Soil Health and Nitrogen Management in Organic Production

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Outline

1. Concept of Soil Health
   - A definition
   - Roles of soil organic matter
   - Six principles

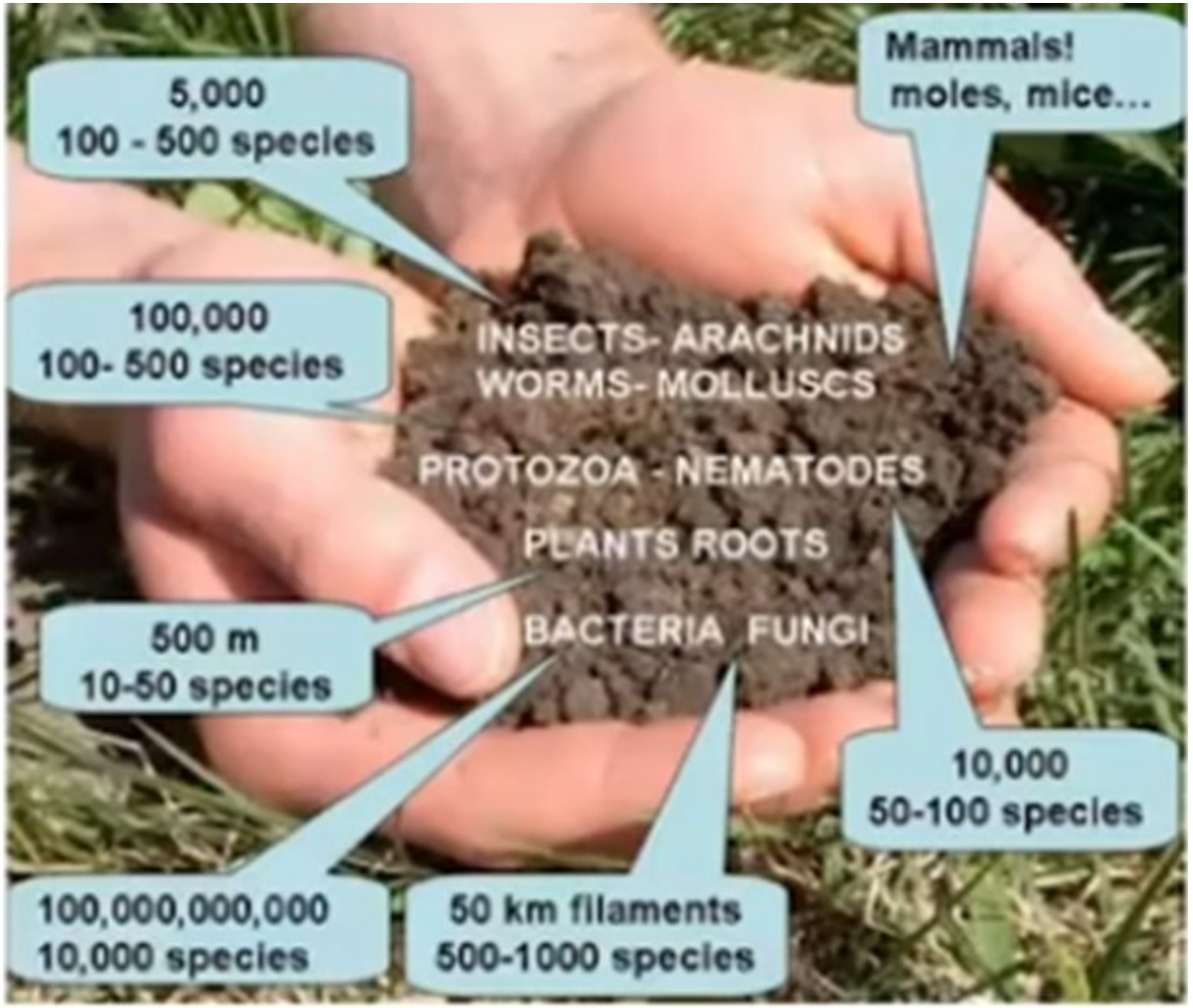
2. Nitrogen (N) Management in Organic Production
   - N in plants and soils
   - Uniqueness of organic N management
   - Organic fertilizers and N mineralization
   - Effect of carbon-to-nitrogen (C/N) ratio
   - An online tool for N mineralization simulation
   - Matching crop's N demand and N supplies
   - N supplies from healthy soil vs. non-healthy soil

Soil Health Defined

Continued capacity of soil to **function**[2] as **a vital living ecosystem**[1] that sustains plants, animals, and humans

(USDA-NRCS)

Soil Biological Properties



Number or length and
Number of species (estimate) in handful of soil

Soil dwellers
https://esdac.jrc.ec.europa.eu/themes/soil-biodiversity

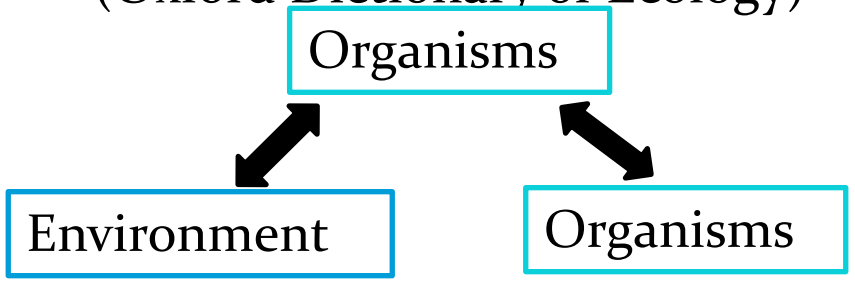
Soil is the most diverse ecosystem on earth (based on DNA sequencing)

(Scow, K. UC Davis, OFRF beginning farmer online training program)

1. (Vital Living) Soil Ecosystem

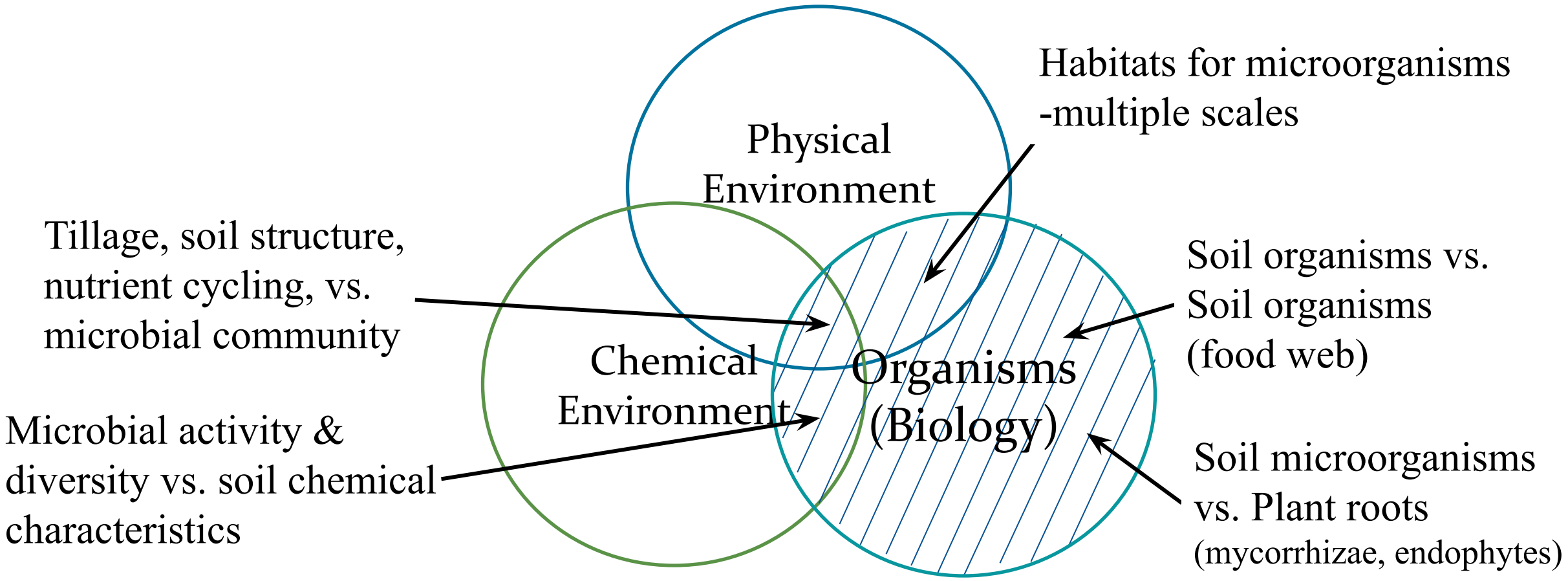
✔ Ecology: The scientific study of **the interrelationships among organisms and between organisms, and between them and all aspects,** living and non-living, **of their environments**.

(Oxford Dictionary of Ecology)

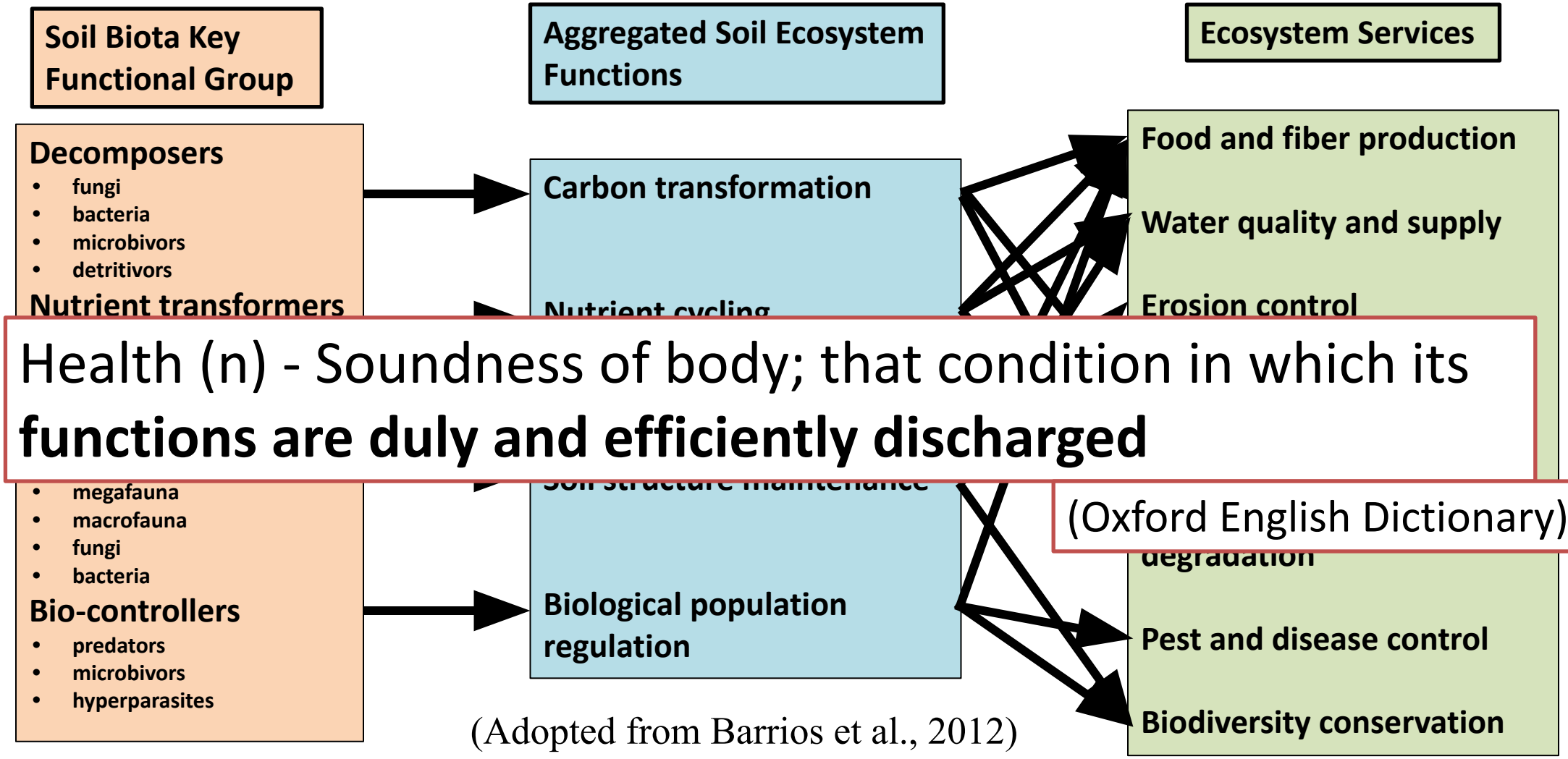


✔ Soil ecosystem: A biological community of interacting organisms and their environment in soil (Oxford Languages)

1. (Vital Living) Soil Ecosystem (Cont.)



2. A Lots of Functions and Ecosystem Services

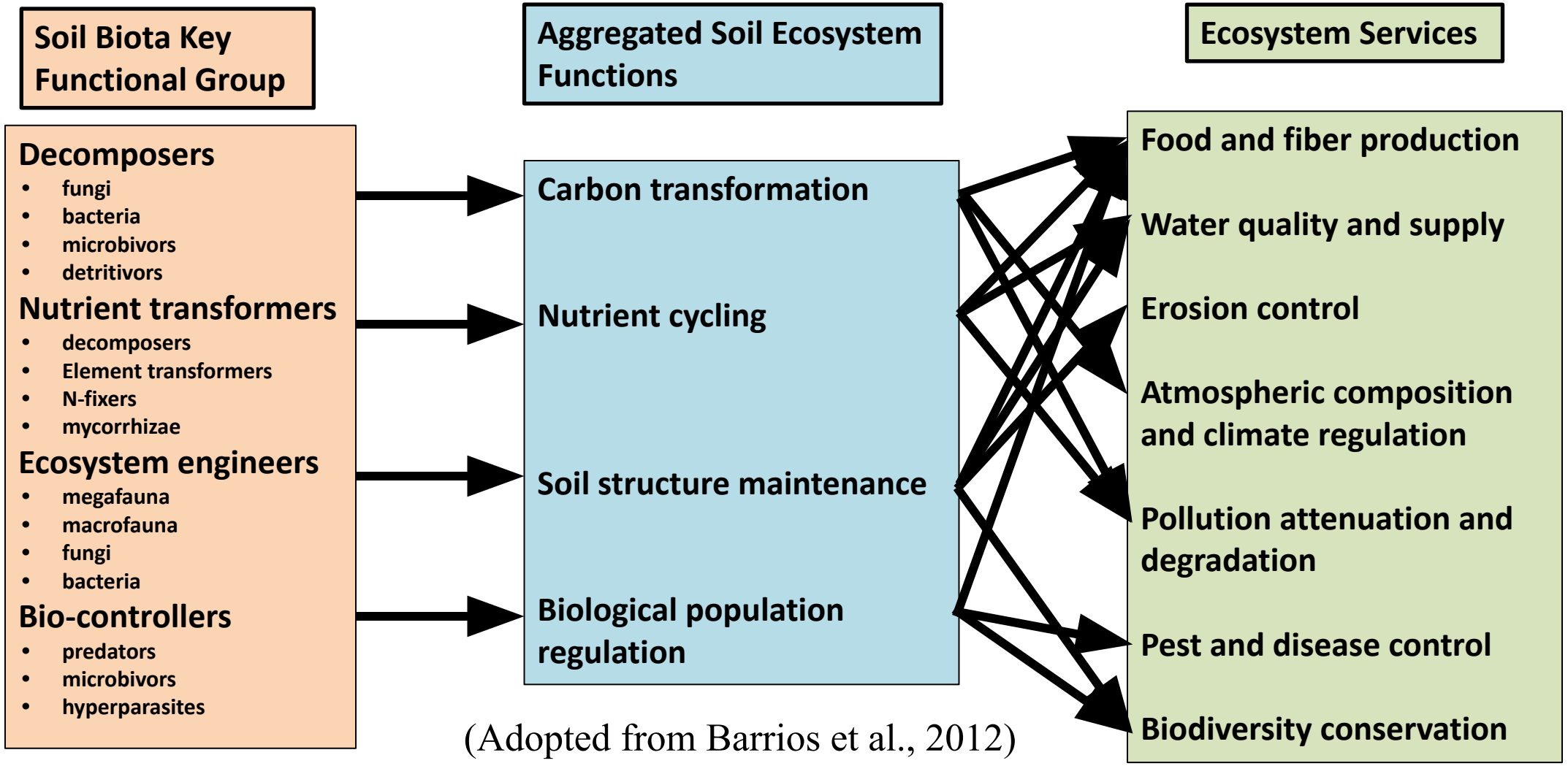


Health (n) - Soundness of body; that condition in which its **functions are duly and efficiently discharged**

(Oxford English Dictionary)

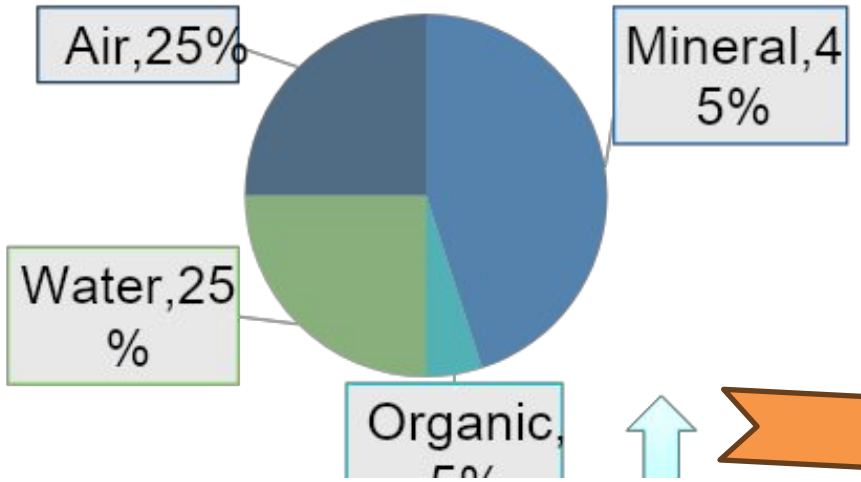
(Adopted from Barrios et al., 2012)

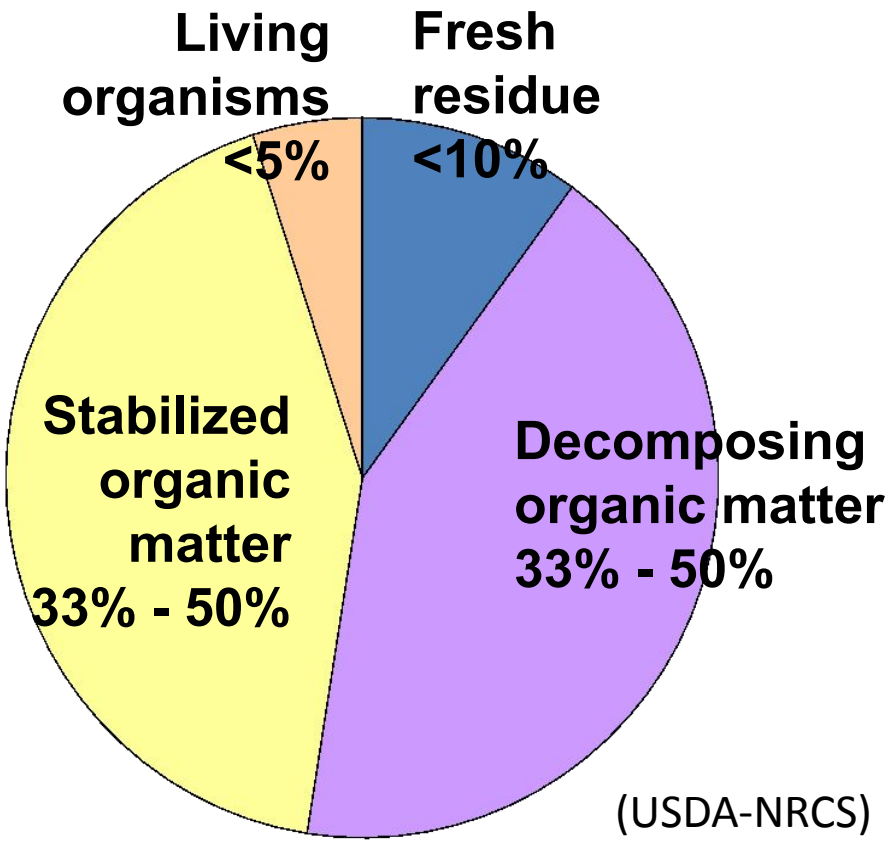
Healthy Soil



(Adopted from Barrios et al., 2012)

Soil Organic Matter (SOM); The Key to Soil Health

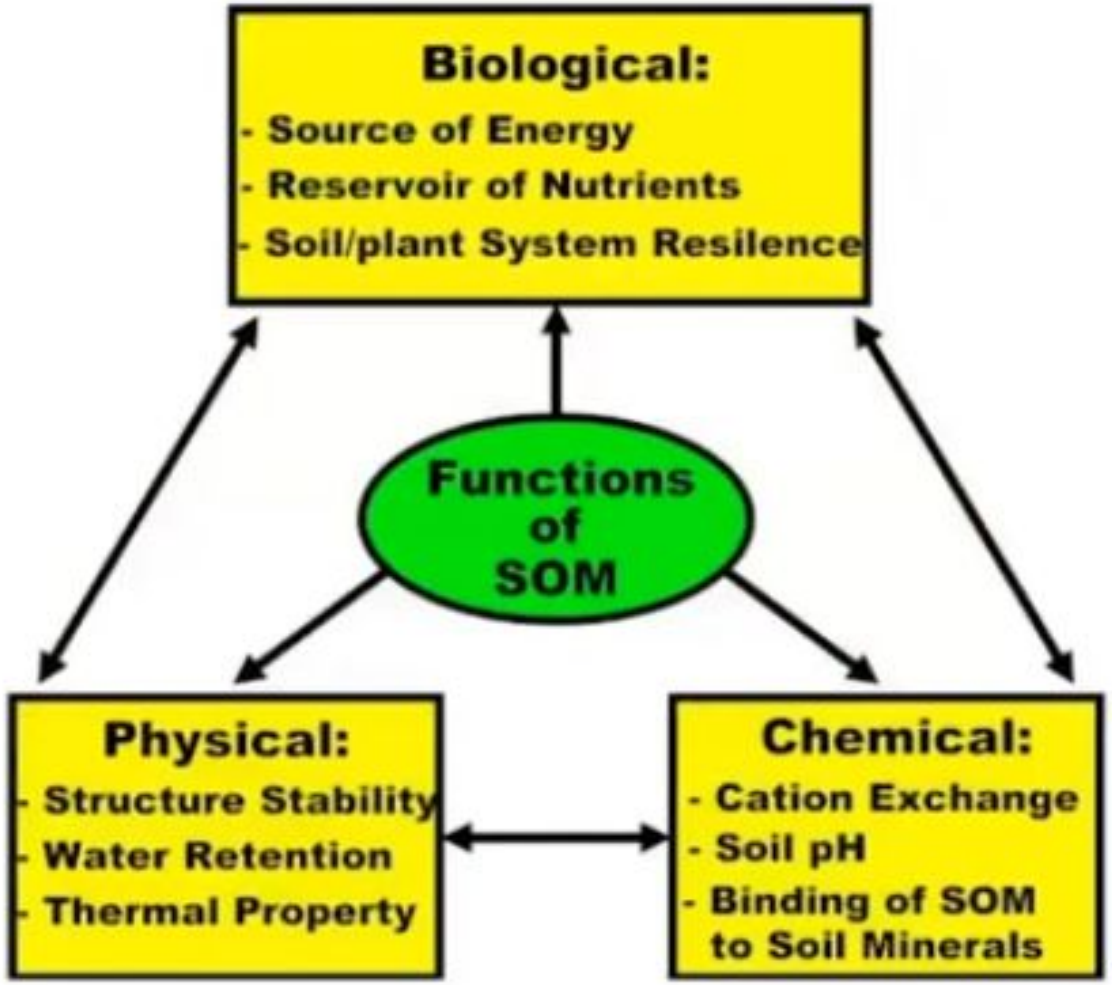


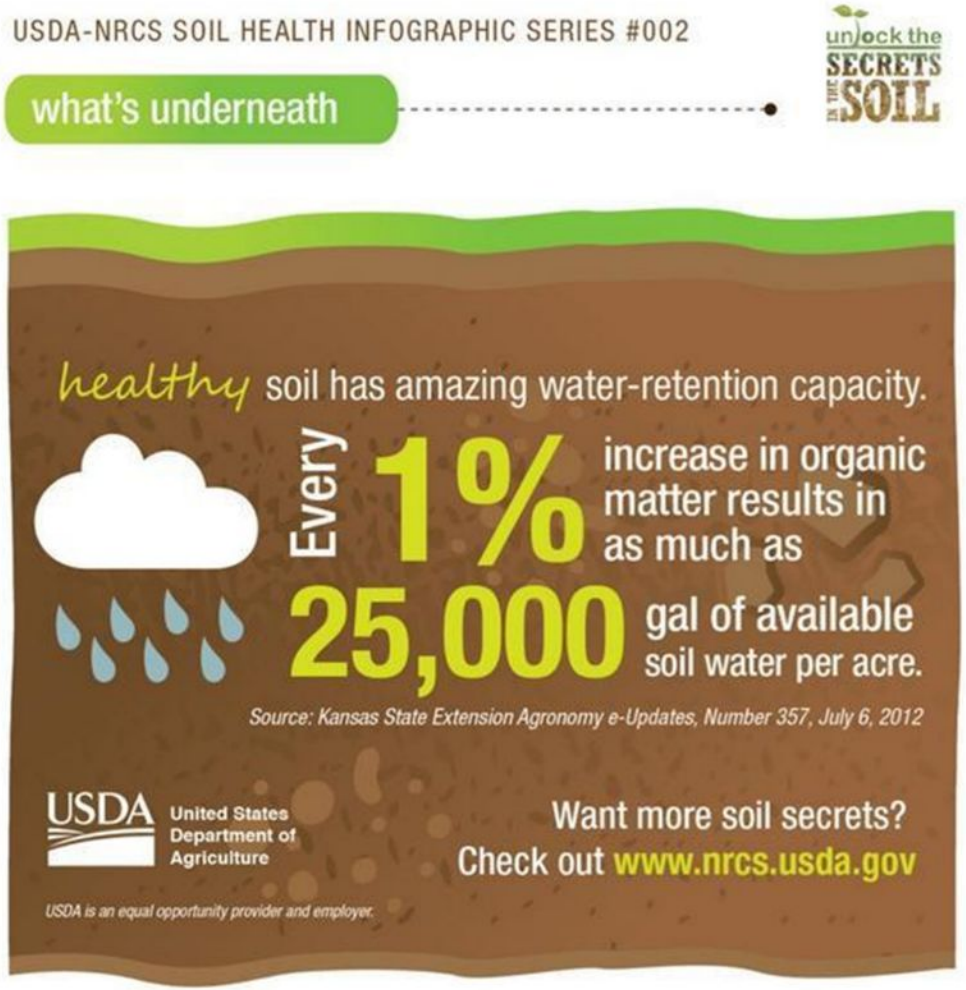


(USDA-NRCS)

- Biologically active and inactive
- High cation exchange capacity
- Form soil aggregates

Benefits of Soil Organic Matter





(Scow, K. UC Davis, OFRF beginning farmer online training program)

Six Soil Health Principles

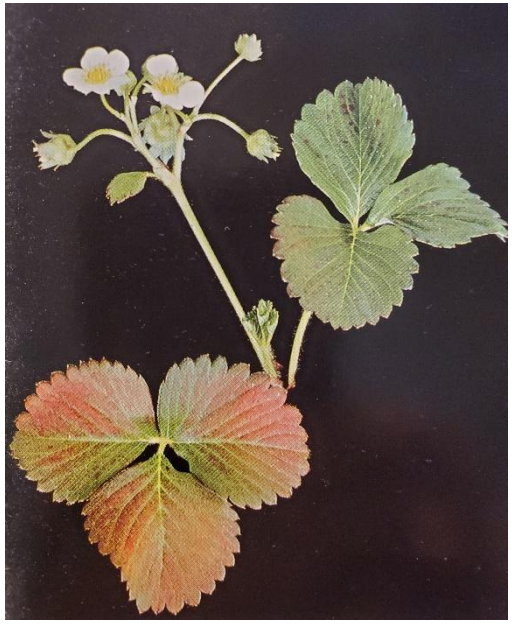
1. Keep the soil covered
2. Minimize soil disturbance
3. Increase crop diversity
4. Keep living roots in the soil
5. Integrate livestock
6. Judicious use of organic amendments

(Adopted from USDA-NRCS, SFA, OFRF)

Nitrogen Management in Organic Production

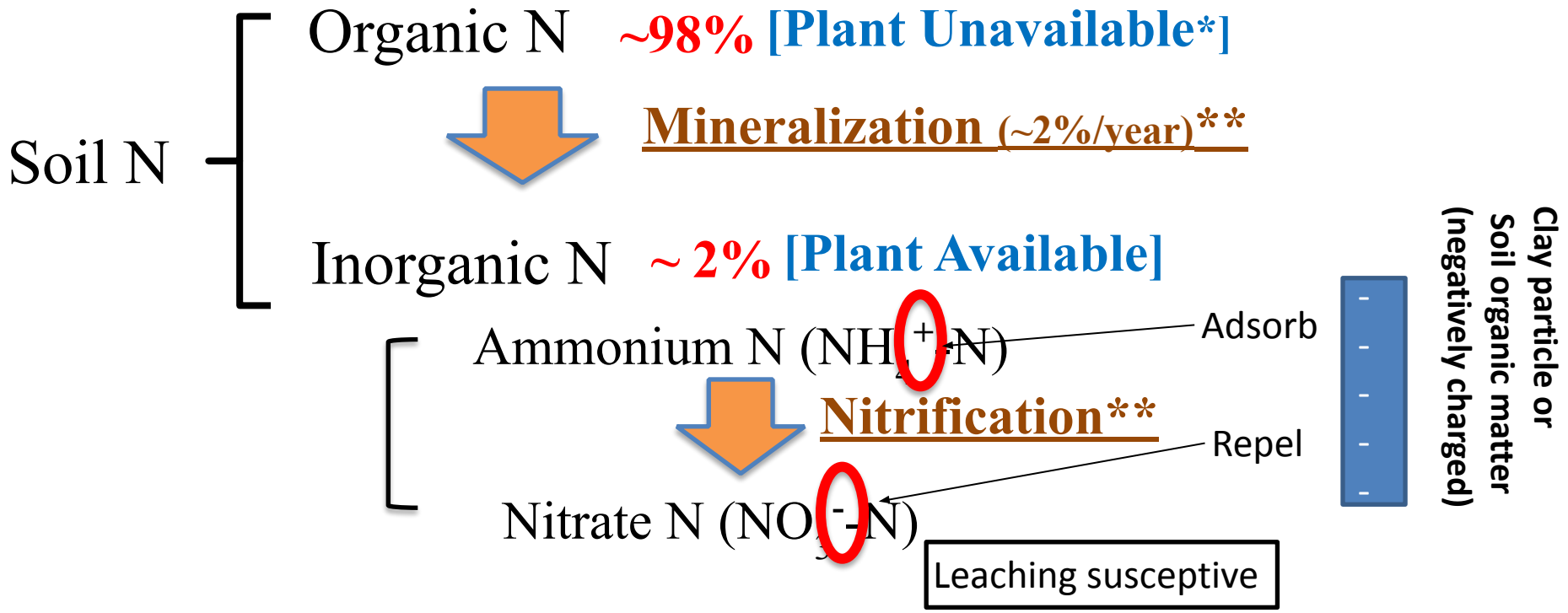
N in Plants; A Key to Crop Production

- *Primary nutrient affecting plant growth*
  - *photosynthesis (chlorophyll)*
  - *biomass structure (protein)*
  - *metabolism (enzyme)*
  - *energy production (ATP)*
  - *reproduction (DNA, RNA)*
- *N deficiency*
  - *Yellowish green leaves, smaller plants, lower yield*
- *N excess*
  - *Dark green leaves, large plants, susceptive to diseases*



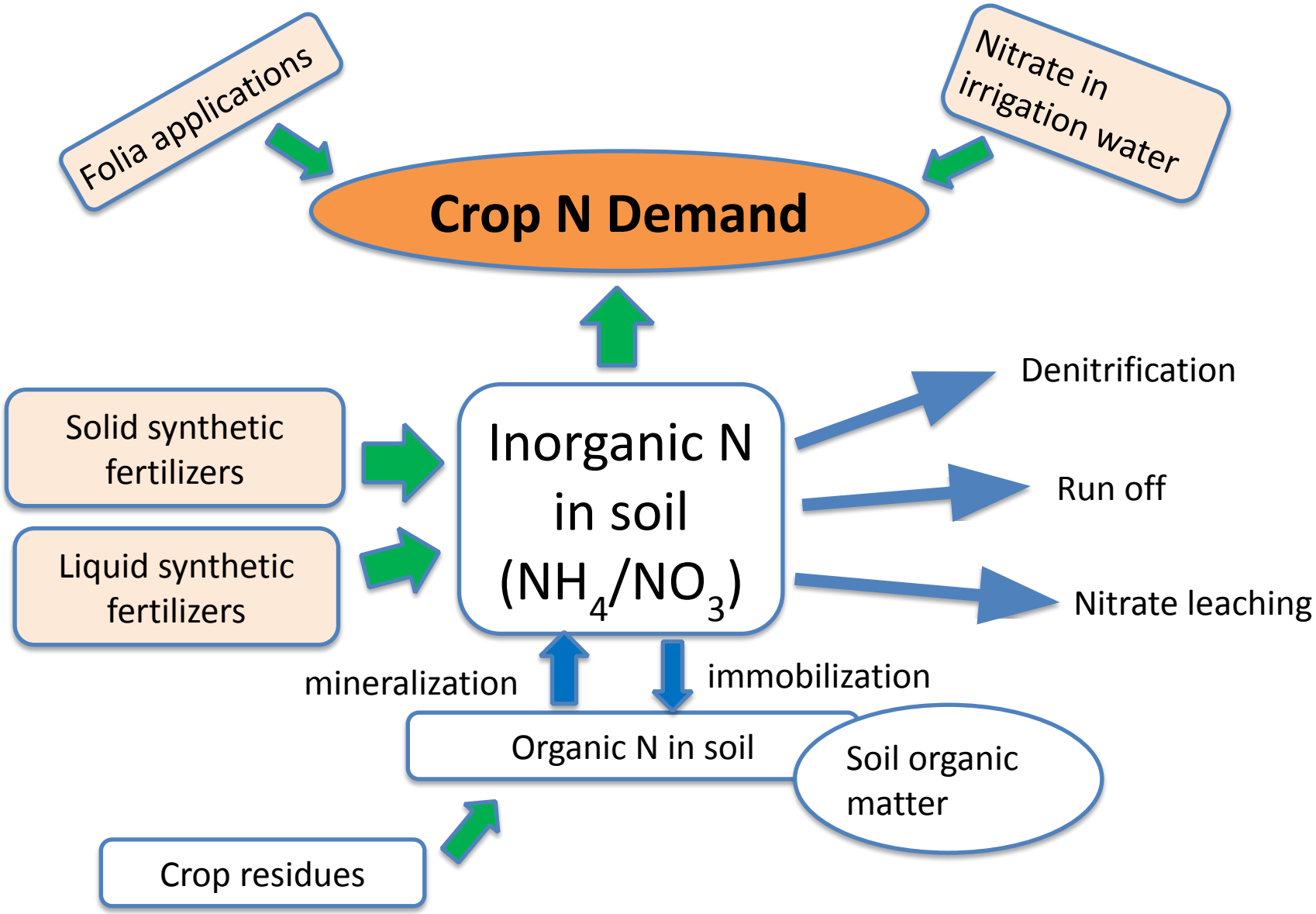
N deficient strawberry plant (Ulrich et al., 1980)

N Forms in Soil and Plant Availability

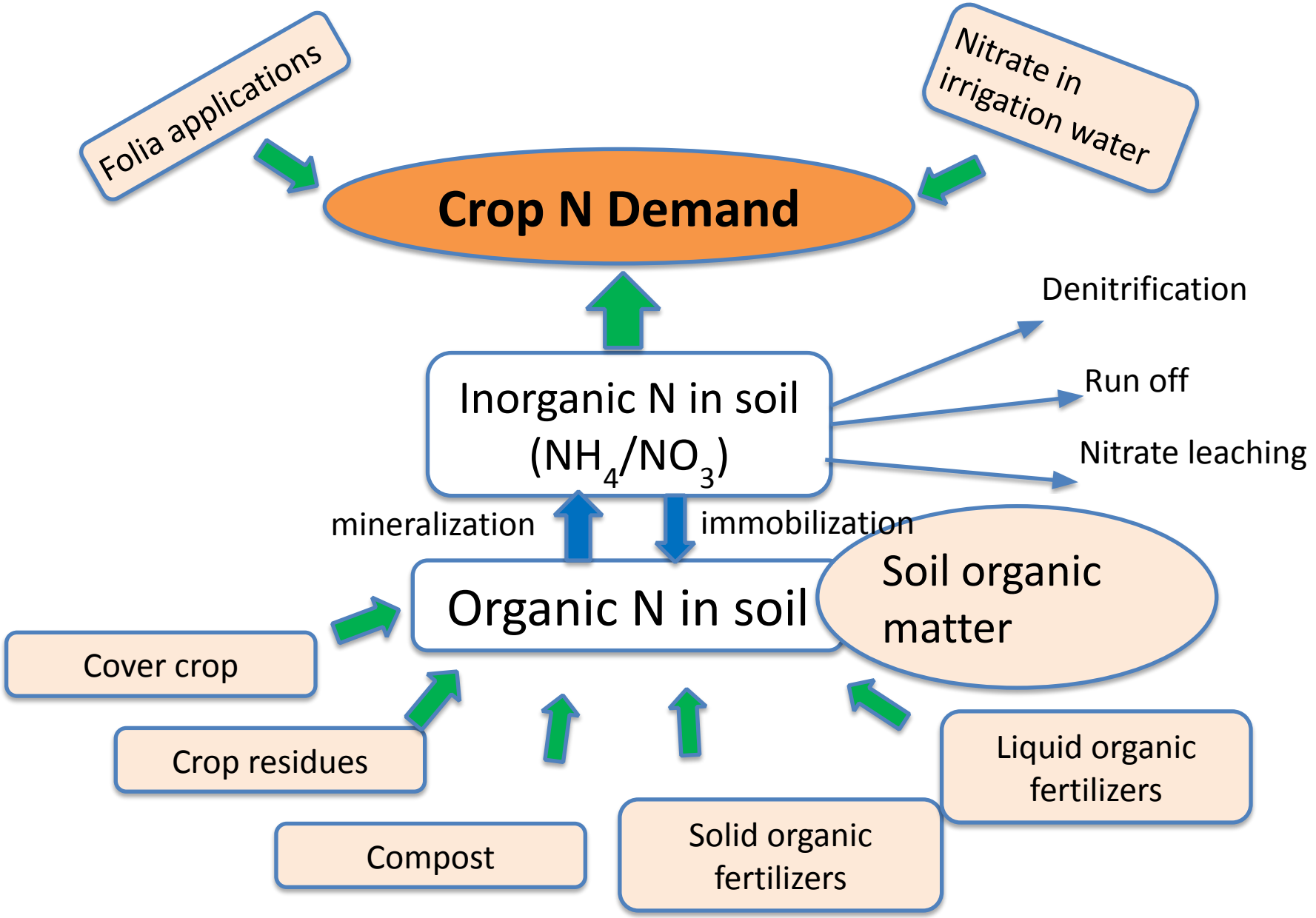


* Plants can absorb small amounts of organic N and some crop plants can do more than others

** **Biological processes** affected by ***environmental factors*** such as ***soil temperature. moisture, etc.***

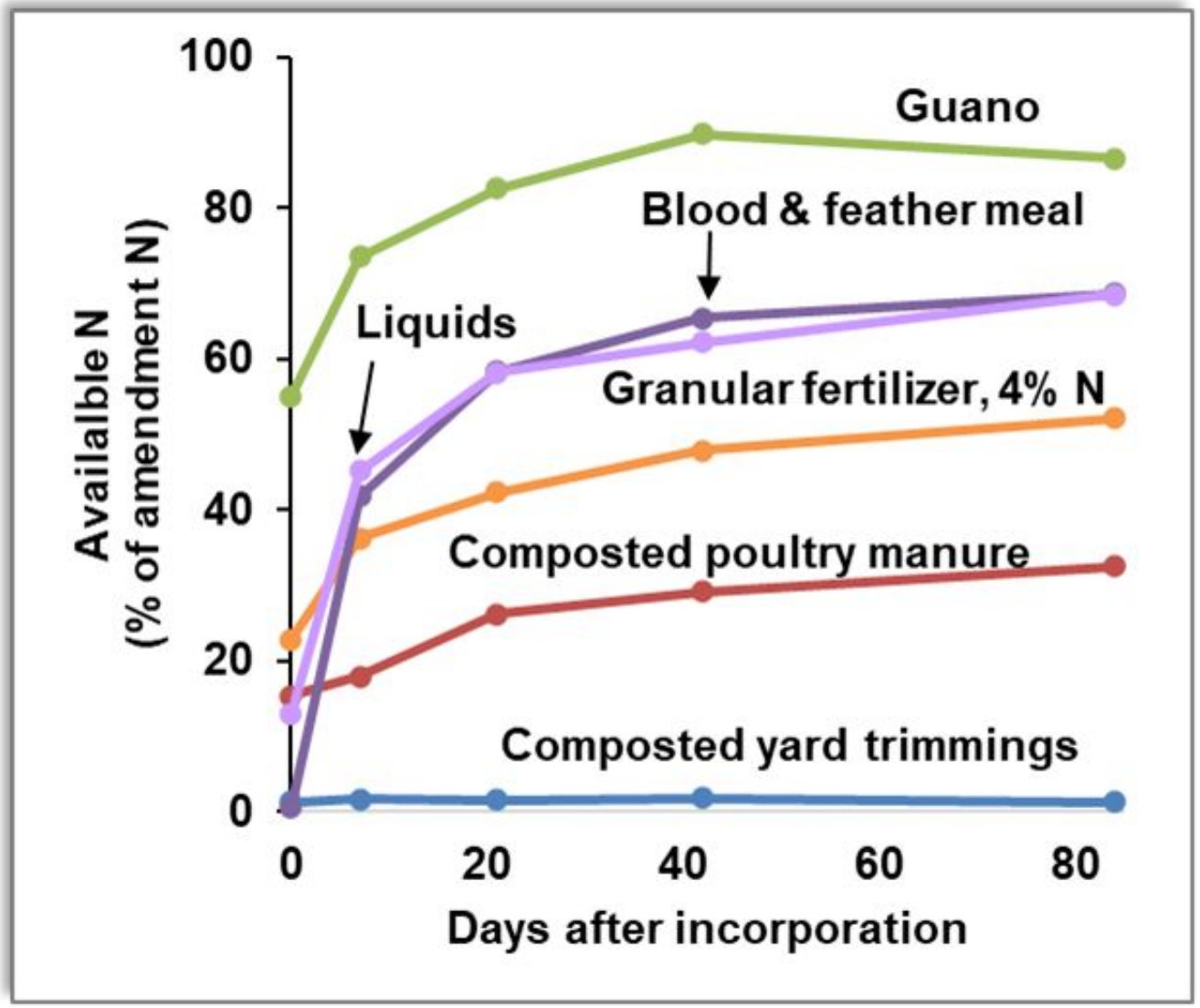


N dynamics in conventional systems

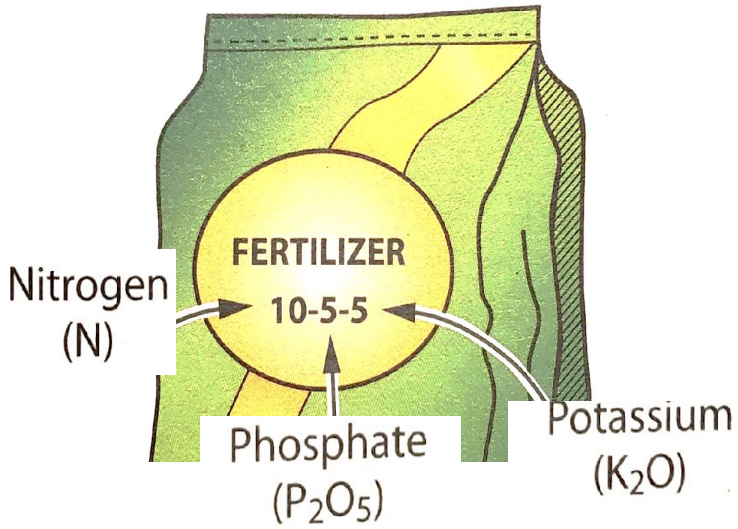


N dynamics in organic systems

N Release Patterns of Organic Fertilizers



Lazicki et al., 2020

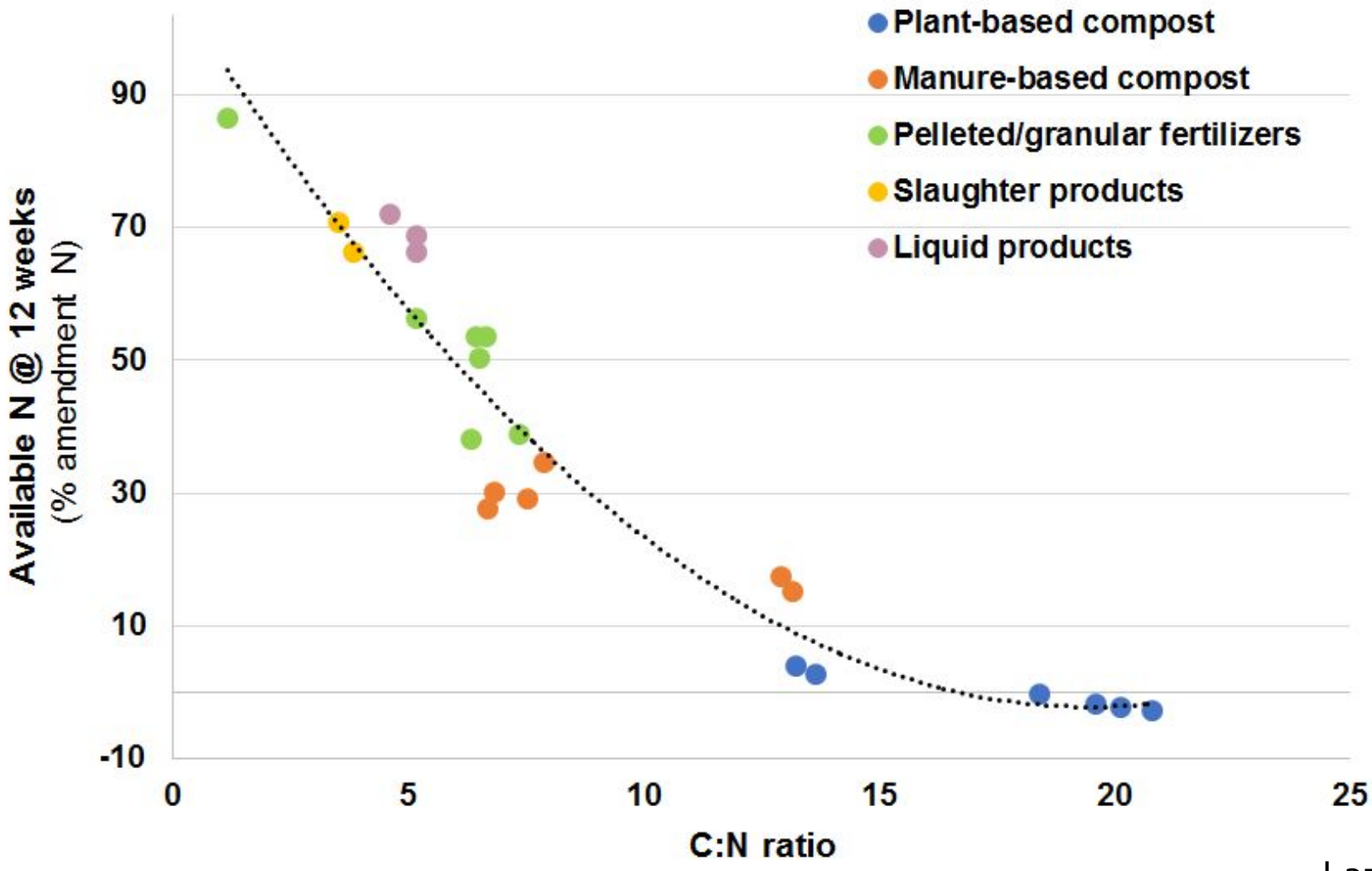


Total N vs. Plant available N after 12 Weeks

Material	Average total N content (%)	N available after 12 weeks	Plant available N content (%)
Municipal yard trimmings composts	1.25	-3 – 4%	0 – 0.1
Poultry manure composts	3.5	30 – 35%	1.1 – 1.2
Granular fertilizers	4.5	38 – 60%	1.7 – 2.7
Blood & feather meals	14	65 – 70%	9.1 – 9.8
Liquid fertilizers	3.0	50 – 100%	1.5 – 3.0
Guano	12.5	80 – 90%	10 - 11

Based on Lazicki et al., 2020

Effect of C to N ratio on N release



Lazicki et al., 2020

Online Tools

English: http://geisseler.ucdavis.edu/Amendment_Calculator.html
Spanish: http://geisseler.ucdavis.edu/Calculadora_N_Abonos.html

To be integrated with CropManage!

Geisseler Lab

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Nutrient Management

Nitrogen Mineralization from Organic Amendments

The calculations in this tool are based on an analysis of 113 datasets from the scientific literature. Nitrogen mineralization rates are adjusted based on soil temperature data from local CIMIS weather stations. Soil moisture is assumed to be optimal near field capacity. **When amendments are incorporated into dry soil, N mineralization would be slower than calculated. The tool should not be used when amendments are left on the soil surface.**
Information on lines marked with an * needs to be provided. If no information on amendment and soil properties are entered, the tool will use average values. In this case, however, the calculations will be less accurate for a specific situation.

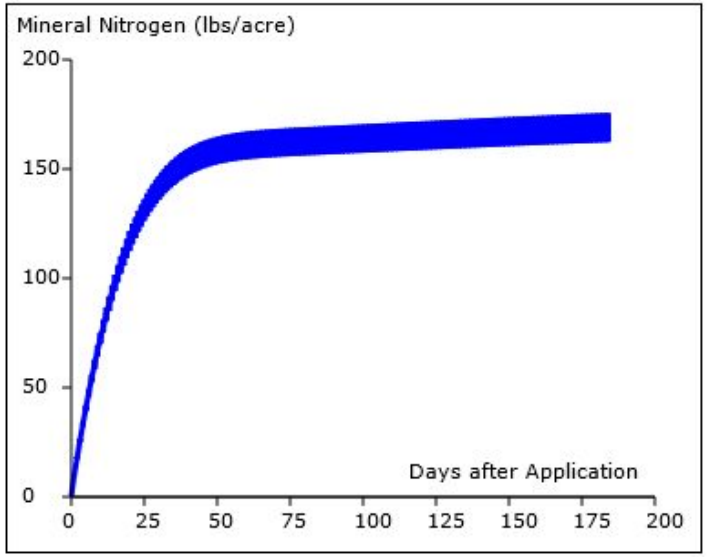
Mineralización del nitrógeno a partir de abonos orgánicos

Los cálculos de esta herramienta se basan en un análisis de 113 conjuntos de datos de la literatura científica. Las tasas de mineralización del nitrógeno (N) se ajustan en función de los datos de temperatura del suelo procedentes de las estaciones meteorológicas locales del CIMIS. Se supone que la humedad del suelo es óptima cerca de la capacidad del campo. Cuando las abonos se incorporan al suelo seco, la mineralización del N será más lenta de lo calculado. La herramienta no debe utilizarse cuando se dejan abonos en la superficie del suelo.
Es necesario proporcionar información sobre las líneas marcadas con un *. Si no se introduce información sobre los abonos y las propiedades del suelo, la herramienta utilizará valores medios. En este caso, sin embargo, los cálculos serán menos precisos para una situación concreta.

The online tool

Output: Feather meal, Sacramento Valley

Nitrogen Mineralization

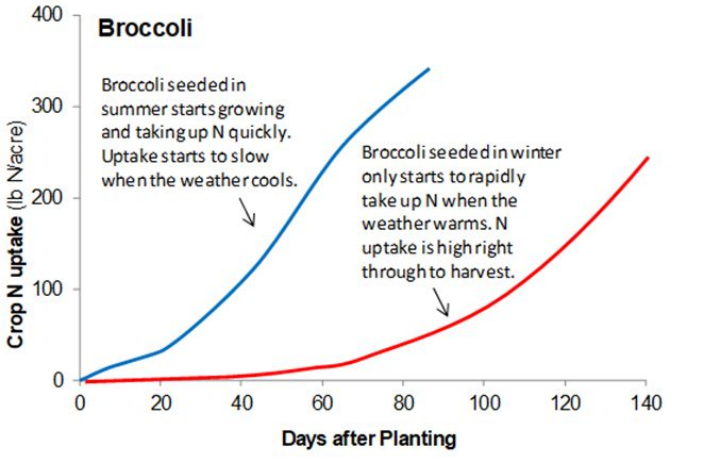


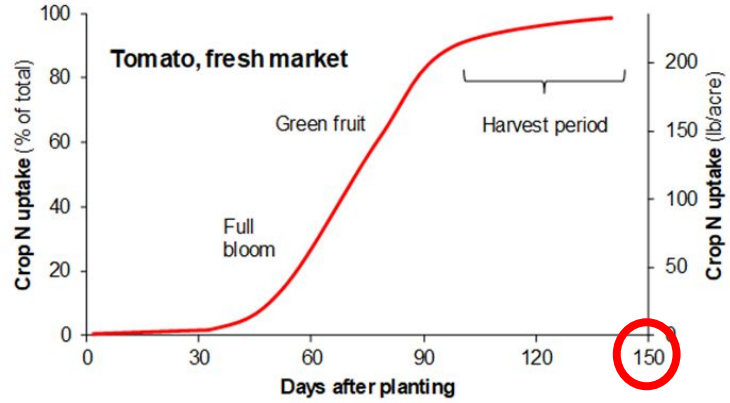
The graph and the calculations are based on average values from scientific studies. Weather conditions, soil properties, amendment characteristics and management all can affect N mineralization rates. It is therefore **important to monitor N availability of the field with soil or leaf analyses**. More information about soil and leaf sampling can be found here.

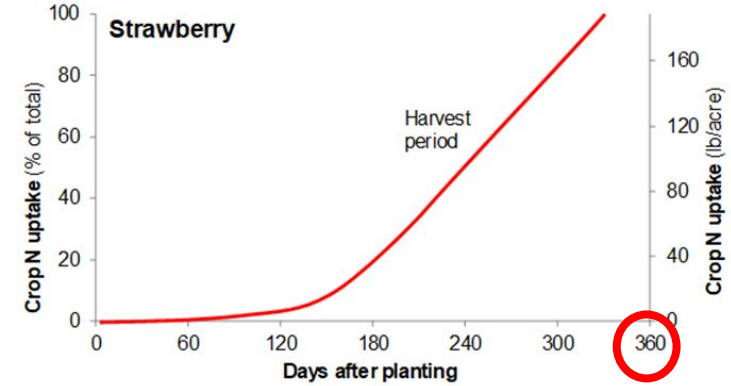
Total N applied:	276 lb/ac
Total mineral N applied:	1.3 lb/ac
Estimated available N:	162 - 176 lb/ac
Percent available:	59 - 64 %

Synchronize N Supply with Crop's N Demand

- How can we synchronize (= match) N supply from multiple organic sources with the crop N demand?
  - Efficient N supply
  - Save money
  - Reduced N losses to the environment



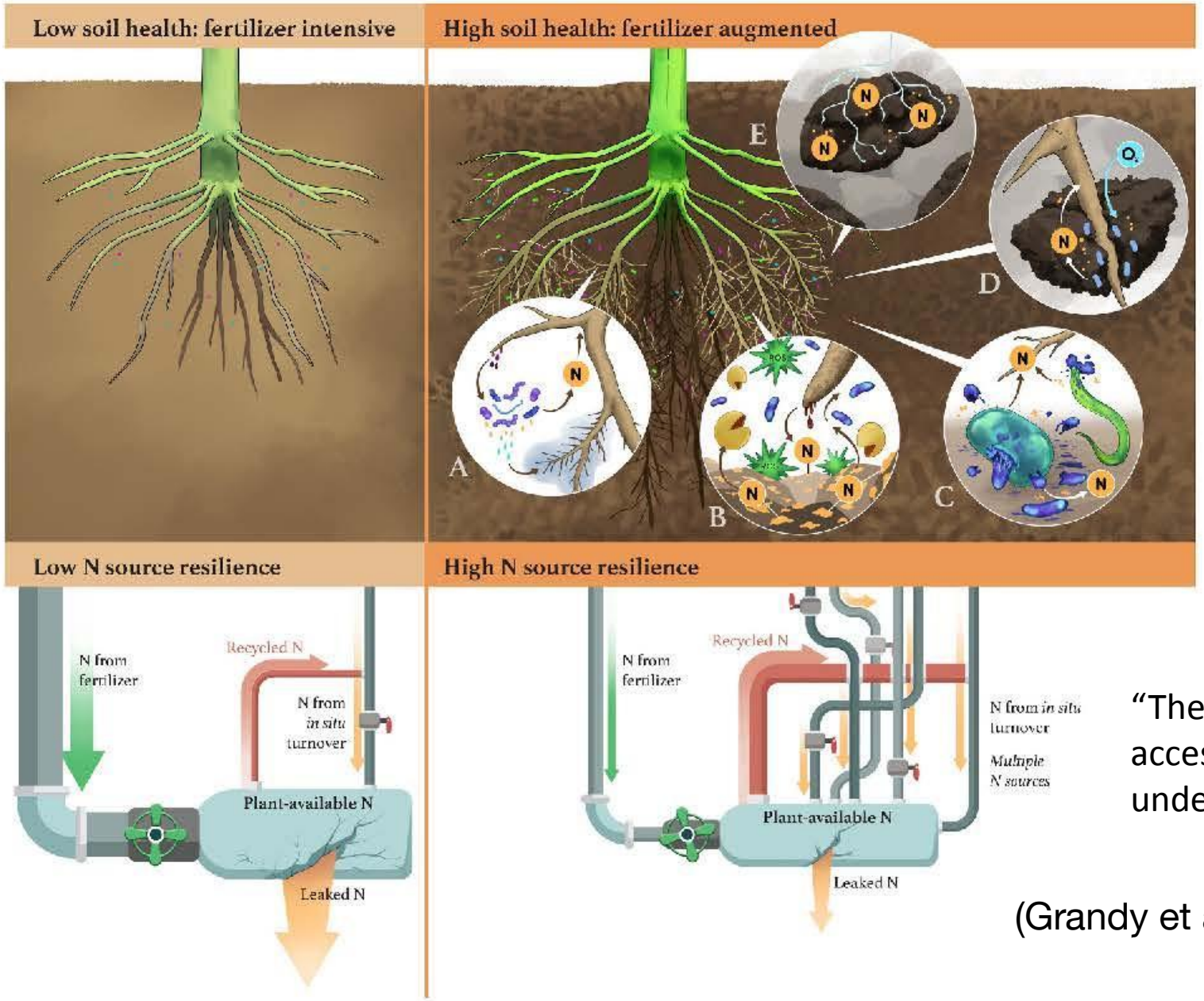




Resources:

- Crop Nitrogen Uptake and Partitioning by D. Geisseler and W.R. Horwath http://geisseler.ucdavis.edu/Guidelines/N_Uptake.html
- Estimating Nitrogen Availability in Organic Annual Production: For Nitrogen Budgeting and Other Purposes. UCANR publication 8712, https://anrcatalog.ucanr.edu/Details.aspx?itemNo=8712

Effect of soil health on soil N availability



A: Root exudates->auxin production by microbes -> fine roots development

B: Root exudates-> higher microbial activities -> mineral –associate organic N release

C: Protists, nematodes -> feed on microbes -> release N

D: Fine roots grow into aggregates and open microsites ->access available N

E: Mycorrhizae penetrate aggregates -> access occluded pockets of N

"The multiple pathways for plants to access N provide more resilient N supply under variable conditions"

(Grandy et al., 2022 Soil Biol. Biochem.)

Thank you!

Question?

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