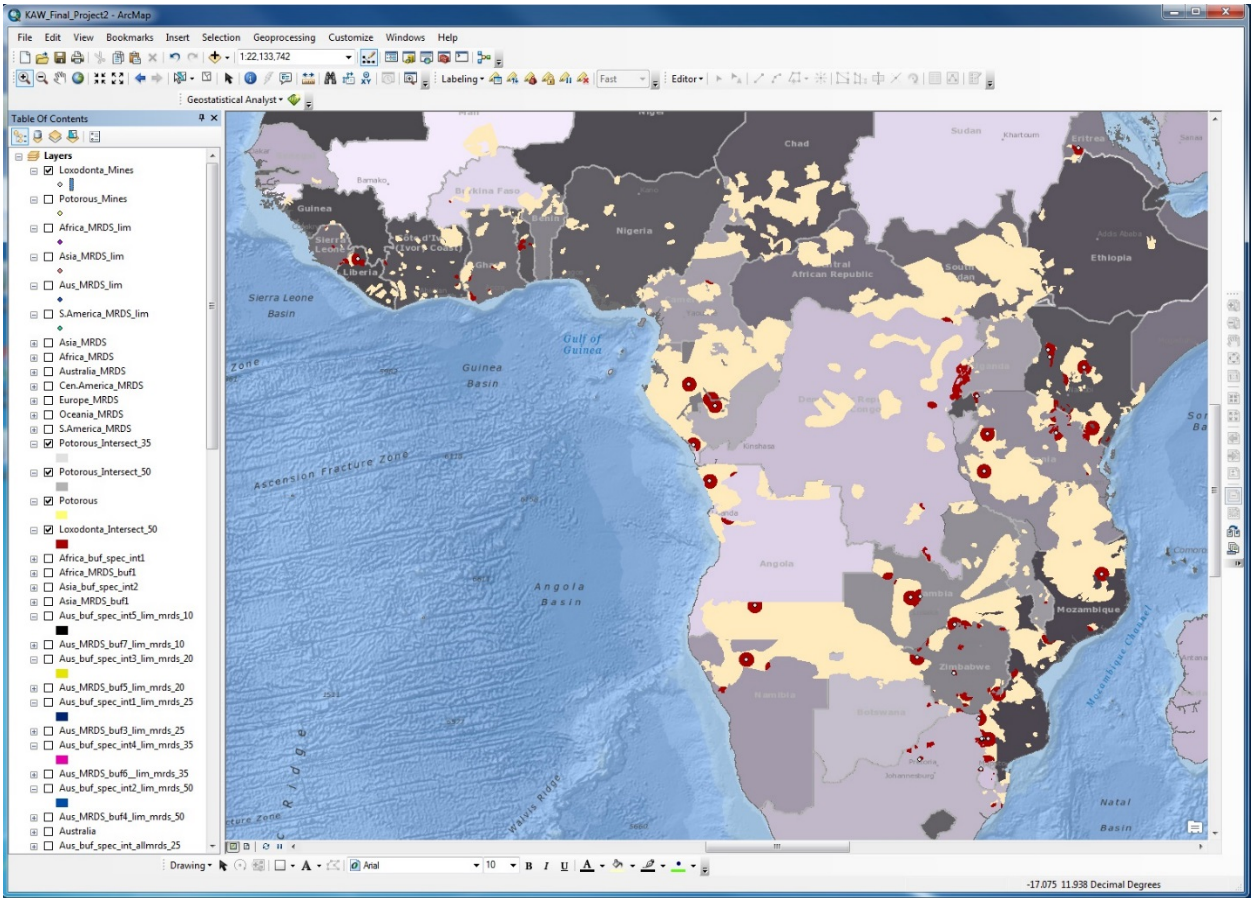

Figure 11. Map of Africa showing mine sites within Loxodonta Africana habitat (tan dots), which are surrounded by a 50 km buffer zone (deep red haloes), within the larger Loxodonta habitats areas (tan polygons). The fractured nature of Loxodonta habits is likely highly impacted by the mining in the area as these areas of coincidence only serve to fracture the habitats further.

6. Conclusions

Globally, mining and endangered species must find a way to coexist in a way that preserves the world's most threatened species while also allowing our increasingly minerals dependent society to thrive. Table 4 shows that around 50% of all the continents investigated in this study are covered by threatened species habitat, and 13% (over 11 million km^2) of this habitat is in direct coincidence with mine sites (Fig. 12). Given these findings, it is apparent that there is a large enough portion of land used by endangered species that is dramatically affected by the mining industry. As this industry grows, mine sites will likely migrate into increasingly remote areas, and it is probable that even more habitat will be athropogenically altered. Moving forward, it will be important to set up best practices procedures at mine sites that are specific to the local threatened flora and fauna and can help protect the biodiversity in the area.

Country	Continent Area (CA) (km²)	Species Area (SA) (km²)	SA % of CA	50 km Buffer Zone (BZ) (km²)	BZ % SA
Africa	33,252,661	19,352,123	58.19	2,399,508	12.40
Australia	9,598,124	6,803,484	70.88	1,201,544	17.66
Asia	113,454,799	52,979,405	46.69	5,133,208	9.700
South America	20,631,615	8,861,802	42.95	2,346,410	26.48
Total	176,937,200	87,996,814	50.00	11,080,669	13.00

Table 4. Global species data by continent.

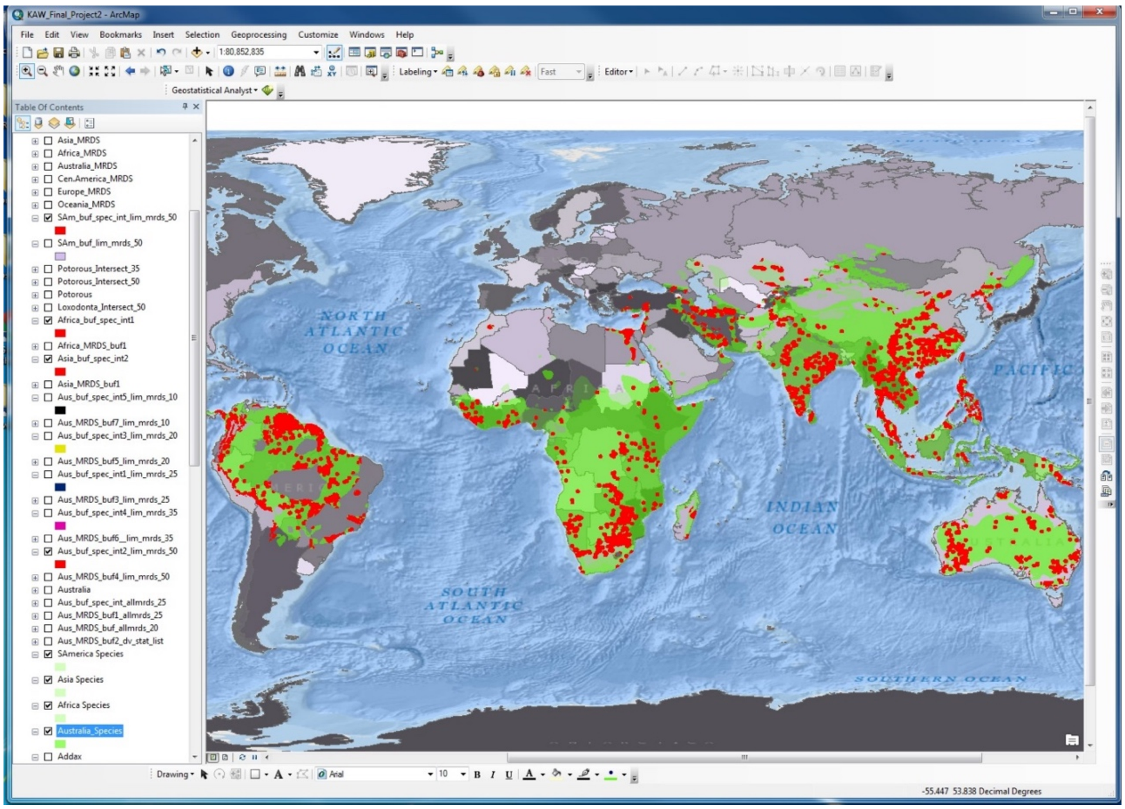

Figure 12. Global map data (Africa, Asia, Australia, South America) on endangered species habitat (light green) and 50 km areas of intersection

7. References

Ayyad, M.A. (2003) *Case studies in the conservation of biodiversity: degradation and threats.* Journal of Arid Environments. **54**, 165–182.

Bond, W. J. (1994) *Biodiversity and Ecosystem Function: Keystone Species*. Springer Berlin Heidelberg. 237-253.

Kesler, S.E. (2007) *Mineral Supply and Demand into the 21st Century on Deposit Modelling, Mineral Resources Assessment and Their Role in Sustainable Development.* USGS Circular. **1294**, 55-62.

McKee, J.K., *et al.* (2004) *Forecasting global biodiversity threats associated with human population growth.* Biological Conservation. **115**, 161–164.

World Wildlife Fund. *Endangered Species List.* Accessed: Apr. 20, 2016. http://www.worldwildlife.org/species/directory?sort=extinction_status