The Effect of Ethanol on Fuel Price Behavior and the Viability of Cellulosic Biofuels

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Biofuels in the US

- Biofuels have traditionally been used by the relatively poor.
- Biofuels are now being used in richer countries as vehicle fuel.
  - 25-30% of Brasil's transport sector energy from sugar cane.
  - 9.4% of US's transport fuel in 2010 corn ethanol.

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  - 25-30% of Brasil's transport sector energy from sugar cane.
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- In 2007, US congress passes the Energy Independence and Security Act.
- Massive incentives to expand domestic production of biofuels.
  - \$.45 corn and \$1.01 cellulosic blender's credits.
  - \$.54 ethanol import tariff.

Biofuels in the US

Why Biofuels?

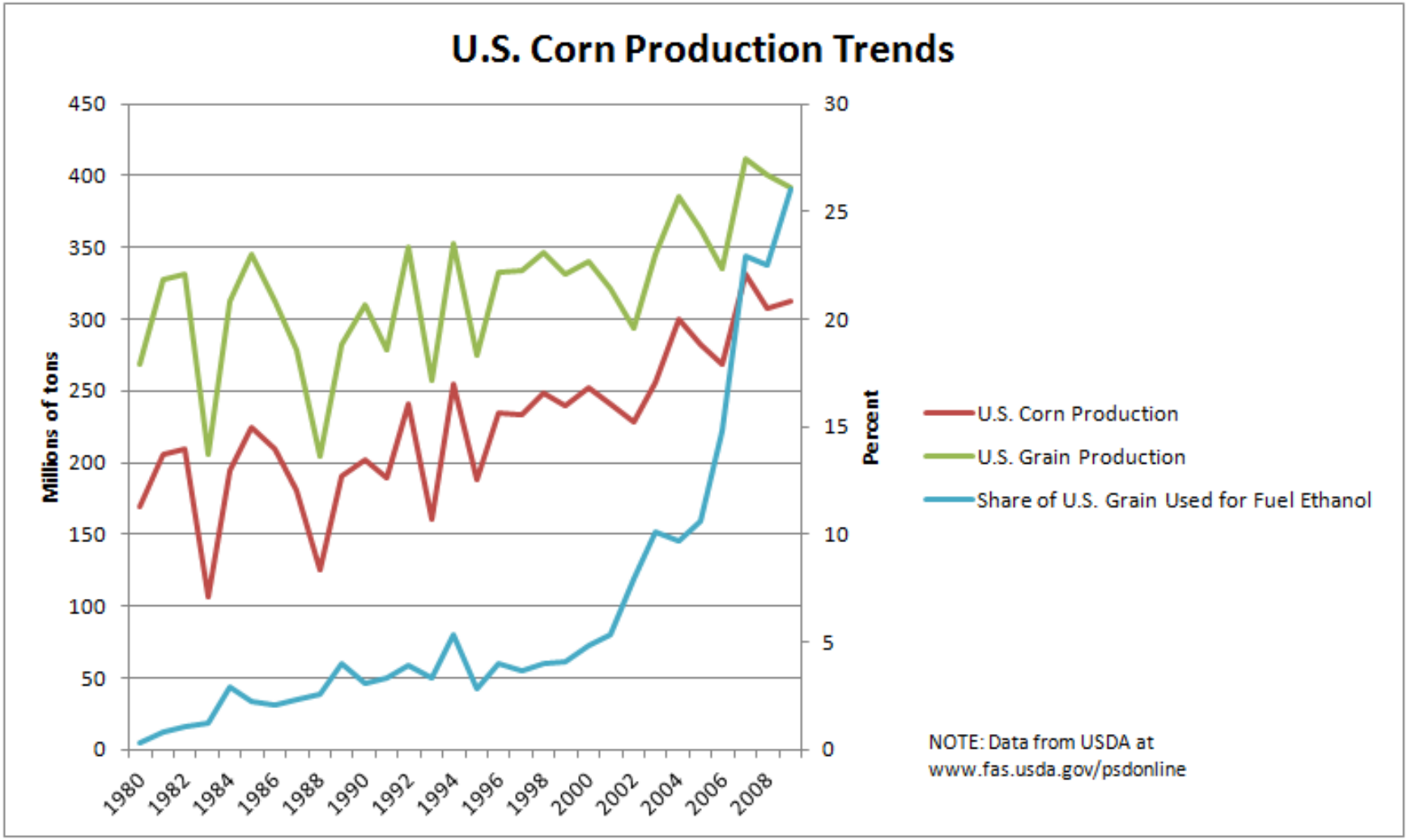
- Create energy independence: reduction of imbalances caused by oil imports.
- Reduce dependency on volatile nations.
- Better than a 'normal' farm bill.*
- Reduction of CRP outlays.**
- Fewer greenhouse gas emissions.***
- *Affect levels and volatility of gas prices...*

Biofuels in the US

Ethanol's role

- Ethanol is increasingly blended with petrol as a form of transport sector fuel.
- So long as ethanol not perfectly correlated with oil price, there will be effects on gasoline price behavior.

Biofuels in the US



Biofuels in the US

Why care?

- There could be an unintended consequence of this policy in the behavior of gasoline price.
- New gas price behavior may affect household driving and purchasing decisions.
- Opportunity to improve the domestic ethanol policy.

Biofuels in the US

Organization

1. Motivation: why would this matter?
2. Simple theoretical model.
3. Empirical Analysis.
4. Potential cellulosic biofuel effects on gasoline prices.

Motivation

Household Behavior

- Literature finds households have RW energy price forecasts and "irrationality" of households in car consumption behavior.

  Anderson, Kellogg and Sallee 2010, Allcott et. al. 2011, Allcott and Wozny 2011.

- Evidence that certainty over expectations matter in intensive and extensive margin driving decisions. Cozad and LaRiviere 2011.
- Households have heterogeneous demand for ethanol as substitute for gasoline. Anderson 2011

Motivation

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- Household beliefs about future fuel price behavior.
- Use of ethanol as a substitute for gasoline.

Theoretical Model

Price Behavior of Blended Gasoline

Consider a case in which there are two inputs, e and o, representing ethanol and oil that must be used in fixed proportion in production of gasoline:

$$y_t = \min[\alpha y_{e,t}, (1-\alpha) y_{o,t}]$$

$$p_{j,t} = p_{j,t-1} + \nu_{j,t}|_{j=e,o} \qquad \begin{matrix} \nu_{e,t} \\ \nu_{o,t} \end{matrix} \sim \left(\begin{matrix} 0 \\ 0 \end{matrix}, \begin{pmatrix} \sigma_e^2 & \sigma_{e,o} \\ \sigma_{e,o} & \sigma_o^2 \end{pmatrix} \right) \qquad (1)$$

$\Rightarrow$ RW price paths. e = ethanol, o = oil, t indexes time.

Theoretical Model

Price Behavior of Blended Gasoline

Consider the resultant behavior of gasoline:

$$p_{gt} = \alpha(p_{e,t-1} + \nu_{e,t}) + (1-\alpha)(p_{o,t-1} + \nu_{o,t}). \tag{2}$$

$$Var(p_g) = \alpha^2\sigma_e^2 + (1-\alpha)\sigma_o^2 + \alpha(1-\alpha)\sigma_{e,o}. \tag{3}$$

Theoretical Model

Price Behavior of Blended Gasoline

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$$Var(p_g) = \alpha^2\sigma_e^2 + (1-\alpha)\sigma_o^2 + \alpha(1-\alpha)\sigma_{e,o}. \tag{3}$$

The variance of blended gasoline is less than the variance of the 'pure' input oil whenever

$$\sigma_e^2 + \frac{1-\alpha}{\alpha}\sigma_{e,o} < \sigma_o^2. \tag{4}$$

Takeaway: Ethanol can affect gas price levels and volatility mechanically.

First Cut Empirics

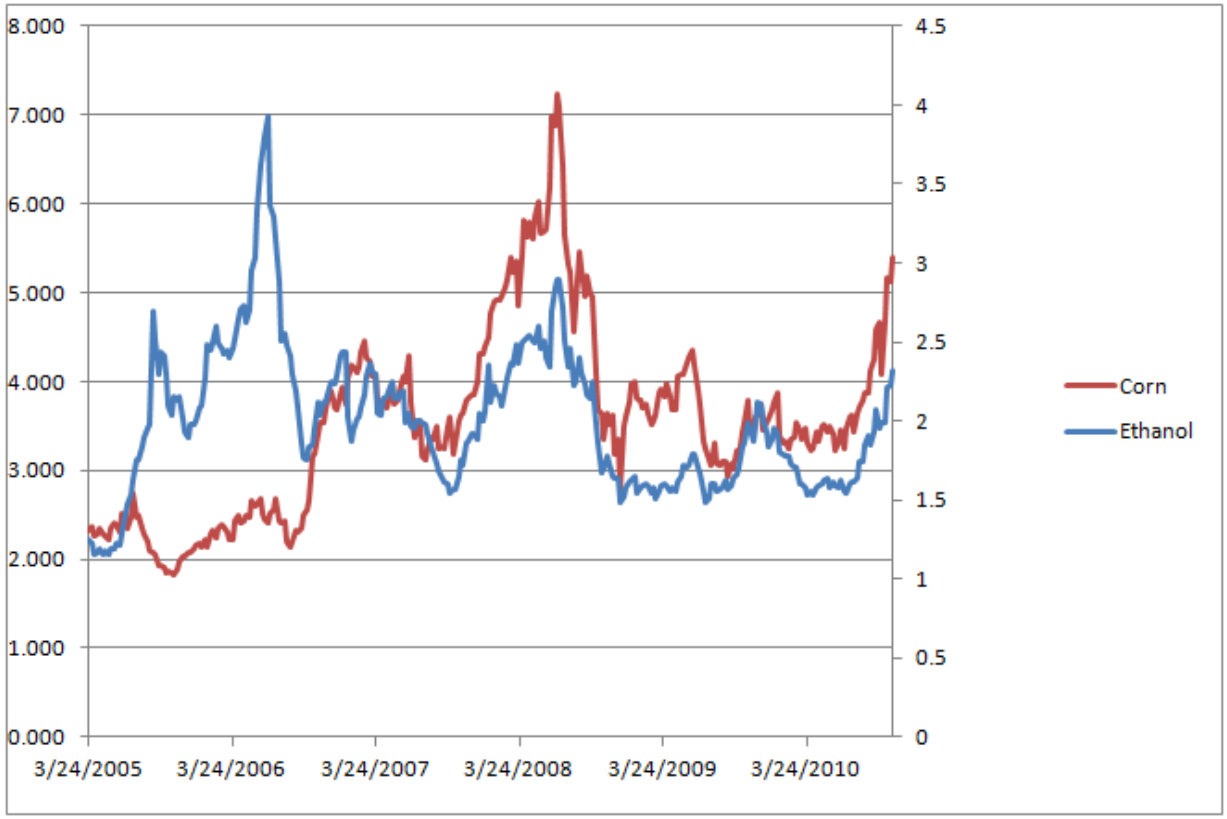
- Not close to a finished product.
- Descriptive at best.
- Several important issues ignored.

Empirical Strategy

- Test for impact of ethanol use in a city's gasoline on gasoline price changes, changes in volatility.
- Control for both pre and post 2007.
- Ethanol endogenous $\rightarrow$ use corn as instrument. Not perfect due to inventories problem and lags production process.

Empirical Strategy

Corn vs. ethanol

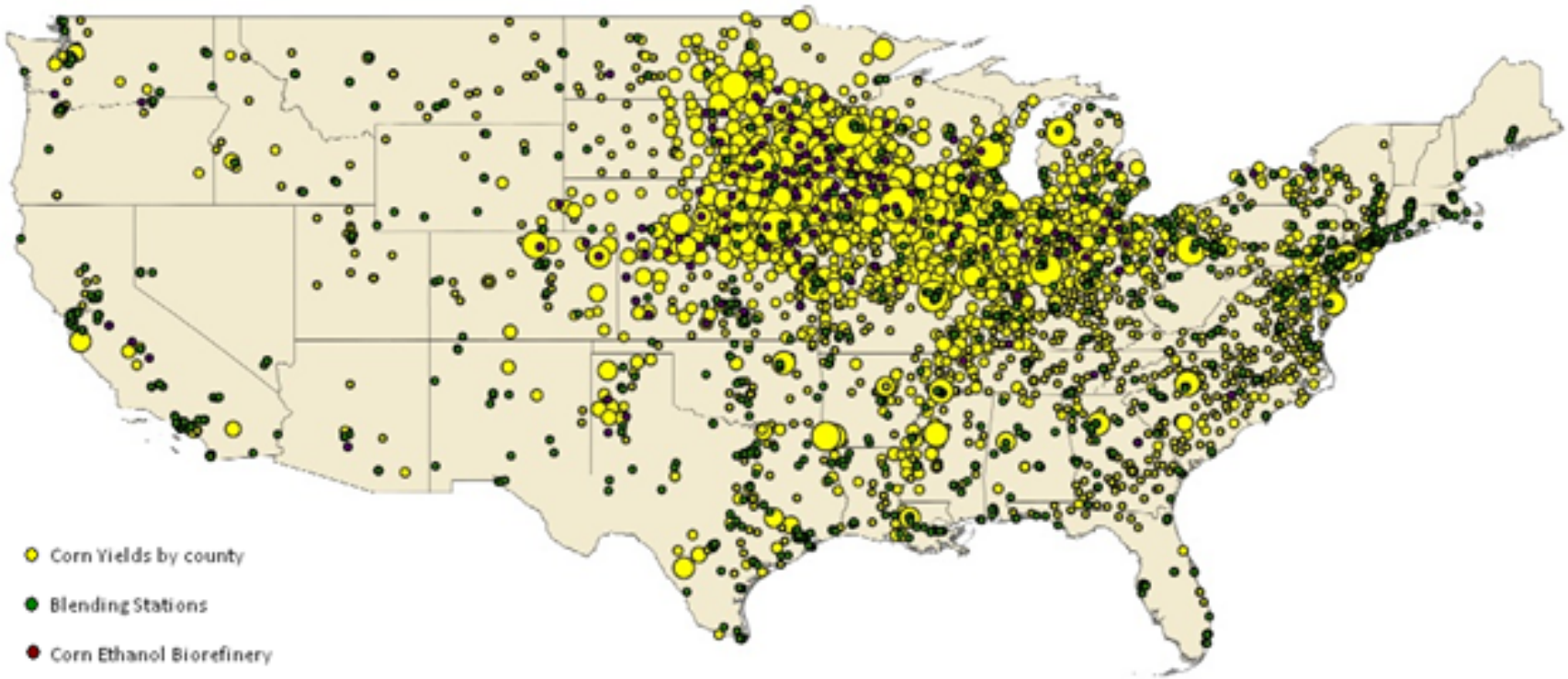


Data

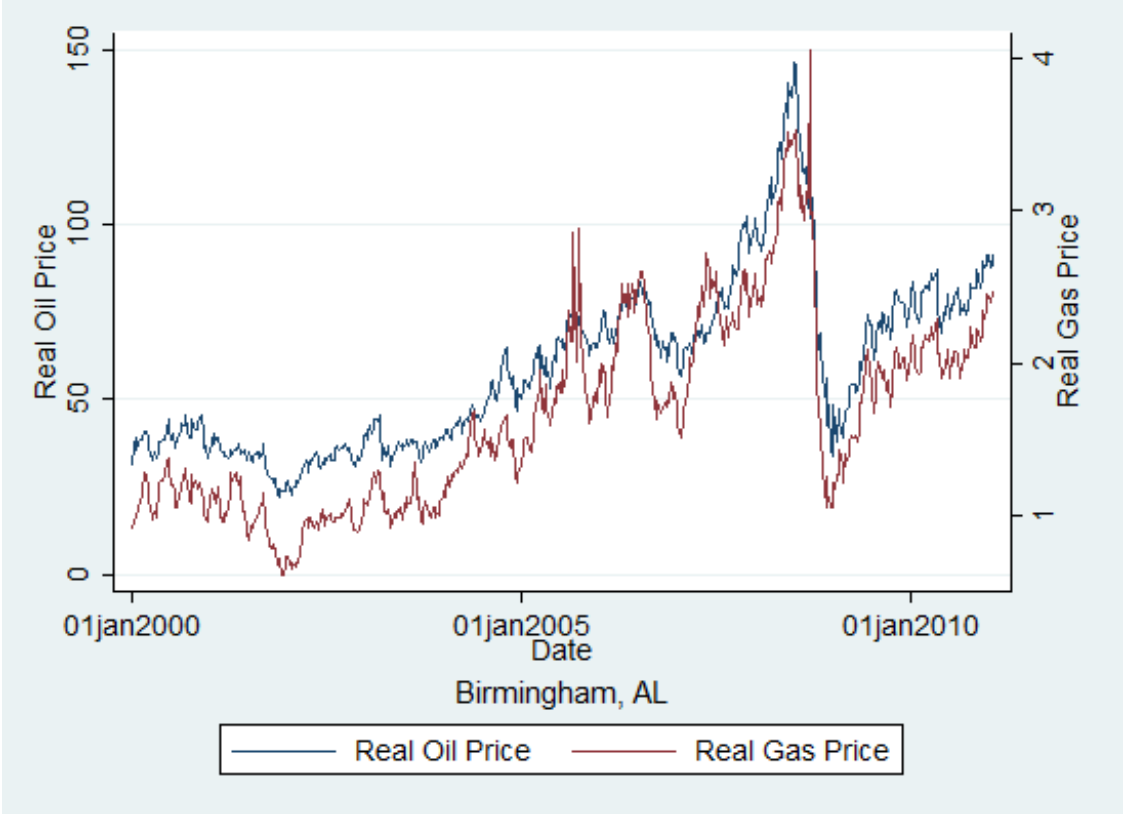
- Weekly post 2000 retail gasoline prices of 183 cities throughout the US (Bloomberg).
- Weekly post 2000 WTI oil (Cushing, OK), Yellow #2 corn (Chicago), ethanol (IA) (Bloomberg).
- Monthly CPI from St. Louis Fed.
- Geocoded location data on all US terminals (2011), ethanol refineries (2011), and corn harvest by county (2008). Many sources.
- Use ArcGIS to get distances to four closest vertical links in production process for each of the 183 cities.

$\Rightarrow$ Unbalanced panel with $\sim$ 183*64*500 = 5,760,000 obs

Spatial Distribution of Observations



Gasoline vs. Oil price by city



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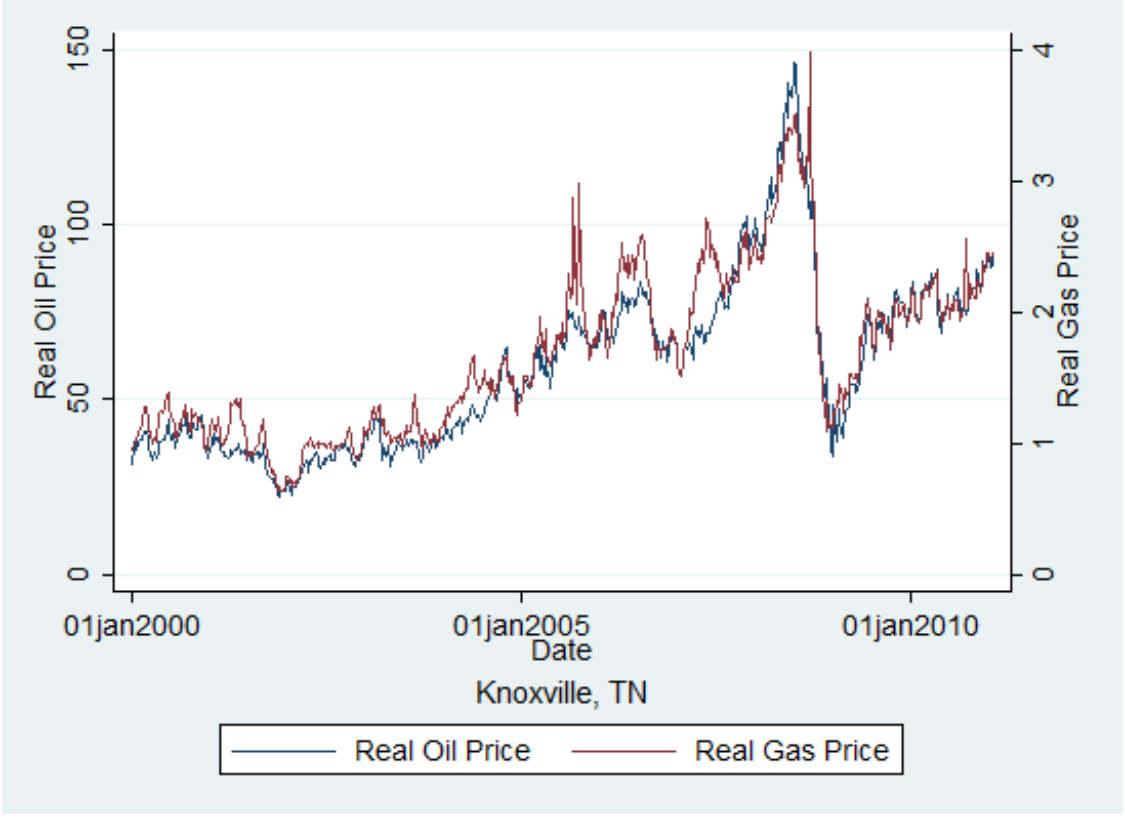

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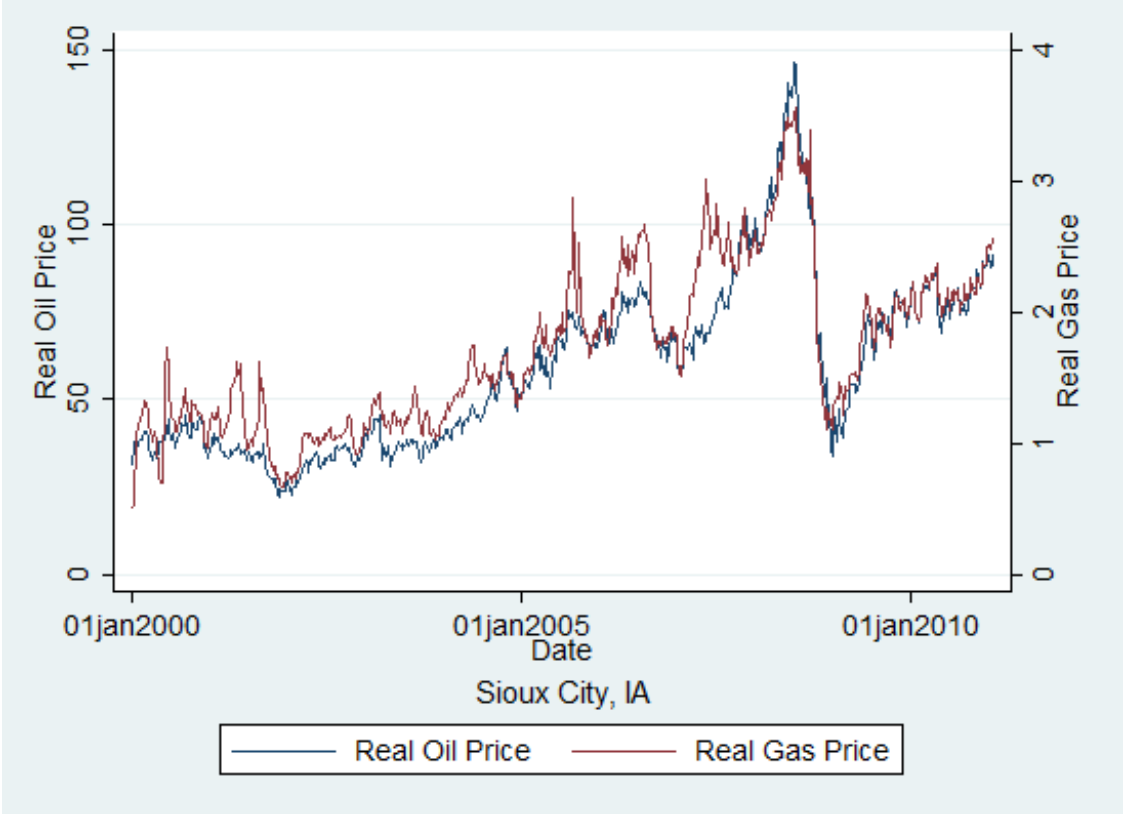

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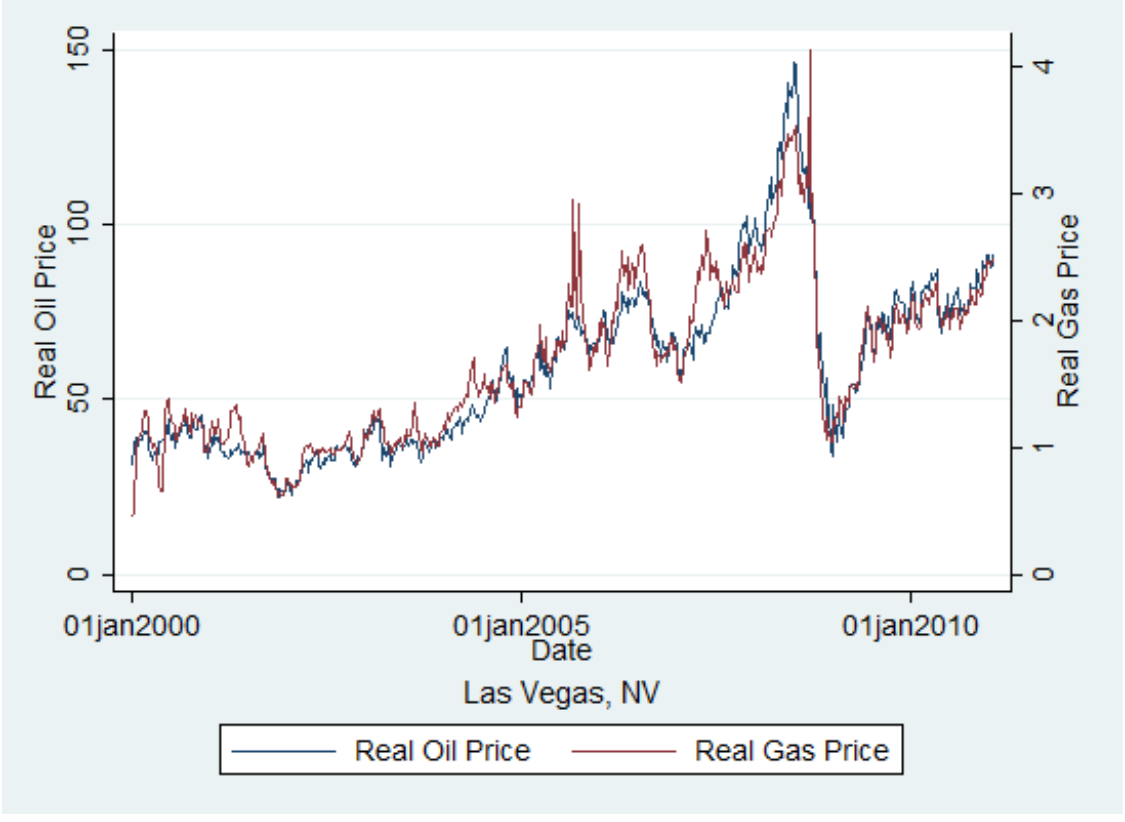

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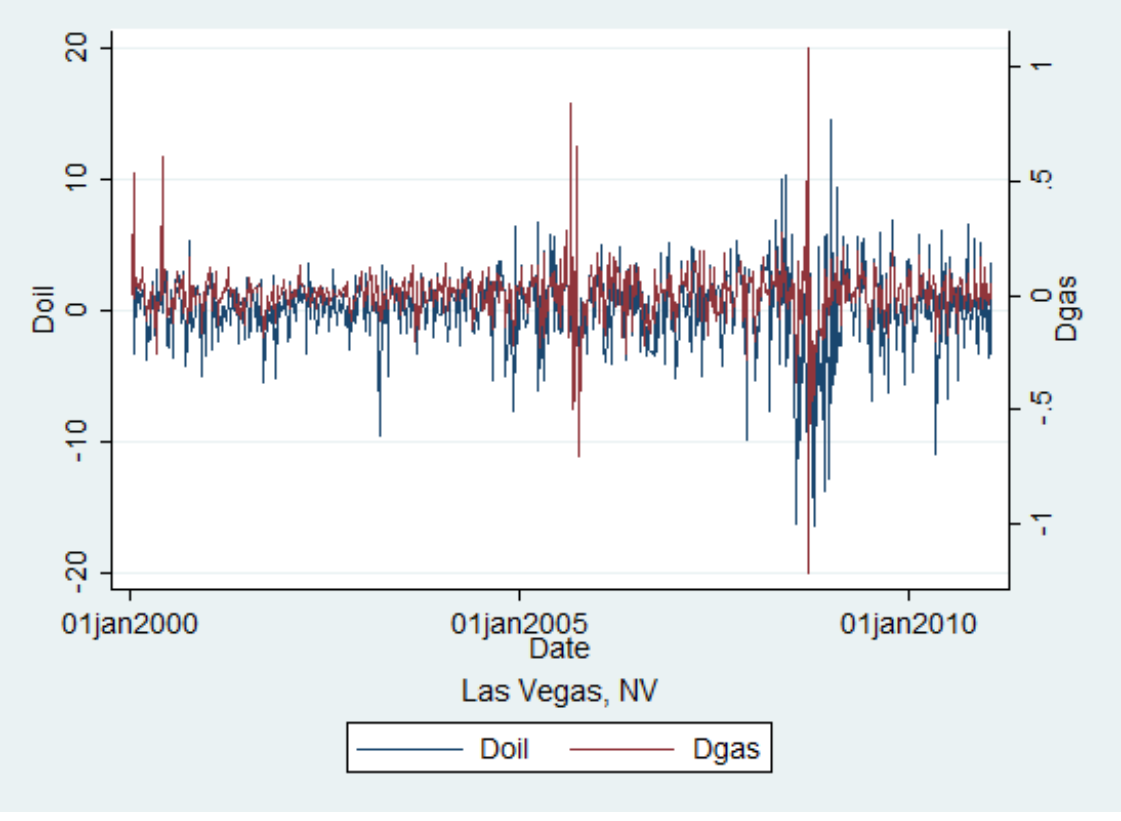

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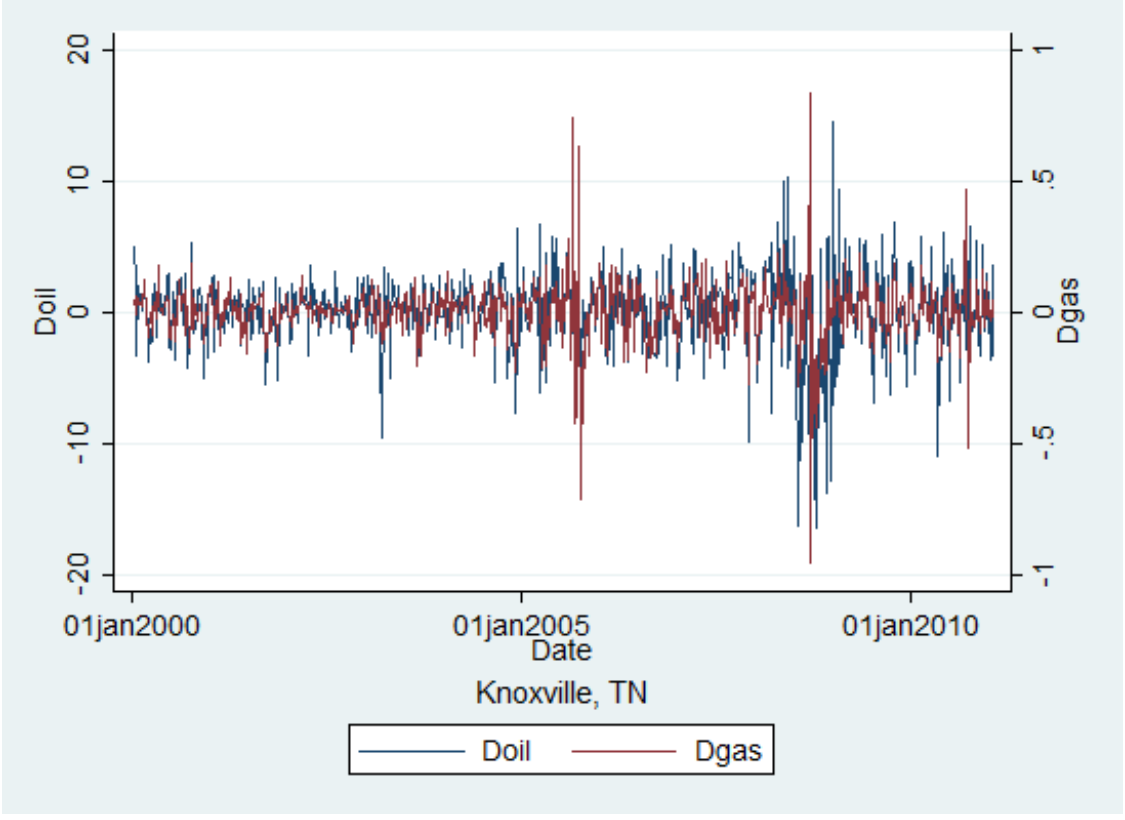

Empirical Strategy

Different Specifications of FE Panel:

$$
\begin{aligned}
y_{it} &= \alpha + \Sigma_{s=0}^{T_o} \Delta_{t-s} P_{ot} \gamma_s + \Sigma_{s=0}^{T_c} \Delta_{t-s} P_{ct} \gamma_s + \phi_i \\
&+ dist_{ct} * \Delta_t P_{ct} \beta_{ct} + dist_{tr} * \Delta_t P_{ct} \beta_{tr} + dist_{rc} * \Delta_t P_{ct} \beta_{rc} \\
&+ dist_{ct} * 1(Jan2007) * \Delta_t P_{ct} \tilde{\beta_{ct}} \\
&+ dist_{tr} * 1(Jan2007) * \Delta_t P_{ct} \tilde{\beta_{tr}} \\
&+ dist_{rc} * 1(Jan2007) * \Delta_t P_{ct} \tilde{\beta_{rc}} + \epsilon_{it}
\end{aligned}
$$

$\Delta_{t-s} P_{ot} \equiv P_{o,t-s} - P_{o,t-s-1}$

$y_{it} = \{\Delta_1 G_{it}, \Delta_2 G_{it}, \frac{1}{N} \Sigma_{n=1}^{N} \left(P_{t-n} - \frac{1}{N} \Sigma_{n=1}^{N} P_{t+s-n}\right)^2\}$

Summary Statistics

Table: Summary Statistics

	Ave	SE	Min	Max
City to Term	6.84	19.4	0	168.8
Term to Ref	189.6	222.2	0	2864.2
Ref to Corn	40.1	14.9	8.75	76.9
Real Gas Price	1.83	.663	.46	4.59

N = 91758. i = 183. Real Jan 2011 USD

Results

Casual Observations

- Base upon post 2005 correlations, the theoretical exercise would imply more volatility in the areas using ethanol.
- Consistent with the preliminary "results" here.
- NOTE: Anectodotal conversation with gasbuddy.com researchers corroberates this finding.

Extensions

Implications for Cellulosic Biofuels

- Consider the price behavior of cellulosic ethanol.
- Impossible to say without market for dedicated feedstock, but could be good or bad.
- Act as hedge against both volatility and high price?

Thanks. Comments desired.

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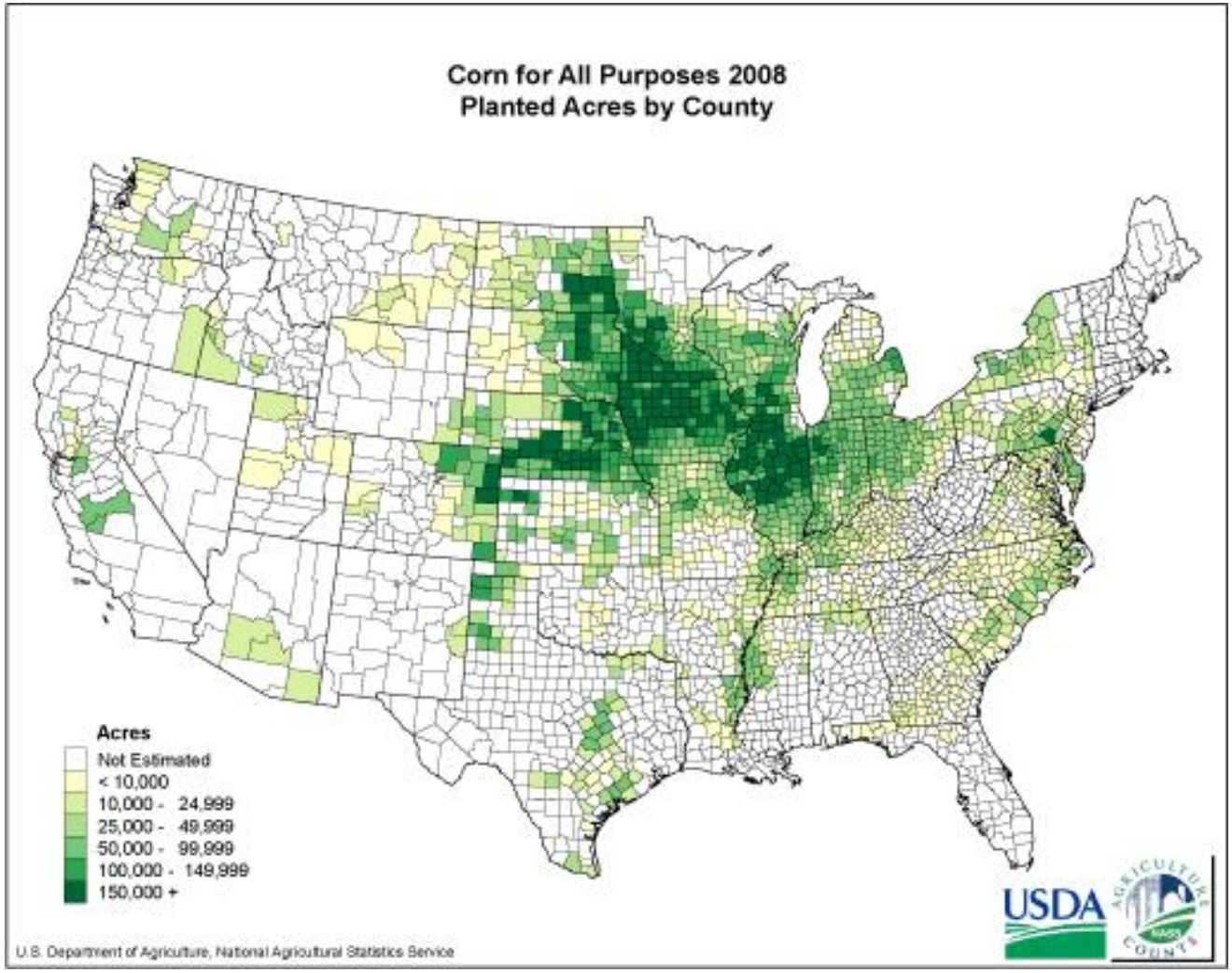
2nd Generation Biofuels: Switchgrasses



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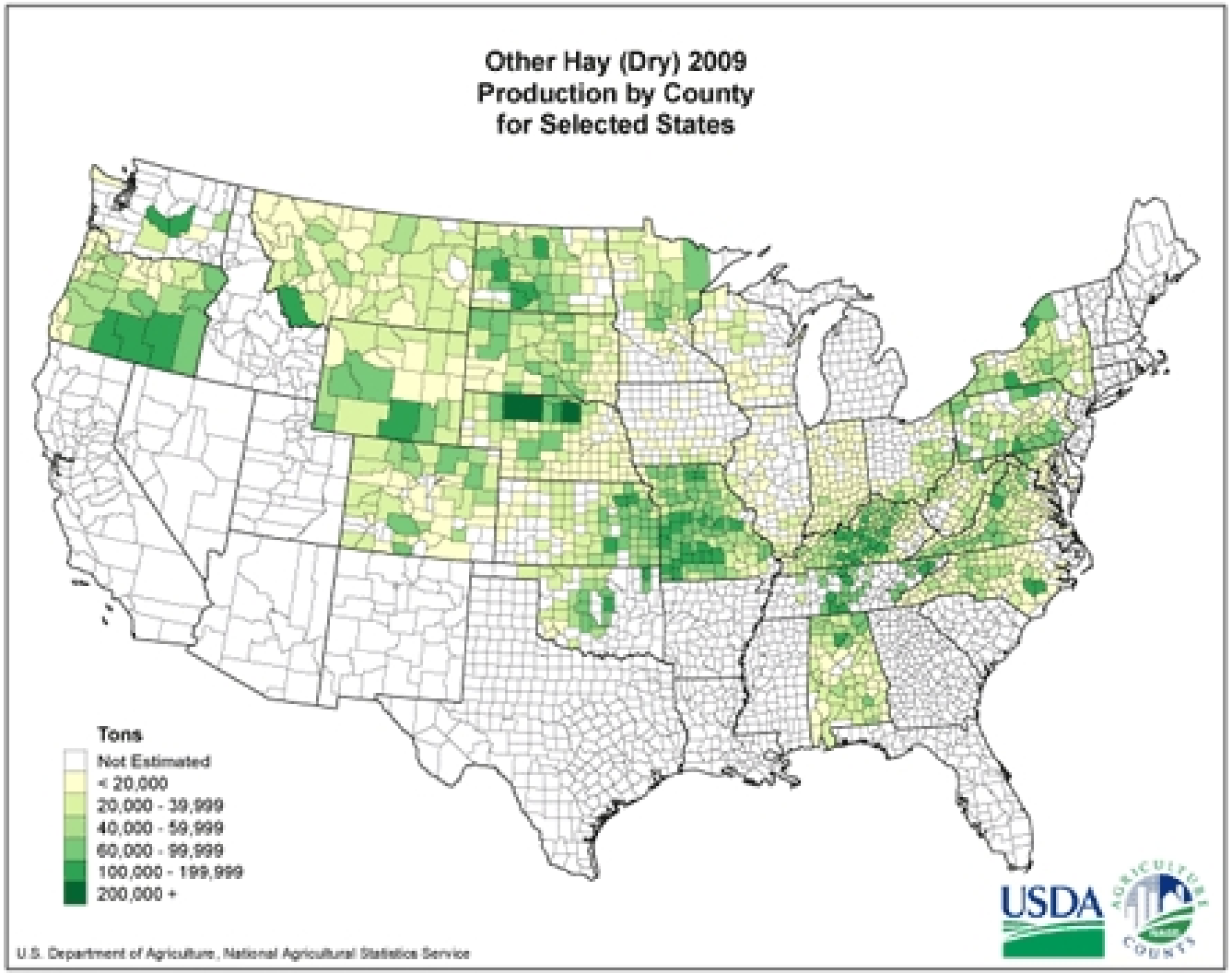

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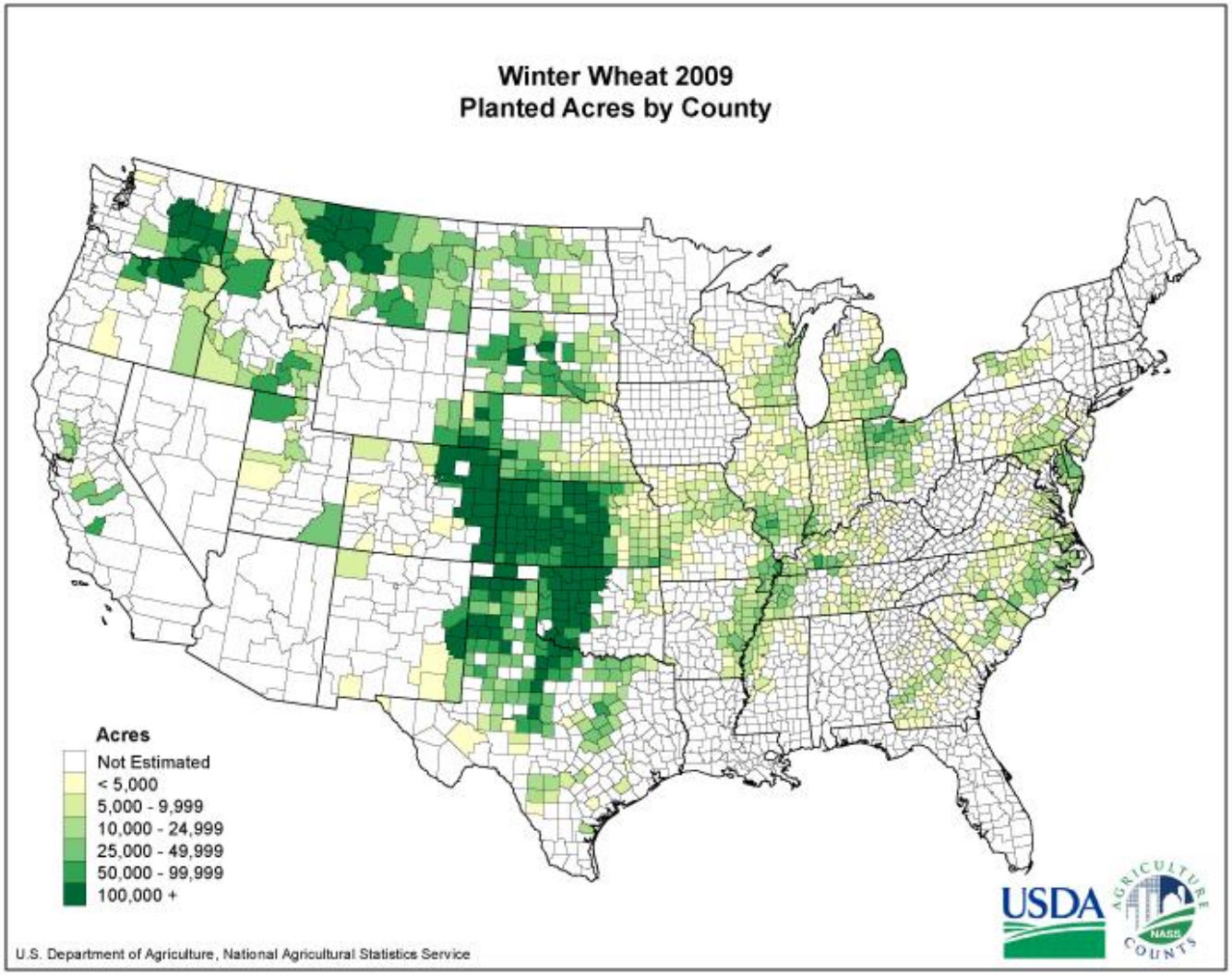
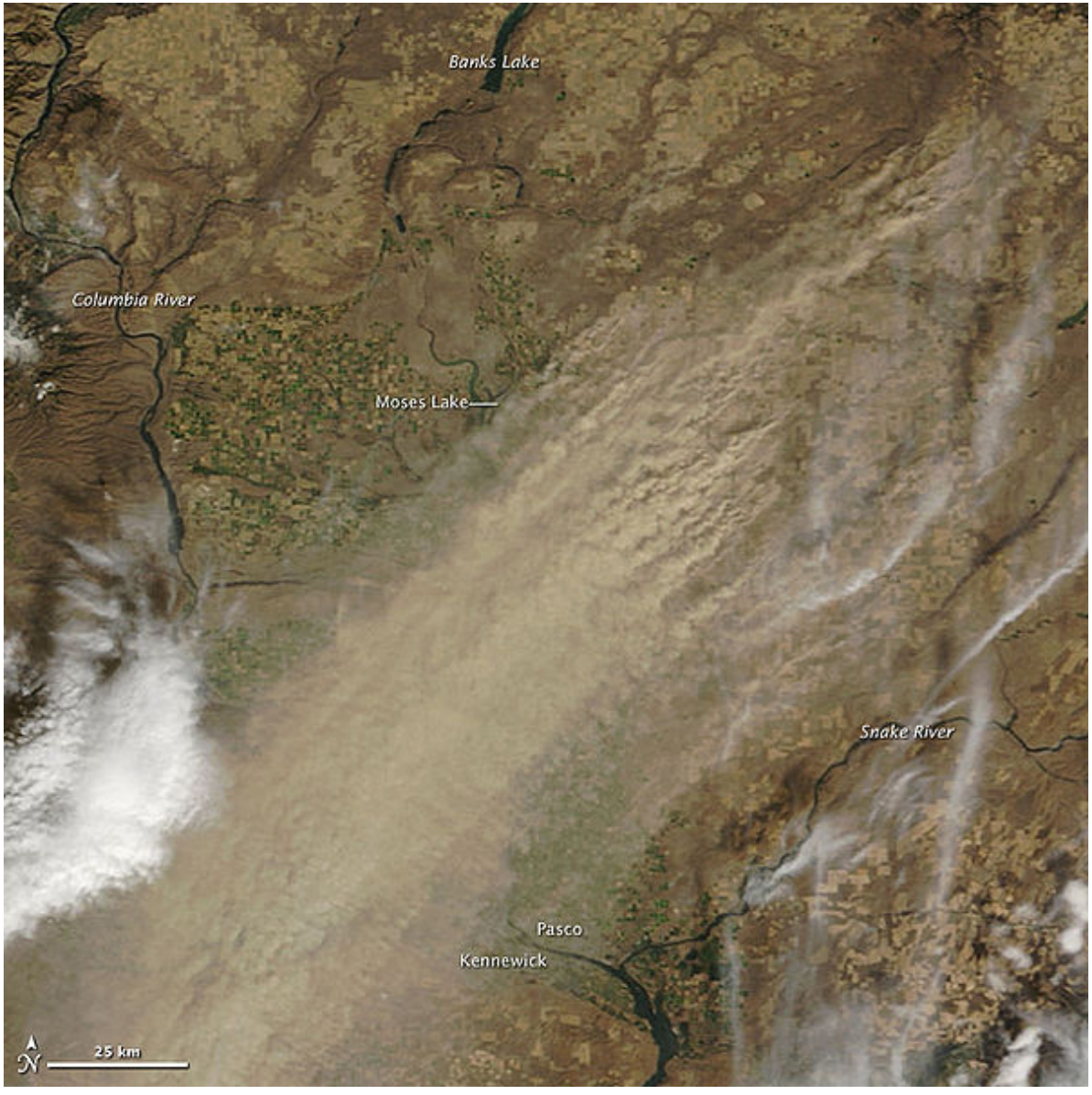


Biofuels in the US

Switchgrass: Potential fringe benefits

- Energy Information Administration (EIA) and other estimates (Bourne and Clark 2007) find that the cellulosic biofuels may lead to 80% less GHG emissions than petrol. Corn ethanol is almost a wash.
- May be grown on marginal land and using dryland farming techniques.
  - In the inland Pacific Northwest of US, the soil erosion is non-trivial due to dryland farming.
  - Greenhouse gas emissions from tillage practices are non-trivial also.

2nd Generation Biofuels: Switchgrasses



Biofuels in the US

Switchgrass: Policy Mechanism

- Switchgrass producers offered a \$1.02/gallon credit to producers
- For every gallon an obligated party doesn't mix that they are mandated, they pay \$1.58/gallon.

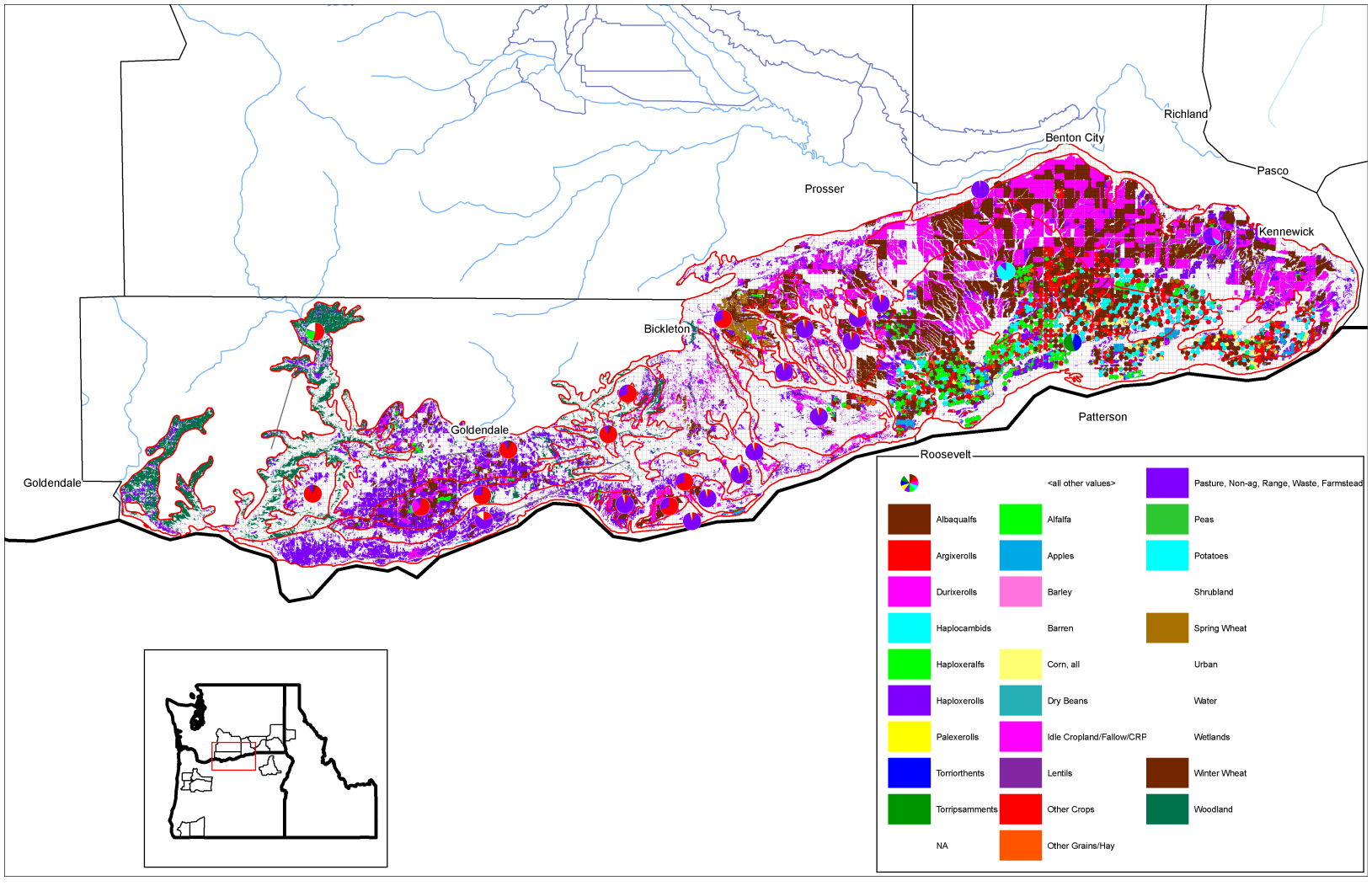
- The mandate recently became more subjectively flexible according to the "regulator's" policy.
- Replaces a rule that had mandate penalty chained to wholesale price of gasoline.

Biofuels in the US

Switchgrass: Northwest Viability Questions

- Is switchgrass viable in these dryland regions?
- What are farmers in this region growing?

2nd Generation Biofuels: Switchgrasses



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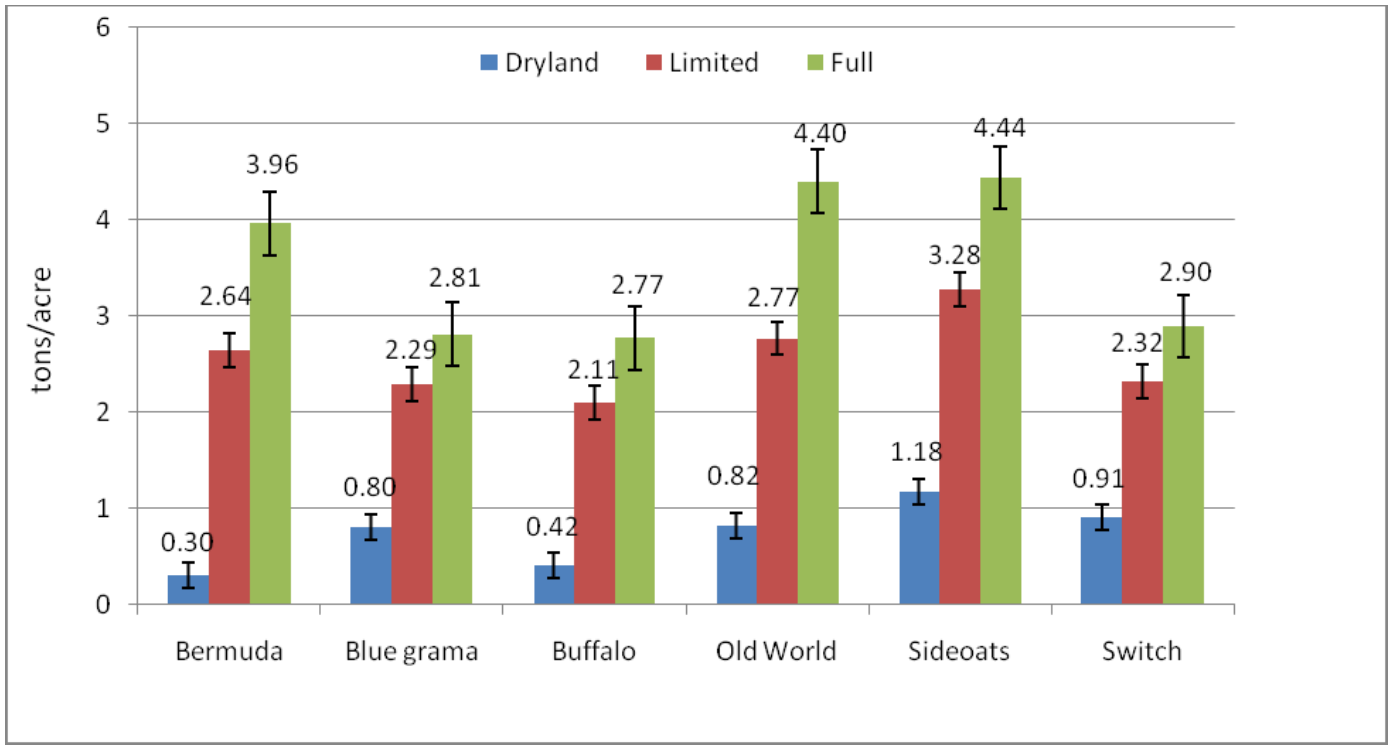


Buttrey et. al. (2009). 5.74 inches of rain in dryland treatment growing season. This is 70% of annual rainfall in some inland NW regions.

Biofuels in the US

Switchgrass: Northwest Viability Questions

- Is switchgrass viable in these dryland regions?

- Considering the WW-SF rotation alternative of wheat farmers, is this a viable option?
- Method: Given a price of feedstock due to mandates, what is the needed productivity of switchgrass farmers would need for conversion.
- Use 2009 test plot data from Yakima Valley.

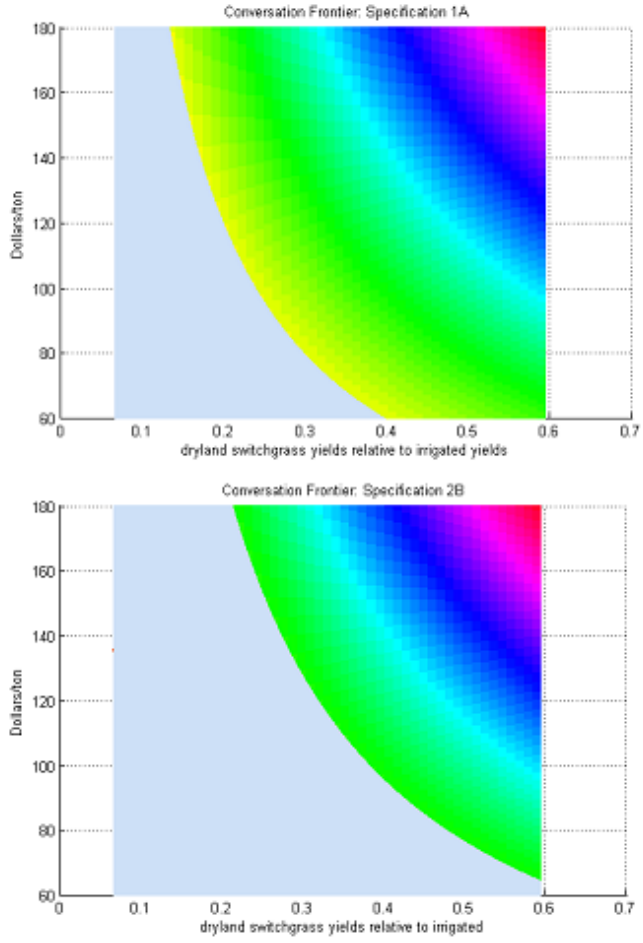
Biofuels in the US

Switchgrass: Northwest Viability Questions

- Is switchgrass viable in these dryland regions?
- What are the effects on the regional economy?

- Regional CGE model is regional level. Include major industries, outputs, households and iunputs. Agriculture section is modeled very explicitly. Land modeled in a novel way.
- Jointly minimize all excess demands in all markets.
- Largely dependent on Armington elasticities and production function specifications.

2nd Generation Biofuels: Switchgrasses



Biofuels in the US

Switchgrass: Northwest Viability Questions

- Is switchgrass viable in these dryland regions?

$\rightarrow$ Probably not.

- Unirrigated switchgrass in this area, if it could grow, is seems unlikely.

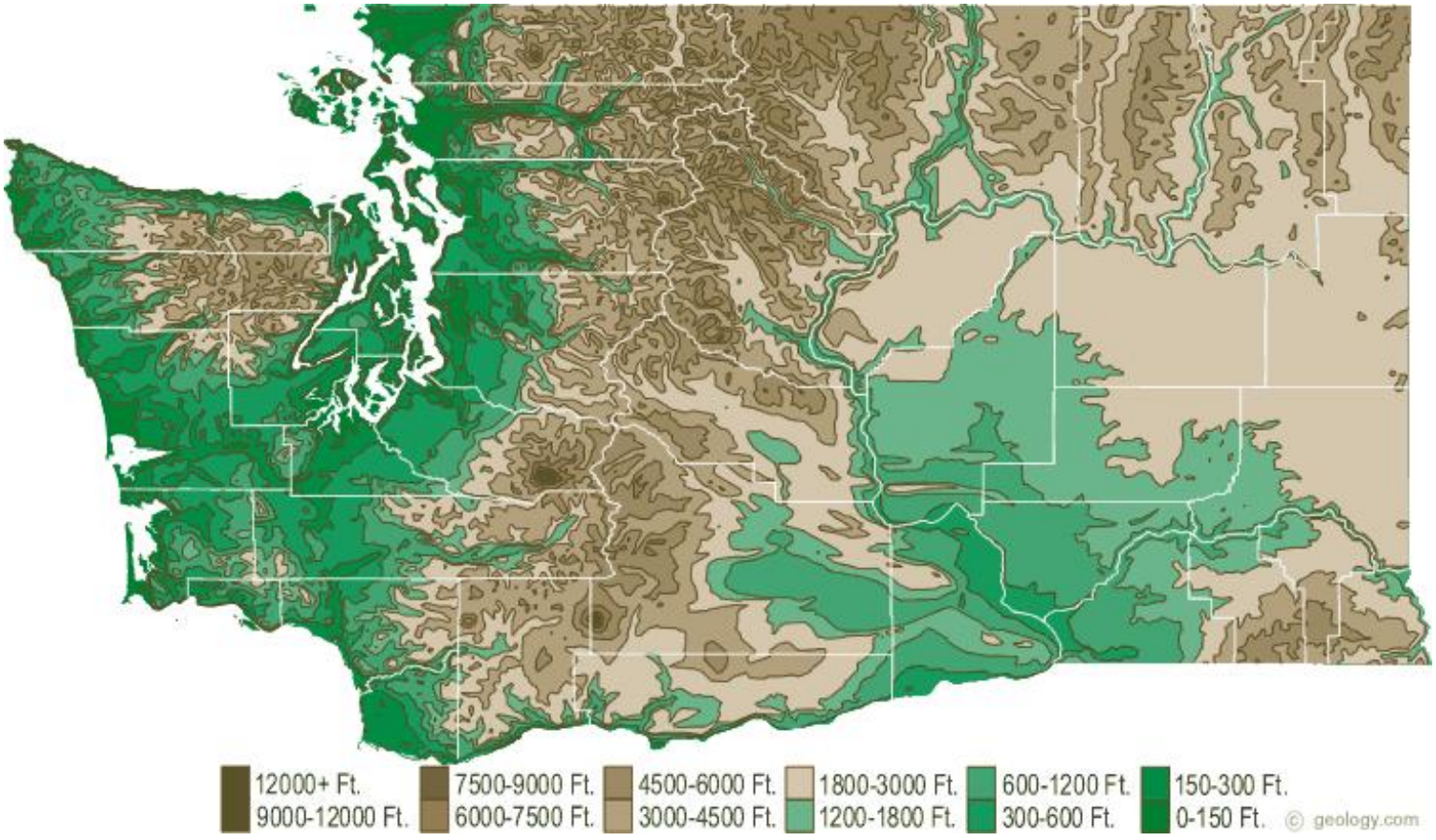
Biofuels in the US

Switchgrass: Future Research in Irrigation?

- There is a significant possibility that new water rights along the Columbia will soon be allotted.
- What would the benefit of irrigating the dryland wheat region?

- Unirrigated switchgrass in this area, if it could grow, is seems unlikely.

2nd Generation Biofuels: Switchgrasses



Biofuels in the US

Future Work

- Fully integrate a rainfall and soil quality fixed effects into a more in depth analysis.
- On a national level, how do land tenure contracts affect switchgrass's potential.
- National level general equilibrium analysis.

Extensions to 2nd Generation Biofuels

- No capacity .
-