Study Guide to the FOOD FOR THOUGHT lecture:

Getting Biofuels Right
The Biofuel vs Food vs the Environment Dilemma

Presented by **David Tilman** at Oregon State University 25 February 2008

Slides and streaming video available at http://agsci.oregonstate.edu/orb/events

The production of this series of study guides by Megan McKenzie of Outreach in Biotechnology was made possible through funding by The American Society of Plant Biologists.

About the speaker

G David Tilman is Regents' Professor and McKnight Presidential Chair in Ecology at the University of Minnesota, and Director of the University's Cedar Creek Ecosystem Science Reserve. His research explores how managed and natural ecosystems can meet human needs for food and energy sustainably. Tilman has written five books and published more than 200 peer-reviewed papers; he has been the world's most highly cited environmental scientist for three decades.

Terms

Biofuels: solid, liquid, or gaseous fuels derived from biomass. Two common strategies are used to produce liquid biofuels to meet transportation needs: Sugar or starch crops (like sugar cane or corn, respectively) are used for yeast fermentation to produce ethanol, and oil crops like soybean or algae are chemically processed to make biodiesel. A third promising strategy produces cellulosic ethanol from plant cell wells (rather than only from sugars and starches) and requires less fossil fuel input.

Biomass: material derived from plants, animals, and their by-products. The carbon used to make biomass is absorbed from the atmosphere as carbon dioxide (CO_2) by photosynthetic organisms like plants and algae, using energy from the sun. (Fossil fuels like coal, oil, and gas are also derived from biological material; however, this material absorbed CO_2 from the atmosphere many millions of years ago.)

Gasification: under high temperatures, in the presence of oxygen, biomass can be converted to synthesis gas (syngas), which can be used as a fuel. Gasification is more efficient than direct combustion of the original biomass, since more energy is extracted.

Carbon neutral: a balance between the amount of carbon released and the amount sequestered or offset. Neutrality can be achieved by using renewable energy sources that don't produce any CO_2 and by sequestering atmospheric CO_2.

Renewable energy: an energy source replenished by natural processes at a rate comparable or faster than its rate of consumption. Examples include solar radiation, tides, winds, and hydroelectricity.

Carbon sequestering: the long-term storage of carbon in soil (by incorporating it into biomass), underground, or the ocean, thus reducing atmospheric levels of CO_2 (the principal anthropogenic greenhouse gas). Fertile soils are rich in sequestered carbon.

Greenhouse gasses: the gases present in the earth's atmosphere that reduce heat loss into space and therefore contribute to global temperatures through the greenhouse effect. Since the industrial revolution, human activity has increased the concentration of greenhouse gasses, including CO_2, methane, and nitrous oxide.

Take-home messages

Within the next 50 years, our global population will stabilize at about nine billion. This population will consume about 140% more resources per person, thereby effectively doubling our current need for food and energy.

As our population grows, the issue is not that we'll run out of fossil fuels, but that our use of fossil fuels is releasing massive amounts of greenhouse gasses, causing devastating climate change that negatively impacts the livability of our global environment and our capacity to grow food.

Currently, the biggest release of greenhouse gasses worldwide is not from cars, but from coal-fired electric plants. In fact, cars and buildings are consuming about equal amounts of energy. But the production of electricity for buildings generates twice the volume of greenhouse gasses than the production of petroleum.

Together, the following strategies can stabilize greenhouse gas emissions while meeting our food and energy needs:

- Increase the energy efficiency of buildings and vehicles. This could cut energy use by up to 50%.
- Replace fossil fuels with renewable energy sources. This could curtail greenhouse gas release.
- Produce carbon neutral biofuels from wastes and biomass grown on *degraded* (not fertile) land. This strategy could potentially replace 15-30% of petroleum use.
- Reserve fertile land for food production, carbon storage, and biodiversity.

Begin by viewing Tilman's introduction (streaming video segment 6:55-12:25).

We will then focus on the segments of his lecture in which he talks about global land use in the context of biofuel and food production. Your total watching time will be about 25 minutes. Read each question before you watch the selected segment on streaming video.

Questions

Short answer

1. Tilman explains that, in an ideal situation, the production of biofuels is a carbon neutral process since biomass takes CO_2 out of the atmosphere while it is growing, and returns it as it is burned (streaming video segment 6:55-12:25, as above). However, we have been making biofuels mostly from crops like corn and soybean. It takes a considerable amount of energy to grow these crops (tilling, fertilizing, irrigating, etc) and to make biofuel from them (transporting, converting, etc). Moreover, even if all of the US corn and soybean crops were used to produce biofuel rather than as food (!), we would see only a 2.5% and 3% new energy gain for ethanol and biodiesel production, respectively (table, streaming video segment 22:15-24:10). Why is this?

Potential of US Food-Based Biofuels		
	Current Biofuel Production	**Entire 2005 US Crop to Biofuel**
Corn Ethanol	1.7% of Gasoline **14%** of Corn	12% of Gasoline **100%** of Corn 2.5% Energy Gain
Soybean Biodiesel	0.1% of Diesel **1.5%** of Soybeans	6% of Diesel **100%** of Soybeans 3% Energy Gain

2. Clearing *new* land increases the net amount of CO_2 released into the atmosphere for many decades. This release of CO_2 creates a carbon debt that can take a long time to repay, even if that land is used to grow biofuels. In the example that Tilman gives of clearing land in Brazil to grow soybean for biodiesel production, how many years does he say it would take to pay off the carbon debt incurred (streaming video segment 24:10-29:20)?

3. Tillman discusses alternatives to growing biofuels on fertile land, including increasing energy efficiency, using more renewable energy, making biofuels from 'wastes', and growing biofuels on degraded land (streaming video segment 32:50-36:45). What are two ways Tillman mentions that can decrease energy use in buildings?

4. Tillman suggests using better agronomic practices to increase carbon sequestration in cropland while allowing for collection of crop wastes for biofuel production via gasification. He refers to gasification as the "technology of scoundrels" (streaming video segment 36:45-39:50). What percent of the global petroleum supply does Tilman estimate could be replaced using gasification?

Essay

5. Tillman would like to see much of the approximately 500 million hectares of the degraded, abandoned farmland around the world reclaimed. One of the major perks of cultivating degraded farmland for biofuel production is that the carbon debt has already been paid.

   In recent experiments, Tilman learned that a diverse mixture of *native* prairie grasses planted on degraded land were highly efficient at creating above-ground biomass to use for biofuels, and below-ground biomass for long-term carbon sequestering – far more efficient that any single species. Moreover, the grasses needed only to be planted once and did not require irrigation or fertilization.

   Tilman points out that biofuels produced by growing native species on degraded land may well be carbon negative. Explain what he means by this and why it's a good thing. Construct an answer 75-125 words in length. Make sure you consider the importance of carbon debt, of using plants native to the region, and sustainability in your answer (streaming video 39:50-48:10).