THE IMPACT OF LAND USE CHANGE ON THE 3-D STRUCTURE OF SHRUBLAND AND DRYLAND SAVANNA ECOSYSTEMS

WASHINGTON-ALLEN, Robert A. (1); LOUHAICHI, Mounir (2); MUDE, Andrew (3); LIAO, Chuan (4); CLIFTON, Kathryn M. (2); CLARK, Patrick E. (5)

1: Department of Geography, University of Tennessee, 304 Burchfiel Bldg, Knoxville, TN 37996,USA; 2: CGIAR/ICARDA, P.O. Box 950764, Amman,11195, Jordan; 3: CGIAR/ILRI, P.O. Box 30709, Nairobi, Kenya; 4: Department of Natural Resources, Cornell University, 309 Fernow Hall, Ithaca, NY 14853, USA; 5: United States Department of Agriculture, Agricultural Research Service, Northwest Watershed Research Center, 800 E. Park Blvd., Suite 105, Boise, ID 83712, USA

M.Louhaichi@cgiar.org

Rationale

Drylands cover 41% of the terrestrial land surface and provide $1 trillion in ecosystem goods and services to 36% of the global population. However the degree of Dryland degradation is largely unknown, particularly the impacts to carbon stocks such as livestock forage from droughts and land use practices. Subsistence pastoral societies are particularly vulnerable due to interactions between livestock and carbon stocks where drought induced reduction of carbon stocks may result in widespread livestock mortality, then famine, and thus human mortality. Newly implemented livestock insurance programs in northern Kenya and southern Ethiopia may provide avenues for stock replenishment and thus renewal of livelihoods in global Drylands. However, robust indicators of livestock mortality due to drought-induced forage loss are required. Terrestrial laser scanning (TLS) or ground light detection-and-ranging (LIDAR) is a remote sensing technology that has been successfully used in Dryland ecosystems to assess changes in the three-dimensional (3D) structure of soil and vegetation, including soil sediment loads and vegetation biomass (Olsoy et al., 2014a, b), that are diagnostic of impacts from grazing, drought, fire (Delgado et al. 2012), and wind and water erosion (Li et al. 2010). Consequently, local scale TLS linked to regional scale satellite imagery may provide an indicator of critical forage loss due to drought.

Methods used and partnership set up

The University of Tennessee's Dept. of Geography in collaboration with ICARDA, ILRI, USDA-ARS, and Cornell University's Dept. of Natural Resources collected TLS data in the cold desert shrub-steppe ecosystem of the East Bank Plateau of Amman, Jordan and in mixed *Acacia-Commiphora* woodlands of Borana Plateau in southern Ethiopia. ICARDA and ILRI maintain these research sites and conduct field studies in Jordan and Ethiopia, respectively. The study plots are the size of a Landsat pixel (30-m X 30-m) to link local scale TLS to regional scale satellite imagery. A paired-plot: shrubland restoration versus cropping, and livestock grazing was conducted in Jordan and 3-levels of livestock grazing, i.e., high, moderate, and no livestock grazing (a conservation fodder bank) were compared in 4 different villages in southern Ethiopia. We used a FARO Focus 3D X330 with built in GPS, a high resolution digital camera, and a 905-nm scanning laser at approximately 1 million points s^{-1} at 7-mm spacing per 10-m range over a 650-m radius through 360° in the horizontal plane and 300° in the vertical. This scan spacing resulted in 28 million total points per scan. Each scan has a range accuracy of ± 2-mm with a spot size of 4.5-mm diameter. Four cardinal direction and 1 plot center scan were taken per site for a total of 10 scans from the paired plots and 61 scans from the villages.. Vegetation structure, including height, volume, crown and basal area, diameter-at-breast height (dbh) ,canopy cover, leaf area index (LAI), & plant density and soil structure, including topography can be directly measured using TLS. Biomass and sediment loss, i.e., soil erosion are indirectly estimated using allometric equations that use height. A Kolmogorov–Smirnov (K-S) tests was conducted on the height diversity histograms of the vegetation point clouds at each site, which is representative of the foliage profile, to test the null hypothesis that different land uses do not impact land cover.

Results

Volumetrically, the cold desert shrub steppe of Jordan intercepted 14% of the 28 million points emitted. The mixed *Acacia-Commiphora* woodlands intercepted 36% of the points, suggesting that there is greater leaf area or biomass in the savanna ecosystems than in the shrublands. K-S tests indicated significant differences in vegetation height diversity between the study sites in Jordan (open access = one-level canopy and lower height compared to restored site = two-level canopy and greater height) and Ethiopia (fodder banks > height than moderate and high intensity grazing sites, Figure 1). Shrubs covered < 5% on the grazed/cropping open access site and < 30% on the restored site in Jordan. Additionally, the restored site showed greater surface roughness than the open access site that is indicative of the action of wind and water erosion.

Outcomes

This research has quantified the impact of different land uses on forage availability or changes in carbon stocks that are relevant to subsistence pastoralists. Such information can inform agro-ecological models and can be linked to broader implications for management decisions. The development of sound policy is dependent on improved information for management decisions. This research will also assist future work in arid lands by determining the best indicator and methods for vegetation measurements with ground and airborne LiDAR systems in Drylands. With this information other Dryland sites will be scanned and their ecological and degradation status will be determined.

Acknowledgements

This research was supported by the University of Tennessee, Department of Geography, the International Center for Agricultural Research in the Dry Areas (ICARDA), the CGIAR Research Program on Dryland Agricultural Production Systems (CRP DS), and the International Livestock Research Institute (ILRI).