A Cost-Effectiveness Framework for Landscape Rehabilitation and Carbon Sequestration in North Kenya

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Research Brief

Adapting Livestock to Climate Change Collaborative Research Support Program

Abstract

Return on investments in land management can be increased by targeting management interventions based on knowledge of the potential of different types of land to produce biomass, resist degradation, and recover from disturbance. The 'ecological site' system was developed by the USDA to provide such information to land-use planners and land managers. We developed a rapid approach to defining ecological sites in areas where detailed soil maps are not available. Preliminary results from applying this approach in Laikipia, Kenya illustrate its value for quickly generating ecological site information. Such information can guide decisions about where development money should be focused for greatest impact.

Maximizing Return on Investments in Land Management with Ecological Site Information

Background

In response to the growing world population, hundreds of millions of dollars are invested in programs designed to increase agricultural production in drylands, including projects designed to expand crop production and bolster livestock production, and projects intended to mitigate climate change. These often fail and can leave the land even more degraded because of a failure to consider variation in the land's *potential*: its productive capacity, resistance to degradation and resilience, or potential to recover. A lack of understanding of land potential can also create confusion about the relative effects of land degradation and climate change on production.

Jeff Herrick and a local herder discussing changes in the soil in response to disturbances as they examine some soil samples. (Photo by Corinna Riginos)

At the same time, aid and development organizations are looking to expand programs in which payments for ecological services, such as carbon sequestration, provide an alternative income source for people living in drylands. These programs would also benefit from an understanding of variation in the land's ability to provide these services, now and under future climate and management scenarios.

Knowledge of land characteristics and production potential can dramatically increase the return on investment in land management by focusing on areas where it will have the greatest impact. An understanding of land potential can be used to determine where: (1) land is not meeting its productive or service-providing potential, (2) production expectations exceed the land's potential, and (3) proposed intensification or new management actions are likely to lead to irreversible degradation. The challenge is to provide this information and tools to land planners and managers in order make decisions on a sound understanding of land potential.

Ecological Site System

The *Ecological Site* system (Bestelmeyer et al., 2009) was developed by the USDA over the past several decades using new knowledge about land resilience and thresholds or *tipping points* of change. This system builds on the USDA Land Capability Classification System that has been widely applied by USAID. An ecological site does not represent an individual location; rather it is a term used to classify functionally similar locations. In contrast to a *land cover class* it can be thought of as a *land potential class*.

Soils within an ecological site generally have similar depth, texture and mineralogy, are located on similar landforms, occur in a similar climate zone, and so share similar production potential and ecological resilience. Ecological sites, like the soils they are based on, repeat across the landscape. In relatively homogenous areas such as old lake plains, entire soil map units may be included in the same ecological site. In others, such as hill slopes and alluvial plains, ecological sites may repeat across the landscape at scales as fine as tens of meters.

"Land production programs often fail and frequently leave the land even more degraded because of a failure to consider variation in the land's productive capacity, resistance to degradation and resilience, or potential to recover."

The emphasis on resilience within the ecological site system is critical for guiding the development of sustainable production systems in many of the marginally productive rangelands that are now being converted to crop production. Many of the same factors that make these areas marginal for livestock production also make them much less resilient to disturbances or climatic changes. Understanding local variability in resilience and potential production is key to effective land-use planning for both agricultural intensification and effective management and restoration of current rangelands.

Extensive guidelines for developing ecological site classifications exist for rangelands in regions of the world with good quality soil surveys (Bestelmeyer et al., 2009; Rangelands June 2011; Herrick et al., 2006; Herrick et al., 2010). These resources, however, are not available for most rangelands in Africa, where land intensification programs are rapidly expanding.

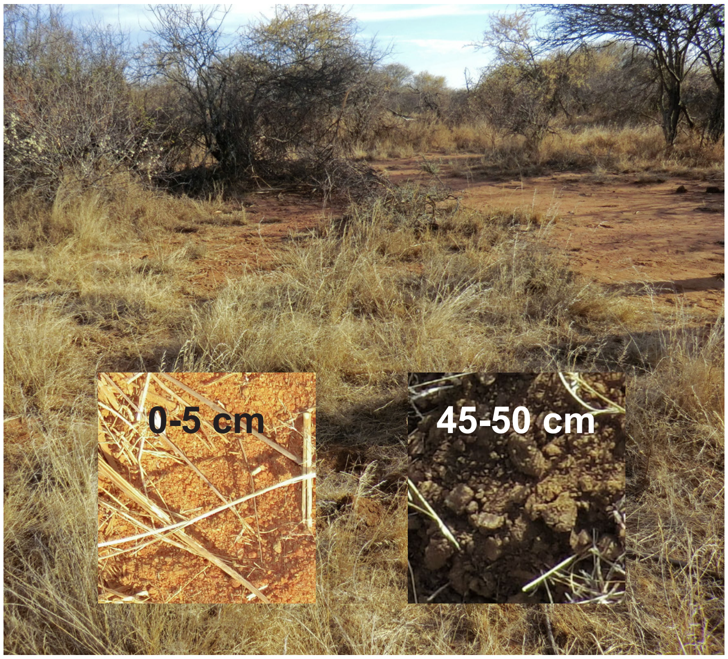
Our Study

In January 2011, we tested a rapid approach to ecological site development in Laikipia, Kenya that made use of existing knowledge and site visits but was not based on preexisting soil surveys. We found our approach could be used to develop preliminary ecological site designations that explain current patterns of production and past response to restoration treatments, as well as to identify areas with the greatest recovery potential.

The Laikipia region includes deep soils with adequate rainfall on the slopes of Mt. Kenya and shallow, highly eroded soils in some of the more arid regions. Our work focused on the Mpala Research Centre and Conservancy in Laikipia, as well as adjacent properties, including a communally-owned group ranch. This area is situated at the intersection of several of the region's major soil types. The land is largely managed for livestock production and wildlife conservation, but crop production has expanded in recent years.

In our review of existing knowledge and information, we found that regional soil and geological surveys for Laikipia lacked the spatial precision and description of soil processes needed to define ecological sites. Local knowledge, where available, was often more helpful, particularly where herders could identify areas with high and low productivity and describe vegetation responses to grazing, drought and fire. The knowledge of herders, however, was generally site-specific, making it difficult to establish an understanding of where these patterns might repeat in the landscape.

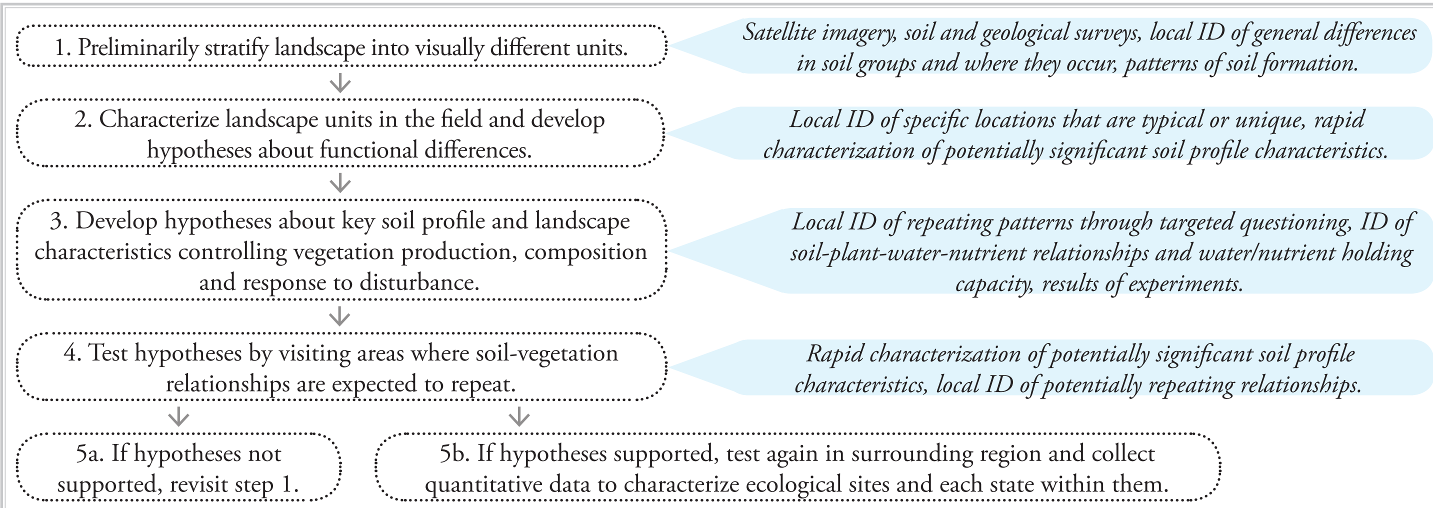
Recognizing these limitations in existing knowledge and information, as well as significant time constraints, we developed a rapid, opportunistic, and iterative approach to the development of an ecological site framework that relied heavily on our understanding of how different soil and landscape characteristics affect water and nutrient availability to plants.



The Red Over Black Cotton Ecological Site Group, which we identified in Laikipia, is easily confused with the Red Ecological Site Group because of their similar soil surface characteristics. The Red Over Black group, however, has much higher potential production and carbon content and is more resistant and resilient to degradation. (Photo by Jeff Herrick)

This approach was applied during an intensive 10 days of field work in January 2011 by two individuals who have extensive ecological site experience, was supported by a technician, and involved extensive local input along with scientific, technical and logistical support from the Mpala Research Center, and Conservancy.

Based on our experiences in Kenya and other parts of the world, we believe that formal training of such eco-site savvy professionals could be accomplished in as little as a year, provided that the individuals already have some knowledge and understanding of landscape patterns and processes or higher education in soil and ecological processes.



A Flow chart diagramming the process used to define different ecological sites and the types of spatial, local, and scientific knowledge needed for each step.

Preliminary Findings

Our approach was surprisingly effective, allowing us to develop preliminary ecological site concepts with a relatively high level of confidence in a very short period. We identified three major ecological site groups in the vicinity of Mpala Research Centre: Black Cotton, Red over Black Cotton and Red. The Red Ecological Site Group was the least resistant, most variable and most susceptible to erosion in the region. Each group contains a large amount of variability in potential production, resistance to degradation and resilience. We identified soil characteristics associated with variability within groups of ecological sites. However, more information is needed to confidently define specific ecological sites.

Our approach was successfully repeated in January 2012 in a much larger region of northern Namibia. Based on our Kenyan experience, we increased our efforts to pre-stratify the landscape using available satellite imagery and then focused our field sampling on more limited areas based on image interpretation with local herders.

Implications

Our method demonstrates that a rapid, simplified approach to defining ecological sites can be effectively used in areas where detailed soil and geological information is lacking. Soil mapping initiatives currently underway, such as the Africa Soil Information Service (AfSIS), should speed up the process, but may not be sufficient for predicting site potential and resilience. Interpretation of soil profiles, local vegetation, and the processes that have led to current conditions are also necessary and should be compiled from local knowledge of management history, patterns of production, and response to disturbances coupled with the knowledge of professionals with training in soil science and ecological site classification.

Formal training in landscape process would be complemented by education for capturing and interpreting local knowledge relevant to defining ecological sites.

Development and application of the ecological site system in African rangelands would:

Guide land planning efforts by providing information on:

- The capacity of the land to support crops or respond positively to restoration efforts
- The capacity of the land to support different amounts of biomass or store different amounts of soil carbon

Reduce flooding and increase perennial stream flow by focusing efforts to increase infiltration on areas with the greatest potential for significant improvement.

Reduce dam siltation by focusing erosion control efforts on critical areas.

Increase probability of successful management and restoration efforts by focusing efforts on area most likely to respond.

Assess treatment options based on the ability of a site to respond.

Judge the effectiveness of management and treatments.

Increase the utility and cost-effectiveness of monitoring.

Collect and store local knowledge in a way that it can be easily used by future generations.

Further Reading

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A Cost-Effectiveness Framework for Landscape Rehabilitation and Carbon Sequestration in North Kenya (CARBON)

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The CARBON project was initiated to: (1) Develop protocol for assessing current land health and site potential, (2) Determine risks of carbon loss and potential for recovery, (3) Quantify the potential for carbon sequestration and landscape rehabilitation, and (4) Test cost-effectiveness of rehabilitation at different sites.

Carbon sequestration through improved management of African rangelands has significant potential to contribute to climate change mitigation while simultaneously improving livelihoods among the rural poor. However, since most of Africa's rangelands are substantially degraded, increasing carbon sequestration will require urgent action to arrest and reverse this degradation. As yet there is little knowledge about where the costs of not arresting degradation, or where the opportunities for rehabilitating landscapes for greater carbon sequestration, forage production, and ecosystem functioning, are greatest. We have developed a process-based framework for deciding where to focus management and rehabilitation efforts in northern Kenya. We have (1) developed participatory tools for assessing land health and potential for degradation; (2) used these tools to predict where rehabilitation interventions are most needed or most likely to succeed in increasing carbon sequestration, ecosystem functioning, and forage production; and (3) tested these predictions and the cost-effectiveness of the associated interventions. This work has been carried out in northern Kenya and has strengthened and built upon existing partnerships among the Mpala Research Centre, local NGOs, local pastoralist communities, USAID Kenya, and the University of Nairobi. With this project, we have (1) strengthened local capacity and support it with scientific tools necessary to scale up rehabilitation efforts over a large region; and (2) provided training opportunities for young Kenyan rangeland scientists. Together, these activities have advanced the long-term goals of improving land management, increasing carbon sequestration, and improving pastoralist livelihoods in the Horn of Africa region.

The Adapting Livestock Systems to Climate Change Collaborative Research Support Program is dedicated to catalyzing and coordinating research that improves the livelihoods of livestock producers affected by climate change by reducing vulnerability and increasing adaptive capacity.

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