

Supplement of

Large-diameter trees control forest structure and function in successional temperate forests

Chang-Bae Lee et al.

Correspondence to: Chang-Bae Lee (kecolee@kookmin.ac.kr)

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Table S1. Summary of indices for taxonomic diversity, functional diversity, community-weighted mean, stem density, and aboveground biomass across forest strata in the temperate forests of South Korea. The summary statistics for environmental drivers were only described at the whole community level because the values were the same across forest strata and the whole community. We used 1,956, 1,955, and 1,885, 0.16 ha plots for whole community, overstory, and understory, respectively, because plots with zero values for biomass or functional dispersion in each forest stratum were excluded. Abbreviations: Min, minimum; Max, maximum; SEr, standard error; SR, species richness; SD, Shannon H index; SE, species evenness; FDis, functional dispersion; CWM, community-weighted mean; MUL, multitrait; H, maximum height; LS, leaf size; SM, seed mass; AGB, aboveground biomass; MAT, mean annual temperature; MAP, mean annual precipitation; CEC, cation exchange capacity. The summary statistics for abiotic variables were described only at the whole community level because the values were the same across forest strata and the whole community.

Variables	Unit	Overstory (n = 1955)				Understory (n = 1885)				Whole community (n = 1956)			
		Min	Max	Mean	SEr	Min	Max	Mean	SEr	Min	Max	Mean	SEr
Taxonomic diversity													
SR	Unitless	2	29	11.46	0.09	2	20	7.71	0.08	2	30	13.2	0.11
SD	Unitless	0.05	2.82	1.47	0.01	0.14	2.78	1.57	0.01	0.05	2.87	1.56	0.01
SE	Unitless	0.13	0.98	0.43	<0.01	0.23	1	0.71	<0.01	0.11	0.98	0.41	<0.01
Functional diversity													
FDisMUL	unitless	0.01	5.88	1.16	0.02	0.03	6.23	1.23	0.02	0.01	6.05	1.23	0.02
FDisH	unitless	<0.01	2.24	0.89	0.01	<0.01	2.95	1.24	0.01	<0.01	2.28	0.95	0.01
FDisLS	unitless	<0.01	3.90	0.63	0.01	<0.01	5.19	0.46	0.01	<0.01	4.10	0.66	0.01
FDisSM	unitless	<0.01	9.98	1.36	0.03	<0.01	10.51	1.21	0.03	<0.01	10.28	1.42	0.03
Community weighted mean													
CWMH	m	7.8	34.93	27.03	0.11	3.84	34.85	20.16	0.14	7.5	34.91	26.49	0.11
CWMLS	cm ²	1.42	315.14	39.18	0.55	1.03	293.71	49.14	0.65	1.32	312.26	39.69	0.54
CWMSM	mg	9.02	11297.56	1411.71	25.03	2.74	17733.15	1169.98	33.57	9.16	10695.25	1380.57	24.05
Stand structural attribute													
Stem density	unitless	15	550	169.97	1.67	2	155	31.33	0.49	15	596	200.18	1.80
Ecosystem function (response variable)													

AGB	Mg/ha	6.28	468.63	127.70	1.11	0.13	20.94	4.48	0.08	6.89	472.80	132.54	1.13
<i>Abiotic factors</i>													
Elevation	m									1	1648.76	416.84	6.22
Slope	°									0.13	39.64	16.32	0.17
MAT	°C									4.92	15.45	10.72	0.04
MAP	mm									1029	2176	1328	3.85
Aridity	unitless									0.88	2.73	1.22	< 0.01
CEC	mmol(c)/kg									101.60	244.20	151.97	0.59

Table S2. Summary of attributes of large-diameter trees (largest 1% of trees) and all smaller-diameter trees attributes in overstory and whole community. For 1% large-diameter trees, other biotic variables except DBH, SR, Stem density and AGB were not calculated because it was impossible to quantify functional dispersion variables (i.e. FDisMUL, FDisH, FDisLS and FDisSM) due to the value of 1 in the number of 1% large-diameter tree in most plots ($n = 922$). Abbreviations: Min, minimum; Max, maximum; SEr, standard error; DBH, diameter at breast height; SR, species richness, SD, Shannon H index; SE, species evenness; FDis, functional dispersion; CWM, community-weighted mean; AGB, aboveground biomass; MUL, multtrait; H, maximum height; LS, leaf size; SM, seed mass; 99%, 99% remaining trees; ovrem, overstory remaining trees excluding the 1% large-diameter trees.

Variables	Unit	Min	Max	Mean	SEr
1) 1% large-diameter trees' attributes					
DBH	cm	12	91.49	37.03	0.20
SR	unitless	1	5	1.66	0.02
Stem density	unitless	1	11	2.83	0.03
AGB	Mg/ha	0.19	77.00	10.94	0.13
2) 99% remaining trees' attributes in whole community					
<i>Taxonomic diversity</i>					
SR_99%	unitless	2	30	13.13	0.11
SD_99%	unitless	0.05	2.88	1.56	0.01
SE_99%	unitless	0.11	0.99	0.41	< 0.01
<i>Functional diversity</i>					
FDisMUL_99%	unitless	0.01	6.07	1.15	0.01
FDisH_99%	unitless	<0.01	2.30	0.96	0.01
FDisLS_99%	unitless	<0.01	2.59	0.42	0.01
FDisSM_99%	unitless	<0.01	10.30	1.41	0.03
<i>Community weighted mean</i>					
CWMH_99%	m	7.37	34.90	26.35	0.11
CWMLS_99%	cm ²	1.35	317.14	40.34	0.55
CWMSM_99%	mg	9.18	10112.49	1377.50	23.70
<i>Stand structural attribute</i>					
Stem density_99%	unitless	14	585	197.41	1.77
3) remaining trees' attributes in overstory					
<i>Taxonomic diversity</i>					
SR_ovrem	unitless	2	29	11.38	0.09
SD_ovrem	unitless	0.05	2.84	1.47	0.01
SE_ovrem	unitless	0.13	0.99	0.43	< 0.01
<i>Functional diversity</i>					
FDisMUL_ovrem	unitless	0.01	5.90	1.09	0.01
FDisH_ovrem	unitless	< 0.01	2.27	0.89	0.01

FDisLS_ovrem	unitless	< 0.01	2.42	0.40	0.01
FDisSM_ovrem	unitless	< 0.01	10	1.34	0.03
<i>Community weighted mean</i>					
CWMH_ovrem	m	7.67	34.92	26.92	0.11
CWMLS_ovrem	cm ²	1.46	320.25	39.79	0.56
CWMSM_ovrem	mg	9.02	10710.92	1411.55	24.69
<i>Stand structural attribute</i>					
Stem density_ovrem	unitless	14	539	167.14	1.65

Table S3. Functional trait data of woody plant species used in this study. The scientific names of the plant species followed The Plant List (<http://www.theplantlist.org>). The functional traits of woody plant species were obtained from multiple sources. Abbreviations: MH, maximum height; LL, leaf length; LW, leaf width; LS, leaf size; SM, seed mass.

Sources for functional traits:

1. Korea National Arboretum. 2014. Korea Biodiversity Information System. Available from: <http://www.nature.go.kr>
2. National Institute of Biological Resources. 2011. Korea Species Database. Available from: <http://species.nibr.go.kr>
3. Kim DH, Song JH, Chang KW, Lee JC. 2010. Seeds of woody plant in Korea. National Institute of Forest Science, Seoul.
4. Royal Botanic Gardens Kew. 2016. Seed Information Database (SID). Version 7.1. Available from: <http://data.kew.org/sid/>
5. Mean value in same genus from SID of Royal Botanical Gardens Kew

Family	Scientific name	Functional trait data					Source for functional trait data		
		H(m)	LL(cm)	LW(cm)	LS(cm ²)	SM(mg)	LF & MH	LL & LW	SM
Adoxaceae	<i>Sambucus sieboldiana</i> var. <i>pinnatisecta</i>	3	5.5	6.5	35.75	3.83	1	1	4
Adoxaceae	<i>Sambucus racemosa</i> subsp. <i>kamtschatica</i>	5.5	5	2.5	12.5	1.29	1	1	4
Adoxaceae	<i>Viburnum furcatum</i>	5	15	8.75	131.25	32.86	1	1	4
Adoxaceae	<i>Viburnum odoratissimum</i> var. <i>awabuki</i>	12.5	13	6	78	26.1	1	1	4
Anacardiaceae	<i>Rhus chinensis</i>	7	8.5	4.25	36.13	60	1	1	3
Anacardiaceae	<i>Toxicodendron trichocarpum</i>	7	7.5	4	30	23.95	1	1	3
Anacardiaceae	<i>Toxicodendron succedaneum</i>	13	8.5	8.5	72.25	23.95	1	1	5
Anacardiaceae	<i>Toxicodendron sylvestre</i>	5.5	9.5	3	28.5	23.95	1	1	5
Anacardiaceae	<i>Toxicodendron vernicifluum</i>	20	13.5	4.5	60.75	23.95	1	1	5
Aquifoliaceae	<i>Ilex integra</i>	10	7.5	2.75	20.63	30.3	1	1	4
Aquifoliaceae	<i>Ilex crenata</i>	3	2.25	0.13	0.29	12	1	1	4
Aquifoliaceae	<i>Ilex macropoda</i>	15	6.5	3.75	24.38	8.56	1	1	3
Aquifoliaceae	<i>Ilex rotunda</i>	10	7.5	3.5	26.25	13.18	1	1	4
Aquifoliaceae	<i>Ilex cornuta</i>	2.5	6.75	6.75	45.56	17.65	1	1	4
Araliaceae	<i>Aralia elata</i>	4	8.5	4.5	38.25	1.20	1	1	3

Araliaceae	<i>Dendropanax trifidus</i>	15	15	6.5	97.5	7.19	1	1	4
Araliaceae	<i>Kalopanax septemlobus</i>	25	20	20	400	10	1	1	3
Betulaceae	<i>Alnus incana</i> subsp. <i>kolaensis</i>	20	9	7	63	2.04	1	1	4
Betulaceae	<i>Alnus firma</i>	7	8.5	3.9	33.15	3.45	1	1	3
Betulaceae	<i>Alnus japonica</i>	20	9	4.75	42.75	1.33	1	1	3
Betulaceae	<i>Alnus pendula</i>	7	8.5	3	25.5	2.06	1	1	5
Betulaceae	<i>Betula costata</i>	30	6.5	2.4	15.6	0.9	1	1	3
Betulaceae	<i>Betula davurica</i>	20	5.5	4	22	0.63	1	1	3
Betulaceae	<i>Betula schmidtii</i>	30	6	3.75	22.5	0.33	1	1	3
Betulaceae	<i>Betula ermanii</i>	10	7.5	4.75	35.63	0.7	1	1	3
Betulaceae	<i>Betula pendula</i>	25	6	5	30	0.5	1	1	4
Betulaceae	<i>Carpinus tschonoskii</i>	15	6	4	24	13	1	1	4
Betulaceae	<i>Carpinus cordata</i>	15	10.75	5.5	59.13	8	1	1	3
Betulaceae	<i>Carpinus laxiflora</i>	15	5.75	3	17.25	3.85	1	1	3
Betulaceae	<i>Carpinus turczaninowii</i>	6.5	4	2.5	10	13	1	1	4
Betulaceae	<i>Corylus heterophylla</i>	3	8.5	8.5	72.25	1213.83	1	1	5
Betulaceae	<i>Corylus sieboldiana</i> var. <i>mandshurica</i>	3.5	10	8	80	1194.94	1	1	4
Betulaceae	<i>Corylus sieboldiana</i>	4	8.5	8.5	72.25	1086	1	1	3
Betulaceae	<i>Ostrya japonica</i>	20	7.5	3.75	28.13	10	1	1	4
Bignoniaceae	<i>Catalpa ovata</i>	8	17.5	17.5	306.25	2.34	1	1	4
Cannabaceae	<i>Aphananthe aspera</i>	20	7.5	4.5	33.75	44.11	1	1	5
Cannabaceae	<i>Celtis koraiensis</i>	15	16	12.5	200	66.78	1	1	5
Cannabaceae	<i>Celtis sinensis</i>	20	7.5	4	30	126.4	1	1	3
Cannabaceae	<i>Celtis biondii</i>	15	5	2.75	13.75	136.5	1	1	4

Caprifoliaceae	<i>Lonicera maackii</i>	5	7.5	2.75	20.63	2.6	1	1	3
Caprifoliaceae	<i>Weigela subsessilis</i>	2.5	4	3	12	0.44	1	1	4
Celastraceae	<i>Euonymus macropterus</i>	10	8.5	5	42.5	28.85	1	1	3
Celastraceae	<i>Euonymus hamiltonianus</i>	8	10	5	50	30.8	1	1	4
Celastraceae	<i>Euonymus oxyphyllus</i>	4	7.5	3.5	26.25	21	1	1	3
Celastraceae	<i>Euonymus alatus</i>	3	4	4	16	16.3	2	2	3
Celastraceae	<i>Euonymus sachalinensis</i>	4	10	10	100	50	2	2	3
Cornaceae	<i>Alangium platanifolium</i>	4	9	8.5	76.5	580	1	1	4
Cornaceae	<i>Cornus macrophylla</i>	15	13	13	169	54.64	1	1	3
Cornaceae	<i>Cornus walteri</i>	10	9.5	9.5	90.25	61.97	1	1	4
Cornaceae	<i>Cornus kousa</i>	7	8.5	5.25	44.63	78.1	1	1	3
Cornaceae	<i>Cornus officinalis</i>	7	8	4.25	34	140.03	1	1	3
Cornaceae	<i>Cornus controversa</i>	20	8.5	5.5	46.75	43	1	1	3
Cupressaceae	<i>Chamaecyparis obtuse</i>	40	0.305	0.16	0.05	3.2	1	1	3
Cupressaceae	<i>Cryptomeria japonica</i>	40	1.29	0.155	0.2	4.1	1	1	3
Cupressaceae	<i>Juniperus rigida</i>	8	1.6	0.1	0.16	15.02	1	1	4
Cupressaceae	<i>Platycladus orientalis</i>	25	0.22	0.18	0.04	17.2	1	1	4
Cupressaceae	<i>Thuja koraiensis</i>	20	2.1	0.2	0.42	0.7	1	1	3
Daphniphyllaceae	<i>Daphniphyllum macropodum</i>	6.5	15	4.5	67.5	42.24	1	1	5
Ebenaceae	<i>Diospyros kaki</i>	15	12	7	84	384.61	1	1	3
Ebenaceae	<i>Diospyros lotus</i>	15	9	6	54	173	1	1	3
Elaeagnaceae	<i>Elaeagnus umbellate</i>	3.5	5	2	10	19.3	1	1	3
Ericaceae	<i>Rhododendron yedoense</i>	1.5	5.5	2	11	0.08	1	1	4
Ericaceae	<i>Rhododendron mucronulatum</i>	3	5.5	2	11	0.16	1	1	3

Ericaceae	<i>Rhododendron weyrichii</i>	4.5	4.75	3.75	17.81	0.18	1	1	5
Ericaceae	<i>Rhododendron schlippenbachii</i>	5	7.5	4.5	33.75	0.39	1	1	3
Ericaceae	<i>Vaccinium bracteatum</i>	3	4.25	1.75	7.44	0.64	1	1	5
Ericaceae	<i>Vaccinium oldhamii</i>	2.5	5.5	3	16.5	0.67	1	1	3
Eucommiaceae	<i>Eucommia ulmoides</i>	15	10.5	4.5	47.25	71	1	1	5
Euphorbiaceae	<i>Croton congestus</i>	7	6	4	24	5.83	1	1	5
Euphorbiaceae	<i>Mallotus japonicas</i>	10	15	10.5	157.5	19.08	1	1	5
Euphorbiaceae	<i>Neoshirakia japonica</i>	6	11	7.5	82.5	12.45	1	1	5
Fagaceae	<i>Castanea crenata</i>	15	15	5	75	20586	1	1	3
Fagaceae	<i>Castanopsis sieboldii</i>	15	9.5	3.5	33.25	649.33	1	1	5
Fagaceae	<i>Quercus myrsinifolia</i>	15	9.5	2.5	23.75	810	1	1	4
Fagaceae	<i>Quercus aliena</i>	25	17.5	11	192.5	2100	1	1	3
Fagaceae	<i>Quercus gilva</i>	20	8.5	2.75	23.38	2983	1	1	4
Fagaceae	<i>Quercus variabilis</i>	30	11.5	5.5	63.25	3800	1	2	3
Fagaceae	<i>Quercus dentate</i>	20	23.5	15.25	358.38	2801	1	1	3
Fagaceae	<i>Quercus mongolica</i> subsp. <i>crispula</i>	30	9.25	9.25	85.56	2980	1	1	4
Fagaceae	<i>Quercus acuta</i>	20	10	4	40	2997.35	1	1	3
Fagaceae	<i>Quercus acutissima</i>	25	15	3.5	52.5	3900	1	2	3
Fagaceae	<i>Quercus mongolica</i>	30	13.5	4	54	2270	1	1	3
Fagaceae	<i>Quercus serrata</i>	23	6	4.25	25.5	1567	1	1	3
Fagaceae	<i>Quercus glauca</i>	15	9.5	3	28.5	526.32	1	1	3
Fagaceae	<i>Quercus salicina</i>	10	12	3	36	2684	1	1	4
Ginkgoaceae	<i>Ginkgo biloba</i>	60	10	8	80	1383	1	1	3
Hamamelidaceae	<i>Corylopsis coreana</i>	1.5	7	8.75	61.25	13.95	1	1	3

Hamamelidaceae	<i>Distylium racemosum</i>	15	4.5	2.25	10.13	21.47	1	1	5
Hydrangeaceae	<i>Philadelphus schrenkii</i>	3	10	5.5	55	0.15	1	1	5
Hydrangeaceae	<i>Philadelphus tenuifolius</i>	2	10.5	6	63	0.15	1	1	3
Juglandaceae	<i>Juglans mandshurica</i>	20	17.5	10	175	9259	1	1	3
Juglandaceae	<i>Platycarya strobilacea</i>	15	7.5	3	22.5	10	1	2	3
Lamiaceae	<i>Clerodendrum trichotomum</i>	2	14	9	126	39.4	1	1	3
Lauraceae	<i>Actinodaphne lancifolia</i>	15	8.5	3	25.5	764.41	1	1	5
Lauraceae	<i>Cinnamomum yabunikkei</i>	15	10.5	3.5	36.75	241.04	1	1	5
Lauraceae	<i>Lindera glauca</i>	5	6.5	2.75	17.88	41.48	1	1	3
Lauraceae	<i>Lindera erythrocarpa</i>	15	12.5	4	50	87	1	1	3
Lauraceae	<i>Lindera obtusiloba</i>	3	10	8.5	85	109	1	1	3
Lauraceae	<i>Lindera sericea</i>	3	10.5	4	42	132	1	1	4
Lauraceae	<i>Machilus japonica</i>	10	14	3	42	3333	1	1	5
Lauraceae	<i>Machilus thunbergii</i>	20	11	5	55	3333	1	1	5
Lauraceae	<i>Neolitsea aciculata</i>	10	8.5	3	25.5	233	1	1	5
Lauraceae	<i>Neolitsea sericea</i>	10	12.5	5.5	68.75	233	1	1	5
Leguminosae	<i>Albizia julibrissin</i>	4	1.05	0.325	0.34	65	1	1	3
Leguminosae	<i>Gleditsia japonica</i>	20	4.25	3	12.75	141.1	1	1	4
Leguminosae	<i>Maackia amurensis</i>	20	5.5	3.25	17.88	47	1	2	3
Leguminosae	<i>Maackia floribunda</i>	8.5	4.5	4.5	20.25	38.8	4	4	4
Leguminosae	<i>Robinia pseudoacacia</i>	25	3.5	3.5	12.25	19.2	1	1	3
Lythraceae	<i>Lagerstroemia indica</i>	5	4.75	2.5	11.88	2.1	1	1	3
Magnoliaceae	<i>Magnolia Kobus</i>	10	10	4.5	45	191	1	1	3
Magnoliaceae	<i>Magnolia obovata</i>	20	30	19	570	271	1	1	3

Magnoliaceae	<i>Magnolia sieboldii</i>	7	10.5	7.5	78.75	35	1	1	3
Malvaceae	<i>Firmiana simplex</i>	15	20.5	20.5	420.25	96.2	1	1	4
Malvaceae	<i>Tilia taquetii</i>	4.5	6.25	4.5	28.13	70.75	1	1	5
Malvaceae	<i>Tilia mandshurica</i>	10	11.5	11	126.5	76.7	1	1	4
Malvaceae	<i>Tilia amurensis</i>	20	6	5	30	10	1	1	3
Meliaceae	<i>Melia azedarach</i>	15	3.5	3.5	12.25	347	1	1	4
Meliaceae	<i>Toona sinensis</i>	20	10	5	50	5.3	1	1	4
Moraceae	<i>Broussonetia papyrifera</i>	12	13.5	10.5	141.75	2.1	1	1	3
Moraceae	<i>Broussonetia × hanjiana</i>	3	12.5	5	62.5	2.1	1	1	3
Moraceae	<i>Cudrania tricuspidata</i>	5.5	8	4.5	36	2.44	1	1	5
Moraceae	<i>Ficus erecta</i>	3	13	5.5	71.5	0.98	1	1	3
Moraceae	<i>Morus cathayana</i>	11.5	13.75	10.5	144.38	2.81	1	1	5
Moraceae	<i>Morus alba</i>	3	10	10	100	7	1	1	3
Moraceae	<i>Morus australis</i>	7.5	12	7.75	93	1.36	1	1	3
Oleaceae	<i>Chionanthus retusus</i>	25	4	4.25	17	150.28	1	1	3
Oleaceae	<i>Fraxinus mandshurica</i>	30	14.5	4.5	65.25	58	1	1	3
Oleaceae	<i>Fraxinus chiisanensis</i>	30	14.5	4.5	65.25	47.57	2	2	3
Oleaceae	<i>Fraxinus chinensis</i> subsp. <i>rhynchophylla</i>	10	10.5	5	52.5	25.62	1	1	3
Oleaceae	<i>Fraxinus sieboldiana</i>	10	7.5	2.5	18.75	17	1	1	3
Oleaceae	<i>Ligustrum japonicum</i>	4	6.5	3	19.5	21.1	1	1	4
Oleaceae	<i>Ligustrum lucidum</i>	7.5	8.5	4	34	31	1	1	4
Oleaceae	<i>Ligustrum ovalifolium</i>	5	8	3.5	28	23.6	1	1	3
Oleaceae	<i>Ligustrum obtusifolium</i>	4	4.5	1.6	7.2	31	1	1	3
Oleaceae	<i>Syringa reticulata</i>	5	8.5	6.25	53.13	13.04	1	1	5

Oleaceae	<i>Syringa villosa</i> subsp. <i>wolfii</i>	5	9.5	5	47.5	6.66	1	1	5
Paulowniaceae	<i>Paulownia coreana</i>	17.5	19	15.5	294.5	0.22	1	1	3
Pentaphylacaceae	<i>Cleyera japonica</i>	12	6.25	2.75	17.19	0.45	1	1	4
Pentaphylacaceae	<i>Eurya japonica</i>	1	5.5	2	11	0.47	1	1	3
Phyllanthaceae	<i>Flueggea suffruticosa</i>	2.5	3.5	1.75	6.13	2.61	1	1	3
Pinaceae	<i>Abies koreana</i>	18	1.795	0.225	0.4	11	1	1	4
Pinaceae	<i>Abies nephrolepis</i>	25	2.18	0.18	0.39	34.8	1	1	4
Pinaceae	<i>Abies holophylla</i>	40	4	0.2	0.8	23	1	1	3
Pinaceae	<i>Larix kaempferi</i>	25	2.315	0.07	0.16	6.59	1	1	3
Pinaceae	<i>Picea jezoensis</i>	40	2	0.175	0.35	2.4	1	1	3
Pinaceae	<i>Pinus thunbergii</i>	20	8.89	0.105	0.93	14	1	1	3
Pinaceae	<i>Pinus rigida</i>	25	10.5	0.2	2.1	6.6	1	2	3
Pinaceae	<i>Pinus densiflora</i>	35	11	0.15	1.65	9.2	1	1	3
Pinaceae	<i>Pinus koraiensis</i>	30	9.5	0.15	1.43	668	1	1	3
Pittosporaceae	<i>Pittosporum tobira</i>	2.5	7	3	21	38	1	1	3
Rhamnaceae	<i>Berchemiella berchemiifolia</i>	15	9.5	4	38	33	1	1	3
Rhamnaceae	<i>Hovenia dulcis</i>	10	11.5	9	103.5	22	1	1	3
Rhamnaceae	<i>Rhamnella franguloides</i>	7	9	3.25	29.25	69.4	1	1	5
Rhamnaceae	<i>Rhamnus davurica</i>	5	7.5	3.75	28.13	20.6	1	1	3
Rhamnaceae	<i>Rhamnus taquetii</i>	1	2	2	4	16.4	1	1	5
Rhamnaceae	<i>Ziziphus jujuba</i> var. <i>inermis</i>	8	4	1.75	7	303.03	1	1	3
Rosaceae	<i>Amelanchier asiatica</i>	7.5	6	3.25	19.5	5.7	1	1	4
Rosaceae	<i>Crataegus pinnatifida</i>	6	7.5	5.5	41.25	36.66	1	1	3
Rosaceae	<i>Malus toringo</i>	6	4.5	4	18	13.6	1	1	3

Rosaceae	<i>Malus baccata</i>	6	6.5	6.5	42.25	17.41	1	1	4
Rosaceae	<i>Photinia villosa</i>	5	5.5	3.5	19.25	5	1	1	4
Rosaceae	<i>Prunus maackii</i>	15	8.5	3.9	33.15	364.3	1	1	3
Rosaceae	<i>Prunus mandshurica</i>	7.5	8.5	8.5	72.25	364.3	1	1	3
Rosaceae	<i>Prunus padus</i>	15	9	4.5	40.5	41	1	1	3
Rosaceae	<i>Prunus mume</i>	5	7	7	49	1042	1	1	3
Rosaceae	<i>Prunus serrulata</i>	15	9	4.25	38.25	52.91	1	1	3
Rosaceae	<i>Prunus persica</i>	6	11.5	0.25	2.88	2792	1	1	3
Rosaceae	<i>Prunus sargentii</i> var. <i>vere cunda</i>	15	6.5	3.25	21.13	104	1	1	4
Rosaceae	<i>Prunus maximowiczii</i>	15	6	3	18	683.3	1	1	3
Rosaceae	<i>Prunus sargentii</i>	20	10	5.5	55	40	1	1	3
Rosaceae	<i>Prunus davidiana</i>	5	10	2.75	27.5	2449	1	1	3
Rosaceae	<i>Prunus armeniaca</i>	8.5	7	5.5	38.5	683.3	1	1	3
Rosaceae	<i>Prunus buergeriana</i>	10	9	9	81	463.89	1	1	5
Rosaceae	<i>Prunus spachiana</i>	10	8	4	32	153.8	1	1	4
Rosaceae	<i>Prunus yedoensis</i>	15	9	4	36	112.36	1	1	4
Rosaceae	<i>Prunus serrulata</i> var. <i>pubescens</i>	20	6.5	3.45	22.43	61.35	1	1	4
Rosaceae	<i>Pyrus pyrifolia</i>	5	9.5	9.5	90.25	45	1	1	3
Rosaceae	<i>Pyrus ussuriensis</i>	10	7.5	3.5	26.25	43.05	1	1	3
Rosaceae	<i>Pyrus calleryana</i> var. <i>fauriei</i>	3	3.5	3.5	12.25	17.86	1	1	4
Rosaceae	<i>Rhaphiolepis indica</i> var. <i>umbellate</i>	3	6.5	3	19.5	92	1	1	4
Rosaceae	<i>Sorbaria sorbifolia</i>	2	8	1.75	14	50.3	1	1	4
Rosaceae	<i>Sorbus commixta</i>	8	4.5	1.5	6.75	5.53	1	2	3
Rosaceae	<i>Sorbus alnifolia</i>	15	7.5	5.25	39.38	16	1	1	3

Rutaceae	<i>Phellodendron amurense</i>	10	7.5	4	30	9.5	1	1	3
Rutaceae	<i>Tetradium daniellii</i>	7	8.5	8.5	72.25	9.45	1	1	5
Rutaceae	<i>Zanthoxylum ailanthoides</i>	15	11.5	4	46	29.45	1	1	5
Rutaceae	<i>Zanthoxylum schinifolium</i>	3	3	1.05	3.15	15.3	1	2	3
Rutaceae	<i>Zanthoxylum bungeanum</i>	3	2.25	2.25	5.06	18.87	1	1	3
Sabiaceae	<i>Meliosma myriantha</i>	10	16	5.5	88	45.6	1	1	3
Sabiaceae	<i>Meliosma oldhamii</i>	10	7.5	2.75	20.63	11.03	1	1	5
Salicaceae	<i>Idesia polycarpa</i>	15	17.5	14	245	1.8	1	1	4
Salicaceae	<i>Populus tremula</i> var. <i>davidiana</i>	10	4	3.5	14	0.12	1	1	4
Salicaceae	<i>Populus glandulosa</i>	20	5.5	4.5	24.75	0.14	1	1	3
Salicaceae	<i>Populus × tomentiglandulosa</i>	20	5.5	4.5	24.75	0.16	1	1	3
Salicaceae	<i>Populus suaveolens</i>	30	5.5	5.5	30.25	0.65	1	1	4
Salicaceae	<i>Salix gracilistyla</i>	2.5	7.5	1.65	12.38	0.16	1	1	5
Salicaceae	<i>Salix hallaisanensis</i>	6	8.5	4.5	38.25	1.2	1	1	5
Salicaceae	<i>Salix pierotii</i>	20	8.5	1.35	11.48	0.95	1	1	4
Salicaceae	<i>Salix xerophila</i>	3.5	6.5	4	26	0.34	1	1	4
Salicaceae	<i>Salix chaenomeloides</i>	20	6.5	3.5	22.75	0.17	1	1	5
Salicaceae	<i>Salix caprea</i>	6	11	5	55	0.25	1	1	3
Sapindaceae	<i>Acer pictum</i>	20	11	11	121	27.4	1	1	3
Sapindaceae	<i>Acer palmatum</i>	15	6	7	42	40	1	1	3
Sapindaceae	<i>Acer pseudosieboldianum</i>	20	8.5	8.5	72.25	4.4	1	1	3
Sapindaceae	<i>Acer triflorum</i>	20	7.5	5	37.5	164.22	1	1	3
Sapindaceae	<i>Acer mandshuricum</i>	10	7.5	2	15	110	1	1	3
Sapindaceae	<i>Acer caudatum</i> subsp. <i>ukurundense</i>	14	11	10.5	115.5	10.47	1	1	3

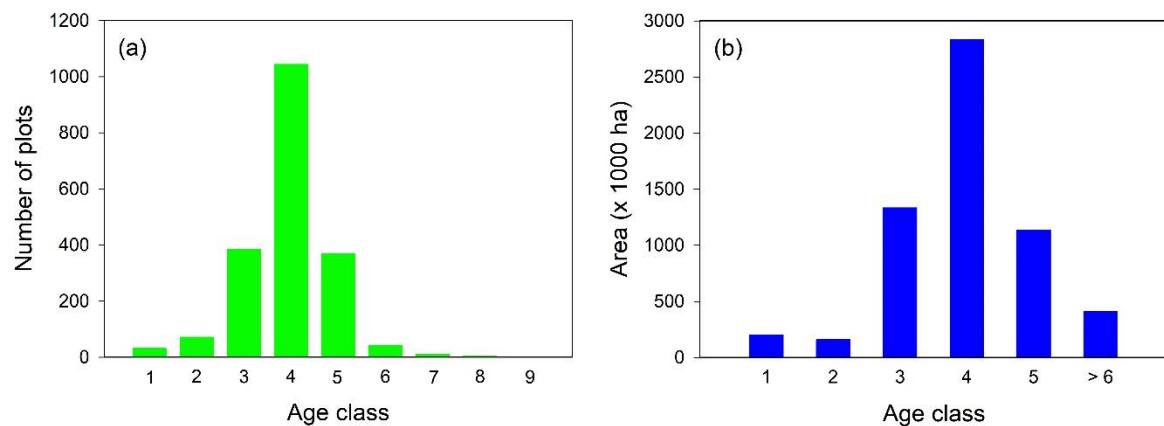
Sapindaceae	<i>Acer tegmentosum</i>	15	11.5	11.5	132.25	41.1	1	1	3
Sapindaceae	<i>Acer saccharum</i>	40	11	11	121	55.2	1	1	4
Sapindaceae	<i>Acer tschonoskii</i> subsp. <i>koreanum</i>	10	7	7.5	52.5	21.8	1	1	3
Sapindaceae	<i>Acer tataricum</i> subsp. <i>ginnala</i>	8	7	4.5	31.5	9.2	1	1	3
Sapindaceae	<i>Acer buergerianum</i>	15	8	4	32	11	1	1	3
Sapindaceae	<i>Acer barbinerve</i>	10	7.5	6.5	48.75	66	1	1	3
Sapindaceae	<i>Koelreuteria paniculata</i>	9	6.5	4	26	119.1	1	1	3
Schisandraceae	<i>Illicium anisatum</i>	4	7.5	3.5	26.25	37.24	1	1	3
Simaroubaceae	<i>Ailanthus altissima</i>	20	10	5	50	29.4	1	1	4
Simaroubaceae	<i>Picrasma quassoides</i>	11	7	2.25	15.75	29.4	1	1	4
Staphyleaceae	<i>Euscaphis japonica</i>	5.5	6	3	18	59.3	1	1	3
Staphyleaceae	<i>Staphylea bumalda</i>	5	6.5	2.5	16.25	24	1	1	3
Styracaceae	<i>Styrax japonicas</i>	10	5	3	15	250	1	1	3
Styracaceae	<i>Styrax obassis</i>	10	13.5	5	67.5	233	1	1	3
Symplocaceae	<i>Symplocos tanakana</i>	5	5.5	3.5	19.25	95.53	1	1	3
Symplocaceae	<i>Symplocos sawafutagi</i>	2	6	3.25	19.5	95.53	1	1	3
Symplocaceae	<i>Symplocos coreana</i>	4	6.5	4	26	95.5	1	1	5
Taxaceae	<i>Cephalotaxus harringtonii</i>	2.5	2.5	2.5	6.25	524.72	1	1	4
Taxaceae	<i>Taxus cuspidate</i>	17	1.75	0.3	0.53	50.2	1	1	3
Taxaceae	<i>Torreya nucifera</i>	25	2.18	0.33	0.72	1464	1	1	3
Theaceae	<i>Camellia japonica</i>	7	8.5	5	42.5	1075	1	1	3
Theaceae	<i>Stewartia pseudocamellia</i> var. <i>koreana</i>	11	7	3.5	24.5	12.94	1	1	3
Ulmaceae	<i>Hemiptelea davidii</i>	20	4	1.5	6	11.01	1	1	4
Ulmaceae	<i>Ulmus laciniata</i>	20	15	12.5	187.5	18.07	1	1	5

Ulmaceae	<i>Ulmus davidiana</i> var. <i>japonica</i>	20	6.5	4	26	18.03	1	1	3
Ulmaceae	<i>Ulmus davidiana</i>	15	6	0.4	2.4	7.08	1	1	4
Ulmaceae	<i>Ulmus macrocarpa</i>	10	9.5	5.5	52.25	8.7	1	1	3
Ulmaceae	<i>Ulmus parvifolia</i>	10	4	2	8	3.2	1	1	3
Ulmaceae	<i>Zelkova serrata</i>	26	4.5	1.75	7.88	19	1	1	3

Table S4. Results of two separate principal component analyses (PCAs) for topographic and climatic variables.

	PC1	PC2	PC3	PC4
Topographic variables				
Explained variance (%)	41.748	26.232	16.631	15.389
Loadings				
Latitude	0.525	-0.437	0.475	-0.555
Longitude	0.484	-0.549	-0.375	0.569
Elevation	0.478	0.548	0.511	0.458
Slope	0.512	0.455	-0.611	-0.398
Climatic variables				
Explained variance (%)	67.413	31.695	0.892	
Loadings				
Mean annual temperature	-0.339	0.897	0.283	
Mean annual precipitation	0.631	0.440	-0.639	
Aridity	0.698	0.038	0.715	

Figure S1. Histogram for the age classes of forest stands: (a) age classes of 1956 plots used in this study and (b) forest area for each age class in South Korea as a whole. The age classes of the study plots were extracted using the forest type map provided by Korea Forest Service (Korea Forest Service, 2021). Forest areas for age classes in South Korea were calculated from statistical yearbook of forestry (Korea Forest Service, 2019). Age classes: 1, 0–10 years; 2, 11–20 years; 3, 21–30 years; 4, 31–40 years; 5, 41–50 years; 6, 51–60 years; 7, 61–70 years; 8, 71–80 years; 9, 81–90 years.



References

- Korea Forest Service. (2019). Statistical Yearbook of Forest. Republic of Korea: Korea Forest Service.
- Korea Forest Service. (2021). FGIS. Available at: <https://map.forest.go.kr/forest/> Last accessed 16th October 2021.

Figure S2. Locations of 1,956 study plots in the temperate forests of South Korea.

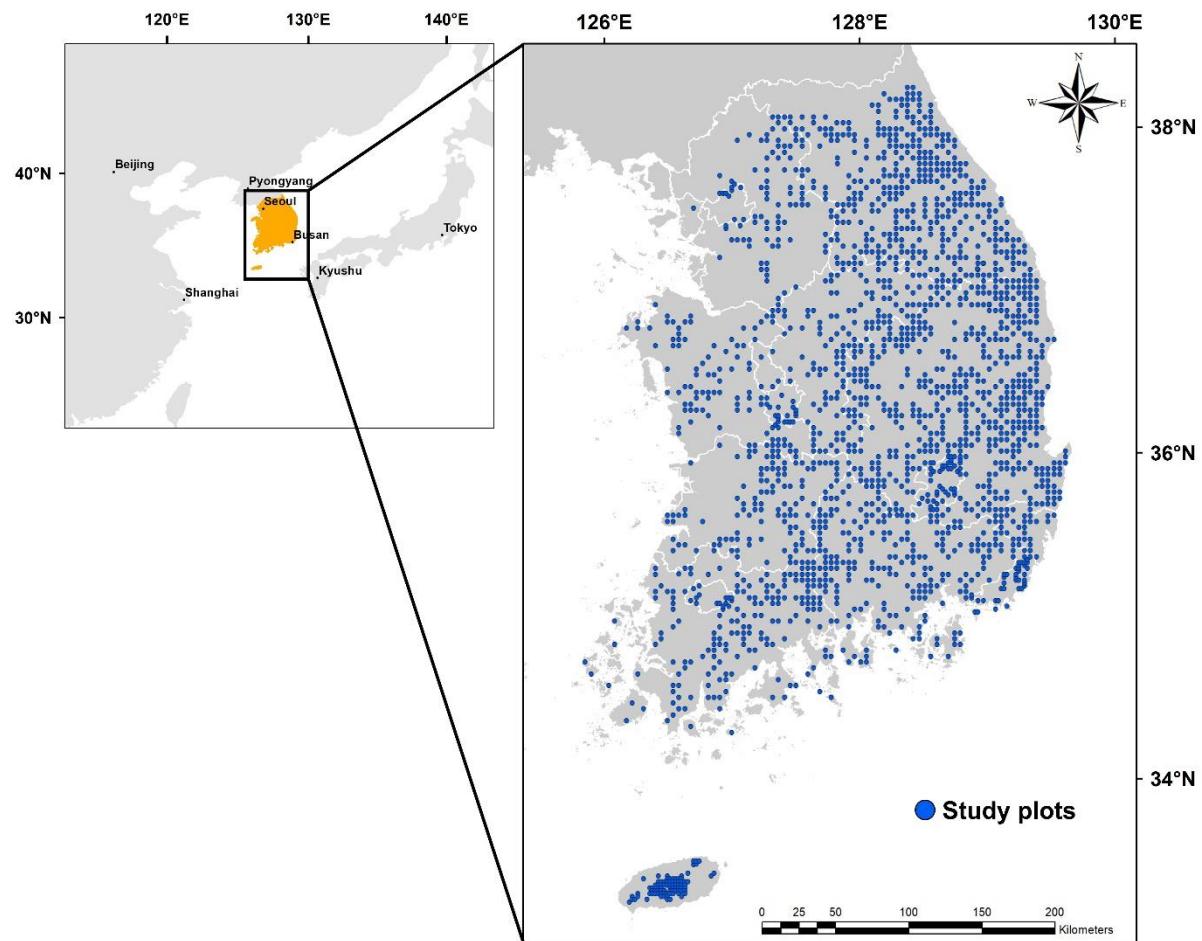


Figure S3. Four tree categories such as 1) 1% large-diameter trees, 2) 99% remaining trees, 3) overstory remaining trees and 4) understory trees), and sample sizes in each forest stratum and whole community used for analysis in this study. N indicates sample size used for analysis.

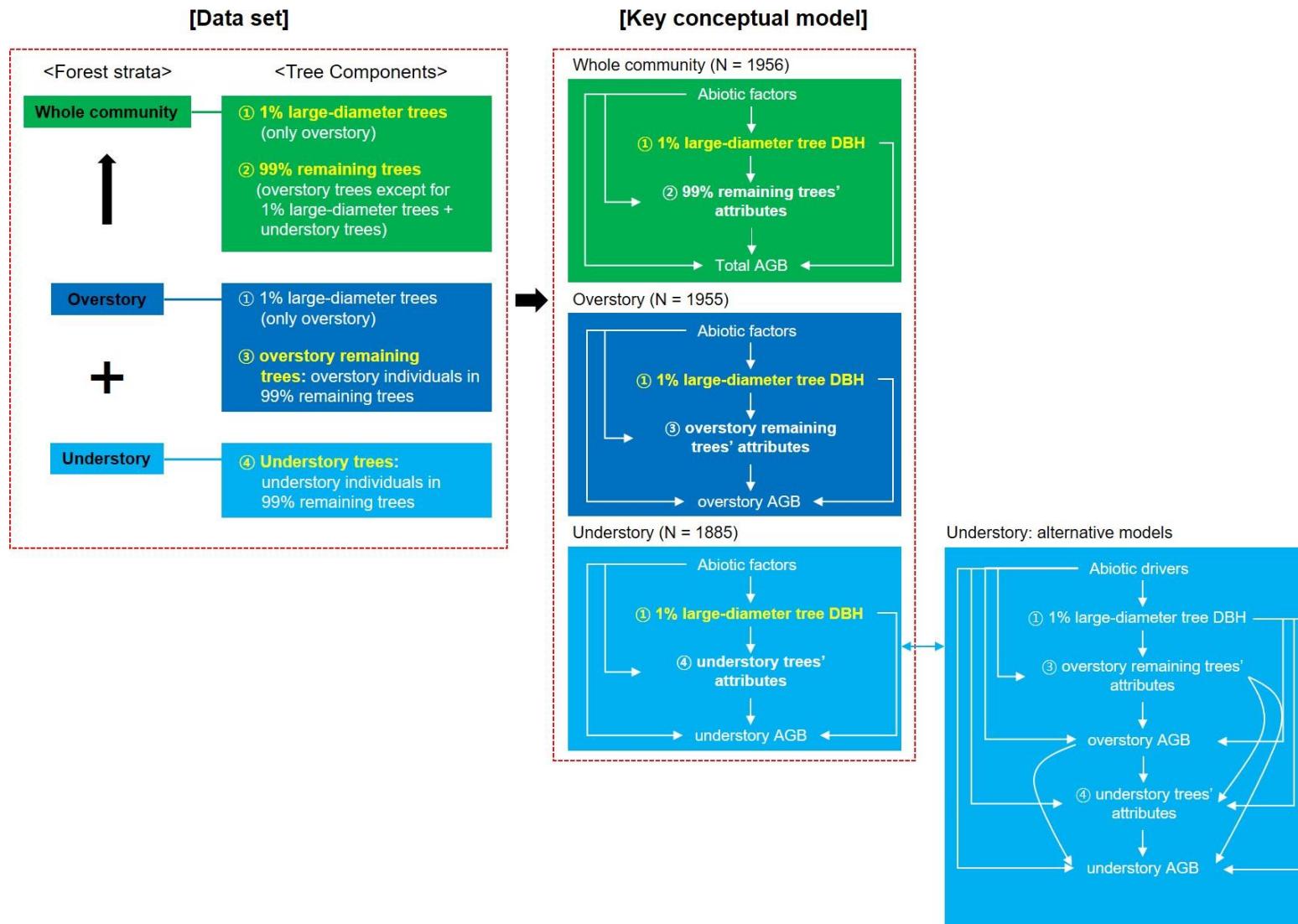


Figure S4. Correlation matrices between the (a) abiotic variables and biotic variables of (b) whole community, (c) 99% remaining trees excluding the 1% large-diameter trees in whole community, (d) overstory, (e) overstory remaining trees excluding the 1% large-diameter trees in overstory, and (f) understory. Abbreviations: MAT, mean annual temperature; MAP, mean annual precipitation; CEC, cation exchange capacity; SR, species richness; SD, Shannon H index; SE, species evenness; FDis, functional dispersion; CWM, community-weighted mean; MUL, multitrait; H, maximum height; LS, leaf size; SM, seed mass; 99%, 99% remaining trees; wh, whole community; over, overstory; ovrem, overstory remaining trees excluding the 1% large-diameter trees in overstory; under, understory.

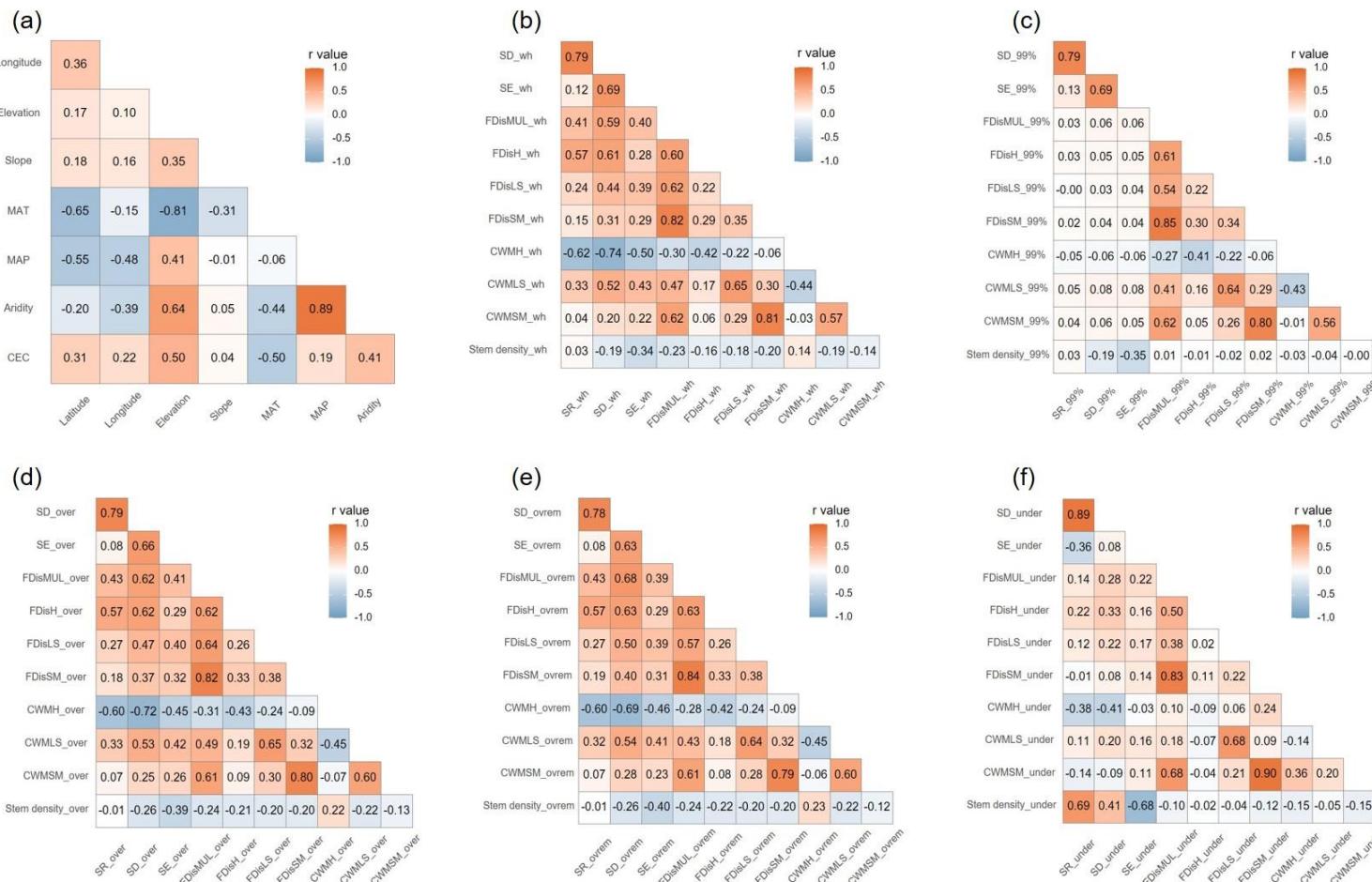


Figure S5. Standardized coefficients (a–c, e–g, and i–k) of predictors with the 95% confidence intervals and relative importance (d, h, and l) between the biotic and abiotic drivers of complementary diversity (CD), functional dominance (FD), and stand structure (SS) models for overstory, understory, and whole community with large-diameter trees terms. The relative importance of biotic or abiotic drivers was simply calculated as the ratio between the parameter estimates of the biotic or abiotic drivers and the sum of all parameter estimates expressed as a percentage. PCclim and PCtopo represent the first axes of principal component analyses for climatic and topographic variables, respectively. 1% Large_DBH indicates 1% large-diameter tree's DBH. Other abbreviations for the variables are shown in Figure S3.

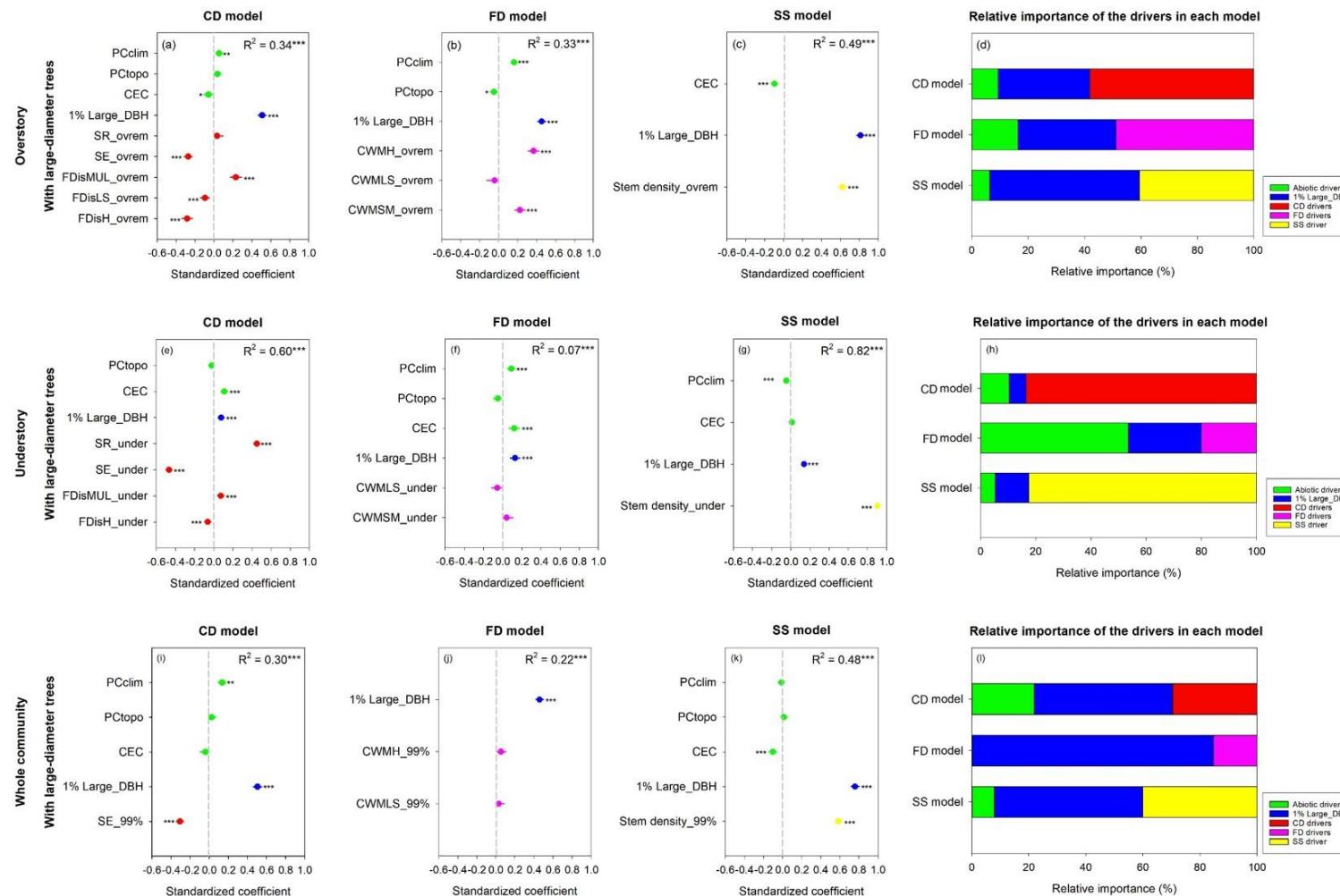


Figure S6. Standardized coefficients (a–c, e–g, and i–k) of predictors with the 95% confidence intervals and relative importance (d, h, and l) between the biotic and abiotic drivers of complementary diversity (CD), functional dominance (FD), and stand structure (SS) models for overstory, understory, and whole community without 1% large-diameter trees terms. The relative importance of biotic or abiotic drivers was simply calculated as the ratio between the parameter estimates of the biotic or abiotic drivers and the sum of all parameter estimates expressed as a percentage. PCclim and PCtopo represent the first axes of principal component analyses for climatic and topographic variables, respectively. Other abbreviations for the variables are shown in Figures S3 and S4.

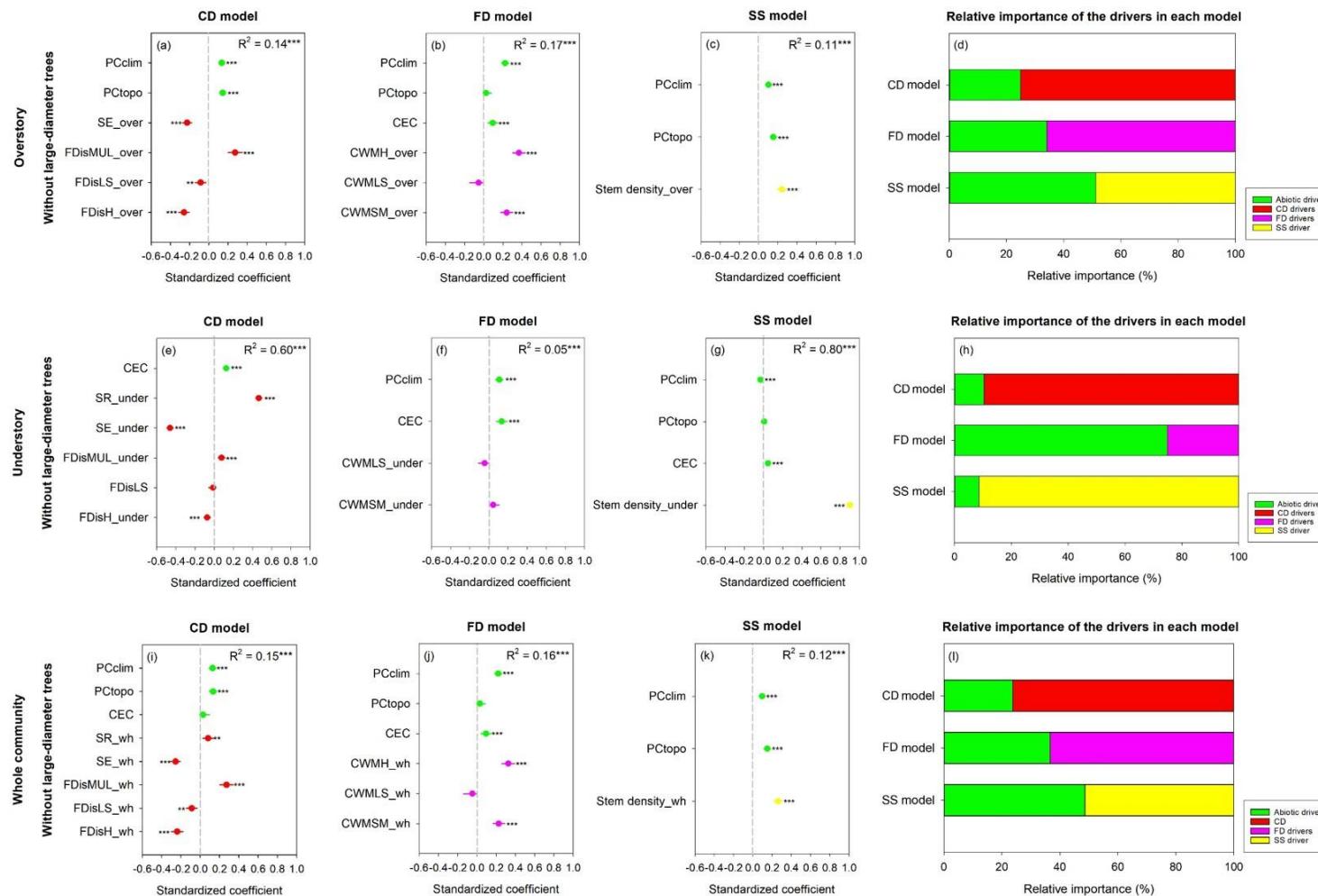


Figure S7. Relative effects of multiple predictors for the aboveground biomass (AGB) of understory (a, b) with or (c, d) without 1% large-diameter trees when considering the effects of overstory attributes with abiotic drivers on understory AGB. The relative importance of biotic or abiotic drivers was simply calculated as the ratio between the parameter estimates of biotic or abiotic drivers and the sum of all parameter estimates expressed as a percentage. Abbreviations for variables are shown in Figures S3 and S4.

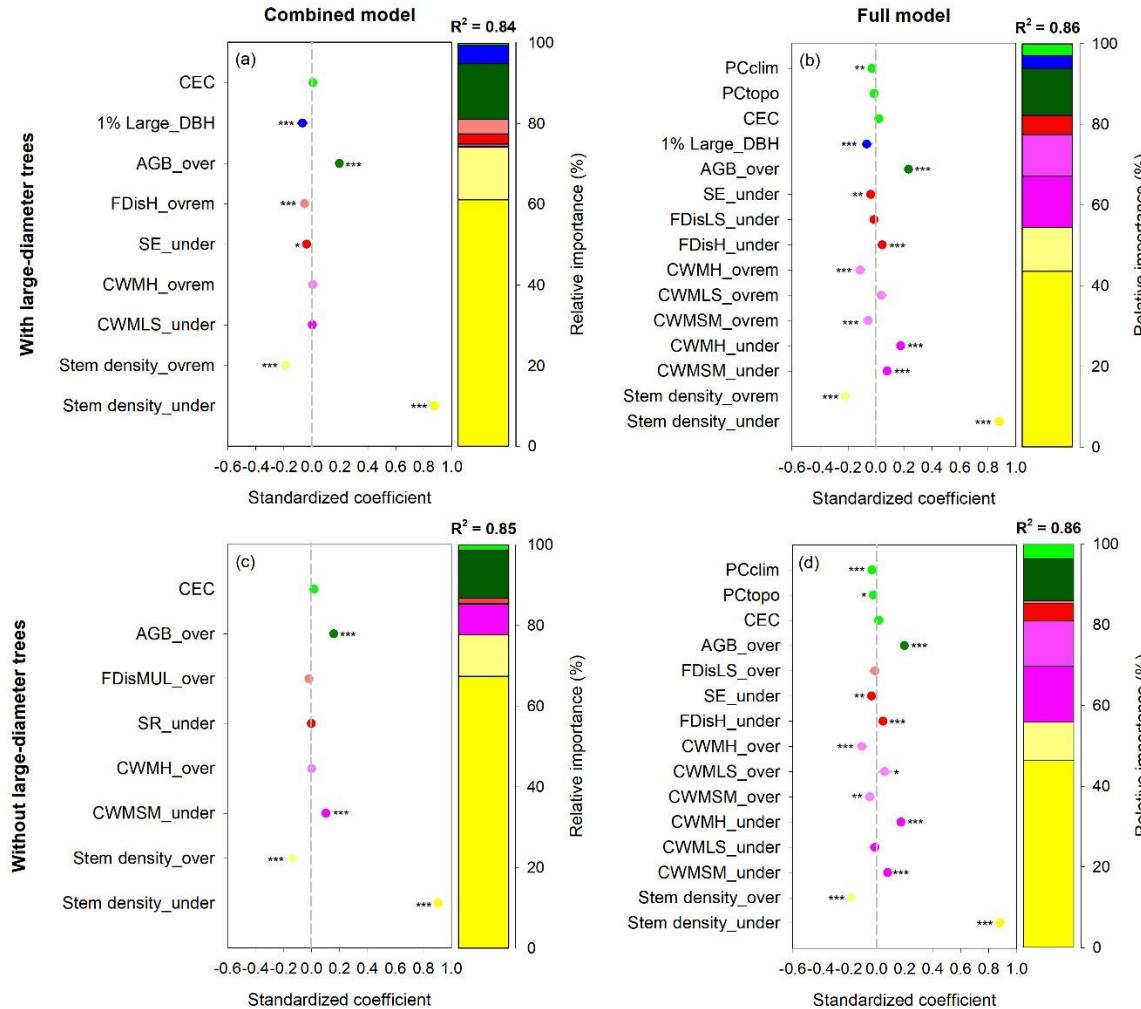


Figure S8. Piecewise structural equation model (pSEM) accounting for the effects of multiple predictors on understory aboveground biomass in the temperate forests of South Korea. The pSEM is an interaction model that considers the effects of the overstory. Blue and red arrows indicate positive and negative pathways, respectively. Solid and dashed arrows represent significant and nonsignificant pathways, respectively. Standardized coefficients are shown for each pathway and covariance. Abbreviations for the variables are shown in Figures S3 and S4.

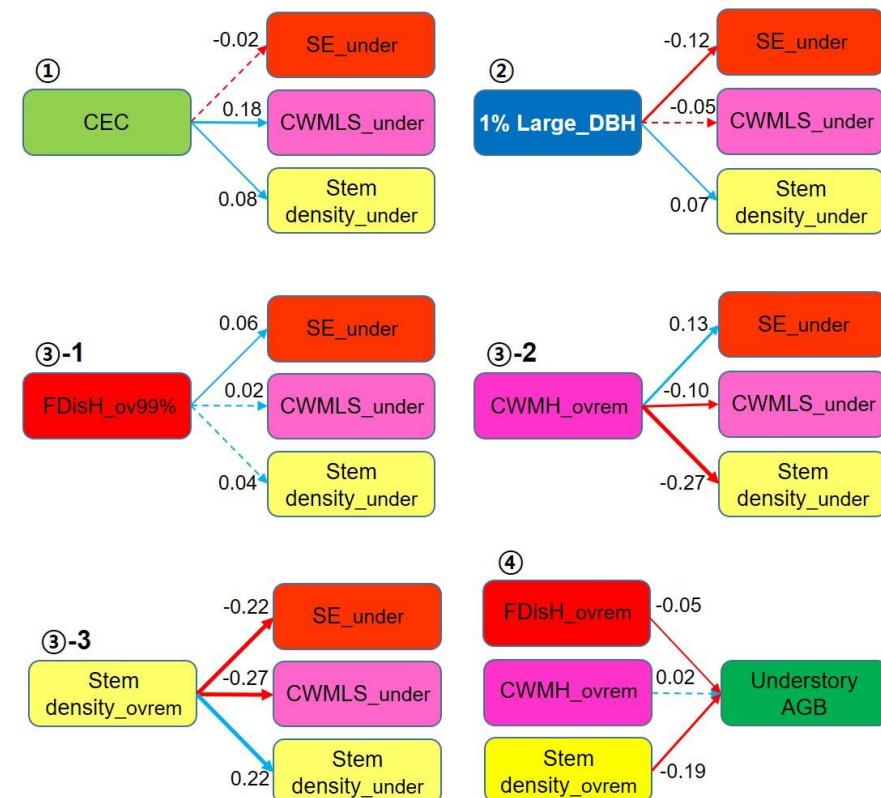
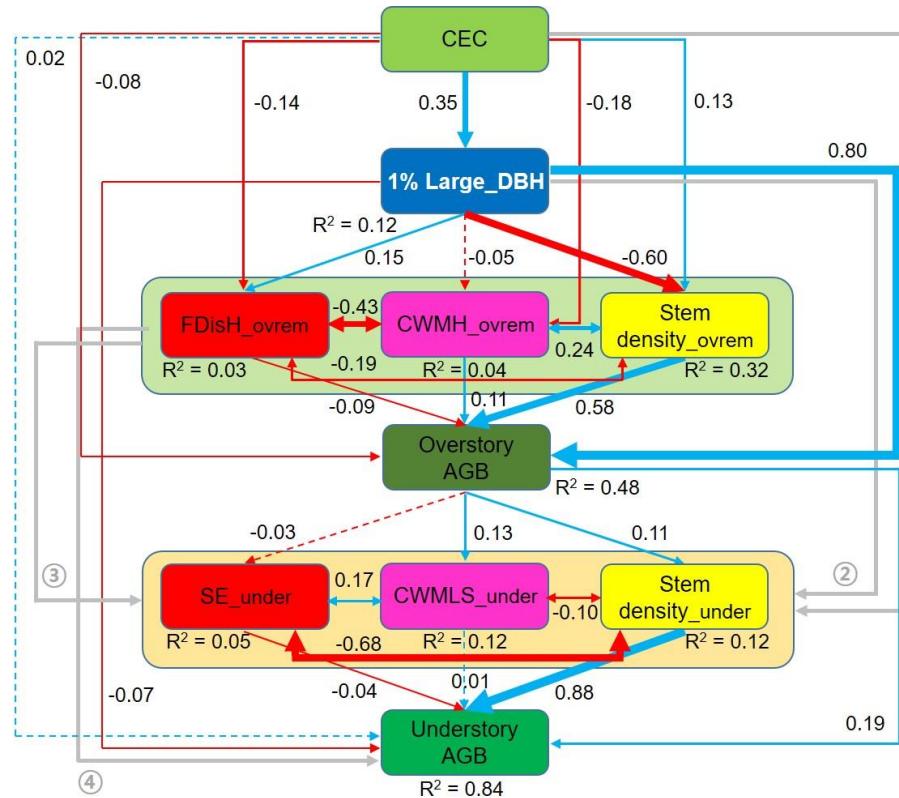


Figure S9. Relative contributions of multiple predictors on understory aboveground biomass in the interaction model between the understory and overstory in accordance with the structural equation model of Figure S7. The relative contribution was simply quantified as the ratio between the parameter estimate of the predictor and the sum of all parameter estimates, and it was expressed as a percentage. Abbreviations for the variables are shown in Figures S3 and S4.

