"4 Rs Are Not Enough: We Need 7 Rs for Nutrient Management and Soil and Water Conservation"

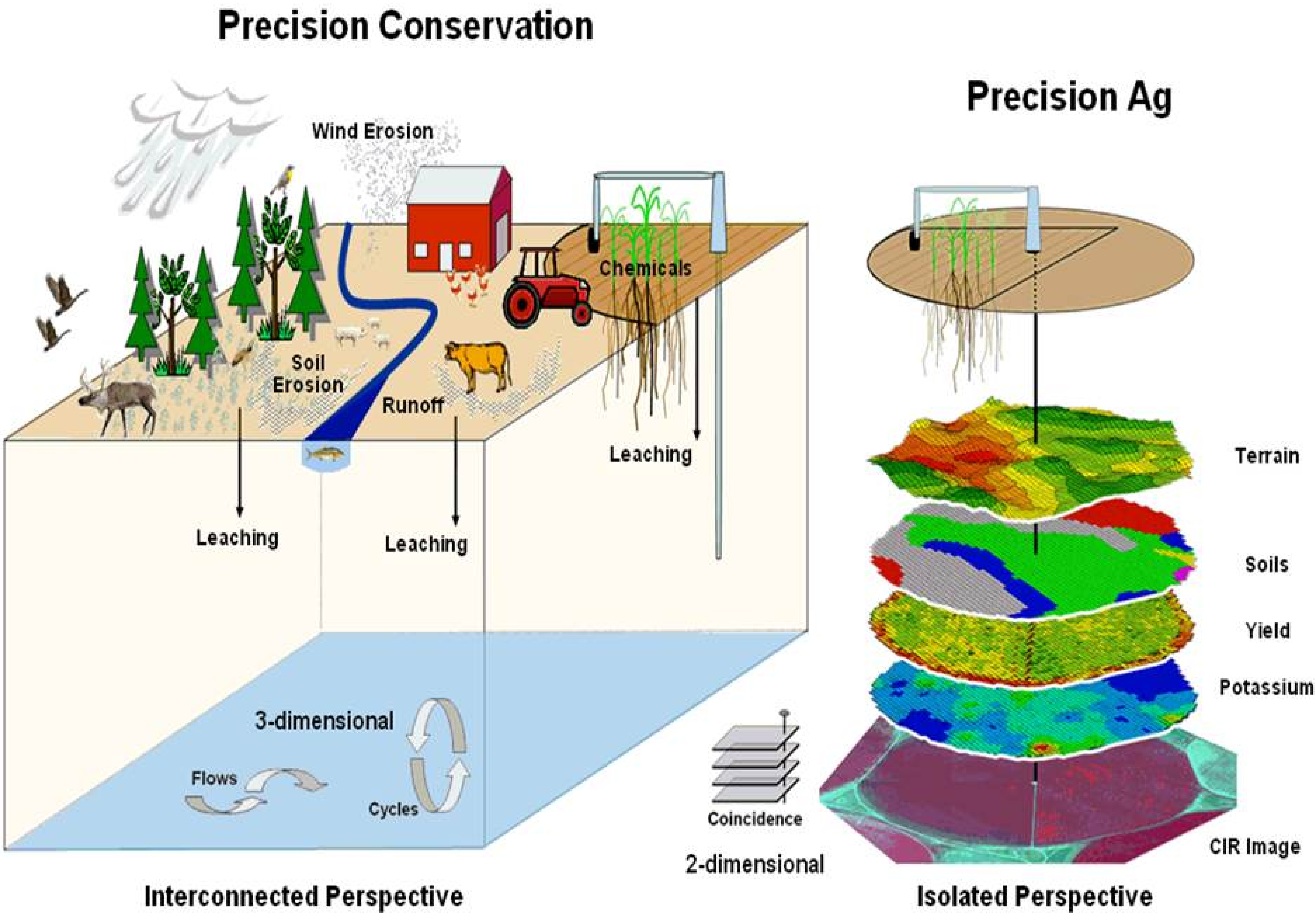
Photo NASA

Dr. Jorge A. Delgado
Soil-Plant-Nutrient Research Unit, USDA/ARS

July 28, 2015

Thank You!

InfoAg 2015


Precision Conservation
Precision Ag
Wind Erosion
Chemicals
Soil
Erosion
Runoff
Leaching
Leaching
Leaching
Terrain
Soils
Yield
Potassium
CIR Image
3-dimensional
Flows
Cycles
Coincidence
2-dimensional
Interconnected Perspective
Isolated Perspective

Precision Conservation was originally defined as a set of spatial technologies and procedures linked to mapped variables, which is used to implement conservation management practices that take into account spatial and temporal variability across natural and agricultural systems (Berry et al., 2003).

Precision Conservation connects farm fields, grasslands, and range areas with the natural surrounding areas such as buffers, riparian zones, forest, and water bodies.

Nutrient Management Plans

Cox (2005) simplified the Berry et al. (2003) precision conservation concept as applying the right conservation practice, at the right place, at the right time, and at the right scale (the 4 Rs for conservation).

Nutrient Management Plans

The 4 Rs for nutrient management (Roberts, 2007); the right product, at the right rate, at the right time, and at the right place.

Nutrient Management Plans

This presentation covers the Delgado (2015) publication that proposes that the 4 Rs (right product, at the right rate, at the right time, and at the right place) are not enough to reduce environmental impacts.

Journal Advances in Soil Science 2015

OK that 4 Rs is not spelled out in the title?

4 4 Rs Are Not Enough

We Need 7 Rs for Nutrient Management and Conservation to Increase Nutrient Use Efficiency and Reduce Off-Site Transport of Nutrients

J.A. Delgado

CONTENTS

4.1 Introduction 90
4.1.1 Climate Change and Population Growth 90
4.1.2 Depletion of Water Resources Is of Great Concern 91
4.1.3 Environmental Impacts of Off-Site Transport of Nitrogen and Phosphorus 92
4.1.4 Impacts of Erosion on Soil Quality 94
4.2 Geospatial Technologies and Tools to Increase Efficiency with Precision Farming and Precision Conservation 95
4.3 Nutrient Management 95
4.3.1 Spatial Variability of Yields and Pathways for Nutrient Losses 95
4.3.2 Variable Rates 96
4.4 Water Management: Spatial Irrigation 97
4.5 RS and Sensors for Precision Farming and Management Zones 97
4.6 Precision Conservation for Improving Management within and Off the Field 98
4.6.1 Spatial Erosion 98
4.6.2 Grassed Waterways 99
4.6.3 Contour Planting with Deep Furrows to Collect Water 100
4.6.4 Management of Critical Areas 100
4.6.5 Precision Harvesting of Crop Residue 101
4.6.6 Drainage Management 106
4.6.7 Precision Conservation Agriculture 107
4.7 Precision Conservation for Management of Nonfield Areas 107
4.7.1 Buffers 107
4.7.2 Riparian Buffers 109
4.7.3 Nutrient Traps and Sediment Ponds 110
4.7.4 Wetlands 110
4.8 Connecting Nutrient Flows at a Watershed Level for Ecosystem Services 111
4.9 Precision Regulation 113
4.10 Research and Development Priorities 114
4.11 Summary and Conclusions 117
References 117

Nutrient Management Plans

7 Rs for nutrient management and conservation.

If we are to increase conservation effectiveness and nutrient use efficiency and minimize the losses of sediment and nutrients to the environment, we need to apply the right product (fertilizer), at the right fertilizer rate, with the right method of fertilizer application, with the right conservation practice, and with conservation practice at the right place, and at the right scale of conservation practice, with both the fertilizer and the conservation practice applied at the right time (right product, right rate, right method, right practice, right place, right scale, and right time: the 7 Rs of nutrient management and conservation).

The Roberts (2007) definition of right place also mentions that conservation tillage, buffer strips, cover crops, and irrigation management are other practices that can help keep the nutrients at the right place. However, the right conservation practices, at the right time, right place and right scale as defined by Cox (2005) have not been in a prominent position in the 4 Rs of nutrient management. For example, when Murell et al. (2009) reviewed in detail the right place as defined by Roberts (2007), conservation practices were not discussed in the document, and the right place was defined as applying the fertilizer and incorporating it within the soil close to the root zone.

This presentation covers the Delgado (2015) publication that proposes that the 4 Rs (right product, at the right rate, at the right time, and at the right place) are not enough to reduce environmental impacts.

The paper proposes that a nutrient management plan needs to include how management at a given site will maintain sustainability and soil productivity.

For example, incorporating the 4 Rs for nutrient management alone without thinking about soil and water conservation does not address:

- how to maintain or increase soil quality
- how to maintain or increase soil carbon sequestration
- how to reduce soil erosion to maintain sustainability and productivity at the site

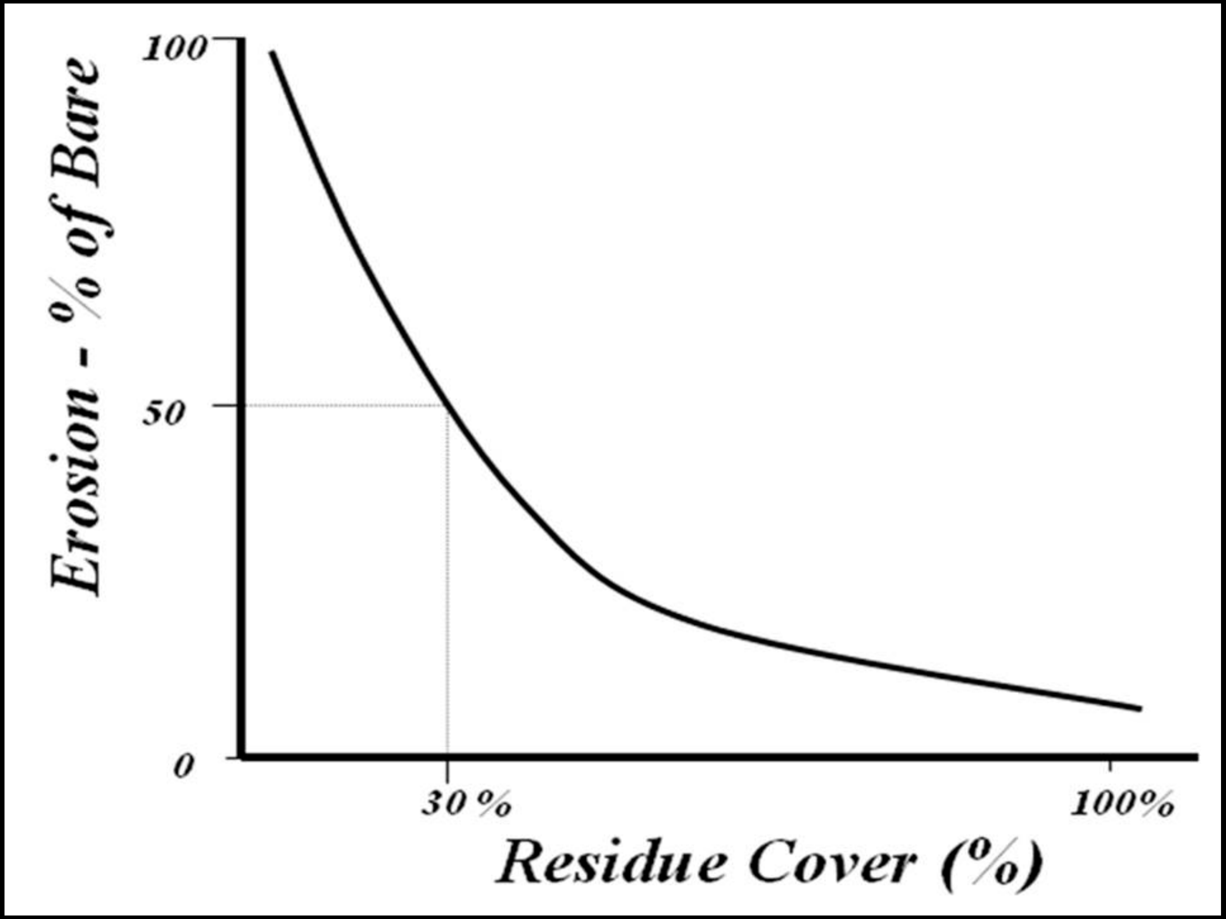
Again, there is a need to bring crop advisors and nutrient managers together with soil and water conservation practitioners to increase application of precision conservation.

4 Rs alone (limitations)

Location where the 4 Rs alone will not reduce the off-site transport of nutrients (see Section 4.6.2 regarding the development of ephemeral gullies). Precision conservation needs to be merged with precision farming. Nutrient management and conservation need to incorporate 7 Rs to increase nutrient use efficiency and reduce off-site transport of nutrients. (From NRCS, Development of Ephemeral Gullies.) Potential precision conservation practices that can be applied at this site are grass waterways, buffers, crop residue management, no-till, and others.

4 Rs alone (limitations).

This site demonstrates the need for the 7 Rs in nutrient management and conservation to increase nutrient use efficiency and reduce off-site transport of nutrients and environmental impacts. (From NRCS, Development of Ephemeral Gullies.)



Effect of residue cover on soil erosion expressed as a percent of erosion occurring on a bare, residue-free surface. (From Cruse, R. M., and C. G. Herndl, *J. Soil Water Conserv.* 64:286–291, 2009.)

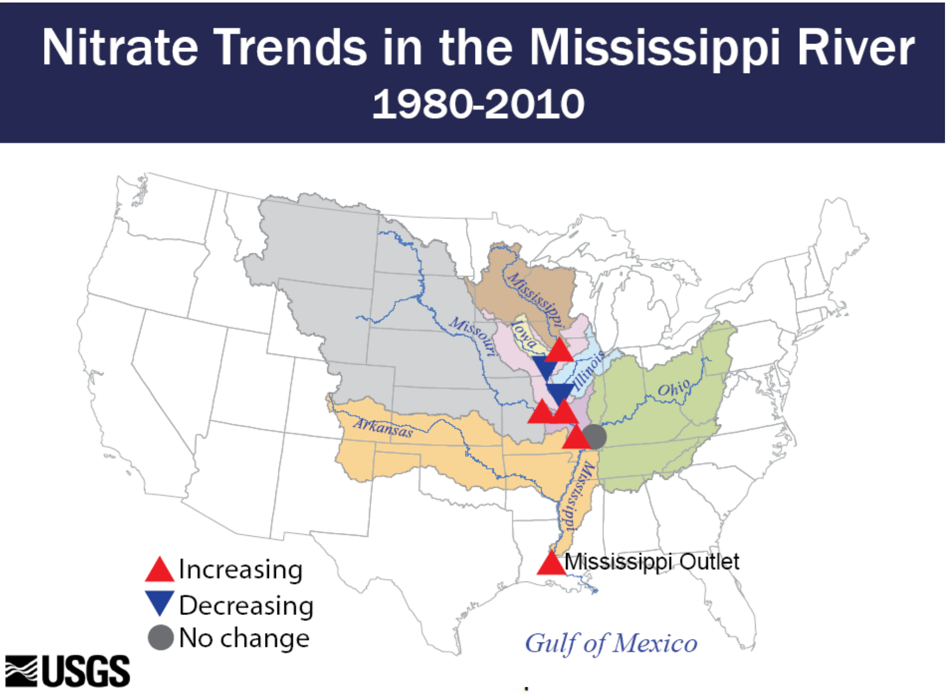
4 Rs alone will not improve soil quality/soil productivity.

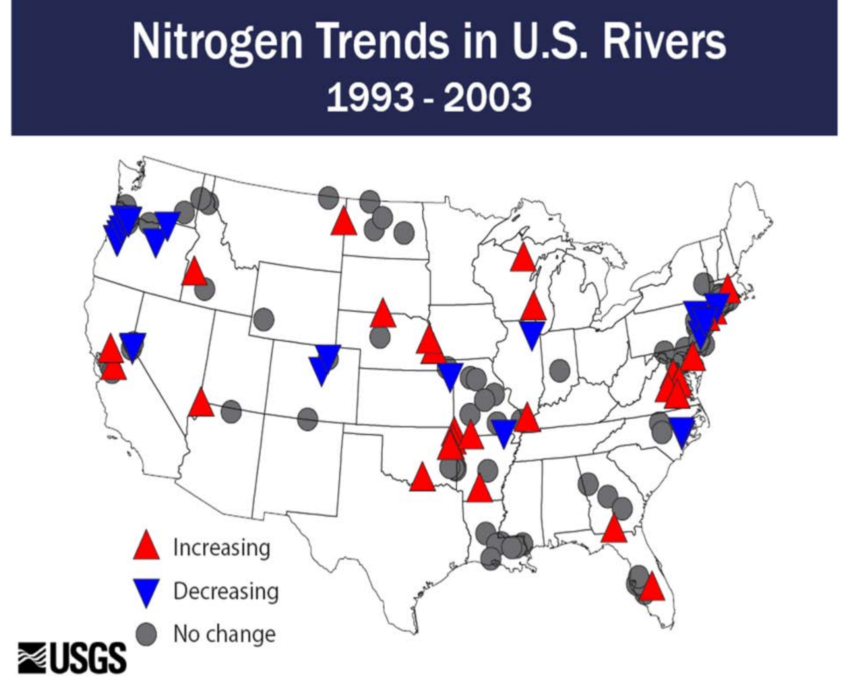
It is important that we consider site-specific factors and precision conservation when we manage soils and nutrients in order to maintain soil quality and minimize erosion and off-site transport of nutrients (Berry et al. 2003)

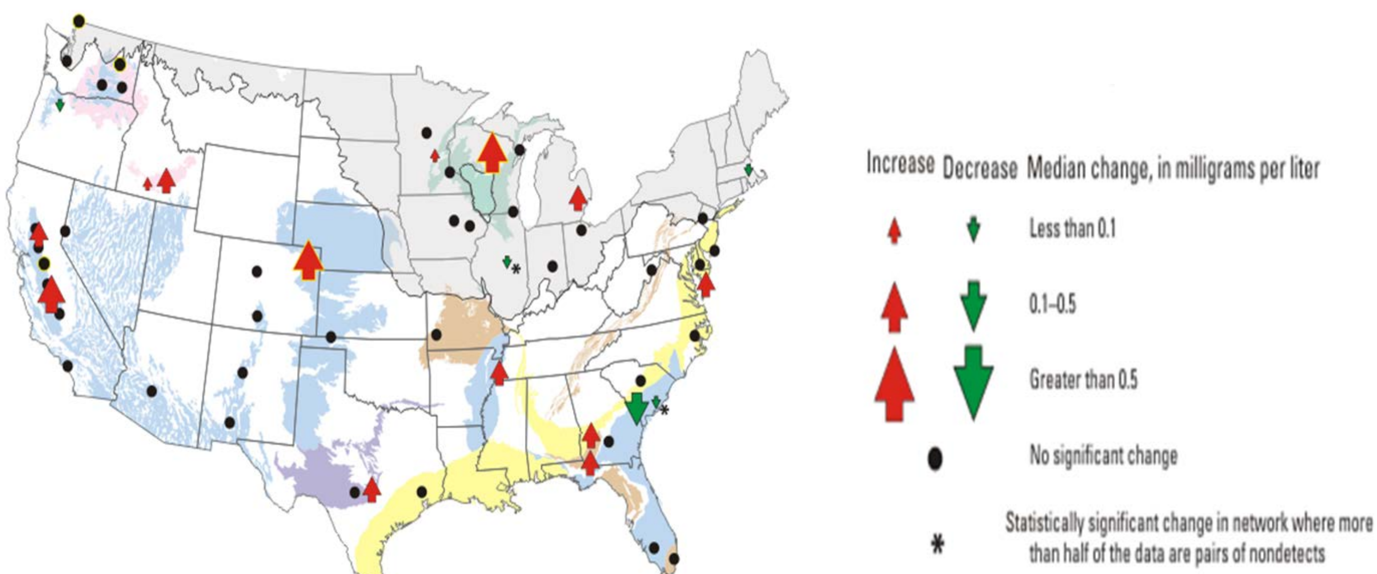
Nutrient Management Plans

It is not all about losses of nutrients due to erosion. Other flow pathways are important, and precision conservation can contribute to reduced nutrient losses to the environment.

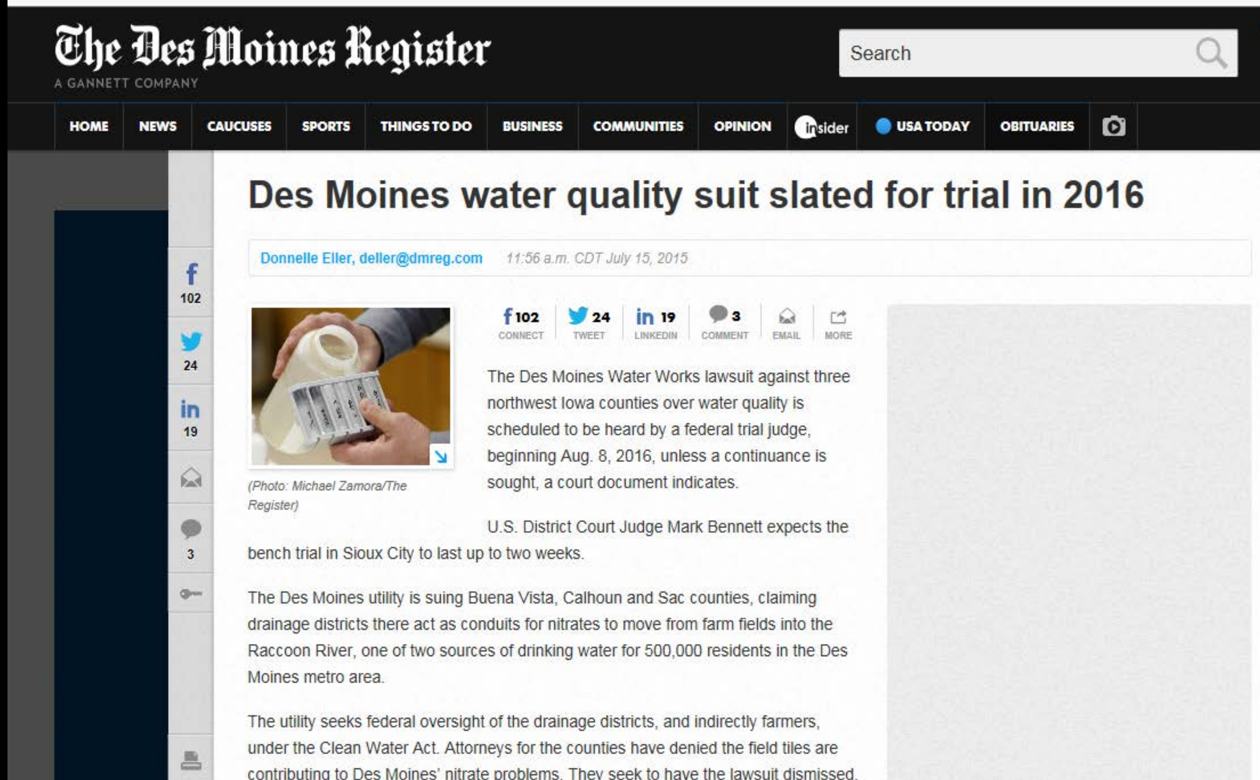
For example, leaching can contribute to losses of nitrogen. We can put conservation practices in the landscape using precision conservation to reduce the losses and transport of nitrate to the environment. We can use conservation practices such as buffers, riparian buffers, denitrification traps, phosphorus traps, and wetlands to reduce transport of nutrients to the environment.







Groundwater-Quality Trends NO_3-N report by Lindsey and Rupert, 2012; there is NO_3 problems even in the humid zones.



The Des Moines Register
A GANNETT COMPANY

Search

HOME | NEWS | CAUCUSES | SPORTS | THINGS TO DO | BUSINESS | COMMUNITIES | OPINION | insider | USA TODAY | OBITUARIES

Des Moines water quality suit slated for trial in 2016

Donnelle Eller, deller@dmreg.com 11:56 a.m. CDT July 15, 2015

f 102 CONNECT | 24 TWEET | in 19 LINKEDIN | 3 COMMENT | EMAIL | MORE

(Photo: Michael Zamora/The Register)

The Des Moines Water Works lawsuit against three northwest Iowa counties over water quality is scheduled to be heard by a federal trial judge, beginning Aug. 8, 2016, unless a continuance is sought, a court document indicates.

U.S. District Court Judge Mark Bennett expects the bench trial in Sioux City to last up to two weeks.

The Des Moines utility is suing Buena Vista, Calhoun and Sac counties, claiming drainage districts there act as conduits for nitrates to move from farm fields into the Raccoon River, one of two sources of drinking water for 500,000 residents in the Des Moines metro area.

The utility seeks federal oversight of the drainage districts, and indirectly farmers, under the Clean Water Act. Attorneys for the counties have denied the field tiles are contributing to Des Moines' nitrate problems. They seek to have the lawsuit dismissed.

The Des Moines Water Works lawsuit against three northwest Iowa counties over water quality is scheduled to be heard by a federal trial judge, beginning Aug. 8, 2016, unless a continuance is sought, a court document indicates.

The Des Moines utility is suing Buena Vista, Calhoun and Sac counties, claiming drainage districts there act as conduits for nitrates to move from farm fields into the Raccoon River, one of two sources of drinking water for 500,000 residents in the Des Moines metro area.

Nutrient Management Plans

As an example, suppose nitrogen fertilizer is applied to a field and we increase yields. Does the nitrogen stop at the field or does it move? We know that it moves. So as far as the fertilizer that was applied by the nutrient manager using the 4 Rs concept, should the nutrient manager look outside of the field to manage that applied nitrogen? Would applying a buffer to reduce surface transport, applying a denitrification trap to denitrify that NO_3, or managing drainage to increase denitrification be options considering spatial and temporal variability and be part of a 7 Rs approach?

Read the magazine story to find out more.

Wood Chips Help Curb Nitrate Leaching

By Ann Perry
February 16, 2012

Wood chips can significantly stem nitrate flow from crop fields into the surrounding watershed, according to a U.S. Department of Agriculture (USDA) study.

This work was conducted by Agricultural Research Service (ARS) scientists in Ames, Iowa. ARS is USDA's chief intramural scientific research agency.

Nitrates that leach out from Midwestern crop fields are channeled via underground tile drains, constructed by early settlers to drain soggy prairies, into nearby surface waterways. The nitrates can eventually end up in the Gulf of Mexico and feed the development of oxygen-deficient "dead zones."

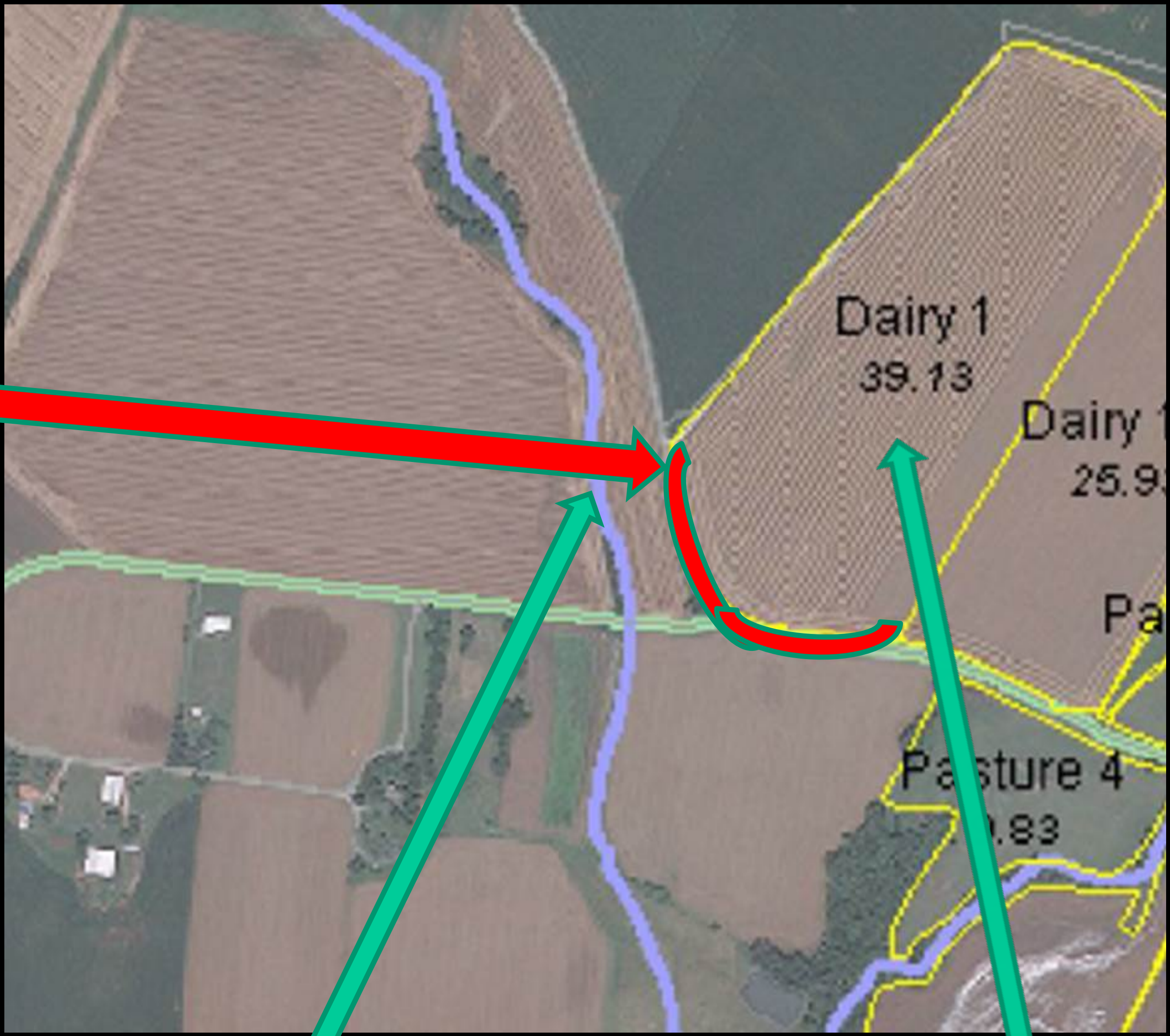
But microorganisms that live in wood use a process called denitrification to convert those nitrates flowing from the field into nitrogen gas or nitrous oxide, which then diffuse into the atmosphere.

ARS microbiologist Tom Moorman and others at the agency's National Laboratory for Agriculture and the Environment in Ames installed perforated plastic drainage pipes four feet

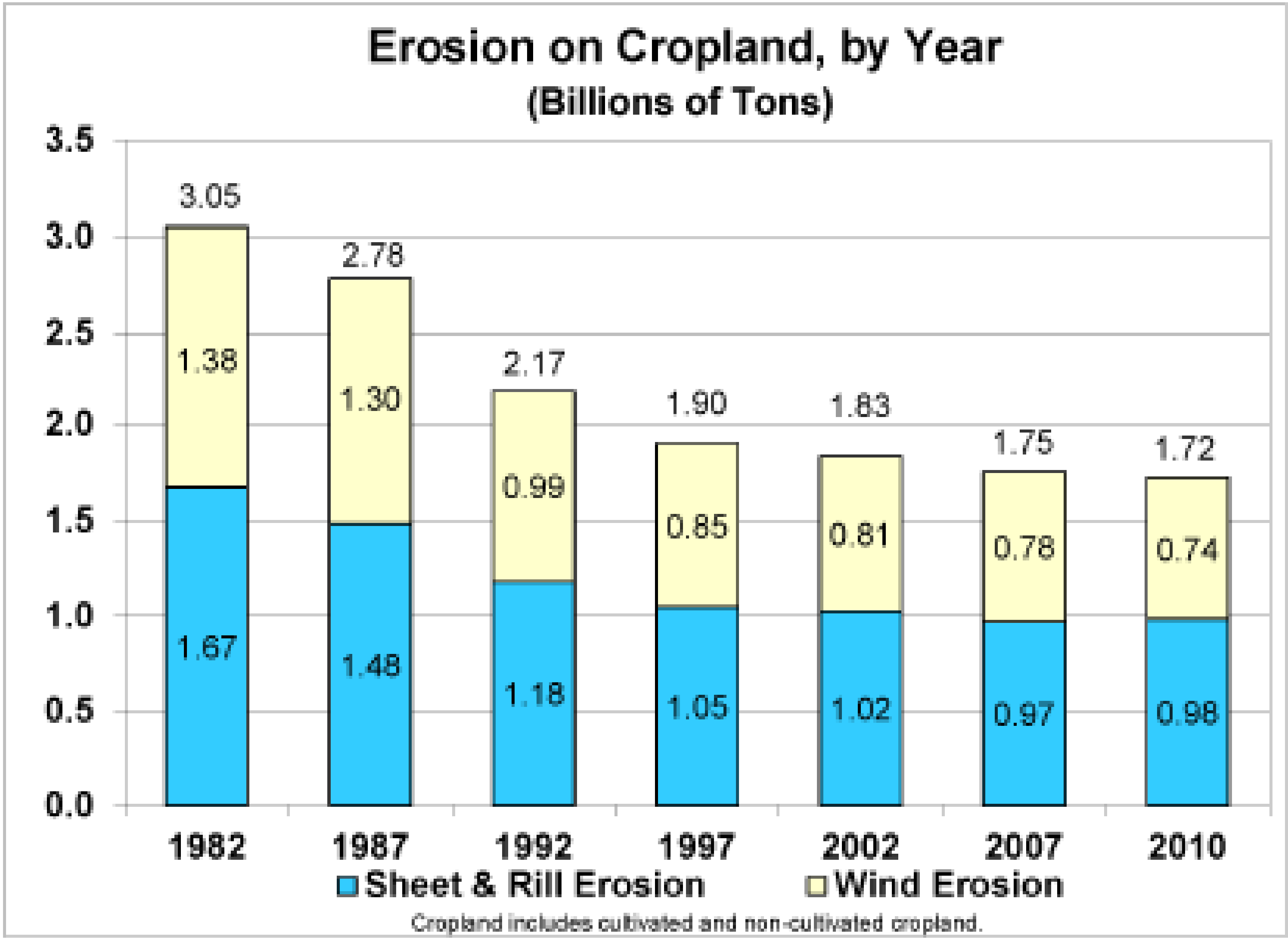
Example -Wood Chips -Denitrification bioreactors Precision conservation Delgado and Berry 2008

There is also potential to use denitrification traps to remove NO3-N from underground flows or water flows (Hey et al., 2005; Hunter, 2001). We suggest that Precision Conservation techniques could be used to analyze map and data information to strategically locate these nutrient traps at positions that can maximize the effectiveness in removing phosphorus and nitrates via denitrification.

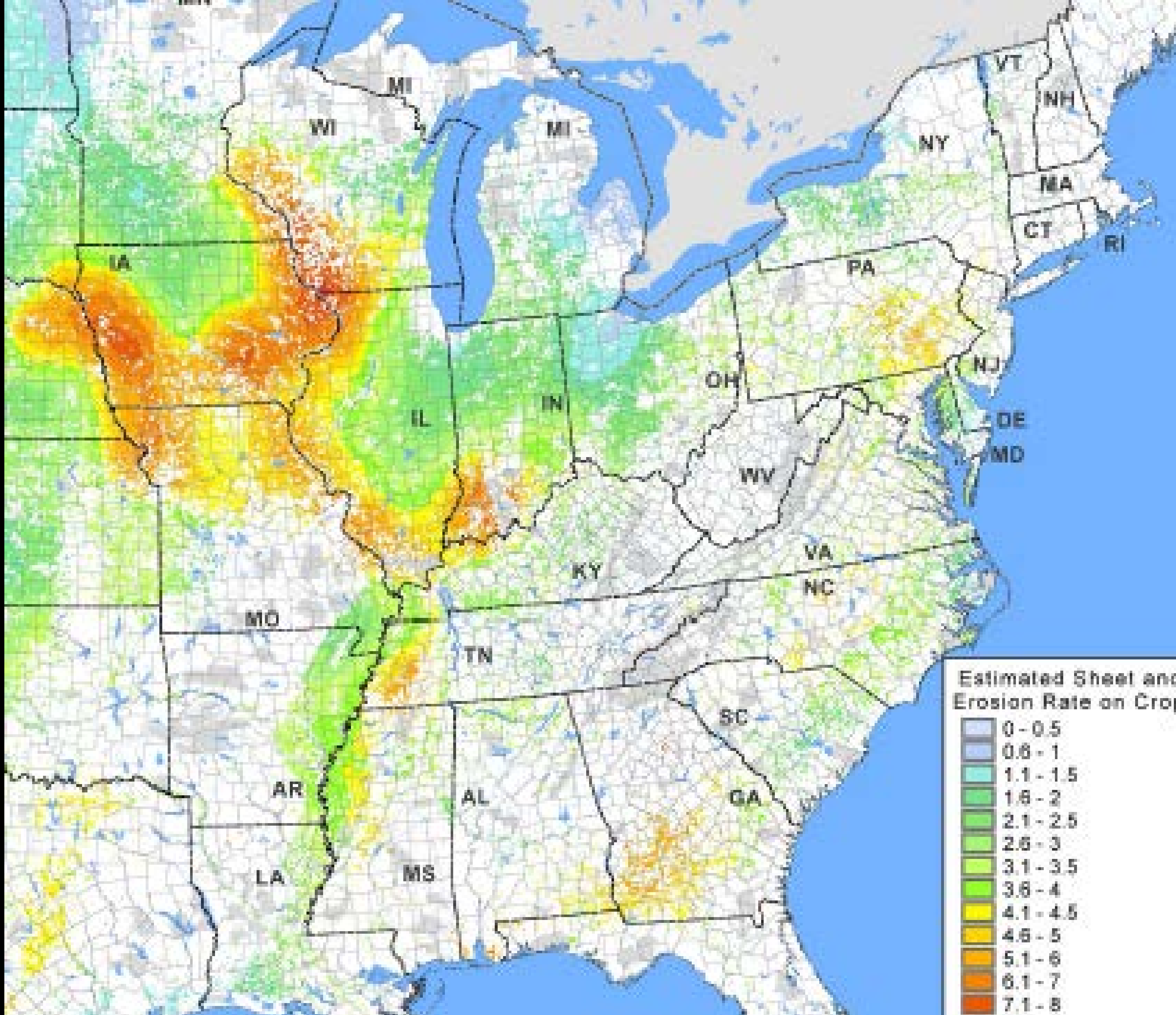
Example – Precision Conservation Wood Chips - Denitrification bioreactors Delgado and Berry 2008



Nutrient Management Plans
4 Rs is not enough, we need 7R s to apply precision conservation to reduce nutrient transport



NRCS 2010 National Resources Inventory


MI
WI
MI
NY
VT
NH
MA
CT
RI
PA
IA
NJ
OH
IL
IN
DE
MD
WV
VA
KY
NC
MO
TN
SC
AR
AL
GA
LA
MS
Estimated Sheet and
Erosion Rate on Crop
0 - 0.5
0.6 - 1
1.1 - 1.5
1.6 - 2
2.1 - 2.5
2.6 - 3
3.1 - 3.5
3.6 - 4
4.1 - 4.5
4.6 - 5
5.1 - 6
6.1 - 7
7.1 - 8

Additionally, climate change can increase the potential for higher erosion rates, which is also of concern because erosion has been reported to lower agricultural productivity by 10% to 20% (Quine and Zhang 2002; Cruse and Herndel 2009).

Source:

Iowa

NRCS

Potential erosion N loss from soil organic matter

SOM %➔	1	2	3	4
tons/acre	------------ lbs N /acre -----------			
2	3	6	9	12
4	6	12	17	23
6	9	17	26	35
8	12	23	35	46

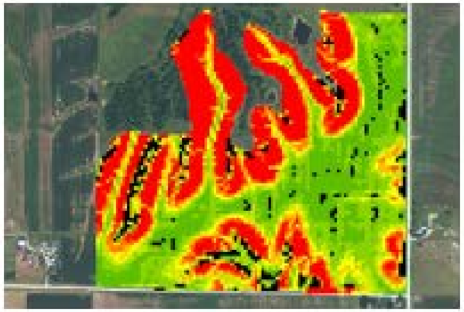
Potential erosion N loss from manure (55% water)

tons/manure acre	%Total N → 2	3	4	5
	------------ lbs N /acre -----------			
0.25	5	7	9	11
0.75	14	20	27	34
1.5	27	41	54	68
3	54	81	108	135

AGREN

SoilCalculator

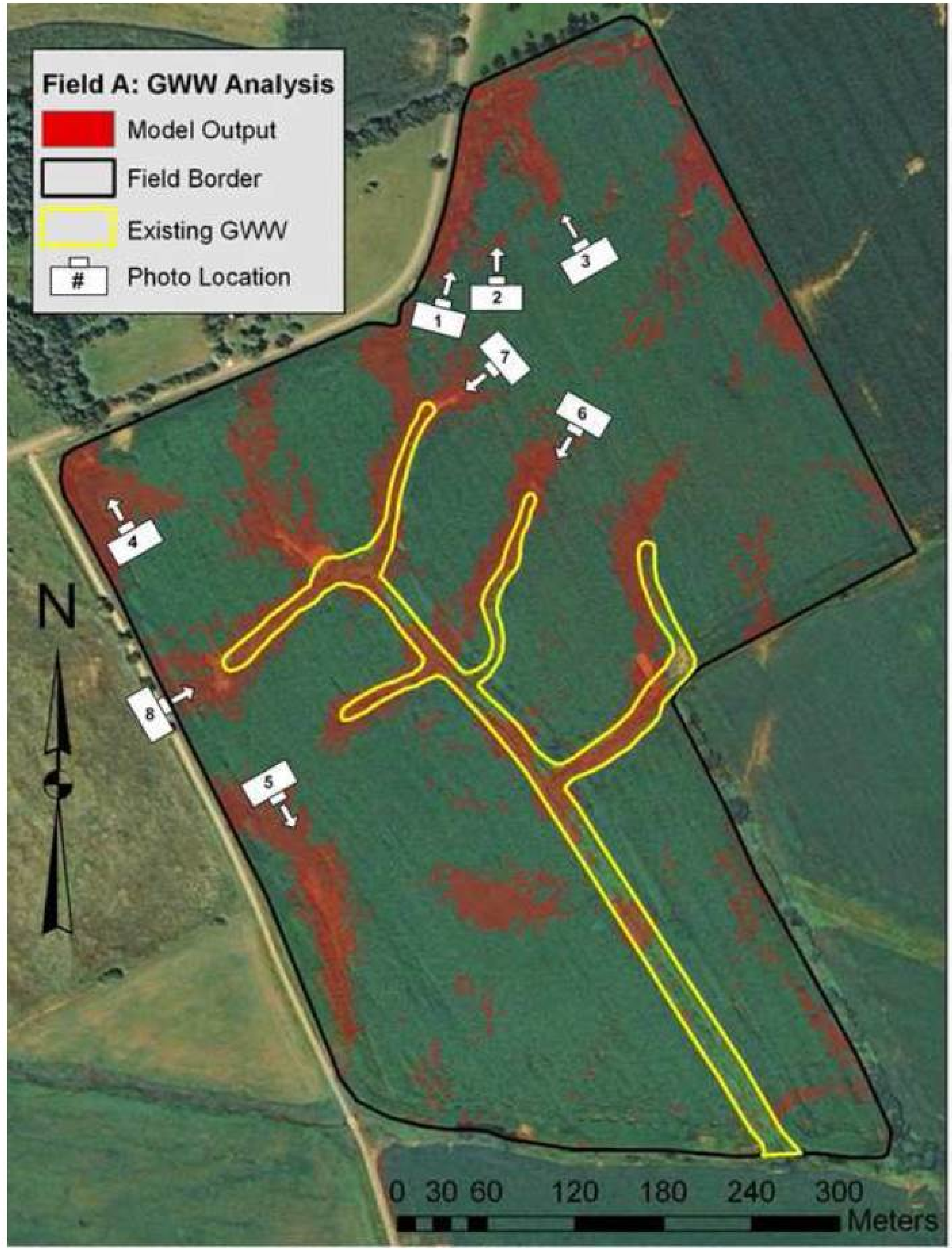
Calculate and control erosion with SoilCalculator

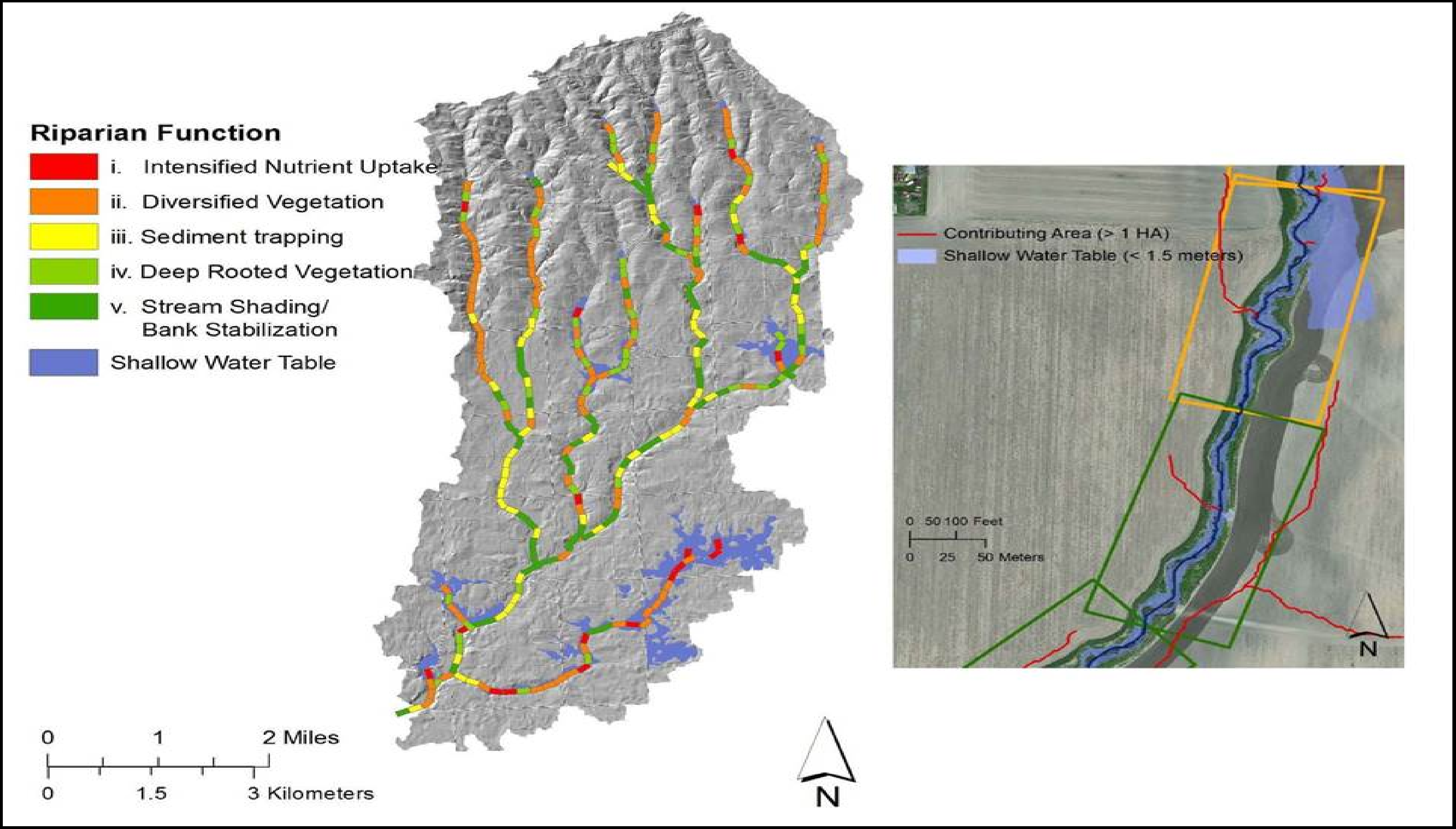


Soil erosion has a significant, negative impact on crop yields, especially in years when weather conditions are unfavorable. Erosion also results in lost nutrients and lowered land values.

Agren® SoilCalculator allows service providers to plug in various crop rotations, tillage systems, and conservation practices and view the resulting erosion predictions for up to three scenarios

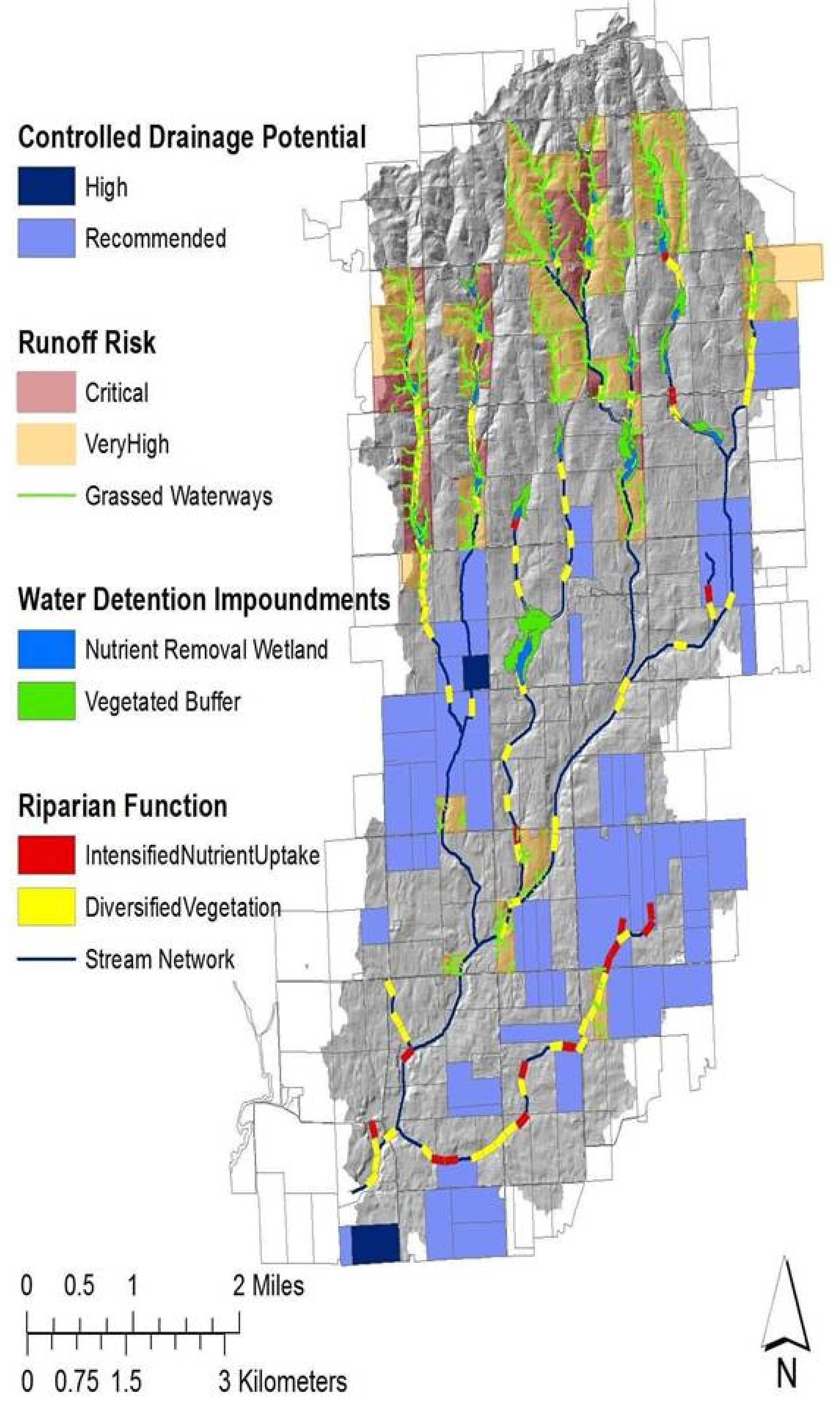
Aerial photograph of field A identifying probability of erosion model output (values >0.5 are shown in red), existing grassed waterways (GWWs), and locations of photographed eroded areas (1 m contour lines are shown in gray). (From Luck, J. D. et al., *J. Soil Water Conserv.* 65:280–288, 2010.)





Distribution of potential riparian buffer functions in Lime Creek and inset showing runoff pathways, shallow water table areas, and riparian segments used for classification. (From Tomer, M. D. et al., *J. Soil Water Conserv.* 68:113A–120A, 2013.)

One possible conservation planning scenario for Lime Creek. (From From Tomer, M. D. et al., *J. Soil Water Conserv.* 68:113A–120A, 2013.)



Thank You!

InfoAg 2015

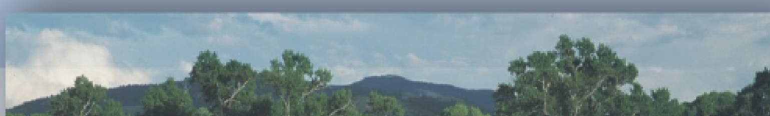
Extra

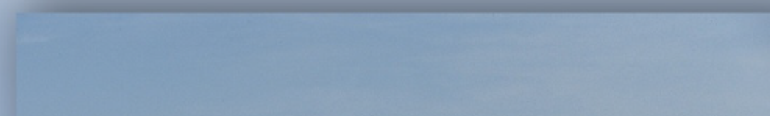
USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

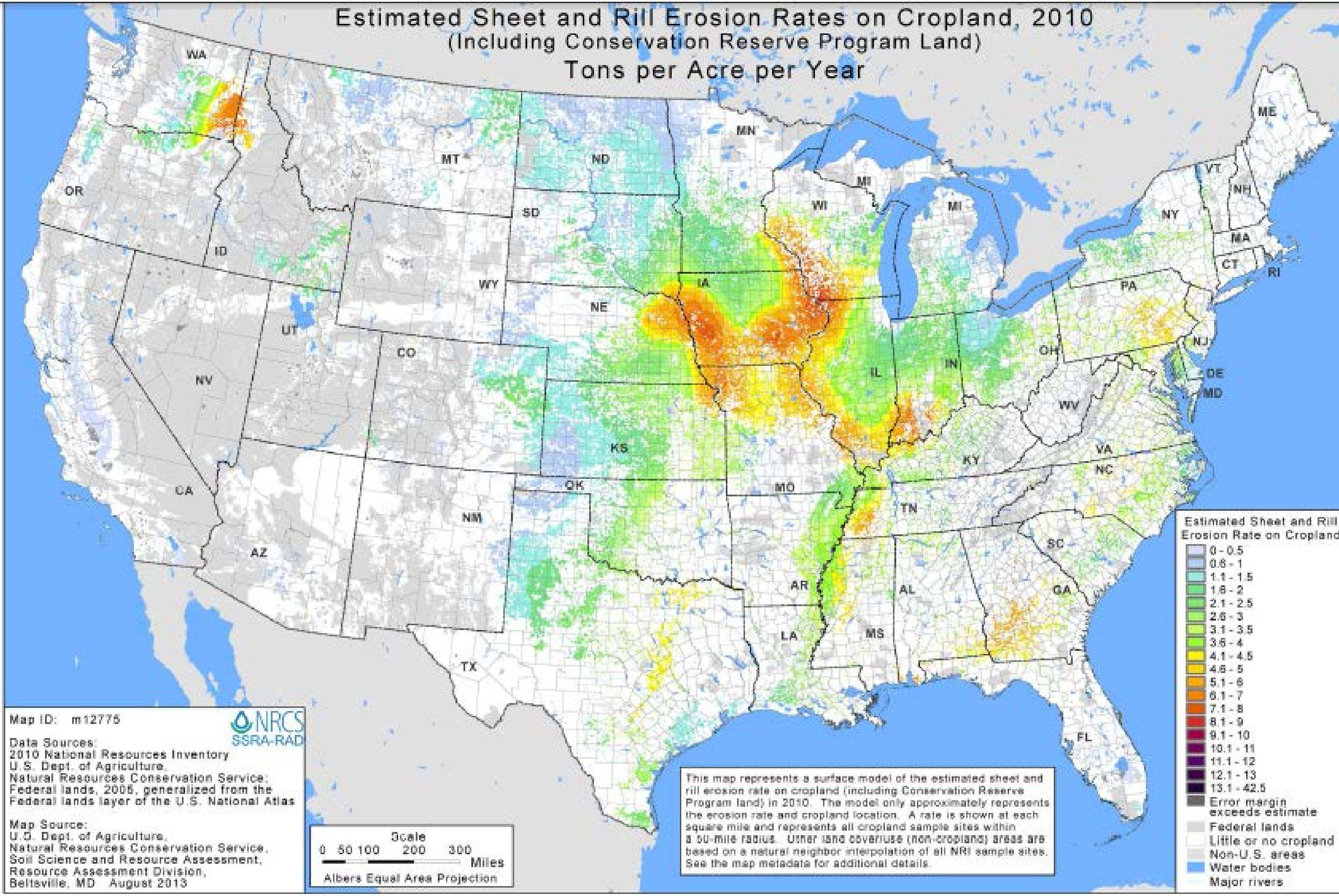
IOWA STATE UNIVERSITY
Center for
CSSM
Survey Statistics and Methodology

Summary Report

2010 National Resources Inventory






Estimated Sheet and Rill Erosion Rates on Cropland, 2010
(Including Conservation Reserve Program Land)
Tons per Acre per Year
WA
OR
ID
MT
ND
SD
WY
NE
IA
MN
WI
MI
MI
NY
VT
NH
ME
MA
CT
RI
PA
NJ
DE
MD
OH
IN
IL
WV
VA
KY
NC
TN
SC
GA
AL
MS
AR
LA
MO
KS
OK
TX
NM
CO
UT
NV
CA
AZ
FL
Estimated Sheet and Rill Erosion Rate on Cropland
0 - 0.5
0.6 - 1
1.1 - 1.5
1.6 - 2
2.1 - 2.5
2.6 - 3
3.1 - 3.5
3.6 - 4
4.1 - 4.5
4.6 - 5
5.1 - 6
6.1 - 7
7.1 - 8
8.1 - 9
9.1 - 10
10.1 - 11
11.1 - 12
12.1 - 13
13.1 - 42.5
Error margin exceeds estimate
Federal lands
Little or no cropland
Non-U.S. areas
Water bodies
Major rivers
This map represents a surface model of the estimated sheet and rill erosion rate on cropland (including Conservation Reserve Program land) in 2010. The model only approximately represents the erosion rate and cropland location. A rate is shown at each square mile and represents all cropland sample sites within a 50-mile radius. Other land cover/use (non-cropland) areas are based on a natural neighbor interpolation of all NRI sample sites. See the map metadata for additional details.
Map ID: m12775
NRCS
SSRA-RAD
Data Sources:
2010 National Resources Inventory
U.S. Dept. of Agriculture,
Natural Resources Conservation Service;
Federal lands, 2005, generalized from the
Federal lands layer of the U.S. National Atlas
Map Source:
U.S. Dept. of Agriculture,
Natural Resources Conservation Service,
Soil Science and Resource Assessment,
Resource Assessment Division,
Beltsville, MD August 2013
Scale
0 50 100 200 300
Miles
Albers Equal Area Projection

Nutrient Management Plans

It’s my understanding that these predictions and assessments of sheet and rill erosion are not considering gully erosion rates. There is a need to use precision conservation to identify areas where conservation practices can be implemented to apply, for example, grass waterways to reduce the formation of these gullies and reduce loss of nutrients.

Nutrient Management Plans

Conservation practices have helped significantly reduce erosion losses in the USA during the last 30 years (by 43%). Since erosion contributes to transport of soil organic matter and nutrients such as nitrogen, phosphorus, and other macro and micro nutrients off site, reducing erosion losses reduces losses of nutrients. However, during the last few years (2007-2010) erosion losses have not been reduced significantly. Additionally, projected changes in climate and projected increases in precipitation for some areas of the USA, as well as projected increases in precipitation intensities, are projected to contribute to increases in erosion rates in the future due to higher precipitation.

Outline

- ***Major Global Challenges***

Dr. Jorge A. Delgado
Soil-Plant-Nutrient Research Unit, USDA/ARS

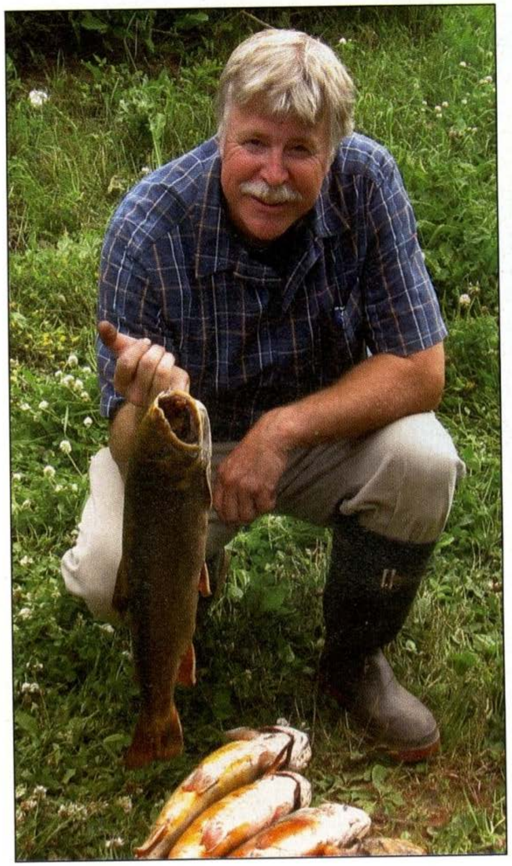
Bakker et al. (2004) concluded that the best methodology to represent the effects of erosion was the plot methodology and that an average of 4% loss in productivity per every 10 cm of soil loss should be considered realistic as far as the negative impacts to yield production from erosion.

More important was the report from Bakker et al. (2004) showing that the relationship of yield losses to soil depth lost will be convex, so any further losses in soil depth after the first 10 cm of soil lost will become increasingly severe and damaging to soil quality, reducing yield by a greater amount.

IN THE NEWS

Runoff from potato farms blamed for fish kills on Canadian island

Kathy Birt



Gerald MacDougall, manager of forest, fish and wildlife for the Prince Edward Island Department of Environment, cleans up dead fish from a recent Dunk River fish kill.

Journal of Soil and Water Conservation

2007

Volume 6: November-December

Page 136 A

Source:

Department of Environmental Protection

Maine

- ***Major New Challenges***

A Changing Climate

Dr. Jorge A. Delgado
Soil-Plant-Nutrient Research Unit, USDA/ARS

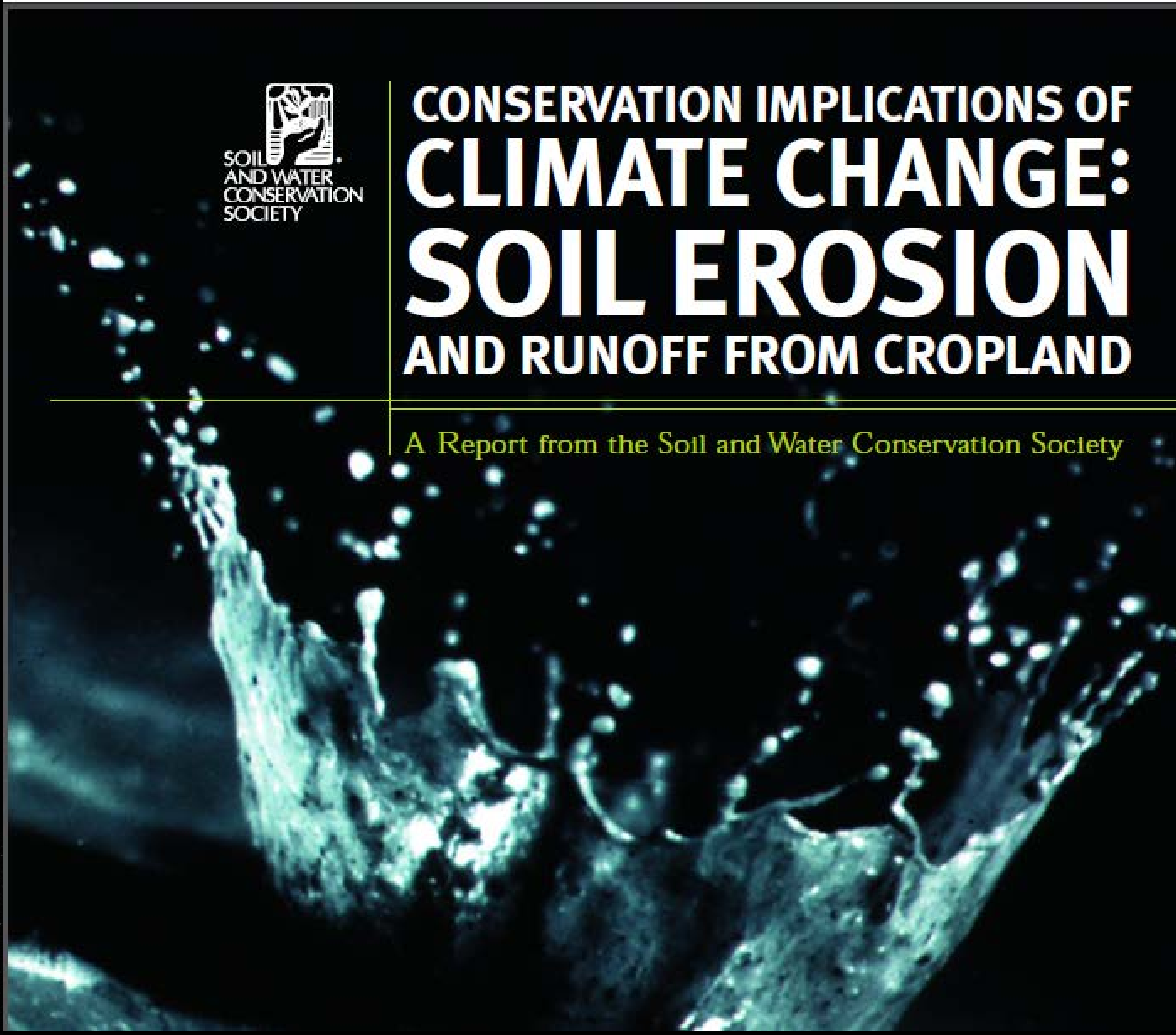
Major World Challenges Related to Soil and Water Conservation

- Extreme weather events are creating environmental problems, accelerating the rate of erosion and threatening agricultural production needed for food security.

Photo EPA

Photo ARS

Photo NRCS


SOIL AND WATER CONSERVATION SOCIETY
CONSERVATION IMPLICATIONS OF
CLIMATE CHANGE:
SOIL EROSION
AND RUNOFF FROM CROPLAND
A Report from the Soil and Water Conservation Society

Pruski and Nearing (2002) reported that the predicted erosion rate will increase by 1.7% for every 1% increase in total rainfall due to climate change.

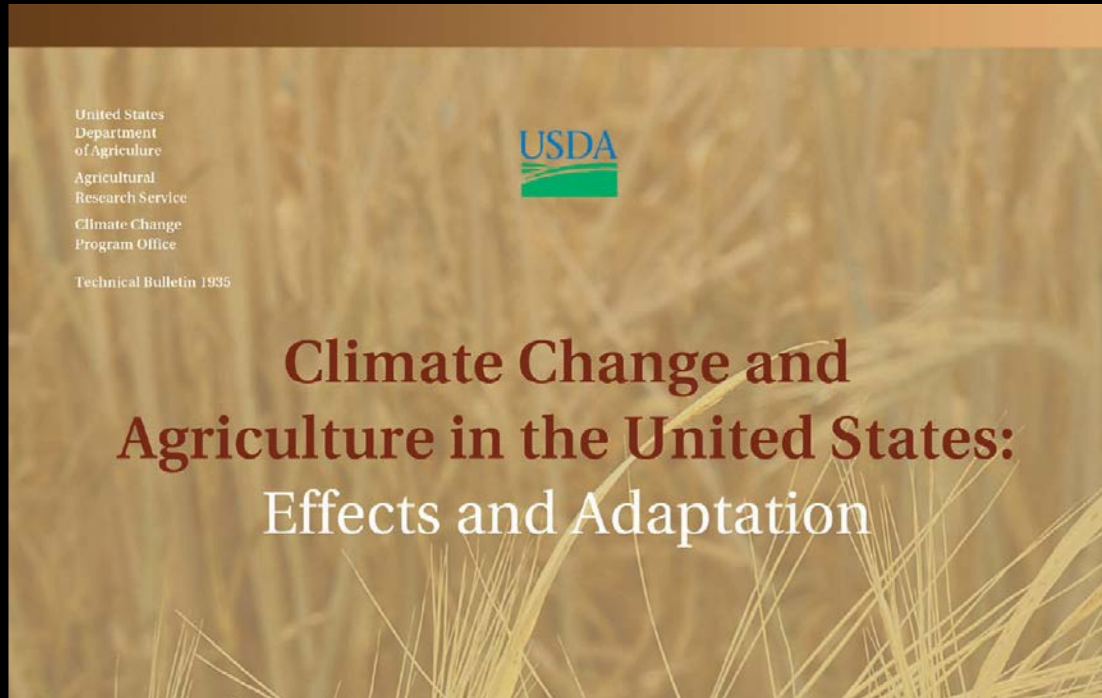
It's not only about changes in total precipitation. Several publications have reported that, over the last few decades, rainfall intensities have also increased in many parts of the world, including in the United States (Karl and Knight, 1998; Soil and Water Conservation Society, 2003; Groisman et al. 2005). These reports show that the number of large events is on the rise and that the increases have been the greatest for the most extreme of events. These reports are in agreement with the IPCC 4th Assessment Report (Meehl et al., 2007) that predicted that for many parts of the globe, general increases in the intensity of precipitation could be expected.

Drier areas (e.g., the southwestern United States is projected to be drier in the future) could also increase the potential for wind erosion, so it is important that we implement precision conservation to account for this temporal and spatial variability in weather patterns.

Also keep in mind that erosion can contribute to the transport of nutrients from inorganic fertilizer and from organic manure sources, so it is important for nutrient management and the 4 Rs that precision conservation be considered as part of nutrient management plans.

Bakker et al. (2004) conducted a detailed analysis of 24 studies that were published during the 1970s to early 2000s examining erosion’s effects on productivity and that measured the quantity of lost productivity per amount of eroded soil.

They found that the average yield lost across the different methodologies was 4.3%, 10.9%, and 29.6% loss in soil productivity per every 10-cm loss of soil measured with comparative plots, transect methods, and desurfacing experiments, respectively.



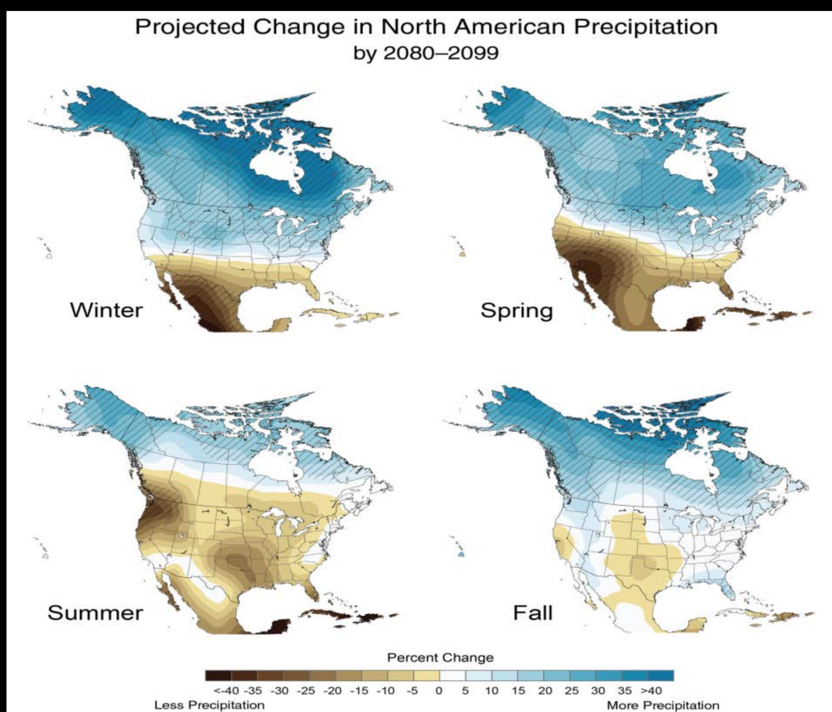
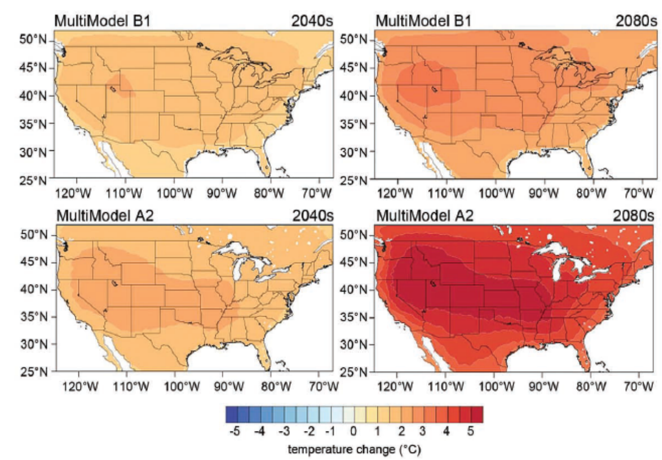


Fig. 3.6. Projections of U.S. summer surface temperature from a 16-model ensemble for a low emissions scenario (SRES-B1, top panels) and a high emissions scenario (SRES-A2, bottom panels) relative to 1970-1999. The near-term differences between scenarios (left panels showing the 2040s) are much smaller than the long-term differences (right panels showing the 2080s). Data source: CMIP3.



29

doi:10.2489/jswc.66.4.118A

FEATURE

Conservation practices to mitigate and adapt to climate change

Jorge A. Delgado, Peter M. Groffman, Mark A. Nearing, Tom Goddard, Don Reicosky, Rattan Lal, Newell R. Kitchen, Charles W. Rice, Dan Towery, and Paul Salon

Climate change, in combination with the expanding human population, presents a formidable food security challenge: how will we feed a world population that is expected to grow by an additional 2.4 billion people by 2050? Population growth and the dynamics of climate change will also exacerbate other issues, such as desertification, deforestation, erosion, degradation of water quality, and depletion of water resources, further complicating the challenge of food security. These factors, together with the fact that energy prices may increase in the future, which will increase the cost of agricultural inputs, such as fertilizer and fuel, make the double those of nonirrigated systems. The yields of nonirrigated systems could also potentially be reduced due to these stresses. Since there is a direct relationship between soil and water conservation practices and maintaining and/or increasing productivity, the research suggests that without the application of the best soil and water conservation practices, it will not be possible to maintain the productivity levels that are needed to feed the additional billions of people the world is expected to have by 2050. A sound scientific approach that applies concepts in agronomy, soil science, and conservation will be needed to maintain sustainable and productive agri-

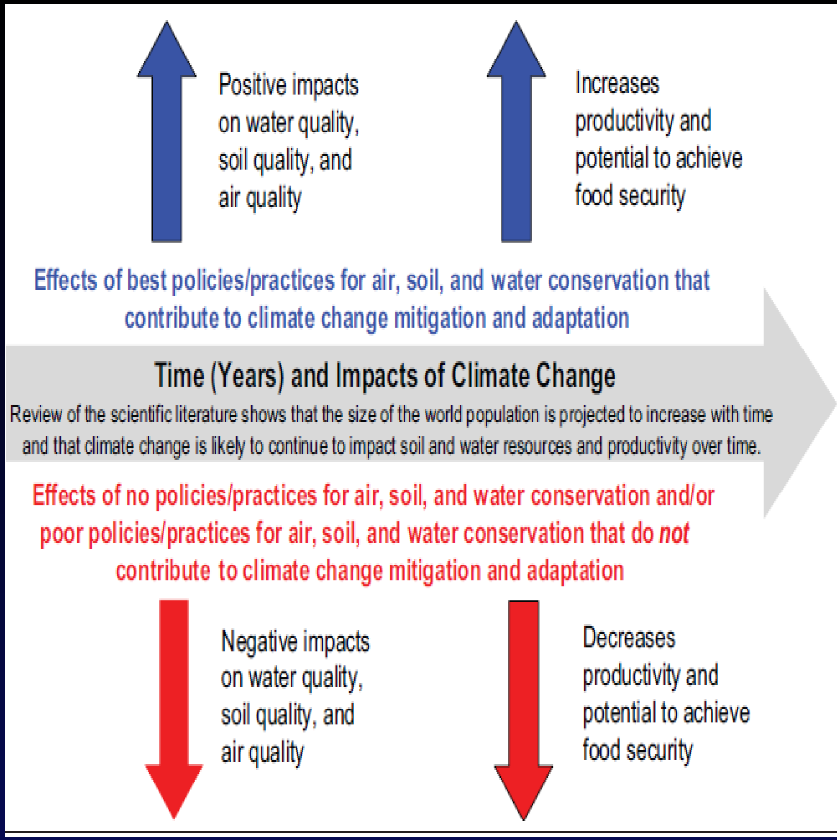
entific societies provide opportunities for scientists, conservation practitioners, consultants, farmers, and the general public to get together to share ideas and could be great forums for discussing the principles summarized in this document.

This review of current science strongly suggests that the future of the planet's food security will depend on how water and soil resources are managed today and in the future. These challenges can be met by maximizing soil and water conservation to develop sustainable systems essential to mitigate climate change and adapt to it.

MAJOR WORLD CHALLENGES RELATED

Delgado et al. 2011 *Journal of Soil and Water Conservation*

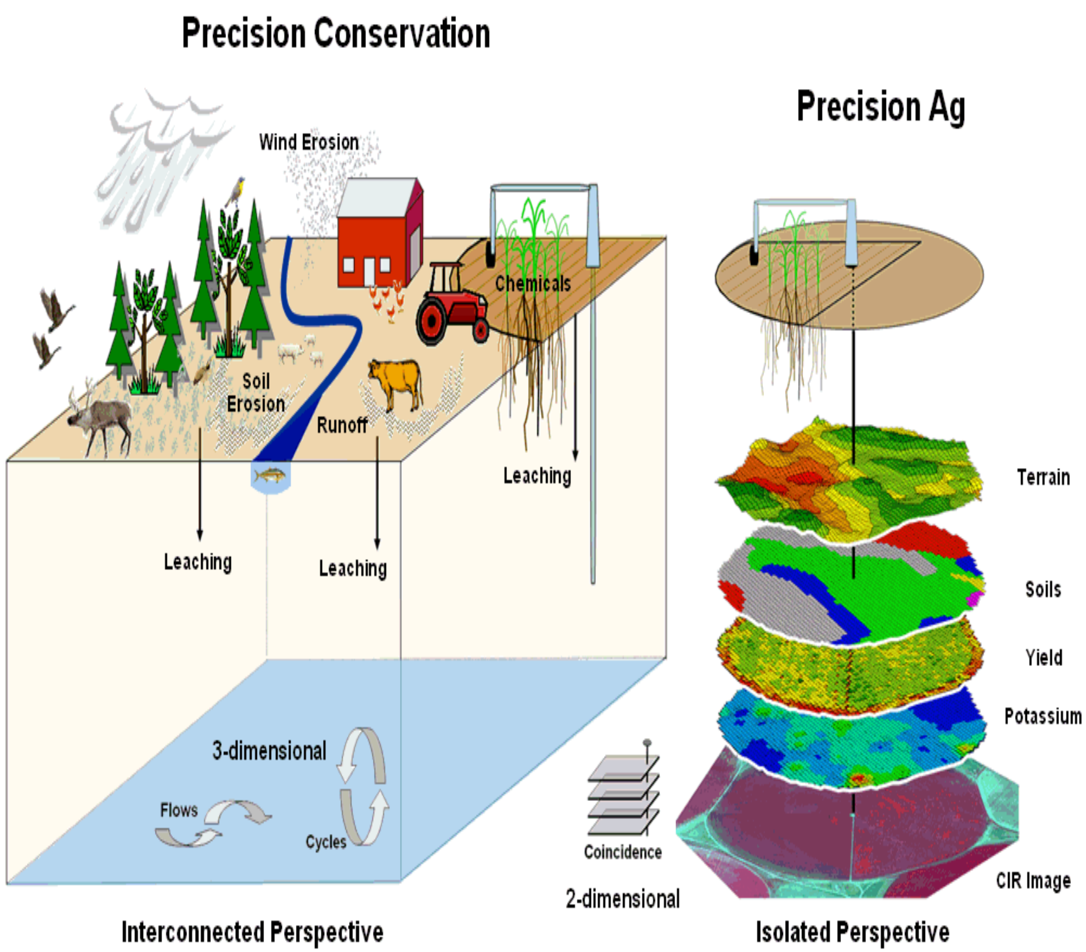
The scientific literature suggests that with use of good policies, conservation programs, and practices we could have a better opportunity to achieve food security (good air, soil and water quality), while with bad policies and/or a lack of policies/conservation practices for climate change mitigation and adaptation, we will have lower air quality, soil quality and water quality, and there will be less potential to achieve food security.



Nutrient Management Plans

Nutrient management needs to be aware of the challenges ahead if climate change has the potential to increase erosion rates. There is the need to use conservation practices for climate change adaptation and improvement of soil quality and soil productivity. Delgado et al. (2011) reported that conservation practices are key for climate change adaptation and mitigation. Precision conservation could be a key tool for climate change adaptation.

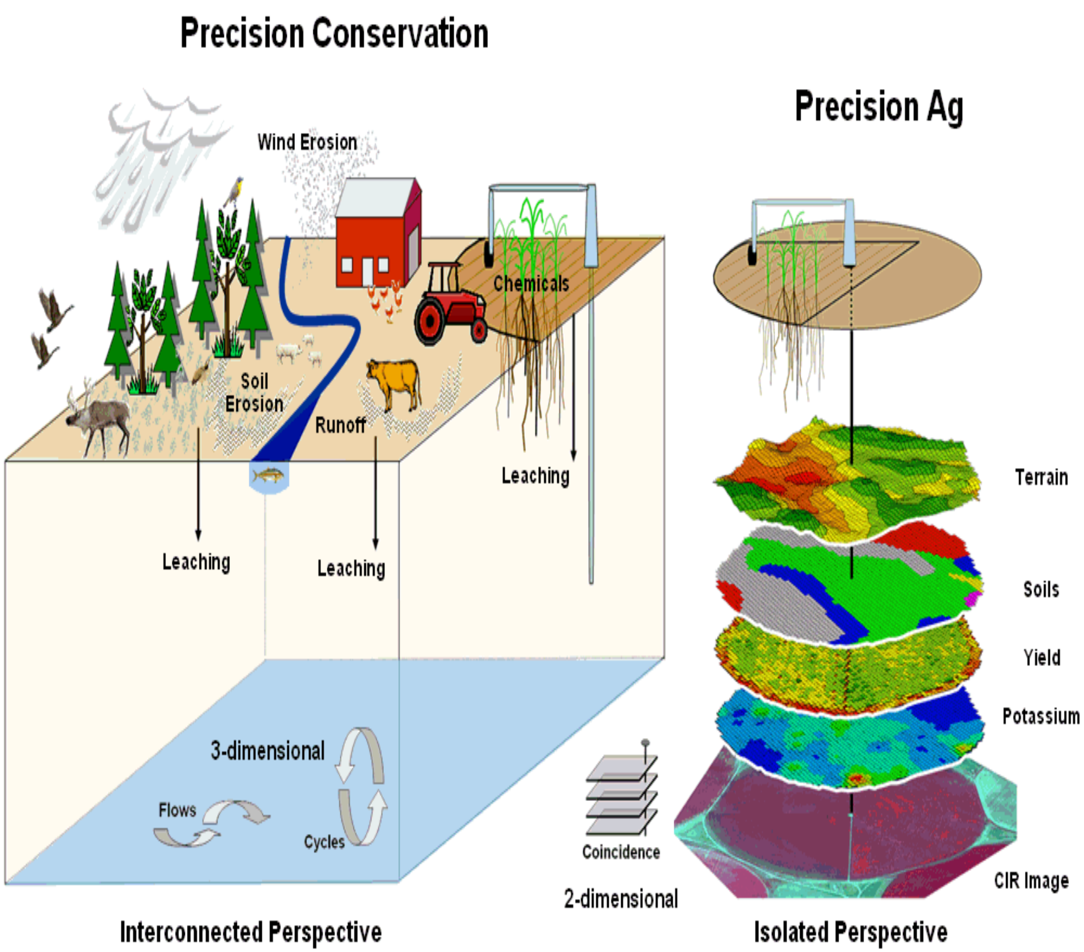
Precision Conservation



New Recent Advances in Precision Conservation:

Assessment of Watershed Hot Spots and Flows

Precision Conservation



New Recent Advances in Precision Conservation:

Assessment of Field Spatial Erosion and Spatial Buffer Practices

Take Home Message

New Advances in Precision Conservation Assessment of Watershed Hot Spots and Flows can:

•assess variable hydrology and erosion across the watershed

• help develop site specific conservation practices such as sight specific ponds, grass waterways, buffers, denitrification farms, and may be able to manage these flows

Nutrient Management Plans

There are several peer-review papers presenting these concepts about how precision conservation can be used to assess the potential use of conservation practices. There are several papers showing that precision conservation can work.

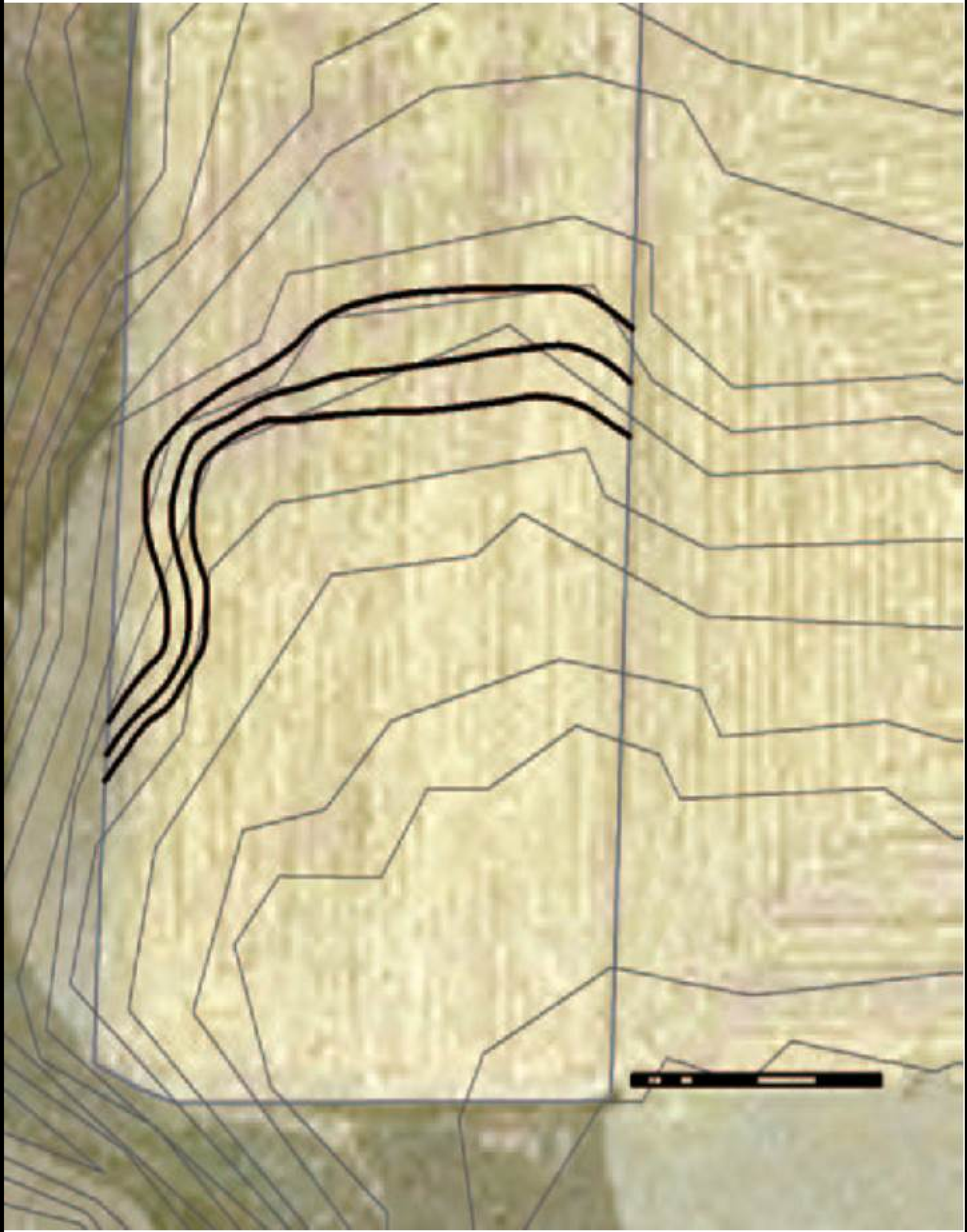
A Few Examples: See Delgado and Berry 2008

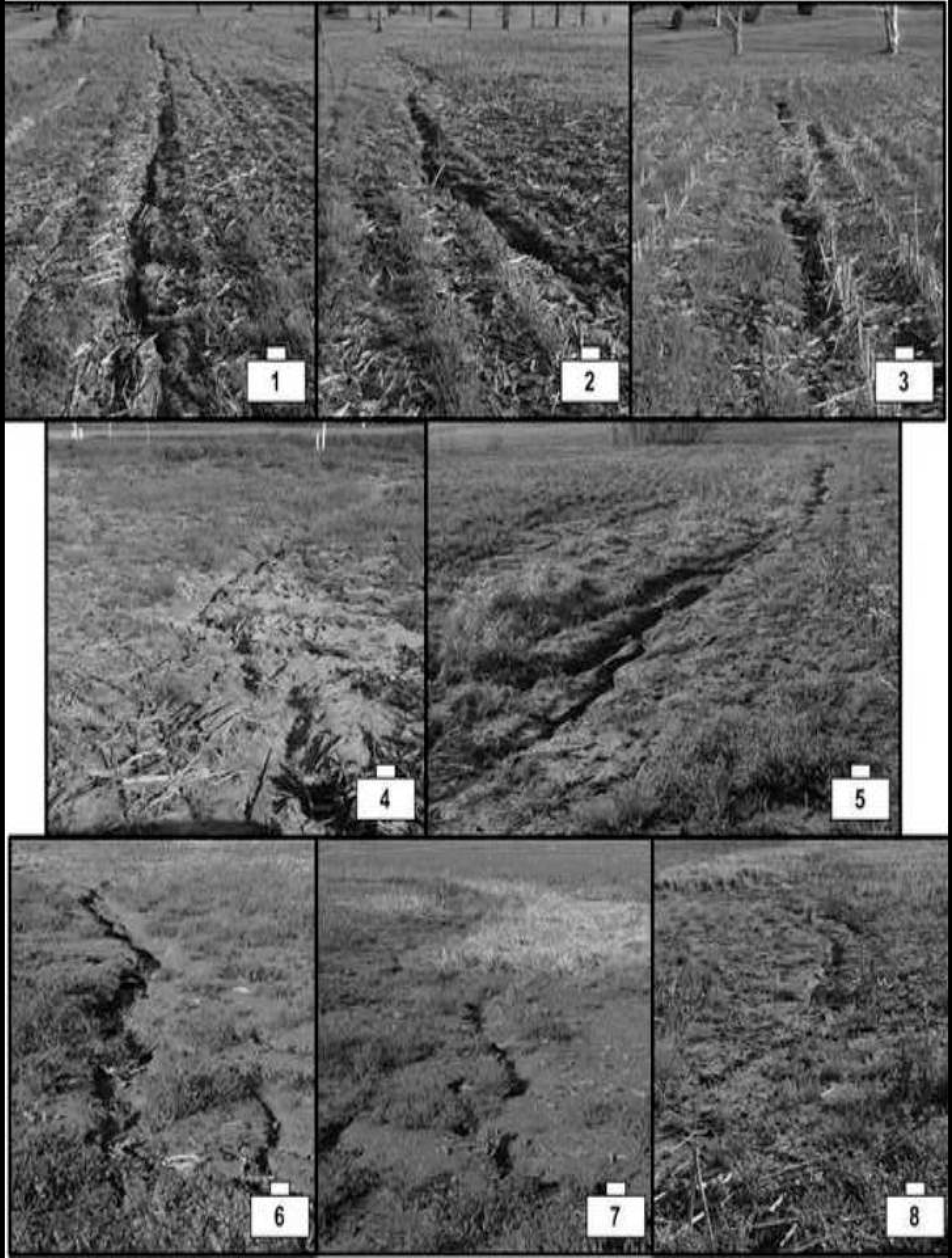
Table 1 (*continued*)

Location	Conservation practice	Definition	Precision conservation potential
			chemicals out of the field (Schumacher *et al.*, 2005).
Field/natural area	Nutrient traps	Installation of nutrient traps or denitrification traps to remove nutrients from field outflows.	Spatial assessment of field erosion and variable hydrology can be used for development of maps to identify areas with higher flows of phosphorus and nitrates in fields and/or field borders and natural areas. There is the potential to use phosphorus sorbing materials (PSMs) to decrease the potential for off-site transport of phosphorus in runoff water. There is also potential to use denitrification traps to reduce NO_3-N concentrations in runoff water or underground water flows (Hunter, 2001; Penn *et al.*, 2007).

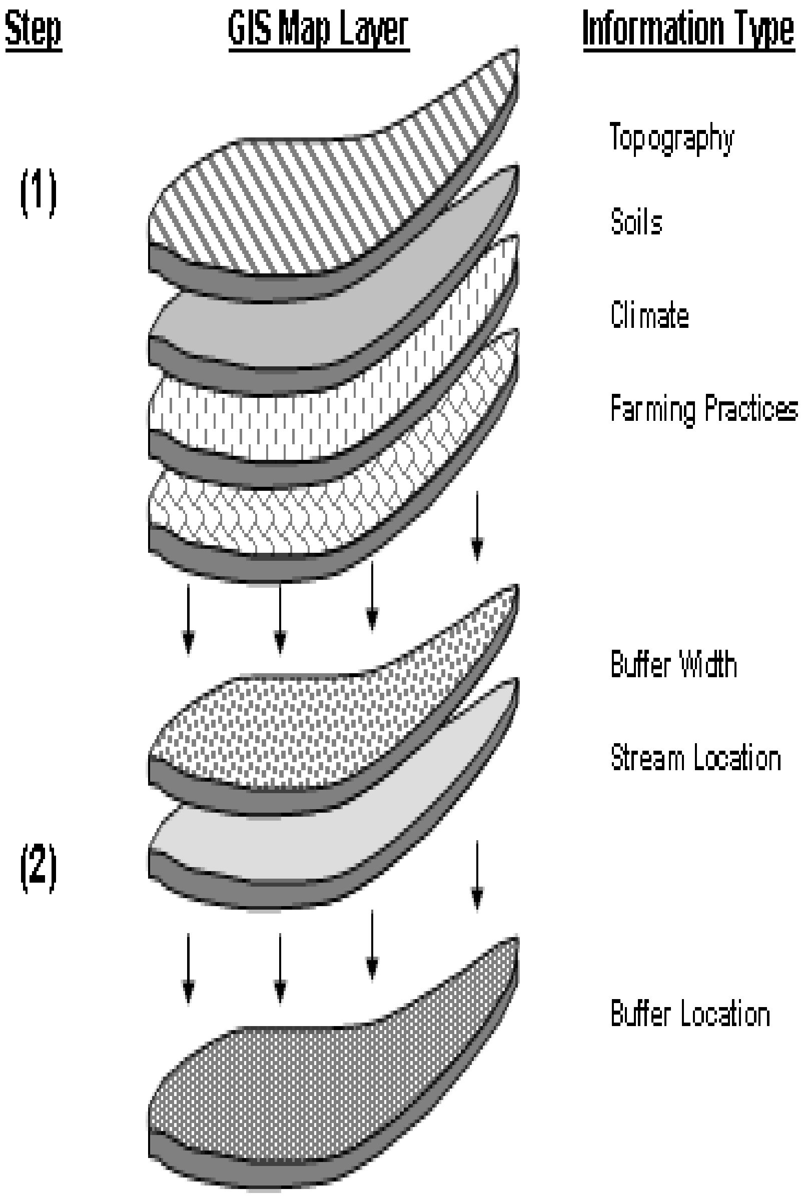
[a] Some of these are practices recommended by USDA-NRCS. We suggest that there is potential to apply the concepts of Precision Conservation to these USDA-NRCS-recommended practices and to other practices included in this report. We suggest that these practices can be implemented site specifically in fields and natural areas by using layers of information that identify hot spots across the landscape. We also suggest that there is potential to use models, map and data analysis software, and Precision Conservation techniques to modify these practices, taking the site-specific spatial and temporal information about flows into consideration. There is also potential to implement these practices using different device shapes and/or species to better account for variable spatial and temporal hydrology and flows. We suggest that there is significant potential to develop new practices for Precision Conservation of soil and water, such as the integration of animal behavior management with soil and water conservation.

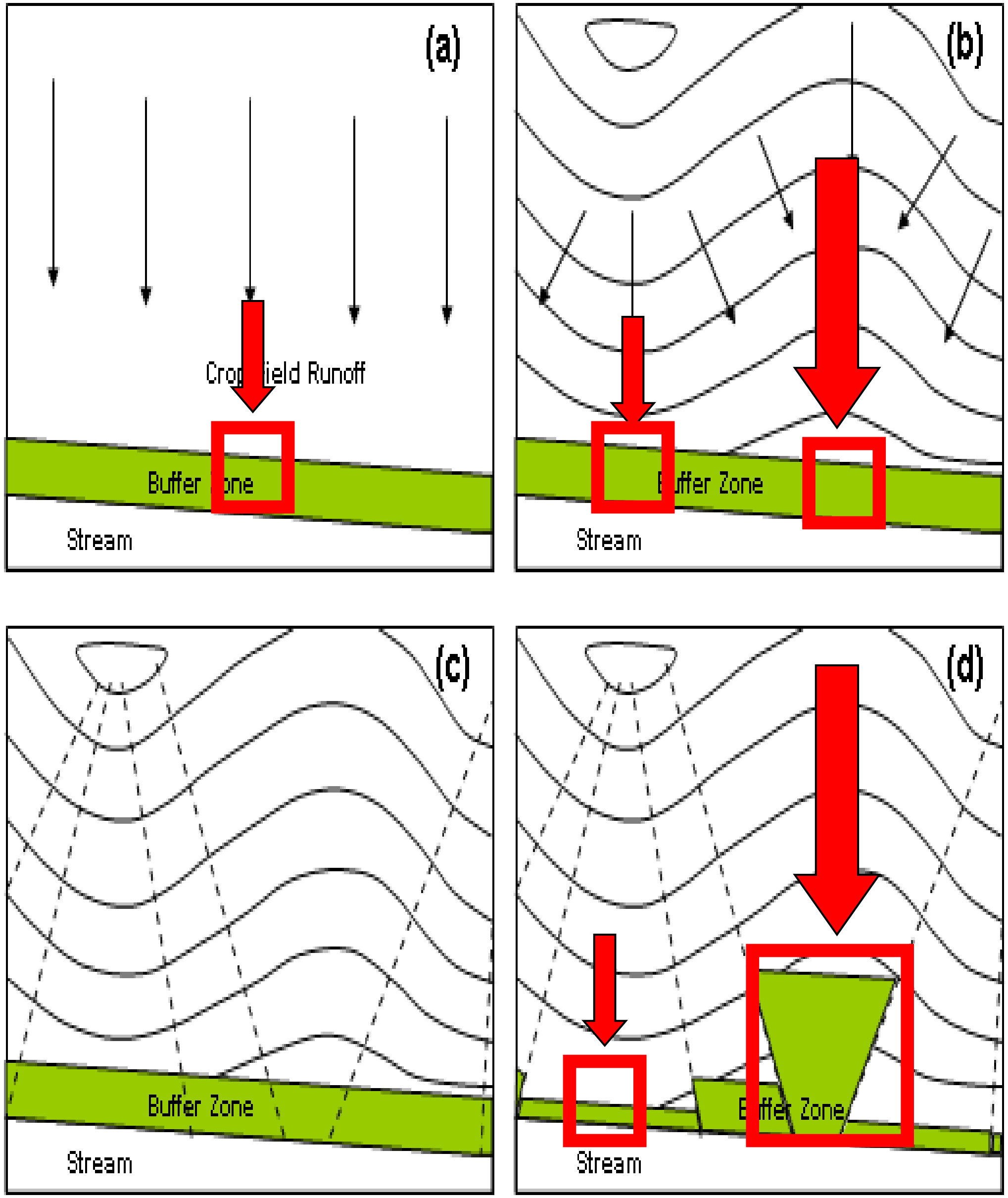
Schematic of contour furrow application to a winter wheat field. (From Williams, J. D. et al., *J. Soil Water Conserv.* 66:355–361, 2011.)





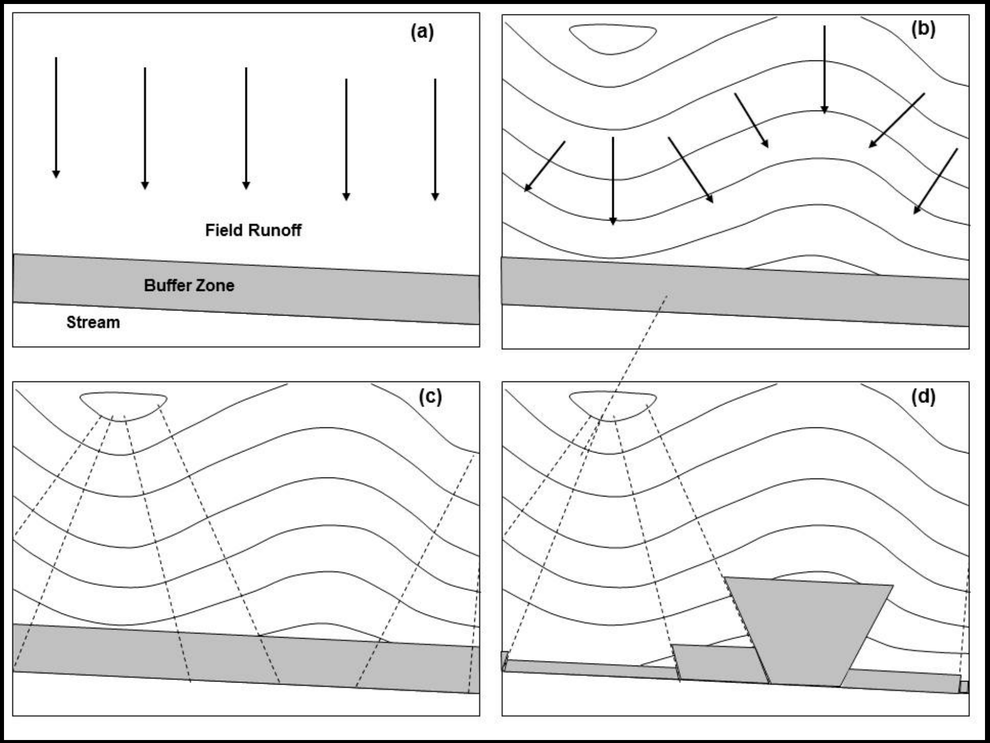
Photographs of eroded areas in field A taken in April 2009 (locations and viewpoint identified in Figure 4.6). (From Luck, J. D. et al., *J. Soil Water Conserv.* 65:280–288, 2010.)

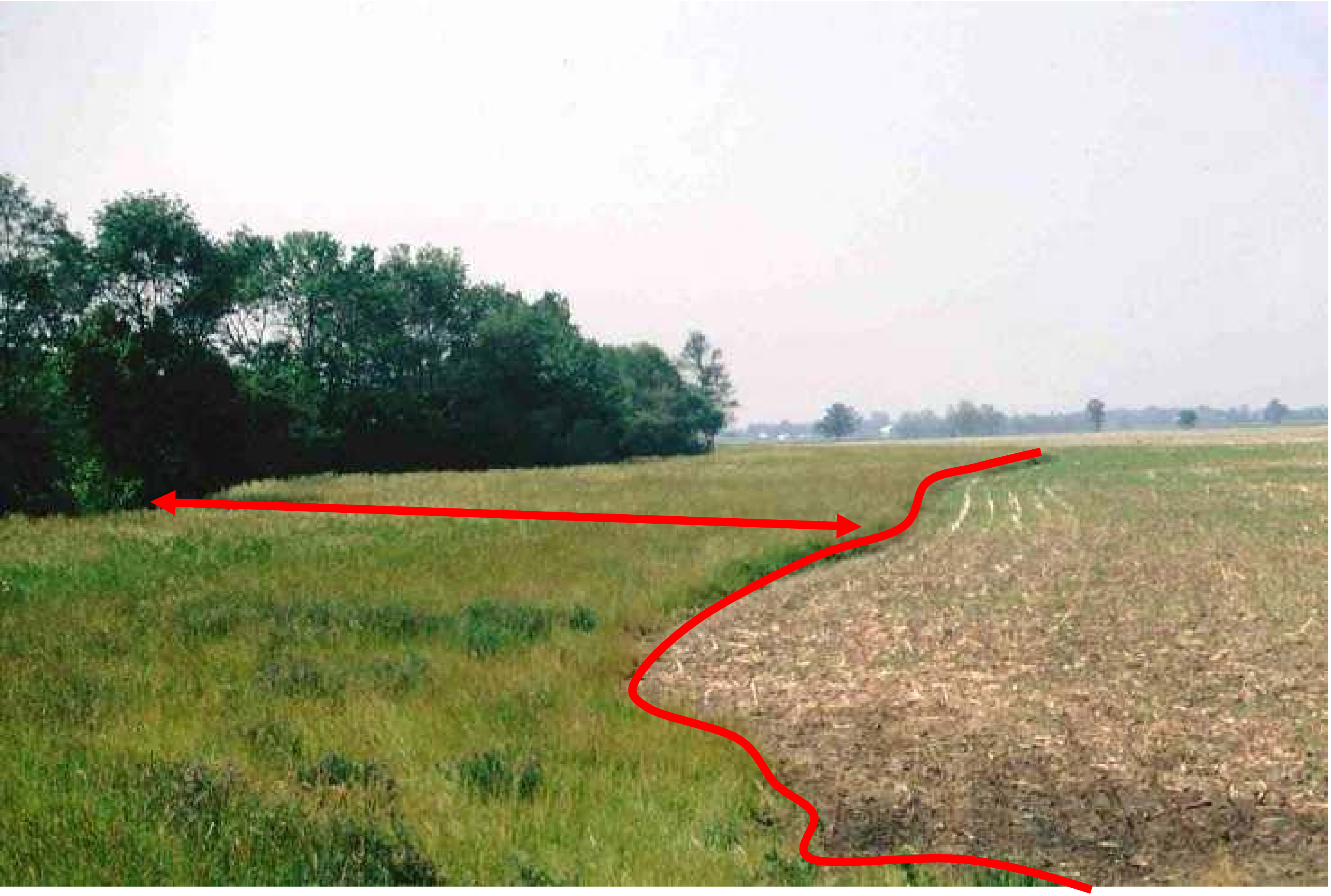




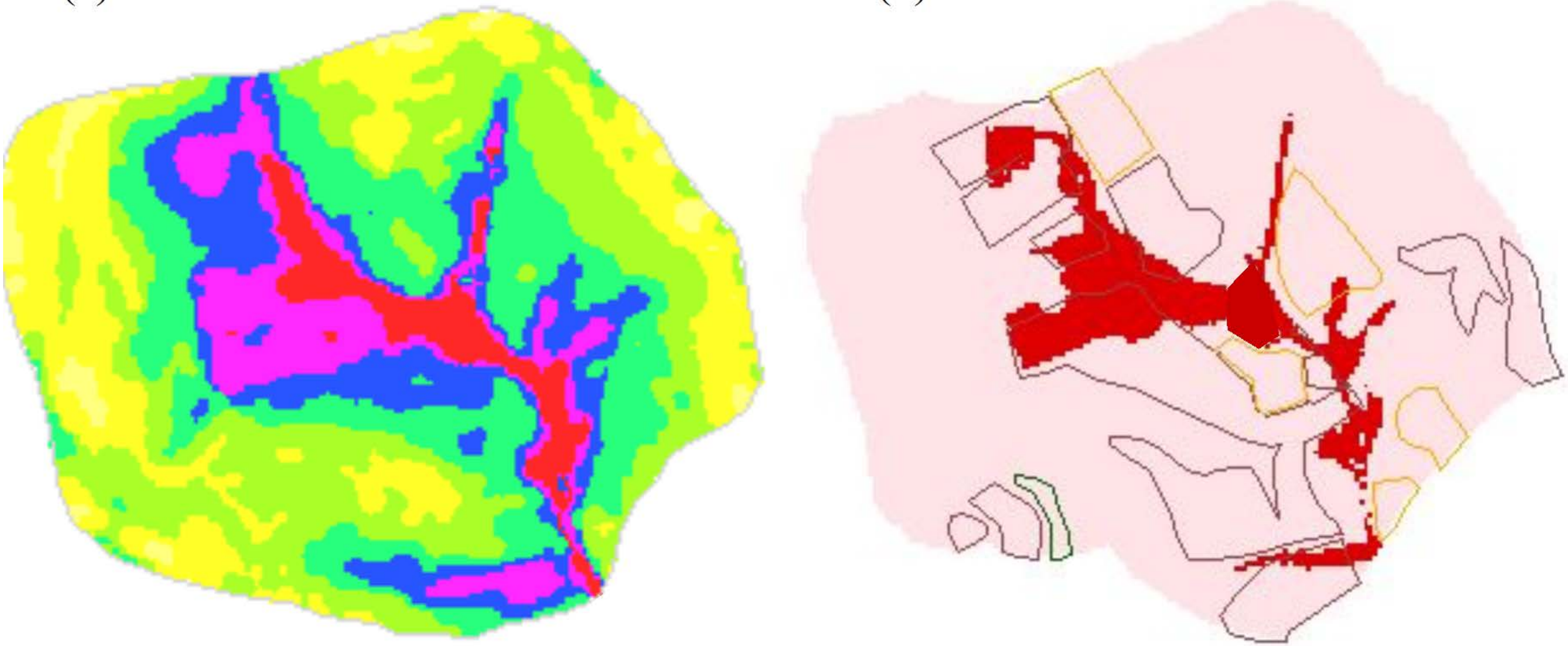
Dosskey et al. 2005, JSWC

Diagrams of crop-field runoff patterns, topographic contours, and alternative buffer designs: (a) uniform runoff flow to a uniform-width buffer, (b) nonuniform runoff flow to a uniform-width buffer, (c) nonuniform runoff areas and the corresponding uniform-width buffer locations to which they flow, and (d) nonuniform runoff areas and the corresponding variable-width buffer areas to which they flow. Both (a) and (d) yield an approximately constant level of pollutant filtering along the entire length of the buffer. (From Dosskey, M. G. et al., *J. Soil Water Conserv.* 62:349–354, 2005.)





(a) VSAs (b) HSAs and CMAs



From Qui et al. 2007, JSWC

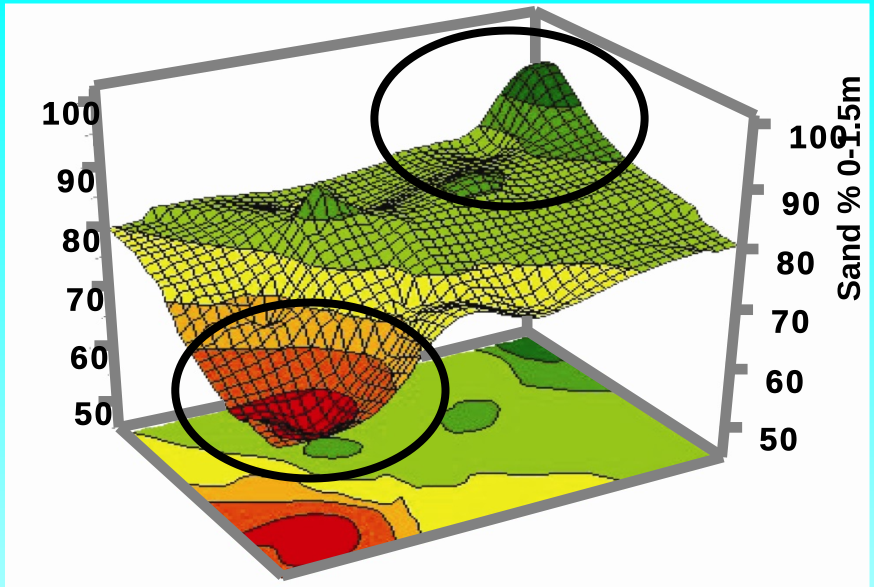


***Figure 5**. Spatial distribution of sand content in the top 1.5 m of soil for Study One across the different productivity zones during the 2000 growing season.*

From Delgado and Bausch, 2005, JSWC

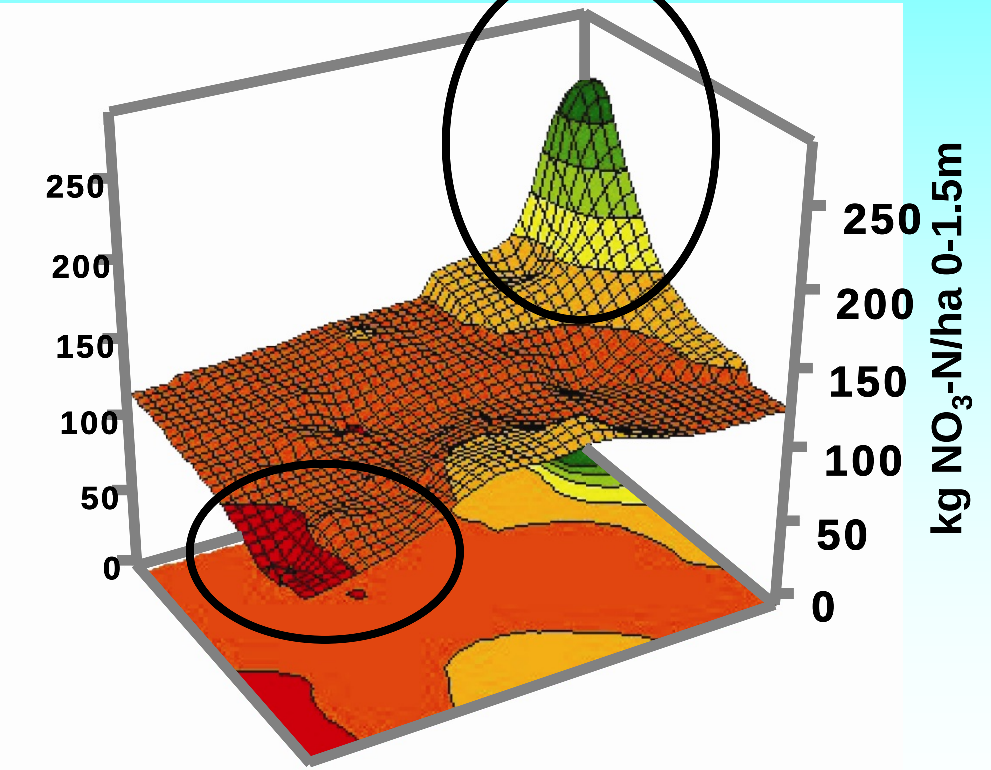
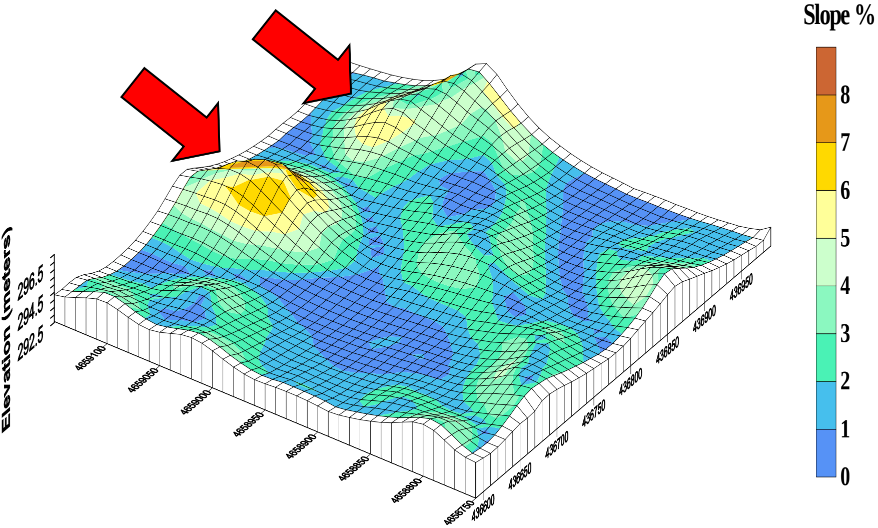
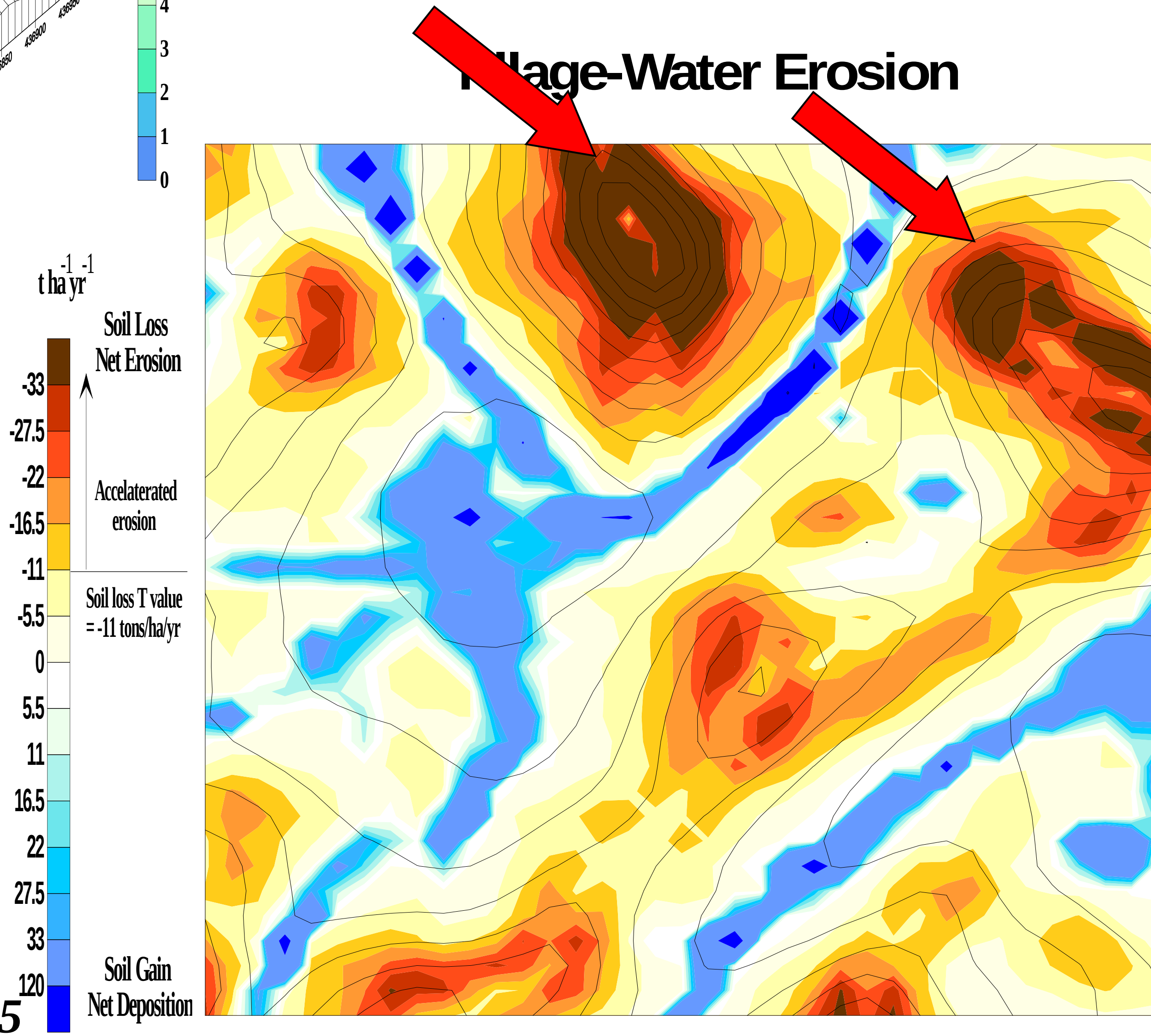


***Figure 8**. Spatial distribution of predicted NO_3-N leaching from the root zone of corn (1.5 m depth) in Study One across the different productivity zones during the 2000 growing season.*



Erosion patterns developed from (a) tillage, (b) water, (c) tillage-water, and (d) total erosion
(cesium-137 [137Cs]) modeling of the research field are displayed. Cesium-137 sampling sites are also displayed
on a contour map of slope percent for the field. (From Schumacher, J. A. et al., *J. Soil Water Conserv.* 62:355–362, 2005.)

Schumacher et al. JSWC 2005



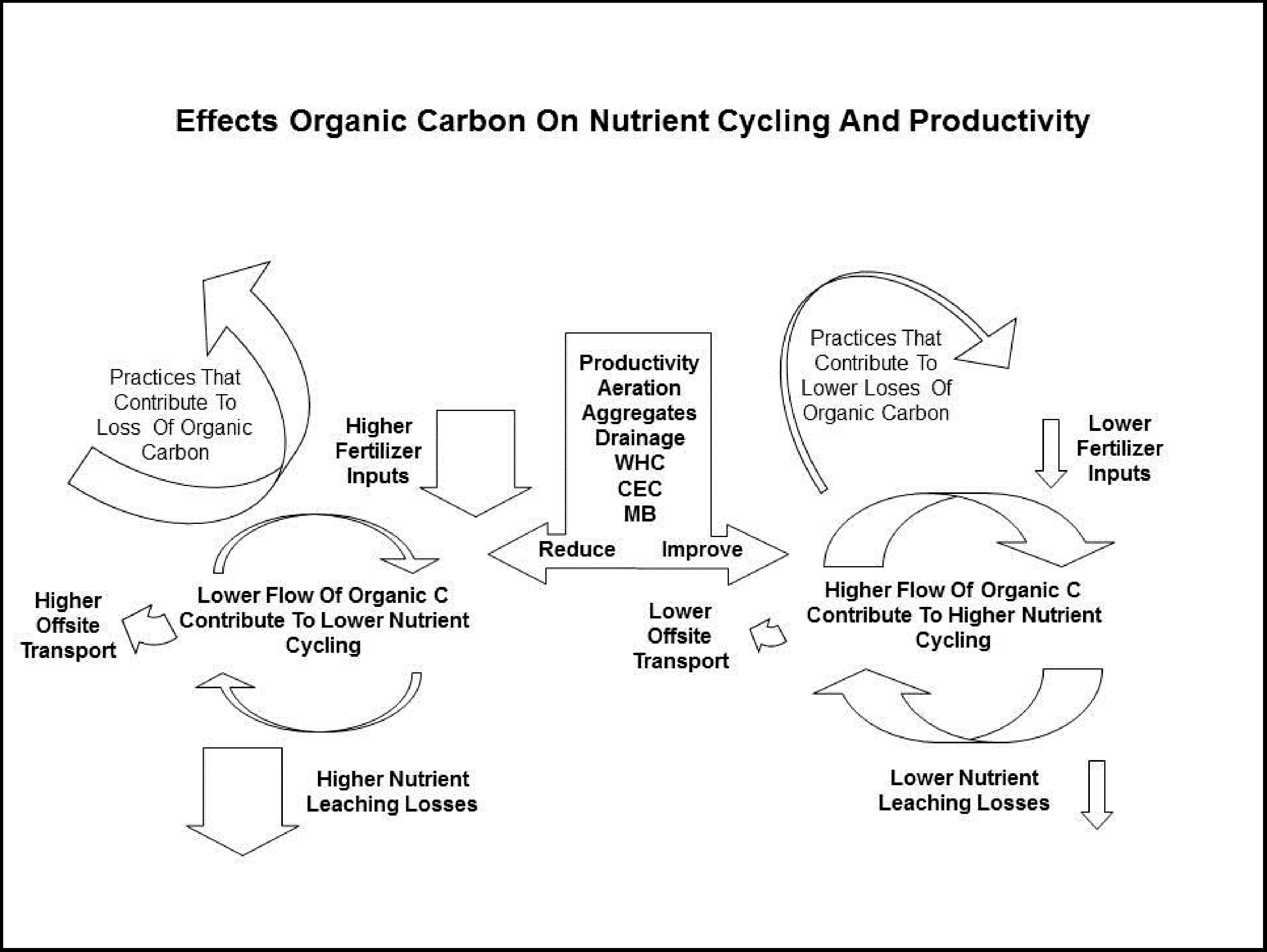
Take Home Message

New Advances in Precision Conservation Assessment of Field Spatial Erosion and buffer practices can:

- **assess the effects of management practices on spatial field erosion.**
- **identify spatial flows in and out of field**
- **potentially be use to develop spatial buffer practices**
- **determine the best vegetation to manage temporal variability of soil and surface hydrology**

- ***4 Rs (limitations)***

Dr. Jorge A. Delgado
Soil-Plant-Nutrient Research Unit, USDA/ARS



Effects of organic carbon on nutrient cycling and productivity. (From Delgado, J. A., and R. F. Follett, *J. Soil Water Conserv.* 57:455–464, 2002.)

- ***Precision Conservation (Definitions)***

Dr. Jorge A. Delgado
Soil-Plant-Nutrient Research Unit, USDA/ARS

Nutrient Management Plans

We could join these two concepts—the 4 Rs for nutrient management (Roberts, 2007; The right product, at the right rate, at the right time, and at the right place) and the Berry et al. (2003) precision conservation concept. We need to add the 4 Rs for conservation (Cox, 2005) to establish 7 Rs for nutrient management and conservation.

Nutrient Management Plans

At a minimum, to bring conservation, specifically precision conservation, to the forefront of nutrient management, we should add one R to the 4 Rs.

At a minimum we should have the right product (fertilizer), at the right fertilizer rate, at the right time, with the right method of fertilizer application, with the right conservation practice.

Nutrient Management Plans

Without getting into any legal debate, the fact is that there are some lawsuits related to nitrogen. As an example, there is the case of Des Moines Water Works, which is claiming that NO_3 that moves via drainage and gets into the rivers is impacting water quality. Will that point to who owns that NO_3 that moves from the field to the drainage?

Can precision conservation and managing nutrients while they are in the farm contribute to reduced movement of nitrogen and other chemicals? There are several papers proposing that we can manage the landscape using precision conservation practices to reduce the transport of nutrients.

Could precision conservation help reduce these loads of nutrients by managing nutrients not only in the field, but also throughout the farm wherever possible, and in the landscape? See the following example.

Nutrient Management Plans

We are at a crossroads where we have the technology to start applying not only precision information to increase nutrient use efficiency to reduce nutrient losses to the environment, but also conservation practices to increase conservation effectiveness, which can also contribute to reduced nutrient losses to the environment. We need to expand the concept of 4 Rs to add the 4 Rs of conservation. We need the right conservation practice, at the right place, at the right time, and at the right scale (the 4 Rs for conservation).).

Nutrient Management Plans

Can precision conservation and managing nutrients while they are in the farm contribute to reduced movement of nitrogen and other chemicals? There are several papers proposing that we can manage the landscape using precision conservation practices to reduce the transport of nutrients.

Could precision conservation help reduce these loads of nutrients by managing nutrients not only in the field, but also throughout the farm wherever possible, and in the landscape? See the following example.

Nutrient Management Plans

We need to start considering incorporating precision conservation and using buffers, riparian buffers, denitrification traps, phosphorus traps, controlled drainage, and wetlands to reduce transport of nutrients to the environment. The 4 Rs should be expanded to the 7 Rs, or at least to the 5 Rs concept. Precision conservation states that in a farm, we cannot look only at the field where we put the fertilizer and manure (organic fertilizer); we need to take the opportunity to manage nutrients in the whole farm, before they leave the farm, to increase nutrient use efficiencies while reducing potential nutrient losses to the environment.