**NASA DEVELOP National Program**

**Spring 2016 Project Proposal**

**NASA Langley Research Center**

**El Salvador Ecological Forecasting II**

Utilizing NASA Earth Observations to Develop a Historical Baseline Trajectory of Changes in Forest Cover and Degradation Indicators in El Salvador

**Project Overview**

***Objective:*** To develop a methodology for stakeholders to determine long-term changes in forest cover and identify indicators of forest degradation in El Salvador’s pine-oak forest of La Montañona in order to develop baseline trajectories against which future monitoring and modeling of forest change can be compared.

***Community Concern:*** The area of La Mancomunidad La Montañona contains a culturally- and ecologically-important pine oak forest threatened by the encroachment of surrounding agricultural and pastoral activities that are largely managed through unsustainable slash and burn methods. Among other ecosystem services, the forest of La Montañona recharges numerous springs and rivers upon which the communities downstream rely as their only sources of water. Land planners are beginning to implement activities to promote conservation agriculture and protect forest resources, but there exist minimal information on where forest degradation due to agricultural expansion is most severe. An accurate and spatially explicit assessment of historical forest change is needed in order to monitor future achievements in reducing deforestation and forest degradation. At the national scale, there is an effort underway to implement a climate change adaptation and mitigation strategy. This includes undertaking a forest inventory and preparing a plan to reduce carbon emissions through reduced deforestation and degradation (e.g. REDD+) and through climate-smart agriculture. The proposed spatial assessment could enrich these current efforts and help the communities in La Mancomunidad to improve land use management.

***National Application Areas Addressed:*** Ecological Forecasting, Agriculture

***Study Location:*** La Mancomunidad La Montañona, Chalatenango, El Salvador

***Study Period:*** 1982 - 2015

***Advisor(s):*** Dr. Kenton Ross (NASA DEVELOP National Program)

**Partner Overview**

***Partner Organization(s):***

The Earth Institute, Columbia University (ABES Project) (Collaborator; POC: Dr. Sean Smukler, Assistant Professor; Sean Kearney, PhD student, University of British Columbia)

La Mancomunidad La Montañona, Chalatenango, El Salvador (End User; POC: Arnulfo Alberto, Director)

Ministerio de Medio Ambiente y Recursos Naturales (MARN), El Salvador (End-User, POC: Giovanni Molina, Geo-environmental information systems manager)

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

MARN works with the ABES Project who is currently using a combination of RapidEye and Quickbird satellite imagery along with field measurements of woody biomass to develop land use/land cover (LULC) maps and woody biomass estimates for the La Montañona region (~400 km2) for two individual years— 2012 and 2015. These maps will be used primarily to assess the impacts of the ABES Project agroforestry and silvopastoral interventions in the region. These interventions and analysis methods have been piloted in La Montañona with the aim of providing guidance for national scale approaches. At the national scale, MARN has acquired RapidEye data and is in the process of analyzing LiDAR but lacks ground data to calibrate such datasets for woody biomass. Developing a robust model to calibrate Landsat from RapidEye and potentially LiDAR using ABES ground data would enable an analyses of land use/land cover and woody biomass change and contribute substantially to MARN’s efforts to develop change trajectories and monitoring protocols required of REDD+.

***NASA Earth Observations Capacity:***

La Mancomunidad La Montañona, Chalatenango, El Salvador – Do not currently use Earth observations to determine LULC change or forest degradation.

Ministerio de Medio Ambiente y Recursos Naturales (MARN) – Do not currently use Earth observations to determine LULC change or forest degradation.

***Collaborator & Boundary Organization Support:***

The Earth Institute (EI), Columbia University (ABES Project) – The EI team has had direct and frequent contact with the office of La Mancomunidad and consulted with Arnulfo in order to identify priority analyses that could be achieved with NASA Earth observations. EI will act as an intermediary to incorporate analyses and decision support tools, created by DEVELOP, into tools and trainings already planned by EI through the ABES Project for early- to mid-2016.

***End-User Benefit:***

The office of La Mancomunidad will be initiating a four-year project in late 2015 to promote conservation management and plans to use historical change in land use/land cover and forest degradation as part of their criteria for prioritizing activity areas. The EI has also been in direct regular contact with MARN, both in person and via email. Giovanni has expressed interest in the final products and models proposed by this DEVELOP project. The hand-off of products/tools to MARN will come through one or more remote training sessions with the DEVELOP team, likely facilitated by EI and the ABES Project.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform** | **Sensor** | **Geophysical Parameter** |
| **Landsat 4,5,7, & 8** | TM, MSS, ETM+, OLI/TIRS | Land use/ land cover; vegetation Parameters |
| **RapidEye Constellation** | Jena-Optronik | Land use/land cover; vegetation parameters |
| **QuickBird** | BGIS 2000 | Land use/land cover; vegetation parameters |
| **WorldView-2** | Star trackers, solid state IRU, GPS | Land use/land cover; vegetation parameters |
| **LiDAR** | Unknown at this time | Vegetation metrics |
| **Aerial Imagery** | Unknown at this time | Land use/land cover (validation) |

***NASA Earth Observations Use:***

Landsat 4 – 8 MSS, TM, ETM+, OLI/TIRS: Used to determine land use/land cover change

***Ancillary Dataset(s):***

Field surveys; RapidEye (La Mancomunidad: 2012, 2014, 2015; El Salvador: 2010/11); QuickBird (December 2012); WorldView-2 (December 2015, expected); LiDAR (2014, possibly available); Airborne imagery (<1 m, 2014, possibly available)

***Models:***

TerrSet Land Change Modeler (POC: Chris Ferraro, DEVELOP Alumni)

**Decision Support Tool & End-Product Overview**

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| --- | --- | --- |
| **Proposed End Products** | **Decision to be Impacted** | **Current Partner Tool/Method** |
| Land Use/ Land Cover Time Series and Change Detection (~1982 – 2015) | Where to prioritize activities of projects promoting conservation management based on areas of deforestation, degradation, and agricultural/grazing encroachment on key forested areas | Visual observation and previous experience in the field. Currently no objective or remote-sensing based methods being used. The ABES team has plans to assess change from 2012 - 2015 |
| Woody Biomass Time Series and Change Detection (~1982 – 2015) | How to quantify a historical baseline of carbon stocks against which to compare future scenarios and monitoring | None for biomass before 2012. Tree cover change has been estimated from 2000 – 2012 using the globally available dataset from Hansen et al. 2013 |
| Calibration Model for Land Use/Land Cover Classification and Change Detection using Landsat Imagery | Where to prioritize future monitoring and intervention activities related to land use/cover change, especially with respect to forest management and smallholder agriculture | N/A |
| Calibration Model for Woody Biomass Mapping and Change Detection Using Landsat Imagery | How to quantify a historical baseline of carbon stocks and where to prioritize future monitoring and intervention activities related to deforestation, forest degradation and carbon storage through conservation management | N/A |

*Land Use/Cover Time Series and Change Detection (~1982 – 2015) –* Landsat 8 imagery will be used to develop a land use/cover classification map, calibrated for 2014 using a combination of ground observations, RapidEye imagery, and/or aerial imagery. A minimum of 6 classes will be identified: Mixed-Pine Forest, Broadleaf Forest, Cropland, Pasture/Grassland, Urban/Bare and Water. Classification maps will then be developed for 2012 and 2015 using the same calibration and validated using ground observations from those dates. Upon satisfactory performance, classification maps will be produced for as far back in time as imagery is available.

*Woody Biomass Time Series and Change Detection (~1982 – 2015)* – Landsat 8 imagery from 2014 will be calibrated to estimate woody biomass using a combination of ground surveys, RapidEye imagery and/or LiDAR. Predicted biomass maps will be developed for 2012 and 2015 and validated using ground observations from those dates. Upon satisfactory performance, woody biomass, and prediction uncertainty, will be predicted as far back in time as imagery is available.

*Calibration Model for Land Use/Cover Classification and Change Detection using Landsat Imagery* – A model will be developed which stakeholders—primarily MARN—can utilize to assess historical and future changes in land use/cover at the regional to national scale. Model development would include steps to account for imagery correction (e.g. atmospheric, geographic), classify land use/cover, detect change and validate results.

*Calibration Model for Woody Biomass Mapping and Change Detection using Landsat Imagery* – Same as the land use/cover model above, only for estimating woody biomass. Validation would include an estimation of prediction uncertainty.

***Previous Related DEVELOP Work:***

2015 Spring & Summer (Fort Collins) – Colorado Agriculture I & II: Mapping Forest Harvest History Using Landsat Imagery

2015 Summer (Marshall/Wise County) – Thailand Agriculture: Monitoring Land Cover Change and Crop Extent for Enriched Agricultural Land Management

***Software & Scripting:***

ERDAS IMAGINE – Land classifications

ArcGIS – Raster Manipulation/Analysis, Image Enhancement & Map Creation

TerrSet – Forecast modeling of change