

10 Years of Precision Ag

Where have we been and where to next?

Shattered dreams?

Terry L. Kastens, KSU Ag Economics
Kevin C. Dhuyvetter, KSU Ag Economics

KARA's 10th Annual Ag Technology Conference
Salina, Kansas
January 25-26, 2007



Early Precision Ag “Movement”

- **GPS signal availability early 1990s**
 - Yield monitors
 - Grid soil sampling and VRA
- **Dreams**
 - Salvation for the little guy (free GPS)
 - Salvation for the big guy (can manage like the little guy)
 - No more excessive environmental pollution
 - Higher yields on less inputs (more efficient production)
 - More profit

Early Precision Ag “Movement”

- Engineers give us all the cool electronic stuff to work with the GPS signals
- Agronomists help us use the cool electronic stuff to make better crop input decisions
 - Here’s where the money was supposed to have been made!

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Precision agriculture

From Wikipedia, the free encyclopedia

Precision farming or **precision agriculture** is an **agricultural** concept relying on the existence of *in-field variability*. It requires the use of new technologies, such as **global positioning** (GPS), **sensors**, **satellites** or aerial images, and information management tools (**GIS**) to assess and understand variations. Collected information may be used to more precisely evaluate optimum sowing density, estimate fertilizers and other inputs needs, and to more accurately predict crop yields. It seeks to avoid applying same practices to a crop, regardless of local soil/climate conditions and may help to better assess local situations of disease or lodging.

In the Midwest it is associated not with **sustainable agriculture** but with mainstream farmers who are trying to maximize profits by spending money only in areas that need fertilizer. This practice allows the farmer to vary the rate of fertilizer across the field according to the need identified by GPS guided Grid Sampling. Fertilizer that would have been spread in areas that don't need it can be placed in areas that do, thereby optimizing its use.

Precision farming may be used to improve a field or a farm management from several perspectives :

- agronomical perspective : adjustment of cultural practices to take into account the real needs of the crop (e.g., better fertilization management)
- technical perspective : better time management at the farm level (e.g. planification of agricultural activity)
- environmental perspective : reduction of agricultural impacts (better estimation of crop nitrogen needs implying limitation of nitrogen run-off)
- economical perspective : increase of the output and/or reduction of the input, increase of efficiency (e.g., lower cost of nitrogen fertilization practice)

Other benefits for the farmer may be to help him set a history of his/her farm practices and results, to help him in his decision making and traceability requirements (as increasingly required in developed countries).

Apparently, site-specific, more efficient, inputs is what it's all about . . .

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Early on prescient quotes:

- Precision Ag will allow us to make better uniform [i.e., field-scale] decisions

Randy Taylor

- 1) What we learn with PA will give us better field-scale decisions
- 2) Maybe farmers will now “twist the dial” at least at the field scale

- I’m still confused but at a much higher level than before

MIMC program

PA will induce better questions

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Early on prescient KARA-thinkers

- Involved K-State folks, farmers, and agribusiness folks from around the state who:
 - Recognized the deficiencies of public providers of the requisite knowledge for our farms
 - Recognized the value of on-farm research
- Recognized the value of science at the farm level
 - Increase the scientific aspects of how we gain knowledge as farmers
 - Increase the amount of critical thinking we do
 - Improve our presentations of what we learn to others
 - Helps us develop thicker skins

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**A trip down memory lane
... at least for some of us
(slides from earlier presentations)**

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January 1998

PA Data mostly will be aggregated, stored, and analyzed by:

- Farmer himself?
- Fert/herb input provider?
- Crop consultants?
- Seed people?
- Machinery manufacturers?
- Universities?

Early on we worried about data protocols . . .

January 1998

Level of Aggregation/Analysis:

- Farm?
- Group of farms (producer alliance)?
- Small single-dealer or regional customer group?
- company customer database like Farmland Industries, Deere, Pioneer, K-State?

Answers will come from data bases . . .

January 1998

PA Conference Last Fall

(Ag Electronics Assn, Farm Foundation, NC Land Grant Institutions)

1. standards for collecting complete data
2. economic benefits for pooling data
3. capacity to handle data

Early on we worried about data protocols . . .

January 1998

Which is More Important for K-State's Precision Ag Focus?

- Help farmers interpret their maps
- Make broader inferences

Even worried about what a university's role "should" be . . .

December 1998

Numbers for Decision Making: Where Should They Come From? How Specific Should They Be?

Terry Kastens
Kevin Dhuyvetter

Agricultural Economics
Kansas State University

Gathering information for farm decision making . . .

January 1999

Site-specific Fertilizer Management with Limited Soil Tests

Terry Kastens, Agricultural Economist

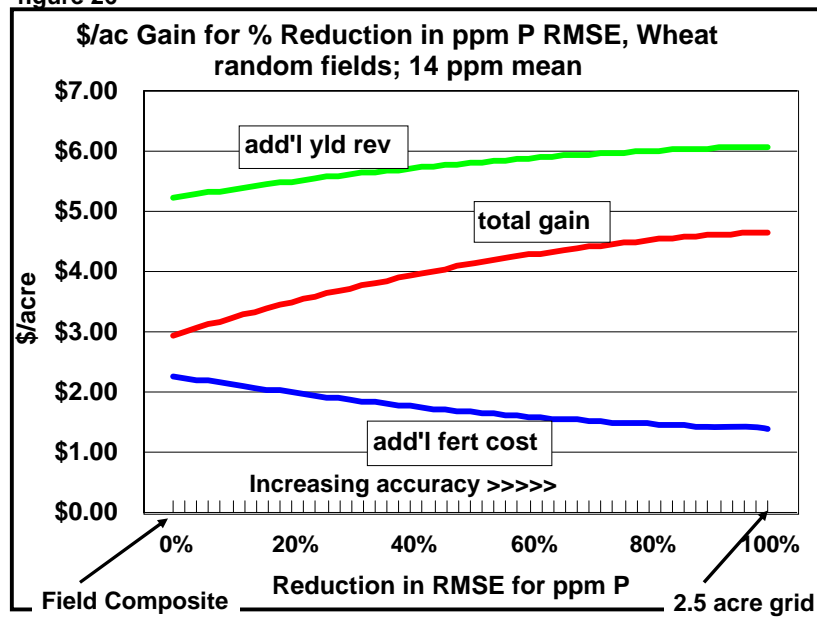
K-State Research and Extension
Kansas State University
email: tkastens@agecon.ksu.edu
phone 785-532-5866

Making due with crappy information

13

figure 26

January 1999



Accuracy matters, but will it matter enough to overcome cost of acquisition?

14

January 2000

Conclusions

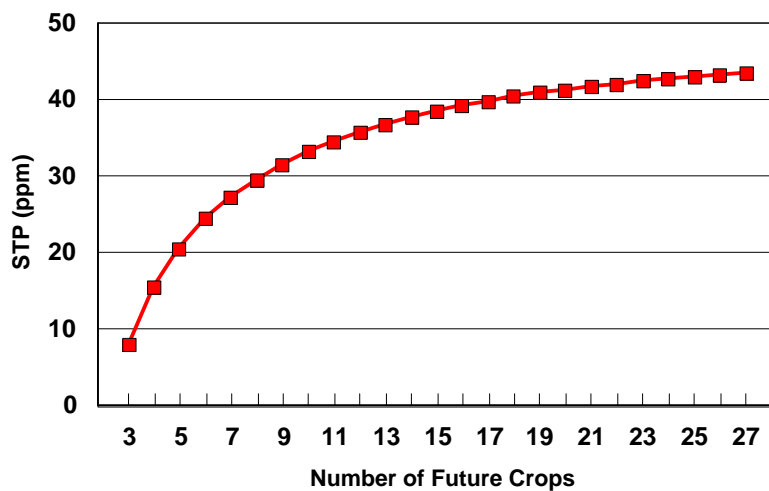
- basing fertilizer decisions on farm or site-specific data demands more complex response functions
- P-response function considerations
 - treat fertP and STP as substitutes
 - consider buildup over time
 - should consider dynamic models along with discounting
 - operator time horizon matters
 - in short horizons the steady-state path is not optimal
- site-specific P management for study farm
 - breakeven at best at the 2.5 acre scale
 - easy to justify at some scale

There is a scale at which VRA will pay, but perhaps not the one we envisioned.

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April 2000

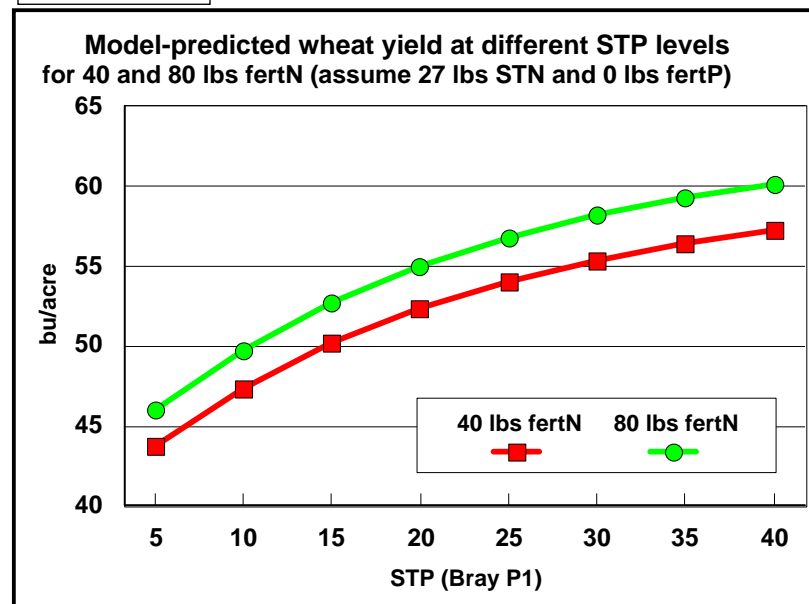
Optimal Steady-state STP by Horizon
(build to this STP after 1st crop; then maintain over horizon)



P work that never would have been done without PA

16

April 2000



P work that never would have been done without PA

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What Staggenborg wanted us to do . . .

Assessment sort of half way through the PA decade . . .

Scott wanted us to update this study

We'll inject our current comments and back them up a little more later

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August 2000

Crude Generalizations from FICPA

1. No current precision ag activities (typically agronomic ones) stand out as being extremely profitable
2. Despite years of research, returns to VRT N are likely to be small or non-existent
 - Will be a tagalong activity
 - Better yield goals would help
 - Sugar beets are an exception
 - Pollution concerns are an exception
3. Yield-goal research has died down
 - Are yield goals merely a holdover of old ways?

Today: 1 and 2 still true; 3 was not quite right – yield goals still quite important to N recommendations

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August 2000

Crude Generalizations from FICPA

4. Remote sensing is the hot topic (64 studies)
 - Spatially dense, low cost per data point
 - Multiple images during the year
 - Non-invasive (don't have to go to field)
 - Notable profits haven't surfaced
 - Geo-rectification and registering problems
 5. Electrical soil conductivity semi-hot (20)
 - Spatially dense, low cost per data point
 - Gains are site-specific
 - Soil moisture influences
- RS and EC measure everything

Remote sensing was especially hot then and hasn't gone away (still building slowly)
EC interest really hot a couple of years ago, but not disappearing either

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August 2000

Crude Generalizations from FICPA

6. Management zones are appealing but not especially successful

- 4 successful, 4 not, 8 unsure
- Thought to maximize the information acquired from a single soil sample
- Rely on farmer intuition
- Each factor needs different zone classifications, P-mgt, K-mgt, RS, EC, yield-based, and farmer-drawn zones are all different
- Optimal zones become grids

Management zones, where they exist, are mostly intuitive – persist because of the lack of feasible alternatives (actually, they are losing ground)

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August 2000

Crude Generalizations from FICPA

7. Grid sampling works but is too expensive

- At some sufficiently small scale it works
- At some sufficiently large scale it's profitable
- Optimal cell size is site-specific
- Despite attempts by research and business to discredit, it remains viable
 - At 2% of farms, USDA deems most popular PA activity

8. Yield monitors & yield mapping here to stay

- 55% (26% w/ mapping) of CHAMP combines
- Adoption based on faith
- Some frustration after multiple years

Is grid sampling growing? Probably slowly?

#8 likely still true today

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August 2000

Crude Generalizations from FICPA

9. National databases for farm-level data are being questioned

- Can't generalize across the U.S.
- Data quality and consistency a problem
- May become one-way information providers competing with DTN
- May provide one-way PA info like mPower3

10. More DGPS choices than ever

- Beacon, WAAS, satellite
- SA off implies 15-16 feet accuracy 95% of time

National databases are DEAD!

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August 2000

Crude Generalizations from FICPA

11. VRT lime is likely to be profitable

- Yields turn down with excess pH
- Kansas has a transition area where only some parts of a field gain from lime

12. VRT P is also likely to be profitable

- It is the capital investment characteristics of lime and P that make VRT potentially profitable. Information-gathering and VRT costs can be spread across years.

These probably were overstatements

24

January 2001

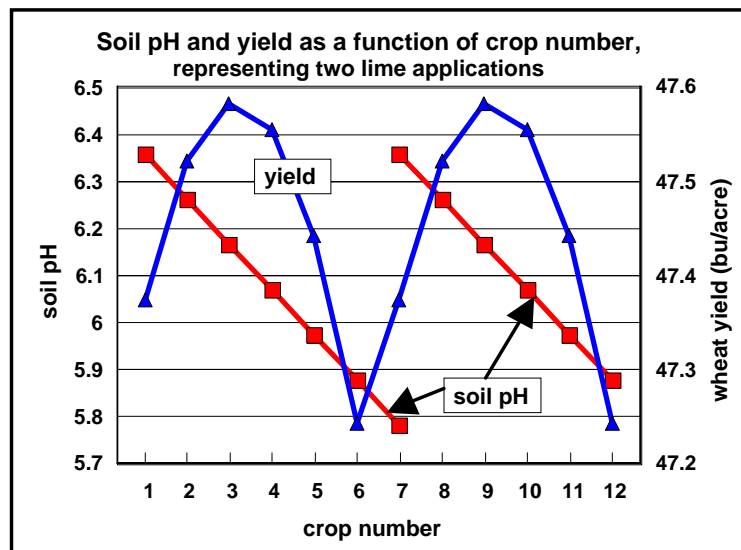
An Economic Study of Lime and Fertilizer P Rates in Central Kansas Wheat Production

Terry Kastens, K-State Agricultural Economist
Sara Schumacher, K-State Ag. Econ. Ph.D. Student
John Schmidt, K-State Agronomist

presented at:
Fourth Annual Kansas Precision Agriculture Conference
Great Bend, Kansas
January 30-31, 2001

25

January 2001



Some farms likely are managing lime/pH better than they did as a result of PA
Are they using VRA on lime? Well, maybe sort-of. . .

26

March 2001

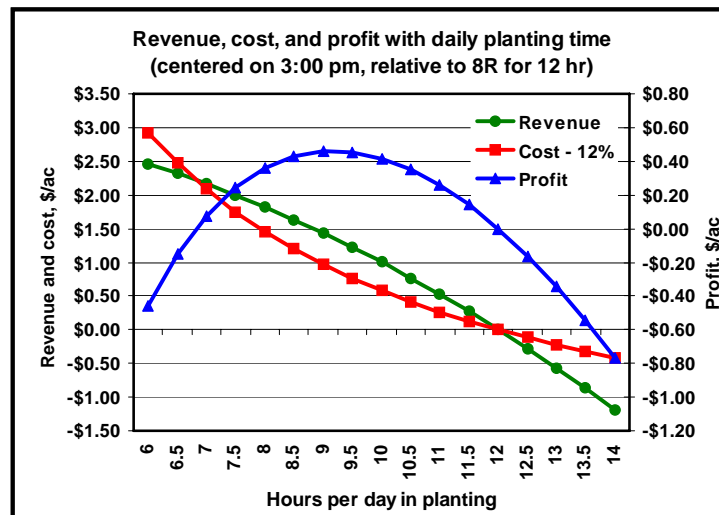
Regression-Based Modeling

Terry L. Kastens, Agricultural Economist
Kevin C. Dhuyvetter, Agricultural Economist
Randal K. Taylor, Agricultural Engineer
John P. Schmidt, Agronomist
Scott Staggenborg, Agronomist

K-State Research and Extension
Kansas State University
Manhattan, Kansas
March 2001

An 8-hour workshop for making proper inferences from our farms' data
It wouldn't have happened without PA
Better field-scale decisions result

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Can farm-level data and regression help make profitable decisions? You bet!

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August 2001

Combining Farm and University Information for Better Fertilizer Decisions

InfoAg 2001 Conference
Indianapolis, Indiana Aug. 7-9, 2001
Risk and Profit Conference
Manhattan, Kansas Aug. 16-17, 2001

Terry L. Kastens, Ag. Economist
Kevin C. Dhuyvetter, Ag. Economist
John P. Schmidt, Agronomist

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schmidt@ksu.edu – 785-532-7211
paper at www.agecon.ksu.edu/kdhuyvetter/

30

August 2001

Problem #1

- **Models behind university fertilizer recommendations are usually not explicit**
 - What happens to yields at less or more than the recommended fertilizer rates?
 - What happens to profits?
- **Difficult to assess expected profits for VRT/PA without an explicit yield/fertilizer relationship**

So began a whole line of research that tried to get mathematical models for decision-making from agronomy understanding

It wouldn't have happened without PA

Better field-scale decisions result

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January 2002

Spatial Interpolation Accuracy

Fifth Annual Kansas Precision Agriculture Conference
Great Bend, Kansas
January 29-30, 2002

Scott Staggenborg, Agronomist
Terry Kastens, Ag. Economist

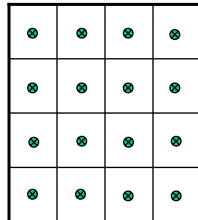
Kansas State University
sstaggen@oznet.ksu.edu – 785-532-2277
tkastens@agecon.ksu.edu – 785-532-5866

paper at www.agecon.ksu.edu/kdhuyvetter/

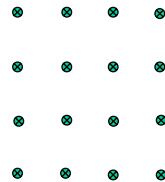
32

January 2002

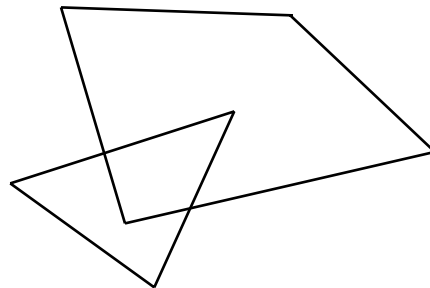
Raster



Vector

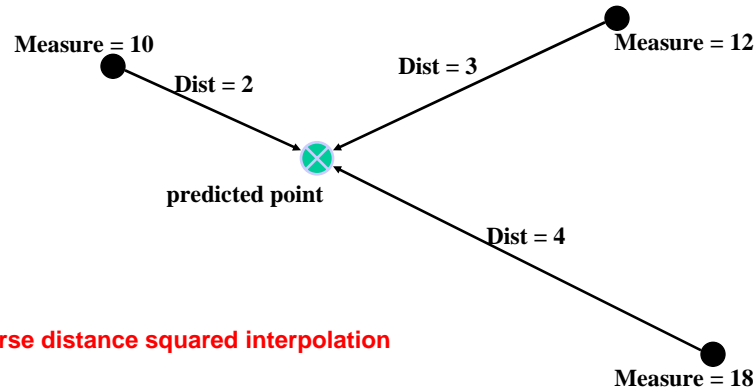


Vector (points, lines, polygons)



33

January 2002



Inverse distance squared interpolation

$$\text{prediction} = \frac{\frac{1}{2^2} \times 10 + \frac{1}{3^2} \times 12 + \frac{1}{4^2} \times 18}{\frac{1}{2^2} + \frac{1}{3^2} + \frac{1}{4^2}} = 11.7$$

Wow, this is wild stuff for a farmer audience!

But not wild for the KARA audience

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December 2003

Managing Fertilizer Programs on Leased Land in the Eastern Corn Belt

Indiana Crop Advisor Conference
Indianapolis, Indiana
December 16-17, 2003

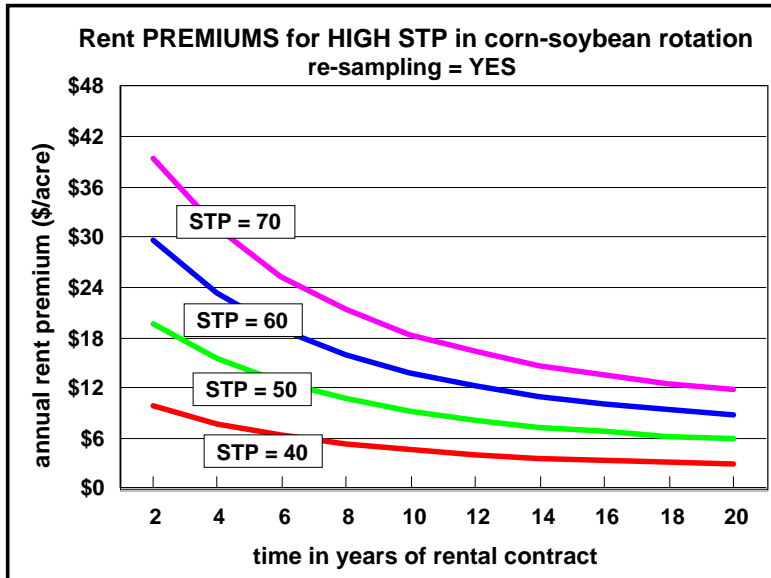
Terry L. Kastens, Ag. Economist
Kevin C. Dhuyvetter, Ag. Economist
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schmidt@ksu.edu – 785-532-7211

paper at www.agmanager.info

December 2003

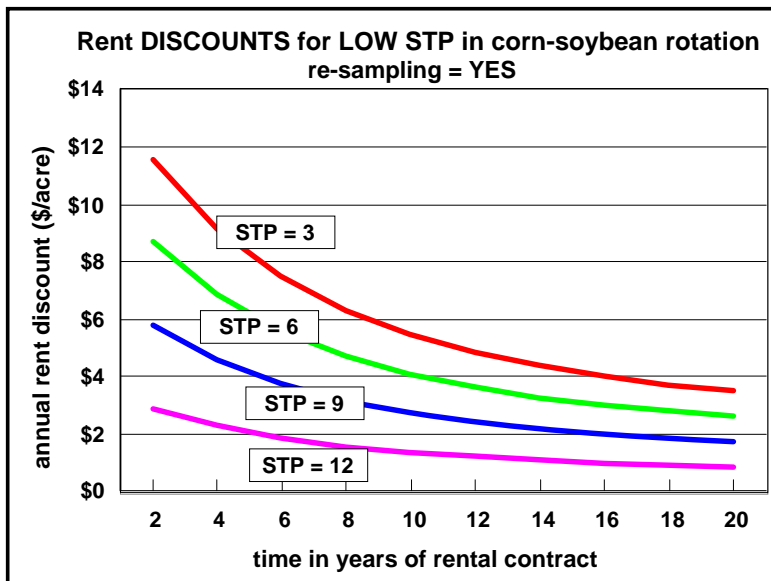
High STP case



An aside: 50% higher phosphate prices would increase all premiums 50%

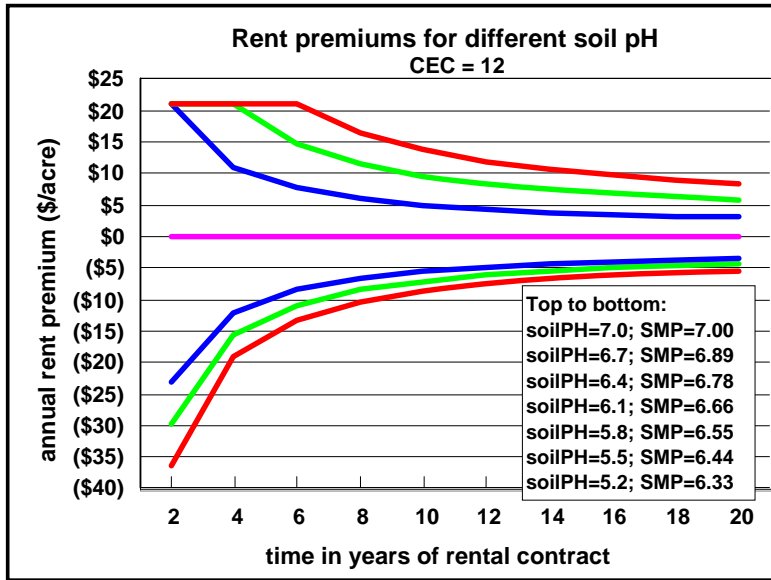
December 2003

Low STP case



December 2003

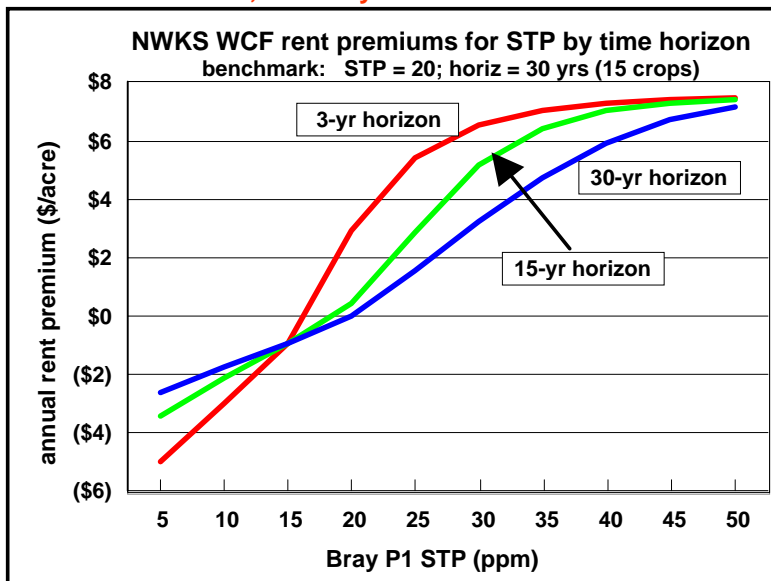
High and low soil pH



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December 2003

In KS, we likely would believe this



39

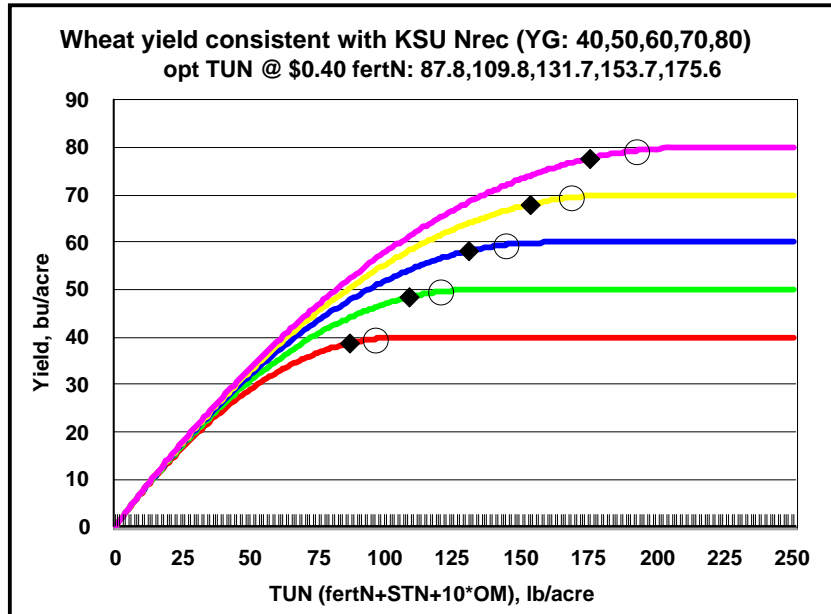
March 2006

N Response Functions for Today's Production Costs



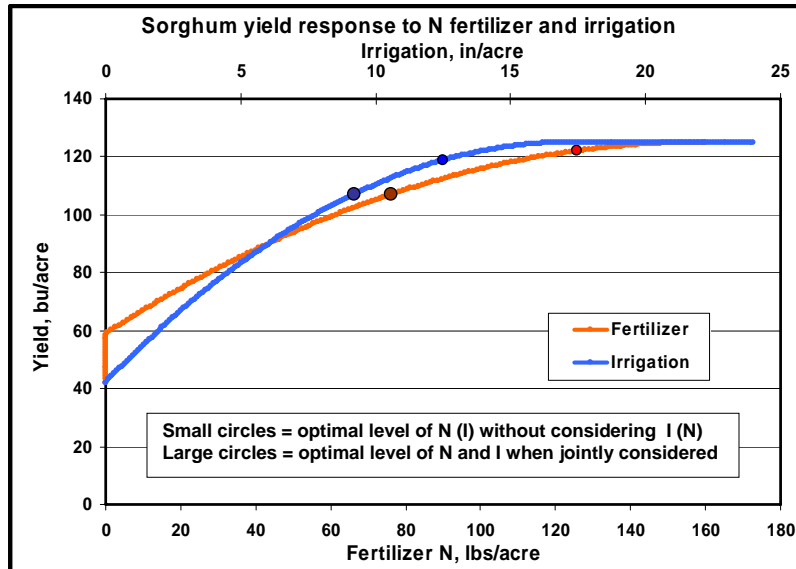
Slope at diamonds is 0.40/3.20

March 2006



March 2006

When considering irrigation and N together, optimal values decrease significantly...



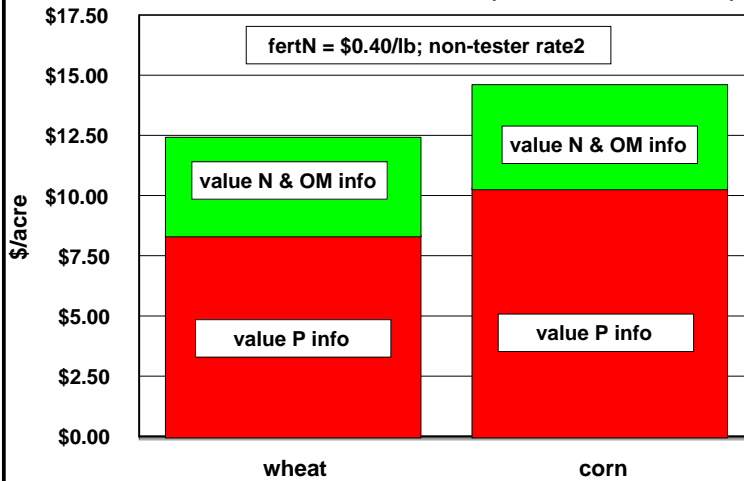
Sorghum price = \$2.10/bu, N price = \$0.40/lb, irrigation cost = \$6.50/inch

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P information more valuable than N information

March 2006

Benefit of soil testing for STN, STP, and OM
Wheat (YG = 50); Corn (YG = 85); avg: STN,40; STP,16; OM,1.6
soil test for STN, STP, and OM (assume costs \$1/acre)



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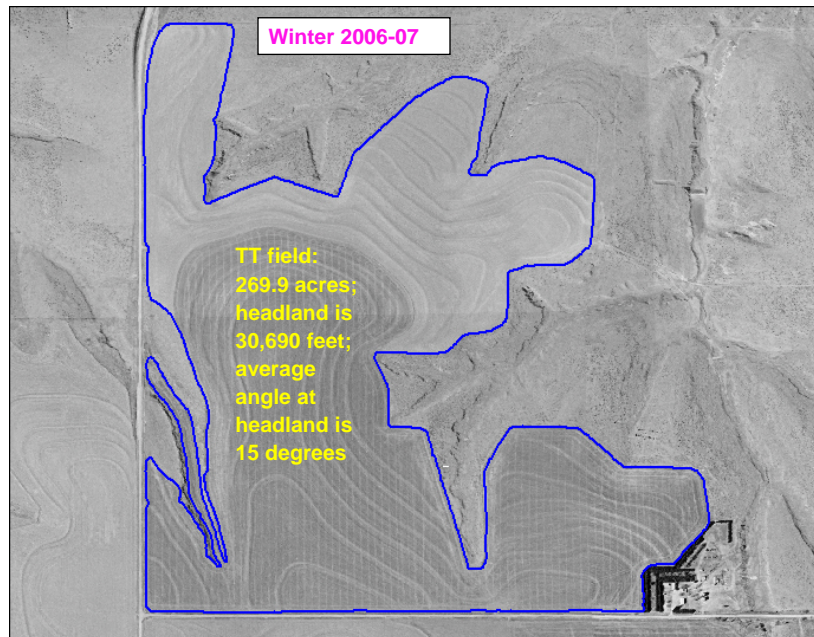
Auto-guidance and Boom Control: When do these Toys Pay?

Winter 2006-07

Terry L. Kastens, KSU Ag Economics
Kevin C. Dhuyvetter, KSU Ag Economics
Dietrich L. Kastens, Kastens Inc., Herndon, KS
www.agmanager.info



Ag Profitability Conferences
Kansas
Winter, 2006-2007



Another extremely inefficient Kastens field

Winter 2006-07



Winter 2006-07



End of memory lane It's about time!

Well, not quite . . .
Findings from 10 years of the *CropLife* Purdue Survey
But first a couple of words about technology

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Technology

- **Early adopters get the profits**
 - Bid into cash rents and land values
 - Higher rents mean higher costs and non-adopters find themselves going broke in the face of rents they perceive as “too high”
 - Rate of getting “bid into rents” depends on adoption rate
- **Speed of adoption depends on:**
 - A) magnitude of expected profitability
 - B) degree of confidence in the expected profit
 - C) size of investment

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Technology: speed of adoption

- **Big and obvious gains probably non-existent**
- **Small, obvious, gains along with small investment implies fast adoption (“duh” technologies)**
 - Roundup Ready soybeans (90% in 9 years)
 - GPS guidance (lightbars/autoguidance)??
- **Many technologies are adopted very slowly**
 - Tractors (over 40 years)
 - No-till (after decades still only around 30%)
 - Variable rate application in PA??

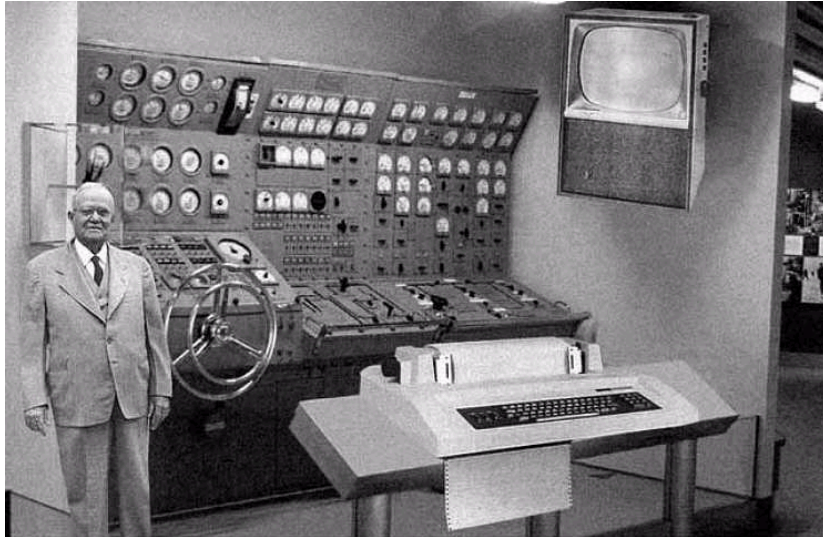
50

Technology: how to get an edge

- **Invest in the “duh” technologies quickly**
 - You don’t have a choice
- **Consider investing in slow moving technologies**
 - The profits will last for years (because not bid into rents)

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Predicting technologies isn't particularly easy . . .



Scientists from the RAND Corporation have created this model to illustrate how a "home computer" could look like in the year 2004. However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the Fortran language, the computer will be easy to use.

Popular Science, 1954

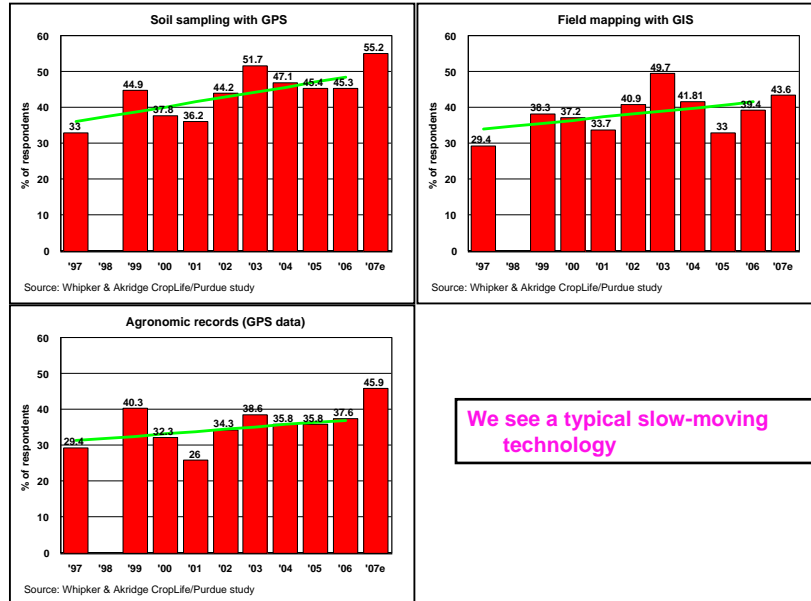
52

Whipker & Akridge CropLife/Purdue Survey

- 1996: what were the greatest opportunities for PA?
 - Better agronomic understanding
 - Improved dealer profit due to offering new services
 - Improved crop yields
- Did it happen? In 2006 all rankings averaged between 3.7 and 4.5 where 1 meant no impact and 7 meant large impact – so sort of ho hum
- Very few (<10%) of dealers believe that PA improved crop input efficiency (2006)

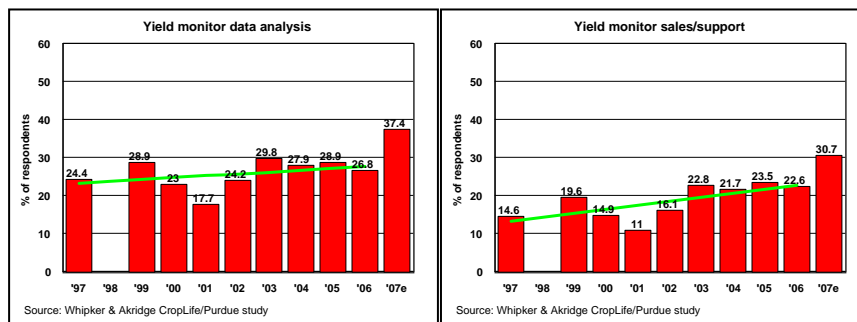
53

Percent of service providers offering services



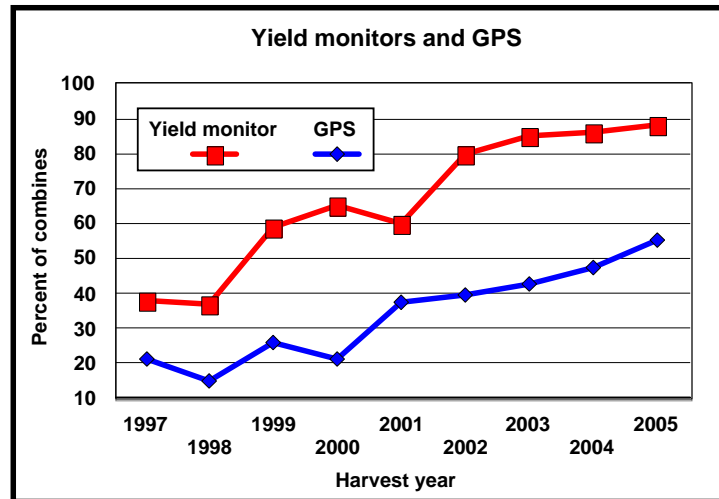
54

Percent of service providers offering services



55

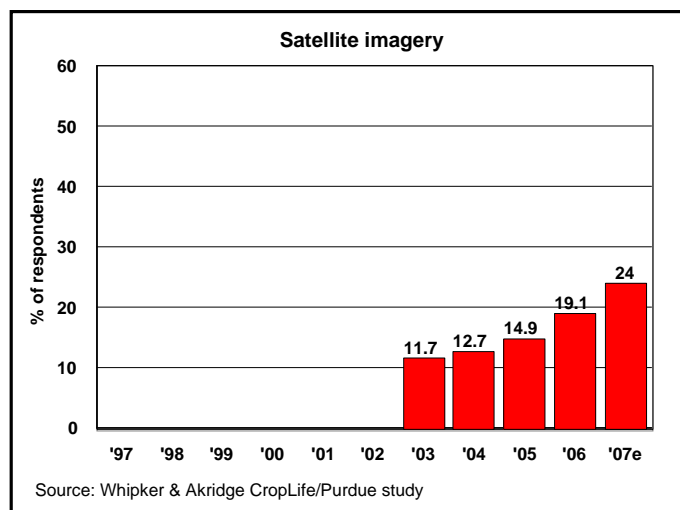
Information from custom harvesters:



- In 2005, members providing maps – 47.8%
 - For providers, this % of customers mapped – 5.7%

56

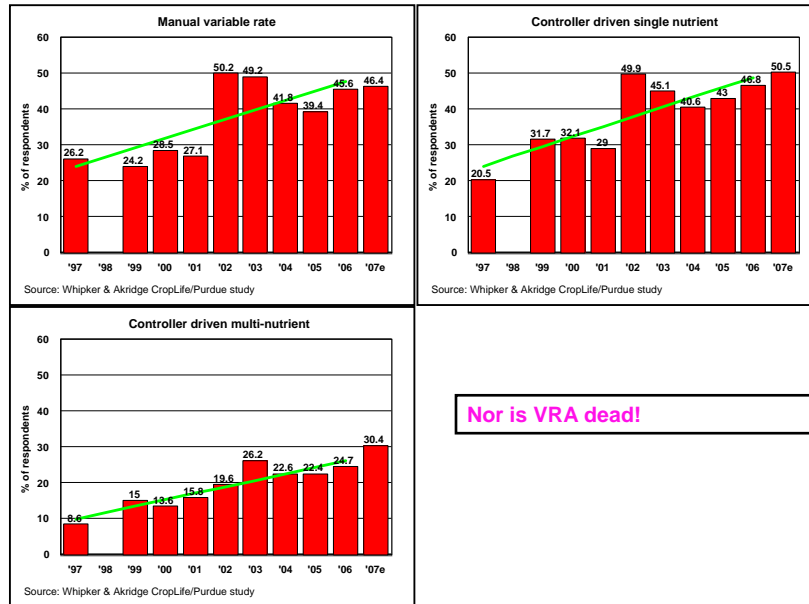
Percent of service providers offering services



Remote sensing (satellite imagery) is far from dead!

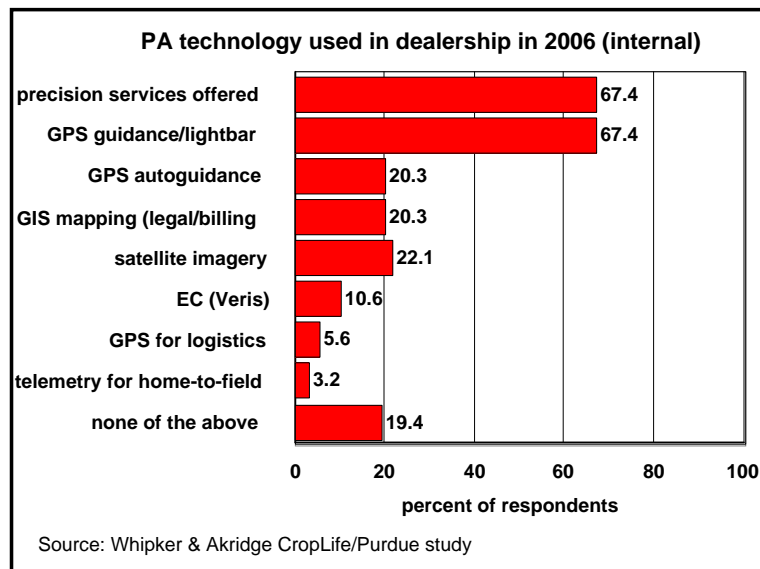
57

Percent of service providers offering services



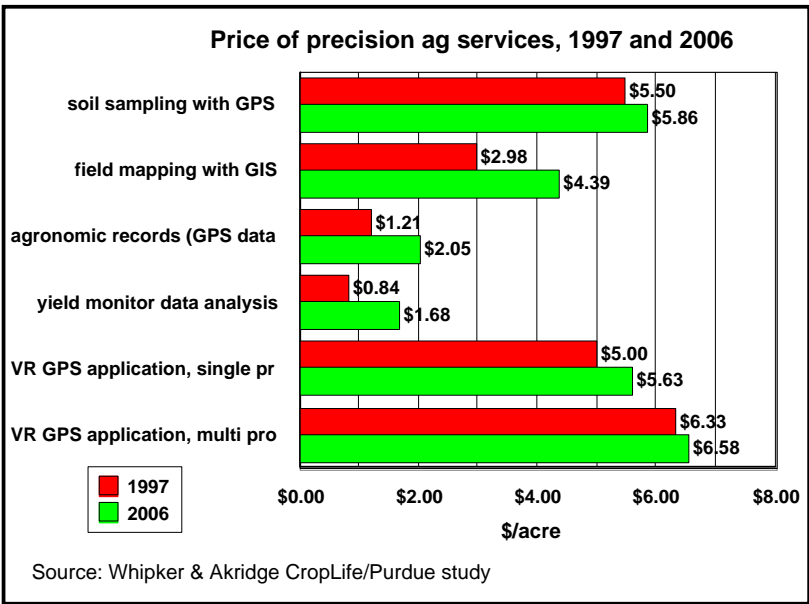
58

Service providers are purchasers of PA technologies as well



Service providers probably somewhat merely like big farmers

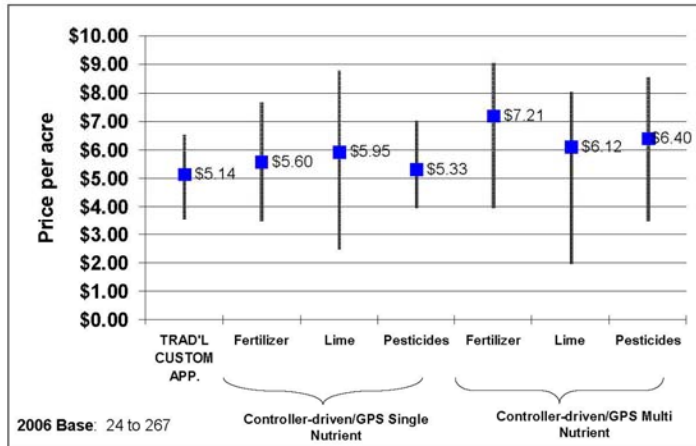
59



Prices did not drop over time like we might have expected

Whipker and Akridge

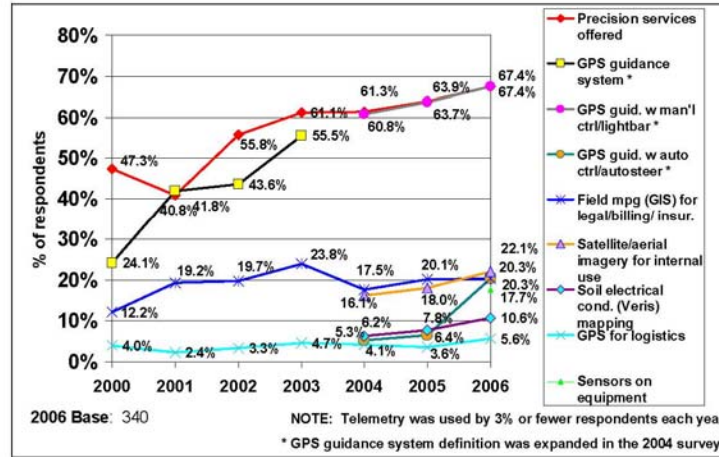
Figure 51. Prices Charged for Precision Application Services



But, aren't charging a really big markup for using a controller either
Greater premium for multi-nutrient likely due to handling more stuff?

Whipker and Akridge (internal use of technologies)

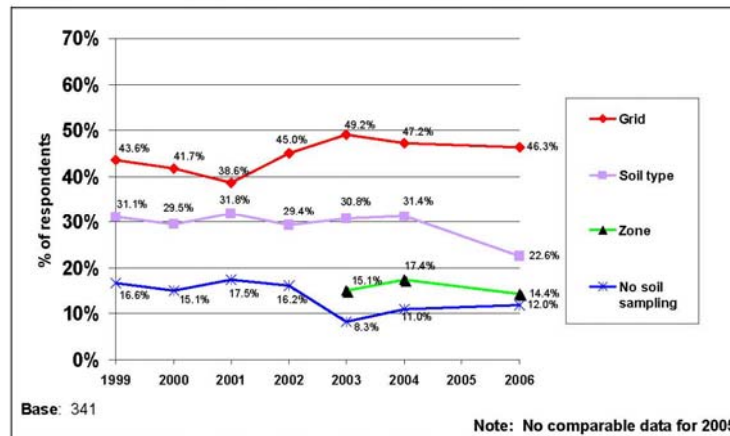
Figure 23. Use of Precision Technology over Time



Slowly growing technology? Autoguidance not slow!

Whipker and Akridge

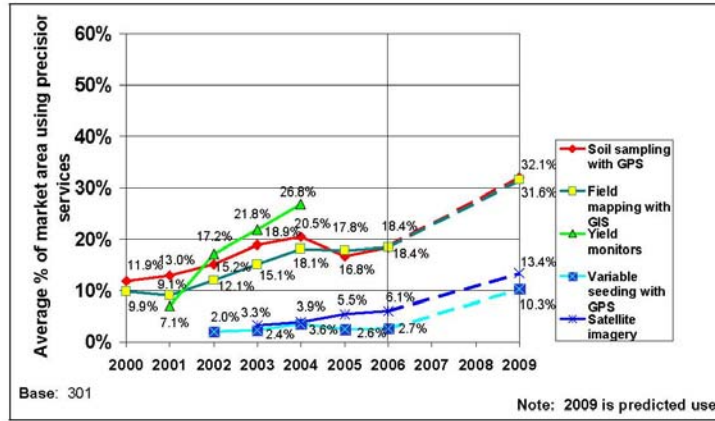
Figure 31. Types of Soil Sampling Offered Over Time



Grid sampling probably doing a little better than zone sampling

Whipker and Akridge

Figure 56. Estimated Market Area Using Precision Services



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Whipker and Akridge

Figure 58. Estimated Market Area Using Single Nutrient Controller-Driven Application

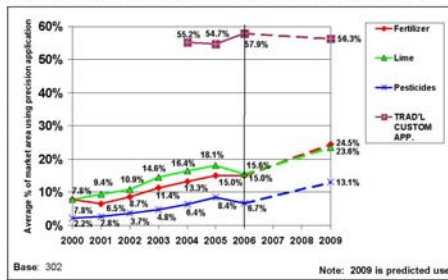
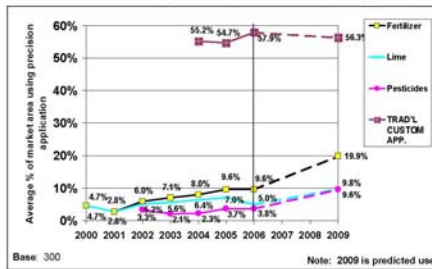


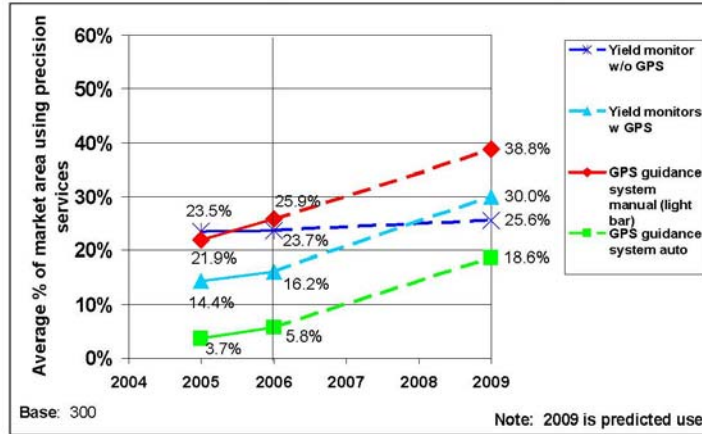
Figure 59. Estimated Market Area Using Multi-Nutrient Controller-Driven Application



65

Whipker and Akridge

Figure 57. Estimated Market Area Using Yield Monitors and Guidance Systems



Likely will be much faster if farm consolidation increases rapidly (think of internal use growth)

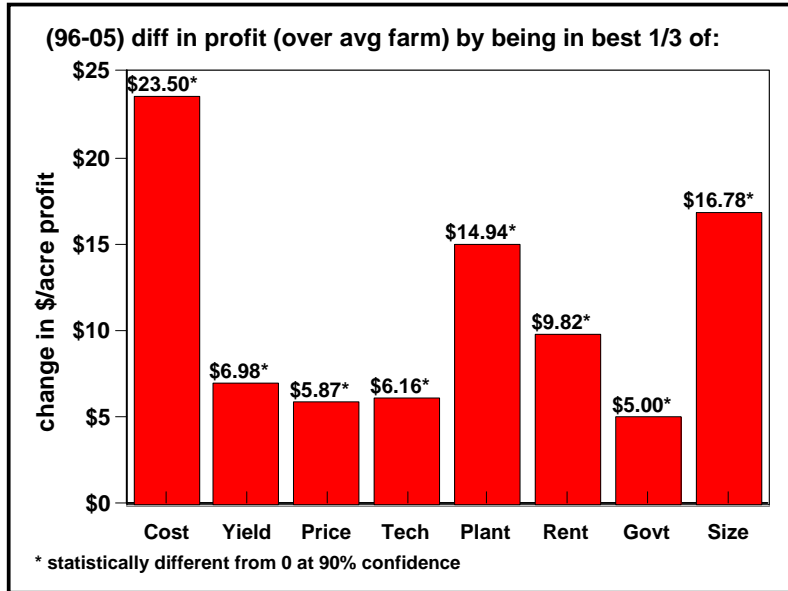
66

PA after 10 years (unforeseen sleeper #1)

- Improvements in machinery efficiency
 - Light bars
 - GPS autoguidance
 - Machine control
- Never underestimate the economic importance of improved machinery decisions

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Cost differences drive profit differences across farms



Machinery large part of costs, but other stuff matters too

How important are farm machinery costs for Kansas farmers?

Kansas Farm Management Association Enterprise Analysis
Nonirrigated Crops – State Averages, 2002-2004

	Corn	Irr Corn	Sorghum	Wheat	Soybean	Alfalfa
Number of Farms	109	37	171	307	168	50
Average Acres	356	481	325	587	321	49
Costs, \$ per Acre						
Seed	\$27.45	\$45.16	\$9.42	\$6.38	\$23.61	\$6.68
Fertilizer	34.53	46.42	22.07	18.81	4.17	8.96
Herb-Ins	23.41	41.38	20.21	4.95	16.60	10.53
Crop Ins	6.60	11.59	4.17	3.86	5.20	0.24
Machinery	70.26	107.65	56.10	59.19	63.16	80.79
Other	18.70	100.03	16.26	16.00	18.17	21.92
Land	35.90	53.82	19.30	22.68	30.16	44.59
Interest	17.21	32.59	12.58	11.95	14.39	15.49
Total Cost	\$234.04	\$438.64	\$160.12	\$143.81	\$175.45	\$189.20
Machinery, %	30.0%	24.5%	35.0%	41.2%	36.0%	42.7%

Machinery costs are highly variable across farms ...

Kansas Farm Management Association Enterprise Analysis Nonirrigated Crops -- State Averages, 2002-2004						
	Corn	Irr Corn	Sorghum	Wheat	Soybean	Alfalfa
Number of Farms	109	37	171	307	168	50
Average Acres						
High profit farms	512	552	446	742	452	87
Mid profit farms	325	525	321	633	329	192
Low profit farms	231	362	207	386	183	79
Machinery Costs, \$/acre						
High profit farms	\$52.07	\$88.51	\$44.16	\$48.57	\$50.73	\$64.04
Mid profit farms	\$64.46	\$105.36	\$54.26	\$53.51	\$61.04	\$80.62
Low profit farms	\$94.40	\$129.28	\$69.88	\$75.55	\$77.71	\$97.68
High less low, \$	-\$42.34	-\$40.77	-\$25.72	-\$26.98	-\$26.98	-\$33.64
High less low, %	-44.8%	-31.5%	-36.8%	-35.7%	-34.7%	-34.4%

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Machinery costs are important in explaining profitability differences across farms ...

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High less low, \$	-\$42.34	-\$40.77	-\$25.72	-\$26.98	-\$26.98	-\$33.64
High less low, %	-44.8%	-31.5%	-36.8%	-35.7%	-34.7%	-34.4%
Differences between high profit farms and low profit farms in ...						
Net returns	\$108.15	\$158.42	\$79.78	\$80.72	\$79.16	\$141.93
Total costs	-\$101.95	-\$106.81	-\$65.97	-\$52.86	-\$58.78	-\$78.16
Cost/net returns	94.3%	67.4%	82.7%	65.5%	74.3%	55.1%
Mach/total costs	41.5%	38.2%	39.0%	51.0%	45.9%	43.0%
Mach/net returns	39.1%	25.7%	32.2%	33.4%	34.1%	23.7%

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- **Adopting new machinery technologies is an important way that farm managers lower their machinery costs to distinguish themselves from others for the purpose of increasing profit.**

- Using GPS to assist machinery operations is an especially important new technology.

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PA after 10 years (unforeseen sleeper #2)

- **PA thinking leads to better crop production decisions outside of VRA**
 - Taylor was right
 - MIMC was right
- **Recognized the value of farm-level science**
 - Increasing the scientific level of our approach to gaining knowledge
 - Increasing the amount of critical thinking we do
 - Improving our presentations of what we learn to others
 - Developing thicker skins
- **Do we care if these things are called precision ag?**

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