Soil Health Planning Principles

"a practical approach to Farming in the 21st Century"

Mike Kucera

Agronomist Lincoln
Nebraska

Soil Health What is It?

- The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans
  - Nutrient cycling
  - Water (infiltration & availability)
  - Filtering and Buffering
  - Physical Stability and Support
  - Habitat for Biodiversity

Soil Health

Planning Principles Must be Addressed

- Manage more by Disturbing Soil Less
- Use Diversity of Plants to add diversity to Soil Micro-organisms
- Grow Living Roots Throughout the year
- Keep the Soil Covered as Much as Possible
- Manage compaction
- Control erosion

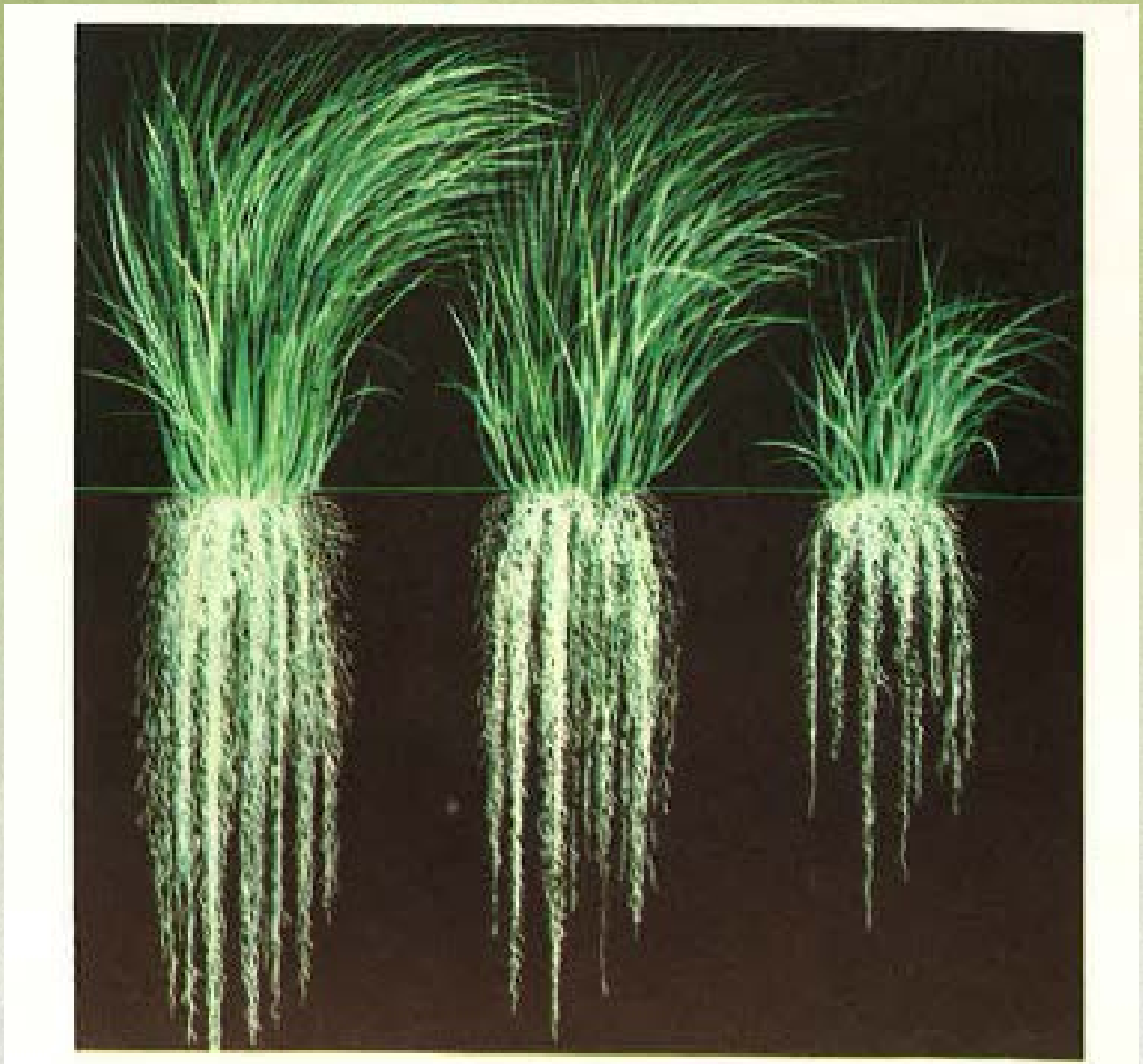
Goal: To create the most favorable habitat possible for the soil food web

Soil Health Principle 1

Manage More by Disturbing Soil Less

- Agricultural Disturbance Destroys Dynamic Soil Properties
- Destroy “Habitat” for Soil Organisms
- Creates a “Hostile” Environment
- Three Types of Disturbance
  - Physical (tillage)
  - Chemical (Fertilizer)
  - Biological (overgrazing)

Biological Disturbance (overgrazing vs. proper grazing)



What things change when you stop tilling the soil?

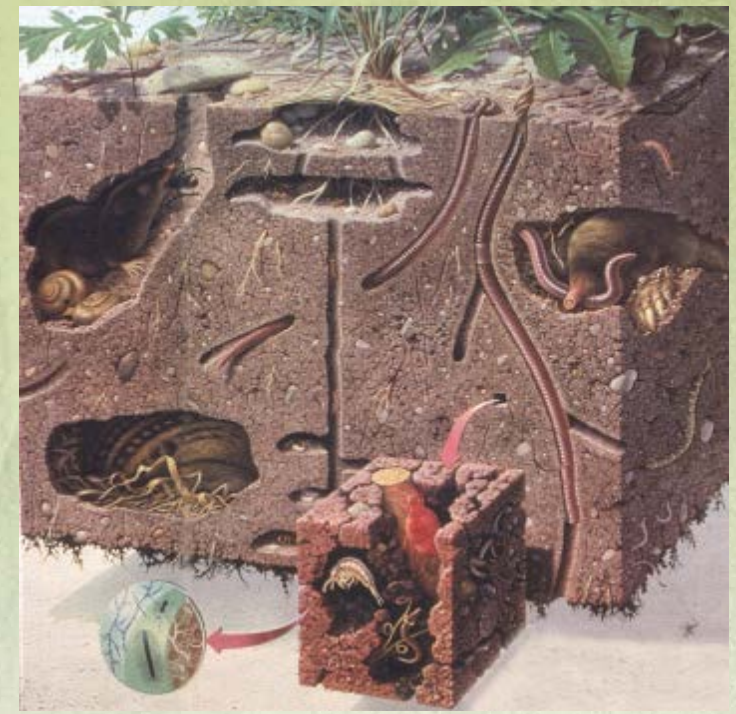
- Soil pores remain continuous
- Soil aggregates form and are not destroyed
- Soil Food Web increases and diversifies
- Weed seeds are not planted
- Water is captured and stored
- Bulk density increases slightly; then stabilizes
- Soil fungi and earthworms increase
- Microarthropods increase (>20% of nutrient cycle)

Human nature drives us to tillage!

- We can see what we accomplished!

** Soil Biology Team **
The “living soil”

Most “soil critters” are bothered by tillage!



Earthworms, insects and rodents are the most visible components of the “living soil” team. They work in tandem either soil microorganisms and fungi to contribute to aeration and nutrient cycling as part of a “soil factory” team effort.

Intensive tillage "butchers the biology" in the soil. It cuts, slices, and dices the soil and blend's, mixes, and inverts the soil creating havoc for the soil biology (fauna).

CO_2 loss

CO_2 loss

Before Primary Tillage

After Primary Tillage

After Secondary Tillage

Hard to believe that the same results can be achieved using simpler biological methods!!!

Healthy Soils are forgiving soils

Soil Health Principle 2

Use Diversity of Plants to add diversity to Soil Organisms

- Plants interact with particular microbes
  - Trade sugar from roots for nutrients
- Microbes convert plant material to OM
- Requires a diversity of plant carbohydrates to support the variety of microbes
- Lack of plant diversity will drive system to favor some microbes more than others

Impact of Biodiversity

- Lack severely limits any cropping system
- A diverse and fully functioning system provides nutrients, energy and water
- Diversity above ground equals diversity below ground

How to Increasing Diversity in a Crop Rotation

- Lengthen the rotation by adding more crops
  - Increases soil organic matter
  - Breaks pest cycles
  - Improves nutrient utilization and availability
  - Utilize available water deeper in the soil profile
  - Provide windows for management
    - spread manure
    - Plant & harvest crops
- Add more plants in the current crop rotation
  - Utilize cover crops during non-cropping part of the year

Cover Crop Role in Diversity

1. Allow you to look at cropping periods rather than years
2. Can be used to accelerate rejuvenating soil health
3. Getting 6 to 8 weeks of growth is adequate to get some of the “rotation” effect benefits!
4. Will increase soil biological diversity “Diversity above = diversity below”

Simplified Crop Classification

- Plant morphology
  - Broad leaf
  - Grasses
- Plant growth habits
  - Cool season
  - Warm season

Crop Classification Warm Season

Grasses

- Corn
- Millet
- Sudan
- Sudex
- Sorghum

Broadleaf

- Alfalfa
- Soybean
- Buckwheat
- Chick pea
- Cow pea
- Sunflower

Crop Classification Cool Season

Grasses

- Barley
- Rye
- Triticale
- Wheat

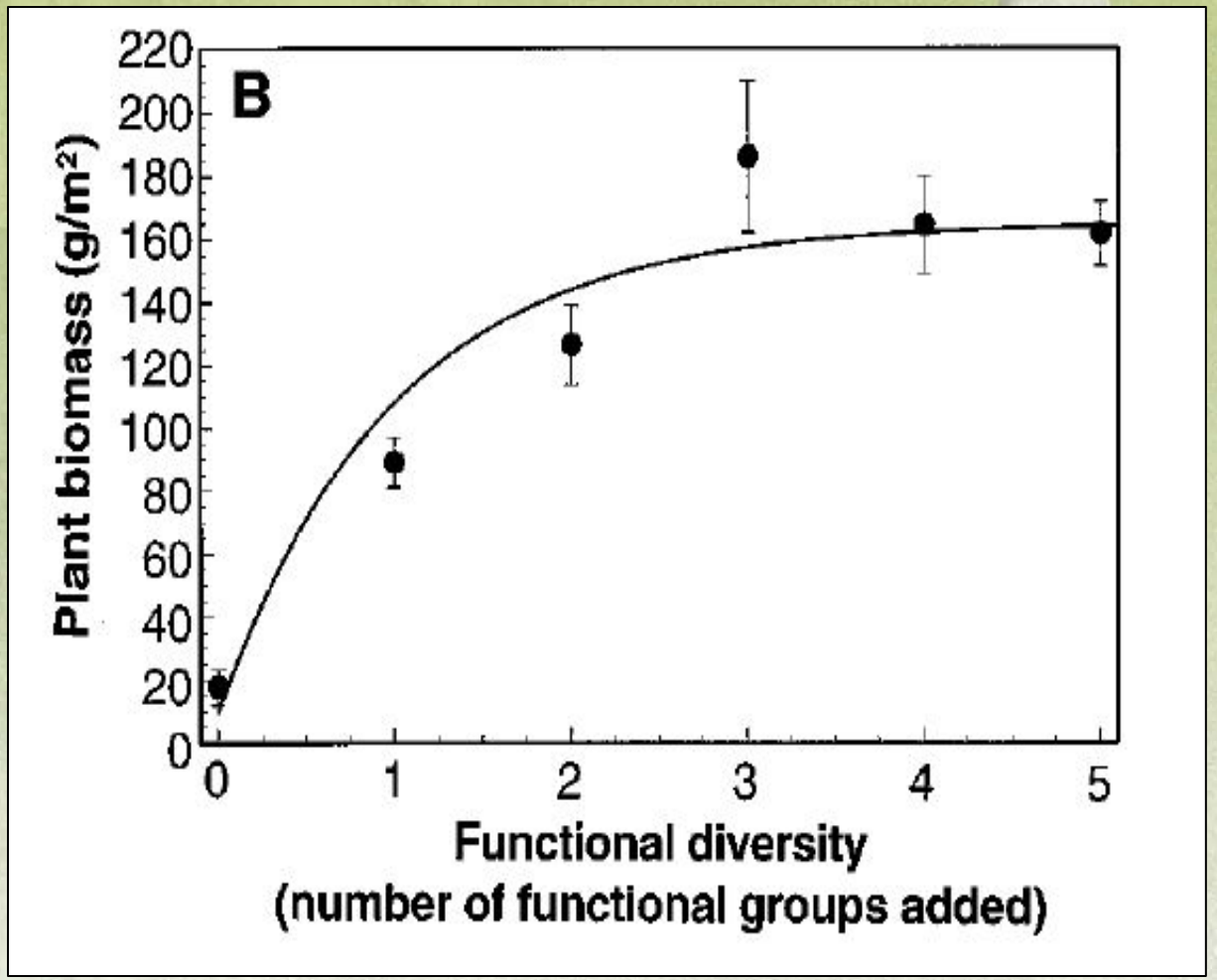
Broadleaf

- Canola
- Clovers
- Mustards
- Pea
- Radish
- Turnips

Mimic Native Prairies

- Diversity of Plants
- Diversity of Function

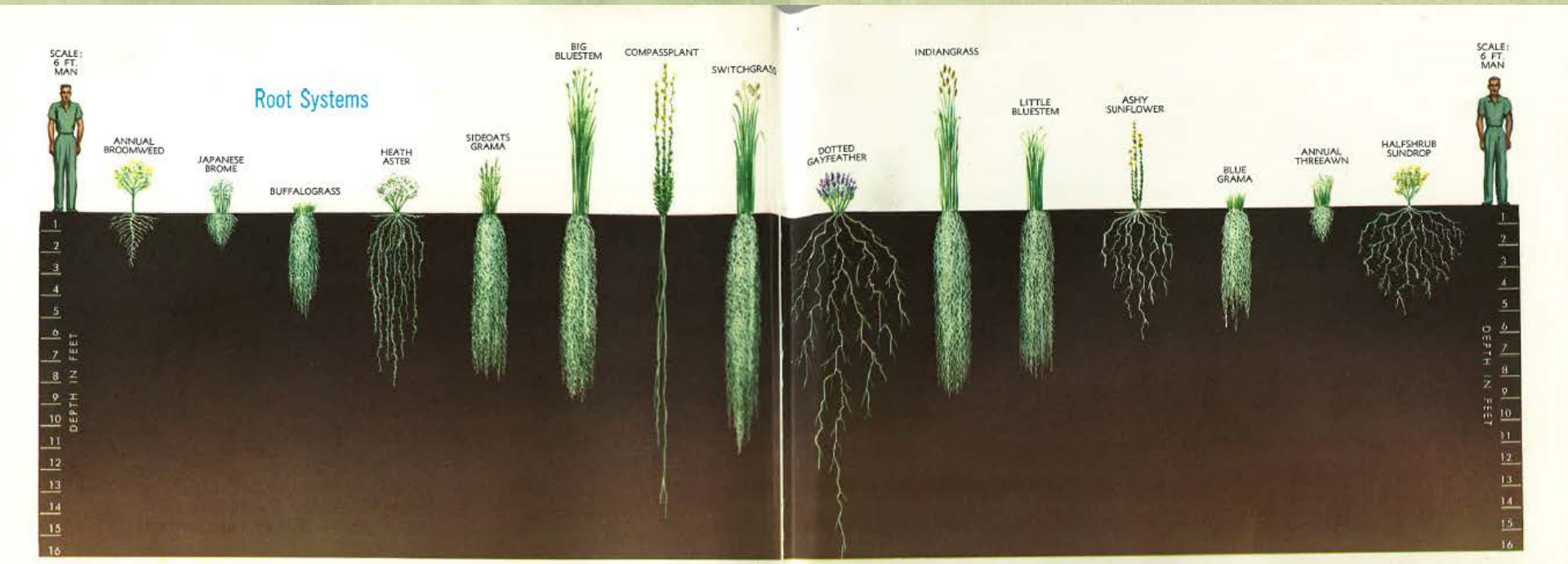
The Influence of Functional Diversity and Composition on Ecosystem Processes



David Tilman,* Johannes Knops, David Wedin, Peter Reich,
Mark Ritchie, Evan Siemann

Diversity in Root Systems

- Diversity in root systems= diversity in soil biota



Mixture of cereal rye, hairy vetch, and field peas as a winter cover crop

Mixture of cereal rye, hairy vetch and crimson clover

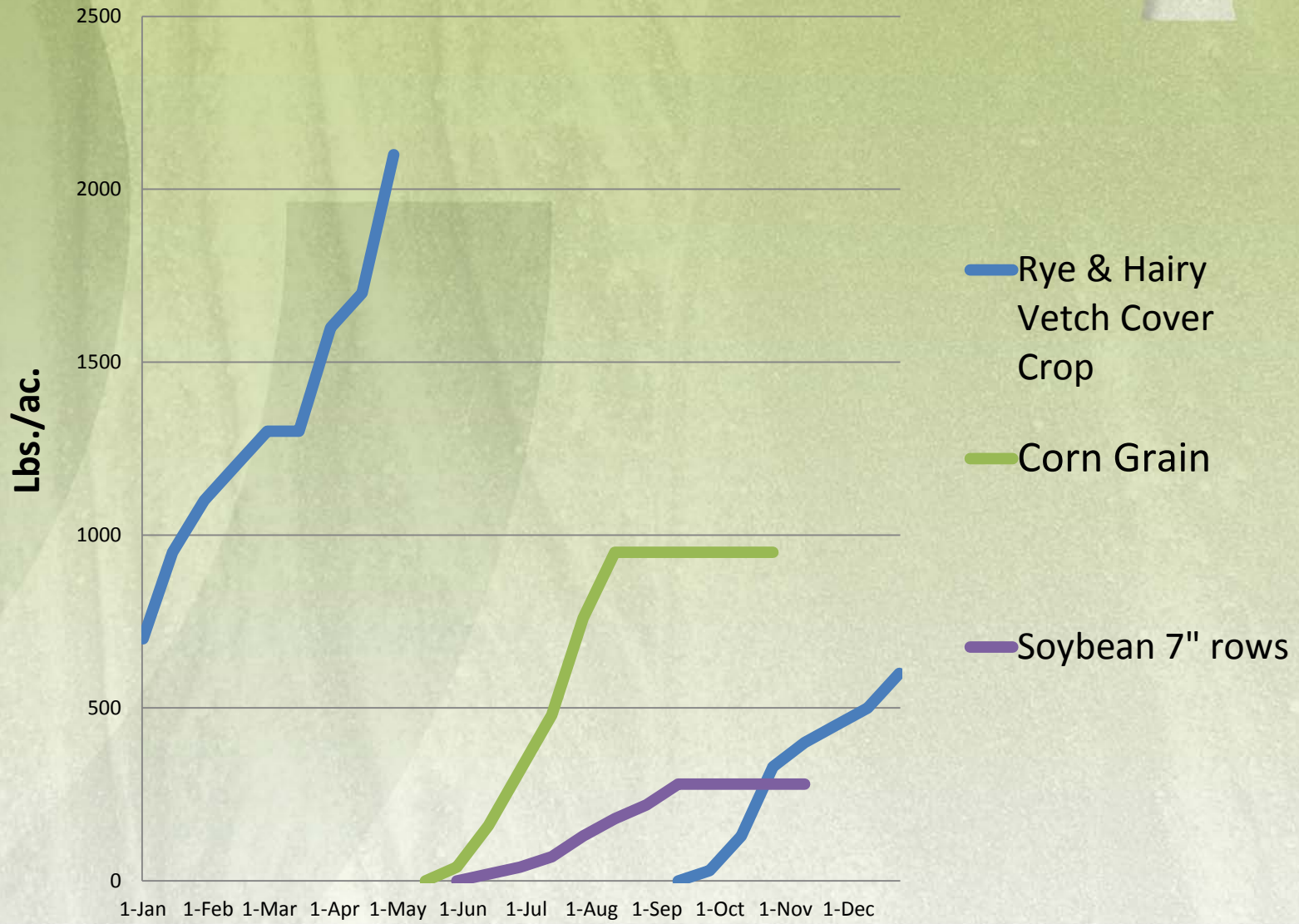
Soil Health Principle 3

Grow Living Roots Throughout the Year

Benefits:

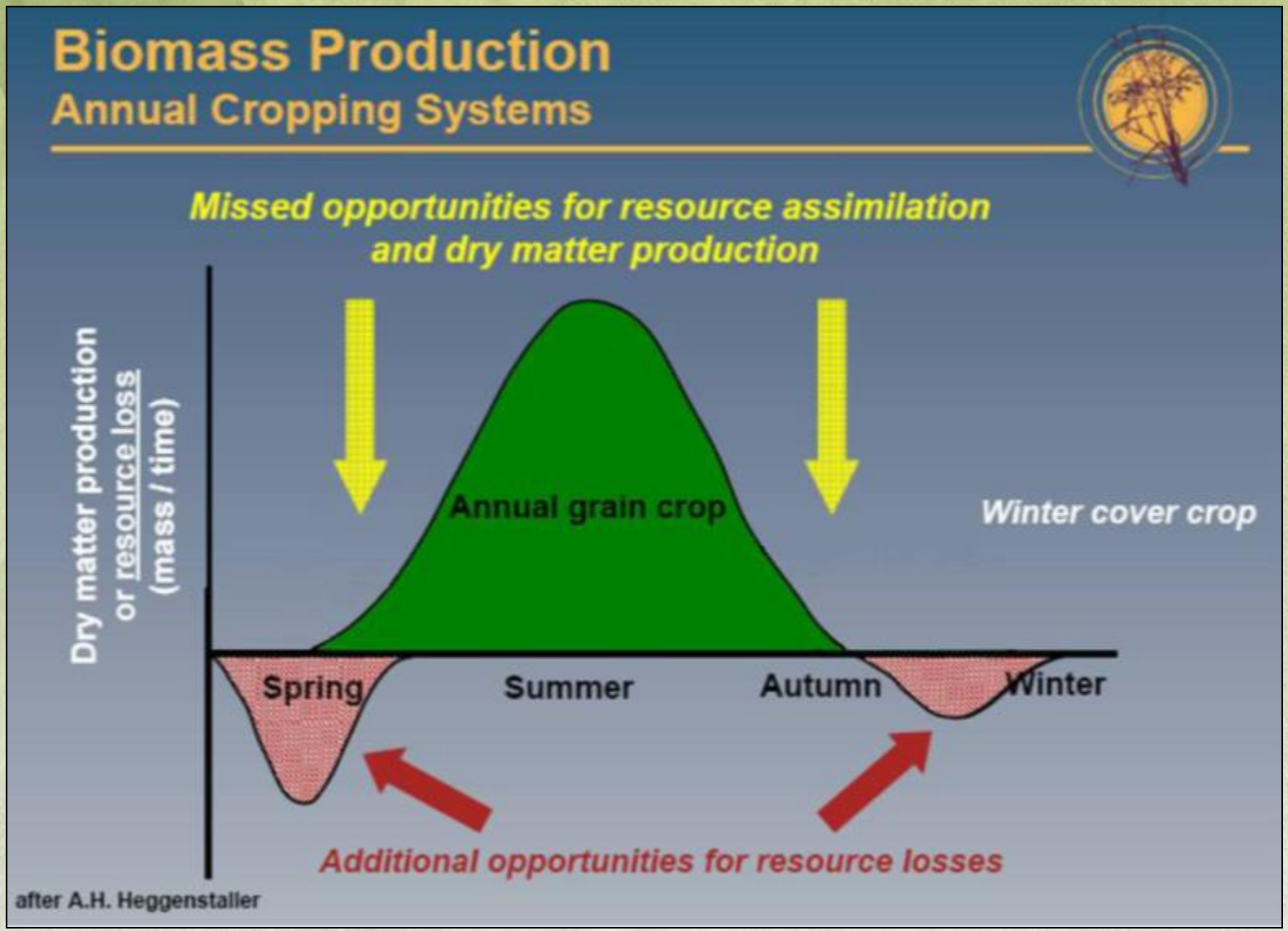
- Increases microbial activity influences the N mineralization and immobilization
- Increases plant nutrient/vitamin uptake/ concentrations with mychorrhizal and bacteria associations
- Increases biodiversity and biomass of soil organisms
- Improves physical, chemical and biological properties of soils
- Sequesters and redeposit nutrients
- Increases OM

Root Mass in Top 4” of Soil

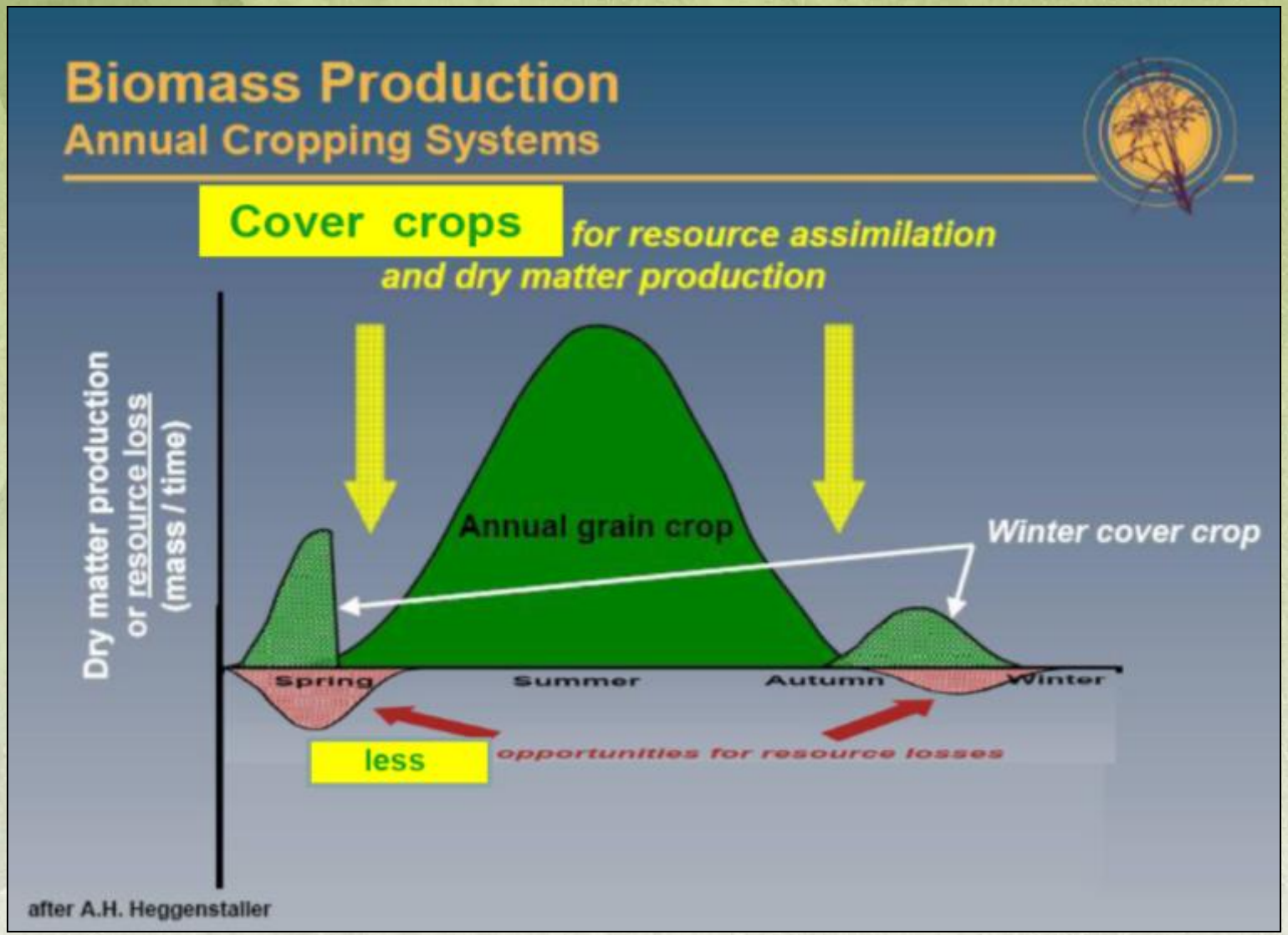


Biomass Production

Annual Cropping Systems



A. H. Heggenstaller, University of Alberta



A. H. Heggenstaller, University of Alberta

How to Keep a Living Root All Year Long

- Lengthen or intensify Rotation
  - Add Wheat
  - Double crop
- Select Shorter Season Varieties
  - Choose 100 -104 day
  - Only need 6 - 8 weeks to provide benefit
- Interseed into Growing Crops
  - Planting cover crop before harvesting of cash crop

Photos 29 Oct 2003

Hairy vetch

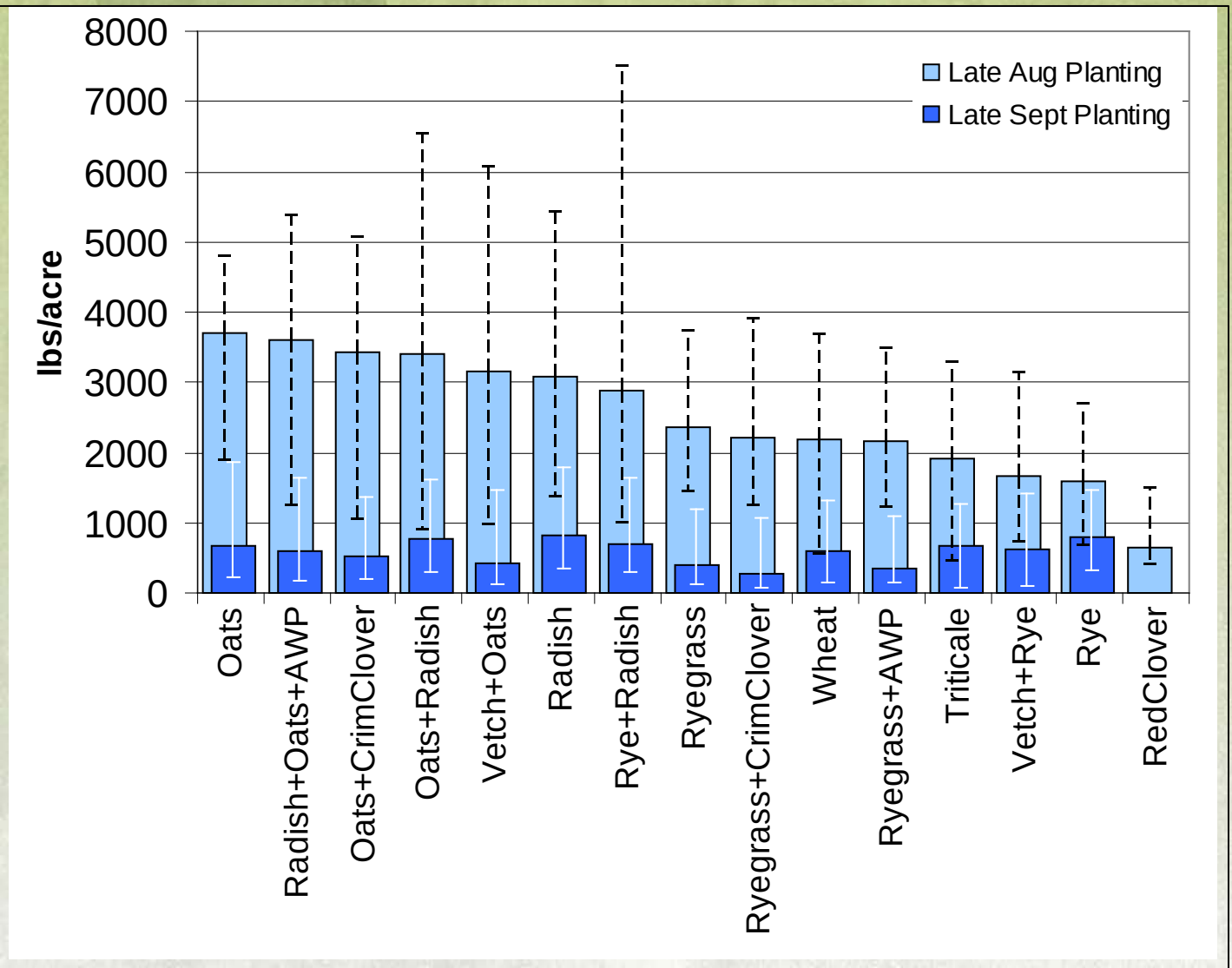
good fall growth

Hairy vetch planted into corn July 17

Hairy vetch planted into bean June 29

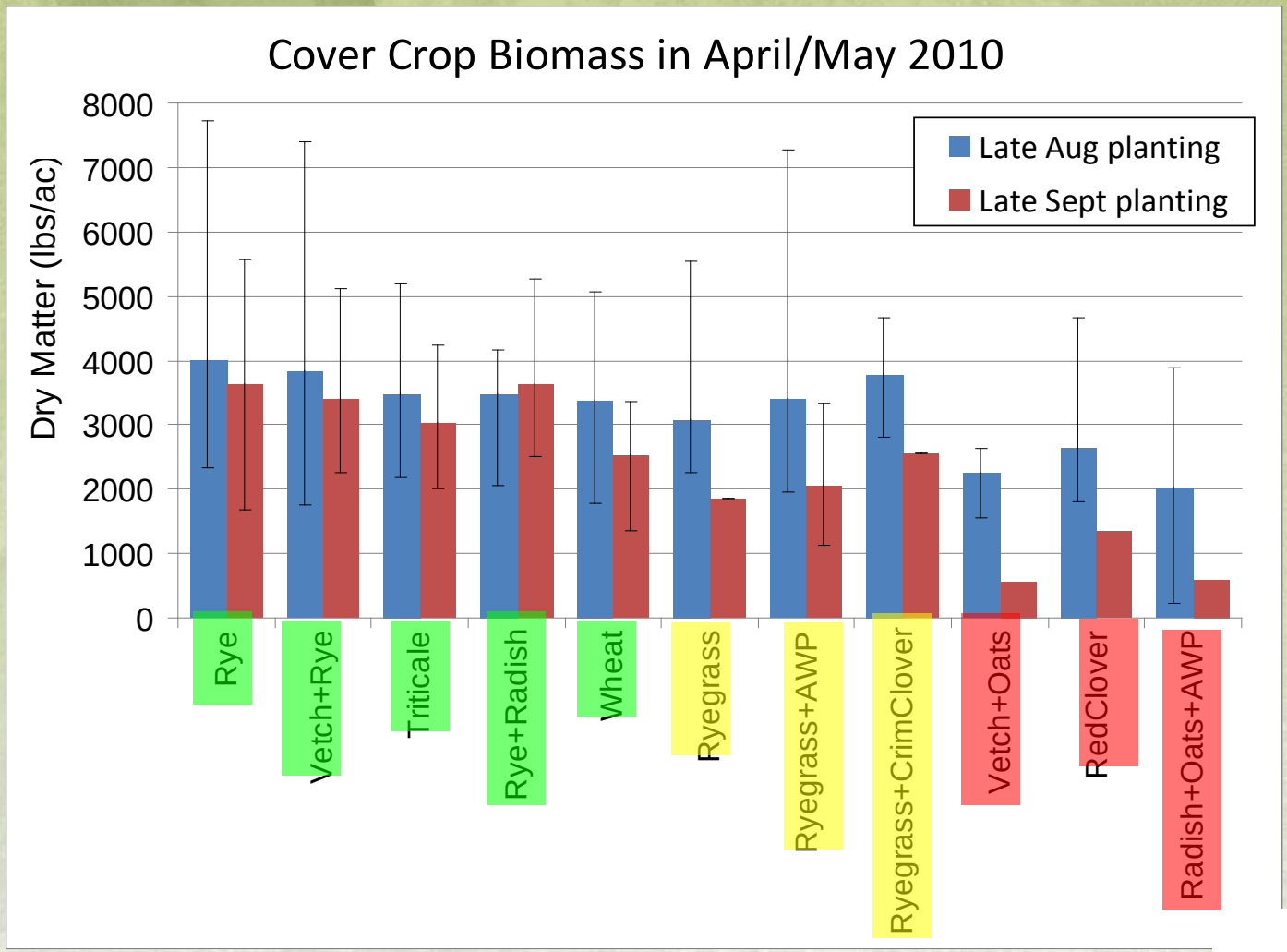
Fall Biomass Data

Dry Matter of Both Planting Dates Measured in November



- Lose 50% to 80% of fall growth potential with a 1 month planting delay
- Later planting defers growth potential to spring
- Rye is the least impacted by a later planting date

Spring Biomass Data



Rye and triticale containing mixtures were least impacted by a later planting date

Ryegrass containing mixtures were moderately impacted by a later planting date

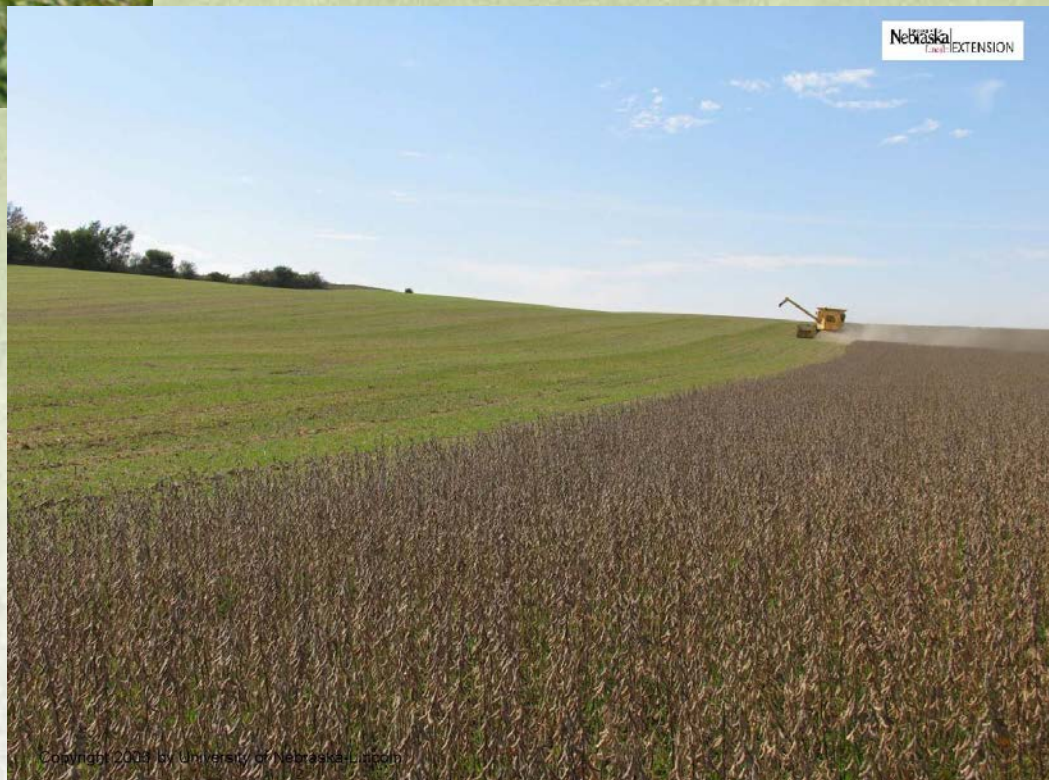
Legumes w/ no spring growing companions were heavily impacted by a later planting date

PENN STATE CMEG Crop Management Extension Group

unlock the SECRETS IN THE SOIL

How are farmers getting it done?

Aerial Seeding

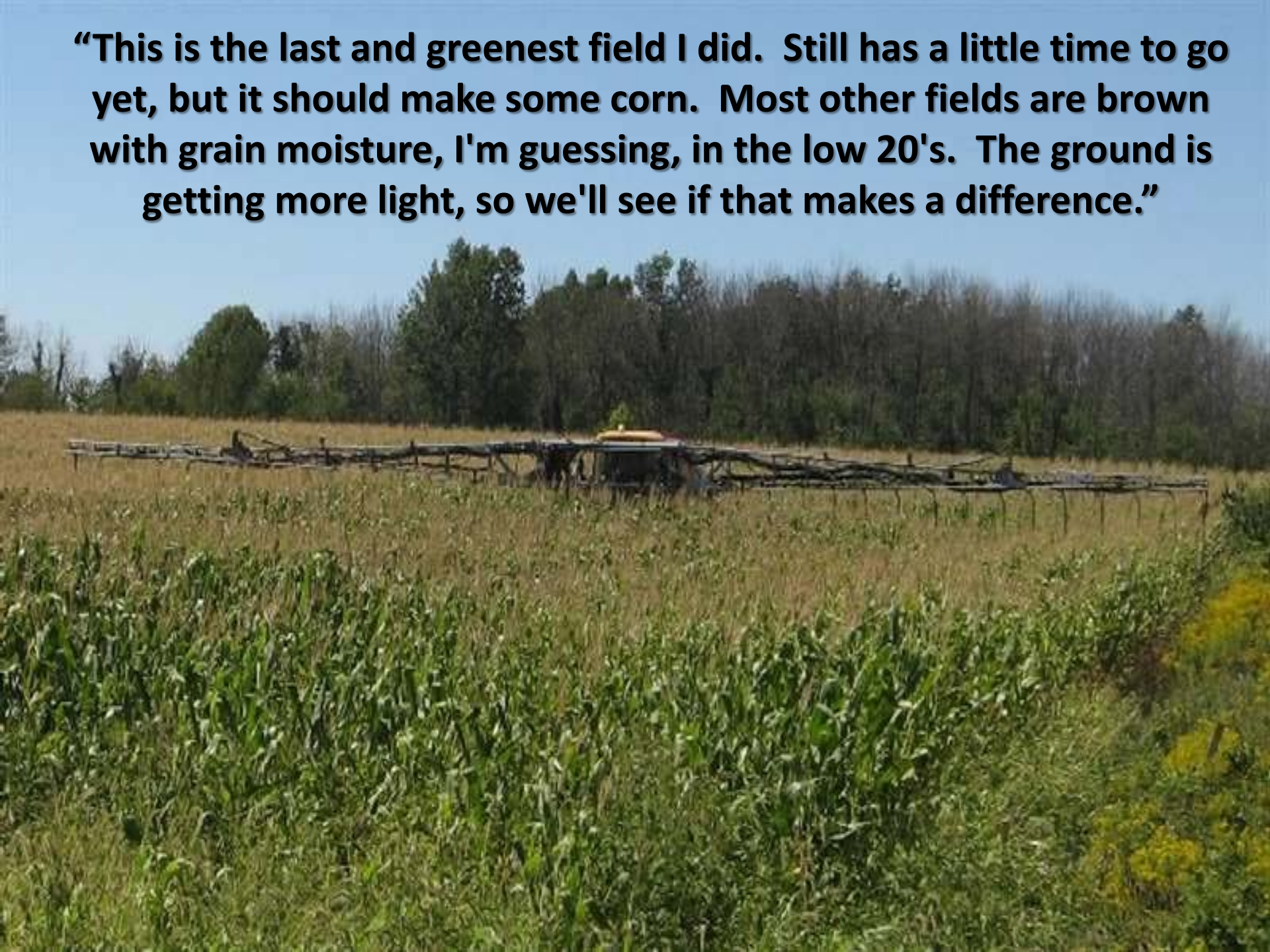


Penn State Cover Crop InterSeeder & Applicator

unlock the SECRETS IN THE SOIL

Highboy air seeders

- Seed cover crops into corn & beans
- Uses a Hagie STS 12 with a Gandy Orbit Air seed box.
- Covers 90 feet / 36 rows and the hopper holds 65 bu. “


“This is the last and greenest field I did. Still has a little time to go yet, but it should make some corn. Most other fields are brown with grain moisture, I'm guessing, in the low 20's. The ground is getting more light, so we'll see if that makes a difference.”

Broadcast while defoliating cotton

Seeded a multi-species cover crop mix

- Cereal rye
- Crimson clover
- Hairy Vetch

Corn Copper --
cuts top out of mature corn

Soil Health Principle 3

Keep it Covered as Much as Possible

Benefits:

- Control Erosion
- Protect Soil Aggregates
- Suppresses Weeds
- Conserves Moisture
- Cools the Soil
- Provides Habitat for Soil Organisms

“Carbon” coverings for the soil!

Live crop biomass =

“active protective blanket”

Both are food sources for the soil biology!

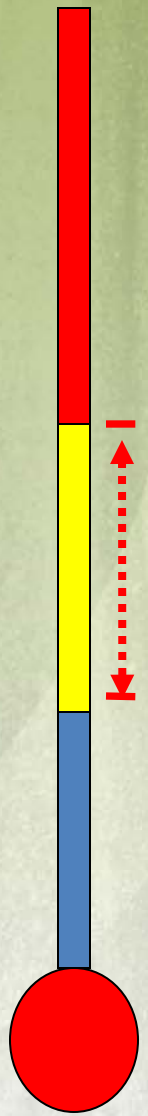
Dead crop residue =

“passive protective blanket”

Soil Temperatures

- Conserve moisture and reduce temperature.
- Crop yields are limited more often by hot and dry, not cool and wet.

When soil temperature reaches



140 F — Soil bacteria die

130 F — 100% moisture is lost through evaporation and transpiration

113 F — Some bacteria species start dying

100 F — 15% moisture is used for growth

95 F — 85% moisture lost through evaporation and transpiration

70 F — 100% moisture is used for growth

J.J. McEntire, WUC, USDA SCS, Kernville TX, 3-58 4-R-12198. 1956

What happens to residue?

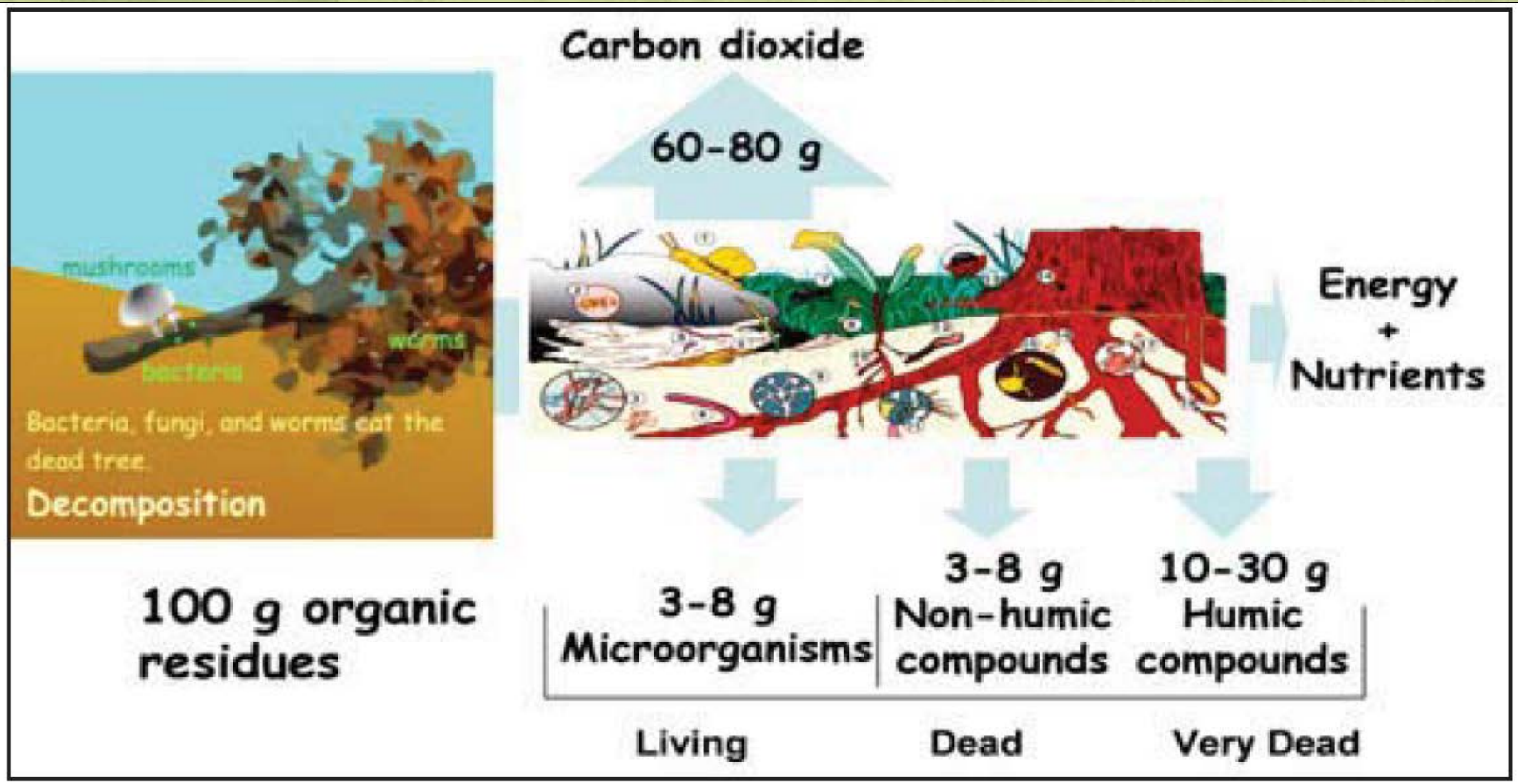


Diagram by Dr. Rafiq Islam

Soil Organic Matter Nutrient Bank Account.

- 1.0% OM = 20,000 #
  - 10,000 # Carbon (5 ton) @ $4/ton = $20
  - 1,000 # Nitrogen @ $.50/# = $500
  - 100 # Phosphorous @ $.70/# = $70
  - 100# Potassium @ $.40/# -=$40
  - 100 lbs of Sulfur @ $.50/# = $ 50
  - Total $680
- Mineralization Rate = 2-3% from Organic N to Inorganic N.
- Resulting in 20 to 30 lbs of useable N per acre.

Soil Organic Matter & Available Water Capacity

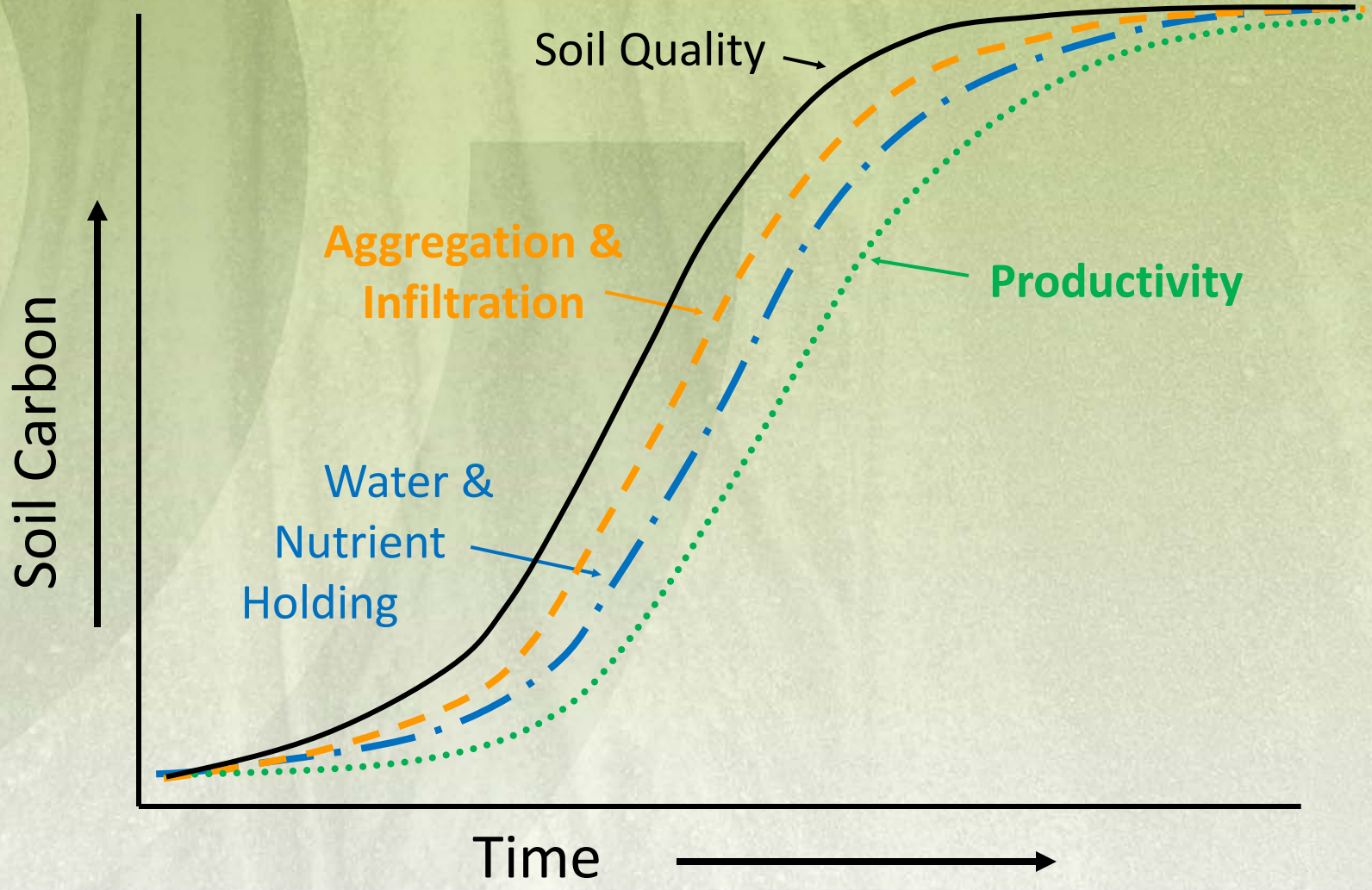
Percent SOM	Sand	Silt Loam	Silty Clay Loam
1	1.0	1.9	1.4
2	1.4	2.4	1.8
3	1.7	2.9	2.2
4	2.1	3.5	2.6
5	2.5	4.0	3.0

Inches of Water/One Foot of Soil

1 acre inch = 27,150 gallons of water

Berman Hudson
Journal Soil and Water Conservation 49(2) 189 194 189-
March April 1994 –
Summarized by:
Dr. Mark Liebig, ARS, Mandan, ND
Hal Weiser, Soil Scientist, NRCS, Bismarck, ND

Benefits of Soil Carbon



Soil Organic Matter Facts

- Soil organic matter (SOM) is <6% of soil by weight but controls >90% of the function
- Density of SOM: .6 g/cm^3 Density of Soil: 1.45 g/cm^3
- SOM has less density than soil so it has more space for air and water storage.
- SOM is negatively charged, but binds both cations and anions
- Every Pound SOM holds 18-20# of Water!
- As soil organic matter increases from 1% to 3%, the available water holding capacity of the soil doubles (Hudson, 1994).
- Soils stockpile 1500 gigatons of carbon in SOM, more than Earth's atmosphere and all the plants combined (Dance, 2008).
- The majority of the SOM is present in the top 10 cm of soil

Silt loam soil

Available Water holding Capacity (AWC)
(cm H2O/ 25 cm soil)
(in. H2O/ ft. soil)

2.3 cm
1.10 in.

3.2 cm
1.54 in.

4.2 cm
2.02 in.

5.1 cm
2.45 in.

SOM = 0% **1%** **2%** **3%**

soil matrix water **+** **Soil organic matter "sponge" water**

Source: Berman Hudson, 1994. JSWC 49:189-194.

Control All Forms of Soil Erosion

Soil Compaction Management


Questions??