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Department of
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University of California, Davis
Climate Change • Sustainable Agriculture
Environmental Quality • Landscape Processes

Soil Organic Matter as a Source of Plant-Available Nitrogen

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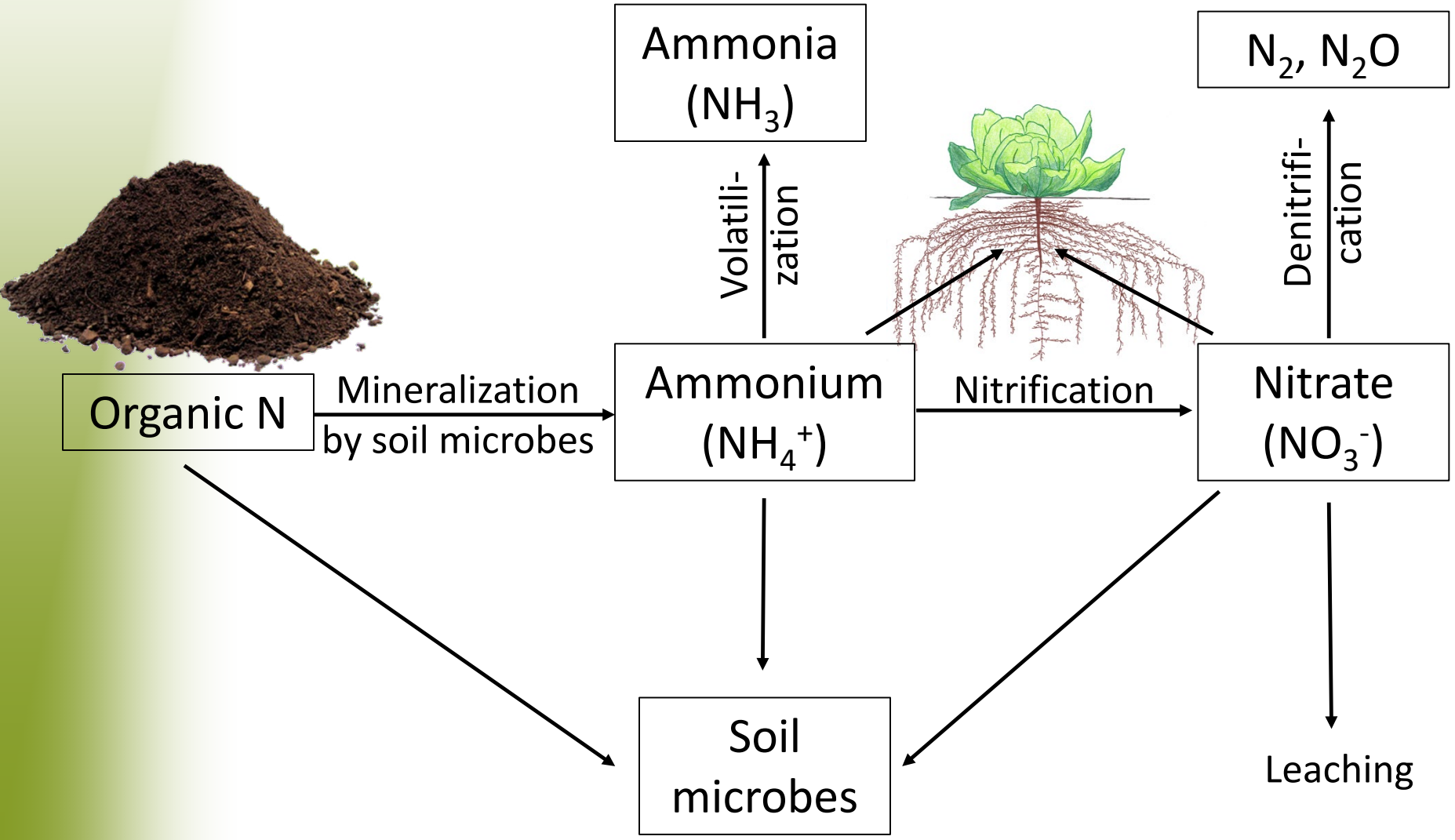
Content

- Background
- N mineralization from soil organic matter
  - How is N mineralization related to soil properties?
  - How does N mineralization change over the course of a year?
  - How much N is mineralized each year in Central Valley soils?

Nitrogen pools and turnover in soil



Plant available N in soil

Residual soil nitrate:

- Directly available form of N.
- Origin:
  - Mineralization of organic N in spring
  - Left over fertilizer N from previous crop

Potentially available N:

- Nitrogen mineralized during the season from soil organic matter and other sources

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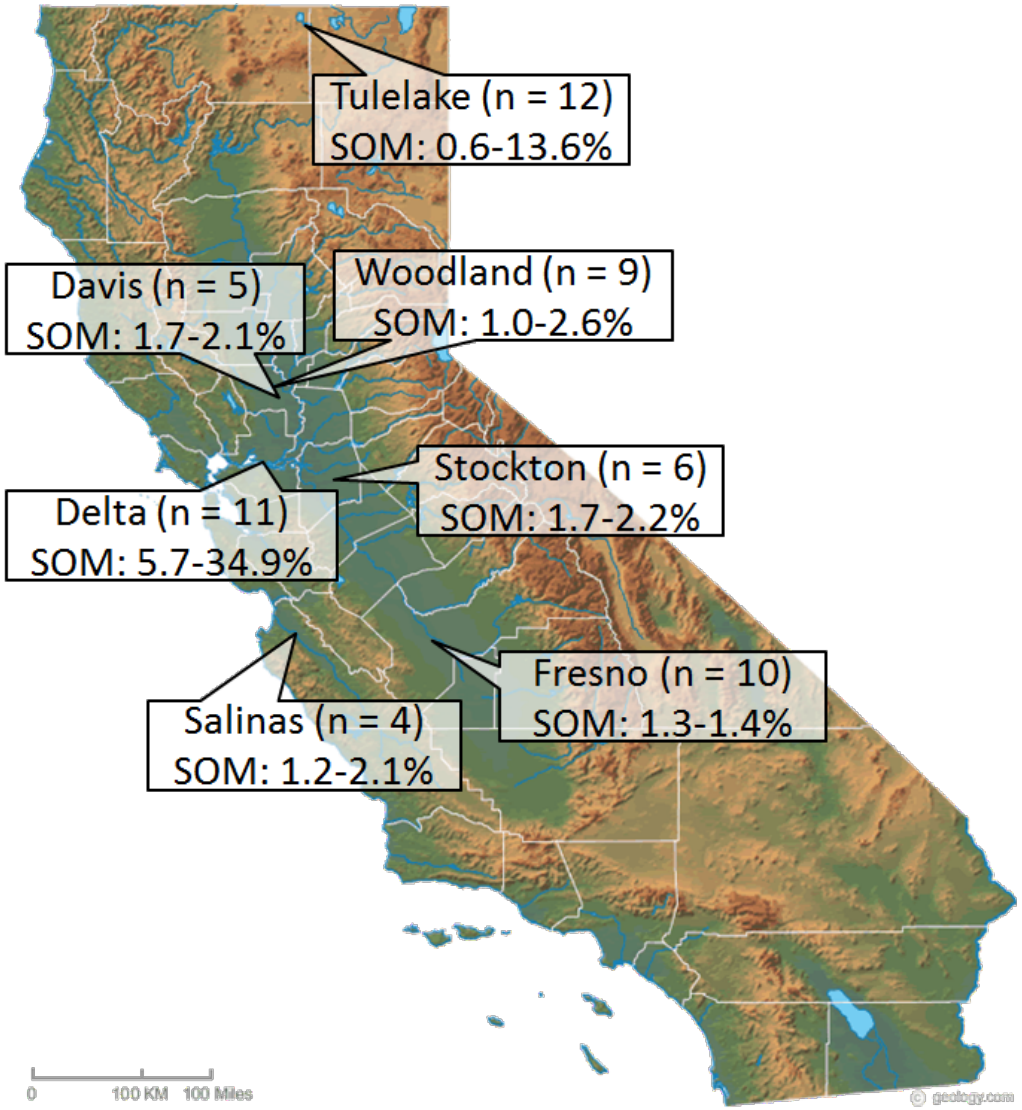
Nitrogen mineralization

- Soil microorganisms decompose residue
- Need N and C as building blocks for their own biomass
- C is also used as energy source
- **N mineralization:** Release excess N in the form of NH_4^+ into soil solution
- **N immobilization:** Uptake of NO_3^- or NH_4^+ from soil solution and incorporation into microbial tissue

Our study

- Undisturbed soil cores were sampled in spring 2016 and 2017 from 57 fields
- Additional samples for soil analyses were taken right next to the cores
- Cores were kept at optimal moisture content and 41, 59, or 77 °F for 10 weeks
- Increases in ammonium and nitrate during these 10 weeks were determined

Study locations



Soil analyses

- pH
- Electrical conductivity (EC)
- Texture
- Bulk density
- Total C and N
- Particulate organic C and N
- Permanganate oxidizable C
- FDA hydrolysis
- Pyrophosphate Extractable Fe
- Dithionite Extractable Fe

- Net N mineralization

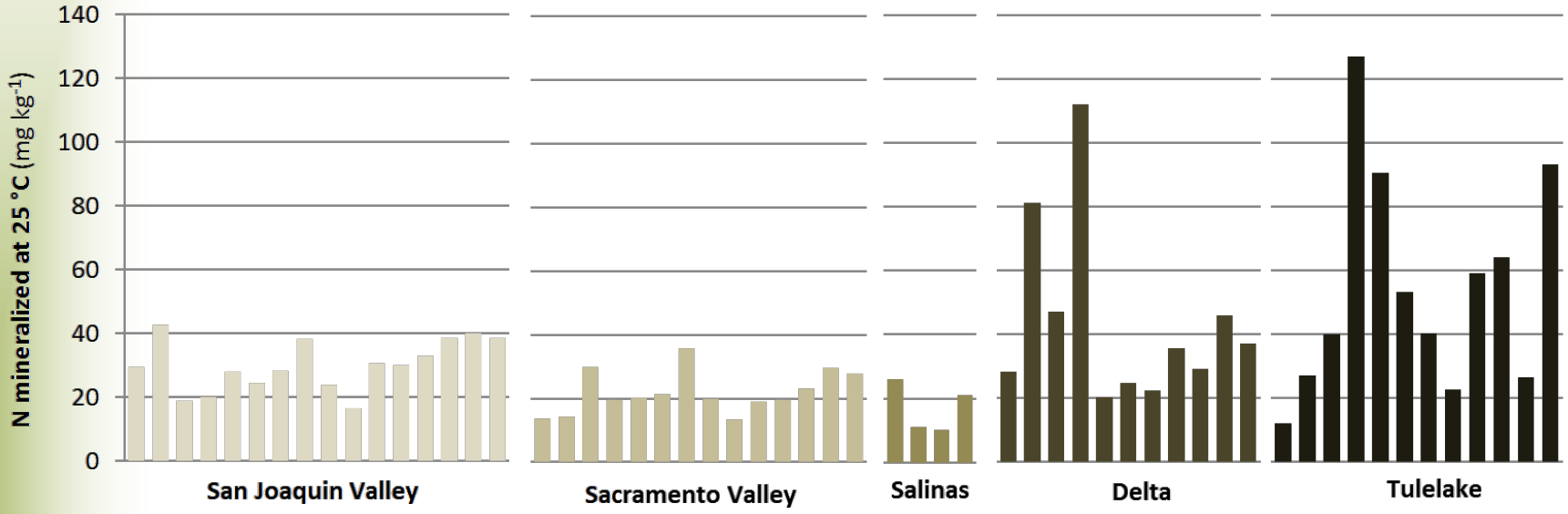
Soil characteristics

(Average with range in parentheses)

Region	Number of sites	SOM (%)	pH	EC (dS m^{-1})	Sand (%)	Clay (%)
Salinas Valley	4	1.6 (1.2 - 2.1)	7.5 (7.2 - 7.7)	0.2 (0.1 - 0.2)	47 (38 - 60)	16 (12 - 21)
Sacramento Valley	14	1.9 (1 - 2.6)	7.7 (7.2 - 8.1)	0.2 (0.1 - 0.3)	26 (5.5 - 65)	29 (11 - 59)
Northern San Joaquin Valley	6	2.0 (1.7 - 2.2)	7.6 (7.2 - 7.9)	0.2 (0.1 - 0.5)	16 (12 - 31)	38 (30 - 44)
Southern San Joaquin Valley	10	1.6 (1.3 - 2.0)	7.6 (7.2 - 8.1)	1.3 (0.4 - 2.5)	27 (8.7 - 35)	36 (20 - 49)
Delta	11	15.6 (5.7 - 34.2)	6.5 (5.9 - 7.3)	0.3 (0.1 - 0.6)	10 (0.9 - 19)	43 (32 - 61)
Tulelake	10	8.6 (5.4 - 13.5)	7.1 (6.2 - 7.6)	0.4 (0.1 - 1.0)	8 (2.3 - 16)	56 (49 - 69)

Miller et al., 2019

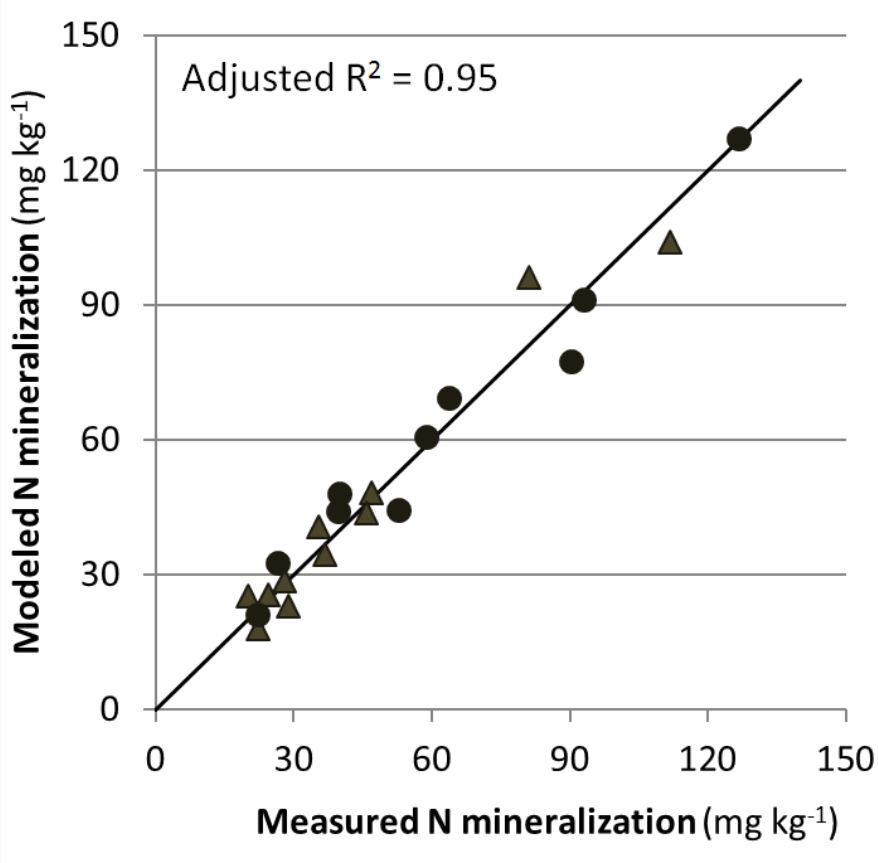
N mineralization rate in undisturbed soil cores



The cores were kept at 77 °F and a soil moisture content near field capacity for 10 weeks

Miller et al., 2019

Soil properties and N mineralization: Soils with a high SOM content

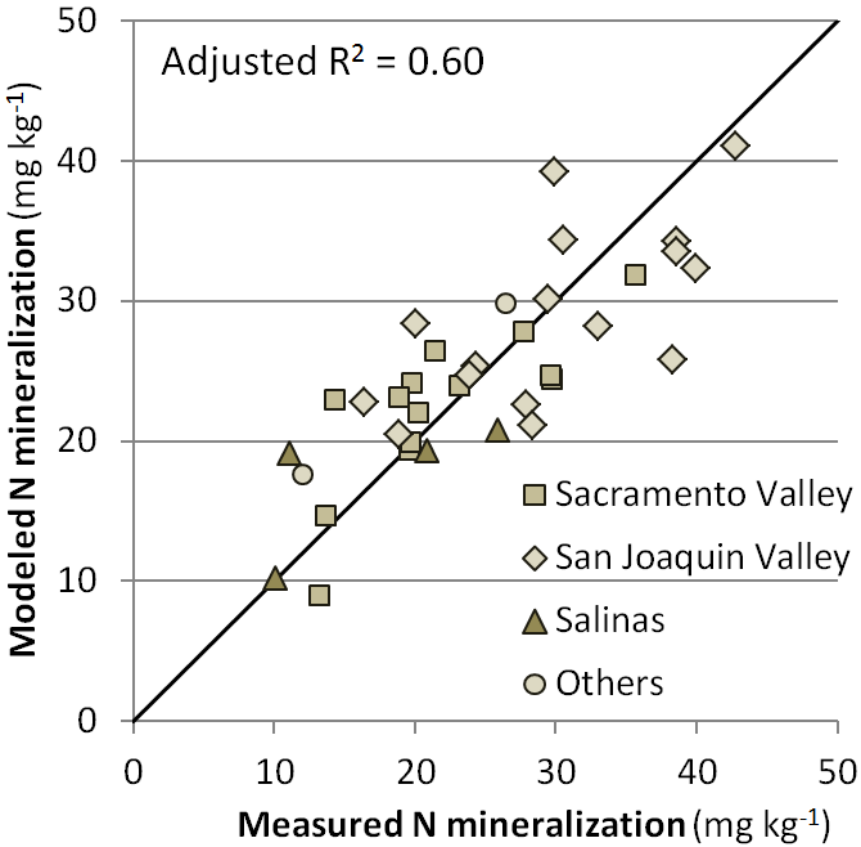


Relevant soil properties:

- Total carbon
- Total nitrogen
- Particulate organic matter
- Sand

Miller et al., 2019

Soil properties and N mineralization: Soils with a low SOM content



Relevant soil properties:

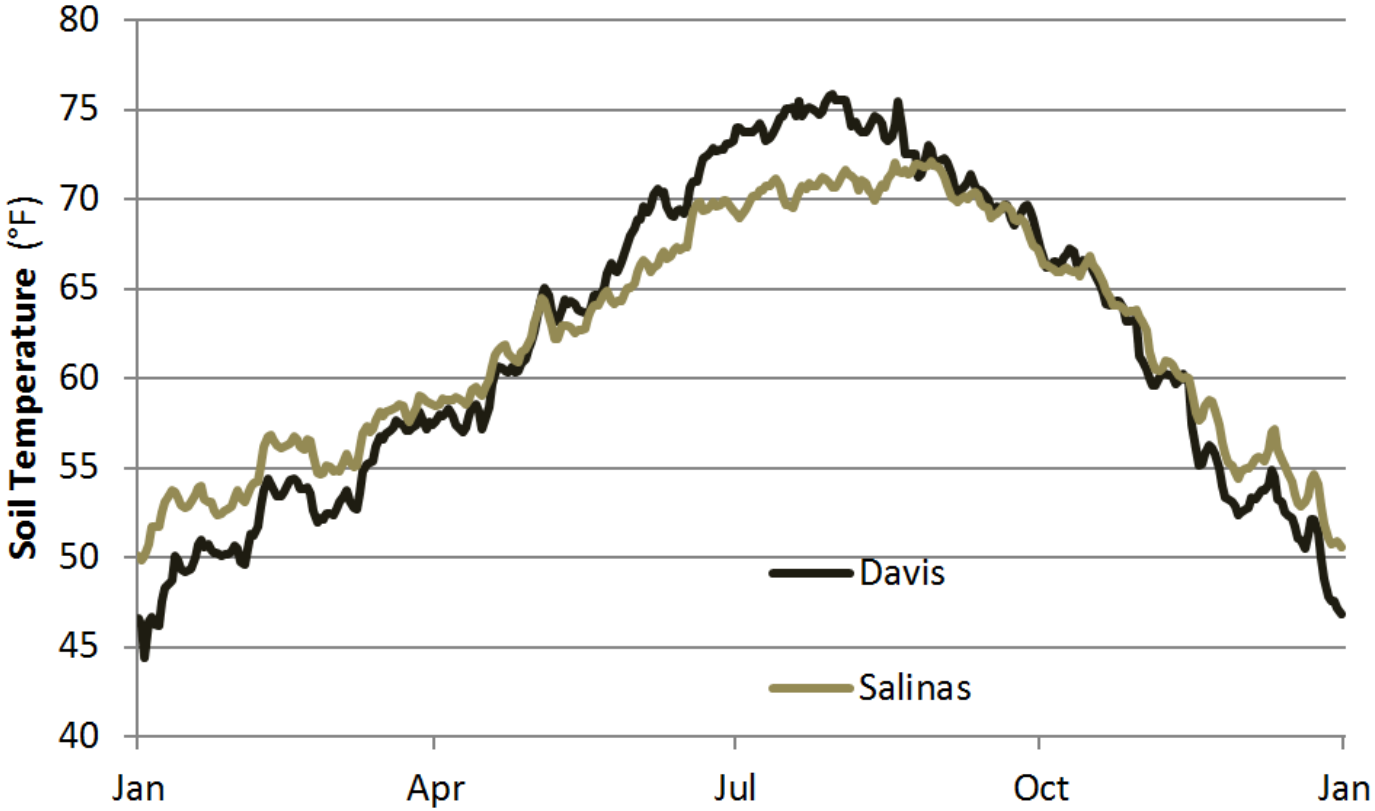
- Total carbon
- FDA hydrolysis
- Silt

Miller et al., 2019

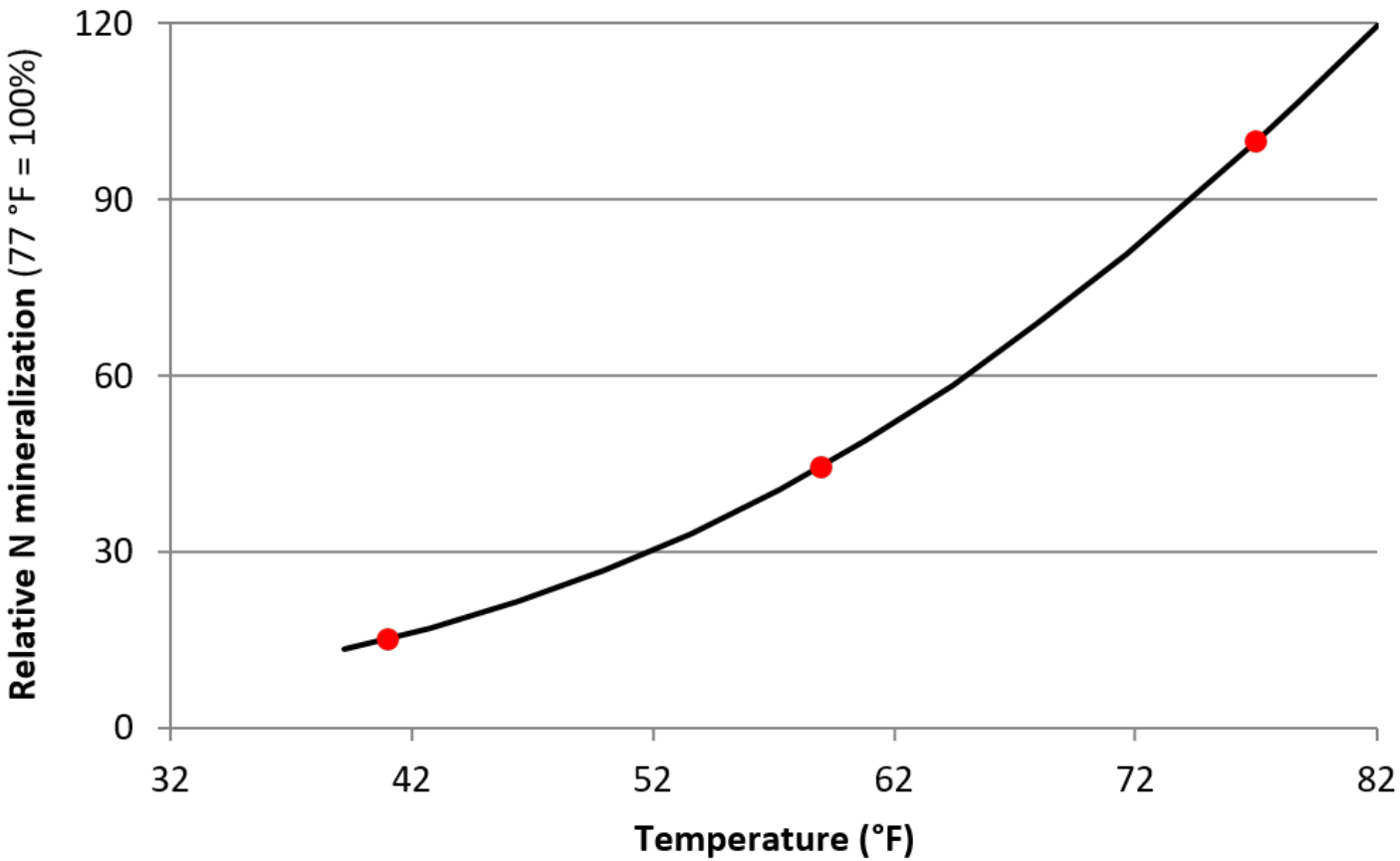
Factors affecting N mineralization from soil organic matter

- Soil temperature
- Soil moisture
- Soil organic matter content
- Management

Soil temperature

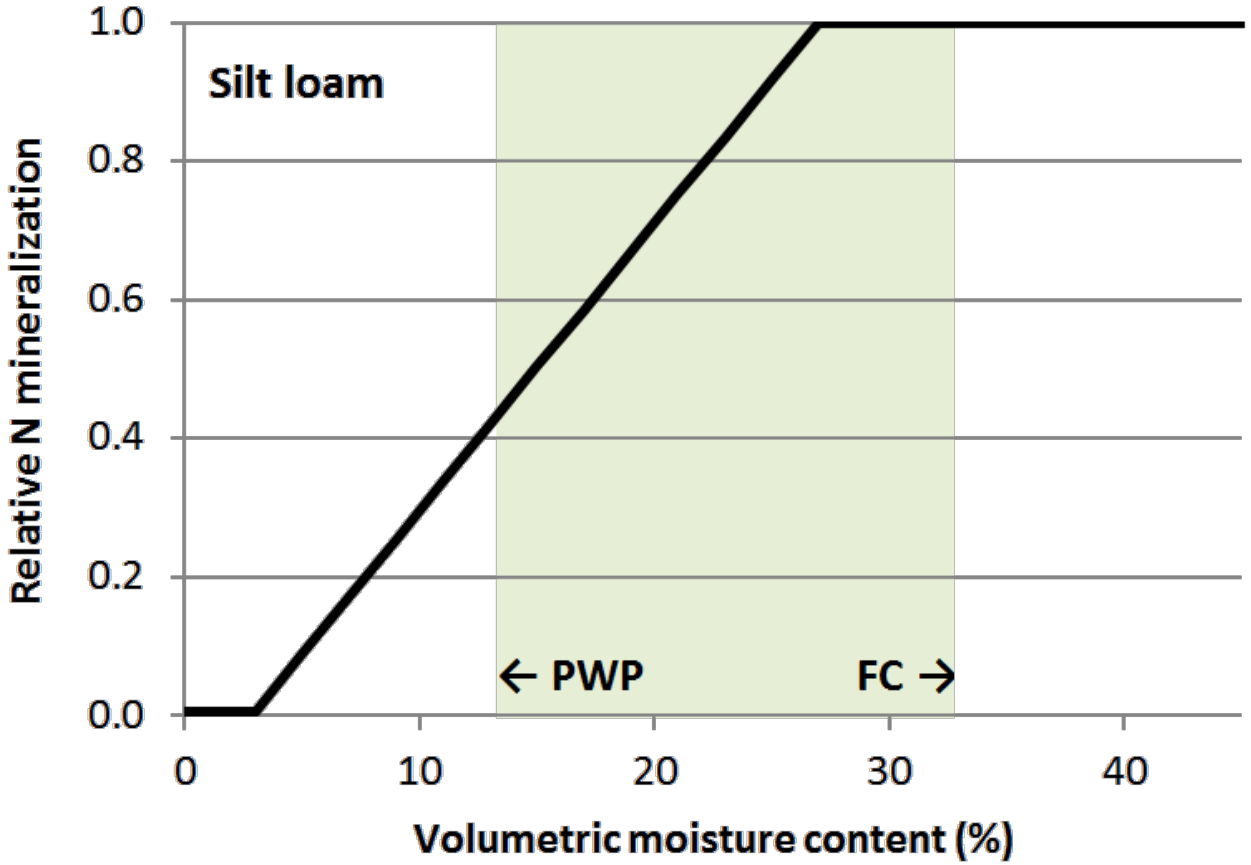


Temperature effects

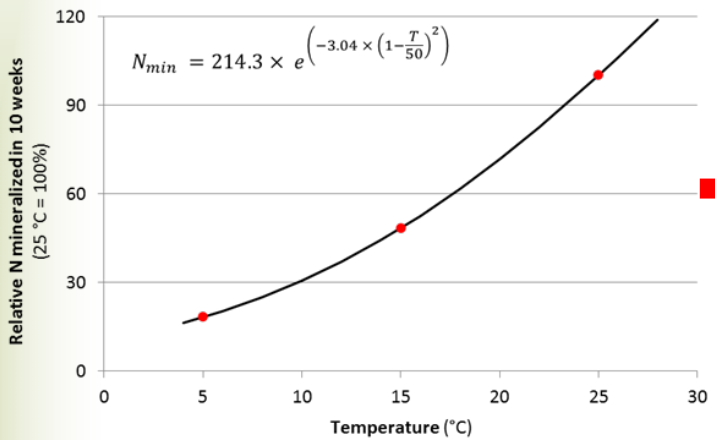


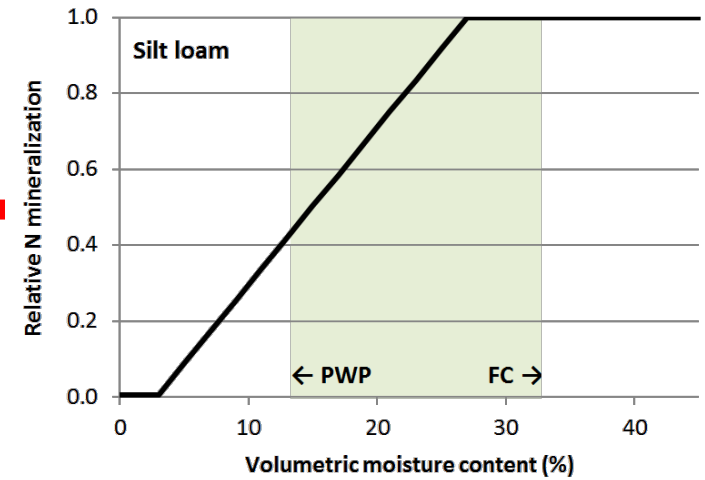
Geisseler and Miller, 2018

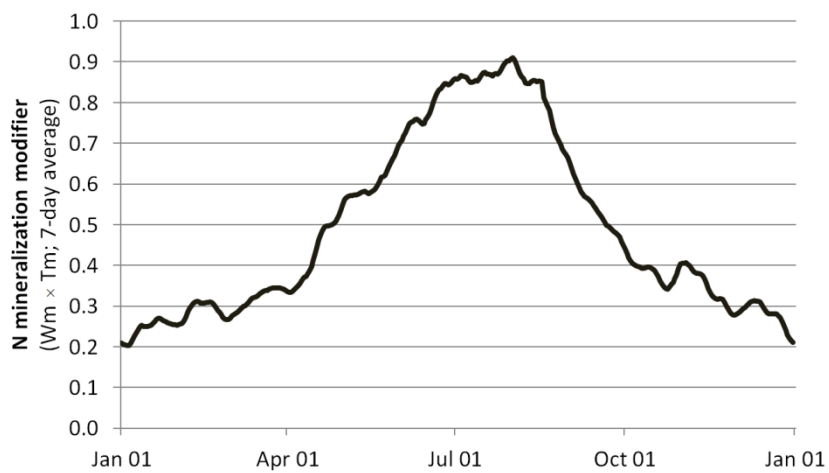
Soil moisture effects



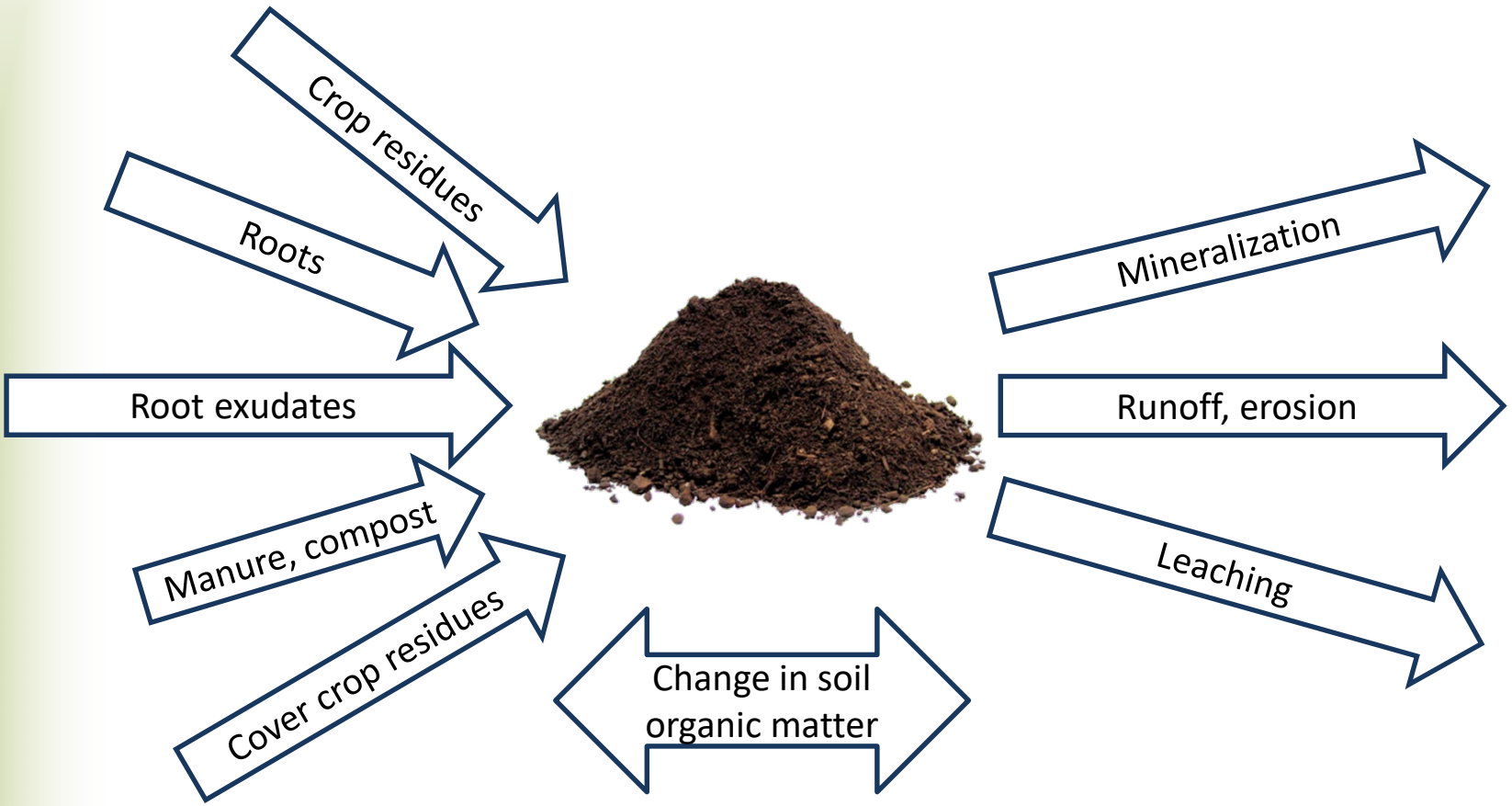
Temperature and moisture effects







Input and output of organic N



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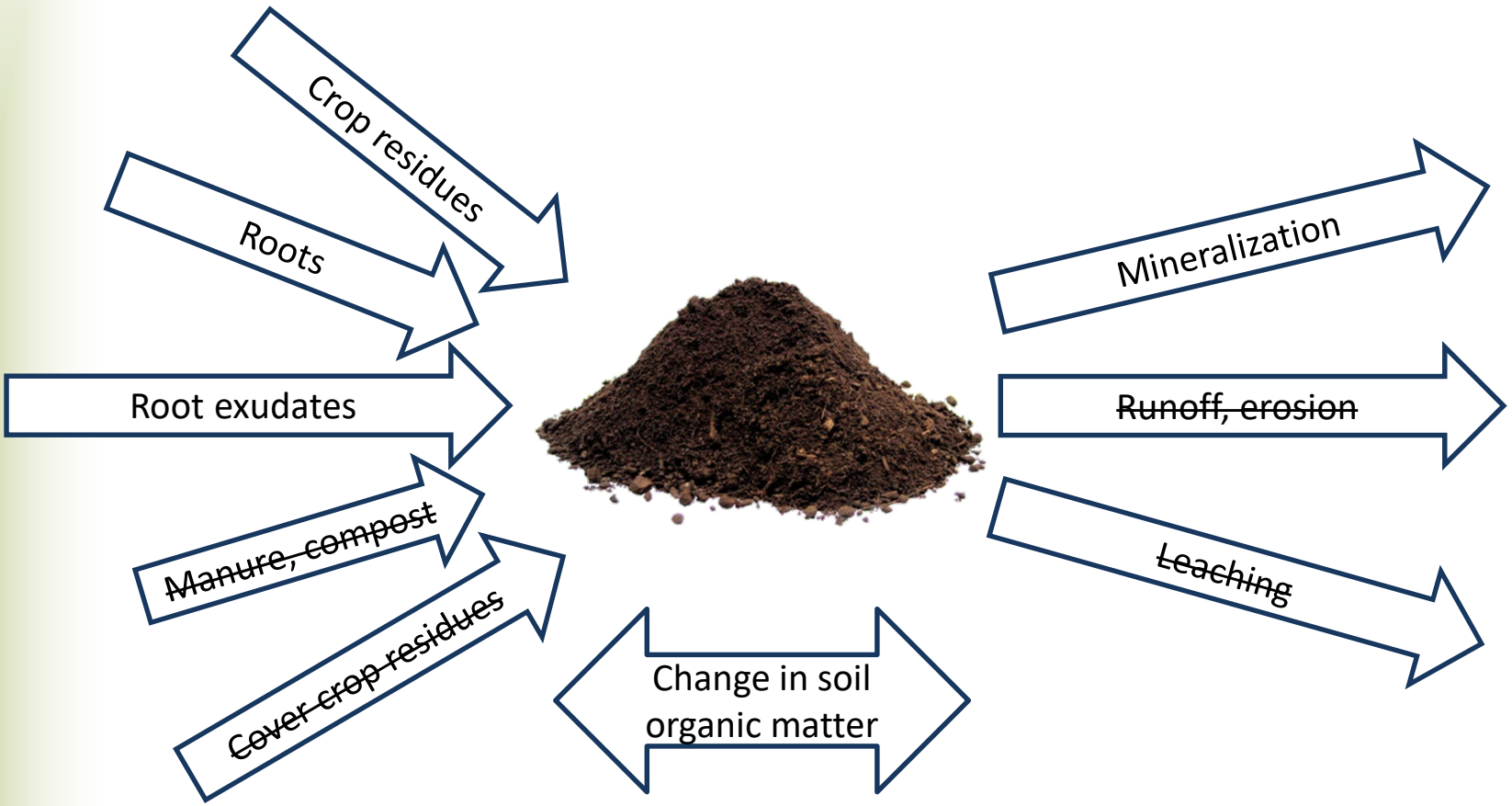

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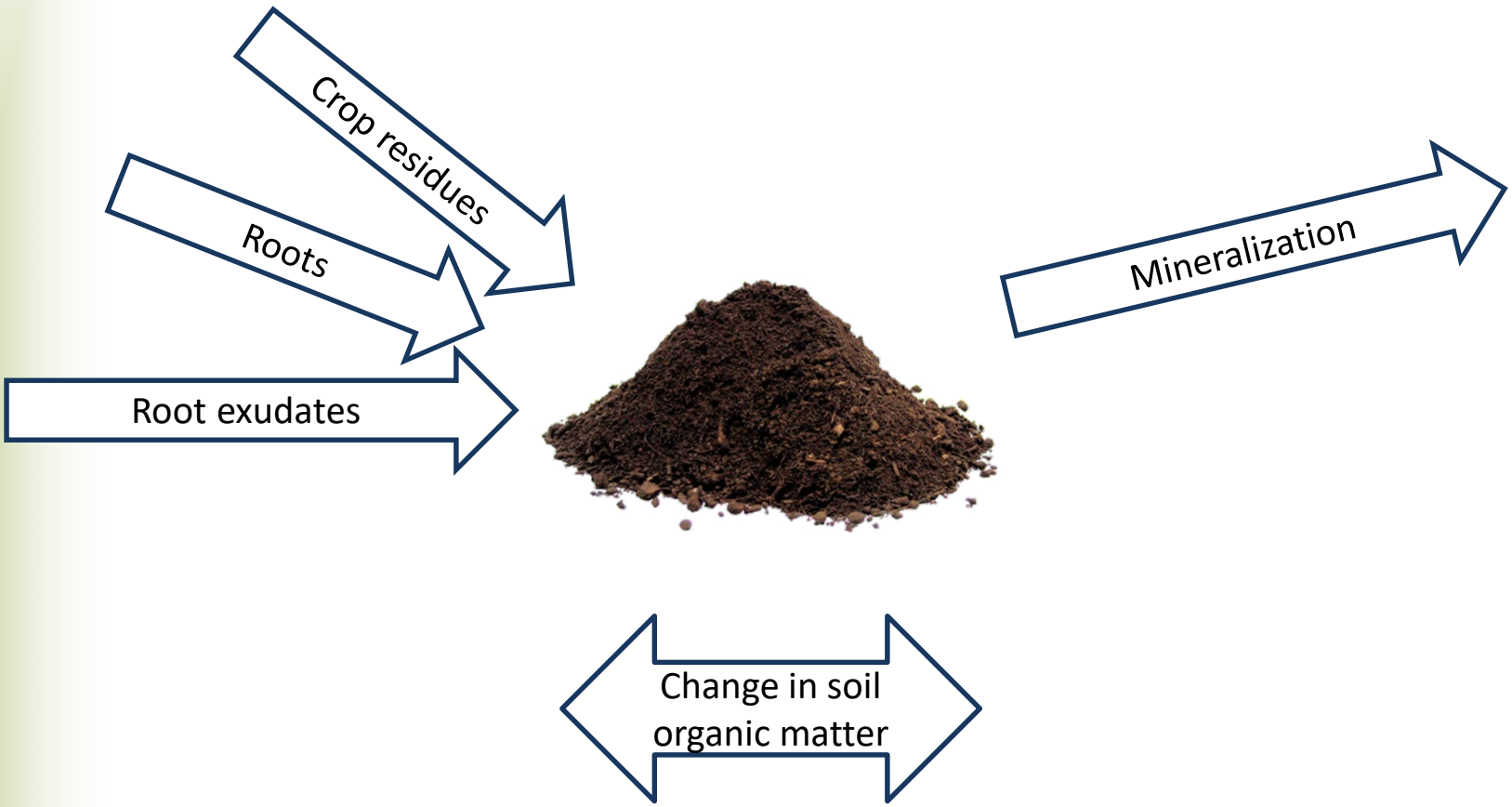


Organic N inputs to our Central Valley soils I

Crop	n	N input (lbs/acre per year)		
		Residue	Roots	Residue & roots
Wheat	6	48	18	66
Corn	5	68	29	97
Sorghum	1	50	15	66
Sunflower	2	44	2	46
Tomatoes	12	53	5	58
Alfalfa	3			100
Fallow	1	0	0	0
Weighted average				**70**

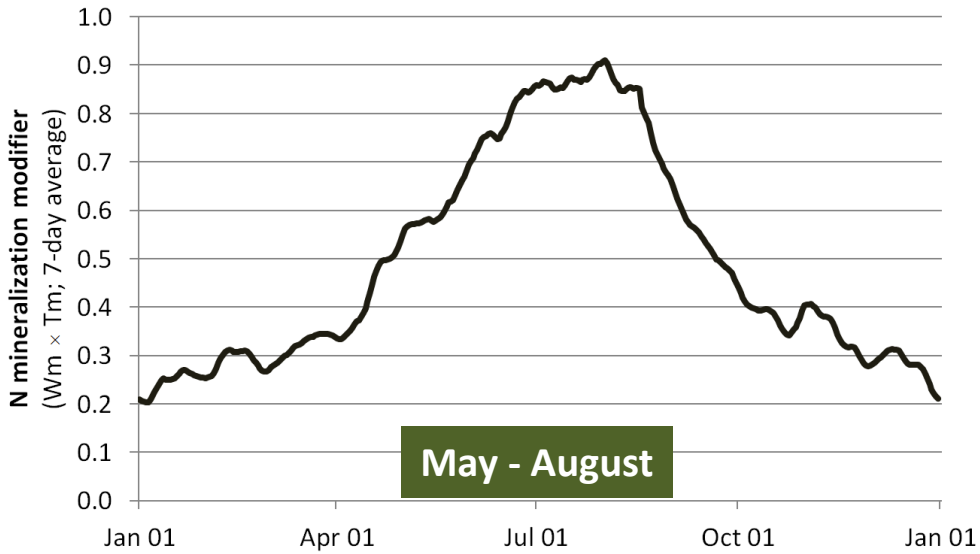
Geisseler et al., 2019

Organic N inputs to our Central Valley soils II

N source	lbs N/acre per year
Average annual N input with roots and residues:	70
Rhizodeposition	23
Input with decreasing soil organic matter content:	17
Total organic N input:	**70-110**

Geisseler et al., 2019

N mineralization throughout the year



- In the Central Valley, the annual N mineralization likely ranges from 70-110 lbs/acre in fields with no history of legume cover crops and manure applications
- About half of the annual N is mineralized during a 4-month growing season

Geisseler et al., 2019

Should soil N mineralization be included in the ILRP budgets?

- No
- ILRP budget focusses on N removed, not total N uptake
- Difference between N removed and N uptake is N in residues and roots
- Residues and roots will decompose and turn into soil organic matter
- This soil organic matter will contribute to N mineralization in the future

Conclusions

- Soil core incubations are valuable tool to
  - Compare different soils
  - Determine effect of soil properties
  - But overestimate N mineralization rates
- The organic N budget suggests that 70-110 lbs N/acre are mineralized per year in the top foot of the profile in Central Valley soils under annual crop rotations
- About half of the N is mineralized during a 4-month growing season
- Type and management of crop residues likely change the seasonal pattern of N mineralization

Acknowledgement

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