**Mesoamerica Ecological Forecasting**

*Assessing Land Cover Change Trends to Inform Management Planning for the Mesoamerican Biological Corridor*

**Project Team**

***Project Team:***

Hanna Jung (Deliverables Lead)

Ross Kalter (Technical Lead)

Amelia Untiedt

Cristina Villalobos-Heredia

***Advisors & Mentors:***

Betzy Hernández (NASA SERVIR Science Coordination Office)

Dr. Emil Cherrington (NASA SERVIR Science Coordination Office)

Lauren Carey (NASA SERVIR Science Coordination Office)

Africa Flores (NASA SERVIR Science Coordination Office)

Sylvia Wilson (USGS SilvaCarbon)

Dr. Robert Griffin (University of Alabama Huntsville)

Dr. Jeffrey Luvall (NASA Marshall Space Flight Center)

***Fellow:***

Brianne Kendall (Science Systems & Applications, Inc., Marshall Space Flight Center)

***Team Contact:*** Hanna Jung, hannatjung96@gmail.com

***Partner Contact:*** Jorge Cabrera, jcabrera@sica.int

**Project Overview**

***Project Synopsis:***

The Mesoamerican Biological Corridor (MBC) is a collaborative effort that defines natural corridors between approximately 600 protected areas and promotes ecological health and sustainable development in southern Mexico and Central America. The team partnered with NASA SERVIR and several Central American organizations to utilize NASA Earth observations to address intensifying deforestation within the MBC. Land Use Land Cover (LULC) trend maps and Deforestation Detection Timeseries Analysis maps were produced to visualize areas of forest cover change in the last three decades to assist partners with future land management and transboundary conservation efforts.

***Abstract:***

In 1992, Central America and Mexico drew up an agreement to establish the Mesoamerican Biological Corridor (MBC) which defines natural corridors to connect nearly 600 protected areas. The MBC is home to 9% of the world's terrestrial species on 0.7% of the world's landmass, yet this biodiverse area has been impacted by great levels of deforestation. The MBC supports protected areas and the important conservation efforts that are tied into the area’s economic and sustainable development. The NASA DEVELOP team partnered with NASA SERVIR, Sistema de la Integración Centroamericana (SICA), Tropical Agriculture Research and High Education Center (CATIE), and Ministries of the Environment for Costa Rica, El Salvador, and Guatemala to assess forest cover change in the MBC. While the southern states of Mexico are included in the MBC, the team excluded Mexico in this study. The team acquired data from Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), and Landsat 9 OLI-2 to develop a forest versus non-forest classification. This classification was used to create a Land Use Land Cover Change (LULC) trend map and Deforestation Detection Time Series analysis between 1992 and 2022. The team found that minimum distance classification was the most effective classifier for the project scope. Analysis showed that 6.18% of the study area experience forest loss and 10.99% experienced forest growth. These observations will help partners visualize the evolution and severity of deforestation and allow decision making for future land management and transboundary conservation efforts.

***Key Terms:***

Deforestation, land use change, Mesoamerican Biological Corridor, biodiversity, Landsat, remote sensing

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

***Study Location:*** Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama

***Study Period:*** January 1992 – January 2022

***Community Concerns:***

* The MBC forms a mega biodiversity hotspot with 200 distinct ecosystem classes and contains between 7-10% of all known life forms. Despite the establishment of the MBC, there are intensifying concerns of deforestation surrounding the protected areas both locally and regionally.
* Within these protected areas, almost all have human populations, in many cases indigenous inhabitants. Deforestation affects all the countries and indigenous communities that comprise the MBC, and international relationships must be maintained for proper management.
* The MBC is a transboundary initiative that works to reduce tensions and maintain relationships between countries which continues to be a challenge for the region.

***Project Objectives:***

* Classify Forest and Non-forest land cover in the MBC by using a Minimum Distance Classifier
* Identify forest cover change in the past thirty years by producing LULC trend map of 1992 and 2022
* Visualize deforestation at the regional level by generating deforestation time series analysis

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Sistema de la Integración Centroamericana (SICA)** | Jorge Cabrera, Technical Advisor |  End User |
| **Tropical Agriculture Research and High Education Center (CATIE)** | Juan Carlos Mendez, Deputy General Director; Pablo Ibach, Climate Action Unit Coordinator; Christian Brenes, Research Analyst | End User |
| **Ministry of the Environment & Energy (MINAE) of Costa Rica** | Rafael Monge, Director | End User |
| **Ministry of the Environment & Natural Resources (MARN) of El Salvador** | Giovanni Molina, Director | End User |
| **Ministry of the Environment & Natural Resources (MARN) of Guatemala** | Kenset Rosales, Director | End User |

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

All of the partners are familiar with remote sensing and NASA Earth observations methods and use them frequently. The Ministry of the Environment & Energy of Costa Rica, the Ministry of Environment & Natural Resources of El Salvador, and the Ministry of Environment & Natural Resources of Guatemala are all responsible for resource management and environmental protection in their own respective countries. Policies and laws created through these agencies are focused on the support and development of their own countries. SICA aims to create a harmonious development for all individuals of the Central American region. The policies and protocols of SICA are focused on the integration of the entire region, rather than a single country. The Tropical Agriculture Research and High Education Center (CATIE) also operates on a regional scale, promoting Green Development and sustainable well-being for all of Latin America and the Caribbean.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), surface reflectance, tasseled cap brightness, greenness, and wetness | NDVI, SAVI, surface reflectance, and tasseled cap brightness, greenness, and wetness will be used to analyze land cover change including deforestation. |
| **Landsat 7 ETM+** | NDVI, SAVI, surface reflectance, tasseled cap brightness, greenness, and wetness | NDVI, SAVI, surface reflectance, and tasseled cap brightness, greenness, and wetness will be used to analyze land cover change including deforestation. |
| **Landsat 8 OLI** | NDVI, SAVI, surface reflectance, tasseled cap brightness, greenness, and wetness | NDVI, SAVI, surface reflectance, and tasseled cap brightness, greenness, and wetness will be used to analyze land cover change including deforestation.  |
| **Landsat 9 OLI-2** | NDVI, SAVI, surface reflectance, tasseled cap brightness, greenness, and wetness | NDVI, SAVI, surface reflectance, and tasseled cap brightness, greenness, and wetness will be used to analyze land cover change including deforestation. |

***Ancillary Datasets:***

* Environmental Systems Research Institute (Esri) World Countries (Generalized) (January 2015) – Polygons of world countries for raster clipping
* United Nations Environment Programme (UNEP) World Database on Protected Areas – Polygons of protected areas for land use land cover change maps
* CATHALAC 2010 Land Cover Classification map provided by SERVIR – Map of 15 land cover classifications used as predictor image for classifier training
* Temporally harmonized annual Landsat mosaics for 1984-2022 at 100m spatial resolution provided by SERVIR - annual cloud-free mosaiced images designed by NASA SERVIR
* Map of indigenous communities of Central America provided by SERVIR – Polygons of indigenous communities for visual analysis of change detection map

***Software & Scripting:***

* Google Earth Engine JavaScript API – Landsat derived land classification
* Esri ArcGIS Pro 2.9.0 – Map creation and analysis
* Microsoft Excel V. 2108 – Chart generation

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Land Use Land Cover (LULC) Trend Maps** | Landsat 5 TMLandsat 7 ETM+Landsat 8 OLILandsat 9 OLI-2 | These maps will spatially demonstrate the forest cover vs. non-forest cover change in the region since the creation of the MBC, which can be used to inform decisions about future land management and transboundary conservation efforts. | N/A |
| **Deforestation Detection Timeseries Analysis** | Landsat 5 TMLandsat 7 ETM+Landsat 8 OLI | This analysis will provide insight to deforestation trends in the region from 1992-2022 and provide insight for future forest loss.  | N/A |
| **Methodology Tutorial** | Landsat 5 TMLandsat 7 ETM+Landsat 8 OLILandsat 9 OLI-2 | A robust methodology tutorial will be created for partners to replicate the team’s research methods for more detailed portions of the MBC. | N/A |

***Product Benefit to End User:***

The LULC trend maps will provide clarification through the holistic view of land cover change throughout the MBC in Central America. The LULC trend maps along with the time series analysis will help piece together issues concerning growing deforestation throughout regions of the MBC, allowing the partner organizations to find appropriate action to mitigate biodiversity loss and climate concerns. Partner organizations can enhance their management plan by considering, analyzing, and assembling relevant human disturbances as they relate to changes seen within these end products.

**References**

Bengtsson, Z.; Beaudry, B.; Torres-Pérez, J.; McCullum, A. (2021). Using Google Earth Engine for Land Monitoring Applications. *NASA Applied Remote Sensing Training Program (ARSET)*. <https://appliedsciences.nasa.gov/join-mission/training/english/arset-using-google-earth-engine-land-monitoring-applications>

Ray, D. K., Welch, R. M., Lawton, R. O., & Nair, U. S. (2006). Dry season clouds and rainfall in northern Central America: Implications for the Mesoamerican Biological Corridor. *Global and Planetary Change, 54*(1-2), 150-162. <https://doi.org/10.1016/j.gloplacha.2005.09.004>

Sze, J. S., Carrasco, L. R., Childs, D., & Edwards, D. P. (2022). Reduced deforestation and degradation in Indigenous Lands pan-tropically. *Nature Sustainability*, *5*(2), 123-130, Reduced deforestation and degradation in Indigenous Lands pan-tropically. <https://doi.org/10.1038/s41893-021-00815-2>