University of California

Nitrogen Management Training

for Certified Crop Advisers

MODULE 2

Nitrogen Cycling and Soil Transformations

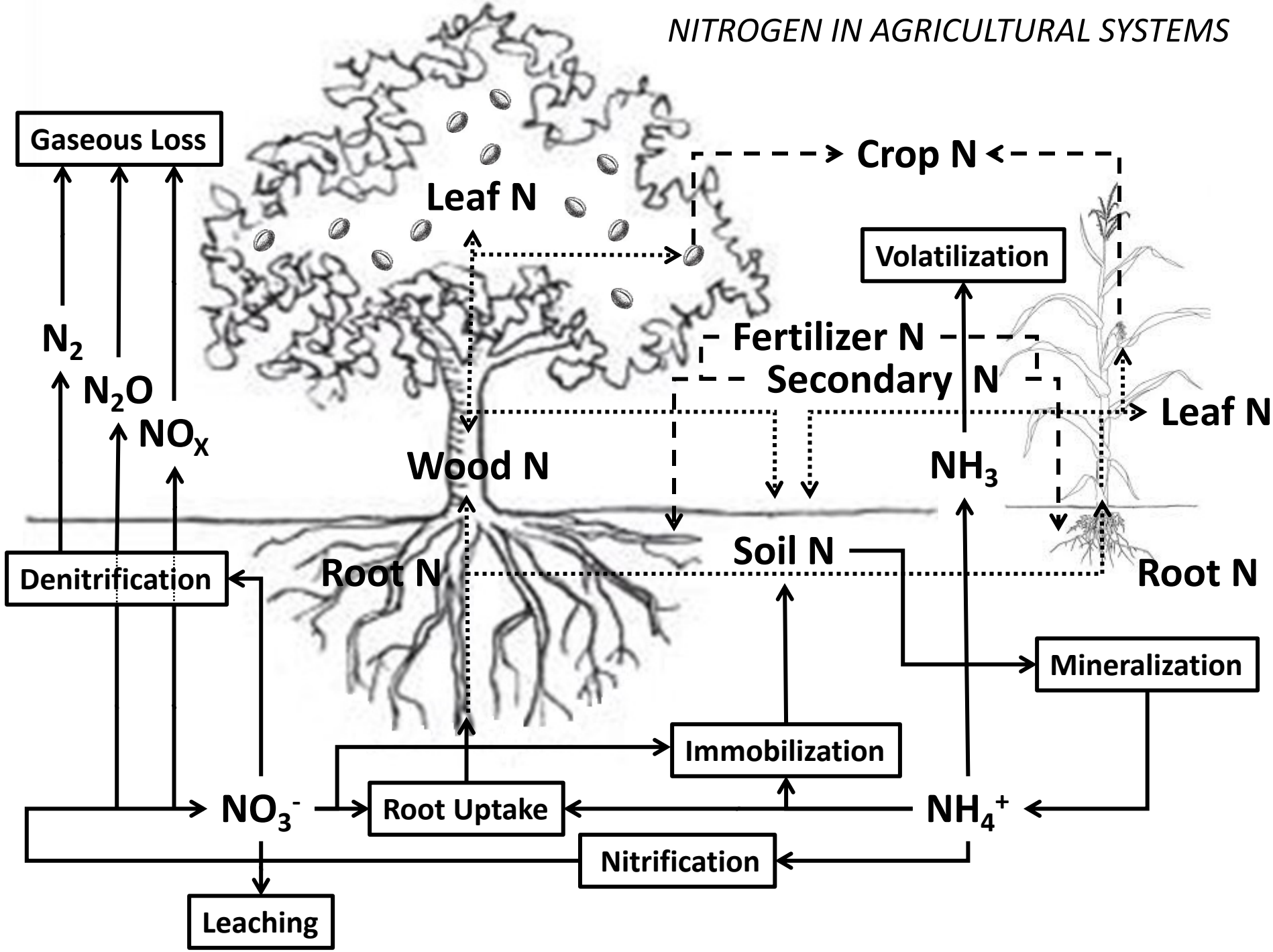
PART 1

Mineralization, Immobilization and Nitrification

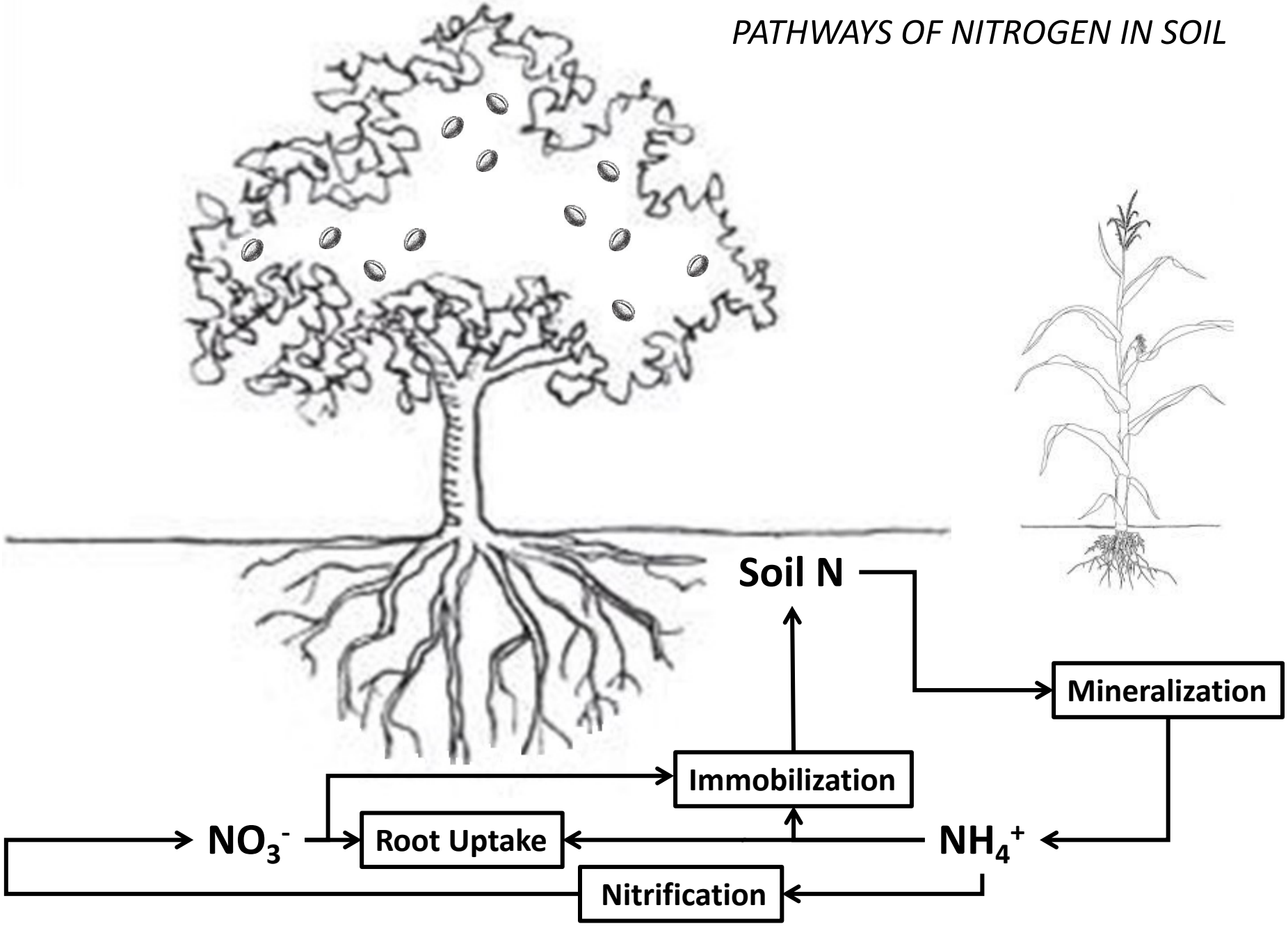
Sat Darshan Khalsa
Department of Plant Sciences
UC Davis

UC Cooperative Extension | University of California Agriculture and Natural Resources

NITROGEN IN AGRICULTURAL SYSTEMS



PATHWAYS OF NITROGEN IN SOIL



Overview of Nitrogen Cycling in Soils

- Mineralization
  - Supply of nitrogen from organic sources
  - Beneficial for nitrogen supply to plants

- Immobilization
  - Mechanism to retain nitrogen in soil
  - Beneficial for nitrogen status of microbes

- Nitrification
  - Conversion of ammonium into nitrate
  - Control can led to reduced nitrogen losses

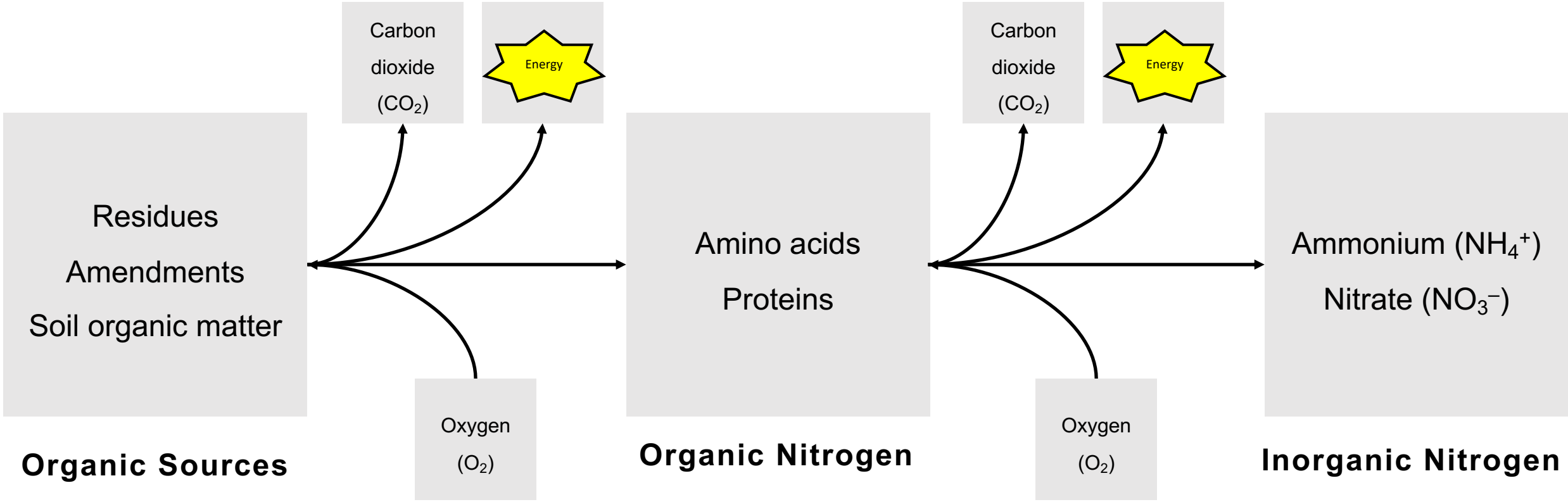
Mineralization of Soil Nitrogen

- Biochemical dynamics of soil nitrogen mineralization
  - Conversion from organic sources into inorganic nitrogen
  - Heterotrophic process by microbes under aerobic conditions
  - Available nitrogen occurs when in excess of microbial need

- Impact of substrate quality and environmental conditions
  - Carbon to nitrogen ratio (C:N) controls mineralization
  - Tillage, moisture and temperature also have a strong influence
  - Sources include residues, amendments and soil organic matter

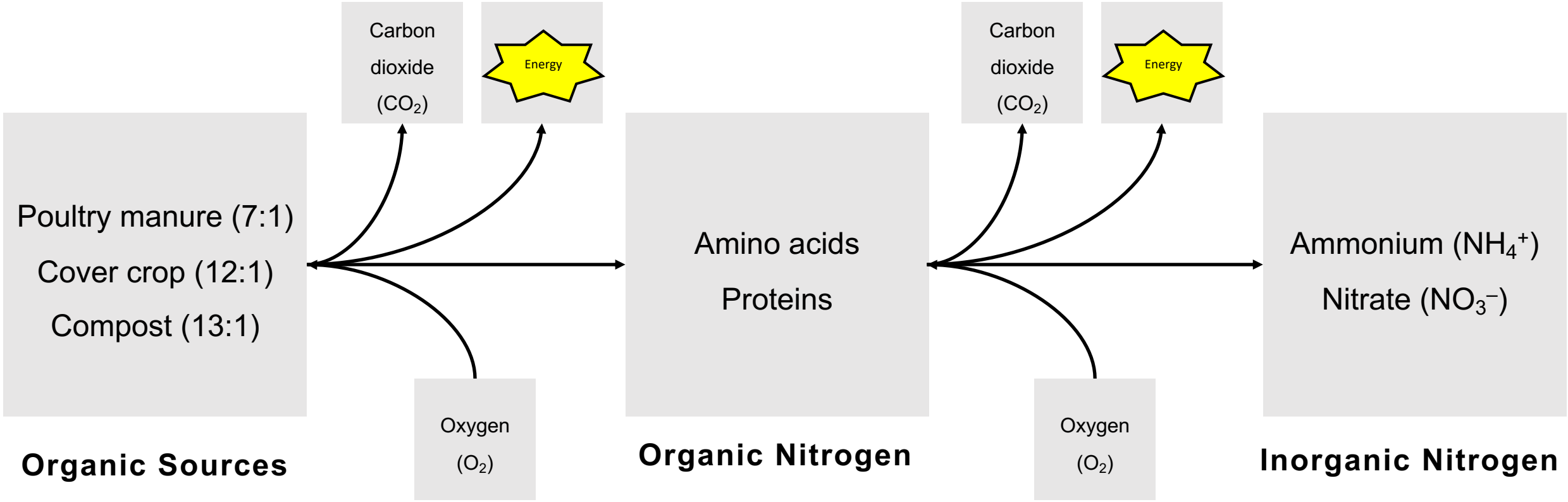
Biochemical Dynamics

Conversion from organic sources into inorganic nitrogen



Substrate Quality

Quality is determined by the carbon to nitrogen ratio (C:N) of the organic source



Environmental Conditions

What about the role of tillage, soil moisture and temperature?

Tillage

Increases mineralization

No Tillage

Reduces mineralization

Slows Decomposition

Aerated Soils

Increases mineralization

Saturated Soils

Reduces mineralization

Reduced Oxygen

High Temperature

Increases mineralization

Low Temperature

Reduces mineralization

Lower Microbial Activity

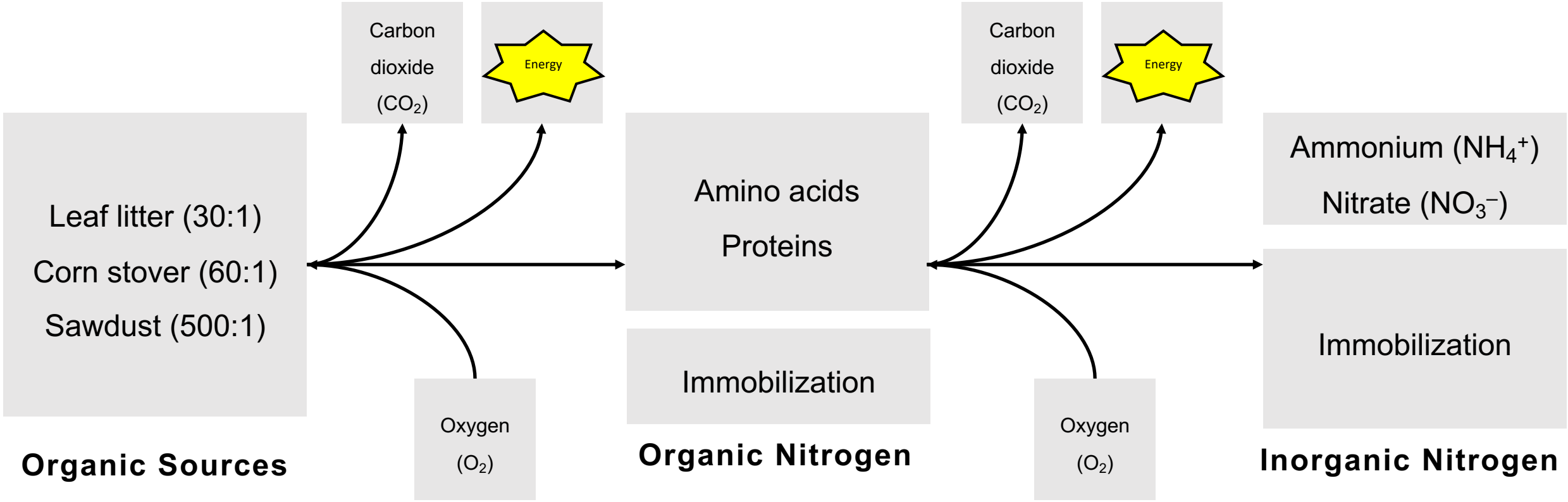
Immobilization of Soil Nitrogen

- Immobilization of organic and inorganic nitrogen
  - Microbes immobilize nitrogen when supply is lacking
  - Immobilization of inorganic nitrogen is also prevalent
  - Intracellular process by microbes requires energy

- Impact of substrate quality and soil conditions
  - Carbon to nitrogen ratio (C:N) controls immobilization
  - Nitrogen fertilizer and labile carbon have a strong influence
  - Microbes compete with plants for inorganic nitrogen

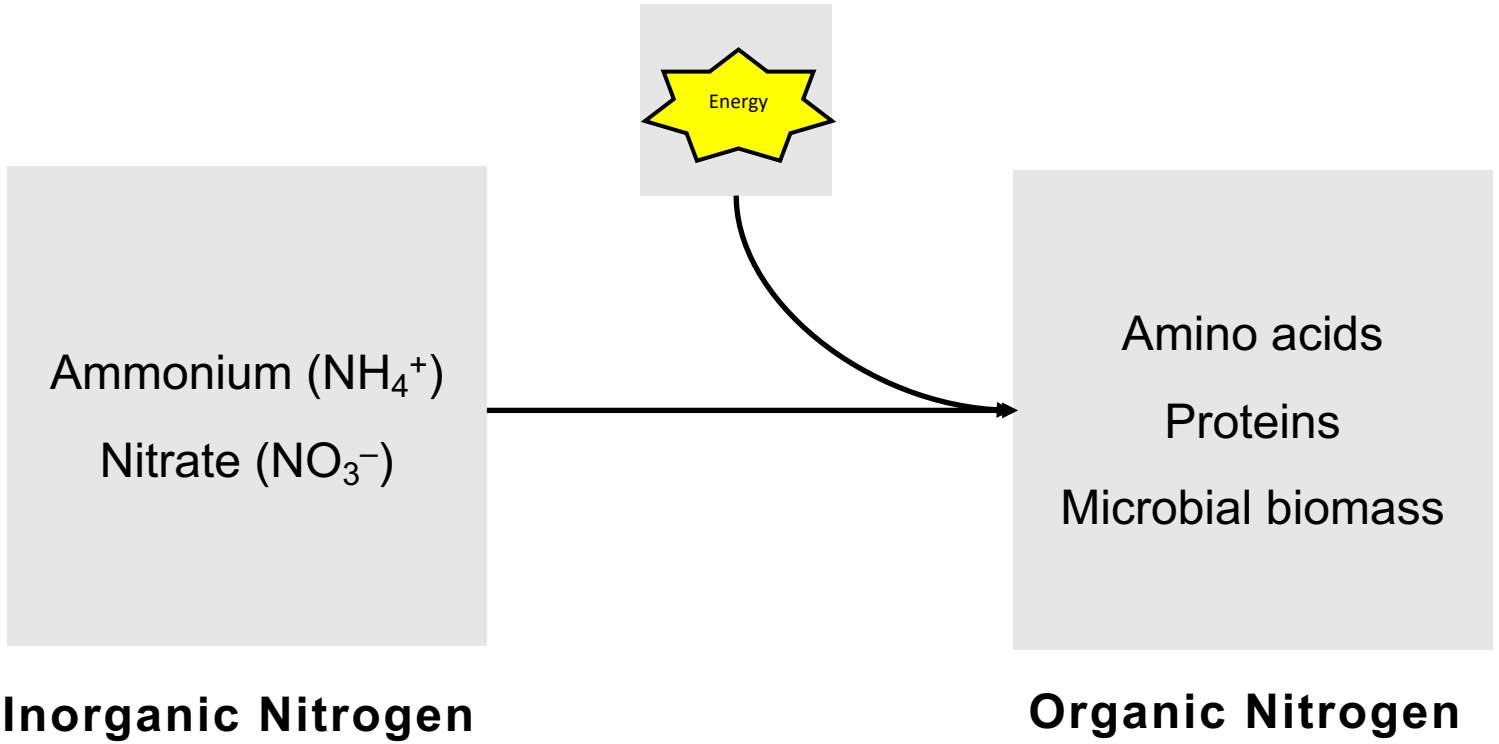
Substrate Quality

Quality is determined by the carbon to nitrogen ratio (C:N) of the organic source



Immobilization of Inorganic Nitrogen

Conversion from inorganic nitrogen into organic forms



Nitrification of Soil Nitrogen

- Biochemical dynamics of soil nitrogen nitrification
  - Conversion from ammonium (NH_4^+) into nitrate (NO_3^-)
  - Autotrophic process by microbes under aerobic conditions
  - Nitrogen is conserved during nitrification yet changes form

- Impact of soil conditions specifically temperature
  - Steady decline in NH_4^+ results in increasing NO_3^-
  - Nitrite (NO_2^-) is an intermediary with limited accumulation
  - A 50% increase in soil temperature can double nitrification rates

Biochemical Dynamics

Conversion from ammonium (NH_4^+) into nitrate (NO_3^-)

Step 1: Ammonium to nitrite

$$NH_4^+ + 1\tfrac{1}{2}O_2 \xrightarrow{Nitrosomonas} NO_2^- + 2H^+ + H_2O + energy$$

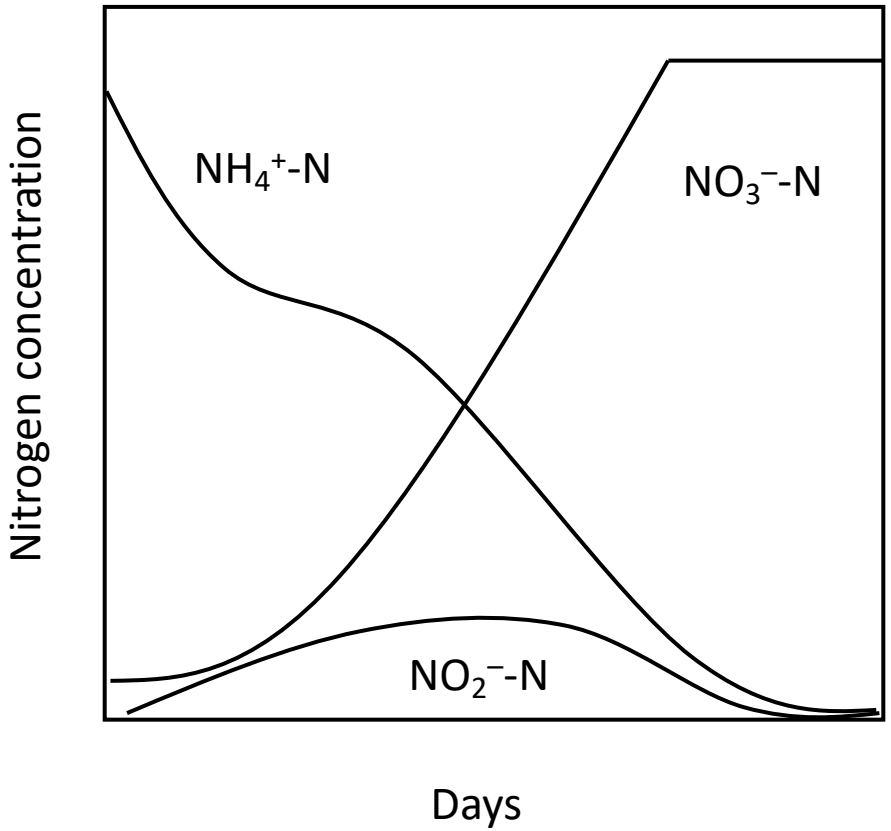
- Nitrite (NO_2^-) is toxic and doesn't accumulate
- Rapid conversion to nitrate (NO_3^-)

Step 2: Nitrite to nitrate

$$NO_2^- + \tfrac{1}{2}O_2 \xrightarrow{Nitrobacter} NO_3^- + energy$$

- Nitrate (NO_3^-) is readily available for plant uptake
- Risk of loss via denitrification and/or leaching

Nitrification

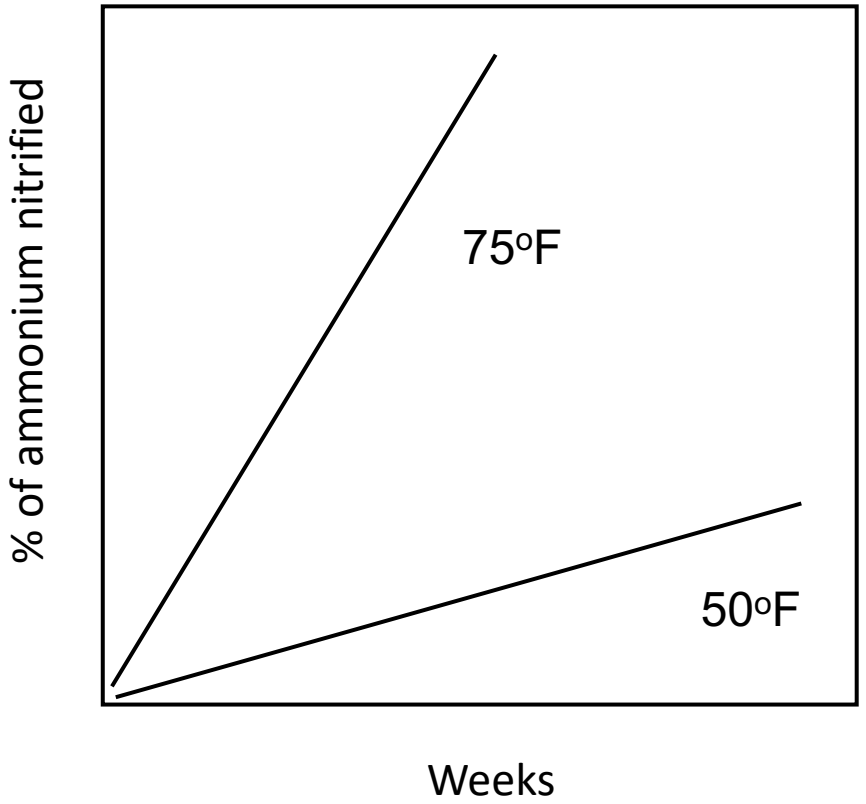


Nitrification over 14 days

Over 14 days under favorable nitrification conditions, there is a steady decline in ammonium and an increase in nitrate.

Nitrification driven by temperature

Nearly 100% of ammonium will be nitrified over four weeks at 50°F while an increase in temperature by 50% doubles the nitrification rate.



Review of Nitrogen Cycling in Soils

- Mineralization
  - Heterotrophic conversion of organic to inorganic forms
  - Favored under lower C:N of less than 20:1
- Immobilization
  - Microbial process for organic and inorganic forms
  - Favored under higher C:N of greater than 30:1
- Nitrification
  - Autotrophic conversion of ammonium (NH_4^+) to nitrate (NO_3^-)
  - Controlled mainly by soil temperature

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Course materials available at:

ciwr.ucanr.edu/NitrogenManagement

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