

A TEACHING TOOL: A KEY TO SELECTED GYMNOSPERMS

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ABSTRACT

Commentary on teaching gymnosperm identification is presented along with a key to selected gymnosperms utilized as a teaching tool when teaching students ornamental plant identification at North Carolina State University.

Ornamental plant identification has been taught by the author for twenty-three years. A group of plants that students dread are the gymnosperms - taught near the end of the fall semester in HS 211 Ornamental Plants I, an introductory course that is required of landscape/design majors. Students have difficulty with this group because many plants look superficially alike. Leaves are very small compared to angiosperms, and common or vernacular names (e.g., arbor-vitae, cedar, cypress, pine, yew) are applied to several genera. Faculty and students are fortunate to have a large number of gymnosperm taxa represented on the campus of North Carolina State University (NCSU), in residential property located in nearby neighborhoods, and at the JC Raulston Arboretum (JCRA) located one mile from campus. Student identification skills and retention have increased since the development and utilization of the gymnosperm key as a teaching/learning tool in the course. The objective of this article is to make the key available to other teachers who can utilize it for teaching gymnosperms at their institution.

METHODS

Gymnosperms selected for inclusion in the key came from three primary sources, including gymnosperm taxa readily available on the NCSU campus, lists of plant materials distributed by the North

Carolina Association of Nurserymen and North Carolina Association of Landscape Contractors, and additional taxa of gymnosperms found in residential properties in neighborhoods adjacent to NCSU. The JC Raulston Arboretum has an extensive gymnosperm collection. These plants were utilized for review of taxa previously covered in labs. Taxa included the genera *Abies* Mill., *Calocedrus* Kurz., *Cedrus* Trew., *Cephalotaxus* Sieb. & Zucc., *Chamaecyparis* Spach., *Cryptomeria* D. Don, *Cunninghamia* R. Br., *x Cupressocyparis* Dallim., *Cupressus* L., *Ginkgo* L., *Juniperus* L., *Larix* Mill., *Metasequoia* Miki ex Hu & Cheng, *Picea* A. Dietr., *Pinus* L., *Platycladus* Spach., *Podocarpus* L'Herit. ex Pers., *Pseudolarix* Gordon, *Pseudotsuga* Carr., *Sciadopitys* Sieb. & Zucc., *Taxodium* Rich., *Taxus* L., *Thuja* L., *Thujopsis* Sieb. & Zucc. ex Endl. and *Tsuga* Carr.

A number of gymnosperm references (Bloom 1972; Den Ouden & Boom 1978; Harrison 1975; Hornibrook 1973; Krussman 1985; Welch 1979) were utilized to develop a taxonomic foundation of gymnosperm identification. Live material of taxa were examined at the Coker Arboretum of the University of North Carolina - Chapel Hill, the JC Raulston Arboretum of NCSU, and the National Arboretum in Washington, DC. Experience obtained through teaching students, nurserymen and landscapers through Plant Certification Workshops, visits to numerous additional gardens, and graduate student supervision of gymnosperm projects (Fantz et al. 1999; Hatch 1984; Rouse et al. 2000) strengthened this gymnosperm foundation.

RESULTS AND DISCUSSION

Students are provided with a taxonomic overview before being introduced to taxa. Branch patterns can be important in identification. **Spur branches** (dwarf shoots) are lateral shoots with sparse elongation each season, typically less than 1 cm. **Pins** are short lateral branches, typically between 3-20 cm long. **Sprays** are branches with several years growth that exhibit a distinctive pattern, such as a fan or spear, and are useful when they are borne in a plane, hemi-

sphere or 3-dimensional pattern. In general, gymnosperms drop branches under stressful conditions such as droughts or cold winter conditions. Gymnosperms reproduce by **cones/strobili**, a dense cluster of sporophylls (cone scales) on an axis with a seed(s) naked on the sporophyll surface, sometimes with seed surpassed by an appendage (aril) or a fleshy scale. Strobili bear sporophylls and cones bear sporophylls subtended by bracts that are free or fused to the sporophyll. Field interpretation of these structures is difficult for students, and the distinction between terms creates student confusion. Therefore, the terms are used as synonymous in teaching plant identification characters. The **umbo** is the blunt to pointed projection on the cone scale. Students become aware that female cones are larger, thus a better tool for identification as they are more easily observed. Male cones become important tools for identification for dioecious genera (e.g., *Juniperus*), particularly at the level of cultivar, or when they are clustered and more easily observed.

Color is a poor tool to use for identification. Students have different perceptions of color when viewing the same specimen. Many students have difficulty with various hues of a color such as shades of greens. Colors are more important in distinguishing cultivars selected for lighter or darker shades of green, blues or grays represented by various degrees of glaucousness, and cream, silver and yellow hues in variegated foliage where chlorophyll production is not as abundant as more mature foliage.

Leaves are the primary identification organ. Gymnosperms become easier for students to learn when they are divided into distinct morphological groups based upon leaf morphology. However, terms utilized for the leaf type will vary for a genus in different references. Therefore, leaf terminology for each group is defined below. Students found these terms easy to use as defined. An important feature are those leaves that bear **glaucous bands** which appear as white lines to the naked eye. One can observe under magnification

that the stomates are arranged in a straight line with the guard cells bearing the glaucous wax coating on its surface.

Linear leaves are elongated and flat in cross section with nearly parallel sides. This group includes a number of genera that can be subdivided into four groups, of which one includes deciduous genera. *Podocarpus* and *Taxus* bear leaves green below. *Abies* and *Pseudotsuga* bear sessile leaves with white glaucous bands below. *Cephalotaxus*, *Cunninghamia* and *Tsuga* bear petiolate leaves with white glaucous bands below. Deciduous genera *Larix* and *Pseudolarix* bear leaves clustered on dwarf shoots (the leaves turning yellowish/orange in fall in the latter), whereas *Metasequoia* and *Taxodium* bear leaves 2-ranked on short lateral branches (the branches opposite in *Metasequoia* and alternate in *Taxodium*).

Needle-like leaves are elongated, narrow leaves with 2 or more sides in cross-section, the sides being flat or curved. This group includes *Pinus* with needles in clusters of 2, 3 or 5 on spur shoots (fascicles), *Cedrus* with needles in clusters of 10-20 on spur shoots and *Sciadopithys* with whorls of 20-30 needles on twigs.

Saber-like leaves are short, narrow and sword-like with four sides in cross-section (two lateral sides longest). A leaf view from the side resembles a saber blade. *Cryptomeria* has strongly falcate (sickle-shaped curvature) leaves with stomatal bands on the two lateral surfaces. In addition, twigs bear leaves abruptly altering in length. The warm season leaves are longer and more numerous. The cool season leaves are shorter and fewer in number. *Picea* have straight to weakly falcate leaves bearing stomatal bands on all four surfaces.

Awl leaves spread outward from the twig and are short, narrow and taper to a point with a saucer-like cross-section. These leaves are common in *Juniperus* and juvenile selections of genera in the Cupressaceae Bartling such as *Chamaecyparis* and *Cupressus*.

Scale leaves are short, broad, appressed leaves hiding the twig. *Thuja* has leaves bearing a raised blister-like gland. The gland is sunken in other genera with scale leaves. *Chamaecyparis* and *Thuja* bear glaucous white markings on the leaves with *Thuja* bearing scales resembling “rabbit ears” with sunken areas bearing the glaucous marking. *Calocedrus* and *Platyclusus* lack the markings with *Calocedrus* bearing elongate scales appearing 4-ranked and *Platyclusus* bearing short imbricated scales.

Intermediate leaves are those intermediate between awl and scale leaves in form. Leaves typically are ascending, shorter and slightly broader than awl leaves, but narrower and longer than scale leaves. These represent the period of growth as a plant changes from the juvenile to adult stage. These leaves are found commonly in some cultivars of *Juniperus* and in *x Cupressocyparis leylandii* (Dallim. & A.B. Jackson) Dallim.

The following key was developed to identify gymnosperms growing in the Raleigh, NC area. Teachers utilizing this key in other areas may need to modify some characters presented in the key to adapt it for gymnosperms found in their teaching area. The species and cultivars included follow the guidelines established above. Teachers interested in modifying the key for their teaching program can send a disc along with an addressed return envelope to the address given above.

Key to gymnosperm groups

- 1. Leaves deciduous Group A, p.48
- 1.’ Leaves evergreen.....2.

- 2. Leaves linear..... Group B, p.49
- 2.’ Leaves awl-shaped, needle-like, saber-like or scale-like3.

- 3. Leaves needle-like, borne in clustersGroup C, p.52
- 3.’ Leaves awl-shaped, saber-like or scale-like4.

- 4. Leaves alternate, saber-like..... Group D, p.55
- 4.’ Leaves opposite or verticillate in threes, awl-shaped or scale-like5.

- 5. Branchlets 2-ranked in flattened sprays; leaves all scale-like Group E, p. 56
- 5.’ Branchlets spreading more or less in all directions in spreading sprays; leaves all awl-shaped or both awl-shaped and scale-like on the plant..... Group F, p. 58

Group A: Deciduous leaves

- 6. Leaves fan-shaped; seeds lacking wings.....*Ginkgo biloba*
- 6.’ Leaves linear; seeds winged7.

- 7. Spur branches present; leaves clustered on dwarf shoots8.
- 7.’ Spur branches absent; leaves 2-ranked on short branches.....9.

- 8. Fall foliage color yellow to orange; female cones reddish-brown; cones clustered*Pseudolarix amabilis*
- 8.’ Fall foliage lacking, greenish-brown; female cones purplish-red; cones solitary..... *Larix decidua*

- 9. Lateral leaf-bearing branchlets opposite; female cones ovoid-ellipsoid, dropping for winter; winter buds conspicuous; male cones axillary*Metasequoia glyptostroboides*
- 9.’ Lateral leaf bearing-branchlets alternate; female cones globular, persisting through winter; winter buds inconspicuous; male cones in pendulous racemes [*Taxodium*]10.

- 10. Leaves on lateral branchlets ascending-appressed, 5-10 mm,

long *Taxodium ascendens*
 10.' Leaves on lateral branchlets spreading, 2-ranked, 10-17 mm,
 long 11.

11. Leaves rust-brown in fall; lateral pins lacking secondary shoots,
 deciduous in first year..... *Taxodium distichum*
 11.' Leaves green in fall; lateral pins sometimes with secondary
 shoots, semievergreen, falling in second year
 *Taxodium mucronatum*

Group B: Evergreen, linear leaves

12. Leaves green below (these species dioecious, seeds on female
 plants) 13.
 12.' Leaves with white glaucous bands below 16.

13. Leaves elongated, (8-15 cm), broad (7-11) mm, spirally ar-
 ranged; seeds solitary with a basal purple aril; midrib raised promi-
 nently on both surfaces *Podocarpus macrophyllus*
 13.' Leaves short (0.5-4 cm), narrow (2-5 mm), somewhat 2-ranked
 or hemispherical on upper side of branch; seeds solitary, partially
 enclosed in a red aril; midrib prominently raised only on lower sur-
 face [*Taxus*] 14.

14. Bud scales non keeled; leaves gradually short acuminate; peti-
 ole short *Taxus baccata*
 14.' Bud scales keeled; leaves abruptly acuminate; petiole distinct
 15.

15. Lowermost bud scales obtuse, slightly keeled; petiole greenish;
 juvenile shoots olive-green, reddish on sunny side; leaves 2-ranked
 on spreading shoots; seeds 2-sided [*T. baccata* x *T. cuspidata*; note
 bud scale shape, leaf arrangement and seeds with *T. baccata* charac-

teristics] *Taxus x media*
 15.' Lowermost bud scales acute, keeled; petiole yellowish; leaves
 irregularly 2-ranked on spreading shoots; seeds slightly 3-4 angled
 *Taxus cuspidata*

16. Leaves sessile, contracted above the base, leaving a circular
 scar on abscission; pegs lacking on twigs 17.
 16.' Leaves petiolate, leaving the stalk on abscission; twigs with
 persistent pegs (stalks) 21.

17. Female cones pendulous; terminal bud lanceoloid, long and
 narrow, sharply pointed; leaves short-petiolate, spirally arranged,
 spreading with odor of camphor when bruised; leaf apex entire
 *Pseudotsuga menziesii*

17.' Female cones erect; terminal bud ovoid, short and squat,
 bluntly-pointed; leaves sessile, crowded, pectinate below and imbri-
 cate above on twig, spreading-ascending lacking camphor odor;
 leaf apex emarginate to entire 18.

18. Leaves pectinate, 2-3.5 cm long, apex sharply bifid on young
 plants, emarginate on older plants; female cones cylindric, 10-15 cm
 long, greenish to brownish at maturity; scales 2.5-4 cm wide 19.
 18.' Leaves non-pectinate, 1.5-2.5 cm long, apex obtuse; female
 cones oblong to ovoid, 3.5-7 cm long, purplish at maturity; scales
 1.5-2 cm wide 20.

19. Young branchlets brownish-gray, slightly grooved, short-
 pubescent in grooves; winter buds small, slightly resinous; female
 cones 10-12 cm, yellowish-green; scales 2.5 cm wide ... *Abies firma*
 19.' Young branchlets green-yellow, glossy, slightly pubescent to
 glabrous; winter buds ovoid, non- resinous; female cones 12-15 cm,
 reddish-brown; scales 3-4 cm wide *Abies nordmanniana*

20. Each glaucous band with 8-12 stomatal lines; winter buds
 globular; bract scales of cone exerted and reflexed *Abies fraseri*

20.' Each glaucous band with 4-8 stomatal lines; winter buds ovate; bract scales hidden to slightly exerted *Abies balsamea*

21. Female cones prominent on cultivated plants, scales +/- woody22.

21.' Female cones often lacking in cultivated plants, seed enclosed in fleshy purple aril25.

22. Leaf apex pungent; leaves elongate (3-7 cm); female cone scale apex prickly; male cones terminal, appearing later as twig growing through cone; messy litter layer of large fallen branches23.

22.' Leaf apex non-pungent; leaves short (0.5-2 cm); female cone scale apex broadly obtuse; litter layer of branches inconspicuous
.....24.

23. Juvenile leaves bluish-green from stomatal bands borne on upper surface.....*Cunninghamia lanceolata* 'Glauca'

23.' Juvenile leaves dark glossy green
.....*Cunninghamia lanceolata* 'Chasons Gift'

24. Leaves 2-ranked, 0.5-1.5 cm long, margin minutely serrate; female cones ellipsoid, 1.5-2.5 cm, brown*Tsuga canadensis*

24.' Leaves spirally ranked, 1.5-2.5 cm long, margin entire; female cones ovoid, 2-3.5 cm, yellowish-brown.....*Tsuga caroliniana*

25. Tree or large shrub; leaves bluish-green, 3.5-6 cm 2-ranked or forming broad, outward-turned V; infrequent in cultivation.....

..... *Cephalotaxus harringtonia* var. *harringtonia*

25.' Shrub, mounded to 3 m tall; leaves yellowish-green to green, 2-5 cm, forming an acute, inward-curved V; frequent in cultivation [*Cephalotaxus harringtonia* var. *drupacea*]26.

26. Rotund, columnar shrub, taller (2-3.5 m) than wide (1.5-2.5 m); leaves crowded, all radially borne on ascending branches

..... *Cephalotaxus harringtonia* 'Fastigiata'

26.' Broad, spreading shrub, wider than tall; leaves 2-ranked.....27.

27. Dwarf shrub, to 1 m tall by 1-1.5 m wide; leaves to 2 cm, arranged nearly planar.....*Cephalotaxus harringtonia* 'Prostrata'

27.' Medium shrub, to 2 m tall by 2-2.5 m wide; leaves to 4 cm, arranged V-shaped *Cephalotaxus harringtonia* 'Nana'

Group C: Evergreen, needle-like leaves

28. Leaves borne in clusters of 10-3029.

28.' Leaves borne in fascicles of 2-532.

29. Needles 8-12 cm long, borne in whorls of 20-30 from axils of scale-like leaves, each consisting of 2 fused needles which appear as a flat leaf with grooves on both surfaces, more deeply below.....

.....*Sciadopithys verticillata*

29.' Needles borne on spur shoots in whorls of 10-20, acicular, non grooved.....30.

30. Leaves 2.5-5 cm long, pliable; female cones 7-10 cm long reddish-brown, scales 5-6 cm broad; leading branchlets pendulous.....

.....*Cedrus deodara*

30.' Leaves 1.5-3 cm long, stiff; female cones 5-7 cm long, light brown, scales 3.5-4 cm broad; leading branchlets spreading.....31.

31. Leaves 1.5-2.5 cm long, often blue-tinted; trunk commonly single, bark grayish*Cedrus libani* ssp. *atlantica*

31.' Leaves 2-3 cm long, medium-green; trunk often multiple, bark red-brown.....*Cedrus libani* ssp. *libani*

32. Needles 5 per fascicle, bluish-green; sheaths deciduous; female cones cylindric33.

32.' Needles 2-3 per fascicle, sheath persistent35.

33. Needles 3-8 cm long; female cones sessile, yellowish-ochre; peduncles 2-5 mm; seeds with rudimentary wings *Pinus flexilis*
33.' Needles 7-20 cm long; female cones pedunculate, brownish; peduncles 20-50 mm; seeds prominently winged.....34.
34. Needles 7-13 cm long; female cones grayish-brown, 8-16 cm long, 2 cm wide; peduncles 20-25 mm; seeds with wings 18-20 mm long *Pinus strobus*
34.' Needles 12-20 cm long; female cones purplish-brown, 15-30 cm long, 4-7 cm wide; peduncles 30-50 mm; seeds with wings 20-25 mm long.....*Pinus wallichiana* [syn. = *P. griffithii*]
35. Needles all 2 per fascicle36.
35.' Needles all 3 per fascicle or combination of 2 and 3 per fascicle41.
36. Needles short, 3-7 cm long37.
36.' Needles medium-sized, (5) 7-12 cm long39.
37. Shrub ascending to 2 m, or prostrate; needles 3-4 cm long, falcately incurved, weakly twisted; buds 5-6 mm long, apex short-pointed; seeds light grayish-brown.....*Pinus mugo*
37.' Tree 8-30 m; needles 4-8 cm long, stiff, twisted; buds 6-12 mm long, apex blunt; seeds brown or blackish.....38.
38. Needles glaucous, bluish-green, minutely serrate; female cones tawny yellow, non persistent, umbo small, non-prickly; juvenile twigs dull yellowish; tree to 30 m with strong central leader
..... *Pinus sylvestris*
38.' Needles yellowish-green to dark green, serrate; female cones reddish-brown, lustrous, long persisting; umbo broad with protruding, hook-like, upturned prickle; juvenile twigs bloomy, bluish-gray; tree to 15 m, terminal leader lacking *Pinus virginiana*

39. Leaves pliable, bluish-green [needles 2 and 3 in juvenile plants]; sheaths 5-6 mm long; female cones long-stalked, long-persistent*Pinus echinata*
39.' Leaves stiff, green [needles in juvenile plants all 2]; sheaths 8-12 mm long; female cones sessile, deciduous40.
40. Needles spirally twisted, stiffly pliable, entire to weakly serrate; no strong central leader; candles form in late fall; female cones sessile with short stalk to 0.5 cm; buds non resinous
..... *Pinus thunbergii*
40.' Needles weakly twisted, rigid, minutely serrate; 1-2 strong central leaders; candles form in spring; female cones sessile; buds resinous *Pinus nigra*
41. Leaves 35-50 mm long; female cones 15-25 cm long; buds 35-50 mm long; needles 3 per fascicle [3 and 4 in juvenile plants and some adult selections]*Pinus palustris*
41.' Leaves 5-25 cm long; female cones 3-11 cm long; buds 6-12 mm long; needles 3, or 2 and 3 per fascicle.....42.
42. Leaf sheath 3-6 mm; needles 5-9 cm long; female cones 3-6 cm long; seeds 9-13 mm long with wing 10-12 mm, readily shed [needles 3 per fascicle].....*Pinus bungeana*
42.' Leaf sheath 12-25 mm; needles 15-30 cm long; female cones 6-11 cm long; seeds 6-7 mm long with wing 15-30 mm long, persisting [needles 3, or 2 and 3 per fascicle]43.
43. Needles 2 and 3 per fascicle, dark green, stiffly flexible, persisting well back along major branches and ascending; female cones glossy, chestnut-brown, deciduous, 9-15 cm long; seeds black or gray speckled *Pinus elliotii*
43.' Needles 3 per fascicle [2 and 3 per fascicle in some juvenile plants], green to yellowish-green, pliable, deciduous back on major branches and forming compact "leaf balls" at branch apices, needles spreading; female cones dull, rust-brown, long-persistent, 6-11 cm

long; seeds brown-red*Pinus taeda*

Group D: Evergreen, alternate saber leaves

44. Leaves strongly falcate, curved upward and inward, laterally compressed with stomatal bands on both sides, keeled above and below; female cones subglobular, 1.5-2.5 diameter; scales with 3-5 apical long-acuminate, spiny processes; bark reddish-brown, peeling in longitudinal strips; male cones conspicuous

..... *Cryptomeria japonica*

44.' Leaves straight to weakly falcate, quadrangular with stomatal bands on all four surfaces, non keeled; female cones ovoid to cylindrical, pendulous, 3.5-12 cm long, scales suborbicular subtended by small bracts; bark scaly; male cones inconspicuous [*Picea*]45.

45. Leaves rigid, apically pungent, more or less radially spreading on twigs to a right angle; buds light yellowish-brown with reflexed scales

.....*Picea pungens*

45.' Leaves stiffly pliable, apically non-pungent, vigorous shoots with half or more leaves ascending at angles of 30-60 degrees; buds brownish with spreading scales

46. Buds pointed, acute, scales with acute spreading tips, terminal bud bearing few, acuminate, keeled scales at base; leaves lustrous, dark green (cultivars with lighter green and bluish-green leaves); female cones 10-15 cm long, present only on older plants.....

.....*Picea abies*

46.' Buds obtuse, scales loosely imbricate, glabrous, apex obtuse and bifid; leaves glaucous, bluish-green; female cones 3.5-5 cm long, present at young age (ca 2-2.5 m tall plants).....*Picea glauca*

Group E: Evergreen, opposite scale leaves and branchlets in flattened sprays

47. Scales with raised blister or plustular-like glands near apex; female cones obloid or ellipsoid; seeds flat, thin winged on each side

.....48.

47.' Scales with glands sunken in pouches that appear as a vertical slit near apex; female cones subglobular, conspicuous

.....49.

48. Leaves conspicuously glandular, non glaucous below, abruptly acute; female cones 8-10 mm long, scales 8-10 with usually 4 fertile

.....*Thuja occidentalis*

48.' Leaves inconspicuous glandular, bearing white markings below, acuminate; female cones 12 mm long, scales 10-12 with usually 6 fertile

.....*Thuja plicata*

49. Sprays with white markings below, conspicuous on inner parts of branchlets, inconspicuous to absent on exposed tips and dryer brownish branchlets; female cones subglobular, 6-12 mm diam. or broadly ovoid

.....50.

49.' Spray lacking white markings below; female cones subglobular, 10-20 mm diam. or cylindrical

.....53.

50. Leaves below with raised margin and depressed in between, sunken portion broad, glaucous, resembles "tear-drop" or "rabbit ear"; scales 4-6 mm long; female cone broad ovoid, 12-15 mm long, scales 6-8, imbricate, umbo near apex prominent, curved; seeds flattened, winged

.....*Thujopsis dolabrata*

50.' Leaves lacking sunken area, glaucous near edge of imbricate scale; female cone subglobular, 6-12 mm diam., scales peltate, umbo central, erect, inconspicuous; seeds weakly compressed with thin broad wings [*Chamaecyparis*]

.....51.

51. Scales loosely appressed, slightly spreading apically, acute to acuminate; lateral scales subequal facial scales; markings in deltoid

blotches (resemble bow-ties, butterfly wings, stenciled X and Y's); female cones 6-8 mm diam.*Chamaecyparis pisifera* 51.' Scales closely appressed, acute to obtuse apically; lateral scales longer than facial scales; markings resemble thin X and Y's; female cones 8-12 mm diam.....52.

52. Leaves obtuse, dark lustrous green above, nonglandular, white markings below prominent; female cones brown; bark rather smooth, peeling in longitudinal strips..... *Chamaecyparis obtusa* 52.' Leaves acute, green to brownish above, conspicuously glandular, white markings below weak to lacking; female cones glaucous, bluish-green; bark with scaly ridges covered with small scales*Chamaecyparis lawsoniana*

53. Leaves subequal, appearing 4-ranked, 6-12 mm long, apex deltoidly acute, slightly spreading; female cones cylindric, 1.8-2 cm, non glaucous, scales flat, weakly keeled; seeds 8-12 mm long; bark thin, cinnamon-red, deeply furrowed..... *Calocedrus decurrens* [syn. = *Libocedrus decurrens*] 53.' Leaves unequal, appearing imbricated, 2-5 mm long; female cones subglobular, glaucous; seeds 3-5 mm long; bark thin, reddish-brown54.

54. Sprays elongated, radially on branches; leaves nonglandular, keeled; female cones uncommon, scales 8, nonfleshy; seeds tubercled [branches have a slow spiral twist] *X Cupressocyparis leylandii* 54.' Sprays fan-shaped in vertical planes becoming obliquely horizontal with age; leaves with small resinous gland, non-keeled; female cones common, scales 6, umbo bluntly acute, somewhat fleshy; seeds ovoid, wingless*Platycladus orientalis* [syn. = *Thuja orientalis*]

Group F: Evergreen, opposite/whorled awl leaves OR awl-shaped and scale leaves in spreading sprays

55. Foliage with white markings beneath on inner branchlets; branches and branchlets primarily thread-like with elongated major branches and remote, shortened lateral branches.....*Chamaecyparis pisifera*.....56.

55.' Foliage lacking conspicuous white markings below, uniformly glaucous or with white bands on upper surface; branchlets not thread-like57.

56. Foliage green above, glaucous beneath..... *Chamaecyparis pisifera* 'Filifera' 56.' Foliage golden yellow above *Chamaecyparis pisifera* 'Filifera Aurea'

57. Leaves opposite, foliage soft to the touch, nonprickly plants monoecious; female cones with woody peltate scales.....58. 57.' Leaves in whorls of 3, foliage often prickly, or opposite and prickly, harsh to the touch; plants dioecious; female cones berry-like, scales fleshy [*Juniperus*].....61.

58. Female cones large, subglobular, 20-30 mm diam., umbo prominent, erect, blunt; leaves mostly scales, prominently glandular; branchlets quadrangular; male cones large, conspicuous59. 58.' Female cones small, subglobular, 6-8 mm diam., umbo minute; leaves mostly awl-shaped, glaucous; branchlets non quadrangular [*Chamaecyparis pisifera*].....60.

59. Pyramidal to broad columnar tree; foliage light green, more or less glaucous; female cone scales 6-8.....*Cupressus glabra* 59.' Narrow columnar tree (pencil-like); foliage dark green, non glaucous; female cone scales 8-14..... *Cupressus sempervirens* 'Stricta'

60. Leaves 3-4 mm long, spreading, straight to weakly curved; branchlets irregularly arranged, silvery gray, "wooly" or "mossy" in appearance, some short sprays with intermediate to scale-like leaves and bearing female cones; loosely pyramidal tree, 5-10 m
 *Chamaecyparis pisifera* 'Squarrosa'
 60.' Leaves 5-6 mm long, ascending, strongly incurved; branchlets green or glaucous, glaucous branchlets compact, greyish-blue; female cones uncommon; symmetrical pyramidal shrub, 1.5-2.5 m
*Chamaecyparis pisifera* 'Boulevard'
61. Prostrate or creeper, ground cover; primary stem lays along the ground with erect lateral branches bearing spreading secondary branches62.
 61.' Plant an erect shrub or tree; primary stem erect with lateral branches usually spreading in all directions69.
62. Leaves awl-like and scale-like on same plant, sometimes intermediate in form, opposite or occasionally awl-shaped in whorls of 3's (branchlets commonly a 4-pointed star when one looks at the twig ends) [*Juniperus horizontalis*]63.
 62.' Leaves all awl-shaped, in whorls of 3 (appear as 6-pointed star when one looks at end of branchlet)66.
63. Leaves mostly scale-like, opposite; female cone, cones conspicuous, scattered; lateral branches short, 2-3 cm tall
 *Juniperus horizontalis* 'Wiltonii' [syn. = 'Blue Rug']
 63.' Leaves intermediate-shaped, awl-shaped ascending, opposite or occasionally in whorls of 3's, sometimes with a few scale leaves; female cone, cones inconspicuous; lateral branches more elongated64.
64. Height: 15-25 cm tall; foliage steel blue
*Juniperus horizontalis* 'Bar Harbor'
 64.' Height: 23-50 cm tall; foliage grayish-green, turning purplish

- during colder weather [Andorra Cultivar Group]65.
65. Medium growing, 23-37 cm tall
 *Juniperus horizontalis* 'Plumosa Compacta'
 65.' Tall growing, 30-50 cm tall*Juniperus horizontalis* 'Plumosa'
66. Foliage soft to slightly prickly to touch; leaves jointed to twig, non-decurrent, 10-15 mm long, wide-spreading, upper surface with 2 white longitudinal bands on upper surface of leaf; female cones large, 8-12 mm diam. [*Juniperus conferta*]67.
 66.' Foliage harsh prickly to touch; leaves decurrent, 5-8 mm long, stiff, spiny-pointed, spreading-ascending, bluish with 2 white basal spots from which 2 glaucous lines run down pulvini edges; female cones medium-sized, 7-9 mm diameter68.
67. Needles green, loosely spaced on twigs; height 25-60 cm
*Juniperus conferta* 'Emerald Sea'
 67.' Needles ocean blue-green, more compactly spaced, height 20-30 cm *Juniperus conferta* 'Blue Pacific'
68. Terminal shoots elongated, lateral branchlets few, short, widely spaced (prominent whip shoots); low spreading mounded shrub to 0.5-0.6 m tall, to 2 m broad.....*Juniperus procumbens*
 68.' Terminal shoots short, lateral branchlets prominent, closely spaced (whip shoots lacking); dwarf shrub, compact mat
*Juniperus procumbens* 'Nana'
69. Leaves all or mostly [above 80%] awl-shaped70.
 69.' Leaves mostly scale-like or both scale and awl-shaped74.
70. Leaves 80-95% awl-shaped with scale-like leaves on drooping matured branches*Juniperus chinensis* 'Japonica'
 70.' Leaves all awl-shaped, scale leaves lacking71.
71. Leaves rigid pungent, deeply sulcate above; female cones 6-8

- mm diam., glaucous near umbos [appearing as a face]; tree with graceful pendulous branches.....*Juniperus rigida*
 71.' Leaves stiff, prickly, slightly concave above; female cones 5-6 mm diam., glaucous over entire surface; columnar tree-like shrub ...
72.
72. Leaves in whorls of 3's, jointed at base; leaves 12-15 mm long; female cones common [*Juniperus communis*].....73.
 72.' Leaves opposite, decurrent; leaves 5-8 mm long; female cones lacking (juvenile state).....*Juniperus virginiana*
73. Plant narrow columnar, pencil-like, to 3 m tall
 *Juniperus communis* 'Hibernica'
 73'. Plant cone-shaped, dwarf shrub to 1 m tall
 *Juniperus communis* 'Compacta'
74. Leaves mostly scale-like (80% or higher), awl-shaped leaves more prominent on shaded branches or selections propagated from cuttings of these branches75.
 74.' Leaves both scale and awl-shaped, commonly between 40-60% of each.....85.
75. Tree to 30 m tall; branchlets thin, stringy [*Juniperus virginiana* -adult form]76.
 75.' Shrub to 6 m tall; branchlets non stringy77.
76. Foliage dark green; form pyramidal columnar, 3-5 m tall
 *Juniperus virginiana* 'Emerald Sentinel'
 76.' Foliage bluish-green; form narrow columnar, 6-8 m tall
*Juniperus virginiana* 'Glauca'
77. Male cones prominent amongst scale-like leaves [higher percentage awl leaves in shade] [*Juniperus x pfitzeriana* Pfitzer Group [syn. = *Juniperus x media*]]78.

- 77.' Cones lacking or female cones prominent; shrub taller than broad, primary branches horizontal or borne at 45-60 degrees.....81.
78. Foliage purplish-blue and prickly, resulting from higher percentage [ca 20-40%] of awl-shaped leaves present
 *Juniperus x pfitzeriana* 'Pfitzeriana Glauca'
 78.' Foliage green or yellowish.....79.
79. Leaves green, yellow pigments lacking
*Juniperus x pfitzeriana* 'Pfitzeriana'
 79.' Leaves yellow or gold-tinged on young shoots80.
80. Foliage yellow *Juniperus x pfitzeriana* 'Pfitzeriana Gold Lace'
 80.' Foliage green, golden-yellow on juvenile shoots
*Juniperus x pfitzeriana* 'Pfitzeriana Aurea'
81. Foliage bluish, glaucous; primary branches 45 degree angle; female cones 5 mm diameter; shrub 3-5 m tall [*Juniperus x pfitzeriana* Hetz Group].....82.
 81.' Foliage vivid greenish, scale-like leaves with prominent glaucous markings around overlapping edges (alligator/ reptilian-like); primary branches nearly horizontal; female cones 6-8 mm diameter; tree-like shrub to 10 m83.
82. Foliage bluish, glaucous, yellow pigmentation lacking.....
 *Juniperus x pfitzeriana* 'Hetzii'
 82.' Foliage bluish with golden apices on young growth.....
*Juniperus x pfitzeriana* 'Blue and Gold'
83. Tall erect shrub with irregular open areas, "a living piece of sculpture"; foliage 90% or more scale leaves [*Juniperus chinensis* Hollywood Group]84.
 83.' Dwarf shrub, trunk arching near ground to spread horizontal, parallel to ground; foliage 70-90% scale leaves .*Juniperus davurica*

84. Foliage tufted, brilliant medium-dark green.....
*Juniperus chinensis* 'Robusta Green'
 84.' Foliage tufted, vivid medium green.....
*Juniperus chinensis* 'Kaizuka' [syn. = 'Tortulosa']
85. Main trunk erect with branches spreading, trunk ascending to 7-
 10 m tall; female cones 5-7 mm diam
*Juniperus chinensis* [Hollywood Group] 'Variegated Kaizuka'
 85.' Main trunk bending to bear very rigid primary branches hori-
 zontal, parallel to ground; spreading shrub 0.5-2 m tall; female
 cones 4-6 mm diameter [*Juniperus davurica*]86.
86. Leaves ca 40-60% scale and awl-shaped, scale leaves with
 prominent glaucous markings around overlapping edges of adjacent
 scales (alligator/reptilian-like) [*Juniperus davurica* Parson Group]
87.
 86.' Leaves ca 80-90% scale-like, diamond-shaped.....adult cultivar
 forms
87. Foliage sage green; shrub to 1 x 3 m.....
*Juniperus davurica* 'Expansa' [syn. = *J. chinensis* 'Parsonii']
 87.' Foliage green and yellow, yellowish shoots of awl-shaped
 leaves .*Juniperus davurica* 'Expansa Aureospicata' [syn. = *J. chinensis*
 'Expansa Variegata']

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