Efficacy of Compost in Irrigated Pasture for Yield and Soil Health

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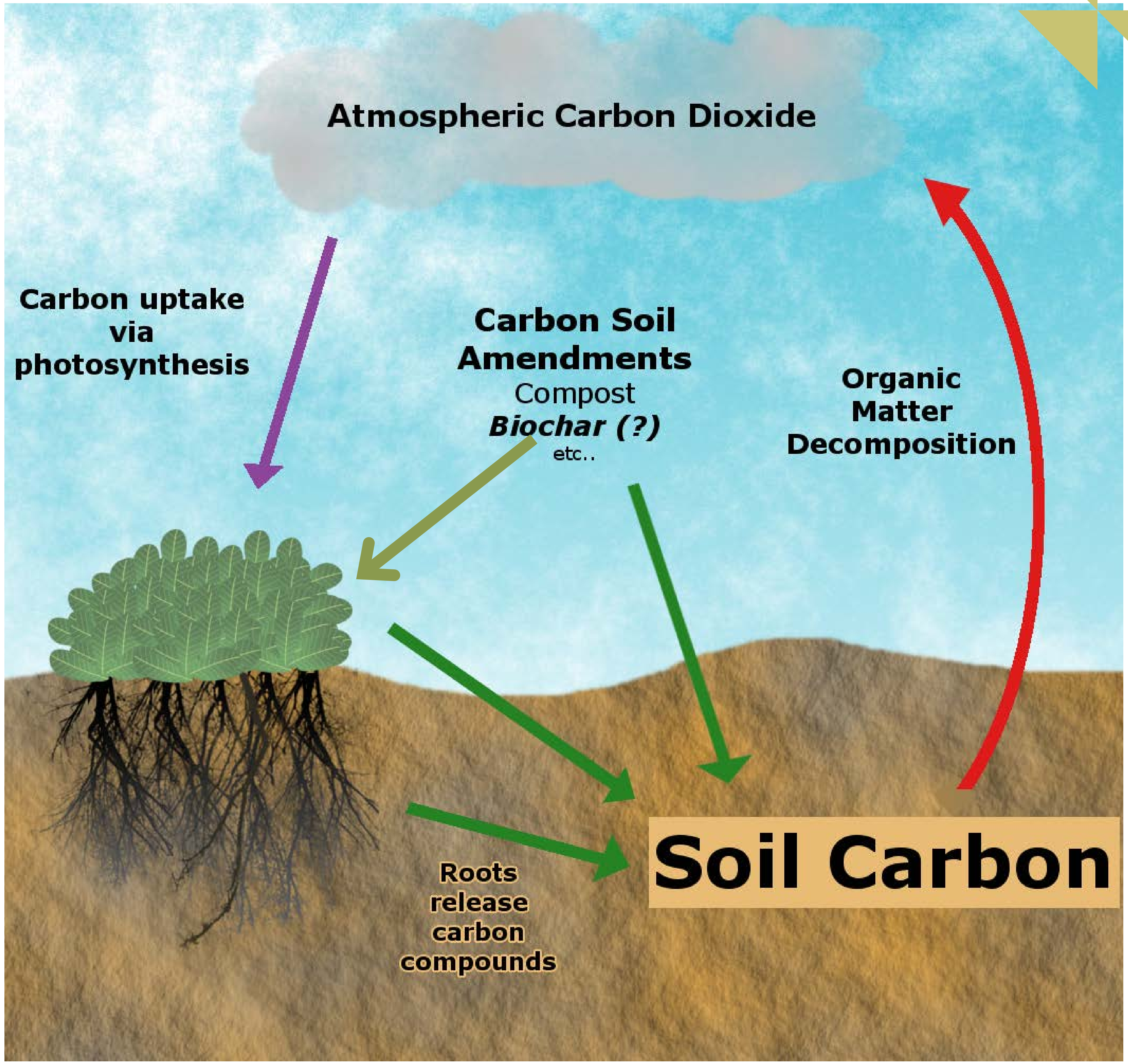
Why Compost?

People already doing it and seeing good results

- Nitrous oxide - Emissions reduction
- Food waste
- Carbon sequestration in CA studies
- Scalability: where and under what circumstances does compost add to soil C or other goals.
- Trade offs in how treatments impact C cycling in deep horizons

How Would Compost Increase Soil Carbon?

- Main pathway: Production (Yield) > Inputs to soil > Inputs exceed respiration
- Compost > Increase production (Yield) OR increase efficiency of soil organic conversion
- Compost needs to increase soil C over and above the raw addition of C in compost to be a net gain.



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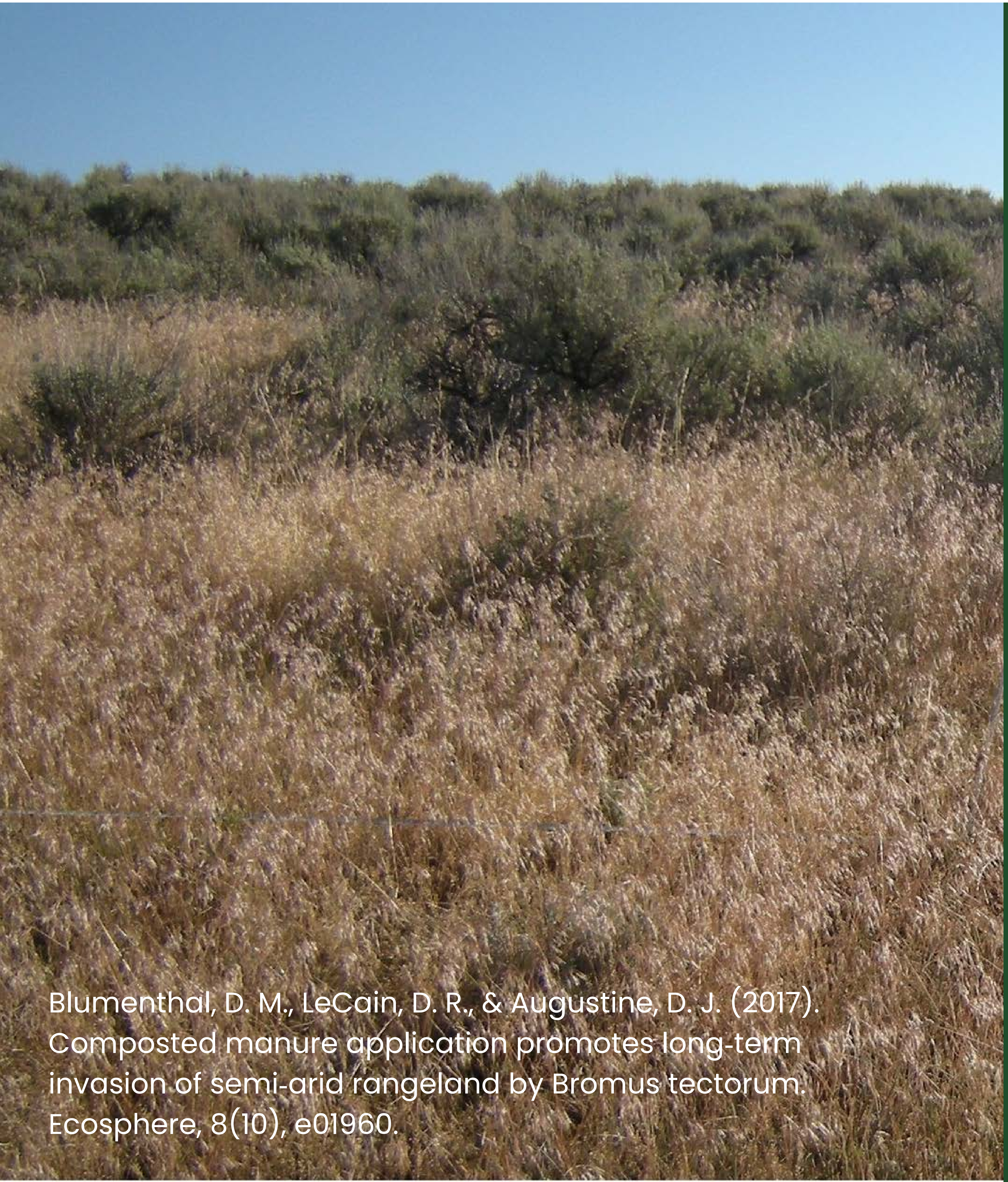


Blumenthal, D. M., LeCain, D. R., & Augustine, D. J. (2017). Composted manure application promotes long-term invasion of semi-arid rangeland by Bromus tectorum. Ecosphere, 8(10), e01960.

Risks of Compost

- Annuals more are more effective at using nutrients
- Most annuals in our region are undesirable
- Nutrients beyond N can benefit annuals such as cheatgrass (Phosphorus) (Blumenthal et al. 2017)
- CA studies done in an annual grassland where this would be less of a risk
- Compost can increased respiration (Ryals et al. 2014)

Project Goals

Test the efficacy of a 1-time compost application to..

- Increase grass productivity.
    - Collected 2021, 2022, 2023

- Sequester carbon and increase soil organic matter.
    - Collected 2022 & 2023

- To alter species composition.
    - Collected 2021 & 2023

What We Are Looking For

How effective is a 1-time application of compost to increase soil organic matter, and enhance plant growth compared to fertilizer?

- If effective, we would see an increase in above-ground production (yield) and below ground soil organic matter and soil C
- If effective, we would see no adverse impacts from compost use compared to fertilizer or doing nothing.

What We Did

2020	2021	2022	2023
Tested compost sources; picked a source; sampled soils for application rates	Applied compost & treatments; collected biomass & species data; tested soils for end-of-season N	Split plot design; collected soils data; will collect yield data	Collect soils data; analyze results; develop recommenda tions

Timeline

Treatments Applied

Control
(nothing)

Compost

Fertilizer

Compost +
Fertilizer

Equal Available N

Compost Criteria

- Compost quality was of concern to our stakeholder group
  - Salts
  - Fungi: Bacteria ratio
  - Moderate C:N ratio
- Tested 4 commercial scale composts for NPK, salts, and fungi:bacteria ratio
- Selected compost
  - C:N = 18 (C:N 10 – 20less plant available N short-term, but could supply longer-term(slow-release)
  - Salts: 25 mmhos/cm
  - Highest Fungal:Bacterial Ratio

Treatment Ammendments - NPK

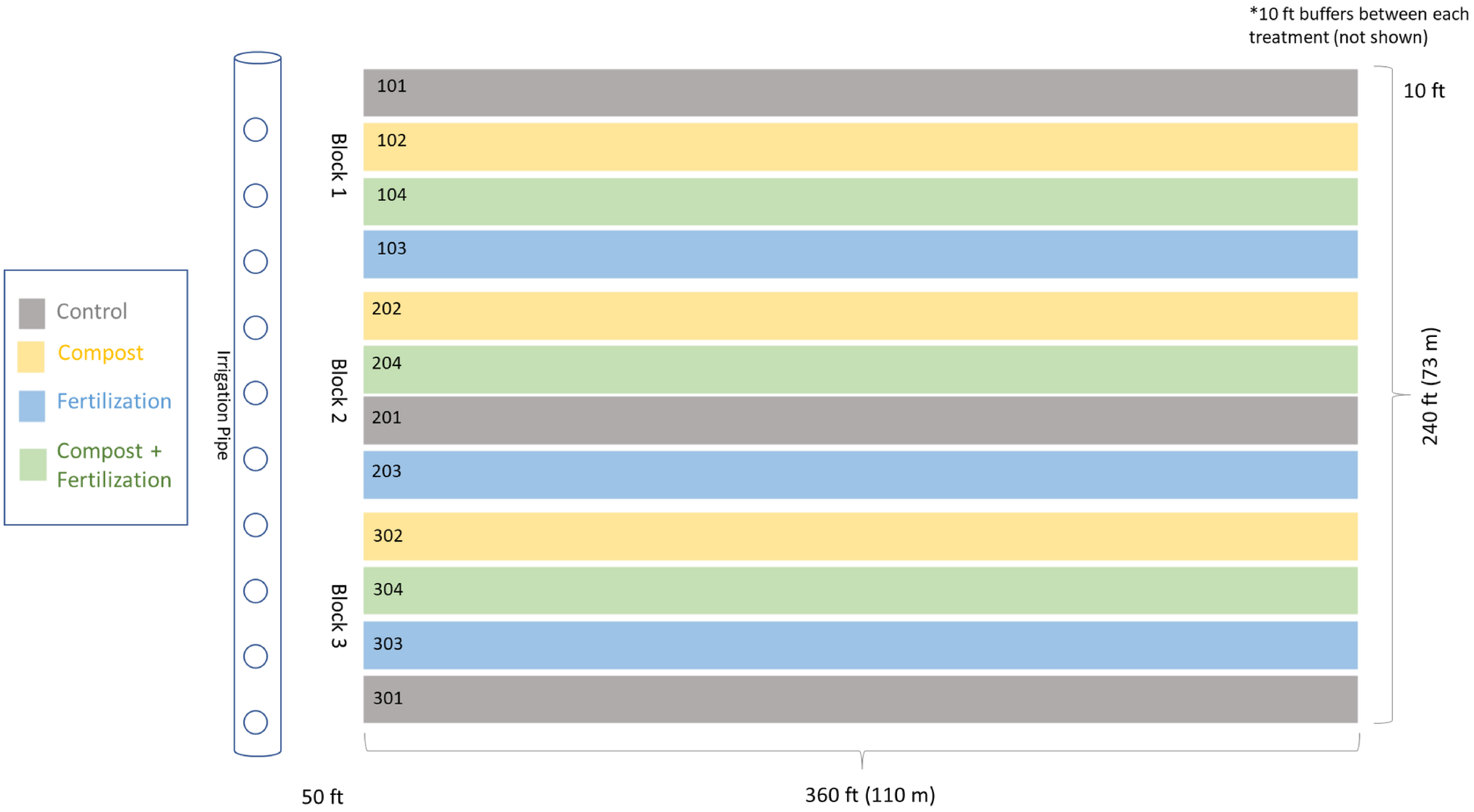
Site	Treatment	Compost Mass (tons/acre)	Compost-C (tons/acre)	Compost-N (lbs/acre)	Fert-N (lbs/acre)	P (lbs/acre)	K (lbs/acre)
Ridgeway	Compost	18.8	4.69	90	---	347	628
Fruita	Compost	10.4	2.60	50	---	193	349
Ridgeway	Fert+Compost	6	1.50	28.8	61.2	111	201
Fruita	Fert+Compost	6	1.50	28.8	21.2	111	201
Ridgeway	Fert	0	---	---	90	50	---
Fruita	Fert	0	---	---	50	40	40

- Compost Amendments first optimized for forage N requirements (accounted for existing soil N, , **assumes 20% of org N is 'plant available in Yr1**)
- Compost P & K concentrations exceeded forage requirement

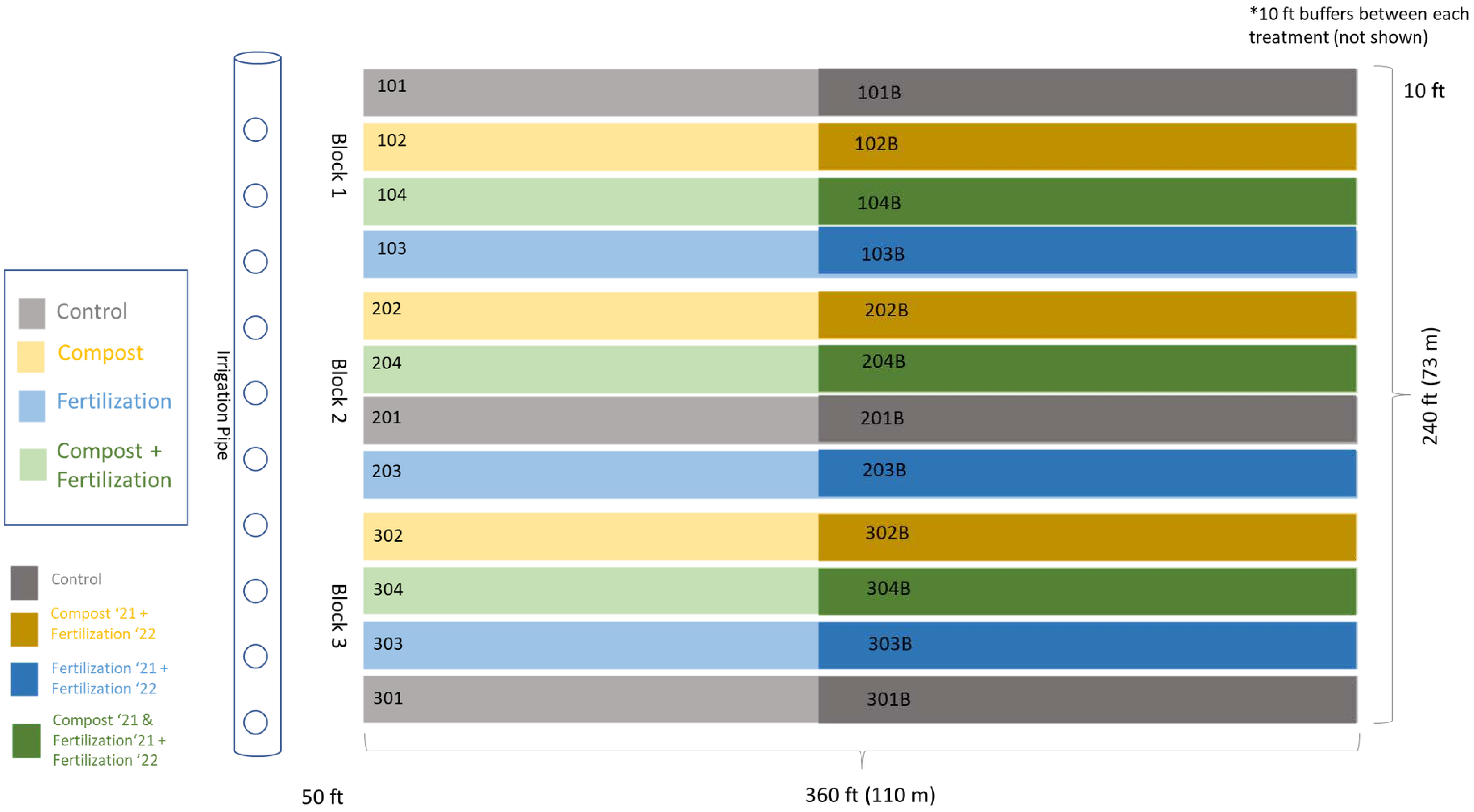
Calibration

- Used drop seeder
- Calibrated weights by driving over a tarp of known area, then weighing it.

Plot Layout - 2021



Plot Layout - 2022



Experimental Design

Compost Only x 3 @ 2 Sites | Compost + Fertilizer 3 @ 2 Sites | Fertilizer Only 3 @ 2 Sites | Control x3 @ 2 Sites

Data Collection

Clip biomass & collect spp. before each cutting

June/ July '21 & '22

Collect soils data

March/ April '22 & '23

Analyze Soils in Lab

'22 & '23

Collect Spp. Composition data

June/ July '21 & '23

What Happened?

How Would Compost Increase Soil Carbon?

- Main pathway: Production > Inputs to soil > Inputs exceed respiration
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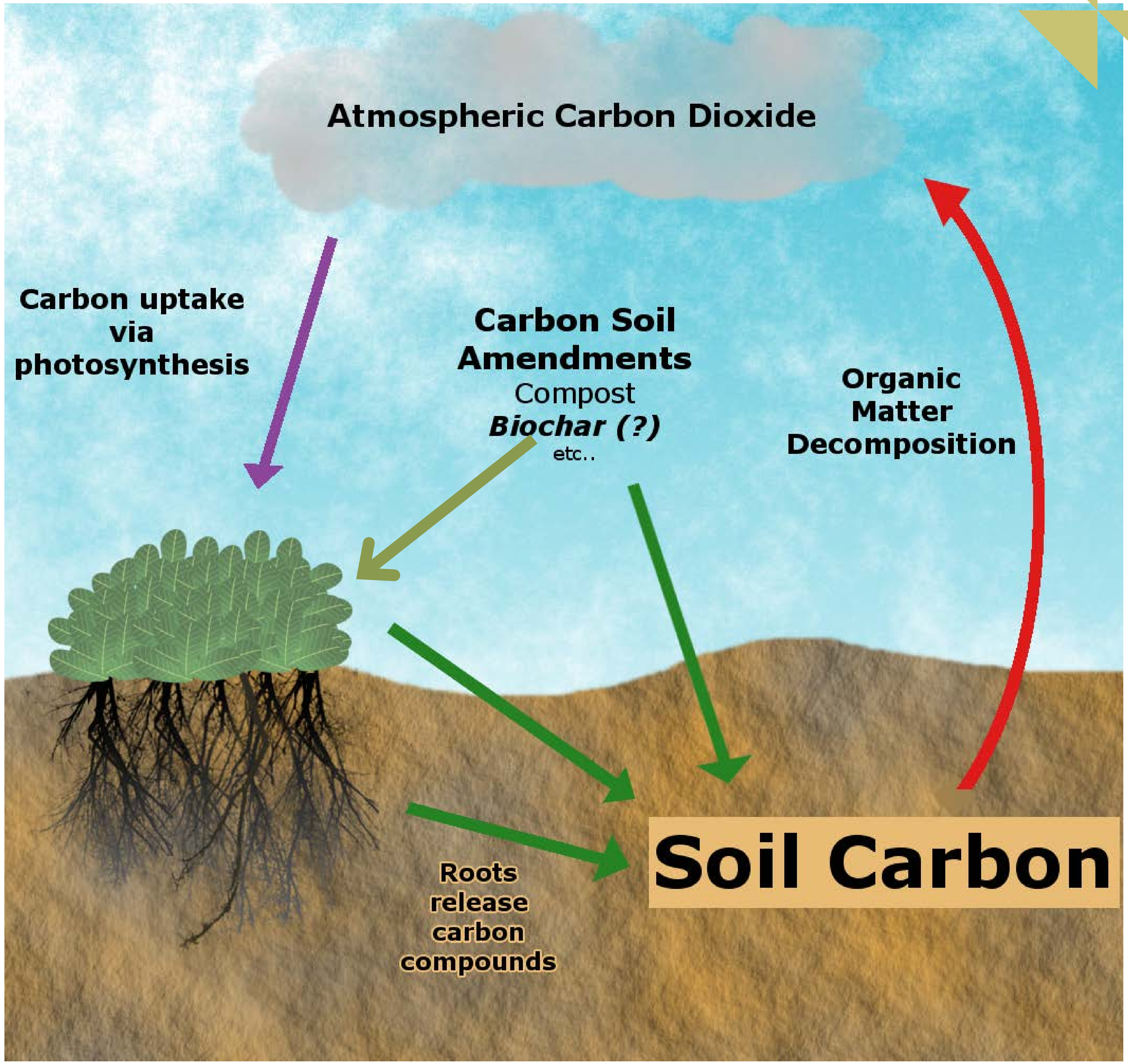

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Results - Grass Yield

- Compost plots were less productive ($p = 0.008$; 1,585+458) compared to fertilized plots and were not different than controls (i.e., untreated).

Results - Grass Yield

Lag Effects?

- Any negative effect from compost was not apparent in Yr2 (no differences among plots treated differently in Yr1 in Yr2).
- Plots where fert. applied in Yr2 were significantly more productive than non fertilized plots ($p = 0.001745$), but there was no difference among treatments from Yr1

Why? What Happened to the N in the compost?

Where did the N go?

- Lost to atmosphere
- Still there - not enough time for the microbes to break down the compost to make it available to plants
- Did microbes use N in compost to digest the carbon? C:N Ratio should have been adequate
- Review of 44 studies, Yield was not different in compost versus control in 50% of studies (Kutos et al. 2023).

SOC and Soil Health Results

Results - SOC Stocks

- A 1-time application of compost did not increase SOC Stocks. No difference among treatments at any horizon sampled.
- No treatment effects on total nitrogen stocks.
- Compost did not increase soil salinity. (No treatment effects on soil salinity).

Results - Soil Health Metrics

- Carbon (TC, SIC, SOC)
- Nitrogen (NH4, NO3, TON)
- Phosphorus (Olsen P)
- POX-C (proxy for microbial/active carbon)
- Water holding capacity
- Beta-glucosidase (Microbial extracellular enzyme)
- PH
- Soil Respiration
- Water Stable Aggregates
- CEC (Cation Exchange Capacity)
- Salts

Results - Soil Health Metrics

No difference among treatments in soil health metrics analyzed.

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- Nitrogen (NH4, NO3, TON)
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Why didn't we see significant treatment effects on soil health metrics?

- N in compost not available to plants
- Building SOC and soil health metricstakes time.
- Soils are spatially heterogenous which makes change hard to detect.
- Despite higher yield in fert plots, SOC was not greater in these plots.

Plant Species Composition Results

Species Composition

- There were no difference in the proportion of exotic species pre and post treatment across sites.

Other

- Orchardgrass increased overall except on fertilized plots (weak sig.)

How does this compare to other studies?

Study Comparison - SOC

Study	Was there an increase in SOC?	Amount applied	How long did it take?	Location of Study
Mclelland et al. 2022	Yes, in top 10 cm	4.9 T/Ac in Irr. Pasture ('12, '18) (109 N lb/acre)	Observed after 8 yrs	Northern Front Range, CO
Kutos et al. 2023	15 studies = No; 22 studies = Yes, difference between compost/ control = 59%	Various	Various, ranges from 1 yr to 5 yr	Various
Mikha et al. 2017	No	9.8 T/Acre and 4.9 T/Acre	2 years	Northern CO
Ryals et al. 2014	Yes	7 kg/m2 or 28 T/Acre; C:N 11	Observed after 3 yrs	California; various sites

Take homes

Should I use compost in my operation?

- Real question is for what – what is your goal and your context?
  - Consider costs/ benefits and risks of the practice

- Key take-homes
  - N demands of your crop
  - Timing of application
  - Incorporation
  - As part of crop rotation to reduce N use

Conclusions

- We did not we did not detect differences among treatments in SOC, and soil health metrics, and yield was not higher in compost-applied plots. However, salts were not an issue despite high application rates.
- Change is slow
- Think mechanism when considering new practices! I.e., how does C get into the soil, and how does the proposed treatment influence that?

Thank you & GO TEAM

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Thank You!

Please take my evaluation
And talk to Analissa if you are interested in targeted grazing on specialty crops

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Economic Considerations

Site	Treatment	Compost Added (tons/acre)	Compost (lbsN/acre)	MAP (lbsN/acre)	Urea (lbsN/acre)	Compost ($/acre)	MAP ($/acre)	Urea ($/acre)	Total ($/acre)
Ridgway	Compost	18.8	90	----	----	$362	----	----	$362
Fruita	Compost	10.4	50	----	----	$201	----	----	$201
Ridgway	Fert+Compost	6	29	----	61	$117	----	$54	$171
Fruita	Fert+Compost	6	29	----	21	$117	----	$19	$135
Ridgway	Fert Only	0	----	10.58	79.42	----	$15	$71	$85
Fruita	Fert Only	0	----	8.46	41.54	----	$32	$37	$49

Results - Soil Inorganic Carbon

- Highly variable
- Large proportion of total carbon (>75% in Fruita)
- Important consideration because possible for practices aimed at increasing SOC can decrease SIC, which would likely be a net loss of C.