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SUPPLEMENTARY INFORMATION

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Temporal trade-off between gymnosperm resistance and resilience increases forest sensitivity to extreme drought

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Supplementary information for

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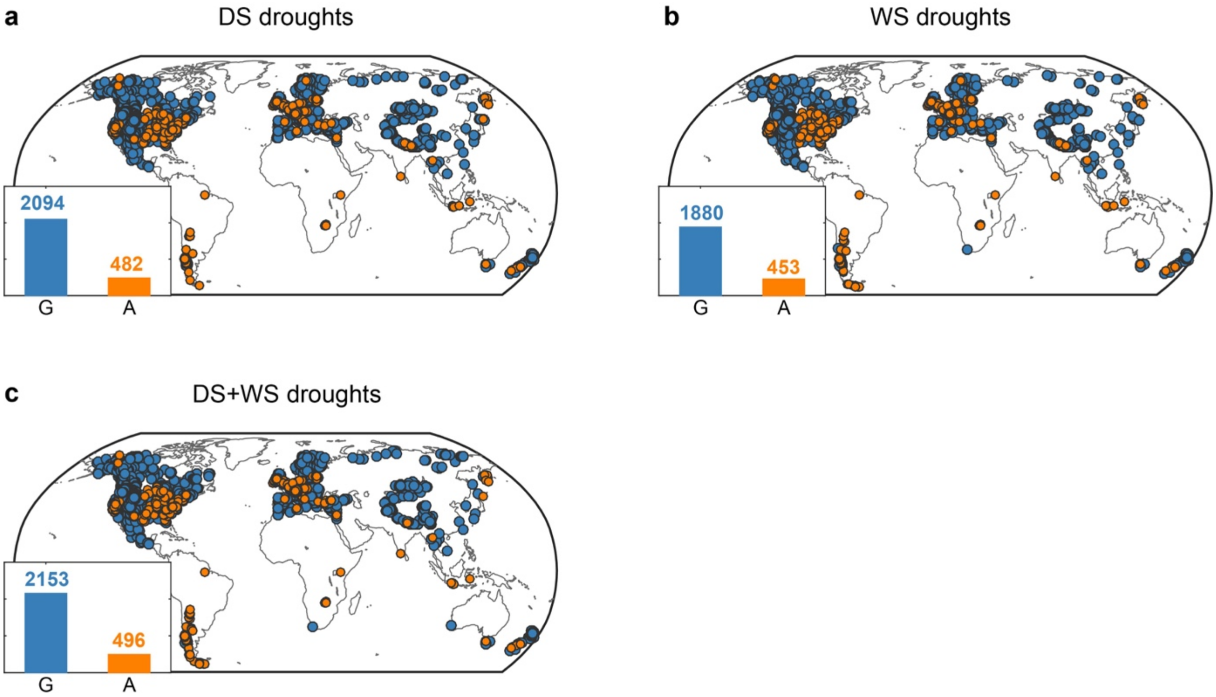

Figure 1. Spatial distributions of the tree-ring sites that experienced (a) droughts in the dry season (DS droughts), (b) droughts in the wet season (WS droughts), and (c) droughts in both dry and wet seasons (DS+WS droughts) for gymnosperm (G) and angiosperm (A) forests. The gymnosperm sites are marked in blue, and the angiosperm sites are marked in orange. The insets show the total number of gymnosperm and angiosperm sites that experienced droughts.

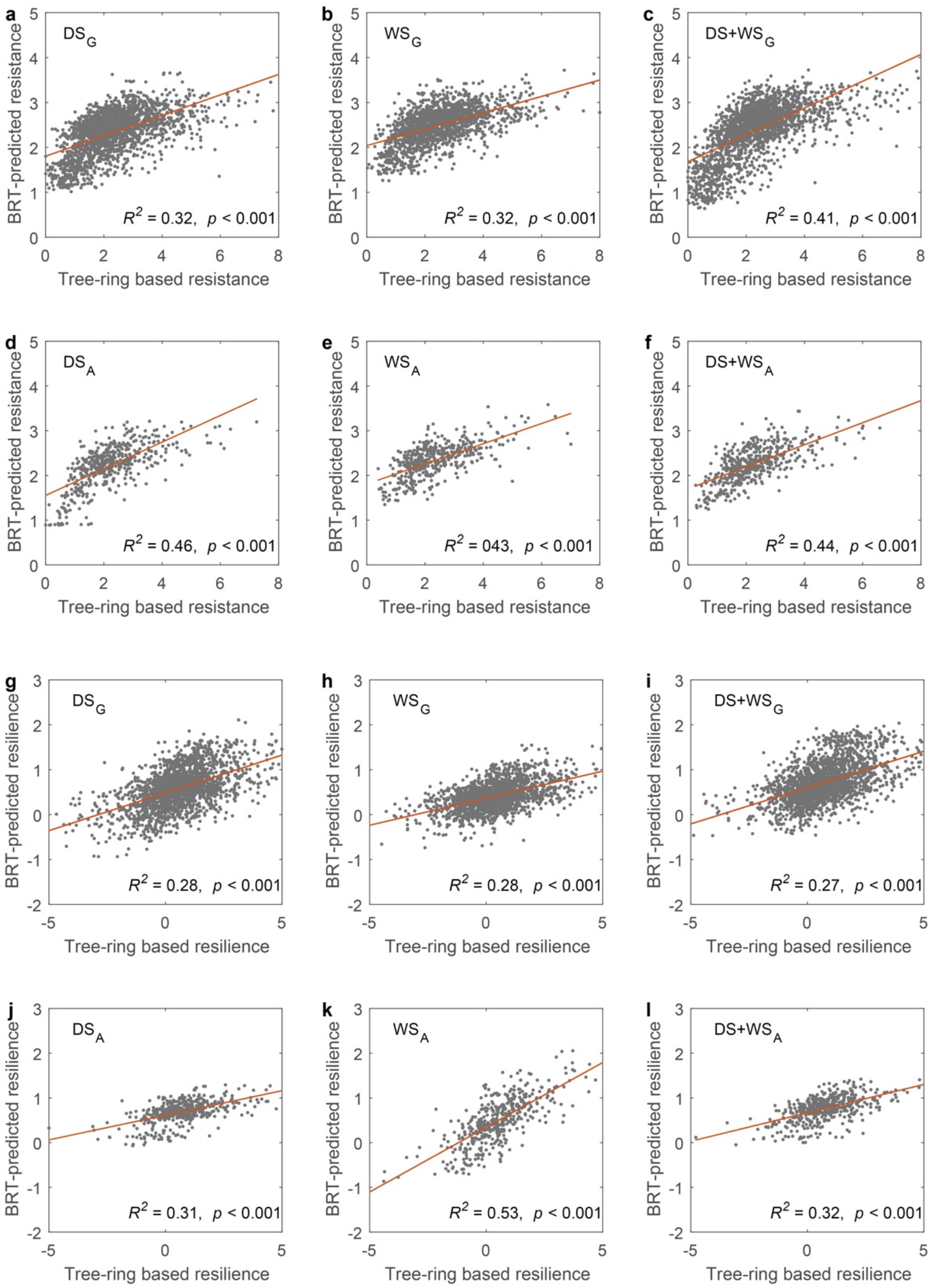

Figure 2. Tree-ring-based resistance vs. boosted regression tree (BRT) predicted resistance for (a) gymnosperms in DS droughts (DS_G), (b) gymnosperms in WS droughts (WS_G), (c) gymnosperms in DS+WS droughts ($DS+WS_G$), (d) angiosperms in DS droughts (DS_A), (e) angiosperms in WS droughts (WS_A), and (f) angiosperms in DS+WS droughts ($DS+WS_A$). (g-i) Analysis as in (a-f) but for tree-ring-based resilience vs. BRT-predicted resilience.

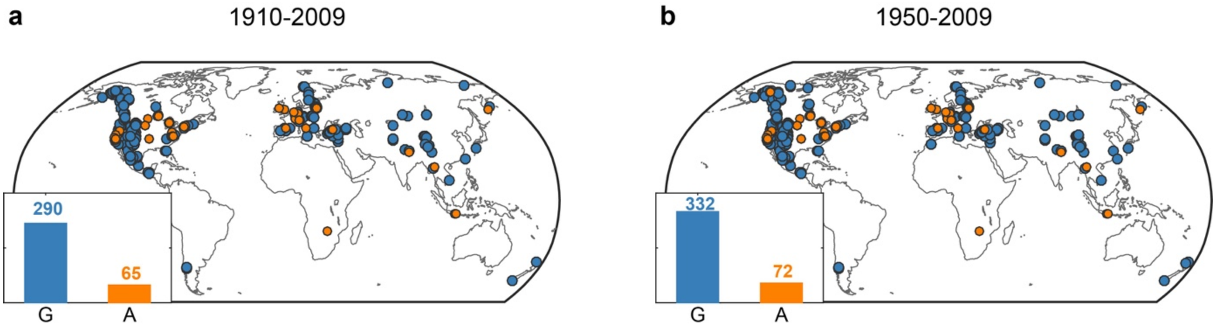

Figure 3. Spatial distributions of tree-ring sites that experienced droughts during (a) all four periods (before 1950, 1950-1969, 1970-1989, and 1990-2009) from 1910-2009, and (b) all three periods (1950-1969, 1970-1989, and 1990-2009) from 1950-2009. The gymnosperm sites (G) are marked in blue, and the angiosperm sites (A) are marked in orange. The insets show the total number of gymnosperm (blue) and angiosperm (orange) sites that experienced droughts.

Tables

Supplementary Table 1 Information for the 38 main species (≥ 20 sites with tree-ring data) of used in this study. Species codes are derived from the ITRDB and the latin names of species refer to Grissino-Mayer (1993, ref[1]) and The Plant List (theplantlist.org).

No.	Species Code	Latin Name & Authority	Genus	Family	Group	Number of sites
1	PSME	*Pseudotsuga menziesii* (Mirb.) Franco	*Pseudotsuga*	Pinaceae	Gymnosperms	209
2	PISY	*Pinus sylvestris* L.	*Pinus*	Pinaceae	Gymnosperms	184
3	PIPO	*Pinus ponderosa* Dougl. ex Laws.	*Pinus*	Pinaceae	Gymnosperms	172
4	PCGL	*Picea glauca* (Moench) Voss	*Picea*	Pinaceae	Gymnosperms	171
5	PCAB	*Picea abies* (L.) Karst	*Picea*	Pinaceae	Gymnosperms	148
6	TSME	*Tsuga mertensiana* (Bong.) Carr.	*Tsuga*	Pinaceae	Gymnosperms	98
7	PCEN	*Picea engelmannii* Parry ex Engelm.	*Picea*	Pinaceae	Gymnosperms	75
8	FASY	*Fagus sylvatica* L.	*Fagus*	Fagaceae	Angiosperms	61
9	ABLA	*Abies lasiocarpa* (Hook.) Nutt.	*Abies*	Pinaceae	Gymnosperms	60
10	PINI	*Pinus nigra* Arnold	*Pinus*	Pinaceae	Gymnosperms	60
11	LASI	*Larix sibirica* Ledeb.	*Larix*	Pinaceae	Gymnosperms	55
12	PCMA	*Picea mariana* (Mill.) Britt., Sterns & Poggenb.	*Picea*	Pinaceae	Gymnosperms	51
13	PIED	*Pinus edulis* Engelm. in Wisliz.	*Pinus*	Pinaceae	Gymnosperms	48
14	QURO	*Quercus robur* L.	*Quercus*	Fagaceae	Angiosperms	47
15	ABAL	*Abies alba* Mill.	*Abies*	Pinaceae	Gymnosperms	45
16	NOPU	*Nothofagus pumilio* (Poepp. & Endl.) Oerst.	*Nothofagus*	Nothofagaceae	Angiosperms	45
17	PCSI	*Picea sitchensis* (Bong.) Carr	*Picea*	Pinaceae	Gymnosperms	45
18	LADE	*Larix decidua* Mill.	*Larix*	Pinaceae	Gymnosperms	42
19	QUMA	*Quercus macrocarpa* Michx	*Quercus*	Fagaceae	Angiosperms	39
20	QUPE	*Quercus petraea* (Matluschka) Liebl.	*Quercus*	Fagaceae	Angiosperms	39
21	QUSP	*Quercus* L.	*Quercus*	Fagaceae	Angiosperms	35
22	LALY	*Larix Iyalli* Parl.	*Larix*	Pinaceae	Gymnosperms	33
23	QUST	*Quercus stellata* Wangenh	*Quercus*	Fagaceae	Angiosperms	33
24	LAGM	*Larix gmelinii* (Rupr.) Kuzen.	*Larix*	Pinaceae	Gymnosperms	31
25	QUDG	*Quercus douglasii* Hook. and Am.	*Quercus*	Fagaceae	Angiosperms	29
26	PIFL	*Pinus flexilis* James	*Pinus*	Pinaceae	Gymnosperms	28

27	QUAL	*Quercus alba* L.	*Quercus*	Fagaceae	Angiosperms	27
28	PIBN	*Pinus bankasiana* Lamb.	*Pinus*	Pinaceae	Gymnosperms	25
29	ABSB	*Abies spectabilIs* (D.Don) Mirb.	*Abies*	Pinaceae	Gymnosperms	24
30	PIST	*Pinus strobus* L.	*Pinus*	Pinaceae	Gymnosperms	24
31	TSCA	*Tsuga Canadensis* (L.) Carrière	*Tsuga*	Pinaceae	Gymnosperms	24
32	LIBI	*Libocedrus bidwillii* Hook.f.	*Libocedrus*	Cupressaceae	Gymnosperms	23
33	NOSO	*Nothofagus solandri* (Hook.f.) Oerst.	*Nothofagus*	Nothofagaceae	Angiosperms	23
34	PIAL	*Pinus albicaulis* Engelm.	*Pinus*	Pinaceae	Gymnosperms	23
35	JUOC	*Juniperus occidentalis* Hook.	*Juniperus*	Cupressaceae	Gymnosperms	22
36	JUSP	*Juniperus* L.	*Juniperus*	Cupressaceae	Gymnosperms	21
37	PICE	*Pinus cembra* L.	*Pinus*	Pinaceae	Gymnosperms	20
38	PICO	*Pinus contorta* Dougl. ex Loud.	*Pinus*	Pinaceae	Gymnosperms	20

Supplementary Table 2 Predictive factors used in the boosted regression tree (BRT) model.

Factor	Description	Unit	Source
Age	Average stand age in droughts	y	ITRDB
Severity	12-month SPEI	–	SPEI data set
Tree density	Stand density per hectare	trees ha^{-1}	Crowther et al., 2015 (ref[2])
Nm	Foliar nitrogen concentration per unit dry mass	mg g^{-1}	Butler et al., 2017 (ref[3])
Pm	Foliar phosphorus concentration per unit dry mass	mg g^{-1}	Butler et al., 2017 (ref[3])
SLA	Specific leaf area	mm^2 mg^{-1}	Butler et al., 2017 (ref[3])
WD	Wood density	g cm^{-3}	Zanne et al., 2009 (ref[4])
Rooting depth	Maximum rooting depth	m	Earth2Observe
Height	Canopy height	m	Simard et al., 2011(ref[5])
HSM	Hydraulic safety margin	Mpa	Chaot et al., 2012 (ref[6])
P50	Water potential at 50% loss of hydraulic conductivity	Mpa	Chaot et al., 2012 (ref[6])
Isohydricity	Degree of isohydricity	–	Konings et al., 2017 (ref[7])
AWC	The classes of available water-storage capacity of the soil	–	Harmonized World Soil Database, Wieder et al., 2014 (ref[8])
CEC	Cation-exchange capacity of the topsoil	cmol kg^{-1}	Harmonized World Soil Database, Wieder et al., 2014 (ref[8])
PREC	Mean annual precipitation	mm y^{-1}	CRU TS 4.01(ref[9])
TEMP	Mean annual temperature	℃	CRU TS 4.01(ref[9])

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