Ethiopia Ecological Forecasting

Mapping Four Decades of Fire History for Targeted Conservation in the South-Central Highlands of Ethiopia

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Community Concerns

- **Positive** effects of intentional burning on social-ecological system functioning
- **Negative** effects of increased fires on wildlife habitat and soil erosion
- **Negative** consequences of forced burning cessation

- **Efficacy** of past and future conservation efforts
- **Limited** capacity and data availability
Objectives

- **Quantify** fire extent and distribution on the Bale-Arsi massif over a 42-year time period
- **Provide** land managers with the most current and complete record of fires in the region
- **Compare** patterns of burning to observed land changes
- **Demonstrate** a reproducible methodology

Image Credits: Stephen Chignell
Methodology
Data Acquisition
- MSS, SRTM
- TM, ETM+
- OLI
- MODIS burned area

Data Processing
- LandsatLinkr
- Gap-filling & Normalized Burn Ratio
- Aggregation

Analysis
- Tasseled Cap Compositing
- Thresholding
- Landsat Validation

Results
- Time Series Visualization
- Fire extent
- Burn Frequency
- Land Cover Assessment
Earth Observations

- Terra/Aqua
  MODIS

- Shuttle Radar Topography Mission (SRTM)

- Landsat 1, 3
  Multispectral Scanner (MSS)

- Landsat 5
  Thematic Mapper (TM)

- Landsat 7
  Enhanced Thematic Mapper (ETM+)

- Landsat 8
  Operational Land Imager (OLI)
Data Acquisition & Pre-processing

- Landsat imagery
- Atmospheric correction
- Cloud mask
- Georegistration
- Spectral calibration

Graph showing the number of images per year for different Landsat satellites.
Tasseled cap visualization (1973-2015)

Brightness + Greenness + Wetness
Burned area mapping (1995-2015)
Gap-filling burned areas
Detecting burned areas with clouds
Post-processing

- **Aggregate** burned areas within each year
- **Clip** to areas higher than 3000 m
- **Sieve** out burned areas < 1 hectare (11 pixels) to eliminate noise
- **Remove** erroneous burned areas detected on Tulu Deemtu
Results
Time series visualization
**Landsat & MODIS spatial extents**

- Landsat NBR: 274 km²
- MCD45A1: 260 km²
- MCD64A1: 222 km²

Additional note:
- MODIS MCD45A1: Potential burned area covered by clouds (86 km²)
Landsat and MODIS time series
Spatial patterns of burning

(Photo credits: Johansson et al. 2012 Ecology and Society)
Vegetation types burned

- Erica shrub: 71.6%
- Alpine shrub: 14.7%
- Grasslands: 3.7%
- Herbaceous: 6.3%
- Deciduous: 0.5%
- Sparse veg.: 3.0%
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Ericaceous shrub burned

Bale Mountains National Park

- Green: Erica shrubland
- Red: Burned inside park
- Blue: Burned outside park
Wildlife habitat burned

- Mountain nyala
- Ethiopian wolf

Habitat area (km²)

- Burned
- Unburned

Image Credits: Paul Evangelista
Discussion
Errors and uncertainties

- Gaps in the Landsat record for the region.
- Scan line interpolation.
- Potentially omitted fires due to cloud cover.
Conclusions

- **35% of ericaceous vegetation burned** in the Bale Mountains between 1995-2015, but **few areas experienced repeated fires**.

- **LandsatLinkr expedites pre-processing**, but data gaps and cloud cover remain challenging for time series analysis in remote, tropical alpine regions.

- **Final products for partners:**
  - Spectrally comparable and composited tasseled cap time series (1973-2015)
Future work

Density analyses

Galama Mountains

Sentinel 2 data

Incorporate field data
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