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DUDLEY MEMORIAL VOLUME

CONTAINING A PAPER

BY

WILLIAM RUSSEL DUDLEY

AND

APPRECIATIONS AND CONTRIBUTIONS

IN HIS MEMORY

BY

FRIENDS AND COLLEAGUES

(WITH PORTRAIT)

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THE GYMNOSPERMS GROWING ON THE GROUNDS OF LELAND STANFORD JR. UNIVERSITY.

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THE GYMNOSPERMS are biologically more primitive than the Angiosperms. The flowers are always unisexual and without perianth (except *Gnetales*). The staminate flowers resemble those of the club-mosses and are short or elongated shoots bearing a number of spiral or verticillate stamens. The ovulate flowers are of a more varied structure, but the ovules are not enclosed in an ovary as in the Angiosperms.

The Gymnosperms comprise only trees and shrubs, and are represented by four living and two extinct orders. Representatives of two of the orders, *Ginkgoales* and *Coniferae*, are cultivated on the University grounds.*

GINKGOALES.

A single species, *Ginkgo biloba*, is the sole survivor of this ancient order of Gymnosperms.

1. *Ginkgo biloba* L. Ginkgo or Maidenhair Tree.

Leaves deciduous, clustered on short stubby twigs, fan-shaped, thickened on the margin and usually divided, parallel-veined; flowers diœcious; staminate in slender aments; ovulate in pairs on long stalks; fruit drupe-like, with an ill-scented, fleshy coat surrounding a smooth oval stone.

Native of China and Japan. Handsome staminate trees are on the grounds of the Stanford Residence, and a few young trees are planted on the Campus.

CONIFERÆ.

Trees or shrubs with more or less resinous wood and usually narrowly linear or needle-like evergreen or rarely deciduous leaves. Flowers monœcious or diœcious. Fruit a woody cone or fleshy and drupe-like.

* In the spring of 1909 Professor Dudley prepared a key to the *Coniferae* growing on the Campus for the use of the students of Forest Botany. As only a few carbon copies were made the present paper was undertaken in order that Professor Dudley's work might be embodied in permanent form. Although the key has been the basis of this paper the writer has gone over the field with considerable thoroughness, verifying the identifications, and has added the following species not credited to the Campus by Professor Dudley: *Agathis loranthifolia*, *Cephalotaxus pedunculata*, *Picea Parryana*, *P. sitchensis*, *Pinus Cembra*, *P. edulis*, *P. excelsa*, *P. Jeffreyi*, *P. Lambertiana*, *P. monticola*, *P. nigra*, *P. Pinea*, *Sciadopitys verticillata* (probably added to our collections since the key was prepared), *Taxodium mucronatum*, *Thuyopsis dolabrata*.

The Coniferæ are the prevailing Gymnosperms of the present geological age. They are represented by two families and about forty genera.

Fruit composed of a solitary stone surrounded by a fleshy, greenish or bright red aril.

1. *Taxaceæ*.

Fruit a woody cone made up of scales, each of which bears 1-several seeds in its axil (scales coalescent and fleshy in *Juniperus*).

2. *Pinaceæ*.

1. TAXACEÆ. Yew Family.

Trees or shrubs with durable close-grained wood. Leaves flat, linear or broader, usually 2-ranked by a twist of the compressed petioles, decurrent on the branchlets. Flowers diœcious, axillary; staminate composed of many stamens; ovulate of a single erect ovule. Fruit a stone more or less enclosed by a fleshy aril-like disk.

Fruit drupe-like; aril completely enclosing stone.

Leaves broadly lanceolate; pollen-sacs 2.

1. *Podocarpus*.

Leaves linear or nearly so; pollen-sacs 3-4.

Flowers pedunculate, clustered in heads; pollen-sacs 3.

2. *Cephalotaxus*.

Flowers axillary; pollen-sacs 4.

3. *Torreya*.

Fruit with a bright red cup-shaped aril partly enclosing the stone.

4. *Taxus*.

1. *Podocarpus*.

Trees or sometimes shrubs with linear or lanceolate alternate or opposite evergreen leaves. Fruit drupe-like, borne on a thickened foot-stalk; seeds inverted.

A genus of over 40 species, chiefly in the tropics and subtropics of the southern hemisphere. Many species are valuable timber trees.

1. *Podocarpus macrophylla* Don.

Leaves alternate, lanceolate, sometimes falcate, 2-5 inch long, about $\frac{1}{2}$ inch wide, bright green and lustrous above, pale beneath; fruit greenish, on a thickened purplish foot stalk.

One specimen, planted by Professor Dudley, is on the lawn at 8 Alvarado Row.

2. *Cephalotaxus*.

Leaves linear, acute and often sharp-pointed, spirally arranged but usually appearing 2-ranked. Flowers diœcious, pedunculate, clustered in small heads. Fruit drupe-like; endosperm uniform.

A small genus containing but 4 species, all of which are native of Japan and China.

Leaves appearing 2-ranked by a twist in the petiole.

Leaves $\frac{1}{2}$ - $\frac{3}{4}$ inch long, abruptly acute.

1. *C. drupacea*.

Leaves about 2 inches long, gradually tapering from near base.

2. *C. Fortunei*.

Leaves spreading from all sides, at least on the principal shoots, spiny-tipped.

3. *C. pedunculata*.

1. *Cephalotaxus drupacea* Siebold.

Leaves appearing 2-ranked and opposite, $\frac{1}{2}$ - $\frac{3}{4}$ inch long, scarcely $\frac{1}{8}$ inch wide, abruptly acute, margins not revolute; fruit elliptic, about $\frac{3}{4}$ inch long; stone smooth.

Native of northern China and Japan, where it attains a height of 30-40 feet. One ovulate shrub is at the west end of Encina Garden and a couple of small staminate specimens are in the nursery.

2. *Cephalotaxus Fortunei* Hook.

Leaves 2-ranked, margins thin, slightly revolute, gradually tapering to the sharp-pointed apex, about 2 inches long, over $\frac{1}{8}$ inch wide.

Tree 40-60 feet high with long, slender, drooping branches. Native of northern China. One small staminate tree is north of the live oak on the Mausoleum lawn.

3. *Cephalotaxus pedunculata* Siebold.

Leaves on leading shoots and principal branches scattered on all sides of the stem, $1\frac{1}{2}$ inches long, sharply acute, margins distinctly revolute.

A small Japanese tree, 20-25 feet high, with the spreading branches in whorls.

One small sterile shrub in very poor condition is in the eastern part of the Cactus Garden.

3. *Torreya*.

Leaves flat and linear, appearing 2-ranked, spiny-tipped. Flowers dioecious, axillary; pollen sacs 4, arranged in a semi-circle; fruit drupe-like, the greenish aril completely enclosing the stone; endosperm nutmeg-like.

A genus of four species, widely separated geographically and of very local distribution. One is in Florida, one in California, and the other two are in China and Japan.

1. *Torreya californica* Torrey. California Nutmeg.

Leaves $1\frac{1}{2}$ -2 inches long, $\frac{1}{8}$ inch wide, tapering slightly to the sharp-pointed apex, dark glossy green above, pale beneath; fruit $1-1\frac{1}{2}$ inches long.

Tree sometimes 80 feet high, with spreading or drooping branches and smooth, scaly bark. Native of central and northern California in the Coast Ranges and the Sierra Nevada.

4. *Taxus*. Yew.

Trees or shrubs with spreading or erect branches and scaly bark. Leaves flat, linear, 2-ranked. Flowers diœcious, axillary; pollen-sacs 6-8, arranged in a circle. Fruit with a bright red fleshy viscid open cup partly enclosing the erect stone.

A genus of approximately 8 closely related species, distributed through the north temperate regions.

1. *Taxus baccata* L. English Yew.

Leaves linear, 2-ranked, usually falcate, shortly acuminate, dark green above, pale beneath, $\frac{1}{4}$ - $\frac{3}{4}$ inch long; fruit $\frac{1}{3}$ - $\frac{1}{2}$ inch broad, with almost globose aril.

The English Yew is a native of Europe, western Asia and northern Africa. It has long been cultivated and many garden forms exist. Several shrubs are in the neighborhood of the Cactus Garden, especially near the entrance.

1a. *Taxus baccata fastigiata* Loud. Irish Yew.

Leaves linear, as in the typical form, but spreading from all sides of the erect fastigiate branches.

Specimens are on the borders of the Cactus Garden.

1b. *Taxus baccata adpressa* Carr.

This variety is distinguished by its broader and shorter, oblong obtuse leaves.

Our specimens are the compact erect form. They are on the east and west sides of the Cactus Garden.

2. PINACEÆ. Pine Family.

Trees or shrubs with resinous wood. Leaves linear, needle-like or scale-like, spirally arranged or decussately opposite, evergreen or in a few genera deciduous. Flowers diœcious; staminate in ament-like deciduous clusters; pollen-sacs 2-several. Fruit, a woody cone, made up of several scales, each with or without a subtending bract, bearing 1 or more seeds at

base on the upper surface (scales coalescent and fleshy in *Juniperus*); seeds often winged.

Leaves and cone-scales spirally arranged.

Leaves usually broad at base and tapering to a sharp point; ovules and seed 1 to each scale. Tribe 1. *Araucareæ*.

Leaves linear or needle-like.

Leaf-bases not decurrent on twigs; ovules and seeds 2 to each scale, pendent. Tribe 2. *Abietæ*.

Leaf-bases decurrent on twigs; ovules and seeds several to each scale, erect. Tribe 3. *Taxodæ*.

Leaves and cone-scales opposite, the former often scale-like.

Tribe 4. *Cupresseæ*

Tribe 1. *Araucareæ*.

A very distinct tribe composed of the two genera *Agathis* and *Araucaria*. These are almost wholly restricted in their distribution to the tropical or extra-tropical realms.

Scales persistent; seeds free.

1. *Agathis*.

Scales deciduous; seeds adherent.

2. *Araucaria*.

1. *Agathis*.

Leaves opposite or alternate, ovate-lanceolate, attenuate, parallel-veined and of a firm leathery texture. Flowers diœcious, solitary, the staminate elongated. Cones ovate to globose, axillary; scales persistent; seeds winged only on one side, free.

1. *Agathis loranthifolia* Salisbury. Amboyna Pine.

Leaves opposite or sometimes alternate, 1½-4 inches long, ovate-lanceolate, glaucous green; staminate flowers 2 inches long; cones globose or turbinate, 3-4 inches long.

A large forest tree, often 8 to 10 feet in diameter and 100 feet or more high. Native of the mountains of the Malay Archipelago. One young specimen, which seems perfectly hardy in this climate, is in Professor Durand's garden.

2. *Araucaria*.

Leaves evergreen, flattened, lanceolate or short-ovate to awl-shaped, usually sharp-pointed. Flowers normally diœcious; cones erect, their scales deciduous; ovules and seeds 1 to each scale, pendent; anthers with several elongated pendent pollen-sacs.

Araucaria is represented by 10 species, all of which are restricted to the southern hemisphere.

Leaves lanceolate to ovate.

Leaves lanceolate; spiny tip of scale about $\frac{1}{2}$ inch long.

Leaves 2-ranked, dark green; scales nearly as broad as long, bract and scale distinct toward the apex. 1. *A. Bidwillii*.

Leaves spreading from all sides of the branches; scales over twice as long as broad, bract and scale completely united.

2. *A. brasiliana*.

Leaves broadly ovate, concave, stiff and very spiny-tipped; spiny tip of scale $1\frac{1}{2}$ inches long. 3. *A. imbricata*.

Leaves awl-shaped; bark exfoliating.

4. *A. Cunninghamii*.

1. *Araucaria Bidwillii* Hooker.

Leaves narrowly ovate-lanceolate, flat, rigid, sharp-pointed, dark green and shiny, those on the branches twisted and 2-ranked, 1-2 inches long; cones ovate-globose, 8-10 inches long; scale and bract distinct above the middle, free part of scale $\frac{3}{4}$ inch broad; bract 2 inches long, nearly as wide, thin, sharply and very prominently keeled at apex, terminated by a reflexed linear-lanceolate spine, $\frac{3}{4}$ inch long.

A forest tree 100 to 150 feet high. Native of the Brisbane Mountains, Australia, where it is known as the Bunya-Bunya. A large tree is on the grounds of the Stanford Residence, and smaller specimens are near the Mausoleum Avenue and in Encina Garden.

2. *Araucaria brasiliana* Rich.

Leaves linear-lanceolate, tapering to a spiny tip, flat, straight, spreading from all sides of the branches, rather pale glaucous green, 1-2 inches long; cones globose, 6-8 inches long; bracts and scales completely united and indistinguishable, wedge-shaped and somewhat 4-sided, 2 inches long, $\frac{3}{4}$ inch broad, terminated by a linear-lanceolate spine, $\frac{1}{2}$ inch long.

A tree 75 to 100 feet high. Native of southern Brazil. Two small trees are between the Cactus Garden and the Mausoleum.

3. *Araucaria imbricata* Pavon. Monkey Puzzle.

Leaves broadly ovate, closely set and spreading from all sides of the branches, straight, concave, rigid, very sharp-pointed, $\frac{3}{4}$ -1 inch long; cones globose, 6-8 inches long; scales wedge-shaped, 2 inches long, about 1 inch broad, terminated by a slender subulate spine $1\frac{1}{2}$ inches long.

A forest tree, often 100 feet high, forming extensive forests in the Andes of southern Chili. A good specimen is on the Mausoleum lawn, and other smaller trees are on the Campus.

4. *Araucaria Cunninghamii* Ait.

Leaves awl-shaped, enlarged at base, $\frac{1}{2}$ inch long, spreading from all sides of the branches, rigid; cones ovate-globose, 3-4 inches long; scales wedge-shaped, $\frac{1}{2}$ inch broad, terminated by an awl-shaped awn $\frac{1}{3}$ its length.

A large tree, 100 to 150 feet high, with exfoliating bark. An Australian species forming extensive forests in New South Wales and Queensland. One tree is at the east end of Roble Garden and another is on the southwest border of the Cactus Garden.

Araucaria excelsa R. Br. The Norfolk Island Pine resembles *A. Cunninghamii*, but the branches are in very symmetrical and rather distant whorls. This species is not cultivated on the grounds, but is planted in gardens at San Jose and San Francisco.

Tribe 2. Abietæ.

Leaves and floral parts spirally arranged; ovulate scales subtended by bracts, becoming woody and forming a cone in fruit; ovules 2, adnate to the upper surface of scale near the base, pendent; seeds usually with a conspicuous membranous wing; cotyledones 3 or more.

Leaves in 1-5-leaved clusters, surrounded at base by membranous sheaths; cones maturing the second year.

1. *Pinus*.

Leaves without basal sheaths, scattered or clustered on short, stubby branchlets; cones maturing the first year.

Leaves clustered on short, stubby branchlets; cones erect.

2. *Cedrus*.

Leaves single, spirally arranged or appearing 2-ranked.

Cones pendent; scales persistent.

Branchlets rough with the persistent, woody leaf-bases; bracts not exerted.

3. *Picea*.

Branchlets smooth; leaf-bases sessile; bracts 3-parted, well exerted.

4. *Pseudotsuga*.

Cones erect; scales deciduous; branchlets smooth.

5. *Abies*.1. *Pinus*. Pines.

Trees or a few shrubs. Leaves evergreen, needle-shaped, in clusters of 2-5 (solitary in one species) from the axils of scale-like primary leaves, each cluster surrounded at base by a persistent or deciduous sheath of membranous scales; cones maturing the second year, their scales persistent, woody, often thickened or awned with a prickle at apex. Seeds usually winged.

The pines with approximately eighty living species constitute the largest genus of the Gymnosperms. They are restricted to the northern hemisphere and chiefly to the temperate regions.

Sheaths deciduous; leaves with 1 vascular bundle, in 5s (except No. 6, 7); wood light-colored and soft.

Cones cylindric; scales thin; wings elongated; leaves in 5s, serrulate.

White Pines.

Leaves not sharp-pointed; resin ducts not surrounded by strengthening cells.

Leaves grayish green, soft, recurved or drooping; branchlets glabrous.

Leaves 5-8 inches long, drooping; cones 6-10 inches long; scales abruptly pointed at apex. 1. *P. excelsa*.

Leaves 2-4 (rarely 5) inches long; cones 2-4 inches long; scales rounded at apex. 2. *P. Strobus*.

Leaves bluish green, stiff and erect; branchlets puberulent; cones 4-11 inches long; scales pointed. 3. *P. monticola*.

Leaves sharp-pointed and stiff, 2-4 inches long, dark bluish green; resin ducts surrounded by strengthening cells; cones 12-20 inches long.

4. *P. Lambertiana*.

Cones not cylindric; scales thickened; wings reduced to a ring; leaves not serrulate. Stone Pines.

Leaves in 5s; cones $2\frac{1}{2}$ -3 inches long. 5. *P. Cembra*.

Leaves in 2s or 4s; cones $\frac{3}{4}$ -2 inches long.

Leaves in 4s.

6. *P. quadrifolia*.

Leaves in 2s.

7. *P. edulis*.

Sheaths persistent; leaves with 2 vascular bundles, in 2s or 3s (except Torreyana); wood resinous. Pitch Pines.

Leaves in 5s, about 10 inches long.

8. *P. Torreyana*.

Leaves in 2s or 3s.

Leaves in 3s.

Cones with the umbo ending in a stout, hooked projection; leaves 8 or more inches long.

Leaves grayish green, drooping; cones chocolate-colored, ovate.

9. *P. Sabiniana*.

Leaves dull green, spreading; cones light brown, cylindric-ovate.

10. *P. Coulteri*.

Cones with rounded or flattened apophysis; umbo with or without a slender prickle.

Umbo with a prominent prickle; apophysis but little thickened.

Branchlets glaucous; leaves bluish green.

11. *P. Jeffreyi*.

Branchlets not glaucous; leaves bright yellowish green.

12. *P. ponderosa*.

Umbo without or with a rudimentary prickle.

Leaves slender, drooping, 8-10 inches long; cones cylindric, 4-8 inches long; apophysis low-pyramidal.

13. *P. canariensis*.

Leaves not drooping, 4-6 inches long, dark green; cones ovate and unsymmetrical; apophysis on the outside rounded.

14. *P. radiata*.

Leaves in 2s.

Cones unsymmetrical; scales much enlarged on the outside; armed with prominent prickles.

15. *P. muricata*.

Cones nearly symmetrical; prickles none or inconspicuous.

Leaves slender and flexible, 2-4 inches long; apophysis flattened, deep, lustrous brown.

16. *P. halepensis*.

Leaves stout and rigid.

Cones and leaves 4 inches long or more.

Seeds $\frac{3}{4}$ inch long, with a very short wing; apophysis low, somewhat 6-sided.

17. *P. pinea*.

Seeds scarcely $\frac{1}{2}$ inch long, much shorter than the wings; apophysis pyramidal and sharply keeled.

18. *P. pinaster*.

Cones and leaves $1\frac{1}{2}$ -3 inches long.

Trees of good size.

Leaves flattened; cone-scales with a flattened apex projecting beyond the dorsal umbo.

19. *P. sylvestris*.

Leaves rounded on the back, grooved beneath, 2-3 inches long; apex of scale not projecting.

20. *P. nigra*.

Low dwarf shrub with dense foliage of dull green leaves.

21. *P. montana*.

1. *Pinus excelsa* Wall.

Branchlets greenish brown, glabrous, glaucous; leaves very slender, flaccid, drooping, grayish green, 6-8 inches long; cones on stalks 1-2 inches long, cylindric, 6-10 inches long; scales sharp-pointed; seeds $\frac{1}{3}$ inch long; wings 1 inch long, acute.

A native of the Himalaya Mountains, where it attains a height of 150 feet. One tree is in the Arboretum northeast of the Cactus Garden.

2. *Pinus Strobus* L. White Pine.

Branchlets glabrous, green or greenish brown; leaves soft and very flexible, 2-5 inches long, light bluish green; cones on stalks $\frac{1}{2}$ -1 inch long,

cylindric, 2-4 inches long; scales oblong-obovate, flexible; seed reddish brown, mottled with black, $\frac{1}{4}$ inch long; wings 4 times as long, acutish.

A native of eastern America, extending from Newfoundland to Manitoba, south to Georgia and Iowa. Specimens are along Pine Avenue, between University Avenue and the automobile road and in the nursery south of the lath-house.

3. *Pinus monticola* Don. Mountain White Pine.

Branchlets puberulent, yellowish or reddish brown; leaves stiff, bluish green and glaucous, $1\frac{1}{2}$ -4 inches long; cones short-stalked, cylindric, 5-11 inches long, yellowish brown; scales pointed by the slightly thickened umbo; seeds $\frac{1}{3}$ inch long, reddish brown, mottled with black; wings 3 times as long, acute.

A native of western America, extending from British Columbia to Idaho and the high mountains of California. One tree east of Cactus Garden, a few others are scattered through the Arboretum.

4. *Pinus Lambertiana* Dougl. Sugar Pine.

Branchlets pubescent, brown; leaves $\frac{3}{4}$ inch long, stout, sharp-pointed, dark bluish green with conspicuous white lines on back; cones on stalks, 2-3 $\frac{1}{2}$ inches long, cylindric, light brown, shiny, 10-20 inches long; seed $\frac{1}{2}$ inch long, dark brown or nearly black; wing rounded at apex.

A Pacific Coast species, extending from southern Oregon to northern Lower California. The largest and most magnificent of all the pines. Several trees are north of the Angel of Grief, and one or two fairly large trees are north of the Stanford Residence.

5. *Pinus Cembra* L. Swiss Stone Pine.

Branchlets with yellowish brown tomentum; leaves straight, dark green on back, bluish white inside, 2-3 $\frac{1}{2}$ inches long; cones short-peduncled, ovate, light brown, 2 $\frac{1}{2}$ -3 $\frac{1}{2}$ inches long; scales rounded at apex; apophysis much broader than high; seed $\frac{1}{2}$ inch long.

Native of the Alps and extending northward to Russia and northern Asia, where it attains 70 or occasionally 120 feet. One small tree which has not fruited is at the entrance of the Cactus Garden.

6. *Pinus quadrifolia* Parl. Parry's Piñon.

Branchlets puberulous, light grayish brown; leaves 3-5 (usually 4), rigid, incurved, light green on back, whitish inside, $1\frac{1}{2}$ -2 inches long; cones subglobose, $1\frac{1}{2}$ -2 inches long, chestnut brown; apophysis thick, pyramidal, conspicuously keeled: umbo with minute recurved prickles; seed $\frac{1}{2}$ inch long.

Tree attaining 40 feet, with spreading branches forming a rounded top; bark dark brown tinged with red, shallowly fissured. Native of the extreme southern part of California and extending into the mountains of northern Lower California. There are no specimens of this tree in the Arboretum, but one tree which fruited in 1911 is at 17 Salvatierra Street, and another small specimen is at 8 Alvarado Row.

7. *Pinus edulis* Engelm. Piñon.

Leaves in 2s or rarely 3s, stout, rigid, incurved, dark green on the back, marked within by several rows of stomata, $\frac{3}{4}$ -1½ inches long, persistent for 3 or 4 years or sometimes longer; staminate flowers dark red; cones $\frac{3}{4}$ -1½ inches long and nearly as broad; seeds ovate, dark red-brown below, orange-yellow above, $\frac{1}{2}$ inch long; wings $\frac{1}{8}$ inch wide.

A small tree with a divided trunk, 30 to 40 feet high. Native of the southern Rocky Mountains, extending from eastern Utah and southwestern Wyoming southward to the mountains of northern Mexico. One young tree is in Professor Durand's garden.

8. *Pinus Torreyana* Parry. Torrey Pine.

Branchlets greenish or purplish, glabrous; leaves rigid, dark green, 8-12 inches long; cones broadly ovate, 4-6 inches long, chocolate-brown; apophysis low-pyramidal; umbo elongated, reflexed, with a short spiny tip; seed $\frac{3}{4}$ inch long; short-winged.

Tree 40 or occasionally 60 feet high, with spreading branches and dark brown bark. Perhaps the rarest pine, known only in two small groves: one is at Del Mar, San Diego County, the other is on Santa Rosa Island off the coast of southern California. Good-sized trees are near the middle of the Arboretum just west of University Avenue.

9. *Pinus Sabiniana* Dougl. Digger Pine.

Leaves slender, drooping, grayish green, 8-12 inches long; cones pendent on stalks 2 inches long, light red-brown, 6-10 inches long; apophysis pyramidal, sharply keeled, flattened at the straight or incurved apex; seeds $\frac{3}{4}$ inch long; short-winged.

Tree 50 to 80 feet high with the trunk usually divided into several stems, forming a round-topped head. Native of the inner Coast Ranges and the foothills of the Sierra Nevada, California. Specimens are in the Roble Garden, near the Museum, and in the Nursery.

10. *Pinus Coulteri* Don. Coulter Pine.

Leaves stout, acuminate, dark bluish green, not drooping, 6-12 inches long; cones short-stalked, cylindric-ovate, yellowish brown, 9-14 inches long;

apophysis elongated-pyramidal, gradually narrowed into straight or incurved umbo; seed $\frac{1}{2}$ inch long.

Tree 80 feet high, forming a loose pyramidal head. Native of the Coast Ranges of California. Trees are planted in the Roble Garden near the Museum and elsewhere.

11. *Pinus Jeffreyi* Murry. Jeffrey's Pine.

Leaves stout, 5-8 inches long, pale bluish green; cones conic-ovate, light brown, 6-12 inches long; apophysis depressed, keeled; umbo elongated into a slender recurved spine; seed about $\frac{1}{2}$ inch long.

Forest tree attaining a height of nearly 200 feet, with short spreading branches forming an open pyramidal head. Native of the mountains of Oregon and California. Specimens are in the Nursery south of the lath-house.

12. *Pinus ponderosa* Dougl. Western Yellow Pine.

Branchlets reddish brown; leaves dark yellowish green, 5-10 inches long; cones ovate-oblong, light reddish brown, $3\frac{1}{2}$ -5 inches long; apophysis flattened, keeled; umbo triangular, ending in a stout, straight or incurved prickle; seed $\frac{1}{4}$ inch long; wing 1 inch long.

Tree 150 or occasionally 230 feet, forming a spire-like head. Native of western America, extending from British Columbia to Mexico, and from western Nebraska and Texas to California. A row of trees is west of the Nursery lath-house, others are between University Avenue and the Mausoleum, and a few large trees are north of the Stanford Residence.

13. *Pinus canariensis* C. Sm. Canary Island Pine.

Branchlets yellowish; leaves slender, 8-11 inches long, light green, flexible, usually drooping, flattened; cones ovoid, 4-7 inches long, light brown, lustrous; apophysis low-pyramidal, umbo obtuse or sometimes depressed; seed $\frac{1}{2}$ inch long.

Tree 80 feet high with slender branches forming a round-topped head. Native of the Canary Islands and Teneriffe. Several trees are west of the Nursery and one near Mausoleum Avenue. Some of the trees west of the nursery which were severely burned three or four years ago are sending out new shoots from the burned branches and trunks. The primary leaves on these shoots are silvery glaucous.

14. *Pinus radiata* Gord. Monterey Pine.

Leaves bright green, 3-6 inches long; cones light brown, lustrous, conic-ovate, unsymmetrical, 3-5 inches long, 2-4 inches broad; scales on upper sur-

face with rounded apophysis, those on the lower surface with nearly flat apophysis; prickles very minute; seeds black, $\frac{1}{4}$ inch long, half the length of the wing.

Tree 80 to 100 feet, broadly pyramidal or with round-topped head. Native of the coast of California and abundant at Monterey. Commonly cultivated on the University grounds.

15. *Pinus muricata* Don. Prickle-cone Pine.

Leaves bright green, rather stout, 4-6 inches long, strongly serrate; cones 2-2½ inches long, very unsymmetrical by the enlargement of scales on outside; prickles prominent; seeds $\frac{1}{3}$ inch long; wings $\frac{1}{2}$ inch long.

A compact pyramidal or branching tree 50 to 90 feet high, with dense foliage. Native of the California coast. Specimens are among the pines between the Post Office and the Quadrangle. Others were formerly back of the Chemistry Building.

16. *Pinus halepensis* Ait. Aleppo Pine.

Leaves dull green, very slender for the group, 2½-3 inches long, tufted at the end of the branches; cones conical, smooth, 2½-3 inches long, deep lustrous brown; scales flattened, $\frac{3}{4}$ inch broad; apophysis but slightly thickened, flat and smooth, except for a rather faint transverse ridge.

A low spreading tree with an open, thin and straggling aspect, 20-40 feet high. Native of the Mediterranean region, extending from Portugal to Asia Minor. Several trees are planted in the Arboretum; one especially fine specimen is between the Mausoleum and the Museum.

16a. *Pinus halepensis* Pityusa Stevens.

Larger tree than the typical form, with leaves 4-5 inches long and cones 3-5 inches long.

Native of the eastern Mediterranean region. Specimens are south of the Nursery.

17. *Pinus Pinea* L. Italian Stone Pine.

Leaves stout, straight, deep shiny green, 5-8 inches long; cones 5-6 inches long, broadly ovate, lustrous brown; scales thick and heavy, 1 inch broad; apophysis but slightly elevated, often 6-sided; umbo with a short blunt prickle; seeds $\frac{3}{4}$ inch long, with broad but very short wings.

Tree 25-60 feet, with a broad, rounded head. Common on the sandy shore of Tuscany. One tree is north of the Nursery lath-house.

18. *Pinus Pinaster* Ait. Cluster Pine.

Leaves glossy green, very stout, stiff and twisted, acute, 5-9 inches long, appearing in definite and somewhat remote bands; cones, in the older trees,

clustered, conic-oblong, 4-7 inches long; apophysis nearly $\frac{3}{4}$ inch broad, low-pyramidal, conspicuously keeled with a prominent triangular umbo; seed $\frac{1}{3}$ inch long; wing about 1 inch long.

Tree 100 feet high with regular pyramidal habit and rapid growth. Native of the coastal region of southern Europe. A variety has been extensively used in Europe to reclaim wastes of maritime sands. Several trees are in the row of pines between the Post Office and the Quadrangle. A handsome specimen is in the rear of Madrone Hall, and a few trees are south of the Nursery.

19. *Pinus nigra* Arnold. Austrian Pine.

Leaves stout and very rigid, $1\frac{1}{2}$ - $2\frac{1}{2}$ inches long, abruptly sharp-pointed, rounded on the back, deeply grooved beneath, dark green; cones $2\frac{1}{2}$ inches long, light brown; scales about 1 inch long, $\frac{3}{8}$ inch broad; apophysis low-pyramidal, slightly keeled and with a minute prickle.

This species is more generally known under the name *Pinus Austriaca*. It is a native of southeastern Europe. A small tree is southwest of the Nursery lath-house.

20. *Pinus sylvestris* L. Scotch Pine.

Leaves light green, flattened and twisted, stiff, 1 - $1\frac{1}{2}$ inches long; cones 2 - $2\frac{1}{2}$ inches long, light brown; scales $\frac{1}{2}$ inch broad; apophysis, at least of the middle scales, with a dorsal knob-like, keeled and truncated thickening, and a thin, somewhat recurved apex; seed $\frac{1}{4}$ inch long; wing narrow, acute.

A forest tree 70-100 feet high, with pyramidal head and scattered foliage. The Scotch Pine is one of the important timber trees of Europe. Several trees are in the Nursery north of the lath-house, and one is in about the middle of the Arboretum near University Avenue.

21. *Pinus montana* Mill. Swiss Mountain Pine.

Leaves stout and crowded, $\frac{3}{4}$ -2 inches long, bright green, acutish; cones $\frac{3}{4}$ - $2\frac{1}{4}$ inches long, light grayish brown; apophysis low-pyramidal, with a black band surrounding the umbo.

A variable species, often a low dwarf shrub, or sometimes a pyramidal tree 40 feet high. Native of the mountains of central and southwestern Europe. One dwarf specimen is on the west side of the Cactus Garden.

2. *Cedrus*. Cedars.

Large forest trees, with stiff 4-sided, more or less sharply-pointed leaves in clusters at the ends of short, stubby lateral branchlets. Flowers monœcious, erect; cones ovate, 3-5 inches long, with broad, thin, closely imbricated scales.

A genus of three closely allied species, confined to northern Africa, Asia Minor and the Himalaya Mountains. These are the true cedars, although the name is applied to a number of totally different genera, such as *Libocedrus*, *Juniperus*, *Thuja* and *Chamaecyparis*.

Branches stiff horizontal or ascending, not pendulous; cones truncate and often concave at apex.

Branches mostly ascending; leading shoots not nodding; leaves mostly less than 1 inch long, thicker than broad. 1. *C. atlantica*.

Branches horizontal; leading shoots nodding; leaves 1-1¼ inches long, broader than thick. 2. *C. Libani*.

Branches and leading shoots pendulous; cones obtuse; leaves often 2 inches long. 3. *C. Deodara*.

1. *Cedrus atlantica* Manetti. Mt. Atlas Cedar.

Leaves mostly less than 1 inch long, rigid, dark or glaucous green, thicker than broad; cones 2-3 inches long, light brown.

A pyramidal tree 120 feet high, with ascending branches and erect, or at least not drooping, leading shoots. A horticultural variety, *glauca*, has leaves very glaucous with a silvery hue. Native of the mountains of northern Africa. Frequently planted on the University grounds. A handsome specimen of the variety is east of the Cactus Garden.

2. *Cedrus Libani* Barr. Cedar of Lebanon.

Leaves 1 inch long or more, dark green or in some forms bluish green or even silvery, broader than thick; cones 3-4 inches long, brown.

Large forest tree, with wide-spreading, horizontal branches and nodding leading shoots. Native of the mountains of Syria and Asia Minor. Two trees are east of the Cactus Garden, near the silver-leaved Mt. Atlas Cedar, and another is in the western part of the Nursery, surrounded by a cluster of the Mt. Atlas Cedar.

3. *Cedrus Deodara* Loud. Deodar.

Leaves 1-2 inches long, dark bluish green, rigid, as thick as broad; cones 3½-5 inches long, reddish brown.

Large forest tree, often 150 feet high, with branches and leading shoots pendulous. Several horticultural varieties are in cultivation: one, *argentea*, has silvery leaves. Native of the Himalaya Mountains. Specimens are in Encina and Roble Gardens, and the variety, *argentea*, is in the Arboretum north of the Mausoleum.

3. *Picea*. Spruce.

Trees with spreading or sometimes pendulous branches. Leaves linear, flat or 4-sided, spirally arranged, sometimes appearing 2-ranked, not narrowed into a leaf-stalk; leaf-scars raised on prominent woody pedicels, which give the twigs a decided roughness after the leaves have fallen. Cones pendulous, their scales persistent, completely concealing the very short bracts.

The eighteen known species are confined in their distribution to the north temperate and subarctic regions.

Leaves quadrangular with stomata on all 4 sides.

Cone-scales rounded at apex.

Leaves $\frac{1}{3}$ - $\frac{2}{3}$ inch long, obtuse; branchlets not long-pendulous.

Young twigs glabrous; cones $1\frac{1}{2}$ -2 inches long.

1. *P. canadensis*.

Young twigs pubescent; cones 3-5 inches long.

2. *P. orientalis*.

Leaves $1\frac{1}{4}$ -2 inches long, sharp-pointed.

3. *P. Smithiana*.

Cone-scales not rounded at apex; leaves acute or sharp-pointed.

Leaves dark green, abruptly acute; cone-scales firm on the margins, truncate at apex.

4. *P. excelsa*.

Leaves blue green, acuminate and callous-tipped; cone-scales rhomboidal, their margins flexuose.

5. *P. Parryana*.

Leaves flattened, with 2 silvery bands of stomata above.

6. *P. sitchensis*.

1. *Picea canadensis* (Mill.) B. S. P. White Spruce.

Leaves spreading from all sides of glabrous twigs, $\frac{1}{2}$ - $\frac{2}{3}$ inch long, $\frac{1}{24}$ inch wide, sharp-pointed, dull glaucous green; flowers pale red or yellowish; cones $1\frac{1}{4}$ -2 inches long, about 1 inch broad; scales rounded at apex, $\frac{1}{3}$ inch wide.

A tree 50-150 feet high, with a symmetrical pyramidal head. Native of north temperate and subarctic America, extending from Alaska to Labrador and from Montana to New England. One tree is near the center of the Cactus Garden.

2. *Picea orientalis* (L.) Carr. Caucasian Spruce.

Leaves spreading from all sides of the pubescent twigs, $\frac{1}{3}$ - $\frac{1}{2}$ inch long, $\frac{1}{12}$ inch wide, 4-sided, blunt at apex, dark lustrous green; flowers carmine; cones 3-5 inches long, about $1\frac{1}{2}$ inches broad; scales rounded at apex, $\frac{2}{3}$ inch wide.

Native of the Caucasus and Asia Minor. Two trees are near the center of the Cactus Garden.

3. *Picea Smithiana* (Wall) Bois. Himalaya Spruce.

Leaves spreading from all sides of the long pendulous branches, $1\frac{1}{4}$ -2 inches long, $\frac{1}{20}$ inch wide, sharp-pointed, light green; cones 5-7 inches long, about 2 inches broad; scales firm and shiny, about $\frac{3}{4}$ inch wide, crowded into close spirals, rounded at apex.

A common tree in the coniferous forests of the Himalaya Mountains. One tree is on the west side of the Cactus Garden and two others are near the Angel of Grief.

4. *Picea excelsa* Link. Norway Spruce.

Leaves spreading from all sides of the sparsely pubescent light brown twigs, $\frac{1}{2}$ - $\frac{2}{3}$ inches long, $\frac{1}{24}$ inch wide, 4-sided, sharp-pointed, bright green; cones $2\frac{3}{4}$ -5 inches long, about half as broad; scales $\frac{2}{3}$ inch wide, their exposed tips 3-sided, the 2 lateral margins oblique from a truncate and erose apex.

Native of the mountains of central and northern Europe. One tree is on the west side of the Cactus Garden, and others are planted elsewhere on the Campus.

5. *Picea Parryana* Sargent. Blue Spruce.

Branchlets glabrous; leaves stout, rigid, acuminate and sharp-pointed with a callous tip, $\frac{3}{4}$ - $1\frac{1}{8}$ inches long, or less on fertile branches, bluish green, or sometimes silvery, marked on both sides with 4-7 rows of stomata; staminate flowers yellow tinged with red; cones oblong-cylindric, about 3 inches long, pale chestnut brown and glossy; scales rhomboidal, flexuose on the margins, erose at the summit; seeds $\frac{1}{8}$ inch long; wings twice as long.

Forest tree, 80 to 150 feet high, with a trunk sometimes 3 feet in diameter. Native of the mountains of Colorado, eastern Utah and Wyoming. A young tree is in Professor Durand's garden.

6. *Picea sitchensis* Carr. Tideland Spruce.

Leaves spreading from all sides of the light brownish yellow glabrous twigs, green and rounded below, flat, slightly keeled and with 2 broad silvery bands above, sharply acute, $\frac{1}{2}$ -1 inch long; cones cylindric-oval, $2\frac{1}{2}$ -4 inches long; scales rounded and erose at apex.

Tree 100 to 200 feet high, with slender horizontal branches. Native of the northwest coast, extending from Alaska to northern California. One tree is in the Arboretum between the the Automobile road and the carline near the old Sempervirens avenue. This tree was apparently identified as *Picea Parryana* in Dudley's key.

4. *Pseudotsuga*.

Large evergreen forest trees, with flat, indistinctly 2-ranked leaves, narrowed at base into short petiole; leaf-scars sessile. Cones pendent, their 3-pronged bracts much exserted; seeds prominently winged.

A genus of three species; two in western America, and one in Japan.

1. *Pseudotsuga taxifolia* Britton. Douglas Fir.

Leaves $\frac{3}{4}$ - $1\frac{1}{2}$ inches long, obtuse, dark green above, paler beneath; cones oblong-ovate, 2-4 inches long, light reddish brown, with broad, rounded scales and well exserted 3-parted bracts.

The Douglas Fir is the most important timber tree of western America. It often attains a height of 200 feet or even more, and a trunk 12 feet in diameter. Frequently planted in the Arboretum. Native trees are growing on the Palo Alto estate at the north end of Jasper Ridge.

5. *Abies*. Firs.

Trees generally pyramidal in outline, with their branches in whorls. Leaves solitary, scattered along the twigs in definite spirals, but often appearing 2-ranked by a twist near the base, linear, flat or slightly 4-sided, sometimes narrowed at base but not into a distinct leaf-stalk; leaf-scars sessile on the smooth twigs. Cones erect on the branches, their scales deciduous, and bracts exserted beyond scales or concealed by them.

A genus of 24 known species, which inhabit the northern or mountainous parts of the northern hemisphere.

Leaves stomatiferous and alike in color on both surfaces.

Leaves rigid, spreading from all sides, $\frac{1}{3}$ - $\frac{1}{2}$ inch long, closely crowded on the twigs, their much enlarged bases nearly contiguous.

Leaves $\frac{1}{3}$ - $\frac{1}{2}$ inch long, steel green, $\frac{1}{12}$ inch wide, somewhat 4-angled.

1. *A. pinsapo*.

Leaves $\frac{1}{2}$ - $\frac{2}{3}$ inch long, dark green, $\frac{1}{8}$ inch wide.

2. *A. barboensis*.

Leaves curved upward on twigs, more or less 2-ranked, pale glaucous green, 1-2 inches long.

3. *A. concolor*.

Leaves stomatiferous only on lower surface.

Leaves bright green on lower surface, distinctly 2-ranked.

4. *A. Momi*.

Leaves silvery on lower surface with 2 broad bands of stomata.

Leaves not pungently acute.

Leaves obtuse.

Leaves distinctly 2-ranked, forming flat sprays; twigs ill-scented when bruised.

5. *A. grandis*.

Leaves mostly curved upward; twigs not ill-scented.

Cones 6 inches long or less; bracts projecting beyond scales;
leaves $\frac{2}{3}$ -1 inch long, bright green on upper surface.

6. *A. nordmanniana*.

Cones 8 inches long; bracts concealed by scales; leaves $1\frac{1}{4}$
inches long, dark green on upper surface.

7. *A. cilicia*.

Leaves acute.

8. *A. cephalonica*.

Leaves pungently acute; bracts long-exserted.

9. *A. venusta*.

1. *Abies pinsapo* Boiss. Spanish Fir.

Leaves dark steely green on both surfaces, rigidly spreading from all sides of the twig, crowded, their much enlarged bases nearly contiguous, $\frac{1}{3}$ - $\frac{1}{2}$ inch long, $\frac{1}{12}$ inch wide, slightly keeled on both surfaces, stomatiferous on both surfaces, with inconspicuous gray bands, obtuse but curved upward at tip and appearing acute; cones about 8 inches long, $1\frac{1}{2}$ - $1\frac{3}{4}$ inches broad; scales wedge-shaped, 1 inch wide; bracts short, rounded, not stalked.

The Spanish Fir is a native of central and southern Spain, where it forms extensive forests on the mountains at altitudes of 4,000-6,000 feet. Excellent specimens of this species are at the southeastern border of the Cactus Garden.

2. *Abies barborensis* M'Nab. Algerian Fir.

Leaves dark lustrous green on both surfaces, rigidly spreading from all sides of twig, enlarged at base, less crowded than in the preceding; $\frac{1}{2}$ - $\frac{1}{4}$ inch long, $\frac{1}{8}$ inch wide, rounded at apex, flat but keeled on both surfaces, stomatiferous bands inconspicuous on both surfaces; cones 10 inches long, dull grayish brown; scales rounded at apex, tapering to base, $1\frac{1}{2}$ inches wide; bracts short, rounded.

Native of Mt. Barbor and Mt. Tababor, Algeria, where it is found with the Mt. Atlas cedar. It is a forest tree, often 60 feet high, with compact branches forming symmetrical pyramidal heads. Two trees are along the eastern border of the Cactus Garden near *Abies grandis*.

3. *Abies concolor* (Gord.) Parry. White Fir.

Leaves ascending or indistinctly 2-ranked, glaucous green and stomatiferous on both surfaces, 1-2 inches long, $\frac{1}{12}$ inch wide, obtuse or acutish, faintly grooved above, keeled below, with 2 lateral shallow grooves; cones 6-10 inches long, $1\frac{1}{4}$ inches broad; scales broader than long, rounded at apex, gradually tapering to the base; bracts half the length of scales, oblong,

denticulate and mucronate at the emarginate or truncate apex; seeds $3/12-4/12$ inch long, dark dull brown; wings rose-colored, widest near the middle.

A large forest tree, sometimes 200 feet or more high, with a trunk 6 feet in diameter, dull grayish brown bark and short stout horizontal branches in remote whorls. Native of western America, extending from southern Oregon to the high mountains of northern Lower California and eastward to New Mexico. A number of young trees are scattered along Mausoleum Avenue, and others are planted elsewhere on the Campus.

4. *Abies Momi* Siebold. Momis Fir.

Leaves appearing 2-ranked, flat, $3/4-1\frac{1}{4}$ inches long, $1/12-1/8$ inch wide, grooved and bright green above, faintly keeled and bright yellowish green beneath, inconspicuously emarginate; cones 2-3 inches long; scales transversely oval or reniform, $1\frac{1}{2}$ inches wide, $3/4$ inch long, lateral margins dentate; bracts stalked, $2/3$ as long as scales; spatulate, mucronately pointed.

The Momis Fir is a Japanese species and is often cultivated in Japanese gardens and about the temples, where trees over 100 feet high and 6 feet in diameter are to be found. One small tree is north of the Cactus Garden and another is just back of the Angel of Grief.

5. *Abies grandis* (Dougl.) Lindl. Lowland Fir.

Leaves appearing 2-ranked, forming a flat spray, $2/3-1\frac{1}{3}$ inches long, thin and flexible, deeply grooved and dark lustrous green above, silvery white below, with 2 broad bands of stomata, emarginate; cones cylindric, slightly narrowed at rounded apex, $2-3\frac{1}{2}$ inches long, $1-1\frac{1}{2}$ inches broad; scales broader than long, rounded at apex, abruptly or gradually narrowed to the stalk-like base; bracts about $1/4$ the length of scales, obcordate, irregularly serrate, mucronate; seeds $1/2$ inch long, light brown; wings $1/2-3/4$ inch long.

A large forest tree, sometimes attaining a height of 250 feet and a diameter of 4 to 5 feet, clothed with long downward sweeping branches. The wood is ill-scented and is known among lumbermen as Stinking Fir. Native of northwestern America, ranging from Vancouver Island southward along the lowlands of the coast to Mendocino County, California, and eastward to the Bitterroot Mountains of western Montana and the Blue Mountains of eastern Oregon. One tree is situated on the western border of the Cactus Garden and a number of young trees are planted elsewhere in the Arboretum.

6. *Abies Nordmanniana* (Stevens) Spach. Caucasian Fir.

Leaves curved upward, $3/4-1\frac{3}{4}$ inches long, $1/12$ inch wide, obtuse, slightly grooved and dark shiny green above, keeled, and with 2 broad silvery bands of stomata below; cones about 8 inches long, $1\frac{3}{4}$ inches broad;

scales $1\frac{1}{2}$ inches wide, lateral margins lobed near the apex, serrate, tapering to a short slender stalk; bracts $1\frac{1}{4}$ inches long, their recurved, mucronate apex exerted beyond scales.

The Caucasian or Nordmann Fir is a native of Crimea and the Caucasus, where it inhabits the mountains at about 2,000 feet. It is a large forest tree, sometimes attaining 150 feet in height and 6 feet in diameter. Two handsome trees are in the Cactus Garden, and other smaller trees are planted on the University grounds.

7. *Abies cilicia* (Kotsch.) Carr. Cilician Fir.

Leaves curved upward, closely resembling those of the preceding, but darker green above and usually longer, $1-1\frac{3}{4}$ inches; cones about 10 inches long, $1\frac{3}{4}$ inches broad; bracts not exerted.

The Cilician Fir with the Cedar of Lebanon forms extensive forests in the Cilician Taurus at elevations of 4,000-6,000 feet. Two large trees are near the center of the Cactus Garden.

8. *Abies cephalonica* Loud. Cephalonian Fir.

Leaves spreading at right angles from all sides of the twig, dark shiny green above, with 2 silvery bands beneath, tapering from base to the sharp-pointed apex, their bases dilated lengthwise; cones cylindric, 5-6 inches long; scales rounded above and entire, wedge-shaped toward base; bracts projecting beyond scales, linear-oblong, unequally toothed at apex.

Native of the island of Cephalonia, Greece. One specimen is on the southwest border of the Cactus Garden.

9. *Abies venusta* (Dougl.) Koch. Santa Lucia Fir.

Leaves appearing 2-ranked, $1-1\frac{1}{4}$ inches long, $\frac{1}{8}$ inch wide, tapering at both ends and ending in a sharp spiny tip at apex, bright green above, grayish beneath with 2 broad bands of stomata; cones ovate, 3-4 inches long; bracts much exceeding the scales.

Native of the Santa Lucia Mountains. Tree often 100 to 150 feet high, narrowed toward the top into a spire-like head. A young tree is on the left hand side of the Palo Alto entrance to the Campus, another is in Encina Garden.

Tribe 3. Taxodeæ.

Leaves and floral parts spirally arranged, or the leaves whorled in *Sciadopitys*; ovuliferous scales bractless, forming woody cones; ovules usually several to each scale and erect; seeds small, sharply and irregularly angled.

Leaves in whorls, elongated.

6. *Sciadopitys*.

Leaves spirally arranged or appearing 2-ranked.

Leaves persistent for more than one season; seeds several to a scale.

Cone-scales with several sharp projections. 7. *Sequoia*.

Cone-scales without sharp points. 8. *Cryptomeria*.

Leaves deciduous with the slender twigs, or sometimes persistent for a year;
seeds 2 to a scale. 9. *Taxodium*.

6. *Sciadopitys*.

Evergreen pyramidal tree, with long needle-like leaves in whorls. Flowers monœcious; staminate with spirally arranged 2-celled anthers. Cones ovate-oblong, with broadly orbicular scales.

1. *Sciadopitys verticillata* Sieb. & Zucc. Umbrella Pine.

Leaves in whorls of 15-30, 3-6 inches long, grooved on both surfaces, dark green above, and with white band beneath; cones 3-4 inches long.

This species, which is the only member of the genus, is a native of Japan. One young specimen is temporarily placed in the Nursery lath-house.

7. *Sequoia*.

Tall massive forest trees with trunks usually heavily buttressed at base, covered with thick fibrous bark. Leaves evergreen, linear or scale-like, decurrent on the twigs. Flowers terminating the branchlets, monœcious; pollen-sacs several on the lower half of the connective. Cones maturing the first year, with spirally arranged, peltate scales; seeds several to each scale, reddish brown.

Once a genus of several species widely distributed over North America, Europe and Asia, but now reduced to two and restricted to the Coast Ranges and the Sierra Nevada of California.

Leaves of 2 kinds, ordinarily flat, linear and 2-ranked, but on leading shoots often scale-like and spreading from all sides of the branchlets.

1. *S. sempervirens*.

Leaves all scale-like and scattered on all sides of the branchlets.

2. *S. Washingtoniana*.

1. *Sequoia sempervirens* Endl. Redwood.

Leaves distichously spreading, about $\frac{3}{4}$ inch long, or those on leading shoots smaller and scale-like; cone oblong, $\frac{3}{4}$ -1 inch long.

Tall, magnificent forest trees often 200-300 feet high. The tallest tree authentically measured is 340 feet. Native of the fog belt of the California Coast Ranges, extending from southwestern Oregon to the Santa Lucia Mountains in Monterey County, and inland not more than 20 to 30 miles.

Frequently planted on the University grounds but enduring badly in the dry soil. Native trees are on the estate along San Francisquito Creek. A notable individual is the "Palo Alto" at the railway bridge between Palo Alto and Menlo Park.

2. *Sequoia Washingtoniana* Sudw. Giant Sequoia.

Leaves scale-like, arising from all sides of the branchlets, $\frac{1}{8}$ - $\frac{1}{4}$ inch long, glaucous green; cone ovate-oblong, 2-3½ inches long.

The Giant Sequoia is the largest and probably the oldest of trees. It is 200-325 feet high and attains a diameter of 30 feet. Native of the western slopes of the Sierra Nevada, where it usually occurs in small, isolated groves, but it forms rather extensive forests in the basins of the Tulare, Kings and Kaweah rivers. Frequently planted on the University grounds, and apparently better adapted to our local climate and soil than the Redwood.

8. *Cryptomeria*.

Pyramidal tree with reddish brown bark. Leaves linear-subulate, arising from all sides of the twigs, decurrent. Flowers small, monœcious; staminate oblong; pistillate globose. Cones globose, with thick, wedge-shaped scales furnished with a recurved projection on the back and pointed lobes at the apex.

A monotypic Japanese genus.

1. *Cryptomeria japonica* Don.

Leaves compressed, somewhat incurved, $\frac{1}{2}$ -1 inch long; cones reddish brown.

A handsome evergreen tree extensively planted in Japan, especially about temples. A few trees are planted on the University grounds, but it does not thrive in our dry soil. An excellent specimen is at 9 Lasuen St.

1a. *Cryptomeria japonica elegans* Beissn.

Low dense tree or shrub, with horizontal branches and pendulous branchlets; leaves linear, flattened, soft, bright green changing to bronze in winter.

A garden form. Good specimens are on the grounds of the Stanford Residence.

9. *Taxodium*.

Tall, deciduous or evergreen trees, with cinnamon brown, flaky bark. Leaves linear, 2-ranked, falling off in the autumn or the second year with the short slender lateral twigs; flowers monœcious, the staminate with 4-5 pollen-sacs to each anther, the pistillate solitary or in pairs at the ends of the branch-

lets of the previous year; cones globose or nearly so, maturing the first year, their scales spirally arranged, thickened at apex and mucronate; seeds 2 to each scale, triangular, winged.

Leaves deciduous; flowers appearing in the spring.

1. *T. distichum*.

Leaves persistent; flowers appearing in the autumn.

2. *T. mucronatum*.

1. *Taxodium distichum* Rich. Bald Cypress.

Leaves deciduous in the autumn, narrowly linear, light green, $\frac{1}{2}$ - $\frac{3}{4}$ inch long; staminate flowers purplish, in panicles 4-5 inches long; cones 1 inch long, without mucros at maturity.

Tall tree becoming 150 feet high, with a buttressed trunk, sometimes 12 feet in diameter. Native of the southeastern United States. A handsome specimen of this very ornamental tree is near the Angel of Grief, and another young tree is at 23 Salvatierra.

2. *Taxodium mucronatum* Tenore. Mexican Bald Cypress.

Similar to the last but leaves persistent through the winter; flowers appearing in the autumn instead of the spring; pollen-sacs 7-9 instead of 4-5.

Native of eastern and southern Mexico. Several notably large trees are known; one of these, the Cypress of Montezuma, was a noted tree four centuries ago. A young specimen that is withstanding our winters badly, is in Professor Durand's garden. This specimen has now passed through three winters, and although the tips of the young shoots have been killed by frost, the leaves have retained their persistent character.

Tribe 4. Cupressæ.

Leaves and floral parts decussately opposite or ternate, the former scale-like or sometimes subulate. Ovuliferous scales woody or coalescent and fleshy; ovules 2-many to each scale.

Cones woody.

Scales flat or wedge-shaped, imbricate.

Seeds 4-5 to each scale; branchlets frond-like; leaves with broad scales.

10. *Thuyopsis*.

Seeds usually 2 (1-3) to each scale.

Leaves appearing in whorls of 4, flat.

11. *Libocedrus*.

Leaves decussately opposite.

12. *Thuya*.

Scales peltate.

Cones maturing the second year; seeds many to each scale.

13. *Cupressus*.

Cones maturing the first year; seeds few to each scale.

14. *Chamæcyparis*.

Cones becoming fleshy and berry-like.

15. *Juniperus*.

10. *Thuyopsis*.

Evergreen forest tree with a pyramidal head. Leaves decussately opposite, convex above and somewhat sac-like. Flowers monœcious, solitary and terminal; staminate cylindric; cone subglobose, with 8-10 wedge-shaped scales; seeds 5 to each scale, compressed.

A monotypic Japanese genus.

1. *Thuyopsis dolabrata* Sieb. & Zucc. Hatchet-leaved Arborvitæ.

Leaves glossy green above, silvery white beneath, rounded at apex, the upper and lower appressed, the lateral spreading, hatchet-shaped; cones $\frac{1}{2}$ inch long; scales reflexed at apex.

A native of canyons and moist slopes of Japan. Two young trees are at 9 Lasuen St.

11. *Libocedrus*.

Evergreen aromatic trees, with fibrous bark and flattened spray-like branchlets. Leaves scale-like, imbricate in 4 rows. Flowers monœcious; staminate with 12-16 stamens; pollen-sacs 4. Cones oblong, with 6 scales, the lower pair much reduced, only the middle pair fertile; seeds 2 to each scale, winged.

A genus of about 8 species; one is a Californian species, the others are in western South America, New Zealand, New Caledonia, New Guinea, Formosa and southwestern China.

1. *Libocedrus decurrens* Torr. Incense Cedar.

Leaves yellowish green, appearing in whorls of 4, the lateral nearly covering the obscurely pitted inner ones; cones $\frac{4}{5}$ inch long, about $\frac{1}{3}$ inch thick; scales with a short recurved mucro.

Tree sometimes 150 feet high, with an irregularly lobed trunk tapering from a broad base, and a reddish brown, fibrous bark. Native of the Sierra Nevada and the inner Coast Ranges, extending from southern Oregon to northern Lower California. The row of trees back of the Engineering Buildings is of this species. Other trees are planted elsewhere on the University grounds.

12. *Thuya*.

Evergreen trees with thin, scaly bark and decussate scale-like leaves. Flowers monœcious; staminate ovoid, with 4-6 pollen-sacs. Cones ovoid-

oblong, erect or drooping, maturing in one season; scales 8-12, the middle 2 or 3 pairs fertile.

Four species are recognized in this genus, two in North America and two in Asia.

Cones pendulous; scales thin, with a minute mucro.

1. *T. plicata*.

Cones erect; scales angled on the back, with a stout, recurved dorsal hook.

2. *T. orientalis*.

1. *Thuya plicata* Don. Western Red Cedar.

Leaves bright green and glossy above, dark green beneath, with whitish triangular markings; cones cylindric-ovoid, scarcely over $\frac{1}{2}$ inch long; scales 8-10, elliptic-oblong, usually the 3 middle pairs fertile; seeds compressed, notched at the apex, with 2 narrow wings.

A large forest tree, 200 feet high, with short horizontal branches often with pendulous tips. Native of northwestern America, extending from Alaska to northern California. A specimen is in the eastern part of Encina Garden and another is near Mausoleum Avenue.

2. *Thuya orientalis* L. Arborvitæ.

Leaves acute, bright green, with a small dorsal gland; cones erect, globose-ovate, $\frac{3}{4}$ inch long; scales usually 6, oval; angled on the back, and with a dorsal horn-like process, the uppermost pair sterile; seeds wingless.

Pyramidal trees 25 feet high or bushy. Native of Persia and extending to eastern Asia. There are many garden forms of this extensively cultivated species. Abundantly planted on the University grounds.

12. *Cupressus*.

Evergreen trees or rarely shrubs. Leaves decussately opposite, appressed, small, scale-like. Flowers monoecious, very small, terminating short branchlets. Cones globose or nearly so, consisting of 3-7 pairs of peltate woody scales, each bearing many seeds, maturing the second year.

Branchlets terete or quadrangular, not forming flat spays.

Leaves glandless or with an obscure dorsal gland.

Branchlets erect or spreading, the ultimate rather short and stout.

Ultimate branchlets terete or nearly so; cones usually $1\frac{1}{4}$ inch long or more.

1. *C. sempervirens*.

Ultimate branchlets 4-sided; cones globose, 1 inch or less broad.

Staminate cones subglobose, with 2 lateral anthers in each row; seeds dull grayish or blackish brown.

2. *C. macrocarpa*.

Staminate cones oblong-ovoid, with 3 anthers to each row; seeds reddish brown.

3. *C. Goveniana*.

Branchlets usually pendulous, the ultimate terete, slender, elongated; cones globose, $\frac{1}{2}$ inch broad.

4. *C. torulosa*.

Leaves conspicuously glandular and very fragrant.

5. *C. Macnabiana*.

Branchlets flattened, forming frond-like sprays on long, pendulous branches.

6. *C. funebris*.

1. *Cupressus sempervirens* L. Italian Cypress.

Tree attaining 80 feet, the typical form with erect branches forming a narrow columnar head; leaves closely appressed, ovate, glandless or with inconspicuous dark pits; staminate flowers cylindric, with 4 lateral anthers in each row; cones oblong or subglobose, $1\frac{1}{4}$ inches long or more, glossy; seeds nearly $\frac{1}{4}$ inch long, reddish brown, with light-colored hilum.

The columnar form is the classical Cypress of the Greeks and Romans, and is much cultivated in southern Europe. It is the type of the species, but is not now known in the wild state. Commonly planted on the University grounds.

1a. *Cupressus sempervirens horizontalis* Gord.

Branches horizontal, forming a broad pyramidal head, otherwise like the typical form.

This form is also common on the Campus.

2. *Cupressus macrocarpa* Hartw. Monterey Cypress.

Branchlets short and stout, arising from all 4 sides of the twig; leaves dark green, glandless or glands marked by a dark pit; rhombic-ovate, acutish; staminate flowers subglobose, with 2 lateral anthers in each row; cones globose to oblong, $\frac{3}{4}$ - $1\frac{1}{2}$ inches long; scales 8-12, with a short obtuse umbo; seeds sharply angled, $\frac{3}{16}$ inch long, chestnut brown, with a conspicuous light-colored hilum.

Tree attaining 40 feet or occasionally 70 feet, broadly oval in outline, with spreading branches or, especially in its native habitat, with horizontal branches forming a broad flat-topped head. The Monterey Cypress, which is the most abundantly planted tree on the University grounds, is restricted in its wild state to two small groves occupying the two promontories, Point Lobos and Cypress Point, that mark the boundary of Carmel Bay.

3. *Cupressus Goveniana* Gord.

Branchlets arising from all 4 sides of the twigs, quadrangular; leaves ovate, acute, glandless or with an inconspicuous dark pit; staminate flowers

oblong, with 3 lateral anthers; cones subglobose or oblong, $\frac{1}{2}$ - $\frac{3}{4}$ inch broad; seeds reddish brown with hilum of similar color.

Tree attaining 50 feet, with slender spreading or erect branches, forming a broad, open, or pyramidal head. Native of the coastal region of northern and central California. Two trees are on either side of the first cross street between the Library and the Gymnasium.

4. *Cupressus torulosa* Don. Himalayan Cypress.

Ultimate branchlets usually arising from only 2 sides of the twig, terete, slender; leaves ovate, acute, bluish green; staminate flowers cylindric, with 3-4 lateral anthers in each row; cones globose, $\frac{1}{2}$ inch broad; scales 8-10 with a small, sharp umbo; seeds light brown, glossy, flattened and broadly winged.

Tall, slender tree, attaining 150 feet, with short horizontal branches and slender pendulous branchlets. Native of the Himalaya Mountains. Several trees are around the Cactus Garden.

5. *Cupressus Macnabiana* Murr. MacNab Cypress.

Leaves ovate, obtuse, thickened at apex, conspicuously glandular and very fragrant; staminate flowers very small, globose, with 1-2 lateral anthers in each row; cones subglobose, $\frac{1}{2}$ - $\frac{3}{4}$ inch broad; scales usually 6, with a prominent conical umbo; seeds reddish brown, with a broad light-colored hilum.

Low spreading tree or shrub, or sometimes forming a pyramidal tree 20 feet high or more. Native of northern California, extending from Lake County to the vicinity of Mt. Shasta, and also in Lassen County. Several trees are between the Library and University Avenue. Flowers are produced abundantly almost the year round.

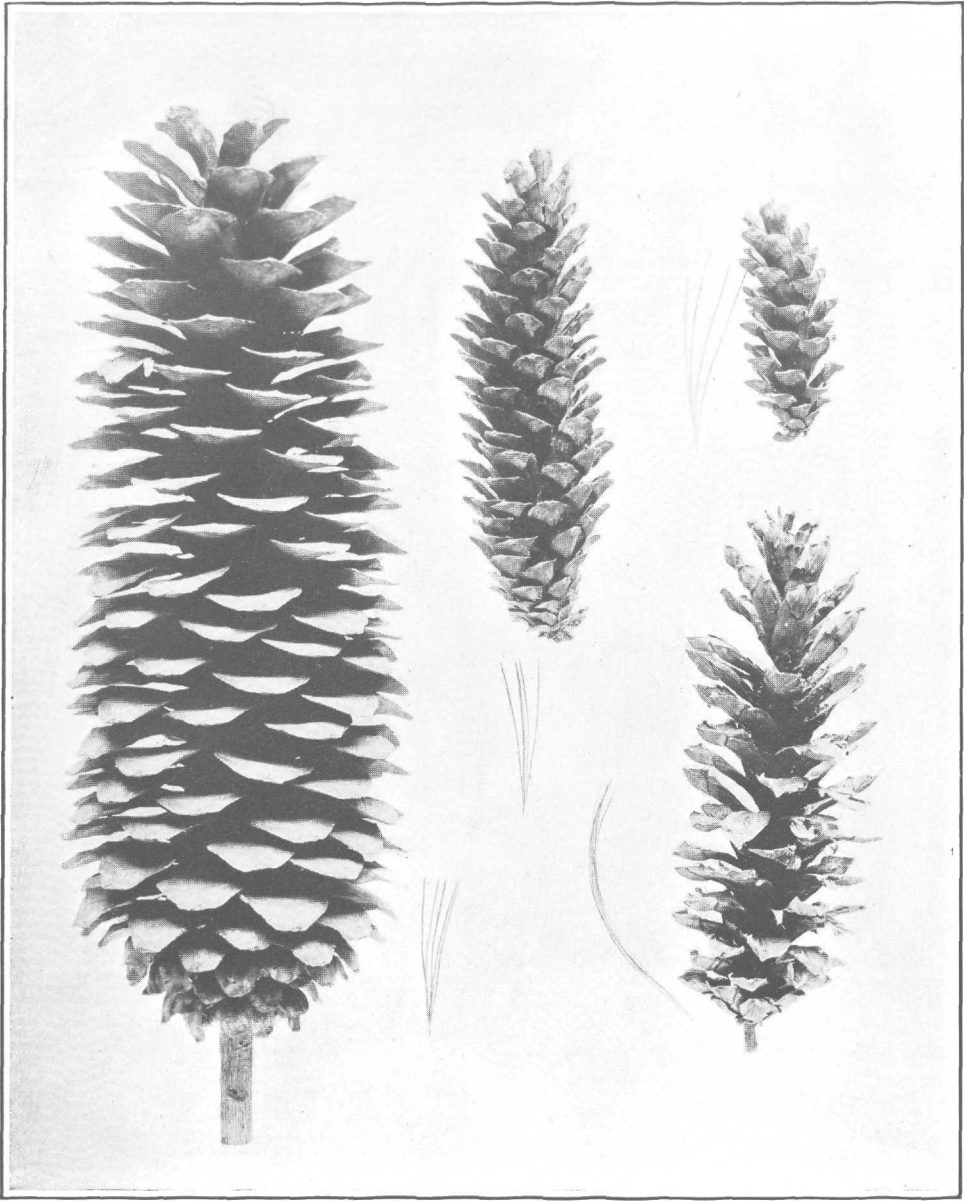
6. *Cupressus funebris* Endl. Funeral Cypress.

Branchlets somewhat flattened; leaves deltoid-ovate, light green; cones short-peduncled, globose, $\frac{1}{3}$ inch broad; scales 8, with a short mucro.

Tree often 60 feet, with wide-spreading branches curved upwards and bearing long slender pendulous branchlets. Native of China. Several trees are near the Cactus Garden and others are on the west side of University Avenue near the center of the Arboretum.

13. *Chamæcyparis*.

Evergreen trees with flattened branchlets densely clothed with opposite scale-like leaves in 4 rows. Flowers monœcious on separate branchlets; staminate oblong, pistillate subglobose. Cones globose, maturing the first



GROUP OF FIVE-LEAVED PINES.

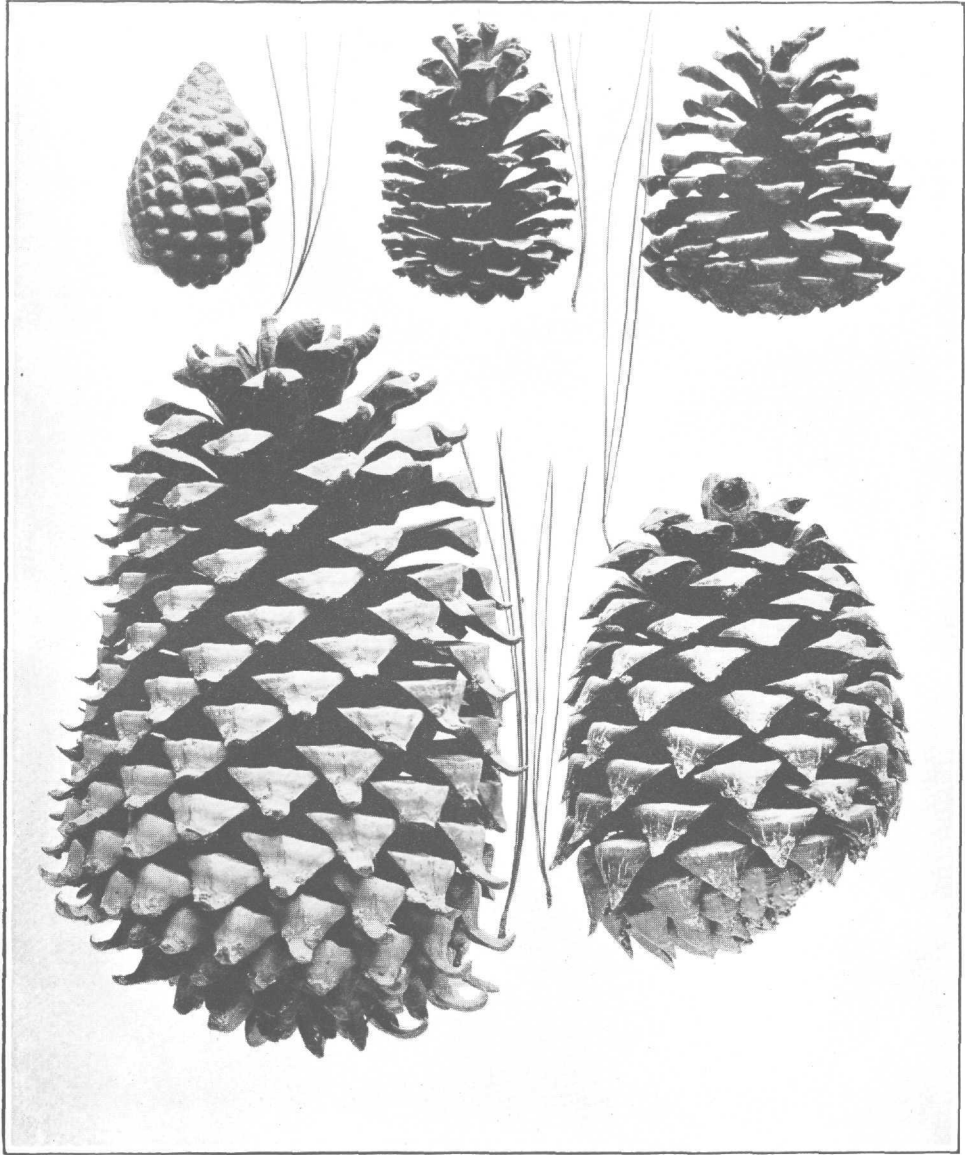
Pinus Lambertiana

Pinus monticola

Pinus Strobus

Pinus excelsa

(Reduced to one-third natural size.)



GROUP OF THREE-LEAVED PINES.

Pinus radiata

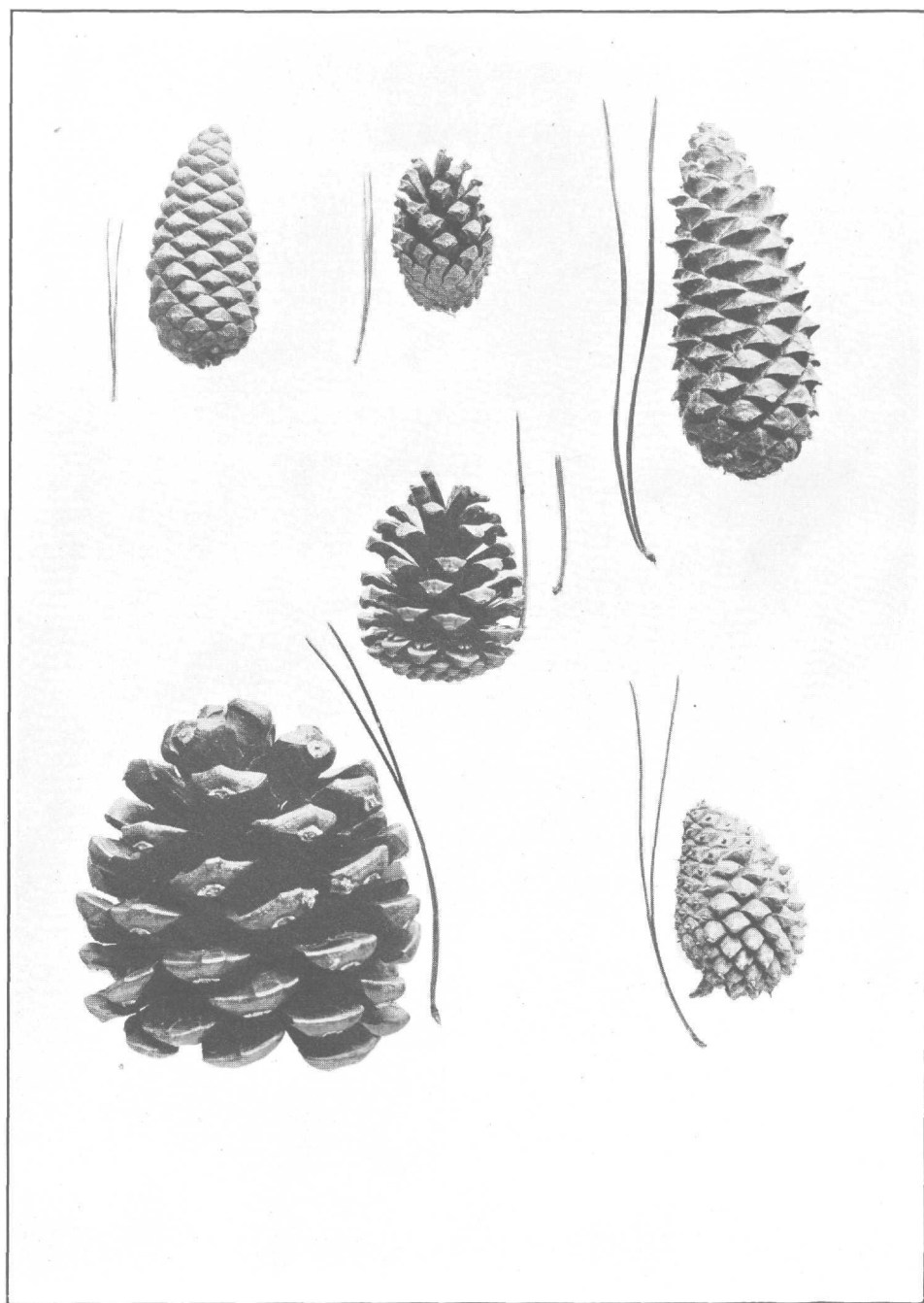
Pinus ponderosa

Pinus canariensis

Pinus Coulteri

Pinus Sabiniana

(Reduced to one-third natural size.)



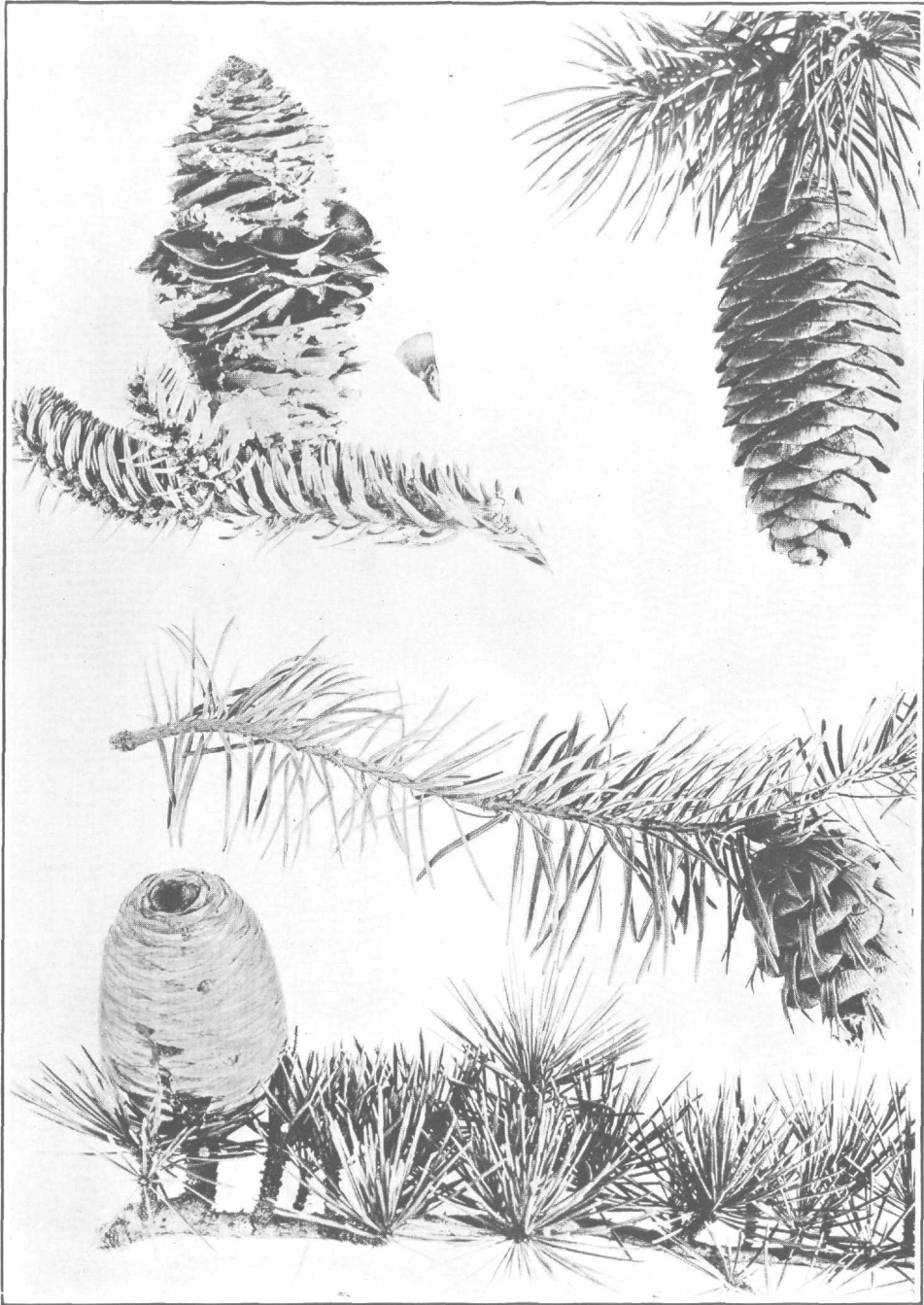
GROUP OF TWO-LEAVED PINES.

Pinus halepensis
Pinus Pinca

Pinus sylvestris
Pinus nigra

Pinus Pinaster
Pinus muricata

(Reduced to two-fifths natural size.)

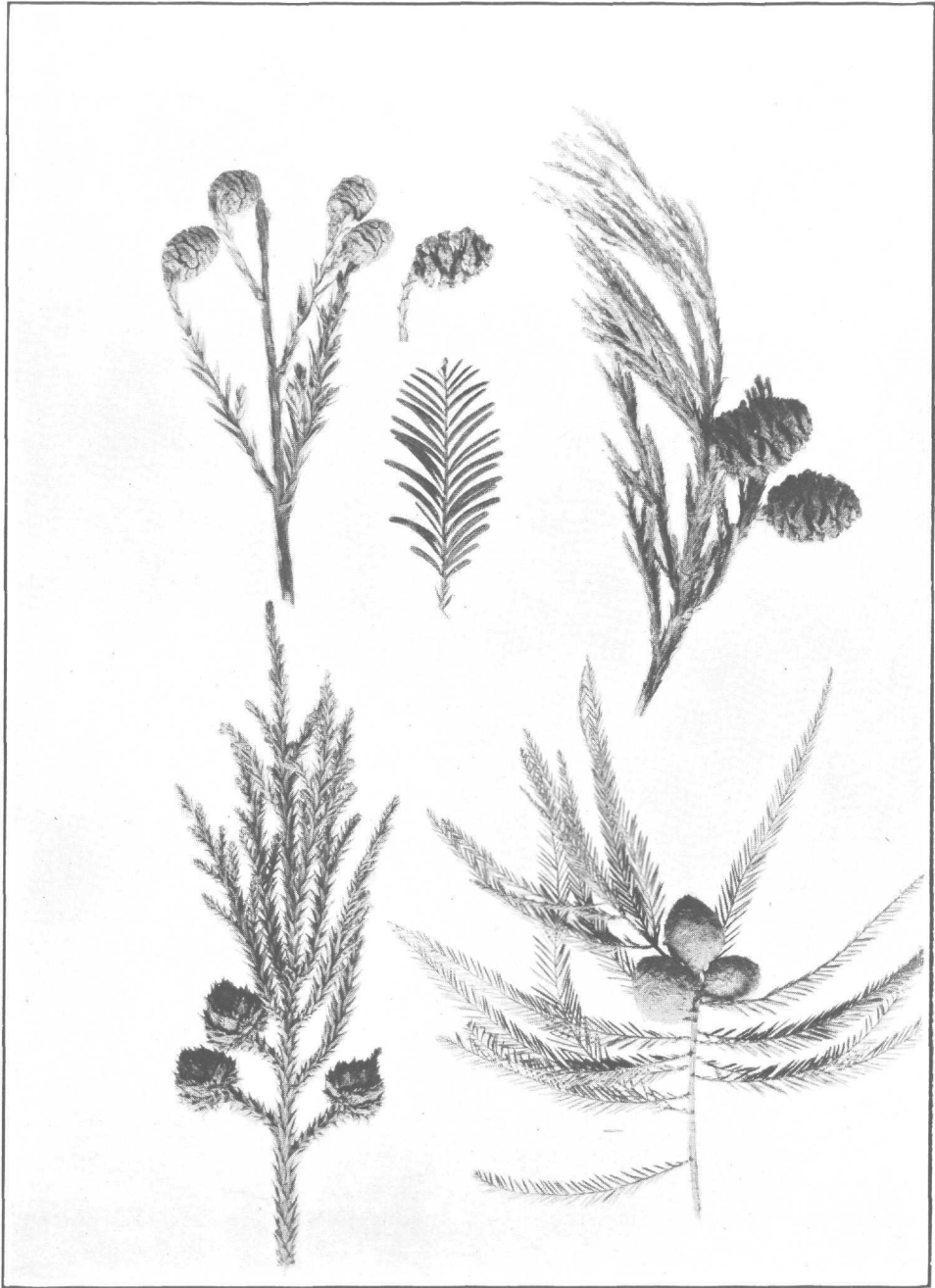


GROUP OF THE ABIETEÆ.

Abies cephalonica
Cedrus Libani

Picea excelsa
Pseudotsuga taxifolia

(Reduced to one-half natural size.)



GROUP OF THE TAXODIÆÆ.

Sequoia sempervirens
Cryptomeria japonica

Sequoia Washingtoniana
Taxodium distichum

(Reduced to one-half natural size.)



GROUP OF THE CUPRESSEÆ.

Cupressus macrocarpa

Chamæcyparis Lawsoniana

Thuya orientalis

Libocedrus decurrens

(Reduced to one-half natural size.)

year; scales abruptly dilated and flattened at apex, with short, prominent points; seeds 1-5 to each scale, slightly compressed.

Six species are known. They are confined to the Atlantic and Pacific Coast regions of North America and to Japan and Formosa.

1. *Chamæcyparis Lawsoniana* Parl. Lawson Cypress.

Leaves closely appressed to the flattened frond-like branchlets, bright green and with a gland on the back, paler beneath with whitish markings; staminate flowers red; cone about $\frac{1}{3}$ inch broad, red brown.

Tree sometimes 200 feet high, with horizontal spreading and usually pendulous. Native of the coastal region of Oregon and northern California. A variable species with over 60 garden forms. Young trees are along Alvarado Row, others are in the Arboretum but they endure our dry season badly. A handsome specimen is in the lawn at the Stanford Residence and another is at 9 Lasuen Street.

14. *Juniperus*.

Evergreen trees with opposite or ternate, scale-like or needle-shaped leaves. Flowers are dioecious or monœcious, minute; staminate oblong-ovate; anthers with 4-8 pollen-sacs. Cones globose or oblong, with 2-3 series of fleshy coalescent scales, berry-like, maturing the second year; seeds 1-several, ovate, terete or angled.

A genus of about 30 species widely scattered over the northern hemisphere from the Arctic Circle to the mountains of the subtropical regions. Flowers monœcious, axillary; leaves jointed at base, spreading and needle-shaped.

1. *J. communis*.

Flowers dioecious, terminal; leaves not jointed at base, often scale-like.

Leaves all alike, in 3s, slightly spreading; prostrate shrub.

2. *J. recurva squamata*.

Leaves often of 2 kinds, those on vigorous shoots in 3s, acicular, those on foliage branches in 2s, minute and scale-like.

Trees; fruit erect.

3. *J. virginiana*.

Low shrub with procumbent branches; fruit pendulous on recurved peduncles.

4. *J. Sabina*.

1. *Juniperus communis* L.

Leaves widely spreading, jointed at the base, narrowly linear-lanceolate, sharp-pointed, $\frac{1}{2}$ inch long or less, concave and with a broad white band above; fruit sub-sessile, dark blue and glaucous, $\frac{1}{4}$ - $\frac{1}{3}$ inch broad.

A small tree or erect shrub. Widely scattered over the northern hemisphere. A variable species with many geographical varieties and garden forms. One specimen is west of the Cactus Garden.

1a. *Juniperus communis hemispherica* Parl.

A low dense shrub; leaves $\frac{1}{3}$ inch long or less, stouter and stiffer than those of the typical form.

A geographical variety found in the mountains of southern Europe and northern Africa. One bush on the west side of the Cactus Garden near the typical form.

1b. *Juniperus communis oblonga* Loud.

Erect shrub with widely spreading branches and pendulous branchlets; leaves strongly concave, the longest $\frac{3}{4}$ inch long.

A geographical variety, native of Transcaucasia. One specimen is west of the Cactus Garden.

2. *Juniperus recurva squamata* Parl.

Leaves in 3s, straight, slightly spreading, linear-lanceolate, $\frac{1}{4}$ inch long, sharp-pointed; fruit $\frac{1}{3}$ inch broad, 1-seeded.

Prostrate shrub with long trailing branches. Native of the Himalaya Mountains. One specimen is on the southwest border of the Cactus Garden.

3. *Juniperus virginiana* L. Red Cedar.

Leaves of leading shoots acicular, in 3s, those of the foliage branches in 2s, small and scale-like, acute or acutish; fruit erect on short peduncles, globose or ovoid, $\frac{1}{3}$ inch broad, 1-seeded.

Tree with a maximum height of about 100 feet, with spreading branches and often pendulous branchlets. A variable species with many garden forms. Native of eastern North America. One tree with wide spreading branches and pendulous branchlets is east of the Cactus Garden, and another smaller and more compact specimen is west of the Cactus Garden, near *J. communis*.

4. *Juniperus Sabina* L.

Leaves of leading shoots often in 3s and acicular, those of the foliage branches scale-like, in 2s, obtusish; fruit pendulous, on elongated curved peduncles, globose, 1-3-seeded.

A variable species with many garden forms. Native of eastern North America, Europe and Asia. There are several staminate specimens along the border of the Cactus Garden.