Groundwater, Bioenergy and Soil Health – Is the Nexus Sustainable?

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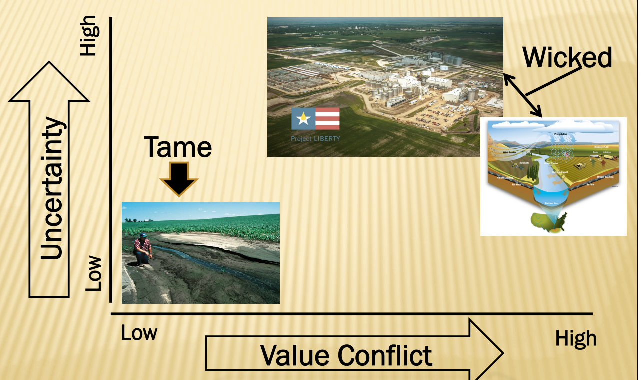
Presentation Overview

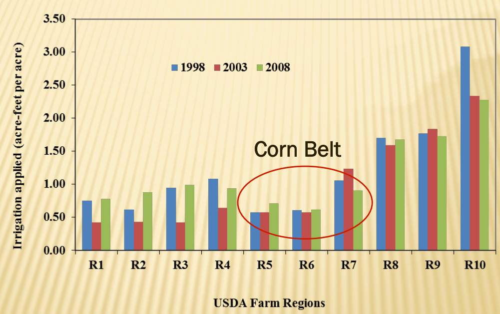
- Balancing the soil/water/energy nexus – a complex challenge but unique opportunity
- Groundwater use and supply examples
- Bioenergy production components & water use
- Soil health effects on water availability & quality
- How, sustainable bioenergy and bio-product feedstock production can meet the challenges and help fulfill the opportunities

Unlike Soil Erosion, the Nexus is a Wicked Problem



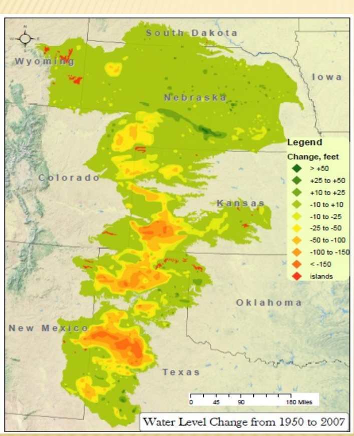
Adapted from S.S. Bete, 2010

Irrigation Water Withdrawal



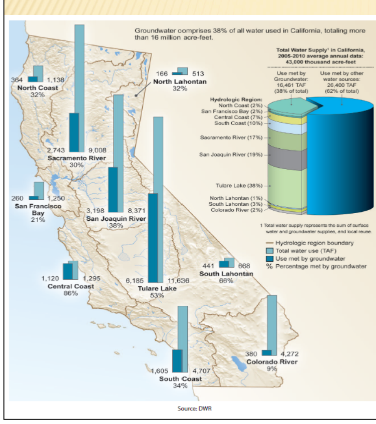
Water resource limitations are arguably the lynchpin in the quest for global food security. Some thus question how will bioenergy production will affect this resource.

Ogallala aquifer elevation change, 1950 – 2007



Currently, irrigation supports 40% of global food production, but it occupies only about 18% of the agricultural landscape. Groundwater resources, being used for critical, irrigated food production in several regions of the world, are being depleted because their recharge rates are well below extraction rates.

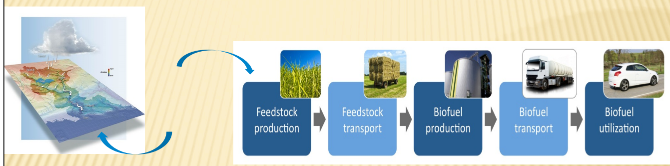
California Groundwater Use



- Groundwater supplies an average of 38% of total water.
- The majority is used for agricultural production on 4.05 million ha of cropland.
- In 2015, the 4th year of severe drought groundwater use soared to almost 60% of the water supply

Sourced from Chapter 2 of the State of California's Groundwater Update 2013.,

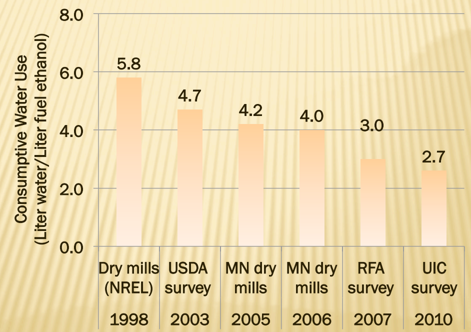
Bioenergy Production has many Components



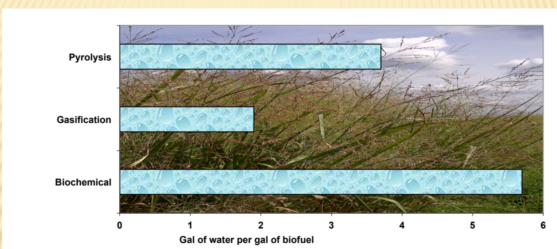
Feedstock production and conversion use most of the water

However, based simply on human energy needs and the reality that fossil fuel reserves are diminishing, aggressively developing sustainable, economic technologies to produce liquid fuels from plant biomass is no longer optional—it is mandatory.

Corn Dry Mill – Water Consumption

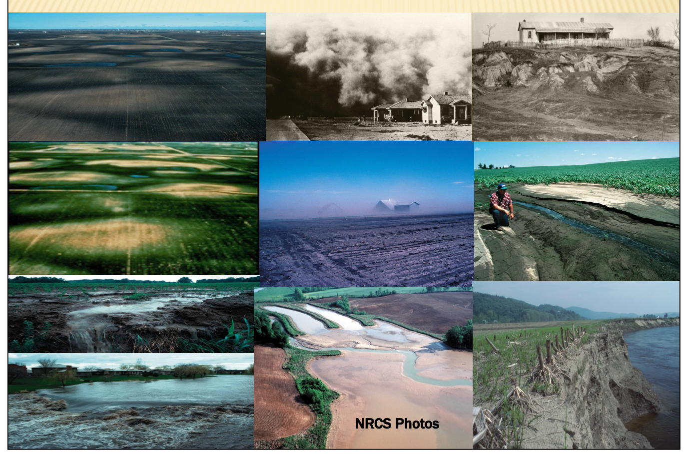


Cellulosic Biofuel – Water Conssumption



Indirect water use – electricity generation, oil production, natural gas production, etc.

Soil Health Effects on Water Resources



Soil Health Can Directly Affect Water Quality

Requirements for Balancing the Nexus

- Agriculture must provide sustainable supplies of food, feed and fuel without negatively impacting water quality or quantity
  - Food production must double from current levels to feed nine billion people
  - "Rich" societies use a lot of energy because:
    - Its use is directly related to the rate of doing work
    - Therefore, energy use and human development opportunities are strongly correlated
    - Having renewable energy is the only way nine billion people can achieve their full potential

Tools for Balancing the Nexus

- ➢ Central Great Plains Ethanol/Water Calculator
- ➢ DOE's Water Analysis Tool for Energy Resources (WATER)
- ➢ Estimating Water Footprint for biofuel from various feedstocks
- ➢ Integrated multi-location, multi-institution, multi-agency and private sector partnerships
  - ➢ CENUSA
  - ➢ DOE – Landscape design study

Central Great Plains Ethanol/Water Calculator

Step 1 Select a Crop	Step 2 Enter Available Target Yield bu/a	Step 3 Select a Location	Step 4 Enter % of Average Precipitation (0%-200%)	Step 5 Enter Amount of Stored Soil Water Used (in)	Average Growing Season Precipitation (in)	Assumed Growing Season
Corn	200	Akron	80	6	10.00	May 14-Sep 30
	Total Water Required (in)	Water from Precip (in)	Water from Soil (in)	Irrigation Required (in)		
	28.4	8.00	6	14.4		
Ethanol Produced (gal)	Total Water Required (gal)	Water from Precip (gal)	Water from Soil (gal)	Irrigation Required (gal)		
530	770114	217203	162902	390010		
gal water/gal Eth	1453	410	307	736		

Central Great Plains Ethanol/Water Calculator

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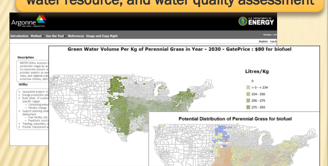
WATER (Water Analysis Tool for Energy Resources)

http://WATER.es.anl.gov

An on-line interactive visual tool for water use, water resource, and water quality assessment



Feedstock
- Corn
- Corn stover
- Soybean
- Wheat straw
- Switchgrass and Miscanthus
- Forest wood resource, short rotation woody crops
- Algae, rapeseeds, camelina, others

Conversion process:
- Biochemical
- Thermal chemical
- Chemical

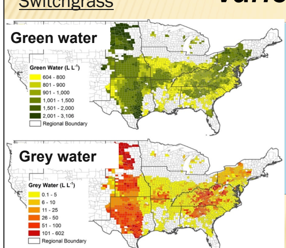
- Multiple production pathways
- feedstock production and conversion stages
- Selection of feedstock and biorefinery location at state level
- Metric: fuel product, feedstock, land use
- Blue, green, and grey water footprint at county level

- Petroleum gasoline and diesel
  - Conventional, oil sands
- Natural gas
- Electricity

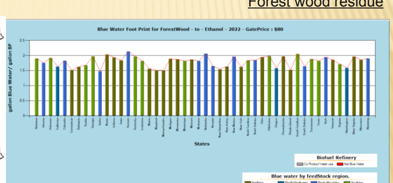
Spatial resolution:
County, state, USDA regions – biofuel
State level – power
PADD, Canadian regions – oil
Play – shale gas

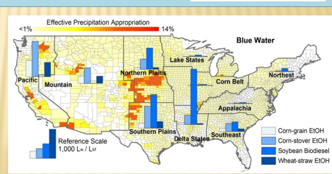
Water Footprint of Biofuel Produced from Various Feedstocks

Switchgrass



Forest wood residue



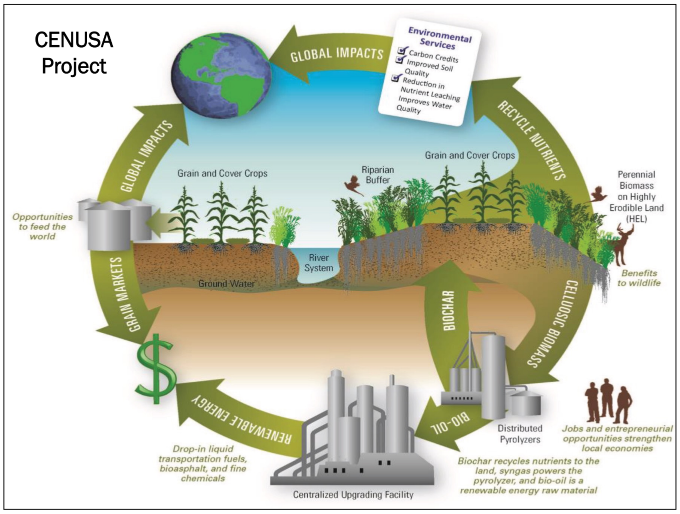


Blue water footprint of switchgrass-based biofuel is solely dependent on conversion process, 2-6 gal/gal

Crop residue, conventional feedstock

https://greet.es.anl.gov/publication-country-level-water-footprint; Chiu and Wu, 2012.

- ➢ Integrated multi-location, multi-institution, multi-agency and private sector partnerships



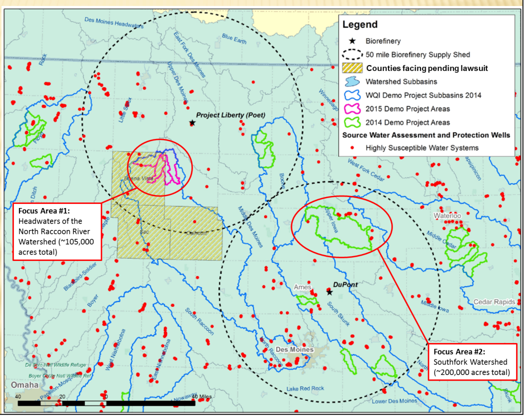
Landscape Design for Sustainable Bioenergy Systems

Project Summary:

The team will work with growers and biomass end-users to utilize subfield agronomic models to target areas within existing cellulosic ethanol feedstock supply sheds, in Iowa and Kansas, to build baseline datasets, monitor key environmental indicators, implement conservation practices, and monitor the environmental and economic impacts to the watersheds and the biomass supply chain.

Targeted Watershed Areas

We are also focusing on fields and practices subject to wind erosion in Abengoa supply shed in Southwest Kansas and surrounding areas



Summary

➢As stated by Hillel in his 1991 book "Out of the Earth: Civilization and the life of the soil" today's water and soil resources are knowingly being exploited and degraded at global scales in ways that are consistent with past failed civilizations.

➢Renewable energy is essential for human well-being – therefore, biofuels *(liquid fuels from plant material) are no longer optional — we must have them — but they must be produced in a socially, economically, & environmentally sustainable manner.*

Conclusions

➢A sustainable Nexus among groundwater, bioenergy, and soil health is achievable

➢Producers will "buy in" to the Nexus because overall "Return on Investment" or ROI will be increased through improved site- or even sub-field-specific soil and crop management

➢*Finally, we also conclude that* perceived food vs. fuel conflicts can be solved without having a negative impact on soil, water, or air resources by using our knowledge to address the water – soil – energy nexus as an integrated system.

Our Ultimate Goal: To Recognize and Capitalize on Nature's Diversity!