

Table S1. Character data used in this study. All characters except seed cone orientation are binary, with “1” indicating presence and “0” absence. For seed cone orientation, “0” indicates pendulous cones, “1” indicates cones borne horizontally or laterally, “2” indicates erect cones, and “3” indicates no consistent cone orientation. Taxa known from detailed studies or observations are indicated in bold with a footnote, where the number corresponds to the reference given below. Taxa in red are missing information on key characters and were not used in the analysis.

Species	Clade	Sacci	Buoyant	Down	Drop	Seed Cone Orientation
<i>Agathis atropurpurea</i>	Araucariaceae	0	0	0	0	2
<i>Agathis australis</i> ²	Araucariaceae	0	0	0	0	2
<i>Agathis borneensis</i>	Araucariaceae	0	0	0	0	2
<i>Agathis corbassonii</i>	Araucariaceae	0	0	0	0	2
<i>Agathis dammara</i>	Araucariaceae	0	0	0	0	2
<i>Agathis lanceolata</i>	Araucariaceae	0	0	0	0	2
<i>Agathis macrophylla</i>	Araucariaceae	0	0	0	0	2
<i>Agathis microstachya</i>	Araucariaceae	0	0	0	0	2
<i>Agathis montana</i>	Araucariaceae	0	0	0	0	2
<i>Agathis moorei</i>	Araucariaceae	0	0	0	0	2
<i>Agathis ovata</i>	Araucariaceae	0	0	0	0	2
<i>Agathis robusta</i>	Araucariaceae	0	0	0	0	2
<i>Agathis silbae</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria angustifolia</i> ³	Araucariaceae	0	0	0	0	2
<i>Araucaria araucana</i> ¹	Araucariaceae	0	0	0	0	2
<i>Araucaria bernieri</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria bidwillii</i> ³	Araucariaceae	0	0	0	0	2
<i>Araucaria biramulata</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria columnaris</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria cunninghamii</i> ³	Araucariaceae	0	0	0	0	2
<i>Araucaria heterophylla</i> ³	Araucariaceae	0	0	0	0	2
<i>Araucaria humboldtensis</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria hunsteinii</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria laubefelsii</i> ³	Araucariaceae	0	0	0	0	2
<i>Araucaria luxurians</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria montana</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria muelleri</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria nemorosa</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria rulei</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria schmidii</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria scopulorum</i>	Araucariaceae	0	0	0	0	2
<i>Araucaria subulata</i>	Araucariaceae	0	0	0	0	2
<i>Wollemia nobilis</i> ¹	Araucariaceae	0	0	0	0	2

Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Actinostrobus acuminatus</i>	Cupressaceae	0	0	0	1	1
<i>Actinostrobus arenarius</i>	Cupressaceae	0	0	0	1	1
<i>Actinostrobus pyramidalis</i> ¹	Cupressaceae	0	0	0	1	1
<i>Athrotaxis cupressoides</i> ⁴	Cupressaceae	0	0	1	1	0
<i>Athrotaxis laxifolia</i> ⁴	Cupressaceae	0	0	1	1	0
<i>Athrotaxis selaginoides</i> ⁵	Cupressaceae	0	0	1	1	0
<i>Austrocedrus chilensis</i> ¹	Cupressaceae	0	0	0	1	2
<i>Callitris endlicheri</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Callitris macleayana</i>	Cupressaceae	0	0	0	1	1
<i>Callitris preissii</i> ⁵	Cupressaceae	0	0	0	1	1
<i>Callitris rhomboidea</i>	Cupressaceae	0	0	0	1	1
<i>Callitropsis nootkatensis</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Calocedrus decurrens</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Calocedrus formosana</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Calocedrus macrolepis</i>	Cupressaceae	0	0	0	1	1
<i>Chamaecyparis formosensis</i>	Cupressaceae	0	0	0	1	1
<i>Chamaecyparis lawsoniana</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Chamaecyparis obtusa</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Chamaecyparis pisifera</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Chamaecyparis thyoides</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Cryptomeria japonica</i> ⁴	Cupressaceae	0	0	1	1	0
<i>Cunninghamia konishii</i> ⁴	Cupressaceae	0	0	1	1	0
<i>Cunninghamia lanceolata</i> ⁴	Cupressaceae	0	0	1	1	0
<i>Cupressus cashmeriana</i>	Cupressaceae	0	0	0	1	1
<i>Cupressus chengiana</i>	Cupressaceae	0	0	0	1	1
<i>Cupressus duclouxiana</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Cupressus dupreziana</i>	Cupressaceae	0	0	0	1	1
<i>Cupressus funebris</i> ⁵	Cupressaceae	0	0	0	1	1
<i>Cupressus sempervirens</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Cupressus torulosa</i>	Cupressaceae	0	0	0	1	1
<i>Diselma archeri</i> ⁵	Cupressaceae	0	0	0	1	3
<i>Fitzroya cupressoides</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Fokienia hodginsii</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Glyptostrobus pensilis</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis arizonica</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis bakeri</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis benthamii</i>	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis forbesii</i>	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis glabra</i>	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis goveniana</i> ⁵	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis guadalupensis</i>	Cupressaceae	0	0	0	1	1

Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Hesperocyparis lusitanica</i>	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis macnabiana</i>	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis macrocarpa</i>⁴	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis montana</i>	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis nevadensis</i>	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis sargentii</i>	Cupressaceae	0	0	0	1	1
<i>Hesperocyparis stephensonii</i>⁵	Cupressaceae	0	0	0	1	1
<i>Juniperus angosturana</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus ashei</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus barbadensis</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus bermudiana</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus blancoi</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus californica</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus chinensis</i>⁵	Cupressaceae	0	0	1	1	0
<i>Juniperus coahuilensis</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus comitana</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus communis</i>⁴	Cupressaceae	0	0	0	1	3
<i>Juniperus convallium</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus deppeana</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus drupacea</i>	Cupressaceae	0	0	0	1	3
<i>Juniperus durangensis</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus excelsa</i>⁵	Cupressaceae	0	0	1	1	0
<i>Juniperus flaccida</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus formosana</i>	Cupressaceae	0	0	0	1	3
<i>Juniperus gamboana</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus gracilior</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus horizontalis</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus indica</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus komarovii</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus microsperma</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus monosperma</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus monticola</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus occidentalis</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus osteosperma</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus oxycedrus</i>⁴	Cupressaceae	0	0	0	1	3
<i>Juniperus phoenicea</i>⁵	Cupressaceae	0	0	1	1	0
<i>Juniperus pinchotii</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus pingii</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus procera</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus procumbens</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus przewalskii</i>	Cupressaceae	0	0	1	1	0

Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Juniperus pseudosabina</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus recurva</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus rigida</i> ⁴	Cupressaceae	0	0	0	1	3
<i>Juniperus sabina</i> ⁵	Cupressaceae	0	0	1	1	0
<i>Juniperus saltillensis</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus saltuaria</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus saxicola</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus scopulorum</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus semiglobosa</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus squamata</i> ⁴	Cupressaceae	0	0	0	1	3
<i>Juniperus taxifolia</i>	Cupressaceae	0	0	0	1	3
<i>Juniperus thurifera</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus tibetica</i>	Cupressaceae	0	0	1	1	0
<i>Juniperus virginiana</i> ⁴	Cupressaceae	0	0	1	1	0
<i>Libocedrus austrocaledonica</i>	Cupressaceae	0	0	0	1	1
<i>Libocedrus bidwillii</i>	Cupressaceae	0	0	0	1	1
<i>Libocedrus plumosa</i> ⁶	Cupressaceae	0	0	0	1	1
<i>Libocedrus yateensis</i>	Cupressaceae	0	0	0	1	1
<i>Metasequoia glyptostroboides</i> ⁴	Cupressaceae	0	0	0	1	2
<i>Microbiota decussata</i> ⁵	Cupressaceae	0	0	0	1	1
<i>Neocallitropsis pancheri</i> ¹	Cupressaceae	0	0	0	1	1
<i>Papuacedrus papuana</i> ¹	Cupressaceae	0	0	0	1	2
<i>Pilgerodendron uviferum</i> ⁴	Cupressaceae	0	0	0	1	2
<i>Platycladus orientalis</i> ⁴	Cupressaceae	0	0	1	1	0
<i>Sequoia sempervirens</i> ⁴	Cupressaceae	0	0	0	1	2
<i>Sequoiadendron giganteum</i> ⁴	Cupressaceae	0	0	0	1	2
<i>Taiwania cryptomerioides</i> ¹	Cupressaceae	0	0	0	1	2
<i>Taxodium distichum</i> ⁴	Cupressaceae	0	0	0	1	3
<i>Taxodium mucronatum</i>	Cupressaceae	0	0	0	1	3
<i>Tetraclinis articulata</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Thuja koraiensis</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Thuja occidentalis</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Thuja plicata</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Thuja standishii</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Thuja sutchuenensis</i>	Cupressaceae	0	0	0	1	1
<i>Thujopsis dolabrata</i> ⁴	Cupressaceae	0	0	0	1	1
<i>Widdringtonia cedarbergensis</i>	Cupressaceae	0	0	0	1	2
<i>Widdringtonia nodiflora</i>	Cupressaceae	0	0	0	1	2
<i>Widdringtonia schwarzii</i> ⁴	Cupressaceae	0	0	0	1	2
<i>Xanthocyparis vietnamensis</i> ¹	Cupressaceae	0	0	1	1	0
<i>Abies alba</i> ⁷	Pinaceae	1	1	1	1	2

Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Abies amabilis</i>	Pinaceae	1	1	1	1	2
<i>Abies bracteata</i>	Pinaceae	1	1	1	1	2
<i>Abies concolor</i>	Pinaceae	1	1	1	1	2
<i>Abies fabri</i>	Pinaceae	1	1	1	1	2
<i>Abies fargesii</i>	Pinaceae	1	1	1	1	2
<i>Abies firma</i>	Pinaceae	1	1	1	1	2
<i>Abies fraseri</i>	Pinaceae	1	1	1	1	2
<i>Abies grandis</i> ⁷	Pinaceae	1	1	1	1	2
<i>Abies holophylla</i>	Pinaceae	1	1	1	1	2
<i>Abies homolepis</i>	Pinaceae	1	1	1	1	2
<i>Abies kawakamii</i>	Pinaceae	1	1	1	1	2
<i>Abies koreana</i>	Pinaceae	1	1	1	1	2
<i>Abies lasiocarpa</i> ⁸	Pinaceae	1	1	1	1	2
<i>Abies magnifica</i>	Pinaceae	1	1	1	1	2
<i>Abies mariesii</i>	Pinaceae	1	1	1	1	2
<i>Abies nebrodensis</i>	Pinaceae	1	1	1	1	2
<i>Abies nephrolepis</i>	Pinaceae	1	1	1	1	2
<i>Abies nordmanniana</i>	Pinaceae	1	1	1	1	2
<i>Abies numidica</i>	Pinaceae	1	1	1	1	2
<i>Abies pinsapo</i>	Pinaceae	1	1	1	1	2
<i>Abies procera</i>	Pinaceae	1	1	1	1	2
<i>Abies sachalinensis</i>	Pinaceae	1	1	1	1	2
<i>Abies sibirica</i>	Pinaceae	1	1	1	1	2
<i>Abies veitchii</i>	Pinaceae	1	1	1	1	2
<i>Cathaya argyrophylla</i>	Pinaceae	1	1	1	?	2
<i>Cedrus atlantica</i>	Pinaceae	1	1	1	1	2
<i>Cedrus deodara</i> ⁹	Pinaceae	1	1	1	1	2
<i>Cedrus libani</i>	Pinaceae	1	1	1	1	2
<i>Keteleeria davidiana</i>	Pinaceae	1	1	1	?	2
<i>Keteleeria evelyniana</i>	Pinaceae	1	1	1	?	2
<i>Larix decidua</i> ¹	Pinaceae	0	0	1	0	2
<i>Larix gmelinii</i> ¹	Pinaceae	0	0	1	0	2
<i>Larix griffithiana</i>	Pinaceae	0	0	1	0	2
<i>Larix kaempferi</i> ¹	Pinaceae	0	0	1	0	2
<i>Larix laricina</i>	Pinaceae	0	0	1	0	2
<i>Larix occidentalis</i>	Pinaceae	0	0	1	0	2
<i>Larix potaninii</i>	Pinaceae	0	0	1	0	2
<i>Nothotsuga longibracteata</i>	Pinaceae	?	?	?	?	?
<i>Picea abies</i> ¹	Pinaceae	1	1	1	1	2
<i>Picea alcoquiana</i>	Pinaceae	1	1	1	1	2
<i>Picea asperata</i>	Pinaceae	1	1	1	1	2

Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Picea brachytyla</i>	Pinaceae	1	1	1	1	2
<i>Picea breweriana</i>	Pinaceae	1	1	1	1	2
<i>Picea chihuahuana</i>	Pinaceae	1	1	1	1	2
<i>Picea crassifolia</i>	Pinaceae	1	1	1	1	2
<i>Picea engelmannii</i>¹⁰	Pinaceae	1	1	1	1	2
<i>Picea farreri</i>	Pinaceae	1	1	1	1	2
<i>Picea glauca</i>	Pinaceae	1	1	1	1	2
<i>Picea glehnii</i>	Pinaceae	1	1	1	1	2
<i>Picea jezoensis</i>	Pinaceae	1	1	1	1	2
<i>Picea koraiensis</i>	Pinaceae	1	1	1	1	2
<i>Picea koyamiae</i>	Pinaceae	1	1	1	1	2
<i>Picea likiangensis</i>	Pinaceae	1	1	1	1	2
<i>Picea mariana</i>	Pinaceae	1	1	1	1	2
<i>Picea maximowiczii</i>	Pinaceae	1	1	1	1	2
<i>Picea meyeri</i>	Pinaceae	1	1	1	1	2
<i>Picea morrisonicola</i>	Pinaceae	1	1	1	1	2
<i>Picea obovata</i>	Pinaceae	1	1	1	1	2
<i>Picea omorika</i>	Pinaceae	1	1	1	1	2
<i>Picea orientalis</i>¹¹	Pinaceae	1	0	0	1	0
<i>Picea pungens</i>	Pinaceae	1	1	1	1	2
<i>Picea purpurea</i>	Pinaceae	1	1	1	1	2
<i>Picea retroflexa</i>	Pinaceae	1	1	1	1	2
<i>Picea rubens</i>	Pinaceae	1	1	1	1	2
<i>Picea schrenkiana</i>	Pinaceae	1	1	1	1	2
<i>Picea sitchensis</i>¹²	Pinaceae	1	1	1	1	2
<i>Picea smithiana</i>	Pinaceae	1	1	1	1	2
<i>Picea spinulosa</i>	Pinaceae	1	1	1	1	2
<i>Picea torano</i>	Pinaceae	1	1	1	1	2
<i>Picea wilsonii</i>	Pinaceae	1	1	1	1	2
<i>Pinus albicaulis</i>	Pinaceae	1	1	1	1	2
<i>Pinus aristata</i>	Pinaceae	1	1	1	1	2
<i>Pinus arizonica</i>	Pinaceae	1	1	1	1	2
<i>Pinus armandii</i>	Pinaceae	1	1	1	1	2
<i>Pinus attenuata</i>	Pinaceae	1	1	1	1	2
<i>Pinus ayacahuite</i>	Pinaceae	1	1	1	1	2
<i>Pinus balfouriana</i>	Pinaceae	1	1	1	1	2
<i>Pinus bhutanica</i>	Pinaceae	1	1	1	1	2
<i>Pinus brutia</i>	Pinaceae	1	1	1	1	2
<i>Pinus bungeana</i>	Pinaceae	1	1	1	1	2
<i>Pinus canariensis</i>	Pinaceae	1	1	1	1	2
<i>Pinus caribaea v. bahamensis</i>	Pinaceae	1	1	1	1	2

Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Pinus caribaea</i> v. <i>caribaea</i>	Pinaceae	1	1	1	1	2
<i>Pinus caribaea</i> v. <i>hondurensis</i>	Pinaceae	1	1	1	1	2
<i>Pinus cembroides</i>	Pinaceae	1	1	1	1	2
<i>Pinus chiapensis</i>	Pinaceae	1	1	1	1	2
<i>Pinus clausa</i>	Pinaceae	1	1	1	1	2
<i>Pinus contorta</i>¹³	Pinaceae	1	1	1	1	2
<i>Pinus coulteri</i>	Pinaceae	1	1	1	1	2
<i>Pinus cubensis</i>	Pinaceae	1	1	1	1	2
<i>Pinus culminicola</i>	Pinaceae	1	1	1	1	2
<i>Pinus dalatensis</i>	Pinaceae	1	1	1	1	2
<i>Pinus densata</i>	Pinaceae	1	1	1	1	2
<i>Pinus densiflora</i>	Pinaceae	1	1	1	1	2
<i>Pinus devoniana</i>	Pinaceae	1	1	1	1	2
<i>Pinus douglasiana</i>	Pinaceae	1	1	1	1	2
<i>Pinus durangensis</i>	Pinaceae	1	1	1	1	2
<i>Pinus echinata</i>	Pinaceae	1	1	1	1	2
<i>Pinus edulis</i>	Pinaceae	1	1	1	1	2
<i>Pinus elliottii</i>	Pinaceae	1	1	1	1	2
<i>Pinus engelmannii</i>	Pinaceae	1	1	1	1	2
<i>Pinus fenzeliana</i>	Pinaceae	1	1	1	1	2
<i>Pinus flexilis</i>	Pinaceae	1	1	1	1	2
<i>Pinus gerardiana</i>	Pinaceae	1	1	1	1	2
<i>Pinus glabra</i>	Pinaceae	1	1	1	1	2
<i>Pinus greggii</i>	Pinaceae	1	1	1	1	2
<i>Pinus halepensis</i>	Pinaceae	1	1	1	1	2
<i>Pinus hartwegii</i>	Pinaceae	1	1	1	1	2
<i>Pinus heldreichii</i>	Pinaceae	1	1	1	1	2
<i>Pinus herrerae</i>	Pinaceae	1	1	1	1	2
<i>Pinus hwangshanensis</i>	Pinaceae	1	1	1	1	2
<i>Pinus jeffreyi</i>	Pinaceae	1	1	1	1	2
<i>Pinus johannis</i>	Pinaceae	1	1	1	1	2
<i>Pinus kesiya</i>	Pinaceae	1	1	1	1	2
<i>Pinus koraiensis</i>	Pinaceae	1	1	1	1	2
<i>Pinus krempfii</i>	Pinaceae	1	1	1	1	2
<i>Pinus lambertiana</i>	Pinaceae	1	1	1	1	2
<i>Pinus lawsonii</i>	Pinaceae	1	1	1	1	2
<i>Pinus leiophylla</i>	Pinaceae	1	1	1	1	2
<i>Pinus longaeva</i>	Pinaceae	1	1	1	1	2
<i>Pinus luchuensis</i>	Pinaceae	1	1	1	1	2
<i>Pinus lumholtzii</i>	Pinaceae	1	1	1	1	2

Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Pinus maximartinezii</i>	Pinaceae	1	1	1	1	2
<i>Pinus merkusii</i>	Pinaceae	1	1	1	1	2
<i>Pinus monophylla</i>	Pinaceae	1	1	1	1	2
<i>Pinus montezumae</i>	Pinaceae	1	1	1	1	2
<i>Pinus monticola</i>	Pinaceae	1	1	1	1	2
<i>Pinus morrisonicola</i>	Pinaceae	1	1	1	1	2
<i>Pinus mugo</i>¹⁴	Pinaceae	1	1	1	1	2
<i>Pinus muricata</i>	Pinaceae	1	1	1	1	2
<i>Pinus nelsonii</i>	Pinaceae	1	1	1	1	2
<i>Pinus nigra</i>¹⁴	Pinaceae	1	1	1	1	2
<i>Pinus occidentalis</i>	Pinaceae	1	1	1	1	2
<i>Pinus oocarpa</i>	Pinaceae	1	1	1	1	2
<i>Pinus palustris</i>	Pinaceae	1	1	1	1	2
<i>Pinus parviflora</i>	Pinaceae	1	1	1	1	2
<i>Pinus patula</i>	Pinaceae	1	1	1	1	2
<i>Pinus peuce</i>	Pinaceae	1	1	1	1	2
<i>Pinus pinaster</i>	Pinaceae	1	1	1	1	2
<i>Pinus pineana</i>	Pinaceae	1	1	1	1	2
<i>Pinus pinea</i>	Pinaceae	1	1	1	1	2
<i>Pinus ponderosa</i>	Pinaceae	1	1	1	1	2
<i>Pinus praeternissa</i>	Pinaceae	1	1	1	1	2
<i>Pinus pringlei</i>	Pinaceae	1	1	1	1	2
<i>Pinus pseudostrobus</i>	Pinaceae	1	1	1	1	2
<i>Pinus pumila</i>	Pinaceae	1	1	1	1	2
<i>Pinus pungens</i>	Pinaceae	1	1	1	1	2
<i>Pinus quadrifolia</i>	Pinaceae	1	1	1	1	2
<i>Pinus radiata</i>	Pinaceae	1	1	1	1	2
<i>Pinus remota</i>	Pinaceae	1	1	1	1	2
<i>Pinus resinosa</i>	Pinaceae	1	1	1	1	2
<i>Pinus rigida</i>	Pinaceae	1	1	1	1	2
<i>Pinus roxburghii</i>	Pinaceae	1	1	1	1	2
<i>Pinus rzedowskii</i>	Pinaceae	1	1	1	1	2
<i>Pinus sabiniana</i>	Pinaceae	1	1	1	1	2
<i>Pinus serotina</i>	Pinaceae	1	1	1	1	2
<i>Pinus sibirica</i>	Pinaceae	1	1	1	1	2
<i>Pinus squamata</i>	Pinaceae	1	1	1	1	2
<i>Pinus strobiformis</i>	Pinaceae	1	1	1	1	2
<i>Pinus strobus</i>	Pinaceae	1	1	1	1	2
<i>Pinus sylvestris</i>	Pinaceae	1	1	1	1	2
<i>Pinus tabuliformis</i>	Pinaceae	1	1	1	1	2
<i>Pinus taeda</i>	Pinaceae	1	1	1	1	2

Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Pinus taiwanensis</i>	Pinaceae	1	1	1	1	2
<i>Pinus teocote</i>	Pinaceae	1	1	1	1	2
<i>Pinus torreyana</i>	Pinaceae	1	1	1	1	2
<i>Pinus tropicalis</i>	Pinaceae	1	1	1	1	2
<i>Pinus uncinata</i>	Pinaceae	1	1	1	1	2
<i>Pinus virginiana</i>	Pinaceae	1	1	1	1	2
<i>Pinus wallichiana</i>	Pinaceae	1	1	1	1	2
<i>Pinus yunnanensis</i>	Pinaceae	1	1	1	1	2
<i>Pseudolarix amabilis</i>	Pinaceae	1	1	1	?	2
<i>Pseudotsuga japonica</i>	Pinaceae	0	0	1	0	2
<i>Pseudotsuga macrocarpa</i>	Pinaceae	0	0	1	0	2
<i>Pseudotsuga menziesii</i>¹⁵	Pinaceae	0	0	1	0	2
<i>Pseudotsuga sinensis</i>	Pinaceae	0	0	1	0	2
<i>Tsuga canadensis</i>¹	Pinaceae	0	0	0	0	1
<i>Tsuga caroliniana</i>	Pinaceae	0	0	0	0	1
<i>Tsuga chinensis</i>	Pinaceae	0	0	0	0	1
<i>Tsuga diversifolia</i>	Pinaceae	0	0	0	0	1
<i>Tsuga dumosa</i>	Pinaceae	0	0	0	0	1
<i>Tsuga forrestii</i>	Pinaceae	0	0	0	0	1
<i>Tsuga heterophylla</i>¹⁶	Pinaceae	0	0	0	0	1
<i>Tsuga mertensiana</i>¹⁷	Pinaceae	1	1	1	0	2
<i>Tsuga sieboldii</i>	Pinaceae	0	0	0	0	1
<i>Acmopyle pancheri</i>¹⁸	Podocarpaceae	1	1	1	1	2
<i>Acmopyle sahniana</i>	Podocarpaceae	1	1	1	1	2
<i>Afrocarpus falcatus</i>¹⁹	Podocarpaceae	1	1	1	1	2
<i>Afrocarpus gracilior</i>¹⁹	Podocarpaceae	1	1	1	1	2
<i>Afrocarpus mannii</i>¹⁹	Podocarpaceae	1	1	1	1	2
<i>Afrocarpus usambarensis</i>¹⁹	Podocarpaceae	1	1	1	1	2
<i>Dacrycarpus cinctus</i>	Podocarpaceae	1	1	1	1	2
<i>Dacrycarpus compactus</i>	Podocarpaceae	1	1	1	1	2
<i>Dacrycarpus dacrydioides</i>	Podocarpaceae	1	1	1	1	2
<i>Dacrycarpus imbricatus</i>	Podocarpaceae	1	1	1	1	2
<i>Dacrycarpus kinabaluensis</i>	Podocarpaceae	1	1	1	1	2
<i>Dacrycarpus veillardi</i>	Podocarpaceae	1	1	1	1	2
<i>Dacrydium araucariooides</i>¹	Podocarpaceae	0	0	0	0	2
<i>Dacrydium balansae</i>	Podocarpaceae	1	1	1	?	2
<i>Dacrydium beccarii</i>	Podocarpaceae	1	1	1	?	2
<i>Dacrydium cypressinum</i>	Podocarpaceae	1	1	1	?	2
<i>Dacrydium elatum</i>	Podocarpaceae	1	1	1	?	2
<i>Dacrydium guillauminii</i>¹	Podocarpaceae	0	0	0	0	2
<i>Dacrydium lycopodioides</i>¹	Podocarpaceae	0	0	0	0	2

Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Dacrydium magnum</i>	Podocarpaceae	1	1	1	?	2
<i>Dacrydium nausoriense</i>	Podocarpaceae	1	1	1	?	2
<i>Dacrydium nidulum</i>	Podocarpaceae	1	1	1	?	2
<i>Dacrydium xanthandrum</i>	Podocarpaceae	1	1	1	?	2
<i>Falcatifolium falciforme</i> ¹⁹	Podocarpaceae	1	1	1	1	2
<i>Falcatifolium taxoides</i>	Podocarpaceae	1	1	1	1	2
<i>Halocarpus bidwillii</i>	Podocarpaceae	1	1	1	1	2
<i>Halocarpus biformis</i>	Podocarpaceae	1	1	1	1	2
<i>Halocarpus kirkii</i> ²⁰	Podocarpaceae	1	1	1	1	2
<i>Lagarostrobus franklinii</i> ^{21,22}	Podocarpaceae	1	0	1	1	0
<i>Lepidothamnus fonkii</i>	Podocarpaceae	1	1	1	1	2
<i>Lepidothamnus laxifolius</i> ²⁰	Podocarpaceae	1	1	1	1	2
<i>Manoao colensoi</i> ²⁰	Podocarpaceae	1	1	1	1	2
<i>Microcachrys tetragona</i> ²⁰	Podocarpaceae	1	1	1	1	2
<i>Nageia fleuryi</i>	Podocarpaceae	1	1	1	?	2
<i>Nageia formosensis</i>	Podocarpaceae	1	1	1	?	2
<i>Nageia nagi</i>	Podocarpaceae	1	1	1	?	2
<i>Nageia wallichiana</i>	Podocarpaceae	1	1	1	?	2
<i>Parasitaxus usta</i> ¹	Podocarpaceae	1	1	1	1	2
<i>Pherosphaera fitzgeraldii</i> ²²	Podocarpaceae	1	1	1	1	0
<i>Pherosphaera hookeriana</i>	Podocarpaceae	1	1	1	1	0
<i>Phyllocladus alpinus</i>	Podocarpaceae	1	0	0	1	3
<i>Phyllocladus asplenifolius</i>	Podocarpaceae	1	0	0	1	3
<i>Phyllocladus hypophyllus</i>	Podocarpaceae	1	0	0	1	3
<i>Phyllocladus toatoa</i> ²³	Podocarpaceae	1	0	0	1	3
<i>Phyllocladus trichomanoides</i> ²³	Podocarpaceae	1	0	0	1	3
<i>Podocarpus acutifolius</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus affinis</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus alpinus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus angustifolius</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus annamiensis</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus archboldii</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus aristulatus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus bracteatus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus brassii</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus brevifolius</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus chinensis</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus chingianus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus coriaceus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus costalis</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus costaricensis</i>	Podocarpaceae	1	1	1	1	2

Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Podocarpus cunninghamii</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus dispermus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus drouynianus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus elatus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus elongatus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus fasciculus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus gnidioides</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus grayae</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus guatemalensis</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus henkelii</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus hispaniolensis</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus lambertii</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus latifolius</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus lawrencii</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus longifoliolatus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus lucienii</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus macrophyllus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus matudae</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus milanjianus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus nakaii</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus nerifolius</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus nivalis</i> ²⁰	Podocarpaceae	1	1	1	1	2
<i>Podocarpus novae-caledoniae</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus nubigenus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus oleifolius</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus parlatorei</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus pilgeri</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus polyspermus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus polystachyus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus purdieanus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus rotundus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus rubens</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus rumphii</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus salignus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus salomonensis</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus sellowii</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus spathoides</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus spinulosus</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus subtropicalis</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus sylvestris</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus totara</i> ²⁰	Podocarpaceae	1	1	1	1	2

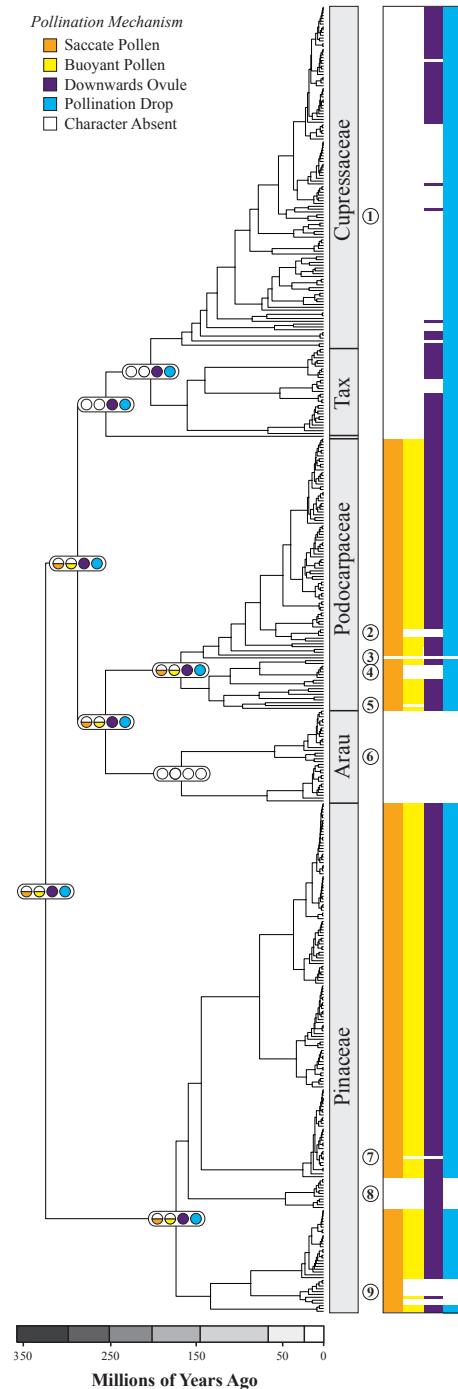
Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Podocarpus trinitensis</i>	Podocarpaceae	1	1	1	1	2
<i>Podocarpus urbanii</i>	Podocarpaceae	1	1	1	1	2
<i>Prumnopitys andina</i> ²⁰	Podocarpaceae	1	1	1	1	2
<i>Prumnopitys ferruginea</i> ²⁰	Podocarpaceae	1	1	1	1	2
<i>Prumnopitys ferruginoides</i>	Podocarpaceae	1	1	1	1	2
<i>Prumnopitys ladei</i>	Podocarpaceae	1	1	1	1	2
<i>Prumnopitys taxifolia</i>	Podocarpaceae	1	1	1	1	2
<i>Retrophyllum comptonii</i>	Podocarpaceae	1	1	1	?	2
<i>Retrophyllum minor</i>	Podocarpaceae	1	1	1	?	2
<i>Retrophyllum rospigliosii</i>	Podocarpaceae	1	1	1	?	2
<i>Retrophyllum vitiense</i>	Podocarpaceae	1	1	1	?	2
<i>Saxegothaea conspicua</i> ¹⁹	Podocarpaceae	0	0	0	0	1
<i>Sundacarpus amarus</i>	Podocarpaceae	1	1	?	?	?
<i>Sciadopitys verticillata</i> ²⁴	Sciadopityaceae	0	0	0	1	2
<i>Amentotaxus argotaenia</i> ¹	Taxaceae	0	0	1	1	0
<i>Amentotaxus formosana</i>	Taxaceae	0	0	1	1	0
<i>Amentotaxus poilanei</i>	Taxaceae	0	0	1	1	0
<i>Amentotaxus yunnanensis</i>	Taxaceae	0	0	1	1	0
<i>Austrotaxus spicata</i>	Taxaceae	0	0	?	?	?
<i>Cephalotaxus fortunei</i>	Taxaceae	0	0	1	1	0
<i>Cephalotaxus griffithii</i>	Taxaceae	0	0	1	1	0
<i>Cephalotaxus hainanensis</i>	Taxaceae	0	0	1	1	0
<i>Cephalotaxus harringtonia</i> ¹	Taxaceae	0	0	1	1	0
<i>Cephalotaxus koreana</i>	Taxaceae	0	0	1	1	0
<i>Cephalotaxus lanceolata</i>	Taxaceae	0	0	1	1	0
<i>Cephalotaxus latifolia</i>	Taxaceae	0	0	1	1	0
<i>Cephalotaxus mannii</i>	Taxaceae	0	0	1	1	0
<i>Cephalotaxus oliveri</i>	Taxaceae	0	0	1	1	0
<i>Cephalotaxus sinensis</i>	Taxaceae	0	0	1	1	0
<i>Cephalotaxus wilsoniana</i>	Taxaceae	0	0	1	1	0
<i>Pseudotaxus chienii</i>	Taxaceae	0	0	1	1	0
<i>Taxus baccata</i> ¹	Taxaceae	0	0	1	1	0
<i>Taxus brevifolia</i>	Taxaceae	0	0	1	1	0
<i>Taxus canadensis</i>	Taxaceae	0	0	1	1	0
<i>Taxus chinensis</i>	Taxaceae	0	0	1	1	0
<i>Taxus cuspidata</i>	Taxaceae	0	0	1	1	0
<i>Taxus floridana</i>	Taxaceae	0	0	1	1	0
<i>Taxus fuana</i>	Taxaceae	0	0	1	1	0
<i>Taxus globosa</i>	Taxaceae	0	0	1	1	0
<i>Taxus sumatrana</i>	Taxaceae	0	0	1	1	0
<i>Taxus wallichiana</i>	Taxaceae	0	0	1	1	0

Species	Clade	Sacci	Buoyant	Down	Drop	Seed cone orientation
<i>Torreya californica</i>	Taxaceae	0	0	0	1	1
<i>Torreya grandis</i>¹	Taxaceae	0	0	0	1	1
<i>Torreya jackii</i>	Taxaceae	0	0	0	1	1
<i>Torreya nucifera</i>	Taxaceae	0	0	0	1	1
<i>Torreya taxifolia</i>	Taxaceae	0	0	0	1	1

Table S2. Support for transition rate models of character evolution in Pinaceae that allow transitions to a state with vestigial sacci and downwards-facing drops (referred to as “with state”) and those that exclude them (“without state”). This character combination is not known to occur in extant Pinaceae and models that exclude it receive higher support (best supported model shown in bold).

Model	Pinaceae (with state)	Pinaceae (without state)
ARD ₁	59.03	57.09
ARD ₁ *	58.55	55.27
ARD ₂	62.86	58.41
ARD ₂ *	59.64	55.64
ARD ₃	54.49	50.04
ARD₃*	51.27	47.27
ARD ₄	54.30	50.63
ARD ₄ *	53.27	49.27
ARD ₅	57.03	55.09
ARD ₅ *	56.55	53.27

Figure S1. Ancestral character states in backbone nodes as determined by parsimony reconstruction methods, where half-filled circles indicate ambiguous character states. Numbers on the phylogeny represent clades or individual taxa that do not have buoyant pollen, and correspond to the numbers listed in Table 1 of the main text.



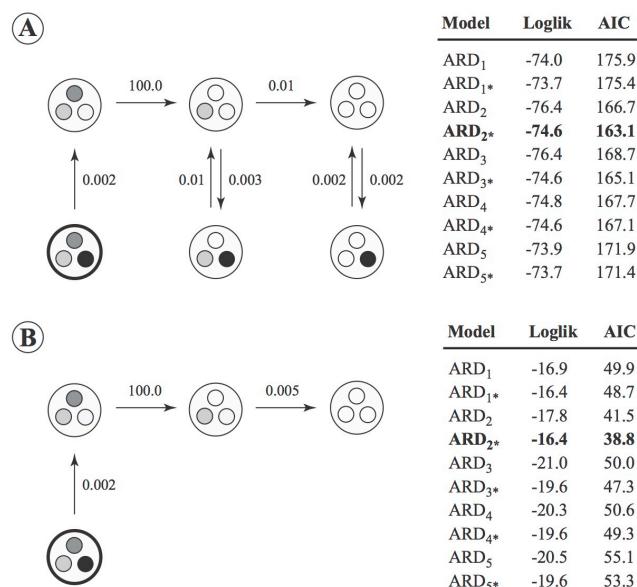
Trait evolution in *Tsuga*

Most *Tsuga* species have highly reduced frills around the pollen grains that are believed to be vestigial sacci, and the pollen is not buoyant in water. One species (*Tsuga mertensiana*) has more typical sacci, although these are not as well developed as in most saccate conifer species. These grains are described as buoyant and functional (Owens et al. 1998), although more work needs to be done on their physical properties.

This variation in saccus morphology in *Tsuga* and uncertainty in their physical properties complicates understanding character evolution in the clade, which is only further complicated by the phylogenetic relationships among the taxa. Molecular analyses suggest that *Tsuga mertensiana* is nested within a non-saccate *Tsuga* clade (Havill et al. 2008; Leslie et al. 2012), implying that fully developed sacci and pollen buoyancy has either been lost twice within the lineage or has been lost once and then regained in *T. mertensiana*. When the pollen buoyancy character is reconstructed by itself, likelihood suggests two losses of buoyancy, although not with high support. On the other hand, correlated models of character evolution favor the re-evolution of pollen buoyancy in *T. mertensiana* (Fig. 4A,C in main text).

Due to these complications, and the uncertainty in the physical properties of the pollen, we ran an alternative set of analyses in which *T. mertensiana* pollen was scored as non-buoyant. As expected, the best-fit models for this data set are those in which pollen buoyancy is never regained once lost (ARD₂ models). This is the case both for all conifers (Fig. S2A) and for Pinaceae (Fig. S2B).

Figure S2. Support for transition rate models of character evolution if *Tsuga mertensiana* pollen is scored as non-buoyant in A) all conifers and B) Pinaceae. The best-supported model (ARD_{2*}) is given in bold and transition rates for this model are shown in on the left side of the panel. The color scheme follows Fig. 4 in the main text; light gray = saccate, gray = buoyant, black = downwards-facing ovules, white = character absent. A thick circle around the character state indicates the fixed root state.



Diversification Analyses

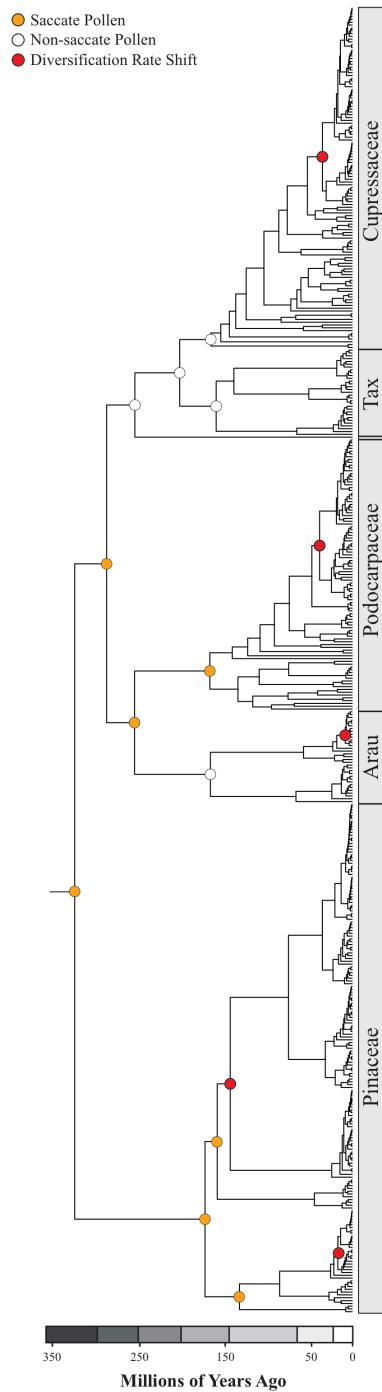
Differential diversification due to shifts between character states could potentially influence ancestral state character reconstruction (Madison et al., 2007). We therefore used the Binary State Speciation and Extinction model (BiSSE; Madison et al., 2007), a method that obtains joint estimates of speciation, extinction, and transition rates for binary characters, to test if transitions to and from saccate pollen were related to shifts in diversification. BiSSE models were implemented in the R package *diversitree* (Fitzjohn, 2012).

These analyses indicate that saccate clades do have significantly higher speciation and extinction rates compared to non-saccate conifer clades, although their net diversification rate was not significantly different (Table S3). An ancestral state character reconstruction based on the BiSSE model was the same as results from our initial ML model (Fig. S3), suggesting that differential diversification does not have a major influence on the distribution of character states or in the reconstruction of ancestral states.

Table S3. Results of BiSSE analysis. Results are significantly different ($p < 0.01$) from a model in which rates are held constant. Net refers to net diversification rate.

State	Origination Rate (λ)	Extinction Rate (μ)	Net ($\lambda - \mu$)
Non-saccate	0.121	0.114	0.007
Saccate	0.205	0.199	0.006

Fig. S3. Ancestral character state reconstruction for saccate pollen using BiSSE. For clarity, only major backbone nodes are shown. Red circles indicate nodes where previous analyses (Leslie et al. 2012; Leslie et al. 2013) found shifts to higher net diversification rates in conifers. Note that these instances are not associated with changes in saccate pollen.



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