



Background

- The Sandown Centre for Regenerative Agriculture in North Saanich, BC, Canada, is situated on degraded land previously used as a racetrack. In 2021, remediation using regenerative agriculture began, and 18-22 sheep were introduced to graze the 16-ha enclosed meadow area.¹
- A 2021 study by Hayes *et al.* documented soil properties during initial grazing.¹ Data were collected at this time point (Year 1) and in the present 2024 study (Year 3), with sheep grazing in the interim.

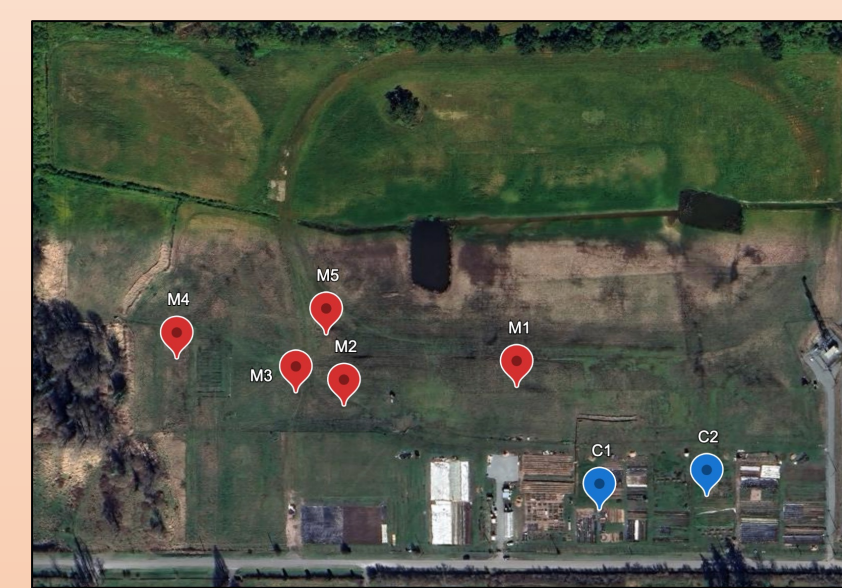


Figure 1. (Left) Photo of sheep on meadow site. Taken August 9, 2024, by E. Saatchi

Figure 2. (Right) Aerial photo of sampling layout (made using Avenza Maps)

- The Tea Bag Index (TBI) uses standardized green and rooibos teabags as to simulate decomposition in the natural environment.² Mass loss after soil incubation is used to calculate **stabilization rate (S)** of easily digestible labile material, **decomposition rate (k)** of lignified recalcitrant material, and the **percent material lost (B_g and B_r)**.^{1,2} Higher rates indicate greater decomposition.^{1,2}
- High % organic matter, microbial biomass and diversity, aggregate stability, pH (site-dependent), decomposition rate, and low compaction are measures positively correlated with soil health.³

Hypothesis

Long-term grazing will improve properties positively correlated with soil health: Organic carbon, bacterial & fungal biomass, F:B ratio, decomposition rates, and associated mass loss will increase. Compaction will decrease. pH will remain constant.

Methods

- Teabag sets buried at five meadow and two undisturbed reference sites, each set containing two green & two rooibos (n = 28). Bags were buried in square formation (Aug. 13, 2024) and retrieved after 92 days (Nov. 13, 2024).
- Compaction data and composite soil sample collected from each site upon teabag burial & retrieval, assessed for:
 - Aggregate stability — Slakes app⁴
 - Total organic carbon — muffle furnace⁵
 - Microorganism composition — direct shadowing microscopy⁶
 - pH (CaCl₂)⁷
- Tea was oven dried, then organic material incinerated at 550 °C for three hours and ash weight measured.¹
- TBI calculations from Keuskamp *et al.* (2013), B_g and B_r calculations from Hayes *et al.* (2024), biological assays from Dr Elaine's™ Soil Food Web SMAApp. T-tests and ART ANOVA performed in R.

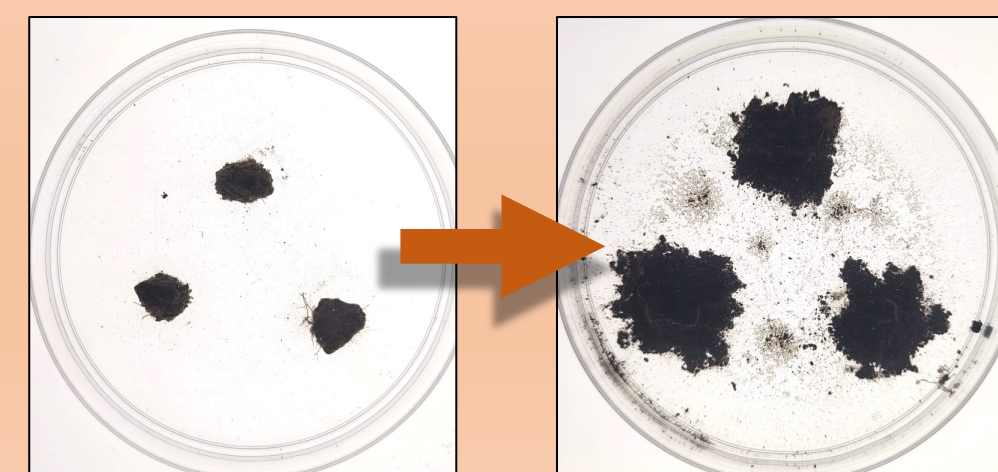


Figure 3. Aggregate stability assessment

Results

Table 1. Mean soil properties across Year 1 and Year 3 reference and grazed sites

Test	Year 1: Reference	Year 1: Grazed	Year 3: Reference	Year 3: Grazed
Compaction (depth in cm to 10.5 kg/cm ³)	11	20	17	31
pH (CaCl ₂)	7.0	6.7	6.9	7.1
Total organic carbon (%)	5.8	3.8	7.0	5.6
Bacterial biomass (µg/g)	1325	490	5978	5200
Fungal biomass (µg/g)	75.6	102.4	78.6	121.5
Fungal to bacterial biomass ratio (F:B)	0.057	0.209	0.008	0.045

- Mean pH remained constant across sampling years – **reject H₀**
- Mean **organic carbon** was 1.5 – 2% lower in grazed sites versus reference but increased 1.8% in grazed sites in Year 3 – **reject H₀**
- Mean penetration depth was twice as deep in grazed sites compared to reference and higher overall in Year 3 (less **compaction**) – **reject H₀**

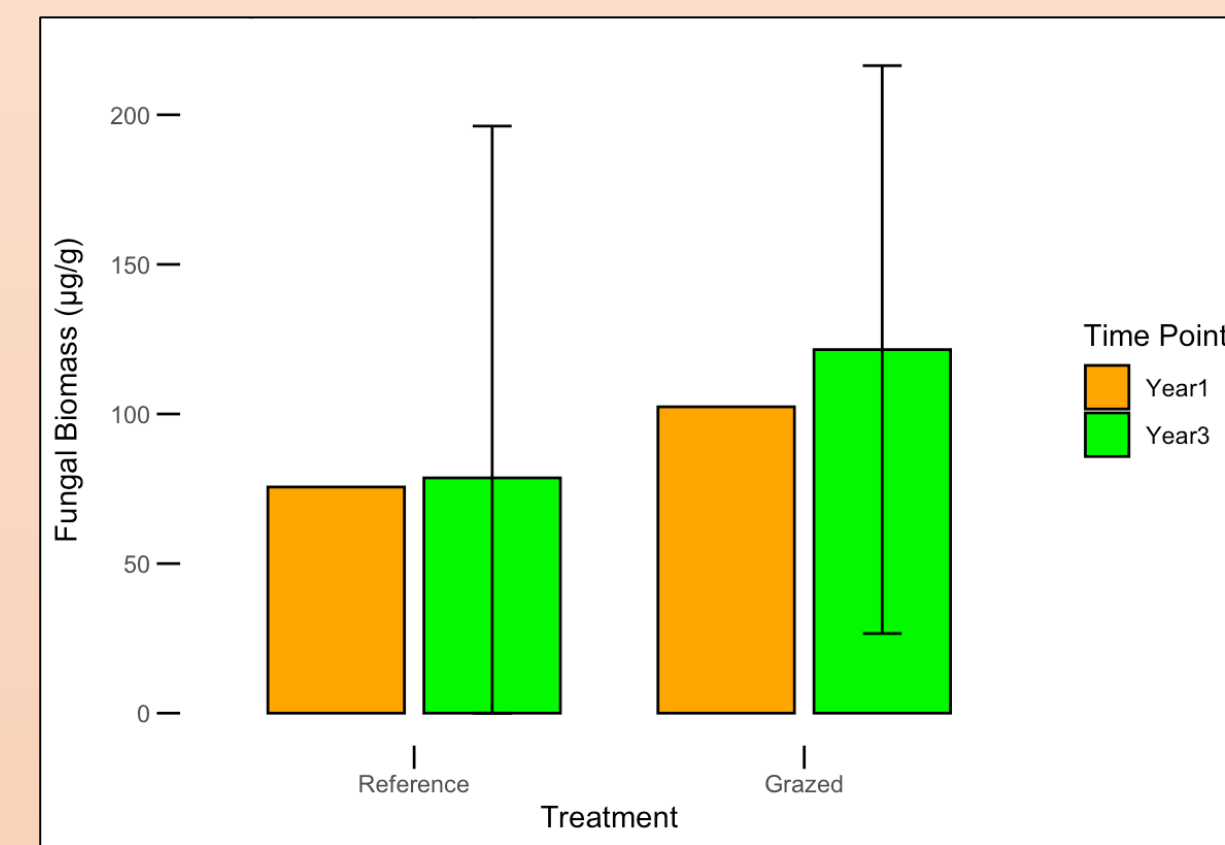


Figure 4. Fungal biomass by treatment and year

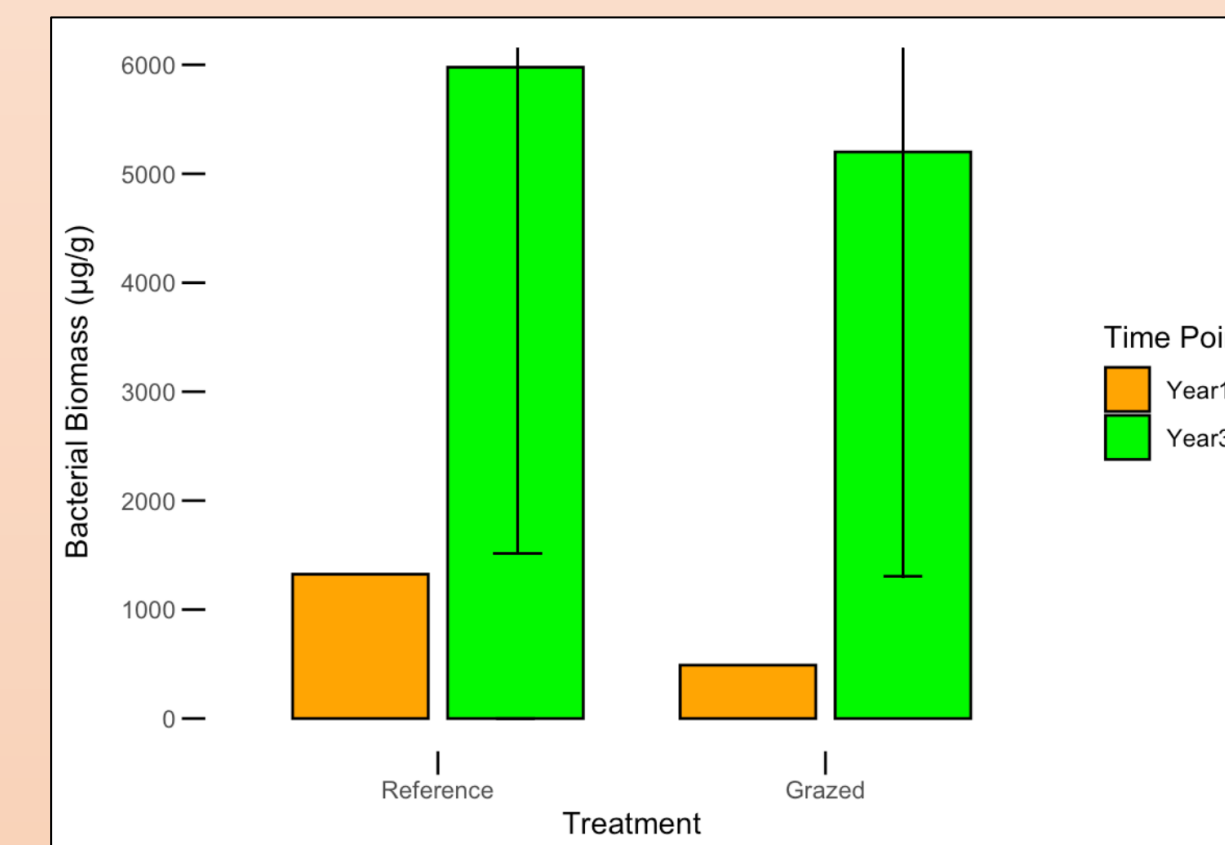


Figure 5. Bacterial biomass by treatment and year

- Mean **fungal biomass** is greater in grazed sites, with greatest increase in Year 3 – **reject H₀**
- Mean **bacterial biomass** 10.5 times greater in Year 3 than in Year 1 for both treatments – **reject H₀**
 - F:B ratio remains low for all treatments, relatively higher in Year 1 sites (p = 0.044) – **fail to reject H₀**

Table 2. Decomposition metrics across Year 1 and Year 3 reference and grazed sites

Decomposition metric	Year 1: Reference	Year 1: Grazed	Year 3: Reference	Year 3: Grazed
Stabilization rate (S)	0.231	0.225	0.475	0.417
Decomposition rate (k)	0.0100	0.0061	0.0041	0.0029
Percent material loss: green tea (B _g)	65	65	44	49
Percent material loss: red tea (B _r)	43	43	16.5	14.5



Sample loss — due to poor weather conditions and unforeseen circumstances, final sample size reduced to n = 13.

- Stabilization rate (S)** higher in Year 3 – **reject H₀**; **decomposition rate (k)** lower in Year 3 – **fail to reject H₀**
- B_g and B_r** both decreased in Year 3 across treatments, B_r more significantly – **fail to reject H₀**

Discussion

- High bacterial biomass is characteristic of degraded soils, but coupled with increased fungal biomass could suggest early-stage microbial succession from delayed nutrient accumulation or high rainfall.^{1,8}
 - Increased bacterial dominance explains greater green tea loss (B_g) compared to red tea (B_r) as bacteria decompose labile material while fungal breakdown of lignin is suppressed.^{1,9} Higher stabilization rate (S) & lower decomposition rate (k) supports this.
 - Grazing stimulates plant root exudate production and produces manure, creating nutrient substrates for microbial growth.¹⁰
- Improvement in compaction indicates increased soil porosity and habitat for beneficial microorganisms.^{11,12} May need more time to see if the grazing system is balanced and continues to enhance soil organic carbon for improved aeration and water infiltration.^{11,12}
- Reduced sample size, poor aggregate quality, and insufficient data from M1, M2, and C2 sample sites diminished experimental reliability. Trends can be observed in mean data across treatments and sampling years, although t-tests and ART ANOVA prove insignificant findings.

Conclusions

- After grazing for 3 years, compaction, organic carbon, bacterial & fungal biomass, and stabilization rate (S) showed improvement, while F:B ratio, decomposition rate (k), B_g & B_r showed decline.
- Results show potential signs of early-stage soil regeneration, including microbial succession and population increase as soil conditions improve, although bacterial dominance could disrupt soil ecosystems.
- Reduced sample size and high variability in findings highlight the need for replication to confirm results, and room for experimental extension.

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