Empirical Analysis of the Sources of Corn Used for Ethanol Production in the United States: 2001-2009

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Findings: minimal land-use change from corn use for ethanol over the last decade

Empirical decomposition analysis showed that recent corn use for ethanol production were largely due to:

- **Reallocation of domestic corn consumption in favor of ethanol**
- **Increases in domestic production of corn – two-thirds from increases in corn yield**

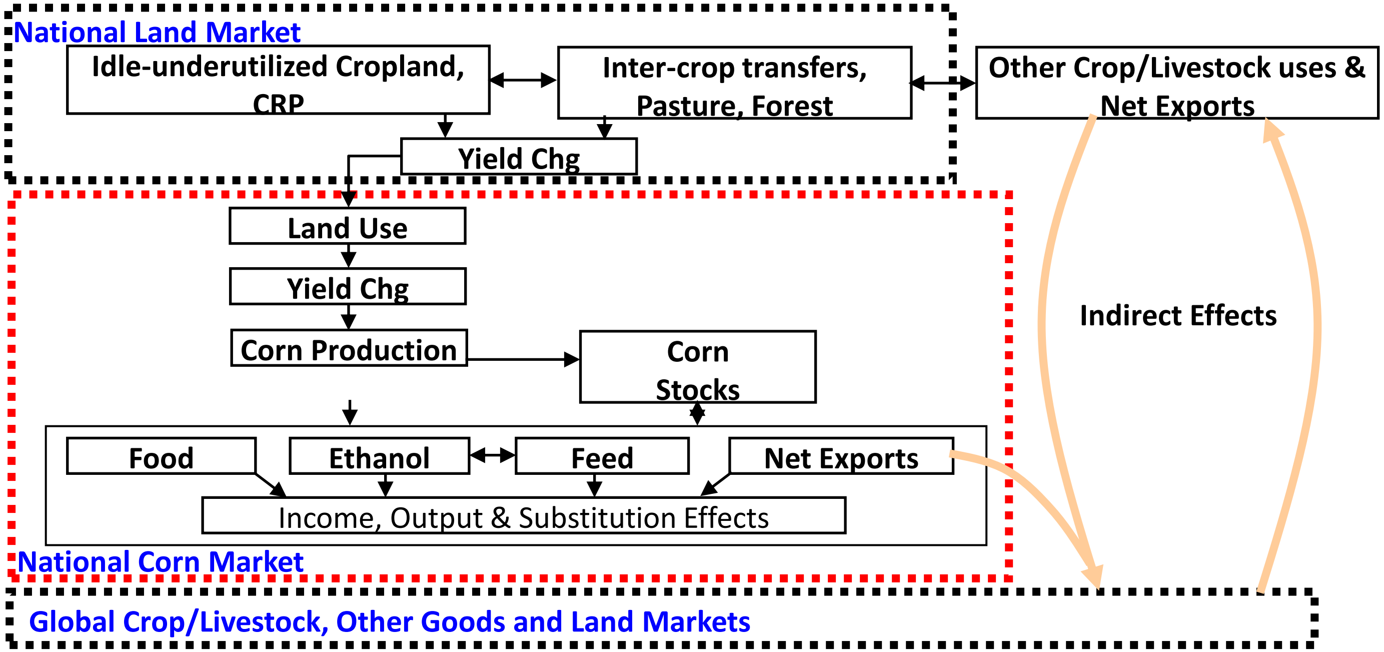
Implication: The domestic market for corn adjusted flexibly to ethanol production with minimal land-use change and little export market impacts

*Oladosu G., K. Kline, R. Uria-Martinez and L. Eaton "Sources of corn for ethanol production in the United States: a decomposition analysis of the empirical data"; Biofuels, Bioprod. Bioref. (2011); **DOI: 10.1002/bbb.305**

Outline

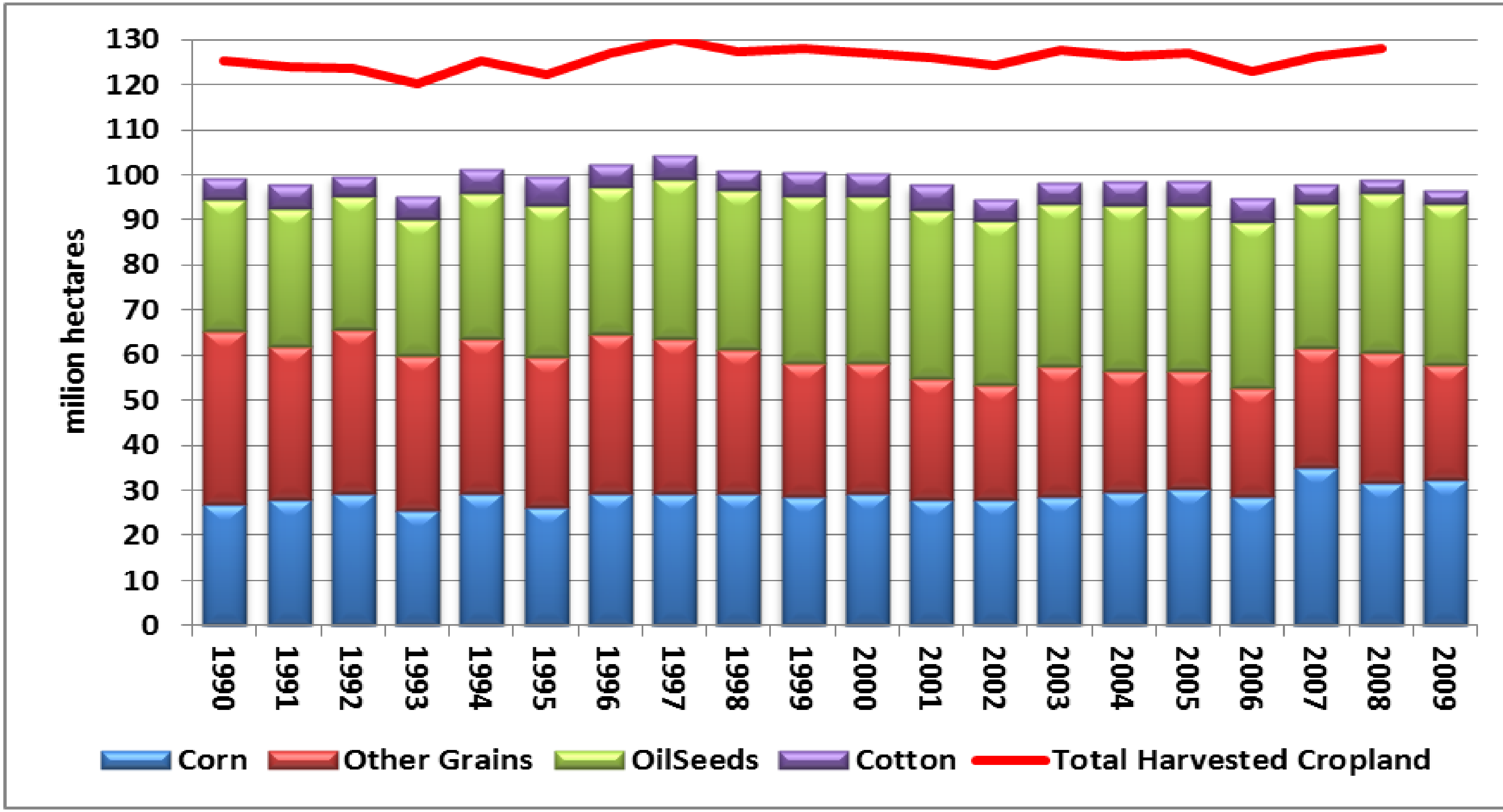
- Introduction
- Review of the Empirical Data
- Methodology & Results
- Conclusions

Indirect Land-Use Change (ILUC) is Unobservable; Estimation Involves Many Assumptions



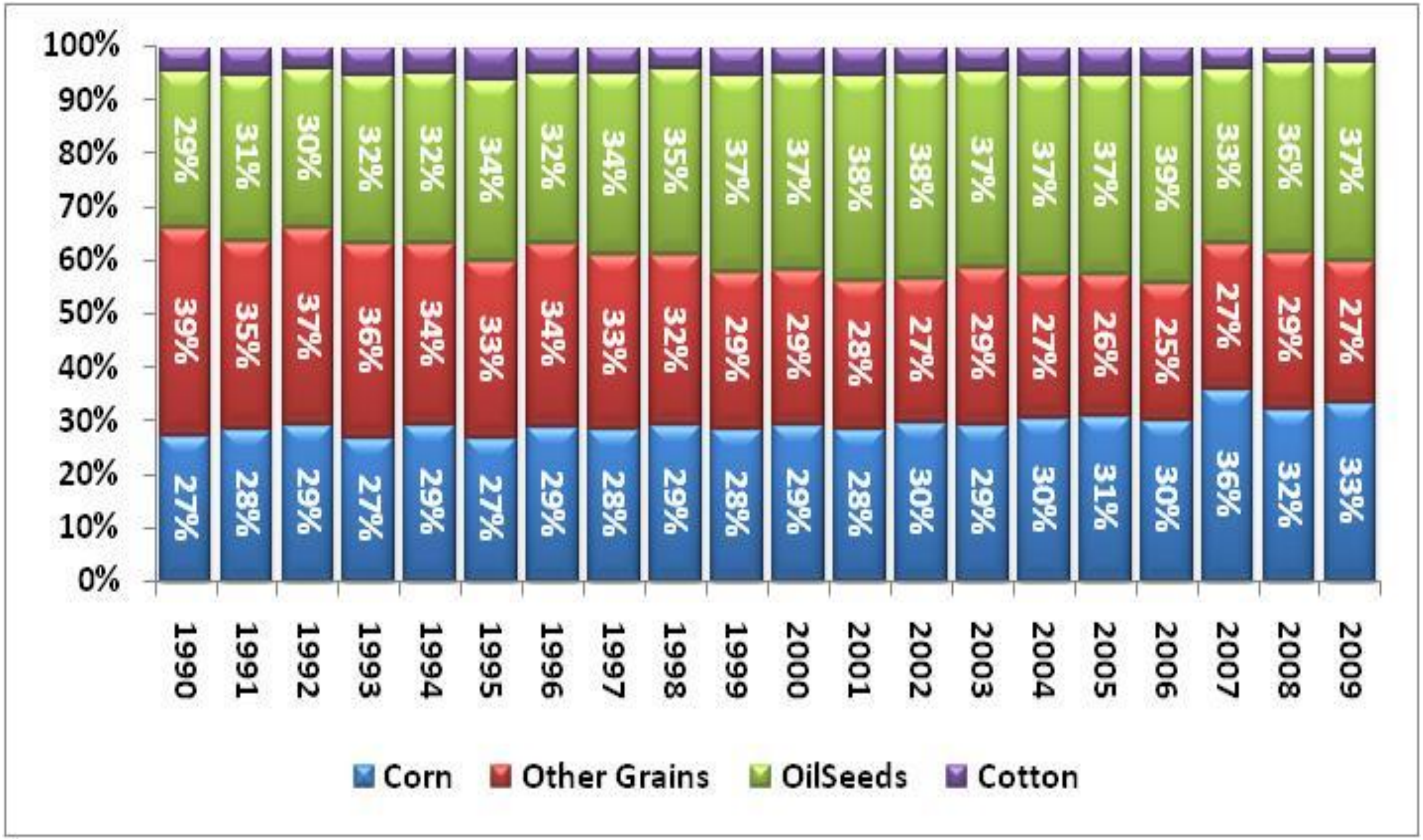
- LUC is influenced by a multitude of interacting factors
  - Modeling complex interactions involves many assumptions
- Rapid growth in ethanol production over the last decade
  - Provides empirical data to begin evaluating these assumptions

Review of the Empirical Corn Data



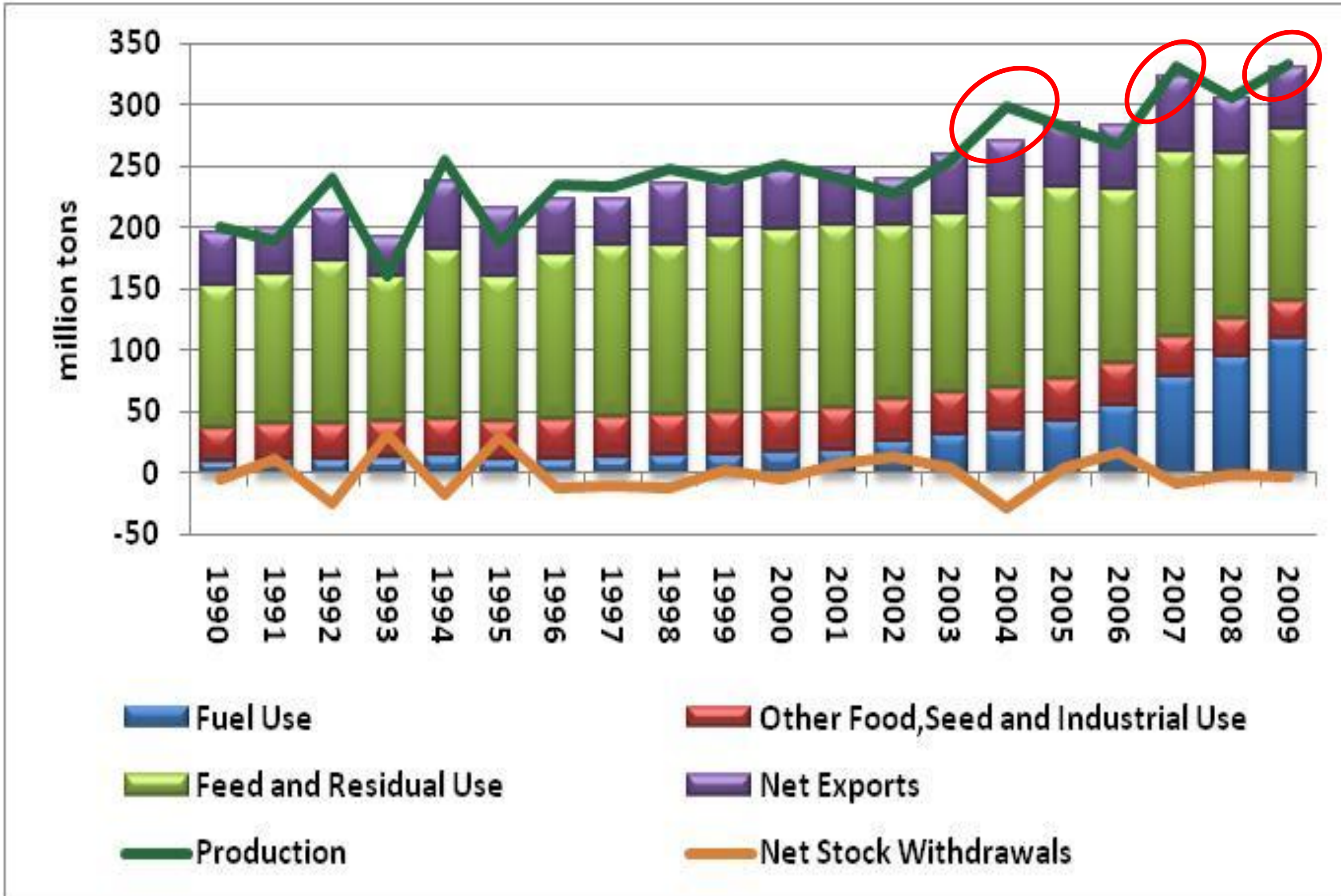
- Harvested cropland changed little since 1990

Review of the Empirical Corn Data: Harvested Area Changed Little from 2001-2009



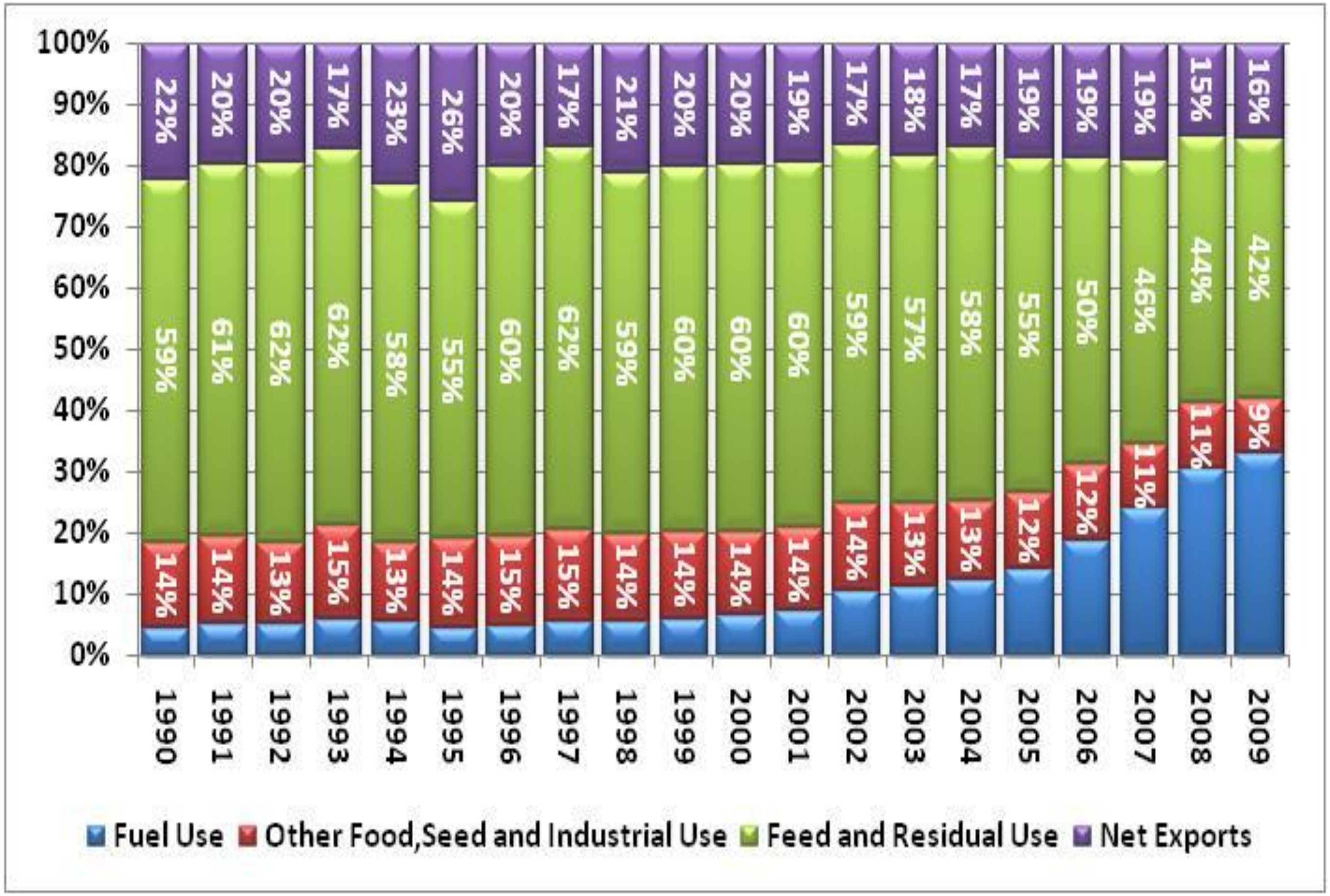
- **Corn share of major crops area around 30%**
- **Oilseeds share about 37%**

Review of the Empirical Corn Data: Exports Up 50% from 2002 -07, as Use for Ethanol Quintupled



- Corn production increased in 2003, 2004, 2007 & 2009

Review of the Empirical Corn Data: Exports Up 50% from 2002 -07, as Use for Ethanol Quintupled



- Export share stable from 2001-2007
- Ethanol use share +26% from 2001-2009
- Other uses share -23% from 2001-2009

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Methodology & Results: Index Decomposition Analysis (IDA)- Isolates the Contributions of Individual Factors

- Used extensively for energy decomposition analysis (see references*)
- Allocates the change in a given variable (y) to each contributing factor - if all other factors were held constant
- The log. mean divisia index (LMDI I) formulation:

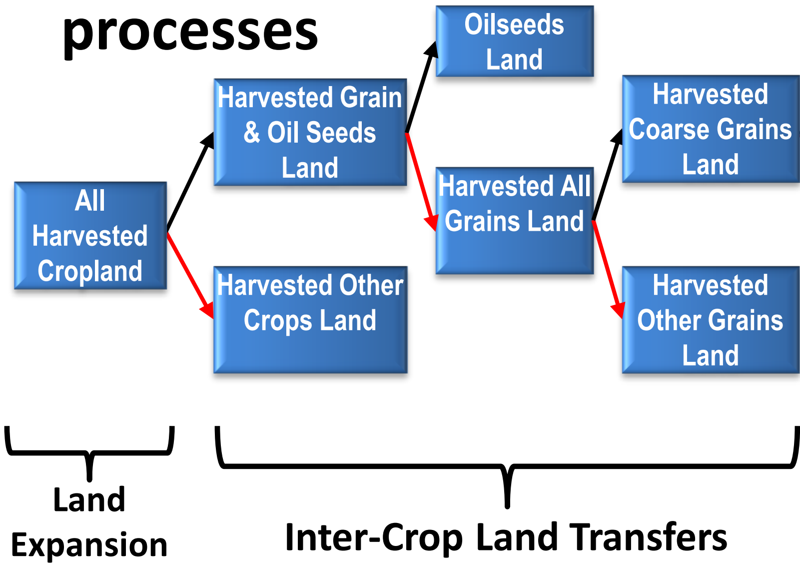
$$\Delta y^D = \sum_{i=1}^{n}\left(\frac{(y_{t1}-y_{t0})}{ln\left(\frac{y_{t1}}{y_{t0}}\right)}\right) ln\left(\frac{x_{i,t1}}{x_{i,t0}}\right) = \sum_{i=1}^{n} \Delta y \frac{g_{xi}}{g_y}$$

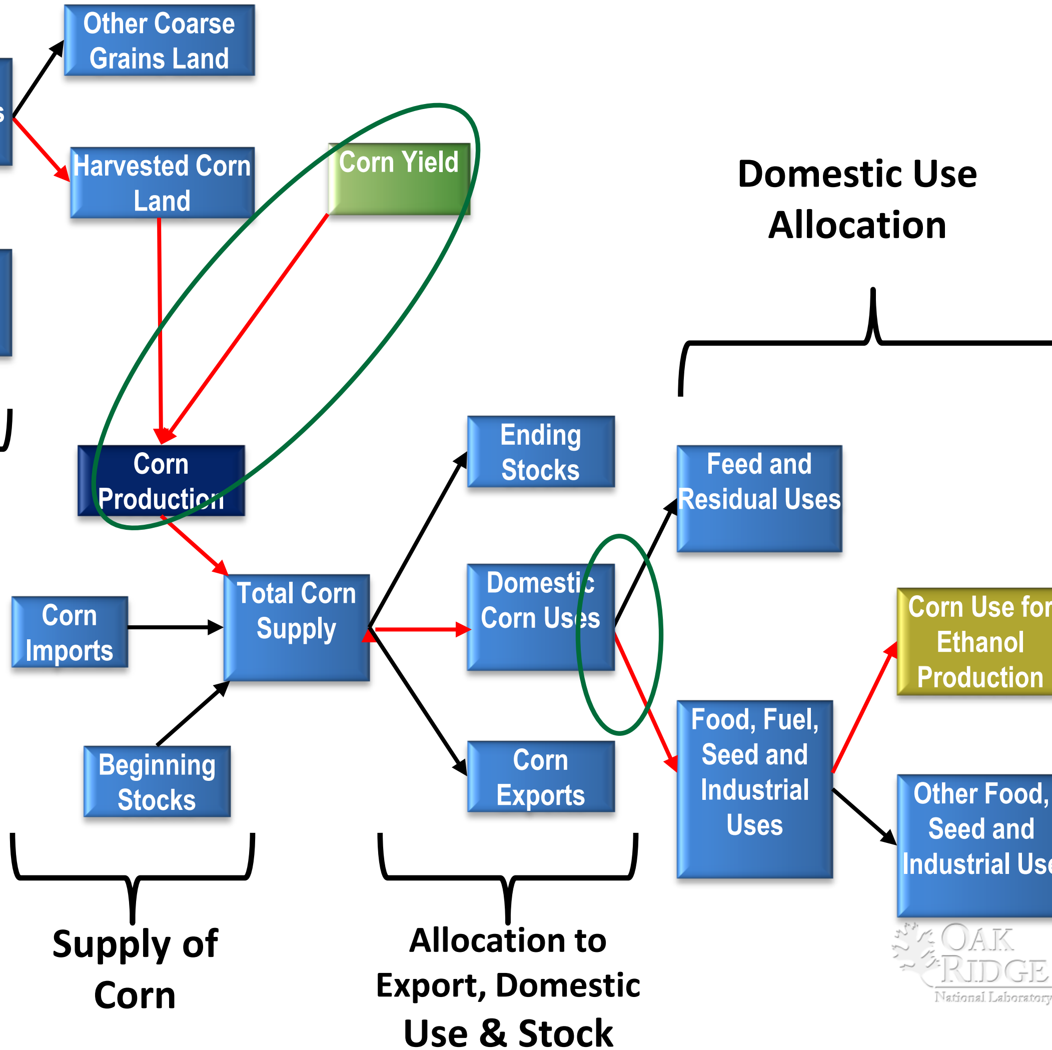
Factor Contributions

- Addresses need to isolate the role of individual factors

Methodology & Results: Decomposition of the Sources of Corn Use for Ethanol Production

- Corn use for ethanol can be traced through a chain of linked processes





Main assumptions of iLUC:

- Diversion of corn exports
- Displacement of land previously under other crops

Decomposition Analysis: Multiplicative Relationship Describes the Role of Factors in Corn Use for Ethanol

$$Q_{ce} = \underbrace{\left(\frac{Q_{ce}}{Q_{ffsi}}\right)\left(\frac{Q_{ffsi}}{Q_{dom}}\right)}_{\text{Domestic Use Reallocation}} \underbrace{\left(\frac{Q_{dom}}{Q_{sup}}\right)}_{\text{Domestic Share of Supply}} \underbrace{\left(\frac{Q_{sup}}{Q_{prd}}\right)}_{\text{Supply}} Q_{prd}$$

$$Q_{prd} = \underbrace{Y_{corn}}_{\text{Yield}} \underbrace{\left(\frac{A_{corn}}{A_{cgrn}}\right)\left(\frac{A_{cgrn}}{A_{grn}}\right)\left(\frac{A_{grn}}{A_{grn+oilsd}}\right)\left(\frac{A_{grn+oilsd}}{A_{all}}\right)}_{\text{Inter-Crop Land Transfers}} \underbrace{A_{all}}_{\text{Land Expansion}}$$

Q_{ce} = Corn use for ethanol production (million tons)

Q_{ffsi} = Corn use for food, fuel, seed and industrial purposes (million tons)

Q_{dom} = Total domestic corn use (million tons)

Q_{prd} = Total corn production (million tons)

Q_{sup}= Total corn supply (million tons)

Y_{corn} = Annual corn yield in (tons/ha)

A_{corn} = Annual corn harvested area (mha)

A_{cgrn} = Annual coarse grain harvested area (mha)

A_{grn} = Annual all grain* harvested area (mha)

$A_{gn+oilsd}$ = Annual all grain plus oilseeds harvested area (mha)**

A_{all} = Annual total harvested cropland area (mha)

* Grains include corn, barley, oats, rye, sorghum (coarse grains), wheat, milled rice (other grains)
** Oilseeds include soybean, cottonseed, peanut, rapeseed, and sunflower seed

Decomposition Results 2001-2009: Domestic Use Reallocations and Production Accounted for Most of the Change in Corn Use for Ethanol

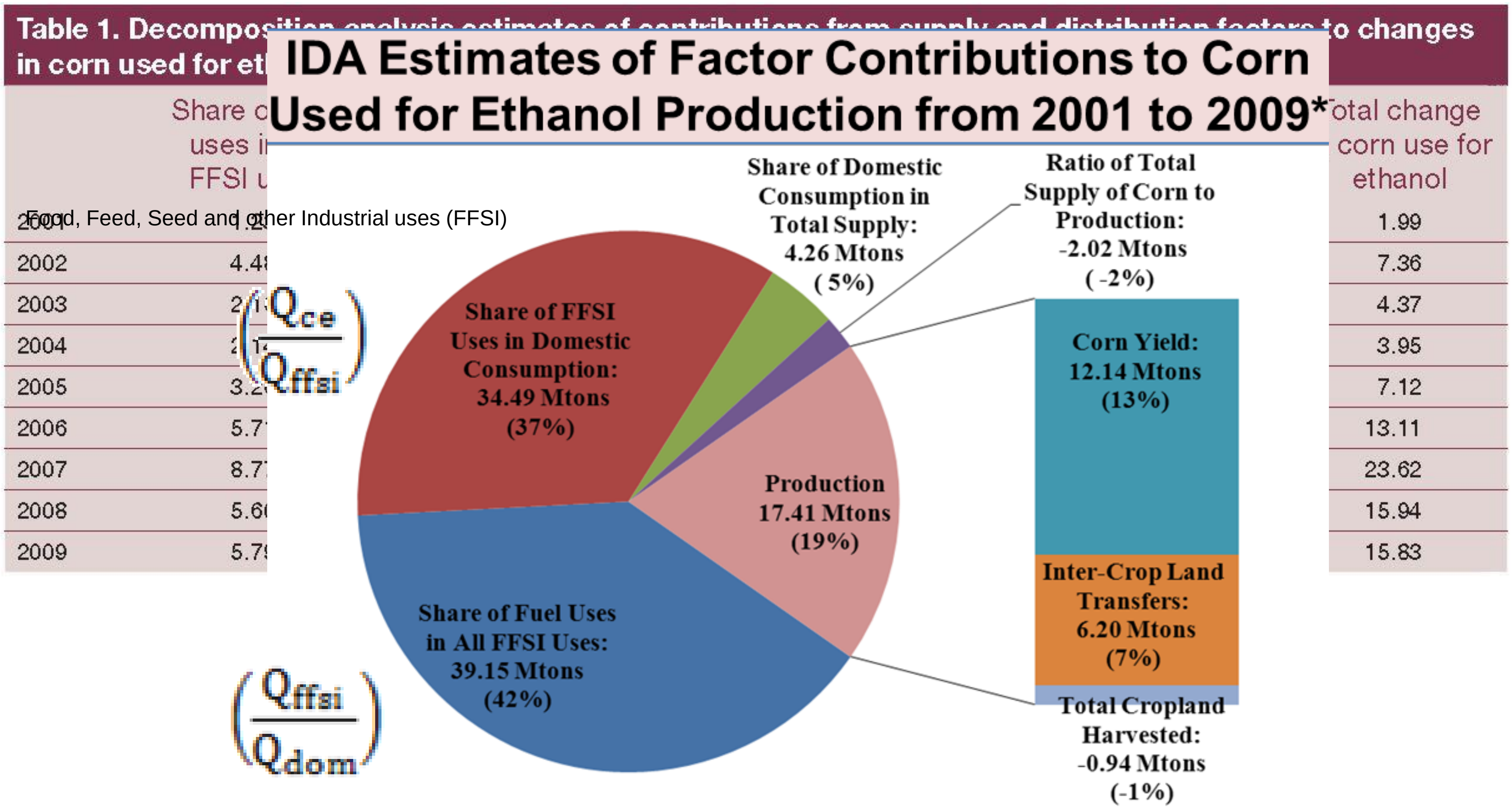
Table 1. Decomposition analysis estimates of contributions from supply and distribution factors to changes in corn used for ethanol production from 2001 to 2009 (million tons).

	Share of fuel uses in all FFSI uses	Share of FFSI uses in domestic consumption	Share of domestic consumption in total supply	Ratio of total supply of corn to production	Production	Total change in corn use for ethanol
2001	1.23	0.52	0.57	0.38	–0.72	1.99
2002	4.48	2.89	1.60	–0.38	–1.24	7.36
2003	2.16	0.77	–0.10	–1.69	3.23	4.37
2004	2.14	–0.07	–2.30	–0.78	4.97	3.95
2005	3.26	2.65	–0.11	3.56	–2.24	7.12
2006	5.71	7.67	2.37	–0.12	–2.52	13.11
2007	8.77	6.66	–0.78	–4.90	13.86	23.62
2008	5.60	11.19	2.99	2.58	–6.42	15.94
2009	5.79	2.21	0.01	–0.66	8.49	15.83

- **Net Contribution from domestic use reallocation 2001-2009: 79%**
- **Net Contribution from production 2001-2009: 19%**
- **Net Contribution from domestic share of supply 2001-2009: 5%**
- **Net contribution from supply/production ratio 2001-2009: -2%**

$$\left(\frac{Q_{dom}}{Q_{sup}}\right)$$

Decomposition Results 2001-2009: Domestic Use Reallocations and Production Accounted for Most of the Change in Corn Used for Ethanol



- Yield changes accounted for 13% of increase in corn used for ethanol production from 2001-2009 (almost 70% of the production contribution)

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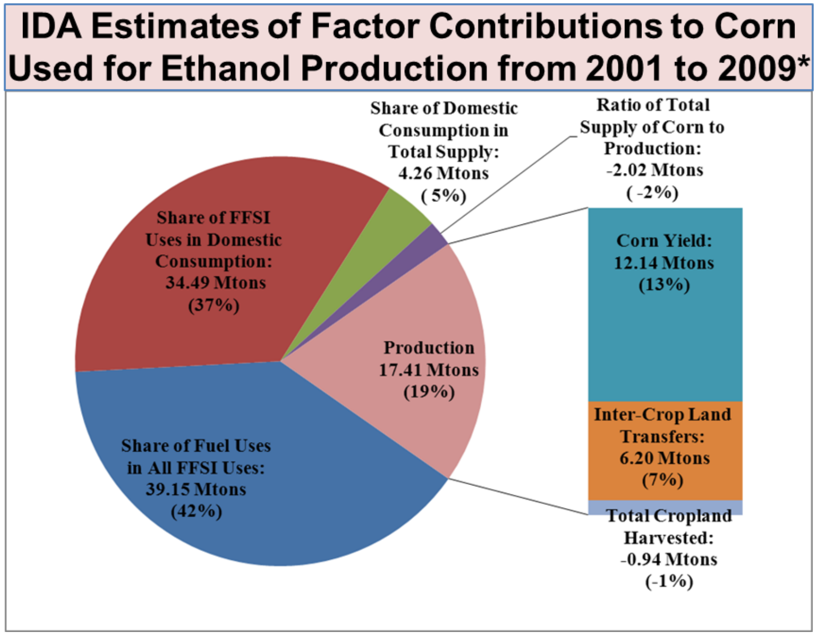
Findings: Minimal land-use change occurred with corn used for ethanol over the last decade



Empirical decomposition analysis showed that recent corn use for ethanol production was largely derived from:

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Implication: The domestic market for corn adjusted to ethanol production with minimal land-use change and little export market impact

Conclusions: The 2001-2009 Data Do Not Support ILUC Assumptions

- **Domestic market's response to corn use for ethanol very flexible**
- **Year to year variations in factor contributions**
  - **Cannot use single year observation or two-point comparisons to predict long-term ILUC**
  - **Crucial dynamics in the determinants of ILUC require further examination**

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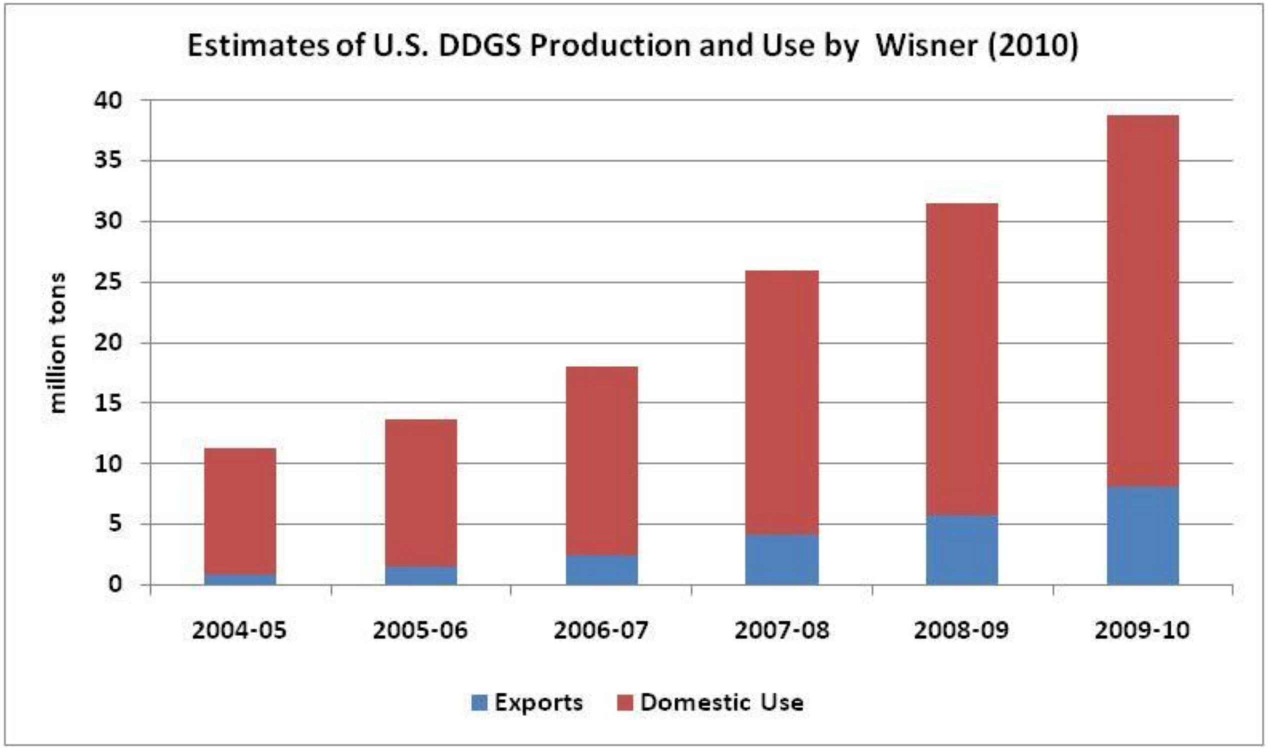
Additional Slides

Economic Conditions Influence Domestic and Export Crop Markets

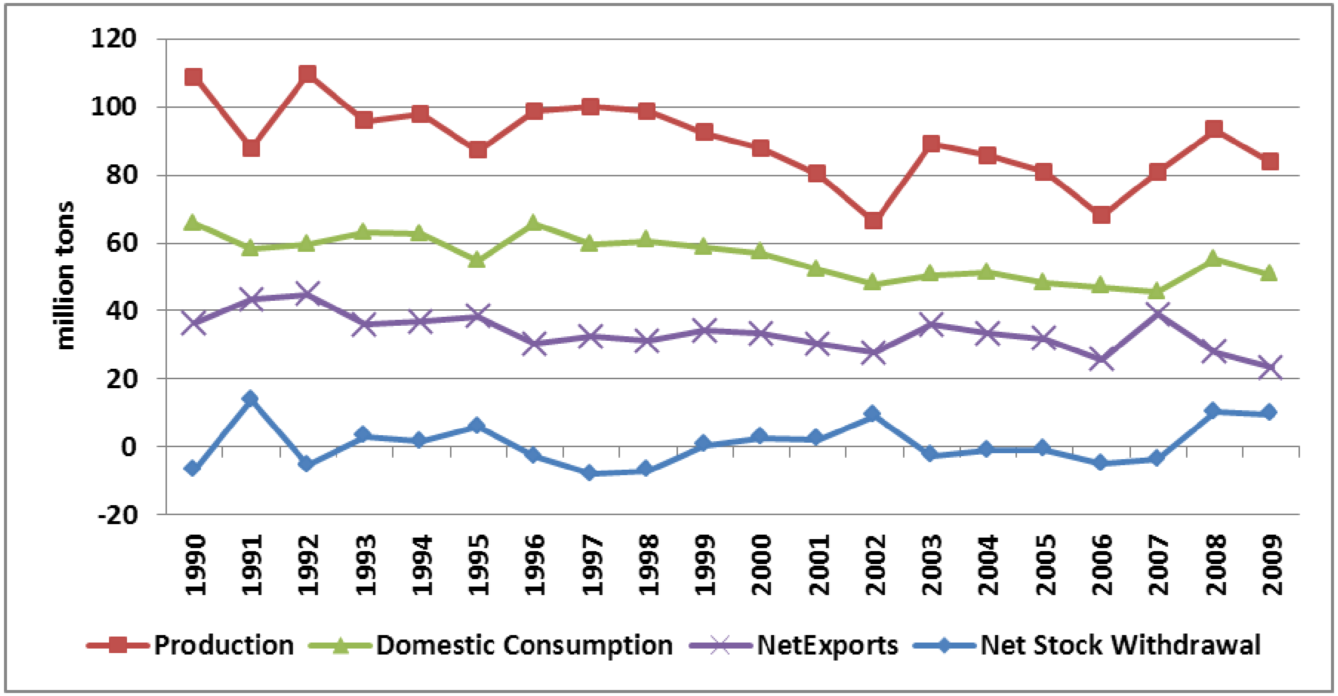
- **2001 & 2002: economy in recovery**
  - **Corn production declines; corn ethanol begins to increase**
- **2003,2004: economic growth**
  - **Corn production increases; corn ethanol increases rapidly**
- **2005,2007: economic growth**
  - **Corn production declined in 2005, increased in 2007; corn ethanol keeps increasing**
- **2006: economic slowdown**
  - **Corn production declines; corn ethanol keeps increasing**
- **2008: economic decline**
  - **Corn production declines; corn ethanol keeps increasing**

Other Markets 2004-2009: Dried Distiller Grains (DDGs) Production/Use



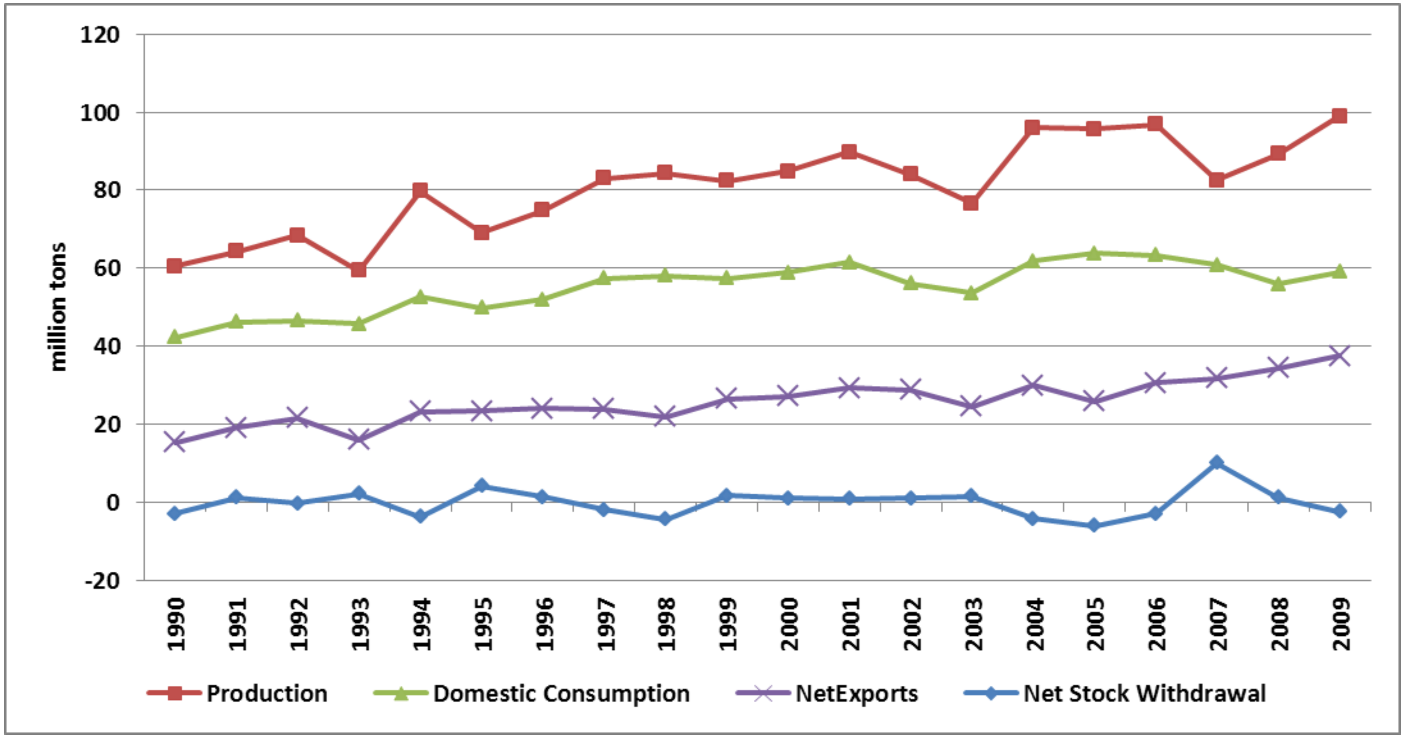
- Corn ethanol returns between 30-40% of corn use as DDGS
- Exports of DDGS estimated at 6 million tons of corn by 2008
  - In addition to the increase in corn exports during the period
- Studies suggest higher efficiency of DDGs relative to corn/soybean (Bremer et al, 2010)

Other Markets - All Grains (Minus Corn) Supply/Use: 1990-2009 – Declining production trend 1990-2002



- **All grains (minus corn) production increased in 2003, 2007 & 2008; corn production increased in 2003,2004 & 2007**
- **Domestic use declined slightly from 2002-2007**
- **Exports increased in 2003 & 2007**

Other Markets - Oilseeds Supply/Use: (1990-2009)



- Oilseeds production increased in 2004 and was flat through 2006; corn production increased in 2003, 2004 & 2007
- Domestic use rose slightly from 2003-2006; declined in 2007 & 2008
- Exports increased from 2003 – 2007, with a slight dip in 2005