**NASA DEVELOP National Program**

 USGS at Colorado State University - Fort Collins, CO

**Summer 2015**

**Short Title: Ethiopia Ecological Forecasting**

**Subtitle:** Mapping Fire History for Habitat Conservation in Ethiopia's Bale Mountains Using a Time Series of Landsat Data

**VPS Title:** Mapping Fire History in Ethiopia with a 42-Year Landsat Time Series

**Project Team & Partners**

**Project Team:**

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**Advisors & Mentors:**

Paul Evangelista (Natural Resource Ecology Laboratory, Colorado State University)

**Partner Organizations**

The Murulle Foundation, End-User & Boundary Organization, POC: Nicholas Young

Colorado State University, Natural Resource Ecology Laboratory, Collaborator & End-User, POC: Nicholas Young

**Project Details**

**Applied Sciences National Applications Addressed:** Ecological Forecasting, Disasters

**Study Area:** South-central Ethiopia, including the Bale-Arsi massif and surrounding lowlands (WRS1 Landsat Scene Path 180, Row 55; WRS2 Landsat Scene Path 167, Row 55)

**Study Period:** 1973-2015

**Earth Observations & Parameters**

Landsat 8, Operational Land Imager (OLI) - Burned area

Landsat 7, Enhanced Thematic Mapper (ETM+) - Burned area

Landsat 5, Thematic Mapper (TM) - Burned area

Landsat 5, Multispectral Scanner (MSS) - Burned area

Landsat 3, Multispectral Scanner (MSS) - Burned area

Landsat 1, Multispectral Scanner (MSS) - Burned area

Aqua/Terra, Moderate Resolution Imaging Spectroradiometer (MODIS) - Burned area product

Space Shuttle, Shuttle Radar Topography Mission (SRTM) - Elevation

**Ancillary Datasets Utilized**

* Natural Resource Ecology Laboratory - Geotiff of Mountain Nyala habitat
* The Murulle Foundation – Esri shapefile of Bale Mountains National Park boundary
* Published literature and reports – Point locations of fire dates and occurrences

**Models Utilized**

* Laboratory for Applications of Remote Sensing in Ecology, Oregon State University LandsatLinkr package
* Laboratory for Applications of Remote Sensing in Ecology, Oregon State University LandTrendr model

**Software Utilized**

ArcGIS - Raster processing, Tasseled Cap transformation for Landsat 8 OLI data, analysis of polygons from the MODIS burned area product, creating maps of burned areas

IDL and ENVI - Interface for LandTrendr model, raster processing

R and RStudio - Interface for the LandsatLinkr package, graphing

**Project Overview**

**80-100 Word Objectives Overview**

Ethiopian pastoralists have a long history of managing high-elevation shrublands with intentional burning, but these fires may lead to unintended consequences, such as reduced habitat for the endangered Mountain Nyala. We quantified fire distribution in Ericaceuos shrublands of the Bale-Arsi massif, Ethiopia, mapping burned areas over 42 years (1973-2015) using Landsat Multispectral Scanner, Thematic Mapper, Enhanced Thematic Mapper, and Operational Land Imager data, as well as the Moderate Resolution Imaging Spectroradiometer Burned Area product. Our findings improved the understanding of past fire extent, which will inform future conservation efforts by The Murulle Foundation and its partners in Ethiopia.

**Abstract**

The Bale-Arsi massif of south-central Ethiopia comprises one of the largest and least studied mountain systems in Africa. An internationally recognized biodiversity hotspot, the region is home to Bale Mountains National Park and the Sanetti Plateau, which provide critical alpine habitat for numerous endemic and endangered species such as the Mountain Nyala. Ethiopian agro-pastoralists in the region practice intentional burning to clear land for grazing and planting; however, pressures related to climate change and increasing populations have made understanding the frequency and extent of burning a top data need for conservationists and park managers seeking to balance conservation goals with the needs of local communities. We quantified historical fire occurrence and extent in the unique, high-altitude Ericaceous shrublands of Bale, using 42 years (1973-2015) of Landsat data. Multispectral images were spatially and spectrally linked within the LandsatLinkr R package, masked for clouds using a 30 m Shuttle Radar Topography Mission (SRTM) digital elevation model, and subsequently analyzed using the LandTrendr disturbance algorithm. The resulting fire extents were validated using the Moderate Resolution Imaging Spectroradiometer (MODIS) Burned Area product, as well as ancillary field records compiled from the literature. Maps and spatial data of fire date and extent were disseminated to project partners working in Bale. These will enable targeted conservation efforts in the park, and inform management approaches that ensure the preservation of the region's natural resources and the social-ecological systems they support.

**Community Concerns**

* Pastoralists in the south-central Ethiopian highlands have a long history of burning Ericaceous shrublands to improve their livelihoods; burning shrubs increases grazing value, controls toxic caterpillars, and reduces predator attacks on livestock.
* Natural and intentional burning of Afro-alpine grasslands and Ericaceous heath shrublands in the Bale-Arsi massif may reduce the critical habitat of the endangered Mountain Nyala and increase soil erosion.
* Cessation of intentional burning is expected to allow shrubs to replace Afro-alpine grasslands, to grow out of reach of pastoralists’ cattle, and to create high fuel loads susceptible to much larger, high-intensity fires when they do eventually burn.
* Previous efforts to establish conservation areas in the Bale Mountains have had limited and varying success, and limited data availability for fire history in the Bale Mountains impedes future fire management planning.

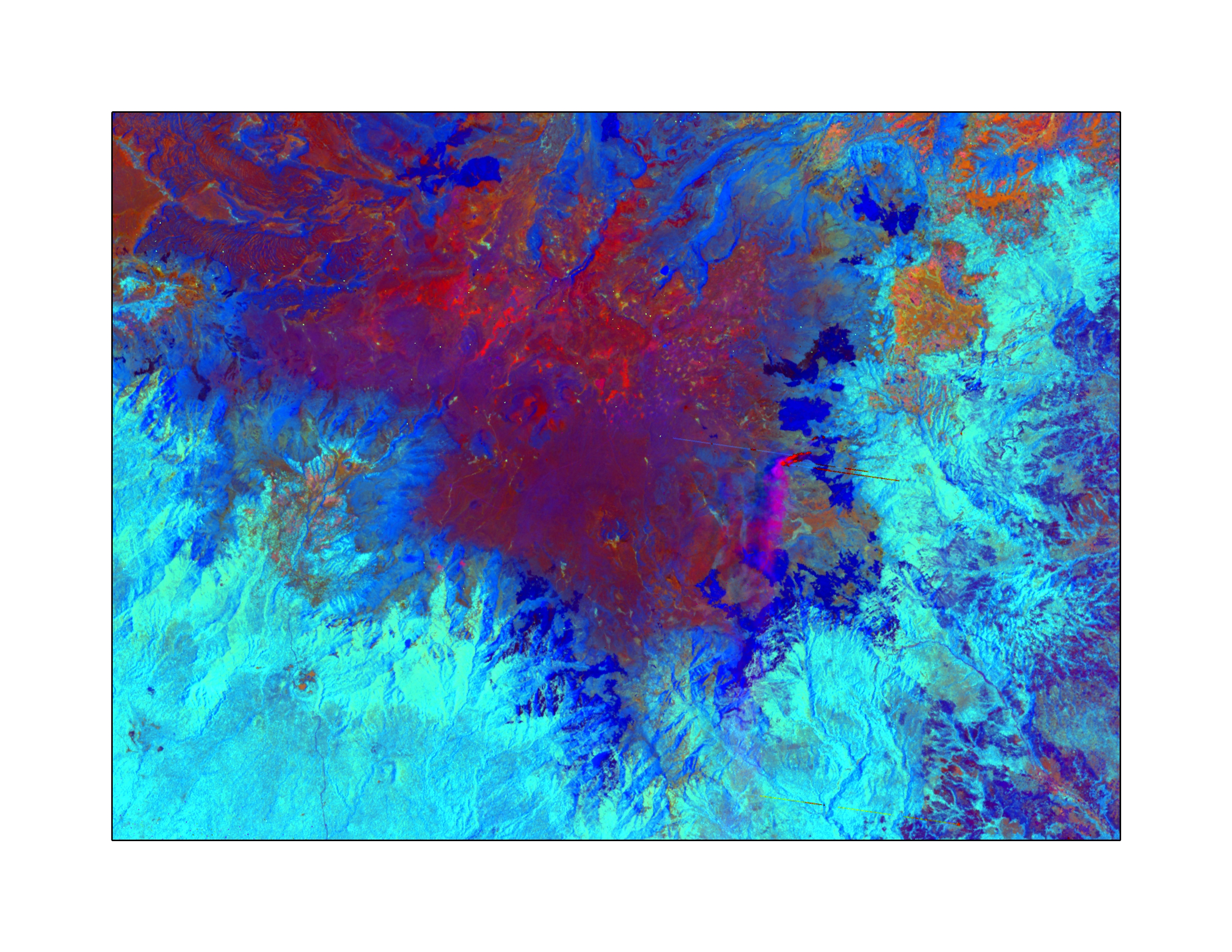
**Current Management Practices & Policies**

As a 501(c)(3) non-profit, The Murulle Foundation (TMF) focuses on fostering participatory grassroots projects that build enduring coexistence of people and ecosystems. TMF has worked with multiple land management organizations in Ethiopia, including the Ethiopian Wildlife Conservation Authority, the Ethiopian Ministry of Environment and Forest, and the Frankfurt Zoological Society. The Murulle Foundation has used Landsat data for basic land cover mapping in the past, but it is currently relying on limited field observations of fires in highland shrub ecosystems.

**Decision Support Tools & Benefits**

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| **End-Product** | **Earth Observations Used** | **Benefit & Impact** |
| Fire frequency and extent map | Landsat 1, 3 MSS, Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, MODIS Burned Area Product, SRTM DEM | Focus management of Ericaceous shrublands based on fire history, and inform Mountain Nyala habitat suitability modeling |
| LandsatLinkr and LandTrendr tutorials | Landsat 1, 3 MSS, Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, SRTM DEM | Tutorial on how to use LandTrendr with MSS data, as well as how to use LandsatLinkr and LandTrendr for a study area outside of North America, both of which are nover, reproducible applications of these tools |

**Project Imagery**

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**Caption:** 3-band tasseled cap composite of Landsat TM scene (03/09/2000) of the Bale Mountains. Burned areas (dark blue) and smoke (pink) are visible near image center. Image Credit: Ethiopia Ecological Forecasting Team.

**Image:** Bale\_fire\_2000.jpg