University of California

Nitrogen Management Training

for Grower Nitrogen Management Plan Self-Certification

CURRICULUM BINDER

A training program developed in cooperation with: California Department of Food and Agriculture's Fertilizer Research and Education Program and University of California

University of California
Agriculture and Natural Resources

December 2018

University of California

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for Grower Nitrogen Management Plan Self-Certification

Many of you may have heard that with the adoption of the new Waste Discharge Requirement by some of the coalitions, new requirements are coming.

For the next season only the Eastern San Joaquin WQC will be required to follow the new rules and forms.

If farming in both Coalitions be aware of the differences.

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Agriculture and Natural Resources

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Nitrogen Management Training
for Grower Nitrogen Management Plan Self-Certification

Original Presentation Developed By:

- University Of California, Davis
  - Patrick Brown
  - Daniel Geisseler
  - Allan Fulton
  - Tim Hartz
  - Stuart Pettygrove
  - Terry Prichard
  - Larry Schwankl
  - Carol Frate
  - Marsha Campbell Mathews
  - Gabriele Ludwig, Almond Board of CA
  - Asif Maan, CASS
  - Rob Mikkelsen, IPNI
  - Jerome Pier, Crop Production Services
  - Sebastian Saa, Almond Board of CA

Table of Contents

Irrigated Lands Regulatory Program (ILRP)

- Managed by the Regional Water Quality Control Board
- Applies to all growers who irrigate commercial crops
- Board uses Waste Discharge Requirements (WDR) to specify what growers and coalitions must implement to protect groundwater and surface water.

Regulations: Waste Discharge Requirements

- Growers with irrigated lands must either join regional coalitions or meet WDR requirements individually.

- <u>Coalition Tasks in the Central Valley:</u>
  - Groundwater quality assessments and plans
  - Monitoring long term groundwater quality trends
  - Assess which BMPs protect groundwater quality
  - Surface water quality monitoring
  - Compilation of data submitted by growers and reports to Regional Water Board

Regulations: Waste Discharge Requirements

- Growers are responsible for:
  - **Annual Farm Management Plans**- suspended until new WDR takes effect – 2020
    - Review whole operation for possible impacts to ground and surface water
  - **Annual Nitrogen Management Plans**
    - Require plan certification if in high vulnerability areas
    - Certification is by Certified Crop Advisor or self-certified grower
  - **Annual Nitrogen Management Plan Summary Report**
  - **Sediment and Erosion Management Plans** where needed
  - **Attend one outreach event (yearly)**

Certifying Nitrogen Management Plans

- Required if field is located in a high vulnerability groundwater area
  - Coalition has identified which parcels are in high vulnerability areas in their Groundwater Assessment Report (GAR)
- Options for certification:
  - Certified Crop Adviser with Nitrogen Management Training (Any crop and any field)
  - Grower Self-Certification (Owned or managed fields only)

Grower Self-Certification Requirements

- Nitrogen Management Plan Certification Training
  - 4 hours
  - Passing grade (70%) on test*
- Certification Period
  - 3 years
- Re-certification
  - Continuing Education Units (CEU) required
    - 3 hours in 3 year time period
    - If you have already passed the exam, you may attend this course today for 1 CEU

* Test can be taken multiple times

Nitrogen Management Plan Certification Training

- Sponsored by **CDFA/FREP** Project Grant
- Project administered by Coalition for Urban Rural Environmental Stewardship (**CURES**)
- Certification presentations are by Certified Crop Advisors (CCA) who have completed the UC/CDFA Nitrogen Management Program as a trainer
- Coalition facilitates the training meetings

Nitrogen Management Plan Certification Training

- Regulatory Oversight of Grower Trainings
  - Water Board has approved this NMP training approach
  - Expect scrutiny to gauge effectiveness of the program
  - **CDFA** and the **coalitions** will audit presentations at grower trainings to ensure professionalism by CCAs

Nitrogen Management Plan Certification Training

- Provide information for
  - Efficient use of nitrogen fertilizers
  - Minimize environmental impacts
  - Meet Regulatory compliance requirements
    - Nitrogen Management Plan
    - Nitrogen Management Summary Report

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: _____

1. Crop Year (Harvested):		4. APN(s):	5. Field(s) ID	Acres
2. Member ID#				
3. Name:				

CROP NITROGEN MANAGEMENT PLANNING		N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
6. Crop		**17. Nitrogen Fertilizers**		
7. Production Unit		18. Dry/Liquid N (lbs/ac)		
8. Projected Yield (Units/Acre)		19. Foliar N (lbs/ac)		
9. N Recommended (lbs/ac)		**20. Organic Material N**		
10. Acres		21. Available N in Manure/Compost (lbs/ac estimate)		
Post Production Actuals				
11. Actual Yield (Units/Acre)		**22. Total Available N Applied** (lbs per acre)		
12. Total N Applied (lbs/ac)		**23. Nitrogen Credits (est)**		
13. ** N Removed (lbs N/ac)		24. Available N carryover in soil; (annualized lbs/acre)		
14. Notes:				
		25. N in Irrigation water (annualized, lbs/ac)		
		26. Total N Credits (lbs per acre)		
		27. Total N Applied & Available		

PLAN CERTIFICATION		
28. CERTIFIED BY:	**29. CERTIFICATION METHOD**	
	30. Low Vulnerability Area, No Certification Needed	
	31. Self-Certified, approved training program attended	
DATE:	32. Self-Certified, UC or NRCS site recommendation	
	33. Nitrogen Management Plan Specialist	

Overview of Nitrogen and Groundwater Quality Issues

Section 1

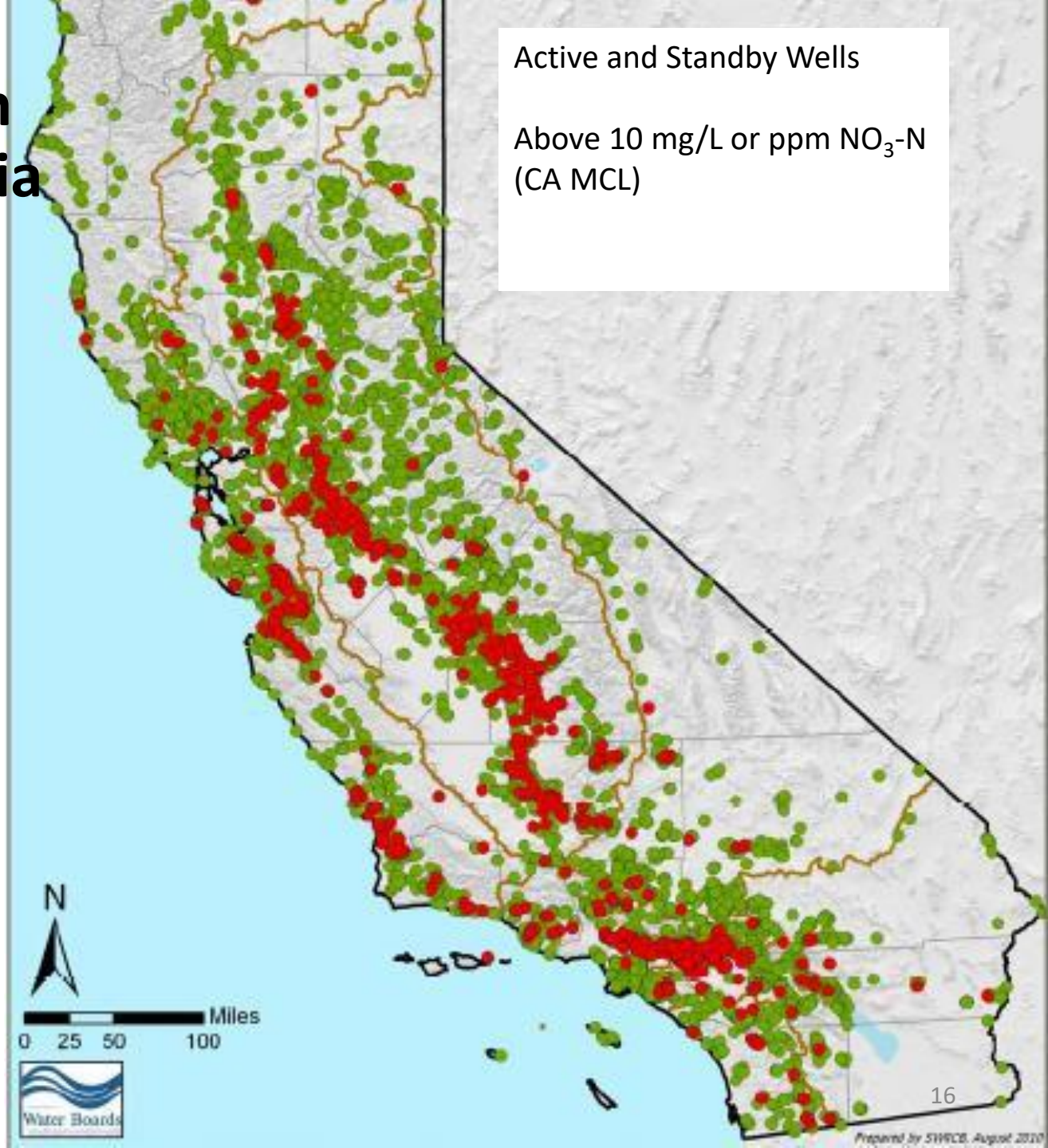
Section 1 Learning Objectives

- Recall areas that are more vulnerable to nitrate contamination.
- Recognize how nitrate became a problem.
- List the sources of nitrogen.
- Distinguish between the different ways to measure nitrate in the groundwater.

Nitrate Problem Areas in California

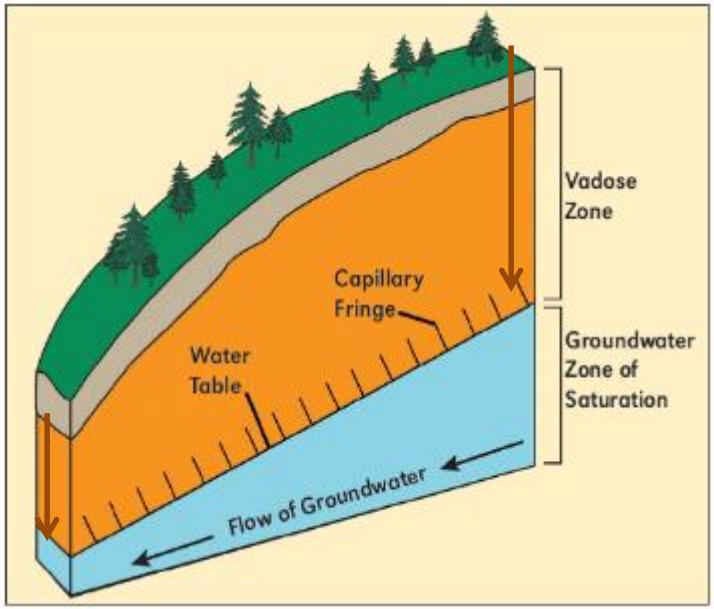
Areas with shallow groundwater and intensive agriculture are vulnerable to nitrate contamination

- **Above** MCL 10 ppm NO_3-N Maximum Contaminant Level
- **Below** MCL



Why is Shallow Groundwater Most Affected?

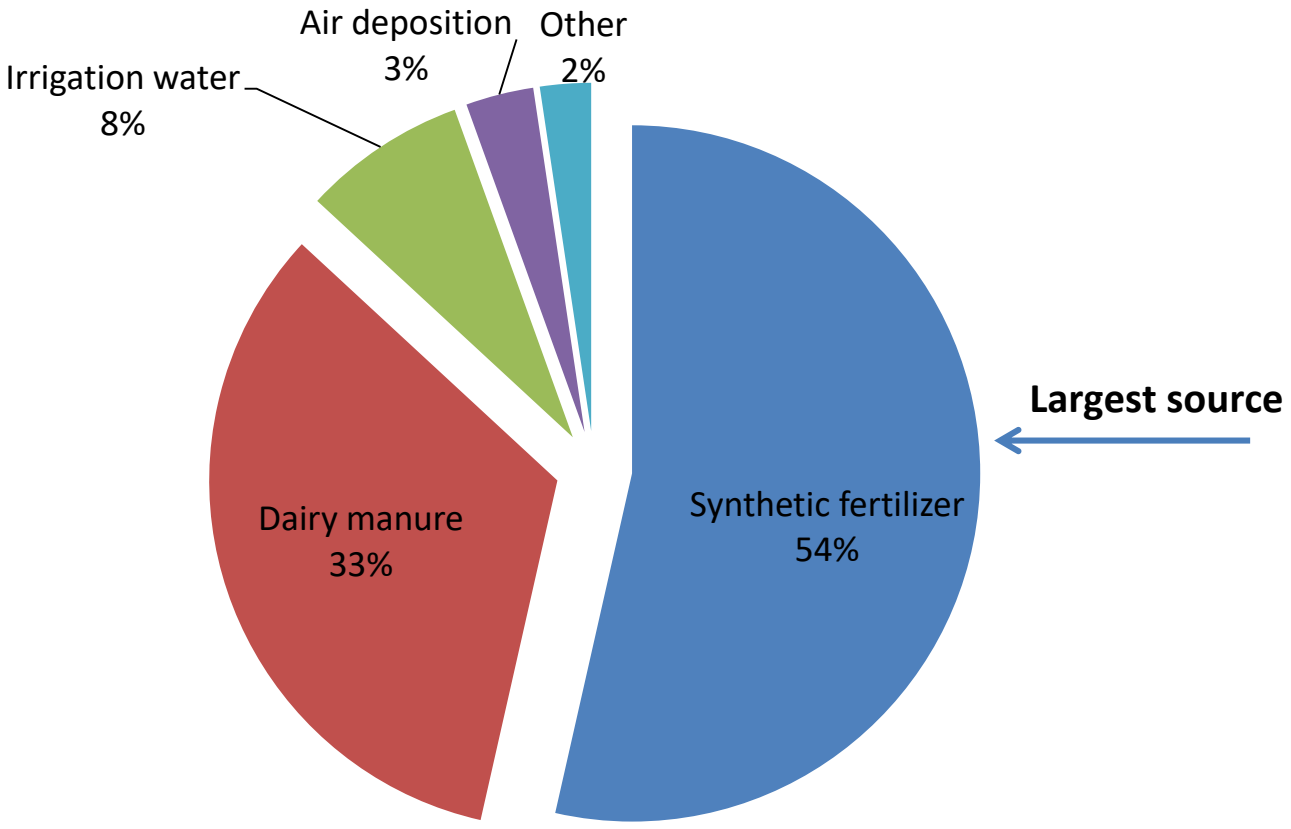
- Nitrate (NO_3^-) is an anion (negatively charged) and is not retained by the soil. It moves with water.
- Water moving below the root zone can carry nitrate with it.
- After years of downward flow with water, nitrate eventually reaches the aquifer.
- The ***closer*** the groundwater is to the source, the **sooner** nitrate will reach the groundwater.



How Did Nitrate Become a Problem?

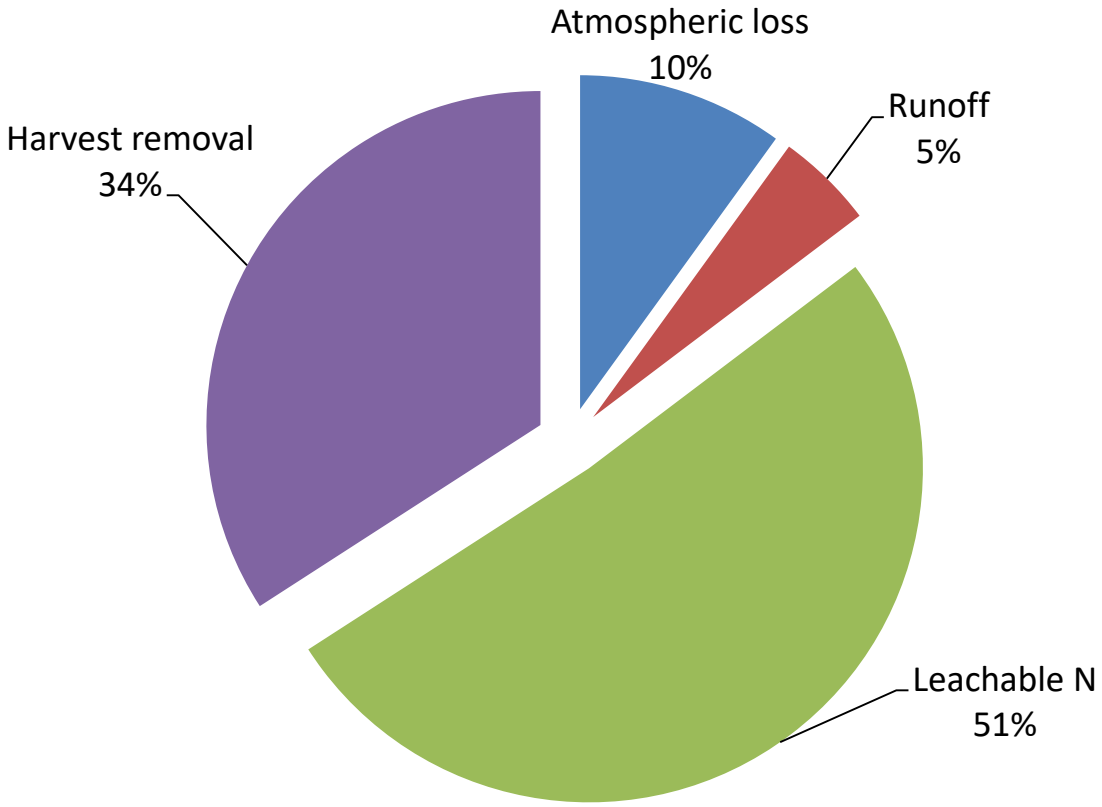
- In nature, nitrogen (N) cycles through soil, water, and plants at low concentrations (approx. 2ppm).
- Agriculture requires high N input to produce profitable crops which increases soil N concentrations.
- **Inefficiency** of irrigation and N applications leads to nitrate leaching losses.

Where is Nitrogen Coming From in California?



Data from Salinas Valley and Tulare Lake Basin

Of the Total N Inputs Where is Nitrogen Going in California?



Data from Salinas Valley and Tulare Lake Basin

Dealing with Nitrate Pollution

- No inexpensive method exists to remove nitrate once it is in water
- Source control: Accounting for all the sources of nitrogen in the system leads to more efficient use of nitrogen and fertilizer products.
    - Sources of nitrogen:
        - Mineralization of organic nitrogen
        - Residual soil nitrogen
        - Nitrogen in irrigation water
        - Nitrogen fertilizers

Nitrate. What is the Problem?

- Nitrate in Drinking Water
  - Federal/CA Maximum Contaminant Level (MCL) is 10 ppm Nitrate expressed as NO_3–N)
    - MCL was determined by US EPA, “to prevent methemoglobinemia in infants” decreasing the ability of blood to carry oxygen (blue baby syndrome)
  - Concentrations in drinking water of some CA aquifers exceed this level.
    - CA State Water Resources Control Board noted that 8% of drinking water wells exceed the nitrate threshold.

Measuring Nitrate Concentrations

Preferred Unit

Maximum contaminant levels

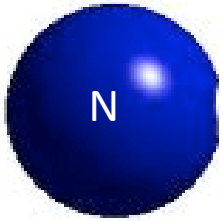
Measuring **Nitrate-N**:

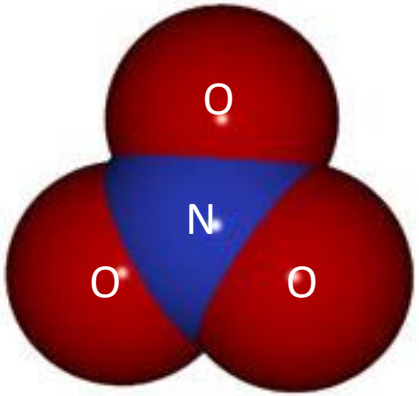
10 ppm NO_3^--N
(measures only the N in the Nitrate)

=

Measuring **Nitrate**:

45 ppm NO_3
(measures **N + O_3**)





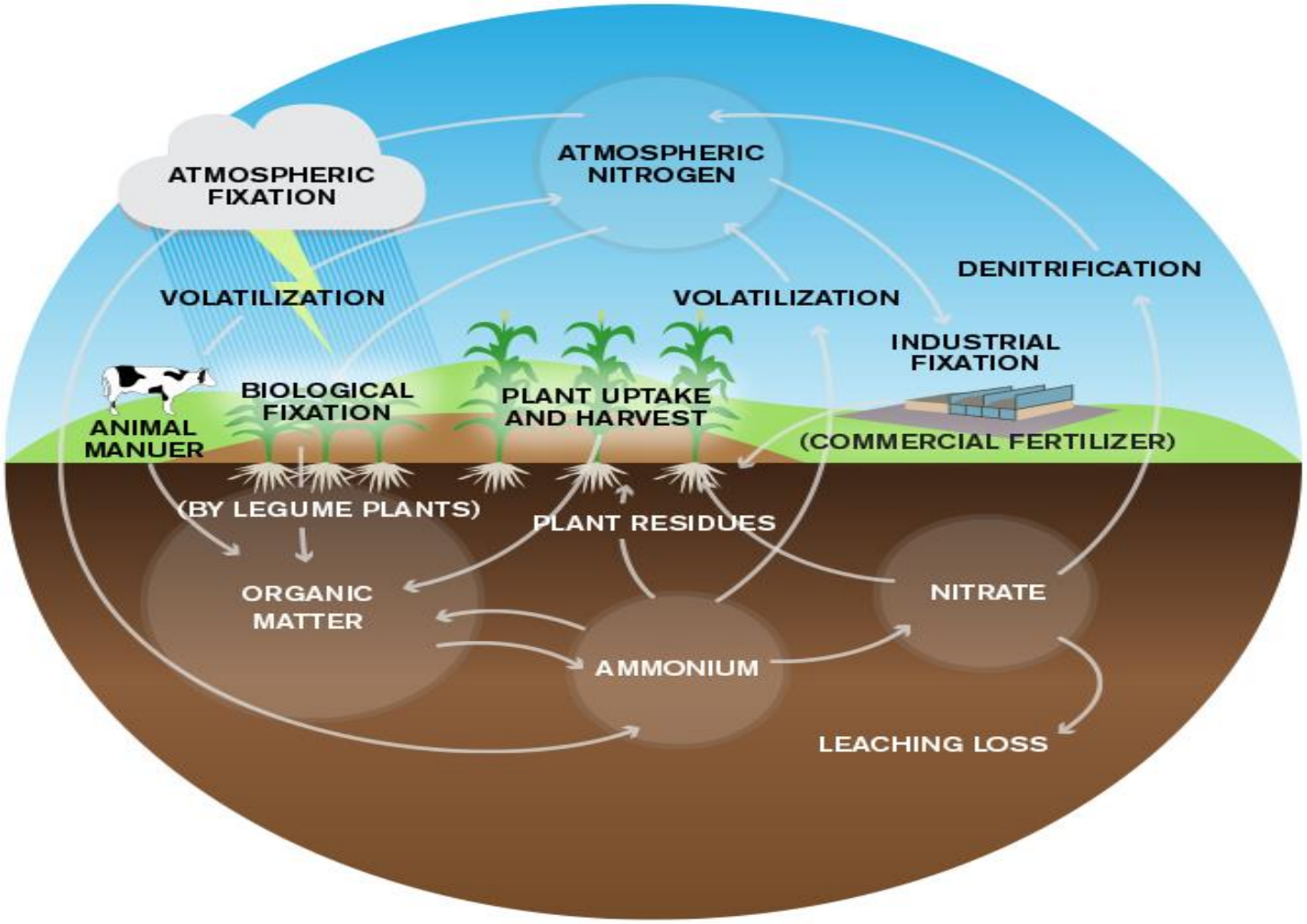
Nitrogen in Crop Production Systems

Section 2

Section 2 Learning Objectives

- Identify the parts of the nitrogen cycle and recognize conditions that favor each process
  - Mineralization
  - Nitrification
  - Plant uptake
  - Microbe uptake (Immobilization)
  - Volatilization
  - Denitrification
  - Leaching

NITROGEN CYCLE

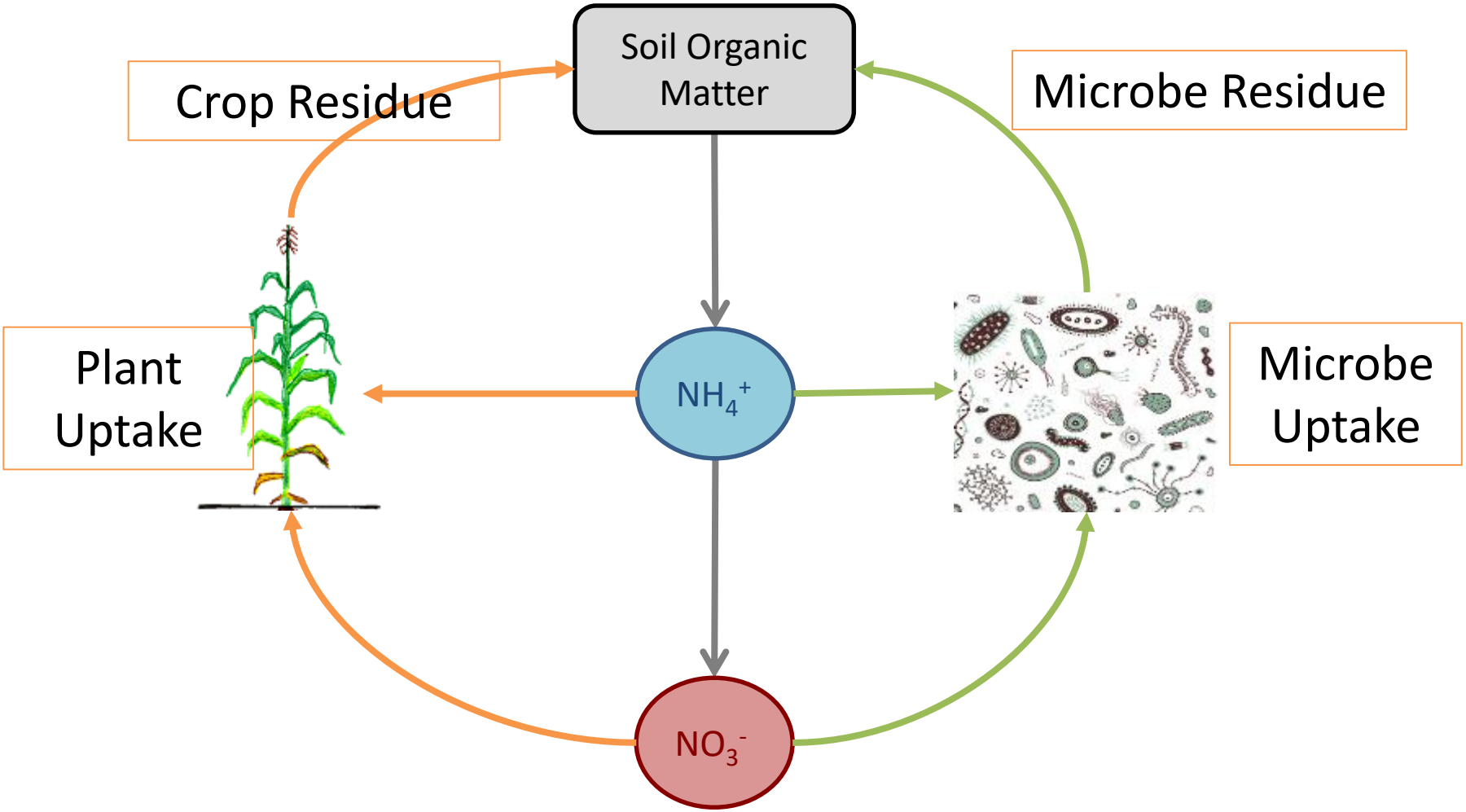


The atmosphere is the largest pool (N_2) at 78% of the atmosphere with the soil organic matter (organic N) the next largest pool.

Both pools are not available for non-legume plants. Must be transformed to mineral N for uptake.

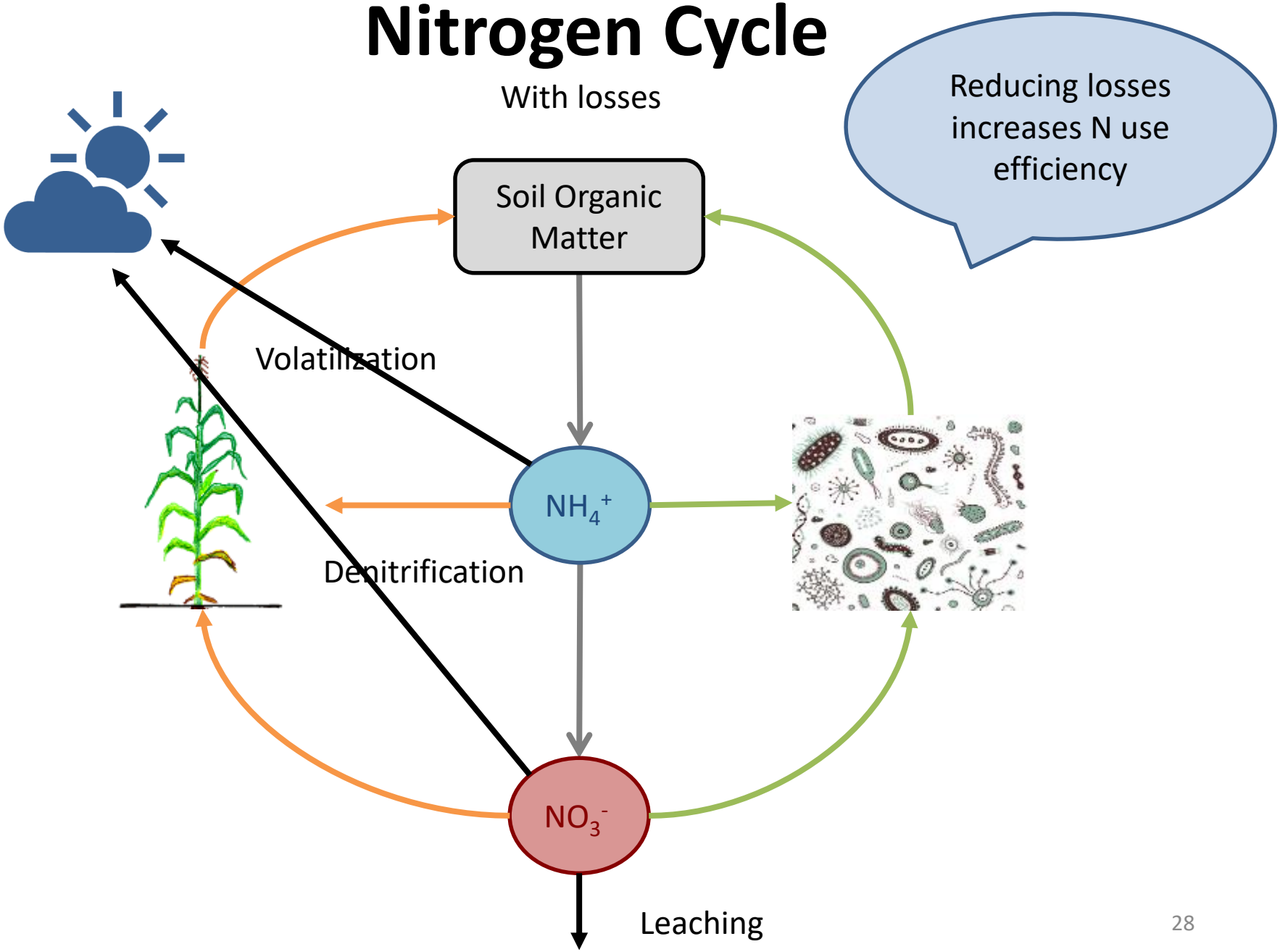
Nitrogen Cycle

Without losses, fertilizer inputs, or crop removal



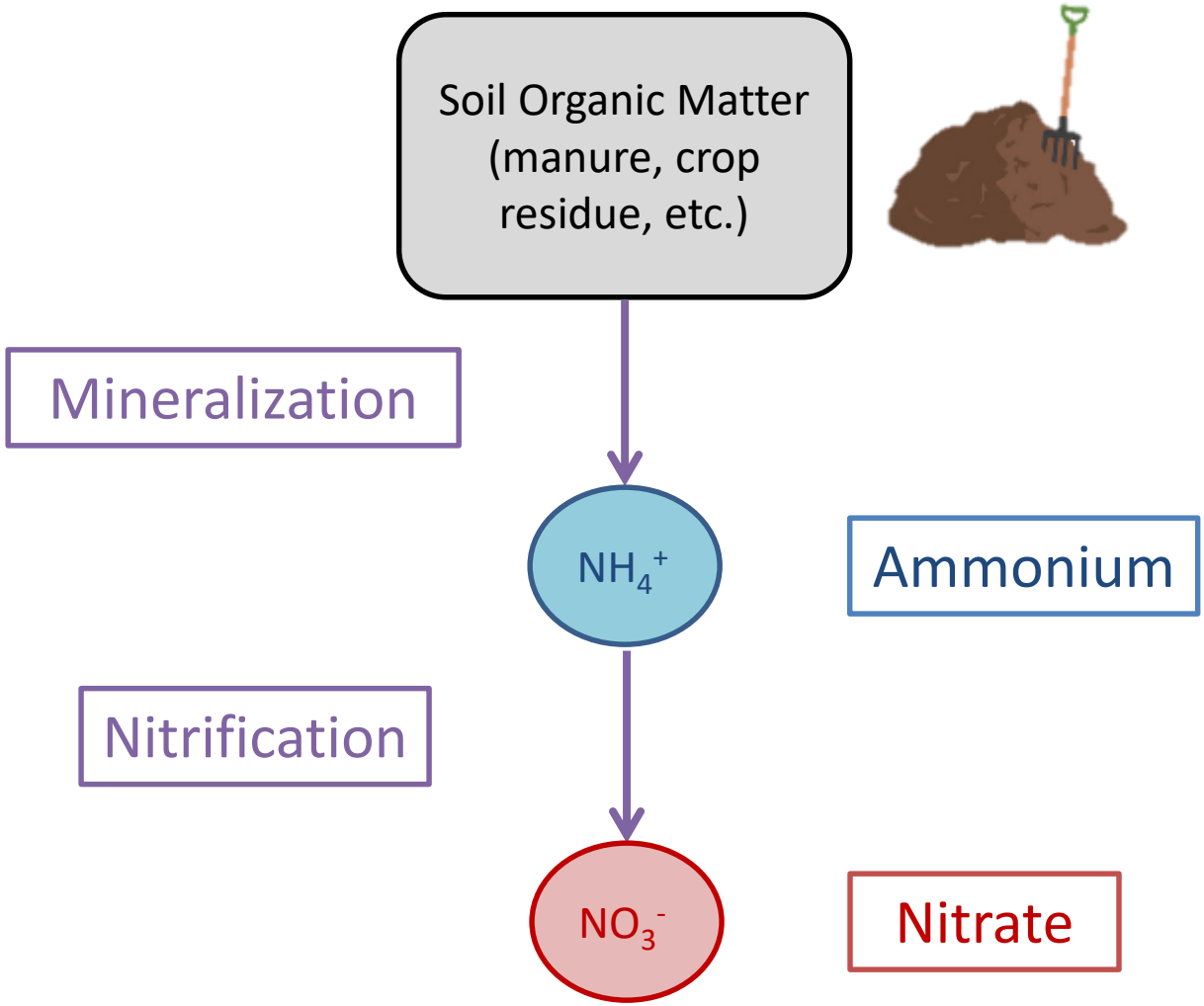
Nitrogen Cycle

With losses



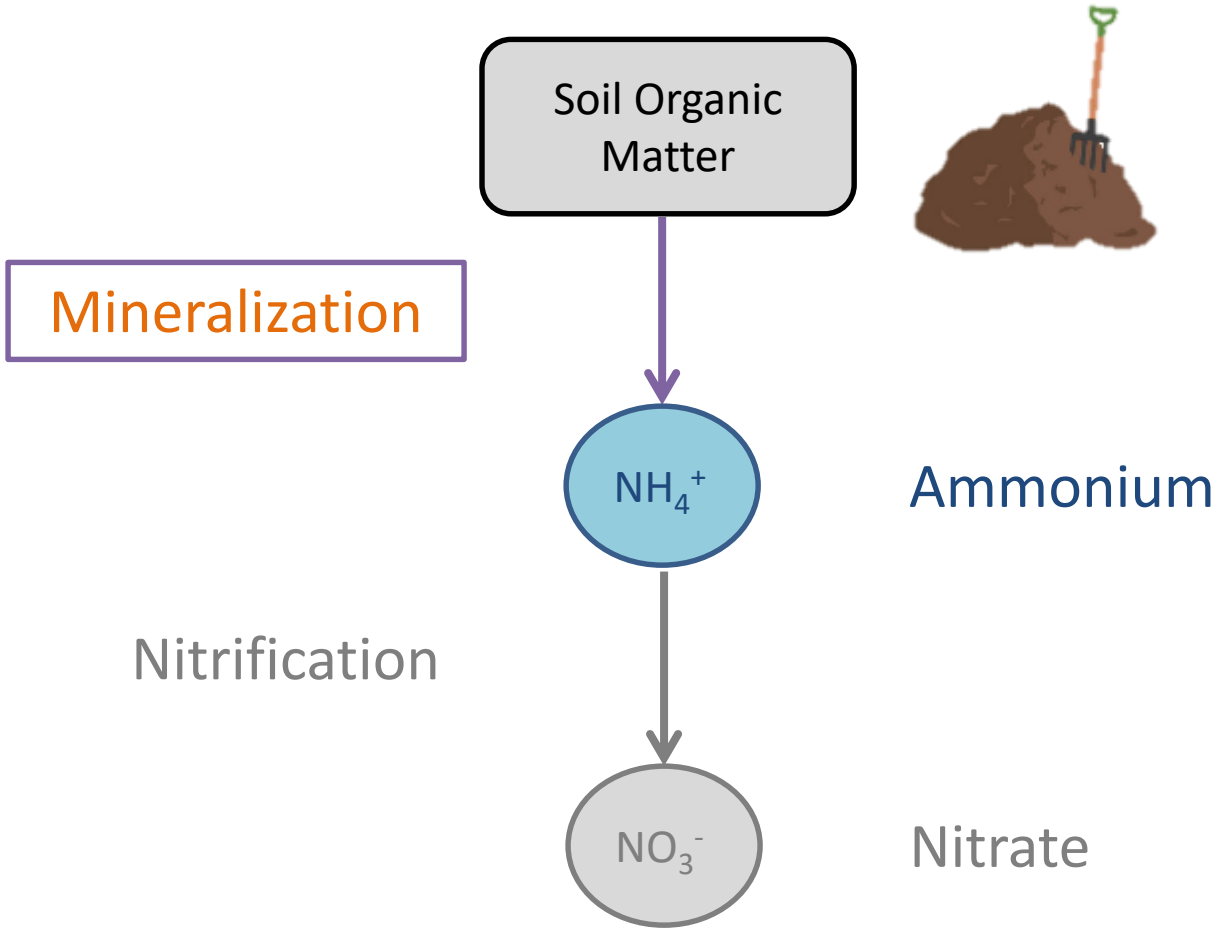
Nitrogen Cycle

Mineralization and Nitrification



Mineralization

A microbial process that converts **organic** N to plant available **inorganic** N in the form of ammonium (NH_4^+)



Soil Organic Matter

- Soil organic matter consists of fresh residues, partially decomposed organic materials, and humus

- Soil organic matter stores soil carbon and nutrients in the soil

- The process of N release from soil organic matter is driven by microbes
  - Carbon and nutrients are taken up as microbes grow then they are released as mineral N upon death (mineralization).

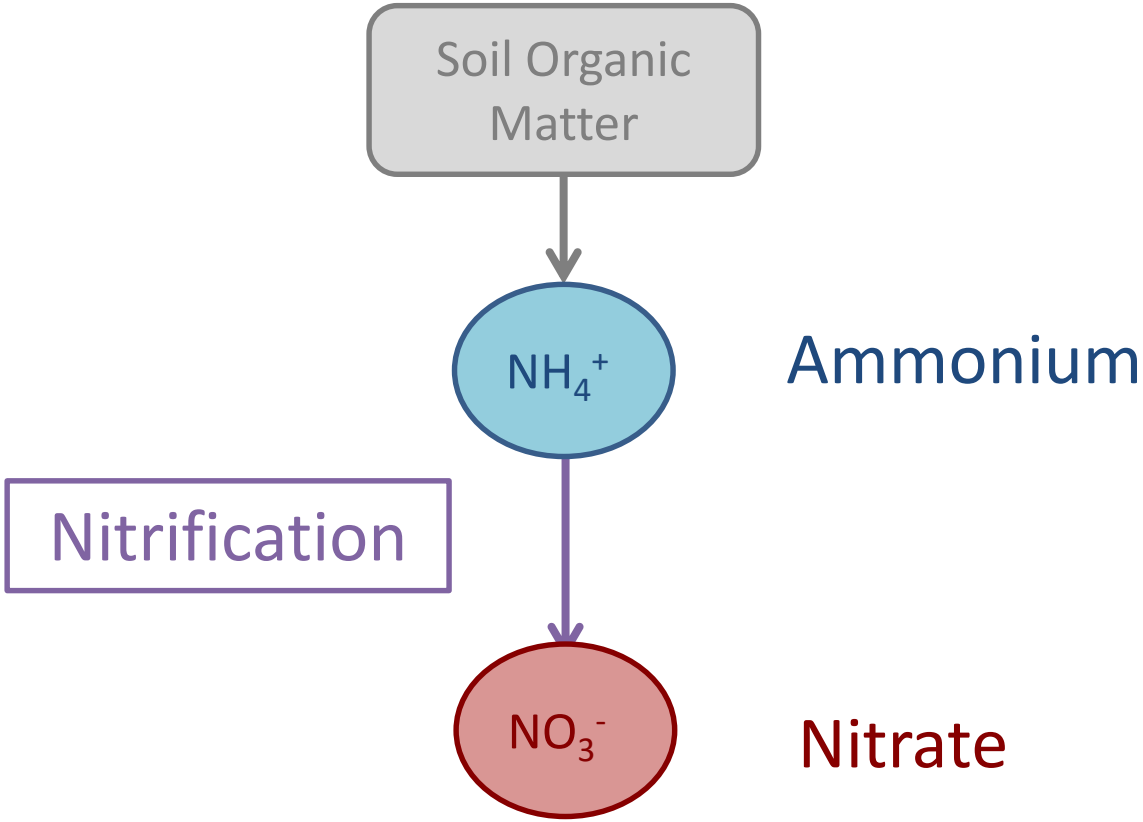
Mineralization

Organic N to Mineral N

- Carbon-to-Nitrogen ratio (C:N) of organic materials is one of the main factors controlling mineralization rates.
- Environmental conditions such as , tillage (aeration), temperature, and moisture enhance mineralization rates.
- If N is limiting to microbial metabolism, the N liberated by mineralization may be retained by the microbial biomass and is not available for plant utilization.

Nitrification

A microbial process that converts ammonium (NH_4^+) to nitrate (NO_3^-)



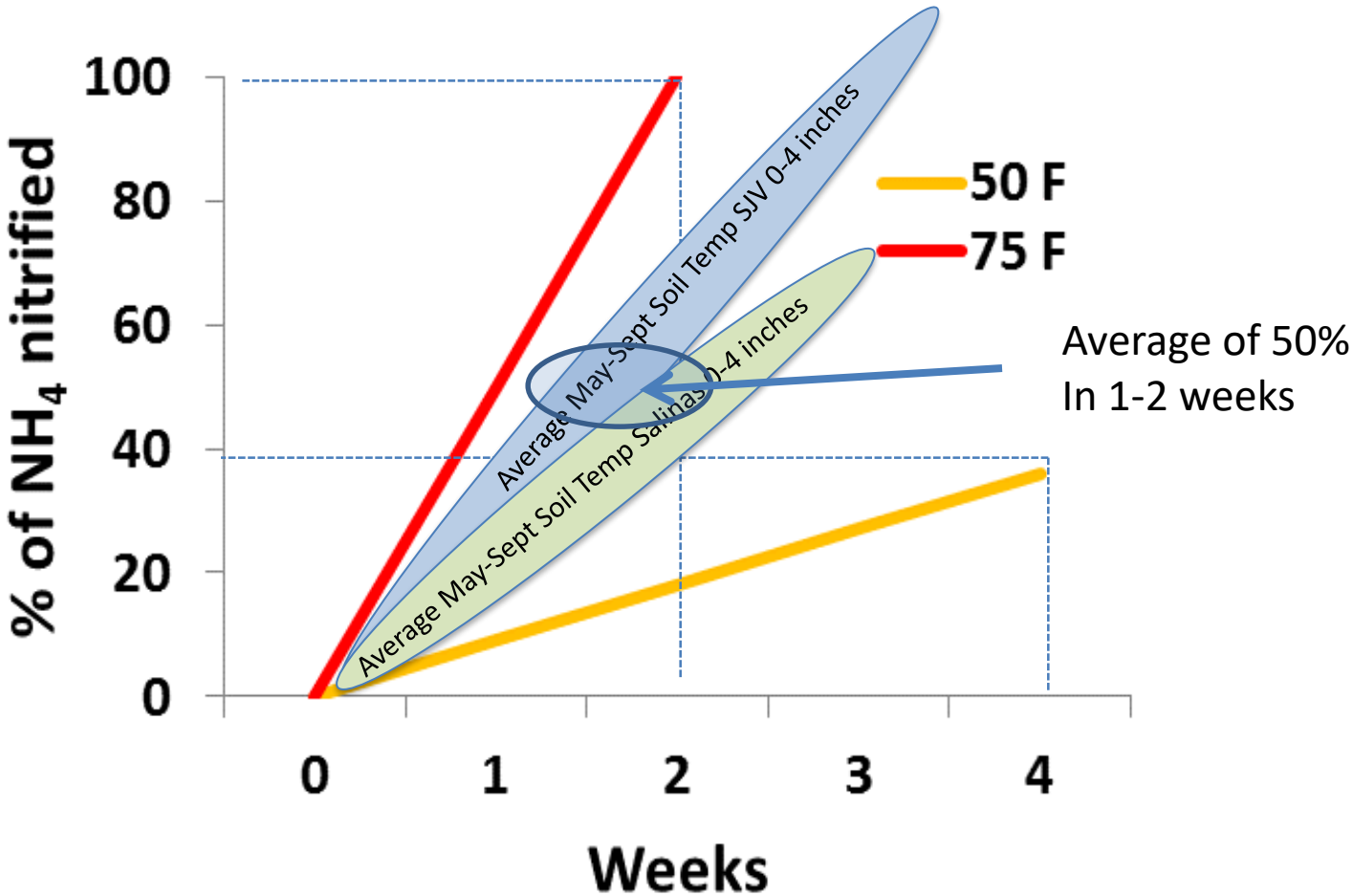
Nitrification

Ammonium → Nitrate

- Ammonium is used as an energy source by bacteria resulting in the production of nitrate
  - Nitrate is readily available for plant uptake

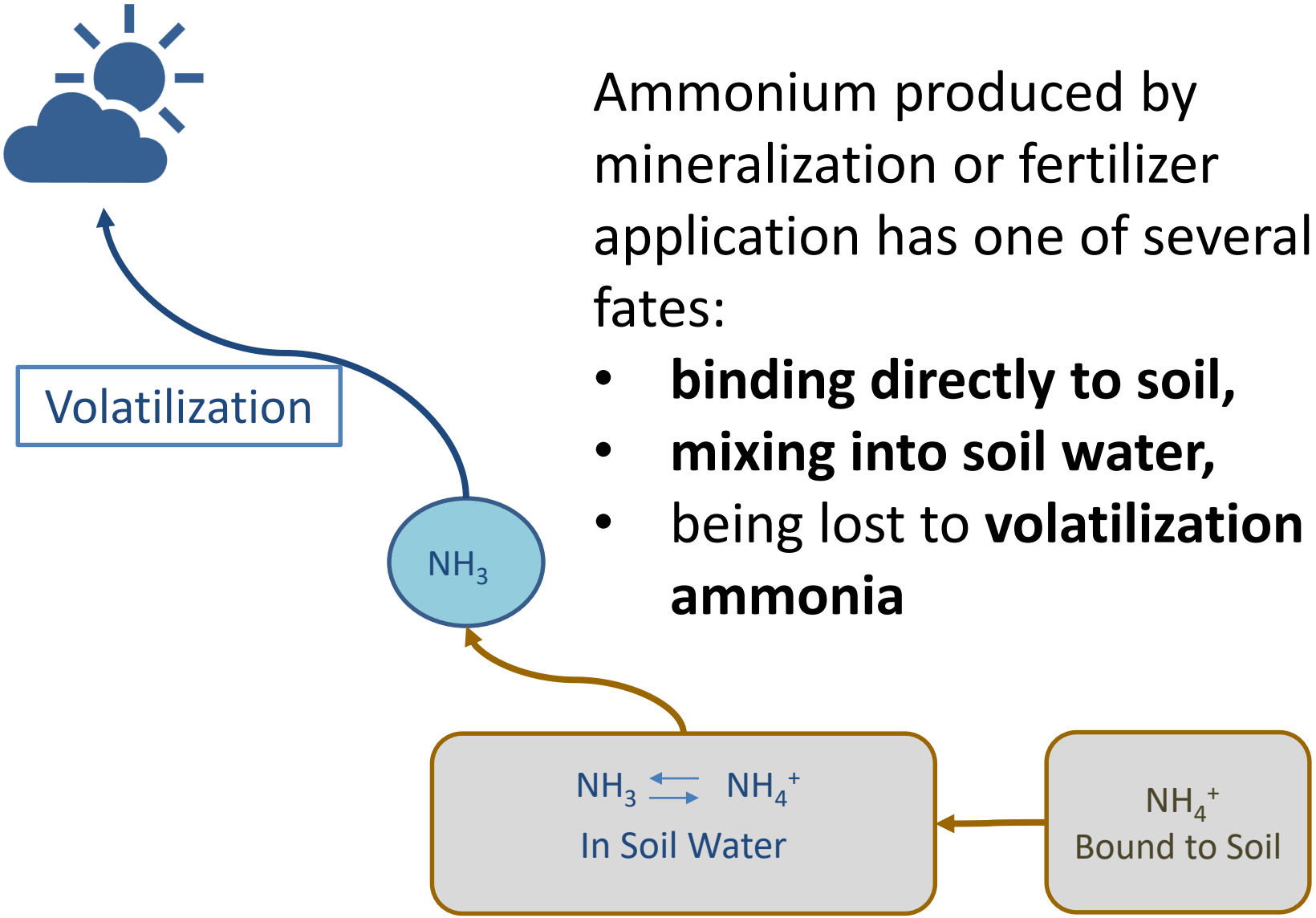
- Process enhanced by warm, moist, and well aerated soils

Nitrification: How Quickly Does it Occur?



(Figure: Estimate of nitrification rates in California soils (San Joaquin and Salinas Valleys), depending on soil temperature. Adapted from Western Fertilizer Handbook)

Nitrogen Cycle –Ammonium losses



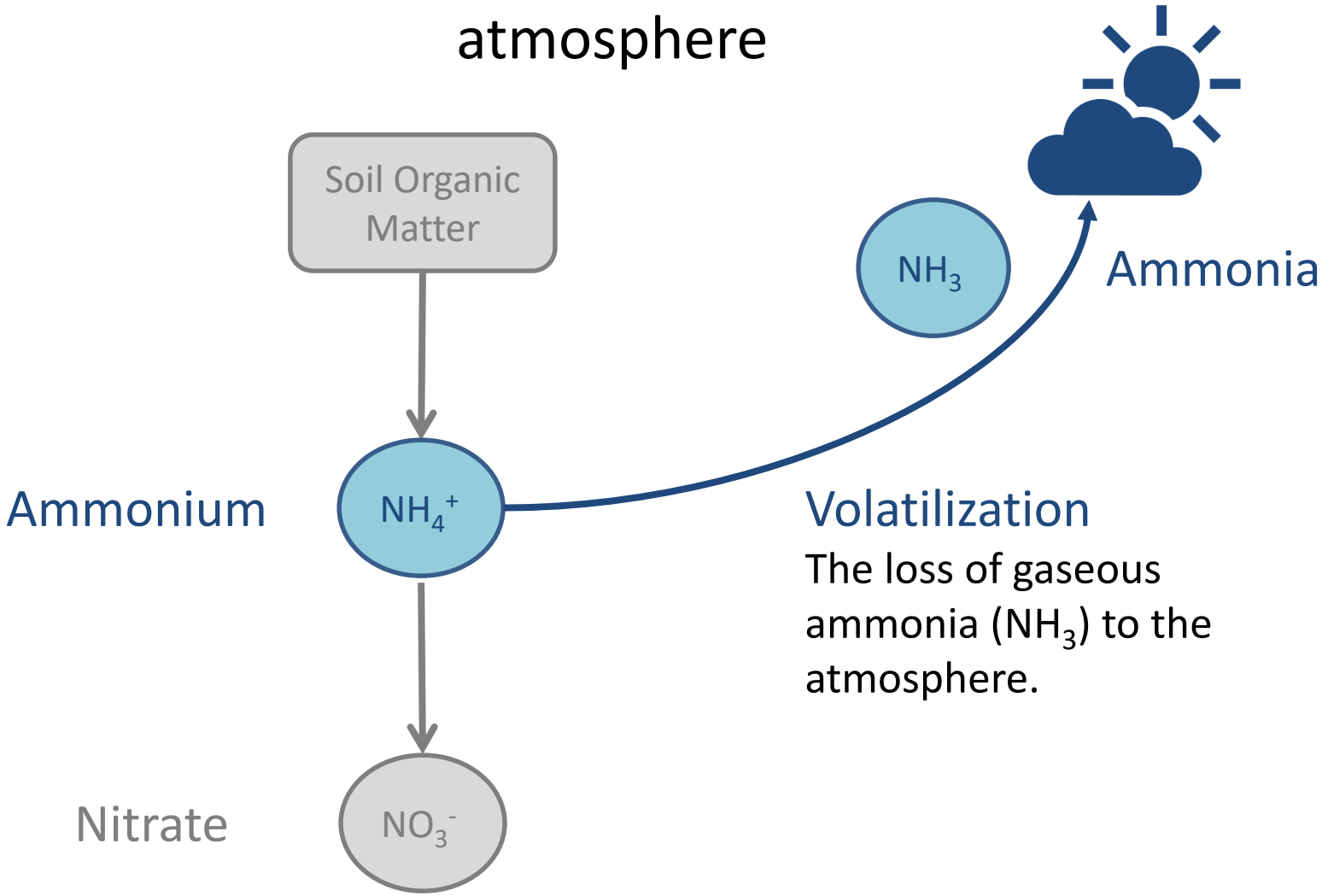
Ammonium produced by mineralization or fertilizer application has one of several fates:

- **binding directly to soil,**
- **mixing into soil water,**
- being lost to **volatilization as ammonia**

an equilibrium exists between NH_4^+ and NH_3 in the soil water

Ammonia Volatilization

Volatilization is the loss of gaseous ammonia to the atmosphere

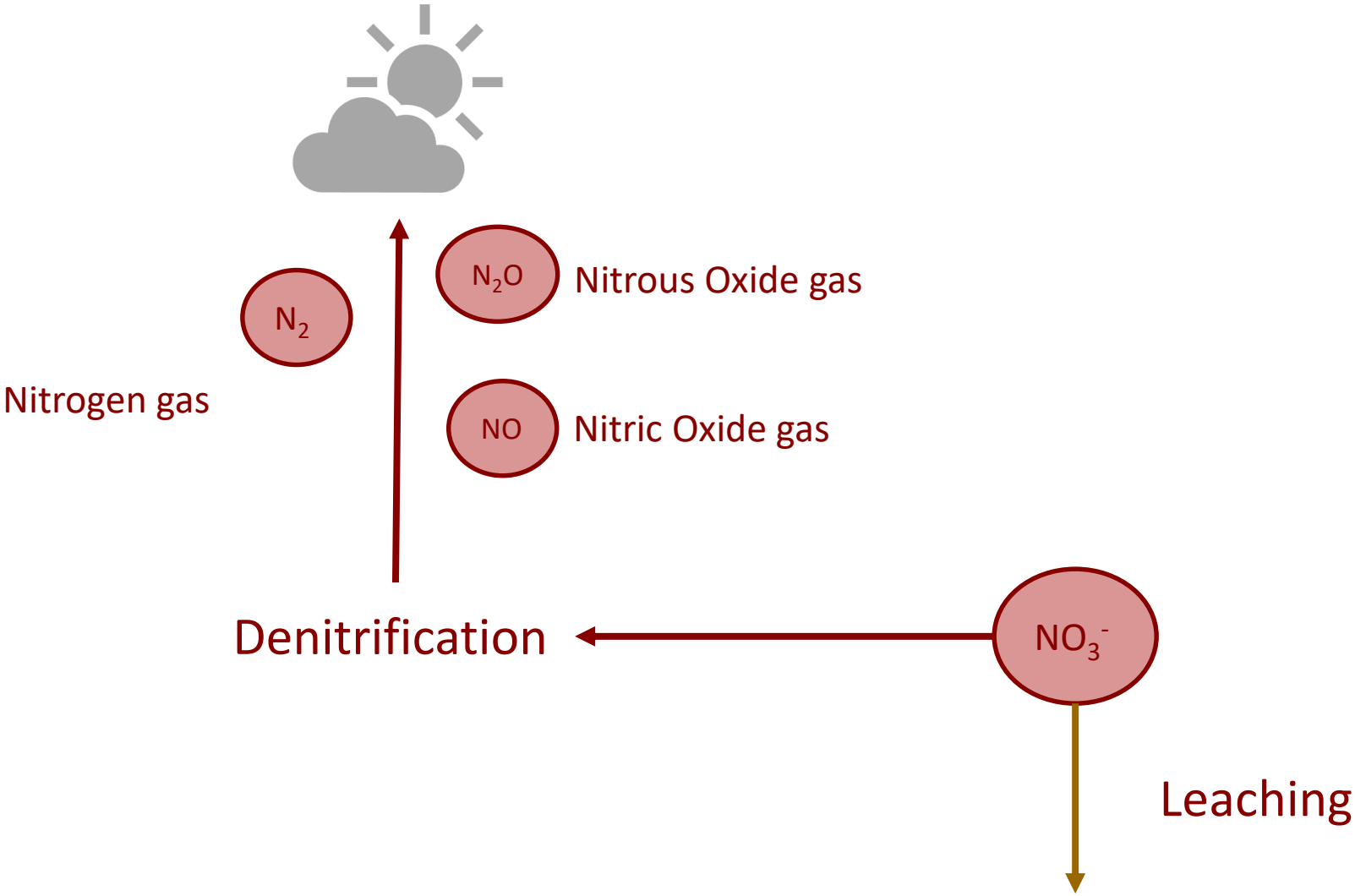


Ammonia Volatilization

The loss of gaseous ammonia (NH_3) to the atmosphere.

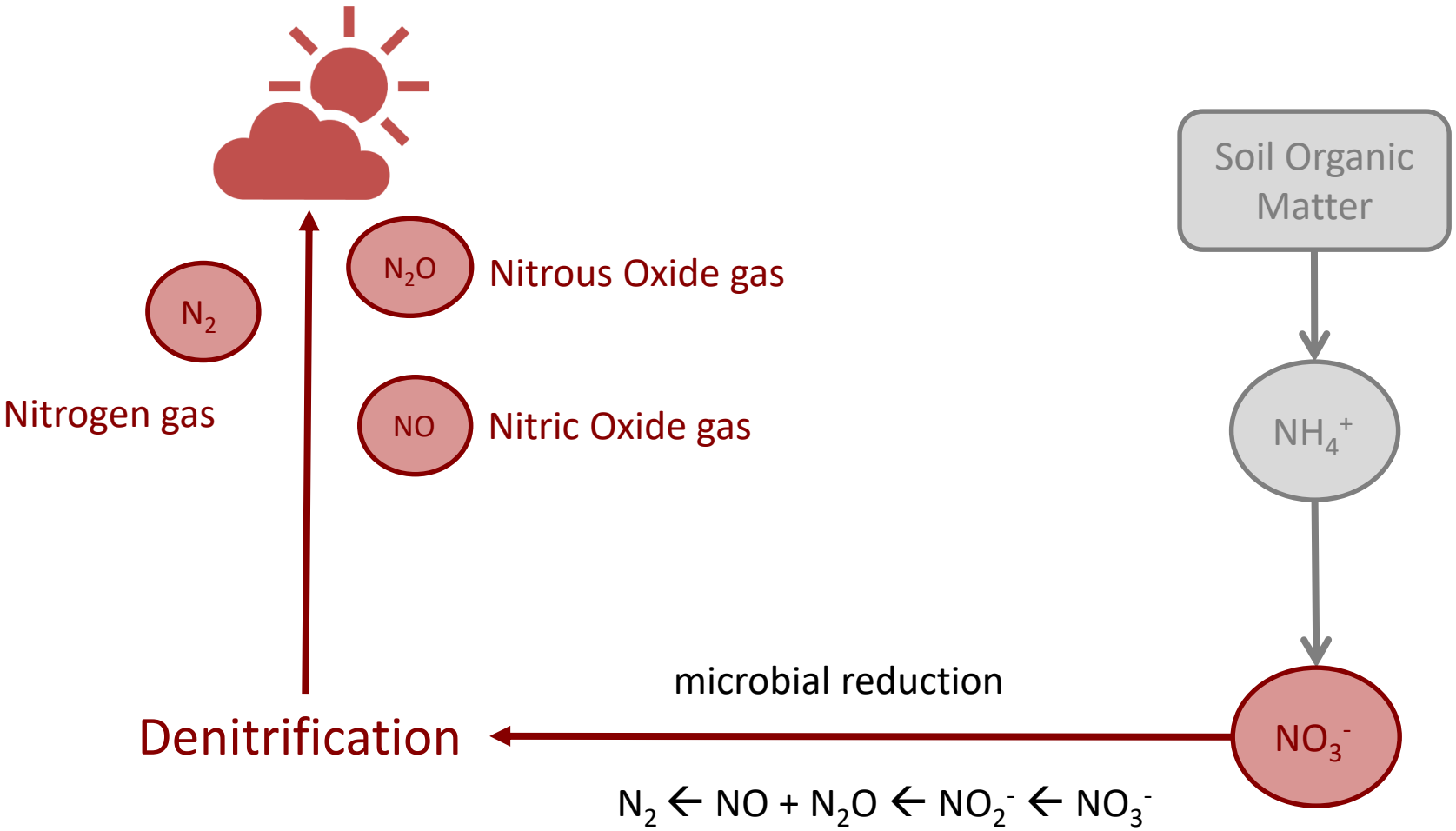
- Materials where ammonia gas is present or is a result of their breakdown include fresh manure, ammonia injections, urea, and UAN
- Conditions that favor volatilization
  - Lack of soil incorporation
  - Dry soil (low moisture content)
  - Coarse-textured soils (sandy)
  - High pH soils/water

Nitrogen Cycle –Nitrate Losses



Denitrification

A microbial reduction of nitrate (NO_3^-) to a gaseous form of nitrogen (N_2, NO, or N_2O)



Denitrification

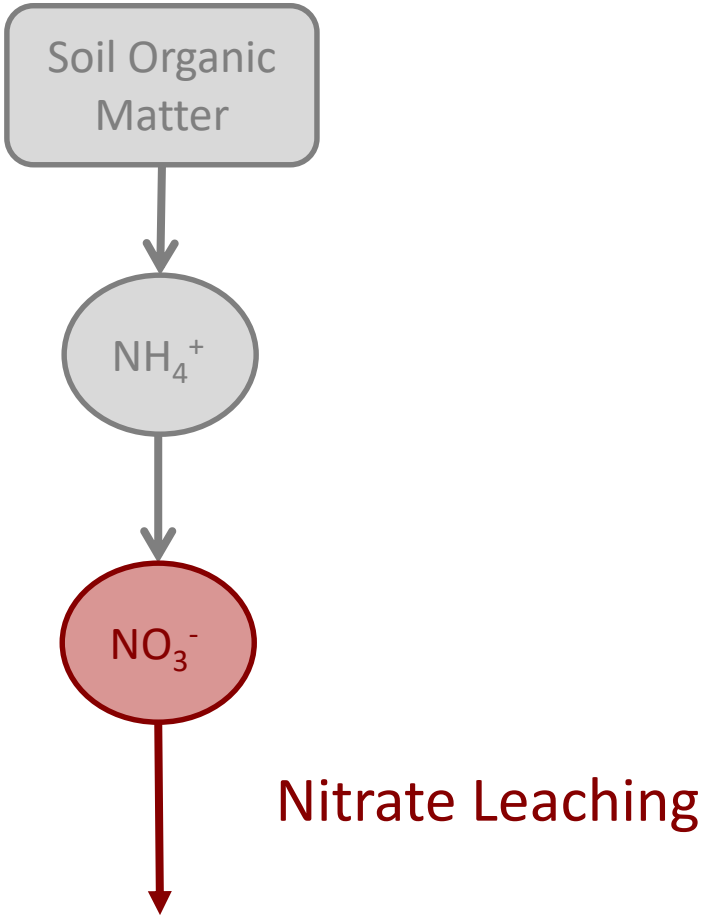
Anaerobic reduction of $NO_3 \rightarrow N_2O$, NO, and N_2 gas

- Occurs under warm, anaerobic conditions
  - Most significant in wetlands and rice paddies
- In irrigated agriculture most N loss occurs during a brief period when the soil is warm, wet, and high in nitrate (i.e. fertigation)
- Of the N losses denitrification is potentially the smallest

  (1- 4 lb N/acre per irrigation or rain event)

Nitrate Leaching

Loss of nitrate (NO_3^-) from the soil due to irrigation or rain. Greatest loss potential of nitrogen from the soil.

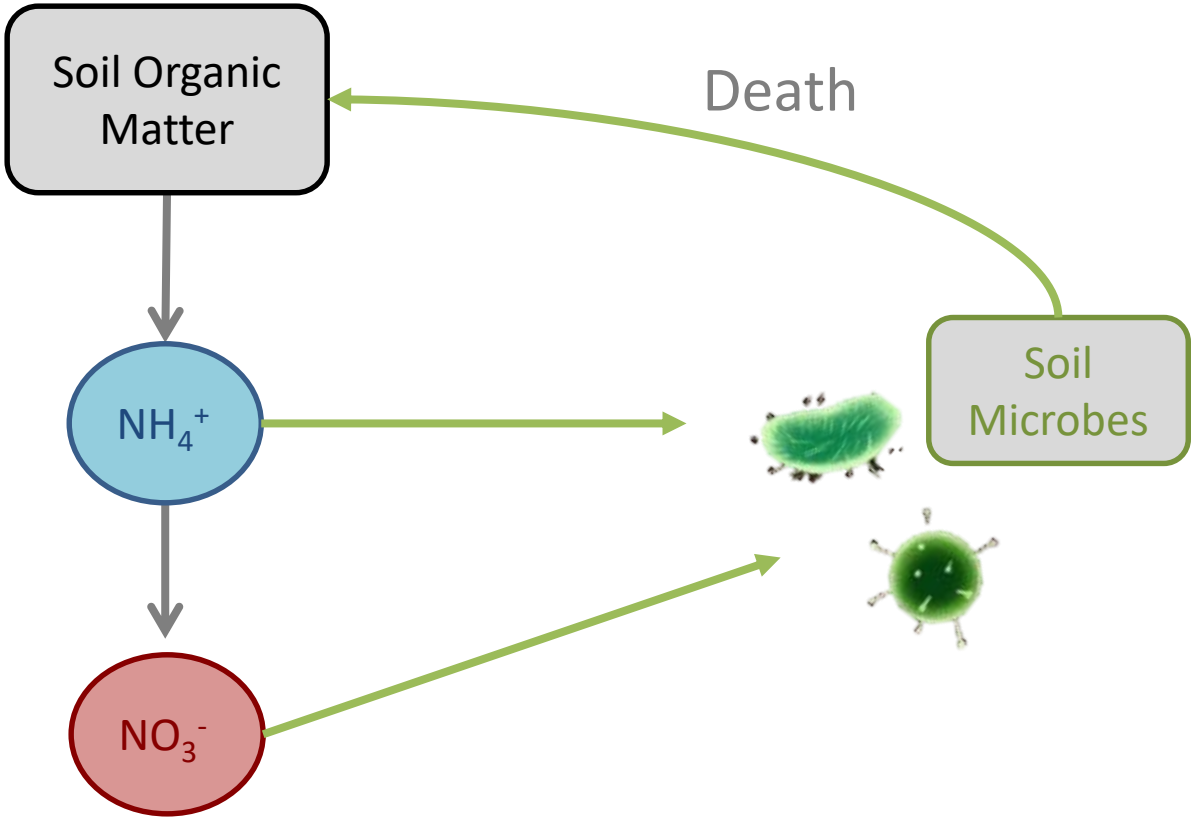


Nitrate Leaching

Movement of nitrate below the root zone

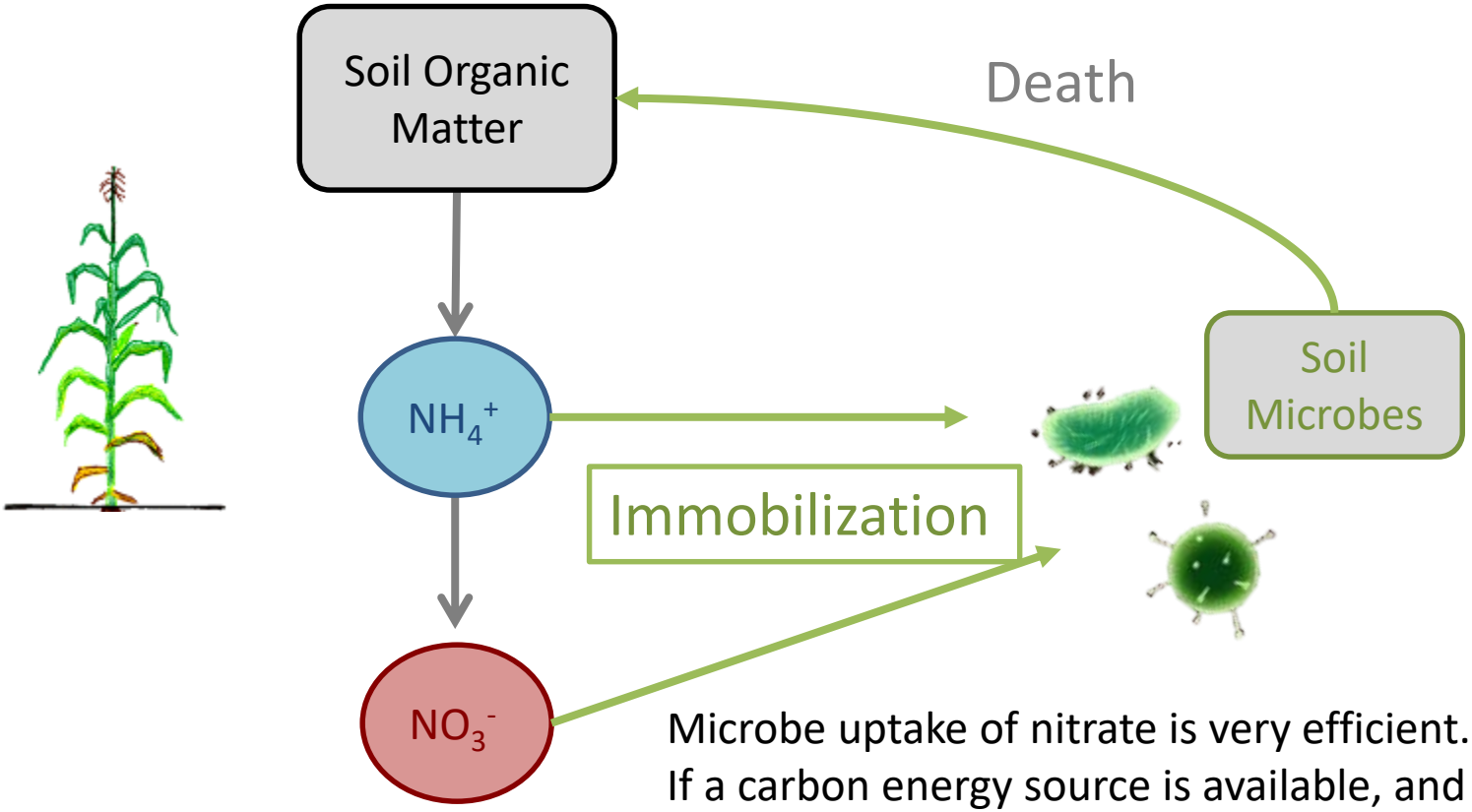
- Reasons why nitrate can leach:
  - Nitrate (NO_3^-) is negatively charged, so it is not held by the soil particles because they are also negatively charged
  - Poor management practices such as applying excess N and irrigation water and not matching application timing with crop demand

Nitrogen Cycle- Microbes



Immobilization

Microbes incorporate **mineral** N from soil solution into **organic** compounds in their cells

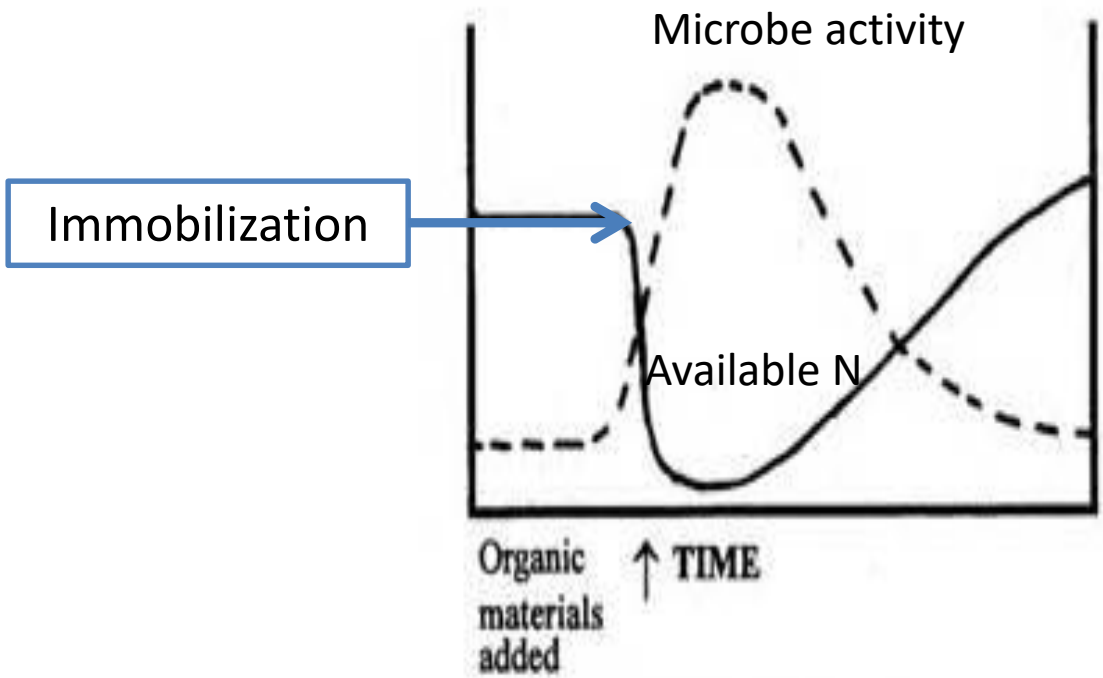


Microbe uptake of nitrate is very efficient.
If a carbon energy source is available, and temperature/moisture conditions are favorable
Microbe N uptake can cause crops to be N deficient.

Immobilization

Mineral N to Organic N

- If C:N ratio is high microbes have priority in using available mineral N until decomposition of SOM declines to about 20:1 C:N



Organic Matter Decomposition in Soils

- Decomposition rates depend on the source:
  - Main Sources: Crop and plant residues (including cover crop, compost) and animal manure
  - Sources contain different organic carbon compounds depending on crop residue type and age

1. Sugars, Starches 2. Proteins 3. Hemicellulose and cellulose 4. Woody tissues (lignin)	Rapid decomposition ↓ Slow decomposition

C:N Ratio Controls Mineralization and Immobilization Rates

Typical Carbon and Nitrogen Contents and C:N Ratios of Some Organic Materials			
Organic Material	% C	% N	C/N
Sawdust	50	0.05	600
Newspaper	39	0.3	120
Wheat Straw	38	0.5	80
Corn residue	40	0.7	57
Rotted Manure	41	2.1	**20**
Broccoli Residues	35	1.9	18
Young Alfalfa	40	3.0	13
Vetch Cover Crop	40	3.5	11
Soil Bacteria	50	10	5
Soil Fungi	50	5	10

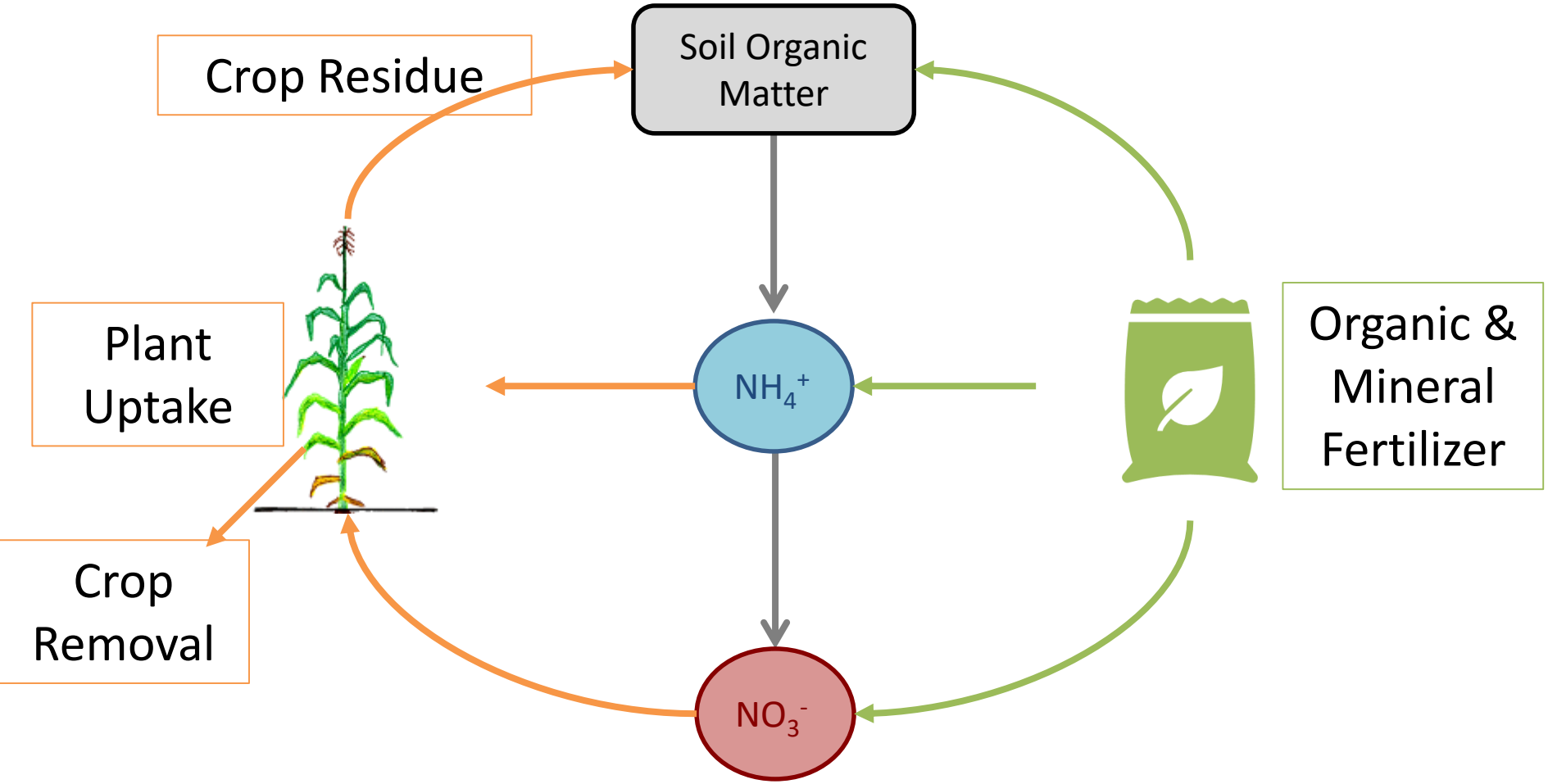
Slow Decomposition /Favors Immobilization

20:1 (2% N)

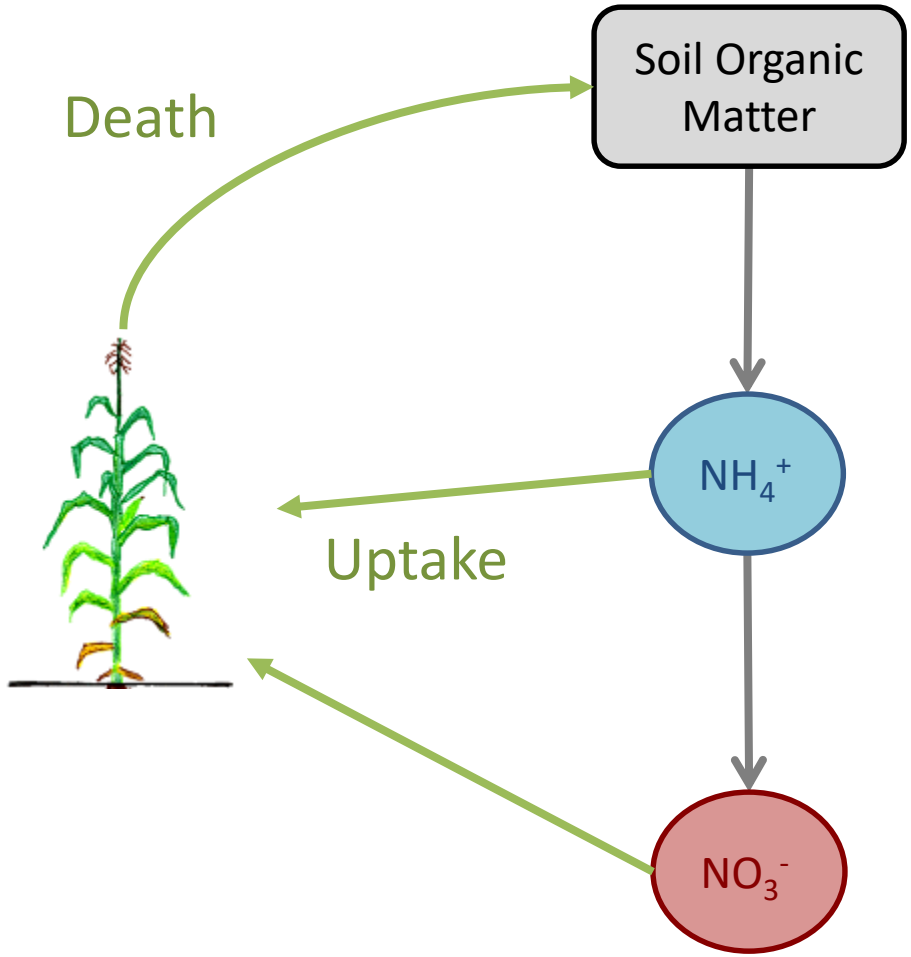
Faster Decomposition /Favors Mineralization

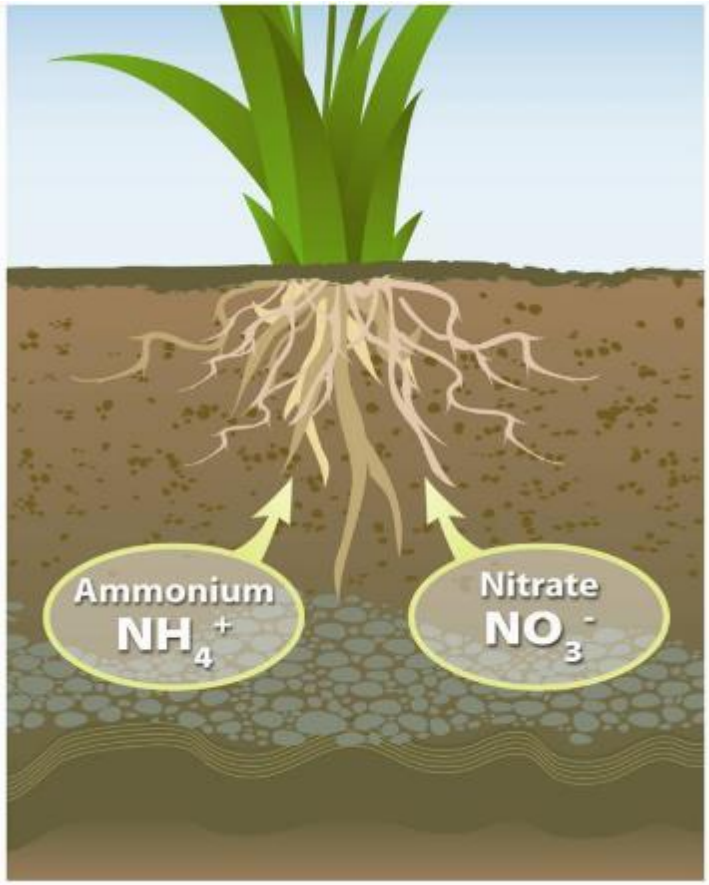
Generally: **A C:N ratio** of 20:1 (2% N) is the dividing line between **mineralization** (immediate release) and **immobilization** (N binding and subsequent release).

Nitrogen Cycle- fertilizer inputs and crop removal



Nitrogen Cycle –Crop Removal





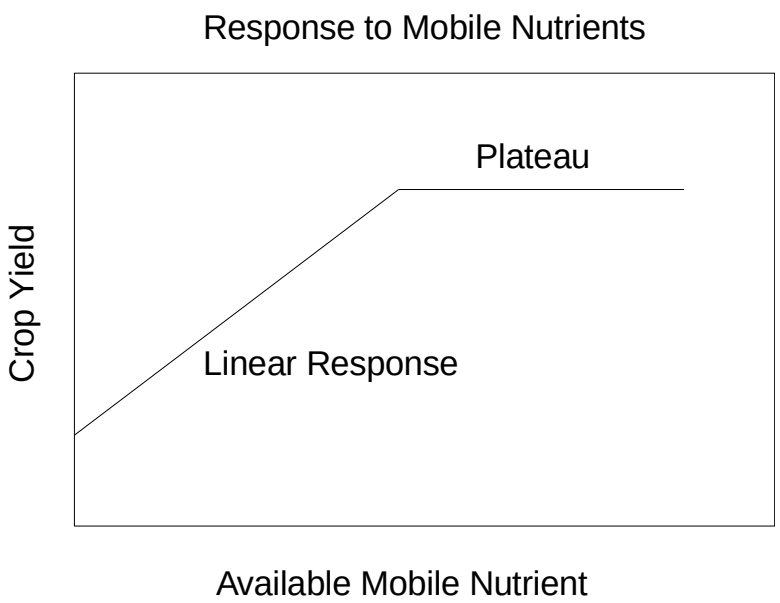
- Ammonium is only available in soils for short periods of time until converted to nitrate
- Therefore, on a whole the most N form taken up is nitrate.

Nitrogen Assimilation

- Assimilation drives plant N uptake
  - **Nitrogen assimilation** is the formation of organic **nitrogen** compounds like amino acids from mineral **nitrogen** compounds
  - Plants only assimilate the needed amount plus a small amount of “luxury consumption”
  - Thus N available in the soil, that is in excess of plant needs, may be leached to groundwater

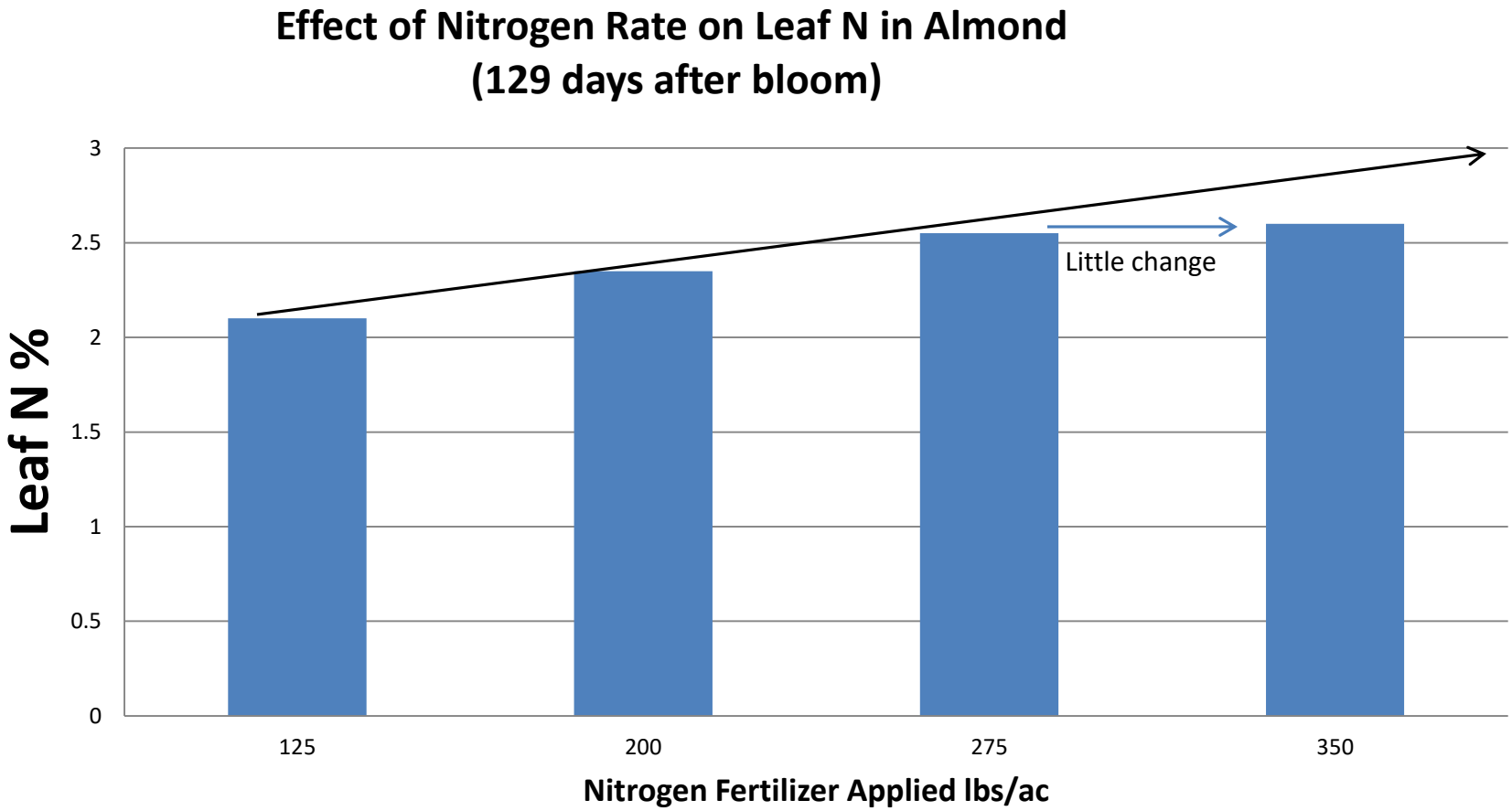
Nitrogen and Crop Productivity

- Nitrogen availability generally limits crop productivity until adequacy is reached, then response to N plateaus
  - Fertilization past a level of adequacy does **not** increase productivity



Nitrogen in Plants

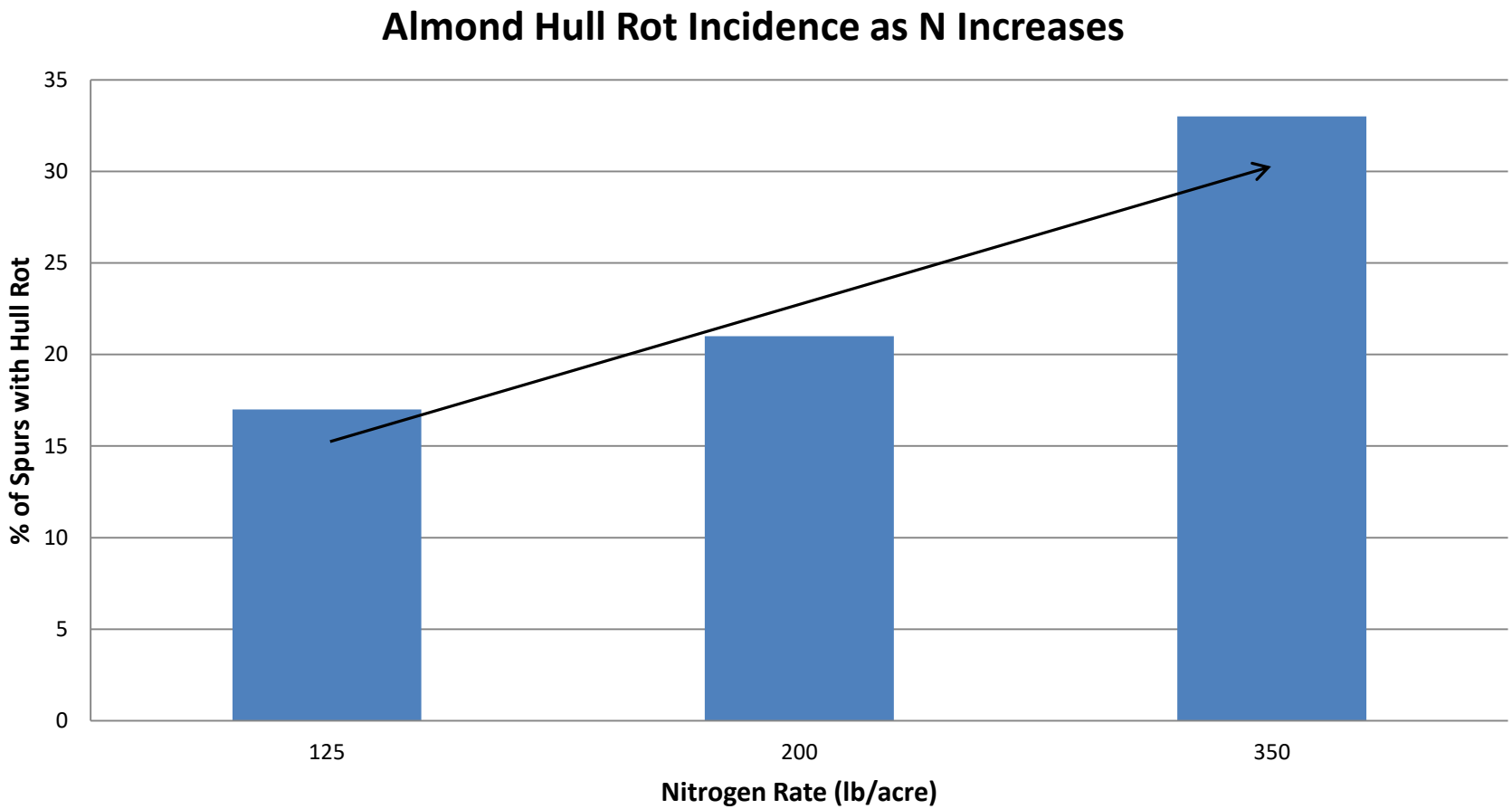
N in Excess of Demand is Inefficiently Used



From Muhammad, 2013

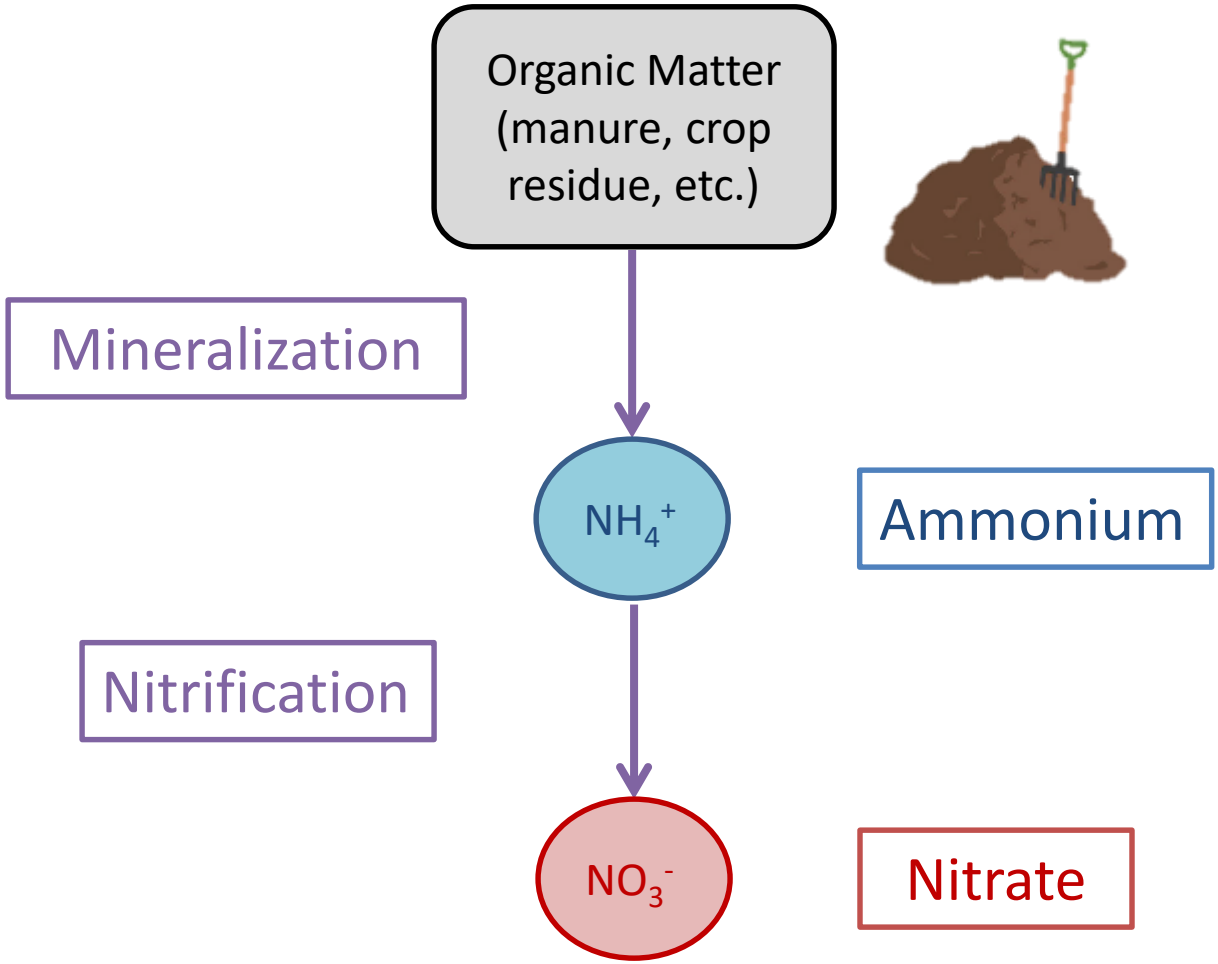
Nitrogen in Plants

Excess N Example

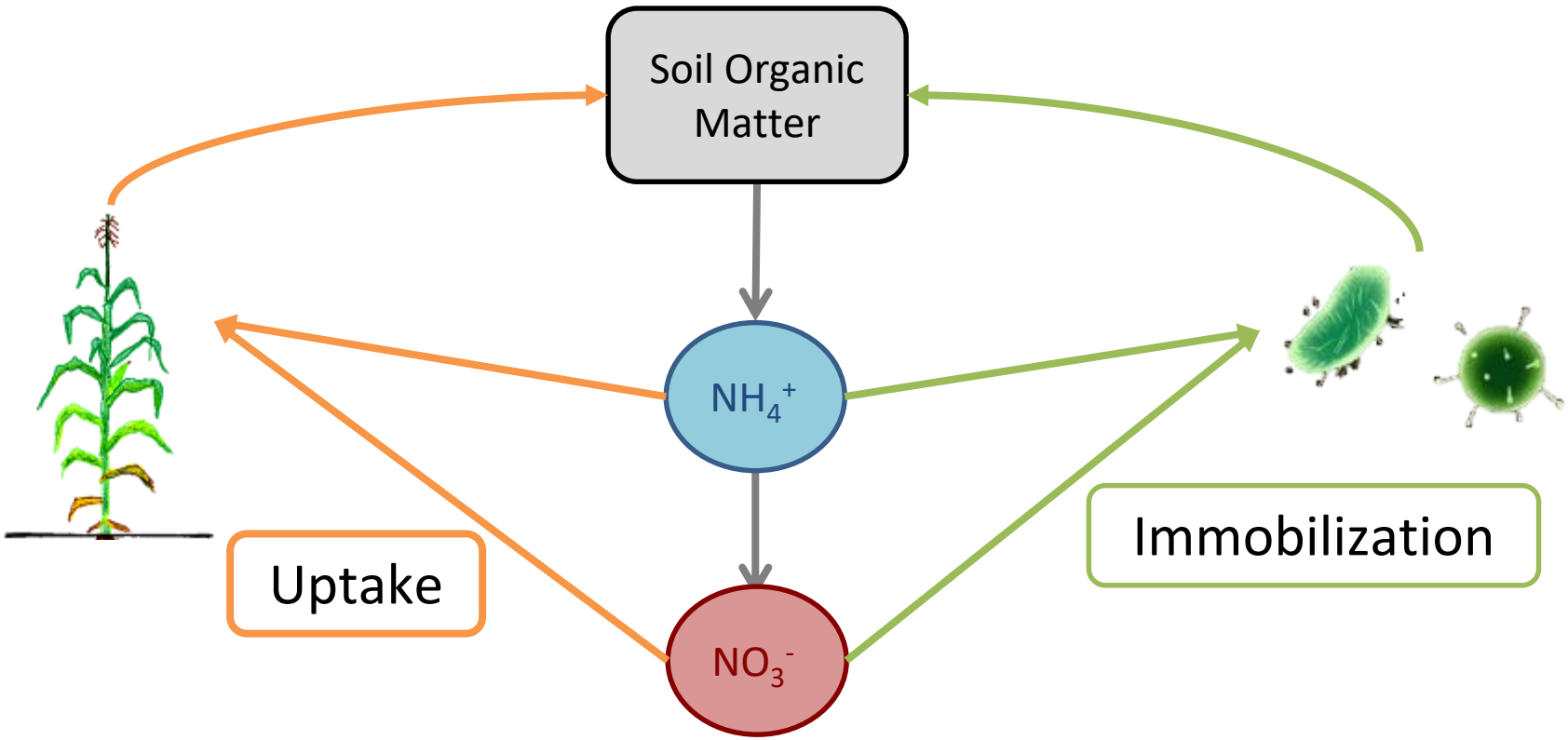


(Elana Peach-Fine, MSc. 2013)

Nitrogen Cycle Review – Mineralization and Nitrification

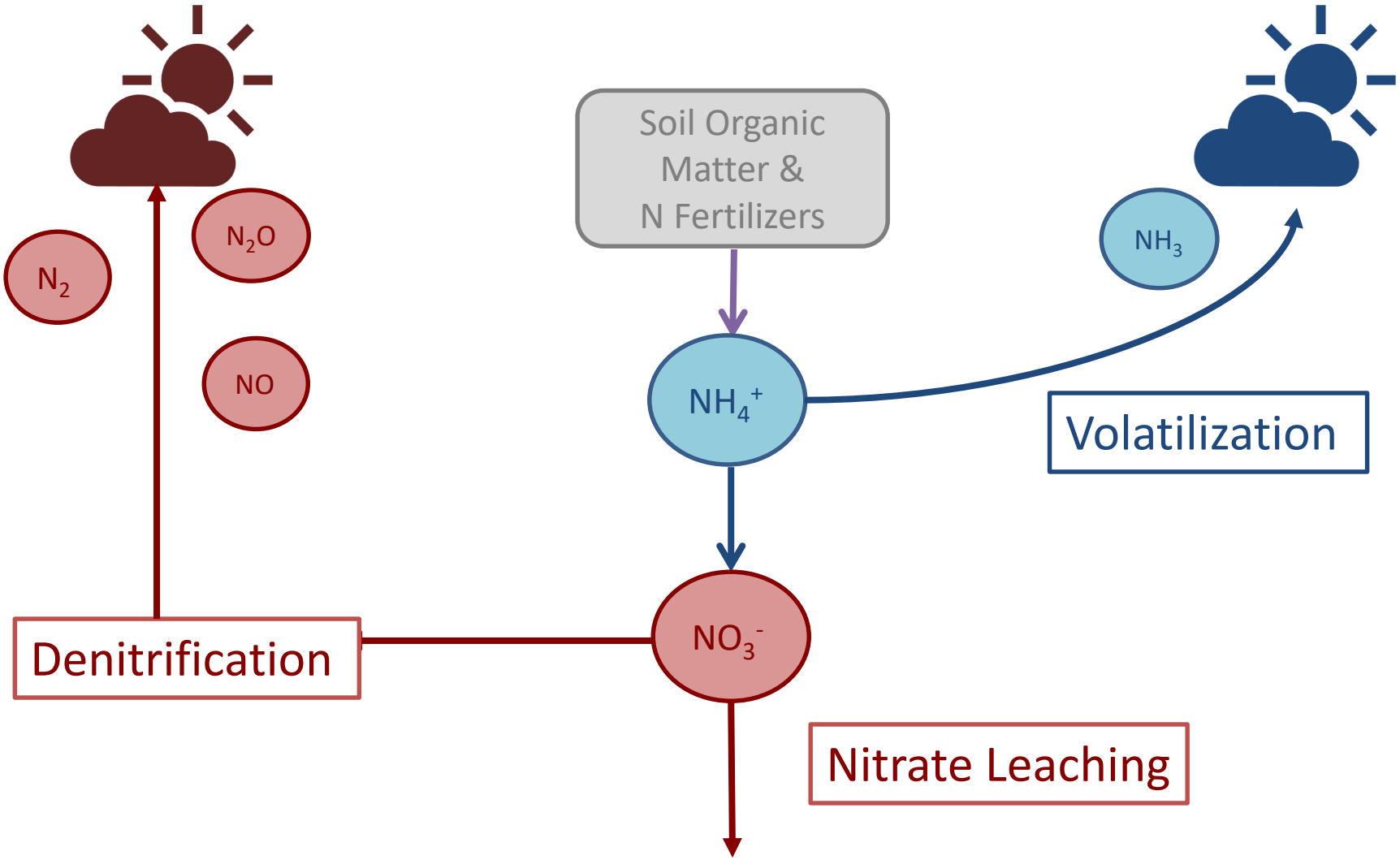


Nitrogen Cycle Review –Plants and Microbes



Microbe uptake of nitrate is very efficient.
If a carbon energy source is available, and temperature/moisture conditions are favorable **Microbe N uptake can cause crops to be N deficient**.

Nitrogen Cycle Review – N Losses



Nitrogen Fertilizers and Management

Section 3

Section 3 Learning Objectives

- Recognize the different categories of nitrogen fertilizers and their composition
- Identify their potential for N loss

Nitrogen Source Groups

- Ammonium-forming fertilizers
  - Form ammonium on reaction with soil moisture or by urease enzyme conversion of urea
- Ammonium fertilizers
- Nitrate fertilizers
- Combination fertilizers
- Organic materials
  - Release mineral N over time through microbial activity

Ammonium-forming Fertilizers

Anhydrous ammonia NH_3 (AA)

- When AA contacts water or moist soil, it forms ammonium and hydroxyl ions raising the pH around the application site
- $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$
- Higher pH favors more NH_3 in solution

Volatilization of Anhydrous Ammonia

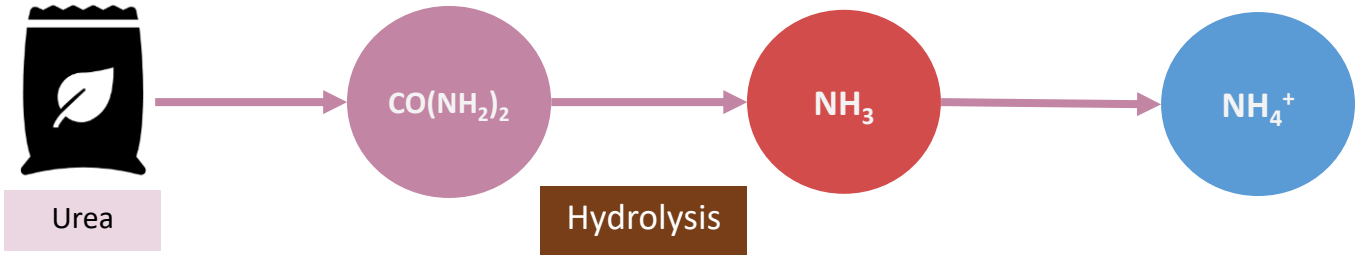
How large can losses be?

- In a field trial conducted by UC Davis to quantify ammonia volatilization loss from water run AA, they found that:
  - Ammonia volatilization averaged 30% of applied N over the whole field
  - Ammonium concentration declined down the length of the furrow by more than 50%
    - Poor N application uniformity

Ammonium-forming Fertilizers

Urea

- Highly soluble and uncharged
  - Moves some what freely through soil with water
- Enzymatic breakdown of urea in the soil produces NH_4^+ and bicarbonate
  - Bicarbonate increases soil pH
- Rate of hydrolysis increases with temperature and decreases under high application rates



Volatilization of Urea

How large can losses be?

- When urea is surface applied and not incorporated volatilization losses can be high
  - Up to 30% loss in 14 days without rainfall or irrigation
- Factors that increase volatilization
  - Surface application without incorporation or irrigation
  - High temperature and wind speed
  - Low soil buffering capacity (sandy soils)
  - High pH soils

Ammonium Fertilizers

- Ammonium sulfate [$(NH_4)_2SO_4$] (21-0-0)
- Ammonium/phosphorus combinations
  - Monoammonium phosphate (MAP)
  - Diammonium phosphate (DAP)
  - Ammonium polyphosphate (10-34-0)
- Ammonium fertilizers are temporarily resistant to leaching until converted to nitrate
  - Short timeframe especially in warmer weather

Nitrate Fertilizers

- Potassium nitrate
- Calcium nitrate (CN-9)

- Nitrate is negatively charged and moves with the water front
  - Most susceptible to N loss via leaching

Combination Fertilizers

- Combination fertilizers can provide a rapid availability of nitrate and a continued supply as the ammonium is converted to nitrate.
- Ammonium nitrate (NH_4NO_3)
- Calcium ammonium nitrate (CAN-17)
  - 17% N (32% of N as ammonium, 68% as nitrate)
- Urea ammonium nitrate (UAN) solutions
  - 32% N (50% as urea, 25% ammonium, 25% nitrate)
  - different concentrations (UAN-28, UAN-32, etc.)

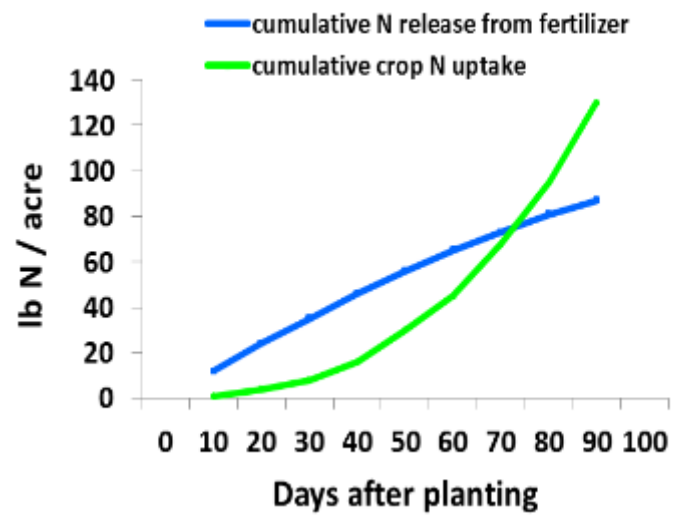
Organic Materials

- Organic materials differ from mineral fertilizers by the rate that N mineralizes and becomes plant available
- Sources
  - Manure and other animal byproducts
  - Cover crops, compost and green waste
- Contains both
  - Mineral N (immediately available) NH_4^+ and NO_3^-
  - Organic N (slowly available after microbial conversion)

Controlled Release Fertilizers

The release of nutrients can be controlled using an organic coating on fertilizers

- Benefits
  - Can slow the transformation of $NH4^+$ to NO_3^-
  - May reduce leaching potential compared to preplant or single sidedress systems
- Drawbacks
  - Higher cost per unit of N
  - Match between N release and crop N uptake is often imperfect



Section 3 Summary

- Selecting the appropriate N source for the crop / irrigation management situation can lead to the greatest nitrogen use efficiency.

- Reducing nitrogen losses from:
  - Volatilization
  - Denitrification
  - Runoff
  - Leaching

Irrigation and Nitrogen Management

Section 4

Section 4 Learning Objectives

- Describe the three steps to becoming a more efficient irrigator
  - Proper irrigation scheduling
  - Measure applied water
  - Design and maintain high performing irrigation systems
- Recall what causes non-uniformity in pressurized irrigation systems and identify methods to address non-uniformity
- Identify proper methods for fertigation timing and length

The Crop Water Requirement is Met By:

- Available soil moisture stored in the root zone at the beginning of the season
- In-season rainfall that is stored in the soil (including frost protection water applications if stored in the root zone)
- Applied irrigation water

The Crop Water Requirement is Met By:

- Stored soil moisture
  - which is at a maximum at the beginning of the season.

- In-season effective rainfall
  - that enters the root zone tends to occur in the first few months of the season

    In-season effective rainfall and stored soil moisture to meet the entire (orchard) crop water use in the first month and from 15 to 35% each season

-
- **The remainder of the crop water requirement must come from irrigation – applied water**

Applying Irrigation Water Efficiently

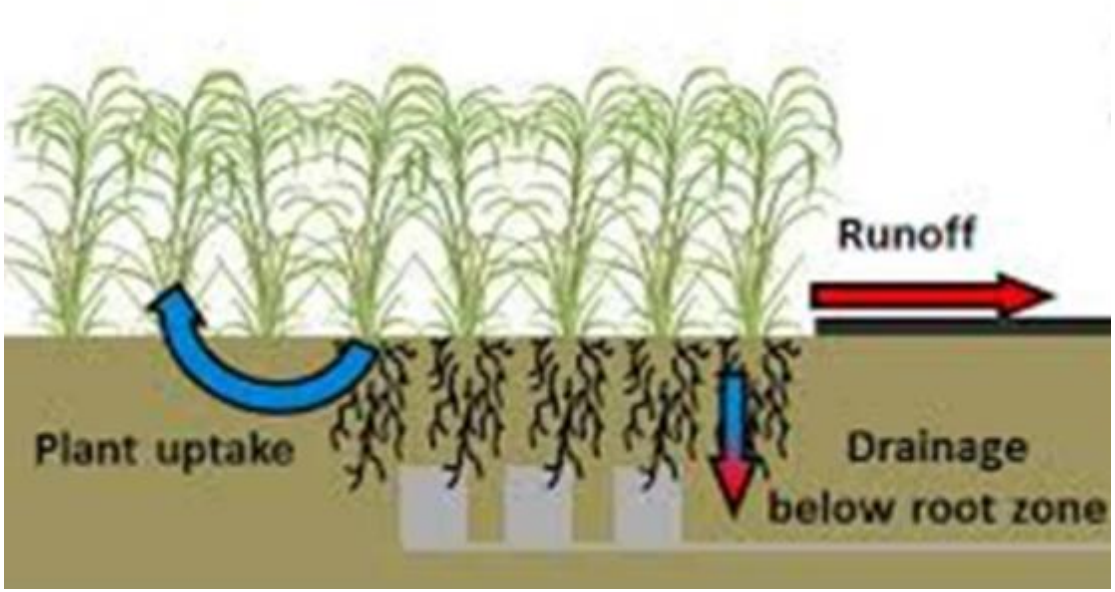
- Irrigation efficiency is a measure of how much applied water goes to beneficial uses
  - Beneficial uses: plant water needs, salt leaching, frost protection
  - Non-beneficial uses or losses: Deep percolation below root zone in excess of that required for salt leaching, surface runoff that is not reused

$$\text{Irrigation Efficiency (\%)} = \frac{Benefically\ used\ water}{Total\ Water\ Applied} \text{ x } 100$$

Irrigation and Nitrogen Management

- Successful nitrogen management depends on efficient irrigation management

Excess applied water will runoff or leach to ground waters



Irrigation Application

- Irrigation scheduling:
  - Timely application of water to meet the crop water requirement
    - When to apply irrigation
    - How much to apply

Scheduling Aids

No single soil, plant, or weather monitoring method provides the best or complete scheduling solution

Methods

Soil based:

Stored soil moisture status

Plant Based:

Plant water status

Weather based:

ET estimates of crop water use

How Do We Become More Efficient Irrigators?

- Proper Irrigation Scheduling: Use soil moisture, crop water status, or weather information to understand irrigation needs.

Soil Based

Plant Based

Weather, ET Based

Irrigation Scheduling

Soil Monitoring Approach

- There are numerous soil moisture monitoring techniques, devices, and services available to growers.

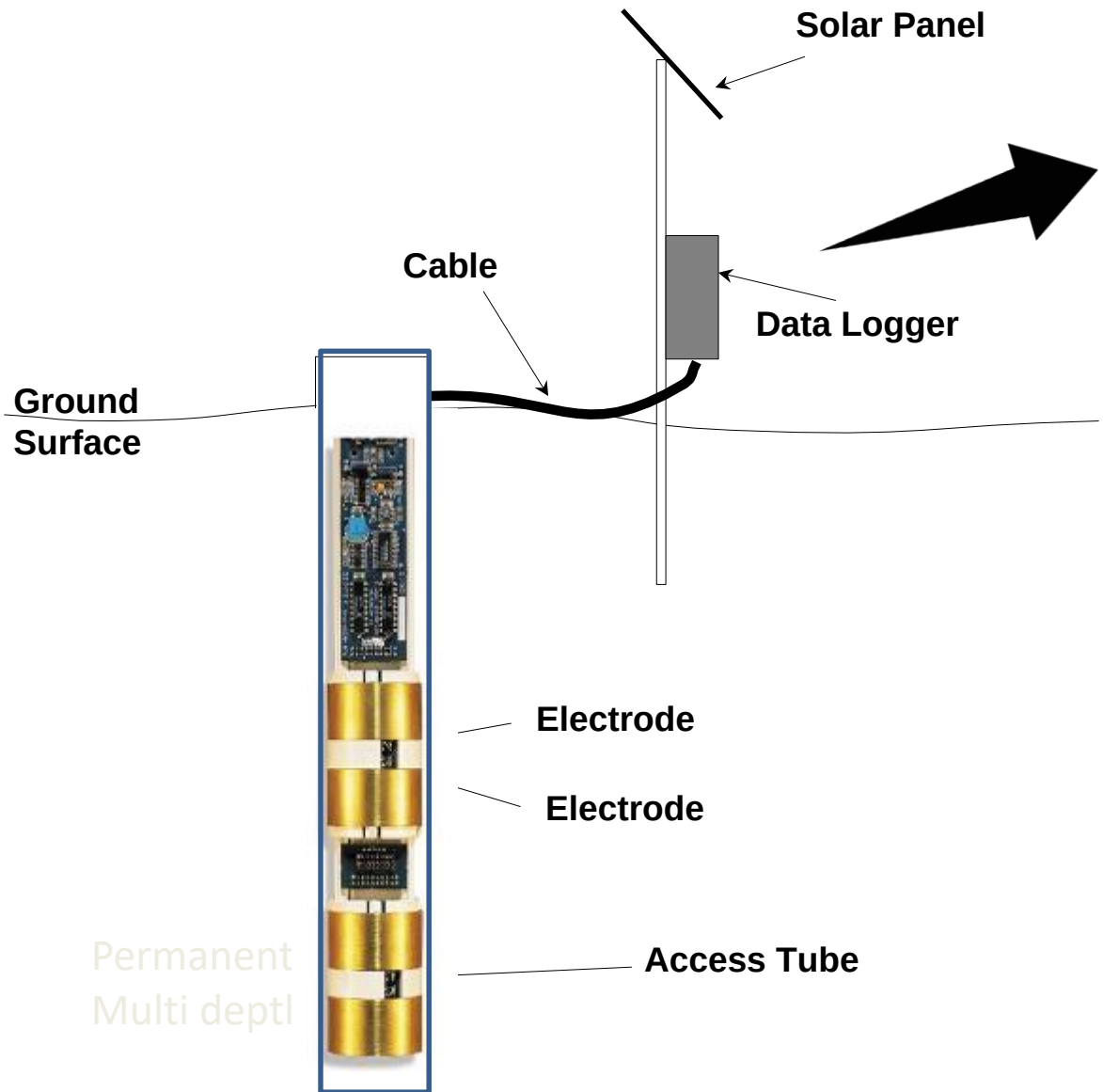
Electrical Resistance Blocks

Feel Method

Tensiometer

Irrigation Scheduling

Electronic Remote Soil Monitor



Capacitance based probe monitors soil moisture continuously at various depths unattended with communications

Permanent
Multi deptl

Soil Monitoring Approach

Drawbacks

- Most soil monitoring techniques tell when to irrigate, but not all provide how much to irrigate.

- Effective use is subject to representative placement of sensors and good understanding of the crop root zone.

Irrigation Scheduling

Plant Monitoring Approach

- Using plant cues for visual signs of water stress

- Measure signs of plant water stress

  To Indicate when to irrigate

Pressure Chamber

Crop Water Stress Index

Plant Monitoring Approach

Drawbacks

- Limited information, available for some crops (almond, prune, walnut, wine grape, and cotton)
- Methods tend to be labor intensive – working toward automation
- Crop stress and readings tell you when to irrigate, (plant is stressed) but not how much to apply

Irrigation Scheduling

Weather Monitoring Approach

- Climatic conditions, especially solar radiation, drive plant water use.
- Monitor the weather and use it to estimate crop water use (evapotranspiration, ETc).

A concise review of irrigation scheduling using crop ET calculations is available at:
ucmanagedrought.ucdavis.edu/Agriculture/Irrigation_Scheduling/Evapotranspiration_Scheduling_ET/

Irrigation Scheduling

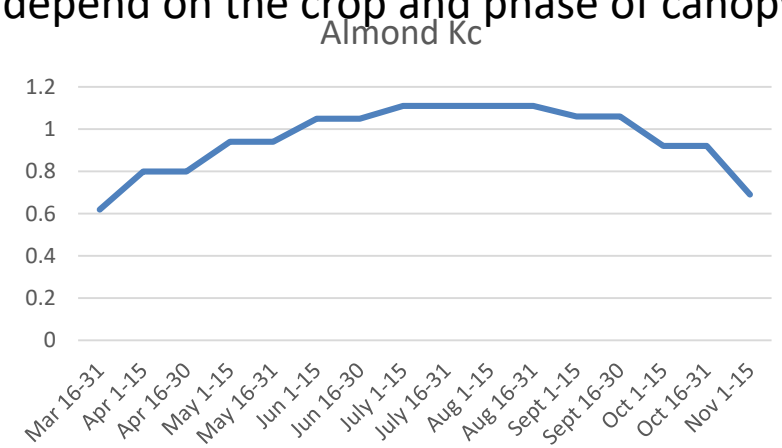
Weather Monitoring Approach

$$ET_o \times K_c = ET_c$$

ETo Reference Crop Water Use
Kc Crop Coefficient
ETc Crop Water Use

- Models rely on weather measurements taken in irrigated grass pasture to predict **reference crop ET_o**.

- Must use a **crop coefficient K_c** to adjust the reference value.
  - K_c values depend on the crop and phase of canopy development.



Weather Monitoring Approach

- California has the CIMIS network to provide weather information and estimates of Reference Crop ETo (ET of pasture grass).

$$ET_o \times K_c = ET_c$$

- ETc estimates soil moisture depletion and indicates when and how much to irrigate

Date	ET_o Reference crop ET	k_c Crop coefficient	ET_c inches Crop ET
1June	0.25	0.95	0.24
2June	0.25	0.95	0.24
3June	0.25	0.95	0.24
4June	0.25	0.95	0.24
5June	0.24	0.95	0.23
6June	0.24	0.95	0.23
7June	0.24	0.95	0.23
		Weekly	**1.65**

www.cimis.water.ca.gov

Weather Monitoring Approach

Drawbacks

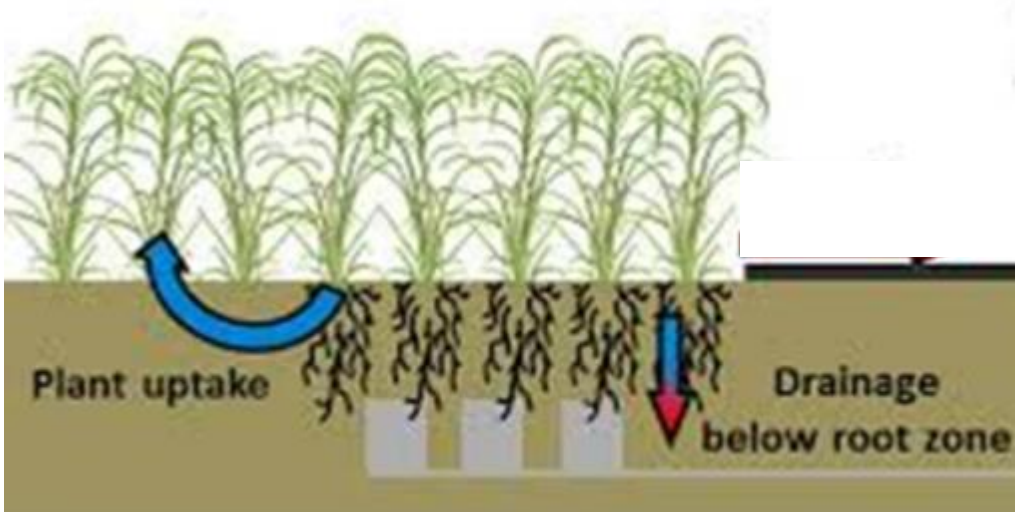
- Crop coefficient (Kc) used to adjust the reference ET can be a source of variability and error from one field to the next
  - Especially with annual crops
- Additional questions arise when the crop is deficit irrigated.

Irrigation Scheduling

- Use ET based scheduling, with occasional plant or soil based monitoring to verify the schedule.
  - ensure the crop water demand is met
  - minimize excess nitrogen leaching

How Do We Become More Efficient Irrigators?

- Measure applied water.
  - Measure applied water and control applications to meet the irrigation requirement to reduce the amount of water leaching past the root zone.



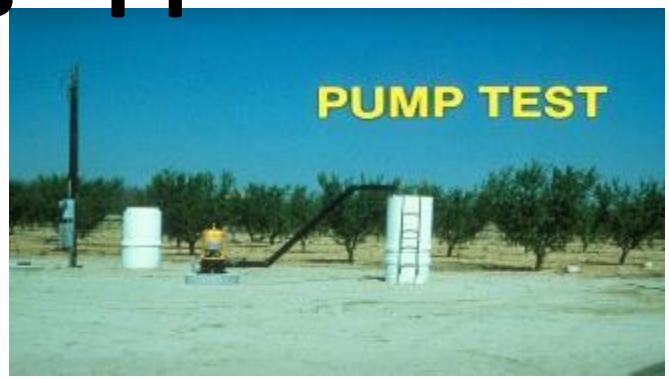
Options for Measuring Applied Water

- Measure gallons applied with a flow meter

- Use emitter flow rate
  - emitter flow rate x emitters/acre x hours of operation = gallons applied

**Gallons applied* per acre / 27,154 = *inches applied*
Inches applied / hours of operation = *inches per hour*

Options for Measuring Applied Water



- Use a Pump test
  - gal / min x hours of operation = gallons applied
- Use Manufacturers flow rates
  - Flow rate at operational pressure x hours of operation = gallons applied
    - Blue nozzle @ 40psi = 0.89 gpm
    - 0.89 gpm x nozzles/acre = Gal per min per acre

******Gallons applied* per acre / 27,154 = *inches applied*
Inches applied / hours of operation = *inches per hour*

Rapid Assessment of Application vs. Water Requirement

Step 1

Determine soil moisture depletion since last irrigation **or** estimate (ET)

Soil Moisture Depletion

Corn (Planted April 1) ET (in/day)

	Location						
	Orland	Madera	Merced	Stockton	Modesto	Parlier	Visalia
May 1-15	0.04	0.04	0.04	0.04	0.04	0.04	0.04
May 16-31	0.05	0.05	0.05	0.04	0.05	0.05	0.05
Jun 1-15	0.13	0.14	0.14	0.13	0.14	0.14	0.14
Jun 16-30	0.22	0.24	0.24	0.23	0.23	0.24	0.24
July 1-15	0.31	0.30	0.30	0.28	0.28	0.29	0.29
July 16-31	0.30	0.30	0.30	0.28	0.28	0.27	0.29
Aug 1-15	0.25	0.28	0.27	0.25	0.25	0.25	0.27
Aug 16-31	0.17	0.20	0.19	0.19	0.18	0.20	0.20
Sept 1-15	0.09	0.13	0.13	0.07	0.13	0.13	0.14
Total*	23.79	24.88	24.59	22.52	23.51	24.03	24.64

ET estimates of corn water use at various locations

Rapid Assessment

Step 2

Measure flow and determine how much water has been applied (inches)

$$\text{Water Applied (inches)} = \frac{(\text{Flow (gpm)} \div 449) \times \text{Irrigation time (hrs)}}{\text{Acres Irrigated}}$$

*If flow is measured in cfs, no need to divide by 449 in equation

Example: Irrigation flow to a 20 acre field is 1000 gpm for 9 hrs

$$\text{Water Applied (inches)} = \frac{(1000 \text{ gpm} \div 449) \times 9 \text{ hrs}}{20 \text{ Irrigated acres}} = 1.0 \text{ inch}$$

Rapid Assessment

Step 3 Is the risk of deep percolation high?

- Compare the amount applied to the amount used since last irrigation.
  - Leaching occurs when runoff is minimal and applied water is greater than crop use since the last irrigation.

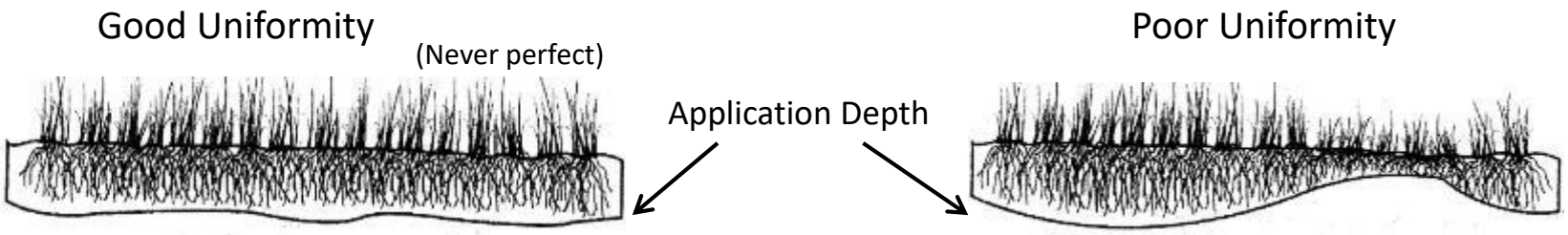
Irrigation System Evaluation

- An irrigation system evaluation can help determine average application rate and distribution uniformity.



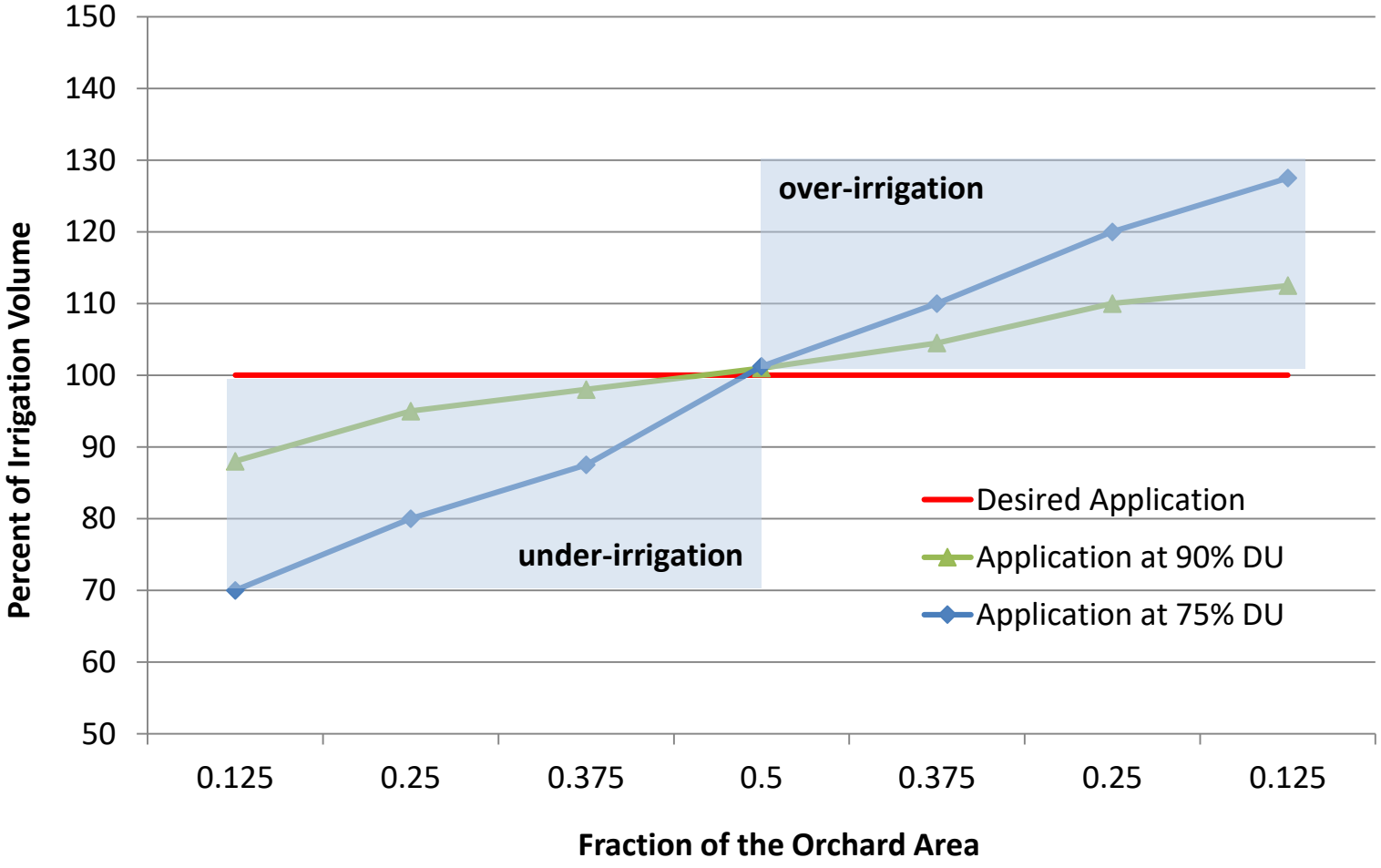
Irrigation System Evaluation

Irrigation Uniformity: A measure of how evenly water is applied to the field

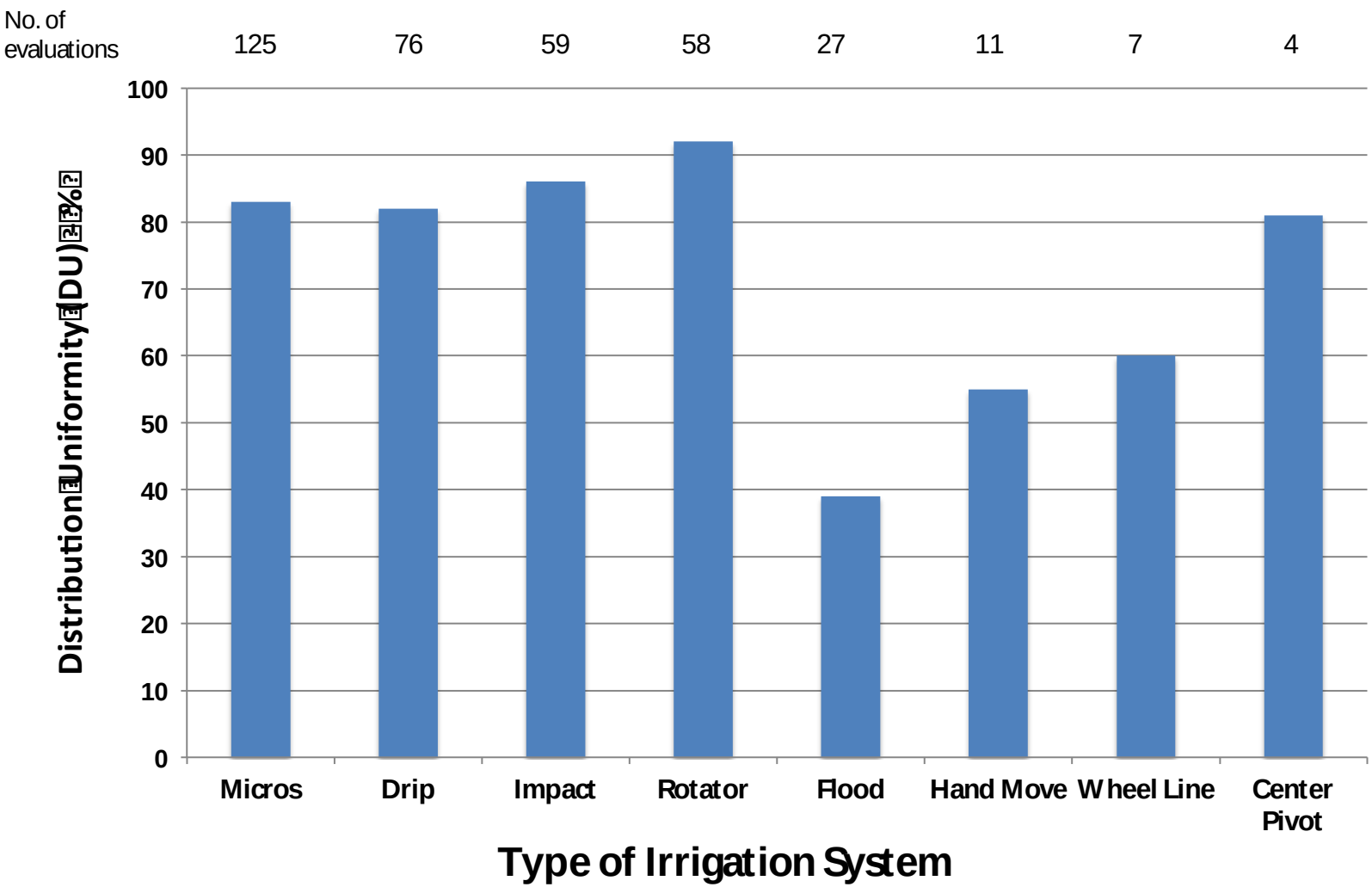


- Poor uniformity means that portions of the field are getting less water than others.
  - Causes poor plant performance due to water logging and nitrate leaching.

Distribution Uniformity



Irrigation Uniformities of Various Irrigation Systems



Field evaluation results from the mobile lab of:

TCRCD
Tehama County Resource Conservation District

Using a Distribution Uniformity (DU) Test

- Improve DU to minimize difference in the over and under-irrigation levels of the field.
- A DU of about 90% is ideal, trees are able to produce optimally with about 90% of full irrigation *.
- Fields with lower DU should be analyzed to determine the problem and solutions implemented to improve DU.

* Shackel, K. et.al.2017 ABC Water Production Function Report

How do we become more efficient irrigators?

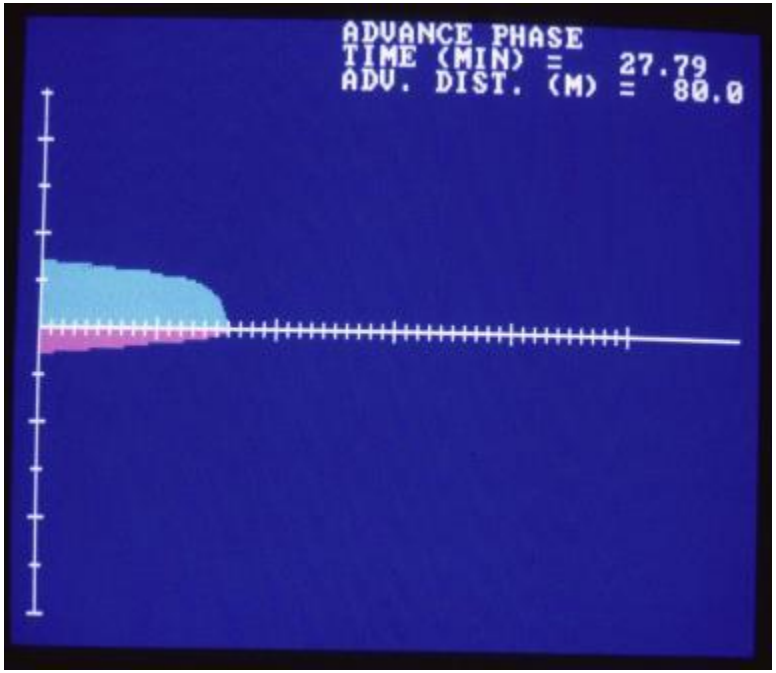
Design and maintain high performing irrigation systems.

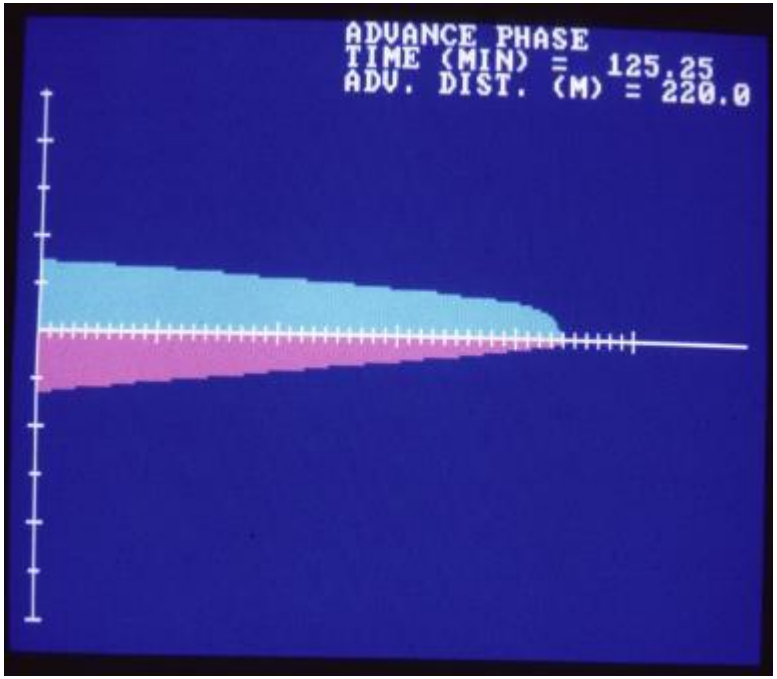
- Lets look at different types of irrigation systems and see how they can be improved.

Surface Irrigation

– Furrow and border strip irrigation

Surface Irrigation: Furrow Irrigation Example

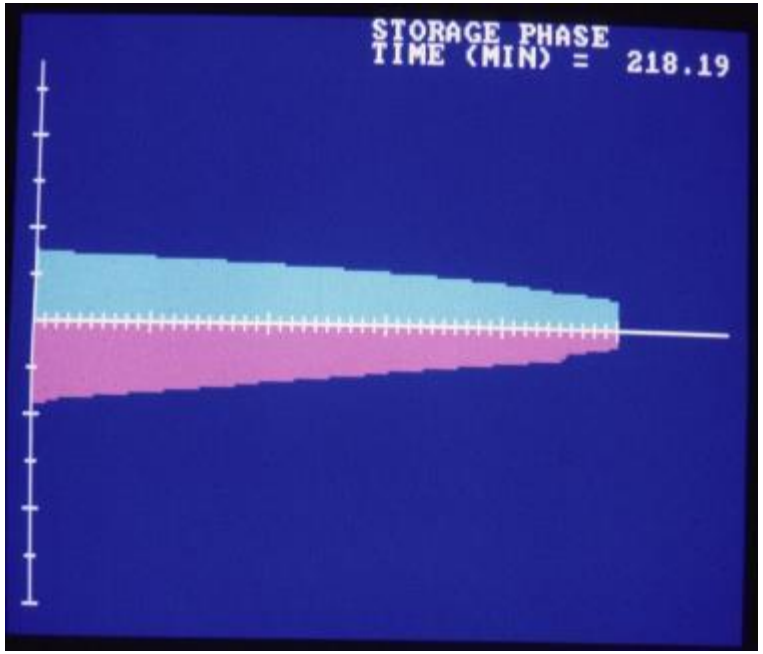


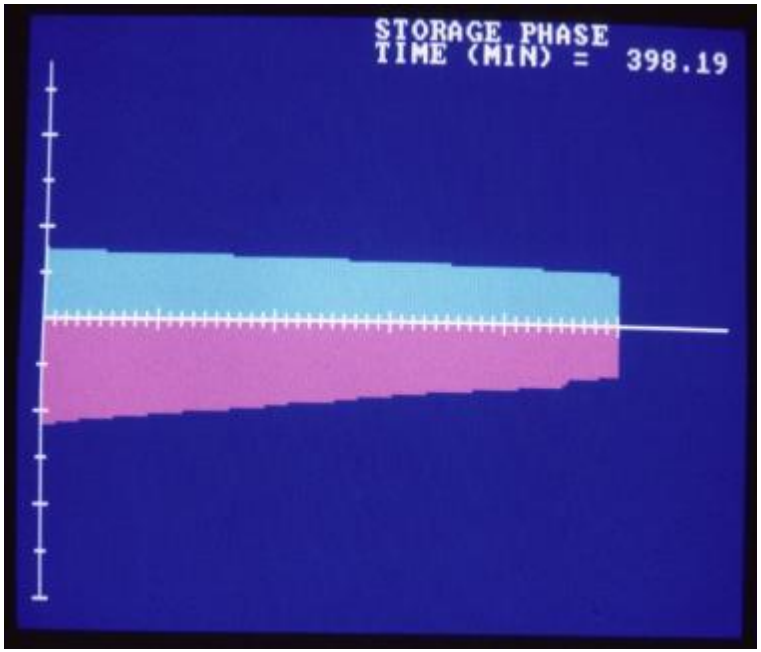


1 Water flows across the field top to bottom in furrow irrigation. Blue segment represents water on field surface; pink is infiltration.

2 More water has infiltrated at field head, where it has been present the longest.

Surface Irrigation: Furrow Irrigation Example





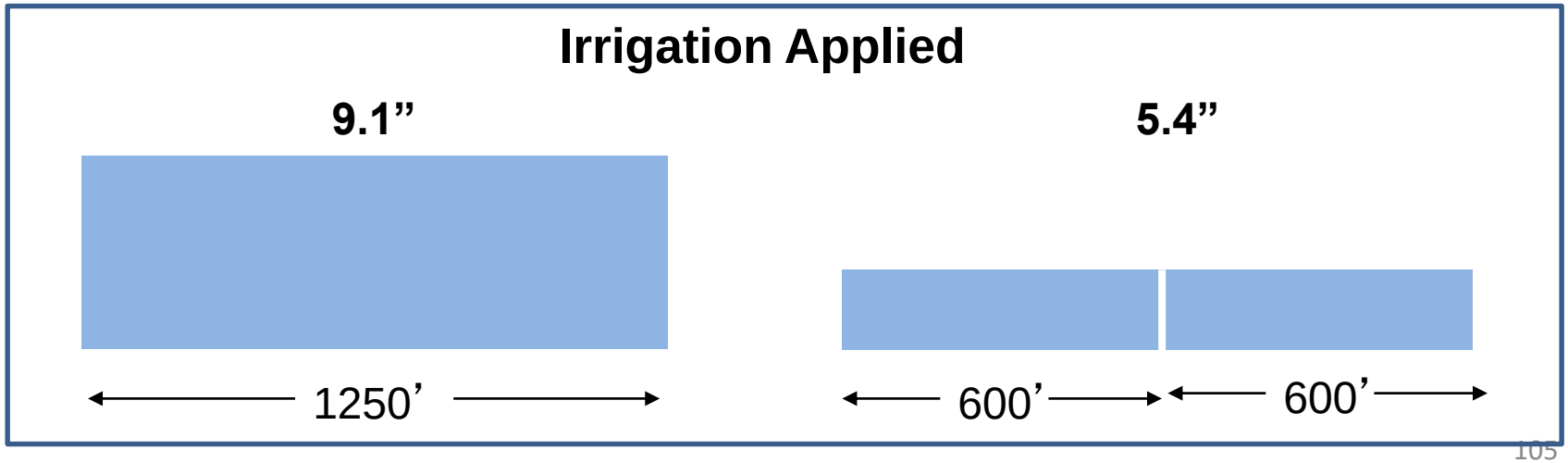
3 Water is run off the field tail to allow enough to infiltrate there to satisfy the crops' needs. The runoff should be collected and reused.

4 End of irrigation event. Water has infiltrated field tail, and field head has received excess. This water goes to deep percolation, potentially leaching any N present.

Surface Irrigation Improvements

Shortened Field Length

- Shortening field length gets water across the field quicker, resulting in less deep percolation.
  - Often the most effective option, but least popular due to expense



Surface Irrigation Improvements

Increased Field Slope

- Increasing the field slope can decrease the amount of irrigation water necessary to irrigate.

	0.001 slope	0.002 slope
Irrigation Amount Applied	5.1"	4.8"

Surface Irrigation Improvements

Border Check Flow

- Increase the flow per foot of border check

	Wide check (200')	Narrow check (100')
Irrigation Water Applied	5.1"	4.3"

Field Study: Usually run 2 valves per check; make checks half as wide and run 1 valve at a time

→ more flow per foot of check width

Surface Irrigation Improvements

Torpedoes

- Using a torpedo gets water across the field quicker, resulting in less deep percolation.

	Torpedoed Furrow	Non-torpedoed Furrow
Irrigation Water Appied	9.4"	12.9"

Surface Irrigation Improvements

Reusing Tailwater Runoff

- Collecting and reusing tailwater runoff makes the best use of expensive and limited irrigation water.

Surface Irrigation

- What if these options for improvement are not practical or effective?
- A change in irrigation method may be needed

Pressurized Irrigation

- Pressurized irrigation systems include sprinklers, microsprinklers, and surface and subsurface drip
- Amount of water applied is controlled through sprinkler or emitter choices, design features, and scheduling decisions

Pressurized Irrigation

Sprinkler Improvements

- Determine the application rate
  - Need to know the system application rate (in/hr) in order to know how long to run the system to provide plants with enough water
  - Hours of operation = $\frac{\text{inches of water use (ETc)}}{\text{application rate } (\frac{\text{in}}{\text{hr}})}$

Pressurized Irrigation

Sprinkler Improvements

- Application Rate
  - $$\frac{\text{96.3 x Nozzle Discharge (gpm)}}{\text{Lateral line spacing (ft) x Spacing between laterals (ft)}}$$

- Example: The application rate for a sprinkler system with a 24’ by 48’ spacing and an average nozzle discharge of 1 gpm
  - Application Rate= $\frac{\text{96.3 x 1.0 (gpm)}}{\text{24 (ft)x 48 (ft)}} = 0.084\ in/hr$

Pressurized Irrigation

Sprinkler Improvements

- Determine sprinkler application uniformity
  - Use a catch can test or volume/pressure measurement
  - A consultant or mobile evaluation team can be hired to conduct test and provide suggestions

Pressurized Irrigation

Microirrigation Improvements

- Determine the application rate
  - You need to know how much is being applied (application rate) to match the irrigation requirement (from irrigation scheduling).
  - Field sample emitter discharge rates to determine the application rate.

Pressurized Irrigation

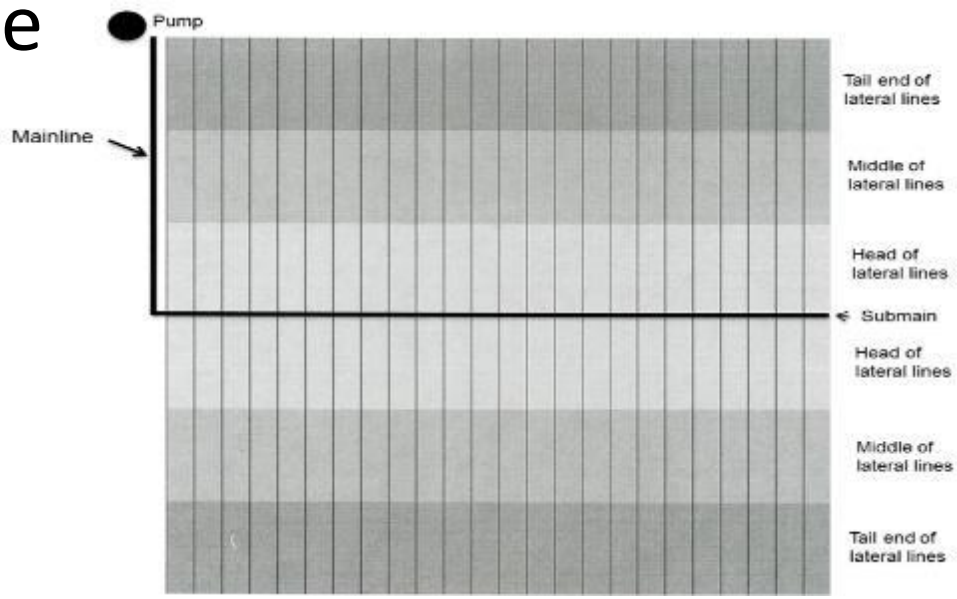
Microirrigation Improvements

- Determine distribution uniformity
  - Irrigation uniformity can be a problem with microirrigation systems too.
- What causes non-uniformity?
  - Pressure differences
  - Maintenance issues (clogging and leaks)

Pressurized Irrigation

Addressing Non-uniformity

- Friction loss from the pump to the tail end cause pressure change at the emitter or sprinkler
- Other pressure differences can be due to elevation change



Pressurized Irrigation

Addressing Non-uniformity

- Pressure differences
  - The discharge rate (gph) of drippers microsprinklers and sprinklers changes with the operating pressure.
  - For example, a 1 gph dripper is only 1 gph at a certain pressure (e.g. 15 psi). If operated at a higher pressure, the discharge rate will be higher.

Pressurized Irrigation

Addressing Non-uniformity

- Addressing pressure differences
  - Use in-field line pressure regulators on sub-mains
  - Use pressure-compensating (PC) drippers microsprinklers and sprinklers
    - PC drippers microsprinklers and sprinklers have a nearly constant discharge rate across a range of operating pressures.
  - Consider pipe sizing and how that affects water delivery and friction loss

Pressurized Irrigation

Addressing Non-uniformity

- Maintenance problems
  - Clogging of emitters or microsprinklers
  - Leaks and breaks

Pressurized Irrigation

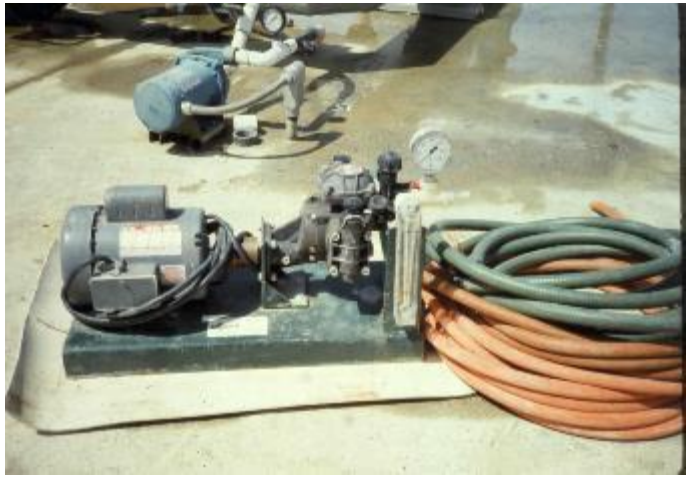
Addressing Non-uniformity

- Addressing maintenance problems
  - Clean and flush filters, mainlines, submains and lateral lines regularly
  - Walk the field and monitor for leaks and breaks frequently
  - Check emitters for biological and chemical clogging at least twice per season

Fertigation

Microirrigation

- Material injected into the drip system should be applied as evenly (uniformly) as water applied by the system.



Fertigation

Injection Timing

- Injections should last at least 1 hour* for uniform application
  - When products are injected too quickly, there is insufficient time to distribute the fertilizer uniformly
- At least 1 hour* of clean water should follow injection so that all fertilizer leaves the lines
  - Fertilizer left in the system can foster biological growth and cause plugging

*depending on length of lines, shorter lateral lines may require less time for application and flush and longer lateral lines may require additional time.

Fertigation

Injection Timing

- Inject N during the middle to near end of an irrigation event
  - Target fertilizer in the root zone where crop can use it
  - Early injection can result in nitrogen moved out of the root zone

Managing Salinity

Leaching salts and not nitrate

- Periodic soil and irrigation water testing will help determine when leaching is needed
  - Leaching is not necessary every irrigation or perhaps even every season but only when soil salinity crop tolerances are approached.

- Leaching is most efficient in the winter and should not coincide with critical periods of nitrogen uptake and fertilization

Rainfall

- We have little control over the amount and timing of rainfall but we can minimize N available in the soil to reduce leaching by:
  - Coordinating the timing of N fertilizers with the period of highest crop demand
  - Applying reasonable rates for crop production levels
  - Minimizing the amount of N in the root zone going into rainy season

Section 4 Summary

- Efficient irrigation practices are critical to good nitrogen management
- How do you become a more efficient irrigator?
  - Use weather, soil moisture, or crop water status information to understand irrigation needs
  - Measure applied water
  - Design and maintain high performing irrigation systems

Efficient Nitrogen Management

Section 5

Section 5 Learning Objectives

- Identify the 4R principles
- Apply the right rate equation to determine crop N demand
- Recognize the benefits of increasing Nitrogen Use Efficiency (NUE)
- Recall the components needed to calculate N contribution of organic materials
- Interpret lab reports to determine N contribution of irrigation water

Applying the 4R Principle

Right Rate	• Match supply with crop demand
Right Time	• Apply coincident with crop demand and uptake
Right Place	• Ensure delivery to active root zone
Right Source	• Supply nitrogen in plant available form

Apply the Right N Rate

The right rate equation

Demand

Crop N Demand

=

Supply

N mineralized in soil

N in irrigation water

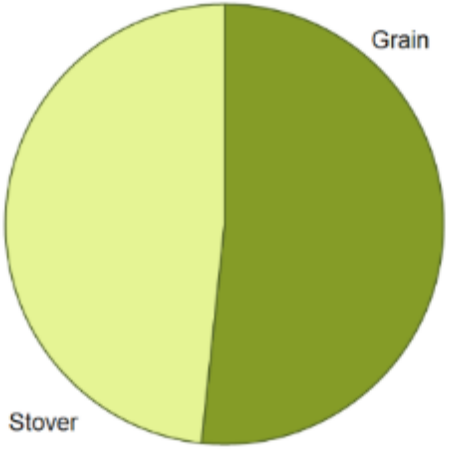
N in fertilizer

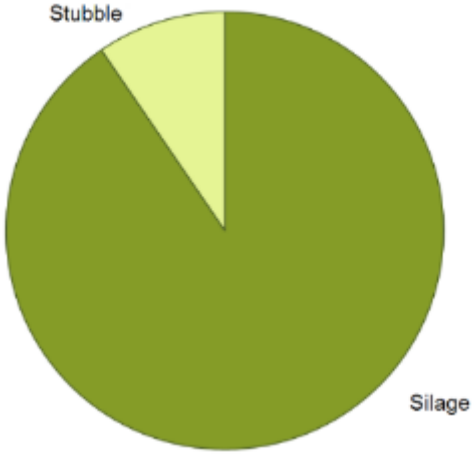
Use the right rate equation to avoid excess N, increase nitrogen use efficiency, and increase profitability by accounting for all N inputs.

Right Rate: N Demand

How to determine crop nitrogen demand in crops

- N in the harvested crop (removed from field) + N in crop residue
  - Example grain corn:
    - Significant N left in field
- N in the harvested crop (removed from field)
  - Example silage corn:
    - Most N removed from field





Right Rate: N Demand

Crop	Yield	Removal Rate	Total N Removed
Corn silage	30 ton/acre	10 lbs. N/ton	300 lbs. N/acre
Corn grain	6 ton/acre	24 lbs. N/ton	144 lbs. N/acre

The difference is the amount of N in the Stover **156** lbs. N/acre

- If grain corn is provided with only 144 lbs. N/acre (N removed) reduced yield will occur
  - Therefore, provide from all N sources:

    N removed + N in crop residue

(Modified from: 4R Plant Nutrition: A Manual for Improving the Management of Plant Nutrition, 2012 IPNI)

Right Rate: N Demand

Typical range (lb N / acre)			
Crop	Seasonal N application	Total crop N uptake	N removal in harvest
Lettuce	120-200	110-140	60-80
Strawberry	160-260	180-200	70-100
Celery	200-300	180-240	120-160

- Fertilization rates often exceed N uptake or removal
  - Though the total N uptake more closely matches the application rate, a large portion of residue is returned to the field after harvest resulting in soil N available for the next crop
  - So, application rate should be adjusted to meet the amount taken up through harvest from all sources of N

Right Rate: N Demand Examples

ALMOND

Nonpareil
- N removal 68 lb per 1000 kernels

Monterey
- N removal 65 lb per 1000 kernels

Growth Requirement
- Yield 2,000-4,000 = 0 lb N
- Yield 1,000-2,000 = 20 lb N
- Yield <1,000 = 30 lb N

PISTACHIO

Kerman:
- N removal 28 lb per 1000*

Growth Requirement:
- On-year: 25 lb N
- Off-year=25-40 lb N

*Dry CPC assessed yield

Walnut

- N removal 19 lb per 1000 lb in shell
  8% moisture

Growth Requirement:
- Mature orchard = included in above
- Immature orchard: not yet available

Right Rate: N Demand

Nitrogen Use Efficiency (NUE) when most N is removed by crop

$$NUE = \frac{Lbs\ N\ \boldsymbol{removed}\ by\ crop}{Lbs\ N\ applied\ all\ sources}$$

Examples: silage corn mature orchards

This is the easiest to use method which accounts for most of the N uptake only removed N used as demand

Right Rate: N Demand

Nitrogen Use Efficiency (NUE) when most N is removed by crop

$$NUE = \frac{Lbs\ N\ \boldsymbol{removed}\ by\ crop + N\ \boldsymbol{for\ growth\ requirement}}{Lbs\ N\ applied\ all\ sources}$$

Examples: immature orchards

Right Rate: N Demand

Nitrogen Use Efficiency (NUE) when only part of N is removed with crop

$$NUE = \frac{Lbs\ N\ \boldsymbol{used}\ by\ the\ crop}{Lbs\ N\ applied\ all\ sources}$$

- Used = N removed at harvest + N in crop residue

Examples: grain corn, tomatoes, vegetables

- This is a more difficult method as N removed and N in the crop residue is used to calculate N demand

Right Rate: N Demand

Nitrogen Use Efficiency (NUE)

- What is a reasonable NUE ?
  - Achievable NUE= 70% (More of a target)
  - Average worldwide < 50%
- The highest efficiency is achieved by a combination of right rate, right time, right place and right source.
- Management of croplands to minimize Losses via volatilization, denitrification, runoff and leaching

Right Rate: N Demand

Methods for Setting Realistic Yield Goals

- Use experience of the potential of a particular field and then consider environmental conditions.
  - For annuals, weather at planting can have a major effect.
  - For perennials, the past year's yield plus winter and spring weather can be critical.

- Set target of 10% above the field's 3-5 year average, excluding years with unusual negative conditions
  - Caution: Estimating too high of a yield can result in early season over application

Right Rate: N Demand

Estimating total demand example: Monterey Almond

Crop N Demand

Monterey Almond

$$= \frac{\text{N removed per unit of crop yield} \times \text{Estimated Yield} + \text{N needed for tree maintenance}}{\text{Nitrogen Use Efficiency}}$$

Right Rate: N Demand

Example for estimating crop demand

- Example Almonds:
  - Mature Monterey almonds N removal with crop = 65lb N/ 1000 lbs kernels
  - N required for tree maintenance 20lb per acre
  - Yield expected is 2000 lbs kernels per acre
  - Estimated crop demand?

Demand Function

Estimating total demand Example: Monterey Almonds

$$\frac{214 \text{ lbs. N}}{\text{acre}} = \frac{\frac{65 \text{ lbs. N}}{1{,}000 \text{ lb yield}} \times \frac{2{,}000 \text{ lb yield}}{\text{acre}} + \frac{20 \text{ lb } N}{\text{acre}}}{0.7}$$

Monterey Almond

Apply the Right N Rate

The right rate equation

Demand

214 lbs. N /acre

Monterey Almond

=

Supply

N mineralized in soil

N in irrigation water

N in fertilizer

Right Rate: N Supply

N mineralized in the soil

- Perennial crops: mature with similar practices each year
  - Residual N as mineral and organic matter mineralized during the season is considered cycled each year and **is not considered** in the next season's supply
- Annual crops
  - Residual N as mineral and organic matter mineralized during the season **must be considered** in the next season's N supply

Right Rate: N Supply

N mineralized in the soil

- Annual crops
  - Residual N as mineral and organic matter mineralized during the season **must be considered** in the next season's N supply
  - The rate of mineralization is controlled by many factors with little predictability
    - Best practice is to use preplant or before side-dressing soil analysis to assess available N in the rootzone.
      - Be aware that post sampling rainfall and irrigation can reduce measured N in the rootzone

Apply the Right N Rate

The right rate equation

Demand

214 lbs. N /acre

Monterey Almond

=

Supply

N mineralized in soil

N in irrigation water

N in fertilizer

0 lbs. N /acre

Right Rate: N Supply

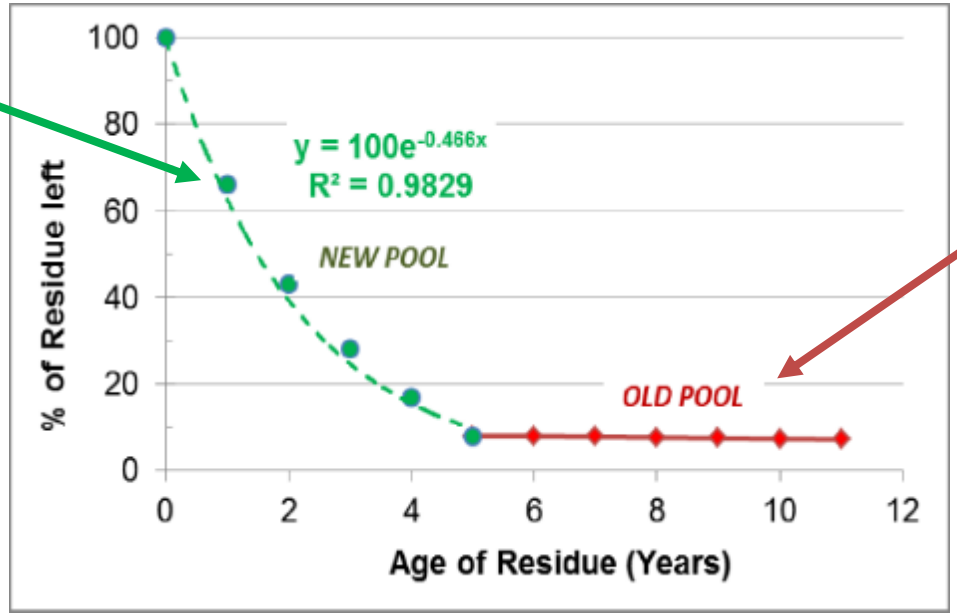
N Mineralized in the Soil

- Soil organic matter is available in new/active pool for mineralization

Active OM

Crop residues
Manure
Compost
Cover crop

Relatively quick breakdown



Stable OM

Very Slow to breakdown

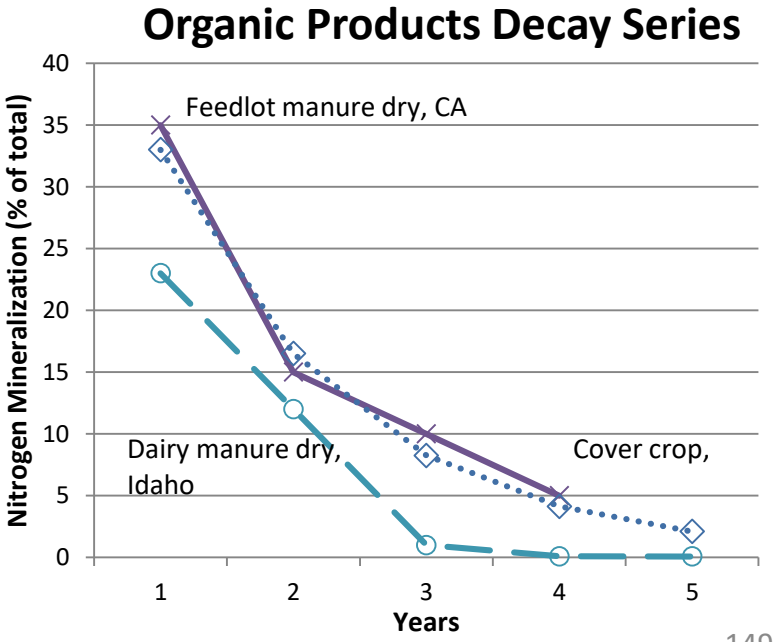
Notes:
Slide from Dr. Lucas, Ohio State

Right Rate: N Supply

N Mineralized in the Soil

- Soil organic matter when a single application of organic matter is made
  - N credits = dry lbs OM x %N x % decomposition in 1st year

First Year Decomposition Rates	
Cured Compost	5-10%
Dried Manure	20-30%
Cover Crop	10-35%



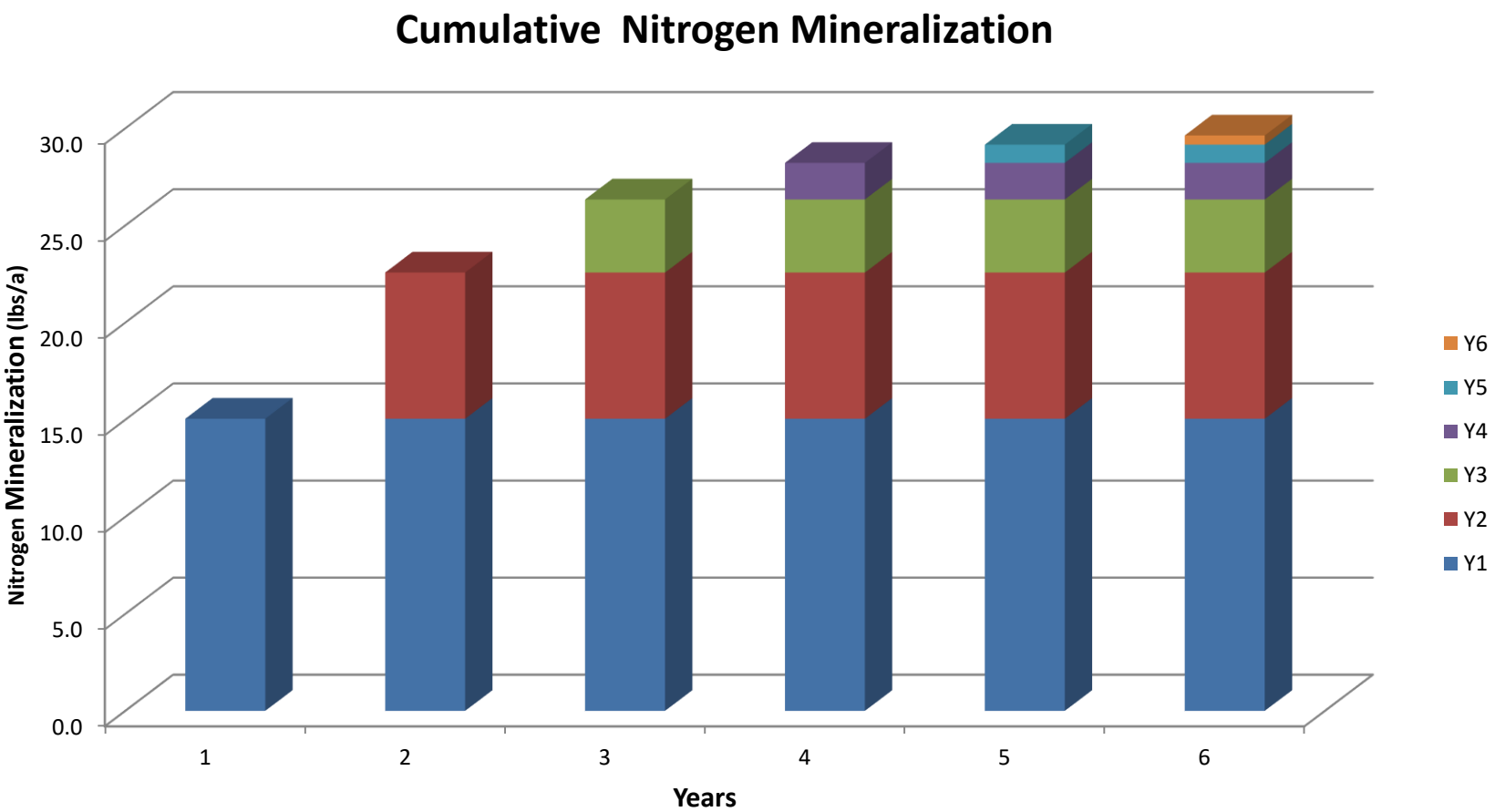
Right Rate: N Supply

N Mineralized in the Soil

- Consistent application each year of OM or the growing of a cover crop
  - N Contribution = Dry lbs. OM x % N x 70%*

*If incorporated the efficiency of decomposition and uptake is about 70% over time. Therefore 70% of the total N content of the application is available that year

Continual application of the same amount of organic N each year 43 lbs N / acre



In each subsequent year of application the available mineral N increases and a steady state is approached after about 4 years.

Right Rate: N Supply

N in the Soil

- Soil Nitrate Testing should be performed at planting or before side-dress
  - Especially important for annual crops
- Challenges with Test
  - Spatial Variability
  - Turn around time from lab
  - Will the nitrate be there after irrigation?
  - If nitrate is coming from mineralization of an organic source, how much and how quickly will more nitrate be available?

Right Rate: N Supply

N in irrigation water

- Formula for Nitrate-N

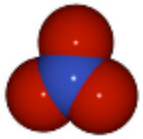
Nitrate-N concentration (ppm) x inches irrigation applied x 0.23

- Example
  - 2.3 ppm Nitrate-N and you apply 36 in. of water
    - 2.3 x 36 x 0.23 =
    - 19 lb N per 36 inches of water applied

Right Rate: N Supply

N in irrigation water

- What if your lab report lists your water as Nitrate (ppm)?



- Formula for converting Nitrate to Nitrate-N

Nitrate concentration(ppm) ÷ 4.43 = Nitrate-N concentration (ppm)

Apply the Right N Rate

The right rate equation

Demand

214 lbs. N /acre

Monterey Almond

=

Supply

0 lbs. N /acre

N mineralized in soil

19 lbs. N /acre

N in irrigation water

N in fertilizer

Apply the Right N Rate

The right rate equation

Demand

214 lbs. N /acre

Monterey Almond

=

Supply

0 lbs. N /acre

N mineralized in soil

19 lbs. N /acre

N in irrigation water

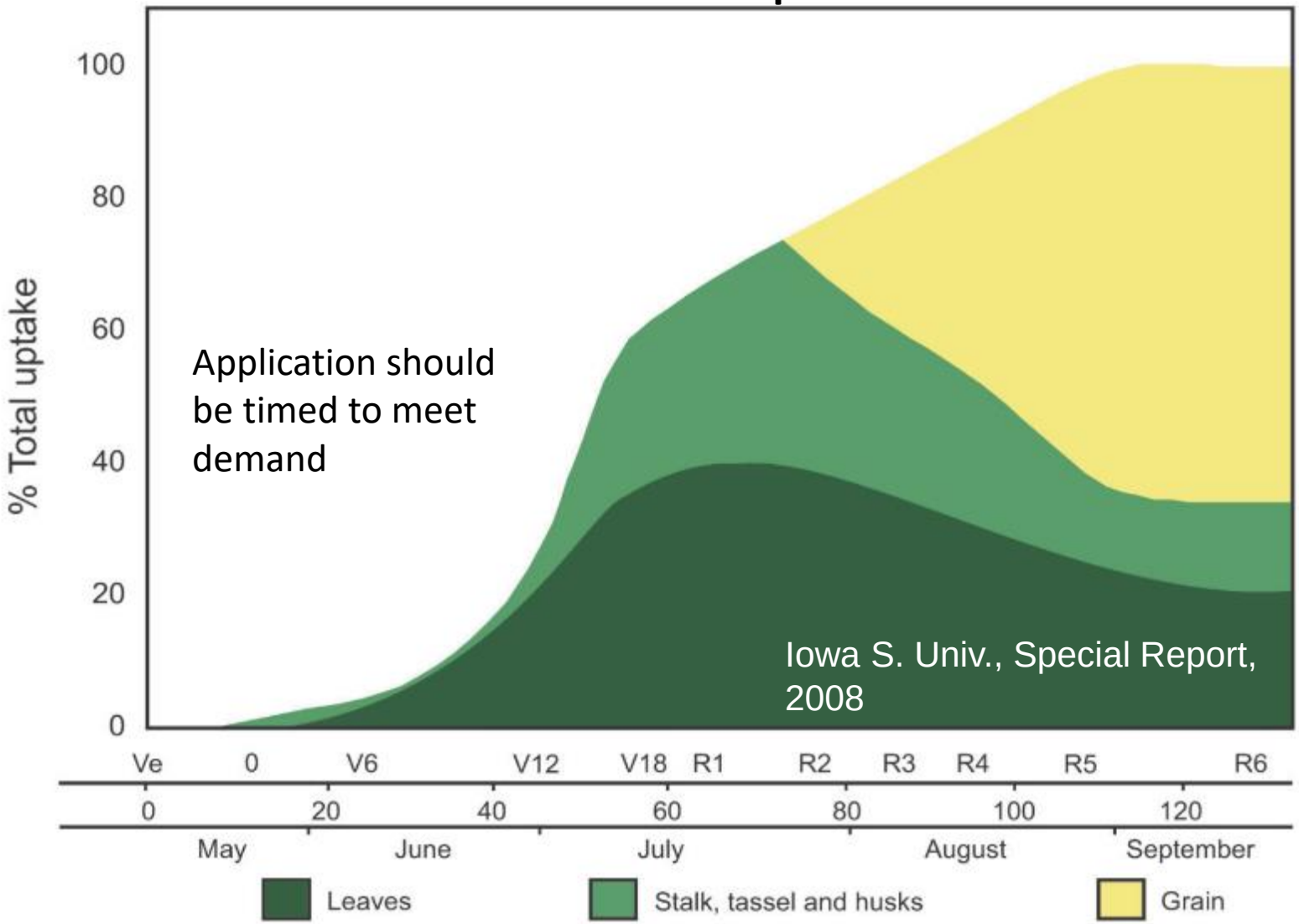
195 lbs. N /acre

N in fertilizer

= Demand –
N mineralized –
N in water

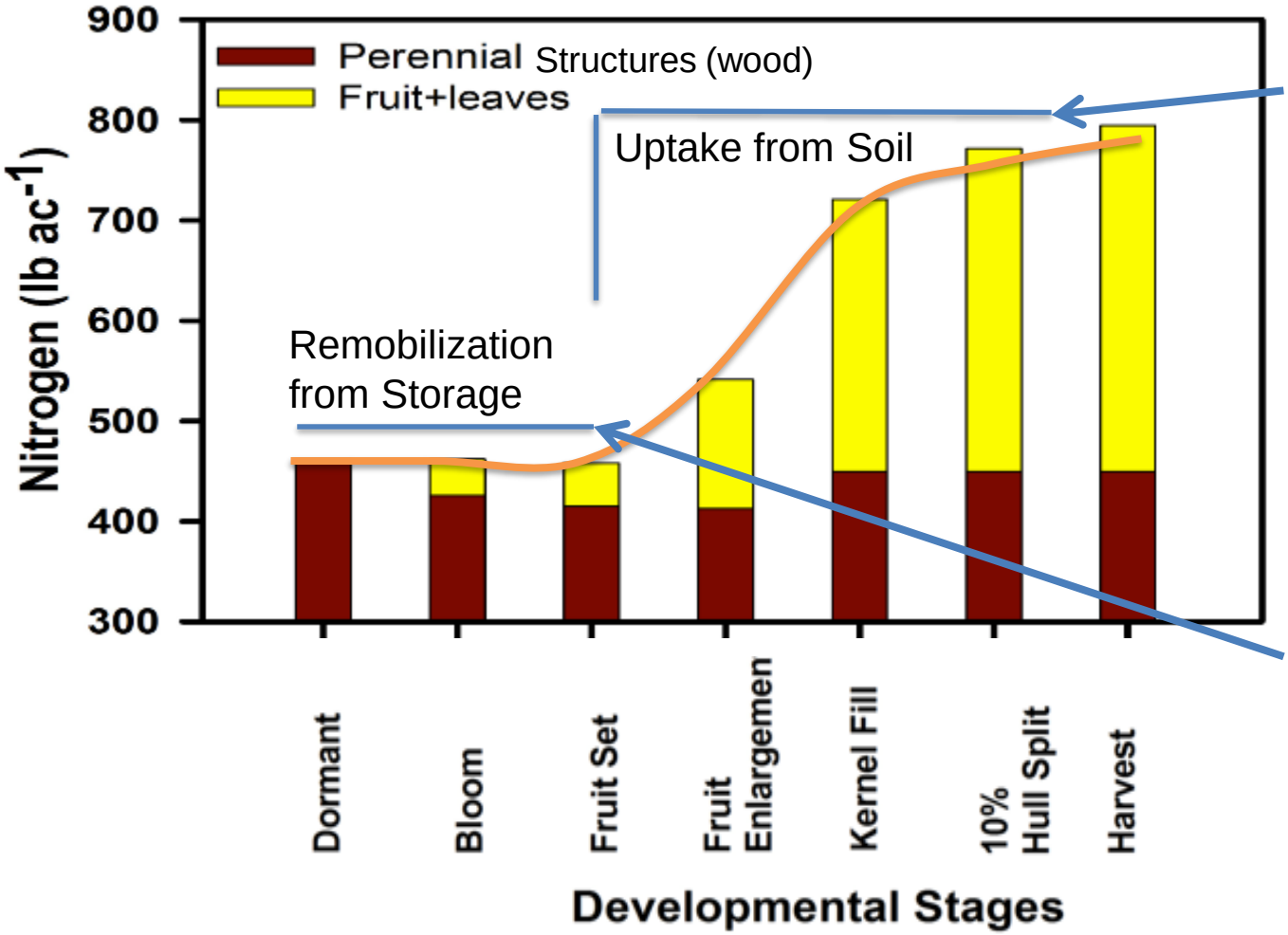
Right Timing to meet 'Demand'

Corn Example



Right Rate and Timing 'Demand'

Almond Example

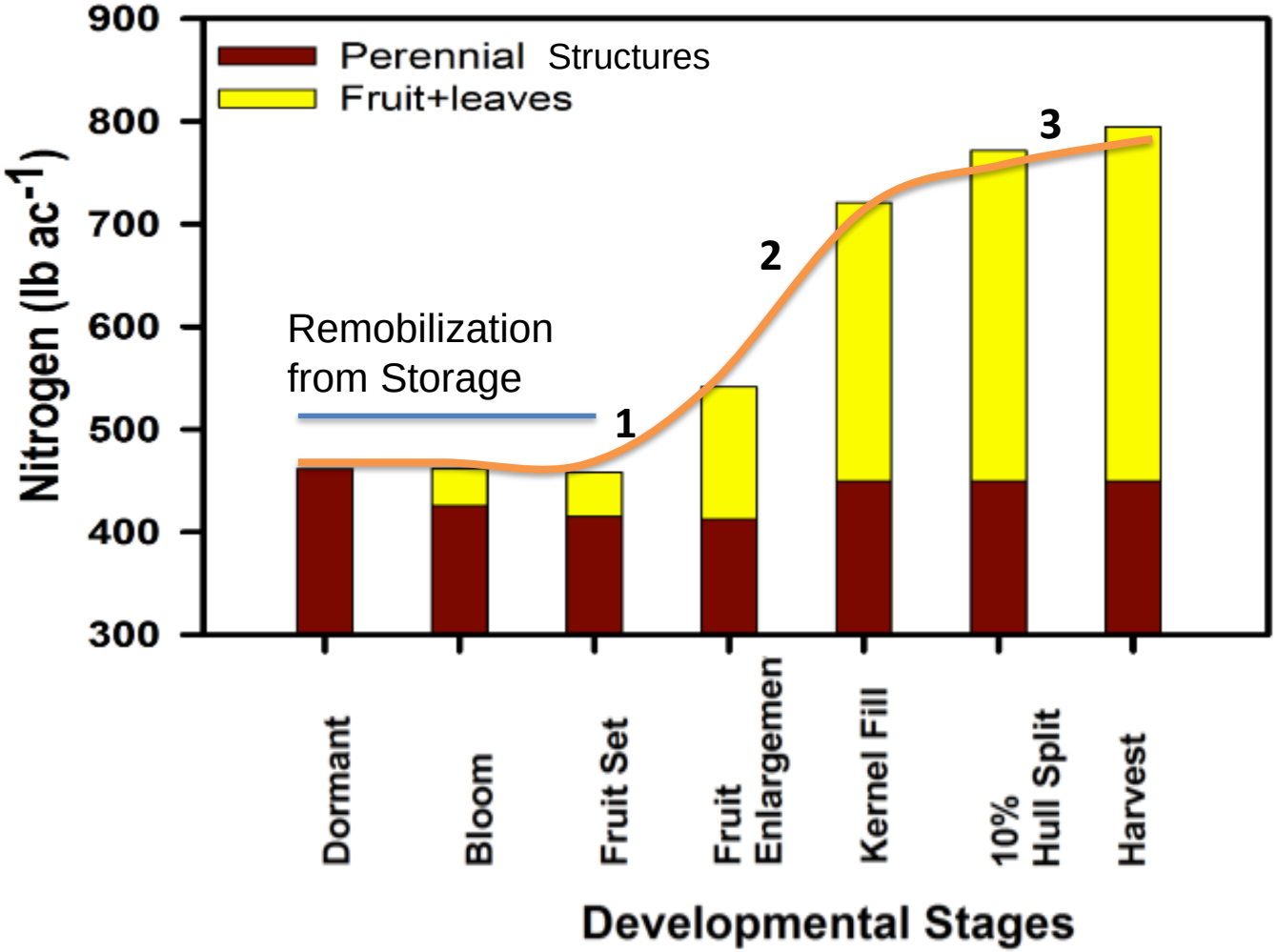


Uptake commences at mid-leaf out and is essentially complete by hull split.

From dormancy to fruit set there is very little N uptake. Only N redistribution.

Right Rate and Timing 'Demand'

Almond Example

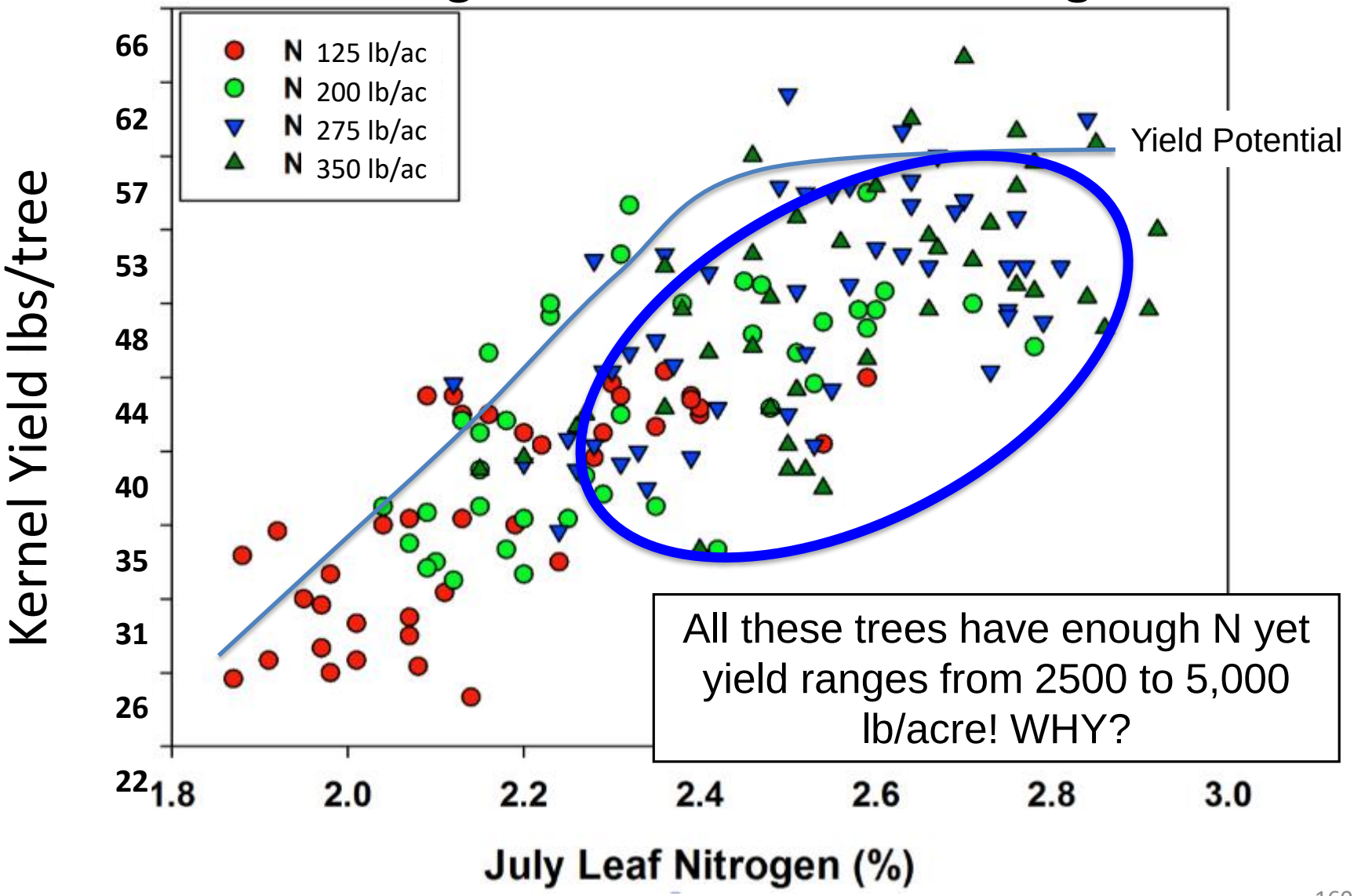


Recommended N Split:

1. 20% Leaf Out-Fruit Enlargement
2. 30% Fruit Enlargement/30% Kernel Fill
3. 20% Hull-split through early Post-Harvest

Right N Source

N Management Alone is Not Enough



All these trees have enough N yet yield ranges from 2500 to 5,000 lb/acre! WHY?

Right Rate

Nutrient Balance: Law of the Minimum

- The efficiency of nitrogen depends on the adequacy of all essential elements and growth conditions
  - If a nutrient is inadequate yield can be lost and response to other elements will be limited
  - If a nutrient is oversupplied money, time, and energy is wasted

Right Place

Where are the roots? Where does N uptake occur?

- How to manage
  - for a crop with a 1-foot rooting depth?
  - for a crop with a 4-foot rooting depth?

(Photo's Courtesy Tim Hartz and IPNI)

Right Place

Where are the roots? Where does N uptake occur?

- Soil and irrigation practices will influence this greatly

Depth range of most N uptake

	Depth of Main Root Zone (inches)
Almond	8-23
Apricot	8-16
Cherry	4-16
Peach	0-32
Plum	10-24
Walnut	0-16

The Right Place

- Manage irrigation systems to ensure N is delivered in the root zone
  - Apply irrigation evenly across the orchard
  - Apply the correct amount of irrigation water to prevent leaching and saturated soil conditions
  - Irrigate after dry fertilization to minimize NH_3 volatilization
  - Inject liquid fertilizers at a time to position the fertilizer where the roots are located

Right Place

Fertigation in Pressurized Systems

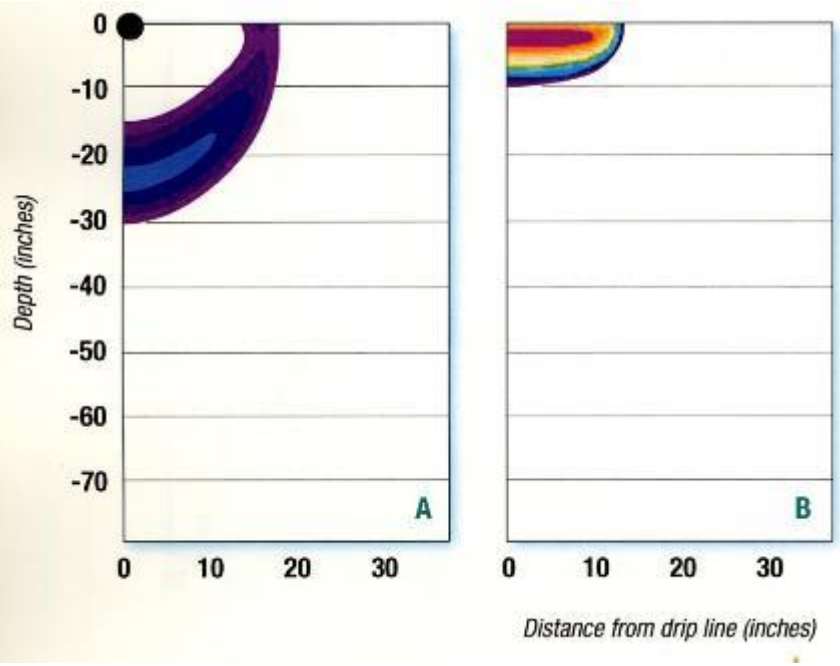
- Time injection so that material stays in crop root zone
  - Inject N during the middle to near end of an irrigation event.

Right Place

Fertigation in Pressurized Systems

Surface Drip

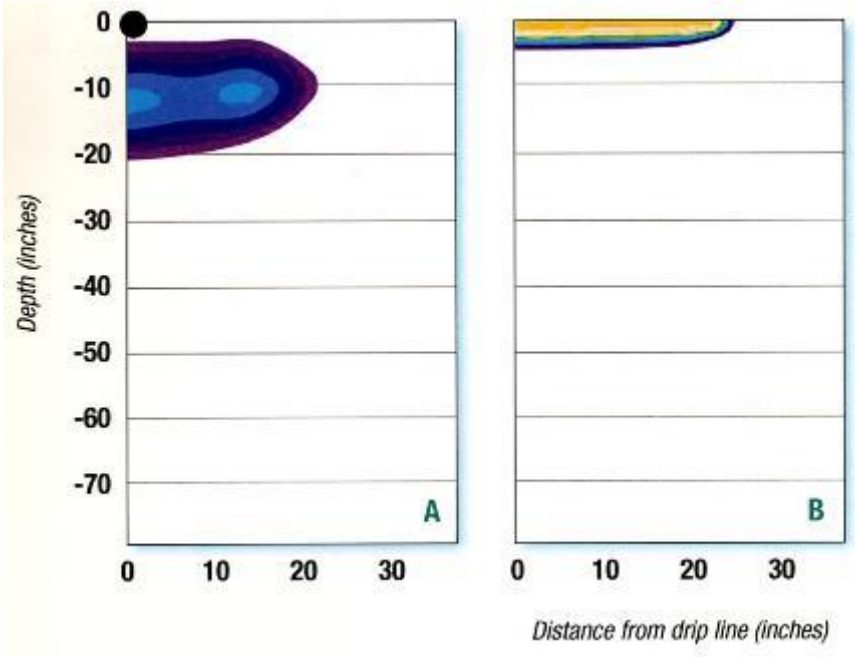
Loam



2 hour injection near **start** of 27 to 36 hour Irrigation. **N levels elevated at 30 in.**

2 hour injection near **end** of 27 to 36 hour Irrigation **N confined to top 10 in.**

Silt Loam



2 hour injection near **start** of 27 to 36 hour Irrigation **N levels elevated at 20 in**

2 hour injection near **end** of 27 to 36 hour Irrigation **N confined to top 6 in.**

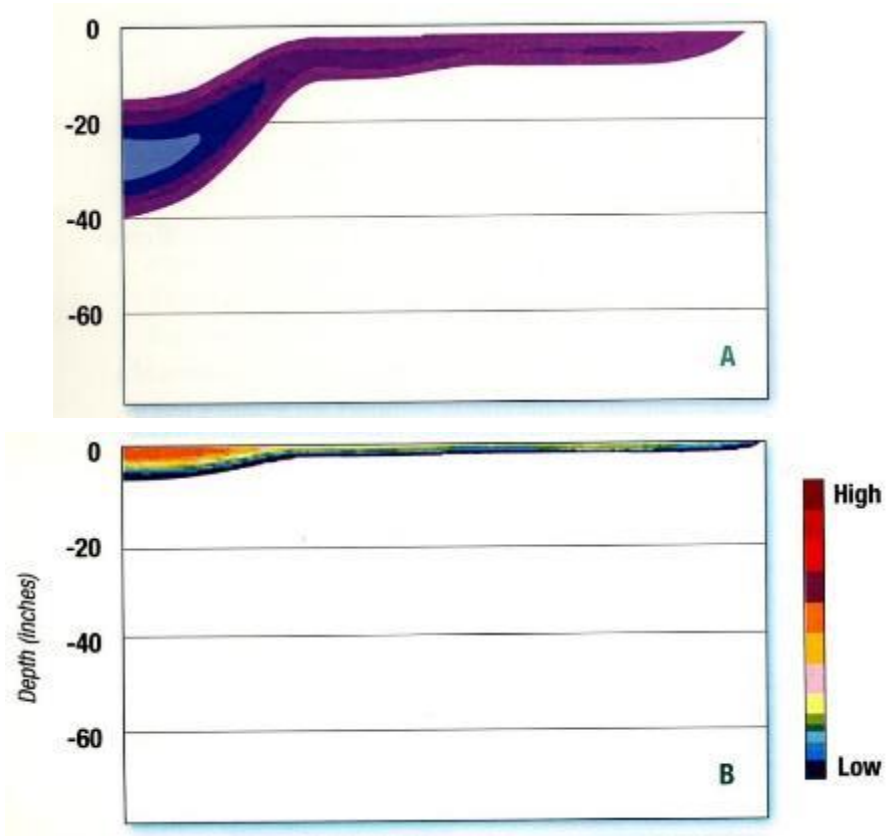
(Blaine Hanson, “Fertigation with Microirrigation”)

Right Place

Fertigation in Pressurized Systems

Microsprinklers

Silt Loam



2 hour injection near **start** of Irrigation

hour injection near **end** of Irrigation

(Blaine Hanson, “Fertigation with Microirrigation”)

Section 5 Summary

- The highest nitrogen use efficiency is achieved by the best combination of right rate, right time, right place and right source.
  - This requires understanding the dynamics of nitrogen in the soil and the plant and irrigation system performance to reduce nitrogen losses

Nitrogen Management Plan
&
Nitrogen Plan Summary Report

Section 6

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: _____

1. Crop Year (Harvested):		4. APN(s):	5. Field(s) ID	Acres
2. Member ID#				
3. Name:				

CROP NITROGEN MANAGEMENT PLANNING		N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
6. Crop		**17. Nitrogen Fertilizers**		
7. Production Unit		18. Dry/Liquid N (lbs/ac)		
8. Projected Yield (Units/Acre)		19. Foliar N (lbs/ac)		
9. N Recommended (lbs/ac)		**20. Organic Material N**		
10. Acres		21. Available N in Manure/Compost (lbs/ac estimate)		
Post Production Actuals				
11. Actual Yield (Units/Acre)		**22. Total Available N Applied** (lbs per acre)		
12. Total N Applied (lbs/ac)		**23. Nitrogen Credits (est)**		
13. ** N Removed (lbs N/ac)		24. Available N carryover in soil; (annualized lbs/acre)		
14. Notes:				
		25. N in Irrigation water (annualized, lbs/ac)		
		26. Total N Credits (lbs per acre)		
		27. Total N Applied & Available		

PLAN CERTIFICATION		
28. CERTIFIED BY:	**29. CERTIFICATION METHOD**	
	30. Low Vulnerability Area, No Certification Needed	
	31. Self-Certified, approved training program attended	
DATE:	32. Self-Certified, UC or NRCS site recommendation	
	33. Nitrogen Management Plan Specialist	

Nitrogen Management Plan Summary Report

- A report of the nitrogen applied per unit of yield during the previous crop year

- ***All growers in High Vulnerability areas*** *must submit Summary Report to the coalition*
- ***Due date:*** *Most Central Coalitions have March 1st due date for the previous year's nitrogen application and A/Y calculation (Applied N divided by Yield)*
- *(Check your local coalition to confirm due dates)*

NMP Summary Report – 2018 Crop Year

Note:
Not all Coalition's use the same forms

Refer to your Nitrogen Management Plan for information to complete this form.[1]

Year Crop Harvested (Box 1):2018 Member ID (Box 2): _____

Submittal Date: Before March 1 2019 Forms Completed By: _____

All calculations should be on a per acre basis.

	Site Location Information[1]	Crop (6)	Total Acres (10)	Total Available N Applied (20+23) pounds per acre	A/Y Total Available N (20+23) / Actual Yield (11)[2]	Production Unit (7)
1						
2						
3						
4						
5						

1 Box number refers to the 4-page nitrogen management plan.
2 Reporting Actual Yield is not required; this column was added to assist you with required A/Y calculations.
3 Gross weight includes all part of the crop that is removed from the field including culls, shells/hulls, etc.

Walnut Nitrogen Management Planning
A Case Study

Walnut

- Conditions:
  - 10 acres Mature Walnuts
  - Soil – Clay Loam, 5ft deep over consolidated layer
  - Irrigation water
    - 36 inches / season applied via solid set sprinkler
    - Nitrate from water test = 1.1 ppm Nitrate-N
  - Estimated yield 3.0 tons per acre
  - No organic material applied (manure or composts)
  - Winter cover *crop (peas, beans, vetch, and barley*)

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: ____Walnuts by River___

1. Crop Year (Harvested):	2018	4. APN(s):	5. Field(s) ID	Acres
2. Member ID#	xxxx			
3. Name:	Your Name			
CROP NITROGEN MANAGEMENT PLANNING		N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N

1. Enter the Crop Year for which your report is based on
2. Enter the membership ID #
3. Enter the name of the person completing this form. This needs to be the owner or manager of the farm or the individual certifying the plan

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: ____Walnuts by River___

1. Crop Year (Harvested):	2018	4. APN(s):	5. Field(s) ID	Acres
2. Member ID#	xxxx	020-025-016	1	10
3. Name:	Your Name			
CROP NITROGEN MANAGEMENT PLANNING		N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N

4. Enter the Assessor's Parcel Number (APN). If field has more than one APN enter both
5. Enter the Field Identification (ID) for each unique management unit. Also include field acreage.

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: ____Walnuts by River___

1. Crop Year (Harvested):	2018	4. APN(s):	5. Field(s) ID	Acres
2. Member ID#	xxxx	020-025-016	1	10
3. Name:	Your Name			

CROP NITROGEN MANAGEMENT PLANNING	
6. Crop	Walnut
7. Production Unit	tons
8. Projected Yield (Units/Acre)	3.0
9. N Recommended (lbs/ac)	
10. Acres	

6. Enter crop name
7. Enter the standard production unit (tons, lbs., cartons, etc.)
8. Enter your projected yield per acre

Nitrogen Recommended Box 9

Box 9: Enter the amount of **Nitrogen Recommended** (estimated amount needed) to be applied to meet your expected yield.

*Use crop recommendations from CDFA, UCCE, NRCS, UCR, commodity organizations or site-specific knowledge based on previous experience to appropriately estimate the amount of Nitrogen (N) needed.

Right Rate: N Recommended Box 9

Crop N Demand

Mature Walnut

$$= \frac{\text{N removed per unit of crop yield} \times \text{Estimated Yield} + \text{N needed for tree maintenance}}{\text{Nitrogen Use Efficiency}}$$

Right Rate: N Recommended Box 9

$$\frac{159 \text{ lbs. N}}{\text{acre}} = \frac{\frac{37 \text{ lbs. N}}{\text{ton yield}} \times \frac{3 \text{ ton yield}}{\text{acre}}}{0.7}$$

Mature Walnut

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: ____Walnuts by River___

		4. APN(s):	5. Field(s) ID	Acres
1. Crop Year (Harvested):	2018			
2. Member ID#	xxxx	020-025-016	1	10
3. Name:	Your Name			

CROP NITROGEN MANAGEMENT PLANNING	
6. Crop	Walnut
7. Production Unit	tons
8. Projected Yield (Units/Acre)	3.0
9. N Recommended (lbs/ac)	159
10. Acres	10

9. Enter the amount of Nitrogen recommended per acre
10. Enter total irrigated acres for the management unit covered

Estimating Supply

Demand

159 lbs. N /acre

=

Supply

N in Organic Materials

N in irrigation water

N in fertilizer

Mature Walnut

Organic Material N Box 21

Winter Cover crop

Peas, beans, vetch, and barley

- Center on right mowed 4 inches high a few weeks earlier

Organic Material N Box 21

- Cover Crop: Peas, beans, vetch, and barley
  - 3000 lbs Dry Matter/ cover crop planted acre
  - 60 % of total tree acreage planted
  - Average of 3000 x 0.60 = 1800 lbs. dry matter / ac

- Legumes = 2.8% N Grasses 1.5% N
  - average of mix = 2.4% N
  - 1800 lbs. x .024 = 43 lbs. N /ac
  - At 70% efficiency: 43 x .70 = 30 lbs. N /acre

N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
17. Nitrogen Fertilizers		
18. Dry/Liquid N (lbs/ac)		
19. Foliar N (lbs/ac)		
20. Organic Material N		
21. Available N in Manure/Compost (lbs/ac estimate)	30	
22. Total Available N Applied (lbs per acre)		
23. Nitrogen Credits (est)		
24. Available N carryover in soil; (annualized lbs/acre)		
25. N in Irrigation water (annualized, lbs/ac)		
26. Total N Credits (lbs per acre)		
27. Total N Applied & Available		

N in Irrigation Water Box 25

- Irrigation Water
  - 36 inches / season applied via solid set sprinkler
  - Nitrate from water test = 1.1 ppm Nitrate-N
- Formula for Nitrate-N
  - Nitrate-N concentration (ppm) x inches irrigation applied x 0.23 lbs/ac inch conversion
- 1.1 ppm Nitrate-N x 36 in. x 0.23 = 9 lbs. N /ac

N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
17. Nitrogen Fertilizers		
18. Dry/Liquid N (lbs/ac)		
19. Foliar N (lbs/ac)		
20. Organic Material N		
21. Available N in Manure/Compost (lbs/ac estimate)	30	
22. Total Available N Applied (lbs per acre)		
23. Nitrogen Credits (est)		
24. Available N carryover in soil; (annualized lbs/acre)		
25. N in Irrigation water (annualized, lbs/ac)	9	
26. Total N Credits (lbs per acre)		
27. Total N Applied & Available		

Planned N Fertilizer Application

Box 18/19

Demand

159 lbs. N /acre

Mature Walnut

=

Supply

30 lbs. N /acre

9 lbs. N /acre

120 lbs. N /acre

Fertilizer Application =
Demand – N mineralized – N in water

N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
17. Nitrogen Fertilizers		
18. Dry/Liquid N (lbs/ac)	120	
19. Foliar N (lbs/ac)	0	
20. Organic Material N		
21. Available N in Manure/Compost (lbs/ac estimate)	30	
22. Total Available N Applied (lbs per acre)		
23. Nitrogen Credits (est)		
24. Available N carryover in soil; (annualized lbs/acre)	0	
25. N in Irrigation water (annualized, lbs/ac)	9	
26. Total N Credits (lbs per acre)		
27. Total N Applied & Available		

Calculated Fields

N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
17. Nitrogen Fertilizers		
18. Dry/Liquid N (lbs/ac)	120	
19. Foliar N (lbs/ac)	0	
20. Organic Material N		
21. Available N in Manure/Compost (lbs/ac estimate)	30	
22. Total Available N Applied (lbs per acre)	150	
23. Nitrogen Credits (est)		
24. Available N carryover in soil; (annualized lbs/acre)	0	
25. N in Irrigation water (annualized, lbs/ac)	9	
26. Total N Credits (lbs per acre)	9	
27. Total N Applied & Available	159	

- Box 22: sum of box #18, #19, and #21
- Box 26: sum of box #24 and #25
- Box 27: sum of box #22 and #26

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: Walnuts by River

1. Crop Year (Harvested):	2018	4. APN(s):	5. Field(s) ID	Acres
2. Member ID#	xxxx	020-025-016	1	10
3. Name:	Your Name			

CROP NITROGEN MANAGEMENT PLANNING		N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
6. Crop	Walnut	**17. Nitrogen Fertilizers**		
7. Production Unit	tons	18. Dry/Liquid N (lbs/ac)	120	
8. Projected Yield (Units/Acre)	3.0	19. Foliar N (lbs/ac)	0	
9. N Recommended (lbs/ac)	159	**20. Organic Material N**		
10. Acres	10	21. Available N in Manure/Compost (lbs/ac estimate)	30	
Post Production Actuals				
11. Actual Yield (Units/Acre)		**22. Total Available N Applied** (lbs per acre)	150	
12. Total N Applied (lbs/ac)		**23. Nitrogen Credits (est)**		
13. ** N Removed (lbs N/ac)		24. Available N carryover in soil; (annualized lbs/acre)	0	
14. Notes:				
		25. N in Irrigation water (annualized, lbs/ac)	9	
		26. Total N Credits (lbs per acre)	9	
		27. Total N Applied & Available	159	

PLAN CERTIFICATION		
28. CERTIFIED BY:	**29. CERTIFICATION METHOD**	
	30. Low Vulnerability Area, No Certification Needed	
	31. Self-Certified, approved training program attended	
DATE:	32. Self-Certified, UC or NRCS site recommendation	
	33. Nitrogen Management Plan Specialist	

Box 27 & 9 should have equivalent values

Recording Actual Values in NMP

- At the end of the season you have:
  - Produced a yield of 3.2 tons
  - Applied a total of 170 lbs. of N
    - Including contributions from cover crop and irrigation water

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: ____Walnuts by River___

		4. APN(s):	5. Field(s) ID	Acres
1. Crop Year (Harvested):	2018			
2. Member ID#	xxxx	020-025-016	1	10
3. Name:	Your Name			

CROP NITROGEN MANAGEMENT PLANNING	
6. Crop	Walnut
7. Production Unit	tons
8. Projected Yield (Units/Acre)	3.0
9. N Recommended (lbs/ac)	159
10. Acres	10
Post Production Actuals	
11. Actual Yield (Units/Acre)	**3.20**
12. Total N Applied (lbs/ac)	**170**
13. ** N Removed (lbs N/ac)	

11. Enter actual yield
12. Enter total lbs. N applied per acre

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: ____Walnuts by River___

1. Crop Year (Harvested):	2018	4. APN(s):	5. Field(s) ID	Acres
2. Member ID#	xxxx	020-025-016	1	10
3. Name:	Your Name			

CROP NITROGEN MANAGEMENT PLANNING		N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
6. Crop	Walnut	**17. Nitrogen Fertilizers**		
7. Production Unit	tons	18. Dry/Liquid N (lbs/ac)	120	131
8. Projected Yield (Units/Acre)	3.0	19. Foliar N (lbs/ac)	0	0
9. N Recommended (lbs/ac)	159	**20. Organic Material N**		
10. Acres	10	21. Available N in Manure/Compost (lbs/ac estimate)	30	30
Post Production Actuals				
11. Actual Yield (Units/Acre)	**3.20**	**22. Total Available N Applied** (lbs per acre)	150	161
12. Total N Applied (lbs/ac)	**170**	**23. Nitrogen Credits (est)**		
13. ** N Removed (lbs N/ac)		24. Available N carryover in soil; (annualized lbs/acre)	0	0
14. Notes:		25. N in Irrigation water (annualized, lbs/ac)	9	9
		26. Total N Credits (lbs per acre)	9	9
		27. Total N Applied & Available	159	170

PLAN CERTIFICATION		
28. CERTIFIED BY:	**29. CERTIFICATION METHOD**	
	30. Low Vulnerability Area, No Certification Needed	
	31. Self-Certified, approved training program attended	
DATE:	32. Self-Certified, UC or NRCS site recommendation	
	33. Nitrogen Management Plan Specialist	

PLAN CERTIFICATION		
28. CERTIFIED BY:	29. CERTIFICATION METHOD	
John Doe	30. Self-Certified, approved training program attended	x
	31. Self-Certified, NRCS site recommendation	
DATE:	32. Certified Crop Advisor	
12/31/2018		

28. Signature or certifier and date of plan certification
29. Place an X in the box signifying the method used for certification

NMP Summary Report – 2016 Crop Year

Refer to your Nitrogen Management Plan for information to complete this form.[1]

Year Crop Harvested (Box 1): 2018 Member ID (Box 2): _____

Submittal Date: Before March 1 2019 Forms Completed By: _____

1. Crop Year (Harvested): **2018**
2. Member ID# **1000**
3. Name: **John Doe**

CROP NITROGEN MANAGEMENT PLANNING

6. Crop Walnut
7. Production Unit Tons
8. Projected Yield (Units/Acre) 3
9. N Recommended (lbs/ac) 159
10. Acres 10
Post Production Actuals
11. Actual Yield (Units/Acre) 3.2
12. Total N Applied (lbs/ac) 170

All calculations should be on a per acre basis.

	Site Location Information[1]	Crop (6)	Total Acres (10)	Total Available N Applied (20+23) pounds per acre	A/Y Total Available N (20+23) / Actual Yield (11)[2]	Production Unit (7)
1	*APN/Field or Mgmt. Unit*	*Walnut*	*100*	*170*	*53*	*Tons*
2						
3						
4						
5						

Total Available N (A): = 170 lbs/acre

Yield (Y) = 3.2 tons

A/Y = 170 / 3.2 = 53

Silage Corn Nitrogen Management Planning

Corn Silage

- Conditions:
  - 10 acres silage corn
  - Soil– sandy loam
  - Irrigation water
    - 24 inches ETc (crop water use)
    - Water test = 9.0 ppm Nitrate-N
  - Estimated yield 30 tons per acre
  - No organic material applied

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: ____Corn 1__

1. Crop Year (Harvested):	2018	4. APN(s):	5. Field(s) ID	Acres
2. Member ID#	xxxx	020-025-016	1	10
3. Name:	Your Name			

CROP NITROGEN MANAGEMENT PLANNING	
6. Crop	Corn
7. Production Unit	tons
8. Projected Yield (Units/Acre)	30.0
9. N Recommended (lbs/ac)	
10. Acres	10

Right Rate: N Recommended Box 9

Estimated Crop Demand

$$= \frac{\text{Lbs. N removed} \times \text{Estimated Yield}}{\text{NUE}}$$

https://www.ipni.net/app/calculator/home

IPNI Nutrient Removal Calculator

Right Rate: N Recommended Box 9

415 lbs. N /acre

$$= \frac{\frac{9.7 \text{ lbs. N}}{\text{ton yield}} \times \frac{30 \text{ tons}}{\text{acre}}}{0.7}$$

https://www.ipni.net/app/calculator/home

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: Corn 1

1. Crop Year (Harvested):	2018	4. APN(s):	5. Field(s) ID	Acres
2. Member ID#	xxxx	020-025-016	1	10
3. Name:	Your Name			

CROP NITROGEN MANAGEMENT PLANNING	
6. Crop	Corn
7. Production Unit	tons
8. Projected Yield (Units/Acre)	30.0
9. N Recommended (lbs/ac)	415
10. Acres	10

Estimating N Supply

Demand

415 lbs. N /acre

=

Supply

N in soil

N in irrigation water

N in fertilizer

Soil Available Nitrogen Box 24

- Soil test pre plant
- Mineral N available in the top 2 feet of soil
  - 2 ft x 33 lbs. N/ft = **66 lbs. N/acre**

Primary Nutrients	
Nitrate-Nitrogen	33.0 Lbs/AF
Phosphorus-P_2O_5	174 Lbs/AF
Potassium-K_2O (Exch)	1020 Lbs/AF
Potassium-K_2O (Sol)	125 Lbs/AF

N in Irrigation Water Box 25

Irrigation Water

24 inches ETc (crop water use)

- If more water is being applied than crop ET some water is leaching and the crop is not receiving all N applied.
- In this case, only the amount of N in the ET water volume should be credited.
- Depending on location, time of planting, corn variety, and weather the ET of corn can range from 21-27 in.

N in Irrigation Water Box 25

- Irrigation Water
  - 24 inches ETc (crop water use)
  - Water test = 9.0 ppm Nitrate-N

- Formula for Nitrate-N
  - Nitrate-N concentration (ppm) x inches irrigation applied x 0.23 lbs/ac inch conversion

- 9.0 ppm Nitrate-N x 24 in. x 0.23 = 50 lbs. N /ac

Planned N Fertilizer Application

Box 18/19

Demand

415 lbs. N /acre

=

Supply

66 lbs. N /acre

50 lbs. N /acre

299 lbs. N /acre

Fertilizer Application =
Demand – N mineralized – N in water

N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
17. Nitrogen Fertilizers		
18. Dry/Liquid N (lbs/ac)	299	
19. Foliar N (lbs/ac)	0	
20. Organic Material N		
21. Available N in Manure/Compost (lbs/ac estimate)	**0**	
22. Total Available N Applied (lbs per acre)	**299**	
23. Nitrogen Credits (est)		
24. Available N carryover in soil; (annualized lbs/acre)	66	
25. N in Irrigation water (annualized, lbs/ac)	50	
26. Total N Credits (lbs per acre)	**116**	
27. Total N Applied & Available	**415**	

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: ____Corn 1__

1. Crop Year (Harvested):	2018	4. APN(s):	5. Field(s) ID	Acres
2. Member ID#	xxxx	020-025-016	1	10
3. Name:	Your Name			

CROP NITROGEN MANAGEMENT PLANNING		N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
6. Crop	Corn	**17. Nitrogen Fertilizers**		
7. Production Unit	tons	18. Dry/Liquid N (lbs/ac)	299	
8. Projected Yield (Units/Acre)	30.0	19. Foliar N (lbs/ac)	0	
9. N Recommended (lbs/ac)	415	**20. Organic Material N**		
10. Acres	10	21. Available N in Manure/Compost (lbs/ac estimate)	0	
Post Production Actuals				
11. Actual Yield (Units/Acre)		**22. Total Available N Applied** (lbs per acre)	299	
12. Total N Applied (lbs/ac)		**23. Nitrogen Credits (est)**		
13. ** N Removed (lbs N/ac)		24. Available N carryover in soil; (annualized lbs/acre)	66	
14. Notes:		25. N in Irrigation water (annualized, lbs/ac)	50	
		26. Total N Credits (lbs per acre)	116	
		27. Total N Applied & Available	415	

PLAN CERTIFICATION		
28. CERTIFIED BY:	**29. CERTIFICATION METHOD**	
	30. Low Vulnerability Area, No Certification Needed	
	31. Self-Certified, approved training program attended	
DATE:	32. Self-Certified, UC or NRCS site recommendation	
	33. Nitrogen Management Plan Specialist	

Box 27 & 9 should have equivalent values

Recording Actual Values in NMP

- At the end of the season you have:
  - Produced a yield of 30.5 tons /ac
  - Applied a total of 420 lbs. of N
    - Including contributions:
      - Soil N Test 66 lb N
      - Irrigation water 50 lb N
      - Fertilizer 304 lb N

NITROGEN MANAGEMENT PLAN WORKSHEET

NMP Management Unit: ____Corn 1__

1. Crop Year (Harvested):	**2018**	4. APN(s):	5. Field(s) ID	Acres
2. Member ID#	**xxxx**	020-025-016	1	10
3. Name:	Your Name			

CROP NITROGEN MANAGEMENT PLANNING		N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
6. Crop	Corn	**17. Nitrogen Fertilizers**		
7. Production Unit	tons	18. Dry/Liquid N (lbs/ac)	299	304
8. Projected Yield (Units/Acre)	30.0	19. Foliar N (lbs/ac)	0	0
9. N Recommended (lbs/ac)	415	**20. Organic Material N**		
10. Acres	10	21. Available N in Manure/Compost (lbs/ac estimate)	**0**	**0**
Post Production Actuals				
11. Actual Yield (Units/Acre)	30.50	**22. Total Available N Applied** (lbs per acre)	**299**	**304**
12. Total N Applied (lbs/ac)	**420**	**23. Nitrogen Credits (est)**		
13. ** N Removed (lbs N/ac)		24. Available N carryover in soil; (annualized lbs/acre)	66	66
14. Notes:		25. N in Irrigation water (annualized, lbs/ac)	50	50
		26. Total N Credits (lbs per acre)	**116**	**116**
		27. Total N Applied & Available	**415**	**420**

PLAN CERTIFICATION		
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DATE:	32. Self-Certified, UC or NRCS site recommendation	
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John Doe	30. Self-Certified, approved training program attended	x
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DATE:	32. Certified Crop Advisor	
12/31/2018		

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Resources for Nitrogen Application and Management Practices

Section 7

Fertilization Guidelines for CA Crops

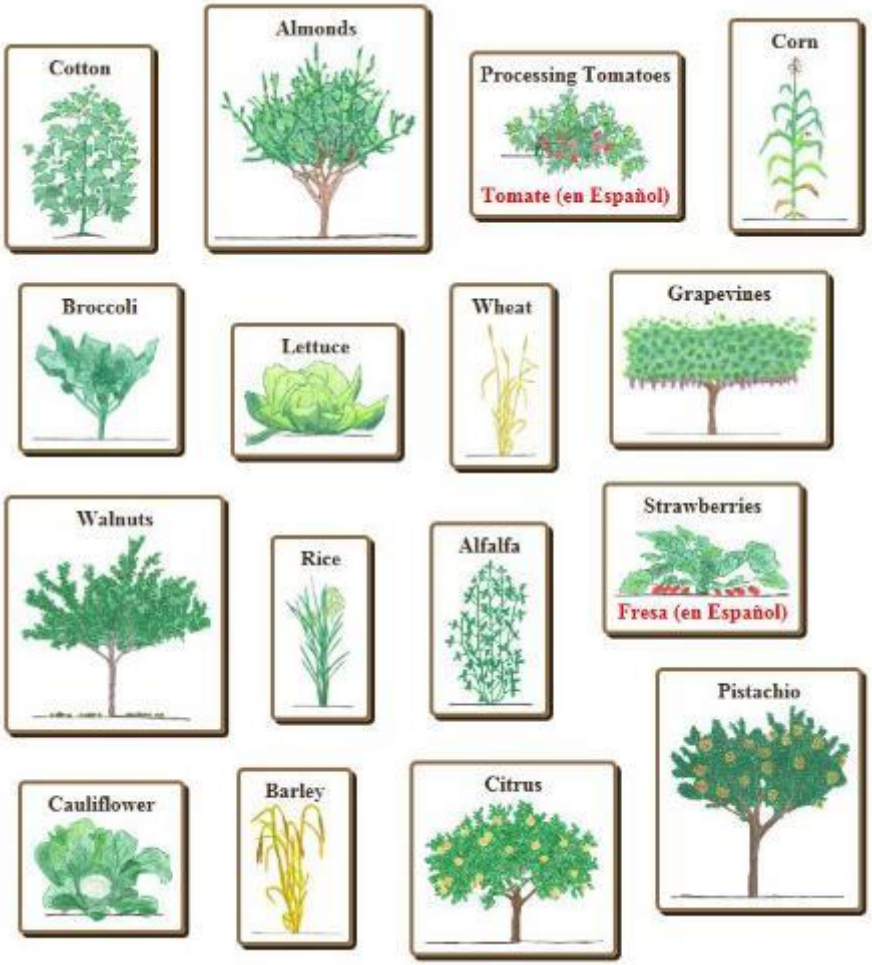
http://apps.cdfa.ca.gov/frep/docs/guidelines.html

Go here for:

- Application rates & times
- Fertilizer placement
- Fertilizer type
- Deficiencies
- Tissue Analysis

Google:

"CDFA FREP Guidelines"



UC Davis Resources

Fruit and Nut Research and Information
http://fruitsandnuts.ucdavis.edu/

Vegetable crops
http://vric.ucdavis.edu/main/veg_info.htm

Citrus
http://fruitsandnuts.ucdavis.edu/datastore/?ds=391&reportnumber=612&catcol=2806&categorysearch=Citrus

Avocado

http://fruitsandnuts.ucdavis.edu/datastore/?ds=391&reportnumber=612&catcol=2806&categorysearch=Avocado

Go here for:

- Information on biology, fertilization and management of crops
- Links to literature searchable by crop

UC Cooperative Extension Irrigation Management

http://ucanr.edu/sites/irrmgm/

Go here for:

- Introduction to irrigation management

Maintained by Dr. Larry Schwankl, this page contains background information on irrigation management. Covered are topics like dairy irrigation management, fertigation safety, irrigation system maintenance, and drought management.

Waterright

http://www.waterright.org/

Go here for:

- How to get started with irrigation scheduling
- Irrigation scheduling planning tools
- Water and energy management

WATERIGHT is a "multi-function, educational resource for irrigation water management." The site is aimed at homeowners, commercial turf growers, and agriculture. It houses information on managing irrigation for specific crops, and integrates CIMIS weather forecasts and soil type into its instructions..

IPNI Crop Nutrient Removal Calculator

https://www.ipni.net/app/calculator/home

Go here for:

- N, P, K harvest removal estimates of field crops
- Multilingual crop nutrient calculator

IPNI NUTRIENT REMOVAL CALCULATOR

Crops

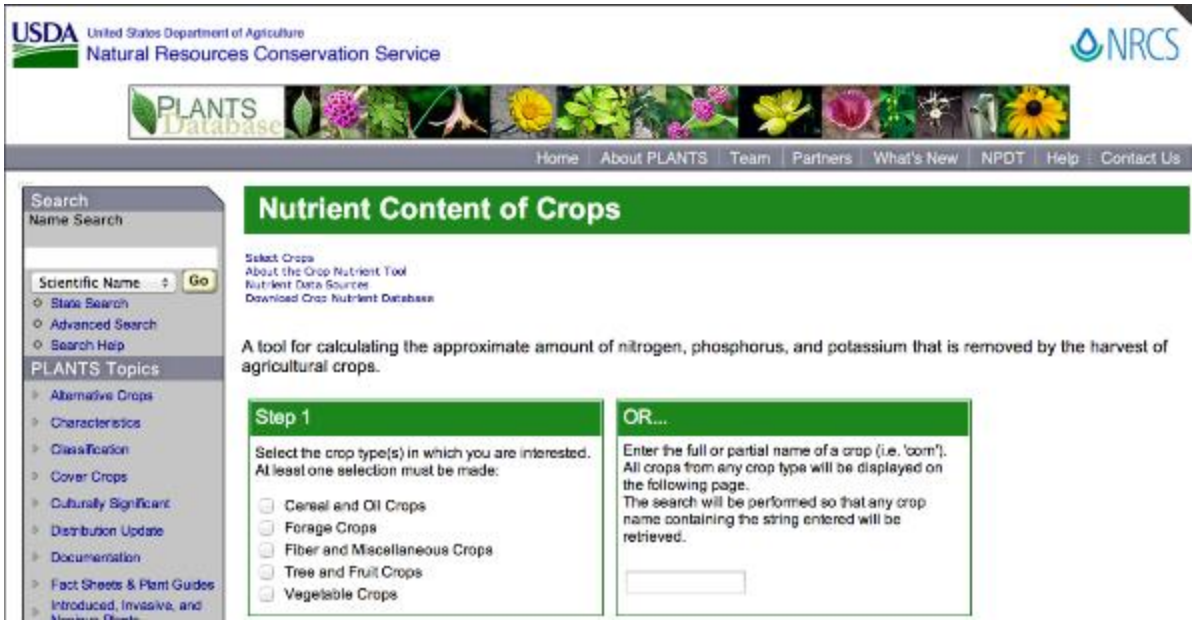
- Alfalfa (DM)
- Almonds, with shell
- Alsike clover (DM)
- Apples
- Bahiagrass
- Barley grain
- Barley straw
- Barley straw per unit of grain yield
- Beans, dry

This tool provides crop nutrient removal estimates for field crops. Estimates are provided for N, P, and K. Results are calculated based on user-selected yield goals and can be displayed in either metric or US units.

NRCS Crop Nutrient Tool

Go here for:

- Elemental N, P, K harvest removal estimates of field crops
- Explanation of how removal calculations are made



http://plants.usda.gov/npk/main

Nitrogen Management Grower Certification Program Exam

- You must take the test individually
- The test is CLOSED book
- You are free to leave once you finish and turn in your exam
- You will need to score 70% or greater to pass the test
- Please also take the time to fill out our evaluation sheet
- If you do not know your ID number, we can look it up for you later
- If you have already passed the test, you will earn 1 CEU by attending todays course

Test Taking

- You may elect to skip test today, study the materials at home, and return to take the test at an upcoming meeting or call the coalition office for details on taking it at their office.
- The pass rate for more than 3,000 growers through 2018 was over 80%.
- If you do not pass (70%), you may take a re-test at another grower training session (you will not need to sit through the whole course, just take the test) or at the coalition office.
  - The retake pass rate is near 100%
- You can elect not to take the test and work with a Certified Crop Advisor for NMP certification.