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Integrated ag landscapes for profit and risk management

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Introduction

The emerging cellulosic bioenergy and bioproduct industries can provide several agronomic opportunities. New biomass markets give land managers additional choices that can create revenue, mitigate operational risks, and proactively manage soil quality.

The most abundant near term cellulosic resources in the Midwest are agricultural residues, specifically corn stover (US DOE, 2011). Residue removal can provide a number of benefits, but must be done carefully because of the important roles that residues play in the agronomic system, i.e. limiting soil erosion and maintaining soil carbon levels (Johnson et al., 2006; Wilhelm et al., 2010). Dedicated bioenergy crops, such as switchgrass or miscanthus, can provide a number of agronomic and environmental benefits, but typically will not provide sufficient economic return to compete with traditional row crops at the whole field scale.

This report discusses new tools and approaches that help land managers explore alternative decisions that mitigate, and even take advantage of, subfield scale variability in soil characteristics, surface slope and grain yield to engage new cellulosic biomass markets. The high resolution data needed to make alternative subfield decisions, i.e. yield maps, are available to most land managers. This report presents the challenges and opportunities for managing subfield variability through cellulosic biomass production, and discusses decision support tools that can use your existing data to understand these opportunities.

Agronomic impacts of subfield variability

It is intuitively and quantitatively understood that variability in soil characteristics and surface slope impact productivity (Figs 1a-1d). Variability in productivity has a compounding impact on sustainable residue removal opportunities (Figs 1e-1f). The field in Fig 1 has significant potential for delivering corn stover to emerging cellulosic biomass markets (Muth et al., 2012). Removing corn stover residue on high productivity areas of the field, greater than 200 bu/acre, can even help the land manager with potential residue management challenges. This can provide operational benefits such as reduced tillage passes and accelerated soil heating in the spring. However, decisions to removal the corn stover uniformly across the field will cause high soil erosion and soil carbon losses on parts of the field (Fig 1f). Variable rate residue removal is one approach that has potential to increase cellulosic biomass production while managing the entire field sustainably (Muth and Bryden, 2012). However, the areas of the field that where stover removal is unsustainable also present other operational challenges, including profitability.

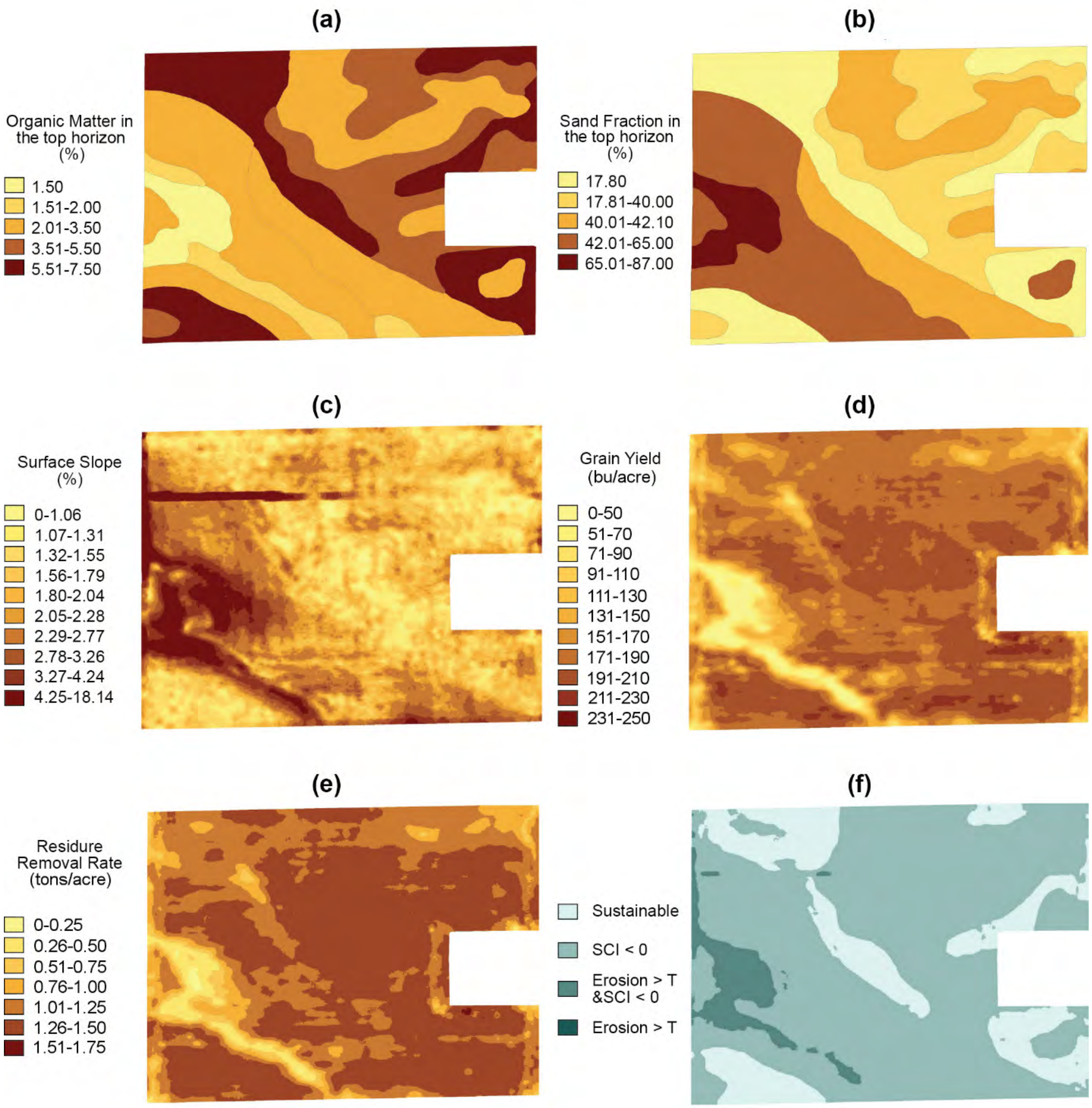

Figure 1. North Central Iowa field, 140 acres managed with a corn-soybean rotation. Figures a-d show variability in soil, surface slope, and productivity. Figures e and f show that in this field the subfield variability creates long term sustainability challenges for parts of the field using uniform corn stover removal practices.

When profitability is evaluated at the subfield scale (Fig 2) it becomes clear that the areas of the field where corn stover removal would be most damaging to the soil resource are also operated at a high net cash flow loss. These areas represent a significant financial risk for the enterprise operating on the field. The question then becomes, can cellulosic biomass crops be integrated into the productive landscape in a way that simultaneously increases profit, decreases risk, and actively improves soil health and conservation.

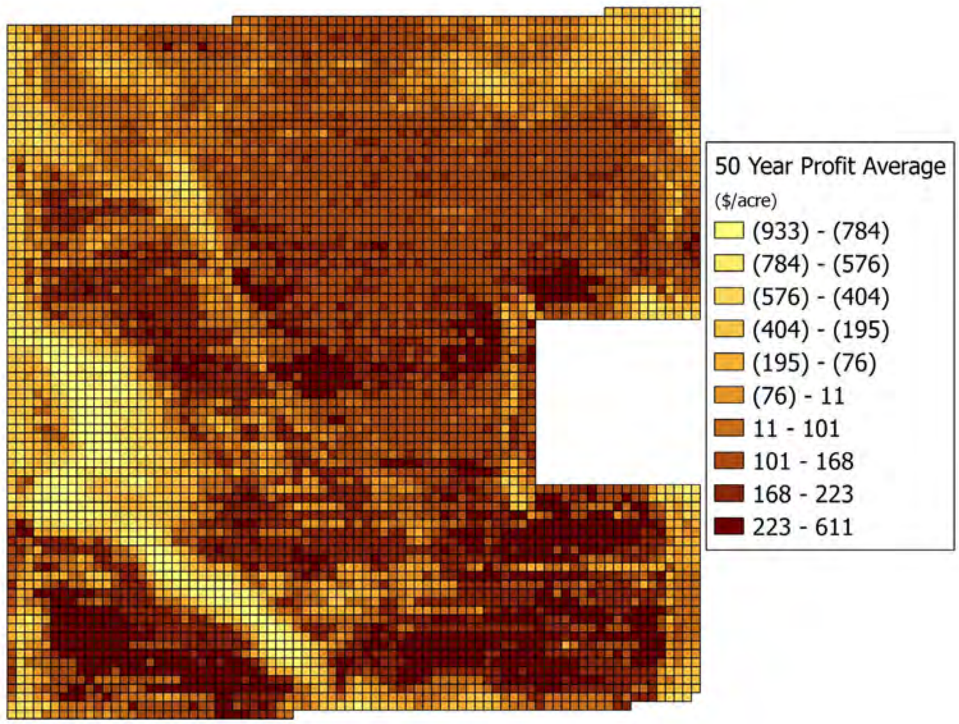

Figure 2. Three years of crop yield data calibrated with a crop growth model and run over 50 years of weather history on a 30 ft grid. Each grid cell is then evaluated with a standard crop budget assuming uniform management practices across the field.

Integrated landscape designs

There are several opportunities and challenges with subfield scale conversion to dedicated cellulosic biomass resources. The first challenge is that robust markets for these feedstocks haven't emerged sufficiently for land managers to make integrated landscape decisions. A second challenge is that operational complexity will typically increase with diverse and integrated feedstock production systems. These challenges have not currently been overcome, but significant progress has been made over the past several years building the required biomass markets within the cellulosic ethanol, bioproduct, and animal feed industries. Furthermore, emerging precision agriculture technologies including equipment and agronomic services are showing promise for simplifying the management of integrated feedstock production systems.

Integrated landscape concepts also provide a number of opportunities. These include reduced operational and financial risks, proactive soil quality management, and potentially increased profitability. Figure 3 presents a scenario for the case study field where low productivity, low profit areas of the field are converted to switchgrass. A series of management scenarios were then evaluated for to determine the productivity, sustainability, and soil quality performance of the integrated landscape. The management details for these scenarios are available in Koch et al., 2012. Table 1 provides several of the performance parameters. Scenario 1 represents the standard corn-soybean practices for the field. Only 39 tons of cellulosic biomass are produced sustainably under this scenario and nearly 350 tons of soil is lost annually. Scenario 2 includes a cover crop in the rotation and the performance parameters are significantly improved. Scenario 4 includes the switchgrass with the corn-soybean rotation and cover crop. This scenario provides the most cellulosic biomass and has significant soil quality impacts. This scenario also has the potential to reduce financial risk through large decreases in annual production cost in lower productivity areas of the field.

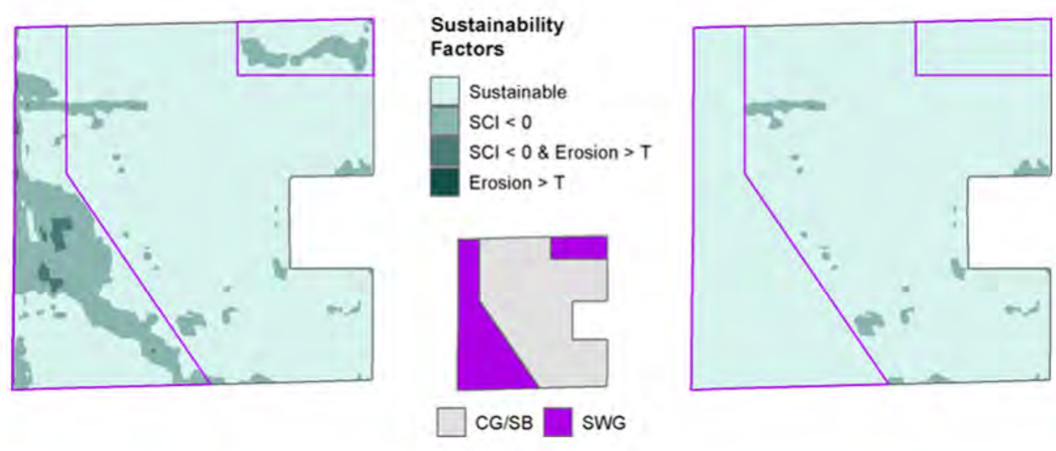

Figure 3. Soil health and conservation impacts of converting to switchgrass production on low profit areas of the field.

Table 1. Key performance parameters for integrated landscape scenarios as shown in Figures 1 and 3.

Scenarios	Annual Sustainable Biomass (tons)	Percentage of Field Sustainable	Annual Soil Loss (tons)
Scenario 1 (Corn/Soybean)	39	21%	348
Scenario 2 (Corn/Rye Cover Crop/Soybean)	154	83%	201
Scenario 3 (Corn/Soy & Switch)	125	48%	171
Scenario 4 (Corn/Rye Cover Crop/Soy & Switch)	213	96%	126

Decision support services

Many challenges remain to practical, large scale implementation of integrated feedstock production landscapes that maximize sustainable delivery of biomass to food, feed, fiber, and fuel markets. There are currently several projects being executed and services being deployed that support integrated production decisions.

USDA is sponsoring a program in the Midwest to investigate a regional system for producing fuels from feedstocks derived from high biomass producing herbaceous perennials using the pyrolytic conversion process. The program, called CenUSA, has research and education teams that concentrate their activities on nine separate objectives:

- Developing cultivars and hybrids of perennial grasses optimized for bioenergy production.
- Developing sustainable production systems that optimize perennial biomass yields and ecosystem services.
- Developing flexible, efficient, and sustainable logistics systems.
- Identifying and characterizing sustainable bioenergy systems to achieve social, economic, and environmental goals and understand socioeconomic and environmental consequences of perennial bioenergy systems.
- Identifying germplasm characteristics amenable to pyrolytic conversion and evaluating performance of pyrolytic biofuels.

- Evaluating policy, market, and contract mechanisms to facilitate broad adoption by farmers.
- Developing procedures for managing risks and protecting health for each component of the biofuel production chain.
- Providing interdisciplinary education and engagement opportunities for undergraduate and graduate students.
- Developing outreach programs for all stakeholders within the bioenergy system.

The private sector is also developing tools to support integrated feedstock production landscapes. One example is Praxik, LLC. Praxik uses several data management and simulation techniques to extend the value of precision agriculture data, and provides this value to decision makers through a range of applications deployed through websites or web-services. These applications include a Sustainable Residue Calculator which is used to evaluate the impact of agricultural residue removal practices on long term soil health. This application can also help design adjustments to management practices that help create sustainable residue removal opportunities. Praxik also provides subfield crop budget services which create profitability estimates like the one in Fig 2. In November, 2013 Praxik released the first comprehensive manure management planning tool in Iowa, mmp360 (www.mmp360.com). Praxik's mmp toolset automates the execution of RUSLE2 and the P-Index calculator required to complete the Iowa DNR Manure Management Plans.

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