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Human Activity Impacts on Belize Deforestation (1995-2010) and Future Trend Prediction

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Predicted Probability of Deforestation in Belize

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Abstract

Belize is a Central American country that is known for its high biodiversity. According to the Water Center of the Humid Tropics of Latin America and the Caribbean (CATHALAC) and NASA, Belize's forest cover decreased from 75.9% in late 1980 to 62.7% in 2010. In this project, we developed a spatial model of deforestation in Belize. We hypothesized that factors influencing the potential of deforestation in Belize included elevation, distance to human-built facilities, distance to roads, and whether an area is protected. We performed a binary logistic regression to generate a best-fit model of deforestation probability. Whether an area is protected, and the distance to the nearest human-built facilities were statistically significant predictors of deforestation in Belize.

Figure 1. Rainforests in Belize

Figure 2. Illegal logging in Belize

Methods

In ArcGIS 10.2.2, we located forested areas in Belize in 1995 and areas that were deforested between 1995 and 2010. We then created 100 random points within each set as our random and known points, respectively. We calculated the distance from each point to the nearest roads and to human-built facilities and performed an independent-samples t-test for significance of these factors on deforestation. We also tested the significance of elevation and whether an area is protected as predictors of deforestation. We input variables that significantly differed between random and known points into a binary logistic regression after normalizing the data. We then used the output constants and coefficients to generate an equation to predict the deforestation potential among the current forests in Belize. We built a GIS data model to calculate the potential for the current forest areas of the whole country using the equation. To test the validity of the model, we calculated the percentage of the areas that were actually deforested that fell in those with high deforestation potential in our model.

We obtained our data from the following datasets: Belize Forest Cover Change 1980-2010 (CATHALAC, MNRE, NASA, USAID, and SERVIR), GIS and Spatial Data for Belize (BERDS), and Belize Transportation Network as of 2000 (Belize Ministry of Natural Resources' GeoNode Implementation). We performed all the statistical analyses with IBM SPSS Statistics 22, and all GIS data used the WGS_1984_UTM_Zone_16N coordinate system.

Variable	p-value
Distance to roads	0.000
Elevation	0.258
Distance to human-built facilities	0.000
Protected area	0.000

Table 1. P-values based on the independent-samples t-tests for all variables.

Results

Distance to roads, distance to human-built facilities, and whether an area was protected in 1995 significantly predicted the probability of deforestation in Belize. Elevation was not a significant predictor of deforestation (Table 1). The best-fit model for predicting the potential of deforestation at a certain location is

$$P(Deforestation) = \frac{1}{1+e^{-(0.934-0.907*Protected-2.494*DistanceToFacilities)}}$$

where *P(Deforestation)* is the probability of deforestation, *Protected* is whether an area is protected (protected = 1, not protected = 0), and *DistanceToFacilities* is the distance to the nearest human-built facilities. The model can account for 9.3% of the variance (R^2=0.093).

Based on the regression result, about 43% of the current forests have a high potential of deforestation—the probability is greater than 0.5 (Figure 3 and Figure 4).

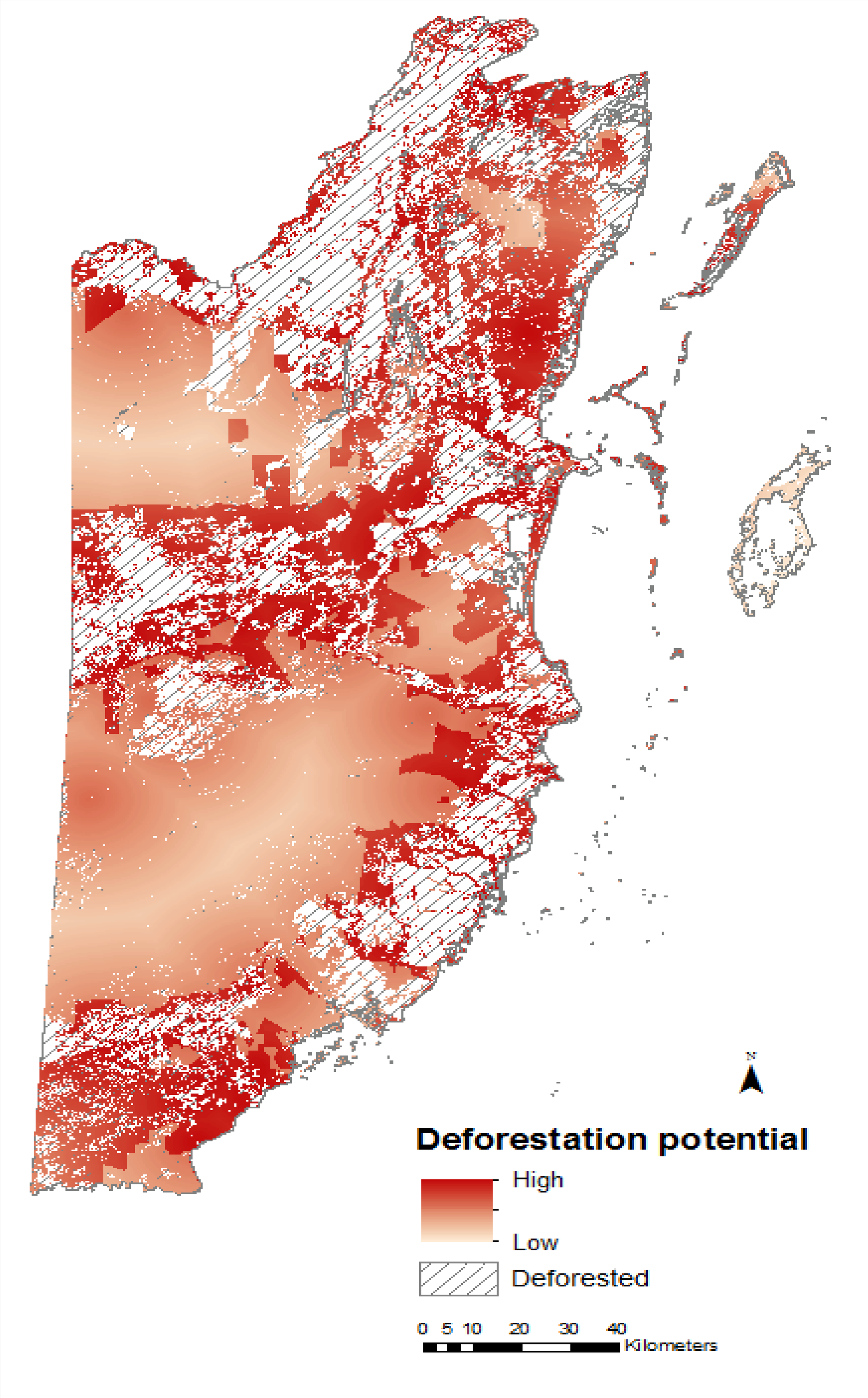

Figure 3. Potential of deforestation in Belize. The raster layer was generated by calculating coefficients for each significant variable through a binary logistic model.

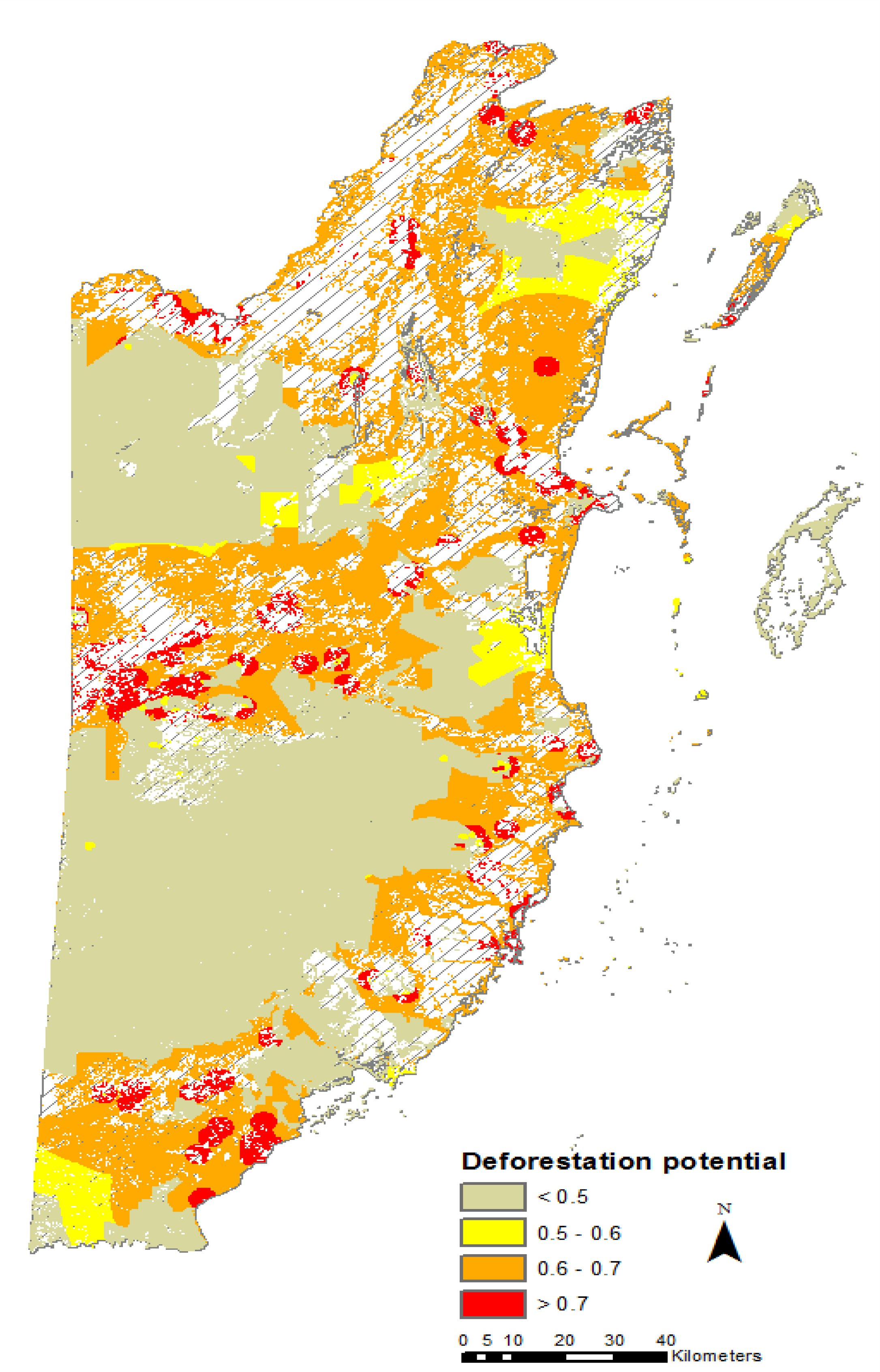

Figure 4. Areas where the probability of deforestation is greater than 0.5.

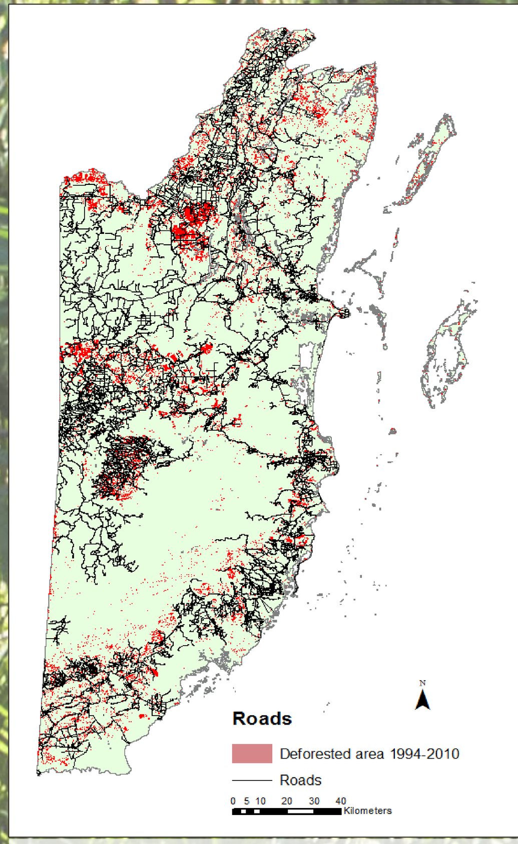

Figure 5. Major roads of Belize. The distance to roads was a significant predictor of deforestation potential individually (p-value<0.001), but was not significant in the overall model.

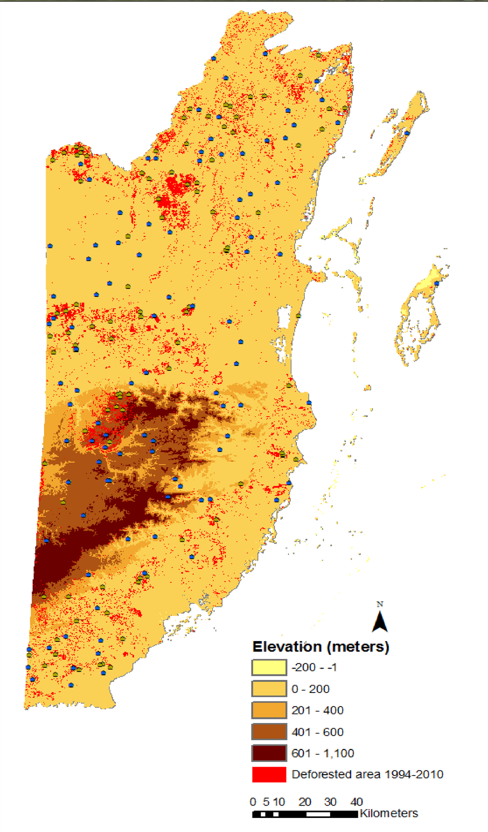

Figure 6. Belize elevation profile. Elevation is not a significant predictor for deforestation potential either individually or in the overall model (p-value= 0.258). This map also shows the known points and random points we created.

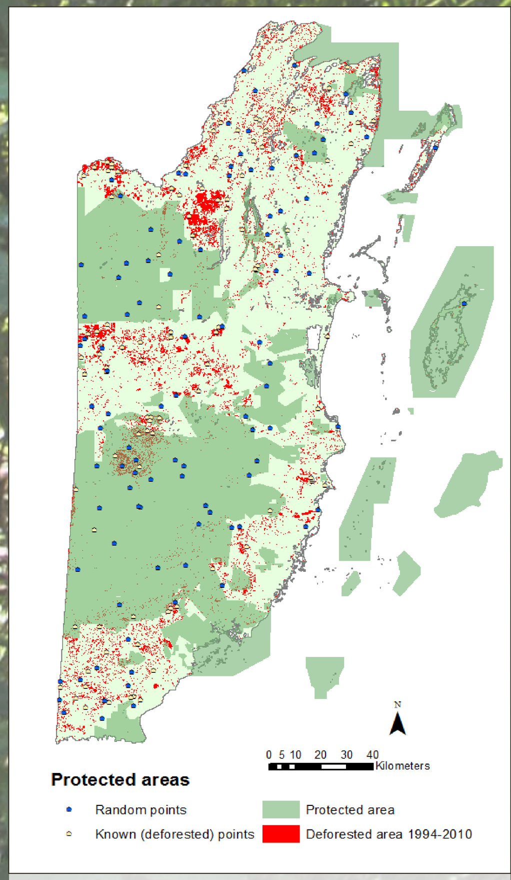

Figure 7. Protected area in Belize. Whether an area is protected was a significant predictor of deforestation potential (p-value<0.001). This map also shows the known points and random points we created.

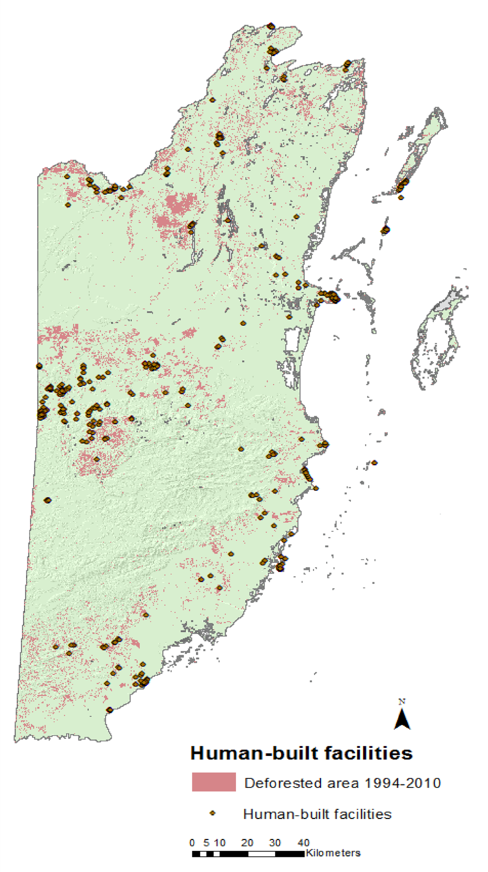

Figure 8. Human-built facilities in Belize. The distance to these points was a significant predictor of the probability of deforestation (p-value<0.001).

Discussion

Whether an area was protected and the distance to human-built facilities were the best predictors of deforestation in our model. It was surprising that even though the distance to roads significantly predicted deforestation alone, it did not when we combined all the variables in our model. This result might be due to the overwhelming effect of protected areas on deforestation potential.

This model appears to be a reasonably robust predictor of deforestation in Belize. Over 80% of all the deforested area since 1995 falls in the area where the deforestation probability is greater than 0.5 in our model. However, the method of building this model can still be improved by separating the country into two parts. We could have developed our model based on half of the country, and used the model to predict the deforestation potential of the other half. This method would allow us to test the model in a more accurate way.

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