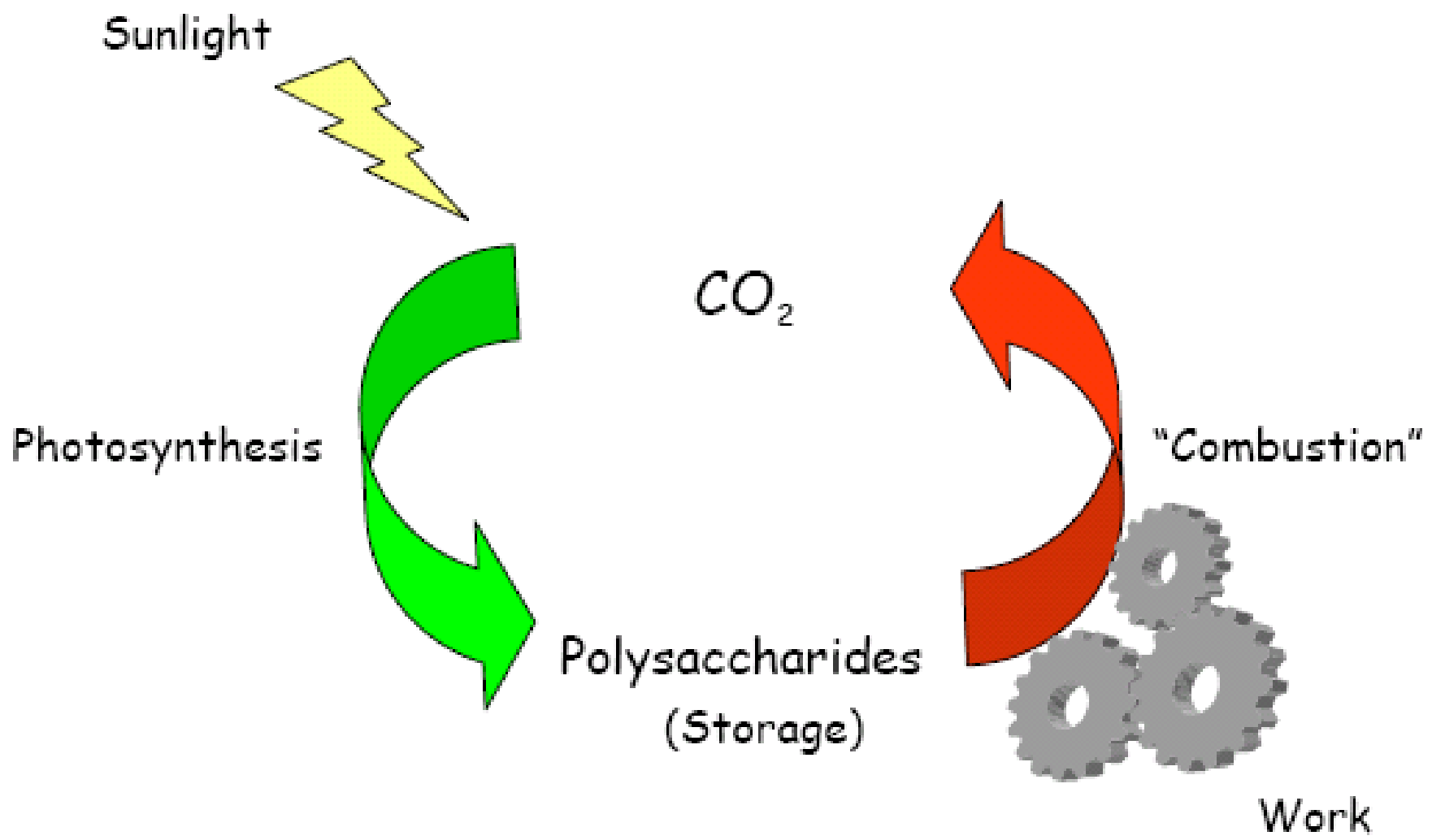


Combustion of biomass provides carbon neutral energy



Feedstock Credit is Critical to Findings of Greenhouse Gas Benefits

Source of Fuel*	Making Feed-stock	Refining Fuel	Vehicle Operation (Burning Fuel)	Net Land Use Effects		Total GHGs	% Change in Net GHGs vs. Gasoline
				Feedstock Uptake from Atmosphere (GREET)	Land Use Change		
Gasoline	+4	+15	+72	0	-	+92	-
Corn Ethanol (GREET)	+24	+40	+71	-62	-	+74	-20%
						+135 without feedstock credit	+47% without feedstock credit

Greenhouse gasses (CO2) per mega joule of fuel

Why a feedstock credit?

- Land already exists
- Forests and Grassland
- Cropland produces carbon benefit in form of protein, carbohydrates, fats.

Land Use Change Emissions Mean All Foregone Storage and Ongoing Sequestration

Emission from Land Use Change

- Release of carbon stored in plants and soil when forest and grassland is plowed up directly or indirectly

Foregone ongoing sequestration

- Foregone annual, ongoing carbon sequestration on former grassland and forest that was converted or on croplands that would revert to grassland or forest absent biofuel demand



What About Abandoned Lands in Eastern Europe or Former Soviet Union?

- Our average Latin America – 337 t/ha
- Former Soviet Union Abandoned – 328 t/ha (assuming 50% forest, 50% grassland, 10 years of abandonment)
- Compare 711 t/ha temperate evergreen forest with 823 t/ha tropic rainforest

Feedstock Credit Without Land Use Change Is One Sided Accounting of Land Use Effect

Biofuel can only justify atmospheric credit if and to extent:

(1) growing feedstock for biofuel causes a NET INCREASE in carbon removed by land overall, or

(2) the biofuel uses material that would otherwise return to the atmosphere anyway without doing work.

The Basic Story

- Most diverted grain replaced (even after crediting biofuel feed by-products)
- Breaking out cropland will replace most new demand
- Gains versus losses are low

Corn-based ethanol (2015) 1.8 tonnes/hectare/year gain
(GHG Co2 eqv.)

Switchgrass (2015) 8.6 tonnes/hectare/year gain

versus

Forest conversion 604-1146 tonnes/hectare loss + ongoing
sequestration

Grassland conversion 75 – 305 tonnes/hectare loss (+ displaced
grass feed)

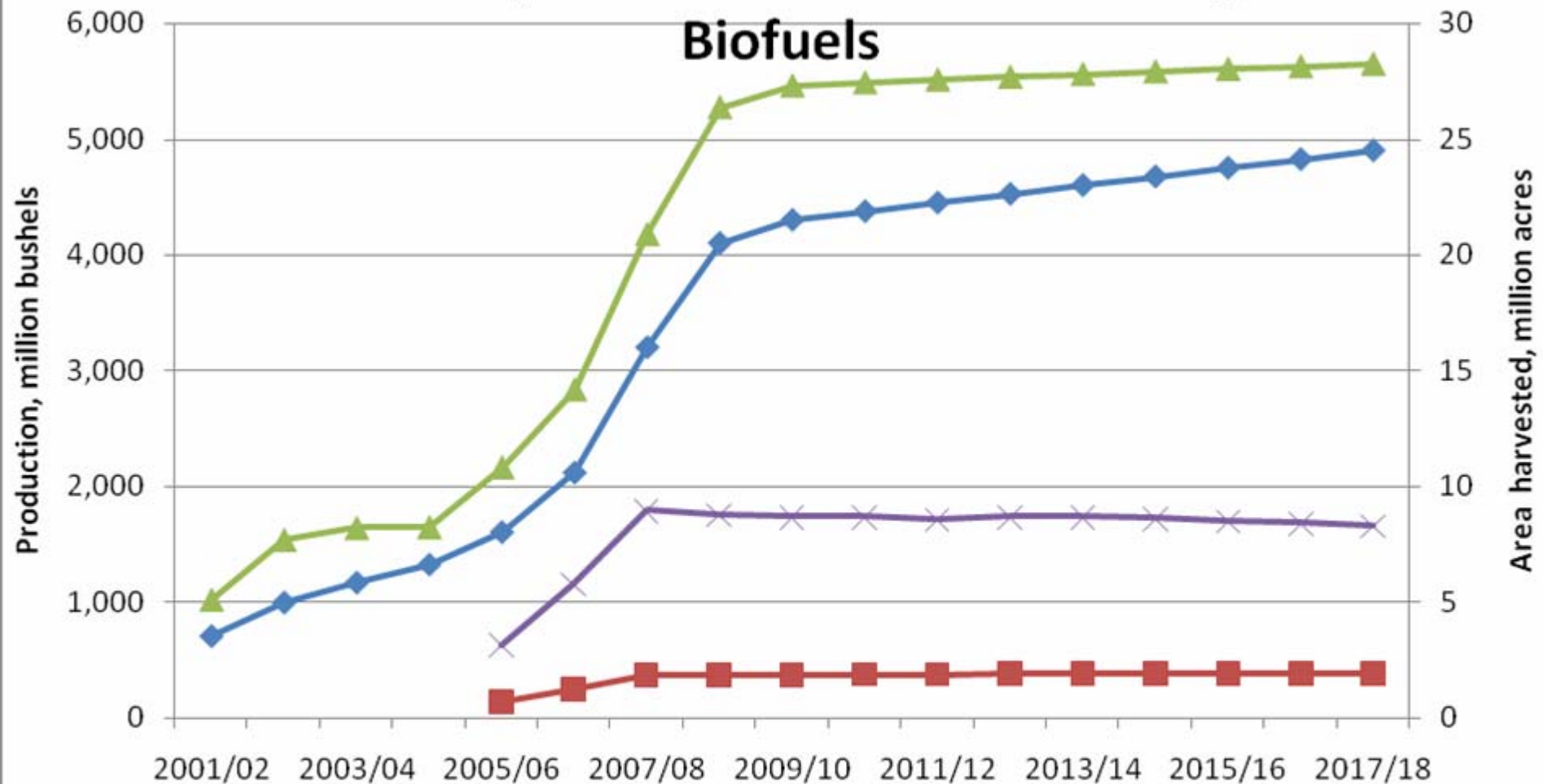
Our weighted average 350 t/ha

GREENHOUSE GAS RESULTS

grams of greenhouse gas emissions (CO₂ equ.) per mega joule

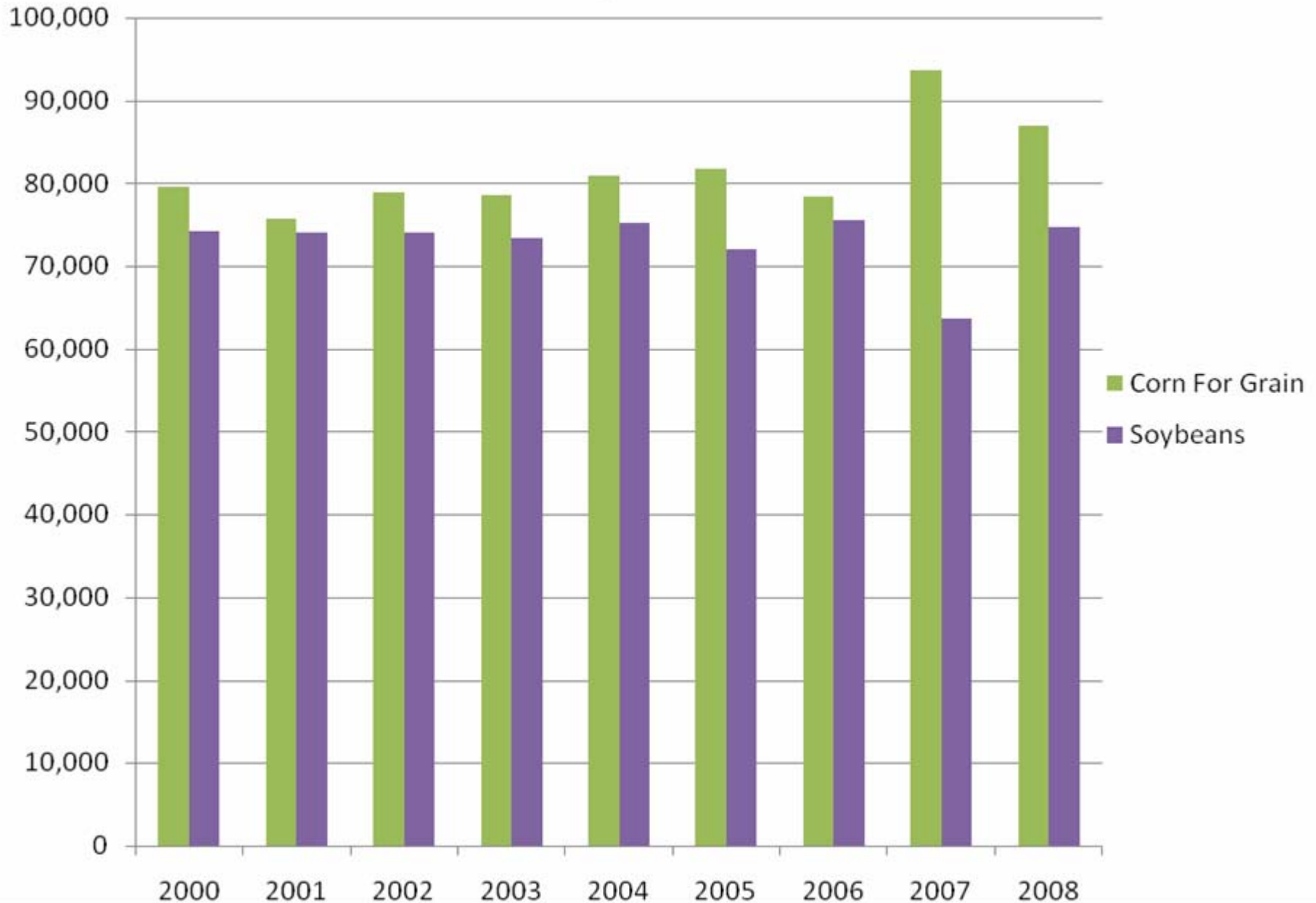
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Gasoline	+4	+15	+72	0	–	+92	–
Corn Ethanol (GREET)	+24	+40	+71	-62	–	+74	-20%
						+135 without feedstock credit	+47% without feedstock credit
Corn Ethanol + Land Use Change	+24	+40	+71	-62	+104	+177	+93%
Biomass Ethanol (GREET)	+10	+9	+71	-62	–	+27	-70%
Biomass Ethanol + Land Use Change	+10	+9	+71	-62	+111	+138	+50%

Corn and Soybean Production and Acreage for Biofuels

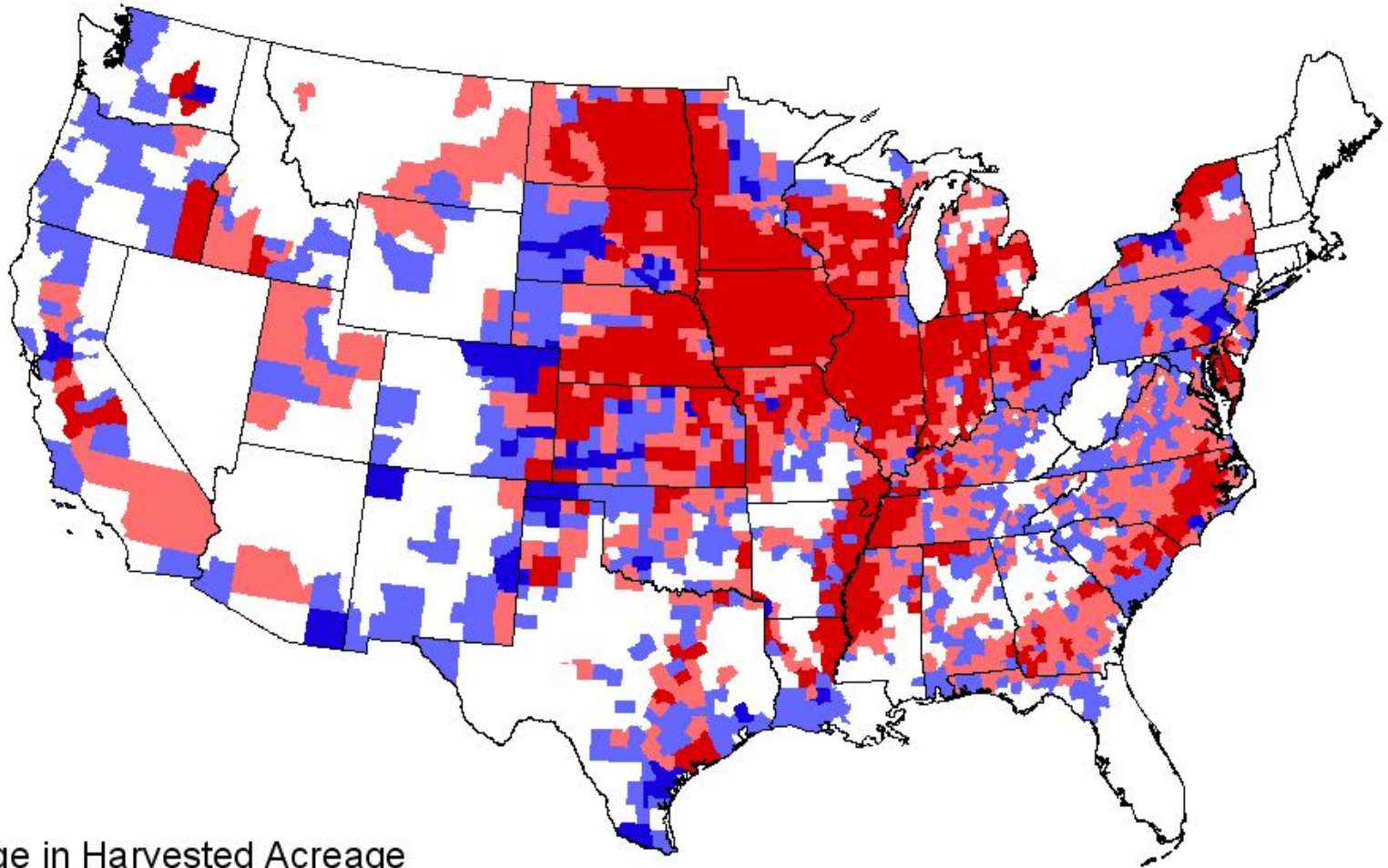


- ◆ Corn Production for Ethanol
- ▲ Corn acreage harvested for ethanol
- Soybean Production for Biodiesel
- × Soybean acreage harvested for biodiesel

Planted Acreage, U.S. 2000-2008



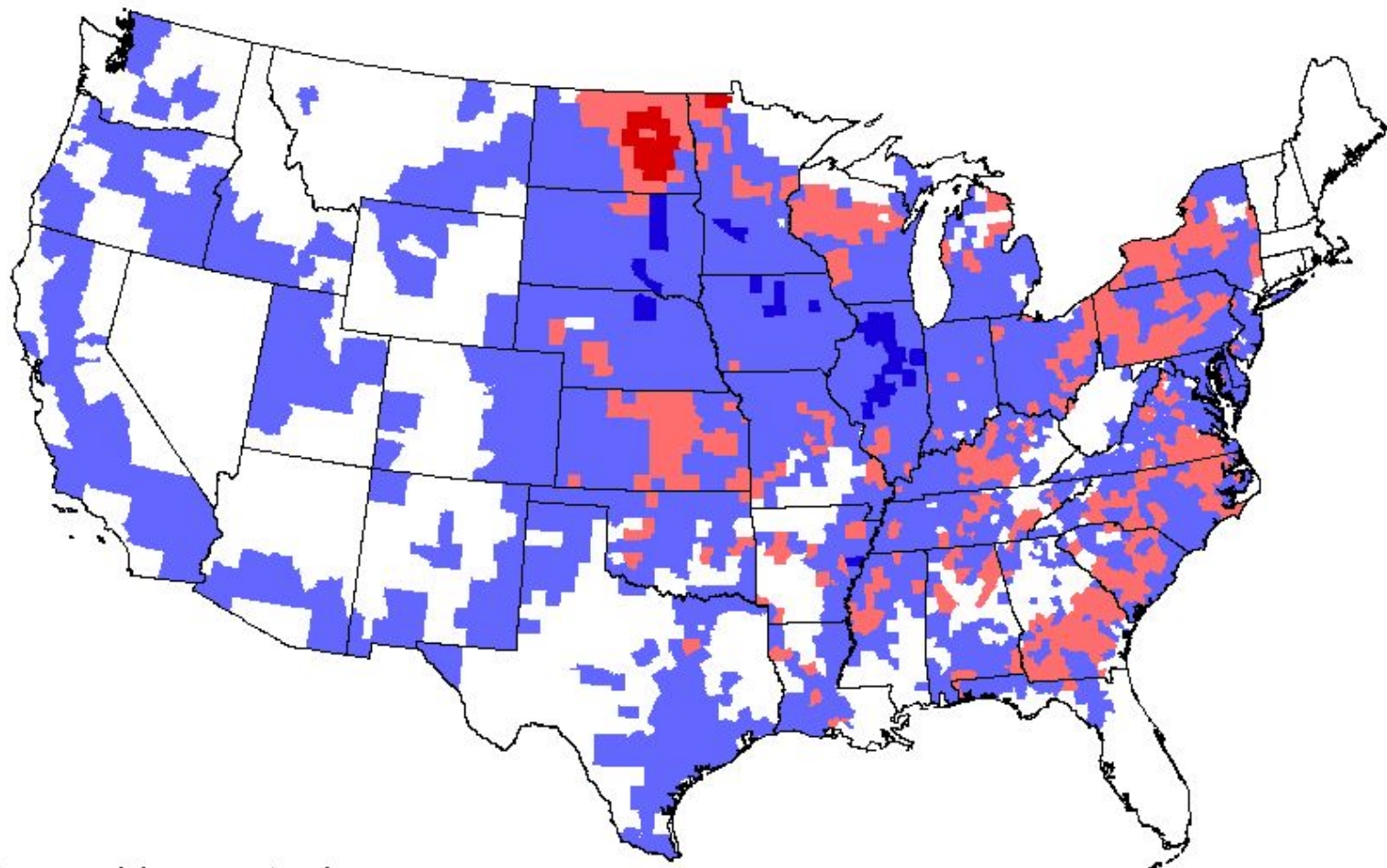
Change in Harvested Corn Acreage, 2000-2007



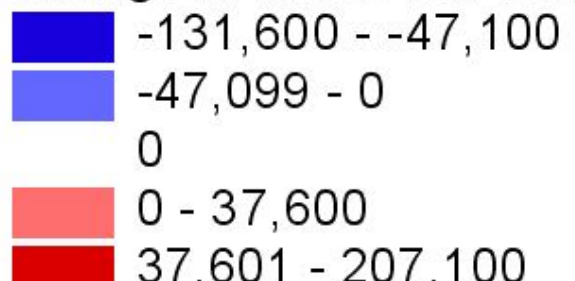
Change in Harvested Acreage



Change in Soybean Acreage Harvested, 2000-2007



Change in Acres Harvested



Corn and Soybean Harvested Acres and Prices

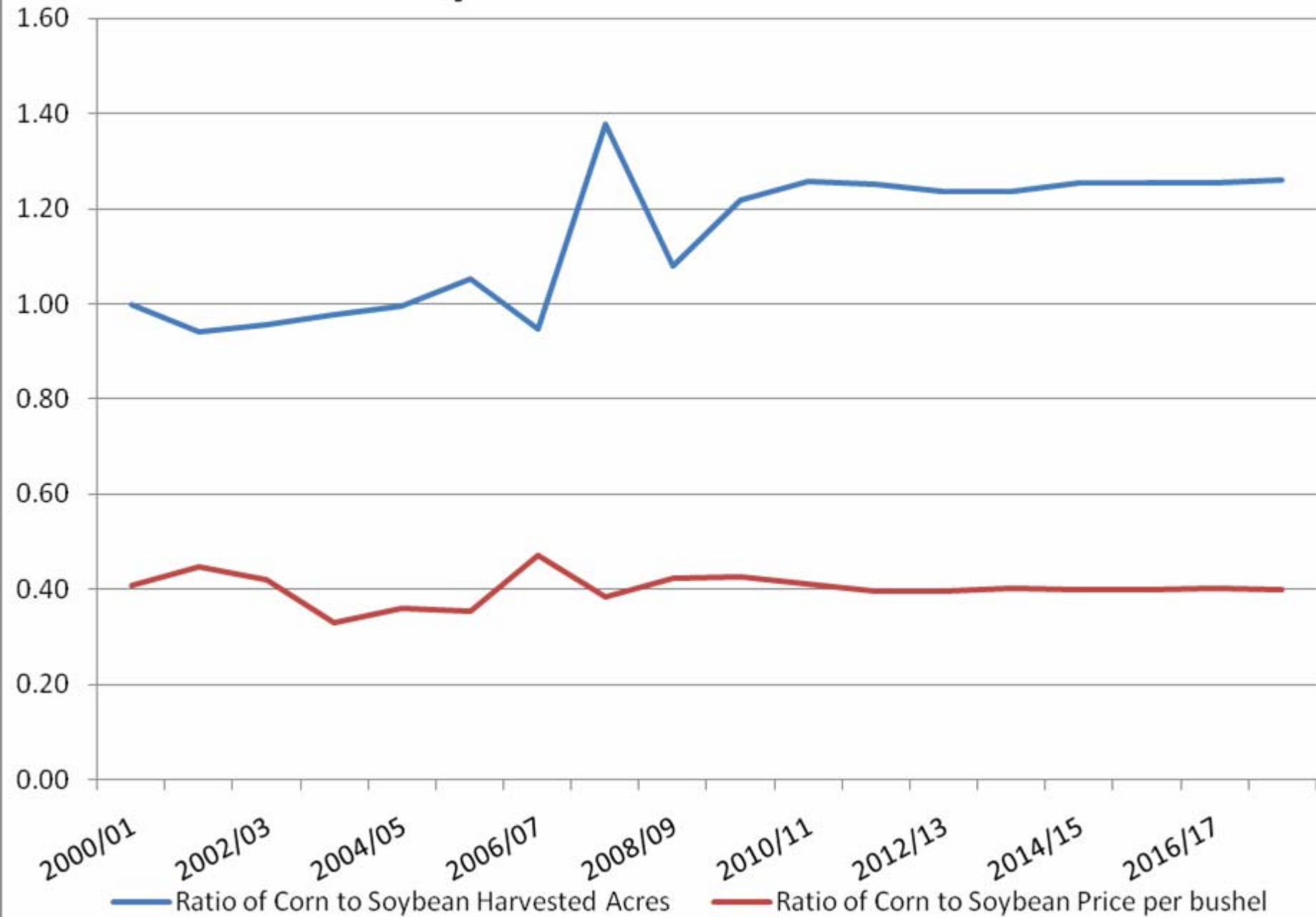
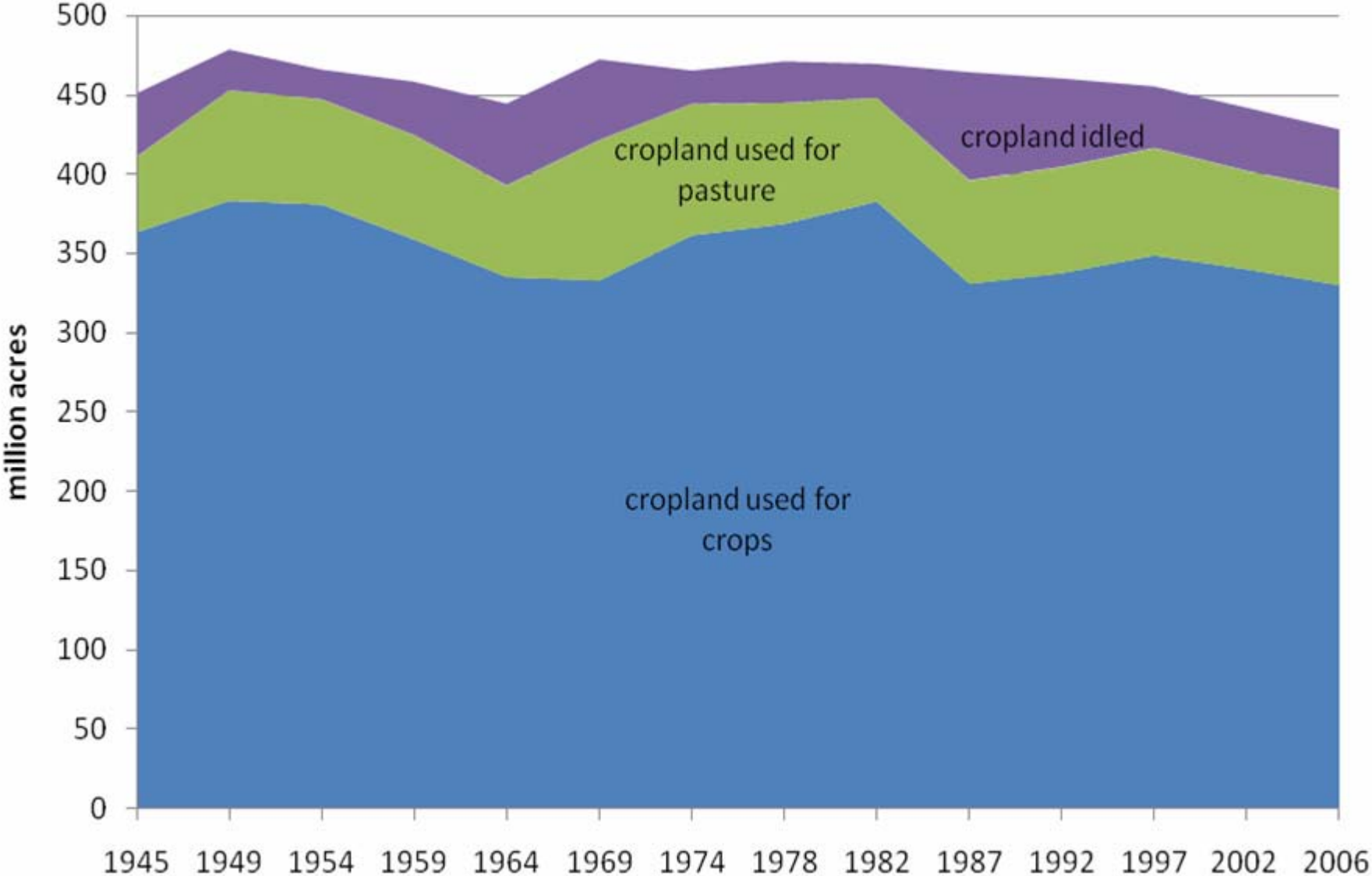


Table 1—Corn and Soybean area, 2000-2017

Crop	2000/01	2006/07	2007/08 (est.)	2017/18 (proj.)
	Million acres			
Corn (harvested)	72.2	86.0	79.3	84.6
Soybeans (harvested)	72.1	62.3	73.3	67.1
Total	144.3	148.3	152.6	151.7
Eight major crops (planted)	247.6	246.5	252.1	244.0

Source: NASS data for 2000/01 and 2006/07, NASS estimates for 2007/08, USDA baseline for 2017/18.

Disposition of U.S. Cropland, 1945-2006



Most profitable CRP acres likely to recrop to meet 32 million acre cap

Area	Most Profitable	Expiring in 2008-12
Midwest States ¹	3,424,693	5,242,555
Other States	3,934,131	15,141,087
U.S. Total	7,358,824	20,383,642

¹Includes Illinois, Indiana, Iowa, Ohio, Missouri, Nebraska, Minnesota, Wisconsin, and South Dakota

Table 4—Estimated change in sheet and rill erosion from recropping CRP land to meet 32 million acre cap

Area	CRP Acres Potentially Recropped	Sheet and Rill Erosion rate (tons per acre per year)		Total Erosion (tons per year)	
		Corn and Soybean Rotations	CRP Cover	Sum of Corn Soybean Erosion	Sum of CRP Erosion
Midwest States ¹	3,424,693	2.47	0.22	8,457,570	756,261
Other States	3,934,131	1.69	0.17	6,612,176	680,415
U.S. total	7,358,824	2.05	0.20	15,069,746	1,436,676

¹Includes Illinois, Indiana, Iowa, Ohio, Missouri, Nebraska, Minnesota, Wisconsin, and South Dakota

Factors Increasing Nitrogen

- Shift to corn/corn from corn/soybeans
- Increased marginal value of nitrogen
- Increase in crop area – reduction in CRP

Donner/Kucharik (PNAS 2008)

- 15 billion gallons mean
 - 10% (increase in nitrogen flow to Gulf (1% increase in yields plus CRP land)
 - 18% (corn comes from soybeans)

N flows roughly 40% higher than EPA goal, and 60% higher than biological goal

WRI Study in 2006

- “Beyond the RFS: The Environmental and Economic Impacts of Increased Grain Ethanol Production in the U.S.”, Liz Marshall and Suzie Greenhlagh
- Compares a 5 Bn gallon ethanol baseline for 2012 with 7.5 to 15 Bn gallon RFS mandates
- Cropland increases from 320 M acres to 324-332 M acres
- Corn acreage increases from 80.5 M acres to 82.5-90.7 M acres
- Fertilizer use increases 2-8.4 percent
- N losses to water increase 1.5-5.6 percent
- Soil erosion increases 1.5-5.3 percent

Table 8—Parameters of regressions on nitrogen use on corn per acre, 1964-2005

Dependent variable	Adjusted R-Square (percent)		Corn yield (lbs/bus hel)	Corn price (lbs/\$)	Nitrogen Price Index (lbs/index point)	Obs. (number)
N use per acre	96.0	coefficients	0.8087	21.408	-0.1576	407
<i>F statistic</i>	3,472.88	<i>t statistics</i>	20.33	12.58	-3.44	

Sources: Fertilizer use time-series data, ERS, USDA at

<http://www.ers.usda.gov/Data/FertilizerUse/>

and State-level corn yield and price data, NASS, USDA and BLS producer price index data for nitrogen fertilizer prices.

Table 9—Estimated changes in N fertilizer use, 2005 and 2017/18 prices and yields

Year	2005 ¹	2017/18 ²	Percent change from 2005
Corn price, \$/bushel	\$2.00	\$3.60	80.0%
Corn yield, bu/acre	152.4	177.4	16.4%
N price index, 1982=100	197	325.9	65.4%
Pounds per acre	139.6	169.1	21.1%
Corn acres planted, million	81.8	92	12.5%
N fertilizer use, million tons	11,420	15,560	36.2%

¹Actual pounds per acre for 2005.

²Estimated pounds per acre and pounds per bushel based on prices, yields, and N fertilizer price index. N price index for 2017/18 set at 2008 level.

Table 2

Summary of 'Normal+50' nitrogen strip trials for corn after corn in 2007

Trial ID	N form	Time	Normal rate lbs. N/acre	Yield		
				Normal rate	Normal+50	Yield Difference
				bu./acre		
ST2007044A	UAN	Preplant	140	196	209	12.7
ST2007047A	NH3	Preplant	165	193	191	-1.8
ST2007052A	UAN	Preplant	150	161	168	7.1
ST2007053A	NH3	Preplant	192	176	176	0.0
ST2007274A	NH3	Preplant	100	170	170	0.1
ST2007277A	NH3	Preplant	130	192	205	12.8
ST2007386A	NH3	SD	173	147	158	11.3
ST2007443A	NH3	Fall	165	177	189	11.4
ST2007444A	NH3	Fall	223	199	211	11.6
ST2007445A	NH3	Fall	198	174	178	4.4
ST2007446A	NH3	Fall	221	186	187	1.8
ST2007447A	NH3	Preplant	168	186	192	6.1
ST2007449A	NH3	Preplant	173	203	206	2.8
ST2007079A	NH3+NS	Fall	205	208	216	7.4
ST2007565A	NH3	Fall	155	191	177	4.8
Average			171	184	190	6.2

Nitrous Oxide

- If biofuels increase price by \$1.00 and 21 lbs of nitrogen fertilizer per acre producing 3 additional bushels – a 7 to 1 ratio
- A 6% nitrous oxide formation rate for this added N, versus 1.5% normal, implies a more than 50% increase in nitrous oxide emissions from U.S. corn land

Pesticides Corn Versus Soybeans

- Corn 2.6 lbs/acre v. soybeans 1.1 lbs
- Corn acute human toxicity/lb 8 times higher than soybean
- Corn chronic human toxicity/lb twice soybean
- Adjusted for quantity and toxicity
corn acre = 21 x soybeans for acute toxicity
corn acre = 5 x soybeans for chronic toxicity

Table 10—Parameters of regression on pesticide active ingredient use on corn per acre, 1990-2005

Dependent variable	Adjusted R-Square (percent)		Corn yield (lbs/bushel)	Corn price (lbs/\$)	Price Index (lbs/index point)	Obs. (number)
AI use per acre	96.0	coefficients	0.010851	0.908	-0.008	165
<i>F statistic</i>	<i>1,022.74</i>	<i>t statistics</i>	<i>4.59</i>	<i>8.56</i>	<i>-2.20</i>	

Sources: Pesticide use time-series data, NASS at http://www.pestmanagement.info/nass/app_usage.cfm and State-level corn yield and price data, NASS, USDA and price index data for ag chemicals prices.

Table 11—Estimated changes in pesticide use on corn acres 2005 and 2017/18 prices and yields

Year	2005 ¹	2017/18 ²	Percent change from 2005
Corn price, \$/bushel	\$2.00	\$3.60	80.0%
Corn yield, bu/acre	152.4	177.4	16.4%
N price index, 1982=100	123	137	11.4%
Pounds per acre	2.0817	4.0974	96.8%
Corn acres planted, million	81.8	92	12.5%
pesticide use, million pounds active ing.	170	377	121.4%
Chronic Index units per pound, average ³	18,430	25,000	35.6%
Acute index units per pound, average ⁴	1.08	0.75	-30.6%
Chronic index units, million units	3,138,317	9,424,012	200.3%
Acute index units, million units	183.9	282.7	53.7%

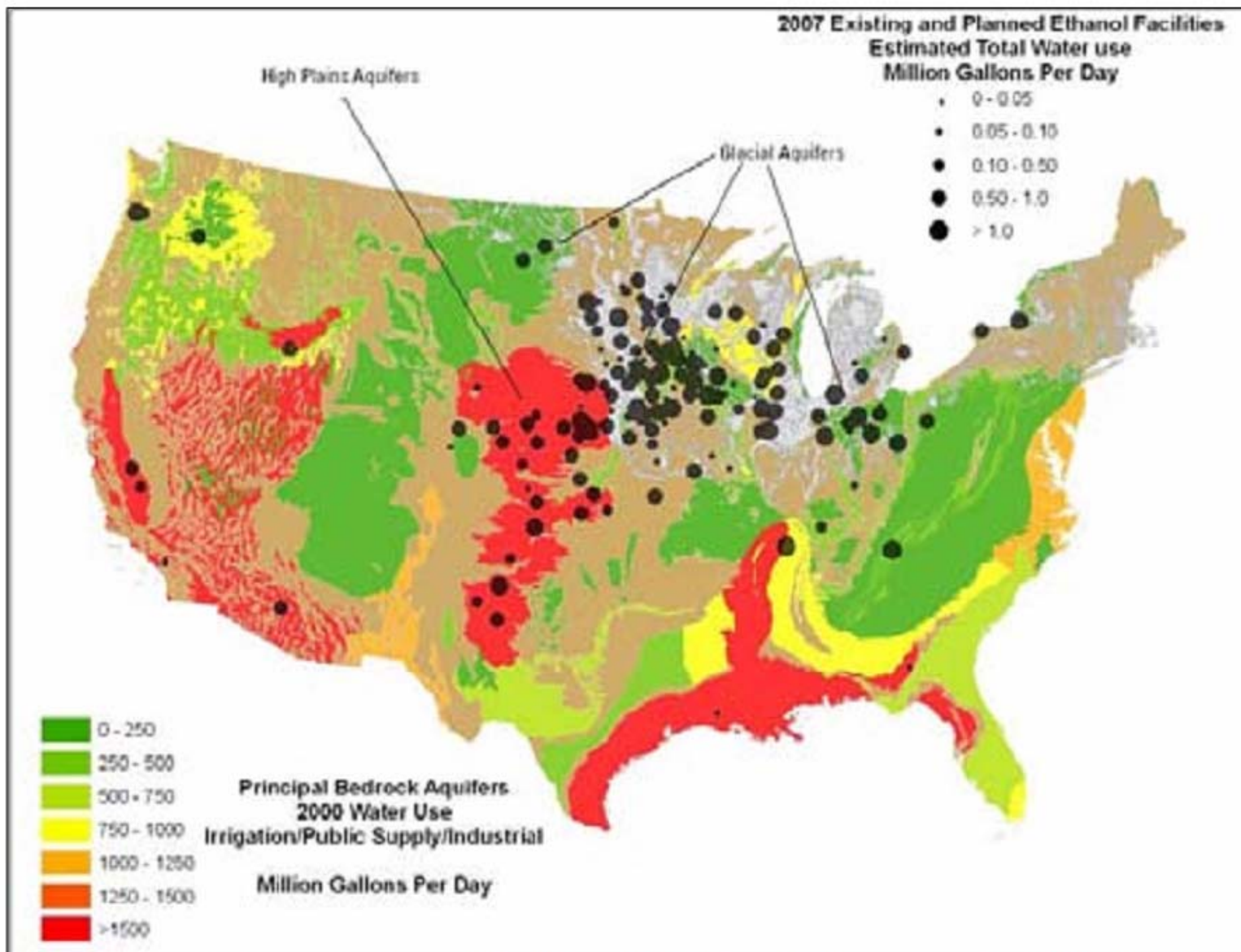
¹Actual pounds per acre for 2005.

²Estimated pounds per acre and pounds per bushel based on prices, yields, and N fertilizer price index. N price index for 2017/18 set at 2008 level.

³Average chronic index per pound of corn pesticide AI in 2000 to 2003, increased for 2017/18. ⁴Average acute index per pound of corn pesticide AI in 2000 to 2003, decreased for 2017/18.

Calculating Increased Nitrogen Oxide in Switching from Corn/Soybeans to Corn/Corn (per acre/year)

- Corn Fertilizer in Rotation with Soybeans: 170 bushel corn – at 1.2 lbs of N/bushel equals 204 lbs of N, minus soybean credit equals – 154
+ 20 lbs starter fertilizer for soybeans (maybe)
Total 174 lbs
- Corn Fertilizer Without Rotation
Corn = 1.2 lbs/bushel = 204 (no soybean credit)
Corn after corn -- 204 + 204 = 408
Difference: Increase of 234 pounds per acre/year (408-174)
- Nitrous Oxide formation: at 1.7% of N forms nitrous oxide = 3.978 pounds/acre/year increase
At 310 global warming potential equals 1,233.18 lbs of CO₂
At 453.59237 g/lb equals 559,361 grams of CO₂/acre/yr



Existing and planned ethanol facilities (2007) and their estimated total water use mapped with the principal bedrock aquifers of the United States and total water use in year 2000. SOURCE: Janice Ward, U.S. Geological Survey.