

Supplementary Materials: Does Pastoral Land-Use Legacy Influence Topsoil Carbon and Nitrogen Accrual Rates in Tallgrass Prairie Restorations?

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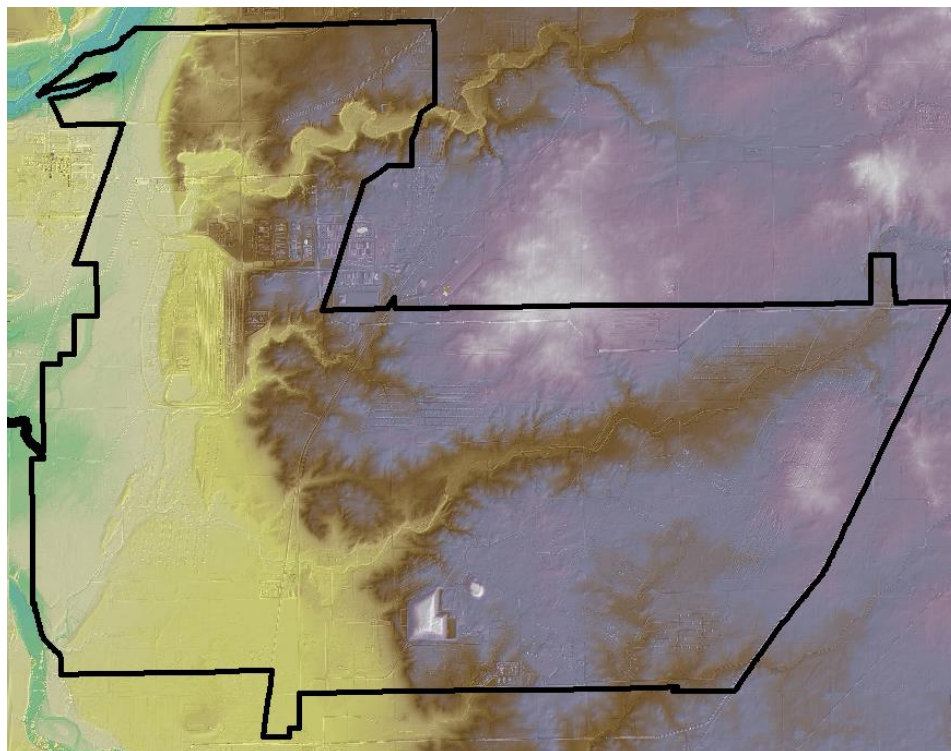


Figure S1. Digital elevation model of Midewin National Tallgrass Prairie. Colors that represent elevation are, from lowest to highest elevation: pale blue, pale green, vanilla, yellow, brown, purple, pink, white. Elevation ranges from 153 to 257 meters above sea level.

Table S1. Means and S.E.M.s of elevation (m) and water accumulation (WA; \log_{10}) for land-use histories and PERMANOVA F-ratio and P-values for effects on soil carbon and nitrogen. Degrees of freedom are 3 (model) and 23 (residual). P is cow pasture, PC is pasture converted from row crop fields, C is row crop fields, REM is remnant prairie, RB is restored bison prairie, ROP is restored old pasture, and RC is restored from row crop fields.

Land-Use History	Elevation	WA	<i>Elevation:WA</i>
			<i>interaction</i>
P	185±6	1.45±0.4	-
PC	204±3	0.40±0.3	-
C	197±5	0.65±0.3	-
REM	172±7	0.83±0.3	-
RB	184±3	0.85±0.2	-
ROP	162±0	0.60±0.3	-
RC	167±2	0.91±0.3	-
<i>F-ratio</i>	<i>1.1</i>	<i>0.2</i>	<i>0.4</i>
<i>P-value</i>	<i>0.3</i>	<i>0.8</i>	<i>0.5</i>

Table S2. Means and S.E.M.s, ANOVA estimates and 95% confidence intervals of 0–10 cm soil bulk density (g cm^{-3}) in 2008 and 2018 for land-use histories. Degrees of freedom are 6 (model) and 20 (residual). P is cow pasture, PC is pasture converted from row crop fields, C is row crop fields, REM is remnant prairie, RB is restored bison prairie, ROP is restored old pasture, and RC is restored from row crop fields.

Year	Land-Use History	Mean	Estimate	95% CI
2008	RB (Intercept)	0.67±0.05	0.67	0.63 – 0.83
	P	0.66±0.01	-0.02	-0.21 – 0.18
	PC	0.82±0.04	0.15	-0.05 – 0.35
	C	0.83±0.03	0.15	-0.05 – 0.35
	REM	0.49±0.04	-0.18	-0.36 – -0.01
	ROP	0.43±0.09	-0.24	-0.43 – -0.06
	RC	0.73±0.08	0.05	-0.12 – 0.23
2018	RB (Intercept)	0.79±0.04	0.79	0.65 – 0.92
	P	0.69±0.11	-0.1	-0.31 – 0.11
	PC	0.88±0.07	0.09	-0.12 – 0.30
	C	0.75±0.06	-0.04	-0.25 – 0.17
	REM	0.50±0.07	-0.29	-0.47 – -0.11
	ROP	0.54±0.05	-0.25	-0.44 – -0.06
	RC	0.64±0.05	-0.15	-0.33 – 0.03

Table S3. ANOVA estimates and 95% confidence intervals of root and soil C:N ratios in 2008 and 2018 for land-use histories. Degrees of freedom are 6 (model) and 20 (residual). P is cow pasture, PC is pasture converted from row crop fields, C is row crop fields, REM is remnant prairie, RB is restored bison prairie, ROP is restored old pasture, and RC is restored from row crop fields.

Year	Land-Use History	Root C:N Estimate	Root C:N 95% CI	Soil C:N Estimate	Soil C:N 95% CI
2008	RB (Intercept)	41.63	33.23 – 50.03	11.99	11.59 – 12.39
	P	0.01	-12.82 – 12.84	-0.61	-1.22 – 0.01
	PC	-0.57	-13.40 – 12.26	0.19	-0.42 – 0.81
	C	-26.68	-39.51 – -13.86	-1.38	-2.00 – -0.77
	REM	11.9	0.63 – 23.16	-0.18	-0.72 – 0.36
	ROP	10.13	-1.75 – 22.01	0.33	-0.23 – 0.90
	RC	3.83	-7.43 – 15.10	-0.33	-0.87 – 0.21
2018	RB (Intercept)	7.06	6.16 – 7.95	12.35	11.35 – 13.35
	P	-0.06	-1.43 – 1.31	-0.05	-1.58 – 1.48
	PC	-0.74	-2.11 – 0.63	-0.25	-1.78 – 1.28
	C	-1.84	-3.21 – -0.47	1.11	-0.41 – 2.64
	REM	-0.91	-2.11 – 0.30	1.05	-0.3 – 2.39
	ROP	-0.39	-1.65 – 0.88	-1.05	-2.47 – 0.37
	RC	0.26	-0.94 – 1.46	0.22	-1.13 – 1.56

Table S4. ANOVA estimates and 95% confidence intervals of isotopic mixing model results for C3-derived soil C (0–10 cm) for land-use histories. Degrees of freedom are 6 (model) and 20 (residual). P is cow pasture, PC is pasture converted from row crop fields, C is row crop fields, REM is remnant prairie, RB is restored bison prairie, ROP is restored old pasture, and RC is restored from row crop fields.

Land-Use History	Estimate	95% CI
RB (Intercept)	0.77	0.69 – 0.85
P	0.01	-0.11 – 0.13
PC	-0.08	-0.20 – 0.04
C	-0.2	-0.32 – -0.08
REM	-0.09	-0.20 – 0.01
ROP	0.08	-0.04 – 0.19
RC	-0.11	-0.22 – 0.00

Table S5. FDR-adjusted P-values for pairwise comparisons of PERMANOVA distance matrix for 0–10 cm soil nutrients Ca, Cu, Mn, Zn, K, P, NO₃, Mg, Na, and NH₄ for land-use histories. PERMANOVA test F-ratio is 2.1 and P-value is 0.001. Degrees of freedom are 6 (model) and 20 (residual). P is cow pasture, PC is pasture converted from row crop fields, C is row crop fields, REM is remnant prairie, RB is restored bison prairie, ROP is restored old pasture, and RC is restored from row crop fields.

	RB	P	PC	RC	ROP	REM
P	0.58	-	-	-	-	-
PC	0.86	0.44	-	-	-	-
RC	0.18	0.11	0.44	-	-	-
ROP	0.11	0.11	0.16	0.20	-	-
REM	0.19	0.19	0.26	0.21	0.11	-
C	0.11	0.19	0.26	0.32	0.11	0.19

Table S6. Means and S.E.M.s of 0–10 cm soil C and N concentrations (g C or N kg⁻¹), stocks (kg C or N m⁻²), relative change in C and N concentrations (%), and C and N accrual rates (g C or N m⁻²yr⁻¹) for land-use histories. P is cow pasture, PC is pasture converted from row crop fields, C is row crop fields, REM is remnant prairie, RB is restored bison prairie, ROP is restored old pasture, and RC is restored from row crop fields.

Year	Land-Use History	g C kg ⁻¹ soil	g N kg ⁻¹ soil	kg C m ⁻²	kg N m ⁻²	Relative Change in g C kg ⁻¹ soil	Relative Change in g N kg ⁻¹ soil	g C m ⁻² yr ⁻¹	g N m ⁻² yr ⁻¹
2008	P	35±3	3.1±0.2	2.39±0.1	0.20±0.01	-	-	-	-
	PC	31±2	2.5±0.1	2.66±0.1	0.21±0.01	-	-	-	-
	C	28±2	2.7±0.2	2.33±0.2	0.22±0.02	-	-	-	-
	REM	61±11	5.2±1.0	3.10±0.5	0.25±0.05	-	-	-	-
	RB	37±3	3.1±0.3	2.55±0.2	0.21±0.02	-	-	-	-
	ROP	59±9	4.8±0.8	2.37±0.2	0.19±0.02	-	-	-	-
	RC	35±8	3.0±0.7	2.35±0.2	0.20±0.02	-	-	-	-
2018	P	40±6	3.3±0.6	2.70±0.1	0.21±0.01	5.4±13	11.5±9	1.0±1.6	30.5±19
	PC	31±2	2.7±0.0	2.76±0.1	0.23±0.03	6.4±6	1.8±6	2.3±3.4	9.5±22
	C	23±1	1.9±0.2	1.70±0.2	0.14±0.02	-28.5±12	-18.1±5	-7.8±2.5	-61.1±8
	REM	61±9	4.6±0.7	2.99±0.3	0.22±0.02	-9.5±7	3.1±11	-3.4±3.3	-10.2±41
	RB	35±2	2.8±0.1	2.75±0.2	0.22±0.01	-7.8±4	-5.4±4	1.2±0.4	19.4±5
	ROP	56±5	4.9±0.4	3.02±0.1	0.26±0.01	6.3±7	-2.7±7	7.0±1.6	63.1±22
	RC	39±7	3.2±0.6	2.53±0.2	0.19±0.02	9.4±9	14.4±9	-0.8±1.5	17.3±22

Table S7. FDR-adjusted P-values for pairwise comparisons of PERMANOVA distance matrix for 0–10 cm soil C and N concentrations (g C or N kg^{−1}) and stocks (kg C or N m^{−2}) in 2008 and 2019 for land-use histories. PERMANOVA soil concentration test F-ratio is 2.8 and P-value is 0.03 for 2008, and for 2018 F-ratio is 4.0 and P-value is 0.01. PERMANOVA soil stocks test F-ratio is 0.8 and P-value is 0.6 for 2008, and for 2018 F-ratio is 3.3 and P-value is 0.02. Degrees of freedom are 6 (model) and 20 (residual). P is cow pasture, PC is pasture converted from row crop fields, C is row crop fields, REM is remnant prairie, RB is restored bison prairie, ROP is restored old pasture, and RC is restored from row crop fields.

g C and N kg ^{−1} soil						
2008	RB	P	PC	RC	ROP	REM
P	0.86	-	-	-	-	-
PC	0.25	0.21	-	-	-	-
RC	0.96	0.96	0.86	-	-	-
ROP	0.21	0.21	0.21	0.21	-	-
REM	0.22	0.25	0.21	0.21	0.86	-
C	0.26	0.21	0.7	0.86	0.21	0.21
2018	RB	P	PC	RC	ROP	REM
P	0.68	-	-	-	-	-
PC	0.42	0.31	-	-	-	-
RC	0.75	0.98	0.65	-	-	-
ROP	0.17	0.23	0.17	0.22	-	-
REM	0.22	0.31	0.22	0.23	0.75	-
C	0.17	0.22	0.22	0.31	0.17	0.18
kg C and N m ^{−2}						
2008	RB	P	PC	RC	ROP	REM
P	0.78	-	-	-	-	-
PC	0.81	0.78	-	-	-	-
RC	0.78	0.95	0.78	-	-	-
ROP	0.78	0.78	0.78	0.81	-	-
REM	0.78	0.78	0.78	0.78	0.78	-
C	0.78	0.78	0.78	0.78	0.78	0.78
2018	RB	P	PC	RC	ROP	REM
P	0.91	-	-	-	-	-
PC	0.79	0.77	-	-	-	-
RC	0.68	0.73	0.6	-	-	-
ROP	0.33	0.26	0.6	0.26	-	-
REM	0.73	0.73	0.73	0.6	0.61	-

C 0.26 0.26 0.26 0.26 0.26 0.26

Table S8. ANOVA estimates and 95% confidence intervals for 0–10 cm soil C and N concentrations (g C or N kg⁻¹) and stocks (kg C or N m⁻²) in 2008 and 2018 for land-use histories. Degrees of freedom are 6 (model) and 20 (residual). P is cow pasture, PC is pasture converted from row crop fields, C is row crop fields, REM is remnant prairie, RB is restored bison prairie, ROP is restored old pasture, and RC is restored from row crop fields.

Year	Response Variable	Land-Use History	Concentration Estimate	Concentration 95% CI	Stock Estimate	Stock 95% CI
2008	Carbon	RB (Intercept)	37	28 – 52	1.59	1.39 – 1.80
		P	-2	-20 – 17	-0.05	-0.36 – 0.26
		PC	-6	-23 – 11	0.04	-0.28 – 0.35
		C	-9	-26 – 8	-0.07	-0.38 – 0.24
		REM	24	4 – 47	0.14	-0.14 – 0.41
		ROP	22	1 – 47	-0.06	-0.35 – 0.23
		RC	-2	-18 – 14	-0.07	-0.34 – 0.20
	Nitrogen	RB (Intercept)	3.1	2.3 – 4.4	0.45	0.39 – 0.51
		P	0.0	-1.6 – 1.7	0.00	-0.10 – 0.09
		PC	-0.6	-2.0 – 0.9	0.01	-0.09 – 0.10
		C	-0.4	-1.9 – 1.1	0.02	-0.08 – 0.11
		REM	2.1	0.4 – 4.2	0.04	-0.04 – 0.12
		ROP	1.7	-0.1 – 3.8	-0.02	-0.11 – 0.06
		RC	-0.1	-1.5 – 1.3	-0.01	-0.09 – 0.07
2018	Carbon	RB (Intercept)	35	27 – 46	2.75	2.31 – 3.19
		P	5	-11 – 22	-0.05	-0.72 – 0.63
		PC	-3	-17 – 11	0.01	-0.66 – 0.69
		C	-12	-25 – 0.0	-1.05	-1.72 – -0.37
		REM	26	9.0 – 45	0.25	-0.35 – 0.84
		ROP	21	4.0 – 41	0.27	-0.34 – 0.88
		RC	4	-10 – 18	-0.22	-0.81 – 0.37
	Nitrogen	RB (Intercept)	2.8	2.2 – 3.8	0.22	0.17 – 0.26
		P	0.4	-0.8 – 1.9	0.00	-0.07 – 0.06
		PC	-0.2	-1.3 – 1.1	0.02	-0.05 – 0.08
		C	-1.0	-2.0 – 0.0	-0.08	-0.14 – -0.01
		REM	1.7	0.4 – 3.2	0.00	-0.06 – 0.06
		ROP	2.1	0.6 – 3.9	0.04	-0.02 – 0.10

RC	0.4	-0.8 – 1.5	-0.03	-0.08 – 0.03
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Table S9. FDR-adjusted P-values for pairwise comparisons of PERMANOVA distance matrix for relative change in 0–10 cm soil C and N concentrations and C and N accrual rates for land-use histories. PERMANOVA relative change test F-ratio is 1.9 and P-value is 0.1. PERMANOVA accrual rate test F-ratio is 2.6 and P-value is 0.5. Degrees of freedom are 6 (model) and 20 (residual). P is cow pasture, PC is pasture converted from row crop fields, C is row crop fields, REM is remnant prairie, RB is restored bison prairie, ROP is restored old pasture, and RC is restored from row crop fields.

Relative Change in g C and N kg ⁻¹ soil						
	RB	P	PC	RC	ROP	REM
P	0.56	-	-	-	-	-
PC	0.56	0.9	-	-	-	-
RC	0.49	0.83	0.67	-	-	-
ROP	0.56	0.65	0.9	0.56	-	-
REM	0.75	0.65	0.67	0.56	0.61	-
C	0.49	0.49	0.49	0.49	0.49	0.49
g C and N m ⁻² yr ⁻¹						
	RB	P	PC	RC	ROP	REM
P	0.79	-	-	-	-	-
PC	0.77	0.77	-	-	-	-
RC	0.77	0.77	0.74	-	-	-
ROP	0.31	0.38	0.43	0.31	-	-
REM	0.66	0.66	0.67	0.67	0.31	-
C	0.31	0.31	0.43	0.31	0.31	0.66