Ecography

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Supplementary material

Appendix 1

Table A1. Site level summary statistics. Mean cones is the average number of seed cones produced per tree, across all years. CV_p is the ratio of the standard deviation to the long term mean of seed cone production at each site, with higher values indicating more variable cone production. Within site *r* is the degree of synchrony (mean pairwise Spearman correlation) between all trees and across all years at a site. Within cluster *r* is calculated in the same manner but is measured between sites within each cluster (representing how synchronous a site is with others in the identified cluster). Monsoonality is the 30-year mean of July, August, and September precipitation- reported in both absolute quantities (millimeters) and percent of annual precipitation. Climatic water deficit was calculated using the CWD and AET function in R (Redmond 2018) and is the 30-year average of the difference between potential and actual evapotranspiration at 800-meter resolution. Mean live canopy area was included as a scalar to account for differences between stands across sites and is the average area of live canopy of all trees within a site.

Cluster	Elevation (m)	Latitude	Longitude	Mean cones (tree/year)	CV_p	Within site *r*	Within cluster *r*	Monsoonality (mm / % annual ppt)		CWD (mm)	Mean live canopy area (m2)
A	2061	40.87	106.14	26	1.81	0.88	0.85	107	23.2%	288	18.78
A	2099	40.59	108.67	38	1.85	0.79	0.85	114	23.6%	311	19.49
B	1905	39.00	108.89	10	1.77	0.42	0.49	111	24.1%	562	12.27
B	2121	38.94	108.91	15	1.68	0.6	0.53	119	25.3%	402	19.35
B	1925	38.74	107.61	30	1.29	0.59	0.54	121	26.4%	438	21.38
B	1897	38.64	109.01	28	1.62	0.49	0.54	160	30.5%	439	13.37
B	2274	38.62	107.59	36	1.3	0.44	0.52	143	29.2%	223	17.86
B	2312	38.62	109.05	46	1.39	0.59	0.59	175	30.1%	316	21.4
B	1897	38.45	108.02	21	1.85	0.52	0.44	118	35.0%	447	15.29
C	2306	38.38	108.07	42	1.04	0.45	0.72	167	34.1%	243	16.72
B	2155	38.13	108.57	30	1.31	0.54	0.54	153	33.8%	352	16.59
B	1967	38.12	108.50	28	1.45	0.41	0.51	148	34.5%	366	21.86
C	1966	37.88	108.59	37	1.32	0.69	0.64	136	31.6%	422	20.97
C	2196	37.86	108.63	53	1.13	0.63	0.54	135	30.8%	297	24.79
C	2422	36.49	106.46	46	1.31	0.52	0.60	187	38.2%	176	22.21
C	2117	36.39	106.49	45	1.27	0.67	0.65	163	40.4%	307	15.33
C	2208	35.71	106.62	36	1.18	0.48	0.63	215	41.7%	246	17.25
C	1930	35.68	106.66	39	1.12	0.52	0.59	193	46.3%	533	13.55
D	1853	35.28	106.48	20	2.38	0.73	0.53	186	42.0%	604	18.64
D	2013	35.25	106.36	16	2.2	0.75	0.68	214	40.9%	435	11.83
D	1892	34.20	107.21	59	1.24	0.64	0.68	178	52.9%	754	27.37
D	2261	34.06	107.23	50	1.35	0.78	0.58	322	56.1%	278	18.24
C	2066	34.04	107.13	40	1.44	0.54	0.43	223	54.7%	561	18.66
D	1770	33.44	108.84	39	1.56	0.77	0.73	233	41.4%	345	26.27
D	2072	33.39	108.82	53	1.38	0.56	0.72	248	42.2%	347	25.23
D	1479	33.30	108.88	36	1.64	0.68	0.74	217	43.7%	529	27.57
B	2176	32.83	108.36	46	1.16	0.51	0.28	297	46.8%	255	37.77
B	1887	32.81	108.15	42	1.52	0.73	0.36	256	53.1%	598	32.87

Table A2. 1st IQR, median, and 3rd IQR of Spearman's ρ with monthly weather variables for three years prior to year of seed cone maturation. Bold shows strongest correlations used in full model.

VPD				**PPT**			
Month	1st IQR	median	3rd IQR	Month	1st IQR	median	3rd IQR
J (yr_{-3})	-0.129	0.084	0.240	J (yr_{-3})	-0.008	0.099	0.210
F	-0.193	-0.004	0.258	F	-0.189	-0.048	0.154
M	-0.015	0.149	0.307	M	-0.295	-0.182	-0.002
A	0.044	0.136	0.252	A	-0.357	-0.169	-0.097
M	-0.158	0.134	0.314	M	-0.198	-0.057	0.102
J	0.003	0.147	0.297	J	-0.407	-0.259	-0.073
J	-0.225	-0.038	0.128	J	-0.160	-0.056	0.107
A	-0.018	0.136	0.199	A	-0.403	-0.273	-0.072
S	-0.211	-0.113	-0.010	S	0.017	0.123	0.300
O	-0.265	-0.081	0.087	O	-0.181	-0.114	0.040
N	0.126	0.209	0.384	N	-0.329	-0.189	-0.009
D	-0.194	0.064	0.344	D	-0.374	-0.206	-0.052
J (yr_{-2})	-0.142	0.160	0.343	J (yr_{-2})	-0.373	-0.132	0.090
F	-0.082	0.189	0.459	F	-0.368	-0.103	0.172
M	-0.230	-0.054	0.097	M	-0.189	0.000	0.208
A	-0.215	-0.018	0.093	A	-0.188	-0.046	0.130
M	-0.180	0.000	0.152	M	-0.143	0.011	0.130
J	-0.156	-0.043	0.075	J	-0.097	0.130	0.239
J	-0.200	-0.080	0.058	J	0.163	0.262	0.407
A	**-0.552**	**-0.448**	**-0.176**	A	0.170	0.281	0.536
S	-0.399	-0.153	-0.033	S	0.014	0.240	0.391
O	-0.219	-0.119	0.049	O	-0.076	0.147	0.302
N	-0.389	-0.138	-0.071	N	-0.046	0.148	0.339
D	-0.318	-0.178	-0.060	D	-0.038	0.134	0.222
J (yr_{-1})	-0.326	-0.242	-0.090	J (yr_{-1})	-0.136	0.086	0.273
F	-0.160	0.046	0.258	F	-0.128	-0.026	0.232
M	-0.260	-0.079	0.163	M	-0.049	0.185	0.427
A	-0.539	-0.399	-0.324	A	0.240	0.423	0.525
M	-0.553	-0.448	-0.390	M	0.285	0.354	0.460
J	-0.334	-0.233	-0.042	J	-0.022	0.112	0.274
J	-0.198	-0.147	-0.023	J	-0.035	0.102	0.238
A	-0.158	-0.075	0.055	A	-0.095	-0.007	0.179
S	0.004	0.170	0.230	S	-0.290	-0.083	0.003
O	-0.153	-0.029	0.152	O	-0.146	-0.077	0.053
N	-0.110	-0.029	0.078	N	-0.225	-0.044	0.144
D	-0.288	-0.103	0.134	D	-0.098	0.085	0.214

Table A3. 1st IQR, median, and 3rd IQR of Spearman's ρ with bimonthly averages of weather variables for the three years prior to year of seed cone maturation. Bold shows strongest correlation used in full model.

VPD				**PPT**			
Month	1st IQR	median	3rd IQR	Month	1st IQR	median	3rd IQR
JF(yr_{-3})	-0.116	0.033	0.245	JF(yr_{-3})	-0.100	0.095	0.177
FM	-0.142	0.056	0.350	FM	-0.260	-0.092	0.002
MA	-0.037	0.197	0.391	MA	-0.334	-0.207	-0.080
AM	0.022	0.155	0.354	AM	-0.308	-0.176	-0.001
MJ	-0.025	0.147	0.222	MJ	-0.244	-0.163	-0.088
JJ	0.082	0.217	0.302	JJ	-0.213	-0.095	0.020
JA	-0.042	0.107	0.277	JA	-0.296	-0.157	-0.011
AS	-0.147	-0.015	0.163	AS	-0.203	-0.042	0.108
SO	-0.222	-0.136	0.039	SO	-0.065	0.139	0.241
ON	-0.121	0.019	0.205	ON	-0.257	-0.111	0.004
ND	0.124	0.229	0.386	ND	-0.365	-0.209	-0.067
DJ	-0.278	0.317	0.421	DJ	-0.411	-0.236	-0.008
JF(yr_{-2})	-0.058	0.297	0.466	JF(yr_{-2})	-0.445	-0.077	0.225
FM	-0.048	0.071	0.358	FM	-0.320	-0.040	0.179
MA	-0.248	-0.064	0.113	MA	-0.170	-0.065	0.176
AM	-0.169	-0.084	0.092	AM	-0.211	0.001	0.157
MJ	-0.074	-0.004	0.079	MJ	-0.031	0.069	0.230
JJ	-0.253	-0.107	-0.003	JJ	0.097	0.300	0.431
JA	-0.496	-0.345	-0.270	JA	0.252	0.352	0.521
AS	-0.527	-0.437	-0.245	AS	0.181	0.441	0.549
SO	-0.403	-0.182	0.004	SO	0.125	0.253	0.369
ON	-0.295	-0.180	0.067	ON	-0.099	0.101	0.392
ND	-0.394	-0.237	-0.033	ND	-0.120	0.194	0.292
DJ	-0.391	-0.280	-0.155	DJ	-0.008	0.123	0.314
JF(yr_{-1})	-0.286	-0.059	0.073	JF(yr_{-1})	-0.159	0.017	0.287
FM	-0.221	-0.130	0.235	FM	-0.098	0.076	0.346
MA	-0.484	-0.355	-0.053	MA	0.135	0.352	0.497
AM	**-0.659**	**-0.564**	**-0.453**	AM	0.307	0.499	0.616
MJ	-0.512	-0.383	-0.262	MJ	0.213	0.336	0.403
JJ	-0.431	-0.251	-0.160	JJ	-0.114	0.070	0.247
JA	-0.240	-0.089	0.031	JA	-0.052	0.087	0.223
AS	-0.078	-0.014	0.151	AS	-0.227	-0.099	0.028
SO	-0.066	0.042	0.205	SO	-0.365	-0.053	-0.001
ON	-0.123	-0.063	0.097	ON	-0.268	-0.116	0.024
ND	-0.169	-0.055	0.123	ND	-0.085	0.011	0.145
DJ	-0.249	-0.104	0.173	DJ	-0.169	-0.011	0.258

Table A4. To identify which tree size variable is most strongly associated with seed cone production, we performed linear mixed effect models to assess the relationship between mean cone production (number of cones per tree) at the tree-level and three metrics of tree size: mean live canopy area, height, and basal area (measured at root collar). Because our metrics of tree size were correlated with one another, we built three separate linear mixed models and included site as a random intercept. Our analyses indicated that live canopy area was the strongest tree-level correlate with mean seed cone production.

Variable	β	SE	T value
Live Canopy Area	8.59	1.20	7.19
Basal Area	4.84	1.27	3.80
Height	4.95	1.41	3.50
			df=185

Table A5. Multiple regression on distance matrices (MRM) model of synchrony between sites. Significance of individual terms and full model determined using permutation tests (n=999).

Variable	MRM Coefficient	*P* value
April/May VPD_{yr-1}	0.052	0.014
August VPD_{yr-2}	0.053	0.025
Geographic Distance	0.000	0.496
$R^2 = 0.29$	*F=51.4*	*P = 0.001*

Table A6. All model subsets within 4 AICc units of top model.

Canopy	CWD	VPD_{yr-1}	VPD_{yr-2}	Monsoon	$Cones_{yr-1}$	VPD_{yr-1} x CWD	VPD_{yr-2} x CWD	VPD_{yr-1} x Monsoon	VPD_{yr-2} x Monsoon	df	logLik	AICc	delta	weight
0.21	-0.28	-0.53	-0.23	0.28	-0.34	-	-	-0.19	0.29	11.00	-1596.47	3215.69	0.00	0.32
0.21	-0.29	-0.54	-0.22	0.29	-0.34	-	-0.08	-0.19	0.32	12.00	-1595.52	3215.93	0.24	0.28
0.21	-0.28	-0.53	-0.23	0.29	-0.34	-0.03	-	-0.18	0.29	12.00	-1596.28	3217.45	1.76	0.13
0.21	-0.29	-0.54	-0.22	0.29	-0.34	0.00	-0.08	-0.19	0.32	13.00	-1595.52	3218.08	2.39	0.10
NA	-0.32	-0.54	-0.23	0.38	-0.32	-	-	-0.19	0.29	10.00	-1599.45	3219.52	3.83	0.05