**NASA DEVELOP National Program**

**2019 Spring Project Proposal**

**Georgia – Athens**

**Talamanca-Osa Ecological Forecasting**

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

**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 in the lowlands on the Osa Peninsula. The proposed corridor would connect the existing jaguar populations in each park and provide a cohesive natural environment for animals to move through. In order to design the biological corridor, corridor modeling and current land use classification maps assessing vegetation cover and crop types are needed. NASA DEVELOP and the Arizona Center for Nature Conservation are collaborating to update and extend the current land use and land cover dataset created in previous DEVELOP projects, model areas of current and future human-jaguar conflict, and identify optimal corridors maximizing jaguar movement between protected areas. Landsat 8 OLI, Terra ASTER, Sentinel-2 MSI and PlanetScope imagery will be used to develop land use and land cover classifications, characterize corridor terrain, and forecast agricultural expansion and development.

***Community Concern:*** In Costa Rica, deforestation for towns, roads, and agriculture has led to habitat loss for many species in the biodiverse country. 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 areas to survive, like the jaguar. Habitat loss and fragmentation has led to limited habitat availability, forcing jaguars to move closer to human populations, which has increased conflict with humans. Poaching for trophy or retaliation against jaguars for eating livestock is a serious threat. Increasing community awareness of the importance of jaguar conservation may decrease 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 about extending 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 population.

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

***Study Location:*** Proposed wildlife corridor running between La Amistad International Peace Park in the Talamanca Mountains and Corcovado National Park in the lowlands on the Osa Peninsula in Costa Rica.

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

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

**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 |

***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 to establish a jaguar monitoring program in the proposed study area of Costa Rica comprised of a network of camera traps across the study area. Images from the camera traps combined with ground surveys are currently used to monitor jaguar population density and distribution. More efficient and effective methods to identify conservation needs of jaguars and their prey, assess habitat condition and evaluate potential biological corridors connecting the Osa Peninsula to the Talamanca Mountains.

***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 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, causing human-jaguar conflicts and restricting jaguar movement between conserved lands of Costa Rican national parks.

***Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*Arizona Center for Nature Conservation – Phoenix Zoo* – The Arizona Center for Nature Conservation will share their results with their numerous and varied partners across Costa Rica, including the local NGOs Osa Conservation, Las Alturas del Bosque Verde, Finca Bellavista and ProCAT. The products of updated land use and land cover classifications, suitable corridors, and optimal corridor models will be used in their collaborative efforts to establish a wildlife 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 team is 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 POC for partner communications through the term.

***Transition Plan*:** The final hand off will be a virtual WebEx meeting between the DEVELOP team, Dr. Jan Schipper, and Annie Johnson. End products will be handed off through Google Drive to Dr. Schipper and shared with the rest of Arizona Center for Nature 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 and 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 medium spatial resolution ASTER, Landsat and Sentinel-2 imagery, in targeted areas of agriculture and development. |

***Ancillary Datasets:***

2014 Digital Atlas of Costa Rica – 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 to 2030 in the Osa Peninsula. The same trends model will forecast land use/land cover, especially expansion of agriculture, in the area extending to the Talamanca Mountains in the northern portion of the proposed jaguar corridor.

Arizona Center for Nature Conservation *in situ* camera trap data – Ground verification of jaguar presence

***Modeling:***

TerraSet Land Change Modeler, Clark Labs (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 and ArcGIS Pro – 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** |
| **Current (2018-2019) EVI Analysis Maps** | The partners will use the results of the current (2018-2019) EVI analysis data and determined forest vegetation type and health as indicators of habitat suitability for jaguar corridors. | Landsat 8 OLI imagery, supplemented with Terra ASTER and Sentinel-2 MSI data as needed to fill cloud gaps, will be used to compute vegetation health indices using Google Earth Engine analysis functions. | I |
| **Current (2018-2019) Land Use and Land Cover Classification Maps** | The partners will use the results of the current (2018-2019) surface reflectance analysis data and determined land use/land cover as an indicator of habitat suitability and human-jaguar conflict risk for jaguar corridor analysis. | Landsat 8 OLI data, supplemented with ASTER, Sentinel-2 MSI and PlanetScope data as needed to fill cloud gaps, will be used to classify land use/land cover conditions in the proposed corridor using Google Earth Engine and ArcGIS analysis functions. | I |
| **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 with high risk for human-jaguar conflict. These conflict areas will inform the corridor analysis in the second term. | Ancillary land use/land cover time series end products of the Osa Peninsula Water Resources I and II projects will be input to TerraSet 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 |
| **Potential Jaguar Corridors** | The partners will use corridor model data to prioritize locations for 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 modeling. Modeling potential jaguar corridors will be continued and optimized in the second term. | N/A |

***End-User Benefit*:** Partners will use the generated current and extended land use/land cover analyses covering the potential corridor area between La Amistad and Corcovado Parks and the projected agricultural expansion and potential risk areas for human-jaguar conflict to prioritize optimal areas for conservation through the Payment for Ecosystem Services (PES). The ultimate benefit of establishing the corridor will be jaguar movement between protected lands and minimizing human-jaguar conflict.

**Project Timeline & Previous Related Work**

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

***Multi-Term Objectives:***

* **Term 1 (Proposed Term)**: 2019 Spring (Georgia – Athens) – Talamanca-Osa Ecological Forecasting I
  + The first term of the project will focus on extending the most current land use/land cover and EVI datasets (2017) from the previous 2018 Spring (Georgia – Athens) Osa Peninsula Water Resources I NASA DEVELOP project from its 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 will be used to forecast future land use/land cover from current (2018/2019) conditions to 2030 and assess risk for future human-jaguar conflict. These data, combined with additional datasets of terrain characteristics, will be input to exiting corridor modeling software to obtain initial characterization of habitat suitability for jaguar corridors.

* **Term 2**: 2019 Summer (Georgia – Athens) – 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 select areas for Payment for Ecosystem Services and protected conservation. The partners will focus environmental education and awareness efforts to reduce retaliatory jaguar killing and target farmers for investing in jaguar-friendly agricultural products.

***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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McRae, B. H., Dickson, B. G., Keitt, T. H., & Shah, V. B. (2008).Using circuit theory to model connectivity in ecology and conservation. *Ecology, 89*(10), 2712–2724. https://doi.org/10.1890/07-1861.1

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