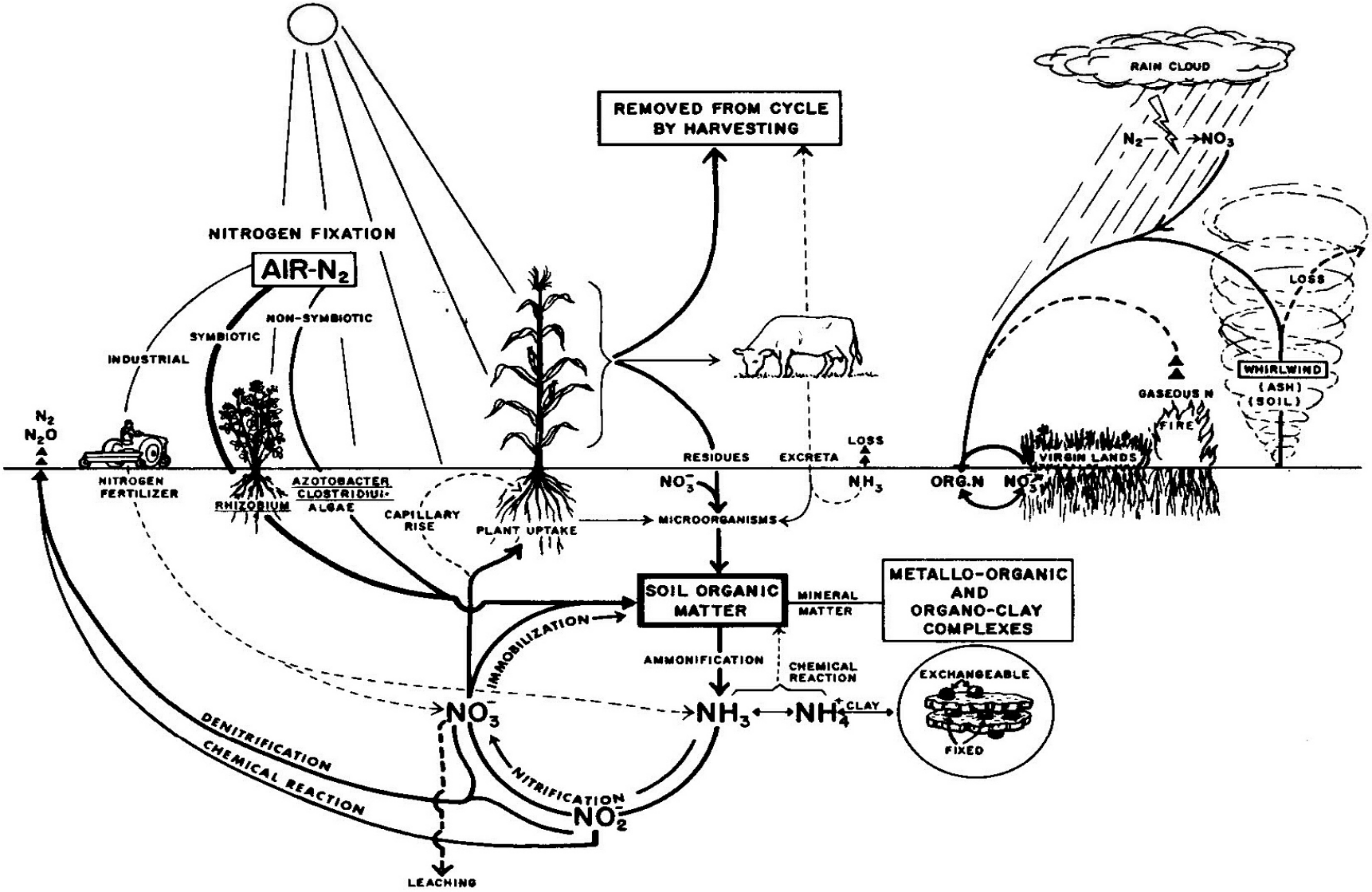
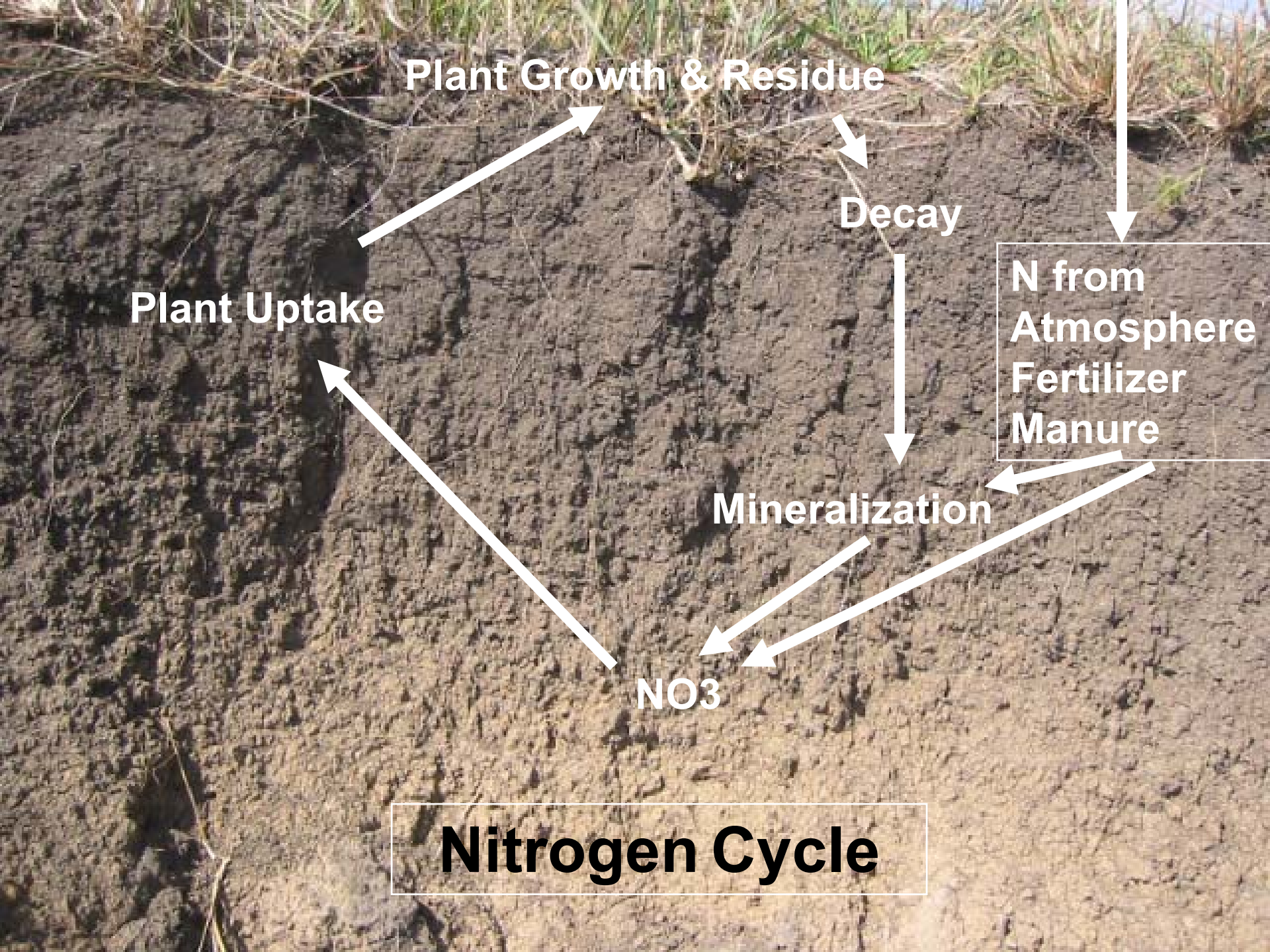
NUTRIENT CYCLES & YOUR FERTILIZER PROGRAM

Nutrient Cycle?

1. Nutrients are removed from the land any time grain or forage is transported from the area.
2. How are the nutrients replaced? Higher yields - the more nutrients that have to be replaced.
3. Carbon comes from the air and from microorganisms decomposing organic matter.
4. Others come from soil minerals, decomposition of organic matter, soil microbes including Rhizobia, manures and fertilizer.

Nitrogen Cycle




Plant Growth & Residue
Decay
Plant Uptake
N from
Atmosphere
Fertilizer
Manure
Mineralization
NO3
Nitrogen Cycle

Nitrogen Cycle

1. Plant and Animal Uptake and Removal
2. Decomposition of residues left on the field by microorganisms. This is known as immobilization.
3. Immobilization is the tie-up of N and other nutrients.
4. Mineralization is the release of ammonium, nitrate, and other nutrients from the microbes for use by plants.

Gains in Nitrogen Cycle

5. Rainfall – 5 to 10 of N lbs per acre per year
6. Nitrogen fixing microorganisms –10 to 50 lbs of N per acre per year
7. Rhizobia associated with legumes - 25 to 150 lbs of N or more
8. Fertilizer and Manure

Nitrogen Losses from the System

1. Nitrogen Removal in Grain
2. Nitrogen Removal in Forage or Residue
   - (% Protein/100 X 0.16) X (lbs of forage removed per acre)
3. Leaching (Proper timing of N application and use of cover crop to avoid leaching)
4. Denitrification (caused by poor soil aeration)
5. Small N loss from plant leaves during growth.

C:N Ratio and Rate of Residue Decomposition

1. Average microbe C:N ratio is 8:1
2. 1/3 of the carbon used by microbes is incorporated into their cells
3. 2/3 of the carbon is respired as CO2
4. Therefore, microbes need 1 lb N for every 24 lbs of carbon in their food
5. If the C:N ratio is greater than 24:1 the microbes must scavenge soil solution for Nitrogen

C:N Ratio: An Example

- Wheat Straw
- 100 lbs per bushel of wheat grain
- 50 bushels of wheat/A = 5000 lbs Straw
- 42 % C in straw = 2100 lbs of Carbon/A
- 4 % Protein in straw = 32 lbs of N/A
- C:N Ratio = 66:1

N Release From Wheat Straw

C:N ratio 66:1
5000 lbs of straw/acre

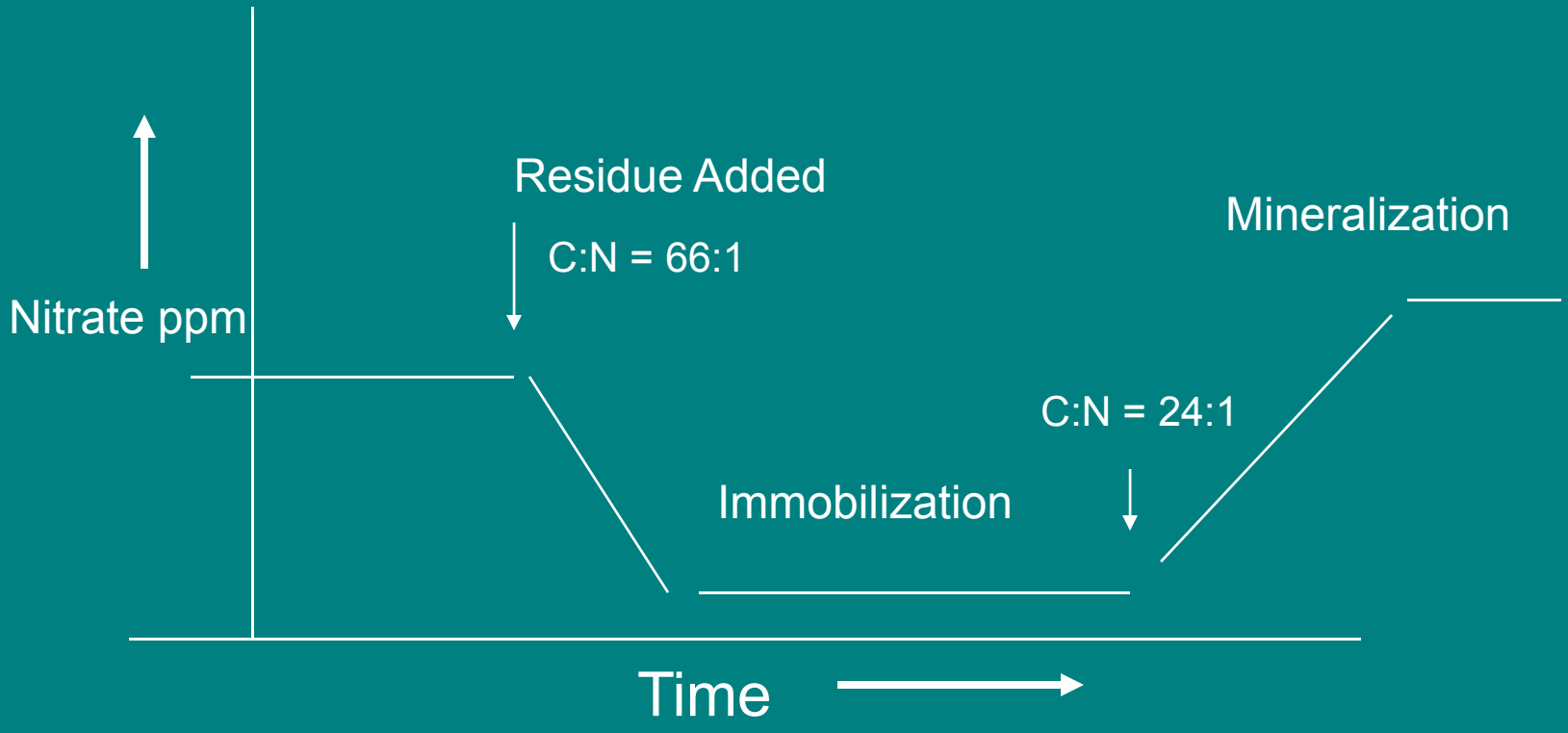
Carbon: 2100 lbs of lbs of Carbon per acre

88 lbs of N is needed to bring the C:N ratio to 24:1

88 – 32 = 56 lbs of N will be taken from the soil by the decomposers before N can be released.

Nitrogen Tie-up or Nitrogen Release

- Wheat Straw C:N = 66:1



Cover Crop Contribution

Grass cover crop

12 to 15 inches tall, about 2000 lbs of dry hay with 13 % protein.

This is 2.1 % N or 42 lbs of N/ton or a C:N ratio of 20:1

If left on the soil it will be available to succeeding crop, however, release of N will be less and slower. Higher the protein the more available N.

If cover crop is removed, no N value to next crop

Cover Crop Contribution

Legume cover crop

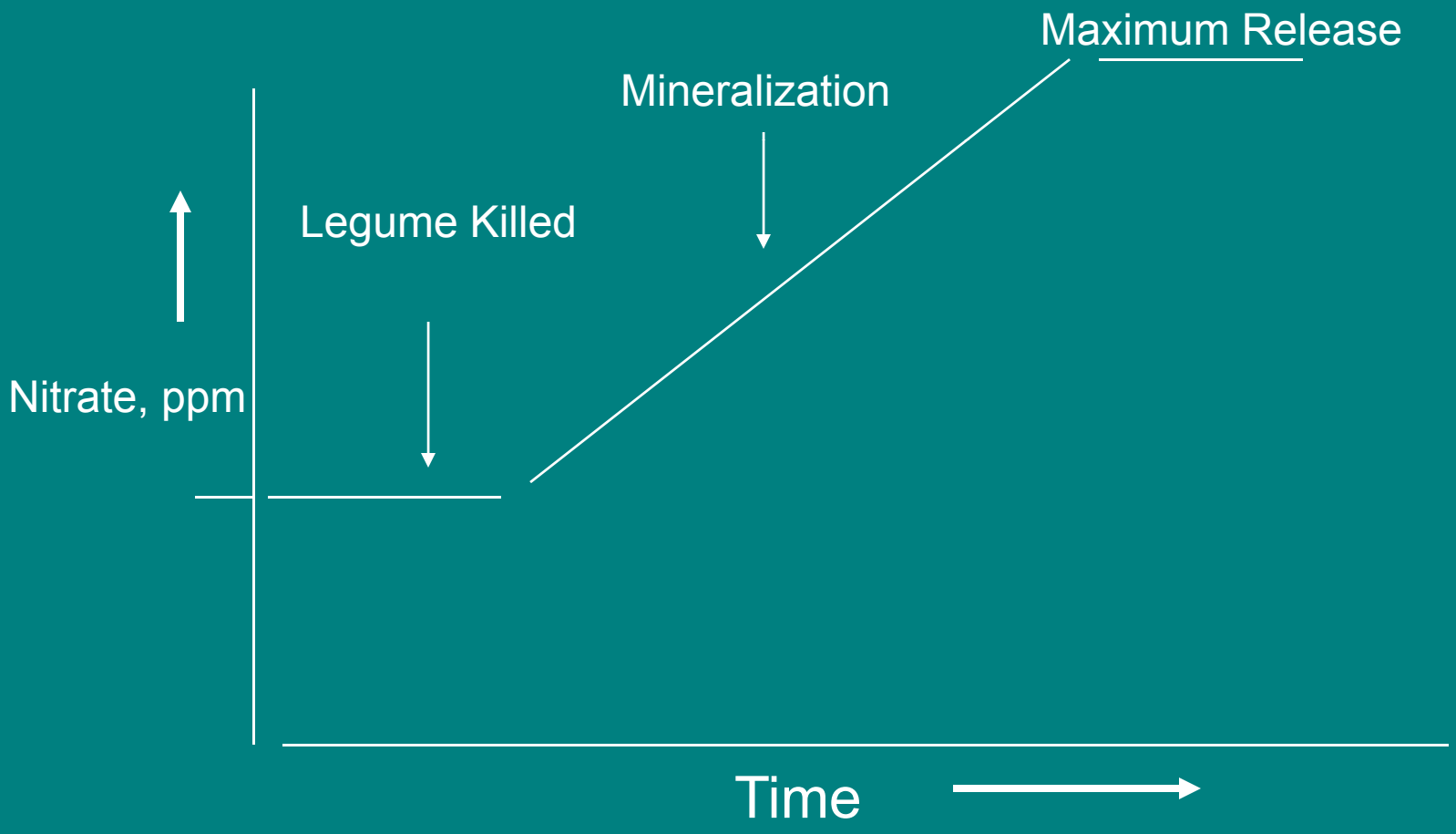
12 inches tall, about 2000 lbs of dry hay @ 18 % protein or 2.9 % N = 58 lbs of N/ton

If left on the soil it will be available for the next crop

If Legume is Grazed, there will be about 46 lbs of N remaining for the next crop

Nitrogen Tie-up or Nitrogen Release

- Legume Cover Crop C:N = 13.8



Estimated N Release Time

% Protein	% N	C:N ratio	Release time
22	3.5	11:1	Very quickly
18	2.9	14:1	Early summer
13	2.1	20:1	Late summer
8	1.3	23:1	Late summer and next crop
4	0.6	70:1	2 or more years from now

Cover Crop Nutrients
1.83 tons/acre

Nutrient	lbs/acre	
Carbon, C	1520	
Nitrogen, N	110	C:N = 13.8
Phosphorus, P2O5	28	
Potassium, K2O	123	
Sulfur, S	16	
Zinc, Zn	0.13	
Calcium, Ca	60	

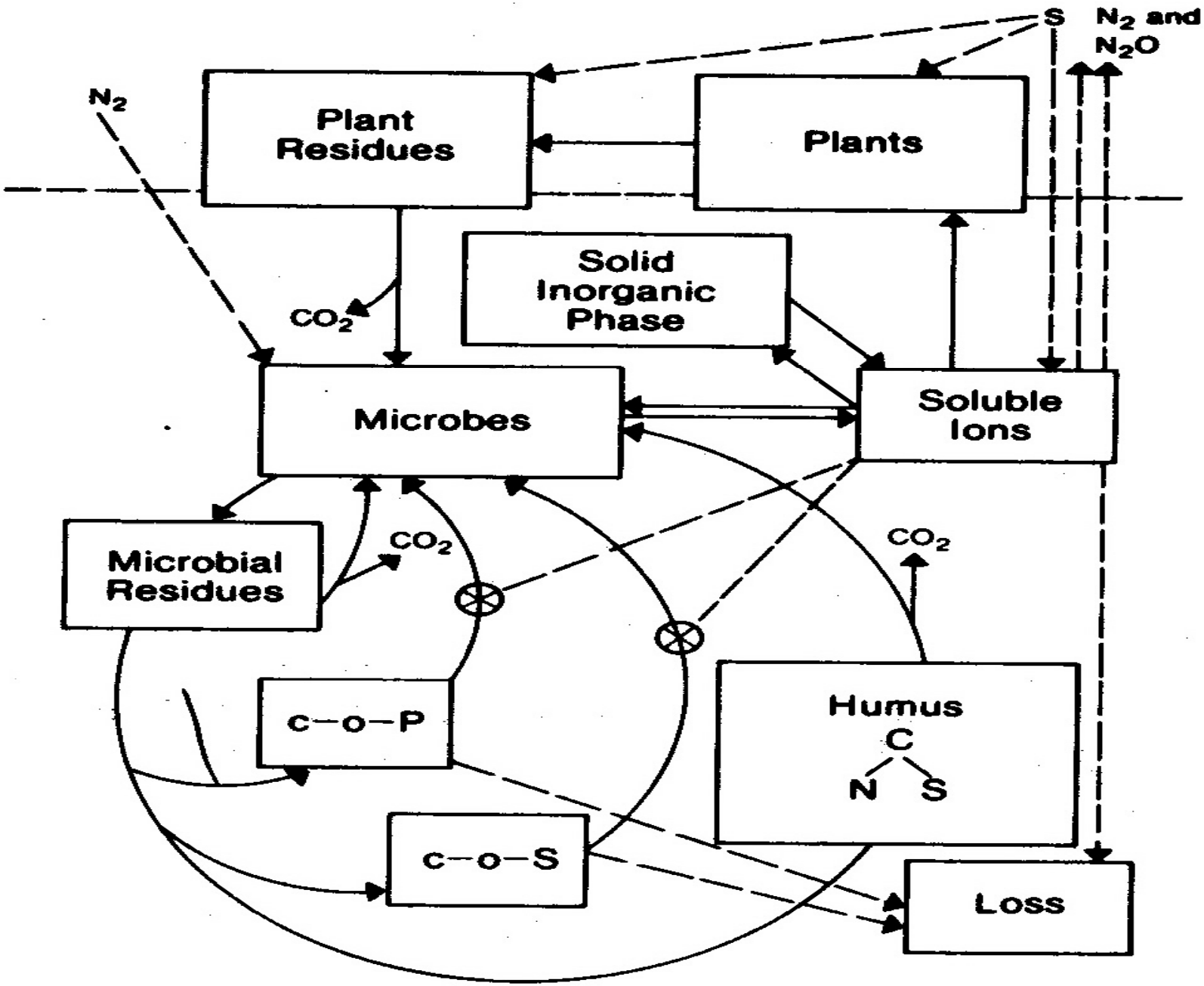
Suggested N Credits for Legume Crops

	% Stand	lb. N/A
Alfalfa	100%	100
	50%	50
	less than 50%	none
Sweet Clover (green manure)		80
Red Clover		50
Soybeans		20-50
Dry Beans		20-30

Cover Crop Contribution

- Cover crop contribution will not show up in the nitrate soil test
- No-till farmer has to evaluate N contribution of the cover crop
- Legumes and other high protein forages are necessary to give N to the next crop.
- Harvest of the cover crop for hay or silage negates N contribution

The Carbon Cycle




Air (Carbon Dioxide)
Plants (Carbon)
Residue Decomposition = CO2
Soil Organic Matter (Carbon)
Decomposition = CO2 and Nutrients
Roots (Oxygen and Nutrients)

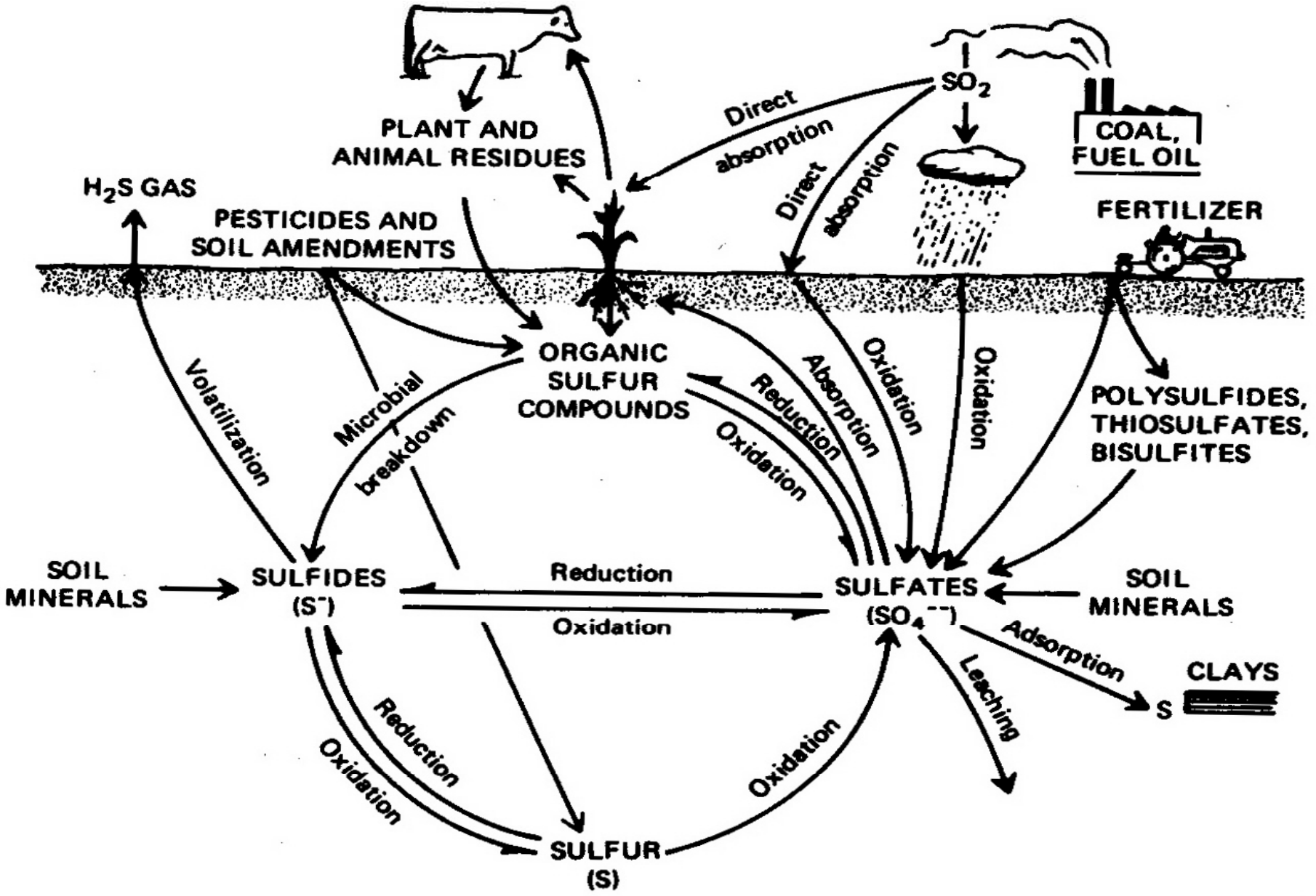
Total Organic Carbon

- Food for Microbes, especially recent additions to organic matter
- Nutrient for Plants
- Soil Organic Matter is 58 % C
- Soil Aeration very Important to Form CO_2
- Soil Organic Matter test
  - Loss on Ignition (LOI)

Carbon/Organic Matter

- Organic Matter is about 58 % C
- Ratio becomes 170 OM : 10 N : 1.4 S
- 1 % OM in 8 inches of Soil is 24,000 lbs/A
- This Quantity of OM Holds About 1400 lbs of N and 200 lbs of S per Acre.

The Sulfur Cycle



Sulfur Cycle

- Loss: Plant and animal uptake and removal
- Gain: Plant and animal residue
- Gain: Sulfur from the atmosphere (less as the atmosphere is cleaned up)
- Gain: From fertilizer
- Gain: Mineralization and oxidation
- Loss: Leaching
- Loss: Lack of Oxygen

No-Till Sulfur Deficiency

- Most of the Sulfur in the soil is held in the organic matter portion of the soil
- The idea is the build soil organic matter to improve soil quality and health and increase soil productivity
- C : N : S ratio
- 100C : 10N : 1.4S

Phosphorus Cycle

- Total P (OM and Minerals)= ~920 ppm P_2O_5
  - However, only a very small of this P is available for plant uptake
  - Some Microbes can dissolve this P but it is very slow
  - Added P from fertilizer or manure is needed for soils testing low in P

Phosphorus Cycle

- P is attached to soil calcium, iron, and aluminum. The P that is on the edge of the soil crystals diffuses into the soil solution for plant uptake. It is called surface phosphorus.
- Available P is measured by soil test. Olsen P, Bray P-1, and Mehlich P-3 measure available P

Phosphorus Forms

- P in solution, H_2PO_4 and HPO_4
  - Very low water solubility, 0.01 to 1 ppm P
- Mycorrhizal hyphae bring P to the plant root
- Some P is used by the microbes for their life process
- Calcium (high pH) or Aluminum/Iron (low pH) bound
- Organic P (about ½ of total P)

Phosphorus Cycle

- Soil test P value
  - Try to have soil test to the top of the medium test range
  - Mehlich P = 25 ppm P
- Only sources of P for plants come from soil organic matter, soil minerals, fertilizer P or manure

Phosphorus Cycle

- Loss: Crop removal
- Loss: Phosphorus carried off in soil during erosion. No till slows soil erosion, therefore less P loss.
- Gain: Phosphorus fertilizer and animal manure
- Gain: Slow process of dissolving phosphorus from insoluble soil minerals by soil microbes, especially mycorrhizae

Available Phosphorus

Goal is always to have P soil test in the medium range or at the top of the medium range.

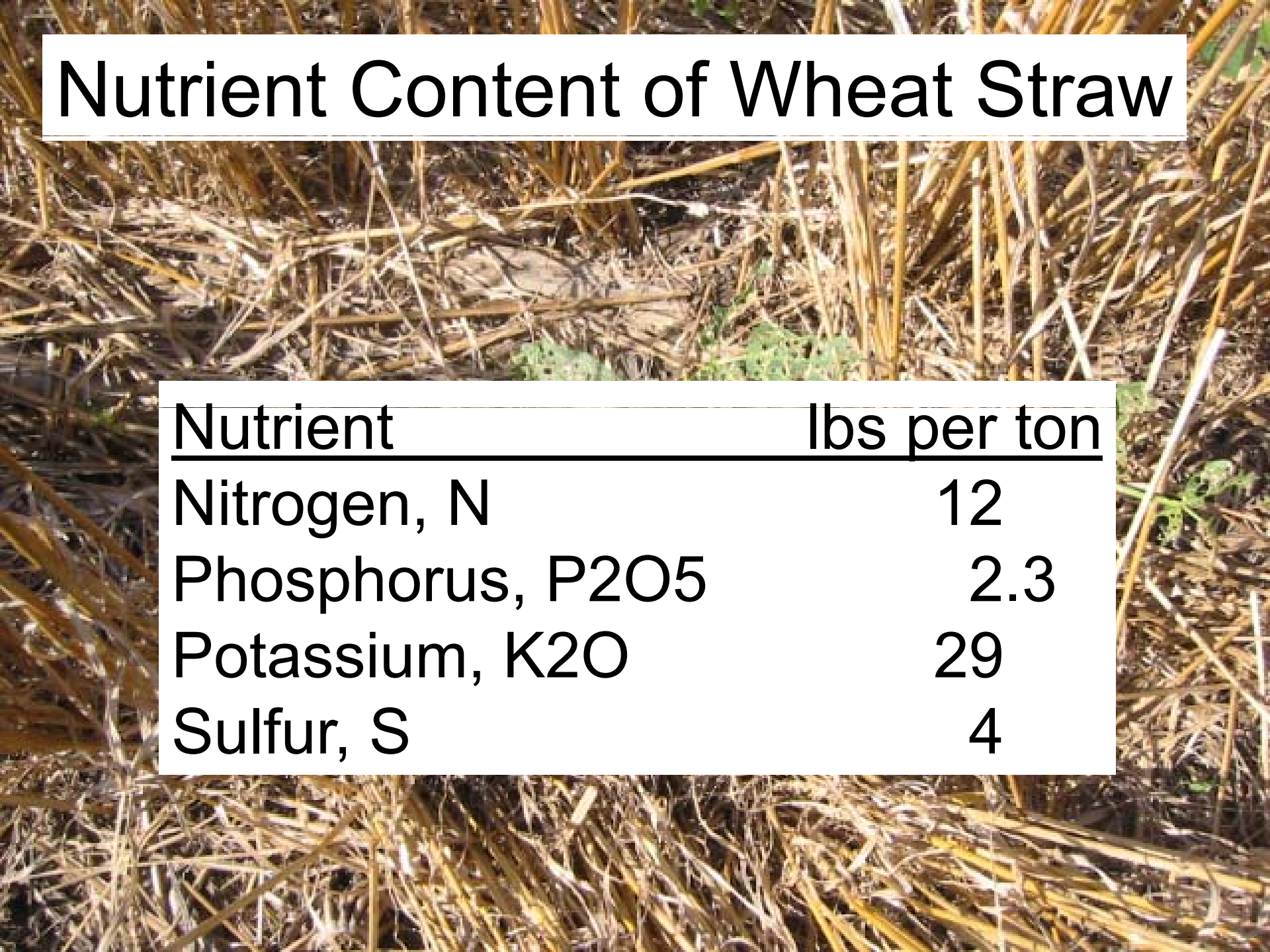
It takes about 18 lbs of P_2O_5 to increase Mehlich P 1 ppm P. This is in addition to crop removal.

Once you are at desired level, about ½ of the crop removal is needed to maintain P soil test level.

Nutrient Crop Removal, lbs/Bu
WHEAT

Nutrient	lb/bu	60 bu/A
Nitrogen, N	1.2	72
Phosphorus, P2O5	0.52	31
Potassium, K2O	0.26	16
Sulfur, S	0.12	7
Zinc, Zn	0.002	0.12

Nutrient Content of Wheat Straw

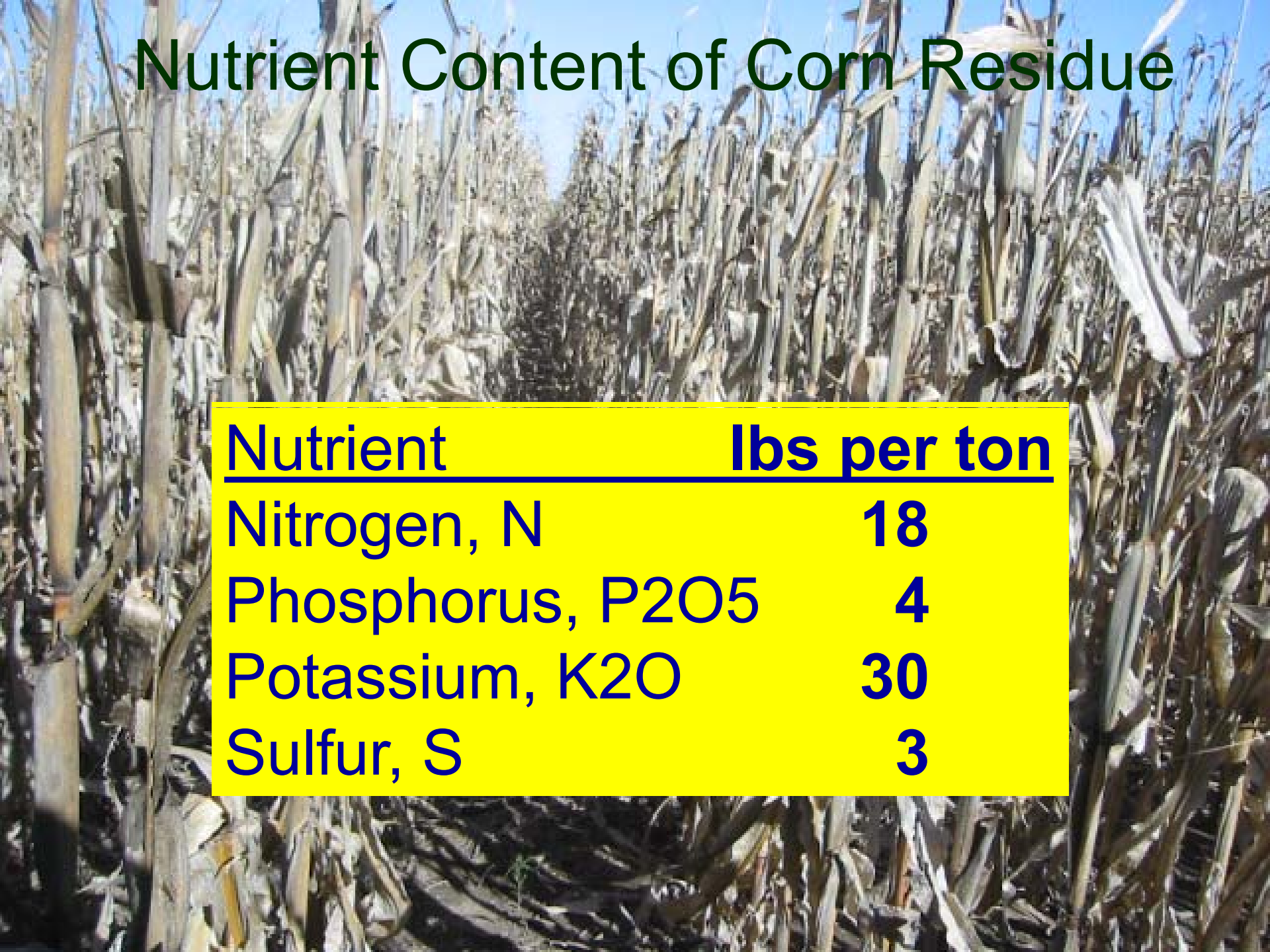


Nutrient	lbs per ton
Nitrogen, N	12
Phosphorus, P_2O_5	2.3
Potassium, K_2O	29
Sulfur, S	4

Nutrient Crop Removal, lbs/Bu
CORN

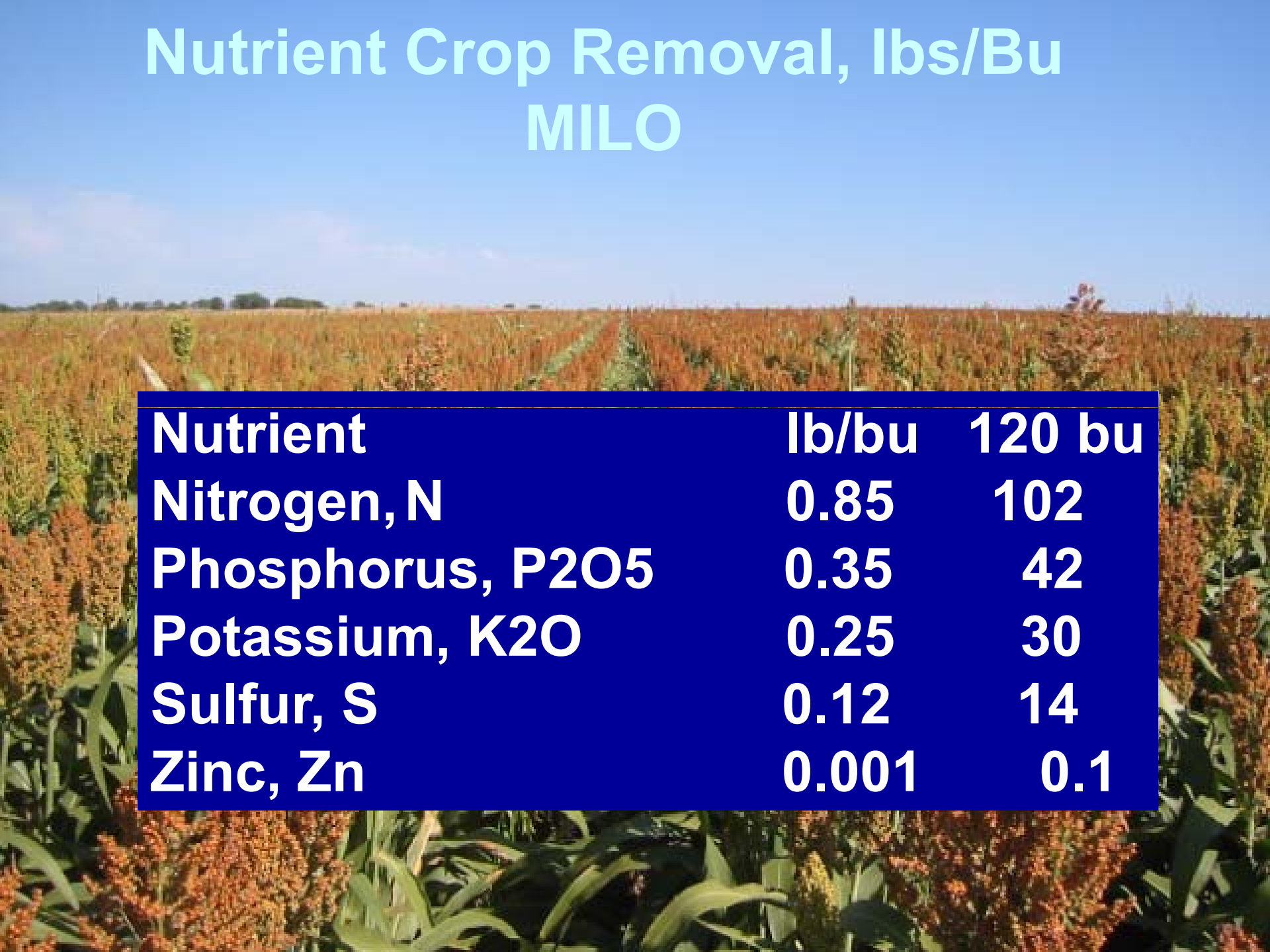
Nutrient	lb/bu	125bu/A
Nitrogen, N	0.75	94
Phosphorus, P2O5	0.33	41
Potassium, K2O	0.23	29
Sulfur, S	0.09	11
Zinc, Zn	0.001	0.13

Nutrient Content of Corn Residue



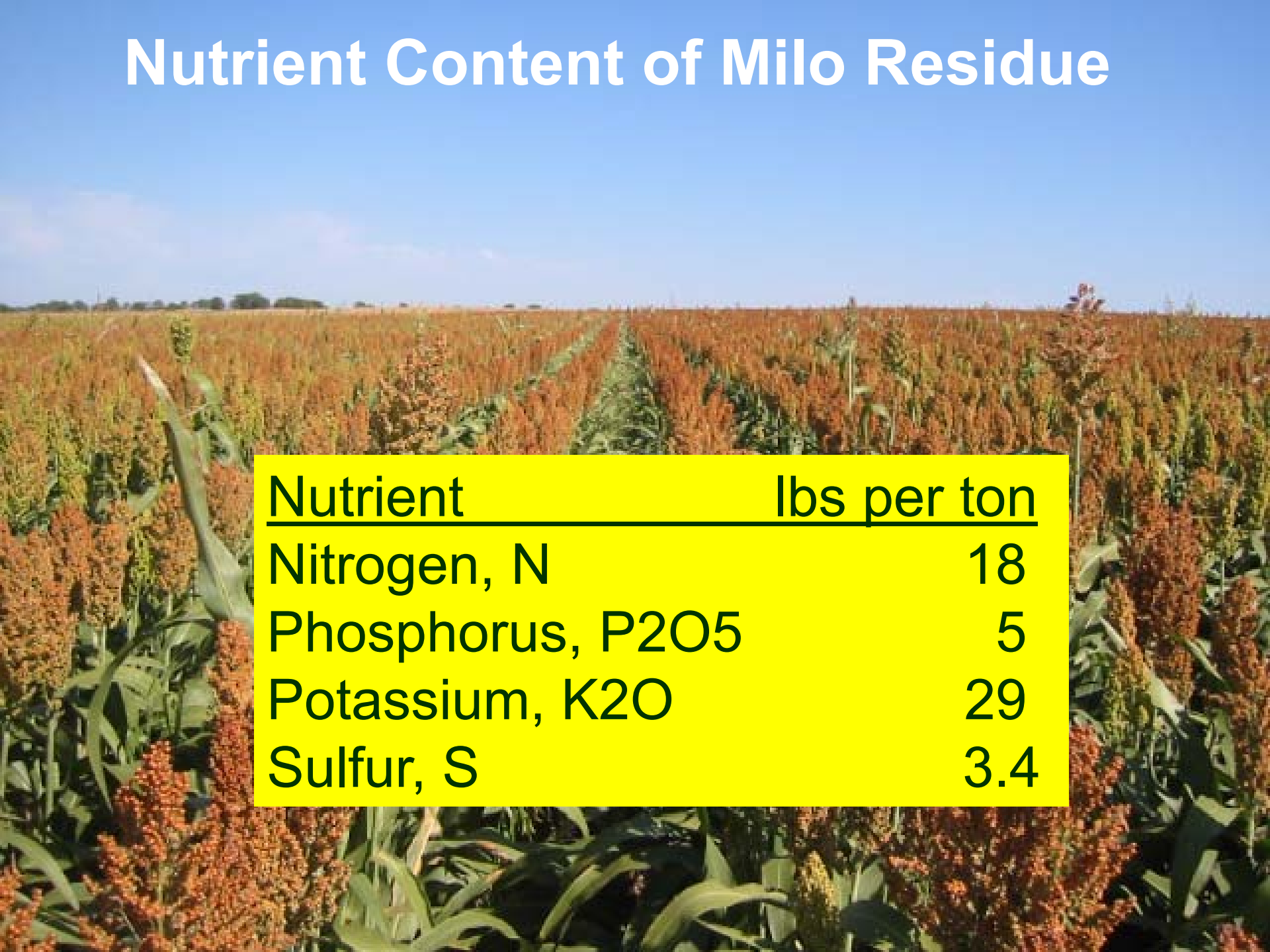
Nutrient	lbs per ton
Nitrogen, N	18
Phosphorus, P_2O_5	4
Potassium, K_2O	30
Sulfur, S	3

Nutrient Crop Removal, lbs/Bu
MILO



Nutrient	lb/bu	120 bu
Nitrogen, N	0.85	102
Phosphorus, P2O5	0.35	42
Potassium, K2O	0.25	30
Sulfur, S	0.12	14
Zinc, Zn	0.001	0.1

Nutrient Content of Milo Residue

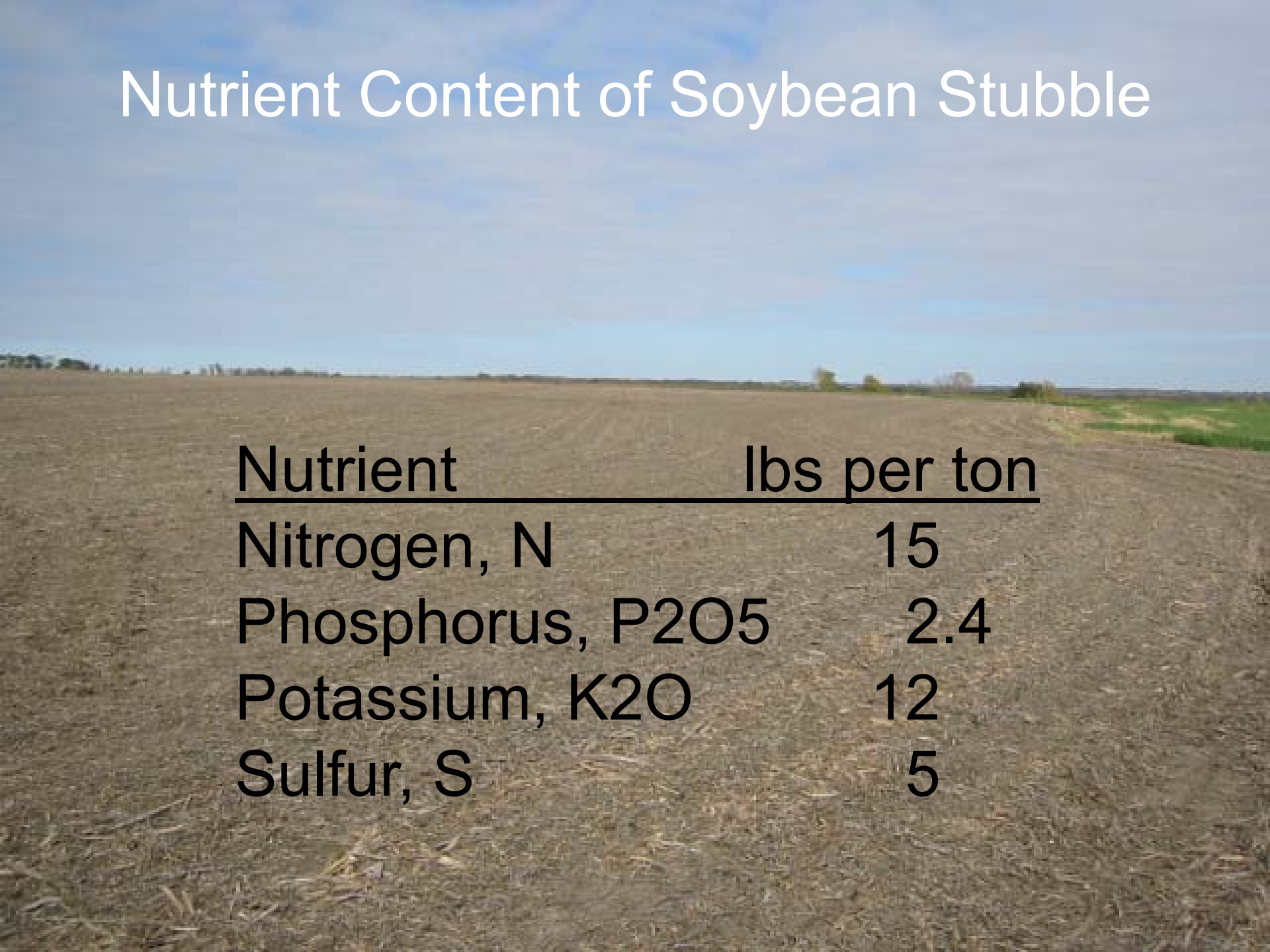


Nutrient	lbs per ton
Nitrogen, N	18
Phosphorus, P_2O_5	5
Potassium, K_2O	29
Sulfur, S	3.4

Crop Nutrient Removal, lbs/bu
SOYBEAN

Nutrient	lb/bu	50 bu/A
Nitrogen, N	3.7	185
Phosphorus, P_2O_5	0.77	39
Potassium, K_2O	1.4	70
Sulfur, S	0.31	16
Zinc, Zn	0.002	0.1

Nutrient Content of Soybean Stubble



Nutrient	lbs per ton
Nitrogen, N	15
Phosphorus, P_2O_5	2.4
Potassium, K_2O	12
Sulfur, S	5

Nutrient Removal

Nutrient		Cotton lbs/500 lbs	Sunflowers lbs/100 lbs
Nitrogen	N	17	3.6
Phosphorus	P2O5	10	1.2
Potassium	K2O	6.7	1.1
Sulfur	S	1.2	0.22
Zinc	Zn	0.01	0.003

How Much N Should I Apply?

- When a crop is harvested, a lot of N is removed in the grain and/or forage.
- If crop residue is left on the surface and has a high C:N ratio carryover nitrate will be used by microbes to start decomposition
- If a legume cover crop is established and not harvested, more N will be available because of N fixation and a low C:N ratio

Fertilizer Recommendations

- Crop and Yield Goal
- Past Crop
- Soil Test Values
- Then You Receive a Suggested Nutrient Rate
- You have to decide what method of application

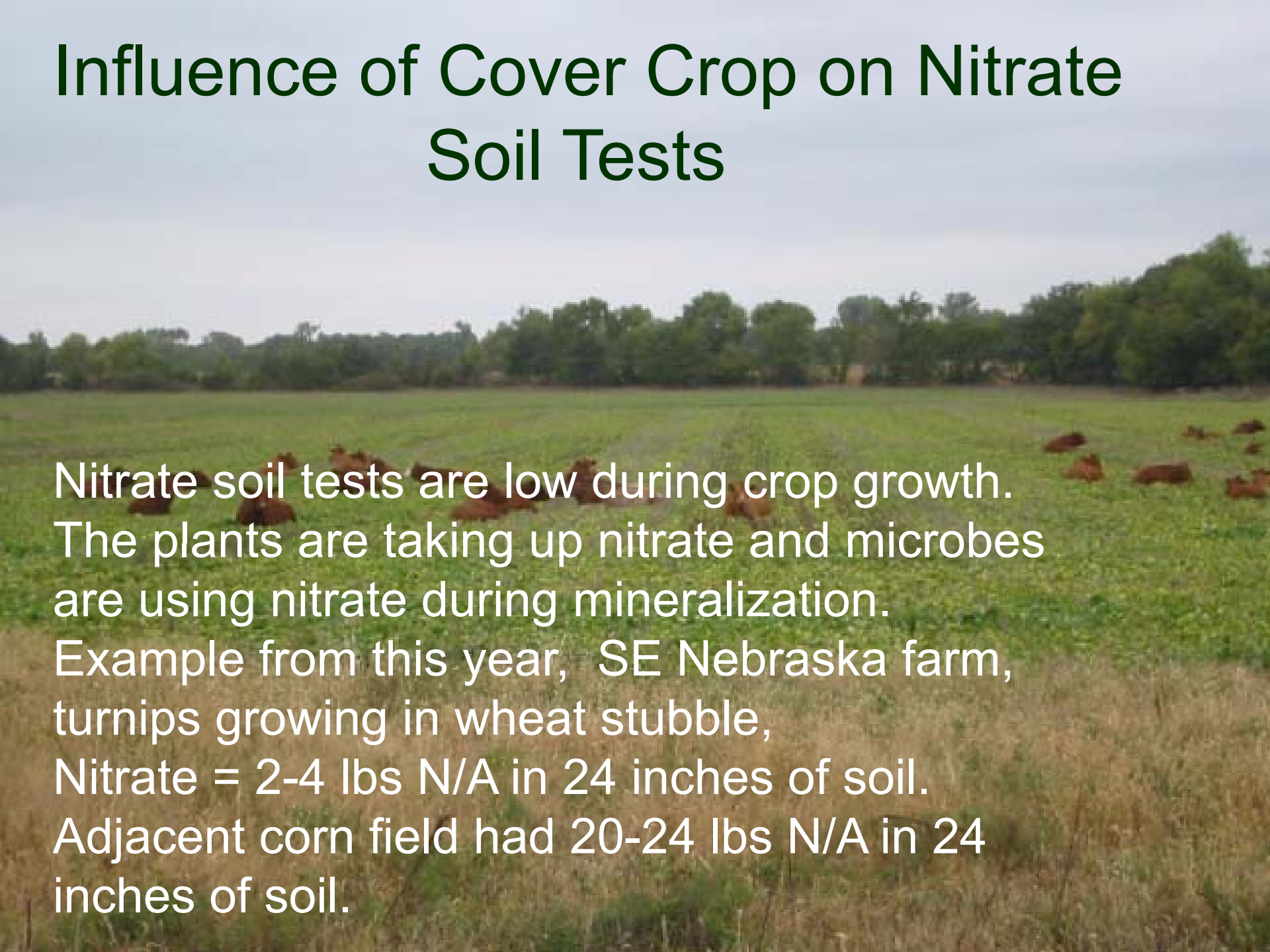
Nitrogen Requirement

- Corn 1.2 lbs N/Bu
- Wheat 2.4 lbs N/Bu
- Milo 1.1 lbs N/Bu
- Grass 40 lbs N/Ton
- Sunflower 50 lbs N/1000 lbs

N Fertilizer Recommendation for Wheat, 60 bu/A

1. N requirement is 2.4 lbs of N/bu
   - Subtract residual nitrate in 24 inches of soil
   - Difference is the N recommendation
2. N recommendation in no-till with a cover crop biomass left on the soil
   - If cover crop biomass protein is greater than 13 %, subtract at least 50 % of the N content of the cover crop

Influence of Cover Crop on Nitrate Soil Tests



Nitrate soil tests are low during crop growth. The plants are taking up nitrate and microbes are using nitrate during mineralization.
Example from this year, SE Nebraska farm, turnips growing in wheat stubble,
Nitrate = 2-4 lbs N/A in 24 inches of soil.
Adjacent corn field had 20-24 lbs N/A in 24 inches of soil.

Nitrogen Recommendation for Wheat

Yield Goal	Lbs of Nitrate/A in Root Zone		
Bu/A	40	60	100
40	55	35	0
60	80	60	45
80	150	130	92
100	200	180	140

Nitrogen Recommendation for Corn

Yield Goal	Lbs of Nitrate/A in Root Zone		
Bu/A	50	100	150
100	70	20	0
125	100	50	0
150	130	80	30
175	160	110	60
200	190	140	90

Phosphorus Recommendations for Wheat

Yield Goal	Phosphorus Soil Test, ppm P		
Bu/A	6-12	13-25	26-50
40	45-55	20-40	0
60	50-60	25-45	0-20
80	55-65	30-50	0-25
100	60-70	35-55	0-30

Phosphorus Recommendations for Corn

Yield Goal	Phosphorus Soil Test, ppm P		
Bu/A	6-12	13-25	26-50
100	40-60	15-35	0
125	45-65	20-30	0
150	50-70	25-45	0
175	55-75	30-50	0-25
200	60-80	35-55	0-30

Potassium Recommendations

Soil Test ppm K	Rating	lbs K2O
0-40	Very Low	90-200
41-80	Low	50-120
81-120	Medium	25-60
121-200	High	0-35
201+	Very High	None

Sulfur Requirement

Crop	Yield Unit	LBS of S
Corn	Bushel	0.18-0.26
Soybean	Bushel	0.20-0.29
Wheat	Bushel	0.28-0.3
Alfalfa	Ton	4.7 – 6.3
Grass	Ton	2.2 – 3.6

Sulfur Recommendations for Wheat

Yield Goal	Sulfate soil test, ppm SO4-S		
Bu/A	6	9	12
40	0	0	0
60	5	0	0
80	10	4	0
100	16	8	2

Sulfur Recommendations for Corn

Yield Goal	Sulfate soil test, ppm SO4-S		
Bu/A	6	9	12
100	8	0	0
125	14	6	0
150	19	11	4
175	25	17	10

Zinc Recommendations

Soil Test ppm Zn	Corrective Rate lb Zn/A
0-0.25	3-12
0.26-0.50	1-7
0.51-.75	0-6
0.76-1.00	0-3
1.01+	None

*Annual rate: Divide Corrective Rate by 6.

Importance of Phosphorus for Corn, Tribune, KS 2004

N Rate	With 40 lbs P_2O_5	Without P_2O_5
0	97	67
40	148	92
80	209	118
120	228	103
160	231	136
200	234	162

- Continuous phosphate application since 1961

Tribune, KS N Rate for Corn

$N+P_2O_5$	Aver Corn Yield, bu/A
0+40	73
40+40	121
80+40	157
120+40	169
160+40	170
200+40	173

- Continuous phosphate application since 1961