The Dirt on Soil Health

Secret to Strong Pastures and Healthy Stock

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2026

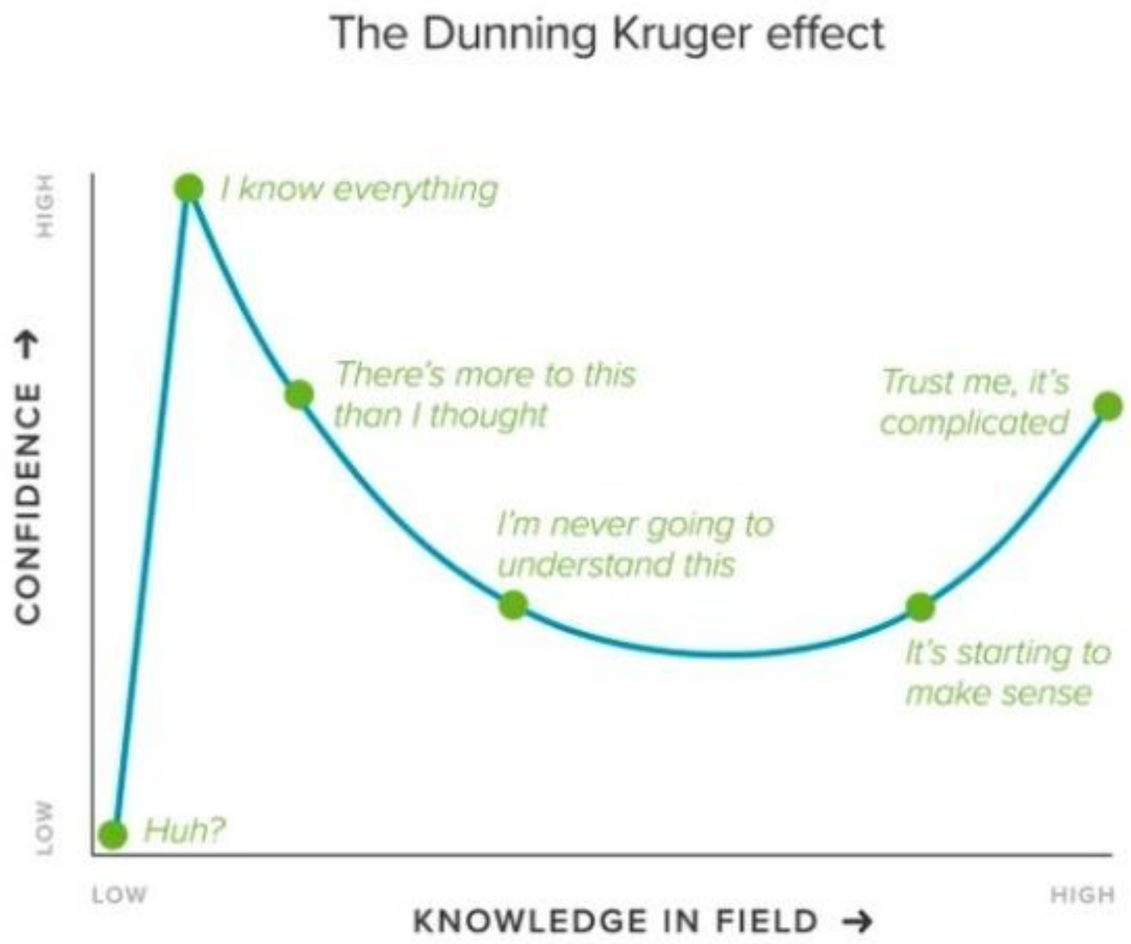
Multi Species Farming

- How do you do it?
- Where do you start?
- What is correct?
- How much does it cost?
- What do I need to know?
- Is anyone else doing this?
- Where do I find help?

Multi Species Farming

- It will be a system
  - Unique to each farm
    - Maybe unique to each paddock
      - May require new paddocks created
- Speed of change depends on
  - Economics, labour, equipment, knowledge, education, partnerships, climate

Goal Setting



Source Internet

Goal Setting

- Need to know where you are going
  - What issues are
  - How to assess if it was a success
- Not necessarily “yield”
  - Identify issues
    - Differentiate cause versus symptoms

Cause Versus Symptom

- Symptom
  - “Evidence of a disorder”
    - Google definition
- Cause
  - “Reason that gives rise to action”
    - Google definition

Cause Versus Symptom

- Need to treat the cause not symptoms
  - If symptom reappears, have not identified actual cause
- May have layers
  - Multiple causes for the symptoms
    - Compaction - over supply N, excess tillage, lack of plant growth, shallow roots, field work when wet, too large of equipment (not enough tyres)

Goal Setting

- Needs to be first step
  - What do you want to change?
  - What are the issues?
  - What are the limitations?
  - What tools do you have access to?
  - Budget?
  - Time frame?

Cover Crop Needs Assessment

Name _____ Acres _____

Conventional Organic

Grain Mixed Farm Livestock

Moisture

Dry OK Moist

Soil Texture

Sandy Soil Loam Clay Soil

Soil Fertility Level

Low Medium High

End use:

Hay Grazing Green manure Soil Improvement
Ground Cover Relay Crop Intercrop

Issues (rated):

Hard Pan Poor aggregation Slow infiltration Weeds Low N

Erosion Low OM Low fertility Grazing Hay/Silage Salinity

Seeding date:

Early spring Late spring Early summer Late summer Early fall

Seeding method:

Broadcast Drilled

Termination:

Cultivation Herbicide First Frost Last Frost Over winter Grazing/Hay

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Last Crop:

Next Crop:

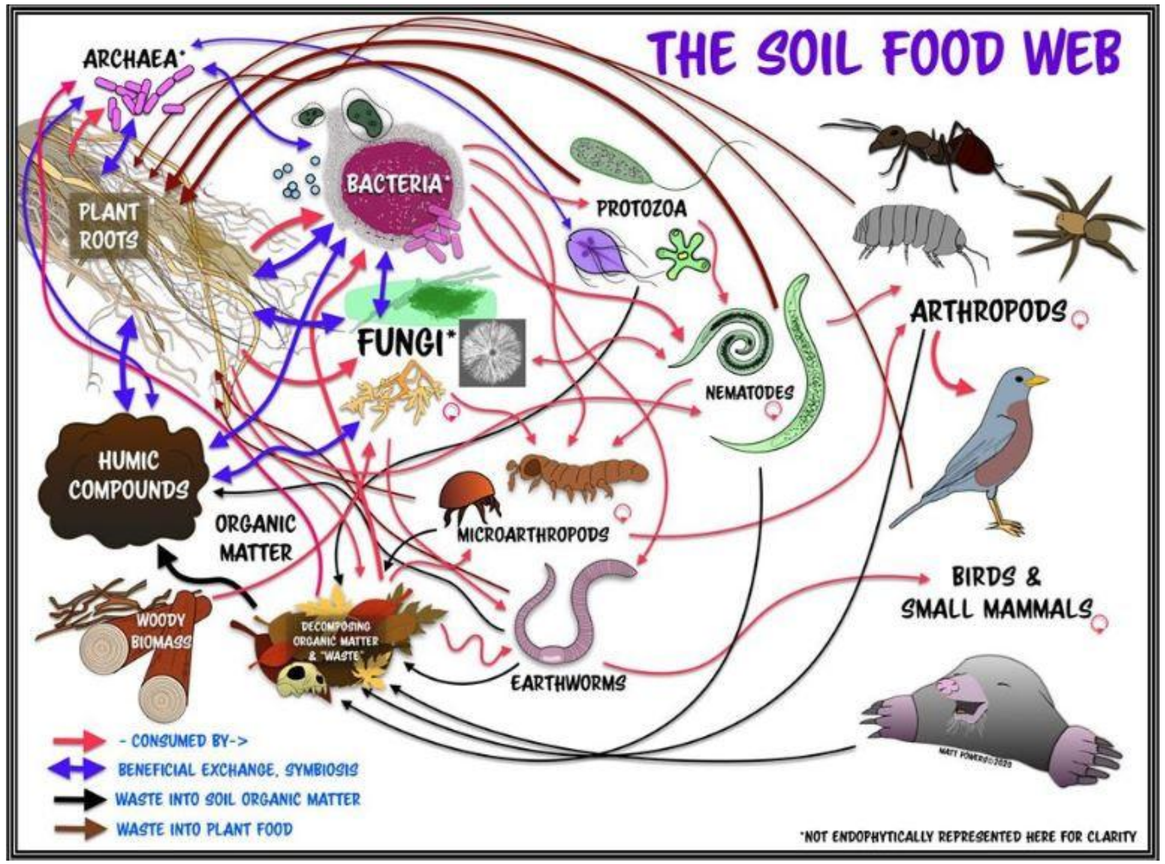
Weed Concerns:

Seed producer is supplying:

Soil Biology

Soil Microbiology

- Soils are a series of ecosystems
- Simplified overview
  - Primary Level
    - Bacteria and fungi
  - Secondary Level
    - Protozoa, ameoba, nematodes
  - Third Level
    - Larger predators



Picture Source: Matt Powers

Soil Biology

- Living functional soils will not require much support
- Chemistry takes jobs away from the soil biology
  - Developed over 10,000’s of years
- When changing plant types we may have to help build soil microbe populations

Picture: Ellie Wentworth Brown

Soil Ratios

- All about balance
- Albrecht, Carbon:Nitrogen, Fungal:Bacterial
  - Will be more as we learn
- Texture we cannot change
  - Soil Organic Matter we can

Albrecht

- First, do a mineralogical test on the soil along with chemical extraction
  - Need to see what is in your soils and what is available
- Balanced soil fertility is crucial
  - Address soil nutritional deficiencies
  - Plant deficiencies mainly due to microbial deficiencies if soil nutrients are good

Carbon:Nitrogen Ratio

- Important to know to see where the nitrogen and carbon wants to flow in the soil
  - Low C:N ratio, carbon hungry
    - Needs carbon injection
  - High C:N ratio, nitrogen hungry
    - First N added will feed biology

Carbon:Nitrogen Ratio

- “Tired” paddocks
  - Sod bound
  - Wide C:N ratio
  - Low productivity
    - Low bacterial activity
  - Woody “weeds”
  - Low energy system
  - Needs sugar, carbon, bacteria function

Carbon:Nitrogen Ratio

- Plant residue C:N ratio is also important
- Regulates how quickly the residue will rot, just like a rumen
  - Narrow C:N ratio - fast rot
    - Quick nutrient release
  - Wide C:N ratio - slow rot
    - Creates soil armour
    - Ties up nutrients

Carbon:Nitrogen Ratio

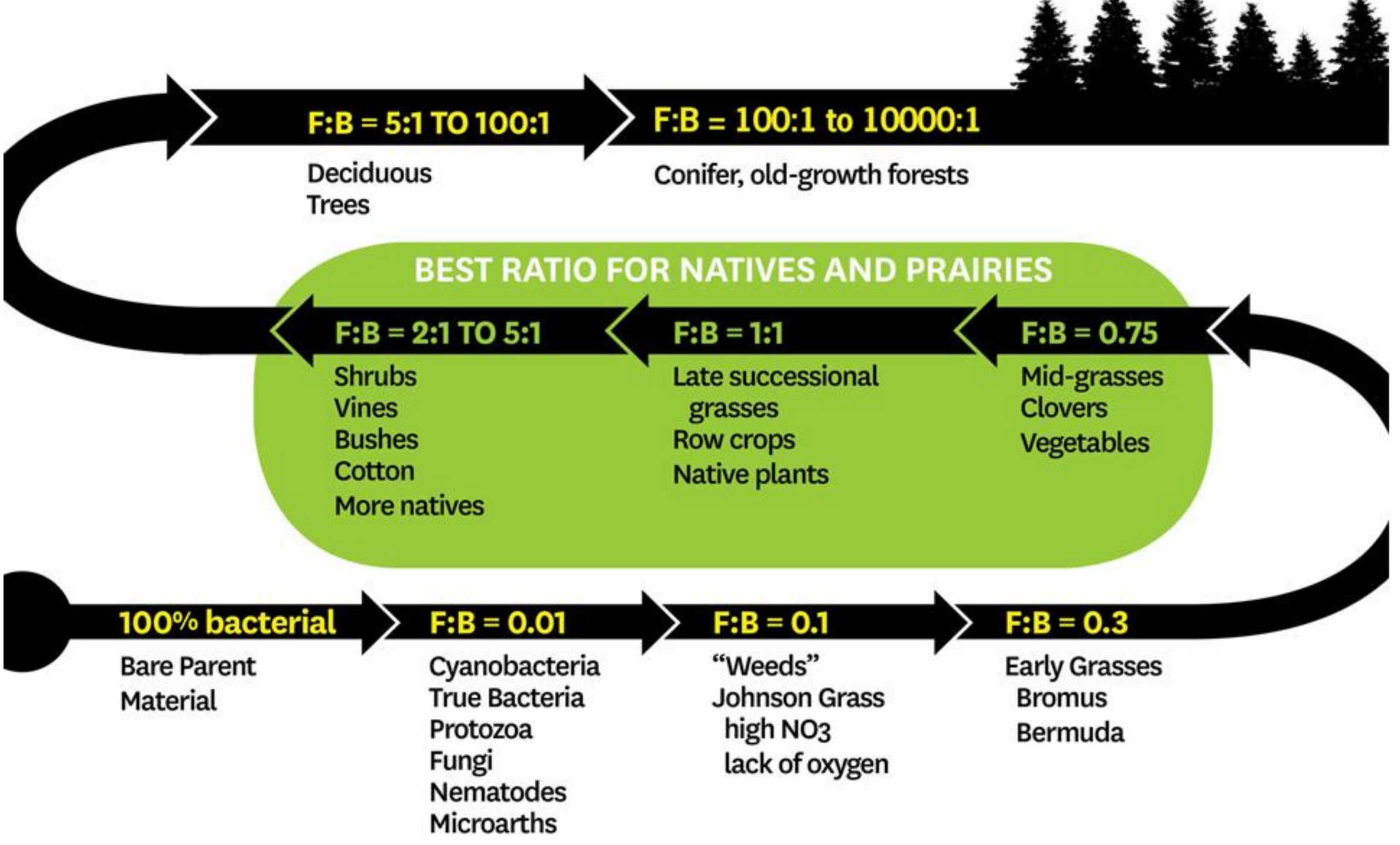
- Lower C:N ratio
  - Green plant material
  - Vegetative plants
  - Higher protein plants
- Wider C:N ratio
  - Straw
  - Mature plants

Carbon:Nitrogen Ratio

- Need to feed the soil and rumen both types
  - Need green and brown materials for things to work properly
- Too much high C:N ratio residue
  - Soils require more inputs
  - Manure is blocky
- Too much low C:N ratio residue
  - Erosion
  - Compaction
  - Manure is runny

Fungal:Bacterial Ratio

- Important: different plant types need different microbial populations
  - Some need more bacterial dominated soils
  - Others fungal dominated soils
- If not correct ratio, plant may struggle
- “Wrong” plants will want to grow



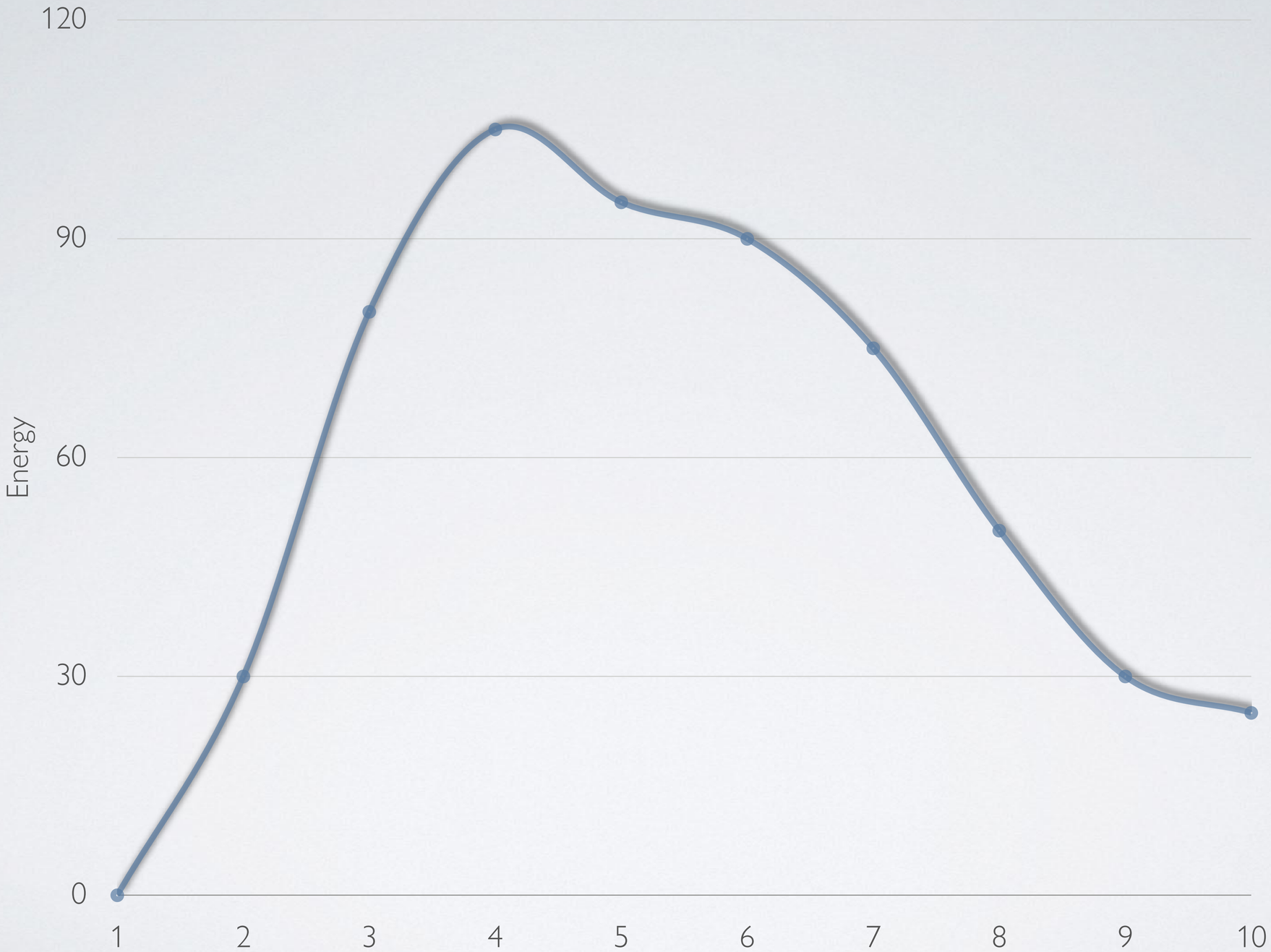
https://sustainablegrowthtexas.com/sgtx-custom-blends-follow-road-map-to-match-biology-with-desired-plant-growth/

Fungal:Bacterial Ratio

- Our management moves these ratios
- Tillage, synthetic inputs, and non mycorrhizal plants, good grazing management decreases F:B ratio
  - Damages fungi, promotes bacteria
- Zero tillage, living roots, using mycorrhizal friendly plants, good grazing management increases F:B ratio

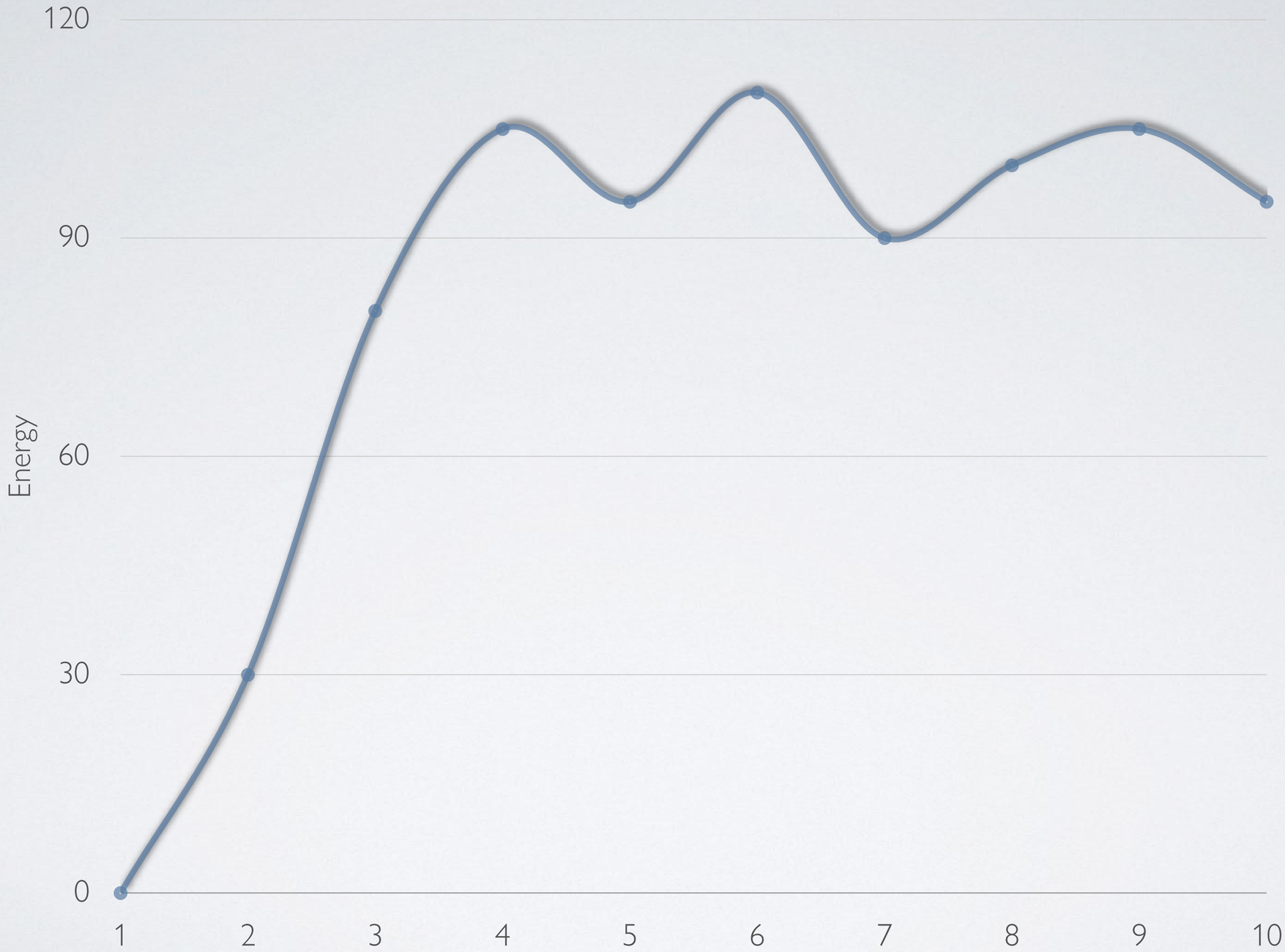
Fungal:Bacterial Ratio

- As perennial forage become more mature
  - Root exudates decrease
    - Bacteria population decrease
      - Nutrient cycling slows down
        - Productivity decreases
- Systems gravitate to lowest energy state under constant management


120
90
60
30
0
Energy
1
2
3
4
5
6
7
8
9
10

Fungal:Bacterial Ratio

- Perennial stands - need holistic management
  - Adaptive Multi Paddock grazing
  - Manage grass using livestock
    - Graze part trample part
      - Feed the soil microbes
      - Create soil armour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Soil Health Principles

Soil Health Principles

1. Keep plant in the vegetative stage for as many days possible

2. Increase functional plant diversity

3. Reduce tillage

4. Reduce reliance on synthetic inputs

5. Properly incorporate livestock

Vegetative Plant

- Key for building healthy soils
- Up to 80% of the C captured through photosynthesis is released as root exudate
  - Drops off dramatically at stem elongation
- Builds mycorrhizae fungi
- Absorbs excess soil nitrate to create complex N compounds
- Plays catch and release with nutrients

Vegetative Plant

- Creates a micro water cycle
  - Green leaves cool quicker than the air
    - Water condenses
      - Absorbed or rolls off
      - Absorbed water used as root exudate
      - Rolled off water hydrates the soil (somewhat)

Vegetative Plant

- Vegetative plant
  - Higher root:shoot ratio
  - Cools the soil surface
  - Uses soil moisture
    - Decreases evaporation
      - Reduces salinization
    - Increases transpiration
      - Builds soil aggregates

Vegetative Plant

- Very important end of season
  - Before plants go inactive
- Soil biology uses root exudates to weatherproof the soil aggregates
  - Makes them more stable to degradation

Increase Functional Plant Groups

- Functional Plant Groups
    1. Grass
    2. Legume
    3. Brassica
    4. Non Brassica Broadleaf
    5. Forb
- Summer and winter active species
    - Annual, biennial and perennial

Reducing Tillage

- There is a time and place for tillage
  - Need goals
  - “Surgical tillage”
    - SoilKee
  - Add C with tillage pass
  - As shallow as possible
  - Maintain soil armour as much as possible

Reducing Synthetics

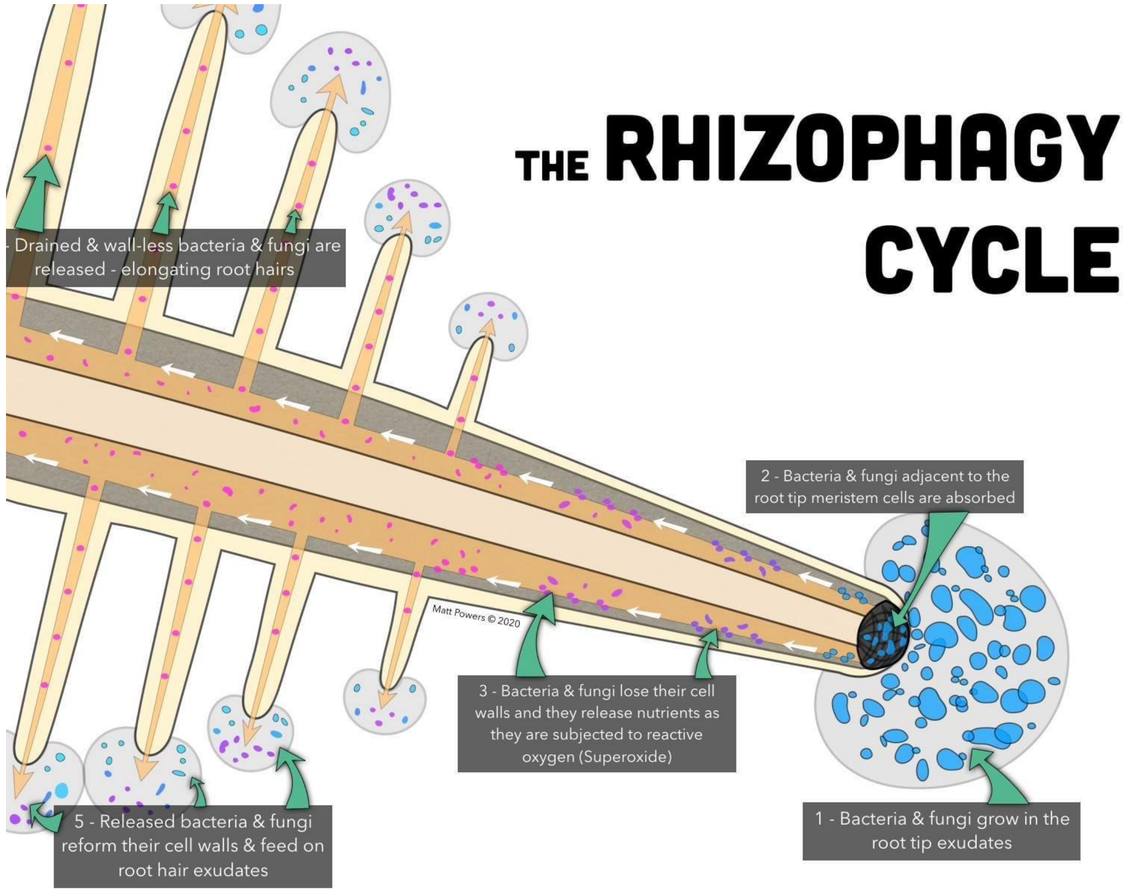
- Application of synthetic inputs replaces a natural system
  - Fertiliser —> reduces root exudates —> reduces microbial function and drops Brix
  - Fungicides —> simplifies plant microbiome and drops Brix
  - Insecticides —> kills target and non target insects —> reduces other populations like birds

Fertiliser

- At best synthetic N is 50% used by the plant
- Synthetic P < 15% used by the plant
- Preferred path of nutrient uptake is Rhizophagy (Dr. James White)
  - First identified in University of Queensland 2010
- Estimated 85% of nutrients “should” be taken up this way

Rhizophagy

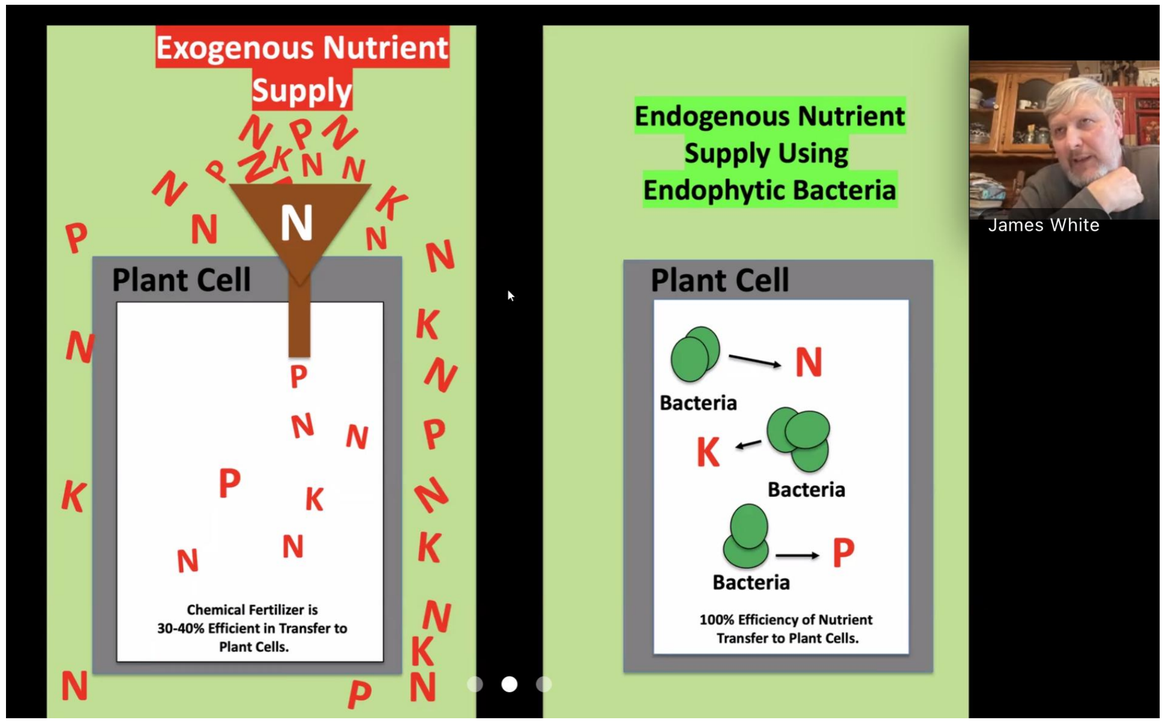
- Root tips absorb microbe
- Root cell strips microbe cell walls off
- Root cell digests the cytoplasm keeping the nucleus
- Nuclei cycle within the root cell, replicating them
- Nuclei get “shot” out of the root tip and fed root exudate to reform cell wall and microbial function
- Microbe restarts soil function and the cycle repeats



Source: Internet

Fertiliser

- Fertiliser can be more predictable than other nutrient sources
- Fertiliser replaces microbial role
- BUT fertiliser application will
  - Reduce drought tolerance
  - Reduce plant Brix
  - Over application of N will create compaction, disease and insect attacks



Fertiliser

- Legumes fix N
  - Other plants create relationship with free living soil borne N fixers
- Mycorrhizal fungi source P and micronutrients
- Soil microbes cycle other nutrients
- Addition of compost or feed pellets (i.e. lucerne pellets)
- Deep tap rooted green manure cover crops

Fertiliser Substitutes

- Compost
- Compost extracts
- Proper grazing
- Feed pellets
- Green manures
- Multi species blends
- Responsible manure applications

Insecticides

- Insects and disease are the garbagemen of nature
  - Takes out the “garbage”
- Keep Brix over 12, less issues
  - Challenge in drought
- Insecticides take out more than just the target pest
  - Sometimes the predators

Properly Incorporate Livestock

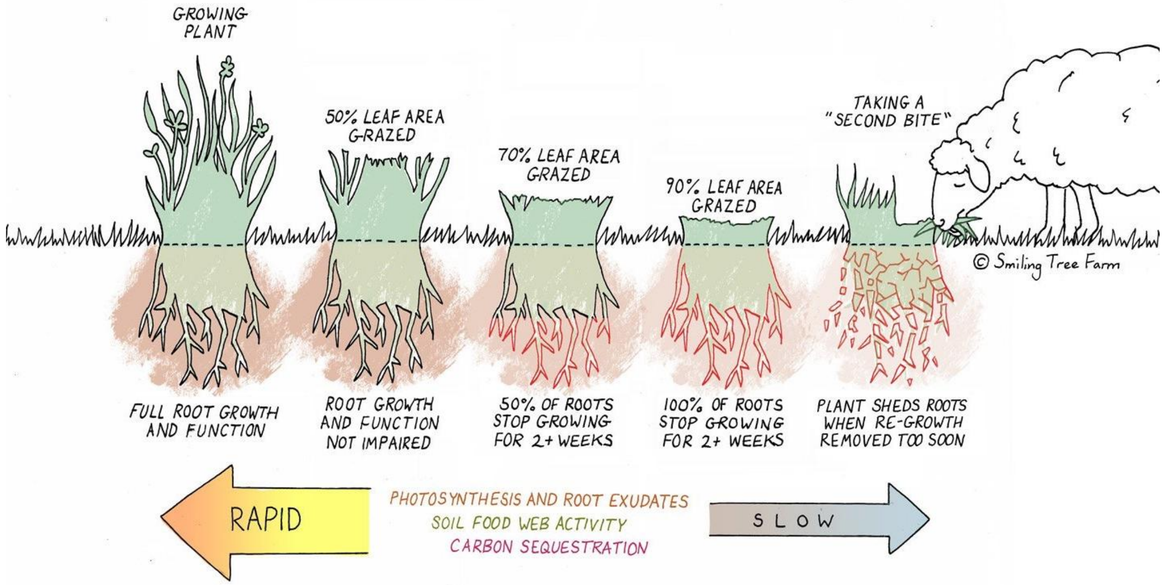
- Most soils are built on forage plants and grazing animals
  - Many civilizations are destroyed by over grazing, under resting, and over resting plants
    - “Dirt: The Erosion of Civilizations” David Montgomery

Properly Incorporating Livestock

- Soil -> Soil Microbes <-> Plants -> Animals -> Soil
- Using grazing animals to manage the forage
  - Not the other way around
- Great way to cycle nutrients
  - Manage residues

Properly Incorporating Livestock

- Allow plants to get through most of their yearly life cycle
  - Develop strong root system
- Vegetative stage
  - Graze 1/2 leave 1/2
- Dormant stockpile
  - Before waking up, graze down
    - Let recover
      - Alejandro Carrillo



Source: Internet

Soil Health

- Growing season grazing
  - Jay Fuhrer - “graze 1/2 leave 1/2”
  - Alan Savory - partial rest
    - Animals are allowed to back graze on plants already grazed without full recovery
  - Use electric fence to keep animals moving forward
    - Replaces role of predators

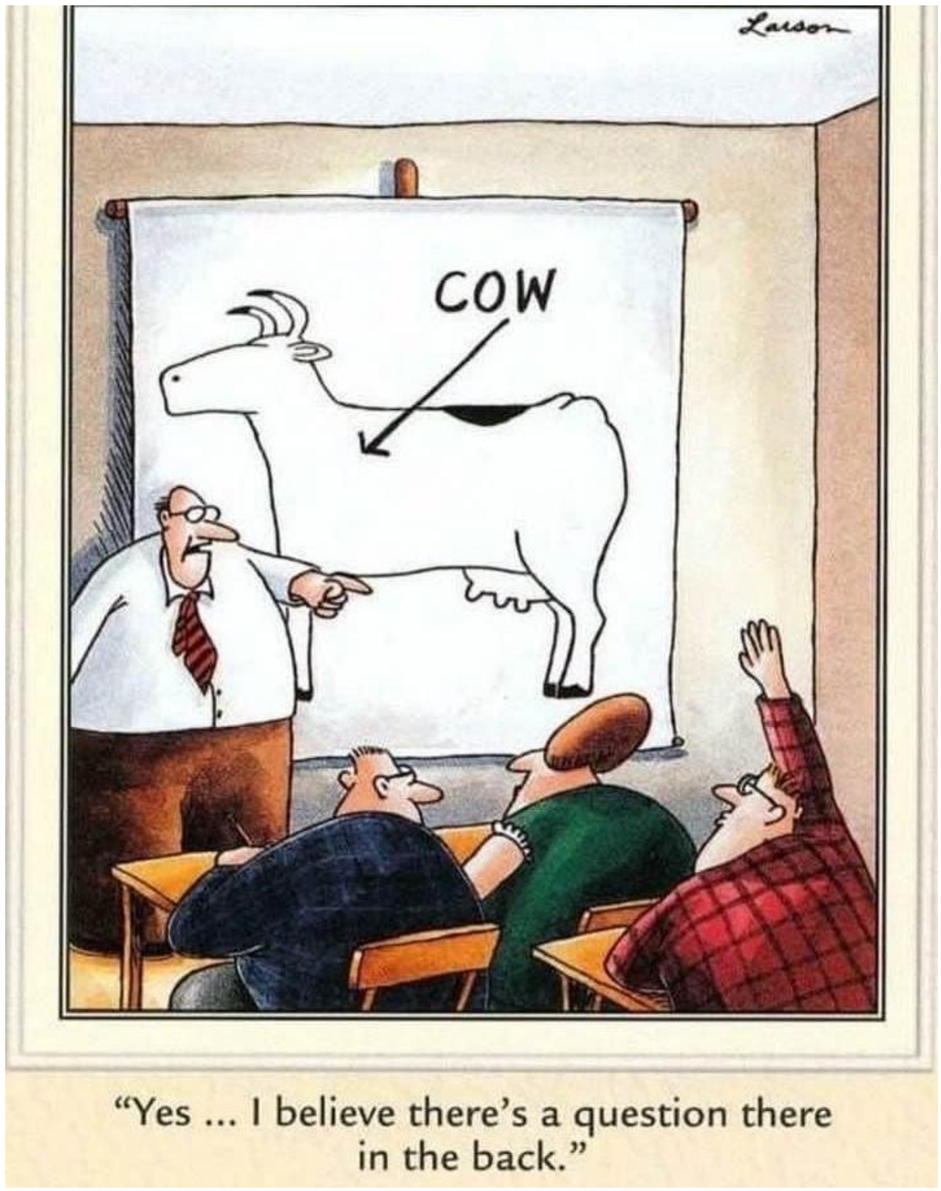
Cover Crop Feed and Forage Report			
Menoken Farm			
19-Sep-16			
Specie	**Crude Protein**	**RFV**	**TDN**
Annual Ryegrass - Top/half	15.67%	110.81	61.88%
Annual Ryegrass - Bottom/half	8.02%	109.05	60.12%
Cowpea - Top/half	14.79%	218.90	69.38%
Cowpea -Bottom/half	4.35%	103.72	58.94%
Hairy Vetch - Top/half	14.75%	126.74	60.78%
Hairy Vetch - Bottom/half	6.07%	85.59	52.08%
Pearl Millet - Top/half	9.77%	83.95	59.18%
Pearl Millet - Bottom/half	1.77%	86.91	57.79%
Radish - Top/half	10.74%	105.20	56.08%
Radish - Bottom/half	6.54%	75.30	48.09%
Soybean - Top/half	17.90%	190.15	67.95%
Soybean - Bottom/half	11.76%	114.08	59.10%
Sudan - Top/half	7.83%	83.93	58.21%
Sudan - Bottom/half	7.52%	84.78	57.56%
Sunflower - Top/half	10.38%	193.66	65.57%
Sunflower - Bottom/half	6.06%	123.83	58.30%
Sweet clover - Top/half	24.53%	228.51	72.25%
Sweet clover - Bottom/half	12.62%	97.47	55.15%
Cool Season Cover Crop Mix (fall seeded)	26.79%	208.43	71.32%
Source: Dairyland Laboratories, Inc.			

Properly Incorporating Livestock

- Cover crops can get livestock from pasture paddocks into crop land
  - Rest perennials
    - Especially before they go dormant
  - Emergency fodder
    - Grazing, bale, silage

Properly Incorporating Livestock

- Cropper?
- Do not need to own the livestock
  - Partner with someone
  - Payment will reflect work each does
- Great to utilize residues and cover crops
- Income diversification



Source: Internet

Never does Nature separate the animal and vegetable worlds. This is a mistake she cannot endure, and of all the errors which modern agriculture has committed this abandonment of mixed husbandry has been the most fatal.

Albert Howard

Cover Cropping

Cover Cropping

- Definition: growing plants to protect and improve the soil
    - Can get more detailed but then limits our thinking
- Needs to be goal oriented
- Needs to be planned like our other paddocks
- Colin Seis - no kill pasture cropping

Cover Cropping

- Build on synergies
- Avoid contamination and competition
  - Look at previous crop, this crop and next crop
- What weeds are growing?
- Where is the F:B ratio?
  - Where would we like it to move?

Fodder Blends

- Goals. Goals. Goals.
  - Type of livestock
  - Time of seeding
  - Time of grazing/cutting
  - Feed constraints
  - Soil constraints
  - Management

Full Season

- Intent is to seed the cover crop and let it grow full season
  - Hay, graze, silage, or green manure
- Has full season to address issues
- May have to graze, mow or clip so it does not get past flowering
- Or terminate and seed summer active before the soil dries out

Legacy Effect

- Dr. Christine Jones
- 1 seed —> 9 billion microbes
  - Each seed own microbiome
  - Different seed from different production systems —> different microbiome
  - Different functional plant groups —> different microbiome
  - Your soil unique microbiome

Legacy Effect

- Planted seed will bring their own microbiome, have access to soil microbiome and previous rhizosheaths, and other growing plants microbiomes
- Plants with similar microbiomes, roots do not like to intermingle
- Dissimilar microbiomes encourages root intermingling
  - Sharing of microbes

Legacy Effect

- Sharing of microbiome microbes triggered by each plant
  - New microbe may be needed to turn plant genes on/off
    - Plant becomes more resilient
- Seed gets improved microbiome
  - More adapted to local soils and climate

Designing Blends

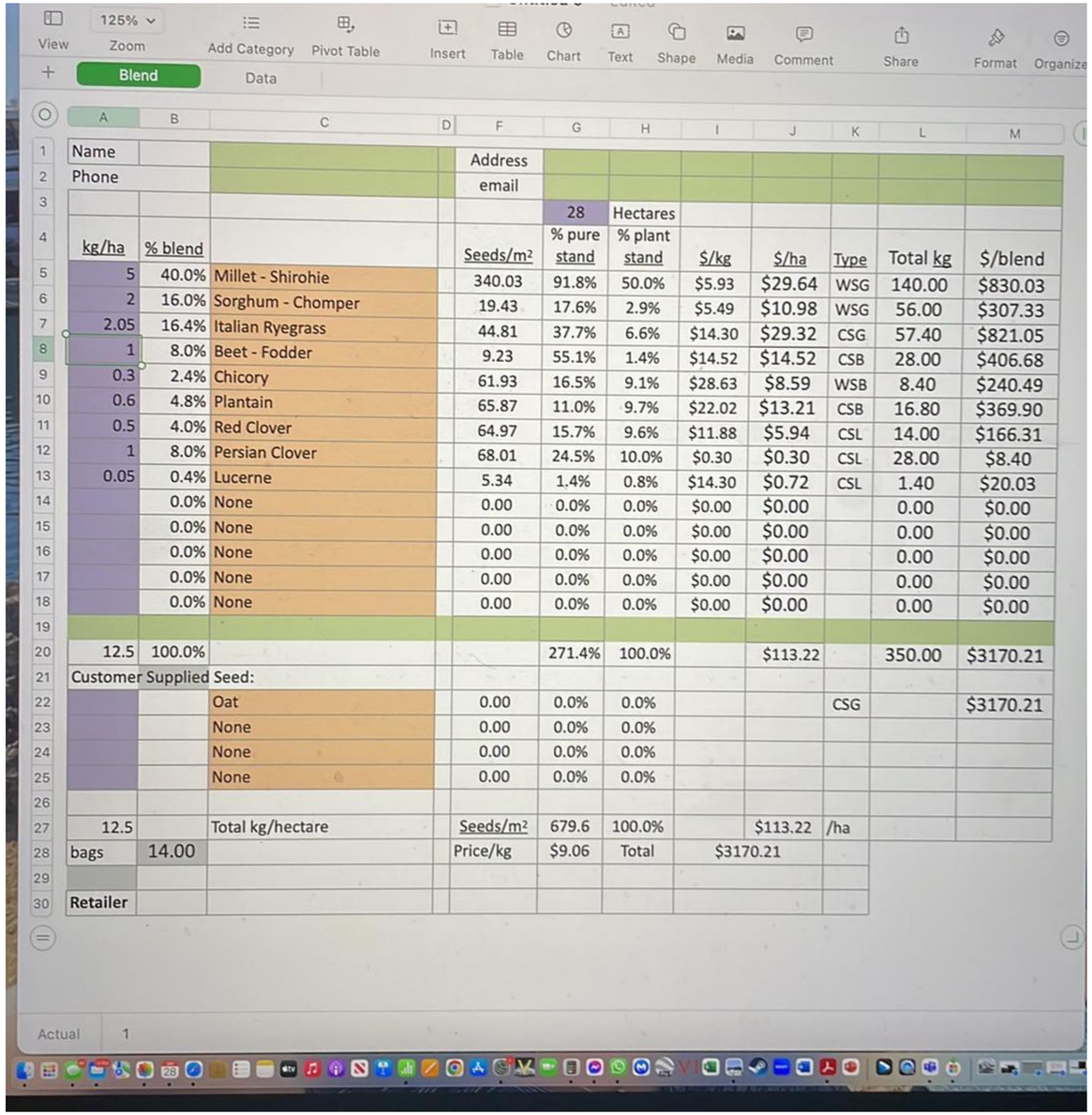
- Need to understand role of different plants and functional groups
- Quorum Sensing (Dr. Christine Jones)
  - Increasing plant diversity multiplies microbial impact
    - Watch not to dilute beneficial effect of essential species

Designing Blends

- Goals
  - What are you addressing?
    - What species have that ecological function?
    - When are you seeding?
    - How are you seeding?
    - When is it utilized?

Designing Blends

- Identify potential species
  - What is available
- Find out seeds per kilogram
  - Cost per kilogram
- What is monoculture seed density
- What plant density are you aiming for
  - How many other species are you using
- Get away from ryegrass clover mixes
  - More plant diversity



	A	B	C	D	F	G	H	I	J	K	L	M
1	Name				Address							
2	Phone				email							
3						28	Hectares					
4	kg/ha	% blend			Seeds/m²	% pure stand	% plant stand	$/kg	$/ha	Type	Total kg	$/blend
5	5	40.0%	Millet - Shirohie		340.03	91.8%	50.0%	$5.93	$29.64	WSG	140.00	$830.03
6	2	16.0%	Sorghum - Chomper		19.43	17.6%	2.9%	$5.49	$10.98	WSG	56.00	$307.33
7	2.05	16.4%	Italian Ryegrass		44.81	37.7%	6.6%	$14.30	$29.32	CSG	57.40	$821.05
8	1	8.0%	Beet - Fodder		9.23	55.1%	1.4%	$14.52	$14.52	CSB	28.00	$406.68
9	0.3	2.4%	Chicory		61.93	16.5%	9.1%	$28.63	$8.59	WSB	8.40	$240.49
10	0.6	4.8%	Plantain		65.87	11.0%	9.7%	$22.02	$13.21	CSB	16.80	$369.90
11	0.5	4.0%	Red Clover		64.97	15.7%	9.6%	$11.88	$5.94	CSL	14.00	$166.31
12	1	8.0%	Persian Clover		68.01	24.5%	10.0%	$0.30	$0.30	CSL	28.00	$8.40
13	0.05	0.4%	Lucerne		5.34	1.4%	0.8%	$14.30	$0.72	CSL	1.40	$20.03
14		0.0%	None		0.00	0.0%	0.0%	$0.00	$0.00		0.00	$0.00
15		0.0%	None		0.00	0.0%	0.0%	$0.00	$0.00		0.00	$0.00
16		0.0%	None		0.00	0.0%	0.0%	$0.00	$0.00		0.00	$0.00
17		0.0%	None		0.00	0.0%	0.0%	$0.00	$0.00		0.00	$0.00
18		0.0%	None		0.00	0.0%	0.0%	$0.00	$0.00		0.00	$0.00
19												
20	12.5	100.0%				271.4%	100.0%		$113.22		350.00	$3170.21
21	Customer Supplied Seed:											
22			Oat		0.00	0.0%	0.0%			CSG		$3170.21
23			None		0.00	0.0%	0.0%					
24			None		0.00	0.0%	0.0%					
25			None		0.00	0.0%	0.0%					
26												
27	12.5		Total kg/hectare		Seeds/m²	679.6	100.0%		$113.22	/ha		
28	bags	14.00			Price/kg	$9.06	Total	$3170.21				
29												
30	Retailer											

Designing Blends

- Seeding tools
  - Disk opener
    - Least disturbance
  - Tine
    - More soil movement
    - Pick appropriate opener
  - Broadcast
    - Highest risk to establish


LEMKEN
6910
JOHN DEERE


New Holland
SC330


A.E.
WALKER
12/90

Cover Crop Blender

Name				Address							
Phone				email							
					150	Hectares					
kg/ha	% blend			Seeds/m²	% pure stand	% plant stand	$/kg	$/ha	Type	Total kg	$/blend
0.33	2.3%	Teff		87.28	8.3%	19.2%	$0.00	$0.00	WSG	49.50	$0.00
4.3	30.1%	Cow Peas		6.45	53.8%	1.4%	$0.00	$0.00	WSL	645.00	$0.00
2.65	18.6%	Lablab		1.46	33.1%	0.3%	$0.00	$0.00	WSL	397.50	$0.00
0.5	3.5%	Sunflower		8.82	6.3%	1.9%	$0.00	$0.00	WSB	75.00	$0.00
1	7.0%	Buckwheat		3.09	1.7%	0.7%	$0.00	$0.00	WSB	150.00	$0.00
1	7.0%	Millet - Shirohie		68.01	18.4%	14.9%	$0.00	$0.00	WSG	150.00	$0.00
2	14.0%	Sorghum Sudan		19.43	17.6%	4.3%	$0.00	$0.00	WSG	300.00	$0.00
2	14.0%	Crimson Clover		106.87	36.7%	23.5%	$0.30	$0.60	CSL	300.00	$90.00
0.5	3.5%	Balansa Clover		154.28	110.2%	33.9%	$0.00	$0.00	CSL	75.00	$0.00
	0.0%	None		0.00	0.0%	0.0%	$0.00	$0.00		0.00	$0.00
	0.0%	None		0.00	0.0%	0.0%	$0.00	$0.00		0.00	$0.00
	0.0%	None		0.00	0.0%	0.0%	$0.00	$0.00		0.00	$0.00
	0.0%	None		0.00	0.0%	0.0%	$0.00	$0.00		0.00	$0.00
	0.0%	None		0.00	0.0%	0.0%	$0.00	$0.00		0.00	$0.00
14.28	100.0%				286.0%	100.0%		$0.60		2142.00	$90.00
Customer Supplied Seed:											
		None		0.00	0.0%	0.0%					$90.00
		None		0.00	0.0%	0.0%					
		None		0.00	0.0%	0.0%					
		None		0.00	0.0%	0.0%					
14.28		Total kg/hectare		Seeds/m²	455.7	100.0%		$0.60	/ha		
bags	85.68			Price/kg	$0.04	Total	$90.00				
Retailer											

Management

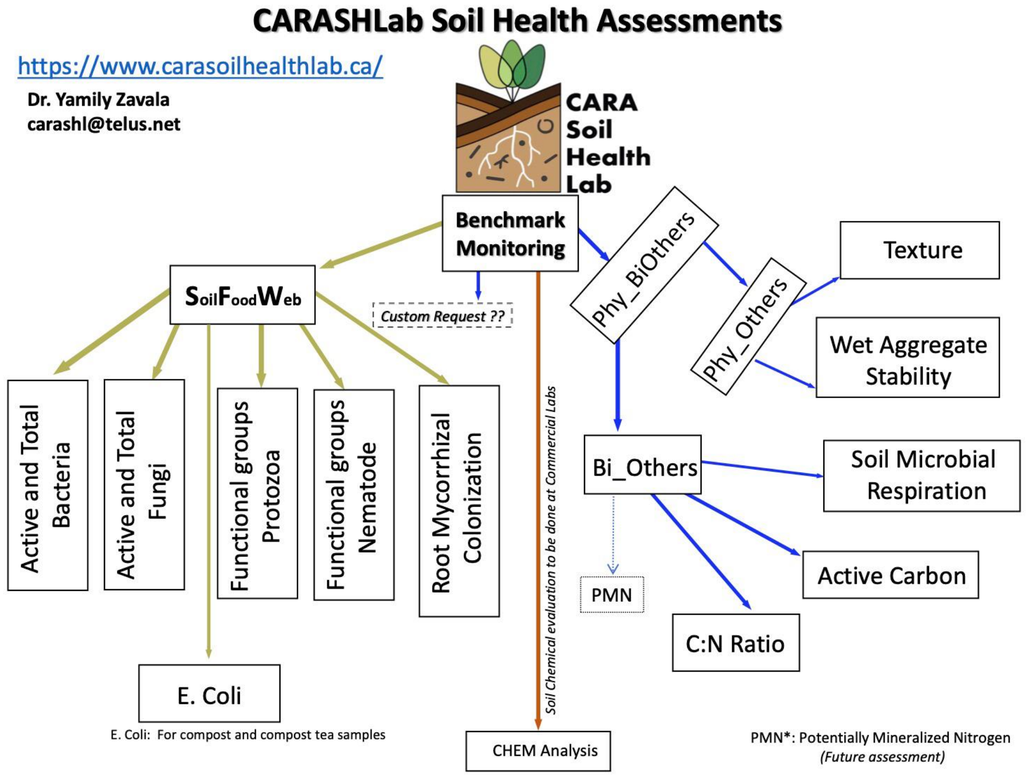
- How does management affect the microbial community?
  - Bacteria
  - Fungi
  - Nematodes
  - Protozoa
- Good and bad
- Our soil/plant/animal management has microbial implications

Measuring Change

- What matrices are we watching?
  - Soil aggregate stability
  - Micro aggregate stability
  - Water infiltration
  - Compaction
    - Penetrometer
  - Soil organic carbon (SOC)

Measuring Change

- What matrices are we watching?
  - Microbial population and composition
    - F:B ratio
    - Respiration rates
  - Chemistry test
    - Albrecht
  - C:N ratio



Measuring Change

- What matrices are we watching?
  - Soil observations
    - Structure
    - Colour
    - Smell
    - Depth of horizons
    - Root depth

- Run video

- Run video

Chemistry

Physics

Biology

Plant diversity

Organic Matter

Living roots

Livestock integration

Reduced tillage

Soil Health

CARBON

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