Supporting Information

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SI Text

Ancestral state reconstruction was performed in Mesquite (1). Average precipitation values were binned by 500 mm/y bins and categorized as very dry, dry, mesic, or wet. Continuous characters were reconstructed using squared-change parsimony (2). Discrete characters were reconstructed using maximum-likelihood trait reconstruction (3, 4). As implemented in Mesquite, this uses a marginal probability reconstruction with an Mk1 model. Likelihoods are reported as proportional likelihoods.

1. Maddison WP, Maddison DR (2011) Mesquite: A modular system for evolutionary analysis. Version 2.75 http://mesquiteproject.org. Accessed December 1, 2012.
2. Maddison WP (1991) Squared-change parsimony reconstructions of ancestral states for continuous-valued characters on a phylogenetic tree. *Syst Biol* 40:304–314.
3. Schluter D, Price T, Mooers AO, Ludwig D (1997) Likelihood of ancestor states in adaptive radiation. *Evolution* 51:1699–1711.
4. Pagel M (1999) The maximum likelihood approach to reconstructing ancestral character states of discrete characters on phylogenies. *Syst Biol* 48:612–622.

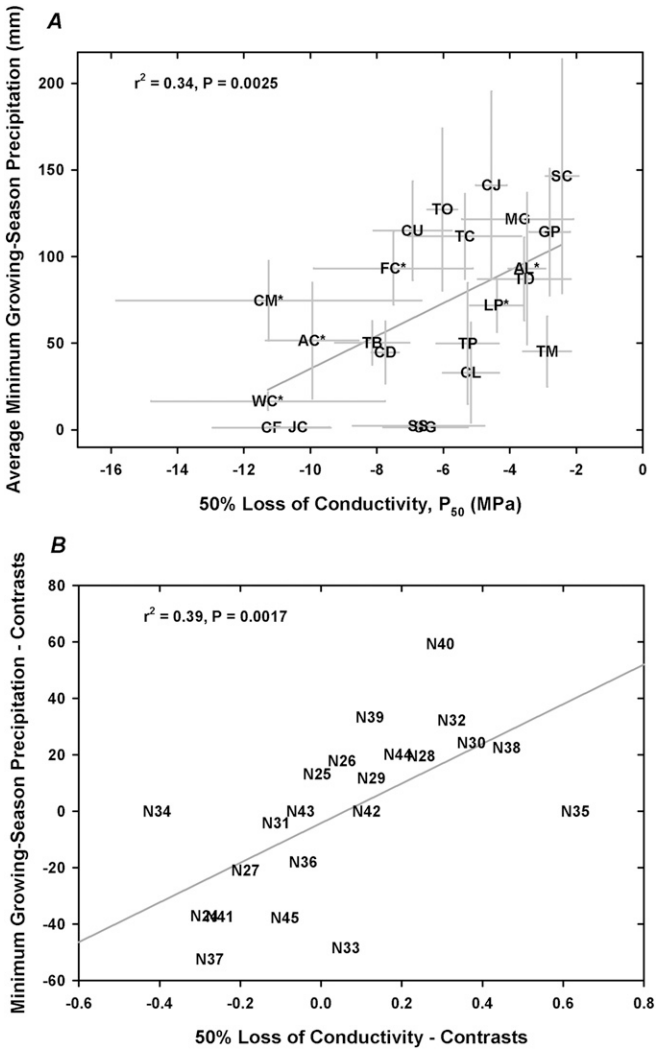

Fig. S1. (*A*) The average minimum growing-season precipitation (across species natural distributions) versus cavitation resistance (P_{50}) in Cupressaceae species growing in a common garden habitat. The coordinates of species' distributions were manually identified using the Google Maps service and then coupled to the global-regional climate database of Peel et al. (1) (http://www.hydrol-earth-syst-sci.net/11/1633/2007/hess-11-1633-2007-supplement.zip; last accessed in July 2011). Only one station was identified in the vicinity of natural *Metasequoia* populations, but data from at least four stations were reliably identified for the remaining species. Detailed climate descriptions for *Metasequoia* can be found in refs. 2 and 3. The driest monthly average precipitation (millimeters) was reported from April to September in species native to the northern hemisphere, and from October to March for species from the southern hemisphere. Data are means ± 1 SD. *Sciadopitys verticillata* and *Taxus baccata* are shown but not included in the regression analysis. (*B*) Phylogenetic contrasts analyses indicate that the relationship between P_{50} and precipitation is not significantly influenced by the phylogenetic relationships among sampled species.

1. Peel MC, Finlayson BL, McMahon TA (2007) Updated world map of the Koppen-Geiger climate classification. *Hydrol Earth Syst Sci* 11:1633–1644.
2. LePage BA, Yang H, Matsumoto M (2005) *The Geobiology and Ecology of Metasequoia*, eds LePage BA, Williams CJ, Yang H (Springer, Dordrecht), pp 3–94.
3. Liu Y-J, Arens NC, Li C-S (2007) Range change in *Metasequoia:* Relationship to palaeoclimate. *Bot J Linn Soc* 154:115–127.

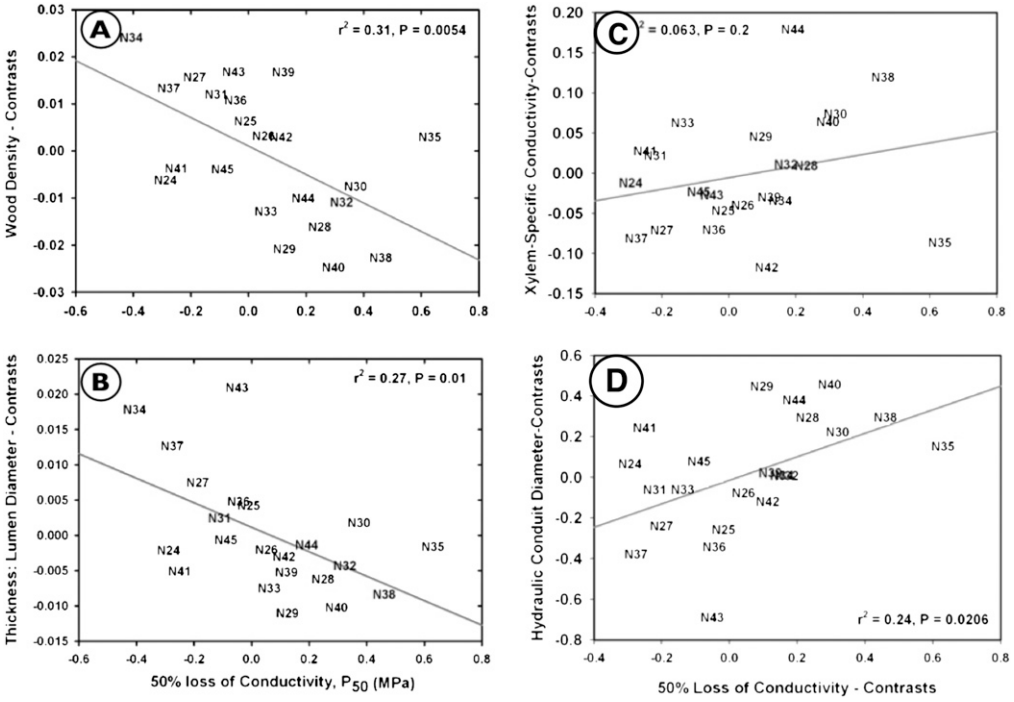

Fig. S2. Phylogenetic independent contrast analyses of the carbon and hydraulic costs of cavitation resistance in the Cupressaceae: (*A*) wood-density contrasts; (*B*) tracheid double-wall thickness to lumen span ratio contrasts, (*C*) xylem-specific conductivity contrasts, and (*D*) hydraulic conduit diameter contrasts.

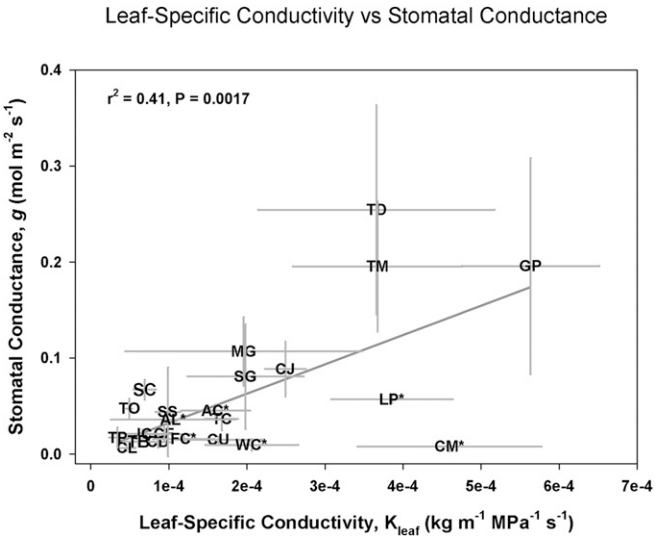

Fig. S3. Stomatal conductance plotted as a function of leaf-specific conductivity. *T. baccata* and *S. verticillata* are plotted but not included in the analyses.

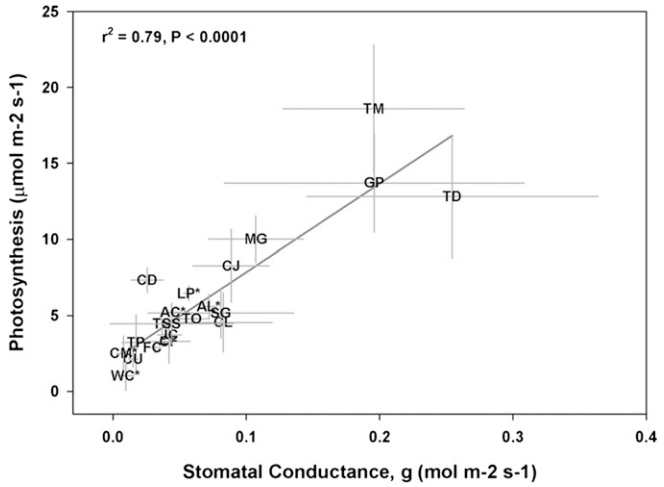

Fig. S4. Photosynthesis plotted as a function of stomatal conductance in the Cupressaceae. *T. baccata* and *S. verticillata* are plotted but not included in the analyses.

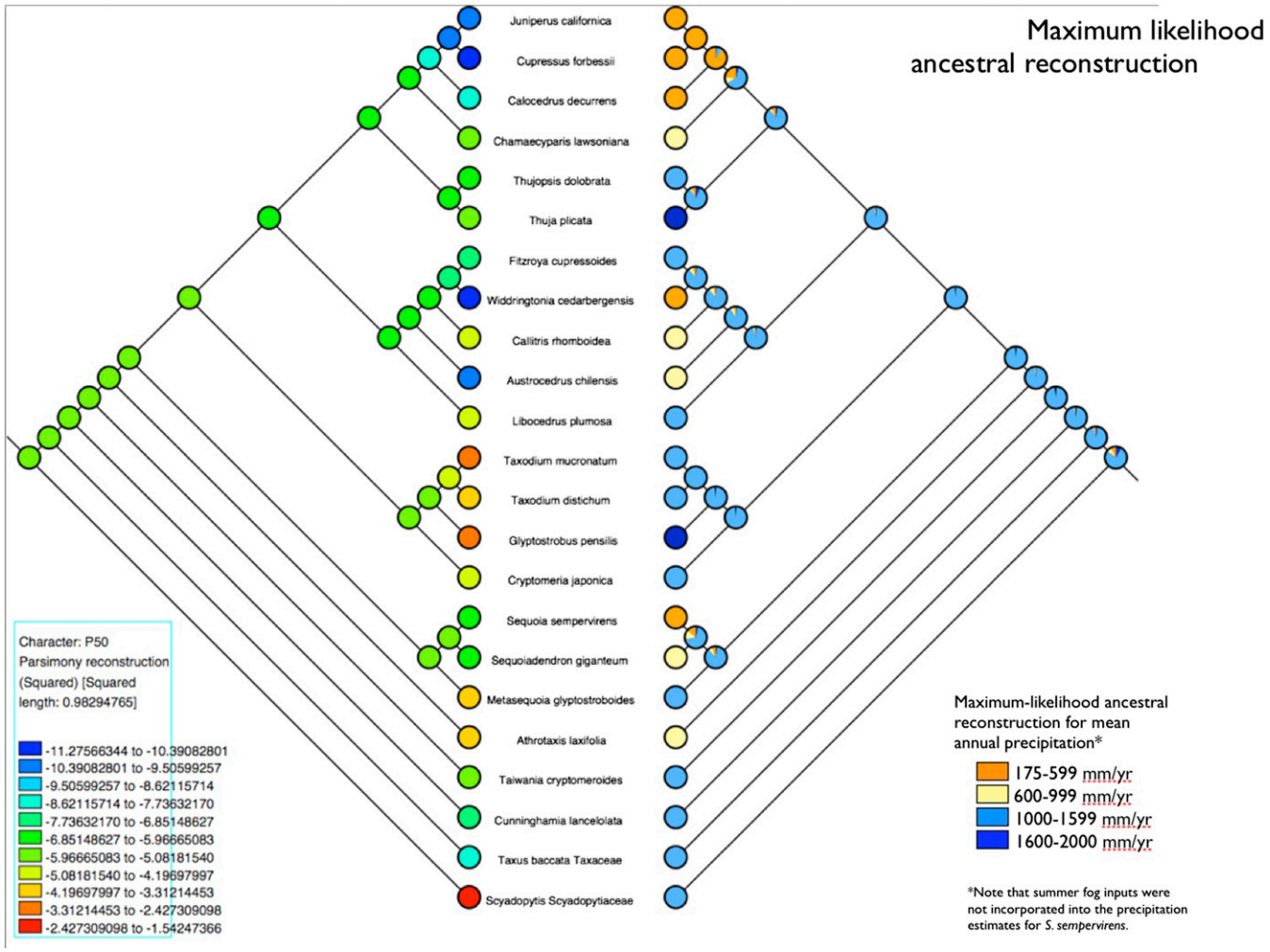

Fig. S5. Ancestral state reconstructions for mean annual precipitation (*Right*) complemented with a reconstruction for species P_{50} (*Left*).

Table S1. Study species, accession numbers, location of collection

Species	Location and accession
Athrotaxis laxifolia Hook.	SFBG, not cataloged
Austrocedrus chilensis (D.Don) Pic. Serm. and Bizzarri	UCBG, nos. 49.0367, 83.0802
Calocedrus decurrens (Torr.) Florin	UCBG, no.87.1602
Chamaecyparis lawsoniana (A. Murray) Parl	SFBG, no.1960–0712
Callitris macleayana (F. Muell.) F. Muell.	UCSC, nos. 75.196, 75.188, 75.465
Calocedrus decurrens (Torr) Florin	SFBG, no.XY-2004
Cryptomeria japonica (Thunb. ex L. f.) D. Don.	SFBG, not cataloged
Cunninghamia lanceolata (Lamb.) Hook.	UCBG, nos. 65.0340, 65.0587, 74.0739
Cupressus forbesii (Jeps.)	SFBG, no.1980–0055
Fitzroya cupressoides (Molina) I. M. Johnst.	UCBG, no.2007.0165
Glyptostrobus pensilis (Staunton ex D. Don) K. Koch	UCBG, no.70.0169
Juniperus californica Carriere	UCBG, no.83.0567
Libocedrus plumosa (D. Don) Sarg.	UCSC, no.81.1172
Metasequoia glyptostroboides Hu and W.C. Cheng	UCBG, no.49.0500
Sequoiadendron giganteum (Lindl.) J. Bucholz	UCBG, no.2002.1062
Sequoia sempervirens (D. Don) Endl.	Campus, University of California at Berkeley
Taxodium distichum (L.) Rich.	UCBG, no.60.1174, 80.0259
Taxodium mucronatum (Ten.)	UCBG, no. 74.0722, 95.0540
Taiwania cryptomeroides Hayata	SFBG, nos. 1984.93, 1990.616
Thuja plicata Donn ex D. Don	SFBG, nos. XY-2657, XY-2658, 1977–0128, 1981–0135
Thujopsis dolabrata Siebold and Zucc.	SFBG, nos XY-2660, 1967–0341
Widdringtonia cedarbergensis J.A. Marsh	SFBG, no. 2004–0570
Sciadopitys verticillata (Thunb.) Siebold and Zucc.(Sciadopityaceae)	SFBG, Japanese Tea Garden, not cataloged
Taxus baccata (L.) (Taxaceae)	SFBG, no.XY-2640

SFBG, San Francisco Botanical Garden (location coordinates: 37.78°N, −122.43°W); UCBG, University of California Botanical Garden, Berkeley, CA (location coordinates: 37.87°N, −122.24°W); and UCSC, University of California, Santa Cruz Arboretum (Location coordinates: 36.98°N, −122.06°W).

Table S2. Fossil taxa used to calibrate the Cupressaceae phylogeny

Node	Fossil taxon	Geological period	Distribution applied (mean ± SD)	BEAST reconstruction mean (95% HPD)	References
24	*Parasciadopitys*	Early Middle Triassic	240.75 ± 5.75	249.57 (251.93–229.53)	1
25	*Taxus* aff.	Early Jurassic	190.85 ± 9.35	193.46 (210.43–176.08)	2
28	*Athrotaxis ungeri*	Early Cretaceous	124.1 ± 25.4	134.04 (153.13–116.58)	3 (originally in) 4
30	*Glyptostrobus* aff.	Aptian-Albian	112.35 ± 13.65	113.69 (127.12–101.1)	5 and references therein
31	*Widdringtonia americana*	Cenomanian	96.6 ± 3.9	95.95 (102.32–89.59)	6
32	*Chamaecyparis corpulenta*	Santonian	84.65 ± 1.85	84.5 (88.04–81.03)	7
35	*Juniperus pauli*	Priabonian	35.55 ± 1.75	35.15 (38.68–31.93)	8
37	*Tetraclinis* aff.	Ypresian	52.2 ± 3.8	53.19 (60.26–46.28)	9 and references therein
40	*Callitris leaensis*	Rupelian	31.15 ± 2.85	31.81 (36.85–26.57)	10
41	*Taxodium wallissii*	Maastrichtian	68.2 ± 3	67.75 (73.78–62)	11
44	*Metasequoia* aff.	Cenomanian	96.6 ± 3.9	95.28 (102.78–87.58)	12 and references therein

HPD, highest posterior density.

1. Yao X, Taylor TN, Taylor EL (1997) A taxodiaceous seed cone from the Triassic of Antarctica. *Am J Bot* 84:343–354.
2. Florin R (1951) Evolution in Cordaites and Conifers. *Acta Horti Berg.* 15:285–388.
3. Archangelsky S (1963) A new Mesozoic flora from Tico, santa Cruz Province, Argentina. *Bull Brit Mus Nat His Geol* 8:47–92.
4. Hill RS, Brodribb TJ (1999) Southern conifers in time and space. *Aust J Bot* 47:639–696.
5. LePage BA (2007) The taxonomy and biogeographic history of *Glyptostrobus* Endlicher (Cupressaceae). *Bulletin of the Peabody Museum of Natural History* 48:359–426.
6. McIver EE (2001) Cretaceous *Widdringtonia* Endl. (Cupressaceae) from North America. *Int J Plant Sci* 162:937–961.
7. McIver EE (1994) An early Chamaecyparis (Cupressaceae) from the Late Cretaceous of Vancouver Island, British Columbia Canada. *Can J Bot* 72:1787–1796.
8. Kvacek Z (2002) A new juniper from the Palaeogene of central Europe. *Feddes Repert* 113:492–502.
9. Stockey RA, Kvacek J, Hill R, Rothwell GH, Kvacek Z 2005 The fossil record of the Cupressaceae, in *A Monograph of the Cupressaceae and Sciadopitys* Farjon A ed. (Royal Botanic Gardens, Kew, Richmond, Surrey, UK) pp 54–68.
10. Paull R, Hill RS (2010) Early oligocene callitris and fitzroya (cupressaceae) from tasmania. *Am J Bot* 97:809–820.
11. Aulenback KR, LePage BA (1998) *Taxodium wallisii* sp. Nov.: First occurrence of *Taxodium* from the Upper Cretaceous. *Int J Plant Sci* 159:367–390.
12. LePage BA, Yang H, Matsumoto M (2005) *The Evolution and Biogeographic History of Metasequoia. The Geobiology and Ecology of Metasequoia*, eds LePage BA, Williams CJ, Yang H (Springer, Dordrecht, The Netherlands), p 434.

Table S3. rbc*L* and mat*K* sequences used to build the Cupressaceae phylogeny

Taxon	rbc*L*	mat*K*	References
Athrotaxis laxifolia	L25754	AF152176	1, 2
Austrocedrus chilensis	EU161449	AF152177	2
Callitris rhomboidea	L12537.2	AF152180	2, 3
Calocedrus decurrens	L12569.2	AF152178	4
Chamaecyparis lawsoniana	AY380880.1	AF152181.1	4, 5
Cryptomeria japonica	L25751	AF152184	1, 2
Cunninghamia lanceolata	L25757	AF152185.1	1, 2
Cupressus forbesii	AY988244	AY988343	6
Fitzroya cupressoides	—	AF152194.1	2
Glyptostrobus lineatus	L25750	—	1
Glyptostrobus pensilis	—	AF152196	2
Juniperus californica	AY988258	AY988357	6
Libocedrus plumosa	L12574	AF152200	4
Metasequoia glyptostroboides	AJ235805	AF152203.1	2, 3
Sciadopitys verticillata	L25753	AB030114	1, 7
Sequoia sempervirens	L25755	AF152209.1	1, 2
Sequoiadendron giganteum	AY056580	AF152210	2, 8
Taiwania cryptomeroides	L25756	AF152211.1	1, 2
Taxodium distichum	AF127427	AF152212	2
Taxodium mucronatum	—	AB030119.1	7
Taxus baccata	AF456388	AF457109	9
Thuja plicata	AF127428	AF152216	2
Thujopsis dolabrata	L12577	AF152217	4
Widdringtonia cedarbergensis	L12538	—	4
Widdringtonia schwarzii	—	AF152218	2

1. Brunsfeld SJ, et al. (1994) Phylogenetic relationships among the genera of Taxodiaceae and Cupressaceae: Evidence from rbcL sequences. *Syst Bot* 19:253–262.
2. Gadek PA, Alpers DL, Heslewood MM, Quinn CJ (2000) Relationships within Cupressaceae sensu lato: A combined morphological and molecular approach. *Am J Bot* 87:1044–1057.
3. Chase MW, et al. (1993) Phylogenetics of seed plants: An analysis of nucleotide sequences from the plastid gene rbcL. *Ann Mo Bot Gard* 80:528–580.
4. Gadek PA, Quinn CJ (1993) An analysis of relationships within the Cupressaceae sensu stricto based on rbcL sequences. *Ann Mo Bot Gard* 80:581–586.
5. Little DP, Schwarzbach AE, Adams RP, Hsieh C-F (2004) The circumscription and phylogenetic relationships of *Callitropsis* and the newly described genus *Xanthocyparis* (Cupressaceae). *Am J Bot* 91:1872–1881.
6. Little DP (2006) Evolution and circumscription of the true cypresses (Cupressaceae: Cupressus). *Syst Bot* 31:461–480.
7. Kusumi J, Tsumura Y, Yoshimaru H, Tachida H (2000) Phylogenetic relationships in Taxodiaceae and Cupressaceae sensu stricto based on matK gene, chlL gene, trnL-trnF IGS region, and trnL intron sequences. *Am J Bot* 87:1480–1488.
8. Rydin C, Kallersjo M, Friis EM (2002) Seed plant relationships and the systematic position of Gnetales based on nuclear and chloroplast DNA: conflicting data, rooting problems, and the monophyly of conifers. *Int J Plant Sci* 163:197–214.
9. Quinn C, Price R, Gadek P (2002) Familial concepts and relationships in the conifer based on rbcL and matK sequence comparisons. *Kew Bull* 57:513–531.