**Costa Rica & Panama Ecological Forecasting II**

*Identifying Current and Future Areas of Environmental Concern in La Amistad International Park to Inform Resource Management*

**Project Team**

***Project Team:***

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***Advisors & Mentors:***

Dr. Marguerite Madden (University of Georgia, Department of Geography)

Dr. Sergio Bernardes (University of Georgia, Department of Geography)

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***Past or Other Contributors:***

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**Project Overview**

***Project Synopsis:***

The Meosamerican Biological Corridor connects the diverse ecosystems of Central America spanning from southern Mexico to Panama. Within this region exists 22 distinct ecosystems in need of conservation priority, including lowland rainforests and pine savannas. The team liaised with the Central American Integration System and utilized NASA Earth observations to address biodiversity concerns in southern Costa Rica and northern Panama. A Short-term Forest Change Tool and land use conflict maps were provided to the Ministry of Environment and Energy in Costa Rica and the National Environmental Authority in Panama.

***Abstract:***

Seven percent of all scientifically known life forms lie within the 202,230 square miles of Central America, making this area ecologically unique and increasing the need for environmental management. The Mesoamerican Biological Corridor forms a conservation partnership throughout Central America to establish a forested corridor of over 600 protected areas. Although conservation programs exist, deforestation still afflicts the area, putting strain on these diverse ecosystems. La Amistad International Park in southern Costa Rica and northern Panama in particular faces conflicting land use changes. Expanding agricultural development and urbanization, combined with concern over indigenous land rights, have raised questions about the implementation of sustainability goals and communication strategies within the region. To help address these issues, the NASA DEVELOP Costa Rica & Panama Ecological Forecasting II team continued a partnership with the Ministry of Environment and Energy in Costa Rica and the National Environmental Authority in Panama. The team created a Land Use Conflict Identification Strategy (LUCIS) model based on land cover maps for 2019 and 2029 that were created in term I using imagery from Landsat 8 Operational Land Imager (OLI). With partner input, the team applied weights to different objectives and combined suitability maps to identify areas of potential biodiversity conflict. Additionally, the team created a Short-term Forest Change (SFTC) Tool using Terra Moderate Resolution Imaging Spectroradiometer, Landsat 8 OLI, and Sentinel-2 Multispectral Instrument to help the partners identify areas of immediate, major forest changes. The LUCIS model indicated higher agricultural growth when compared to the ecological category.

***Keywords:***

land use land cover, Land Use Conflict Identification Strategy, conservation, SFTC Tool

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

***Study Location:*** La Amistad International Park in Costa Rica and Panama

***Study Period:*** January 2009 to December 2019, Forecasting to 2029

***Community Concerns:***

* Seven percent of all scientifically known life forms lie within the 202,230 square miles of Central America, making this area unique and increasing the need for environmental management.
* Despite the establishment of the Mesoamerican Biological Corridor, deforestation continues to plague the area and sustaining the corridor remains a challenge.
* Concern over indigenous land rights, agriculture and development expansion, and the pressure of financial and resource management is an ongoing issue.
* Countries within the corridor region have allocated resources for conservation and transboundary initiatives, but strategies for communication and conservation have not been concrete.

***Project Objectives:***

* Use NASA Earth observations to identify and forecast potential conflict areas in land conservation
* Produce Land Use Conflict Identification Strategy (LUCIS) maps that will provide partners with information on areas of immediate and future biodiversity concern
* Apply methods from Hansen Global Forest Change and past DEVELOP projects to create a Short-term Forest Change (SFTC) Tool that will allow partners to monitor major forest changes in the corridor

***Previous Term:*** 2019 Fall (GA) – Costa Rica & Panama Ecological Forecasting

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Ministerio de Ambiente y Energía, Centro Nacional de Información Geoambiental (Costa Rica)** | Rafael Monge Vargas, Director | End User | Yes |
| **Autoridad Nacional del Ambiente (Panama)** | Roney Samaniego, GIS Analyst | End User | Yes |

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

The Ministerio de Ambiente y Energía of Costa Rica (MINAE) federally promotes an environmental management system through institutional legislation for land use change governance. Many laws exist to drive conservation and sustainable development of forest plantations as well as primary and secondary forests. Biodiversity Law No. 7788 (May 27, 1998) specifically oversees the management of the ecologically rich biosphere in the La Amistad Caribe Conservation Area within the northernmost Costa Rican region of La Amistad International Park. Additionally, the Centro Nacional de Información Geoambiental (CENIGA) provides the necessary scientific and environmental knowledge for MINAE to amend laws through energy, environment, seas, and land management projects. The two units coordinate bilateral relations with the Autoridad Nacional del Ambiente of Panama based on the Cooperation for Crossborder Development ratified by Costa Rica in 1995 and Panama in 1994. Both parties use remote sensing and *in situ* observations to determine policies for the conservation, protection, and restoration of the environment. Biodiversity conservation and sustainability measures in Panama follow the Sustainable Production and Biodiversity Conservation Systems Project.

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

The ecological integrity of La Amistad International Park can be supported by providing MINAE and the Autoridad Nacional del Ambiente with the STFC Tool to monitor deforestation in conservation areas. The tool can identify changes in vegetation for a user-defined time period to help end users identify changes in forest cover. Additionally, the output maps from the LUCIS model will allow MINAE to better identify and predict conflict areas among different stakeholders, including indigenous peoples, and guide land conservation practices for immediate and future biodiversity protection. The Autoridad Nacional del Ambiente will enhance its management plan with improved land use and land cover maps.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Surface reflectance | Landsat 8 OLI imagery was used to calculate the Enhanced Vegetation Index and Normalized Difference Vegetation Index in the STFC Tool. |
| **Terra MODIS** | Vegetation indices | MODIS imagery and derived products were used to detect changes in greenness and provide greater temporal coverage within the STFC Tool |
| **Sentinel-2 MSI** | Surface reflectance | Sentinel-2 MSI aided in identifying changes in forest cover within the STFC Tool. |

***Ancillary Datasets:***

* Technological Institute of Costa Rica Digital Atlas – Collection of data involving geography of Costa Rica used to map regions of forests, protected areas, wild areas, etc.
* MINAE In-house Geospatial Server Data – Data supplied by MINAE included boundaries of legally-recognized regions of indigenous settlements, pineapple and banana palm plantations, and landslide and other natural hazard risk zones in Costa Rica used to locate areas of conflict
* Japan Aerospace Exploration Agency Advanced Land Observing Satellite Digital Surface Model – Topographic information used for accurately assigning classification cutoffs for land cover
* Open Geospatial Consortium Services of the National Territorial Information System – Information on political administrative divisions, river basins, and roads used in determining land features and areas within the park

***Modeling:***

* Land Use Conflict Identification Strategy (LUCIS) Model (POC: Austin Stone, University of Georgia) – Modeling connectivity between protected lands for strategic land use planning

***Software & Scripting:***

* Esri ArcMap 10.7 – Map creation and analysis
* QGIS 3.10.2 – Data download
* TerrSet 3.18 – Map creation and analysis
* Google Earth Engine API – Image processing, modeling

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Current Land Use Conflict Potential Map** | Landsat 8 OLI | The map provides a current assessment of land use vulnerabilities to assist partners in short-term decision making. It allows partners to target regions in need of conservation efforts. | N/A |
| **Forecasted Land Use Conflict Potential Map** | Landsat 8 OLI | The conflict potential map enables partners to identify future threats to land use and biodiversity to mitigate potentially harmful current development and agriculture plans. | N/A |
| **Short-term Forest Change (STFC) Tool** | Landsat 8 OLI  Terra MODIS  Sentinel-2 MSI | The tool processes monthly maps of forest change that permit partners to continue motoring areas with conservation priority. | IV |
| **STFC Tool Operating Procedures Manual** | N/A | The manual guides usage of the STFC Tool. | N/A |
| **La Amistad: Conserving a Friendship Between Borders Story Map** | N/A | The interactive map combines  multimedia in a bilingual narrative of the study site outlining the project and the importance of international conservation partnerships. | N/A |

**Project Handoff Package**

***Transition Plan:*** The team scheduled a WebEx handoff with partners for April 1st to summarize findings. During this presentation, the team gave a tutorial of the STFC Tool. At the conclusion of the term, all deliverables listed below in the Handoff Package section, excluding maps and the STFC Tool, were translated and put into NASA Export Control. Following NASA approval, the DEVELOP Georgia – Athens Lead, Shelby Ingram, sent all products to partners via email. After the handoff meeting, map products were emailed to partners and the STFC Tool was released once posted on the DEVELOP GitHub.

***Software Release Plan:*** The STFC Tool required Software Release Category IV. The team informed partners that they would not receive the tool until it has completed software release. The team made a final reminder of the nature of software release to the partners during the handoff meeting on April 1. For the interim period between the final handoff meeting and the release, the team supplied partners with an operating procedures guide, allowing partners to understand and use the tool upon its release.

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***Handoff Package:***

* STFC Tool Operating Procedures Manual
* Current Land Use Conflict Potential Map
* Forecasted Land Use Conflict Potential Map
* La Amistad: Conserving Friendship Between Borders Story Map
* Executive Summary
* Project Summary
* Technical Paper
* Poster
* Presentation

**References**

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