

Growing Crops for Biofuels: Implications for Water Resources

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Why the demand for ethanol?

- **Ethanol replacing MTBE as additive**
- **Energy Independence and Security Act 2007**
 - Reduce dependence on volatile regions for fuel
 - Renewable fuel increase from 4 B gal (2006) to 36 B gal (2022)



Corn
(Grain)



Sugarcane
(Sugar)



Switchgrass
(Cellulose)



Soybean
(Oil)

Do biofuel crops use more water
than conventional crops?

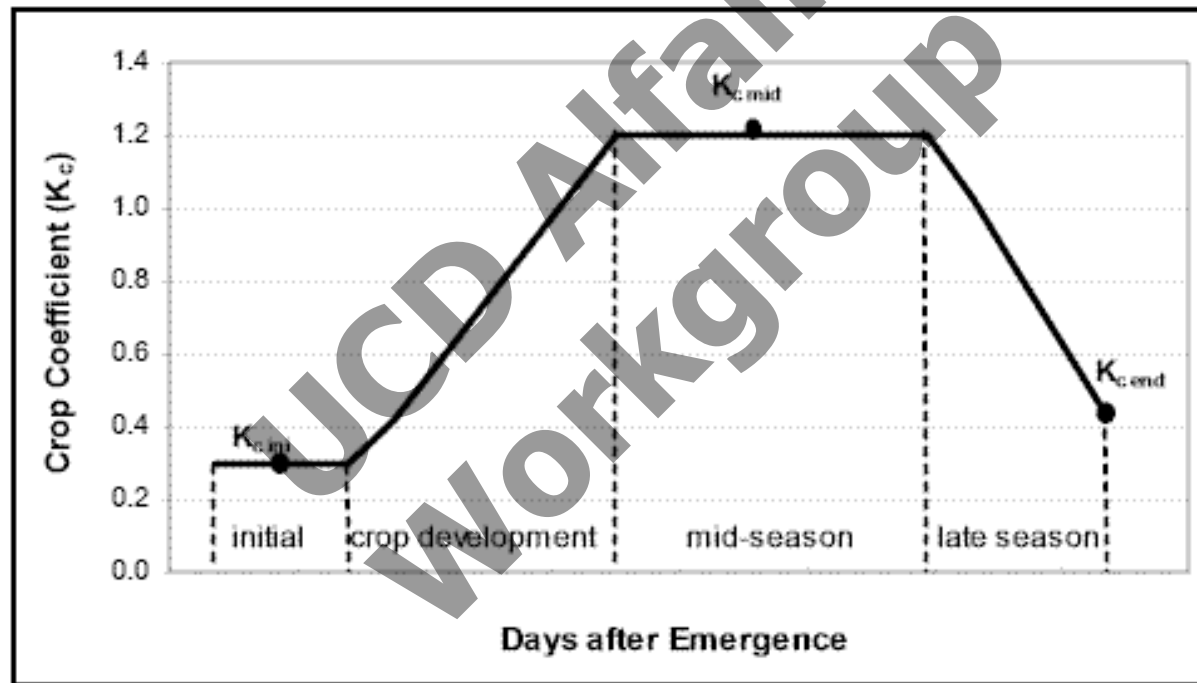
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Peak Water Use Relative to Grass (Crop Coefficients, Kc)

Crop	Kc mid
Sugar cane	1.25
Alfalfa	1.20
Corn	1.20
Cotton	1.18
Soybean	1.15
Winter wheat	1.15
Sudangrass	1.15
Sorghum	1.05

(Allen et al., 1998)

Crop coefficient curve (K_c)



Crop Water Use, Mesa, AZ

<i>Crop</i>	<i>Water Use (inches)</i>
Sugar cane (Imperial Valley)	78
Alfalfa	74
Blue panic grass	52
Cotton	41
Corn	40
Sorghum	25
Wheat	24
Soybean	22

(Erie et al., 1982; Bali et al., 2007 - sugarcane)

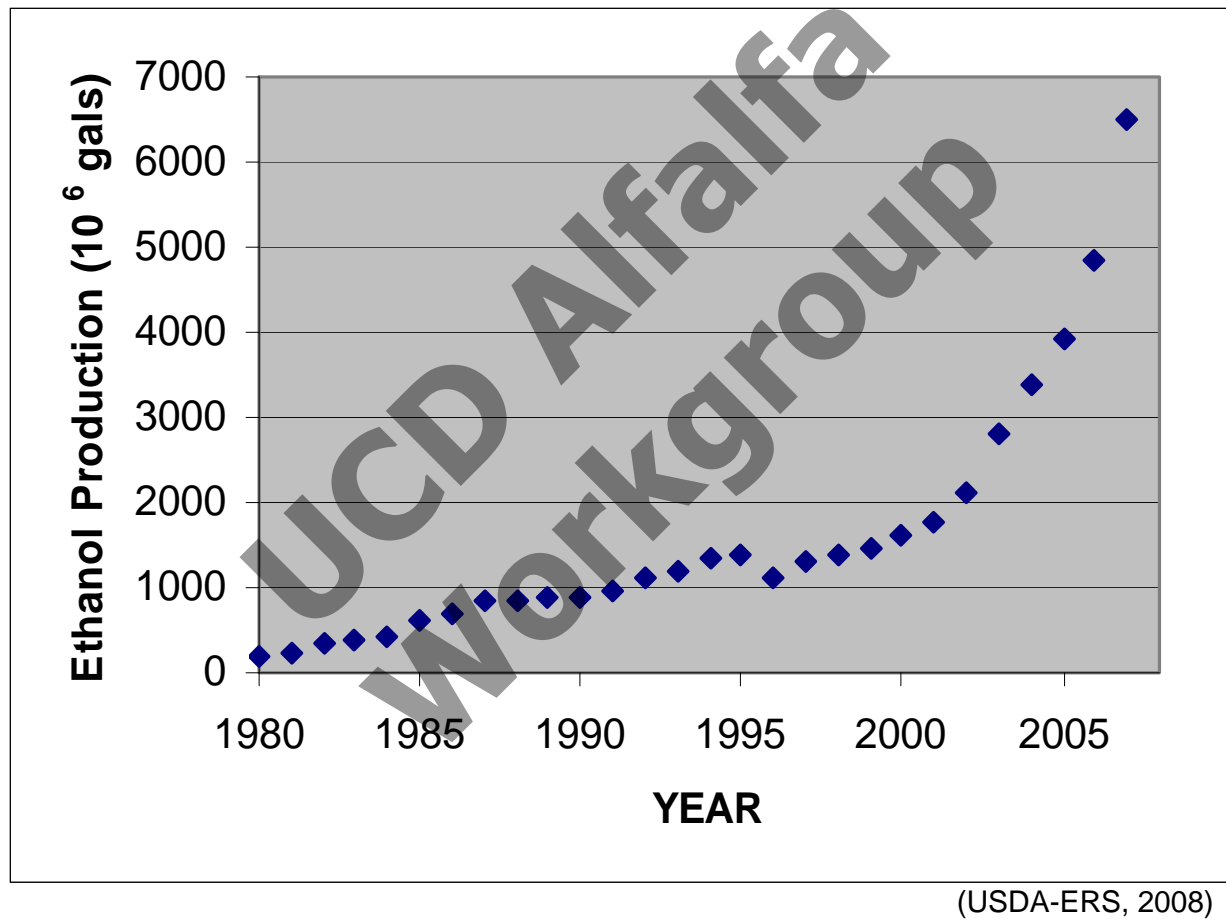
Water Use Efficiency (WUE)

<i>Crop</i>	<i>Harvestable</i>	<i>Total</i>
	<i>WUE (lb/a/in)</i>	<i>WUE (lb/a/in)</i>
Sugar cane	328	328
Alfalfa	235	235
Cotton	39	268
Corn	235	470
Sorghum	192	427
Wheat	248	551

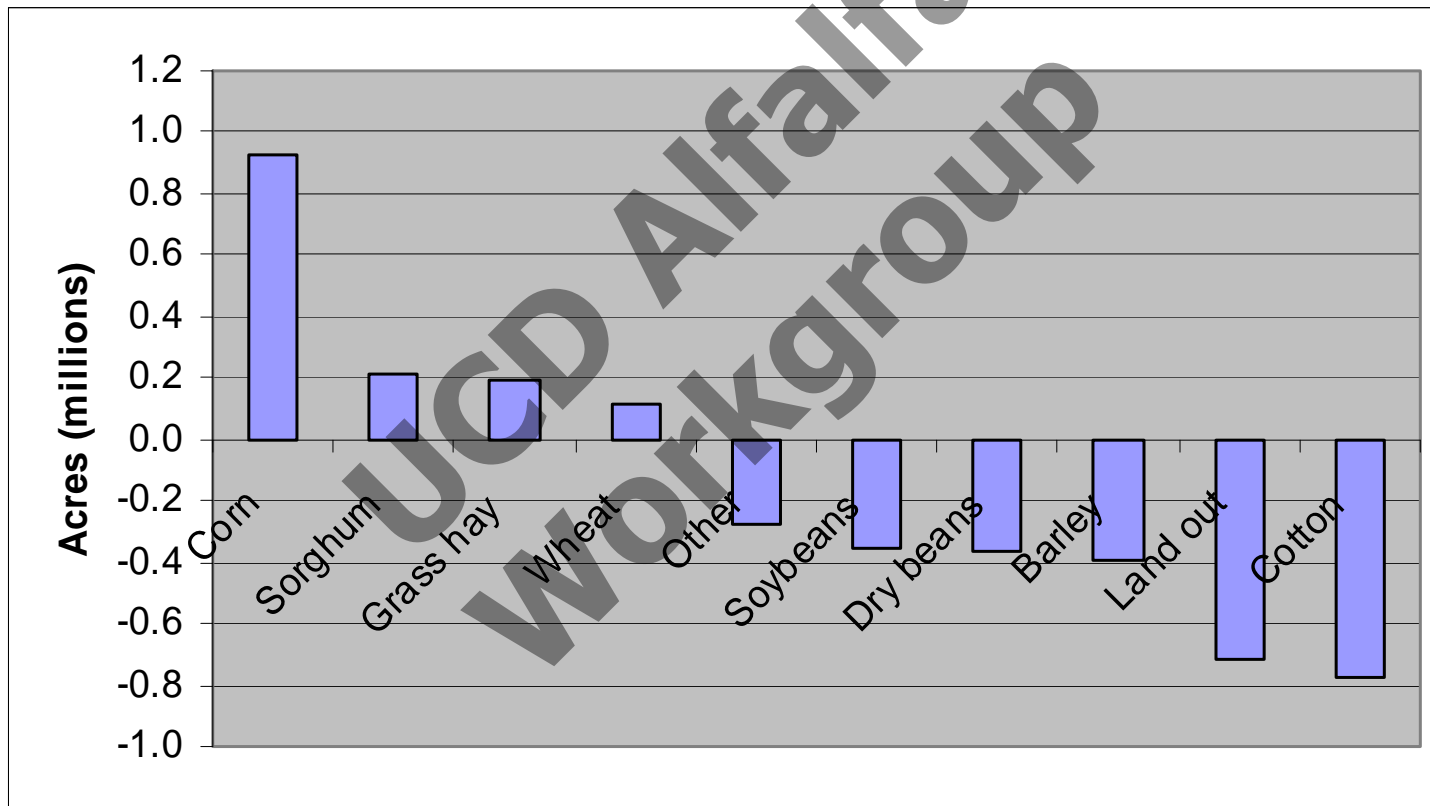
Has biofuel crop production in the
U.S. changed irrigation water
application?

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Historic US Fuel Ethanol Production

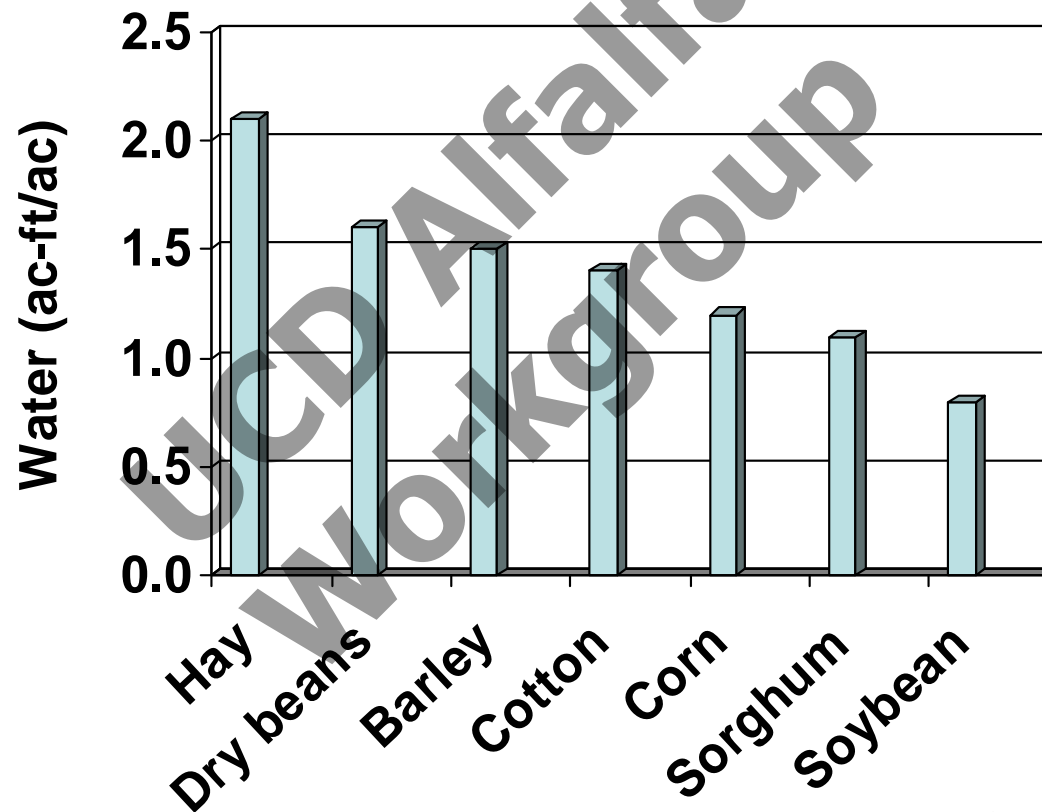


Acres Change US Irrigated Crops, 2000-2007



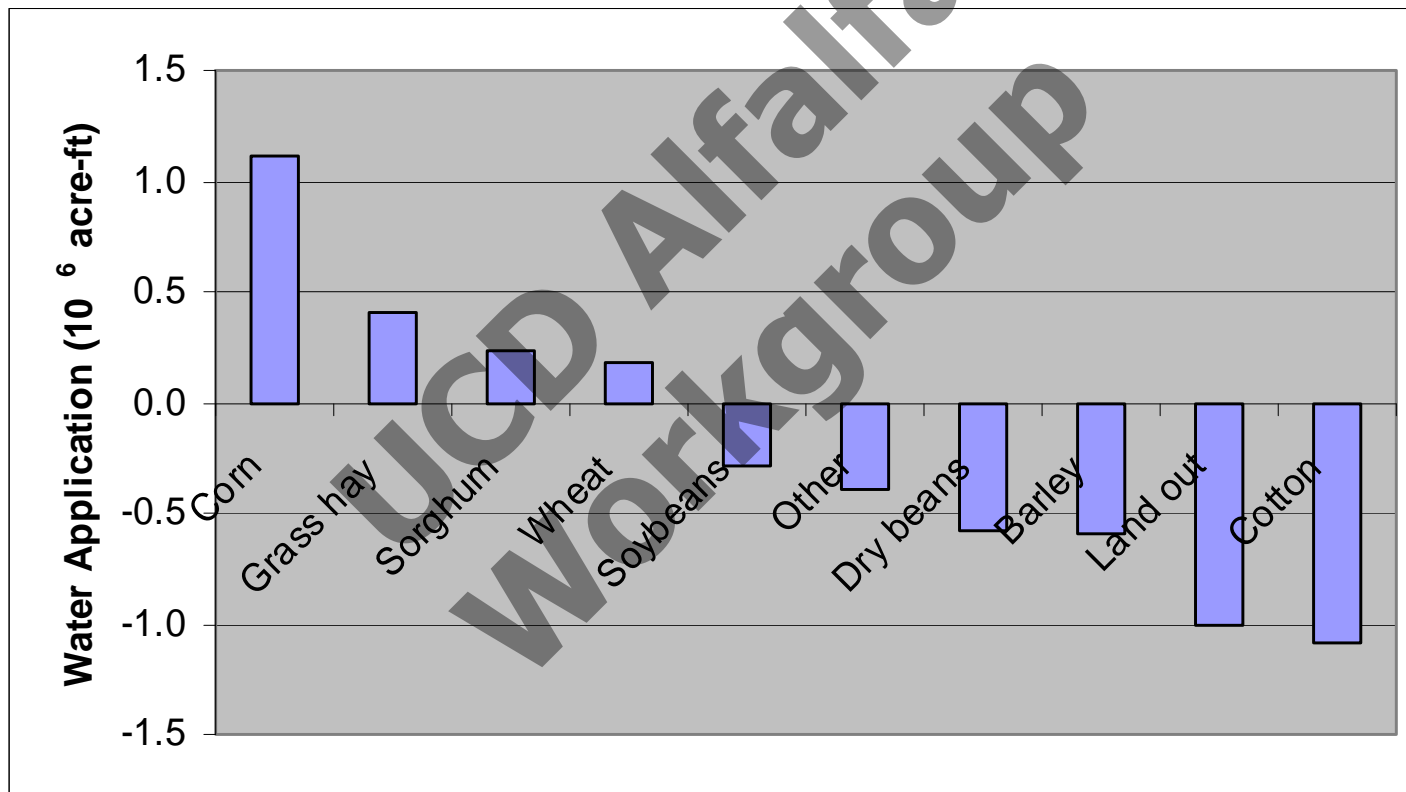
(USDA-NASS, 2008)

Water Application to US Crops



(USDA-NASS, 2008)

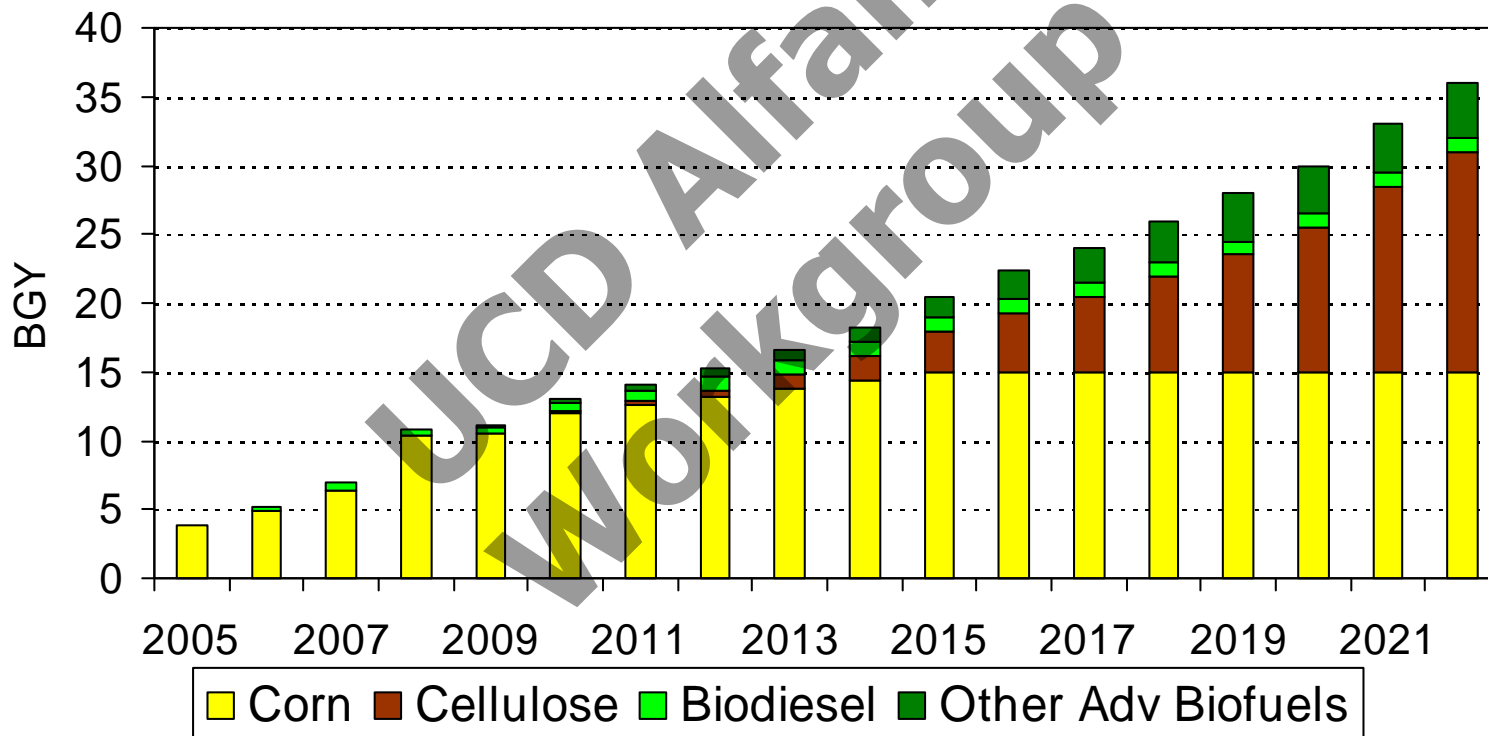
Irrigation Water Application Change, US Crops, 2000-2007



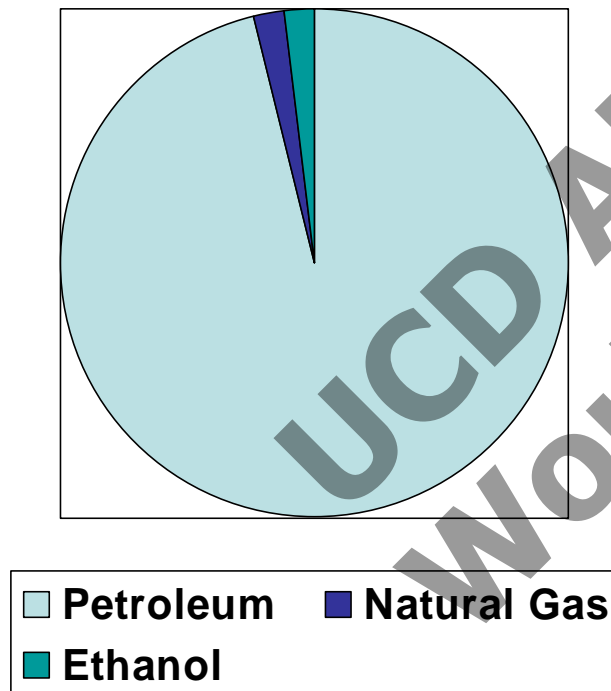
(USDA-NASS, 2008)

How much irrigation water is committed to future biofuel crop production?

Biofuel Production by Feedstock (2007 Energy Bill)



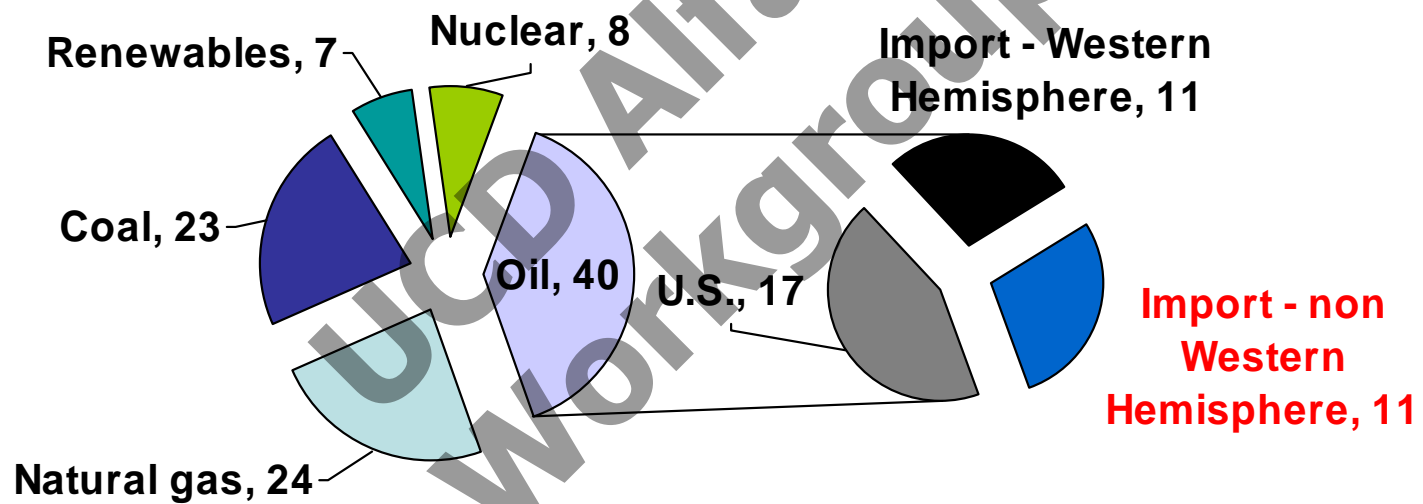
Energy consumption in Transportation Sector by Source in U.S., 2007



- 23% of corn crop to produce 2% of energy
- Need 14 times the US crop acreage to produce corn for all transportation needs
- By 2030, project 11% of transportation energy to be met by biofuels

(EIA, 2008)

US Energy Consumption by Source



Biofuels production, cropped area, and irrigation withdrawals (2005 and 2030)

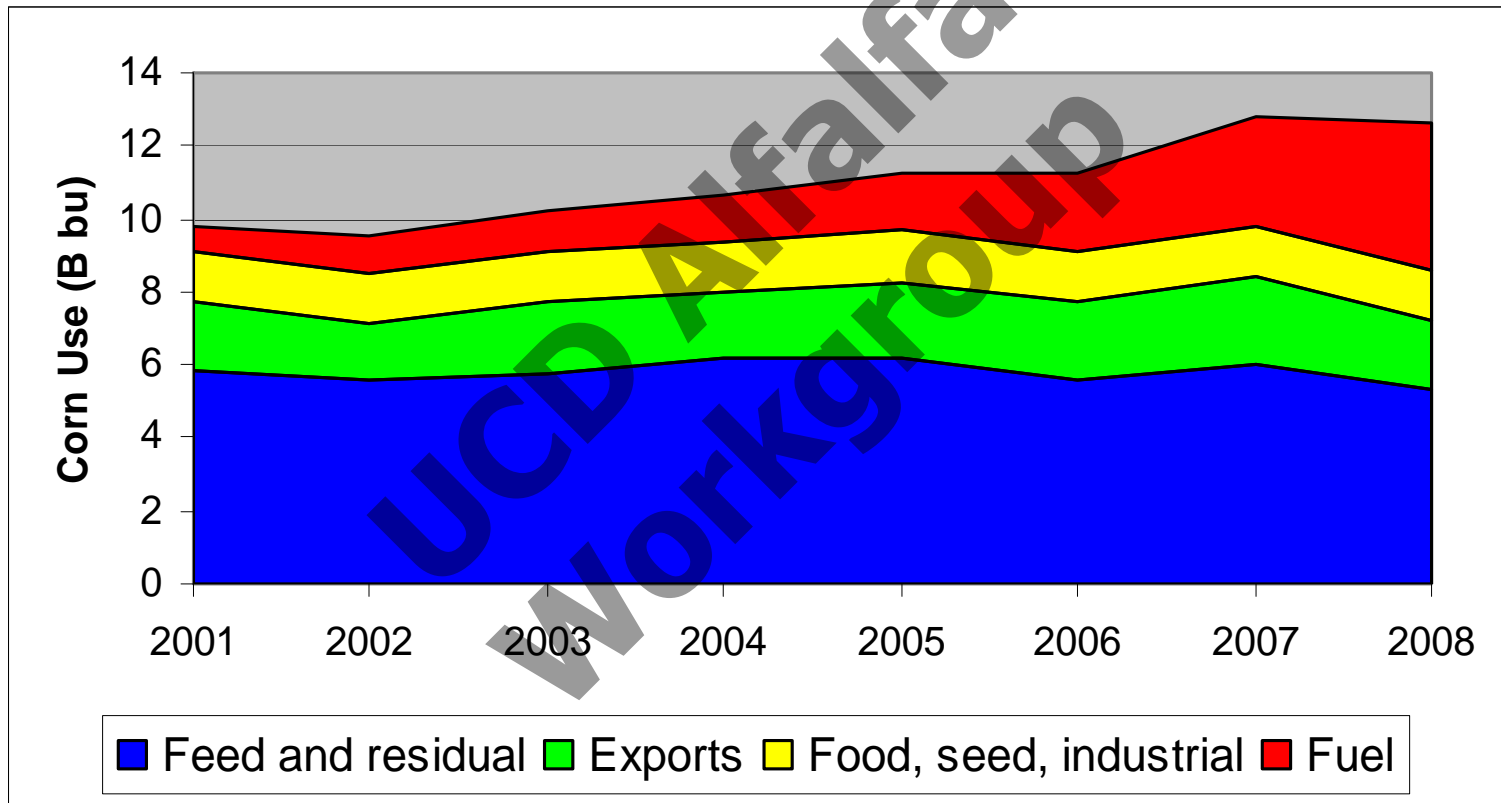
Country	Crop	Biofuel Production		Cropped area used for biofuels		Irrigation for biofuels	
		2005	2030	2005	2030	2005	2030
		Billion gallons		% total crop area		% total irrigation	
USA	Corn	4.0	15.0	5.0	10	3.5	22
Brazil	Sugarcane	3.4	9.1	3.5	7	2.7	8
China	Corn	0.9	4.7	1.1	4	2.2	7
India	Sugarcane	0.5	2.4	0.2	1	1.2	5
World		9.7	37.3	0.8	3	2.0	4

(modified from de Fraiture, 2008)

What “gives” by growing biofuels?

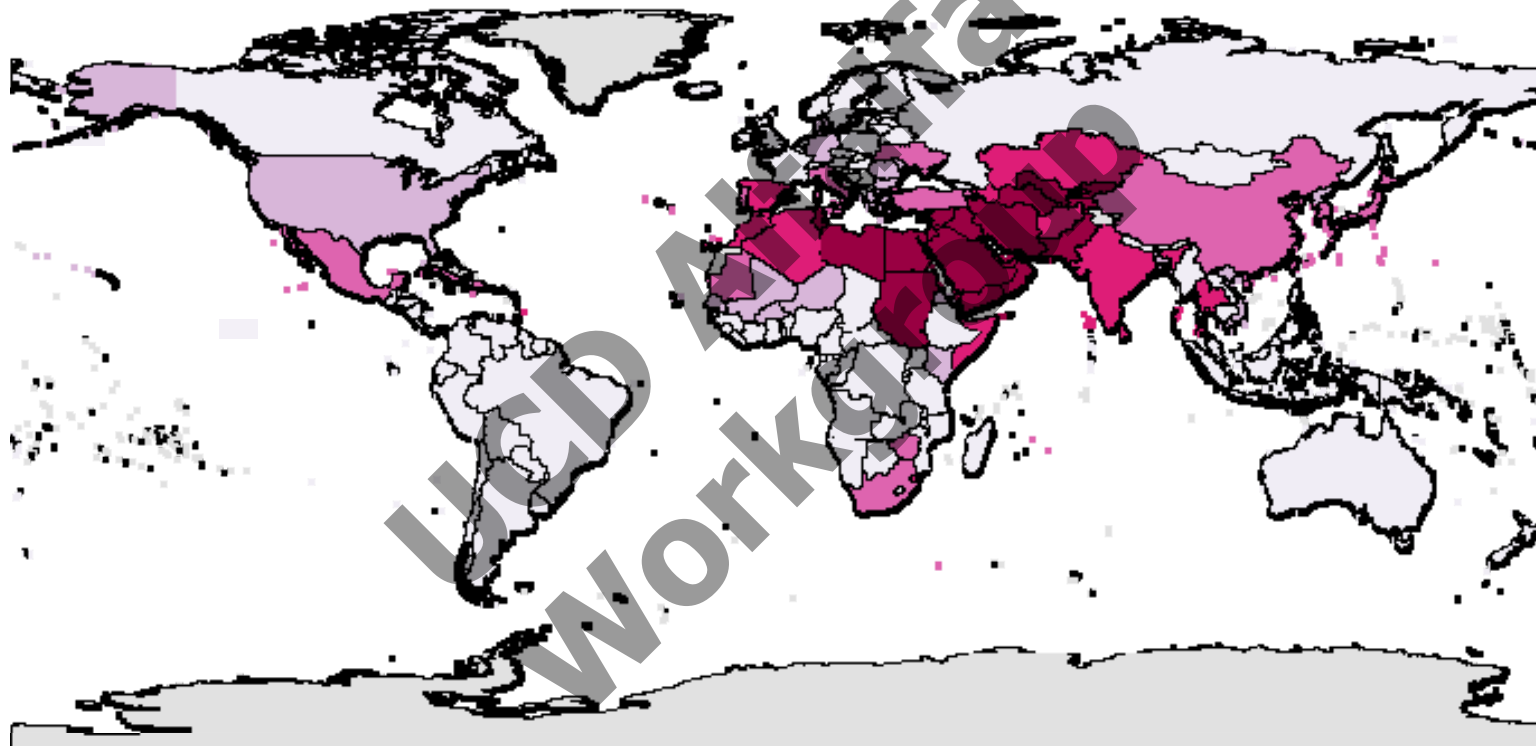
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Corn Use, U.S., 2001-2008



(USDA-ERS, 2008)

Proportion of renewable water resources withdrawn for agriculture, 2001



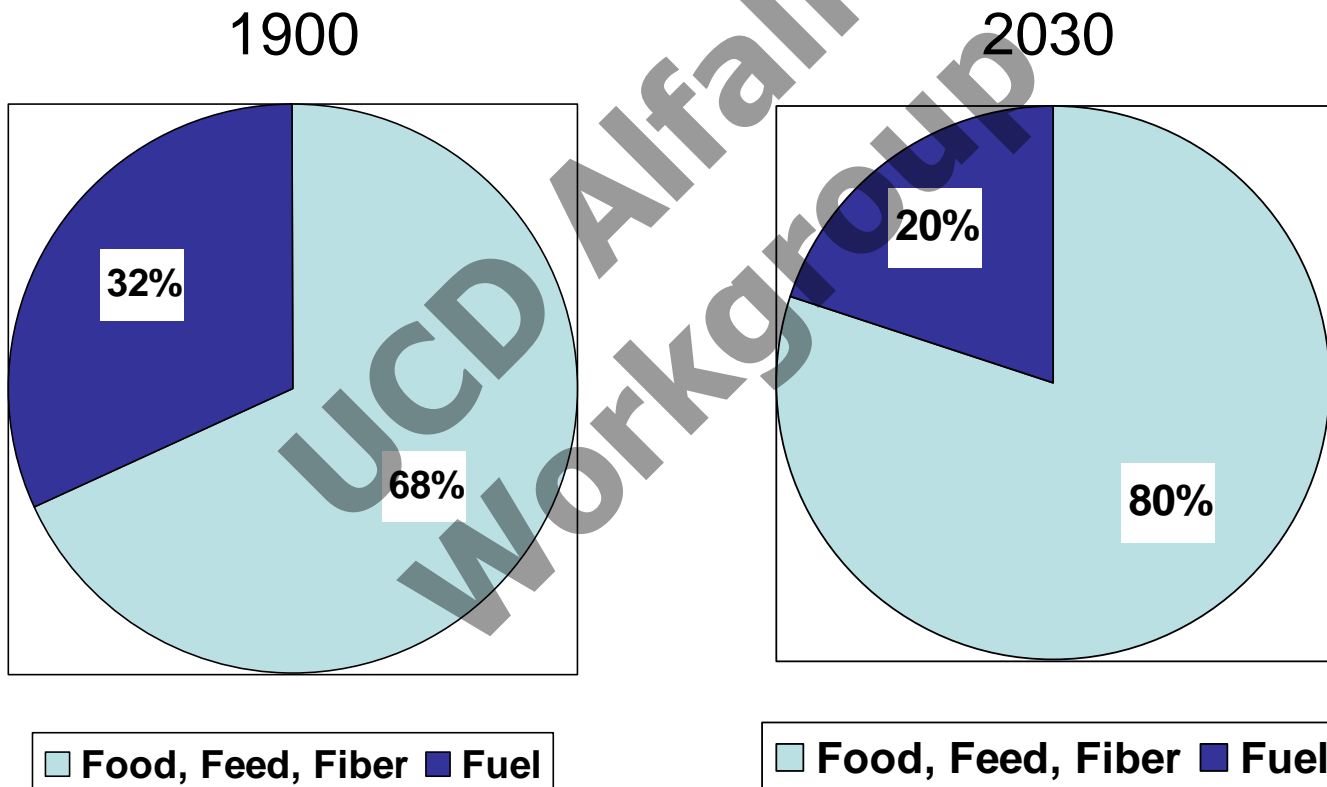
■ No Data ■ Less than 5% ■ 5 - 10% ■ 10 - 20% ■ 20 - 40% ■ Greater than 40%

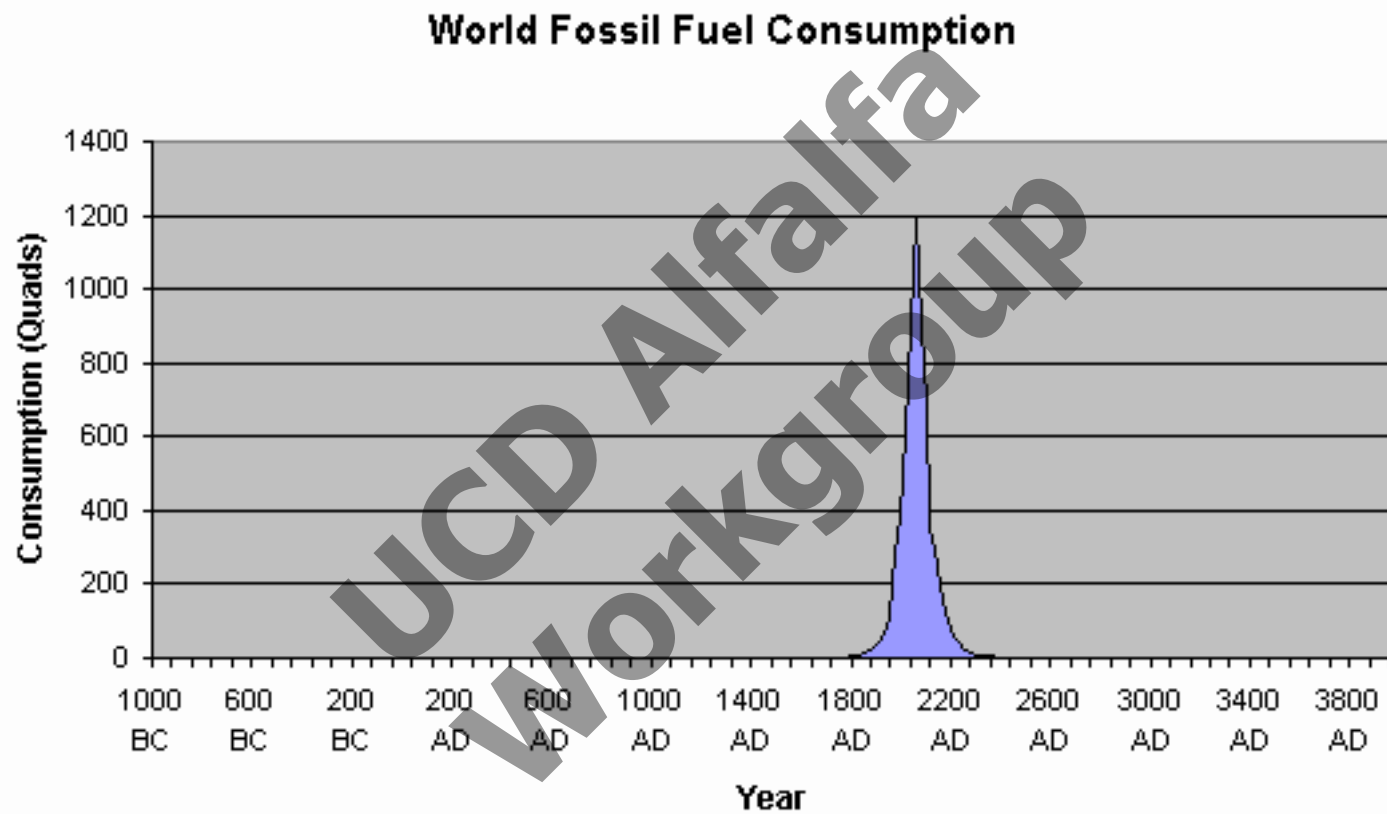
Biofuel crops displace resources

- Food
- Water
- Feed
- Exports
- People

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U.S. Crop Area % in Fuel Crops: 2030 vs 1900





(Ray Joesten, 2003)

<http://go.funpic.hu>

Transportation after the Petroleum Age

