TAXODIACEAE

杉科 shan ke

Fu Liguo (傅立国 Fu Li-kuo)[1], Yu Yongfu (于永福)[2]; Robert R. Mill[3]

Trees evergreen, semievergreen, or deciduous, monoecious; trunk straight; main branches ± whorled. Leaves spirally arranged or scattered (decussate in *Metasequoia*), monomorphic, dimorphic, or trimorphic on same tree, lanceolate, subulate, scalelike, or linear. Microsporophylls and cone scales spirally arranged (decussate in *Metasequoia*). Pollen cones borne in panicles, or solitary or clustered at branch apices, or axillary, small; microsporangia with (2 or)3 or 4(–9) pollen sacs; pollen nonsaccate. Seed cones terminal or borne near apex of previous year's growth, ripening in 1st year, persistent or late deciduous; cone scales developing after ovules originate in bract axils; bracts and cone scales usually spirally aranged (decussate in *Metasequoia*), sessile, opening when ripe (falling in *Taxodium*), semiconnate and free only at apex, or completely united; bracts occasionally rudimentary (in *Taiwania*); ovules 2–9 per bract axil, erect or pendulous; cone scales of mature cones flattened or shield-shaped, woody or leathery, 2–9-seeded on abaxial side. Seeds flat or triangular, wingless (in *Taxodium*), narrowly winged all round or on 2 sides, or with a long wing on proximal part. Cotyledons 2–9. 2*n* = 22*.

Nine genera and 12 species: Asia, North America, and (*Athrotaxis* D. Don) Tasmania; eight genera (one endemic, three introduced) and nine species (one endemic, four introduced) in China.

A merger of the Taxodiaceae and Cupressaceae is increasingly supported by both morphological and molecular evidence (see note under Cupressaceae). However, the two groups are kept as separate families here for pragmatic reasons.

Tsui Hung-pin, Cheng Wan-chün, Fu Li-kuo & Chao Chi-son. 1978. Taxodiaceae. *In:* Cheng Wan-chün & Fu Li-kuo, eds., Fl. Reipubl. Popularis Sin. 7: 281–312.

1a. Leaves and cone scales decussate (but leaves spirally arranged on leading branchlets); lateral branchlets deciduous; cone scales shieldlike, woody, 5–9-seeded (when fertile); seeds compressed, winged all round ..... 8. *Metasequoia*
1b. Leaves and cone scales spirally arranged (but leaves often appearing falsely 2-ranked or alternate); other characters various.
2a. Cone scales or bracts leathery.
3a. Leaves linear-lanceolate, margin serrulate; bracts large; cone scales 3-seeded ..... 1. *Cunninghamia*
3b. Leaves scalelike or subulate, margin entire; bracts rudimentary; cone scales 2-seeded ..... 2. *Taiwania*
2b. Cone scales woody.
4a. Deciduous or semievergreen; fertile cone scales 2-seeded; seeds irregularly triquetrous or slightly flattened.
5a. Deciduous or semievergreen; pollen cones borne in pendulous racemes or panicles; seeds irregularly triquetrous, large, wingless ..... 5. *Taxodium*
5a.Semievergreen; pollen cones borne on short, erect branchlets; seeds elliptic, slightly flattened, small,
with a single, terminal, recurved wing ..... 4. *Glyptostrobus*
4b. Evergreen; fertile cone scales 2–9-seeded; seeds flattened.
6a. Leaves subulate; seed cones sessile; umbo of cone scales with a central spine and 4 or 5(–7) toothlike projections ..... 3. *Cryptomeria*
6b. Leaves all scalelike, or scalelike on main branchlets and linear on lateral branchlets; seed cones pedunculate; umbo of cone scales without spines or projections.
7a. Leaves all scalelike; seed cones with 25–40 cone scales, ripening in autumn of 2nd year 6. *Sequoiadendron*
7b. Leaves scalelike on main branchlets and linear on lateral branchlets; seed cones with 15–20
cone scales, ripening in 1st year ..... 7. *Sequoia*

1. CUNNINGHAMIA R. Brown ex Richard & A. Richard in A. Richard, Comm. Bot. Conif. Cycad. 80, 149. 1826, nom. cons.

杉木属 shan mu shu

Belis Salisbury.

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Flora of China 4: 54–61. 1999.

Trees evergreen, monoecious; branches whorled or irregularly so; winter buds ovoid. Leaves spirally arranged, sessile, lanceolate or linear-lanceolate, stomatal bands present on both surfaces but fewer adaxially, base attenuate, margin serrulate. Pollen cones terminal, clustered; microsporophylls many, spirally arranged, sessile, scalelike, distal margin serrulate; pollen sacs 3, pendulous. Seed cones 1–3 together, terminal, globose, ovoid, or cylindric-ovoid; bracts and cone scales spirally arranged, sessile, connate proximally; bracts persistent, broadly ovate or triangular-ovate, flat, large, leathery, base cordate, margin irregularly and finely serrulate, apex long acuminate, hard; ovules 3 per bract axil, sessile; cone scales of mature cones sessile on and fused to proximal middle part of abaxial side of bract, minute, distal part free, 3-lobed, lobes irregularly serrulate at apex. Seeds 3, sessile on adaxial side of cone scale, flat, with 2 narrow, lateral wings. Cotyledons 2. Germination epigeal. 2*n* = 22*.

One species: ?Cambodia, China, Laos, N Vietnam.

The minute cone scales of *Cunninghamia* have often been overlooked, and in much of the literature what is termed the cone scale is in fact the bract.

1. Cunninghamia lanceolata (Lambert) Hooker, Bot. Mag. 54: t. 2743. 1827.

杉木 shan mu

Trees or shrubs to 50 m tall; trunk to 3 m d.b.h.; bark dark gray to dark brown, or reddish brown, longitudinally fissured, cracking into irregular flakes; crown pyramidal. Leaves glossy deep green adaxially, narrowly linear-lanceolate, straight or slightly falcate, 0.8–6.5(–7) cm × 1.5–5 mm, midvein green abaxially, 0.3–1.2 mm wide, flat with median longitudinal keel throughout, stomatal bands present on both surfaces, bands on adaxial surface 0.5–1.5 mm wide, of 7–28 rows of stomatal, white powdery or not, bands on abaxial surface 1.2–2.8 mm apart, 0.3–0.8(–1) mm from leaf margin, not or rarely white powdery, base decurrent, margin denticulate, sometimes indistinctly so, especially on old trees, with 18–55(–90) teeth per side, apex usually symmetric and spinescent, spine 0.3–2 mm. Pollen cone fascicles terminal, 1–3(–5) together, broadly obovoid, each of 8–20 cones, occasionally a few also around base of seed cone; peduncle 2–4 mm; cones narrowly oblong-conical. Seed cones terminal, 1–4 together, at pollination shortly cylindric-ovoid, ca. 12 × 8 mm, later becoming ovoid or subglobose, 1.8–4.5 × 1.2–4 cm; bracts glaucous or rather glossy, broadly ovate or triangular-ovate, base with short claw 1/5–1/2 × total length of bract, distal part gradually narrowed toward pointed apex, 1/14–1/5 × total length of bract. Seeds dark brown, oblong or narrowly ovate, 5–6 × ca. 4 mm, narrowly winged laterally. Pollination Jan–May, seed maturity Aug–Nov.

Mixed broad-leaved forests or forming small, pure stands, rocky hillsides, roadsides; 200–2800 m. Exact native distribution uncertain owing to widespread planting: Anhui, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hainan, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Sichuan, C and N Taiwan, Yunnan, Zhejiang [?Cambodia, Laos, N Vietnam].

A very variable species: specimens occur with spinescent or obtuse leaf apices and with or without white stomatal bands on the adaxial leaf surface. The latter character is at least partly dependent on the age of the tree and the position of the leaf on the tree: leaves exposed to sunlight have less conspicuous adaxial stomatal bands than those in shade, as do leaves of old trees. Variants also occur with strongly glaucous leaves.

The most important fast-growing timber tree of the warm regions S of the Chang Jiang valley; it is propagated by seed, cuttings, or suckers. The wood is strongly resistant to rot, is not eaten by termites, and is easily worked; it is used in constructing buildings, bridges, ships, and lamp posts, in furniture manufacture, and for wood fiber.

1a. Abaxial stomatal bands of leaves with (14–)16–28 rows of stomata; seed cones 2.5–4.5 × 2.5–4 cm ..... 1a. var. *lanceolata*

1b. Abaxial stomatal bands of leaves with 7–15(–20) rows of stomata; seed cones 1.8–3 × 1.2–2.5 cm ..... 1b. var. *konishii*

1a. Cunninghamia lanceolata var. **lanceolata**

杉木(原变种) shan mu (yuan bian zhong)

Pinus lanceolata Lambert, Descr. Pinus 1: [52]. 1803; *Belis jaculifolia* Salisbury; *B. lanceolata* (Lambert) Hoffmannsegg; *Cunninghamia chinensis* de Vos; *C. lanceolata* var. *corticosa* Z. Y. Que & J. X. Li; *C. sinensis* R. Brown ex Richard & A. Richard; *C. unicanaliculata* D. Y. Wang & H. L. Liu; *C. unicanaliculata* var. *pyramidalis* D. Y. Wang & H. L. Liu; ?*Larix chinensis* Miller (1768), not Beissner (1896); *Raxopitys cunninghamii* J. Nelson.

Abaxial stomatal bands of leaves with (14–)16–28 rows of stomata. Seed cones 2.5–4.5 × 2.5–4 cm.

Forests, rocky hillsides, roadsides; 200–2800 m. Exact native distribution uncertain owing to widespread planting: Anhui, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hainan, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Sichuan, Yunnan, Zhejiang [?Cambodia, ?Laos, N Vietnam].

1b. Cunninghamia lanceolata var. **konishii** (Hayata) Fujita, Trans. Nat. Hist. Soc. Formosa 22: 49, 476. 1932.

台湾杉木 tai wan shan mu

Cunninghamia konishii Hayata, Gard. Chron., ser. 3, 43: 194. 1908; *C. kawakamii* Hayata.

Abaxial stomatal bands of leaves with 7–15(–20) rows of stomata. Seed cones 1.8–3 × 1.2–2.5 cm.

Mixed broad-leaved forests or forming small pure stands, frequently associated with *Chamaecyparis formosensis* and *C. obtusa* var. *formosana*, often planted; 1300–2000 m. Fujian, C and N Taiwan [N Laos, ?Vietnam].

2. TAIWANIA Hayata, J. Linn. Soc., Bot. 37: 330. 1906.

台湾杉属 tai wan shan shu

Trees evergreen, monoecious; main branches horizontally spreading; branchlets pendulous, slender, long; winter buds small. Leaves spirally arranged, dimorphic: those of old branchlets densely arranged, subulate, scalelike, upwardly curved, triangular or quadrangular in cross section, with stomatal bands present on both surfaces, base short, decurrent, apex acute or obtuse, apiculate; those of young trees and new branchlets “S”-shaped-ovate or subulate, ± quadrangular in cross section, laterally compressed, apex straight to incurved, sharply pointed. Pollen cones borne in terminal clusters; microsporophylls many, spirally arranged; microsporangia 2–4, ovate. Seed cones terminal, solitary, erect, small; bracts rudimentary; ovules 2 per bract axil; cone scales of mature cones cuneately narrowed into claw and ± flat proximally, broadening distally into an exposed, rounded-spatulate, transversely convex portion, leathery, margin subentire, hyaline, densely and microscopically puberulent with extremely short, 2- or 3-celled hairs (margin thus appearing finely lacerate at low magnification), apical portion small, ± incurved, obtusely truncate, concavely notched, with small, protruding mucro. Seeds flat, with narrow, lateral wings, base and apex both notched. Cotyledons 2.

One species: China, N Myanmar.

1. Taiwania cryptomerioides Hayata, J. Linn. Soc., Bot. 37: 330. 1906.

台湾杉 tai wan shan

Taiwania cryptomerioides var. *flousiana* (Gaussen) Silba; *T. flousiana* Gaussen; *T. yunnanensis* Koidzumi.

Trees to 75 m tall; trunk to 3.5 m d.b.h.; bark brownish gray, cracking into long, irregular flakes; crown conical or broadly rounded. Leaves of old branchlets 1.5–8(–9) mm × 0.8–2.5 mm, stomata in 8–13 rows on adaxial, long side and in 6–9 rows on 2 abaxial flanks. Leaves of young trees and new branchlets borne at 40–70° to axis, bluish green, 1–2.5 cm × 1.2–2 mm, stomata in 3–6 rows on each surface. Pollen cones in clusters of 2–7; microsporophylls 10–36, each with 2 or 3 pollen sacs. Seed cones shortly cylindric to ellipsoid or narrowly so, 1–2.2 cm × 6–11 mm; cone scales 15–39, median scales broadly obdeltoid, 6–7 × 7–8 mm, claw ca. 2/5 × total length of scale. Seeds oblong-ovate, narrowly elliptic, or narrowly elliptic-obovate, 4–7 × 2.5–4.5 mm (including wings 1–1.5 mm wide projecting 1–1.5 mm beyond apex of seed). Pollination Apr–May, seed maturity Oct–Nov. 2*n* = 22*, 33.

Coniferous, broad-leaved, or mixed evergreen valley forests on acid, red, or brown soils in warm or warm temperate regions with high summer and autumn rainfall but drier winters, usually scattered and associated with *Chamaecyparis formosensis*, *C. obtusa* var. *formosana*, *Cunninghamia lanceolata*, *Pinus wallichiana*, or *Tsuga dumosa*, but sometimes forming pure stands; 500–2800 m. SE Guizhou (Leigong Shan), SW Hubei (Lichuan Xian, Maoba), SE Sichuan (Youyang Xian), Taiwan (Zhongyang Shan), SE Xizang (Zayü Xian), W Yunnan [N Myanmar].

A rare species in China, decreasing as a result of cutting for timber. It may attain an age of over 2000 years and, within its native range, can be used for afforestation. The wood is easily worked, and is used in building, making furniture and coffins (“Chinese coffin tree”), bridge and boat construction, and paper manufacture.

3. CRYPTOMERIA D. Don, Ann. Nat. Hist. 1: 233. 1838.

柳杉属 liu shan shu

Trees evergreen, monoecious; trunk straight; bark reddish brown to dark gray, fibrous, peeling off into long shreds; crown pyramidal or ovoid; branches ± whorled, horizontal or erect-spreading; winter buds small. Leaves persisting 4 or 5 years, spirally 5-ranked, spreading or directed forward, subulate, straight or incurved at apex, adaxial and abaxial surfaces convex, lateral surfaces slightly flattened, keeled, stomatal bands present on all 4 surfaces, base decurrent, apex acute. Pollen cones axillary toward apex of 2nd year branchlets, usually crowded into a short, terminal, sessile, oblong raceme, plum red turning yellow when mature; microsporophylls many, spirally arranged; pollen sacs (3 or)4 or 5(or 6). Seed cones terminal, solitary or occasionally aggregated, nodding, sessile, ± globose, rosettelike and resembling opening buds, ripening in 1st year, persisting 1–2 years longer with branchlet growth often temporarily continuing through cone; bracts and cone scales connate; bracts borne on middle or proximal middle part of abaxial surface of cone scales, triangular, small; ovules 2–5 per bract axil; cone scales persistent, shield-shaped, cuneate, thickened distally, woody, umbo with a central spine and 4 or 5(–7) toothlike projections on distal margin; apical scales small and sterile. Seeds irregularly compressed-ellipsoid or -triangular-ellipsoid, very narrowly winged. Cotyledons (2 or)3(or 4). Germination epigeal. 2*n* = 22*.

One species: China, Japan.

1. Cryptomeria japonica (Thunberg ex Linnaeus f.) D. Don, Trans. Linn. Soc. London 18: 167. 1839.

日本柳杉 ri ben liu shan

Trees to 40 m tall; trunk to at least 2 m d.b.h.; bark reddish brown, fibrous, peeling off in strips; crown pyramidal; main branches whorled, horizontally spreading or slightly pendulous; branchlets usually

pendulous, those of 1st year green. Leaves on leader branchlets borne at 15–45° to axis, those on short (fertile) branchlets at 30–55° to axis, subulate to linear, ± straight or strongly incurved, (0.4–)0.7–1.4(–2) cm × 0.8–1.2 mm (width measured near base of two wider surfaces), rigid, stomatal bands with 2–8 rows of stomata on each surface. Cones borne from 5th year onward. Pollen cones borne in racemes of 6–35, ovoid or ovoid-ellipsoid, (2–)2.5–5(–8) × (1.3–)2–3(–4) mm, each cone (except basal and apical) subtended by a leaf shorter than to 1.5 × length of cone. Seed cones borne in groups of 1–6, globose or subglobose, 0.9–1.6(–2.5) × 1–2(–2.5) cm; cone scales 20–30, proximal 2 margins often convex in outline, or all 4 margins ± concave in outline, middle part with or without distinct shoulders at widest point, apex usually recurved, umbo rhombic, distally with 4 or 5(–7) toothlike projections 1–3.5 mm. Seeds 2–5 per cone scale, brown or dark brown, irregularly ellipsoid or multiangular and ± compressed, 4–6.5 × 2–3.5 mm; wings 0.2–0.25 mm wide. Pollination Feb–Apr, seed maturity Oct. 2*n* = 22.

Forests on deep, well-drained soils subject to warm, moist conditions, also cultivated as an ornamental and planted for timber; below 1100 m to 2500 m. Native in Fujian, Jiangxi, Sichuan, Yunnan, Zhejiang; introduced in Anhui, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Shandong, Sichuan, Taiwan, Yunnan, Zhejiang [Japan].

Fast-growing on deep, well-drained soils in montane areas with a warm, moist climate, but intolerant of poor soils and cold, drier climates. The wood is strongly rot resistant, easily worked, and is used for buildings, bridges, ships, lamp posts, furniture, utensils, and paper manufacture. The species is also cultivated as an ornamental tree.

1a. Leaves ± straight at least in proximal 1/2, often recurved apically on leader branchlets, arising at 35–45° to axis on leader branchlets, 45–55° on fertile branchlets, rigid and hard; most pollen cones longer than their subtending leaf; cone scales 20–30, each bearing 2–5 seeds; distal projections of bracts and cone scales 2–3.5 mm ..... 1a. var. *japonica*

1b. Leaves usually strongly incurved throughout, arising at 15–30° to axis on leader branchlets, 30–40° on fertile branchlets, rigid but relatively soft; most pollen cones shorter than their subtending leaf; cone scales ca. 20, each bearing 2 seeds; distal projections of bracts and cone scales 1–2 mm ..... 1b. var. *sinensis*

1a. Cryptomeria japonica var. **japonica**
日本柳杉(原变种) ri ben liu shan (yuan bian zhong)
Cupressus japonica Thunberg ex Linnaeus f., Suppl. Pl. 421. 1782; *Taxodium japonicum* (Thunberg ex Linnaeus f.) Brongniart.

Leaves ± straight at least in proximal 1/2, often recurved apically on leader branchlets, arising at 35–45° to axis on leader branchlets, 45–55° on fertile branchlets, rigid and hard. Most pollen cones longer than their subtending leaf. Cone scales 20–30, each bearing 2–5 seeds; distal projections of bracts and cone scales 2–3.5 mm.

Cultivated as an ornamental and planted for timber. Anhui, Fujian, Gansu, Guangxi, Guizhou, Hubei, Hunan, Jiangsu, Jiangxi, Shandong, Sichuan, Taiwan, Yunnan, Zhejiang [native to Japan].

1b. Cryptomeria japonica var. **sinensis** Miquel in Siebold & Zuccarini, Fl. Jap. 2: 52. 1870.
柳杉 liu shan

Cryptomeria kawaii Hayata; *C. mairei* (H. Léveillé) Nakai; *Cupressus mairei* H. Léveillé.

Leaves usually strongly incurved throughout, arising at 15–30° to axis on leader branchlets, 30–40° on fertile branchlets, rigid but relatively soft. Most pollen cones shorter than their subtending leaf. Cone scales ca. 20, each bearing 2 seeds; distal projections of bracts and cone scales 1–2 mm.

• Forests on deep, well-drained soils subject to warm, moist conditions; below 1100 m in native range, but ascending to 2500 m in Yunnan as a cultivated tree. Native in Fujian (Nanping Shi), Jiangxi (Lu Shan), Sichuan, Yunnan, NW Zhejiang (Tianmu Shan); introduced in S Anhui, Guangdong, Guangxi, Guizhou, Henan, Hubei, Hunan, S Jiangsu, Jiangxi, Sichuan, Yunnan, Zhejiang.

This variety has been treated at species rank by some authors, under the invalid name *Cryptomeria fortunei* Hooibrenk.

4. GLYPTOSTROBUS Endlicher, Syn. Conif. 69. 1847.
水松属 shui song shu

Trees semievergreen, monoecious; winter buds small; branchlets dimorphic: perennial and annual; perennial branchlets remaining green for several years, with white lines of stomatal dots, becoming ridged and grooved with decurrent leaf bases; annual branchlets deciduous, short, never developing scars or buds. Leaves spirally arranged, sessile, trimorphic: leaves on main branches, perennial branchlets (after 1st year), and fertile branchlets radially spreading, scalelike, relatively thick (resembling leaves of *Cupressus* but spirally arranged), persistent for 2 or 3 years; leaves on annual branchlets of mature trees in 3 rows, radially spreading, subulate, quadrangular in cross section (resembling leaves of *Cryptomeria*), deciduous with branchlet as a unit; leaves of annual branchlets of young trees and seedlings often 2-ranked, sessile, linear, flat, thin, deciduous (resembling leaves of *Taxodium*). Pollen cones terminal on short, erect branchlets bearing scalelike leaves, solitary, ellipsoid; microsporophylls 15–20, spirally arranged, sessile; pollen sacs (2–)5–7(–9). Seed cones terminal, shortly pedunculate, erect when mature, ±

pyriform; bracts of mature cones ± completely connate with cone scales (free only at apex), triangular, recurved, borne on central or middle distal part of abaxial side of cone scales; ovules 2 per bract axil; cone scales 20–22, spirally arranged, sessile, woody, basal scales sterile, median scales 2-seeded, with 6–10 triangular, acute teeth at distal margin, distal scales ligulate, multiangular, sterile. Seeds ellipsoid, slightly flattened, small, with a single, terminal, recurved wing. Cotyledons 4 or 5. Germination epigeal. 2*n* = 22*.

One species: China, extinct in the wild in N Vietnam.

A Tertiary relict species, the only surviving member of a genus formerly widespread prior to the Quaternary glaciations. Resembling the American genus *Taxodium* (which is introduced in China) in its vegetative characters, and occurring in similar habitats.

1. Glyptostrobus pensilis (Staunton ex D. Don) K. Koch, Dendrologie 2 (2): 191. 1873.

水松 shui song

Thuja pensilis Staunton ex D. Don in Lambert, Descr. Pinus, ed. 2, 2: 115. 1828; *Glyptostrobus aquaticus* (Antoine) R. Parker; *G. heterophyllus* (Brongniart) Endlicher; *G. sinensis* A. Henry ex Loder; *Sabina aquatica* Antoine; *Taxodium japonicum* (Thunberg ex Linnaeus f.) Brongniart var. *heterophyllum* Brongniart; *T. sinense* J. Forbes.

Trees to 15(–25) m tall; trunk to 1.2 m d.b.h., basal part (ca. 0.7 m) buttressed; bark brown or grayish white with brown tinge, cracking into long, irregular strips; main branches spreading horizontally; lateral branchlets in 2 rows, those of older branches often very dense and broomlike. Scale leaves on mature branchlets appressed, 1.5–3 × 0.4–0.6 mm, with scattered, white, stomatal spots, adaxial surface convex, base decurrent, apex incurved, slightly hooked. Leaves of 1st year branchlets erect-spreading at 40–45° to axis, 1.5–2 mm apart, forming a narrowly oblong-lanceolate branchlet outline, subulate, slightly falcately recurved distally, 2–7 × 0.4–0.6 mm, with stomatal lines along all surfaces and on branchlet axis, trailing edge with narrow, membranous wing decurrent onto branchlet axis. Seed cones obovoid, 1.4–2.5 × 0.9–1.5 cm; bracts ± connate with cone scales except for triangular apex located in middle or distal middle part of cone scale; cone scales flattened, median scales obovate, 1–1.3 cm × 3–5.5 mm, base cuneate, apical margin with 6–10 triangular, outwardly curved teeth adaxially. Seeds brown, elliptic, slightly flattened, 5–7 × 3–4 mm, with a basal wing 4–7 mm. Pollination Jan–Mar, seed maturity Sep–Oct(–Nov), persisting until following spring.

River deltas, etc., on flooded or waterlogged soil in full sun; near sea level. Fujian, S Guangdong, S Guangxi, Hainan, E Jiangxi, E Sichuan, SE Yunnan (Pingbian Miaozu Zizhixian), Zhejiang [N Vietnam (extinct in the wild)].

May no longer exist in the wild anywhere in China; rare in all provinces except Guangdong. Most frequent along the Zhu Jiang delta, in Guangdong, and along the lower reaches of the Min Jiang in Fujian, but possibly not native in the latter province. Somewhat similar in vegetative features to the introduced *Taxodium distichum* var. *imbricatum*, which is planted in similar habitats within the range of *Glyptostrobus pensilis*. The former differs in its flat leaves (of young branchlets), which lack a narrow wing along their trailing edges, and in its subulate, spreading leaves (of 1st year branchlets on older trees), which are softer, with incurved (not recurved) apices.

Wind-felled trees are used in constructing buildings, bridges and furniture. The roots have high buoyancy and are used to make life buoys, bottle corks, etc. Tannins extracted from the bark and the cone scales are used in tanning, dyeing, and fishing nets. Often planted in wet places for erosion control, as a windbreak, and because it is believed to bring good luck; consequently the tree is not normally deliberately felled by villagers.

5. TAXODIUM Richard, Ann. Mus. Natl. Hist. Nat. 16: 298. 1810.

落羽杉属 luo yu shan shu

Trees deciduous or semievergreen, monoecious; main branches persistent; lateral branches alternate and deciduous in winter; winter buds globose, small. Leaves spirally arranged, alternate, dimorphic: those on main branches persistent, inclined or curved upward and ± appressed to branchlets, subulate; those on annual branchlets deciduous together with branchlet as a unit, 2-ranked, linear or usually subulate. Pollen cones borne in long, pendulous, catkinlike racemes or panicles, ovoid; microsporophylls 6–many, spirally arranged; pollen sacs 4–9. Seed cones solitary, attached laterally by minute peduncle to apex of previous year's growth, globose or ellipsoid but faceted; bracts and cone scales falling at maturity, spirally arranged; bracts attached to a conical axis, not overlapping, peltate, rhombic, each almost completely connate with its cone scale but with free, protruding, triangular, acute apex; ovules 2 per bract axil; cone scales shield-shaped, woody at maturity, apex irregularly quadrangular. Seeds 2 per cone scale, irregularly triquetrous, large, strongly keeled, wingless, water dispersed. Cotyledons 4–9. Germination epigeal. 2*n* = 22.

Two species: Guatemala, Mexico, United States; both introduced in China.

The number of distinct species of *Taxodium* is open to dispute: *T. mucronatum* might be better treated as a variety of *T. distichum*. The genus is similar in vegetative characters to *Metasequoia*, differing in its alternate (not opposite) branching and leaf arrangement. It also resembles *Glyptostrobus*, differing chiefly in its seeds which are strongly 3-angled and wingless (instead of 1-winged).

Taxodium is now important in the afforestation of low lying river deltas with waterlogged soils, especially in SE China.

1a. Trees deciduous; leaves 10–15 mm, those on annual branchlets 2-ranked; pollen cones borne in crowded, short, dense racemes or panicles; seed cones dull, lacking glaucous bloom (but white powdery) ..... 1. *T. distichum*

1b. Trees semievergreen or evergreen; leaves 7–11 mm, those on annual branchlets spirally arranged and scattered; pollen cones borne in long, slender, lax, spikelike panicles; seed cones glaucous ..... 2. *T. mucronatum*

1. Taxodium distichum (Linnaeus) Richard, Ann. Mus. Natl. Hist. Nat. 16: 298. 1810.

落羽杉 luo yu shan

Trees deciduous, to 50 m tall; pneumatophores present or absent around trunk; trunk swollen and buttressed at base, strongly tapered upward, to 2 m d.b.h.; bark brown, reddish brown, or gray, peeling off in long strips; crown conical, finally broadly conical, or relatively narrow and pyramidal; main branches spreading horizontally or ascending; lateral branchlets 2-ranked, axis green in 1st year, turning brown or brownish red in 1st winter. Leaves 2-ranked on annual branchlets or not, light green adaxially, yellowish green or grayish green abaxially, turning dark reddish brown in autumn, linear and flat or subulate, 4–15 × ca. 1 mm, midvein depressed adaxially, raised abaxially, stomatal lines 4–8, apex acute or sharply pointed. Pollen cones borne in terminal, crowded, short, dense racemes or panicles 5–12 cm, shortly pedunculate, ovoid. Seed cones brownish yellow or white powdery, not glaucous, globose, oblong-globose, or ovoid, (1.4–)2–4 × (1.3–)1.8–3 cm; cone scales shield-shaped, woody, ± conspicuously longitudinally grooved at apex. Seeds brown or reddish brown, irregularly triangular-pyramidal, 1.2–2.6 × 0.5–2.3 cm, sharply ridged. Pollination Mar–Apr, seed maturity (Jul–)Oct.

Used for afforestation on marshy soils, and cultivated as an ornamental. Anhui, Fujian, Guangdong, Guangxi, Henan, Hubei, Jiangsu, Jiangxi, Sichuan, Yunnan, Zhejiang [native to SE United States].

The wood is used in buildings, ship construction, furniture manufacture, etc.

1b. Main branches spreading horizontally; leaves on annual branchlets 2-ranked, linear, flat ..... 1a. var. *distichum*

1a. Main branches ascending; leaves on annual branchlets not 2-ranked, mostly subulate, a few linear and flat ..... 1b. var. *imbricatum*

1a. Taxodium distichum var. **distichum**

落羽杉(原变种) luo yu shan (yuan bian zhong)

Cupressus disticha Linnaeus, Sp. Pl. 2: 1003. 1753; *Taxodium distichum* var. *nutans* Carrière (1867), not (Aiton) Sweet (1827).

Main branches spreading horizontally. Leaves on annual branchlets 2-ranked, linear, flat.

Used for afforestation on marshy soils, and cultivated as an ornamental. Mainly S of the Chang Jiang valley: Anhui, Fujian, Guangdong (Guangzhou Shi), Guangxi, Henan (Jigong Shan), Hubei (Wuhan Shi), Jiangsu (Nanjing Shi), Jiangxi (Lu Shan), Sichuan, Yunnan, Zhejiang (Hangzhou Shi) [native to SE United States].

1b. Taxodium distichum var. **imbricatum** (Nuttall) Croom, Cat. Pl. New Bern, ed. 2, no. 3048. 1837.

池杉 chi shan

Cupressus disticha var. *imbricata* Nuttall, Gen. N. Amer. Pl. 2: 224. 1818; ?*C. disticha* var. *nutans* Aiton; *Glyptostrobus lineatus* (Poiret) Druce; *Taxodium ascendens* Brongniart; ?*T. ascendens* var. *nutans* (Aiton) Rehder; ?*T. distichum* var. *nutans* (Aiton) Sweet (1827), not Carrière (1867); *T. imbricatum* (Nuttall) R. M. Harper; *Thuja lineata* Poiret.

Main branches ascending. Leaves on annual branchlets not 2-ranked, mostly subulate, a few linear and flat.

Used for afforestation on marshy soils. Anhui, Fujian, Henan (Jigong Shan), Hubei (Wuhan Shi), Jiangsu (Nanjing Shi, Nantong Shi), Jiangxi, Zhejiang (Hangzhou Shi) [native to SE United States]. Vegetative material of var. *imbricatum* is superficially almost indistinguishable from *Glyptostrobus pensilis*. However, the appressed, subulate leaves of the former are more distinctly alternate, softer in texture, and with an incurved apex; while the spreading, linear leaves lack the thin, winglike margin along their trailing edge that is a feature of *G. pensilis*.

2. Taxodium mucronatum Tenore, Ann. Sci. Nat., Bot., sér. 3, 19: 355. 1853.

墨西哥落羽杉 mo xi ge luo yu shan

Taxodium distichum (Linnaeus) Richard var. *mexicanum* (Carrière) Gordon; *T. distichum* var. *mucronatum* (Tenore) A. Henry; *T. mexicanum* Carrière.

Trees deciduous in cooler areas or semievergreen in warmer areas, to 50 m tall; trunk swollen at base, strongly tapered, to 4 m d.b.h.; bark peeling off in long strips; crown broadly conical; main branches spreading horizontally; branchlets pendulous on mature trees, lateral ones spirally arranged. Leaves spirally arranged and scattered on annual branchlets, borne at 25–45° to axis, 0.6–0.7 mm apart, forming an elliptic branchlet outline 4–10 × 0.7–1.4 cm, linear, distally tapered, flat, 7–11 × 0.8–1 mm, soft and thin, midvein 0.15–0.25 mm wide, stomatal bands of 4 or 5 well-separated lines, marginal bands 0.2–0.3 mm wide, apex mucronate. Pollen cones borne in long, slender, lax, spikelike

panicles (5–)13–25 cm, almost sessile, ovoid. Seed cones glaucous, ovoid, 1.5–2.5 cm.

Used for afforestation on marshy soils in subtropical areas. Hubei (Wuhan Shi), Jiangsu, Jiangxi, Sichuan, Zhejiang [native to Guatemala, Mexico, S United States].

The wood has similar uses to that of *Taxodium distichum*.

6. SEQUOIADENDRON J. Buchholz, Amer. J. Bot. 26: 536. 1939.

巨杉属 ju shan shu

Wellingtonia Lindley (1853), not C. F. W. Meissner (1840).

Trees evergreen, tall and massive, very long lived, monoecious; winter buds small, with bud scales. Leaves spirally arranged, sessile, appressed to branchlets or ± radially spreading, all scalelike, ovate to lanceolate, flat adaxially, convex abaxially, stomatal lines present on both surfaces, resin canal central. Pollen cones solitary at apex of short branchlets, sessile. Seed cones terminal, pendulous, pedunculate, elliptic, ripening in autumn of 2nd year, persistent on tree for many years; ovules 3–12 per bract axil, erect; cone scales shield-shaped, woody when mature, apically grooved. Seeds 3–9 per cone scale, in 1 or 2 rows, flattened, with 2 lateral wings broader than body of seed. Cotyledons (3 or)4(or 5). 2*n* = 22.

One species: United States; introduced in China.

1. Sequoiadendron giganteum (Lindley) J. Buchholz, Amer. J. Bot. 26: 536. 1939.

巨杉 ju shan

Wellingtonia gigantea Lindley, Gard. Chron. 1853: 823. 1853; *Sequoia gigantea* (Lindley) Decaisne (1854), not Endlicher (1847).

Trees to 90 m tall; trunk strongly buttressed at base, to 12 m d.b.h.; bark brown, spongy, deeply fissured and finally separating into cinnamon-colored fibers; crown conical when young, becoming open with age; branches of young trees spreading, on older trees drooping; axis of branchlets green or dark green in 1st year, thereafter pale brown to reddish brown. Leaves blue-green, base decurrent, distal free portion 3–5 mm, apex sharply pointed. Seed cones ellipsoid, 5–8 × 3–5.5 cm; cone scales shieldlike, ca. 2.5 cm, apical scales 6–10 mm wide, with distal groove, ending in a long, terete spine at middle when young. Seeds pale brown, elongate-ellipsoid, 3–6 mm.

Cultivated. Shandong, Jiangsu, Jiangxi, Zhejiang (Hangzhou Shi) [native to W United States].

In the wild, this tree can reach an age of 3500 years.

7. SEQUOIA Endlicher, Syn. Conif. 197. 1847, nom. cons.

北美红杉属 bei mei hong shan shu

Trees evergreen, very tall and massive, monoecious; winter buds small, with many overlapping bud scales. Leaves spirally arranged, sessile, dimorphic: those on main branchlets closely appressed or slightly spreading, ovate-oblong, scalelike; those on lateral branchlets 2-ranked, sessile, linear, adaxial surface with a few interrupted stomatal lines or none, abaxial surface with 2 white stomatal bands, base twisted, apex abruptly acute. Pollen cones solitary at apex of branch or in leaf axils, shortly pedunculate; microsporophylls numerous, spirally arranged, each with 2–5 pollen sacs. Seed cones terminal, pendulous, pedunculate, ovoid-ellipsoid or ovoid, ripening in 1st year, subtended by many spirally arranged, sessile, scalelike leaves; ovules 3–7 per bract axil, erect; cone scales of mature cones shield-shaped, woody. Seeds 2–5 per cone, flattened, with lateral wings. Cotyledons 2. 2*n* = 66.

One species: United States; introduced in China.

1. Sequoia sempervirens (D. Don) Endlicher, Syn. Conif. 198. 1847.

北美红杉 bei mei hong shan

Taxodium sempervirens D. Don in Lambert, Descr. Pinus 2: [24]. 1824; *Sequoia gigantea* Endlicher (1847), not (Lindley) Decaisne (1854).

Trees to 100(–110) m, suckering from base in native range; trunk buttressed at base, slightly tapered above, to 5 (–8) m d.b.h.; bark reddish brown or cinnamon colored, 15–25 cm thick, fibrous, exfoliating in broad, dark brown plates; crown narrow; branches slender on young trees, finally stout, borne horizontally or basal ones deflexed. Leaves bright deep green adaxially, ca. 6 mm on main branchlets, 0.8–2 cm on lateral branchlets, midvein raised abaxially. Pollen cones ovoid, 1.5–2 mm; pollen yellow-green. Seed cones very small at pollination, maturing pale reddish brown, ovoid-elliptic or ovoid, 2–3.5 × 1.2–1.5 cm; cone scales shield-shaped, apically grooved, expanded into a rhomboid disc, occasionally with central mucro. Seeds pale brown, elliptic-oblong, ca. 1.5 mm; wing as wide as seed.

Cultivated. Fujian, Guangxi, Jiangsu (Nanjing Shi), Jiangxi, Taiwan, Zhejiang (Hangzhou Shi) [native to W United States].

8. METASEQUOIA Hu & W. C. Cheng, Bull. Fan Mem. Inst. Biol., n.s., 1: 154. 1948, nom. cons.

水杉属 shui shan shu

Trees deciduous, monoecious; main branches irregularly whorled; branchlets of several kinds: persistent or deciduous, opposite or subopposite, developing from paired, superimposed axillary buds, 1 of which remains dormant as a winter bud; winter buds ovoid or ellipsoid, with 6–8 pairs of decussate, ovate, membranous, scales; branchlets each subtended by ca. 4 whorls of early deciduous, salmon-colored basal scales. Leaves deciduous together with lateral branchlet as a unit, decussate, 2-ranked, spirally arranged on leading branchlets, ± sessile; blade linear, flattened, soft, midvein depressed adaxially, raised abaxially, stomatal bands 4–8, on abaxial surface only, or on both surfaces on seedling leaves, base twisted. Pollen cones developing in autumn but not shedding pollen until following spring, borne in spikes or panicles, shortly pedunculate; microsporophylls 15–20, decussate, each with 3 pollen sacs, except apical and basal with 2. Seed cones terminal or subterminal on previous year's growth, solitary, shortly pedunculate at pollination, becoming long pedunculate and pendulous, subglobose, slightly cubic, or occasionally oblong-globose, ripening in 1st year; peduncle clothed with decussate, linear leaves; cone scales 16–24, persistent, decussate, shieldlike, woody, grooved, 5–9-seeded (when fertile), base cuneate, distal part transversely rhombic. Seeds 5–9, compressed-obovoid, winged all round, apex emarginate. Cotyledons 2. Germination epigeal. $2n = 22$*.

• One species: China.

A relict species of the Cretaceous and Cenozoic, when this genus was widely distributed in what is now NE China, Europe, Greenland, Japan, North America, and Russia (Siberia).

1. Metasequoia glyptostroboides Hu & W. C. Cheng, Bull. Fan Mem. Inst. Biol., n.s., 1: 154. 1948.

水杉 shui shan

Metasequoia glyptostroboides var. *caespitosa* Y. H. Long & Y. Wu; *Sequoia glyptostroboides* (Hu & W. C. Cheng) Weide.

Trees to 50 m tall; trunk buttressed at base, to 2.5 m d.b.h.; bark of young trees pale orange-brown with darker flakes and exfoliating, finally dark reddish brown to gray, fissured; crown narrowly conical or pyramidal, finally broadly conical; branches ascending; branchlets pendulous, axis pinkish green or pale purple in 1st year, later brownish gray; winter buds to 5 × 3 mm, apex obtuse, scales yellowish brown, ca. 2–2.5 × 2–2.5 mm. Lateral branchlets deciduous, opposite, each subtended by leaflike scale, with longer and shorter leaves alternating irregularly, forming an ovate-elliptic outline 3–7 × 1.5–4 cm. Leaves borne at 45–60° to branchlet axis, 2–5 mm apart, bluish green or yellowish green adaxially, paler abaxially, turning orange or red in autumn, linear, 0.8–1.5 cm × 1.2–2 mm on old trees but longer on younger trees, stomatal hands 0.4–0.6 mm, indistinct, marginal bands 0.5–0.6 mm wide, apex obtuse or with hyaline mucro, more sharply acute on leaves of leader branchlets. Pollen cones ovoid, 2.5–5.5 × 2–3.8 mm; bracts triangular-ovate or obovate, ca. 4 × 3 mm, lowest minutely ciliate distally, others glabrous. Seed cones purplish black when young, oblong-ellipsoid and to 9 × 5.5 mm at pollination, subglobose and 1.4–2.5 × 1.6–2.3 cm when mature; basal cone scales 9-ovulate, middle 7-ovulate, distal 5-ovulate, apical sterile. Seeds ca. 5 × 4 mm. Pollination Feb–Mar, before leaves, seed maturity Oct–Nov.

• Riparian habitats on valley floors and in moist ravine bottoms, on acidic, montane yellow-earth soils in regions with moderate climate, high sunshine, and high summer and autumn rainfall, associated with *Castanea henryi*, *Houttuynia cordata*, *Liquidambar acalycina*, *Populus adenopoda*, species of *Pterocarya*, etc.; (750–)1000–1300(–1500) m. SW Hubei (Lichuan Xian), NW Hunan (Longshan Xian, Sangzhi Xian), E Sichuan (Shizhu Xian); also widely cultivated as an ornamental or planted for afforestation in Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hebei, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Liaoning, Shaanxi, Shandong, Shanxi, Sichuan, Yunnan, Zhejiang.

A rare species as a native plant because the valley floors are now largely under rice cultivation.