**Talamanca-Osa Ecological Forecasting II**

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

**VPS Title:** Corridor Connection: A Pathway to Survival

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:*** As a result of agricultural development, deforestation, and human conflict, the jaguar (*Panthera onca*) is endangered in Costa Rica. To ensure species preservation, it is crucial to connect forest fragments through the application of wildlife corridors. NASA DEVELOP collaborated with two conservation organizations to model optimal locations for the implementation of a jaguar corridor that would reconnect two populations in southern Costa Rica. Using NASA Earth observation data, this project forecasted land use classifications to the year 2030 to investigate changes in the landscape for corridor modeling. Results from this study will assist in policy, planning and conservation efforts.

***Abstract:***

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.

***Keywords:***

jaguar, corridor, Linkage Mapper, TerrSet, Costa Rica, land use and land cover, remote sensing, forecasting

***National Application Area Addressed:*** Ecological Forecasting

***Study Location:*** Southern Puntarenas Province of Costa Rica within the Osa, Golfito, Coto Brus, Buenos Aries, and Corredores Cantons

***Study Period:*** January1987 to February 2019, Forecasting to 2030

***Community Concerns:***

* Between the 1940s and the 1980s, Costa Rica had one of the highest deforestation rates in the world, with a 21 percent decrease in forest cover.
* Significant habitat loss, habitat fragmentation, and agricultural and urban expansion have negatively impacted endemic and endangered species in the region, such as the jaguar that can require a home range of up to 40 km.
* Habitat loss and fragmentation reduce the long-term survivability of jaguars by isolating populations, resulting in a loss in genetic diversity and the increased likelihood of inbreeding. This is especially prevalent in Corcovado National Park with an estimated 12 remaining individuals.
* Crops like pineapple and African oil palm plantations act as barriers to movement.
* Decreased habitat size drives jaguars closer to humans, increasing the likelihood of human-jaguar conflict and retaliatory hunting.
* Since jaguars are an apex predator and keystone species, the reduced number of individuals causes a negative trophic cascade.

***Project Objectives:***

* Conduct historical land use and land cover analyses (1987 and 1997)
* Forecast land use and land cover classifications to the year 2030
* Create a human-jaguar conflict risk map based on environmental and human use factors
* Model corridors to aid jaguar movement between La Amistad International Peace Park and Corcovado National Park in Costa Rica

***Previous Term:*** 2019 Spring (GA) – Talamanca-Osa Ecological Forecasting

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Arizona Center for Nature Conservation – Phoenix Zoo** | Dr. Jan Schipper, Field Conservation Research Director | End User | Yes |
| **Osa Conservation** | Hilary Brumberg, Healthy Rivers Program Coordinator | End User | No |

***Decision-Making Practices & Policies:***

The Arizona Center for Nature Conservation – Phoenix Zoo is in a collaborative effort with Osa Conservation and other non-governmental organizations across Costa Rica, such as the National University of Costa Rica (UNA) and ProCAT, to establish a jaguar monitoring program called Camera Traps for Cats and Prey. The program uses images from these traps and additional ground survey data to monitor jaguar density and distribution. These data then inform conservation programs like the Payments for Ecosystem Services (PES) program that fiscally compensates farmers for adopting wildlife-friendly farming practices and converting farming and pastoral lands back to natural habitats. This program mitigates jaguar home range diminution by restoring vital habitats, but risk area identification and respective fund allocation are needed to increase effectiveness. Arizona Center for Nature Conservation officials have worked with NASA DEVELOP for one previous term and currently use the maps and analyses provided to assess historical trends in land use and land cover. They have used some imaging analysis, such as the manual interpretation of Landsat imagery, but they lack software and expertise to perform more advanced geospatial analyses and modeling. Osa Conservation has worked with NASA DEVELOP for three previous terms and uses the maps and data provided to target and monitor critical areas for watershed, coral reef, and riparian restoration.

***Project Benefit to End User:***

The Arizona Center for Nature Conservation will share these results with partners across Costa Rica, including local non-governmental organizations such as Las Alturas del Bosque Verde, Finca Bellavista, and ProCAT. Our partner organizations can use the forecasted land use and land cover classification and the human-jaguar conflict risk map to target optimal areas for corridor implementation connecting La Amistad and Corcovado National Parks. This strategic corridor placement can reduce human-jaguar conflict (especially in upland agricultural areas), reduce retaliatory hunting, and increase the possibility of genetic exchange across the region. Osa Conservation will use these maps in conjunction with the current land use land cover map from Term I of this project to further analyze the effectiveness of Forest Law 7575 of 1996, which protects forested lands and ecosystems. Riparian corridors act as crucial habitats for jaguars and are included under the protection of Forest Law 7575. The classifications of these watersheds will assist in the creation of initiatives for restoration and conservation.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Surface reflectance | 1987 and 1997 Landsat 5 Thematic Mapper (TM) surface reflectance data were used to evaluate changes in vegetation and land use. |
| **Landsat 8 OLI** | Surface reflectance | Landsat 8 Operational Land Imager (OLI) data were used to classify land use and land cover based on surface reflectance from 2013 through 2019. |
| **PlanetScope** | Surface reflectance | PlanetScope data provided high temporal (daily) and spatial resolution (3 m) imagery to verify classifications in targeted areas of agriculture and development. |
| **Terra ASTER** | Elevation | The Terra Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER) 2011 digital elevation model was used to calculate slope and elevation. |

***Ancillary Datasets:***

* 2008 and 2014 Digital Atlas of Costa Rica – Administrative boundaries, protected lands, roads, rivers, watersheds, population, and habitat fragments
* Japan Aerospace Exploration Agency Global ALOS 3D World – Global-scale elevation data to assist in corridor modeling
* MapCruzin – Shapefiles of points of interest, roads, and water to use as inputs for human-jaguar conflict risk areas and TerrSet Land Change Modeler
* Socioeconomic Data and Applications Center (SEDAC) Population Counts per Square Kilometer – Used to project population counts to 2030

***Modeling:***

* TerrSet Land Change Modeler, Clark Labs (POC: Dr. Sergio Bernardes, University of Georgia) – Used to forecast land use and land cover to 2030
* Linkage Mapper Version 2.0.0 (POC: Dr. Steve Padgett-Vasquez, University of Georgia) – Used to forecast land use and land cover data to model a potential jaguar corridor using least-cost path analysis

***Software & Scripting:***

* Esri ArcMap 10.7 – Image classification, modeling, and map creation
* Google Earth Engine API – Image processing, including image enhancement, gap filling, mosaicking, and classification

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Forecasted (2030) Land Use and Land Cover Classification Map** | Landsat 5 TM  Landsat 8 OLI  PlanetScope | The results of the land use and land cover data forecasted to  2030 was used to identify  areas that are at high risk for human-jaguar conflict as well as to locate optimal habitat fragment connections. Our product will assist partners in corridor implementation. | I |
| **Forecasted Human-Jaguar Conflict Risk Map** | Terra ASTER | These data can help our partners determine optimal areas for monitoring and education. | I |
| **Modeled Optimal Jaguar Corridors** | Terra ASTER | Partners can use the modeled corridors to prioritize locations for the implementation of a jaguar corridor. | I |

**Project Handoff Package**

***Transition Plan:*** Through Google Hangouts, a virtual handoff was conducted involving the Talamanca**-**Osa Ecological Forecasting II Team, the Arizona Center for Nature Conservation – Phoenix Zoo, and Osa Conservation. The DEVELOP team presented end products and methodologies to partners, and following the handoff meeting at the end of week 10, products were made available through Google Drive.

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***Handoff Package:***

* Project Summary
* Technical Paper
* Poster
* Presentation
* Project Video
* Forecasted (2030) Land Use and Land Cover Classification Map
* Forecasted Human-Jaguar Conflict Risk Map
* Modeled Optimal Jaguar Corridors
* Detailed methodology document

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