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Mapping Grasslands Suitable for Cellulosic Biofuels in the Greater Platte River Basin, United States

Introduction

Biofuels are an important component in the development of alternative energy supplies, which is needed to achieve national energy independence and security in the United States. The most common biofuel product today in the United States is corn-based ethanol; however, its development is limited because of concerns about global food shortages, livestock and food price increases, and water demand increases for irrigation and ethanol production. Corn-based ethanol also potentially contributes to soil erosion, and pesticides and fertilizers affect water quality. Studies indicate that future potential production of cellulosic ethanol is likely to be much greater than grain- or starch-based ethanol. As a result, economics and policy incentives could, in the near future, encourage expansion of cellulosic biofuels production from grasses, forest woody biomass, and agricultural and municipal wastes. If production expands, cultivation of cellulosic feedstock crops, such as switchgrass (*Panicum virgatum L.*) and miscanthus (*Miscanthus* species), is expected to increase dramatically.

The main objective of this study is to identify grasslands in the Great Plains that are potentially suitable for cellulosic feedstock (such as switchgrass) production. Producing ethanol from noncropland holdings (such as grassland) will minimize the effects of biofuel developments on global food supplies. Our pilot study area is the Greater Platte River Basin, which includes a broad range of plant productivity from semiarid grasslands in the west to the fertile corn belt in the east. The Greater Platte River Basin was the subject of related U.S. Geological Survey (USGS) integrated research projects (Thormodsgard, 2009).

Methods

In this study, we applied the dynamic modeling of ecosystem performance (DMEP) method (Wylie and others, 2008) to identify grasslands that are potentially suitable for cellulosic feedstock development in the GPRB. DMEP monitors and models ecosystem performance (EP), a surrogate approach for measuring ecosystem productivity. EP accounts for current and future ecosystem services, site conditions, and projected climate changes. We used remotely sensed vegetation condition information from the archival records of satellite data (expedited Moderate Resolution Imaging Spectroradiometer (eMODIS) time series Normalized Difference Vegetation Index (NDVI) data with a 250-meter spatial resolution), site geophysical and biophysical features (such as elevation, slope and aspect, and soils), and weather and climate drivers to build site potential and EP models to estimate grassland site potentials (long-term grass productivities) and range conditions (Gu and others, 2012). In this study, Growing Season averaged NDVI (GSN) was used as a proxy for grassland productivity (Gu and others, 2013).

We presumed areas that had consistently high grassland productivity and that varied from fair-to-good rangeland condition (that is with multiyear persistent ecosystem overperformance or normal performance relative to site conditions and weather-based productivity estimates) were potentially suitable for cellulosic feedstock development.

On the other hand, we assumed that the following grassland conditions were not appropriate for cellulosic feedstock development: unproductive, degraded, or highly vulnerable to erosion. Unproductive conditions include grasslands with poor soils, dry climate conditions, or other conditions not conducive to vegetation growth. Degraded grasslands have multiyear persistent ecosystem underperformance with poor rangeland conditions caused by wildfire, insect infestation, or heavy grazing. Grasslands that are highly vulnerable to erosion include the Sand Hills ecoregion in Nebraska, where removal of biomass may lead to sand dune reactivation and migration.

Furthermore, we used regression analyses of eMODIS GSN and rangeland productivity, derived from the Soil Survey Geographic (SSURGO) Database (*http://soildatamart.nrcs.usda.gov*), to verify the reliability of the use of GSN as a proxy for grassland productivity (Gu and others, 2013).

Results

The scatterplot of the eMODIS long-term mean GSN (MGSN) and SSURGO rangeland productivity for the Greater Platte River Basin is shown in figure 1. A strong relationship between MGSN and SSURGO productivity (coefficient of determination (R^2) = 0.74; 8,000 samples) supports the validity of using GSN as a proxy for grassland productivity.

Grassland areas that are potentially suitable for cellulosic feedstock production in the Greater Platte River Basin are shown in figure 2. Pixels that either over-performed or performed normally for at least 7 of 9 years from 2000 to 2008 (derived from the EP model) and had either moderate (green, productivity between 2,750 to 3,600 kilogram per hectare per year (kg ha^{-1} $year^{-1}$)) or high (blue, productivity greater than 3,600 kg ha^{-1} $year^{-1}$) grassland long-term site potential were identified as potentially suitable. Most of the Sand Hills ecoregion was excluded from the identified suitable areas to avoid ecologically hazardous land use and land cover changes.

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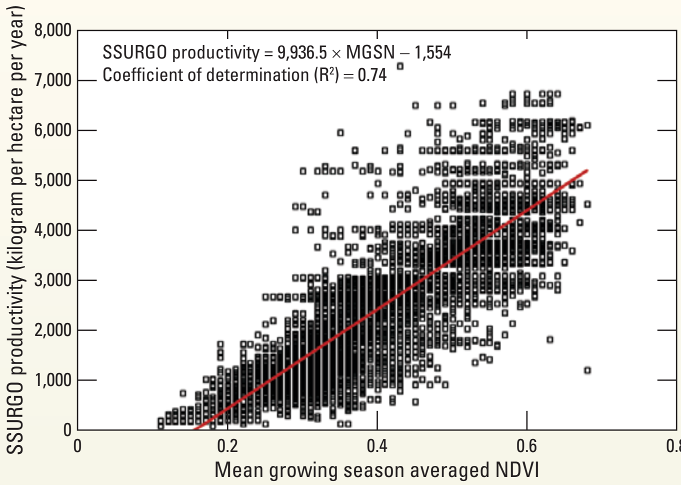

Figure 1. Relation between expedited Moderate Resolution Imaging Spectroradiometer (eMODIS) Mean Growing Season averaged Normalized Difference Vegetation Index (NDVI) and Soil Survey Geographic (SSURGO) Database rangeland productivity in the Greater Platte River Basin. NDVI represents the photosynthetic capacity of vegetation canopy and the unit is a dimensionless ratio.

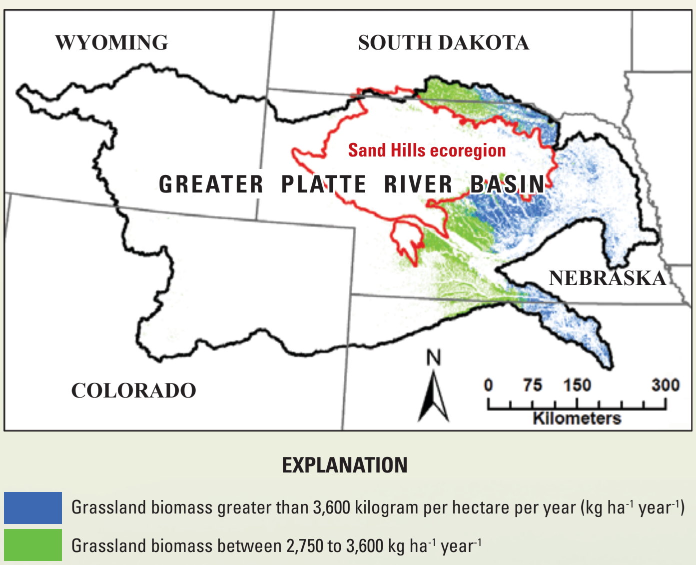

Figure 2. Map delineates potentially suitable areas (in green and blue) for cellulosic feedstock production within the Greater Platte River Basin. The spatial resolution of the map is 250 meter.

North Platte River Valley as seen from Scottsbluff National Monument, Nebraska.

Summary

This approach demonstrates the power of ecosystem models and biophysical information extracted from the extensive satellite image archives to monitor grasslands and to project future potential biofuel feedstock source areas. This study provides a new monitoring and modeling approach that can contribute to decision support tools to help land managers and decision makers make optimal land use decisions regarding possible conversion to cellulosic feedstock production. This research represents a first step in identifying grassland areas suitable for sustainable production of cellulosic feedstock. Further studies are needed to evaluate environmental and climate effects (such as carbon sequestration) caused by possible expansion of cellulosic feedstock production in the potentially suitable areas, and quantitatively compare future climate-based projections of corn and grassland productivity in these areas.

Acknowledgments

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References

Gu, Y., Boyte, S.P., Wylie, B.K., and Tieszen, L.L., 2012, Identifying grasslands suitable for cellulosic feedstock crops in the Greater Platte River Basin—Dynamic modeling of ecosystem performance with 250 m eMODIS: Global Change Biology Bioenergy, v. 4, p. 96–106.

Gu, Y., Wylie, B.K., and Norman, B.B., 2013, Mapping grassland productivity with 250-m eMODIS NDVI and SSURGO database over the Greater Platte River Basin, USA: Ecological Indicators, v. 24, p. 31–36. (Also available at *http://dx.doi.org/10.1016/j.ecolind.2012.05.024*).

Soil Survey Geographic Database, Soil Survey Staff 2009, accessed January 2012, at *http://soildatamart.nrcs.usda.gov.*

Thormodsgard, J., 2009, Greater Platte River Basins—Science to sustain ecosystems and communities: U.S. Geological Survey Fact Sheet 2009–3097, 6 p.

Wylie, B.K., Zhang, L., Bliss, N., Ji, L., Tieszen, L.L., and Jolly, M., 2008, Integrating modeling and remote sensing to identify ecosystem performance anomalies in the boreal forest, Yukon River Basin, Alaska: International Journal of Digital Earth, v. 2, p. 196–220.

Web page: *http://lca.usgs.gov/lca/biofuels_platte/index.php*

By Bruce K. Wylie[1] and Yingxin Gu[2]

[1]U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center. 47914 252nd Street, Sioux Falls, SD 57198, (*wylie@usgs.gov*).
[2]ASRC Research and Technology Solutions, contractor to the USGS EROS Center. 47914 252nd Street, Sioux Falls, SD 57198, (*ygu@usgs.gov).*