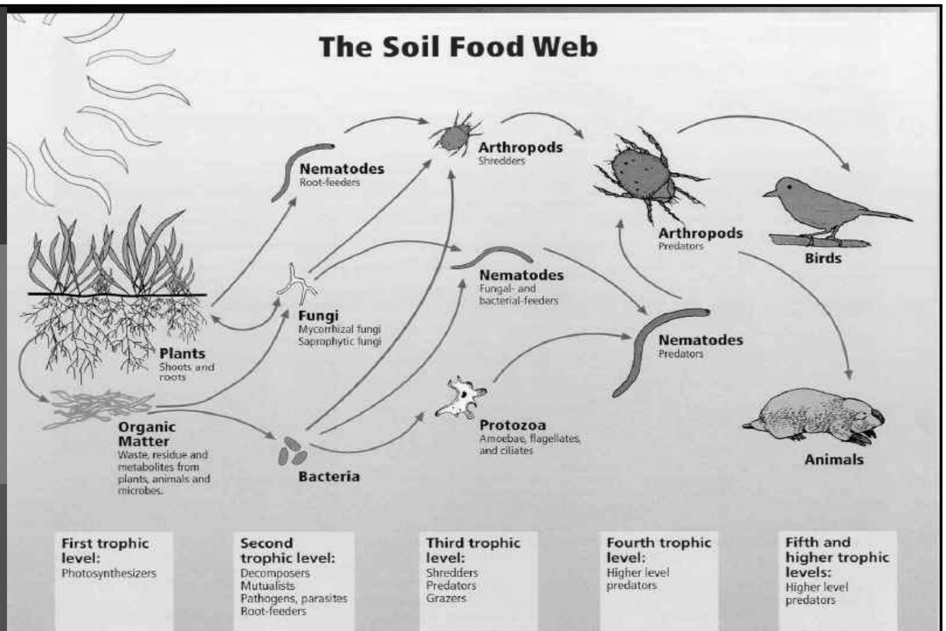
Organic Nitrogen Inputs and the Soil Food Web

What is the Food Web?

- An incredible diversity of organisms make up the food web. They range in size from the tiniest one-celled bacteria, algae, fungi, and protozoa, to the more complex nematodes and micro-arthropods, to the visible earthworms, insects, small vertebrates, and plants.



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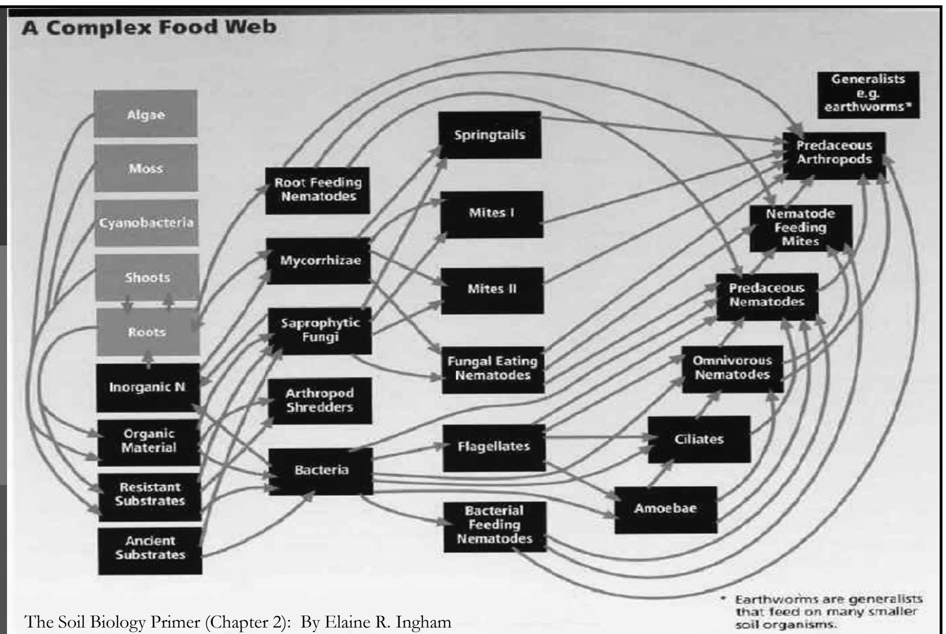

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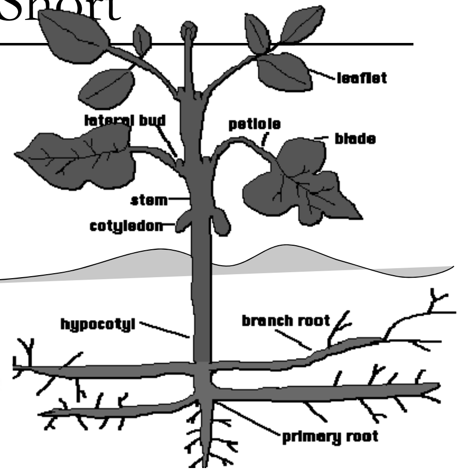
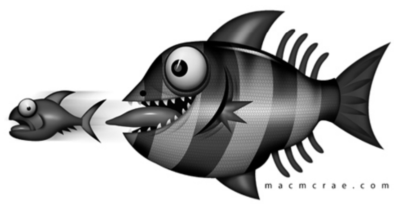
Figure 4

The Food Web in Short





Nutrients

Food Web Organisms Help Promote: Healthy Plants

- These food web organisms feed on plant residues, breaking them down and capturing the nutrients.
- Microbes release nutrients directly and through microbial decomposition.
- Microbes add stabilized nutrients to both the Active and Stable fraction of the soil.
- The organisms also fix nitrogen from the atmosphere for the plant’s use.

www.soilfoodweb.com

Why is a diversity of organisms important?

- The decomposition of organic matter is the first step in the nutrient cycle and involves many types of microorganisms in an interactive web.
- In this interaction, one organism will break down an organic compound in the soil making the surplus by-products available as nutrients for other organisms.
- These organisms will in turn do the same thing and continue the cycle, eventually making the nutrients available to plants and animals.
- The microbial concentration and diversity associated with the soil will impact the speed and extent of this nutrient cycling.

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Typical Numbers of Soil Organisms in Healthy Ecosystems

		Agricultural Soils	Prairie Soils	Forest Soils
Bacteria	Per teaspoon of soil (one gram dry)	100 million to 1 billion.	100 million to 1 billion.	100 million to 1 billion.
Fungi	Per teaspoon of soil (one gram dry)	Several yards. (Dominated by vesicular-arbuscular mycorrhizal (VAM) fungi).	Tens to hundreds of yards. (Dominated by vesicular-arbuscular mycorrhizal (VAM) fungi).	Several hundred yards in deciduous forests. One to forty miles in coniferous forests (dominated by ectomycorrhizal fungi).
Protozoa	Per teaspoon of soil (one gram dry)	Several thousand flagellates and amoebae, one hundred to several hundred ciliates.	Several thousand flagellates and amoebae, one hundred to several hundred ciliates.	Several hundred thousand amoebae, fewer flagellates.
Nematodes	Per teaspoon of soil (one gram dry)	Ten to twenty bacterial-feeders. A few fungal-feeders. Few predatory nematodes.	Tens to several hundred.	Several hundred bacterial- and fungal-feeders. Many predatory nematodes.
Arthropods	Per square foot	Up to one hundred.	Five hundred to two thousand.	Ten to twenty-five thousand. Many more species than in agricultural soils.
Earthworms	Per square foot	Five to thirty. More in soils with high organic matter.	Ten to fifty. Arid or semi-arid areas may have none.	Ten to fifty in deciduous woodlands. Very few in coniferous forests.

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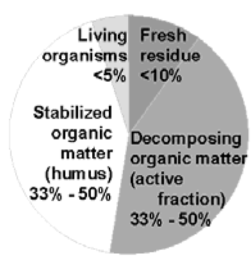
Organic Matter

- Organic matter is the vast array of carbon compounds in soil. Originally created by plants, microbes, and other organisms, these compounds play a variety of roles in nutrient, water and biological cycles.
- Organic matter can be divided into two major categories:
  - Active fraction
  - Stabilized organic matter
- Two other categories of organic compounds are living organisms and fresh organic residue.

Components of Soil Organic Matter



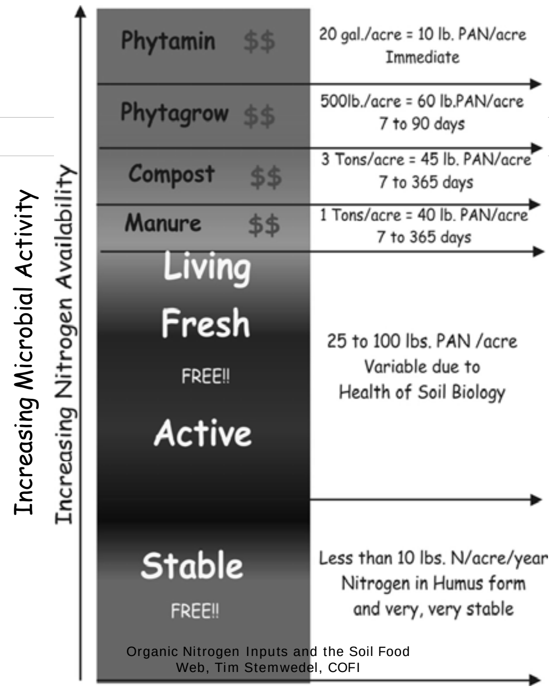
Soils with high organic matter content are the most productive, store more water and contribute to a better environment.

Active Fraction

- This matter is actively used and transformed by living plants, animals and microbes for food.

Stabilized Organic Matter

- Many soil organisms decompose plant and animal tissues, and transform the organic matter into new compounds. After years or decades of these transformations, what remains are large, complex compounds that few microbes can degrade. Other compounds become bound inside soil aggregates where microbes cannot reach. These hard-to-decompose, or stabilized, substances make up a third to a half of soil organic matter.
- Stabilized organic matter acts like a sponge and can absorb six times its weight in water. In sandy soils, water held by organic matter will make the difference between crop failure or success during a dry year.



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The Nitrogen Fertilizer Input Cycle

- ❖ Nitrogen Input is applied to the soil.
- ❖ Macro-organisms start the breakdown. (fungi, protozoa)
- ❖ The result of this macrobial action is amines and ammonia compounds. (plant food)
- ❖ Bacteria further break down amines & ammonia compounds into nitrites.
- ❖ Plants cannot use this form of nitrogen, so it is further broken down by bacteria into nitrates.
- ❖ Plants can then absorb this form of nitrogen and the cycle continues.

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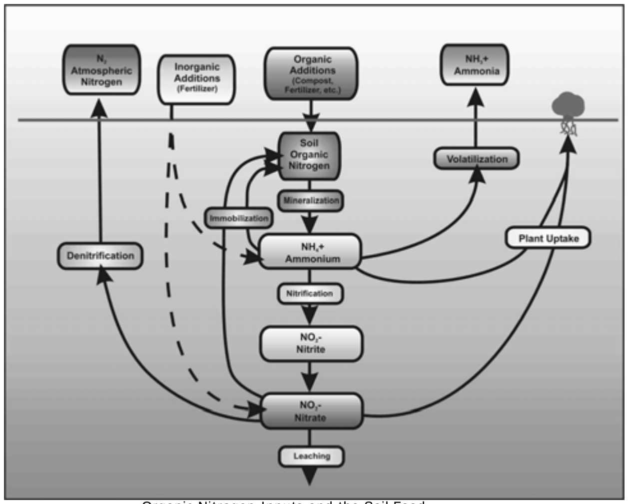
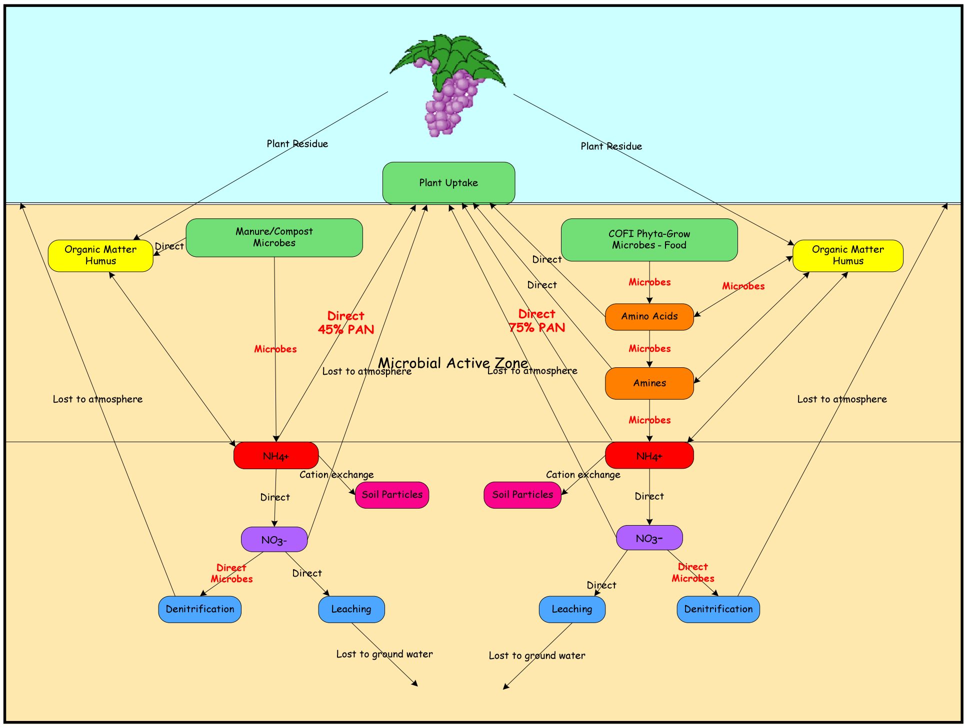
The Nitrogen Fertilizer Input Cycle



Understanding the Nitrogen Cycle

- Now that you understand the process, you can see that the application of nitrate-based fertilizers completely bypasses this cycle, essentially "feeding the plant."
- So, our goal with most organic fertiizer inputs is to "feed the soil", the organisms living in the soil, that eventually "feed" the plant.



Feeding the Soil Increases and Improves the Biological Structure of the Soil

- Benefits:
  - Less disease – fewer and possibly no pesticide applications
  - Reduced fertilizer requirements due to stabilization of the Nitrogen.
  - Better soil structure – less water required, better root growth due to soil aggregation, higher organic matter, less nitrates, less soluble salts.
  - When pesticide is used, it will be degraded rapidly in the soil due to microbial decomposition due to higher organic matter.
  - Run-off and groundwater contamination will be reduced due to soil aggregation and higher organic matter.

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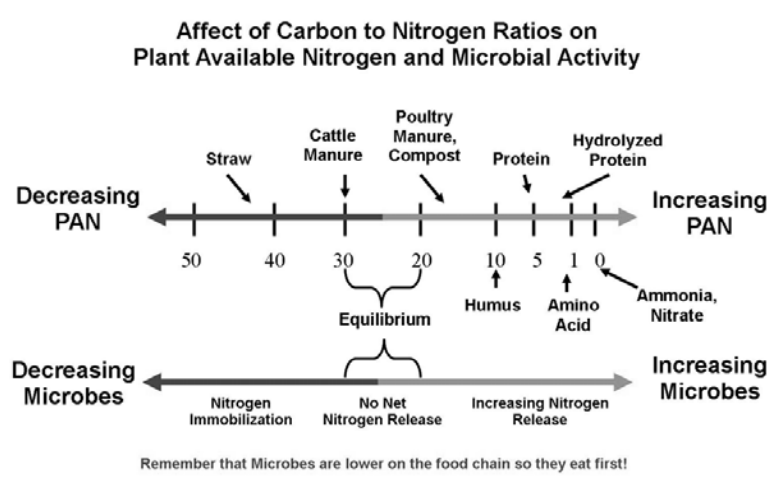
Differences in Inputs

- Organic Nitrogen Inputs vary dramatically in their composition resulting in significant differences in Plant Available Nitrogen (PAN)
- The higher the C:N ratio the lower the PAN
- The higher the C:N ratio the lower the Microbial Activity. This is because microbes need Nitrogen to reproduce.
- Salt Index

Organic Fertilizers



PAN Efficiency

Organic Fertilizers

Fertilizing Material	PAN Efficiency
Layer Poultry Litter	69%
Broiler Poultry Litter	53%
Feather Meal	88%
Seabird Guano	94%
Liquid Fish	92%
Corn Steep	88%
Molasses Deriv.	81%
Liquid Guano	97%

Cost Analysis

Organic Fertilizers

Fertilizing Material	$/Ton 0r Gal.	$/ lb N
Layer Poultry Litter 4% N	$250	$4.55
Broiler Poultry Litter 4% N	$250	$5.88
Feather Meal 12% N	$750	$3.57
Meat & Bone 8% N	$600	$4.44
Seabird Guano 12% N	$900	$4.00
Liquid Fish 5% N	$4.00	$17.37
Liquid Guano 4.5% N	$4.00	$18.35

Plant Available Nitrogen (PAN)

Plant Available Nitrogen (PAN) is the quantity of Nitrogen made available during the growing season after fertilizing materials are applied. A certain amount of the Nitrogen is immobilized, and the remaining Nitrogen is available to the plant. Some fertilizing options are better than others in terms of **PAN**. The worksheet below illustrates how to calculate **PAN** when determining which material/fertilizer is more effective in terms of available Nitrogen as well as price.

Variables needed: C:N Ratio of the material/fertilizer, % N in the material fertilizer, pounds of product used and price per pound

Example: We will compare turkey litter to feather meal. The C:N Ratio of turkey litter is 12.5 and the %N is 4%. The C:N Ratio of feather meal is 4 and the %N is 12%. For this example, turkey litter is $250/ton and feather meal is $700/ton. We will use 1,000 lbs of material.

Calculations	Turkey Litter Example	Feather Meal Example
Calculate for Total N: Number of Pounds Used x %N	Calculate for Total N: 1000 x 4% = 40 lbs	Calculate for Total N: 1000 x 12% = 120 lbs
Calculate for Total C: C:N Ratio x Total N	Calculate for Total C: 40 x 12.5 = 500	Calculate for Total C: 120 x 4 = 480
Calculate 25% Lb New Tissue: Total C x 25%	Calculate 25% Lb New Tissue: 500 x 25% = 125	Calculate 25% Lb New Tissue: 480 x 25% = 120
Calculate N Immobilized, Using Microbe C:N of 8: New Tissue / 8	Calculate N Immobilized, Using Microbe C:N of 8: 125 / 8 = 15.63	Calculate N Immobilized, Using Microbe C:N of 8: 120 / 8 = 15
Calculate PAN: Total N - N Immobilized	Calculate PAN: 40 - 15.63 = 24.37	Calculate PAN: 120 - 15 = 105
Calculate Cost per pound PAN: (Cost per Pound / PAN) x Pounds Used	Calculate Cost per pound PAN: (0.125 / 24.37) x 1000 = $5.13	Calculate Cost per pound PAN: (0.35 / 105) x 1000 = $3.33
Calculate In-Season Efficiency: PAN / Total N	Calculate In-Season Efficiency: 24.37 / 40 = 61%	Calculate In-Season Efficiency: 105 / 120 = 88%

Results: In this example, we see that although feather meal costs more per ton than turkey litter, it actually costs less per pound when we determine how much Nitrogen is available from the two products. The feather meal is also significantly more efficient than the turkey litter regardless of the cost. When choosing a fertilizing material based on its Nitrogen content, the rule of thumb is to choose the material with the lower C:N Ratio.

Salt Index Ratings

	Salt Index
Sodium Nitrate, 16.5% N	100
Potassium Sulfate, 50% K_2O, 18% S	42.6
Gypsum, 23% Ca, 17% S	8.1
Manure Salts, 20%	112.7
Manure Salts, 30%	91.9
Seabird Guano 12-12-1	42.9
Feather Meal 12% N	1.4
Bone Meal 3% N, 15% P_2O_5	1.8
Blood Meal 13% N, 1.5 P_2O_5	2.8
Meat & Bone Meal 8-5-1	3.9

Other Considerations

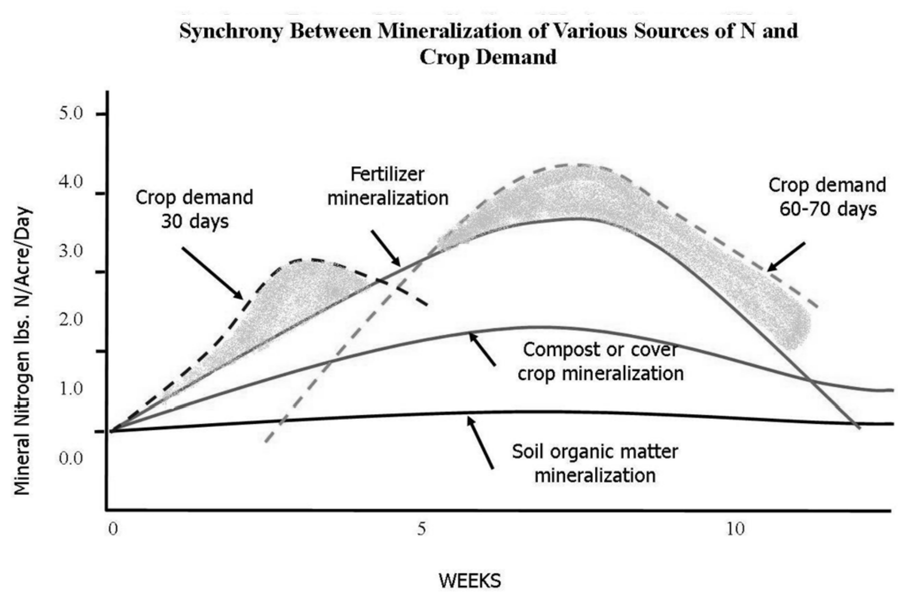
- Solubility and Insolubility
- Nutrient Availability

Other Considerations

- Solubility and Insolubility
  - Some inputs have high solubility and generally have a negative or neutral impact on the Food Web and Nitrogen Cycle of the soil
  - High Solubility: Dry and Liquid Guano
  - Low Solubility: Proteins
  - Both: Manure, Liquid fish, Corn Steep

Other Considerations

- Nutrient Availability
  - High nutrient availability products generally have low C:N ratios and high mineralized nutrient content (NH_3, NO_3, etc).
    - Dry and Liquid Guano
    - Sodium Nitrate
  - Low nutrient availability products have higher C:N ratios with low levels of mineralized nutrients.
    - Proteins, Fish Emulsion/Tankage
  - Products containing both.
    - Manure, Hydrolyzed Fish, Blends



Conclusions

- The Food Web is the micro-organisms that mineralize organic matter and produce humus for future use and soil stability
- (Big Fish eat little fish)

- Soil is comprised of Living/Fresh & Active or Stable Organic Matter (Living/Fresh and Active is more available)
- PAN is higher for Low C:N ratio Inputs. High C:N contributes to the Stable portion (i.e.: not this crop)
- Feed the Soil – not Feed the Plant for long term success.

Further Conclusions

- Low Cost per pound on N is not always the cheapest.
- Salt Index is important. Salt kills microbes.
- Solubility and Availability is important if you need a fast acting fertilizer.
- Synchronizing applications with crop demand is critical for success.

Thank You!

- This presentation will be available at www.organicag.com
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