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INTERNATIONAL
PLANT NUTRITION
INSTITUTE

What is the nitrogen contribution from added organic materials?

Rob Mikkelsen

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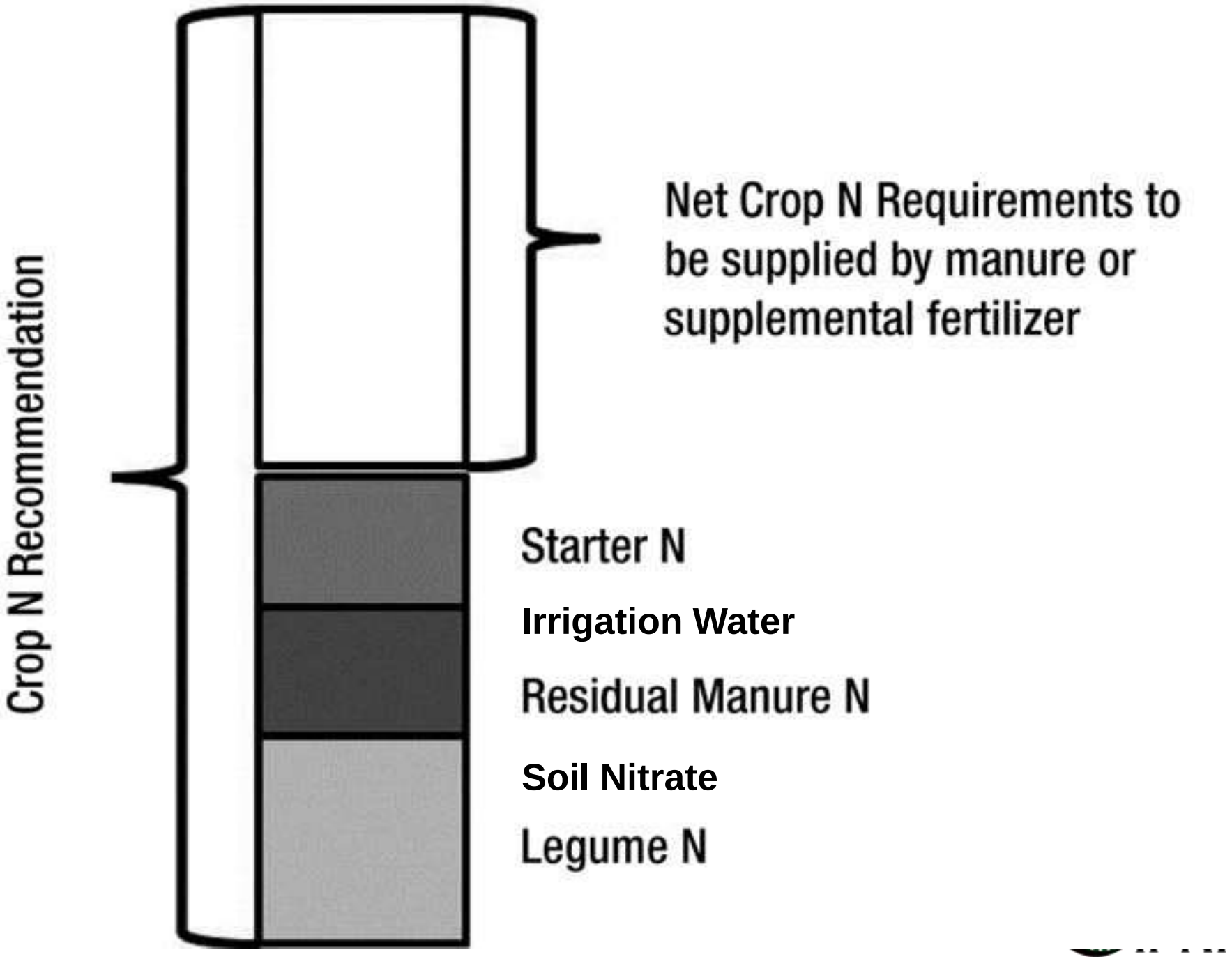
Fertilizer Research and Education Conference, Nov. 2, 2017

Key Question:

How much organic N do I apply to meet the fertilizer equivalent of 50, 100, 200 lb N/acre?


Crop N Recommendation
Net Crop N Requirements to be supplied by manure or supplemental fertilizer
Starter N
Irrigation Water
Residual Manure N
Soil Nitrate
Legume N

Organic N Sources: What Are They?

- Animal Manure
- Compost
- Organic Fertilizer
- Soil Organic Matter
- Cover Crops

Organic N Sources: What Are They?

Cover Crops

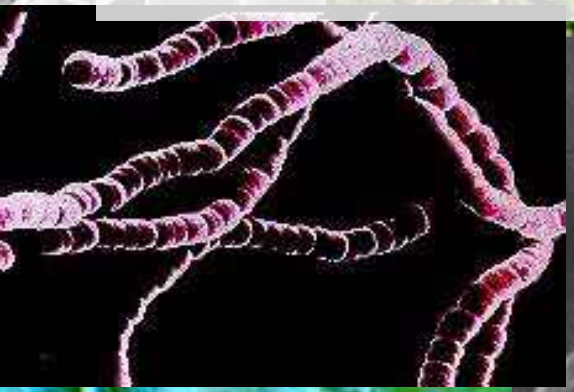
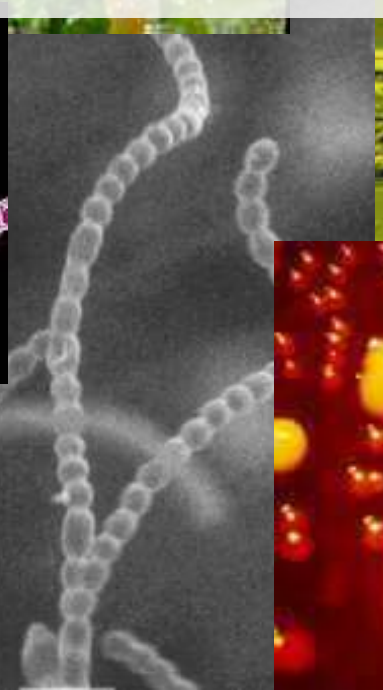
Estimating Plant-Available Nitrogen (PAN)

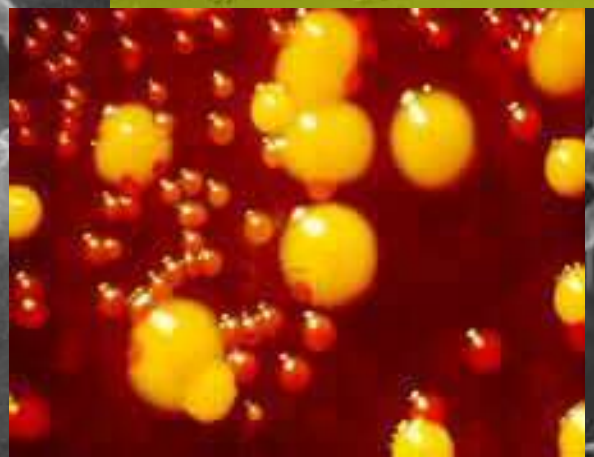
1. Manure characteristics

2. Soil properties and management

Mineralization Process

- Fungi, bacteria, yeasts, actinomycetes, some small critters (nematodes, rotoifers)
- Nitrogen temporarily tied up by microbes

Mineralization

- Breakdown of organic nutrient sources
- Conversion to inorganic, plant available forms
- Rate and timing of mineralization depends on many variables
    - Soil temperature
    - Soil moisture
    - Incorporation/depth of incorporation
    - Soil microorganisms
    - Carbon to nitrogen ratio
    - Particle size
    - 10-50% a year

Immobilization

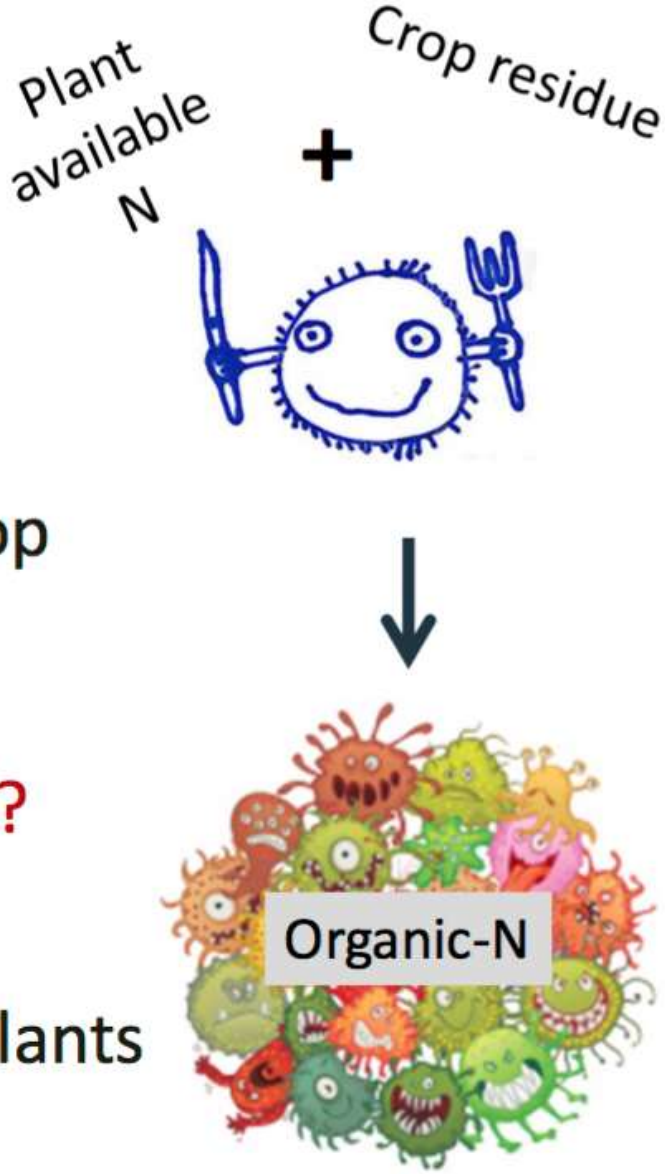
- The opposite of mineralization
- Happens when nitrogen is limiting in the environment
- Nitrogen limitation is governed by C/N ratio
- C/N typical for soil microbial biomass is 20
- C/N < 20 →Mineralization
- C/N > 20 →Immobilization

Immobilization

Uptake of available N by microbes

Why need to know about it?

- Crop residue is microbes' energy
  Microbes use plant available N
- We need to provide more N for crop



Is immobilized N lost from the system? Yes/No?

No – just temporarily unavailable to plants

FACTORS AFFECTING RATE OF DECOMPOSITION

TEMPERATURE	• Microbial activity responds exponentially to increased temperature until enzymes denature, etc.
MOISTURE	• Microbial activity has optimum moisture • Low moisture = dessication, slow diffusion • High moisture = low O2 availability; no lignin degradation
pH	• Most microbes exhibit optimum activity near pH 7. • Fungi most active in acid soil and bacteria in moderate soil pH.

Non-environmental Factors Affecting Decomposition

- "Quality" of the organic matter
  (C:N, lignin, water solubility)
- Placement of the material
- Tillage

Temperature, moisture, P loss, NH_3

Major Environmental Factors

Soil Temperature:

Mineralization slows below 50 F,

Rate doubles for every 15 rise in temperature (Q_{10})

Soil Moisture:

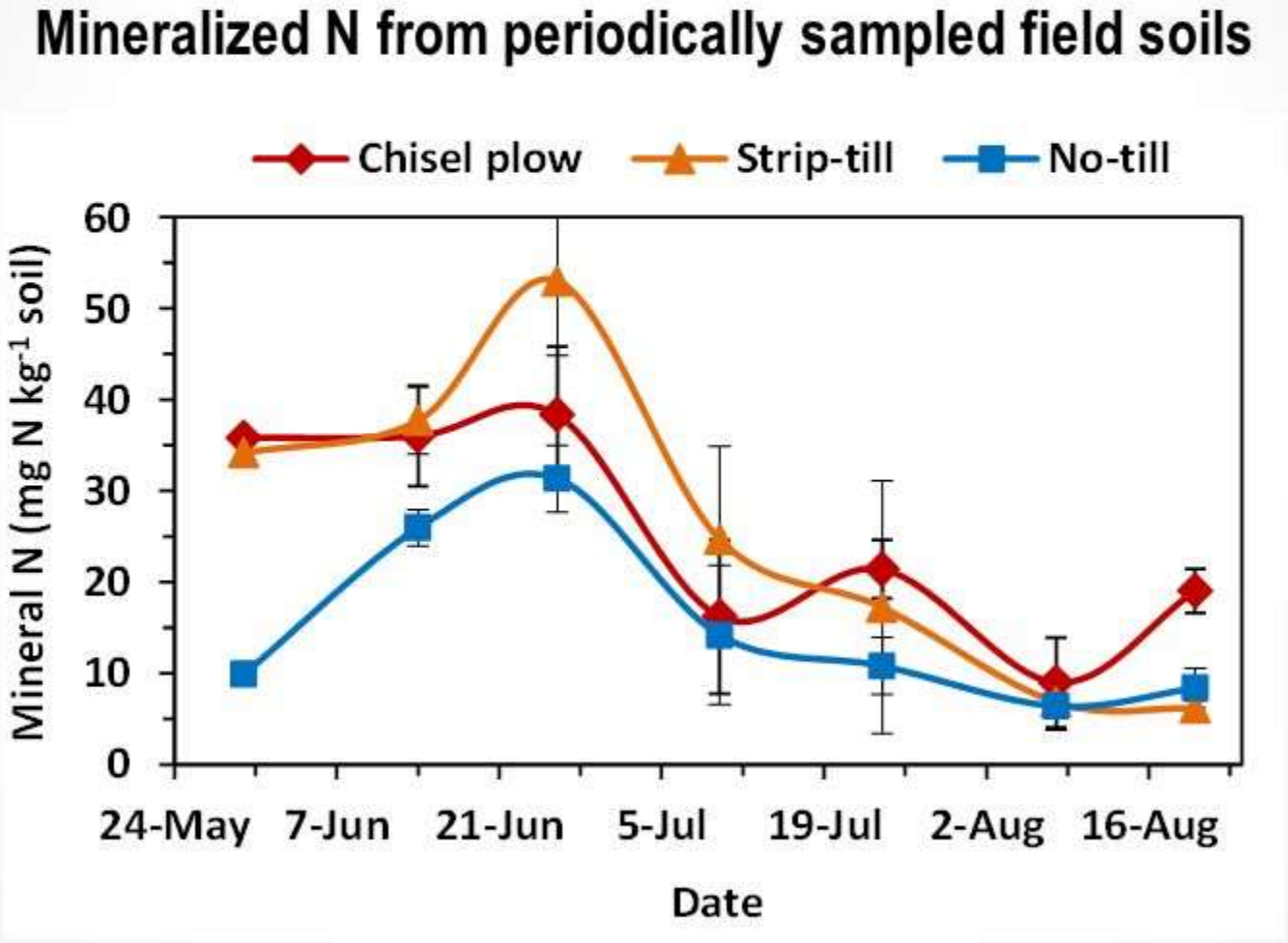
Excessively dry or wet inhibit mineralization

Tillage:

Stimulates a temporary increase in mineralization lasting for days or weeks

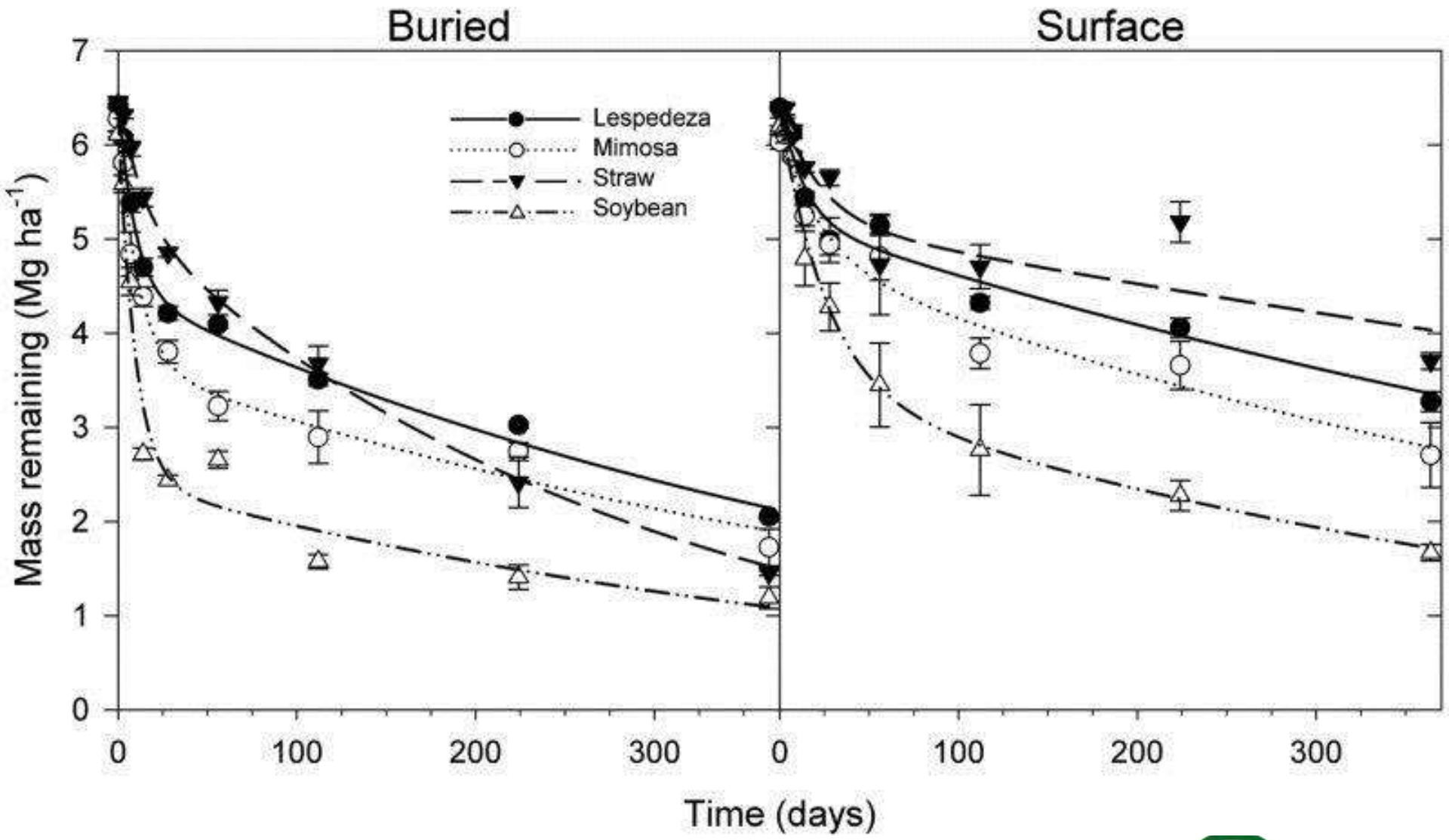
Rule of Thumb: Where most plants thrive, mineralization is rapid

Tillage Increases N Mineralization Rate



(Chen, et al., unpublished data, the project funded by **USDA-NIFA** ORG program)

Cover Crop Decomposition: Placement



Mulvaney et al. Agronomy Journal 102:1425-1433

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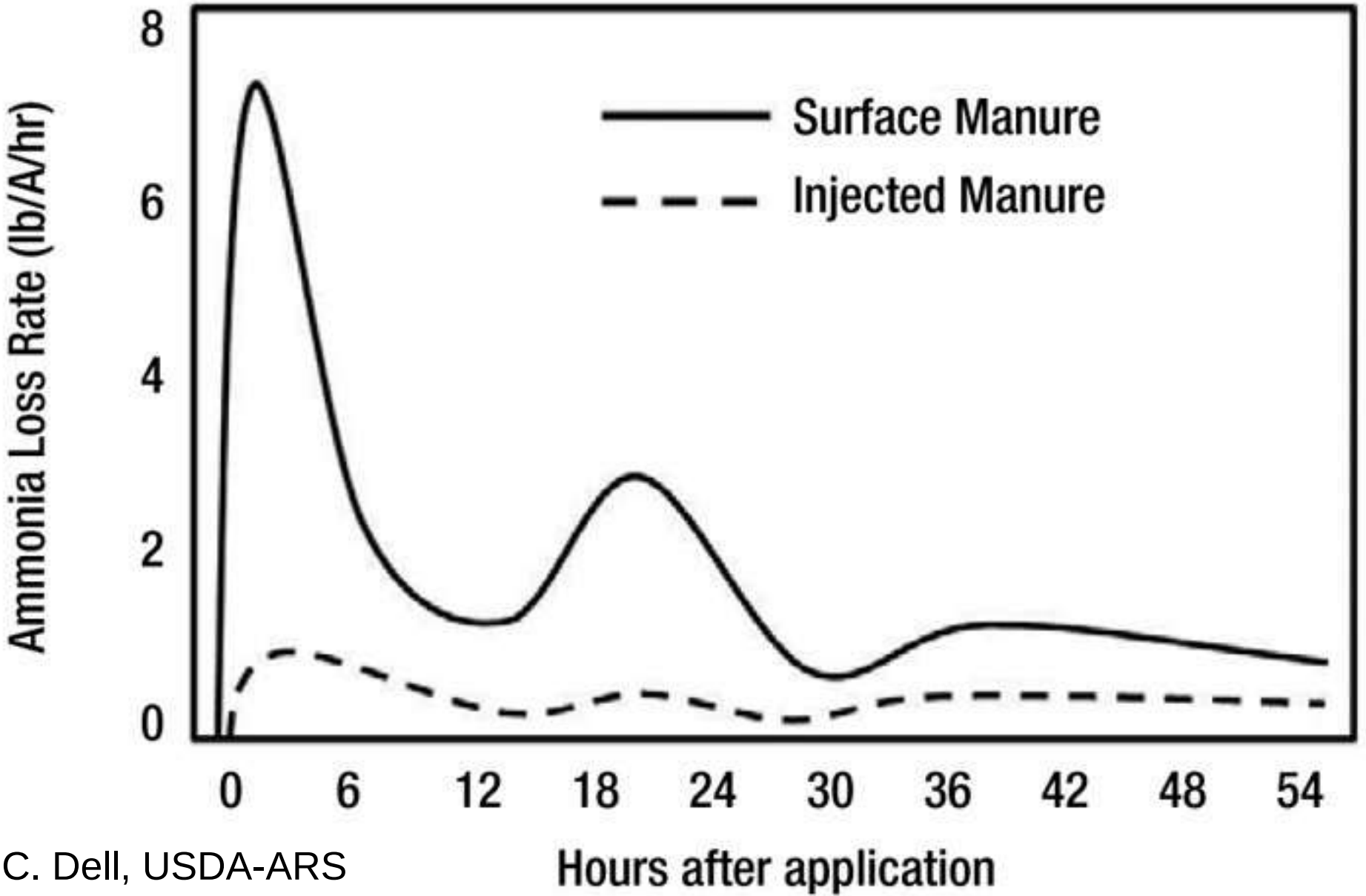
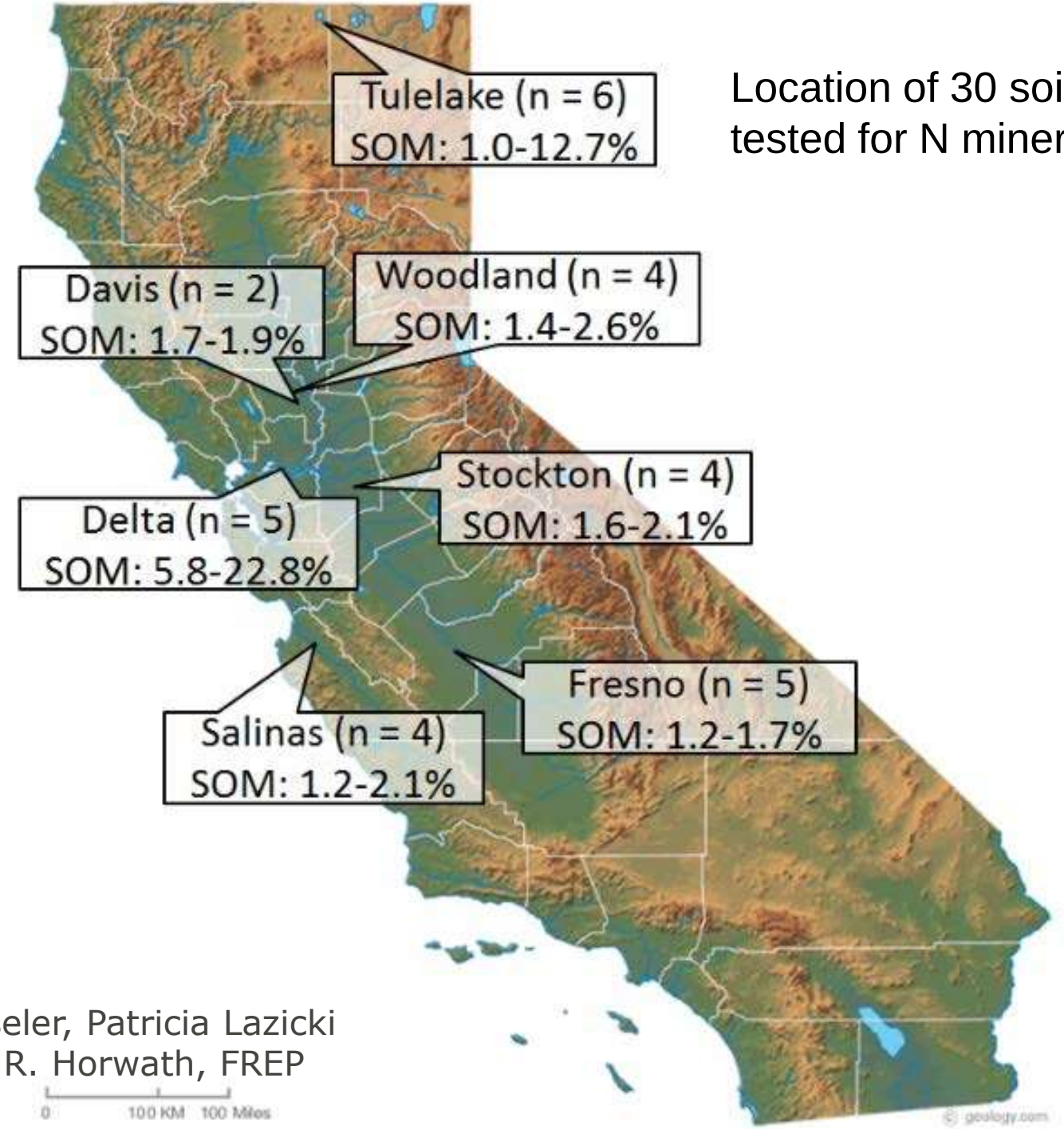
Ammonia volatilization:

Surface-applied and injected dairy manure



C. Dell, USDA-ARS



Location of 30 soils tested for N mineralization

Daniel Geisseler, Patricia Lazicki and William R. Horwath, FREP

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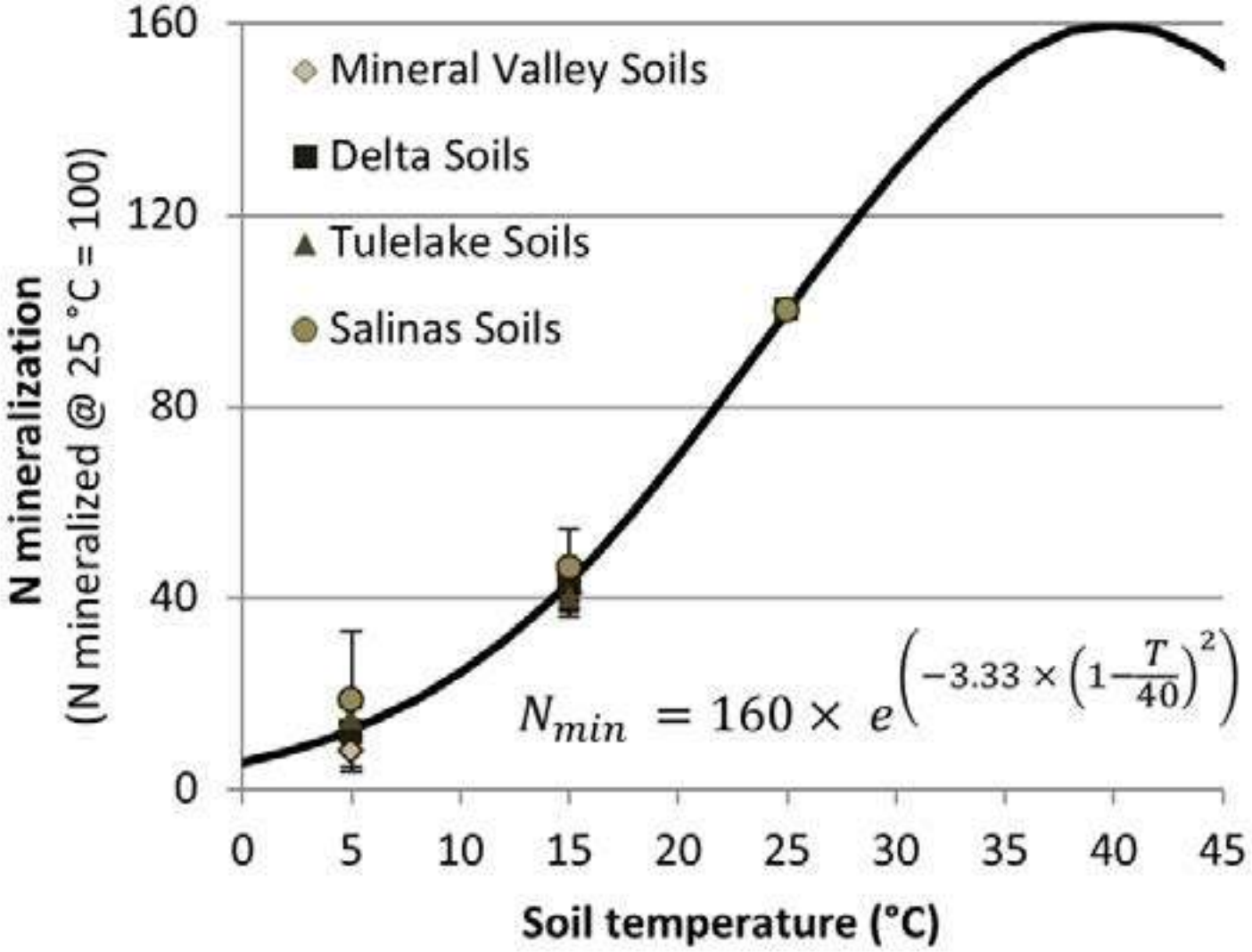
Soil temperature impacts N mineralization of 30 California soils



Daniel Geisseler, Patricia Lazicki and William R. Horwath, FREP

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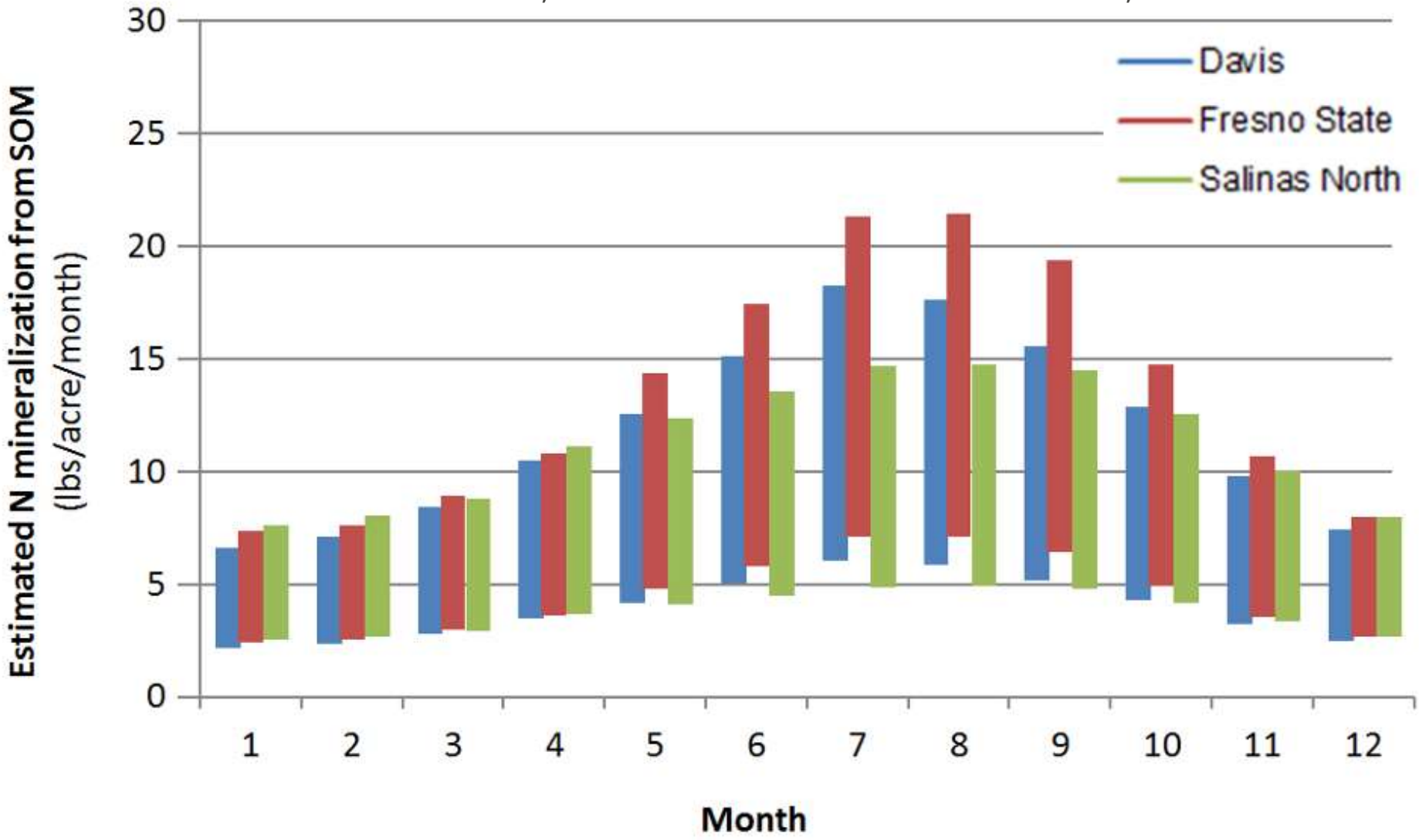
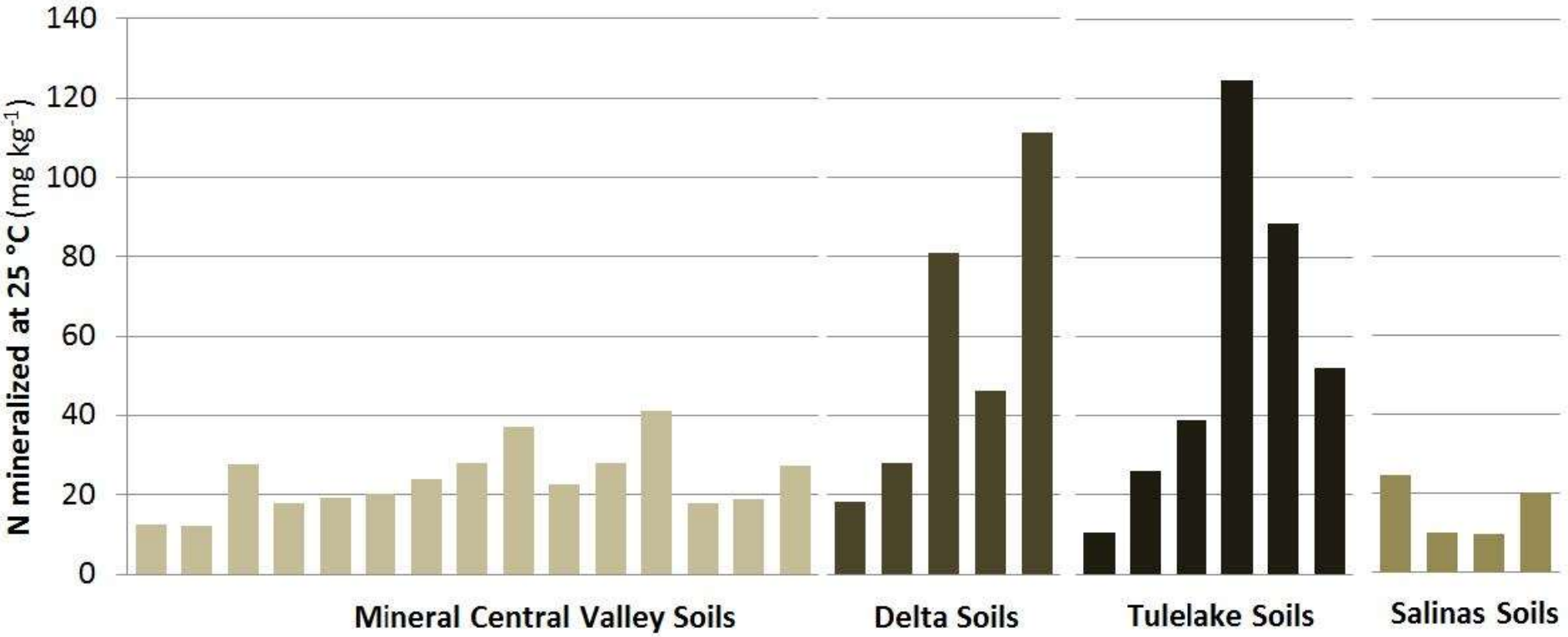
Estimated monthly N mineralization rates from soil organic matter

(Monthly average temperature 2% organic matter content in the top foot)

Daniel Geisseler, Patricia Lazicki and William R. Horwath, FREP



Estimating soil nitrogen mineralization for fertilizer adjustments:



Daniel Geisseler; 2017
http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=23500

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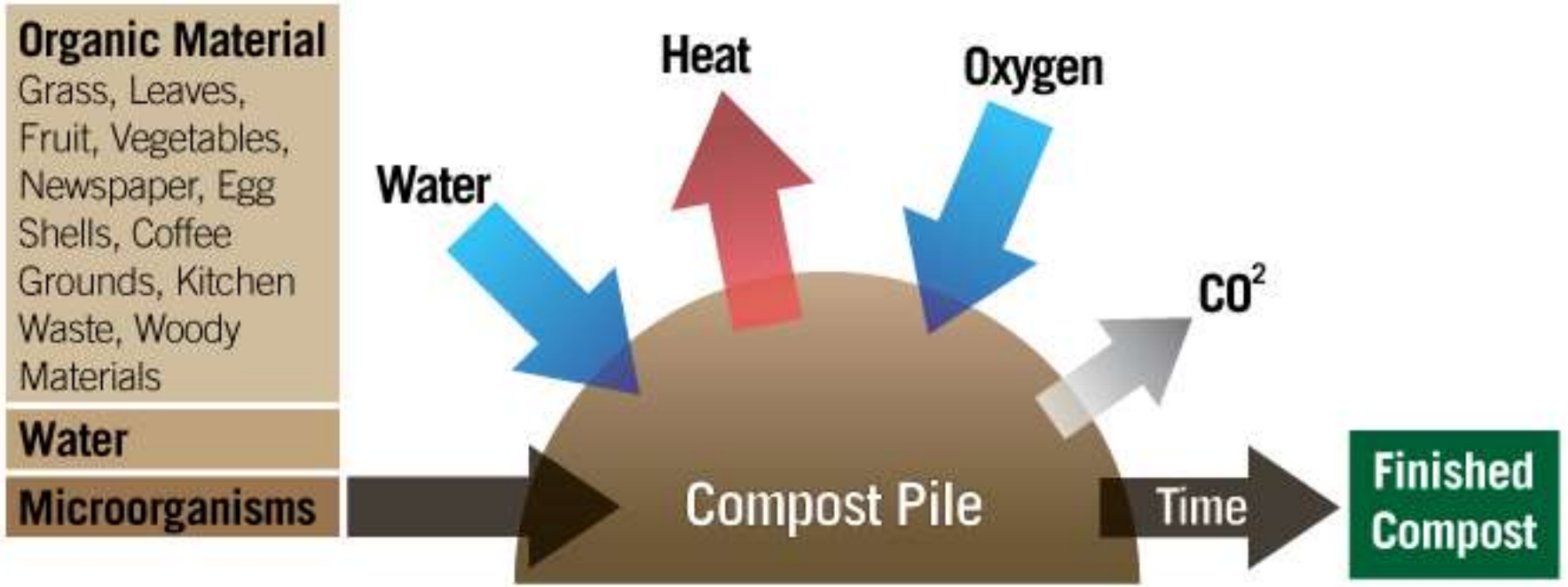
COMPOST

Benefits

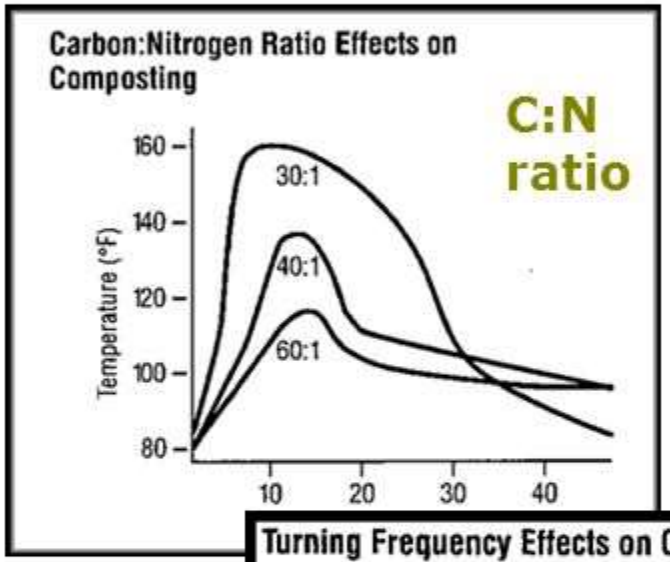
- Nitrogen Contribution
- Slow-release Nutrition
- Organic Matter
- Microbial Stimulation, Pathogen Reduction
- Soil Physical Properties
- Soil Water-holding Capacity

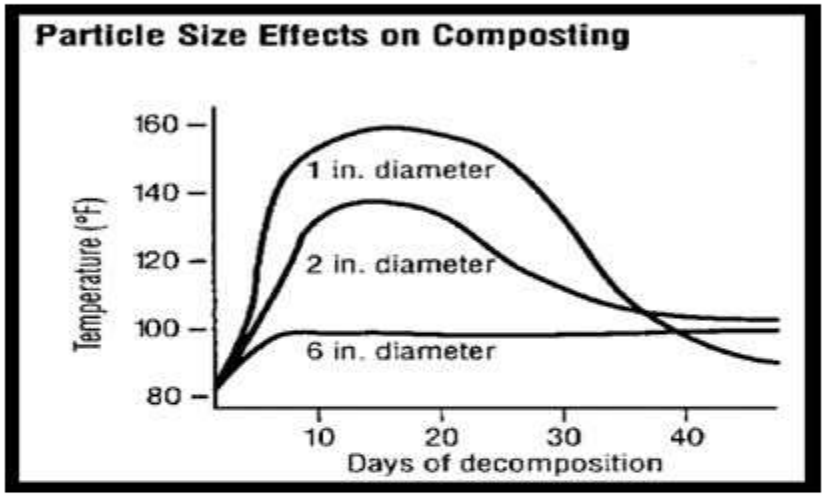
Challenges

- Cost
- Reduced Nutrient Value
- Quality

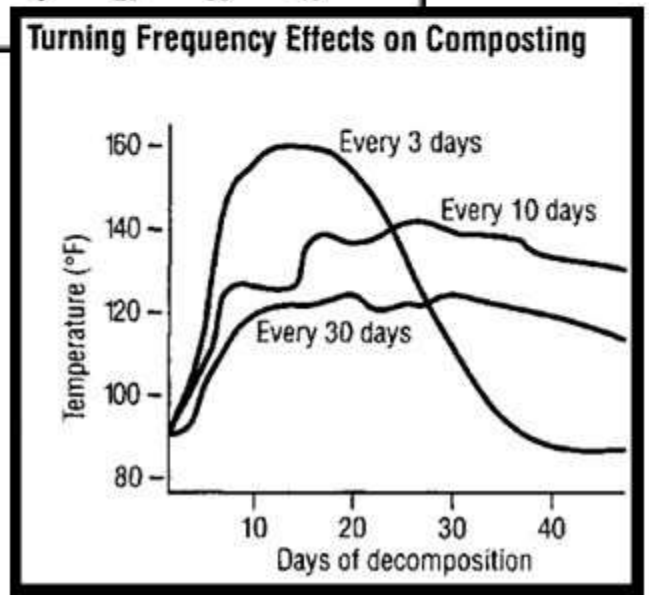

Organic Material
Grass, Leaves, Fruit, Vegetables, Newspaper, Egg Shells, Coffee Grounds, Kitchen Waste, Woody Materials
Water
Microorganisms
Heat
Oxygen
Water
CO^2
Compost Pile
Time
Finished Compost

Factors affecting the compost process





Aeration



Size and texture

Moisture also critical

Compost Maturity

Very Immature	**C/N ratio greater than 25, and/or stability test is greater than 12, and/or NH_4 is greater than 500 and no nitrate present.**
Immature	**Unstable compost** **Odors likely** **High toxicity potential** **Immobilization (tie-up) of available nitrogen**
Moderately Mature	**Stability test greater than 6 and less than 8 and/or when nitrate is detected and is greater than 25 ppm N.**
Mature	**Cured compost** **Odor production not likely** **Limited toxicity potential** **Positive impact on available soil nitrogen**
Very Mature	**Well-cured compost** **No continued decomposition** **No odors**

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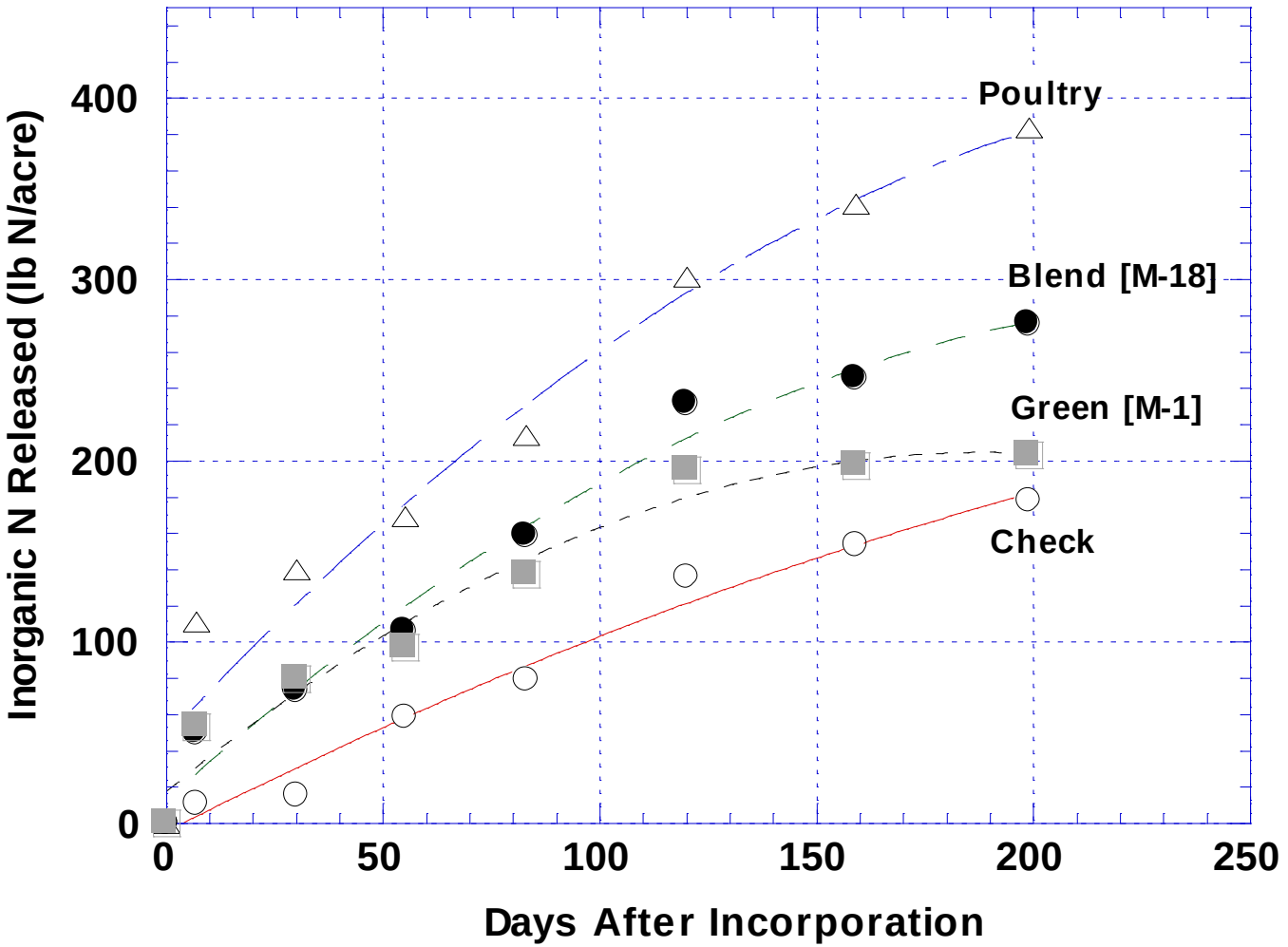
Inorganic N release – Spring and summer 2000



Marc Buchanan, 2002.
Compost Maturity and Nitrogen Release Characteristics in Central Coast Vegetable Production

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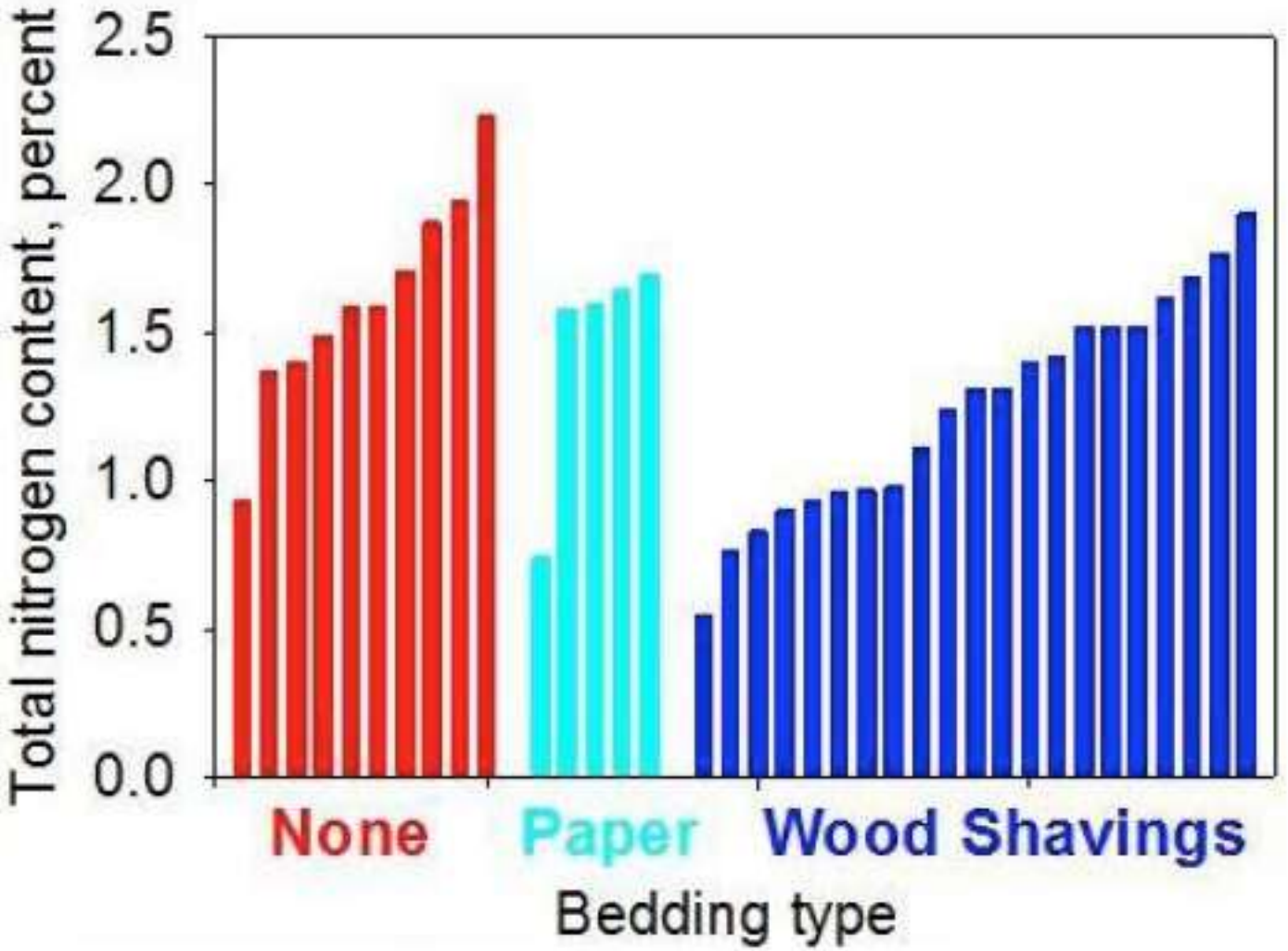
Range of N concentration in horse manure from 37 farms

King County, Washington



Andy Bary et al. , 2016

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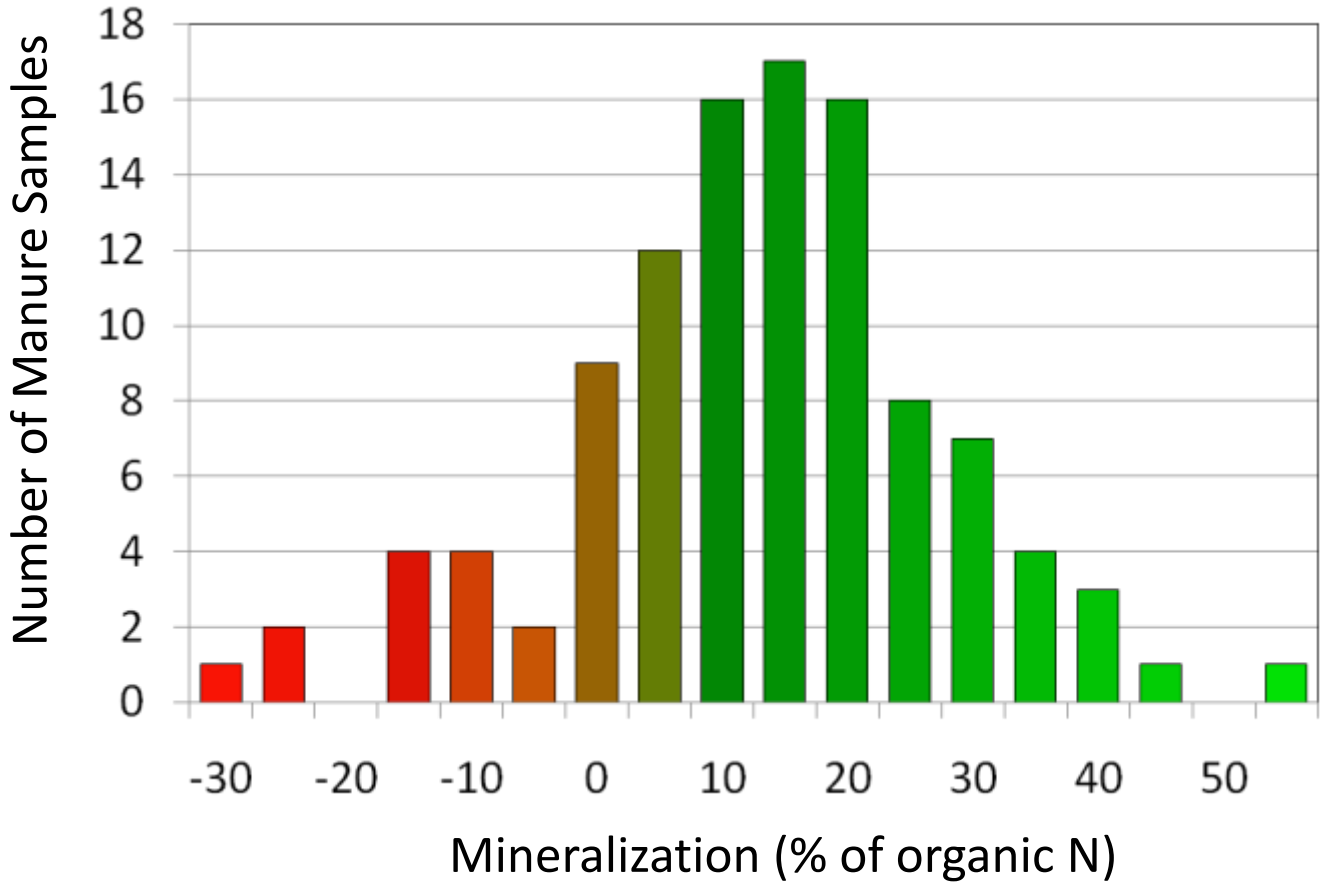
Nitrogen mineralization from 107 individual dairy manure samples after 8 weeks of incubation



Van Kessel and Reeves, 2002. Biol. Fertil. Soils. 36:118-123

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Estimated availability of organic N in manures

(Pettygrove et al., 2009)

Manure type	% applied organic N mineralized		
	Initial 4-8 weeks	Year 1	Year 2
Dairy lagoon water	15-35	40-50	15
Dairy lagoon sludge and slurry; corral manure	10-20	20-30	15
Dairy mechanical screen solids	5-15	10-20	5
Aerobically composted cattle or horse manure (finished or mature)	0-7	0-10	5
Solid poultry manure	20-35	50	15

Manure Technical Bulletin Series
University of California Cooperative Extension

Manure Nitrogen Mineralization

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Table 1. Guidelines for animal manure N mineralization in California.

	Year 1	Year 2
	- % applied organic N mineralized-	
Dairy lagoon water	40-50	15
Dairy lagoon sludge and slurry; corral manure	20-30	15
Dairy mechanical screen solids	10-20	5
Aerobically composted cattle or horse manure (finished or mature)	0-10	5
Solid poultry manure	50	15

Stu cautions:

Annual mineralization factors are useful where only one crop per year is grown and where only short time periods are available each year for manure application.

Annual factors are less satisfactory in regions with mild winters and year-round crop production where manure can be applied at almost any time of the year.

Manure Nitrogen Mineralization. 2009. Univ Calif Coop Ext.

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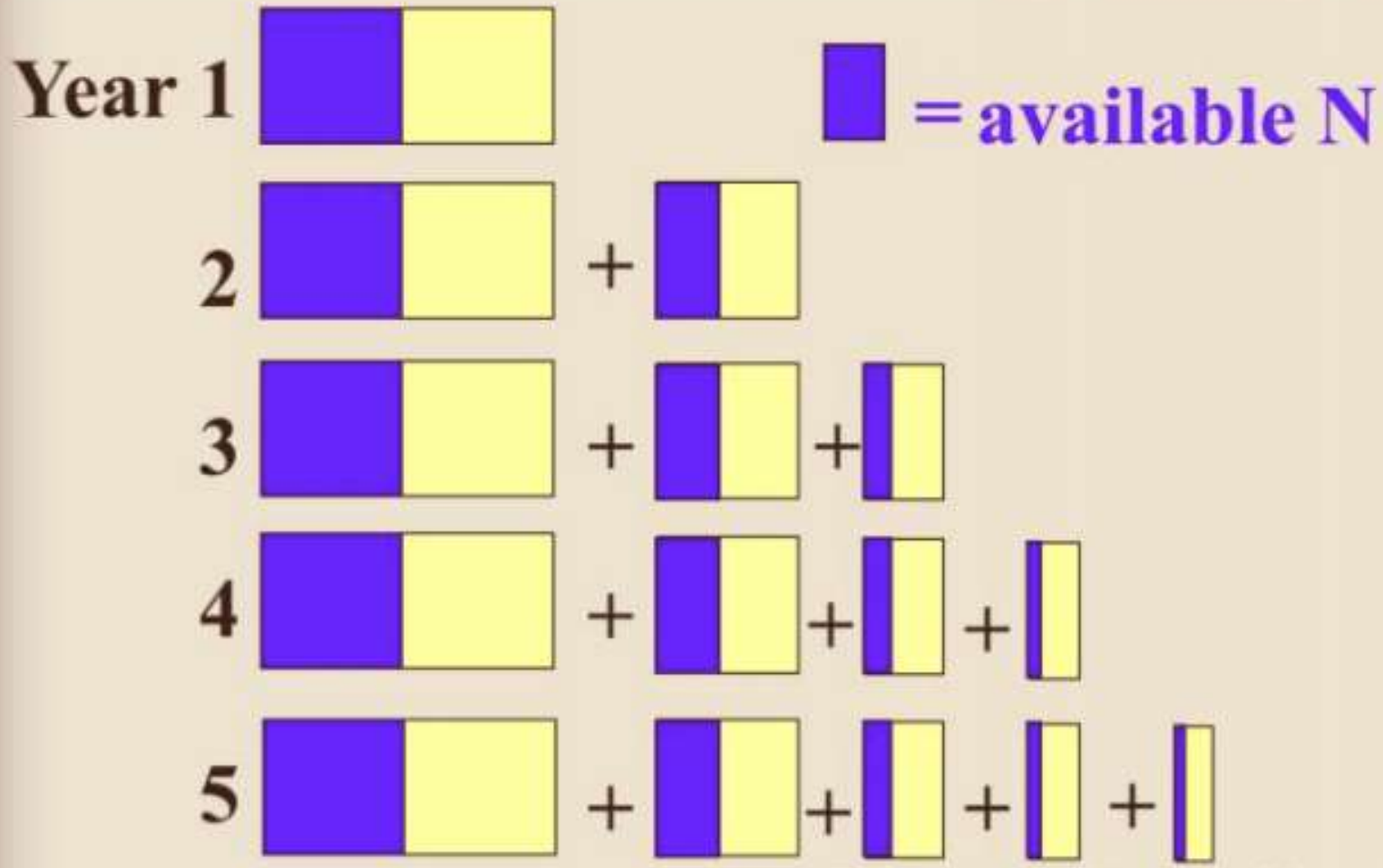
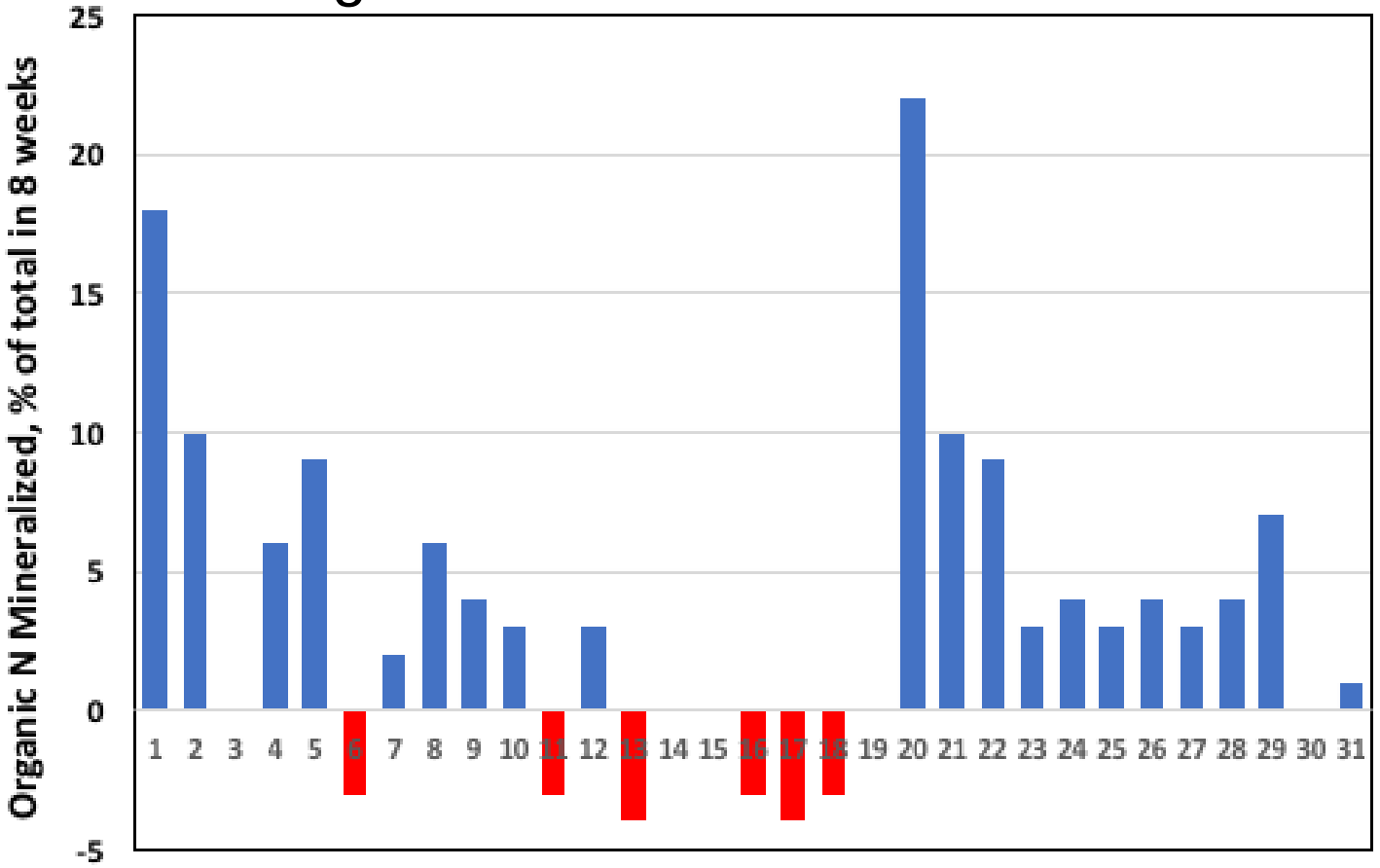
WASHINGTON STATE UNIVERSITY
EXTENSION

Cumulative available N from an organic source



Courtesy of Dan Sullivan, OSU

Mineralization of the organic N fraction of 31 organic fertilizer materials following 8 weeks of incubation in Yolo silt loam



Nitrogen and Carbon Mineralization Dynamics of Manures and Composts
(Hartz et al., 2000; HortSci 35:209-212)

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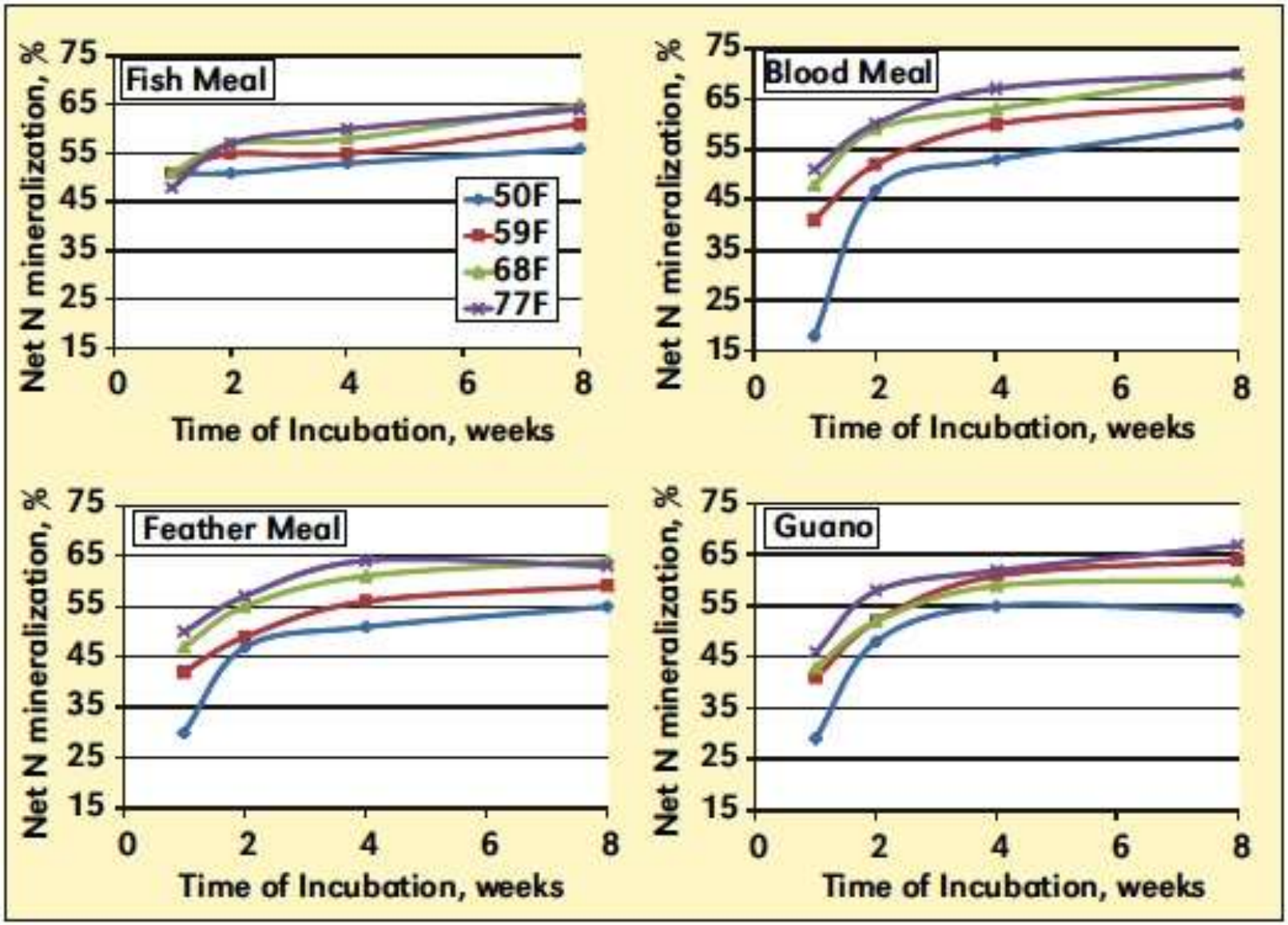
N Mineralization of Commercial Organic Fertilizers



Hartz, UCD

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Cover Crops: A 4 to 6-month cover crop (legume mix) adds between 100 and 200 lb/acre N to the soil for the succeeding crop.

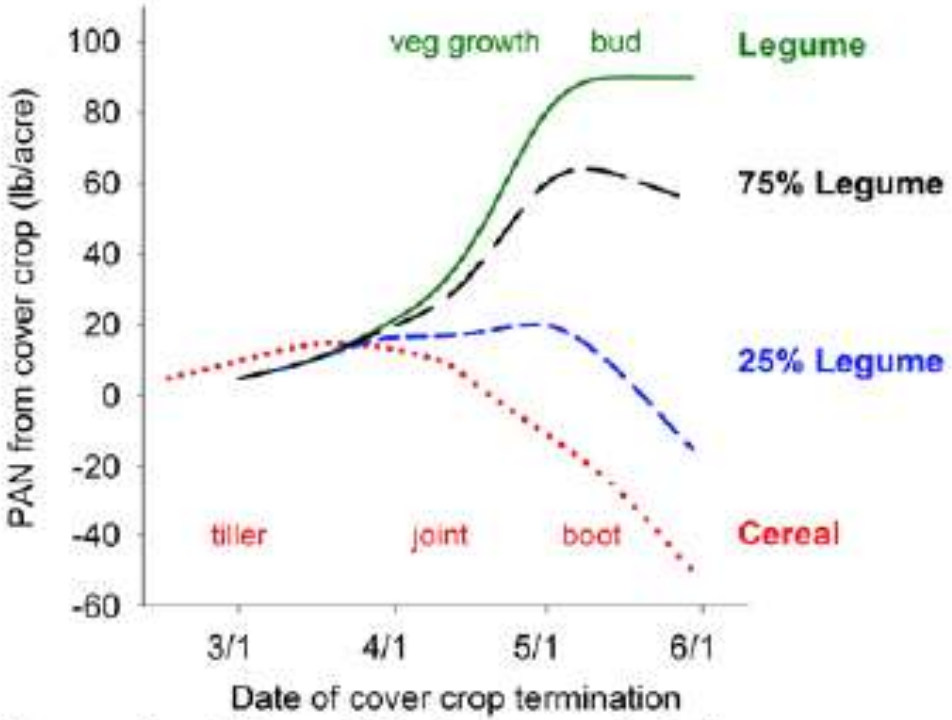

FIgure 4.—Effect of kill date on typical plant-available N (PAN) release from cereal, legume, or mixed stands. Based on compilation of field data from Willamette Valley cover crop trials. Source: D. Sullivan.

Species Composition

Sampling Methods Published

Kill Date (herbicide or tillage)

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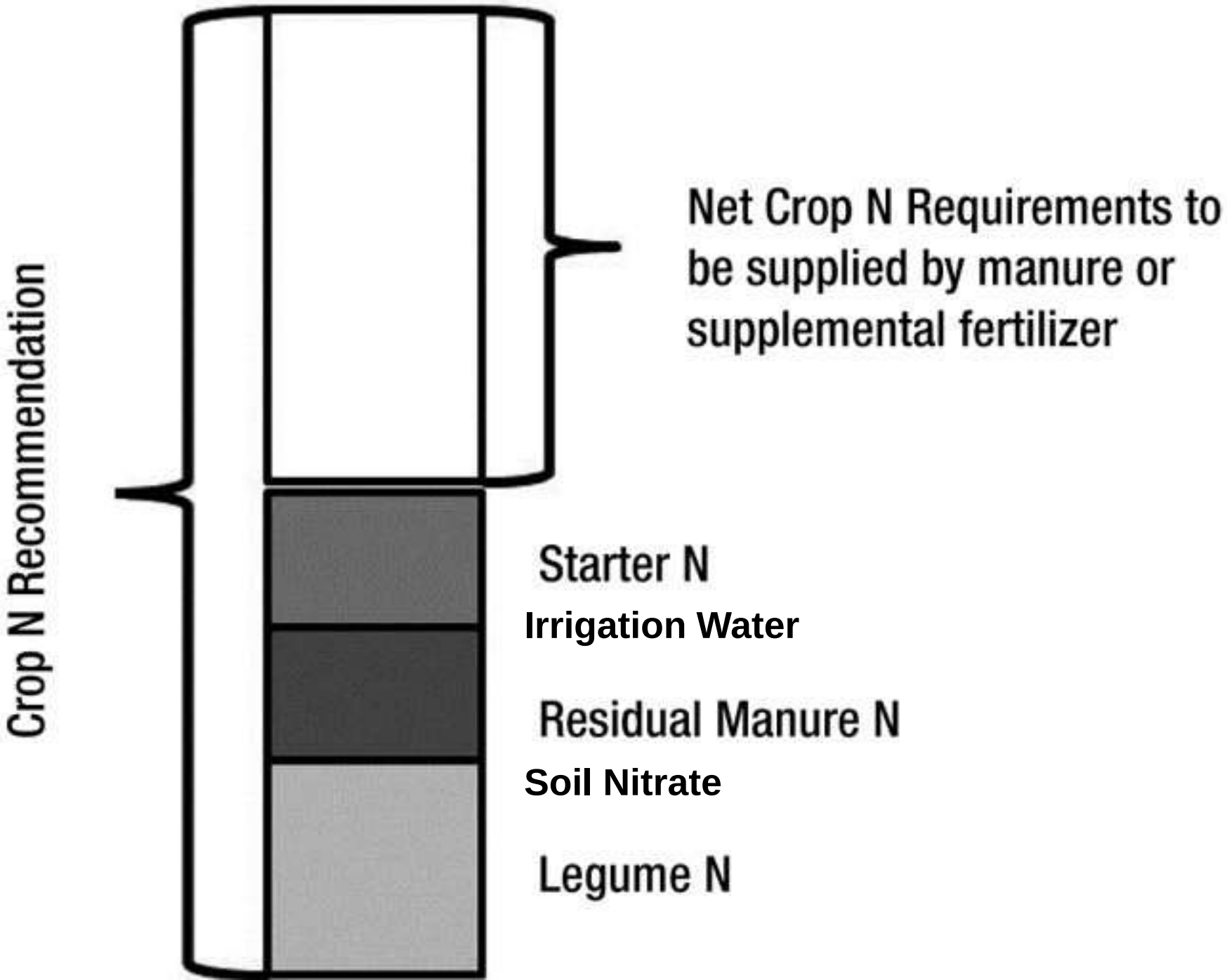
Crop N Recommendation
Net Crop N Requirements to be supplied by manure or supplemental fertilizer
Starter N
Irrigation Water
Residual Manure N
Soil Nitrate
Legume N

Summary from Richard Smith's FREP report yesterday:

- Uncertain rates of N release from organic fertilizers due to the variable effects of temperature, fertilizer placement and fertilizer N concentration

- Difficulty synchronizing N release from soil and organic fertilizers with the high crop N demand over the last half of the crop cycle

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Theoretical N availability from organic materials vs crop demand

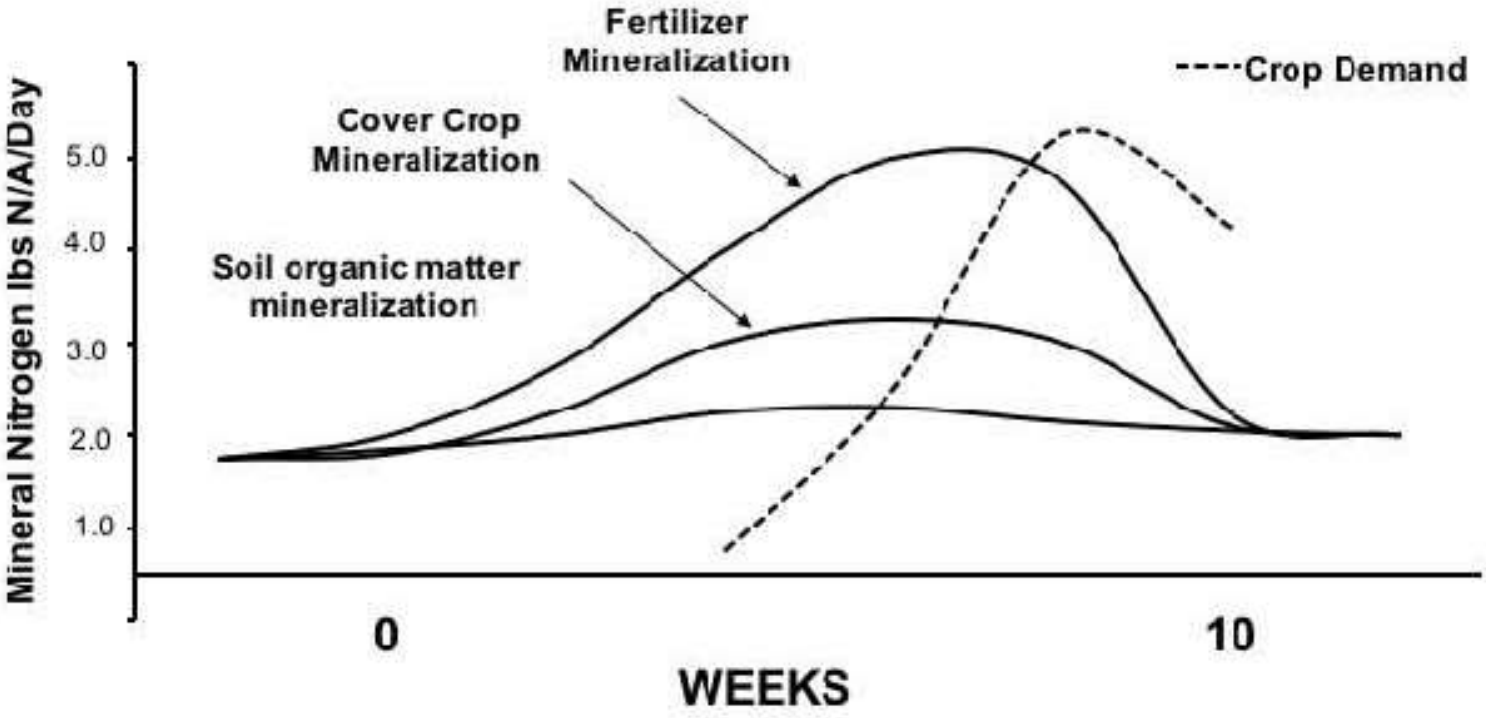
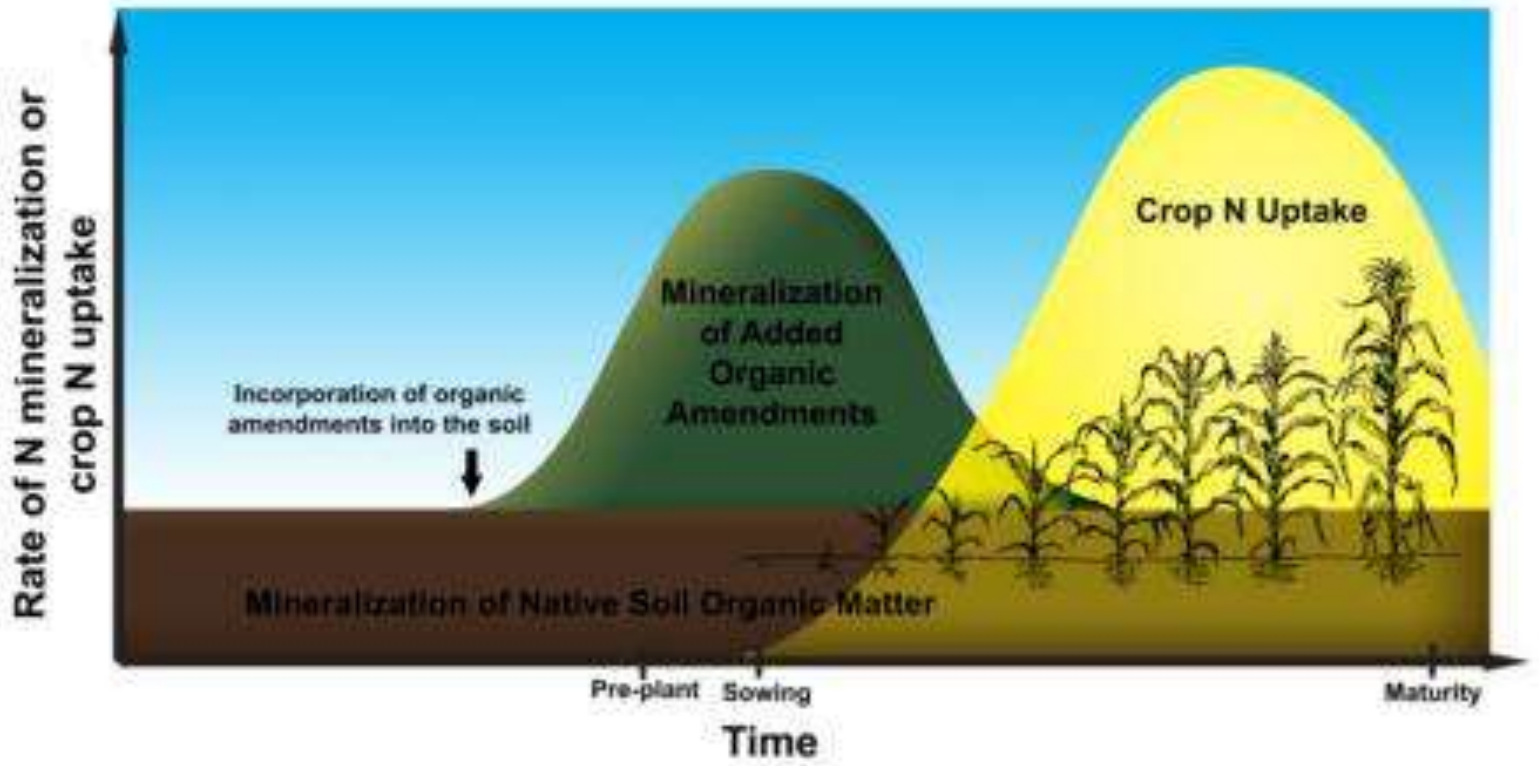
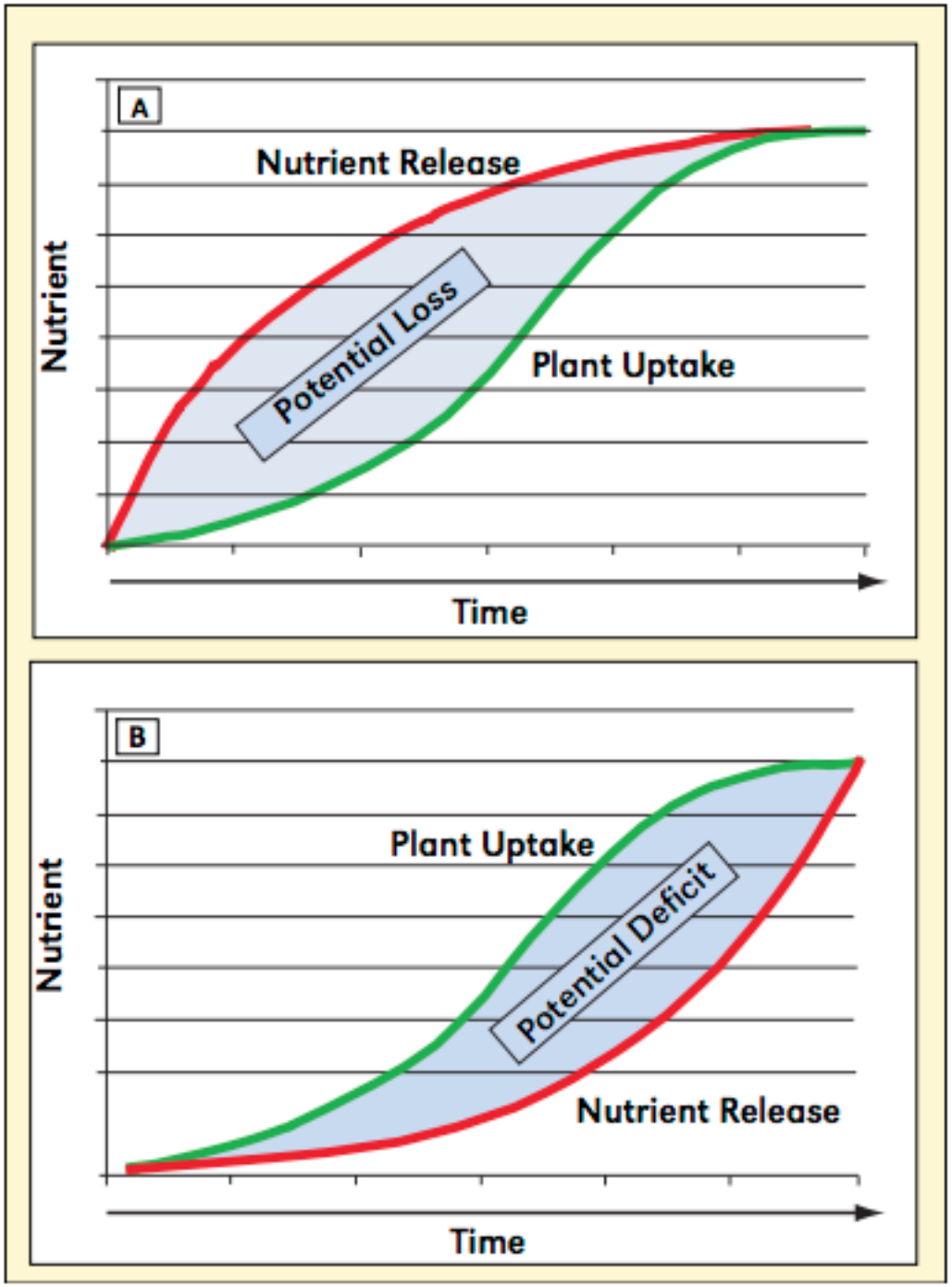


Figure 3. Theoretical depiction of N supplied to a crop from mineralization of soil organic matter, mineralization of crop residues and organic fertilizers

- Richard Smith et al. 2017


Rate of N mineralization or crop N uptake
Crop N Uptake
Mineralization of Added Organic Amendments
Incorporation of organic amendments into the soil
Mineralization of Native Soil Organic Matter
Pre-plant
Sowing
Maturity
Time

Synchrony



N release too fast

N release too slow

Nitrogen Sources for Organic Crop Production
By Robert Mikkelsen and T.K. Hartz
Better Crops, 2008

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Nitrogen Release from Organic Materials

- Because mineralization can be unpredictable & uncontrollable:
  - Nutrients released at times when plant need is not high resulting in build up of nutrients & salts in soil
  - Nutrients released too slow to meet the N demand of growing crop
  - Organic nutrient sources are often over applied to insure adequate N available for good crop yields

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UC strategies recommended for managing N in fields having a history of regular manure applications:

1. In fields with a history (at least 3-7 years in most of California) of regular manure additions, reduce manure application rates to the point that total manure N applied is approximately equal to projected crop demand.

During periods of high crop N demand, apply carefully targeted doses of N using fertilizers or manures having high NH_4 and low organic N, e.g., poultry manure or dairy lagoon water that has gone through a solids separation treatment.

2. Use soil nitrate testing before applying fertilizer or manure, e.g., in spring.

3. Use plant tissue N sampling.

4. Use post-harvest soil nitrate testing with deep (3-4 ft) samples.

5. Establish check strips from which manure and N fertilizer applications are excluded, and use these check strips for soil and plant sampling and yield measurement.

6. Re-examine ways to reduce leaching of nitrate past the root zone.

Manure Nitrogen Mineralization UC Cooperative Extension Manure Technical Bulletin Series, Pettygrove 2009.

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Calculating the Application Rate

All the excellent science and sophisticated modelling of N availability is lost by ignoring the simple things:

Calibrate the Spreader!

Testing, Testing, Testing

Careful monitoring is the key
to using any nutrient the “Right Way”

From Dan sullivan>

Nitrogen fertilizer replacement value. This value for a particular compost can b
estimated using its inorganic nitrogen content. The organic nitrogen in compost
decomposes very slowly in soil after application, and can be ignored in
estimating short term N fertilizer replacement value.

A compost that contains 0.1 percent inorganic nitrogen (1000 ppm N) on a dry
weight basis contains 2 pounds inorganic nitrogen per dry ton, or about 0.5
pounds of inorganic nitrogen per cubic yard of compost.

So, if you apply 3 cubic yards of compost per 1,000 square feet (about an inch
depth) of this compost, you apply the equivalent of 1.5 lb inorganic nitrogen pe
1,000 square feet. This compost application would replace 3 pounds urea
fertilizer (46-0-0) per 1,000
square feet.

FERTILIZING WITH MANURE AND OTHER ORGANIC AMENDMENTS

By
Andy Bary, Senior Scientific Assistant, WSU Puyallup Research and Extension Center, Craig Cogger, Extension Soil Scientist Emeritus, WSU Puyallup Research and Extension Center, Dan Sullivan, Professor, Department of Crop and Soil Science, Oregon State University

Using Soil Testing to Adjust Application Rates