

Title: Green Infrastructure Microbial Community Response to Simulated Pulse Precipitation Events in the Semi-Arid Western United States

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SUPPORTING INFORMATION

Table S1. List of plant species present in grass and diverse plots at the Green Infrastructure Research Facility (GIRF).

Scientific Name	Common Name	Plant Type	Plant Abundance	
			Diverse Plots	Grass Plots
<i>Schizachyrium scoparium</i>	Little Bluestem	C4 grass	2	14
<i>Elymus cinereus</i>	Great Basin Wild Rye	C3 grass	2	4
<i>Bouteloua gracilis</i>	Blue Grama Grass	C4 grass	2	7
<i>Gaillardia sp.</i>	Blanket Flower	Perennial herb	4	0
<i>Monarda sp.</i>	Bee Balm	Perennial herb	3	0
<i>Penstemon strictus</i>	Rocky Mountain Beardtongue	Perennial herb	6	0
<i>Potentilla sp.</i>	Cinquefoil	Shrub	5	0
<i>Ribes aureum</i>	Golden Currant	Shrub	6	0
<i>Echinacea purpurea</i>	Coneflower	Perennial herb	2	0
<i>Ribes alpinum</i>	Alpine Currant	Shrub	1	0
<i>Penstemon pinifolius</i>	Pineleaf Beardtongue	Perennial herb	1	0

Table S2. Meteorological and soil sensors associated with the Wasatch Environmental Observatory (WEO). Data from the sensors are logged at 15-minute intervals and can be retrieved from the HydroShare data repository (www.hydroshare.org).

Sensor Type	Measurement	Instrument	Accuracy
Climate	Air temperature	Apongee ST110	± 0.1 °C
Climate	Precipitation	Geonor T-200B	± 0.1 %
Soil	Soil moisture	METER Teros 11	± 0.03 m ³ /m ³

Table S3. Climate and soil moisture values recorded at the Green Infrastructure Research Facility (GIRF) and Todd's Meadow during simulated precipitation pulse events in 2020 and 2021.

Measurement	GIRF		Todd's Meadow
	September 2020	June 2021	June 2021
Average daily air temperature (°C)	20.30 ± 0.16	25.70 ± 0.12	19.10 ± 0.20
Range of daily air temperature (°C)	3.81 - 35.40	14.90 - 36.70	9.10 - 32.90
Total natural precipitation (mm)	0.30	1.40	9.50
Average soil moisture at 10-20 cm depth (%)	10.80 ± 0.001	16.40 ± 0.03	13.90 ± 0.03
Range of soil moisture at 10-20 cm depth (%)	10.00 - 12.00	6.99 - 22.20	12.60 - 16.40

Table S4. Climate and soil moisture values recorded at the Green Infrastructure Research Facility (GIRF) and Todd's Meadow in 2020 and 2021 during the growing season for each year (May 1 to October 1).

Measurement	GIRF		Todd's Meadow
	September 2020	June 2021	June 2021
Average daily air temperature (°C)	21.70 ± 0.07	21.90 ± 0.06	16.30 ± 0.06
Range of daily air temperature (°C)	2.56 - 38.40	2.17 - 37.30	-2.55 - 34.80
Total natural precipitation (mm)	49.7	160.7	287.5
Average soil moisture at 10-20 cm depth (%)	13.50 ± 0.02	15.20 ± 0.02	18.53 ± 0.05
Range of soil moisture at 10-20 cm depth (%)	9.45 - 24.70	5.72 - 24.10	9.65 - 36.63

Table S5. List of sampling dates associated with pulsed precipitation events at the Green Infrastructure Research Facility (GIRF) and Todd’s Meadow during 2020 and 2021 field seasons. Precipitation at GIRF was simulated, except as noted, while the event at Todd’s Meadow was due to rainfall.

Location	Date	Day(s) Post Pulse	Notes
GIRF	9/3/20	Pre-pulse	Water added 9/6/2020
	9/9/20	3 d post-pulse	Major windstorm on 9/8/2020 delayed sampling
	9/11/20	5 d post-pulse	
	9/15/20	9 d post-pulse	
	9/22/20	16 d post-pulse	
GIRF	6/21/21	Pre-pulse	
GIRF	6/22/21	1 d post-pulse	Rain Event on 6/24/2021; ~3 mm of precipitation
	6/23/21	2 d post-pulse	
	6/24/21	3 d post-pulse	
	6/28/21	7 d post-pulse	
	6/30/21	9 d post-pulse	
	7/7/21	16 d post-pulse	
Todd’s Meadow	6/17/21	Pre-pulse	Rain Event 6/24/2021; 4.3 mm of precipitation
	6/25/21	1 d post-pulse	
	6/27/21	3 d post-pulse	

Table S6. Mean (\pm SE) vector length and angles of ecoenzyme activity rates associated with different plant treatments and pulse events at the Green Infrastructure Research Facility (GIRF) and Todd’s Meadow.

Location	Year	Plant Treatment	Vector Variable	Mean (\pm SE)
GIRF	2020	Diverse	Length	1.00 \pm 0.05
		Grass	Length	0.94 \pm 0.04
		Mulch	Length	0.95 \pm 0.06
		Diverse	Angle	45.10 \pm 1.33
		Grass	Angle	44.50 \pm 1.21
		Mulch	Angle	46.30 \pm 1.69
GIRF	2021	Diverse	Length	1.21 \pm 0.05
		Grass	Length	1.25 \pm 0.05
		Mulch	Length	1.11 \pm 0.04
		Diverse	Angle	42.50 \pm 0.65
		Grass	Angle	44.20 \pm 0.69
		Mulch	Angle	43.00 \pm 0.50
Todd’s Meadow	2021	Reference	Length	1.36 \pm 0.02
		Reference	Angle	44.00 \pm 0.33

Table S7. Experimental and natural pulse event significant paths as determined from PSEM analysis. ‘Weight’ references the path coefficient for each path showing the direction(s) of influence between parameters. Single-headed arrows indicate one-way directionality of the path, while double-headed arrows indicate bidirectional influence.

Pulse Event	Path	Weight	<i>p</i>
September 2020 (Fisher’s C = 33.4, <i>p</i> = 0.221, 28 degrees of freedom)	Microbial Biomass C ↔ Microbial Biomass N	0.699	<0.001
	Microbial Biomass N ↔ Organic Matter Content	0.291	0.028
	Gravimetric Soil Moisture → Organic Matter Content	-0.309	0.037
	LAP → Organic Matter Content	0.601	0.031
	AP → Organic Matter Content	-0.633	0.007
	Organic Matter Content → Organic N	0.886	<0.001
	Proteolysis → Organic N	0.196	0.023
	Organic N → Inorganic N	0.373	0.011
	POX → Inorganic N	0.486	0.001
	Inorganic N → pH	-0.295	0.050
	LAP ↔ AP	0.757	<0.001
	LAP ↔ BG	0.756	<0.001
	AP ↔ BG	0.639	<0.001
	June 2021 (Fisher’s C = 39.067, <i>p</i> = 0.08, 28 degrees of freedom)	Microbial Biomass N → AP	0.321
Microbial Biomass C → BG		0.311	0.047
Gravimetric Soil Moisture → LAP		0.500	0.007
Gravimetric Soil Moisture → AP		0.406	0.002
Gravimetric Soil Moisture → POX		0.463	0.002
pH → AP		0.303	0.020
pH → POX		-0.282	0.046
Organic Matter Content → Organic N		0.662	<0.001
LAP → Inorganic N		-0.861	0.002
AP → Inorganic N		0.985	<0.001
LAP ↔ AP		0.697	<0.001
LAP ↔ BG		0.522	<0.001
BG ↔ POX		-0.338	0.012
Todd's Meadow (Fisher’s C = 18.557, <i>p</i> = 0.949, 30 degrees of freedom)		POX → Organic Matter Content	-0.788
	Gravimetric Soil Moisture → pH	0.462	<0.001
	LAP ↔ AP	0.919	<0.001
	LAP ↔ BG	0.970	<0.001
	AP ↔ BG	0.943	<0.001

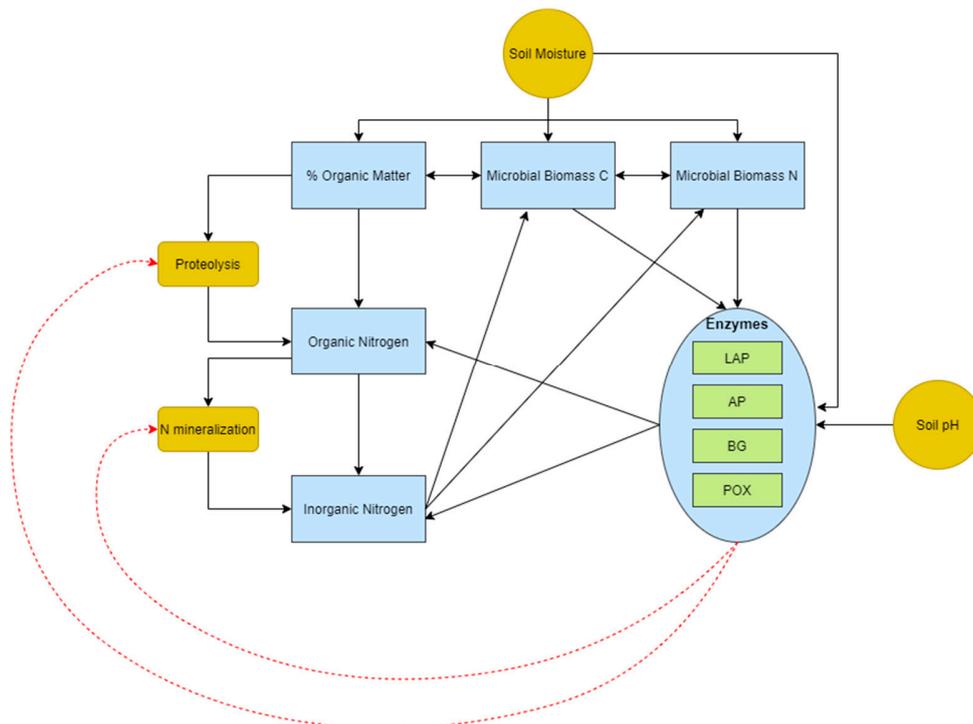


Figure S1. Conceptual model of microbial community and N cycling processes.

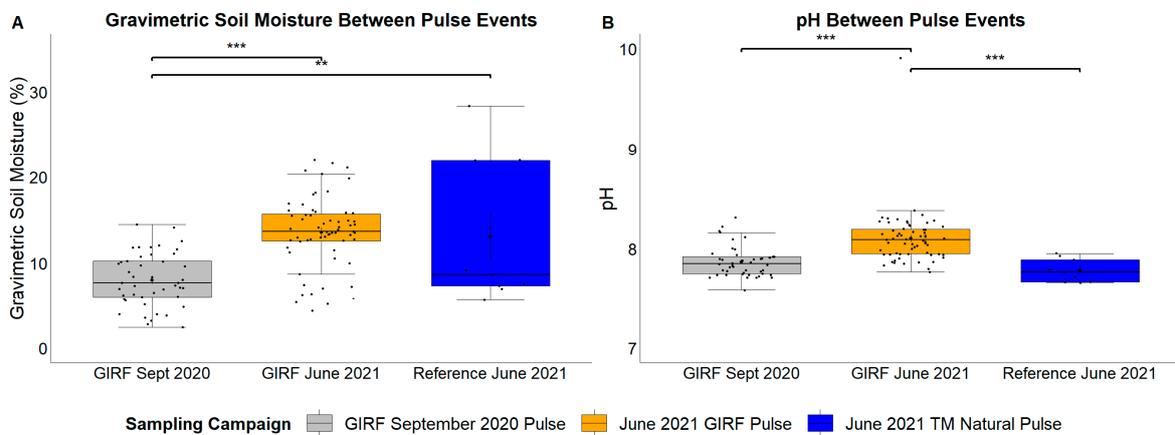


Figure S2. Comparison of A) gravimetric soil moisture and B) pH between experimental and natural pulse events. Significance levels ‘***’ ≤ 0.001 , ‘**’ ≤ 0.01 , ‘*’ ≤ 0.05 .

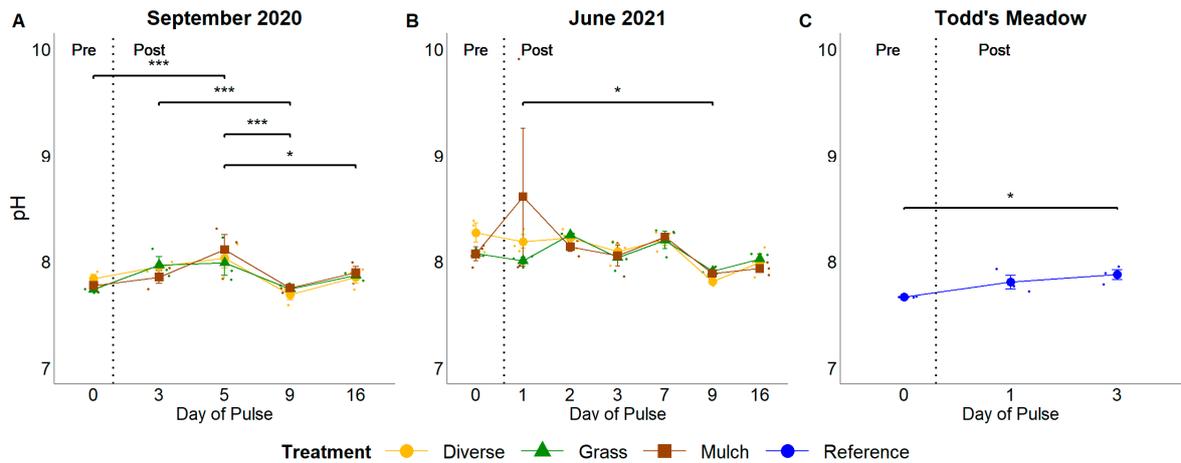


Figure S3. pH responses during experimental and natural pulse events. A) illustrate changes during September 2020 experimental pulse event. B) illustrate changes during June 2021 experimental pulse event. C) illustrate changes during the 2021 Todd's Meadow natural pulse event. Significance levels $*** \leq 0.001$, $** \leq 0.01$, $* \leq 0.05$.

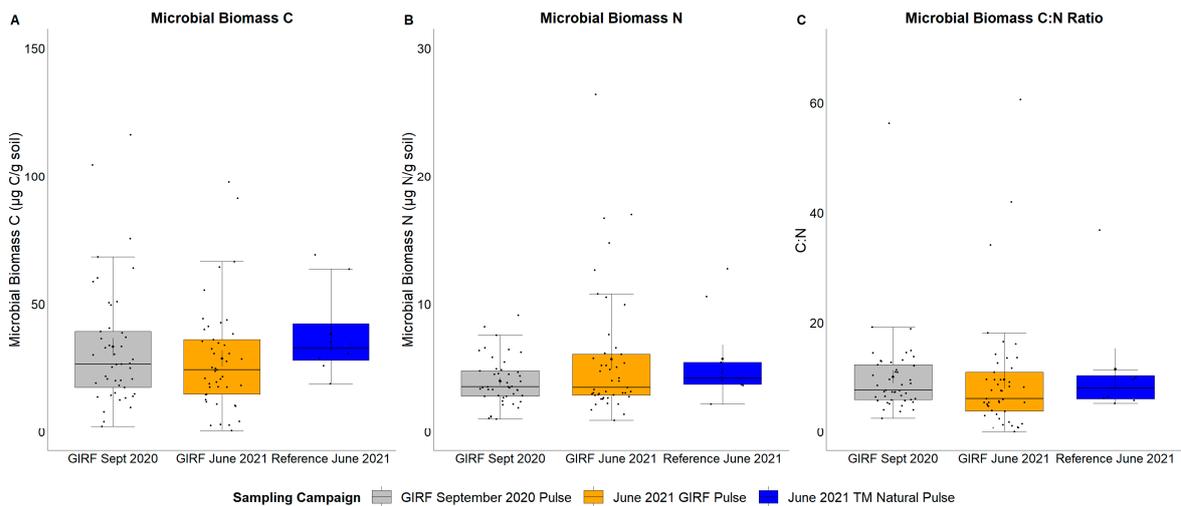


Figure S4. Comparison of microbial biomass C and N content and C:N ratios between pulse events. A) microbial biomass C content, B) microbial biomass N content, and C) C:N ratios. Significance levels $*** \leq 0.001$, $** \leq 0.01$, $* \leq 0.05$.

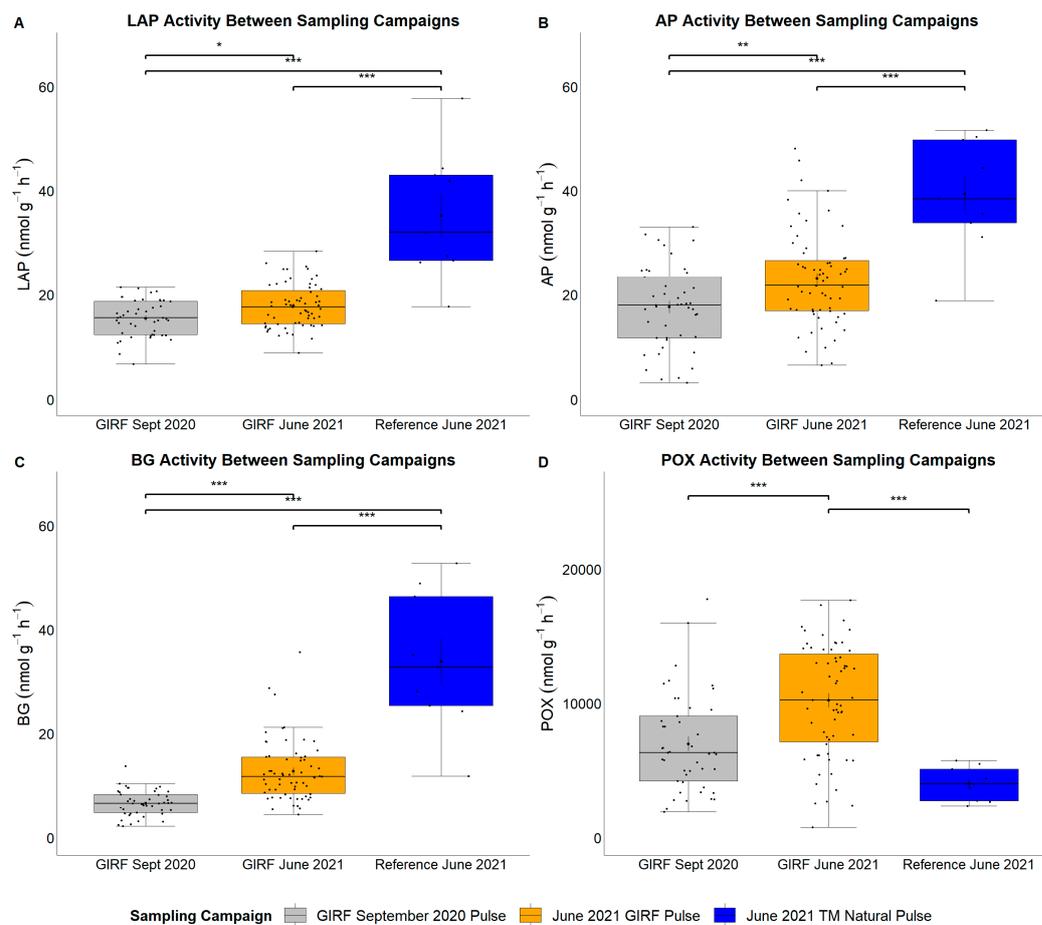


Figure S5. Comparison of ecoenzyme activity rates between the experimental and natural pulse events. Significance levels ‘***’ ≤ 0.001 , ‘**’ ≤ 0.01 , ‘*’ ≤ 0.05 .

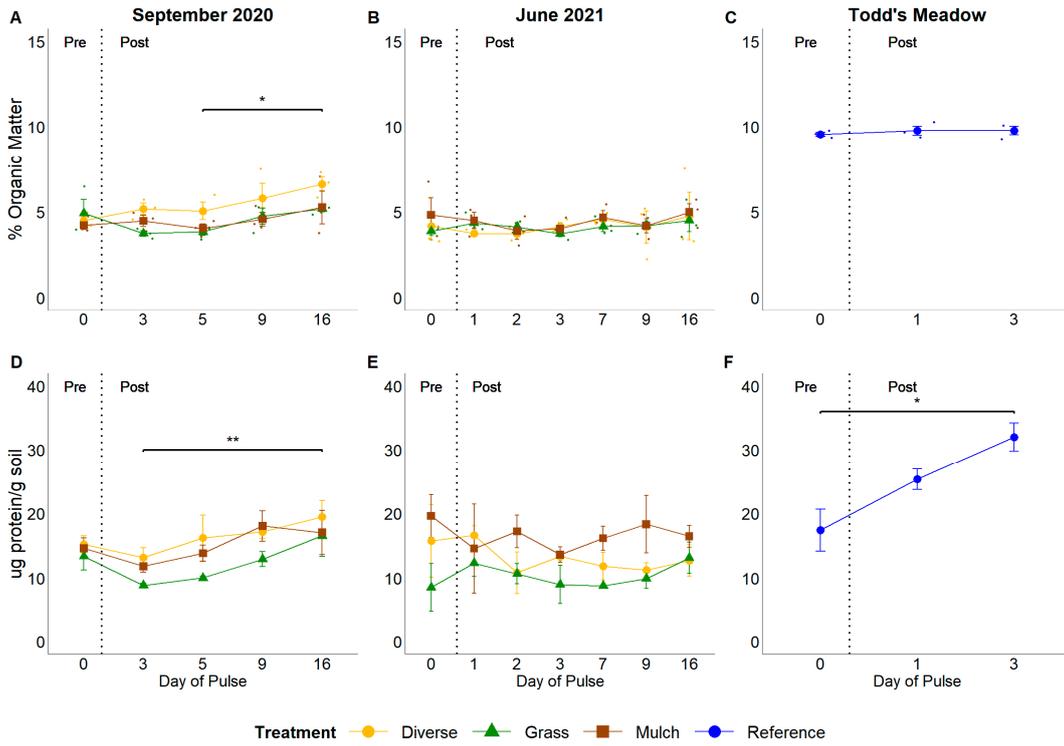


Figure S6. Percent organic matter and protein concentrations during the pulse events. Changes in A, B, C) percent organic matter; D, E, F) protein concentration over the pulse events. Significance levels ‘***’ ≤ 0.001 , ‘**’ ≤ 0.01 , ‘*’ ≤ 0.05 .

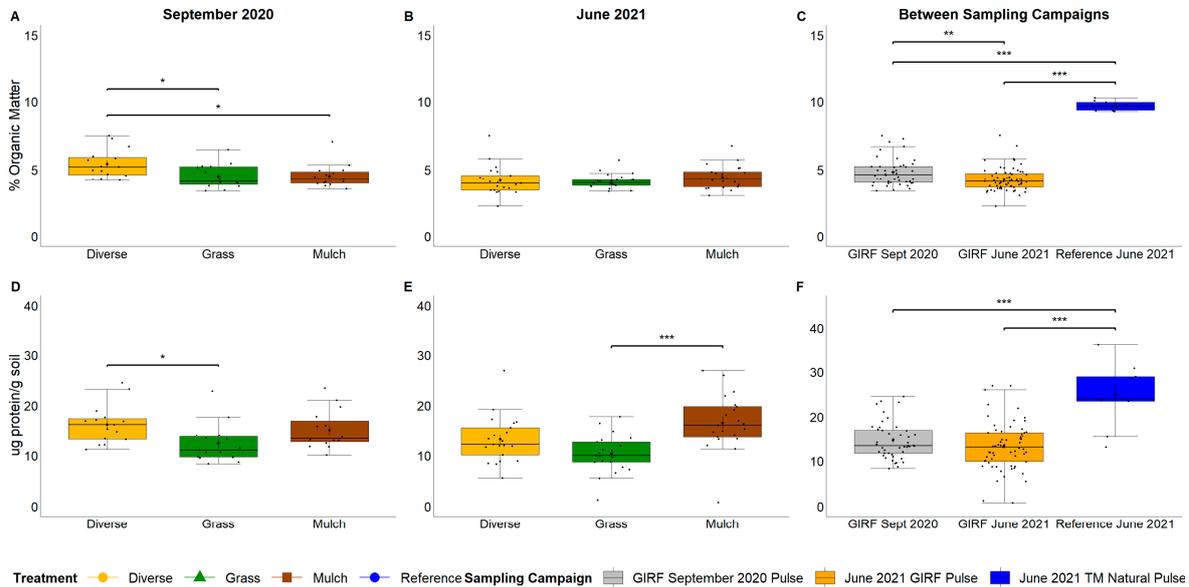


Figure S7. Comparison of organic matter and protein concentrations. A, B) percent organic matter; D, E) protein concentration between treatments for the experimental pulse events. C) Comparisons of percent organic matter between pulse events. F) Comparisons of protein concentration between pulse events. Significance levels ‘***’ ≤ 0.001 , ‘**’ ≤ 0.01 , ‘*’ ≤ 0.05 .

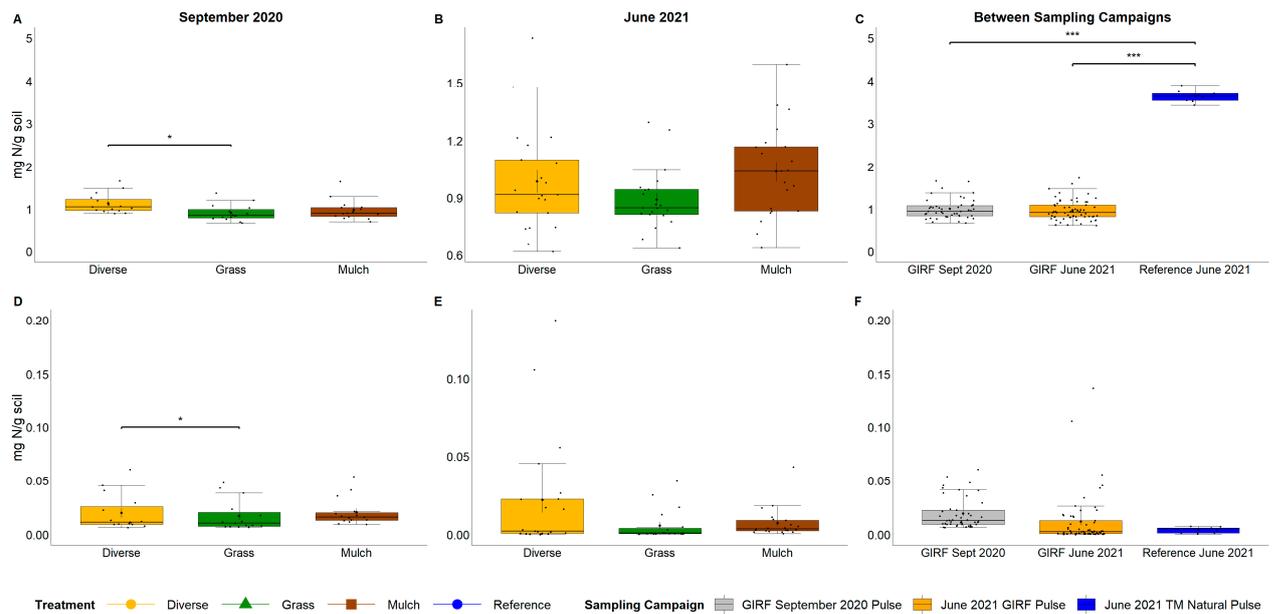


Figure S8. Comparison of organic and inorganic N. A, B) organic N; D, E) inorganic N between treatments for the experimental pulse events. C) Comparisons of organic N between pulse events. F) Comparisons of inorganic N between pulse events. Significance levels ‘***’ ≤ 0.001 , ‘**’ ≤ 0.01 , ‘*’ ≤ 0.05 .

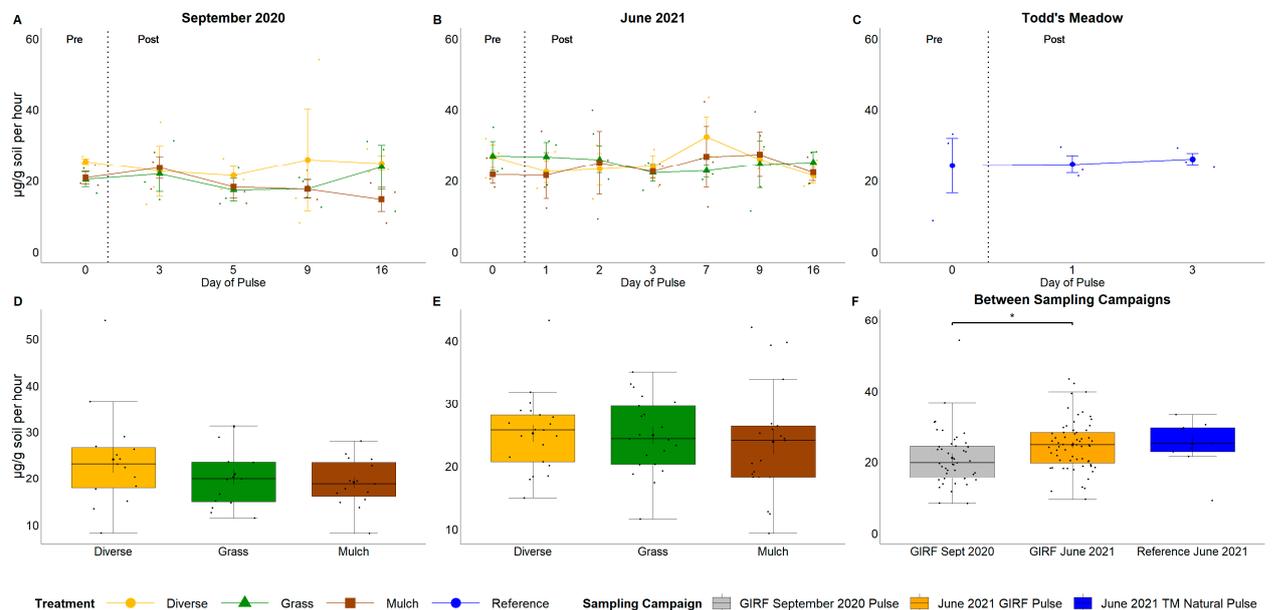


Figure S9. Proteolytic rates. A, B, C) over pulse events; D, E) between treatments; and F) between pulse events. Significance levels ‘***’ ≤ 0.001 , ‘**’ ≤ 0.01 , ‘*’ ≤ 0.05 .

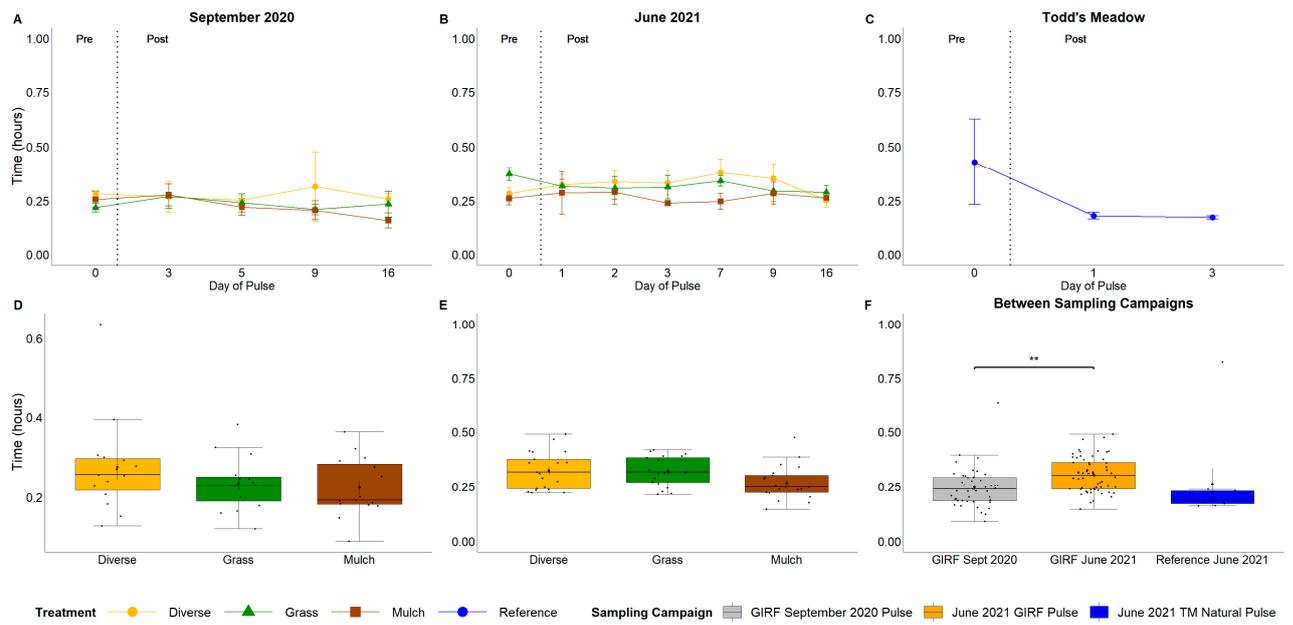


Figure S10. Potential protein turnover. A, B, C) over pulse events; D, E) between treatments; and F) between pulse events. Significance levels ‘***’ ≤ 0.001 , ‘**’ ≤ 0.01 , ‘*’ ≤ 0.05 .

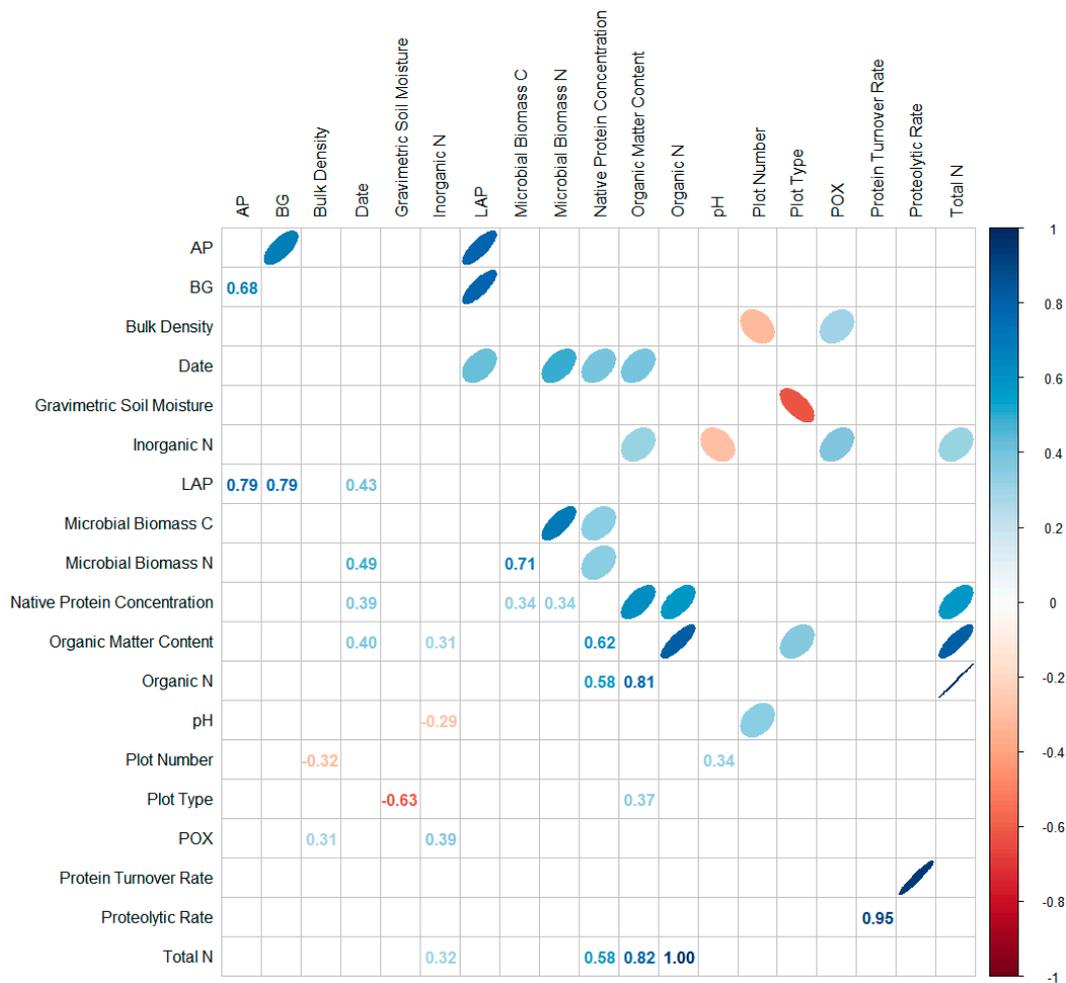


Figure S11. September 2020 experimental pulse Pearson correlation matrix. Only significant (p -value < 0.05) correlations are shown. All abbreviations (e.g. AP, BG, LAP, etc.) are defined in the main text.

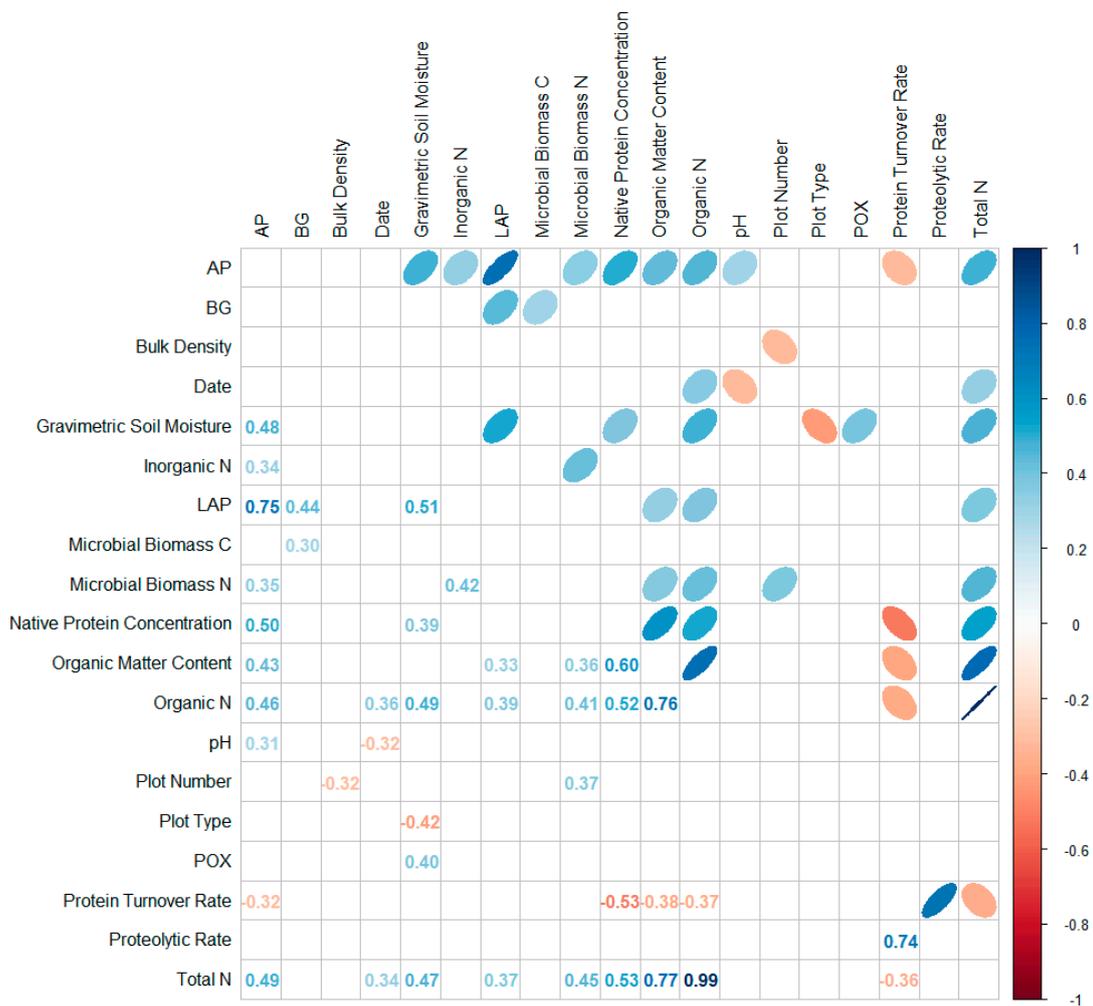


Figure S12. June 2021 experimental pulse Pearson correlation matrix. Only significant (p -value < 0.05) correlations are shown. All abbreviations (e.g. AP, BG, LAP, etc.) are defined in the main text.

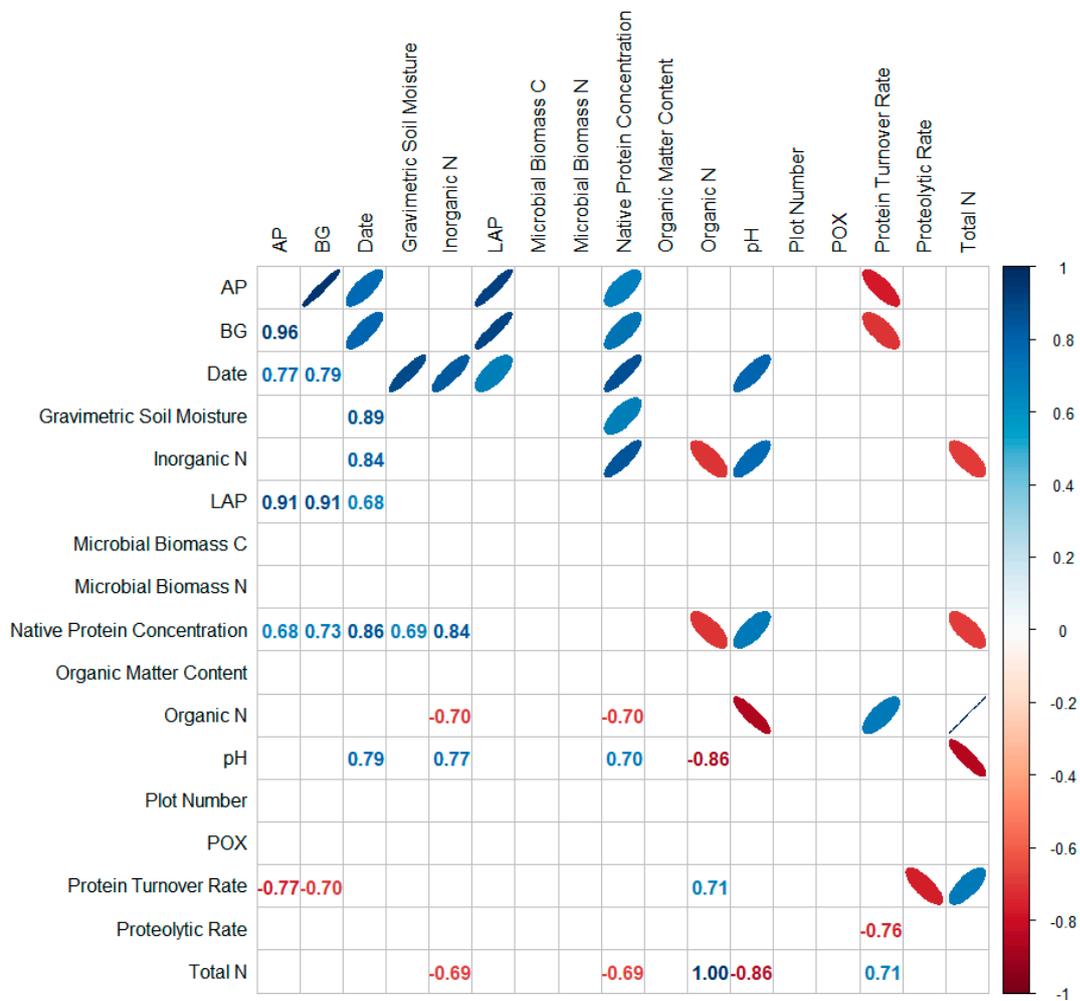


Figure S13. 2021 Todd's Meadow natural pulse Pearson correlation matrix. Only significant (p -value < 0.05) correlations are shown. All abbreviations (e.g. AP, BG, LAP, etc.) are defined in the main text.