Ecography

E5975
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Supplementary material

Appendix S1

Cedar Creek oak savanna community species list (n = 261) and phylogeny (Nexus format, branch-length adjusted with fossil ages for included nodes) and references used to resolve the phylogeny.

Community Phylogeny: #NEXUS

BEGIN TREES;
TRANSLATE
1 Acer_negundo,
2 Acer_rubrum,
3 Achillea_millefolium,
4 Agastache_foeniculum,
5 Agropyron_repens,
6 Agrostis_scabra,
7 Ambrosia_artemisiaefolia,
8 Ambrosia_coronopifolia,
9 Ambrosia_sp.,
10 Amelanchier_alnifolia,
11 Amelanchier_arborea,
12 Amelanchier_laevis,
13 Amelanchier_sanguinea,
14 Amelanchier_sp.,
15 Amorpha_canescens,
16 Amphicarpa_bracteata,
17 Andropogon_gerardii,
18 Anemone_cylindrica,
19 Antennaria_neglecta,
20 Antennaria_plantiginifolia,
21 Antennaria_sp.,
22 Apocynum_androsaemifolium,
23 Apocynum_cannabinum,
24 Apocynum_sibiricum,
25 Apocynum_sp.,
26 Aquilegia_canadensis,
27 Aralia_nudicaulis,
28 Arenaria_lateriflora,
29 Aristida_basiramea,
30 Aristida_tuberculosa,
31 Artemisia_campestris,
32 Artemisia_ludoviciana,
33 Asclepias_ovalifolia,
34 Asclepias_sp.,
35 Asclepias_syriaca,
36 Asclepias_tuberosa,
37 Asclepias_verticillata,
38 Aster_azureus,
39 Aster_ericoides,
40 Aster_lanceolatus,
41 Aster_macrophyllus,
42 Aster_sp.,
43 Betula_papyrifera,
44 Bouteloua_curtipendula,
45 Bouteloua_hirsuta,
46 Bromus_inermis,
47 Bromus_kalmii,
48 Bromus_sp.,
49 Calamagrostis_canadensis,
50 Calamovilfa_longifolia,
51 Campanula_aparinoides,
52 Campanula_rotundifolia,
53 Carex_pennsylvanica,
54 Carex_spp.,
55 Ceanothus_americanus,
56 Celastrus_scandens,
57 Chenopodium_album,
58 Chenopodium_leptophyllum,
59 Chenopodium_sp.,
60 Chrysopsis_villosa,
61 Circaea_quadrisulcata,
62 Comandra_richardsiana,
63 Comandra_umbellata,
64 Conyza_canadensis,
65 Coreopsis_palmata,
66 Cornus_racemosa,
67 Cornus_sp.,
68 Cornus_stolonifera,
69 Corylus_americana,
70 Crepis_tectorum,
71 Cyperus_filiculmis,
72 Cyperus_Schweinitzii,
73 Cyperus_sp.,
74 Danthonia_spicata,
75 Delphinium_virescens,
76 Desmodium_canadense,
77 Desmodium_glutinosum,
78 Digitaria_sanguinalis,
79 Digitaria_sp.,
80 Dryopteris_spinulosa,
81 Elymus_canadensis,
82 Elymus_trachycaulus,
83 Equisetum_laevigatum,
84 Equisetum_sp.,
85 Eragrostis_spectabilis,
86 Erechtites_hieracifolia,
87 Erigeron_canadensis,
88 Erigeron_strigosus,
89 Eupatorium_rugosum,
90 Euphorbia_corollata,
91 Euphorbia_glyptosperma,
92 Euphorbia_sp.,
93 Fragaria_vesca,

94 Fragaria_virginiana,
95 Fraxinus_pennsylvanica,
96 Galium_aparine,
97 Galium_boreale,
98 Galium_triflorum,
99 Geranium_maculatum,
100 Glechoma_hederacea,
101 Gnaphalium_uliginosum,
102 Hackelia_americana,
103 Hedeoma_hispidum,
104 Helianthemum_bicknellii,
105 Helianthus_giganteus,
106 Helianthus_laetiflorus,
107 Heuchera_richardsonii,
108 Hieracium_longipilum,
109 Ilex_sp.,
110 Ilex_verticillata,
111 Juniperus_communis,
112 Koeleria_cristata,
113 Lactuca_canadensis,
114 Lactuca_sp.,
115 Lathyrus_ochroleucus,
116 Lathyrus_venosus,
117 Lechea_stricta,
118 Lepidium_sp.,
119 Leptoloma_cognatum,
120 Lespedeza_capitata,
121 Liatris_aspera,
122 Lithospermum_canescens,
123 Lithospermum_carolinense,
124 Lobelia_spicata,
125 Lonicera_dioica,
126 Lonicera_tatarica,
127 Lychnis_alba,
128 Lycopus_uniflorus,
129 Lysimachia_ciliata,
130 Maianthemum_canadense,
131 Mirabilis_hirsuta,
132 Mollugo_verticillata,
133 Monarda_fistulosa,
134 Muhlenbergia_racemosa,
135 Oenothera_biennis,
136 Oenothera_sp.,
137 Osmorrhiza_Claytoni,
138 Oxalis_sp.,
139 Oxalis_stricta,
140 Oxybaphus_hirsutus,
141 Panicum_cappilare,
142 Panicum_lanuginosum,
143 Panicum_oligosanthes,
144 Panicum_perlongum,
145 Panicum_praecocius,
146 Panicum_virgatum,
147 Parthenocissus_quinquefolia,
148 Parthenocissus_sp.,
149 Parthenocissus_vitacea,
150 Pedicularis_canadensis,
151 Pedicularis_sp.,
152 Penstemon_gracilis,
153 Penstemon_grandiflorus,
154 Penstemon_sp.,
155 Petalostemum_candida,
156 Petalostemum_purpureum,
157 Phalaris_arundinacea,
158 Phlox_pilosa,
159 Phlox_sp.,
160 Physalis_heterophylla,
161 Physalis_virginiana,
162 Pinus_strobus,
163 Plantago_major,
164 Poa_pratensis,
165 Polygala_polygama,
166 Polygonatum_biflorum,
167 Polygonatum_sp.,
168 Polygonella_articulata,
169 Polygonum_convolvulus,
170 Polygonum_scandens,
171 Polygonum_sp.,
172 Polygonum_tenue,
173 Populus_balsamifera,
174 Populus_grandidentata,
175 Populus_tremuloides,
176 Potentilla_arguta,
177 Potentilla_palustris,
178 Potentilla_simplex,
179 Potentilla_sp.,
180 Prenanthes_alba,
181 Prunus_americana,
182 Prunus_pensylvanica,
183 Prunus_serotina,
184 Prunus_sp.,
185 Prunus_virginiana,
186 Pteridium_aquilinum,
187 Pyrola_rotundifolia,
188 Pyrola_sp.,
189 Quercus_elipsoidalis,
190 Quercus_macrocarpa,
191 Quercus_sp.,
192 Ranunculus_rhomboideus,
193 Rhamnus_cathartica,
194 Rhamnus_frangula,
195 Rhus_glabra,
196 Rhus_radicans,
197 Robinia_pseudacacia,
198 Rosa_arkansana,
199 Rosa_blanda,
200 Rubus_alleghaniensis,
201 Rubus_flagellaris,
202 Rubus_idaeus,
203 Rubus_occidentalis,
204 Rubus_sp.,
205 Rubus_strigosus,
206 Rudbeckia_hirta,
207 Rumex_acetosella,
208 Salix_humilis,
209 Salix_sp.,
210 Schizachne_purpurascens,
211 Schizachyrium_scoparium,
212 Scleria_triglomerata,
213 Scutellaria_parvula,
214 Senecio_pauperculus,
215 Setaria_glauca,
216 Setaria_viridis,
217 Sisyrinchium_campestre,
218 Smilacina_racemosa,
219 Smilacina_stellata,
220 Smilax_herbacea,
221 Solanum_carolinense,
222 Solanum_dulcamara,
223 Solidago_canadensis,

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224 Solidago_gigantea,
225 Solidago_graminifolia,
226 Solidago_missouriensis,
227 Solidago_nemoralis,
228 Solidago_rigida,
229 Solidago_sp.,
230 Solidago_speciosa,
231 Sonchus_arvensis,
232 Sorghastrum_nutans,
233 Spiraea_alba,
234 Spiraea_tomentosa,
235 Sporobolus_cryptandrus,
236 Sporobolus_heterolepis,
237 Stachys_palustris,
238 Stellaria_longifolia,
239 Stipa_spartea,
240 Streptopus_roseus,
241 Taraxacum_officinale,
242 Taraxacum_sp.,
243 Tradescantia_occidentalis,
244 Tradescantia_sp.,
245 Tragopogon_dubius,
246 Trientalis_borealis,
247 Trifolium_pratense,
248 Trifolium_sp.,
249 Urtica_dioica,
250 Uvularia_sessifolia,
251 Vaccinium_angustifolium,
252 Vaccinium_myrtilloides,
253 Verbascum_thapsis,
254 Viburnum_lentago,
255 Viola_palustris,
256 Viola_pedatifida,
257 Viola_sagittata,
258 Viola_Selkirkii,
259 Viola_sp.,
260 Vitis_riparia,
261 Zanthoxylem_americanum;
TREE Oaksavcommphylo = (((83:133.333328,8
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monocoteudicot:164.0)seedplant:75.0)euphyllophyte:1.0;
END;
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Appendix S2

Fossil ages in millions of years, with reference used to date nodes of phylogenies for branch length reconstruction (Wikstöm et al. 2001).

//WIKSTROM AGES (mya)//	
Asteraceae	44
Betulaceae	19
Caryophyllales	84
euasterid1	107
euasterid2	107
eurosid2	95
eurosid1	98
Fagaceae	34
Fagales	61
Gentianales	71
Lamiaceae	23
monocoteudicot	161
rosid	121
Poaceae	12
Poales	72
Rhamnaceae	55
Rosaceae	47
Solanaceae	41
Polygonaceae	28
Cyperaceae	16
Myrtales	88
Salicaceae	20
Sapindales	61
Fabaceae	56
Rosales	76
Polemoniaceae	35
Ericaceae	12
Ericales	100
Boraginaceae	59
Liliaceae	48
seedplant	325
euphyllophyte	400
Ranunculaceae	65

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Appendix S3

Sensitivity analysis of phylogenetic signal of functional traits and trait correlations with species light availability niche. For each trait, the number (n) of species is given for the test of phylogenetic signal. The significance of phylogenetic signal was tested by comparing the rank of the observed variance (σ^2) to a null model based on 9999 random iterations of trait distributions across the composite phylogeny. The observed rank is compared to a two-tail test of significance, i.e. an observed rank of 250 equals a p-value of 0.05 and suggests trait conservatism. Phylogenetic trait-niche correlations were tested using univariate and multivariate generalized estimating equations (GEE). For the GEE analysis, multivariate 1 includes all five traits and multivariate 2 include all traits, but leaf area. Direction and magnitude of correlations are indicated by the sign and size of the β co-efficient, respectively. Phylogenetically corrected degrees of freedom (pDF) are provided for each model. The number of taxa used for the univariate model and the multivariates models are provided under n_2 and n_3, respectively. Traits include leaf area (cm^2); plant height at maturity (m); leaf perimeter per leaf area (cm^{-1}) [PA]; minimum rooting depth (m); specific leaf area ($cm^2\ g^{-1}$) [SLA]; and species light availability niche.
Sensitivity to topology was tested by analyzing phylogenetic signal and trait-environment correlations across 50 phylogenetic trees with polytomies randomly resolved. The mean of these 50 analyzes are presented. Sensitivity to branch length was tested by analyzing phylogenetic signal and trait-environment correlations with a phylogeny where all branch lengths were set to 1 Significance for trait correlations was corrected for multiple tests (k = 5) using a sequential bonferroni adjustment. † $p < 0.08$, * $p < 0.01$, ** $p < 0.001$, *** $p < 0.0001$.

Sensitivity analysis of topology

Trait	Phylogenetic signal			Phylogenetic trait correlations with light availability niche													
				univariate					multivariate 1					multivariate 2			
Trait	n_1	σ^2 Rank		n_2	pDF	β	t		n_3	pDF	β	t		pDF	β	t	
Leaf area	113	1366		86	18.4	–0.07	–5.09	*	39	9.1	–0.04	–1.15		–	–	–	–
Height at maturity	86	5156		65	11.8	–0.07	–3.54	*	39	9.1	–0.03	–0.96		9.1	–0.04	–1.94	
PA	113	132	*	86	18.4	0.21	10.74	***	39	9.1	0.16	3.27		9.1	0.20	5.56	*
Rooting depth	86	1064		65	11.8	0.13	3.69	*	39	9.1	–0.05	–1.34		9.1	–0.04	–1.16	
SLA	107	186	*	83	17.8	–0.26	–9.12	***	39	9.1	–0.22	–4.53	†	9.1	–0.21	–4.56	*
Species niche																	
Light availability	139	1	***		–	–	–			–	–	–		–	–	–	

Sensitivity analysis of branch length

Trait	Phylogenetic signal			Phylogenetic trait correlations with light availability niche													
				univariate					multivariate 1					multivariate 2			
Trait	n_1	σ^2 Rank		n_2	pDF	β	t		n_3	pDF	β	t		pDF	β	t	
Leaf area	113	54	**	86	24.5	–0.09	–4.06	**	39	13.8	0.02	0.39		–	–	–	
Height at maturity	86	1819		65	16.8	–0.07	–2.17		39	13.8	–0.07	–1.85		13.75	–0.06	–1.82	
PA	113	17	**	86	24.5	0.18	5.52	***	39	13.8	0.10	1.09		13.75	0.08	1.11	
Rooting depth	86	4343		65	16.8	0.00	0.04		39	13.8	–0.06	–0.74		13.75	–0.06	–0.78	
SLA	107	2570		83	23.7	–0.31	–6.16	***	39	13.8	–0.35	–3.44	**	13.75	–0.36	–3.56	*
Species niche																	
Light availability	139	1	***		–	–	–			–	–	–		–	–	–	

Appendix S4

Sensitivity analysis of phylogenetic community structure at the landscape scale (0.375 ha) to phylogeny topology and branch length. Observed test statistics (least mean squares correlation coefficient (LMS) or regression slope of 50th and 75th quantile) for the relationship between pairwise co-occurrences and phylogenetic distances were compared to those in which species abundances within communities were randomized 999 times. A rank of 975 or higher indicates phylogenetic clustering, and a rank of 25 or lower indicates phylogenetic overdispersion at an alpha level of 0.05. Sensitivity to topology was tested by computing phylogenetic community structure using 25 phylogenetic trees with polytomies randomly resolved. The mean observed rank of the observed community is given along with the standard error (SE). To test the effects of branch length, phylogenetic community structure was computed using a phylogeny where all branch lengths were set to 1.

	Topology		Branch length	Branch length new ages
Test	Mean obs. rank	SE	Obs. rank	Obs. rank
LMS	995.9	0.6	913	999
50 quantile	994.8	3.6	574	999
75 quantile	991.8	0.5	520	999

Appendix S5

Phylogenetic structure of communities within plots among neighbors (0.5 m^2). Each plot was analyzed separately. There were 24 neighbors per plot. Observed test statistics (least mean squares correlation co-efficient [LMS] or regression slope of 75th quantile [75q]) for the relationship between pairwise co-occurrences and phylogenetic distances were compared to those in which species abundances within communities were randomized 999 times. The rank of the observed community is given relative to the distribution of the 999 simulated communities. A rank of 975 or higher indicates phylogenetic clustering, and a rank of 25 or lower indicates phylogenetic overdispersion at an alpha level of 0.05. Variance of light availability (σ^2_{light}) across neighborhoods within each plot is also provided. Sensitivity to topology was tested by computing phylogenetic community structure using 25 phylogenetic trees with polytomies randomly resolved. The mean observed rank of the observed community is given along with the standard error (SE) [subscript top]. To test the effects of branch length, phylogenetic community structure was computed using a phylogeny where all branch lengths were set to 1 (subscript BL).

plot	σ^2_{light}	LMS	75q	LMS_{top}	$LMS_{top}SE$	$75q_{top}$	$75q_{top}SE$	LMS_{BL}	$75q_{BL}$
1	0.041	207	228	215	8	27	3	331	116
3	0.025	125	1	190	8	39	4	230	185
4	0.037	927	811	713	8	820	7	782	720
5	0.037	996	943	999	0	966	2	972	940
6	0.065	990	864	924	5	702	8	987	961
7	0.019	765	504	556	8	237	8	952	719
8	0.015	283	89	102	4	8	2	29	104
9	0.002	448	152	122	6	85	5	293	115
10	0.001	299	131	224	8	582	6	245	368
11	0.030	880	960	857	6	917	6	857	792
13	0.008	801	893	895	6	962	3	342	430
15	0.003	38	258	30	2	322	7	21	73
16	0.029	998	996	978	2	970	3	931	993
17	0.026	215	299	445	7	266	8	103	100
18	0.000	733	288	574	8	252	8	416	158
19	0.034	864	792	775	7	855	7	314	215
20	0.000	61	114	207	7	362	9	189	439
21	0.008	726	511	931	4	777	7	860	716
22	0.008	721	41	850	6	144	8	2	4
24	0.034	539	758	818	8	634	10	278	301
28	0.091	836	966	772	8	938	4	864	905
101	0.055	990	999	985	1	999	0	977	996
102	0.086	997	999	972	2	964	3	964	999
103	0.09	909	993	977	2	990	0	917	983
901	0.035	586	709	558	8	596	11	620	746
902	0.008	532	238	204	7	61	4	448	8
903	0.059	983	999	999	0	999	0	977	985
904	0.029	837	750	743	9	636	9	523	232
905	0.017	865	213	676	8	63	5	201	5

Appendix S6

Correlations between phylogenetic community structure and environmental variation with spatial extent held constant. Correlations were tested using parametric Pearson's correlation co-efficient (R) and non-parametric Kendall's tau. Correlations were tested using phylogenetic community structure results from least mean square (LMS) and 75th quantile regression (75q) analysis. Correlations were also tested with phylogenetic community structure results from topology (subscript top) and branch length (subscript BL) sensitivity analysis.

Test	Pearson's R	t	p-value	tau	z	p-value
LMS	0.52	3.19	0.0036	0.44	3.29	0.0010
75q	0.71	5.17	< 0.0001	0.54	4.04	0.0001
LMS_{BL}	0.65	4.41	0.0001	0.47	3.55	0.0004
$75q_{BL}$	0.68	4.84	< 0.0001	0.46	3.46	0.0005
LMS_{top}	0.56	3.48	0.0017	0.39	2.95	0.0032
$75q_{top}$	0.59	3.75	0.0009	0.39	2.91	0.0036