Title: Nutrient enrichment increases herbivory and pathogen damage in grasslands

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Table S1: List of the 27 contributing Nutrient Network experimental sites and their respective geographical coordinates, mean annual temperature (MAT), and mean annual precipitation (MAP).

Country	**Site Name**	**Habitat**	**Latitude**	**Longitude**	**MAT**	**MAP**
Argentina	Fortín Chacabuco	grassland steppe	-41.01	-71.15	8.6	862
Argentina	Las Chilcas	mesic grassland	-36.28	-58.27	15.1	925
Argentina	Mar Chiquita	grassland	-37.72	-57.42	13.9	838
Argentina	Potrok Aike	semiarid grassland	-51.92	-70.41	6.3	202
Australia	Bogong	alpine grassland	-36.87	147.25	5.7	1592
Australia	Burrawan	semiarid grassland	-27.73	151.14	18.4	683
Australia	Mt. Caroline	savannah	-31.78	117.61	17.3	330
Australia	Yarramundi	mesic grassland	-33.61	150.73	17.2	898
Canada	Koffler Scientific Reserve	pasture	44.02	-79.54	6.4	815
Finland	Kilpisjärvi	tundra grassland	69.05	20.83	-4.1	551
Germany	Bad Lauchstaedt	old field	51.39	11.88	8.9	497
Germany	JeNut	mesic grassland	50.93	11.53	8.6	610
India	Kibber	alpine grassland	32.32	78.01	1.1	504
Portugal	Companhia das Lezirias	annual grassland	38.82	-8.79	16.5	554
South Africa	Ukulinga	mesic grassland	-29.67	30.4	18.1	880
Switzerland	Fruebuel	pasture	47.11	8.54	6.5	1355
Switzerland	Val Mustair	alpine grassland	46.63	10.37	0.3	1098
US	Bunchgrass	montane grassland	44.28	-121.97	5.5	1647
US	Chichaqua Bottoms	tallgrass prairie	41.79	-93.39	9.3	855
US	Cedar Creek LTER	tallgrass prairie	45.42	-93.21	6.3	750
US	Konza LTER	tallgrass prairie	39.07	-96.58	11.9	877
US	Mclaughlin UCNRS	annual grassland	38.86	-122.41	13.5	867
US	Saline Experimental Range	mixedgrass prairie	39.05	-99.10	11.8	607
US	Shortgrass Steppe LTER	shortgrass prairie	40.82	-104.77	8.4	365
US	Sheep Experimental Station	shrub steppe	44.24	-112.20	5.5	262
US	Spindletop	pasture	38.14	-84.50	12.5	1140
US	Temple	tallgrass prairie	31.04	-97.35	19.1	871

Table S2: List of plant species sampled on the 27 contributing sites.

Country	Site Name	Taxon	Functional group
Argentina	Fortín Chacabuco	*Cerastium junceum*	Forb
		Juncus balticus	Grass
		Pappostipa speciosa	Grass
		Rumex acetosella	Forb
	Las Chilcas	*Ambrosia tenuifolia*	Forb
		Festuca arundinacea	Grass
		Hydrocotyle bonariensis	Forb
		Leersia hexandra	Grass
		Paspalidium paludivagum	Grass
		Paspalum dilatatum	Grass
	Mar Chiquita	*Ambrosia tenuifolia*	Forb
		Festuca arundinacea	Grass
		Spartina densiflora	Grass
		Stenotaphrum secundatum	Grass
		Veronica peregrina	Forb
	Potrok Aike	*Carex andina*	Grass
		Nardophyllum bryoides	Forb
		Perezia recurvata	Forb
		Poa spiciformis	Grass
		Stipa speciosa	Grass
Australia	Bogong	*Craspedia jamesii*	Forb
		Hypochaeris radicata	Forb
		Plantago euryphylla	Forb
		Poa hiemata	Grass
		Rumex acetosella	Forb
		Rytidosperma nudiflorum	Grass
	Burrawan	*Epaltes australis*	Forb
		Eragrostis curvula	Grass
		Eragrostis sororia	Grass
		Eremochloa bimaculata	Grass
		Fimbristylis dichotoma	Grass
		Glandularia aristigera	Forb
	Mt. Caroline	*Avena barbata*	Grass
		Crassula colorata	Forb
		Erodium botrys	Forb
		Hypochaeris glabra	Forb
		Stipa nitida	Grass
	Yarramundi	*Axonopus fissifolius*	Grass
		Cynodon dactylon	Grass
		Ehrharta stipoides	Grass
		Eragrostis curvula	Grass
		Lotus corniculatus	Legume
		Paspalum sp.	Grass
		Setaria parviflora	Grass
Canada	Koffler Scientific Reserve	*Asclepias syriaca*	Forb
		Bromus inermis	Grass
		Cirsium arvense	Forb
		Daucus carota	Forb
		Euthamia spgraminifolia	Forb
		Monarda fistulosa	Forb
		Solidago altissima	Forb
		Vicia tenuifolia	Legume
Finland	Kilpisjärvi	*Agrostis mertensii*	Grass
		Anthoxanthum odoratum	Grass
		Carex bigelowii	Grass
		Festuca ovina	Grass
		Persicaria vivipara	Forb
		Ranunculus acris	Forb
		Sibbaldia procumbens	Forb
Finland	Kilpisjärvi	*Solidago virgaurea*	Forb
		Taraxacum sp.	Forb
		Trollius europaeus	Forb
		Viola biflora	Forb
Germany	Bad Lauchstaedt	*Artemisia vulgaris*	Forb
		Cirsium arvense	Forb
		Hypochaeris radicata	Forb
		Lolium perenne	Grass

Country	Site Name	Taxon	Functional group
Germany	Bad Lauchstaedt	*Picris hieracioides*	Forb
		Solidago canadensis	Forb
		Taraxacum campylodes	Forb
		Trifolium repens	Legume
	JeNut	*Convolvulus arvensis*	Forb
		Crepis biennis	Forb
		Elymus repens	Grass
		Lolium perenne	Grass
		Poa pratensis	Grass
		Taraxacum campylodes	Forb
		Trifolium repens	Legume
India	Kibber	*Cousinia thomsonii*	Forb
		Heracleum thomsonii	Forb
		Polygonum aviculare	Forb
		Silene graminifolia	Forb
		Stipa orientalis	Grass
Portugal	Companhia das Lezirias	*Avena barbata*	Grass
		Cladanthus mixtus	Forb
		Coleostephus myconis	Forb
		Crepis vesicaria	Forb
		Echium plantagineum	Forb
		Gaudinia fragilis	Grass
		Ornithopus compressus	Legume
		Rumex acetosella	Forb
		Rumex bucephalophorus	Forb
		Tolpis barbata	Forb
		Tuberaria guttata	Forb
South Africa	Ukulinga	*Chaetacanthus burchellii*	Forb
		Eragrostis curvula	Grass
		Eriosema cordatum	Legume
		Physalis peruviana	Forb
		Scabiosa columbaria	Forb
		Tagetes minuta	Forb
		Themeda triandra	Grass
Switzerland	Fruebuel	*Alchemilla xanthochlora*	Forb
		Alopecurus pratensis	Grass
		Dactylis glomerata	Grass
		Heracleum sphondylium	Forb
		Phleum pratense	Grass
		Plantago lanceolata	Forb
		Ranunculus acris	Forb
		Taraxacum campylodes	Forb
		Trifolium repens	Legume
		Veronica chamaedrys	Forb
	Val Mustair	*Anthoxanthum odoratum*	Grass
		Campanula scheuchzeri	Forb
		Cerastium arvense	Forb
		Festuca halleri	Grass
		Festuca rubra	Grass
		Galium anisophyllon	Forb
		Hieracium pilosella	Forb
		Myosotis alpestris	Forb
		Trifolium pratense	Legume
	Bunchgrass	*Bromus carinatus*	Grass
		Carex hoodii	Grass
		Festuca idahoensis	Grass
		Lupinus latifolius	Legume
		Penstemon procerus	Forb
	Chichaqua Bottoms	*Oenothera parviflora*	Forb
		Schizachyrium scoparium	Grass
	Cedar Creek LTER	*Andropogon gerardii*	Grass
		Elymus repens	Grass
		Lespedeza capitata	Legume
		Poa pratensis	Grass
		Solidago missouriensis	Forb
	Konza LTER	*Ambrosia psilostachya*	Forb
		Andropogon gerardii	Grass
		Bouteloua curtipendula	Grass
		Carex meadii	Grass

Country	Site Name	Taxon	Functional group
US of America	Konza LTER	*Panicum oligosanthes*	Grass
		Salvia azurea	Forb
		Schizachyrium scoparium	Grass
		Solidago missouriensis	Forb
		Sorghastrum nutans	Grass
		Symphyotrichum oblongifolium	Forb
		Acmella decumbens	Forb
	Mclaughlin UCNRS	*Avena fatua*	Grass
		Bromus hordeaceus	Grass
		Centaurea solstitialis	Forb
		Geranium dissectum	Forb
		Lactuca serriola	Forb
	Saline Experimental Range	*Ambrosia psilostachya*	Forb
		Artemisia ludoviciana	Forb
		Bouteloua curtipendula	Grass
		Psoralea tenuiflora	Legume
		Schizachyrium scoparium	Grass
		Sporobolus compositus	Grass
	Shortgrass Steppe LTER	*Carex duriuscula*	Grass
		Chenopodium leptophyllum	Forb
		Chondrosum gracile	Grass
		Elymus elymoides	Grass
		Ipomopsis laxiflora	Forb
		Sphaeralcea coccinea	Forb
	Sheep Experimental Station	*Alyssum desertorum*	Forb
		Bromus sp.	Grass
		Crepis acuminata	Forb
		Elymus spicatus	Grass
		Koeleria macrantha	Grass
		Poa secunda	Grass
	Spindletop	*Dactylis glomerata*	Grass
		Erigeron annuus	Forb
		Festuca arundinacea	Grass
		Plantago lanceolata	Forb
		Poa pratensis	Grass
		Silene latifolia	Forb
		Vicia grandiflora	Legume
	Temple	*Ambrosia trifida*	Forb
		Centaurea melitensis	Forb
		Gaillardia pulchella	Forb
		Mimosa nuttallii	Legume
		Monarda citriodora	Forb
		Salvia azurea	Forb
		Solanum dimidiatum	Forb
		Sorghum halepense	Grass
	Temple	*Symphyotrichum ericoides*	Forb

Coverage

Sites differed both in the taxa that were scored for damage (Table S3) and also the proportion of the total plant cover that was constituted by these taxa, i.e., 'coverage'. We were concerned that coverage might differ between treatments (e.g., higher or lower coverage in nutrient versus control plots), and that systematic differences in coverage could bias our results. Therefore, we tested whether the distribution of coverages differed between control plots and plots of each nutrient treatment using two-sample Kolmogorow-Smirnov tests (distributions and medians shown in Fig. S1). These nonparametric tests quantify differences in the cumulative probabilities of two empirical distributions. The null hypothesis is that the sample distribution (e.g., coverage in nitrogen addition plots) is drawn from the reference distribution (coverage in control plots). Therefore, a significant *p* value would suggest that these distributions were different. We found that coverage of control plots was not significantly different from coverage in N addition plots (p= 0.54), P addition plots (p = 0.70, or N&P addition plots (p= 0.70). We supplemented this non-parametric test of the cumulative distributions of coverage with an ANOVA, and similarly found that mean coverage did not differ among treatments (df= 3, F= 0.46, p= 0.71). Therefore, while coverage varied among plots, it did not differ systematically across treatments.

To better understand this variation in coverage, we also tested whether particular sites consistently had high or low coverage. At the site level, we plotted mean coverage in control plots against mean coverage in nutrient plots (Fig. S2). Linear models showed that sites with higher coverage in control plots also had higher coverage in N addition plots (Fig. S2A; R^2= 0.64), P addition plots (Fig. S2B; R^2= 0.44), and N&P addition plots (Fig. S2C; R^2= 0.37). Therefore, much of the variation in coverage was attributable to differences among sites. These differences arose, in large part, due to the decisions made by PIs at each site regarding which taxa (and how many taxa) to score for damage. Mean site coverage ranged from 28% (Ukulinga) to 98% (Yarramundi; Table S2), with three quarters of the sites having mean coverages between 50% and 76% (site mean coverages reported in Table S4).

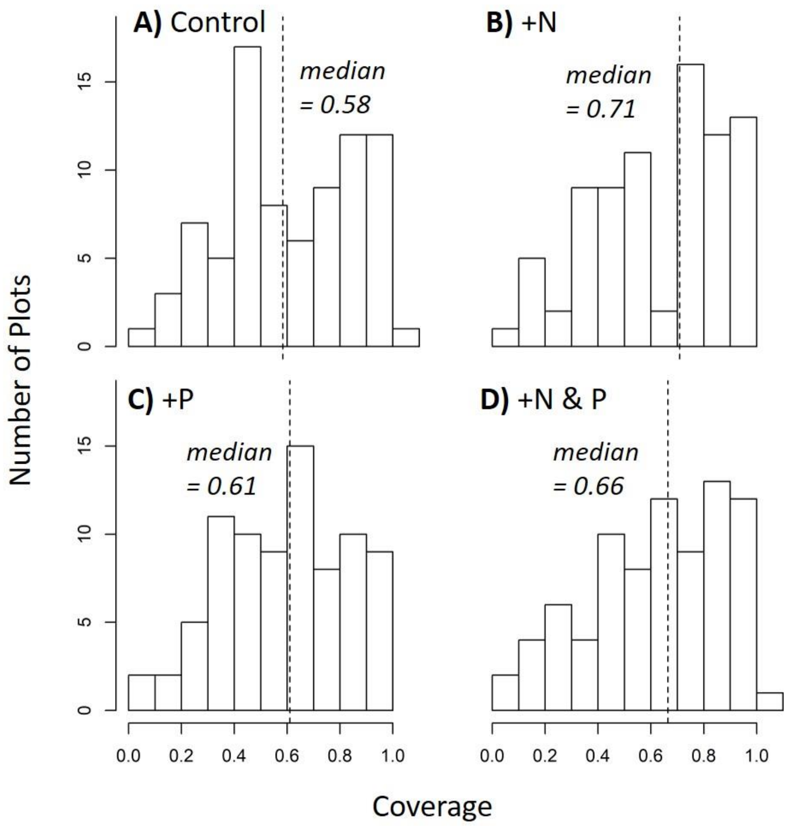

Figure S1. Coverage did not systematically differ between A) control plots and B) N addition plots (p = 0.54), C) P addition plots (p = 0.70, or D) N&P addition plots (p = 0.70). Histograms show the distribution of coverages in each treatment; vertical dashed lines indicate medians. Statistics that compare distributions are derived from two-sample Kolmogorow-Smirnov tests. Similarly, mean coverage did not differ among treatments, as tested with ANOVA (df= 3, F= 0.46, p= 0.71).

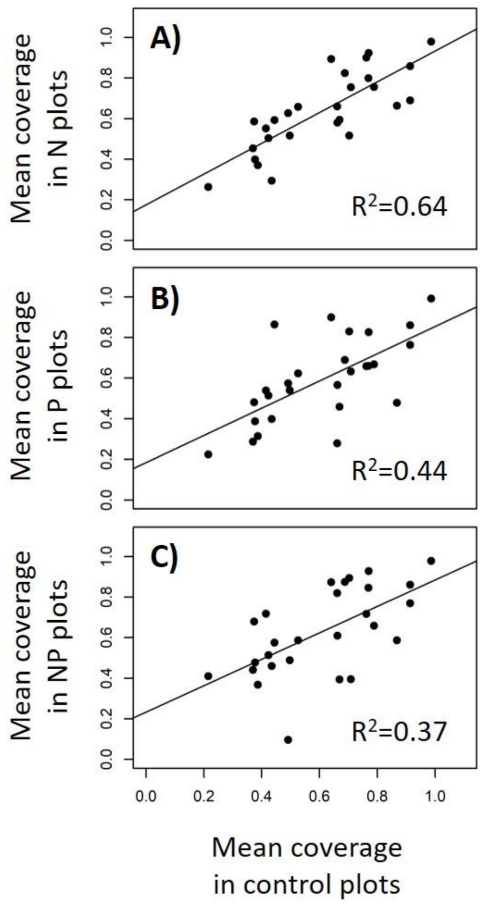

Figure S2. Much of the variation in coverage is aggregated at the site level. Sites that have higher mean coverage in control plots also have higher mean coverage in A) N addition plots (R^2= 0.64), B) P addition plots (R^2= 0.44), and C) N&P addition plots (R^2= 0.37). Solid lines indicate fits of simple linear regressions.

Table S3: Response of community-level leaf damage (%) to local nutrient addition and climate variables. Effects of nutrient addition (Nitrogen and Phosphorus), Mean annual temperature (MAT), and Mean annual precipitation (MAP) on the plot-level leaf damage by invertebrate herbivores and pathogens (taxa are weighted by their respective abundance within plots). The table shows estimates and standard errors (SE) from mixed effects models with MAT, MAP, N, P, all possible interactions between climate variables and nutrient manipulation, and site as random effects. Asterisks indicate significance levels as follows: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; (*) $p < 0.1$. Significant effects shown graphically in the main text (Fig. 2 and 3).

	Invertebrate		**Pathogen**	
Predictors	*Estimates*	*SE*	*Estimates*	*SE*
(Intercept)	0.90 ***	0.12	1.33 ***	0.17
MAT	0.16	0.12	0.18	0.17
MAP	**0.34****	**0.12**	**0.30(*)**	**0.17**
N	**0.25 ****	**0.08**	0.01	0.08
P	0.12	0.08	0.04	0.08
N:P	-0.16	0.11	-0.003	0.11
MAT:N	-0.03	0.08	0.04	0.08
MAP:N	-0.02	0.08	-0.01	0.08
MAT:P	0.01	0.08	0.01	0.08
MAP:P	-0.03	0.08	0.03	0.08
MAT:N:P	0.11	0.11	0.01	0.11
MAP:N:P	0.002	0.11	0.08	0.11
Random Effect Variance				
sites	0.30		0.67	
residuals	0.26		0.26	
Fixed Effect Variance	0.14		0.15	
# sites	27		27	
# observations	323		323	
Marginal R^2	0.20		0.14	
Conditional R^2	0.63		0.76	

Table S4: List of the 27 contributing Nutrient Network experimental sites, their mean coverage (i.e., proportion of plant cover made up of taxa scored for damage; Fig. S1 & S2) and their respective leaf damages. Damage on individual leaves represents an average across mean damages of all taxa. Values shown here are averages across the three control plots within sites.

Country	Site Name	Mean Coverage	Damage individual leaves % Invert./ Pathogens	Community total damage % Invert./ Pathogens
Argentina	Fortín Chacabuco	0.83	0.86 / 4.27	0.02 / 0.25
Argentina	Las Chilcas	0.51	2.17 / 1.8	1.96 / 2.95
Argentina	Mar Chiquita	0.65	4.73 / 1.73	4.33 / 2.31
Argentina	Potrok Aike	0.72	0 / 0.42	0 / 0.28
Australia	Bogong	0.77	2.23 / 4.33	0.83 / 0.91
Australia	Burrawan	0.87	0.80 / 3.17	0.76 / 1.71
Australia	Mt. Caroline	0.62	3.99 / 0.44	1.55 / 0.02
Australia	Yarramundi	0.98	1.50 / 3.39	0.81 / 2.99
Canada	Koffler Scientific Reserve	0.77	2.72 / 14.71	1.33 / 10.99
Finland	Kilpisjärvi	0.56	0.60 / 1.62	0.07 / 0.30
Germany	Bad Lauchstaedt	0.36	8.40 / 6.11	1.37 / 2.60
Germany	JeNut	0.41	4.94 / 8.57	6.74 / 15.23
India	Kibber	0.60	0.96 / 1.44	0.01 / 0.22
Portugal	Companhia das Lezirias	0.60	1.22 / 6.05	0.57 / 6.61
South Africa	Ukulinga	0.28	5.77 / 9.80	2.77 / 8.89
Switzerland	Fruebuel	0.62	8.62 / 8.68	6.84 / 8.18
Switzerland	Val Mustair	0.39	2.22 / 0.58	2.15 / 0.12
US	Bunchgrass	0.74	16.9 / 14.08	14.88 / 11.71
US	Chichaqua Bottoms	0.40	1.80 / 20.10	0.45 / 14.94
US	Cedar Creek LTER	0.53	3.32 / 35.62	0.34 / 20.50
US	Konza LTER	0.78	2.86 / 8.96	3.86 / 12.72
US	Mclaughlin UCNRS	0.53	1.64 / 0.16	1.10 / 0.04
US	Saline Experimental	0.45	4.95 / 6.70	3.91 / 4.23
US	Shortgrass Steppe LTER	0.75	2.13 / 1.70	1.44 / 2.11
US	Sheep Experimental	0.60	2.47 / 1.30	0.65 / 9.45
US	Spindletop	0.86	3.97 / 3.14	2.20 / 3.47
US	Temple	0.49	6.80 / 4.62	5.69 / 5.30

Table S5: Response of damage on individual leaves (%) to local nutrient addition. Effects of nutrient addition (Nitrogen and Phosphorus) on the proportion of leaf area damaged by invertebrate herbivores and pathogens (ln+1 transformed) across taxa. Taxa were grouped into grasses, forbs, and legumes. Estimates and standard errors (SE) result from mixed effects models with site, taxon-plot-site ID, and taxon as random effects. We defined grasses as intercept. Asterisks indicate significance levels as follows: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; (*) $p < 0.1$. Significant effects shown graphically in the main text (Fig. 5).

	Invertebrate		**Pathogen**	
Predictors	*Estimates*	*SE*	*Estimates*	*SE*
(Intercept)	0.66 ***	0.12	1.05 ***	0.14
N	**0.18 *** **	**0.05**	**0.14 ****	**0.05**
P	0.08	0.05	**0.09 (*)**	**0.05**
FORB	0.05	0.10	-0.09	0.11
LEGUME	**0.69 *** **	**0.18**	**-0.37 (*)**	**0.20**
N:P	**-0.14 ***	**0.07**	-0.11	0.07
N: FORB	0.02	0.07	**-0.23 *** **	**0.07**
N: LEGUME	**-0.28 ***	**0.14**	0.07	0.14
P: FORB	0.02	0.07	**-0.14 ***	**0.07**
P: LEGUME	-0.11	0.13	0.13	0.13
N: P: FORB	0.11	0.10	0.16	0.10
N: P: LEGUME	0.21	0.19	-0.15	0.20
Random Effect Variance				
sites	0.23		0.38	
taxa| plots| sites	0.12		0.14	
taxa	0.21		0.27	
residuals	0.71		0.71	
Fixed Effect Variance	0.03		0.02	
# sites	27		27	
# taxa| plots| sites	2047		2047	
# taxa	153		153	
# observations	10491		10491	
Marginal R^2	0.02		0.01	
Conditional R^2	0.45		0.53	

Table S6: Response of damage on individual leaves (%) to local nutrient addition: functional group means. Effects of nutrient addition (Nitrogen and Phosphorus) on the proportion of leaf area damaged by invertebrate herbivores and pathogens (ln+1 transformed) across taxa. Taxa were grouped into grasses, forbs, and legumes. To test if functional group means after experimental nutrient addition significantly differ from zero, we removed the main effects intercept and the main effect of functional groups from a mixed effects model with site, taxon-plot-site ID, and taxon as random effects (see method section and Figure 5). Here we show the resulting estimates and standard errors (SE). Asterisks indicate significance levels as follows: *** $p< 0.001$; ** $p< 0.01$; * $p< 0.05$; (*) $p< 0.1$. Significant effects shown graphically in the main text (Fig. 5).

	Invertebrate		**Pathogen**	
Predictors	*Estimates*	*SE*	*Estimates*	*SE*
N: GRASS	**0.18 *** **	**0.05**	**0.14 ** **	**0.05**
N: FORB	**0.20 *** **	**0.05**	**-0.09 (*)**	**0.05**
N: LEGUME	-0.10	0.13	**0.21 (*)**	**0.13**
P: GRASS	0.08	0.05	**0.09 (*)**	**0.05**
P: FORB	**0.10 ***	**0.05**	-0.04	0.05
P: LEGUME	-0.03	0.12	**0.22 (*)**	**0.12**
N: P: GRASS	**-0.14 ***	**0.07**	-0.11	0.07
N: P: FORB	-0.03	0.06	0.05	0.06
N: P: LEGUME	0.07	0.18	-0.26	0.18

Table S7: Response of damage on individual leaves (%) to climate variables. Effects of the site variables Mean annual temperature (MAT), and Mean annual precipitation (MAP) on the proportion of leaf area damaged by invertebrate herbivores and pathogens (ln+1 transformed) across taxa. Taxa were grouped into grasses, forbs, and legumes. Estimates and standard errors (SE) result from mixed effects models using control plots only with site, taxon-plot-site ID, and taxon as random effects. We defined grasses as intercept. Asterisks indicate significance levels as follows: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; $^{(*)}$ $p < 0.1$. Significant effects shown graphically in the main text (Fig. 6).

	Invertebrate		**Pathogen**	
Predictors	*Estimates*	*SE*	*Estimates*	*SE*
(Intercept)	0.67 ***	0.09	1.04 ***	0.13
MAT	0.08	0.10	0.20	0.14
MAP	**0.14** $^{(*)}$	**0.09**	0.20	0.12
FORB	0.08	0.08	-0.12	0.11
LEGUME	**0.65** ***	**0.17**	**-0.42** $^{(*)}$	**0.22**
MAT: FORB	0.11	0.08	**-0.22** *	**0.10**
MAT: LEGUME	-0.19	0.17	-0.08	0.22
MAP: FORB	-0.02	0.08	0.04	0.09
MAP: LEGUME	0.21	0.15	-0.02	0.17
Random Effect Variance				
sites	0.13		0.30	
taxa| plots| sites	0.13		0.14	
taxa	0.13		0.26	
residuals	0.61		0.71	
Fixed Effect Variance	0.08		0.07	
# sites	27		27	
# taxa| plots| sites	519		519	
# taxa	153		153	
# observations	2685		2685	
Marginal R^2	0.08		0.05	
Conditional R^2	0.43		0.52	

Table S8: Response of damage on individual leaves (%) to climate variables: functional group slopes. Effects of the site variables Mean annual temperature (MAT), and Mean annual precipitation (MAP) on the proportion of leaf area damaged by invertebrate herbivores and pathogens (ln+1 transformed) across taxa. Taxa were grouped into grasses, forbs, and legumes. To test if functional group slopes significantly differ from zero, we removed the main effects intercept and the main effect of functional group from a mixed effects model with site, taxon-plot-site ID, and taxon as random effects (see method section and Figure 6). Here we show the resulting estimates and standard errors (SE). Asterisks indicate significance levels as follows: *** $p< 0.001$; ** $p< 0.01$; * $p< 0.05$; (*) $p< 0.1$. Significant effects shown graphically in the main text (Fig. 6).

	Invertebrate		**Pathogen**	
Predictors	*Estimates*	*SE*	*Estimates*	*SE*
MAT: GRASS	0.08	0.10	0.20	0.14
MAT: FORB	**0.18 (*)**	**0.08**	-0.03	0.13
MAT: LEGUME	-0.11	0.17	0.12	0.24
MAP: GRASS	**0.14 (*)**	**0.09**	0.20	0.12
MAP: FORB	0.11	0.08	**0.24 ***	**0.12**
MAP: LEGUME	**0.34 ***	**0.15**	0.18	0.19