Balancing Economic, Environmental and Social Goals in Nutrient Management

A5/A8/S4 Symposium – Fertilizer Efficiency, Crop Yields, and Environmental Impacts
November 3, 2009

Paul E. Fixen
Goals or pillars of sustainability

Environmental
- Air quality
- Water quality
- Biodiversity
- Other ecosystem services

Social
- Food
- Fiber
- Fuel
- Working conditions
- Culture, etc.

Economic
- Profitability
- Risk
- Cash flow
- Marketing
- Credit, etc.

Sustainable crop and nutrient management must support cropping systems that contribute to all three pillars.
Our topic today requires a modified view of the pillars

“Balanced” nutrient management
“This global effort to help small farmers is endangered by an **ideological** wedge that threatens to split the movement in two.  
- On one side is a **technological** approach that increases **productivity**.  
- On the other side is an **environmental** approach that promotes **sustainability**.

**Productivity or sustainability** - they say you have to choose. It's a false choice, and it's dangerous for the field.”
A primary sustainability objective for agronomic science and practice

To contribute all we can to improving:

- Global productivity
- Resource use efficiency

Globalization has merged these two objectives into one

- Due to the strong global character of demand for agricultural products and many of the most critical environmental issues
  - Improving efficiency without improving productivity increases pressure to produce more on other lands
  - Squandering resources to maximize productivity puts more pressure on other lands to reduce environmental impact

Is this the same as obtaining “balance”?
The problematic balance paradigm

Productivity  Nutrient Management  Efficiency
Balance is precarious ... perhaps a polarizing perspective
A more useful perspective?

Improving productivity and resource use efficiency as a singular goal
As yields climb …

• More nutrients are contained in removed crop
• Potentially more nutrients necessary to replace those removed
  – More nutrients at risk of being lost to the environment
• The challenge of increasing productivity and NUE increases
  – Development and adoption of nutrient BMPs becomes more important
  – Adoption of efficiency enhancing technologies plays a larger role
BMPs are the in-field manifestation of the 4Rs

**Right Source at Right Rate, Right Time, Right Place**
Performance indicators

- Productivity
- Profitability
- Durability
- Healthy environment

CROPPING SYSTEM

OBJECTIVES

- Net profit
- Resource use efficiencies: Energy, Labor, Nutrient, Water
- Return on investment
- Stability
- Water & air quality
- Farm income
- Working conditions
- Quality
- Soil erosion
- Nutrient balance
- Yield
- Net profit
- Nutrient loss
- Adoption
- Soil productivity
- Ecosystems services
- Farm income
- Ecosystems services

ENVIRONMENTAL

4R Nutrient Stewardship

- 4R Nutrient Stewardship
  - Right Source
  - at Right Rate, Right Time, Right Place

ENGLISH

Stakeholder input

Performance indicators

- Performance indicators
  - Biodiversity
  - Nutrient loss
  - Water & air quality
  - Adoption
  - Soil productivity
  - Ecosystems services
  - Farm income

Individuals working on one indicator remain cognizant of other important indicators

Right Source at Right Rate, Right Time, Right Place
An example

Yield loss
Lower water use efficiency
Soil erosion
A primary objective for agronomic science and practice: **To contribute all it can to improving productivity and resource use efficiency**

Sustainably meeting this objective will require close cooperation across scales ... disciplines ... sectors ... geographies

with major roles for research, education and policy.
The role of policy

Don’t make things worse!
Nitrogen Partial Factor Productivity ($PFP_N$) for Maize in the U.S.

- 2003 is average of 2002 and 2004
- 2006-2008 extrapolated using regression

Improvement in productivity and efficiency

Bruulsema and Snyder, 2009
Although cause and effect are not established, there is an interesting relationship between $\text{PFP}_N$ and TN flux

\[ Y = -31,885x + 3,239,029 \]

$r^2 = 0.36$  \hspace{0.5cm} $P$ value = 0.002

Policy should accelerate positive change

(Snyder, 2009)
Nitrogen Rate and Source Effects on N$_2$O Emissions in No-till Continuous Maize


Important?

A role for policy?

20 to 50 % reduction in loss possible with N source selection

NT-CC, growing season average, 2007 and 2008

Cumulative N$_2$O-N emissions, kg N/ha

(246 kg N/ha applied in 2007; 202 kg N/ha in 2008)
Average is the enemy of efficient and effective N management … and policy.
Adaptive management for improved NUE

• Scientific truths are seldom permanent but change as scientific knowledge grows.

• So ... BMPs are dynamic and evolve as:
  – Science and technology expands opportunities
  – Practical experience teaches the astute observer what works under local conditions.

• Adaptive management transforms:
  – generally good practices based on scientific principles into
  – best practices based on local practical experience.
The site-specific nature of BMPS makes adaptive management important in their identification.


Productivity, profitability durability, environmental impact (nutrient use efficiency)

Policy should facilitate this cycle

Decision Support
Based on scientific principles

Recommendation of right source, rate, time, place

Stakeholder input

Feedback loop
The role of education

Integration and communication

Interdisciplinary research focused on nitrogen cycle processes in the environment integrated with experiential learning of public policy.
Goal: To produce graduates who have a broad and rigorous training in N cycling who seamlessly integrate N cycle science for effective communication with public policy makers.
The role of research

Integration, cooperation, sharing
“The main challenge ... is to increase the productivity of agriculture in a sustainable manner.”

Two of six high priority natural resource management options for action:

- Develop networks of knowledge, science and technology practitioners ... for the collective good.
- Connect globalization and localization pathways that link locally generated knowledge and innovations to public and private agriculture knowledge, science and technology.
Research universities and institutes, working together with the business sector and using contemporary electronic resources, have a unique opportunity to accelerate the “flattening” of the world.

"With respect to increasing productivity of the land …"
Eras of globalization (Friedman)

• Globalization 1.0: 1492-1800
  – Change agent: countries and muscle

• Globalization 2.0: 1800-2000
  – Change agent: multinational companies

• Globalization 3.0: Current
  – Change agent: individuals with power to collaborate & compute globally; enabled by fiber optics & software
  – Allows a soil testing lab in the Midwest U.S. to do its data management & programming in Bangalore

• opportunity to flatten the world of nutrient management research
NUTROHUB: A GLOBAL PLANT NUTRITION RESEARCH AND EXTENSION COMMUNITY

Concept from Purdue Agronomy

Provides web access to the tools scientists need to collaborate on modeling, research, and educational efforts.
Could develop data management processes that reach across large geographic scales

The data set as a legitimate product of discovery ... the item “on the library shelf”

The National Academy of Sciences: Researchers have a responsibility to devise ways to share their data in the best ways possible - repositories of astronomical images, protein sequences, archaeological data, cell lines, reagents, transgenic animals, etc.

Murrell, 2008
• National Ecological Observatory Network
• A continental scale research platform
• “Ecologists will use a distributed network of sensors linked by advanced cyber infrastructure to predict responses of the biosphere to changes in land use, invasive species, and climate over the next **30 to 50 years.**” ... the ecologists’ **Hubble Telescope**
• Funded by NSF ($25 million initially); 60 sites across the U.S.
• “...will contribute data sets to encourage “best practices” to solve environmental challenges ...”
• Planning took a decade; hundreds of ecologists collaborating

**Is there a NEON, a Hubble Telescope, for nutrient management?**

• Viewing the improvement of **productivity** and **efficiency** as a singular nutrient management objective may be useful in balancing these goals.

• Accomplishing this objective will demand close cooperation and understanding among **scales, disciplines, geographies and sectors**.

• The **4R Nutrient Stewardship** framework, including its numerous **system performance indicators**, helps connect specific practices to balanced sets of performance indicators.

• **Balance** among these goals can likely be advanced through:
  – **Research** that produces high quality, publicly available data sets
  – **Education** that seamlessly integrates all aspects of nutrient science for policy, practice and communication to the public
  – **Policy that** facilitates adoption of effective practices and enables new ones while allowing for site-specific adaptive management.