Agricultural Policy and Land Conversion on the Northern Great Plains

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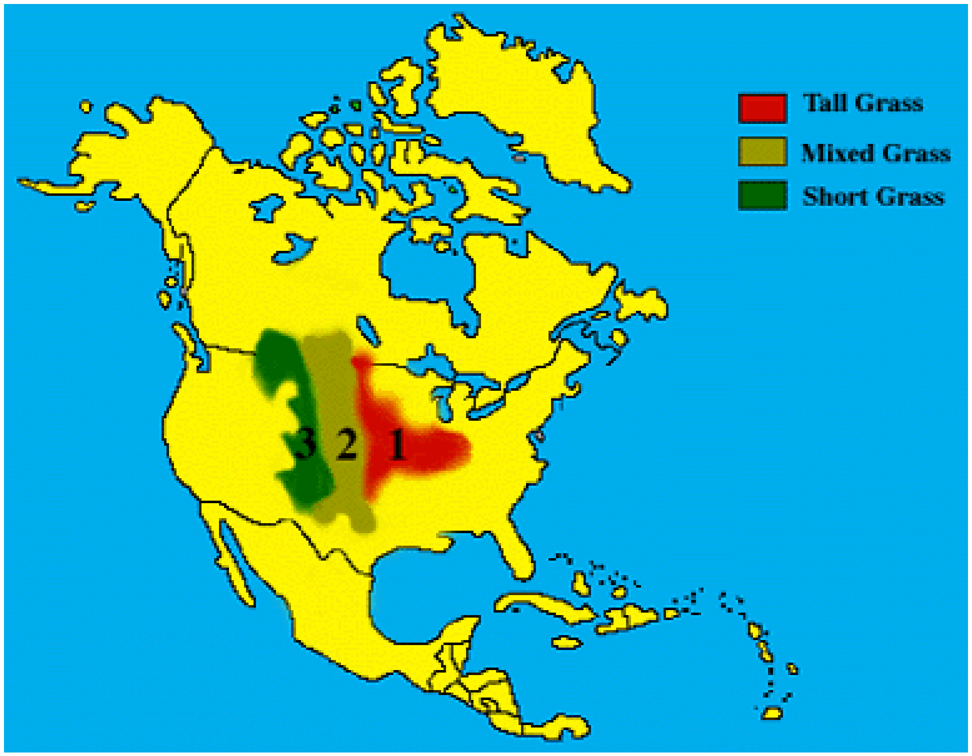
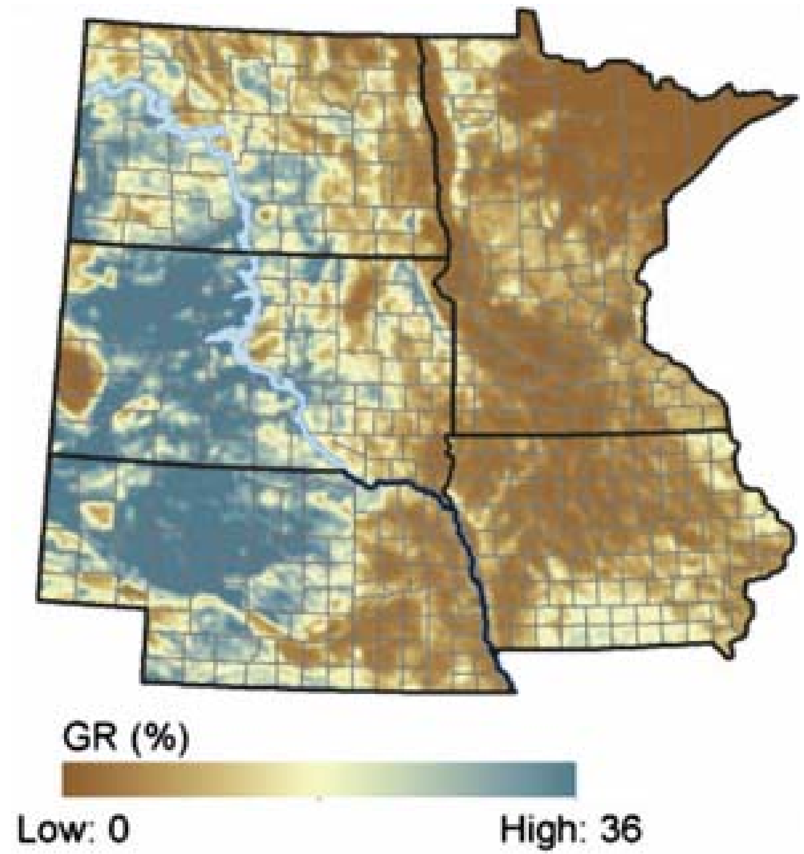
Snapshots



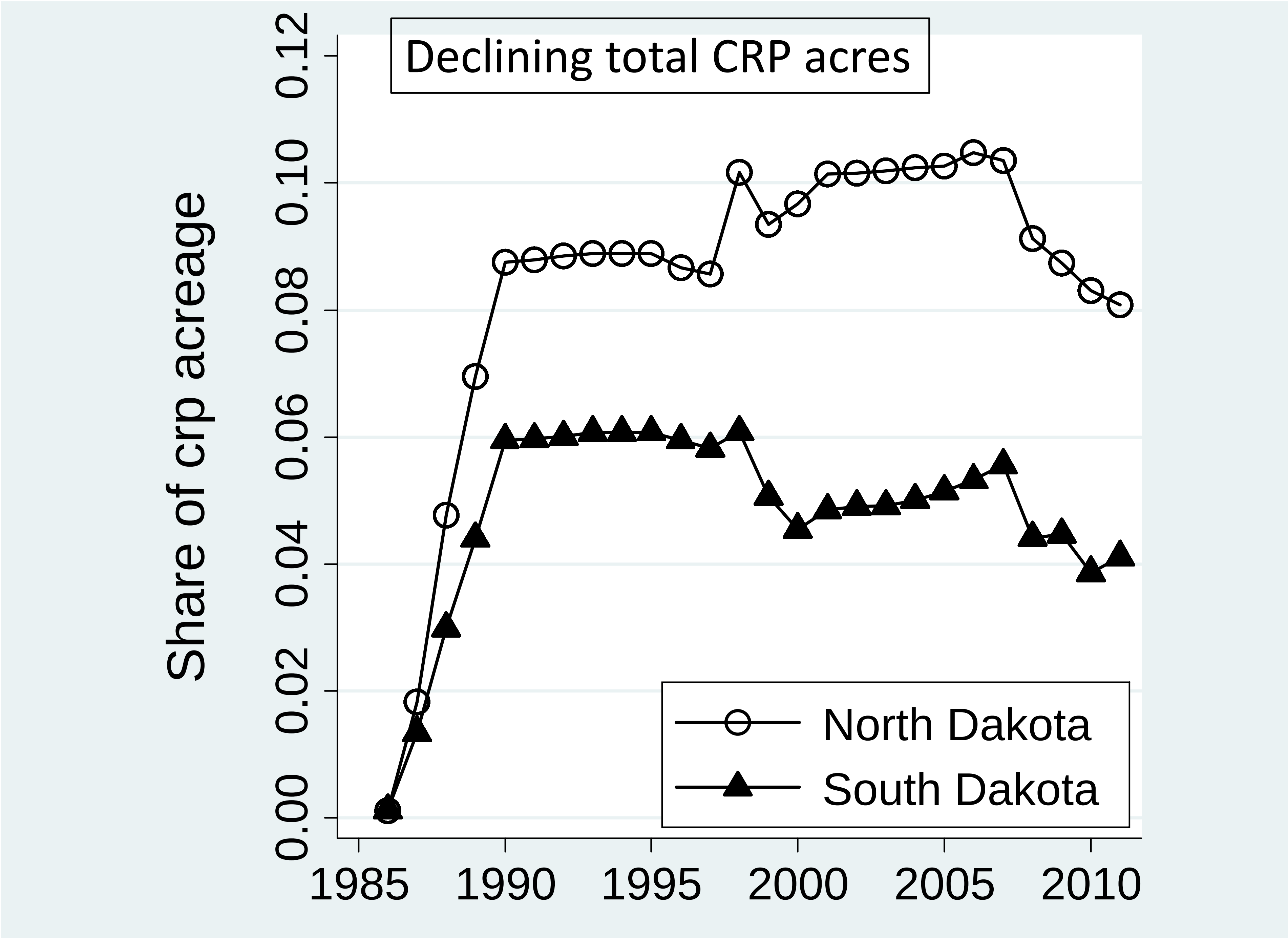
Pre-settlement

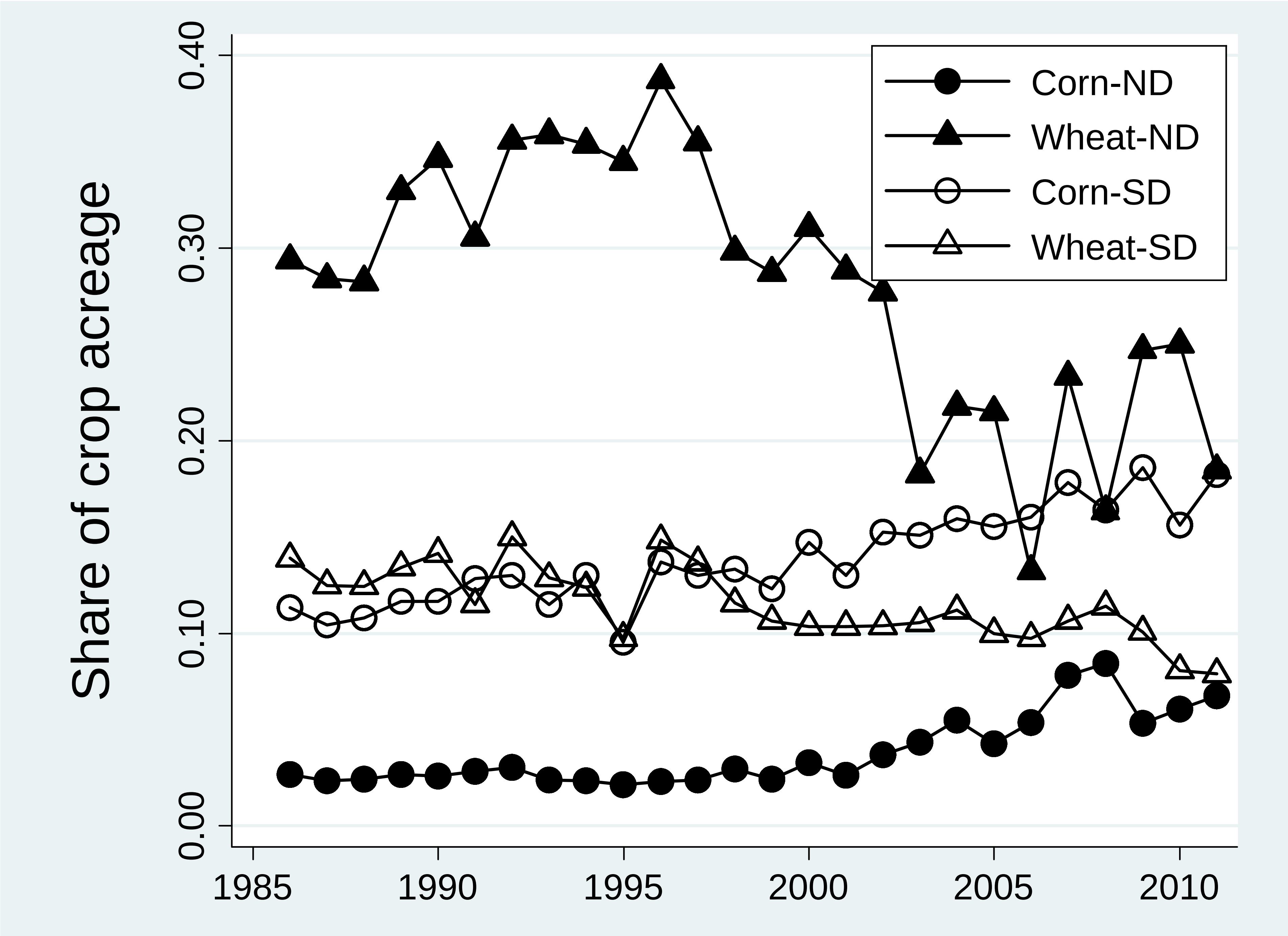


2006, (Wright & Wimberley, 2013)

Recent trend

- Conversion 1950 to ’90s didn’t receive much attention
- Stephens et al. (2008), satellite data: 0.4% native grassland conversion rate, 1989-2003 on Missouri Coteau
- Rashford et al. (2011), NRI data: project about 1%/year conversion over 2006-’11 on Prairie Pothole region
- Johnston (2012), remotely sensed NASS Land Cover Cropland Data Layer: Dakotas part of PPR had 16.9% conversion over 2001-’10
- Wright & Wimberly (2013), CDL: Over 2006-’11 about 2 mill. ac. grassland converted to corn & soybean production in W. Corn Belt
- USDA FSA estimates that 0.4 mill. ac. with no prior cropping history was plowed in 2012 crop year

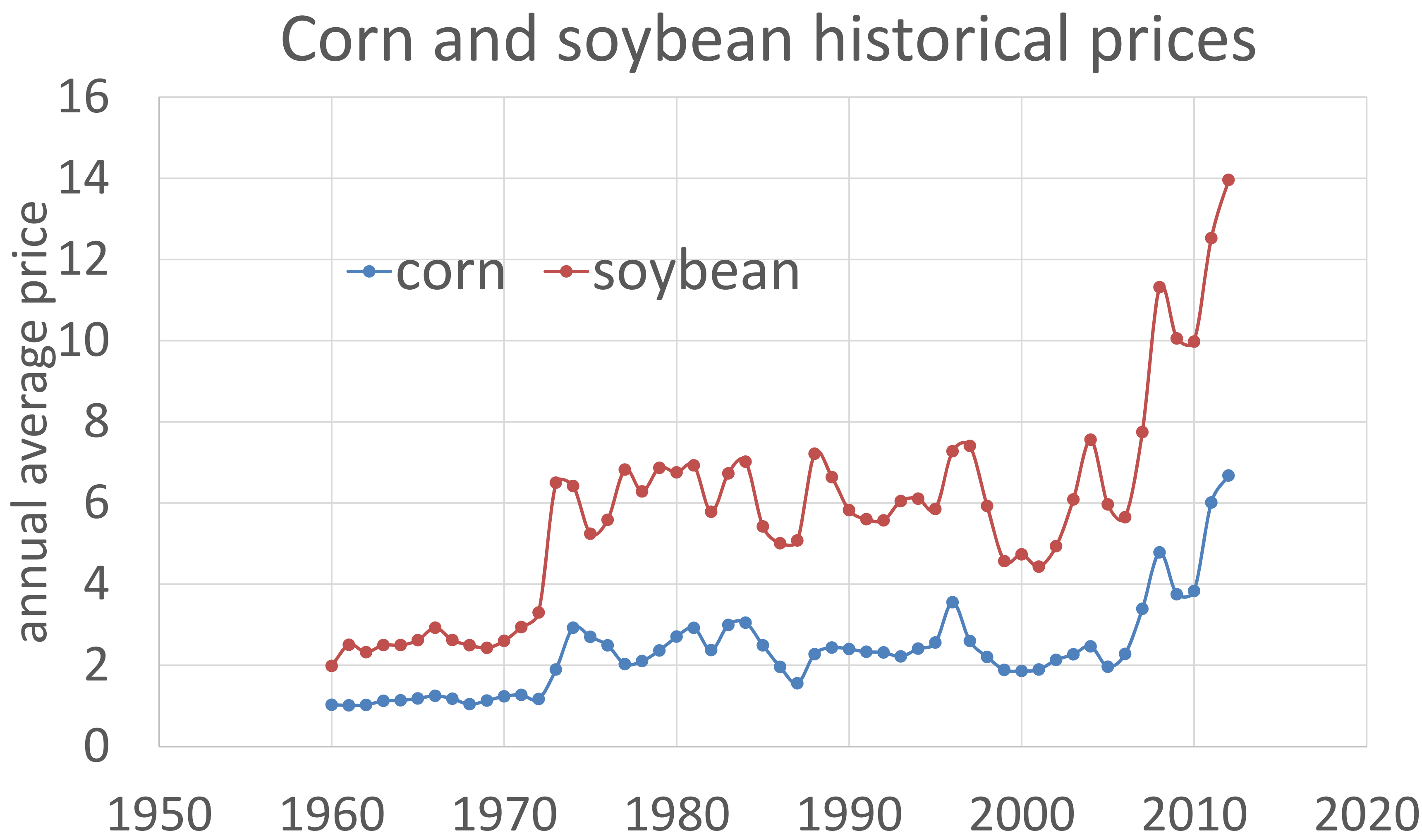

Declining total CRP acres
Share of crp acreage
0.00
0.02
0.04
0.06
0.08
0.10
0.12
1985
1990
1995
2000
2005
2010
North Dakota
South Dakota



Share of crop acreage
0.00
0.10
0.20
0.30
0.40
1985
1990
1995
2000
2005
2010
Corn-ND
Wheat-ND
Corn-SD
Wheat-SD

Potential Reasons: Technology & Market

- Mechanization & Seed innovations?
  - Bigger machines
  - less need for machinery, labor, chemicals
  - Drought tolerance
- Commodity prices due to biofuel policies, global demand, etc.?
- Undoubtedly, these are major factors, especially in recent years



Corn and soybean historical prices
annual average price
corn
soybean
0
2
4
6
8
10
12
14
16
1950
1960
1970
1980
1990
2000
2010
2020

Government Attention

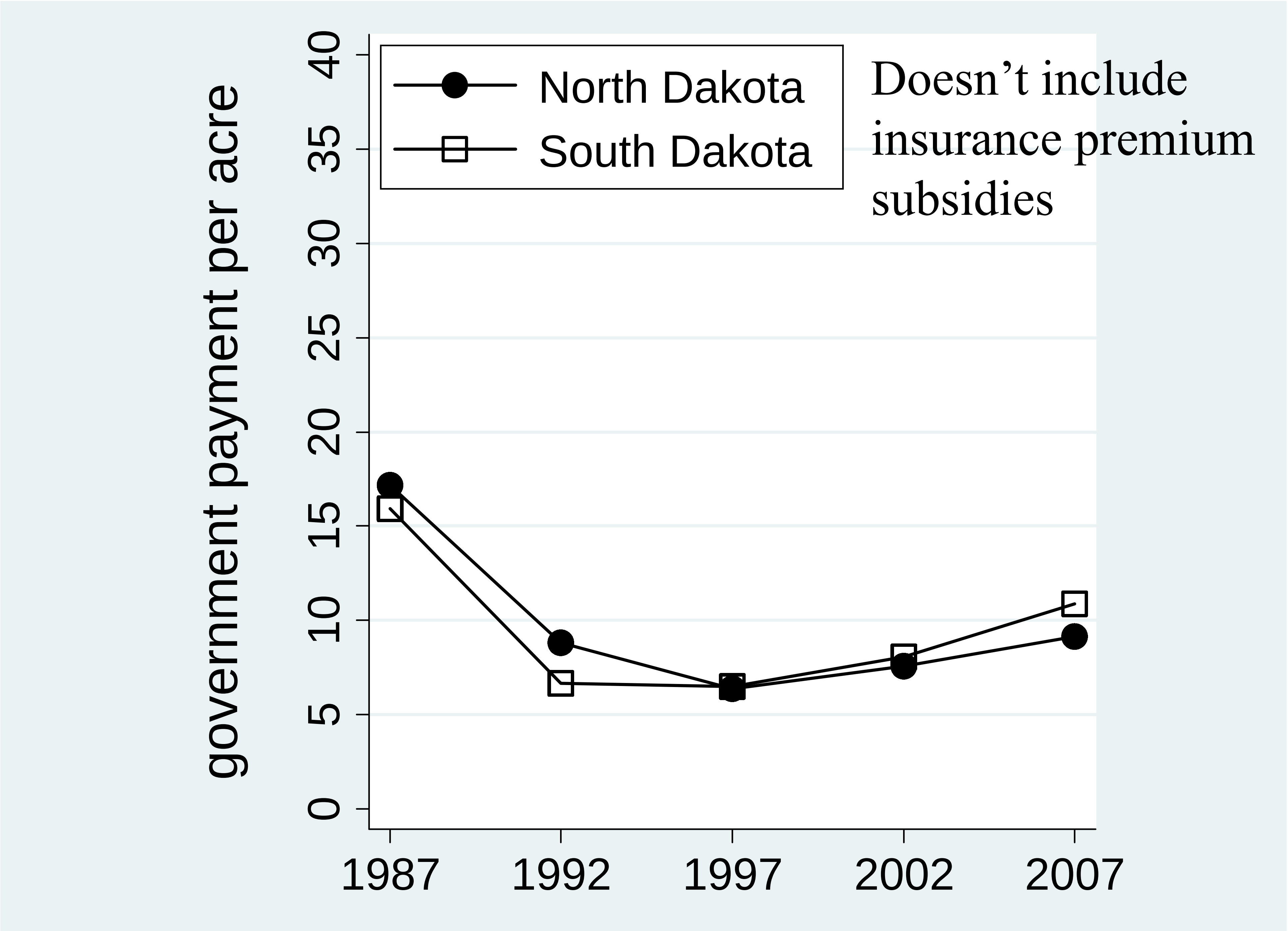
- At request of Congress, GAO reviewed issues related to grassland conversions. (report produced in 2007). Another report is presently in the works
- Manager's statement accompanying 2008 Farm Act directed USDA to conduct a study of the role of farm programs in grassland to cropland conversion. (report produced in 2011)
- Between 2002-2007 FSA tracked native grassland loss and data are available

Policy?

- Our focus is on policy, specifically risk management policy
- Major expansions in crop insurance subsidies since 1980. Now about $7-9 billion/year spent on it
- Payment coupled directly to yield and acreage
- Goodwin, Vandeveer, and Deal (2004) represents the earlier consensus: effects are not large
- Claassen et al. (2011a, 200b) and Miao et al. (2011) used simulation approach to show that risk aversion and subsidy transfer motives provide little incentive to convert due to crop insurance

Policy Now

- Sodsaver provisions in 2008 and 2014 Farm Bills
- In 2014, reduces crop insurance subsidy by 50% on first four years under cropping
- Applicable only to IA, MN, MT, NE, ND, SD
- Governor's signature no longer needed
- Maximum allowable acreage under CRP falls from 32 to 24 million

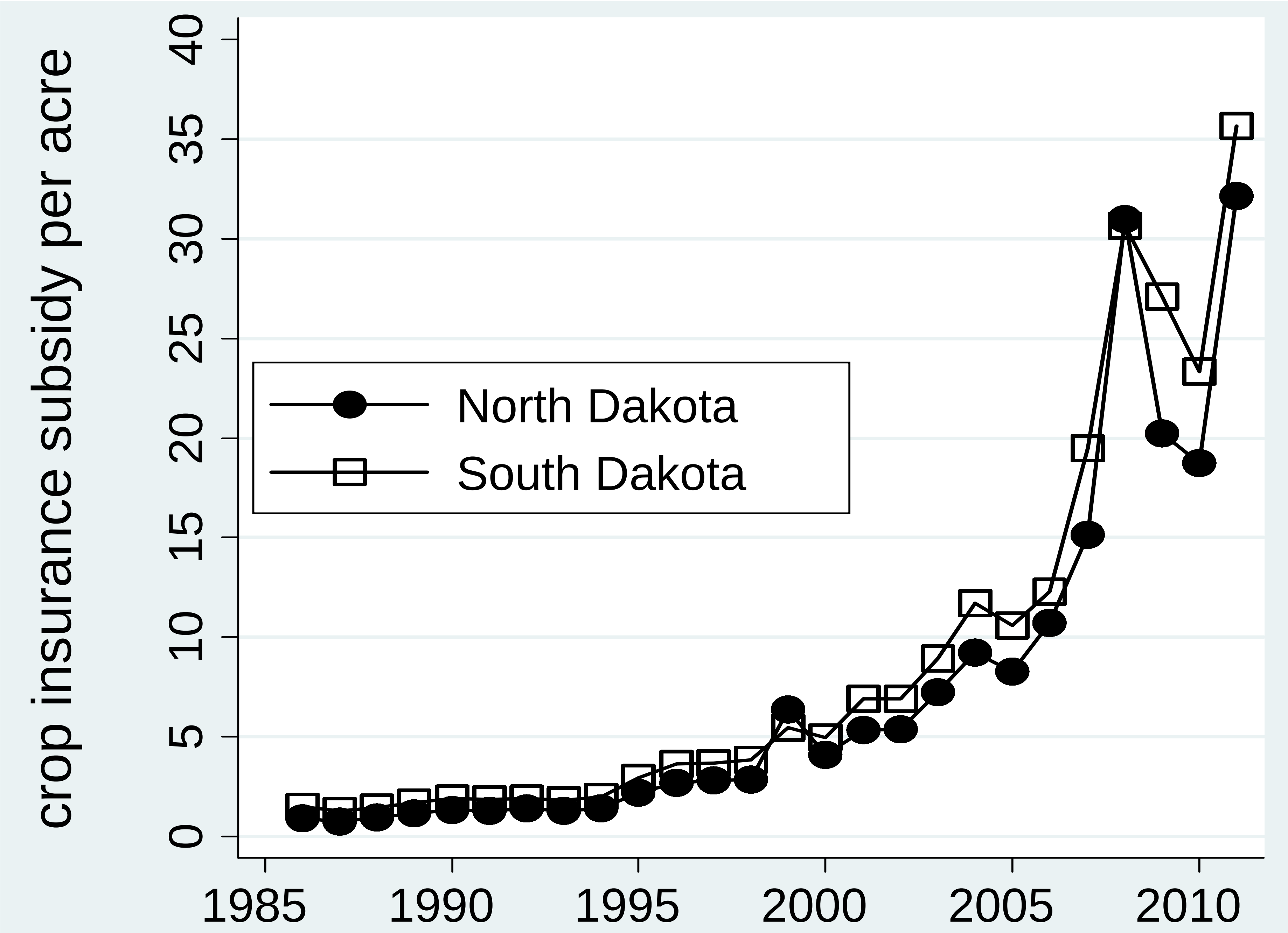


Doesn’t include insurance premium subsidies
North Dakota
South Dakota
government payment per acre
0
5
10
15
20
25
30
35
40
1987
1992
1997
2002
2007

Numbers for Corn in Recent Years

		Total insurance subsidy	Total acres	*Premium subsidy/ acre
2010	ND	$88.4 mill.	2.4 mill.	$37.5
	SD	$160.6 mill.	5.1 mill.	$31.6
2011	ND	$152.7 mill.	2.8 mill.	$55.3
	SD	$253.6 mill.	5.5 mill.	$46.3
2012	ND	$183.0 mill.	3.5 mill.	$52.8
	SD	$266.1 mill.	5.8 mill.	$45.5

*Not incl. A&O costs to insurance companies paid by government

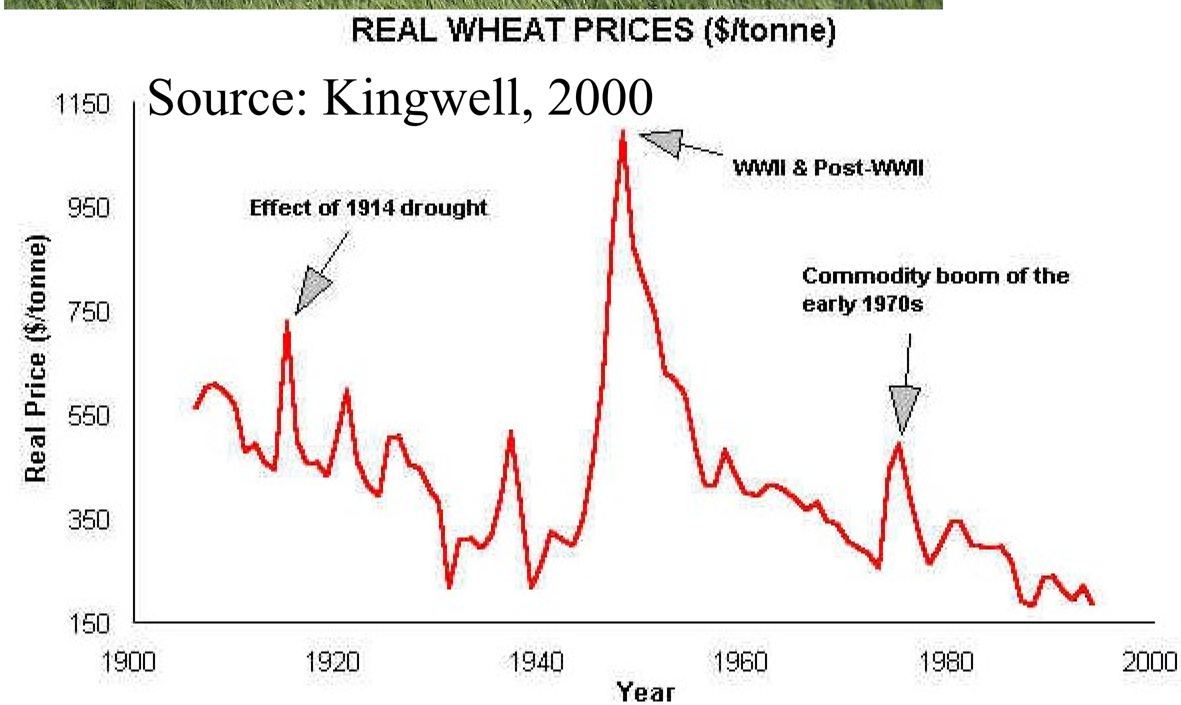

crop insurance subsidy per acre
0
5
10
15
20
25
30
35
40
1985
1990
1995
2000
2005
2010
North Dakota
South Dakota

Rents vs subsidy for corn

		$ CRP rent	$ Cash rent (non-irrigated land)	$ per acre subsidy
2010	ND	34.94	46	37.5
	SD	50.41	71.5	31.6
2011	ND	36.23	51	55.3
	SD	56.23	78	46.3
2012	ND	37.62	57	52.8
	SD	59.91	93	45.5

Churn, Churn, Churn

Native grassland conversion can be costly + much cropland is let back into grassland later



Source: Kingwell, 2000

We think another, dynamic, channel by which risk policy affects conversion is relevant

Conversion Cost

- Rock and brush removal, extensive land shaping, gulleys, gopher mounds, drainage, weed killing
- < $30/ac. on well-suited SD land (Faulstich 2011)
- Ransom *et al*. (2008) suggest costs of $55/ac. for ND land, equally divided between chemical treatment and mechanical cultivation
- > $100/acre for land new to cropping (Renner 2011)

θ = one-time conversion cost.

Switching Costs

- Cost of switching from improved pasture to cropping is small, \$15/ac
- Cost of establishing pasture much larger. For IA, Barnhart and Duffy (2012) estimate \$200/acre, but should be lower in Dakotas

κ_{cg} = cost of switching from cropping to grass;

κ_{gc} = cost of switching from grass to cropping.

- High switching costs should make land conversion less attractive, especially if prices are not persistent

Stochastics

- We build a Markov two-state model of crop revenues (high and low), with a persistence parameter
- A real options model of land values under different choices but absent infinite unconditional variance associated with standard model

$\lambda a \geq 0$ is constant hazard rate for transitioning from state l to state h;

$\lambda b \geq 0$ is constant hazard rate for transitioning from state h to state l;

$\lambda \geq 0$ is 'anti-persistence' scaling parameter to allow for changing persistence, or flux between states.

Notes on Stochastics

- Unlike most continuous time versions of real option models, it has bounded variance
- It has a closed form solution and is simple

  Equilibrium Prob(state l) $= b/(a+b)$

  Equilibrium Prob(state h) $= a/(a+b)$

  Independent of λ
- But λ should matter
  - present value of being in state h will depend on it
  - If switching costs are incurred then low λ mean low costs
  - Gov't policy sends <u>signals</u> on revenue persistence

Model

$R_{c,h}$ = high state crop returns;

$R_{c,h} - \delta$ = low state crop returns;

R_g = grassland returns;

r = interest rate

ϕ = risk intervention parameter

that reduces δ

Assumptions and Consequences

- We assume that $R_{c,h} > R_g > R_{c,h} - \delta$. Otherwise grass production wouldn't be competitive, and situation wouldn't represent the sorts of land choices we're interested in, on presently marginal land
- **Proposition**: Sodbusting only occurs in state h. Also, once any sod is busted then the land owner will follow either a 'crop always' system or an 'alternate' system, where in the 'crop always' system the land owner crops under both states h and l; and in the 'alternate' system the land owner crops under state h but grazes under state l

Consider Two-Stage Decision Process

- **Stage I: Whether to convert native grasslands?**
  - As long as conversion has not occurred, a land owner may consider this question each year
- **Stage II: Whether to switch?**
  - After conversion, keep land in crop production or switch it back to grass-based production? After having switched to grass, should land stay in grass or switch back to crop next year?
- Apply backward induction: Stage II is looked at first and conclusions are used when deciding in Stage I

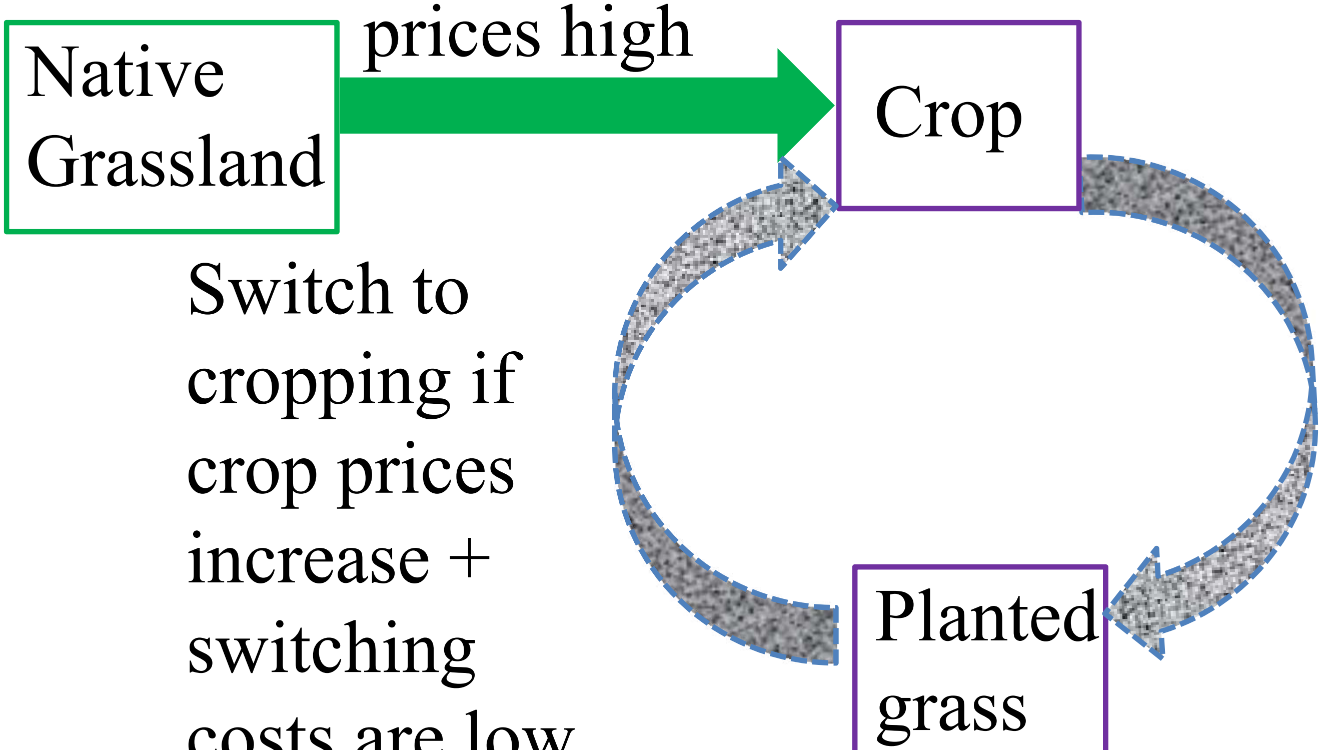
Analyzing effects of crop insurance subsidies on grassland conversion

- Real option approach:
  - Recognizing the process is complicated, and owners have options along the way
  - Dynamics: don't know when prices will be high/ low
  - Conversion costs have to be incurred up front
  - Switching costs between crop and grass
- Risk protection policy mitigates the impacts of downside price risk

WE CALL STAGE 2 ALTERNATION BETWEEN CROPPING & GRASS THE '**ALTERNATE**', OR 'ALT' SYSTEM

Stage 2 addressed elsewhere; Song, Zhao, Swinton 2011

Incur conversion cost + crop prices high



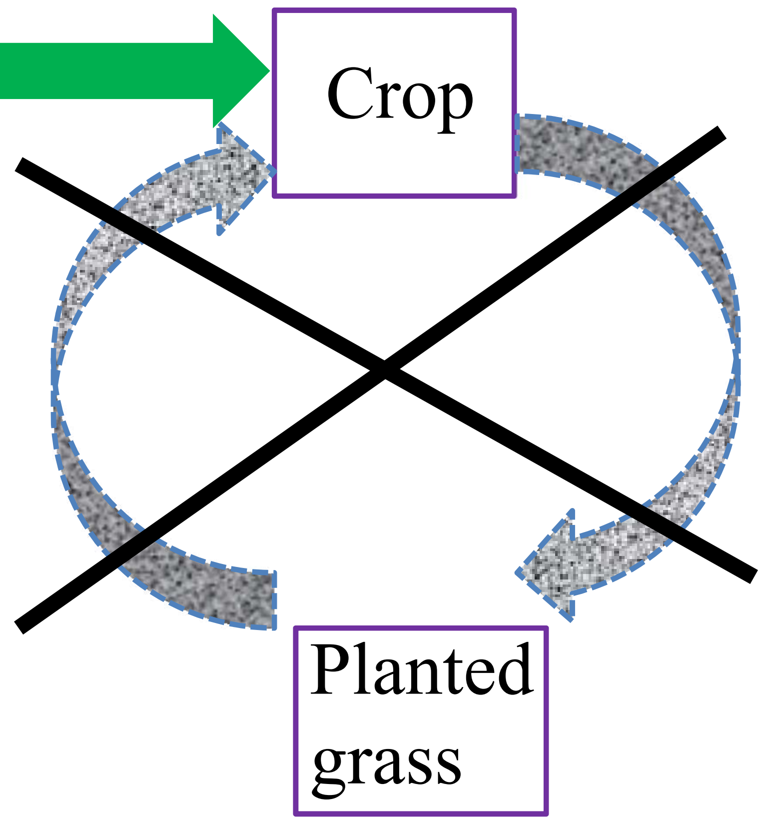
Switch to cropping if crop prices increase + switching costs are low

Switch to planted grass if crop prices fall + switching costs are low

Stage 1: To convert? Stage 2: Cropping System?

Two-stage game against nature

But if *i*) crop prices don't vary much over time, or *ii*) are strongly autocorrelated (persistent) or *iii*) switching costs are high then any converted land might be in '**crop always**', or 'ca' system



And how Stage 2 plays out determines Stage 1 conversion incentives. If switching costs are low or one doesn't need to switch very often then land with higher conversion costs will be converted

Model Solution under 'Crop Always'

- Following standard Bellman equation statistical methods, if one commences in state h then value is

$$\Phi(h;\mathrm{ca}) \approx R_{c,h}t + (1 - rt)E_t[\Phi \mid h]$$

where $R_{c,h}\,t$ is income over a small immediate time interval, 1- rt is the locally valid approximation of the time discount factor and $E_t[\Phi \mid h]$ is the present time expectation of value after time increment t given initial state h.

Now

$$E_t[\Phi \mid h] = \lambda bt\Phi(l;\mathrm{ca}) + (1 - \lambda bt)\Phi(h;\mathrm{ca})$$

Model Solution, Cont'd

- Substitute in and take time limit to obtain

$$r\Phi(h;\text{ca}) = R_{c,h} + \lambda b[\Phi(l;\text{ca}) - \Phi(h;\text{ca})].$$

- LHS is opportunity cost of capital given value when under ca and in state *h*
- RHS is comprised of sum of two parts
  - Immediate returns flow
  - Capital risk component if state changes to *l*

We can't solve this yet as it is coupled with value under state *l*

Model Solution, Cont'd

- A similar argument can be used to conclude that if one starts in state *l* then

$$r\Phi(l;\mathrm{ca}) = R_{c,h} - \delta + \lambda a[\Phi(h;\mathrm{ca}) - \Phi(l;\mathrm{ca})].$$

- Solve system to obtain

$$\Phi(h;\mathrm{ca}) = \frac{R_{c,h}}{r} - \frac{\lambda b \delta}{ru};$$

$$\Phi(l;\mathrm{ca}) = \frac{R_{c,h}}{r} - \frac{(r+\lambda b)\delta}{ru}; \quad u = r + \lambda a + \lambda b.$$

Comment on Persistence

- Note

$$\lim_{\lambda\to\infty}\Phi(h;\mathrm{ca}) = \lim_{\lambda\to\infty}\Phi(l;\mathrm{ca})$$

$$= R_{c,h}/r - b\delta/[r(a+b)]$$

As state persistence vanishes then the difference between state dependent values also vanishes

Stated another way,

$$\Phi(h;\mathrm{ca}) - \Phi(l;\mathrm{ca}) = \frac{\delta}{u},$$

and this decreases to 0 as persistence vanishes

Model Solution under 'Alternate'

- Following a similar approach to solve out for valuation under 'alternate' system

$$\Phi(l;\text{alt}) =$$

$$\frac{\lambda a(R_{c,h} - \lambda b\kappa_{cg}) + (r + \lambda b)(R_g - \lambda a\kappa_{gc})}{r(r + \lambda a + \lambda b)};$$

$$\Phi(h;\text{alt}) =$$

$$\frac{(r + \lambda a)(R_{c,h} - \lambda b\kappa_{cg}) + \lambda b(R_g - \lambda a\kappa_{gc})}{r(r + \lambda a + \lambda b)}.$$

- Switching costs are built in as revenue discounts

Which System?

- Only state *l* present value matters when choosing between cropping systems in stage two. Why?
- Only in state *l* do benefits from avoiding cropping at a loss arise under the 'alternate' system
- Define $\Delta^{l}_{\text{ca-alt}} \equiv \Phi(l;\text{ca}) - \Phi(l;\text{alt}) + \kappa_{cg}$

$$= \frac{(r+\lambda b)(R_{c,h} - \delta - R_g)}{ru} + \frac{\lambda a \kappa_{gc}}{u}$$

$$+ \frac{ab\lambda^2(\kappa_{cg} + \kappa_{gc})}{ru} + \kappa_{cg}.$$

- In state *l*, the grower remains in cropping if and only if $\Delta^{l}_{\text{ca-alt}} > 0$

Breakeven δ

$$\hat{\delta} = R_{c,h} - R_g + \lambda a \kappa_{gc} + (r + \lambda a)\kappa_{cg}$$

satisfies $\Delta^{l}_{\text{ca-alt}} = 0$

- ‘crop always’ is preferred among the two choices whenever $\delta \leq \hat{\delta}$ for otherwise converting to grass is the better option
- **Proposition**: An increase in any of $\{R_{c,h}, \lambda, a, \kappa_{cg}, \kappa_{gc}\}$ or decrease in R_g expands set of circumstances under which ‘crop always’ is preferred to ‘alternate’
- How parameters affect conversion is a different matter

Sodbusting Incentives

- In the model, sod-busting occurs whenever expected increase in NPV of profit (appropriately calculated) to be had upon converting exceeds conversion cost
- This of course depends on the second-stage choice
- It is state *h* present value that matters when making a non-trivial conversion decision because sod-busting only occurs in state *h*
- Native sod 'graze always' system has value R_g/r
- Compare with the two cropping system choices
- When $\delta \le \hat{\delta}$ then the landowner's state *h* choice is between 'graze always' and 'crop always'

Sodbusting Incentives: vs. 'Crop Always'

- Consider when 'crop always' is preferred over 'alternate'choice, i.e., when $\delta \leq \hat{\delta}$
- Then difference between expected benefits and expected costs is given by ('con'= native grass)

$$\Delta^{h}_{\text{ca-con}} = \Phi(h;\text{ca}) - \frac{R_g}{r} - \theta = \frac{R_{c,h} - R_g}{r} - \frac{\lambda b \delta}{ru} - \theta.$$

- Define

$$\hat{\theta}^{\text{ca}} = \frac{R_{c,h} - R_g}{r} - \frac{\lambda b \delta}{ru}.$$

- If $\theta < \hat{\theta}^{\text{ca}}$ then conversion takes place
- When λ is larger (more flux) then fewer acres meet threshold

Sodbusting Incentives: vs. 'Alternate'

- Consider when 'alternate' is choice over 'crop always', i.e., when $\delta > \hat{\delta}$.
- Then difference between expected benefits and expected costs is given by

$$\Delta^{h}_{\text{alt-con}} = \Phi(h;\text{alt}) - \frac{R_g}{r} - \theta$$

$$= \frac{(r+\lambda a)(R_{c,h} - R_g - \lambda b\kappa_{cg}) - ab\lambda^2\kappa_{gc}}{ru} - \theta.$$

- Define $\hat{\theta}^{\text{alt}} = \dfrac{(r+\lambda a)(R_{c,h} - R_g - \lambda b\kappa_{cg}) - ab\lambda^2\kappa_{gc}}{ru}$

  so that conversion occurs whenever $\theta \le \hat{\theta}^{\text{alt}}$

Interaction with λ not so obvious

Static Choice Graph in (δ,θ) Space

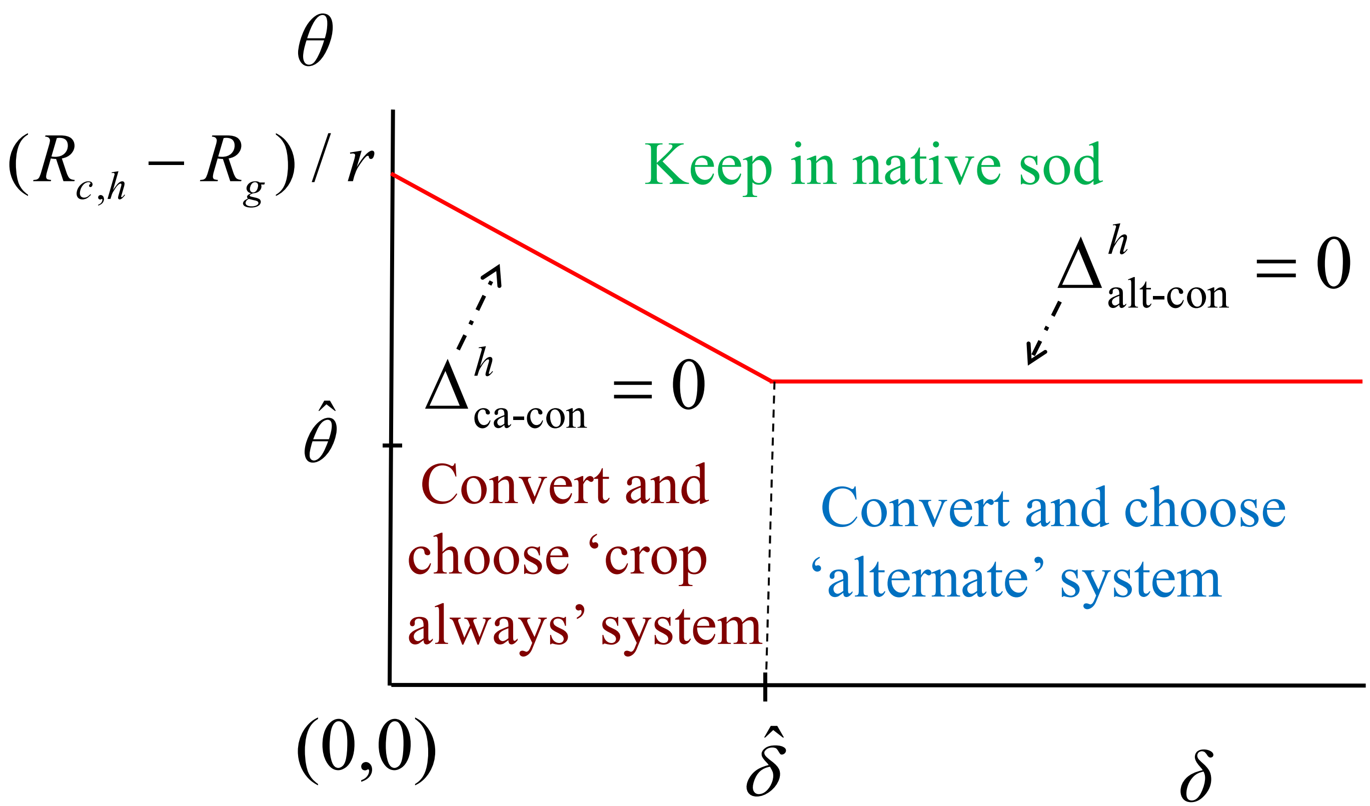


Figure 1. Sodbusting choices in (δ, θ) space

Effects of Risk Intervention

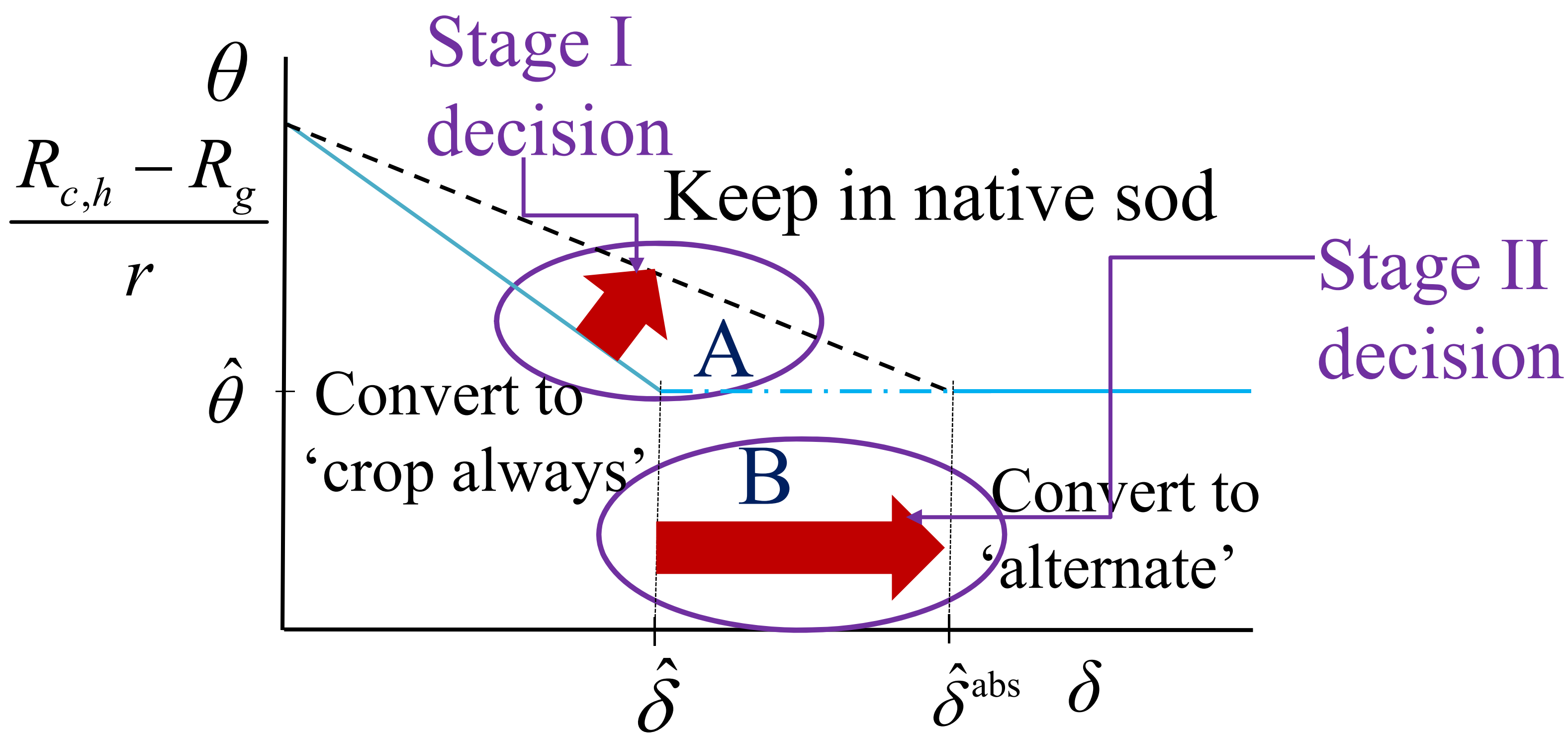
- Suppose the government agrees to absorb, or 'abs' fraction $\phi \in (0,1)$ of revenue shortfall below $R_{c,h}$, perhaps through revenue insurance. Then we must adjust $\hat{\delta}$ and $\Delta^{h}_{\text{ca-con}}$

$$\hat{\delta} \rightarrow \hat{\delta}^{\text{abs}} = \frac{R_{c,h} - R_g + \lambda a \kappa_{gc} + (r + \lambda a)\kappa_{cg}}{1-\phi} > \hat{\delta},$$

$$\Delta^{h}_{\text{ca-con}} \rightarrow \Delta^{h,\text{abs}}_{\text{ca-con}} = \frac{R_{c,h} - R_g}{r} - \frac{\lambda b(1-\phi)\delta}{ru} - \theta \geq \Delta^{h}_{\text{ca-con}}.$$

- However $\Delta^{h}_{\text{alt-con}}$ is unaffected because it doesn't involve δ. This is because grass is chosen over low return crop production when cropping

Risk management interventions reduce need to switch later. Reduced capitalized cost of switching makes Stage 1 conversion more attractive



Effect of risk intervention on sodbusting choices in (δ, θ) space

Comment on Areas A and B

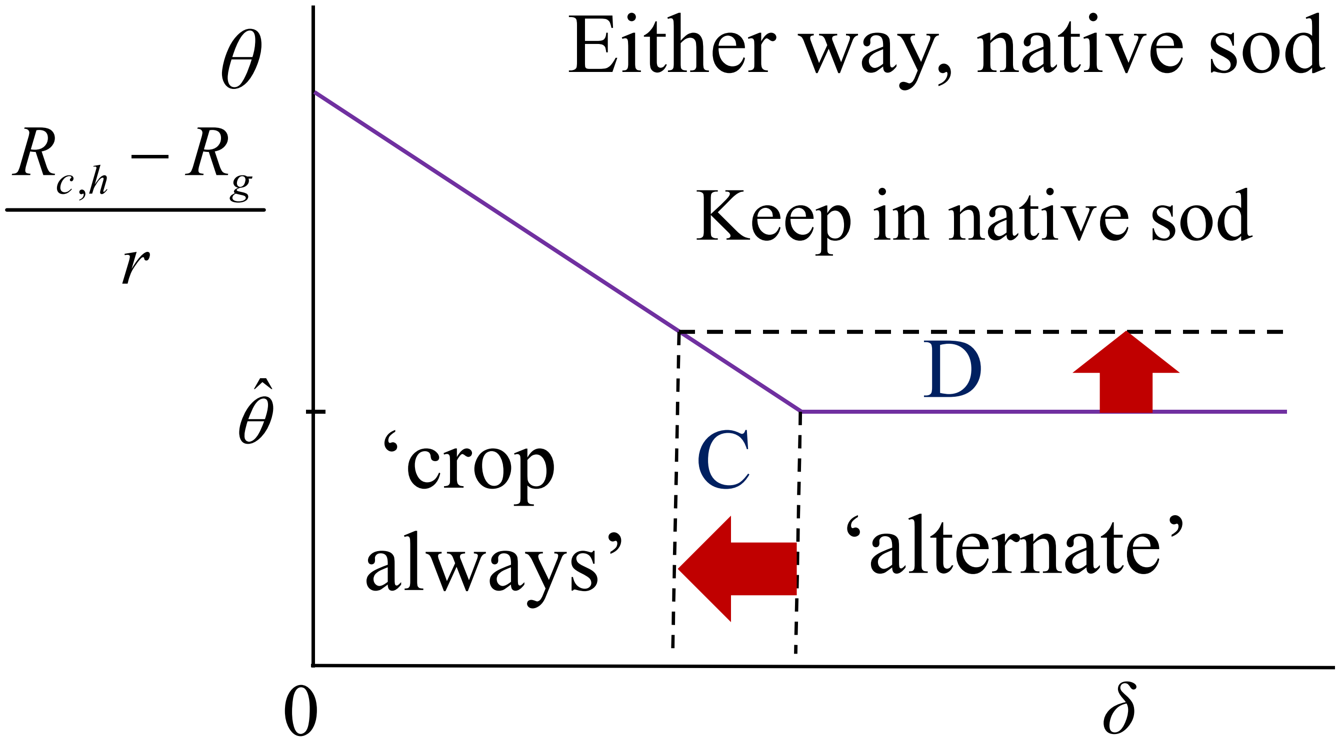
$$\hat{\delta}^{\text{abs}} - \hat{\delta} = \frac{\phi\hat{\delta}}{1-\phi}; \qquad \frac{d^2[\phi/(1-\phi)]}{d\phi^2} > 0.$$

- Both areas are convex in the subsidy parameter, so area of parameter set that converts to ‘crop always’ may be increasingly sensitive to intervention as extent of intervention grows

Effects of Change in Switching Costs

- Market events and technological innovations have reduced costs of switching land
  - Broad-spectrum herbicide Roundup® (glyphosate) has been off-patent since 2000. Its price declined by about 40% in US during patent protection phase-out
  - Related trend: biotech seeds have reduced weed management costs, and so switching costs since roll-out in mid 1990s

Innovations that reduce switching costs promote the ‘alternate’ system at expense of ‘crop always’ **and** ‘native sod’

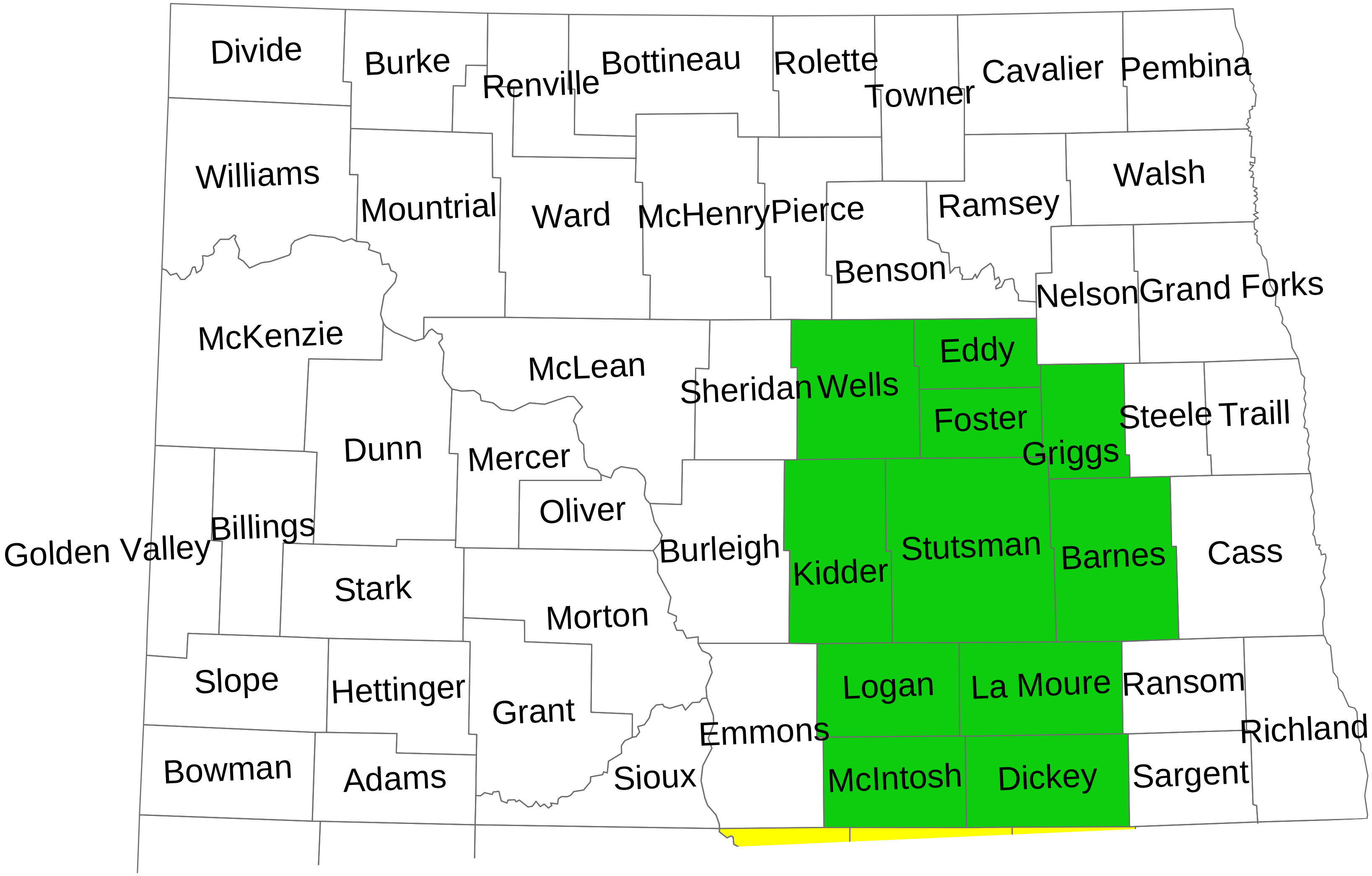


Effect of reduced switching costs, as in herbicide and machinery innovations

Model Calibration & Simulation

- We need values for
  - Returns parameter set $R_{c,h}$, $R_{c,l}$ - δ and R_g
  - Dynamic parameter set a, b, λ and r
  - Friction parameter set κ_{cg}, κ_{gc} and θ
  - Policy parameter $\phi \in (0,1)$
- Returns $R_{c,h}$ and $R_{c,l}$ - δ over 1989-2006 are from ND State Univ. Extension annual crop budgets for the SC ND region
- Sample mean used to split into high/low returns
- Data rejects unit root, accepts stationarity

Figure SM2. Cropping Returns over 1989-2012 in South Central North Dakota (in 2006 dollars)



Counties considered in South Central North Dakota

Policy Simulations

- Based on data for SC North Dakota over 1989-2012, simulations show the following
- Offsetting 20% of a cropping-return shortfall increases sodbusting cost threshold, below which sodbusting will occur, by 41% (or $43.7/acre)

Back-of Envelope Inference

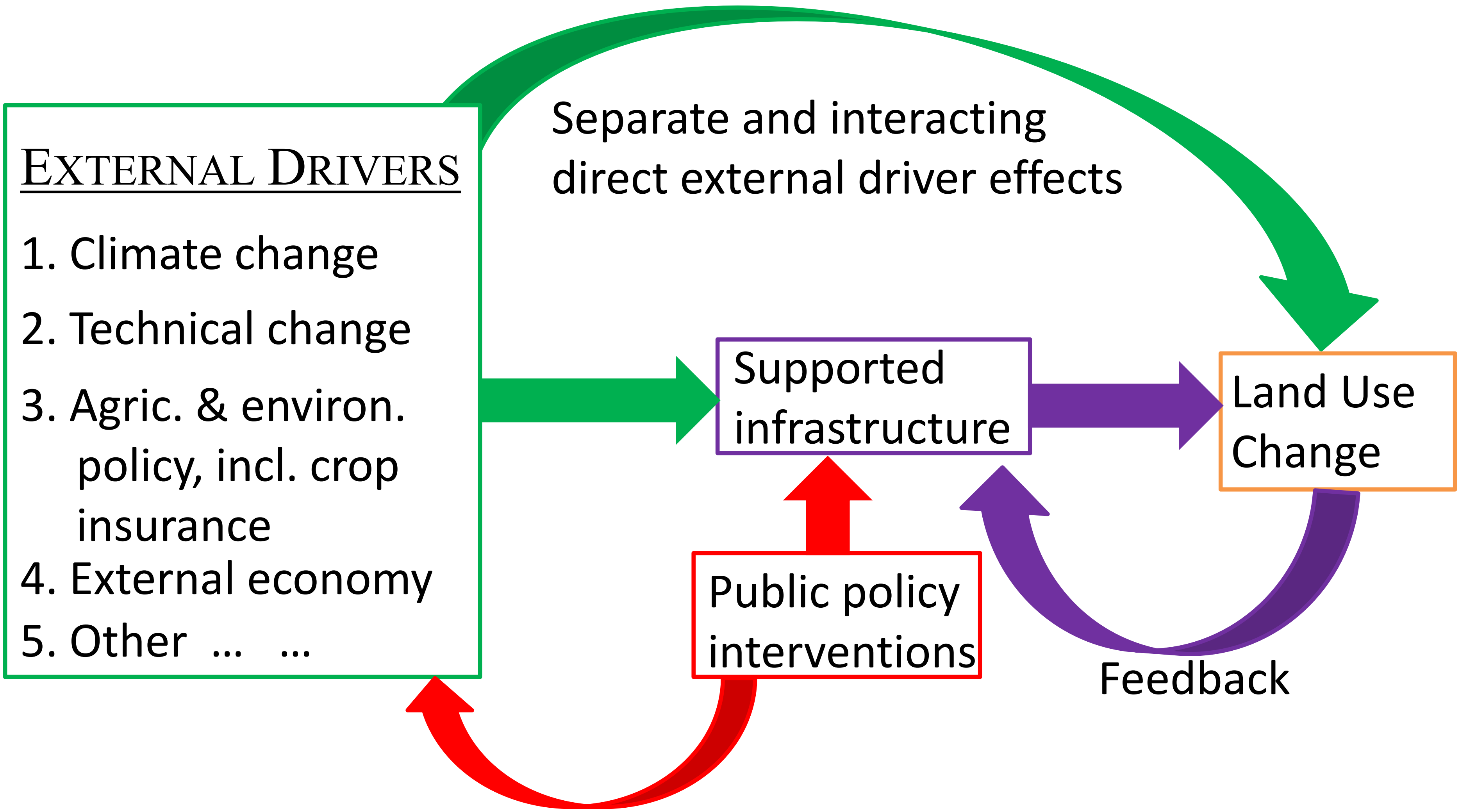
- To know how this 41% increase in threshold value maps to land-use change, a distribution of one-time sodbusting costs is required
- Given scarce data, we use maximum entropy
- If distribution's support is $[0,\infty)$ and mean is \$55/acre (Ransom et al. 2008), then entropy maximizing distribution is exponential
- Then 41% increase in threshold value implies 8.9% land-use change

Policy Implications and Issues

- Provisions like the “Sodsaver” provisions in 2008 and 2014 Farm Bills may have (had) larger impacts than existing literature suggests (Likely second-order when compared with commodity prices though)
- We need to know more about farmers’ grassland conversion decisions
  - Need to track converted land, conversion costs, switching costs, and factors affecting these costs
  - Conversion and switching costs can be used as factors in conservation targeting (e.g., purchase of land easements)

Concluding Comments

- Existing research on how crop insurance might affect grassland conversion emphasizes risk management in sense of reducing risk, increasing income in presence of risk aversion. These effects have been shown to be quite small, at least until recently
- Our study posits an alternative channel, to do with managing sunk costs, in increasing expected benefits from incurring them
- Other neglected issues may be quite large too; consider infrastructure feedbacks
- As cropping grows in a region, unit operating cost are likely to fall and those for grassland will rise



Schematic of direct and indirect factor impacts

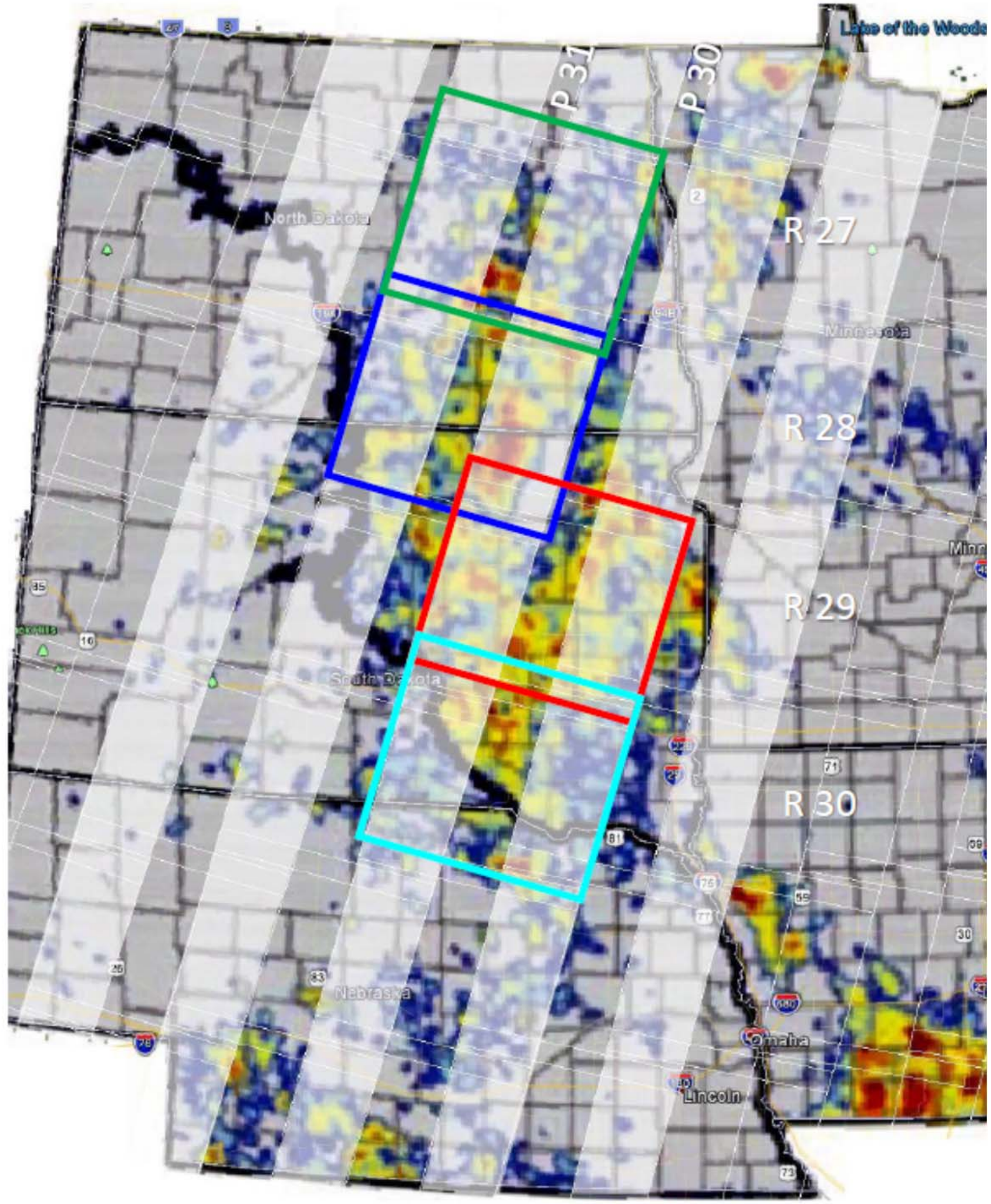
Big Satellite Data

3-Year incr. needed

74	74	74	74
77	77	77	77
80	80	80	80
83	83	83	83
86	86	86	86
89	89	89	89
92	92	92	92
95	95	95	95
	98	98	98
	01	01	01
	04	04	04

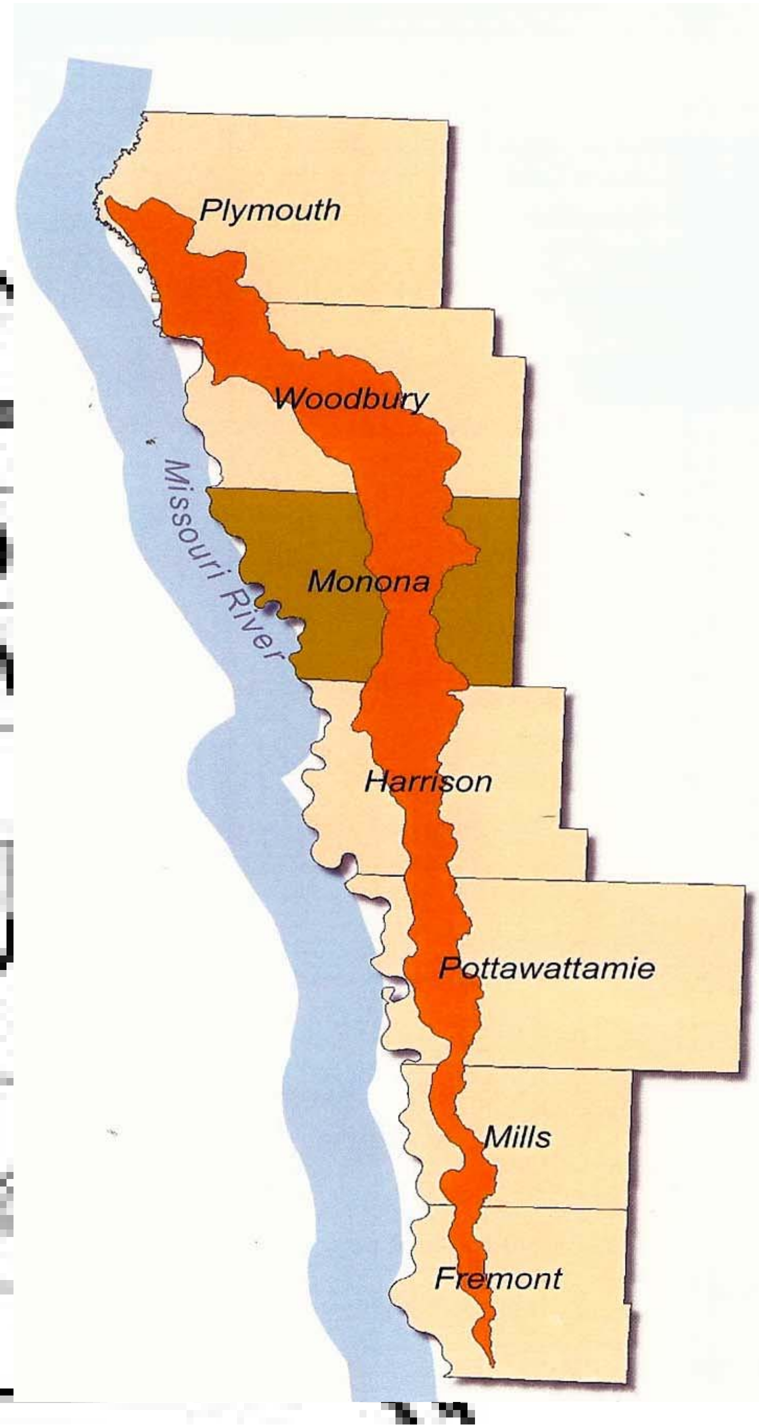
Start of NASS data

ND 1997
SD 2006
NE 2002



Loess Hills

LANDFORM REGIO
Northwest Iowa Plains
Des Moines Lobe
Missouri Alluvial Plain
Loess Hills
Southern Io
Drift Plai
(SIDP)



Plymouth
Woodbury
Missouri River
Monona
Harrison
Pottawattamie
Mills
Fremont

Other Research Areas

- Animal Health Econ.: an important issue, albeit one where funding is difficult to obtain. My interests here are generally less empirical:
  - game theory and information economics to better understand disease management problems, and no better place than MSU
  - somewhat related theme is animal sector 'industrialization' where such control technologies as antibiotics allow for scale economies
  - Food quality/safety

Other Research Areas

- Crop Insurance & Crop Production Economics: e.g.,
  - trying to make sense of crop insurance choice data
  - recognizing crop insurance in CRP enrollment formula
  - statistical nature of crop systemic risk
  - rail/barge market interactions for Upper Midwest commodities headed to New Orleans
  - seeds, yield trends, pesticides, input competition
- Low-brow micro theory and methods

Elton R. Smith Endowment

- I don't know this department's goals and needs and so would not like to commit too much. Consider transition and later
- Transition:
  - one or two graduate students that I don't want to leave stranded;
  - learn more about distinctive features of state agriculture & natural resources, i.e., get out and about for field trips

Elton R. Smith Endowment

- Later: Some ideas to float
  - graduate students working on Michigan issues, especially on outreach oriented and well-defined data projects that might generate traffic
  - seminar program as done under previous occupant;
  - discuss outreach publication support?
  - Endowment's mission statement mentions 'global vision of policy education and research.' This dept's extensive development area might complement research/outreach on management of exotic infectious animal diseases of concern to US.

Question?