The Impact of Indirect Land Use Change (ILUC)

Assessing Land Uses and Possible Sustainable Transition Paths to Biofuels Development

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Rotterdam

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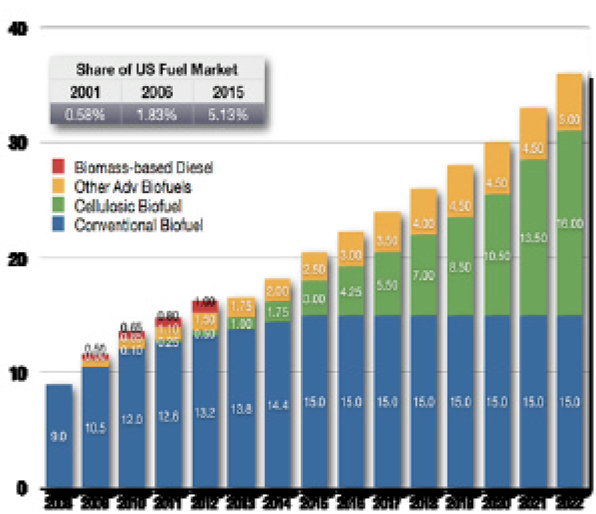
Biofuels Mandates in the US



- Represents a "*Sea Change*" in US agriculture -

(where exactly are we going to grow the biofuel crops and what will be the "returns"?)

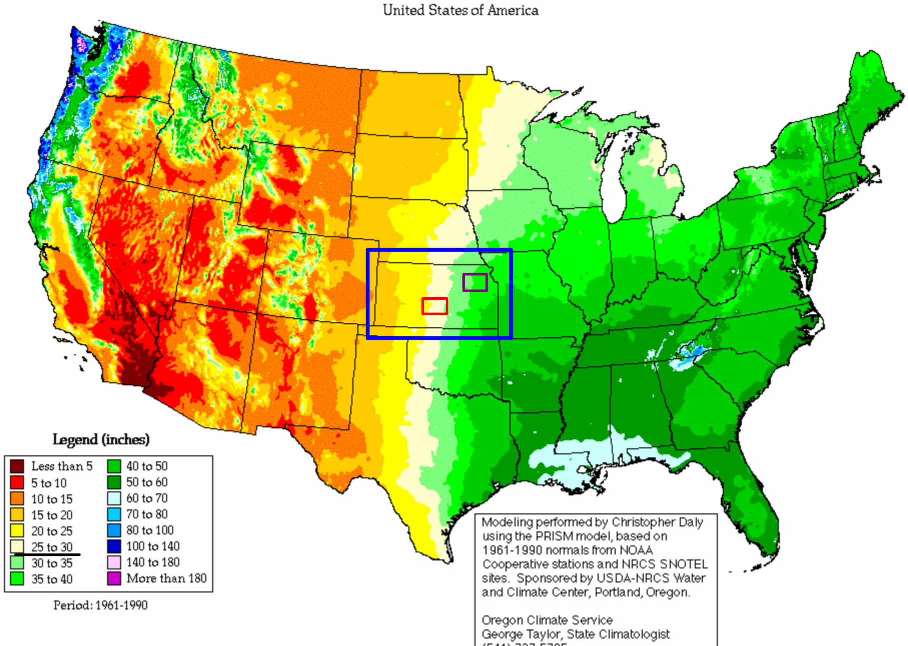
Plant-Derived Liquid Fuels - Four Options

Liquid Fuels by Feedstock and Land Capability Class

	Arable Lands	Non-arable Lands
Starch and Cellulose-based	Ethanol from Grain Ethanol from Crop Residues	Cellulosic Ethanol from Perennials (herbaceous and woody)
Lipid-based	Biodiesel from Annual Oilseeds	Biodiesel from Perennial Oilseeds

Annual Average Precipitation

United States of America



Marginal Land Use, Environmental Quality Concerns, and Resource Assessment

Minimal Cover - Exposure to Wind/Rainfall Erosion

Highly Erodible Land Definitions (Erosion Index, EI)

- EI (water) = RKLS/T > 8
  - R = Rainfall factor
  - K = Soil erodibility factor
  - LS = slope and slope length factors
  - T = Soil loss tolerance level
- EI (wind) = CI/T > 8
  - C = Climate factor
  - I = Soil erodibility factor

Which of these factors is present on a land base will determine which crops and management are produced and utilized and yields and returns.

Land Capability Class Utilization – Marginal Lands

Reno County KS

	Acres	# of Acres by Land Capability Class (LCC) 1	2	3	4	5	6
Open water	15,176						
Developed, Open Space	37,579						
Developed, Low Intensity	11,938						
Developed, Medium Intensity	2,269						
Developed, High Intensity	1,110						
Barren Land	125						
Deciduous Forest	19,716						
Evergreen Forest	12						
Mixed Forest	1						
Scrub/Shrub	175		52	52	19	28	26
Grassland/Herbaceous	299,960	3,502	93,911	98,891	31,023	23,478	47,936
Pasture/Hay	2,662	930	881	455	398	0	0
Cultivated Crops	415,866	30,851	208,943	143,700	25,668	3,650	2,723

What is the "environmental holding capacity" of these lands for biofuel purposes?

Decreasing Land Capability – Increasing EI

Camelina

- **Relatively low input crop (BTU & $)**
- **Adapts well to marginal conditions**
- 30 to 40% oil

Brassica Juncea

- Canola like oil quality
  - 40% oil content
- **Can be grown in low rainfall areas (8 inches)**
  - 800 to 1,000 lb yields
- **Meal suitable for livestock feed**

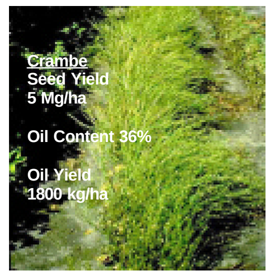
Brassica Juncea

Perennial Oilseed Crop Systems

Many factors that disqualify land for annual cropping may not apply to perennial crops!

Environmental Advantages of Perennial Oilseed Production

- **Exposure to wind and water erosion occurs primarily during establishment of annual crops is minimized with perennials**
- **Perennials possess deep root systems that enable them to access more soil moisture and survive frequent droughts that decimate annual crops thereby significantly reducing water requirements**
- **Perennials can possibly provide N fixation**



One Strategy for Biomass and Land Utilization

Selective Targeting of Soils within a County for Biomass Removal, Production, and Environmental Enhancement

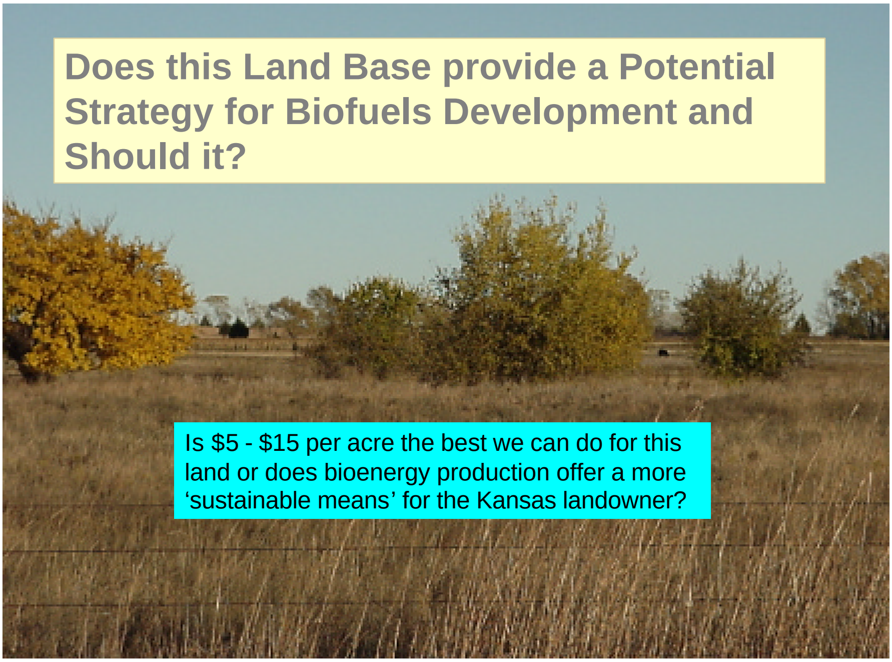
Jefferson County, Kansas (NE Kansas)

County & Soil	Area (acres)	Erosion Index (EI)	Maximum Switchgrass Yield (tons/ acre)	Minimum Switchgrass Yield (tons/ acre)	Average Switchgrass Yield (tons/acre)	Average Annual C Sequestration Potential (tons/acre/year)	Total Switchgrass Production (tons) at 25% Penetration	Total Gallons of Bioethanol
STEINAUER	10	24.06	12.44	0.25	5.22	0.7158	13	956
KONAWA	692	11.13	11.63	1.29	5.72	0.7600	990	74,220
MARTIN	38,493	14.97	12.82	1.48	6.29	0.8098	60,501	4,537,612
PAWNEE	100,805	11.97	10.99	1.25	5.57	0.7469	140,442	10,533,114
SHELBY	46,837	**12.99**	11.43	1.27	5.44	0.7349	63,657	**4,774,296**
OSKA	15,058	**37.28**	8.98	0.17	4.07	0.6151	15,337	**1,150,307**
SOGN	8,174	**28.93**	4.52	0.01	1.76	0.4110	3,587	**269,003**
JUDSON	2,314	9.06	13.78	0.78	6.30	0.8111	3,646	273,423
VINLAND	39,462	**47.62**	6.16	0.01	2.59	0.4846	25,569	**1,917,694**
SIBLEYVILLE	3,173	15.10	7.84	0.14	3.34	0.5505	2,650	198,749
KENNEBEC	16,988	**2.97**	14.87	1.52	7.03	0.8753	29,862	**2,239,626**
GYMER	3,647	4.74	12.85	1.45	6.43	0.8223	5,862	439,639
WABASH	8,379	**3.93**	12.16	1.32	5.81	0.7675	12,163	**912,190**
EUDORA	7,675	7.63	10.71	1.18	5.34	0.7264	10,246	768,428
READING	6,137	**3.40**	12.45	1.43	6.24	0.8055	9,571	**717,827**
GRUNDY	28,986	**3.93**	11.72	1.40	5.89	0.7746	42,664	**3,199,816**
KIMO	4,400	3.40	11.59	1.26	5.62	0.7508	6,178	463,335
MORRILL	2,572	7.63	10.68	1.27	5.40	0.7320	3,475	260,624
HAIG	1,622	3.93	10.59	1.03	5.30	0.7229	2,149	161,199
WYMORE	320	6.68	9.85	1.10	4.98	0.6945	398	29,833
SARPY	1,404	5.48	8.70	0.96	4.48	0.6510	1,574	118,045

Possible Candidates for ACR Removal on these Soil Types

Begin Targeting Herbaceous Energy Crop Production on these Soil Types

Does this Land Base provide a Potential Strategy for Biofuels Development and Should it?



Conclusions

- Yield improvements in all crops will be extremely important
- Land bases and definitions of their "environmental holding capacity" need to be defined more stringently and factored into resource assessments and supply analyses