Supplementary Materials

Use of functional traits to distinguish successional guilds of tree species for restoring forest ecosystems

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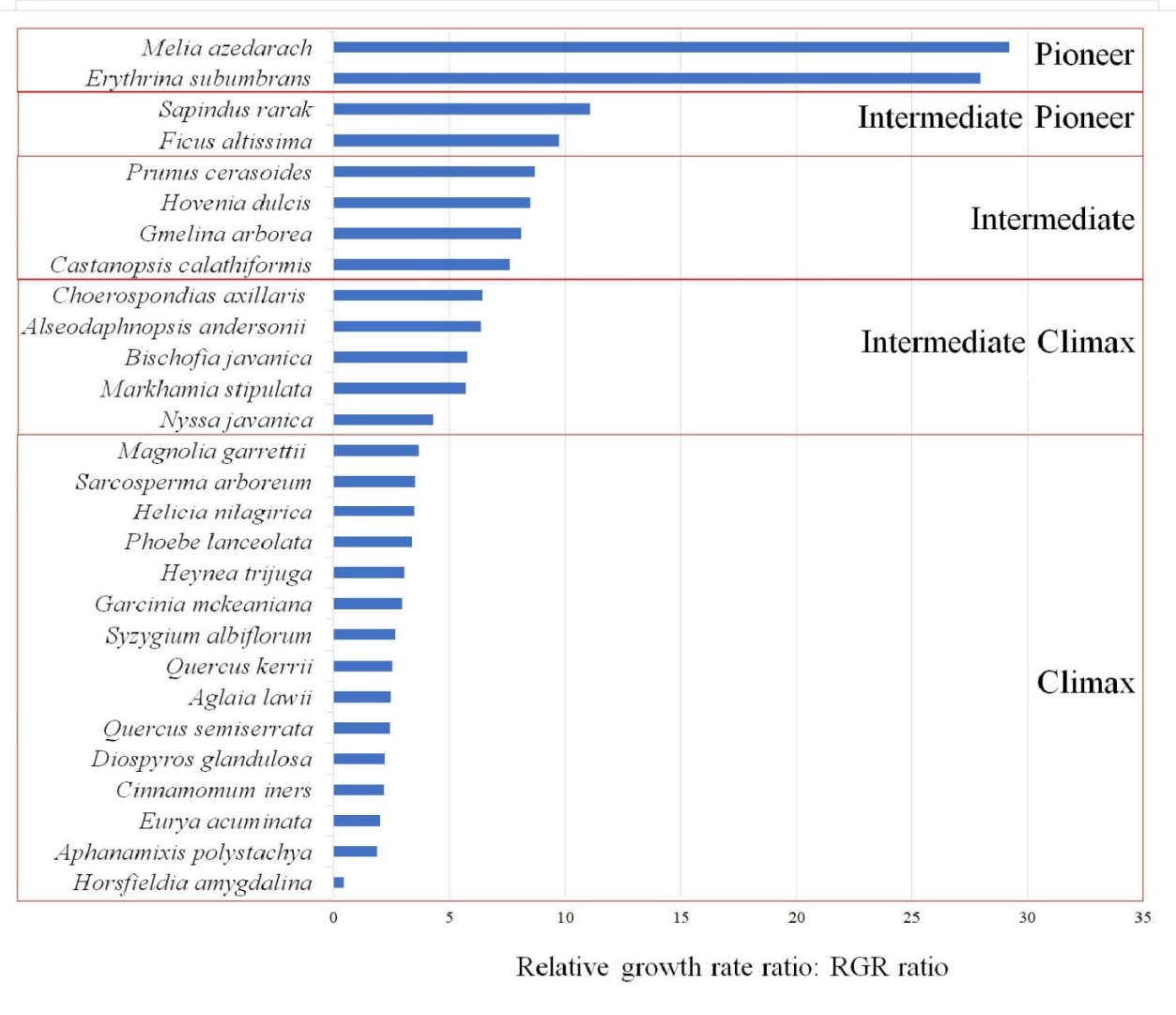

Figure S1. Relative growth rate (RGR) ratio as an indicator of successional status (the ratio between relative growth rate pre- and post-canopy closure)

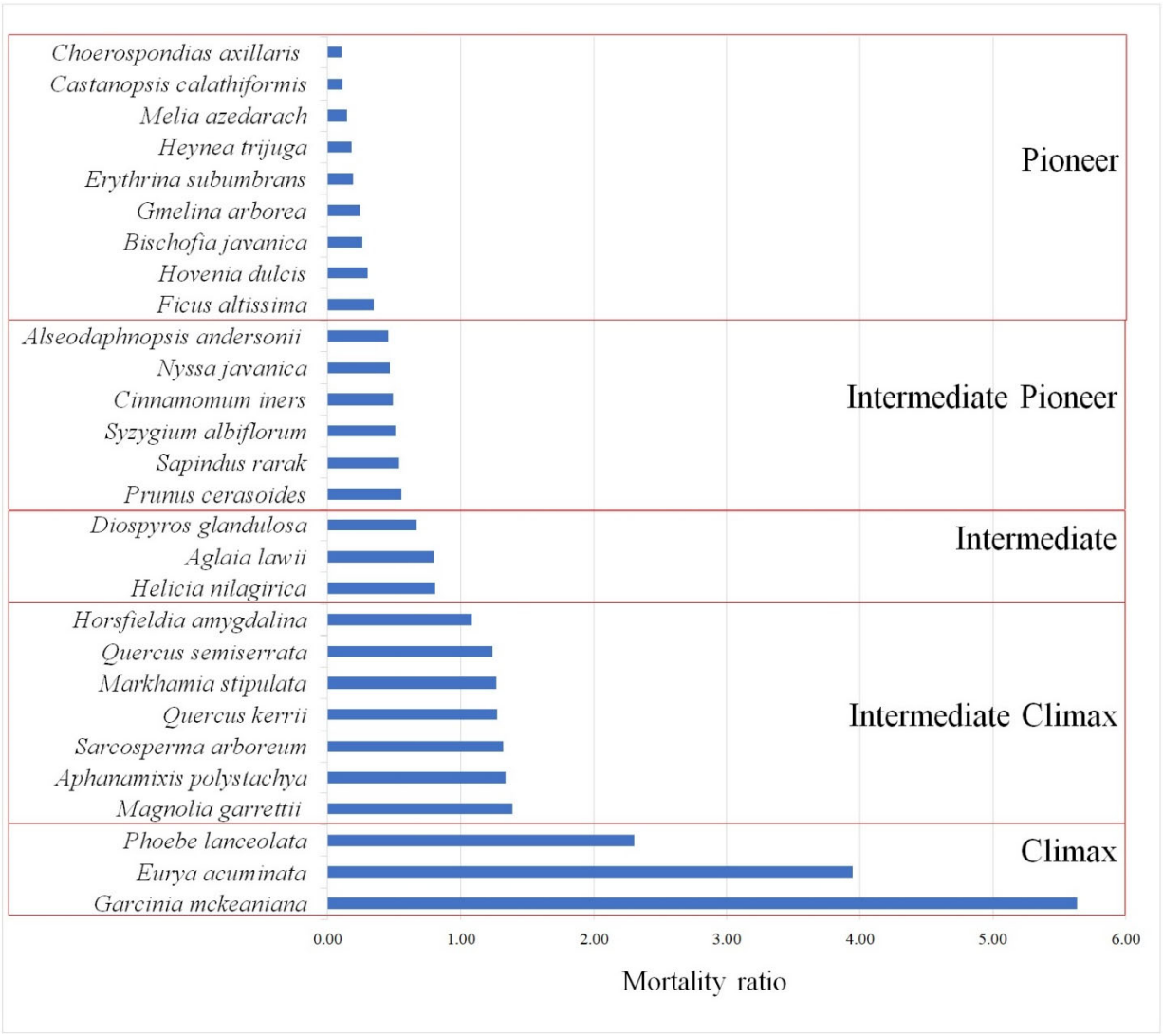

Figure S2. Mortality ratio as an indicator of successional status (the ratio between mortality pre- and post-canopy closure)

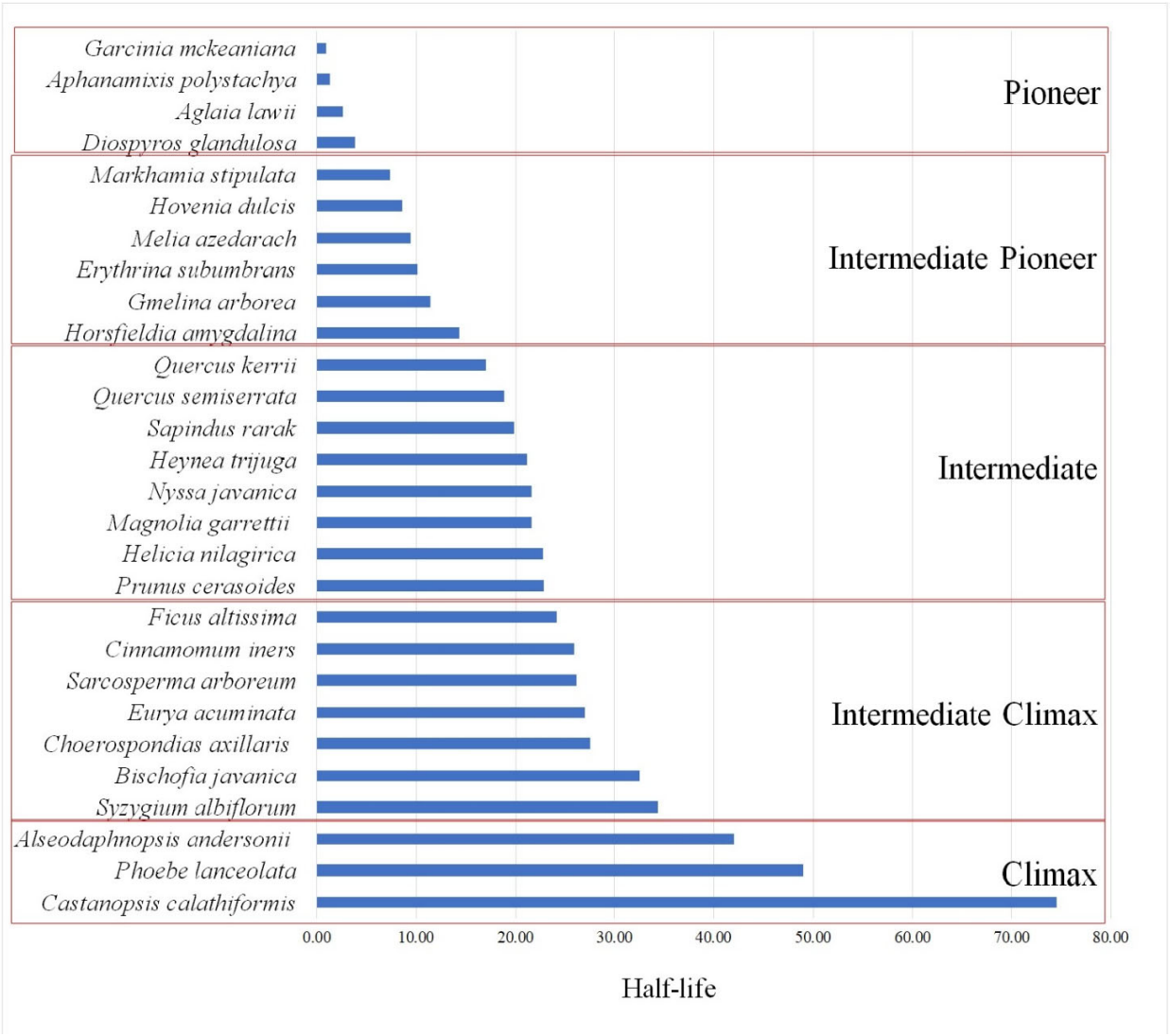

Figure S3. Survival half-life as an indicator of successional status.

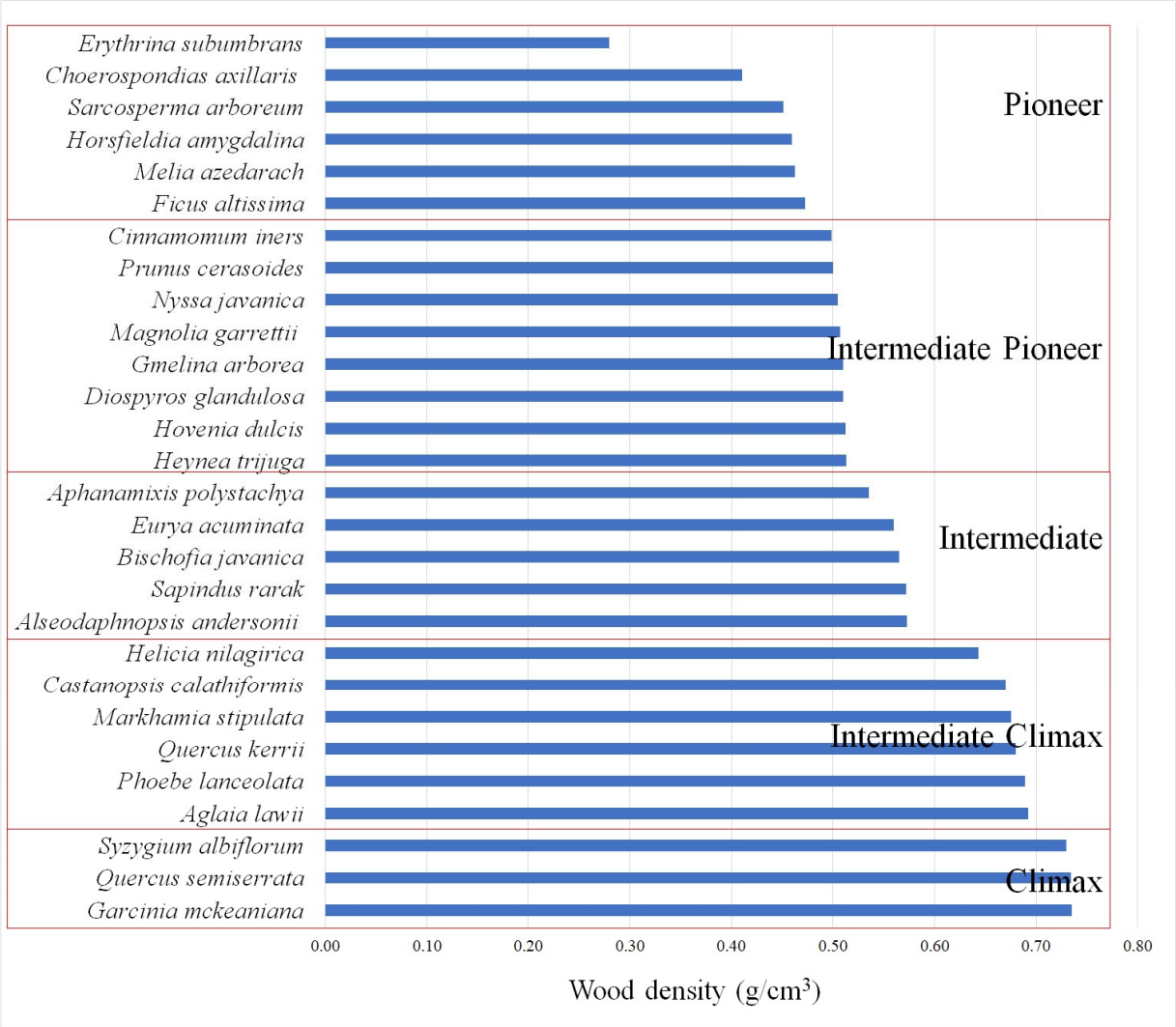

Figure S4. Wood density (g/cm^3) as an indicator of successional status

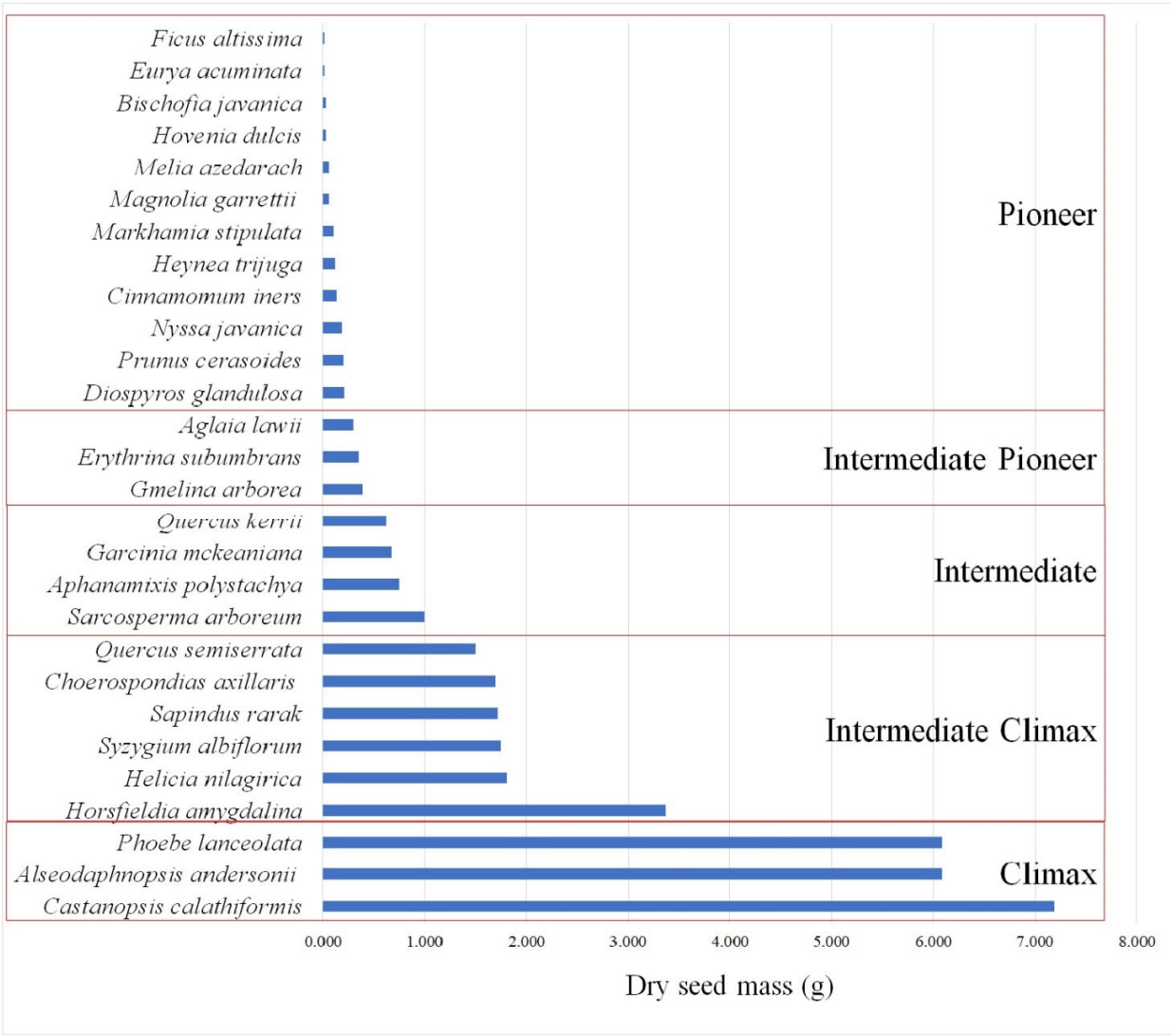

Figure S5. Seed size as an indicator of successional status.

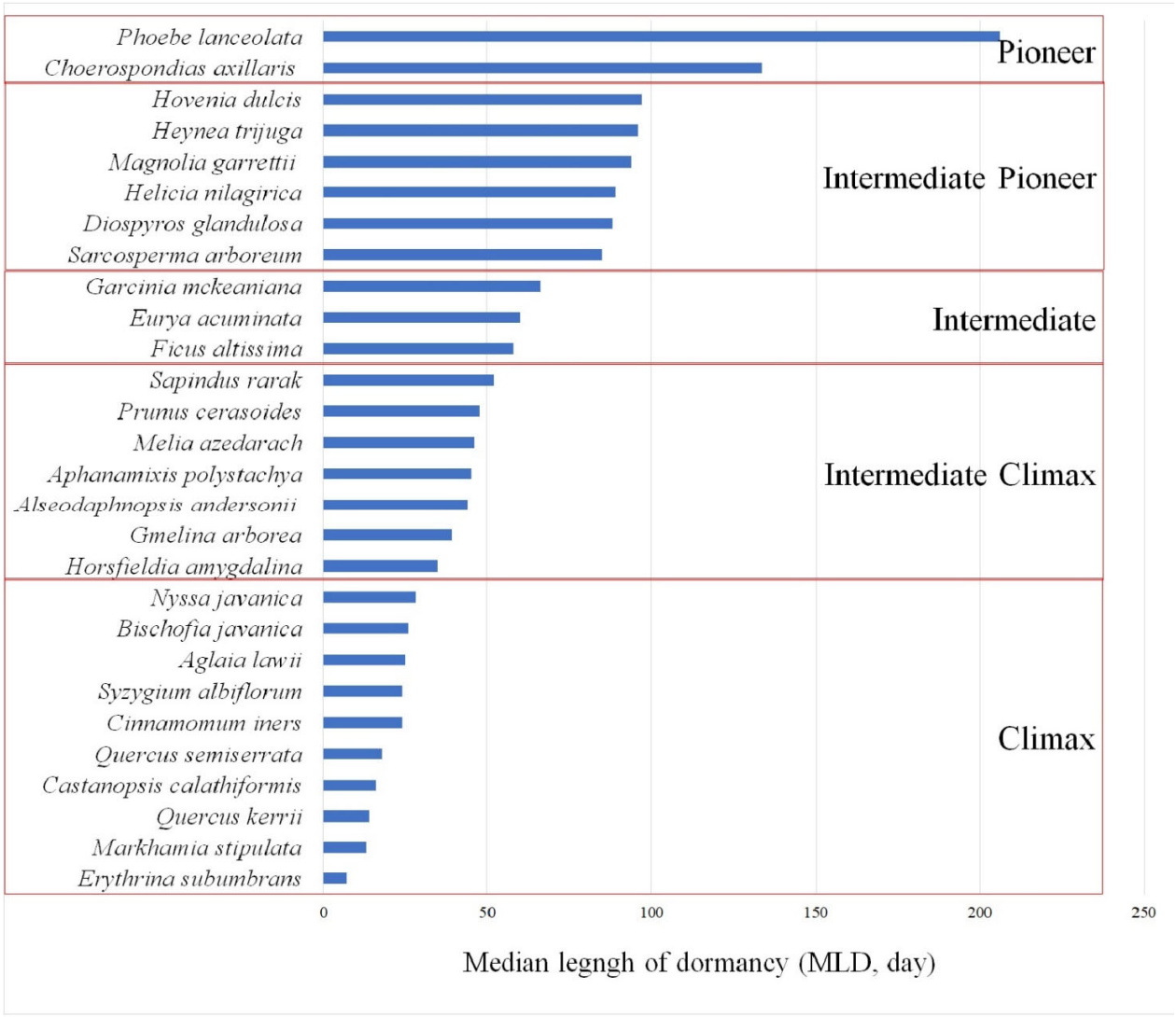

Figure S6. Median length of dormancy (MLD) as an indicator of successional status

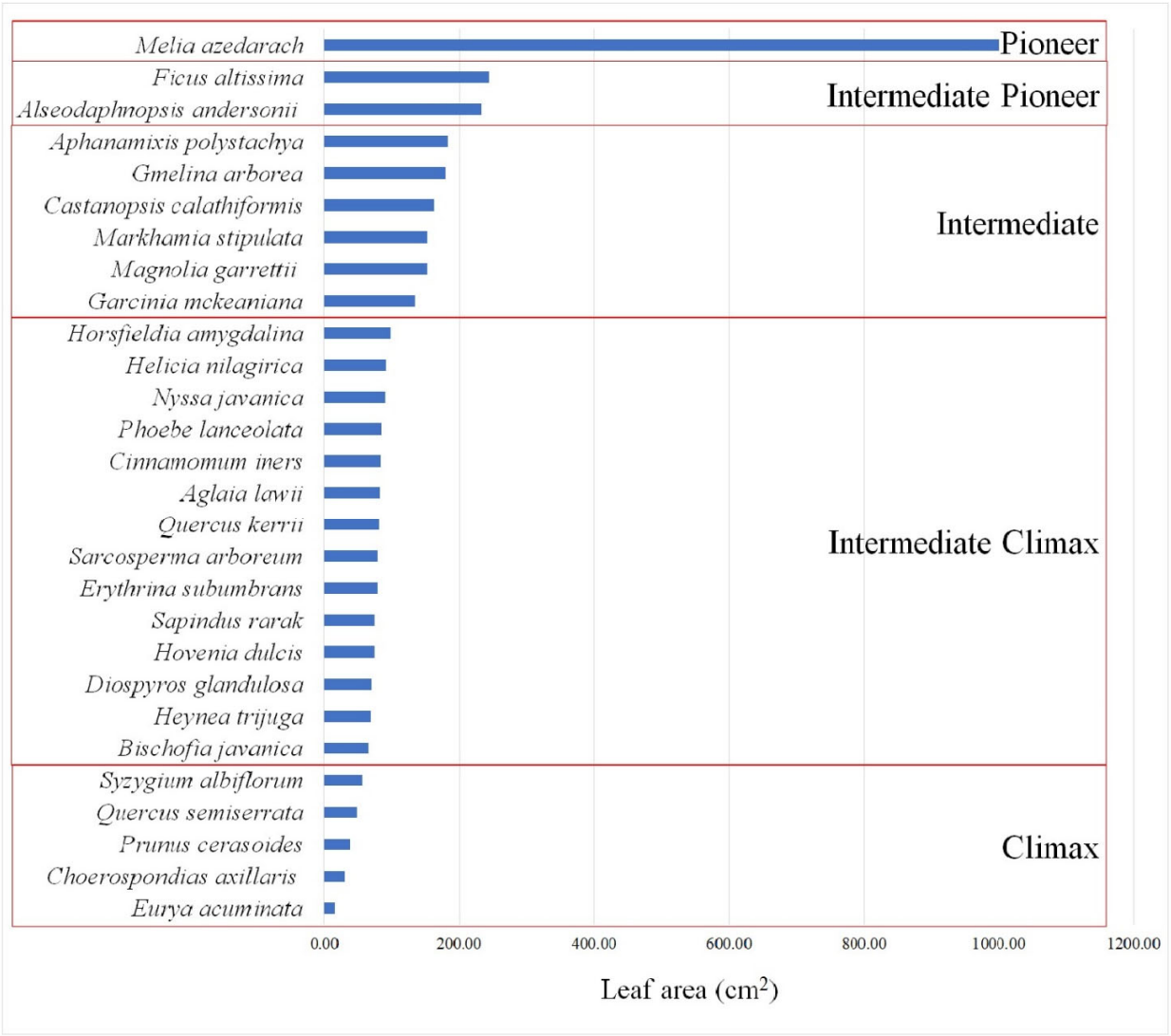

Figure S7. Leaf area as an indicator of successional status

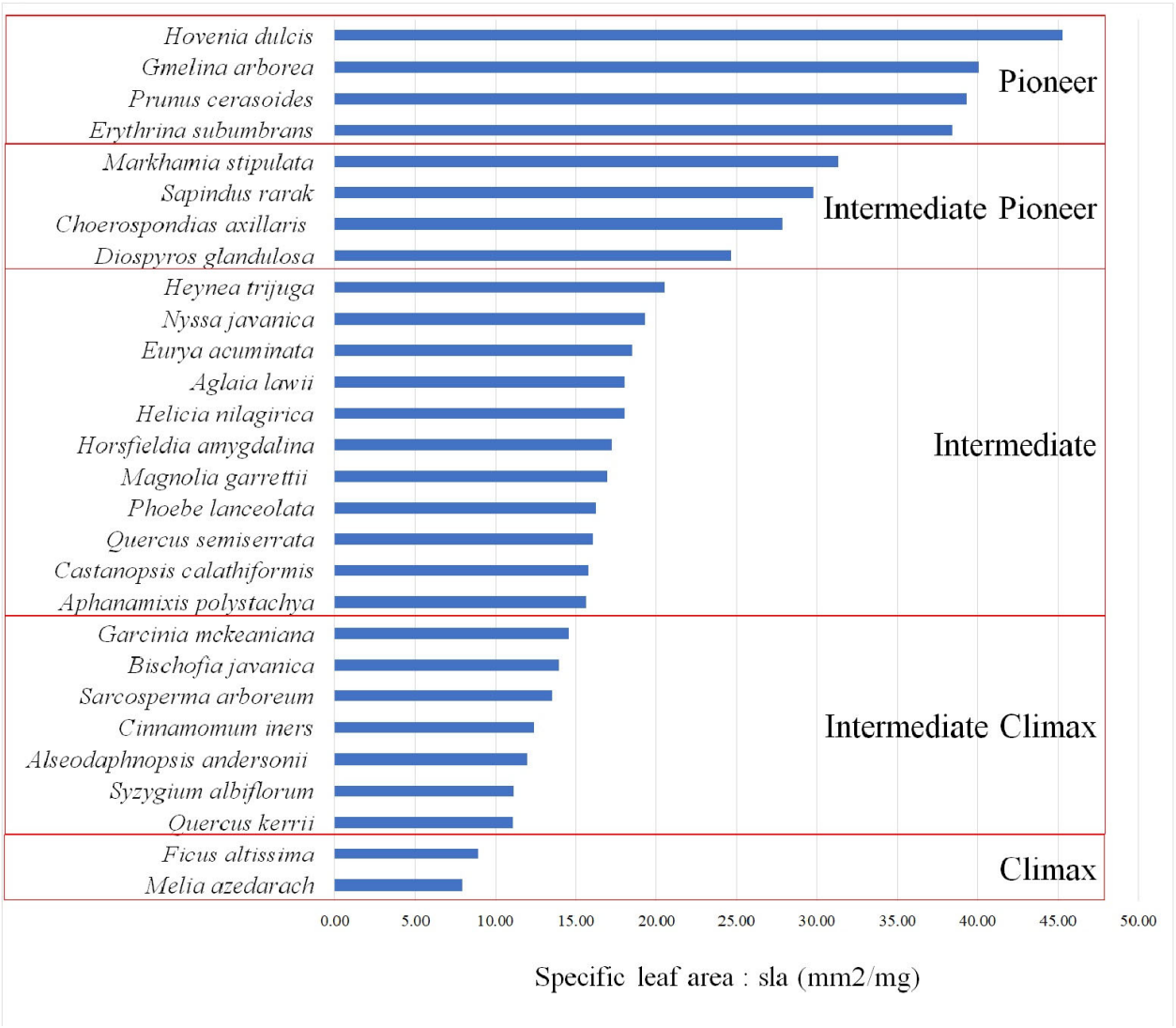

Figure S8. Specific leaf area (SLA) as an indicator of successional status.

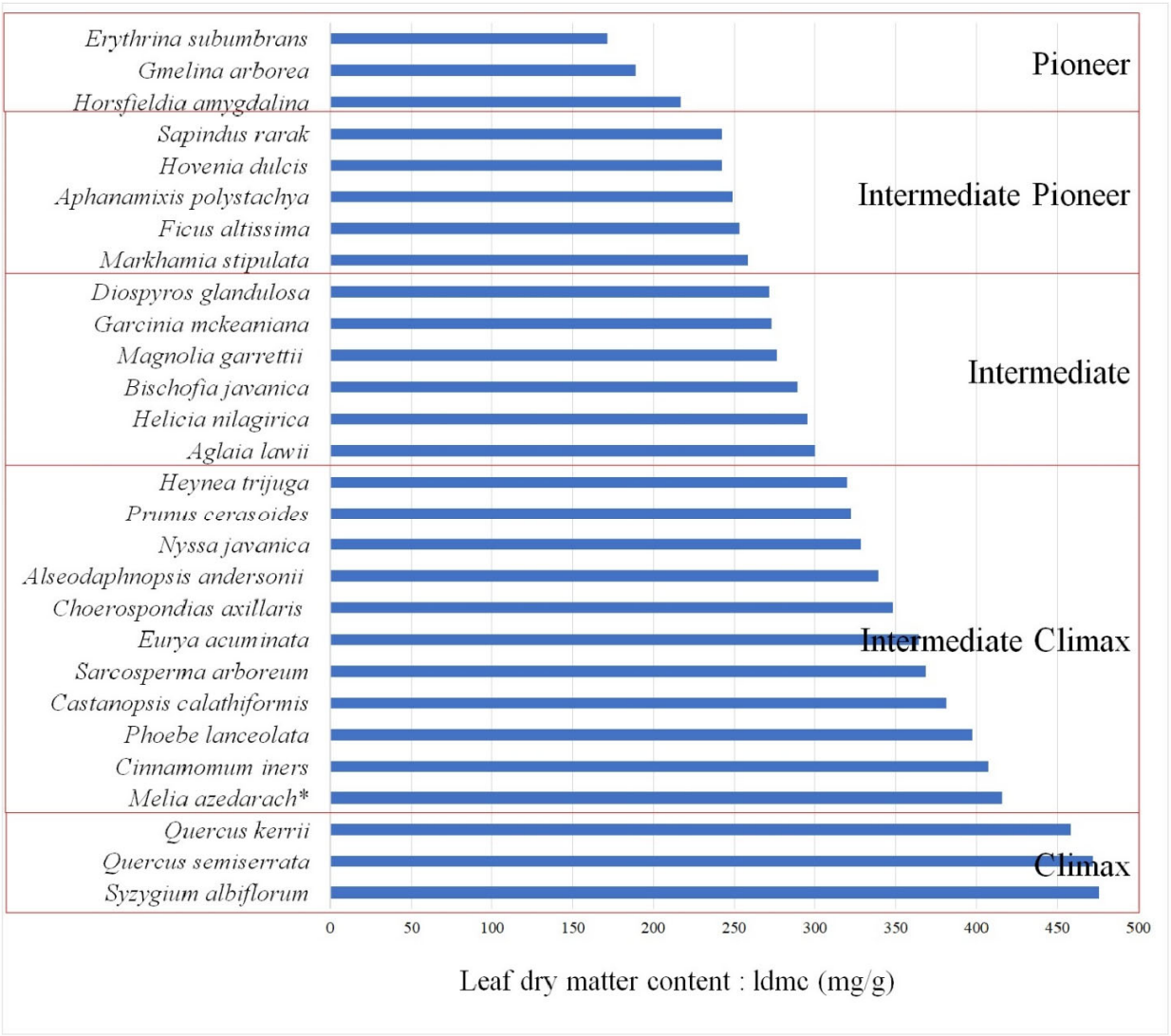

Figure S9. Leaf dry matter content (LDMC) as an indicator of successional status.

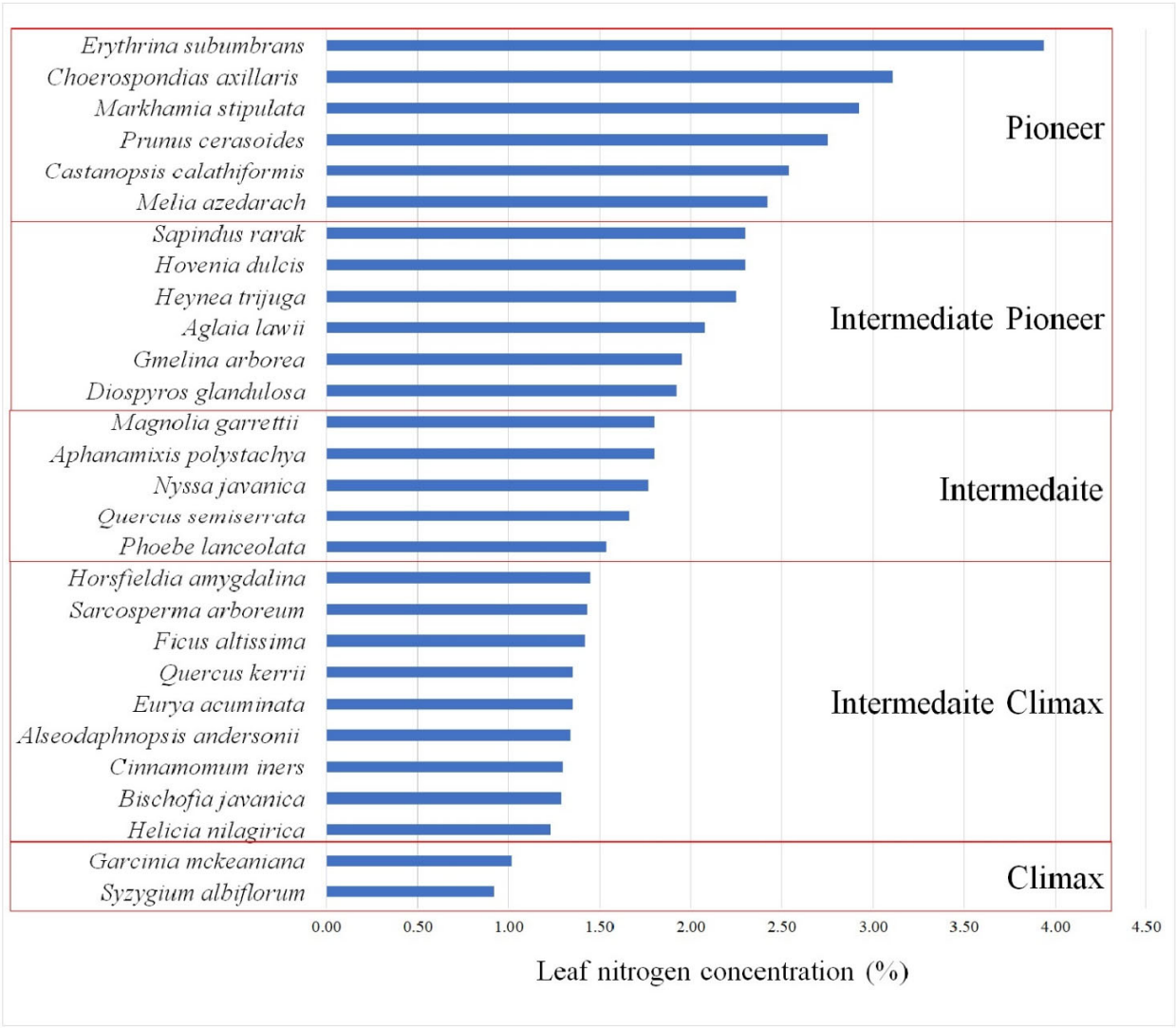

Figure S10. Leaf nitrogen concentration (LNC) as indicator of successional status

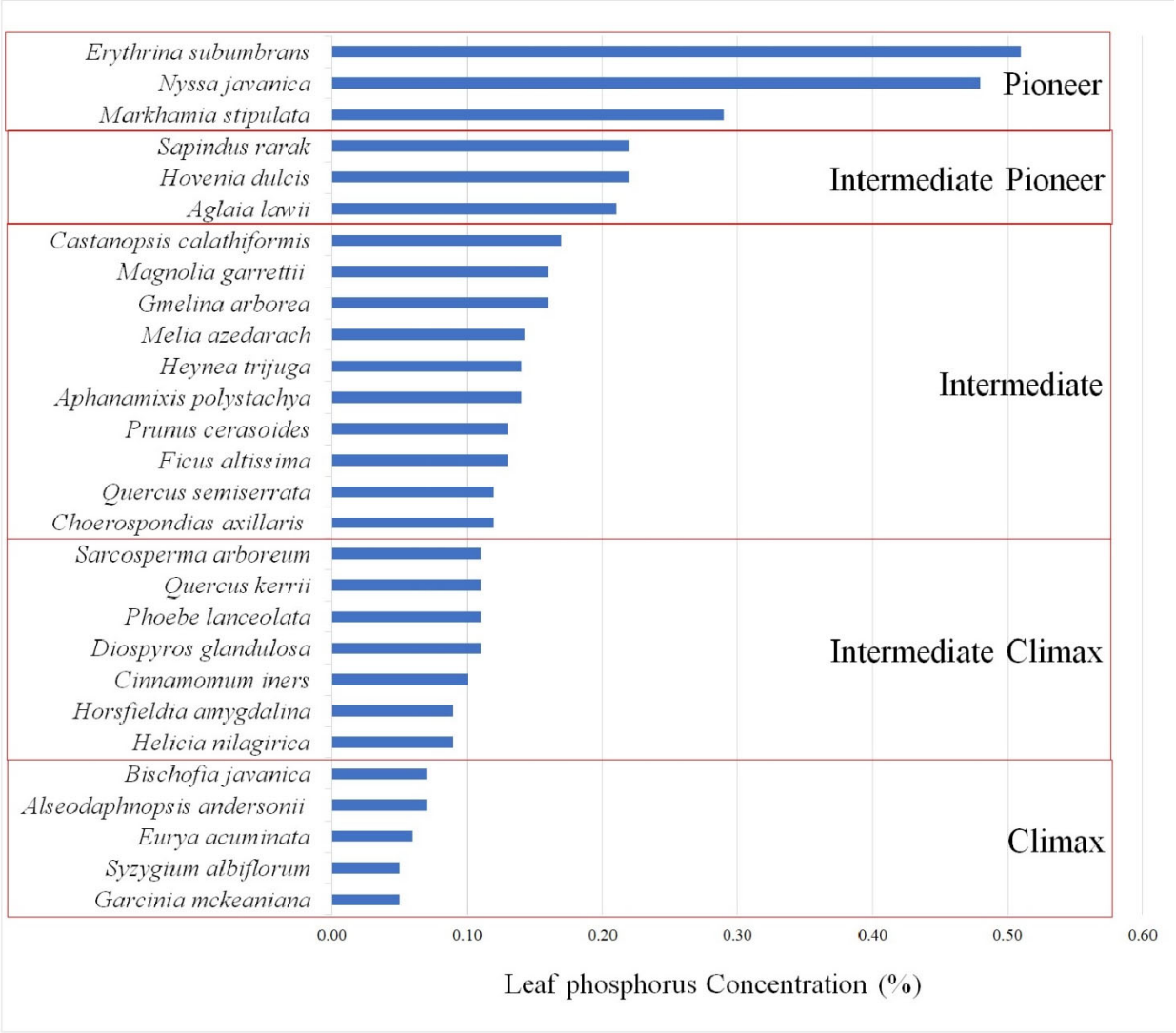

Figure S11. Leaf phosphorus concentration (LPC) as indicator of successional status.

Table S1. Seedling type as an indicator of successional status

Epigeal seedling (Pioneer feature)	Semi-hypogeal seedling (Intermediate feature)	Hypogeal seedling (Climax feature)
Markhamia stipulata	*Erythrina subumbrans*	*Quercus kerrii*
Bischofia javanica	*Alseodaphnopsis andersonii*	*Castanopsis calathiformis*
Nyssa javanica		*Quercus semiserrata*
Gmelina arborea		*Cinnamomum iners*
Hovenia dulcis		*Aglaia lawii*
Prunus cerasoides		*Horsfieldia amygdalina*
Sapindus rarak		*Aphanamixis polystachya*
Ficus altissima		*Syzygium albiflorum*
Eurya acuminata		*Garcinia mckeaniana*
Diospyros glandulosa		*Sarcosperma arboreum*
Magnolia garrettii		*Helicia nilagirica*
Spondias axillaris		*Heynea trijuga*
Melia azedarach		*Phoebe lanceolata*

Table S2. Germination response to light and shade (GRLS) as an indicator of successional status

High light condition (Pioneer feature)	Both condition (Intermediate feature)	Low light condition (Climax feature)
Diospyros glandulosa	*Alseodaphnopsis andersonii*	*Aglaia lawii*
Erythrina subumbrans	*Aphanamixis polystachya*	*Bischofia javanica*
Eurya acuminata	*Castanopsis calathiformis*	*Helicia nilagirica*
Ficus altissima	*Choerospondias axillaris*	*Horsfieldia amygdalina*
Garcinia mckeaniana	*Cinnamomum iners*	*Sarcosperma arboreum*
Gmelina arborea	*Hovenia dulcis*	
Heynea trijuga	*Markhamia stipulata*	
Magnolia garrettii	*Nyssa javanica*	
Melia azedarach	*Phoebe lanceolata*	
Prunus cerasoides	*Quercus kerrii*	
Syzygium albiflorum	*Quercus semiserrata*	
	Sapindus rarak	

Table S3. Data sources for the for the functional trait variables used in this study

No.	Variable	Abbreviation	Units	Primary/ Secondary	Source/method
1	Relative growth rate ratio	RGR ratio		Primary/ Secondary	FORRU; this study
2	Mortality ratio	M ratio		Primary/ Secondary	FORRU; this study
3	Half-life	HR	Year	Primary/ Secondary	FORRU; this study
4	Wood density	WD	(g/cm^3)	Secondary	Titinan, 2019.; Kanlayarat, 2017.; Zanne et al., 2009.
5	Crown length NS	CNS	m	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
6	Crown length EW	CEW	m	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
7	Crown area	CA	m^2	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
8	Tree height	TH	m	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
9	Crown width ratio	CWR	m^2/m	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
10	First branch height	FBH	m	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
11	Crown depth	CD	m	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
12	Leaf area	LA	cm^2	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
13	Specific leaf area	SLA	mm^2/mg	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
14	Leaf mass per area	LMA	mg/mm^2	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
15	Leaf dry matter content	LDMC	mg/g	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
16	Leaf thickness	LTK	nm	Secondary	Shannon & Tiansawat, 2019

Table S3. (continued).

No.	Variable	Abbreviation	Units	Primary/ Secondary	Source/method
17	Leaf toughness	LTG	N/mm	Secondary	Shannon & Tiansawat, 2019
18	Leaf nitrogen concentration	LNC	%	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
19	Leaf phosphorus concentration	LPC	%	Primary/ Secondary	Shannon & Tiansawat, 2019; this study
20	Seed length	SL	mm	Primary/ Secondary	CMU, 2020; FORRU database; Khlangsap et al., 2019; Naruangsri, 2017; Pakkard. G., 1997; Slik JWF, 2009 onwards; this study
21	Seed width	SW	mm	Primary/ Secondary	CMU, 2020; FORRU database; Khlangsap et al., 2019; Naruangsri, 2017; Pakkard. G., 1997; Slik JWF, 2009 onwards; this study
22	Seed thickness	ST	mm	Primary/ Secondary	CMU, 2020; FORRU database; Khlangsap et al., 2019; Naruangsri, 2017; Pakkard. G., 1997; Slik JWF, 2009 onwards; this study
23	Seed volume	SV	mm^3	Primary/ Secondary	CMU, 2020; FORRU database; Khlangsap et al., 2019; Naruangsri, 2017; Pakkard. G., 1997; Slik JWF, 2009 onwards; this study
24	Dry seed mass	DSM	g	Secondary	CMU, 2020; FORRU database; Naruangsri, 2017, Pakkard. G., 1997; Waiboonya, 2017
25	Median length of dormancy	MLD	day	Secondary	FORRU database; Waiboonya, 2017.
26	Seedling type	ST		Secondary	Flora of China; FORRU database; Naruangsri, 2017, Plant Resources of South-East Asia; Slik JWF, 2009 onwards.
27	Germination response to light and shade	GRLS		Secondary	FORRU database

Table S4. Data for 27 functional traits (mean values) of 28 framework tree species. Non-correlated traits are indicated with an asterisk. RGR = relative growth rate; NS = North to South; EW = East to West; LNC = leaf nitrogen content; LPC = leaf phosphorus content; GRLS germination response to light and shade.

No.	Species	RGR height ratio *	mortality ratio *	half-life *	wood density *	crown lenght NS	crown lenght EW	crown area	tree height	crown ratio (area/height)	first branch height	crown depth	leaf area *	specific leaf area *	leaf mass per area *
				Year	g/cm^3	m	m	m	m	m^2/m	m	m	cm^2	mm^2/mg	mg/mm^2
1	*Aglaia lawii*	2.44	0.80	2.6	0.69	2.20	1.92	4.57	2.53	0.80	1.97	1.04	83.20	18.06	0.06
2	*Alseodaphnopsis andersonii*	6.39	0.46	42.0	0.57	2.85	2.99	7.62	6.38	1.00	2.59	3.83	233.19	11.97	0.09
3	*Aphanamixis polystachya*	1.89	1.34	1.4	0.54	1.79	1.69	2.55	3.31	1.15	2.43	1.44	182.91	15.61	0.07
4	*Bischofia javanica*	5.76	0.26	32.5	0.57	2.97	2.92	7.38	5.85	1.22	2.24	3.61	66.03	13.94	0.08
5	*Castanopsis calathiformis*	7.62	0.11	74.5	0.67	8.44	9.96	71.87	16.57	4.79	3.71	12.78	162.50	15.76	0.07
6	*Choerospondias axillaris*	6.46	0.11	27.6	0.41	6.22	7.25	38.11	16.20	2.32	4.23	11.97	30.52	27.83	0.04
7	*Cinnamomum iners*	2.20	0.49	25.9	0.50	5.11	4.85	20.05	8.20	2.50	1.74	6.47	83.96	12.40	0.08
8	*Diospyros glandulosa*	2.24	0.67	3.8	0.51	2.02	2.06	3.64	6.03	0.72	3.34	2.03	70.61	24.65	0.04
9	*Erythrina subumbrans*	27.95	0.19	10.1	0.28	3.60	3.50	12.57	9.65	1.05	4.65	5.00	78.89	38.45	0.03
10	*Eurya acuminata*	2.02	3.94	27.0	0.56	3.38	3.38	10.67	8.27	1.30	5.17	3.10	16.90	18.50	0.06
11	*Ficus altissima*	9.76	0.35	24.1	0.47	4.10	4.02	16.24	7.72	1.67	2.00	5.72	243.82	8.91	0.12
12	*Garcinia mckeaniana*	2.95	5.63	0.9	0.74	3.81	3.68	13.70	6.14	2.01	2.50	3.53	134.40	14.59	0.07
13	*Gmelina arborea*	8.10	0.24	11.4	0.51	1.42	1.55	2.30	6.71	0.31	3.57	3.77	180.27	40.09	0.03
14	*Helicia nilagirica*	3.47	0.80	22.7	0.64	2.37	2.32	5.21	6.08	0.92	1.37	4.71	92.07	18.03	0.06
15	*Heynea trijuga*	3.06	0.18	21.1	0.51	4.56	4.84	18.39	8.69	2.27	3.73	4.94	69.02	20.49	0.05
16	*Horsfieldia amygdalina*	0.44	1.08	14.4	0.46	3.18	3.39	10.59	6.04	1.75	2.02	3.84	98.59	17.23	0.06
17	*Hovenia dulcis*	8.51	0.30	8.6	0.51	2.00	2.04	4.15	7.84	0.63	3.41	3.68	74.44	45.31	0.02
18	*Magnolia garrettii*	3.67	1.39	21.6	0.51	5.82	6.50	32.78	12.12	2.62	2.64	9.49	151.93	16.92	0.06
19	*Markhamia stipulata*	5.70	1.27	7.4	0.68	2.95	3.26	11.01	5.17	7.85	1.79	3.39	152.90	31.32	0.03
20	*Melia azedarach*	29.23	0.15	9.4	0.46	13.58	13.65	190.17	16.44	11.40	7.65	8.80	1001.29	7.92	0.13
21	*Nyssa javanica*	4.31	0.47	21.6	0.51	7.18	6.80	40.09	12.58	3.28	4.95	7.63	90.40	19.30	0.05
22	*Phoebe lanceolata*	3.39	2.31	49.0	0.69	3.69	3.83	11.54	5.60	2.25	0.89	4.68	84.47	16.24	0.06
23	*Prunus cerasoides*	8.71	0.55	22.8	0.50	5.36	5.27	22.59	11.86	1.90	4.01	10.12	37.85	39.29	0.03
24	*Quercus kerrii*	2.51	1.27	17.0	0.68	2.46	2.30	5.68	6.05	0.74	2.76	3.68	81.68	11.12	0.09
25	*Quercus semiserrata*	2.42	1.24	18.8	0.73	5.06	4.90	22.14	9.22	2.43	1.31	7.93	48.30	16.05	0.06
26	*Sapindus rarak*	11.09	0.54	19.9	0.57	2.72	2.93	7.60	5.55	0.85	3.41	3.68	74.44	29.74	0.02
27	*Sarcosperma arboreum*	3.51	1.32	26.1	0.45	4.98	4.68	18.87	9.32	1.91	4.21	5.20	79.70	13.49	0.07
28	*Syzygium albiflorum*	2.65	0.51	34.4	0.73	3.84	3.38	10.88	8.53	1.33	3.21	5.31	56.59	11.17	0.09

Table S4. (continued).

No.	Species	leaf dry matter content *	leaf thickness	leaf toughness	LNC *	LPC *	seed length	seed width	seed thickness	seed volume	dry seed mass *	median length of dormancy *	seedling type *	GRLS *
		mg/g	nm	N/mm	%	%	mm	mm	mm	mm^3	g	day		
1	*Aglaia lawii*	300.05	0.12	3.80	2.08	0.21	14.00	7.00	6.00	588.00	0.30	25	hypogeal	shade
2	*Alseodaphnopsis andersonii*	339.19	0.16	4.49	1.34	0.07	37.03	21.11	20.04	15665.33	6.09	44	semi-epigeal	both
3	*Aphanamixis polystachya*	249.20	0.16	4.90	1.8	0.14	14.58	10.80	9.41	1481.74	0.74	45	hypogeal	both
4	*Bischofia javanica*	289.06	0.17	3.58	1.29	0.07	5.08	3.97	3.24	65.10	0.02	26	epigeal	shade
5	*Castanopsis calathiformis*	381.00	0.10	4.08	2.54	0.17	29.21	23.00	22.39	15042.27	7.19	16	hypogeal	both
6	*Choerospondias axillaris*	348.22	0.08	1.17	3.11	0.12	17.00	14.32	13.71	3337.56	1.70	133.65	epigeal	both
7	*Cinnamomum iners*	406.77	0.14	9.13	1.3	0.1	9.51	6.63	6.44	406.05	0.13	24	hypogeal	both
8	*Diospyros glandulosa*	271.59	0.11	1.61	1.92	0.11	14.20	8.93	2.80	355.06	0.20	88.15	epigeal	sun
9	*Erythrina subumbrans*	171.76	0.13	1.38	3.94	0.51	13.90	8.63	7.82	938.06	0.35	7	semi-epigeal	sun
10	*Eurya acuminata*	364.09	0.11	2.82	1.35	0.06	0.50	0.50	0.50	0.13	0.00	60	epigeal	sun
11	*Ficus altissima*	253.23	0.29	7.87	1.42	0.13	1.54	0.99	0.97	1.49	0.00	58	epigeal	sun
12	*Garcinia mckeaniana*	273.07	0.19	5.82	1.02	0.05	26.29	12.07	7.48	2373.56	0.67	66	hypogeal	sun
13	*Gmelina arborea*	188.88	0.12	0.97	1.95	0.16	17.25	8.00	7.07	975.66	0.39	39.15	epigeal	sun
14	*Helicia nilagirica*	295.50	0.14	3.73	1.23	0.09	20.37	19.95	18.96	7704.99	1.80	89	hypogeal	shade
15	*Heynea trijuga*	319.48	0.11	3.15	2.25	0.14	10.44	9.59	8.85	886.06	0.11	96	hypogeal	sun
16	*Horsfieldia amygdalina*	216.88	0.15	5.66	1.45	0.09	33.40	18.26	17.88	10904.73	3.37	35	hypogeal	shade
17	*Hovenia dulcis*	242.31	0.05	0.77	2.3	0.22	5.57	5.37	2.36	70.59	0.03	97	epigeal	both
18	*Magnolia garrettii*	276.41	0.16	4.27	1.8	0.16	9.88	5.47	3.37	182.13	0.05	93.85	epigeal	sun
19	*Markhamia stipulata*	258.75	0.07	1.88	2.92	0.29	19.84	11.93	1.98	468.65	0.10	13	epigeal	both
20	*Melia azedarach*	415.76	NA	NA	2.42	0.1425	10.84	3.67	2.84	112.89	0.05	46	epigeal	sun
21	*Nyssa javanica*	328.18	0.11	2.39	1.77	0.48	15.11	7.99	2.88	347.37	0.19	28	epigeal	both
22	*Phoebe lanceolata*	397.66	0.11	4.08	1.54	0.11	37.03	21.11	20.04	15665.33	6.09	206	hypogeal	both
23	*Prunus cerasoides*	322.04	0.07	1.15	2.75	0.13	9.70	7.47	6.16	446.35	0.20	47.65	epigeal	sun
24	*Quercus kerrii*	458.25	0.14	6.35	1.35	0.11	15.06	14.68	12.60	2785.62	0.61	14	hypogeal	both
25	*Quercus semiserrata*	471.93	0.09	4.80	1.66	0.12	18.14	16.80	13.46	4101.96	1.50	18	hypogeal	both
26	*Sapindus rarak*	242.31	0.05	0.77	2.3	0.22	16.41	15.91	15.12	3947.58	1.72	52	epigeal	both
27	*Sarcosperma arboreum*	368.14	0.13	4.71	1.43	0.11	18.85	11.77	11.02	2444.95	1.00	85	hypogeal	shade
28	*Syzygium albiflorum*	475.69	0.16	4.25	0.92	0.05	19.34	17.71	16.92	5796.27	1.74	24	hypogeal	sun

Table S5. Previous reports of the successional status of the framework tree species examined in this study
Abbreviation: P = Pioneer, C = Climax, LS = Late Successional, I = Intermediate.

Species	Shannon & Tiansawat (2019)	Jantawong (2017)	Pothong (2019)	Waiboonya (2017)	Sinhaseni (2008)	Betts (2013)	Pakkard (pers. comm., 2021)	Gardner (2007)	Maxwell & Elliott (2001)	Flora of China	PROEA (1998)
Aglaia lawii	LS	-	-	-	-	-	C	C	C	-	-
Alseodaphnopsis andersonii	P	-	-	-	C	-	C	-	C	-	C
Aphanamixis polystachya	P	-	-	-	-	-	P	C	C	-	C
Bischofia javanica	P	P	-	-	-	-	I	-	P	P	-
Castanopsis calathiformis	P	-	-	-	C	-	C	I	-	-	-
Choerospondias axillaris	P	P	-	P	P	P	P	-	-	-	P
Cinnamomum iners	P	-	-	-	-	-	C	C	-	P	-
Diospyros glandulosa	P	-	-	C	C	-	C	-	-	-	-
Erythrina subumbrans	P	P	-	-	P	P	P	P	-	-	P
Eurya acuminata	P	-	-	-	P	-	C	P	-	-	-
Ficus altissima	P	-	-	-	-	P	C	-	P	-	P
Garcinia mckeaniana	P	-	-	-	-	-	C	C	C	-	C
Gmelina arborea	P	P	-	P	-	P	P	P	P	P	
Helicia nilagirica	LS	-	P	-	-	-	C	C	P	-	C

Table S5. (continued)

Species	Shannon & Tiansawat (2019)	Jantawong (2017)	Pothong (2019)	Waiboonya (2017)	Sinhaseni (2008)	Betts (2013)	Pakkard (pers. comm., 2021)	Gardner (2007)	Maxwell & Elliott (2001)	Flora of China	PROEA (1998)
Heynea trijuga	P	C	-	-	P	-	P	P	P	-	-
Horsfieldia amygdalina	LS	-	-	C	-	-	C	-	-	C	C
Hovenia dulcis	P	C	-	C	-	P	P	-	C	P	
Magnolia garrettii	LS	-	-	-	-	P	C	-	C	-	P
Markhamia stipulata	P	-	-	-	P	-	P	P	P	-	-
Melia azedarach	P	P	-	-	-	P	P	P	-	P	-
Nyssa javanica	P	P	-	-	-	P	C	C	-	-	P
Phoebe lanceolata	P	-	C	-	C	-	C	C	P	-	C
Prunus cerasoides	P	P	-	P	P	-	P	P	P	-	-
Quercus kerrii	-	-	-	-	-	-	C	-	-	-	-
Quercus semiserrata	-	-	C	-	-	-	C	-	-	-	-
Sapindus rarak	LS	C	C	-	C	-	I	-	P	-	-
Sarcosperma arboreum	LS	C	C	-	C	-	C	C	-	-	-
Syzygium albiflorum	-	-	-	C	C	-	C	C	-	-	-