Precision Agriculture and Manure Management

Josh McGrath

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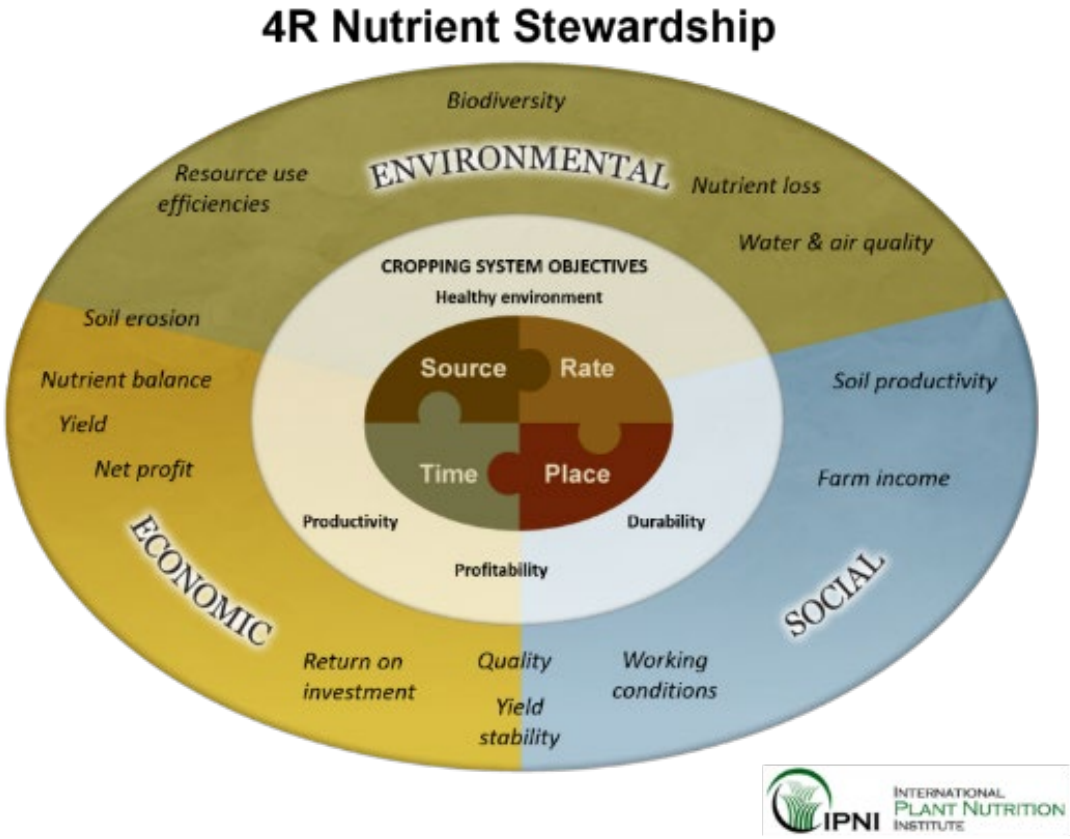
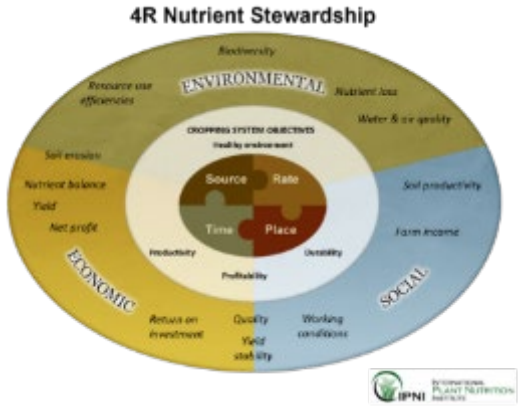
4R performance objectives

- Performance objectives define “Right”
- Competing objectives?
  - Optimized production
  - Minimize environmental impact
  - Maximize Economic Return



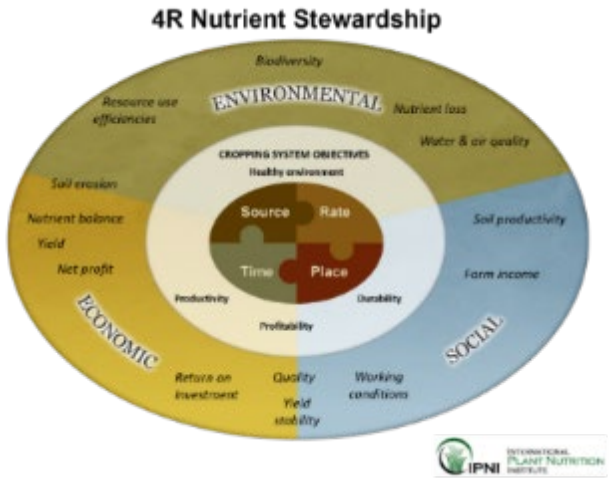
Balancing the “Right”

- Performance objectives define “Right”
- Competing objectives?
  - Optimized production
  - Minimize environmental impact
  - Maximize Economic Return
- How do we balance tradeoffs
  - Max yield ≠ max profit
  - Max profit ≠ environmental optimum
- The most profitable system will likely have some level of environmental impact

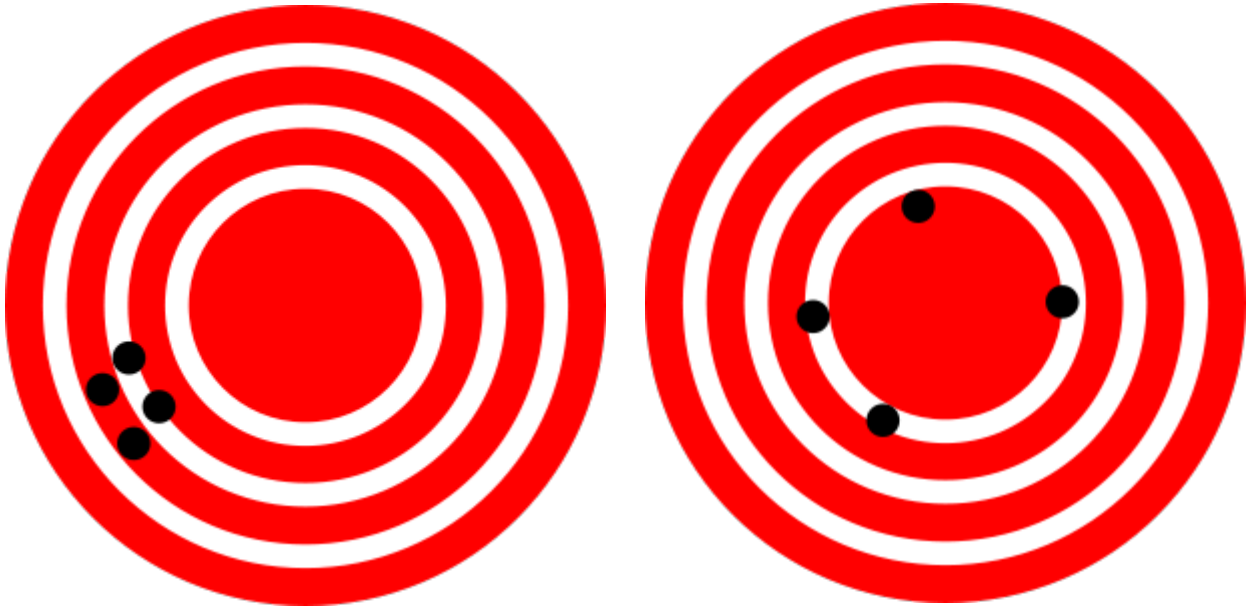


Balance competing objectives

- Site-specific management
  - Target resources
  - Target practices
- Adjust for variability
  - Time
  - Space
  - Management



Why precision?

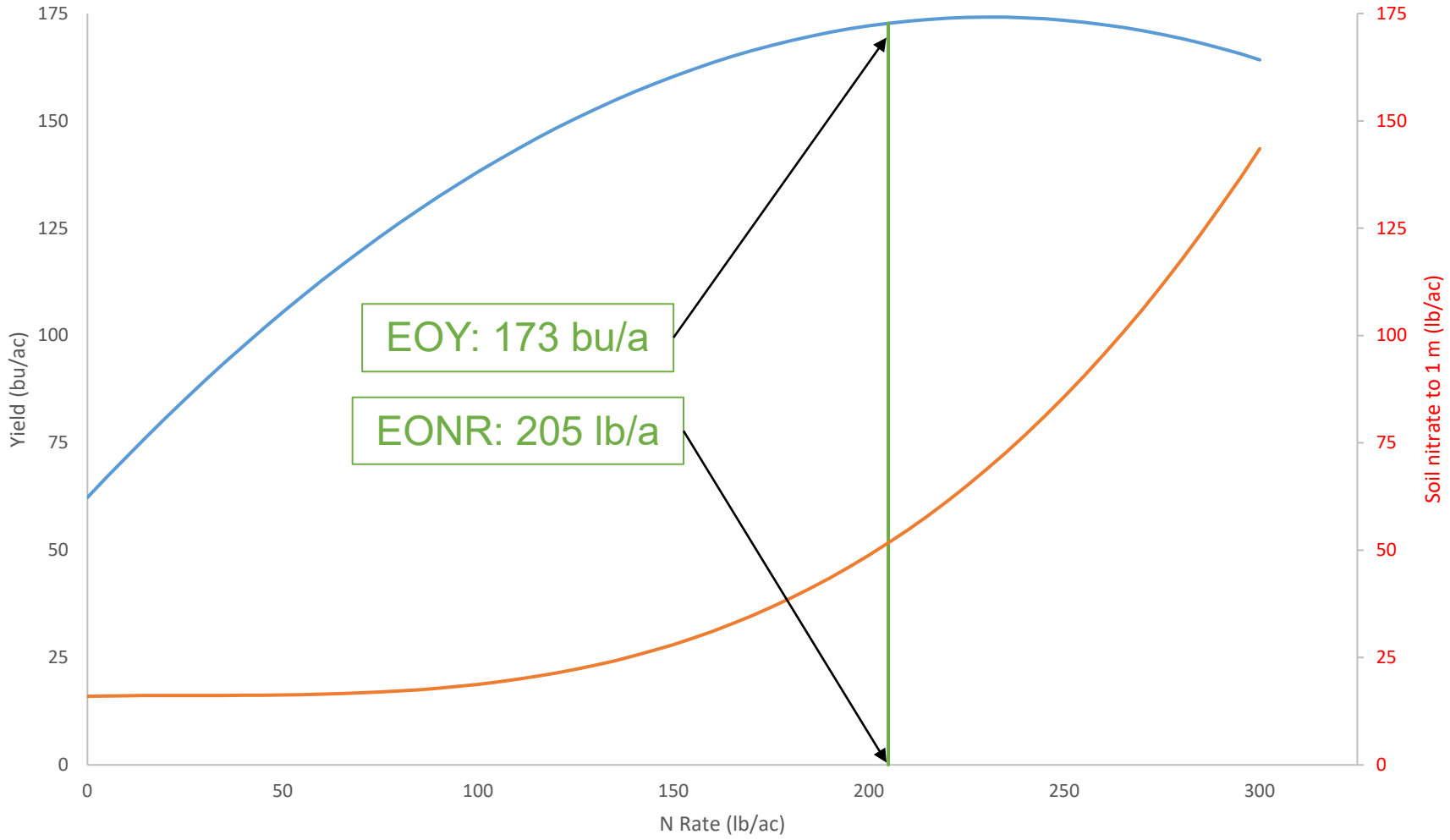


High Precision
Low Accuracy

Low Precision
High Accuracy

http://en.wikipedia.org/wiki/File:High_precision_Low_accuracy.svg

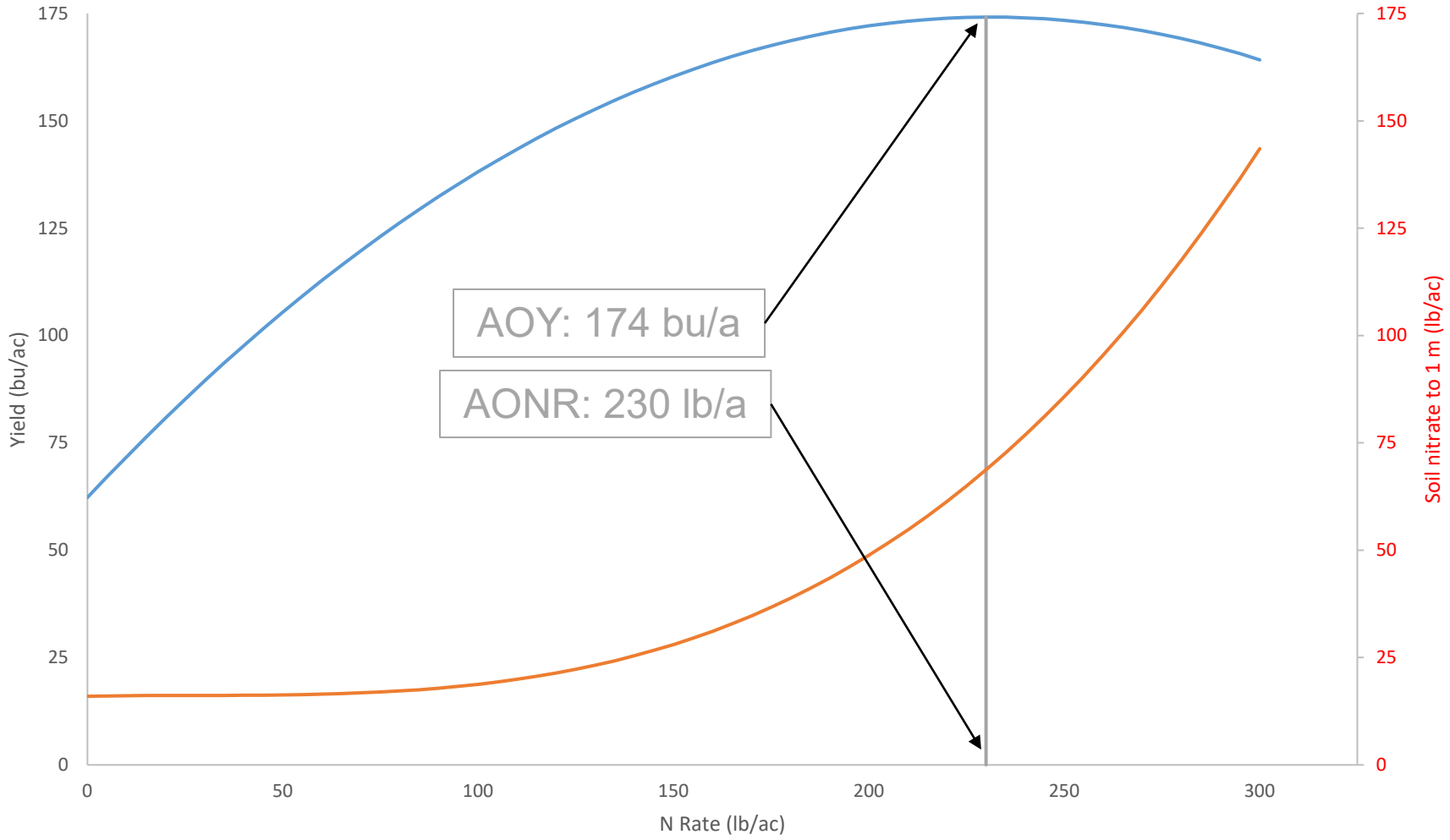
Economic optimum



Data courtesy Frank Coale

University of Kentucky
College of Agriculture, Food and Environment
Cooperative Extension Service

Agronomic optimum



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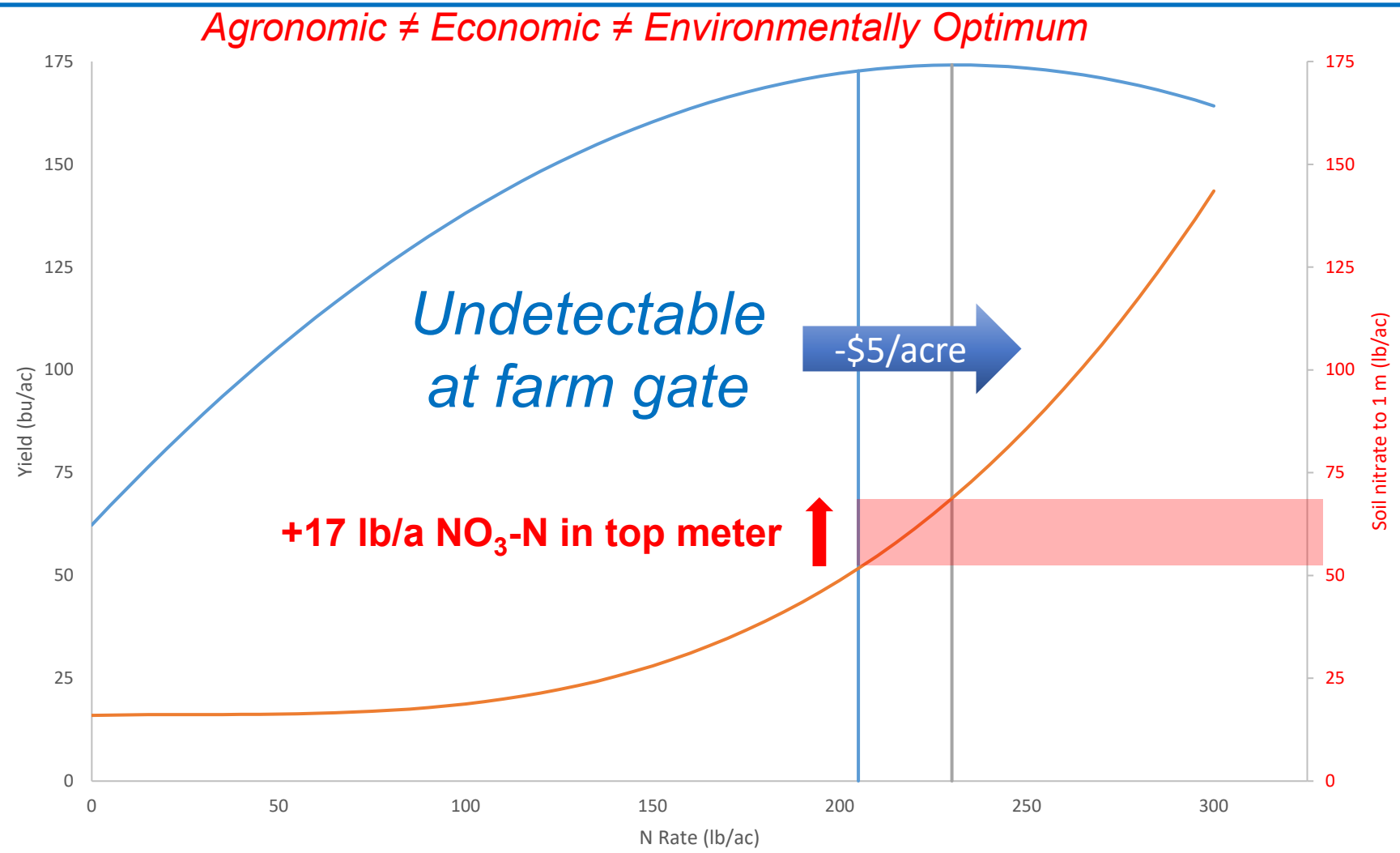
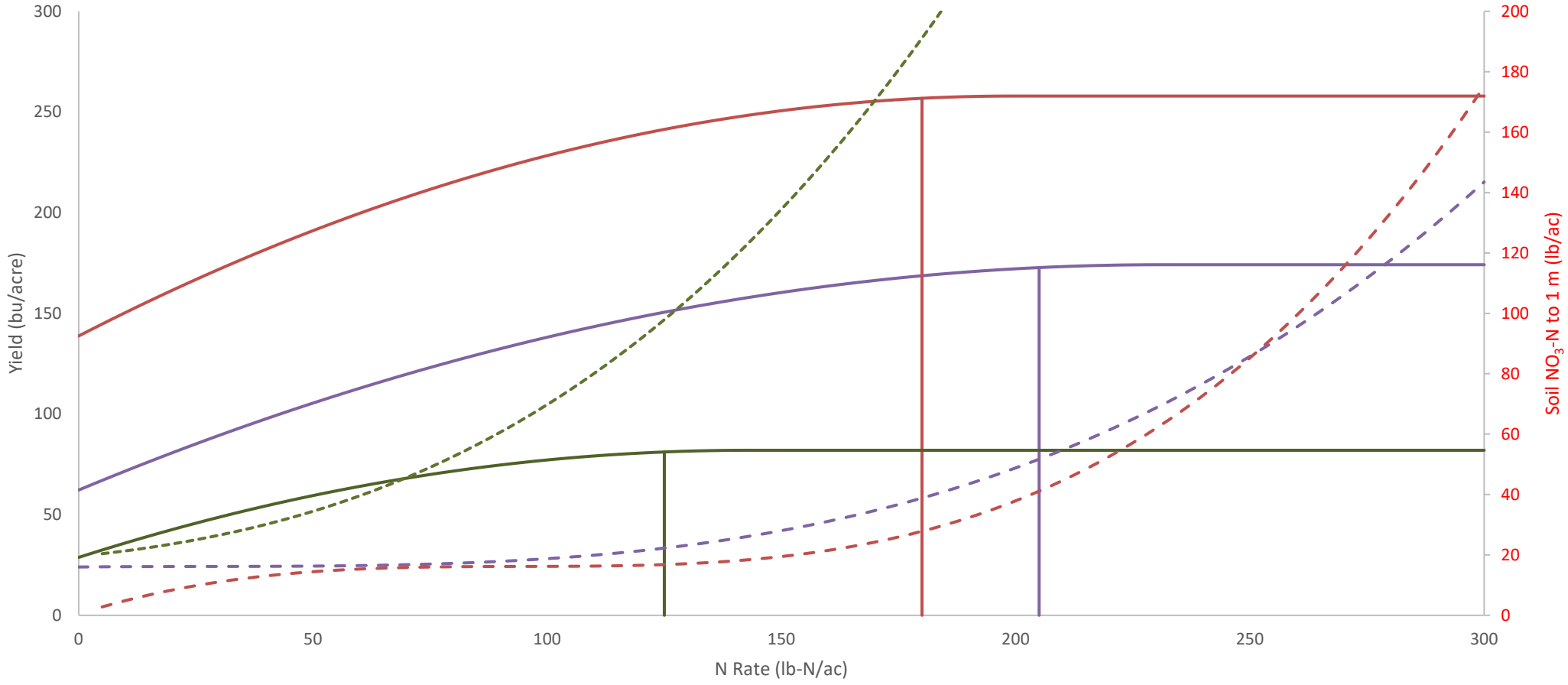
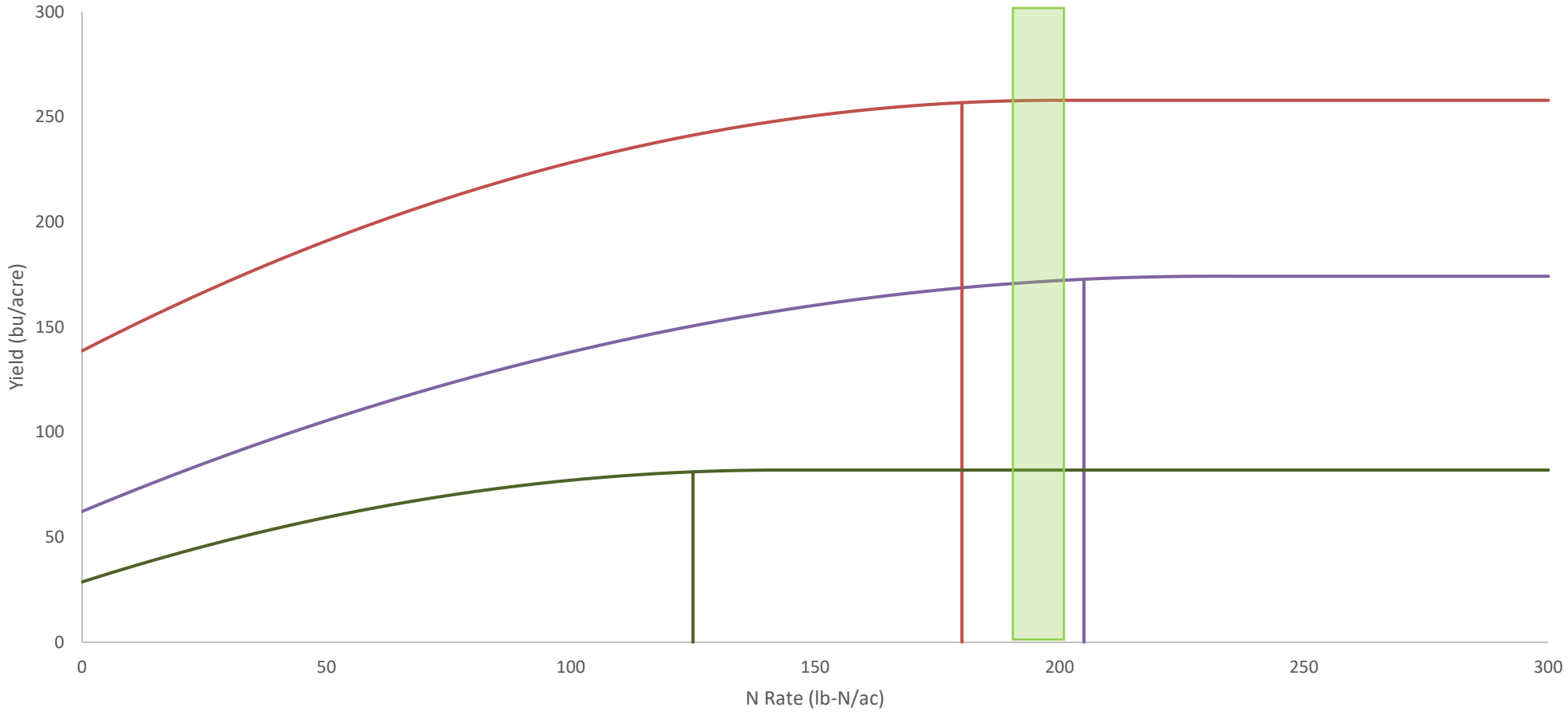
Environmental optimum?



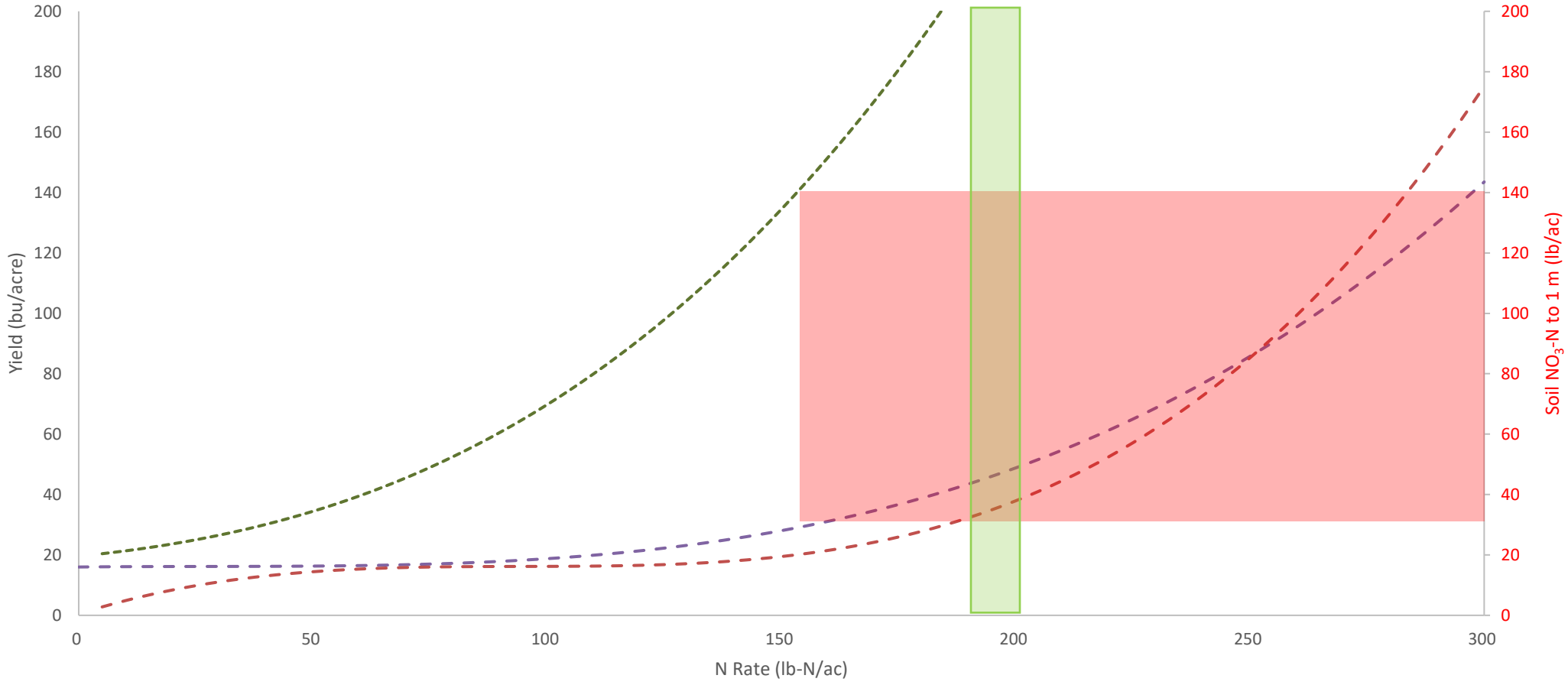
Extrapolating across years and sites



Using accurate recommendations for variable system



Low risk of yield loss – high risk of N loss



Manure and water resources

BMP’s to maximize recovery and protect air and water resources

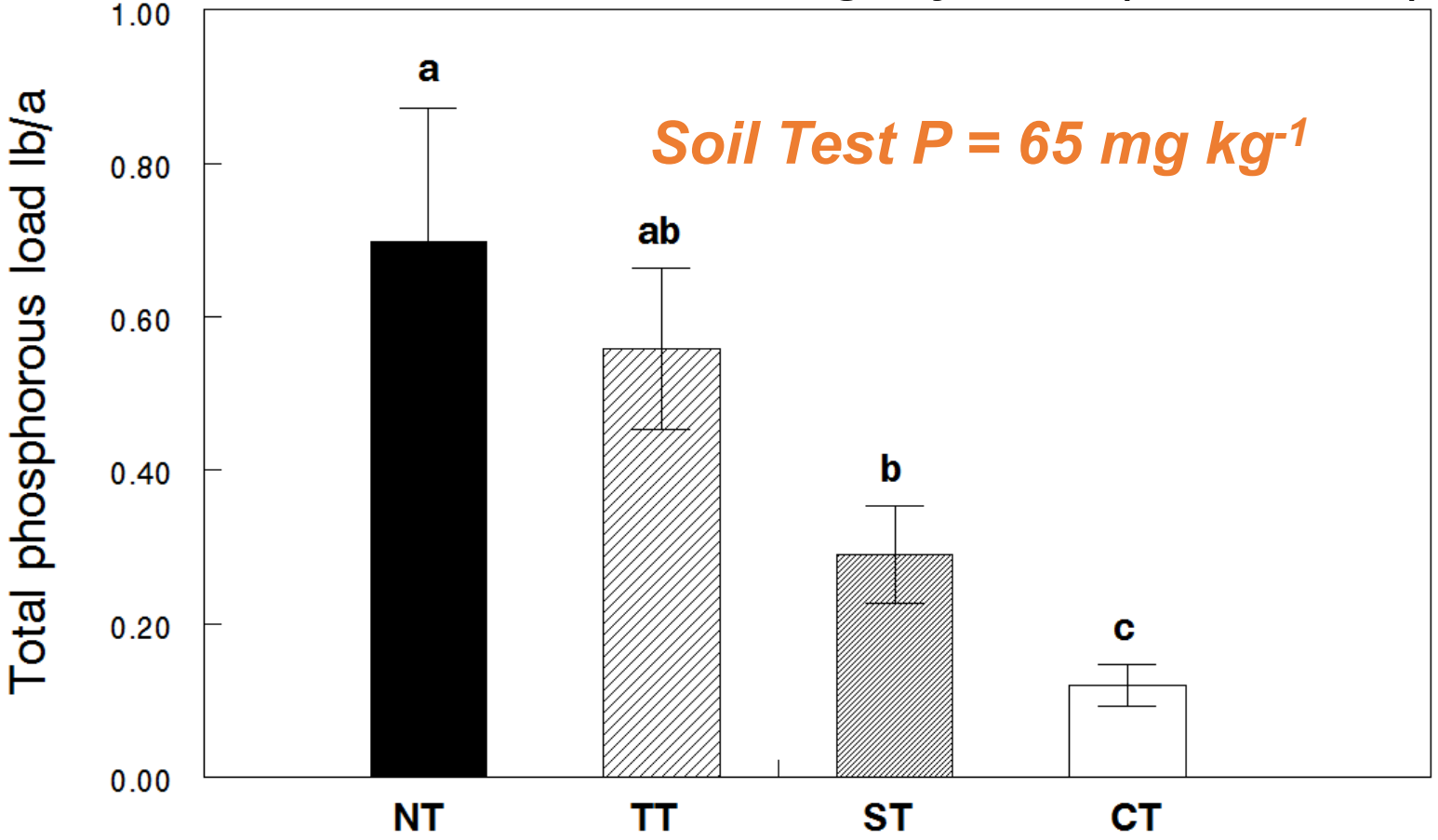
Management matters




- One field, four tillage treatments, three replicates
  - Same manure rate
  - Same soil test P
  - Same hydrology and slope

Management matters

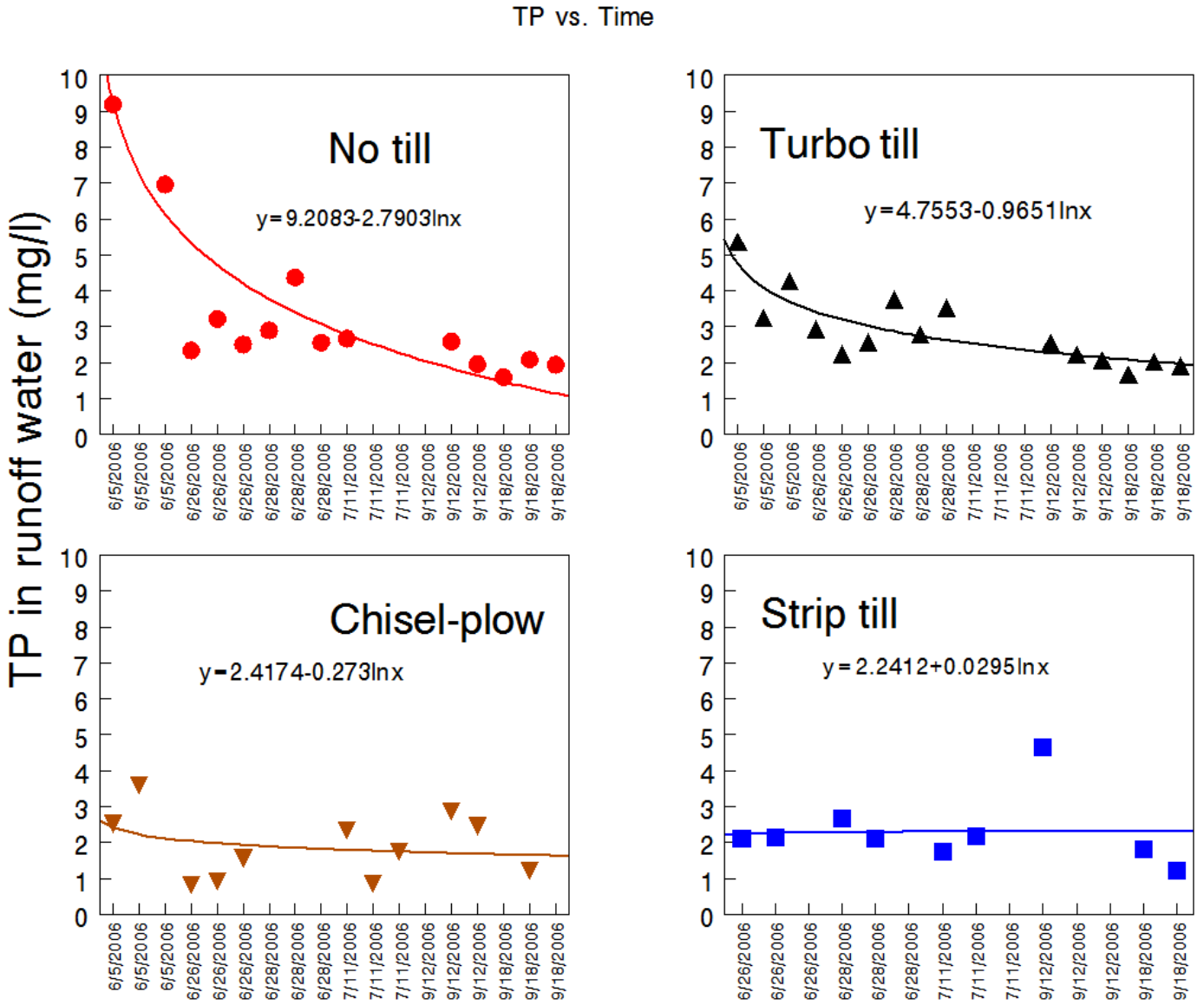
Cumulative P at load from four tillage systems (2006 – 2008)



- One field, four tillage treatments, three replicates
  - Same manure rate
  - Same soil test P
  - Same hydrology and slope
- Very different results

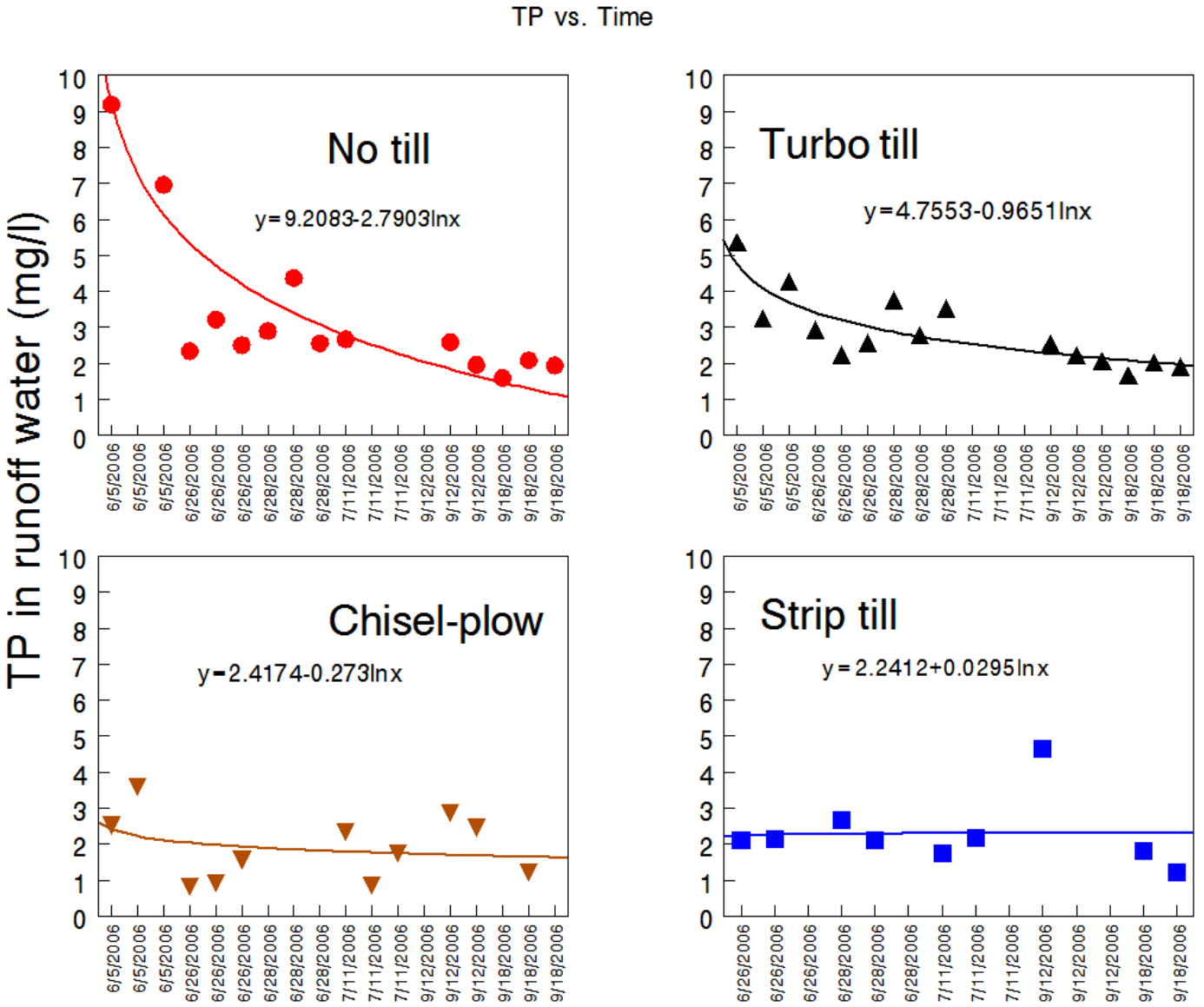
Results varied across time and space

- Surface applied poultry litter provided a strong P signal in runoff immediately after application in 2006



Results varied across time and space

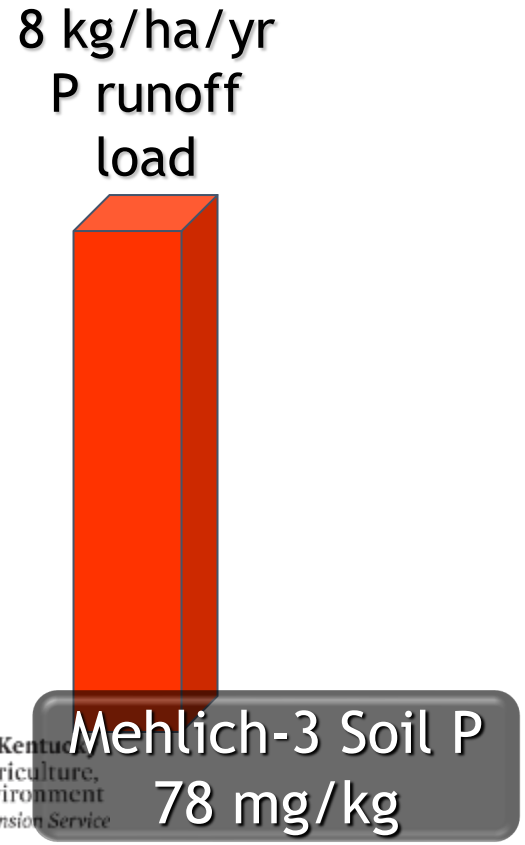
- Surface applied poultry litter provided a strong P signal in runoff immediately after application in 2006
- In subsequent years non-runoff producing rain events preceded first runoff event and there was no treatment effect
- Tillage on steeper slopes would have likely increased total P loading

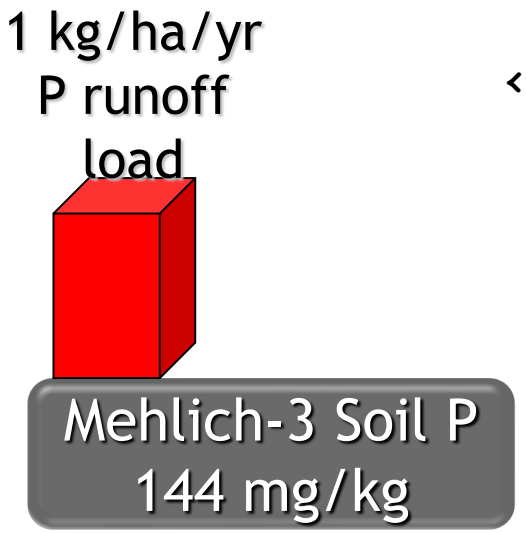


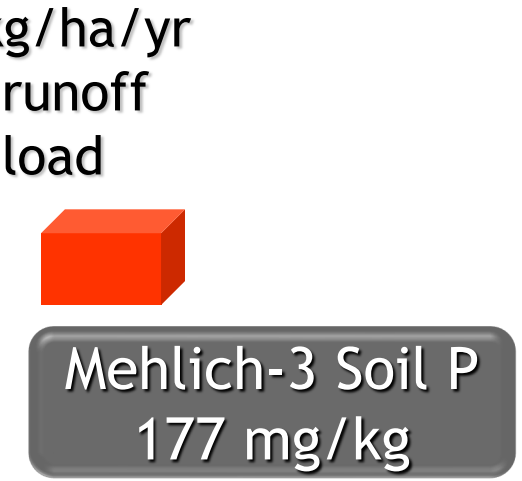
Hydrology overshadows source or management

Budda et al., 2009

Phosphorus loss had inverse relationship with soil phosphorus concentrations?







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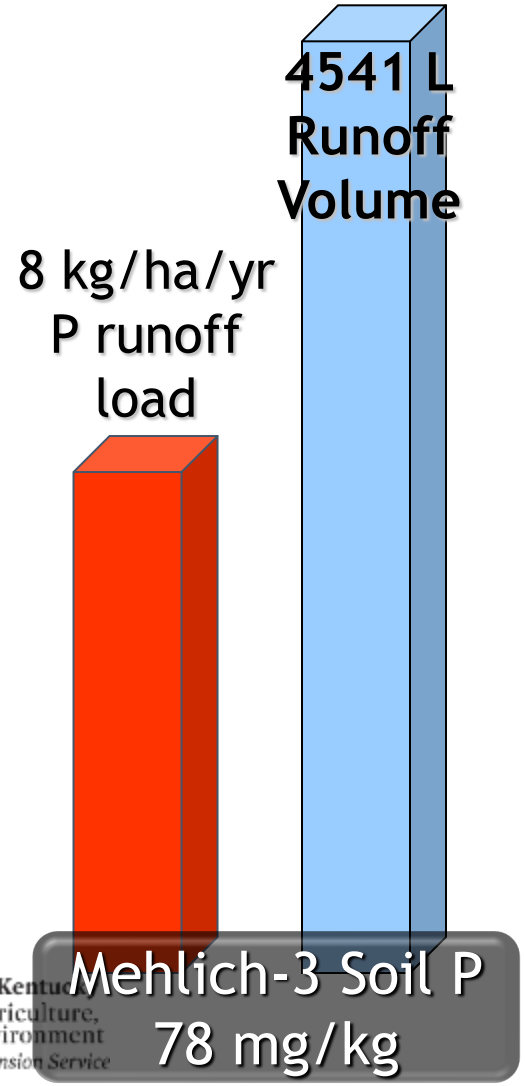
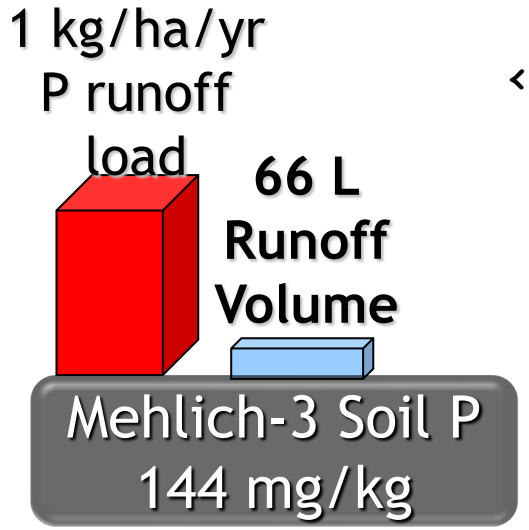
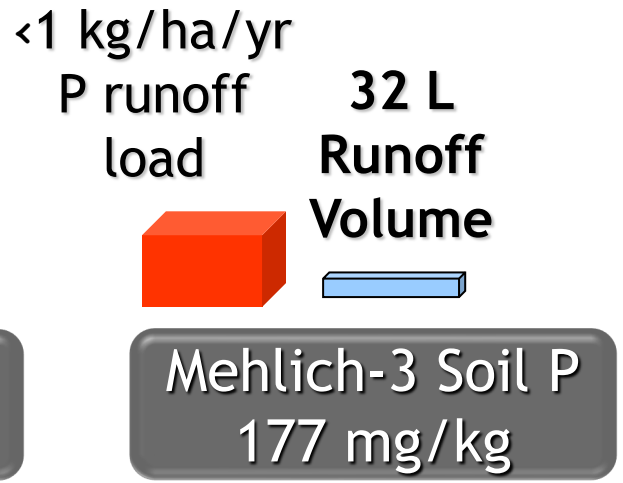


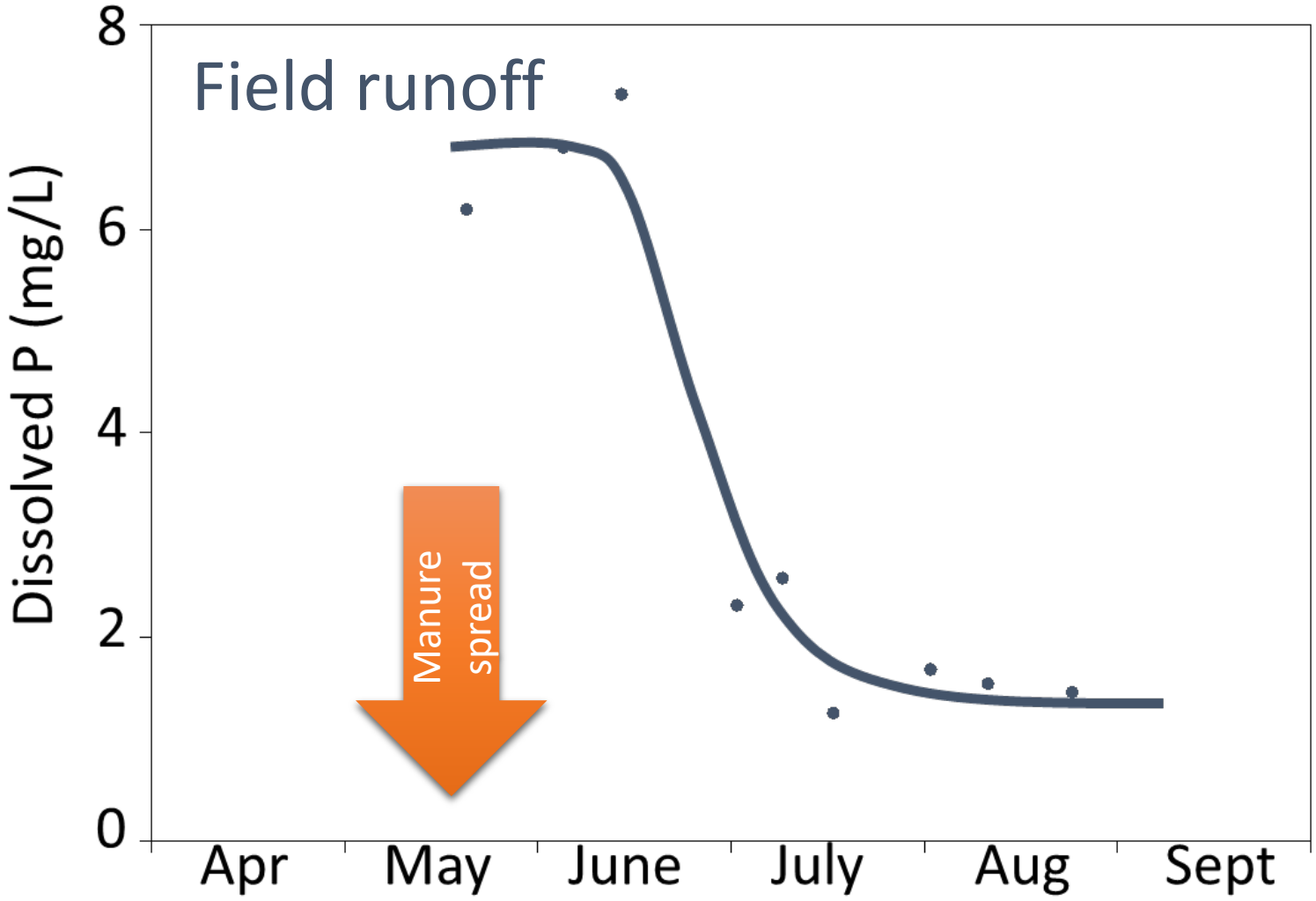
Hydrology drove loss in absence of manure application and overshadowed soil P source





What about that manure signal?

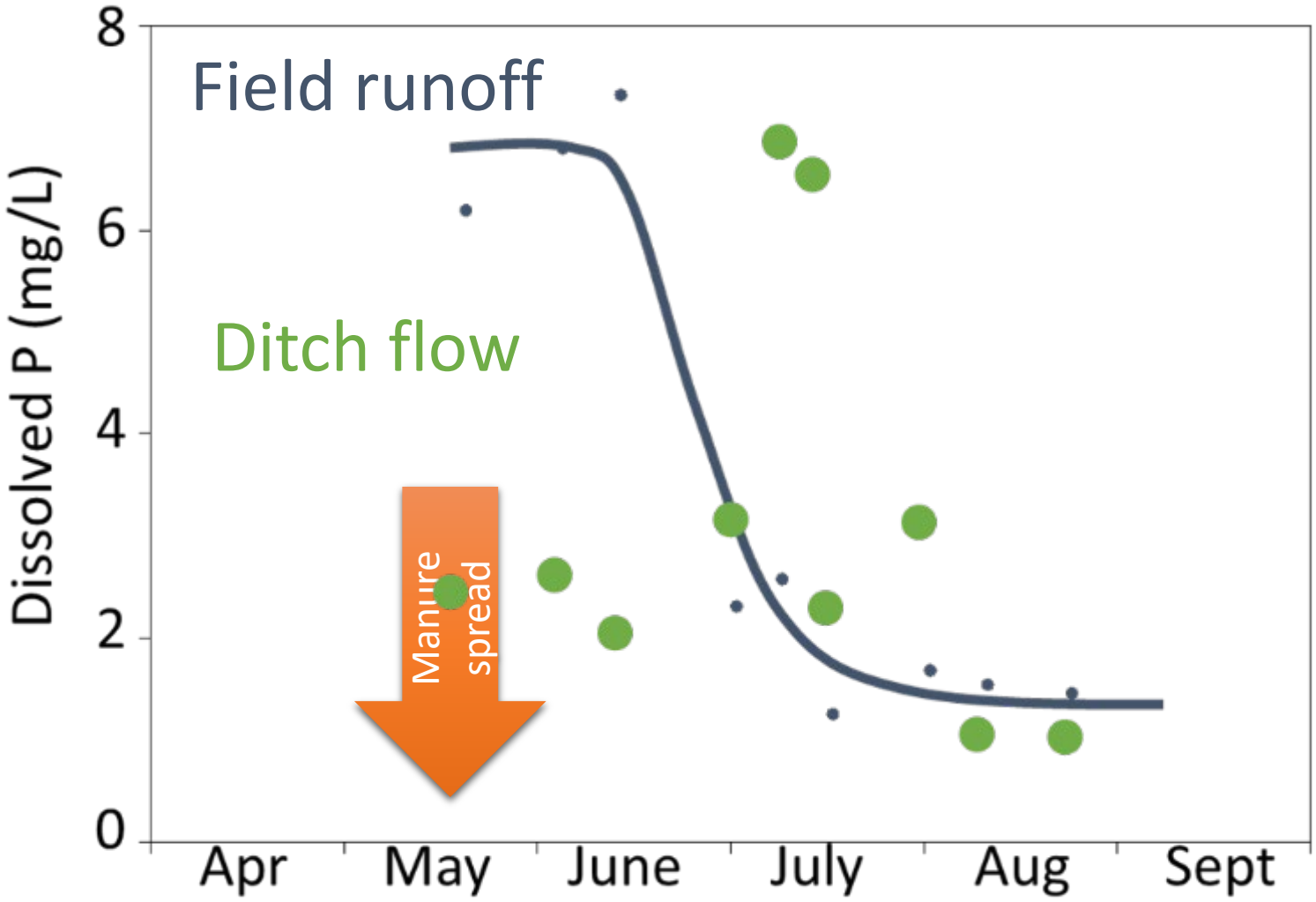
Can we use management to mute the surface runoff signal from manure application



Courtesy Peter Kleinman

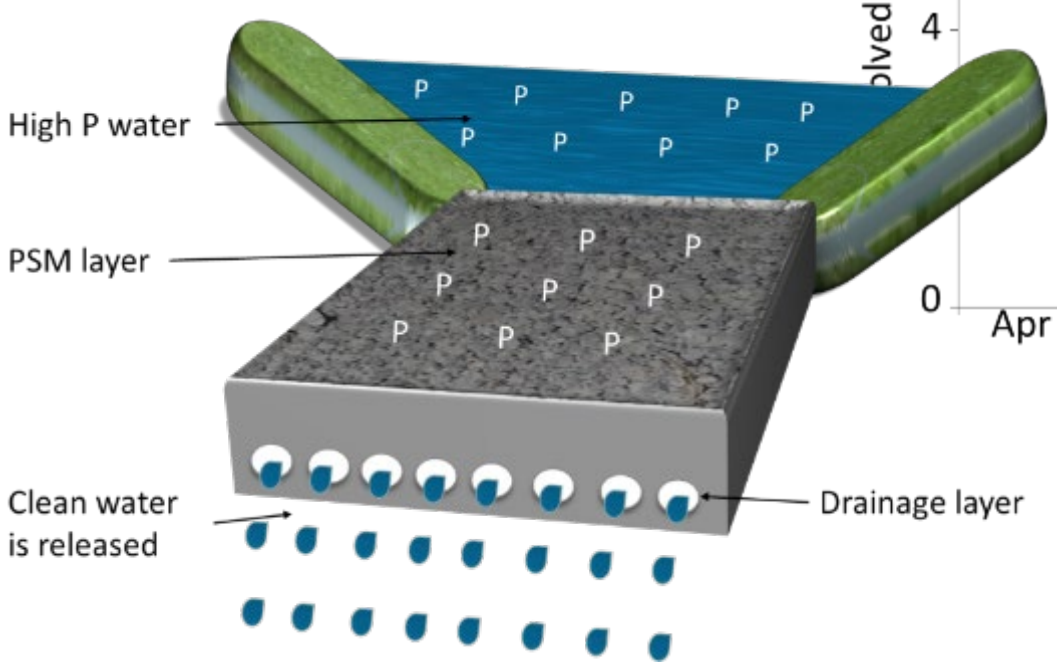
Soil P drove loss in this ditch drained field

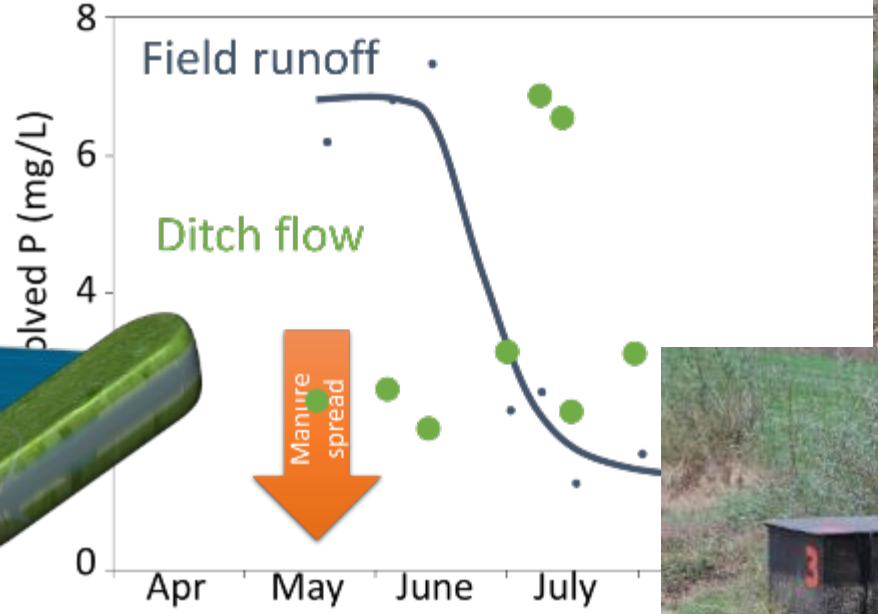
Legacy soil P overshadowed field runoff and incidental transfer from manure



Courtesy Peter Kleinman

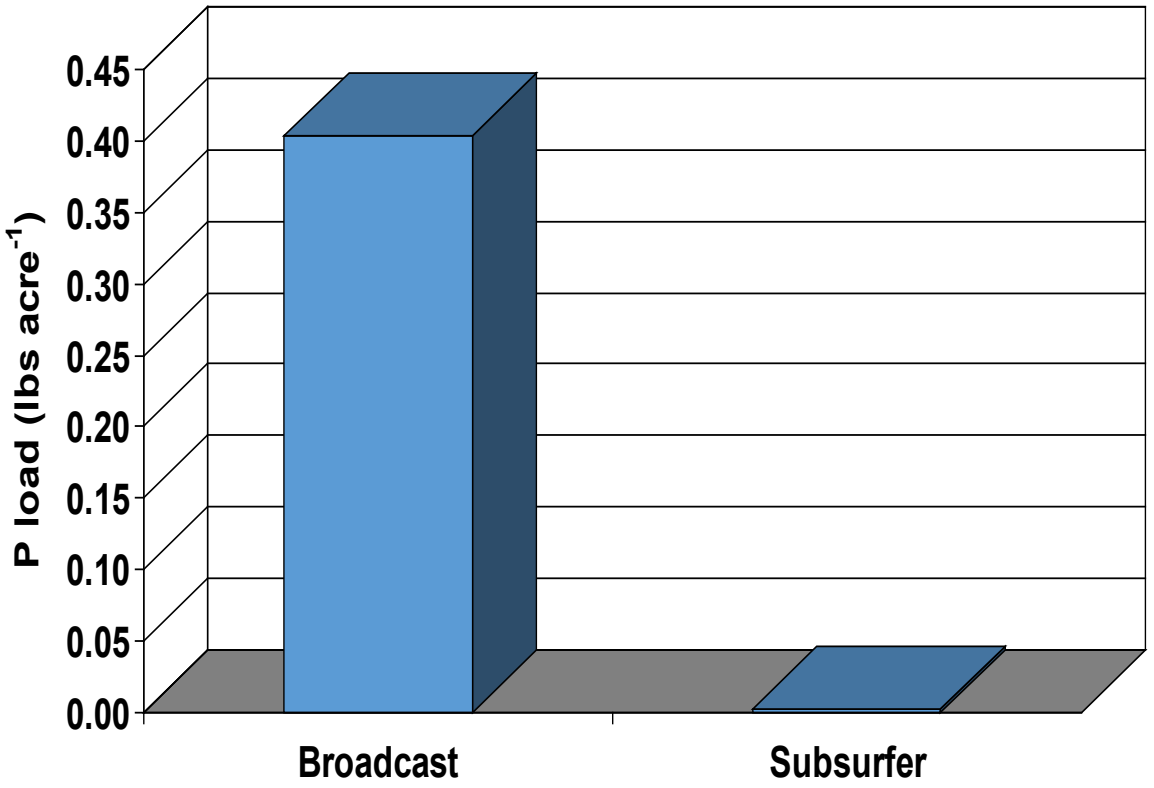
Targeted solutions





More innovation needed

Direct injection of poultry litter



Courtesy of Peter Kleinman

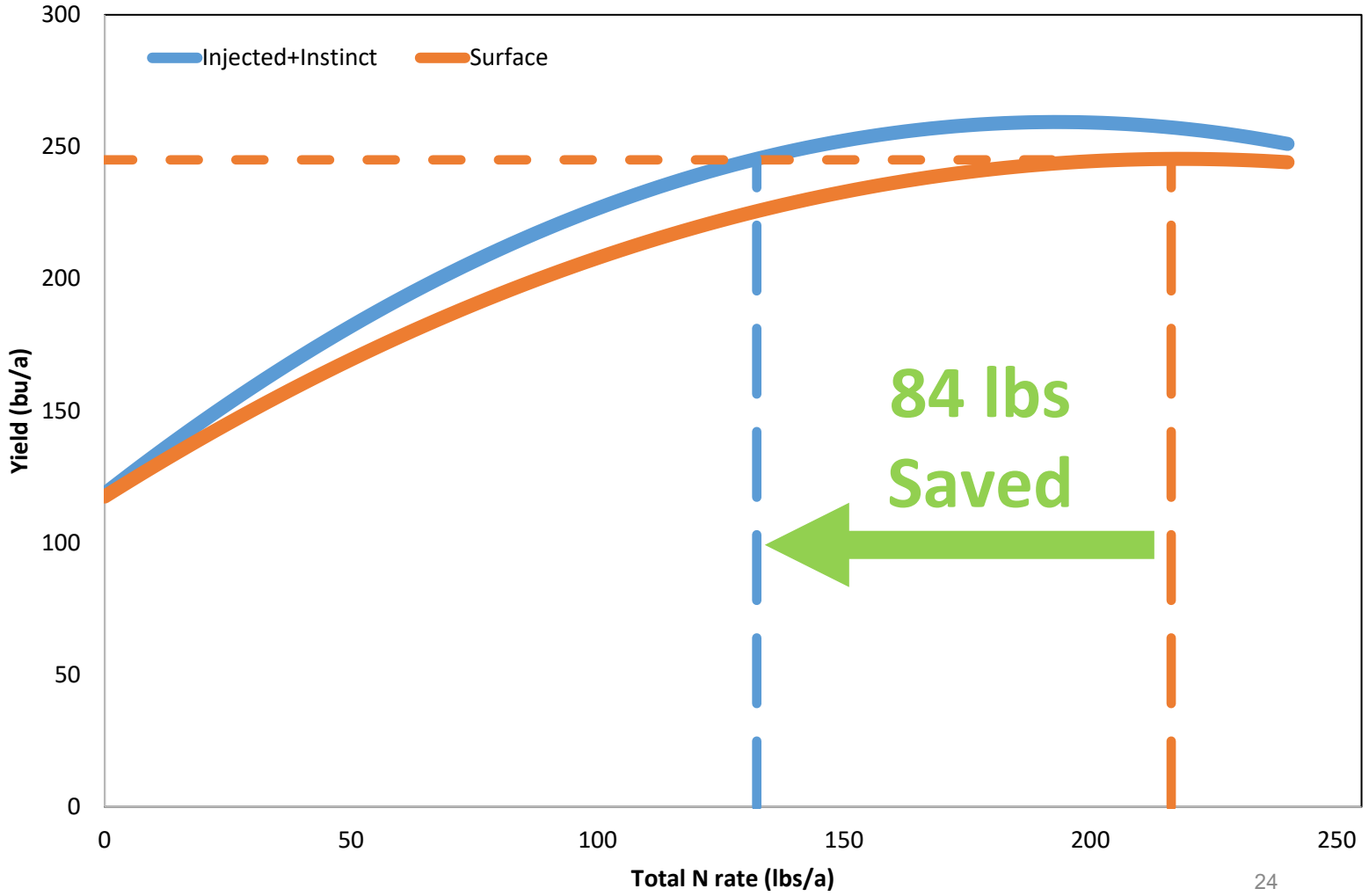
Technology to improve placement and source

- No-till planter double disc opener
- Closing wheels seal the soil surface
- UKY Modified to treat litter with nitrapyrin

Less N and same yield

Sidedress @ 245 bu

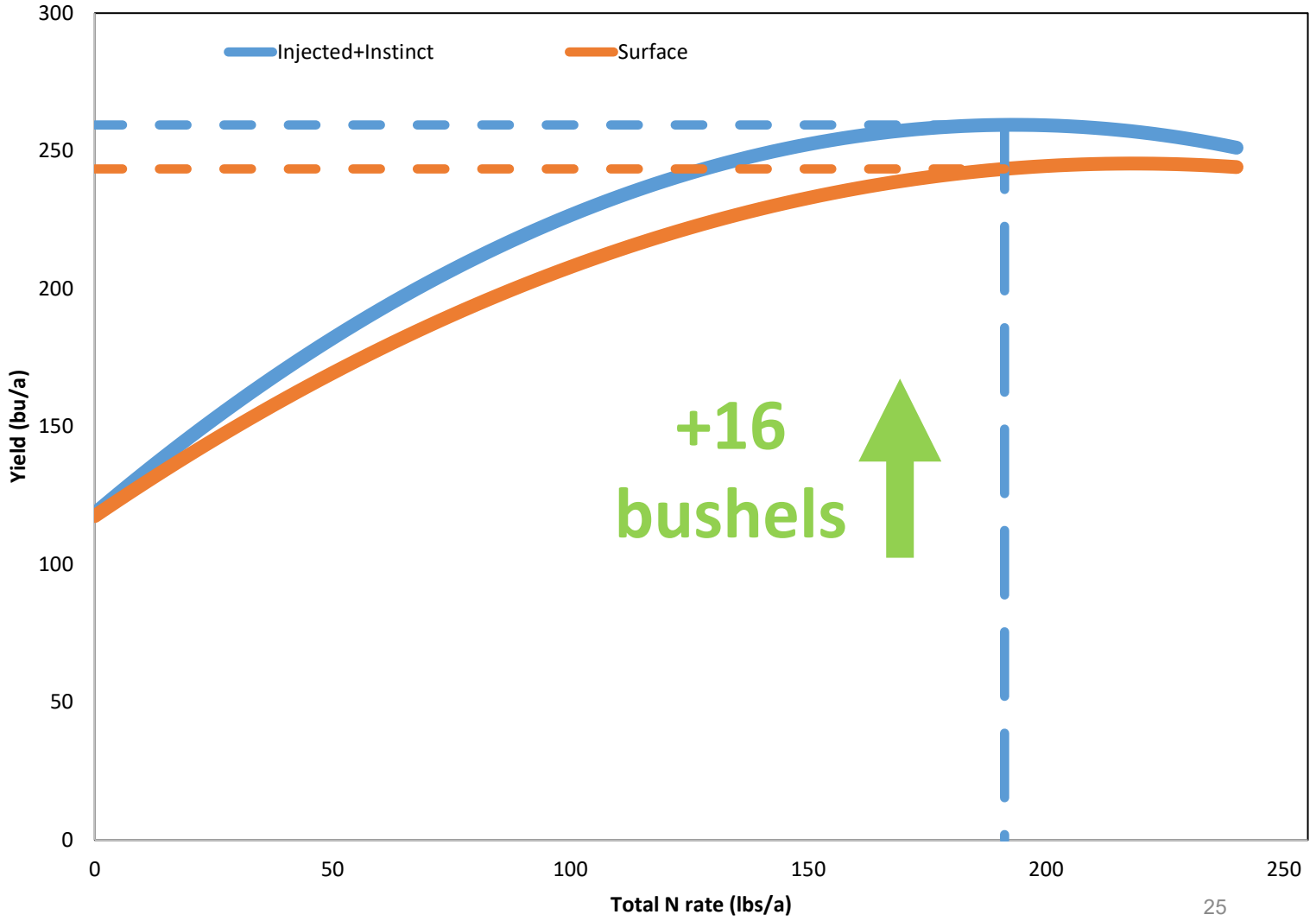
- ✓Normal litter: 126 lb-N/acre
- ✓Injected/treated: 42 lb-N/acre



More yield across all N rates

Yield @ 100 lb-N/a

- ✓Normal litter: 243 bu/acre
- ✓Injected/treated: 259 bu/acre



Working on improved design with OSU and UGA

But wait…There's an emerging P issue

Patel, J.K. 2017. Miles of Algae Covering Lake Erie. The New York Times

Available at https://www.nytimes.com/interactive/2017/10/03/science/earth/lake-erie.html (verified 12 October 2017).

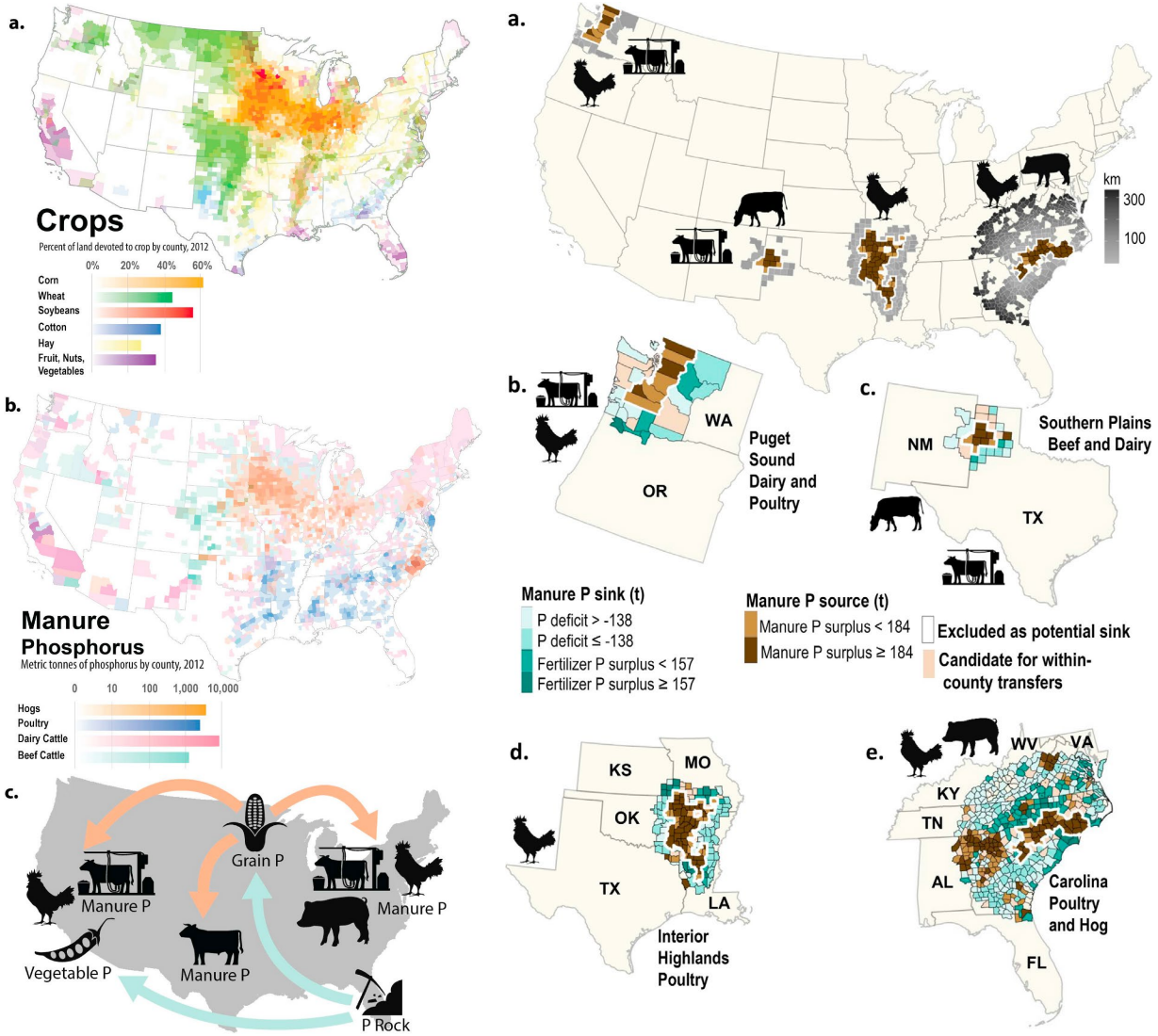
- Past focus has been on areas with significant, historic P surpluses and manure application
- Recent issues in Lake Erie bring to light new concerns

What if soils in agronomic range are problems?

- IPNI reports that 48% of Ohio soil samples in 2015 were below critical level
- Ohio Median STP has fallen each year
- Precision management of soils in agronomic ranges becomes more important

Patel, J.K. 2017. Miles of Algae Covering Lake Erie. The New York Times

The picture is bigger than just livestock



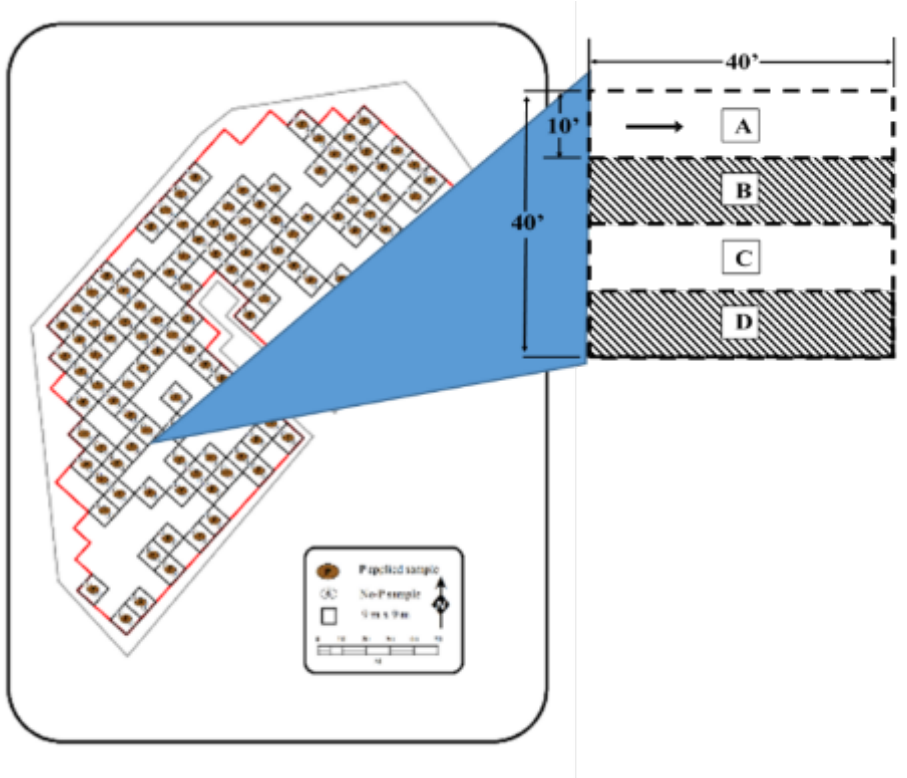
Spiegal et al. 2020. Manuresheds: Advancing nutrient recycling in US agriculture.

PRECISION AGRICULTURE!

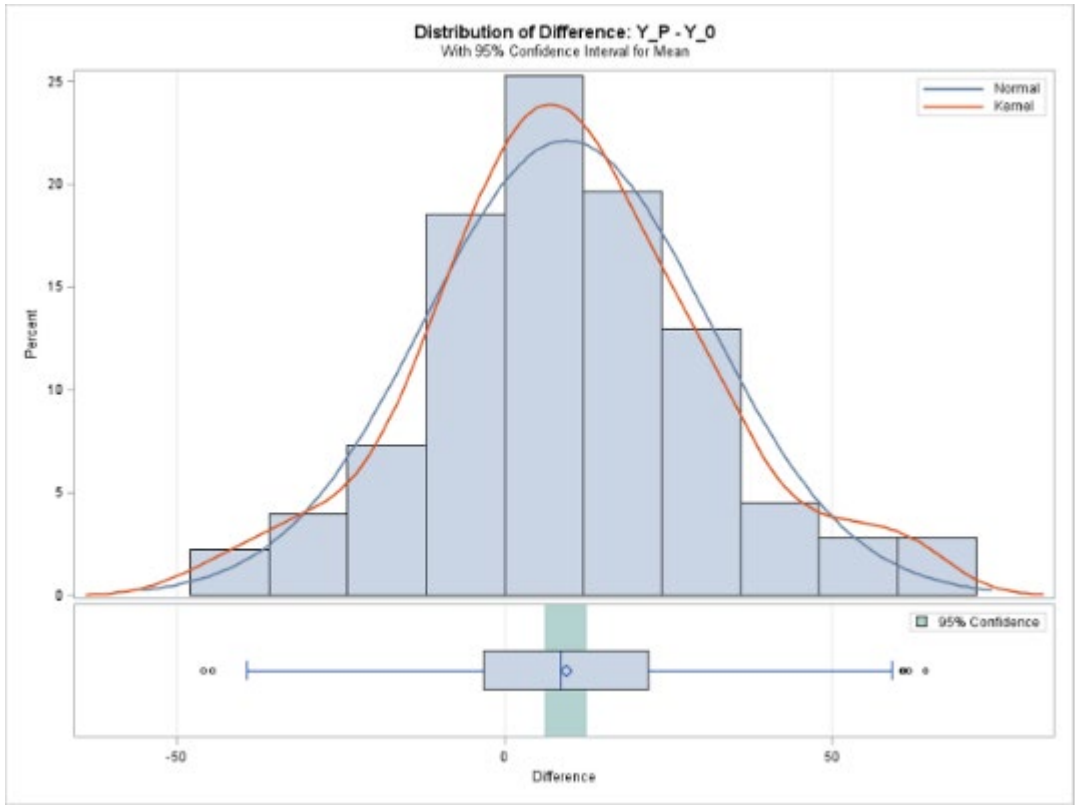
Spatial and temporal targeting

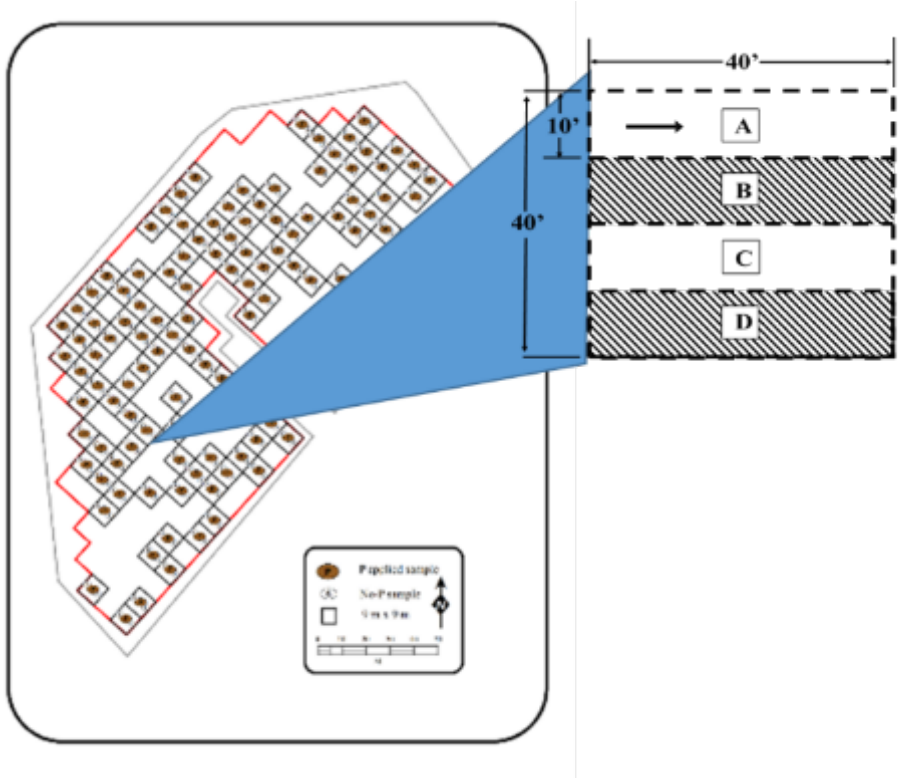
- Site-specific management to better balance competing objectives
- Target resources
- Target practices
- More than variable rate

We need to evaluate how we do precision



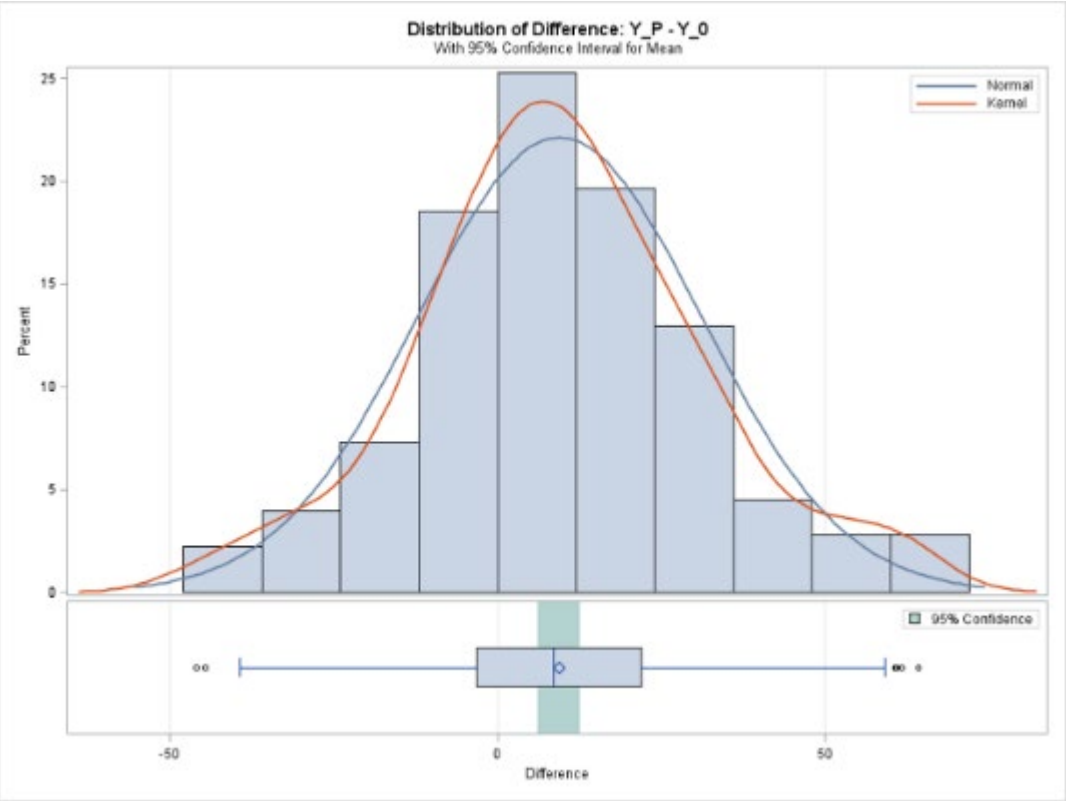
On average soil test worked





On **average significant corn yield response** to P fertilizer, Δ yield = 9 to 18 bu/a in 3 of 4 site-years.

On average soil test worked…but failed 50% of the time



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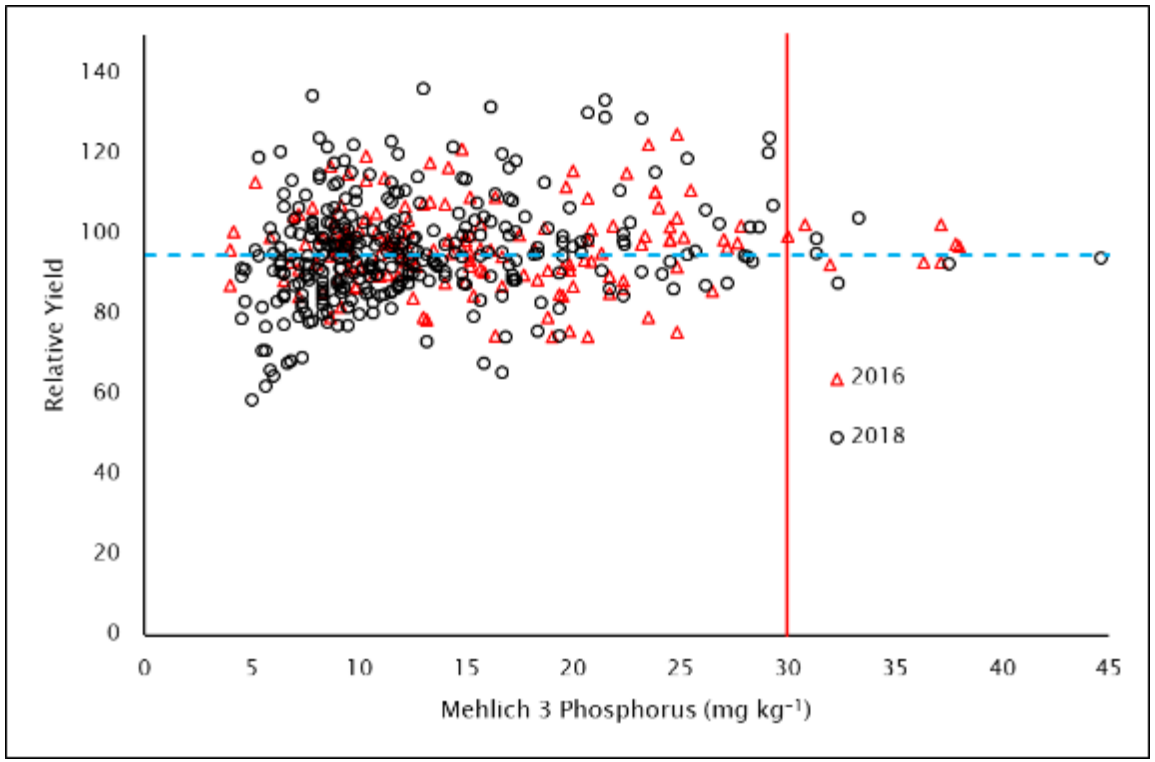
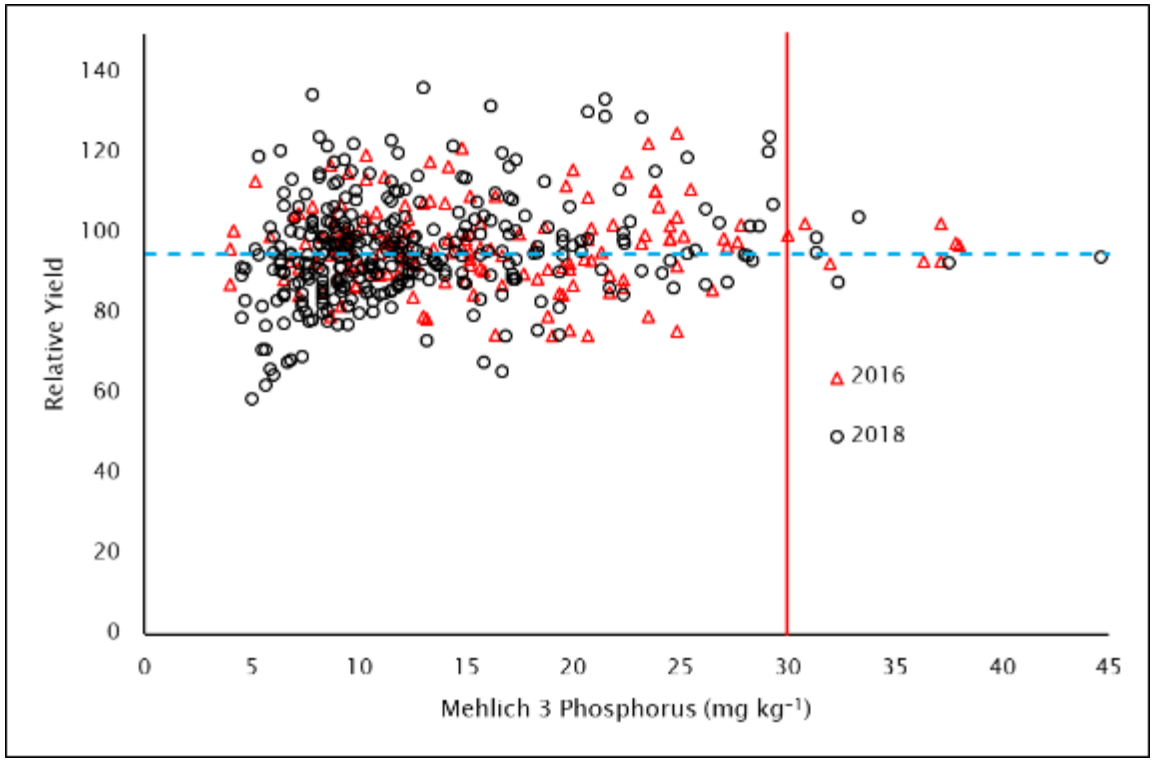


Regardless of soil test
only half the plots need phosphorus fertilizer

We need to understand mechanistic drivers of field scale nutrient requirement

- Precision P management as currently practiced is ***not supported*** by science
  - Grid-based soil sampling is ***wrong***
  - Current P recommendations ***don't*** work for precision ag



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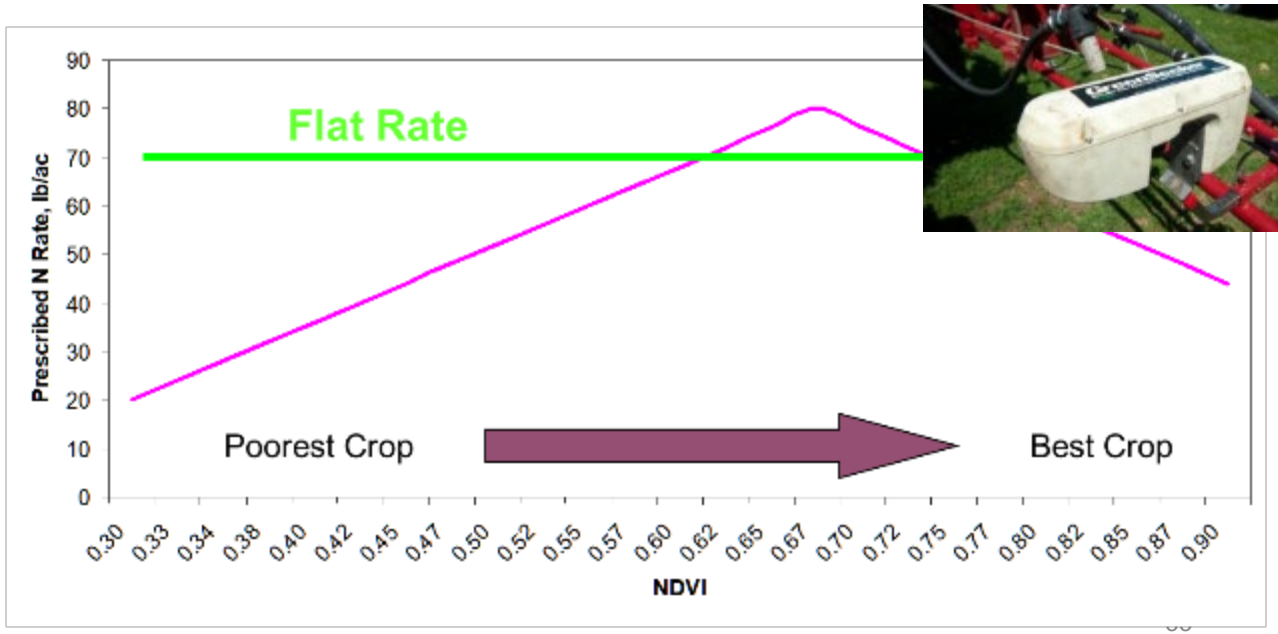
- Sensor-based N management has ***solid*** scientific underpinning



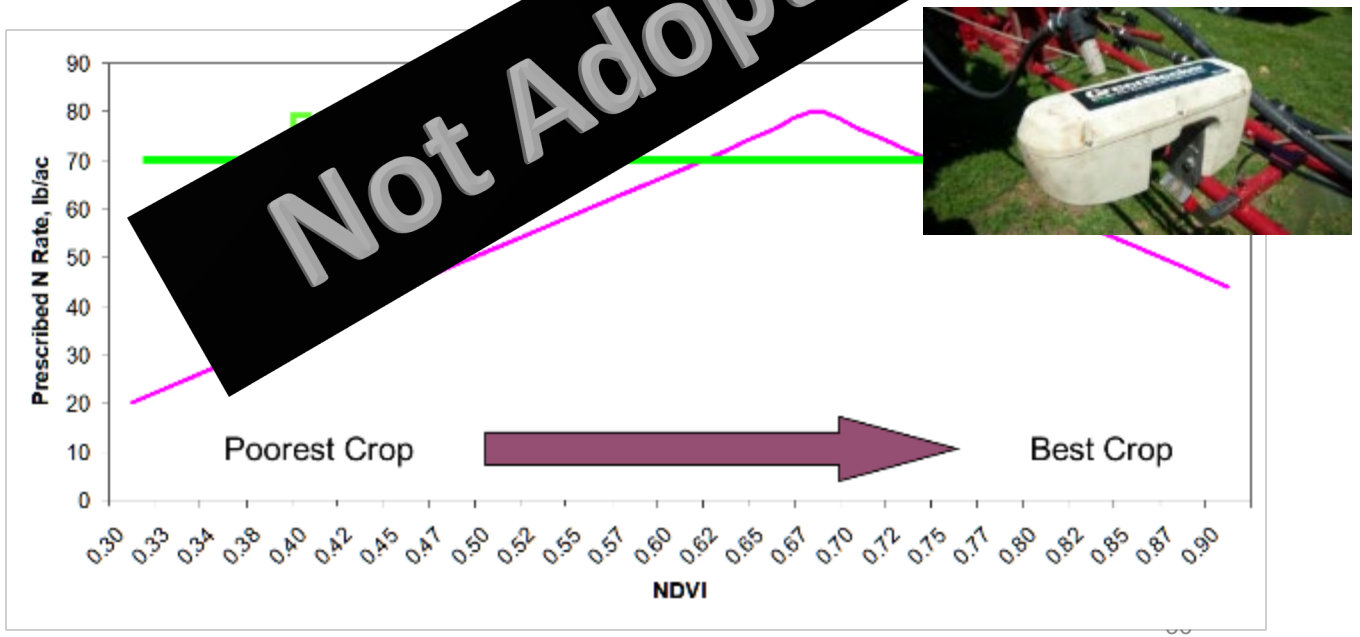
We need to understand ~~mechanistic drivers of field scale nutrient requirement~~ The Human Component

- Precision P management as currently practiced ***not supported*** by
  - Grid-ba pling is
  - recommendations work for precision ag

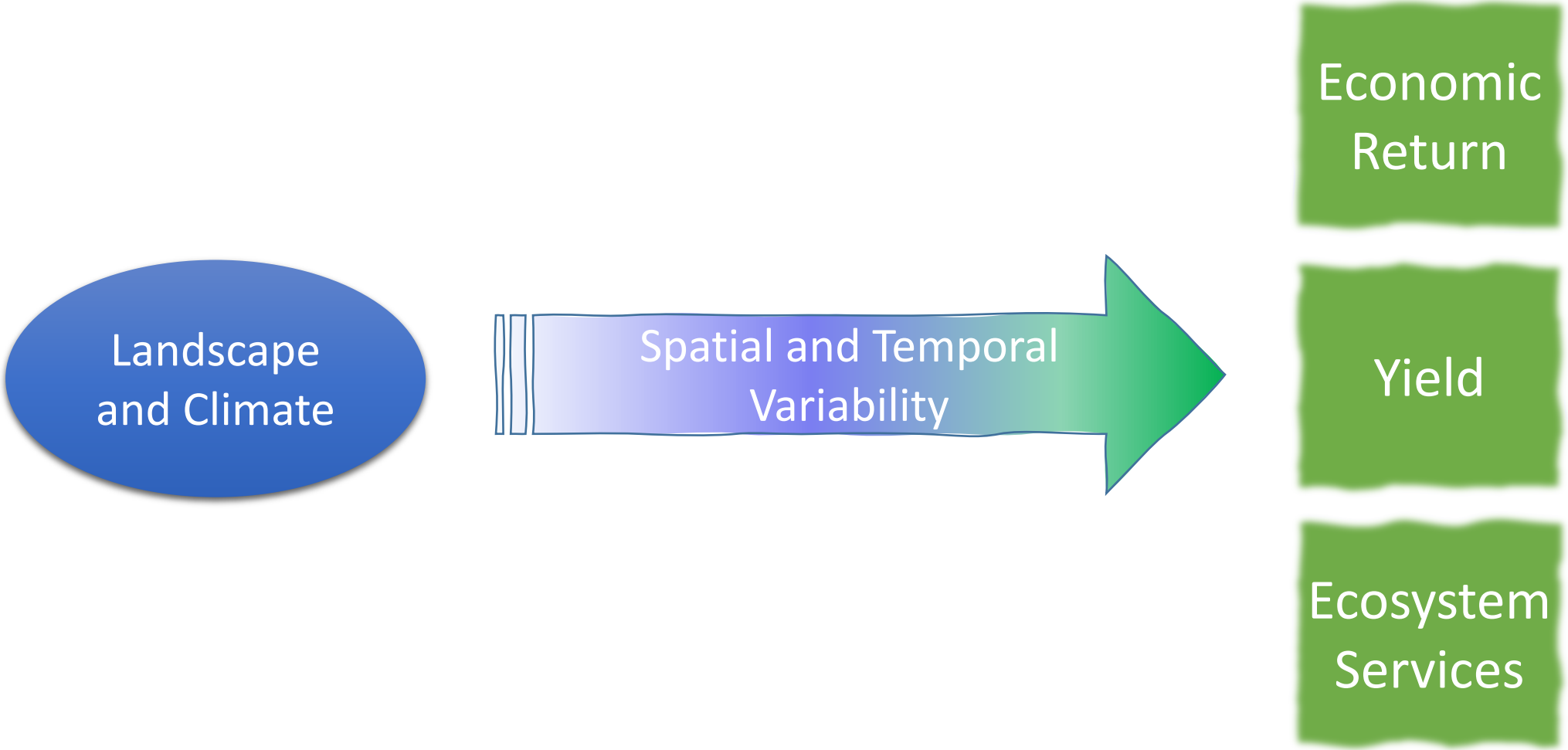
Adopted

- Sensor-based N management has ***solid*** scientific underpi

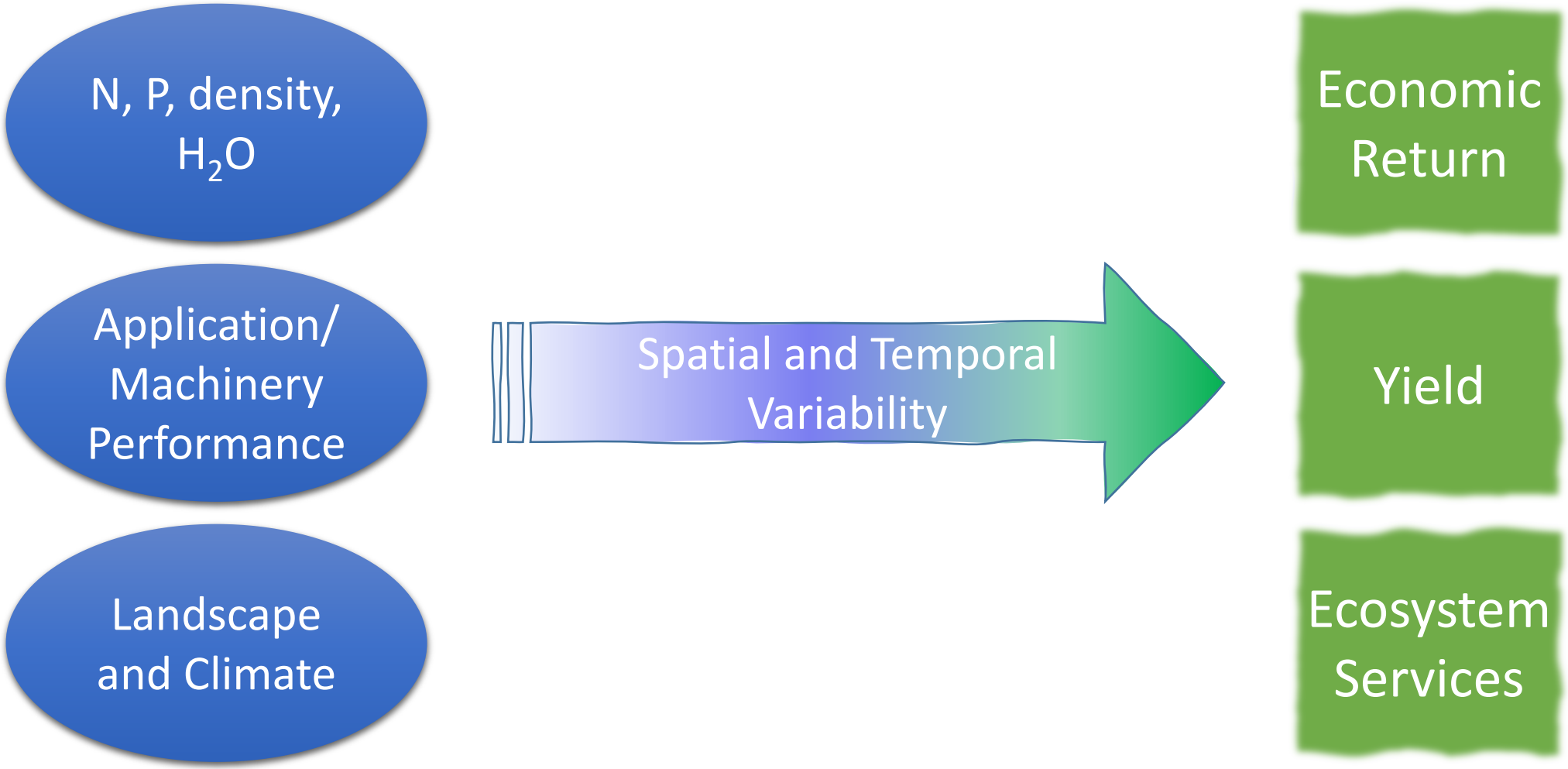
Not Adopted



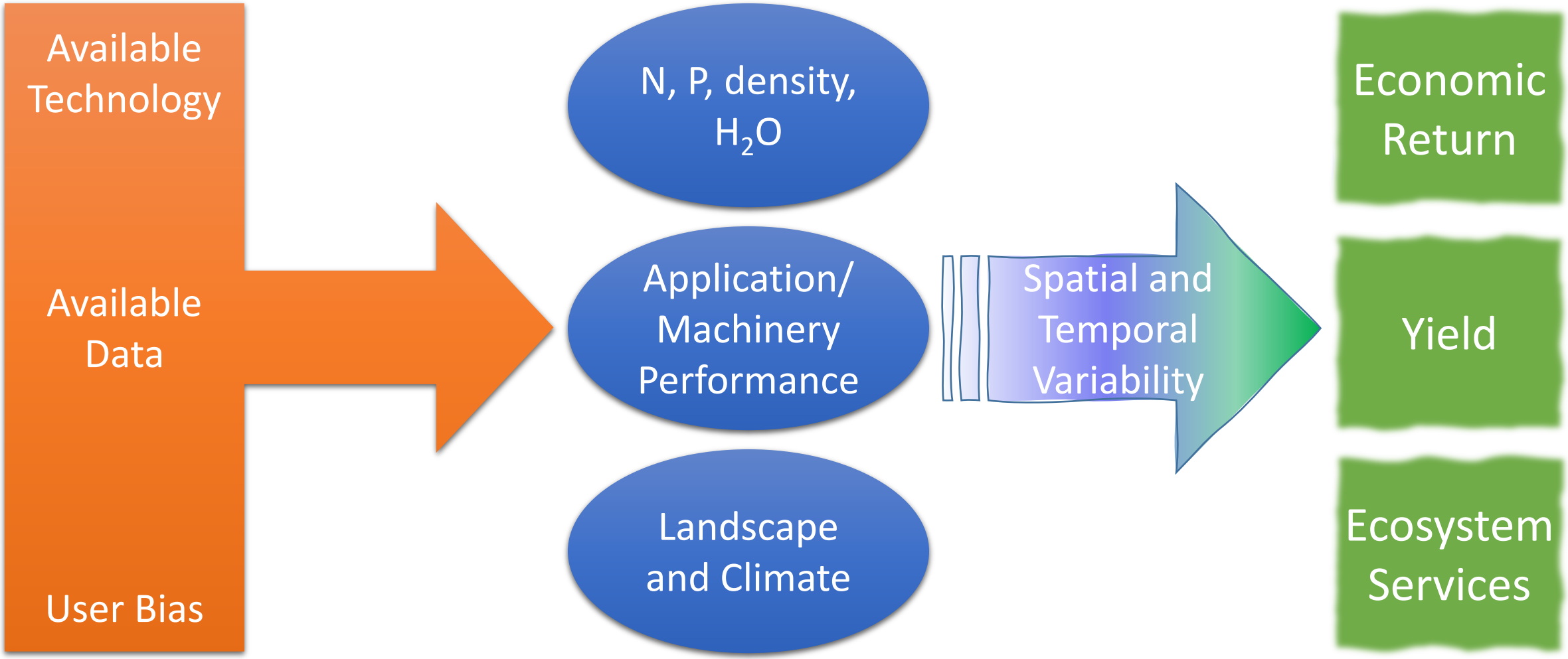
Precision management challenges



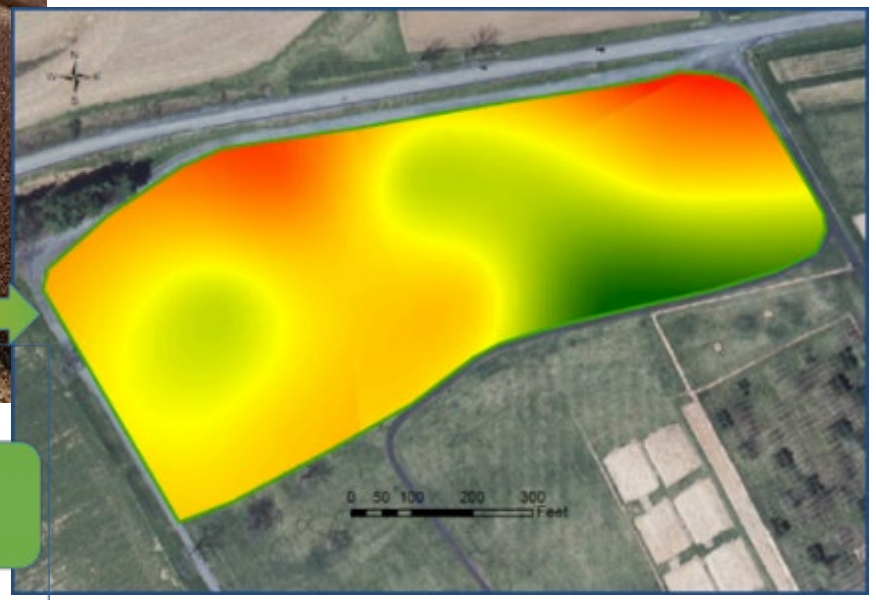
Precision manure management challenges



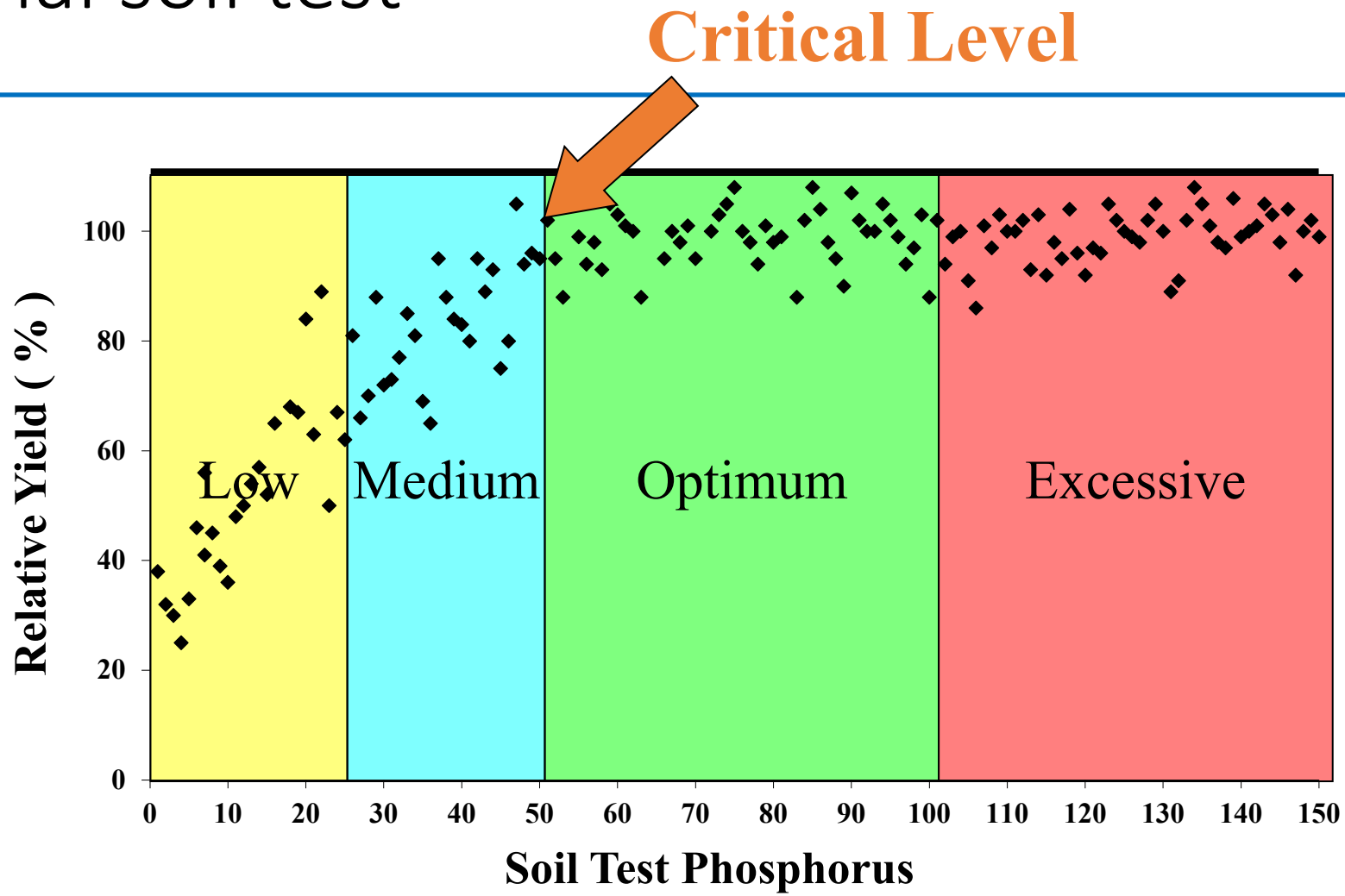
Precision manure management challenges



A more comprehensive view of precision agriculture



Traditional soil test



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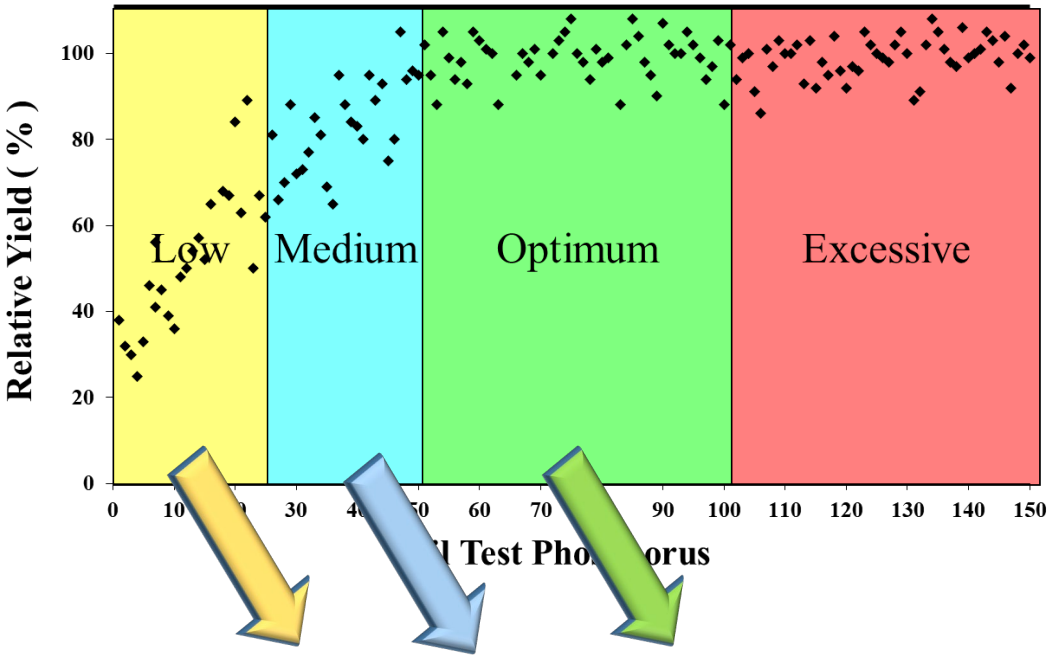
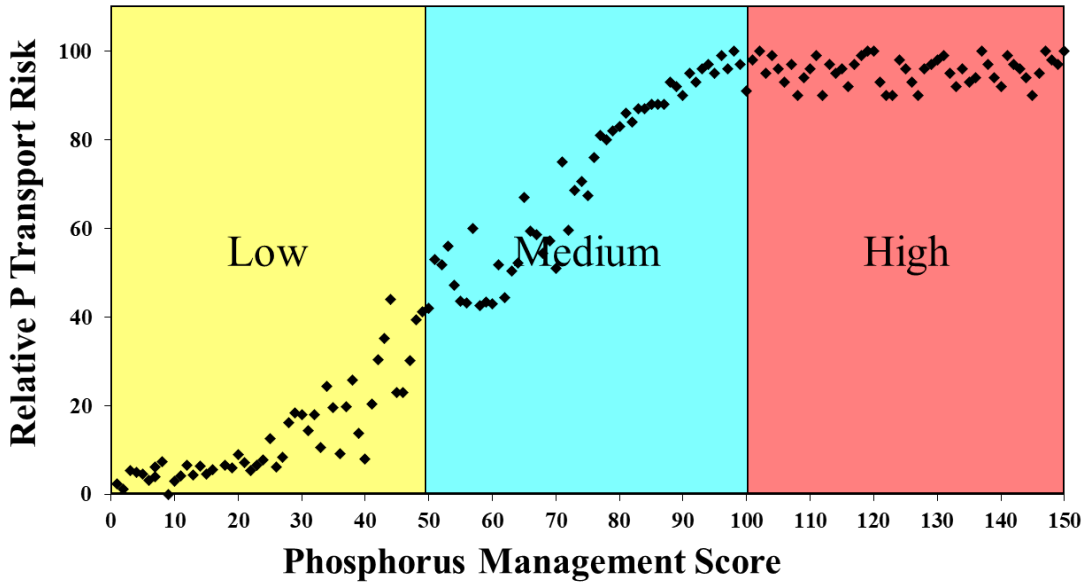


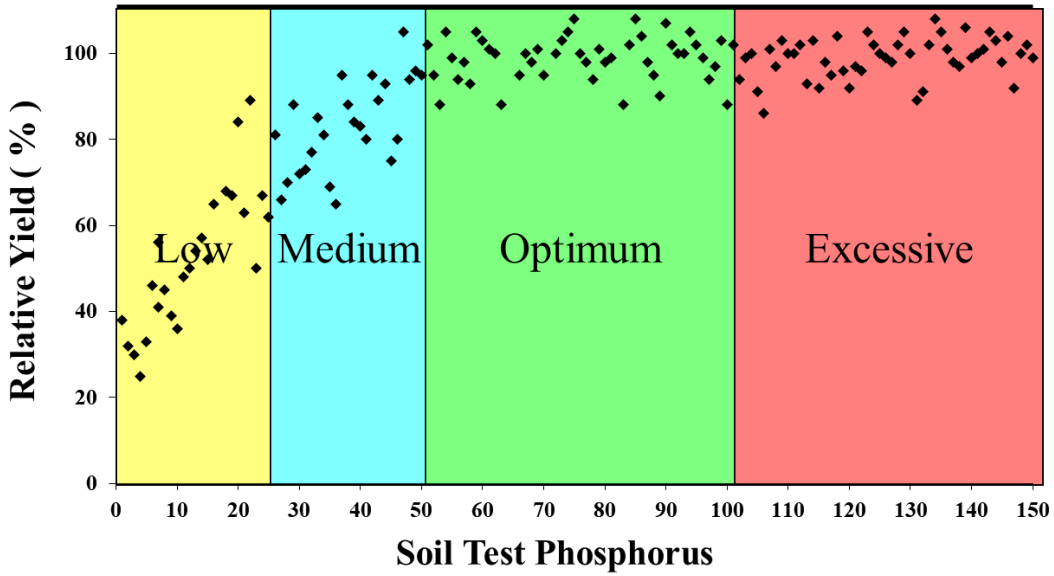
Rate recommendation

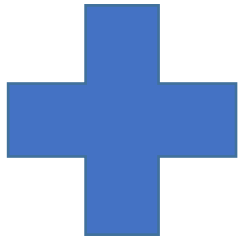
Management tool

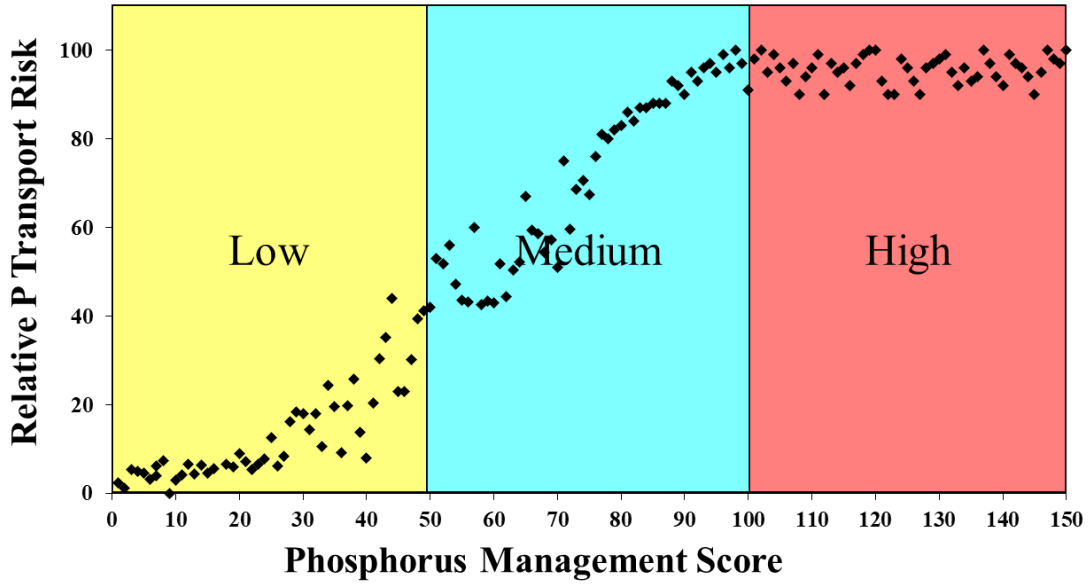
Calibrated and validated P Site Index or Quantitative Model



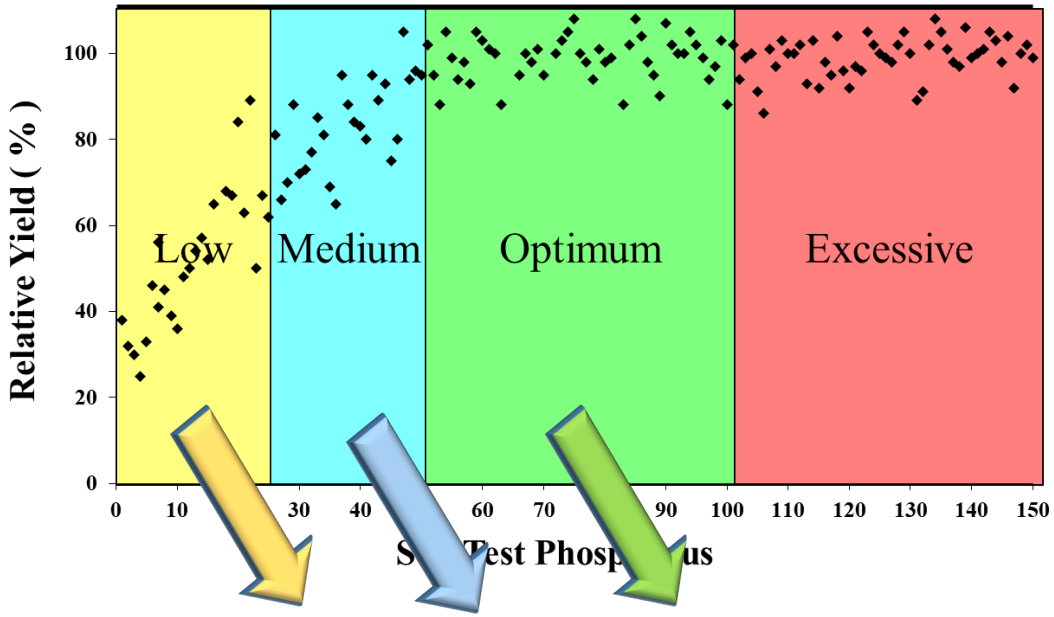
Traditional soil test → Management tool

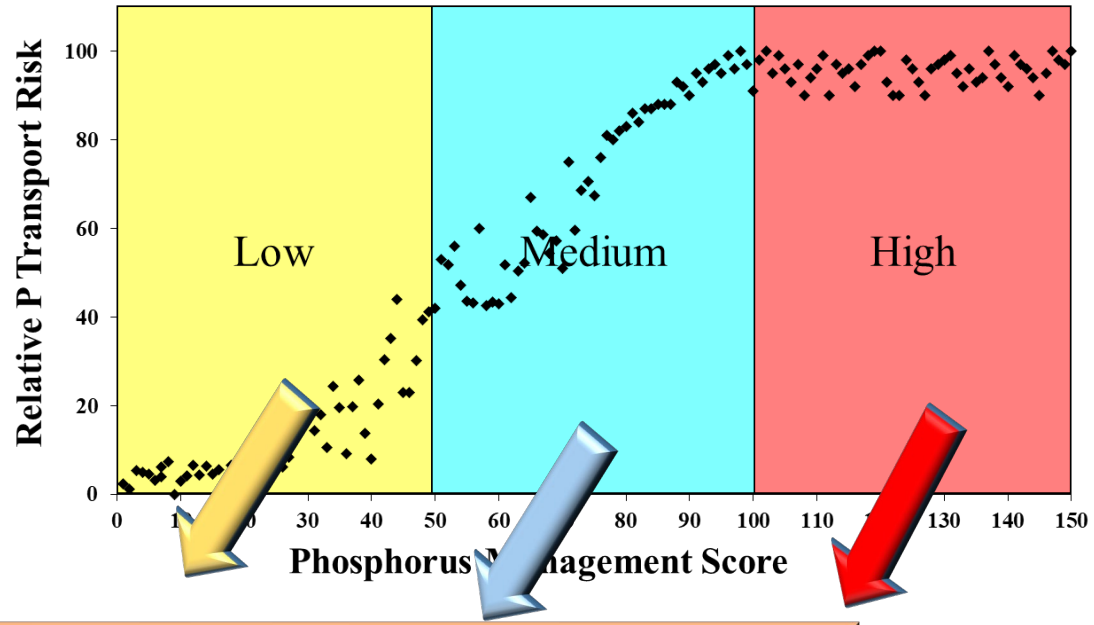






Integrate technology with decision support





Rate + Source + Placement + Timing + Conservation Practice

What can precision ag deliver?

Time for farmer to focus on logistics of conservation

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Better information to support decisions

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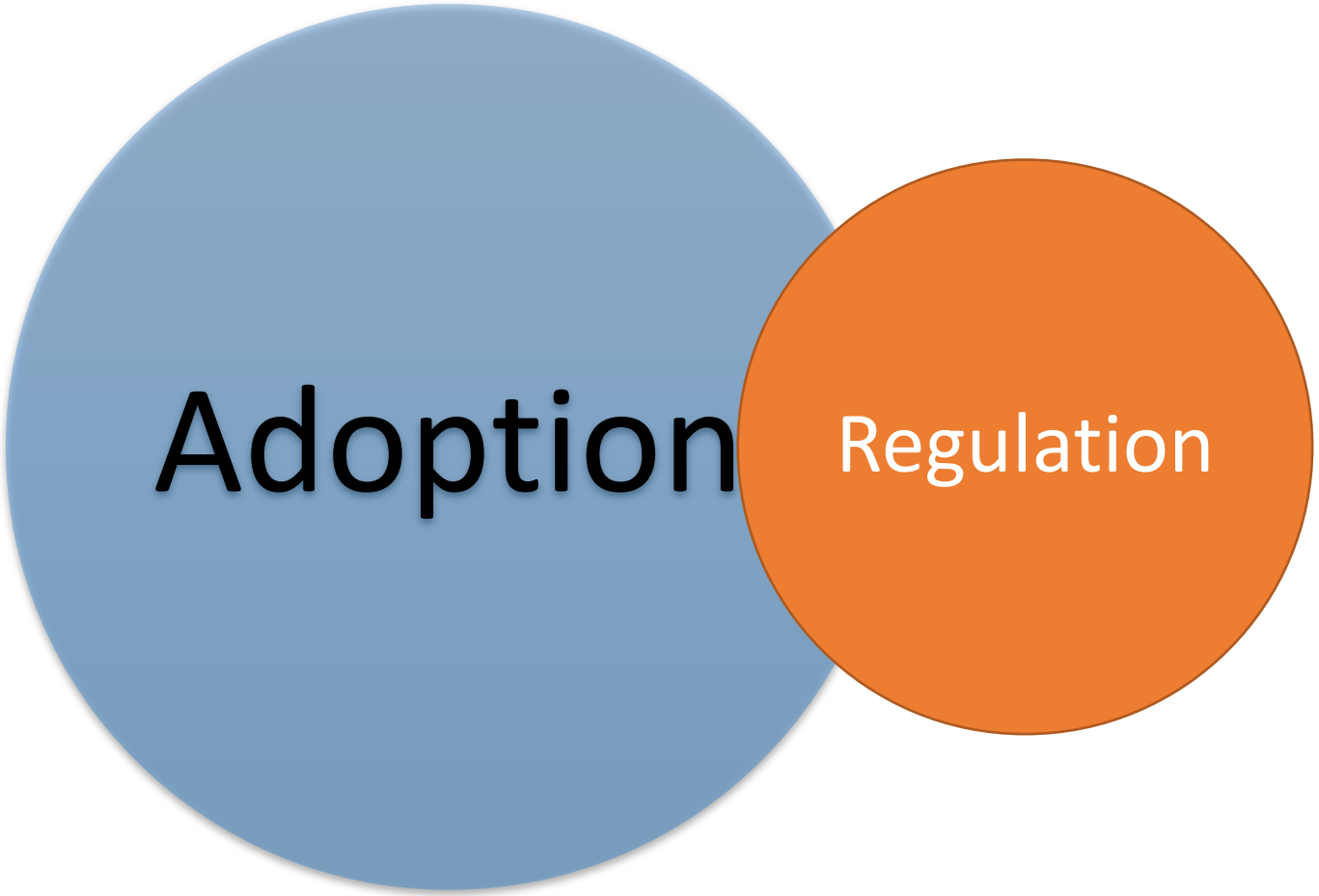
Better information to support decisions

Predictive feedback on conservation outcomes in real time relative to decision making process

What can precision ag deliver?

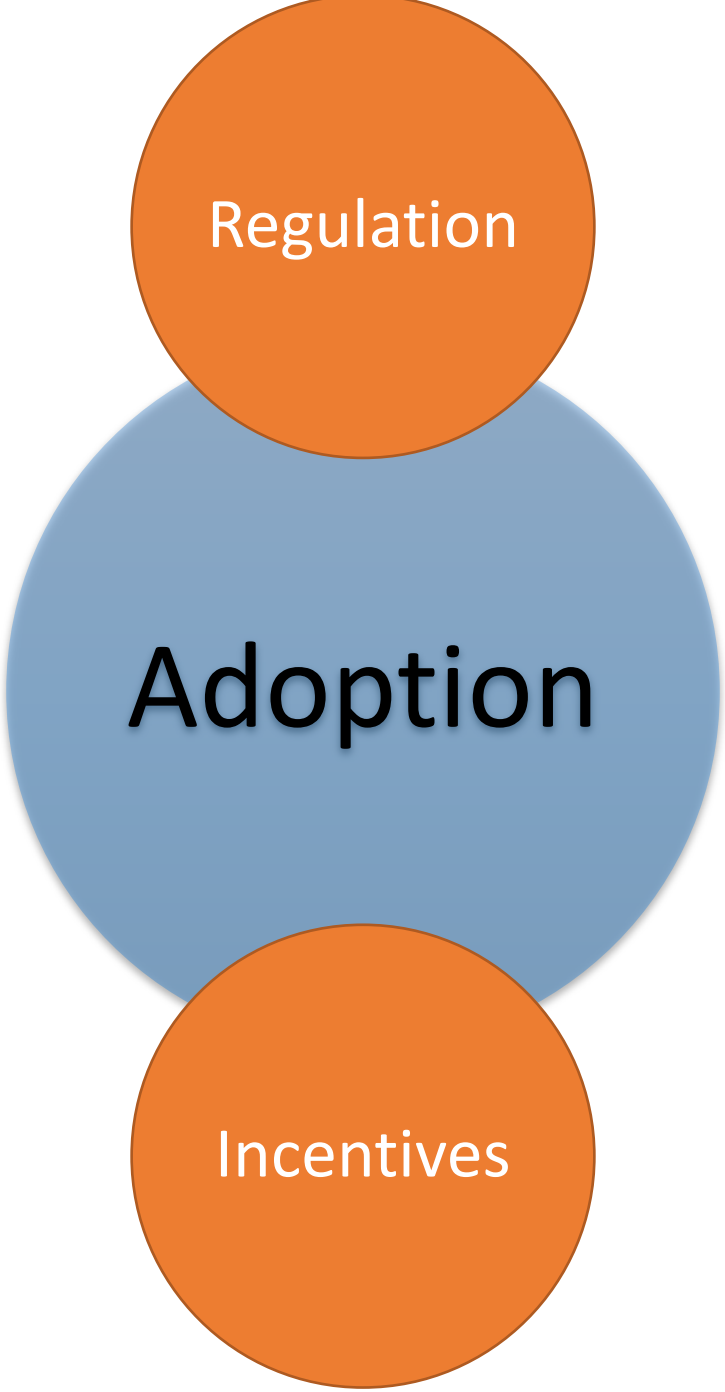
- Time for farmer to focus on logistics of conservation
- Better information to support decisions
- Predictive feedback on conservation outcomes in real time relative to decision making process
- Technology interface designed for adoption

What's driving practice?



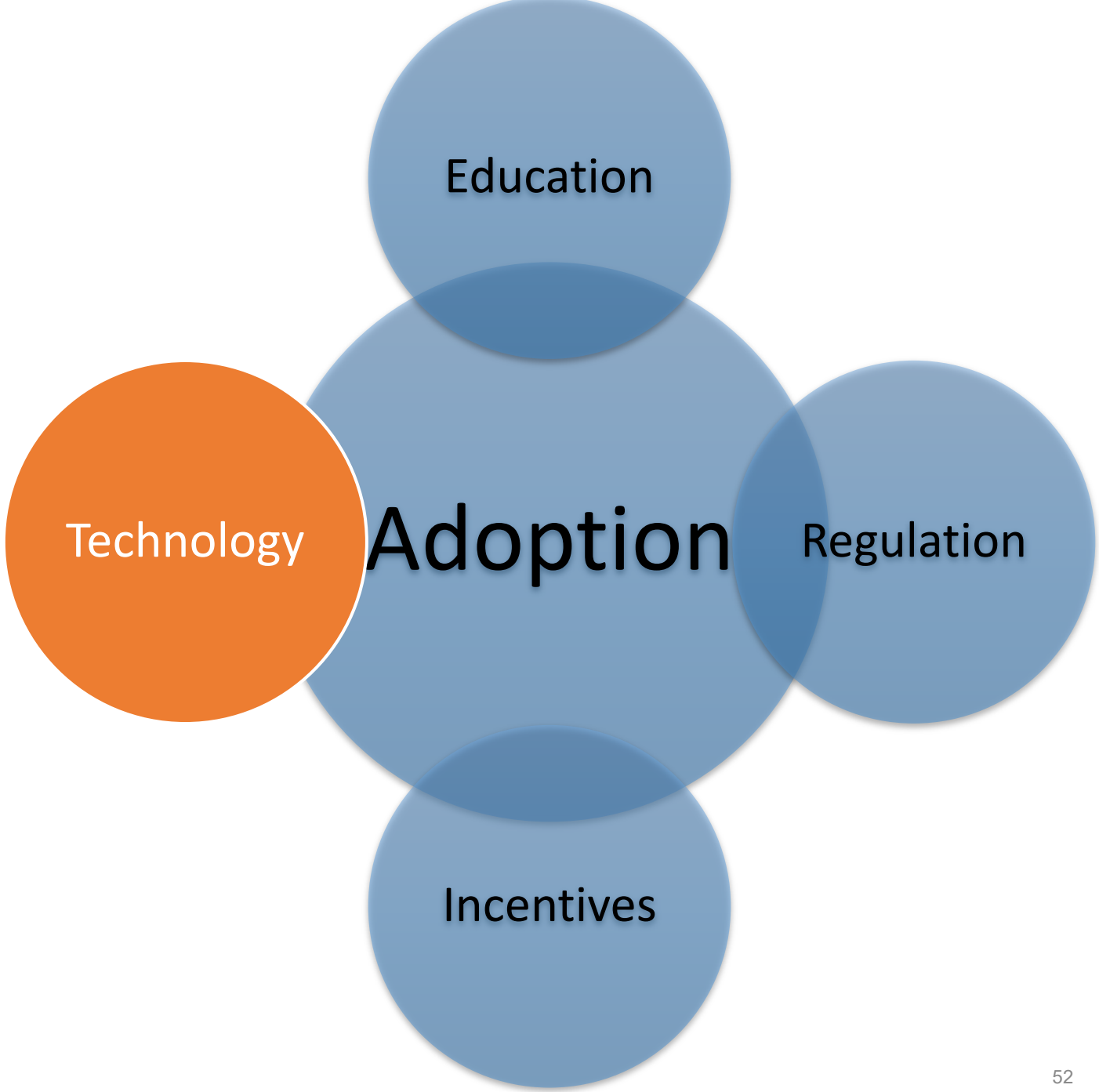
What's driving practice?

Policy environment



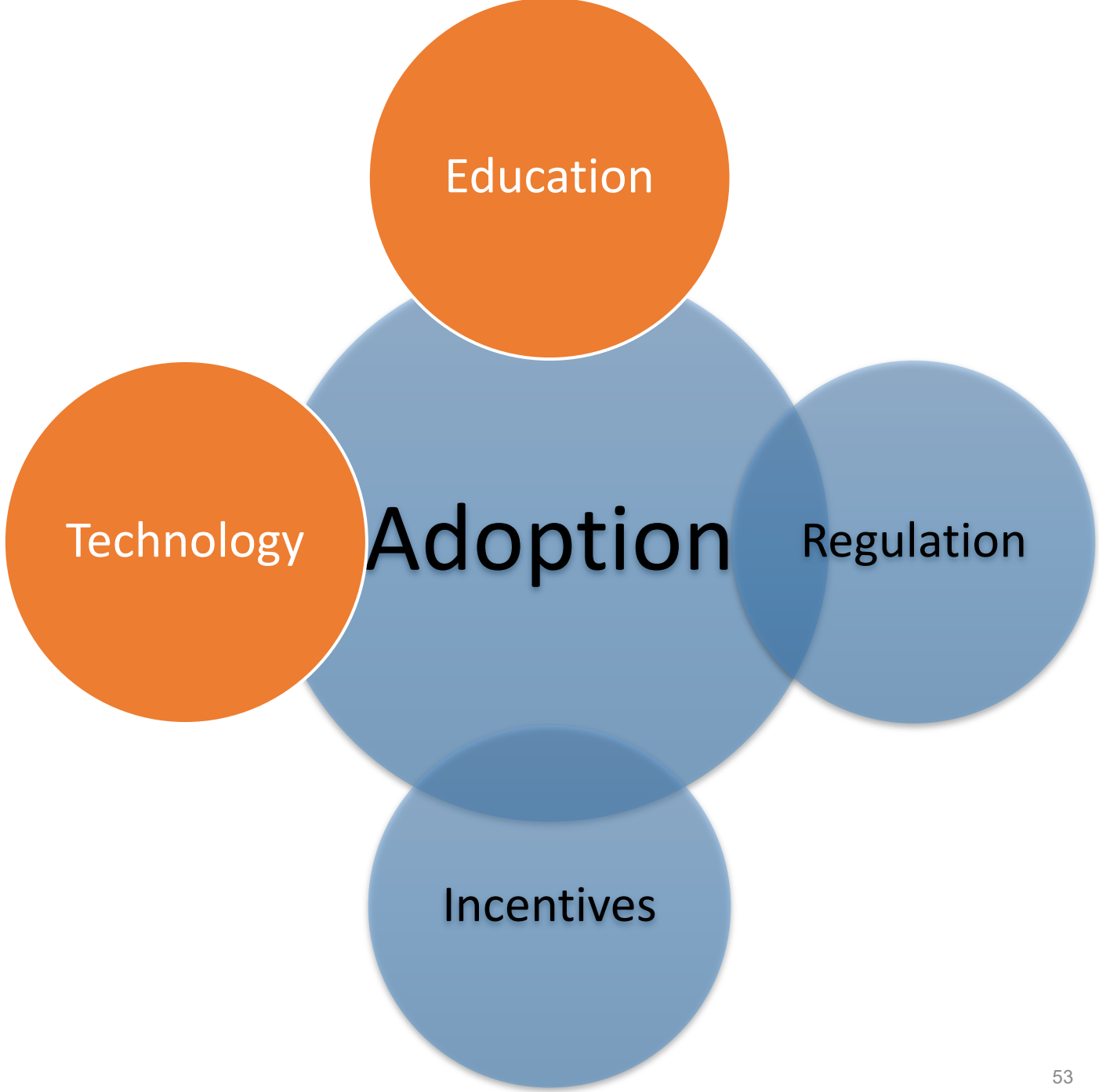
What's driving practice?

Information and technology available to farmers



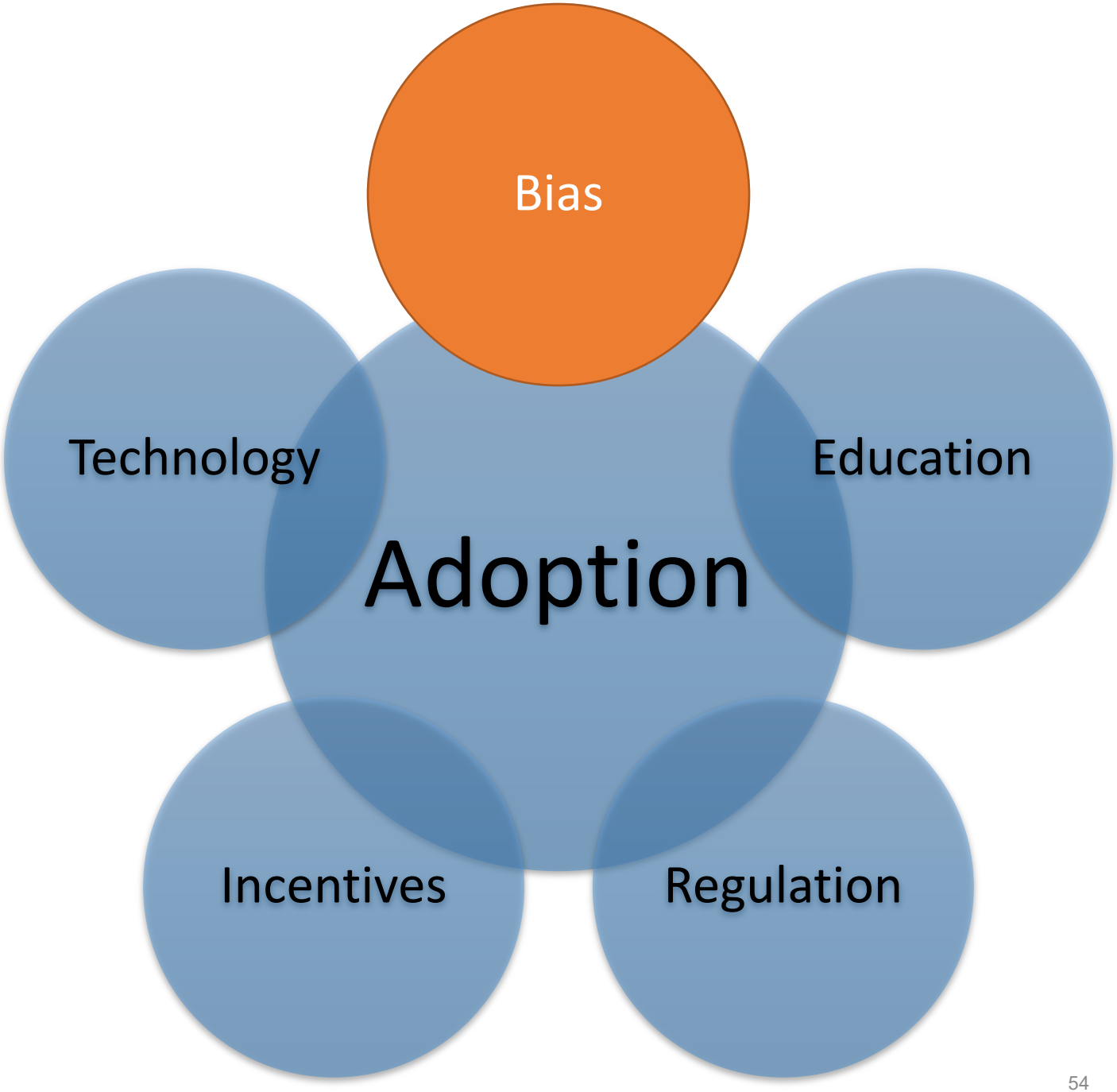
What's driving practice?

Information and technology available to farmers



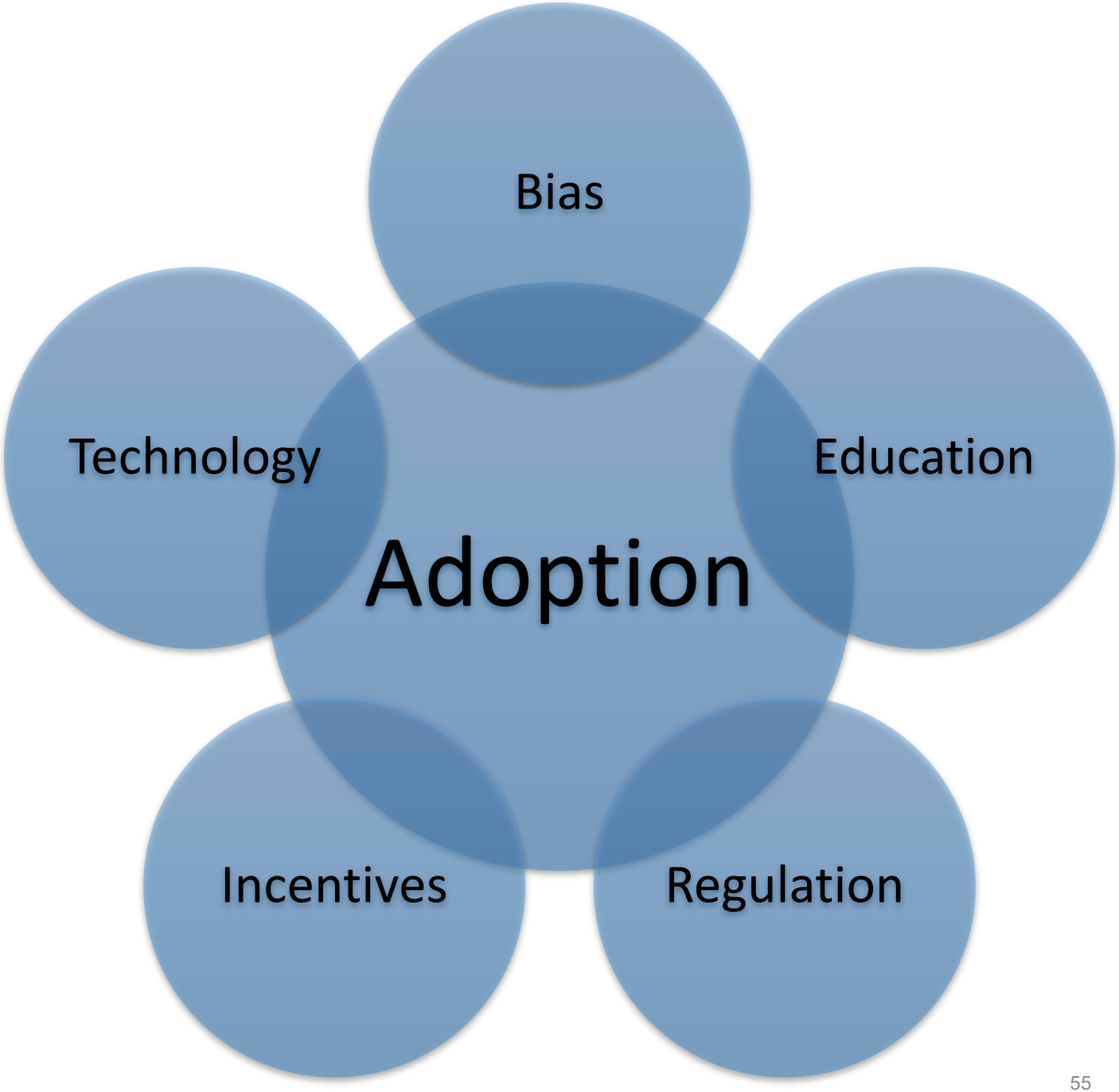
What's driving practice?

Their perception of cost, value, outcome, and impact



What's driving practice?

We need to deliver technology informed by human factors that meets the farmer where they are

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