

# NASA DEVELOP National Program Georgia – Athens

Project Summary – Spring 2018

#### **Osa Peninsula Water Resources**

Assessing Threats to River Water Quality and Mangrove Health Based on Watershed Land Use on the Osa Peninsula, Costa Rica

VPS Title: Water You Waiting For? Protecting Water Resources in the Osa Peninsula, Costa Rica

#### **Project Team**

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### Advisors & Mentors:

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### **Project Overview**

**Project Synopsis:** NASA DEVELOP and Osa Conservation are collaborating to assess the impacts of forestry laws and protected areas on changes in land use and other human activities affecting biodiversity, watershed health, and water quality in the Osa Peninsula of Costa Rica. A time series analysis of satellite imagery will reveal risk factors and patterns between public policy, land use change, deforestation, and erosion. Results and outreach materials from this project will further assist Osa Conservation in their efforts to educate the public, inform environmental policy decisions, and support the restoration of biodiversity in the Osa Region.

#### Abstract:

The Osa Peninsula, located in the southern region of Costa Rica's Pacific Coast, is one of the most biologically-diverse places on Earth and is a popular ecotourism destination. However, the area faces watershed degradation and loss of biodiversity due to deforestation, pollution from agriculture, and human settlement. NASA DEVELOP worked with Osa Conservation to analyze land use and land cover change in the Osa Peninsula to better understand threats to river water quality and mangrove health. This project used Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI), Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), to create a land cover time series map from 1987 to 2017. These time series data were used to compare land use over time, as well as patterns in water quality, mangrove health, erosion, and deforestation. The time series also helped to identify the impact of the creation of protected areas and the 1996 Forest Law 7575, which aimed to support reforestation and riparian health. Osa Conservation will use and distribute results to the National System of Conservation Areas (SINAC),

Ministry of Environment and Energy (MINAE), and local communities to inform land management decisions, policy enforcement, education and outreach initiatives, and watershed restoration and monitoring.

### Keywords:

Biodiversity, watershed health, river health, water quality, land use change, mangrove health, Landsat, ASTER, time series analysis.

# National Application Area(s) Addressed: Water Resources

*Study Location:* Area of Conservation Osa (ACOSA), Costa Rica: Osa Peninsula and Golifo with an emphasis on Esquinas, Rincon, Puerto Jimenez, Sierpe Humedal and Drake Bay

# Study Period: January 1987 – December 2017

# Community Concern:

- Costa Rican forest cover decreased from over 50% during the 1940s to 29% by 1986, meaning that Costa Rica had one of the highest deforestation rates in the world during the 1980s. In response to this, in 1996 the Costa Rican government introduced Forest Law 7575, which aims to support reforestation by protecting riparian zones and compensating landowners for conservation efforts. Understanding land use change patterns before and after the implementation of these policies will help Osa Conservation identify their effectiveness and how lands in area watersheds have been used. This knowledge will help provide information important for the development of environmental policy and public education.
- The principle reason for deforestation across Costa Rica is agriculture. Important monocultures that have replaced forests have been non-native palm oil, teak, and cattle pastures. Understanding the change in area used for each type of agriculture will help to determine the impact on water quality of rivers in the Osa Peninsula.
- The combination of land use change and agricultural practices have led to a decrease in biodiversity in the Osa Peninsula. This leads to a decrease in native species and less productive ecosystems. In addition, the local ecotourism economy of the Osa Peninsula will be negatively impacted if the current rate of biodiversity loss continues.
- Byproducts of agriculture and deforestation have decreased the river water quality in the Osa Peninsula. This ultimately has a negative impact on the many endemic and endangered species living in the region. There is now a growing need to discern which watersheds are at the highest risk of being affected by human activities. This will allow conservationists to better target educational programs, policy enforcement, and monitoring initiatives.
- Mangroves are integral to biodiversity and stability in the region's ecosystem and economy. It is vital to understand how land use in watersheds within Osa Peninsula impacts their health in order to better protect them. If links are found between mangrove health and water quality, this place further emphasis on the importance of watershed conservation efforts.

# Project Objectives:

- Produce high resolution time series maps of land use and land cover change in the Osa Peninsula between 1987-2017.
- Determine rates of land use change in riparian zones.
- Quantify the effectiveness of the 1996 Forest Law 7575 in curbing deforestation and erosion in riparian zones.
- Create accessible public outreach materials to inform the local community on how to implement sustainable practices.

### Partner Overview

Partner Organization:						
Organization	POC (Name, Position/Title)	Partner Type	Boundary Org?			
Osa Conservation	Hilary Brumberg, Watershed	End User	Yes			
	Conservation (Ríos Saludables)					
	Program Coordinator					

### Decision Making Practices & Policies:

The Osa Conservation Watershed Conservation program (Ríos Saludables) currently uses biological and chemical testing to monitor the river water quality across the Osa Peninsula. The data collected from these tests are compared with land use type through visual observations and maps created by the Iniciativa Osa y Golfito (INOGO) land use land cover (LULC) maps. These basic results assess the effects of human activity on river health and are used to inform targeted long-term water quality monitoring, community outreach, and education efforts. Osa Conservation is currently responsible for the conservation and restoration of multiple sites across the Osa Peninsula, including developing a case study of community-based riparian corridor restoration.

### Project Benefit to End User.

Osa Conservation has used Landsat imagery for a variety of small projects, but no analyses have been conducted. This project combines NASA Earth observations with other spatial data to perform analyses that will provide greater insight into the relationship between land use change and water quality on a greater temporal spectrum. One application of this analysis will be to gauge the effect that the 1996 Forest Law, which designated riparian corridors as protected land in Costa Rica, has had on riparian deforestation and reforestation. This will allow Osa Conservation and their collaborators to better understand how historical land cover changes have driven water quality degradation in the region. These insights will help improve land management decisions and more efficiently protect and restore watershed areas.

Earth Observations:		
Platform & Sensor	Parameter	Use
Landsat 5 TM	Land cover	Landsat 5 TM data were used to examine historical
		changes in land use and deforestation.
Landsat 8 OLI	Land cover	Landsat 8 OLI data were used to examine current
		land use and deforestation.
Terra ASTER	Elevation	Terra ASTER data were used to create a DEM of
		the study area.
		Data from PlanetScope were used to examine
PlanetScope	Land cover	recent land cover and also be used to validate the
		results of the Landsat 8 OLI.

#### Earth Observations & End Products Overview

#### Ancillary Datasets:

Atlas Digital de Costa Rica 2008 and 2014 – Aqueducts, aquifers, protected areas, watersheds, geology, geomorphology, habitats affected by climate change, wetlands, lagoons, precipitation, population, provinces, rivers –Inform land use classification

Stanford Iniciativa Osa y Golfito (INOGO) Mapas 2012 – Compare land use classifications from 2012 with Landsat imagery

# Software & Scripting:

ESRI ArcGIS 10.5 - Classification of Landsat and PlanetScope imagery and map creation

End Product(s)	Earth Observations Used	Partner Benefit & Use	Software Release Category
Land Cover Time	Landsat 5 TM	Landsat and PlanetScope data	N/A
Series	Landsat 8 OLI	will be used to identify	
	PlanetScope	locations that have undergone	
		major deforestation,	
		reforestation, and land use	
		change.	
		Elevation data will also be	
		used for visualization of land	
		use and deforestation.	
NDVI Analysis Map	Landsat 5 TM	NDVI maps from different	N/A
	Landsat 8 OLI	study periods (1987, 1999 and	
		2017) will be used to identify	
		vegetation	

# End Products:

### Project Handoff Package

### **Transition Plan:**

The Osa Peninsula Water Resources team will host a virtual hand-off event with the project partners to present findings and share end products. The team will also provide the partners with a package that includes all the deliverables from this term and discuss any questions about the project or planning for future terms.

*Project Continuation Plan*: Based on partner consultation and feedback, the next term will pursue the following objectives:

- Define and integrate environmental and social factors to produce watershed health and water quality risk maps
- Identify areas of mangrove deforestation and mangrove species at risk, produce mangrove health maps, and combine local water quality data to assess whether watershed land use and river water quality affect mangrove health

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### Handoff Package:

- Land Cover Time Series Map
- NDVI Analysis Map
- Final Deliverables
- Project Video

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