Biofuels: Bring back the Prairie

Posted by Stuart Staniford on December 8, 2006 - 1:54am
Topic: Alternative energy
Tags: biofuel, climate change, peak oil [list all tags]

At risk of annoying everyone else by stealing too much real estate here, I couldn't resist drawing attention to a very interesting paper in Science tonight by Tilman et al. Here's the abstract:

> Biofuels derived from low-input high-diversity (LIHD) mixtures of native grassland perennials can provide more usable energy, greater greenhouse gas reductions, and less agrichemical pollution per hectare than can corn grain ethanol or soybean biodiesel. High-diversity grasslands had increasingly higher bioenergy yields that were 238% greater than monoculture yields after a decade. LIHD biofuels are carbon negative because net ecosystem carbon dioxide sequestration (4.4 megagram hectare-1 year-1 of carbon dioxide in soil and roots) exceeds fossil carbon dioxide release during biofuel production (0.32 megagram hectare-1 year-1). Moreover, LIHD biofuels can be produced on agriculturally degraded lands and thus need to neither displace food production nor cause loss of biodiversity via habitat destruction.

So basically, we should return much of the Midwest to prairie and then mow it regularly to make biofuels!

A few other fair-use snippets from the full paper (which is behind a paywall alas):

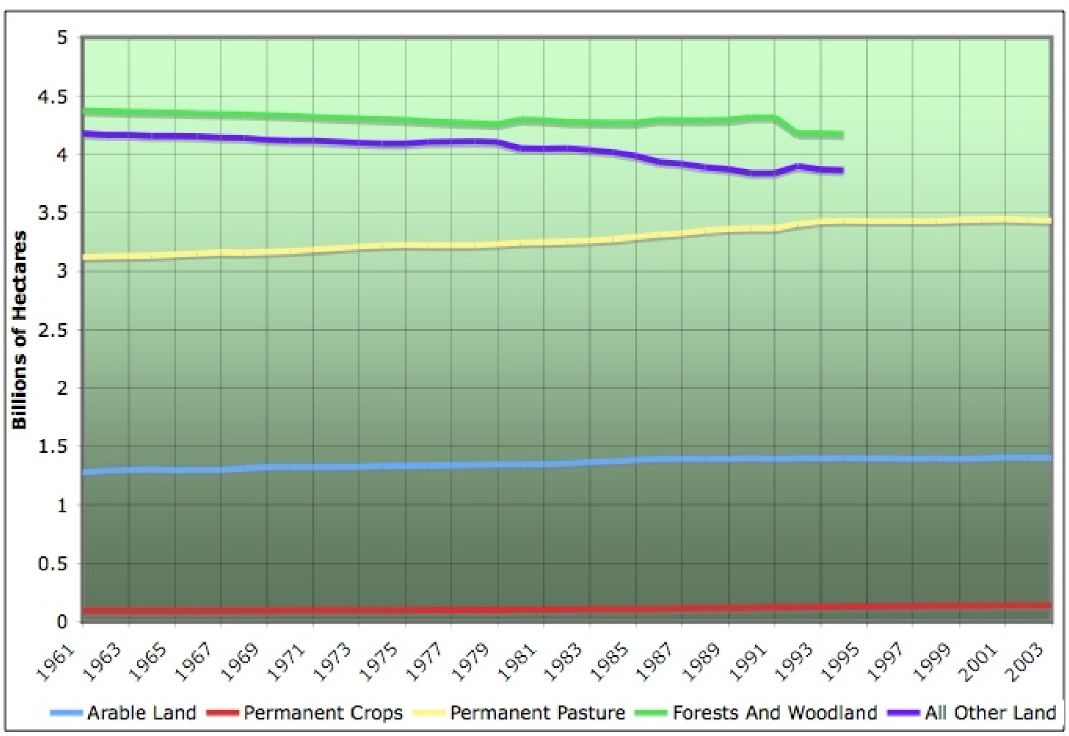
> We performed an experiment on agriculturally degraded and abandoned nitrogen-poor sandy soil. We determined bioenergy production and ecosystem carbon sequestration in 152 plots, planted in 1994, containing various combinations of 1, 2, 4, 8, or 16 perennial herbaceous grassland species (table S1) (10). Species composition of each plot was determined by random draw from a pool of species. Plots were unfertilized, irrigated only during establishment, and otherwise grown with low inputs (10). The 16-species plots are the highest diversity, or the LIHD (low-input, high-diversity), treatment. All plots were burned in early spring to remove aboveground biomass before growth began. Soil samples, collected before planting in 1994 and again in 2004, determined carbon sequestration in soil. Plots were sampled annually from 1996 to 2005 for aboveground biomass production.

> The gross bioenergy yield from LIHD plots was 68.1 GJ ha-1 year-1. Fossil energy needed for biomass production, harvest, and transport to a biofuel production facility was estimated at 4.0 GJ ha-1 year-1 (table S2). Different biofuel production methods capture different proportions of bioenergy in deliverable, usable forms (Fig. 2) (10). Cocombustion of degraded land LIHD biomass with coal in existing coal-fired electric

generation facilities would provide a net gain of about 18.1 GJ ha-1 as electricity (11). Converting LIHD biomass into cellulosic ethanol and electricity is estimated to net 17.8 GJ ha-1 (12). Conversion into gasoline and diesel synfuels and electricity via integrated gasification and combined cycle technology with Fischer-Tropsch hydrocarbon synthesis (IGCC-FT) is estimated to net 28.4 GJ ha-1 (10, 13).

Across their full life cycles, biofuels can be carbon neutral [no net effect on atmospheric CO2 and other greenhouse gases (GHG)], carbon negative (net reduction in GHG), or carbon sources (net increase in GHG), depending on both how much CO2 and other greenhouse gases, expressed as CO2 equivalents, are removed from or released into the atmosphere during crop growth and how much fossil CO2 is released in biofuel production. Both corn ethanol and soybean biodiesel are net carbon sources but do have 12% and 41% lower net GHG emissions, respectively, than combustion of the gasoline and diesel they displace (14). In contrast, LIHD biofuels are carbon negative, leading to net sequestration of atmospheric CO2 across the full life cycle of biofuel production and combustion (table S3). LIHD biomass removed and sequestered more atmospheric CO2 than was released from fossil fuel combustion during agriculture, transportation, and processing (0.32 Mg ha-1 year-1 of CO2), with net life cycle sequestration of 4.1 Mg ha-1 year-1 of CO2 for the first decade and an estimated 2.7 to 3 Mg ha-1 year-1 for subsequent decades. GHG reductions from use of LIHD biofuels in lieu of gasoline and diesel fuel are from 6 to 16 times greater than those from use of corn grain ethanol and soybean biodiesel in lieu of fossil fuels

To put this in context, here's global land use:



Major classes of global land use shown as individual trend lines. Source: FAO.

If the 1.4 billion hectares of ag land were *all* LIHD plantations sequestering about 3 tonnes net of CO_2/ha/year, which is around 0.8 tonnes of carbon, then we would sequester an additional 1.1

gigatons of C. This should be compared with the 8 and rising gigatons of C emitted from fossil fuel burning. Obviously, we couldn't do this with all ag land either. Thus the contribution to offsetting global carbon emissions from this could only be modest. However, the net energy story sounds like it might be quite strong, so this may be a useful wedge to both our energy and climate problems (assuming that deriving fuel from a diverse feedstock can be made commercially practicable).