Linking Land Degradation & Agricultural Productivity in sub-Saharan Africa

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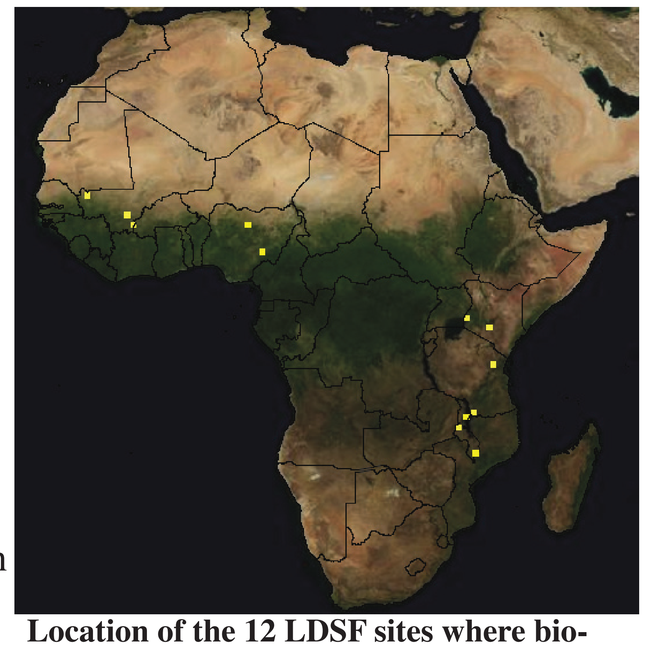
Objective

To conduct landscape-scale assessments of ecological health to identify key constraints to agricultural productivity at sentinel sites across sub-Saharan Africa.

Background

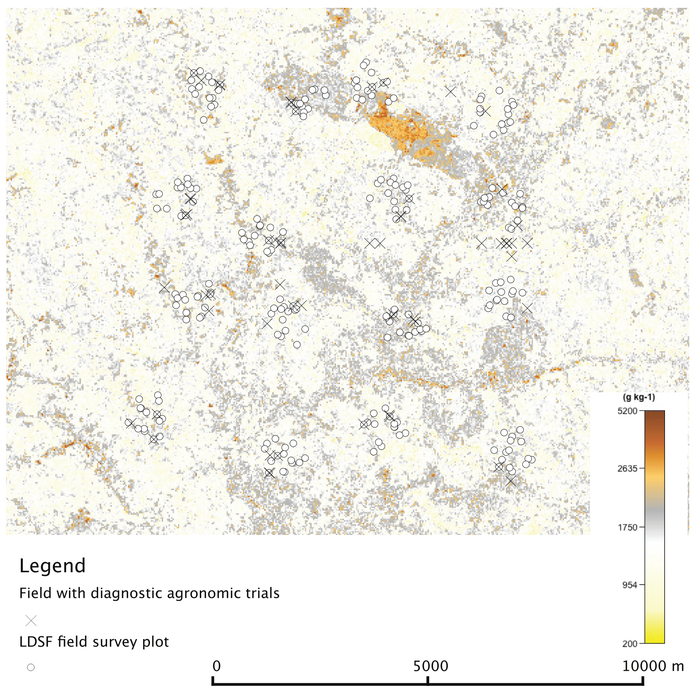
Biophysical surveys and agronomic diagnostic trials were co-located at 12 (100 km^2) sentinel sites in five countries in sub-Saharan Africa (image right) in 2009, 2010 and 2011, as part of the Africa Soil Information Service (AfSIS) project. Preliminary results from five of these sites are explored here: Thuchila, Malawi; Kontela and Koloko, Mali; Mbinga (photo below) and Kiberashi, Tanzania. The Land Degradation Surveillance Framework (LDSF), a spatially stratified sampling design, was implemented to assess current status of land degradation, measuring key metrics such as erosion prevalence, root depth restrictions and soil organic carbon (SOC), which were combined with measurements of total grain yields from thirty-two replicated trials (each with eight treatments) per site using multilevel models.



Location of the 12 LDSF sites where biophysical baseline surveys and agronomic trials were conducted.

Exploring interactions between soil functional properties, land degradation risk and agricultural productivity

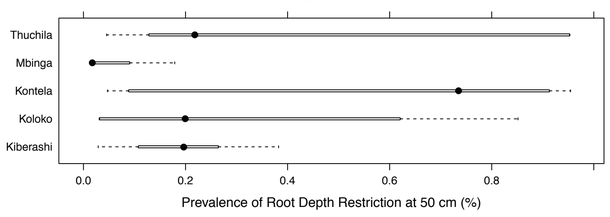
The maps on the right show locations of diagnostic trials and LDSF baseline plots in Thuchila, Malawi. The model used for generating the SOC map was developed using Landsat ETM+ reflectance and measured SOC values from about 8,000 LDSF plots across sub-Saharan Africa. These maps demonstrate the utility of statistical models and satellite imagery in estimating soil functional properties and land degradation risk across landscapes, which can be used to identify target areas for land management interventions.



Soil organic carbon (SOC) (left) and soil erosion prevalence (right) for Thuchila, Malawi.

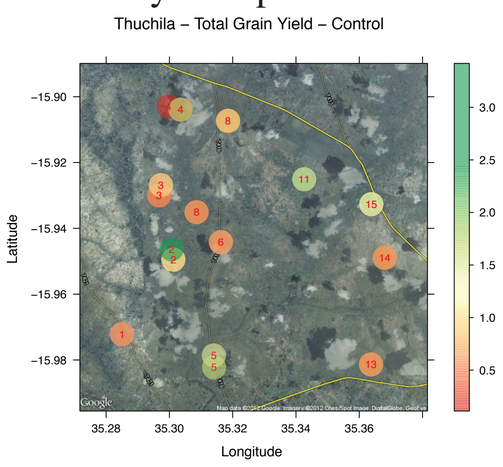
Our current research focuses on understanding the interactions between soil functional properties, land degradation and agricultural productivity by exploring the effects of nutrient omissions on yields.

Below: Between site variability in root-depth restrictions for the 5 landscapes studied.

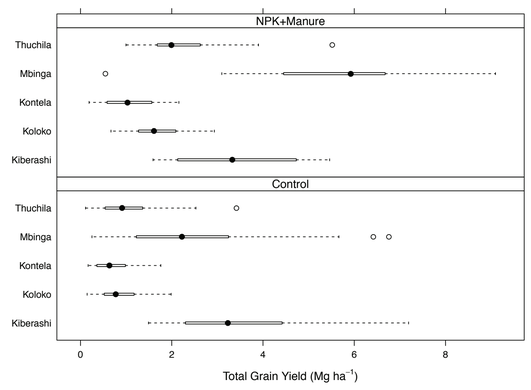


Understanding yield variability

Current results indicate that both soil and other ecological variables are necessary to explain the variability of crop yields across landscapes, and to assess constraints to agricultural productivity. For example, yields for control treatments vary strongly both between and within sites, and so do the responses of crops to various fertilizer treatments.



Variability in control treatment yields within the Thuchila site (0.5- 3 Mg ha^{-1}).



Left: Boxplots showing control and NPK treatment yields in the 5 sites included in this study.

This highlights the importance of understanding spatial heterogeneity and other ecological metrics, beyond treatment effects. Preliminary results from exploring the effects of N, P, K and micronutrient omissions indicate that soil organic carbon, pH and erosion prevalence explain a large part of these effects. We generated two clusters for the nutrient omission data, one with strong N and P omission effects and the other with weak or no effects of omitting these nutrients. Early results show that we can classify these omission effects with about 90% accuracy using predicted SOC, erosion (see maps above) and soil pH, and work is currently focusing on the potential mapping of these nutrient omission effects.

Right: Confusion matrix for classification of omission effects based on Landsat predicted SOC, erosion and pH.

Winner \ W...	"No"	"Yes"
"No"	1385	10
"Yes"	15	180

Correct classified: Wrong classified:
Accuracy: 98.428 Error: 1.572 %

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