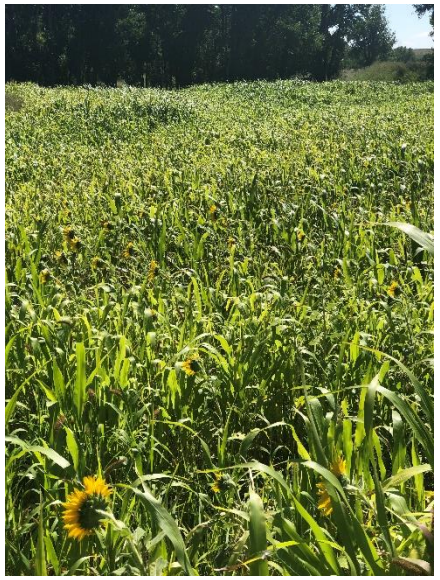
United States Department of Agriculture

Cover Crops

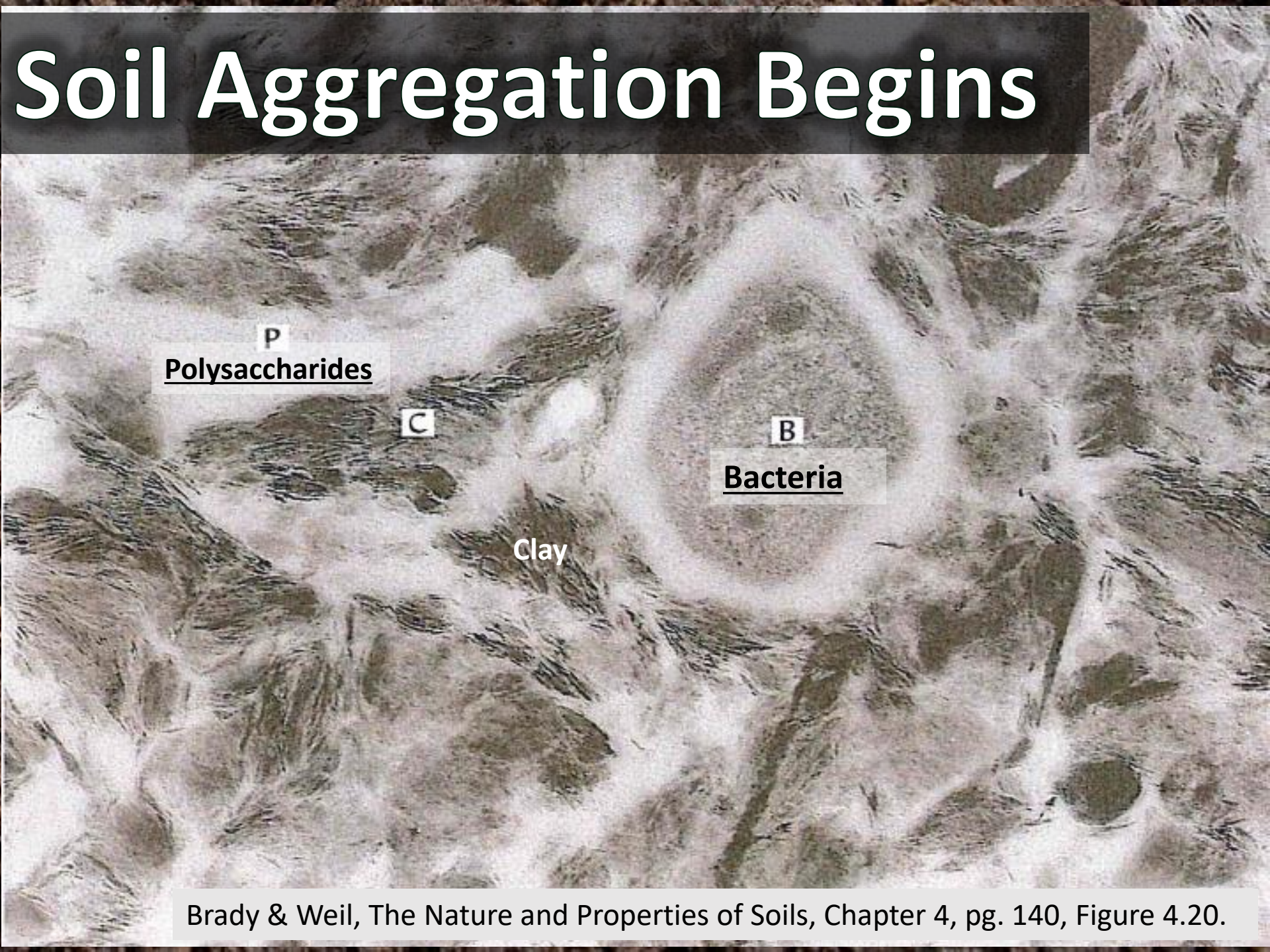
"If you're trying to make your soil healthier, You shouldn't see it very often"



Is it a Cover Crop or Biological Primer?

- Cover Crops have been used mainly to provide cover to protect from forms of erosion.
- Many soil health innovators realize that cover crops can be more than providing cover, they are biological primers that jump start the revitalization of the degraded soil ecosystem.

Soil Aggregation Begins



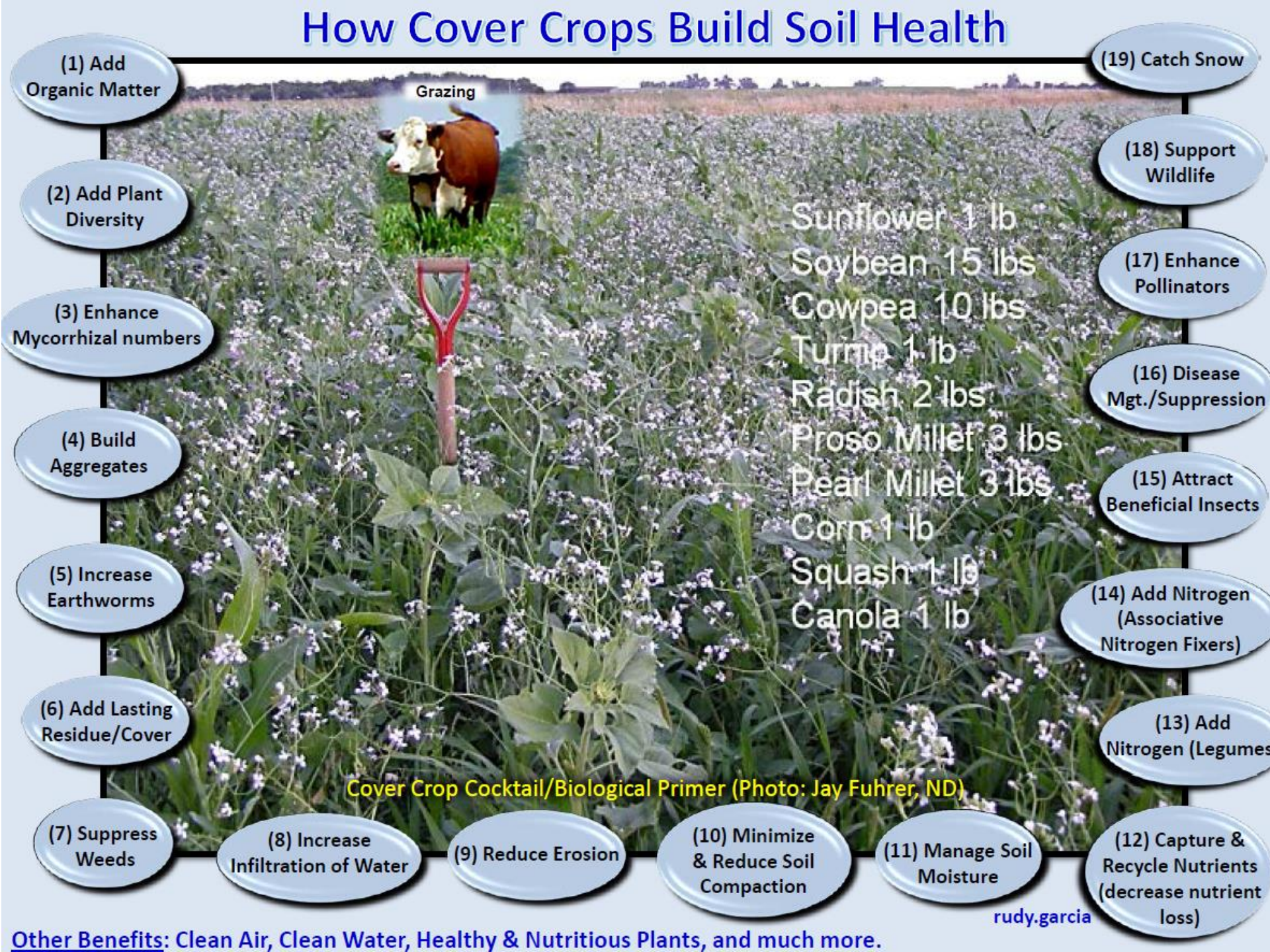
Brady & Weil, The Nature and Properties of Soils, Chapter 4, pg. 140, Figure 4.20.

2nd most important biological process = Nitrogen fixation

What is the most important biological process?

Cover Crops from a Farmer's Perspective:
Gabe Brown talks about Biological Primers (cover crops)

How Cover Crops Build Soil Health



(1) Add Organic Matter

(2) Add Plant Diversity

(3) Enhance Mycorrhizal numbers

(4) Build Aggregates

(5) Increase Earthworms

(6) Add Lasting Residue/Cover

(7) Suppress Weeds

(8) Increase Infiltration of Water

(9) Reduce Erosion

(10) Minimize & Reduce Soil Compaction

(11) Manage Soil Moisture

(12) Capture & Recycle Nutrients (decrease nutrient loss)

(13) Add Nitrogen (Legumes

(14) Add Nitrogen (Associative Nitrogen Fixers)

(15) Attract Beneficial Insects

(16) Disease Mgt./Suppression

(17) Enhance Pollinators

(18) Support Wildlife

(19) Catch Snow

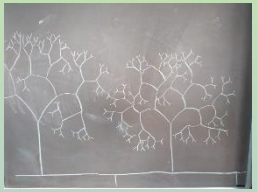
Cover Crop Cocktail/Biological Primer (Photo: Jay Fuhrer, ND)

rudy.garcia

Other Benefits: Clean Air, Clean Water, Healthy & Nutritious Plants, and much more.

Mycorrhizal Fungi: Highways for Water and Nutrients in Arid Soils

Michael F. Allen* Vadose Sone Journal 6:291-297



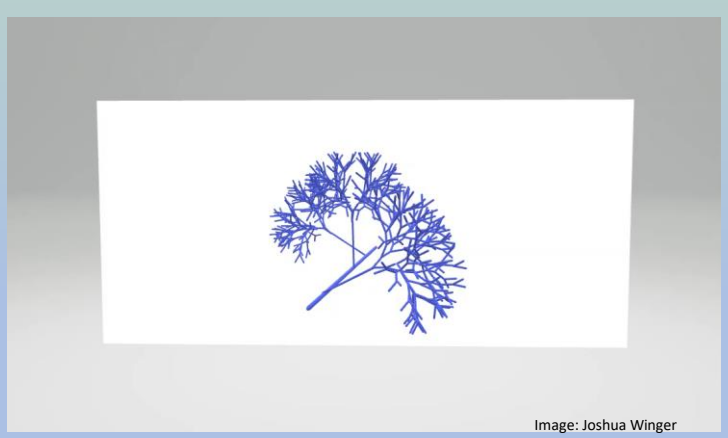


Image: Joshua Winger

Fungal hyphal length in soil up to 1 km/cm3 soil
AM fungal hyphae can exceed 108 m/m3 (e.g., Miller et al., 1995).

In AM systems, two types of mycelial networks
1st is the “runner” or “arterial” hyphae that extend from an infection point into the soil matrix looking for nutrient resources or new root tips available for infection. These hyphae tend to be large (often 10 µm in diameter or larger), with relatively infrequent branching.

2nd Absorbing networks thus have a distinct fan-shaped architecture starting with a single large hypha, branching into two smaller hyphae, branching into four smaller hyphae, and so forth, to an eight-order branching unit, with 128 tips, each about 2 µm in diameter (Friese and Allen, 1991; Allen et al., 2003). The absorbing unit extends about 6 cm into the soil from a root.

USDA
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What is your resource concern?

Cover Crops

Designing for what you don't have!

Identify Resource Concerns

- Provide crop diversity
- Provide soil surface armor (erosion)
- Build soil aggregates
- Improve the water cycle
- Integrated Pest Management
- Build soil organic matter
- Nutrient cycling
- Air Quality
- Enhance pollinator /predator habitat
- Adjust carbon/nitrogen ratios
- Wildlife winter food & shelter
- Livestock integration
- Nitrogen fixation

Considerations for successful cover crop planning

- Site preparation/Early weed control is essential
- Herbicide carryover and label restrictions
- Timing and species (adequate growing season)
- Crop rotation/diversity
- Seeding method seed-soil contact (broadcast vs. drilling, adequate equipment)
- Seed size/seeding depth
- Site and moisture conditions

Considerations for successful cover crop planning (cont.)

- Moisture management (cover benefits, water use)
- Nutrient cycling considerations (C:N ratio, living root)
- Weed, insect and disease management
- Termination method/timing – know before you plant how your are going to terminate
- Establishment of next cash crop
- Economics (yield impacts, cost of establishment, soil improvement,)
  - ("can we afford not to use a cover crop" J. Fuhrer, 2016)

Why Diverse Cover Crop Mixes?

1. If *Soil Health* is the goal, *Crop Diversity* cannot be ignored or overstated
2. Plants were created to grow in diverse ecosystems
3. *Resilience* comes from *Diversity*
4. Balanced “diet” for soil biology
5. Balance: because even good things (legumes, brassicas) when not used in moderated balance can be harmful

Cover Crop impacts on Soil

Worms underneath decomposing cow pie
165 worms per cubic foot. = 7.2 million worms per acre.

Brad McIntyre farm. Caldwell Id. April 29, 2014

More types of seeds more stable is the mix

Nurture Nature with System Synergies

No Tillage

Minimum carbon loss

Cover Crops

Maximum carbon input

Carbon management

Sustainability

Dr. Don Reicosky

Questions to ask when planning cover crops with a producer

1. What are the Goals/Concerns?
2. What are the environmental (climate, rainfall, frost, growing season) considerations?
3. What is the timeframe?
4. What is the budget?

Main Reason – Soil Erosion

Suppress Weeds

Spring 2008 Weed Suppression (ND)

What are your goals/resource concerns? Generally speaking….

1. The more specific your goals/concerns, the less diverse your mixes will typically be

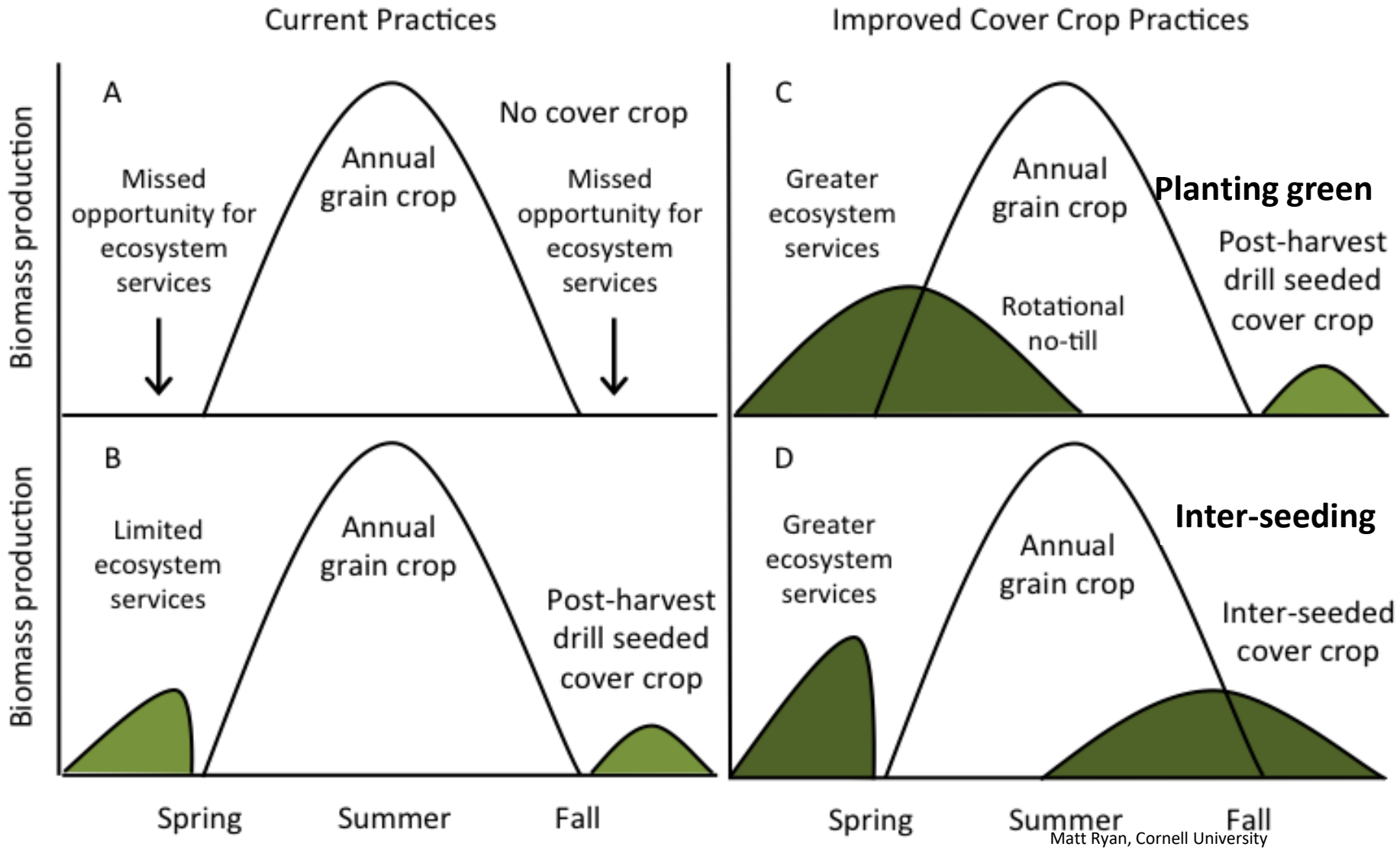
2. The tighter your planting windows, the fewer species will work and thus the less diverse your mixes will be

3. Minimum of 6 to 8 weeks of growth necessary to achieve most benefits

What is your timeframe?

1. Spring - fallow ground / prevent plant or prior to a summer crop
2. Early Summer - Right after small grain hay harvest
3. Late Summer – Delay after wheat harvest
4. Fall - After fall crops (over winter cc)

Cover crops niches for summer annual crops



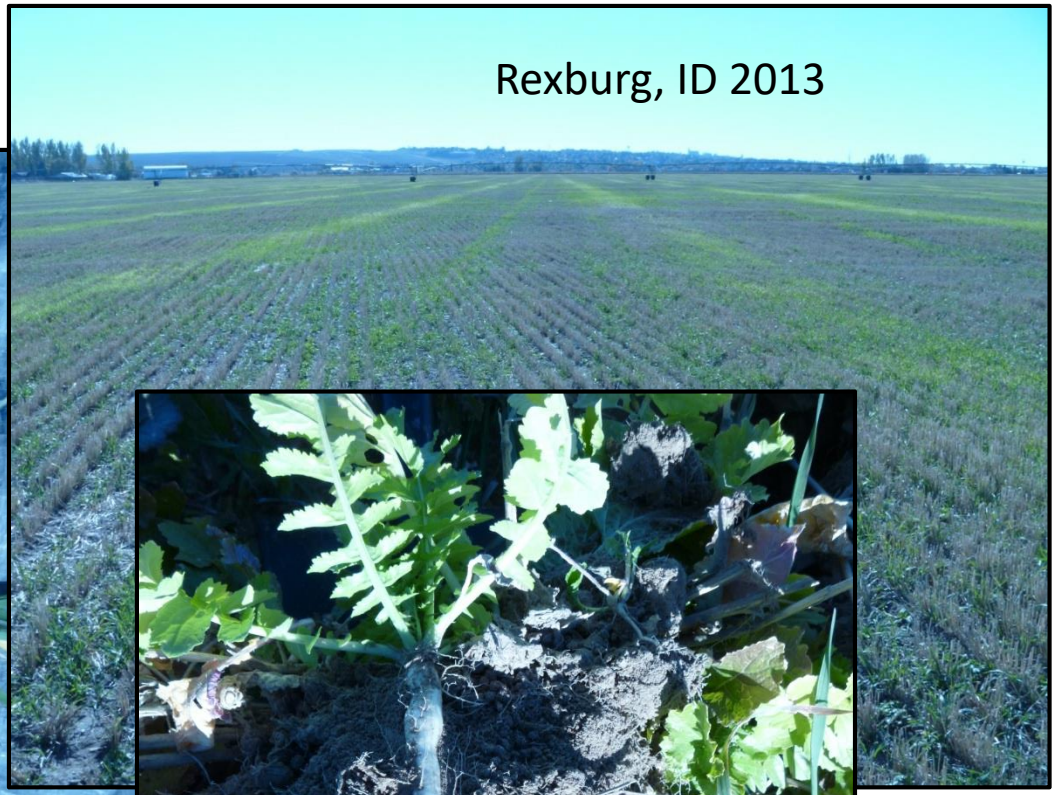
Matt Ryan, Cornell University

Cover Crop Termination Methods

- Frost termination
- Crimper / Roller (mature enough to kink the stem)
- Herbicide burn down
- Grazing
- Shredding / mowing
- Organic methods (propane flame)
- Combination of methods

Cover Crop Tips

- Use species that are adaptable to your environment
- Adjust species composition to season of use
- Diversity (speeds up biological time)
- Be aware of herbicide residuals
- Check with crop insurance eligibility
- Don’t use a species in the mix if you are planning to seed it in that field next year
- If grass finishing, do not allow any grains to set seed
- “It can’t grow in the bin, when in doubt seed it”! (G. Brown)


Rexburg, ID 2013

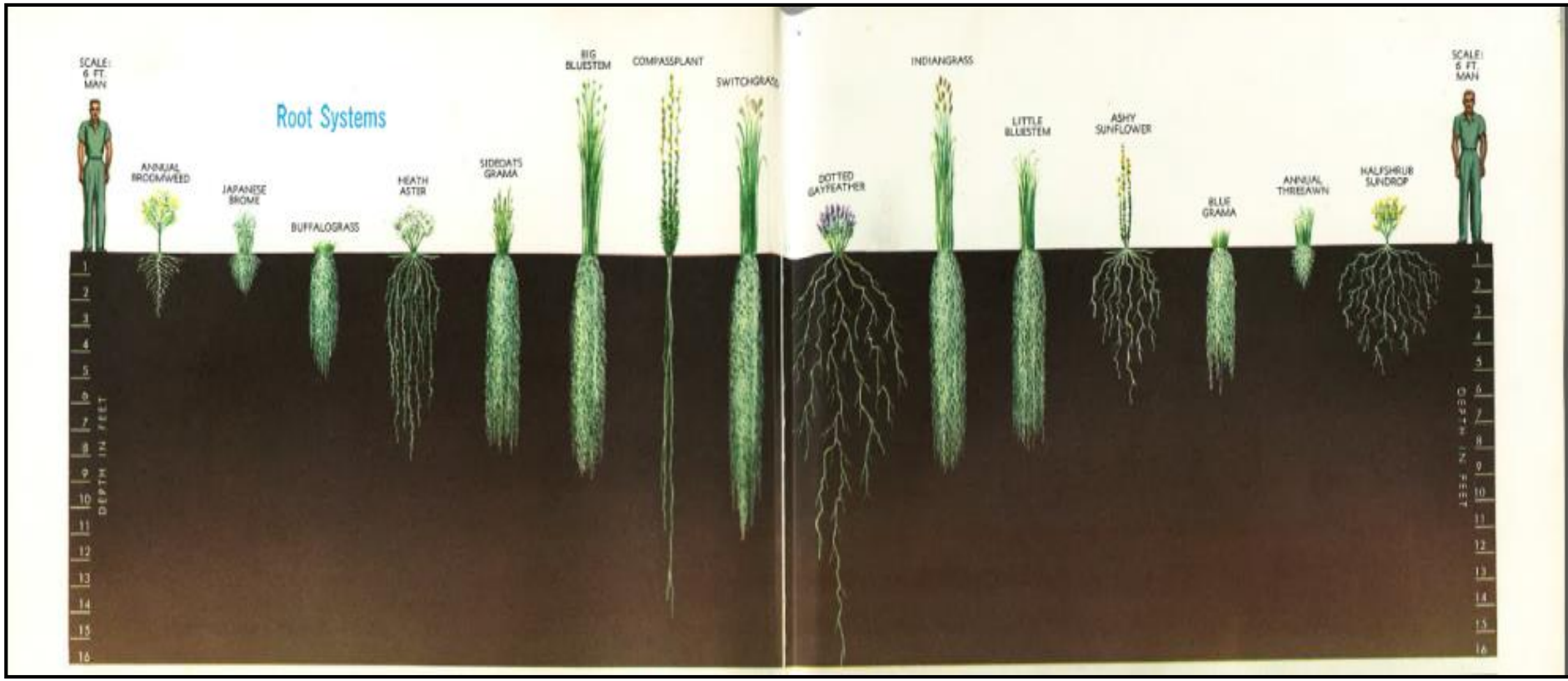
Diversify!

- Hard to improve Soil Health if there is no diversity of crop types.
- Need to add species diversity.

Grace, Id 2014 8 way cover mix

Diversity in Root Systems

- Diversity in root systems = diversity in soil biota



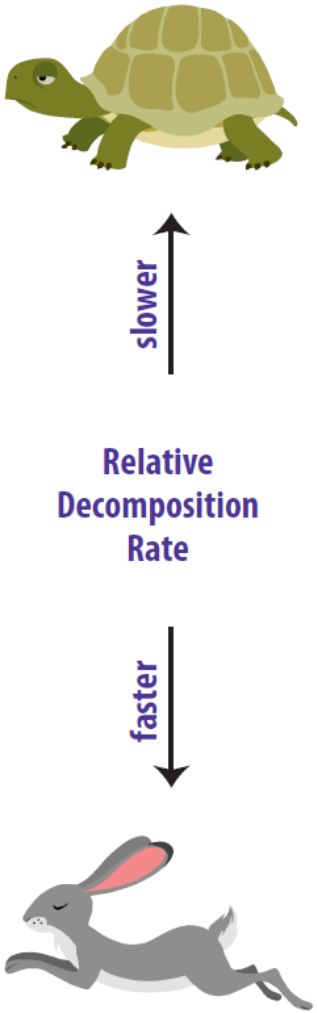
Soil Moisture Management

Grazed cover crop
Sundance, WY 2018

- Increase Infiltration
- Reduce Evaporation
- Remove Excess Moisture
- Terminate while cover crop is vegetative (before peak water use occurs)
- Six weeks of growth to achieve “rotation effect”

C:N Ratio for Various Crops (Nutrient Cycling)

Material	C:N Ratio
rye straw	82:1
wheat straw	80:1
oat straw	70:1
corn stover	57:1
rye cover crop (anthesis)	37:1
pea straw	29:1
rye cover crop (vegetative)	26:1
mature alfalfa hay	25:1
Ideal Microbial Diet	**24:1**
rotted barnyard manure	20:1
legume hay	17:1
beef manure	17:1
young alfalfa hay	13:1
hairy vetch cover crop	11:1
soil microbes (average)	8:1



Rye
- •High C:N
- •Ties up N
- •Compounds problem following another high C:N crop

Hairy Vetch
- •Low C:N
- •Release lots of N
- •Decomposes Fast

Rye & Hairy Vetch Mix
- •Balance C:N ratio
- •Control decomposition
- •Ideal cover crop mix

Get 4 Things Right

1. **The Right Species**
2. **The Right Inoculants**
3. **The Right Seeding Rates**
4. **The Right Seeding Time**

Do you know your cover crops?

- Cool Season Grasses?
- Warm Season Grasses?
- Cool Season Broadleaf's (legumes, brassicas)?
- Warm Season Broadleaf (legumes, non-legumes)?
- Perennial, Biannual, Annual?
- Tap root?
- Fibrous root?
- C:N Ratios?
- Growing season for each group/species (frost sensitivity)?
- Diversity?
- Moisture Use?
- Other Considerations?

USDA United States Department of Agriculture
USDA-ARS Northern Great Plains Research Laboratory

Cover Crop Chart

AREA 4 SCD Cooperative Research Farm

GROWTH CYCLE	PLANT ARCHITECTURE	RELATIVE WATER USE
A = Annual	♈ = Upright	= Low
B = Biennial	✱ = Upright-Spreading	= Medium
P = Perennial	≈ = Prostrate	= High

COOL — WARM

-- GRASS --	BROADLEAF								LEGUME				-- GRASS --
A BARLEY ♈										A AMARANTH ♈	A FOXTAIL MILLET ♈
A OAT ♈	A/B CANOLA ✱	A/B CAMELINA ♈								A BUCKWHEAT ♈	A PEARL MILLET ♈
A WHEAT ♈	A/P MUSTARD ✱	A PHACELIA ♈	A FIELD PEA ✱	A BERSEEM CLOVER ♈	A/B VETCH ≈	A COWPEA ✱	A CLUSTER BEAN ♈			A QUINOA ♈	A PROSO MILLET ♈
A CEREAL RYE ♈	A RADISH ✱	A FLAX ♈	A LENTIL ✱	A CRIMSON CLOVER ♈	P BIRDSFOOT TREFOIL ≈	A/P FENUGREEK ♈	A SUNNHEMP ♈			P CHICORY ✱	A GRAIN SORGHUM ♈
A TRITICALE ♈	B TURNIP ✱	A KALE ✱	A LUPIN ♈	B/P RED CLOVER ♈	A/B SWEET CLOVER ♈	P PIGEONPEA ✱	A MUNG BEAN ✱			A CUCURBITA ≈	A SUDAN GRASS ♈
A ANNUAL FESCUE ♈	B BEET ✱	A SPINACH ✱	A/P MEDIC ✱	P WHITE CLOVER ≈ ♈	P SAINFOIN ♈	A CHICKPEA ✱	A SOYBEAN ✱			A SAFFLOWER ♈	A TEFF ♈
P SALINE TOLERANT ♈	A/B CARROT ✱	A/B CHARD ✱	P ROUNDHEAD LESPEDEZA ♈	P KURA CLOVER ≈	P ALFALFA ♈	A FAVA BEAN ♈	A/P PEANUT ✱ ≈			A SUNFLOWER ♈	A CORN ♈

V 2.1. January 2016

◈ *Additional Information*

Cover Crop Chart
USDA-ARS NGPRL

Cover Crop Periodic Table, Wyoming NRCS Soil Health

Cool Season

Warm Season

Broadleaf

Legumes

Grass	Brassica	Broadleaf	Legumes		Broadleaf	Grass
Italian Ryegrass	Camalina					Teff
Annual Ryegrass	African Cabbage					Browntop Millet
Black Oat	Hybrid Brassicas					German Millet
Cereal Rye	Kale	Phacelia	Ladino Clover	Balansa Clover	Sunn Hemp	Chicory	Foxtail Millet
Winter Triticale	Rapeseed	Plantain	Alsike Clover	Arrow leaf Clover	Guar	Pollinator Mix	Proso Millet
Spring Triticale	Turnips	Pollinator Plants	Alfalfa	Red Clover	Mungbean	Buckwheat	Japanese Millet
Oat	Hybrid Turnips	Flax	Sweet Clover	Persian Clover	Cowpea	Safflower	Pearl Millet
Forage Oat	Forage Collards	Beets	Berseem Clover	Crimson Clover	Soybean	Sunflower	Sudangrass
Winter Wheat	Canola		Winter Lentil	Spring Lentil		Okra	Sorghum Sudan
Spring Wheat	Broadleaf Mustard		Hariy Vetch	Woolypod Vetch		Melons & Squash	Forage Sorghum
Spring Forage Barley	Mustard		Common Vetch	Winter Pea			Egyptian Wheat
Winter Barley	Radish		Spring Pea	Chickpea			Grain Sorghum
Beardless: Triticale, Barley, Wheat	Oil Seed Radish		Chickling Vetch	Faba Bean			BMR Grazing types
							Corn

Cover crops listed from smallest seed to largest in columns. (many seeds are very similar like brassica family)

Not an all-inclusive list, but should provide the producer with alternatives to develop cover crop mixes.

Cool Season Grasses

- Annual Ryegrass
- Cereal Rye
- Barley
- Oats
- Winter Wheat
- Triticale

Spring Oats planted

Cereal Rye

Photos: Michael Kucera & Jodie Reisner

Warm Season Grasses

- Pearl Millet
- Sorghum-Sudan grass
- Grazing corn

Brown rib sorghum - sudan grass

Pearl Millet

Photos: Michael Kucera & Jodie Reisner

Cool Season Broadleaf

- Oilseed Radish
- Turnip
- Kale and Collards

Radish

Impact Forage Collard

Photos: Michael Kucera & Jodie Reisner

Warm Season Broadleaves

- Buckwheat (NRCS planning restrictions)
- Safflower
- Sunflower

Cool Season Legumes

- Hairy Vetch
- Crimson Clover
- Winter Pea

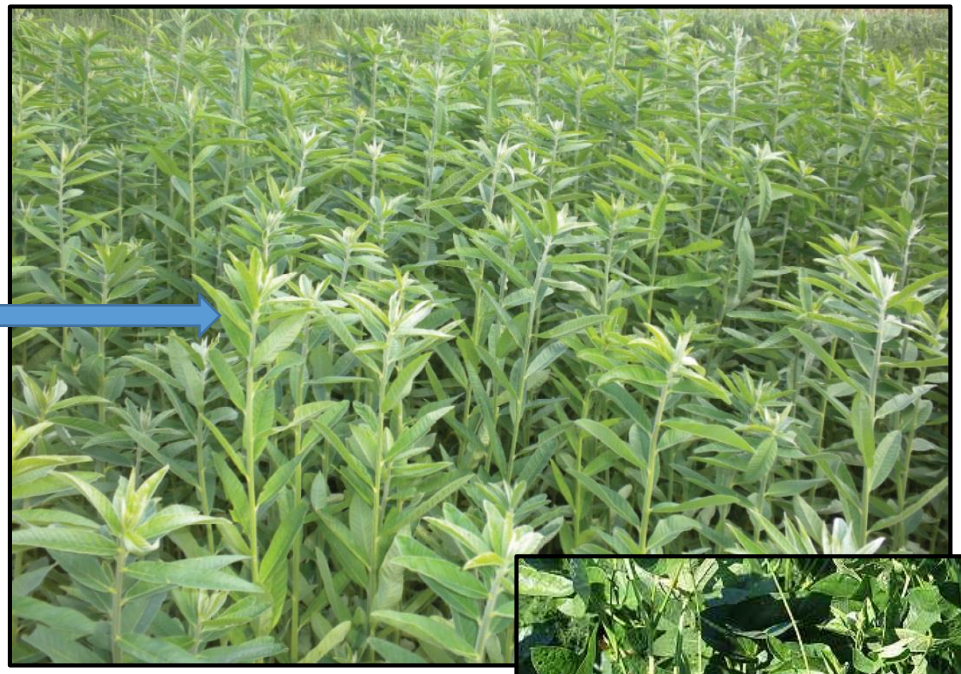
Hairy Vetch
Crimson Clover

Hairy or Woollypod Vetch

Balansa Clover

Warm Season Legumes

- Cowpea
- Soybean
- Sunn hemp
- Chickpea
- Mungbean



cowpea

Cover Crop Herbicide Restrictions

- Forage and grain (food chain)
  - Herbicide must be labeled for all crops
  - Rotation/plant back restrictions
  - Forage restrictions (grazing, haying)
- Cover only (soil building or erosion)
  - At your own risk (some labels lack info)
  - Review labels/experience
  - Climate & soils (biological activity)

Read Herbicide Labels Thoroughly

- “Cover crops for soil building or erosion control may be planted any time, but do not graze or harvest for food or feed. Stand reductions may occur in some areas”.

Example cool & warm season Biological Primer mixes

Cool Season Cover crop	**PLS/acre**
Barely	8
Oat	5
Lentil or Vetch	2
Pea	15
Clover, Crimson	1
Radish	1
Rape	1
Turnip	1
Total	34 Lbs

Warm Season cover Crop	**PLS/acre**
Pearl Millet	3
Sudangrass	4
Buckwheat	3
Safflower	2
Radish	1
Turnip	1
Canola	1
Spring Lentil	2
Pea	15
Crimson Clover	1
Total	33 Lbs

Cover Crop Seeding Rates

- Seeding rates variable depending on location, goals, and objectives
- Consider economics of seeding mixes and consider return on investment
- Examples: Idaho 30-40 PLS for irrigated cropland
- Kansas dryland 750K seeds/ac
- Indiana 12 live plants per/sq. ft.
- Based on your local knowledge and experience
- Legumes $$$$$$

2014 Cover Crop Mix: (J. Fuhrer 2016) warm season /cool season mix

#/acre	Species
5	Super sweetsorg / sudan
5	BMR grazing corn
3	Soybean
1	Cowpea
1	Mung bean
2	Forage collards
1	Hunter turnips
1	Wildlife grain sorghum
1	German millet
1	Berseem Clover, Crimson Clover, Arrowleaf Clover
1	Sunflower
1	Buckwheat, Oats, Safflower

Total 23 lbs Cost $27.00/ acre

YouTube grazing cover crops PNW

GFE 2016 - Gabe Brown "Cover Crops for Grazing"

YouTube ada county conservation district

Saving Our Soil: Mob grazing and No-till in Furrow Irrigation

You Tube: Jerry Doan Utah

Grazed Cover Cropping--Drew Leitch

Local examples of producers implementing cover crops

- Soil health principles are universal, how you implement them in your operation is unique!
- Each operation is unique and their approach to cover crops may be different.

Grazed cover crop, residue from previous year. Grace, ID

Arlen Gentert, (farm manager)
Winecup Gamble Ranch,
Montello, NV

Implementing
5 Principles of Soil Health

Southeast, Rolling multi species over crops and planting the same day

Photosynthesis 365 day

J. Raybould – St. Anthony ID
Planted 9/7/12
40 DAP = Oct 17

2014 St. Anthony

McIntyre Farms: Caldwell, Id 2013

Cover crop mix:
-Radish
-Turnip
-Sudan grass
-Millet
-Buckwheat
-Oats
-Soybean
-Rape
-Vol. wheat

- Planted: 8/10/2013
- No-Till Drilled into wheat stubble
- Grazed Oct. 17, 2013,
  End grazed: Dec 17, 2013
- Grazed for 61 days
  Biomass: 13,684 lbs DM/ ac
  23.1 % DM

- 300 head of wild mother cows
- 3 acres per day
- Stock density: ~106,000 lbs / acre
- Previous crop: Irrigated winter wheat
- Planned crop:
- 2014 Irrigated grain corn -274 bu /ac
  - Idaho no-till record
- 2015 spring peas

Cover Crop Feed and Forage Report

Menoken Farm – Jay Fuhrer

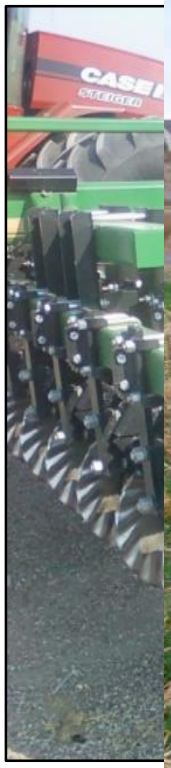
19-Sep-16

Species	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%

6 way mix: wheat, turnip. radish, soybean, cowpea, sudan grass

Planted: July 25, 2012

Marsing, ID
Deruyter dairy & McIntyre Farms



Oct 31, 2012


Tex Creek, Wildlife mgt area,
Idaho Dept of Fish & Game Idaho Falls, Id
13 way cover crop mix – Great plains no-till drill
Improve forage diversity for wildlife

Terminating cover crops and planting in one pass









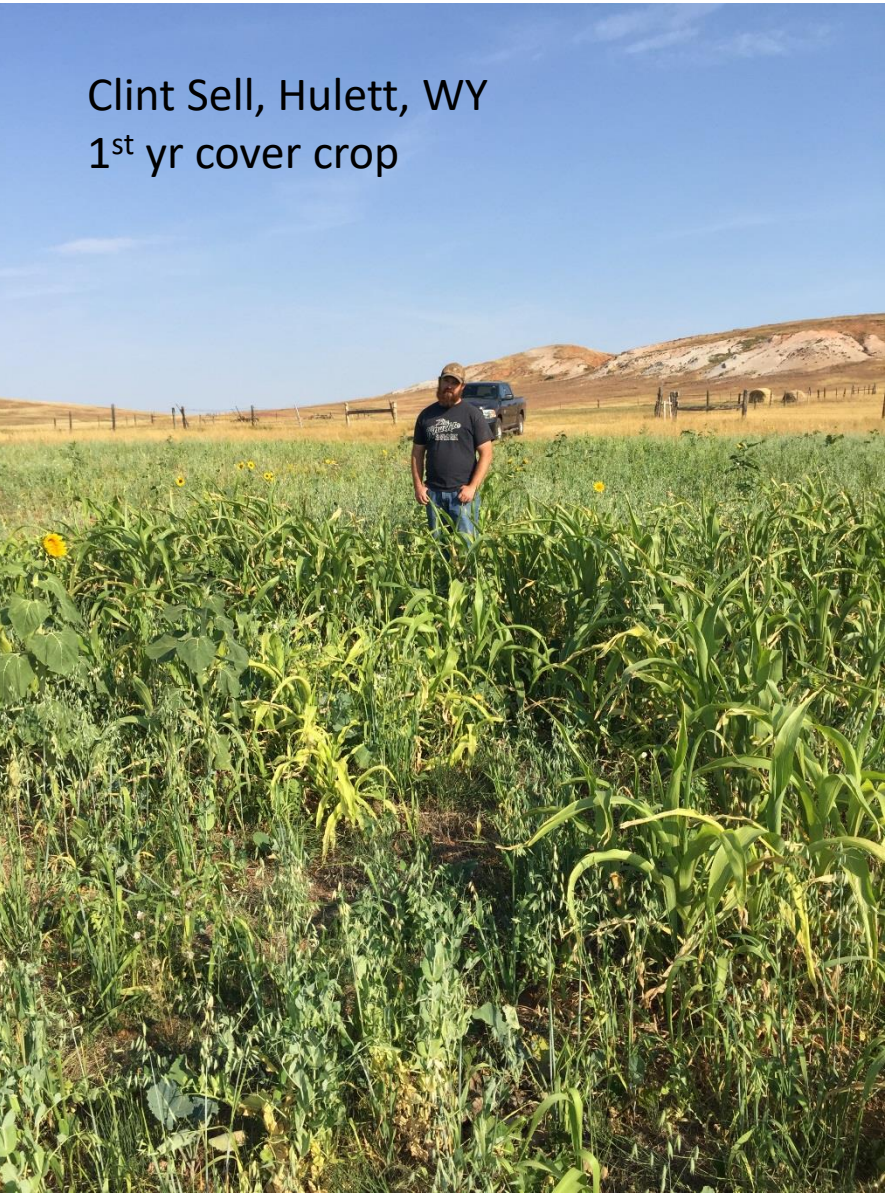

Sundance, WY, hayfield / soil regeneration

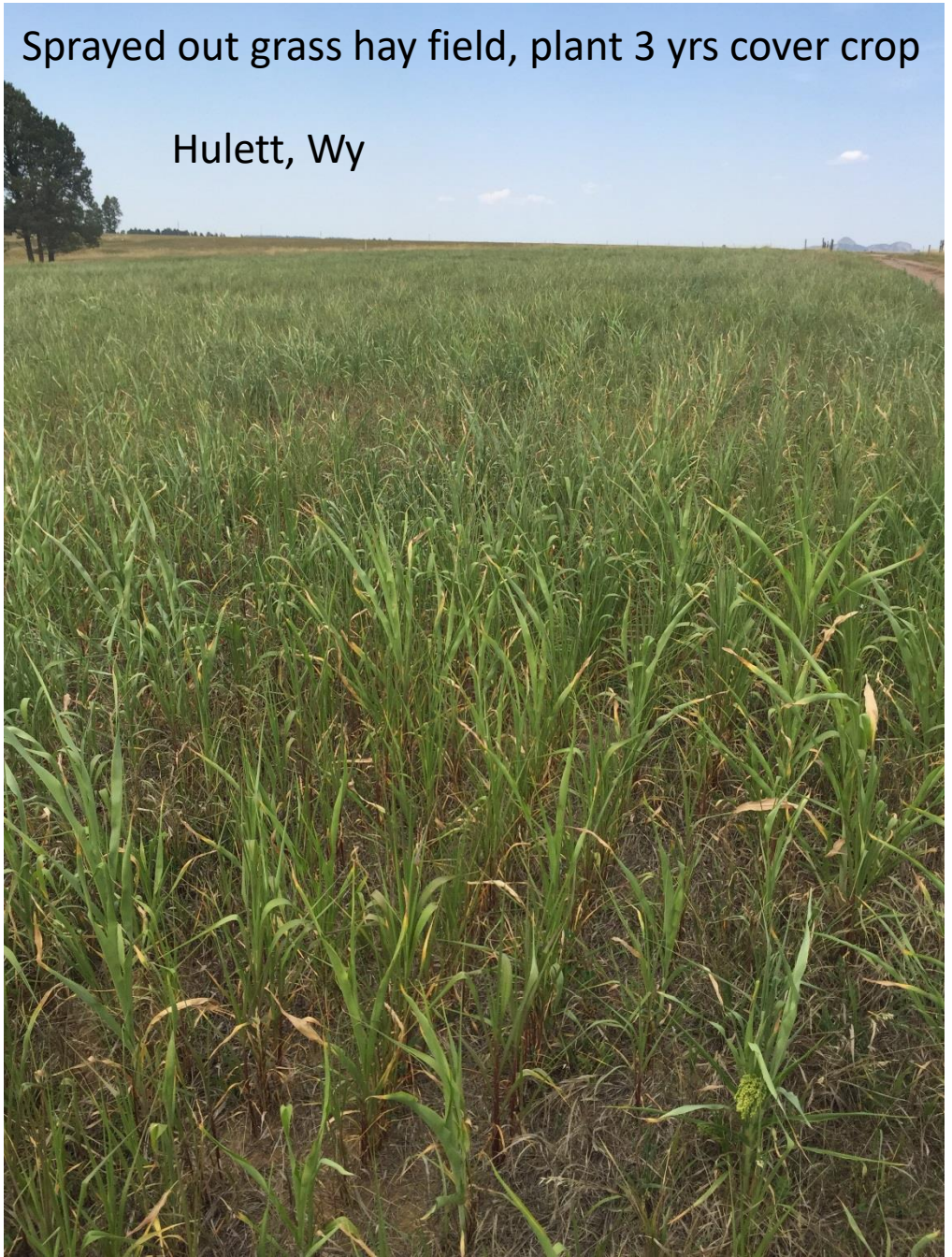
Regenerating 250 acres of dryland hay 16” rainfall
10 way warm season cover crop mix / winter grazing
No till drill
Weed sprayer
Sold hay equipment


Cover crop field day,
Gillette WY

USDA

United States Department of Agriculture






Casper radish
compaction


Hulett, winter CC in brome hay
Spray and plant


Wheatland, w , CC mix

Bailey Rapp discussing a multi-species cover crop mix with Marlon Winger


Pocatello


Pocatello


Marsing, Teff in the mix

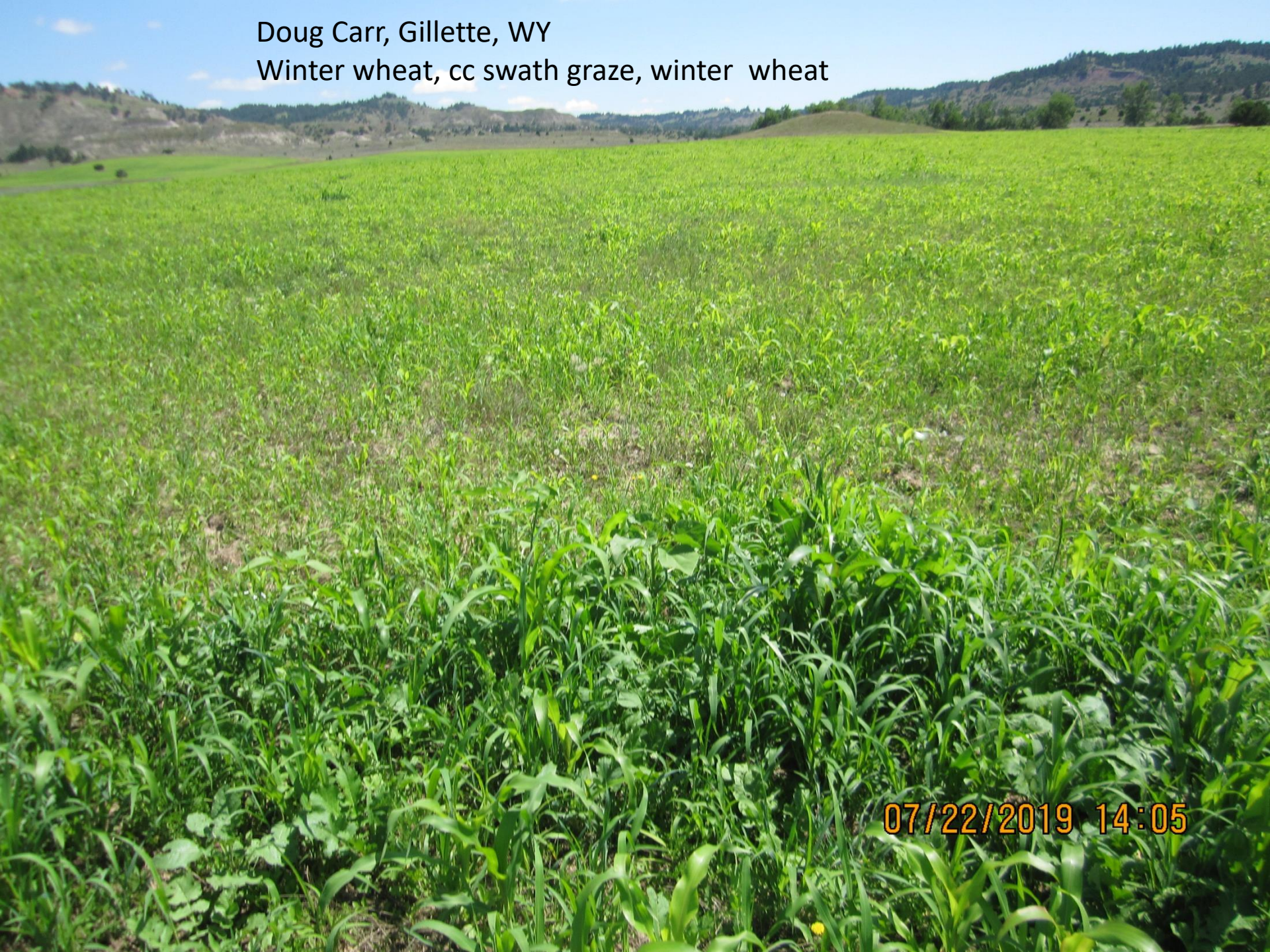

Soda
Springs

3. Maximizing the diversity of plants in the crop rotation/ cover crops

10 way cover crop mix, following 3 way winter grain mix cut for hay
Cameron Williams, Grace, Idaho

J. Clapperton. "Every type of plant exudes substances from its roots that attract specific microorganisms. The more diverse the community, the more extensive will be its services".

Radish only, low C:N ratio


Doug Carr, Gillette, WY
Winter wheat, cc swath graze, winter wheat
07/22/2019 14:05

USDA United States Department of Agriculture

Cover Crop Planning Tools

- Cover Crop 340 Practice Standard – *example Idaho 340 job sheet*
- Midwest Cover Crop Council http://www.mccc.msu.edu/index.htm
- Resources and Publications http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/resource/
- MO Extension Bulletin: G4161 Cover Crops in Missouri
- Sustainable Agriculture Research & Education (SARE)
  - Online Book and Topic Room on Cover Crops
- Cover Crops for Sustainable Crop Rotation and Soil Health and the SARE cover crops topic room at http://www.sare.org/Learning-Center/Topic-Rooms/Cover-Crops
- No Till Farmer Pulses and Minuses
- Various industry cover crop calculators

Lets make a mix

- ..\National Standards\340 cover crop\2015 340\Cover crop job sheet 2015.xlsm
- **Build your own mix**

105 cover crops in plots, Bladen NE

- **Cover crop companies – good resources**
- When and how is it planted/ when and how is it terminated?
- Where does it fit in the crop rotation
- What resource concerns does it address