Modeling Deforestation Risk in Madagascar's National Parks

Background and Conceptual Overview:

Madagascar is considered a one of the eight 'hottest' biodiversity hotspots in the world, and upwards of 80% of all species on the island are endemic, i.e. found no where else on the planet. (1) Some of the more well-known endemic animals are the lemur, of which there are around 100 species, the fossa, and over 30 species of tenrec. However, despite considerable conservation efforts, researchers claim that it is unlikely many of the large Malagasy animal species will maintain viable populations beyond 2020 – 2040 due to fragmentation of existing forests. (1, 2) Deforestation is primarily caused by human in Madagascar, these being charcoal production, slash and burn agriculture, illegal logging, and forest fires. (3) Understanding the areas in Madagascar with the highest risk of deforestation from natural and human-sourced causes will help policy makers decide where to devote resources to better protect these areas. Publicly available geospatial data on forest cover, nature preserve location, elevation, human settlements, roads, and location of crop cultivation were analyzed in ArcMap 10.6.1 to identify areas in Madagascar that are at a high risk of deforestation. For policy making purposes, only areas that were in existing national parks were highlighted, as these areas might be the easiest to increase preservation efforts for.

Key Datasets and Spatial Mechanism Being Modeled:

1) Slope: Areas with a low slope are more sensitive to deforestation, since they are more easily converted to farmland or a charcoal production operation, and in the case of logging, easier to access with logging equipment. A 30-meter elevation map was used along with the Slope tool to identify the slope of all areas in Madagascar. Forested areas with a slope of 1-15 degrees slope were assigned a high-risk score of 3, 15-20 degree sloped areas were assigned a medium-risk score of 2, and all slopes greater than 20 degrees were assigned a low-risk score of 1. (4)

2) Proximity to roads: A three level hierarchy was established around roads according to OpenStreetMap using the Euclidian Distance tool. Areas within 1km of a road were assigned as high risk, between 1-5 kilometers were assigned moderate risk, and between 5-15km assigned low risk. Areas outside of this 15km buffer will not be assigned a risk weight associated with road proximity.

3) Proximity to nearest populated settlement: All settlements recorded in a dataset produced by a collaboration between the National Geospatial-Intelligence Agency (NGA), UN OCHA, and Madagascar National Disaster Management Office (BNGRC) were used. This dataset failed to identify every settlement accurately, but was accurate enough to identify most. A risk buffer hierarchy using the Euclidian Distance tool was used identical to proximity to roads.

4) Proximity to cultivation: Areas of cultivation as of 2006 were used to identify areas at risk of being converted into farmland. A dataset from the Critical Ecosystem Partnership Fund (CEPF) was used that identified places of cultivation based on satellite imagery was used. Using the Euclidian Distance tool, a risk buffer hierarchy was constructed, with areas within 500 meters being high-risk, 500 – 1000 meters categorized as medium-risk, and 1km to 5km being low-risk was modeled around every recorded location of cultivation to account for the risk of expanding food production into forested areas.

5) Protected Areas: A map of all protected areas in Madagascar was downloaded from the GeoNode opensource data consortium of Madagascar. Protected areas in Madagascar were hypothesized to have a "reverse" effect on the risk calculation, with protected areas being assigned a "protected" score of -3, and areas being considered to be protected assigned a value of -1.

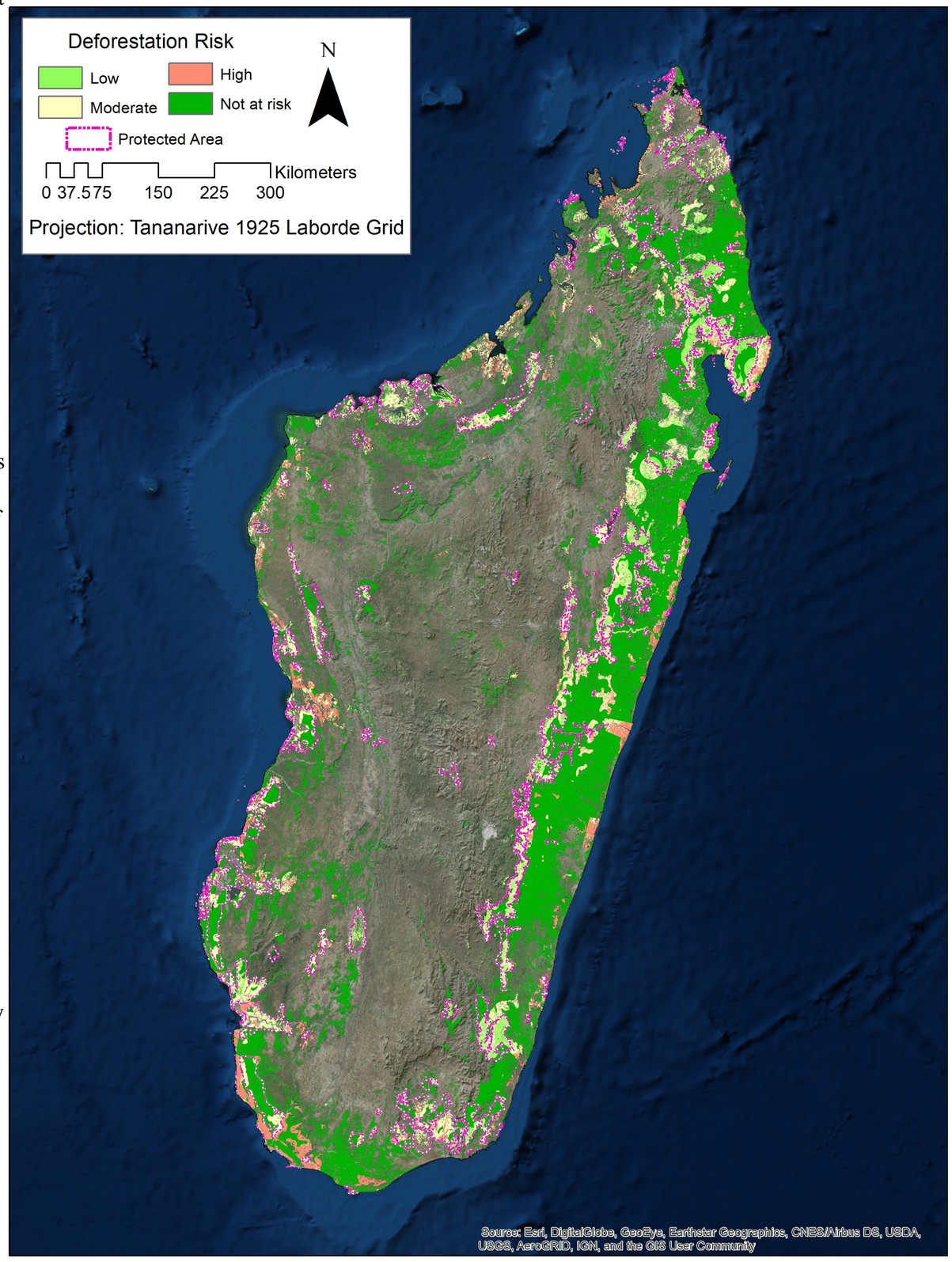
6) Forest Cover: Information on areas categorized into any of the forest types according to the raster dataset made by the Critical Ecosystem Partnership Fund (CEPF) were categorized as "forested". Only these forested areas were modeled as the areas that might be at risk in the final model.

GIS Procedures:

Using map algebra, specifically the Raster Calculator tool, all areas with risk scores were added together and then restricted to forested areas. The scores, ranging from 1 – 12 were then reclassified into three risk categories, low being a score of 1-4, medium risk being 4-7, and high risk being 7-12. Only areas with medium or high risk were used to calculate the forested area in national parks that was at risk of being deforested.

Results:

The most popular national parks in Madagascar according to tripadvisor were organized according to total area. (5) The proportion of the park at medium to high risk of deforestation according the my model were calculated using the Zonal Statistics tool. As we can see in Table 1, these 13 poplar parks had a from 9% - 99% of their area at risk of deforestation



Name of Malagasy Nature Reserve	Total Area in Hectares	Percent at Risk of Deforestation
Nosy Mangabe	596	39.16%
Analamazaotra	860	99.27%
Mantadia	15,456	57.77%
Montagne d'Ambre	28,658	50.21%
Andringitra	32,074	8.40%
Zombitse - Vohibasia	36,898	62.24%
Ranomafana	40,534	77.67%
Zahamena	64,935	15.94%
Isalo	86,567	9.00%
Ankarafantsika	136,607	42.02%
Tsimanampesotse	203,744	28.77%
Masoala	224,287	17.58%
Corridor Forestier Ankeniheny Zahamena	373,033	26.47%

Model Evaluation:

As we can see from the below images, the model is accurate at predicting some areas of deforestation. Areas highlighted as at high risk of deforestation that were categorized as forested areas in 2006 can be seen to be cleared for agriculture or other uses.

Because this is a risk model, it is difficult to identify areas where the model is completely wrong. The primary risk being modeled is proximity to human beings. The next question is what interventions the government of Madagascar might adopt to better protect its national parks. This is a more complicated question to answer, as each park has its own administration and challenges in keeping its forests intact. The most obvious answer might be to promot more ecotourism, so that the parks might provide a better income source for local people in the area. However, this is not as easily done as it is recommended by a remote GIS student.

Terraced Rice Fields within a high risk zone of Ankarafansika National park can be seen (above). Additionall, a deforested area in the same national park can be seen in an area identified as low-risk by the model. The model is not laser-accurate, but still succeed in identifying some parks that might be prioritized for additional protection.

Sources

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Datasets

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