Oikos

OIK-07260

Croy, J. R., Meyerson, L. A., Allen, W. J., Bhattarai, G. P. and Cronin, J. T. 2020. Lineage and latitudinal variation in *Phragmites australis* tolerance to herbivory: implications for invasion success. – Oikos doi: 10.1111/oik.07260

Appendix 1

Populations of *Phragmites australis* used in this common garden study.

Table A1.1. Origin and lineage designation for each source population of *Phragmites australis*.

Population	Lineage	Site name	State/province	Latitude	Longitude
PLM	Invasive	Pass-a-Loutre	Louisiana	29.13	-89.23
RRM	Invasive	Rockefeller Road 4	Louisiana	29.68	-92.81
ECM	Invasive	Cameron	Louisiana	29.77	-93.29
CRM	Invasive	Creole 2	Louisiana	29.880	-93.07
SCM	Invasive	Georgetown	South Carolina	33.35	-79.26
PCN	Native	Palm Canyon Road	California	33.83	-116.31
SCRN	Native	Santa Clara River	California	34.36	-119.01
MJN	Invasive	Mojave River	California	34.540	-117.29
LCN	Native	Little Caliente Hot Springs	California	34.54	-119.62
ARM1	Invasive	Little Rock	Arkansas	34.69	-92.29
I40M	Invasive	I-40	Arizona	34.72	-114.49
SALM	Invasive	Salinas River	California	35.59	-120.65
NCM	Invasive	Mackay Island	North Carolina	36.51	-75.95
NCN	Native	Mackay Island	North Carolina	36.51	-75.95
MDN	Native	Choptank	Maryland	38.77	-75.95
TCM	Invasive	Choptank	Maryland	38.77	-75.95
NJM	Invasive	Estell Manor	New Jersey	39.41	-74.73
NJN	Native	Estell Manor	New Jersey	39.41	-74.73
APM	Invasive	Appoquinimink	Delaware	39.45	-75.64
CTM	Invasive	Ragged Rock	Connecticut	41.31	-72.36
CTN	Native	Ragged Rock	Connecticut	41.31	-72.36
FPM	Invasive	Falmouth	Massachusetts	41.55	-70.60
FPN	Native	Falmouth	Massachusetts	41.55	-70.60
PPM	Invasive	Pleasant Prairie	Minnesota	42.53	-87.95
NYE	Native	Montezuma	New York	43.00	-76.70
NYM	Invasive	Montezuma	New York	43.00	-76.70
RCN	Native	Wells	Maine	43.36	-70.48
MEE	Native	Arrowsic	Maine	43.88	-69.78
BSCM	Invasive	Bath	Maine	44.51	-70.35
NBM	Invasive	Moncton	New Brunswick	46.10	-64.80
NBS	Native	Moncton	New Brunswick	46.10	-64.80

Appendix 2

Biomass-related figures illustrating growth rate across the growing season, differences among tolerance metrices, population variability in total biomass by clipping treatment, and population variability in Tolerance$_{TOTAL}$.

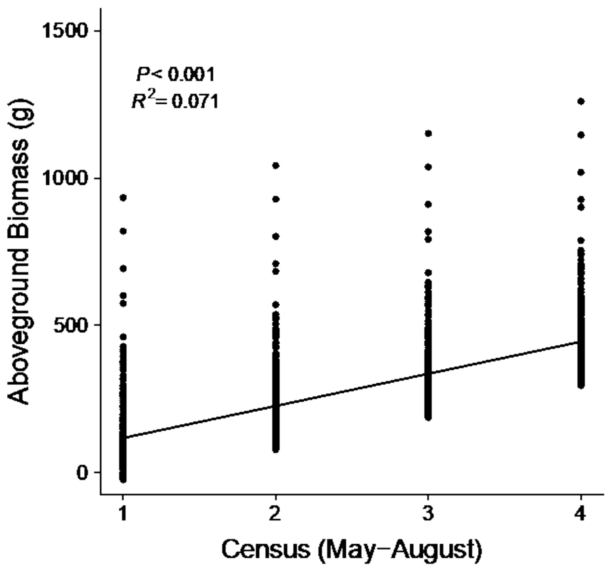

Figure A2.1. Monthly estimates *P. australis* aboveground biomass from May to August showing a linear growth rate. Three randomly-selected stems and total stem number were measured each month. Stem heights were converted to stem biomass via a regression equation using previously-collected data (R^2 = 0.91, p < 0.001, n=29).

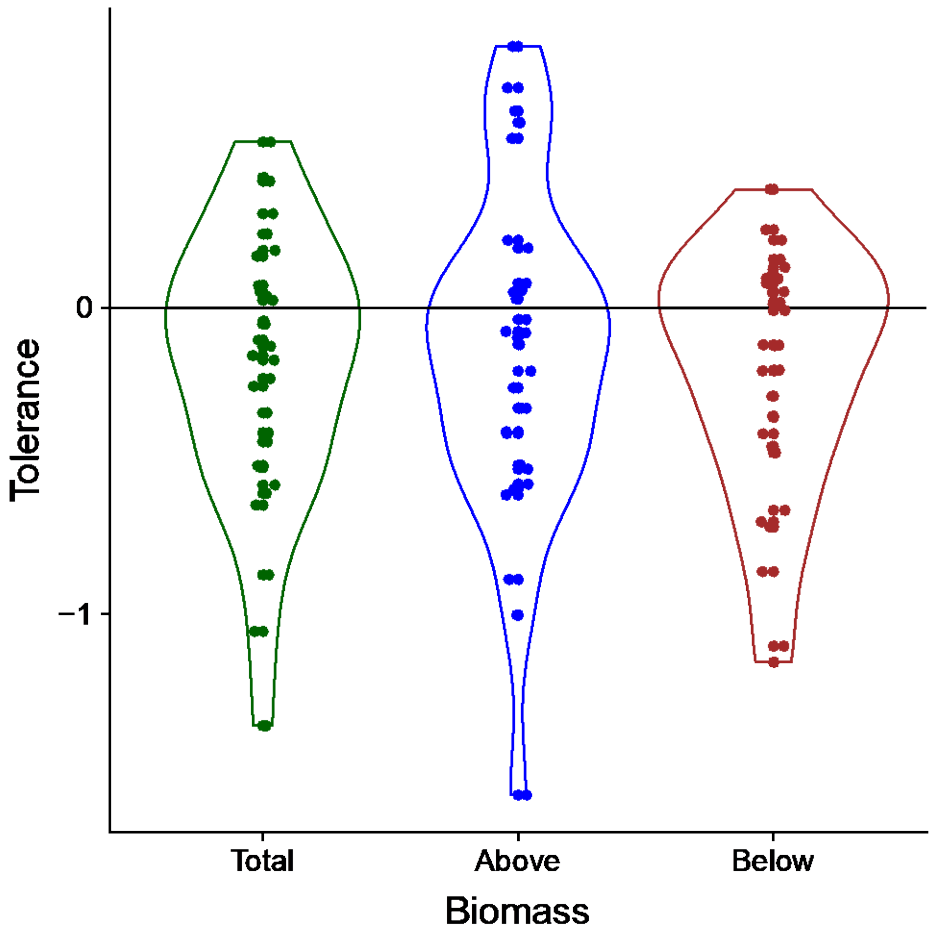

Figure A2.2. Violin plots (box plot with a mirrored and rotated kernel density plot) illustrating the variation among populations of *Phragmites australis* in $\text{Tolerance}_{\text{total}}$, $\text{Tolerance}_{\text{above}}$, and $\text{Tolerance}_{\text{below}}$, calculated as: Tolerance_{x} = *ln*[mean end-of-season biomass of clipped plants/mean end-of-season biomass of unclipped plants; where x = biomass type]. Horizontal line plotted at y = 0 denotes where there is no effect of folivory on plant biomass.

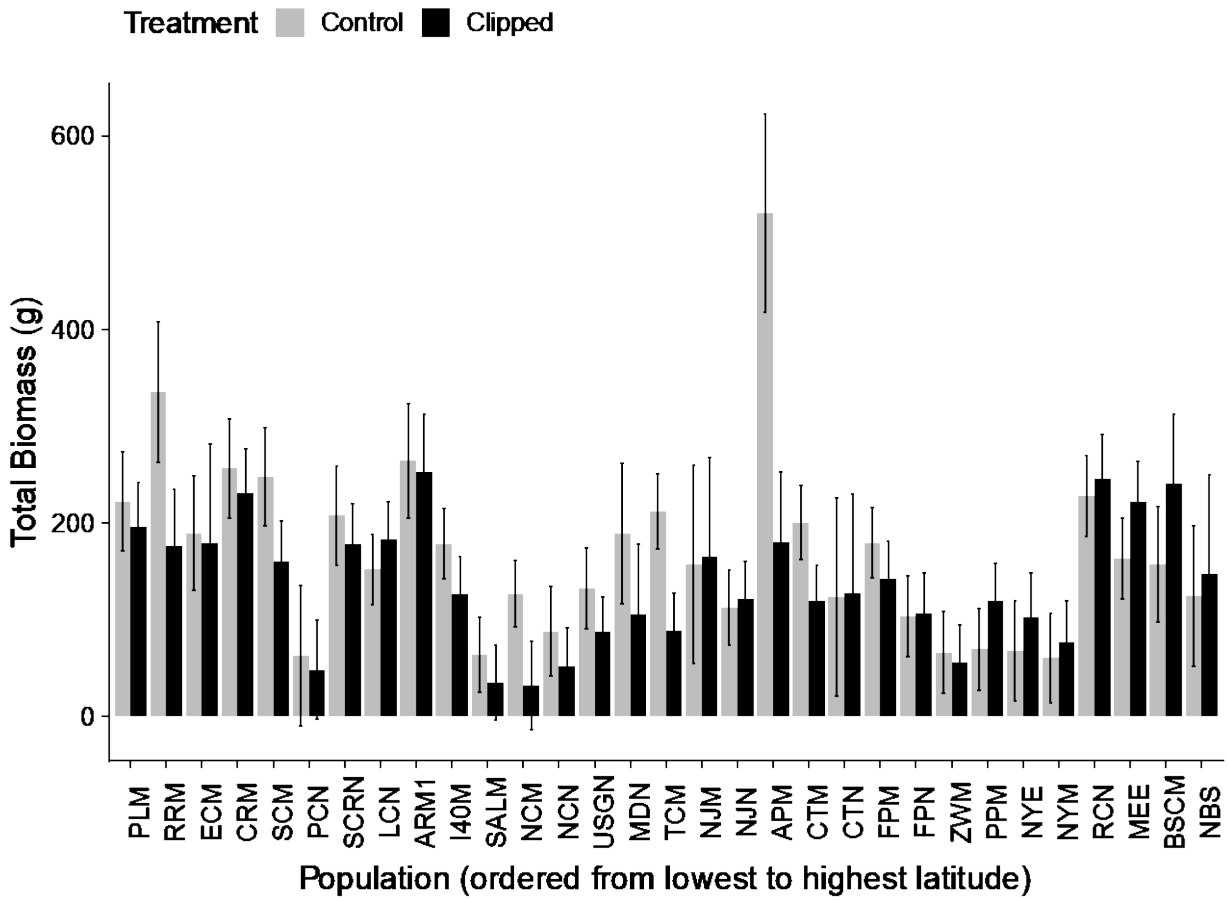

Figure A2.3. Biomass least-squares means (LSM) ± SE for unclipped (gray) and clipped (black) treatments within each population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right). LSM ± SE were extracted from linear model accounting for planting date as a covariate.

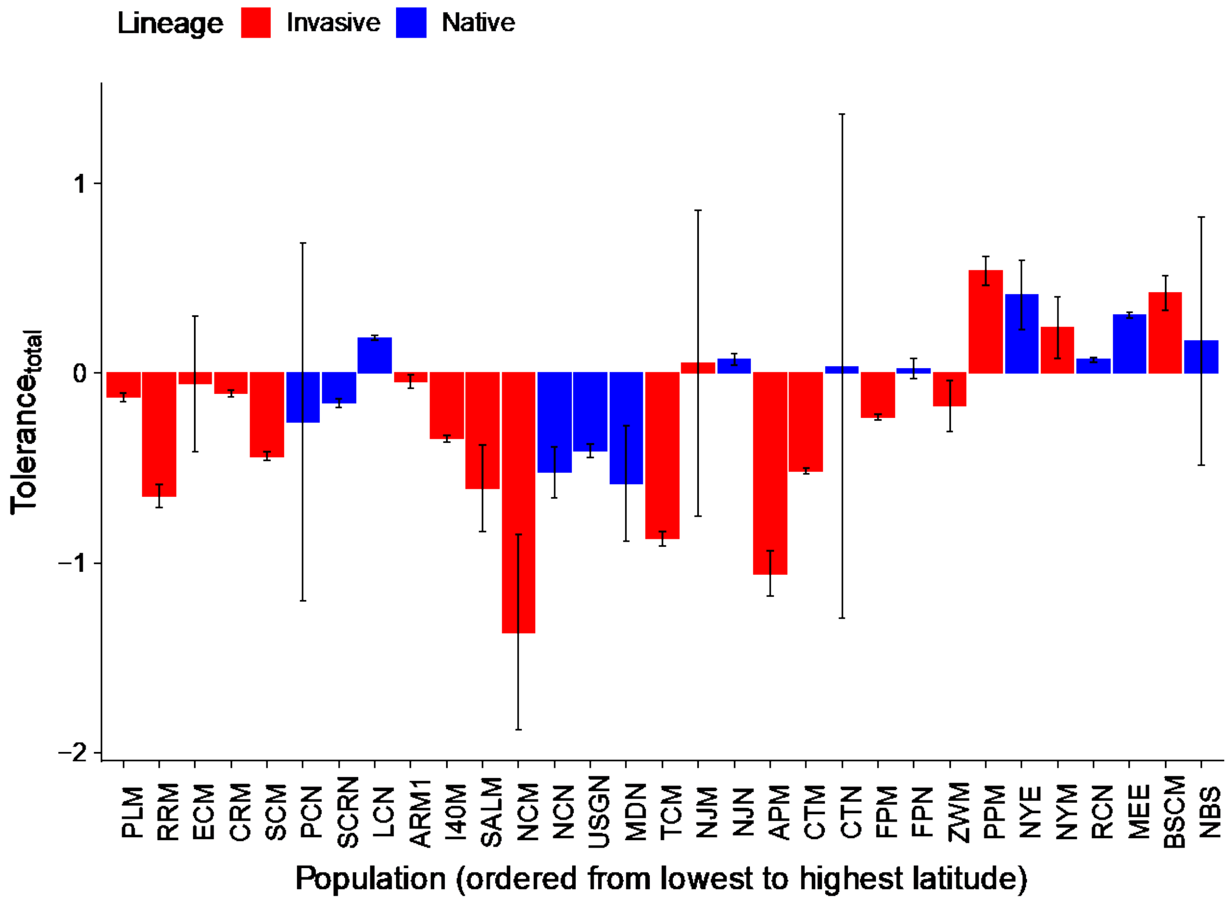

Figure A2.4. $\text{Tolerance}_{\text{total}}$ ± SE for population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right and colored by lineage). SEs for tolerance were calculated as: $\frac{(SD_E)^2}{n_E \bar{\bar{X}}_E{}^2} + \frac{(SD_C)^2}{n_C \bar{\bar{X}}_C{}^2}$, where SD is the standard deviation, n is the number of replicates, and $\bar{X}$ is the mean for that group. Subscripts *E* and *C* indicate experimental and control groups, which are the clipped and unclipped treatments for this study, respectively. Details on error propagation method can be found in Hedges et al. (1999).

Appendix 3

Description of trait and plasticity principal components, the model selection procedure for tolerance-individual trait relationships, principal component biplots, and treatment means for each population.

Table A3.1. Principal components (PCs) for trait values and plasticity, the percentage of total trait variation explained, and individual trait loadings for each PC. Traits included leaf phenolics, silica, percent carbon (%C), percent nitrogen (%N), carbon to nitrogen ratio (C:N), specific leaf area (SLA), leaf toughness, root mass fraction (RMF), stem density, and log-transformed relative growth rate (RGR).

	Principal component	Variance explained	Phenolics	Silica	%C	%N	C:N	SLA	Toughness	RMF	Stems	RGR
Constitutive	PC1	31%	0.25	0.43	-0.16	0.22	-0.39	0.39	-0.21	0.31	-0.20	-0.44
	PC2	19%	0.14	-0.08	0.49	0.63	-0.31	-0.16	0.09	-0.37	0.24	-0.14
	PC3	12%	-0.51	0.04	0.31	0.13	0.11	0.22	0.49	0.05	-0.55	-0.16
	PC4	9%	0.31	-0.27	-0.47	-0.16	-0.21	0.10	0.48	-0.48	-0.15	-0.23
	PC5	9%	-0.52	-0.22	-0.35	0.17	-0.52	0.07	0.16	0.27	0.36	0.17
	PC6	8%	-0.26	-0.33	-0.15	0.10	-0.20	-0.22	-0.60	-0.26	-0.52	-0.04
	PC7	6%	-0.15	0.36	-0.15	-0.08	-0.06	-0.79	0.17	0.09	0.01	-0.39
	PC8	4%	-0.16	-0.44	0.09	-0.13	0.25	0.14	-0.16	0.11	0.33	-0.73
	PC9	3%	0.42	-0.50	0.09	0.13	-0.05	-0.26	0.17	0.61	-0.26	0.06
	PC10	0%	-0.01	0.02	-0.49	0.66	0.57	-0.01	0.02	0.01	0.02	0.00
Plastic	PC1	26%	-0.29	-0.25	0.26	-0.34	0.61	-0.07	-0.29	-0.09	0.46	--
	PC2	21%	0.30	-0.23	-0.62	-0.55	0.03	0.35	-0.18	0.08	-0.08	--
	PC3	17%	-0.35	0.31	0.01	-0.11	0.12	-0.12	-0.44	0.56	-0.48	--

PC4	12%	-0.28	0.13	0.06	0.23	-0.18	0.66	-0.48	-0.4	0.00	--
PC5	10%	0.22	0.74	-0.16	-0.23	0.07	-0.32	-0.17	-0.42	0.13	--
PC6	8%	-0.61	-0.24	-0.33	-0.16	-0.17	-0.34	0.14	-0.44	-0.28	--
PC7	5%	0.22	-0.34	-0.10	0.24	-0.36	-0.45	-0.63	0.03	0.20	--
PC8	2%	0.40	-0.24	0.34	0.00	0.31	-0.06	-0.14	-0.38	-0.64	--
PC9	0%	0.01	0.00	0.54	-0.62	-0.57	0.02	0.00	0.01	0.01	--

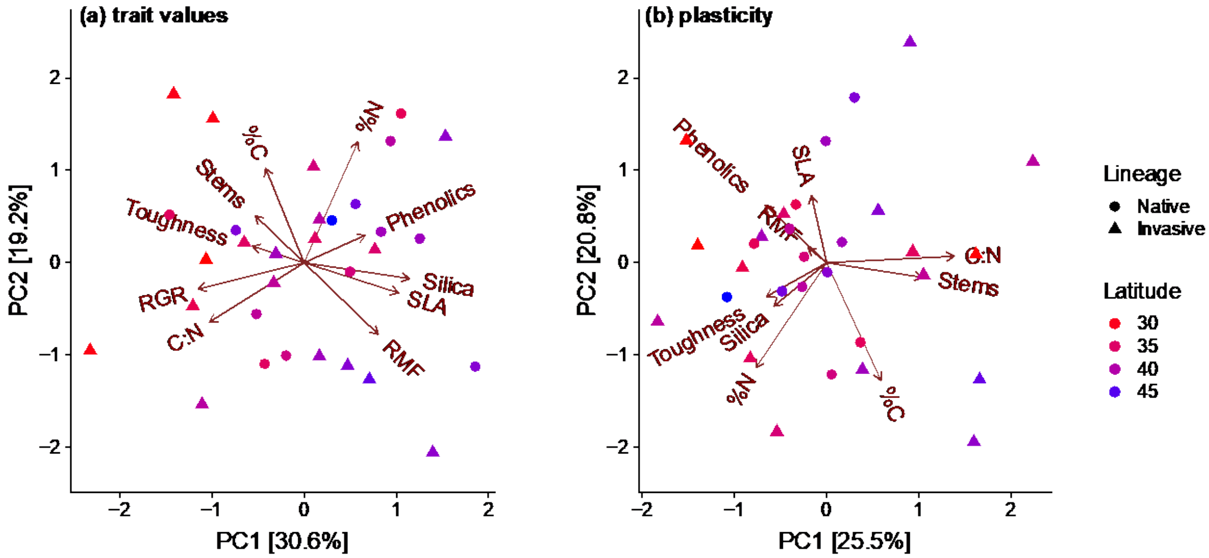

Figure A3.1. Ordination biplots for the first two axes of (a) trait values and (b) plasticity principal components. Points are colored by population latitude of origin, with blue indicating higher latitudes and red indicating lower latitudes. The native and invasive *Phragmites australis* lineages are depicted with circles and triangles, respectively. Vectors for each trait are overlain to illustrate both correlations among traits and also the traits that diverge across *P. australis* latitude of origin and between lineages. Points that lay closer together represent populations with similar functional traits. Traits included leaf phenolics, silica, percent carbon (%C), percent nitrogen (%N), carbon to nitrogen ratio (C:N), specific leaf area (SLA), leaf toughness, root mass fraction, stem density, and log-transformed relative growth rate (RGR).

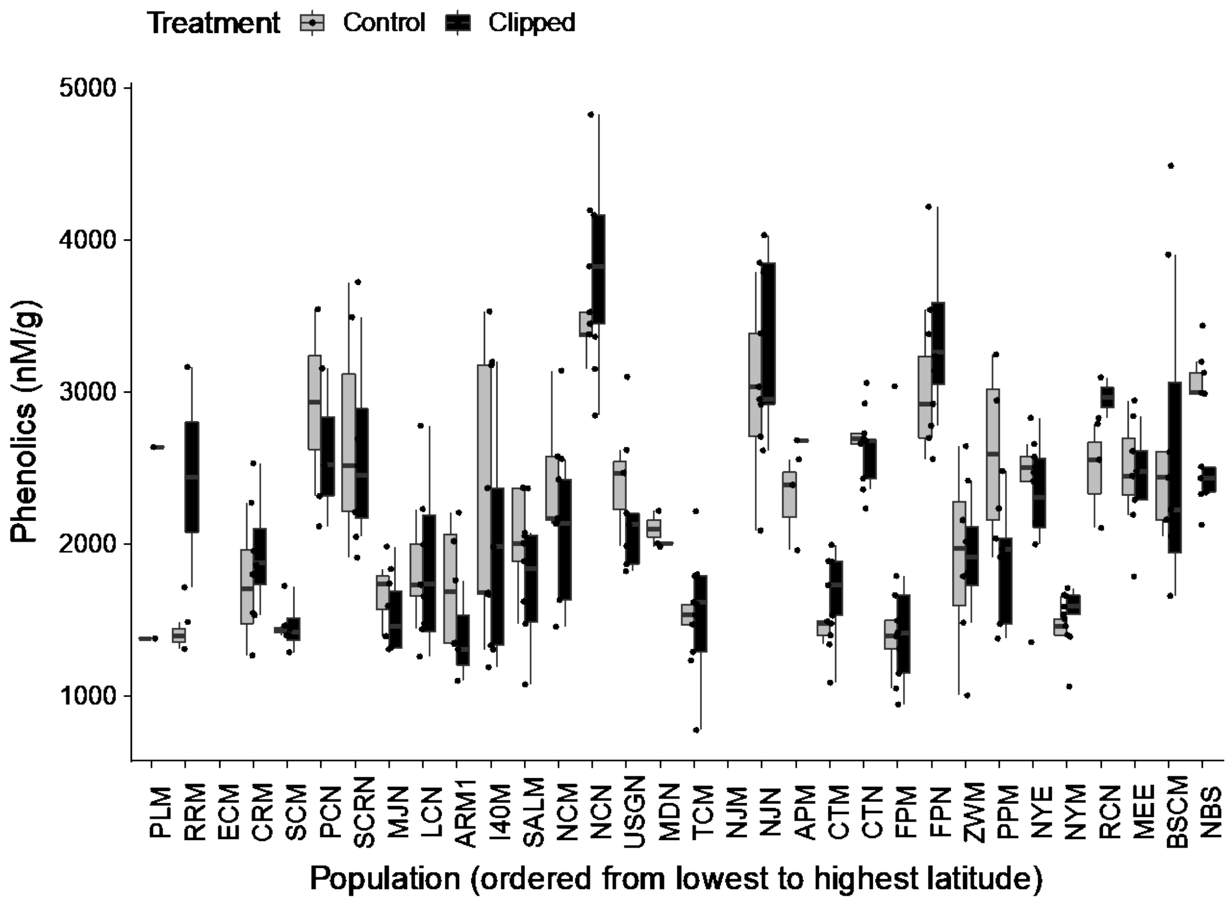

Figure A3.2. Boxplots of leaf phenolic concentrations for unclipped (gray) and clipped (black) treatments within each population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right).

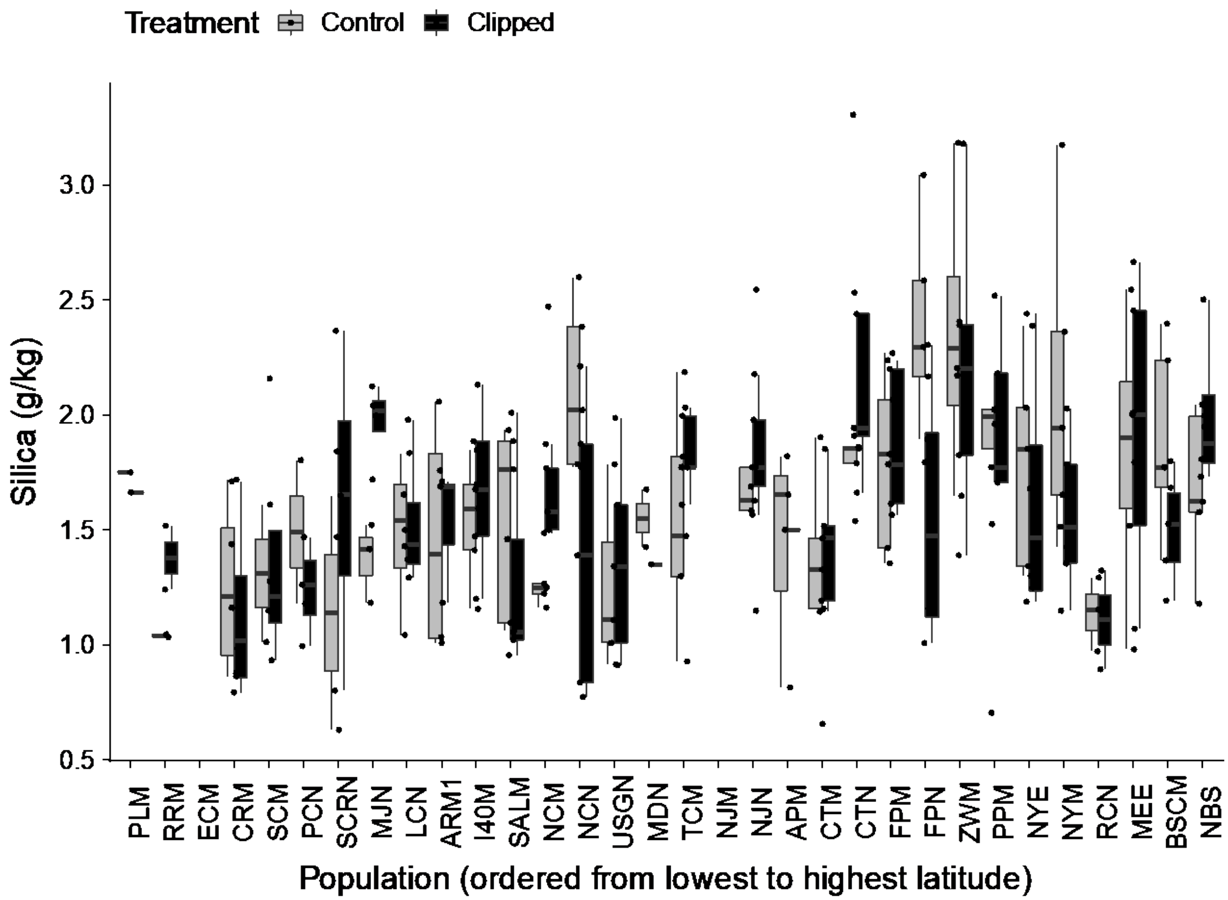

Figure A3.3. Boxplots of leaf silica concentrations for unclipped (gray) and clipped (black) treatments within each population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right).

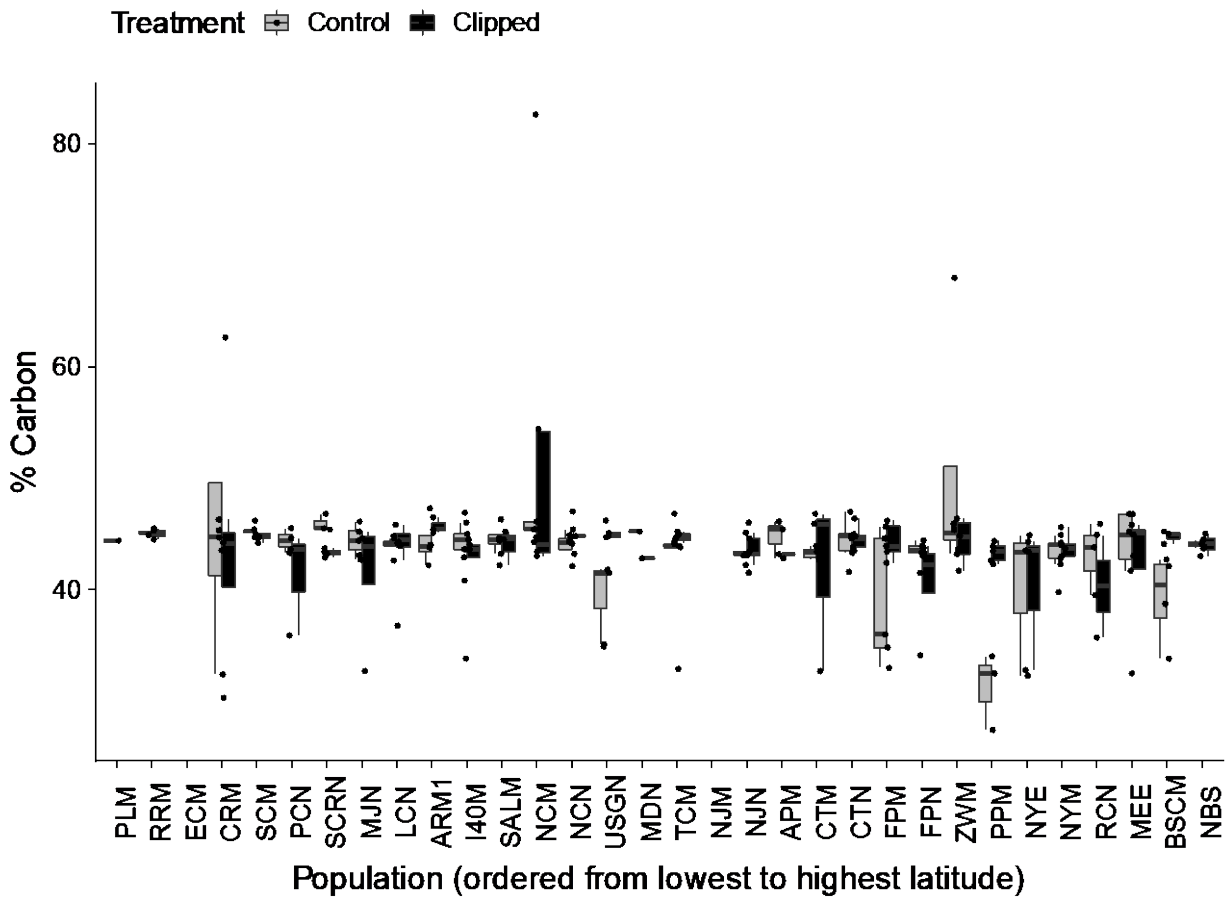

Figure A3.4. Boxplots of leaf percent carbon for unclipped (gray) and clipped (black) treatments within each population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right).

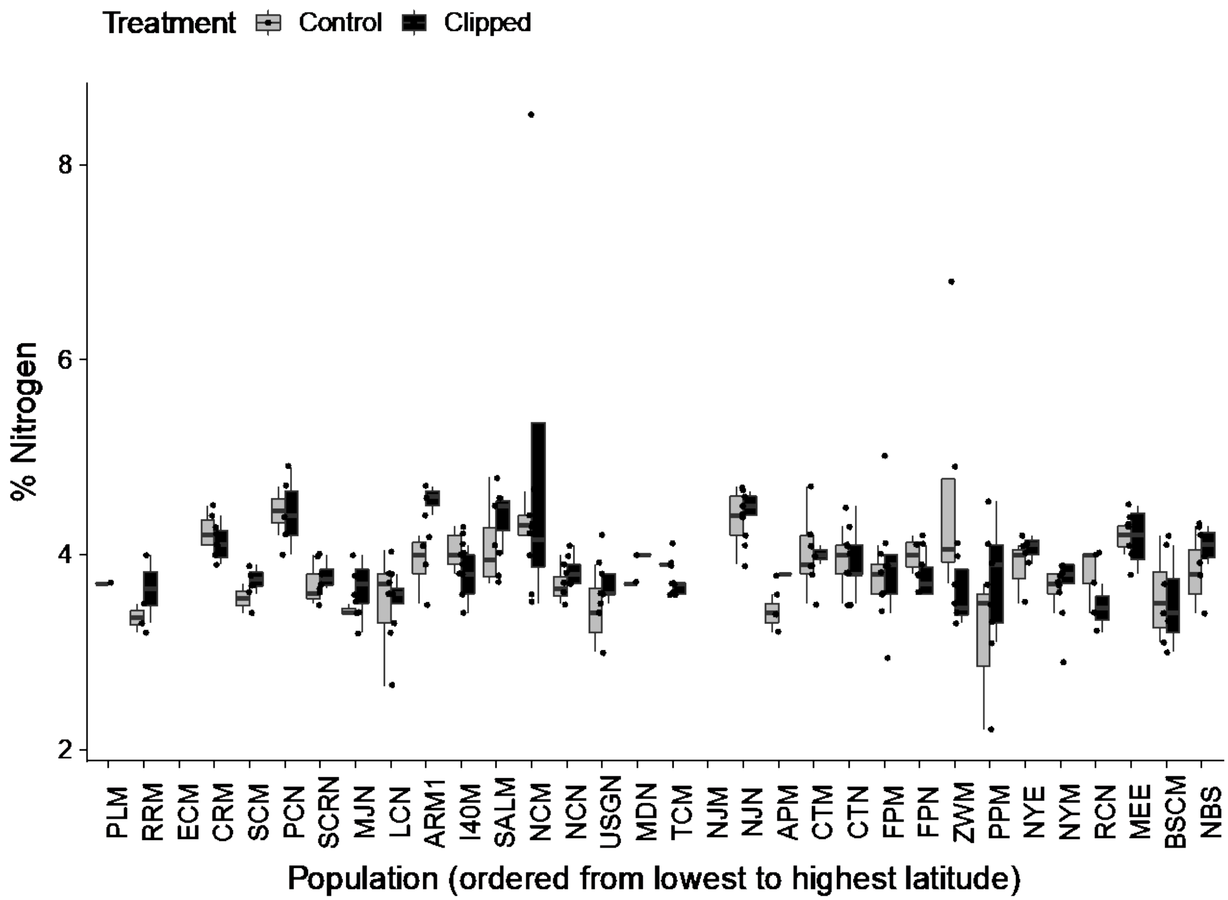

Figure A3.5. Boxplots of leaf percent nitrogen for unclipped (gray) and clipped (black) treatments within each population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right).

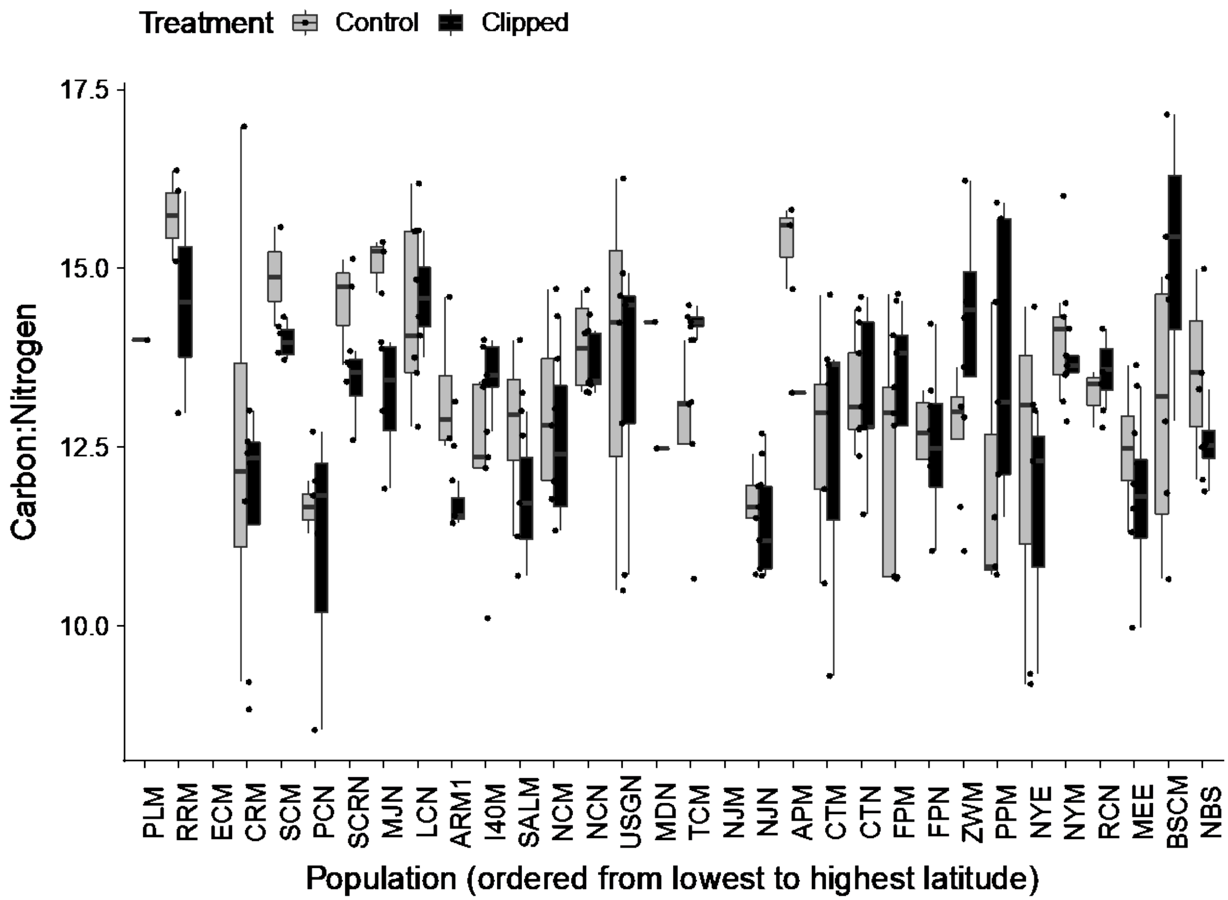

Figure A3.6. Boxplots of leaf carbon:nitrogen for unclipped (gray) and clipped (black) treatments within each population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right).

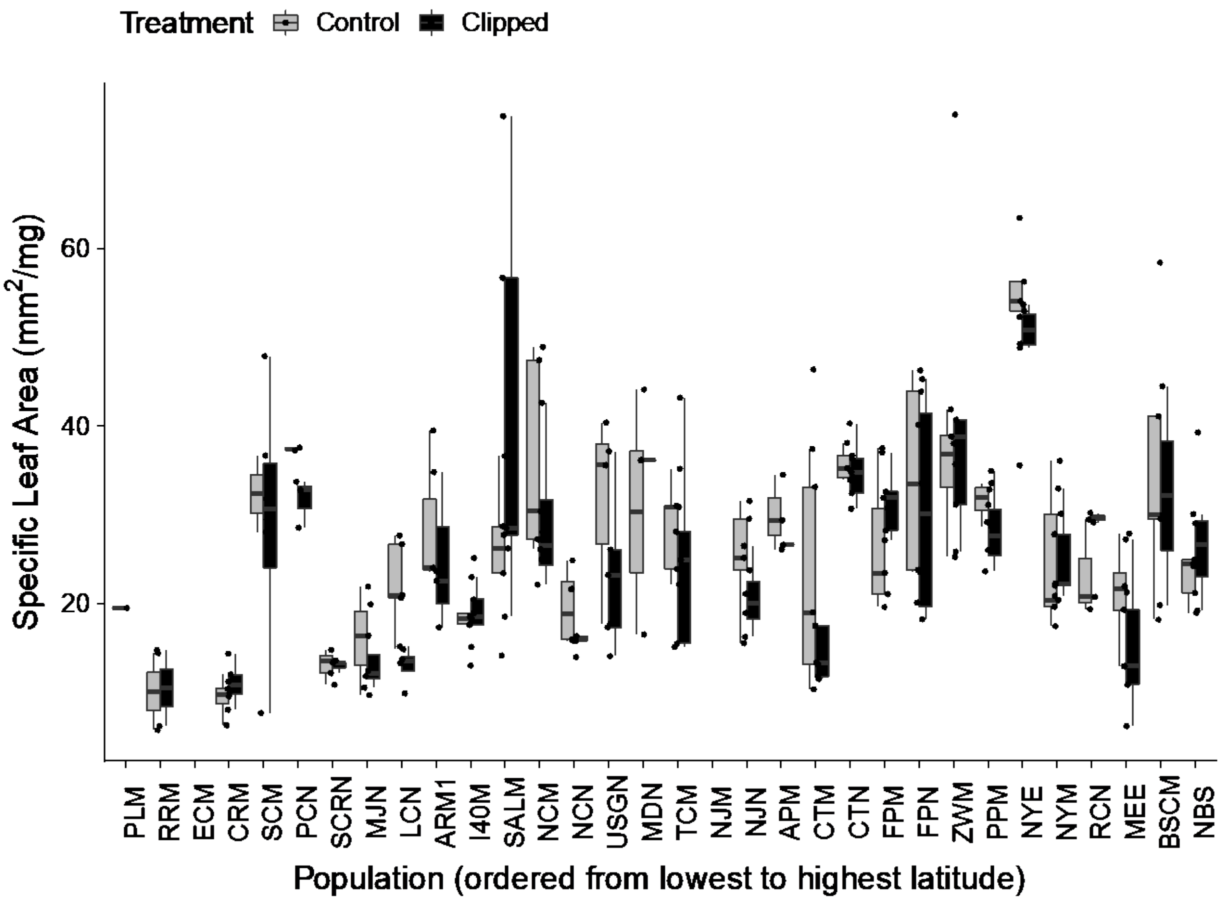

Figure A3.7. Boxplots of specific leaf area for unclipped (gray) and clipped (black) treatments within each population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right).

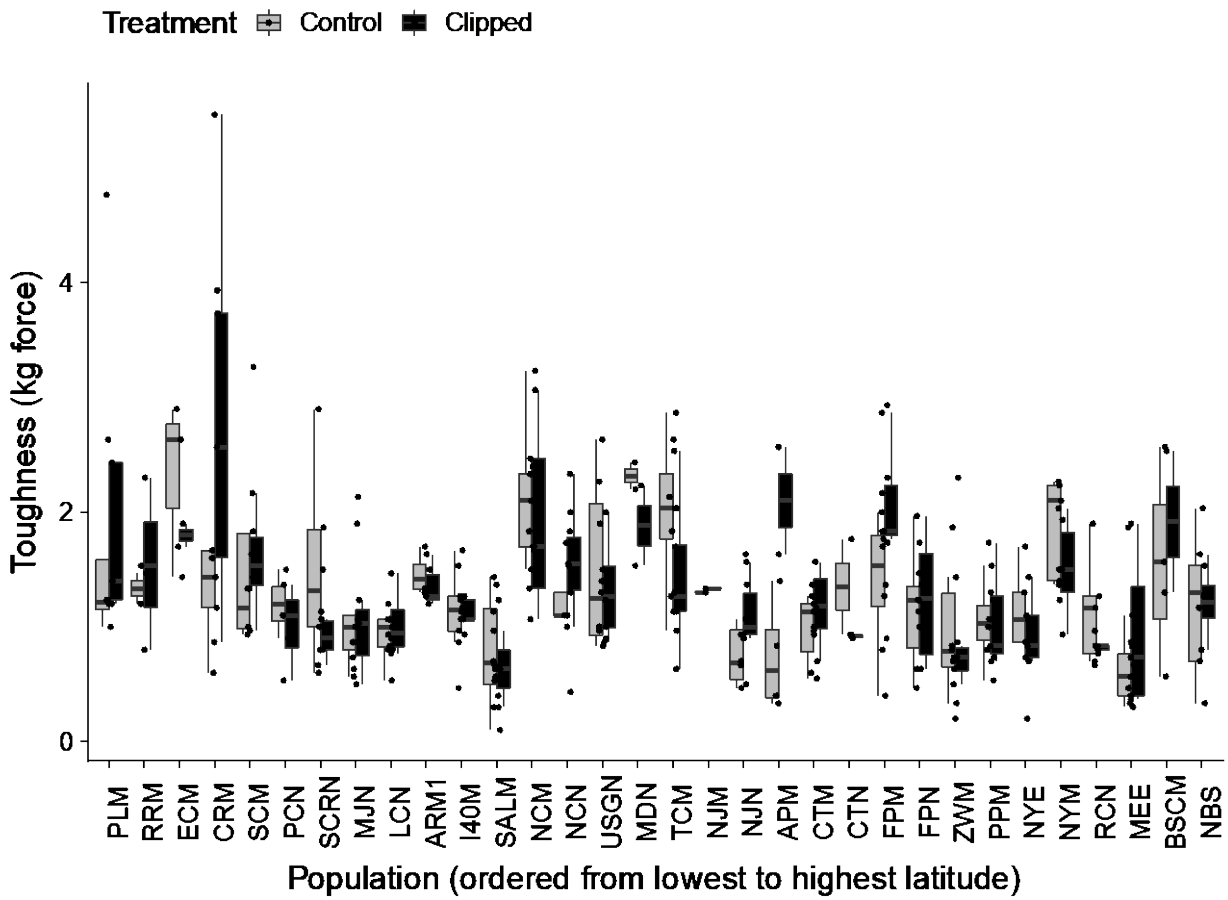

Figure A3.8. Boxplots of leaf toughness for unclipped (gray) and clipped (black) treatments within each population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right).

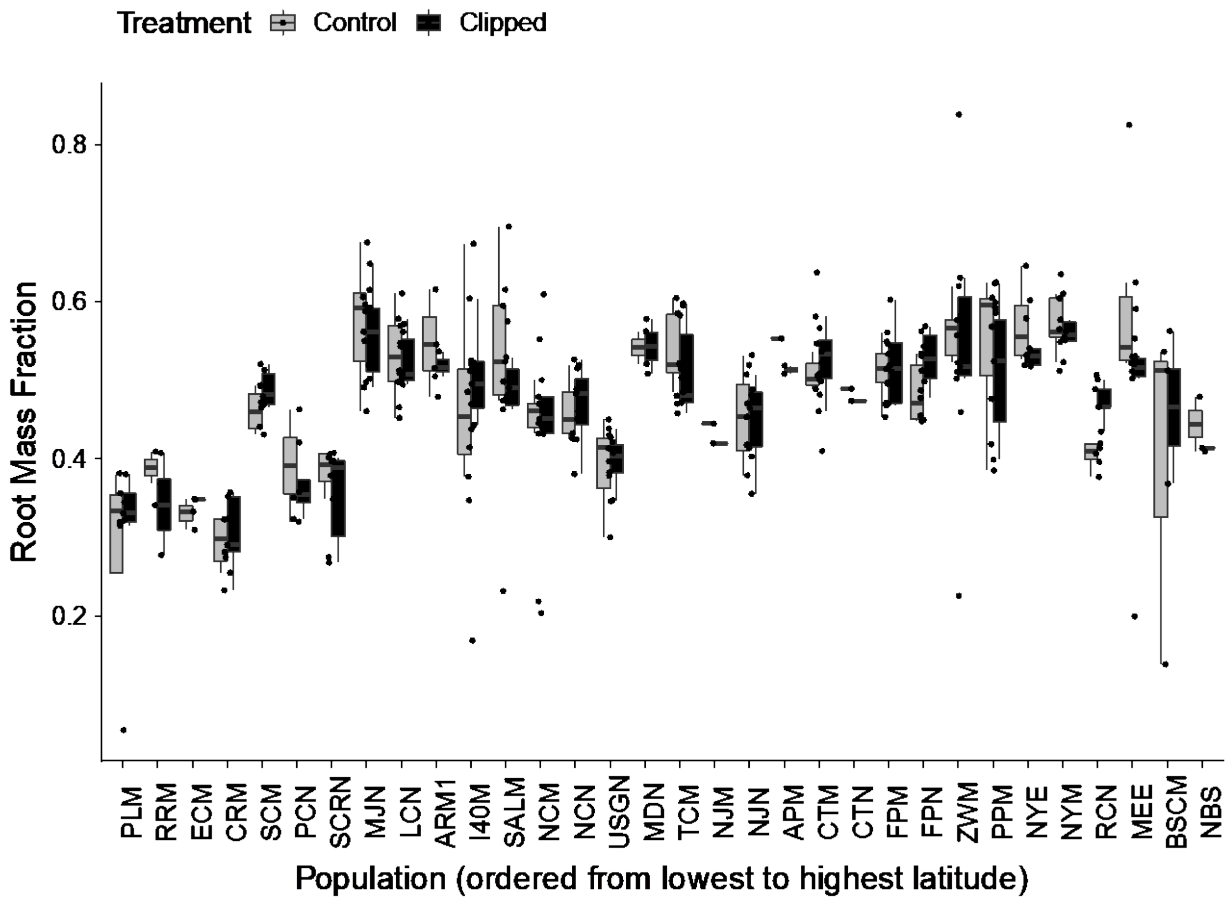

Figure A3.9. Boxplots of root mass fraction for unclipped (gray) and clipped (black) treatments within each population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right).

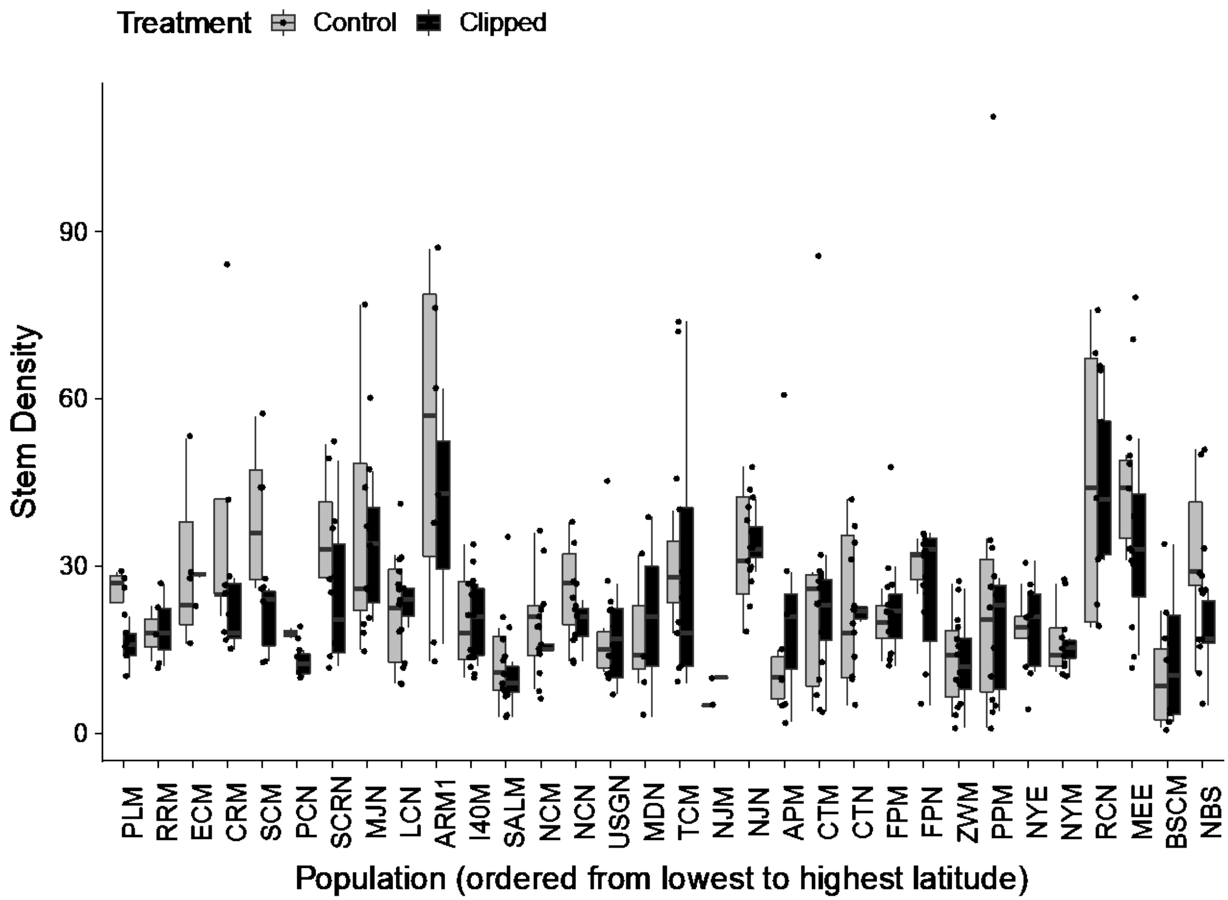

Figure A3.10. Boxplots of stem density for unclipped (gray) and clipped (black) treatments within each population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right).

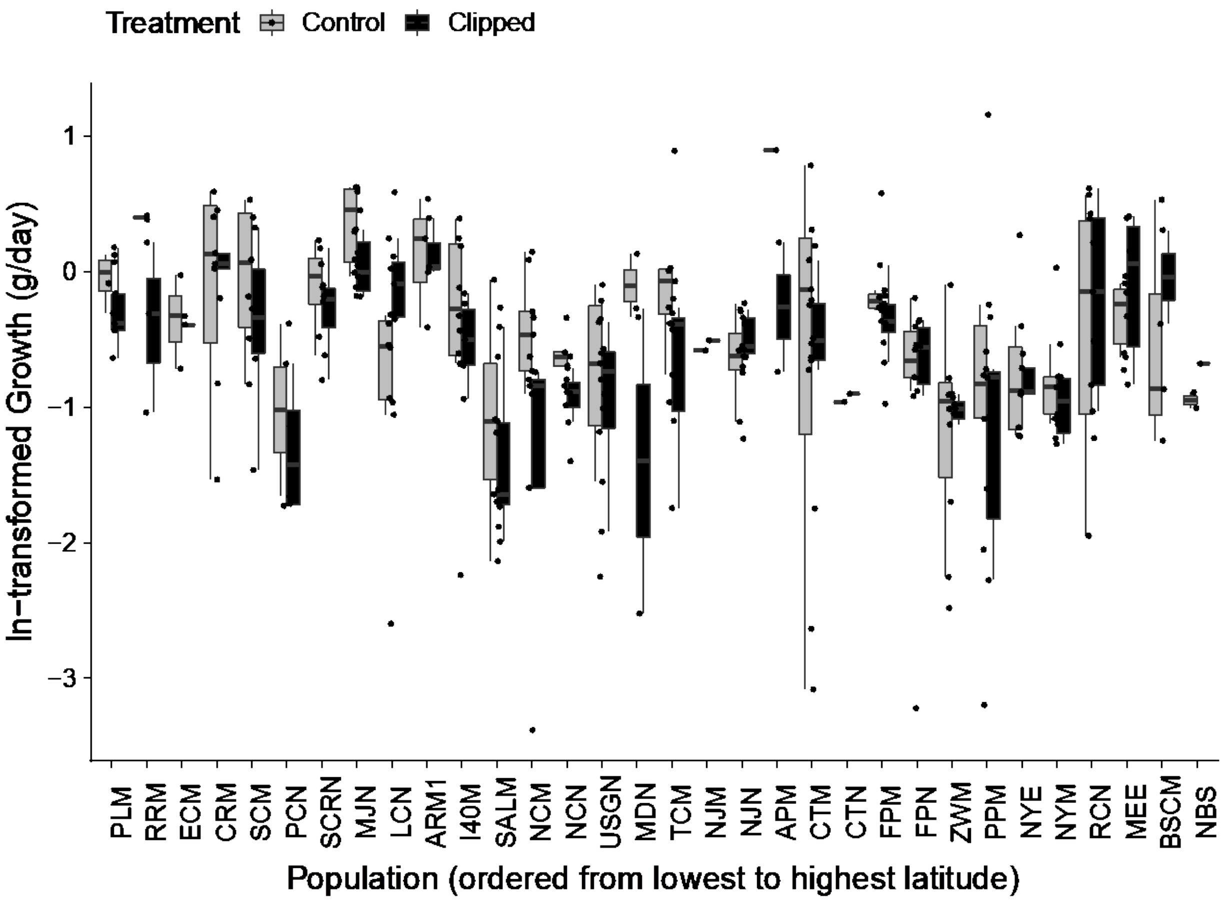

Figure A3.11. Boxplots of ln-transformed relative growth rate (grams per day) for unclipped (gray) and clipped (black) treatments within each population of *Phragmites australis* (ordered from lowest to highest latitude of origin from left to right).

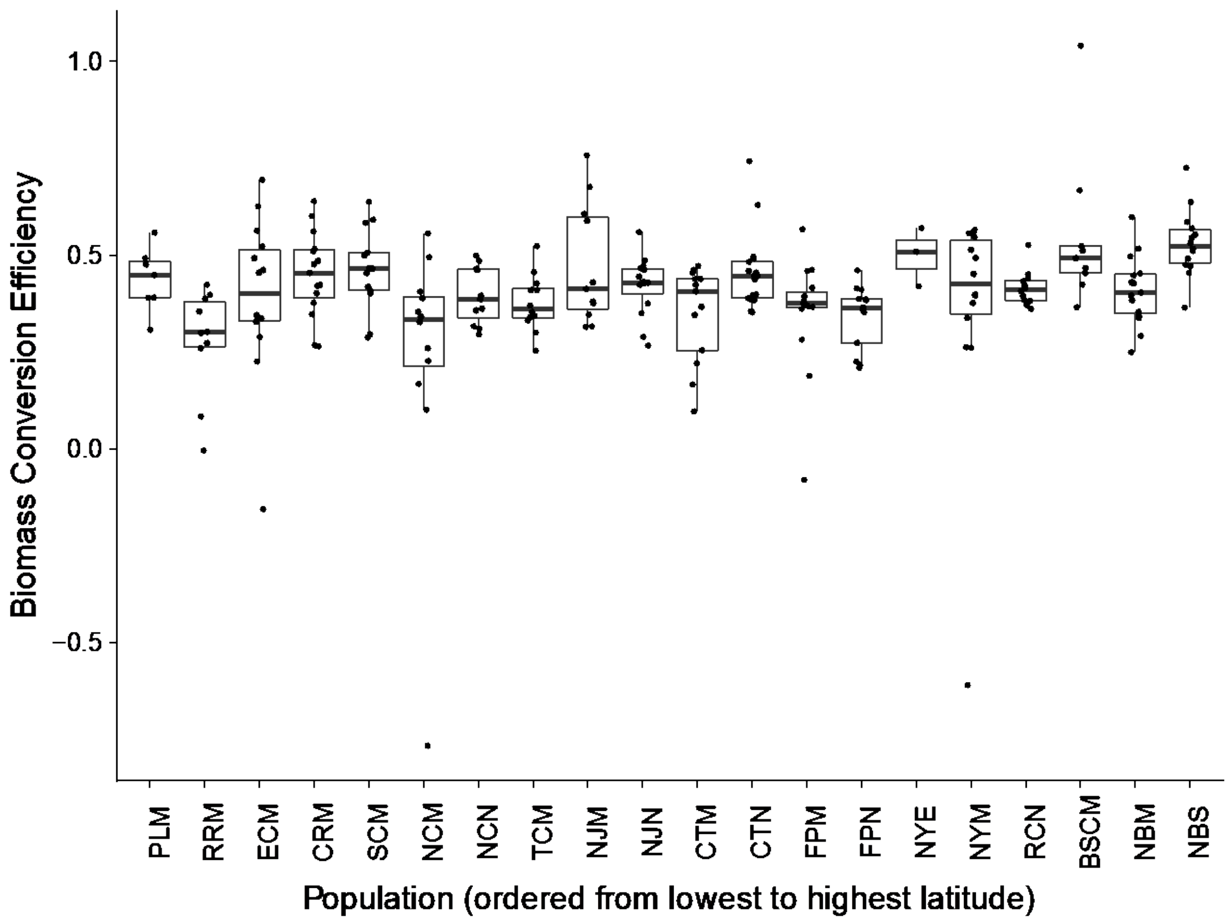

Figure A3.12. Boxplots of *Phragmites australis* resistance to a generalist leaf chewing insect, *Spodoptera frugiperda,* measured as the change in caterpillar mass per unit area of plant tissue consumed (biomass conversion efficiency), based on data collected by Bhattarai et al. (2017b). High values of biomass conversion efficiency indicate lower resistance. Populations are ordered from lowest to highest latitude of origin from left to right.