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Appendix S1. List of 63 species recorded within the full 240 experimental plots at the Bracken field site across the 2010 growing season (prior to treatments). Nomenclature follows Gleason and Cronquist (1991).

Achillea millefolium L.
Agropyron repens (L.) Beauv.
Agrostis stolonifera L.
Antennaria neglecta Greene.
Apocynum androsaemifolium L.
Asclepias syriaca L.
Barbarea vulgaris R. Br.
Bromus inermis Leysser.
Carex blanda (Dewey) Boott.
Carex gracillima Schwein.
Carex granularis Muhl.
Carex pensylvanica Lam.
Centaurea jacea L.
Cerastium arvense L.
Cerastium fontanum L.
Cirsium vulgare (Savi) Tenore.
Dactylis glomerata L.
Danthonia spicata (L.) F. Beauv.
Daucus carota L.
Dianthus armeria L.
Echium vulgare L.
Erigeron annuus (L.) Pers.
Erysimum cheiranthoides L.
Festuca rubra L.
Fragaria virginiana Duchesne.
Gallium mollugo L.
Hieracium aurantiacum L.
Hieracium caespitosum Dumort.
Hypericum perforatum L.
Inula helenium L.
Juncus tenuis Willd.
Lepidium campestre (L.) R. Br.
Leucanthemum chrysanthemum L.
Linaria vulgaris Hill.
Lotus corniculata L.
Medicago lupulina L.
Melilotus alba Desr.
Oxalis stricta L.
Phleum pratense L.
Physalis heterophylla Nees.
Plantago lanceolata L.
Poa compressa L.
Poa pratensis L.
Potentilla argentea L.
Potentilla recta L.
Prunella vulgaris L.
Ranunculus abortivus L.
Ranunculus acris L.
Rumex acetosella L.
Rumex crispus L.
Satureja vulgaris (L.) Fritsch.
Sisyrinchium montanum Greene.
Solidago Canadensis L.
Taraxacum officinale Weber Ex Wiggers.
Tragopogon dubius Scop.
Trifolium dubium Sibth.
Trifolium hybridum L.
Trifolium pratense L.
Trifolium repens L.
Veronica serpyllifolia L.
Vicia cracca L.
Vicia tetrasperma (L.) Moench.

References

Gleason, H. A., & Cronquist, A. (1991). Manual of Vascular Plants of Northeastern United States and Adjacent Canada. 2nd Edition. Bronx, NY: The New York Botanical Garden.

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Appendix S2. Images of field experiment at various times during the growing season.

FIGURE 1. Field site showing the broad layout of the experiment with several rows of the rainout and other treatment plots laid out in randomized order (August 11, 2011).

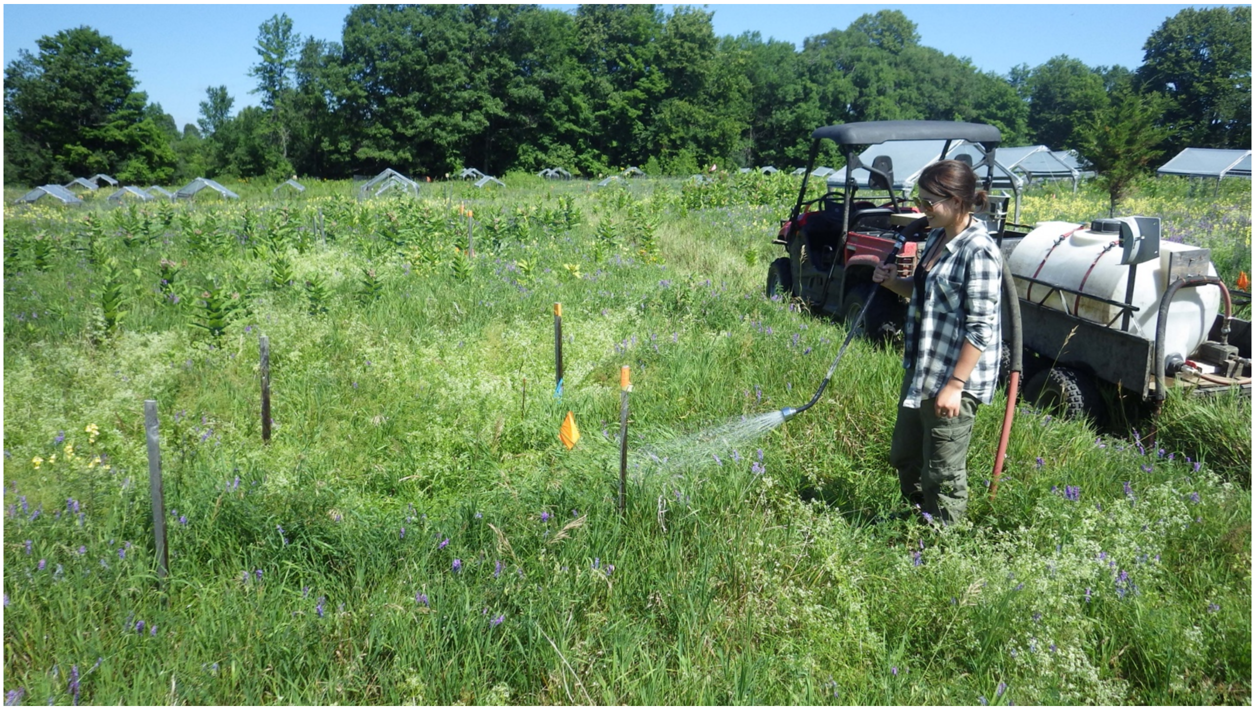

FIGURE 2. Water addition treatment plot (July 20, 2015).

FIGURE 3. Herbivore exclosure treatment plot (May 27, 2011)

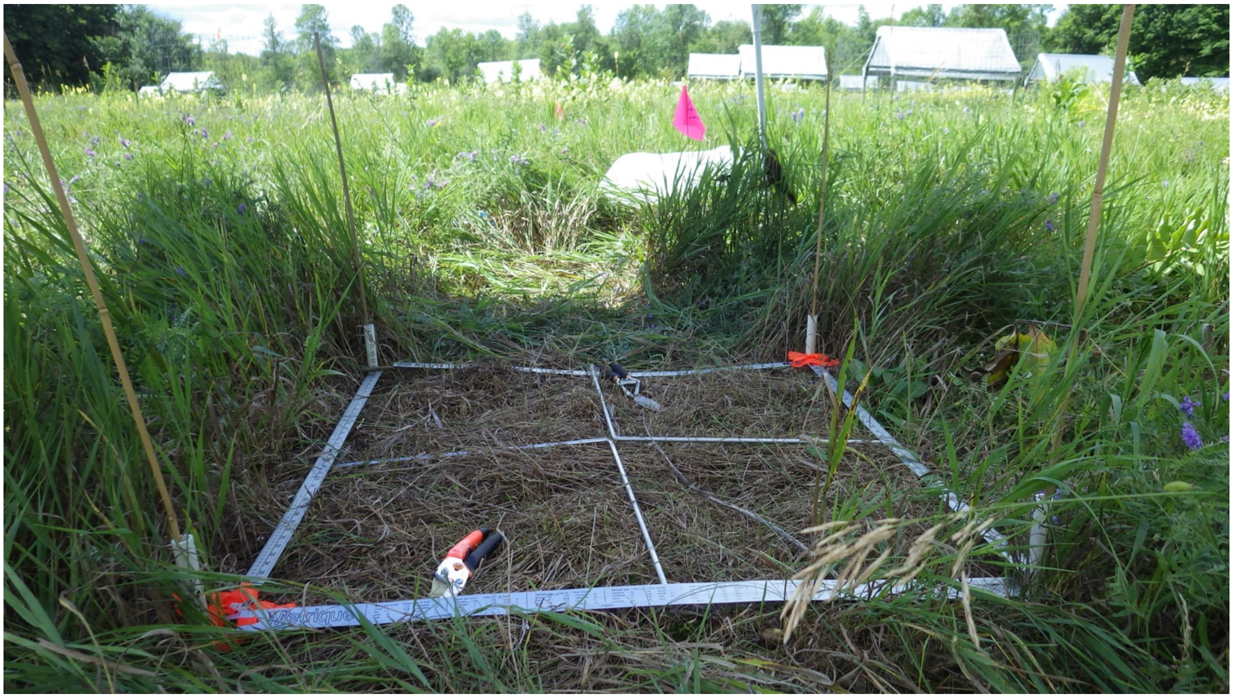

FIGURE 4. A harvested plot (July 22, 2015).

FIGURE 5. One of the exclosure plots with substantial build-up of previous years' standing dead mass outside the central 1 m^2 harvest sampling area but inside the edges of the fencing (May 25, 2017).

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Appendix S3. Historical total summer (June, July, and August) precipitation (2000 – 2015) recorded by Environment Canada near the study site.

Mean weekly summer (June, July, and August) precipitation for the pre-treatment period (2000 – 2010) was 15.87 mm (i.e. L / m^2). Accordingly, each 2.95 m^2 experimental plot would have historically received an average of 46.82 L of precipitation weekly during the months of June, July, and August.

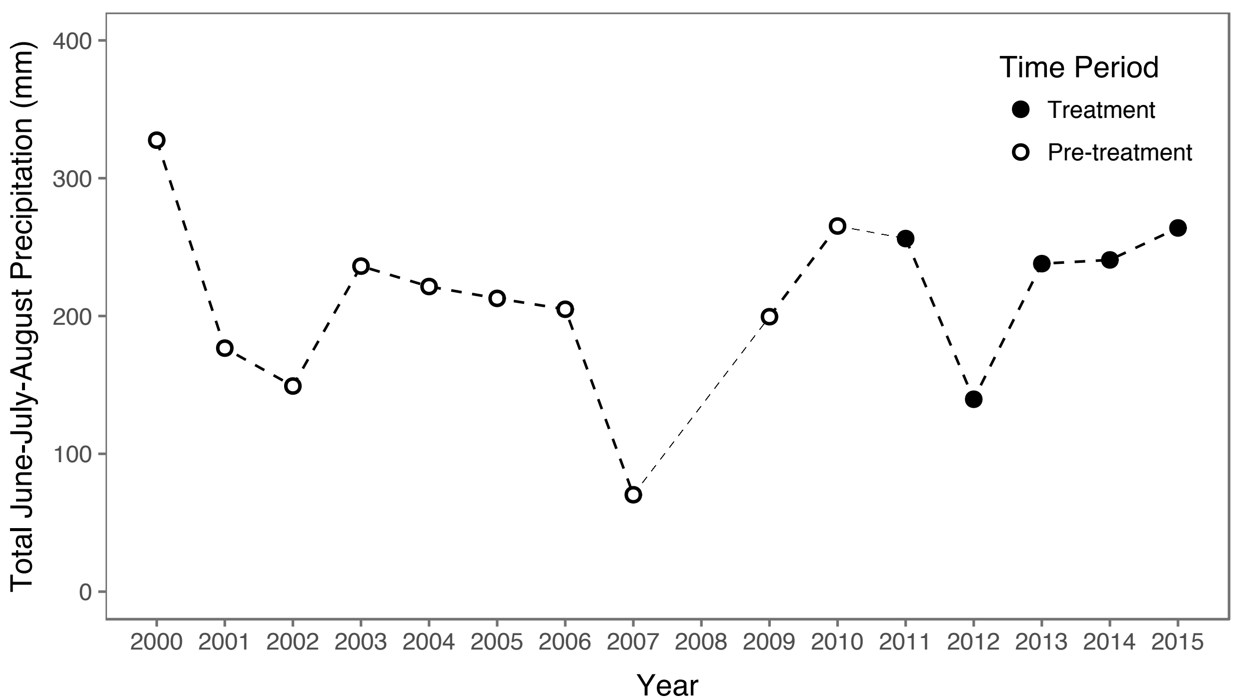

FIGURE 1. Total Kingston, ON summer precipitation (June, July and August) for the treatment period (2011 – 2015) and for 11 years prior to the treatment period (data were unavailable for 2008). Data sourced from Environment Canada's Kingston Climate weather station (44.223, -76.599) for 2009 – 2015 and Kingston Pumping weather station (44.244, -76.481) for 2000 – 2007 (http://climate.weather.gc.ca/prods_servs/cdn_climate_summary_e.html). Produced with *ggplot2* (Wickham 2009).

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Appendix S4. Assessment of the effects of the rainout shelter treatment on plot microclimates.

Methods:

Soil temperature, air temperature, and light penetration readings were taken around midday on July 27, 2016, a clear and calm day, to determine whether the soil moisture treatment — i.e. rainout shelters and water additions — altered plot microclimates. The soil temperature measurements were taken using a digital thermometer (Model No. 7867; Fisher Scientific) at two depths (2 cm and 10 cm) for each of 60 unharvested plots (20 reduced soil moisture plots, 20 natural soil moisture plots, and 20 increased soil moisture plots). Each measurement is the average of four readings (NE, NW, SW, and SE corners).

For each of 10 rainout shelter plots, air temperature was recorded using a Digi-Sense temperature probe (Model No. 8528-30; Cole-Parmer Instrument Co.) and photosynthetically active radiation (PAR) was recorded using a Quantum Sensor (Model No. LI-190R; LI-COR Biosciences) at a height of 1 m above ground and centered underneath the rainout shelter, and also (at the same time) outside of and adjacent to the rainout shelter. Each measurement is the average of three readings.

Paired t-tests were used to analyze the light penetration and air temperature data. Soil temperature data were analyzed using a two-way analysis of variance (ANOVA) with Type II sums of squares and measurement depth and soil moisture treatment as fixed factors (function 'Anova'; package *car*). Pairwise differences among treatments were tested using LSMEANS with Tukey's HSD *post-hoc* tests (function 'lsmeans'; package *lsmeans*).

Results:

The rainout shelters significantly reduced light intensity by 26.4 % ($t_9 = 6.30$, $P = 0.00014$). Light intensity was not, however, reduced below the light saturation points of *Bromus inermis* or *Poa pratensis* — two of the most abundant plant species (Figure C1). No difference in air temperature was found inside versus outside the rainout shelters ($t_9 = 0.87$, $P = 0.41$; Figure C2). As expected, soil temperature was significantly lower at the 10 cm than the 2 cm measurement depth (Table C1). Across the two measurement depths soil temperature varied significantly between soil moisture treatments with post hoc analyses revealing that the increased soil moisture treatment significantly reduced soil temperature by 1.75 °C on average (Table C2, Figure C3).

TABLE 1. Analysis of variance (ANOVA) for plot soil temperature (°C). Factors in this analysis include 2 cm and 10 cm measurements depths (measurement depth), and decreased (n = 20), natural (n = 20), and increased (n = 20) soil moisture treatments (watering treatment). Plot elevation, soil depth, and clay content were included as covariates.

Source	**SS**	**df**	**MS**	**F**	***P***
Measurement Depth	2915.60	1	2915.60	794.36	< 0.0001
Watering Treatment	27.74	2	13.87	3.78	0.026
Measurement Depth × Watering Treatment	6.66	2	3.33	0.91	0.41
Residuals	418.42	114	3.66		

TABLE 2. Tukey HSD post hoc test on the pairwise differences in plot soil temperature among the soil moisture treatment groups: W-1 = reduced soil moisture; W0 = natural soil moisture; W1 = increased soil moisture

Comparison	**Mean Soil Temperature Diff.**	**SE**	**t ratio**	***P***
W0 – W-1	0.90	0.61	1.48	0.30
W1 – W-1	-0.86	0.61	-1.41	0.34
W1 – W0	-1.75	0.61	-2.89	0.0126

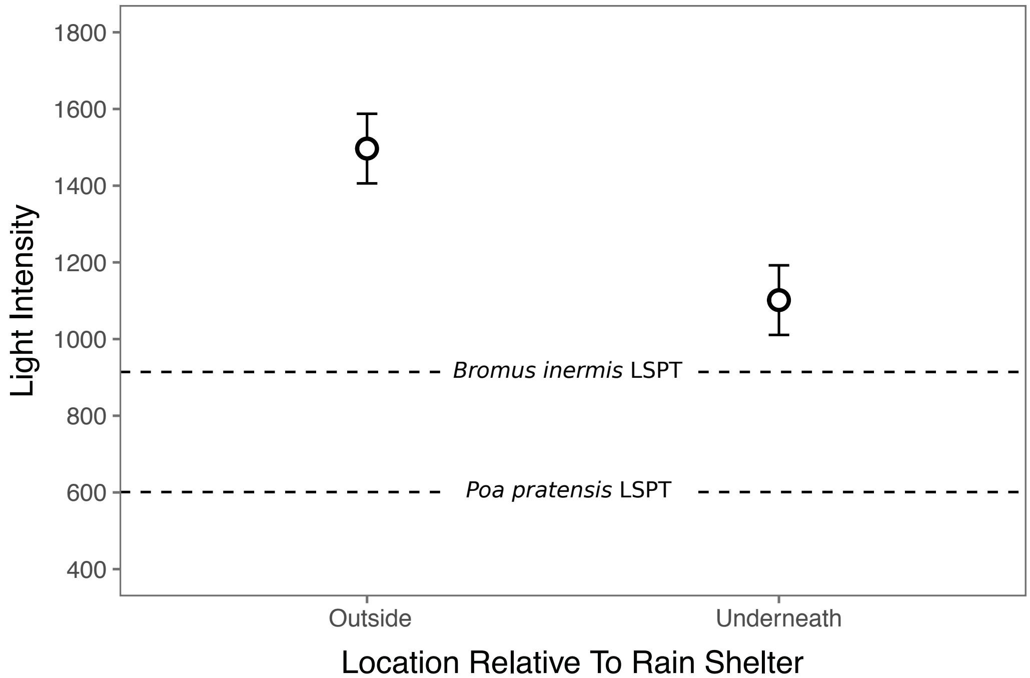

FIGURE 1. Light intensity (µmol PAR m^{-2} s^{-1}) outside of and underneath the rainout shelters. Dashed lines represent *Bromus inermis* and *Poa pratensis* light saturation points (LSPTs) (Smith and Knapp 2001). Points represent least square means (n = 10) (function 'lsmeans'; package *lsmeans*) with 95 % confidence intervals (CIs). Produced with *ggplot2* (Wickham 2009).

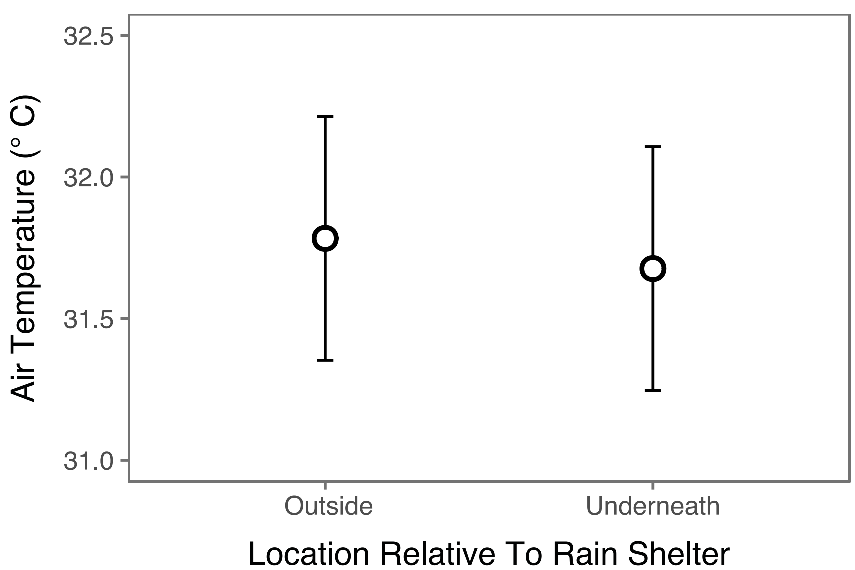

FIGURE 2. Air temperature (°C) outside of and underneath the rainout shelters. Points represent least square means (n = 10) (function 'lsmeans'; package *lsmeans*) with 95 % confidence intervals (CIs). Produced with *ggplot2* (Wickham 2009).

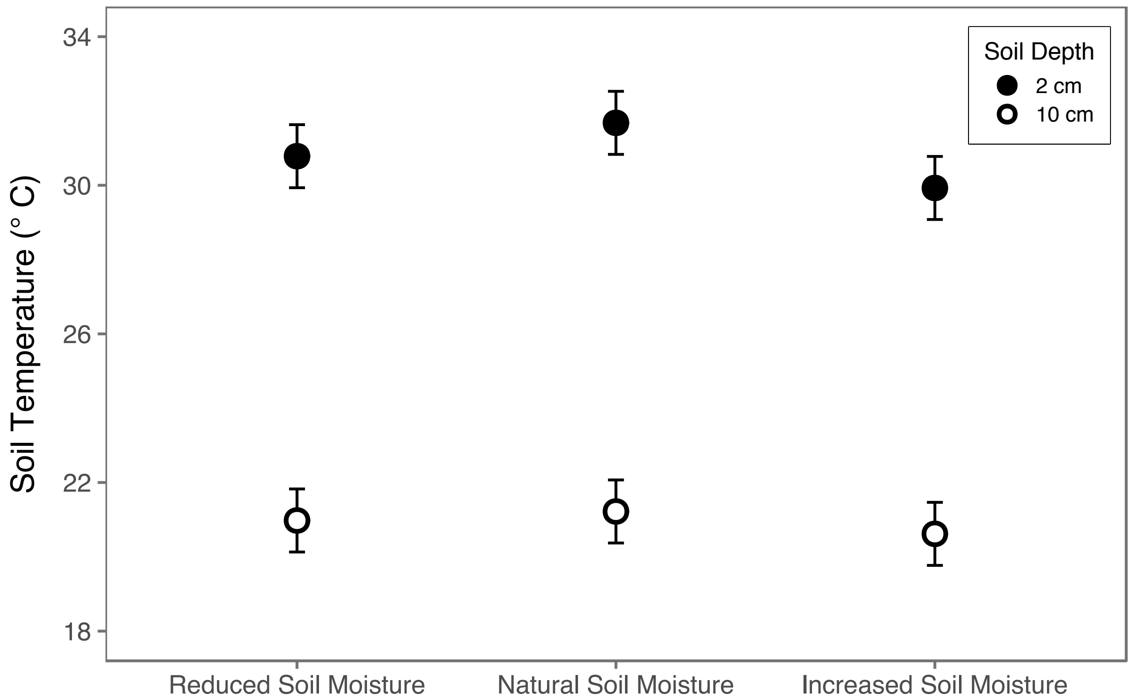

FIGURE 3. Plot soil temperatures (°C) at 2 and 10 cm depth under the three soil moisture treatments. Data points are least square means (n = 20) (function 'lsmeans'; package *lsmeans*) with 95 % confidence intervals (CIs). Produced with *ggplot2* (Wickham 2009).

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Appendix S5. List of 33 species recorded at the Bracken field site within the 120 plots harvested in 2015. Four additional distinct but very rare species were recorded but identification was not possible. Nomenclature follows Gleason and Cronquist (1991).

Agrostis stolonifera L.
Asclepias syriaca L.
Aster lanceolatus Willd.
Aster novae-angliae L.
Aster umbellatus Miller.
Barbarea vulgaris R. Br.
Bromus inermis Leysser.
Carex livida
Centaurea jacea L.
Cerastium arvense L.
Cerastium fontanum L.
Erigeron annuus (L.) Pers.
Festuca rubra L.
Gallium mollugo L.
Hieracium spp.
Hypericum perforatum L.
Linaria vulgaris Hill.
Lotus corniculata L.
Panicum linearifolium Scribn.
Phleum pratense L.
Physalis heterophylla Nees.
Plantago lanceolata L.
Poa pratensis L.
Potentilla recta L.
Ranunculus acris L.
Silene vulgaris (Moench) Garcke.
Solidago rugosa Mill.
Solidago Canadensis L.
Stellaria media (L.) Villars.
Taraxacum officinale Weber Ex Wiggers.
Trifolium dubium Sibth.
Trifolium pratense L.
Vicia cracca L.

References

Gleason, H. A., & Cronquist, A. (1991). Manual of Vascular Plants of Northeastern United States and Adjacent Canada. 2nd Edition. Bronx, NY: The New York Botanical Garden.

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Appendix S6. Mixed model ANCOVA results for the effects of the watering treatments on soil volumetric water content.

TABLE 1. Mixed model ANCOVA results for the effects of the watering treatments on soil volumetric water content (vol %) at 12 watering dates across the 2016 growing season (date). Factors in this analysis include decreased (n = 40), natural (n = 40), and increased (n = 40) soil moisture treatments (watering treatment). Plot elevation, soil depth, and clay content were included as covariates. Block (proportion of variance explained = 16%) and plot (proportion of variance explained = 51%) were included as random factors in the model.

Source	F	df	Residual df	*P*
Watering Treatment	87.31	2	105.37	< 0.0001
Date	540.18	11	1287.00	< 0.0001
Plot Elevation	0.49	1	70.98	0.48
Plot Soil Depth	2.66	1	110.03	0.11
Clay Content	4.14	1	111.82	0.044
Watering Treatment × Date	100.49	22	1287.00	< 0.0001

TABLE 2. Mixed model ANCOVA results for the effects of the watering treatments on soil plot volumetric water content (vol %) on July 28 (pre-watering), July 28 (post-watering), August 2, and August 4 (date). Factors in this analysis include decreased (n = 40), natural (n = 40), and increased (n = 40) soil moisture treatments (watering treatment). Plot elevation, soil depth, and clay content were included as covariates. Block and plot were included as random factors in the model.

Source	F	df	Residual df	*P*
Watering Treatment	60.10	2	105.45	< 0.0001
Date	293.41	3	351.00	< 0.0001
Plot Elevation	0.0017	1	59.16	0.97
Plot Soil Depth	3.48	1	111.00	0.065
Clay Content	12.83	1	112.86	0.00050
Watering Treatment × Date	203.59	6	351.00	< 0.0001

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Appendix S7. Mixed model ANCOVA for total plot above-ground live plant dry biomass.

TABLE 1. Mixed model ANCOVA for total plot above-ground live plant dry biomass (g / m^2). Factors in this analysis include decreased (n = 39), natural (n = 40), and increased (n = 40) soil moisture (soil moisture), natural (n = 59) and increased (n = 60) soil nutrients (soil nutrients), and the absence (n = 60) or presence (n = 59) of herbivore exclosures (exclosure). Plot elevation, soil depth, and clay content were included as covariates. Block was included as a random factor in the model (proportion of variance explained = 24%).

Source	F	df	Residual df	*P*
Soil Moisture	36.70	2	95.17	< 0.0001
Soil Nutrients	44.88	1	95.61	< 0.0001
Exclosure	0.0009	1	95.73	0.98
Plot Elevation	0.16	1	68.76	0.69
Plot Soil Depth	12.51	1	101.95	0.00061
Clay Content	0.20	1	102.93	0.66
Soil Moisture × Soil Nutrients	3.47	2	95.76	0.035
Soil Moisture × Exclosure	1.24	2	95.44	0.29
Soil Nutrients × Exclosure	0.74	1	95.47	0.39
Soil Moisture × Soil Nutrients × Exclosure	1.04	2	95.46	0.36

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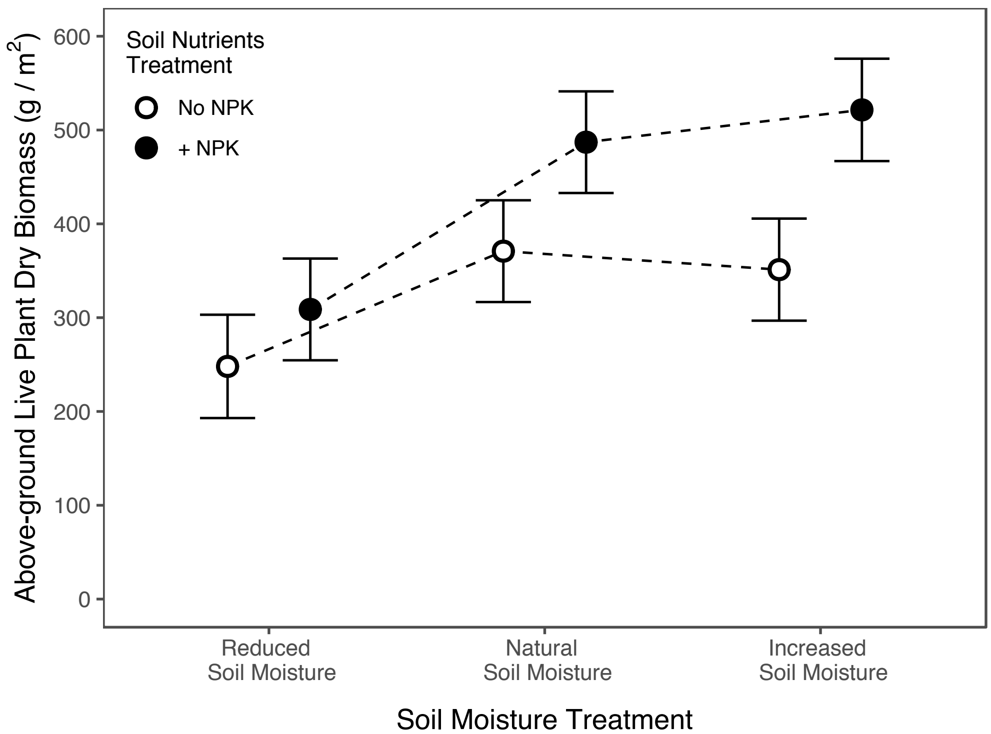
Appendix S8. Soil moisture treatment × soil nutrients treatment interaction plot for the analyses of aboveground live plant biomass. Since the exclosure treatment had no significant effects on shoot biomass, the data from the exclosure and non-exclosure plots have been combined for this figure. Data points are least square means (n= 20) with 95 % confidence intervals (CIs).



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Appendix S9. Plot standing dead material in proportion to total live shoot biomass.

TABLE 1. Mixed model ANCOVA for plot standing dead relative biomass. Factors in this analysis include decreased (n = 39), natural (n = 40), and increased (n = 40) soil moisture (soil moisture), natural (n = 59) and increased (n = 60) soil nutrients (soil nutrients), and the absence (n = 60) or presence (n = 59) of herbivore exclosures (exclosure). Plot elevation, soil depth, and clay content were included as covariates. Block was included as a random factor in the model (proportion of variance explained = 0%).

Source	F	df	Residual df	*P*
Soil Moisture	4.38	2	28.86	0.022
Soil Nutrients	0.00018	1	74.71	0.99
Exclosure	1.86	1	103.97	0.18
Plot Elevation	0.30	1	18.56	0.59
Plot Soil Depth	0.00073	1	97.81	0.98
Clay Content	1.28	1	81.37	0.26
Soil Moisture × Soil Nutrients	0.85	2	83.77	0.43
Soil Moisture × Exclosure	0.71	2	103.60	0.49
Soil Nutrients × Exclosure	0.41	1	103.34	0.53
Soil Moisture × Soil Nutrients × Exclosure	0.10	2	103.67	0.90

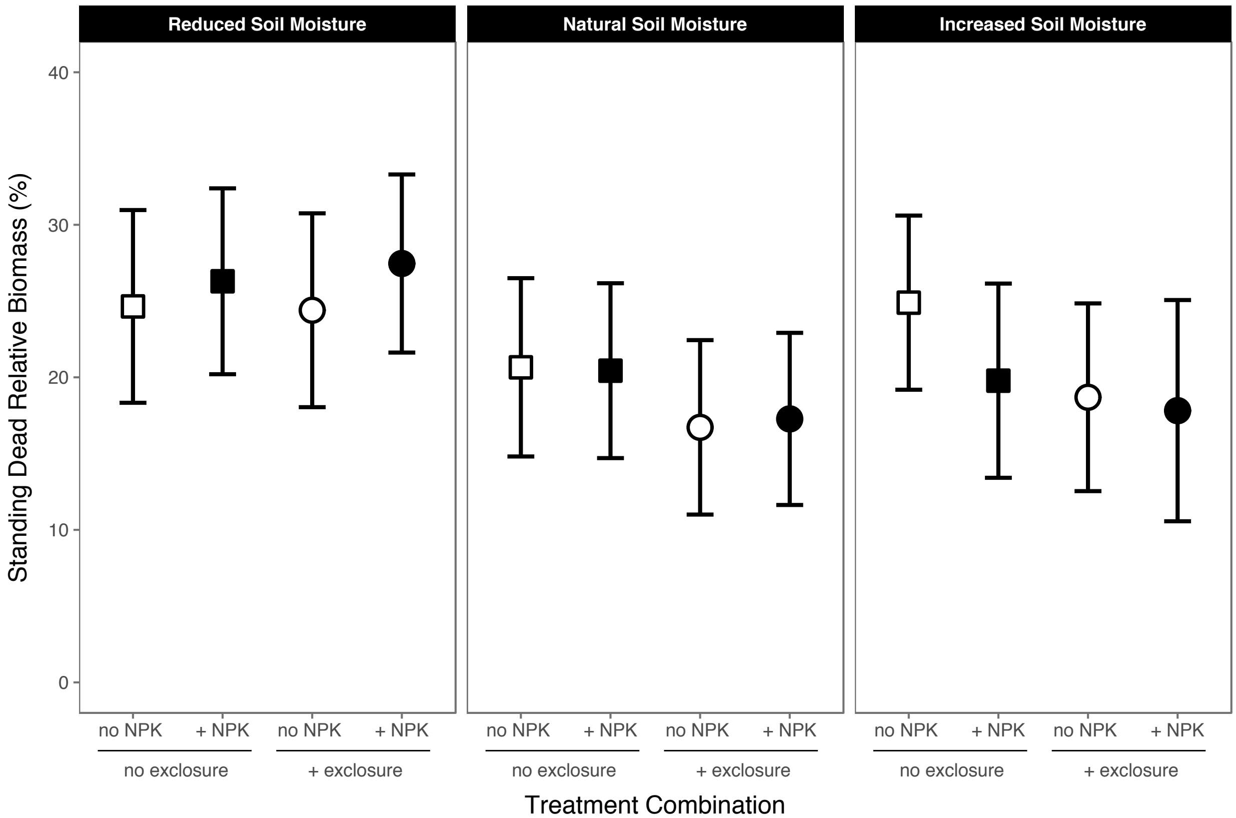

FIGURE 1. Effects of soil moisture (reduced, natural and increased), soil nutrients (natural levels [no NPK, white points] and increased [+ NPK, black points]), and herbivore exclosure treatments (exclosure absent [no exclosure, square points] and exclosure present [+ exclosure, circle points]) on the proportion of standing dead to live plant biomass in each plot (%). Data points are least square means (function 'lsmeans'; package *lsmeans*) with 95 % confidence intervals (CIs). Produced with *ggplot2* (Wickham 2009).

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Appendix S10. Species pools and species proportional abundances in each experimental treatment group.

TABLE 1. List of species and respective proportional abundances (% of total plot biomass dry weight) recorded within the soil moisture treatment groups at the Bracken field site in 2015. Nomenclature follows Gleason and Cronquist (1991).

Reduced Soil Moisture		**Natural Soil Moisture**		**Increased Soil Moisture**	
Species	**%**	**Species**	**%**	**Species**	**%**
B. inermis	66	*B. inermis*	54	*B. inermis*	50
L. vulgaris	15	*A. syriaca*	14	*A. syriaca*	11
A. syriaca	5.8	*P. pratensis*	9.9	*P. pratensis*	9.6
G. mollugo	5.7	*L. vulgaris*	8.2	*L. vulgaris*	8.1
V. cracca	4.6	*V. cracca*	4.9	*G. mollugo*	5.4
P. pratensis	1.8	*C. jacea*	3.9	*C. jacea*	4.3
C. jacea	0.11	*A. novae-angliae*	1.7	*V. cracca*	4.2
C. livida	0.0059	*G. mollugo*	1.6	*A. novae-angliae*	1.8
Hieracium spp.	0.0021	*P. heterophylla*	1.0	*C. livida*	1.3
C. fontanum	< 0.001	*Hieracium spp.*	0.67	*C. arvense*	1.1
		C. livida	0.27	*Hieracium spp.*	0.87
		C. arvense	0.18	*S. Canadensis*	0.69
		S. Canadensis	0.083	*S. rugosa*	0.66
		P. pratense	0.041	*A. lanceolatus*	0.39
		Unknown	0.025	*F. rubra*	0.38
		H. perforatum	0.012	*B. vulgaris*	0.079
		S. vulgaris	0.0085	*H. perforatum*	0.053
		C. fontanum	0.0036	*P. pratense*	0.036
		R. acris	0.0033	*T. dubium*	0.015
		P. recta	< 0.001	*P. recta*	0.0057
				L. corniculata	0.0049
				T. pratense	0.0045
				A. stolonifera	0.0045
				Unknown 1	0.0042
				P. lanceolata	0.0038
				T. officinale	0.0036
				E. annuus	0.0034
				S. media	0.0027
				P. linearifolium	0.0025
				Unknown 2	0.0011
				A. umbellatus	< 0.001
				Unknown 3	< 0.001

TABLE 2. List of species and respective proportional abundances (% of total plot dry weight biomass) recorded within the soil nutrient treatment groups at the Bracken field site in 2015. Nomenclature follows Gleason and Cronquist (1991).

Natural Soil Nutrient Levels		**Increased Soil Nutrient Levels**	
Species	**%**	**Species**	**%**
B. inermis	52	*B. inermis*	58
P. pratensis	11	*A. syriaca*	13
A. syriaca	7.9	*L. vulgaris*	11
L. vulgaris	7.9	*P. pratensis*	5.8
V. cracca	5.8	*V. cracca*	3.6
G. mollugo	5.2	*G. mollugo*	3.2
C. jacea	4.1	*C. jacea*	2.4
A. novae-angliae	2.7	*C. arvense*	0.76
C. livida	1.2	*P. heterophylla*	0.68
Hieracium spp.	1.1	*A. novae-angliae*	0.35
S. Canadensis	0.65	*A. lanceolatus*	0.26
F. rubra	0.32	*S. rugosa*	0.23
S. rugosa	0.28	*H. spp.*	0.18
C. arvense	0.12	*C. livida*	0.17
H. perforatum	0.057	*B. vulgaris*	0.052
Unknown	0.022	*P. pratense*	0.043
T. dubium	0.013	*S. Canadensis*	0.032
P. pratense	0.011	*F. rubra*	0.017
P. recta	0.0054	*S. vulgaris*	0.006
L. corniculata	0.0044	Unknown 2	< 0.001
T. pratense	0.0041	*H. perforatum*	< 0.001
A. stolonifera	0.0040	*C. fontanum*	< 0.001
Unknown 1	0.0038	*A. umbellatus*	< 0.001
P. lanceolata	0.0034	Unknown 3	< 0.001
T. officinale	0.0032		
C. fontanum	0.0032		
E. annuus	0.0030		
R. acris	0.0029		
S. media	0.0024		
P. linearifolium	0.0023		

TABLE 3. List of species and respective proportional abundances (% of total plot dry weight biomass) recorded within the herbivore exclosure treatment groups at the Bracken field site in 2015. Nomenclature follows Gleason and Cronquist (1991).

Herbivore Exclosure Absent		**Herbivore Exclosure Present**	
Species	**%**	**Species**	**%**
B. inermis	57	*B. inermis*	53
L. vulgaris	10	*A. syriaca*	14.3
P. pratensis	8.3	*L. vulgaris*	9.7
A. syriaca	7.1	*P. pratensis*	7.4
V. cracca	5.3	*G. mollugo*	6.2
C. jacea	5.1	*V. cracca*	3.8
G. mollugo	1.8	*A. novae-angliae*	1.9
Hieracium spp.	1.1	*C. jacea*	1.2
C. arvense	0.82	*P. heterophylla*	0.78
A. novae-angliae	0.75	*C. livida*	0.58
C. livida	0.63	*F. rubra*	0.16
S. Canadensis	0.59	*C. arvense*	0.15
S. rugosa	0.51	*Hieracium spp.*	0.12
A. lanceolatus	0.30	*B. vulgaris*	0.060
F. rubra	0.14	Unknown	0.019
P. pratense	0.056	*S. vulgaris*	0.0064
H. perforatum	0.050	*P. pratense*	0.0034
T. dubium	0.011	*E. annuus*	0.0026
L. corniculata	0.0037	*C. fontanum*	0.0026
T. pratense	0.0035	*S. media*	0.0021
A. stolonifera	0.0034	*P. recta*	0.0019
Unknown 1	0.0032	Unknown 2	< 0.001
P. lanceolata	0.0029	*A. umbellatus*	< 0.001
T. officinale	0.0027		
P. recta	0.0027		
R. acris	0.0025		
P. linearifolium	0.0019		
C. fontanum	< 0.001		
Unknown 3	< 0.001		

References

Gleason, H. A., & Cronquist, A. (1991). Manual of Vascular Plants of Northeastern United States and Adjacent Canada. 2nd Edition. Bronx, NY: The New York Botanical Garden.

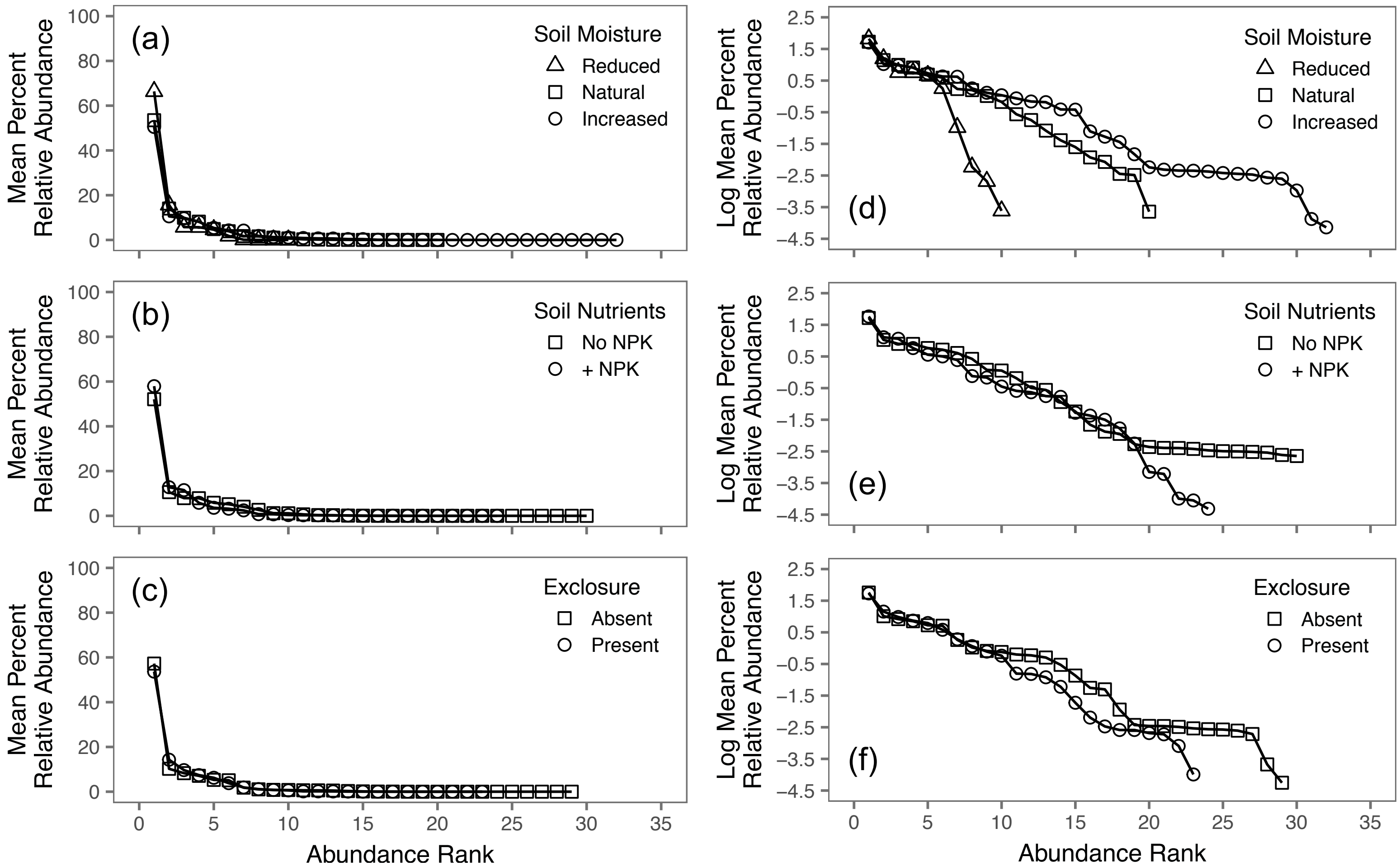

FIGURE 1. Species rank abundance curves for the (a, d) soil moisture treatments (decreased [n = 39], natural [n = 40], and increased [n = 40]), (b, e) soil nutrients treatments (no NPK [n = 59] and + NPK [n = 60]), and (c, f) herbivore exclosure treatments (exclosure absent [n = 60] versus present [n = 59]). The Y-axes data in (a – c) are log-transformed in (d – f) respectively. Complete treatment species pools and proportional abundances can be found in Appendix G.

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Appendix S11. 2010 plant species composition analyses.

TABLE 1. PERMANOVA on the dissimilarity matrix accounting for total dissimilarity of 2010 ('initial') plant species composition among plots that were subsequently assigned to: three soil moisture treatments (decreased [n = 39], natural [n = 40], and increased [n = 40]), two nutrients treatments (natural [n = 59] and increased [n = 60]), and two herbivore exclosure treatments (absent [n = 60] versus present [n =59]).

Source	df	SS	MS	F	R^2	*P*
Soil Moisture	2	0.21	0.11	0.88	0.015	0.59
Soil Nutrients	1	0.12	0.12	0.99	0.0085	0.44
Exclosure	1	0.12	0.12	1.02	0.0088	0.43
Soil Moisture × Soil Nutrients	2	0.17	0.086	0.71	0.012	0.75
Soil Moisture × Exclosure	2	0.17	0.084	0.69	0.012	0.77
Soil Nutrients × Exclosure	1	0.041	0.041	0.34	0.0029	0.91
Soil Moisture × Soil Nutrients × Herbivory	2	0.28	0.14	1.16	0.020	0.31
Residuals	107	12.98	0.12		0.92	
Total	118	14.10			1.00	

TABLE 2. PERMANOVA on the dissimilarity matrix accounting for nestedness-resultant dissimilarity of 2010 ('initial') plant species composition among plots that were subsequently assigned to: three soil moisture treatments (decreased [n = 39], natural [n = 40], and increased [n = 40]), two nutrients treatments (natural [n = 59] and increased [n = 60]), and two herbivore exclosure treatments (absent [n = 60] versus present [n =59]).

Source	df	SS	MS	F	R^2	*P*
Soil Moisture	2	0.020	0.0098	0.87	0.014	0.47
Soil Nutrients	1	0.018	0.018	1.62	0.013	0.25
Exclosure	1	0.034	0.034	3.06	0.025	0.10
Soil Moisture × Soil Nutrients	2	0.0034	0.0017	0.15	0.0026	0.77
Soil Moisture × Exclosure	2	0.0070	0.0035	0.31	0.0052	0.70
Soil Nutrients × Exclosure	1	0.00064	0.00064	0.057	0.00047	0.72
Soil Moisture × Soil Nutrients × Exclosure	2	0.066	0.033	2.95	0.049	0.073
Residuals	107	1.20	0.011		0.89	
Total	118	1.35			1.00	

TABLE 3. PERMANOVA on the dissimilarity matrix accounting for spatial turnover of 2010 ('initial') plant species composition among plots that were subsequently assigned to: three soil moisture treatments (decreased [n = 39], natural [n = 40], and increased [n = 40]), two nutrients treatments (natural [n = 59] and increased [n = 60]), and two herbivore exclosure treatments (absent [n = 60] versus present [n =59]).

Source	df	SS	MS	F	R^2	*P*
Soil Moisture	2	0.13	0.064	0.83	0.015	0.60
Soil Nutrients	1	0.026	0.026	0.34	0.0030	0.81
Exclosure	1	0.067	0.067	0.87	0.0077	0.53
Soil Moisture × Soil Nutrients	2	0.12	0.060	0.78	0.014	0.63
Soil Moisture × Exclosure	2	0.065	0.032	0.42	0.0073	0.86
Soil Nutrients × Exclosure	1	0.030	0.030	0.39	0.0034	0.77
Soil Moisture × Soil Nutrients × Exclosure	2	0.089	0.044	0.57	0.010	0.77
Residuals	107	8.28	0.077		0.94	
Total	118	8.81			1.00	

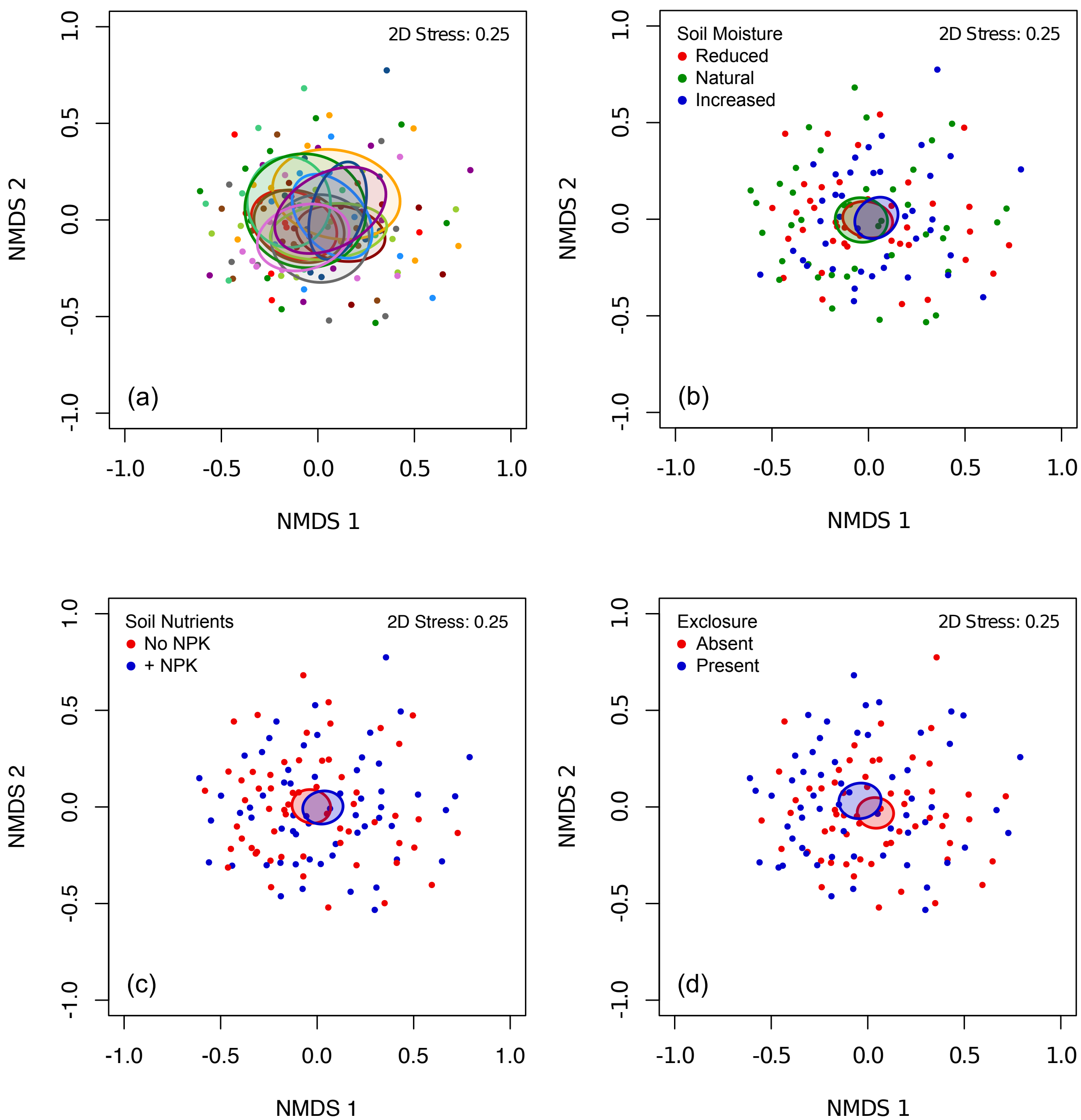

FIGURE 1. Nonmetric multidimensional scaling (NMDS) plots showing 2010 ('initial') plant species composition similarity (Bray-Curtis, presence/absence species matrix) among plots that were subsequently assigned to: (a) all twelve treatment combinations, (b) three soil moisture treatments (decreased [n = 39], natural [n = 40], and increased [n = 40]), (c) two nutrients treatments (no NPK [n = 59] and + NPK [n = 60]), and (d) two herbivore exclosure treatments (exclosure absent [n = 60] versus present [n = 59]). Ellipses are 95% confidence intervals of the mean for each treatment level. Each dot (119 in total) represents a 1 × 1 m plot.

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Appendix S12. 2015 plant species composition analyses.

TABLE 1. PERMANOVA on the dissimilarity matrix accounting for total dissimilarity of 2015 plant species composition among plots assigned to: three soil moisture treatments (decreased [n = 39], natural [n = 40], and increased [n = 40]), two nutrients treatments (natural [n = 59] and increased [n = 60]), and two herbivore exclosure treatments (absent [n = 60] versus present [n =59]).

Source	df	SS	MS	F	R^2	*P*
Soil Moisture	2	0.98	0.49	9.36	0.13	< 0.0001
Soil Nutrients	1	0.26	0.26	5.03	0.036	0.0015
Exclosure	1	0.090	0.090	1.71	0.012	0.16
Soil Moisture × Soil Nutrients	2	0.17	0.084	1.61	0.023	0.13
Soil Moisture × Exclosure	2	0.085	0.043	0.81	0.012	0.59
Soil Nutrients × Exclosure	1	0.036	0.036	0.69	0.0049	0.61
Soil Moisture × Soil Nutrients × Exclosure	2	0.082	0.041	0.78	0.011	0.61
Residuals	107	5.62	0.053		0.77	
Total	118	7.33			1.00	

TABLE 2. PERMANOVA on the dissimilarity matrix accounting for nestedness-resultant dissimilarity of 2015 plant species composition among plots (n = 119) assigned to: three soil moisture treatments (decreased [n = 39], natural [n = 40], and increased [n = 40]), two nutrients treatments (natural [n = 59] and increased [n = 60]), and two herbivore exclosure treatments (absent [n = 60] versus present [n =59]).

Source	df	SS	MS	F	R^2	*P*
Soil Moisture	2	1.17	0.58	36.10	0.36	< 0.0001
Soil Nutrients	1	0.17	0.17	10.67	0.053	0.0021
Exclosure	1	0.046	0.046	2.86	0.014	0.097
Soil Moisture × Soil Nutrients	2	0.091	0.045	2.81	0.028	0.061
Soil Moisture × Exclosure	2	0.055	0.027	1.70	0.017	0.20
Soil Nutrients × Exclosure	1	0.019	0.019	1.20	0.0059	0.29
Soil Moisture × Soil Nutrients × Exclosure	2	-0.0053	-0.0026	-0.16	-0.0016	0.97
Residuals	107	1.73	0.016		0.53	
Total	118					

TABLE 3. PERMANOVA on the dissimilarity matrix accounting for spatial turnover of 2015 plant species composition among plots (n = 119) assigned to: three soil moisture treatments (decreased [n = 39], natural [n = 40], and increased [n = 40]), two nutrients treatments (natural [n = 59] and increased [n = 60]), and two herbivore exclosure treatments (absent [n = 60] versus present [n =59]).

Source	df	SS	MS	F	R^2	*P*
Soil Moisture	2	-0.30	-0.15	-6.22	-0.12	1.00
Soil Nutrients	1	-0.0035	-0.0035	-0.14	-0.0014	0.77
Exclosure	1	0.011	0.011	0.43	0.0043	0.64
Soil Moisture × Soil Nutrients	2	0.061	0.030	1.24	0.025	0.39
Soil Moisture × Exclosure	2	0.0039	0.0020	0.080	0.0016	0.80
Soil Nutrients × Exclosure	1	0.017	0.017	0.70	0.0070	0.56
Soil Moisture × Soil Nutrients × Exclosure	2	0.062	0.031	1.27	0.025	0.38
Residuals	107	2.61	0.024		1.06	
Total	118	2.46			1.00	

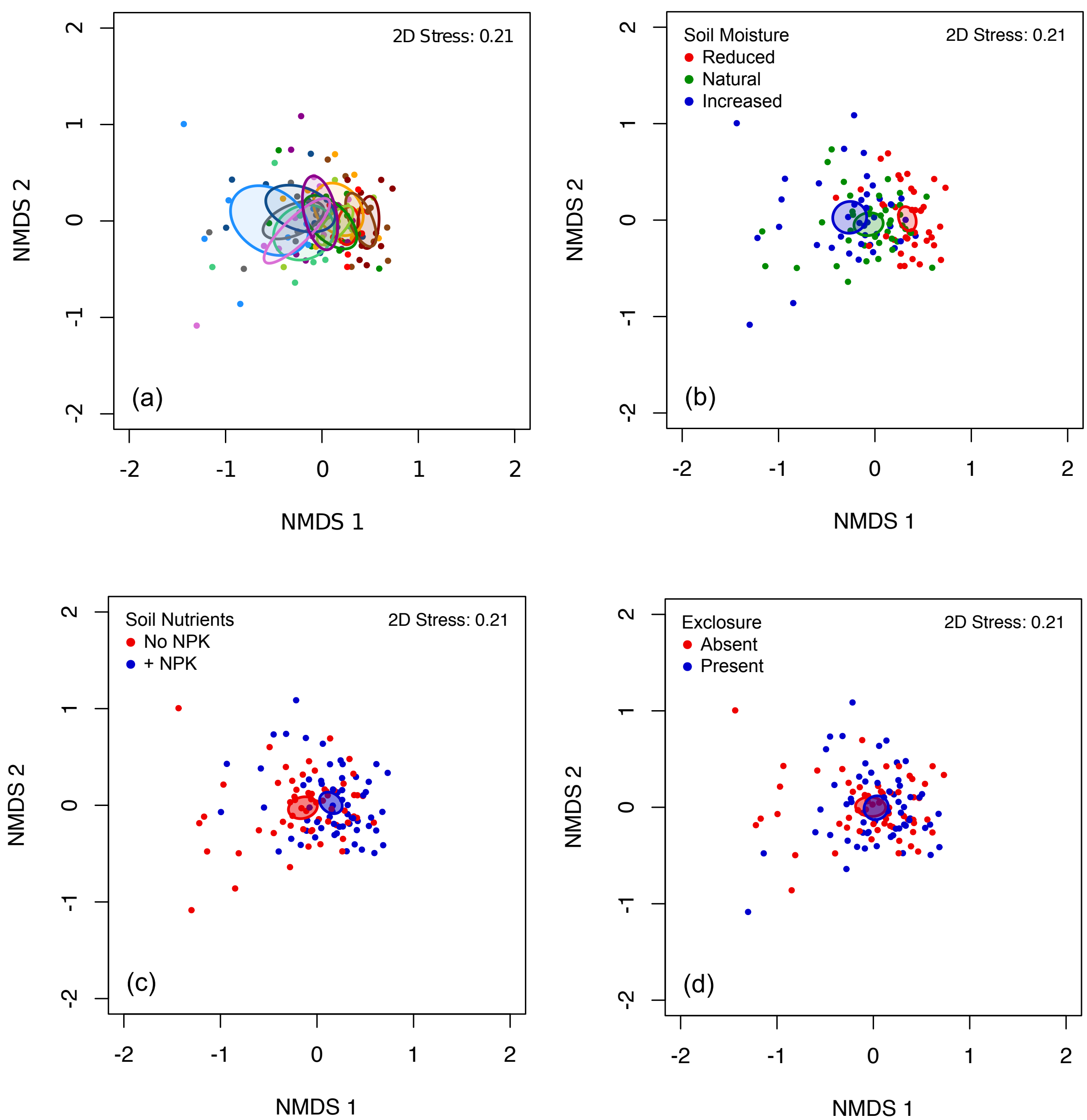

FIGURE 1. NMDS plots showing 2015 plant species composition similarity (Bray-Curtis, species' harvested above-ground biomass (abundance) matrix, Wisconsin double standardized and square-root transformed data) among plots assigned to: (a) all twelve treatment combinations, (b) three soil moisture treatments (decreased [n = 39], natural [n = 40], and increased [n = 40]), (c) two nutrients treatments (no NPK [n = 59] and + NPK [n = 60]), and (d) two herbivore exclosure treatments (exclosure absent [n = 60] versus present [n = 59]). Ellipses are 95% confidence intervals of the mean for each treatment level. Each dot (119 in total) represents a 1 × 1 m plot.

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Appendix S13. Post hoc Tukey HSD tests of soil moisture treatment intergroup comparisons on the absolute (g / 0.5 m^2) and relative biomass of species where mixed model ANCOVA identified soil moisture as a significant factor (Table 2).

	Reduced – Natural Soil Moisture		**Reduced – Increased Soil Moisture**		**Natural – Increased Soil Moisture**	
Species	**Mean Difference**	***P***	**Mean Difference**	***P***	**Mean Difference**	***P***
Bromus inermis						
Absolute biomass	–	–	–	–	–	–
Relative biomass	0.14	**0.023**	0.18	**0.0023**	0.041	0.71
Poa pratensis						
Absolute biomass	-18.66	**< 0.0001**	-18.55	**< 0.0001**	0.11	1.00
Relative biomass	-0.080	**< 0.0001**	-0.078	**< 0.0001**	0.0016	1.00
Cerastium arvense						
Absolute biomass	-0.39	0.86	-2.35	**0.0050**	-1.96	**0.022**
Relative biomass	-0.0020	0.73	-0.0087	**0.0032**	-0.0068	**0.027**
Carex livida						
Absolute biomass	-0.55	0.81	-2.92	**0.0044**	-2.36	**0.025**
Relative biomass	-0.0025	0.95	-0.020	**0.036**	-0.017	**0.075**

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Appendix S14. Plant shoot tissue nitrogen (N) and phosphorus (P) analyses.

Methods:

A subsample of each plot's oven-dried total harvested shoot plant tissue (i.e. including standing dead and live biomass) was randomly selected and ground using a mechanical grinder (Retsch ZM 200). N concentrations were determined by analyzing 40-50 mg subsamples using combustion and gaseous N detection (Elementar Macrocube, Hanau, Germany). P concentrations were determined using acid digestion in accordance with Parkinson and Allen (1975). Note that because of logistical constraints with the analyses, the N and P concentration datasets consist of 41 and 30 samples respectively across the whole experiment (n = 120), but since these samples were randomly selected across all the treatments, the conclusions should be robust.

Results:

The NPK fertilizer applications significantly increased plant tissue nitrogen concentrations by approximately 32% overall (Table R1; Figure R1). In addition, the soil moisture treatments also tended to alter plant tissue nitrogen concentrations ($P < 0.07$), but the magnitude of this effect was very small. By contrast, with regards to phosphorous concentration there was a significant interaction between the two soil resource manipulations indicating that the impact of the fertilization treatment depended on the soil moisture treatment (Table R2; Figure R2). Specifically, fertilizer addition only increased P concentrations in the ambient or added water treatments (by 91% and 86%, respectively), suggesting that low soil moisture in the rainout treatment prevented plants from acquiring the fertilizer P (Tukey HSD, $P < 0.05$).

TABLE 1. Mixed model ANCOVA for plant tissue nitrogen concentration (g N / 100g DW). Factors in this analysis include decreased (n = 15), natural (n = 10), and increased (n = 16) soil moisture (soil moisture), and natural (n = 24) and increased (n = 17) soil nutrients (soil nutrients). Plot elevation, soil depth, and clay content were included as covariates. Block was included as a random factor in the model (proportion of variance explained = 0%).

Source	**F**	**df**	**Residual df**	***P***
Soil Moisture	2.97	2	27.43	0.068
Soil Nutrients	34.76	1	30.61	< 0.0001
Plot Elevation	0.83	1	29.95	0.37
Plot Soil Depth	0.79	1	19.07	0.39
Clay Content	2.91	1	28.08	0.099
Soil Moisture × Soil Nutrients	0.52	2	29.47	0.60

TABLE 2. Mixed model ANCOVA for plant tissue phosphorus concentration (g P / 100g DW). Factors in this analysis include decreased (n = 8), natural (n = 14), and increased (n = 8) soil moisture (soil moisture), and natural (n = 12) and increased (n = 14) soil nutrients (soil nutrients). Plot elevation, soil depth, and clay content were included as covariates. Block was included as a random factor in the model (proportion of variance explained = 0%).

Source	**F**	**df**	**Residual df**	***P***
Soil Moisture	24.84	2	19.45	< 0.001
Soil Nutrients	111.57	1	20.75	< 0.001
Plot Elevation	1.31	1	17.57	0.27
Plot Soil Depth	1.32	1	7.21	0.29
Clay Content	3.15	1	20.99	0.090
Soil Moisture × Soil Nutrients	6.86	2	19.60	0.0055

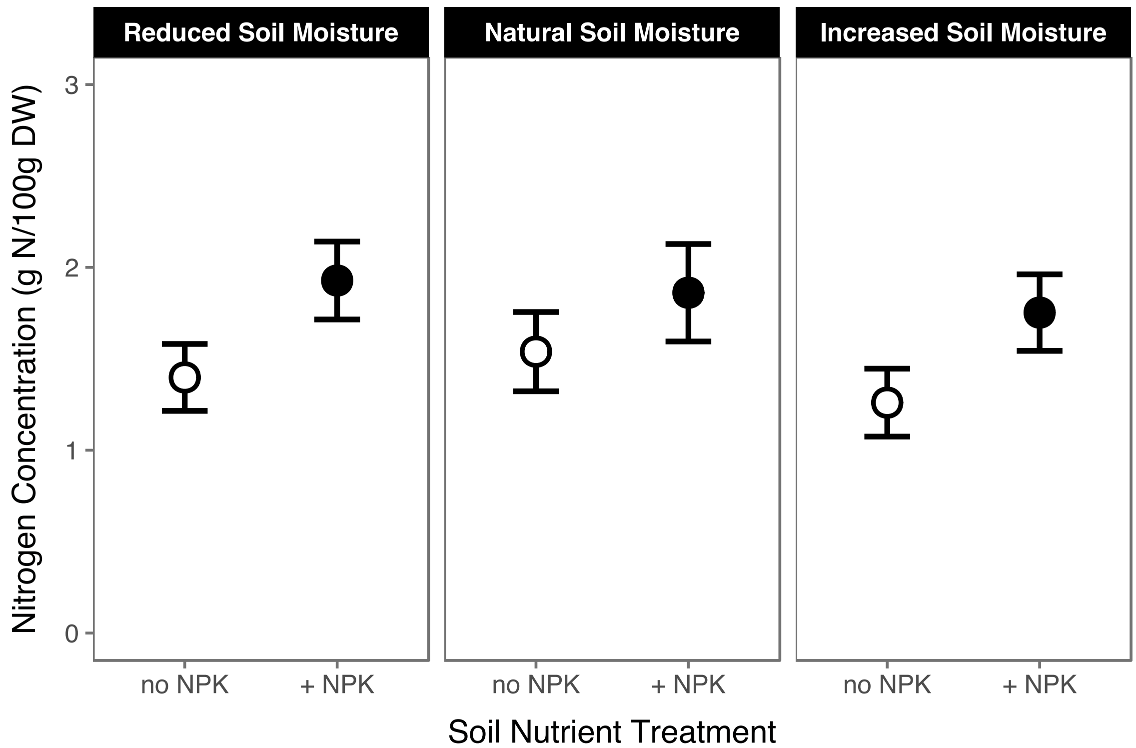

FIGURE 1. Effects of soil moisture (reduced [n = 15], natural [n = 10] and increased [n = 16]) and soil nutrients (natural levels [no NPK, white points, n = 24] and increased [+ NPK, black points, n = 17]) on plot plant tissue nitrogen concentration (g N/100g DW). Data points are least square means (function ‘lsmeans’; package *lsmeans*) with 95 % confidence intervals (CIs). Produced with *ggplot2* (Wickham 2009).

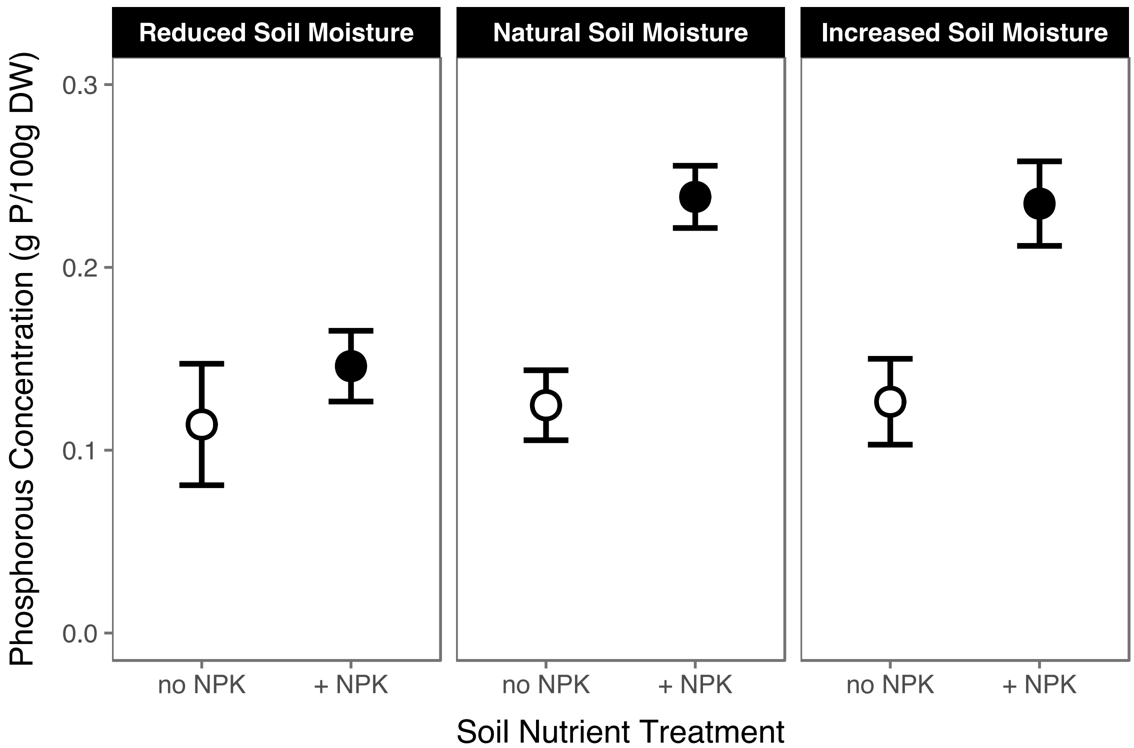

FIGURE 2. Effects of soil moisture (reduced [n = 8], natural [n = 14] and increased [n = 8]) and soil nutrients (natural levels [no NPK, white points, n = 12] and increased [+ NPK, black points, n = 14]) on plot plant tissue phosphorous concentration (g P/100g DW). Data points are least square means (function 'lsmeans'; package *lsmeans*) with 95 % confidence intervals (CIs). Produced with *ggplot2* (Wickham 2009).

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Appendix S15. Statistical results of the analyses of the experimental treatment effects on Shannon Index, Evar, and species richness.

TABLE 1. Mixed model ANCOVA for plot Shannon index. Factors in this analysis include decreased, natural, and increased soil moisture, natural and increased soil nutrients, and the presence or absence of herbivore exclosures. Plot elevation, soil depth, and sand content were included as covariates. Block was included as a random factor in the model (proportion of variance explained = 10%).

Source	F	df	Residual df	*P*
Soil Moisture	23.25	2	95.38	< 0.0001
Soil Nutrients	5.88	1	96.22	0.017
Exclosure	2.10	1	97.05	0.15
Plot Elevation	0.42	1	36.79	0.52
Plot Soil Depth	2.85	1	102.84	0.094
Sand Content	0.41	1	91.35	0.52
Soil Moisture × Soil Nutrients	0.43	2	96.26	0.65
Soil Moisture × Exclosure	2.41	2	95.81	0.095
Soil Nutrients × Exclosure	0.21	1	96.12	0.65
Soil Moisture × Soil Nutrients × Exclosure	0.0477	2	96.53	0.95

TABLE 2. Mixed model ANCOVA for plot Evar (Smith and Wilson's (1996) evenness) index. Factors in this analysis include decreased, natural, and increased soil moisture, natural and increased soil nutrients, and the presence or absence of herbivore exclosures. Plot elevation, soil depth, and sand content were included as covariates. Block was included as a random factor in the model (proportion of variance explained = 0%).

Source	F	df	Residual df	*P*
Soil Moisture	0.18	2	95.78	0.84
Soil Nutrients	1.94	1	96.92	0.17
Exclosure	0.080	1	97.93	0.78
Plot Elevation	1.56	1	20.23	0.23
Plot Soil Depth	1.21	1	83.96	0.28
Sand Content	0.011	1	52.07	0.92
Soil Moisture × Soil Nutrients	0.096	2	96.68	0.91
Soil Moisture × Exclosure	0.26	2	96.37	0.77
Soil Nutrients × Exclosure	0.058	1	96.72	0.81
Soil Moisture × Soil Nutrients × Exclosure	0.054	2	97.40	0.95

TABLE 3. Quasi-Poisson ANCOVA for plot species richness per 0.5 m^2. Factors in this analysis include decreased, natural, and increased soil moisture, natural and increased soil nutrients, and the presence or absence of herbivore exclosures. Plot elevation, soil depth, and sand content were included as covariates.

Source	**F**	**df**	**Residual df**	***P***
Soil Moisture	33.68	2	40.83	< 0.0001
Soil Nutrients	6.31	1	15.30	< 0.001
Exclosure	2.60	1	6.31	0.014
Plot Elevation	4.62	1	11.20	0.0011
Plot Soil Depth	0.43	1	1.05	0.31
Sand Content	2.60	1	6.29	0.014
Soil Moisture × Soil Nutrients	1.77	2	2.15	0.12
Soil Moisture × Exclosure	1.60	2	1.94	0.15
Soil Nutrients × Exclosure	0.36	1	0.86	0.36
Soil Moisture × Soil Nutrients × Exclosure	0.21	2	0.25	0.78
Residuals	42.89	104		
Total	97.07	118		