Assessing Habitat Suitability and Human-Jaguar Conflict Areas to Identify Potential Jaguar Corridors Connecting La Amistad and Corcovado National Parks in Costa Rica

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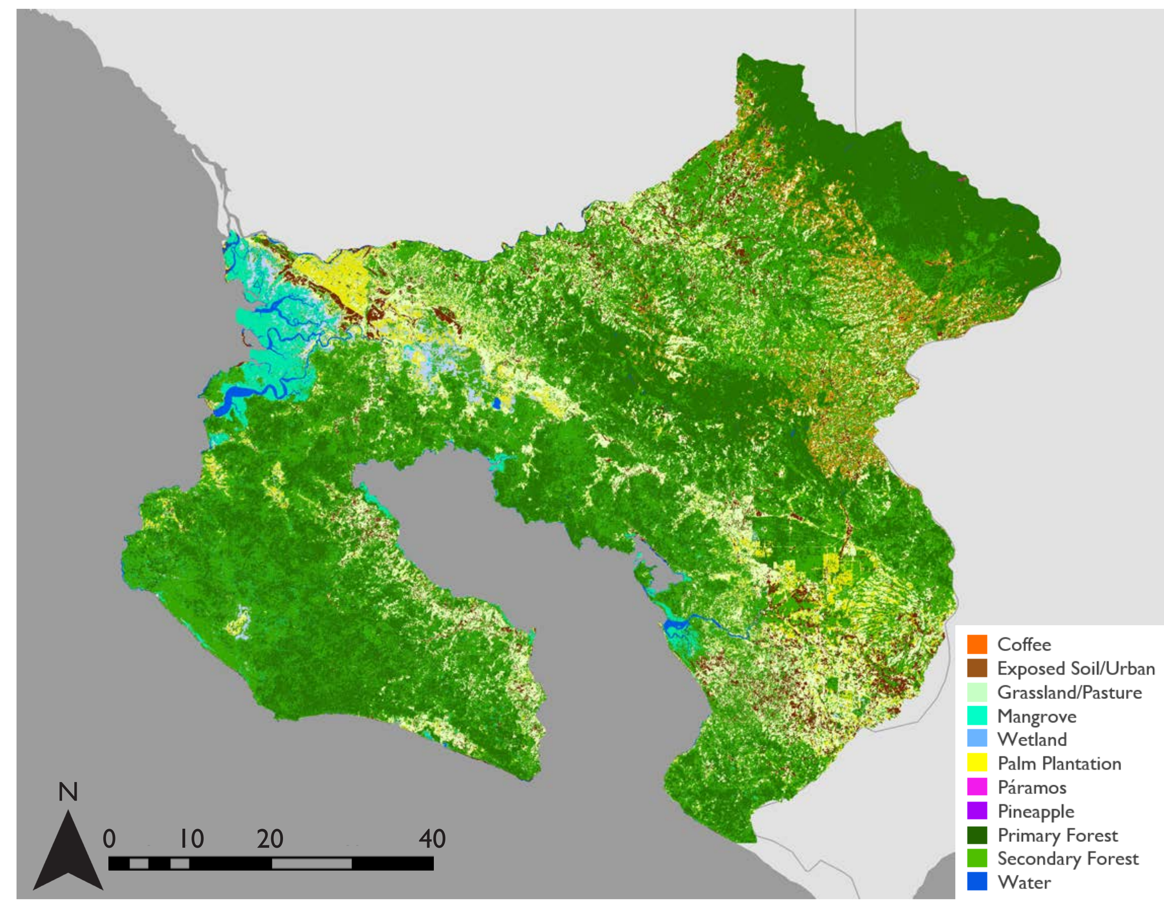
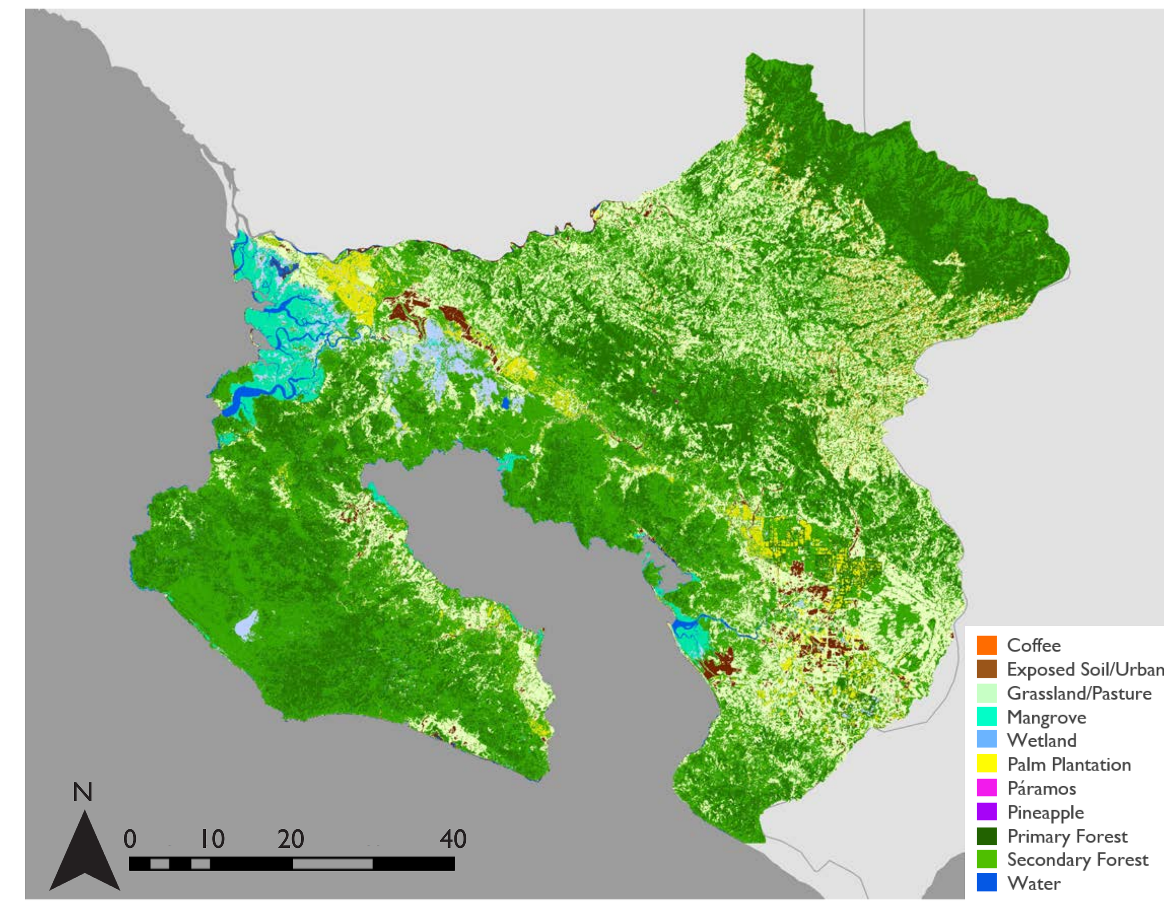
La Amistad International Peace Park in the Talamanca Mountains and Corcovado National Park on the Osa Peninsula in Costa Rica are home to two isolated jaguar (Panthera onca) populations. As agricultural and urban land uses have expanded in Costa Rica, jaguar home ranges have been reduced by 40 percent. NASA DEVELOP collaborated with the Arizona Center for Nature Conservation – Phoenix Zoo and Osa Conservation to design optimal corridors between these two protected areas to reconnect isolated populations. This project used Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI) to assess trends in land use and land cover (LULC) from 1987 to 2019. From these analyses in conjunction with elevation data from Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and vector data of roads and urban centers, we forecasted LULC to 2030 using the TerrSet Land Change Modeler. These data were then used to identify forecasted human-jaguar conflict risk areas, created by urban and agricultural expansion. A compilation of these inputs informed a suitability assessment that was used in Linkage Mapper to model wildlife corridors. The results from Linkage Mapper highlighted a potential corridor through the Buenos Aires Canton of the study area. Our partners will use these findings for monitoring and educational outreach efforts and the implementation of a jaguar corridor.



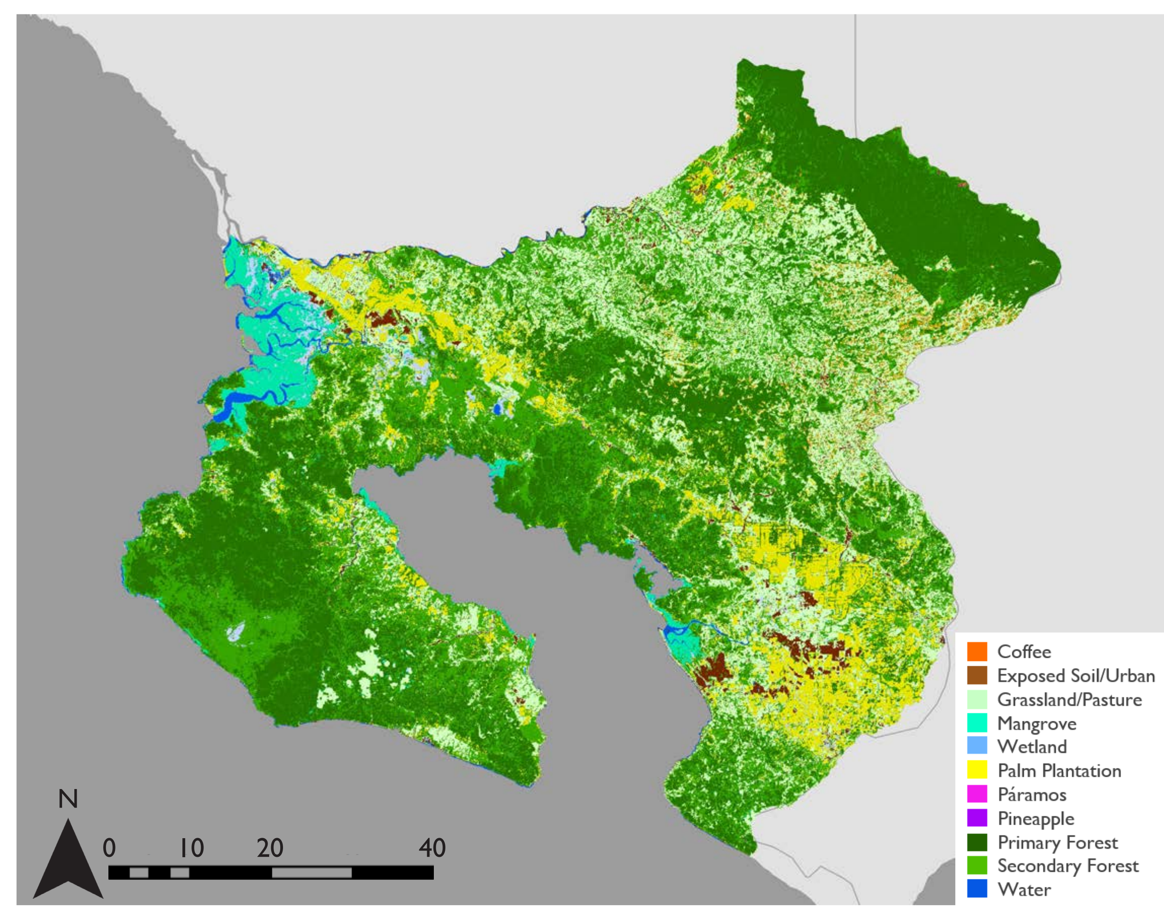
Land Use and Land Cover 1987



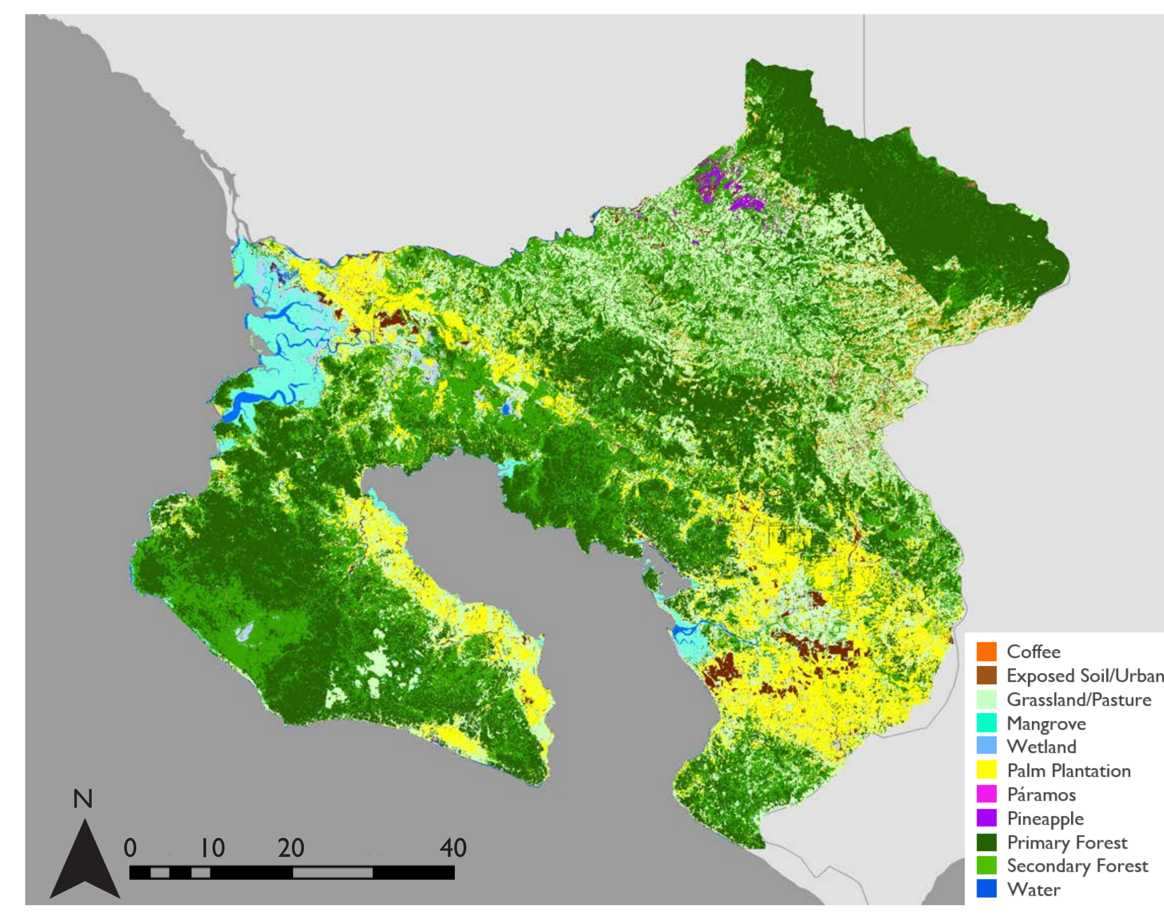
Land Use and Land Cover 1997

LULC time series maps for 1987, 1997 and 2019 were the initial products that we used to analyze trends in vegetation cover. We forecasted to 2019 with the 1987 and 1997 LULC maps for comparison with the actual 2019 LULC map that was created in the previous term. Comparatively, the forecasted 2019 map was 65.2 percent accurate. In an attempt to increase accuracy, we combined the three classes that are classified as closed canopy and less than 100 years old: natural palm, melina and teak and secondary forest. By doing so, this increased our 2019 forecasted accuracy by 1.3 percent. Given this, we can assume an accuracy of approximately 66.5 percent for our forecasted 2030 result.

From 1987 to 1997, palm plantations and exposed soil/urban decreased by 1.31 percent and 3.63 percent respectively, while grassland/pasture increased by 8.40 percent. African oil palms are replanted every 25 to 30 years. In preparation for planting, non-productive stands are cleared and left fallow, or are ploughed for the sewing of a legume cover crop to fix Nitrogen in the soil (Hashim, Muhamad, Chan, Choo, & Mohd Basri, 2010). As 1997 could have been a replanting year, this would account for the observed decrease in African oil palm and exposed soil and an increase in grasslands (planted legumes) occurring around the Inter-American Highway, which aligns with 2012 through 2019 trends in palm plantation expansion. Consequently, primary forest also decreased from 1987 to 1997 by 6.08 percent. This reduction could be accounted to the clearing of lands for palm plantations before environmental policies like Forest Law 7575 of 1996 were enacted.



Land Use and Land Cover 2019



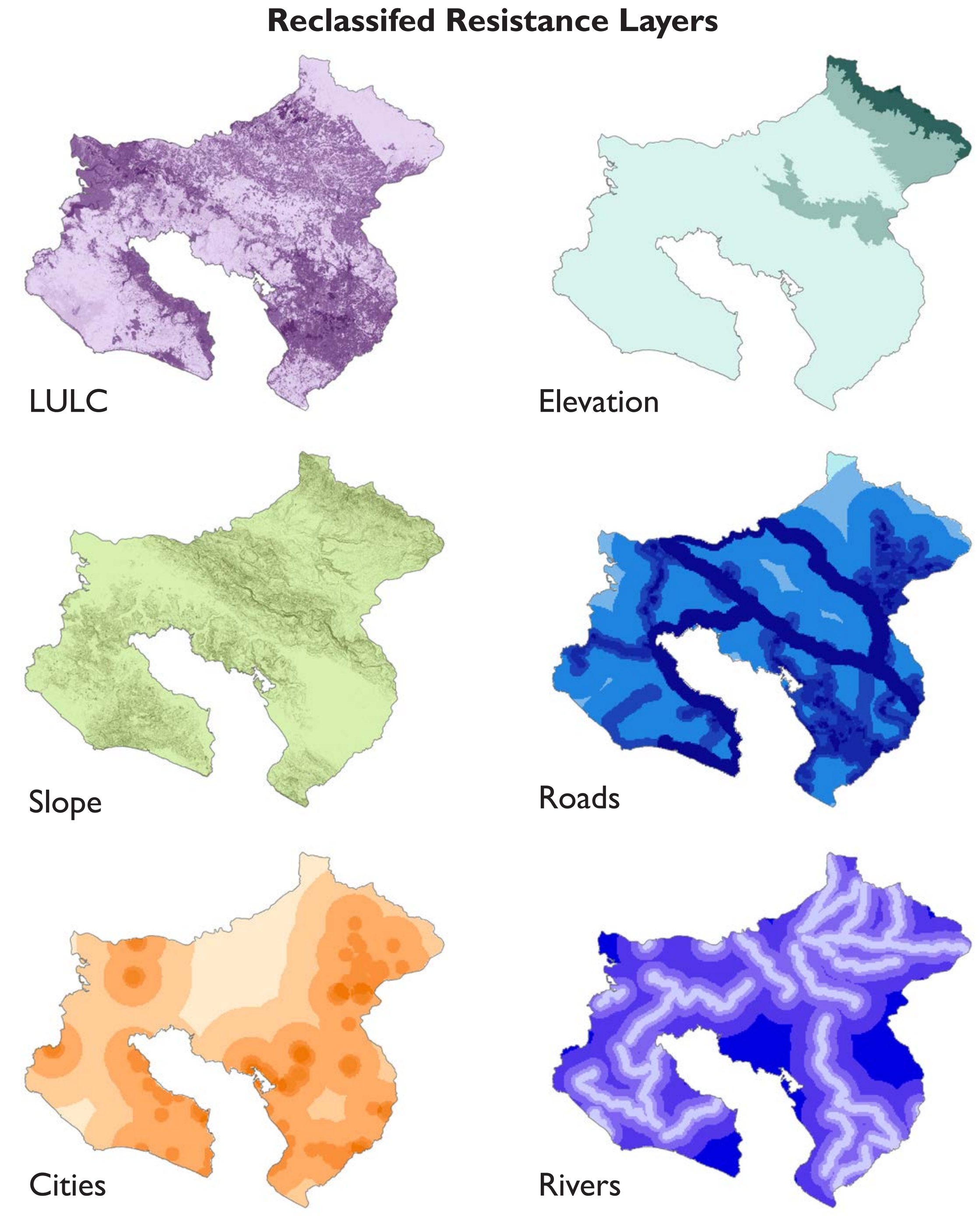
Forecasted Land Use and Land Cover 2030

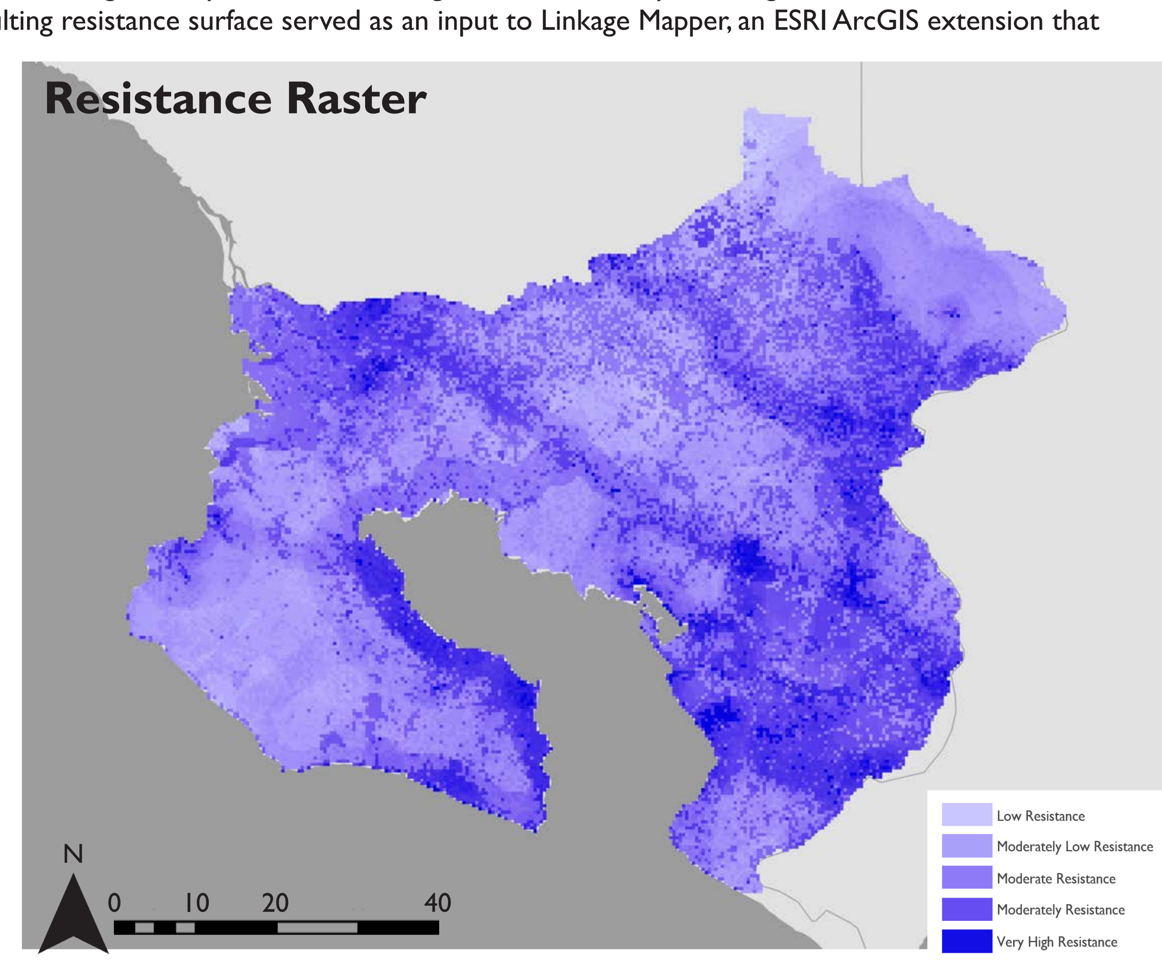
From 1997 to 2019, secondary forests increased in protected areas while secondary and old growth forests declined outside of these areas with a staggering total decrease of 10.88 percent across the study area. This particularly occurred in the southeastern portion of our study area where exposed soil, urbanization, and palm plantations rapidly expanded. African oil palm plantations have continued to develop along the Inter-American Highway, with an overall increase of 6.55 percent. Contrastingly, primary forest increased by 8.65 percent from 1997 to 2019, mainly occurring in protected areas as a potential result of Forest Law 7575 of 1996.

Results from TerrSet showed an overall significant transition of forested areas to grassland. A recent study by Ospina et al. (2012) showing an increase in grassland and pasture areas in Costa Rica further verifies our findings. While it is important to quantify rates and patterns of land use changes, it is equally beneficial to understand the environmental impacts of these changes. Land conversion from forests and other natural vegetation to pastoral lands alter the physical, biological and chemical properties of the surrounding soil leading to reductions in the composition of soil carbon (Ospina et al. 2012). It is therefore important for future studies to consider policies that control land use conversions to grassland in the study area. From 2019 to 2030, it is predicted with a confidence of 67 percent that primary forests will remain relatively constant, while secondary forests will decline by 4.25 percent and be replaced with oil palm plantations, increasing by 3.66 percent, specifically on the northern gulfline of the Osa Peninsula.

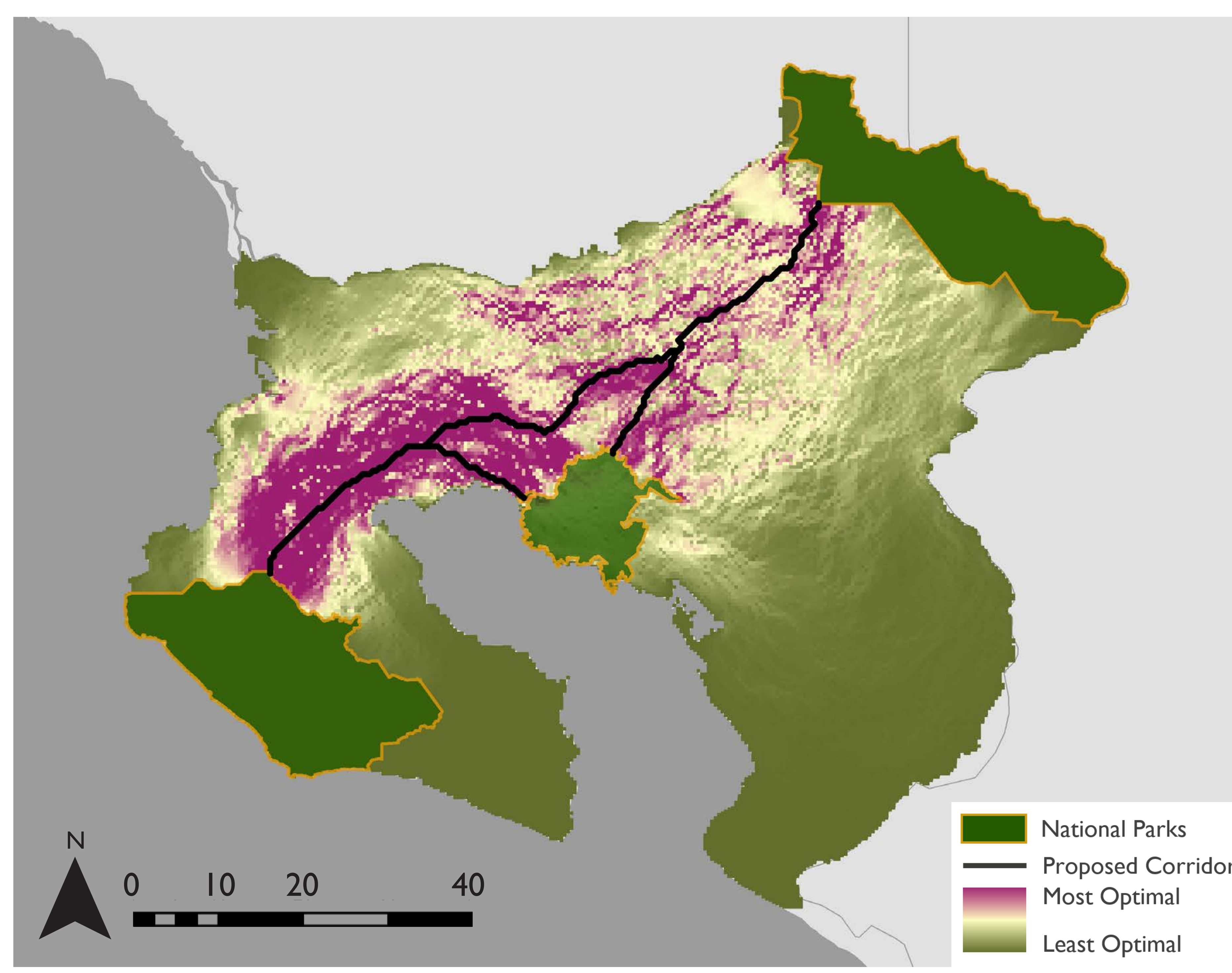
For the corridor modeling and connectivity analyses, we utilized a resistance surface that represents the difficulty experienced by a jaguar moving through the study region as the primary input. The resistance raster was created using inputs including LULC, elevation, slope, and distance to roads, human settlements and rivers. Resistance values were assigned to each layer on a scale of zero to ten, ten being the highest energetic cost, or highest level of difficulty, for a jaguar to move through that specific cell. We assigned each raster layer a weight of influence within the model and used the Raster Calculator tool in ArcMap to create an overall resistance surface. The resulting resistance surface served as an input to Linkage Mapper, an ESRI ArcGIS extension that utilizes a least-cost approach to locate pathways between habitat cores.

Reclassifed Resistance Layers





The resistance raster informed the corridor model within Linkage Mapper and resulted in two potential least-cost paths, one connecting Corcovado directly to La Amistad and another linking Corcovado to La Amistad by going through Piedras Blancas. These results were expected, as we predicted the model to create a least-cost path that would run through the Buenos Aires canton to avoid moving closer to palm plantations and larger settlements on the eastern side of the study area. The modeled corridor runs through areas containing pineapple plantations, which is not an ideal habitat for jaguars, but they are more likely to prefer these areas as a temporary space for movement as opposed to those with higher densities of humans and vehicular traffic. Based on the modeled least-cost path, Pinchpoint Mapper, an additional tool within Linkage Mapper, utilized Circuitscape to run a connectivity analysis. This analysis provided us with multiple diffuse pathways to connect the habitat network instead of one single least-cost path. Shades of magenta indicate the highest levels of current that are allowed through the resistance layer and indicate a more optimal corridor that has the lowest resistance to movement for jaguars through the landscape.



Jaguar Corridor Model

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