"Potential for Use Nitrogen Index for Ecuador and Conservation Practices for Climate Change and Conservation of our Biosphere"

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Thank You!

USAID, SANREM, Virginia Tech, INIAP and Universidad Estatal de Bolivar

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SOIL PLANT
NUTRIENT RESEARCH
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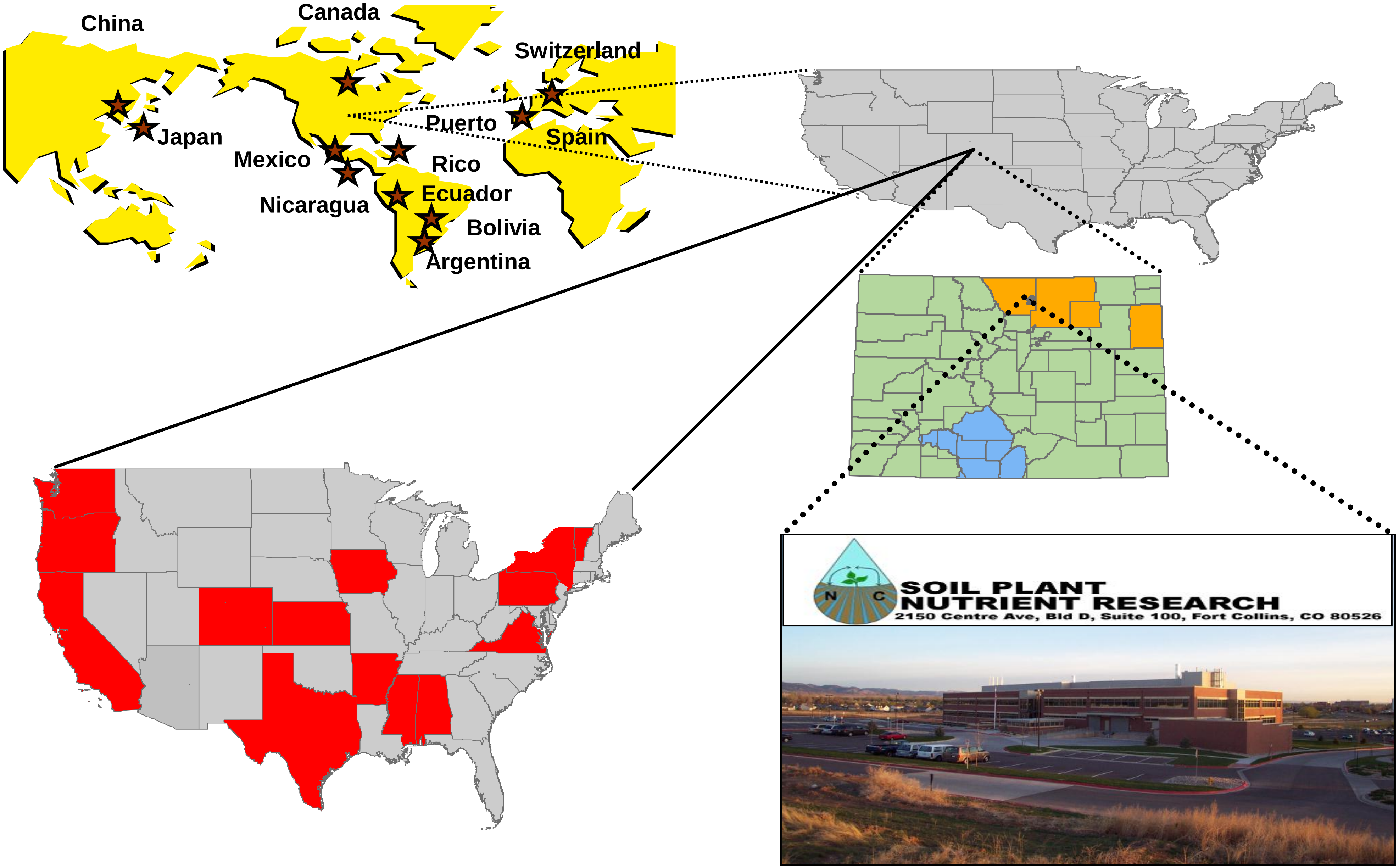
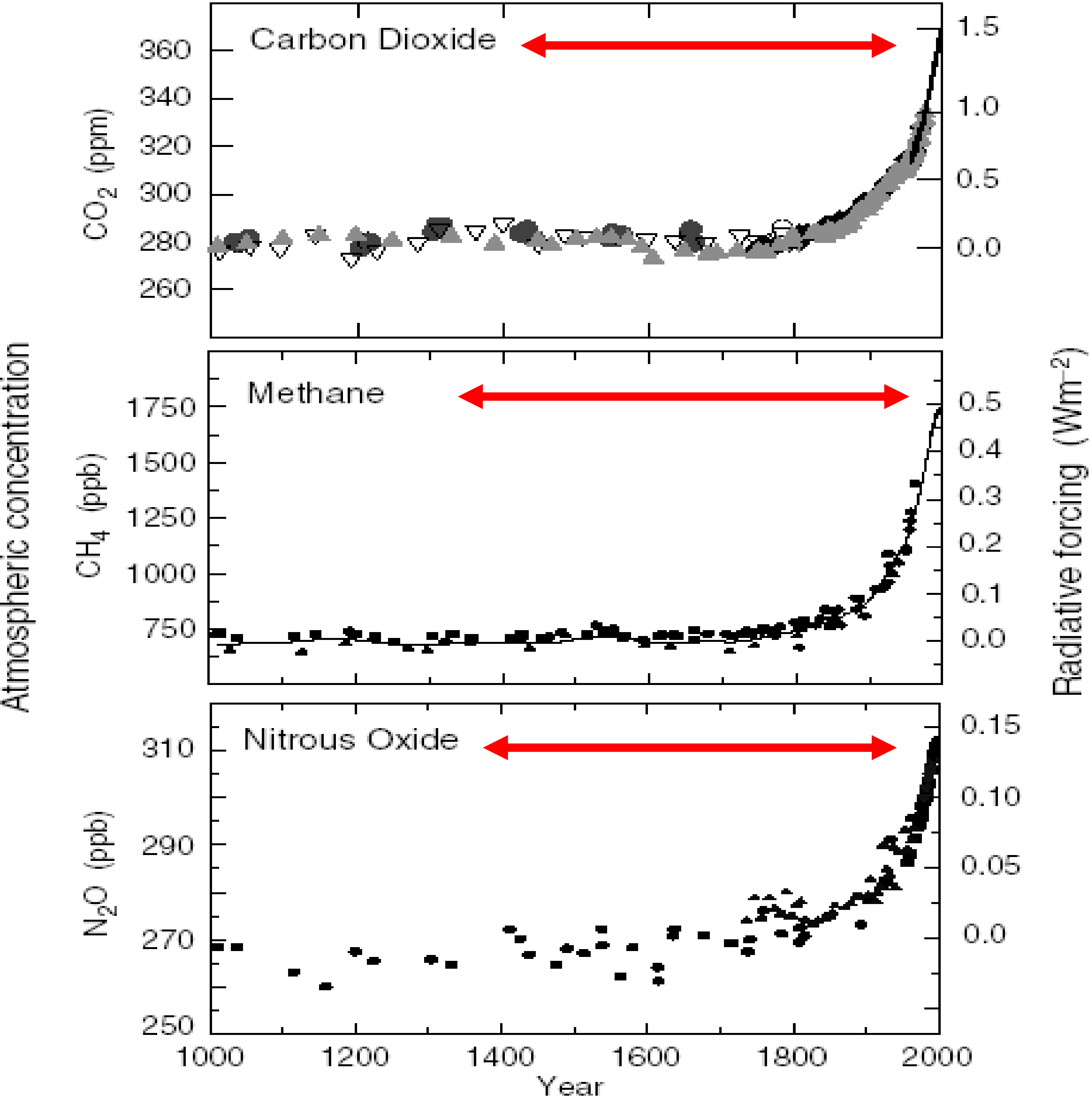
- Nitrogen inputs are needed and crucial for maintaining agricultural production.
- Nitrogen is one of the most dynamics and mobile elements. It is also susceptible to losses via several pathways.
- With average worldwide recoveries of 50%, we need to continue developing tools that can help us improve the management of N.
- Develop nutrient management systems that minimize the loss of nutrients to ground and surface water while maintaining a profitable agricultural economy.

Cooperators - Locations



“Example of Hot Spots Across the Globe”

“Cooperators – Locations”

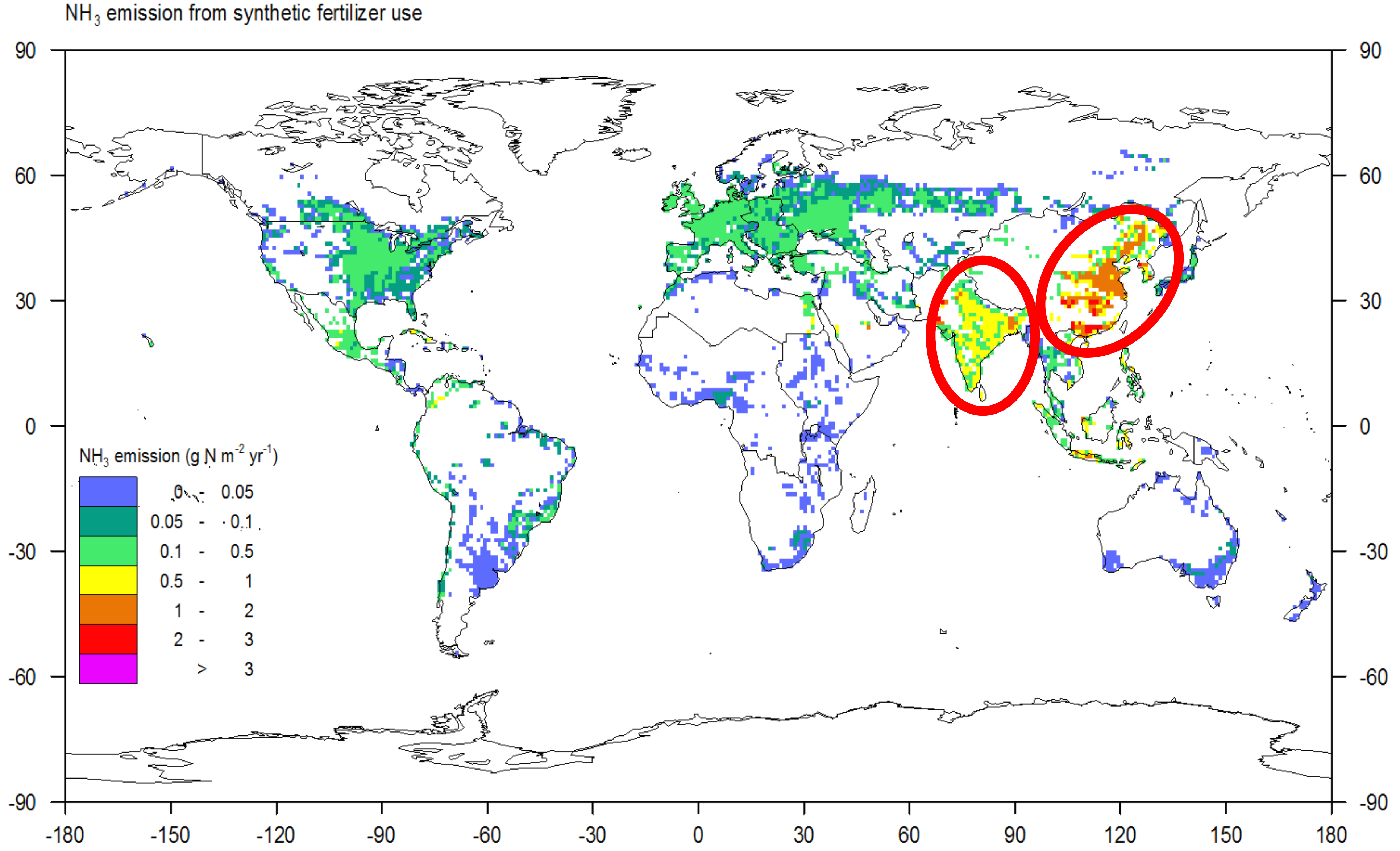


Atmospheric Concentrations of trace gases from 1000 A.D.

From IPCC (2001)

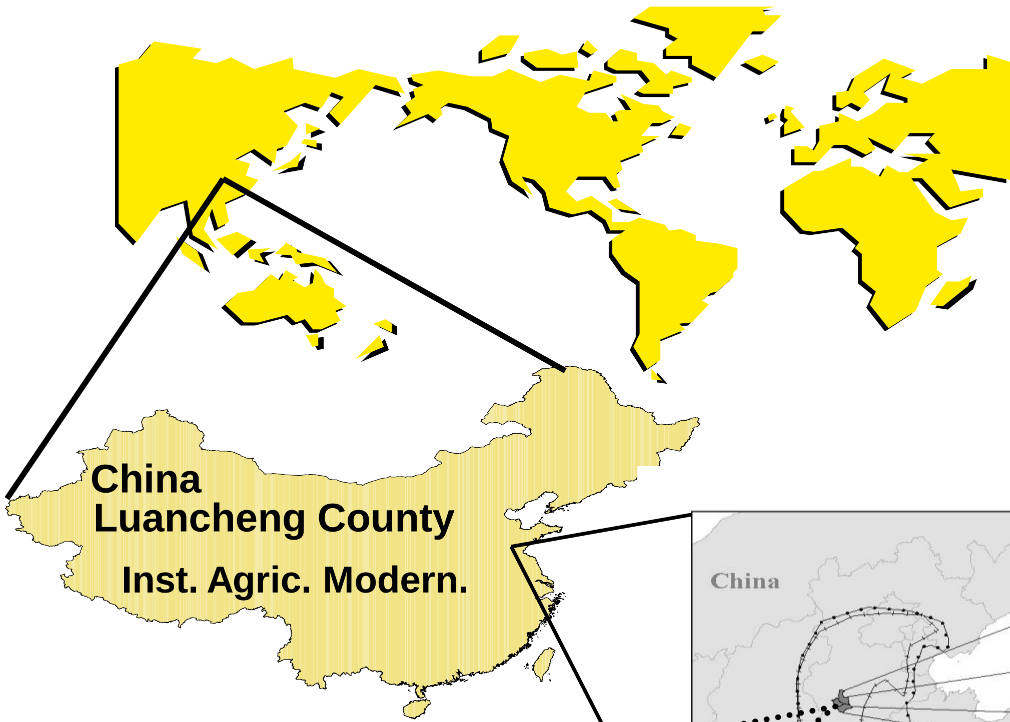
Mosier, ARS

Ammonia emission from fertilizer



Lemunyon NRCS

Selected Cooperators - Locations



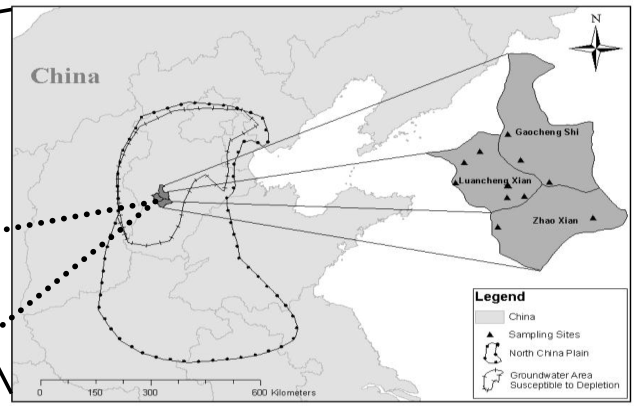
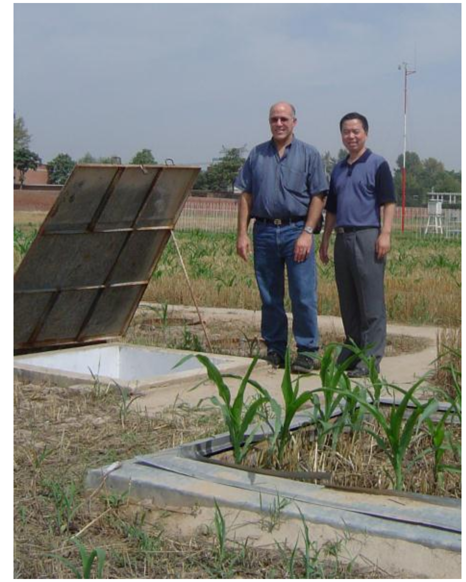
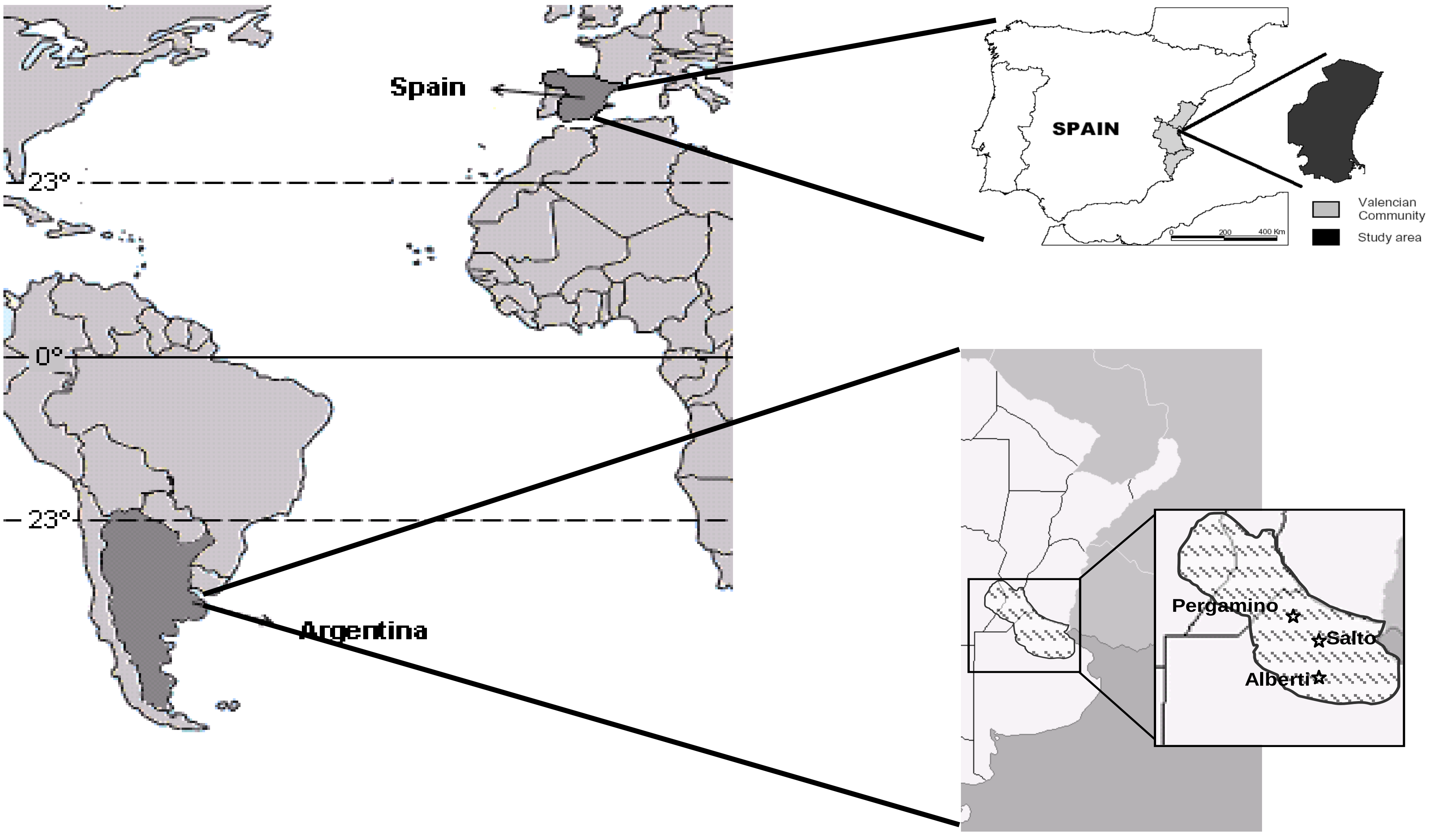


Figure 1. Map layout indicating the location of the North China Plain (NCP) (approximate area); northwestern region of the NCP susceptible to underground water depletion (approximate area); and locations of village study sites within Luancheng Xian, Gao Cheng Shi and Zhao Xian counties. Scale bar not relative to blowup image.



Selected Cooperators - Locations



Location of Spain (Valencia Study sites) and Argentina (Study Sites), (Lavado et al, 2010).

Selected Cooperators - Locations

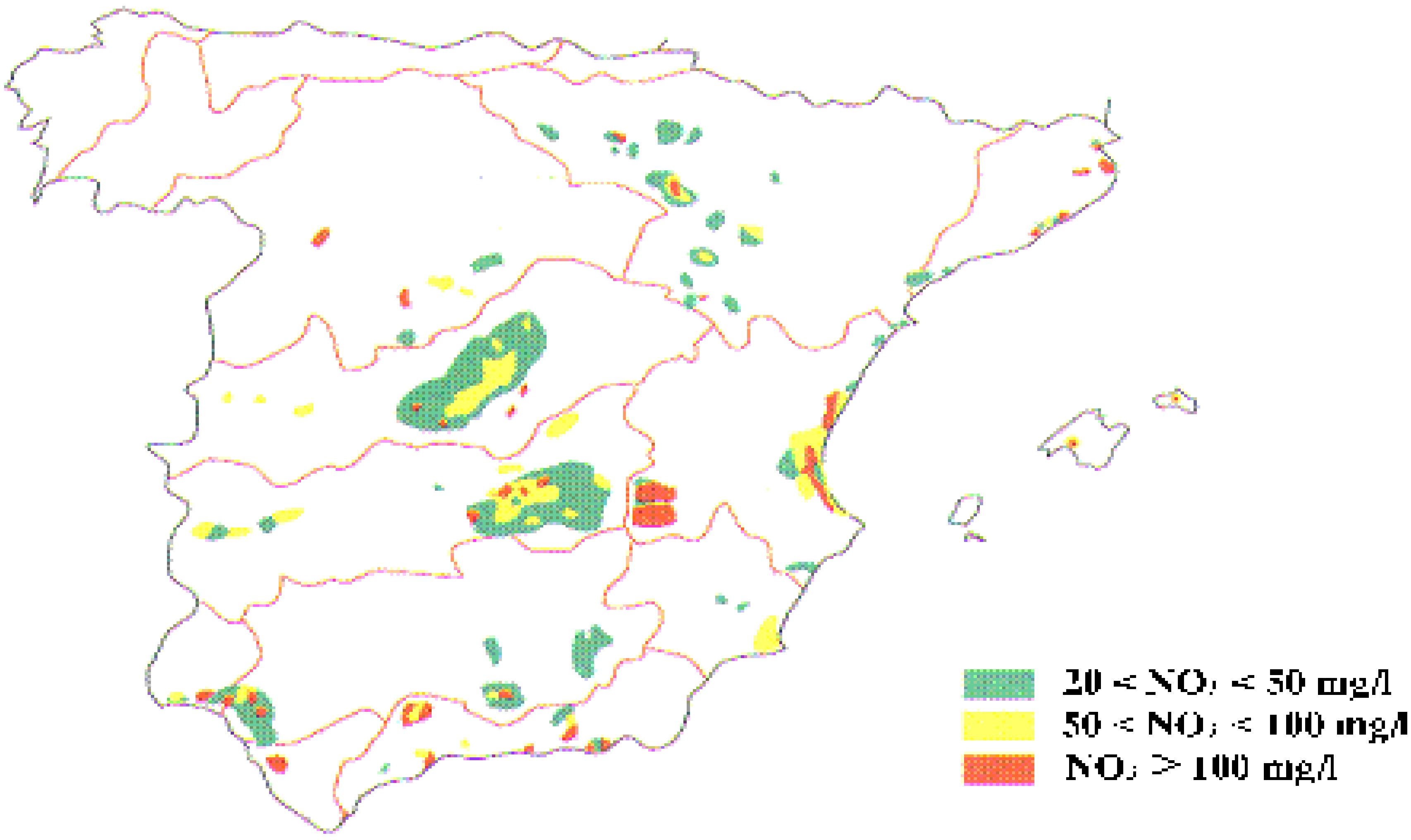
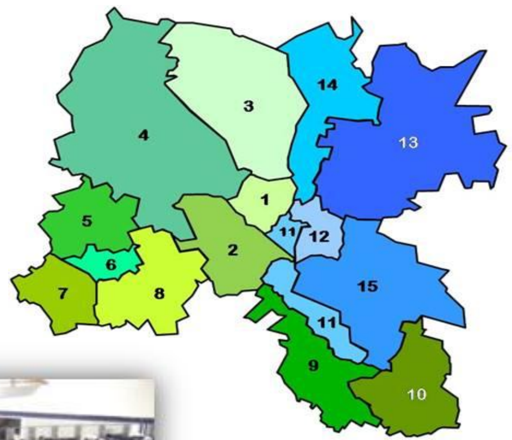


Figure 5. Spatial distribution of the nitrate content in the groundwater of Spain (Varela, 1991).

Selected Cooperators - Locations

The Region of La Laguna,

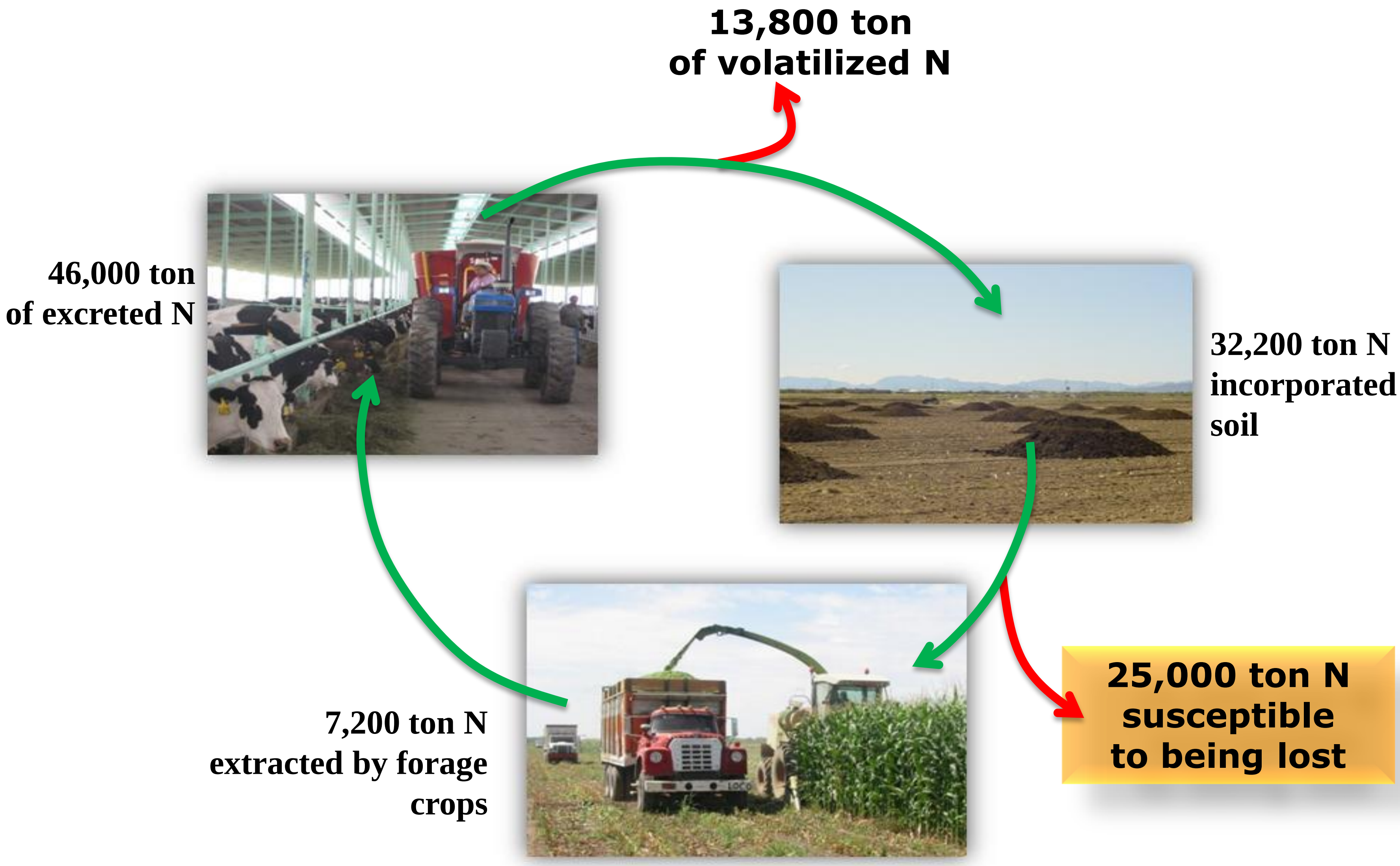
in the States of Coahuila and Durango, México



Dairy cattle in México:	2.2 million
Dairy cattle in La Laguna:	0.44 million
Average herd size:	1,300 cows
Manure production:	7.5 million of ton/year (as excreted)
	0.925 million of ton/year (dry matter)

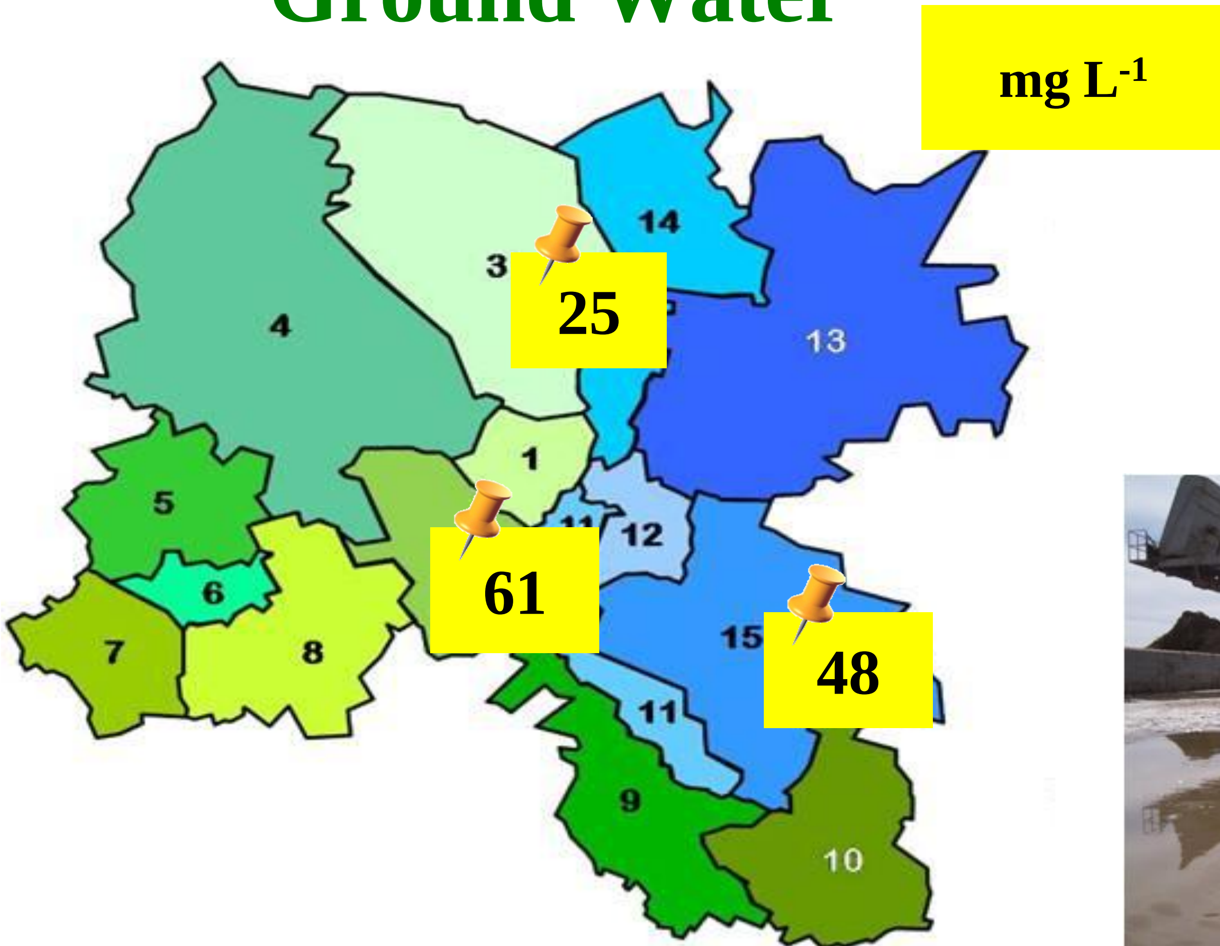
Selected Cooperators - Locations

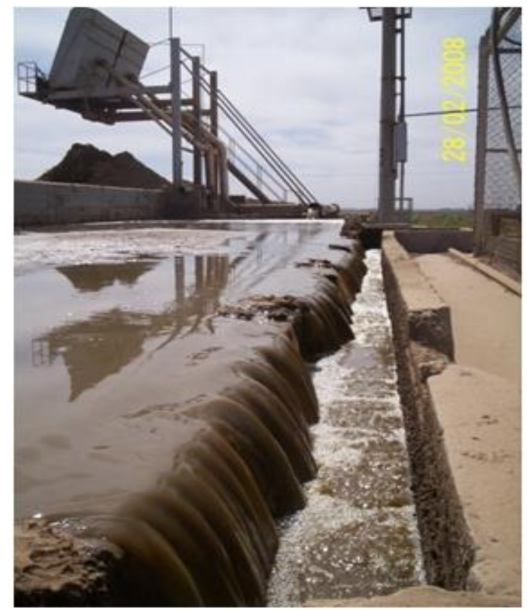
Gross N Balance in Dairy Farms at La Laguna



Figueroa et al., 2009

Average Nitrate Concentration of Ground Water



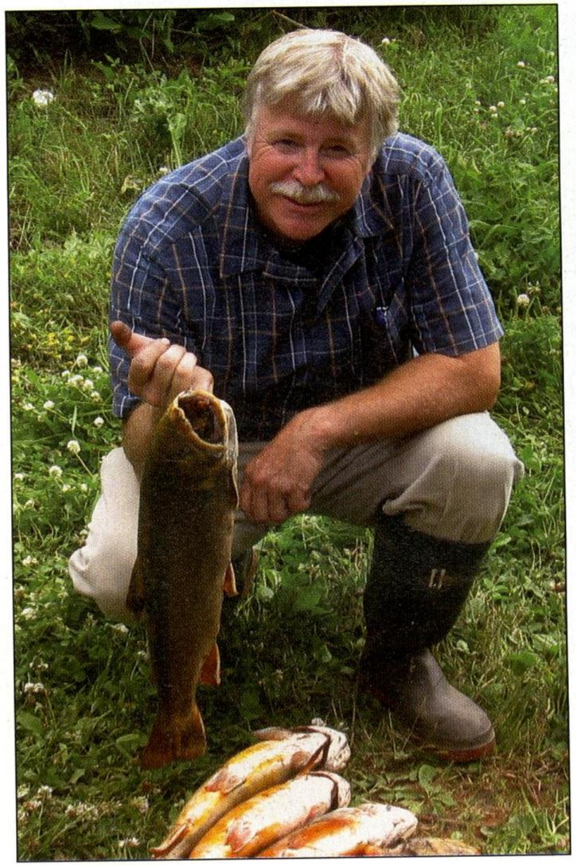


Martínez et al., 2006. Agrofaz 6:379-386

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

“Example of Hot Spots Across the USA”

“Cooperators – Locations”

Hundreds of dead fish surface in Tamarac country club's waterways

Fertilizer or pesticides suspected in deaths of scores of fish in Tamarac

By Joel Marino Staff Writer
July 28, 2008

South Florida Sun-Sentinel

SunSentinel.com

Source:

Department of Environmental Protection

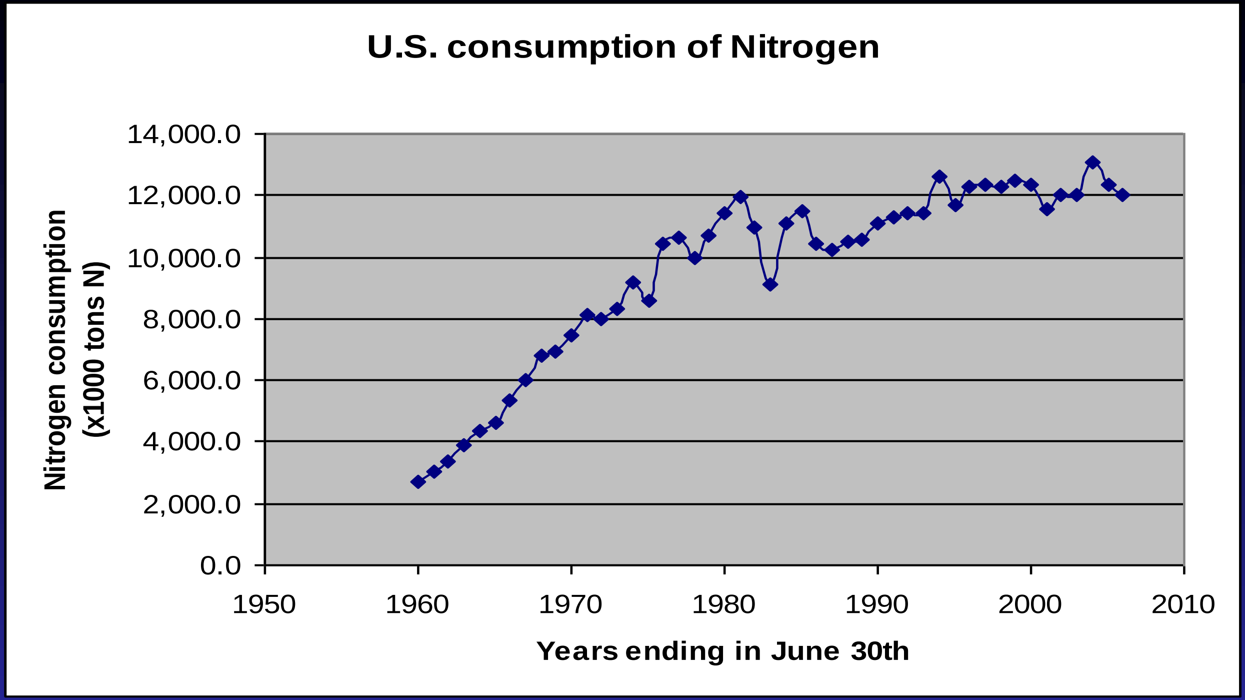
Maine

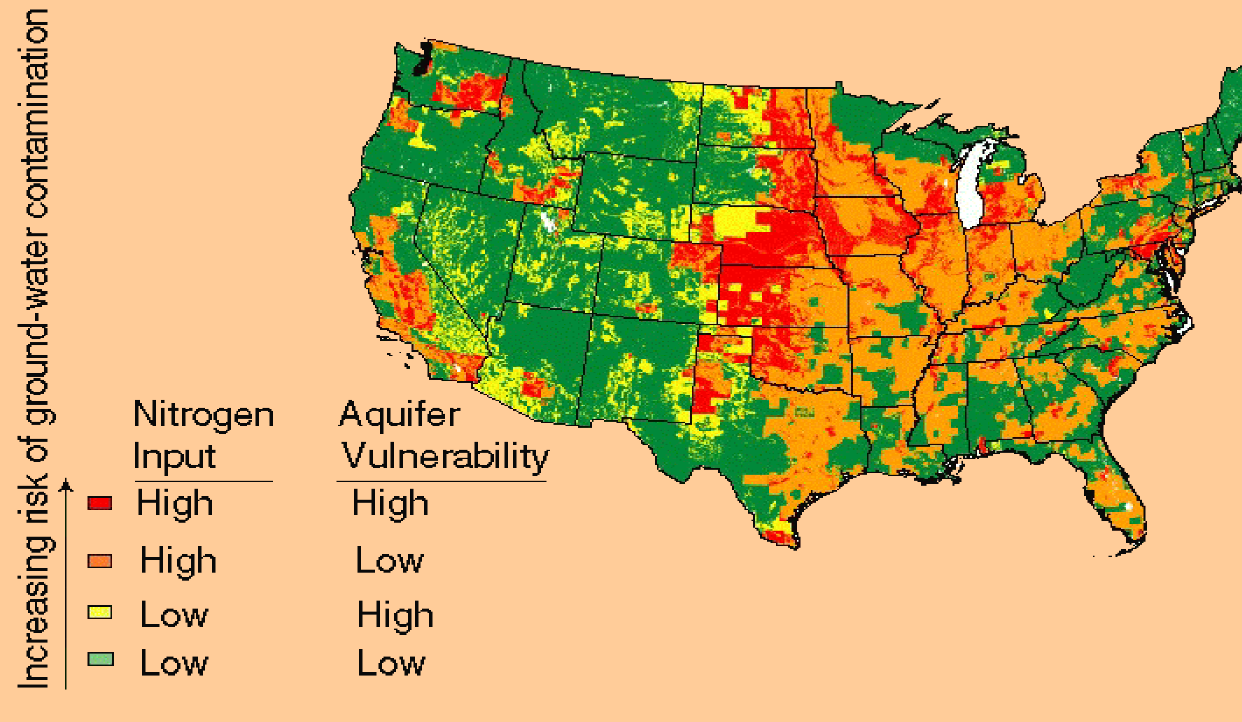
CORRELATION BETWEEN NITRATE CONTENT OF NEBRASKA GROUND WATERS AND SEVERAL FACTORS [1]

Independent Variable	r value
1. Overlying soil clay content	-0.49**
2. Irrigation well density	0.43**
3. Total fertilizer use	0.28**
4. Irrigation well dept	-0.28**
5. Water pH	-0.23**
6. Cattle density	0.18*
7. Human density	0.06

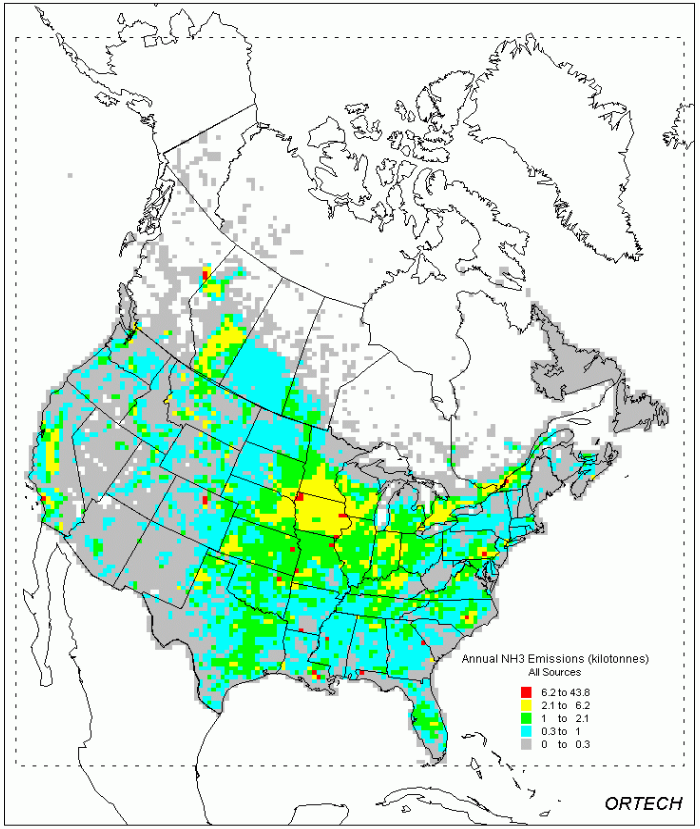
[1] Individual well water nitrate level related site characteristics 1, 4, and 5 above and to average county wide statistics for characteristics 2, 3, 6, and 7. Water sampled from 480 wells, 1971-1972.

Follett, ARS

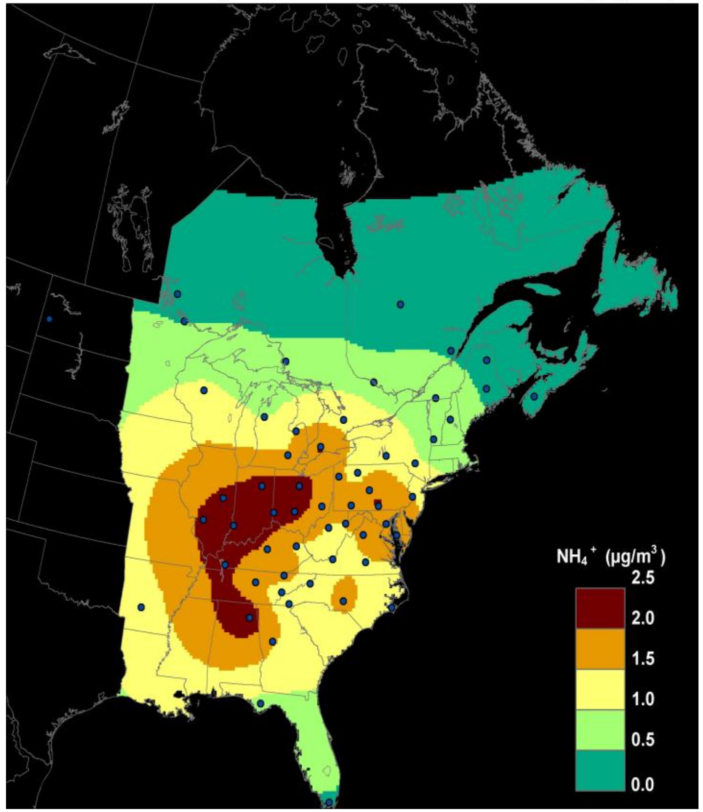

U.S. consumption of Nitrogen
Nitrogen consumption
(x1000 tons N)
14,000.0
12,000.0
10,000.0
8,000.0
6,000.0
4,000.0
2,000.0
0.0
1950
1960
1970
1980
1990
2000
2010
Years ending in June 30th


Increasing risk of ground-water contamination
Nitrogen Input
Aquifer Vulnerability
High
High
High
Low
Low
High
Low
Low

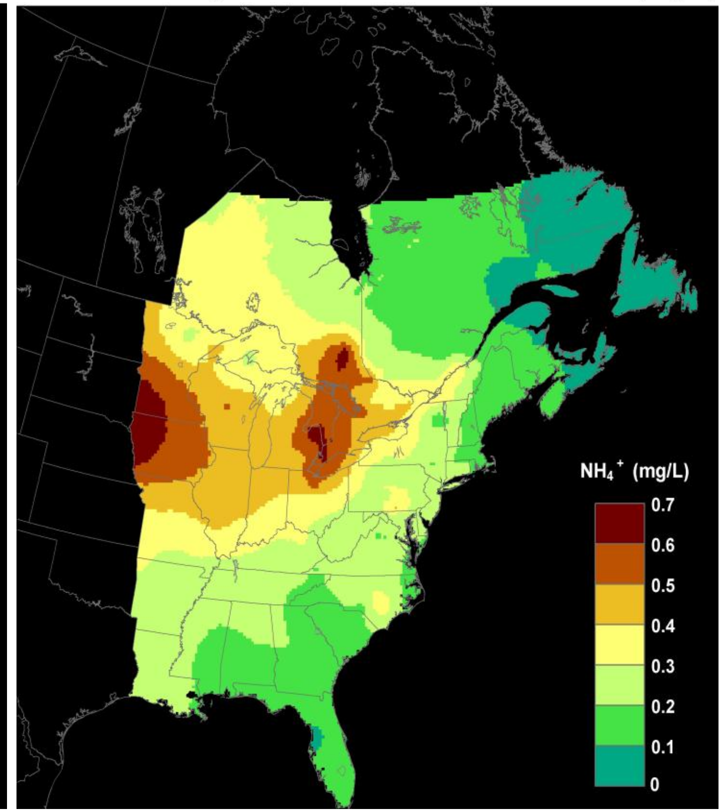
NH_3 emissions and NH_4^+ in air and precipitation (1995-1998)



1995 - 1998 Average Ammonium Concentrations in Air (µg/m³)



1995 - 1998 Average Ammonium P-W Mean Concentrations (mg/L)



1990 Annual Anthropogenic NH_3 Emissions, AQPP CHRONOS 21-km North American Grid, Prepared by CEPS

Lemunyon, NRCS

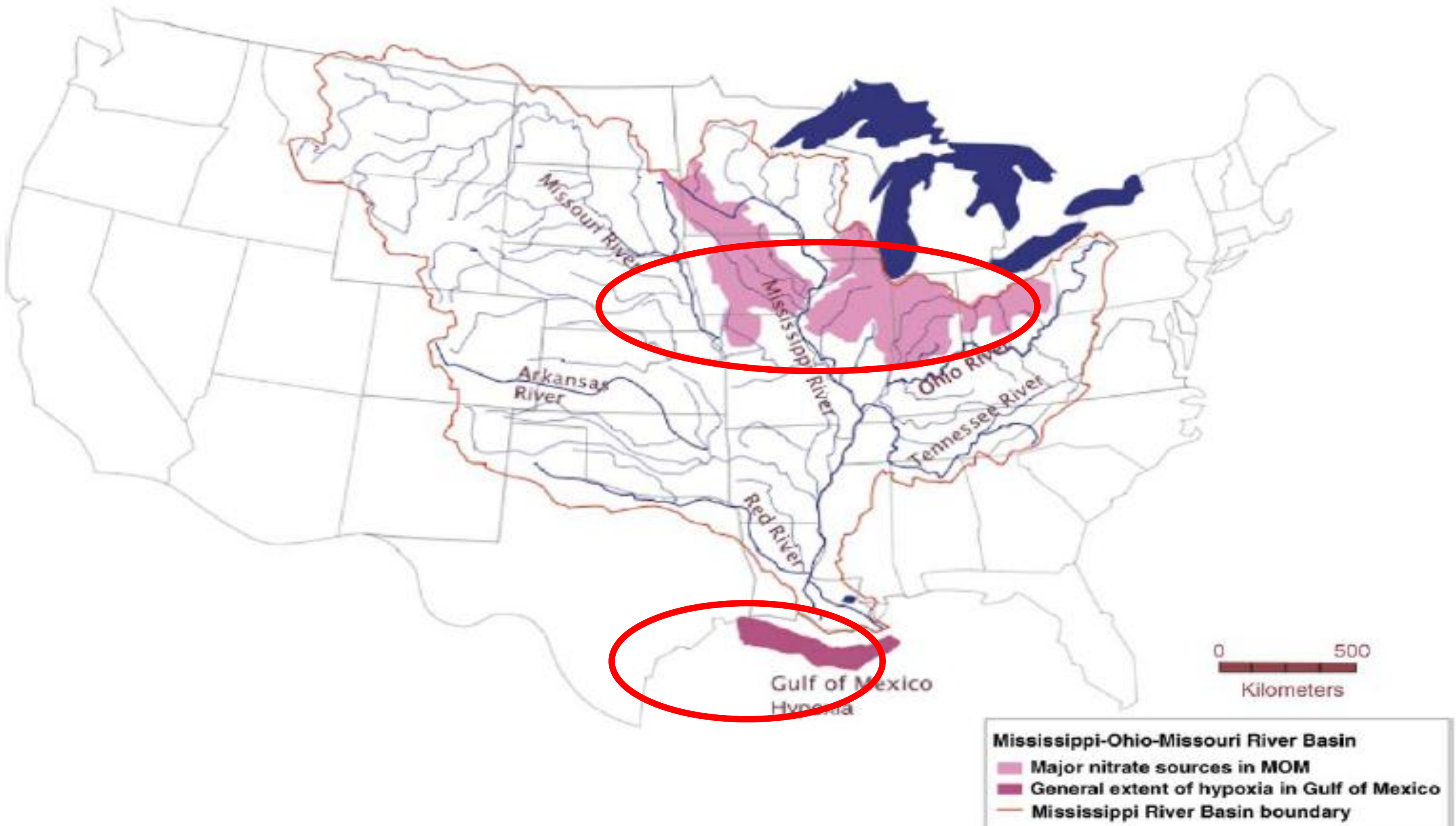


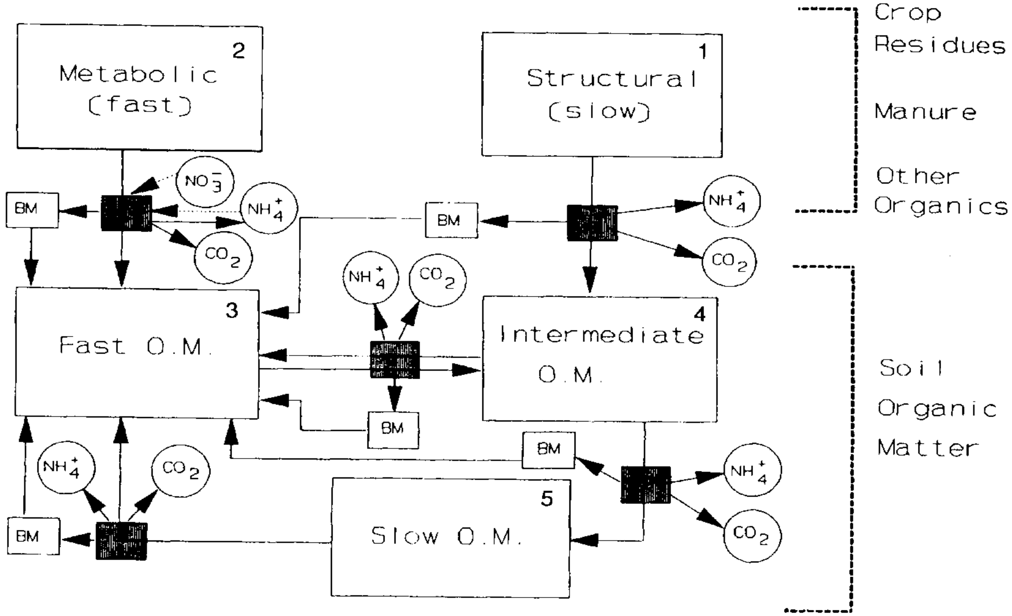
Fig. 1. Mississippi–Ohio–Missouri (MOM) River Basin in the United States, showing location and general extent of Gulf of Mexico hypoxia in Louisiana coastline and location of high nitrogen loadings in the basin (>1000 kg N km^{-2} yr^{-1}) (nitrogen loading source location from Goolsby et al., 1999).

Nitrogen Cycle

and

N loss pathways

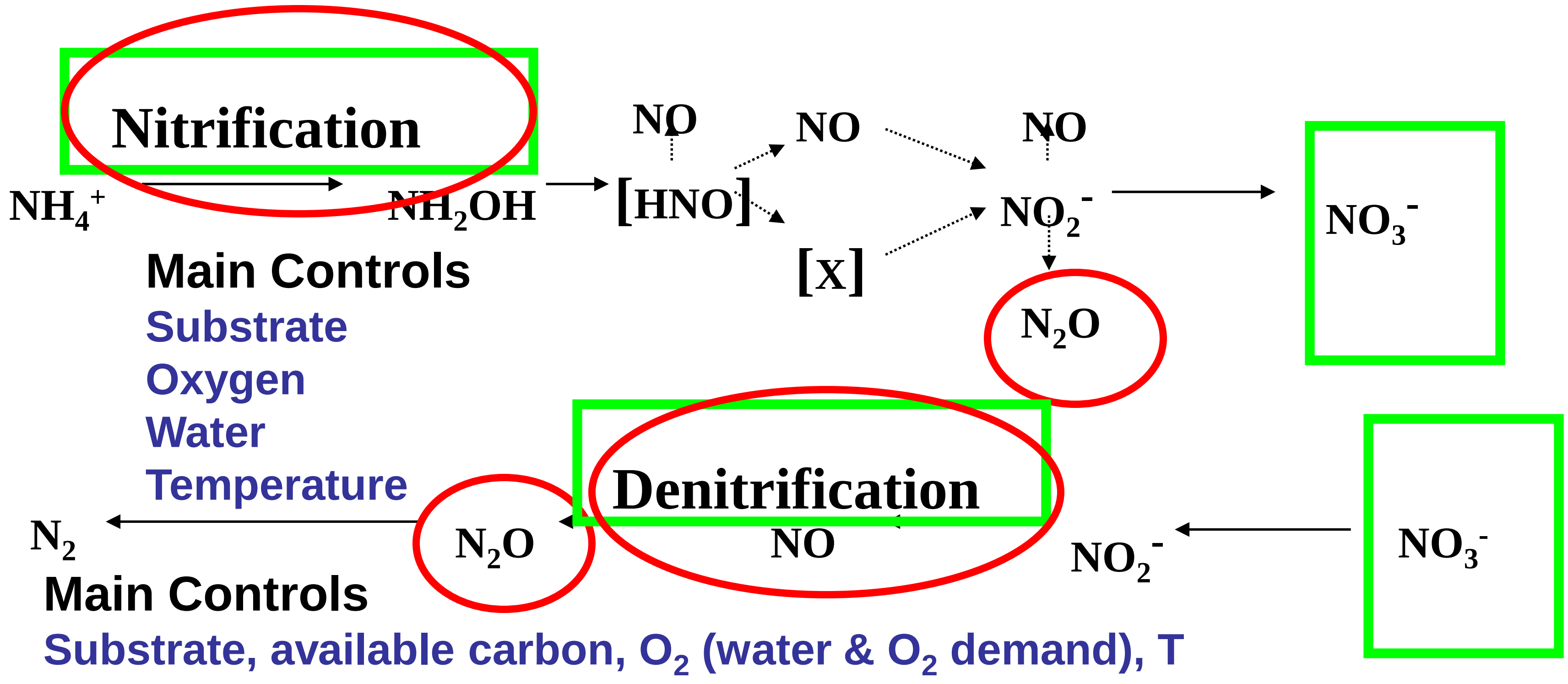
Nitrogen Management of Agricultural Systems



How do we manage nitrogen in order to increase Nitrogen use efficiencies and reduce nitrogen loss to the environment?

How is NO_3 Leached from the Soil?
How Can NO_3 Leaching be Minimized?

How is N_2O Produced in the Soil?
How Can N_2O Emissions be minimized?



Effect of N fertilizer on N_2O and CH_4 uptake

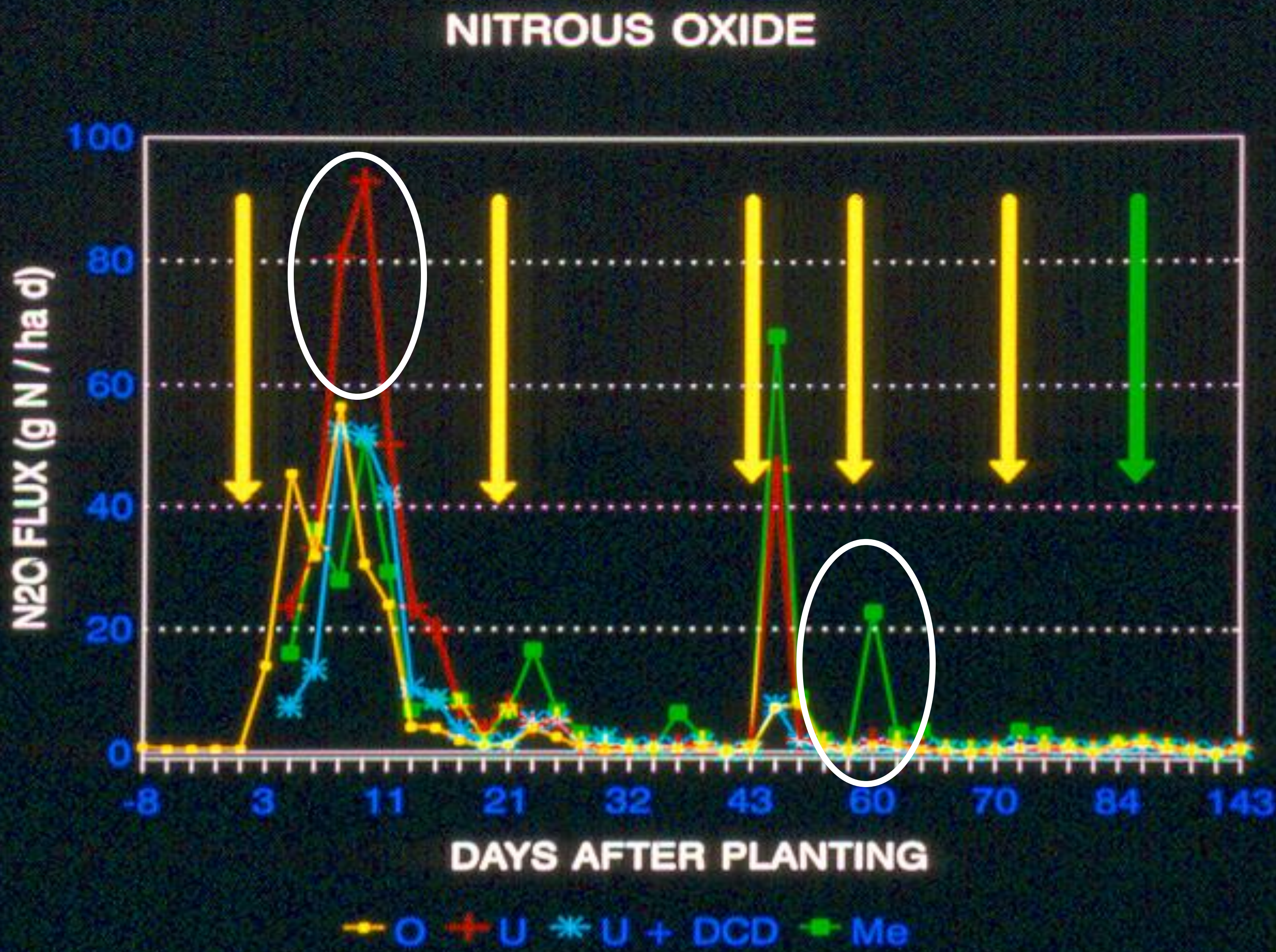
	g N_2O-N ha^{-1} d^{-1}	g CH_4–C ha^{-1} d^{-1}
Native grassland	0.3	6.3
Fertilized grassland	0.6	4.1
Irrigated wheat		
Urea	6.0	0.9
Control	2.0	0.8
Irrigated Corn (Maize)		
Urea	16.5	0.6
Control	1.1	0.6

Mosier et al. 1991, 1995, 1996

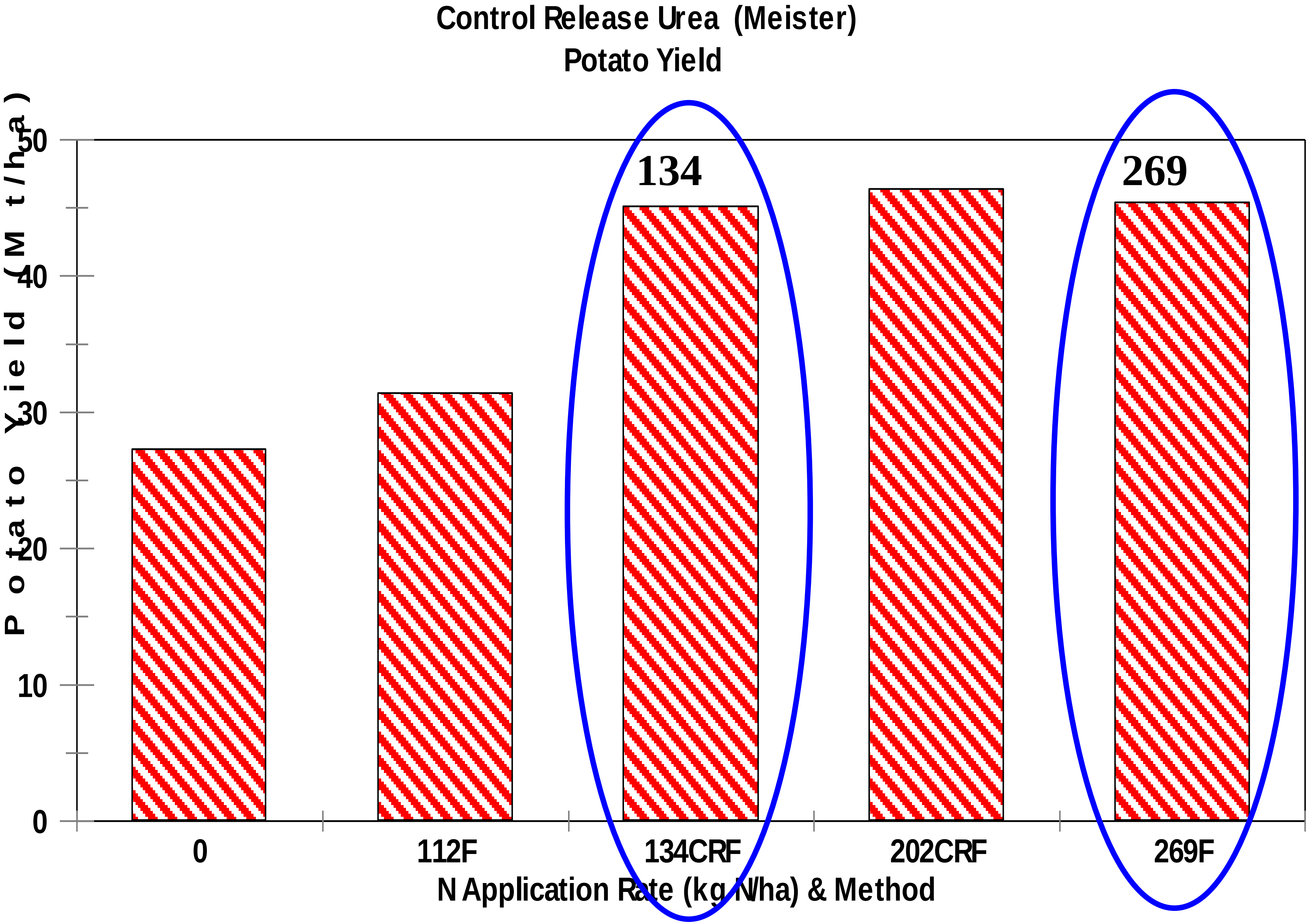
Effect of N fertilizer and NI on N_2O

		$g\ N_2O\text{-}N\ ha^{-1}$
Irrigated Corn (Maize)		
	Urea	1651
	Urea + nitrapyrin	980
	Urea + ECC	483
	Control	108
Irrigated wheat		
	Urea	929
	Urea + ECC	509
	Urea + DCD	437
	Control	440

Mosier et al. 1991, 1995, 1996



Delgado and Mosier 1996, J. Environmental Quality



Delgado et al. 1998, Shoji et al. 2001

"Nitrogen Management"

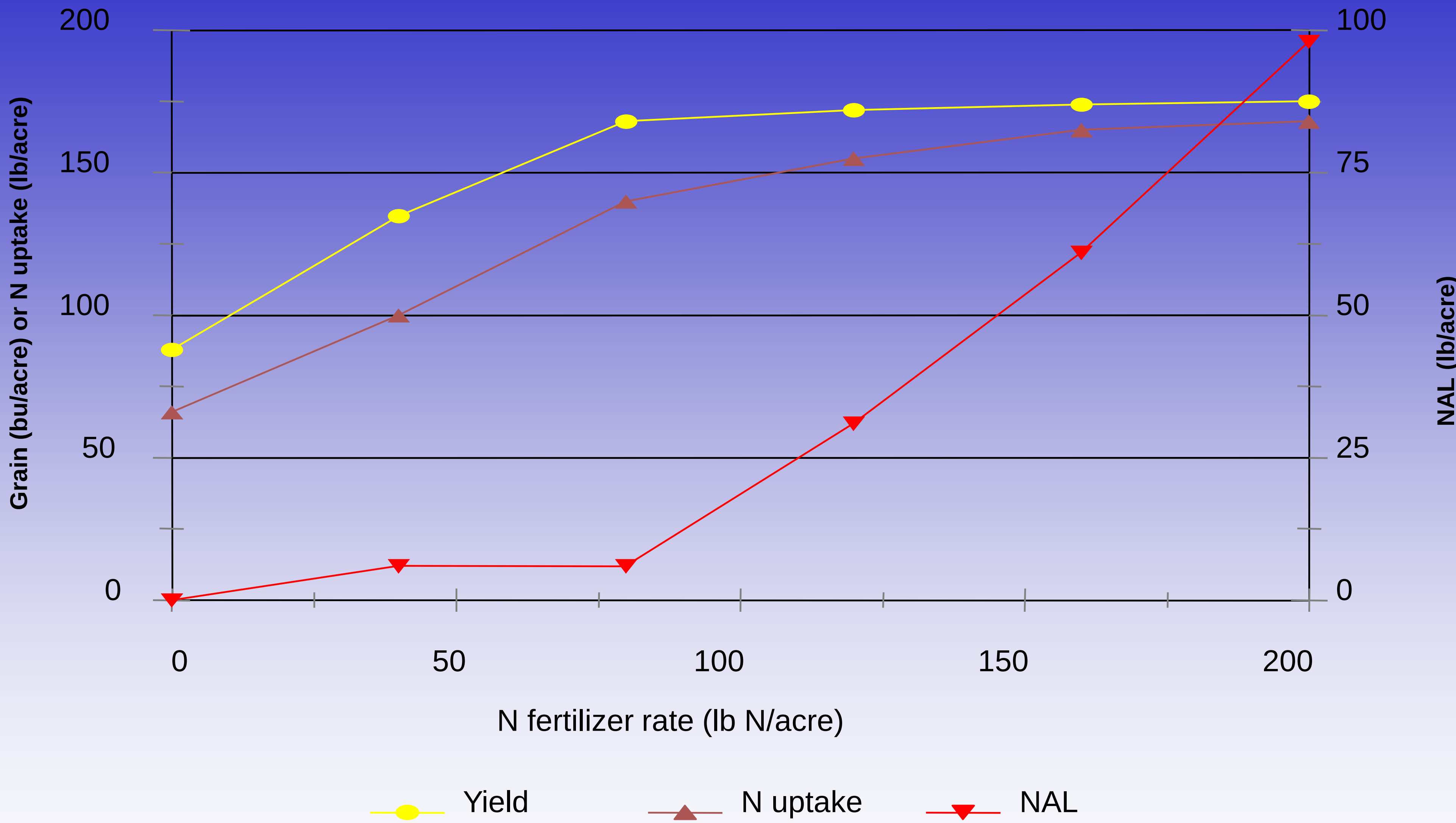


Figure 13. Effect of N fertilizer rate applications on yield and N uptake by irrigated corn (Adapted from Bock and Hergert, 1991). Potential N available to leach (NAL) assuming major pathway for losses is leaching. The NAL was estimated as NAL = N applied – N uptake .

Delgado 2004

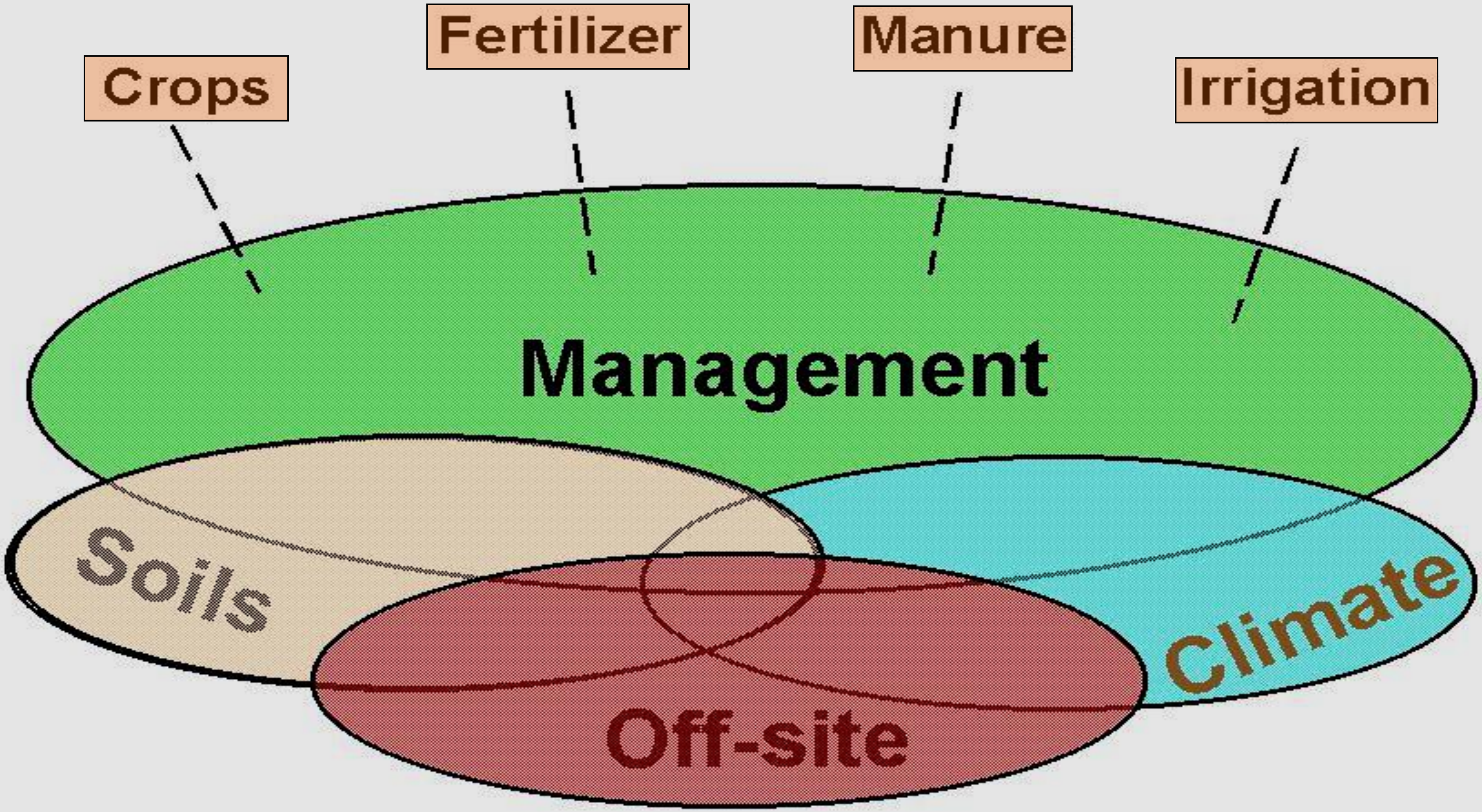
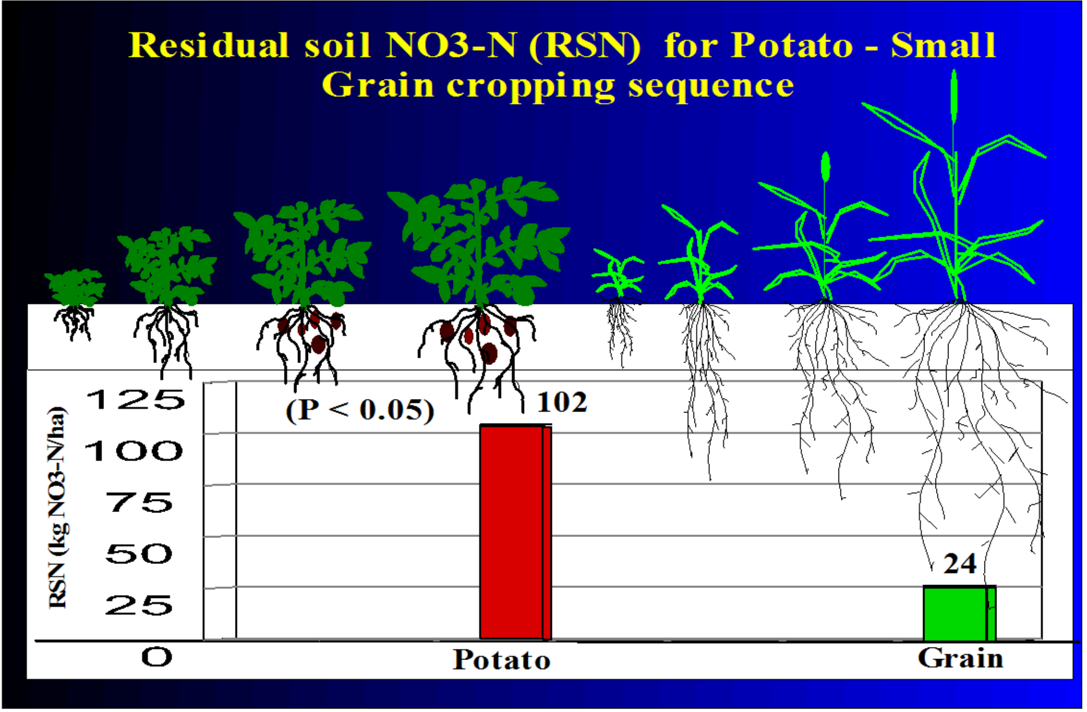
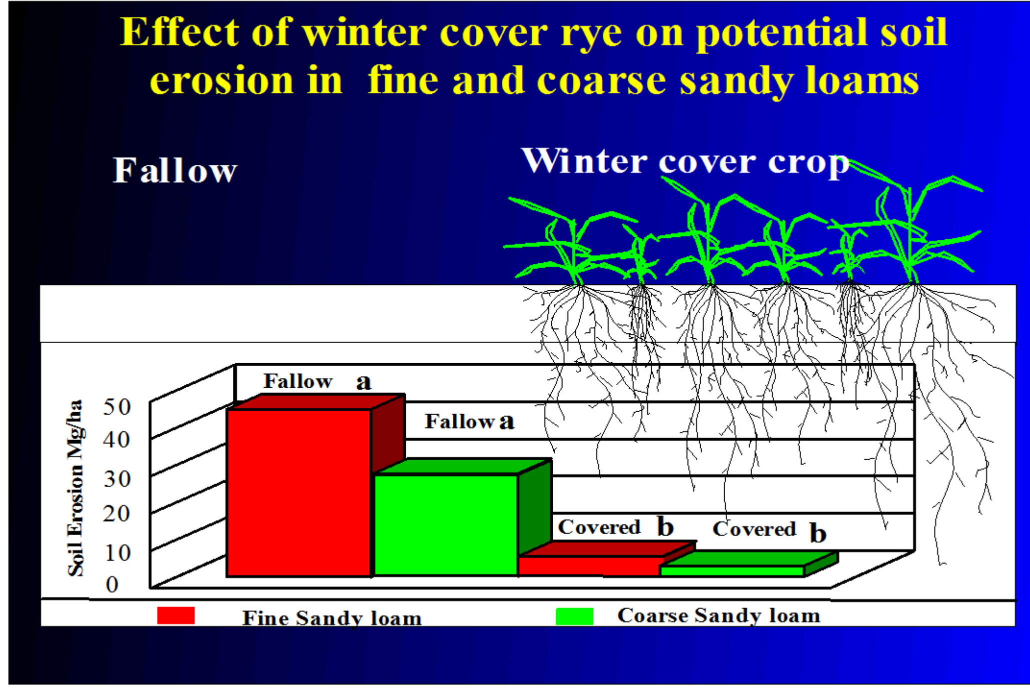
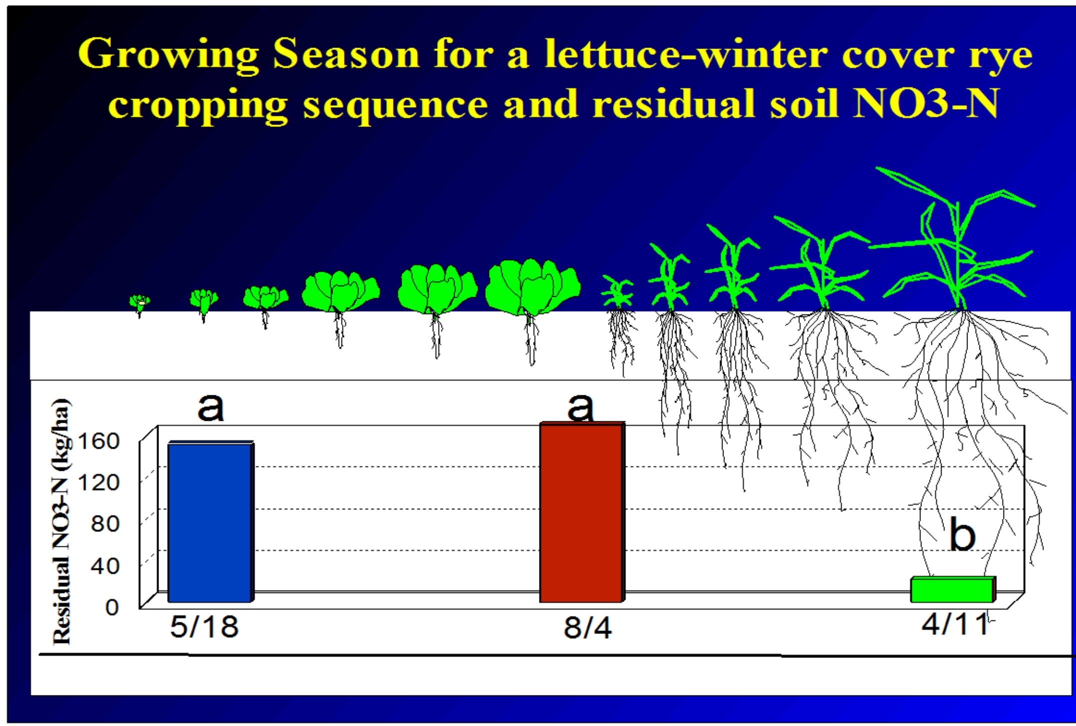


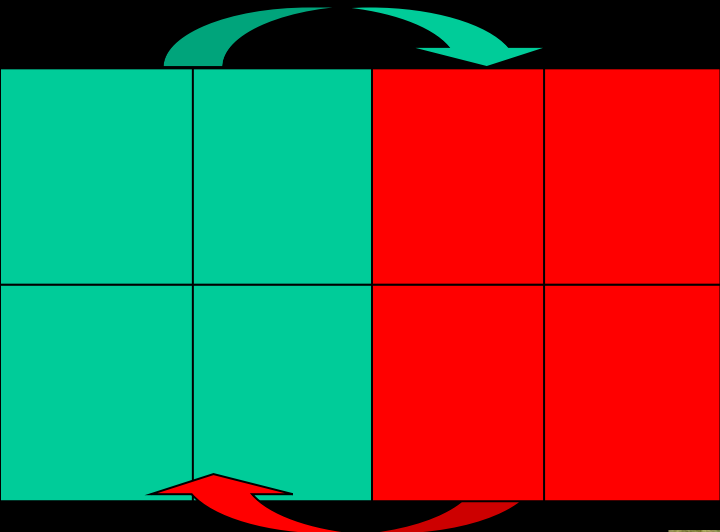
Figure 5. Essential components of NO_3-N leaching index (NLI) (From Shaffer and Delgado, 2002).


Residual soil NO3-N (RSN) for Potato - Small Grain cropping sequence
RSN (kg NO3-N/ha)
125
100
75
50
25
0
(P < 0.05)
102
24
Potato
Grain


Effect of winter cover rye on potential soil erosion in fine and coarse sandy loams
Fallow
Winter cover crop
Soil Erosion Mg/ha
50
40
30
20
10
0
Fallow a
Fallow a
Covered b
Covered b
Fine Sandy loam
Coarse Sandy loam


Growing Season for a lettuce-winter cover rye cropping sequence and residual soil NO3-N
Residual NO3-N (kg/ha)
160
120
80
40
0
a
a
b
5/18
8/4
4/11

^{15}N Studies



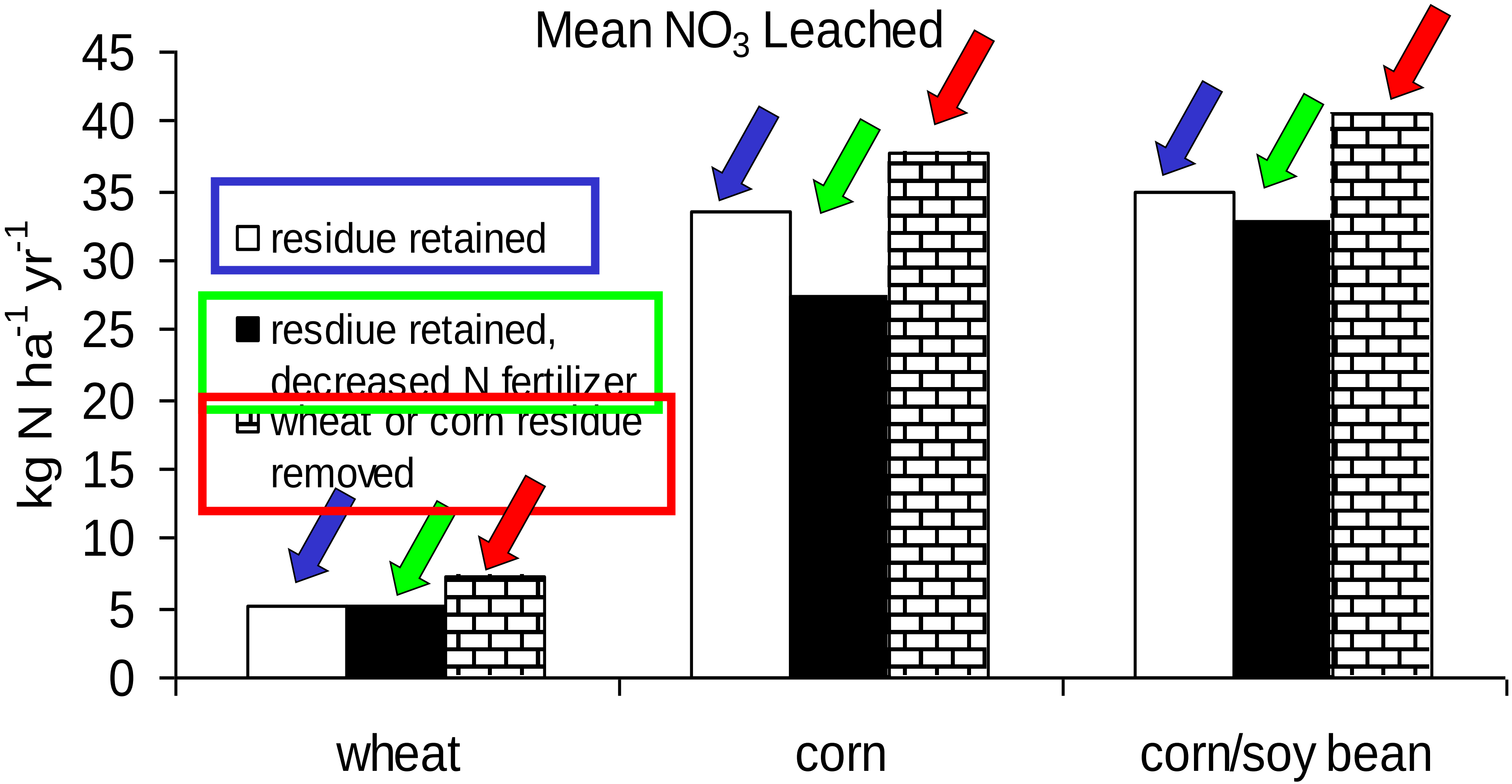
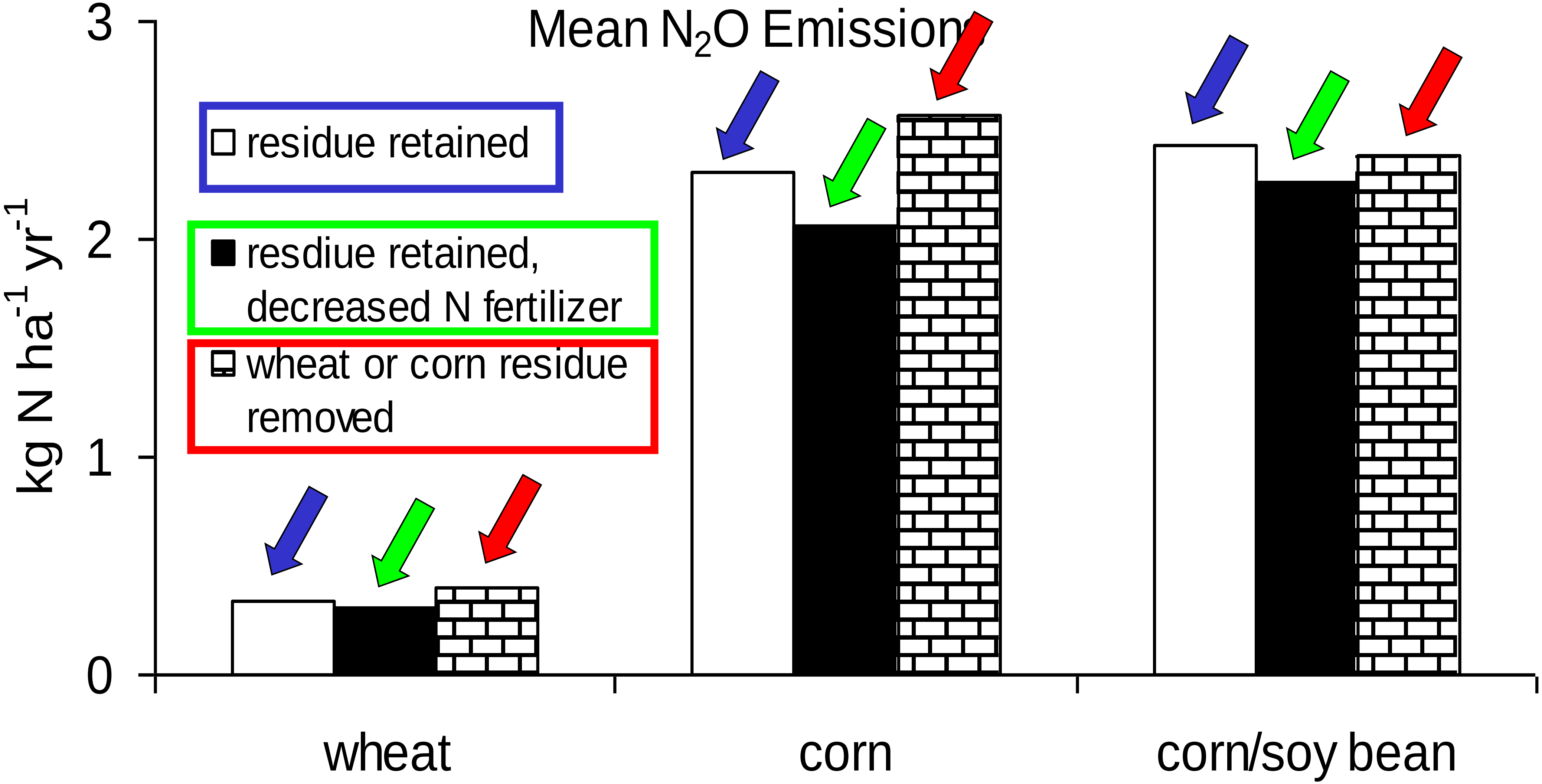


Figure 3. Mean Nitrous Oxide (N_2O) and nitrate leaching (NO_3-N) from a 10 year site specific simulation of a dryland wheat – fallow rotation in Colorado (wheat); corn-corn rotation in Ohio (corn) and a corn-soybean rotation in Ohio (soy). The simulated scenarios were: 1) aboveground crop residue kept in the field (residue retained); 2) removing aboveground crop residue (residue removed); and 3) aboveground crop residue kept in the field but removal of a similar amount of N from the fertilizer input (residue retained, decrease fertilizer).

Delgado et al. 2010 J. Nutrient Cycling



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Delgado et al. 2010 J. Nutrient Cycling

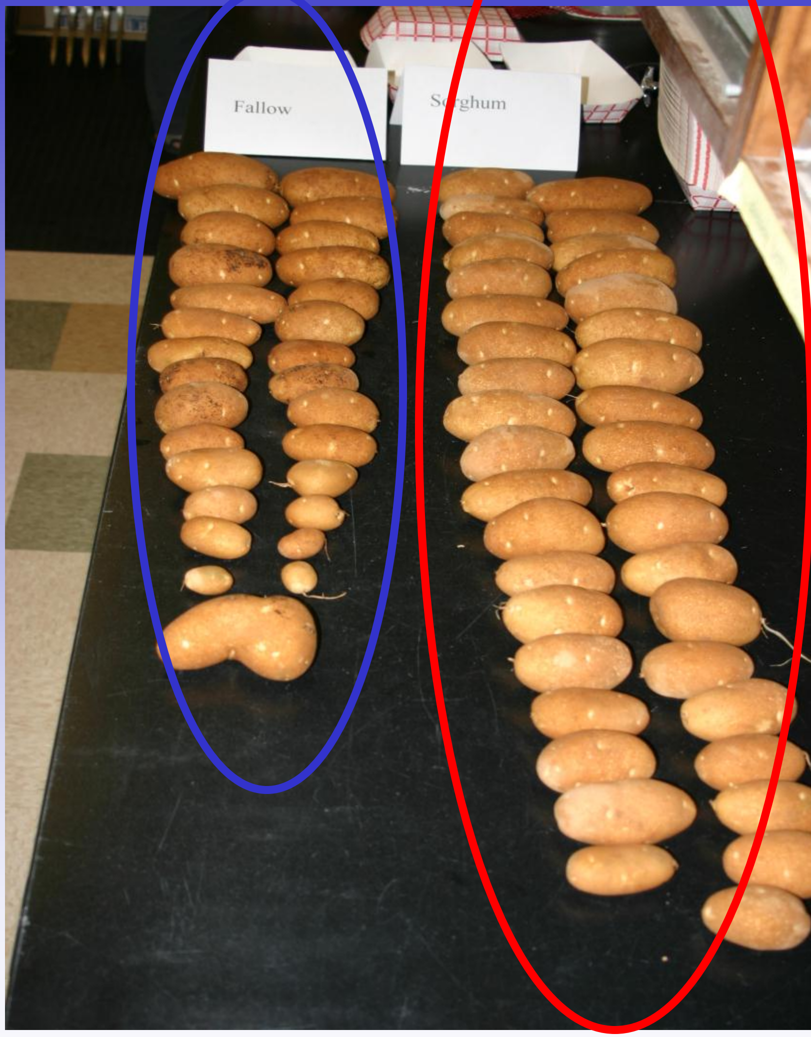
Table 2. 15N applications, recoveries and losses in irrigated cover crop studies.

Location	Crop	N source	Applied ^{15}N (kg N ha^{-1})	Soil recovery (% ^{15}N)	Plant recovery (% ^{15}N)	Lost (% ^{15}N)
Colorado	Wheat[a]	Fertilizer	95	27	47	26
	Potato[b]	Wheat residue	37	79	7	14
Colorado	Wheat[a]	Fertilizer	95	25	49	26
	Potato[b]	Wheat residue	41	79	6	15
Colorado	Barley[a]	Fertilizer	95	28	40	32
	Potato[b]	Barley residue	35	69	13	18
Washington	Mustard	Fertilizer	56	24	34	42
	Potato[c]	Mustard residue	142	66	29	5
Average		Fertilizer		26 ± 2	43 ± 7	31 ± 8
		Crop residue		73 ± 7	14 ± 11	13 ± 6

Delgado et al. 2010 J. Nutrient Cycling

Take Home Message
Sorghum Sudan:

	Ctw
Canola	233 b
Fallow	274 b
Sorghum sudan-HS	308 ab
W-Mustard	225 b
Sorghum-sudan	390 a
Sorghum-sudan-hay	386 a



Delgado et al. 2007 J. Soil and Water Conservation

New Concepts for Nitrogen Management

New Nitrogen Index

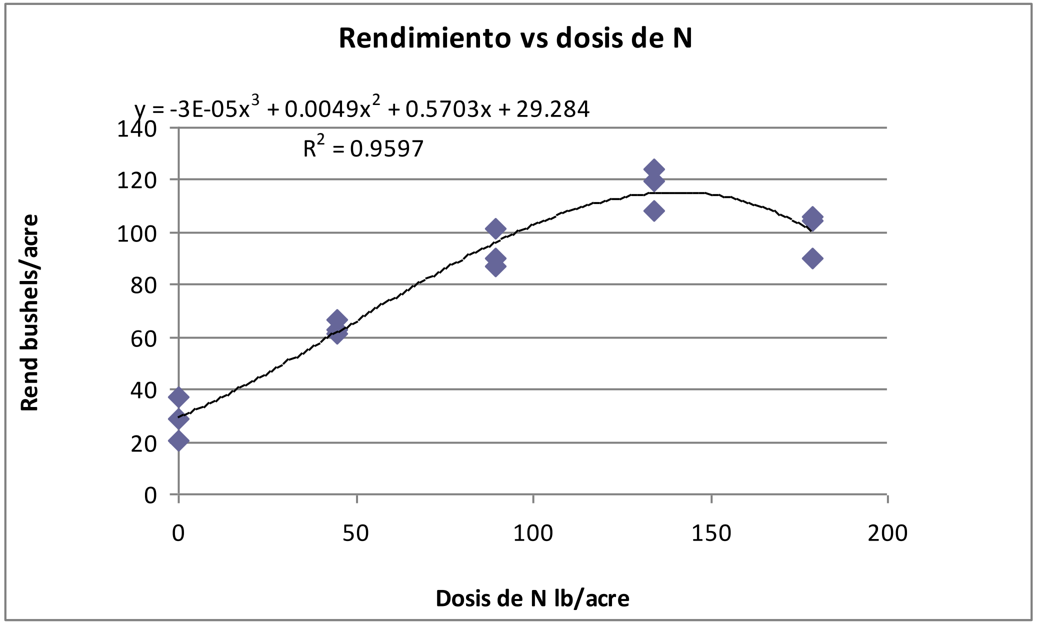
Mexico, Spain, Ecuador, Bolivia, California, Caribbean, …..

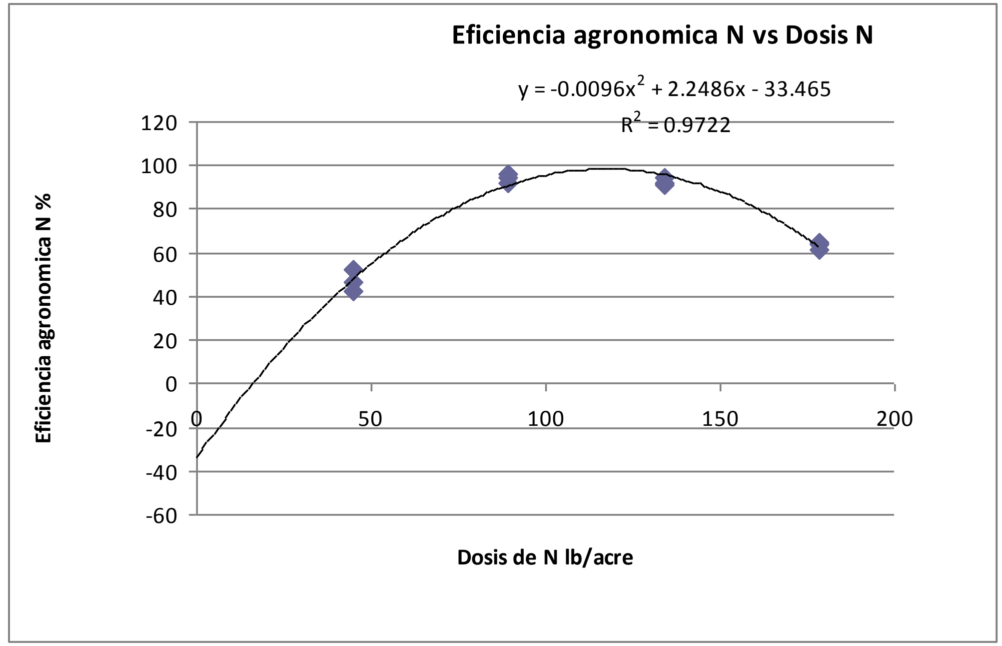
Delgado et al., 2008. Ecol. Eng. 32:108-120

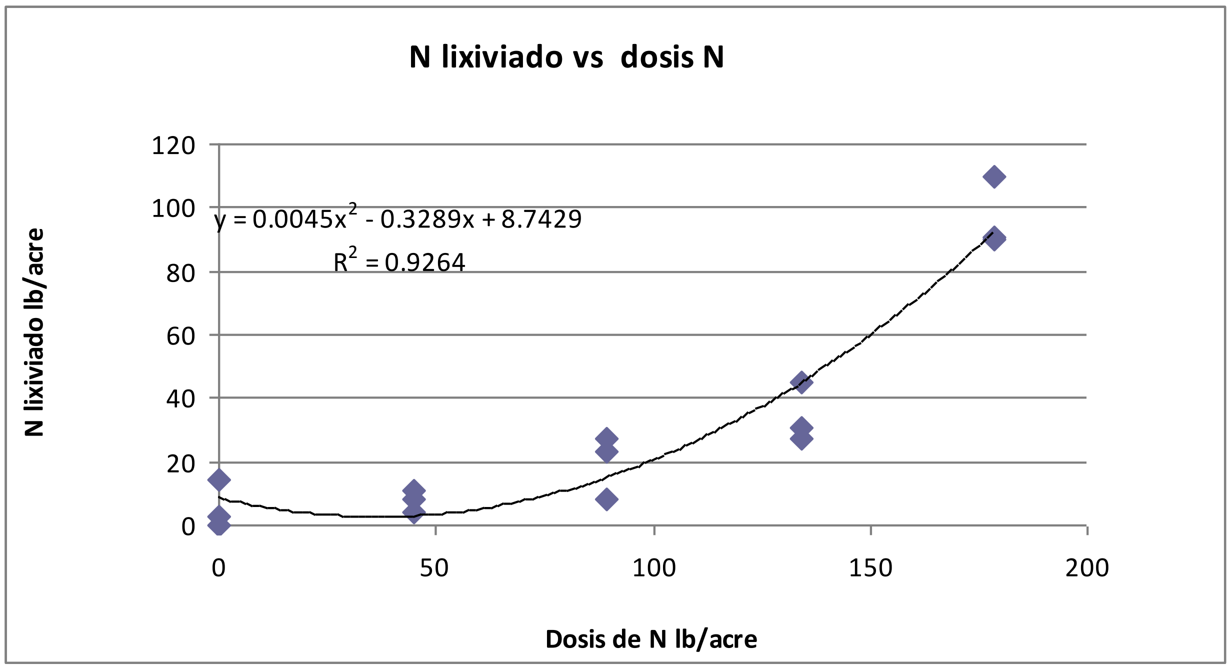
Team Efforts Across Nations – Case Scenarios

Ecuador




Rendimiento vs dosis de N
y = -3E-05x3 + 0.0049x2 + 0.5703x + 29.284
R2 = 0.9597
Rend bushels/acre
140
120
100
80
60
40
20
0
0
50
100
150
200
Dosis de N lb/acre


Eficiencia agronomica N vs Dosis N
y = -0.0096x2 + 2.2486x - 33.465
R2 = 0.9722
Eficiencia agronomica N %
120
100
80
60
40
20
0
-20
-40
-60
0
50
100
150
200
Dosis de N lb/acre


N lixiviado vs dosis N
y = 0.0045x2 - 0.3289x + 8.7429
R2 = 0.9264
N lixiviado lb/acre
120
100
80
60
40
20
0
0
50
100
150
200
Dosis de N lb/acre



“Conservation Practices to Mitigate and Adapt to Climate Change ”

Photo NASA

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

The Soil and Water Conservation Society invited the authors to review the science of conservation practices and their potential for climate change mitigation and adaptation.

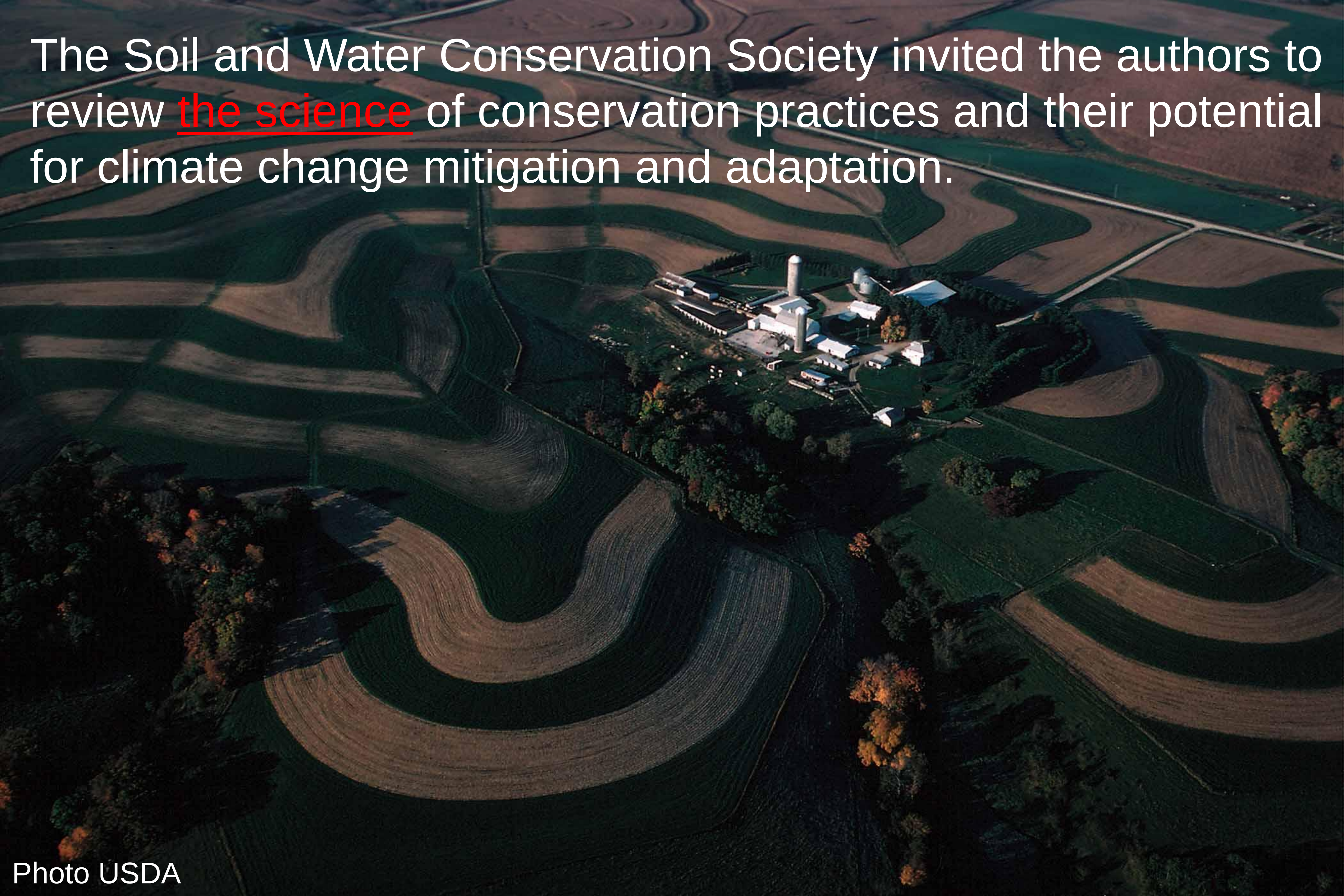


Photo USDA

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 future of food security a major concern.

Additionally, it has been reported that climate change can increase potential erosion rates, which can lower agricultural productivity by 10% to 20% (or more in extreme cases). Climate change could contribute to higher temperatures and evapotranspiration and lower precipitation across some regions. This will add additional pressure to draw irrigation water from some already overexploited aquifers, where the rate of water recharge is lower than the withdrawal rates. These and other water issues exacerbated by climate change present a serious concern because, on average, irrigated system yields are frequently 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 agricultural systems for stable food security.

Jorge A. Delgado is a soil scientist at the USDA Agricultural Research Service, Fort Collins, Colorado. **Peter M. Groffman** is a microbial ecologist at the Cary Institute of Ecosystems Studies, Millbrook, New York. **Mark A. Nearing** is a research agricultural engineer at the USDA Agricultural Research Service, Tuscon, Arizona. **Tom Goddard** is a senior policy advisor at the Government of Alberta, Canada. **Don Reicosky** is a former soil scientist at the USDA Agricultural Research Service, Morris, Minnesota. **Rattan Lal** is a professor in the School of Environment & Natural Resources at the Ohio State University, Columbus, Ohio. **Newell R. Kitchen** is a soil scientist at the USDA Agricultural Research Service, Columbia, Missouri. **Charles W. Rice** is a professor of soil microbiology at Kansas State University, Manhattan, Kansas. **Dan Towery** is the owner of Ag Conservation Solutions, Lafayette, Indiana. **Paul Salon** is a member of the SWCS, New York Chapter.

With so many large population centers of millions of people who need a steady supply of food, a supply that comes from agricultural fields, ranches, and other agroecosystems that could significantly be impacted by climate change, it is becoming increasingly accepted that systems around the globe will need to apply basic principles of conservation agriculture to maintain/increase agricultural productivity. Hugh Hammond Bennett, who has been called "the father of soil conservation," once said, "From every conceivable angle—economic, social, cultural, public health, national defense—conservation of natural resources is an objective on which all should agree" (USDA NRCS n.d.) Bennett's contributions were part of a larger effort to develop a scientifically sound conservation system, a system that today could serve as a framework not only for climate change mitigation but also for climate change adaptation.

This document is an overview of the science on conservation practices that could potentially be used to mitigate and adapt to climate change. Following is a list that summarizes some basic principles based on a review of peer-reviewed scientific publications. We recommend that these principles be considered, discussed, and even modified as new findings are brought to light that can be used to improve conservation. Meetings of professional scientific 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.

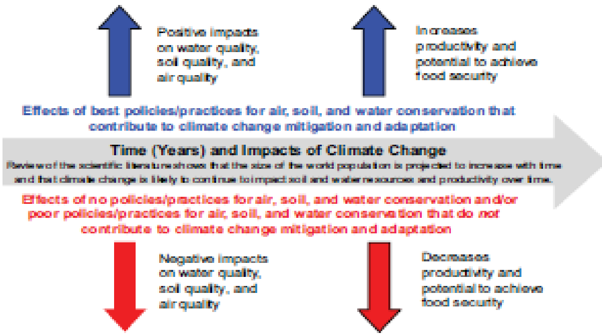
MAJOR WORLD CHALLENGES RELATED TO SOIL AND WATER CONSERVATION

From conducting a review of the scientific, peer-reviewed literature, we have identified the following major world challenges related to soil and water conservation:

- Climate change is occurring, and the implementation of sound conservation practices will be key for each country's health, social stability, and security. There are a large number of peer-reviewed publications that report on the effects of a changing climate. The potential role of conservation practices in contributing to food security is shown in figure 1, which illustrates the relationship between climate change, soil and water resources, and food security.
- Extreme weather events are creating environmental problems, accelerating the rate of erosion, and threatening agricultural production needed for food security. Increases in erosion rates due to climate change will result in lower productivity. Additionally, Hugh Hammond Bennett suggested that without conservation of natural resources, environmental problems such as accelerated erosion could negatively impact society and threaten national security (USDA NRCS n.d.).
- Population growth and the development of new, stronger economies, such as those of China and India are increasing the demand for world resources. By 2050, the world population is expected to increase by 2.4 billion people, and as the economies of countries with large populations improve, even more pressure will be put on the world's agricultural systems. This increased demand for resources coupled with climate change could threaten the potential to achieve food security.
- Key world agroecosystems that rely on significant amounts of irrigation water are being threatened because water resources are being depleted, a result of water use exceeding water storage replacement. Since irrigated systems have, on average, double the yields of nonirrigated systems, the depletion and salinization of these key world resources results in additional pressure to increase agricultural productivity.
- Due to anticipated impacts from climate change, deforestation, erosion, depletion of water resources, and other environmental problems, as well as potentially higher fuel prices, which could impact agricultural inputs, food security will increasingly become a concern in the coming decades. This could become an even greater concern if extreme events, such as droughts or floods, or even extreme pest or disease outbreaks (e.g., blight, a potato disease that contributed to the infamous potato famine in Ireland) begin to occur on systems that are already stressed.

Figure 1

There is a close relationship between climate change, limited global water and soil resources, population growth, and food security. As climate change impacts the world's soil and water resources, it threatens to negatively impact food production (i.e., decrease food production and/or food production potential). As the climate changes, conservation practices have the potential to help us achieve maximum sustainable levels of food production, which will be essential to efforts to feed the world's growing population. Good policies/practices for air, soil, and water conservation will contribute to positive impacts on air, soil, and water quality; soil productivity; and efforts towards achieving and/or maintaining food security. These good policies/practices will contribute to climate change mitigation and adaptation. Poor policies/practices for air, soil, and water conservation (or a lack of policies/practices) will contribute to negative impacts on air, soil, and water quality; soil productivity; and efforts toward achieving and/or maintaining food security.



SOIL AND WATER CONSERVATION PRINCIPLES APPLIED TO CLIMATE CHANGE MITIGATION AND ADAPTATION

From conducting a review of the scientific, peer-reviewed literature, we have identified principles for (1) communication of soil and water conservation programs, (2) soil and water conservation practices, and (3) development of new science and technologies. These principles, which can be applied to climate change mitigation and adaptation, are listed below:

Principles for Communication of Soil and Water Conservation Programs

- Develop Communication that Connects Science to Land Managers. Better communication with farmers and farmers' groups is key to increasing the efficiency of soil and water conservation programs.
- Develop Communication that Connects Science to the Public. Better communication with the general public is essential to increasing awareness of the benefits of soil and water conservation programs.
- Teach the Value of Soil Carbon. Understanding the relationship between carbon (C) sequestration and soil and water quality benefits is key. Conservationists, farmers, policy advisors, K-12, and university students—in short, the general public—should have an understanding of how soil carbon can assist in climate change mitigation and adaptation.
- Embrace Technology. Transfer of new technologies to increase conservation effectiveness will contribute to climate change mitigation and adaption efforts.
- Improve Historical Context. Development of long-term data records, programs, and studies are important for developing conservation programs that will contribute to climate change mitigation and adaptation.
- Ongoing Training Essential. Education programs and the mentoring of new personnel are important for maintaining an educated workforce that will compete to develop the most efficient management practices.
- Enhance Exchange. Forums for exchanging information between farmers, professional societies, scientists, conservation practitioners, and the general public, and to discuss the advantages and disadvantages of recent advances, are needed to continue advancing the field of soil and water conservation and are important for climate change mitigation and adaptation.

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

- Surface Residue Protects. Conservation agriculture increases sustainability.

“Conservation Practices to Mitigate and Adapt to Climate Change ”

- Jorge A. Delgado USDA ARS, Fort Collins, Colorado.
- Peter M. Groffman Cary Institute of Ecosystems Studies, Milbrook, New York.
- Mark A. Nearing USDA ARS, Tuscon, Arizona.
- Tom Goddard Government of Alberta, Canada.
- Don Reicosky USDA ARS (Former)
- Rattan Lal The Ohio State University, Columbus, Ohio.
- Newell R. Kitchen USDA ARS, Columbia, Missouri.
- Charles W. Rice Kansas State University, Manhattan, Kansas.
- Dan Towery is the owner of Ag Conservation Solutions, Lafayette, Indiana.
- Paul Salon SWCS, New York Chapter.

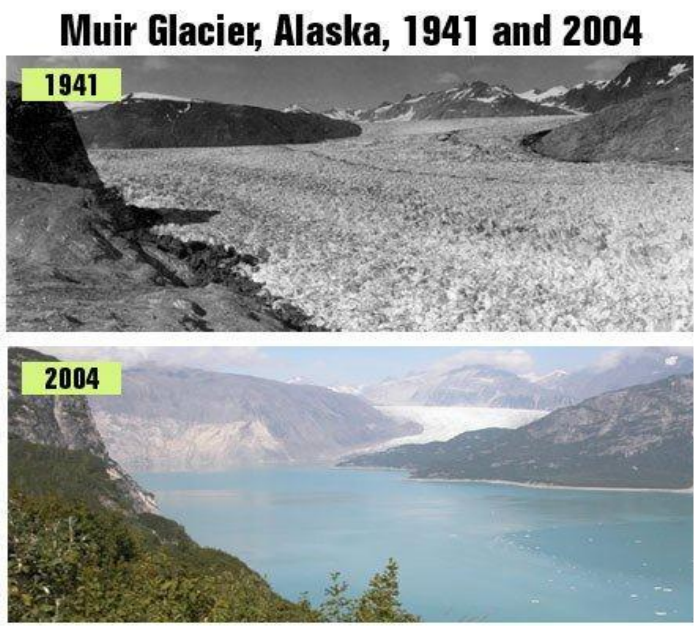
Photo NASA

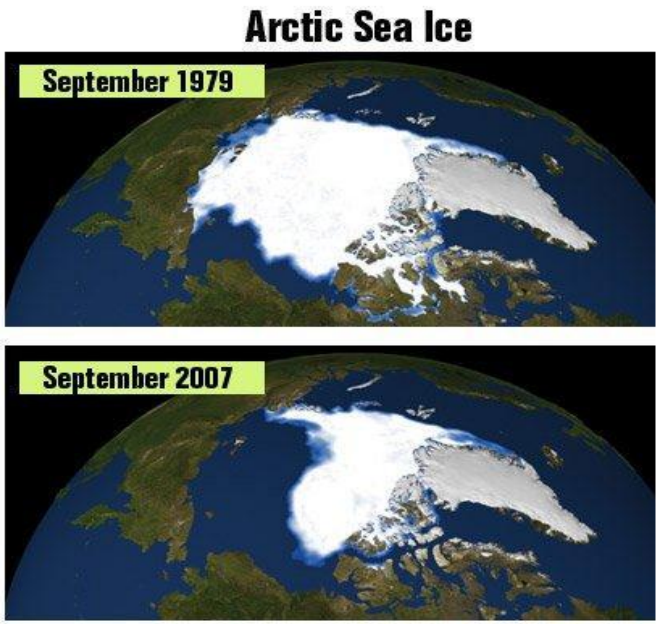
The 20th century's Green Revolution showed that science-based solutions could provide answers to global challenges to the benefit of societies.

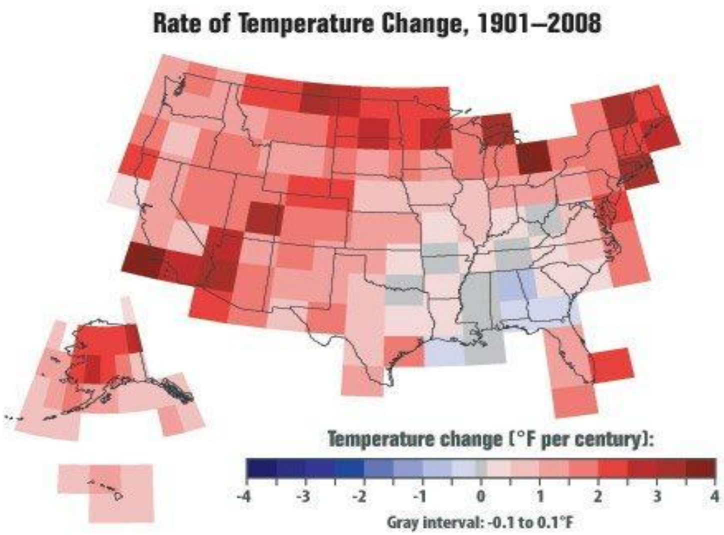
Despite the success of the Green Revolution, today there are new concerns, and the threat of climate change is among the most severe threats that face our planet in the 21st century (USDA NRCS 2010).

Major World Challenges Related to Soil and Water Conservation

• Climate change is occurring, and the implementation of sound conservation practices will be key for each country's health, social stability, and security.







Photos EPA

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

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).

Major World Challenges Related to Soil and Water Conservation

• Key world agroecosystems that rely on significant amounts of irrigation water are being threatened because water resources are being depleted, a result of water use exceeding water storage replacement.

•Since irrigated systems have, on average, double the yields of non-irrigated systems, the depletion and salinization of these key world resources results in additional pressure to increase agricultural productivity.

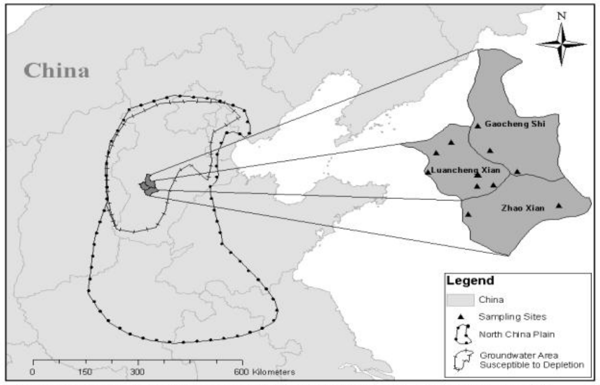
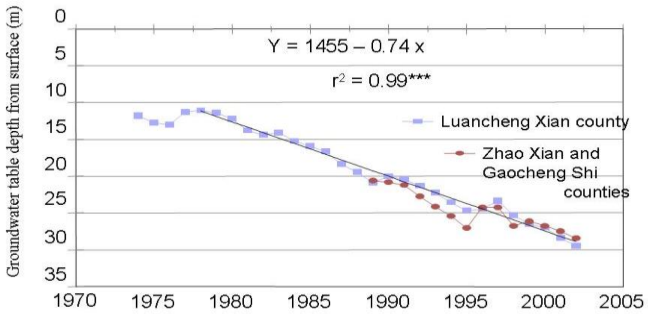


Figure 1. Map layout indicating the location of the North China Plain (NCP) (approximate area); northwestern region of the NCP susceptible to underground water depletion (approximate area); and locations of village study sites within Luancheng Xian, Gao Cheng Shi and Zhao Xian counties. Scale bar not relative to blownup image.

JSWC



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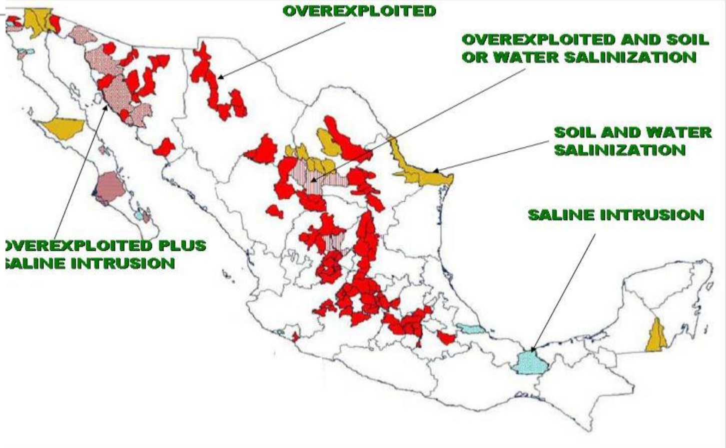

Overexploited aquifers, with saline intrusion and/or water salinization (CNA, 2004).

CAN 2004

Additionally, there are reports that for some regions, the melting of glaciers may affect the availability of water that is used for cities and/or irrigated lands. This presents a serious concern because, on average, irrigated systems have yields that are twice those of nonirrigated systems (Rangely 1987; Bucks et al. 1990; Tribe 1994).

Photo EPA (Kilimanjaro)

Another concern that could affect the maximization of yields is energy costs, which are expected to rise in the future and which may reduce key fertilizer and agrochemical inputs at a farm level (UNEP GRID-Arendal 2009).

Nonirrigated systems could also see their yields potentially reduced due to these stresses since it has been reported that for every increase in temperature of 1°C (1.8°F), there is a potential reduction in yield, not only from heat stress, but also from the interaction of heat stress and drought stress that may be put on crops (Peng et al. 2004; Auffhammer 2011; Lobell et al. 2011).

For example, across Africa, an increase in temperature of 1°C under drought conditions could affect 100% of the maize area, potentially reducing yields by at least 20% (Auffhammer 2011; Lobell et al. 2011).

Major World Challenges Related to Soil and Water Conservation

Population growth and the development of new, stronger economies, such as those of China and India, are increasing the demand for world resources.

By 2050, the world population is expected to increase by 2.4 billion people, and as the economies of countries with large populations improve, even more pressure will be put on the world's agricultural systems. This increased demand for resources coupled with climate change could threaten the potential to achieve food security.

Major World Challenges Related to Soil and Water Conservation

Due to anticipated impacts from climate change, deforestation, erosion, depletion of water resources, and other environmental problems, as well as potentially higher fuel prices, which could impact agricultural inputs, food security will increasingly become a concern in the coming decades.

- This could become an even greater concern if extreme events, such as droughts or floods, or even extreme pest or disease outbreaks (e.g., blight, a potato disease that contributed to the infamous potato famine in Ireland) begin to occur on systems that are already stressed.

The Carbon and Nitrogen Cycles and Agricultural Influences on Greenhouse Gases

Greenhouse Gases Contributed by Agriculture are an Important Factor in Climate Change.

Agriculture plays an important role in the GHG fluxes of CO_2, N_2O and CH_4, contributing 6% of total United States GHG emissions, a total of 427.5 Tg CO_2 equivalents (table 2; figure 2) (USEPA 2010b).

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Communication of Soil and Water Conservation Programs

- Teach the Value of Soil Carbon.

Understanding the relationship between carbon (C) sequestration and soil and water quality benefits is key. Conservationists, farmers, policy advisors, K-12 and university students—in short, the general public—should have an understanding of how soil carbon can assist in climate change mitigation and adaptation.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

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-*Better communication with farmers and farmers' groups is key to increasing the efficiency of soil and water conservation programs.*

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

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Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Communication of Soil and Water Conservation Programs

- Improve Historical Context.

-Development of long-term data records, programs, and studies are important for developing conservation programs that will contribute to climate change mitigation and adaptation.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Communication of Soil and Water Conservation Programs

- Ongoing Training Essential.

-Education programs and the mentoring of new personnel are important for maintaining an educated workforce that will compete to develop the most efficient management practices.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Communication of Soil and Water Conservation Programs

•Enhance Exchange.

-Forums for exchanging information between farmers, professional societies, scientists, conservation practitioners, and the general public, and to discuss the advantages and disadvantages of recent advances, are needed to continue advancing the field of soil and water conservation and are important for climate change mitigation and adaptation.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

- Cover the Surface.

  -Harvesting of plant residues should be avoided if soil function will be compromised.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

- Soil Function Improves with Soil Carbon.

  -Soil C sequestration is beneficial for the environment.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

•Surface Residue Protects.

-Conservation agriculture increases sustainability.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

•Value Perennial Crops.

-A large number of peer-reviewed manuscripts report that perennial bioenergy crops (e.g., switchgrass) can contribute to C sequestration and better protect the environment than grain cropping used for energy.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

- Off-Field Remediation Practices Are Helpful.

  -Off-the-field conservation practices can contribute to climate change mitigation and adaptation (e.g., riparian forest buffer, wetland).

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

•Improve Landscape Diversity with Agroforestry.

-Agroforestry can contribute to landscape diversity, benefiting the environment.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

•Effectiveness Enhanced with Landscape-Targeting Precision Conservation.

-We need to account for spatial and temporal variability and avoid a one-size-fits-all approach if we are to maximize conservation. The scientific literature has many examples that show that to maximize conservation, managers will need to consider the effects of climate change on yield, productivity, and the environment. These effects are likely to be mixed and to vary greatly by region, by field, within field, and by crop type.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

•Promote Energy Efficiency.

-Green programs can save energy at the farm level (e.g., wind, solar, and biomass programs).

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

- Value Water More.

  -Water-use efficiency needs to be increased, and water quality needs to be protected.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

- Greater Diversity Needed.

  -Diverse cropping systems will be key to mitigating and adapting to climate change. Development of new varieties that can be used for tolerance of drought, temperature stress, and other effects of climate change will be needed.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

- Minimize Gas Losses.

  -Practices that can reduce emissions of methane (CH_4) and other greenhouse gases at the farm level will contribute to sustainability.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Soil and Water Conservation Practices for Climate Change Mitigation and Adaptation

- "Tighter" Nutrient Cycles.

-Practices that can capture nutrients and energy from manure contribute to conservation. Cycling of crop residues, use of cover crops, and increasing fertilizer-use efficiencies are some examples of ways to contribute to tighter nutrient cycles.

Soil and Water Conservation Principles Applied to Climate Change Mitigation and Adaptation

Principles for Development of New Science and Technologies

- Research Pays Dividends Long Term.

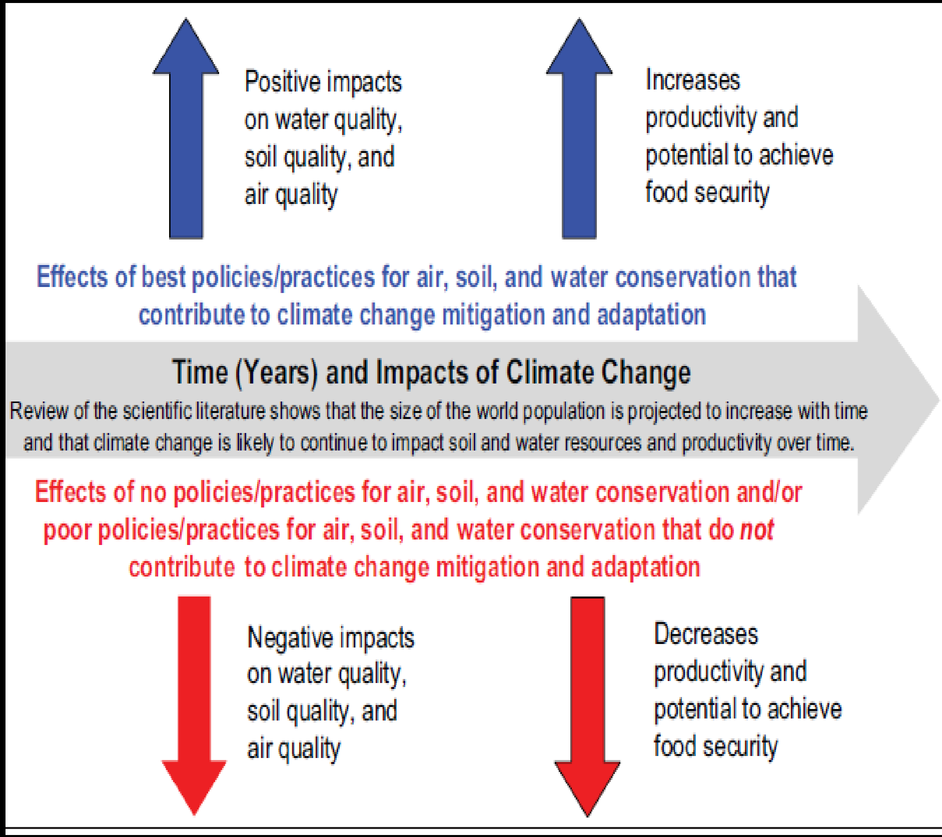
  -Research programs greatly contribute to soil and water conservation, making them important for climate change mitigation and adaptation.

Table 1

The majority of this table is adapted from Eagle et al. (2010). Other results from Adler et al. (2007) life cycle analysis of bioenergy systems and from a matrix of conservation practices developed by USDA Natural Resources Conservation Service (NRCS), West Technology Center, were also incorporated, as well as additional comments from the authors of this document. The effect of management practices on soil carbon sequestration (CS), the net flux of nitrous oxide and methane greenhouse gas (GHG) emissions, and on the change in upstream and process emissions (UPE, fuel, fertilizer, etc.) are estimated. All estimated values were expressed as equivalents of carbon dioxide. A positive, high, and very high sequestration potential are represented by +, ++, and +++, respectively, while net equivalent emissions are represented by –. The net carbon sequestration impact (NCSI) is the sum of CS, GHG and UPE.

Management practice*	CS	GHG	Additional benefits to the producer and environment	UPE	NCSI
Agroforestry					
Windbreaks for crops and livestock	++	+	Improves crop and livestock protection and wildlife habitat. Provides alternative income source. Has potential to contribute to adaptation (e.g., minimize impacts of extreme wind storms).	+	+++
Silvopasture with rotational grazing	++	+	Provides annual income from grazing; long-term income from wood products. Has potential to contribute to adaptation (e.g., provide a viable income and serve as a tool against a changing climate).	+	++
Riparian forest buffer	++	+	Improves water quality and wildlife habitat. Provides alternative income source (specialty crops, hunting fees). Has potential to contribute to adaptation (e.g., use targeted, strategically located riparian forests to reduce impacts of extreme events due to higher water flow).	+	+++
Livestock					
Organic soil amendments (especially manure)	+	+	Provides nutrients for crops; improves water quality when nutrient management plans are followed and manure is not over applied. Has potential to contribute to adaptation (e.g., result in higher nutrient cycling capacity and soils with improved soil quality that may be able to adapt better and maintain productivity in a changing climate).	+	++
Rotational grazing	++	+	Reduces water requirements. Helps withstand drought. Increases long-term grassland productivity. Has potential to contribute to adaptation (e.g., provide economic alternative due to higher-quality forage).	+	++
Improve grazing management rangeland	++	+	Potentially increases carbon sequestration on land, depending on previous crop(s) grown. Has potential to contribute to adaptation (e.g., provide economic alternative due to improved grasslands and soils with improved soil quality that may be able to adapt better and maintain productivity in a changing climate).	na	+
Cropland					
Change from conventional to conservation tillage	+	+	Improves soil, water, and air quality. Reduces soil erosion and fuel use; saves expenses, time, and labor. Has potential to contribute to adaptation (e.g., provide economic alternative due to savings in energy).	+	+
Change from conventional to no-till	+	–	Improves soil, water, and air quality. Reduces soil erosion and fuel use; saves expenses, time, and labor. Has potential to contribute to adaptation (e.g., provide economic alternative due to savings in energy).	+	+
Improved irrigation management	+	+	Improves air quality, reduces water quantity usage. Has potential to contribute to adaptation, since saving water (reduced usage) will be crucial in the coming decades to deal with a changing climate in drier regions and to respond to droughts.	+	+
Crop diversity crop rotation	+	+	Reduces erosion and water requirements. Improves soil and water quality, reduces nitrogen and other fossil-fuel-intensive inputs. Has potential to contribute to adaptation (e.g., provide economic alternative that may be able to adapt better and maintain productivity in a changing climate that could bring new pests and diseases due to warmer weather).	+	+
Crop conversion to pasture	++	+	Reduces erosion and increases carbon sequestration. Has potential to contribute to adaptation (e.g., provide economic alternative that may be able to adapt better and maintain economic productivity in a changing climate).	+	+++
Effective nitrogen management	na	+	Reducing losses of reactive nitrogen can contribute to improved water quality; saves expenses,	+	+

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.



Additional Information/Final Comments

All of this information is available at the SWCS website (http://www.swcs.org/) and also published in the *Journal of Soil and Water Conservation* (http://www.jswconline.org/).

Thank You!