Federal crop insurance participation and adoption of sustainable production practices by U.S. farms

Jennifer Ifft and Margaret Jodlowski

April 6, 2018

We appreciate Environmental Defense Fund support for this research.

Outline

Motivation

Ongoing debate over the environmental impacts of farm policy and crop insurance

- Increased interest in how the Federal Crop Insurance Program (FCIP) could (dis)incentivize environment “goods” (“bads”), i.e. cover crops
- Currently mixed and/or weak evidence on the environmental impacts of crop insurance (technically consistent with theory)
  - No strong evidence for a “large negative” environmental impact
- Complex set of factors including unobserved states of nature and risk impact of various practices/inputs

Cover crops

Thursday, November 16, 2017

Contact: Alex Rausch
515-725-2853

IOWA FARMERS USING COVER CROPS MAY BE ELIGIBLE FOR CROP INSURANCE PREMIUM REDUCTION

New IDALS-Funded Program Aims to Incentivize Expanded Use of Cover Crops to Improve Water Quality

DES MOINES – Iowa Deputy Secretary of Agriculture Mike Naig today announced a new program aimed at increasing acres of cover crops in the state. Iowa farmers who plant cover crops this fall (2017) may be eligible for a $5 per acre premium reduction on their crop insurance in 2018. The Iowa Department of Agriculture and Land Stewardship (IDALS) worked with the United States Department of Agriculture's (USDA) Risk Management Agency (RMA), who oversees the federal crop insurance program, to establish a 3 year demonstration project aimed at expanding the usage of cover crops in Iowa.

Figure: Will a premium reduction lead to higher cover crop adoption?

https://www.iowaagriculture.gov/press/2017press/press11162017.asp

Cover crops

Figure: Jenny's dad discusses cover crops

Research questions

The relationship between the risk that crop insurance addresses and the agronomic risk related to production practices is complex, even without consideration of the environmental impact.

- How can the relationship between production and environmental risk be characterized?
- How can we use complex farm survey data to better characterize the relationship between crop insurance and production practices?
  - Implications for “sustainability”?

Background

- Early theoretical model of Horowitz and Lichtenberg (1993)
  - Input is risk-increasing if it increases variability of yields across different states of nature
  - Predicts that crop insurance will increase use of risk-increasing inputs; decrease use of risk-decreasing inputs
- Findings and basic premise questioned by Babcock and Hennessy (1996)
  - Input is risk-increasing if it increases the probability of a low yields.
- Environmental impact is now typically treated as "an empirical question"

Related Literature

- Development/Experiment Literature
  - Cole et al. (2017)
  - Karlan et al. (2014)
- US Farm Survey Data
  - Weber et al. (2016)
  - Chang and Mishra (2012)
  - Smith and Goodwin (1996)
  - Horowitz and Lichtenberg (1993)
- Administrative data
  - Walters et al. (2012)

Related Literature

- Aggregate Data
  - Schoengold et al. (2014)
  - Claassen et al. (2011)
  - Goodwin et al. (2004)
  - Wu (1999)

Access to farm level data

- Each farm operator makes decisions about crop insurance, crop acreage, and production expenses and practices individually; while environmental externalities are often observed in aggregate
- Studies using county-level data are unlikely to have precise results or provide insight on farm-level decision making
- Use of ARMS Phase II and Phase III data for major field crops
  - Commodity-specific ARMS Phase II survey collects detailed data on a wide range of production and conservation practices

Measuring crop insurance participation

- Common in the literature to use a binary variable to represent the extensive margin of crop insurance participation
- Fails to capture variation in the intensity; also unlikely to have sufficient cross-farmer variation
- We observe the premium paid (proxy for coverage level) and number of acres enrolled with ARMS Phase II
  - Coverage level and other details for some years for some crops

Measuring sustainability

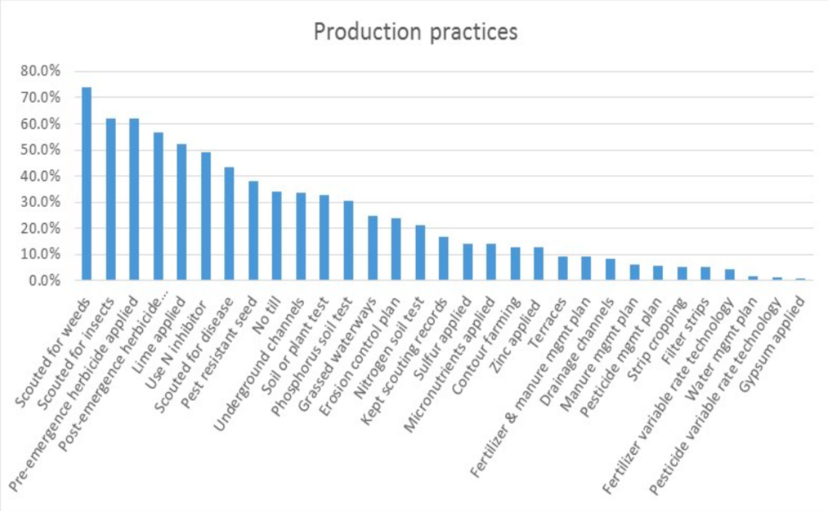
- Sustainable practices are difficult to describe qualitatively, let alone with quantatative data
- Outcomes to-date:
  - Land use changes
  - Expenses on inputs
  - Specific practices
- Several approaches allow us to see if if ‘environmentally beneficial’ practices move together
  - Principal Components Analysis
  - Cluster Analysis
  - Regression Trees
  - Others?

Empirical approach

Causal identification

- Is it possible to isolate the the causal effect of crop insurance from the tangle of other farm production and financial decisions that are made based on the same factors?
- RCTs from the developing world show evidence that insurance alters production practices
- Machine learning techniques can be used to improve robustness
  - Establishing causality is a longer-term objective

Data


Production practices
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Scouted for weeds
Scouted for insects
Pre-emergence herbicide applied
Post-emergence herbicide...
Lime applied
Use N inhibitor
Scouted for disease
Pest resistant seed
No till
Underground channels
Soil or plant test
Phosphorus soil test
Grassed waterways
Erosion control plan
Nitrogen soil test
Kept scouting records
Sulfur applied
Micronutrients applied
Contour farming
Zinc applied
Terraces
Fertilizer & manure mgmt plan
Drainage channels
Manure mgmt plan
Pesticide mgmt plan
Strip cropping
Filter strips
Fertilizer variable rate technology
Water mgmt plan
Pesticide variable rate technology
Gypsum applied

Table

Data

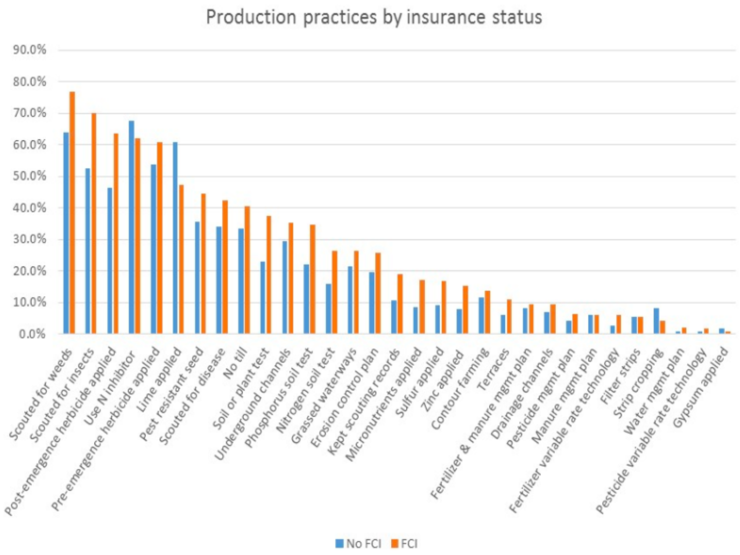

Pest management practices
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Restricted use license
Rotate crops
Cultivated field
Use resistant varieties
Till, chop, mow
Clean equipment
Alternate pesticides
Pest mgmt training
Use treated seeds
Consider beneficials
Adjust row spacing
Adjust planting dates
Water management
ID pests in a lab
Soil analysis
Apply beneficial organisms
Wireworm traps
Pheremone lures

Table

Data: practices by insurance status

	n	mean	sd	n	mean	sd	Difference significant at:
	No FCI			FCI			
Percent of corn fields with:							
Pest resistant seed	4,294	35.6%	47.9%	9,559	44.6%	49.7%	***
No till	2,543	33.3%	47.1%	5,711	40.4%	49.1%	***
Terraces	4,294	6.1%	24.0%	9,559	10.9%	31.2%	***
Grassed waterways	4,294	21.4%	41.1%	9,559	26.3%	44.0%	***
Contour farming	4,294	11.5%	31.9%	9,559	13.8%	34.5%	***
Strip cropping	3,271	8.3%	27.7%	7,891	4.3%	20.2%	***
Underground channels	3,271	29.3%	45.5%	7,891	35.3%	47.8%	***
Drainage channels	3,271	7.1%	25.7%	7,891	9.4%	29.2%	***
Filter strips	3,386	5.3%	22.5%	7,046	5.6%	23.0%	
Erosion control plan	3,386	19.6%	39.7%	7,046	25.9%	43.8%	***
Fertilizer & manure mgmt plan	3,386	8.2%	27.5%	7,046	9.4%	29.2%	**
Manure mgmt plan	3,386	6.0%	23.7%	7,046	6.0%	23.7%	
Pesticide mgmt plan	3,386	4.1%	19.8%	7,046	6.4%	24.4%	***
Water mgmt plan	3,386	0.8%	8.7%	7,046	2.1%	14.2%	***
Lime applied	4,294	60.9%	48.8%	9,559	47.3%	49.9%	***
Sulfur applied	1,751	9.3%	29.1%	3,848	16.8%	37.4%	***
Gypsum applied	3,386	1.8%	13.3%	7,046	0.8%	9.0%	***
Micronutrients applied	843	8.4%	27.8%	1,768	17.2%	37.7%	***
Zinc applied	843	7.9%	27.1%	1,768	15.3%	36.0%	***
Pre-emergence herbicide applied	4,294	53.6%	49.9%	9,559	60.8%	48.8%	***
Post-emergence herbicide applied	4,294	46.4%	49.9%	9,559	63.6%	48.1%	***
Fertilizer variable rate technology	4,294	2.9%	16.7%	9,559	6.0%	23.7%	***
Pesticide variable rate technology	4,294	1.0%	10.1%	9,559	1.7%	13.1%	***
Soil or plant test	1,931	23.0%	42.1%	4,181	37.4%	48.4%	***
Nitrogen soil test	4,294	15.9%	36.6%	9,559	26.3%	44.0%	***
Scouted for weeds	4,294	64.0%	48.0%	9,559	76.7%	42.3%	***
Scouted for insects	3,259	52.6%	49.9%	7,534	69.9%	45.9%	***
Scouted for disease	3,271	34.1%	47.4%	7,891	42.4%	49.4%	***
Kept scouting records	2,363	10.8%	31.0%	5,378	19.0%	39.2%	***
Use N inhibitor	4,294	67.7%	163.6%	9,559	62.0%	154.7%	**
Phosphorus soil test	3,386	22.2%	41.6%	7,046	34.8%	47.6%	***

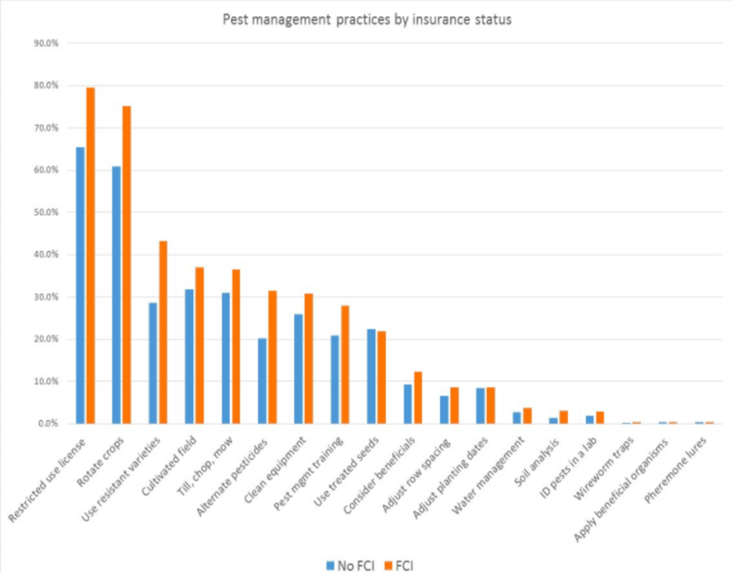
Data


Production practices by insurance status
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Scouted for weeds
Scouted for insects
Post-emergence herbicide applied
Use N inhibitor
Pre-emergence herbicide applied
Lime applied
Pest resistant seed
Scouted for disease
No till
Soil or plant test
Underground channels
Phosphorus soil test
Nitrogen soil test
Grassed waterways
Erosion control plan
Kept scouting records
Micronutrients applied
Sulfur applied
Zinc applied
Contour farming
Terraces
Fertilizer & manure mgmt plan
Drainage channels
Pesticide mgmt plan
Manure mgmt plan
Fertilizer variable rate technology
Filter strips
Strip cropping
Water mgmt plan
Pesticide variable rate technology
Gypsum applied
No FCI
FCI

Data: pest control practices by insurance status

	n	mean	sd	n	mean	sd	Difference significant at:
	No FCI			FCI			
Pest control measures:							
Adjust row spacing	4,294	6.6%	24.9%	9,559	8.6%	28.0%	***
Adjust planting dates	4,294	8.5%	27.9%	9,559	8.5%	27.9%	
Alternate pesticides	4,294	20.1%	40.1%	9,559	31.4%	46.4%	***
Till, chop, mow	4,294	31.0%	46.2%	9,559	36.5%	48.2%	***
Water management	4,294	2.7%	16.1%	9,559	3.8%	19.1%	***
Clean equipment	4,294	25.9%	43.8%	9,559	30.8%	46.2%	***
Soil analysis	2,659	1.4%	11.7%	6,361	3.0%	17.0%	***
Consider beneficials	4,294	9.3%	29.0%	9,559	12.3%	32.9%	***
Use treated seeds	2,774	22.3%	41.6%	5,949	21.9%	41.4%	
ID pests in a lab	2,543	1.9%	13.7%	5,711	2.9%	16.8%	**
Apply beneficial organisms	3,682	0.3%	5.7%	8,029	0.3%	5.6%	
Pheremone lures	1,931	0.4%	6.0%	4,181	0.3%	5.4%	
Wireworm traps	908	0.1%	3.3%	2,513	0.4%	6.3%	
Cultivated field	4,294	31.8%	46.6%	9,559	37.0%	48.3%	***
Use resistant varieties	3,386	28.5%	45.2%	7,046	43.1%	49.5%	***
Rotate crops	3,386	60.9%	48.8%	7,046	75.1%	43.2%	***
Pest mgmt training	4,294	20.9%	40.7%	9,559	27.9%	44.9%	***
Restricted use license	908	65.4%	47.6%	2,513	79.5%	40.3%	***

Data


Pest management practices by insurance status
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Restricted use license
Rotate crops
Use resistant varieties
Cultivated field
Till, chop, mow
Alternate pesticides
Clean equipment
Pest mgmt training
Use treated seeds
Consider beneficials
Adjust row spacing
Adjust planting dates
Water management
Soil analysis
ID pests in a lab
Wireworm traps
Apply beneficial organisms
Pheremone lures
No FCI
FCI

Data: quantities and costs by insurance status

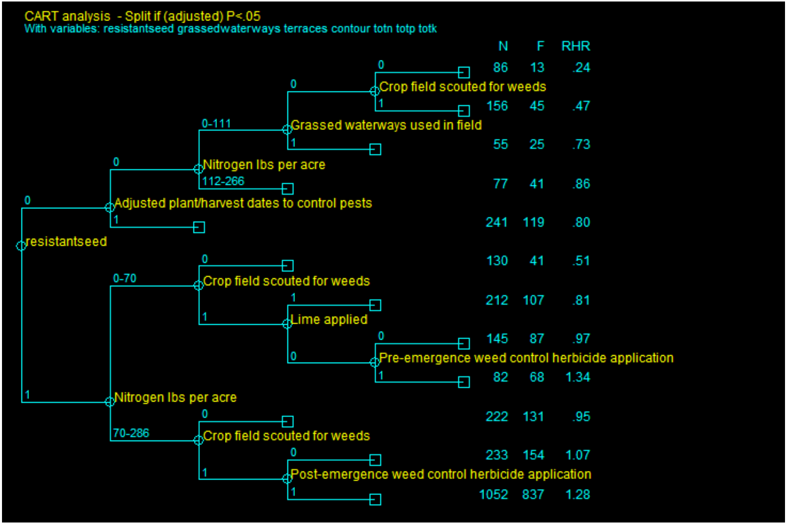
	n	mean	sd	n	mean	sd	Difference significant at:
	No FCI			FCI			
Practices measured continuously:							
N (lbs/acre)	4,294	94.4	70.7	9,559	118.6	63.3	***
P (lbs/acre)	4,294	40.4	37.0	9,559	41.1	35.0	
K (lbs/acre)	4,294	49.4	52.6	9,559	44.0	51.8	***
Lime (tons/acre)	4,294	1.2	1.3	9,559	1.0	1.3	***
Sulfur (lbs/acre)	1,751	0.9	4.5	3,848	1.6	5.3	***
Manure (tons/acre)	3,015	2.5	6.3	6,746	1.2	4.2	***
Manure (gals/acre)	4,294	287.7	1304.1	9,559	215.9	1121.5	***
Times cultivated for pest control (#)	3,386	0.5	1.0	7,046	0.4	0.7	***
Cost of biological controls per acre ($)	1,931	0.03	0.6	3,748	0.0	0.6	
Cost of biological controls total ($)	1,927	0.02	0.9	3,743	0.8	31.4	

Table: All farms

Classification and Regression Tree analysis

- CaRT begins with the full sample and splits it
- Splitting criteria is partially set by researcher
- Goal of splits is to create the minimum number of subgroups ("leafs") with distinct values of the "failure" variable (crop insurance coverage, in our case)
- Splits occur at an optimized value of the RHS variable

Classification and Regression Tree results: all years



Year-by-year results

Modeling challenges

- A general theoretical model that encompasses interaction between riskiness of inputs/practices and environmental impact of inputs over different states of nature may be intractable
- Biophysical modeling may allow for prediction
- Increasingly availability of field-level data also promising

References I

Babcock, B. A. and Hennessy, D. A. (1996). Input demand under yield and revenue insurance. *American journal of agricultural economics*, 78(2):416–427.

Chang, H.-H. and Mishra, A. K. (2012). Chemical usage in production agriculture: Do crop insurance and off-farm work play a part? *Journal of environmental management*, 105:76–82.

Claassen, R., Cooper, J. C., and Carriazo, F. (2011). Crop insurance, disaster payments, and land use change: the effect of sodsaver on incentives for grassland conversion. *Journal of Agricultural and Applied Economics*, 43(2):195–211.

Cole, S., Giné, X., and Vickery, J. (2017). How does risk management influence production decisions? evidence from a field experiment. *The Review of Financial Studies*, 30(6):1935–1970.

Goodwin, B. K., Vandeveer, M. L., and Deal, J. L. (2004). An empirical analysis of acreage effects of participation in the federal crop insurance program. *American Journal of Agricultural Economics*, 86(4):1058–1077.

Horowitz, J. K. and Lichtenberg, E. (1993). Insurance, moral hazard, and chemical use in agriculture. *American journal of agricultural economics*, 75(4):926–935.

Karlan, D., Osei, R., Osei-Akoto, I., and Udry, C. (2014). Agricultural decisions after relaxing credit and risk constraints. *The Quarterly Journal of Economics*, 129(2):597–652.

References II

Schoengold, K., Ding, Y., and Headlee, R. (2014). The impact of ad hoc disaster and crop insurance programs on the use of risk-reducing conservation tillage practices. *American Journal of Agricultural Economics*, 97(3):897–919.

Smith, V. H. and Goodwin, B. K. (1996). Crop insurance, moral hazard, and agricultural chemical use. *American Journal of Agricultural Economics*, 78(2):428–438.

Walters, C. G., Shumway, C. R., Chouinard, H. H., and Wandschneider, P. R. (2012). Crop insurance, land allocation, and the environment. *Journal of Agricultural and Resource Economics*, pages 301–320.

Weber, J. G., Key, N., and ODonoghue, E. (2016). Does federal crop insurance make environmental externalities from agriculture worse? *Journal of the Association of Environmental and Resource Economists*, 3(3):707–742.

Wu, J. (1999). Crop insurance, acreage decisions, and nonpoint-source pollution. *American Journal of Agricultural Economics*, 81(2):305–320.

Summary stats: practices

	n	mean	sd
Percent of corn fields with:			
Pest resistant seed	20,387	38.1%	48.6%
No till	9,949	34.1%	47.4%
Terraces	20,387	9.1%	28.7%
Grassed waterways	20,387	24.7%	43.2%
Contour farming	20,387	12.9%	33.5%
Strip cropping	17,695	5.3%	22.3%
Underground channels	17,695	33.7%	47.3%
Drainage channels	17,695	8.4%	27.8%
Filter strips	12,783	5.2%	22.3%
Erosion control plan	10,435	23.8%	42.6%
Fertilizer & manure mgmt plan	10,435	9.0%	28.7%
Manure mgmt plan	10,435	6.0%	23.7%
Pesticide mgmt plan	10,435	5.6%	23.0%
Water mgmt plan	10,435	1.6%	12.7%
Lime applied	20,387	52.5%	49.9%
Sulfur applied	7,948	14.0%	34.7%
Gypsum applied	12,783	1.0%	10.1%
Micronutrients applied	4,959	14.0%	34.7%
Zinc applied	4,959	12.8%	33.4%
Pre-emergence herbicide applied	20,387	61.8%	48.6%
Post-emergence herbicide applied	20,387	56.6%	49.6%
Fertilizer variable rate technology	20,387	4.5%	20.7%
Pesticide variable rate technology	20,387	1.3%	11.3%
Soil or plant test	6,113	32.9%	47.0%
Nitrogen soil test	20,387	21.1%	40.8%
Scouted for weeds	20,387	74.1%	43.8%
Scouted for insects	17,325	62.1%	48.5%
Scouted for disease	17,695	43.3%	49.5%
Kept scouting records	14,274	16.7%	37.3%
Use N inhibitor	18,694	49.0%	138.5%
Phosphorus soil test	10,435	30.7%	46.1%

Back

Summary stats: pest management practices

	n	mean	sd
Control pests by:			
Adjust row spacing	16,204	7.5%	26.4%
Adjust planting dates	20,387	7.1%	25.7%
Alternate pesticides	20,387	29.8%	45.8%
Till, chop, mow	16,204	35.0%	47.7%
Water management	16,204	3.6%	18.7%
Clean equipment	16,204	29.9%	45.8%
Soil analysis	15,552	2.5%	15.8%
Consider beneficials	20,387	11.1%	31.5%
Use treated seeds	11,072	21.1%	40.8%
ID pests in a lab	8,256	2.6%	15.9%
Apply beneficial organisms	18,244	0.3%	5.7%
Pheremone lures	6,113	0.3%	5.6%
Wireworm traps	3,421	0.3%	5.7%
Cultivated field	20,387	38.2%	48.6%
Use resistant varieties	12,783	37.2%	48.3%
Rotate crops	12,783	71.0%	45.4%
Pest mgmt training	18,694	27.8%	44.8%
Restricted use license	9,952	74.7%	43.5%

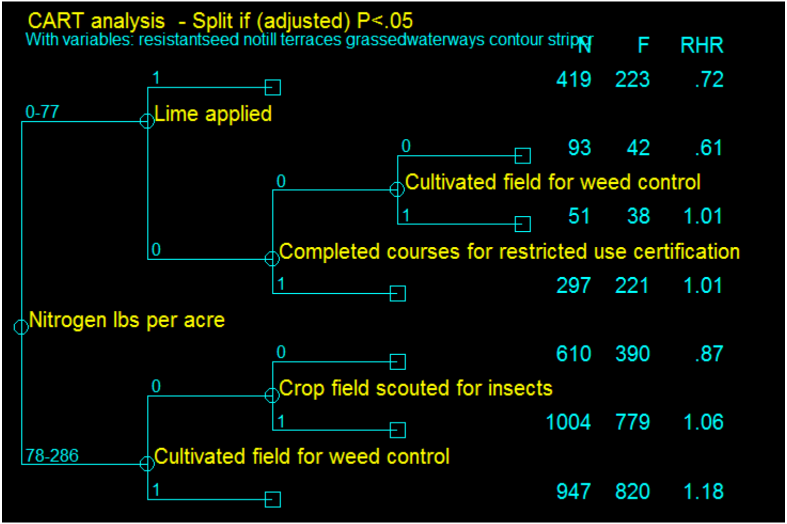
Back

Summary stats: Input costs and quantities

	n	mean	sd
N (lbs/acre)	20,387	111.84	65.62
P (lbs/acre)	20,387	41.82	35.46
K (lbs/acre)	20,387	47.63	52.60
Lime (tons/acre)	20,387	1.10	1.32
Sulfur (lbs/acre)	7,948	1.32	4.86
Manure (tons/acre)	14,600	1.42	4.79
Manure (gals/acre)	13,856	238.09	1181.44
Times cultivated for pest control (#)	10,435	0.44	0.82
Cost of biological controls per acre ($)	5,681	0.03	0.60
Cost of biological controls total ($)	5,672	0.51	25.48

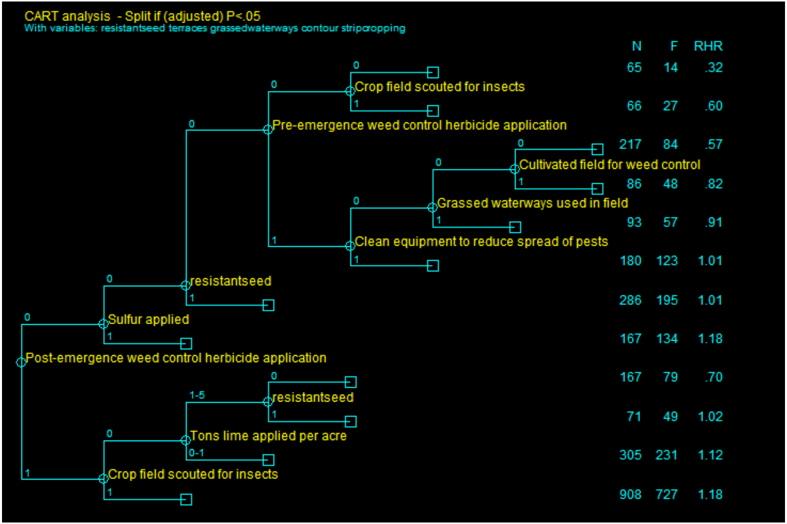
Back

Classification and Regression Tree results: 1996



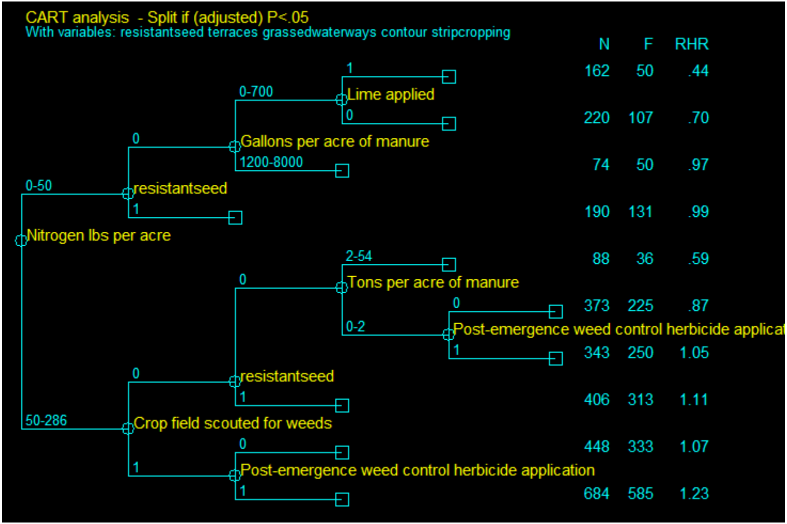
Back

Classification and Regression Tree results: 2000



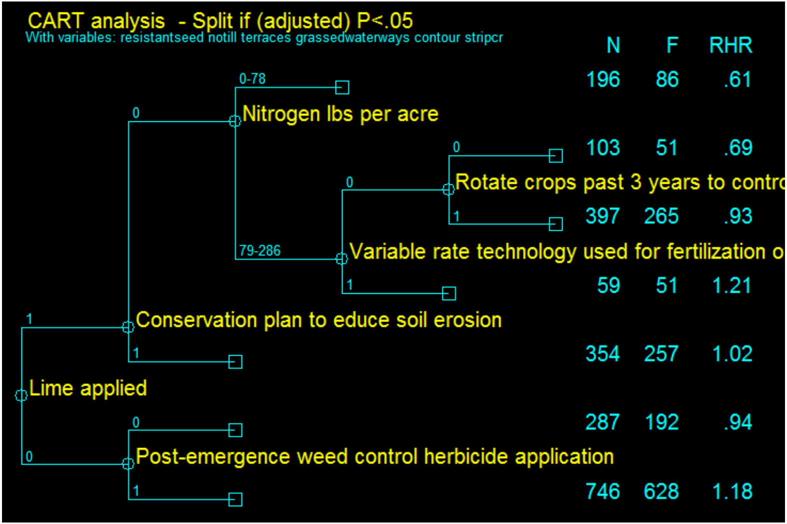
Back

Classification and Regression Tree results: 2001



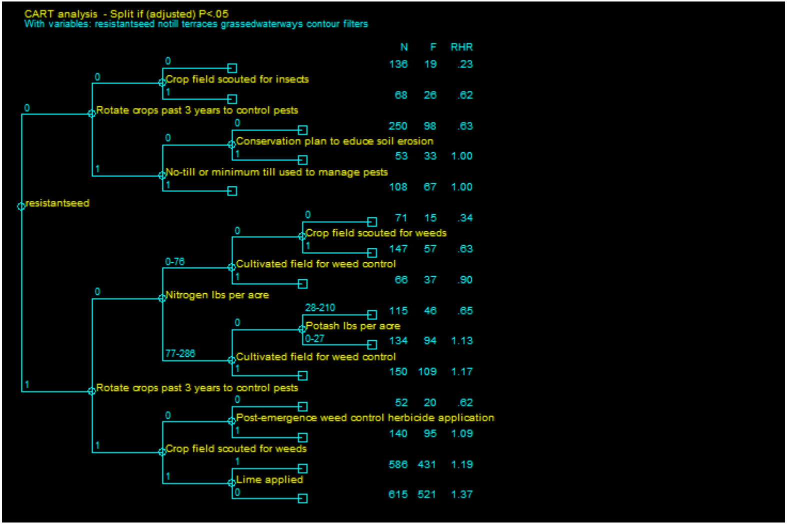
Back

Classification and Regression Tree results: 2005



Back

Classification and Regression Tree results: 2010



Back