Ethiopia Water Resources

Application of Landsat 8 Imagery and Statistical Models for Mapping Critical Headwater Wetlands of Ethiopia

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Abstract

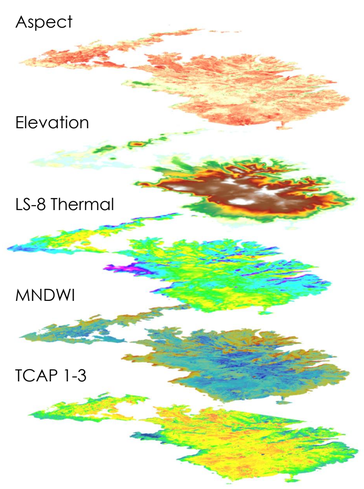
The Bale Mountains of south-central Ethiopia comprise one of Africa's least-studied massifs, and are home to the world-renowned Bale Mountain National Park. A designated Biodiversity Hotspot, the area also serves as the headwaters for five major rivers that flow out of the mountains, supporting 12 million people in the arid lowlands to the east. In recent years, development in the surrounding area has forced many agro-pastoralists into the highlands, and approximately 40,000 people now live within the park boundaries. Mapping the location and extent of the region's water resources has been identified as a key research need for local park officials and conservation groups as they work to sustainably accommodate this massive influx of people and livestock. Of particular concern are the region's numerous alpine lakes and wetlands, as they are essential for wildlife habitat, water quality, and discharge timing for both upstream and downstream users throughout the dry season. This study used environmental indices derived from Landsat 8 Operational Land Imager/Thermal Infrared data, topographic variables, and species distribution models to map all perennial alpine lakes and wetlands in the Bale Mountains. Resulting models of wetlands and lakes had classification accuracies of 97% and 100%, respectively. These represent the first comprehensive maps of their kind in Bale, and will facilitate the targeting of conservation and research efforts in the region. Additionally, the methodology is applicable in other remote areas around the world where field data is sparse and regular monitoring is needed.

Objectives

- Generate the first maps of all perennial alpine lakes and wetlands in one of East Africa's most important headwater regions
- Explore the utility of Landsat 8, topographic variables, and Maximum Entropy modeling for wetland mapping
- Test the efficacy of using Google Earth as a substitute for field-collected training data

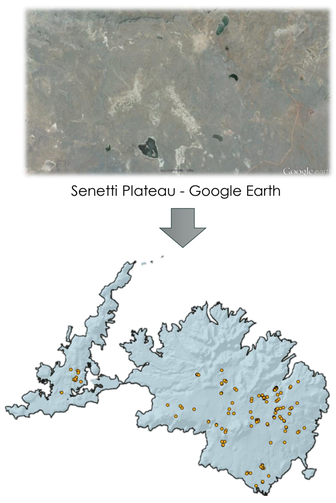
Methodology

Data Processing



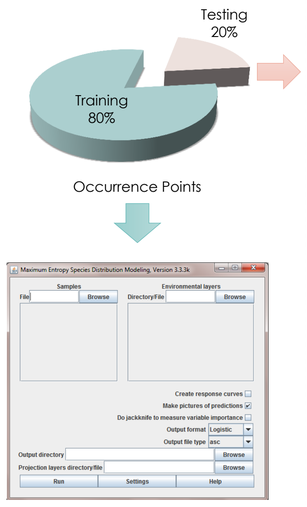
1. Landsat 8 OLI/TIRS imagery (January 2014) and an SRTM elevation model were used to calculate environmental indices related to wetlands. These would serve as predictor variables in the eventual models.

Point Generation



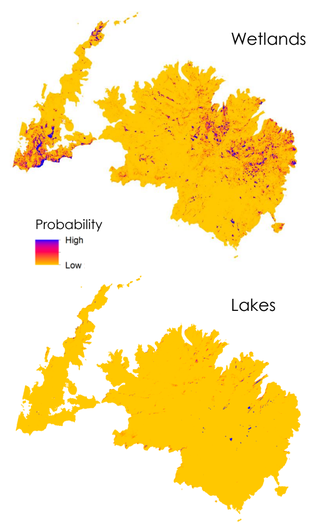
2. Google Earth imagery (Dec & Jan 2014) was used to mark occurrences of alpine wetlands and lakes. This time period represents the dry season, which ensured only perennial wetlands were mapped. Values of predictor variables were then extracted at each point.

Maximum Entropy Modeling



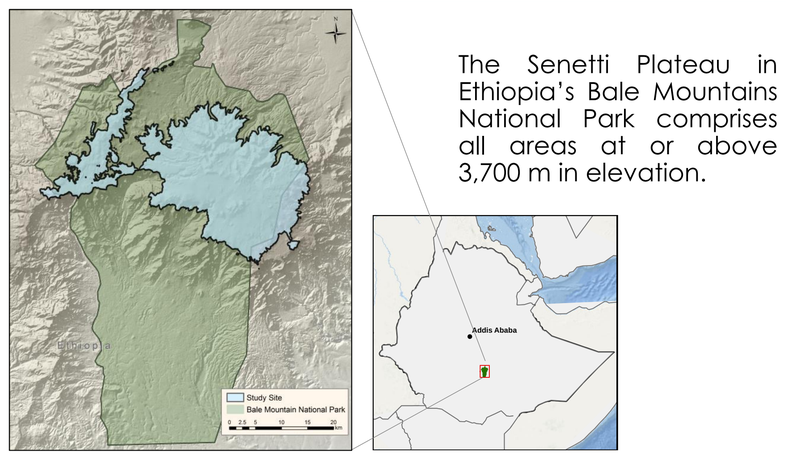
3. Points were split into testing and training groups. Highly correlated predictors were removed and two MaxEnt models were run: one for vegetated wetlands and the other for lakes.

Model Output



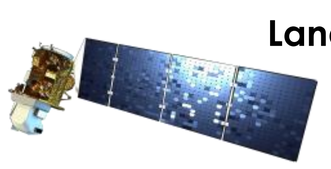
4. Probability layers of predicted presence of wetlands and lakes. Validated using 20% withheld test points. Thresholds applied to produce binary presence/absence maps.

Study Area



The Senetti Plateau in Ethiopia's Bale Mountains National Park comprises all areas at or above 3,700 m in elevation.

Earth Observations



Landsat 8

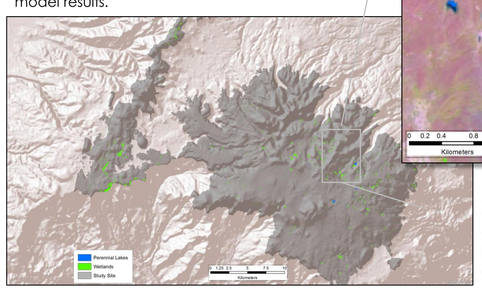
SRTM

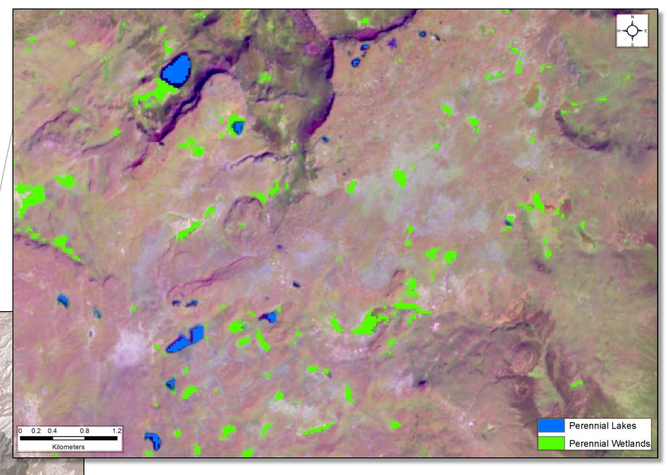
Results

Results show more than 20 perennial lakes on Senetti plateau (total area of 0.27 km^2) and over 40 vegetated wetland regions (total area of 4.82 km^2).

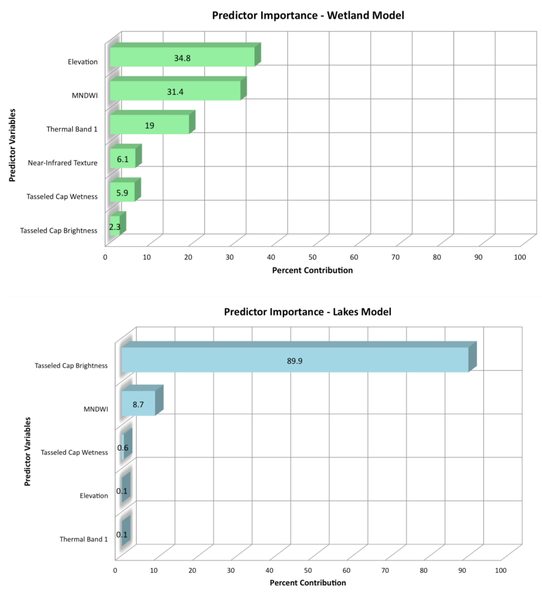
Accuracy Metric	Wetlands	Lakes
% Correctly Classified	97 %	100 %
Area Under The Curve	0.99	1.0
Kappa	0.97	1.0
Sensitivity	1.0	1.0
Specificity	0.97	1.0

Above: Accuracy statistics for each model, produced using the 20 % withheld test points.
Below: Regional view of Senetti Plateau and all model results.





Above: Fine-scale view of model results superimposing false-color Landsat 8 scene. MaxEnt able to distinguish between water and shadows, as well as capture small, isolated wetlands.

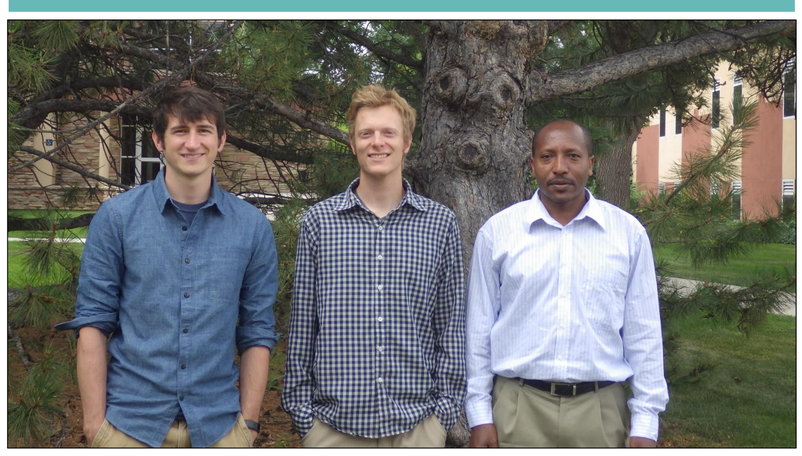


Right & Above-Right: Relative importance of predictors to each model. Wetlands model used a variety of variables while lakes model relied heavily on TCAP Brightness.

Conclusions

- Numerous previously unmapped wetlands and lakes persist on the Senetti Plateau throughout the dry season.
- New technique is robust and able to distinguish water from shadows, as well as identify small, isolated wetland features.
- Google Earth can serve as an adequate surrogate for model training when field-collected points are unavailable.
- Straightforward, reproducible methodology can be used for future monitoring and change assessment.

Team Members



L to R: Ryan Anderson, Stephen Chignell, Tewodros Wakie

Project Partners

- The Murulle Foundation
- Geospatial Centroid at Colorado State University
- USGS Fort Collins Science Center

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