Investing in Your Soil: The Role of Organic Matter in Soil Function

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Investing in Your Soils Overview

- **Why invest?**
- **Differences between organic/ecological nutrient management & conventional**
- **Soil investment strategies (lessons from nature)**
  - **Role of organic matter in soil function**
  - **How do plants and soil interact?**
  - **Soil management and water**
- **Resources**
- **One farmer's view of soil management**

Reasons to invest in your soil's function

- Without sufficient organic matter, soil function can be severely impaired....
- Well-managed soils store and cycle both *nutrients* and *water* more effectively AND help protect water quality above and below ground.
- All farmers are required to develop N management plans (ILRP), and due to SGMA, likely have to report on water usage.

Our soils aren't ready for the stresses that climate change will bring...

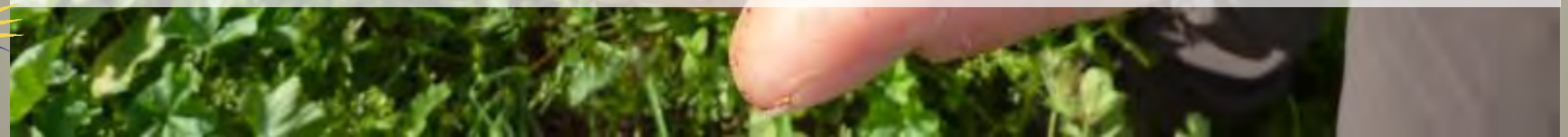

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Table 1. Estimates of all degraded lands (in million km ^{2}) in dry areas (Dregne and Chou, 1994).

Continent	Total area	Degraded area †	% degraded
Africa	14.326	10.458	73
Asia	18.814	13.417	71
Australia and the Pacific	7.012	3.759	54
Europe	1.456	0.943	65
North America	5.782	4.286	74
South America	4.207	3.058	73
Total	**51.597**	**35.922**	**70**

† Comprises land and vegetation.

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How is ecological soil management different from conventional?

- It attempts to relink the C and N cycles in management of agricultural soils, which were severed by Haber-Bosch process
- It's more dependent on healthy soil microbiology, which in turn….
- ….Makes management less precise due to number of variables: Soil temp, moisture, tillage, OM%, C:N ratios of various inputs, including cover crops

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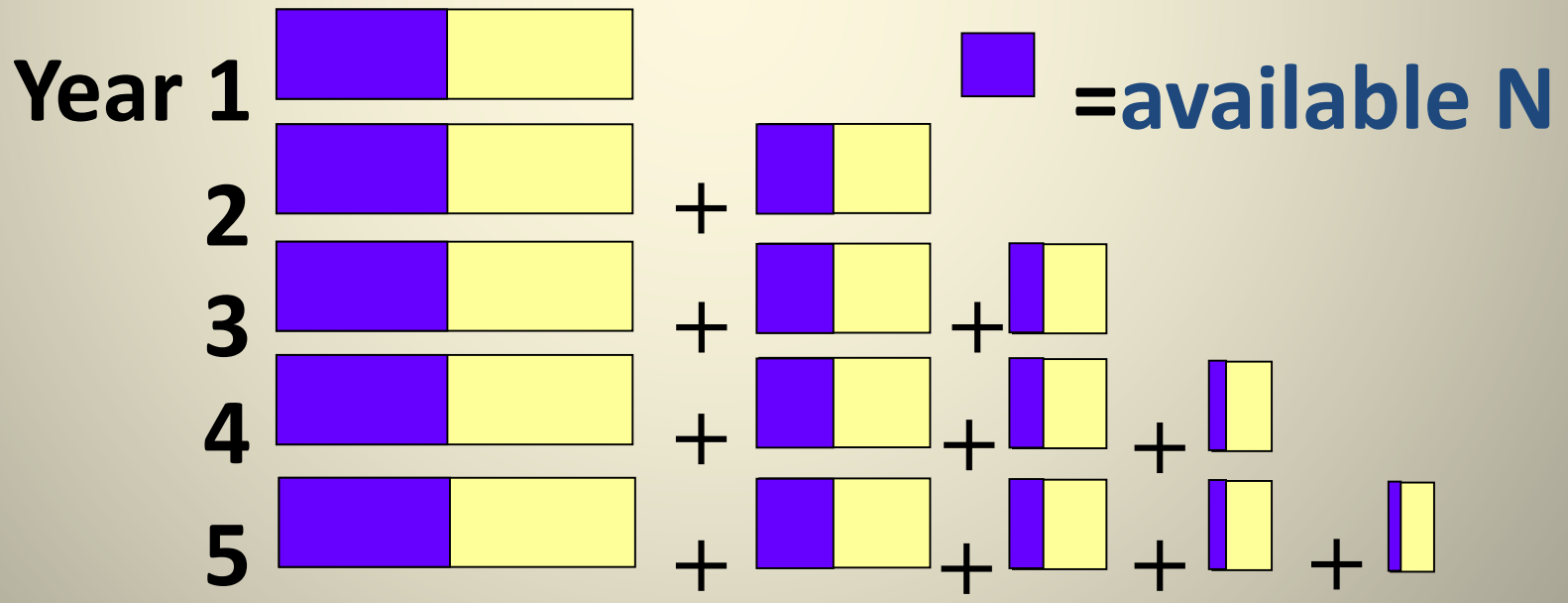
How is ecological soil management different from conventional?

- Slower release (especially N)
- Often higher P applications (with manure & manure-based compost)
- Soil quality builds and provides returns over time



Courtesy of Dan Sullivan OSU Crop & Soil Science

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What lessons (soil investment strategies) from nature can be applied to our agricultural systems?

Regular additions of *organic matter* to the soil

- **Compost, cover crops, green manures, manures, plant residue (leave the straw, invest in your soil!!)**

Diverse sources of organic matter (encourages complexity)

What lessons (soil investment strategies) from nature can be applied to our agricultural systems?

Protect the soil surface (living plants or mulch)

Keep soil disturbance, physical (tillage) or chemical disturbance, to a minimum

Try to match inputs/nutrient availability with crop demand

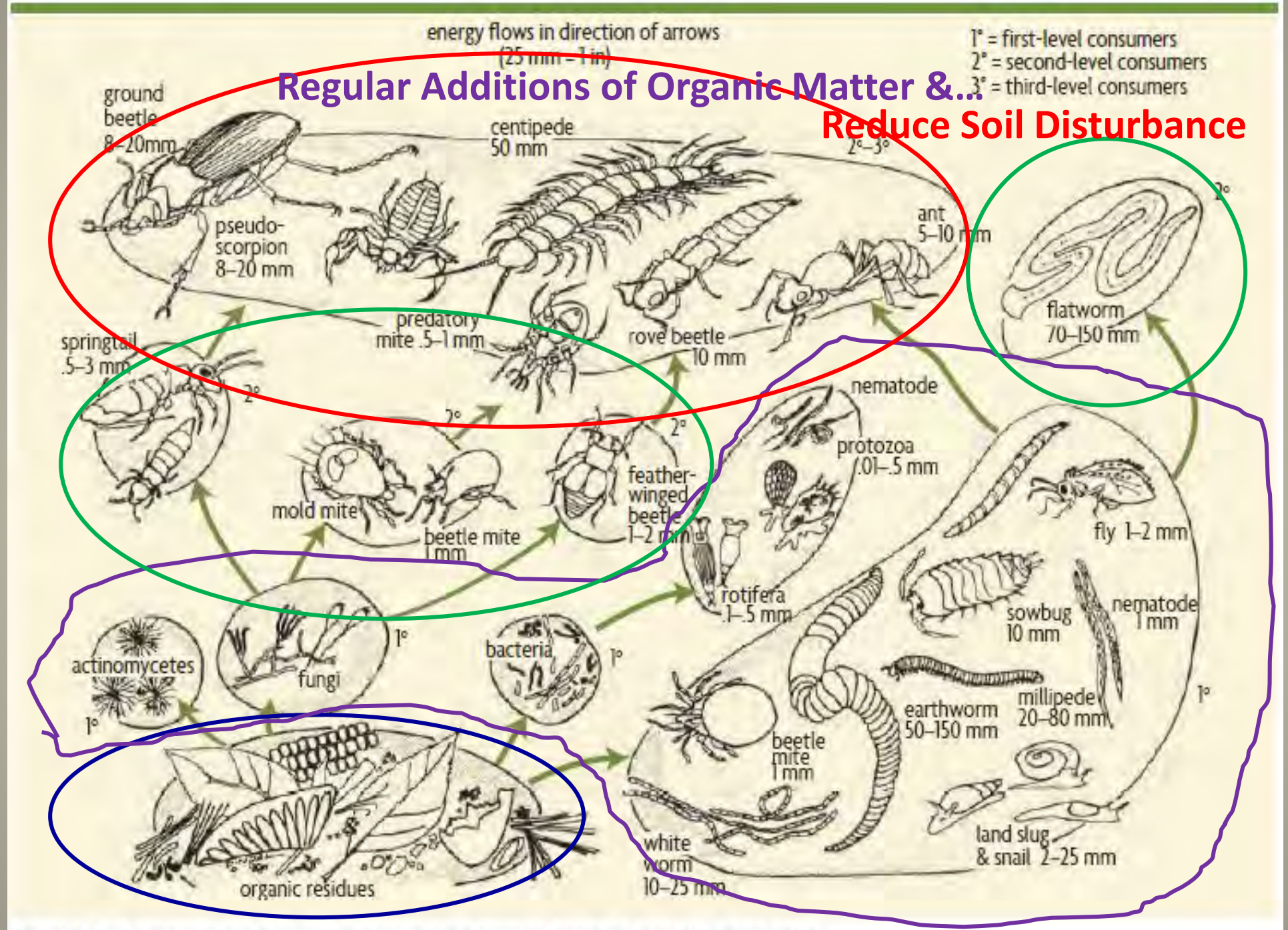
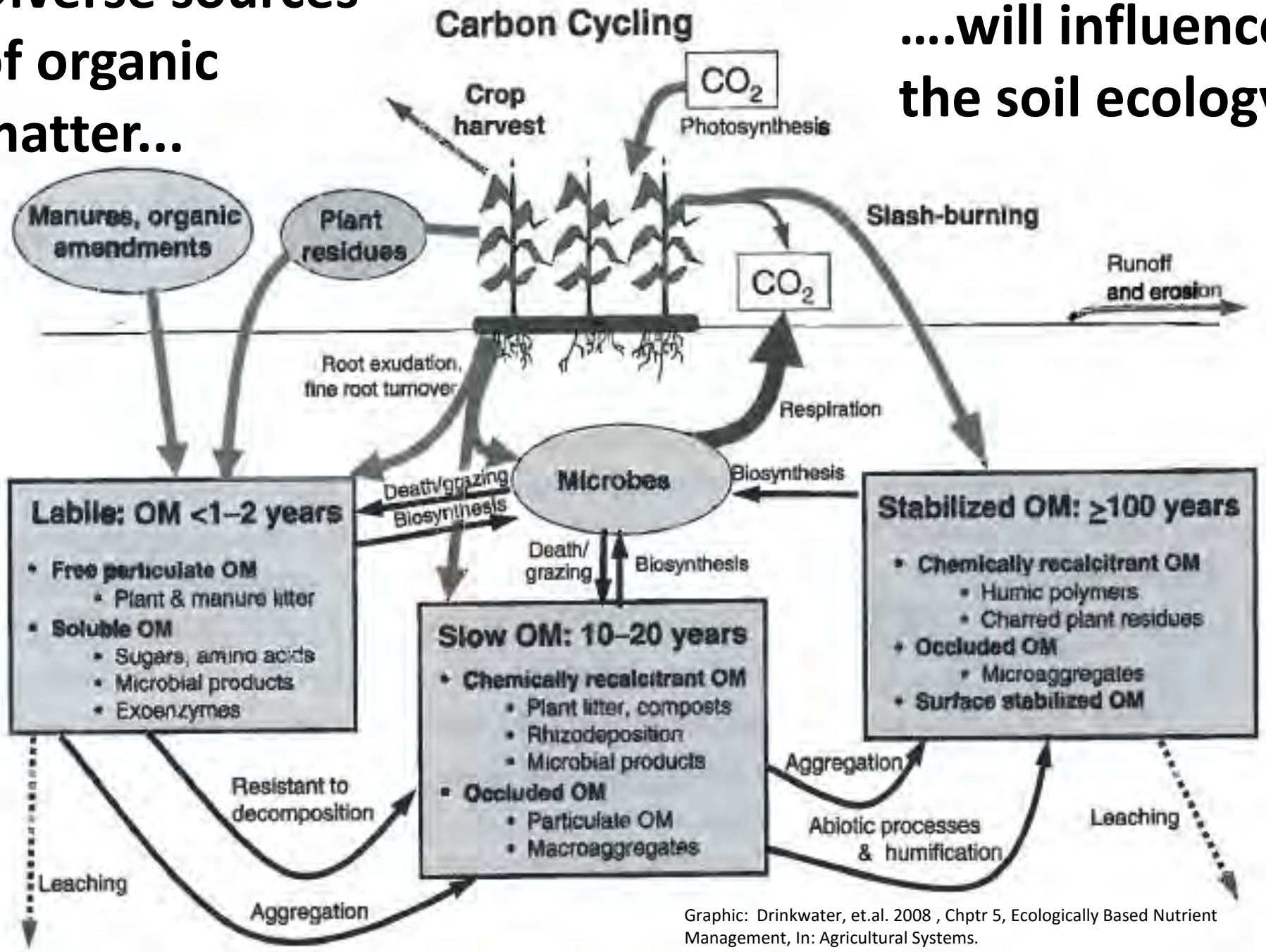


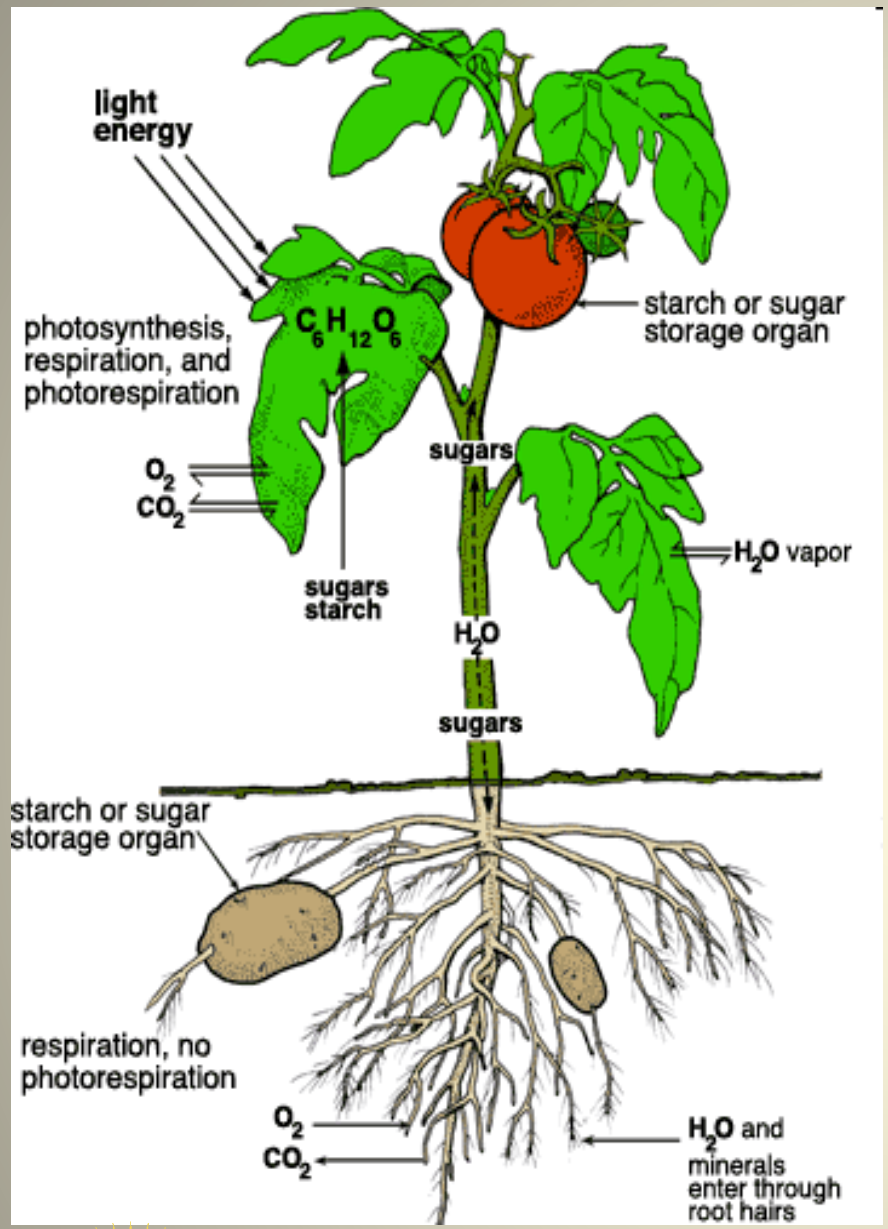
Figure 4.1. Soil organisms and their role in decomposing residues. Modified from D.L. Dindal (1972).

Diverse sources of organic matter...

....will influence the soil ecology



Graphic: Drinkwater, et.al. 2008 , Chptr 5, Ecologically Based Nutrient Management, In: Agricultural Systems.



Protect the Soil (Living Plants) & Diverse Sources of Organic Matter

Up to 20% of carbon (or more) fixed by photosynthesis in plants is transferred to the soil as root exudates.

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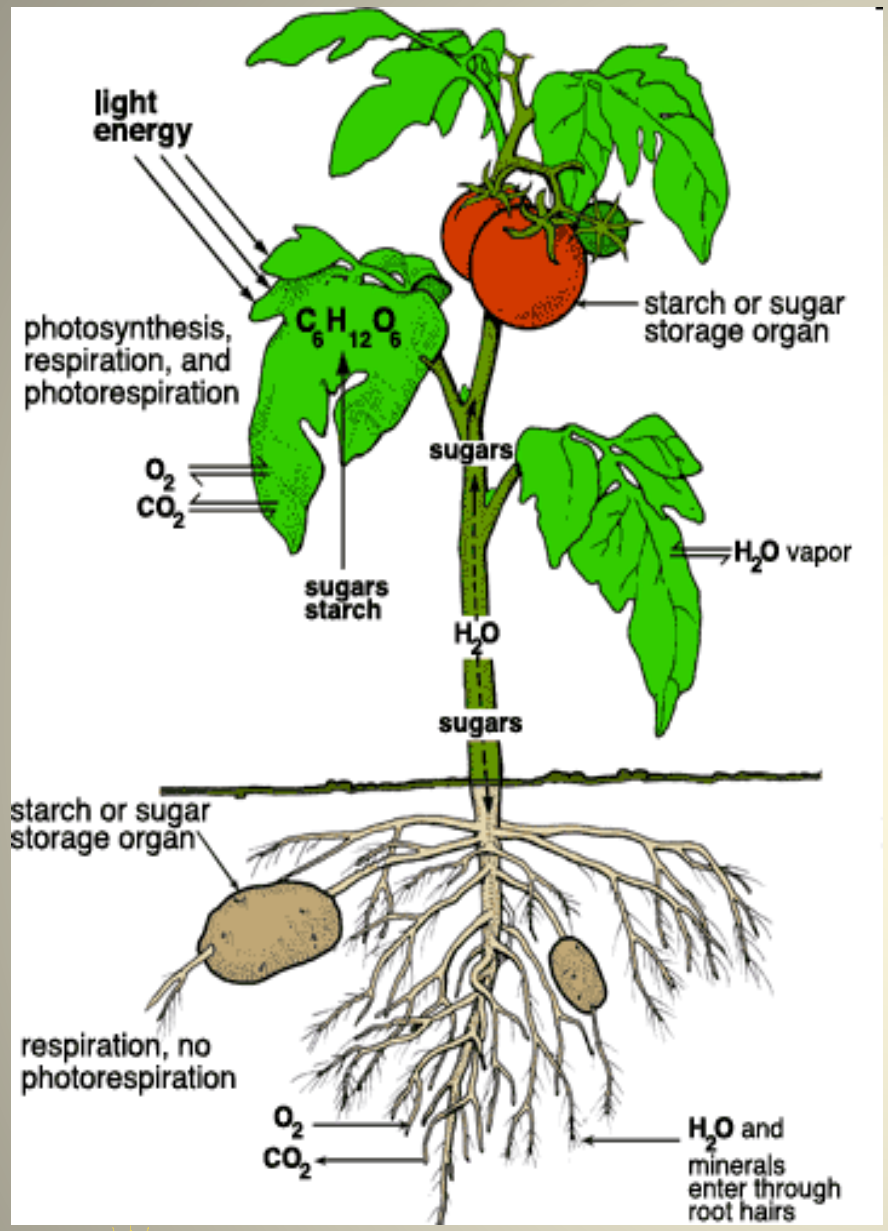

Plant roots exude:

- Water
- Sugars,
- Amino acids,
- Organic acids,
- Vitamins,
- Plant hormones,
- Growth substances,
- Mucilage, and
- Proteins

Signaling and enzyme feedback systems

Crop rotation (diversity) influence (Jackson, et al, 2012, Gardner, et al, 2011)

Exudates encourage microbial growth and the microbes improve uptake of nutrients by plants.

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TIP OF A ROOT WITH
MYCORRHIZAE ATTACHED
(MAGNIFCATION = 100X)
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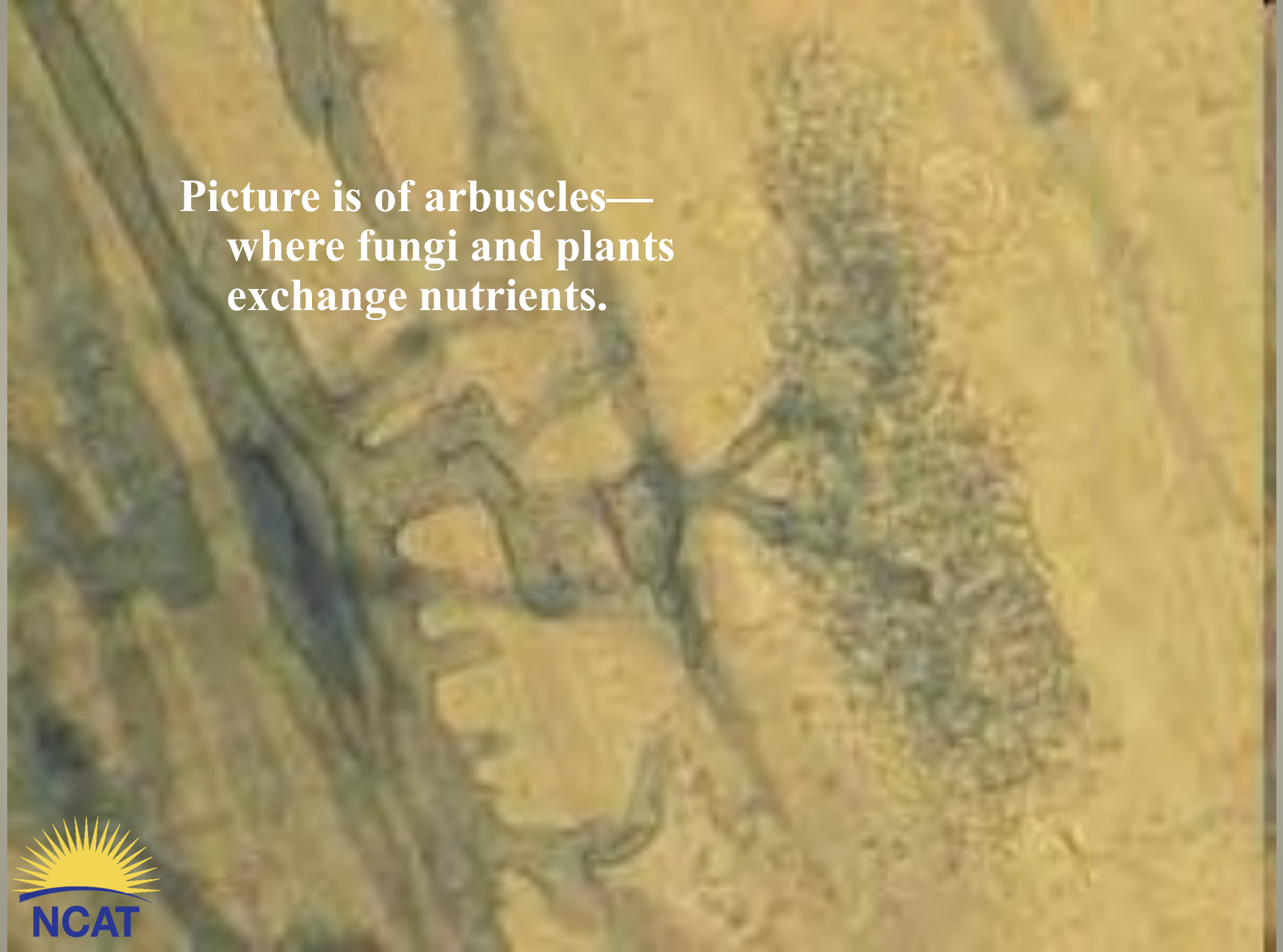
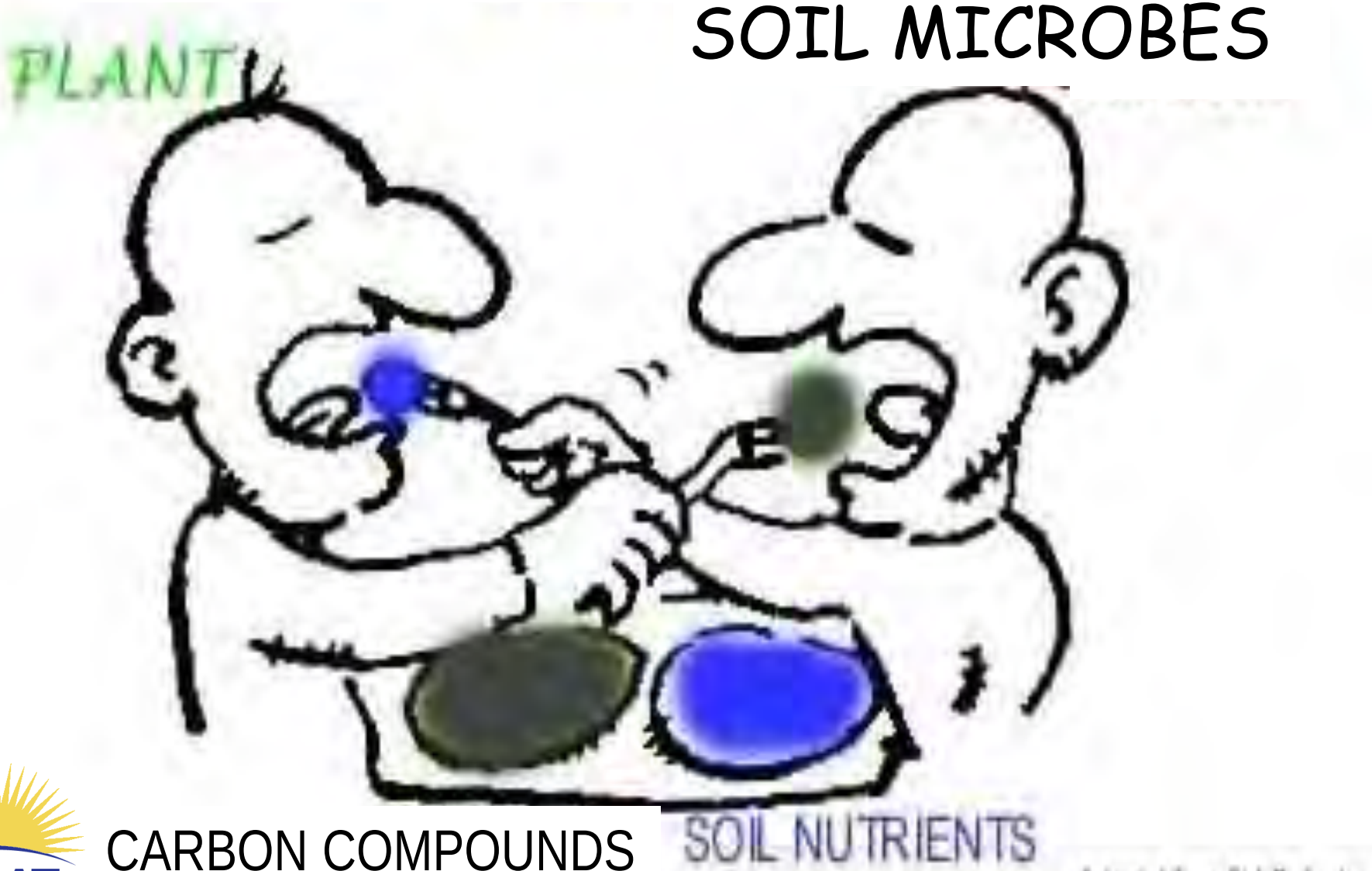

Picture is of arbuscles—
where fungi and plants
exchange nutrients.

Protect the Soil (Living Plants) & Diverse Sources of Organic Matter



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A microscopic view of an arbuscular mycorrhizal fungus growing on a corn root. The substance coating them is glomalin, revealed by a green dye.

From: *"Glomalin: Hiding Place for a Third of the World's Stored Carbon" 2002, Kristine Nichols USDA ARS)*

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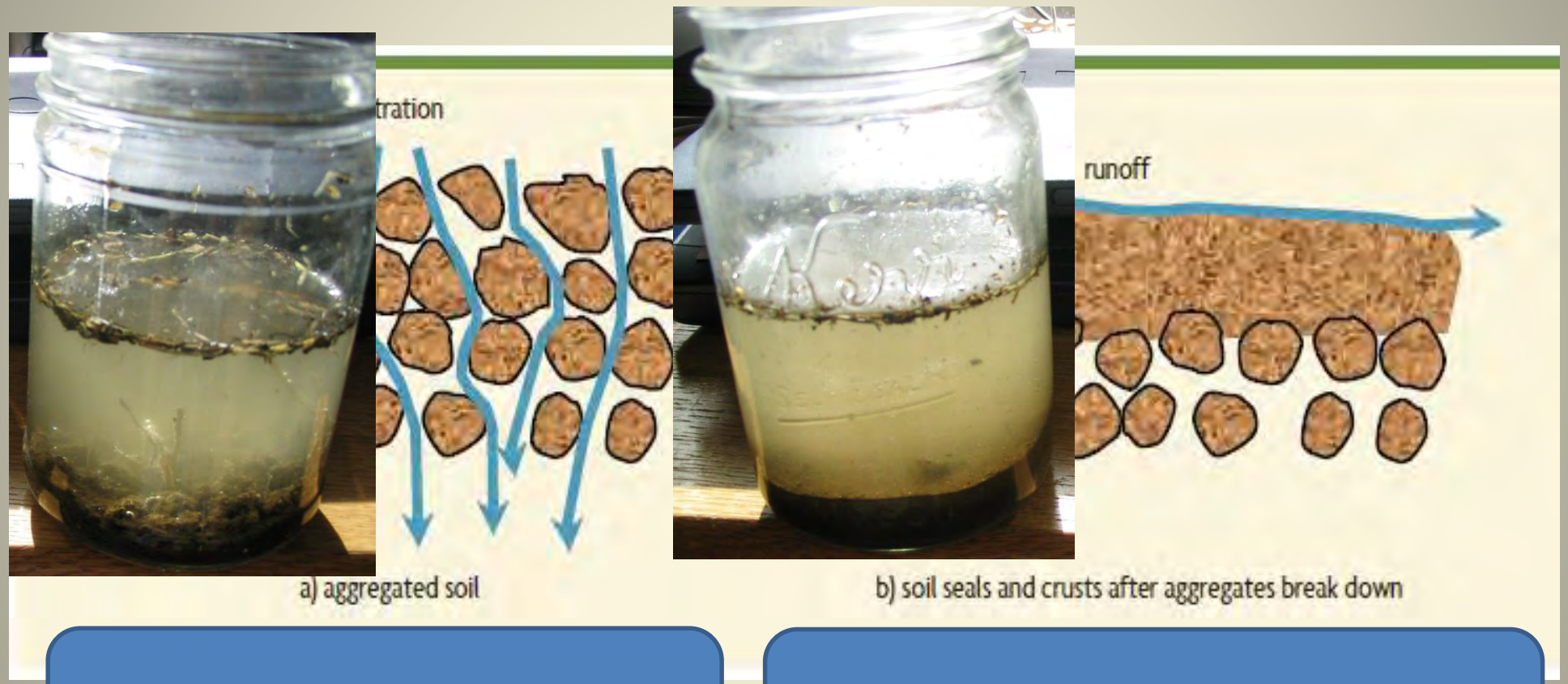
Glomalin, Fungi and Soil Aggregates

Figure 3. Roots, fungi hyphae. and polysaccharides stabilize soil macroaggregates and promote good soil structure.

40-60% of the soil microbial biomass is associated with microaggregates (<250 micrometers)

Soil Aggregates and Water Infiltration



Soil structure = infiltration

No soil structure = no infiltration

Graphic: Building Soils for Better Crops, Magdoff & van Es, 2009.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Increasing soil organic matter can help increase water infiltration into the soil, the root zone, and ultimately, the water table…
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Soil Organic Matter and Available Water Capacity
Inches of Water per Foot of Soil

Hudson, B.D. 1994. Journal of Soil and Water Conservation, 49(2). 189-194, March-April

Percent SOM	Sand	Silt Loam	Silt Clay Loam
1	1.0	1.9	1.4
2	1.4	2.4	1.8
3	1.7	2.9	2.2
4	2.1	3.5	2.6
5	2.5	4.0	3.0

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Principles of Soil Management To Maintain or Increase Soil Function:

Regular additions of *organic matter* to the soil

- Compost, cover crops, green manures, plant residue (leave the straw, invest in your soil!!)

Diverse sources of organic matter (encourages complexity)

Protect the soil surface (living plants or mulch)

Keep soil disturbance, physical (tillage) or chemical disturbance, to a minimum

Try to match inputs/nutrient availability with crop demand

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Photo: Rex Dufour

Cover Crops


Photo: Rex Dufour


Photo: Rex Dufour

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Cover crop in new orchards

Recycling Old Orchards (30+ tons an acre of C)


A mulching opportunity
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Resources

https://attra.ncat.org/soils.html

Latest Headlines

Soils & Compost

Healthy soil can improve crop and livestock production. The publications and other resources listed here offer information on how to assess, improve, and maintain soil health for both croplands and pastures. Several publications address fertilization and composting specifically for organic production. Soil management can also play an important role in protecting water quality, and additional resources are listed on that topic.

Publications

NOTE: Some of the following documents are available as Adobe Acrobat PDFs. Download Acrobat Reader.

A Brief Overview of Nutrient Cycling in Pastures - IP221
PDF Price: FREE
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Alternative Soil Amendments - IP054
PDF Price: $0.99 for non-members
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Arsenic in Poultry Litter: Organic Regulations - IP266
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Assessing the Pasture Soil Resource - IP128
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Biochar and Sustainable Agriculture - IP358
PDF Price: FREE

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What Is Sustainable Agriculture?
Master Publication List
Education
Energy Alternatives
Beginning Farmer
Field Crops
Horticultural Crops
Livestock & Pasture
Local Food Systems

Resources for Soil Assessment and Management

Web Soil Survey:
http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

SARE's *Building Soils for Better Crops*

SARE's *Crop Rotation on Organic Farms. A Planning Manual.*

Cornell's *Soil Health Training Manual*

Good Farmers—generally wise advice with experience behind it.

NRCS: Soil Biology Primer and lots of other information about soil management and function & EQIP and CSP Programs

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Resources for Soil Assessment and Management

Ohio State University's, *The Biology of Soil Compaction* Fact Sheet (2009)

The Organic Center's *Assessing Soil Quality in Organic Agriculture* (2006)

ATTRA: Publications, (800-346-9140; www.attra.ncat.org), *Sustainable Soil Management, Drought Resistant Soils, Soil Management: National Organic Program Regulations,* and many others.

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Resources for Soil Assessment and Management

Bowles, T.M., Acosta-Martínez, V., Calderón, L.E. Jackson. 2014. Soil enzyme activities, microbial communities, and carbon and nitrogen availability in organic agroecosystems across an intensively-managed agricultural landscape. Soil Biology & Biochemistry 68 (2014) 252-262

Burns, R.G., DeForest, J.L., Marxsen, J., Sinsabaugh, R.L., Stromberger, M.E.,Wallenstein, M.D., Weintraub, M.N., Zoppini, A., 2013. Soil enzymes in a changing environment: current knowledge and future directions. Soil Biol.Biochem. 58, 216-234.

Gardner, T., Acosta-Martínez, V., Senwo, Z., Dowd, S.E., 2011. Soil rhizosphere microbial communities and enzyme activities under organic farming in Alabama. Diversity 3, 308-328.

Jackson, L.E., Bowles, T.M., Hodson, A.K., Lazcano, C., 2012. Soil microbial-root and Microbial-rhizosphere processes to increase nitrogen availability and retention in agroecosystems. Curr. Opin. Environ. Sustain. 4, 517-522

Soil Quality: What's Relevant to Growing Almonds?
www.almonds.com/sites/default/files/content/attachments/soil_quality.pdf

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Questions?
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