**NASA DEVELOP National Program**

**2019 Summer Project Proposal**

**Georgia – Athens**

**Talamanca-Osa Ecological Forecasting II**

*Modeling Optimal Biological Corridors Connecting Jaguar Populations in La Amistad and Corcovado National Parks in Costa Rica* *and Identifying at High Risk for Human-Jaguar Conflict*

**Project Overview**

***Project Synopsis*:** Researchers at the Arizona Center for Nature Conservation are working with organizations in Costa Rica to research, design, and implement a biological corridor connecting La Amistad International Peace Park in the Talamanca Mountains to Corcovado National Park on the Osa Peninsula. The proposed corridor would connect isolated jaguar populations in each park. Modeling optimal jaguar habitat requires current and forecasted land use/land cover classification maps assessing vegetation cover and crop types to identify areas of highest risk for human-jaguar conflict. The NASA DEVELOP Georgia – Athens Node, the Arizona Center for Nature Conservation, and Osa Conservation are collaborating to model both areas of current and possible future human-jaguar conflict and identify optimal corridors, which will, in turn, maximize jaguar movement between protected areas. Landsat 8 OLI, Terra ASTER, Sentinel-2 MSI and PlanetScope imagery will be used to develop land use/land cover classifications, characterize corridor terrain, and forecast agricultural expansion and development.

***Community Concern:*** Costa Rica contains 5% of the world’s biodiversity but deforestation for development and agriculture has led to habitat loss for many species. As a result, remaining habitats are broken up into smaller and more fragmented habitats that are disconnected from each other. This is especially a problem for species that need large home ranges, like the jaguar. Habitat loss and fragmentation has forced jaguars to move closer to human populations, therefore increasing conflict with humans. Poaching jaguars for trophy or retaliation against the animal for eating livestock is a serious threat. Increasing community engagement and awareness concerning the importance of jaguar conservation may, in turn, lead to a decrease in illegal poaching, hunting, and deforestation.

***Source of Project Idea:*** Osa Conservation shared the results of previous NASA DEVELOP projects with the Arizona Center for Nature Conservation who then reached out to the DEVELOP National Program Office. They were interested in partnering to extend land use and land cover analyses to include a biological corridor connecting jaguar populations in La Amistad International Peace Park with the shrinking Osa Peninsula jaguar population. They are interested in Earth observations as an efficient and effective method for assessing habitat condition and evaluating potential biological corridors.

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

***Study Location:*** Southern Puntarenas province of Costa Rica within the Osa, Golfito, Coto Brus, and Corredores districts

***Study Period:*** January 2018 – January 2019; Forecasting to 2030

***Advisors:*** Dr. Marguerite Madden (University of Georgia, Department of Geography), Dr. Steve Padgett-Vasquez (University of Georgia, Department of Geography)

**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; Annie Johnson, Field Conservation Research Assistant | End User | Yes |
| **Osa Conservation** | Dr. Andrew Whitworth, Science Director; Hilary Brumberg, Healthy Rivers Program Coordinator | End User | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***

*Arizona Center for Nature Conservation – Phoenix Zoo* – The Arizona Center for Nature Conservation is collaborating with Osa Conservation and ProCAT (Proyecto de Conservacion de Aguas y Tierras) to establish a jaguar monitoring program comprised of a network of camera traps across the study area. Currently, images from the camera traps, combined with ground surveys, are used to monitor jaguar population density and distribution.

*Osa Conservation* – Osa Conservation’s current monitoring of jaguar populations on the Osa Peninsula is through the Camera Traps for Cats and Prey project. Partnering with the Arizona Center for Nature Conservation, these two organizations have established one of the largest networks of camera traps in Central America. The goals of the Camera Traps for Cats and Prey project are to establish the population density and distribution of jaguars, abundance of prey in protected areas, and evaluate potential biological corridors on the Osa Peninsula.

***End User’s Capacity to Use NASA Earth Observations:***

*Arizona Center for Nature Conservation – Phoenix Zoo* – Scientists at the Arizona Center for Nature Conservation have used some basic remote sensing techniques, such as manual interpretation (i.e. tracing) of Landsat imagery, to map forest fragments as potential jaguar habitat. They do not have the required software, hardware, or expertise to perform more advanced image analysis and geospatial modeling for assessing trends in land use/land cover encroaching on jaguar habitat.

*Osa Conservation* – Osa Conservation has used Landsat imagery as a means of visually assessing the land cover for a variety of small projects but has not performed their own analysis. The organization has worked with NASA DEVELOP on three previous projects and has begun using the maps and water quality monitoring data tools provided by those projects. This project combines Earth observations with other spatial data to perform analyses and generate models that Osa Conservation can incorporate into their work to perform their own analysis.

***Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*Arizona Center for Nature Conservation – Phoenix Zoo* – The Arizona Center for Nature Conservation and Osa Conservation will share the project’s results with their numerous and varied partners across Costa Rica, including the local NGOs Las Alturas del Bosque Verde, Finca Bellavista, and ProCAT. The products of updated and forecasted land use/land cover classifications, suitable corridors, and optimal corridor models will be used in their collaborative efforts to establish a biological corridor connecting La Amistad and Corcovado National Parks and reduce human-jaguar conflict, especially in upland agriculture areas.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The Arizona Center for Nature Conservation and Osa Conservation teams are available for weekly phone conferences and monthly Skype video conferences to offer input and guidance to the project team. The Project Lead will serve as a point of contact for partner communications through the term.

***Transition Plan*:** The final hand off will be a training webinar hosted on WebEx. Attendees will be the DEVELOP team, Dr. Jan Schipper and Annie Johnson (Arizona Center for Nature Conservation), and Hilary Brumburg and Dr. Andrew Whitworth (Osa Conservation). End products will be handed off through Google Drive to Dr. Schipper and Dr. Whitworth, and they will share the products with the rest of Arizona Center for Nature Conservation and Osa Conservation staff and their partner organizations.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Surface Reflectance, Enhanced Vegetation Index (EVI) | Landsat 8 OLI data will be used to classify current land use/land cover and assess vegetation health based on surface reflectance and derived EVI. |
| **Terra ASTER** | Surface Reflectance, EVI, Elevation, Slope, Aspect | ASTER data will supplement Landsat 8 OLI data to increase opportunities for cloud-free imagery to classify land use/land cover and derived EVI in this tropical study site. ASTER-derived Global Digital Elevation Model Version 2 (GDEM V2) topographic information also will be used to model corridor paths. |
| **Sentinel-2 MSI** | Surface Reflectance, EVI | Sentinel data will supplement the Landsat and ASTER data (5-day revisit increases potential for gap filling cloud covered areas) and help in examining current land use/land cover and vegetation health. |
| **PlanetScope** | Surface Reflectance, EVI | PlanetScope data will provide high temporal (daily) and spatial resolution (3 m) imagery to examine details of current land use/land cover and verify the classification of ASTER, Landsat, and Sentinel-2 imagery in targeted areas of agriculture and development. |

***Ancillary Datasets:***

2014 Digital Atlas of Costa Rica – The Digital Atlas will be used to delineate administrative boundaries, protected lands, roads, rivers, and human settlements data for land classifications.

NASA DEVELOP 2018 Spring and Summer Term (Georgia – Athens) Osa Peninsula Water Resources I and II projects, land use/land cover datasets (1987, 1997 and 2017) – These data will be used for assessing land use/land cover trends to forecast changes from 2018 to 2030 in the Osa Peninsula. The same trends model will forecast land use/land cover, especially agriculture expansion, in the area extending to the Talamanca Mountains in the northern portion of the proposed jaguar corridor.

Arizona Center for Nature Conservation and Osa Conservation *in situ* camera trap data – These data will be used for ground verification of jaguar presence.

***Modeling:***

Clark Lab TerrSet Land Change Modeler (POC: Sergio Bernardes, University of Georgia)

CIRCUITSCAPE, Version 4.0 (POC: Steve Padgett-Vasquez, University of Georgia)

Linkage Mapper, Version 2.0.0 (POC: Steve Padgett-Vasquez, University of Georgia)

***Software & Scripting:***

Esri ArcGIS 10.6 – Image classification, modeling, and map creation

ArcGIS Pro 2.3 – Image classification, modeling, and map creation

Google Earth Engine API – Image processing, including image enhancement, gap filling, mosaicking, computing EVI, and classification

**Decision Support Tool & End Product Overview**

***End Products:***

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| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Forecasted (2030) Land Use and Land Cover Classification Maps** | The partners will use the results of the trend analysis and forecasted 2030 land use/land cover data to identify areas of expanding agriculture that have a high potential for human-jaguar conflict. These conflict areas will inform the corridor analysis. | Ancillary land use/land cover time series end products of the Osa Peninsula Water Resources I and II projects will be input into the TerrSet Land Change Modeler to identify trends that will be applied to the entire proposed biological corridor study area to forecast land use/land cover conditions to 2030. | N/A |
| **Forecasted Human-Jaguar Conflict Risk Maps** | Partners will use the integrated environmental and human use factors to identify future high-risk areas for human-jaguar conflict in order to prioritize optimal corridors and determine priority areas for monitoring and education. | PlanetScope data will be used to identify deforestation, agriculture, human settlements, roads, and other potential conflict factors in target areas within the proposed corridors. These features will be combined with the rate of agricultural expansion derived from historical land use trends. Rates applied to current land use in the potential corridor area will indicate areas of greatest potential for future (to 2030) human-jaguar conflict. | N/A |
| **Modeled Optimal Jaguar Corridors** | The partners will use modeled potential corridors to prioritize locations for optimal corridor establishment based on jaguar habitat suitability and human-jaguar conflict risk. | The land use/land cover and vegetation health end products will be integrated into CIRCUITSCAPE and Linkage Mapper for assessing model input parameters and initiating jaguar habitat suitability based on least cost analysis. Modeling potential jaguar corridors will be continued and optimized in the second term. | N/A |

***End-User Benefit*:** Partners will use the optimal biological corridor paths generated from current and extended land use/land cover analyses for educational and conservation efforts in the areas in and adjacent to the modeled biological corridor. This will allow partners to prioritize community engagement aimed at reducing retaliatory killing of jaguars and promotion of jaguar-friendly agricultural products. Primarily, the biological corridor will facilitate jaguar movement between protected lands, thereby maximizing the jaguar population while minimizing human-jaguar conflict.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2019 Spring to 2019 Summer

***Multi-Term Objectives:***

* **Term 1**: 2019 Spring (GA) – Talamanca-Osa Ecological Forecasting I
  + The first term of the project focused on extending the most current land use/land cover and EVI datasets (2017) from the previous 2018 Spring Osa Peninsula Water Resources I project from the northern boundary in the Osa Peninsula to the northern anchor of the proposed corridor in the La Amistad International Peace Park within the Talamanca Mountains. The land use/land cover trends identified using time series end products of the previous Osa Peninsula Water Resources projects was used to forecast future land use/land cover from current2017/2018 to 2030 conditions and assess risk for future human-jaguar conflict. These data, combined with additional datasets of terrain characteristics, were input into TERRSET modeling software to obtain an initial characterization of habitat suitability for jaguar corridors.

* **Term 2** **(Proposed Term)**: 2019 Summer (GA) – Talamanca-Osa Ecological Forecasting II
  + End products of the first term will be used to analyze land use pressure from forecasted agriculture and development and create a vulnerability risk map of human-jaguar conflict. These data are required by decision makers to identify optimal jaguar corridors and prioritize areas for environmental education and awareness efforts. These efforts hope to reduce retaliatory jaguar killing and target farmers for investing in jaguar-friendly agricultural products.

***Previous Terms:***

2019 Spring (GA) – Talamanca-Osa Ecological Forecasting I: Determining Habitat Suitability to Establish a Jaguar Corridor between the Talamanca Mountains and the Osa Peninsula in Costa Rica

***Related DEVELOP Work:***

2018 Spring (GA) – Osa Peninsula Water Resources I: Assessing Threats to River Water Quality and Mangrove Health Based on Watershed Land Use on the Osa Peninsula, Costa Rica

2018 Summer (GA) – Osa Peninsula Water Resources II: Utilizing NASA Earth observations to Evaluate Effects of Land Use Change on Watershed Health and Carbon Sequestration in the Osa Peninsula, Costa Rica

2018 Fall (GA) – Osa Peninsula Water Resources III: Evaluating Potential Sites for Coral Reef Restoration in the Golfo Dulce, Costa Rica Based on Turbidity and Sea Surface Temperature

**References:**

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