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

Dory Franklin
USDA – ARS
J. Phil Campbell Sr., Natural Resource Conservation Center

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

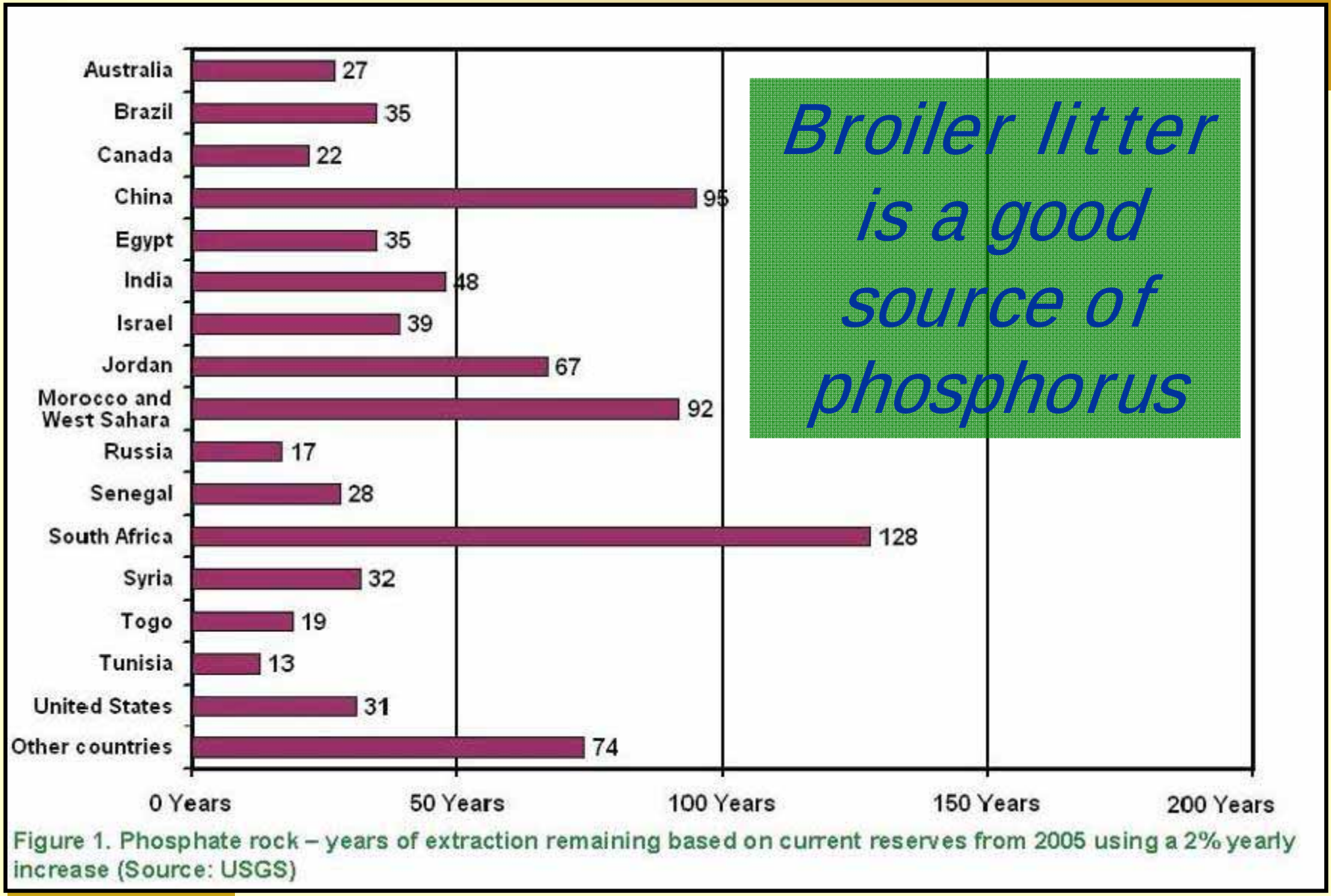
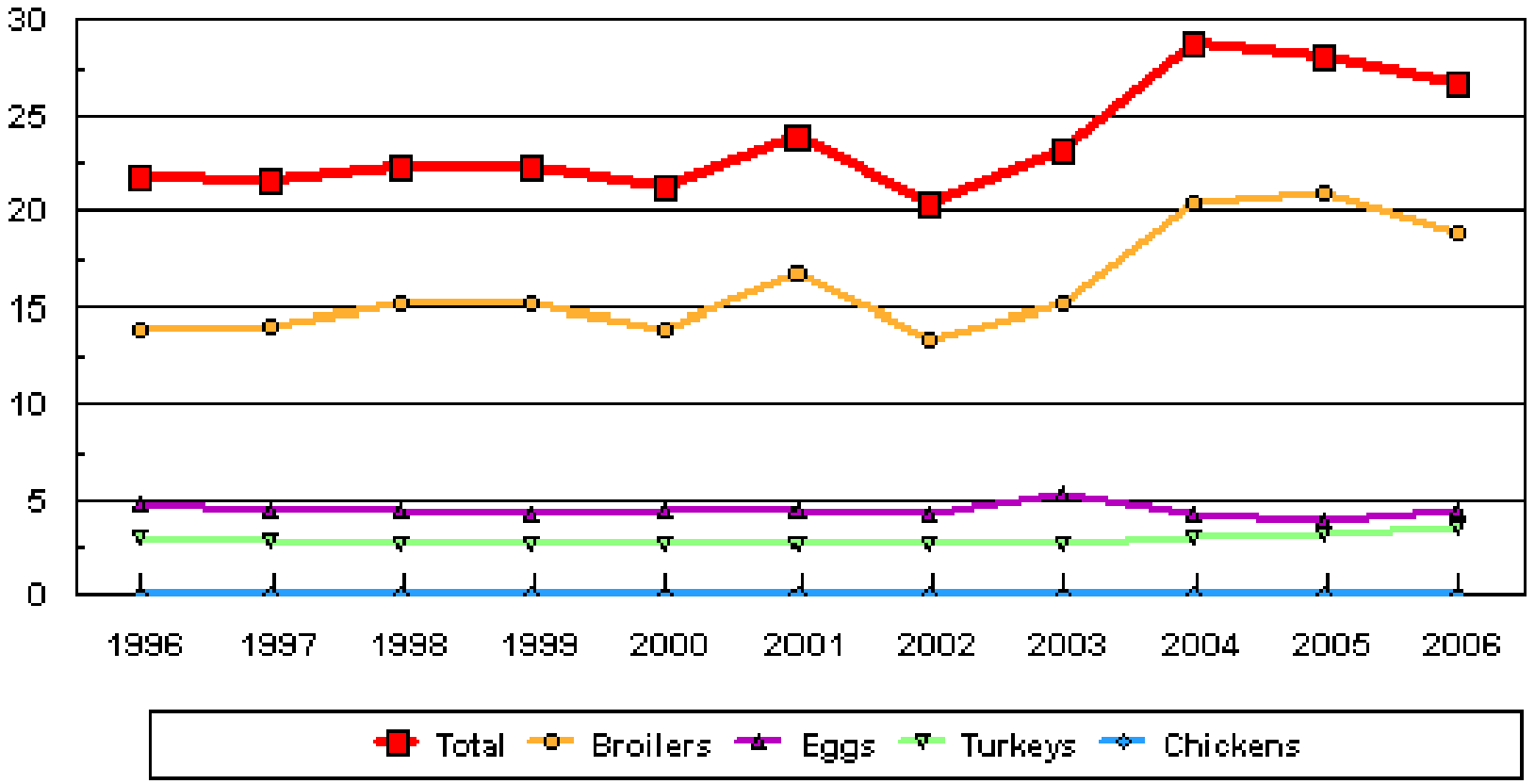
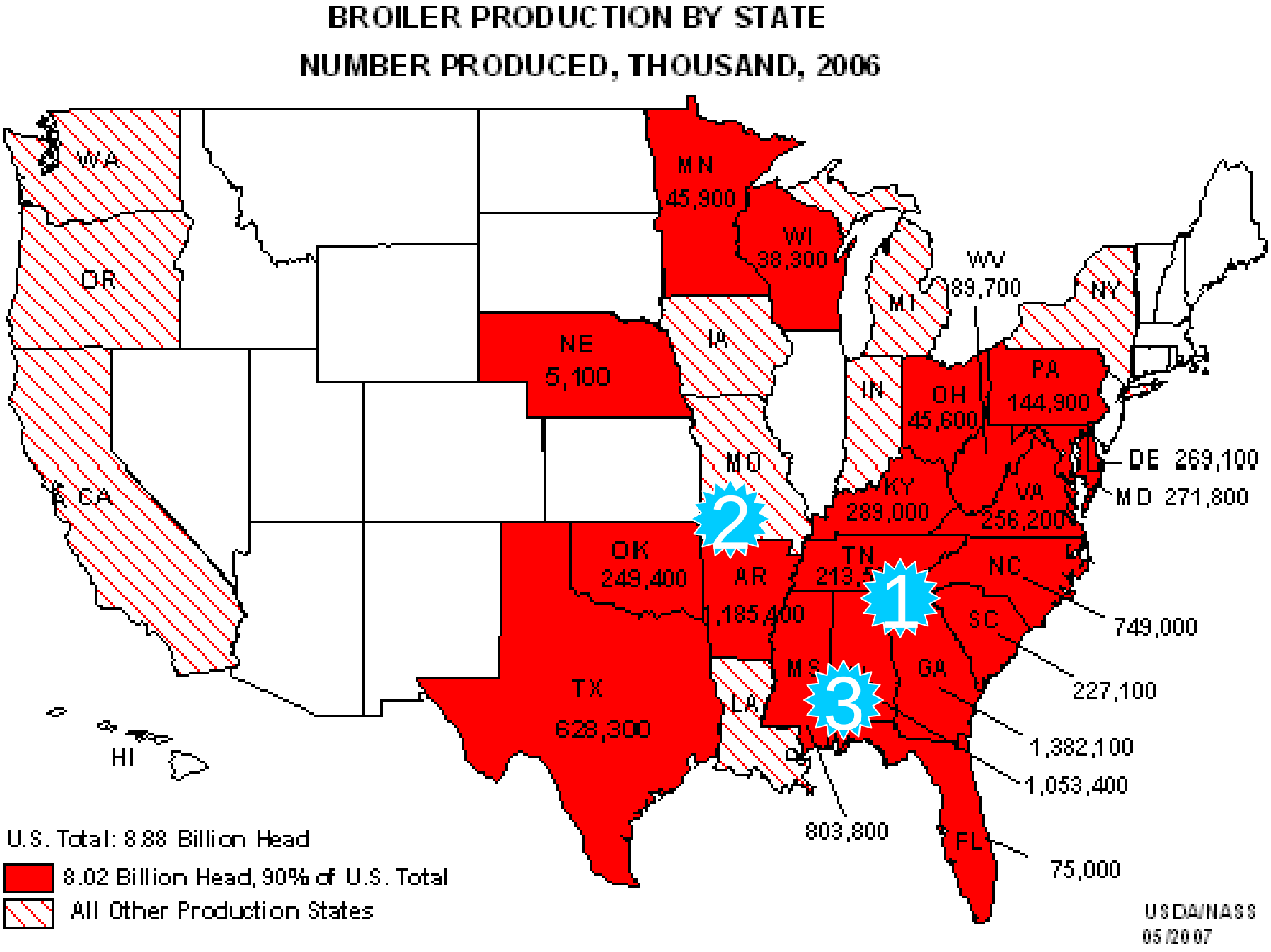


Figure 1. Phosphate rock – years of extraction remaining based on current reserves from 2005 using a 2% yearly increase (Source: USGS)

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



USDA-NASS
April 2007


BROILER PRODUCTION BY STATE
NUMBER PRODUCED, THOUSAND, 2006
WA
OR
CA
HI
MN
45,900
WI
38,300
NE
5,100
IA
MO
OK
249,400
AR
1,185,400
TX
628,300
LA
MS
TN
213,5
KY
289,000
IN
MI
OH
45,600
WV
89,700
PA
144,900
NY
VA
256,200
NC
SC
GA
FL
DE 269,100
MD 271,800
749,000
227,100
1,382,100
1,053,400
803,800
75,000
1
2
3
U.S. Total: 8.88 Billion Head
8.02 Billion Head, 90% of U.S. Total
All Other Production States
USDA/NASS
05/2007

Vulnerability

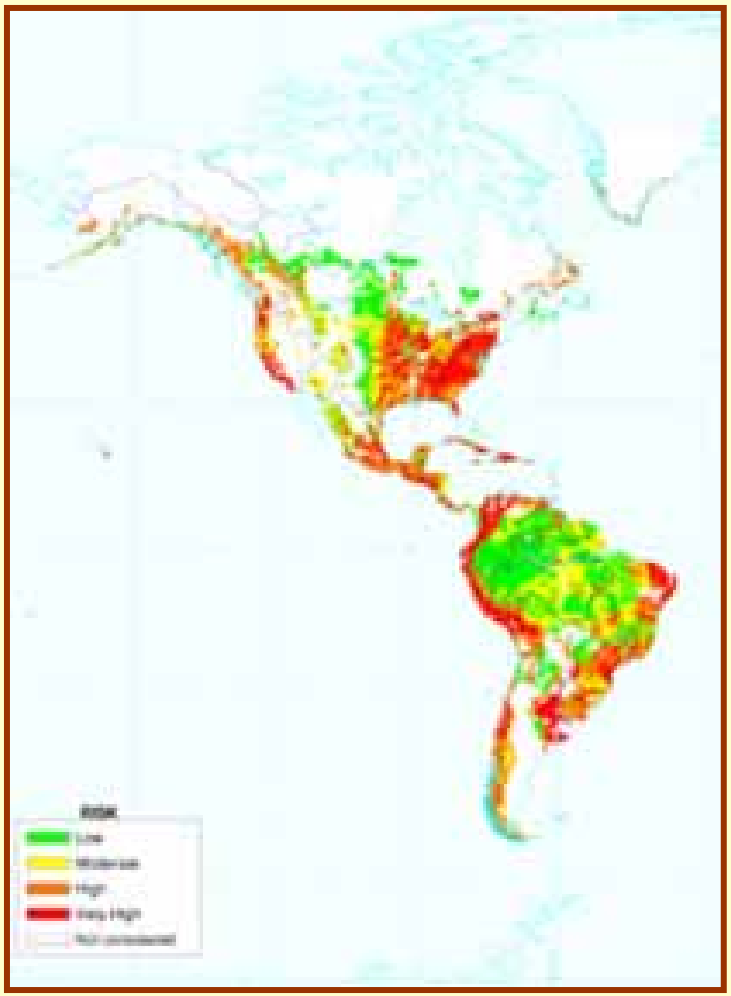
- **Risk of soil loss indicates high potential for surface runoff**

- **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**

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

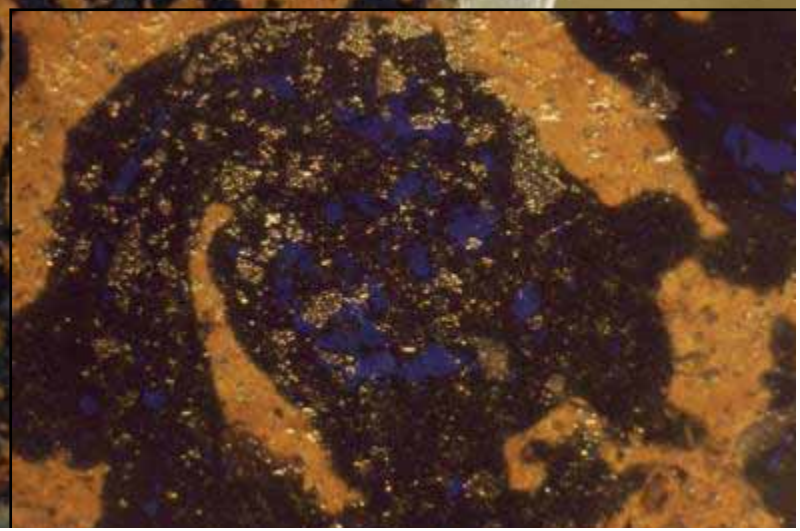
- Increased infiltration increases soil water content
- Compact soils resist root penetration
- Gypsum improves rooting depth and infiltration

(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



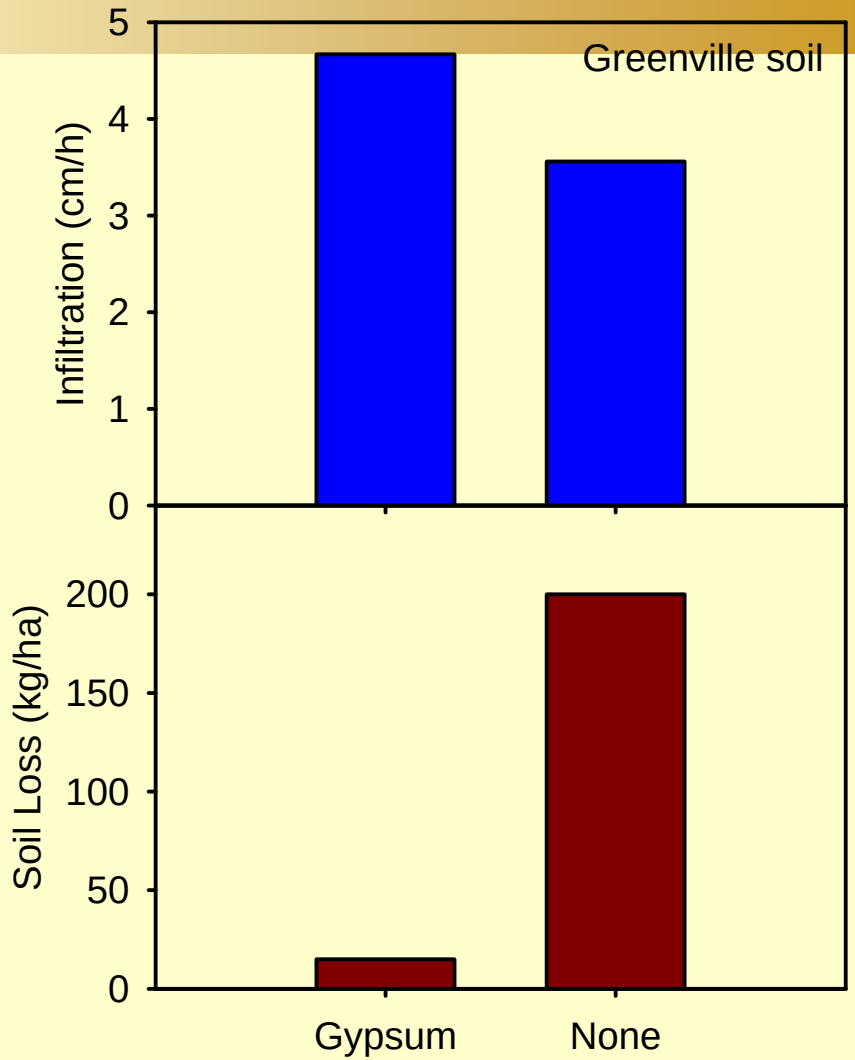
FGD Gypsum as a solution-Drought Mitigation

Gypsum:

Infiltration

Soil loss

On bare soil



(Miller and Scifres, 1988)

FGD Gypsum as a solution-Drought Mitigation

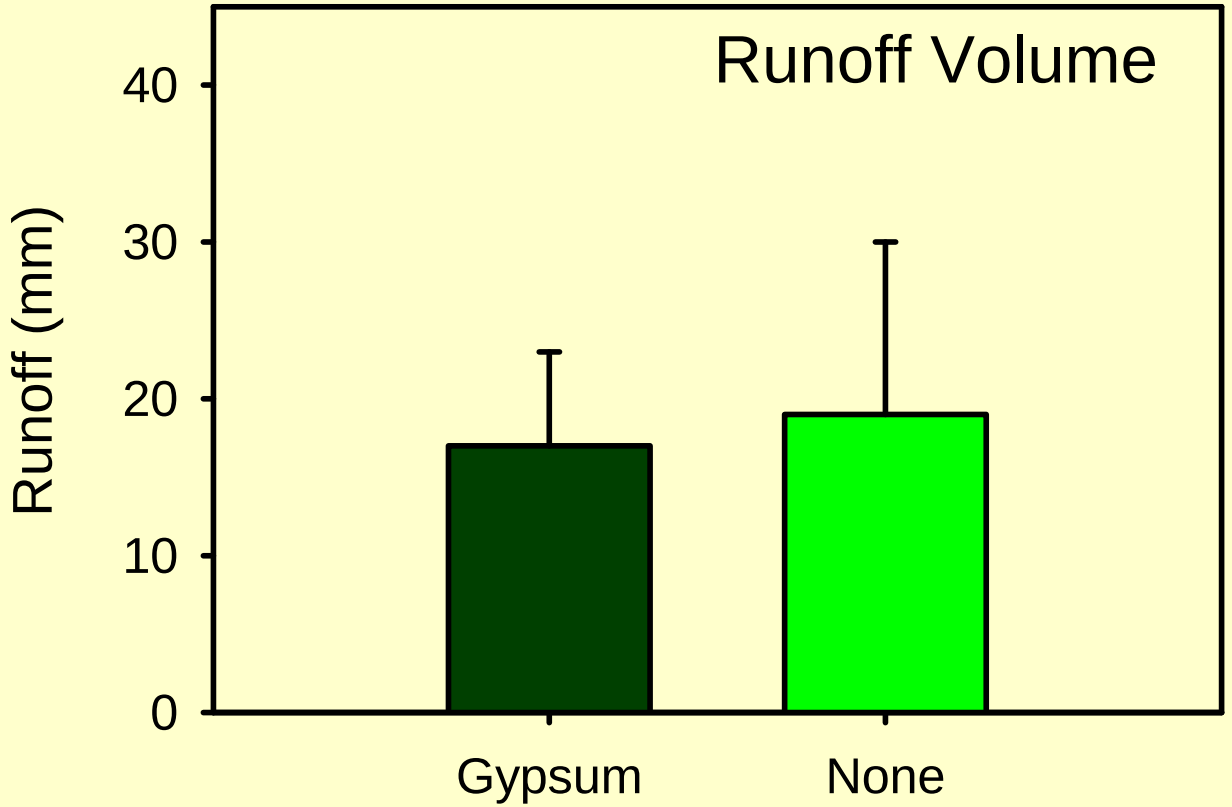
Research topics

Reaction time

Landscape position

27 mm

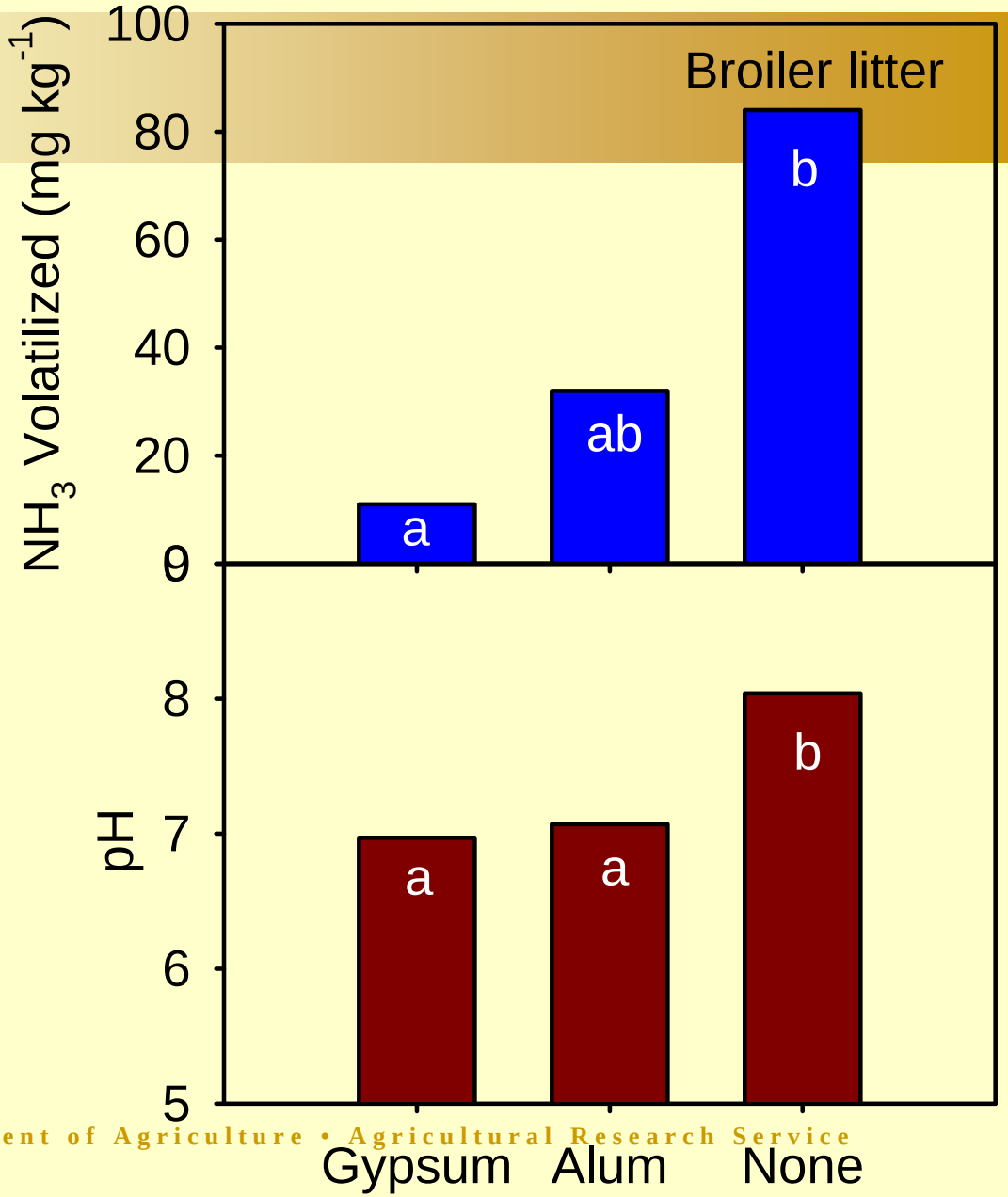
20 mm



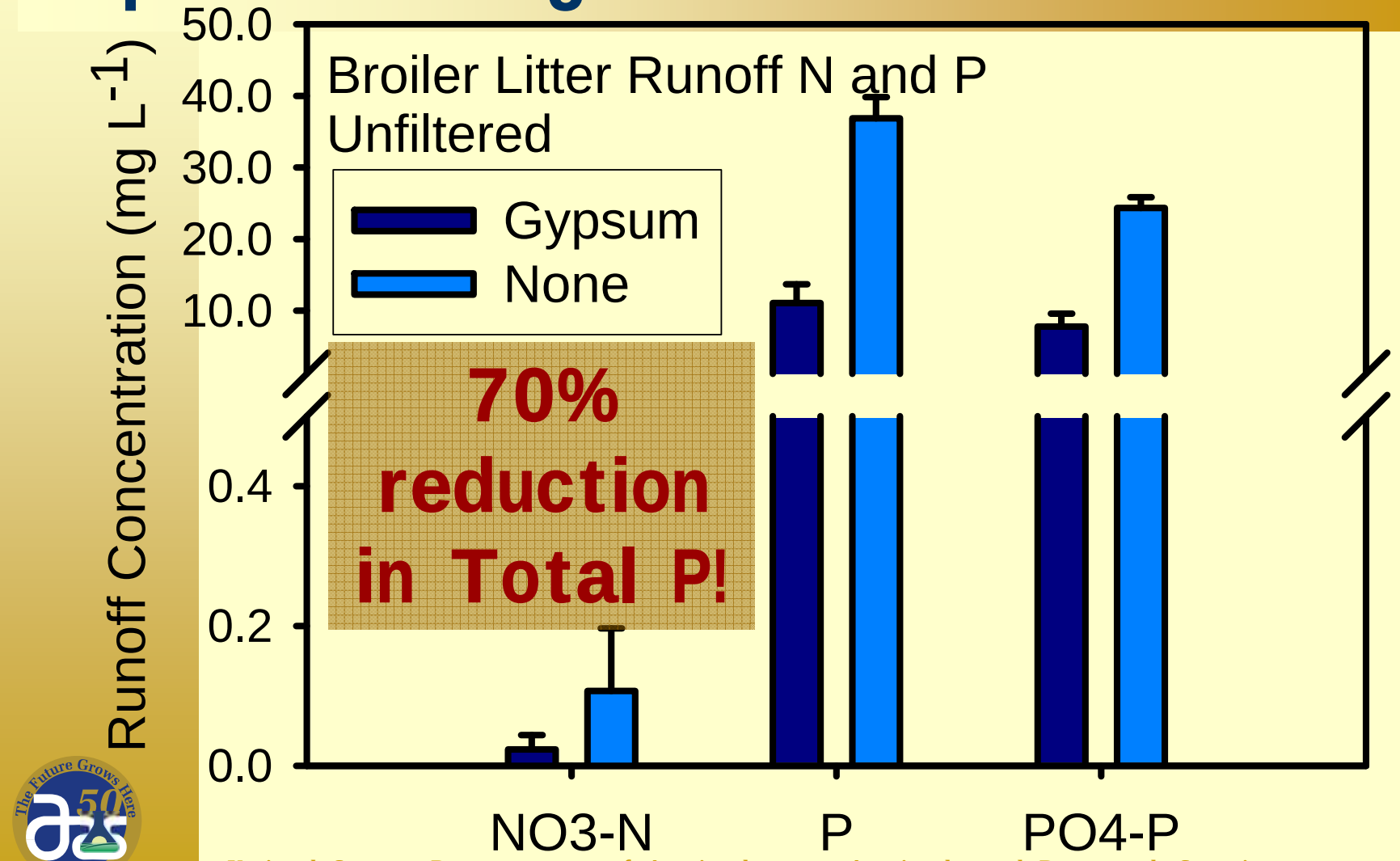
FGD Gypsum as a solution-Reduce Ammonia

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

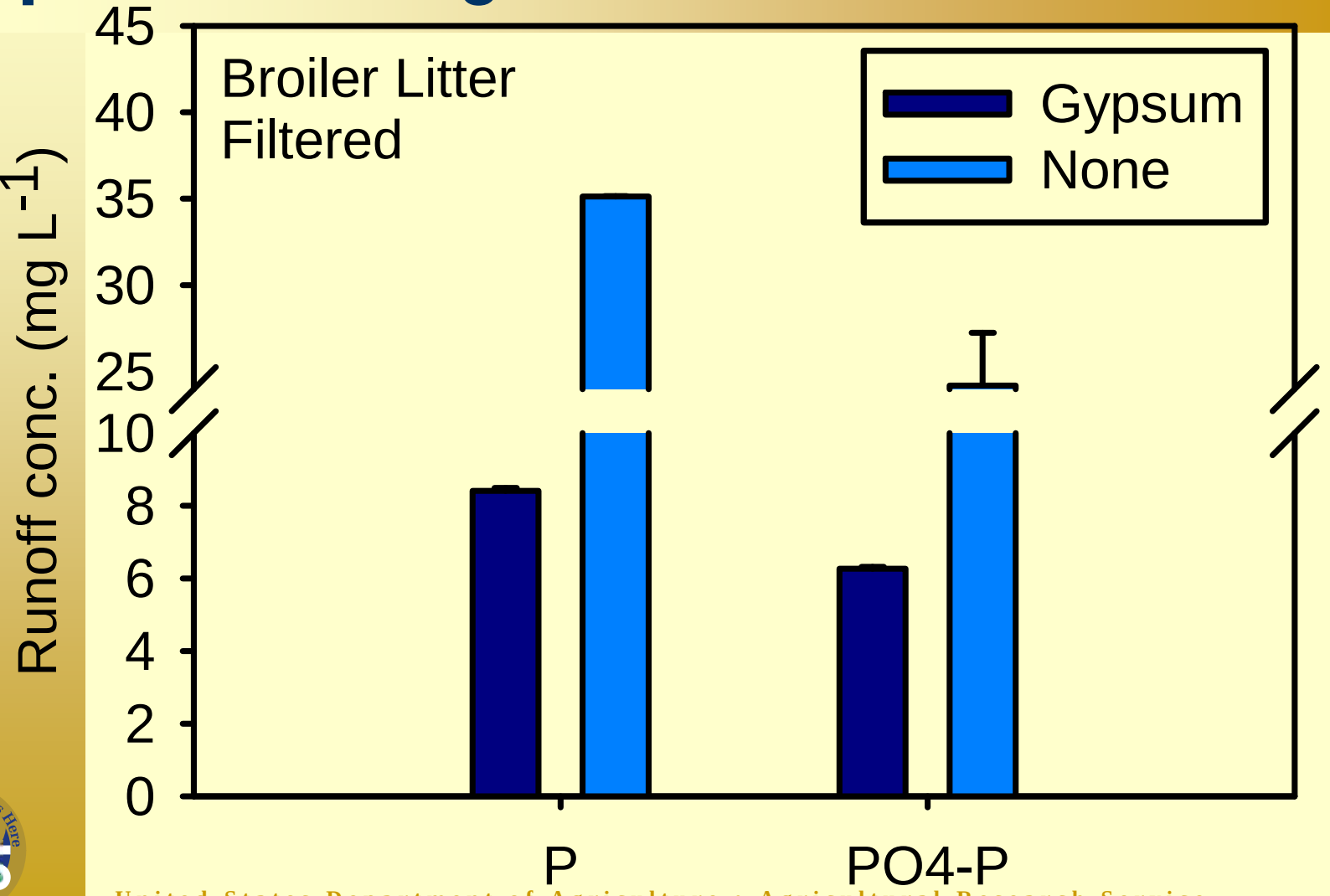
(Franklin et al., 2007)

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

DHF1

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

DHF2

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

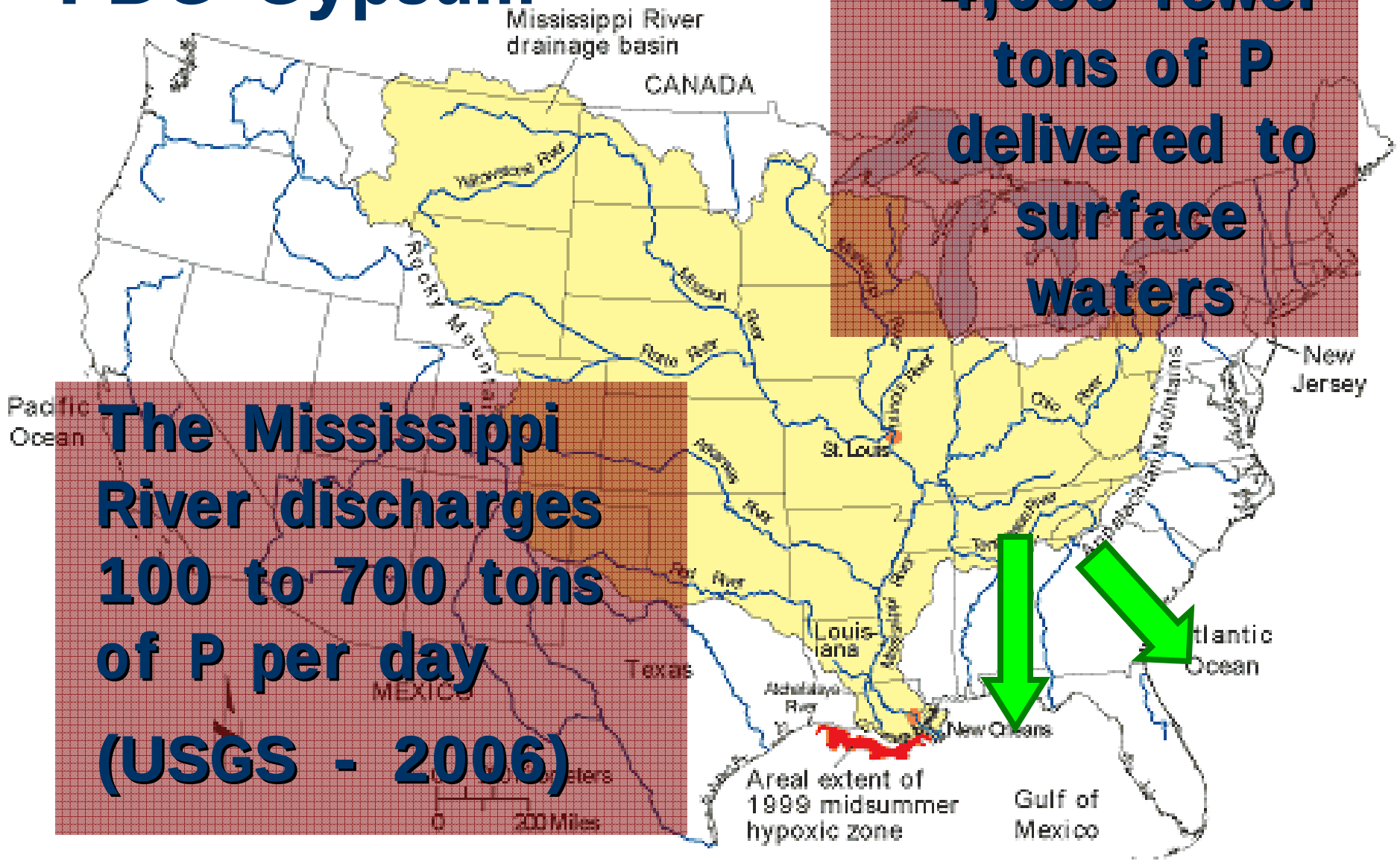
5% of surface applied P is lost in runoff
Gypsum reduces P loss by 70%

116,00 x 0.05 = 5,800 without gypsum
6000 x .3 (70% reduction) = 1800

difference is 4000

DORCAS fRANKLIN, 10/21/2007

Potential Impact in SE of FDG Gypsum



4,000 fewer tons of P delivered to surface waters

The Mississippi River discharges 100 to 700 tons of P per day (USGS - 2006)

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

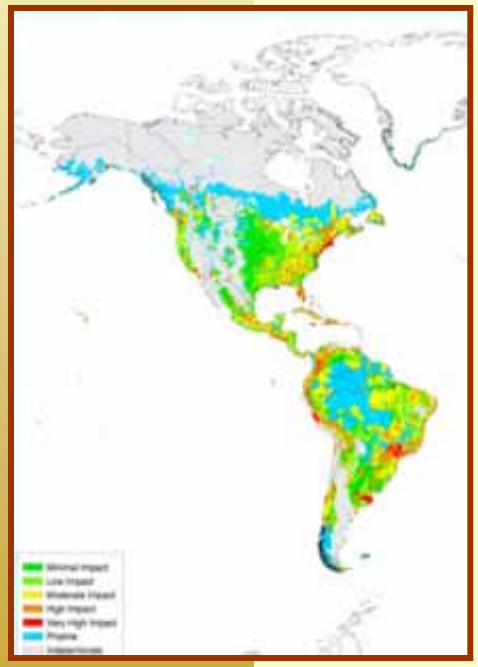
Where are we Vulnerable to Losses?

Human Impact

HEL

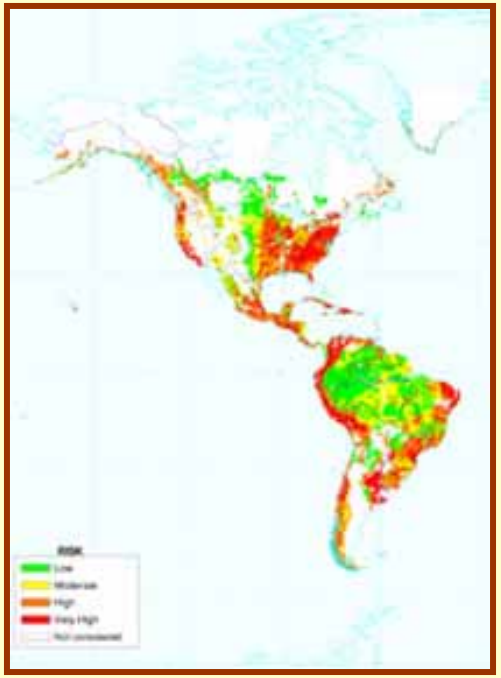
(Highly Erodible Land)

Risk to Erosion



+

=



Teal low, Green moderate, Red high

(*USDA, NRCS*)

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?