Variation in a Sample of *Pinus radiata* Cones from the Nelson District

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(With Figs. 1–22 in Text-figs. A-D and Text-figs. 1–4.)

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Summary

CONES from 250 trees in the Nelson district varied in size, proportions, shape, and in characters of the apophyses, umbos and mucros. Variation was great between the cone populations of different trees, and small within the population of any one tree. Each character seemed to vary continuously between two distinct extremes, and intermediate forms were the most common. Graphical analysis suggested some correlations and emphasised a great diversity of character-combinations. When the variation was compared with earlier descriptions of the species, it appeared to correspond closely with that in its natural habitat.

INTRODUCTION

ABOUT a century ago, the Californian species, *Pinus radiata* D. Don, was introduced into New Zealand. That species now occupies in pure plantations approximately half a million acres of this country. Such is its economic importance in the southern hemisphere that many more or less technical articles have been devoted to it. Some people are aware of its morphological variability, which is of particular interest to silviculturists, wood-users and tree-breeders, but few have studied this variability, and fewer still have tried to describe it. To the earlier taxonomists, it suggested distinct species; to later ones, distinct varieties of one species.

For the genus *Pinus*, the cones, or seed-bearing strobili, provide many of the criteria for distinguishing species, and the earlier descriptions of *Pinus radiata* used these structures almost exclusively for its taxonomic subdivision. This paper aims at describing the variation of the cones as it appeared in a large sample, and comparing it with previous descriptions.

SOURCE OF SPECIMENS

Cones were collected in various parts of the Nelson district. Nearly all of them came from sites not more than thirty miles apart. They represented a total of 250 trees, which were as follows:—

(1) Seventy-two scattered self-sown trees in the coastal area between Upper Moutere and Mapua;

(2) Twenty-six scattered self-sown trees near Wakefield;

(3) One hundred trees comprising two separate samples of fifty each, in a small closed stand of natural regeneration at " Kainui," six miles south of Wakefield;

* Now Forest Research Institute, Rotorua.

(4) Twenty-two felled trees from various parts of a 100-acre plantation at Waimea West;

(5) Thirty miscellaneous trees, some of which were windthrows, some isolated specimens, and some in shelter-belts.

Where possible, four or more mature cones were collected from each tree. For the ninety-eight scattered trees and nearly all of the miscellaneous group, the cones were taken from branches; for those growing in closed stands they were taken from trunks. On the felled trees and windthrows, nearly all the cones were easily reached, and there was probably a personal bias towards the larger sizes on any one tree. On the others, the first accessible cones were taken, provided that they appeared normal. Each cone was marked with the serial number of the tree that bore it, and then put in a sack. On return to the laboratory, the cones were tipped out in a jumbled heap on the floor. From the heap, they were picked at random, until each tree was represented by one cone. All the other cones were put aside for seed extraction.

Variation of Cones

Four characters of the cone as a whole were studied:

(a) length
(b) breadth
(c) ratio of length to breadth
(d) shape.

Table I.

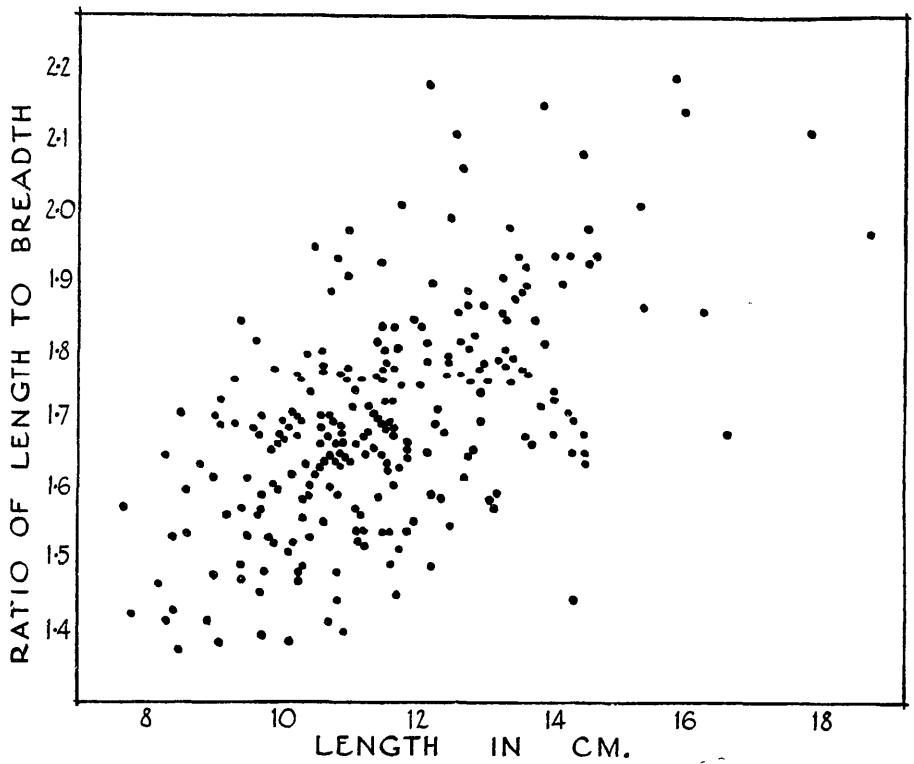
Indicating Variation of Cone Length Within and Between Trees.
(Measurements in cm.)

No. of Trees.	No. of Cones per Tree.	Range.	Mean.	Standard Deviation.
1	66	8.2–12.7	10.0	1.0
1	40	11.4–19.5	16.8	1.7
250	1	7.7–18.8	11.6	1.8

(a) *Length* varied on a single tree, but, as indicated in Table I, this was a smaller variation than that due to differences between trees. In felled plantation trees, the cones on the branches seemed to be smaller than those on the trunks. On open-grown trees, this difference was not apparent; but in samples from two such trees the average length of the cones from trunks was the greater by 0·46 cm. and 0·62 cm. respectively. In view of this, and of the probable bias in collecting from felled trees, differences between the means of cone length for the smaller samples were regarded as insignificant. Within the limits of the whole sample, therefore, site had apparently no effect on cone size. Zobel (1951), in his study of Coulter and Jeffrey pines, noted differences in cone size apparently associated with differences in site. His observations, however, certainly covered sites more diverse than those from which the Nelson sample was drawn.

(b) *Breadth* was measured in the plane of bilateral symmetry—i.e., that which includes the longitudinal axes of cone and peduncle. For the 250 cones, the range was 4·9–10 0 cm., and the mean 6·8 cm.

(c) *Ratio of Length to Breadth* may vary considerably on a single tree, but not enough to obscure the strong variation between trees. Text-fig. 1 shows a



TEXT-FIG. 1.—Dot diagram to show how ratio of length to breadth alters with length.

tendency for the ratio to increase with length, so that in general, short cones were relatively broad and long ones relatively narrow.

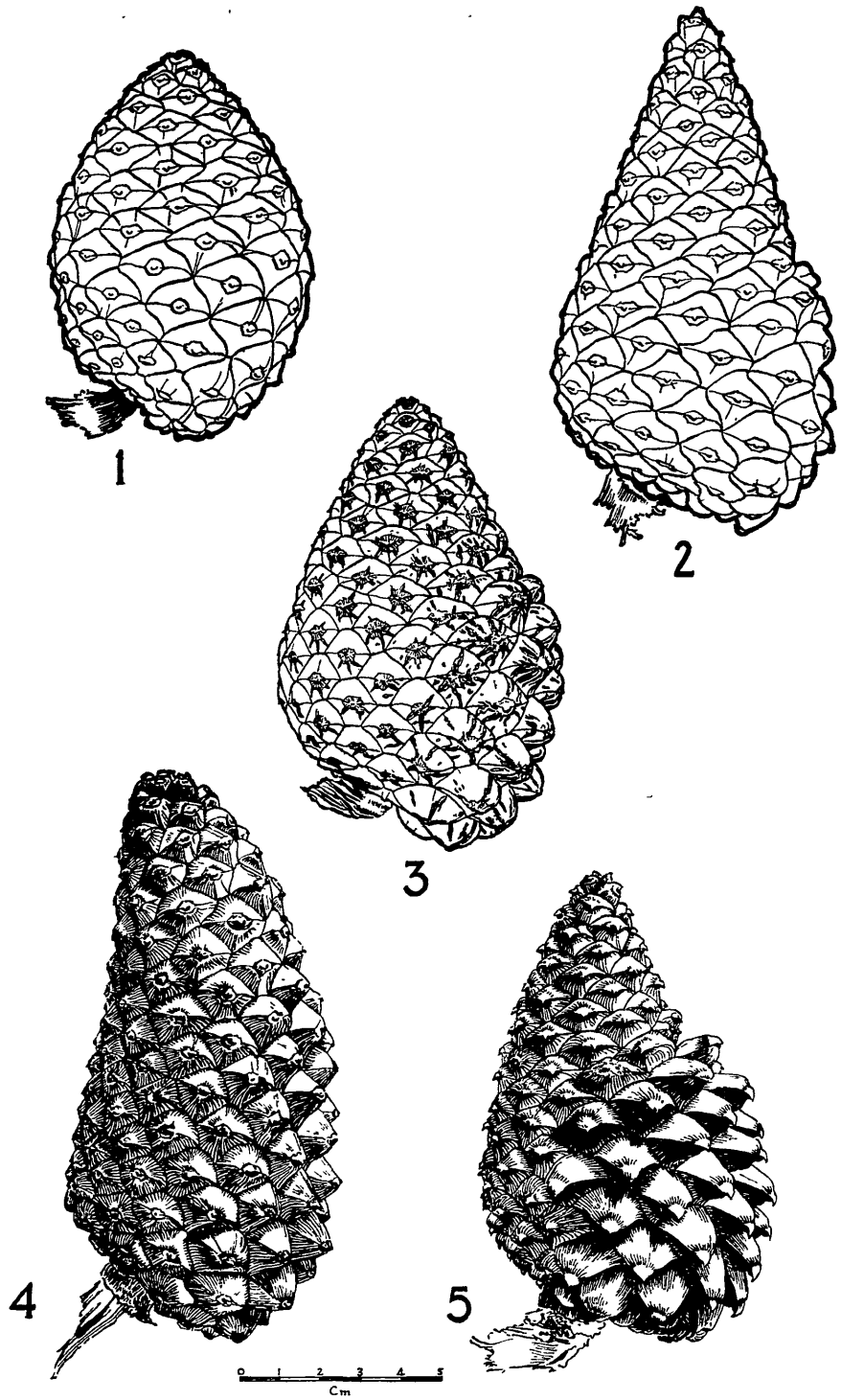
(d) *Shape,* for most of the sample, could best be described as ovoid-conical. The proximal part of the cone is oblique, because there the axis is strongly reflexed and the scales on the outer side, away from the branch, are bigger than those on the inner side. In the distal part of the cone, the axis is nearly always straight and there is radial symmetry. In rare examples, two of which were included in the collection, the axis is recurved right to the apex.

At one end of the range of variation in shape was an almost ovoid cone (Text-fig. A, Fig. 1) . at the other end, an almost conical one (Text-fig. A, Fig. 2). Between these extremes was a complete series of intermediate shapes. Text-fig. 2 is an attempt to show how the variation in shape and length may be correlated. At the same time it tries, by scoring the cones in arbitrary classes for shape, to illustrate the frequency distribution of this character.

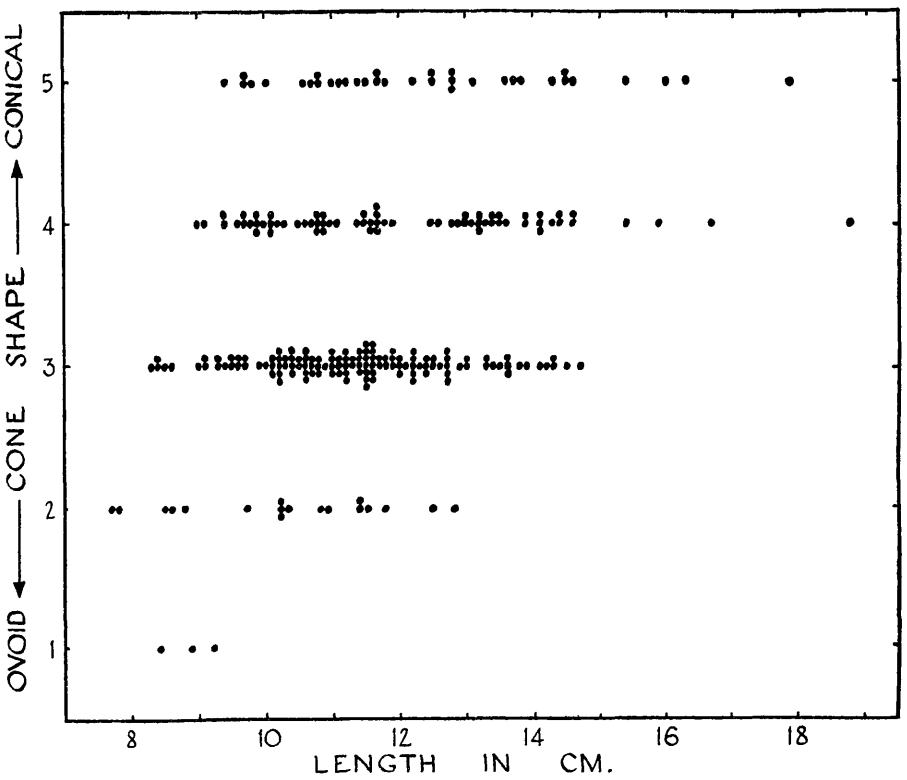
VARIATION OF APOPHYSES

The following variable characters of the apophyses (exposed ends of the scales, making up the surface of the closed cone) were studied:

(a) number or area raised,
(b) elevation,
(c) shape,
(d) flexure,
(e) superficial cracks.



TEXT-FIG. A.—FIGS. 1 and 2—Cones drawn in outline to show extremes of cone shape. FIG. 3—An extreme example of cracks in the apophyses, showing pattern and distribution. FIG. 4—Cone resembling those of *Pinus attenuata* Lemmon. FIG. 5—Cone resembling those of *Pinus muricata* Don. (All figures × ⅔.)



TEXT-FIG. 2.—Diagram to show suggested correlation between cone shape and cone length. (See Table II.)

(a) *Number or area of raised apophyses* On the proximal exterior part of the cone, there is usually a well-defined patch of apophyses which are elevated or swollen in various ways. This patch is usually circular or broadly elliptical with the long axis parallel to the cone axis; it usually occupies an area approximately two-thirds the length and one-half the greatest circumference of the cone, but it may be more or less than this. In the sample, the number of raised apophyses ranged from five to ninety-six, and was most often between forty and sixty. In some cones, the boundary between the raised and the not raised was very distinct; where it crossed an apophysis, one side of this was swollen and the other was flat. In other specimens, the elevation decreased gradually from the centre of the area and there was no clear boundary.

(b) *Degree of Elevation.* The maximum elevation of apophyses on a cone ranged from 0 3 cm. to 1·7 cm. Considerable variation of this character within a tree was sometimes noted.

(c) *Shape.* In this character, it was the proximal exterior apophyses which were considered; those on the rest of cone varied little.

There was a graded series of shapes. At one extreme were angular and pyramidal apophyses (Text-fig. B, Fig. 6), which in one cone were abruptly truncated (Text-fig. B, Fig 7); at the other extreme, they were fully rounded and approximately hemispherical (Text-fig. B, Fig. 8). Intermediate forms (e.g. Text-fig. B, Fig. 9) were the most common.

(d) *Flexure.* On some cones the apophyses were quite erect, except for a few exterior basal ones which were always recurved. In all the other cones there were always various degrees of flexure. An example of the most strongly recurved apophyses is shown in Text-fig. B, Fig. 10.

(e) *Superficial Cracks.* On many cones, there were rough splits or cracks in the surface of the apophysis. These cracks usually radiated from the umbo, but in some specimens they were parallel to one edge of the apophysis or at right angles to the transverse keel, and in some, both kinds were present. Several cones had no cracks; many had very few; at the opposite extreme these cracks were a conspicuous feature of the whole cone (e.g., Text-fig. A, Fig. 3).

In general, this character appeared trivial, but it was studied in detail because Don (1836) apparently thought it important; indeed, he seems to have derived from it his specific epithet—*radiata*. (His original description is reproduced on p. 35.)

Variation of Umbos and Mucros

(a) *Umbo Elevation.* In many specimens, umbo elevation varied. On one cone, for example, in the area of swollen apophyses the umbos were flush with the surface; on the other apophyses, they were raised up to 0·2 cm. In another cone, this condition was reversed. In a third example, they were raised on all apophyses, some more than twice as much as others. In still another, they were depressed on some apophyses and raised on others. The most strongly raised umbos on any cone were usually found at the extreme base on the outer side.

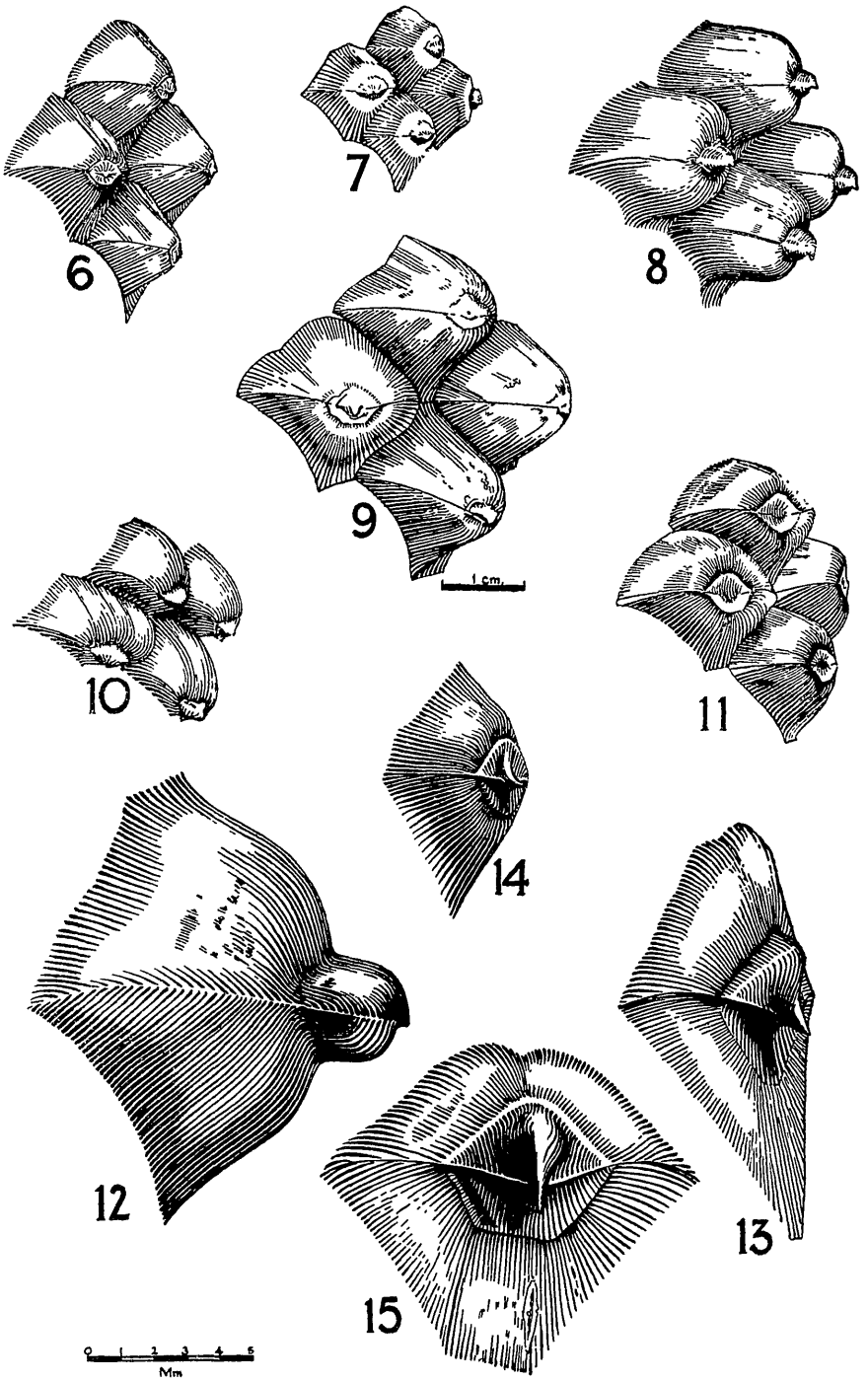
For the whole sample, there was a series, stages in which may be indicated as follows:—

(1) umbos all depressed (Text-fig. B, Fig. 11);
(2) depressed or flush;
(3) flush or slightly raised—e.g, to 0 1 cm.;
(4) all raised more or less;
(5) all strongly raised—maximum 0·35 cm. (Text-fig. B, Fig. 12).

(b) *Mucro Size and Strength.* On cones which have been exposed to the weather for some years, usually only remnants of the mucros remain, but in most cases one or two may be found intact on the inner side. The mucros also varied from cone to cone; they ranged from slender, weak prickles, 0.05 cm. or less in length, to stout ones 0·15 cm. long, and strong enough to scratch the hand of a collector.

(c) *Flexure of Umbo and Mucro.* In some cones the umbos were quite erect, as in Text-fig. B, Fig. 12, but in most they were recurved slightly to strongly. In some cones, every umbo was inclined to the surface of its apophysis as if tilted on its transverse axis, so that the part nearer the apex of the cone projected, and the part nearer the base was depressed, or flush, as shown in Text-fig. B, Fig. 13.

The mucro was usually reflexed at about 45° to the surface of the cone. In many specimens its flexure was stronger on the inner side and weaker on the outer side of the cone. Variation was greatest between cones, and ranged from almost erect mucros, some of which were incurved (Text-fig. B, Fig. 14), to mucros parallel to the cone surface (Text-fig. B, Fig. 15).



TEXT-FIG B.—FIGS 6–11—Details of apophyses in different cones. Each detail was drawn from the centre of the raised area on the proximal outer side of the cone FIG. 6—Pyramidal FIG. 7—Pyramidal and truncated. FIG 8—Extremely rounded, gibbous FIG. 9—Shape intermediate between pyramidal and rounded. FIG 10—Extreme flexure. FIG. 11— Umbos depressed. FIGS 12–15—Details from various parts of different cones FIG. 12—Extreme umbo elevation. FIG 13—Extreme flexure or tilting of umbo. FIG 14—An almost erect, incurved mucro FIG. 15—Extremely reflexed mucro. (Approximate scales Figs. 6–11 × 1½. The differences in size are noteworthy Figs 12–15 × 5)

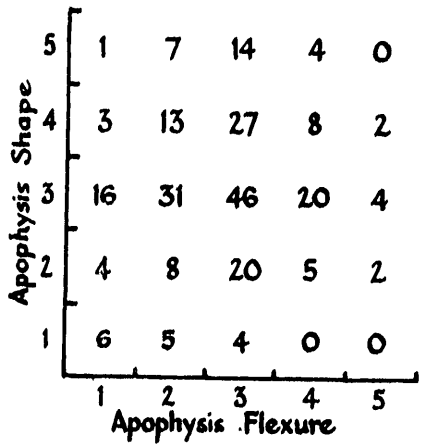
Variation of Characters Considered Two at a Time

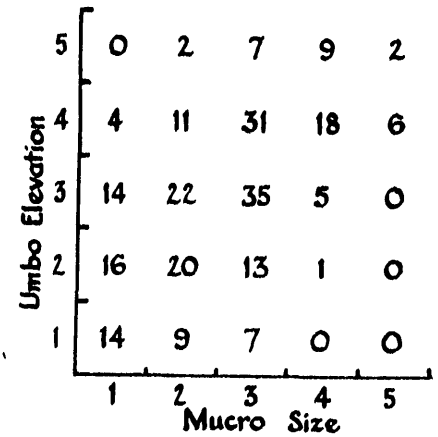
An attempt was made to study these varying characters two at a time by the graphical methods described by Anderson (1949). The only characters scored objectively were cone length, cone breadth and the number of raised apophyses; in the last of these, there was a subjective element whenever the boundary between one area and the other was not distinct. For each of the other characters, five arbitrary classes were chosen and the cones scored from 1 to 5, as indicated in Table II.

Table II.

Indicating Method of Scoring Cones.

	1.....5
Cone Shape	Ovoid.....Conical
Apophysis Shape	Pyramidal.....Hemispherical
„ Elevation	Minimum..... Maximum
„ Flexure	„ ..... „
Superficial Cracks	„ ..... „
Umbo Elevation	„ ..... „
Mucro Size	„ ..... „
Flexure of Umbo and Mucro (Considered together)	„ ..... „





Text-fig. 3 (left).—Frequency distribution of combinations of two characters, suggesting no correlation.

Text-fig. 4 (right).—Frequency distribution of combinations of two characters, probably correlated. (See Table II.)

Forty-five graphs were made, and two of these are represented in Text-figs. 3 and 4. From a visual examination of these graphs, it was considered that positive correlation might exist in the following pairs of characters:—

(1) apophysis elevation — cone length
(2) „ „ — cone shape
(3) „ „ — apophysis shape
(4) „ „ — number of raised apophyses
(5) umbo elevation — cone length
(6) „ „ — cone shape
(7) „ „ — mucro size (Text-fig. 4)

(8)	cone shape	— cone length (Text-fig. 2)
(9)	„ „	— apophysis flexure
(10)	mucro size	— flexure of umbo and mucro

Many of the subjective estimates involved in this approach must have been unreliable. Nevertheless it shed some light on the possible character-combinations and their frequency in the sample.

Two main observations were made:—

1. Intermediate conditions for every character occurred most frequently; the extremes were comparatively rare.
2. Most, but not all, of the possible combinations in pairs were present.

Variation of All Characters Combined

From the sample as a whole, emerged the concept of a population varying continuously, between distinct extremes, in all the characters recorded. The greatest diversity of character-combinations seemed to be in the central portion of the size-range. As the extremes were approached, the combinations appeared to converge, on the one hand, towards

(a) small, relatively broad, almost ovoid cones with few, and weakly, raised apophyses, flush or depressed umbos which were not tilted, and minute mucros (e.g., Text-fig. C, Fig. 19);

and on the other, towards

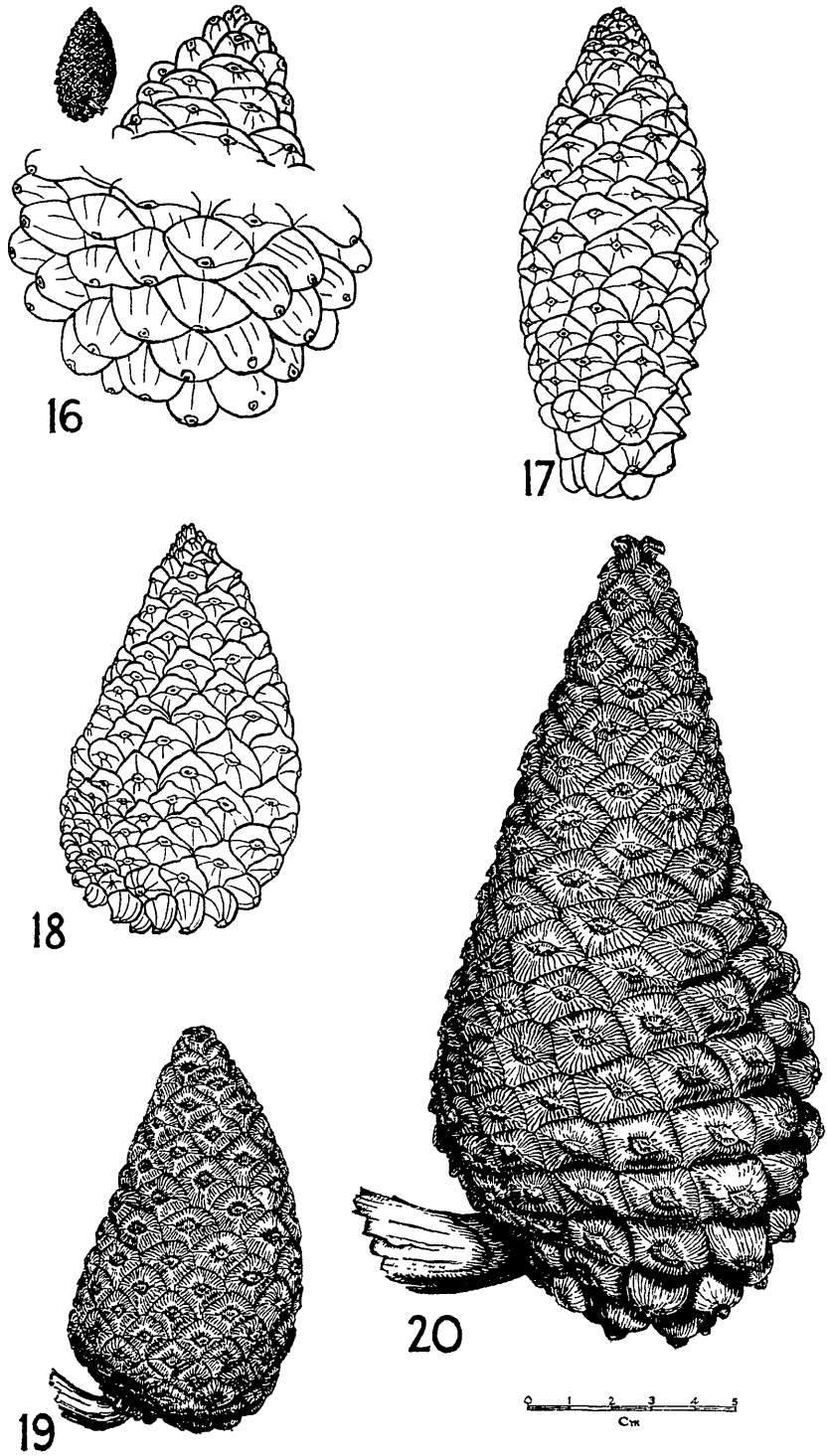
(b) large, relatively narrow, approximately conical cones, with many, and strongly, raised apophyses which were rounded or hemispherical, and raised umbos (e.g., Text-fig. C, Fig. 20).

Even at the extremes, however, the combinations varied, and it seemed impossible to single out a truly typical, small or large cone.

The cones in Figs. 4 and 5, Text-fig. A, showed very unusual character-combinations. The first resembled the cones of *P. attenuata* Lemmon; the second was like those of *P. muricata* D. Don. The author has in his collection other extraordinary cones which include some smaller than any of the 250 in the sample, and one with grotesquely swollen apophyses; he has also seen one 21 cm. long, but, since he did not see the trees that bore them, they could not be considered as part of the sample.

Discussion Based on Previous Descriptions

The earliest descriptions of *Pinus radiata*, as now recognised, were based on scanty material. Coulter's specimens, collected in 1830-31, had two very different kinds of cone, and Don (1836) believed them to represent two species, which he named *P. radiata* and *P. tuberculata*. These specimens came from the Monterey region near sea-level. Others were collected there by Douglas, who reached the coast at Monterey in December, 1830, and named his specimens *P. insignis*. A description of Douglas's specimens was first published by Loudon (1838). Loudon also recognised Don's descriptions, so that these three names, *P. radiata* Don, *P. tuberculata* Don, and *P. insignis* Douglas ex Loudon, all appeared together as referring to distinct species. Another name, *P. californiana* Loiseleur in Nouveau du Hamel V p. 243 (1812), dating from the La Pérouse expedition of 1787, was also given, but Loudon doubted its validity.



TEXT-FIG. C.—FIGS 16–18—After Loudon (1844) FIG. 16—*Pinus radiata* Don FIG 17—*Pinus tuberculata* Don. FIG. 18—*Pinus insignis* Douglas ex Loudon. FIG. 19—One of the smallest Nelson cones, approximating to Lemmon's "var. *levigata*". FIG 20—One of the biggest Nelson cones, similar to Don's type. (All figures × ⅓.)

The three original descriptions were as follows:—

D. Don (1836): "PINUS RADIATA. [Text-fig. C, Fig. 16]

P. foliis ternis? strobilis inæquilateri-ovatis: squamis radiato-rimosis umbilico depresso truncatis; baseos externæ triplò majoribus gibbosis subrecurvis.

Habitat in Californiâ, in maris littore ad Monterey. *Coulter* η. (v.s.sp.)

Arbor rectissima, altitudinem circiter 100 pedes attingens, ramis latè patentibus copiosis ad basin usque ornata *Strobili* aggregati, ovati, 6-pollicares, basi exteriore ventricosi: *squamis* cuneatis, crassis, spadiceis, nitidis, apice dilatatis, depressis, quadrangulis, radiato-rimosis, umbilico depresso; ad basin exteriorem triplò majoribus, apicibus elevatis, gibbosis, subrecurvis.

Found by Dr. Coulter about Monterey in latitude 36°, near the level of the sea, and growing almost close to the beach. The trees grow singly together, and reach the height of 100 feet, with a straight trunk, feathered with branches almost to the ground. It affords excellent timber, which is very tough, and admirably adapted for building boats, for which purpose it is much used

4. PINUS TUBERCULATA [Text-fig. C, Fig. 17.]

P. foliis ternis? strobilis inæquilateri-oblongis aggregatis: squamis apice quadrangulis umbilico depresso truncatis; baseos externæ majoribus elevatis conicis

Habitat in Californiâ, in maris littore ad Monterey *Coulter*. η. (v.s.sp)

Arbor 100-pedalis. *Strobili* oblongi, aggregati (3), fulvo-cinerei, 4-pollicares, 2½ uncias crassitie adæquant: *squamis* cuneatis, apice dilatatis, quadrangularibus, umbilico depresso truncatis, ad basin exteriorem majoribus apice elevatis, conicis.

Found by Dr Coulter along with the preceding, which it resembles in size and habit, but is essentially distinguished by the form of its cones."

J. C. Loudon (1838): "P. INSIGNIS Dougl. The remarkable Pine. [Text-fig. C, Fig. 18.]

Identification. Douglas's specimens in the Horticultural Society's herbarium

Engravings. . . . From Douglas's specimens in the Horticultural Society's herbarium . .

Spec Char. &c Leaves three, and occasionally four, in a sheath; much twisted, varying greatly in length, longer than the cones, of a deep grass green, and very numerous. Cones ovate, pointed, with the scales tuberculate. Buds . . . of the side shoots of young plants, from ⅛in. to ¼in. long and from ¼in to ⅜in. broad, brown, and apparently without resin; on the leading shoots a great deal larger, and resembling in form, and almost in size, those of *P sabiniàna* Leaves, in Douglas's specimen, from 3in. long to 4¼in. long; on the plant in the Horticultural Society's Garden, from 5in. to 7in. long. This pine is well named insignis; its general appearance being indeed remarkable, and totally different from that of every other species that has yet been introduced . . . It was sent home by Douglas in 1833 . ."

The query following " foliis ternis " in Don's descriptions is explained by his statement that the specimens were without leaves, "Dr. Coulter not having been able to find them, from the want of a convenient opportunity to arrange his

vast collections." The feature described as " radiato-rimosis," and indicated in Text-fig. C, Fig. 16, is probably the same as that observed in the Nelson cones (Text-fig. A, Fig. 3).

From modern knowledge of the geographical distribution of the Californian pines, Don's *P. tuberculata* must be regarded as synonymous with *P. radiata*, although Shaw (1914, p. 88) stated that, under a very narrow concept of specific limits, the two might be regarded as separate species.

Loudon's figure (Text-fig. C, Fig. 18) is puzzling, because the position of the peduncle is not shown. If it was on the reverse side of the cone as drawn, it seems that the apophyses would have been incurved; such a curvature has never been seen by the author and it has apparently never been recorded in the literature. Possibly the position of the peduncle should have been shown on the left, slightly inside the margin of the figure.

A much better illustration was given by Forbes (1839), (Text-fig. D, Fig. 21), who would most probably have used Douglas's specimens, as did Loudon. Forbes stated that the cones were " from four to five inches long, and about seven in circumference, of an ovate shape, with an acute slightly curved apex." The figure shows erect mucros, some of which are incurved like that in Text-fig. B, Fig. 14.

Loudon's figure of a *P. radiata* cone (Text-fig. C, Fig. 16) is evidently after Lambert (1837), whose plate probably shows Don's type specimen.

Judging from the account by Hooker and Arnott (1841), there was much confusion over the Californian pines. Of *Pinus radiata* Don they said:

" Dr Coulter found it along the sea shore at Monterrey; and we possess the same collected at Tepic by Dr Sinclair of Her Majesty's Ship Sulphur. On comparing this with the *P. patula* of Scheide and Deppe, as figured in Lambert's Pinus, t. 19, (it is probably also the *P. patula* of Chamisso and Schlechtendahl in 6th Volume of the Linnæa, p. 354) many points of resemblance appear so much so, that we doubt of their being specifically distinct "

Of *P. insignis* they stated:

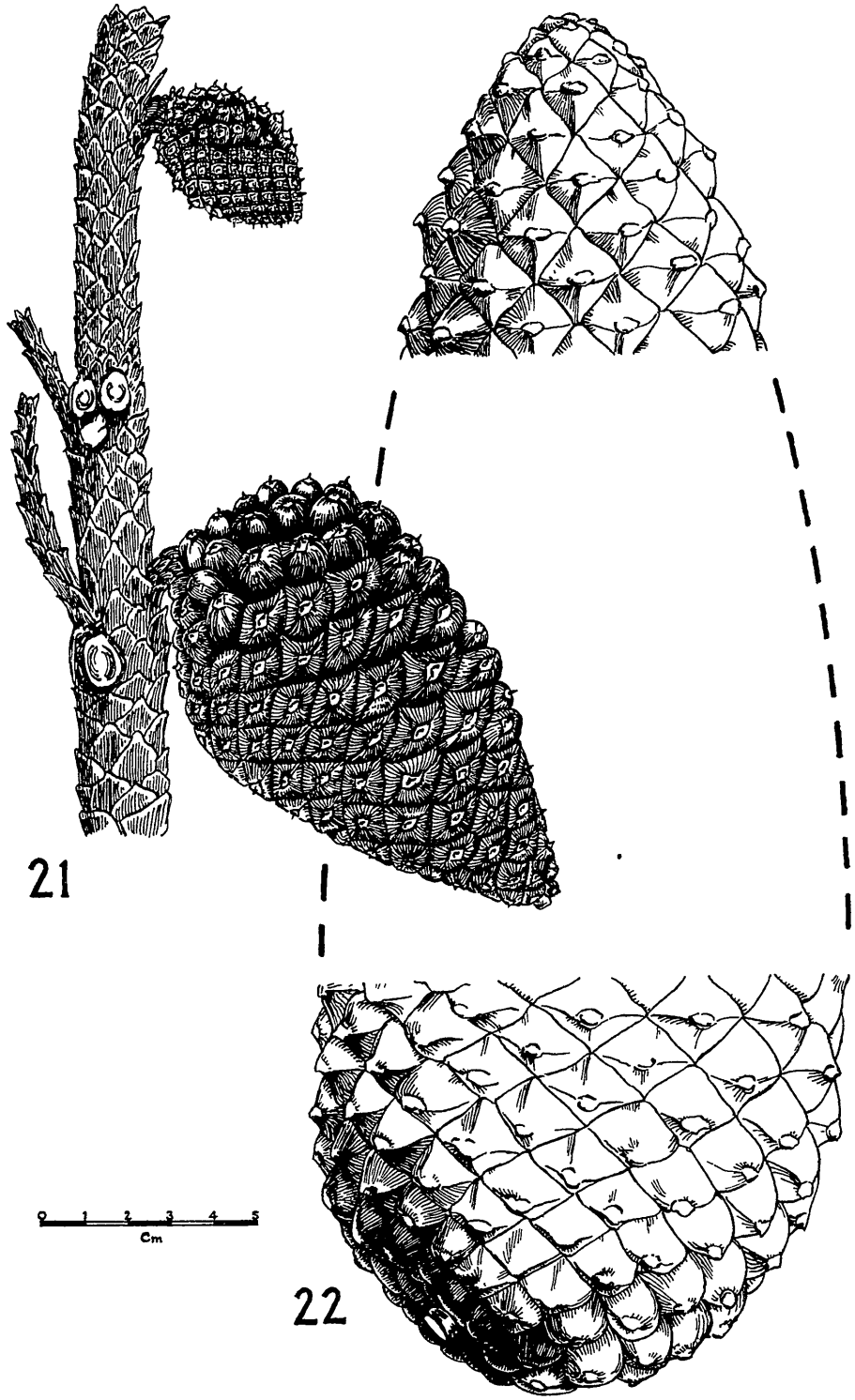
"An accurate specific character and full description of this species are still desiderata."

Pinus sinclairii Hook. et Arn. they described, essentially, as follows:

" This covers the hills from Monterrey to Carmelo and to Punta Pinos. (*Dr Sinclair* of H.M.S. Sulphur.) . . . The ternate or occasionally binate leaves are from three to four inches long, rigid and sharp. The solitary cone we possess is in an old state, the seeds having fallen out, and the scales spreading; it is twelve inches long, and five at its greatest breadth near the base. The scales are from two to three inches long, three-quarters of an inch broad, cuneate, hard and coriaceous, the apex much thickened, and forming a short four-sided pyramid with a short reflexed sharp rigid point. As a species it approaches, in the form of cone and scales, to *P. Montezumæ, Lam. Pin. t.* 22:—but the leaves are quite different."

Henry, in Elwes & Henry (1910), stated:

" The drawing and description represent a large-coned form of *P. radiata* . . . The cone in the Kew Museum labelled ' *P. Sinclairii* (?) ' is *P. Montezumæ;* but it is not the cone described by Hooker and Arnott; and Engelmann in Brewer



TEXT-FIG. D.—FIG. 21—*Pinus insignis* Dougl. ex Loudon (after Forbes, 1839). FIG. 22—*Pinus sinclairii* Hook. et Arn. (after Hooker & Arnott, 1841). (Both figures approximately × $\frac{2}{3}$.)

and Watson, *Bot. Calif.* ii. 128 (1880), is incorrect in assuming *P. Sinclairii* to be a factitious species."

A cone twelve inches (or 30 cm.) long, however, is so much bigger than any other recorded for *P. radiata* that one is compelled to wonder whether the specimens might have become accidentally mixed. As shown in the figure (Text-fig. D, Fig. 22) the cone was not attached to a shoot; the foliage was illustrated separately. Apparently Shaw (1914, p. 88) also regarded this cone with suspicion, for, listing synonyms for *P. radiata*, he wrote:

" *P. sinclairii* Hooker and Arnott in Bot. Beechy Voy. 392, t. 93 (as to leaves)."

Hartweg (1848) wrote, of a stand near San Antonio, San Luis Obispo County

"A small pine wood which became visible on our descent, looked like an oasis in the desert . . . I found the wood to be composed of a variety of Pinus insignis, with larger cones than those about Monterey, from which it also differs in their being produced in less abundance."

This evidently refers to the same tract as that examined by Lindsay (1932), who stated that the cones there were much larger than those to the north, frequently reaching 7½in. (19 cm.) in length, with very large apophyses

Lemmon (1888) suggested the following taxonomic treatment:—

(1) The type: *P. insignis* Dougl. Leaves rather slender. Mature cones ovoid-conical, 3–5 inches (7·6–12·7 cm.) long, apophyses at base outside large hemispherical; prickles very small, deciduous.

DISTRIBUTION: With its headquarters on Point Pinos at Monterey Bay and extending along the coast from Pescadero to San Simeon Bay, with a doubtful var. *binata* on the outlying island of Guadelupe, 600 miles to the south.

(2) Variety *radiata* Don. Leaves shorter and thinner than in the type Cones large, as in Don's *P. radiata* (14·6 cm. long, and 8 9 cm broad at the base, where the apophyses were gibbous).

DISTRIBUTION: Mostly southward from Point Pinos.

(3) Variety *levigata* Lemmon. Smaller trees, with long, slender leaves Cones few, smaller than in the type, almost ovoid, often with no raised apophyses; mucros small and weak.

DISTRIBUTION: Outlying trees on the outskirts of the Monterey forest, farthest from the sea

If Lemmon's concept of the variation of the cones is applied to the Nelson sample, his varieties "*levigata*" and "*radiata*" seem to occupy the extremes of the range, and his type lies near the centre (e.g., Text-fig C, Figs 19 and 20); but, because of the graded variation, it would be arbitrary to sort the whole sample into these three categories. Henry, in Elwes & Henry (1910), made a similar comment, stating that the trees showed a wide variation under cultivation in Great Britain, especially in cone size, and that *P. radiata* was formerly supposed to differ from *P insignis* in having larger cones, but intermediate forms were numerous.

Jepson (1910) figured a " typical medium-sized " cone about 12 cm long, and a " small-sized " cone 7 6 cm. long. The latter would conform in size with Lemmon's var. *levigata* but the apophyses were strongly raised The Nelson sample contained a small cone very like Jepson's.

The fossil cones from Pleistocene sediments, described by Chaney & Mason (1933), were up to 15 cm. long and resembled those near Cambria more than those at Monterey. They were like the one shown in Text-fig. C, Fig. 20. The stand near Cambria marks the southernmost part of the natural distribution of *P. radiata* on the mainland. It is presumably the same as that examined by Hartweg (1848) and Lindsay (1932).

The observations of Hocking (1930) on the cones in Canterbury, New Zealand, are almost identical with those recorded here for Nelson.

CONCLUSIONS

The cones in this Nelson sample came either from planted trees or from the self-sown progeny of such trees. Perhaps up to four tree-generations separated these from their Californian progenitors; of the latter, nothing is known. They were, however, more likely to have been near Monterey, or northward towards San Francisco, than near Cambria, to the south. Also, they were probably few. Despite this, the cones of as few as fifty trees, growing on half an acre in Nelson, appeared to vary almost as widely as those throughout the natural range of the species The morphological variation in California is apparently related in some ways to the geographical distribution, so that characters of the cone might be useful in attempting an infra-specific classification there. In Nelson, however, and in Canterbury (Hocking, 1930) they would probably be quite useless for this purpose unless their variation proved to be correlated with some other feature with a simpler variation pattern

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