4R NUTRIENT STEWARDSHIP FOR CROP PRODUCTION

Sally Flis, CCA, Ph.D.

Director of Agronomy

The Fertilizer Institute

2019

4R Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

The Fertilizer Institute

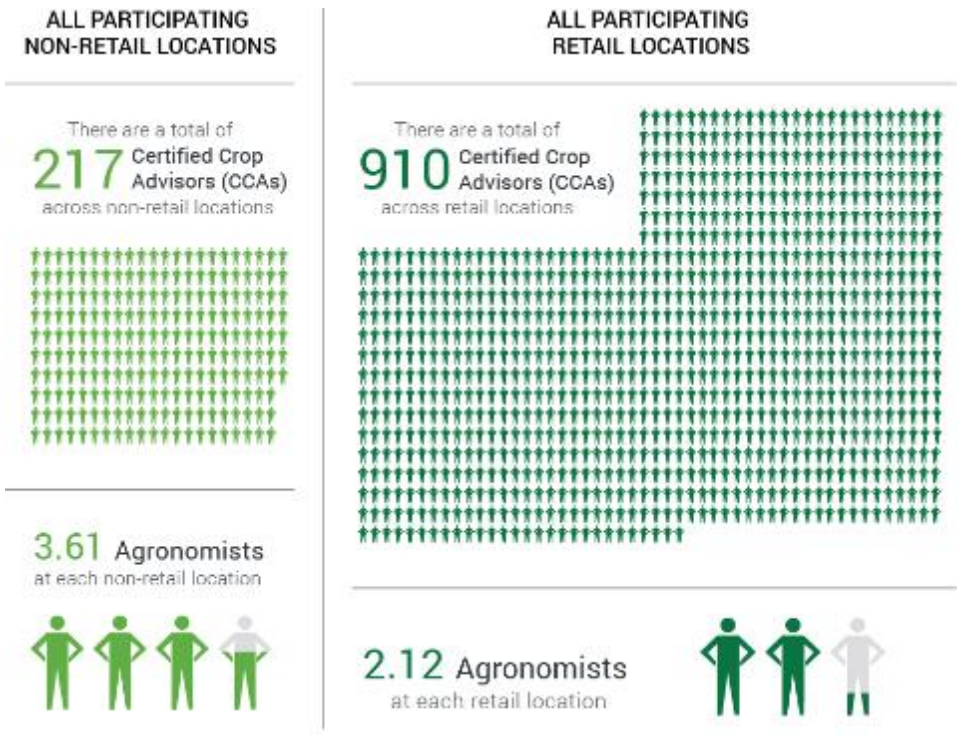
TFI is the voice of the fertilizer industry, representing the public policy, communication, stewardship and sustainability and market intelligence needs of fertilizer producers, wholesalers and retailers as well as the businesses that support them with goods and services.

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

State of the Industry Report

- The U.S. fertilizer industry generates more than $139 billion in economic benefit and provides more than 80,000 direct jobs and 370,000 indirect jobs for a total of more than 450,000 U.S. jobs
- 2017 Report 1,418 representing 21 member companies in the U.S.
- https://www.tfi.org/our-industry/state-of-industry/fertilizer-on-the-farm



Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

It's A Priority

Better crop performance, improved soil health, and cleaner air and water.

RIGHT SOURCE

Matches fertilizer type to crop needs.

RIGHT RATE

Matches amount of fertilizer to crop needs.

RIGHT TIME

Makes nutrients available when crops need them.

RIGHT PLACE

Keeps nutrients where crops can use them.

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

What is 4R Nutrient Stewardship?

- Actively considering all management practices and site specific characteristics when making the right source, right rate, right time, and right place nutrient management decisions

4R Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Water Quality

Sustainability

Nutrient Use Efficiency

Green House Gas Goals

Soil Health

Water Pollution

Air Quality

Regulation

Nutrient Loss

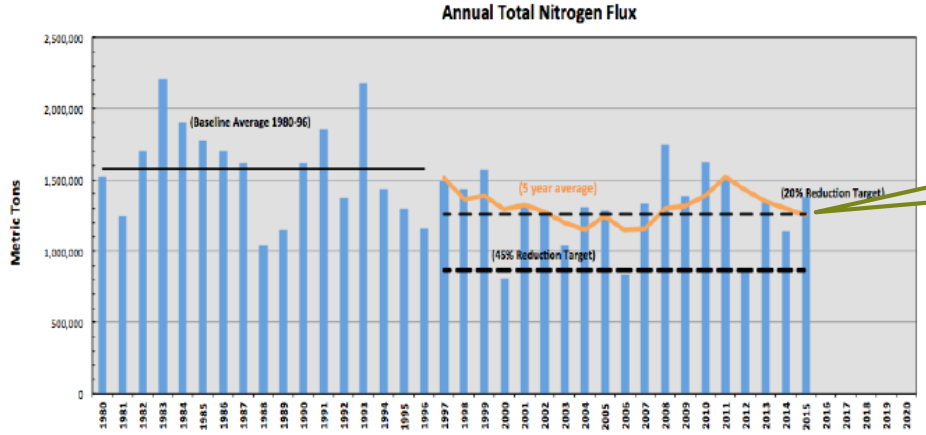
Facebook/Twitter

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

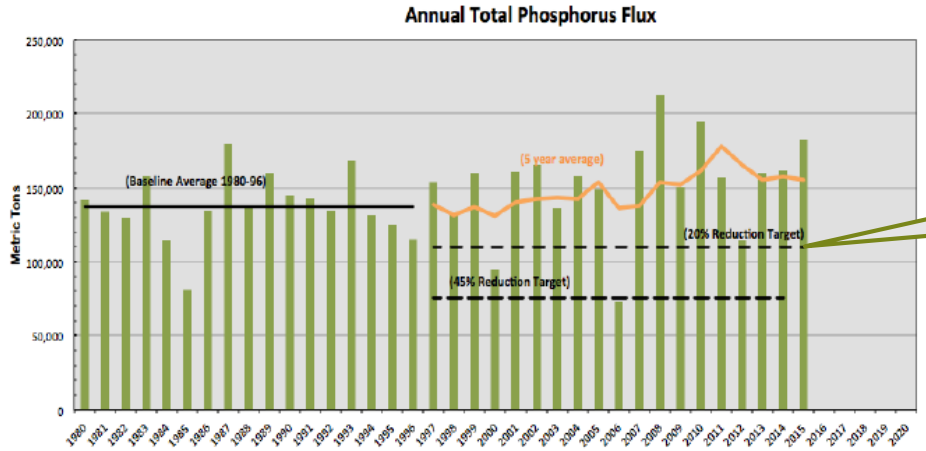
Hypoxia Task Force Report

https://www.epa.gov/sites/production/files/2017-11/documents/hypoxia_task_force_report_to_congress_2017_final.pdf



20% Reduction Target

Figure 3. Annual total nitrogen loads in the Mississippi/Atchafalaya River basin transported to the Gulf of Mexico from 1980-2015. (USGS 2017)



20% Reduction Target

Figure 4. Annual total phosphorus loads in the Mississippi/Atchafalaya River basin transported to the Gulf of Mexico from 1980 to 2015. (USGS 2017)

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Hypoxia Task Force Report

https://toxics.usgs.gov/hypoxia/mississippi/flux_ests/delivery/index.html

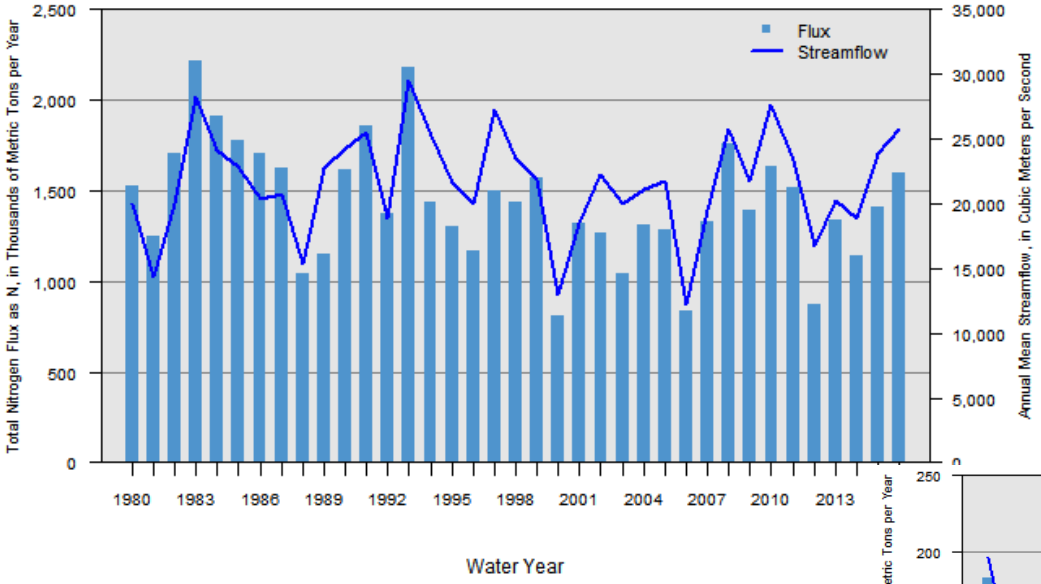


Figure 2. Annual total nitrogen flux and streamflow for total Mississippi-Atchafalaya River Basin.

USGS **2016 Mississippi-Atchafalaya River Basi**

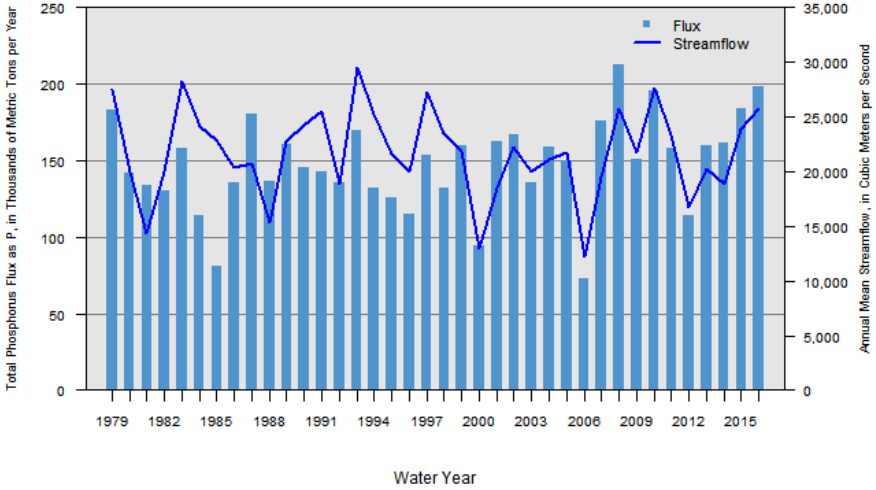


Figure 3. Annual total phosphorus flux and streamflow for total Mississippi-Atchafalaya River Basin.

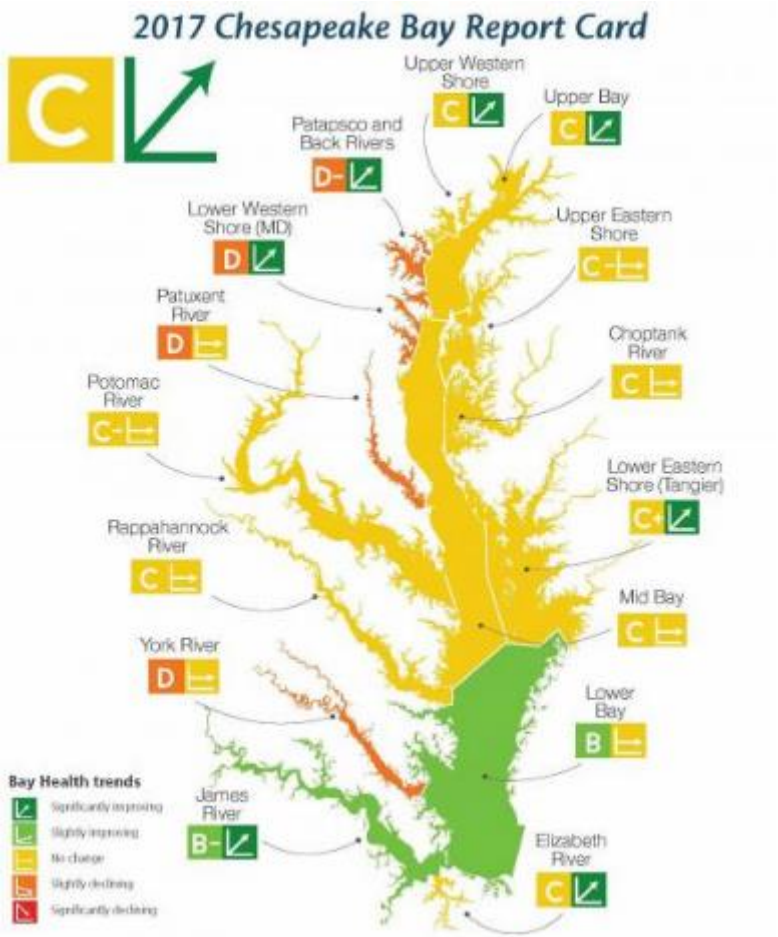
USGS **2016 Mississippi-Atchafalaya River Basin Flux Estimate**

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Chesapeake Bay Report Card 2018

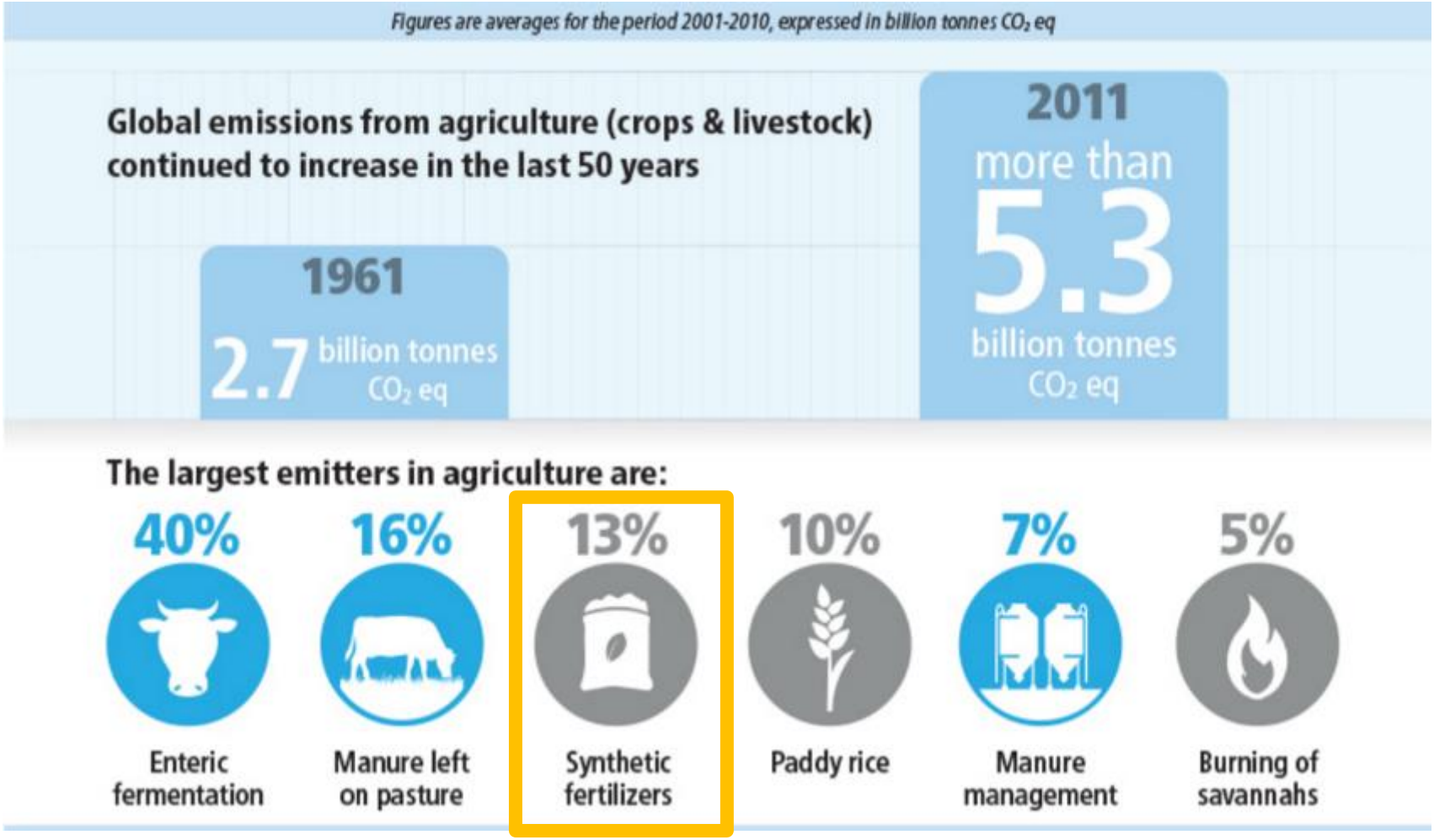
- Long-term trend is statistically, significantly improving over time.
- There are no regions in decline.
- Underwater grasses, dissolved oxygen, and total nutrients all showed positive trends
- However…
- Water clarity showed a negative trend, with several Bay regions making little or no progress
- Keep moving forward with 4R Nutrient Stewardship, Conservation, and Soil Health working together



Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

GHG Emissions – Nitrous Oxide Loss



www.fao.org

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Coca-Cola	Reduce GHG emissions across value chain by 25% by 2020
Unilever	Halve GHG impact of products across the lifecycle by 2020
Walmart Save money. Live better.	Fertilizer optimization on 14 M acres of U.S. farmland by 2020
Kellogg's®	Responsibly source top 10 ingredients & materials by 2020

4R Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

- Reduce GHG emissions across value chain by 28% by 2025, & **sustainably sourcing 100% of our 10 priority ingredients by 2020**

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Performance dashboard: Sustainable sourcing

General Mills

Commitment: Sustainably source 100 percent of our 10 priority ingredients by 2020, representing 40 percent of our annual raw material purchases.

Progress: 76 percent of these raw materials were sustainably sourced in fiscal 2017.

Raw material/Ingredient	Progress* (% of volume sustainably sourced as of May of the year noted) FY14	FY15	FY16	FY17	Primary focus** Environmental	Social	Strategy	Sustainability definition
Cocoa	10%	28%	46%	59%	✓	✓	Origin-direct investment	Direct investment at origin to improve smallholder farmer livelihoods and ingredient quality
Vanilla	45%	45%	22%	22%		✓		
Oats	35%	40%	50%	61%	✓		Continuous improvement	Documented continuous improvement using industry-based environmental metrics with at least 25 percent of acres under measurement***
U.S. wheat	15%	24%	36%	61%	✓			
U.S sugar beets	34%	47%	68%	81%	✓			Documented continuous improvement using Field to Market framework or comparable metrics with at least 25 percent of acres under measurement***
U.S. corn (dry milled)	6%	26%	33%	67%	✓			
U.S. dairy (raw fluid milk)	20%	20%	38%	83%	✓	✓		Documented continuous improvement as outlined in the ICUSD's Stewardship and Sustainability Framework for U.S. Dairy****
Fiber packaging	99%	99%	99%	99%	✓		Verification	Recycled material or virgin wood fiber from regions not contributing to deforestation
Sugarcane	42%	59%	67%	58%	✓	✓		Sourced from independently verified low-risk regions, or compliance with Bonsucro or comparable standards in high-risk regions
Palm oil*****	83%	100%	100%	100%	✓	✓		RSPO mass balanced, segregated sustainable palm, or PalmTrace Credits

Research Fund

https://www.generalmills.com/en/Responsibility/Sustainability/sustainable-sourcing

The Fertilizer Institute
Nourish, Replenish, Grow

Industry Updates

- Walmart – Gigaton Challenge
  - "The adoption of best-in-class agricultural practices, including precision agriculture and feed optimization, can help reduce farmer input costs, improve water quality and reduce greenhouse gas (GHG) emissions."
    - Recommend 4R practices to reach goals

Fertilizer Efficiency programs and practices grouped by expected GHG savings

Low GHG	Medium GHG	High GHG
• Data collection tool that helps benchmark current practices	• Precision agriculture calibrated to optimize yield	• Overall rate recommendations optimized using real-time weather data
• Rate recommendation based on model optimizing fertilizer cost and crop yield	• Mid- to late-season application informed by nitrogen-loss monitoring using real-time weather data	• Use of a nitrification inhibitor
• Land-grant university rate	• Optical sensors	• Optical sensors showing nutrient use efficiency improvement of more than 20%

https://www.walmartsustainabilityhub.com/project-gigaton/agriculture

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Assessing 4R Awareness

- Qualitative online survey
  - Crop advisers
  - Farmers
    - Over 200 ha
    - Growing alfalfa, barley, cotton, dry beans, field corn, grain sorghum, hay, oats, potatoes, rice, rye, soybeans, sugar beets, sugarcane, timothy, or wheat
- Phone survey
  - 203 Farmers

Advisers Awareness of 4R

- 96% Aware of 4R concepts
- 92% Farmers are receptive to new fertilizer science
- 71% Cost or return on investment important to conversations on "new practices"

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

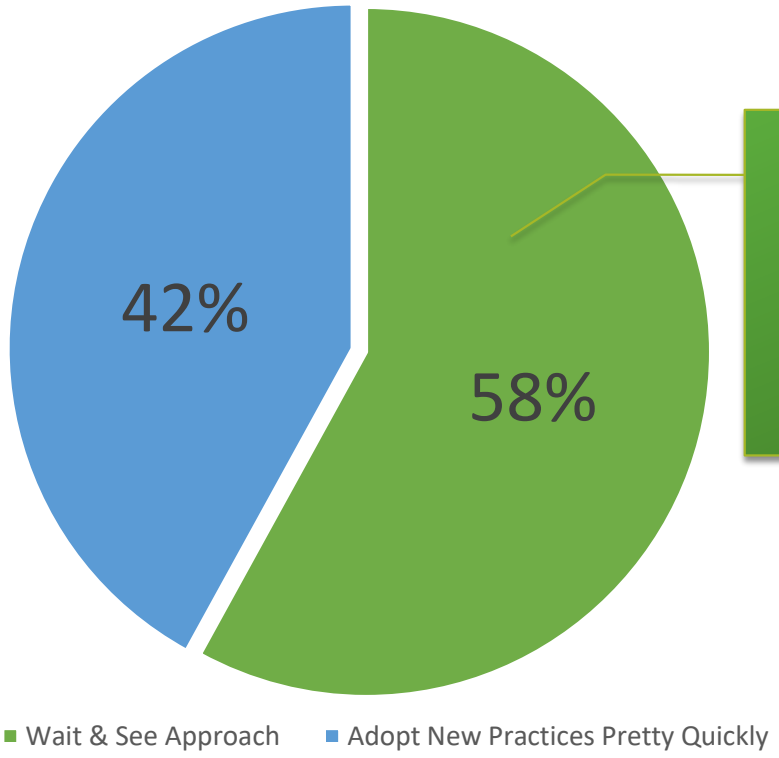
Farmer 4R Awareness

38% - a lot or some about 4R

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Approach to Practice Adoption Split



68% Farm <1,000 acres
68% <$500K gross income
65% over the age of 65

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Farmer Information Sources

76%

Frequently speak to other farmers about fertilizer practices

76%

Agronomist & retailers top fertilizer information source

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Soil Health as Driver of Change

Getting the 4Rs right means:

67% Improving soil health, and that means improving crop performance

50% Minimizing impact on environment & retaining nutrients in the field

45% Action now may reduce the need for regulation later

39% Reducing risks associated with good & bad weather, improving yield

37% Doing more to improve our crop yields and profit

4R Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Cost, Cost, Cost

- Link specific practice & benefits info to a real world example
- Want to see how it works for others
- Cost, ROI, Savings

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

4R Message Can Affect Change

- 4R awareness, favorability, & likelihood to try new practices increased during survey

Favorability

- 67 to 76% for farm income <$500K
- 57 to 70% for those implementing few 4R practices

Try New Practices

- 65 to 76% for those implementing some 4R practices
- 35 to 61% for those implementing not much or no 4Rs

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

4Rs make sense, but farmers want info on costs, equipment needs, logistics, and impacts

Crop advisors are an important information source

Farmers respond positively to communications linked to other farmers & content that provides specific detail for better decision making

It's advantageous to reference the 4Rs collectively, farmers are favorable towards concept as a system

Favorability & likelihood to try new practices increased with increasing 4R awareness

For crop advisors, increased practice adoption has implications for offered services, products & technologies

4 Research Fund

THE FERTILIZER INSTITUTE

The Fertilizer Institute
Nourish, Replenish, Grow

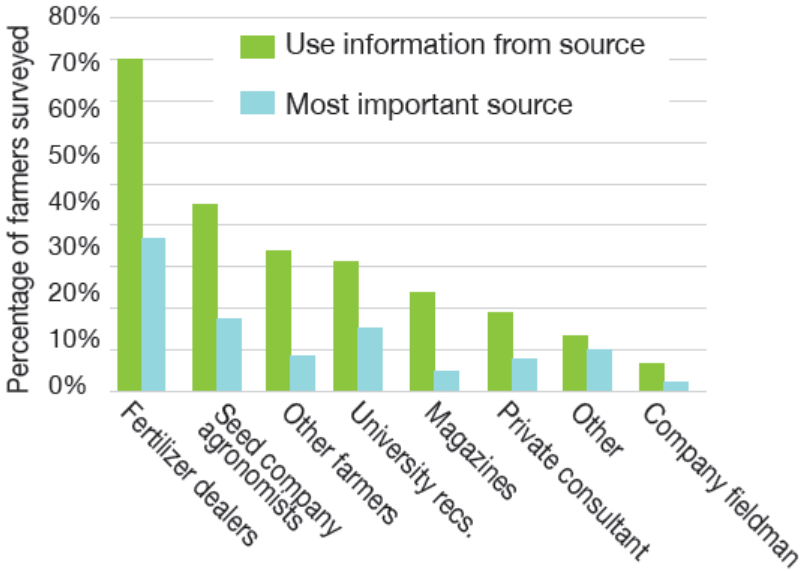
What Practices are Right Practices?

- Provide positive results as demonstrated through research and ongoing systematic assessment (adaptive management)
- Site specific to account for variability related to management, soil, climate, genetics, conservation practices on site etc.
- Every crop nutrient application involves all 4Rs
- Practice use and selection are interrelated, each is linked
- Selected using adaptive management to assess site specific needs for all nutrient applications

Retailers and Agronomists: Farmer's Information Source

- Retailers ranked as most important information source by farmers
- Key role in 4R adoption

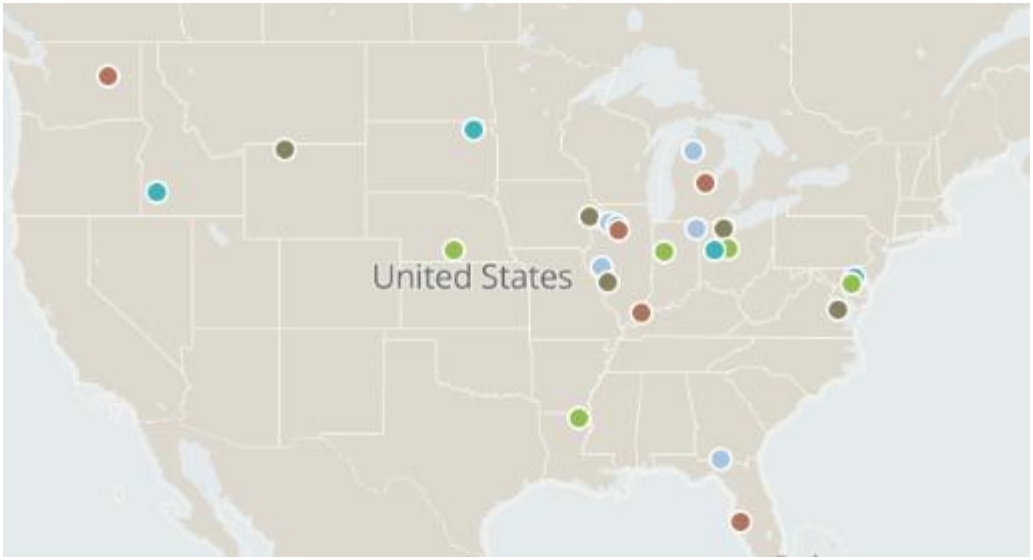
Most common sources of information for farmers on N fertilizer application rates



Sources of information Michigan farmers indicated that they use to determine N fertilizer application rates. Redrawn from Stuart et al. 2014. Land Use Policy 36:210-218.

Who is implementing 4R practices?

- 4R Advocates
  - 10 Advocates – 160,000+ acres
  - 18 States
  - 3 from the Mid-Atlantic
  - http://www.nutrientstewardship.com/advocates/



Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

2019 4R Advocates

- Brian Herbeck, Deweese, NE – Corn, Wheat, Soybean, Alfalfa
  Bill Nejezchleb, Fairfield Non Stock Coop, Fairfield, NE
- Danny Basham, Madisonville, KY - Corn
  Phillip Osborn, Nutrien Ag Solutions, KY
- Dustin Grooms, Plant City, FL - Strawberries
  Jerrod Parker, Chemical Dynamics, INC, FL
- Jonathan Quinn, Warwick, MD – Corn, Soybeans, Wheat, Barley, and Spinach
  Kenny Glenn, Southern States Cooperative, INC, DE
- Michael Ganschow, IL – Corn and soybean
  Malcolm Stambaugh, Growmark FS, IL

Beck Brothers Citrus, Inc.

- Use enhanced efficiency fertilizers – N
- Variable rate applications up to 6 times a season
- Some fertigation
- Leaf tissue analysis to adjust in-season applications
- Use GIS and mapping to examine where there are nutrient concerns in the fields

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Cox Land and Cattle Co.

- 3,000 ac
  - Corn grain
  - Soybeans
  - Corn silage
  - Hay and cover crops
  - 750 cattle – cow/calf
  - No-till since 1988
  - Strip-till in corn

Maria Cox, Farmer
Kyle Lake Crop Consultant

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Soybeans

- Cereal Rye Cover crop
  - Plant soybeans into green standing rye
- 4R Practices
  - 2.5 ac grid sampling
  - Variable rate nutrient prescriptions using grid samples and yield maps
  - All P and K spring applied
  - Test manure for crediting
- Performance
  - 2016 – 71 bu/ac
  - Plus cereal rye hay production

Corn

- Strip-Till planting into cereal rye terminated at 10”
- No-till 25%
- Strip-till 50%
- Tillage on 25% that has hog manure
- 4R Practices
  - Variable rate N, P, K
  - Use N-serve (nitrification inhibitor) on all anhydrous ammonia
  - Split application
- Performance
  - 2016 – 190 bu/ac

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Manure use

- Applied to cover crops
- Spring application
- Beef and swine manure
- Credit for nutrient from manure

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Other Conservation

- Dry Dams
- Conservation Reserve Programs
  - Pollinator Program
  - 80 acres CRP long-term
- Buffer strips around feed lots
- Grassed waterways
- Buffer Strips

Maria says:

- "We use cover crops as a way to build organic matter, prevent erosion, lessen weed pressure, and potentially lower fertilizer application rates long-term."

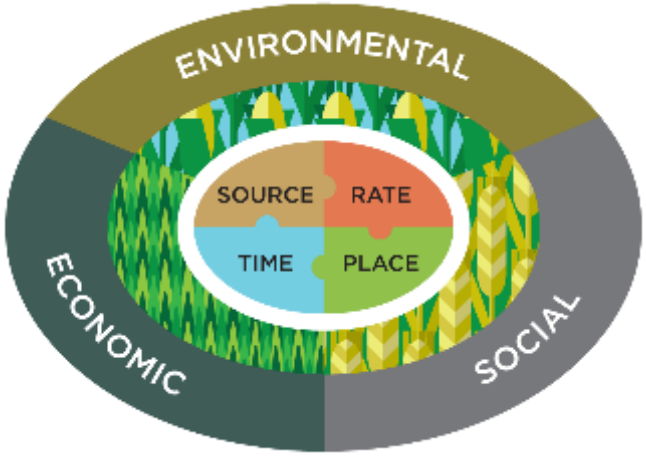
- "4Rs can be implemented in all tillage situations, but we feel a no-till system on fields keeps the fertilizer from eroding and washing away."

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Everyone Plays a Role

- Expand your 4R knowledge with available tools
- Educate stakeholder groups about 4R nutrient stewardship and encourage their engagement
- Utilize the 4Rs to share a common message
- Participate in relevant meetings and committees
- Inform the public when the opportunity arises



Research Fund

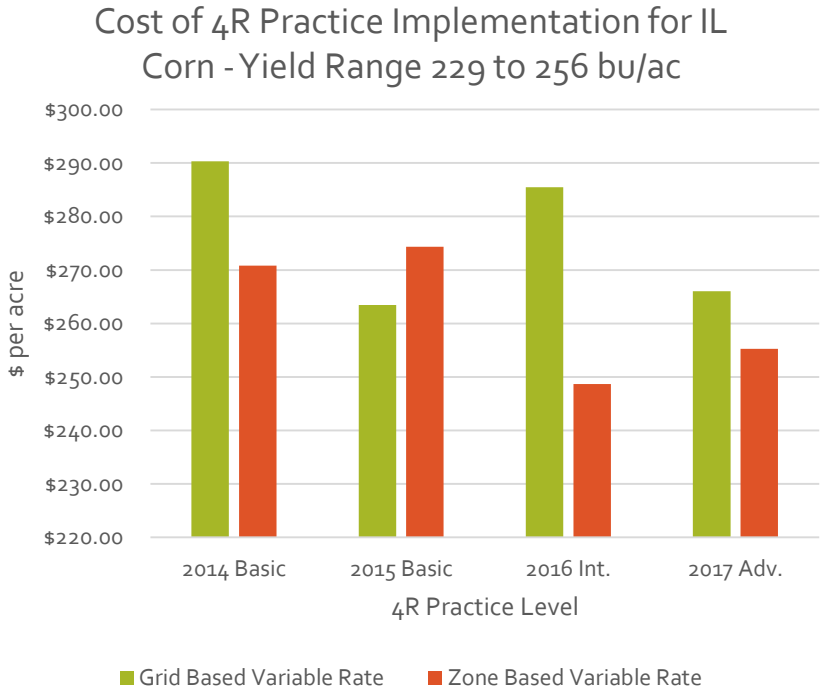
The Fertilizer Institute
Nourish, Replenish, Grow

Economics of 4R Nutrient Stewardship

- Basic: spring pre-plant AA w/ inhibitor, liquid starter w/ seed, early post-plant w/ herbicide, liquid N side-dress with Y-drop

- Intermediate: Liquid starter w/ seed, early post-plant w/ herbicide, side-dress AA with inhibitor

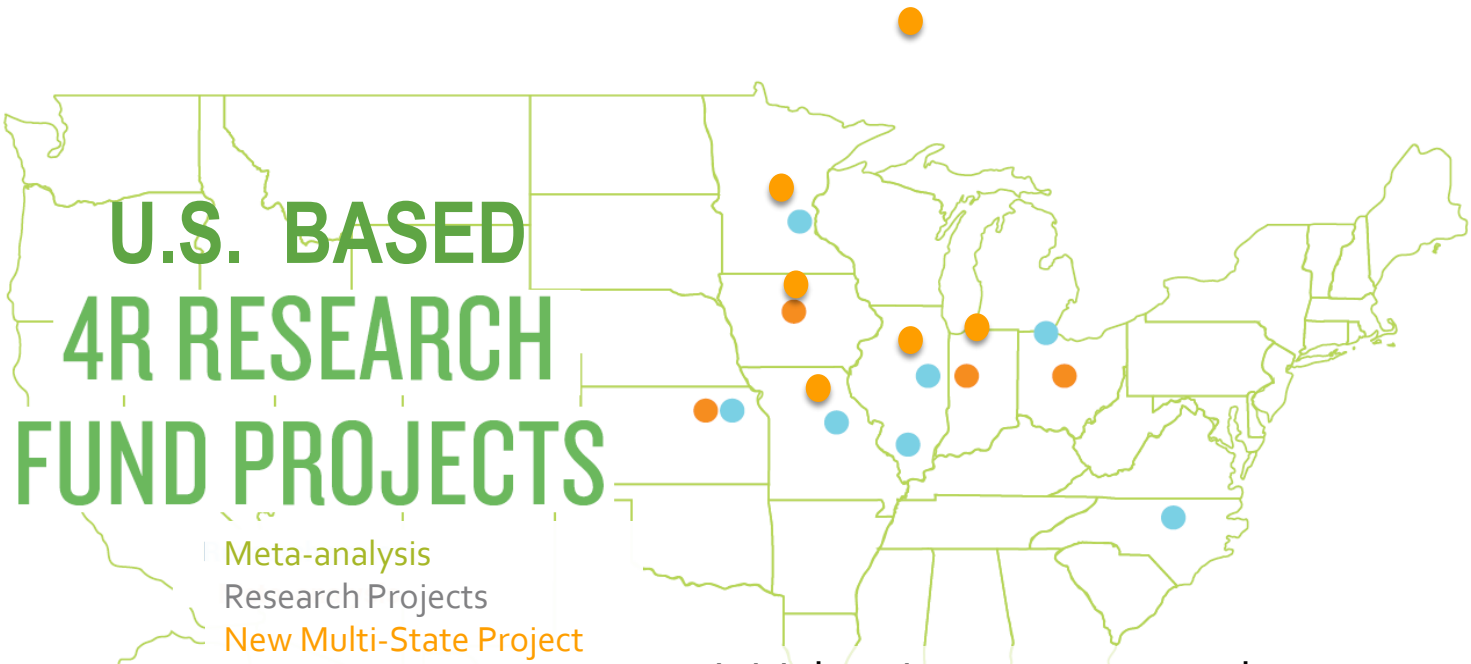
- Advanced: Liquid starter w/ seed, early post-plant w/ herbicide, side-dress AA with inhibitor, liquid side-dress w/Y-drop (V10)



Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

U.S. BASED 4R RESEARCH FUND PROJECTS



Initial projects: 5 meta-analyses

- Knowledge gaps related to 4Rs and environmental impact

Current research projects

- 4R practice impacts on N & P loss via water and air pathways and interaction with supporting conservation

Research Fund

Companies Contributed	Funded Projects	Dollars Contributed	Total Dollars Allocated
84	25	$5.7M	$13M

THE FERTILIZER INSTITUTE

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Common N Findings

- Timing of N application was has a large impact on yield and N loss
  - 14 to 32 bu/ac increase when UAN is split between at planting and sidedress
  - Applying urea at sidedress increases yield compared to both pre-plant and fall application
  - Side-dressing nitrogen fertilizer reduced N_2O loss by 30 to 39%
- Nitrification and urease inhibitor use with UAN or anhydrous ammonia applications decreases N_2O and NO_3 losses

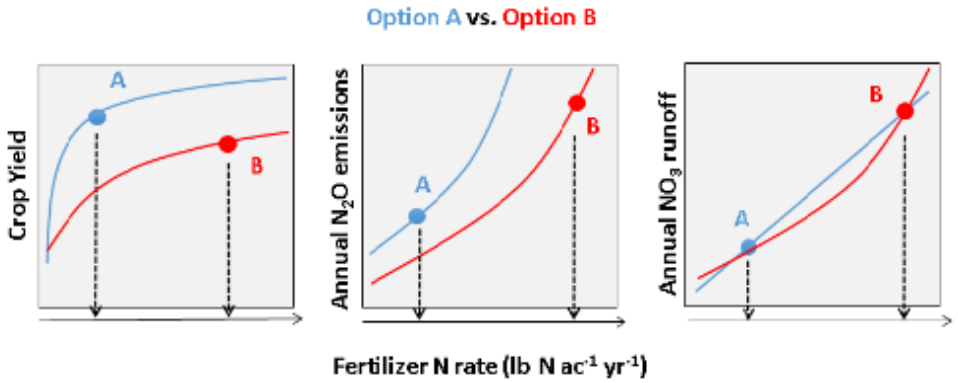
Common P Findings

- Placement of P fertilizer influences P loss
- P application based on crop need and soil test has potential to reduce P losses

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

A Meta-analysis of 4R Nutrient Management in U.S. Corn-Based Systems



- **Rate, Source, Time, and Place** – Crop yield, nitrate (NO_3^-) leaching, and nitrous oxide (N_2O) emissions response to N rates
- Learn how differences in climate and soil across North America affect these responses.

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Rate – Strong positive relationship to NO_3 leaching and N_2O air loss. 2.9 to 11.9 % increase for each 8.9 lb N/ac increase

Source – N_2O losses are highest with Anhydrous Ammonia > Urea = Polymer Coated Urea = Urea Ammonium Nitrate (UAN) = UAN + Agrotain PLUS® > Super U

Time – Side dress fertilizer reduced N_2O emissions 30 to 39 %

Place – Broadcast placement of N fertilized decreased N_2O losses by 25 to 33% compared to injecting or banding

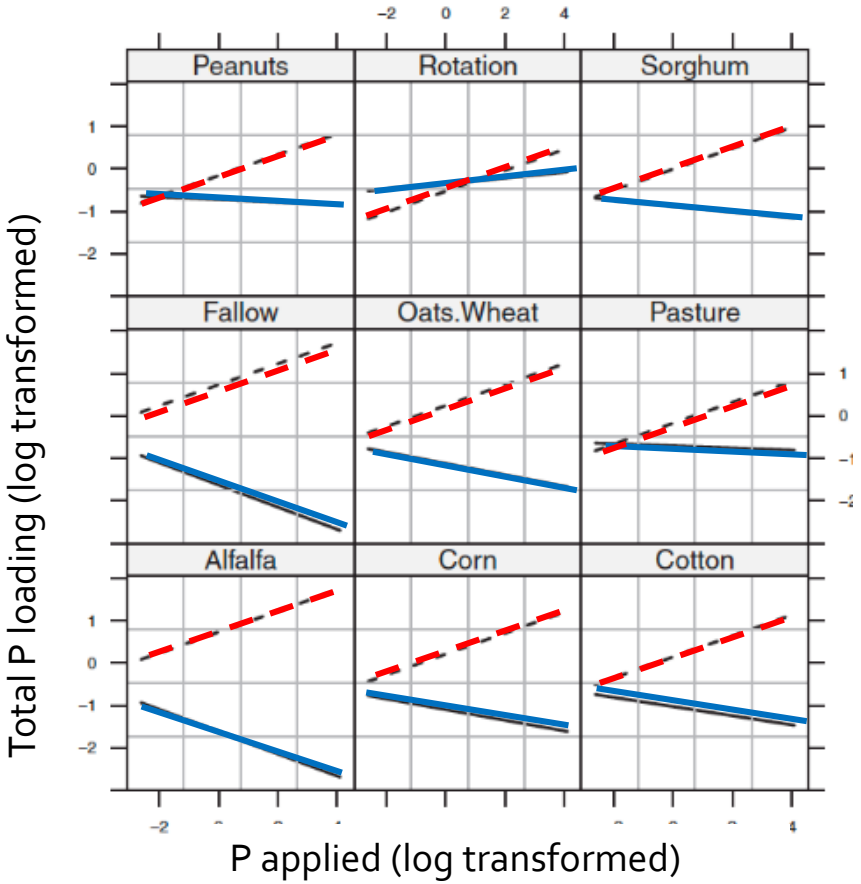
Environmental – Nitrous oxide emissions are higher with warmer temperatures. 1.8^{0}F increase in average July temperate = increased emissions from additional application of 89.2 lb N/ac

A Meta-analysis of 4R Nutrient Management in U.S. Corn-Based Systems

4R Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

4R and Conservation Practices



With conservation practices

Without conservation practices

59% reduction through combination of incorporation of P and conservation

Qian and Harmel. 2016. JAWRA.

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

N Knowledge Gaps

- Lack of studies:
  - Measuring N loss from multiple pathways
  - Comparing suites of 4R practices
  - Measuring N losses outside the growing season
  - Conservation practices

- Need for more studies beyond Midwest cropping systems

P Knowledge Gaps

- Lack of studies:
  - Investigating P sources, timing, *and* placement
  - Addressing P form (particulate vs. dissolved)
  - Conservation Practices
- Need to incorporate P forms into water quality models
- Need for more studies beyond Midwest cropping systems

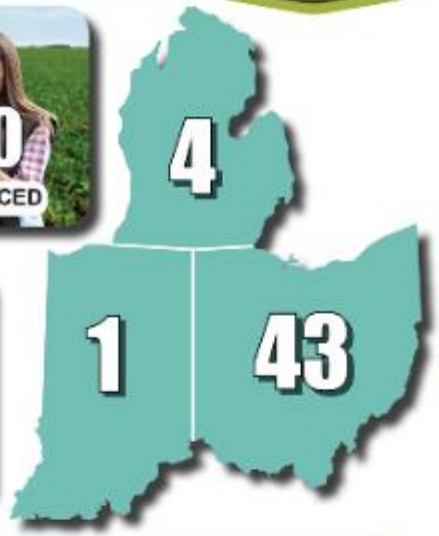
Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

4R NUTRIENT STEWARDSHIP CERTIFICATION PROGRAM

Voluntary program in Western Lake Erie Basin (WLEB) and entire state of Ohio for agricultural retailers & nutrient service providers implementing the 4Rs

NUTRIENT STEWARDSHIP CERTIFICATION



GOALS

Maximize crop nutrient uptake and minimize crop loss

Positively impact local water bodies

Provide up-to-date information on nutrient stewardship

Help the agricultural sector adapt to new research and technology

REQUIREMENTS

Initial training and on-going education

Monitoring of 4R implementation

Nutrient recommendation and application

THIRD-PARTY VERIFIED

Audits review training and education, recommendations to growers and application records

Third-party auditor verification occurs each year

For more information, visit 4rcertified.org

RIGHT SOURCE - RIGHT RATE - RIGHT TIME - RIGHT PLACE

4R Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

2018 Farm Bill

- Research Title
  - Fertilizer Nutrient Research – High Priority
- Conservation Title
  - TSP and CCA
  - More EQIP $ for nutrient management
  - CEAP Reports
- Hopefully by December

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

Bringing it all Together - Challenges

- Challenges on water quality – state and national level
  - Good progress on N
  - What do we need to look at for P?
    - Rates are similar and yield have been increasing, but so is water concentration
- Challenges on emissions – Nitrous Oxide Loss
  - Example – General Mills – goal is 2020 – only 58% suitability on sugar cane
  - Walmart – BIG GOAL – 20+ years away – recommending 4R practices to meet goals and make plan
- CCAs are the trusted advisors
- Knowledge of 4R is high for CCAs and retail
- Farmers are very receptive to 4R message

Resources

- TFI 4R website: www.nutrientstewardship.org
-  1fertilizer
-  @4Rnutrients
-  4R Nutrient Stewardship
- 4R Quarterly Newsletter: sign-up at www.nutrientstewardship.org
- 4R Pocket Guide – request today from TFI
- 4R Educational Modules: http://www.nutrientstewardship.com/4r-training
- 4R Plant Nutrition Manual and 4R CCA Study Guide– purchase from IPNI Publications
- IPNI 4R website: www.ipni.net/4R

Research Fund

The Fertilizer Institute
Nourish, Replenish, Grow

QUESTIONS?