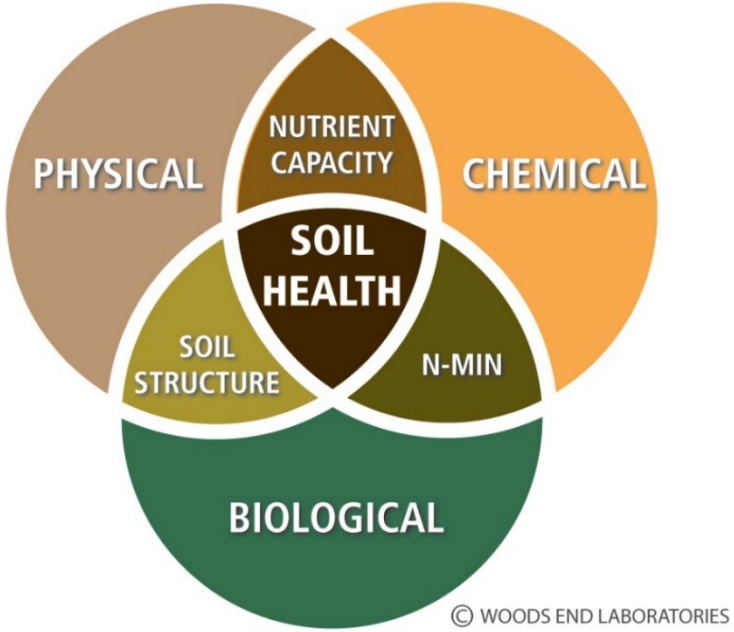
What's a Healthy Soil?



Presenter Will Brinton Ph.D.
Founder, director

Faculty Associate

Prologue for the on-line version

This slide show accompanied a lecture by Dr Brinton in Asilomar, Monterey CA.

NOTES: Soil Health is a popular “new” movement gaining ground with farmers and promising renewed hope for real soil building - regardless of farming preferences and organic status.

Yet, soil health is not new, and is fully and completely an organic creation that has taken 40 years to gain a footing. The presenter will show that the science underlying health was conceived by early organic/bio-dynamic scientists in Europe. That soil health has jumped the border of organic farming is no surprise. Based on current science assessments, organic farming continues to lead conventional farming in virtually all soil health metrics.

Will Brinton

Healthy Soil is ….

- A world *including* roots, microbes, animals
- A complicated trait that's hard to quantify!
- The *road not taken* for modern ag science
- The *brainchild* of early organic farming
- Nature's Plan

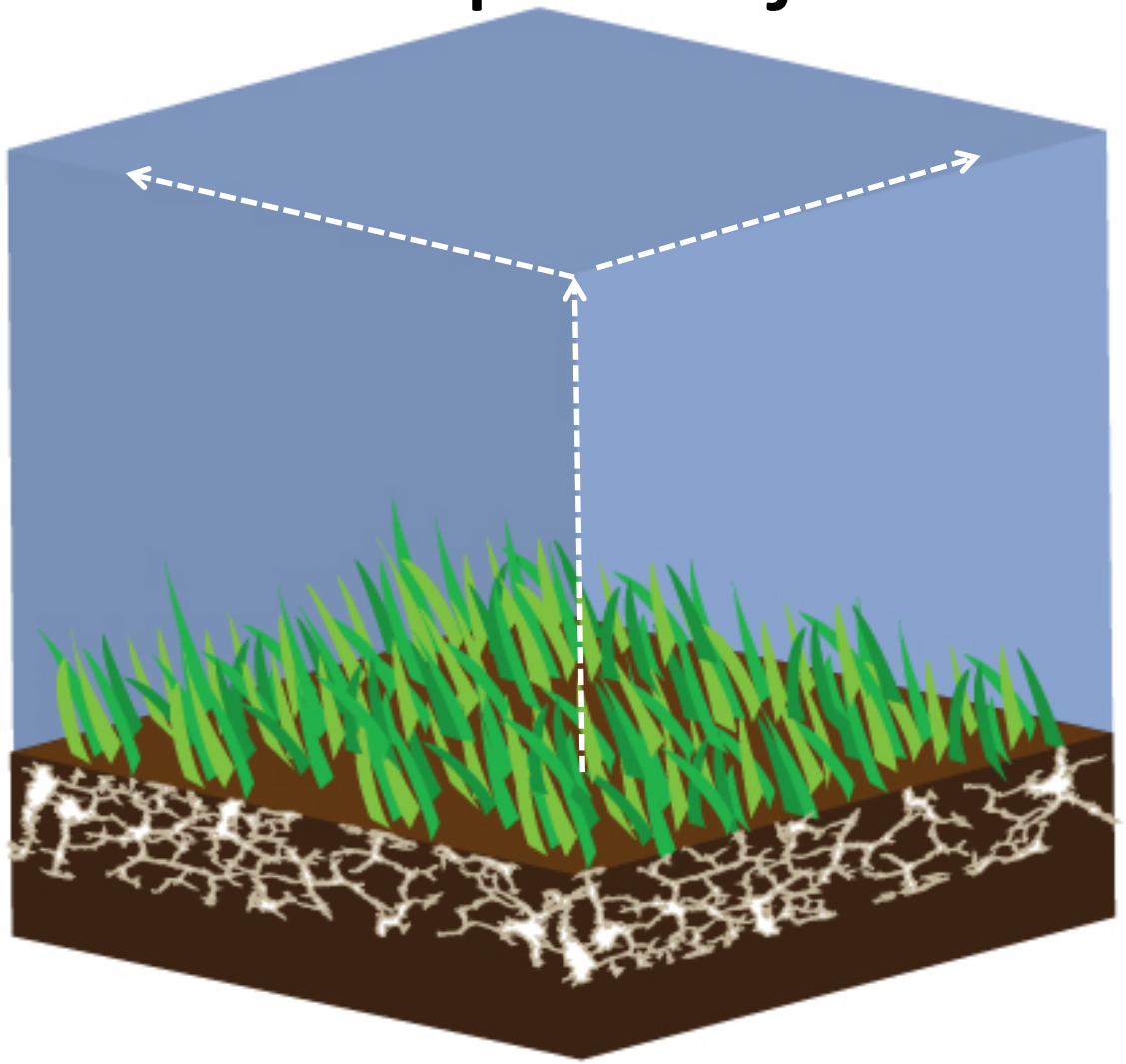
Soil can't be healthy by itself

- Worms/roots/microbes interact, react, transport
- Hard to say what comes first: what are causes vs effects!
- Plants+microbes/animals are working together to improve their habitat.

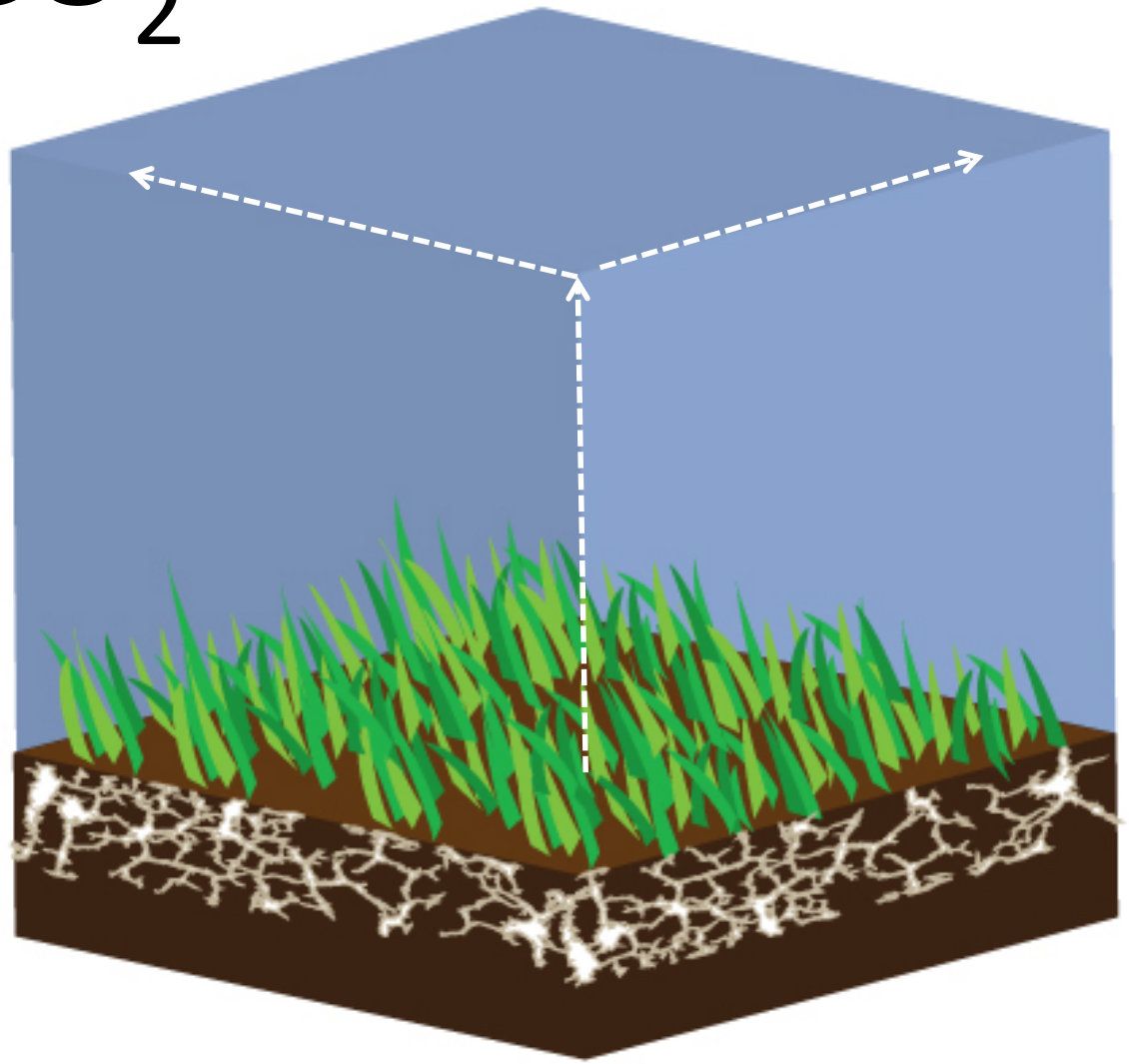
Soil "health" created at least half of this yield.

Photo: Woods End Labs 2014

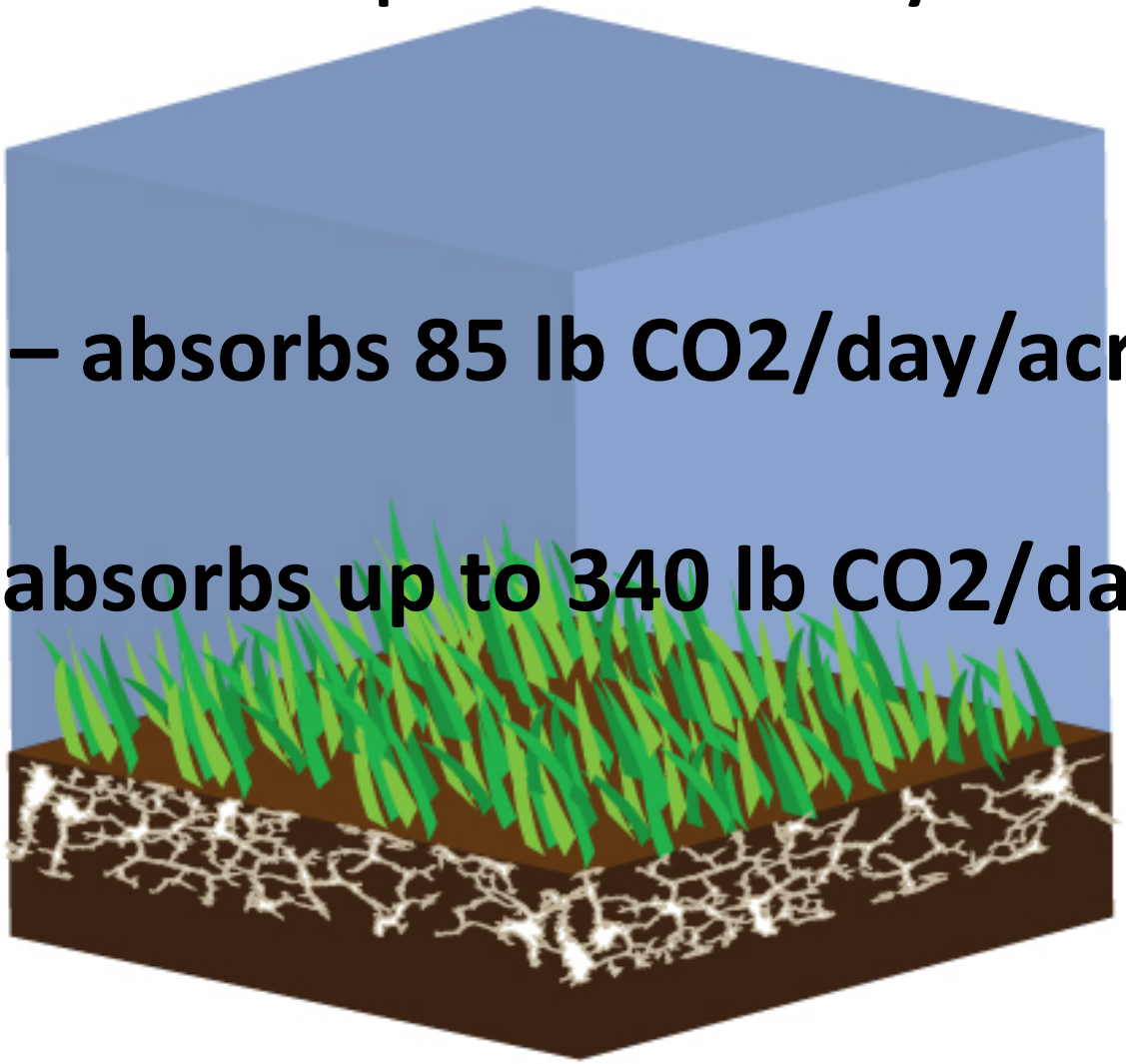
What's the Crop's major nutrient ?



CO_2



In order to produce dry matter;

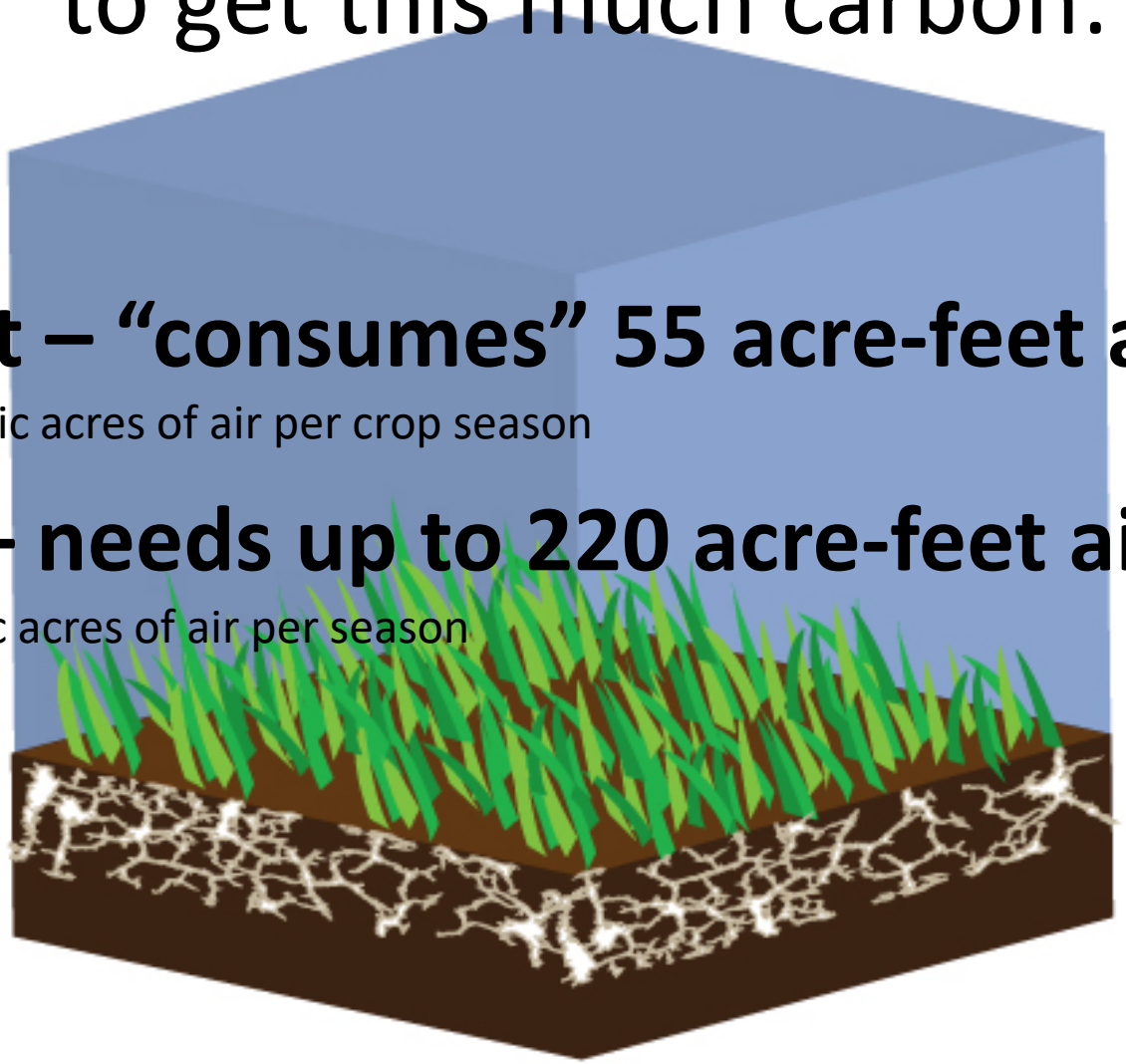


Wheat – absorbs 85 lb CO2/day/acre‡

Corn – absorbs up to 340 lb CO2/day/acre

‡ assuming ≈60 days to accumulate 50 bushels of dry wheat grain or 200 bu. corn

At 400* ppm CO_2 in air, to get this much carbon:



Wheat – "consumes" 55 acre-feet air/day‡

- or 15 cubic acres of air per crop season

Corn – needs up to 220 acre-feet air/day‡

- or 60 cubic acres of air per season

As per the Ideal Gas Law, at STP, 1 cubic foot of air has 0.016 g CO2 or 700 g / acre-foot

Living Soil raises the CO_2 concentration in and above the soil, reducing plants dependency on free air for its photosynthesis needs

ppmv:

≈400

(ambient)

≈800

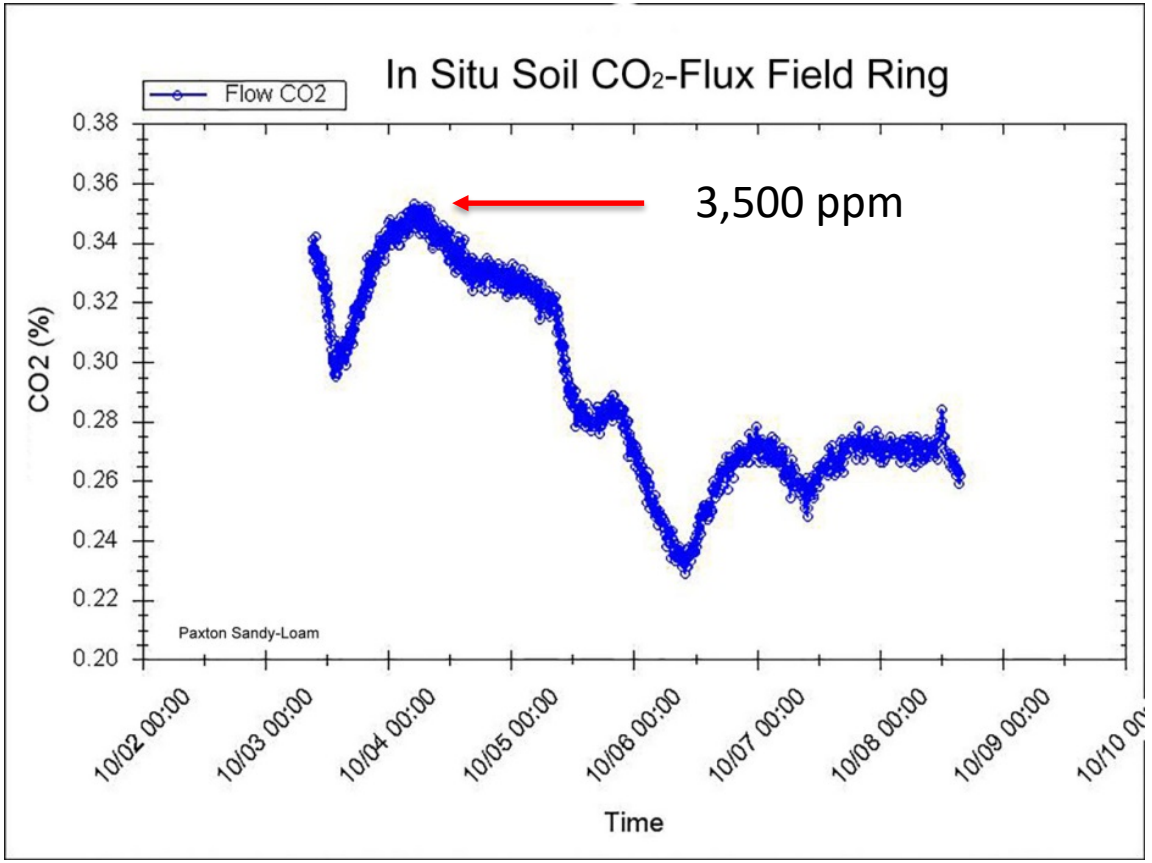
≈1,500

≈4,000

Validation of *In Situ* Soil Pulsating-Breathing Respiration

CO2 Infiltration Ring Chamber (Doran & Brinton 1995)

2” Over soil surface CO2 Flux



Where's the Soil CO_2 Going?

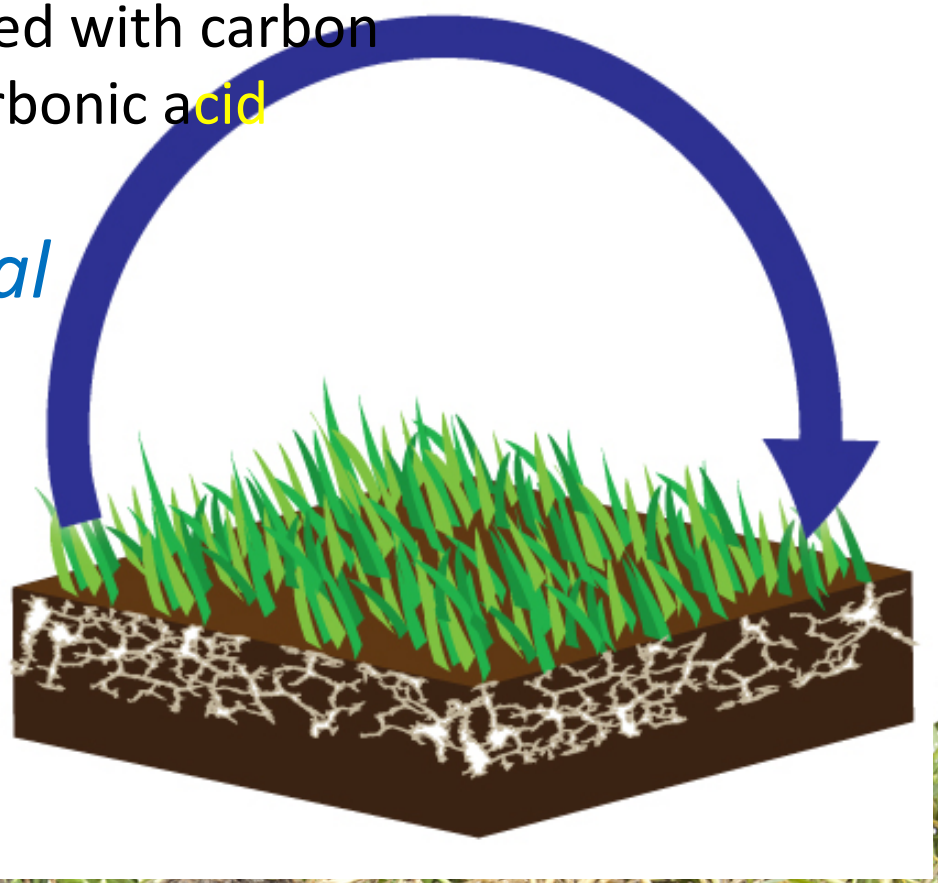
BARE SOIL

COVERED SOIL

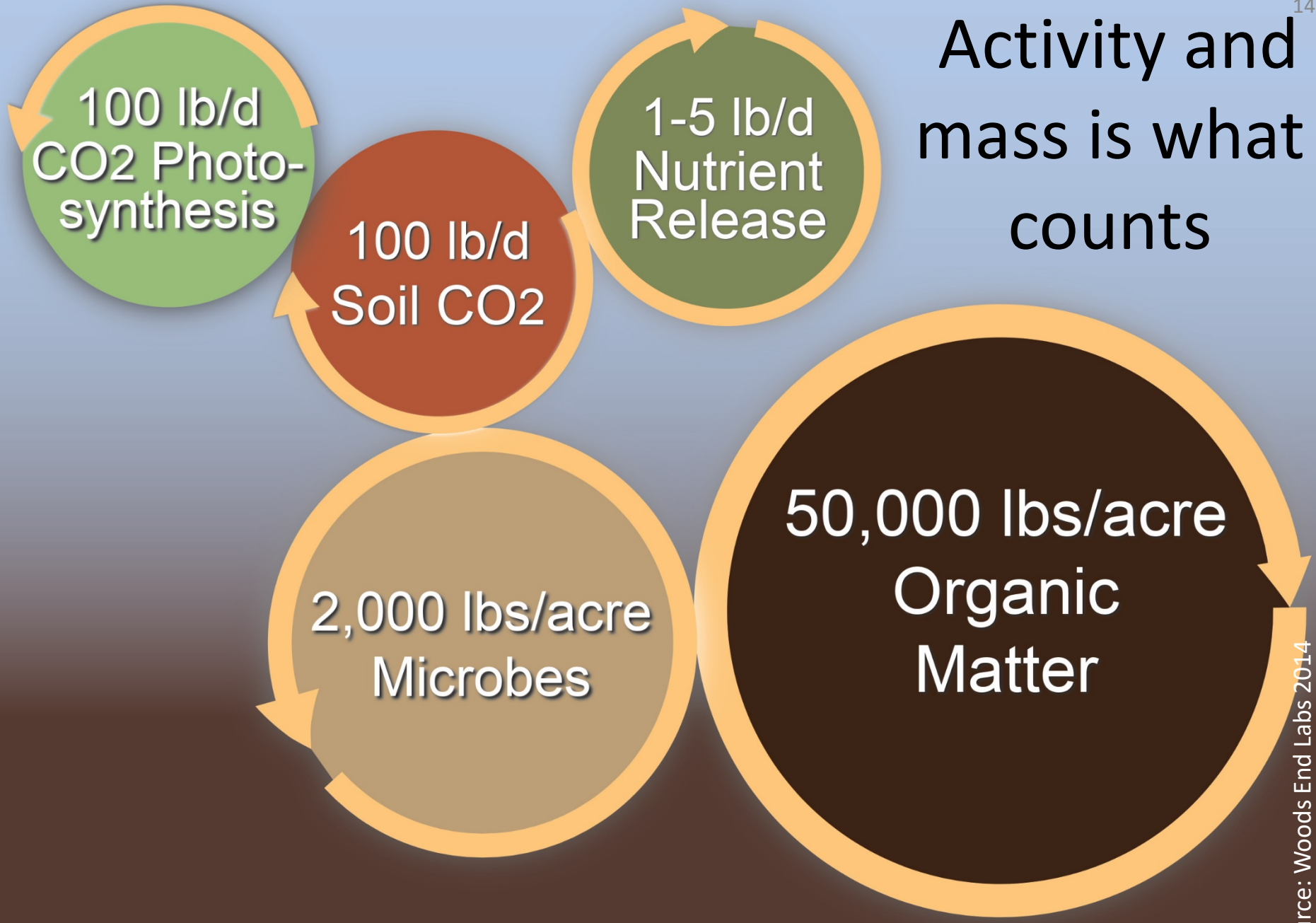
Therefore, living soil biology is:

1. Helping meeting plants' nutrient requirement for CO_2
2. Sequestering AND relinquishing CO_2
3. Releasing available N associated with carbon
4. Dissolving soil minerals via carbonic acid

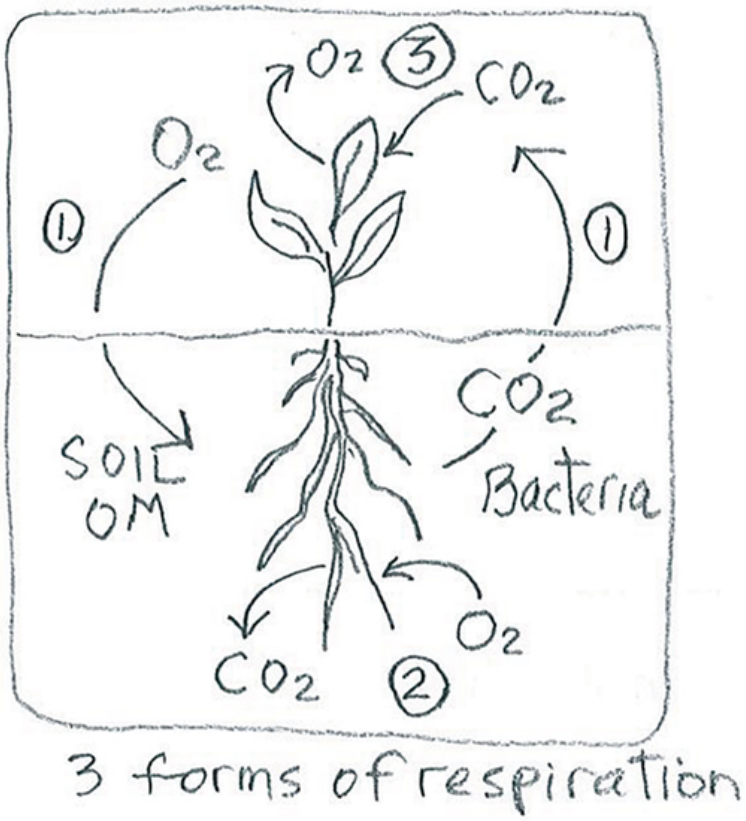
Nature is balancing several equations simultaneously



Activity and mass is what counts



Source: Woods End Labs 2014



3 forms of respiration

1. Soil biological food web: consumes soil organic matter, requires O_2 and produces CO_2
2. Plant root metabolism requires O_2 and releases CO_2
3. Plant above-ground photosynthesis absorbs CO_2 and produces O_2

Notice the roots

- Root mass often similar to above-ground mass
- Roots explore up to 200ft^3/plant*

  (Soil test models assume ~10ft^3)
- Root length may be > 1,000 miles
- Root surface area >35 ball fields

* Liebhardt W (2014) Moving beyond the soil test. RAFS Cambridge Press

Validating Microbial/CO2 induced natural soil mineral weathering

Soils are being constantly “mined” by microbes whose CO2 as a weak acid releases geologic nutrients into biological cycles

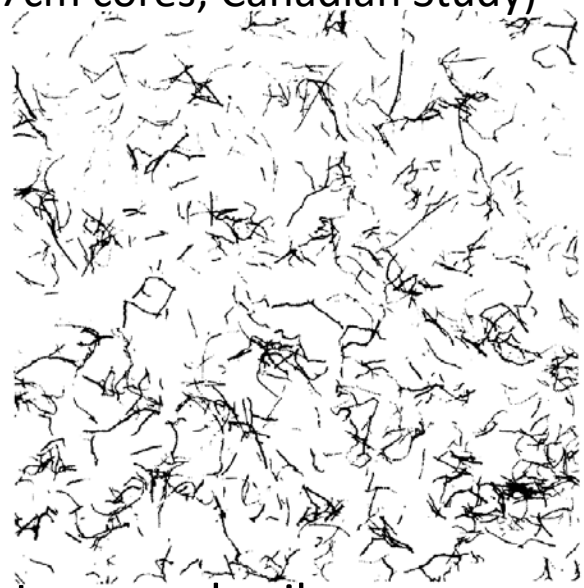
Source: Canadian Jrnl Soil Sci 1998

Unseen world of roots

46	495	852 ft^2 / cubic foot

(Barley Roots extracted from 7cm cores; Canadian Study)

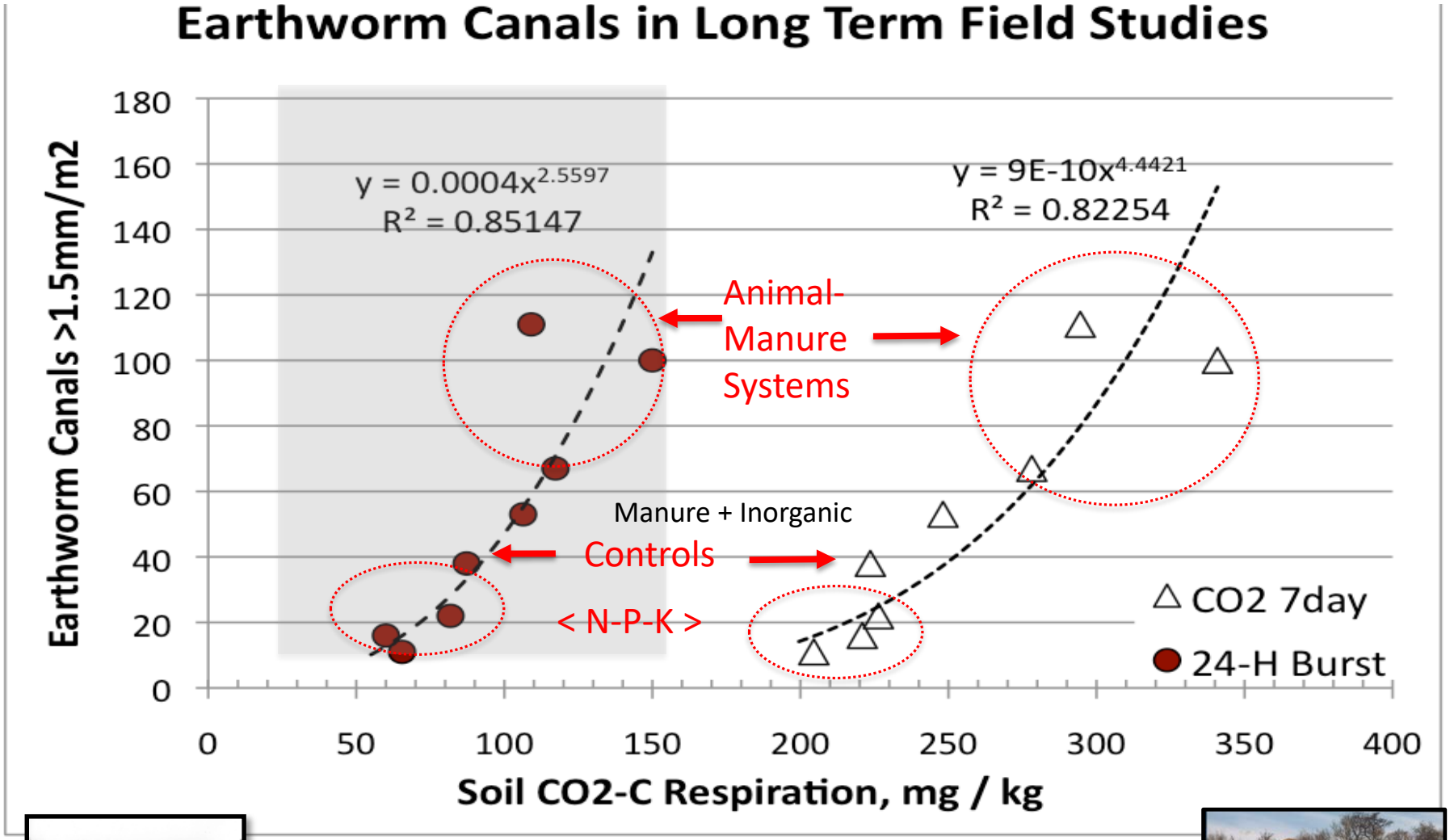
Unhealthy Soil /
Stressed roots



Improved soil
Moderate growth

Healthy Soil
Vigorous roots

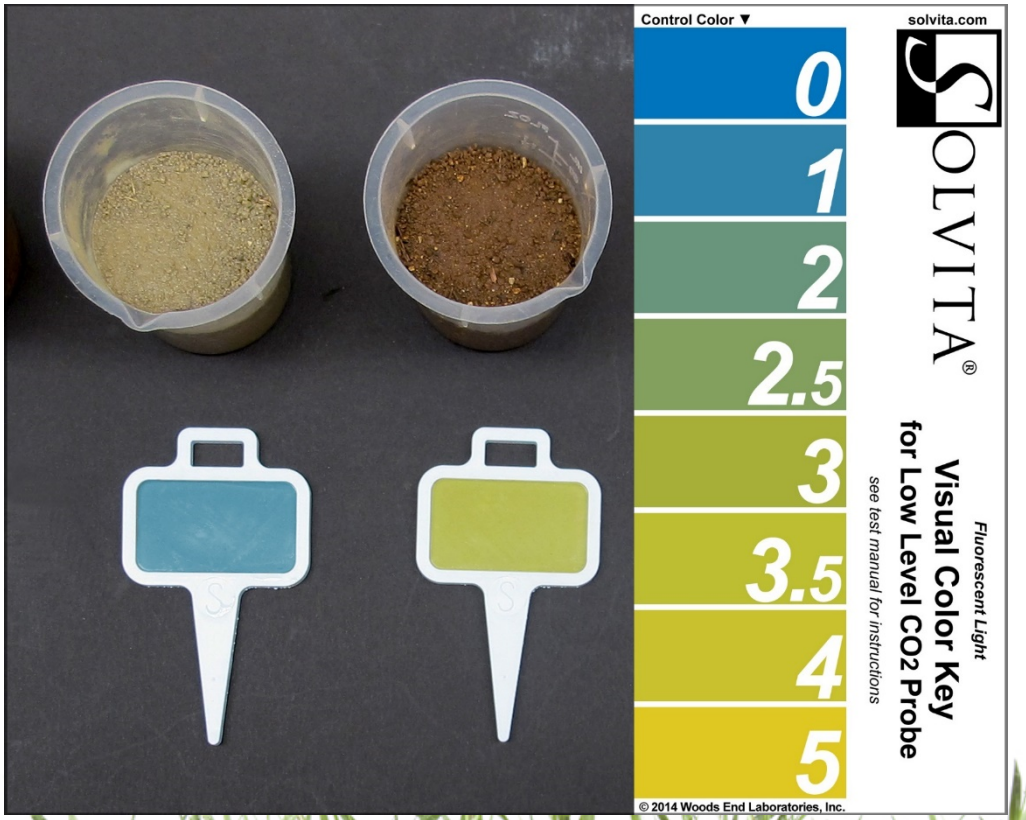
LONG TERM STUDIES SHOW CROP ROTATION AND MANURING VITAL TO SOIL HEALTH



Source: Brinton et al. (1981) Swedish 17-yr Field Plot Studies: CO2 Rates vs Earthworm Canals.

Social Insects may be your earthworms!

Validation Methods: Solvita Soil Respiration Test



Field CO_2 Respiration Research 2017

As found in Organic Growing Systems

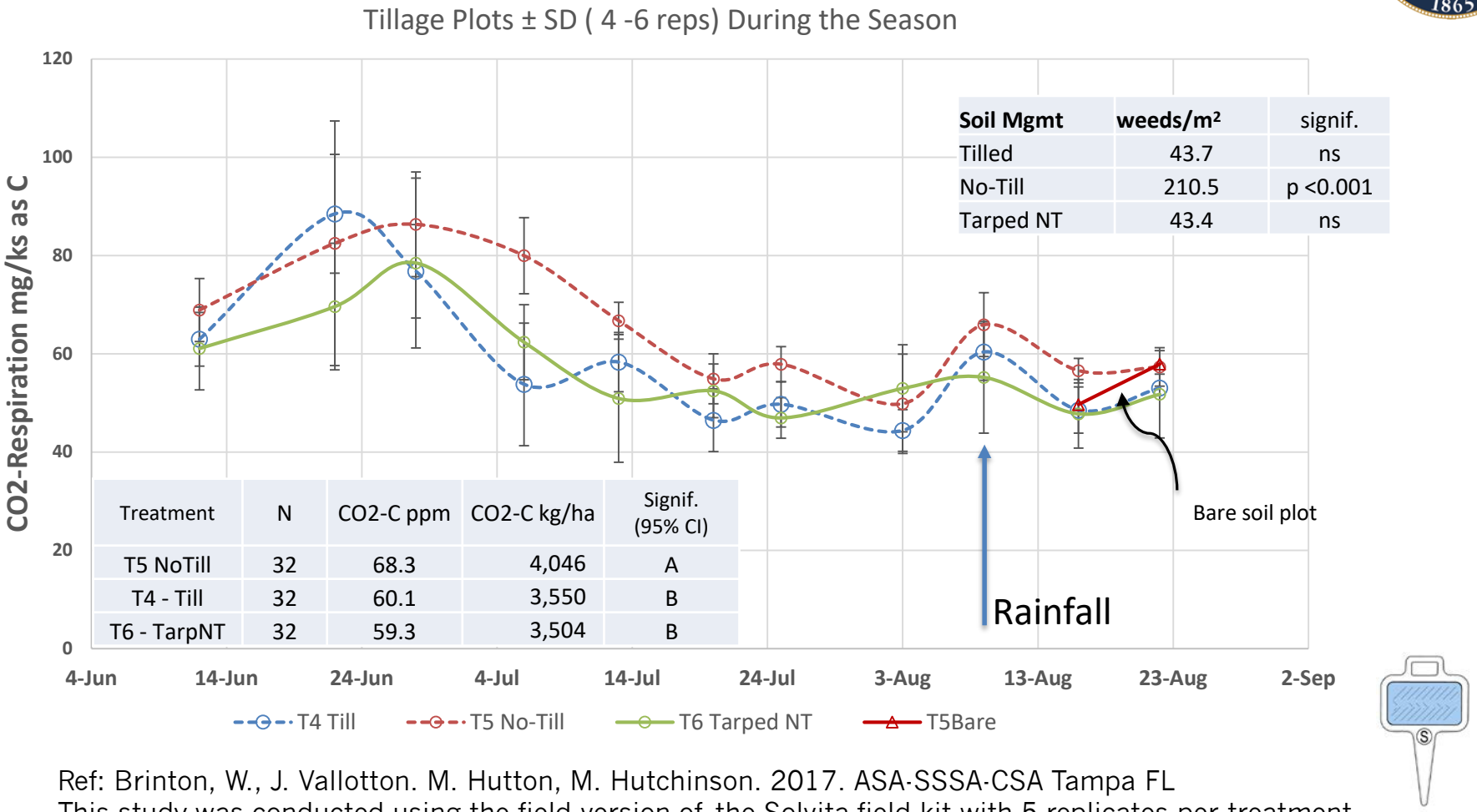
Two long-term trials with 4-6 reps

Permanent Bed Tillage Trial Plots (since 2014) – *How is soil respiration influenced by soil management?*

High-Tunnel Organic (compost since 2013) *How does compost influence soil carbon mineralization changes*

Ref: Brinton, W., J. Vallotton. M. Hutton, M. Hutchinson. 2017. ASA-SSSA-CSA Tampa FL

Results: CO2-C release as influenced by organic tillage vs No-Till plots



Ref: Brinton, W., J. Vallotton. M. Hutton, M. Hutchinson. 2017. ASA-SSSA-CSA Tampa FL
This study was conducted using the field-version of the Solvita field kit with 5 replicates per treatment

Details on CO2 METHOD

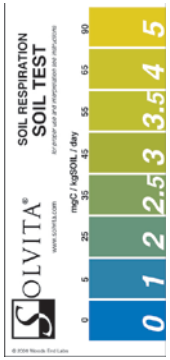
Tests started within 3 hrs of sampling; all samples weighed.

Solvita® CO_2-sensitive probes employed in basal mode (fresh, as-is soil), No drying or grinding

Two jar sizes (¼ and 1-liter) in case very high CO2 concentration

Ambient room temp during measuring:
ranged 19-26°C avg. 22 °C

Results quantified by
Solvita DCR as CO_2-C mg kg^{-1}
= kg ha fresh weight



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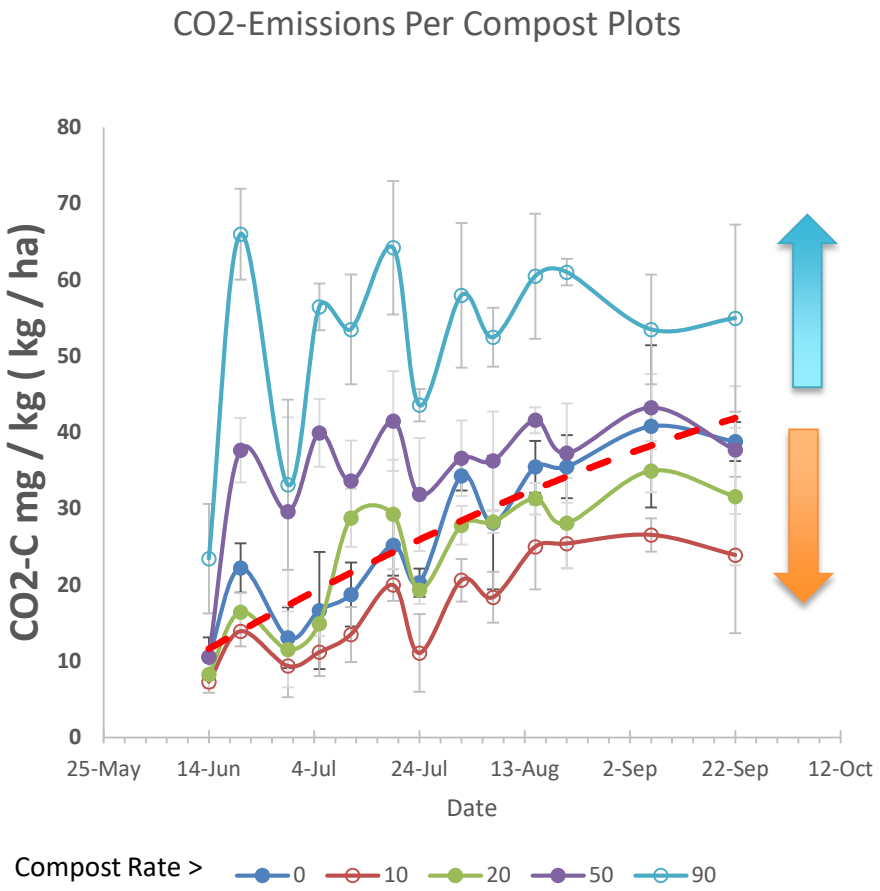
Season compost-soil effects observed with basal Solvita CO_2 respiration



Overall Effects of CO_2-Rate

Treatment Rate t/a (MG/ha)	P, Difference from Control
10 (22)	0.016* (- reduction!)
20 (45)	0.55 (ns)
50 (112)	0.003*** (+)
90 (200)	0.003*** (+)

Source	DF	SS	MS	F	P
DATE	11	6293.41	572.13	16.91	0.000
RATE	4	28791.33	7197.83	212.76	0.000
DATE*RATE	44	3021.80	68.68	2.03	0.001

Ref: Brinton, W., J. Vallotton. M. Hutton, M. Hutchinson. 2017. ASA-SSSA-CSA Tampa FL

Assessment of Organic soil health status as revealed by research

Source: Research Institute for Biological Husbandry, Switzerland

	Total	Microbial biomass carbon	Microbial biomass nitrogen	Total PLFA	Basal respiration	Dehydrogenase activity	Metabolic quotient	Protease activity	Urease activity
Number of studies	56 studies	42 studies	21 studies	8 studies	29 studies	17 studies	22 studies	3 studies	7 studies
Number of paired comparisons	149	100	49	22	66	40	40	7	18
Experimental field comparisons	75	54	28	11	42	18	26	2	5
Farm comparisons	74	46	21	11	24	22	14	5	13
Experimental duration in years (Mean / Median)	16.1 / 10.0	17.2 / 10.0	11.0 / 10.0	25.9 / 10.0	12.6 / 10.0	8.8 / 5.5	12.3 / 8.0	6.6 / 6.0	7.9 / 7.0
Coverage of climatic zones[+]	A, B, C, D	A, B, C, D	A, B, C, D	A, C, D	A, B, C, D	A, B, C, D	A, B, C, D	C	A, B, C
Coverage of continents *	6 of 6	6 of 6	5 of 6	4 of 6	6 of 6	5 of 6	6 of 6	3 of 6	4 of 6

* all except Antarctica

[+] A = Tropical/mega thermal climates, B = Dry climates, C = Temperate/mesothermal climates, D = Continental/Microthermal climates, E = Polar climates

https://doi.org/10.1371/journal.pone.0180442.t001

149 paired scientific studies:

- Location of Studies Used

Source: Lori et al. (FIbL) 2017 Plos One

- **ORGANIC FARMED SOILS HAD:**

41% more biomass carbon

51% more microbial N

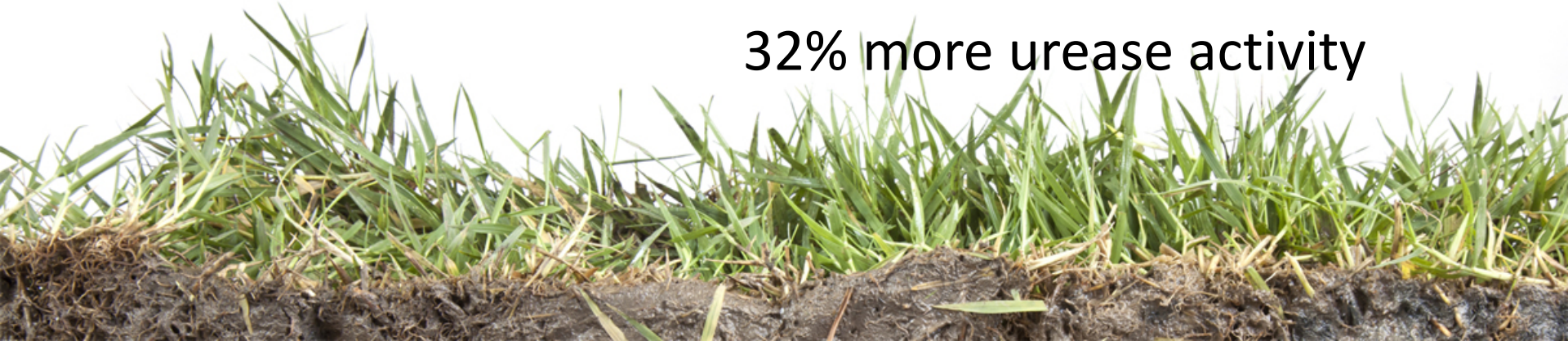
59% more PLFA count

74% more dehydrogenase

4% more efficient CO2 cycle

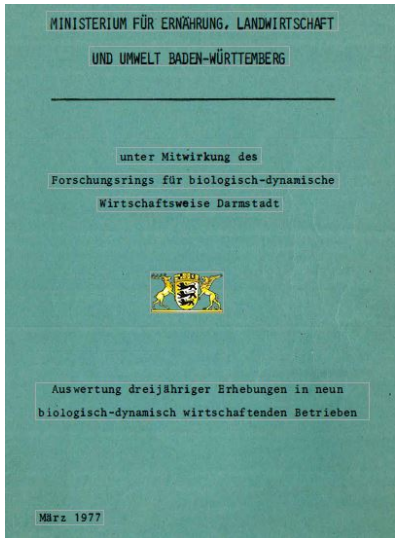
84% greater protease

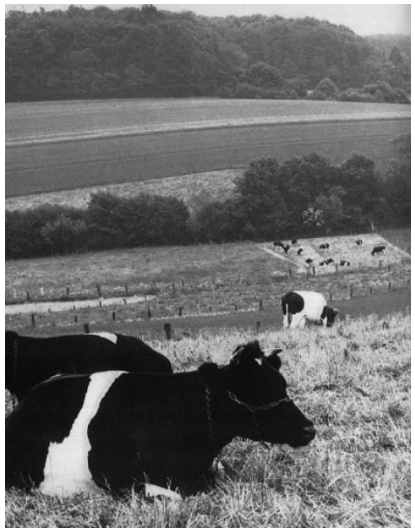
32% more urease activity



Compared to first EU Soil Health Study*

- Location of Studies: 9 paired dairy farms on same soil types



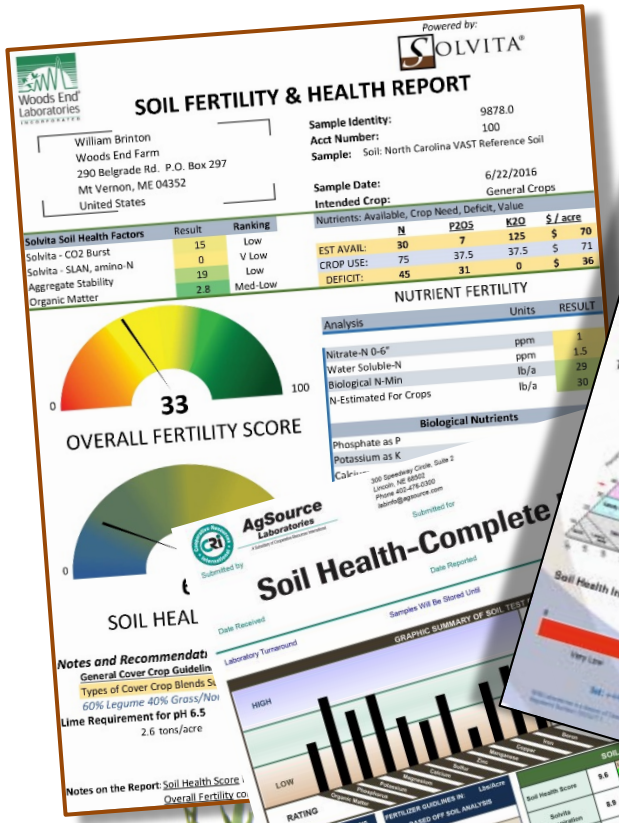


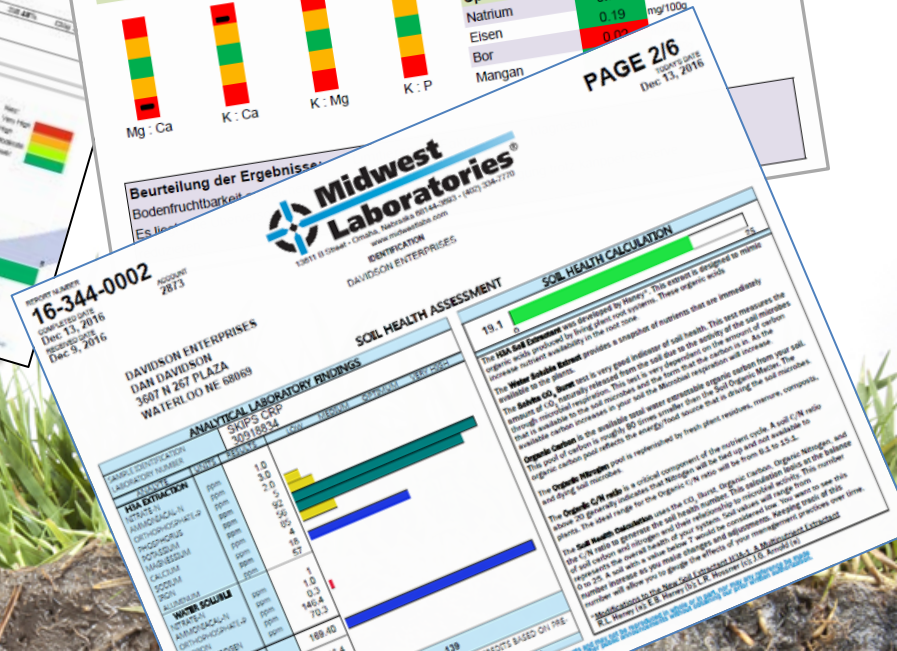
* Source: *German Ministry of Agriculture 1977 Baden-Württemberg*

- **Organic-Bio-Dynamic Farms had**:

10-50% more CO_2 respiration
14% higher N-mineralization
40% more dehydrogenase enzymes
76% more urease enzymes
400% more azotobacter
390% greater earthworm counts

Soil Labs worldwide integrating Solvita biology into lab process….



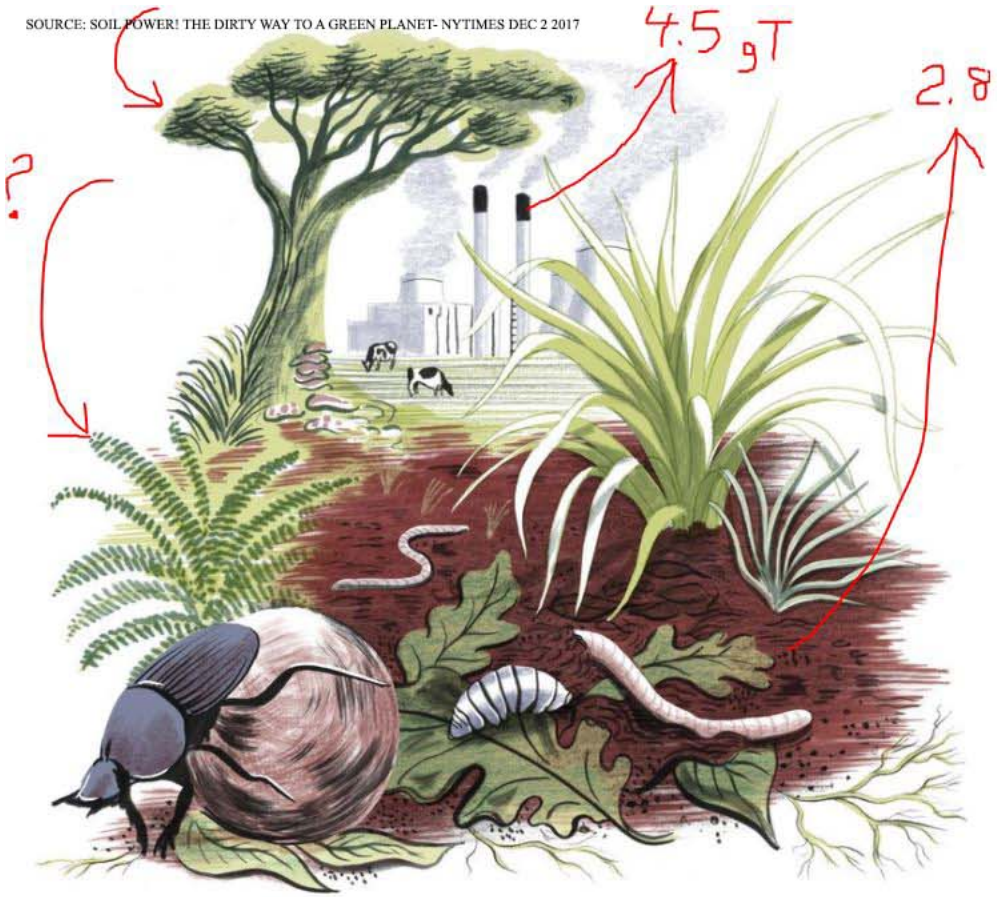


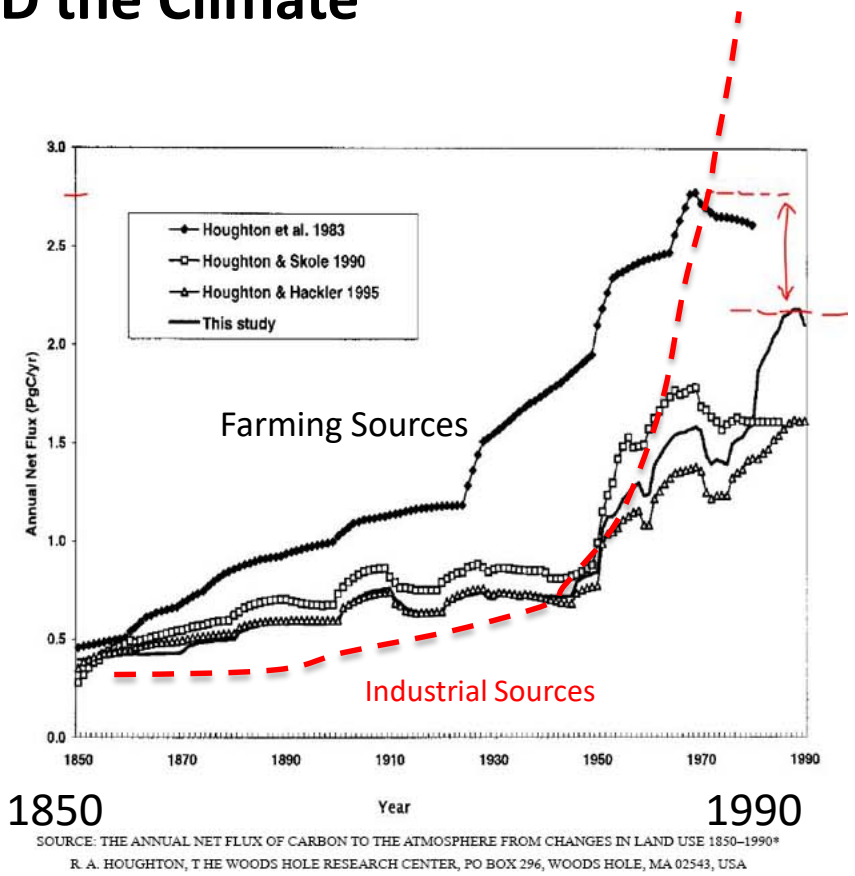
- Soil Health mostly about *context.*
- Healthy soil is not a thing to be "precisely" measured.
- The organic community first created the vision for soil health
- A broad, growing movement to "restore soil" may require the organic community to rephrase some arguments.

Carbon & Farming: A *difficult* Problem

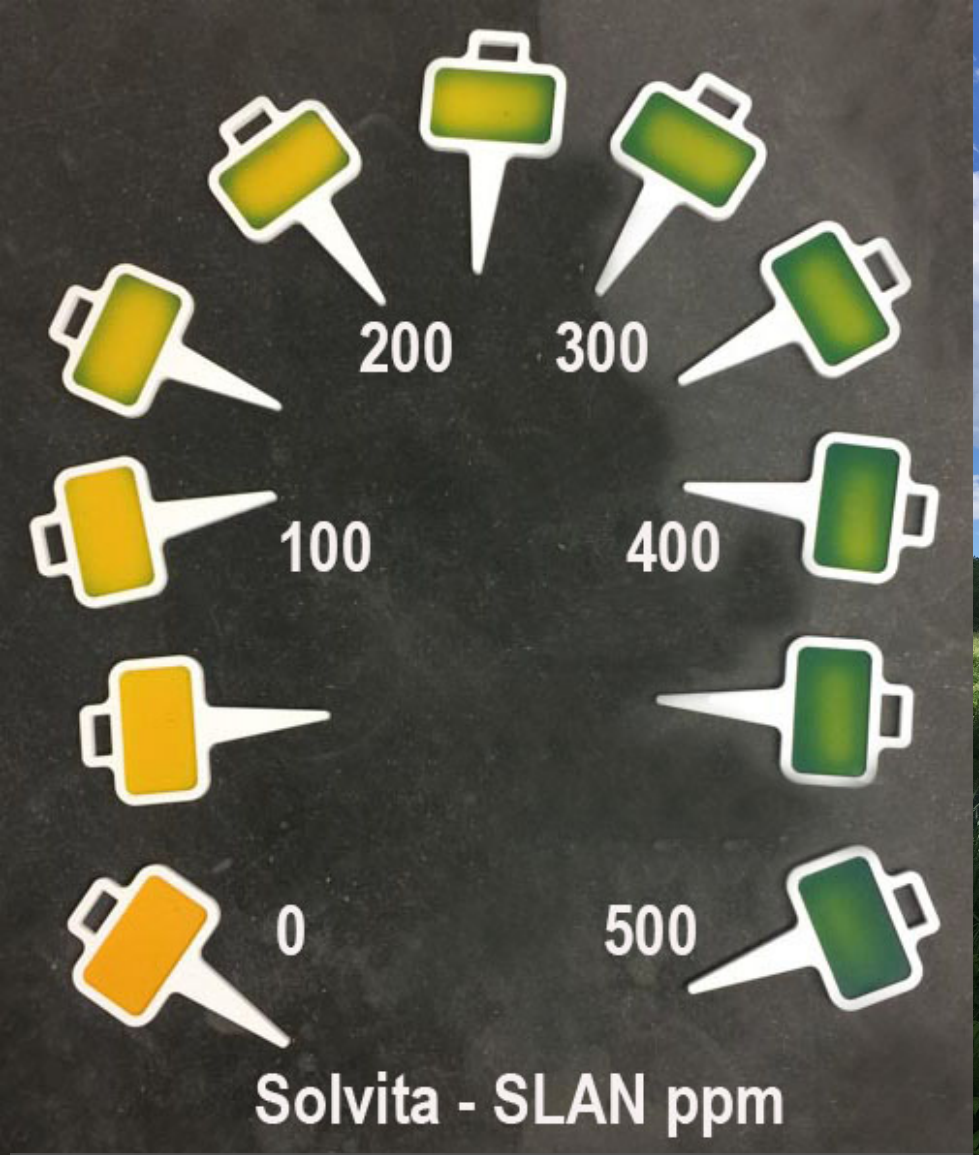
Understanding ***Relinquishing*** vs Sequestering Carbon

vs The Plight of Soil AND the Climate





In pre industrial era, farming abuse of soils was the main contributor to global CO2 rise.



Thank you!

For information on Solvita tests and Soil Health:
visit woodsend.com/soil

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RESOURCES:

- Building your own soil health test system
- Obtaining test kits
- Get a soil-health test
- Articles and Reprints

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