INCREASED BIOFUEL PRODUCTION AND WATER RESOURCES

ROUNDTABLE ON SCIENCE AND TECHNOLOGY FOR SUSTAINABILITY
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Silvia Secchi
Southern Illinois University   ssecchi@siu.edu

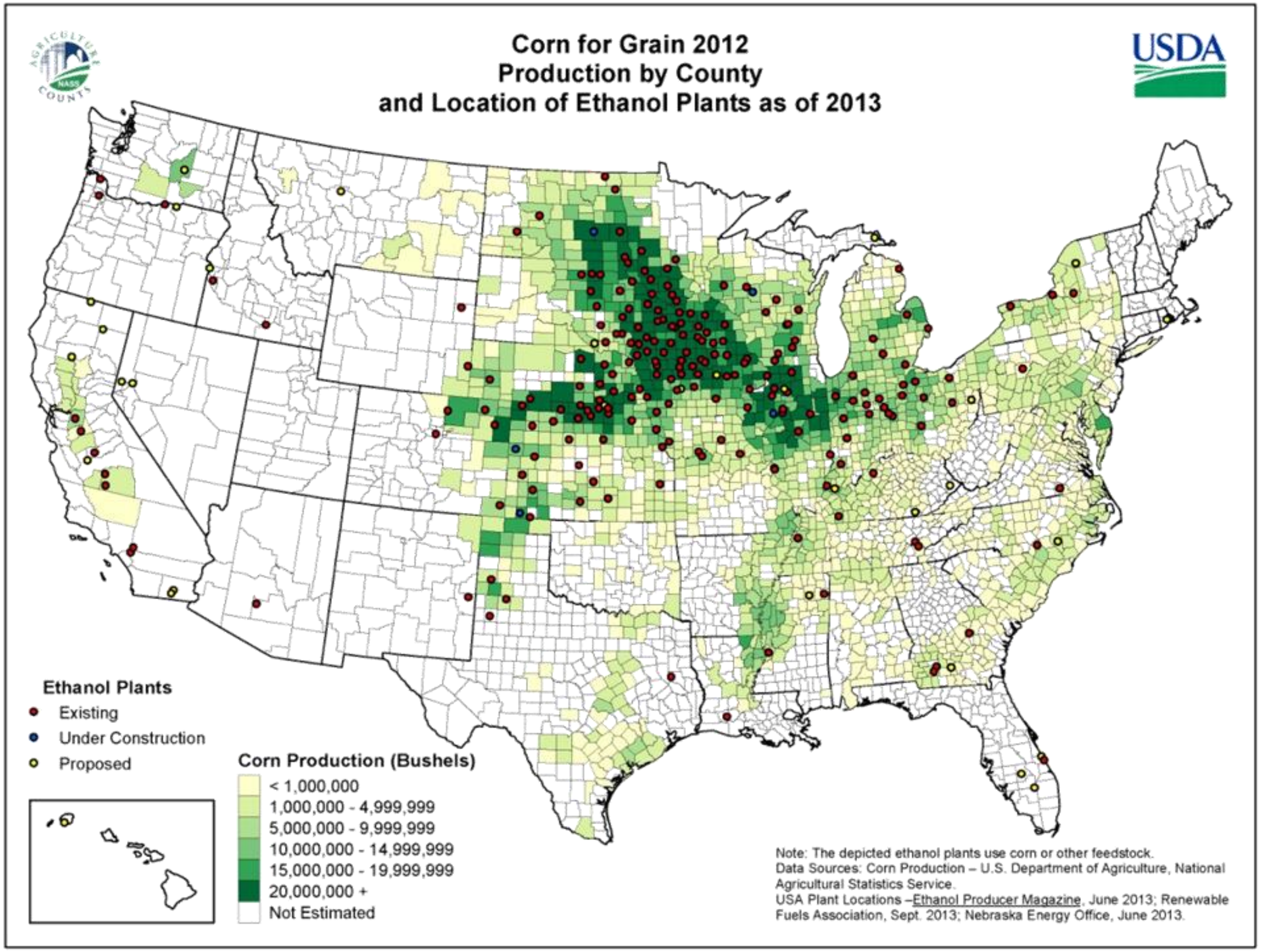
Outline

	Technology	
Water quality	First generation 1	Second generation/ advanced 2
Water quantity	First generation 3	Second generation/ advanced 4

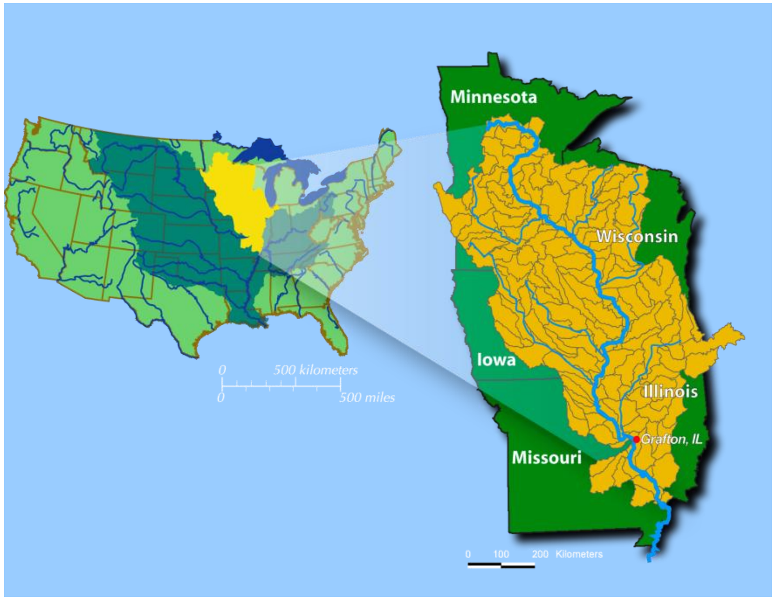
5 Other instances of the energy water nexus

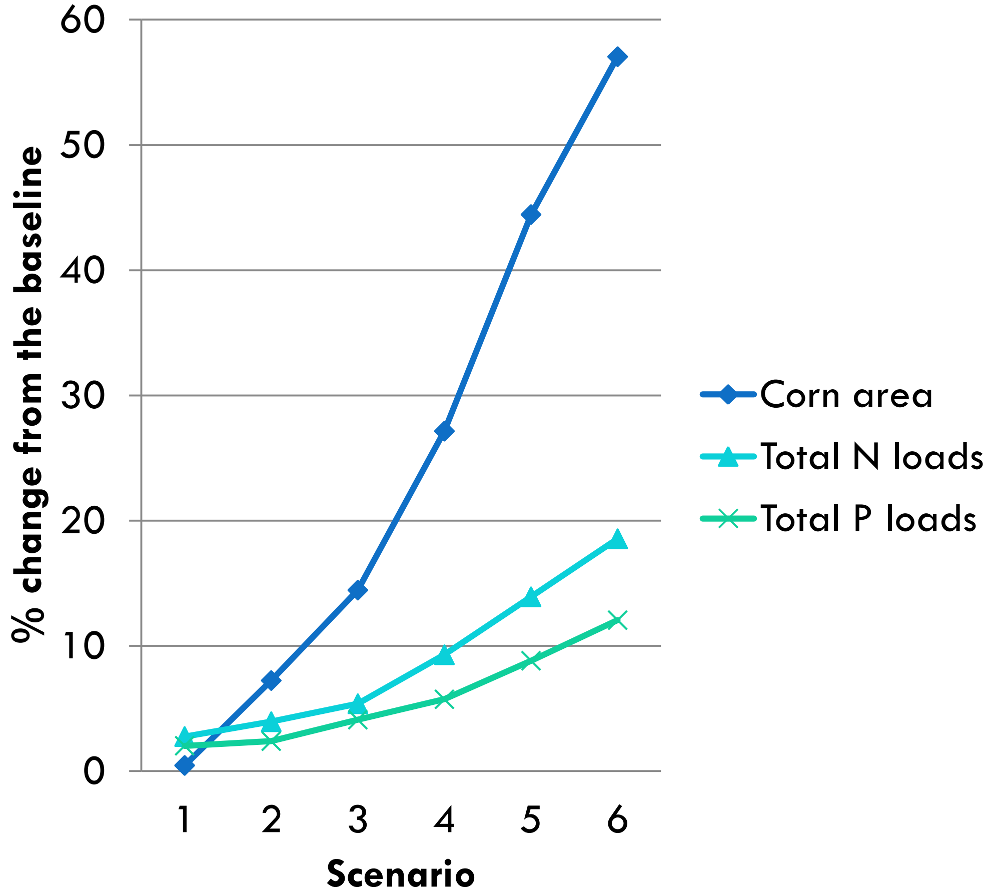
- Hydropower (the Willamette)
- Fracking (indirect impacts for biofuels)

Water quality and corn ethanol



Water quality and corn ethanol





Secchi S., P. W. Gassman, M. Jha, L. Kurkalova, and C. L. Kling. 2011. Water Quality Changes due to Corn Expansion in the Upper Mississippi River Basin. *Ecological Applications* 21(4): 1068–1084.

Water quality and corn ethanol

Historical and projected land use in Iowa on the basis of corn prices

Rotation area	Historic baseline	Corn price 108 \$ Mg^{-1}	Corn price 142 \$ Mg^{-1}	Corn price 167 \$ Mg^{-1}
Intensive margin - current cropland (km^2)				
Corn-soybean	64,389	92,066	38,618	10,717
Corn-corn-soybean	12,944	0	42,784	13,974
Continuous corn	2,556	0	10,664	67,375
Extensive margin - current CRP land (km^2)				
CRP	7,087	4,189	2,492	2,027
Corn-soybean	0	2,898	2,952	1,050
Corn-corn-soybean	0	0	1,501	1,561
Continuous corn	0	0	142	2,449

Secchi, Silvia, Lyubov Kurkalova, Philip W. Gassman, and Chad Hart. "Land use change in a biofuels hotspot: The case of Iowa, USA." *Biomass and Bioenergy* 35, no. 6 (2011): 2391-2400.

Water quality and corn ethanol

Historical and projected environmental indicators in Iowa

	Historic baseline	Corn price 108 \$ Mg^{-1}	Corn price 142 \$ Mg^{-1}	Corn price 167 \$ Mg^{-1}
Intensive margin - current cropland				
Hectares cropped (ha)	8,845,375	8,845,375	8,845,375	8,845,375
Sediment losses (Mg ha^{-1})	2.27	4.12	5.16	7.29
Nitrogen losses (kg ha^{-1})	61.63	68.93	83.78	105.64
Phosphorus losses (kg ha^{-1})	2.16	3.17	3.58	3.91
Soil carbon (Mg ha^{-1})	228.40	223.70	221.20	218.87

Secchi, Silvia, Lyubov Kurkalova, Philip W. Gassman, and Chad Hart. "Land use change in a biofuels hotspot: The case of Iowa, USA." *Biomass and Bioenergy* 35, no. 6 (2011): 2391-2400.

Water quality and corn ethanol

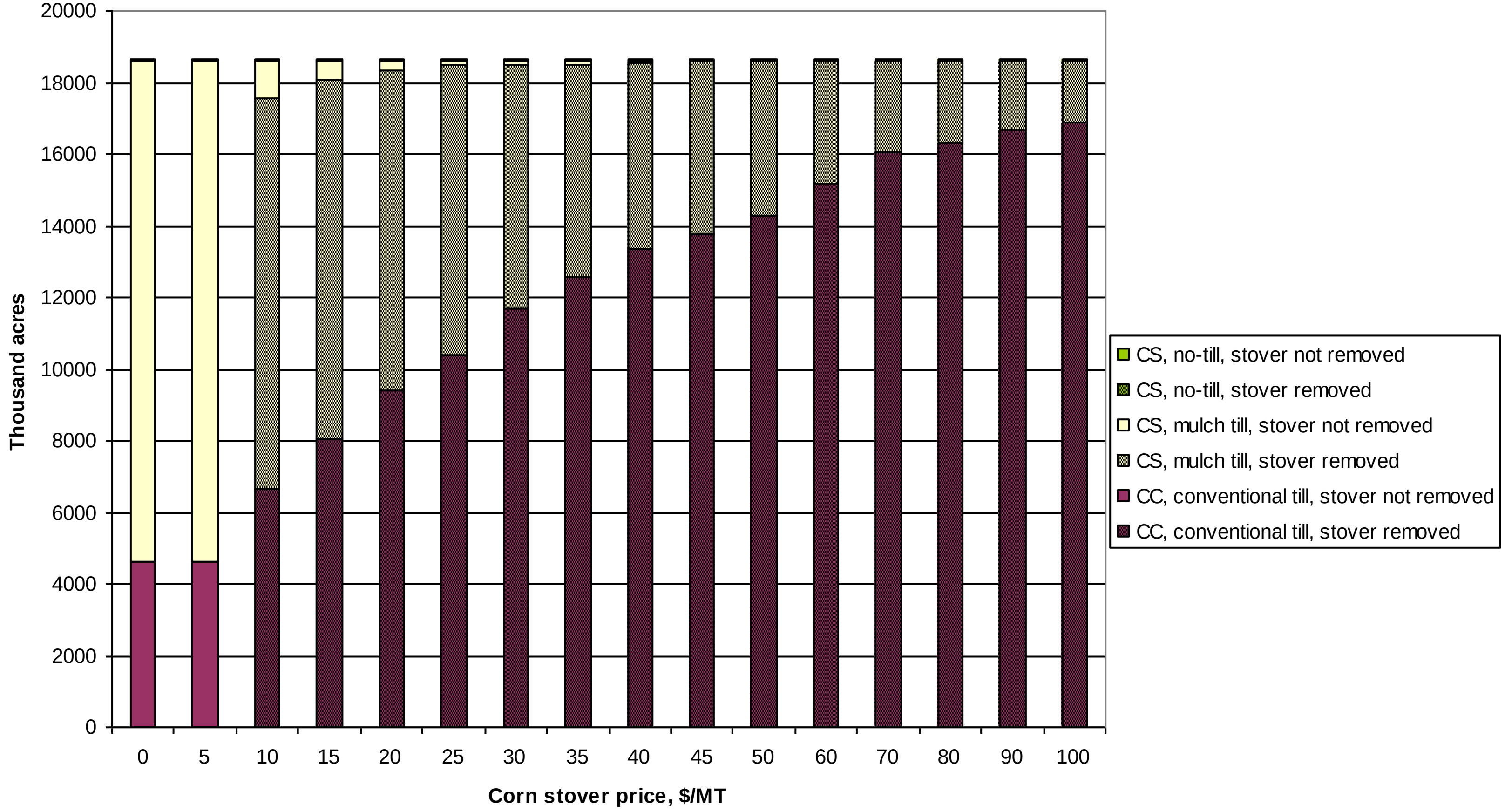
Historical and projected environmental indicators in Iowa

	Historic baseline	Corn price 108 \$ Mg^{-1}	Corn price 142 \$ Mg^{-1}	Corn price 167 \$ Mg^{-1}
Extensive margin - current CRP land				
Hectares cropped (ha)	0	263,703	421,103	462,026
Sediment losses (Mg ha^{-1})	1.65	2.66	5.78	10.71
Nitrogen losses (kg ha^{-1})	10.97	33.68	63.13	92.73
Phosphorus losses (kg ha^{-1})	0.86	1.88	3.51	4.62
Soil carbon (Mg ha^{-1})	194.41	182.95	174.87	169.29

Secchi, Silvia, Lyubov Kurkalova, Philip W. Gassman, and Chad Hart. "Land use change in a biofuels hotspot: The case of Iowa, USA." *Biomass and Bioenergy* 35, no. 6 (2011): 2391-2400.

Water quality and advanced ethanol

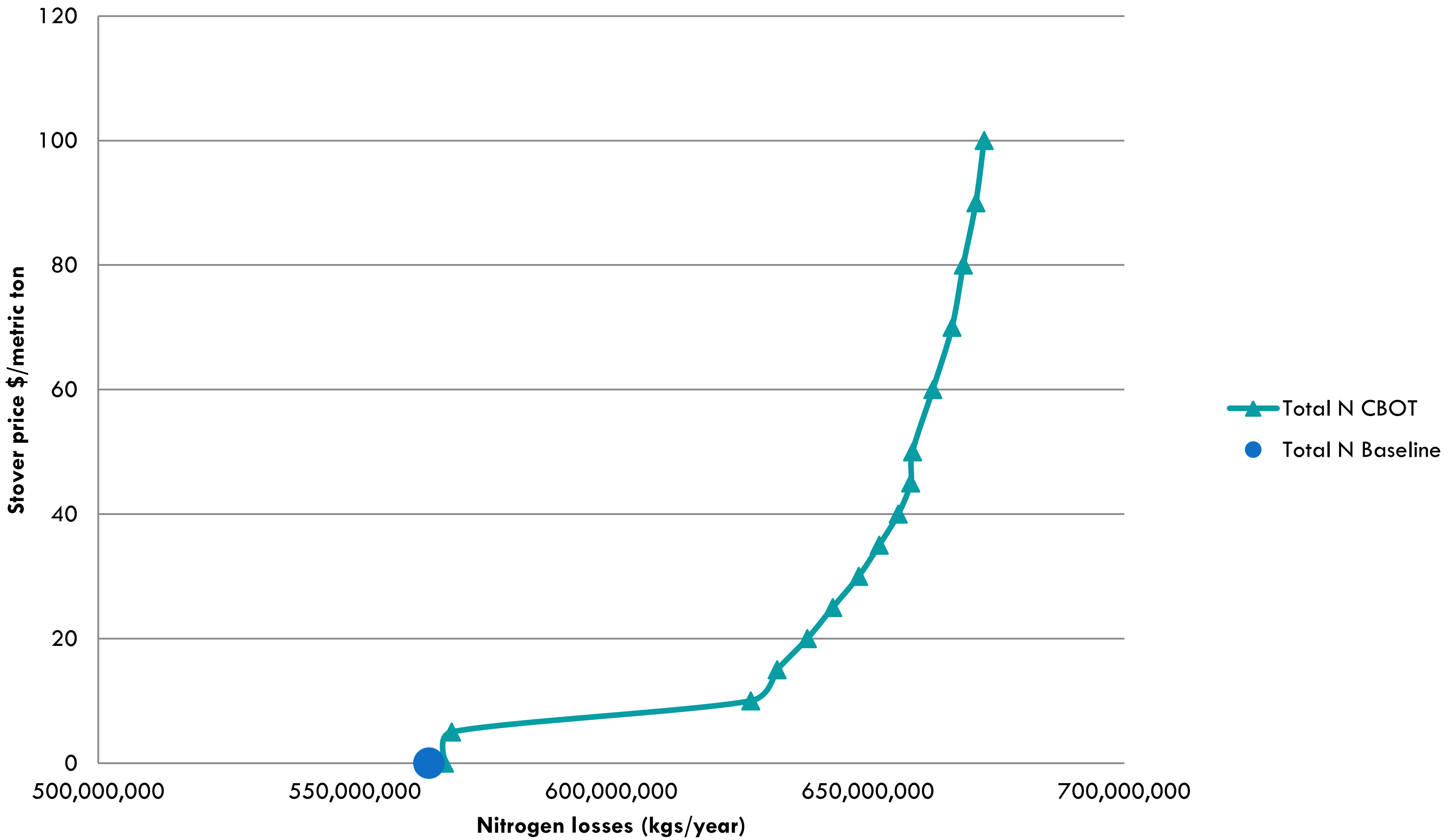
Cropland in alternative farming systems in Iowa (CBOT prices)



Kurkalova, Lyubov A., Silvia Secchi, and Phillip W. Gassman. "Corn stover harvesting: potential supply and water quality implications." In *Handbook of Bioenergy Economics and Policy*, pp. 307-323. Springer New York, 2010.

Water quality and advanced ethanol

Edge-of-field nitrogen loss supply curves corresponding to stover prices



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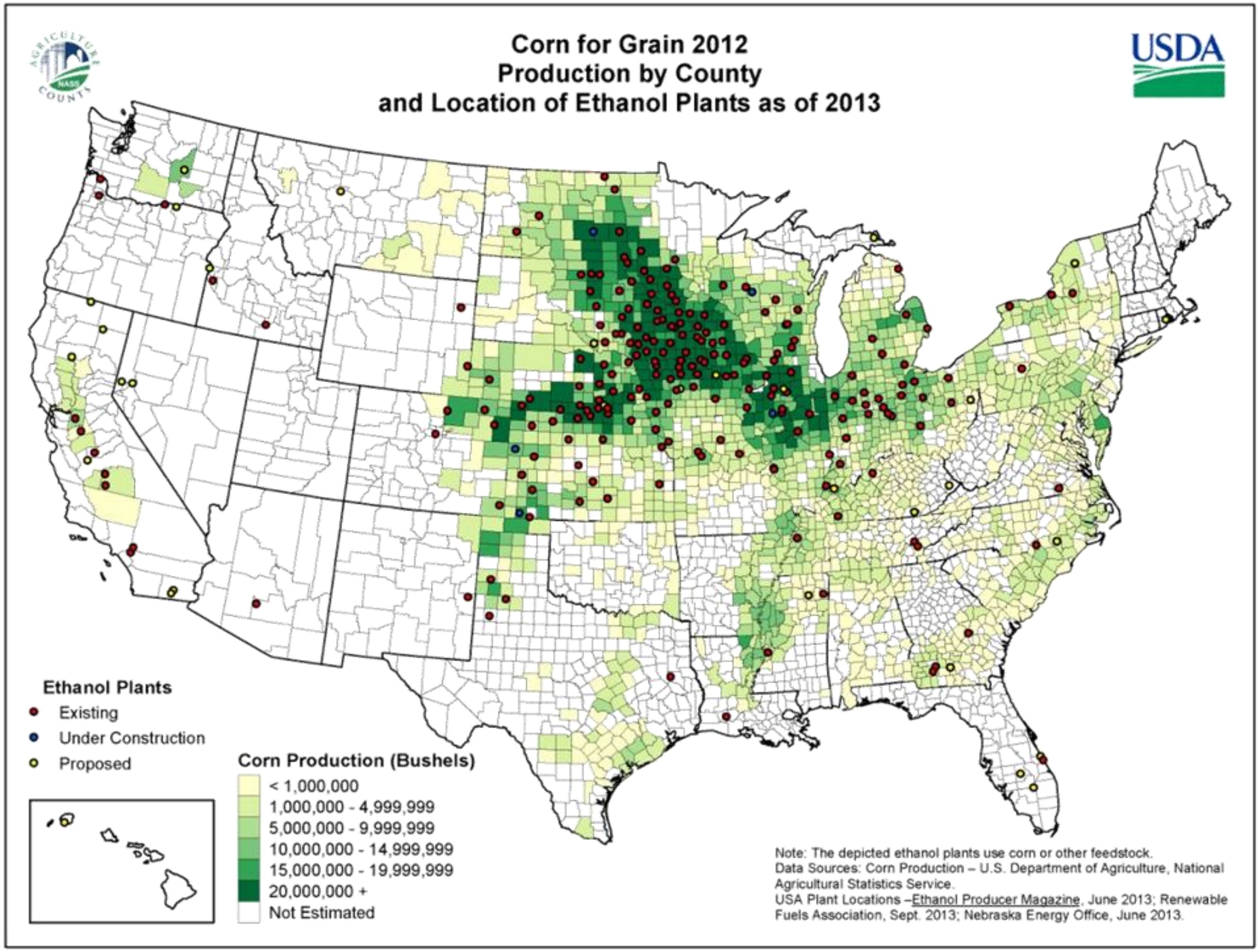
Water quality and corn ethanol (first AND second generation)

- Water markets for water quality are possible
  - There are several experiments in the Chesapeake Bay
  - But the authority of the CWA is limited in many ways to point sources, so the markets are set for point nonpoint trading
  - This will not help in the MARB where the bulk of the problem is caused by NPSP

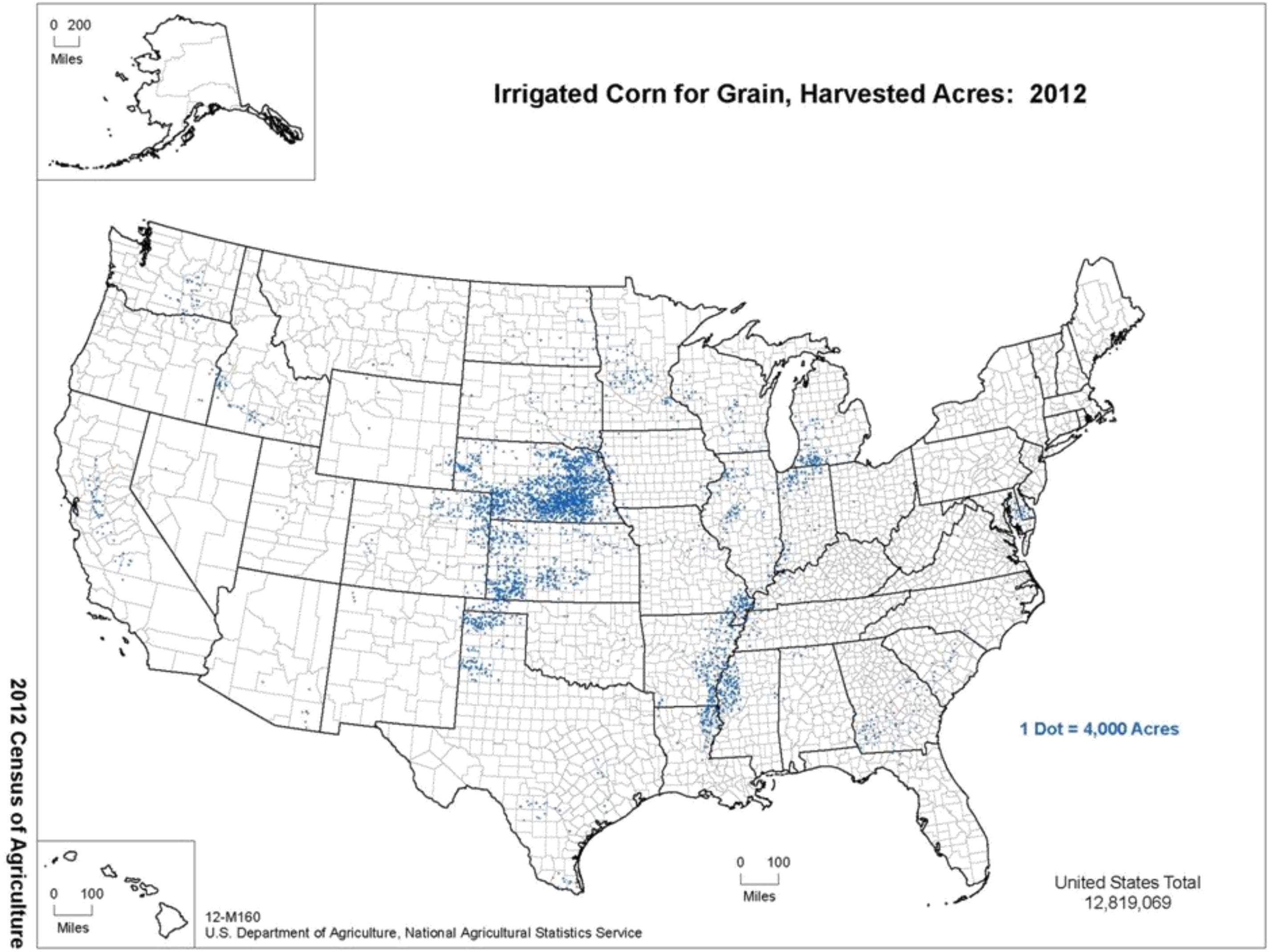
Water quality and advanced ethanol

- What about switchgrass or miscanthus?
  - Substantial crop and revenue risks
  - BCAP program provisions last only the first two establishment years
  - Some form of crop insurance tailored to these crops will be needed
  - Payments for ecosystem services in addition may be necessary
  - **Beware of leakage**

Water quantity and corn ethanol



Water quantity and corn ethanol



Water quantity and corn ethanol

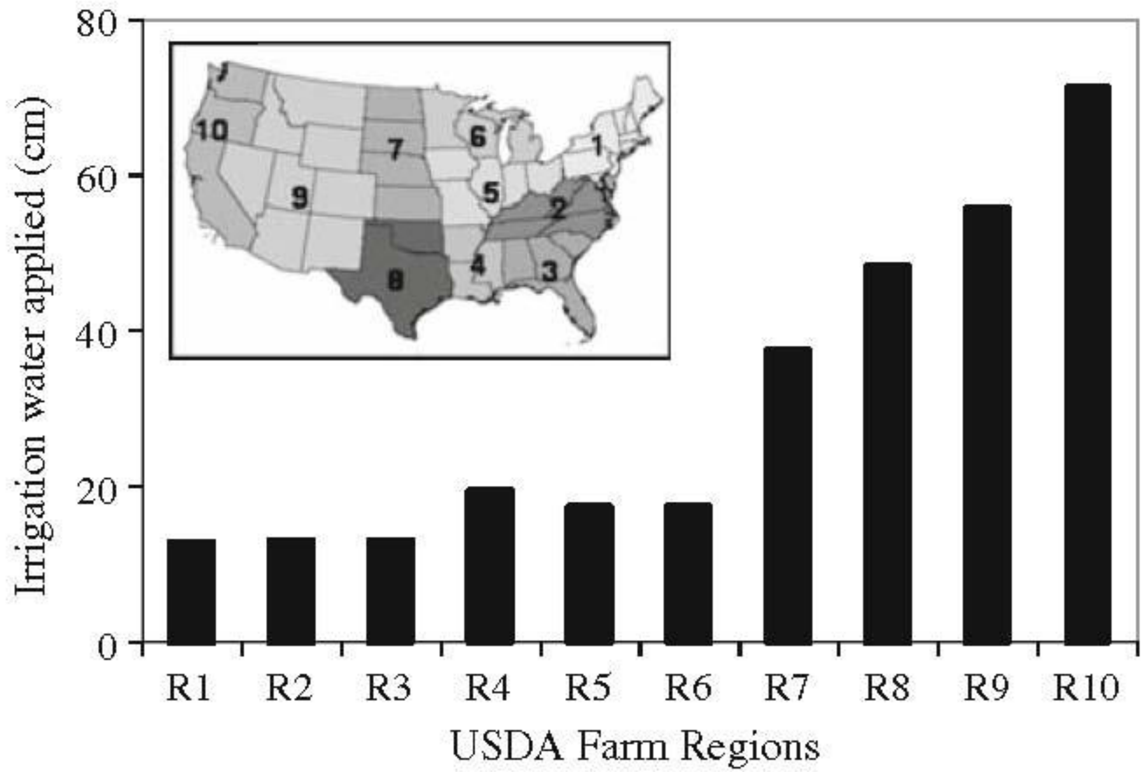


Fig. 3 Corn irrigation rate for the irrigated corn area by USDA region (Data source: USDA 2003)

Wu, May, Marianne Mintz, Michael Wang, and Salil Arora. "Water consumption in the production of ethanol and petroleum gasoline." *Environmental Management* 44, no. 5 (2009): 981-997.

Water quantity and corn ethanol

Table 1 Precipitation and corn irrigation by major corn-producing regions

USDA farm region	Average annual precipitation[a] (cm)	Area irrigated[b] (%)	Percent of U.S. irrigation water consumption for corn[c]	
			Groundwater (%)	Surface water (%)
5	96	2.2	3.4	0.2
6	75	3.9	1.8	0.4
7	55	39.7	53.4	9.5
3 regions total		12	59	10

[a] *Source*: USDC. Average precipitation value from 1895 to 2006, normalized by land area of the region

[b] *Source*: USDA-NASS Quickstat database for 2003 harvested acreage (USDA-NASS 2007, 2008). Irrigated crop areas are from 2003 FRIS (USDA 2003). Irrigated areas are weighted by harvested area for each region for 2003

[c] Calculations of irrigation water applied for corn are based on 2003 *Farm and Ranch Irrigation Survey* (USDA 2003); irrigation water consumption is based on withdrawal/consumption ratio from USGS (1995); ground water and surface water shares are determined from USGS (2000)

Wu, May, Marianne Mintz, Michael Wang, and Salil Arora. "Water consumption in the production of ethanol and petroleum gasoline." *Environmental Management* 44, no. 5 (2009): 981-997.

Water quantity and corn ethanol

- Typically, markets promote efficiency, not conservation
- Markets allocate property rights forever
- The impact of water quantity markets will depend largely on the specific institutional arrangements.
  - Agricultural to agricultural uses
    - This could intensify agricultural production
  - Agricultural to nonagricultural uses
    - This could reduce agricultural production & move water to higher value uses
  - Who gets the property rights? Farmers grandfathered in?
  - What is the geographical scope of the market?

Water quantity and advanced ethanol

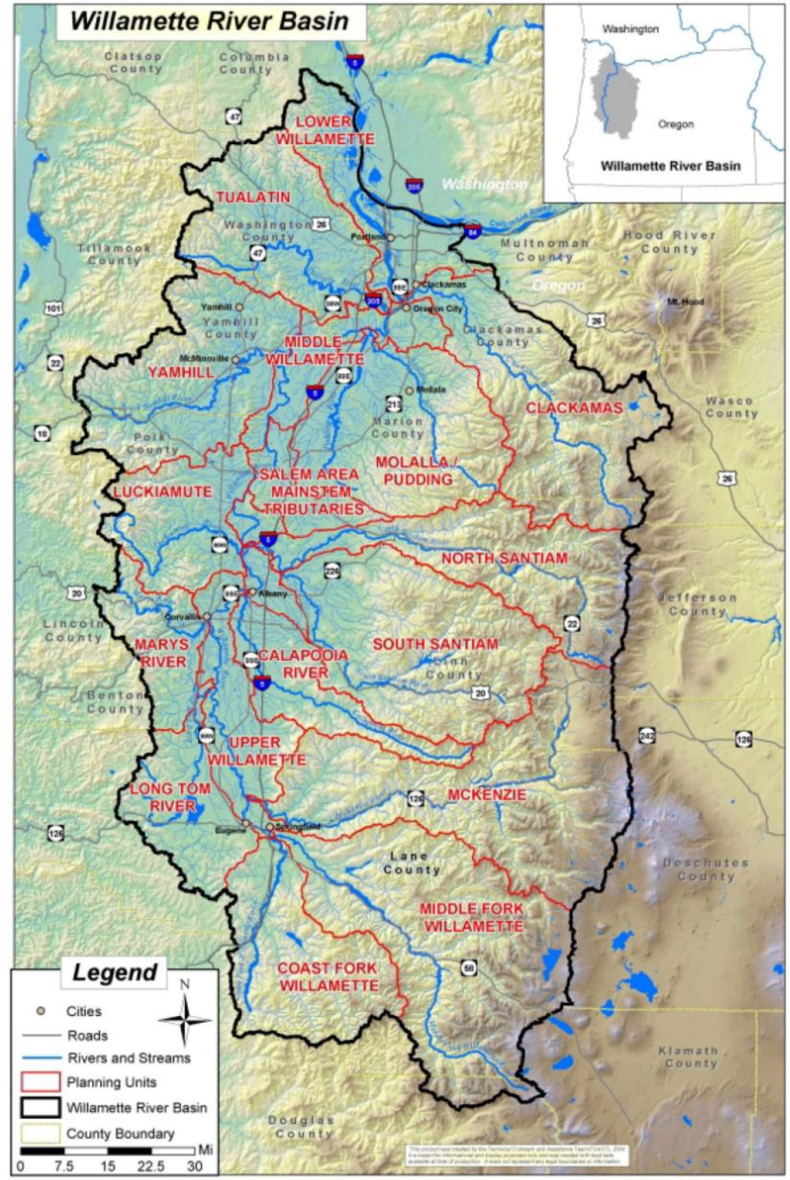
- The impact of a market for corn stover on irrigated agriculture is highly speculative – there are a few studies on the impact of non-irrigated corn stover harvest, none on irrigated corn stover harvest
- Obviously, the effects on water use could be quite large
- Switchgrass has potentially large beneficial effects for the Western part of the Corn belt but leakage is still a concern

Summary

	Technology	
Water quality	First generation **Large scale issue** ***Markets will help if the CWA is changed***	Second generation/advanced **If stover, amplification of the issue, if dedicated crops, alleviation of the problem (w/o leakage)** ***Markets will help if the CWA is changed***
Water quantity	First generation **Hotspot issue (for now*)** ***Impact of markets will depend on specifics***	Second generation/advanced **If stover, amplification of the issue, if dedicated feedstocks, alleviation of the problem (w/o leakage)** **???**

The Willamette river basin

- TMDL for water temperature
- Elevated temperature "poses a major threat to cold-water-dependent aquatic species, especially upper Willamette River spring Chinook and winter steelhead."
- Classic water quality trading set-up: point to non-point
- The non-point activities generate more benefits than lowering the temperature



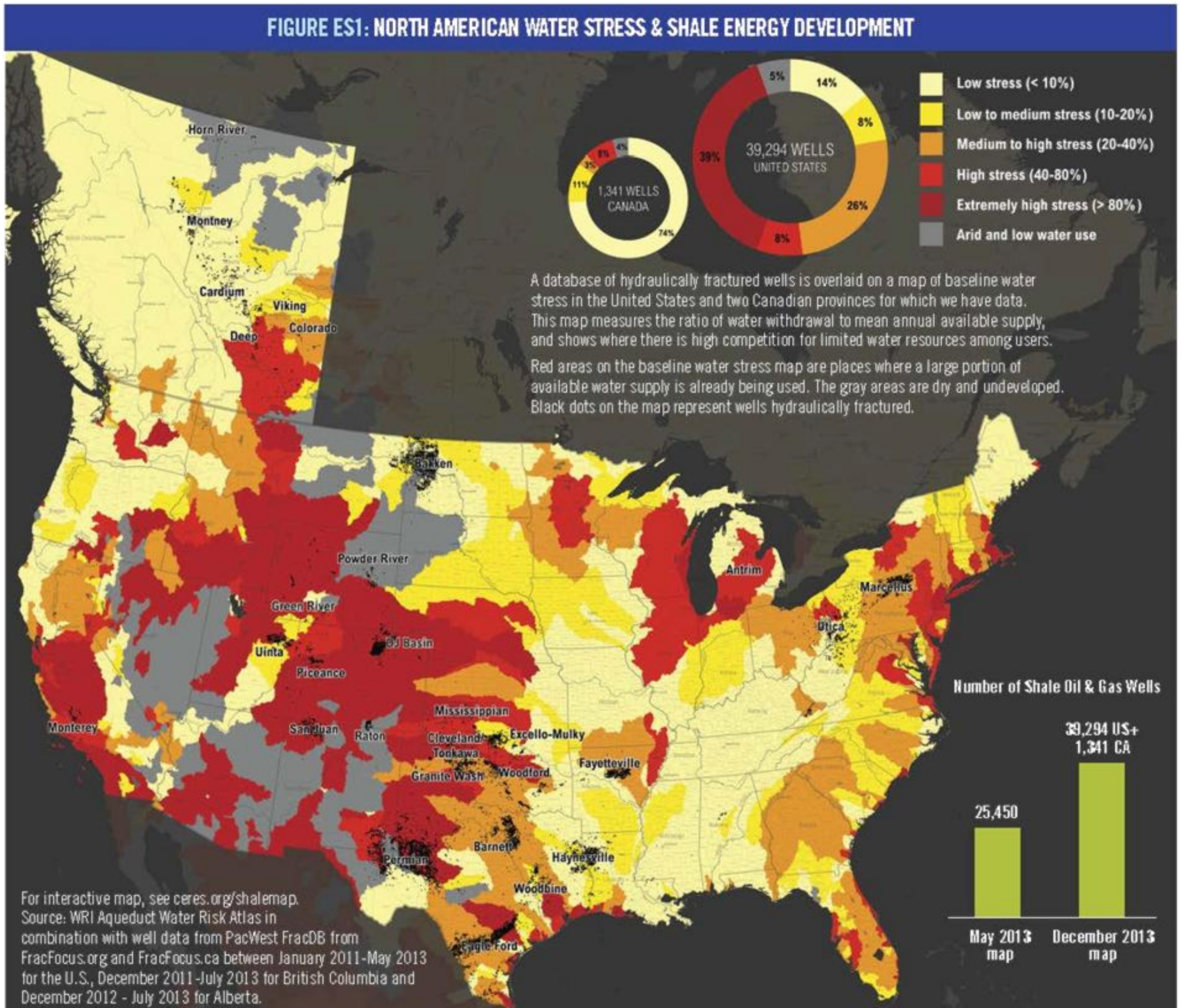
The Willamette

- Market Appraisal
- Credit Definition and Currency Development
- Temperature Credit Portfolio
- Marketplace Creation
- Market Transaction
- Project Evaluation and Market Business Plan

The Willamette

- Kilocalories per unit of time the basic currency for water temperature trades. “A significant amount of research has been compiled on methods to calculate kilocalorie reductions from various activities” .
  - Wastewater reclamation/reuse;
    - Point to point; performance based (Point of Maximum Impact).
  - flow augmentation;
    - Point to nonpoint (reservoir); performance based.
  - riparian shading;
    - Point to non-point; practice based.
  - floodplain/hyporheic restoration;
    - Point to nonpoint (floodplain); performance based*.
  - wetlands discharge/restoration
    - Point to nonpoint (wetland); performance based*.
  - * = model based, ad hoc

Fracking and water



"Nearly half of the wells hydraulically fractured since 2011 were in regions with high or extremely high water stress, and over 55 percent were in areas experiencing drought."

Freyman, Monika. 2014.Hydraulic Fracturing & Water Stress: Water Demand by the Numbers. CERES Report.

Thank you