

Mitigation of Phosphorus and Ammonia losses from Poultry Manure using FGD Gypsum

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USDA – ARS

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Growth of Agriculture

In the last third of the past century:

- 700-fold increase in global use of nitrogenous (mass of N) fertilizers
- 300-fold increase in phosphorus (mass P_2O_5) fertilizers

(Tilman et al., 2001)



Growth Driven By:

- Needs of 6 billion people
- Food, Fiber, Shelter, Water
(Foley et al., 2005)
- AND Now ENERGY!

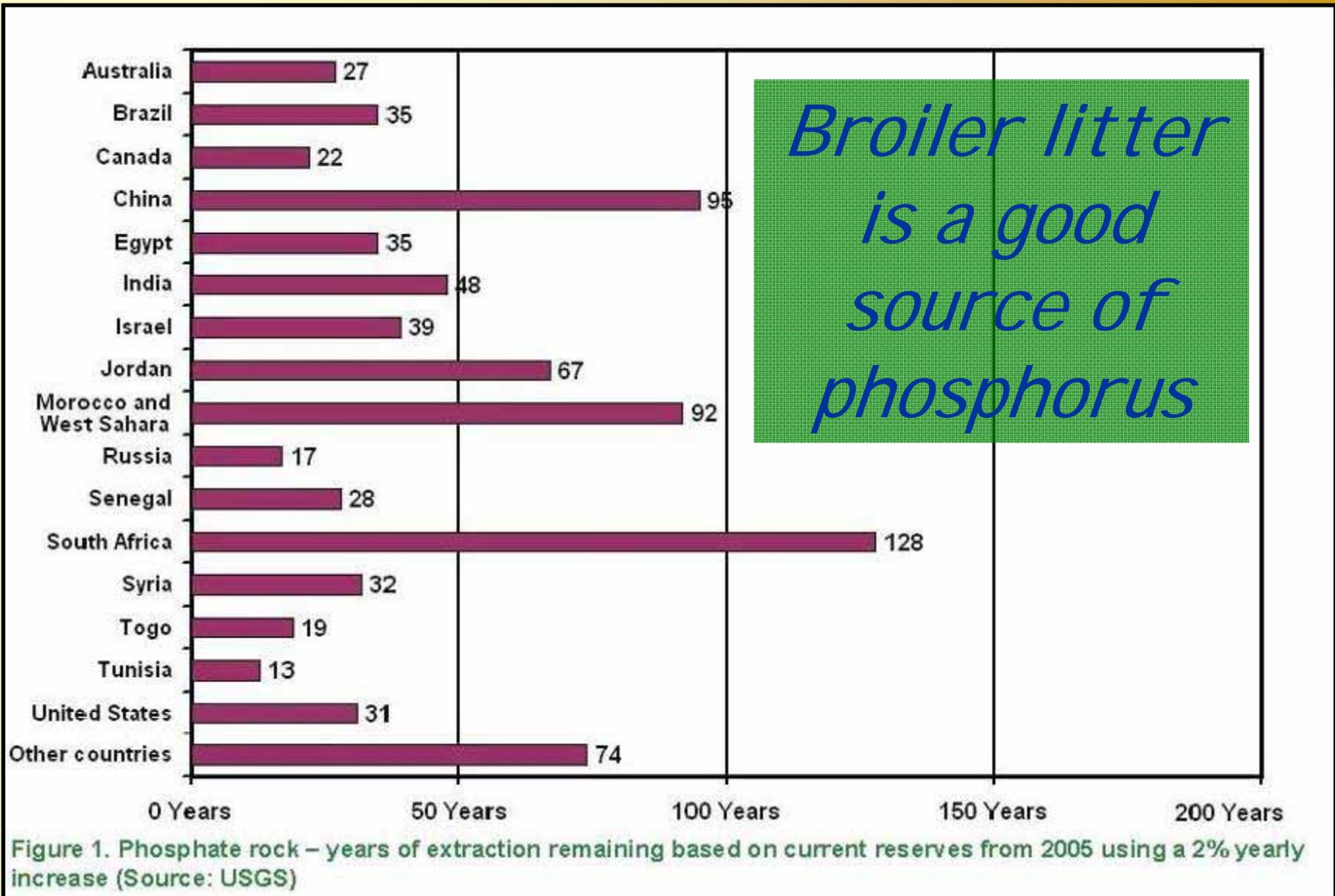


Nutrient use efficiency for sustained Productivity and Environmental Health

- Nutrients must be in the soil to be productive
- Yet we are losing soil and nutrients
- Gypsum may help conserve nutrients

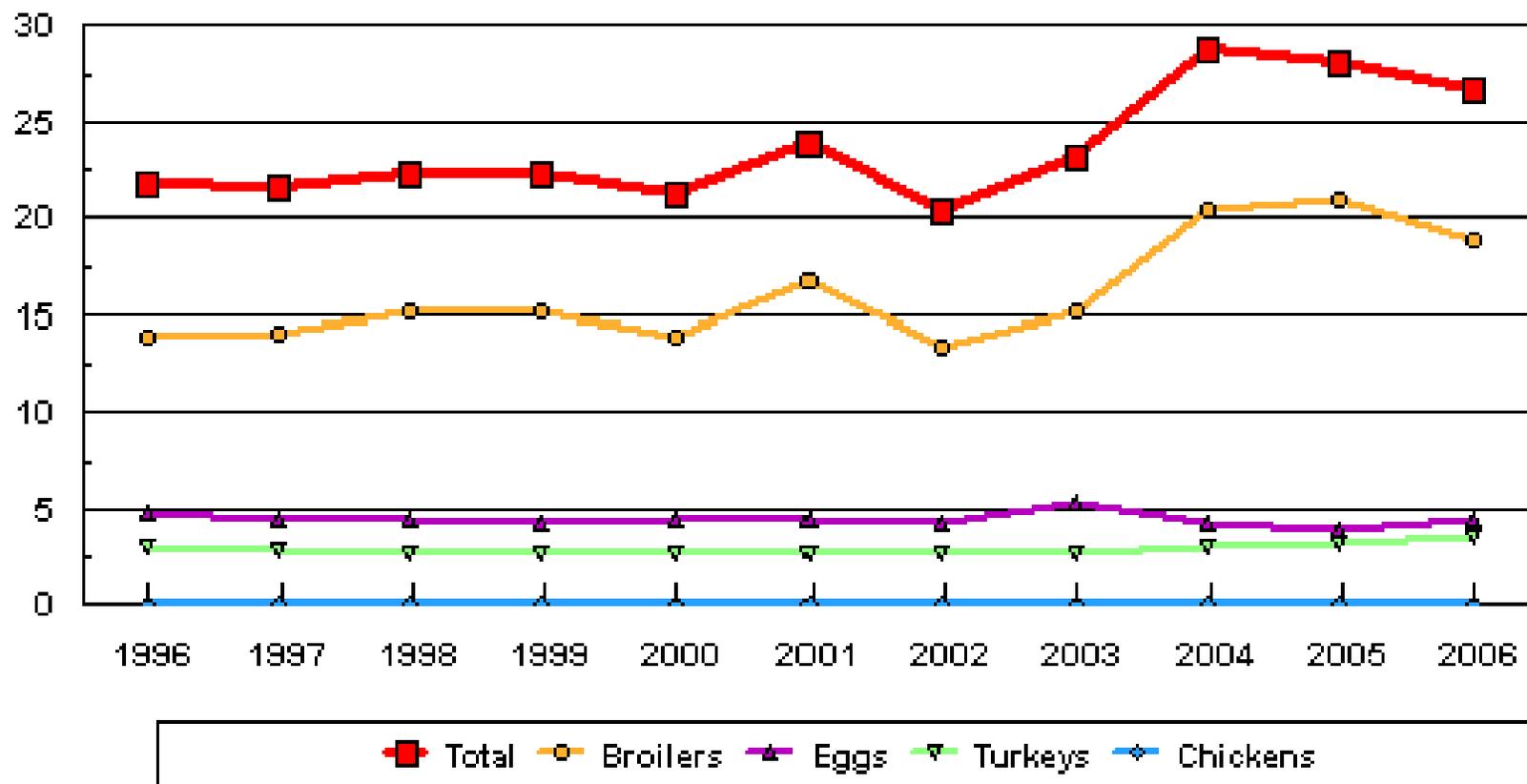


We need to conserve Phosphorus



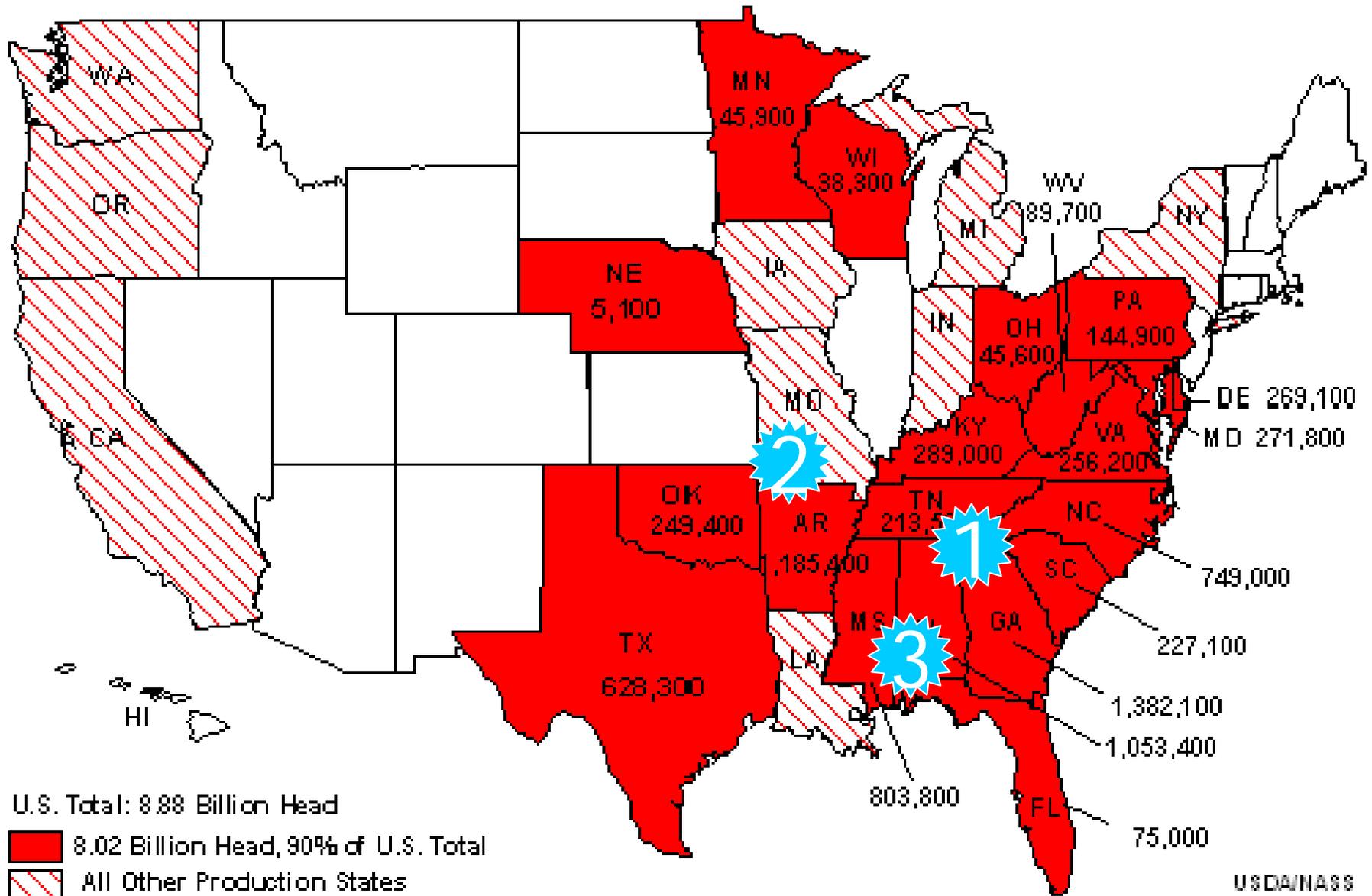
Value of Production: Broilers, Eggs, Turkeys, Chickens, and Total, United States, 1996-2006

Billion Dollars



USDA-NASS
April 2007

BROILER PRODUCTION BY STATE NUMBER PRODUCED, THOUSAND, 2006



U.S. Total: 8.88 Billion Head

8.02 Billion Head, 90% of U.S. Total

All Other Production States

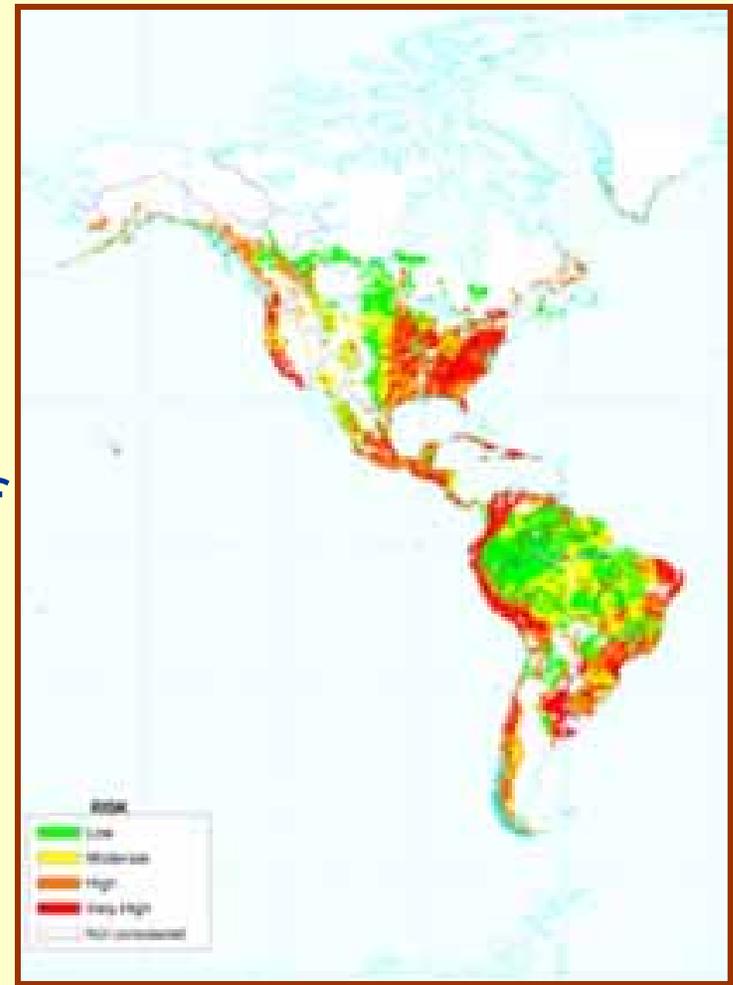
Vulnerability

- Risk of soil loss indicates high potential for surface runoff
- Nutrients placed on the surface are vulnerable to transport via surface runoff
(Hart et al., 2004)
- We need a mechanism to help move nutrients into the soil



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Risk to Erosion



FGD Gypsum as a Solution

- Croplands and Grazinglands
- Increase infiltration – drought mitigation
- Reduce P losses
- Reduce ammonia losses
- Source of calcium and sulphur
- Root-friendly subsoils



FGD Gypsum as a solution- Drought Mitigation

***Estimated Economic Losses in GA
1 to 1.4 billion dollars***

- Increased infiltration increases soil water content
- Compact soils resist root penetration
- Gypsum improves rooting depth and infiltration

(McCray et al., 1991; Toma et al., 1999; Gascho et al., 2001)

FGD Gypsum as a solution- Drought Mitigation

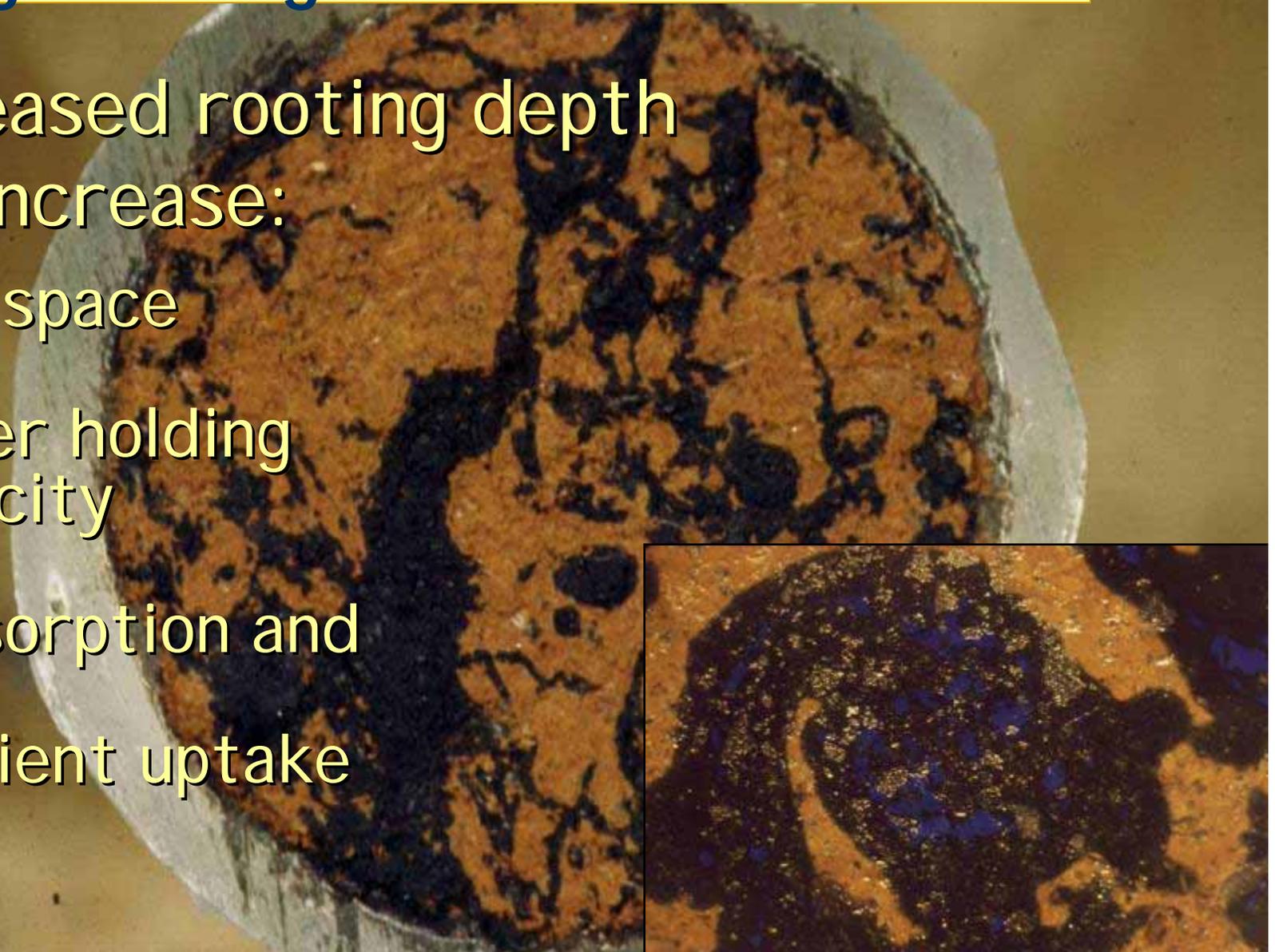
Increased rooting depth
may increase:

Pore space

Water holding
capacity

P adsorption and

Nutrient uptake



FGD Gypsum as a solution- Drought Mitigation

Gypsum:

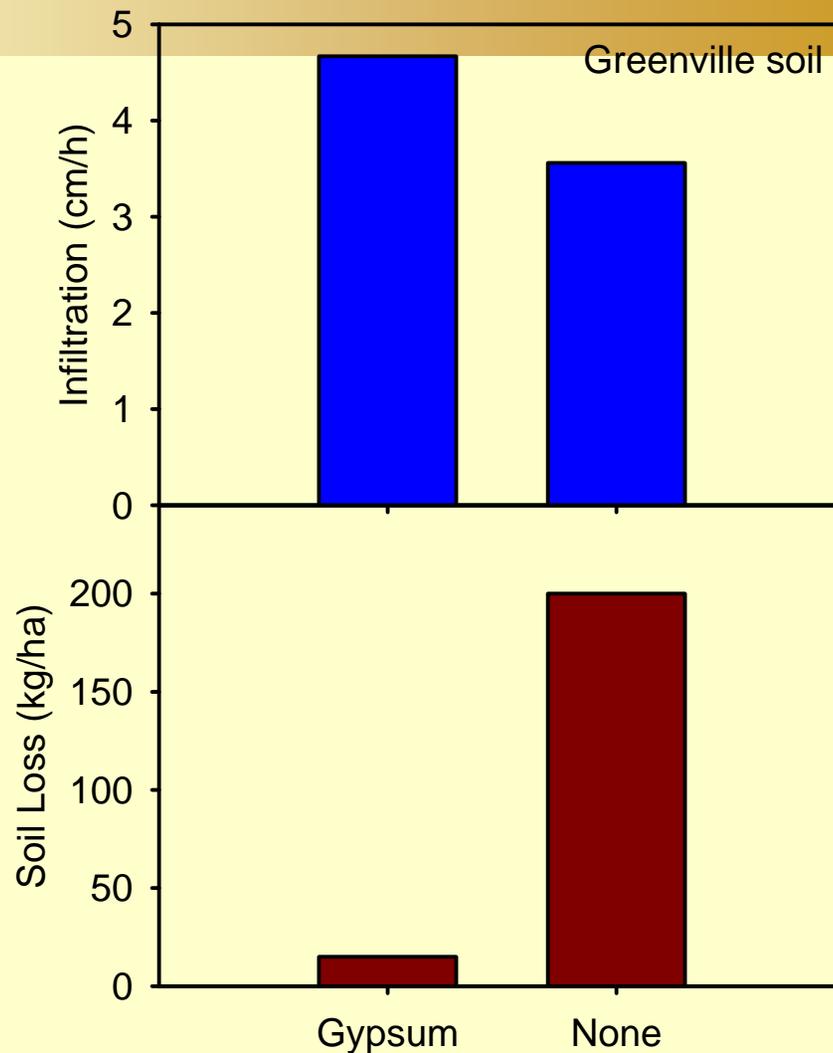


Infiltration



Soil loss

On bare soil



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(Miller and Scifres, 1988)

FGD Gypsum as a solution- Drought Mitigation

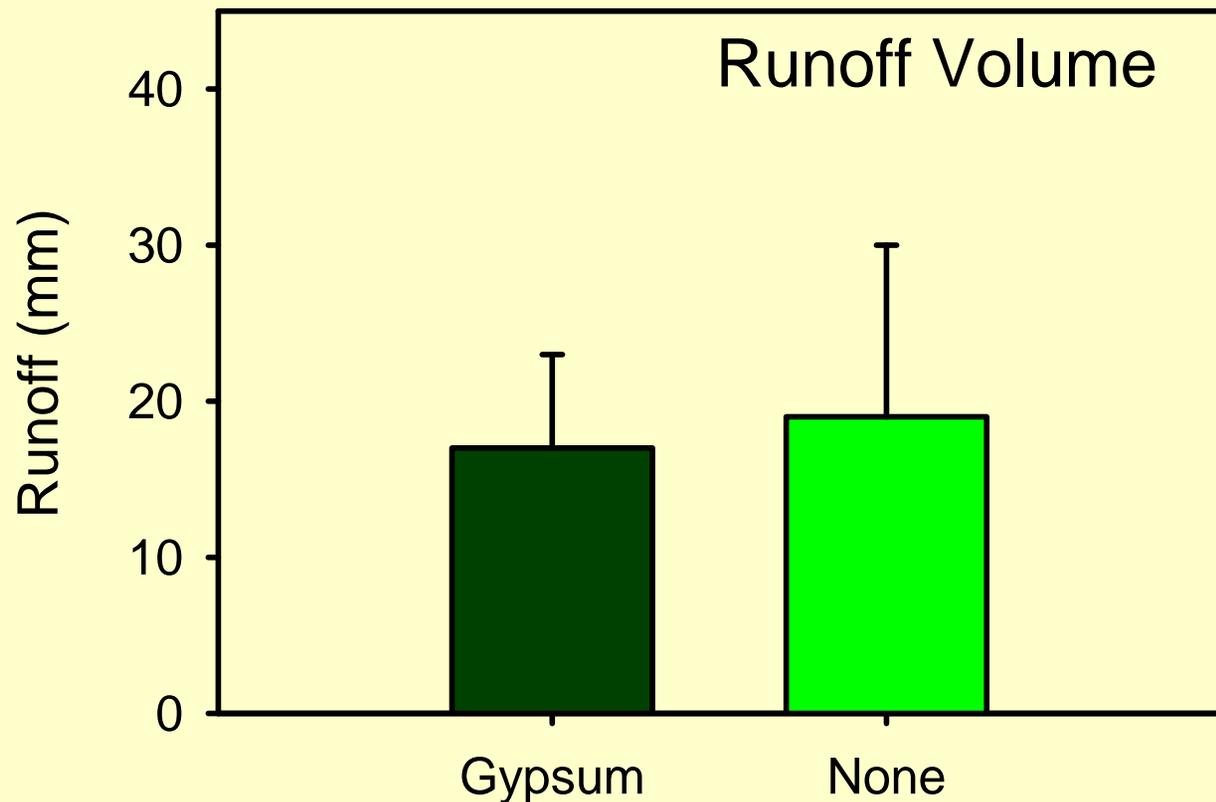
Research topics

Reaction
time

Landscape
position

27 mm

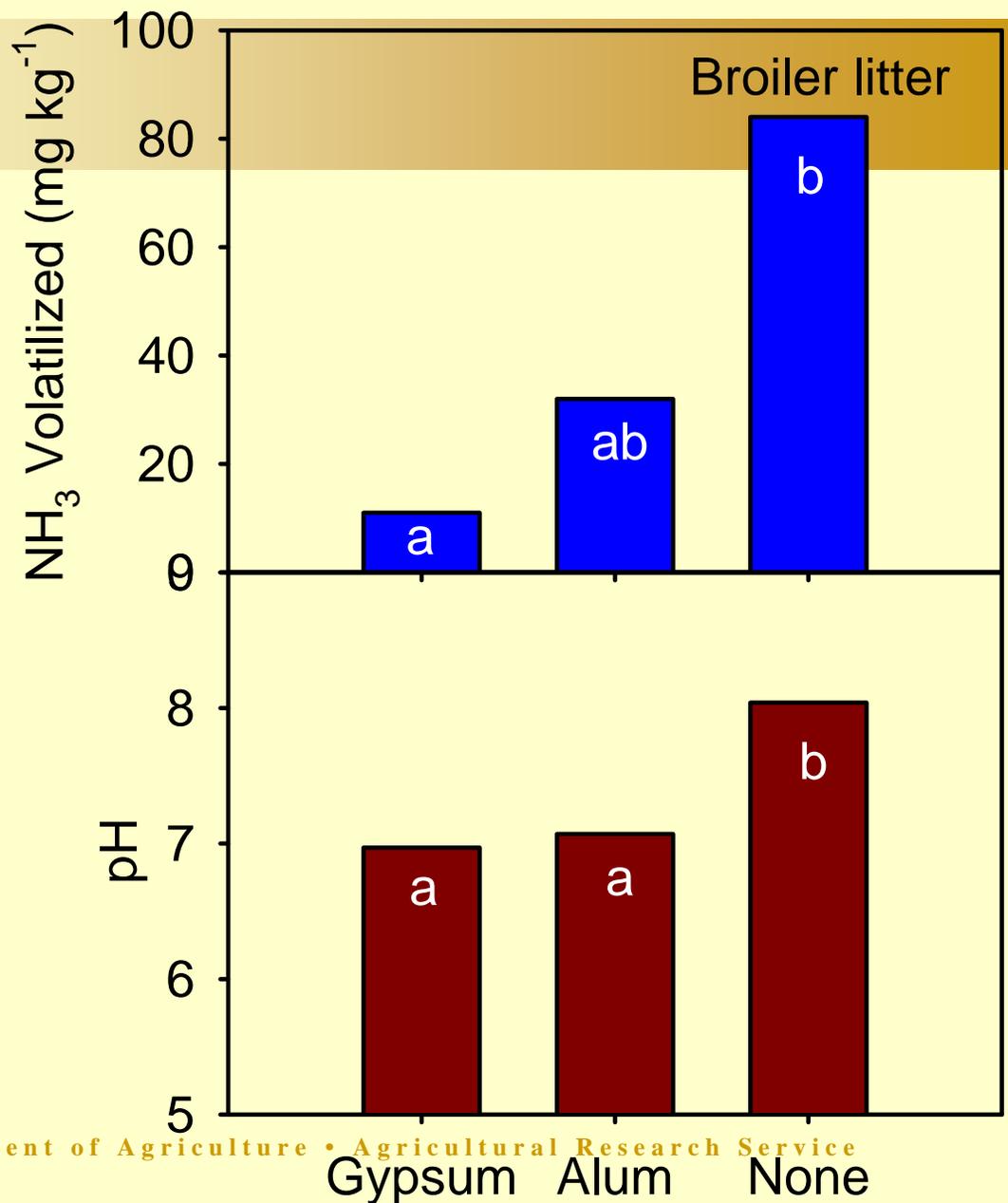
20 mm



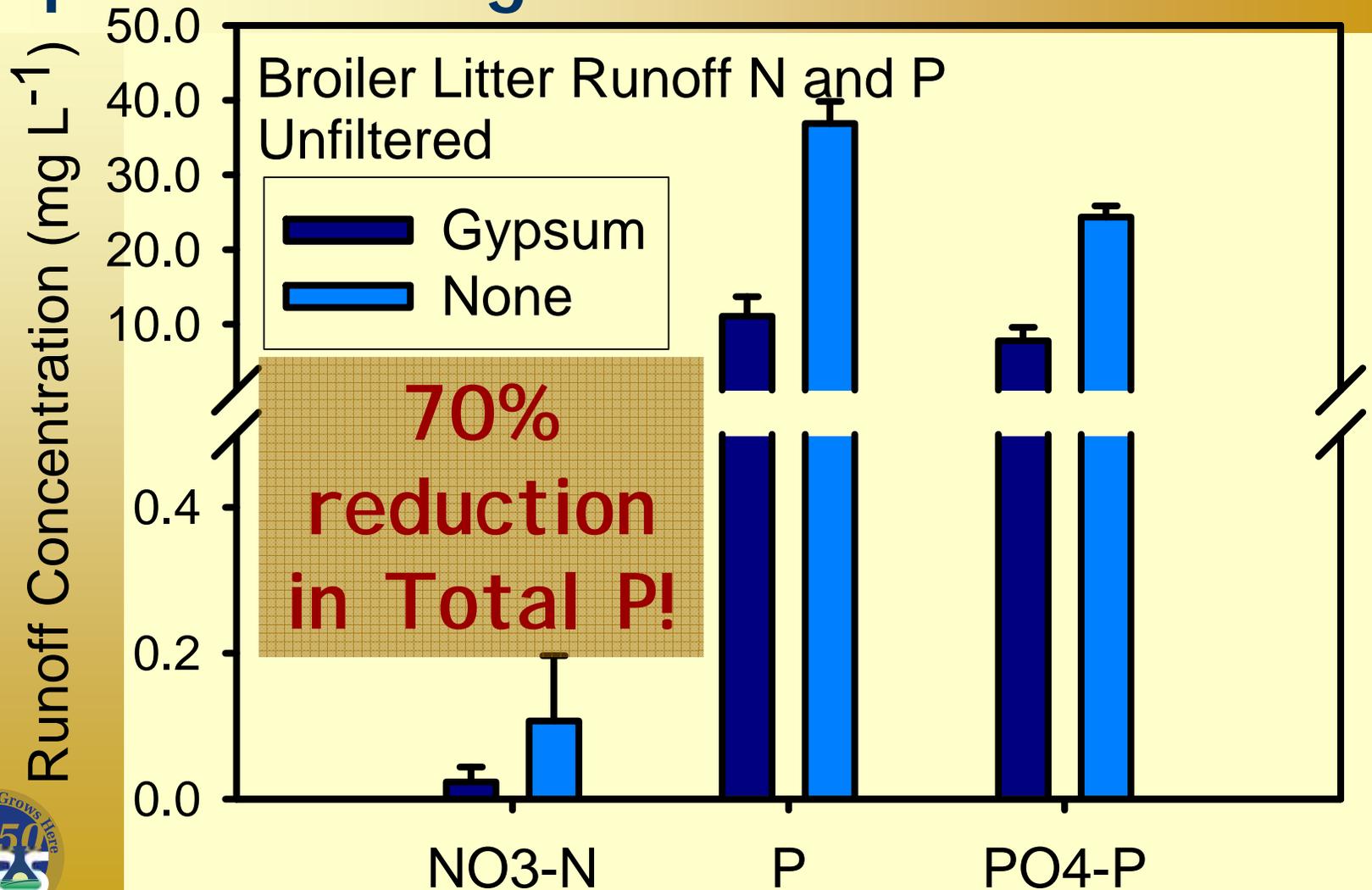
FGD Gypsum as a solution- Reduce Ammonia

Volatilization
from broiler
litter

(Oliveira et al., 2003)



FGD Gypsum as a solution- Phosphorus Mitigation



FGD Gypsum- Management Implications

- Dissolved inorganic N & P fractions (PO_4 , NH_4 or NO_3) are most available to aquatic organisms.
- Conservation tillage systems are usually filter systems and are more effective on particulate forms than on dissolved N & P forms.



FGD Gypsum- Management Implications

Mean total mass losses

Tillage- Intensity Treatment	NH ₄ -N	NO ₃ -N	TKN	DRP	TKP
	----- g ha ⁻¹ -----				
CT-variable	133 a	58 c	1423 a	1 c	459 a
CT-constant	105 a	49 c	1481 a	3 c	527 a
ST-variable	68 a	133 b	478 b	37 b	136 b
ST-constant	291 a	361 a	724 b	69 a	174 b

CT – Conventional and ST – Conservation tillage

(Franklin et al., 2007)

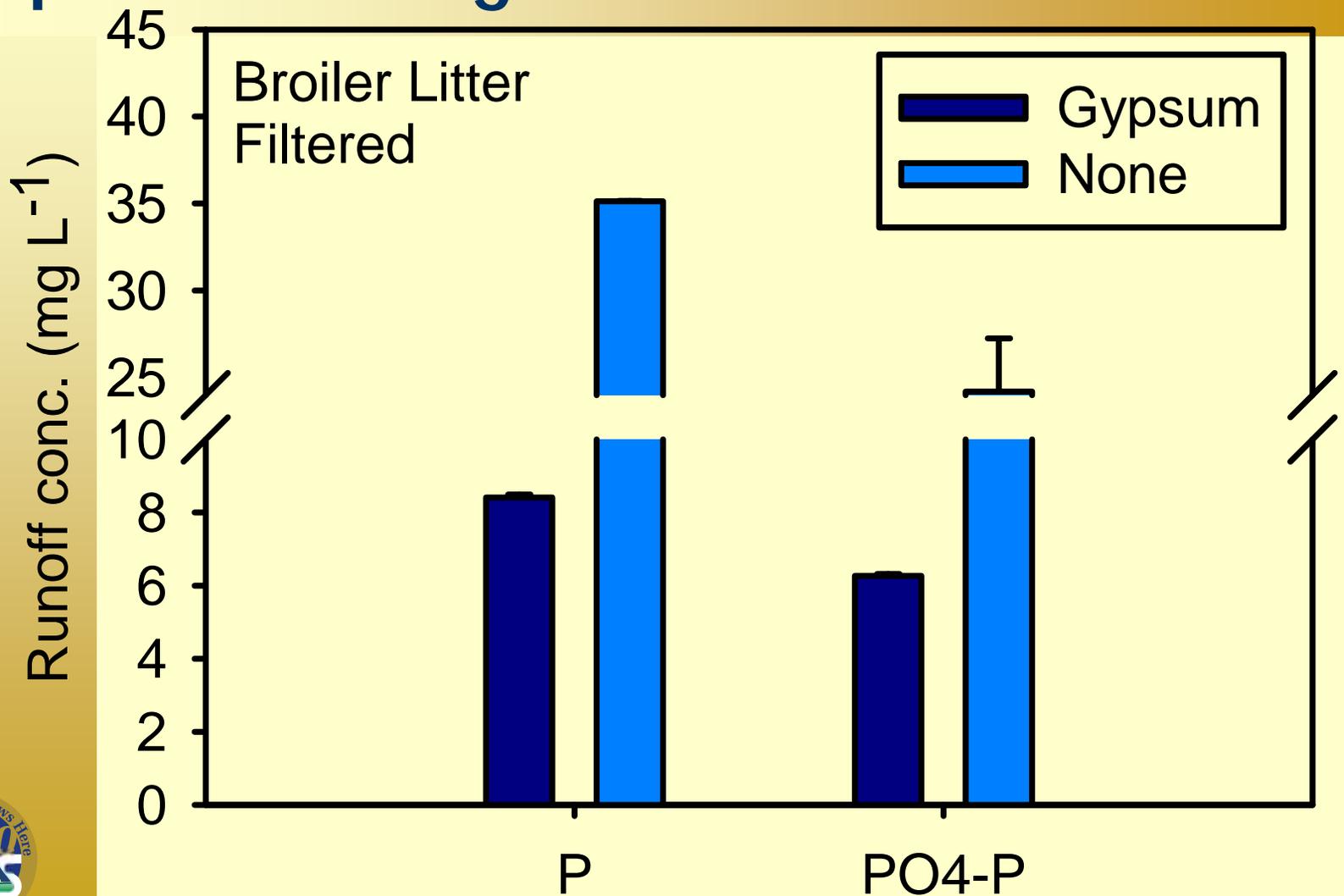


FGD Gypsum- Management Implications

- Hay lands and riparian buffers also act as filtering systems similar to conservation tillage
- Important to find a tool to reduce dissolved forms of N & P



FGD Gypsum as a solution- Phosphorus Mitigation



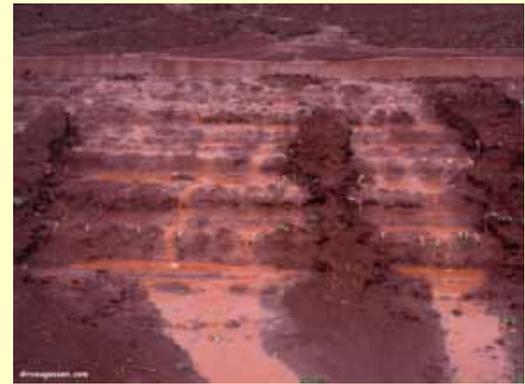
FGD Gypsum- Management Implications

- Using gypsum is a promising solution to reduce both particulate and dissolved N & P forms
- Especially the dissolved fractions



FGD Gypsum- Research Needed

- Gypsum to Broiler litter ratio
- Reaction time
- Gypsum^{FGD} on marginal lands for biofuels
- How much rain will it take to move gypsum into soil?
 - Grasslands
 - Croplands



FGD Gypsum- Research Needed

- Improve rooting depth
 - Compaction pans
 - B horizon

Increase water holding capacity!



*J. Phil Campbell Sr.,
Natural Resource Conservation Center
interested in:*

- Expanding agricultural uses of FGD Gypsum
- Development of safe and effective uses
- Research is needed to document and reveal effectiveness



Potential JPC Research Projects:

FDG Gypsum and Poultry litter

1. Small plot study – evaluate changes in forage and Soil N, P K and micronutrients
2. Small plot study+ – document water quality improvements under natural rainfall events
3. Rainfall simulation – evaluate infiltration over time



FGD Gypsum- Environmental Implications

- May improve effectiveness of riparian buffers to attenuate N & P transport allowing for plant uptake or denitrification
- May reduce N losses thereby improving the N:P ratio for broiler litter applications to grasslands



FGD Gypsum- Environmental Implications

- May improve plant productivity which may in turn improve plant uptake of N & P
- Must look at heavy metals in relation to broiler litter (arsenic, copper, and cadmium)



FGD Gypsum- Environmental Implications

- May help protect marginal and environmentally sensitive lands for biofuel production
- Development of new BMPs which utilize FGD Gypsum to reduce runoff, protect sensitive lands, improve water and nutrient use efficiencies



Phosphorus Mitigation Estimate

- Top five States GA, AR, AL, MS, and NC (*60% of USA*)
- Number of broilers = 5.2 billion
- Amount of litter = 7.8 million tons
- Amount of N = 233,000 tons
- Amount of P = 116,000 tons



Slide 28

DHF1

3% N and 1.5 % P

DORCAS FRANKLIN, 10/21/2007

If 90% of litter is surface applied:

- Amount of Gypsum = 7.02 million tons
- Est. P loss w/o gypsum = 6,000 tons
- Est. P loss with gypsum = 2,000 tons

4,000 fewer tons of P delivered to surface waters each year



Slide 29

DHF2 5% of surface applied P is lost in runoff
Gypsum reduces P loss by 70%

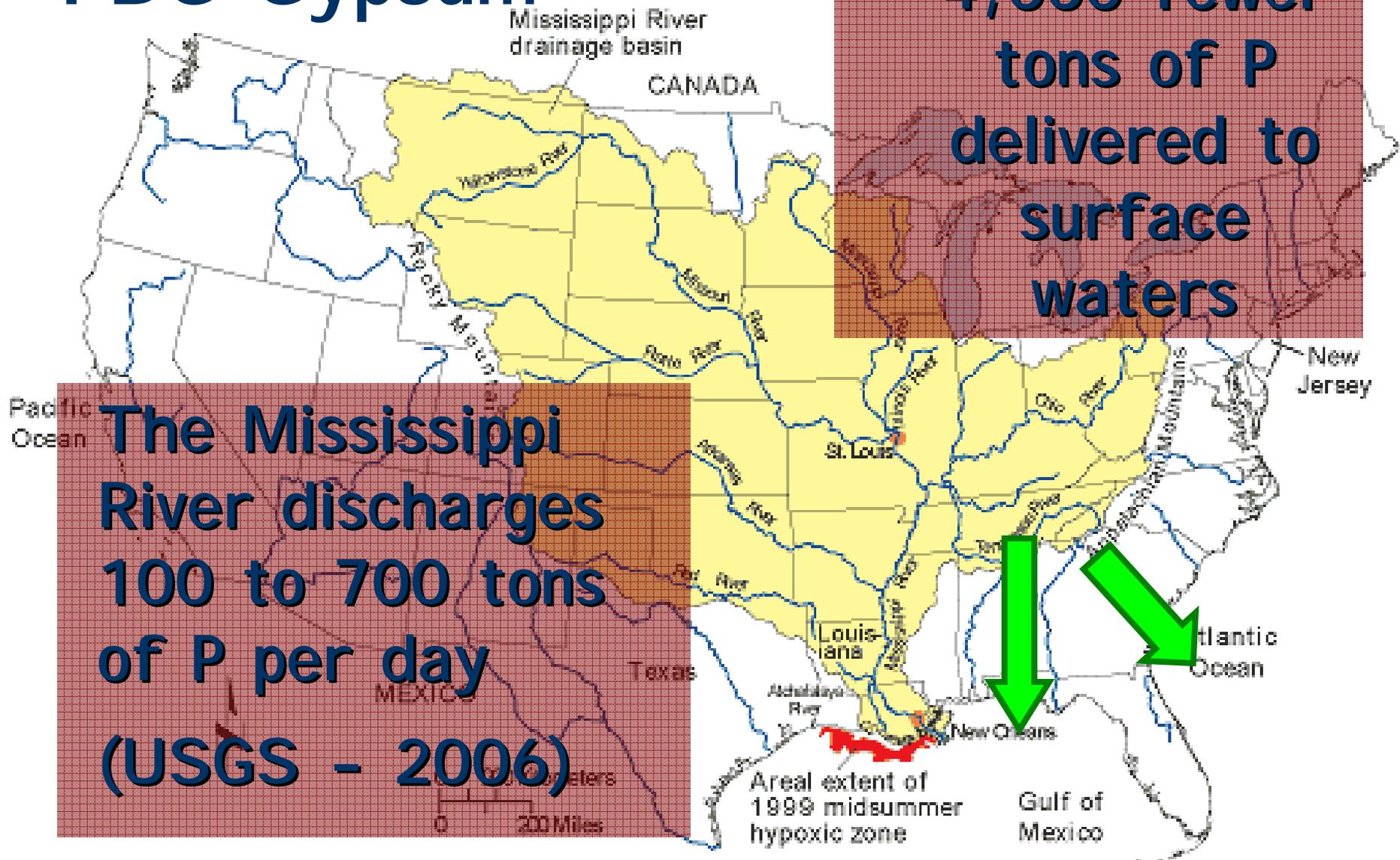
$116,00 \times 0.05 = 5,800$ without gypsum

$6000 \times .3$ (70% reduction) = 1800

difference is 4000

DORCAS FRANKLIN, 10/21/2007

Potential Impact in SE of FDG Gypsum





*Opening gates to a better future
through agricultural research and information.*

JPC Research Project 2: *FDG* *Gypsum and Poultry litter*

Small plot study+ -

Factorial Design: Four rates of
gypsum:poultry, 1:1 on 36 plots

(0, 2, 4, 6, Mg ha⁻¹) or (.9, 1.8, 2.7 tons/ac)

Runoff - TP, Inorg. P, DRP, Org. P

Sediments - kg/ha (gravimetric)

(plots can be irrigated if needed)



JPC Research Project 1: *FDG* *Gypsum and Poultry litter*

Small plot study -

Factorial Design: Four rates of
gypsum:poultry, 1:1 on 36 plots

(0, 2, 4, 6, Mg ha⁻¹) or (.9, 1.8, 2.7 tons/ac)

Soil P - TP, WSP, Mehlich P, and
Org. P

Forage - Productivity, TP, and
Quality



JPC Research Project 3: *FDG* *Gypsum and Poultry litter*

Rainfall simulations - 3 events/small plot
(Baseline, Time zero and After harvest)

Seventy min of runoff at 75 mm/hr (3in)

Sampling: drip, 10, 20., 70 min, composite

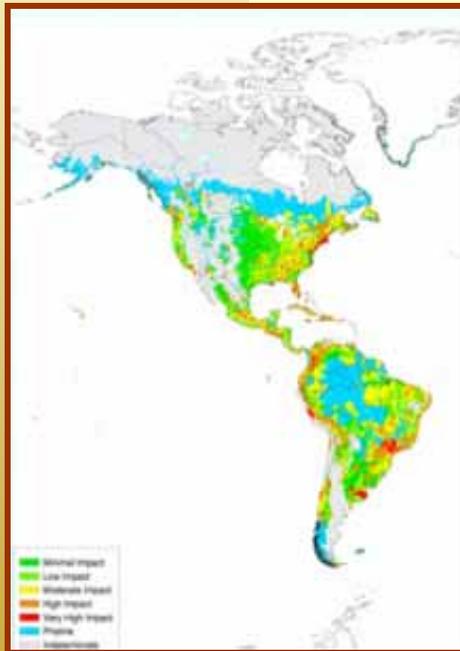
Runoff - TP, Inorg. P, DRP, sediments,
macro- and micro-nutrients

Soil - macro and micronutrients, Se, As



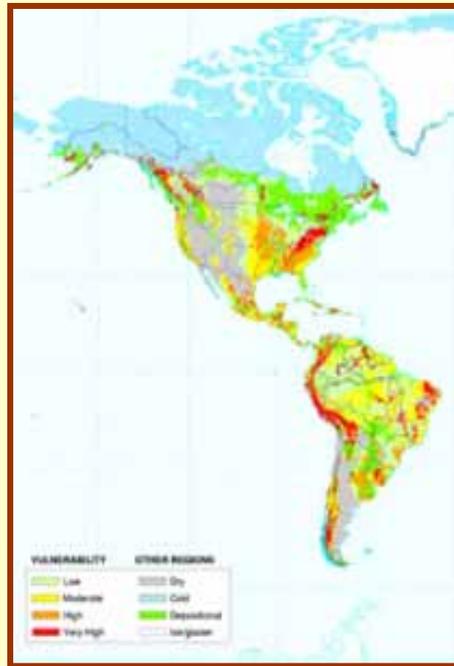
Where are we Vulnerable to Losses?

Human
Impact

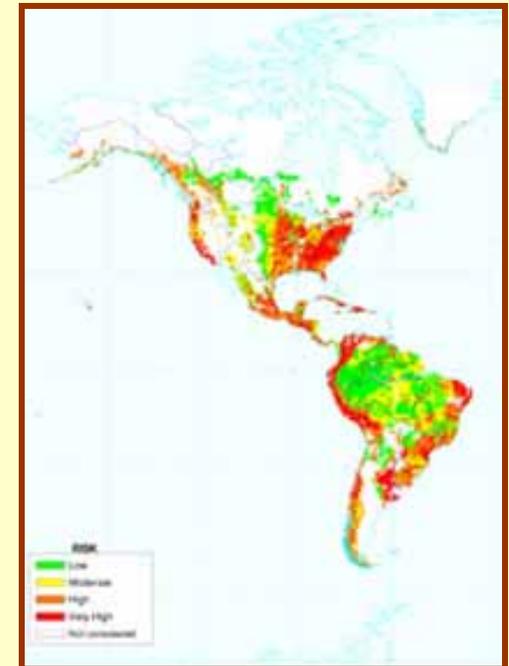


HEL

(Highly Erodible Land)



Risk to
Erosion



+

=

Teal low, Green moderate, Red high

(USDA, NRCS)



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Runoff

- Gypsum was mixed, applied, and rained on immediately – no reaction time
- Short rainfall event (30 min)
- Most effective in the lower landscape positions
- Nitrogen and phosphorus losses?

