Connecting Frontier Science to Frontier Practice:
How do we increase impact of scientific findings?

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“It’s not good to know more unless we do more with what we already know.”

R. K. Bergethon

We know more about K in soils & crops than we use in guidance & practice.
Requires that **change** takes place in:

1) The **process** of on-farm decision making
2) The **services** supporting that process

... and that farmers **adopt** those changes.
Learning from past interventions

- GMO Adoption
- Guidance Systems
- No-till
Adoption of genetically engineered crops in the US

Herbicide tolerant (HT) Soy: <10% to 75% in 6 yrs
Use of automated precision technology in the US

Autosteer (by retailers): <10% to 75% in 9 yrs

Erickson & Widmar, 2015.

2015 Base: 261
Estimated market area using guidance systems in US

Autosteer by farmers: <5% to 64% (predicted) in 13 yrs

Erickson & Widmar, 2015.
In the US after several decades of access to needed technologies: no-till or strip-till occupy 33% of corn, soybean, wheat & cotton area

Arable cropland in conservation agriculture:
- **15%** in N. America
- **9%** globally

Wade et al., 2015.
Lessons from the past ...

• Non-disruptive changes can be adopted rapidly
  – **Simple** rather than involving multiple linked practice changes
  – Perception of limited **cost** relative to **benefit**

• Low level of risk or uncertainty in the outcome

Adoption of scientifically sound improvements in potassium management will require engagement & cooperation of:

- Researchers
- Extension
- Laboratories
- Fertilizer industry
- Local service providers
- Farmer

Non-disruptive low risk solutions
Farmers base management decisions on ...

1. Their own experience & that of their neighbors
   – But have difficulty relating a particular experience to a particular set of conditions
   – Unsure if outcome is due to chance or to a given combination of practices

2. Recommendations from “experts”

   • (1) and (2) can lead to:
     – Rejection of technology by farmers that was selected by researchers which does not do well under real farm conditions
     – Rejection of technology by experts because it did not perform well in trials, but might have done well under commercial conditions
     – Adoption of successful technology.

Adoption of successful technology requires ...

- Well-defined recommendation domains
- Well-defined block or field conditions

**Appropriate data and meta-data from both sides**

**Reduction in the uncertainty of farmer decisions**
Uncertainties obstructing better use of existing K knowledge by farmers

Dimensions of uncertainty ...

**Metric.** ‘How big is it?’
The need for K
Crop response to K
Variability in both

**Temporal.** ‘How does it fluctuate?’
Through the season
Among seasons

**Structural.** ‘Are all necessary factors included?’
Special importance to crop advisers
Validation of model for actual site
Adaptive management (site-specific)

**Translational.** ‘How is the decision framed?’
Serious concern of farmers
Includes factors beyond farm-gate
Full outcome of decisions

Yellow clouds: **scientist** focus

Blue clouds: **farmer** focus

Rowe, 1994.
Another obstruction for K advancement ...

Insidious nature of most K deficiency
Prepositional science informs prescriptive science

Prepositional: ‘How the world is’
- Role of K in plant physiological functions
- Release of K by soil minerals
- etc.

Defining science-based solutions to K management problems

Prescriptive: ‘Technological recipes’
- 4R based K recommendations
- Right source, right rate, right time, right place

The success or failure of prescriptive science informs prepositional science

Mokyr, 2002.
Strategic framework for advancing the prepositional & prescriptive science of soil K assessment

1. Categorize soils according to their K holding capacity
   - Quantify the K pools in each category
     - Is this categorization adequate at various spatial scales?
       - yes
         - For each category, identify key issues for K supply to crops
       - no
         - Modify or create additional categories

2. Apply K in a form, rate, time, and place needed to meet spatial and temporal variability in plant demand
   - K fertilizer not needed
     - yes
     - Are fluxes adequate to meet spatial and temporal variability in plant demand?
       - yes
         - Develop better methods to characterize pool sizes and predict fluxes at various temporal scales
       - no
         - Are pool sizes and fluxes adequately characterized at various temporal scales?
           - yes
           - no
           - no
            - no
Using framework to create deliverables appropriate for the farmer’s technology environment

• Considering adoption drivers
  • As non-disruptive as possible
  • Presenting low outcome uncertainty
  • With limited cost relative to benefit

• Create appropriate user interface
A. Predicted uncertainty in response or need vs
B. Concealed uncertainty in the recommendation

A is likely preferred over B

Implementing the strategy for “doing more with what we already know” will require extensive stakeholder collaboration.
Research scientists
- Reviews & synthesis
- Framework definition
- Models and data gaps

Fertilizer industry
- Fertilizer access
- Timeliness
- Affordability

Extension
- Public & private
- Synthesis & evaluation
- Coalitions

Farmers/Growers
- End user
- ID the problem
- Citizen science

Fertilizer industry
- Fertilizer access
- Timeliness
- Affordability

Lab services
- New analyses
- Field procedures
- Process research

Data services
- Climatic/weather
- Soil data
- Economic, etc.

Traders/processors
- Crop prices
- Crop & food quality
- Practice acceptance

Local service providers
- Last mile delivery
- Adaptive management
- Citizen science

Field to Market

IPNI
Filling the knowledge gaps

- Limited available **resources**
- Tendency to be located **in boundary regions** between traditional disciplines

- Requires efficient **collaboration** across disciplines & among stakeholders
- Will benefit from **data sharing** and communication
- Likely involve **parallel** but linked efforts
Classical Science Model

1. Research question
2. Hypothesis
3. Materials/model
4. Experiment
5. Results (data)
6. Analysis & conclusion

Photo courtesy of NZSTI Cushnahan et al., 2016. Massey U.
Old Paradigm

- Scarce data. Expensive per sample
- ‘Big knowledge’ through generalisation (extrapolation)
- Outcome-led. Research problem is decided at front end, the data is received late in the process

Cushnahan et al., 2016. Massey U.
‘Disrupting’ the science process

Classical Science Process

Data sharing among stakeholders using this process could accelerate **knowledge acquisition**

Data exploration is an iterative, cyclical process

Cushnahan et al., 2016. Massey U.  
Adapted from Blizstein and Pfister, 2015
“The most valuable science institutions will be closely linked to the people and places whose urgent problems need to be resolved ... that they will link research agendas to the quest for improved solutions, often technological ones, rather than to understanding for its own sake.”

Daniel Sarewitz, 2016

We need to remain connected to those who grow crops for a living
First, look for and harvest the low-hanging fruit that will advance K management ... then pursue the more difficult harvest